Red Hat
Training and
Certification

Managing and Building Container Images and Containers

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Version 1.0

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Introduction

This guide with cover additional and supplemental materials for the DO180 custom container course. As part of this guide, students will be learning the following concepts:

Course Objectives

- Exploring RHEL 8.x Differences
- Exploring SystemD and Creating SystemD Services
- Exploring FirewallD and FirewallD Custom Services
- Exploring Cockpit and the Red Hat Web Console
- Rootless Podman
- Leveraging Podman's Pod Capabilities
- Managing Containers with the Red Hat Web Console (Cockpit)
- Running Containers as a Service (SystemD)
- Building Container Images with Buildah (from scratch)
- Building Container Images from Containerfile/Dockerfile Files
- Installing/Configuring/Using Quay Container Registry
- Using ClairV4 and Quay Mirroring with Quay
- Exploring Skopeo to Interact with Container Images

Courses for Reference

- DO180
- RH134
- RH354

This course will use a DO180 course for the hands-on lab environment. The environment has been modified to have an additional machine to perform custom exercises and have the Quay registry installed locally.

Lab Machine Requirements

In addition to the DO180 lab environment, a new VM has been added to that environment. This machine can be setup and configured locally with the following requirements:

VM Requirements

- RHEL 8.4+
- 6 vCPU (8 vCPU Recommended)
- 12GB RAM (16GB Recommended)
- 60GB Storage (Image and Database storage)

Using the Lab Guide

This lab guide and contents within the guide are meant to supplement the course and materials delivered as part of a custom DO180 delivery. It is advisable to download the RH354 course manual and the RH134 course manual prior to the class delivery. The DO180 course guide can be downloaded as part of the course.

Course Materials

All course materials and lab materials for the custom portion of the course can be found here: https://github.com/tmichett/OCP_Demos

The lab guide for this course can be downloaded from here: https://github.com/tmichett/OCP_Demos/blob/main/Containers/Containers.pdf

1. RHEL 8 Changes

RHEL 8.x brought several significant changes and expanded upon other changes that were introduced as part of the **SystemD** switch in RHEL 7.x. This course will highlight some of the most significant changes and enhancements to RHEL 8.x.

RHEL 8.x Enhancements

- TMUX
- SystemD
- FirewallD

Before beginning the course, there is a quick set of steps that will be completed as an exercise so that the environment can be setup and prepared. The **Workstation** machine will be our GUI machine used throughout the week and is running RHEL 8.2. We will also be using a custom RHEL 8.4 system called **server**.

1.1. Setup Exercise

Before you begin using the customized DO180 Workshop Lab Environment a couple things must be accomplished.

Before you Begin

1. Prepare Workstation
2. SSH Keys must be Generated and Distributed for the root user on **server**
3. Github Projects Must be Downloaded
4. Ansible Playbooks Must be Executed

There will be two Github projects used in this course for the custom exercises and demonstrations.

- **OCP Demos**: https://github.com/tmichett/OCP_Demos - The ***/*Containers** directory contains most of the resources being used for the course.
- **Quay_Lab_PoC**: https://github.com/tmichett/quay_lab_poc - This repository contains playbooks that will setup and deploy Quay locally on the **server** system.

The lab environment will need **server** configured to be our **quay.local** system and will need to have access to all packages and keys.

Example 1. Lab Installation and Setup Exercise

1. Create Directories and Download Github Repos

Listing 1. Creating Directory and Switch to Directory

```
[student@workstation ~]$ mkdir github ; cd github
```

Listing 2. Cloning Repositories - Cloning **quay_lab_poc**

```
[student@workstation github]$ git clone https://github.com/tmichett/quay_lab_poc.git
Cloning into 'quay_lab_poc'...
remote: Enumerating objects: 266, done.
remote: Counting objects: 100% (266/266), done.
remote: Compressing objects: 100% (167/167), done.
remote: Total 266 (delta 67), reused 253 (delta 54), pack-reused 0
Receiving objects: 100% (266/266), 5.90 MiB | 22.90 MiB/s, done.
Resolving deltas: 100% (67/67), done
```

Listing 3. Cloning Repositories - Cloning **OCP_Demos**

```
[student@workstation github]$ git clone https://github.com/tmichett/OCP_Demos.git
Cloning into 'OCP_Demos'...
remote: Enumerating objects: 763, done.
remote: Counting objects: 100% (763/763), done.
remote: Compressing objects: 100% (527/527), done.
remote: Total 763 (delta 329), reused 595 (delta 181), pack-reused 0
Receiving objects: 100% (763/763), 37.16 MiB | 29.22 MiB/s, done.
Resolving deltas: 100% (329/329), done.
```

2. Switch to the **OCP_Demos/Containers/labs/server_prep** Folder

```
[student@workstation github]$ cd OCP_Demos/Containers/labs/server_prep
```

3. Execute the **Setup_Workstation.yml** playbook

```
[student@workstation server_prep]$ ansible-playbook Setup_Workstation.yml
```

4. Create SSH keys

```
[student@workstation server_prep]$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/student/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/student/.ssh/id_rsa.
Your public key has been saved in /home/student/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:/FXYb+9b7dGD9CJpwTdsE0MqJkitLBuHYJDofp4Jz3w student@workstation.lab.example.com
The key's randomart image is:
+---[RSA 3072]----+
|+.   ..      .   |
|oo  . ..    oo   |
|o . o... o ..oo  |
| . + + .o o ..o. |
|.   =   S  o.B  o|
| o o     . .* =.+|
|  B o     .+ o +=|
|   B E    . . .o+|
|    .          .+|
+----[SHA256]-----+
```

5. Copy SSH key for the **root** user to **server**

```
[student@workstation server_prep]$ ssh-copy-id root@server
/usr/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/home/student/.ssh/id_rsa.pub"
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/usr/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
root@server's password:

Number of key(s) added: 1

Now try logging into the machine, with:   "ssh 'root@server'"
and check to make sure that only the key(s) you wanted were added.
```

6. Execute the **Setup_Server.yml** playbook

```
[student@workstation server_prep]$ ansible-playbook Setup_Server.yml
```

7. Install the **Container Tools** package on **server**

```
[root@server ~]# yum module install container-tools
```

8. Install **cockpit** on **server**

```
[root@server ~]# yum install cockpit* ①
```

① The **'' is added to install all Cockpit packages and plugins. This will allow the *cockpit-podman** to already be installed and ready on the system.

1.2. TMUX Usage

As part of the upgrade process and package replacement process in RHEL8, several packages have not only been deprecated, they've been completely removed. The **screen** package is one package that is no longer available for installation. Instead, a new terminal program **tmux** has been introduced to provide the **screen** functionality as well as other enhancements.

TMUX Usage

TMUX References

Red Hat Learning Community: https://learn.redhat.com/t5/Platform-Linux/Using-tmux-to-execute-commands-on-servers-in-parallel/m-p/2200

Tactical TMUX: https://danielmiessler.com/study/tmux/

In the example below, we will explore the **screen** functionalities of TMUX with respect to attaching and detaching of sessions.

Example 2. **LAB: Installing TMUX**

1. Install **tmux** with YUM

Listing 4. Installation of TMUX

```
[root@workstation ~]# yum install tmux
Red Hat Enterprise Linux 8.0 AppStream (dvd)     21 MB/s | 5.3 MB     00:00
Red Hat Enterprise Linux 8.0 BaseOS (dvd)        23 MB/s | 2.2 MB     00:00
Last metadata expiration check: 0:00:01 ago on Mon 13 Apr 2020 10:55:47 AM EDT.
Package tmux-2.7-1.el8.x86_64 is already installed.
Dependencies resolved.
Nothing to do.
Complete!
```

2. Launch **tmux**

Listing 5. Using **tmux**

```
[student@workstation ~]$ tmux
```

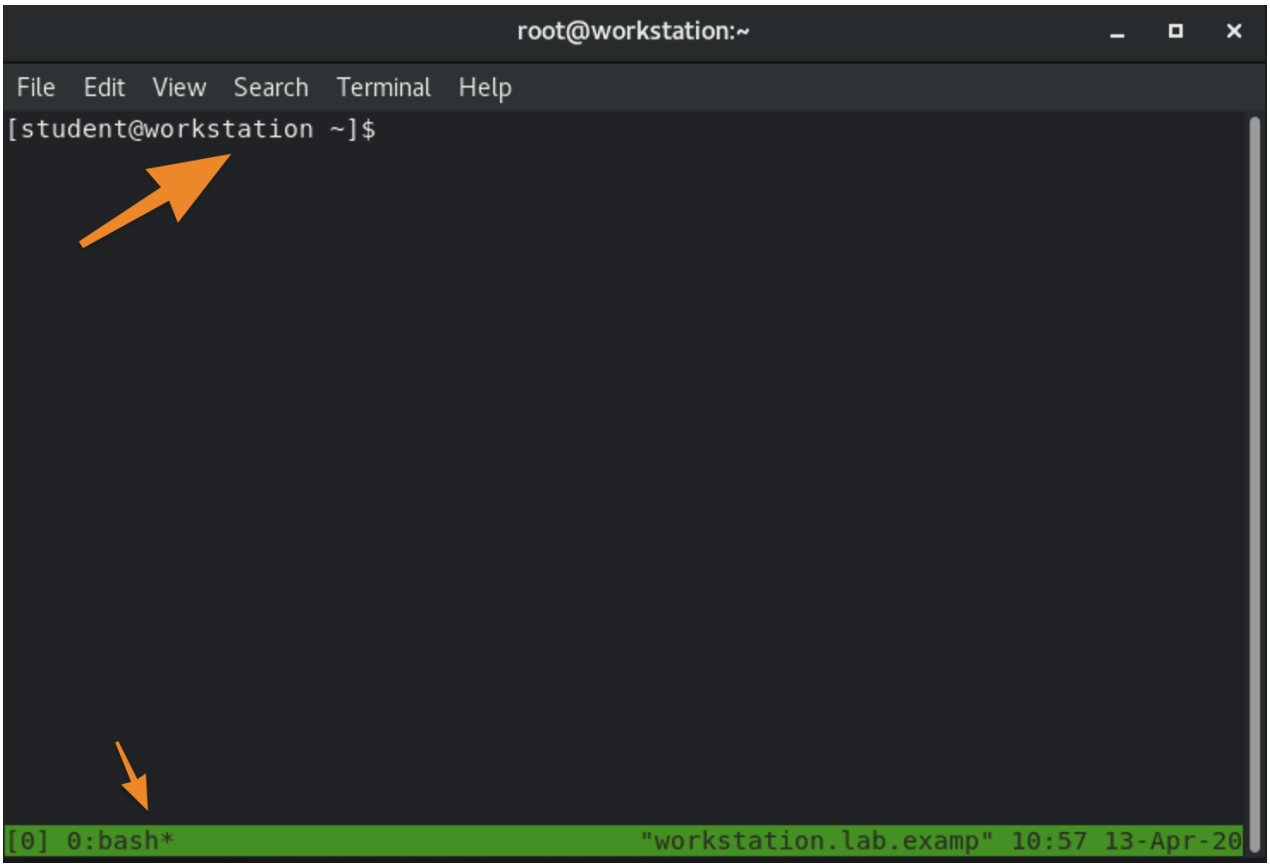


Figure 1. **tmux** *Terminal Window*

3. Placing **tmux** Window in Background (*CTRL+B+D*)

Listing 6. Detaching a **tmux** *Session*

```
[student@workstation ~]$ tmux
[detached (from session 0)]
```

4. Re-attaching to **tmux**

Listing 7. Source Description

```
[student@workstation ~]$ tmux list-sessions
0: 1 windows (created Mon Apr 13 11:01:53 2020) [80x23]

[student@workstation ~]$ tmux attach-session -t 0
```

Naming or Renaming Sessions

It is possible that once you are in a **tmux** session to rename the session.

Listing 8. Renaming a TMUX Session

```
[student@workstation ~]$ tmux rename-session --help
usage: rename-session [-t target-session] new-name

[student@workstation ~]$ tmux rename-session -t 0 travis-demo
```

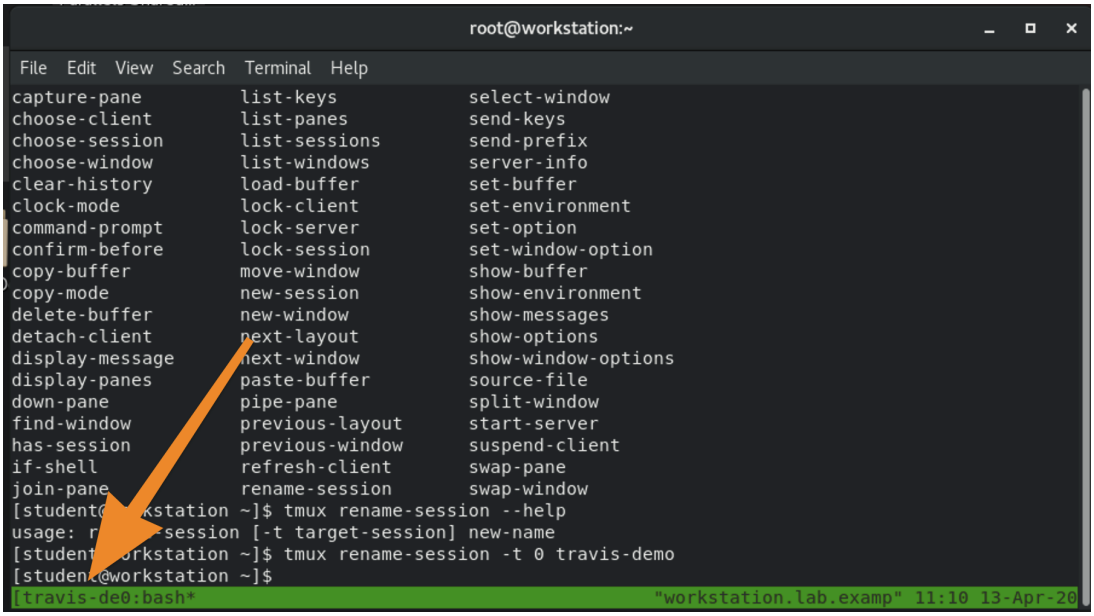


Figure 2. Renamed **tmux** *Session*

```
[student@workstation ~]$ tmux new-session
[detached (from session travis-demo)]

[student@workstation ~]$ tmux list-sessions
travis-demo: 1 windows (created Mon Apr 13 11:08:28 2020) [98x23]

[student@workstation ~]$ tmux attach-session -t travis-demo
```

1.3. SystemD Overview

1.3.1. Understanding SystemD Unit Files and Creating a Service

Starting in RHEL 7, **SystemD** replaced the older style Linux SystemV (sysvinit daemon). This change continued through with RHEL 8 and more systemd tools replaced the traditional legacy tools. This small section will provide references and an overview of how **systemd** can be used to replace the older *init* scripts that were placed in **/etc/init.d/** or some of the other directories.

SystemD References

Linus Torvalds and others on Linux's systemd: https://www.zdnet.com/article/linus-torvalds-and-others-on-linuxs-systemd/

SysVinit Vs systemd Cheatsheet: https://www.2daygeek.com/sysvinit-vs-systemd-cheatsheet-systemctl-command-usage/

Example 3. **LAB: Creating a SystemD Script and Service**

1. Create the Init Script

Listing 9. Init Script to Run at Startup

```
[root@server ~]# vim /usr/bin/systemd_test_service.sh
#!/usr/bin/bash

DATE=`date '+%Y-%m-%d %H:%M:%S'`
echo "This is a sample service started at ${DATE} for the SystemD Custom course." | systemd-cat -p info

while :
do
echo "Looping...";
sleep 30;
done
```

2. Make script executable

Listing 10. Running **chmod** *on script*

```
[root@server ~]# chmod +x /usr/bin/systemd_test_service.sh
```

3. Edit SystemD Service (Unit File)

Listing 11. Editing the .service File

```
[root@server ~]# vim /etc/systemd/system/systemd_test_service.service

[Unit]
Description=Systemd-Test-Service example systemd service.

[Service]
Type=simple
ExecStart=/bin/bash /usr/bin/systemd_test_service.sh

[Install]
WantedBy=multi-user.target
```

4. Fix Permissions on **.service** File

Listing 12. Running **chmod** *on .service File*

```
[root@server ~]# chmod 644 /etc/systemd/system/systemd_test_service.service
```

SystemD Services

Once a script has been created and made executable and a service file has properly been created and placed in **/etc/systemd/system/** directory it is possible to use the **systemctl** command to interact with the service file and make it active on boot.

Default SystemD Directories

It is important to note that there are several default SystemD directories. When defining your own files, the proper location is to place them in **/etc/systemd**. There is more information available in other Red Hat courses, specifically the RH442 Performance Tuning course.

Default Location: **/lib/systemd/**

5. Starting and Enabling a Custom Service

Listing 13. Controlling a Custom Service with **systemctl**

```
[root@server ~]# systemctl enable systemd_test_service.service --now
Created symlink /etc/systemd/system/multi-user.target.wants/systemd_test_service.service →
/etc/systemd/system/systemd_test_service.service.
```

6. Checking Status of a Custom Service

Listing 14. Using **systemctl** *to Check Service Status*

```
[root@server ~]# systemctl status systemd_test_service.service
● systemd_test_service.service - Systemd-Test-Service example systemd service.
   Loaded: loaded (/etc/systemd/system/systemd_test_service.service; enabled; vendor >
   Active: active (running) since Mon 2021-10-25 10:07:42 EDT; 24s ago
 Main PID: 1533 (bash)
    Tasks: 2 (limit: 152500)
   Memory: 612.0K
   CGroup: /system.slice/systemd_test_service.service
           ├─1533 /bin/bash /usr/bin/systemd_test_service.sh
           └─1537 sleep 30

Oct 25 10:07:42 server.lab.example.com systemd[1]: Started Systemd-Test-Service examp>
Oct 25 10:07:42 server.lab.example.com bash[1533]: Looping...
```

7. Checking **/var/log/messages** for Custom Service

Listing 15. Seaching Log file for Custom Service

```
[root@server ~]# grep -i "systemd custom" /var/log/messages
Oct 25 10:07:42 server journal[1536]: This is a sample service started at 2021-10-25 10:07:42 for the SystemD Custom course.
```

SystemD References

Creating a Service at Boot: https://www.linode.com/docs/quick-answers/linux/start-service-at-boot/

Overview of SystemD for RHEL7: https://access.redhat.com/articles/754933

Converting traditional sysV init scripts to Red Hat Enterprise Linux 7 systemd unit files: https://www.redhat.com/en/blog/converting-traditional-sysv-init-scripts-red-hat-enterprise-linux-7-systemd-unit-files

Creating and Modifying SystemD Unit Files: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/system_administrators_guide/sect-managing_services_with_systemd-unit_files

Creating a Linux service with systemd: https://medium.com/@benmorel/creating-a-linux-service-with-systemd-611b5c8b91d6

How to create systemd service unit in Linux: https://linuxconfig.org/how-to-create-systemd-service-unit-in-linux

References

Systemd Timers for Scheduling Tasks: https://fedoramagazine.org/systemd-timers-for-scheduling-tasks/

1.4. FirewallD

Beginning in RHEL 8.0, Red Hat moved away from **iptables** as the back-end firewall implementation and instead moved to NFTables. However, the introduction of FirewallD and the **firewall-cmd** management commands implemented in RHEL 7.x have evolved and leveraging FirewallD is still the preferred firewall management solution in RHEL 8.x.

1.4.1. FirewallD Service Definitions

FirewallD was introduced in RHEL7 as part of the SystemD transition and a new way to manage firewalls without using the underlying firewall implementation (**iptables**). FirewallD with **firewall-cmd** continues to be used in RHEL8 as the preferred method of managing and maintaining firewall rules.

FirewallD Resources

https://firewalld.org/

https://www.liquidweb.com/kb/an-introduction-to-firewalld/

https://cheatography.com/mikael-leberre/cheat-sheets/firewall-cmd/

1.4.2. The firewall-cmd Utility

The **firewall-cmd** utility is the primary method to manage and interact with firewall rules on RHEL7/8 systems. The **firewall-cmd** utility supports BASH completion and allows firewall rules to be added based on defined services or by specifying ports/protocols.

Listing 16. Allowing HTTP through the Firewall by Port/Protocol

```
[root@server ~]# firewall-cmd --add-port=80/tcp
success

[root@server ~]# firewall-cmd --list-all
public (active)
  target: default
  icmp-block-inversion: no
  interfaces: enp1s0
  sources:
  services: cockpit dhcpv6-client ssh
  ports: 80/tcp
  protocols:
  masquerade: no
  forward-ports:
  source-ports:
  icmp-blocks:
  rich rules:

[root@server ~]# firewall-cmd --remove-port=80/tcp
success
```

Listing 17. Allowing HTTP through the Firewall by Service

```
[root@server ~]# firewall-cmd --add-service=
Display all 154 possibilities? (y or n)

[root@server ~]# firewall-cmd --add-service=http
success

[root@server ~]# firewall-cmd --list-all
public (active)
  target: default
  icmp-block-inversion: no
  interfaces: enp1s0
  sources:
  services: cockpit dhcpv6-client http ssh
  ports:
  protocols:
  masquerade: no
  forward-ports:
  source-ports:
  icmp-blocks:
  rich rules:
```

firewall-cmd *Usage Warning*

The **firewall-cmd** utility can be used to make changes to the running firewall as shown in the examples above. This does not make changes to the firewall config file. In order to make the changes to the configuration file, it is necessary to use the **--permanent** options to have the changes written to a file.

When using **--permanent**, and you are not making changes to the current firewall runtime, it is also necessary to use: **firewall-cmd --reload** to reload or load new firewall rules from the firewall configuration file.

Important Header

It is important to note that presently the Red Hat Web Console (cockpit) only supports management of **firewalld** using defined services.

1.4.3. FirewallD Files and Locations

FirewallD has a few locations for files both for configuration and usage. As with most configuration files on a Linux system, those rely in **/etc/**. The user configurable files for FirewallD also reside in **/etc/**. Default configuration files for services, zones, and other FirewallD functionality resides in **/usr/lib/firewalld**. This location contains all defined services files and default configuration files for FirewallD and used by the **firewall-cmd** utility.

Listing 18. FirewallD Configuration Files

```
[root@server ~]# tree /etc/firewalld/
/etc/firewalld/
├── firewalld.conf
├── helpers
├── icmptypes
├── ipsets
├── lockdown-whitelist.xml
├── services
└── zones
    ├── public.xml
    └── public.xml.old

5 directories, 4 files
```

Listing 19. FirewallD Default Configuration Files

```
[root@server ~]# tree /usr/lib/firewalld/
/usr/lib/firewalld/
├── helpers
│   ├── amanda.xml
│   ├── ftp.xml
│   ├── h323.xml
│   ├── irc.xml
│   ├── netbios-ns.xml
│   ├── pptp.xml
│   ├── proto-gre.xml
... output omitted ...
└── zones
    ├── block.xml
    ├── dmz.xml
    ├── drop.xml
    ├── external.xml
    ├── home.xml
    ├── internal.xml
    ├── public.xml
    ├── trusted.xml
    └── work.xml

5 directories, 222 files
```

1.4.4. Defining a Custom Service File

It is possible to define custom **firewalld** service files. These files can be used for your environments for custom applications or custom firewall rules. These service files can also be checked into a version control system such as **git**.

Creating a Custom Service File using Existing File as Base

It is easiest to take an existing service file, copy it to the **/etc/firewalld/services** directory, rename and edit the file.

1. Copy existing FirewallD service file to **/etc/firewalld/services**

Listing 20. Using SSH Service File as a Starting Point

```
[root@server ~]# cp /usr/lib/firewalld/services/ssh.xml /etc/firewalld/services/custom_ssh.xml
```

2. Edit the file and specify the new options

Listing 21. Edit the Custom SSH Service Definition

```
[root@server ~]# vim /etc/firewalld/services/custom_ssh.xml
<?xml version="1.0" encoding="utf-8"?>
<service>
  <short>SSH_Custom</short>
  <description>This is a custom SSH service definition for paranoid people that don't want to run SSH on the default port of 22. This will
allow SSH to run on the port 8022 to meet our defined security guidance.</description>
  <port protocol="tcp" port="8022"/>
</service>
```

3. Listing FirewallD Services to Verify New Service

Listing 22. Getting Listing of FirewallD Services

```
[root@server ~]# firewall-cmd --get-services | grep custom_ssh
```

FirewallD Delays in Discovering a Service

Depending on system speed and refreshing of FirewallD daemon, the new service might not be picked up immediately. It will be discovered or if you are in a hurry, you can run **firewall-cmd --reload** command to immediately have the service discovered and available.

1.4.5. FirewallD Configuration Files

As stated above, the main FirewallD configuration files are located in **/etc/firewalld**. To specifically change or view the configuration file on the system, you generally want to look at the firewalls in the **Firewall Zone**. This is found by opening the corresponding zone file in **/etc/firewalld/zones** directory.

1. Viewing Firewall configuration for the Public Zone.

Listing 23. FirewallD Configuration for Public

```
[root@server ~]# cat /etc/firewalld/zones/public.xml
<?xml version="1.0" encoding="utf-8"?>
<zone>
  <short>Public</short>
  <description>For use in public areas. You do not trust the other computers on networks to not harm your computer. Only selected incoming
connections are accepted.</description>
  <service name="ssh"/>
  <service name="dhcpv6-client"/>
  <service name="cockpit"/>
</zone>
```

2. Adding a custom service

Listing 24. Adding our new Service

```
[root@server ~]# firewall-cmd --add-service=custom_ssh --permanent
success
```

3. Verifying Firewall configuration for the Public Zone.

Listing 25. FirewallD Configuration for Public with Custom Service

```
[root@server ~]# cat /etc/firewalld/zones/public.xml
<?xml version="1.0" encoding="utf-8"?>
<zone>
  <short>Public</short>
  <description>For use in public areas. You do not trust the other computers on networks to not harm your computer. Only selected incoming
connections are accepted.</description>
  <service name="ssh"/>
  <service name="dhcpv6-client"/>
  <service name="cockpit"/>
  <service name="custom_ssh"/>
</zone>
```

Example 4. **LAB: Creating a Quay Firewall Service**

In preparation of the Quay exercises, this lab will be used to create a custom service file for use with FirewallD.

Table 1. Network Ports for Firewalls and Port Mapping for Quay

Service Name	Network Port
Quay HTTPS	8443/TCP
Quay HTTP	8080/TCP
Quay HTTP	80/TCP

Service Name	Network Port
Quay HTTPS	443/TCP
Postgresql Quay	5432/TCP
Postgresql ClairV4	5433/TCP
Redis for Quay	6379
ClairV4 HTTP	8081/TCP

1. Copy the **ssh.xml** to **quay_lab.xml** as a template.

```
[student@workstation ~]$ cp /usr/lib/firewalld/services/ssh.xml ~/quay_lab.xml
```

2. Modify and edit the **quay_lab.xml** with the needed firewall ports.

```
[student@workstation ~]$ vim quay_lab.xml
<service>
  <short>QUAY-LAB</short>
  <description>This service has been created for the Quay Lab PoC. It will be used for deploying Quay, Quay Mirroring, and the
ClairV4 image scanning service. It is also designed to support the Postgres and Redis supporting services.</description>
  <port protocol="tcp" port="80"/>
  <port protocol="tcp" port="8080"/>
  <port protocol="tcp" port="8443"/>
  <port protocol="tcp" port="443"/>
  <port protocol="tcp" port="5432"/>
  <port protocol="tcp" port="5433"/>
  <port protocol="tcp" port="6379"/>
  <port protocol="tcp" port="8081"/>
</service>
```

3. Copy the file to the **server** for later use

```
[student@workstation ~]$ scp quay_lab.xml root@server:/etc/firewalld/services/
quay_lab.xml                                  100%  627   247.8KB/s   00:00
```

1.5. Cockpit

Another change with RHEL 8.x was with the graphical server and the desktop manager. The X11 project and XWindows has been replaced largely with Wayland/Gnome3 as the graphical rendering environment of choice. These changes introduced some dependencies on the graphical management of several system services and components. The Wayland change no longer supports the X11 forwarding, so it was necessary to build tools or extend existing tools to be managed differently. The **cockpit**

project was utilized and implemented in RHEL 8 as the new Red Hat Web Management Console which brought in numerous plugins allowing these services to be managed graphically within a standard web browser.

Red Hat Web Management Console

Leverage portions of the RH354 text around Cockpit and the Red Hat Web Management Console before looking at the additional Cockpit pacakges.

1.5.1. Installing Additional Cockpit Packages

Listing 26. Install all Base Cockpit Packages

```
[root@server ~]# yum install cockpit*
```

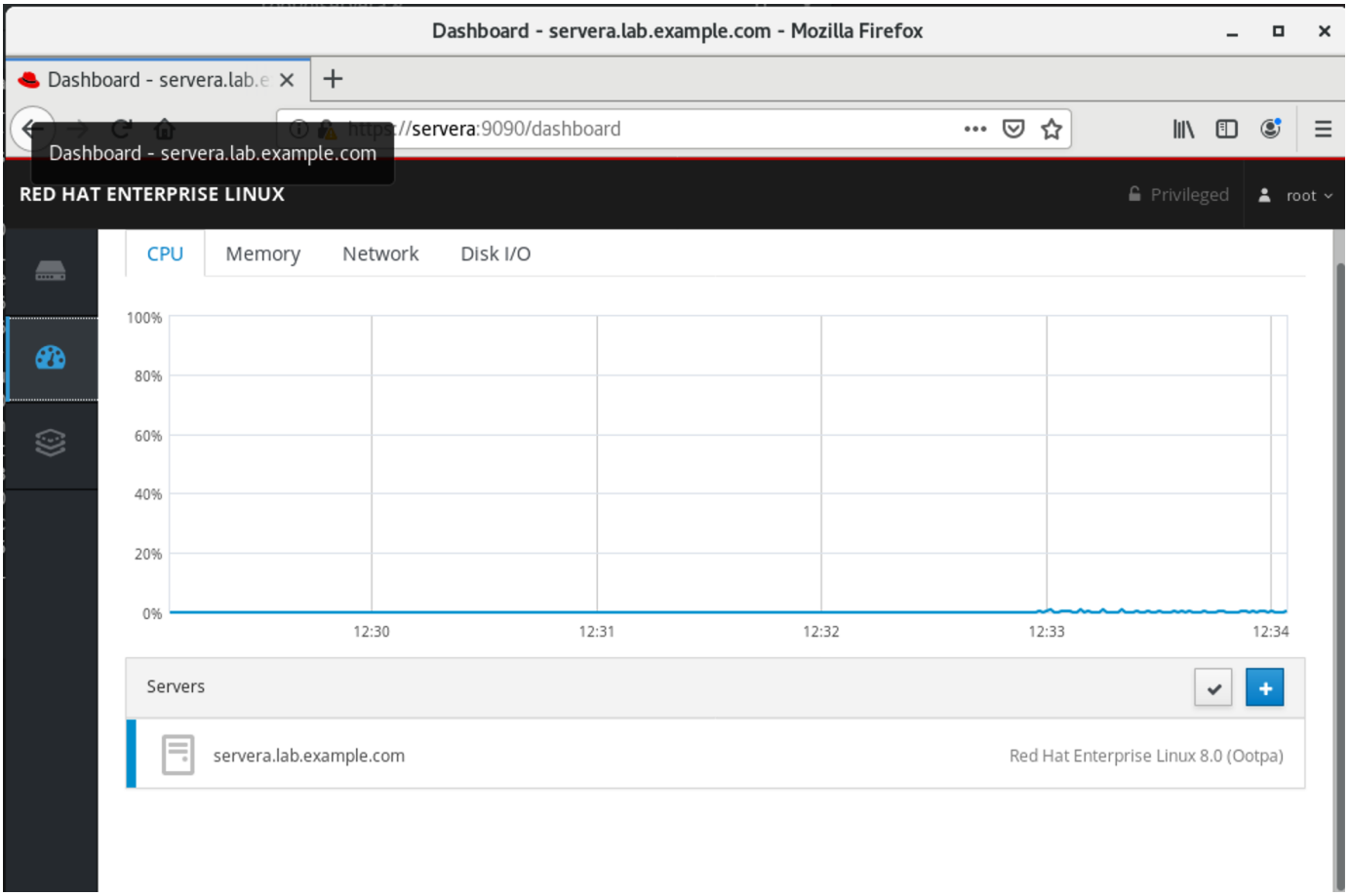


Figure 3. Cockpit Dashboard

Cockpit Plugin and Package Availability

Using the installation method above will install all Cockpit packages and plugins that are available in currently subscribed channels. However, not all components will work until additional back-end components are installed. For example, the **Composer** cockpit plugins need composer and other items installed in order to be able to be fully utilized. This installation gives the **Cockpit Dashboard Plugin** which allows connecting to multiple Web Consoles.

1.5.1.1. Cockpit to Manage Multiple Systems

It is possible to use a single **cockpit** Interface to manage multiple servers.

Example 5. **LAB: Setting up Cockpit to control multiple systems**

1. Ensure cockpit socket/service is running and configured on all systems.

Listing 27. Test and Enable Cockpit (Both **workstation** *and* **server***)*

```
[root@workstation ~]# systemctl enable cockpit.socket --now
Created symlink /etc/systemd/system/sockets.target.wants/cockpit.socket → /usr/lib/systemd/system/cockpit.socket.

[student@workstation ~]$ ssh root@server
Activate the web console with: systemctl enable --now cockpit.socket

[root@server ~]# systemctl enable --now cockpit.socket
Created symlink /etc/systemd/system/sockets.target.wants/cockpit.socket → /usr/lib/systemd/system/cockpit.socket.
```

2. Connect to the Cockpit Web Console

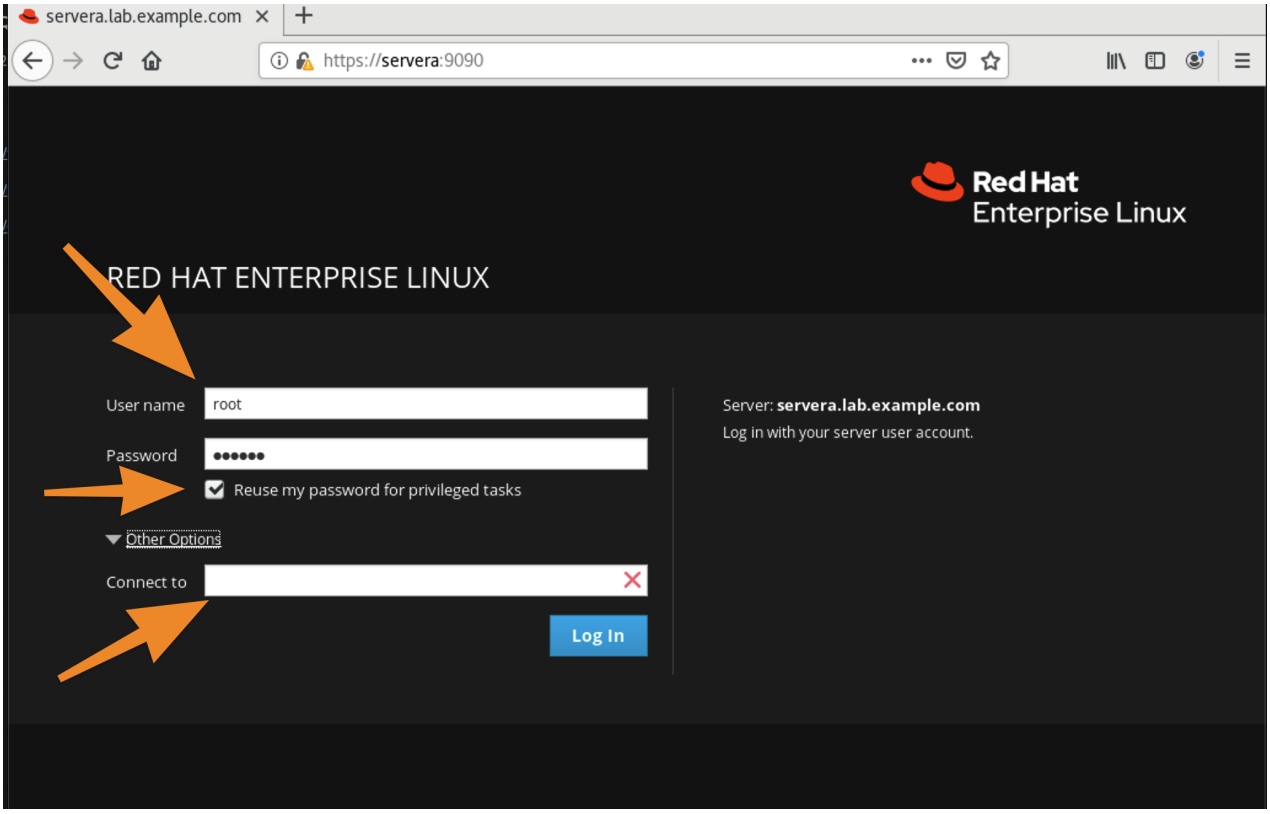


Figure 4. Red Hat Web Console (cockpit)

3. Add another Web Console from the Cockpit Dashboard
   a. Navigate to the Dashboard
   b. Click the "+" and complete the information
      - **workstation.lab.example.com**

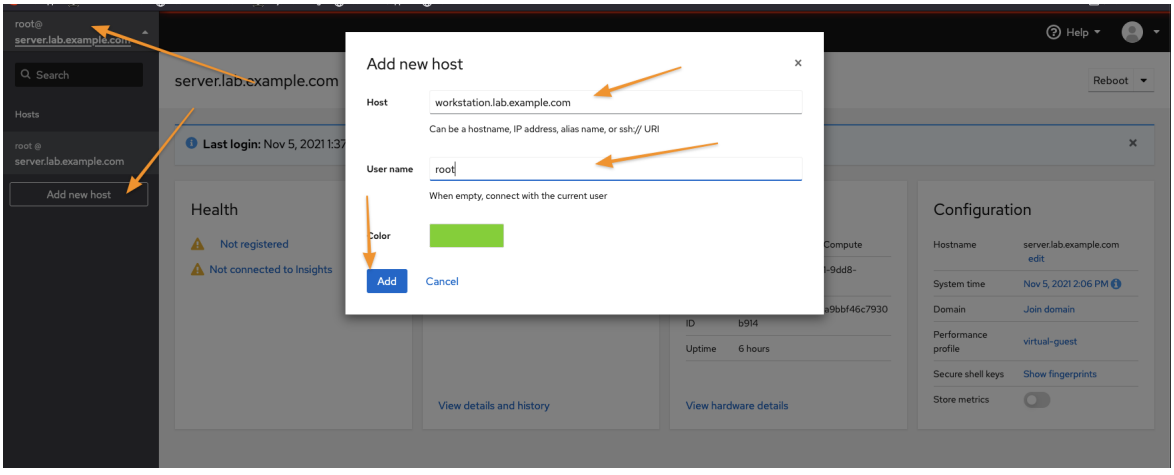


Figure 5. Adding Additional machines

4. Verify the System Fingerprint and click **Connect**

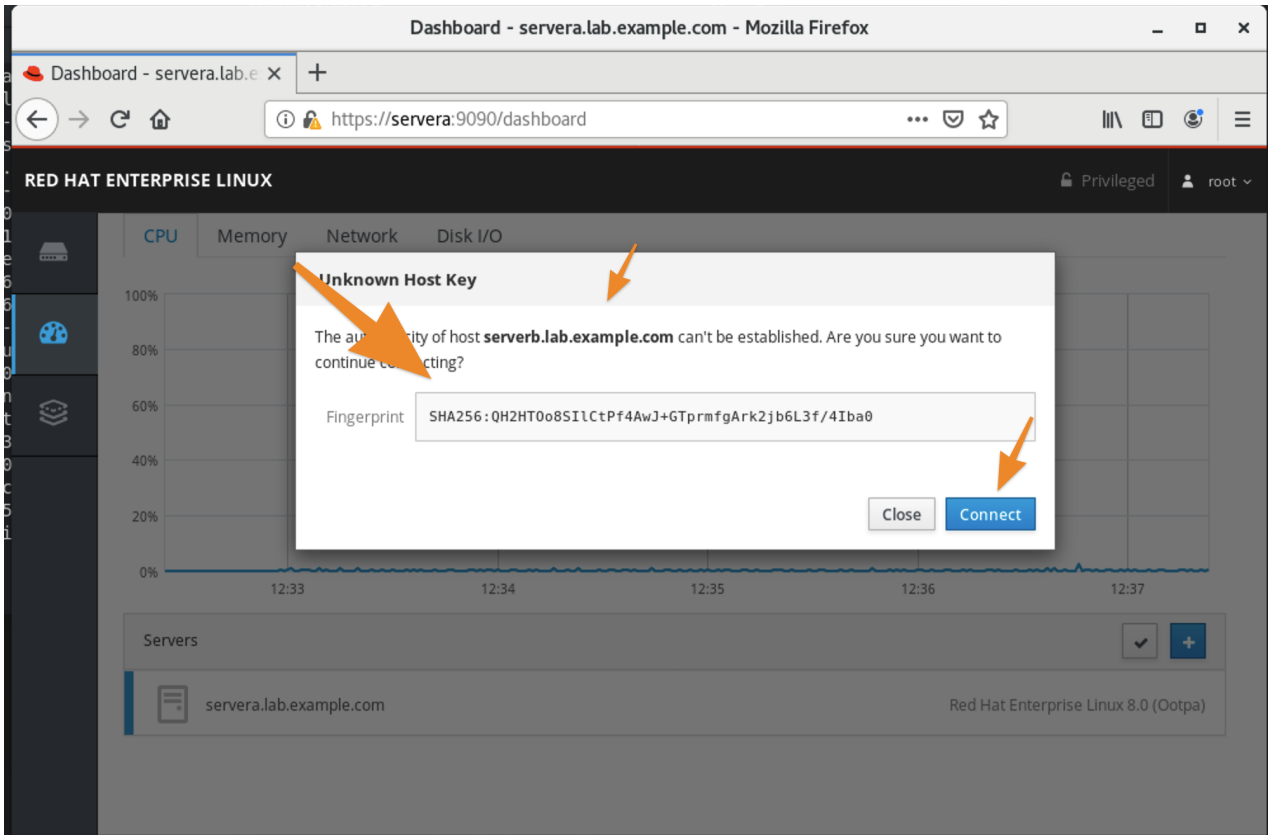


Figure 6. Fingerprint Verification

5. It is now possible to switch systems from the System Drop-down menu

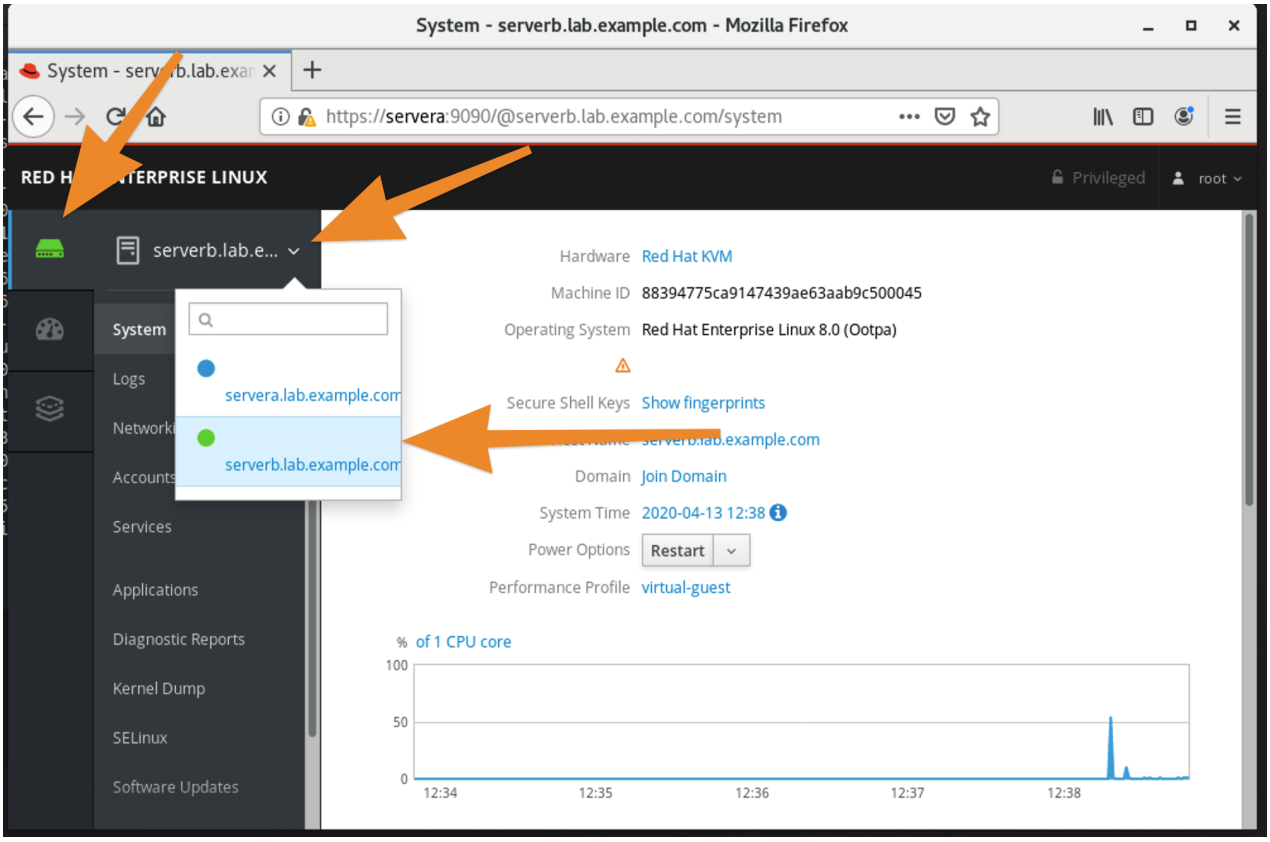


Figure 7. Switching Systems

2. Managing Containers with the New Runtime

2.1. Deploying Containers with the New Container Runtime

2.1.1. The Podman Container Engine

RHEL8 includes he **container-tools** package module. New engine is **podman** replaces **docker** and **moby**. It also contains new tools **buildah** to build container images and **skopeo** to manage images on registries like **runc**. The new toolset allows building/running containers without daemons.

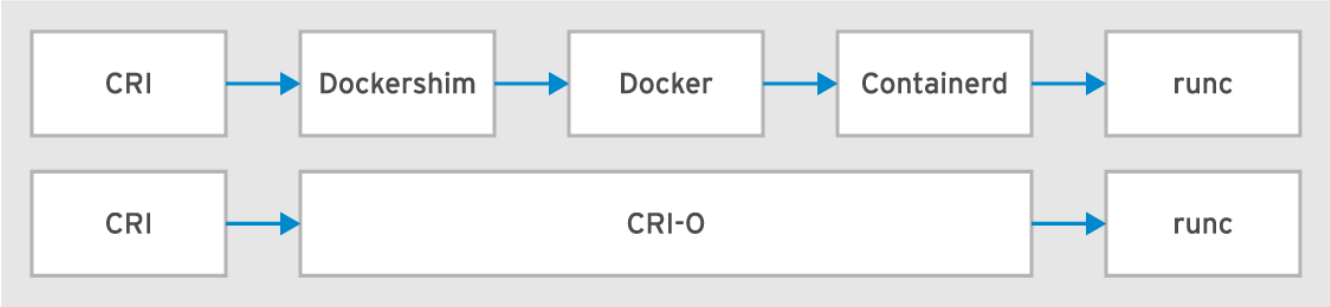


Figure 8. Docker to RHEL8 Container Runtime

Container Runtime Toolset

- Docker replaced with new container runtime
- New toolset supports OCI and reuse of third-party images
- Integrates with **audit** of Docker client-server model
- **container-tools** module provides new container runtime tools and engine.

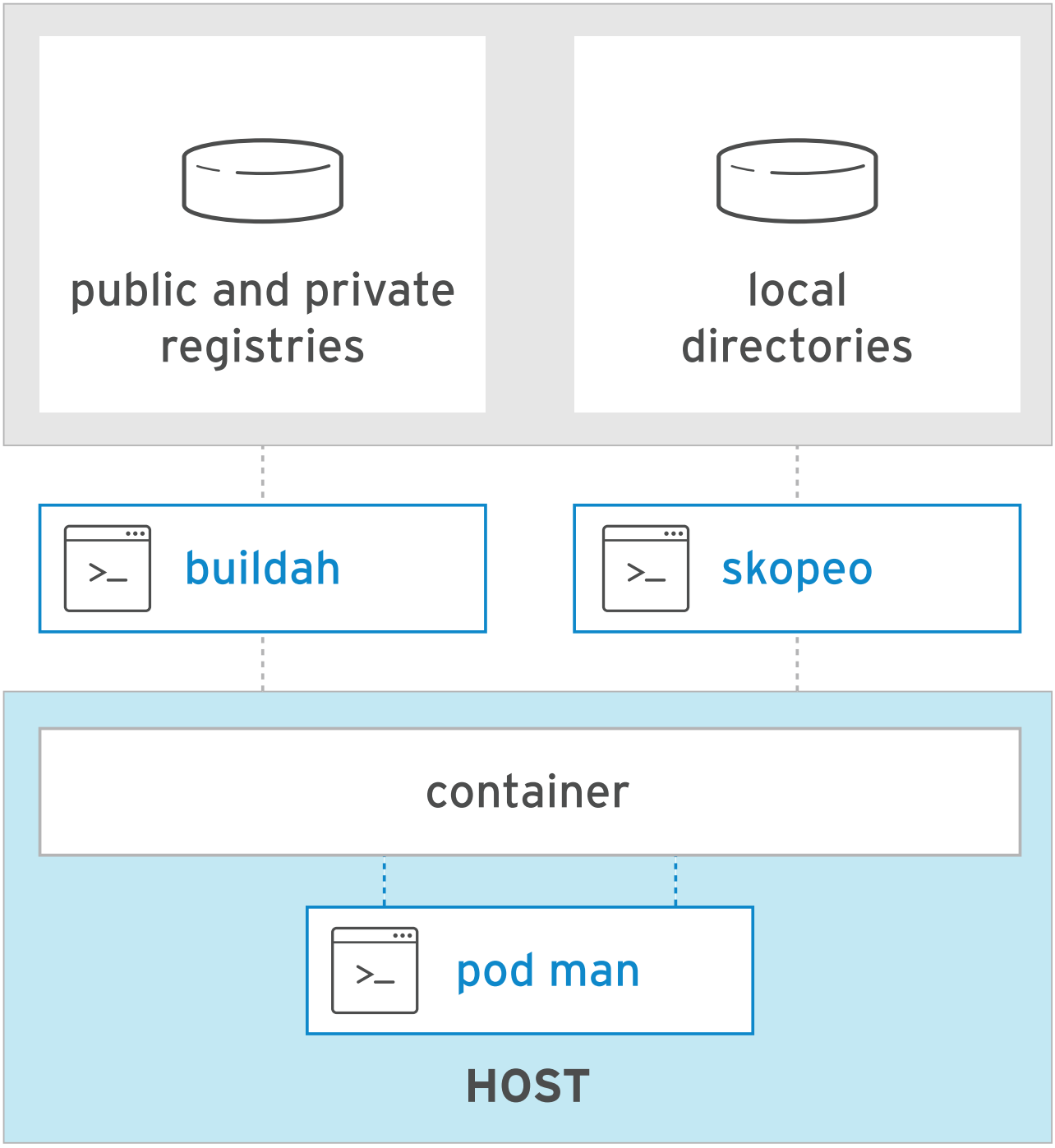


Figure 9. New Container Runtime

Describing new Container Runtime Tool

- The **podman** engine is daemonless and supporting container execution.
- **podman** syntax is similar to the docker command, supporting **Dockerfile** use
- **Buildah** builds container images, from scratch or a Dockerfile.
- Copy and inspect container images in both local and remote container registries with **Skopeo**
- **Skopeo** supports Docker and private registries, the Atomic registry, and local directories, including those which use OCI

RHEL8 includes **Pacemaker** containers with **podman** as a tech preview. Pacemaker supports execution of the container across multiple hosts.

Listing 28. Installation of Container Tools

```
[student@workstation ~]$ sudo yum module install container-tools
```

2.2. Podman Configuration Files

Depending on whether **podman** is being run as a privileged user or as a **rootless** user, the configuration file locations and directives will be difference.

Podman uses the **registry.conf** file on the system to retrieve information for container registries. The file is located at **/etc/containers/registries.conf**. The list of registries Podman uses are configured in the **[registries.search]** section and the **[registries.insecure]** section of the configuration file.

Rootless Podman Configuration

The system-wide **registries.conf** file located at **/etc/containers/registries.conf** can be overridden by a user's configuration file located in **$HOME/.config/containers** directory.

Container Image Registries and Searching

While it is best practice to specify a fully qualified image, it is possible to provide just an image name on the command line. If an image name is specified, it will search the registries in the listed order to determine which image to select.

2.2.1. Root-Based Podman

When running Podman as a privileged user, the default configurations are used. Generally these files are not modified, however, it is a common practice to modify the **registries.conf** file to add additional container image registries as well as alter the registry search order.

Default Configuration Files

- **/etc/containers/storage.conf** - Contains information about the default storage for Podman containers when using **podman** in a non-rootless fashion.
- **/etc/containers/registries.conf** - Contains information about the registries used for **podman** when doing **podman search** and also for pulling/running of container images.

- **/etc/cni/net.d/87-podman-bridge.conflist** - Contains information related to the CNI (container network interface) and IP configuration for the container networks.

2.2.2. Rootless Podman

When running **podman** in **rootless** mode, all configuration files will be based on user configurations and are located within the user's home directory.

User-Based Podman Configuration Files

- **/home/student/.config/containers/storage.conf**: Specifies storage configuration for Podman in **rootless** mode.
- **/home/student/.config/containers/registries.conf**: Specifies registry configuration for Podman in **rootless** mode.

Podman User Configuration Files

If the configuration files don't exist in the user's home directory, **podman** will default back up to **/etc** for the configuration files and if they aren't there, it will fall back to the **/usr/share/containers/** directory.

Listing 29. User Registries

```
[student@servera ~]$ cat .config/containers/registries.conf
unqualified-search-registries = ['registry.lab.example.com']

[[registry]]
location = "registry.lab.example.com"
insecure = true
blocked = false
```

Podman Configuration File Precedence

podman has multiple configuration file locations and the order of precedence depends on the if the files exist. Traditionally in a **rootless** implementation, the configuration files with be in the user's **$HOME/.config/containers** directory. In the case of networking, there is no CNI equivalent for **rootless** Podman as **rootless** containers rely on **SLIRP** for networking.

Containers.conf

1. **$HOME/.config/containers/containers.conf**
2. **/etc/containers/containers.conf**
3. **/usr/share/containers/containers.conf**

Storage Configurations

1. **$HOME/.config/containers/storage.conf**
2. **/etc/containers/storage.conf**

Registry Configurations

1. **HOME/.config/containers/registries.conf**
2. **/etc/containers/registries.d/**
3. **/etc/containers/registries.conf**

Precedence of **1** is the highest and will override all others.

References

- **Podman Project - Config Files and Tutorial**: https://github.com/containers/podman/blob/main/docs/tutorials/rootless_tutorial.md
- **Why can't I use sudo with rootless Podman?**: https://www.redhat.com/sysadmin/sudo-rootless-podman
- **What happens behind the scenes of a rootless Podman container?**: https://www.redhat.com/sysadmin/behind-scenes-podman
- **Rootless containers using Podman**: https://www.redhat.com/sysadmin/rootless-containers-podman
- **Container video series: Rootless containers, process separation, and OpenSCAP**: https://www.redhat.com/sysadmin/container-video-series (Really good by Brian Smith - Former RH TAM, now works in the RHEL Platform BU)
- **Why can't rootless Podman pull my image?**: https://www.redhat.com/sysadmin/rootless-podman

2.3. Container Image Storage

Containers use ephemeral storage for running containers which is an overlay filesystem with a new read/write (RW) layer added to the original container image. This ephemeral storage is removed once the container is removed from the system. Container images on the other-hand are stored locally on the system in the container image storage registry. It is important to know where

the image storage is located for both container images and ephemeral storage for running containers so that it can be monitored for pro-active system administration and cleanup. The storage location for both container images and ephemeral storage is generally defined in the **storage.conf** file.

2.3.1. Root-Based Podman

A default installation of Red Hat Container Tools (podman) will create a configuration file for storage located **/etc/containers/storage.conf**. These are the most likely settings to be used when running Podman as a **root** user.

Listing 30. Default Storage Location

```
[storage]

# Default Storage Driver
driver = "overlay"

# Temporary storage location
runroot = "/var/run/containers/storage"

# Primary Read/Write location of container storage
graphroot = "/var/lib/containers/storage"
```

There are plenty of options regarding containers and image storage, but the primary locations to monitor are **/var/run/containers/storage** and **/var/lib/containers/storage** as these will be the most used locations by **podman**.

2.3.2. Rootless Podman

Podman uses the storage configuration file located **$HOME/.config/containers/storage.conf**. These settings are used because the **overlay** filesystem must use a user-space filesystem overlay so it uses **FUSEFS** storage drives for the user-space filesystems.

Listing 31. Default Storage Location for Rootless Podman

```
[storage]
  driver = "overlay"
  runroot = "/run/user/1000"
  graphroot = "/home/student/.local/share/containers/storage" ①
  [storage.options]

... OUTPUT OMITTED ...

    mount_program = "/usr/bin/fuse-overlayfs" ②
```

① Image storage location

② FUSEFS Overlay Filesystem Driver

There are plenty of options regarding containers and image storage, but the primary locations to monitor are **/var/run/containers/storage** and **/var/lib/containers/storage** as these will be the most used locations by **podman**.

2.4. Container Networking

Podman is meant to provide all management of containers and the container runtime. Podman is capable of managing the container network (SDN) for root-based Podman containers. The CNI controls the specifications for networking and how the SDN

is defined on the system. There is no SDN available for **Rootless** containers as **podman** implements networking for **Rootless** containers using **SLIRP**.

2.4.1. Root-Based Podman

Podman root-level containers can leverage CNI. The containers SDN network is defined in the **/etc/cni/net.d/87-podman-bridge.conflist** configuration file. Containers can communicate to each other within the SDN on the same system.

Listing 32. **/etc/cni/net.d/87-podman-bridge.conflist**

```
{
    "cniVersion": "0.4.0",
    "name": "podman",
    "plugins": [
    {
            "type": "bridge", ①
            "bridge": "cni-podman0", ②
            "isGateway": true,
            "ipMasq": true,
            "ipam": {
        "type": "host-local",
        "routes": [
            {
            "dst": "0.0.0.0/0"
            }
        ],
        "ranges": [ ③
            [
            {
                "subnet": "10.88.0.0/16",
                "gateway": "10.88.0.1"
        }
            ]
        ]
              }
    },
    {
              "type": "portmap",
              "capabilities": {
        "portMappings": true
              }
    },
    {
              "type": "firewall"
    }
      ]
  }
```

① Defines network type as a **Bridge**

② Defines the network name for the bridge as **cni-podman0** for the container SDN

③ Defines the network IP Address range for the container SDN

2.4.2. Rootless Podman

For **rootless** podman the networking for containers leverages **SLIRP**. This is provided by the **slirp4netns** package and provides user-mode networking and namespaces for the networks. Containers running as a **Rootless** container will not receive an IP address from the CNI SDN and cannot communicate with each other or the outside except by using and leveraging **port**

forwarding.

Red Hat Container Catalog

Red Hat Container Catalog: https://catalog.redhat.com/software/containers/search

2.5. Managing Containers using the Red Hat Web Console

The Red Hat Web Management Console (Cockpit) can be used to manage container images as well as running containers. However, in order to manage some of the aspects around containers, certain configurations must already be in place.

Cockpit can almost manage the full container lifecycle. using the **Podman containers** plugin. Container images can be downloaded, managed, deleted. Containers can be launched from container images, stopped, restarted. Containers can even be analyzed providing runtime information, container logs, and even console access. Existing containers can also be turned into new container images using the **Commit** functions.

Container Runtime Details

The **Details** tab can provide container runtime information. This is similar to running the **podman inspect** without providing all the details.

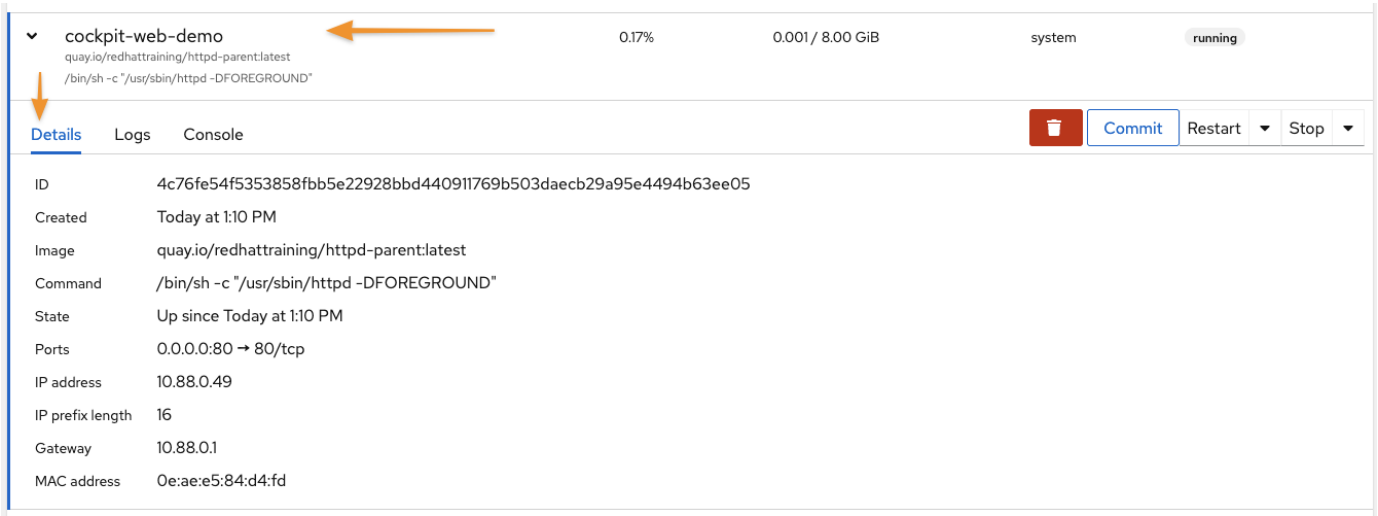


Figure 10. Container Runtime Information

Container Logs

The **Logs** tab is capable of sharing the container logs. This is similar to running the **podman logs** command.

Figure 11. Container Logs

Container Console

Cockpit also allows accessing a console directly inside the running container. Accessing the console via cockpit is the same as running the **podman exec -it <Container> /bin/bash** command.

