



Red Hat Training and Certification

Managing and Building Container Images and Containers

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Introduction

This guide will 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 ..o |
| . + + .o o ...o |
|. = S o.B o|
| o o . .* =.+|
| B o .+ o +=|
| B E . . .0+|
| . .+|
+---[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
```

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.

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
```

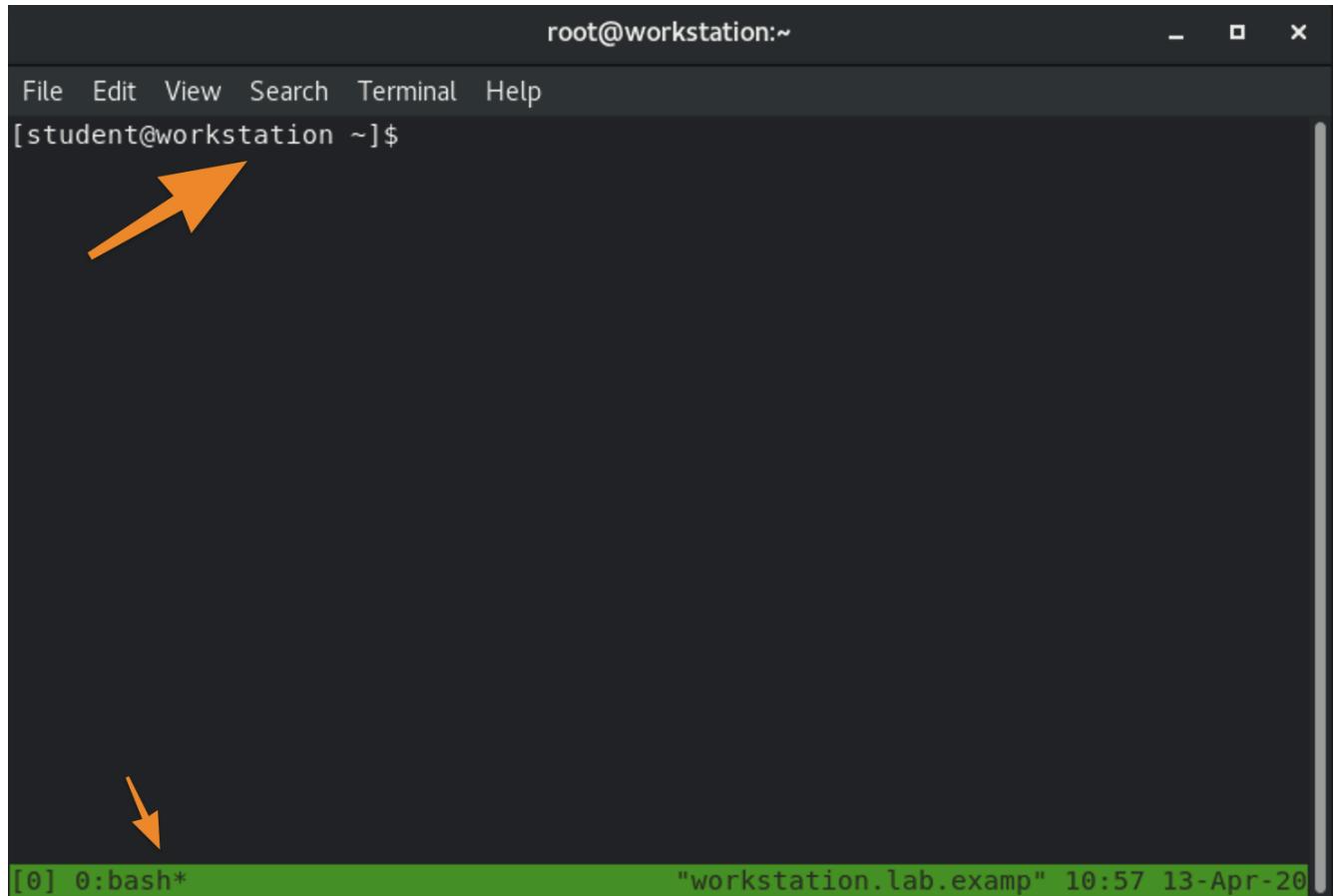


Figure 1. tmux Terminal Window

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
```

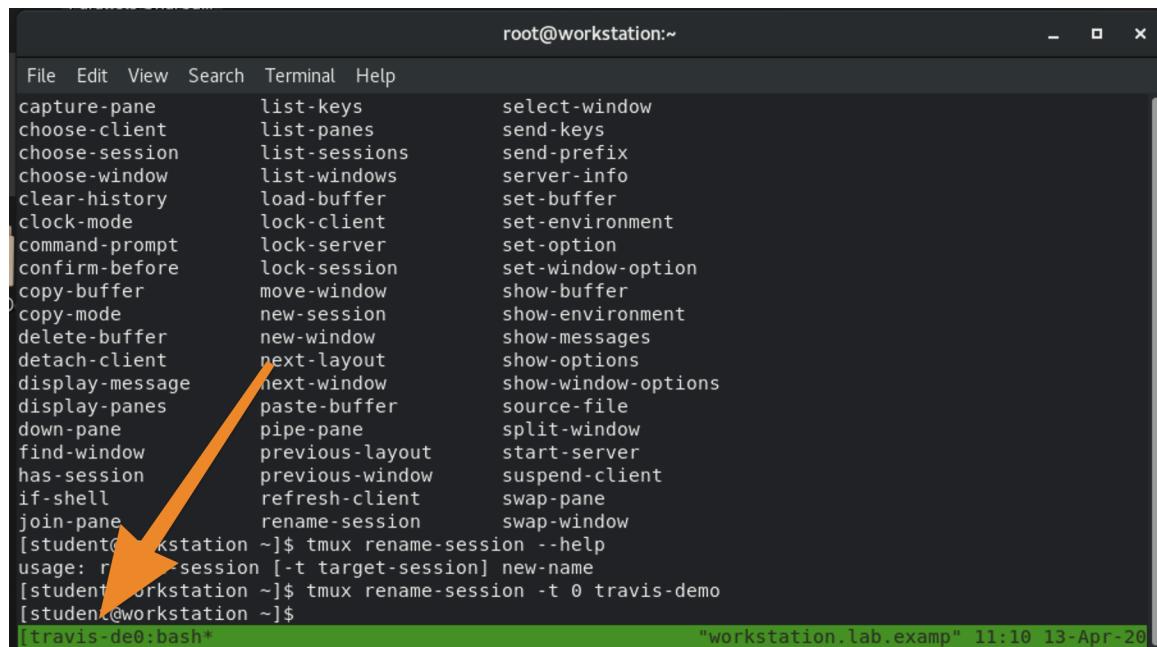
Naming or Renaming Sessions

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
```

```
root@workstation:~ 
File Edit View Search Terminal Help
capture-pane      list-keys          select-window
choose-client    list-panes         send-keys
choose-session   list-sessions      send-prefix
choose-window    list-windows      server-info
clear-history    load-buffer       set-buffer
clock-mode       lock-client      set-environment
command-prompt   lock-server      set-option
confirm-before   move-window      set-window-option
copy-buffer      new-session       show-buffer
copy-mode        new-window       show-environment
delete-buffer    next-layout      show-messages
detach-client    paste-buffer     show-options
display-message  pipe-pane        show-window-options
display-panes    previous-layout source-file
down-pane        previous-window  split-window
find-window      refresh-client   start-server
has-session      rename-session   suspend-client
if-shell         rename-session   swap-pane
join-pane        swap-window     swap-window
[student@workstation ~]$ tmux rename-session --help
usage: rename-session [-t target-session] new-name
[student@workstation ~]$ tmux rename-session -t 0 travis-demo
[student@workstation ~]$ 
[travis-de0: bash*]
```

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/>

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/`

1. 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.
```

2. 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...
```

3. 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>

1.4. FirewallID

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 FirewallID and the **firewall-cmd** management commands implemented in RHEL 7.x have evolved and leveraging FirewallID is still the preferred firewall management solution in RHEL 8.x.

1.4.1. FirewallID Service Definitions

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

FirewallID 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 dhcpcv6-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 dhcpcv6-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. FirewallID Files and Locations

FirewallID 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 FirewallID also reside in **/etc/**. Default configuration files for services, zones, and other FirewallID functionality resides in **/usr/lib/firewalld**. This location contains all defined services files and default configuration files for FirewallID and used by the **firewall-cmd** utility.

Listing 18. FirewallID 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 FirewallID Services to Verify New Service

Listing 22. Getting Listing of FirewallID Services

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

FirewallID Delays in Discovering a Service



Depending on system speed and refreshing of FirewallID 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. FirewallID Configuration Files

As stated above, the main FirewallID 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. FirewallID 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="dhcpcv6-client"/>
  <service name="cockpit"/>
  <service name="custom_ssh"/>
</zone>
```

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 packages.

1.5.1. Installing Additional Cockpit Packages

Listing 26. Install all Base Cockpit Packages

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

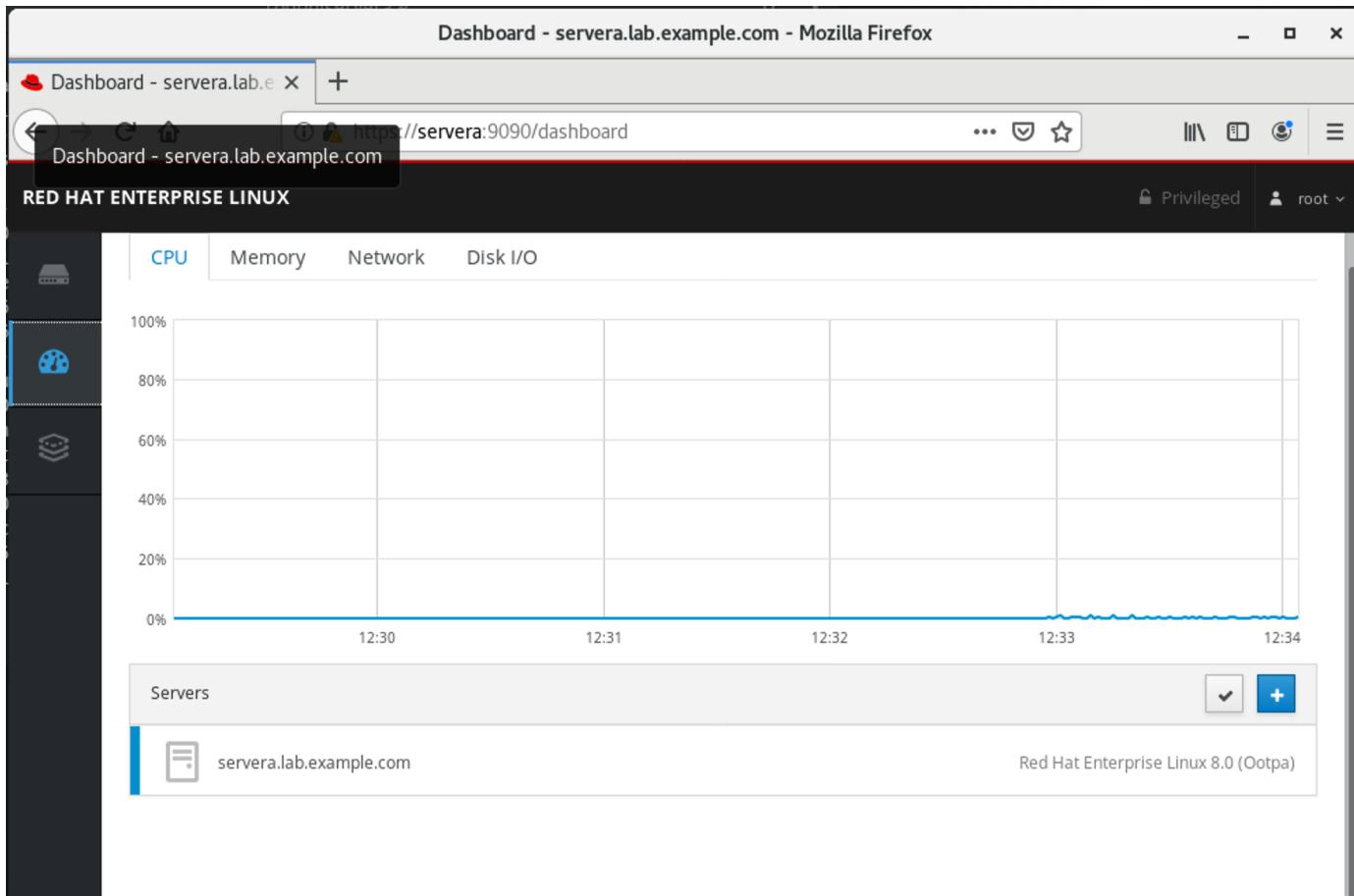


Figure 3. Cockpit Dashboard

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.

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

Listing 27. Test and Enable Cockpit

```
[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

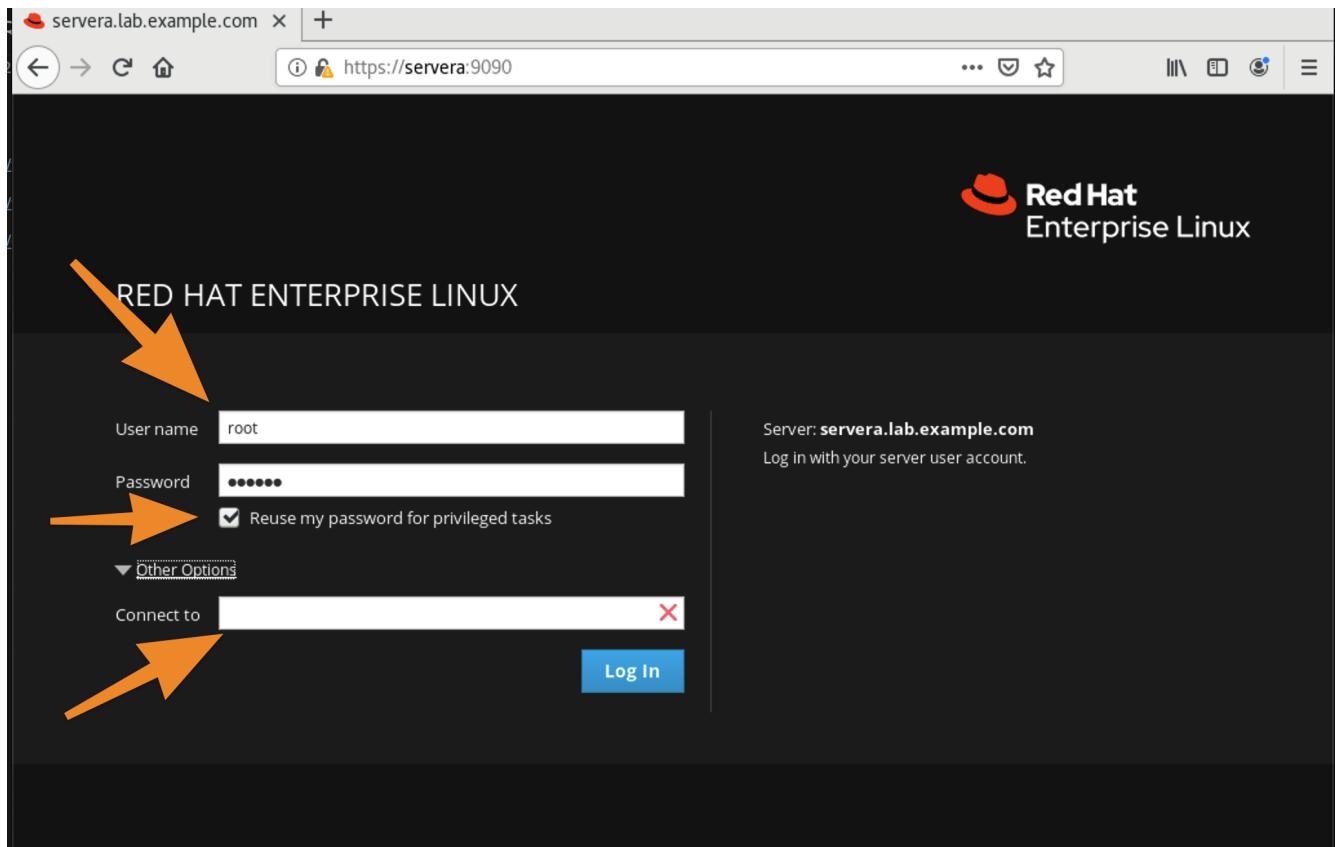


Figure 4. Red Hat Web Console (cockpit)

