Red Hat Enterprise Linux 9

Configuring basic system settings

Set up the essential functions of your system and customize your system environment
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Set up the essential functions of your system and customize your system environment
Abstract

Perform basic system administration tasks, configure the environment settings, register your system, and configure network access and system security. Administer users, groups, and file permissions. Use system roles for managing system configurations interface on multiple RHEL systems. Use systemd for efficient service management. Configure the Network Time Protocol (NTP) with chrony. Backup and restore your system by using ReaR.
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Making Open Source More Inclusive

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

We appreciate your feedback on our documentation. Let us know how we can improve it.

Submitting feedback through Jira (account required)

1. Log in to the Jira website.
2. Click Create in the top navigation bar
3. Enter a descriptive title in the Summary field.
4. Enter your suggestion for improvement in the Description field. Include links to the relevant parts of the documentation.
5. Click Create at the bottom of the dialogue.
CHAPTER 1. CONFIGURING AND MANAGING BASIC NETWORK ACCESS

This section describes only basic options on how to configure network settings in Red Hat Enterprise Linux.

1.1. CONFIGURING THE NETWORK AND HOST NAME IN THE GRAPHICAL INSTALLATION MODE

Follow the steps in this procedure to configure your network and host name.

Procedure

1. From the Installation Summary window, click Network and Host Name.

2. From the list in the left-hand pane, select an interface. The details are displayed in the right-hand pane.

   **NOTE**

   There are several types of network device naming standards used to identify network devices with persistent names, for example, `em1` and `wl3sp0`. For information about these standards, see the Configuring and managing networking document.

3. Toggle the ON/OFF switch to enable or disable the selected interface.

   **NOTE**

   The installation program automatically detects locally accessible interfaces, and you cannot add or remove them manually.

4. Click + to add a virtual network interface, which can be either: Team (deprecated), Bond, Bridge, or VLAN.

5. Click - to remove a virtual interface.

6. Click Configure to change settings such as IP addresses, DNS servers, or routing configuration for an existing interface (both virtual and physical).

7. Type a host name for your system in the Host Name field.
NOTE

- The host name can either be a fully qualified domain name (FQDN) in the format `hostname.domainname`, or a short host name without the domain. Many networks have a Dynamic Host Configuration Protocol (DHCP) service that automatically supplies connected systems with a domain name. To allow the DHCP service to assign the domain name to this system, specify only the short host name.

- When using static IP and host name configuration, it depends on the planned system use case whether to use a short name or FQDN. Red Hat Identity Management configures FQDN during provisioning but some 3rd party software products may require short name. In either case, to ensure availability of both forms in all situations, add an entry for the host in `/etc/hosts` in the format `IP FQDN short-alias`.

- The value `localhost` means that no specific static host name for the target system is configured, and the actual host name of the installed system is configured during the processing of the network configuration, for example, by NetworkManager using DHCP or DNS.

- Host names can only contain alphanumeric characters and `-` or `.`. Host name should be equal to or less than 64 characters. Host names cannot start or end with `-` and `.`. To be compliant with DNS, each part of a FQDN should be equal to or less than 63 characters and the FQDN total length, including dots, should not exceed 255 characters.

8. Click **Apply** to apply the host name to the installer environment.

9. Alternatively, in the **Network and Hostname** window, you can choose the Wireless option. Click **Select network** in the right-hand pane to select your wifi connection, enter the password if required, and click **Done**.

Additional resources

- Performing an advanced RHEL 9 installation

1.2. CONFIGURING AN ETHERNET CONNECTION BY USING NMCLI

If you connect a host to the network over Ethernet, you can manage the connection’s settings on the command line by using the `nmcli` utility.

Prerequisites

- A physical or virtual Ethernet Network Interface Controller (NIC) exists in the server’s configuration.

Procedure

1. List the NetworkManager connection profiles:

```
# nmcli connection show
NAME        UUID                        TYPE       DEVICE
Wired connection 1  a5eb6490-cc20-3668-81f8-0314a27f3f75  ethernet  enp1s0
```
By default, NetworkManager creates a profile for each NIC in the host. If you plan to connect this NIC only to a specific network, adapt the automatically-created profile. If you plan to connect this NIC to networks with different settings, create individual profiles for each network.

2. If you want to create an additional connection profile, enter:

```
# nmcli connection add con-name <connection-name> ifname <device-name> type ethernet
```

Skip this step to modify an existing profile.

3. Optional: Rename the connection profile:

```
# nmcli connection modify "Wired connection 1" connection.id "Internal-LAN"
```

On hosts with multiple profiles, a meaningful name makes it easier to identify the purpose of a profile.

4. Display the current settings of the connection profile:

```
# nmcli connection show Internal-LAN
... connection.interface-name: enp1s0 connection.autoconnect: yes ipv4.method: auto ipv6.method: auto ...
```

5. Configure the IPv4 settings:

- To use DHCP, enter:

```
# nmcli connection modify Internal-LAN ipv4.method auto
```

Skip this step if `ipv4.method` is already set to `auto` (default).

- To set a static IPv4 address, network mask, default gateway, DNS servers, and search domain, enter:

```
# nmcli connection modify Internal-LAN ipv4.method manual ipv4.addresses 192.0.2.1/24 ipv4.gateway 192.0.2.254 ipv4.dns 192.0.2.200 ipv4.dns-search example.com
```

6. Configure the IPv6 settings:

- To use stateless address autoconfiguration (SLAAC), enter:

```
# nmcli connection modify Internal-LAN ipv6.method auto
```

Skip this step if `ipv6.method` is already set to `auto` (default).

- To set a static IPv6 address, network mask, default gateway, DNS servers, and search domain, enter:
7. To customize other settings in the profile, use the following command:

```
# nmcli connection modify <connection-name> <setting> <value>
```

Enclose values with spaces or semicolons in quotes.

8. Activate the profile:

```
# nmcli connection up Internal-LAN
```

### Verification

1. Display the IP settings of the NIC:

```
# ip address show enp1s0
```

2: enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP
group default qlen 1000
  link/ether 52:54:00:17:b8:b6 brd ff:ff:ff:ff:ff:ff
  inet 192.0.2.1/24 brd 192.0.2.255 scope global noprefixroute enp1s0
    valid_lft forever preferred_lft forever
  inet6 2001:db8:1::ffee scope global noprefixroute
    valid_lft forever preferred_lft forever

2. Display the IPv4 default gateway:

```
# ip route show default
default via 192.0.2.254 dev enp1s0 proto static metric 102
```

3. Display the IPv6 default gateway:

```
# ip -6 route show default
default via 2001:db8:1::ffee dev enp1s0 proto static metric 102 pref medium
```

4. Display the DNS settings:

```
# cat /etc/resolv.conf
```

```bash
search example.com
nameserver 192.0.2.200
nameserver 2001:db8:1::ffbb
```

If multiple connection profiles are active at the same time, the order of `nameserver` entries depend on the DNS priority values in these profile and the connection types.

5. Use the `ping` utility to verify that this host can send packets to other hosts:

```
# ping <host-name-or-IP-address>
```

### Troubleshooting
Verify that the network cable is plugged-in to the host and a switch.

Check whether the link failure exists only on this host or also on other hosts connected to the same switch.

Verify that the network cable and the network interface are working as expected. Perform hardware diagnosis steps and replace defect cables and network interface cards.

If the configuration on the disk does not match the configuration on the device, starting or restarting NetworkManager creates an in-memory connection that reflects the configuration of the device. For further details and how to avoid this problem, see the NetworkManager duplicates a connection after restart of NetworkManager service solution.

Additional resources

- **nm-settings(5)** man page

### 1.3. CONFIGURING AN ETHERNET CONNECTION BY USING NMTUI

If you connect a host to the network over Ethernet, you can manage the connection’s settings in a text-based user interface by using the `nmtui` application. Use `nmtui` to create new profiles and to update existing ones on a host without a graphical interface.

**NOTE**

In `nmtui`:

- Navigate by using the cursor keys.
- Press a button by selecting it and hitting `Enter`.
- Select and clear checkboxes by using `Space`.

**Prerequisites**

- A physical or virtual Ethernet Network Interface Controller (NIC) exists in the server’s configuration.

**Procedure**

1. If you do not know the network device name you want to use in the connection, display the available devices:

   ```
   # nmcli device status
   DEVICE      TYPE      STATE                   CONNECTION
   enp1s0      ethernet  unavailable             --
   ...
   ```

2. Start `nmtui`:

   ```
   # nmtui
   ```

3. Select **Edit a connection** and press `Enter`.
4. Choose whether to add a new connection profile or to modify an existing one:

- To create a new profile:
  
  i. Press Add.
  
  ii. Select Ethernet from the list of network types, and press Enter.

- To modify an existing profile, select the profile from the list, and press Enter.

5. Optional: Update the name of the connection profile.
On hosts with multiple profiles, a meaningful name makes it easier to identify the purpose of a profile.

6. If you create a new connection profile, enter the network device name into the Device field.

7. Depending on your environment, configure the IP address settings in the IPv4 configuration and IPv6 configuration areas accordingly. For this, press the button next to these areas, and select:

- Disabled, if this connection does not require an IP address.

- Automatic, if a DHCP server dynamically assigns an IP address to this NIC.

- Manual, if the network requires static IP address settings. In this case, you must fill further fields:
  
  i. Press Show next to the protocol you want to configure to display additional fields.

  ii. Press Add next to Addresses, and enter the IP address and the subnet mask in Classless Inter-Domain Routing (CIDR) format.

  If you do not specify a subnet mask, NetworkManager sets a /32 subnet mask for IPv4 addresses and /64 for IPv6 addresses.

  iii. Enter the address of the default gateway.

  iv. Press Add next to DNS servers, and enter the DNS server address.

  v. Press Add next to Search domains, and enter the DNS search domain.
8. Press **OK** to create and automatically activate the new connection.

9. Press **Back** to return to the main menu.

10. Select **Quit**, and press **Enter** to close the **nmtui** application.

**Verification**

1. Display the IP settings of the NIC:

   ```
   # ip address show enp1s0
   2: enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP
   group default qlen 1000
   link/ether 52:54:00:17:b8:b6 brd ff:ff:ff:ff:ff:ff
   ```
2. Display the IPv4 default gateway:

```bash
# ip route show default
default via 192.0.2.254 dev enp1s0 proto static metric 102
```

3. Display the IPv6 default gateway:

```bash
# ip -6 route show default
default via 2001:db8:1::ffee dev enp1s0 proto static metric 102 pref medium
```

4. Display the DNS settings:

```bash
# cat /etc/resolv.conf
search example.com
nameserver 192.0.2.200
nameserver 2001:db8:1::fbb
```

If multiple connection profiles are active at the same time, the order of `nameserver` entries depend on the DNS priority values in these profile and the connection types.

5. Use the `ping` utility to verify that this host can send packets to other hosts:

```bash
# ping <host-name-or-IP-address>
```

**Troubleshooting**

- Verify that the network cable is plugged-in to the host and a switch.
- Check whether the link failure exists only on this host or also on other hosts connected to the same switch.
- Verify that the network cable and the network interface are working as expected. Perform hardware diagnosis steps and replace defect cables and network interface cards.
- If the configuration on the disk does not match the configuration on the device, starting or restarting NetworkManager creates an in-memory connection that reflects the configuration of the device. For further details and how to avoid this problem, see the NetworkManager duplicates a connection after restart of NetworkManager service solution.

**Additional resources**

- Configuring NetworkManager to avoid using a specific profile to provide a default gateway
- Configuring the order of DNS servers

### 1.4. MANAGING NETWORKING IN THE RHEL WEB CONSOLE

In the web console, the **Networking** menu enables you:
To display currently received and sent packets
- To display the most important characteristics of available network interfaces
- To display content of the networking logs.
- To add various types of network interfaces (bond, team, bridge, VLAN)

**Figure 1.2. Managing Networking in the RHEL web console**

1.5. MANAGING NETWORKING USING RHEL SYSTEM ROLES

You can configure the networking connections on multiple target machines using the `network` role.

The `network` role allows to configure the following types of interfaces:

- Ethernet
- Bridge
- Bonded
- VLAN
- MacVLAN
- InfiniBand

The required networking connections for each host are provided as a list within the `network_connections` variable.
The following example shows how to apply the network role to ensure that an Ethernet connection with the required parameters exists:

An example playbook applying the network role to set up an Ethernet connection with the required parameters

```yaml
---
- hosts: managed-node-01.example.com
  vars:
    network_connections:
      # Create one Ethernet profile and activate it.
      # The profile uses automatic IP addressing
      # and is tied to the interface by MAC address.
      - name: prod1
        state: up
        type: ethernet
        autoconnect: yes
        mac: "00:00:5e:00:53:00"
        mtu: 1450
        roles:
          - rhel-system-roles.network
```

Additional resources

- Preparing a control node and managed nodes to use RHEL system roles

1.6. ADDITIONAL RESOURCES

- Configuring and managing networking
CHAPTER 2. REGISTERING THE SYSTEM AND MANAGING SUBSCRIPTIONS

Subscriptions cover products installed on Red Hat Enterprise Linux, including the operating system itself.

You can use a subscription to Red Hat Content Delivery Network to track:

- Registered systems
- Products installed on your systems
- Subscriptions attached to the installed products

2.1. REGISTERING THE SYSTEM AFTER THE INSTALLATION

Use the following procedure to register your system if you have not registered it during the installation process already.

**Prerequisites**

- A valid user account in the Red Hat Customer Portal.
- See the Create a Red Hat Login page.
- An active subscription for the RHEL system.
- For more information about the installation process, see Performing a standard RHEL 9 installation.

**Procedure**

1. Register and automatically subscribe your system in one step:

   ```bash
   # subscription-manager register --username <username> --password <password> --auto-attach
   Registering to: subscription.rhsm.redhat.com:443/subscription
   The system has been registered with ID: 37207927-ece6-49ea-9174-20b87e9ke7
   The registered system name is: client1.idm.example.com
   Installed Product Current Status:
   Product Name: Red Hat Enterprise Linux for x86_64
   Status:     Subscribed
   ```

   The command prompts you to enter your Red Hat Customer Portal user name and password.

   If the registration process fails, you can register your system with a specific pool. For guidance on how to do it, proceed with the following steps:

   a. Determine the pool ID of a subscription that you require:

   ```bash
   # subscription-manager list --available
   ```

   This command displays all available subscriptions for your Red Hat account. For every subscription, various characteristics are displayed, including the pool ID.
b. Attach the appropriate subscription to your system by replacing \textit{pool\_id} with the pool ID determined in the previous step:

\[
\texttt{# subscription-manager attach --pool=pool\_id}
\]

\section*{NOTE}
To register the system with Red Hat Insights, you can use the \texttt{rhc connect} utility. See Setting up remote host configuration.

Additional resources

- Understanding autoattaching subscriptions on the Customer Portal
- Understanding the manual registration and subscription on the Customer Portal

\section*{2.2. REGISTERING SUBSCRIPTIONS WITH CREDENTIALS IN THE WEB CONSOLE}

Use the following steps to register a newly installed Red Hat Enterprise Linux with account credentials using the RHEL web console.

\section*{Prerequisites}

- A valid user account on the Red Hat Customer Portal. See the Create a Red Hat Login page.
- Active subscription for your RHEL system.

\section*{Procedure}

1. Log in to the RHEL web console. For details, see Logging in to the web console.

2. In the Health filed in the Overview page, click the Not registered warning, or click Subscriptions in the main menu to move to page with your subscription information.

3. In the Overview filed, click Register.
4. In the **Register system** dialog box, select that you want to register using your account credentials.

![Register System](image)

5. Enter your username.

6. Enter your password.

7. Optionally, enter your organization’s name or ID. If your account belongs to more than one organization on the Red Hat Customer Portal, you have to add the organization name or organization ID. To get the org ID, go to your Red Hat contact point.
   - If you do not want to connect your system to Red Hat Insights, clear the **Insights** check box.

8. Click the **Register** button.

At this point, your Red Hat Enterprise Linux system has been successfully registered.

2.3. REGISTERING A SYSTEM USING RED HAT ACCOUNT ON GNOME

Follow the steps in this procedure to enroll your system with your Red Hat account.

**Prerequisites**
A valid account on Red Hat customer portal.
See the Create a Red Hat Login page for new user registration.

Procedure

1. Open the system menu, which is accessible from the upper-right screen corner, and click Settings.

2. Go to About → Subscription.

3. If you are not using the Red Hat server:
   a. In the Registration Server section, select Custom Address.
   b. Enter the server address in the URL field.

4. In the Registration Type section, select Red Hat Account.

5. In the Registration Details section:
   - Enter your Red Hat account user name in the Login field.
   - Enter your Red Hat account password in the Password field.
   - Enter the name of your organization in the Organization field.

6. Click Register.

2.4. REGISTERING A SYSTEM USING AN ACTIVATION KEY ON GNOME
Follow the steps in this procedure to register your system with an activation key. You can get the activation key from your organization administrator.

**Prerequisites**

- Activation key or keys.
  
  See the [Activation Keys](#) page for creating new activation keys.

**Procedure**

1. Open the **system menu**, which is accessible from the upper-right screen corner, and click **Settings**.

2. Go to **About → Subscription**.

3. If you are not using the Red Hat server:
   
   a. In the **Registration Server** section, select **Custom Address**.
   
   b. Enter the server address in the **URL** field.

4. In the **Registration Type** section, select **Activation Keys**.

5. Under **Registration Details**:
   
   - Enter your activation keys in the **Activation Keys** field. Separate your keys by a comma (,).
   
   - Enter the name or ID of your organization in the **Organization** field.
6. Click **Register**.
CHAPTER 3. ACCESSING THE RED HAT SUPPORT

This section describes how to effectively troubleshoot your problems using Red Hat support and sosreport.

To obtain support from Red Hat, use the Red Hat Customer Portal, which provides access to everything available with your subscription.

3.1. OBTAINING RED HAT SUPPORT THROUGH RED HAT CUSTOMER PORTAL

The following section describes how to use the Red Hat Customer Portal to get help.

Prerequisites
- A valid user account on the Red Hat Customer Portal. See Create a Red Hat Login.
- An active subscription for the RHEL system.

Procedure
1. Access Red Hat support:
   a. Open a new support case.
   b. Initiate a live chat with a Red Hat expert.
   c. Contact a Red Hat expert by making a call or sending an email.

3.2. TROUBLESHOOTING PROBLEMS USING SOSREPORT

The sosreport command collects configuration details, system information and diagnostic information from a Red Hat Enterprise Linux system.