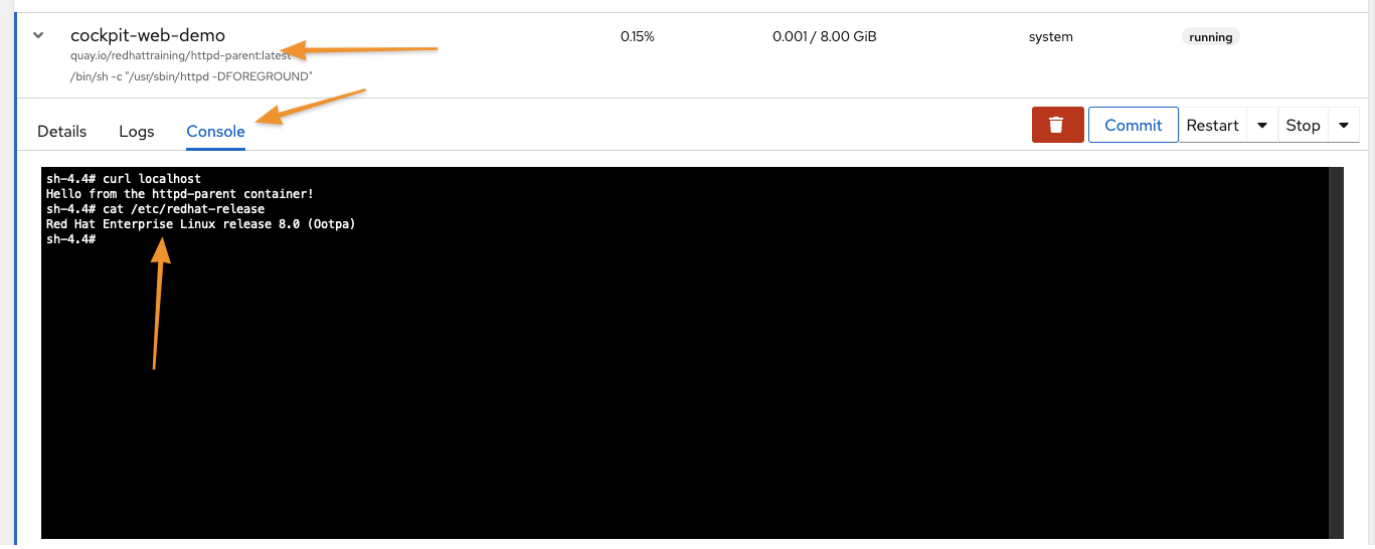


Figure 12. Container Console

2.5.1. Installing Cockpit Podman Plugins

In order to utilize Cockpit to manage containers with Podman there must be two things that are in place.

Cockpit **podman** *Requirements*

- Podman cockpit plugins

- Podman service started and running on the system

1. Install **cockpit-podman** Modules

Listing 33. Installation of Cockpit **podman** *Plugins*

```
[root@servera ~]# yum install cockpit-podman

... OUTPUT OMITTED ...

Complete!
[root@servera ~]#
```

2. Enable **podman** Service in Cockpit

   a. Sign into Cockpit

   b. Click "**Podman containers**"

   c. Click "**Start podman**"

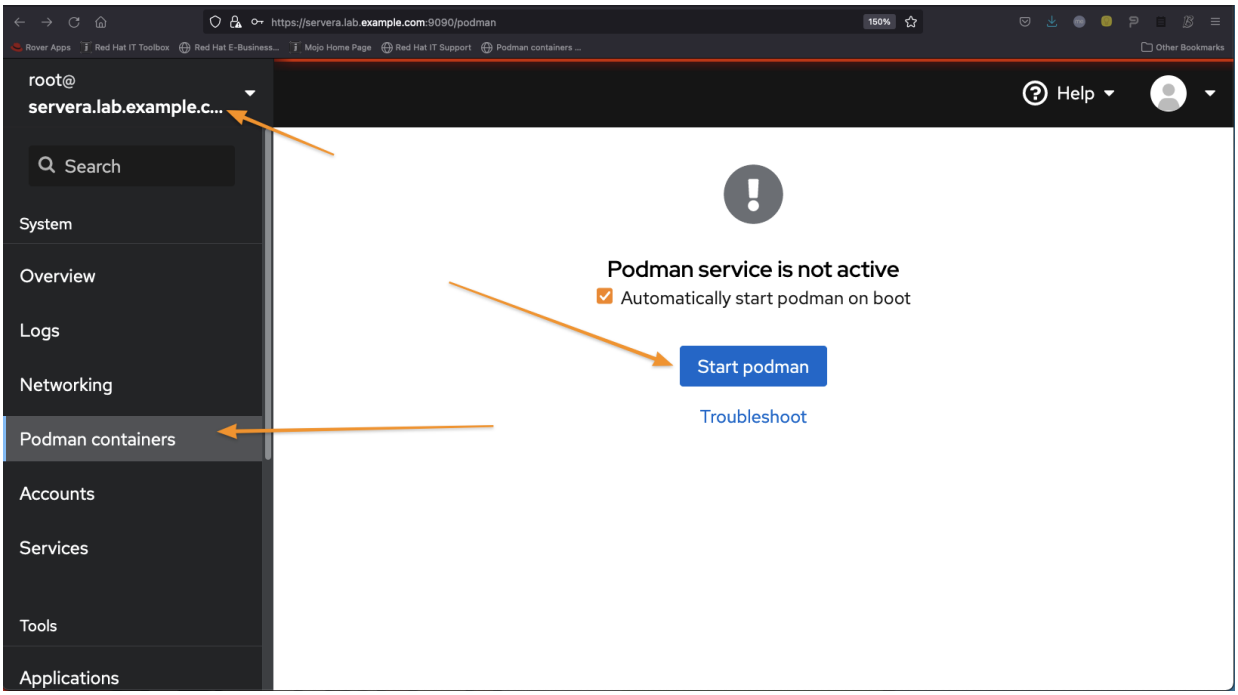


Figure 13. Cockpit - Podman Containers (Setup)

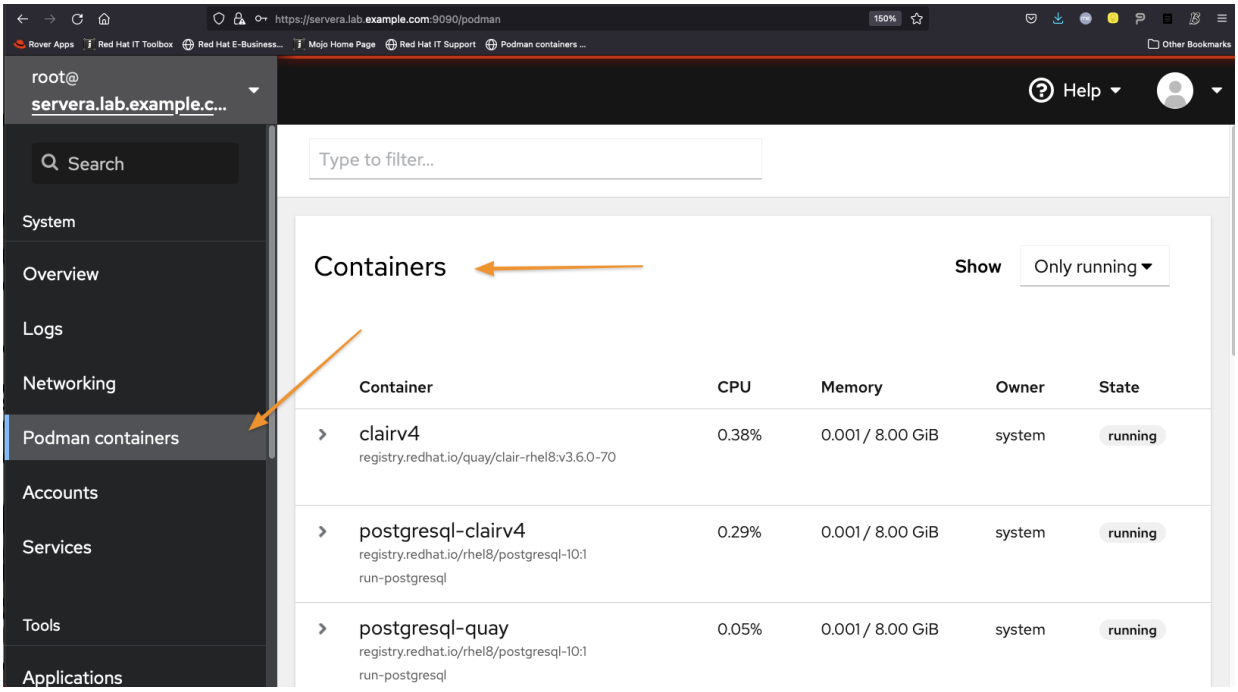


Figure 14. Cockpit - Podman Containers (In-Use)

Ensure Cockpit is both Installed and Enabled

Listing 34. Installing Cockpit

```
[root@servera ~]# yum install cockpit

... OUTPUT OMITTED ...

subscription-manager-cockpit-1.28.13-2.el8.noarch
tracer-common-0.7.5-2.el8.noarch

Complete!
```

Listing 35. Enabling Cockpit Socket

```
[root@servera ~]# systemctl enable cockpit.socket --now
Created symlink /etc/systemd/system/sockets.target.wants/cockpit.socket →
/usr/lib/systemd/system/cockpit.socket
```

2.5.2. Using Cockpit to Manage Containers

Once installed and enabled, the **Podman containers** plugin can begin managing containers and images. There are a few things to remember and consider as the **plugin** can't do everything.

Plugin Considerations and Limitations

- **Registries**: Image registries must be setup and specified ahead of time in the **/etc/containers/registries.conf** file.

- Image registries must be in the configuration file in order for images to be downloaded and used. If the configuration file is updated after the **podman** service has been started, the service must be "restarted" in order for Cockpit to see the changes.
- There are some difficulties with providing authentication information to registries as there isn't currently an interface to login to the registry within Cockpit.

- **Storage Volumes**: It might be necessary to have volumes and permissions setup to properly mount/map the volumes into the running containers

Registry Credentials

In order for Podman to authenticate, you must provide credentials. There needs to be a config file and you may also need to login to **podman** from the command line.

Listing 36. ***.docker/config.json*** *Config File*

```
[student@servera ~]$ cat .docker/config.json
{
  "ServerURL": "https://registry.redhat.io/v1",
  "Username": "RHNID",
  "Secret": "RHNPassword"
}
```

Listing 37. CLI Login

```
[student@servera ~]$ podman login registry.redhat.io
Authenticating with existing credentials...
Existing credentials are valid. Already logged in to registry.redhat.io
```

Example 6. **LAB: Container Image Management with Cockpit**

1. Navigate to the **Images** section and select **Get new image**

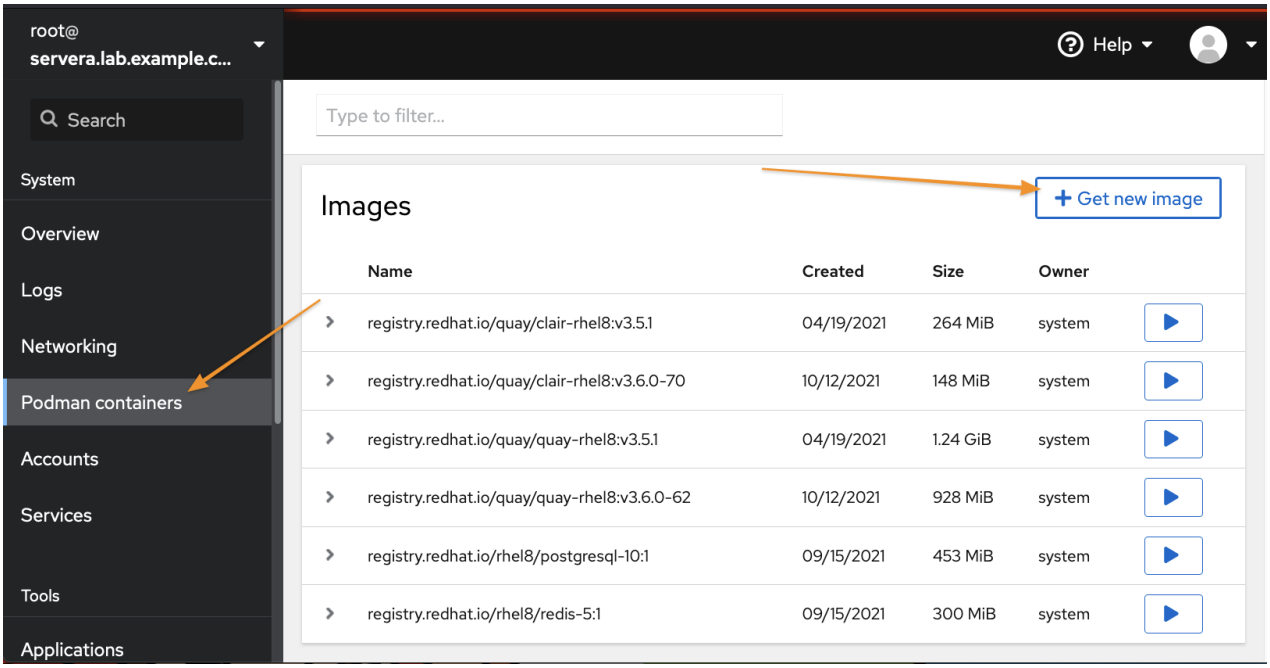


Figure 15. Cockpit - Podman Container Images

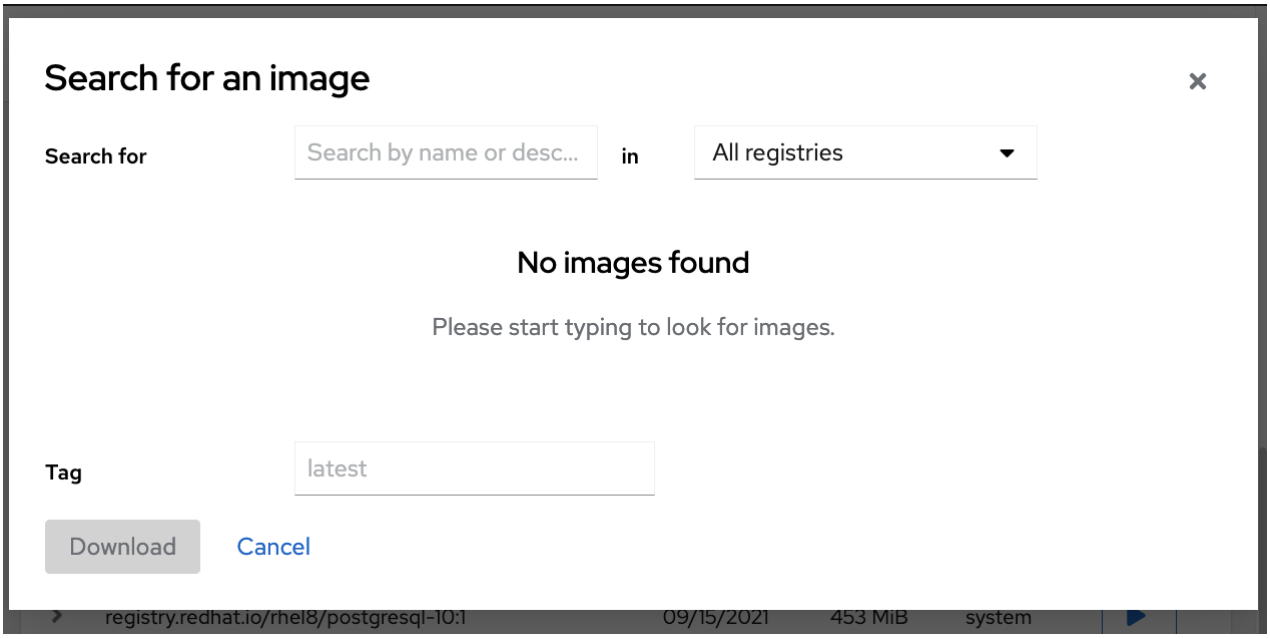


Figure 16. Search for Images

2. Select the registry to search, tags, and image name/description, then click "Download"
   a. Search for the HTTPD-Parent image in the **quay.io** registry.

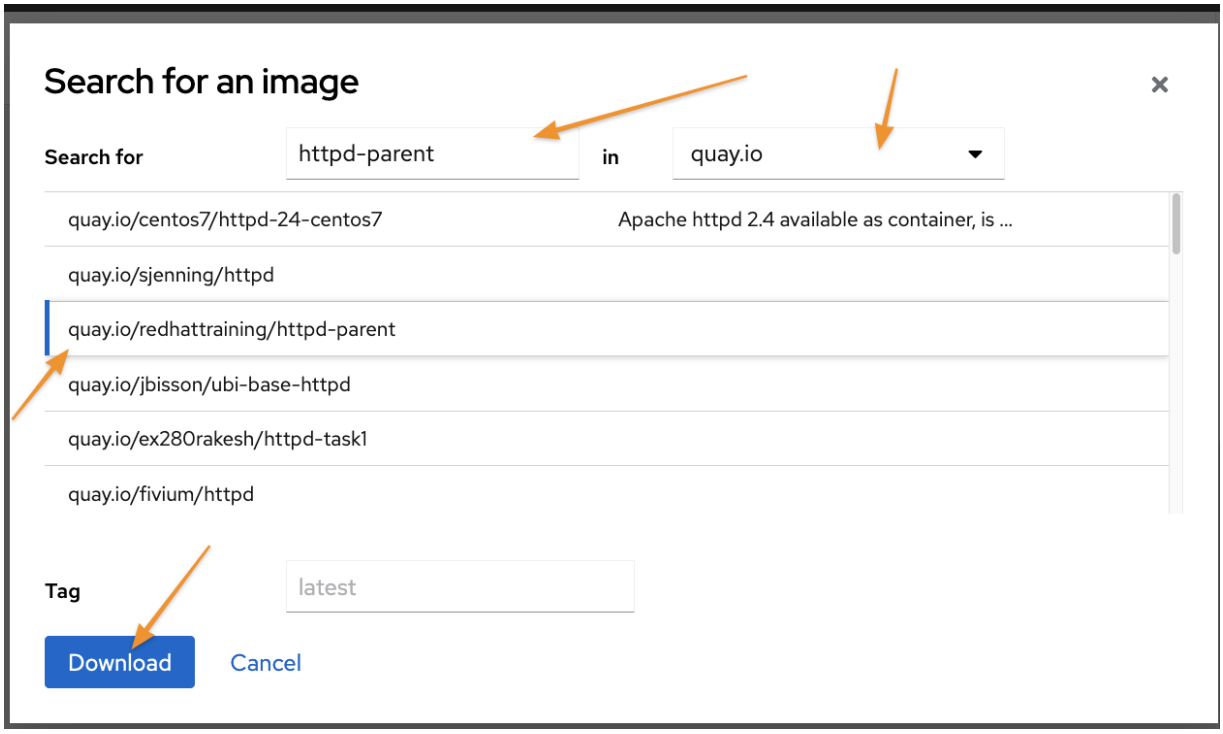


Figure 17. HTTPD 2.4 Parent Image from Red Hat Training - Quay.io

Adding the **quay.io** *Registry to* **/etc/containers/registries.conf**

Update the **registries.conf** file and then restart the **podman** service.

Listing 38. Edit **/etc/containers/registries.conf**

```
# To ensure compatibility with docker we've included docker.io in the default search list. However Red
Hat
# does not curate, patch or maintain container images from the docker.io registry.
[registries.search]
registries = ['registry.access.redhat.com', 'registry.redhat.io', 'docker.io', 'quay.io']①
```

① Adding **quay.io**

Listing 39. Restart **podman**

```
[root@servera ~]# systemctl restart podman.service
```

Registry Authentication

It is important to keep in mind, images requiring authentication to a registry will provide errors in Cockpit as you will be accessing the registry as an unauthenticated user.

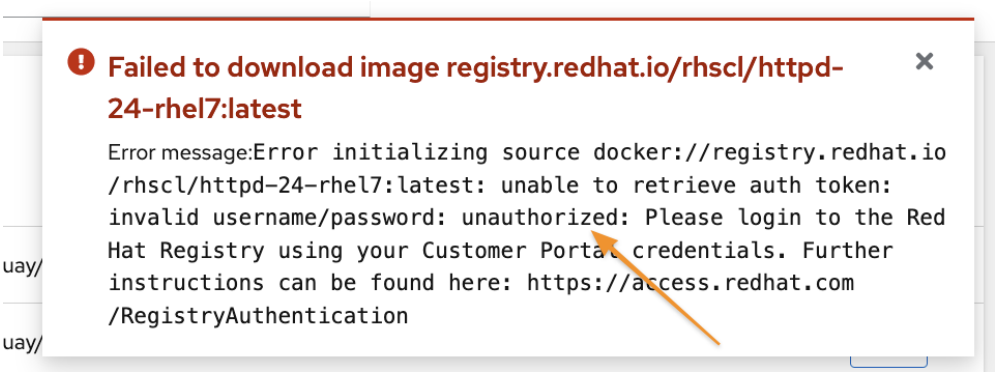


Figure 18. Registry Authentication Issues

Based on timeline and platform difficulties, images downloaded in the Red Hat Web Management Console will be coming from public (unauthenticated) registries.

3. Confirm image was downloaded.

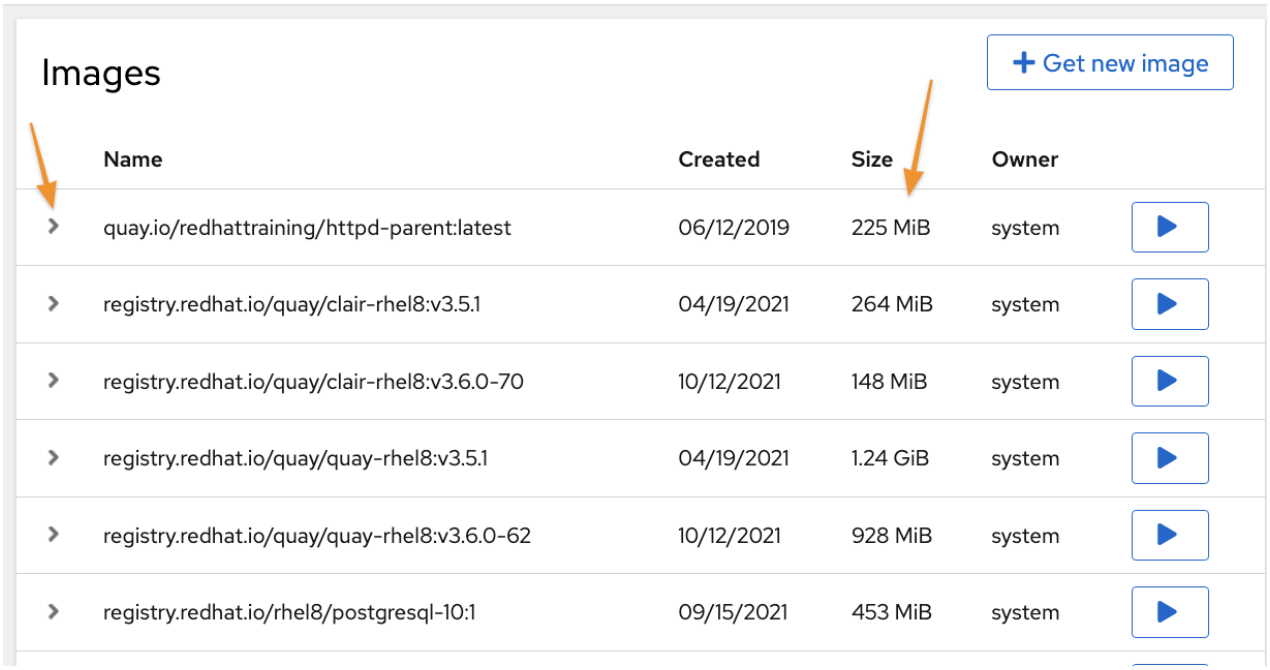


Figure 19. Images in Local Registry

4. Explore image details by clicking the **>** and expanding the available information.

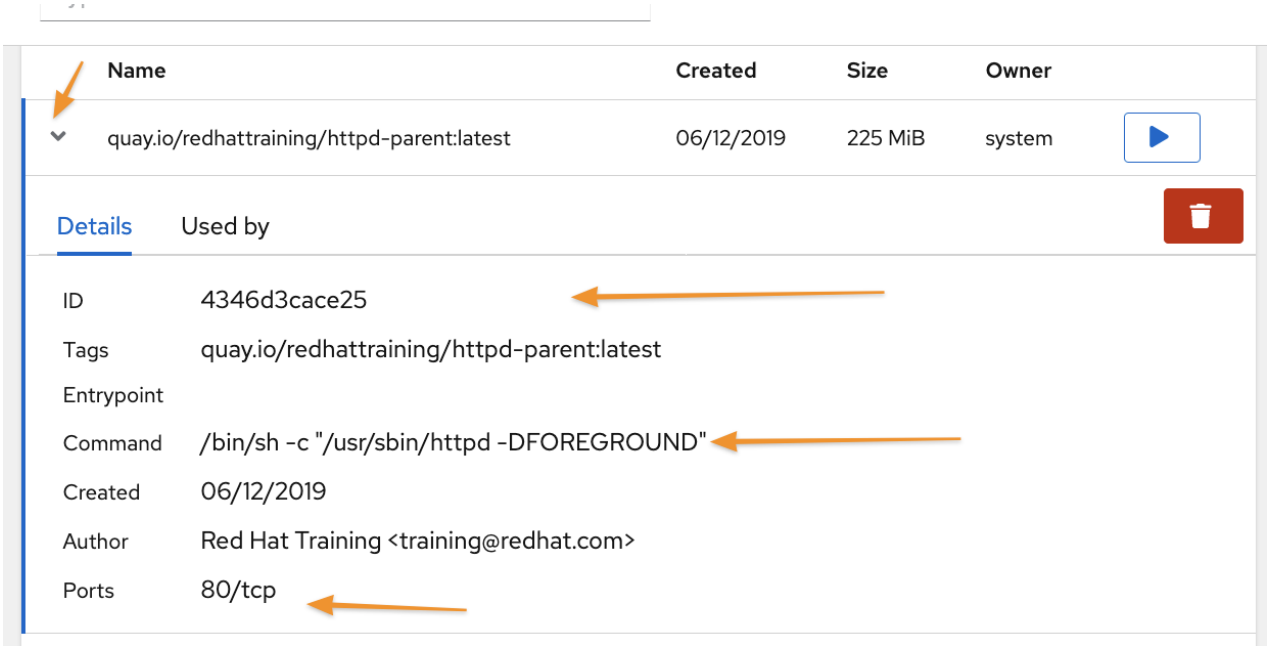


Figure 20. HTTPD-Parent Image Details - Image Information

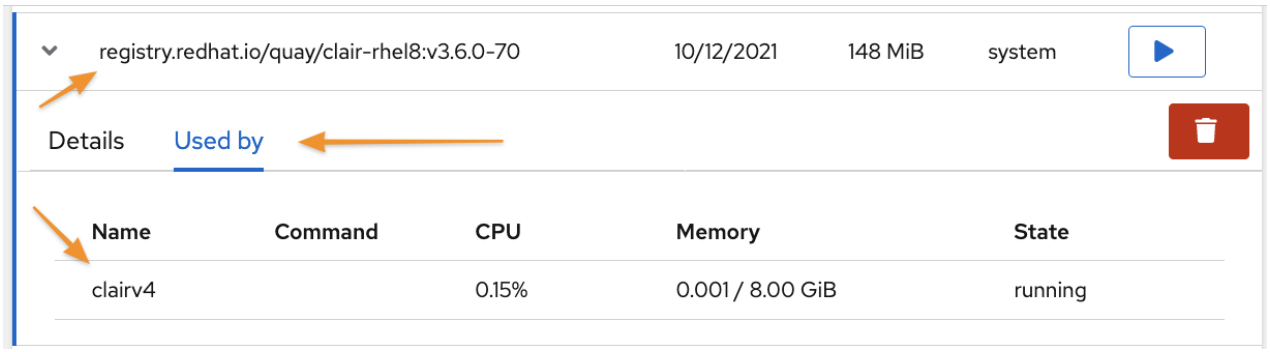


Figure 21. Clair Image Details - Containers Using Image

Container Management with Cockpit

It is possible to manage both **rootless** and **root-based** containers in Cockpit depending on the user you are using to access the management console. In order to create and launch new containers from Cockpit, the image must already be downloaded and existing in the local image registry.

Example 7. **LAB: Container Creation**

1. Select the image to be used to launch the container by clicking the **Play** button.

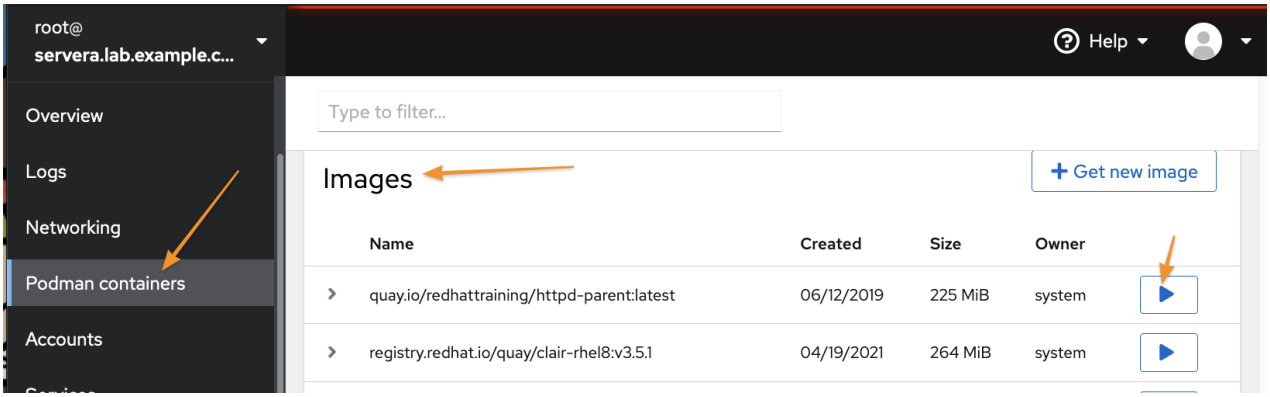


Figure 22. HTTPD-Parent Image Selection

2. Enter details you wish to use for your image and click "Run"
    a. Container Name
    b. Port mapping
    c. Volume mapping

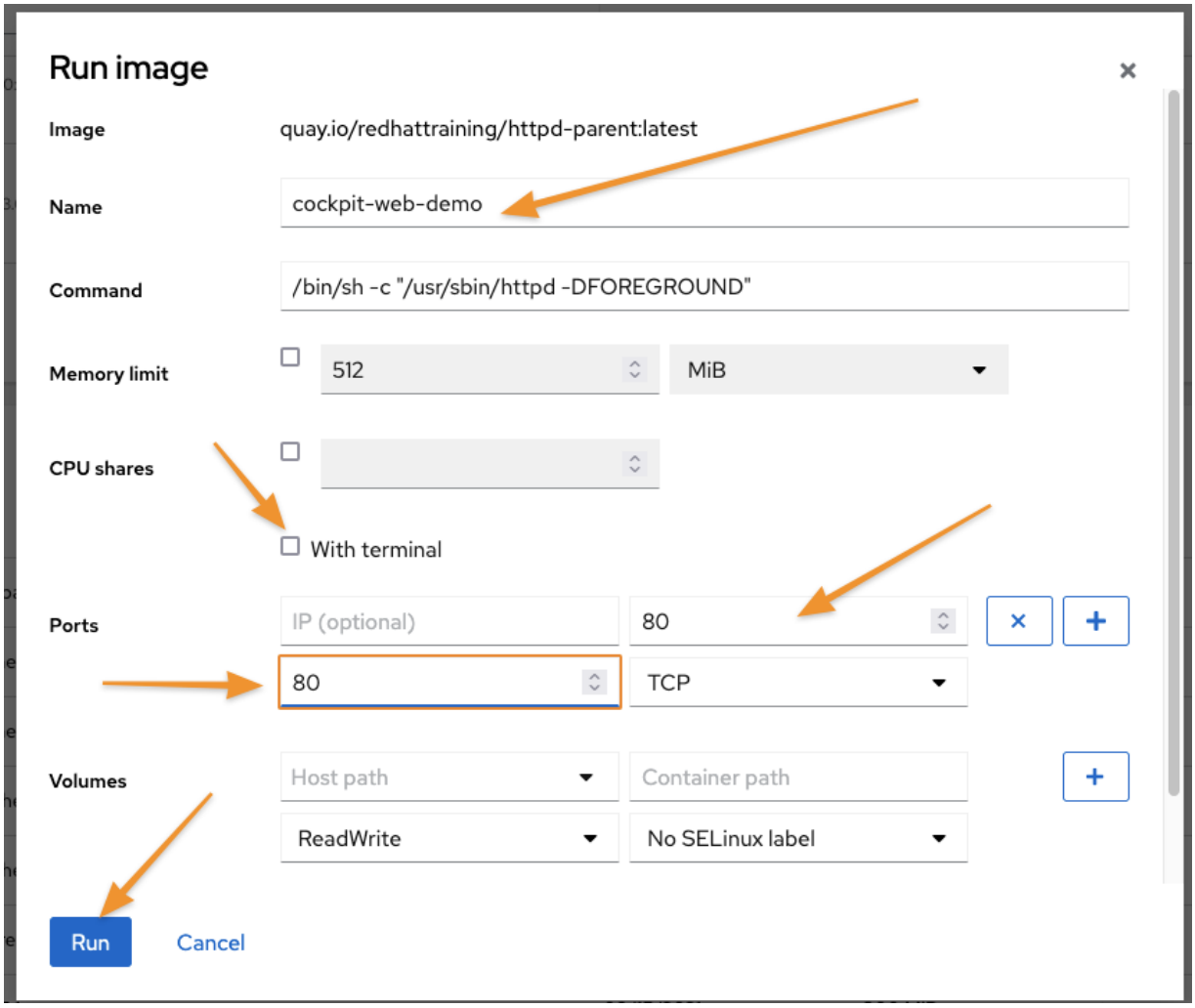


Figure 23. Launcing a Demo Container

NOTE *Regarding* **With terminal**

For several containers, you should **uncheck** the ***With terminal*** option as this could cause the container to exit unexpectedly.

3. Verify container was launched

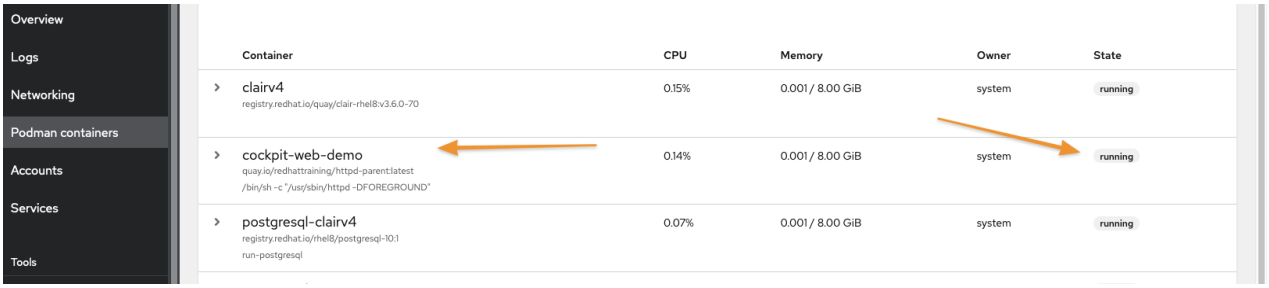


Figure 24. Running Container Verification

Figure 25. Running Container Details

4. Allow connection to container externally through Firewall
   a. Click **Networking**
   b. Click **Edit rules and zones** for the Firewall

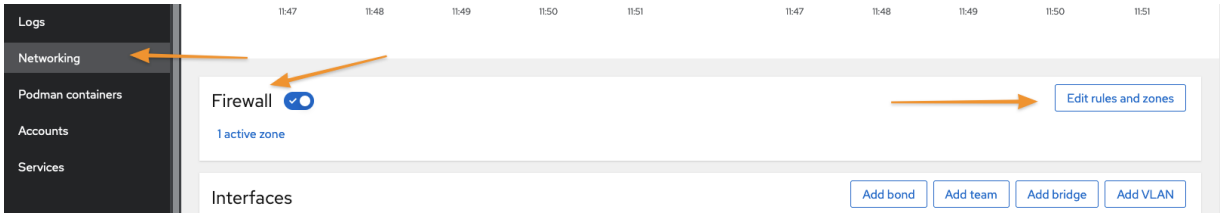


Figure 26. Using Cockpit to Manage Firewalls

5. Click **Add Services** and either select an existing service or create custom ports, then click the **Add Services** button on the **Add services to public zone**.
   a. Verify the service was added

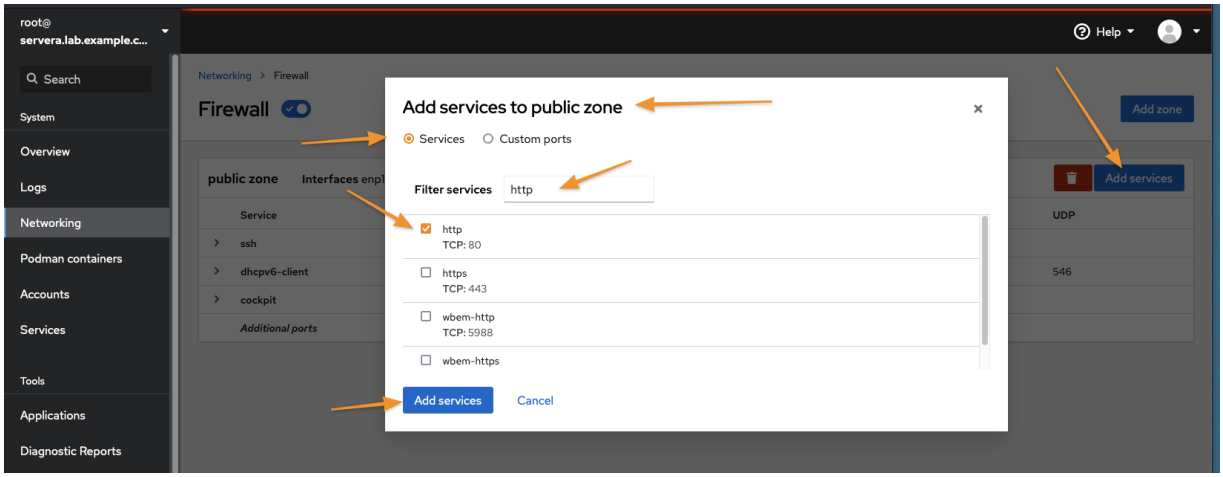


Figure 27. Add the HTTP Service

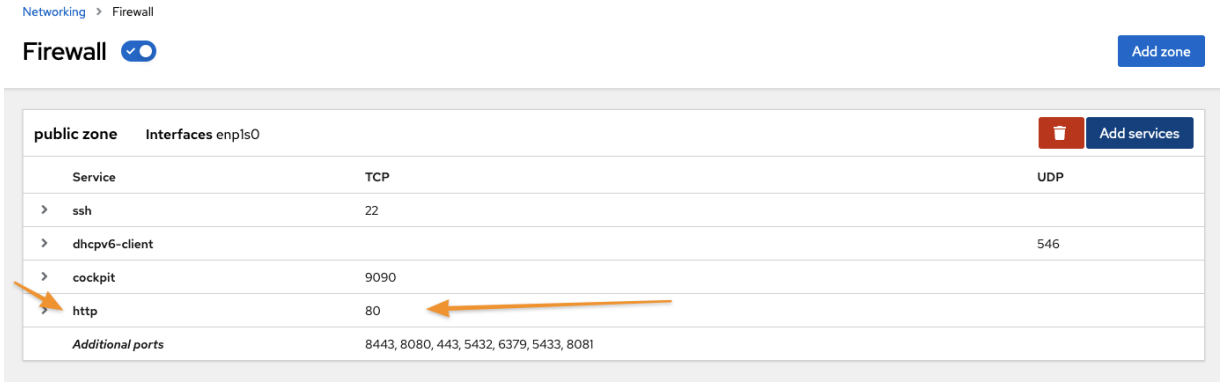


Figure 28. HTTP Service Available

6. Verify the container is running and hosting the website via the console and through a web browser.

Listing 40. Local Container Verification

```
sh-4.4# curl localhost
Hello from the httpd-parent container!
sh-4.4#
```

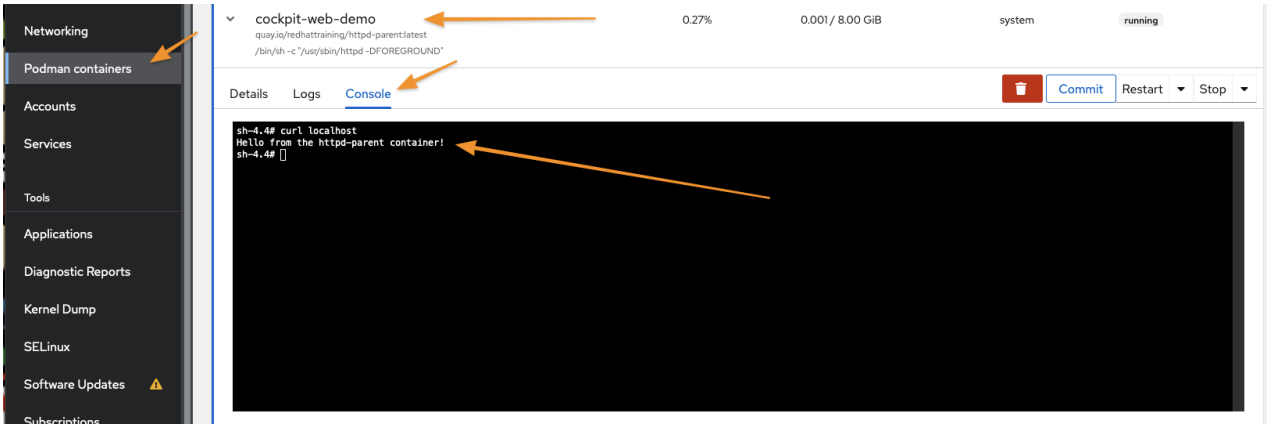


Figure 29. Container Console in Cockpit

Figure 30. Application Verification in Firefox

Example 8. **LAB: Saving a Container Image from a Running Container**

1. Select the container to use as a base for the image
   a. Click **Commit**

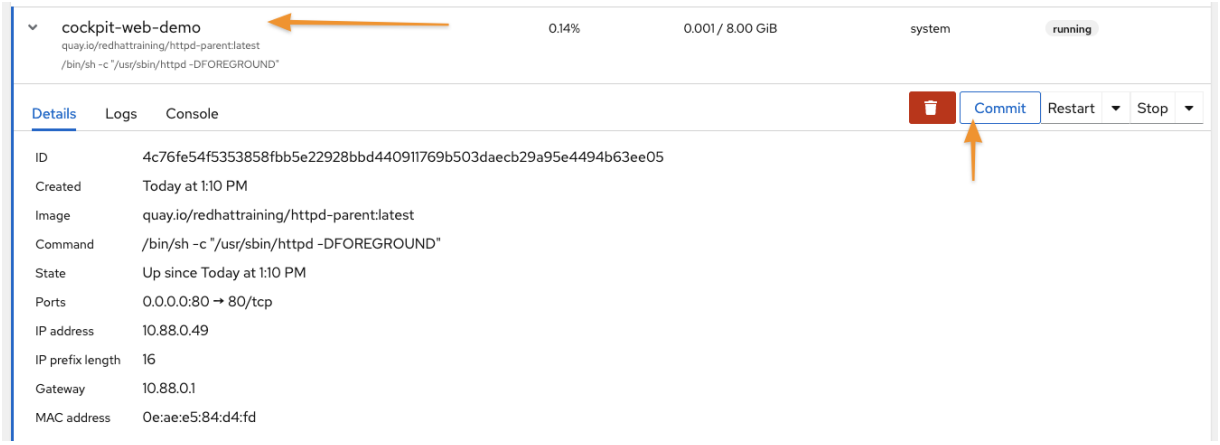


Figure 31. Creating an new image from a container.

2. Select and complete the **Commit image** form
   a. Specify **Image name**

b. Other fields are optional

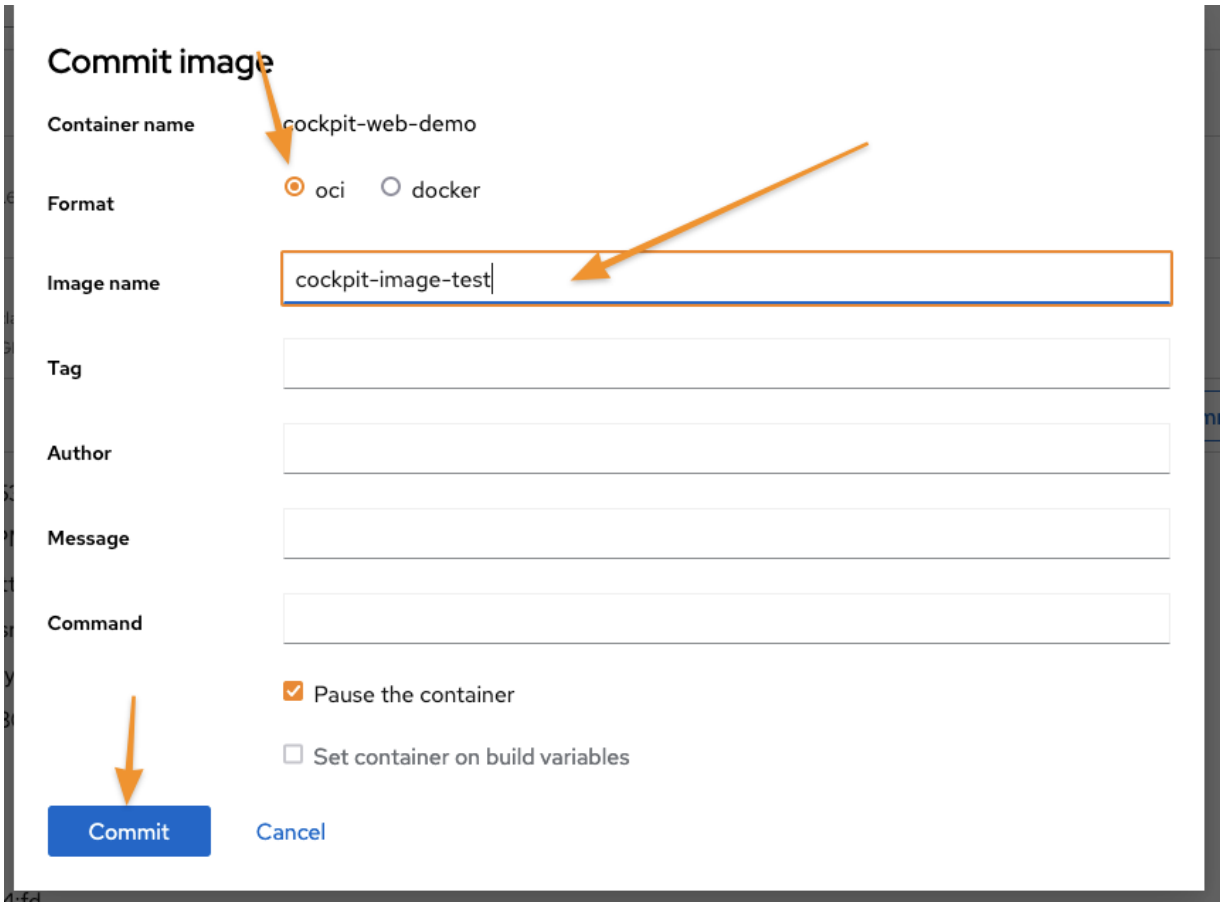


Figure 32. Committing image

Images from a Running Container

It is possible to create images from running container. If the container is running, it will be paused briefly while the image is created.

3. Verify the image was created

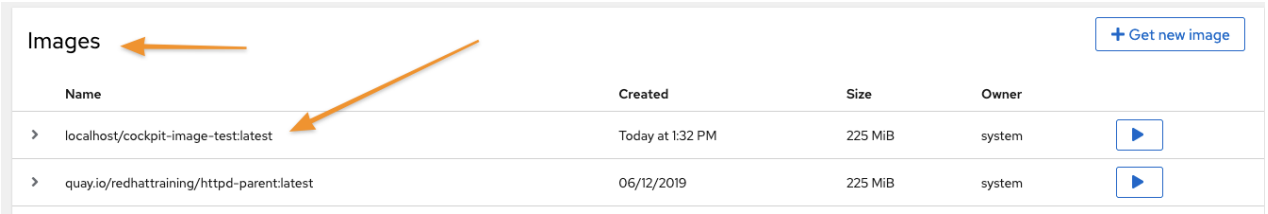


Figure 33. Image Verification

Image Tags

If there is no tag specified when the image is being committed, **podman** will automatically add the ***latest*** tag to the image.

Example 9. **LAB: Container Cleanup**

1. Select the container to stop and remove.
   a. If you just want to stop a running container, click **Stop**
   b. To stop and remove the container, click the **Trashcan**

Figure 34. Container Cleanup

Deleting a Running Container

Running containers must be stopped before they can be deleted or removed. If a container is running, and you click the **Trashcan** it will stop and delete the container. This is similar to performing a **podman rm -f <Container>** as it will force stop and then remove the container.

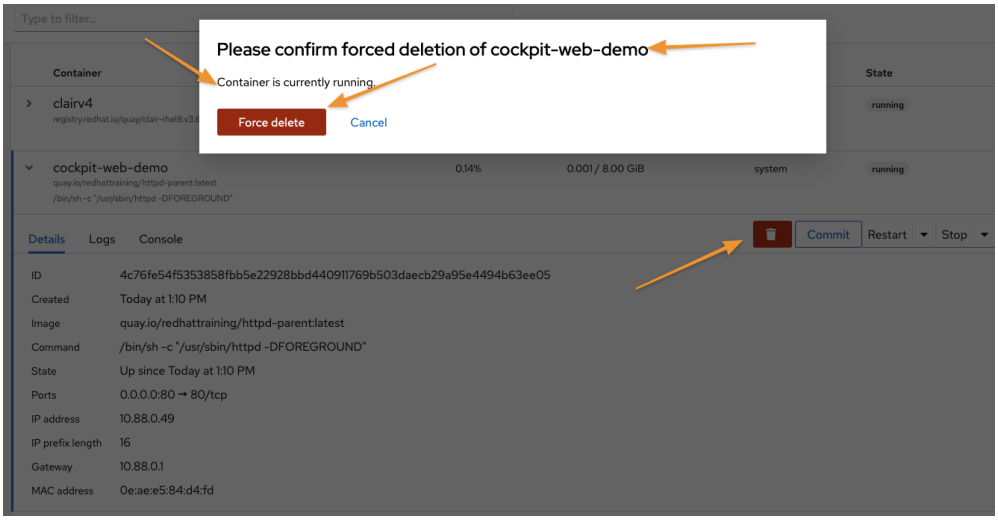


Figure 35. Force Removing a Running Container

2.5.2.1. Using Cockpit to Manage Containers (Rootless)

Just as Podman can manage containers as a "rootless" user, it is also possible to manage containers within Cockpit as a "rootless" user. All the same principles apply in Cockpit as they do with **podman**. Additionally, Cockpit has multiple options if the user happens to be in the **sudoers** file.

Example 10. **LAB: Exploring Cockpit Containers as the *student* User**

1. Login to Cockpit as the Student user

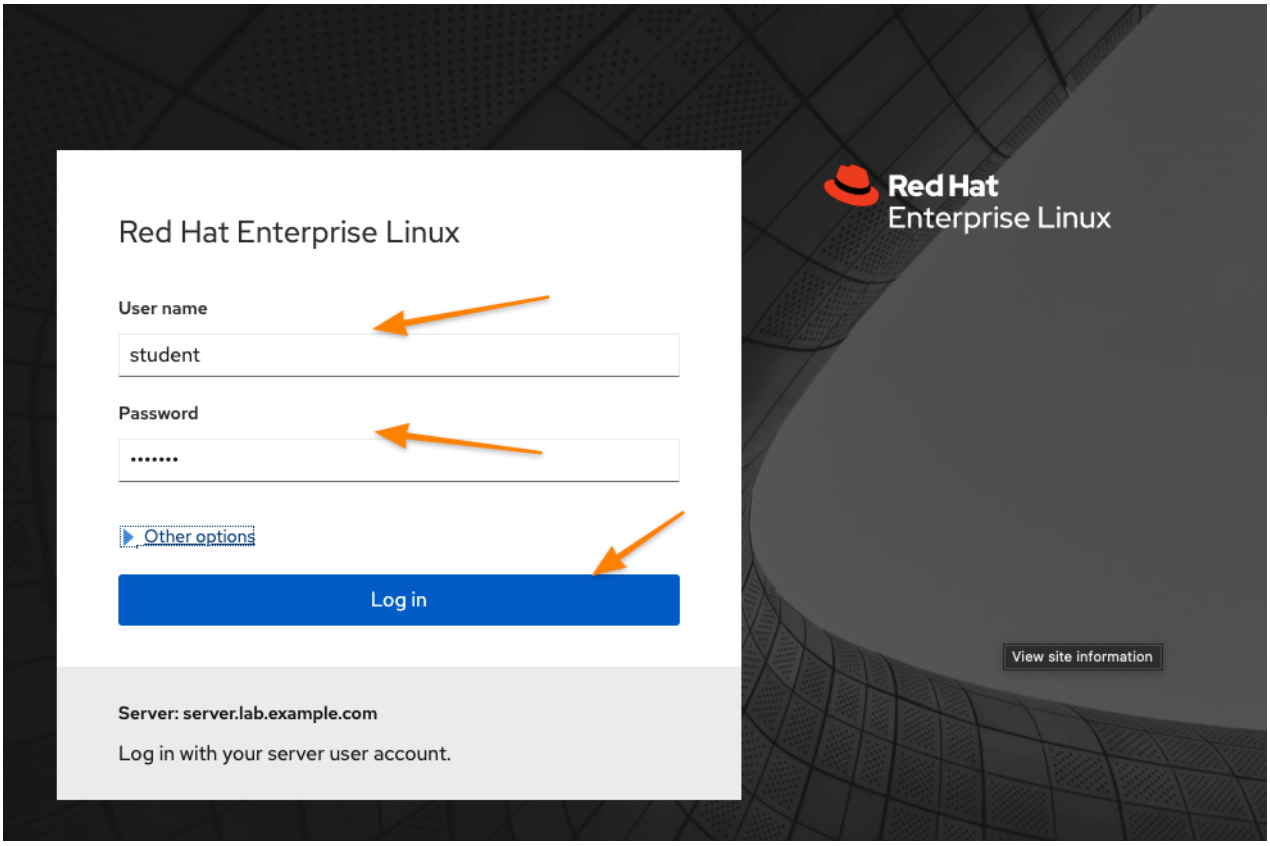


Figure 36. Cockpit Student Login

2. Navigate to the **Podman containers** section

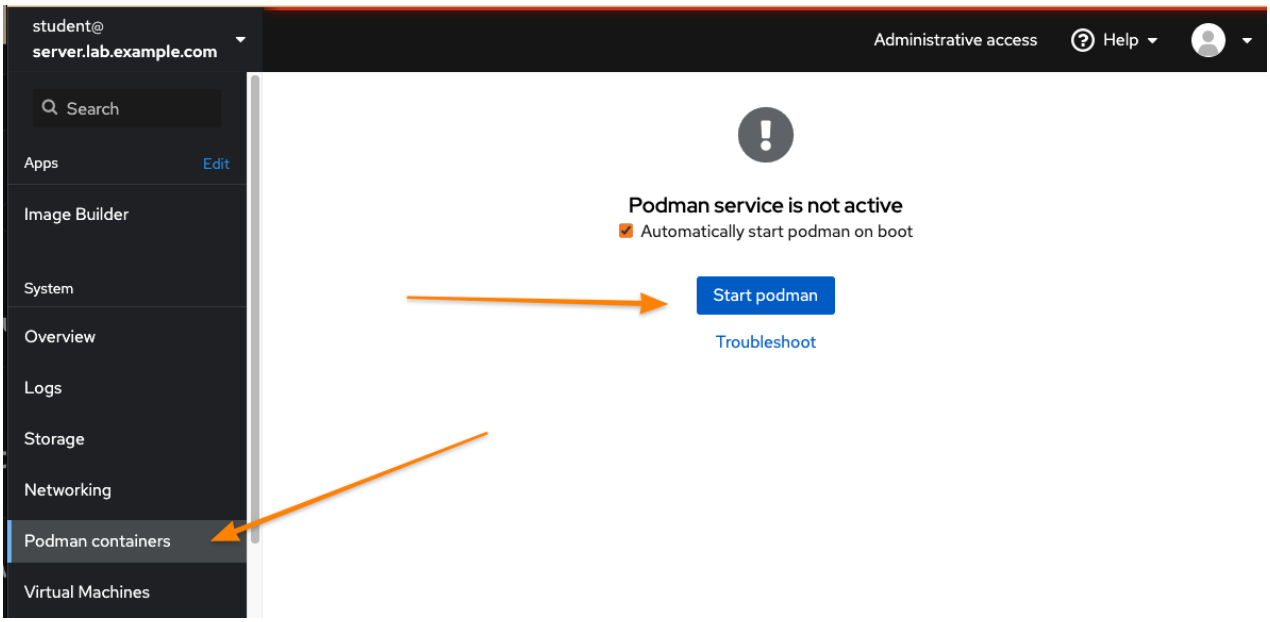


Figure 37. Podman containers plugin

3. Click **Start podman**

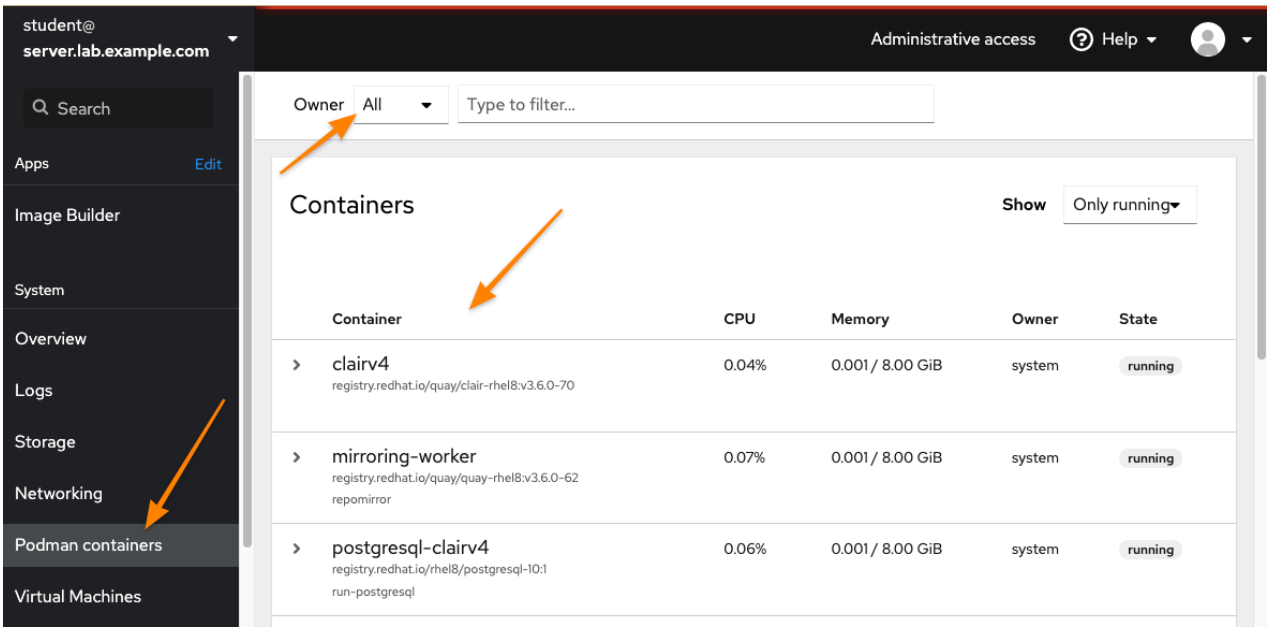


Figure 38. Podman containers - Owner All View

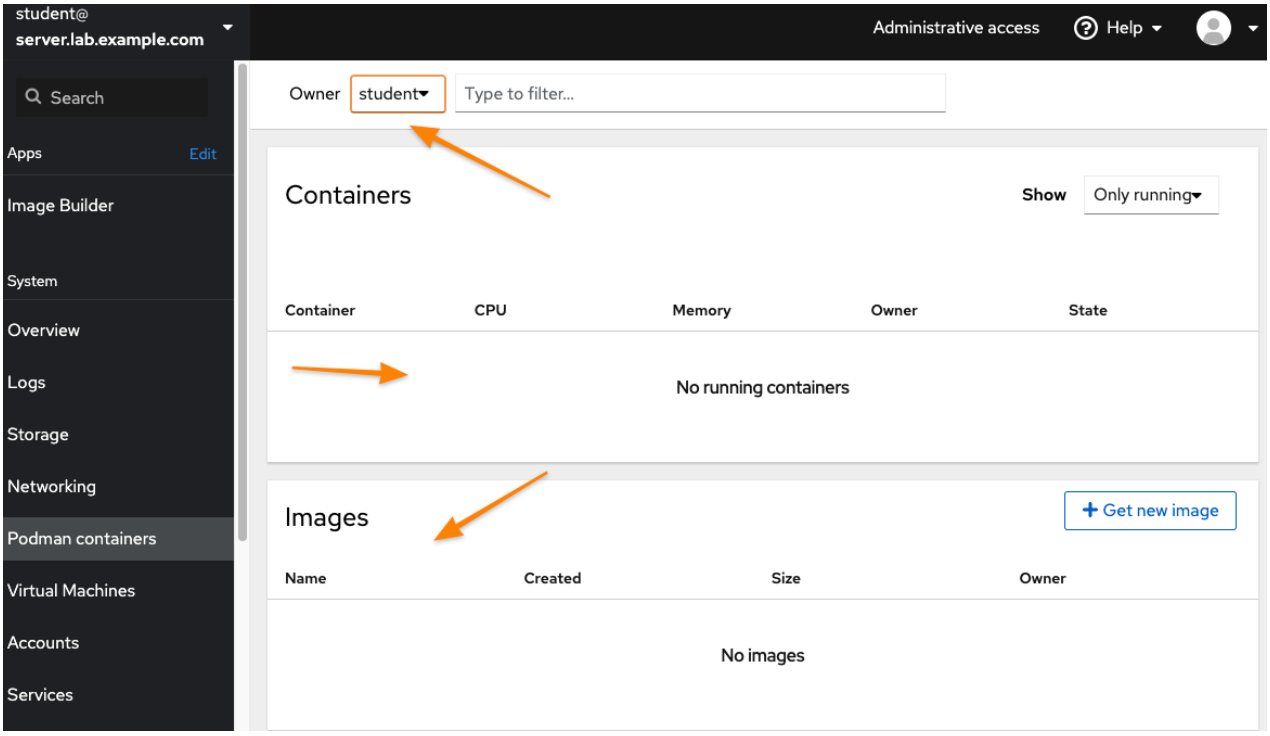


Figure 39. Podman containers - Owner **student** *View*

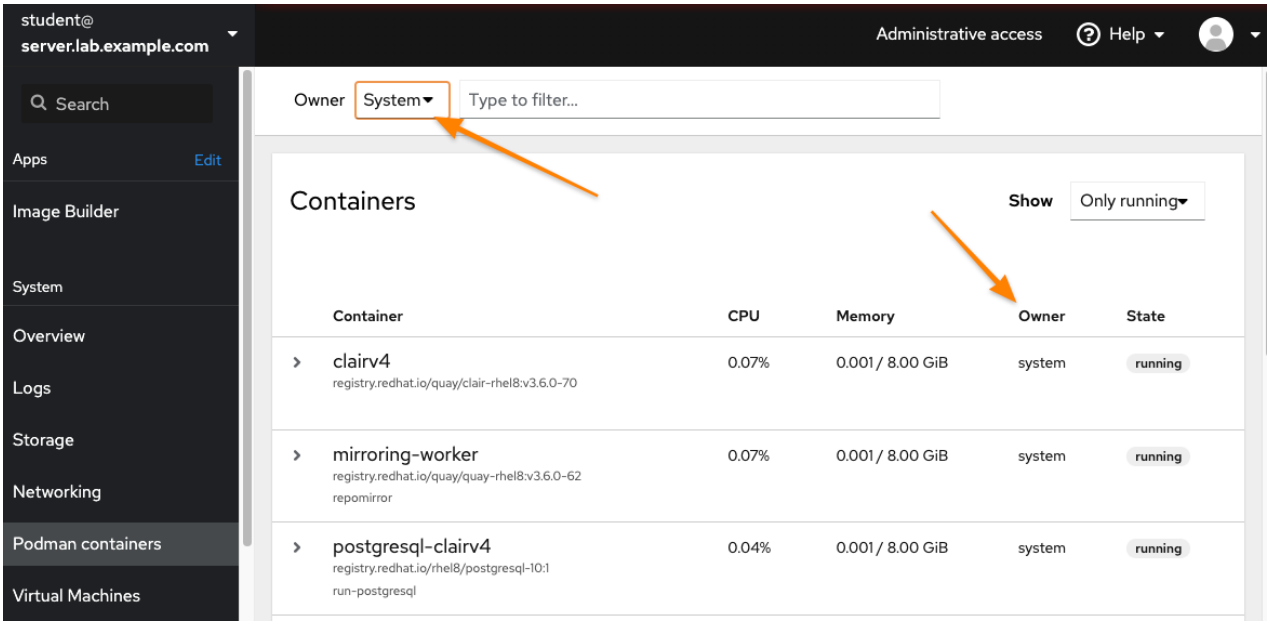


Figure 40. Podman containers - Owner **System** *View*

The **student** user is able to become root as it exists in the **sudoers** file. Based on Cockpit's abilities, the **student** user can see both containers and images owned by **student**, but it can also see containers and images owned by **system**.