3. Add another Web Console from the Cockpit Dashboard

- Navigate to the Dashboard
- Click the "+" and complete the information

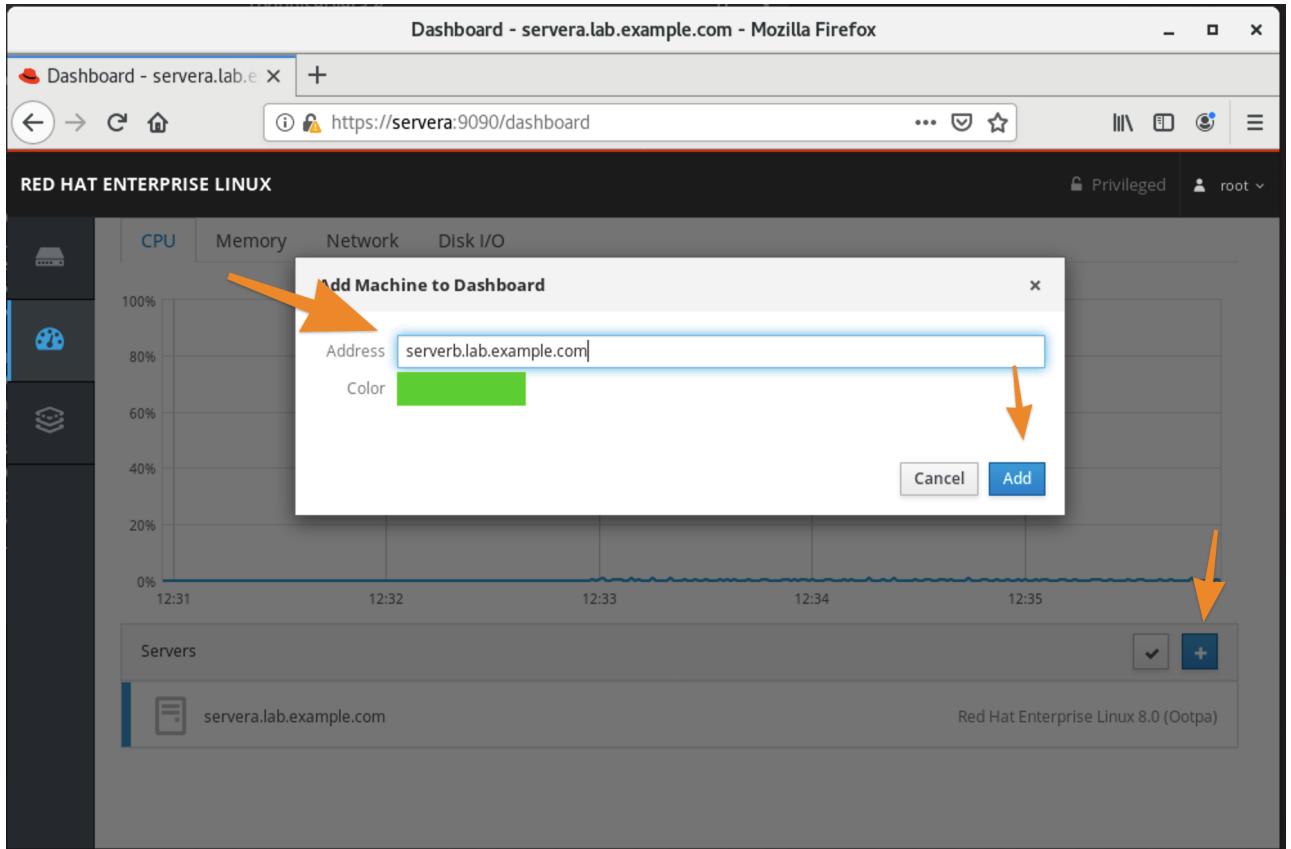


Figure 5. Adding Additional machines

4. Verify the System Fingerprint and click **Connect** image::Chapter3-87075.png[title="Fingerprint Verification", align="center"]
5. It is now possible to switch systems from the System Drop-down menu

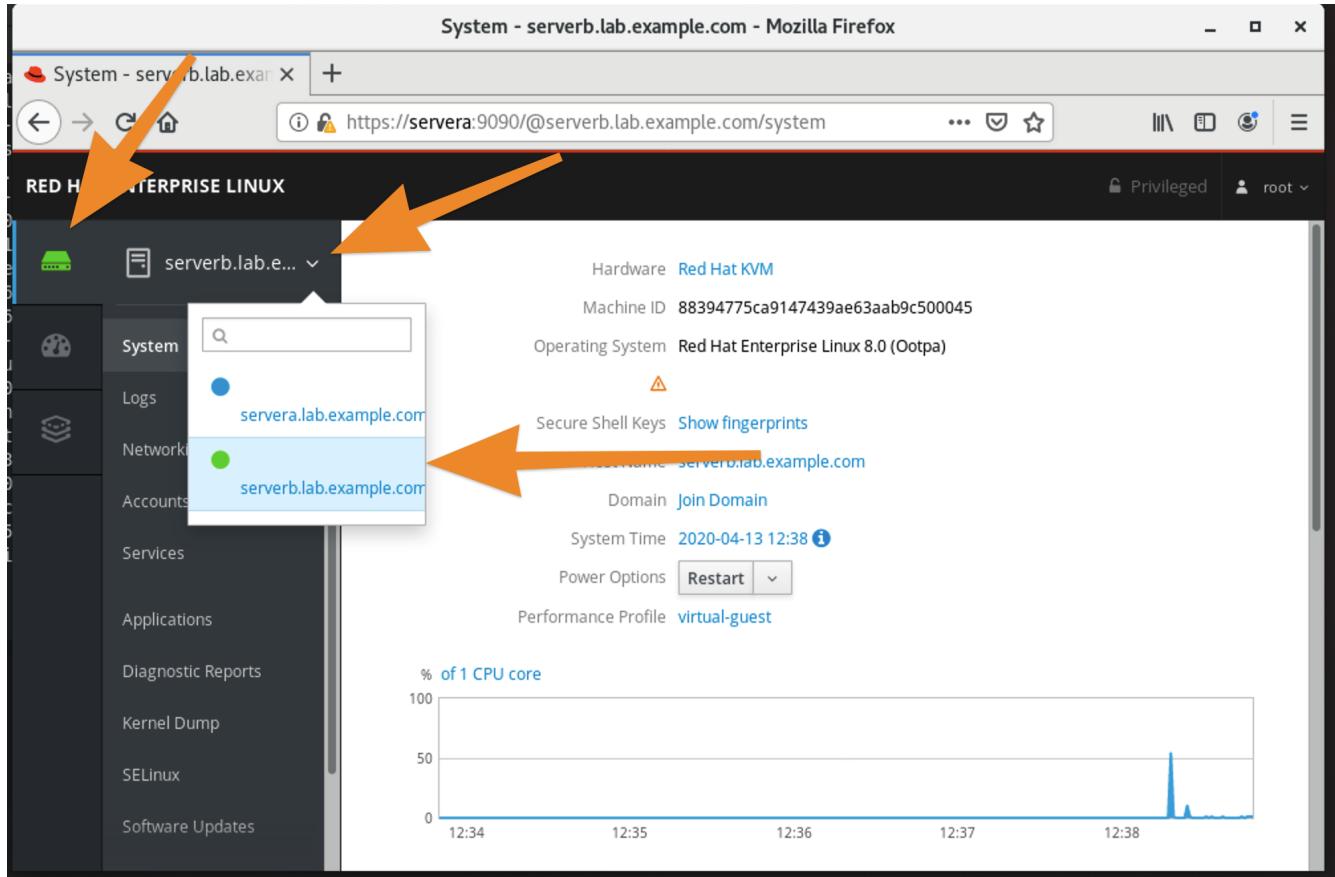


Figure 6. Switching Systems

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 the **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.

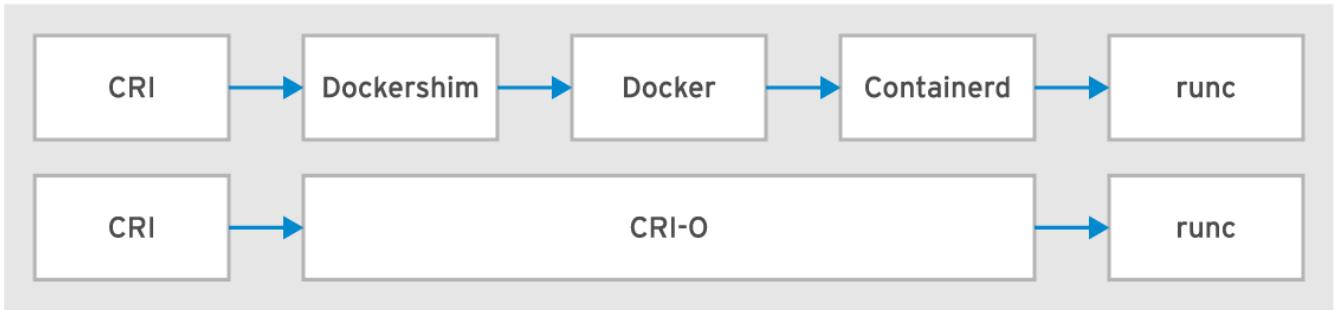


Figure 7. Docker to RHEL8 Container Runtime

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.

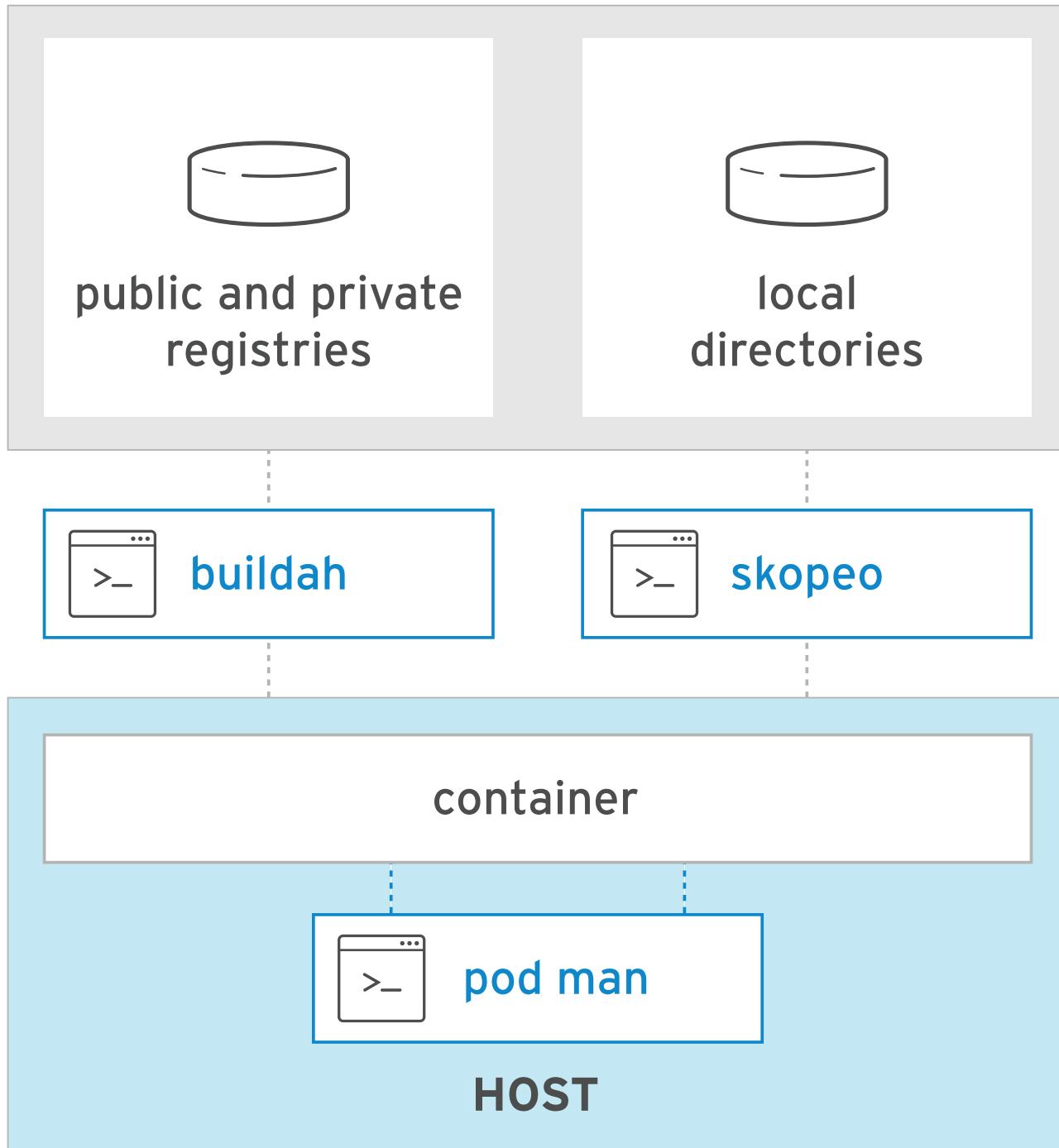


Figure 8. New Container Runtime

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.

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.

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 will 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 29. 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 30. 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.conf` configuration file. Containers can communicate to each other within the SDN on the same system.