The following section describes how to use the sosreport command to produce reports for your support cases.

Prerequisites
- A valid user account on the Red Hat Customer Portal. See Create a Red Hat Login.
- An active subscription for the RHEL system.
- A support-case number.

Procedure
1. Install the sos package:
   ```bash
   # dnf install sos
   ```
NOTE

The default minimal installation of Red Hat Enterprise Linux does not include the `sos` package, which provides the `sosreport` command.

2. Generate a report:

```
# sosreport
```

3. Attach the report to your support case.

Note that when attaching the report, you are prompted to enter the number of the relevant support case.

Additional resources

CHAPTER 4. CHANGING BASIC ENVIRONMENT SETTINGS

Configuration of basic environment settings is a part of the installation process. The following sections guide you when you change them later. The basic configuration of the environment includes:

- Date and time
- System locales
- Keyboard layout
- Language

4.1. CONFIGURING THE DATE AND TIME

Accurate timekeeping is important for several reasons. In Red Hat Enterprise Linux, timekeeping is ensured by the NTP protocol, which is implemented by a daemon running in user space. The user-space daemon updates the system clock running in the kernel. The system clock can keep time by using various clock sources.

Red Hat Enterprise Linux 9 and later versions use the chronyd daemon to implement NTP. chronyd is available from the chrony package. For more information, see Using the chrony suite to configure NTP.

4.1.1. Displaying the current date and time

To display the current date and time, use either of these steps.

Procedure

1. Enter the `date` command:

   $ date
   Mon Mar 30 16:02:59 CEST 2020

2. To see more details, use the `timedatectl` command:

   $ timedatectl
   Local time: Mon 2020-03-30 16:04:42 CEST
   Universal time: Mon 2020-03-30 14:04:42 UTC
   RTC time: Mon 2020-03-30 14:04:41
   Time zone: Europe/Prague (CEST, +0200)
   System clock synchronized: yes
   NTP service: active
   RTC in local TZ: no

Additional resources

- Configuring time settings using the web console
- `man date(1)` and `man timedatectl(1)`

4.2. CONFIGURING THE SYSTEM LOCALE
System-wide locale settings are stored in the `/etc/locale.conf` file that is read at early boot by the `systemd` daemon. Every service or user inherits the locale settings configured in `/etc/locale.conf`, unless individual programs or individual users override them.

**Procedure**

- To list available system locale settings:

  ```
  $ localectl list-locales
  C.utf8
  aa_DJ
  aa_DJ.iso88591
  aa_DJ.utf8
  ...
  ```

- To display the current status of the system locales settings:

  ```
  $ localectl status
  ```

- To set or change the default system locale settings, use a `localectl set-locale` sub-command as the root user. For example:

  ```
  # localectl set-locale LANG=en_US
  ```

**Additional resources**

- `man localectl(1)`, `man locale(7)`, and `man locale.conf(5)`

### 4.3. CONFIGURING THE KEYBOARD LAYOUT

The keyboard layout settings control the layout used on the text console and graphical user interfaces.

**Procedure**

- To list available keymaps:

  ```
  $ localectl list-keymaps
  ANSI-dvorak
  al
  al-plisi
  amiga-de
  amiga-us
  ...
  ```

- To display the current status of keymaps settings:

  ```
  $ localectl status
  ...
  VC Keymap: us
  ...
  ```

- To set or change the default system keymap. For example:
4.4. CHANGING THE FONT SIZE IN TEXT CONSOLE MODE

You can change the font size in the virtual console by using the `setfont` command.

- Enter the `setfont` command with the name of the font, for example:

  ```bash
  # setfont /usr/lib/kbd/consolefonts/LatArCyrHeb-19.psfu.gz
  ```

**NOTE**

The `setfont` command searches for multiple hard-coded paths by default. Therefore, `setfont` does not require the full name and path to the font.

- To double the size of the font horizontally and vertically, enter the `setfont` command with `-d` parameter:

  ```bash
  # setfont -d LatArCyrHeb-16
  ```

**NOTE**

The maximum font size that you can double is 16x16 pixel.

- To preserve the selected font during the reboot of the system, use the `FONT` variable in the `/etc/vconsole.conf` file, for example:

  ```bash
  # cat /etc/vconsole.conf
  KEYMAP="us"
  FONT="eurlatgr"
  ```

- You can find various fonts in the `kbd-misc` package, which is installed with the `kbd` package. For example, the font `LatArCyrHeb` has many variants:

  ```bash
  # rpm -ql kbd-misc | grep LatAr
  /usr/lib/kbd/consolefonts/LatArCyrHeb-08.psfu.gz
  /usr/lib/kbd/consolefonts/LatArCyrHeb-14.psfu.gz
  /usr/lib/kbd/consolefonts/LatArCyrHeb-16+.psfu.gz
  /usr/lib/kbd/consolefonts/LatArCyrHeb-16.psfu.gz
  /usr/lib/kbd/consolefonts/LatArCyrHeb-19.psfu.gz
  ```

**NOTE**

The maximum supported font size by the virtual console is 32 pixels. You can reduce the font readability problem by using smaller resolution for the console.
4.5. ADDITIONAL RESOURCES

- Performing a standard RHEL 9 installation
CHAPTER 5. USING SECURE COMMUNICATIONS BETWEEN TWO SYSTEMS WITH OPENSSH

SSH (Secure Shell) is a protocol which provides secure communications between two systems using a client-server architecture and allows users to log in to server host systems remotely. Unlike other remote communication protocols, such as FTP or Telnet, SSH encrypts the login session, which prevents intruders to collect unencrypted passwords from the connection.

Red Hat Enterprise Linux includes the basic OpenSSH packages: the general openssh package, the openssh-server package and the openssh-clients package. Note that the OpenSSH packages require the OpenSSL package openssl-libs, which installs several important cryptographic libraries that enable OpenSSH to provide encrypted communications.

5.1. SSH AND OPENSSH

SSH (Secure Shell) is a program for logging into a remote machine and executing commands on that machine. The SSH protocol provides secure encrypted communications between two untrusted hosts over an insecure network. You can also forward X11 connections and arbitrary TCP/IP ports over the secure channel.

The SSH protocol mitigates security threats, such as interception of communication between two systems and impersonation of a particular host, when you use it for remote shell login or file copying. This is because the SSH client and server use digital signatures to verify their identities. Additionally, all communication between the client and server systems is encrypted.

A host key authenticates hosts in the SSH protocol. Host keys are cryptographic keys that are generated automatically when OpenSSH is first installed, or when the host boots for the first time.

OpenSSH is an implementation of the SSH protocol supported by Linux, UNIX, and similar operating systems. It includes the core files necessary for both the OpenSSH client and server. The OpenSSH suite consists of the following user-space tools:

- **ssh** is a remote login program (SSH client).
- **sshd** is an OpenSSH SSH daemon.
- **scp** is a secure remote file copy program.
- **sftp** is a secure file transfer program.
- **ssh-agent** is an authentication agent for caching private keys.
- **ssh-add** adds private key identities to **ssh-agent**.
- **ssh-keygen** generates, manages, and converts authentication keys for **ssh**.
- **ssh-copy-id** is a script that adds local public keys to the **authorized_keys** file on a remote SSH server.
- **ssh-keyscan** gathers SSH public host keys.
NOTE

In RHEL 9, the Secure copy protocol (SCP) is replaced with the SSH File Transfer Protocol (SFTP) by default. This is because SCP has already caused security issues, for example CVE-2020-15778.

If SFTP is unavailable or incompatible in your scenario, you can use the -O option to force use of the original SCP/RCP protocol.

For additional information, see the OpenSSH SCP protocol deprecation in Red Hat Enterprise Linux 9 article.

Two versions of SSH currently exist: version 1, and the newer version 2. The OpenSSH suite in RHEL supports only SSH version 2. It has an enhanced key-exchange algorithm that is not vulnerable to exploits known in version 1.

OpenSSH, as one of core cryptographic subsystems of RHEL, uses system-wide crypto policies. This ensures that weak cipher suites and cryptographic algorithms are disabled in the default configuration. To modify the policy, the administrator must either use the update-crypto-policies command to adjust the settings or manually opt out of the system-wide crypto policies.

The OpenSSH suite uses two sets of configuration files: one for client programs (that is, ssh, scp, and sftp), and another for the server (the sshd daemon).

System-wide SSH configuration information is stored in the /etc/ssh/ directory. User-specific SSH configuration information is stored in ~/.ssh/ in the user’s home directory. For a detailed list of OpenSSH configuration files, see the FILES section in the sshd(8) man page.

Additional resources

- Man pages listed by using the man -k ssh command
- Using system-wide cryptographic policies

5.2. CONFIGURING AND STARTING AN OPENSSH SERVER

Use the following procedure for a basic configuration that might be required for your environment and for starting an OpenSSH server. Note that after the default RHEL installation, the sshd daemon is already started and server host keys are automatically created.

Prerequisites

- The openssh-server package is installed.

Procedure

1. Start the sshd daemon in the current session and set it to start automatically at boot time:

```
# systemctl start sshd
# systemctl enable sshd
```

2. To specify different addresses than the default 0.0.0.0 (IPv4) or :: (IPv6) for the ListenAddress directive in the /etc/ssh/sshd_config configuration file and to use a slower dynamic network configuration, add the dependency on the network-online.target target unit
to the `sshd.service` unit file. To achieve this, create the
`/etc/systemd/system/sshd.service.d/local.conf` file with the following content:

```ini
[Unit]
Wants=network-online.target
After=network-online.target
```

3. Review if OpenSSH server settings in the `/etc/ssh/sshd_config` configuration file meet the requirements of your scenario.

4. Optionally, change the welcome message that your OpenSSH server displays before a client authenticates by editing the `/etc/issue` file, for example:

```text
Welcome to ssh-server.example.com
Warning: By accessing this server, you agree to the referenced terms and conditions.
```

Ensure that the `Banner` option is not commented out in `/etc/ssh/sshd_config` and its value contains `/etc/issue`:

```bash
# less /etc/ssh/sshd_config | grep Banner
Banner /etc/issue
```

Note that to change the message displayed after a successful login you have to edit the `/etc/motd` file on the server. See the `pam_motd` man page for more information.

5. Reload the `systemd` configuration and restart `sshd` to apply the changes:

```bash
# systemctl daemon-reload
# systemctl restart sshd
```

**Verification**

1. Check that the `sshd` daemon is running:

```bash
# systemctl status sshd
```

2. Connect to the SSH server with an SSH client.
Additional resources

- sshd(8) and ssd_config(5) man pages.

5.3. SETTING AN OPENSSH SERVER FOR KEY-BASED AUTHENTICATION

To improve system security, enforce key-based authentication by disabling password authentication on your OpenSSH server.

Prerequisites

- The openssh-server package is installed.
- The ssdh daemon is running on the server.

Procedure

1. Open the /etc/ssh/sshd_config configuration in a text editor, for example:

   # vi /etc/ssh/sshd_config

2. Change the PasswordAuthentication option to no:

   PasswordAuthentication no

   On a system other than a new default installation, check that PubkeyAuthentication no has not been set and the KbdInteractiveAuthentication directive is set to no. If you are connected remotely, not using console or out-of-band access, test the key-based login process before disabling password authentication.

3. To use key-based authentication with NFS-mounted home directories, enable the use_nfs_home_dirs SELinux boolean:

   # setsebool -P use_nfs_home_dirs 1

4. Reload the ssdh daemon to apply the changes:

   # systemctl reload sshd

Additional resources

- sshd(8), ssd_config(5), and setsebool(8) man pages.
### 5.4. GENERATING SSH KEY PAIRS

Use this procedure to generate an SSH key pair on a local system and to copy the generated public key to an OpenSSH server. If the server is configured accordingly, you can log in to the OpenSSH server without providing any password.

**IMPORTANT**

If you complete the following steps as root, only root is able to use the keys.

#### Procedure

1. To generate an ECDSA key pair for version 2 of the SSH protocol:

   ```
   $ ssh-keygen -t ecdsa
   Generating public/private ecdsa key pair.
   Enter file in which to save the key (/home/joesec/.ssh/id_ecdsa):
   Enter passphrase (empty for no passphrase):
   Enter same passphrase again:
   Your identification has been saved in /home/joesec/.ssh/id_ecdsa.
   Your public key has been saved in /home/joesec/.ssh/id_ecdsa.pub.
   The key fingerprint is:
   SHA256:Q/x+qms4j7PCQ0qFd09iZEFHA+SqwBKRNuU72oZfaCl
   joesec@localhost.example.com
   The key's randomart image is:
     +----[ECDSA 256]----+   
     |.oo..o=++        |   
     |.. o .oo .       |   
     |...0+.+...       |   
     |0.00.0 +S .      |   
     |.=.+.  .0       |   
     |E:*+. . . .     |   
     |.==.+ +.. 0   |   
     | . 00*+0.     |   
     +----[SHA256]-----+
   
   You can also generate an RSA key pair by using the `-t rsa` option with the `ssh-keygen` command or an Ed25519 key pair by entering the `ssh-keygen -t ed25519` command.
   
2. To copy the public key to a remote machine:

   ```
   $ ssh-copy-id joesec@ssh-server-example.com
   /usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
   joesec@ssh-server-example.com's password:
   ...
   Number of key(s) added: 1
   
   Now try logging into the machine, with: "ssh 'joesec@ssh-server-example.com'" and check to make sure that only the key(s) you wanted were added.
   
   If you do not use the `ssh-agent` program in your session, the previous command copies the most recently modified `~/.ssh/id*.pub` public key if it is not yet installed. To specify another public-key file or to prioritize keys in files over keys cached in memory by `ssh-agent`, use the
**NOTE**

If you reinstall your system and want to keep previously generated key pairs, back up the `~/.ssh/` directory. After reinstalling, copy it back to your home directory. You can do this for all users on your system, including **root**.

### Verification

1. Log in to the OpenSSH server without providing any password:

   ```
   $ ssh joesec@ssh-server-example.com
   Welcome message.
   ...
   Last login: Mon Nov 18 18:28:42 2019 from ::1
   ```

### Additional resources

- **ssh-keygen(1)** and **ssh-copy-id(1)** man pages.

### 5.5. USING SSH KEYS STORED ON A SMART CARD

Red Hat Enterprise Linux enables you to use RSA and ECDSA keys stored on a smart card on OpenSSH clients. Use this procedure to enable authentication using a smart card instead of using a password.

#### Prerequisites

- On the client side, the `opensc` package is installed and the `pcscd` service is running.

#### Procedure

1. List all keys provided by the OpenSC PKCS #11 module including their PKCS #11 URIs and save the output to the `keys.pub` file:

   ```
   $ ssh-keygen -D pkcs11: > keys.pub
   $ ssh-keygen -D pkcs11:
   ssh-rsa AAAAB3NzaC1yc2E...KKZMzcQZzx
   pkcs11:id=%02;object=SIGN%20pubkey;token=SSH%20key;manufacturer=piv_II?module-path=/usr/lib64/pkcs11/opensc-pkcs11.so
   ecdsa-sha2-nistp256 AAA...J0hkYnnsM=
   pkcs11:id=%01;object=PIV%20AUTH%20pubkey;token=SSH%20key;manufacturer=piv_II?
   module-path=/usr/lib64/pkcs11/opensc-pkcs11.so
   ```

2. To enable authentication using a smart card on a remote server (**example.com**), transfer the public key to the remote server. Use the `ssh-copy-id` command with `keys.pub` created in the previous step:

   ```
   $ ssh-copy-id -f -i keys.pub username@example.com
   ```

3. To connect to **example.com** using the ECDSA key from the output of the `ssh-keygen -D` command in step 1, you can use just a subset of the URL, which uniquely references your key, for example:
$ ssh -i "pkcs11:id=%01?module-path=/usr/lib64/pkcs11/opensc-pkcs11.so" example.com
Enter PIN for 'SSH key':
[example.com] $

4. You can use the same URI string in the ~/.ssh/config file to make the configuration permanent:

   $ cat ~/.ssh/config
   IdentityFile "pkcs11:id=%01?module-path=/usr/lib64/pkcs11/opensc-pkcs11.so"
   $ ssh example.com
   Enter PIN for 'SSH key':
   [example.com] $

Because OpenSSH uses the p11-kit-proxy wrapper and the OpenSC PKCS #11 module is registered to PKCS#11 Kit, you can simplify the previous commands:

   $ ssh -i "pkcs11:id=%01" example.com
   Enter PIN for 'SSH key':
   [example.com] $

If you skip the id= part of a PKCS #11 URI, OpenSSH loads all keys that are available in the proxy module. This can reduce the amount of typing required:

   $ ssh -i pkcs11: example.com
   Enter PIN for 'SSH key':
   [example.com] $

Additional resources

- Fedora 28: Better smart card support in OpenSSH
- p11-kit(8), opensc.conf(5), pcscd(8), ssh(1), and ssh-keygen(1) man pages

5.6. MAKING OPENSSH MORE SECURE

The following tips help you to increase security when using OpenSSH. Note that changes in the /etc/ssh/sshd_config OpenSSH configuration file require reloading the sshd daemon to take effect:

   # systemctl reload sshd

   IMPORTANT

   The majority of security hardening configuration changes reduce compatibility with clients that do not support up-to-date algorithms or cipher suites.

Disabling insecure connection protocols

- To make SSH truly effective, prevent the use of insecure connection protocols that are replaced by the OpenSSH suite. Otherwise, a user’s password might be protected using SSH for one session only to be captured later when logging in using Telnet. For this reason, consider disabling insecure protocols, such as telnet, rsh, rlogin, and ftp.

Enabling key-based authentication and disabling password-based authentication
Disabling passwords for authentication and allowing only key pairs reduces the attack surface and it also might save users’ time. On clients, generate key pairs using the `ssh-keygen` tool and use the `ssh-copy-id` utility to copy public keys from clients on the OpenSSH server. To disable password-based authentication on your OpenSSH server, edit `/etc/ssh/sshd_config` and change the `PasswordAuthentication` option to `no`:

```
PasswordAuthentication no
```

### Key types

- Although the `ssh-keygen` command generates a pair of RSA keys by default, you can instruct it to generate ECDSA or Ed25519 keys by using the `-t` option. The ECDSA (Elliptic Curve Digital Signature Algorithm) offers better performance than RSA at the equivalent symmetric key strength. It also generates shorter keys. The Ed25519 public-key algorithm is an implementation of twisted Edwards curves that is more secure and also faster than RSA, DSA, and ECDSA. OpenSSH creates RSA, ECDSA, and Ed25519 server host keys automatically if they are missing. To configure the host key creation in RHEL, use the `sshd-keygen@.service` instantiated service. For example, to disable the automatic creation of the RSA key type:

```
# systemctl mask sshd-keygen@rsa.service
```

**NOTE**

In images with `cloud-init` enabled, the `ssh-keygen` units are automatically disabled. This is because the `ssh-keygen` template service can interfere with the `cloud-init` tool and cause problems with host key generation. To prevent these problems the `etc/systemd/system/sshd-keygen@.service.d/disable-sshd-keygen-if-cloud-init-active.conf` drop-in configuration file disables the `sshd-keygen` units if `cloud-init` is running.