Launching and managing containers is also performed the same way as the student user.

Example 11. **LAB: Working with Containers in Cockpit as *student*.**

1. Download a container image.
   a. Registry: **registry.access.redhat.com**
   b. Image: **ubi7**

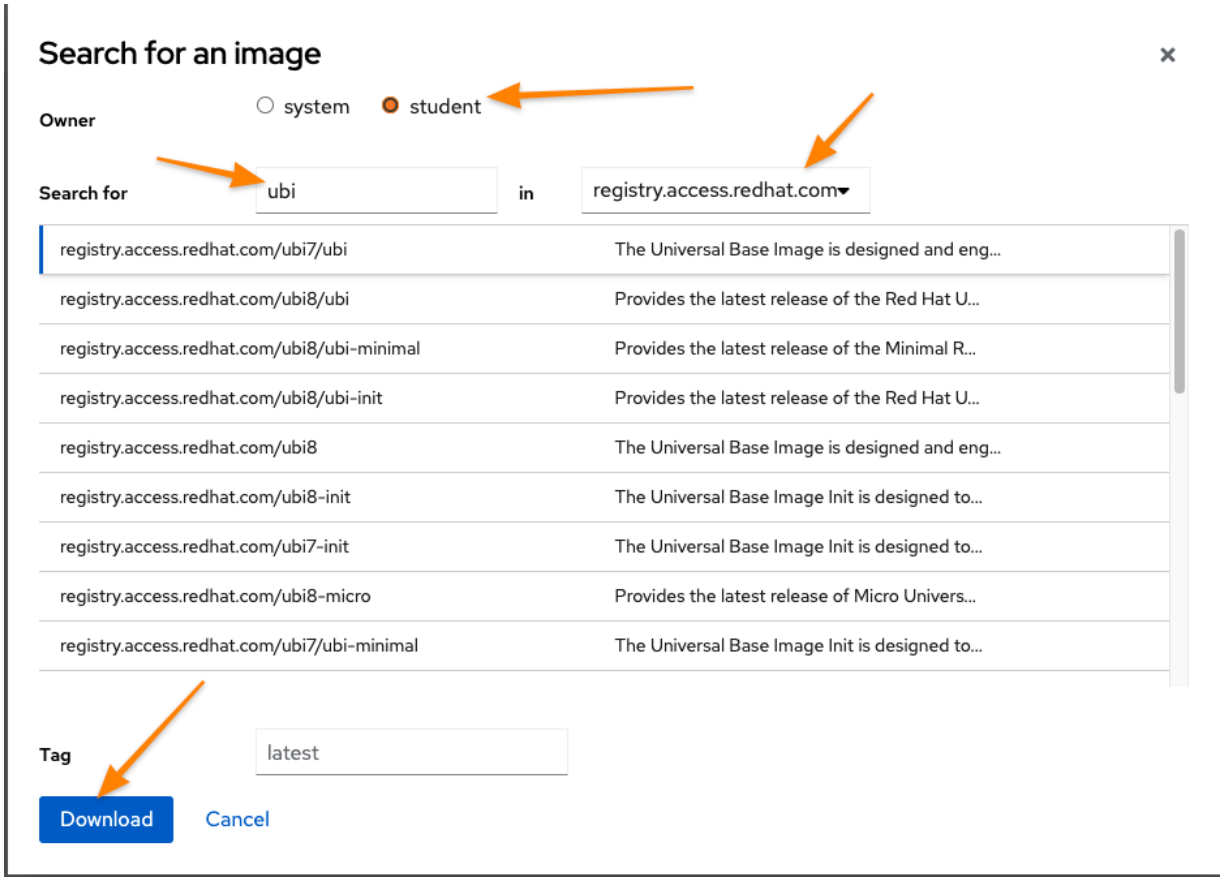


Figure 41. UBI7 Image Download

2. Launch a Container with the UBI7 Image
   a. Container Name: ubi7-test
   b. Image: **registry.access.redhat.com/ubi7/ubi:latest**

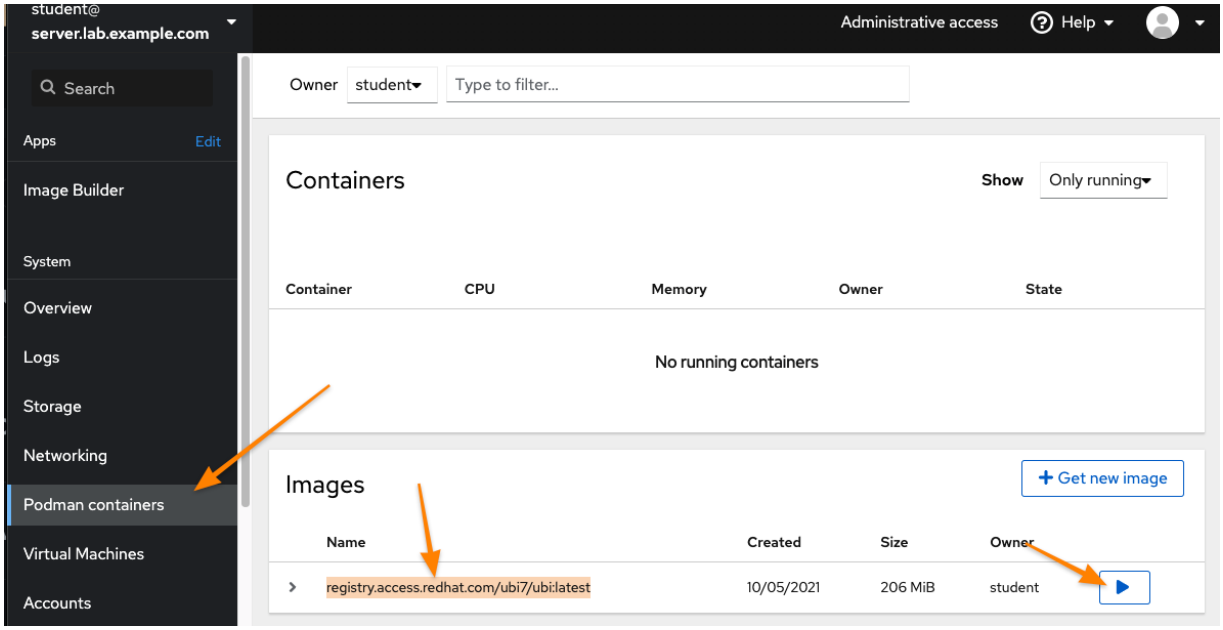
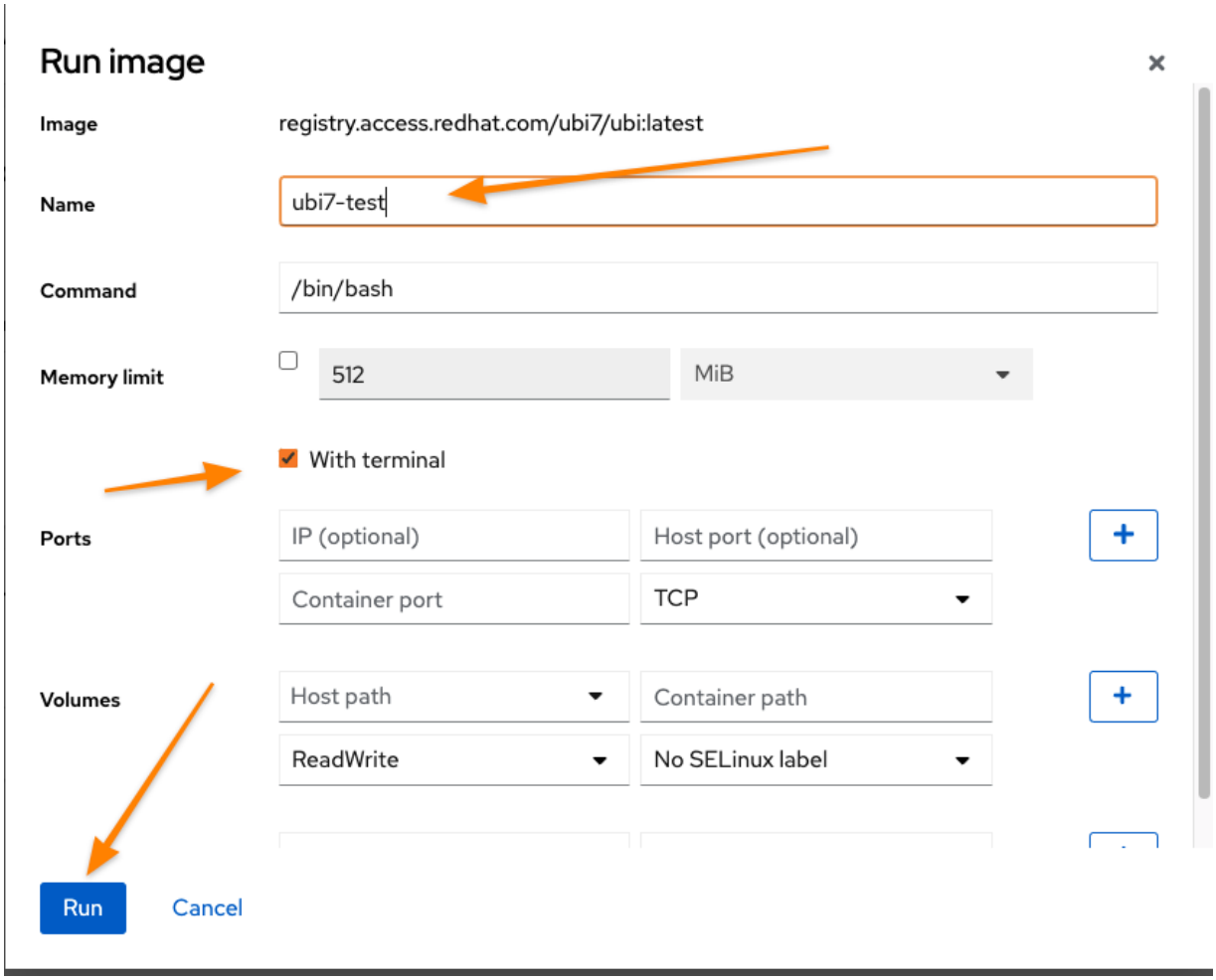


Figure 42. UBI7 Image - Local Repository



3. Explore the **ubi7-test** Container

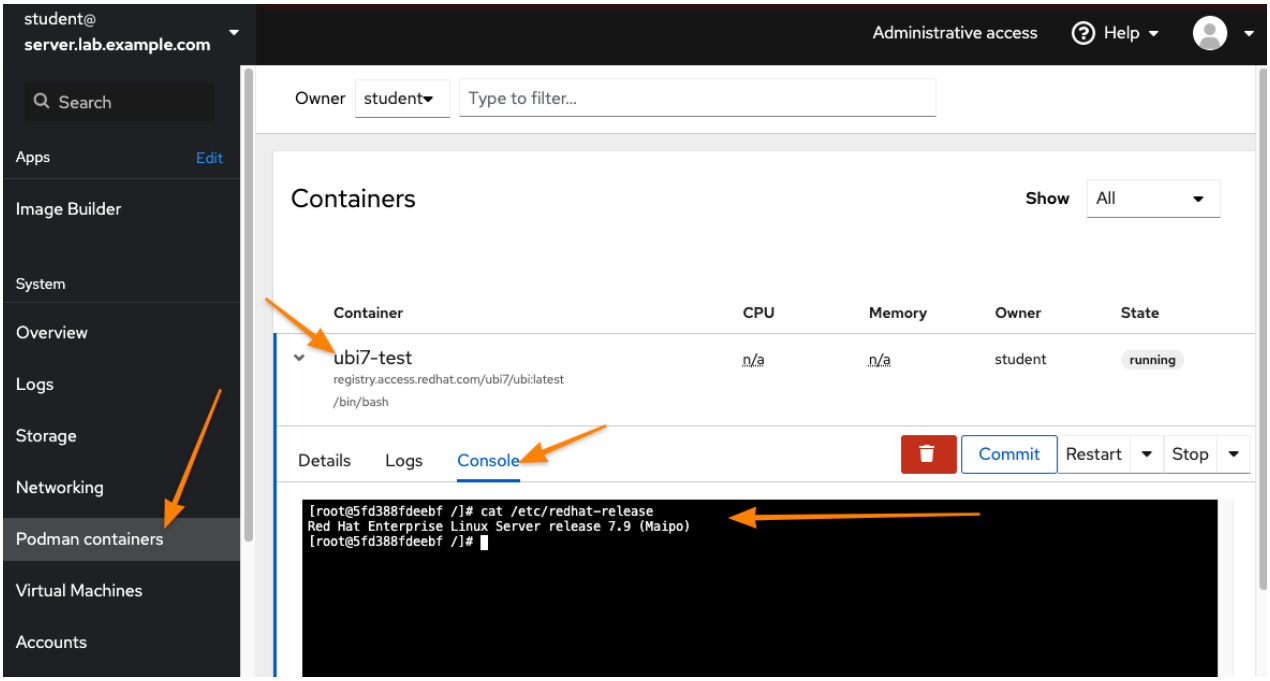


Figure 43. UBI7 Container - Interactive Console

4. Cleanup running Container (*force delete*)

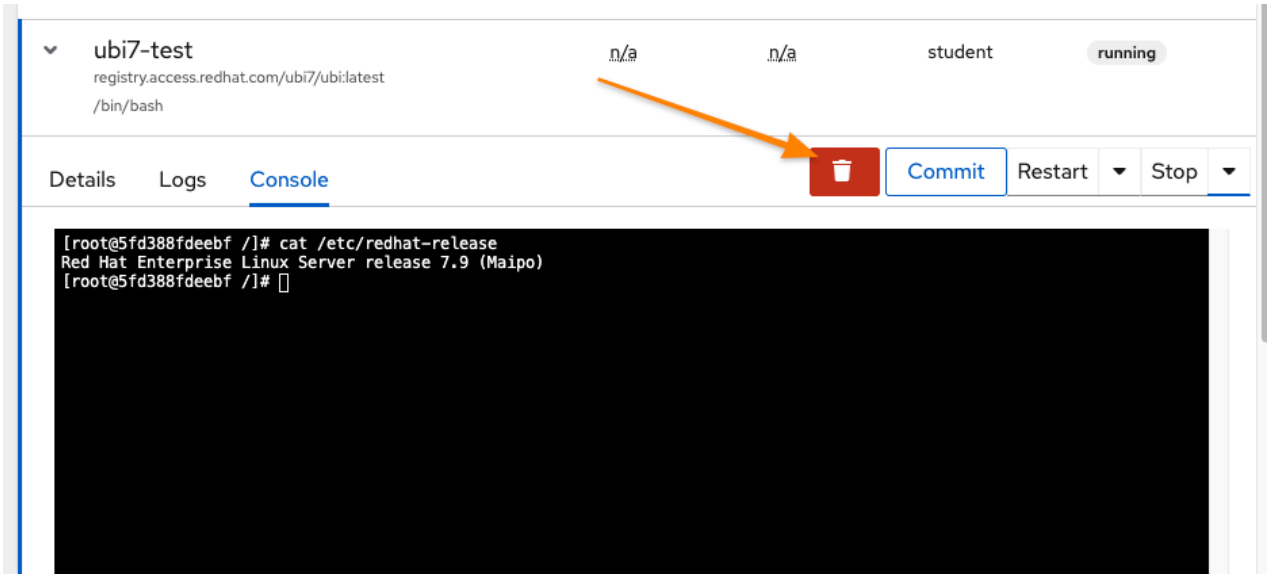


Figure 44. UBI7 Container - Deletion

5. Cleanup unneeded images

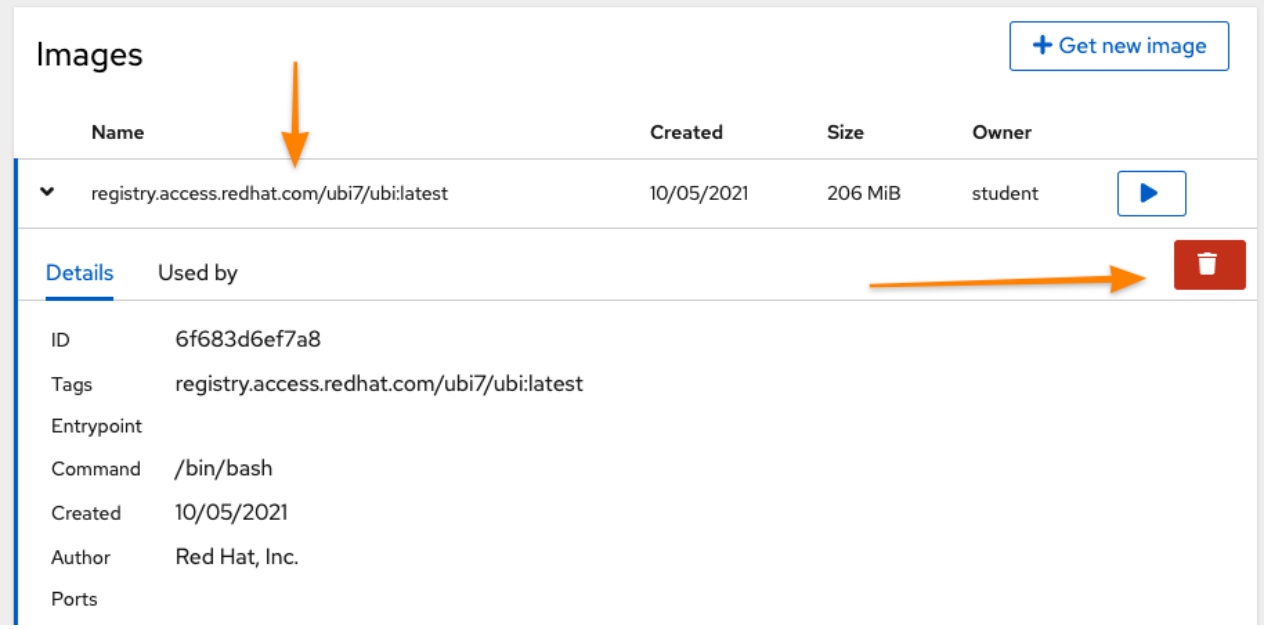


Figure 45. UBI7 Image - Deletion

6. Verify both the container and image have been deleted

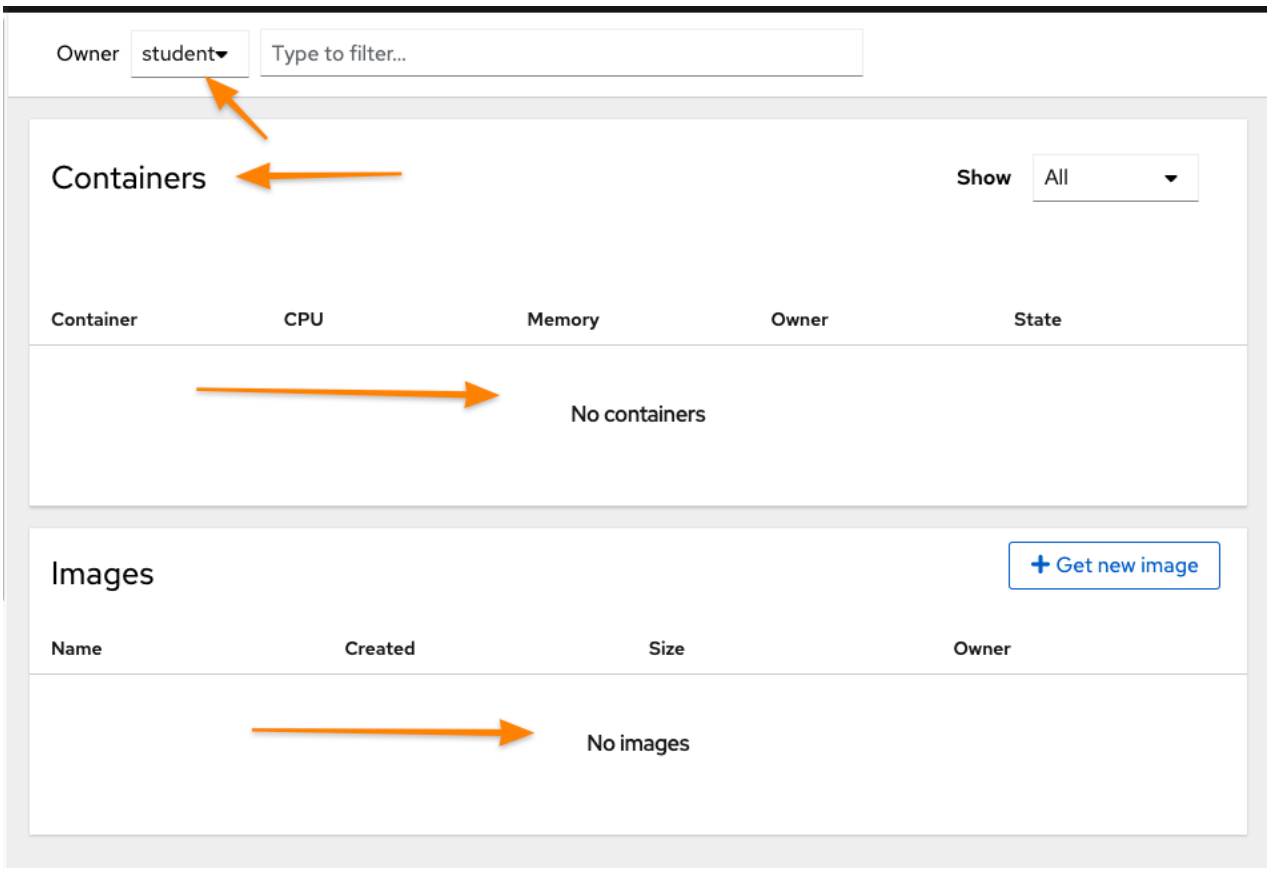


Figure 46. Cleanup Successful

References

Oracle Linux: Use Cockpit to Manage Podman Containers: https://docs.oracle.com/en/operating-systems/oracle-linux/8/tutorial-cockpit-podman/#Before-You-Begin

Managing your Podman containers with Cockpit on Fedora: https://www.tutorialworks.com/podman-monitoring-cockpit-fedora/

3. Podman Pods and Container/Pod Resource Files

Podman has replaced **Docker/Moby** in RHEL 8 and will be the container management application moving forward. **Podman** (short for Pod Manager) is a daemon-less way to run containers and pods as a standard non-privileged user or as a privileged or "root" user. Podman also lends itself nicely to Kubernetes since it manages both containers and pods. Remember that the smallest item that Kubernetes/Openshift manages is a pod and that pods consist of one or more containers.

3.1. Using and Leveraging Pods with Podman

Generally the concept of pod is associated with orchestration tools such as Red Hat Openshift and Kubernetes. A pod is a collection of one or more containers and will always include an **Infrastructure** or **Infra** container. The **Infra** container is meant to serve as a placeholder for the namespace allowing the pod to remain while allowing containers to be stopped and started while the pod stays running.

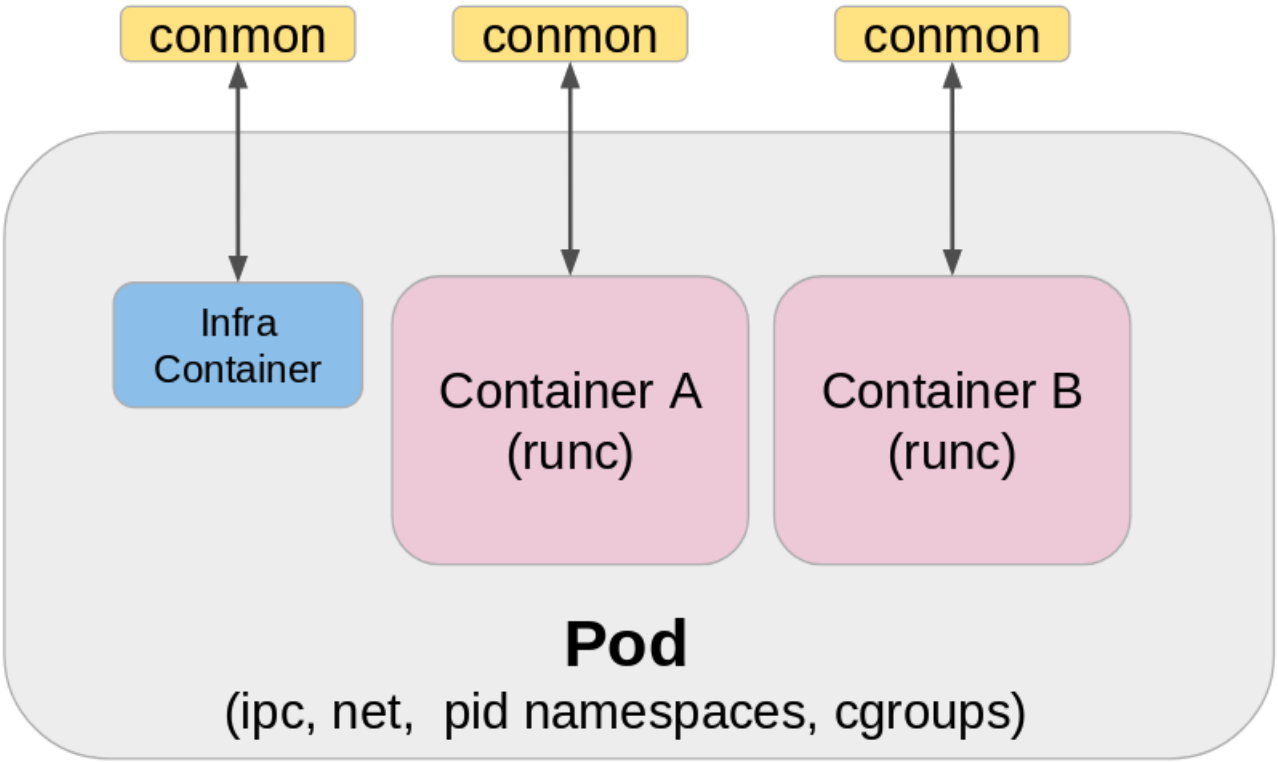


Figure 47. Example of a Pod

When using **pods** port bindings and network port mapping is done at the **pod** level, therefore this is assigned to the **infra** container. In order to change and modify ports on the container, it is necessary to delete the **pod** as once resources have been assigned, they can't be changed.

Podman is capable of managing pods with the **podman pod** command. It is possible to get assistance and help from **podman** directly by using the **podman pod --help** command.

Listing 41. **podman** *Pod Management*

```
[root@server ~]# podman pod --help
Manage pods

Description:
  Pods are a group of one or more containers sharing the same network, pid and ipc namespaces.

Usage:
  podman pod [command]

Available Commands:
  create      Create a new empty pod
  exists      Check if a pod exists in local storage
  inspect     Displays a pod configuration
  kill        Send the specified signal or SIGKILL to containers in pod
  pause       Pause one or more pods
  prune       Remove all stopped pods and their containers
  ps          List pods
  restart     Restart one or more pods
  rm          Remove one or more pods
  start       Start one or more pods
  stats       Display a live stream of resource usage statistics for the containers in one or more pods
  stop        Stop one or more pods
  top         Display the running processes of containers in a pod
  unpause     Unpause one or more pods
```

Additional more detailed help is available by using the **podman pod <command> --help** for command specific help.

Listing 42. **podman pod stop** *Help*

```
[root@server ~]# podman pod stop --help
Stop one or more pods

Description:
  The pod name or ID can be used.

  This command will stop all running containers in each of the specified pods.

Usage:
  podman pod stop [options] POD [POD...]

Examples:
  podman pod stop mywebserverpod
  podman pod stop --latest
  podman pod stop --time 0 490eb 3557fb

Options:
  -a, --all                       Stop all running pods
  -i, --ignore                    Ignore errors when a specified pod is missing
  -l, --latest                    Act on the latest container podman is aware of
                                  Not supported with the "--remote" flag
      --pod-id-file stringArray   Write the pod ID to the file
  -t, --time uint                 Seconds to wait for pod stop before killing the container (default 10
```

3.1.1. Creating a Pod and Adding a Container

Podman pods are created just like containers. It is possible to skip the **podman pod create** command to create the pod and then subsequently run the pod with the **podman pod run** command. Instead, you can directly use the **podman pod run** command to

create and run the pod. When creating a pod with a container as a single command, you MUST use the **new:<name>** directives to name a new Pod letting **podman** know you aren't attempting to reuse an existing Pod.

Listing 43. Creating a Container and Running in a Pod (Multiple Commands)

```
[root@server ~]# podman pod create --name rht-demo -p 8080:80 ①
e18e307bab06dd45d3cc5a90472ea075979aacb3adfc2071dfd68dca284b03a3

[root@server ~]# podman run -d --pod rht-demo --name webserver quay.io/redhattraining/httpd-parent ②
deeb7e789eafa99f45e6774f6ec0f124b1abbf9d211946c2fa2360e515db1c96

[root@server ~]# curl localhost:8080
Hello from the httpd-parent container!

[root@server ~]# podman pod ps
POD ID        NAME      STATUS   CREATED        INFRA ID      # OF CONTAINERS
e18e307bab06  rht-demo  Running  3 minutes ago  3113f296524c  2

[root@server ~]# podman ps
CONTAINER ID  IMAGE                                       COMMAND              CREATED             STATUS                 PORTS
NAMES
3113f296524c  registry.access.redhat.com/ubi8/pause:latest                      3 minutes ago       Up About a minute ago  0.0.0.0:8080-
>80/tcp  e18e307bab06-infra ③
deeb7e789eaf  quay.io/redhattraining/httpd-parent          /bin/sh -c /usr/s...  About a minute ago  Up About a minute ago  0.0.0.0:8080-
>80/tcp  webserver ④
```

① Create the Pod and port forwards for the Pod

② Create a container to run in the Pod. The port forward comes from the **pod** definition.

③ **Infra** Container for the Pod

④ Actually running webserver container. **NOTE: port 8080 forwards to container port 80**.

Listing 44. Creating a Container and Running in a Pod (Single Command)

```
[root@server ~]# podman run -d --pod new:rht-demo -p 80:80 quay.io/redhattraining/httpd-parent
17ac5ef7876afdcaa52a356f14284411617d9e2c7d8ab58ea5545cec61ab7547

[root@server ~]# curl localhost
Hello from the httpd-parent container!
```

3.1.2. Cleaning up Pods and Containers

It is necessary to do cleanup and maintenance on Pods and Containers as this doesn't occur automatically with Podman as it does with Openshift/Kubernetes. Just as with managing regular containers, managing pods requires stopping and deleting Pods before those pods can be removed.

It is possible to delete and remove the pod and running containers in a single instance. In order to delete and remove pods, it is necessary to know the names and status of pods which can be found with the **podman pod ps** command.

Listing 45. Podman Pod Cleanup

```
[root@server ~]# podman pod ps ①
POD ID        NAME      STATUS   CREATED         INFRA ID      # OF CONTAINERS
e18e307bab06  rht-demo  Running  12 minutes ago  3113f296524c  2

[root@server ~]# podman ps ②
CONTAINER ID  IMAGE                                     COMMAND              CREATED         STATUS             PORTS
NAMES
3113f296524c  registry.access.redhat.com/ubi8/pause:latest                       15 minutes ago  Up 13 minutes ago  0.0.0.0:8080->80/tcp
e18e307bab06-infra
deeb7e789eaf  quay.io/redhattraining/httpd-parent          /bin/sh -c /usr/s...  13 minutes ago  Up 13 minutes ago  0.0.0.0:8080->80/tcp
webserver
```

① Running Pods

② Running Containers

In order to delete a pod and the containers running within the pod, you must use the **--force** option.

Listing 46. Source Description

```
[root@server ~]# podman pod rm rht-demo --force ①
e18e307bab06dd45d3cc5a90472ea075979aacb3adfc2071dfd68dca284b03a3

[root@server ~]# podman pod ps ②
POD ID  NAME    STATUS  CREATED  INFRA ID  # OF CONTAINERS

[root@server ~]# podman ps -a ③
CONTAINER ID  IMAGE   COMMAND  CREATED  STATUS  PORTS   NAMES
```

① Stopping all containers and removing the Pod

② Verifying pod has been removed

③ Verifying there are no running containers and all containers have been removed.

podman pod rm *Errors*

You cannot remove a pod that has running or paused containers.

Listing 47. **podman pod rm** *Error*

```
[root@server ~]# podman pod rm rht-demo
Error: pod e18e307bab06dd45d3cc5a90472ea075979aacb3adfc2071dfd68dca284b03a3 has containers that are not ready to be
removed: cannot remove container 3113f296524c48a2eabdcd6f114f64c213e8844ecd2eb754557683dc7c205203 as it is running -
running or paused containers cannot be removed without force: container state improper
```

3.2. Creating a multi-container Pod for Wordpress

Example 12. **LAB: Creating a multi-container Pod for Wordpress**

In this exercise, you will be creating a pod to run the Wordpress application. This pod will contain multiple containers, namely Wordpress and MySQL/MariaDB.

1. Change to the **github/OCP_Demos/Containers/labs/Pods** on Workstation

```
[student@workstation ~]$ cd github/OCP_Demos/Containers/labs/Pods/
```

2. Execute the **Deploy_Exercise_Files** Playbook

```
[student@workstation Pods]$ ansible-playbook Deploy_Exercise_Files.yml
```

3. SSH to the **server** as root

```
[student@workstation ~]$ ssh root@server
```

4. Create the pod for running the Wordpress web application

```
[root@server ~]# podman pod create --name wordpress_pod_demo -p 80:80
5cbe751d69a99b9fdefb5225180c4897c95f60245eaf049570c2980bfdf74e2d
```

5. Verify the pod has been created

Listing 48. Verification of Pod creation

```
[root@server ~]# podman pod ps --ctr-names ①
POD ID        NAME                STATUS   CREATED        INFRA ID      <no value>
5cbe751d69a9  wordpress_pod_demo  Created  2 minutes ago  893b2d69c740  5cbe751d69a9-infra
```

① Added the **--ctr-names** to show container names

Listing 49. Verification using **podman ps** *to get Port mapping*

```
[root@server ~]# podman ps --pod -a
CONTAINER ID  IMAGE                                         COMMAND         CREATED        STATUS                    PORTS
NAMES              POD ID        PODNAME
893b2d69c740  registry.access.redhat.com/ubi8/pause:latest                  3 minutes ago  Created                   0.0.0.0:80-
>80/tcp                            5cbe751d69a9-infra  5cbe751d69a9  wordpress_pod_demo
```

6. Create the Database container

```
[root@server ~]# podman run -d --name db \
>                   -e MYSQL_USER=wordpress \
>                   -e MYSQL_PASSWORD=wordpress \
>                   -e MYSQL_DATABASE=wordpress \
>                   -e MYSQL_ROOT_PASSWORD=somewordpress \
>                   --pod wordpress_pod_demo registry.access.redhat.com/rhscl/mysql-57-rhel7
ec64df9149af45d2ce1f26d03354cd748e28815e25a73430f69180bc8a3246d8
```

Testing the Database to ensure it is up and ready

You can check login to MySQL and verify the service allows login and a simple **select** command.

Listing 50. Testing for Zero Return Code

```
[root@server ~]# podman exec db bash -c 'mysql -u root -e "SELECT 1" &> /dev/null'; echo $?
0
```

Copy/Pasteable Command

Listing 51. Launching MySQL Container

```
podman run -d --name db \
-e MYSQL_USER=wordpress \
-e MYSQL_PASSWORD=wordpress \
-e MYSQL_DATABASE=wordpress \
-e MYSQL_ROOT_PASSWORD=somewordpress \
--pod wordpress_pod_demo registry.access.redhat.com/rhscl/mysql-57-rhel7
```

7. Start the Wordpres Container

```
[root@server ~]# podman run -d --name wp \
>                   -e WORDPRESS_DB_HOST=127.0.0.1:3306 \
>                   -e WORDPRESS_DB_USER=wordpress \
>                   -e WORDPRESS_DB_PASSWORD=wordpress \
>                   -e WORDPRESS_DB_NAME=wordpress \
>                   --pod wordpress_pod_demo quay.io/redhattraining/wordpress:5.3.0
Trying to pull quay.io/redhattraining/wordpress:5.3.0...
Getting image source signatures
Copying blob 60f22fbbd07a [============================>--------] 57.4MiB / 73.1MiB
Copying blob 60f22fbbd07a [============================>--------] 57.5MiB / 73.1MiB

... OUTPUT OMITTED ...

Writing manifest to image destination
Storing signatures
793b3d5de8108204ed9161fdc65cf81214be99a13676e9f8f251f439852c70f2
```

Copy/Pasteable Command

Listing 52. Launching Wordpress Applicatin

```
podman run -d --name wp \
-e WORDPRESS_DB_HOST=127.0.0.1:3306 \
-e WORDPRESS_DB_USER=wordpress \
-e WORDPRESS_DB_PASSWORD=wordpress \
-e WORDPRESS_DB_NAME=wordpress \
--pod wordpress_pod_demo quay.io/redhattraining/wordpress:5.3.0
```

8. Check Podman Pod and Container Status

```
[root@server ~]# podman pod ps --ctr-names
POD ID        NAME               STATUS   CREATED         INFRA ID      <no value>
5cbe751d69a9  wordpress_pod_demo  Running  13 minutes ago  893b2d69c740  wp ,5cbe751d69a9-infra ,db ①
```

① The **wp** container is running for Wordpress. The **infra** container is running for the Pod. The **db** container is running to provide the database for Wordpress

9. Verify Website from CLI

```
[root@server ~]# curl -I http://127.0.0.1/wp-admin/install.php
HTTP/1.1 200 OK
Date: Mon, 25 Oct 2021 16:34:17 GMT
Server: Apache/2.4.38 (Debian)
X-Powered-By: PHP/7.3.12
Expires: Wed, 11 Jan 1984 05:00:00 GMT
Cache-Control: no-cache, must-revalidate, max-age=0
Content-Type: text/html; charset=utf-8
```

10. Open Firewall ports on **server.lab.example.com** for port 80/tcp and check from web browser.

Listing 53. Opening Port

```
[root@server ~]# firewall-cmd --add-service=http --permanent ; firewall-cmd --reload
success
success
```

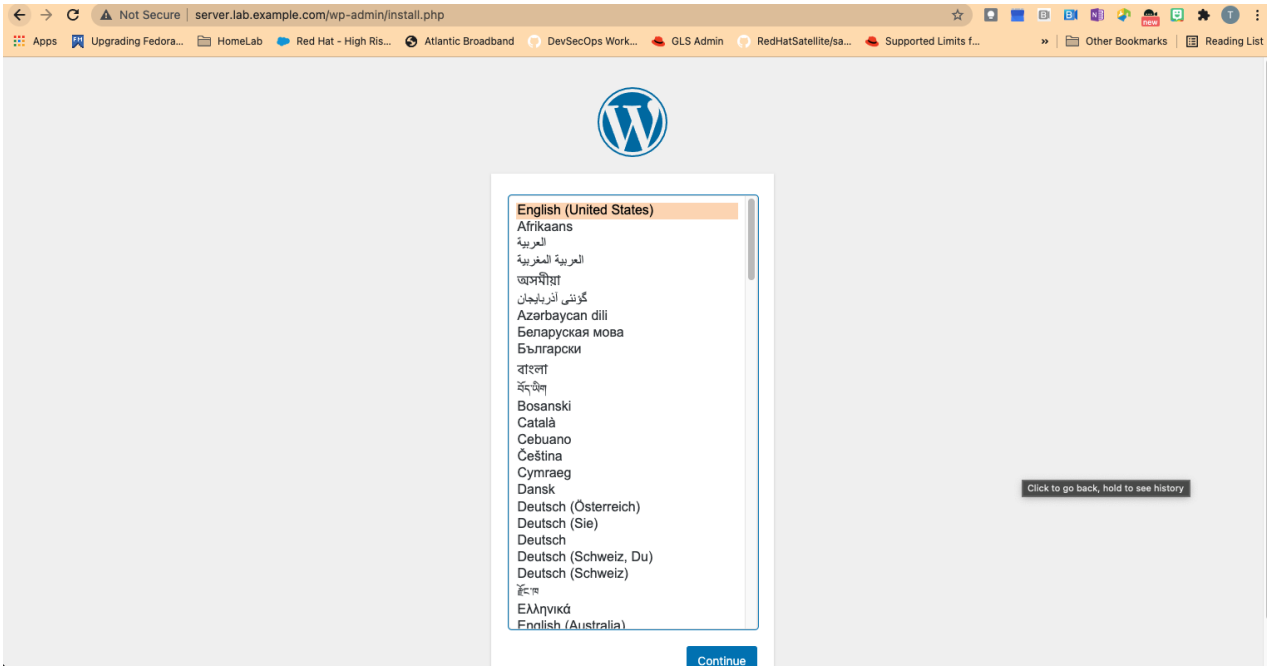


Figure 48. Wordpress Installation Page

11. Cleanup Pods and Containers

Listing 54. Removing Pods and Containers

```
[root@server ~]# podman pod rm wordpress_pod_demo  --force
```

3.3. Podman Image and Container Pruning

It is extremely important to cleanup containers, pods, and container images/volumes when the containers are no longer running as resources are prevented from being used even if the container is stopped. More importantly, it is important from a systems management and maintenance standpoint.

3.3.1. Using Podman Prune Commands

The **podman <subsystem> prune** command can remove and cleanup Pods, containers, container images, and volumes. This command can be useful as it will only cleanup what isn't being used. For example, if containers are stopped, but will be re-run at a later point, there is no reason to cleanup a volume or the container image because the image is being used, even if it is being used by a stopped container.

3.3.1.1. Cleaning Up Pods

Listing 55. Looking at Pods

```
[root@server Buildah]# podman pod ps
POD ID        NAME               STATUS   CREATED        INFRA ID      # OF CONTAINERS
35870e1ae2d0  wordpress_demo_pod  Running  6 minutes ago  bfe7065204b2
```

Listing 56. Stopping a Pod

```
[root@server Buildah]# podman pod stop wordpress_demo_pod
35870e1ae2d067e6bc84e4df7ccd2b30f6df6ba4cdb4c098814311ddec1f5b41
```

Listing 57. Looking at Stopped Pod

```
[root@server Buildah]# podman ps -ap ①
CONTAINER ID  IMAGE                                          COMMAND              CREATED         STATUS                     PORTS
NAMES               POD ID        PODNAME
bfe7065204b2  registry.access.redhat.com/ubi8/pause:latest                        10 minutes ago  Exited (0) 2 minutes ago  0.0.0.0:8880-
>80/tcp  35870e1ae2d0-infra  35870e1ae2d0  wordpress_demo_pod
21ff11d8a20a  registry.access.redhat.com/rhscl/mysql-57-rhel7  run-mysqld           10 minutes ago  Exited (0) 2 minutes ago  0.0.0.0:8880-
>80/tcp  db                  35870e1ae2d0  wordpress_demo_pod
fb2162542a72  quay.io/redhattraining/wordpress:5.3.0          apache2-foregroun...  10 minutes ago  Exited (0) 2 minutes ago  0.0.0.0:8880-
>80/tcp  wp                  35870e1ae2d0  wordpress_demo_pod
```

① The **-ap** will list all containers and the **pod** to which they belong.

Listing 58. Pruning Stopped Pods and Containers for Pods

```
[root@server Buildah]# podman pod prune
WARNING! This will remove all stopped/exited pods..
Are you sure you want to continue? [y/N] y
35870e1ae2d067e6bc84e4df7ccd2b30f6df6ba4cdb4c098814311ddec1f5b41

[root@server Buildah]# podman ps -ap
CONTAINER ID  IMAGE   COMMAND  CREATED  STATUS  PORTS   NAMES   POD ID  PODNAME
```

3.3.1.2. Cleaning Up Containers

Listing 59. Running a Sample Container

```
[root@server Buildah]# podman run --name demo-container-buildah -d -p 8880:80 localhost/demo-container-image
e67dea0b982076219db520581f6e9d1a02e1fe168c2992507f9e0bd973d7d1e
```

Listing 60. Stopping a Sample Container

```
[root@server Buildah]# podman stop demo-container-buildah
e67dea0b982076219db520581f6e9d1a02e1fe168c2992507f9e0bd973d7d1ed
```

*Listing 61. Looking for Stopped Containers (**podman ps -a**)*

```
[root@server Buildah]# podman ps -a
CONTAINER ID  IMAGE                           COMMAND               CREATED        STATUS                         PORTS                 NAMES
e67dea0b9820  localhost/demo-container-image  /usr/sbin/httpd -...  2 minutes ago  Exited (0) About a minute ago  0.0.0.0:8880->80/tcp  demo-
container-buildah ①
```

① Image attached to a running or **stopped** container

Cleanup of Containers

Cleanup of exited/stopped containers is also very important as these containers are reserving system resources, storage space, namespaces, networking, etc. The **podman container prune** command can be used to cleanup and remove all stopped containers.

Listing 62. Container Cleanup

```
[root@server Buildah]# podman container prune
WARNING! This will remove all non running containers.
Are you sure you want to continue? [y/N] y
e67dea0b982076219db520581f6e9d1a02e1fe168c2992507f9e0bd973d7d1ed
```

3.3.1.3. Cleaning Up Images

Image Management

Image management is extremely important when using Podman as there are a limited number of resources on the system - namely storage space. Having a good strategy for container cleanup is needed in order to ensure a healthy system. The **podman image prune** command can be used to cleanup and remove all orphaned images not being used by containers. The **podman rmi** command is used to delete actual tagged images from the local image registry.

Listing 63. Cleanup of Images

```
[root@server Buildah]# podman images | grep demo ①
localhost/demo-container-image                  latest     d21ee320b60a  2 hours ago    553 MB

[root@server Buildah]# podman images prune ②
REPOSITORY  TAG     IMAGE ID  CREATED  SIZE

[root@server Buildah]# podman images | grep demo ③
localhost/demo-container-image                  latest     d21ee320b60a  2 hours ago    553 MB
```

Image Cleanup

It will always be necessary to cleanup images after a pod or a container cleanup because there could be **orphaned** and **dangling** images left after all stopped pods and containers have been pruned. This happens if there are images on the system that are unused and have no tags assigned to them.

Listing 64. Image Listing

```
[root@server Buildah]# podman images
REPOSITORY                                      TAG        IMAGE ID      CREATED        SIZE
localhost/demo-container-image                  latest     d21ee320b60a  3 hours ago    553 MB
```

Listing 65. Image Pruning

```
[root@server Buildah]# podman image prune

WARNING! This will remove all dangling images.
Are you sure you want to continue? [y/N] y
```

Image Cleanup

Actual container image cleanup is performed with the **podman rmi *** command which will delete all images that aren't attached to containers. It won't remove any images that are attached to currently running or stopped containers unless the **--force** option is used. However, when using **--force** this will also stop and remove all containers prior to removing the container images.

Example 13. **LAB: Managing Containers and Images**

Playbooks have been setup to create and launch pods as well as various scripts to perform the launching.

1. Change to the **github/OCP_Demos/Containers/labs/Pods** on Workstation

```
[student@workstation ~]$ cd github/OCP_Demos/Containers/labs/Pods/
```

2. Install Podman Containers Collection

```
[student@workstation Pods]$ ansible-galaxy collection install -r requirements.yml -p collections
Process install dependency map
Starting collection install process
Installing 'containers.podman:1.8.1' to
'/home/student/github1/OCP_Demos/Containers/labs/Pods/collections/ansible_collections/containers/podman
```

3. Create the Registry Credentials File

```
[student@workstation Pods]$ cp vars/registry_login_demo.yml vars/registry_login.yml
[student@workstation Pods]$ vim vars/registry_login.yml
```

4. Launch a Container

```
[student@workstation Pods]$ ansible-playbook Deploy_Container_Demo.yml

PLAY [Deploy HTTPD Server Demo] ***************************************************

... OUTPUT OMITTED ...
```

5. Identify Containers on Workstation

```
[student@workstation Pods]$ sudo podman ps
CONTAINER ID  IMAGE                                  COMMAND               CREATED         STATUS             PORTS
NAMES
51ed5c1fc601  quay.io/redhattraining/httpd-parent:2.4  /bin/sh -c /usr/s...  48 seconds ago  Up 47 seconds ago  0.0.0.0:7080-
>80/tcp  Website_Demo
```

6. Stop Container on Workstation

```
[student@workstation Pods]$ sudo podman stop Website_Demo
51ed5c1fc601e3722b9a6288e7ec879c75e0b4eefb03707ffd8f83056d9654c5
```

7. Prune Containers on Workstation

```
[student@workstation Pods]$ sudo podman container prune
51ed5c1fc601e3722b9a6288e7ec879c75e0b4eefb03707ffd8f83056d9654c5
```

8. Prune Images on Workstation

```
[student@workstation Pods]$ sudo podman image prune
```

9. List and Delete Images on Workstation

```
[student@workstation Pods]$ sudo podman images ①
REPOSITORY                           TAG   IMAGE ID       CREATED       SIZE
quay.io/redhattraining/httpd-parent   2.4   3639ce1374d3   2 years ago   236 MB

[student@workstation Pods]$ sudo podman rmi 3639ce1374d3 ②
Untagged: quay.io/redhattraining/httpd-parent:2.4
Deleted: 3639ce1374d3611e80ed66decd7d5467b72d010c21e19e4f193cd8b944e8c9f5

[student@workstation Pods]$ sudo podman images ③
REPOSITORY   TAG   IMAGE ID   CREATED   SIZE
```

① Listing Images

② Removing desired image

③ Ensuring image was removed

3.4. Using Podman to Create YAML Resource Files

Kubernetes and container orchestration tools typically require custom resource definition file (CRDs) that will fully describe the deployment and all settings. These YAML files are a description of what takes place in a declarative language, much like Ansible.

Just as Kubernetes and Openshift manages containers by creating and managing Pods, so too does Podman. Newer upgrades and features to Podman allow the generation of these YAML files to make transitioning to/from Kubernetes much easier. Additionally, Podman can use these local pod/container definition files to launch and run services locally using Podman.

3.4.1. Creating a Deployment File from a Container

It is possible to create a deployment file for Podman from a running container. These files can simplify things when launching a job multiple times. It isn't necessary to author a bash script to leverage Podman to start and run the jobs. The resulting deployment file will create a pod with the needed container when running the **podman play kube** command as a ***pod*** is the smallest unit that can be managed and Kubernetes/Openshift doesn't manage anything smaller than the pod-level.

Example 14. **LAB: Creating a Deployment File from a Container**

1. SSH to **root@server**

```
[student@workstation ~]$ ssh root@server
```

2. Create a running container from HTTPD-Parent

```
[root@server ~]# podman run -d --name yaml-web-demo -p 8888:80 quay.io/redhattraining/httpd-parent:2.4
fc626111af2376dc25fb3b397fce2c6536b5a3aa45db577d28d0ee41f7cdc791
```

3. Test that the website is running in the container

```
[root@server ~]# curl localhost:8888
Hello from the httpd-parent container!
```

4. Generate the YAML file

```
[root@server ~]# podman generate kube yaml-web-demo > yaml-web-demo.yml
```

5. Inspect the YAML file

```
[root@server ~]# cat yaml-web-demo.yml
# Generation of Kubernetes YAML is still under development!
#
# Save the output of this file and use kubectl create -f to import
# it into Kubernetes.
#
# Created with podman-3.0.2-dev
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: "2021-10-27T15:41:06Z"
  labels:
    app: yaml-web-demo
  name: yaml-web-demo ①
spec:
  containers:
  - command:
    - /bin/sh
    - -c
    - /usr/sbin/httpd -DFOREGROUND
    env:
    - name: PATH
      value: /usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
    - name: TERM
      value: xterm
    - name: container
      value: oci
    - name: DOCROOT
      value: /var/www/html
    image: quay.io/redhattraining/httpd-parent:2.4 ②
    name: yaml-web-demo ③
    ports:
    - containerPort: 80
      hostPort: 8888 ④
      protocol: TCP
    resources: {}
    securityContext:
      allowPrivilegeEscalation: true
      capabilities:
        drop:
        - CAP_MKNOD
        - CAP_AUDIT_WRITE
      privileged: false
      readOnlyRootFilesystem: false
      runAsGroup: 0
      runAsUser: 0
      seLinuxOptions: {}
    workingDir: /
  dnsConfig: {}
status: {}
```

① Pod name is defined

② Container image is defined

③ Container name is defined

④ Container port mapping is defined

Since we didn't create a pod with a separate name, when the command was run, it created a **pod name** which was/is the same as the **container name**. This can cause issues when deploying from the file by creating a warning message. The **podman play kube** will generate a new name for the items so there are no duplicate name conflicts.

6. Stop and Remove Container

```
[root@server ~]# podman rm yaml-web-demo -f
fc626111af2376dc25fb3b397fce2c6536b5a3aa45db577d28d0ee41f7cdc791
```

7. Start a new container with the **podman play kube** command

```
[root@server ~]# podman play kube ./yaml-web-demo.yml ①
a container exists with the same name ("yaml-web-demo") as the pod in your YAML file; changing pod name to yaml-web-demo_pod
Pod: ②
72f468000f4899e89d0def7add5859c0c2cc75c9f0be49c85f4a7db401feed07
Container: ③
72d22f1867e9b8f56921a5f6bba460e2c9fc123db0ed7a119974cfd46ce3305f
```

① **podman play kube** will attempt to create and start both a pod and a container because Kubernetes/Openshift is meant to manage pods

② A Pod has been created for the resource

③ The **yaml-web-demo** container is created

8. Test and verify website

```
[root@server ~]# curl localhost:8888
Hello from the httpd-parent container!
```

9. Show running containers and Pods

```
[root@server ~]# podman pod ps ①
POD ID        NAME               STATUS   CREATED        INFRA ID      # OF CONTAINERS
72f468000f48  yaml-web-demo_pod  Running  2 minutes ago  c6b8cb2eda97  2

[root@server ~]# podman ps | grep yaml ②
72d22f1867e9  quay.io/redhattraining/httpd-parent:2.4                       3 minutes ago      Up 3 minutes ago      0.0.0.0:8888-
>80/tcp                           yaml-web-demo_pod-yaml-web-demo
```

① Showing the **yaml-web-demo_pod** pod

② Showing the **yaml-web-demo** in the **yaml-web-demo_pod**

10. Stop and remove the **yaml-web-demo_pod** and all containers

```
[root@server ~]# podman pod rm yaml-web-demo_pod -f
72f468000f4899e89d0def7add5859c0c2cc75c9f0be49c85f4a7db401feed07
```

11. Verify that the pod and container has been removed

```
[root@server ~]# podman ps -a | grep yaml

[root@server ~]# podman pod ps
POD ID  NAME    STATUS  CREATED  INFRA ID  # OF CONTAINERS
```

3.4.2. Creating a Deployment file from a Pod

It is possible to create a deployment file for Podman from a running pod. This deployment file will contain information about all containers running in the pod and can be used for later deployments.

Example 15. **LAB: Deployment YAML File for a Pod with Multiple Containers**

For this lab, we will be creating a **Wordpress Demo Pod** like we did above but exposing port 9999. Instead of using a script, we will have a YAML file which can deploy the application.

1. SSH to **root@server**

```
[student@workstation ~]$ ssh root@server
```

2. Create a running Pod

```
[root@server ~]# podman pod create --name wordpress_pod_demo -p 9999:80
6690272e241f1155dde5ddc276e8fc5587c6258cf83b6701038713b95ae24971
```

3. Create a Database Container in the Running Pod

```
[root@server ~]# podman run -d --name db \
> -e MYSQL_USER=wordpress \
> -e MYSQL_PASSWORD=wordpress \
> -e MYSQL_DATABASE=wordpress \
> -e MYSQL_ROOT_PASSWORD=somewordpress \
> --pod wordpress_pod_demo registry.access.redhat.com/rhscl/mysql-57-rhel7
```

Copy/Pasteable Command

Listing 66. Deployng a Database Container

```
podman run -d --name db \
-e MYSQL_USER=wordpress \
-e MYSQL_PASSWORD=wordpress \
-e MYSQL_DATABASE=wordpress \
-e MYSQL_ROOT_PASSWORD=somewordpress \
--pod wordpress_pod_demo registry.access.redhat.com/rhscl/mysql-57-rhel7
```

4. Create the Wordpress Container in the Running Pod

```
[root@server ~]# podman run -d --name wp \
> -e WORDPRESS_DB_HOST=127.0.0.1:3306 \
> -e WORDPRESS_DB_USER=wordpress \
> -e WORDPRESS_DB_PASSWORD=wordpress \
> -e WORDPRESS_DB_NAME=wordpress \
> --pod wordpress_pod_demo quay.io/redhattraining/wordpress:5.3.0
```

Copy/Pasteable Command

Listing 67. Deploying Wordpreess Container

```
podman run -d --name wp \
-e WORDPRESS_DB_HOST=127.0.0.1:3306 \
-e WORDPRESS_DB_USER=wordpress \
-e WORDPRESS_DB_PASSWORD=wordpress \
-e WORDPRESS_DB_NAME=wordpress \
--pod wordpress_pod_demo quay.io/redhattraining/wordpress:5.3.0
```

5. Verify Podman and Container Status

```
[root@server ~]# podman pod ps --ctr-names
POD ID        NAME                STATUS   CREATED        INFRA ID      <no value>
6690272e241f  wordpress_pod_demo  Running  3 minutes ago  43def184da95  6690272e241f-infra,wp,db
```

6. Verify Website Status

```
[root@server ~]#  curl -I http://127.0.0.1:9999/wp-admin/install.php
HTTP/1.1 200 OK
Date: Wed, 27 Oct 2021 16:06:26 GMT
Server: Apache/2.4.38 (Debian)
X-Powered-By: PHP/7.3.12
Expires: Wed, 11 Jan 1984 05:00:00 GMT
Cache-Control: no-cache, must-revalidate, max-age=0
Content-Type: text/html; charset=utf-8
```

7. Create YAML File for the Running Pod

```
[root@server ~]# podman generate kube wordpress_pod_demo > wordpress_pod_demo.yml
```

8. Examine the **wordpress_pod_demo.yml** file

```
[root@server ~]# cat wordpress_pod_demo.yml
# Generation of Kubernetes YAML is still under development!
#
# Save the output of this file and use kubectl create -f to import
# it into Kubernetes.
#
# Created with podman-3.0.2-dev
apiVersion: v1
kind: Pod
```

```
metadata:
  creationTimestamp: "2021-10-27T16:08:16Z"
  labels:
    app: wordpresspoddemo
  name: wordpress_pod_demo ①
spec:
  containers:
  - args:
    - apache2-foreground
    command:
    - docker-entrypoint.sh
    env:
    - name: PATH
      value: /usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
    - name: TERM
      value: xterm
    - name: container
      value: podman
    - name: PHP_LDFLAGS
      value: -Wl,-O1 -Wl,--hash-style=both -pie
    - name: APACHE_ENVVARS
      value: /etc/apache2/envvars
    - name: WORDPRESS_SHA1
      value: e3edcb1131e539c2b2e10fed37f8b6683c824a98
    - name: PHP_URL
      value: https://www.php.net/get/php-7.3.12.tar.xz/from/this/mirror
    - name: WORDPRESS_DB_HOST
      value: 127.0.0.1:3306
    - name: PHP_EXTRA_CONFIGURE_ARGS
      value: --with-apxs2 --disable-cgi
    - name: WORDPRESS_VERSION
      value: "5.3"
    - name: WORDPRESS_DB_USER
      value: wordpress
    - name: WORDPRESS_DB_PASSWORD
      value: wordpress
    - name: PHP_CPPFLAGS
      value: -fstack-protector-strong -fpic -fpie -O2 -D_LARGEFILE_SOURCE -D_FILE_OFFSET_BITS=64
    - name: PHP_ASC_URL
      value: https://www.php.net/get/php-7.3.12.tar.xz.asc/from/this/mirror
    - name: PHPIZE_DEPS
      value: "autoconf \t\tdpkg-dev \t\tfile \t\tg++ \t\tgcc \t\tlibc-dev \t\tmake \t\tpkg-config \t\tre2c"
    - name: PHP_SHA256
      value: aafe5e9861ad828860c6af8c88cdc1488314785962328eb1783607c1fdd855df
    - name: PHP_EXTRA_BUILD_DEPS
      value: apache2-dev
    - name: PHP_CFLAGS
      value: -fstack-protector-strong -fpic -fpie -O2 -D_LARGEFILE_SOURCE -D_FILE_OFFSET_BITS=64
    - name: PHP_VERSION
      value: 7.3.12
    - name: GPG_KEYS
      value: CBAF69F173A0FEA4B537F470D66C9593118BCCB6 F38252826ACD957EF380D39F2F7956BC5DA04B5D
    - name: PHP_MD5
    - name: PHP_INI_DIR
      value: /usr/local/etc/php
    - name: APACHE_CONFDIR
      value: /etc/apache2
    - name: WORDPRESS_DB_NAME
      value: wordpress
    image: quay.io/redhattraining/wordpress:5.3.0
    name: wp ②
    ports:
    - containerPort: 80
      hostPort: 9999 ③
      protocol: TCP
```

```
    resources: {}
    securityContext:
      allowPrivilegeEscalation: true
      capabilities:
        drop:
        - CAP_MKNOD
        - CAP_AUDIT_WRITE
      privileged: false
      readOnlyRootFilesystem: false
      seLinuxOptions: {}
    workingDir: /var/www/html
  - args:
    - run-mysqld
    command:
    - container-entrypoint
    env:
    - name: PATH
      value: /opt/app-root/src/bin:/opt/app-root/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
    - name: TERM
      value: xterm
    - name: container
      value: oci
    - name: BASH_ENV
      value: /usr/share/container-scripts/mysql/scl_enable
    - name: PLATFORM
      value: el7
    - name: PROMPT_COMMAND
      value: . /usr/share/container-scripts/mysql/scl_enable
    - name: APP_ROOT
      value: /opt/app-root
    - name: MYSQL_ROOT_PASSWORD
      value: somewordpress
    - name: MYSQL_USER
      value: wordpress
    - name: MYSQL_PASSWORD
      value: wordpress
    - name: HOME
      value: /var/lib/mysql
    - name: STI_SCRIPTS_PATH
      value: /usr/libexec/s2i
    - name: STI_SCRIPTS_URL
      value: image:///usr/libexec/s2i
    - name: MYSQL_DATABASE
      value: wordpress
    - name: ENV
      value: /usr/share/container-scripts/mysql/scl_enable
    - name: SUMMARY
      value: MySQL 5.7 SQL database server
    - name: ENABLED_COLLECTIONS
      value: rh-mysql57
    - name: DESCRIPTION
      value: MySQL is a multi-user, multi-threaded SQL database server. The container image provides a containerized packaging of
the MySQL mysqld daemon and client application. The mysqld server daemon accepts connections from clients and provides access to
content from MySQL databases on behalf of the clients.
    - name: MYSQL_PREFIX
      value: /opt/rh/rh-mysql57/root/usr
    - name: CONTAINER_SCRIPTS_PATH
      value: /usr/share/container-scripts/mysql
    - name: APP_DATA
      value: /opt/app-root/src
    - name: MYSQL_VERSION
      value: "5.7"
    image: registry.access.redhat.com/rhscl/mysql-57-rhel7:latest
    name: db ④
    resources: {}
```

```
    securityContext:
      allowPrivilegeEscalation: true
      capabilities:
        drop:
        - CAP_MKNOD
        - CAP_AUDIT_WRITE
      privileged: false
      readOnlyRootFilesystem: false
      runAsGroup: 27
      runAsUser: 27
      seLinuxOptions: {}
    workingDir: /opt/app-root/src
  dnsConfig: {}
  restartPolicy: Never
status: {}
```

① Pod Name for the **Wordpress_Pod_Demo** Pod

② Container name for Wordpress Container **wp**

③ Container port for the Wordpress Container **9999**

④ Container name for the Database Container **db**

9. Remove Running Pod and all Containers

```
[root@server ~]# podman pod rm wordpress_pod_demo -f
6690272e241f1155dde5ddc276e8fc5587c6258cf83b6701038713b95ae24971
```

10. Verify Pod and Containers Removed

```
[root@server ~]# podman pod ps
POD ID  NAME    STATUS  CREATED  INFRA ID  # OF CONTAINERS

[root@server ~]# podman ps -a | grep wp

[root@server ~]# podman ps -a | grep db
```

11. Deploy Wordpress Pod from YAML File with **podman play kube** command

```
[root@server ~]# podman play kube ./wordpress_pod_demo.yml

... OUTPUT OMITTED ...

Pod:
8bfbdaaf4c17a60180fa918b8fe426f568e697e72f68c22da7a3b70b592756eb
Containers:
b044e3cbc3cbdfaae6a74c3646a43fda971ec044fe1b566f97802688307aae7a
8a4e1ce9e3375d945ad82a503490472b9f955350098afed7716d3a1a13e76c53
```

12. Verify Pod Status

```
[root@server ~]# podman pod ps --ctr-names
POD ID        NAME                STATUS   CREATED             INFRA ID      <no value>
8bfbdaaf4c17  wordpress_pod_demo  Running  About a minute ago  0a19088da270  8bfbdaaf4c17-infra,wordpress_pod_demo-
db,wordpress_pod_demo-wp
```

13. Verify Website

```
[root@server ~]# curl -I http://127.0.0.1:9999/wp-admin/install.php
HTTP/1.1 200 OK
Date: Wed, 27 Oct 2021 16:16:37 GMT
Server: Apache/2.4.38 (Debian)
X-Powered-By: PHP/7.3.12
Expires: Wed, 11 Jan 1984 05:00:00 GMT
Cache-Control: no-cache, must-revalidate, max-age=0
Content-Type: text/html; charset=utf-8
```

14. Cleanup pod and containers

```
[root@server ~]# podman pod rm wordpress_pod_demo -f
```

15. Verify Cleanup

```
[root@server ~]# podman pod ps
POD ID  NAME    STATUS  CREATED  INFRA ID  # OF CONTAINERS

[root@server ~]# podman ps -a | grep wp

[root@server ~]# podman ps -a | grep db
```

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Containers vs. Pods - Taking a Deeper Look: https://iximiuz.com/en/posts/containers-vs-pods/

man pages: *podman-system-prune*, *podman-container-cleanup*, *podman-pod-prune*, *podman-container-prune*, *podman-image-prune*, and *podman-volume-prune*.