Listing 31. /etc/cni/net.d/87-podman-bridge.conf

```
{
  "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.

▼ cockpit-web-demo	0.17%	0.001 / 8.00 GiB	system	running
quay.io/redhattraining/httpd-parent:latest /bin/sh -c "/usr/sbin/httpd -DFOREGROUND"				
Details	Logs	Console	Delete	Commit
ID	4c76fe54f5353858fbb5e22928bbd440911769b503daecb29a95e4494b63ee05			Restart ▾
Created	Today at 1:10 PM			Stop ▾
Image	quay.io/redhattraining/httpd-parent:latest			
Command	/bin/sh -c "/usr/sbin/httpd -DFOREGROUND"			
State	Up since Today at 1:10 PM			
Ports	0.0.0.0:80 → 80/tcp			
IP address	10.88.0.49			
IP prefix length	16			
Gateway	10.88.0.1			
MAC address	0e:ae:e5:84:d4:fd			

Figure 9. 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 10. 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.

+ image::Chapter2-416de.png[title="Container Console", align="center"]

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 32. Installation of Cockpit podman Plugins

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

2. Enable **podman** Service in Cockpit
 - a. Sign into Cockpit
 - b. Click "Podman containers"

c. Click "Start podman"

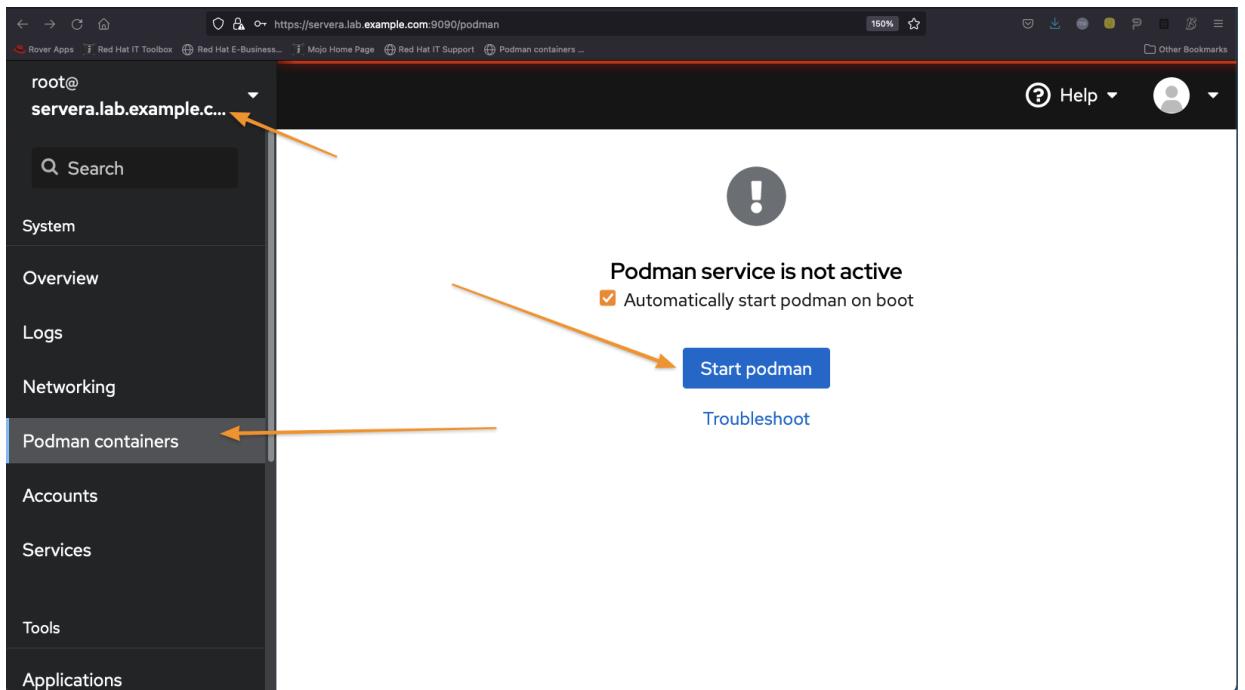


Figure 11. Cockpit - Podman Containers (Setup)

Container	CPU	Memory	Owner	State
clairv4 registry.redhat.io/quay/clair-rhel8:v3.6.0-70	0.38%	0.001 / 8.00 GiB	system	running
postgresql-clairv4 registry.redhat.io/rhel8/postgresql-10:1 run-postgresql	0.29%	0.001 / 8.00 GiB	system	running
postgresql-quay registry.redhat.io/rhel8/postgresql-10:1 run-postgresql	0.05%	0.001 / 8.00 GiB	system	running

Figure 12. Cockpit - Podman Containers (In-Use)

Ensure Cockpit is both Installed and Enabled

Listing 33. 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 34. 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 35. .docker/config.json Config File

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

*Listing 36. 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 2. Container Image Management with Cockpit

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

Name	Created	Size	Owner
registry.redhat.io/quay/clair-rhel8:v3.5.1	04/19/2021	264 MiB	system
registry.redhat.io/quay/clair-rhel8:v3.6.0-70	10/12/2021	148 MiB	system
registry.redhat.io/quay/quay-rhel8:v3.5.1	04/19/2021	1.24 GiB	system
registry.redhat.io/quay/quay-rhel8:v3.6.0-62	10/12/2021	928 MiB	system
registry.redhat.io/rhel8/postgresql-10:1	09/15/2021	453 MiB	system
registry.redhat.io/rhel8/redis-5:1	09/15/2021	300 MiB	system

Figure 13. Cockpit - Podman Container Images

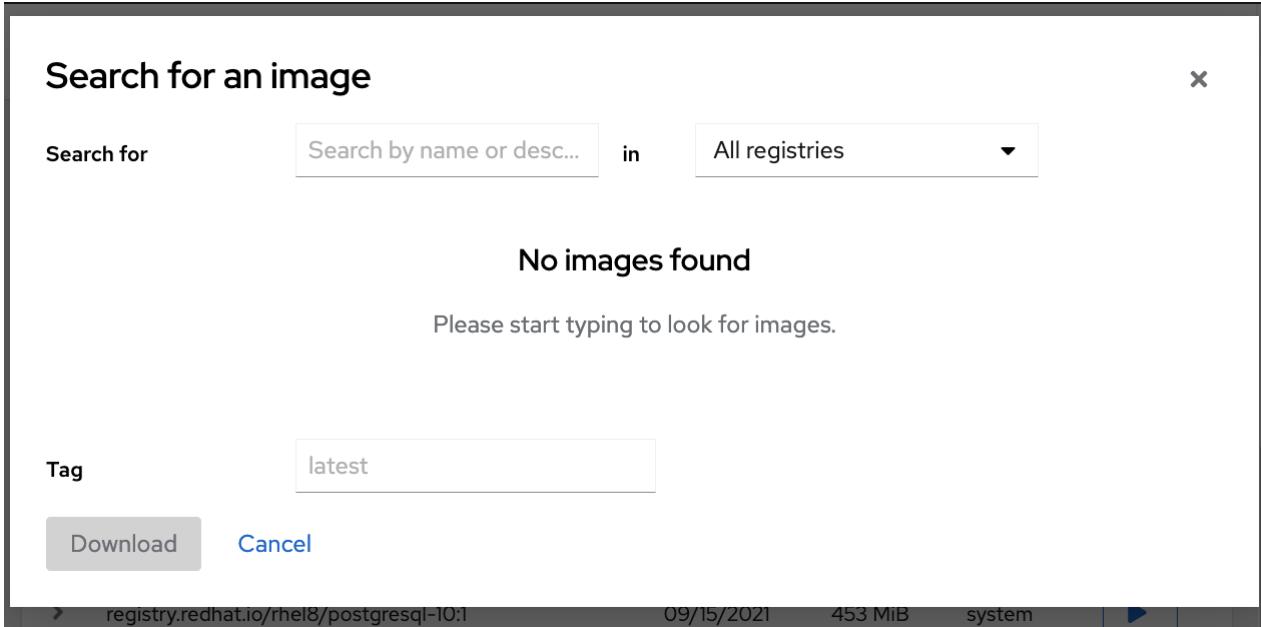


Figure 14. Search for Images

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.

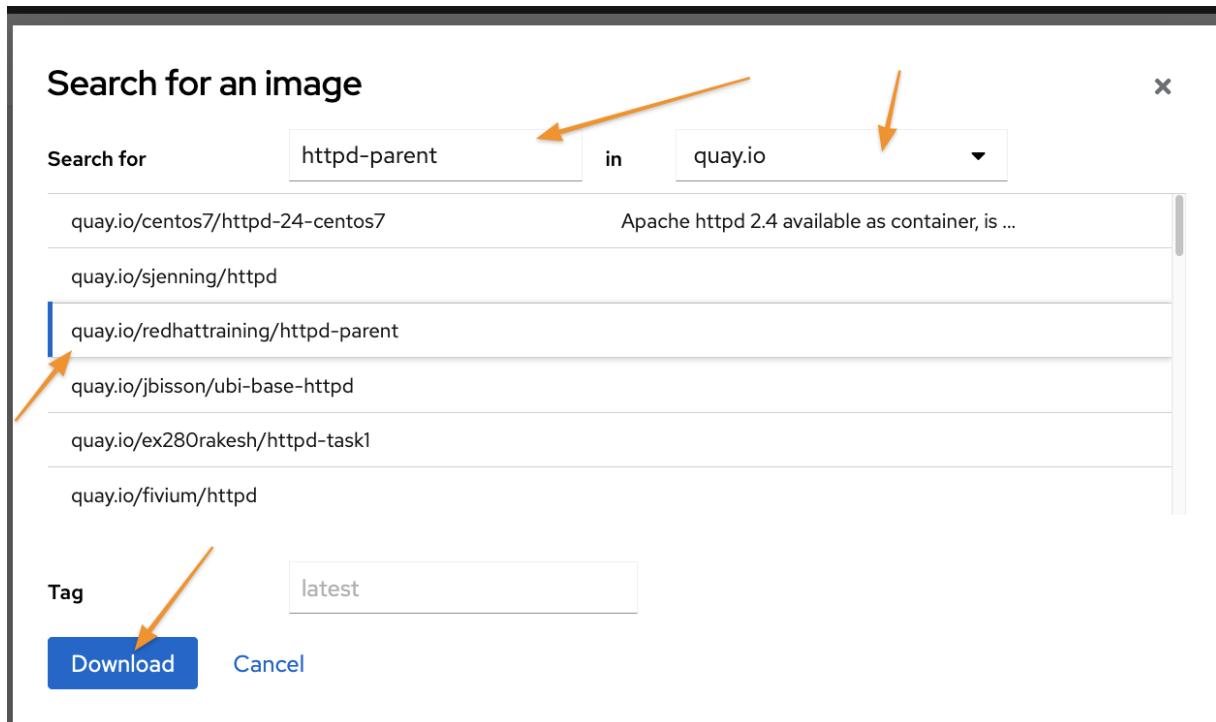


Figure 15. HTTPD 2.4 Parent Image from Red Hat Training - Quay.io

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

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

Listing 37. 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 38. 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.

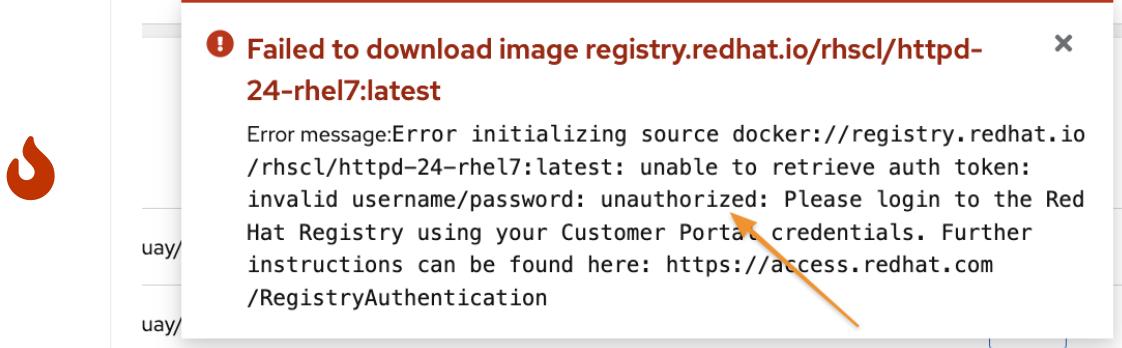


Figure 16. Registry Authentication Issues

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.

Images					+ Get new image
Name	Created	Size	Owner		
quay.io/redhattraining/httpd-parent:latest	06/12/2019	225 MiB	system	▶	
registry.redhat.io/quay/clair-rhel8:v3.5.1	04/19/2021	264 MiB	system	▶	
registry.redhat.io/quay/clair-rhel8:v3.6.0-70	10/12/2021	148 MiB	system	▶	
registry.redhat.io/quay/quay-rhel8:v3.5.1	04/19/2021	1.24 GiB	system	▶	
registry.redhat.io/quay/quay-rhel8:v3.6.0-62	10/12/2021	928 MiB	system	▶	
registry.redhat.io/rhel8/postgresql-10:1	09/15/2021	453 MiB	system	▶	

Figure 17. Images in Local Registry

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

HTTPD-Parent Image Details - Image Information				
Name	Created	Size	Owner	
quay.io/redhattraining/httpd-parent:latest	06/12/2019	225 MiB	system	▶
Details				Used by
ID	4346d3cace25			Delete
Tags	quay.io/redhattraining/httpd-parent:latest			
Entrypoint				
Command	/bin/sh -c "/usr/sbin/httpd -DFOREGROUND"			
Created	06/12/2019			
Author	Red Hat Training <training@redhat.com>			
Ports	80/tcp			

Figure 18. HTTPD-Parent Image Details - Image Information

The screenshot shows a table with the following data:

Name	Command	CPU	Memory	State
clairv4		0.15%	0.001 / 8.00 GiB	running

Figure 19. 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 3. Container Creation

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

The screenshot shows a table with the following data:

Name	Created	Size	Owner
quay.io/redhattraining/httpd-parent:latest	06/12/2019	225 MiB	system
registry.redhat.io/quay/clair-rhel8:v3.5.1	04/19/2021	264 MiB	system

Figure 20. 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

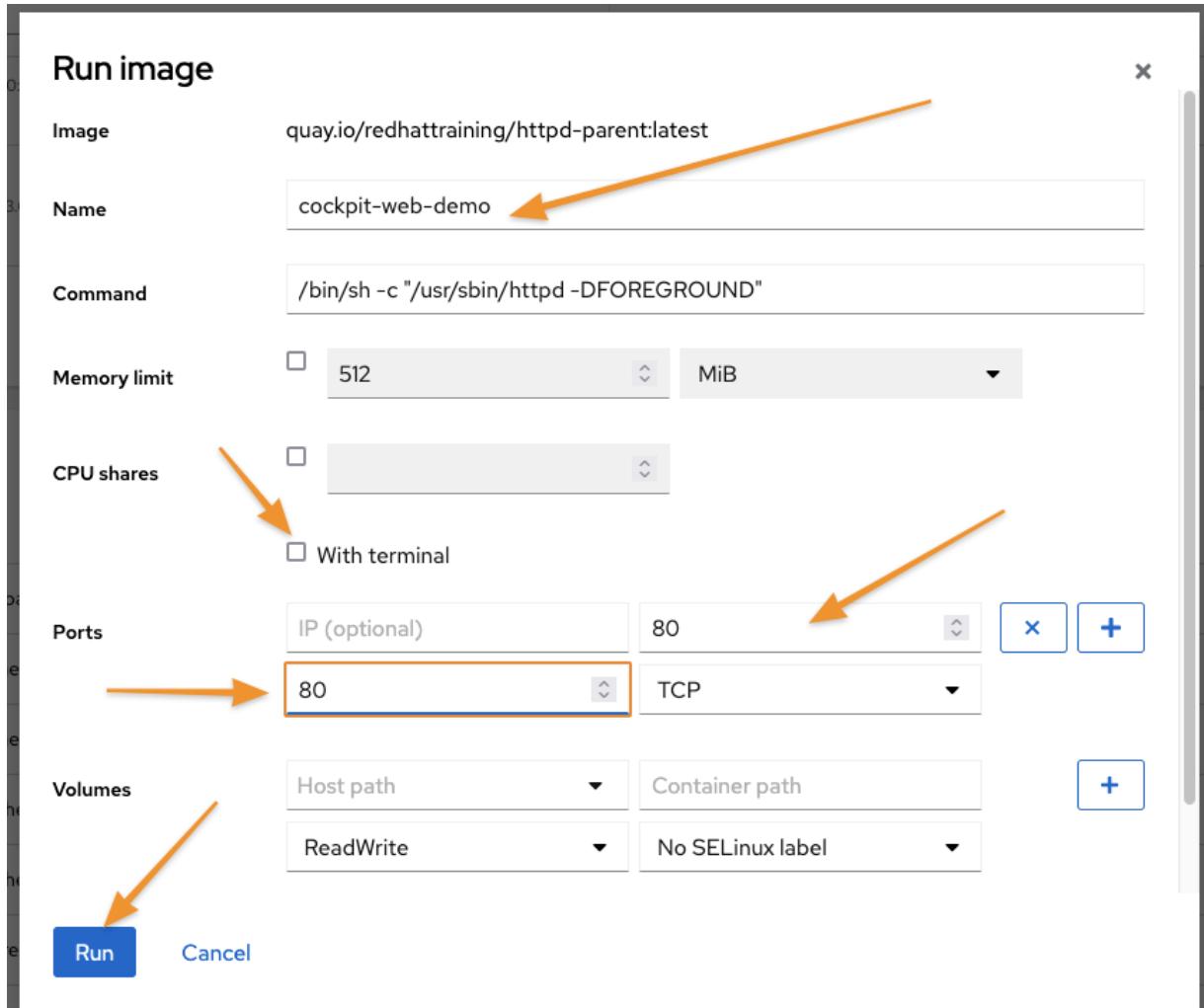


Figure 21. Launching a Demo Container

**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

Container	CPU	Memory	Owner	State
clairv4 registry.redhat.io/quayclair-rhel8v3.6.0-70	0.15%	0.001 / 8.00 GiB	system	running
cockpit-web-demo quay.io/redhattraining/httpd-parent:latest /bin/sh -c "/usr/sbin/httpd -DFOREGROUND"	0.14%	0.001 / 8.00 GiB	system	running
postgresql-clairv4 registry.redhat.io/mariadb/postgresql-l01 run-postgresql	0.07%	0.001 / 8.00 GiB	system	running

Figure 22. Running Container Verification

ID	d22db15153025d5e5966f8651755f3b5b2fa7120376ba6a8d9f0da6d1c8b9f77
Created	Today at 11:46 AM
Image	quay.io/redhattraining/httpd-parent:latest
Command	/bin/sh -c "/usr/sbin/httpd -DFOREGROUND"
State	Up since Today at 11:46 AM
Ports	0.0.0.0:80 → 80/tcp
IP address	10.88.0.40
IP prefix length	16
Gateway	10.88.0.1
MAC address	5a:fb:08:cb:23:71

Figure 23. Running Container Details

4. Allow connection to container externally through Firewall

a. Click **Networking**

b. Click **Edit rules and zones** for the Firewall

Logs	11:47	11:48	11:49	11:50	11:51	11:47	11:48	11:49	11:50	11:51
Networking										
Podman containers										
Accounts										
Services										

Firewall 1 active zone

Interfaces [Add bond](#) [Add team](#) [Add bridge](#) [Add VLAN](#)

Figure 24. 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

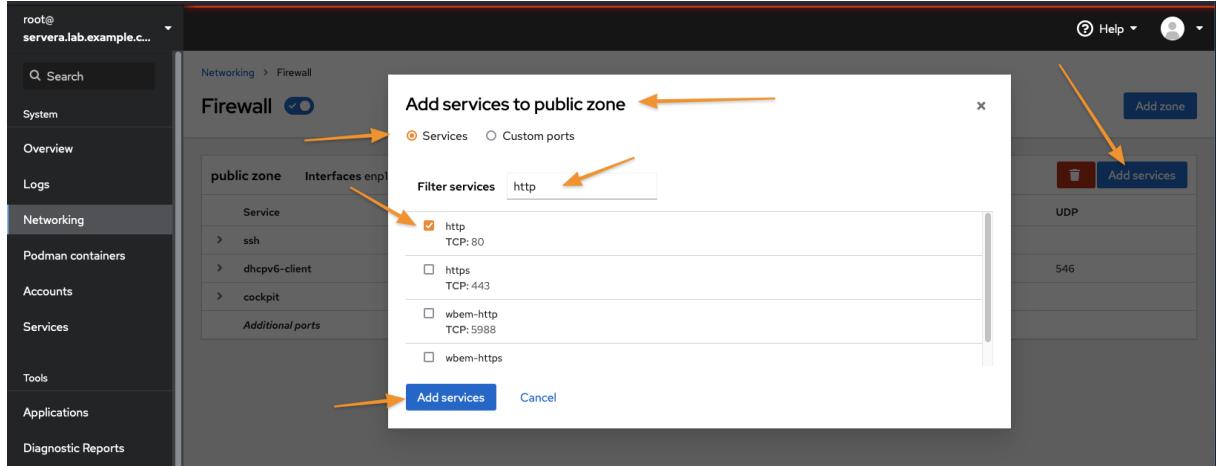


Figure 25. Add the HTTP Service

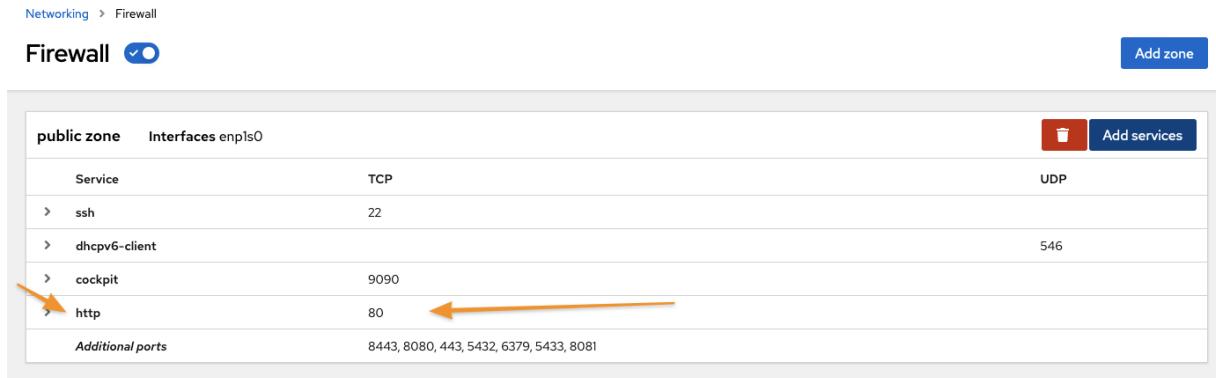


Figure 26. HTTP Service Available

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

Listing 39. Local Container Verification

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

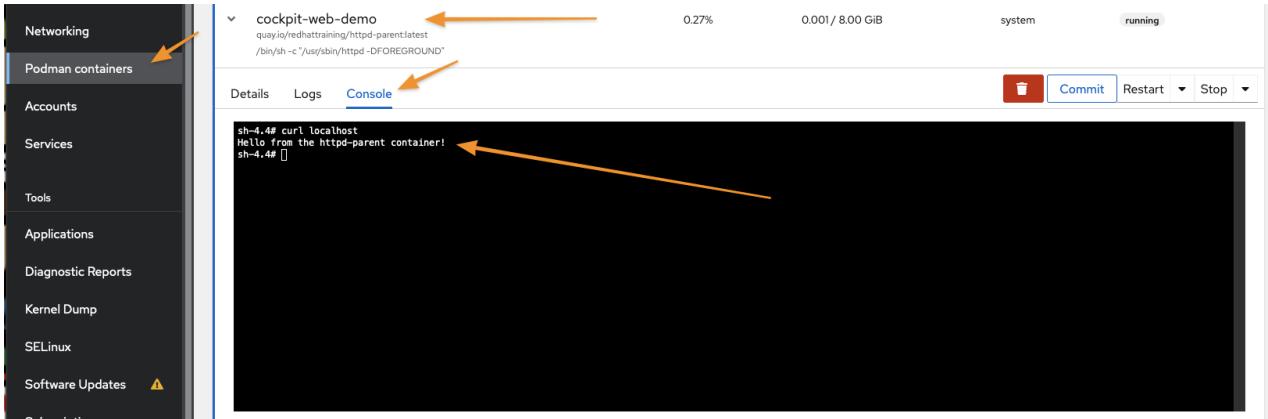


Figure 27. Container Console in Cockpit



Figure 28. Application Verification in Firefox

Example 4. Saving a Container Image from a Running Container

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

- a. Click **Commit**

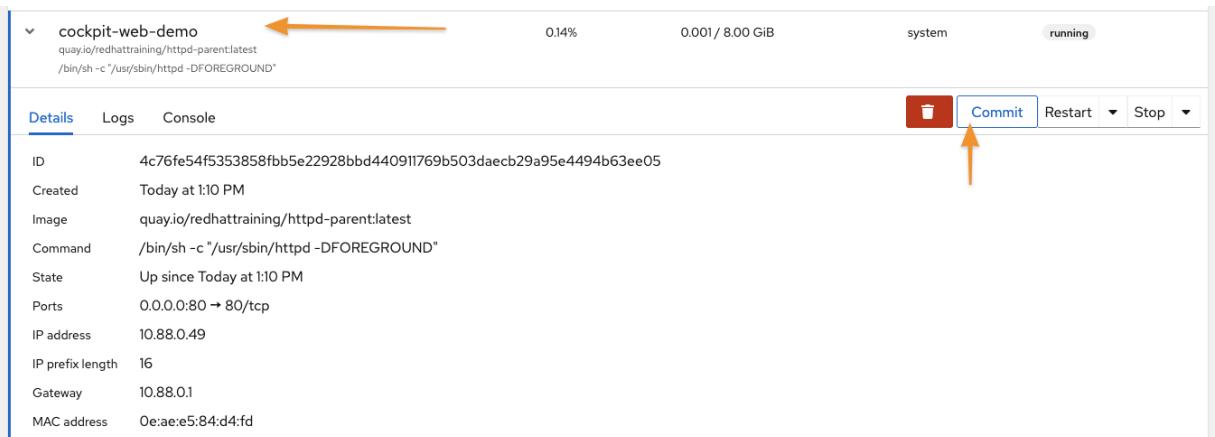


Figure 29. Creating an new image from a container.

2. Select and complete the **Commit image** form

- a. Specify **Image name**

- b. Other fields are optional

Commit image

Container name: cockpit-web-demo

Format: oci docker

Image name: cockpit-image-test

Tag:

Author:

Message:

Command:

Pause the container

Set container on build variables

Commit [Cancel](#)

Figure 30. 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

Name	Created	Size	Owner	Action
localhost/cockpit-image-test:latest	Today at 1:32 PM	225 MiB	system	
quay.io/redhattraining/httpd-parent:latest	06/12/2019	225 MiB	system	

Figure 31. 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 5. 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**

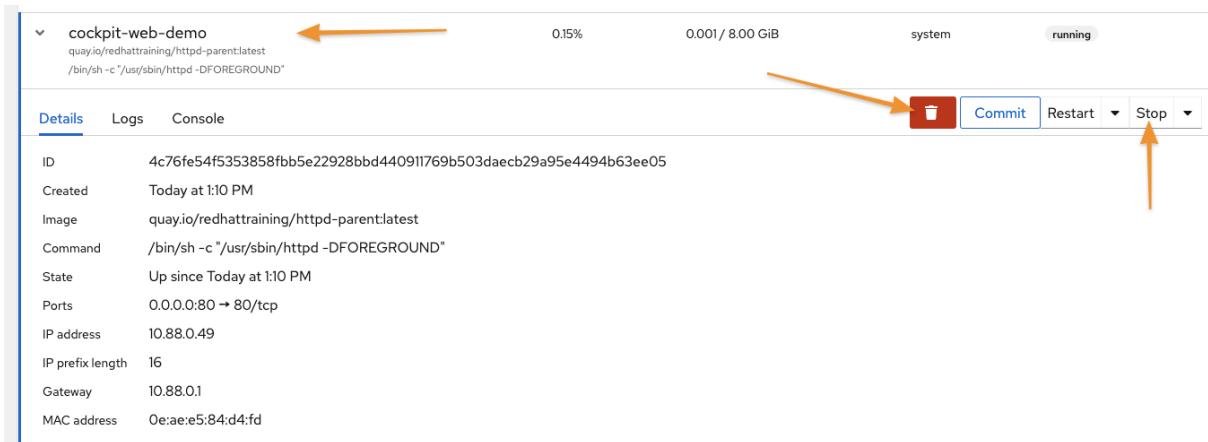


Figure 32. Container Cleanup

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.

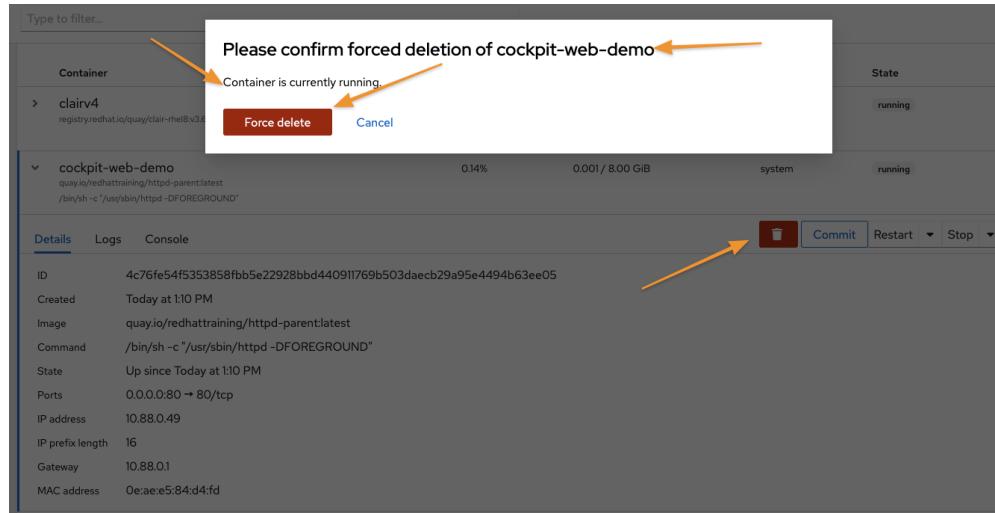


Figure 33. Force Removing a Running Container



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

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.

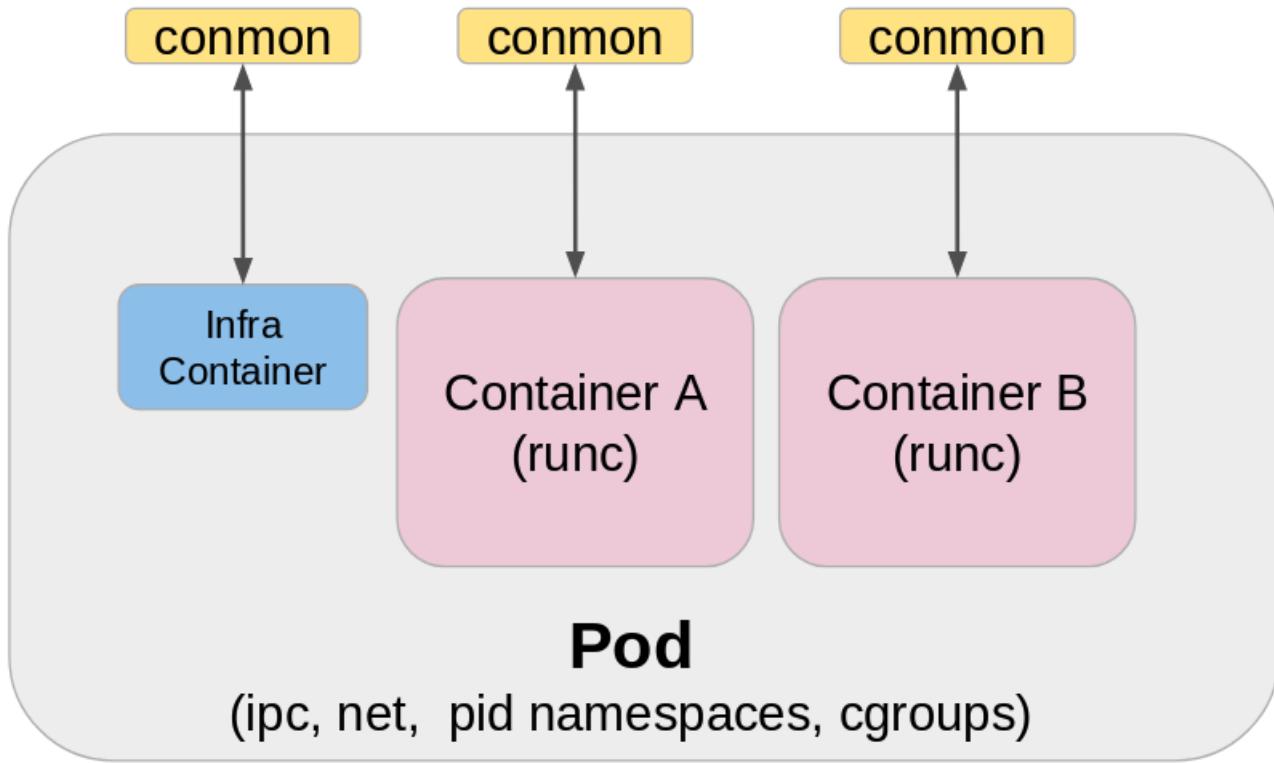


Figure 34. Example of a Pod

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 40. 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 41. 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 42. 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 43. 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
17ac5ef7876afcaa52a356f14284411617d9e2c7d8ab58ea5545cec61ab7547

[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 44. 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
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 45. 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 46. 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 3113f296524c48a2eabdd6f114f64c213e8844ecd2eb754557683dc7c205203 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 6. Exercise - 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. Create the pod for running the Wordpress web application