- To exclude particular key types for SSH connections, comment out the relevant lines in `/etc/ssh/sshd_config`, and reload the `sshd` service. For example, to allow only Ed25519 host keys:

```
# HostKey /etc/ssh/ssh_host_rsa_key
# HostKey /etc/ssh/ssh_host_ecdsa_key
HostKey /etc/ssh/ssh_host_ed25519_key
```

**IMPORTANT**

The Ed25519 algorithm is not FIPS-140-compliant, and OpenSSH does not work with Ed25519 keys in FIPS mode.

### Non-default port

- By default, the `sshd` daemon listens on TCP port 22. Changing the port reduces the exposure of the system to attacks based on automated network scanning and therefore increase security through obscurity. You can specify the port using the `Port` directive in the `/etc/ssh/sshd_config` configuration file.

You also have to update the default SELinux policy to allow the use of a non-default port. To do so, use the `semanage` tool from the `policycoreutils-python-utils` package:
# semanage port -a -t ssh_port_t -p tcp <port_number>

Furthermore, update `firewalld` configuration:

```bash
# firewall-cmd --add-port <port_number>/tcp
# firewall-cmd --remove-port=22/tcp
# firewall-cmd --runtime-to-permanent
```

In the previous commands, replace `<port_number>` with the new port number specified using the `Port` directive.

**Root login**

- `PermitRootLogin` is set to `prohibit-password` by default. This enforces the use of key-based authentication instead of the use of passwords for logging in as root and reduces risks by preventing brute-force attacks.

**WARNING**

Enabling logging in as the root user is not a secure practice because the administrator cannot audit which users run which privileged commands. For using administrative commands, log in and use `sudo` instead.

**Using the X Security extension**

- The X server in Red Hat Enterprise Linux clients does not provide the X Security extension. Therefore, clients cannot request another security layer when connecting to untrusted SSH servers with X11 forwarding. Most applications are not able to run with this extension enabled anyway.
  
  By default, the `ForwardX11Trusted` option in the `/etc/ssh/ssh_config.d/50-redhat.conf` file is set to `yes`, and there is no difference between the `ssh -X remote_machine` (untrusted host) and `ssh -Y remote_machine` (trusted host) command.
  
  If your scenario does not require the X11 forwarding feature at all, set the `X11Forwarding` directive in the `/etc/ssh/sshd_config` configuration file to `no`.

**Restricting access to specific users, groups, or domains**

- The `AllowUsers` and `AllowGroups` directives in the `/etc/ssh/sshd_config` configuration file server enable you to permit only certain users, domains, or groups to connect to your OpenSSH server. You can combine `AllowUsers` and `AllowGroups` to restrict access more precisely, for example:
  
  ```
  AllowUsers *@192.168.1.* *@10.0.0.* !*@192.168.1.2
  AllowGroups example-group
  ```
  
  The previous configuration lines accept connections from all users from systems in 192.168.1.* and 10.0.0.* subnets except from the system with the 192.168.1.2 address. All users must be in the `example-group` group. The OpenSSH server denies all other connections.
The OpenSSH server permits only connections that pass all Allow and Deny directives in `/etc/ssh/sshd_config`. For example, if the **AllowUsers** directive lists a user that is not part of a group listed in the **AllowGroups** directive, then the user cannot log in.

Note that using allowlists (directives starting with Allow) is more secure than using blocklists (options starting with Deny) because allowlists block also new unauthorized users or groups.

### Changing system-wide cryptographic policies

- OpenSSH uses RHEL system-wide cryptographic policies, and the default system-wide cryptographic policy level offers secure settings for current threat models. To make your cryptographic settings more strict, change the current policy level:

  ```
  # update-crypto-policies --set FUTURE
  Setting system policy to FUTURE
  ```

**WARNING**

If your system communicates on the internet, you might face interoperability problems due to the strict setting of the **FUTURE** policy.

You can also disable only specific ciphers for the SSH protocol through the system-wide cryptographic policies. See the Customizing system-wide cryptographic policies with subpolicies section in the Security hardening document for more information.

To opt out of the system-wide cryptographic policies for your OpenSSH server, specify the cryptographic policy in a drop-in configuration file located in the `/etc/ssh/sshd_config.d/` directory, with a two-digit number prefix smaller than 50, so that it lexicographically precedes the `50-redhat.conf` file, and with a `.conf` suffix, for example, `49-crypto-policy-override.conf`.

See the `sshd_config(5)` man page for more information.

To opt out of system-wide cryptographic policies for your OpenSSH client, perform one of the following tasks:

- For a given user, override the global `ssh_config` with a user-specific configuration in the `~/.ssh/config` file.

- For the entire system, specify the cryptographic policy in a drop-in configuration file located in the `/etc/ssh/sshd_config.d/` directory, with a two-digit number prefix smaller than 50, so that it lexicographically precedes the `50-redhat.conf` file, and with a `.conf` suffix, for example, `49-crypto-policy-override.conf`.

**Additional resources**

- `sshd_config(5)`, `ssh-keygen(1)`, `crypto-policies(7)`, and `update-crypto-policies(8)` man pages.


- How to disable specific algorithms and ciphers for ssh service only article.
5.7. CONNECTING TO A REMOTE SERVER USING AN SSH JUMP HOST

Use this procedure for connecting your local system to a remote server through an intermediary server, also called jump host.

Prerequisites

- A jump host accepts SSH connections from your local system.
- A remote server accepts SSH connections only from the jump host.

Procedure

1. Define the jump host by editing the `~/.ssh/config` file on your local system, for example:

   ```
   Host jump-server1
   HostName jump1.example.com
   ```

   - The `Host` parameter defines a name or alias for the host you can use in `ssh` commands. The value can match the real host name, but can also be any string.
   - The `HostName` parameter sets the actual host name or IP address of the jump host.

2. Add the remote server jump configuration with the `ProxyJump` directive to `~/.ssh/config` file on your local system, for example:

   ```
   Host remote-server
   HostName remote1.example.com
   ProxyJump jump-server1
   ```

3. Use your local system to connect to the remote server through the jump server:

   ```
   $ ssh remote-server
   ```

   The previous command is equivalent to the `ssh -J jump-server1 remote-server` command if you omit the configuration steps 1 and 2.

   **NOTE**

   You can specify more jump servers and you can also skip adding host definitions to the configurations file when you provide their complete host names, for example:

   ```
   $ ssh -J jump1.example.com,jump2.example.com,jump3.example.com remote1.example.com
   ```

   Change the host name-only notation in the previous command if the user names or SSH ports on the jump servers differ from the names and ports on the remote server, for example:

   ```
   $ ssh -J johndoe@jump1.example.com:75,johndoe@jump2.example.com:75,johndoe@jump3.example.com:75 joesec@remote1.example.com:220
   ```
Additional resources

- ssh_config(5) and ssh(1) man pages.

5.8. CONNECTING TO REMOTE MACHINES WITH SSH KEYS USING SSH-AGENT

To avoid entering a passphrase each time you initiate an SSH connection, you can use the ssh-agent utility to cache the private SSH key. The private key and the passphrase remain secure.

Prerequisites

- You have a remote host with SSH daemon running and reachable through the network.
- You know the IP address or hostname and credentials to log in to the remote host.
- You have generated an SSH key pair with a passphrase and transferred the public key to the remote machine.

For more information, see Generating SSH key pairs.

Procedure

1. Optional: Verify you can use the key to authenticate to the remote host:
   a. Connect to the remote host using SSH:

      ```
      $ ssh example.user1@198.51.100.1 hostname
      ```

   b. Enter the passphrase you set while creating the key to grant access to the private key.

      ```
      $ ssh example.user1@198.51.100.1 hostname
      host.example.com
      ```

2. Start the ssh-agent.

   ```
   $ eval $(ssh-agent)
   Agent pid 20062
   ```

3. Add the key to ssh-agent.

   ```
   $ ssh-add ~/.ssh/id_rsa
   Enter passphrase for ~/.ssh/id_rsa:
   Identity added: ~/.ssh/id_rsa (example.user0@198.51.100.12)
   ```

Verification

- Optional: Log in to the host machine using SSH.

      ```
      $ ssh example.user1@198.51.100.1
      Last login: Mon Sep 14 12:56:37 2020
      ```
Note that you did not have to enter the passphrase.

5.9. ADDITIONAL RESOURCES

- `sshd(8), ssh(1), scp(1), sftp(1), ssh-keygen(1), ssh-copy-id(1), ssh_config(5), sshd_config(5), update-crypto-policies(8)`, and `crypto-policies(7)` man pages.

- OpenSSH Home Page

- Configuring SELinux for applications and services with non-standard configurations

- Controlling network traffic using firewalld
CHAPTER 6. CONFIGURING BASIC SYSTEM SECURITY

Computer security is the protection of computer systems and their hardware, software, information, and services from theft, damage, disruption, and misdirection. Ensuring computer security is an essential task, in particular in enterprises that process sensitive data and handle business transactions.

This section covers only the basic security features that you can configure after installation of the operating system.

6.1. ENABLING THE FIREWALLD SERVICE

A firewall is a network security system that monitors and controls incoming and outgoing network traffic according to configured security rules. A firewall typically establishes a barrier between a trusted secure internal network and another outside network.

The `firewalld` service, which provides a firewall in Red Hat Enterprise Linux, is automatically enabled during installation.

To enable the `firewalld` service, follow this procedure.

**Procedure**

- Display the current status of `firewalld`:

  ```
  $ systemctl status firewalld
  ● firewalld.service - firewalld - dynamic firewall daemon
     Loaded: loaded (/usr/lib/systemd/system/firewalld.service; disabled; vendor preset: enabled)
     Active: inactive (dead)
     ...
  ```

- If `firewalld` is not enabled and running, switch to the `root` user, and start the `firewalld` service and enable to start it automatically after the system restarts:

  ```
  # systemctl enable --now firewalld
  ```

**Verification steps**

- Check that `firewalld` is running and enabled:

  ```
  $ systemctl status firewalld
  ● firewalld.service - firewalld - dynamic firewall daemon
     Loaded: loaded (/usr/lib/systemd/system/firewalld.service; enabled; vendor preset: enabled)
     Active: active (running)
     ...
  ```

**Additional resources**

- Using and configuring `firewalld`

- `man firewalld(1)`
6.2. MANAGING BASIC SELINUX SETTINGS

Security-Enhanced Linux (SELinux) is an additional layer of system security that determines which processes can access which files, directories, and ports. These permissions are defined in SELinux policies. A policy is a set of rules that guide the SELinux security engine.

SELinux has two possible states:

- Disabled
- Enabled

When SELinux is enabled, it runs in one of the following modes:

- Enabled
  - Enforcing
  - Permissive

In **enforcing mode**, SELinux enforces the loaded policies. SELinux denies access based on SELinux policy rules and enables only the interactions that are explicitly allowed. Enforcing mode is the safest SELinux mode and is the default mode after installation.

In **permissive mode**, SELinux does not enforce the loaded policies. SELinux does not deny access, but reports actions that break the rules to the `/var/log/audit/audit.log` log. Permissive mode is the default mode during installation. Permissive mode is also useful in some specific cases, for example when troubleshooting problems.

**Additional resources**

- Using SELinux

6.3. ENSURING THE REQUIRED STATE OF SELINUX

By default, SELinux operates in enforcing mode. However, in specific scenarios, you can set SELinux to permissive mode or even disable it.

**IMPORTANT**

Red Hat recommends to keep your system in enforcing mode. For debugging purposes, you can set SELinux to permissive mode.

Follow this procedure to change the state and mode of SELinux on your system.

**Procedure**

1. Display the current SELinux mode:

   $ getenforce

2. To temporarily set SELinux:

   a. To Enforcing mode:
# setenforce Enforcing

b. To Permissive mode:

# setenforce Permissive

**NOTE**

After reboot, SELinux mode is set to the value specified in the `/etc/selinux/config` configuration file.

3. To set SELinux mode to persist across reboots, modify the `SELINUX` variable in the `/etc/selinux/config` configuration file.

For example, to switch SELinux to enforcing mode:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#     enforcing - SELinux security policy is enforced.
#     permissive - SELinux prints warnings instead of enforcing.
#     disabled - No SELinux policy is loaded.
SELINUX=enforcing
...
```

**WARNING**

Disabling SELinux reduces your system security. Avoid disabling SELinux using the `SELINUX=disabled` option in the `/etc/selinux/config` file because this can result in memory leaks and race conditions causing kernel panics. Instead, disable SELinux by adding the `selinux=0` parameter to the kernel command line. For more information, see Changing SELinux modes at boot time.

**Additional resources**

- Changing SELinux states and modes

**6.4. ADDITIONAL RESOURCES**

- Generating SSH key pairs
- Setting an OpenSSH server for key-based authentication
- Security hardening
- Using SELinux
- Securing networks
CHAPTER 7. INTRODUCTION TO RHEL SYSTEM ROLES

By using RHEL system roles, you can remotely manage the system configurations of multiple RHEL systems across major versions of RHEL.

Important terms and concepts

The following describes important terms and concepts in an Ansible environment:

Control node
A control node is the system from which you run Ansible commands and playbooks. Your control node can be an Ansible Automation Platform, Red Hat Satellite, or a RHEL 9, 8, or 7 host. For more information, see Preparing a control node on RHEL 9.

Managed node
Managed nodes are the servers and network devices that you manage with Ansible. Managed nodes are also sometimes called hosts. Ansible does not have to be installed on managed nodes. For more information, see Preparing a managed node.

Ansible playbook
In a playbook, you define the configuration you want to achieve on your managed nodes or a set of steps for the system on the managed node to perform. Playbooks are Ansible’s configuration, deployment, and orchestration language.

Inventory
In an inventory file, you list the managed nodes and specify information such as IP address for each managed node. In the inventory, you can also organize the managed nodes by creating and nesting groups for easier scaling. An inventory file is also sometimes called a hostfile.

Available roles on a Red Hat Enterprise Linux 9 control node

On a Red Hat Enterprise Linux 9 control node, the `rhel-system-roles` package provides the following roles:

<table>
<thead>
<tr>
<th>Role name</th>
<th>Role description</th>
<th>Chapter title</th>
</tr>
</thead>
<tbody>
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<td>certificate</td>
<td>Certificate Issuance and Renewal</td>
<td>Requesting certificates by using RHEL system roles</td>
</tr>
<tr>
<td>cockpit</td>
<td>Web console</td>
<td>Installing and configuring web console with the cockpit RHEL system role</td>
</tr>
<tr>
<td>crypto_policies</td>
<td>System-wide cryptographic policies</td>
<td>Setting a custom cryptographic policy across systems</td>
</tr>
<tr>
<td>firewall</td>
<td>Firewalld</td>
<td>Configuring firewalld by using system roles</td>
</tr>
<tr>
<td>ha_cluster</td>
<td>HA Cluster</td>
<td>Configuring a high-availability cluster by using system roles</td>
</tr>
<tr>
<td>kdump</td>
<td>Kernel Dumps</td>
<td>Configuring kdump by using RHEL system roles</td>
</tr>
<tr>
<td>Role name</td>
<td>Role description</td>
<td>Chapter title</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>kernel_settings</td>
<td>Kernel Settings</td>
<td>Using Ansible roles to permanently configure kernel parameters</td>
</tr>
<tr>
<td>logging</td>
<td>Logging</td>
<td>Using the logging system role</td>
</tr>
<tr>
<td>metrics</td>
<td>Metrics (PCP)</td>
<td>Monitoring performance by using RHEL system roles</td>
</tr>
<tr>
<td>network</td>
<td>Networking</td>
<td>Using the network RHEL system role to manage InfiniBand connections</td>
</tr>
<tr>
<td>nbde_client</td>
<td>Network Bound Disk Encryption client</td>
<td>Using the nbde_client and nbde_server system roles</td>
</tr>
<tr>
<td>nbde_server</td>
<td>Network Bound Disk Encryption server</td>
<td>Using the nbde_client and nbde_server system roles</td>
</tr>
<tr>
<td>postfix</td>
<td>Postfix</td>
<td>Variables of the postfix role in system roles</td>
</tr>
<tr>
<td>postgresql</td>
<td>PostgreSQL</td>
<td>Installing and configuring PostgreSQL by using the postgresql RHEL system role</td>
</tr>
<tr>
<td>selinux</td>
<td>SELinux</td>
<td>Configuring SELinux by using system roles</td>
</tr>
<tr>
<td>ssh</td>
<td>SSH client</td>
<td>Configuring secure communication with the ssh system roles</td>
</tr>
<tr>
<td>sshd</td>
<td>SSH server</td>
<td>Configuring secure communication with the ssh system roles</td>
</tr>
<tr>
<td>storage</td>
<td>Storage</td>
<td>Managing local storage by using RHEL system roles</td>
</tr>
<tr>
<td>tlog</td>
<td>Terminal Session Recording</td>
<td>Configuring a system for session recording by using the tlog RHEL system role</td>
</tr>
<tr>
<td>timesync</td>
<td>Time Synchronization</td>
<td>Configuring time synchronization by using RHEL system roles</td>
</tr>
<tr>
<td>vpn</td>
<td>VPN</td>
<td>Configuring VPN connections with IPsec by using the vpn RHEL system role</td>
</tr>
</tbody>
</table>

Additional resources

- Automating system administration by using RHEL system roles
- Red Hat Enterprise Linux (RHEL) system roles
- `/usr/share/ansible/roles/rhel-system-roles.<role_name>/README.md` file
- `/usr/share/doc/rhel-system-roles/<role_name>/` directory
CHAPTER 8. TROUBLESHOOTING PROBLEMS BY USING LOG FILES

Log files contain messages about the system, including the kernel, services, and applications running on it. These contain information that helps troubleshoot issues or monitor system functions. The logging system in Red Hat Enterprise Linux is based on the built-in syslog protocol. Particular programs use this system to record events and organize them into log files, which are useful when auditing the operating system and troubleshooting various problems.

8.1. SERVICES HANDLING SYSLOG MESSAGES

The following two services handle syslog messages:

- The systemd-journald daemon
- The Rsyslog service

The systemd-journald daemon collects messages from various sources and forwards them to the Rsyslog service for further processing. The systemd-journald daemon collects messages from the following sources:

- Kernel
- Early stages of the boot process
- Standard and error output of daemons as they start up and run
- Syslog

The Rsyslog service sorts the syslog messages by type and priority and writes them to the files in the /var/log directory. The /var/log directory persistently stores the log messages.

8.2. SUBDIRECTORIES STORING SYSLOG MESSAGES

The following subdirectories under the /var/log directory store syslog messages.

- /var/log/messages - all syslog messages except the following
- /var/log/secure - security and authentication-related messages and errors
- /var/log/maillog - mail server-related messages and errors
- /var/log/cron - log files related to periodically executed tasks
- /var/log/boot.log - log files related to system startup

8.3. INSPECTING LOG FILES USING THE WEB CONSOLE

Follow the steps in this procedure to inspect the log files using the RHEL web console.

Procedure

1. Log into the RHEL web console. For details see Logging in to the web console.
2. Click Logs.
8.4. VIEWING LOGS USING THE COMMAND LINE

The Journal is a component of systemd that helps to view and manage log files. It addresses problems connected with traditional logging, closely integrated with the rest of the system, and supports various logging technologies and access management for the log files.

You can use the `journalctl` command to view messages in the system journal using the command line, for example:

```
$ journalctl -b | grep kvm
May 15 11:31:41 localhost.localdomain kernel: kvm-clock: Using msrs 4b564d01 and 4b564d00
May 15 11:31:41 localhost.localdomain kernel: kvm-clock: cpu 0, msr 76401001, primary cpu clock
...
```

### Table 8.1. Viewing system information

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>journalctl</code></td>
<td>Shows all collected journal entries.</td>
</tr>
<tr>
<td><code>journalctl FILEPATH</code></td>
<td>Shows logs related to a specific file. For example, the <code>journalctl /dev/sda</code> command displays logs related to the <code>/dev/sda</code> file system.</td>
</tr>
<tr>
<td><code>journalctl -b</code></td>
<td>Shows logs for the current boot.</td>
</tr>
<tr>
<td><code>journalctl -k -b -1</code></td>
<td>Shows kernel logs for the current boot.</td>
</tr>
</tbody>
</table>

### Table 8.2. Viewing information about specific services

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>journalctl -b _SYSTEMD_UNIT=&lt;name.service&gt;</code></td>
<td>Filters log to show entries matching the systemd service.</td>
</tr>
<tr>
<td><code>journalctl -b _SYSTEMD_UNIT=&lt;name.service&gt; _PID=&lt;number&gt;</code></td>
<td>Combines matches. For example, this command shows logs for systemd-units that match <code>&lt;name.service&gt;</code> and the PID <code>&lt;number&gt;</code>.</td>
</tr>
</tbody>
</table>
The plus sign (+) separator combines two expressions in a logical OR. For example, this command shows all messages from the `<name.service>` service process with the PID plus all messages from the `<name2.service>` service (from any of its processes).

This command shows all entries matching either expression, referring to the same field. Here, this command shows logs matching a systemd-unit `<name.service>` or a systemd-unit `<name2.service>`.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>journalctl -b _SYSTEMD_UNIT=&lt;name.service&gt; _SYSTEMD_UNIT=&lt;name2.service&gt;</code></td>
<td>The plus sign (+) separator combines two expressions in a logical OR. For example, this command shows all messages from the <code>&lt;name.service&gt;</code> service process with the PID plus all messages from the <code>&lt;name2.service&gt;</code> service (from any of its processes).</td>
</tr>
<tr>
<td><code>journalctl -b _SYSTEMD_UNIT=&lt;name.service&gt; _SYSTEMD_UNIT=&lt;name2.service&gt;</code></td>
<td>This command shows all entries matching either expression, referring to the same field. Here, this command shows logs matching a systemd-unit <code>&lt;name.service&gt;</code> or a systemd-unit <code>&lt;name2.service&gt;</code>.</td>
</tr>
</tbody>
</table>

### Table 8.3. Viewing logs related to specific boots

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>journalctl --list-boots</code></td>
<td>Shows a tabular list of boot numbers, their IDs, and the timestamps of the first and last message pertaining to the boot. You can use the ID in the next command to view detailed information.</td>
</tr>
<tr>
<td><code>journalctl --boot=ID _SYSTEMD_UNIT=&lt;name.service&gt;</code></td>
<td>Shows information about the specified boot ID.</td>
</tr>
</tbody>
</table>

### 8.5. ADDITIONAL RESOURCES

- man `journalctl(1)`
- Configuring a remote logging solution
CHAPTER 9. MANAGING USERS AND GROUPS

Preventing unauthorized access to files and processes requires an accurate user and group management. If you do not manage accounts centrally or you require a user account or group only on a specific system, you can create them locally on this host.

9.1. INTRODUCTION TO MANAGING USER AND GROUP ACCOUNTS

The control of users and groups is a core element of Red Hat Enterprise Linux (RHEL) system administration. Each RHEL user has distinct login credentials and can be assigned to various groups to customize their system privileges.

9.1.1. Introduction to users and groups

A user who creates a file is the owner of that file and the group owner of that file. The file is assigned separate read, write, and execute permissions for the owner, the group, and those outside that group. The file owner can be changed only by the root user. Access permissions to the file can be changed by both the root user and the file owner. A regular user can change group ownership of a file they own to a group of which they are a member of.

Each user is associated with a unique numerical identification number called user ID (UID). Each group is associated with a group ID (GID). Users within a group share the same permissions to read, write, and execute files owned by that group.

9.1.2. Configuring reserved user and group IDs

RHEL reserves user and group IDs below 1000 for system users and groups. You can find the reserved user and group IDs in the setup package. To view reserved user and group IDs, use:

```
cat /usr/share/doc/setup*/uidgid
```

It is recommended to assign IDs to the new users and groups starting at 5000, as the reserved range can increase in the future.

To make the IDs assigned to new users start at 5000 by default, modify the UID_MIN and GID_MIN parameters in the /etc/login.defs file.

Procedure

To modify and make the IDs assigned to new users start at 5000 by default:

1. Open the /etc/login.defs file in an editor of your choice.
2. Find the lines that define the minimum value for automatic UID selection.

```
# Min/max values for automatic uid selection in useradd
# UID_MIN 1000
```
3. Modify the UID_MIN value to start at 5000.

```
# Min/max values for automatic uid selection in useradd
# UID_MIN 5000
```
4. Find the lines that define the minimum value for automatic GID selection.

```plaintext
# Min/max values for automatic gid selection in groupadd
#
GID_MIN 1000
```

5. Modify the `GID_MIN` value to start at 5000.

```plaintext
# Min/max values for automatic gid selection in groupadd
#
GID_MIN 5000
```

The dynamically assigned UIDs and GIDs for the regular users now start at 5000.

**NOTE**

The UID’s and GID’s of users and groups created before you changed the UID_MIN and GID_MIN values do not change.

This will allow new user’s group to have same 5000+ ID as UID and GID.

**WARNING**

Do not raise IDs reserved by the system above 1000 by changing `SYS_UID_MAX` to avoid conflict with systems that retain the 1000 limit.

---

### 9.1.3. User private groups

RHEL uses the *user private group* (UPG) system configuration, which makes UNIX groups easier to manage. A user private group is created whenever a new user is added to the system. The user private group has the same name as the user for which it was created and that user is the only member of the user private group.

UPGs simplify the collaboration on a project between multiple users. In addition, UPG system configuration makes it safe to set default permissions for a newly created file or directory, as it allows both the user, and the group this user is a part of, to make modifications to the file or directory.

A list of all groups is stored in the `/etc/group` configuration file.

---

### 9.2. GETTING STARTED WITH MANAGING USER ACCOUNTS

Red Hat Enterprise Linux is a multi-user operating system, which enables multiple users on different computers to access a single system installed on one machine. Every user operates under its own account, and managing user accounts thus represents a core element of Red Hat Enterprise Linux system administration.

The following are the different types of user accounts:

- **Normal user accounts:**
Normal accounts are created for users of a particular system. Such accounts can be added, removed, and modified during normal system administration.

- **System user accounts:**
  System user accounts represent a particular applications identifier on a system. Such accounts are generally added or manipulated only at software installation time, and they are not modified later.

---

**WARNING**

System accounts are presumed to be available locally on a system. If these accounts are configured and provided remotely, such as in the instance of an LDAP configuration, system breakage and service start failures can occur.

---

For system accounts, user IDs below 1000 are reserved. For normal accounts, you can use IDs starting at 1000. However, the recommended practice is to assign IDs starting at 5000. For assigning IDs, see the `/etc/login.defs` file.

- **Group:**
  A group is an entity which ties together multiple user accounts for a common purpose, such as granting access to particular files.

### 9.2.1. Managing accounts and groups using command line tools

Use the following basic command-line tools to manage user accounts and groups.

- To display user and group IDs:

  ```
  $ id
  uid=1000(example.user) gid=1000(example.user) groups=1000(example.user),10(wheel)
  context=unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
  ```

- To create a new user account:

  ```
  # useradd example.user
  ```

- To assign a new password to a user account belonging to example.user:

  ```
  # passwd example.user
  ```

- To add a user to a group:

  ```
  # usermod -a -G example.group example.user
  ```

**Additional resources**

- `man useradd(8)`, `man passwd(1)`, and `man usermod(8)`
9.2.2. System user accounts managed in the web console

With user accounts displayed in the RHEL web console you can:

- Authenticate users when accessing the system.
- Set the access rights to the system.

The RHEL web console displays all user accounts located in the system. Therefore, you can see at least one user account just after the first login to the web console.

After logging into the RHEL web console, you can perform the following operations:

- Create new user accounts.
- Change their parameters.
- Lock accounts.
- Terminate user sessions.

9.2.3. Adding new accounts using the web console

Use the following steps for adding user accounts to the system and setting administration rights to the accounts through the RHEL web console.

Prerequisites

- The RHEL web console must be installed and accessible. For details, see Installing the web console.

Procedure

1. Log in to the RHEL web console.
2. Click Accounts.
3. Click Create New Account.
4. In the Full Name field, enter the full name of the user.
   The RHEL web console automatically suggests a user name from the full name and fills it in the User Name field. If you do not want to use the original naming convention consisting of the first letter of the first name and the whole surname, update the suggestion.
5. In the Password/Confirm fields, enter the password and retype it for verification that your password is correct.
   The color bar below the fields shows you the security level of the entered password, which does not allow you to create a user with a weak password.
6. Click Create to save the settings and close the dialog box.
7. Select the newly created account.
8. In the Groups drop-down menu, select the groups that you want to add to the new account.
Now you can see the new account in the Accounts settings and you can use its credentials to connect to the system.

9.3. MANAGING USERS FROM THE COMMAND LINE

You can manage users and groups using the command-line interface (CLI). This enables you to add, remove, and modify users and user groups in Red Hat Enterprise Linux environment.

9.3.1. Adding a new user from the command line

You can use the `useradd` utility to add a new user.

**Prerequisites**

- **Root** access

**Procedure**

- To add a new user, use:

  ```bash
  # useradd options username
  ```

  Replace `options` with the command-line options for the `useradd` command, and replace `username` with the name of the user.

  **Example 9.1. Adding a new user**

  To add the user `sarah` with user ID `5000`, use:

  ```bash
  # useradd -u 5000 sarah
  ```

**Verification steps**

- To verify the new user is added, use the `id` utility.

  ```bash
  # id sarah
  ```
uid=5000(sarah) gid=5000(sarah) groups=5000(sarah)

Additional resources

- `useradd` man page

9.3.2. Adding a new group from the command line

You can use the `groupadd` utility to add a new group.

Prerequisites

- `Root` access

Procedure

- To add a new group, use:

  ```
  # groupadd options group-name
  ```

  Replace `options` with the command-line options for the `groupadd` command, and replace `group-name` with the name of the group.

  **Example 9.2. Adding a new group**

  To add the group `sysadmins` with group ID `5000`, use:

  ```
  # groupadd -g 5000 sysadmins
  ```

Verification steps

- To verify the new group is added, use the `tail` utility.

  ```
  # tail /etc/group
  ```

  The output returns:

  ```
  sysadmins:x:5000:
  ```

Additional resources

- `groupadd` man page

9.3.3. Adding a user to a supplementary group from the command line

You can add a user to a supplementary group to manage permissions or enable access to certain files or devices.
Prerequisites

- **root** access

Procedure

- To add a group to the supplementary groups of the user, use:

  ```
  # usermod --append -G group-name username
  ```

Replace `group-name` with the name of the group, and replace `username` with the name of the user.

**Example 9.3. Adding a user to a supplementary group**

To add the user `sysadmin` to the group `system-administrators`, use:

```
# usermod --append -G system-administrators sysadmin
```

Verification steps

- To verify the new groups is added to the supplementary groups of the user `sysadmin`, use:

  ```
  # groups sysadmin
  ```

  The output displays:

  ```
  sysadmin : sysadmin system-administrators
  ```

### 9.3.4. Creating a group directory

Under the UPG system configuration, you can apply the *set-group identification permission* (*setgid* bit) to a directory. The *setgid* bit makes managing group projects that share a directory simpler. When you apply the *setgid* bit to a directory, files created within that directory are automatically assigned to a group that owns the directory. Any user that has the permission to write and execute within this group can now create, modify, and delete files in the directory.

The following section describes how to create group directories.

Prerequisites

- **Root** access

Procedure

1. Create a directory:

   ```
   # mkdir directory-name
   ```

   Replace `directory-name` with the name of the directory.

2. Create a group:
# groupadd group-name

Replace `group-name` with the name of the group.

3. Add users to the group:

   # usermod --append -G group-name username

Replace `group-name` with the name of the group, and replace `username` with the name of the user.

4. Associate the user and group ownership of the directory with the `group-name` group:

   # chgrp group-name directory-name

Replace `group-name` with the name of the group, and replace `directory-name` with the name of the directory.

5. Set the write permissions to allow the users to create and modify files and directories and set the `setgid` bit to make this permission be applied within the `directory-name` directory:

   # chmod g+rwxs directory-name

Replace `directory-name` with the name of the directory.

Now all members of the `group-name` group can create and edit files in the `directory-name` directory. Newly created files retain the group ownership of `group-name` group.

**Verification steps**

- To verify the correctness of set permissions, use:

  # ls -ld directory-name

Replace `directory-name` with the name of the directory.

The output returns:

```
drwxrwsr-x. 2 root group-name 6 Nov 25 08:45 directory-name
```

**9.3.5. Removing a user on the command line**

You can remove a user account using the command line. In addition to removing the user account, you can optionally remove the user data and metadata, such as their home directory and configuration files.

**Prerequisites**

- You have `root` access.

- The user currently exists.

- Ensure that the user is logged out:
# logindctl terminate-user user-name

**Procedure**

- To only remove the user account, and not the user data:

  ```
  # userdel user-name
  ```

- To remove the user, the data, and the metadata:
  
  a. Remove the user, their home directory, their mail spool, and their SELinux user mapping:

     ```
     # userdel --remove --selinux-user user-name
     ```

  b. Remove additional user metadata:

     ```
     # rm -rf /var/lib/AccountsService/users/user-name
     ```

This directory stores information that the system needs about the user before the home directory is available. Depending on the system configuration, the home directory might not be available until the user authenticates at the login screen.

**IMPORTANT**

If you do not remove this directory and you later recreate the same user, the recreated user will still use certain settings inherited from the removed user.

**Additional resources**

- The `userdel(8)` man page.

## 9.4. MANAGING USER ACCOUNTS IN THE WEB CONSOLE

The RHEL web console offers a graphical interface that enables you to execute a wide range of administrative tasks without accessing your terminal directly. For example, you can add, edit or remove system user accounts.

After reading this section, you will know:

- From where the existing accounts come from.
- How to add new accounts.
- How to set password expiration.
- How and when to terminate user sessions.

**Prerequisites**

- Set up the RHEL web console. For details, see [Getting started using the RHEL web console](#).
- Log in to the RHEL web console with an account that has administrator permissions assigned. For details, see [Logging in to the RHEL web console](#).
9.4.1. System user accounts managed in the web console

With user accounts displayed in the RHEL web console you can:

- Authenticate users when accessing the system.
- Set the access rights to the system.

The RHEL web console displays all user accounts located in the system. Therefore, you can see at least one user account just after the first login to the web console.

After logging into the RHEL web console, you can perform the following operations:

- Create new users accounts.
- Change their parameters.
- Lock accounts.
- Terminate user sessions.

9.4.2. Adding new accounts using the web console

Use the following steps for adding user accounts to the system and setting administration rights to the accounts through the RHEL web console.

**Prerequisites**

- The RHEL web console must be installed and accessible. For details, see Installing the web console.

**Procedure**

1. Log in to the RHEL web console.
2. Click Accounts.
3. Click Create New Account.
4. In the Full Name field, enter the full name of the user.
   The RHEL web console automatically suggests a user name from the full name and fills it in the User Name field. If you do not want to use the original naming convention consisting of the first letter of the first name and the whole surname, update the suggestion.
5. In the Password/Confirm fields, enter the password and retype it for verification that your password is correct.
   The color bar below the fields shows you the security level of the entered password, which does not allow you to create a user with a weak password.
6. Click Create to save the settings and close the dialog box.
7. Select the newly created account.
8. In the Groups drop-down menu, select the groups that you want to add to the new account.
Now you can see the new account in the **Accounts** settings and you can use its credentials to connect to the system.

### 9.4.3. Enforcing password expiration in the web console

By default, user accounts have set passwords to never expire. You can set system passwords to expire after a defined number of days. When the password expires, the next login attempt will prompt for a password change.

**Procedure**

1. Log in to the RHEL 9 web console.
2. Click **Accounts**.
3. Select the user account for which you want to enforce password expiration.
4. Click **edit** on the **Password** line.
5. In the **Password expiration** dialog box, select **Require password change every ... days** and enter a positive whole number representing the number of days after which the password expires.
6. Click **Change**.
   The web console immediately shows the date of the future password change request on the **Password** line.

### 9.4.4. Terminating user sessions in the web console

A user creates user sessions when logging into the system. Terminating user sessions means to log the user out from the system. It can be helpful if you need to perform administrative tasks sensitive to configuration changes, for example, system upgrades.

In each user account in the RHEL 9 web console, you can terminate all sessions for the account except for the web console session you are currently using. This prevents you from losing access to your system.
**Procedure**

1. Log in to the RHEL 9 web console.

2. Click **Accounts**.

3. Click the user account for which you want to terminate the session.

4. Click **Terminate Session**.
   
   If the **Terminate Session** button is inactive, the user is not logged in to the system.

   The RHEL web console terminates the sessions.

---

**9.5. EDITING USER GROUPS USING THE COMMAND LINE**

A user belongs to a certain set of groups that allow a logical collection of users with a similar access to files and folders. You can edit the primary and supplementary user groups from the command line to change the user’s permissions.

**9.5.1. Primary and supplementary user groups**

A group is an entity which ties together multiple user accounts for a common purpose, such as granting access to particular files.

On Linux, user groups can act as primary or supplementary. Primary and supplementary groups have the following properties:

**Primary group**

- Every user has just one primary group at all times.
- You can change the user’s primary group.

**Supplementary groups**

- You can add an existing user to an existing supplementary group to manage users with the same security and access privileges within the group.
- Users can be members of zero or multiple supplementary groups.

**9.5.2. Listing the primary and supplementary groups of a user**

You can list the groups of users to see which primary and supplementary groups they belong to.

**Procedure**

- Display the names of the primary and any supplementary group of a user:

  ```
  $ groups user-name
  ```

  Replace `user-name` with the name of the user. If you do not provide a user name, the command displays the group membership for the current user. The first group is the primary group followed by the optional supplementary groups.
Example 9.4. Listing of groups for user sarah:

$ groups sarah

The output displays:

sarah : sarah wheel developer

User sarah has a primary group sarah and is a member of supplementary groups wheel and developer.

Example 9.5. Listing of groups for user marc:

$ groups marc

The output displays:

marc : marc

User marc has only a primary group marc and no supplementary groups.

9.5.3. Changing the primary group of a user

You can change the primary group of an existing user to a new group.

Prerequisites:

1. root access
2. The new group must exist

Procedure

- Change the primary group of a user:

  # usermod -g group-name user-name

Replace group-name with the name of the new primary group, and replace user-name with the name of the user.

NOTE

When you change a user’s primary group, the command also automatically changes the group ownership of all files in the user’s home directory to the new primary group. You must fix the group ownership of files outside of the user’s home directory manually.

Example 9.6. Example of changing the primary group of a user:
If the user **sarah** belongs to the primary group **sarah1**, and you want to change the primary group of the user to **sarah2**, use:

```
# usermod -g sarah2 sarah
```

**Verification steps**

- Verify that you changed the primary group of the user:

```
$ groups sarah
```

The output displays:

```
sarah : sarah2
```

### 9.5.4. Adding a user to a supplementary group from the command line

You can add a user to a supplementary group to manage permissions or enable access to certain files or devices.

**Prerequisites**

- **root** access

**Procedure**

- To add a group to the supplementary groups of the user, use:

```
# usermod --append -G group-name username
```

Replace `group-name` with the name of the group, and replace `username` with the name of the user.

**Example 9.7. Adding a user to a supplementary group**

To add the user **sysadmin** to the group **system-administrators**, use:

```
# usermod --append -G system-administrators sysadmin
```

**Verification steps**

- To verify the new groups is added to the supplementary groups of the user **sysadmin**, use:

```
# groups sysadmin
```

The output displays:

```
sysadmin : sysadmin system-administrators
```
9.5.5. Removing a user from a supplementary group

You can remove an existing user from a supplementary group to limit their permissions or access to files and devices.

Prerequisites

- root access

Procedure

- Remove a user from a supplementary group:

  # gpasswd -d user-name group-name

  Replace user-name with the name of the user, and replace group-name with the name of the supplementary group.

Example 9.8. Removing user from a supplementary group

If the user sarah has a primary group sarah2, and belongs to the secondary groups wheel and developers, and you want to remove that user from the group developers, use:

  # gpasswd -d sarah developers

Verification steps

- Verify that you removed the user sarah from the secondary group developers:

  $ groups sarah

  The output displays:

  sarah : sarah2 wheel

9.5.6. Changing all of the supplementary groups of a user

You can overwrite the list of supplementary groups that you want the user to remain a member of.

Prerequisites

- root access

- The supplementary groups must exist

Procedure

- Overwrite a list of user’s supplementary groups:

  # usermod -G group-names username
Replace *group-names* with the name of one or more supplementary groups. To add the user to several supplementary groups at once, separate the group names using commas and no intervening spaces. For example: `wheel,developer`.

Replace *user-name* with the name of the user.

**IMPORTANT**

If the user is currently a member of a group that you do not specify, the command removes the user from the group.

**Example 9.9. Changing the list of supplementary groups of a user**

If the user *sarah* has a primary group *sarah2*, and belongs to the supplementary group *wheel*, and you want the user to belong to three more supplementary groups *developer*, *sysadmin*, and *security*, use:

```
# usermod -G wheel,developer,sysadmin,security sarah
```

**Verification steps**

- Verify that you set the list of the supplementary groups correct:

  ```
  # groups sarah
  ```

  The output displays:

  ```
  sarah : sarah2 wheel developer sysadmin security
  ```

### 9.6. CHANGING AND RESETTNG THE ROOT PASSWORD

If the existing root password is no longer satisfactory or is forgotten, you can change or reset it both as the *root* user and a non-root user.

**9.6.1. Changing the root password as the root user**

You can use the `passwd` command to change the *root* password as the *root* user.

**Prerequisites**

- *Root* access

**Procedure**

- To change the *root* password, use:

  ```
  # passwd
  ```

  You are prompted to enter your current password before you can change it.
9.6.2. Changing or resetting the forgotten root password as a non-root user

You can use the `passwd` command to change or reset the forgotten `root` password as a non-root user.

**Prerequisites**

- You are able to log in as a non-root user.
- You are a member of the administrative `wheel` group.

**Procedure**

- To change or reset the `root` password as a non-root user that belongs to the `wheel` group, use:

  ```
  $ sudo passwd root
  ```

  You are prompted to enter your current non-root password before you can change the `root` password.

9.6.3. Resetting the root password on boot

If you are unable to log in as a non-root user or do not belong to the administrative `wheel` group, you can reset the root password on boot by switching into a specialized `chroot jail` environment.

**Procedure**

1. Reboot the system and, on the GRUB 2 boot screen, press the **e** key to interrupt the boot process.
   The kernel boot parameters appear.

   ```
   load_video
   set gfxpayload=keep
   insmod gzio
   linux ($root)/vmlinuz-5.14.0-70.22.1.e19_0.x86_64 root=/dev/mapper/rhel-root ro crash
   kernel=auto resume=/dev/mapper/rhel-swap rd.lvm.lv/swap rhgb quiet
   initrd ($root)/initramfs-5.14.0-70.22.1.e19_0.x86_64.img $tuned_initrd
   ```

2. Go to the end of the line that starts with `linux`.

   ```
   linux ($root)/vmlinuz-5.14.0-70.22.1.e19_0.x86_64 root=/dev/mapper/rhel-root ro crash
   kernel=auto resume=/dev/mapper/rhel-swap rd.lvm.lv/swap rhgb quiet
   ```

   Press **Ctrl+e** to jump to the end of the line.

3. Add `rd.break` to the end of the line that starts with `linux`.

   ```
   linux ($root)/vmlinuz-5.14.0-70.22.1.e19_0.x86_64 root=/dev/mapper/rhel-root ro crash
   kernel=auto resume=/dev/mapper/rhel-swap rd.lvm.lv/swap rhgb quiet rd.break
   ```

4. Press **Ctrl+x** to start the system with the changed parameters.
   The `switch_root` prompt appears.

5. Remount the file system as writable:
mount -o remount,rw /sysroot

The file system is mounted as read-only in the /sysroot directory. Remounting the file system as writable allows you to change the password.

6. Enter the chroot environment:

   chroot /sysroot

   The sh-4.4# prompt appears.

7. Reset the root password:

   passwd

   Follow the instructions displayed by the command line to finalize the change of the root password.

8. Enable the SELinux relabeling process on the next system boot:

   touch /.autorelabel

9. Exit the chroot environment:

   exit

10. Exit the switch_root prompt:

    exit

11. Wait until the SELinux relabeling process is finished. Note that relabeling a large disk might take a long time. The system reboots automatically when the process is complete.

Verification steps

1. To verify that the root password is successfully changed, log in as a normal user and open the Terminal.

2. Run the interactive shell as root:

   $ su

3. Enter your new root password.

4. Print the user name associated with the current effective user ID:

   # whoami

   The output returns:

    root
CHAPTER 10. MANAGING SUDO ACCESS

System administrators can grant sudo access to allow non-root users to execute administrative commands that are normally reserved for the root user. As a result, non-root users can execute such commands without logging in to the root user account.

10.1. USER AUTHORIZATIONS IN SUDOERS

The /etc/sudoers file specifies which users can use the sudo command to execute other commands. The rules can apply to individual users and user groups. You can also define rules for groups of hosts, commands, and even users more easily by using aliases. Default aliases are defined in the first part of the /etc/sudoers file.

When a user enters a command with sudo for which the user does not have authorization, the system records a message that contains the string <username>: user NOT in sudoers to the journal log.

The default /etc/sudoers file provides information and examples of authorizations. You can activate a specific example rule by uncommenting the corresponding line. The section with user authorizations is marked with the following introduction:

```
## Next comes the main part: which users can run what software on
## which machines (the sudoers file can be shared between multiple
## systems).
```

You can create new sudoers authorizations and modify existing authorizations by using the following format:

```
<username> <hostname.example.com>=(<run_as_user>:<run_as_group>) <path/to/command>
```

Where:

- `<username>` is the user that enters the command, for example, user1. If the value starts with %, it defines a group, for example, %group1.

- `<hostname.example.com>` is the name of the host on which the rule applies.

- The section (<run_as_user>:<run_as_group>) defines the user or group as which the command is executed. If you omit this section, `<username>` can execute the command as root.

- `<path/to/command>` is the complete absolute path to the command. You can also limit the user to only performing a command with specific options and arguments by adding those options after the command path. If you do not specify any options, the user can use the command with all options.

You can apply the rule to all users, hosts, or commands by replacing any of these variables with ALL.

WARNING

With overly permissive rules, such as ALL ALL=(ALL) ALL, all users can run all commands as all users on all hosts. This presents serious security risks.
You can specify the arguments negatively by using the ! operator. For example, !root specifies all users except root. Note that allowing specific users, groups, and commands is more secure than disallowing specific users, groups, and commands. This is because allow rules also block new unauthorized users or groups.

**WARNING**

Avoid using negative rules for commands because users can overcome such rules by renaming commands with the alias command.

The system reads the /etc/sudoers file from beginning to end. Therefore, if the file contains multiple entries for a user, the entries are applied in order. In case of conflicting values, the system uses the last match, even if it is not the most specific match.

To preserve the rules during system updates and for easier fixing of errors, enter new rules by creating new files in the /etc/sudoers.d/ directory instead of entering rules directly to the /etc/sudoers file. The system reads the files in the /etc/sudoers.d directory when it reaches the following line in the /etc/sudoers file:

```
#includedir /etc/sudoers.d
```

Note that the number sign (#) at the beginning of this line is part of the syntax and does not mean the line is a comment. The names of files in that directory must not contain a period and must not end with a tilde (~).

Additional resources

- sudo(8) and sudoers(5) man pages

### 10.2. GRANTING SUDO ACCESS TO A USER

System administrators can allow non-root users to execute administrative commands by granting them sudo access. The sudo command provides users with administrative access without using the password of the root user.

When users need to perform an administrative command, they can precede that command with sudo. If the user has authorization for the command, the command is executed as if they were root.

Be aware of the following limitations:

- Only users listed in the /etc/sudoers configuration file can use the sudo command.
- The command is executed in the shell of the user, not in the root shell.

**Prerequisites**

- You have root access to the system.

**Procedure**
1. As root, open the `/etc/sudoers` file.

   # visudo

   The `/etc/sudoers` file defines the policies applied by the **sudo** command.

2. In the `/etc/sudoers` file, find the lines that grant **sudo** access to users in the administrative **wheel** group.

   ```plaintext
   ## Allows people in group wheel to run all commands
   %wheel    ALL=(ALL)       ALL
   ```

3. Make sure the line that starts with `%wheel` is not commented out with the number sign (`#`).

4. Save any changes, and exit the editor.

5. Add users you want to grant **sudo** access to into the administrative **wheel** group.

   ```plaintext
   # usermod --append -G wheel <username>
   ```

   Replace `<username>` with the name of the user.

**Verification steps**

- Verify that the user is in the administrative **wheel** group:

  ```plaintext
  # id <username>
  uid=5000(<username>) gid=5000(<username>) groups=5000(<username>),10(wheel)
  ```

**Additional resources**

- **sudo(8)**, **visudo(8)**, and **sudoers(5)** man pages

---

**10.3. ENABLING UNPRIVILEGED USERS TO RUN CERTAIN COMMANDS**

As an administrator, you can allow unprivileged users to enter certain commands on specific workstations by configuring a policy in the `/etc/sudoers.d/` directory.

**Prerequisites**

- You have root access to the system.

**Procedure**

1. As root, create a new **sudoers.d** directory under `/etc/`:

   ```plaintext
   # mkdir -p /etc/sudoers.d/
   ```

2. Create a new file in the `/etc/sudoers.d` directory:

   ```plaintext
   # visudo -f /etc/sudoers.d/<filename>
   ```

   The file opens automatically.
3. Add the following line to the /etc/sudoers.d/ <filename> file:

```
<username> <hostname.example.com> = (<run_as_user>:<run_as_group>)
<path/to/command>
```

- Replace `<username>` with the name of the user.
- Replace `<hostname.example.com>` with the URL of the host.
- Replace `<run_as_user>:<run_as_group>` with the user or group as which the command can be executed. If you omit this section, `<username>` can execute the command as root.
- Replace `<path/to/command>` with the complete absolute path to the command. You can also limit the user to only performing a command with specific options and arguments by adding those options after the command path. If you do not specify any options, the user can use the command with all options.
- To allow two and more commands on the same host on one line, you can list them separated by a comma followed by a space.
  For example, to allow user1 to execute the dnf and reboot commands on host1.example.com, enter user1 host1.example.com = /bin/dnf, /sbin/reboot.

4. Optional: To receive email notifications every time the user attempts to use `sudo` privileges, add the following lines to the file:

```
Defaults    mail_always
Defaults    mailto="<email@example.com>"
```

5. Save the changes, and exit the editor.

**Verification**

1. To verify if a user can run a command with `sudo` privileges, switch the account:

```
# su <username> -
```

2. As the user, enter the command with the `sudo` command:

```
$ sudo <command>
[sudo] password for <username>:
```

Enter the user’s `sudo` password.

3. If the privileges are configured correctly, the system displays the list of commands and options. For example, with the dnf command, it shows the following output:

```
... usage: dnf [options] COMMAND ...
```

If the system returns the error message `<username> is not in the sudoers file. This incident will be reported`, the file for `<username>` in /etc/sudoers.d/ does not exist.
If the system returns the error message `<username> is not allowed to run sudo on <host.example.com>`, the configuration was not completed correctly. Ensure that you are logged in as root and that the configuration was performed correctly.

If the system returns the error message **Sorry, user <username> is not allowed to execute '<path/to/command>' as root on <host.example.com>**, the command is not correctly defined in the rule for the user.

**Additional resources**

- sudo(8), visudo(8), and sudoers(5) man pages
File system permissions control the ability of user and group accounts to read, modify, and execute the contents of the files and to enter directories. Set permissions carefully to protect your data against unauthorized access.

11.1. MANAGING FILE PERMISSIONS

Every file or directory has three levels of ownership:

- User owner (u).
- Group owner (g).
- Others (o).

Each level of ownership can be assigned the following permissions:

- Read (r).
- Write (w).
- Execute (x).

Note that the execute permission for a file allows you to execute that file. The execute permission for a directory allows you to access the contents of the directory, but not execute it.

When a new file or directory is created, the default set of permissions are automatically assigned to it. The default permissions for a file or directory are based on two factors:

- Base permission.
- The user file-creation mode mask (umask).

11.1.1. Base file permissions

Whenever a new file or directory is created, a base permission is automatically assigned to it. Base permissions for a file or directory can be expressed in symbolic or octal values.

<table>
<thead>
<tr>
<th>Permission</th>
<th>Symbolic value</th>
<th>Octal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No permission</td>
<td>---</td>
<td>0</td>
</tr>
<tr>
<td>Execute</td>
<td>--x</td>
<td>1</td>
</tr>
<tr>
<td>Write</td>
<td>-w-</td>
<td>2</td>
</tr>
<tr>
<td>Write and execute</td>
<td>-wx</td>
<td>3</td>
</tr>
<tr>
<td>Read</td>
<td>r--</td>
<td>4</td>
</tr>
<tr>
<td>Read and execute</td>
<td>r-x</td>
<td>5</td>
</tr>
<tr>
<td>Permission</td>
<td>模式</td>
<td>权限</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Read and write</td>
<td>rw-</td>
<td>6</td>
</tr>
<tr>
<td>Read, write, execute</td>
<td>rwx</td>
<td>7</td>
</tr>
</tbody>
</table>

The base permission for a directory is **777 (drwxrwxrwx)**, which grants everyone the permissions to read, write, and execute. This means that the directory owner, the group, and others can list the contents of the directory, create, delete, and edit items within the directory, and descend into it.

Note that individual files within a directory can have their own permission that might prevent you from editing them, despite having unrestricted access to the directory.

The base permission for a file is **666 (-rw-rw-rw-)**, which grants everyone the permissions to read and write. This means that the file owner, the group, and others can read and edit the file.

**Example 11.1. Permissions for a file**

If a file has the following permissions:

```bash
$ ls -l
-rwxrw----. 1 sysadmins sysadmins 2 Mar 2 08:43 file
```

- `-` indicates it is a file.
- `rwx` indicates that the file owner has permissions to read, write, and execute the file.
- `rw-` indicates that the group has permissions to read and write, but not execute the file.
- `---` indicates that other users have no permission to read, write, or execute the file.
- `.` indicates that the SELinux security context is set for the file.

**Example 11.2. Permissions for a directory**

If a directory has the following permissions:

```bash
$ ls -dl
drwxr----. 1 sysadmins sysadmins 2 Mar 2 08:43 directory
```

- `d` indicates it is a directory.
- `rwx` indicates that the directory owner has the permissions to read, write, and access the contents of the directory.
  As a directory owner, you can list the items (files, subdirectories) within the directory, access the content of those items, and modify them.
- `r-x` indicates that the group has permissions to read the content of the directory, but not write - create new entries or delete files. The `x` permission means that you can also access the directory using the `cd` command.
- `---` indicates that other users have no permission to read, write, or access the contents of the directory.
As someone who is not a user owner, or as group owner of the directory, you cannot list the items within the directory, access information about those items, or modify them.

- . indicates that the SELinux security context is set for the directory.

**NOTE**

The base permission that is automatically assigned to a file or directory is **not** the default permission the file or directory ends up with. When you create a file or directory, the base permission is altered by the `umask`. The combination of the base permission and the `umask` creates the default permission for files and directories.

### 11.1.2. User file-creation mode mask

The user file-creation mode mask (`umask`) is variable that controls how file permissions are set for newly created files and directories. The `umask` automatically removes permissions from the base permission value to increase the overall security of a Linux system. The `umask` can be expressed in **symbolic** or **octal** values.

<table>
<thead>
<tr>
<th>Permission</th>
<th>Symbolic value</th>
<th>Octal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read, write, and execute</td>
<td>rwx</td>
<td>0</td>
</tr>
<tr>
<td>Read and write</td>
<td>rw-</td>
<td>1</td>
</tr>
<tr>
<td>Read and execute</td>
<td>r-x</td>
<td>2</td>
</tr>
<tr>
<td>Read</td>
<td>r--</td>
<td>3</td>
</tr>
<tr>
<td>Write and execute</td>
<td>-wx</td>
<td>4</td>
</tr>
<tr>
<td>Write</td>
<td>-w-</td>
<td>5</td>
</tr>
<tr>
<td>Execute</td>
<td>--x</td>
<td>6</td>
</tr>
<tr>
<td>No permissions</td>
<td>---</td>
<td>7</td>
</tr>
</tbody>
</table>

The default `umask` for both a standard user and for a **root** user is **0022**.

The first digit of the `umask` represents special permissions (sticky bit, `=`). The last three digits of the `umask` represent the permissions that are removed from the user owner (`u`), group owner (`g`), and others (`o`) respectively.

**Example 11.3. Applying the umask when creating a file**

The following example illustrates how the `umask` with an octal value of **0137** is applied to the file with the base permission of **777**, to create the file with the default permission of **640**.
11.1.3. Default file permissions

The default permissions are set automatically for all newly created files and directories. The value of the default permissions is determined by applying the umask to the base permission.

Example 11.4. Default permissions for a directory

When a standard user or a root user creates a new directory, the umask is set to 022 (rwxr-xr-x), and the base permissions for a directory are set to 777 (rwxrwxrwx). This brings the default permissions to 755 (rwxr-xr-x).

<table>
<thead>
<tr>
<th>Symbolic value</th>
<th>Octal value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base permission</strong></td>
<td>rwxrwxrwx</td>
</tr>
<tr>
<td><strong>Umask</strong></td>
<td>rwxr-xr-x</td>
</tr>
<tr>
<td><strong>Default permission</strong></td>
<td>rwxr-xr-x</td>
</tr>
</tbody>
</table>

This means that the directory owner can list the contents of the directory, create, delete, and edit items within the directory, and descend into it. The group and others can only list the contents of the directory and descend into it.

Example 11.5. Default permissions for a file

When a standard user or a root user creates a new file, the umask is set to 022 (rwxr-xr-x), and the base permissions for a file are set to 666 (rw-rw-rw-). This brings the default permissions to 644 (-rw-r--).
11.1.4. Changing file permissions using symbolic values

You can use the `chmod` utility with symbolic values (a combination letters and signs) to change file permissions for a file or directory.

You can assign the following permissions:

- Read (r)
- Write (w)
- Execute (x)

Permissions can be assigned to the following levels of ownership:

- User owner (u)
- Group owner (g)
- Other (o)
- All (a)

To add or remove permissions you can use the following signs:

- `+` to add the permissions on top of the existing permissions
- `-` to remove the permissions from the existing permission
- `=` to remove the existing permissions and explicitly define the new ones

Procedure

- To change the permissions for a file or directory, use:
$ chmod <level><operation><permission> file-name

Replace <level> with the level of ownership you want to set the permissions for. Replace <operation> with one of the signs. Replace <permission> with the permissions you want to assign. Replace file-name with the name of the file or directory. For example, to grant everyone the permissions to read, write, and execute (rwx) my-script.sh, use the chmod a=rwx my-script.sh command.

See Base file permissions for more details.

Verification steps

- To see the permissions for a particular file, use:

  $ ls -l file-name

  Replace file-name with the name of the file.

- To see the permissions for a particular directory, use:

  $ ls -dl directory-name

  Replace directory-name with the name of the directory.

- To see the permissions for all the files within a particular directory, use:

  $ ls -l directory-name

  Replace directory-name with the name of the directory.

Example 11.6. Changing permissions for files and directories

- To change file permissions for my-file.txt from -rw-rw-- to -rw------, use:

  1. Display the current permissions for my-file.txt:

     $ ls -l my-file.txt
     -rw-rw--. 1 username username 0 Feb 24 17:56 my-file.txt

  2. Remove the permissions to read, write, and execute (rwx) the file from group owner (g) and others (o):

     $ chmod go= my-file.txt

     Note that any permission that is not specified after the equals sign (=) is automatically prohibited.

  3. Verify that the permissions for my-file.txt were set correctly:

     $ ls -l my-file.txt
     -rw-------. 1 username username 0 Feb 24 17:56 my-file.txt

- To change file permissions for my-directory from drwxrwx--- to drwxrwxr-x, use:

  1. Display the current permissions for my-directory:

     $ ls -l my-directory
     drwxrwx---. 1 username username 0 Feb 24 17:56 my-directory
1. Display the current permissions for my-directory:

   $ ls -dl my-directory
   drwxrwx---. 2 username username 4096 Feb 24 18:12 my-directory

2. Add the read and execute (r-x) access for all users (a):

   $ chmod o+rx my-directory

3. Verify that the permissions for my-directory and its content were set correctly:

   $ ls -dl my-directory
   drwxrwxr-x. 2 username username 4096 Feb 24 18:12 my-directory

11.1.5. Changing file permissions using octal values

You can use the `chmod` utility with octal values (numbers) to change file permissions for a file or directory.

**Procedure**

- To change the file permissions for an existing file or directory, use:

  $ chmod octal_value file-name

Replace `file-name` with the name of the file or directory. Replace `octal_value` with an octal value. See Base file permissions for more details.

11.2. MANAGING THE ACCESS CONTROL LIST

Each file and directory can only have one user owner and one group owner at a time. If you want to grant a user permissions to access specific files or directories that belong to a different user or group while keeping other files and directories private, you can utilize Linux Access Control Lists (ACLs).

11.2.1. Displaying the current Access Control List

You can use the `getfacl` utility to display the current ACL.

**Procedure**

- To display the current ACL for a particular file or directory, use:

  $ getfacl file-name

Replace `file-name` with the name of the file or directory.

11.2.2. Setting the Access Control List

You can use the `setfacl` utility to set the ACL for a file or directory.

**Prerequisites**
• root access.

Procedure

• To set the ACL for a file or directory, use:

```
# setfacl -m u:username:symbolic_value file-name
```

Replace username with the name of the user, symbolic_value with a symbolic value, and file-name with the name of the file or directory. For more information see the setfacl man page.

Example 11.7. Modifying permissions for a group project

The following example describes how to modify permissions for the group-project file owned by the root user that belongs to the root group so that this file is:

- Not executable by anyone.
- The user andrew has the rw- permissions.
- The user susan has the --- permissions.
- Other users have the r-- permissions.

Procedure

```
# setfacl -m u:andrew:rw- group-project
# setfacl -m u:susan:--- group-project
```

Verification steps

• To verify that the user andrew has the rw- permission, the user susan has the --- permission, and other users have the r-- permission, use:

```
$ getfacl group-project
```

The output returns:

```
# file: group-project
# owner: root
# group: root
user:andrew:rw-
user:susan:---
group::r--
mask::rw-
other::r--
```

11.3. MANAGING THE UMASK

You can use the umask utility to display, set, or change the current or default value of the umask.

11.3.1. Displaying the current value of the umask
You can use the **umask** utility to display the current value of the *umask* in symbolic or octal mode.

**Procedure**
- To display the current value of the *umask* in symbolic mode, use:
  
  ```
  $ umask -S
  ```

- To display the current value of the *umask* in the octal mode, use:
  
  ```
  $ umask
  ```

**NOTE**

When displaying the *umask* in octal mode, you may notice it displayed as a four digit number (0002 or 0022). The first digit of the *umask* represents a special bit (sticky bit, SGID bit, or SUID bit). If the first digit is set to 0, the special bit is not set.

**11.3.2. Displaying the default bash umask**

There are a number of shells you can use, such as **bash**, **ksh**, **zsh** and **tcsh**. Those shells can behave as login or non-login shells. You can invoke the login shell by opening a native or a GUI terminal.

To determine whether you are executing a command in a login or a non-login shell, use the **echo $0** command.

**Example 11.8. Determining if you are working in a login or a non-login bash shell**

- If the output of the **echo $0** command returns **bash**, you are executing the command in a non-login shell.

  ```
  $ echo $0
  bash
  ```

  The default *umask* for the non-login shell is set in the `/etc/bashrc` configuration file.

- If the output of the **echo $0** command returns `-bash`, you are executing the command in a login shell.

  ```
  # echo $0
  -bash
  ```

  The default *umask* for the login shell is set in the `/etc/login.defs` configuration file.

**Procedure**
- To display the default **bash** *umask* for the non-login shell, use:

  ```
  $ grep umask /etc/bashrc
  ```

  The output returns:
# By default, we want umask to get set. This sets it for non-login shell.
  umask 002
  umask 022

- To display the default bash umask for the login shell, use:

  $ grep "UMASK" /etc/login.defs

  The output returns:

  # UMASK is also used by useradd(8) and newusers(8) to set the mode for new
  # If HOME_MODE is not set, the value of UMASK is used to create the mode.

### 11.3.3. Setting the umask using symbolic values

You can use the **umask** utility with symbolic values (a combination letters and signs) to set the **umask** for the current shell session.

You can assign the following permissions:

- Read (**r**)
- Write (**w**)
- Execute (**x**)

Permissions can be assigned to the following levels of ownership:

- User owner (**u**)
- Group owner (**g**)
- Other (**o**)
- All (**a**)

To add or remove permissions you can use the following signs:

- + to add the permissions on top of the existing permissions
- - to remove the permissions from the existing permission
- = to remove the existing permissions and explicitly define the new ones

**NOTE**

    Any permission that is not specified after the equals sign (\(=\)) is automatically prohibited.

**Procedure**

- To set the **umask** for the current shell session, use:
$ umask -S <level><operation><permission>

Replace <level> with the level of ownership you want to set the umask for. Replace <operation> with one of the signs. Replace <permission> with the permissions you want to assign. For example, to set the umask to u=rwx,g=rwx,o=rwx, use umask -S a=rwx.

See User file-creation mode for more details.

NOTE

The umask is only valid for the current shell session.

11.3.4. Setting the umask using octal values

You can use the umask utility with octal values (numbers) to set the umask for the current shell session.

Procedure

- To set the umask for the current shell session, use:

  $ umask octal_value

Replace octal_value with an octal value. See User file-creation mode mask for more details.

NOTE

The umask is only valid for the current shell session.

11.3.5. Changing the default umask for the non-login shell

You can change the default bash umask for standard users by modifying the /etc/bashrc file.

Prerequisites

- root access

Procedure

1. As root, open the /etc/bashrc file in the editor.

2. Modify the following sections to set a new default bash umask:

   ```bash
   if [ $UID -gt 199 ] && [ "id -gn" = "id -un" ]; then
     umask 002
   else
     umask 022
   fi
   
   ```

   Replace the default octal value of the umask (002) with another octal value. See User file-creation mode mask for more details.

3. Save the changes and exit the editor.
11.3.6. Changing the default umask for the login shell

You can change the default `bash umask` for the `root` user by modifying the `/etc/login.defs` file.

**Prerequisites**

- `root` access

**Procedure**

1. As `root`, open the `/etc/login.defs` file in the editor.
2. Modify the following sections to set a new default `bash umask`:

   ```
   # Default initial "umask" value used by login(1) on non-PAM enabled systems.
   # Default "umask" value for pam_umask(8) on PAM enabled systems.
   # UMASK is also used by useradd(8) and newusers(8) to set the mode for new
   # home directories if HOME_MODE is not set.
   # 022 is the default value, but 027, or even 077, could be considered
   # for increased privacy. There is no One True Answer here: each sysadmin
   # must make up their mind.
   
   UMASK 022
   ```

   Replace the default octal value of the `umask` (`022`) with another octal value. See User file-creation mode mask for more details.
3. Save the changes and exit the editor.

11.3.7. Changing the default umask for a specific user

You can change the default `umask` for a specific user by modifying the `.bashrc` for that user.

**Procedure**

1. Append the line that specifies the octal value of the `umask` into the `.bashrc` file for the particular user.

```
$ echo 'umask octal_value' >> /home/username/.bashrc
```

Replace `octal_value` with an octal value and replace `username` with the name of the user. See User file-creation mode mask for more details.

11.3.8. Setting default permissions for newly created home directories

You can change the permission modes for home directories of newly created users by modifying the `/etc/login.defs` file.

**Procedure**

1. As `root`, open the `/etc/login.defs` file in the editor.
2. Modify the following section to set a new default `HOME_MODE`:
# HOME_MODE is used by useradd(8) and newusers(8) to set the mode for new
# home directories.
# If HOME_MODE is not set, the value of UMASK is used to create the mode.

HOME_MODE 0700

Replace the default octal value (0700) with another octal value. The selected mode will be used
to create the permissions for the home directory.

3. If HOME_MODE is set, save the changes and exit the editor.

4. If HOME_MODE is not set, modify the UMASK to set the mode for the newly created home
directories:

UMASK 022

Replace the default octal value (022) with another octal value. See User file-creation mode
mask for more details.

5. Save the changes and exit the editor.
CHAPTER 12. MANAGING SYSTEMD

As a system administrator, you can manage critical aspects of your system with **systemd**. Serving as a system and service manager for Linux operating systems, **systemd** software suite provides tools and services for controlling, reporting, and system initialization. Key features of **systemd** include:

- Parallel start of system services during boot
- On-demand activation of daemons
- Dependency-based service control logic

The basic object that **systemd** manages is a **systemd unit**, a representation of system resources and services. A **systemd** unit consists of a name, type and a configuration file that defines and manages a particular task. You can use unit files to configure system behavior. See the following examples of various systemd unit types:

**Service**
Controls and manages individual system services.

**Target**
Represents a group of units that define system states.

**Device**
Manages hardware devices and their availability.

**Mount**
Handles file system mounting.

**Timer**
Schedules tasks to run at specific intervals.

NOTE
To display all available unit types:

```bash
# systemctl -t help
```

12.1. SYSTEMD UNIT FILES LOCATIONS

You can find the unit configuration files in one of the following directories:

<table>
<thead>
<tr>
<th>Directory</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>/usr/lib/systemd/system/</code></td>
<td><strong>systemd</strong> unit files distributed with installed RPM packages.</td>
</tr>
<tr>
<td><code>/run/systemd/system/</code></td>
<td><strong>systemd</strong> unit files created at run time. This directory takes precedence over the directory with installed service unit files.</td>
</tr>
</tbody>
</table>
The default configuration of **systemd** is defined during the compilation and you can find the configuration in the `/etc/systemd/system.conf` file. By editing this file, you can modify the default configuration by overriding values for **systemd** units globally.

For example, to override the default value of the timeout limit, which is set to 90 seconds, use the **DefaultTimeoutStartSec** parameter to input the required value in seconds.

```
DefaultTimeoutStartSec=required value
```

### 12.2. MANAGING SYSTEM SERVICES WITH SYSTEMCTL

As a system administrator, you can manage system services by using the **systemctl** utility. You can perform various tasks, such as starting, stopping, restarting running services, enabling and disabling services to start at boot, listing available services, and displaying system services statuses.

#### 12.2.1. Listing system services

You can list all currently loaded service units and display the status of all available service units.

**Procedure**

Use the **systemctl** command to perform any of the following tasks:

- List all currently loaded service units:

  ```
  $ systemctl list-units --type service
  UNIT                     LOAD   ACTIVE SUB     DESCRIPTION
  abrt-ccpp.service        loaded active exited  Install ABRT coredump hook
  abrt-oops.service        loaded active running ABRT kernel log watcher
  abrtd.service            loaded active running ABRT Automated Bug Reporting Tool
  ...
  systemd-vconsole-setup.service loaded active exited  Setup Virtual Console
  tog-pegasus.service            loaded active running OpenPegasus CIM Server
  ```

  LOAD   = Reflects whether the unit definition was properly loaded.
  ACTIVE = The high-level unit activation state, or a generalization of SUB.
  SUB    = The low-level unit activation state, values depend on unit type.

  46 loaded units listed. Pass --all to see loaded but inactive units, too.
  To show all installed unit files use `systemctl list-unit-files`

By default, the **systemctl list-units** command displays only active units. For each service unit file, the command provides an overview of the following parameters:
UNIT
  The full name of the service unit
LOAD
  The load state of the configuration file
ACTIVE or SUB
  The current high-level and low-level unit file activation state
DESCRIPTION
  A short description of the unit’s purpose and functionality

- List all loaded units regardless of their state by using the following command with the --all or -a command line option:

  $ systemctl list-units --type service --all

- List the status (enabled or disabled) of all available service units:

  $ systemctl list-unit-files --type service

<table>
<thead>
<tr>
<th>UNIT FILE</th>
<th>STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>abrt-ccpp.service</td>
<td>enabled</td>
</tr>
<tr>
<td>abrt-oops.service</td>
<td>enabled</td>
</tr>
<tr>
<td>abrtd.service</td>
<td>enabled</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
<tr>
<td>wpa_supplicant.service</td>
<td>disabled</td>
</tr>
<tr>
<td>yppbind.service</td>
<td>disabled</td>
</tr>
</tbody>
</table>

  208 unit files listed.

For each service unit, this command displays:

UNIT FILE
  The full name of the service unit
STATE
  The information whether the service unit is enabled or disabled to start automatically during boot

Additional resources

- Displaying system service status

12.2.2. Displaying system service status

You can inspect any service unit to get detailed information and verify the state of the service, whether it is enabled to start during boot or currently running. You can also view services that are ordered to start after or before a particular service unit.

Procedure

Use the systemctl command to perform any of the following tasks:

- Display detailed information about a service unit that corresponds to a system service:

  $ systemctl status <name>.service
Replace `<name>` with the name of the service unit you want to inspect (for example, `gdm`).

This command displays the following information:

- The name of the selected service unit followed by a short description
- One or more fields described in Available service unit information
- The execution of the service unit: if the unit is executed by the `root` user
- The most recent log entries

**Table 12.2. Available service unit information**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loaded</strong></td>
<td>Information whether the service unit has been loaded, the absolute path to the unit file, and a note whether the unit is enabled to start during boot.</td>
</tr>
<tr>
<td><strong>Active</strong></td>
<td>Information whether the service unit is running followed by a time stamp.</td>
</tr>
<tr>
<td><strong>Main PID</strong></td>
<td>The process ID and the name of the corresponding system service.</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>Additional information about the corresponding system service.</td>
</tr>
<tr>
<td><strong>Process</strong></td>
<td>Additional information about related processes.</td>
</tr>
<tr>
<td><strong>CGroup</strong></td>
<td>Additional information about related control groups (<code>cgroups</code>).</td>
</tr>
</tbody>
</table>

**Example 12.1. Displaying service status**

The service unit for the GNOME Display Manager is named `gdm.service`. To determine the current status of this service unit, type the following at a shell prompt:

```
# systemctl status gdm.service
```

```
gdm.service - GNOME Display Manager
 Loaded: loaded (/usr/lib/systemd/system/gdm.service; enabled)
 Active: active (running) since Thu 2013-10-17 17:31:23 CEST; 5min ago
 Main PID: 1029 (gdm)
 CGroup: /system.slice/gdm.service
 ├── 1029 /usr/sbin/gdm
 │   └─ 1047 /usr/bin/Xorg :0 -background none -verbose -auth /r...