4. Container Images

Container images are required and the basis of all running containers. Container images can be built from scratch using various methods, build by extending existing containers (either manually or through Dockerfiles/Containerfiles), or they can be build as part of a CI/CD pipeline with OpenShift or other Source-to-Image (s2i) tools. With the introduction of Podman into the RHEL8 **container-tools** packages also came **buildah**. **Buildah** is capable of creating container images from scratch as well as building and creating images from Docerfiles/Container files.

4.1. Introduction to Buildah

While Podman allows building of containers with Dockerfiles/Container files or committing a running container into a new custom container image, **Buildah** provides a much cleaner approach. Using **Buildah** to construct and publish a container interactively allows much more control over the process and can result in a clean image being committed. Buildah also includes the **buildah config** which is able to commit and add various parameters to the container just like you would in the Dockerfile/Containerfile.

Buildah: A low-level tool for building and manipulating container images. Provides additional tools for building container images and **buildah** libraries are used by **podman** allowing it to have **podman build**. On the back-end, **podman** is using **Buildah** to build the container images.

OpenShift Source-to-Image process also leverages **Buildah** to construct and build the container images. There are also other projects and applications that rely on **Buildah** to construct and build container images such as **ansible-blender**. In Chapter 6, we will be using a simple playbook leveraging Ansible Collections to build and publish an image to a container registry from a **Containerfile**.

Buildah is capable of producing very small OCI comtainer images as it doesn't include any of the build tools within the image itself. Additionally, the resulting container image also doesn't include any compilers or other tools thereby making the image smaller and more secure. Since Buildah images are OCI images, they are portable and can run on a variety of different container images.

4.1.1. Buildah Commands and Overview

Just like Podman, **buildah** commands have very similar options.

Buildah Commands

- **buildah inspect**: Inspects an image
- **buildah from scratch**: Builds a new container image from scratch
- **buildah containers**: View containers
- **buildah images**: View images in local registry
- **buildah rm**: Removes container
- **buildah rmi**: Removes container image
- **buildah from**: Pulls image from remote registry
- **buildah push**: Pushes image to remote registry
- **buildah commit**: Saves and tags the image to the local image registry

- **buildah bud** or **buildah build-using-dockerfile**: Builds container image from Dockerfile/Containerfile

Almost all **Buildah** commands have the equivalent syntax and options to Podman. There are some slight exceptions and any help with **Buildah** commands is available in the man pages or using **buildah <*command*> --help**

Listing 68. The **buildah images** *Command*

```
[root@server ~]# buildah images
REPOSITORY                                      TAG         IMAGE ID       CREATED         SIZE
quay.local:80/redhattraining/hello-world-nginx  latest      8d990e08937e   2 years ago     269 MB
quay.io/redhattraining/httpd-parent             2.4         3639ce1374d3   2 years ago     236 MB
quay.local/travis/httpd-parent                  2.4         3639ce1374d3   2 years ago     236 MB
```

Listing 69. The **buildah inspect** *Command*

```
[root@server ~]# buildah inspect quay.local:80/redhattraining/hello-world-nginx
{
    "Type": "buildah 0.0.1",
    "FromImage": "quay.local:80/redhattraining/hello-world-nginx:latest",

... OUTPUT OMITTED ...

    "OCIv1": {
        "created": "2019-06-26T22:59:13.751737399Z",
        "architecture": "amd64",
        "os": "linux",
        "config": {
            "User": "1001",
            "ExposedPorts": {
                "8080/tcp": {}
            },
            "Env": [
                "PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
                "container=oci"
            ],
            "Cmd": [
                "/bin/sh",
                "-c",
                "nginx -g \"daemon off;\""

... OUTPUT OMITTED ...

        },
        "history": [
            {
                "created": "2019-04-25T16:26:20.260497942Z",
                "comment": "Imported from -"
            },
            {
                "created": "2019-04-25T16:26:28.425556Z"
            },
            {
                "created": "2019-06-26T22:33:55.170741575Z",
                "created_by": "/bin/sh -c yum install -y --disableplugin=subscription-manager --nodocs nginx   && yum clean all"
            },
            {
                "created": "2019-06-26T22:34:02.362527585Z",
                "created_by": "/bin/sh -c #(nop) ADD index.html /usr/share/nginx/html"
            },
            {
                "created": "2019-06-26T22:59:11.622403847Z",
```

```
                "created_by": "/bin/sh -c #(nop) ADD nginxconf.sed /tmp/"
            },
            {
                "created": "2019-06-26T22:59:12.412697298Z",
                "created_by": "/bin/sh -c sed -i -f /tmp/nginxconf.sed /etc/nginx/nginx.conf"
            },
            {
                "created": "2019-06-26T22:59:13.277995379Z",
                "created_by": "/bin/sh -c touch /run/nginx.pid   && chgrp -R 0 /var/log/nginx /run/nginx.pid   && chmod -R g+rwx /var/log/nginx
/run/nginx.pid"
            },
            {
                "created": "2019-06-26T22:59:13.414802016Z",
                "created_by": "/bin/sh -c #(nop) EXPOSE 8080"
            },
            {
                "created": "2019-06-26T22:59:13.593338162Z",
                "created_by": "/bin/sh -c #(nop) USER 1001"
            },
            {
                "created": "2019-06-26T22:59:13.751737399Z"
            }
        ]
    },
    "Docker": {
        "created": "2019-06-26T22:59:13.751737399Z",
        "container_config": {
            "Hostname": "",
            "Domainname": "",
            "User": "1001",
            "AttachStdin": false,
            "AttachStdout": false,
            "AttachStderr": false,
            "ExposedPorts": {
                "8080/tcp": {}
            },

... OUTPUT OMITTED ...

        "config": {
            "Hostname": "",
            "Domainname": "",
            "User": "1001",
            "AttachStdin": false,
            "AttachStdout": false,
            "AttachStderr": false,
            "ExposedPorts": {
                "8080/tcp": {}
            },
            "Tty": false,
            "OpenStdin": false,
            "StdinOnce": false,
            "Env": [
                "PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
                "container=oci"
            ],
            "Cmd": [
                "/bin/sh",
                "-c",
                "nginx -g \"daemon off;\""
            ],

... OUTPUT OMITTED ...

}
```

4.2. Building Containers with Buildah

The DO180 course has taught how to build containers with an existing Dockerfile/Containerfile using Podman as well as taking a running container and using **podman commit** to create the new container image. Since **podman build** essentially uses **Buildah** on the back-end, we will only be exploring using Buildah to build containers from **scratch** interactively on the system and then publishing those containers.

4.2.1. Building images as the root user

Example 16. **LAB: Creating a Custom Container Image Using Buildah**

1. Create a container with Buildah

Listing 70. Creating a Custom Container

```
[root@server ~]# buildah from scratch
working-container
```

2. Inspect the Container

Listing 71. Naming and Inspecting a Custom Container

```
[root@server ~]# buildah config --label name=Demo-Container working-container
[root@server ~]# buildah inspect working-container
{
    "Type": "buildah 0.0.1",
    "FromImage": "",
    "FromImageID": "",

... OUTPUT OMITTED ...

"History": null,
"Devices": []
}
```

3. Mount container disk image and prepare for installation and customization

Listing 72. Installing Packages on Working Container

```
[root@server ~]# buildah mount working-container
/var/lib/containers/storage/overlay/47059b1cb7f2c518e7f98d905b7ae1bcad78e8962575361bdf7dda36701d38a9/merged ①

[root@server ~]# export
Container_Disk_Image=/var/lib/containers/storage/overlay/47059b1cb7f2c518e7f98d905b7ae1bcad78e8962575361bdf7dda36701d38a9/merged ②

[root@server ~]# echo $Container_Disk_Image
/var/lib/containers/storage/overlay/47059b1cb7f2c518e7f98d905b7ae1bcad78e8962575361bdf7dda36701d38a9/merged ③
```

① Mount container image filesystem for modification

② Export Container Disk Image Mountpoint for easy reference

③ Verify **Container_Disk_Image** Variable

4. Prepare container image for installation of RPM Packages

Listing 73. Download Red Hat Release RPM for installation

```
[root@server ~]# yumdownloader --destdir=/tmp redhat-release-server
Last metadata expiration check: 23:16:26 ago on Sun 24 Oct 2021 01:57:13 PM EDT.
```

5. Install the Red Hat Release RPM to setup GPG keys for repository

Listing 74. Install Red Hat Release RPM

```
[root@server ~]# rpm -ivh --root $Container_Disk_Image /tmp/redhat-release-8.4-0.6.el8.x86_64.rpm
warning: /tmp/redhat-release-8.4-0.6.el8.x86_64.rpm: Header V3 RSA/SHA256 Signature, key ID fd431d51: NOKEY
Verifying...                          ################################# [100%]
Preparing...                          ################################# [100%]
Updating / installing...
   1:redhat-release-8.4-0.6.el8       ################################# [100%]
```

6. Setup the Repository on Disk Image

Listing 75. Create repository for container image so files can be installed

```
[root@server ~]# cp  /etc/yum.repos.d/rhel_dvd.repo $Container_Disk_Image/etc/yum.repos.d/
```

7. Install the **httpd** Apache Pacakge to the Container

Listing 76. Install the HTTP package for a webserver

```
[root@server ~]# yum install --installroot $Container_Disk_Image httpd
```

8. Create a custom **index.html** File

Listing 77. Create an **index.html** *file for the webserver*

```
[root@server ~]# echo "This is a custom webserver container for me" >> $Container_Disk_Image/var/www/html/index.html
```

9. Install the Apache Manual for Webserver Documentation

Listing 78. Install the Apache manual for reference documentation

```
[root@server ~]# yum install --installroot $Container_Disk_Image httpd-manual
```

Poor Practice

It is a poor practice to have unneeded items, packages, and documentation in containers. This step normally wouldn't be performed.

10. Set the Container's Runtime Command

Listing 79. Configure webserver to run

```
[root@server ~]# buildah config --cmd "/usr/sbin/httpd -DFOREGROUND" working-container
```

11. Configure and EXPORT the webserver default port

*Listing 80. Configure and open port **80** for the **TCP** protocol for the container*

```
[root@server ~]# buildah config --port 80/tcp working-container
```

12. Set and Configure the Container Image Author

```
[root@server ~]# buildah config --author "Travis Michette <tmichett@redhat.com>" working-container
```

13. Cleanup unneeded files to conserve space on container image.

Listing 81. Clean up yum data to minimize required disk space

```
[root@server ~]# yum clean all --installroot $Container_Disk_Image
13 files removed
```

14. Unmount Container Filesystem image.

Listing 82. Unmount the container image filesystem

```
[root@server ~]# buildah unmount working-container
fb5387521fd7b0c9f6dd567ca0f76222178f0ffbcf38fc990df9d49a60079e1
```

15. Commit container image to local container registry

Listing 83. Commit the container image

```
[root@server ~]# buildah commit working-container demo-container-image ①
Getting image source signatures
Copying blob 1a73c59066af done

... OUTPUT OMITTED ...

Storing signatures
d21ee320b60ad274b010328df6f10f6dfed578623f00855748d8aaa3c29b5e94
```

① This will create a container image tagged **demo-container-image** with the **latest** tag.

16. View and List Container Images

Listing 84. List container images

```
[root@server ~]# buildah images | grep demo
localhost/demo-container-image                  latest      d21ee320b60a   About a minute ago   553 MB
```

17. Test the Container image by launching a container

Listing 85. Testing the Container Image

```
[root@server ~]# podman run --name demo-container-buildah -d -p 8880:80 localhost/demo-container-image
be3bbc8898fc6cab1cef5d78721f46b985e957d30984d591271fffcb5b906994

[root@server ~]# curl localhost:8880
This is a custom webserver container for me

[root@server ~]# curl http://localhost:8880/manual/
```

18. Test image in Web Browser

Listing 86. Open Firewall Ports

```
[root@server ~]# firewall-cmd --add-port=8880/tcp --permanent ; firewall-cmd --reload
success
success
```

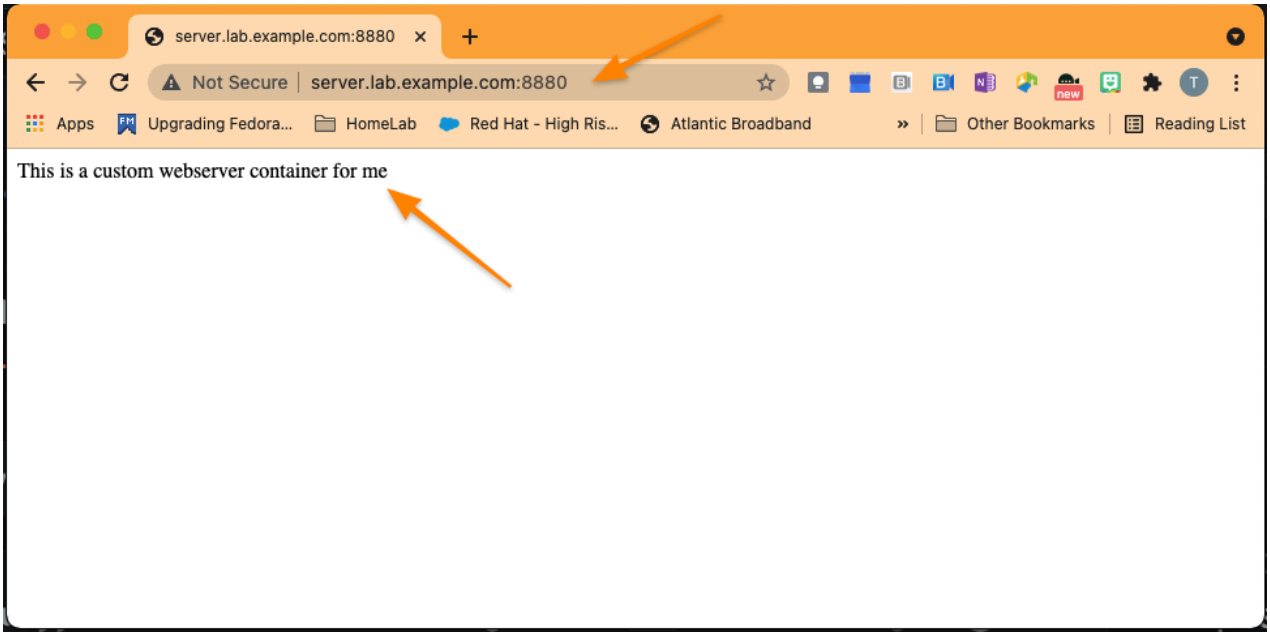


*Figure 49. Custom *index.html*

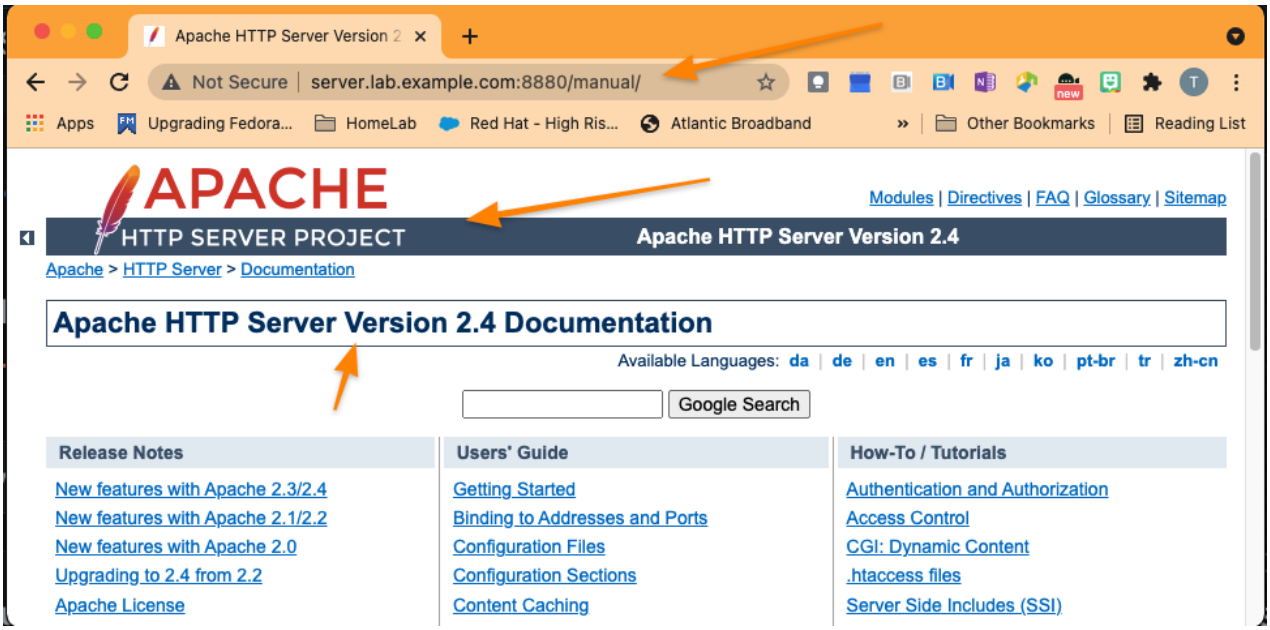


Figure 50. Apache Manual

Cleaning up the Container

1. Stop and Remove the Container

```
[root@server ~]# podman rm demo-container-buildah --force
be3bbc8898fc6cab1cef5d78721f46b985e957d30984d591271fffcb5b906994
```

Image Removal

Normally we could remove images and cleanup, but we will need to check this image into a registry later. This image shouldn't be removed until it has been checked into a remote container registry.

```
[root@server ~]# podman rmi localhost/demo-container-image
```

2. Delete the **working container** image from the system

Listing 87. Delete Working Container from System

```
[root@server ~]# buildah delete working-container
fb5387521fd7b0c9f6dd567ca0f76222178f0ffbcf38fc990df9d49a60079e18
```

4.2.2. Building an Image Using Buildah Rootless

Just like **Podman**, **Buildah** can be used to build container images in **Rootless** mode. The same setup and system configuration

applies to building an image in ***rootless*** mode. The biggest problem with leveraging **Buildah** in rootless mode is the **buildah mount** command. **Buildah** must be used in the ***userspace*** of the system just like FUSEFS with rootless-podman. Therefore, the **buildah mount** command must be used in conjunction with **buildah unshare** as **buildah unshare** provides the "magic" to allow **buildah** to enter the user namespace.

Example 17. **Lab: Building a Container Image in Rootless mode**

We will be completing the steps from above where we build a demo container as a **root** user, but this time we will be leveraging a script to save time. This will be the exact same container image, but will be completed using **buildah unshare <script_name>**.

1. Setup the lab and distribute the script to the **server** system.

Listing 88. Change to Proper Directory

```
[student@workstation ~]$ cd github/OCP_Demos/Containers/labs/Buildah/
```

Listing 89. Run Ansible Playbook

```
[student@workstation Buildah]$ ansible-playbook Deploy_Exercise_Files.yml

... OUTPUT OMITTED ...

PLAY RECAP *********************************************************************
server                     : ok=2    changed=1    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

2. SSH to the **server** system as **Student**

```
[student@workstation Buildah]$ ssh student@server
student@server's password:
```

3. Build the container image using the **rootless_buildah_demo.sh** script and Buildah in **rootless** mode

```
[student@server ~]$ buildah unshare ./rootless_buildah_demo.sh
```

4. Verify image was built and exists

```
[student@server ~]$ buildah images
REPOSITORY        TAG      IMAGE ID       CREATED          SIZE
localhost/demo-container-image   latest   c283aa80afa7   52 seconds ago   553 MB
```

5. Inspect the Image

```
[student@server ~]$ buildah inspect localhost/demo-container-image
{
    "Type": "buildah 0.0.1",
    "FromImage": "localhost/demo-container-image:latest",

... OUTPUT OMITTED ...
```

```
        "history": [
            {
                "created": "2021-10-28T19:39:43.657057139Z",
                "created_by": "/bin/sh",
                "author": "Travis Michette <tmichett@redhat.com>"
            }
        ]
    },
    "Docker": {
        "created": "2021-10-28T19:39:37.118906563Z",
        "container_config": {
            "Hostname": "",
            "Domainname": "",
            "User": "",
            "AttachStdin": false,
            "AttachStdout": false,
            "AttachStderr": false,
            "ExposedPorts": {
                "80/tcp": {}
            },
            "Tty": false,
            "OpenStdin": false,
            "StdinOnce": false,
            "Env": null,
            "Cmd": [
                "/usr/sbin/httpd",
                "-DFOREGROUND"

... OUTPUT OMITTED ...

        "author": "Travis Michette <tmichett@redhat.com>",
        "config": {
            "Hostname": "",
            "Domainname": "",
            "User": "",
            "AttachStdin": false,
            "AttachStdout": false,
            "AttachStderr": false,
            "ExposedPorts": {
                "80/tcp": {}
            },
            "Tty": false,
            "OpenStdin": false,
            "StdinOnce": false,
            "Env": null,
            "Cmd": [
                "/usr/sbin/httpd",
                "-DFOREGROUND"

... OUTPUT OMITTED ...

        "history": [
            {
                "created": "2021-10-28T19:39:43.657057139Z",
                "author": "Travis Michette <tmichett@redhat.com>",
                "created_by": "/bin/sh"
            }
... OUTPUT OMITTED ...

    "History": [
        {
            "created": "2021-10-28T19:39:43.6570571139Z",
            "created_by": "/bin/sh",
            "author": "Travis Michette <tmichett@redhat.com>"
```

```
        }
    ],
    "Devices": null
}
```

4.3. Managing Images and System Storage

Podman doesn't have inherent orchestration and management components. It is extremely important that both developers and administrators be aware of the storage space that leftover containers and container images leave behind as well as the possible impact on the system and system resources/performance.

When building multiple images on a workstation or server, it is important to push those images to a remote registry for permanent storage. It is also equally important to clean up any unused images from the system. You've already learned about some of the **podman prune** operations, but it is also necessary to use either **buildah** or **podman** commands to remove images that were built, tested, and pushed to production that are no longer needed on the developement system.

4.3.1. Pushing Images to an Image Registry with Buildah

Normally after building images and testing the images locally on the developer's workstation, these images should be pushed to a remote container registry for use in production and other environments. We will be leveraging **Buildah** to push the images to the remote container registry.

Example 18. **LAB: Pushing Image to Remote Container Registry**

1. Tag the image with **Buildah**

```
[root@server ~]# buildah tag localhost/demo-container-image quay.io/tmichett/demo-container-image
```

2. Login to Container Registry

```
[root@server ~]# buildah login quay.io
Username: tmichett
Password:
Login Succeeded!
```

3. Push the **demo-container-image** to the remote registry

```
[root@server ~]# buildah push quay.io/tmichett/demo-container-image
Getting image source signatures
Copying blob 5b447f9f7dfc done
Copying config bb055dc001 done
Writing manifest to image destination
Copying config bb055dc001 [--------------------------------------] 0.0b / 538.0b
Writing manifest to image destination
Storing signatures
```

Image and Storage Management

Generally container images are built locally on a developer workstation. It is important to keep the workstation clean of container images not being used. Once built and pushed to the remote registry, it is a good practice to delete the images that might no longer be needed.

4.3.2. Deleting Images from the local image registry with Buildah

In a previous chapter and examples, we've used the **podman rmi** command to remove and delete images and image tags from the local image repository. We will now be using those same options with the **buildah** command to cleanup images built that are no longer needed.

Example 19. **LAB: Using *buildah rmi** *to Remove Images**

We will be using various Buildah commands to list images and remove any unneeded/unused images from the system. We need to ensure that we get all tags removed for an image as well to officially and permanently remove the image from local storage.

1. List local images with the **Buildah** commands

```
[root@server ~]# buildah images
quay.io/tmichett/demo-container-image            latest      bb055dc001a5   14 minutes ago   553 MB ①
localhost/demo-container-image                   latest      bb055dc001a5   14 minutes ago   553 MB ②
```

① Tagged Demo image for pushing

② Original tagged image built using Buildah

While it appears there are two images, both of the **tagged** images have the same image ID of **bb055dc001a5**. In order to remove the image completely, both tags must be used or the image must be removed by the image ID.

2. Remove image by image ID

```
[root@server ~]# buildah rmi -f bb055dc001a5
bb055dc001a5c469f7d49d656889250bbc8bd5c60687dcbb25b437b09d950373
```

In order to remove an image by ID that has multiple tags, it is necessary to use the **-f** option to force image removal.

References

Getting into the weeds with Buildah: The buildah unshare command: https://www.redhat.com/sysadmin/buildah-unshare-command

How rootless Buildah works: Building containers in unprivileged environments: https://opensource.com/article/19/3/tips-tricks-rootless-buildah

Building and managing container images with Buildah: https://mohitgoyal.co/2021/05/16/building-and-managing-container-images-with-buildah/

podman-image-prune: https://docs.podman.io/en/latest/markdown/podman-image-prune.1.html

podman-system-prune: https://docs.podman.io/en/latest/markdown/podman-system-prune.1.html

podman-container-prune https://docs.podman.io/en/latest/markdown/podman-container-prune.1.html

Build Containers the Hard Way: https://github.com/tmichett/build-containers-the-hard-way

Ansible Blender Project: https://github.com/TomasTomecek/ansible-bender

Man Pages: *man podman-image-prune*, *man podman-system-prune*, *man podman-container-prune*, *man buildah*, *man podman*

5. Managing Containers as System Services

5.1. Starting Containers Automatically with the Server

Systemd user unit files can be created for rootless containers allowing them to be managed with **systemctl** commands similar to regular Linux services. By enabling the services, the associated containers can start when the host machine starts. Furthermore, by running in "rootless" mode the services can be managed from a non-privileged account.

5.2. Running Systemd Services as a Regular User

In addition to managing system services, **SystemD** can also manage user services. Users can create their own unit files for their services which can be managed with **systemctl** without requiring **root** access.

When services are enabled as a user service (non-root user), the service automatically starts when you open your first session. The service will stop when you've closed your last session.

Forcing User-Enabled Services to Start/Stop with the Server

It is possible to change the default behavior of user services (**systemd.units**) by using **loginctl enable-linger** command to override the behavior and enable the **Linger** feature. It can be disabled with **loginctl disable-linger**. It is possible to show the **Linger** status for a user using the **loginctl show-user *username*** command.

5.2.1. Creating and Managing Systemd User Services

In order to define **systemd** user services, the **~/.config/systemd/user** directory must be created to store the unit files. User **systemd.unit** files have the same syntax as a regular system unit file.

More Information on SYSTEMD

For more information the **systemd.unit** and **systemd.service** man pages should be used.

User Services with **systemctl**

User services can be controlled with the **systemctl** command. However, the **--user** option must be provided on the command line before the [enable, start, stop, reload] or other options and the service name.

Using **systemctl --user** *Commands*

In order for the **systemctl --user** command to function properly, you must be logged in directly as using **sudo** or **su** commands will not work. The **systemctl** command interacts with a per user **systemd --user** process.

Table 2. Classroom Machines

SystemD Tasks	System Services	User Services
Storing custom unit files	/etc/systemd/system/unit.service	~/.config/systemd/user/unit.service

SystemD Tasks	System Services	User Services
Reloading unit files	systemctl daemon-reload	systemctl --user daemon-reload
Starting and stopping a service	systemctl start UNIT systemctl stop UNIT	systemctl --user start UNIT systemctl --user stop UNIT
Starting a service when the machine starts	systemctl enable UNIT	loginctl enable-linger systemctl --user enable UNIT

5.2.2. Managing Containers Using Systemd Services

With a single container host, running small number of containers, user-based **systemd** files can be configured to automatically start the containers with the server. For larger and production based systems, Red Hat OpenShift should be used.

5.2.2.1. Creating a Dedicated User Account to Run Containers

To simplify management of rootless containers a dedicated container user account can be created for running all containers.

A Container User Account

If you are creating a user account for containers, the user account and group should be a regular user account. It cannot be created with the **--system** option as it would then be considered a system account and out of the reserved account IDs for regular user accounts.

5.2.2.2. Creating the Systemd Unit File

It is possible to use **podman** to generate the **systemd** unit files. In order to generate a **systemd** unit file, you will use **podman generate systemd** command. This works best when you are in the **~/.config/systemd/user/** directory.

Generating **systemd** *Files with Podman*

The **podman generate systemd** uses a container as a model to create the configuration file, so the container must be deleted after the creation of the **systemd** file as **systemd** expect the container to not already exist.

podman generate systemd *Command Options*

- **--name *ContainerName*** - Specifies name of container to use as a model for generating the unit file. This also defines the name of the container built from the **systemd** unit file.
- **--files** - Instructs Podman to create the unit file in the current directory
- **--new** - Instructs Podman to configure the **systemd** service to create the container when the service starts and delete the container when the service stops. Without the **--new** option, Podman configures the service to start/stop the existing container without deleting it.

5.2.2.3. Starting and Stopping Containers Using Systemd

The **systemctl** command can control containers.

Avoid using **podman** *for SystemD containers*

Containers managed with **systemctl** commands are controlled by **systemd**. **systemd** monitors the container status and restarts if a failure is detected. Never use **podman** to start/stop **systemd** containers.

5.2.2.4. Configuring Containers to Start When the Host Machine Starts

By default, **systemd** user services start when a user opens the first session and stops when a users closes the last session on a container host. It is possible to enable the service to start/stop with the server. In order to enable starting/stopping automatically **loginctl enable-linger** must be run.

Listing 90. Enable Login Linger

```
loginctl enable-linger
```

Listing 91. Enable a Container to Start Automatically

```
systemctl --user enable container-web
```

Listing 92. Disable a Container to Starting Automatically

```
systemctl --user disable container-web
```

5.2.3. Managing Containers Running as Root with Systemd

It is also possible to configure containers that should be run as **root** to be managed with **SystemD** unit files. The advantage to using containers as services running as root is that they work exactly like normal system unit files.

Configuring **root** *SystemD Container Files*

- No dedicated user needed
- When **podman generate systemd** is run, it should be in the **/etc/systemd/ system** directory so that the **systemd** unit file is in the correct directory.
- You can use **systemctl** and do not need the **--user** option
- There is no need to enable **Linger** with the **loginctl enable-linger** command.

5.2.4. Orchestrating Containers at Scale

Red Hat Training offers other courses, starting with the free technical overview course Deploying Containerized Applications (DO080) and continuing with Introduction to Containers, Kubernetes, and OpenShift (DO180). For more information, visit https://www.redhat.com/training.

A number of resources are available there, including ways to try out OpenShift for yourself using tools like CodeReady Containers

[https://developers.redhat.com/products/ codeready-containers/overview]. See https://www.openshift.com/try for more information.

5.3. DEMO - Managing Containers as Services

Example 20. DEMO - Managing Containers as Services

1. Create a Container User

```
[root@server ~]# useradd cuser
[root@server ~]# passwd cuser
Changing password for user cuser.
New password: redhat
BAD PASSWORD: The password is shorter than 8 characters
Retype new password: redhat
passwd: all authentication tokens updated successfully
```

2. Login to **server** with the **cuser** that was just created

```
[student@workstation ~]$ ssh cuser@servera
Activate the web console with: systemctl enable --now cockpit.socket

This system is not registered to Red Hat Insights. See https://cloud.redhat.com/
To register this system, run: insights-client --register

[cuser@servera ~]$
```

3. Create Directories and Config Files for Container Registry

```
[cuser@server ~]$ mkdir -p ~/.config/containers/

[cuser@server ~]$ cd ~/.config/containers/

[cuser@server containers]$ scp student@workstation:github/OCP_Demos/Containers/labs/SystemD/registries.conf .
```

4. Create Content for Webserver

```
[cuser@server ~]$ mkdir -p ~/www/html

[cuser@server ~]$ echo "I am a demo webserver" > ~/www/html/index.html
```

5. Login to the container registry

```
[cuser@server ~]$ podman login quay.io
Username: <UN>
Password: <PW>
Login Succeeded!
```

6. Create and Run Reference Container

```
[cuser@server ~]$ podman run -d --name demoweb -p 8080:80 -v ~/www:/var/www:Z quay.io/redhattraining/httpd-parent
```

7. Verify webserver is running

```
[cuser@server ~]$ curl localhost:8080
I am a demo webserver
```

8. Prepare the directory and create a **systemd** unit file

```
[cuser@server ~]$ mkdir -p ~/.config/systemd/user/

[cuser@server ~]$ cd ~/.config/systemd/user/

[cuser@server user]$ podman generate systemd --name demoweb --files --new
/home/cuser/.config/systemd/user/container-demoweb.service
```

9. View **systemd** Unit File

```
[cuser@server user]$ cat /home/cuser/.config/systemd/user/container-demoweb.service
# container-demoweb.service
# autogenerated by Podman 3.0.2-dev
# Tue Oct 26 11:22:02 EDT 2021

[Unit]
Description=Podman container-demoweb.service
Documentation=man:podman-generate-systemd(1)
Wants=network.target
After=network-online.target

[Service]
Environment=PODMAN_SYSTEMD_UNIT=%n
Restart=on-failure
TimeoutStopSec=70
ExecStartPre=/bin/rm -f %t/container-demoweb.pid %t/container-demoweb.ctr-id
ExecStart=/usr/bin/podman run --conmon-pidfile %t/container-demoweb.pid --cidfile %t/container-demoweb.ctr-id --cgroups=no-conmon
--replace -d --name demoweb -p 8080:80 -v /home/cuser/www:/var/www:Z quay.io/redhattraining/httpd-parent
ExecStop=/usr/bin/podman stop --ignore --cidfile %t/container-demoweb.ctr-id -t 10
ExecStopPost=/usr/bin/podman rm --ignore -f --cidfile %t/container-demoweb.ctr-id
PIDFile=%t/container-demoweb.pid
Type=forking

[Install]
WantedBy=multi-user.target default.target
```

10. Remove the Reference Container and Verify

```
[cuser@server user]$ podman rm demoweb -f
c0c418905cb571cbbade303c94486568b3ac87ca3afe72be92a957be421bfcc4

[cuser@server user]$ podman ps -a
CONTAINER ID  IMAGE   COMMAND  CREATED  STATUS  PORTS   NAMES
```

11. Use **systemctl** to Start and Enable the Container Service

```
[cuser@server user]$ systemctl --user enable container-demoweb --now
Created symlink /home/cuser/.config/systemd/user/multi-user.target.wants/container-demoweb.service →
/home/cuser/.config/systemd/user/container-demoweb.service.
Created symlink /home/cuser/.config/systemd/user/default.target.wants/container-demoweb.service →
/home/cuser/.config/systemd/user/container-demoweb.service.
```

SystemD Container Services

Once a containerized application has been provisioned as a SystemD service, it cannot be managed and should not be managed with **podman** instead, the service should be managed with the **user *systemctl*** SystemD commands.

12. Enable **user-linger** so that the service starts when the system boots

```
[cuser@server ~]$ loginctl enable-linger cuser
```

Must Enable User Linger Service

The **enable-linger** will allow SystemD services to start as a user when the system boots. Failure to enable this will result in services being offline until the user logs in for the first time.

13. Verify Container is Running

```
[cuser@server user]$ curl localhost:8080
I am a demo webserver

[cuser@server user]$ podman ps
CONTAINER ID  IMAGE                                 COMMAND               CREATED             STATUS                 PORTS
NAMES
6da1c129c3e2  quay.io/redhattraining/httpd-parent  /bin/sh -c /usr/s...  About a minute ago  Up About a minute ago  0.0.0.0:8080-
>80/tcp  demoweb
```

14. Reboot the server

```
[cuser@server user]$ su -
Password:
Last login: Fri Nov  5 16:12:41 EDT 2021 from 172.25.250.9 on pts/0

[root@server ~]# reboot
```

15. Log back into the server as any user other than **cuser**

```
[student@workstation Buildah]$ ssh root@server
```

16. Verify Status of Website

```
[root@server ~]# curl localhost:8080
I am a demo webserver
```

17. Verify that Container isn't running as root

```
[root@server ~]# podman ps -a
CONTAINER ID  IMAGE   COMMAND  CREATED  STATUS  PORTS   NAMES
```

18. Cleanup Service and Files for Upcoming Exercises

Listing 93. Disable and Stop Container and Service

```
[cuser@server ~]$ systemctl --user disable container-demoweb.service --now
Removed /home/cuser/.config/systemd/user/multi-user.target.wants/container-demoweb.service.
Removed /home/cuser/.config/systemd/user/default.target.wants/container-demoweb.service.
```

Warning Header

The session must be logged into **cuser** through SSH in order for **Linger** and **SystemD** to recognize the **systemctl --user** command!

Listing 94. Verify Container was Stopped and Removed

```
[cuser@server ~]$ podman ps -a
CONTAINER ID  IMAGE   COMMAND  CREATED  STATUS  PORTS   NAMES
```

References

Managing containerized system services with Podman: https://developers.redhat.com/blog/2018/11/29/managing-containerized-system-services-with-podman

Improved systemd integration with Podman 2.0: https://www.redhat.com/sysadmin/improved-systemd-podman

RH134 Course - Section 13.11: Managing Containers as Services: https://rol.redhat.com/rol/app/courses/rh134-8.2/pages/ch13s11

podman generate systemd:https://docs.podman.io/en/latest/markdown/podman-generate-systemd.1.html

podman auto-update: https://github.com/containers/podman/blob/v2.0/docs/source/markdown/podman-auto-update.1.md

Running containers with Podman and shareable systemd services: https://www.redhat.com/sysadmin/podman-shareable-systemd-services

How I learned to stop worrying and love systemd: https://www.redhat.com/sysadmin/love-systemd

Mastering systemd: Securing and sandboxing applications and services: https://www.redhat.com/sysadmin/mastering-systemd

man pages: *podman-generate-systemd*, *podman-auto-update*

6. Container Management with Ansible

Containers can now be managed with the Ansible Podman collection leveraging Ansible Automation Plaatform (AAP). Red Hat curates and maintains several supported Ansible Collections at Ansible Automation Hub. The community collections are available to be installed from Ansible Galaxy.

6.1. Ansible Refresher

The following is a small reminder about Ansible and the basics around an Ansible Control node for managing systems with Ansible.

6.1.1. Ansible Basics

In order to use Ansible, the following items are required:

- **ansible** is installed on the Control Node
- An **ansible.cfg** file exists and points to a working inventory
- An **inventory** file exists containing managed nodes

6.1.1.1. Ansible Concepts and Architecture

Ansible Machine Types

- **Control Node**: Location where Ansible is installed and used to run playbooks and execute Ansible ad-hoc commands
- **Managed Host**: Network device that is managed by an Ansible control node

The required Ansible components are the following:

- **ansible.cfg**: Ansible configuration file with directives on how Ansible should work
- **inventory**: Listing and organization of ansible managed nodes/hosts
- **module**: Small piece of code to perform a variety of tasks (generally written in Python or Powershell)
- **plugins**: Code that can be used to extend and adapt Ansible to new uses. Capable of manipulating data and extracting information from output. (*Used more in the next course DO447*)
- **Ansible Tower/API**: Framework to control and manage Ansible at scale. Ansible Tower is not a core part of Ansible, but is an add-on product to more effectively utilize Ansible with teams.

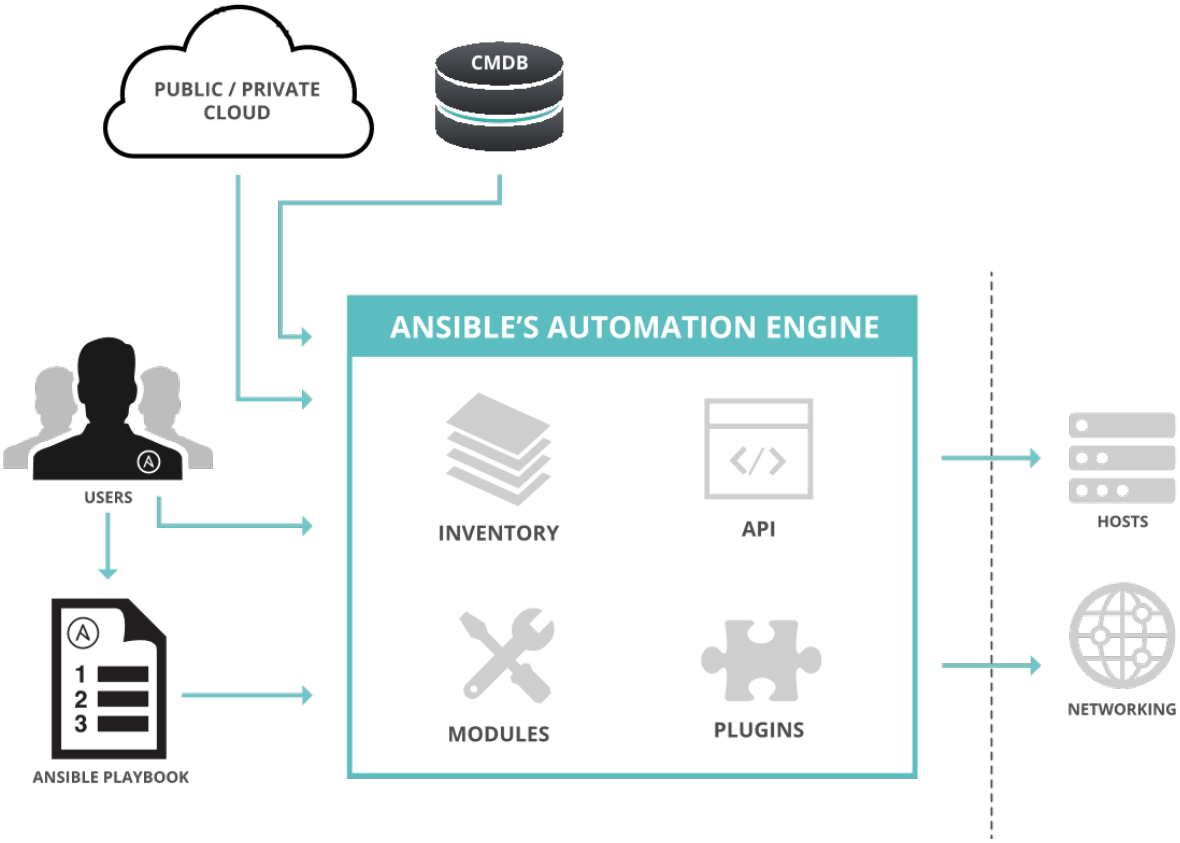


Figure 51. Ansible Architecture

6.1.1.2. Building an Ansible Inventory

An **inventory** file is the minimum needed item for Ansible to run. Inventory files provide a listing of hosts for Ansible to manage. There are multiple ways to define an inventory file.

6.1.1.2.1. Static Inventory

Static inventory files are generally defined in the INI format.

Listing 95. Simple Inventory

```
web1.example.com
web2.example.com
db1.example.com
db2.example.com
192.0.2.42

[webservers]
web1.example.com
web2.example.com
192.0.2.42
```

6.1.1.3. Ansible Configuration Files

It is important to note, there can be multiple Ansible configuration files. Ansible will look for and process configuration files in order.

1. Location specified in **ANSIBLE_CONFIG**
2. The **ansible.cfg** file in the current working directory
3. The **.ansible.cfg** file in the user's home directory
4. The default **/etc/ansible/ansible.cfg** file

It is important to note that the first file in this order Ansible sees is what will be used. Therefore, if anything is setup for the **ansible.cfg** file in locations 1-3, it won't ever use the default file ***/etc/ansible/ansible.cfg***

Ansible Configuration file documentation: http://docs.ansible.com/ansible/intro_configuration.html

Table 3. **Ansible Settings**

Setting	Command Line Option
inventory	Location of the Ansible inventory file.
remote_user	The remote user account used to establish connections to managed hosts.
become	Enables or disables privilege escalation for operations on managed hosts.
become_method	Defines privilege escalation method on managed hosts.

Setting	Command Line Option
become_user	User account to escalate privileges to on managed hosts.
become_ask_pass	Defines whether privilege escalation on managed hosts should prompt for password.

Ansible Collections

Starting with Ansible 2.9 and the new Ansible (AAP), collections have been introduced and allow modules, roles, and other components to be stored in Ansible collections. Similar to Ansible Roles, Ansible Collections must be installed on the system and available for Ansible playbooks.

Ansible Collections can be specified in the **ansible.cfg** file for the path where collections have been installed. As with Ansible Roles, it is common to install Ansible collections to the working directory in a sub-directory called **collections**. When working with Ansible Collections it is necessary to provide this information in the **ansible.cfg** file.

Listing 96. **ansible.cfg** *for Using Collections*

```
[defaults]
remote_user = root
inventory = inventory
COLLECTIONS_PATHS = ~/.ansible/collections:/usr/share/ansible/collections:./collections

[privilege_escalation]
become = False
become_method = sudo
become_user = root
become_ask_pass = False
```

6.2. Ansible Podman Collection

The Ansible Podman collection is a required component in order to have the Ansible Modules needed to manage containers using Podman. Currently, the **containers.podman** is only available via Ansible Galaxy.

6.2.1. Obtaining Podman Collections

In order to leverage Ansible to official manage Podman containers, the **containers.podman** collection must be installed on the Ansible Control node. Currently, there are two main sources for installation of Ansible collections.

Ansible Collections

- Red Hat supported collections for Ansible can be downloaded from Ansible Automation Hub (https://console.redhat.com/ansible/automation-hub).
- Ansible Community collections can be downloaded from Ansible Galaxy (https://galaxy.ansible.com/containers/podman)

Ansible Automation Hub and Ansible Galaxy

It is required that you have a Red Hat Subscription for Ansible Automation Platform (AAP2.0) in order to access Red Hat Supported Ansible collections. The lab and exercises will use the Ansible Galaxy Podman collection.

Listing 97. Installing Ansible Galaxy Podman Collection

```
ansible-galaxy collection install containers.podman
```

containers.podman *Documentation*

https://galaxy.ansible.com/containers/podman https://docs.ansible.com/ansible/latest/collections/containers/podman/index.html https://docs.ansible.com/ansible/latest/collections/containers/podman/podman_container_module.html

6.2.2. Installing and Using the containers.podman Collection

There are multiple methods for the Podman collection to be installed, however, for this course and the exercises, the collection will be installed locally to the **./collections** sub-folder using a requirements.yml file. The **ansible.cfg** will point to this as already available in the path and the Ansible playbooks being utilized will reference the **collections** at the top of the playbook similar to Ansible roles so that throughout the playbook tasks, the shorter module name can be referenced.

Example 21. **LAB: Installing the *containers.podman* Collection**

Installing the Podman Collection

Similar to installation of Ansible Roles, Ansible Collections can be installed in the local working directory in a sub-directory called **collections**. The collections needed for the Ansible projects can be specified in a **requirements.yml** file and installed just like Ansible Roles.

1. Change to the **github/OCP_Demos/Containers/labs/Ansible_Image/** Directory

```
[student@workstation ~]$ cd github/OCP_Demos/Containers/labs/Ansible_Image/
```

2. Create a **requirements.yml** File

Listing 98. Podman Collection **requirements.yml** *File*

```
collections:
- name: containers.podman ①
```

① Listing of collections to download an install

3. Install the roles/collections from the **requirements.yml** File

Listing 99. Installing the Collections

```
[student@workstation Ansible_Image]$ ansible-galaxy collection install -r requirements.yml -p ./collections
Process install dependency map
Starting collection install process
Installing 'containers.podman:1.8.1' to
'/home/student/github/OCP_Demos/Containers/labs/Ansible_Image/collections/ansible_collections/containers/podman'
```

4. Verify the collection(s) are installed

Listing 100. Verifying Installed Collections

```
[student@workstation Ansible_Image]$ tree collections/
collections/
└── ansible_collections
    └── containers
        └── podman
            ├── ansible-collection-containers-podman.spec
            ├── CHANGELOG.rst
            ├── changelog

... OUTPUT OMITTED ...

└── sanity
    ├── ignore-2.10.txt
    ├── ignore-2.11.txt
    ├── ignore-2.12.txt
    ├── ignore-2.9.txt
    └── requirements.txt

64 directories, 146 files
```

Using Collections

Referencing the **collection** and using shorter module names. This allows a cleaner and more streamlined approach and is generally consistent with the older Ansible versions. It is 100% fully acceptable to utilize the fully qualified module names, however, for the course and ease of use we will continue referencing Ansible modules by the shortened/condensed name.

Listing 101. Sample Playbook with Collections

```
---
- name: Deploy Quay Mirror
  hosts: quay
  vars:
    QUAY_DIR: /quay
  vars_files:
    - registry_login.yml
  collections: ①
    - containers.podman

    tasks:

  ## Podman Collections Needed for Login
      - name: Login to Container Registry
        podman_login: ②
          username: "{{ registry_un }}"
          password: "{{ registry_pass }}"
          registry: "{{ registry_url }}"
```

① Importing the collection(s) to be used and referenced by short module names in the playbook.

② Leveraging modules by short module names in the playbook.

6.3. Building Container Images Using Ansible

The **podman_image** module from the **containers.podman** collection is needed in order to work with an manipulate container images. In order to build images, it is necessary to have either a valid **Containerfile** or valid **Dockerfile** for image building.

Example 22. **LAB: Building Container Images with Ansible**

Building Podman Container Images with Ansible

1. Change to the **github/OCP_Demos/Containers/labs/Ansible_Image/** Directory

```
[student@workstation ~]$ cd github/OCP_Demos/Containers/labs/Ansible_Image/
```

2. Verify the **ansible.cfg** file for proper collection usage

Listing 102. **ansible.cfg**

```
[defaults]
remote_user = root
inventory = inventory
COLLECTIONS_PATHS = ~/.ansible/collections:/usr/share/ansible/collections:./collections
```

3. Edit the **httpd_ansible_demo.yml** file

```
[student@workstation Ansible_Image]$ vim httpd_ansible_demo.yml
---
- name: Build and Upload a Container Image
  hosts: localhost
  vars_files:
  ## Add Variables
  collections:
  ## Add Collections
  tasks:
    - name: Login to Container Registry

## Add Login task

    - name: Build and Push Custom Container Image

## Add Container build task
```

4. Start with the top playbook definitions and directives

Listing 103. Ansible Playbook Directives

```
---
- name: Build and Upload a Container Image
  hosts: localhost
  vars_files:
    - vars/registry_login.yml ①
  collections:
    - containers.podman ②

... OUTPUT OMITTED ...
```

① Always provide registry login information

② Always specify the collections to be used

5. Create Playbook with Tasks

Listing 104. Playbook Tasks

```
tasks:
  - name: Login to Container Registry ①
    podman_login:
      username: "{{ registry_un }}"
      password: "{{ registry_pass }}"
      registry: "{{ registry_url }}"

  - name: Build and Push Custom Container Image ②
    podman_image:
      name: httpd_demo_ansible ③
      path: ./ ④
      push: yes ⑤
      username: "{{ registry_un }}" ⑥
      password: "{{ registry_pass }}" ⑦
      push_args: ⑧
        dest: "{{ registry_url }}/{{ registry_un }}"
```

① Initial task to login to registry

② Task using the **podman_image** module to build and push an image

③ Name/Tag of the image being built

④ Path to the **Containerfile** or **Dockerfile**

⑤ Define whether or not to push to remote image registry

⑥ Registry Username

⑦ Registry Password

⑧ Arguments used for pushing to remote registry. Works in conjunction with **push: yes**. Must have registry URL specified along with the location (*which is generally the repository username*).

6. Explore entire playbook

```
[student@workstation Ansible_Image]$ cat httpd_ansible_demo.yml
---
- name: Build and Upload a Container Image
  hosts: localhost
  vars_files:
    - vars/registry_login.yml ①
  collections:
    - containers.podman

  tasks:
    - name: Login to Container Registry ②
      podman_login:
        username: "{{ registry_un }}"
        password: "{{ registry_pass }}"
        registry: "{{ registry_url }}"

    - name: Build and Push Custom Container Image ③
      podman_image:
        name: httpd_demo_ansible ④
        path: ./ ⑤
        push: yes ⑥
        username: "{{ registry_un }}" ⑦
        password: "{{ registry_pass }}" ⑧
        push_args: ⑨
          dest: "{{ registry_url }}/{{ registry_un }}"
```

① Variables file allowing login to registry

② Initial task to login to registry

③ Task using the **podman_image** module to build and push an image

④ Name/Tag of the image being built

⑤ Path to the **Containerfile** or **Dockerfile**

⑥ Define whether or not to push to remote image registry

⑦ Registry Username

⑧ Registry Password

⑨ Arguments used for pushing to remote registry. Works in conjunction with **push: yes**. Must have registry URL specified along with the location (*which is generally the repository username*).

7. Edit the **vars/registry_login.yml** file

```
[student@workstation Ansible_Image]$ cp vars/registry_login_demo.yml vars/registry_login.yml ; vim vars/registry_login.yml
registry_un: UN_Goes_Here ①
registry_pass: Password_Goes_Here ②
registry_url: quay.io
```

① Replace with your Quay Username

② Replace with your Quay Password

8. Run the playbook to build the image

```
[student@workstation Ansible_Image]$ ansible-playbook httpd_ansible_demo.yml
```

Playbook will fail if you don't have the **containers.podman** collection installed.

Listing 105. Installation of Collections

```
[student@workstation Ansible_Image]$ ansible-galaxy collection install -r requirements.yml -p ./collections
```

1. Verify that the **httpd_demo_ansible** and added to the local registry.

```
[student@workstation Ansible_Image]$ podman images
REPOSITORY                                      TAG      IMAGE ID       CREATED
SIZE
localhost/httpd_demo_ansible                    latest   95857ed812de   About a minute ago
255 MB
```

6.4. Deploying Podman Containers Using Ansible

The **podman_container** module from the **containers.podman** collection is needed in order to create/run/remove containers. In order to create containers from container images, it is necessary to have access to the container images locally.

Example 23. **LAB: Creating and Running Containers with Ansible**

Creating and Running Podman Containers with Ansible

1. Change to the **/home/student/github/OCP_Demos/Containers/labs/Ansible_Container** Directory

```
[student@workstation ~]$ cd /home/student/github/OCP_Demos/Containers/labs/Ansible_Container
```

2. Verify the **ansible.cfg** file for proper collection usage

Listing 106. **ansible.cfg**

```
[defaults]
remote_user = root
inventory = inventory
COLLECTIONS_PATHS = ~/.ansible/collections:/usr/share/ansible/collections:./collections
```

3. Create a **requirements.yml** File

Listing 107. Podman Collection **requirements.yml** *File*

```
[student@workstation Ansible_Container]$ vim requirements.yml
collections:
- name: containers.podman ①
```

① Listing of collections to download an install

4. Install the roles/collections from the **requirements.yml** File

Listing 108. Installing the Collections

```
[student@workstation Ansible_Image]$ ansible-galaxy collection install -r requirements.yml -p ./collections
Process install dependency map
Starting collection install process
Installing 'containers.podman:1.8.1' to
'/home/student/github/OCP_Demos/Containers/labs/Ansible_Image/collections/ansible_collections/containers/podman'
```

5. Verify the collection(s) are installed

Listing 109. Verifying Installed Collections

```
[student@workstation Ansible_Image]$ tree collections/
collections/
└── ansible_collections
    └── containers
        └── podman
            ├── ansible-collection-containers-podman.spec
            ├── CHANGELOG.rst
            ├── changelog

... OUTPUT OMITTED ...

└── sanity
    ├── ignore-2.10.txt
    ├── ignore-2.11.txt
    ├── ignore-2.12.txt
    ├── ignore-2.9.txt
    └── requirements.txt

64 directories, 146 files
```

6. Edit the **deploy-httpd-ansible-demo.yml** Starter Playbook

```
[student@workstation Ansible_Container]$ vim deploy-httpd-ansible-demo.yml
```

7. Start with the top playbook definitions and directives

Listing 110. Ansible Playbook Directives

```
---
- name: Launch Container from Red Hat Training Image
  hosts: server
  collections:
    - containers.podman ①

... OUTPUT OMITTED ...
```

① Always specify the collections to be used

8. Create the Playbook with Tasks
   a. Use the **quay.io/redhattraining/httpd-parent:2.4**
   b. Launch Container with network port on 7080
   c. Test Website

Listing 111. Playbook Tasks

```
  tasks:

  ## Start and Run the HTTPD Container
    - name: Start the Apache Container
      podman_container:
        name: Website_Demo
        image: quay.io/redhattraining/httpd-parent:2.4
        state: started
        restart: yes
        ports:
          - "7080:80"

  ## Open Firewall for Automated Testing
    - name: Open Firewall for Website
      firewalld:
        port: 7080/tcp
        permanent: true
        state: enabled
        immediate: yes

- name: Test Website
  hosts: localhost
  tasks:
    - name: Test Website
      uri:
        url: http://server:7080
        return_content: yes
        status_code: 200
      register: result

    - name: Test Website Output
      debug:
        msg: 'The website returned: "{{ result.content }}"'
```

9. Verify entire playbook

```
---
- name: Deploy HTTPD Server Demo
  hosts: server
  collections:
    - containers.podman

  tasks:

## Start and Run the HTTPD Container
    - name:  Start the Apache Container
      podman_container:
        name: Website_Demo
        image: quay.io/redhattraining/httpd-parent:2.4
        state: started
        restart: yes
        ports:
          - "7080:80"

## Open Firewall for Automated Testing
    - name: Open Firewall for Website
      firewalld:
        port: 7080/tcp
        permanent: true
        state: enabled
        immediate: yes

- name: Test Website
  hosts: localhost
  tasks:
    - name: Test Website
      uri:
        url: http://server:7080
        return_content: yes
        status_code: 200
      register: result

    - name: Test Website Output
      debug:
        msg: 'The website returned: "{{ result.content }}"'
```

10. Run Ansible Playbook and Verify Success

```
[student@workstation Ansible_Container]$ ansible-playbook deploy-httpd-ansible-demo.yml
```

6.4.1. Analyzing Running Containers with Ansible

The **podman collection** has several components to manage and collect information from containers. The **podman_container_info** module can be used to get information about running containers. It requires the name of the container and collects all information as a list/dictionary.

Podman Container Info Module

It is important to note that many of the Ansible **fact** modules have been replaced with **info** modules so the facts are returned as lists/dictionaries. You should consult each module's information page and examine the **Return Values** section.

podman_container_info: https://docs.ansible.com/ansible/latest/collections/containers/podman/podman_container_info_module.html#ansible-collections-containers-podman-podman-container-info-module

It is also important to know that in order to access specific elements from the information returned, a mapping of the value must be performed.

Listing 112. Mapping Element Needed

```
- name: Gather Information on Running Containers
  podman_container_info: ①
    name: Website_Demo
  register: container_info

- name: Set Fact for Running Container Image
  set_fact: ②
    ImageName: "{{ container_info.containers | map(attribute='ImageName') | list }}"

- name: Display Running Container Image
  debug: ③
    var: ImageName
```

① Using the **podman_container_info** to gather all facts and information

② Using the **set_fact** module to map the attribute of the information to a known variable name

③ Displaying the information from the set fact

Example 24. **LAB: Analyze a running container with Ansible**

1. Change to **/home/student/github/OCP_Demos/Containers/labs/Ansible_Container** if not already there.