```
[root@server ~]# podman pod create --name wordpress_pod_demo -p 80:80
5cbe751d69a99b9fdefb5225180c4897c95f60245eaf049570c2980bfd74e2d
```

2. Verify the pod has been created

Listing 47. 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 48. Verification using podman ps to get Port mapping

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	POR
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	

3. 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 49. Testing for Zero Return Code

```
[root@server ~]# podman exec db bash -c 'mysql -u root -e "SELECT 1" 8> /dev/null'; echo $?
0
```

4. Start the Wordpress 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 60f22fb07a [=====>-----] 57.4MiB / 73.1MiB
Copying blob 60f22fb07a [=====>-----] 57.5MiB / 73.1MiB
... OUTPUT OMITTED ...
Writing manifest to image destination
Storing signatures
793b3d5de8108204ed9161fdc65cf81214be99a13676e9f8f251f439852c70f2
```

5. 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

6. 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
```

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

Listing 50. Opening Port

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

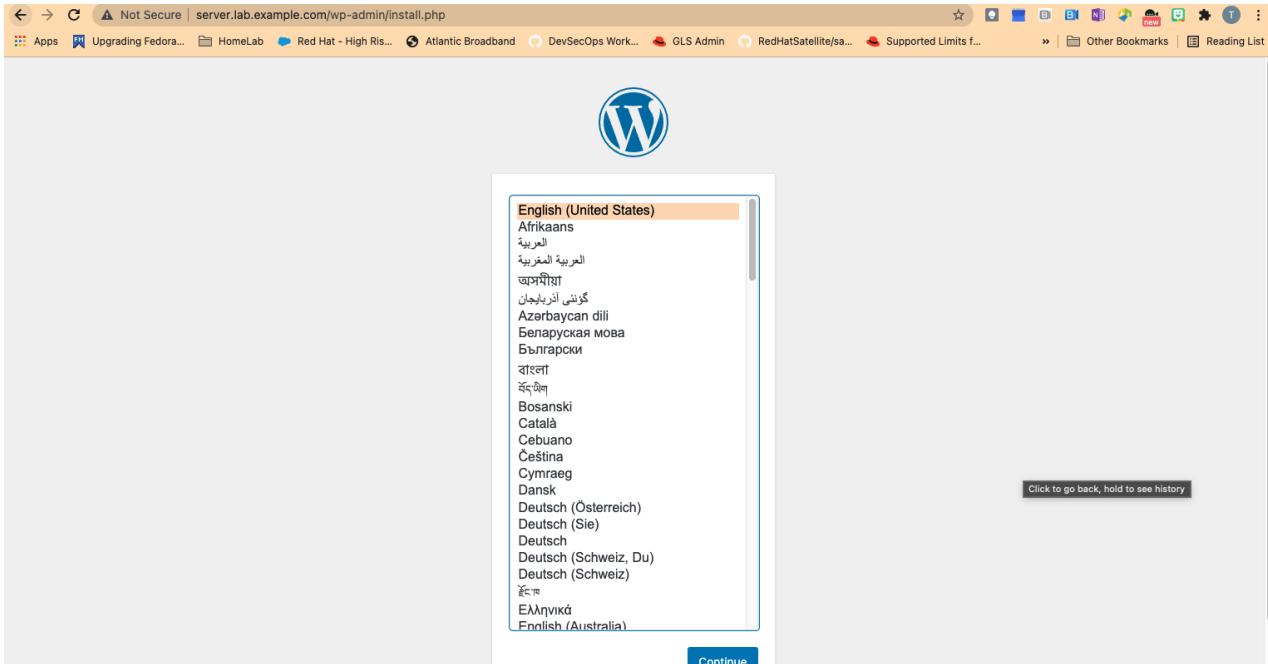


Figure 35. Wordpress Installation Page

8. Cleanup Pods and Containers

Listing 51. 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 52. 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 53. Stopping a Pod

```
[root@server Buildah]# podman pod stop wordpress_demo_pod
35870e1ae2d067e6bc84e4df7cccd2b30f6df6ba4cdb4c098814311ddec1f5b41
```

Listing 54. Looking at Stopped Pod

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

Listing 55. 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
35870e1ae2d067e6bc84e4df7cccd2b30f6df6ba4cdb4c098814311ddec1f5b41

[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 56. Running a Sample Container

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

Listing 57. Stopping a Sample Container

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

*Listing 58. Looking for Stopped Containers (**podman ps -a**)*

```
[root@server Buildah]# podman ps -a
CONTAINER ID  IMAGE          COMMAND           CREATED        STATUS          PORTS
NAMES          POD ID        PODNAME
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 59. 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 60. 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 61. Image Listing

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
localhost/demo-container-image	latest	d21ee320b60a	3 hours ago	553 MB

Listing 62. 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.

Listing 63. 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'
```

Listing 64. 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
```

Listing 65. Launch a Container

```
[student@workstation Pods]$ ansible-playbook Deploy_Container_Demo.yml
PLAY [Deploy HTTPD Server Demo] ****
... OUTPUT OMITTED ...
```

Listing 66. Identify Containers on Workstation

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS
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				

Listing 67. Stop Container on Workstation

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

Listing 68. Prune Containers on Workstation

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

Listing 69. Prune Images on Workstation

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

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: 3639ce1374d3611e80ed66dec7d5467b72d010c21e19e4f193cd8b944e8c9f5

[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

References

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Podman: Managing pods and containers in a local container runtime: https://developers.redhat.com/blog/2019/01/15/podman-managing-containers-pods#man_pages

podman-system-prune, podman-container-cleanup, podman-pod-prune, podman-container-prune, podman-image-prune, and podman-volume-prune.

Stefano's Project on Github: <https://github.com/sstagnaro/rht-contrib>

Spinning up and Managing Pods with multiple containers with Podman: <https://mohitgoyal.co/2021/04/23/spinning-up-and-managing-pods-with-multiple-containers-with-podman/>

What is a dangling image and what is an unused image?: <https://newbedev.com/what-is-a-dangling-image-and-what-is-an-unused-image>



4. Container Images

4.1. Building Containers with Buildah

4.1.1. Building images as the root user

Example 7. EXAMPLE - 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 Package 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. 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
```

13. Unmount Container Filesystem image.

Listing 82. Unmount the container image filesystem

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

14. 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.

15. 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
```

16. Test the Container image by launching a container

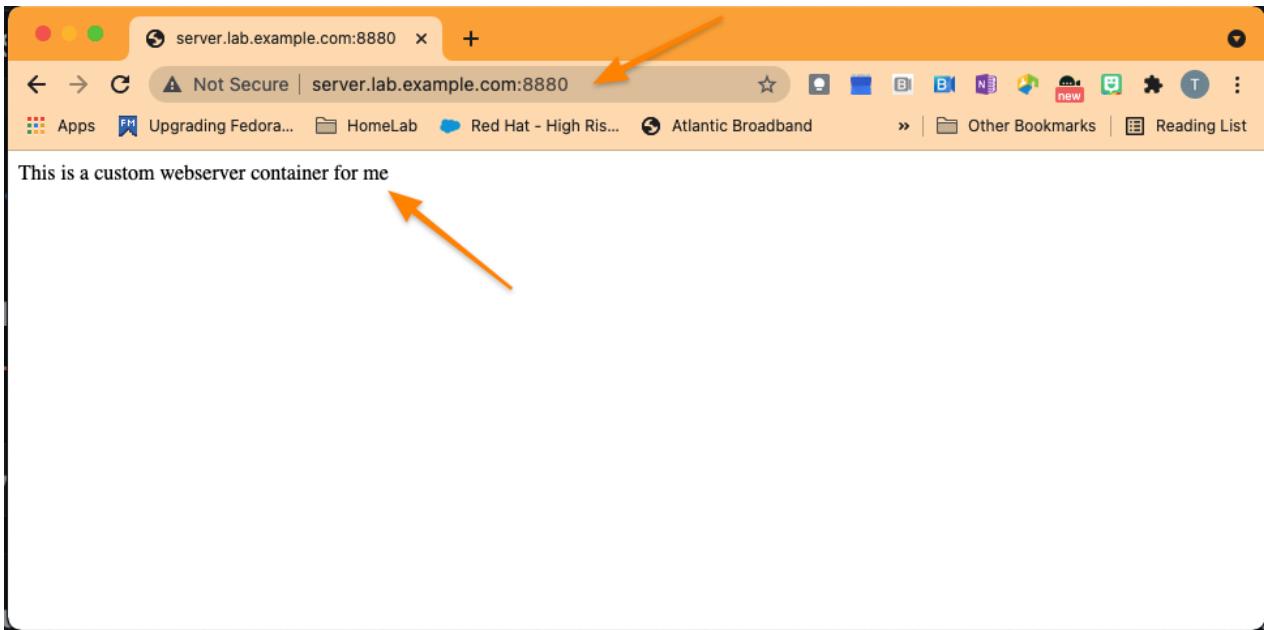
Listing 85. Testing the Container Image

```
[root@server ~]# podman run --name demo-container-buildah -d -p 8880:80 localhost/demo-container-image  
be3bbc8898fc6cab1cef5d78721f46b985e957d30984d591271fffc5b906994  
  
[root@server ~]# curl localhost:8880  
This is a custom webserver container for me  
  
[root@server ~]# curl http://localhost:8880/manual/
```

17. 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 36. Custom *index.html*

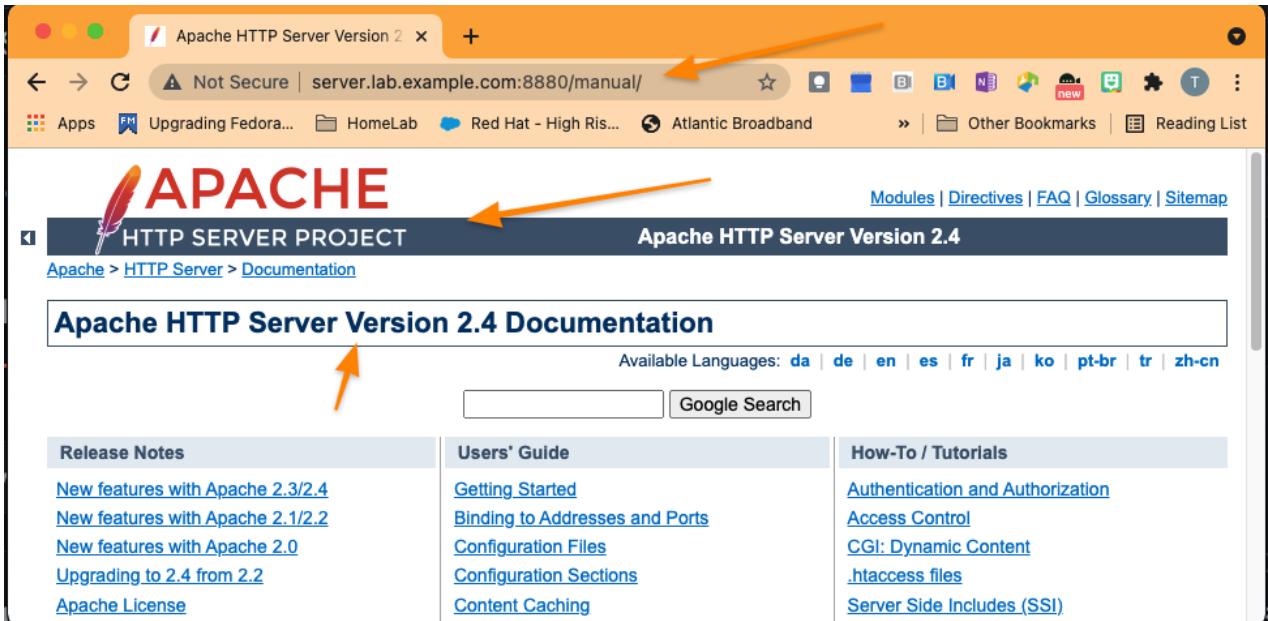


Figure 37. Apache Manual

Cleaning up the Container

1. Stop and Remove the Container

```
[root@server ~]# podman rm demo-container-buildah --force
be3bbc8898fc6cab1cef5d78721f46b985e957d30984d591271fffc5b906994
```

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
```

4.1.2. Building an Image Using Buildah Rootless

4.2. Managing Images and System Storage

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>

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

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



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 1. 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 --user start UNIT
	systemctl stop UNIT	systemctl --user stop UNIT
Starting a service when the machine starts	systemctl enable UNIT	logind 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 user 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 88. Enable Login Linger

```
loginctl enable-linger
```

Listing 89. Enable a Container to Start Automatically

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

Listing 90. 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/** 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 8. DEMO - Managing Containers as Services

1. Create a Container User

```
[root@servera ~]# useradd cuser
[root@servera ~]# 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 **servera** 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@servera ~]$ mkdir -p ~/.config/containers/
[cuser@servera ~]$ cd ~/.config/containers/
[cuser@servera containers]$ wget http://classroom.example.com/content/courses/rhcsa650e/rhel8.2/materials/registries.conf
```

4. Create Content for Webserver

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

5. Login to the container registry

```
[cuser@servera ~]$ podman login registry.lab.example.com
Username: admin
Password: redhat321
Login Succeeded!
```

6. Create and Run Reference Container

```
[cuser@servera ~]$ podman run -d --name demoweb -p 8080:8080 -v ~/www:/var/www:Z registry.lab.example.com/rhel8/httpd-24:1-105
```

7. Verify webserver is running

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

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

```
[cuser@servera ~]$ mkdir -p ~/.config/systemd/user/
[cuser@servera ~]$ cd ~/.config/systemd/user/
[cuser@servera user]$ podman generate systemd --name demoweb --files --new
/home/cuser/.config/systemd/user/container-demoweb.service
```

9. View **systemd** Unit File

```
[cuser@servera user]$ cat /home/cuser/.config/systemd/user/container-demoweb.service
# container-demoweb.service
# autogenerated by Podman 1.9.3
# Fri Sep 18 14:24:15 EDT 2020

[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
ExecStartPre=/usr/bin/rm -f %t/%n-pid %t/%n-cid
ExecStart=/usr/bin/podman run --common-pidfile %t/%n-pid --cidfile %t/%n-cid --cgroups=no-common -d --name demoweb -p 8080:8080 -v
/home/cuser/www:/var/www:Z registry.lab.example.com/rhel8/httpd-24:1-105
ExecStop=/usr/bin/podman stop --ignore --cidfile %t/%n-cid -t 10
ExecStopPost=/usr/bin/podman rm --ignore -f --cidfile %t/%n-cid
PIDFile=%t/%n-pid
KillMode=none
Type=forking

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

10. Remove the Reference Container and Verify

```
[cuser@servera user]$ podman rm demoweb -f
b53201444570b95d4306289a72120e3b883480c22dd5280b9429a02b7f850153

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

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

```
[cuser@servera 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.
```

12. Verify Container is Running

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

[cuser@servera user]$ podman ps
CONTAINER ID  IMAGE          COMMAND           CREATED          STATUS          PORTS
NAMES
4f9af684d605  registry.lab.example.com/rhel8/httpd-24:1-105  /usr/bin/run-http...  29 seconds ago  Up 29 seconds ago  0.0.0.0:8080->8080/tcp  demoweb
```

References



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

6. Container Management with Ansible

Containers can now be managed with the Ansible Podman collection leveraging Ansible Automation Platform (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.

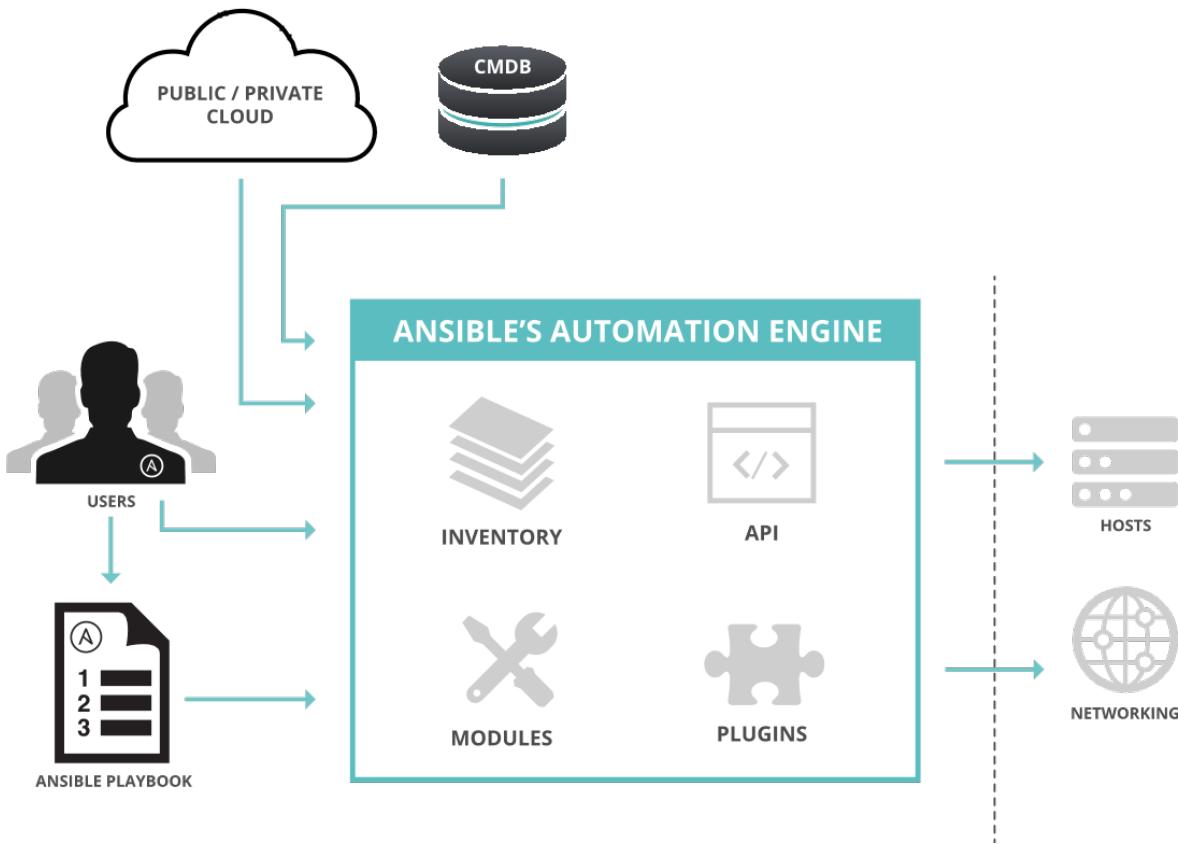


Figure 38. Ansible Architecture

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 91. 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 2. 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 92. ansible.cfg for Using Collections

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

[privilegeEscalation]
become = False
becomeMethod = sudo
becomeUser = root
becomeAskPass = 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 officially 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 93. 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.

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. Create a **requirements.yml** File

Listing 94. Podman Collection requirements.yml File

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

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

Listing 95. 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'
```

3. Verify the collection(s) are installed

Listing 96. 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 97. 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 and manipulate container images. In order to build images, it is necessary to have either a valid **Containerfile** or valid **Dockerfile** for image building.

Building Podman Container Images with Ansible

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

Listing 98. ansible.cfg

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

2. Start with the top playbook definitions and directives

Listing 99. 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

3. Create Playbook with Tasks

Listing 100. 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*).

6.4. 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.

Creating and Running Podman Containers with Ansible

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

Listing 101. ansible.cfg

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

2. Start with the top playbook definitions and directives

Listing 102. 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

3. Create the Playbook with Tasks

Listing 103. Playbook Tasks

```
tasks:  
  
## Podman Collections Needed for Login  
- name: Login to Container Registry  
  podman_login:  
    username: "{{ registry_un }}"  
    password: "{{ registry_pass }}"  
    registry: "{{ registry_url }}"  
  
## Start and Run the HTTPD Container  
- name: Start the Quay Container  
  podman_container:  
    name: Website_Demo  
    image: quay.io/redhattraining/httpd-parent:2.4  
    state: started  
    restart: yes  
    ports:  
      - "7080:80"  
    volume:  
      - "/Webhosting:/var/www/html:Z"
```

4. 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 104. 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

1. 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 105. 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
```

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 3. 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	8443/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 4. Container Port Mapping

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

Table 5. 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

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

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 106. Copy `registry_login.yml_example` to `registry_login.yml`

```
[student@workstation quay_lab_poc]$ cp registry_login.yml_example registry_login.yml
```

Listing 107. 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_Prepares.yml** playbook

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Prepares.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.

An Ansible Failure Possible

It is possible that you will receive an Ansible failure message like this



```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Prepares.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.
- 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 108. File-Based Configuration Method

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Config_Deploy_Files.yml
```

File-Based Configuration Considerations

The **.files/config/config.yaml** file will be used and deployed to control the configuration of the Quay environment.

*Listing 109. TAR File Configuration Method**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.

- Deploy the ClairV4 scanning image by executing the **Quay_Clair_Deploy.yml** playbook

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Clair_Deploy.yml
```

- Deploy the Quay container registry by executing the **Quay_Deploy.yml** playbook.

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Deploy.yml
```

- Deploy the Quay Mirroring Container by executing the **Quay_Mirror_Deploy.yml** playbook.

```
[student@workstation quay_lab_poc]$ ansible-playbook Quay_Mirror_Deploy.yml
```

7.2.2. Setting up the Quay Web Console

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.

7.2.2.1. 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 110. Quay Super Users

SUPER_USERS:

- **quayadmin**
- **travis**

1. Open the Quay web console by navigating to it in your favorite browser using <http://Quay-FQDN:8080>

The screenshot shows a web browser window with the following details:

- Address Bar:** Shows "Not Secure | quay.local:8080".
- Bookmarks Bar:** Contains links like "Upgrading Fedora", "HomeLab", "Red Hat - High Ris...", "Atlantic Broadband", "DevSecOps Work...", and "GLS Admin".
- Header:** Features the "RED HAT QUAY" logo, "EXPLORE", "TUTORIAL", a search bar, and a "SIGN IN" button.
- Login Form:** A central box with fields for "Username or E-mail Address" and "Password", and a "Sign in to Project Quay" button.
- Bottom Left:** A "Create Account" link.
- Bottom Right:** A large orange arrow pointing towards the "Create Account" link.
- Page Footer:** Includes the Red Hat logo, "Documentation", "Quay v3.5.1", and a copyright notice.

2. Click **Create Account** to create the administrator/superuser accounts for Quay as defined in the **config.yaml** file.

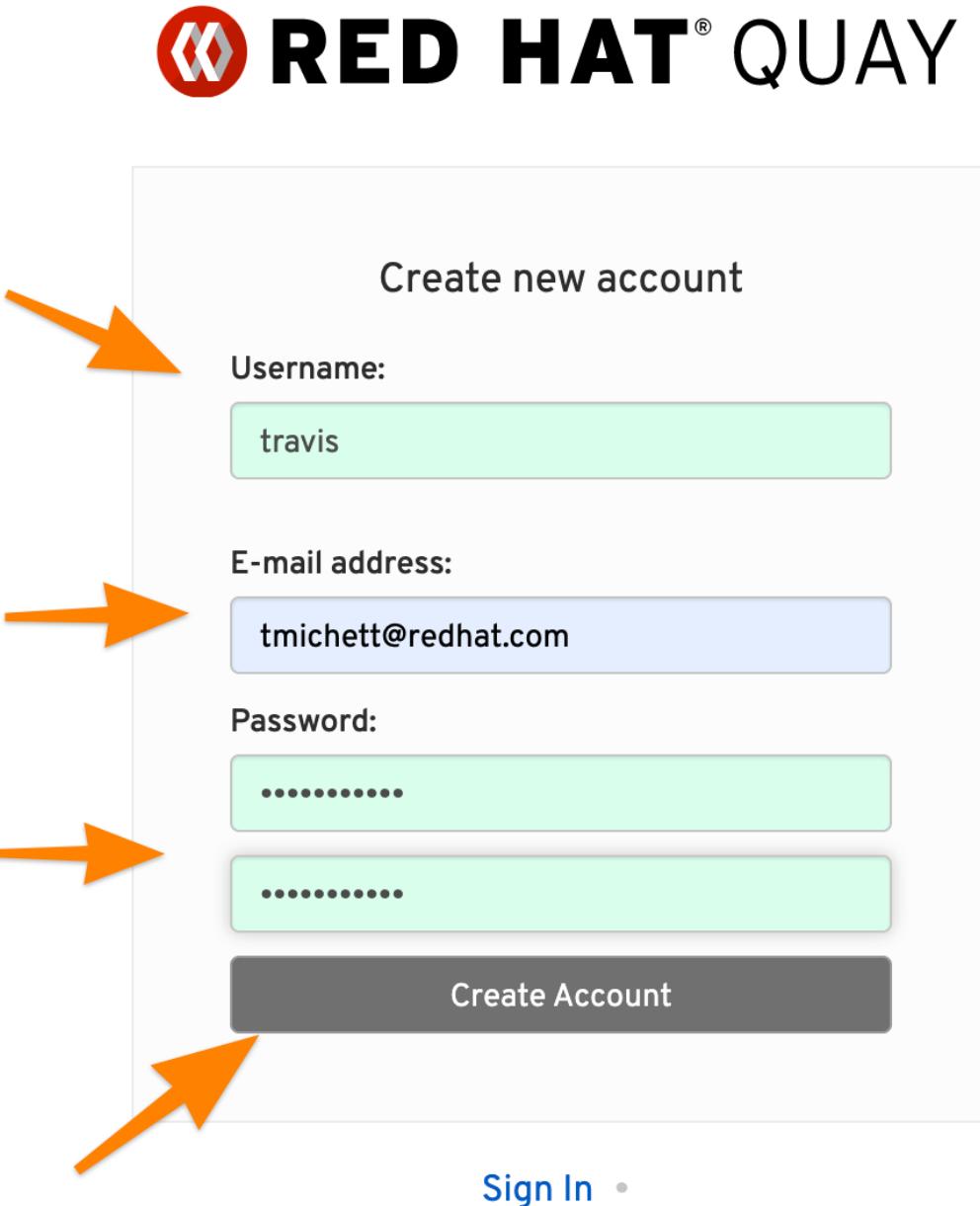
- Repeat this step for all super users in the **config.yaml** file.