```
[student@workstation Ansible_Container]$ cd /home/student/github/OCP_Demos/Containers/labs/Ansible_Container
```

2. Explore the **Gather_Info_Demo.yml** playbook

```
[student@workstation Ansible_Container]$ cat Gather_Info_Demo.yml
---
- name: Container Information
  hosts: localhost

  collections:
    - containers.podman

  tasks:

    - name: Gather Information on Running Containers
      podman_container_info:
        name: Website_Demo
      register: container_info

    - name: Running Container Information
      debug:
        var: container_info

    - name: Set Fact for Running Container Launch Command
      set_fact:
        Args: "{{ container_info.containers | map(attribute='Args') | list }}"

    - name: Display Running Container Launch Command
      debug:
        var: Args

    - name: Set Fact for Running Container Image
      set_fact:
        ImageName: "{{ container_info.containers | map(attribute='ImageName') | list }}"

    - name: Display Running Container Image
      debug:
        var: ImageName
```

3. Run the **Gather_Info_Demo.yml** Playbook

```
[student@workstation Ansible_Container]$ ansible-playbook Gather_Info_Demo.yml

PLAY [Container Information] ***************************************************

TASK [Gathering Facts] *********************************************************
ok: [server]

TASK [Gather Information on Running Containers] ********************************
ok: [server]

TASK [Running Container Information] *******************************************
ok: [server] => {
    "container_info": {

... OUTPUT OMITTED ...

                    "Image": "quay.io/redhattraining/httpd-parent:2.4",

... OUTPUT OMITTED ...

                    "PortBindings": {
                        "80/tcp": [
                            {
                                "HostIp": "",
                                "HostPort": "7080"
                            }
... OUTPUT OMITTED ...

                "Name": "Website_Demo",
                "Namespace": "",
                "NetworkSettings": {

... OUTPUT OMITTED ...

TASK [Set Fact for Running Container Launch Command] ***************************
ok: [server]

TASK [Display Running Container Launch Command] ********************************
ok: [server] => {
    "Args": [
        [
            "-c",
            "/usr/sbin/httpd -DFOREGROUND"
        ]
    ]
}

TASK [Set Fact for Running Container Image] ************************************
ok: [server]

TASK [Display Running Container Image] *****************************************
ok: [server] => {
    "ImageName": [
        "quay.io/redhattraining/httpd-parent:2.4"
    ]
}

PLAY RECAP *********************************************************************
server                     : ok=7    changed=0    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

6.4.2. Controlling Running Containers with Ansible

The **podman collection** has several components to manage and collect information from containers. The **podman_container** module can be used to interact with containers.

Listing 113. Example of Stopping / Removing a Container and Deleting a Container Image

```
---
- name: Container Information
  hosts: localhost
  vars_files:
    - vars/registry_login.yml
  collections:
    - containers.podman

  tasks:

    - name: Stop Running Container
      podman_container:
        name: Website_Demo
        state: stopped

    - name: Remove Stopped Container
      podman_container:
        name: Website_Demo
        state: absent

    - name: Remove Container Image
      podman_image:
        name: quay.io/redhattraining/httpd-parent:2.4
        state: absent
```

Example 25. **LAB: Clean up containers and container images**

1. Get Listing of Running Containers

```
[student@workstation Ansible_Container]$ ssh root@server "podman ps -a | grep -i website"
2ad6b0954ed8  quay.io/redhattraining/httpd-parent:2.4               /bin/sh -c /usr/s...  11 minutes ago  Up 11 minutes ago
0.0.0.0:7080->80/tcp                          Website_Demo
```

2. Get Listing of Container Images

```
[student@workstation Ansible_Container]$ ssh root@server "podman images | grep -i httpd-parent"
quay.io/redhattraining/httpd-parent             2.4         3639ce1374d3  2 years ago    236 MB
```

3. Analyze the **Stop_and_Remove_Demo.yml** Playbook

```
[student@workstation Ansible_Container]$ cat Stop_and_Remove_Demo.yml
---
- name: Container Information
  hosts: server
  collections:
    - containers.podman

  tasks:

    - name: Stop Running Container
      podman_container:
        name: Website_Demo
        state: stopped

    - name: Remove Stopped Container
      podman_container:
        name: Website_Demo
        state: absent

    - name: Remove Container Image
      podman_image:
        name: quay.io/redhattraining/httpd-parent:2.4
        state: absent
```

4. Run the **Stop_and_Remove_Demo.yml** Playbook

```
[student@workstation Ansible_Container]$ ansible-playbook Stop_and_Remove_Demo.yml

PLAY [Container Information] ***************************************************

TASK [Gathering Facts] *********************************************************
ok: [server]

TASK [Stop Running Container] **************************************************
changed: [server]

TASK [Remove Stopped Container] ************************************************
changed: [server]

TASK [Remove Container Image] **************************************************
changed: [server]

PLAY RECAP *********************************************************************
server                     : ok=4    changed=3    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

5. Verify container is gone.

```
[student@workstation Ansible_Container]$ ssh root@server "podman ps -a | grep -i website"
```

6. Verify container image is gone.

```
[student@workstation Ansible_Container]$ ssh root@server "podman images | grep -i httpd-parent"
```

There may be other versions of the image on the system as we are only removing the image tagged with the version tag "2.4". Depending on cleanup, it is possible that a version tagged with "latest" might exist.

```
[student@workstation Ansible_Container]$ ssh root@server "podman images | grep -i httpd-parent"
quay.io/redhattraining/httpd-parent             latest  4346d3cace25  2 years ago    236 MB
```

References

Podman Collections Github Project: https://github.com/containers/ansible-podman-collections

Podman Collection Ansible Galaxy: https://galaxy.ansible.com/containers/podman

Podman Collections from Ansible Docs: https://docs.ansible.com/ansible/latest/collections/containers/podman/

7. Quay Image Registry

The Quay image registry depends on multiple sources and configuration files. The exercises here will go through a local "Proof of Concept" deployment. It will be necessary to open up firewall ports as well as provide persistent storage mount points that can be mounted and accessed within the containers.

There are multiple options for deploying Quay locally. For the purpose of this course, we will be installing the Quay registry with both the Security Scanner and the Mirroring Worker.

Quay Deployment Options

- Stand-Alone Quay Registry
- Quay Registry with a Mirroring Worker
- Quay Registry with Clair Security Scanner
- **Quay Registry with Clair Security Scanner and Mirroring Worker**

SSL and Security

All deployment scenarios allow the use of creating SSL/TLS certificates to secure the network connection. For the purpose of this content, we will be omitting the steps for generating the SSL/TLS certificates and accessing the registry via HTTPS.

Table 4. Network Ports for Firewalls and Port Mapping

Service Name	Network Port
Quay HTTPS	8443/TCP
Quay HTTP	8080/TCP
Quay HTTP	80/TCP

Service Name	Network Port
Quay HTTPS	443/TCP
Postgresql Quay	5432/TCP
Postgresql ClairV4	5433/TCP
Redis for Quay	6379
ClairV4 HTTP	8081/TCP

Local Quay Instance Details

- **Server FQDN**: quay.local
- **Images Used**:
  - registry.redhat.io/rhel8/postgresql-10:1
  - registry.redhat.io/rhel8/redis-5:1
  - registry.redhat.io/quay/quay-rhel8:v3.6.0-62
  - registry.redhat.io/quay/clair-rhel8:v3.6.0-70

Table 5. Container Port Mapping

Container Name	Mapped Port
clairv4	8001:8080
postgres-clairv4	5433:5432
redis	6379:6379
postgres	5432:5432
quay (*Config Container Only*)	8080:8080
quay (*Running Container*)	80:8080

Table 6. Storage Mount Points

Container Name	Mount Point on Host System	Purpose
quay	/quay	Storage for configuration files and images. Multiple sub-directories under this local directory mounted to Quay, Postresql, Redis for persistent storage.
clairv4	/etc/clairv4 ⇒ /clair	Storage for configuration files and images.

7.1. Installing the Quay Image Registry Manually

The Quay registry can be installed as a PoC locally. There is a manual process documented at https://access.redhat.com/documentation/en-us/red_hat_quay/3/html/deploy_red_hat_quay_for_proof-of-concept_non-production_purposes/index and there is an automated method with Ansible and playbooks created for an Ansible Workshop at https://github.com/tmichett/quay_lab_poc.

Quay Server Requirements

- RHEL8 Server with Podman Installed
- Access to **registry.redhat.io**
- Firewall ports opened
- **/etc/hosts** or DNS entry for Quay server
- Postgresql and Redis containers for Quay
- Postresql container for Clair (if using scanning)

For this workshop, the setup to prepare the environment in Chapter 1 provided the changes for the network needed to be able to successfully install Quay and register the FQDN as **quay.local** on both the **workstation** and **server** systems.

7.1.1. Preparing the Server for Quay and Running Supporting Containers

The server needs prepared to run Quay as a service. Firewall ports will need to be opened and the infrastructure containers and components need setup.

Example 26. **LAB: Preparing Infrastructure**

1. SSH to **server** as the root user

```
[student@workstation ~]$ ssh root@server
```

2. Configure Firewall Ports

```
[root@server ~]# firewall-cmd --add-port=80/tcp --add-port=8080/tcp --add-port=443/tcp --add-port=8443/tcp --permanent ; firewall-
cmd --reload
success
success
```

If you completed and created the **quay_lab.xml** custom firewall service, you can use the following command.

```
[root@server ~]# firewall-cmd --add-service=quay_lab --permanent ; firewall-cmd --reload
success
success
```

3. Create Mountpoint and directory and initialize the Quay variable

```
[root@server ~]# mkdir Quay ; export QUAY=/Quay
```

4. Create Postgresql Directory for Persistent Storage

Listing 114. Creating Directory

```
[root@server ~]# mkdir -p $QUAY/postgres-quay
```

Listing 115. Setting up ACL

```
[root@server ~]# setfacl -m u:26:-wx $QUAY/postgres-quay
```

Example 27. **LAB: Setting up Infrastructure Containers**

1. Install **container-tools** Module

```
[root@server ~]# yum module install container-tools
```

2. Login to the container registry

```
[root@server ~]# podman login registry.redhat.io
Username: tmichett@redhat.com
Password:
Login Succeeded!
```

3. Launch the **Postgresql** container

```
[root@server ~]# podman run -d --rm --name postgresql-quay \
> -e POSTGRESQL_USER=quayuser \
> -e POSTGRESQL_PASSWORD=quaypass \
> -e POSTGRESQL_DATABASE=quay \
> -e POSTGRESQL_ADMIN_PASSWORD=adminpass \
> -p 5432:5432 \
> -v $QUAY/postgres-quay:/var/lib/pgsql/data:Z \
> registry.redhat.io/rhel8/postgresql-10:1
Trying to pull registry.redhat.io/rhel8/postgresql-10:1...

... OUTPUT OMITTED ...

Writing manifest to image destination
Storing signatures
c21bf1231538b75d5510b4bd81732ad8f56fa61a98582b985124bd3d5de2ae04
```

Copy/Paste version of Command

```
podman run -d --rm --name postgresql-quay \
-e POSTGRESQL_USER=quayuser \
-e POSTGRESQL_PASSWORD=quaypass \
-e POSTGRESQL_DATABASE=quay \
-e POSTGRESQL_ADMIN_PASSWORD=adminpass \
-p 5432:5432 \
-v $QUAY/postgres-quay:/var/lib/pgsql/data:Z \
registry.redhat.io/rhel8/postgresql-10:1
```

4. Modify the **Postgresql** database to ensure that **pg_trgm** module has been installed.

```
[root@server ~]# podman exec -it postgresql-quay \
> /bin/bash -c \
> 'echo "CREATE EXTENSION IF NOT EXISTS pg_trgm" \
> | psql -d quay -U postgres'
```

Copy/Paste version of Command

```
podman exec -it postgresql-quay \
/bin/bash -c \
'echo "CREATE EXTENSION IF NOT EXISTS pg_trgm" \
| psql -d quay -U postgres'
```

5. Setup the **Redis** Container

```
[root@server ~]# podman run -d --rm --name redis \
>  -p 6379:6379 \
> -e REDIS_PASSWORD=strongpassword \
> registry.redhat.io/rhel8/redis-5:1
Trying to pull registry.redhat.io/rhel8/redis-5:1...

... OUTPUT OMITTED ...

Storing signatures
c847b459ded23acdd30e2a6ec1acfdeb3dd79f1457f7f99082cedb0a40447d73
```

Copy/Paste version of Command

```
podman run -d --rm --name redis \
-p 6379:6379 \
-e REDIS_PASSWORD=strongpassword \
registry.redhat.io/rhel8/redis-5:1
```

Example 28. **LAB: Launch the Quay Configuration Container**

1. Run the Quay container in configuration mode

```
[root@server ~]# podman run --rm -it --name quay_config \
> -p 8080:8080 \
> registry.redhat.io/quay/quay-rhel8:v3.6.0-62 config secret
Trying to pull registry.redhat.io/quay/quay-rhel8:v3.6.0-62...

... OUTPUT OMITTED ...

2021-10-26 17:54:08,319 INFO success: config-editor entered RUNNING state, process has stayed up for > than 1 seconds (startsecs)
config-editor stdout | time="2021-10-26T17:54:07Z" level=warning msg="An error occurred loading TLS: No public key provided for
HTTPS. Server falling back to HTTP."
config-editor stdout | time="2021-10-26T17:54:07Z" level=info msg="Running the configuration editor with HTTP on port 8080 with
username quayconfig"
```

Copy/Paste version of Command

```
podman run --rm -it --name quay_config \
-p 8080:8080 \
registry.redhat.io/quay/quay-rhel8:v3.6.0-62 config secret
```

2. Access a Web Browser and begin the Quay Configuration
    a. URL: **quay.local:8080**
    b. UN: **quayconfig**
    c. PW: **secret**

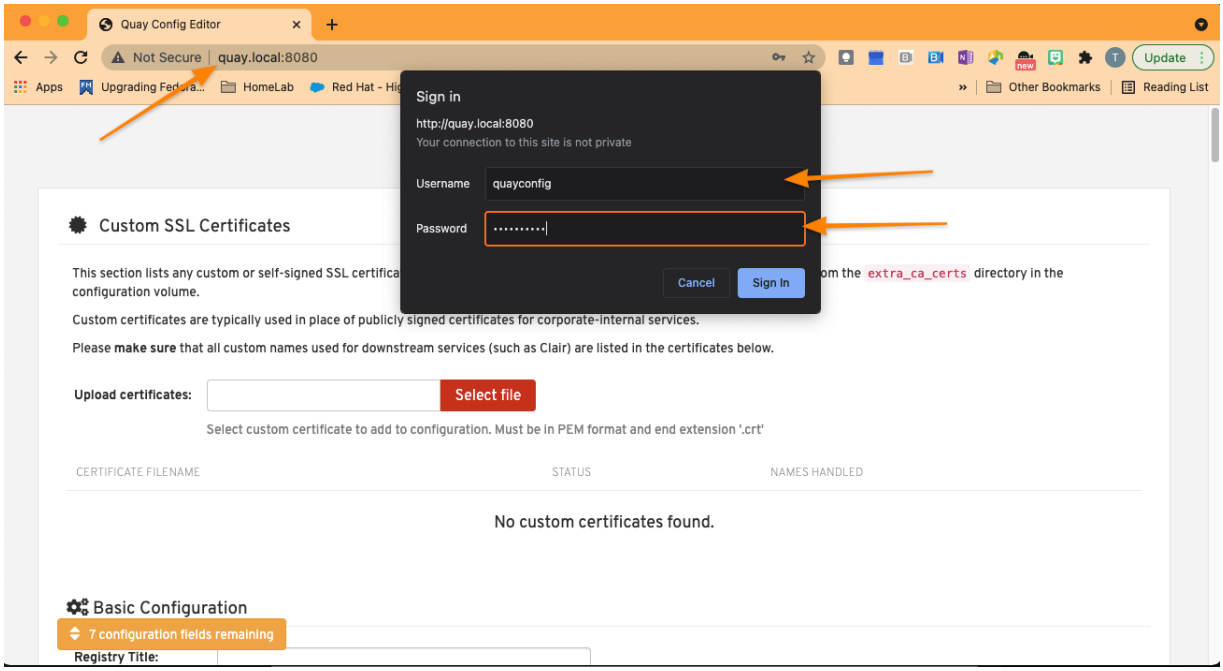


Figure 52. Quay Configuration Login

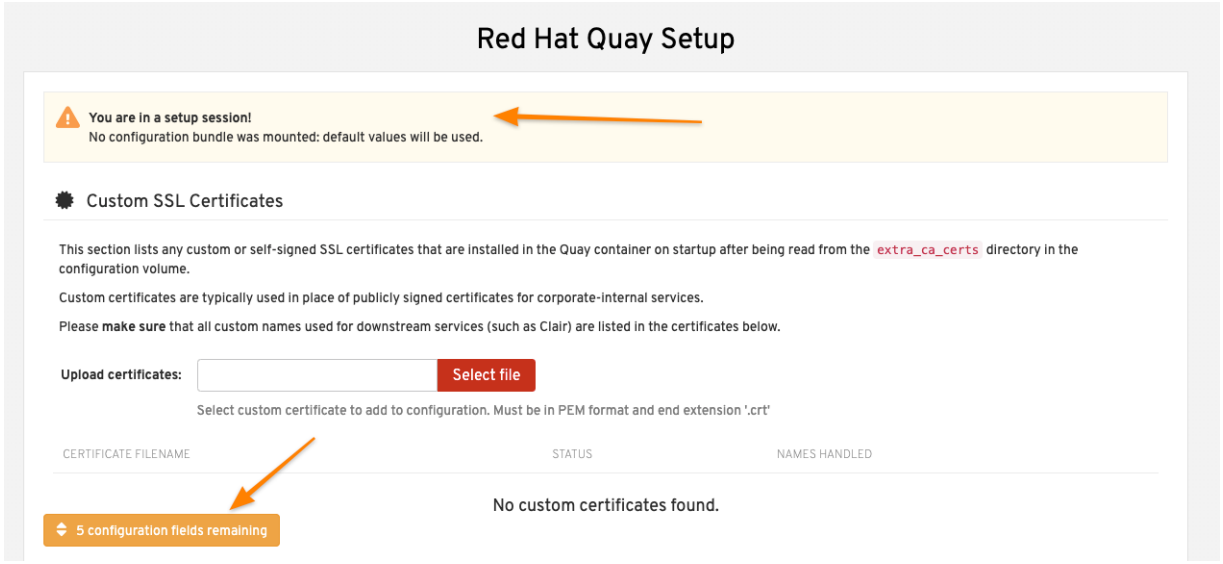


Figure 53. Quay Configuration Site

3. Setup the Server Configuration
    a. Server Hostname: **quay.local**

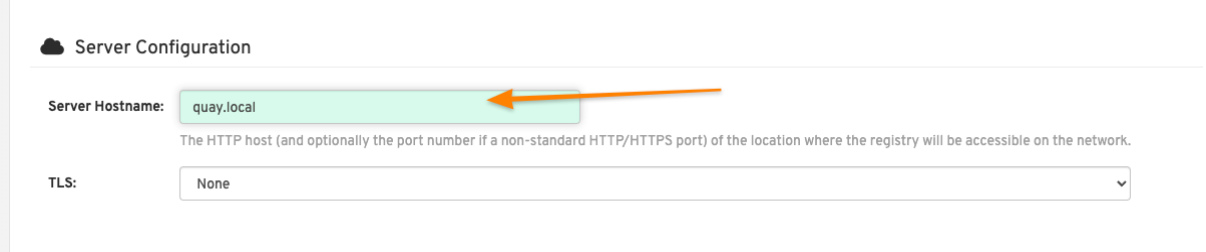


Figure 54. Quay Server Hostname

4. Setup Postgresql Database
    a. Postgresql Database Server: **quay.local**
    b. Postresql User: **quayuser**
    c. Postgresql Password: **quaypass**
    d. Postgresql Database: **quay**
    e. Postrgresql Admin Password: **adminpass**

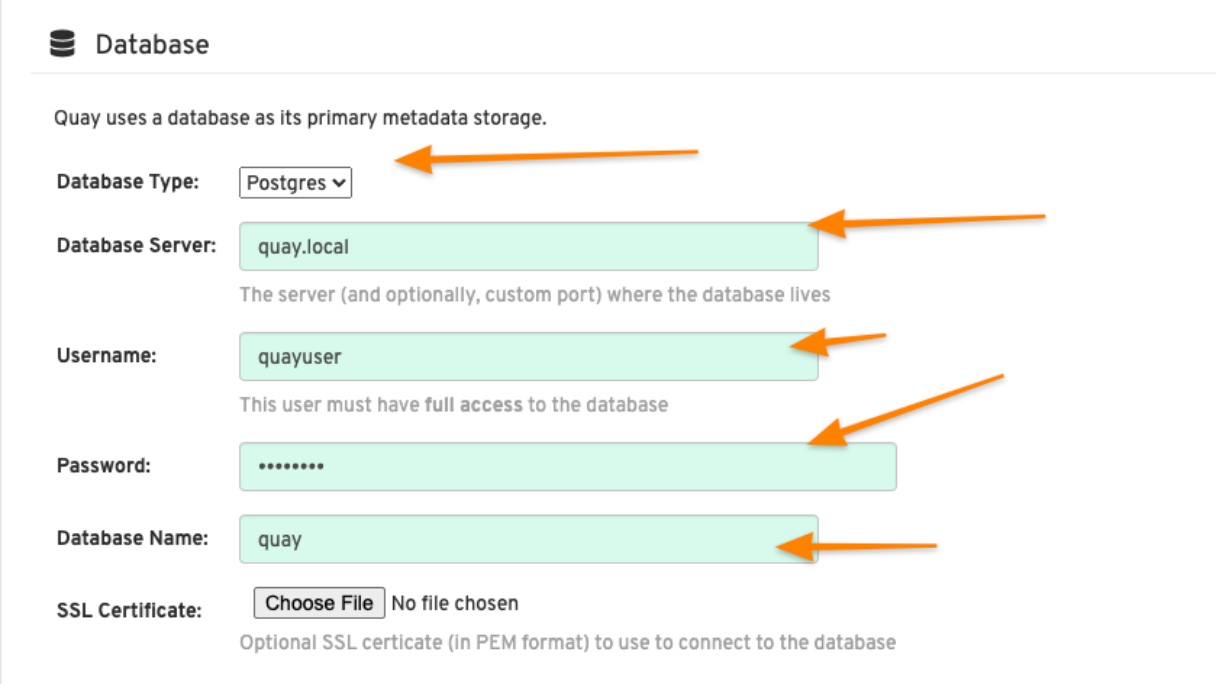


Figure 55. Quay Postgresql DB Setup

5. Setup Redis Information
    a. Redis Hostname: quay.local
    b. Redis Port: 6379
    c. Redis Password: strongpassword

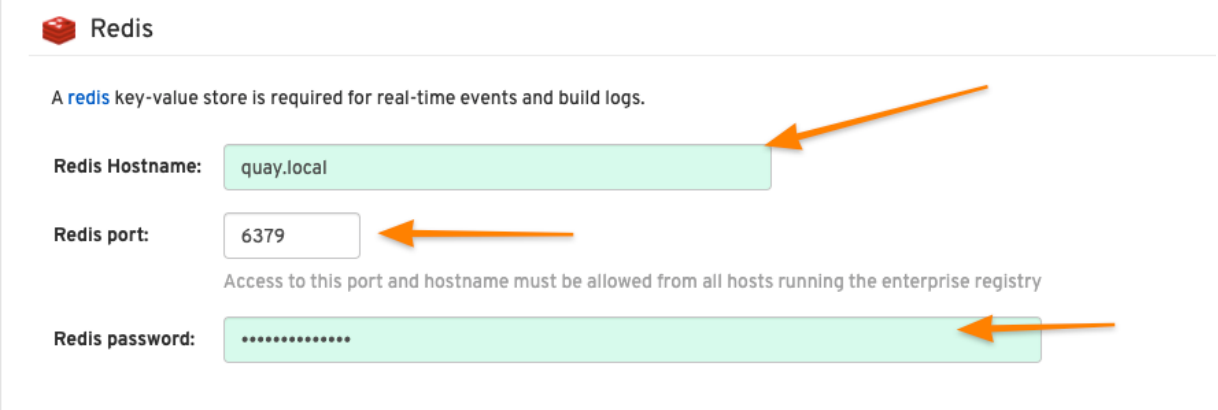


Figure 56. Quay Redis Setup

At this point, there is enough configuration to validate and download the Quay config file for launching and running Quay. We will continue to setup **Repository Mirroring**, **Clair Image Scanning**, and **Admin Accounts**.

Setting up Repository Mirroring

1. Enable Repository Mirroring

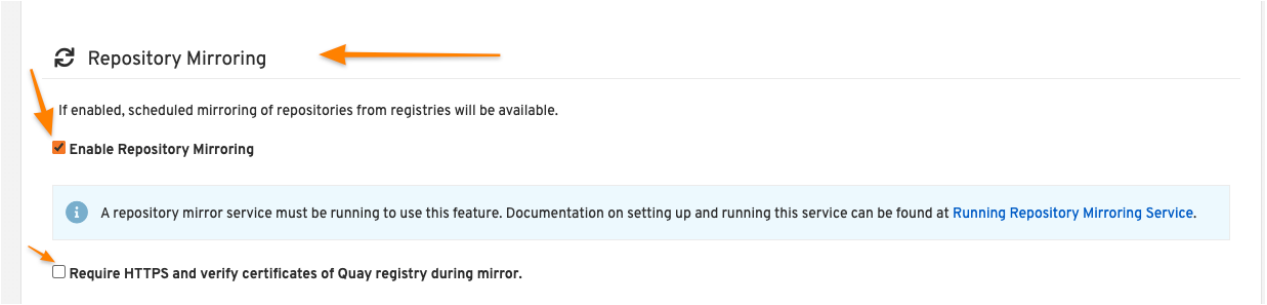


Figure 57. Quay Mirroring Setup

Remember to disable SSL as SSL isn't being used for this setup.

Setting up Security Scanning

1. Select **Enable Security Scanning**
   a. Endpont: **http://quay.local:8081**
   b. Select **Generate PSK** (Make note of this as it will need to be used)
   c. We will use the PSK of: **MTU5YzA4Y2ZkNzJoMQ==**

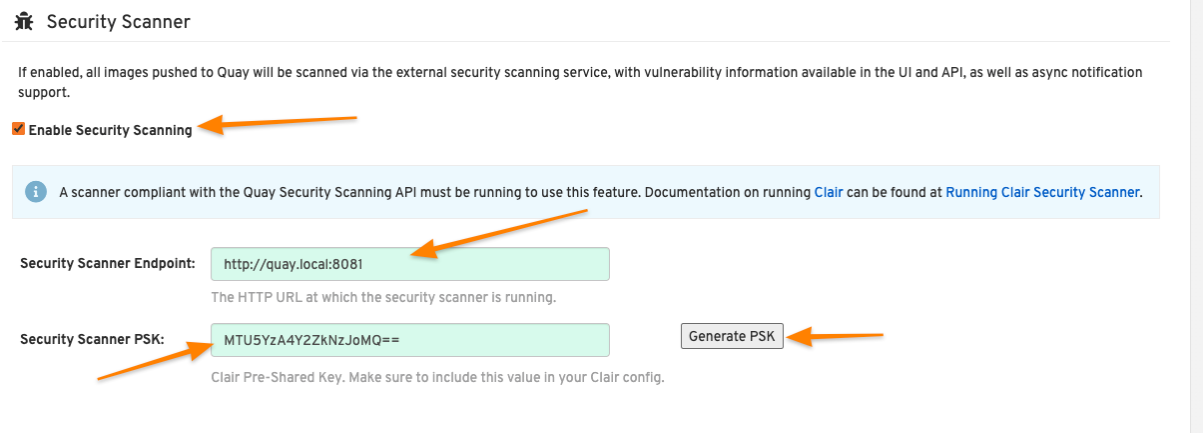


Figure 58. Quay Clair Image Scanning Setup

You **MUST** use the Pre-Shared-Key (PSK) of **MTU5YzA4Y2ZkNzJoMQ==** as we will be leveraging a pre-build CLAIR config.yml file.

Configuring Super Users (Admins)

1. Add superusers to the system
    a. UN: **quayadmin**
    b. UN: ***<your_username>***

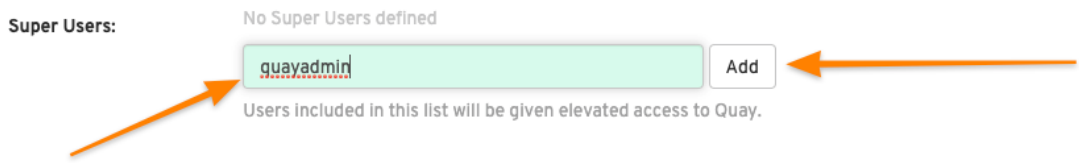


Figure 59. Quay Superuser Setup

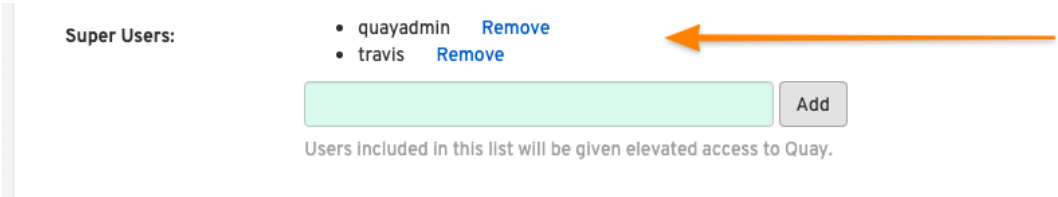


Figure 60. Quay Superuser Setup - Validation

Completing Quay Configuration - Validating and Download Configuration File

1. Validate Configuration Changes

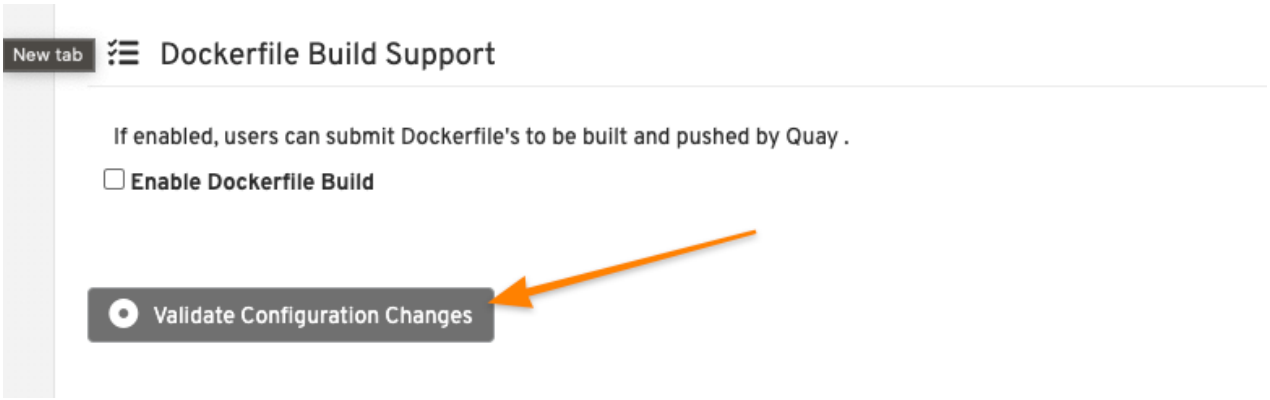


Figure 61. Quay Setup - Validation

2. Download Quay Configuration File

Figure 62. Quay Configuration - File Download

3. Stop and Remove the Quay_Config Container

Listing 116. Killing the Container from **server** *by hitting CTRL-C*

```
... OUTPUT OMITTED ...

Engine"
config-editor stdout | time="2021-10-26T18:30:52Z" level=debug msg="Validating ElasticSearch"
config-editor stdout | time="2021-10-26T18:30:52Z" level=debug msg="Validating ActionLogArchiving"
config-editor stdout | time="2021-10-26T18:30:52Z" level=debug msg="Validating Email"
config-editor stdout | time="2021-10-26T18:30:52Z" level=debug msg="Validating OIDC"

^C

2021-10-26 18:36:55,589 WARN received SIGINT indicating exit request
2021-10-26 18:36:56,591 INFO waiting for stdout, config-editor to die
2021-10-26 18:36:57,596 INFO stopped: config-editor (terminated by SIGTERM)
2021-10-26 18:36:59,599 INFO waiting for stdout to die
2021-10-26 18:37:01,603 INFO stopped: stdout (terminated by SIGTERM")
```

Quay Next Steps

Based on the options in the Quay deployment configuration, it is necessary to setup and configure the Clair Image scanning services before starting the Quay container.

7.1.2. Preparing Quay and Clair Containers

It is necessary to create a storage location for Quay container images and images that will be loaded into the registry. It is also necessary to copy the Quay configuration file and Clair Configuration files and label them appropriately for use. The Clair scanner will use and leverage Postgresql, so it will also be necessary to setup and configure a Postgresql container for Clair.

Example 29. **LAB: Prepare Quay Storage**

1. Create Directory for Quay Config

```
[root@server ~]#  mkdir $QUAY/config
```

2. Copy download configuration file to $QUAY/config

```
[root@server ~]# scp student@workstation:~/Downloads/quay-config.tar.gz $QUAY/config
```

3. Extract the files for use

```
[root@server ~]# cd $QUAY/config ; tar xvf quay-config.tar.gz
extra_ca_certs/
config.yaml
```

4. Verify Files and Return to **Home** directory

```
[root@server config]# ls ; cd
config.yaml  extra_ca_certs  quay-config.tar.gz
```

5. Create and Prepare Local storage

```
[root@server ~]#  mkdir $QUAY/storage ; setfacl -m u:1001:-wx $QUAY/storage
```

Example 30. **LAB: Prepare and Launch Clair**

1. Create the Clair Postgres Storage

```
[root@server ~]# mkdir -p $QUAY/postgres-clairv4 ; setfacl -m u:26:-wx $QUAY/postgres-clairv4
```

2. Launch **Postgresql** Container

```
[root@server ~]# podman run -d --rm --name postgresql-clairv4 \
> -e POSTGRESQL_USER=clairuser \
> -e POSTGRESQL_PASSWORD=clairpass \
> -e POSTGRESQL_DATABASE=clair \
> -e POSTGRESQL_ADMIN_PASSWORD=adminpass \
> -p 5433:5432 \
> -v $QUAY/postgres-clairv4:/var/lib/pgsql/data:Z \
> registry.redhat.io/rhel8/postgresql-10:1
e0db014a5a2f35cc895ef4ad136695a56ae2cda81c86db804810082ad38b9529
```

3. Install **Postgres uuid-ossp module**

```
[root@server ~]# podman exec -it postgresql-clairv4 \
> /bin/bash -c \
> 'echo "CREATE EXTENSION IF NOT EXISTS \"uuid-ossp\"" \
> | psql -d clair -U postgres'
```

4. Create Clair Configuration File and place at **/etc/clairv4/config/config.yml**

   a. https://github.com/quay/clair/blob/main/Documentation/reference/config.md

   b. Use the one already created from **https://github.com/tmichett/quay_lab_poc**

*Listing 117. Make the **/etc/clairv4/config** Directory*

```
[root@server ~]# mkdir -p /etc/clairv4/config/
```

Listing 118. Copying Config File from Workstation

```
[root@server ~]# scp student@workstation:~/github/quay_lab_poc/files/clair_config/config.yaml /etc/clairv4/config/
student@workstation's password':
config.yaml                                     100%  845   559.3KB/s   00:00
```

The PSK from earlier is used in this file. Please ensure you use the same PSK.

5. Deploy the Clair Container

```
[root@server ~]# podman run -d --rm --name clairv4 \
> -p 8081:8081 -p 8089:8089 \
> -e CLAIR_CONF=/clair/config.yaml -e CLAIR_MODE=combo \
> -v /etc/clairv4/config:/clair:Z \
> registry.redhat.io/quay/clair-rhel8:v3.6.0-70
Trying to pull registry.redhat.io/quay/clair-rhel8:v3.6.0-70...

... OUTPUT OMITTED ...

Storing signatures
7f5ec8bd697c83fc2ad9277fd76d4c8c8b48048ec45d59f948cd58f87e03295e
```

7.1.2.1. Starting Quay and the Mirroring Containers

After all configurations have been made and the supporting containers are running, it is possible to launch the Quay and Quay Mirroring containers.

Example 31. **LAB: Starting Quay and the Mirroring Containers**

1. Launch the Quay Container

```
[root@server ~]# podman run -d --rm -p 80:8080 \
> --name=quay \
> -v $QUAY/config:/conf/stack:Z \
> -v $QUAY/storage:/datastorage:Z \
> registry.redhat.io/quay/quay-rhel8:v3.6.0-62
0357e5cfd31fa0336cdc0561bd2d39e332451ba781671abd5b6f2fac2b24c7f0
```

2. Launch the Quay Mirroring Container

```
[root@server ~]# podman run -d --name mirroring-worker \
> -v $QUAY/config:/conf/stack:Z \
> registry.redhat.io/quay/quay-rhel8:v3.6.0-62 repomirror
adcd500ae3e0ca7510134d91b4389812cc55ebb2f1f2ebefcfc318f7ce2f6fd9
```

3. Verify all containers are running

```
[root@server ~]# podman ps
CONTAINER ID  IMAGE                                       COMMAND         CREATED            STATUS                PORTS
NAMES
c21bf1231538  registry.redhat.io/rhel8/postgresql-10:1     run-postgresql  About an hour ago  Up About an hour ago  0.0.0.0:5432-
>5432/tcp                          postgresql-quay
c847b459ded2  registry.redhat.io/rhel8/redis-5:1           run-redis       About an hour ago  Up About an hour ago  0.0.0.0:6379-
>6379/tcp                          redis
e0db014a5a2f  registry.redhat.io/rhel8/postgresql-10:1     run-postgresql  20 minutes ago     Up 20 minutes ago     0.0.0.0:5433-
>5432/tcp                          postgresql-clairv4
7f5ec8bd697c  registry.redhat.io/quay/clair-rhel8:v3.6.0-70                 6 minutes ago      Up 6 minutes ago      0.0.0.0:8081-
>8081/tcp, 0.0.0.0:8089->8089/tcp  clairv4
0357e5cfd31f  registry.redhat.io/quay/quay-rhel8:v3.6.0-62  registry        3 minutes ago      Up 3 minutes ago      0.0.0.0:80-
>8080/tcp                            quay
444cf7561b02  registry.redhat.io/quay/quay-rhel8:v3.6.0-62  repomirror      3 seconds ago      Up 3 seconds ago
mirroring-worker
```

Quay Setup Completed

At this point the Quay setup has been completed with the Mirroring Worker and Clair v4 Image Scanner. You can proceed to the next steps and skip the section called: **Installing the Quay Image Registry with Ansible**. You should proceed to the section titled **Setting up the Quay Web Console and Testing Quay**.

7.2. Installing the Quay Image Registry with Ansible

There is a Github project that can be used to install a Quay image registry locally which includes a Mirroring and ClairV4 scanning process. The Github repository should have been cloned as part of the exercise in Chapter 1. The Github repository is: https://github.com/tmichett/quay_lab_poc and can deploy a fully functional Quay image registry locally.

The Quay playbooks have been broken down so that they can be run to easily deploy Quay. There are options for deploying based on the configuration files being pre-populated as well as using the Quay container to create the TGZ configuration. There is also a special playbook created to bring already deployed containers back online.

7.2.1. Deploying Quay with Ansible

Alternatively, there has been a project created with several playbooks allowing Quay to be deployed in the PoC method via Ansible playbooks.

Example 32. **LAB: Deploying Quay with Ansible**

1. Change to the **github/quay_lab_poc** directory

```
[student@workstation ~]$ cd github/quay_lab_poc/
```

2. Create a registry credential file and update the file with your information

Listing 119. Copy **registry_login.yml_example** *to* **registry_login.yml**

```
[student@workstation quay_lab_poc]$ cp registry_login.yml_example registry_login.yml
```

Listing 120. Edit the file **registry_login.yml**

```
[student@workstation quay_lab_poc]$ vim registry_login.yml
registry_un: UN_Goes_Here ①
registry_pass: Password_Goes_Here ②
registry_url: registry.redhat.io
```

① Replace with your Red Hat Login ID

② Replace with your Red Hat Login Password

3. Run the **Quay_Prepare.yml** playbook

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Prepare.yml

PLAY [Installation of Packages and Preparing the System]
*********************************************************************************************

TASK [Gathering Facts]
*********************************************************************************************************************************************************
ok: [quay.local]

... OUTPUT OMITTED ...

TASK [Start the Quay Config Container]
*********************************************************************************************************************
changed: [quay.local]

TASK [Open the Quay Config Container Site]
*********************************************************************************************************************
[Open the Quay Config Container Site] ①
Go to the Quay Configuration container website and enter the appropriate configuration values. For help, look at
https://github.com/tmichett/quay_lab/References/Quay-3.5_Deployment.pdf. Login with the credentials provided which are UN:
quayconfig and PW: secret. Press 'Enter' when you've completed the configuration and downloaded the file. The file should be placed
in the files directory for this playbook.: ②

... OUTPUT OMITTED ...'

PLAY RECAP
*********************************************************************************************************************************************************
********
quay.local                 : ok=13   changed=10   unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

① This allows you to open the Quay Config Site to create a custom configuration file.

② Once you've opened the Quay config site and completed the configuration as well as downloaded the file you can hit "Enter". It is also possible to hit "Enter" and skip this step so that the already existing configuration file can be used.

It is possible that you will receive an Ansible failure message like this

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Prepare.yml
ERROR! vars file registry_login.yml was not found ①
Could not find file on the Ansible Controller.
If you are using a module and expect the file to exist on the remote, see the remote_src option
```

① This error means you forgot to create/edit the **registry_login.yml** file.

1. Run the configuration file deployment based on using the TAR config file or the file-based configuration method. ***NOTE: You can only choose one method for configuration.***

Listing 121. File-Based Configuration Method

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Config_Deploy_Files.yml
```

The **./files/config/config.yaml** file will be used and deployed to control the configuration of the Quay environment.

+ .TAR File Configuration Method

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Config_Deploy_Tar.yml
```

+ .TAR-Based Configuration Considerations

The **./files/quay-config.tar.gz** file will be used and deployed to control the configuration of the Quay environment. This file MUST have been created as part of the Quay configuration container process with the WebUI and it must be placed in the **./files/quay-config.tar.gz** before running the playbook.

1. Deploy the ClairV4 scanning image by executing the **Quay_Clair_Deploy.yml** playbook

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Clair_Deploy.yml
```

2. Deploy the Quay container registry by executing the **Quay_Deploy.yml** playbook.

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Deploy.yml
```

3. Deploy the Quay Mirroring Container by executing the **Quay_Mirror_Deploy.yml** playbook.

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Mirror_Deploy.yml
```

7.3. Setting up the Quay Web Console and Testing Quay

After all Quay containers have been configured and installed, it is necessary to setup the Admin (Superuser) for Quay as well as test out the system for both image scanning and the ability to mirror container images from upstream repositories.

7.3.1. Configuring the Quay Super User

After the Quay registry has been deployed, it is important to finish configuring the super users (admins) that were defined as part of the setup and configuration file (**config.yaml**) that was created during the Quay preparation section.

It is necessary to look at the **config.yaml** file and configure these users with a password and create the accounts officially before moving forward with utilizing the Quay container registry and the lab environment.

Configure Quay Super Users

It is possible to either look in the configuration file of the **quay-config.tar.gz** or the actual **config.yaml** file for the ***SUPER_USERS*** section. This is where the usernames are defined that will function as Quay super users.

Listing 122. Quay Super Users

```
SUPER_USERS:
    - quayadmin
    - travis
```

Example 33. **LAB** *Configuring Quay and Super Users**

1. Open the Quay web console by navigating to it in your favorite browser using **http://Quay-FQDN**

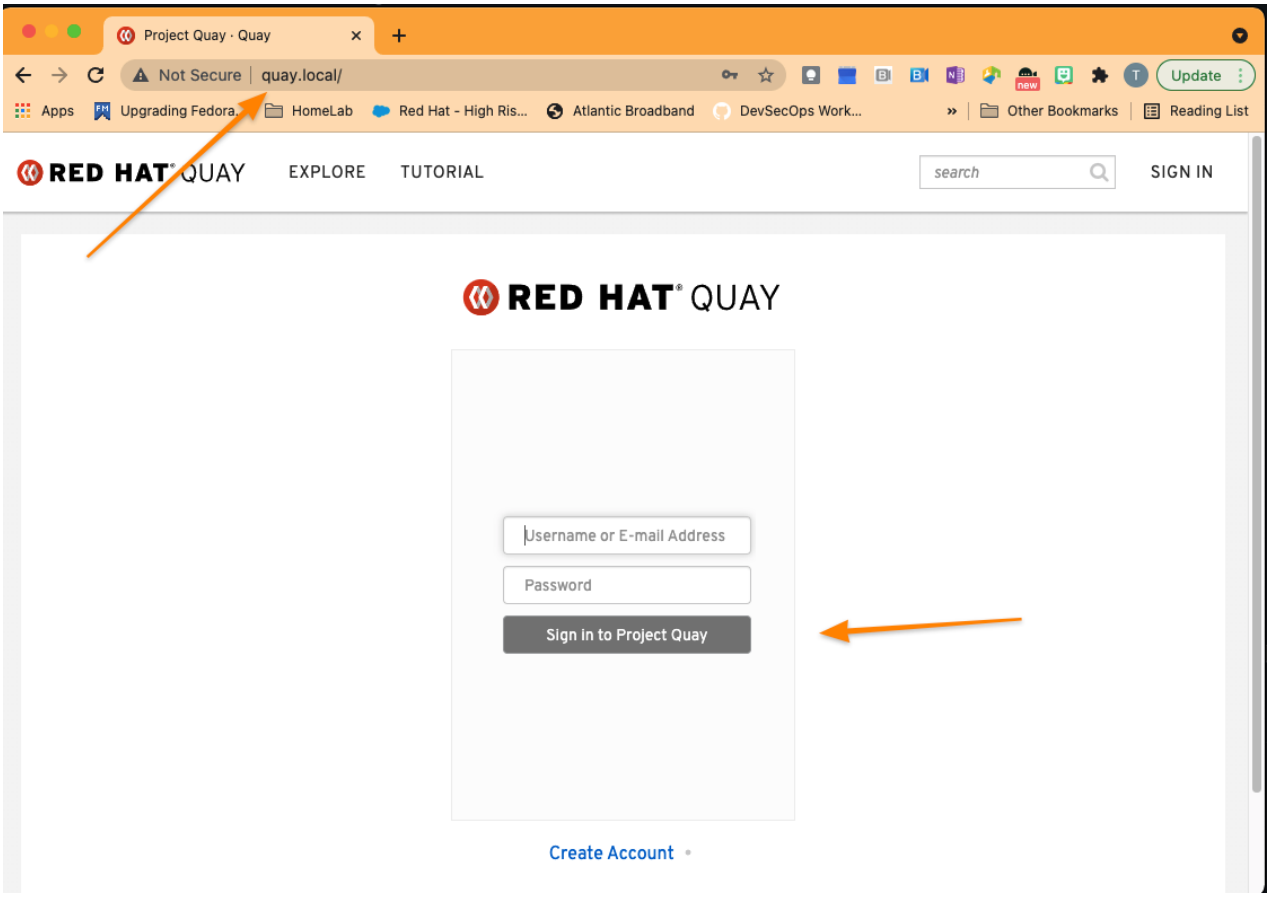
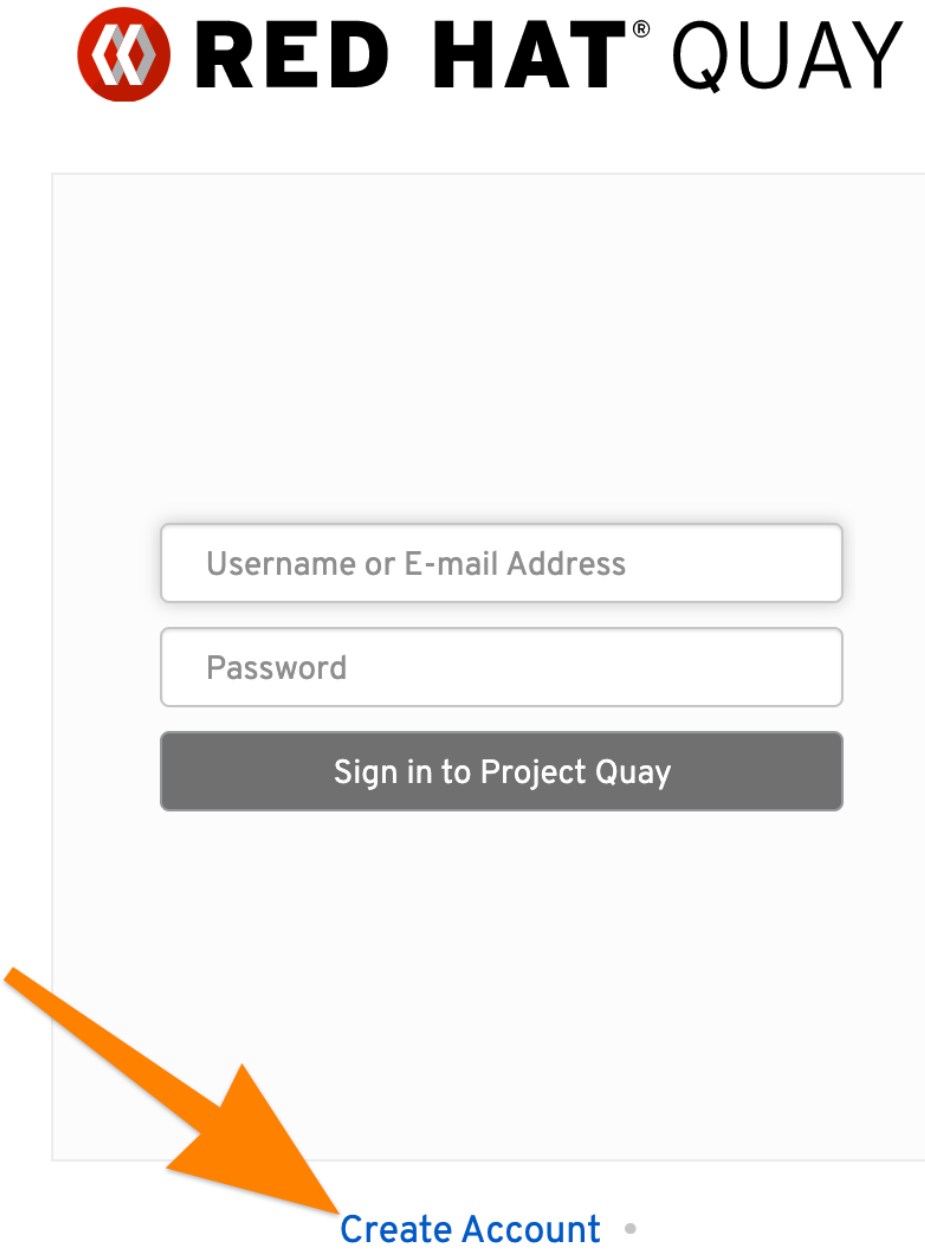
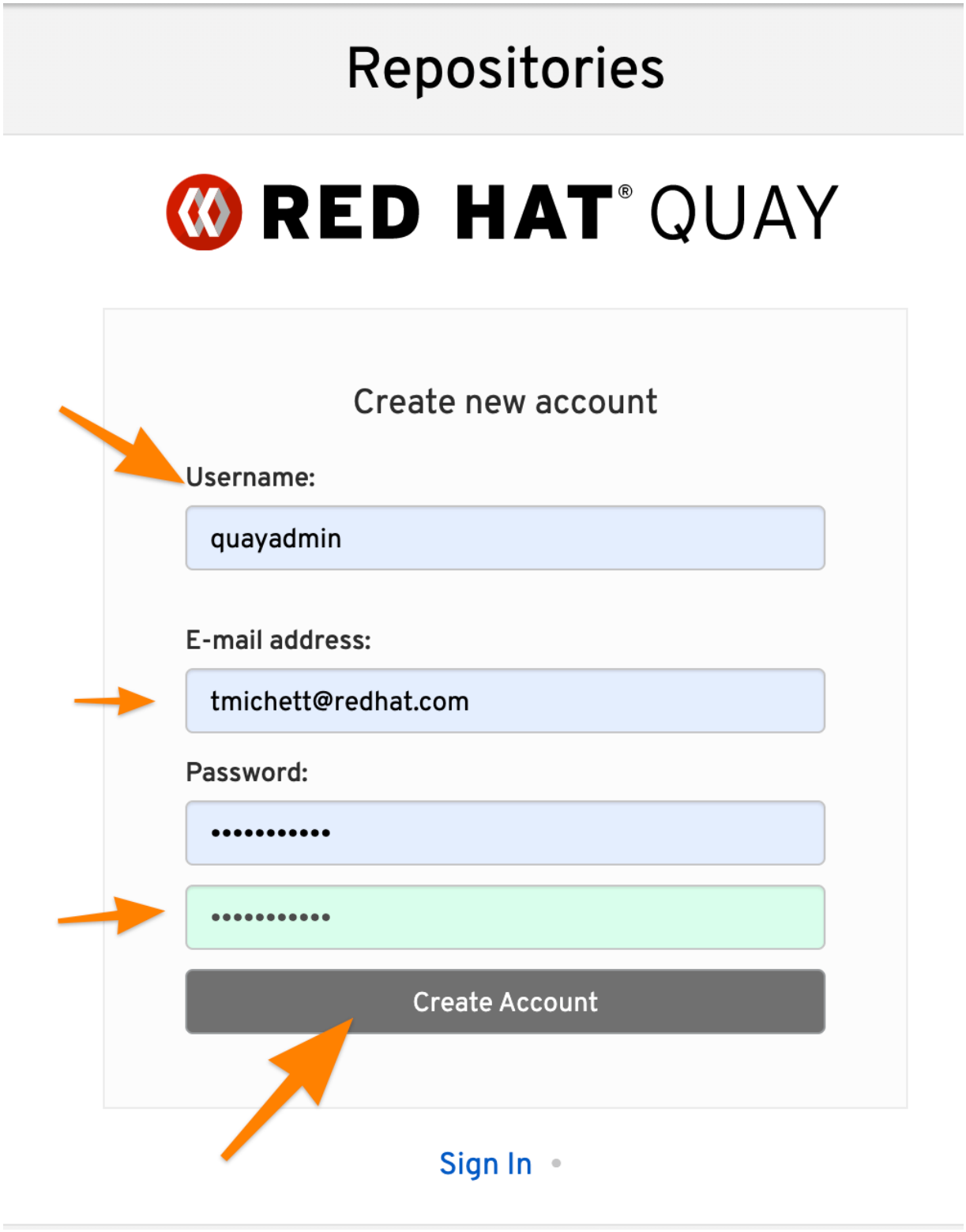
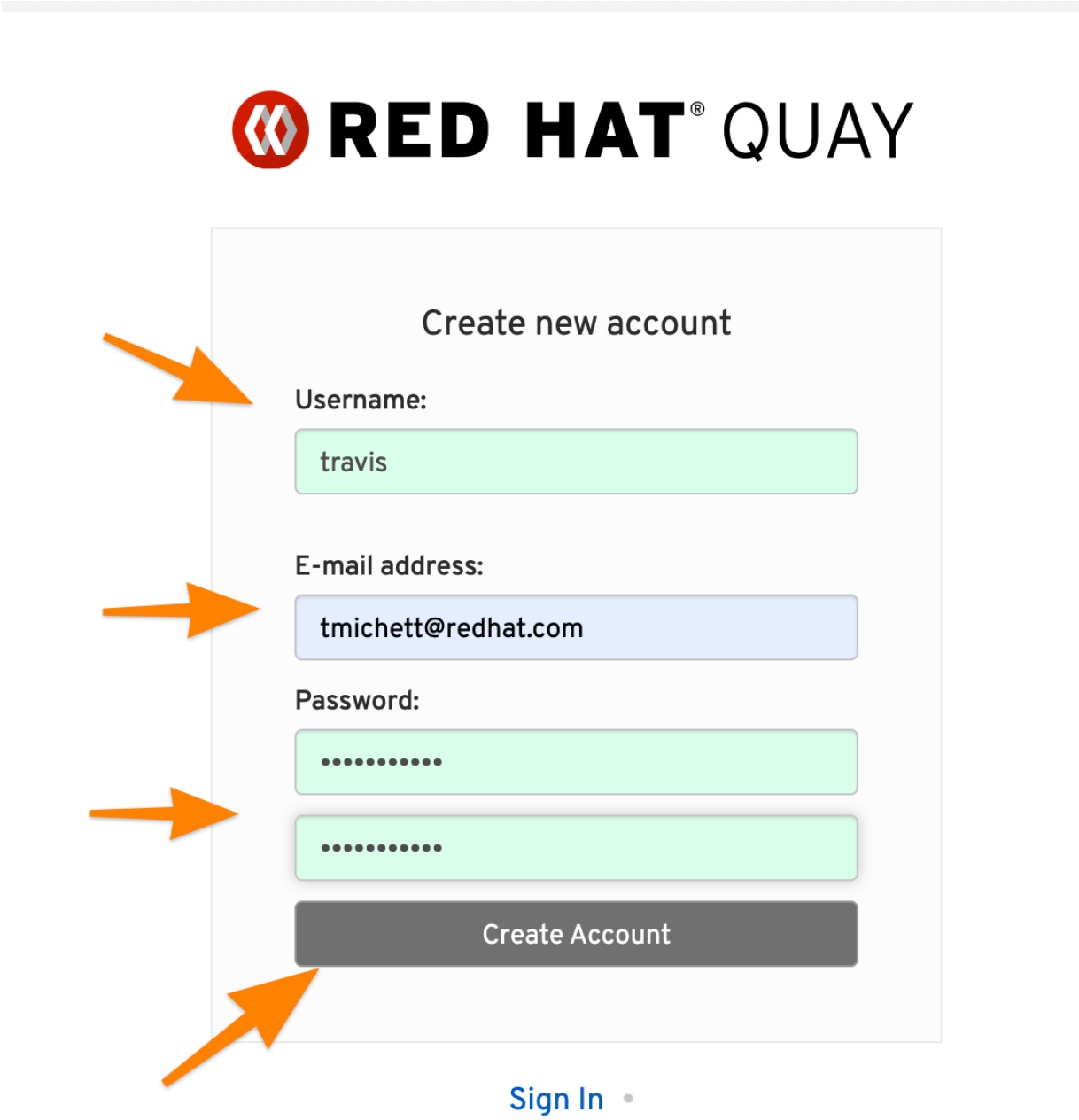


Figure 63. Quay Login Page

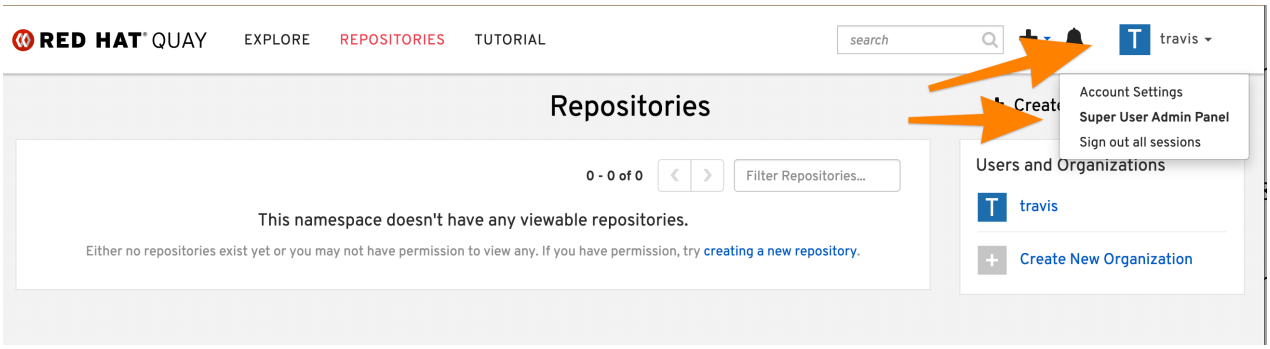
2. Click **Create Account** to create the administrator/superuser accounts for Quay as defined in the **config.yaml** file.
    - Repeat this step for all super users in the **config.yaml** file.


RED HAT® QUAY
Username or E-mail Address
Password
Sign in to Project Quay
Create Account


Repositories
RED HAT® QUAY
Create new account
Username:
quayadmin
E-mail address:
tmichett@redhat.com
Password:
Create Account
Sign In



3. Verify the account was setup properly and you have **Super User** rights by clicking your Username and looking for **Super User Admin Panel**.



7.3.2. Testing Quay and ClairV4 Image Scanning

In order to test the scanning capabilities and ensure that things function properly, update a basic image into the Quay Repository

Example 34. **LAB: Testing Image Scanning**

1. Login to Local Quay Repository (test authentication and account)

Listing 123. **podman** *Authentication*

```
[root@quay ~]# podman login --tls-verify=false quay.local
Username: travis
Password:
Login Succeeded!
```

2. Pull and Download an Image, Tag it, then upload to repository
   a. Image to download: **quay.io/redhattraining/httpd-parent:2.4**
   b. Tag Name: **

Listing 124. Downloading image

```
[root@server ~]# podman pull quay.io/redhattraining/httpd-parent:2.4
Trying to pull quay.io/redhattraining/httpd-parent:2.4...
Getting image source signatures
Copying blob a3ed95caeb02 done
Copying blob a3ed95caeb02 done
Copying blob a3ed95caeb02 done
Copying blob 787f47dbeaac done
Copying blob a3ed95caeb02 skipped: already exists
Copying blob a3ed95caeb02 skipped: already exists
Copying blob a3ed95caeb02 skipped: already exists
Copying blob 6a5240d60dc4 done
Copying blob 408208567b9a done
Copying blob 08b8c9fdec44 done
Writing manifest to image destination
Storing signatures
3639ce1374d3611e80ed66decd7d5467b72d010c21e19e4f193cd8b944e8c9f5
```

Listing 125. Tagging image

```
[root@server ~]# podman tag quay.io/redhattraining/httpd-parent:2.4 quay.local/travis/httpd-parent:2.4
```

Listing 126. Push image