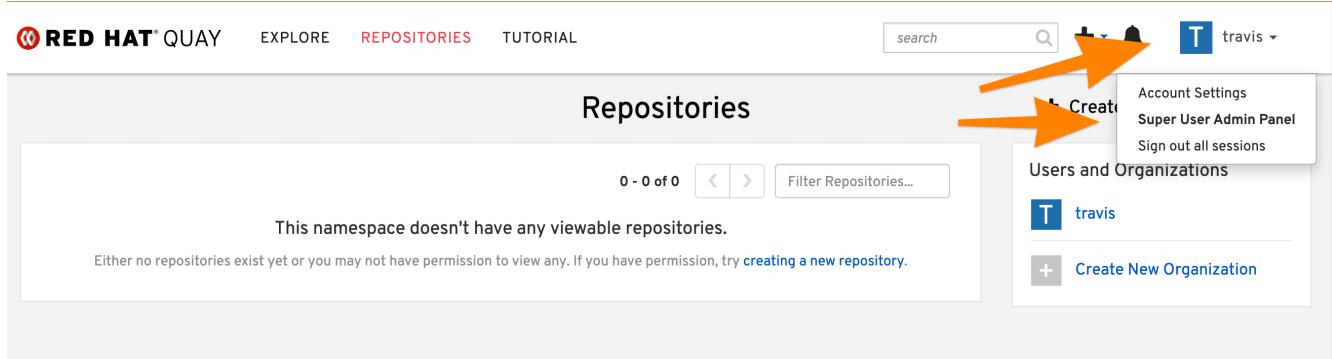
The screenshot shows the 'Create new account' page for Red Hat Quay. At the top, there's a large 'Repositories' header and the Red Hat Quay logo. Below the logo, the text 'Create new account' is centered. The form consists of several input fields:

- Username:** A light blue input field containing the text 'quayadmin'. An orange arrow points to this field from the left.
- E-mail address:** A light blue input field containing the text 'tmichett@redhat.com'. An orange arrow points to this field from the left.
- Password:** A light blue input field containing six dots ('.....').
- Confirm Password:** A light green input field containing six dots ('.....'). An orange arrow points to this field from the left.
- Create Account:** A dark grey button with white text.

At the bottom of the form, there's a 'Sign In' link in blue text.



3. Verify the account was setup properly and you have **Super User** rights by clicking your Username and looking for **Super User Admin Panel**.



7.2.3. 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

1. Login to Quay Repository

Listing 111. podman Authentication

```
[root@quay ~]# podman login --tls-verify=false quay.local:8080
Username: travis
Password:
Login Succeeded!
```

2. Pull and Download an Image, Tag it, then upload to repository

Listing 112. Downloading image

```
[root@quay ~]# podman pull ubuntu:20.04
Resolved "ubuntu" as an alias (/etc/containers/registries.conf.d/000-shortnames.conf)
Trying to pull docker.io/library/ubuntu:20.04...
Getting image source signatures
Copying blob 16ec32c2132b done
Copying config 1318b700e4 done
Writing manifest to image destination
Storing signatures
1318b700e415001198d1bf66d260b07f67ca8a552b61b0da02b3832c778f221b
```

Listing 113. Tagging image

```
[root@quay ~]# podman tag docker.io/library/ubuntu:20.04 quay.local:8080/travis/ubuntu:20.04
```

Listing 114. Push image

```
[root@quay ~]# podman push --tls-verify=false quay.local:8080/travis/ubuntu:20.04
Getting image source signatures
Copying blob 7555a8182c42 done
Copying config 1318b700e4 done
Writing manifest to image destination
Storing signatures
```

3. Verify image exists in Quay

The screenshot shows the Red Hat Quay web interface. At the top, there's a navigation bar with links for 'REPO APPS', 'Red Hat IT Toolbox', 'Red Hat E-Business...', 'Mojo Home Page', 'Red Hat IT Support', and 'Other Bookmarks'. Below the navigation is a header with 'RED HAT QUAY', 'EXPLORE', 'REPOSITORIES', and 'TUTORIAL' buttons, along with a search bar and a user profile for 'travis'. The main content area is titled 'Repositories' and shows a list of repositories. One repository, 'travis/ubuntu', is highlighted with an orange arrow pointing to its name. The list includes columns for 'REPOSITORY NAME', 'LAST MODIFIED', 'ACTIVITY', and 'STAR'. A sidebar on the right is titled 'Users and Organizations' and shows 'travis' with a purple icon.

4. Navigate to image tags and see if the security scan has completed

This screenshot shows the 'Repository Tags' page for the 'travis/ubuntu' repository. The title bar says 'travis / ubuntu'. The page lists a single tag, '20.04', which was last modified 4 minutes ago. To the right of the tag list, there's a 'SECURITY SCAN' section with an orange arrow pointing to it. It shows '4 Medium' vulnerabilities, '2 fixable', and a size of '28.5 MB'. The status is 'Never' and the SHA256 hash is '8978e48081a3'. There are also 'Compact' and 'Expanded' buttons at the top right.

5. Click on Security scan to view the vulnerabilities

This screenshot shows the 'Vulnerabilities' page for the 'travis/ubuntu' repository. The title bar says '8978e48081a3'. On the left, there's a sidebar with icons for 'Manifest', 'Tags', and 'Layers'. The main content area starts with a summary: 'Quay Security Scanner has detected 61 vulnerabilities. Patches are available for 2 vulnerabilities.' An orange arrow points to the '61 vulnerabilities' text. Below this is a donut chart showing the distribution of vulnerabilities: 80% (yellow), 13% (grey), and 7% (orange). Another orange arrow points to the chart. At the bottom, there's a table of vulnerabilities with columns for 'CVE', 'SEVERITY', 'PACKAGE', 'CURRENT VERSION', 'FIXED IN VERSION', and 'INTRODUCED IN LAYER'. Two specific CVE entries are listed: 'CVE-2021-35942 on Ubuntu 20.04 (focal) - medium.' and 'CVE-2021-38604 on Ubuntu 20.04 (focal) - medium.'. There are 'ADD' buttons and file hashes for each entry. At the top right of the table, there are 'Filter Vulnerabilities...' and 'Only show fixable' buttons.

7.2.4. 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.

1. Create a new repository in Quay by clicking **Create New Repository**

The screenshot shows the Red Hat Quay interface. At the top, there's a navigation bar with links for EXPLORE, REPOSITORIES, and TUTORIAL. On the right side of the header are search, notification, and user profile icons. Below the header is a section titled 'Repositories' with a sub-section header '1 - 1 of 1'. It lists one repository: 'travis / ubuntu' (Last modified: Today at 2:53 PM). To the right of the repository list is a sidebar titled 'Users and Organizations' containing 'travis' and a link to 'Create New Organization'. At the top right of the main content area is a prominent orange arrow pointing to a blue '+' icon followed by the text '+ Create New Repository'.

2. Give repository a name and setup the repository visibility

The screenshot shows the 'Create New Repository' form. At the top left is a back arrow labeled 'Repositories'. The main title is 'Create New Repository'. Below it, the repository name 'travis / rhttaining_httpd' is entered in a text input field, with an orange arrow pointing to it from the left. Underneath the name is a description placeholder 'Click to set repository description'. To the right is a 'Repository Description' field with a checked checkbox. Further down is a 'Repository Visibility' section with two options: 'Public' (selected, indicated by an orange circle) and 'Private' (indicated by a radio button). A descriptive text follows each option. At the bottom is a large orange arrow pointing to a blue button labeled 'Create Public Repository'.

3. In the newly created repository, click the **Settings** option from the left-side navigation menu. Set the **Repository State** to **Mirror**.

User Permissions

Select a user... Admin Add Permission

Events and Notifications

No notifications have been setup for this repository.

Click the "Create Notification" button above to add a new notification for a repository event.

Repository Visibility

This Repository is currently public and is visible to all users, and may be pulled by all users.

Make Private

Repository State

This Repository state is currently Mirror. The images and tags are maintained by Quay and Users can not push or modify them.

Mirror

- In the newly created repository, click the **Mirroring** option from the left-side navigation menu.

RED HAT® QUAY EXPLORE REPOSITORIES TUTORIAL search + travis

Repositories travis / rhttraining_httpd ☆

Repository Activity

Pull this container with the following Docker command:

```
docker pull quay.local:8080/travis/rhttraining_httpd
```

Description Click to set repository description

- In the **Mirroring** tab, complete the required information for the repository and create a **Robot User**. Click **Enable Mirror**

 - 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 information to your teammates about this robot account.

Create robot account **Cancel**

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 unable to push to this 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 [REDACTED]

Credentials

Required if the external repository is private.

Username	[REDACTED]
Password	[REDACTED]

Advanced Settings

Verify TLS
Require HTTPS and verify certificates when talking to the external registry.

HTTP Proxy proxy.example.com

HTTPs Proxy proxy.example.com

No Proxy example.com

Enable Mirror



6. Click "Sync Now" to perform immediate synchronization

Enabled

Scheduled mirroring enabled.
Immediate sync available via Sync Now.

External Repository quay.io/redhattraining/httpd-parent >

Tags latest 2.4 >

Sync Interval 5 days >

Next Sync Date Aug 25, 2021 3:24 PM > **Sync Now**

Robot User travis+travis_robot

Advanced Settings



7. Verify synchronization completed on the **Mirroring** tab as well as the **Tag History**

The screenshot shows two main sections of the Quay Image Registry interface.

Status Tab: This section displays synchronization information. It includes fields for State (Last Sync Succeeded), Timeout (None), and Retries Remaining (3 / 3). A large orange arrow points from the text "Verify synchronization completed" to the "Last Sync Succeeded" field.

Status	
State	Last Sync Succeeded
Timeout	None
Retries Remaining	3 / 3

Tag History Tab: This section shows a history of tag changes for the repository "travis / rhttraining_httpd". The sidebar on the left has icons for Repositories, Tag History (selected), Tag Change Log (highlighted by an orange arrow), Metrics, Refresh, and Settings. The main area shows a log of events with columns for DATE/TIME and details. Two specific events are highlighted with orange arrows: "latest was moved to SHA256 4678947be71f from SHA256 4678947be71f" at 3:35 PM and "2.4 was moved to SHA256 0276c26a7a34 from SHA256 0276c26a7a34" at 3:35 PM. Both events occurred on Aug 25, 2021.

travis / rhttraining_httpd		
Tag History		
TAG CHANGE LOG		
Aug 25, 2021		DATE/TIME
latest was moved to SHA256 4678947be71f from SHA256 4678947be71f		Wed, Aug 25, 2021 3:35 PM
2.4 was moved to SHA256 0276c26a7a34 from SHA256 0276c26a7a34		Wed, Aug 25, 2021 3:35 PM
latest was created pointing to SHA256 4678947be71f		Wed, Aug 25, 2021 3:34 PM
2.4 was created pointing to SHA256 0276c26a7a34		Wed, Aug 25, 2021 3:34 PM

7.3. Using the Quay Image Registry

7.4. Inspecting Images with Skopeo on Remote Registries

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.

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

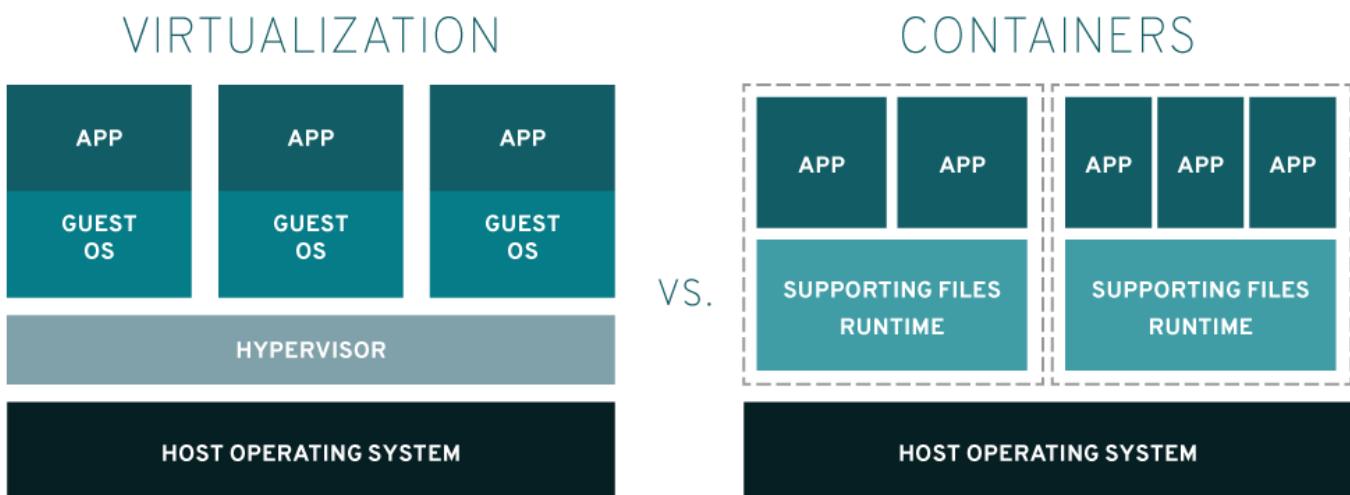


Figure 39. Virtualization vs. Containers

Table 6. 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 and 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 (RHOC 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 115. 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
ecbc6f53bba0d1923ca9e92b3f747da8353a070fccbae93625bd8b47dbe772e
[student@servera ~]
```

Images that have been downloaded with the Podman command can be seen with the **podman images** command.

Listing 116. Listing Local 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 117. 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 118. 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  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 9. DEMO - Running a Basic Container



Before Beginning

```
[student@workstation ~]$ lab containers-basic start
```

1. Install **podman** and other container tools packages

Listing 119. 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

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
registry.lab.example.com/rhel8/httpd-24	latest	7e93f25a946892c9c175b74a0915c96469e3b4845a6da9f214fd3ec19c3d7070	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 120. 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 121. 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 122. Listing All Containers

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS
PORTS NAMES				
9fd13da02e18 ago	registry.access.redhat.com/ubi7/ubi:latest	/bin/bash	About a minute ago	Exited (0) 3 seconds ago
d58f1e8fb4ca ago	registry.access.redhat.com/ubi8/ubi:latest	/bin/bash	9 minutes ago	Exited (127) 4 minutes ago
	cool_shannon 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 123. Removing All Containers

```
[student@servera ~]$ podman rm -a
9fd13da02e181d2dff09808e3f1ac860d637c1be8d57638d90080aec179e850
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 124. 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 125. 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 7. Podman Search Options

Option	Description
--limit <number>	Limits number of listed images per registry
--filter <filter=value>	Filters output based on conditions: <ul style="list-style-type: none"> 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 126. 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 order 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 127. 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 10. 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

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 128. 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

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 129. 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 130. Running Apache and Mapping Network Ports

```
[student@servera ~]$ podman run -d -p 8000:8080 --name webdemo registry.redhat.io/rhel8/httpd-24
```

Listing 131. Verifying the Port Mapping

```
[student@servera ~]$ podman port -a
0d1d688ebbb0 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 132. 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 133. 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 8. 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 134. Using podman exec

```
[student@servera ~]$ podman exec -it demo /bin/bash
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 11. 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

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS
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 135. Install MariaDB Client Package

```
[student@servera ~]$ sudo yum install mariadb
```

Listing 136. 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 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  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 applications 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 12. 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 first step is to connect to the workstation and forward X11 traffic back to the local system.

Example 13. Connecting to the Workstation VM

Listing 137. 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 14. Installing SCAP Workbench**Listing 138. 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 | 0:0.1.36-9.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 15. Launching SCAP Workbench**Listing 139. Using SCAP Workbench*

scap-workbench

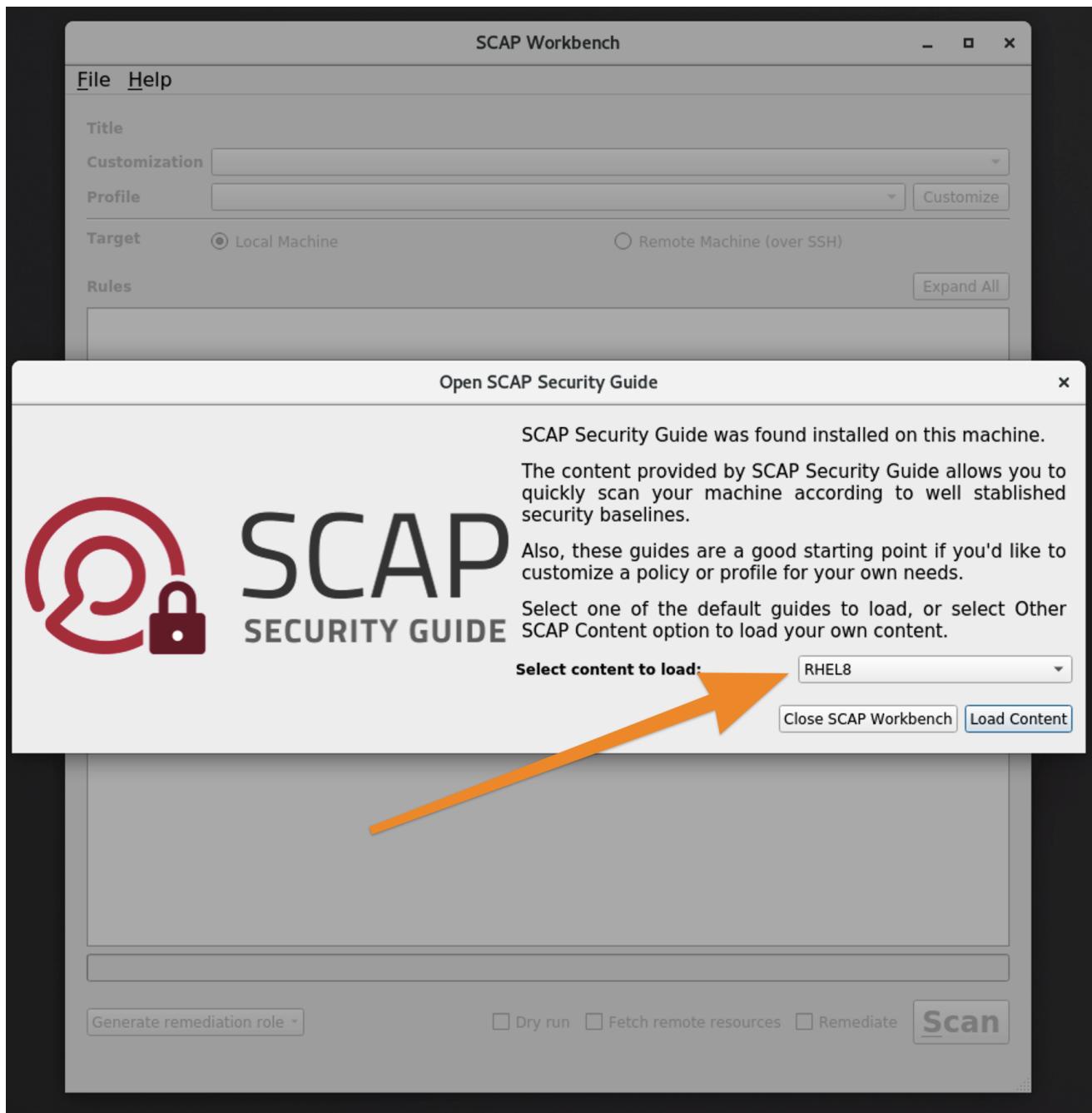


Figure 40. SCAP Workbench Startup

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 16. 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**

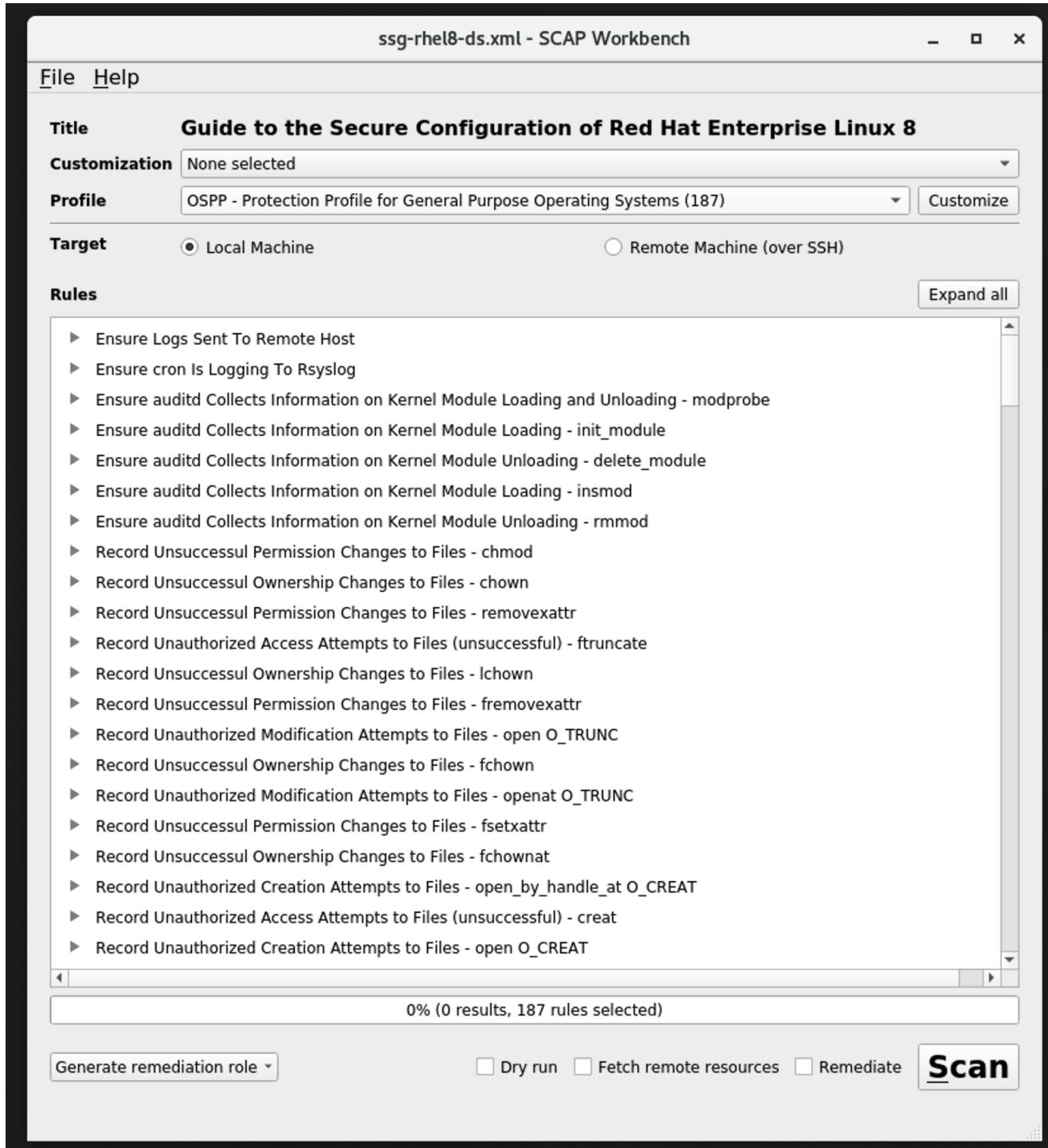


Figure 41. SCAP Workbench OSPP Profile

3. Click "Customize" to create custom SCAP content based on the chosen profile, and give it a name.

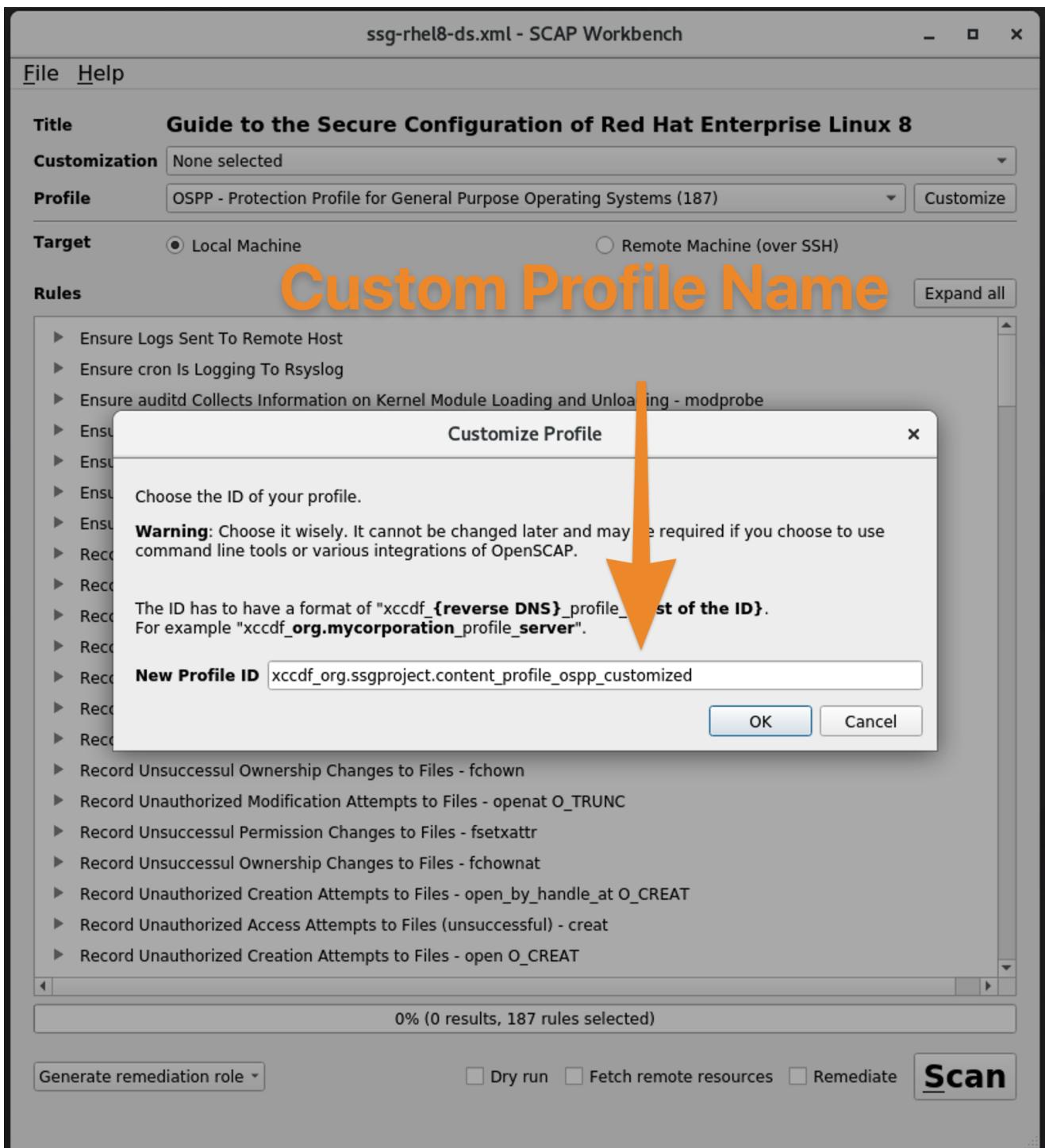


Figure 42. SCAP Custom OSPP Profile Creation



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.

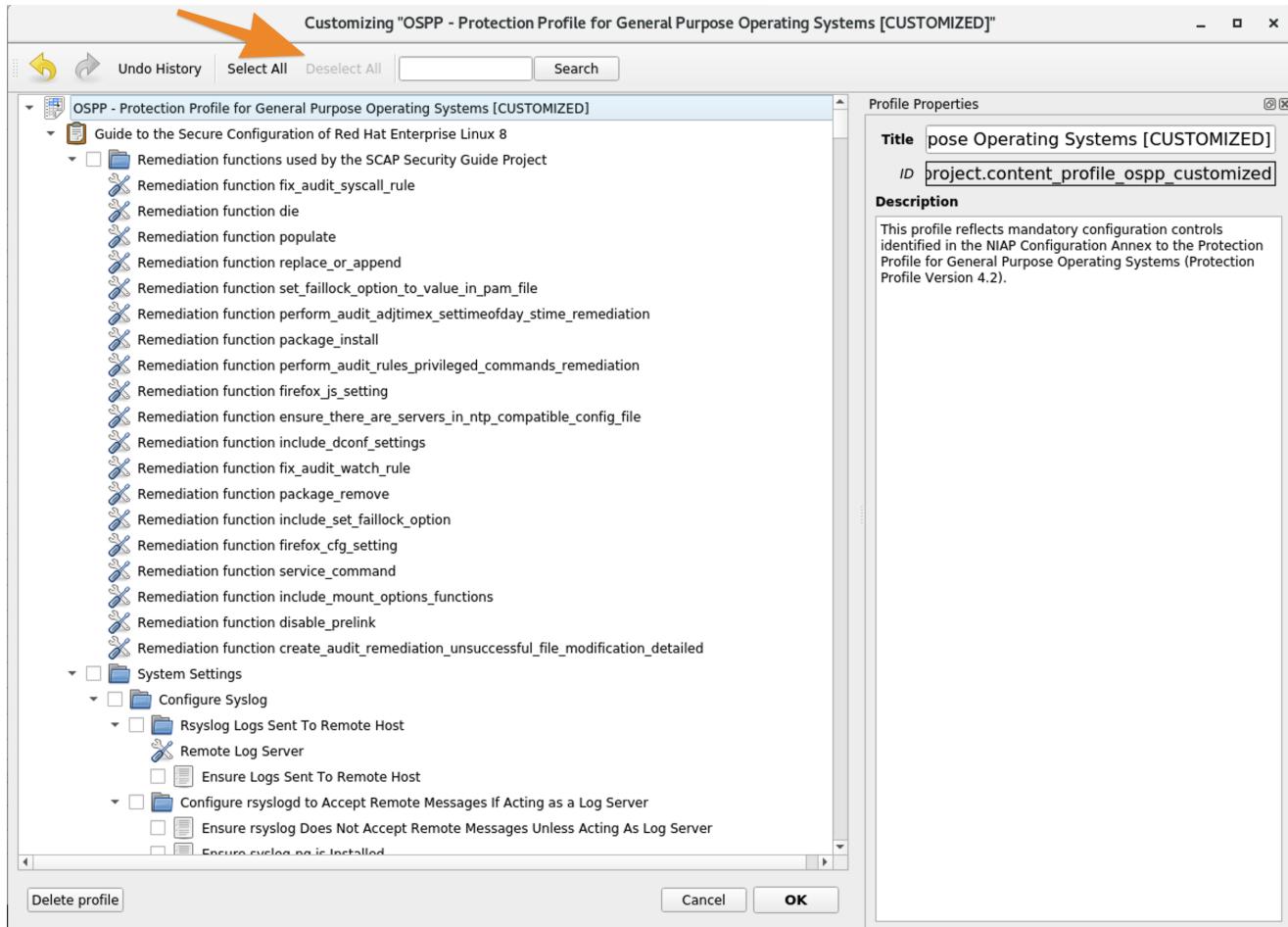


Figure 43. SCAP Custom Profile Selections



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 length** and set the value to **18**

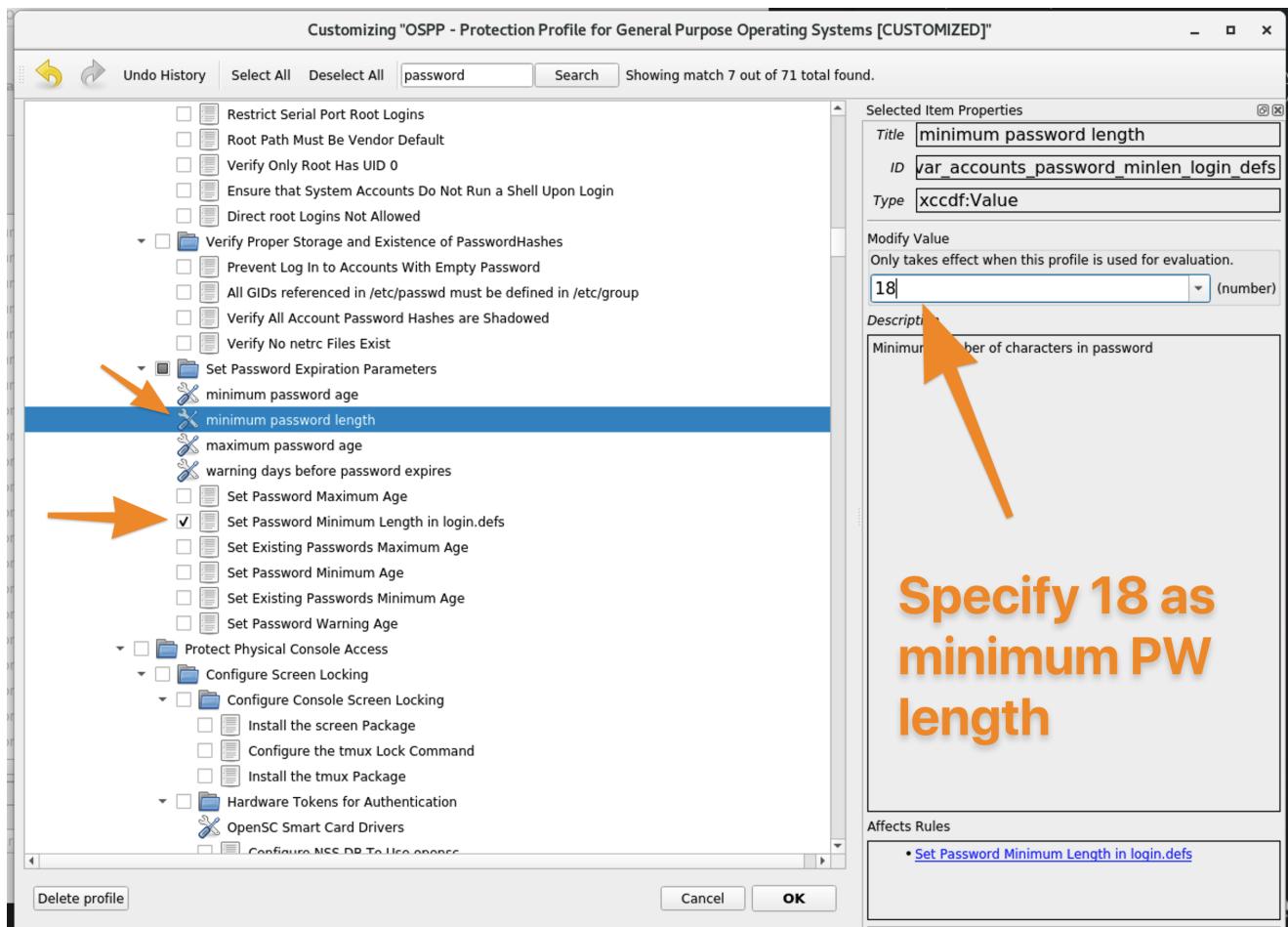


Figure 44. SCAP Custom Profile Password Settings for Login.Defs

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"