```
[root@server ~]# podman push --tls-verify=false quay.local/travis/httpd-parent:2.4
Getting image source signatures
Copying blob c613b100be16 done
Copying blob a3ed95caeb02 done
Copying blob a3ed95caeb02 done
Copying blob a3ed95caeb02 done
Copying blob 574bcc187eda done
Copying blob 24d85c895b6b done
Copying blob a3ed95caeb02 done
Copying blob a3ed95caeb02 skipped: already exists
Copying blob a3ed95caeb02 skipped: already exists
Copying blob 7f9108fde4a1 done
Writing manifest to image destination
Storing signatures
```

3. Verify image exists in Quay

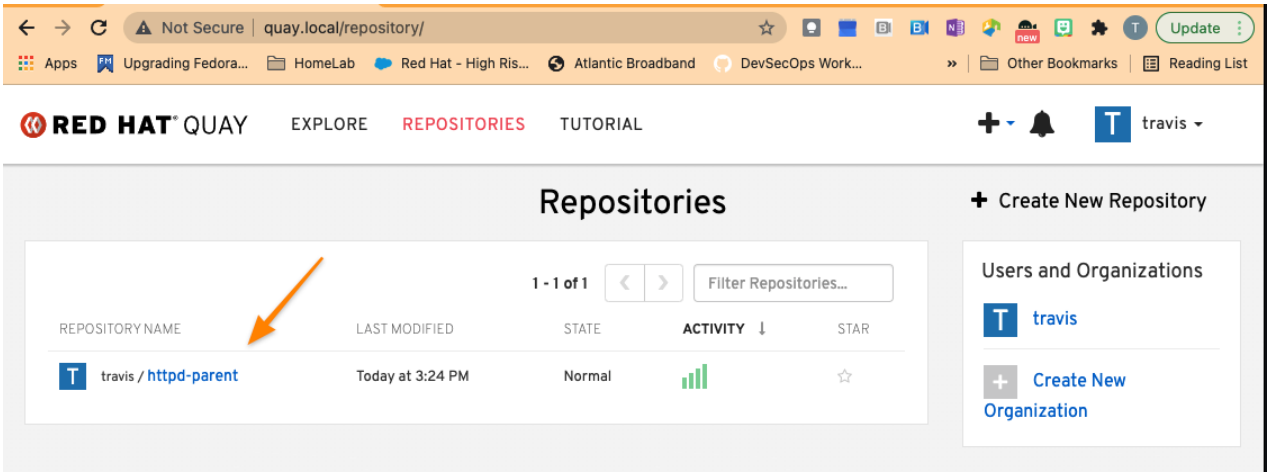


Figure 64. HTTPD Parent Image

4. Navigate to image tags and see if the security scan has completed

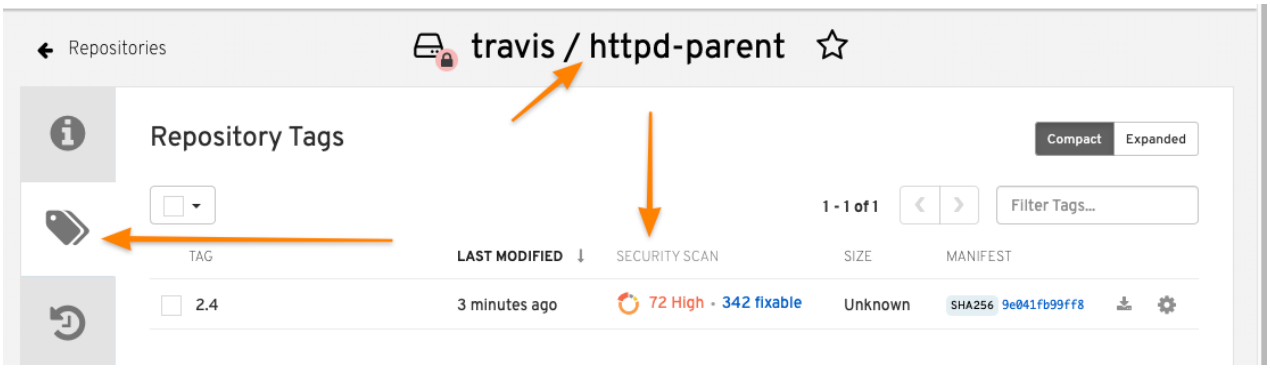


Figure 65. HTTPD Parent Image - Image Tags

5. Click on Security scan to view the vulnerabilities

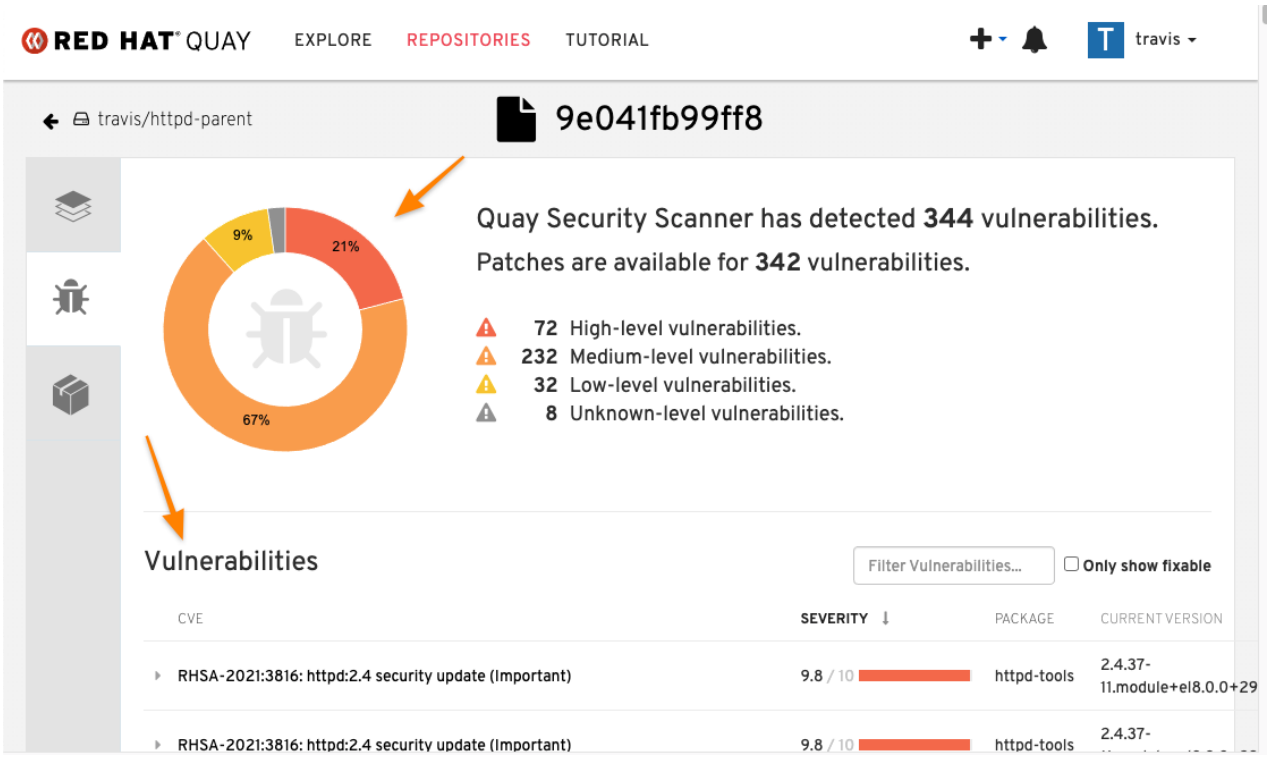


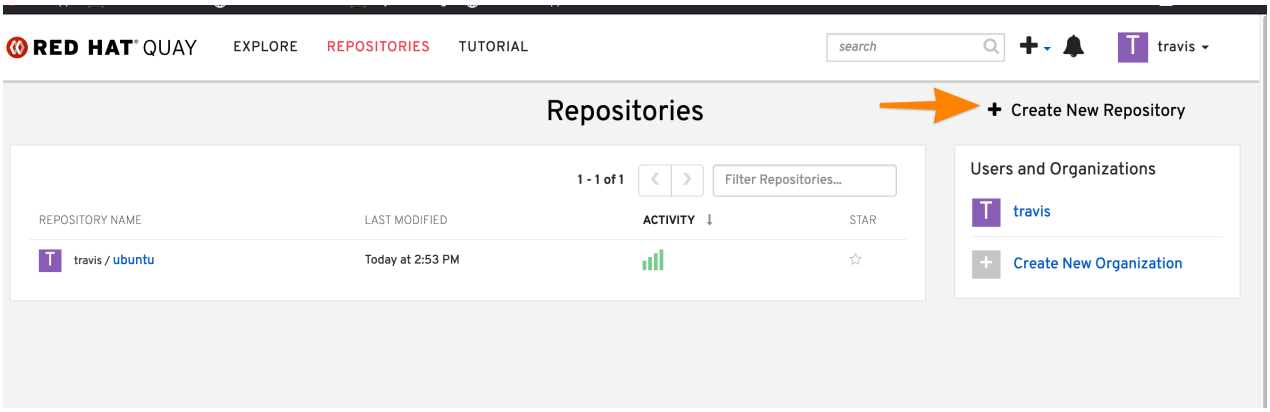
Figure 66. HTTPD Parent Image - Image Vulnerabilities

7.3.3. Testing Repository Mirroring

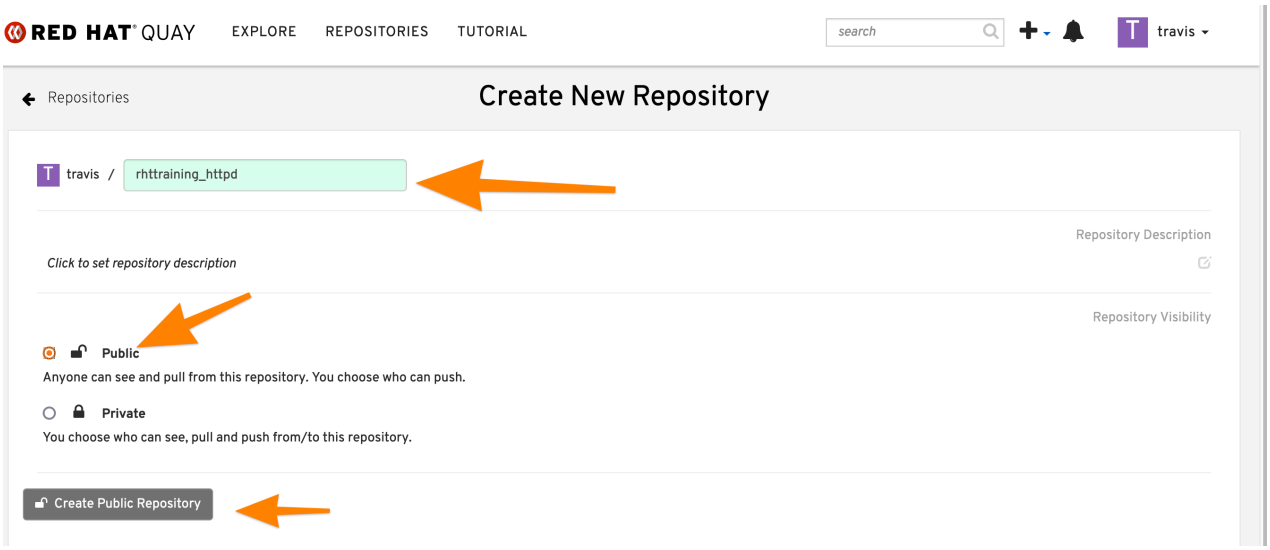
The next step is to ensure that the QUAY Image mirroring container is working and that you can successfully mirror container images from upstream repositories.

Example 35. **LAB: Testing Repository Mirroring**

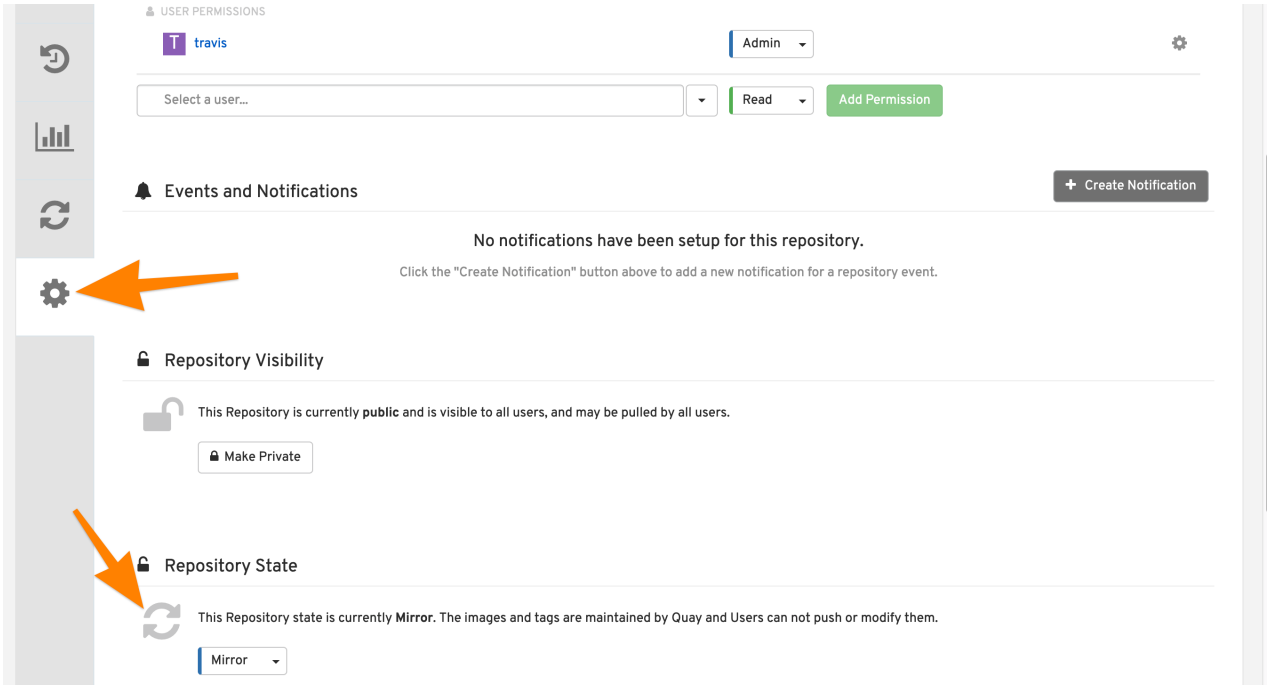
1. Create a new repository in Quay by clicking **Create New Repository**



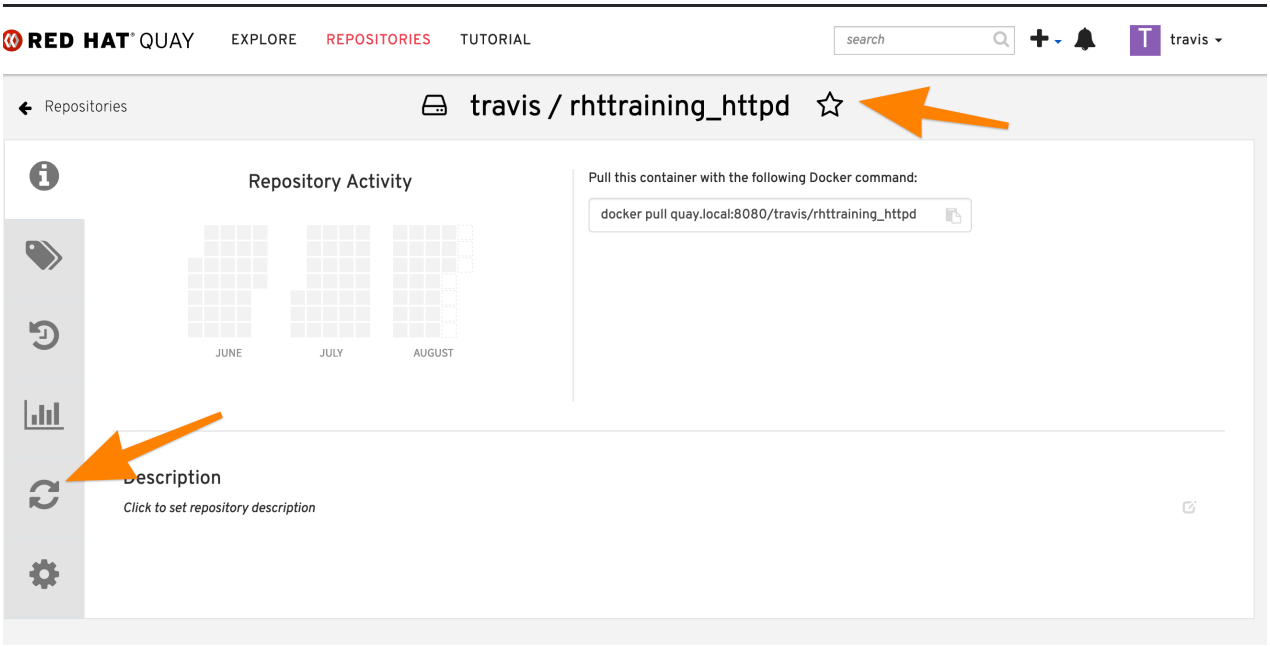
2. Give repository a name and setup the repository visibility



3. In the newly created repository, click the **Settings** option from the left-side navigation menu. Set the **Repository State** to ***Mirror***.



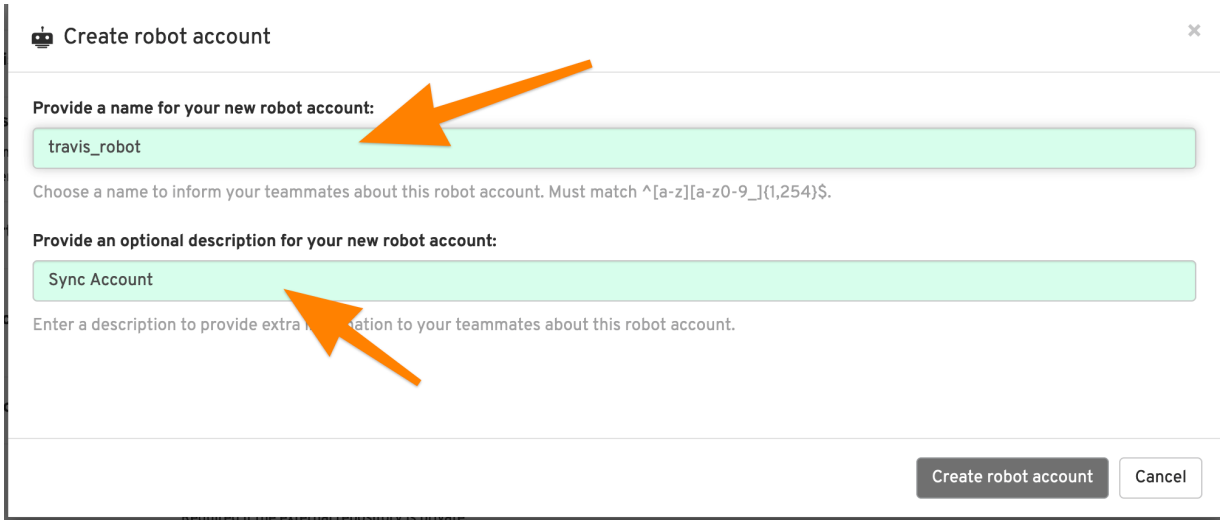
4. In the newly created repository, click the **Mirroring** option from the left-side navigation menu.

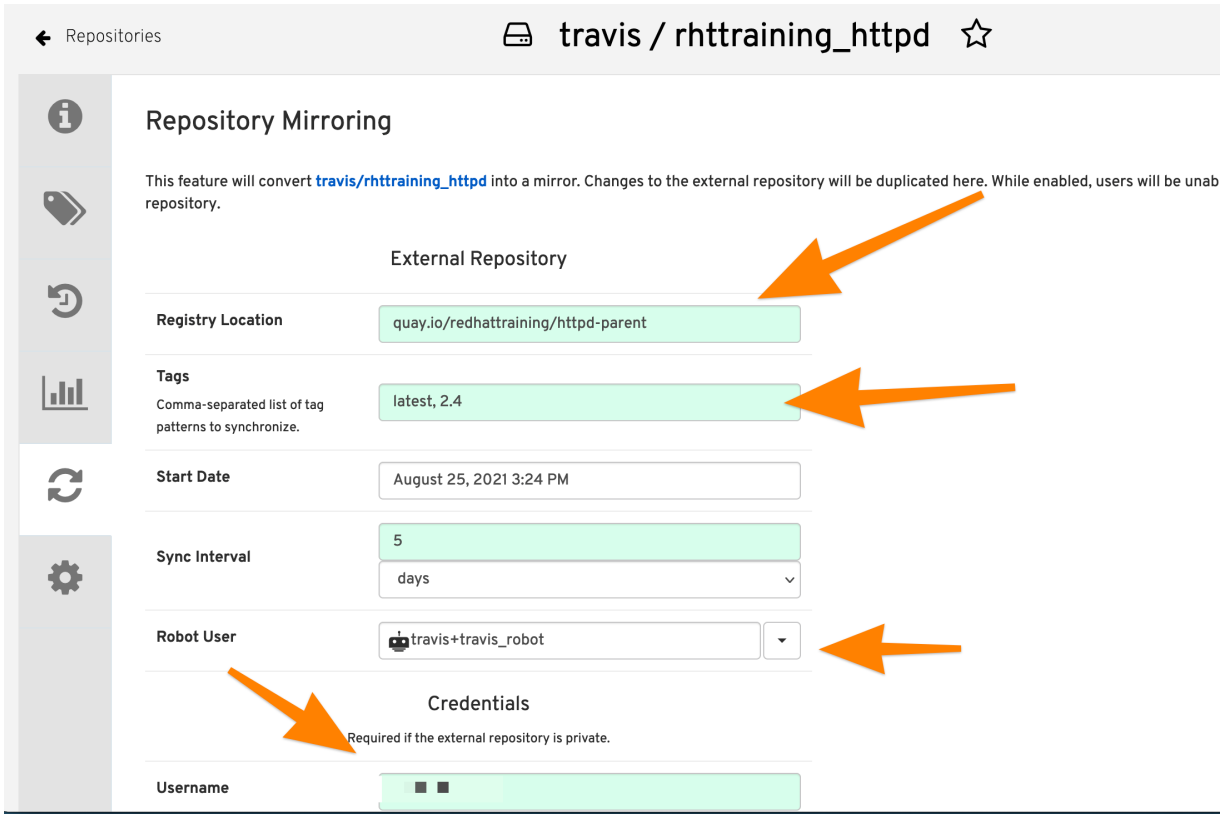


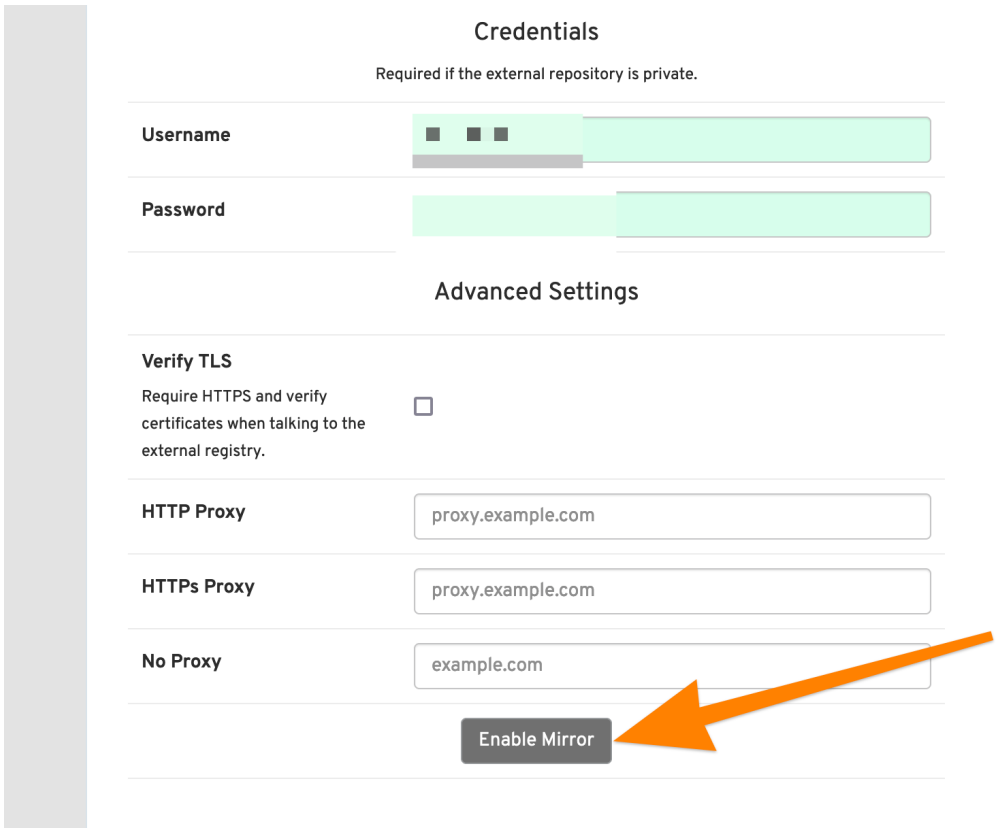
5. In the **Mirroring** tab, complete the required information for the repository and create a **Robot User**. Click **Enable Mirror**

   a. Registry Location - quay.io/redhattraining/httpd-parent

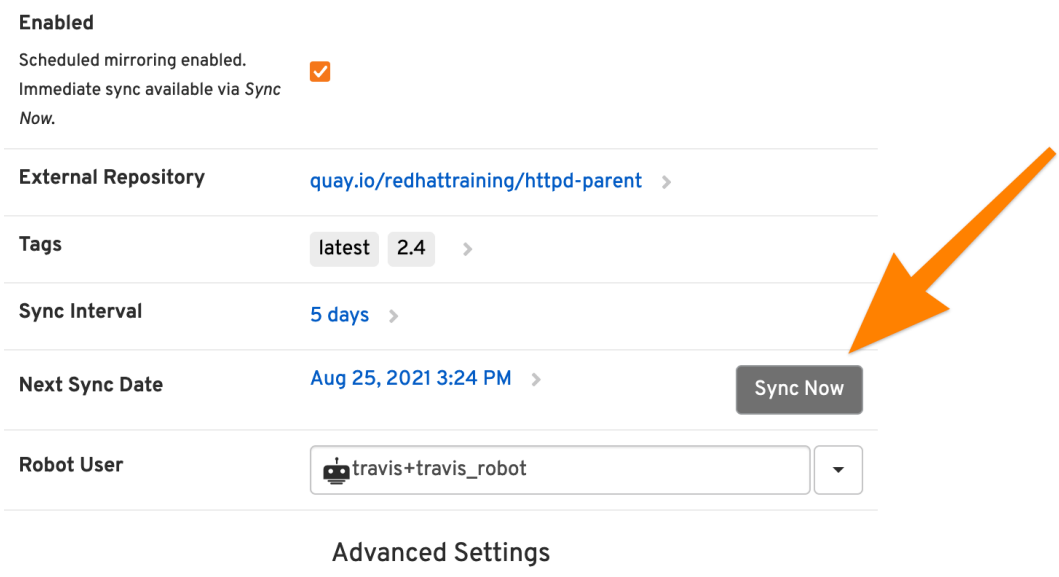
   b. Tags: latest and 2.4


Create robot account
Provide a name for your new robot account:
travis_robot
Choose a name to inform your teammates about this robot account. Must match ^[a-z][a-z0-9_]{1,254}$.
Provide an optional description for your new robot account:
Sync Account
Enter a description to provide extra
ation to your teammates about this robot account.
Create robot account
Cancel

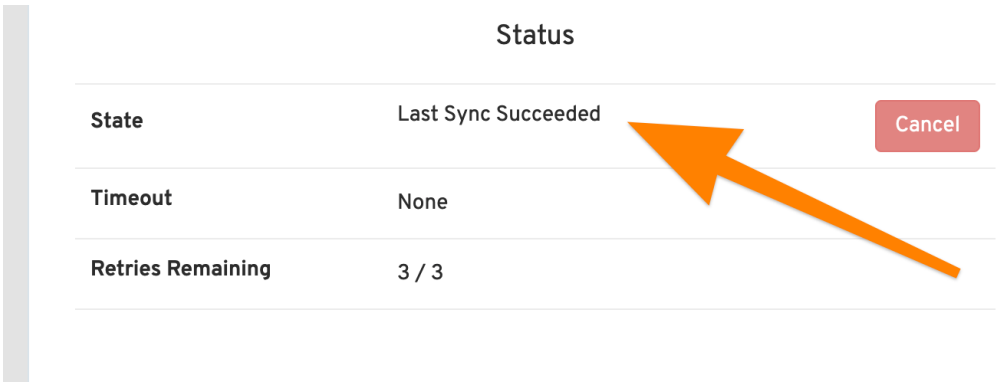

Repositories
travis / rhttraining_httpd
Repository Mirroring
This feature will convert travis/rhttraining_httpd into a mirror. Changes to the external repository will be duplicated here. While enabled, users will be unab
repository.
External Repository
Registry Location
quay.io/redhattraining/httpd-parent
Tags
Comma-separated list of tag patterns to synchronize.
latest, 2.4
Start Date
August 25, 2021 3:24 PM
Sync Interval
5
days
Robot User
travis+travis_robot
Credentials
Required if the external repository is private.
Username

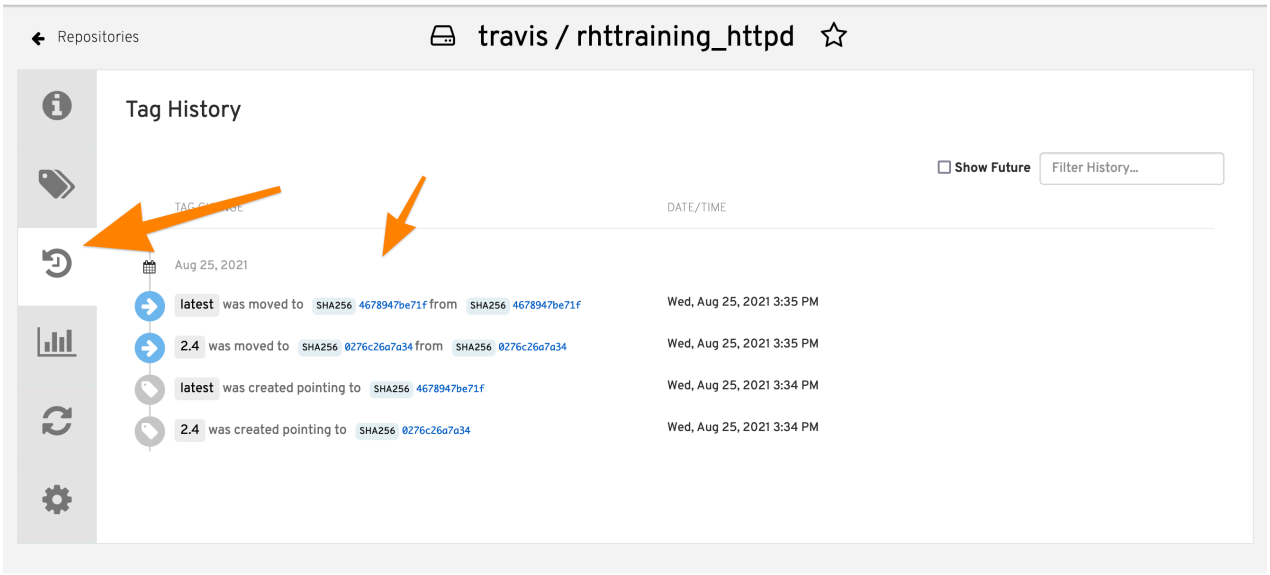


6. Click "**Sync Now**" to perform immediate synchronization



7. Verify synchronization completed on the **Mirroring** tab as well as the **Tag History**





7.3.4. Using the Quay Image Registry

After testing the initial Quay image registry, we will need to use the registry similar to the one located at Quay.io. It is important to understand that since this repository/registry is local, it is fully maintained by the adminstrators that installed it. There were one or more **Superuser** accounts created as part of the installation process. These accounts can create organizations or modify permissions to organizations as well as maintain the infrastructure.

7.3.4.1. Configuring Quay as the Superuser

Example 36. **LAB: Configuring QUAY**

1. Login to the Quay site and open the **Super User Admin Panel**

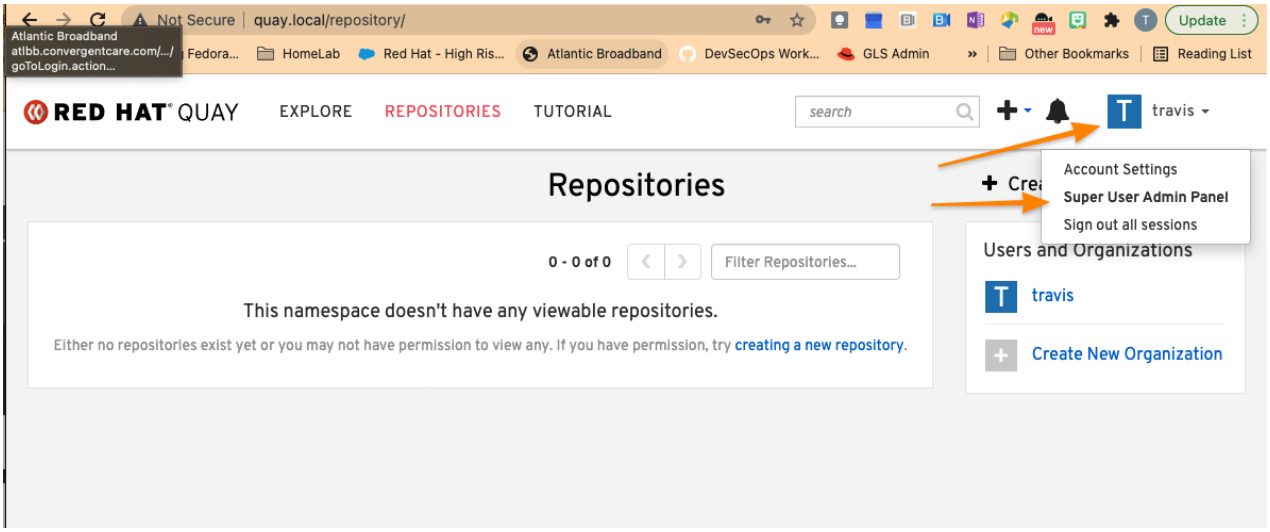


Figure 67. Quay Superuser Panel Access

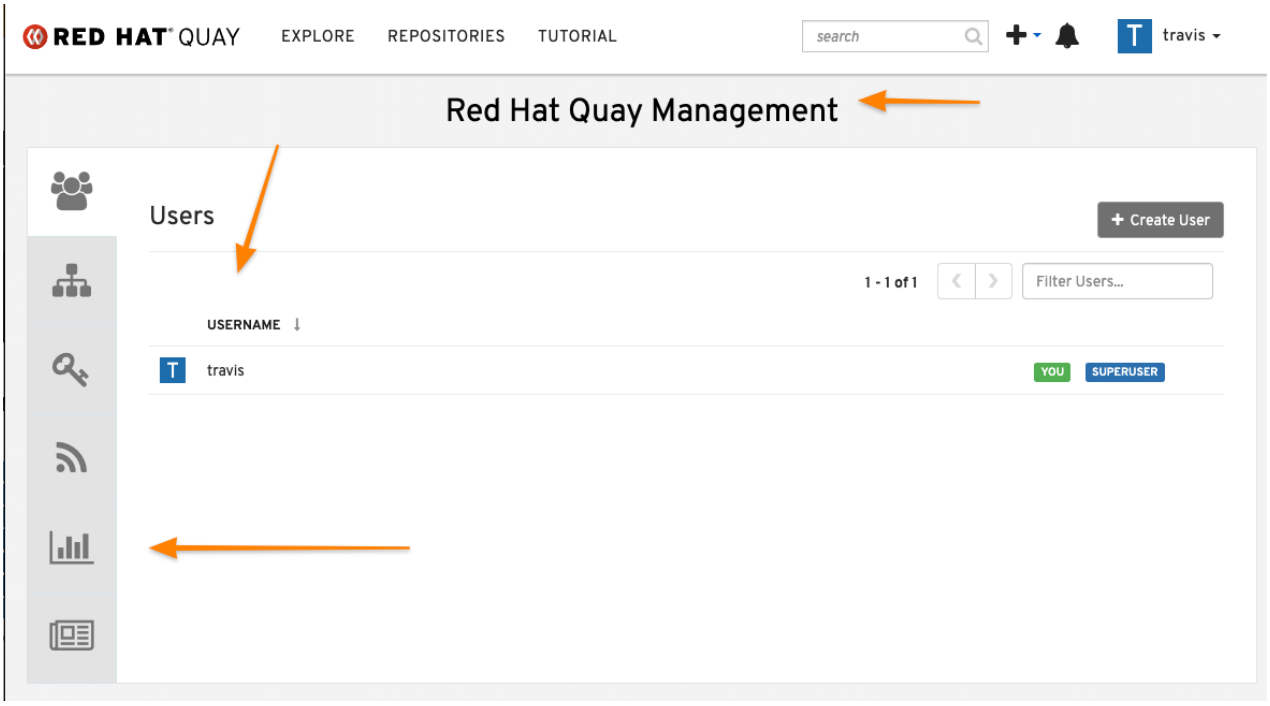


Figure 68. Quay Superuser - User Management

2. Explore the various items on the left-hand menu.
3. Navigate to "Messages" and click **Create Message** to create a system-wide message

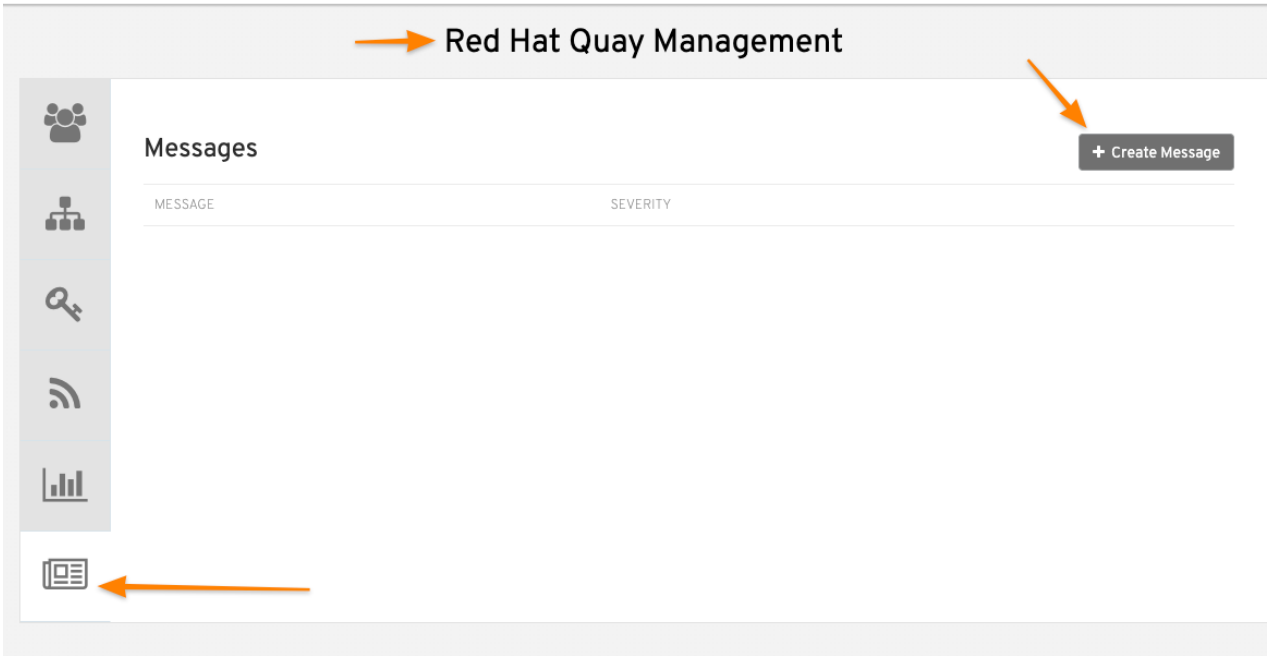


Figure 69. Quay Superuser - System Message

4. Create a system message
    a. SYSTEM Message:
        i. **Attention** The system will be scheduled for maintenance on October 31, 2021. It will be in read-only mode for 24-hours. During this time, you can pull existing containers, but accounts and organizations cannot be created and new images will not be able to be published.

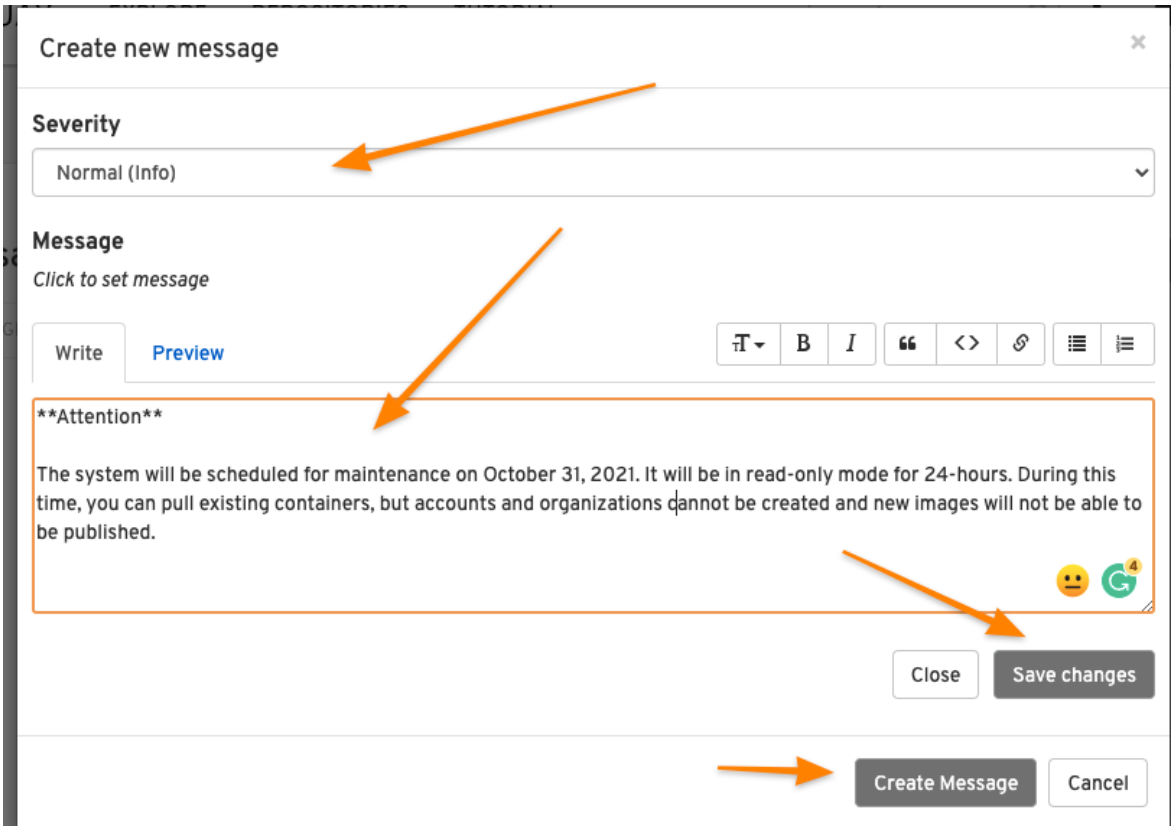


Figure 70. Quay Superuser - System Message Creation

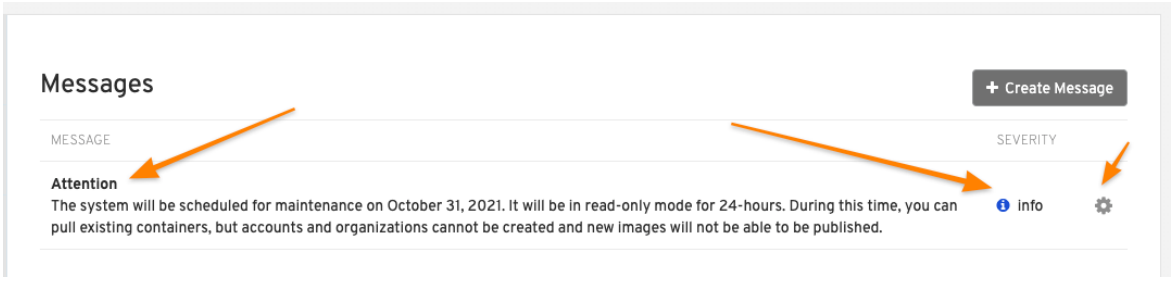


Figure 71. System Message Verification

7.3.4.2. Creating Organizations

Organizations can be created so that multiple users can share container images. After creating an organization, users can be added to the organization so that they can manage images within that organization.

Example 37. **LAB: Configuring/Creating Organizations**

1. Click **Create New Organization**

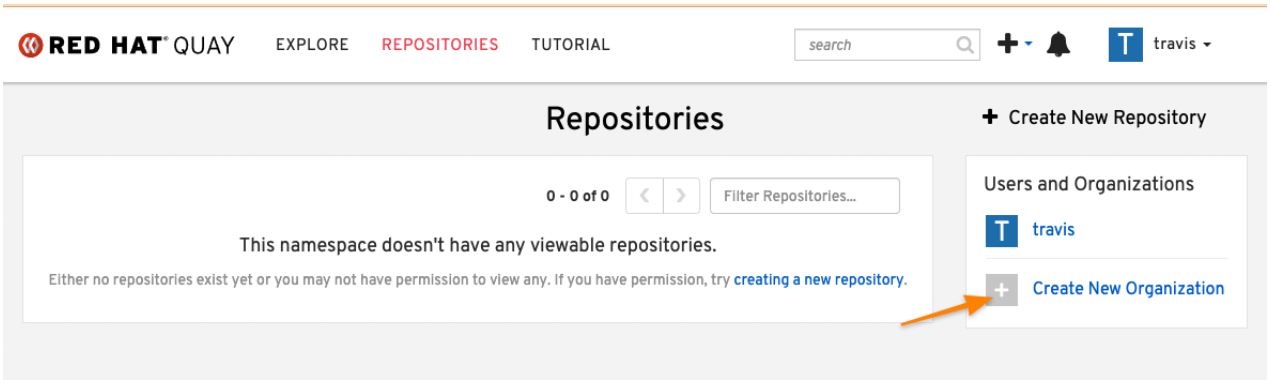


Figure 72. Creating an Organization

2. Provide name for Organization and click **Create Organization**

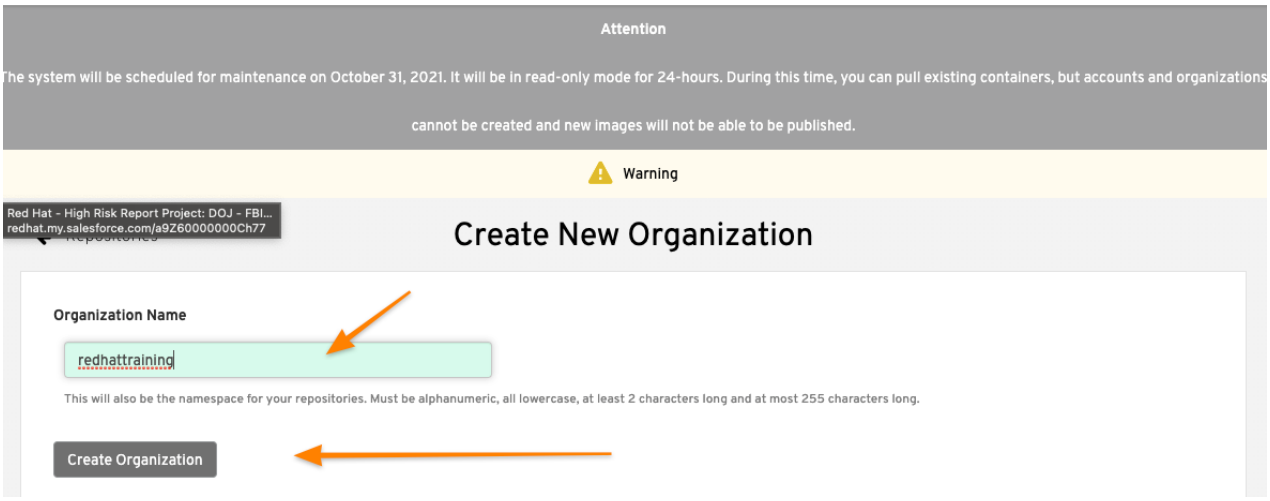


Figure 73. Red Hat Training Organization

When naming the organization, it is important to use all lowercase letters and not have any spaces. Additionally it should be noted that only newer registry versions support naming with "-" and "." in the name.

3. Manage teams and membership

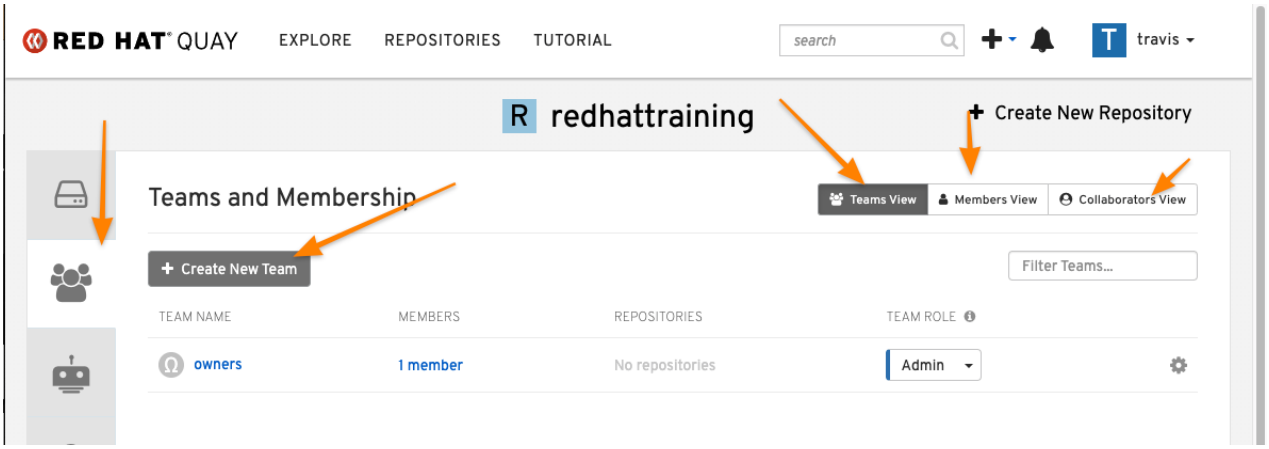


Figure 74. Red Hat Training Organization - Membership

4. Create a team

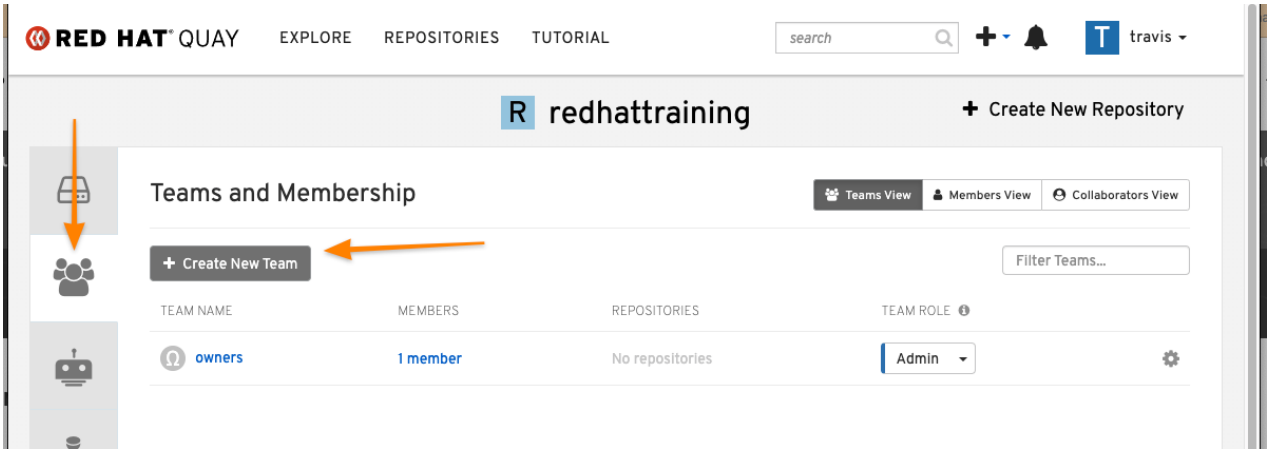


Figure 75. Red Hat Training Organization - Creating a Team

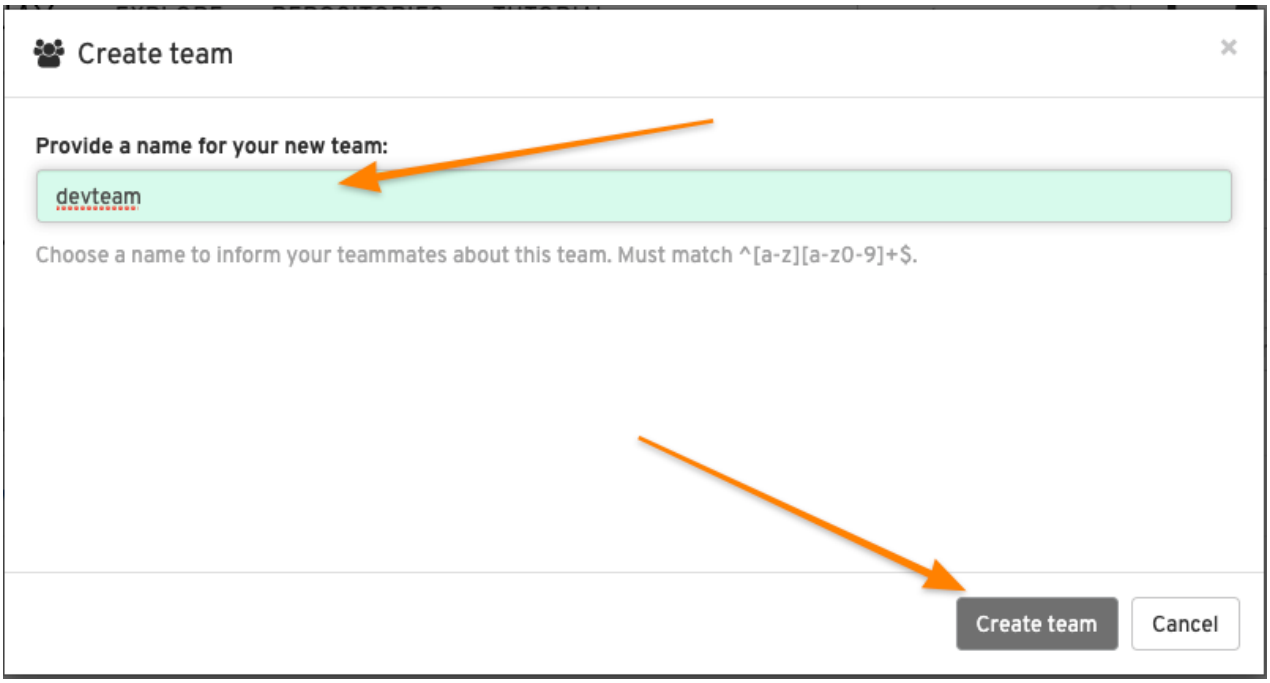


Figure 76. Red Hat Training Organization - Team Creation

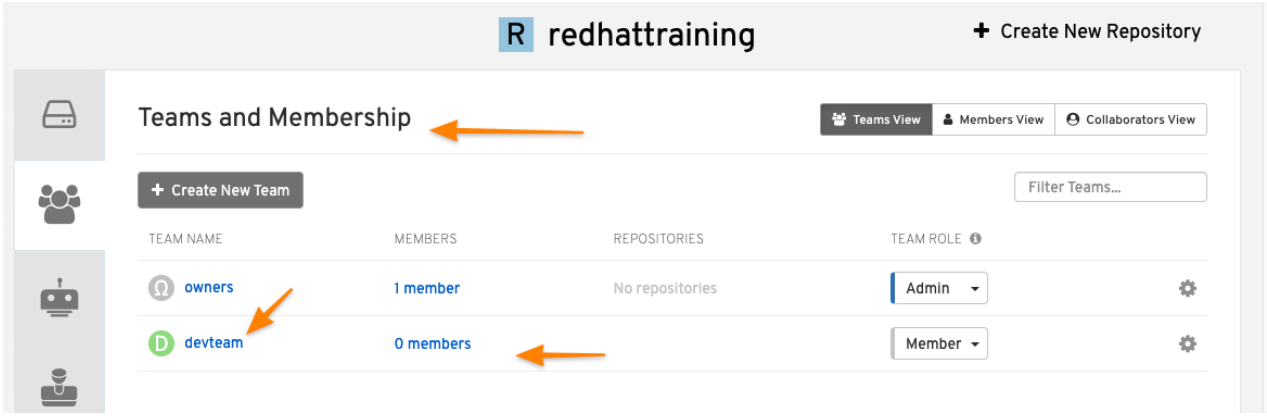


Figure 77. Red Hat Training Organization - Membership Verification

5. Add members to the team by clicking the gear and then clicking **Manage Team Members**

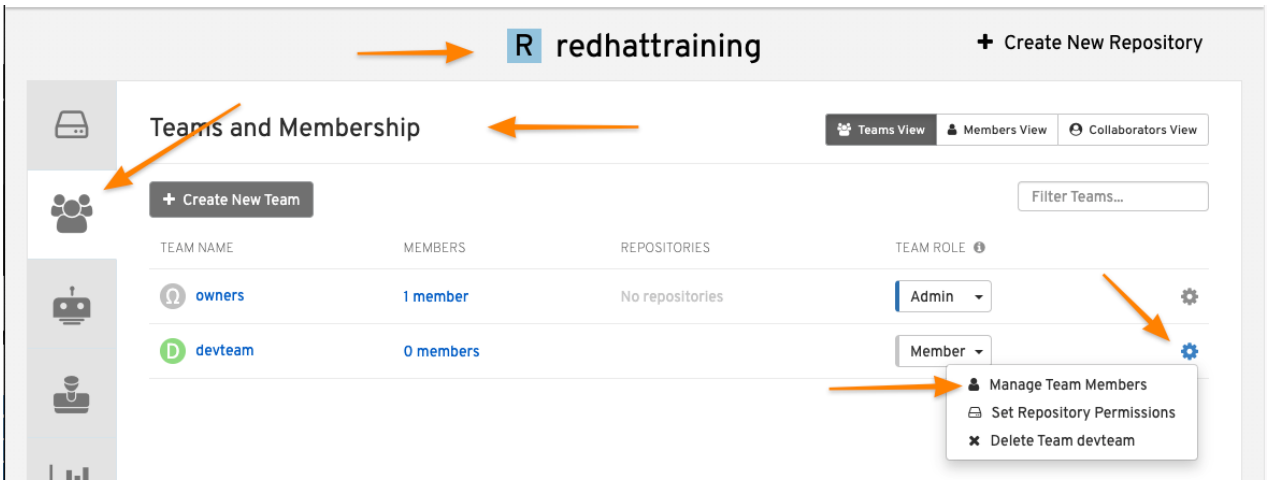


Figure 78. devteam - Membership Modification

6. Search for and add team members and add a team description

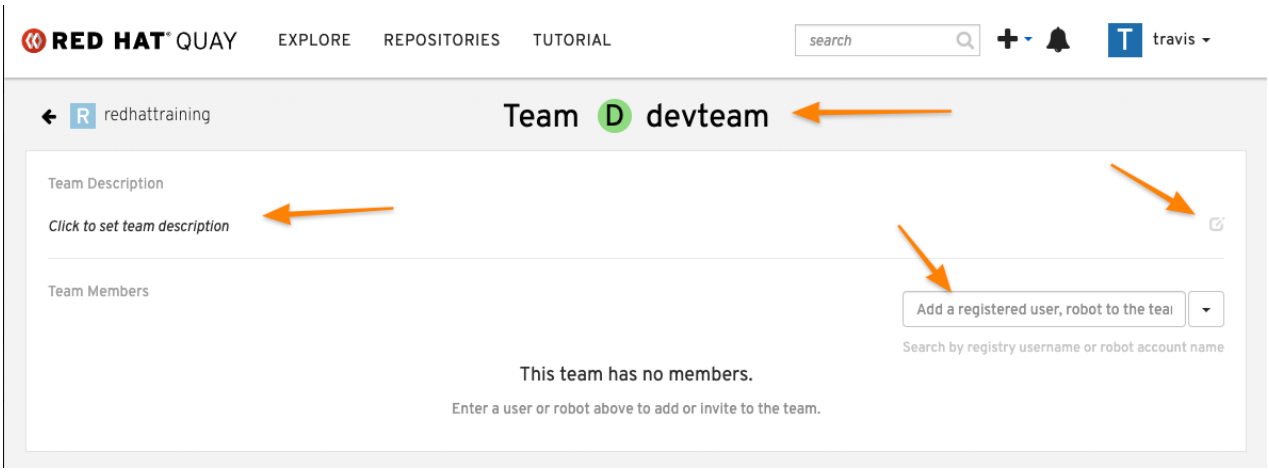


Figure 79. devteam - Edit team and members

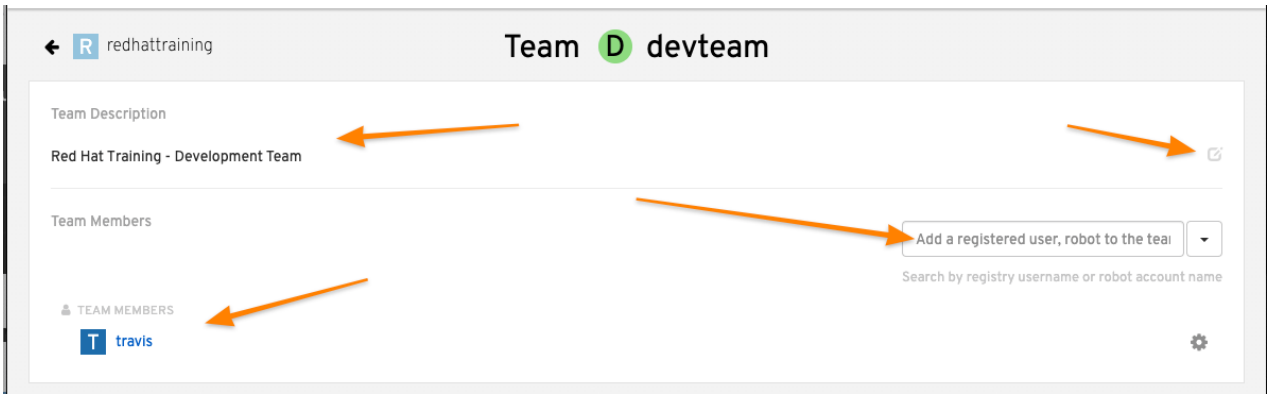


Figure 80. devteam - Final Team Details

7. Create default organization permissions

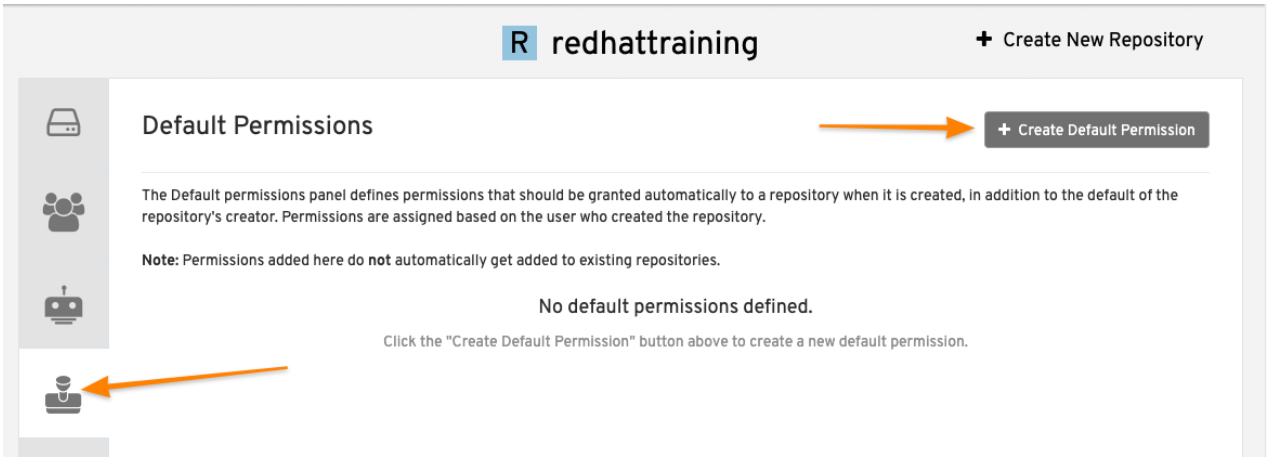


Figure 81. Red Hat Training Organization - Permissions

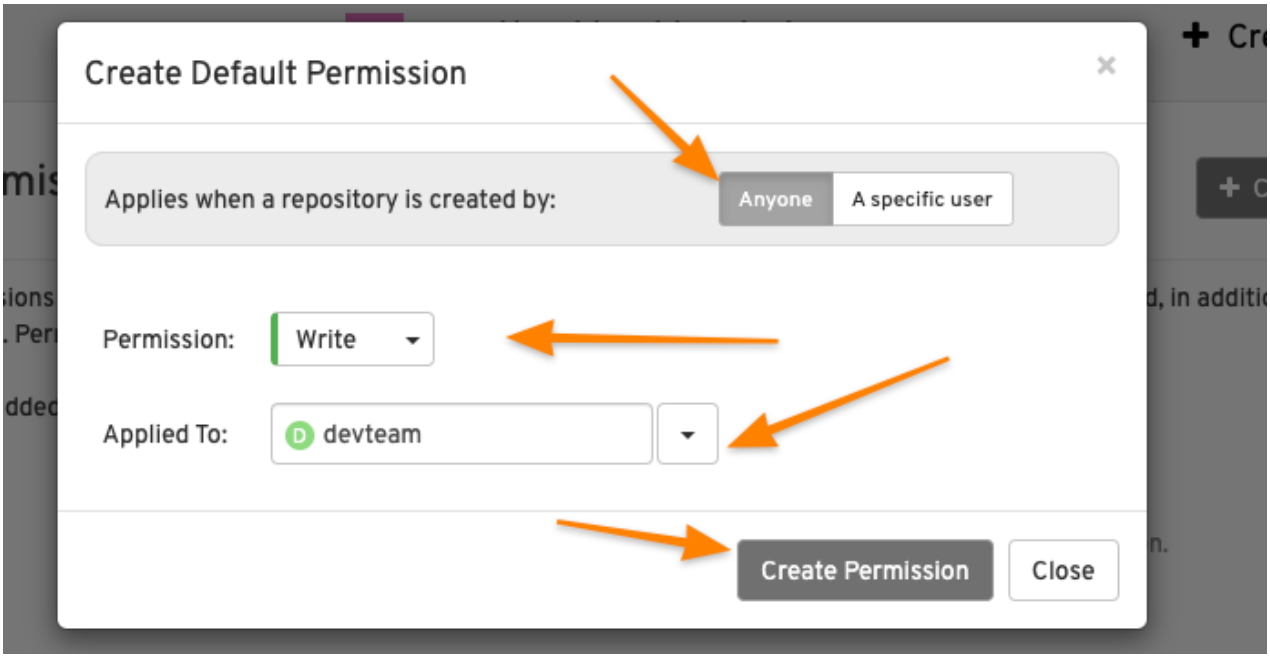


Figure 82. Red Hat Training Organization - Dev Team with Write Permissions

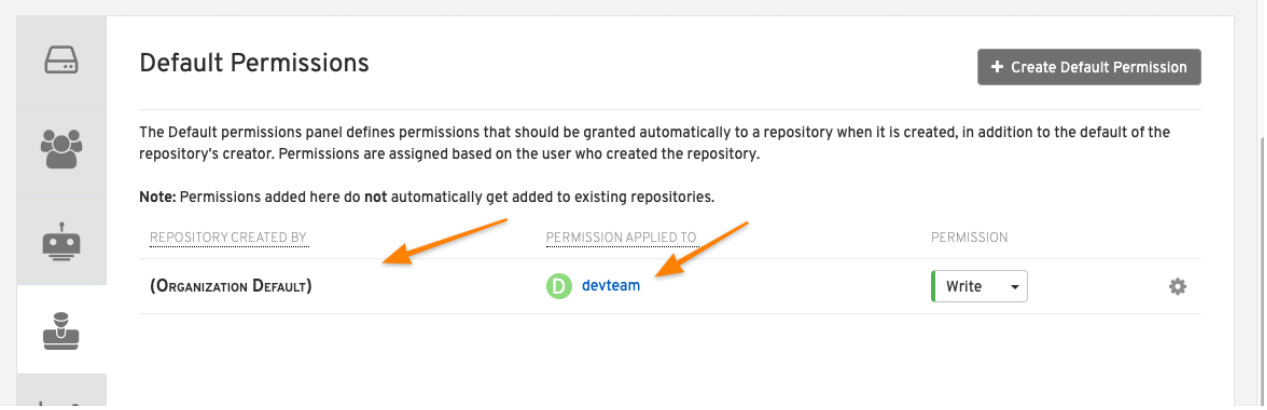


Figure 83. Red Hat Training Organization - Permission Verification

7.3.4.3. Testing Organizations

Once an organization has been created it is important to test the organization and ensure that members can login and create repositories and are also able to push images to those repositories.

Example 38. **LAB: Testing Organizations**

1. Login to **quay.local** from the workstation machine

```
[student@workstation ~]$ podman login quay.local --tls-verify=false
Username: travis
Password:
Login Succeeded!
```

2. Pull an image down from Quay.io

```
[student@workstation ~]$ podman pull quay.io/redhattraining/hello-world-nginx
Trying to pull quay.io/redhattraining/hello-world-nginx...
Getting image source signatures

... OUTPUT OMITTED ...