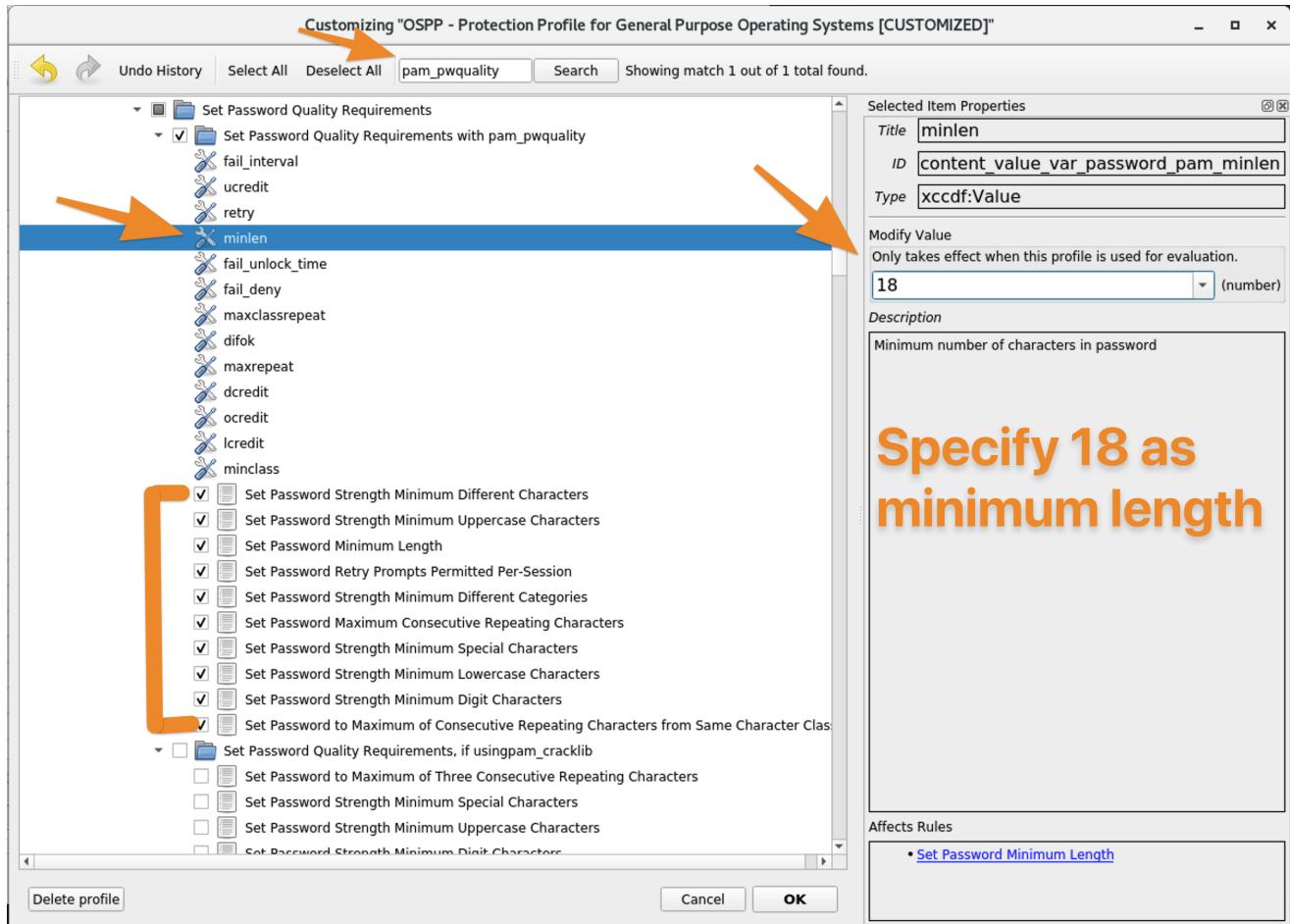


Figure 45. SCAP Custom Profile PAM Quality Requirements

- 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

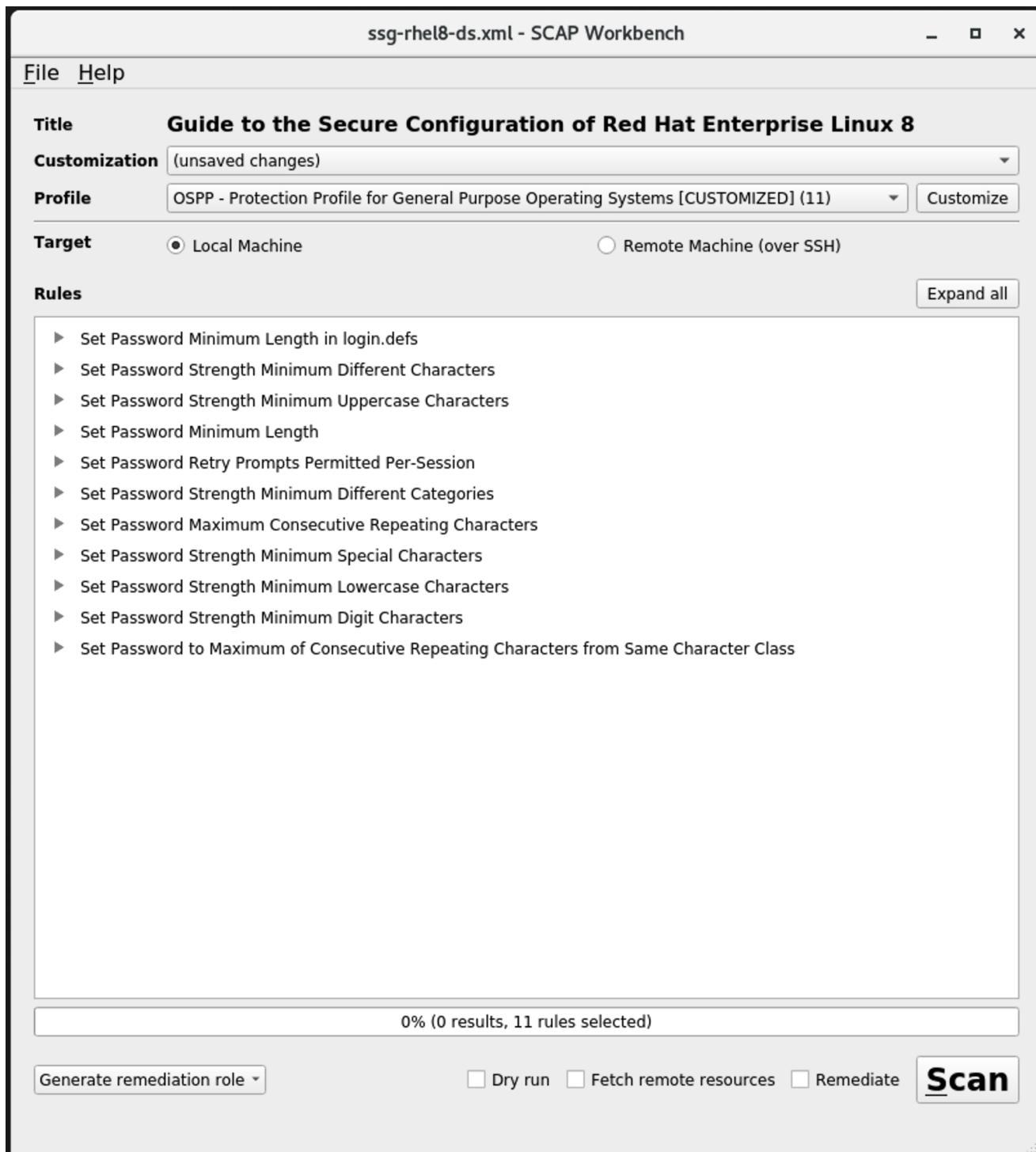


Figure 46. SCAP Custom Profile Selected Settings View

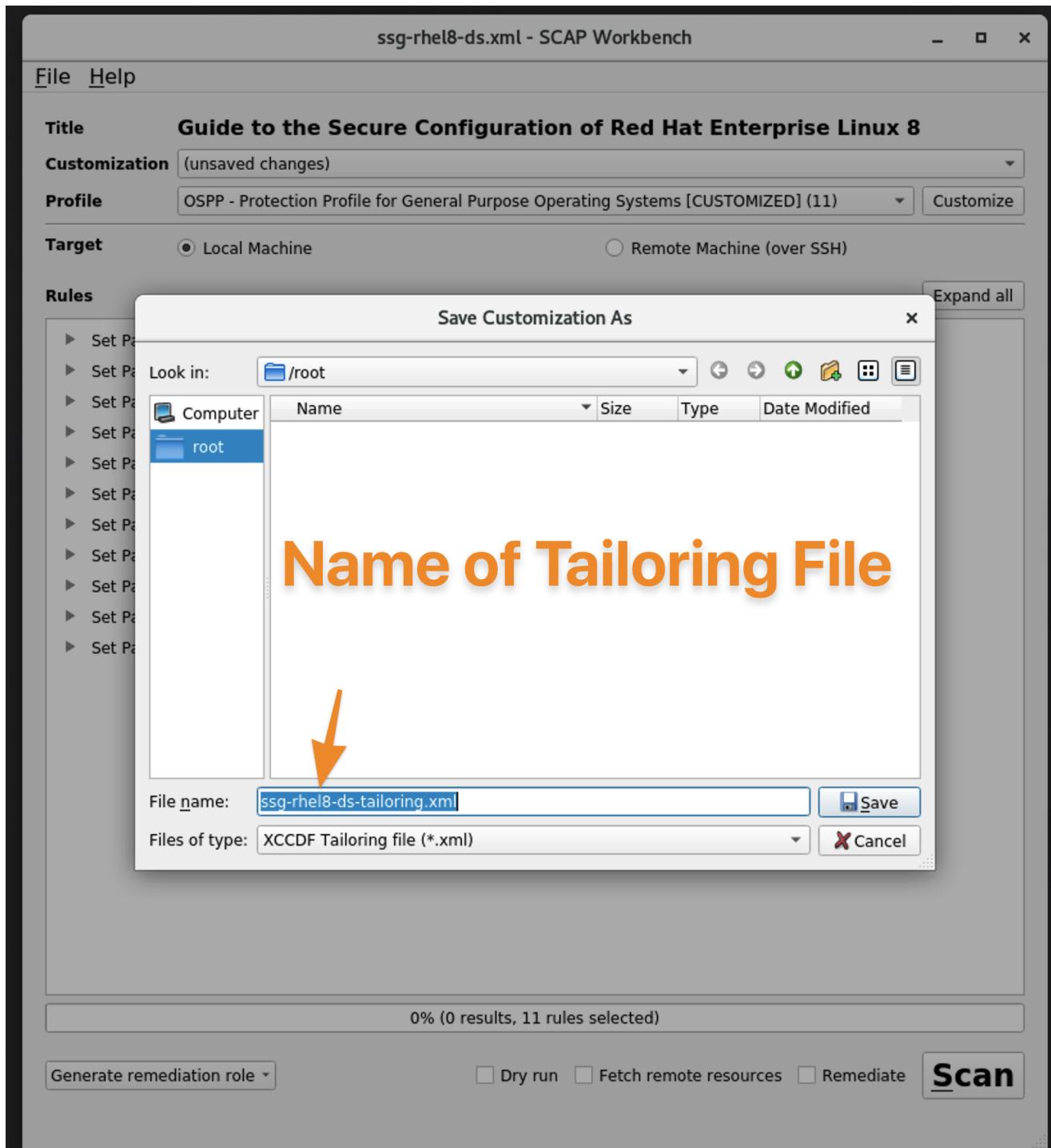


Figure 47. SCAP Custom Profile Creation Saving

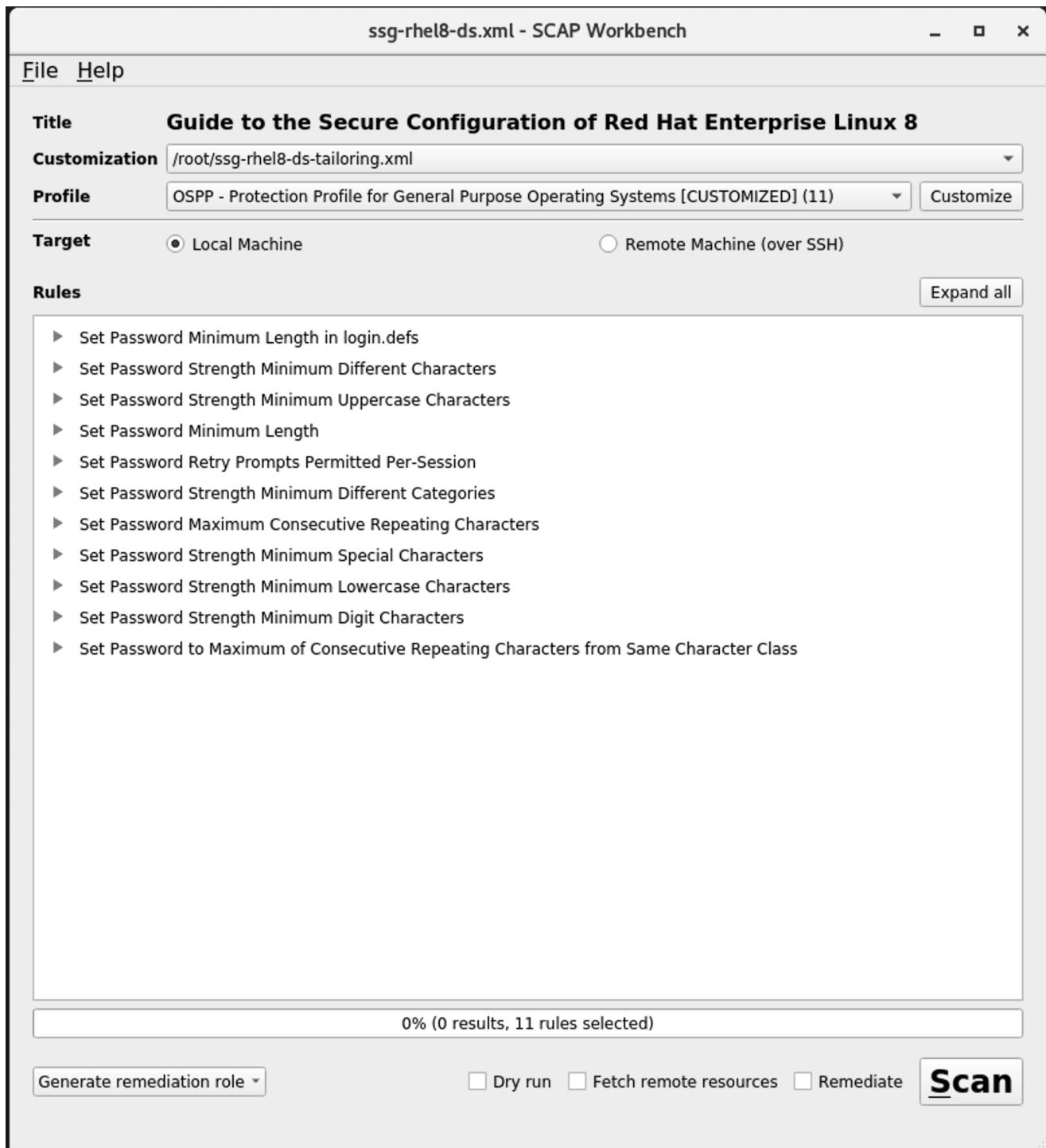


Figure 48. SCAP Custom Profile Final View

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 140. 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 servera

The first step is to connect to the server.

*Example 17. Connecting to the **servera** VM**Listing 141. 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 18. Install software on servera**Listing 142. 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 143. 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 associated 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 144. 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-arguments]

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 Configuration 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 19. Scanning servera



Listing 145. 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_lccredit
Ident CCE-80655-4
Result fail

Title Set Password Strength Minimum Digit Characters
Rule xccdf_org.ssgproject.content_rule_accounts_password_pam_dccredit
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 20. Creating a SCAP Report from a Results File

Listing 146. 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 147. 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 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_lccredit
Ident  CCE-80655-4
Result fail

Title  Set Password Strength Minimum Digit Characters
Rule   xccdf_org.ssgproject.content_rule_accounts_password_pam_dccredit
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 21. Transferring Results

Listing 148. 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:p0Q10JmyF2PFI+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 22. Viewing the SCAP Report**Listing 149. Opening the SCAP HTML Report with Firefox*

```
[root@workstation ~]# firefox Custom_Scan_Report.html
```



Evaluation Characteristics

Evaluation target	servera.lab.example.com
Benchmark URL	/usr/share/xml/scap/ssg/content/ssg-rhel8-ds.xml
Benchmark ID	xccdf_org.ssgproject.content_benchmark_RHEL-8
Benchmark version	0.1.42
Profile ID	xccdf_org.ssgproject.content_profile_ospp_customized
Started at	2020-04-16T09:21:32
Finished at	2020-04-16T09:21:33
Performed by	root
Test system	cpe:/a:redhat:openscap:1.3.0

CPE Platforms

- cpe:/o:redhat:enterprise_linux:8

Addresses

- IPv4 127.0.0.1
- IPv4 172.25.250.10
- IPv6 0:0:0:0:0:0:1
- IPv6 fe80:0:0:0:e6c5:468e:edb6:9b52
- MAC 00:00:00:00:00:00
- MAC 52:54:00:00:FA:0A

Compliance and Scoring

The target system did not satisfy the conditions of 11 rules! Please review rule results and consider applying remediation.

Rule results

11 failed

Severity of failed rules

11 medium

Score

Scoring system	Score	Maximum	Percent
urn:xccdf:scoring:default	0.000000	100.000000	0%

Figure 49. 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

- severa



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 23. Generating Ansible Playbook

Listing 150. 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.openscap_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 151. 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 24. Downloading Ansible Files

Listing 152. 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

[privilegeEscalation]
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 25. Remediation of serverc with Ansible Playbook**Listing 153. 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 uccredit 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 Per-Session - system-auth (change)] ***
ok: [servera.lab.example.com]

TASK [Set Password Retry Prompts 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 ocrediet is set accordingly] ****
changed: [servera.lab.example.com]

TASK [Ensure PAM variable lccredit 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 26. Scanning System after Fixes and Verifying Results*

Listing 154. 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 155. 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 156. Viewing Results on Workstation

```
[root@workstation ~]# firefox Custom_Scan_Report_Fixed.html
```



Compliance and Scoring

There were no failed or uncertain rules. It seems that no action is necessary.

Rule results

11 passed

Severity of failed rules

Score

Scoring system	Score	Maximum	Percent
urn:xccdf:scoring:default	100.000000	100.000000	100%

Rule Overview

<input checked="" type="checkbox"/> pass	<input checked="" type="checkbox"/> fail	<input checked="" type="checkbox"/> notchecked	Search through XCCDF rules	Search
<input checked="" type="checkbox"/> fixed	<input checked="" type="checkbox"/> error	<input checked="" type="checkbox"/> notapplicable	Group rules by: Default	
<input checked="" type="checkbox"/> informational	<input checked="" type="checkbox"/> unknown			
Title			Severity	Result
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Figure 50. Fixed SCAP Scan Results Report in Firefox