Writing manifest to image destination
Storing signatures
8d990e08937e299ce1d9e629e4df86ef824744e9c9d2057a8883553650d25ba9
```

3. Tag image for upload to **quay.local**

```
[student@workstation ~]$ podman tag quay.io/redhattraining/hello-world-nginx quay.local/redhattraining/hello-world-nginx
```

4. Verify images and tags

```
[student@workstation ~]$ podman images
REPOSITORY                                TAG      IMAGE ID       CREATED       SIZE
quay.io/redhattraining/hello-world-nginx  latest   8d990e08937e   2 years ago   269 MB
quay.local/redhattraining/hello-world-nginx  latest   8d990e08937e   2 years ago   269 MB
```

5. Upload (push) image to **Quay.local** Repository in the **redhattraining** Organization

```
[student@workstation ~]$ podman push quay.local/redhattraining/hello-world-nginx --tls-verify=false
Getting image source signatures

... OUTPUT OMITTED ...

Writing manifest to image destination
Storing signatures
```

6. Verify repository appears in Quay WebUI

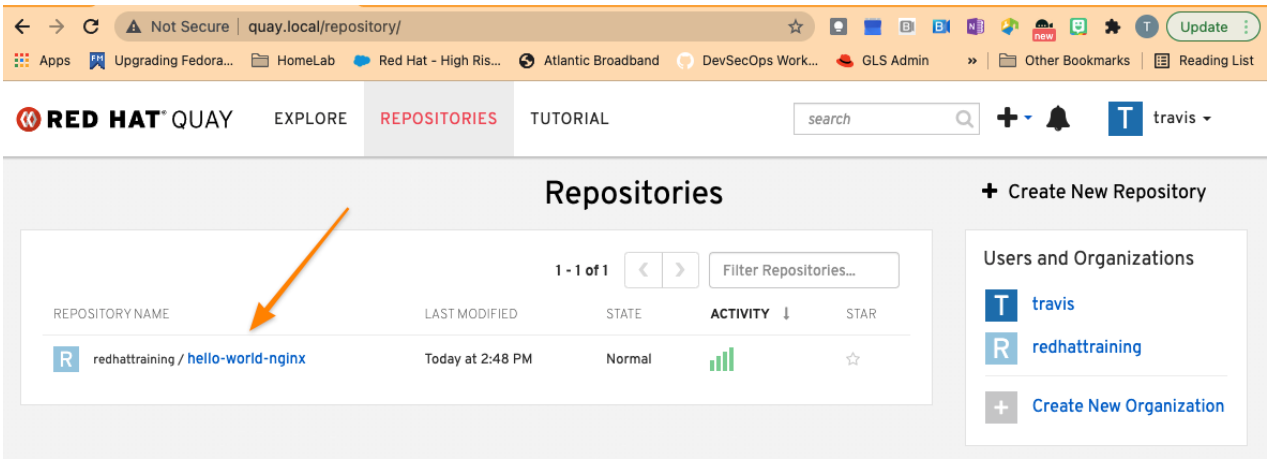


Figure 84. Hello World NGINX Container Image Repository

7. Verify the security scanning worked on image

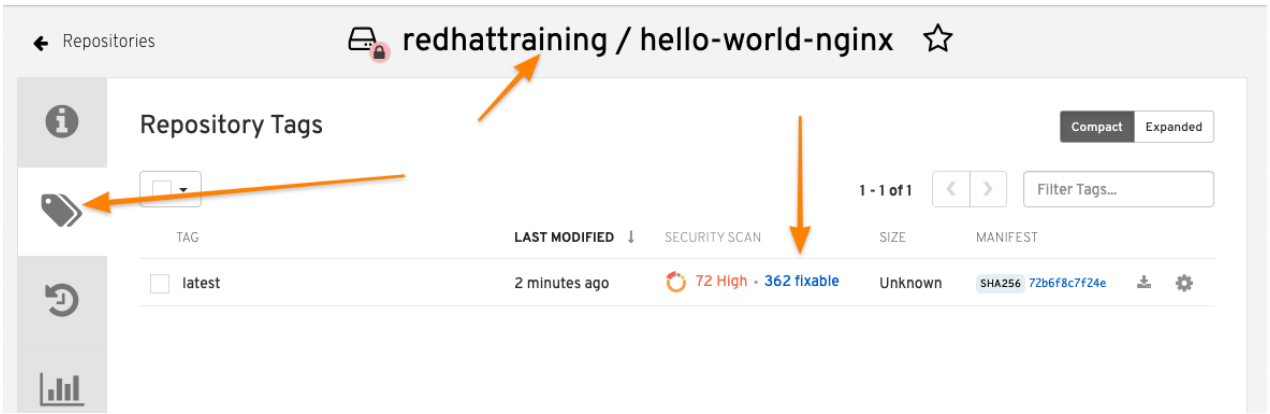


Figure 85. hello-world-nginx - Image Tags and Scan Results

8. Observe the status of the repository

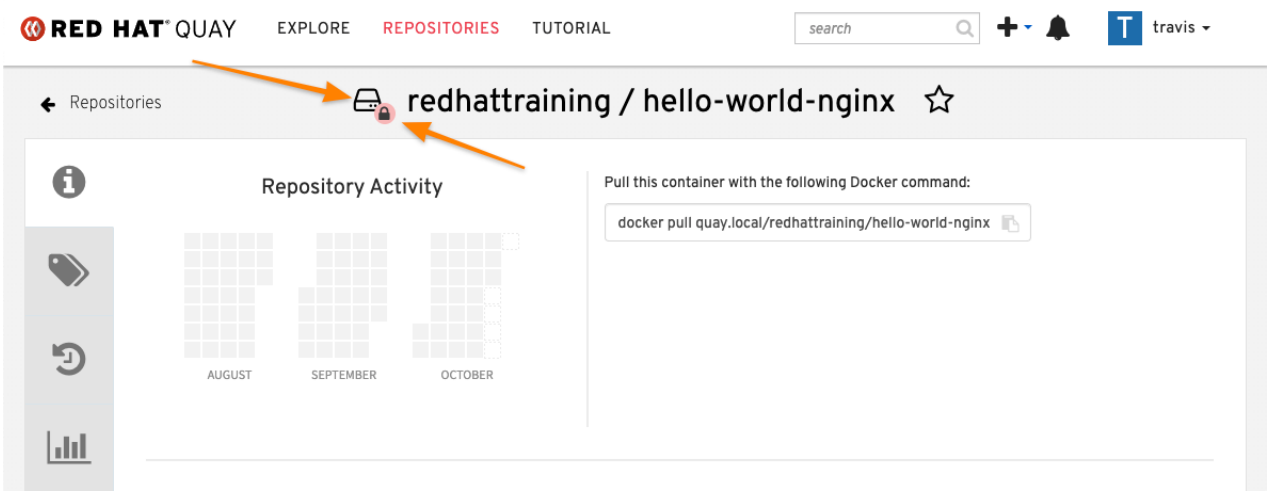


Figure 86. hello-world-nginx - Private (Locked) Repository

9. Unlock Repository for Public Use of Image

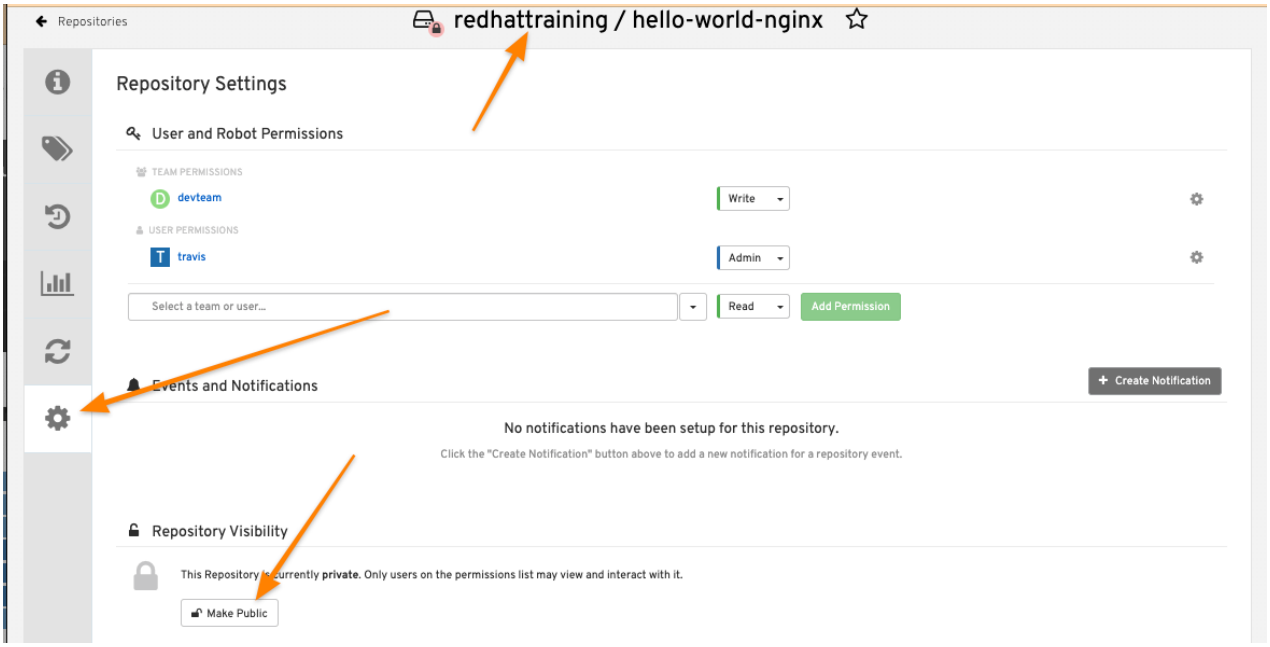


Figure 87. hello-world-nginx - Making Repository Public

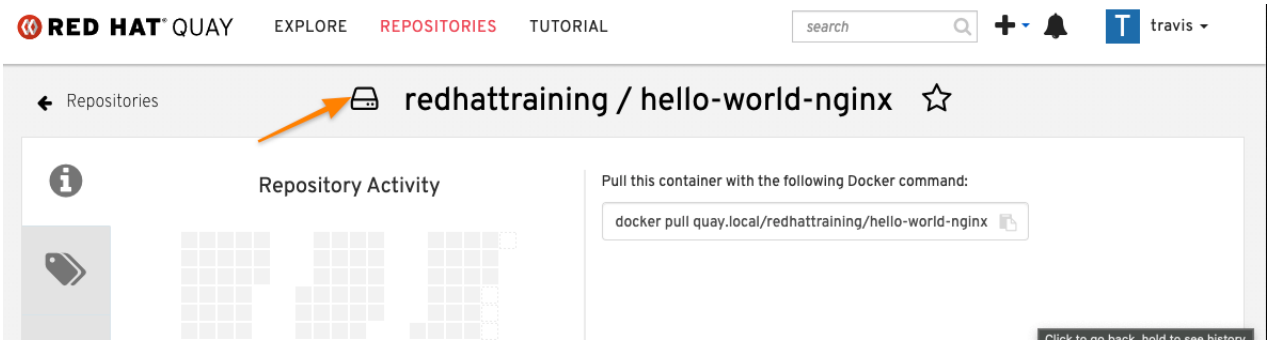


Figure 88. hello-world-nginx - Verifying Unlocked

10. SSH to **server** as root

```
[student@workstation ~]$ ssh root@server
```

11. Login to the Quay registry

```
[root@server ~]# podman login quay.local --tls-verify=false
Username: travis
Password:
Login Succeeded!
```

12. Launch container from the **quay.local/redhattraining/hello-world-nginx** container image.

```
[root@server ~]# podman run -d --name quay_test_nginx -p 10080:8080 quay.local:80/redhattraining/hello-world-nginx
Trying to pull quay.local:80/redhattraining/hello-world-nginx:latest.

... OUTPUT OMITTED ...

Storing signatures
9c9251222721e8ebbd1e38b8a9623b035ba1d814cbfc4dd25fc0256fded25777
```

13. Verify webserver is running

```
[root@server ~]# curl localhost:10080
<html>
  <body>
    <h1>Hello, world from nginx!</h1>
  </body>
</html>
```

7.4. Inspecting Images with Skopeo on Remote Registries

Skopeo is another new command-line utility that can work in conjunction with both Podman, and Buildah. Skopeo can be run as a regular user or root-level user to interact with container images. While both Podman and Buildah work with container images, Skopeo is designed to work with container images and image repositories. Podman is only able to inspect images in the local

image registry whereas Skopeo can inspect both local and remote images.

In addition to gaining information about images from remote registries, Skopeo can also perform a wide array of tasks.

Skopeo Abilities

- Delete images from local or remote image repositories
- Copy images from one image registry to another
- Inspecting remote images
- Syncing images for offline copying to internal registries (air-gapped / isolated environments)
- Login and authenticate to registries

7.4.1. Using Skopeo to Inspect Images and Copy Images

The following exercises will leverage Skopeo to inspect the **quay.local/redhattraining/hello-world-nginx** image remotely. They will also copy the image from the **quay.local/redhattraining** to your private repository.

Example 39. **LAB: Inspecting Remote Images with Skopeo**

1. SSH to **server**

```
[student@workstation ~]$ ssh root@server
```

2. Login to **quay.local** with Skopeo

```
[root@server ~]# skopeo login quay.local --tls-verify=false
Authenticating with existing credentials... ①
Existing credentials are valid. Already logged in to quay.local
```

① Skopeo capable of using cached credentials from Podman

3. Inspect the Container from Remote Registry

```
[root@server ~]# skopeo inspect docker://quay.local:80/redhattraining/hello-world-nginx
{
    "Name": "quay.local:80/redhattraining/hello-world-nginx",
    "Tag": "latest",
    "Digest": "sha256:72b6f8c7f24e852f6307661bbb0d7bc153137c2c23aa49f6dd16cfd0a8e8093b",
    "RepoTags": [
        "latest"
    ],
    "Created": "2019-06-26T22:59:13.751737399Z",
    "DockerVersion": "",
    "Labels": {
        "architecture": "x86_64",
        "authoritative-source-url": "registry.access.redhat.com",
        "build-date": "2019-04-25T16:26:03.051400",
        "com.redhat.build-host": "cpt-0013.osbs.prod.upshift.rdu2.redhat.com",
        "com.redhat.component": "ubi8-container",
        "com.redhat.license_terms": "https://www.redhat.com/licenses/eulas",
        "description": "The Universal Base Image is designed and engineered to be the base layer for all of your containerized
applications, middleware and utilities. This base image is freely redistributable, but Red Hat only supports Red Hat technologies
through subscriptions for Red Hat products. This image is maintained by Red Hat and updated regularly.",
        "distribution-scope": "public",
        "io.k8s.description": "The Universal Base Image is designed and engineered to be the base layer for all of your
containerized applications, middleware and utilities. This base image is freely redistributable, but Red Hat only supports Red Hat
technologies through subscriptions for Red Hat products. This image is maintained by Red Hat and updated regularly.",
        "io.k8s.display-name": "Red Hat Universal Base Image 8",
        "io.openshift.expose-services": "",
        "io.openshift.tags": "base rhel8",
        "maintainer": "Red Hat, Inc.",
        "name": "ubi8",
        "release": "122",
        "summary": "Provides the latest release of Red Hat Universal Base Image 8.",
        "url": "https://access.redhat.com/containers/#/registry.access.redhat.com/ubi8/images/8.0-122",
        "vcs-ref": "d5ff1490fad8f1b57e451d384d3b331e94cf6fe4",
        "vcs-type": "git",
        "vendor": "Red Hat, Inc.",
        "version": "8.0"
    },
    "Architecture": "amd64",
    "Os": "linux",
    "Layers": [
        "sha256:4fc3a6f12060dda18cbd448606cbd27c8dee5e0179f9f76a50a8a1de9e5aa827",
        "sha256:cf8bdd5396ac2c59b14aec87491c8d3c3e6c7be355804b6423f8feeffccbda41",
        "sha256:d5072897bb5d09c20671d4a3714bf9203b13887a3e97df6e7770c65e8e5d949d",
        "sha256:e0ed7e500605c8a40f7717871e9b359e65b239236a094544b89d7b2dda95ba3c",
        "sha256:2eb03ea4690d1339f41ef5082b8644ef44e265b73a008c0e05996f1badeca761",
        "sha256:8e4505e250a0379536b9f1a681943a8585bf258e6c218e29f4f4f70ffee8519a",
        "sha256:a8ab12e20ea0ea02fe1f4b0962365d0c146b988c914a112cdd43605f48a44dc1",
        "sha256:1dbcab28ce46b65c0174e5e82658492107396fead31e9144c343e6bc96e471c7",
        "sha256:1dbcab28ce46b65c0174e5e82658492107396fead31e9144c343e6bc96e471c7",
        "sha256:1dbcab28ce46b65c0174e5e82658492107396fead31e9144c343e6bc96e471c7"
    ],
    "Env": [
        "PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
        "container=oci"
    ]
}
```

4. Use Skopeo to inspect configuration and layers of the container

```
[root@server ~]# skopeo inspect --config docker://quay.local:80/redhattraining/hello-world-nginx
{
    "created": "2019-06-26T22:59:13.751737399Z",
```

```
    "architecture": "amd64",
    "os": "linux",
    "config": {
        "User": "1001",
        "ExposedPorts": {
            "8080/tcp": {}
        },
        "Env": [
            "PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
            "container=oci"
        ],
        "Cmd": [
            "/bin/sh",
            "-c",
            "nginx -g \"daemon off;\""
        ],
        "Labels": {
            "architecture": "x86_64",
            "authoritative-source-url": "registry.access.redhat.com",
            "build-date": "2019-04-25T16:26:03.051400",
            "com.redhat.build-host": "cpt-0013.osbs.prod.upshift.rdu2.redhat.com",
            "com.redhat.component": "ubi8-container",
            "com.redhat.license_terms": "https://www.redhat.com/licenses/eulas",
            "description": "The Universal Base Image is designed and engineered to be the base layer for all of your containerized
applications, middleware and utilities. This base image is freely redistributable, but Red Hat only supports Red Hat technologies
through subscriptions for Red Hat products. This image is maintained by Red Hat and updated regularly.",
            "distribution-scope": "public",
            "io.k8s.description": "The Universal Base Image is designed and engineered to be the base layer for all of your
containerized applications, middleware and utilities. This base image is freely redistributable, but Red Hat only supports Red Hat
technologies through subscriptions for Red Hat products. This image is maintained by Red Hat and updated regularly.",
            "io.k8s.display-name": "Red Hat Universal Base Image 8",
            "io.openshift.expose-services": "",
            "io.openshift.tags": "base rhel8",
            "maintainer": "Red Hat, Inc.",
            "name": "ubi8",
            "release": "122",
            "summary": "Provides the latest release of Red Hat Universal Base Image 8.",
            "url": "https://access.redhat.com/containers/#/registry.access.redhat.com/ubi8/images/8.0-122",
            "vcs-ref": "d5ff1490fad8f1b57e451d384d3b331e94cf6fe4",
            "vcs-type": "git",
            "vendor": "Red Hat, Inc.",
            "version": "8.0"
        }
    },
    "rootfs": {
        "type": "layers",
        "diff_ids": [
            "",
            "",
            "",
            "",
            "",
            "",
            "",
            "",
            "",
            "",
            ""
        ]
    },
    "history": [
        {
            "created": "2019-04-25T16:26:20.260497942Z",
            "comment": "Imported from -"
        },
        {
```

```
            "created": "2019-04-25T16:26:28.425556Z"
        },
        {
            "created": "2019-06-26T22:33:55.170741575Z",
            "created_by": "/bin/sh -c yum install -y --disableplugin=subscription-manager --nodocs nginx   \u0026\u0026 yum clean
all"
        },
        {
            "created": "2019-06-26T22:34:02.362527585Z",
            "created_by": "/bin/sh -c #(nop) ADD index.html /usr/share/nginx/html"
        },
        {
            "created": "2019-06-26T22:59:11.6224038477Z",
            "created_by": "/bin/sh -c #(nop) ADD nginxconf.sed /tmp/"
        },
        {
            "created": "2019-06-26T22:59:12.4126972982Z",
            "created_by": "/bin/sh -c sed -i -f /tmp/nginxconf.sed /etc/nginx/nginx.conf"
        },
        {
            "created": "2019-06-26T22:59:13.2779953792Z",
            "created_by": "/bin/sh -c touch /run/nginx.pid   \u0026\u0026 chgrp -R 0 /var/log/nginx /run/nginx.pid   \u0026\u0026
chmod -R g+rwx /var/log/nginx /run/nginx.pid"
        },
        {
            "created": "2019-06-26T22:59:13.4148020162Z",
            "created_by": "/bin/sh -c #(nop) EXPOSE 8080"
        },
        {
            "created": "2019-06-26T22:59:13.5933381622Z",
            "created_by": "/bin/sh -c #(nop) USER 1001"
        },
        {
            "created": "2019-06-26T22:59:13.7517373992Z"
        }
    ]
}
```

5. Copy **hello-world-nginx** to your private repository

```
[root@server ~]# skopeo copy --tls-verify=false docker://quay.local/redhattraining/hello-world-nginx
docker://quay.local/travis/hello-world-nginx
WARN[0000] '--tls-verify' is deprecated, please set this on the specific subcommand
Getting image source signatures
Copying blob e0ed7e500605 done
Copying blob cf8bdd5396ac done
Copying blob 8e4505e250a0 done
Copying blob d5072897bb5d done
Copying blob a8ab12e20ea0 done
Copying blob 1dbcab28ce46 done
Copying blob 1dbcab28ce46 skipped: already exists
Copying blob 1dbcab28ce46 skipped: already exists
Copying blob 4fc3a6f12060 done
Copying blob 2eb03ea4690d done
Writing manifest to image destination
Storing signatures
```

Ensure you are logged in

```
[root@server ~]# skopeo login quay.local --tls-verify=false
Username: travis
Password:
Login Succeeded!
```

References

Deploy Red Hat Quay for proof-of-concept (non-production) purposes: https://access.redhat.com/documentation/en-us/red_hat_quay/3/html/deploy_red_hat_quay_for_proof-of-concept_non-production_purposes/index

Deploying Quay as a local registry server using local storage and containerized services.

Quay Lab PoC: https://github.com/tmichett/quay_lab_poc Deploying the Quay Registry locally based on the Proof-of-Concept local deployment.

Skopeo - Exercise from redhatgov.io: http://redhatgov.io/workshops/security_openshift/exercise1.4/

Skopeo on Github: https://github.com/containers/skopeo

How to run Skopeo in a container: https://www.redhat.com/sysadmin/how-run-skopeo-container

Introduction to using buildah, podman and skopeo to work on containers: http://redhatgov.io/workshops/rhel_8/exercise1.8/

Appendix A: Running Containers

A.1. Introducing Containers

A.1.1. Introducing Container Technology

Containers provide a way to package and deploy applications avoiding package conflicts and dependencies with runtime environments. A container can be a bundled package or packages that are assembled and deployed in a standard way which run isolated from the host system environment.

A.1.1.1. Comparing Containers to Virtual Machines

Containers provide the same benefits as VMs:

- Security
- Storage Isolation
- Network Isolation

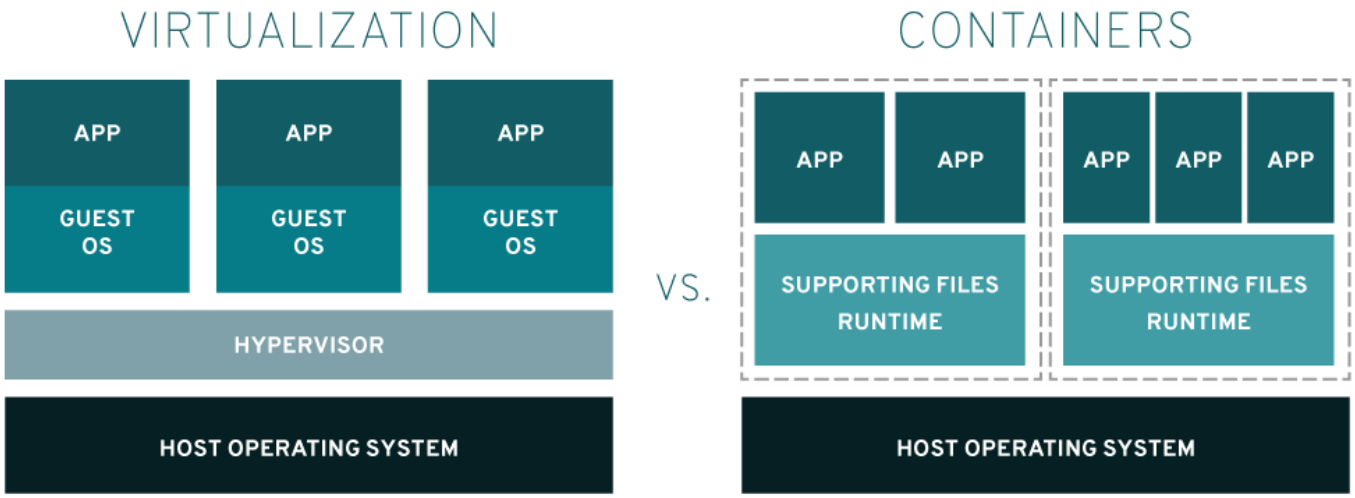


Figure 89. Virtualization vs. Containers

Table 7. Container and Virtualization Differences

Virtualization	Container
Multiple operating systems run on a single hardware platform	Applications run natively on the operating system and share hardware and OS resources across all containers

Virtualization	Container
Uses hypervisor to allocate hardware resources into multiple virtual systems	Shares same OS kernel, but isolates containerized application processes from the rest of the system
Requires a complete OS in the virtual environment to support the application	Requires fewer hardware resources allowing for quick start/stop. Also, uses the host OS and any software that is compatible with the kernel.

A.1.1.2. Exploring the Implementation of Containers

Containers use the following core components of Linux:

- **Control Groups (cgroups)** - Used for resource management
- **Namespaces** - Used for process isolation
- **SELinux and Secomp (Secure Computing Mode)** - Used to enforce security boundaries.

A.1.1.3. Planning for Containers

Containers provide reusability and portability for hosted and containerized applications. These containers can easily be moved between environments are are considered temporary. If containers rely on permanent data, persistent storage should be presented to the container.

A.1.1.4. Running Containers from Container Images

Containers are run from **images**. Images serve as blueprints for creating containers.

Container images package an application together with:

- System libraries
- Programming language runtimes and libraries
- Configuration settings
- Static files

Container images are immutable and built according to specifications such as Open Container Initiative (OCI) image format.

A.1.1.5. Designing Container-based Architectures

It is possible to install complex software applications and services in a single container, but it is often harder to manage. Instead, it is recommended to have each component of an application in a container, forming a type of microservices.

A.1.2. Managing Containers with Podman

To learn about containers, it is best to work with individual containers on a server which serves as a container host. The **Container Tools** package will provide the OCI tools for RHEL allowing containers to be built and run on the host.

Container Tools

- **podman** - Manages containers and container images
- **skopeo** - Used to inspect, copy, delete, and sign container images
- **buildah** - Used to create new container images

The tools above are compatible with the OCI and can be used to manage Linux containers created by OCI-compatible container engines such as docker.

A.1.2.1. Running Rootless Containers

The **podman** command is used to run containers as the **root** user or by non-privileged users. Containers run by non-privileged users are called *rootless containers*.

Rootless containers are more secure but can't do as much, including publishing services through the host's privileged ports (ports below 1024).

Security Concerns - Running a Container as Root

Containers can be run directly as root, but system security is weakened as an attacker could compromise the container.

A.1.3. Managing Containers at Scale

Managing containers at scale is extremely difficult. **Kubernetes** was developed as an orchestration service to assist with managing and deploying containers at scale in an enterprise environment. Red Hat provides a Kubernetes distribution called Red Hat OpenShift Container Platform (RHOCP or OCP).

A.2. Running a Basic Container

A.2.1. Installing Container Management Tools

In RHEL8, Container Tools are in the **container-tools** module. The **container-tools** module provides the container tools needed to run containers (specifically **podman**, **skopeo**, and **buildah**).

A.2.2. Selecting Container Images and Registries

Container registries are repositories for storing and retrieving container images. Container images are generally uploaded or

pushed to a registry by a developer. Images are downloaded or pulled from a container registry to a local system so that the can be used to run containers.

Red Hat Container Registries

- **registry.redhat.io** - Containers based on official Red Hat products
- **registry.connect.redhat.com** - Containers based on third-party products

Older Red Hat Registry

Red Hat is phasing out the older **registry.access.redhat.com** container registry in favor of the new container registries.

Red Hat Container Catalog

The Red Hat Container Catalog (RHCC) is available at https://access.redhat.com/containers and provides a web-based interface for searching container registries for containers.

Classroom Container Registry

The container registry used for the classroom **registry.lab.example.com** is a private container registry running on he

A.2.2.1. Container Naming Conventions

Container images are based on a *fully qualified image name* syntax as follows:

registry_name/user_name/image_name:tag

- **registry_name** - Name of registry storing the image.
- **user_name** - Name of user or organization where the image is located
- **image_name** - Name of the image. Must be unique in the user namespace
- **tag** - Identifies image version. If no image tag is provided, it is assumed that the **latest** image tag is used.

A.2.3. Running Containers

Before running containers on a system a container image must first be pulled from a registry. Podman can be used to download an image from a container registry using the **podman pull** command.

Listing 127. Getting the latest UBI Image (Universal Base Image)

```
[student@servera ~]$ podman pull registry.access.redhat.com/ubi8/ubi:latest
Trying to pull registry.access.redhat.com/ubi8/ubi:latest...
Getting image source signatures
Copying blob c4d668e229cd done

... output omitted ...

Storing signatures
ecbc6f53bba0d1923ca9e92b3f747da8353a070fccbae93625bd8b47dbee772e
[student@servera ~]
```

Images that have been downloaded with the Podman command can be seen with the **podman images** command.

Listing 128. Listing Local Images

```
[student@servera ~]$ podman images
REPOSITORY                               TAG      IMAGE ID       CREATED       SIZE
registry.access.redhat.com/ubi8/ubi      latest   ecbc6f53bba0   2 weeks ago   211 MB
registry.lab.example.com/rhel8/httpd-24  latest   7e93f25a9468   8 weeks ago   430 MB
```

A container is created and run by using the **podman run** command. When executed, Podman creates and starts a new container based on the container image specified in the command.

Listing 129. Running the UBI Image

```
[student@servera ~]$ podman run --name ubi-demo -it registry.access.redhat.com/ubi8/ubi:latest

[root@d58f1e8fb4ca /]# cat /etc/redhat-release
Red Hat Enterprise Linux release 8.2 (Ootpa)
```

podman run *Options*

The **podman run** command supports many options.

- **-t or --tty** - Allocates a **pseudo-tty** (pseudo-terminal) to the container.
- **i or --interactive** - Allows the container to accept standard input.
- **-d or --detach** - Allows the container to run in the background and displays generated container ID.
- **--name** - Allows a name to be specified to the container which must be unique, but allows access to the container with a user generated name rather than a container ID.

Containers Cleanup

It is important to cleanup containers and images after a container has been run. If a user is wanting to execute a quick command within a container, the **podman run --rm** command can be used in order to execute a command in the container and remove the container once the command has been completed.

```
[student@servera ~]$ podman run --rm registry.access.redhat.com/ubi8/ubi cat /etc/redhat-release
Red Hat Enterprise Linux release 8.2 (Ootpa)
```

A.2.4. Analyzing Container Isolation

Containers provide runtime isolation of resources by utilizing Linux namespaces. Processes running in a container are isolated from all other processes on the host machine.

Listing 130. Viewing Processes in a Container

```
[student@servera ~]$ podman run -it registry.access.redhat.com/ubi7/ubi /bin/bash

[root@9fd13da02e18 /]# cat /etc/redhat-release
Red Hat Enterprise Linux Server release 7.8 (Maipo)

[root@9fd13da02e18 /]# ps -eaf
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 20:28 pts/0    00:00:00 /bin/bash
root          15       1  0 20:29 pts/0    00:00:00 ps -eaf

[root@9fd13da02e18 /]# id
uid=0(root) gid=0(root) groups=0(root)
```

A.2.5. DEMO - Running a Basic Container

Example 40. DEMO - Running a Basic Container

Before Beginning

```
[student@workstation ~]$ lab containers-basic start
```

1. Install **podman** and other container tools packages

Listing 131. Installing Container Tools

```
[student@servera ~]$ sudo yum module install container-tools
```

Container Tools

The container tools module installs many container applications.

- buildah
- Cockpit Podman
- podman
- runc
- skopeo

2. Login to the registry

```
[student@servera ~]$ podman login registry.lab.example.com -u admin
Password:
Login Succeeded!
```

Credential Security

While it is possible to specify the **-u** and a username on the command line as well as the **-p** and a password, normally, the password is left to be interactive to prevent the password from being stored in the shell history.

3. Download a Container image.

```
[student@servera ~]$ podman pull registry.lab.example.com/rhel8/httpd-24
Trying to pull registry.lab.example.com/rhel8/httpd-24...
Getting image source signatures
... output omitted ...
7e93f25a946892c9c175b74a0915c96469e3b4845a6da9f214fd3ec19c3d7070
```

4. List available images

```
[student@servera ~]$ podman images
REPOSITORY                                TAG      IMAGE ID       CREATED       SIZE
registry.lab.example.com/rhel8/httpd-24   latest   7e93f25a9468   8 weeks ago   430 MB
```

5. Run image in a container called demo

```
[student@servera ~]$ podman run --name demo registry.lab.example.com/rhel8/httpd-24 &
```

The Apache HTTPD container is set to run the HTTPD service in the foreground. The **&** is added to push the service to the background.

6. Open an interactive shell in the **demo** container.

```
[student@servera ~]$ podman exec -it demo /bin/bash
bash-4.4$
```

7. Explore the container

Listing 132. Determine the Version of Apache

```
bash-4.4$ httpd -v
Server version: Apache/2.4.37 (Red Hat Enterprise Linux)
Server built:   Dec  2 2019 14:15:24
```

Listing 133. Determine UID from Container

```
bash-4.4$ id
uid=1001(default) gid=0(root) groups=0(root)
```

8. Exit the container interactive shell

```
bash-4.4$ exit
exit
```

9. Stop and remove container

```
[student@servera ~]$ podman rm demo --force
[Wed Sep 16 15:47:36.131159 2020] [mpm_event:notice] [pid 1:tid 139897800703424] AH00491: caught SIGTERM, shutting down
71aacac8f4af690b1abfb38a8426a90deb44096c3e4eb8db1f5d07189ed813f
```

podman ps -a *Can List All Containers on a System*

The **podman ps** command lists running containers. However, some containers either exit for various reasons or the system administrator has stopped the container. In these instances, the containers are not running, however, they are still available on the system. The **podman ps -a** command can show the status of all containers (running and stopped).

Listing 134. Listing All Containers

```
[student@servera ~]$ podman ps -a
CONTAINER ID  IMAGE                                    COMMAND    CREATED             STATUS
PORTS  NAMES
9fd13da02e18  registry.access.redhat.com/ubi7/ubi:latest  /bin/bash  About a minute ago  Exited (0) 3 seconds
ago           cool_shannon
d58f1e8fb4ca  registry.access.redhat.com/ubi8/ubi:latest  /bin/bash  9 minutes ago       Exited (127) 4 minutes
ago         ubi-demo
```

Containers can be restarted if they are **stopped** and will contain the same data. However, if a new container is launched from a container image, any data from the *stopped* container is not accessible.

Once a container is no longer of use, it should be cleaned up and removed from the system. The **podman rm** command can remove single containers by container name or container ID. It is also possible to use **podman rm -a** to remove all containers. If you want to stop and remove a container, it is possible to use the **--force** to kill a container process so that it can be removed in a single command.

Listing 135. Removing All Containers

```
[student@servera ~]$ podman rm -a
9fd13da02e181d2dff09808e3f1ac860d637c1be8d57638d90080aeca179e850
d58f1e8fb4caaf960fb51d1942861e33b98070b8af415cc414620bce43ba9f6c
```

A.3. Finding and Managing Container Images

A.3.1. Configuring Container Registries

Podman uses the **registry.conf** file on the system to retrieve information for container registries. The file is located at **/etc/containers/registries.conf**. The list of registries Podman uses are configured in the **[registries.search]** section and the **[registries.insecure]** section of the configuration file.

Rootless Podman Configuration

The system-wide **registries.conf** file located at **/etc/containers/registries.conf** can be overridden by a user's configuration file located in **$HOME/.config/containers** directory.

Container Image Registries and Searching

While it is best practice to specify a fully qualified image, it is possible to provide just an image name on the command line. If an image name is specified, it will search the registries in the listed order to determine which image to select.

The **podman info** command can display information about Podman as well as configured registries.

Listing 136. **podman info** *Demo*

```
[student@servera ~]$ podman info
host:
  arch: amd64

  ... output omitted ...

  registries:
    registry.lab.example.com:
      Blocked: false
      Insecure: true
      Location: registry.lab.example.com
      MirrorByDigestOnly: false
      Mirrors: null
      Prefix: registry.lab.example.com
    search:
    - registry.lab.example.com
```

A.3.1.1. Registry Security

Insecure registries can be listed in the **[registries.insecure]** section of the **registries.conf** file. If a registry is insecure, that means it is not protected with SSL/TLS encryption. In order for an insecure registry to be searchable, it should exist in both the [registries.search]* section and the **[registries.insecure]** section of the **registries.conf** file.

Image Repositories Requiring Authentication

Some container registries require authentication. In this instance, the **podman login** command can be used to login to a container registry.

A.3.2. Finding Container Images

The **podman search** command is used to search container registries for a specific container image.

Listing 137. Using **podman search** *to Find UBI7 Image*

```
[student@servera ~]$ podman search registry.redhat.io/ubi7
INDEX       NAME                                  DESCRIPTION                                     STARS   OFFICIAL   AUTOMATED
redhat.io   registry.redhat.io/ubi7/ubi           The Universal Base Image is designed and eng...   0
redhat.io   registry.redhat.io/ubi7/ubi-minimal   The Universal Base Image Init is designed to...   0

... output omitted ...
```

Table 8. Podman Search Options

Option	Description
--limit <number>	Limits number of listed images per registry
--filter <filter=value>	Filters output based on conditions: • **stars=<number>**: Images must contain at least X stars • **is-automated=<true/false>**: Show only automatically build images • **is-official=<true/false>**: Show only images flagged with official
--tls-verify <true/false>	Enables or disables HTTPS certificate validation. Default=**true**

A.3.2.1. Using the Red Hat Container Catalog

Repositories maintained by Red Hat containing certified container images. The standard **podman** command is compatible with the repositories referenced by the Red Hat Container Catalog (RHCC).

A.3.3. Inspecting Container Images

Information about images can be obtained before downloading them to the system by using the **skopeo inspect** command to inspect images in a container registry and display information about the image.

skopeo inspect

The **skopeo inspect** command can inspect different image formats from multiple sources including remote registries or local directories. The **docker://** transport mechanism instructs skopeo to query a container image registry.

Listing 138. Inspecting an Image

```
[student@servera ~]$ skopeo inspect docker://registry.redhat.io/ubi7/ubi
{
    "Name": "registry.redhat.io/ubi7/ubi",

... output omitted ...

    "Created": "2020-08-03T09:32:22.835719Z",
    "DockerVersion": "1.13.1",

... output omitted ..

        "description": "The Universal Base Image is designed and engineered to be the base layer for all of your containerized applications,
middleware and utilities. This base image is freely redistributable, but Red Hat only supports Red Hat technologies through subscriptions for
Red Hat products. This image is maintained by Red Hat and updated regularly.",

... output omitted ..
```

A.3.4. Removing Local Container Images

Container images are immutable and do not change. In oder to update software in a container, a new image is created to replace the old image. The newest image will always have the **latest** tag associated with it. As container images are replaced with new images, it becomes necessary for older images to be removed from the system to manage storage and images effectively. The **podman rmi** command can remove and delete the images from the local system. The **podman images** command can be used to list local images, and then the **podman rmi** command can remove the image from the system.

Listing 139. Performing Image Cleanup

```
[student@servera ~]$ podman images
REPOSITORY                                TAG      IMAGE ID       CREATED       SIZE
registry.access.redhat.com/ubi8/ubi       latest   ecbc6f53bba0   2 weeks ago   211 MB
registry.access.redhat.com/ubi7/ubi       latest   87dd8ec61bbc   6 weeks ago   215 MB
registry.lab.example.com/rhel8/httpd-24   latest   7e93f25a9468   8 weeks ago   430 MB

[student@servera ~]$ podman rmi registry.access.redhat.com/ubi7/ubi
Untagged: registry.access.redhat.com/ubi7/ubi:latest
Deleted: 87dd8ec61bbc977ed1b2bd29ba089489a8a0281e2e0f62bf43c3fb9c20414194

[student@servera ~]$ podman images
REPOSITORY                                TAG      IMAGE ID       CREATED       SIZE
registry.access.redhat.com/ubi8/ubi       latest   ecbc6f53bba0   2 weeks ago   211 MB
registry.lab.example.com/rhel8/httpd-24   latest   7e93f25a9468   8 weeks ago   430 MB
```

A.3.5. DEMO - Finding and Managing Container Images

Example 41. DEMO - **Finding and Managing Container Images**

1. Verify that the registries are configured

```
[student@servera ~]$ cat .config/containers/registries.conf
unqualified-search-registries = ['registry.lab.example.com']

[[registry]]
location = "registry.lab.example.com"
insecure = true
blocked = false
```

2. Search for an image

```
[student@servera ~]$ podman search registry.lab.example.com/nginx
INDEX         NAME                                    DESCRIPTION   STARS   OFFICIAL   AUTOMATED
example.com   registry.lab.example.com/library/nginx                0
```

3. Inspect the image with Skopeo

```
[student@servera ~]$ skopeo inspect docker://registry.lab.example.com/library/nginx
{
    "Name": "registry.lab.example.com/library/nginx"

    ... output omitted ...
```

It may be necessary to login and authenticate to the container registry.

Listing 140. Autentication to Container Registry

```
[student@servera ~]$ podman login registry.lab.example.com
```

4. Pull the image down

```
[student@servera ~]$ podman pull registry.lab.example.com/nginx
Trying to pull registry.lab.example.com/nginx...

... output omitted ...

Storing signatures
4bb46517cac397bdb0bab6eba09b0e1f8e90ddd17cf99662997c3253531136f8
```

5. Inspect the image with **podman inspect**

```
[student@servera ~]$ podman inspect registry.lab.example.com/nginx
[
    {
        "Id": "4bb46517cac397bdb0bab6eba09b0e1f8e90ddd17cf99662997c3253531136f8",

  ... output omitted ...
```

6. Run the image as a container

```
[student@servera ~]$ podman run -d --name nginxdemo registry.lab.example.com/nginx
b90de12239975532a66bae67e87dcc487252765bee018970be45bd0ed71115af
```

7. Verify Image is Running

```
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE                                 COMMAND               CREATED         STATUS             PORTS  NAMES
b90de1223997  registry.lab.example.com/nginx:latest  nginx -g daemon o...  29 seconds ago  Up 29 seconds ago         nginxdemo
```

8. Delete image and running container in a single command.

```
[student@servera ~]$ podman rmi registry.lab.example.com/nginx --force
Untagged: registry.lab.example.com/nginx:latest
Deleted: 4bb46517cac397bdb0bab6eba09b0e1f8e90ddd17cf99662997c3253531136f8
```

9. Verify container was stopped and image was deleted and removed

Listing 141. Source Description

```
[student@servera ~]$ podman ps -a
CONTAINER ID  IMAGE  COMMAND  CREATED  STATUS  PORTS  NAMES

[student@servera ~]$ podman images
REPOSITORY                              TAG      IMAGE ID       CREATED       SIZE
registry.access.redhat.com/ubi8/ubi     latest   ecbc6f53bba0   2 weeks ago   211 MB
registry.lab.example.com/rhel8/httpd-24 latest   7e93f25a9468   8 weeks ago   430 MB
```

A.4. Performing Advanced Container Management

A.4.1. Administering Containers with Podman

The **podman** command can be used to manage running or stopped containers.

A.4.2. Configuring Containers

The **podman run** command can start containers from an image. It can also be used to provide network access, container storage, and pass environment variables and settings to the container instead of modifying the container image.

A.4.2.1. Mapping Container Host Ports to the Container

When a network port on the container host is mapped to a port in the container, network traffic sent to the host port is redirected and received by the container. The **podman run -p** is used to map network ports from the host to a container port. Another reminder is that the **-d** option can cause a container to run in detached mode (daemon / background mode).

Listing 142. Running Apache and Mapping Network Ports

```
[student@servera ~]$ podman run -d -p 8000:8080 --name webdemo registry.redhat.io/rhel8/httpd-24
```

Listing 143. Verifying the Port Mapping

```
[student@servera ~]$ podman port -a
0d1d688ebbbd    8080/tcp -> 0.0.0.0:8000
```

Container Host Firewall

It is important to note that while there is no firewall service running in the container, the container host must allow the network traffic on whatever port has been forwarded to the container.

Listing 144. Using FirewallD on Container Host

```
[student@servera ~]$ sudo firewall-cmd --add-port=8000/tcp
[sudo] password for student:
success
```

A rootless container cannot open ports on the container host below 1024. Ports above 1024 can be mapped from the container host to any port in the container even when running a rootless container.

A.4.2.2. Passing Environment Variables to Configure a Container

Environment variables can be used to pass values to a container without modifying the container image. In order to see the environment variables a container image accepts, you can use the **podman inspect** command. There are different ways on obtaining information a container can use … one is to look at the **URL** which will point to a web page documenting the possible environment variables and how to use the container image.

The other method of determining possible environment variables can be the **usage** portion returned from **podman inspect** as this will often show how to run the container and provide environment variables with the **-e** on the command line.

Listing 145. Inspecting a Container

```
[student@servera ~]$ podman pull registry.redhat.io/rhel8/mariadb-103:1-102

[student@servera ~]$ podman inspect registry.redhat.io/rhel8/mariadb-103:1-102 | grep url
                "io.openshift.s2i.scripts-url": "image:///usr/libexec/s2i",
                "io.s2i.scripts-url": "image:///usr/libexec/s2i",
                "url": "https://access.redhat.com/containers/#/registry.access.redhat.com/rhel8/mariadb-103/images/1-102",

[student@servera ~]$ podman inspect registry.redhat.io/rhel8/mariadb-103:1-102 | grep usage
                "usage": "podman run -d -e MYSQL_USER=user -e MYSQL_PASSWORD=pass -e MYSQL_DATABASE=db -p 3306:3306 rhel8/mariadb-103",
```

The **podman run -e VARNAME=Value** will pass environment variables to the container and process this inside the container image.

A.4.3. Managing Containers

The **podman ps** command will list running containers while the **podman ps -a** command will list all containers, even if they have been stopped.

Table 9. Podman Commands

Podman Command	IP addresses
podman run	Starts a container based on a given container image and accepts other parameters such as **--name** specifying container name, **-d** for daemon/detached mode, **-p** to perform port forwarding, **it** to allow interactive commands, and more.
podman stop	Stops a container gracefully by name or container ID. The **podman stop --all** can stop all running containers
podman rm	The **podman rm <ContainerName/ID>** removes the stopped container from the host. Using **podman rm -a** will remove all stopped containers. It is also possible to use the **podman rm -a -f** to force stop and remove containers from the system.
podman rmi / podman image rm	Removes the specified image from the system.

Podman Command	IP addresses
podman restart	Restarts a stopped container. Creating a new container with same container ID and reuses the container state and filesystem.
podman kill	Sends UNIX signals to main process in the container. These signals are the same as those used by the **kill** command.

Removing a Container and an Image

It is possible to delete an image for a running container if you use the **-f** option with **podman rmi** command. This will stop and remove the containers using the image and it will then delete the image from the local system.

podman stop *Note*

The **podman stop** command will attempt to stop the container gracefully, but if the stop command fails, it send a **SIGTERM** and **SIGKILL** signal to the container.

A.4.4. Running Commands in a Container

In addition to running commands when launching the container with the **-it** option, it is possible to launch an interactive shell in order to debug a container or inspect the contents and other items in a container. The **podman exec** command can be used on a running container to provide an interactive shell within the container.

Listing 146. Using **podman exec**

```
[student@servera ~]$ podman exec -it demo /bin/bash
bash-4.4$

bash-4.4$ id
uid=1001(default) gid=0(root) groups=0(root)

bash-4.4$ exit
exit
```

A.4.5. DEMO - Performing Advanced Container Management

Example 42. DEMO - Advanced Container Management

1. Login to the Registry

```
[student@servera ~]$ podman login registry.lab.example.com
Username: admin
Password: redhat321
Login Succeeded!
```

2. Launch a MySQL Database

```
[student@servera ~]$ podman run -d --name demodb -e MYSQL_USER=demouser -e MYSQL_PASSWORD=redhat -e MYSQL_DATABASE=items -e
MYSQL_ROOT_PASSWORD=redhat -p 3306:3306 registry.lab.example.com/rhel8/mariadb-103:1-102
```

3. List running containers

```
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE                                          COMMAND     CREATED         STATUS             PORTS
NAMES
9a9bf84dcaab  registry.lab.example.com/rhel8/mariadb-103:1-102  run-mysqld  19 seconds ago  Up 19 seconds ago  0.0.0.0:3306-
>3306/tcp  demodb
```

4. List Port Forwards

```
[student@servera ~]$ podman port -a
9a9bf84dcaab    3306/tcp -> 0.0.0.0:3306
```

5. Attempt to connect to MySQL Instance

Listing 147. Install MariaDB Client Package

```
[student@servera ~]$ sudo yum install mariadb
```

Listing 148. Connect to MySQL Instance

```
[student@servera ~]$ mysql -u demouser -p --port=3306 --host=127.0.0.1
Enter password:
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 8
Server version: 10.3.17-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| items              |
| test               |
+--------------------+
3 rows in set (0.002 sec)
```

6. Stop the Container

```
[student@servera ~]$ podman stop demodb
9a9bf84dcaabf794ed5bc965df38a6ab5ff8856ea5608b46165ad32f48589744
```

7. List running containers

```
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE  COMMAND  CREATED  STATUS  PORTS  NAMES
```

8. Restart SQL Container

```
[student@servera ~]$ podman restart demodb
9a9bf84dcaabf794ed5bc965df38a6ab5ff8856ea5608b46165ad32f48589744
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE                                          COMMAND     CREATED        STATUS            PORTS
NAMES
9a9bf84dcaab  registry.lab.example.com/rhel8/mariadb-103:1-102  run-mysqld  6 minutes ago  Up 2 seconds ago  0.0.0.0:3306->3306/tcp
demodb
```

9. Verify connectivity and data

```
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE                                          COMMAND     CREATED        STATUS            PORTS
NAMES
9a9bf84dcaab  registry.lab.example.com/rhel8/mariadb-103:1-102  run-mysqld  6 minutes ago  Up 2 seconds ago  0.0.0.0:3306->3306/tcp
demodb
[student@servera ~]$ mysql -u demouser -p --port=3306 --host=127.0.0.1
Enter password:
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 8
Server version: 10.3.17-MariaDB MariaDB Server

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| items              |
| test               |
+--------------------+
3 rows in set (0.001 sec)
```

10. List runnign containers

```
[student@servera ~]$ podman ps
CONTAINER ID  IMAGE                                          COMMAND     CREATED         STATUS            PORTS
NAMES
9a9bf84dcaab  registry.lab.example.com/rhel8/mariadb-103:1-102  run-mysqld  10 minutes ago  Up 4 minutes ago  0.0.0.0:3306-
>3306/tcp  demodb
```

11. Delete and stop container

```
[student@servera ~]$ podman rm demodb -f
9a9bf84dcaabf794ed5bc965df38a6ab5ff8856ea5608b46165ad32f48589744
```

12. Verify container was stopped and removed

```
[student@servera ~]$ podman ps -a
CONTAINER ID  IMAGE                                  COMMAND              CREATED      STATUS                     PORTS
NAMES
0d1d688ebbbd  registry.redhat.io/rhel8/httpd-24:latest  /usr/bin/run-http...  3 hours ago  Exited (0) 41 minutes ago  0.0.0.0:8000-
>8080/tcp  webdemo
```

A.5. Attaching Persistent Storage to a Container

A.5.1. Preparing Permanent Storage Locations

Container storage is *ephemeral* meaning any data is gone once the container has been removed. If you want data to be persistent and preserved, then you must provide and mount persistent storage to the container.

A.5.2. Providing Persistent Storage from the Container Host

The easiest way to provide persistent storage to a container is to use a directory on the container host and mount it to the container for persistent storage. Conceptually, this is similar to adding a remote network volume and mounting it to the host file system. When the container is removed/deleted, files from the persistent storage volume remain on the container host filesystem.

A.5.2.1. Preparing the Host Directory

When providing storage to a container, it must be configured so container processes can access the storage. This generally involves:

- Configuring ownership and directory permissions
- Setting appropriate SELinux contexts

The user account within container application must have access to the host directory. Additionally, SELinux context types should be set for **container_file_t** as podman uses this SELinux context type to control what files on a host system the container can access. This is very important for applicaitons running as **root** inside a root container. Without the SELinux contexts being provided and setup correct, it is possible for the container and application to have **root** access on the host system.

A.5.2.2. Mounting a Volume

After creating and configuring the host directory, it is possible to mount the directory to the container using **--volume or -v** and specifying the ***HostDir*** **:** ***ContainerDir*****:Z** which will automatically apply the SELinux **container_file_t** context type to the host directory.

A.5.3. DEMO - Attaching Persistent Storage to a Container

Example 43. DEMO - Adding Persistent Storage to a Container

1. Create a directory for the container storage

```
[student@servera ~]$ mkdir -p webfiles/html
```

2. Place content in the directory for the webserver container

```
[student@servera ~]$ echo "This is a demo website" > webfiles/html/index.html
```

3. Launch a container with the Apache Service

```
[student@servera ~]$ podman run --name webdemo -d -p 8000:8080 -v ~/webfiles:/var/www:Z registry.lab.example.com/rhel8/httpd-24:1-
104
```

4. Verify Website is Running

```
[student@servera ~]$ curl http://localhost:8000
This is a demo website
```

5. Stop and Remove the container

```
[student@servera ~]$ podman rm webdemo -f
7c8616095932675d32ba3f7adc0e678375a317c293591b4adb62d7735c176ac7
```

8. System Security Policy and Compliance

System security and compliance is a primary concern for people when thinking about the protection of systems and integrity of data. This set of hands-on procedures will focus on obtaining the content and necessary packages to perform a basic scan and remediate the system based on scan results. As part of the lab, you will be customizing your own SCAP content for a scan, view the results, and generate an Ansible playbook based on the failed results.

8.1. Customizing SCAP Content

Red Hat includes the SCAP Workbench application as a GUI application which allows scanning, customizing, and saving SCAP scans and results. The SCAP Workbench can be used to perform scans of remote systems over an SSH connection or it can be utilized to scan the local system. Since the SCAP Workbench is a GUI application, it must run on a system with X-Windows installed.

Servers to Configure

- workstation

Packages to Install

- scap-workbench

Since we are using an application on a VM that requires a GUI, we can use X11 forwarding with the SSH connection by specifying a **-X** on the command line.

Step 1 - SSH to Workstation

The fist step is to connect to the workstation and forward X11 traffic back to the local system.

Example 44. Connecting to the Workstation VM

Listing 149. Connecting to Workstation Using SSH

```
# ssh root@workstation -X
```

Step 2 - Install Packages

After connecting to the Workstation VM, you will need to install the SCAP Workbench and its dependencies.

Example 45. Installing SCAP Workbench

Listing 150. Using Yum to Install SCAP Workbench

```
# yum install scap-workbench

Loaded plugins: langpacks, search-disabled-repos
Resolving Dependencies
--> Running transaction check
---> Package scap-workbench.x86_64 0:1.1.6-1.el7 will be installed
--> Processing Dependency: openscap-utils >= 1.2.0 for package: scap-workbench-1.1.6-1.el7.x86_64
--> Processing Dependency: scap-security-guide for package: scap-workbench-1.1.6-1.el7.x86_64
--> Running transaction check
---> Package openscap-utils.x86_64 0:1.2.16-8.el7_5 will be installed
--> Processing Dependency: openscap-containers = 1.2.16-8.el7_5 for package: openscap-utils-1.2.16-8.el7_5.x86_64
---> Package scap-security-guide.noarch 0:0.1.36-9.el7_5 will be installed
--> Processing Dependency: openscap-scanner >= 1.2.5 for package: scap-security-guide-0.1.36-9.el7_5.noarch
--> Running transaction check
---> Package openscap-containers.noarch 0:1.2.16-8.el7_5 will be installed
---> Package openscap-scanner.x86_64 0:1.2.16-8.el7_5 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

================================================================================
 Package                Arch      Version             Repository           Size
================================================================================
Installing:
 scap-workbench         x86_64    1.1.6-1.el7         rhel--server-dvd    1.8 M
Installing for dependencies:
 openscap-containers    noarch    1.2.16-8.el7_5      rhel_updates         27 k
 openscap-scanner       x86_64    1.2.16-8.el7_5      rhel_updates         61 k
 openscap-utils         x86_64    1.2.16-8.el7_5      rhel_updates         27 k
 scap-security-guide    noarch    0.1.36-9.el7_5      rhel_updates        2.6 M

Transaction Summary
================================================================================
Install  1 Package (+4 Dependent packages)

Total download size: 4.5 M
Installed size: 64 M
Is this ok [y/d/N]:
```

Some things might already be installed for you, if SCAP Workbench is already installed, please move on to the next step. Also note the dependencies for SCAP Workbench as they are automatically installed.

Step 3 - Launching SCAP Workbench

In order to run a scan or customize SCAP content, you will need to launch the SCAP Workbench application.

You **must** use SCAP Workbench from a GUI, so it will need to run either locally or through an SSH connection with X11 forwarded.

Example 46. Launching SCAP Workbench

Listing 151. Using SCAP Workbench

```
# scap-workbench
```

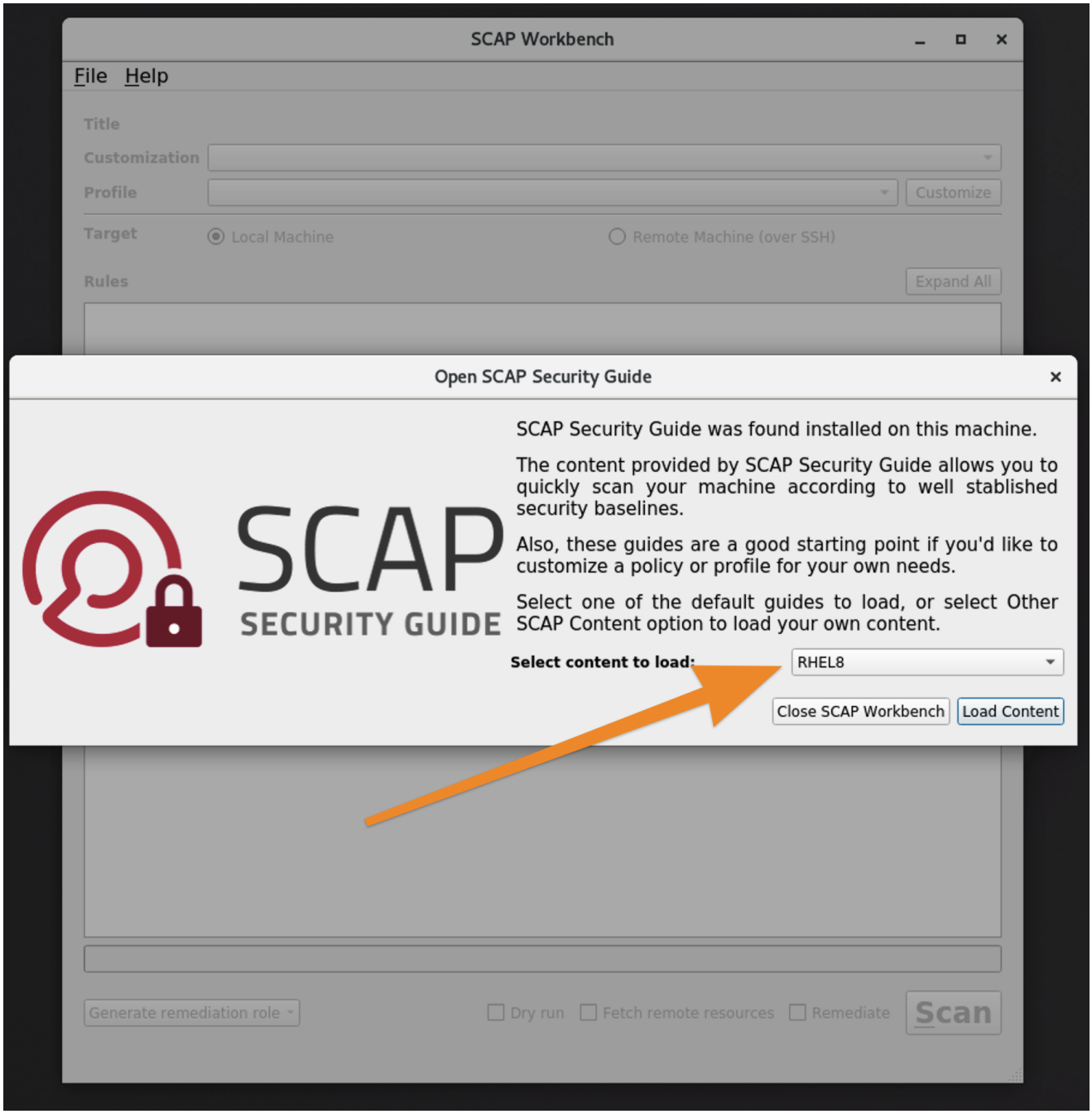


Figure 90. SCAP Workbench Startup

Step 4 - Creating Custom Content

Once SCAP Workbench has been launched, select the content to load. For this lab, we will be using the RHEL7 content.

Example 47. Creating Custom Content

1. For **Select content to load:** select "**RHEL8**", then click "**Load Content**"
2. Select the **Profile** you want to use to start customization

For this example, we will use the **OSPP - Protection Profile for General Purpose Operating Systems** Baseline

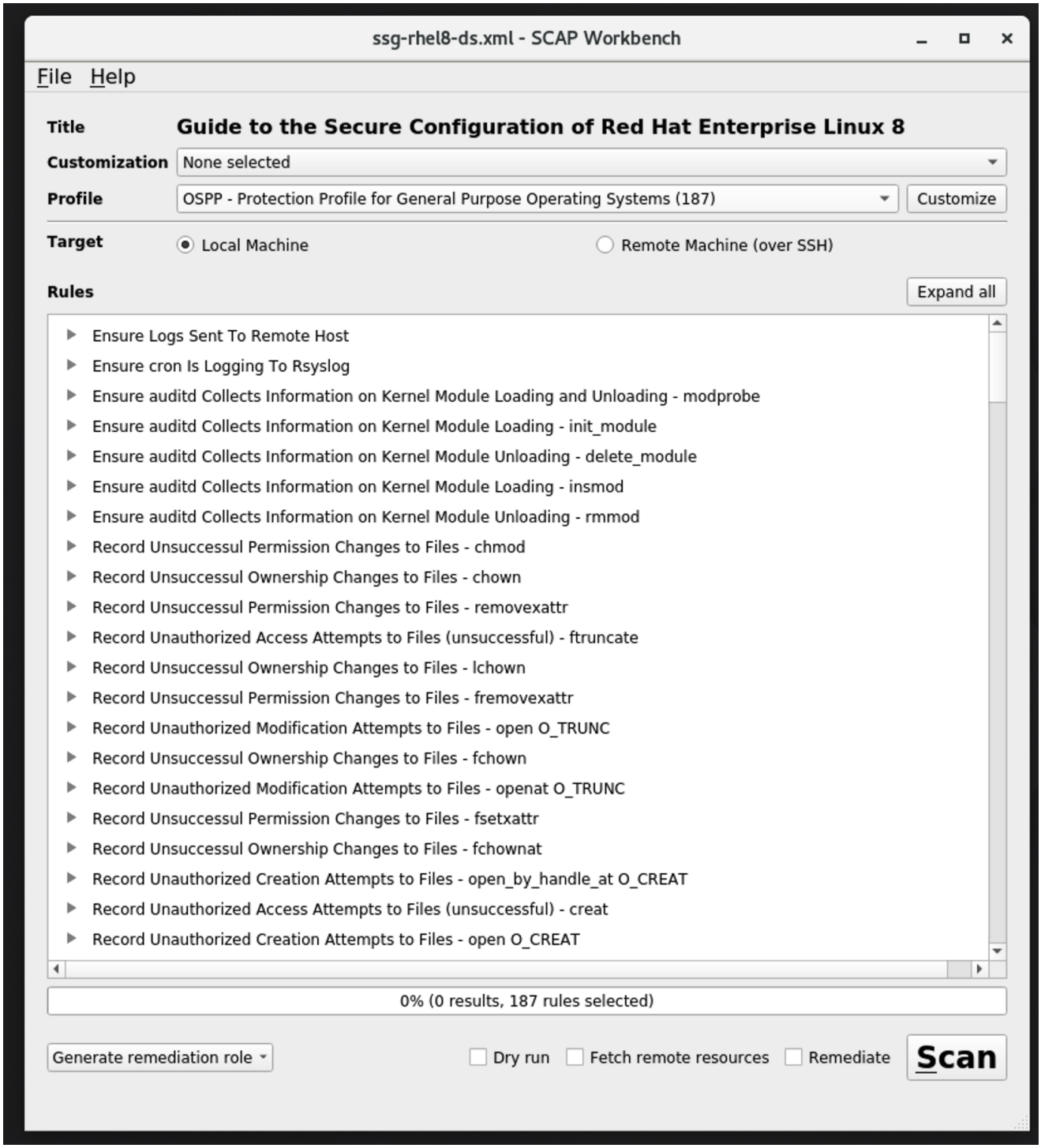


Figure 91. SCAP Workbench OSPP Profile

3. Click "**Customize**" to create custom SCAP content based on the chosen profile, and give it a name.

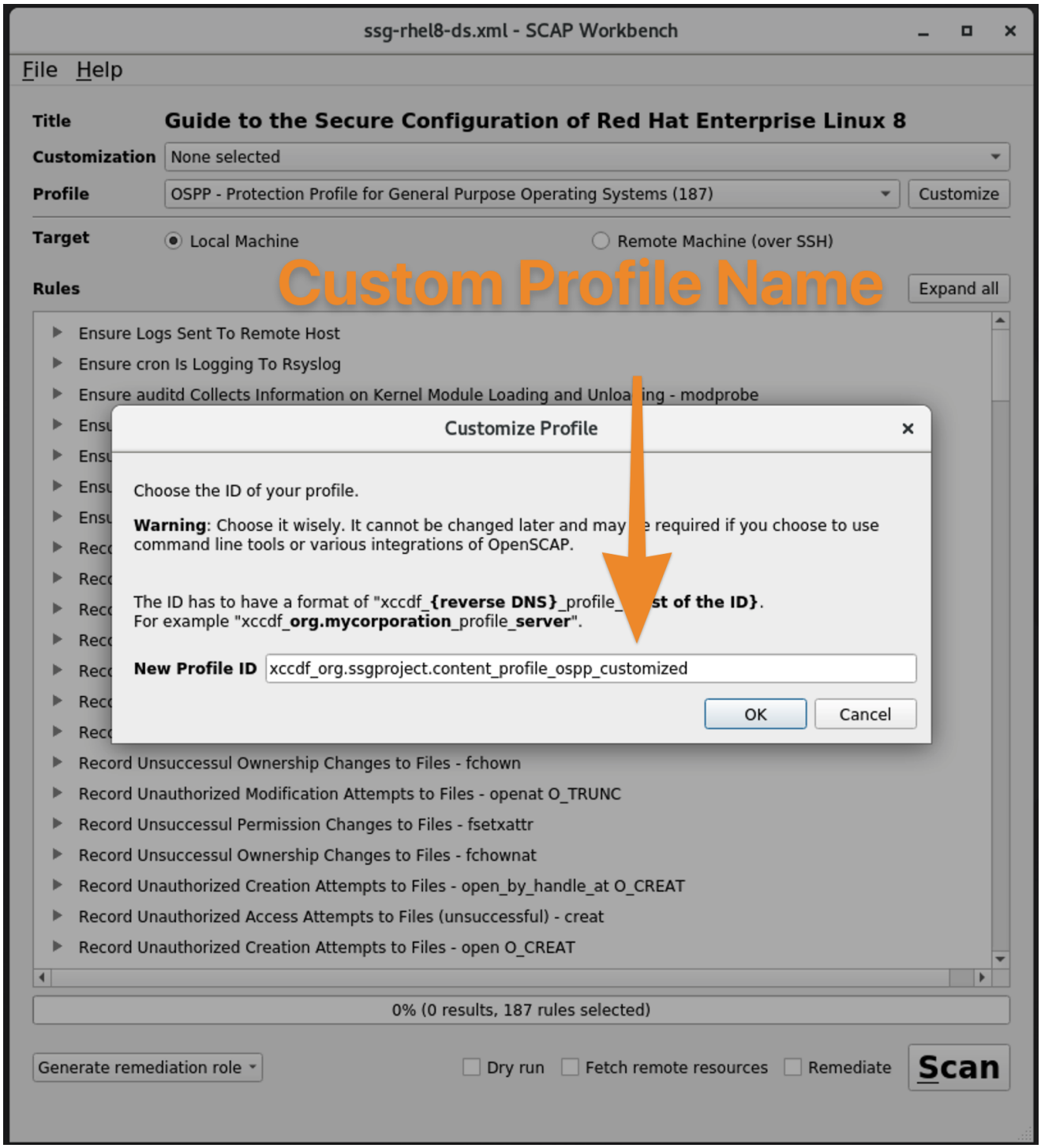


Figure 92. SCAP Custom OSPP Profile Creation

The name for this is: **xccdf_org.ssgproject.content_profile_ospp_customized**

4. Click "Deselect All" so that you can select the items you wish to include in your custom scan profile. **NOTE:** we are doing this to also limit it to a few checks for the example.

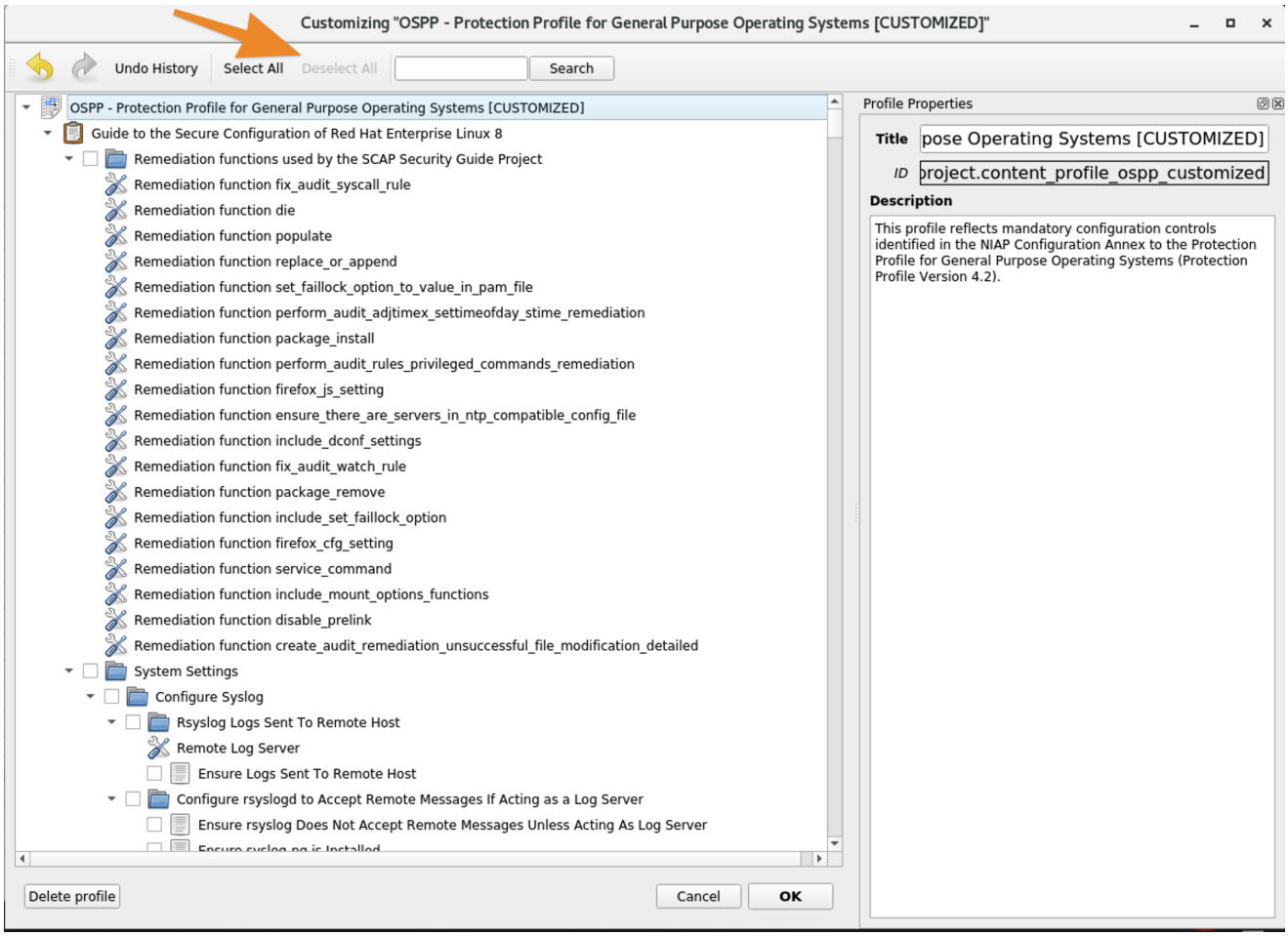


Figure 93. SCAP Custom Profile Selections

For this lab, we will be setting the minimum password length and PAM Password quality settings

5. Search for Password to set **minimum password length** and set the values in **login.defs**. Check **Set Password Minimum Length in login.defs** and click on the **minimum password legnth** and set the value to **18**

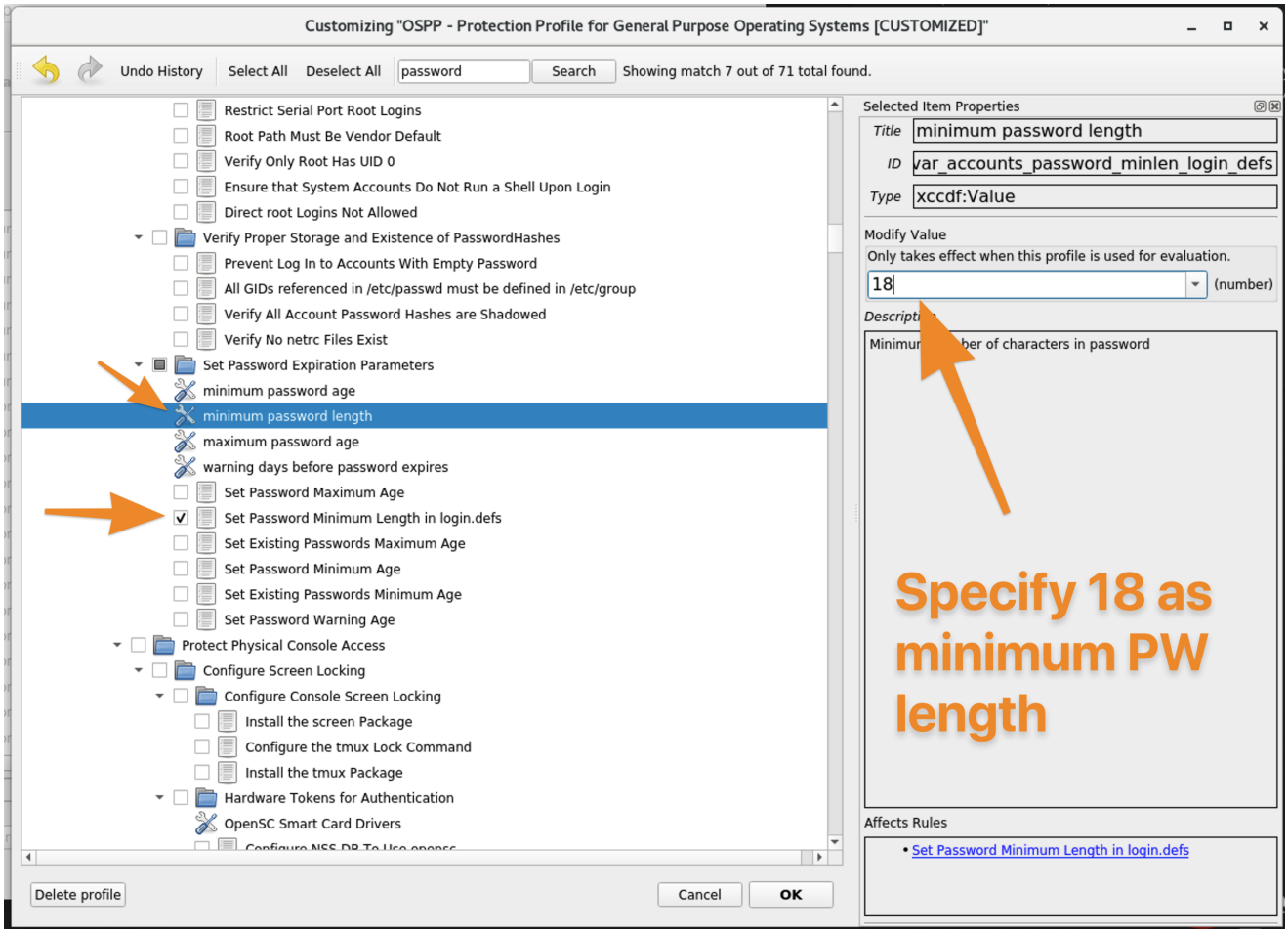


Figure 94. SCAP Custom Profile Password Settings for Login.Defs

6. Set password quality requirements with PAM. Search for the minlen and set it to **18**. Also, place a checkbox in **Set Password Quality Requirements with pam_quality**. Then click "OK"

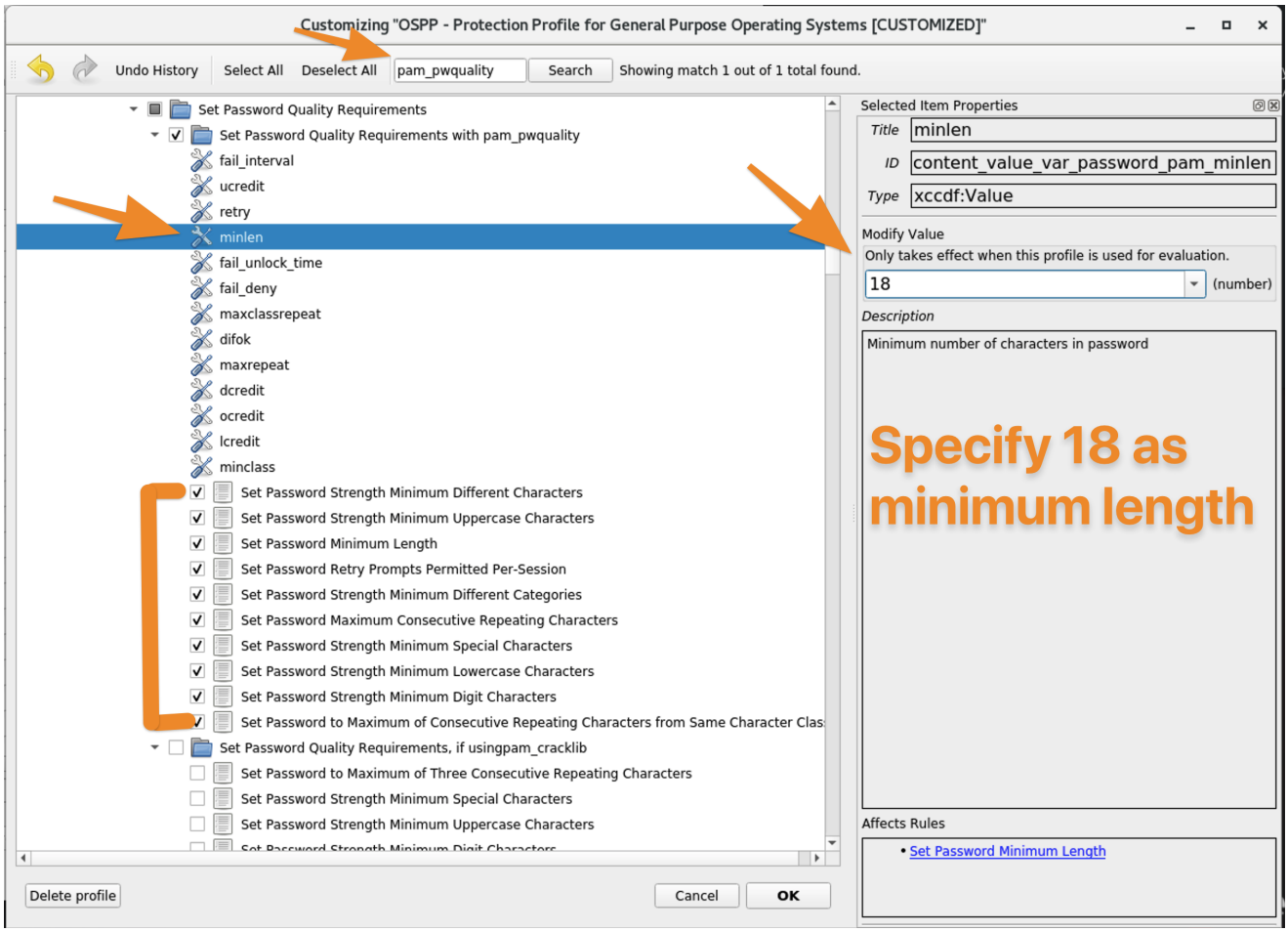


Figure 95. SCAP Custom Profile PAM Quality Requirements

7. At this point, we have taken the default settings from the OSPP profile with only the tailored pieces that we selected. The next step is to click "File ⇒ Save Customization Only" to save the custom content

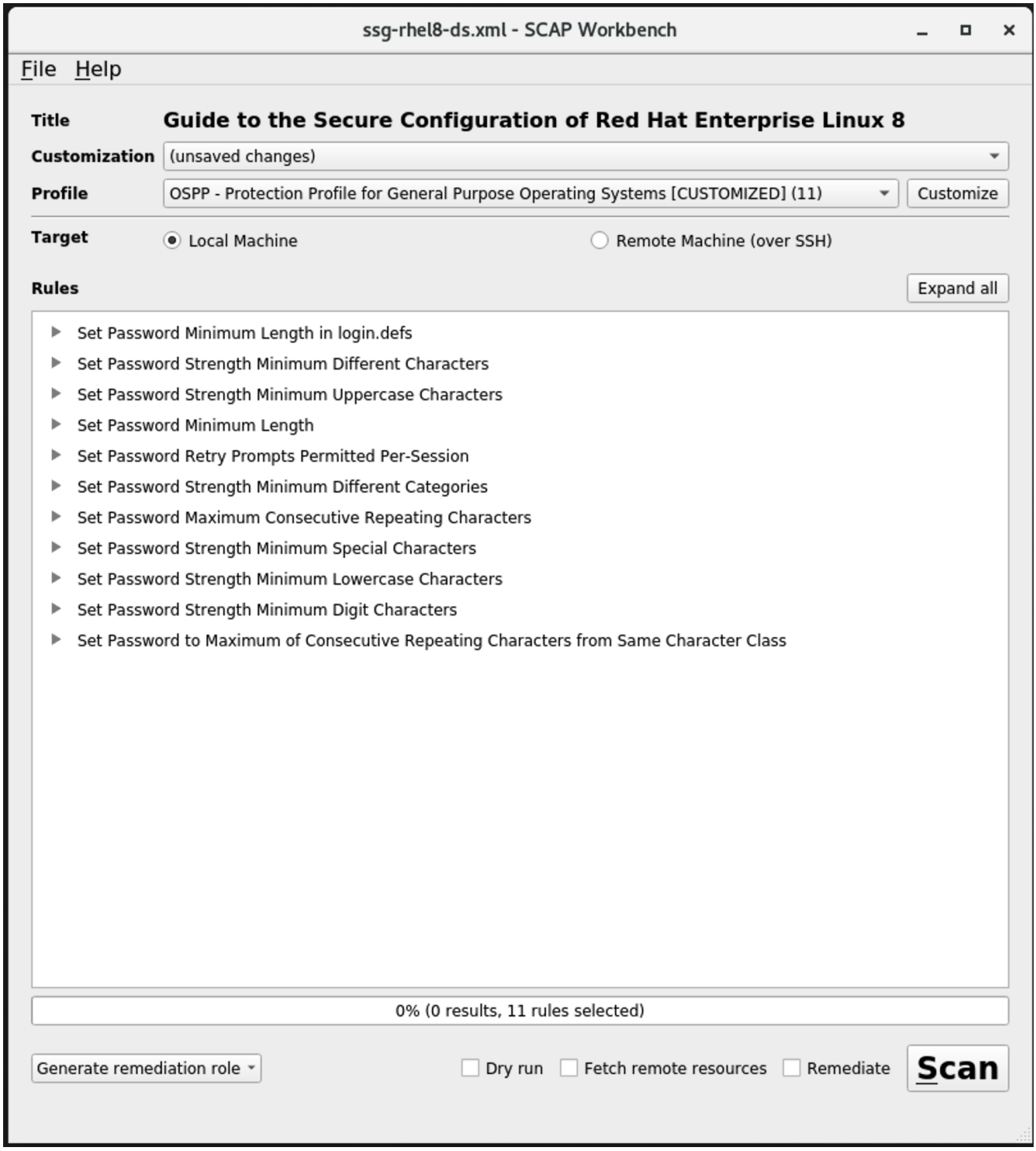


Figure 96. SCAP Custom Profile Selected Settings View

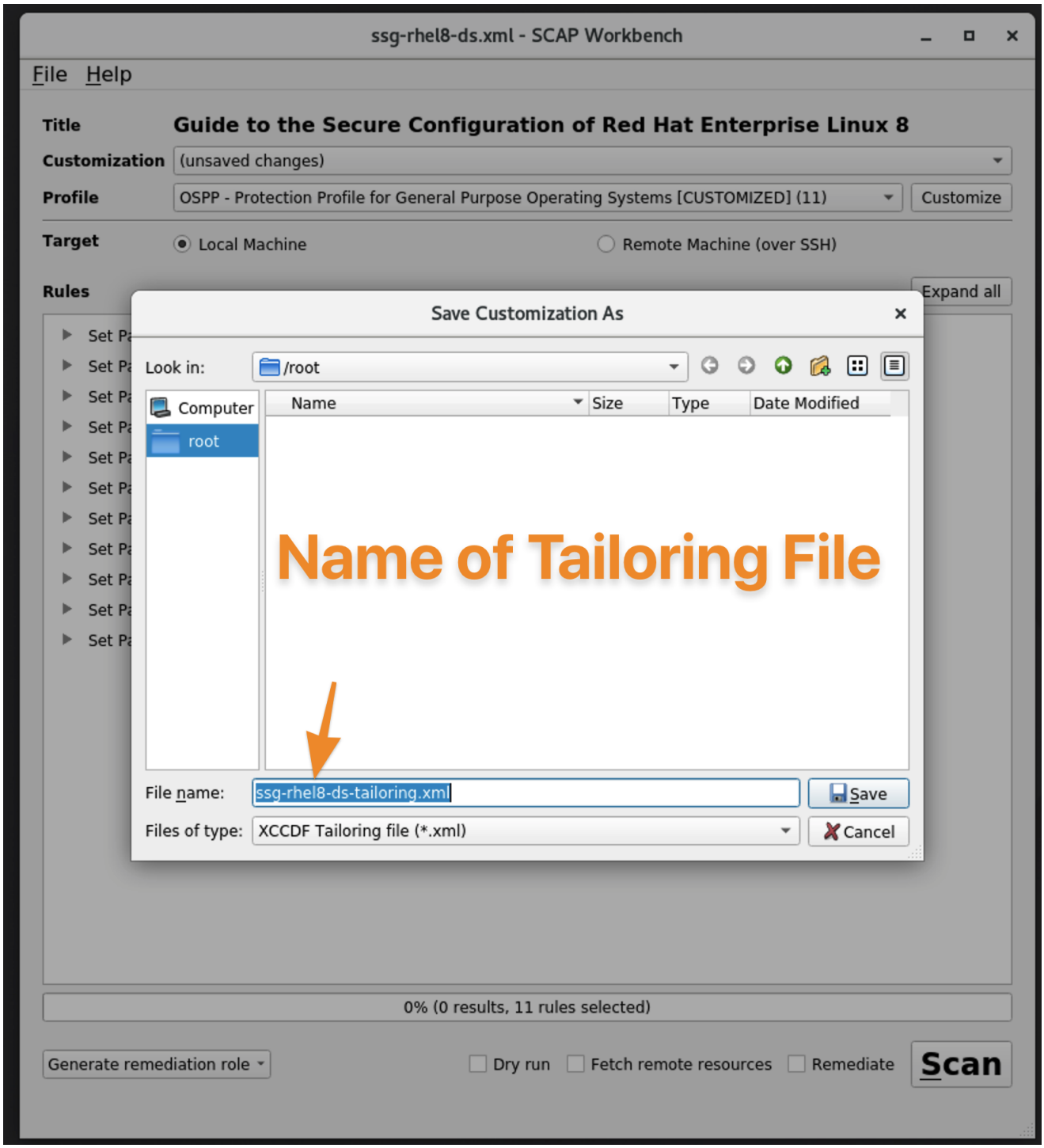


Figure 97. SCAP Custom Profile Creation Saving

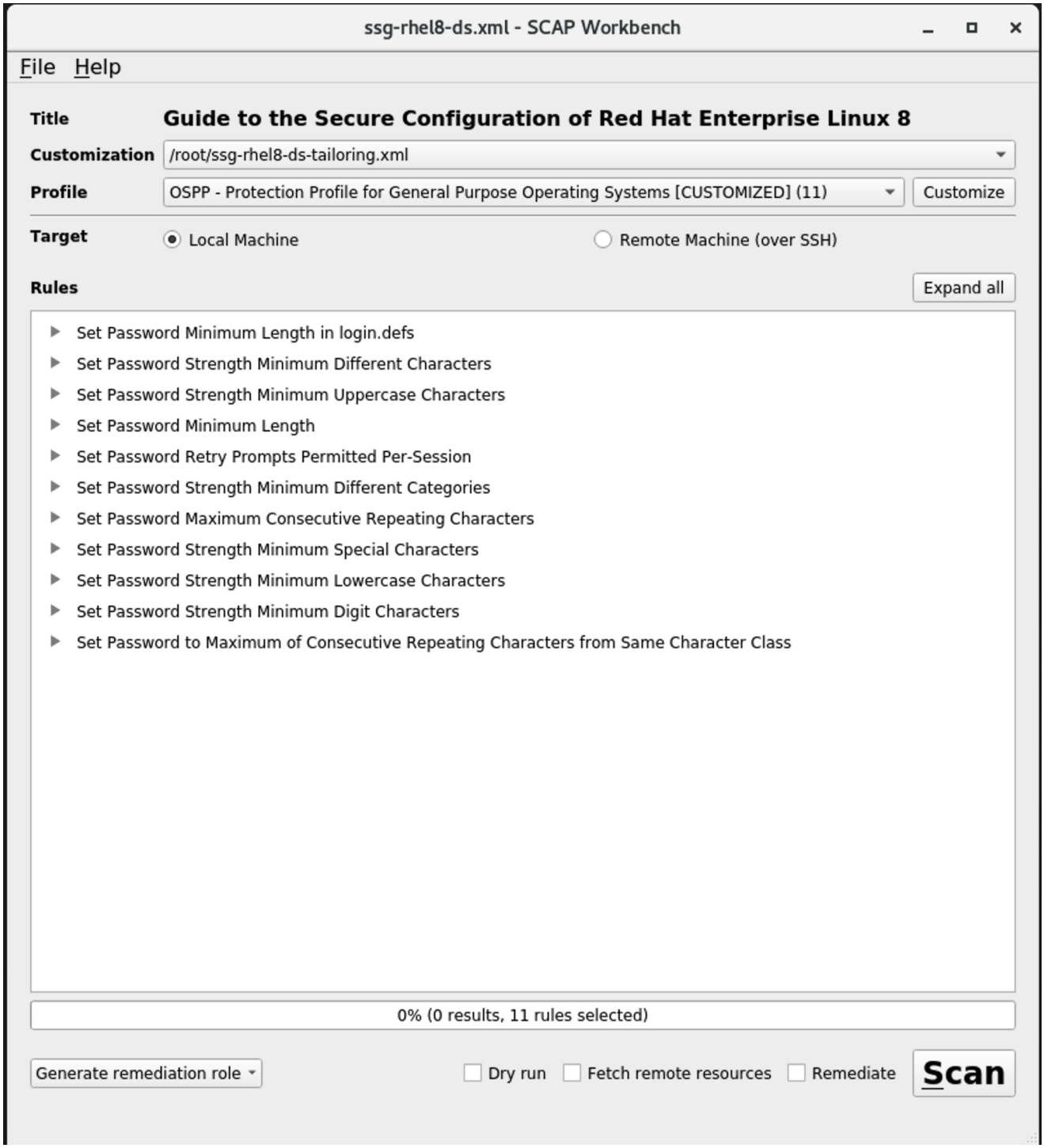


Figure 98. SCAP Custom Profile Final View

8. Copy the custom tailoring file to the server(s) being scanned. In this case, we will want to copy the file to **servera**

Listing 152. Copy custom content

```
[root@workstation ~]# scp ssg-rhel8-ds-tailoring.xml root@servera:
ssg-rhel8-ds-tailoring.xml                    100%   28KB  10.7MB/s   00:00
[root@workstation ~]#
```

8.2. Running a SCAP Scan with Custom Content

Servers to Configure

- servera

Packages to Install

- openscap-scanner
- scap-security-guide

Step 1 - SSH to serverc

The fist step is to connect to the server.

Example 48. Connecting to the **servera** *VM*

Listing 153. Connecting to **servera** *Using SSH*

```
# ssh root@servera
```

Step 2 - Install packages on servera

The second step is to install software on the server.

Example 49. Install software on **servera**

Listing 154. Installing Software on **servera**

```
[root@servera ~]# yum install scap-security-guide
Last metadata expiration check: 0:47:44 ago on Thu 16 Apr 2020 08:26:15 AM EDT.
Dependencies resolved.
================================================================================
 Package          Arch   Version       Repository                          Size
================================================================================
Installing:
 scap-security-guide
                  noarch 0.1.42-11.el8 rhel-8.0-for-x86_64-appstream-rpms 3.4 M
Installing dependencies:
 openscap         x86_64 1.3.0-7.el8   rhel-8.0-for-x86_64-appstream-rpms 3.3 M
 openscap-scanner x86_64 1.3.0-7.el8   rhel-8.0-for-x86_64-appstream-rpms  66 k
 xml-common       noarch 0.6.3-50.el8  rhel-8.0-for-x86_64-baseos-rpms     39 k

Transaction Summary
================================================================================
Install  4 Packages

Total download size: 6.9 M
Installed size: 132 M
Is this ok [y/N]: y


... output omitted ...

  Verifying        : openscap-1.3.0-7.el8.x86_64                              1/4
  Verifying        : openscap-scanner-1.3.0-7.el8.x86_64                      2/4
  Verifying        : scap-security-guide-0.1.42-11.el8.noarch                 3/4
  Verifying        : xml-common-0.6.3-50.el8.noarch                           4/4

Installed:
  scap-security-guide-0.1.42-11.el8.noarch    openscap-1.3.0-7.el8.x86_64
  openscap-scanner-1.3.0-7.el8.x86_64         xml-common-0.6.3-50.el8.noarch

Complete!
```

Learning about SCAP Commands

The SSG man page is a very good source of information for usage of the **oscap** tool as well as provides examples of how to use the SCAP SSG Guide profiles itself.

Listing 155. Looking at **SCAP Security Guide (SSG)** *Man Page*

```
# man scap-security-guide

scap-security-guide(8)      System Manager's Manual     scap-security-guide(8)

NAME
       SCAP  Security Guide - Delivers security guidance, baselines, and asso-
       ciated validation mechanisms utilizing the Security Content  Automation
       Protocol (SCAP).


... output omitted ...

EXAMPLES
       To  scan  your  system utilizing the OpenSCAP utility against the ospp-
       rhel7 profile:

       oscap xccdf eval --profile  ospp-rhel7  --results  /tmp/`hostname`-ssg-
       results.xml  --report  /tmp/`hostname`-ssg-results.html  --oval-results
       /usr/share/xml/scap/ssg/content/ssg-rhel7-xccdf.xml
```

Listing 156. Looking at ***oscap*** *Man Page*

```
# man oscap

OSCAP(8)                System Administration Utilities               OSCAP(8)

NAME
       oscap - OpenSCAP command line tool

SYNOPSIS
       oscap  [general-options]  module operation [operation-options-and-argu-
       ments]

DESCRIPTION
       oscap is Security Content Automation Protocol (SCAP) toolkit  based  on
       OpenSCAP  library.  It  provides  various  functions for different SCAP
       specifications (modules).

       OpenSCAP tool claims to provide capabilities of Authenticated  Configu-
       ration  Scanner  and  Authenticated Vulnerability Scanner as defined by
       The National Institute of Standards and Technology.

... output omitted ...

EXAMPLES
       Evaluate XCCDF content using CPE dictionary and produce html report. In
       this  case  we  use  United  States  Government  Configuration Baseline
       (USGCB) for Red Hat Enterprise Linux 5 Desktop.

              oscap xccdf eval --fetch-remote-resources --oval-results \
                      --profile united_states_government_configuration_baseline
 \
                      --report usgcb-rhel5desktop.report.html \
                      --results usgcb-rhel5desktop-xccdf.xml.result.xml \
                      --cpe usgcb-rhel5desktop-cpe-dictionary.xml \
                      usgcb-rhel5desktop-xccdf.xml
```

Step 3 - Running *oscap* scan

We will run the **oscap** utility to generate a report and a results file that can be sent back to the **workstation** system so that we can create an Ansible playbook for remediation and view the results of the report.

Be very careful about the name of the profile as this was selected during the creation of the custom profile/tailoring file portion when doing SCAP Workbench customizations.

Example 50. Scanning **servera**

Listing 157. Using **oscap** *and the tailoring profile to scan* **servera**

```
# [root@servera ~]# oscap xccdf eval \
--profile xccdf_org.ssgproject.content_profile_ospp_customized \
--tailoring-file ssg-rhel8-ds-tailoring.xml \
--results custom_scan_results.xml \
/usr/share/xml/scap/ssg/content/ssg-rhel8-ds.xml

Title   Set Password Minimum Length in login.defs
Rule    xccdf_org.ssgproject.content_rule_accounts_password_minlen_login_defs
Ident   CCE-80652-1
Result  fail

Title   Set Password Strength Minimum Different Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_difok
Ident   CCE-80654-7
Result  fail

Title   Set Password Strength Minimum Uppercase Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_ucredit
Ident   CCE-80665-3
Result  fail

Title   Set Password Minimum Length
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_minlen
Ident   CCE-80656-2
Result  fail

Title   Set Password Retry Prompts Permitted Per-Session
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_retry
Ident   CCE-80664-6
Result  fail

Title   Set Password Strength Minimum Different Categories
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_minclass
Result  fail

Title   Set Password Maximum Consecutive Repeating Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_maxrepeat
Result  fail

Title   Set Password Strength Minimum Special Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_ocredit
Ident   CCE-80663-8
Result  fail

Title   Set Password Strength Minimum Lowercase Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_lcredit
Ident   CCE-80655-4
Result  fail

Title   Set Password Strength Minimum Digit Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_dcredit
Ident   CCE-80653-9
Result  fail

Title   Set Password to Maximum of Consecutive Repeating Characters from Same Character Class
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_maxclassrepeat
Result  fail
```

Getting Custom Profile Name from Tailoring File

If you need to locate the profile used for the custom scanning content from the tailoring file, you can search for it with **grep**.

```
[root@servera ~]#  grep "Profile id" ssg-rhel8-ds-tailoring.xml
  <xccdf:Profile id="xccdf_org.ssgproject.content_profile_ospp_customized" extends
="xccdf_org.ssgproject.content_profile_ospp">
```

Step 4 - Creating a Results Report

You can create a results report file from the results file so you have a nice HTML file that is easy to ready with the results from the SCAP scan.

Example 51. Creating a SCAP Report from a Results File

Listing 158. Generating a Report

```
[root@servera ~]# oscap xccdf generate report \
custom_scan_results.xml > Custom_Scan_Report.html
```

Combining Steps 3 & 4

It is possible to perform a custom content scan which will generate the results file and the report for transfer back to the workstation for review.

Need to Specify

- **--results**
- **--report**

Listing 159. Creating a Results File and Report During Custom Content Scan

```
[root@servera ~]# oscap xccdf eval \
--profile xccdf_org.ssgproject.content_profile_ospp_customized \
--tailoring-file ssg-rhel8-ds-tailoring.xml \
--results custom_scan_results_2.xml \
--report Custom_Scan_Report_2.html \
/usr/share/xml/scap/ssg/content/ssg-rhel8-ds.xml

Title   Set Password Minimum Length in login.defs
Rule    xccdf_org.ssgproject.content_rule_accounts_password_minlen_login_defs
Ident   CCE-80652-1
Result  fail

Title   Set Password Strength Minimum Different Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_difok
Ident   CCE-80654-7
Result  fail

Title   Set Password Strength Minimum Uppercase Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_ucredit
Ident   CCE-80665-3
Result  fail

Title   Set Password Minimum Length
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_minlen
Ident   CCE-80656-2
Result  fail

Title   Set Password Retry Prompts Permitted Per-Session
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_retry
Ident   CCE-80664-6
Result  fail

Title   Set Password Strength Minimum Different Categories
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_minclass
Result  fail

Title   Set Password Maximum Consecutive Repeating Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_maxrepeat
Result  fail

Title   Set Password Strength Minimum Special Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_ocredit
Ident   CCE-80663-8
Result  fail

Title   Set Password Strength Minimum Lowercase Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_lcredit
Ident   CCE-80655-4
Result  fail

Title   Set Password Strength Minimum Digit Characters
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_dcredit
Ident   CCE-80653-9
Result  fail

Title   Set Password to Maximum of Consecutive Repeating Characters from Same Character Class
Rule    xccdf_org.ssgproject.content_rule_accounts_password_pam_maxclassrepeat
Result  fail
```

Step 5 - Transferring Results File and Report to Workstation

After you have the results files and the report, you should transfer it to your graphical workstation (**workstation**) for further analysis.

Example 52. Transferring Results

Listing 160. Transferring the Results and Report Files

```
[root@servera ~]# scp *.xml *.html root@workstation:
The authenticity of host 'workstation (<no hostip for proxy command>)' can't be established.
ECDSA key fingerprint is SHA256:pOQ1OJmyF2PFI+jxyFoOSCfi+1oWNsUruy2DZNjg+N0.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'workstation' (ECDSA) to the list of known hosts.
root@workstation's password:
custom_scan_results_2.xml                     100% 4086KB  32.4MB/s   00:00
custom_scan_results.xml                       100% 4086KB  60.0MB/s   00:00
ssg-rhel8-ds-tailoring.xml                    100%   28KB  16.2MB/s   00:00
Custom_Scan_Report_2.html                     100%  332KB  44.3MB/s   00:00
Custom_Scan_Report.html                       100%  332KB  37.6MB/s   00:00
[root@servera ~]#
```

Step 6 - Viewing the SCAP scan report

After you have transferred the results file to **workstation** you can open the HTML report in a web browser. In this case we will use ***firefox*** to open the file.

Example 53. Viewing the SCAP Report

Listing 161. Opening the SCAP HTML Report with Firefox

```
[root@workstation ~]# firefox Custom_Scan_Report.html
```

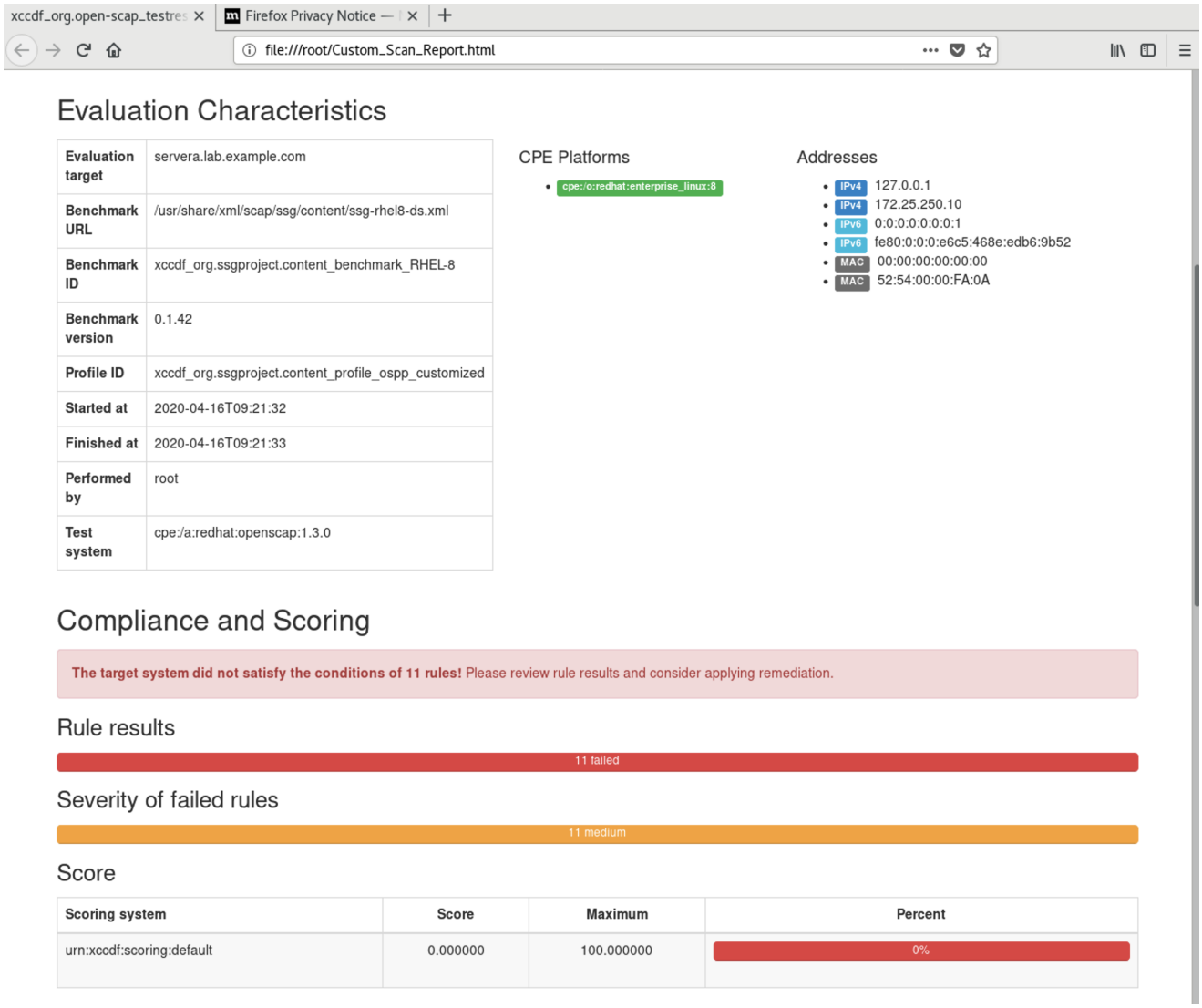


Figure 99. SCAP Scan Results Report in Firefox

Firefox may not open the file based on SELinux context triggers. In order to get around this you can use the command prompt and do **setenforce 0** to allow you to open the report.

8.3. Creating an Ansible Remediation Playbook Based on SCAP Scan Results

The OpenSCAP project and content created by Red Hat can automatically remediate findings from OpenSCAP scans. The findings can be remediated in many ways (**BASH**, **Ansible**, etc.). While things are mostly complete, there are some automated remediations that have not yet been developed.

There are multiple automatic remediation methods developed, but at this time, there isn't a script to fix everything.

Servers to Configure

- servera

We will continue to use **workstation** as our master SCAP system as it should have Ansible and SCAP Workbench installed.

Step 1 - Creating an Ansible Playbook from Results

The first step will be to generate an Ansible playbook from the SCAP scan results for system remediation.

Example 54. Generating Ansible Playbook

Listing 162. Ansible Playbook Generation

```
[root@workstation ~]# oscap xccdf generate fix \
--profile xccdf_org.ssgproject.content_profile_ospp_customized \
--tailoring-file ssg-rhel8-ds-tailoring.xml \
--fix-type ansible \
--result-id "" \
custom_scan_results.xml > Custom_Scan_Fix.yml
```

Viewing Remediation Playbook

It is also a good idea to view the created playbook for the system prior to running it.

```
[root@workstation ~]# cat Custom_Scan_Fix.yml
---
#################################################################################
#
# Ansible remediation role for the results of evaluation of profile
xccdf_org.ssgproject.content_profile_ospp_customized
# XCCDF Version:  unknown
#
# Evaluation Start Time:  2020-04-16T09:21:32
# Evaluation End Time:  2020-04-16T09:21:33
#
# This file was generated by OpenSCAP 1.3.0 using:
#   $ oscap xccdf generate fix --result-id xccdf_org.open-
scap_testresult_xccdf_org.ssgproject.content_profile_ospp_customized --template urn:xccdf:fix:script:ansible
xccdf-results.xml
#
# This script is generated from the results of a profile evaluation.
```

```
# It attempts to remediate all issues from the selected rules that failed the test.
#
# How to apply this remediation role:
# $ ansible-playbook -i "localhost," -c local playbook.yml
# $ ansible-playbook -i "192.168.1.155," playbook.yml
# $ ansible-playbook -i inventory.ini playbook.yml
#
################################################################################


 - hosts: all
   vars:
      var_accounts_password_minlen_login_defs: !!str 18
      var_password_pam_difok: !!str 8
      var_password_pam_ucredit: !!str -1
      var_password_pam_minlen: !!str 18
      var_password_pam_retry: !!str 3
      var_password_pam_minclass: !!str 3
      var_password_pam_maxrepeat: !!str 3
      var_password_pam_ocredit: !!str -1
      var_password_pam_lcredit: !!str -1
      var_password_pam_dcredit: !!str -1
      var_password_pam_maxclassrepeat: !!str 4
   tasks:


    - name: "Set Password Minimum Length in login.defs"
      lineinfile:
        dest: /etc/login.defs
        regexp: "^PASS_MIN_LEN *[0-9]*"
        state: present
        line: "PASS_MIN_LEN        {{ var_accounts_password_minlen_login_defs }}"
      tags:
        - accounts_password_minlen_login_defs
        - medium_severity
        - restrict_strategy
        - low_complexity
        - low_disruption
        - CCE-80652-1
        - NIST-800-53-IA-5(f)
        - NIST-800-53-IA-5(1)(a)
        - NIST-800-171-3.5.7
        - CJIS-5.6.2.1


... Output Omitted ...

    - name: Ensure PAM variable maxclassrepeat is set accordingly

      lineinfile:
        create: yes
        dest: "/etc/security/pwquality.conf"
        regexp: '^#?\s*maxclassrepeat'
        line: "maxclassrepeat = {{ var_password_pam_maxclassrepeat }}"

      tags:
        - accounts_password_pam_maxclassrepeat
        - medium_severity
        - restrict_strategy
        - low_complexity
        - low_disruption
        - NIST-800-53-IA-5
        - NIST-800-53-IA-5(c)
```

Ansible is not setup for the lab

Before we can do the next steps, we will download an Ansible config file and an inventory file so we can properly run the playbook.

Listing 163. Error Output Message

```
[root@workstation ~]# ansible-playbook Custom_Scan_Fix.yml
 [WARNING]: provided hosts list is empty, only localhost is available. Note
that the implicit localhost does not match 'all'


PLAY [all] *********************************************************************
skipping: no hosts matched

PLAY RECAP *********************************************************************
[root@workstation ~]#
```

Step 2 - Downloading Ansible Config and Ansible Inventory Files

This step is needed so that our Ansible system can be configured with various configuration options and the inventory files so we can run the given playbook.

Example 55. Downloading Ansible Files

Listing 164. Downloading Ansible Files

```
[root@workstation ~]# wget http://people.redhat.com/~tmichett/rh354/inventory
--2020-04-16 09:38:50--  http://people.redhat.com/~tmichett/rh354/inventory
Resolving people.redhat.com (people.redhat.com)... 209.132.183.19
Connecting to people.redhat.com (people.redhat.com)|209.132.183.19|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 24
Saving to: 'inventory'

inventory           100%[===================>]      24  --.-KB/s    in 0s

2020-04-16 09:38:50 (2.69 MB/s) - 'inventory' saved [24/24]


[root@workstation ~]# wget http://people.redhat.com/~tmichett/rh354/ansible.cfg
--2020-04-16 09:39:34--  http://people.redhat.com/~tmichett/rh354/ansible.cfg
Resolving people.redhat.com (people.redhat.com)... 209.132.183.19
Connecting to people.redhat.com (people.redhat.com)|209.132.183.19|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 159
Saving to: 'ansible.cfg'

ansible.cfg         100%[===================>]     159  --.-KB/s    in 0s

2020-04-16 09:39:35 (13.8 MB/s) - 'ansible.cfg' saved [159/159]
```

Reviewing Ansible Configurations

The **inventory** file provided only has a single host **servera** in there. On real systems, you must be very cautious of running remediation playbooks against an inventory file as it could apply to unintended systems. Additionally the **ansible.cfg** file provided was created for use in this lab environment. Both of these items should be taken into account when doing going through the process on production systems.

```
[root@workstation ~]# cat inventory
servera.lab.example.com

[root@workstation ~]# cat ansible.cfg
[defaults]
roles_path = /etc/ansible/roles:/usr/share/ansible/roles
log_path   = /tmp/ansible.log
inventory  = ./inventory

[privilege_escalation]
become=True
[root@workstation ~]#
```

Step 3 - Run the Ansible Playbook

This step will utilize the **workstation** system which is configured as your Ansible management node and will run the playbook to remediate the results on the **servera** system.

*Example 56. Remediation of **serverc** with Ansible Playbook*

Listing 165. Running the Ansible Playbook

```
[root@workstation ~]# ansible-playbook Custom_Scan_Fix.yml

PLAY [all] *********************************************************************

TASK [Gathering Facts] *********************************************************
ok: [servera.lab.example.com]

TASK [Set Password Minimum Length in login.defs] *******************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable difok is set accordingly] ****************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable ucredit is set accordingly] **************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable minlen is set accordingly] ***************************
changed: [servera.lab.example.com]

TASK [Set Password Retry Prompts Permitted Per-Session - system-auth (change)] ***
ok: [servera.lab.example.com]

TASK [Set Password Retry Prompts Permitted Per-Session - system-auth (add)] ****
changed: [servera.lab.example.com]

TASK [Ensure PAM variable minclass is set accordingly] *************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable maxrepeat is set accordingly] ************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable ocredit is set accordingly] **************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable lcredit is set accordingly] **************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable dcredit is set accordingly] **************************
changed: [servera.lab.example.com]

TASK [Ensure PAM variable maxclassrepeat is set accordingly] *******************
changed: [servera.lab.example.com]

PLAY RECAP *********************************************************************
servera.lab.example.com    : ok=13   changed=11   unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

After running the playbook, you can see that there were 10 changes that were made to the system and exactly which parameters were changed. The next thing to do is perform another scan of the system to ensure that it is now fully compliant.

Step 4 - Rescan System and Review Results

Example 57. Scanning System after Fixes and Verifying Results

Listing 166. Performing SCAP Verification Scan

```
[root@servera ~]# oscap xccdf eval \
--profile xccdf_org.ssgproject.content_profile_ospp_customized \
--tailoring-file ssg-rhel8-ds-tailoring.xml \
--results custom_scan_results_fixed.xml \
--report Custom_Scan_Report_Fixed.html \
/usr/share/xml/scap/ssg/content/ssg-rhel8-ds.xml
```

Listing 167. Copying Results to Workstation

```
[root@servera ~]# scp custom_scan_results_fixed.xml Custom_Scan_Report_Fixed.html workstation:
root@workstation's password:
custom_scan_results_fixed.xml                 100% 4086KB  60.3MB/s   00:00
Custom_Scan_Report_Fixed.html                 100%  282KB  48.4MB/s   00:00
```

Listing 168. Viewing Results on Workstation

```
[root@workstation ~]# firefox Custom_Scan_Report_Fixed.html
```

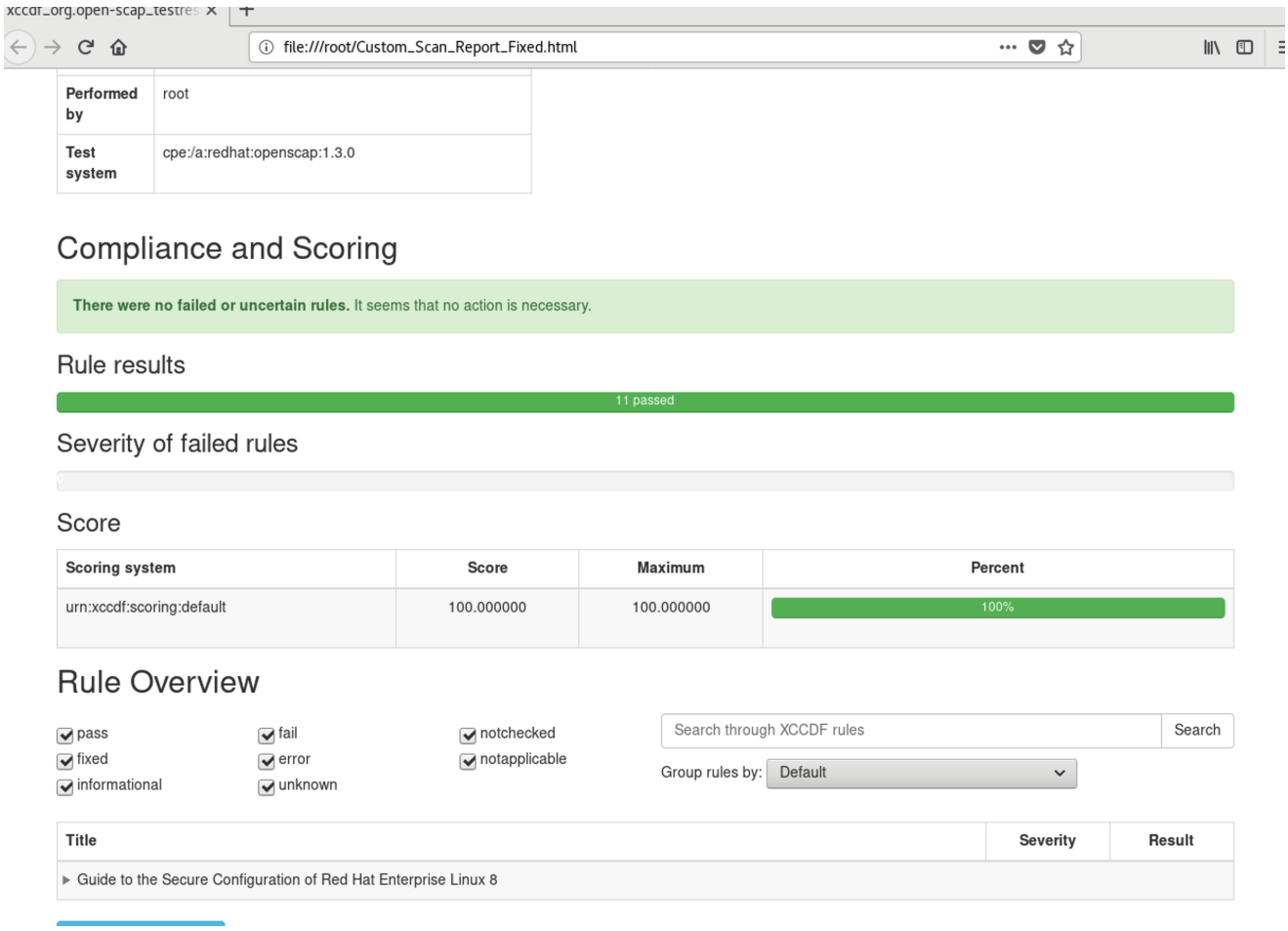


Figure 100. Fixed SCAP Scan Results Report in Firefox