Oct 17 17:31:23 localhost systemd[1]: Started GNOME Display Manager.
```
- Verify that a particular service unit is running:

  ```
  $ systemctl is-active <name>.service
  ```

- Determine whether a particular service unit is enabled to start during boot:

  ```
  $ systemctl is-enabled <name>.service
  ```

**NOTE**

Both `systemctl is-active` and `systemctl is-enabled` commands return an exit status of 0 if the specified service unit is running or enabled.

- Check what services `systemd` orders to start before the specified service unit

  ```
  # systemctl list-dependencies --after <name>.service
  ```

  For example, to view the list of services ordered to start before `gdm`, enter:

  ```
  # systemctl list-dependencies --after gdm.service
  gdm.service
  ├─ dbus.socket
  ├─ getty@tty1.service
  ├─ livesys.service
  ├─ Plymouth-quit.service
  ├─ system.slice
  ├─ systemd-journald.socket
  ├─ systemd-user-sessions.service
  └─ basic.target
  [output truncated]
  ```

- Check what services `systemd` orders to start after the specified service unit:

  ```
  # systemctl list-dependencies --before <name>.service
  ```

  For example, to view the list of services `systemd` orders to start after `gdm`, enter:

  ```
  # systemctl list-dependencies --before gdm.service
  gdm.service
  ├─ dracut-shutdown.service
  └─ graphical.target
      └─ systemd-readahead-done.service
      └─ systemd-readahead-done.timer
      └─ systemd-update-utmp-runlevel.service
   └─ shutdown.target
       └─ systemd-reboot.service
       └─ final.target
       └─ systemd-reboot.service
  ```

**Additional resources**

- [Listing system services](#)
12.2.3. Starting a system service

You can start system service in the current session by using the `start` command.

**Prerequisites**

- Root access

**Procedure**

- Start a system service in the current session:
  
  ```
  # systemctl start <name>.service
  ```

  Replace `<name>` with the name of the service unit you want to start (for example, `httpd.service`).

  **NOTE**

  In `systemd`, positive and negative dependencies between services exist. Starting a particular service may require starting one or more other services (positive dependency) or stopping one or more services (negative dependency).

  When you attempt to start a new service, `systemd` resolves all dependencies automatically, without explicit notification to the user. This means that if you are already running a service, and you attempt to start another service with a negative dependency, the first service is automatically stopped.

  For example, if you are running the `postfix` service, and you attempt to start the `sendmail` service, `systemd` first automatically stops `postfix`, because these two services are conflicting and cannot run on the same port.

**Additional resources**

- `systemctl(1)` man page
- Enabling a system service to start at boot
- Displaying system service status

12.2.4. Stopping a system service

If you want to stop a system service in the current session, use the `stop` command.

**Prerequisites**

- Root access

**Procedure**

- Stop a system service:
  
  ```
  # systemctl stop <name>.service
  ```
Replace `<name>` with the name of the service unit you want to stop (for example, `bluetooth`).

**Additional resources**

- `systemctl(1)` man page
- Disabling a system service to start at boot
- Displaying system service status

### 12.2.5. Restarting a system service

You can restart system service in the current session using the `restart` command to perform the following actions:

- Stop the selected service unit in the current session and immediately start it again.
- Restart a service unit only if the corresponding service is already running.
- Reload configuration of a system service without interrupting its execution.

**Prerequisites**

- Root access

**Procedure**

- Restart a system service:
  
  ```
  # systemctl restart <name>.service
  
  Replace `<name>` with the name of the service unit you want to restart (for example, `httpd`).
  ```

  **NOTE**
  
  If the selected service unit is not running, this command starts it too.

- Optional: Restart a service unit only if the corresponding service is already running:
  
  ```
  # systemctl try-restart <name>.service
  ```

- Optional: Reload the configuration without interrupting service execution:
  
  ```
  # systemctl reload <name>.service
  ```

  **NOTE**
  
  System services that do not support this feature, ignore this command. To restart such services, use the `reload-or-restart` and `reload-or-try-restart` commands instead.

**Additional resources**
12.2.6. Enabling a system service to start at boot

You can enable a service to start automatically at boot, these changes apply with the next reboot.

Prerequisites

- Root access
- The service you want to enable must not be masked. If you have a masked service, unmask it first:

  ```
  # systemctl unmask <name>.service
  ```

Procedure

- Enable a service to start at boot:

  ```
  # systemctl enable <name>.service
  ```
  
  Replace `<name>` with the name of the service unit you want to enable (for example, `httpd`).
- Optional: You can also enable and start a service by using a single command:

  ```
  # systemctl enable --now <name>.service
  ```

Additional resources

- `systemctl (1)` man page
- Displaying system service status
- Starting a system service

12.2.7. Disabling a system service to start at boot

You can prevent a service unit from starting automatically at boot time. If you disable a service, it will not start at boot, but you can start it manually. You can also mask a service, so that it cannot be started manually. Masking is a way of disabling a service that makes the service permanently unusable until it is unmasked again.

Prerequisites

- Root access

Procedure

- Disable a service to start at boot:

  ```
  # systemctl disable <name>.service
  ```
Replace `<name>` with the name of the service unit you want to disable (for example, `bluetooth`).

- Optional: If you want to make a service permanently unusable, mask the service:

  ```bash
  # systemctl mask <name>.service
  ```

  This command replaces the `/etc/systemd/system/<name>.service` file with a symbolic link to `/dev/null`, rendering the actual unit file inaccessible to `systemd`.

**Additional resources**

- `systemctl (1)` man page
- Displaying system service status
- Stopping a system service

## 12.3. Booting into a Target System State

As a system administrator, you can control the boot process of your system, and define the state you want your system to boot into. This is called a `systemd` target, and it is a set of `systemd` units that your system starts to reach a certain level of functionality. While working with systemd targets, you can view the default target, select a target at runtime, change the default boot target, boot into emergency or rescue target.

### 12.3.1. Target unit files

Targets in `systemd` are groups of related units that act as synchronization points during the start of your system. Target unit files, which end with the `.target` file extension, represent the `systemd` targets. The purpose of target units is to group together various `systemd` units through a chain of dependencies.

Consider the following examples:

- The `graphical.target` unit for starting a graphical session, starts system services such as the GNOME Display Manager (`gdm.service`) or Accounts Service (`accounts-daemon.service`), and also activates the `multi-user.target` unit.

- Similarly, the `multi-user.target` unit starts other essential system services such as NetworkManager (`NetworkManager.service`) or D-Bus (`dbus.service`) and activates another target unit named `basic.target`.

You can set the following `systemd` targets as default or current targets:

**Table 12.3. Common systemd targets**

<table>
<thead>
<tr>
<th>Target</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rescue</td>
<td>Unit target that pulls in the base system and spawns a rescue shell</td>
</tr>
<tr>
<td>multi-user</td>
<td>Unit target for setting up a multi-user system</td>
</tr>
<tr>
<td>graphical</td>
<td>Unit target for setting up a graphical login screen</td>
</tr>
<tr>
<td>emergency</td>
<td>Unit target that starts an emergency shell on the main console</td>
</tr>
</tbody>
</table>
12.3.2. Changing the default target to boot into

When a system starts, *systemd* activates the `default.target` symbolic link, which points to the true target unit. You can find the currently selected default target unit in the `/etc/systemd/system/default.target` file. Each target represents a certain level of functionality and is used for grouping other units. Additionally, target units serve as synchronization points during boot. You can change the default target your system boots into. When you set a default target unit, the current target remains unchanged until the next reboot.

Prerequisites

- Root access

Procedure

1. Determine the current default target unit *systemd* uses to start the system:

```
# systemctl get-default
graphical.target
```

2. List the currently loaded targets:

```
# systemctl list-units --type target
```

3. Configure the system to use a different target unit by default:

```
# systemctl set-default <name>.target
```

Replace `<name>` with the name of the target unit you want to use by default.

Example:

```
# systemctl set-default multi-user.target
Removed /etc/systemd/system/default.target
Created symlink /etc/systemd/system/default.target -> /usr/lib/systemd/system/multi-user.target
```

4. Verify the default target unit:

```
# systemctl get-default
multi-user.target
```

5. Apply the changes by rebooting:

```
# reboot
```

Additional resources
12.3.3. Changing the current target

On a running system, you can change the target unit in the current boot without reboot. If you switch to a different target, `systemd` starts all services and their dependencies that this target requires, and stops all services that the new target does not enable. Isolating a different target affects only the current boot.

**Procedure**

1. Optional: Determine the current target:
   
   ```bash
   # systemctl get-default
   graphical.target
   ```

2. Optional: Display the list of targets you can select:
   
   ```bash
   # systemctl list-units --type target
   ```

   **NOTE**
   
   You can only isolate targets that have the `AllowIsolate=yes` option set in the unit files.

3. Change to a different target unit in the current boot:
   
   ```bash
   # systemctl isolate <name>.target
   ```

   Replace `<name>` with the name of the target unit you want to use in the current boot.

   **Example:**
   
   ```bash
   # systemctl isolate multi-user.target
   ```

   This command starts the target unit named `multi-user` and all dependent units, and immediately stops all other unit.

**Additional resources**

- `systemctl(1)` man page

12.3.4. Booting to rescue mode

You can boot to the *rescue mode* that provides a single-user environment for troubleshooting or repair if the system cannot get to a later target, and the regular booting process fails. In rescue mode, the system attempts to mount all local file systems and start certain important system services, but it does not activate network interfaces.

**Prerequisites**
Root access

Procedure

- To enter the rescue mode, change the current target in the current session:

```
# systemctl rescue
```

Broadcast message from root@localhost on pts/0 (Fri 2023-03-24 18:23:15 CEST):

The system is going down to rescue mode NOW!

**NOTE**

This command is similar to `systemctl isolate rescue.target`, but it also sends an informative message to all users that are currently logged into the system.

To prevent **systemd** from sending a message, enter the following command with the `--no-wall` command-line option:

```
# systemctl --no-wall rescue
```

Troubleshooting steps

If your system is not able to enter the rescue mode, you can boot to **emergency mode**, which provides the most minimal environment possible. In emergency mode, the system mounts the root file system only for reading, does not attempt to mount any other local file systems, does not activate network interfaces, and only starts a few essential services.

12.3.5. Troubleshooting the boot process

As a system administrator, you can select a non-default target at boot time to troubleshoot the boot process. Changing the target at boot time affects only a single boot. You can boot to **emergency mode**, which provides the most minimal environment possible.

**Procedure**

1. Reboot the system, and interrupt the boot loader menu countdown by pressing any key except the Enter key, which would initiate a normal boot.

2. Move the cursor to the kernel entry that you want to start.

3. Press the E key to edit the current entry.

4. Move to the end of the line that starts with `linux` and press Ctrl+E to jump to the end of the line:

```
linux ($root)/vmlinuz-5.14.0-70.22.1.e19_0.x86_64 root=/dev/mapper/rhel-root ro crash\
kernel=auto resume=/dev/mapper/rhel-swap rd.lvm.lv/swap rhgb quiet
```

5. To choose an alternate boot target, append the `systemd.unit=` parameter to the end of the line that starts with `linux`:
Replace `<name>` with the name of the target unit you want to use. For example, `systemd.unit=emergency.target`

6. Press Ctrl+X to boot with these settings.

### 12.4. SHUTTING DOWN, SUSPENDING, AND HIBERNATING THE SYSTEM

As a system administrator, you can use different power management options to manage power consumption, perform a proper shutdown to ensure that all data is saved, or restart the system to apply changes and updates.

#### 12.4.1. System shutdown

To shut down the system, you can either use the `systemctl` utility directly, or call this utility through the `shutdown` command.

Using the `shutdown` has the following advantages:

- You can schedule a shutdown by using the `time` argument. This also gives users warning that a system shutdown has been scheduled.
- You can cancel the shutdown.

**Additional resources**

- [Overview of the power management commands with systemctl](https://example.com)

#### 12.4.2. Scheduling a system shutdown

As a system administrator, you can schedule a delayed shutdown to give users time to save their work and log off the system. Use the `shutdown` command to perform the following operations:

- Shut down the system and power off the machine at a certain time
- Shut down and halt the system without powering off the machine
- Cancel a pending shutdown

**Prerequisites**

- Root access

**Procedure**

Use the `shutdown` command to perform any of the following tasks:

- Specify the time at which you want to shut down the system and power off the machine:

  ```bash
  # shutdown --poweroff hh:mm
  ```
Where **hh:mm** is the time in the 24-hour time notation. To prevent new logins, the `/run/nologin` file is created 5 minutes before system shutdown.

When you use the time argument, you can notify users logged in to the system of the planned shutdown by specifying an optional wall message, for example `shutdown --poweroff 13:59
“Attention. The system will shut down at 13:59”`.  

- Shut down and halt the system after a delay, without powering off the machine:

  ```
  # shutdown --halt +m
  ```

  Where `+m` is the delay time in minutes. You can use the `now` keyword as an alias for `+0`.

- Cancel a pending shutdown:

  ```
  # shutdown -c
  ```

Additional resources

- `shutdown(8)` manual page
- Shutting down the system using the systemctl command

### 12.4.3. Shutting down the system using the systemctl command

As a system administrator, you can shut down the system and power off the machine or shut down and halt the system without powering off the machine by using the `systemctl` command.

**Prerequisites**

- Root access

**Procedure**

Use the `systemctl` command to perform any of the following tasks:

- Shut down the system and power off the machine:

  ```
  # systemctl poweroff
  ```

- Shut down and halt the system without powering off the machine:

  ```
  # systemctl halt
  ```

**NOTE**

By default, running either of these commands causes `systemd` to send an informative message to all users that are currently logged into the system. To prevent `systemd` from sending this message, run the selected command with the `--no-wall` command line option.

### 12.4.4. Restarting the system

...
When you restart the system, **systemd** stops all running programs and services, the system shuts down, and then immediately starts again. Restarting the system can be helpful in the following situations:

- After installing new software or updates
- After making changes to system settings
- When troubleshooting system issues

**Prerequisites**

- Root access

**Procedure**

- Restart the system:

  ```bash
  # systemctl reboot
  ```

**NOTE**

By default, when you use this command, **systemd** sends an informative message to all users that are currently logged into the system. To prevent **systemd** from sending this message, run this command with the **--no-wall** option.

12.4.5. Optimizing power consumption by suspending and hibernating the system

As a system administrator, you can manage power consumption, save energy on your systems, and preserve the current state of your system. To do so, apply one of the following modes:

**Suspend**

SUSpending saves the system state in RAM and with the exception of the RAM module, powers off most of the devices in the machine. When you turn the machine back on, the system then restores its state from RAM without having to boot again. Because the system state is saved in RAM and not on the hard disk, restoring the system from suspend mode is significantly faster than from hibernation. However, the suspended system state is also vulnerable to power outages.

**Hibernate**

Hibernating saves the system state on the hard disk drive and powers off the machine. When you turn the machine back on, the system then restores its state from the saved data without having to boot again. Because the system state is saved on the hard disk and not in RAM, the machine does not have to maintain electrical power to the RAM module. However, as a consequence, restoring the system from hibernation is significantly slower than restoring it from suspend mode.

**Hybrid sleep**

This combines elements of both hibernation and suspending. The system first saves the current state on the the hard disk drive, and enters a low-power state similar to suspending, which allows the system to resume more quickly. The benefit of hybrid sleep is that if the system loses power during the sleep state, it can still recover the previous state from the saved image on the hard disk, similar to hibernation.

**Suspend-then-hibernate**

This mode first suspends the system, which results in saving the current system state to RAM and putting the system in a low-power mode. The system hibernates if it remains suspended for a specific period of time that you can define in the **HibernateDelaySec** parameter. Hibernation saves
the system state to the hard disk drive and shuts down the system completely. The suspend-then-hibernate mode provides the benefit of conserving battery power while you are still able to quickly resume work. Additionally, this mode ensures that your data is saved in case of a power failure.

**Prerequisites**

- Root access

**Procedure**

Choose the appropriate method for power saving:

- Suspend the system:
  
  ```
  # systemctl suspend
  ```

- Hibernate the system:
  
  ```
  # systemctl hibernate
  ```

- Hibernate and suspend the system:
  
  ```
  # systemctl hybrid-sleep
  ```

- Suspend and then hibernate the system:
  
  ```
  # systemctl suspend-then-hibernate
  ```

12.4.6. Overview of the power management commands with systemctl

You can use the following list of the `systemctl` commands to control the power management of your system.

<table>
<thead>
<tr>
<th>systemctl command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>systemctl halt</td>
<td>Halts the system.</td>
</tr>
<tr>
<td>systemctl poweroff</td>
<td>Powers off the system.</td>
</tr>
<tr>
<td>systemctl reboot</td>
<td>Restarts the system.</td>
</tr>
<tr>
<td>systemctl suspend</td>
<td>Suspends the system.</td>
</tr>
<tr>
<td>systemctl hibernate</td>
<td>Hibernates the system.</td>
</tr>
<tr>
<td>systemctl hybrid-sleep</td>
<td>Hibernates and suspends the system.</td>
</tr>
</tbody>
</table>

12.4.7. Changing how your system behaves when you press the power button
When you press the power button on your computer, it shuts down the system by default. You can customize this behavior according to your preferences.

Prerequisites

- Administrative access.

Procedure

1. Open the `/etc/systemd/logind.conf` configuration file.

2. Look for the line that says `HandlePowerKey=poweroff`.

3. If the line starts with the `#` symbol, remove it to enable the setting.

4. Replace `poweroff` with one of the following options:
   - `poweroff` to shut down the computer.
   - `reboot` for a system reboot.
   - `halt` to initiate a system halt.
   - `kexec` for a kexec-based reboot.
   - `suspend` to suspend the system.
   - `hibernate` to initiate system hibernation.
   - `ignore` to do nothing.

   For example, to reboot the system upon pressing the power button, use this setting:

   ```
   HandlePowerKey=reboot
   ```

5. Save your changes and close the editor.
CHAPTER 13. CONFIGURING TIME SYNCHRONIZATION

Accurate timekeeping in an IT environment is important. A consistent time across all network devices improves the traceability of log files and certain protocols rely on synchronized clocks. For example, Kerberos uses time stamps to prevent replay attacks.

13.1. USING THE CHRONY SUITE TO CONFIGURE NTP

Accurate timekeeping is important for several reasons in IT. In networking for example, accurate time stamps in packets and logs are required. In Linux systems, the NTP protocol is implemented by a daemon running in user space.

The user space daemon updates the system clock running in the kernel. The system clock can keep time by using various clock sources. Usually, the Time Stamp Counter (TSC) is used. The TSC is a CPU register which counts the number of cycles since it was last reset. It is very fast, has a high resolution, and there are no interruptions.

Starting with Red Hat Enterprise Linux 8, the NTP protocol is implemented by the chronyd daemon, available from the repositories in the chrony package.

The following sections describe how to use the chrony suite to configure NTP.

13.1.1. Introduction to chrony suite

chrony is an implementation of the Network Time Protocol (NTP). You can use chrony:

- To synchronize the system clock with NTP servers
- To synchronize the system clock with a reference clock, for example a GPS receiver
- To synchronize the system clock with a manual time input
- As an NTPv4 (RFC 5905) server or peer to provide a time service to other computers in the network

chrony performs well in a wide range of conditions, including intermittent network connections, heavily congested networks, changing temperatures (ordinary computer clocks are sensitive to temperature), and systems that do not run continuously, or run on a virtual machine.

Typical accuracy between two machines synchronized over the Internet is within a few milliseconds, and for machines on a LAN within tens of microseconds. Hardware timestamping or a hardware reference clock may improve accuracy between two machines synchronized to a sub-microsecond level.

chrony consists of chronyd, a daemon that runs in user space, and chronyc, a command line program which can be used to monitor the performance of chronyd and to change various operating parameters when it is running.

The chrony daemon, chronyd, can be monitored and controlled by the command line utility chronyc. This utility provides a command prompt which allows entering a number of commands to query the current state of chronyd and make changes to its configuration. By default, chronyd accepts only commands from a local instance of chronyc, but it can be configured to accept monitoring commands also from remote hosts. The remote access should be restricted.

13.1.2. Using chronyc to control chronyd
You can control `chronyd` by using the `chronyc` command line utility.

**Procedure**

1. To make changes to the local instance of `chronyd` using the command line utility `chronyc` in interactive mode, enter the following command as `root`:

   ```
   # chronyc
   ```

   `chronyc` must run as `root` if some of the restricted commands are to be used.

   The `chronyc` command prompt will be displayed as follows:

   ```
   chronyc>
   ```

2. To list all of the commands, type `help`.

3. Alternatively, the utility can also be invoked in non-interactive command mode if called together with a command as follows:

   ```
   chronyc command
   ```

**NOTE**

Changes made using `chronyc` are not permanent, they will be lost after a `chronyd` restart. For permanent changes, modify `/etc/chrony.conf`.

### 13.2. USING CHRONY

The following sections describe how to install, start, and stop `chronyd`, and how to check if `chrony` is synchronized. Sections also describe how to manually adjust System Clock.

#### 13.2.1. Managing chrony

The following procedure describes how to install, start, stop, and check the status of `chronyd`.

**Procedure**

1. The `chrony` suite is installed by default on Red Hat Enterprise Linux. To ensure that it is, run the following command as `root`:

   ```
   # dnf install chrony
   ```

   The default location for the `chrony` daemon is `/usr/sbin/chronyd`. The command line utility will be installed to `/usr/bin/chronyc`.

2. To check the status of `chronyd`, issue the following command:

   ```
   $ systemctl status chronyd
   chronyd.service - NTP client/server
   Loaded: loaded (/usr/lib/systemd/system/chronyd.service; enabled)
   Active: active (running) since Wed 2013-06-12 22:23:16 CEST; 11h ago
3. To start **chronyd**, issue the following command as **root**:

```
# systemctl start chronyd
```

To ensure **chronyd** starts automatically at system start, issue the following command as **root**:

```
# systemctl enable chronyd
```

4. To stop **chronyd**, issue the following command as **root**:

```
# systemctl stop chronyd
```

To prevent **chronyd** from starting automatically at system start, issue the following command as **root**:

```
# systemctl disable chronyd
```

### 13.2.2. Checking if chrony is synchronized

The following procedure describes how to check if **chrony** is synchronized with the use of the **tracking**, **sources**, and **sourcestats** commands.

**Procedure**

1. To check **chrony** tracking, issue the following command:

   ```bash
   $ chronyc tracking
   Reference ID    : CB00710F (ntp-server.example.net)
   Stratum         : 3
   Ref time (UTC)  : Fri Jan 27 09:49:17 2017
   System time     : 0.000006523 seconds slow of NTP time
   Last offset     : -0.000006747 seconds
   RMS offset      : 0.000035822 seconds
   Frequency       : 3.225 ppm slow
   Residual freq   : 0.000 ppm
   Skew            : 0.129 ppm
   Root delay      : 0.013639022 seconds
   Root dispersion : 0.001100737 seconds
   Update interval : 64.2 seconds
   Leap status     : Normal
   ```

2. The **sources** command displays information about the current time sources that **chronyd** is accessing. To check **chrony** sources, issue the following command:

   ```bash
   $ chronyc sources
   210 Number of sources = 3
   MS Name/IP address         Stratum Poll Reach LastRx Last sample
   =========================================================================
   ####
   #* GPS0                          0   4   377    11   -479ns[ -621ns] /-  134ns
   ^? a.b.c                         2   6   377    23   -923us[ -924us] +/-   43ms
   ^ d.e.f                         1   6   377    21  -2629us[-2619us] +/-   86ms
   ```

You can specify the optional `-v` argument to print more verbose information. In this case, extra...
You can specify the optional \texttt{-v} argument to print more verbose information. In this case, extra caption lines are shown as a reminder of the meanings of the columns.

3. The \texttt{sourcestats} command displays information about the drift rate and offset estimation process for each of the sources currently being examined by \texttt{chronyd}. To check \texttt{chrony} source statistics, issue the following command:

```
$ chronyc sourcestats
210 Number of sources = 1
Name/IP Address            NP  NR  Span  Frequency  Freq Skew  Offset  Std Dev
===========================================================================
abcd.ghi                11   5   46m     -0.001      0.045      1us    25us
```

The optional argument \texttt{-v} can be specified, meaning verbose. In this case, extra caption lines are shown as a reminder of the meanings of the columns.

Additional resources

- \texttt{chronyc(1) man page}

13.2.3. Manually adjusting the System Clock

The following procedure describes how to manually adjust the System Clock.

Procedure

1. To step the system clock immediately, bypassing any adjustments in progress by slewing, issue the following command as \texttt{root}:

```
# chronyc makestep
```

If the \texttt{rtcfile} directive is used, the real-time clock should not be manually adjusted. Random adjustments would interfere with \texttt{chrony}'s need to measure the rate at which the real-time clock drifts.

13.2.4. Disabling a \texttt{chrony} dispatcher script

The \texttt{chrony} dispatcher script manages the online and offline state of the NTP servers. As a system administrator, you can disable the dispatcher script to keep \texttt{chronyd} polling the servers constantly.

If you enable NetworkManager on your system to manage networking configuration, the NetworkManager executes the \texttt{chrony} dispatcher script during interface reconfiguration, stop or start operations. However, if you configure certain interfaces or routes outside of NetworkManager, you can encounter the following situation:

1. The dispatcher script might run when no route to the NTP servers exists, causing the NTP servers to switch to the offline state.

2. If you establish the route later, the script does not run again by default, and the NTP servers remain in the offline state.

To ensure that \texttt{chronyd} can synchronize with your NTP servers, which have separately managed interfaces, disable the dispatcher script.
Prerequisites

- You installed NetworkManager on your system and enabled it.
- Root access

Procedure

1. To disable the `chrony` dispatcher script, create a symlink to `/dev/null`:

   ```
   # ln -s /dev/null /etc/NetworkManager/dispatcher.d/20-chrony-onoffline
   ```

   **NOTE**

   After this change, the NetworkManager cannot execute the dispatcher script, and the NTP servers remain in the online state at all times.

13.2.5. Setting up `chrony` for a system in an isolated network

For a network that is never connected to the Internet, one computer is selected to be the primary timeserver. The other computers are either direct clients of the server, or clients of clients. On the server, the drift file must be manually set with the average rate of drift of the system clock. If the server is rebooted, it will obtain the time from surrounding systems and calculate an average to set its system clock. Thereafter it resumes applying adjustments based on the drift file. The drift file will be updated automatically when the `settime` command is used.

The following procedure describes how to set up `chrony` for a system in an isolated network.

Procedure

1. On the system selected to be the server, using a text editor running as `root`, edit `/etc/chrony.conf` as follows:

   ```
   driftfile /var/lib/chrony/drift
   commandkey 1
   keyfile /etc/chrony.keys
   initstepslew 10 client1 client3 client6
   local stratum 8
   manual
   allow 192.0.2.0
   ```

   Where **192.0.2.0** is the network or subnet address from which the clients are allowed to connect.

2. On the systems selected to be direct clients of the server, using a text editor running as `root`, edit the `/etc/chrony.conf` as follows:

   ```
   server ntp1.example.net
   driftfile /var/lib/chrony/drift
   logdir /var/log/chrony
   log measurements statistics tracking
   keyfile /etc/chrony.keys
   commandkey 24
   ```
local stratum 10
initstepslew 20 ntp1.example.net
allow 192.0.2.123

Where 192.0.2.123 is the address of the server, and ntp1.example.net is the host name of the server. Clients with this configuration will resynchronize with the server if it restarts.

On the client systems which are not to be direct clients of the server, the /etc/chrony.conf file should be the same except that the local and allow directives should be omitted.

In an isolated network, you can also use the local directive that enables a local reference mode, which allows chronyd operating as an NTP server to appear synchronized to real time, even when it was never synchronized or the last update of the clock happened a long time ago.

To allow multiple servers in the network to use the same local configuration and to be synchronized to one another, without confusing clients that poll more than one server, use the orphan option of the local directive which enables the orphan mode. Each server needs to be configured to poll all other servers with local. This ensures that only the server with the smallest reference ID has the local reference active and other servers are synchronized to it. When the server fails, another one will take over.

13.2.6. Configuring remote monitoring access

chronyc can access chronyd in two ways:

- Internet Protocol, IPv4 or IPv6.
- Unix domain socket, which is accessible locally by the root or chrony user.

By default, chronyc connects to the Unix domain socket. The default path is /var/run/chrony/chronyd.sock. If this connection fails, which can happen for example when chronyc is running under a non-root user, chronyc tries to connect to 127.0.0.1 and then ::1.

Only the following monitoring commands, which do not affect the behavior of chronyd, are allowed from the network:

- activity
- manual list
- rtcdeta
- smoothing
- sources
- sourcestats
- tracking
- waitsync

The set of hosts from which chronyd accepts these commands can be configured with the cmdallow directive in the configuration file of chronyd, or the cmdallow command in chronyc. By default, the commands are accepted only from localhost (127.0.0.1 or ::1).
All other commands are allowed only through the Unix domain socket. When sent over the network, `chronyd` responds with a **Not authorised** error, even if it is from localhost.

The following procedure describes how to access chronyd remotely with `chronyc`.

**Procedure**

1. Allow access from both IPv4 and IPv6 addresses by adding the following to the `/etc/chrony.conf` file:

   ```
   bindcmdaddress 0.0.0.0
   or
   bindcmdaddress ::
   ```

2. Allow commands from the remote IP address, network, or subnet by using the `cmdallow` directive.
   Add the following content to the `/etc/chrony.conf` file:

   ```
   cmdallow 192.168.1.0/24
   ```

3. Open port 323 in the firewall to connect from a remote system:

   ```
   # firewall-cmd --zone=public --add-port=323/udp
   ```
   Optionally, you can open port 323 permanently using the `--permanent` option:

   ```
   # firewall-cmd --permanent --zone=public --add-port=323/udp
   ```

4. If you opened port 323 permanently, reload the firewall configuration:

   ```
   # firewall-cmd --reload
   ```

**Additional resources**

- `chrony.conf(5)` man page

**13.2.7. Managing time synchronization using RHEL system roles**

You can manage time synchronization on multiple target machines using the `timesync` role. The `timesync` role installs and configures an NTP or PTP implementation to operate as an NTP or PTP client to synchronize the system clock.
The following example shows how to apply the timesync role in a situation with just one pool of servers.

**Example 13.1. An example playbook applying the timesync role for a single pool of servers**

```yaml
---
- hosts: timesync-test
  vars:
    timesync_ntp_servers:
      - hostname: 2.rhel.pool.ntp.org
        pool: yes
        iburst: yes
    roles:
      - rhel-system-roles.timesync
```

For a detailed reference on timesync role variables, install the rhel-system-roles package, and see the README.md or README.html files in the /usr/share/doc/rhel-system-roles/timesync directory.

Additional resources

- Preparing a control node and managed nodes to use RHEL system roles

### 13.2.8. Additional resources

- chronyc(1) man page
- chronyd(8) man page
- Frequently Asked Questions

### 13.3. CHRONY WITH HW TIME-STAMPING

Hardware timestamping is a feature supported in some Network Interface Controller (NICs) which provides accurate timestamping of incoming and outgoing packets. NTP timestamps are usually created by the kernel and chronyd with the use of the system clock. However, when HW timestamping is enabled, the NIC uses its own clock to generate the timestamps when packets are entering or leaving the link layer or the physical layer. When used with NTP, hardware timestamping can significantly improve the accuracy of synchronization. For best accuracy, both NTP servers and NTP clients need to use hardware timestamping. Under ideal conditions, a sub-microsecond accuracy may be possible.

Another protocol for time synchronization that uses hardware timestamping is PTP.
Unlike NTP, PTP relies on assistance in network switches and routers. If you want to reach the best accuracy of synchronization, use PTP on networks that have switches and routers with PTP support, and prefer NTP on networks that do not have such switches and routers.

The following sections describe how to:

- Verify support for hardware timestamping
- Enable hardware timestamping
- Configure client polling interval
- Enable interleaved mode
- Configure server for large number of clients
- Verify hardware timestamping
- Configure PTP-NTP bridge

13.3.1. Verifying support for hardware timestamping

To verify that hardware timestamping with NTP is supported by an interface, use the `ethtool -T` command. An interface can be used for hardware timestamping with NTP if `ethtool` lists the `SOF_TIMESTAMPING_TX_HARDWARE` and `SOF_TIMESTAMPING_TX_SOFTWARE` capabilities and also the `HWTSTAMP_FILTER_ALL` filter mode.

Example 13.2. Verifying support for hardware timestamping on a specific interface

```
# ethtool -T eth0
```

Output:

```
Timestamping parameters for eth0:
Capabilities:
    hardware-transmit     (SOF_TIMESTAMPING_TX_HARDWARE)
    software-transmit     (SOF_TIMESTAMPING_TX_SOFTWARE)
    hardware-receive      (SOF_TIMESTAMPING_RX_HARDWARE)
    software-receive      (SOF_TIMESTAMPING_RX_SOFTWARE)
    software-system-clock (SOF_TIMESTAMPING_SOFTWARE)
    hardware-raw-clock    (SOF_TIMESTAMPING_RAW_HARDWARE)

PTP Hardware Clock: 0

Hardware Transmit Timestamp Modes:
    off                   (HWTSTAMP_TX_OFF)
    on                    (HWTSTAMP_TX_ON)

Hardware Receive Filter Modes:
    none                  (HWTSTAMP_FILTER_NONE)
    all                   (HWTSTAMP_FILTER_ALL)
    ptpv1-l4-sync         (HWTSTAMP_FILTER_PTP_V1_L4_SYNC)
    ptpv1-l4-delay-req    (HWTSTAMP_FILTER_PTP_V1_L4_DELAY_REQ)
    ptpv2-l4-sync         (HWTSTAMP_FILTER_PTP_V2_L4_SYNC)
    ptpv2-l4-delay-req    (HWTSTAMP_FILTER_PTP_V2_L4_DELAY_REQ)
    ptpv2-l2-sync         (HWTSTAMP_FILTER_PTP_V2_L2_SYNC)
    ptpv2-l2-delay-req    (HWTSTAMP_FILTER_PTP_V2_L2_DELAY_REQ)
```
13.3.2. Enabling hardware timestamping

To enable hardware timestamping, use the `hwtimestamp` directive in the `/etc/chrony.conf` file. The directive can either specify a single interface, or a wildcard character can be used to enable hardware timestamping on all interfaces that support it. Use the wildcard specification in case that no other application, like `ptp4l` from the `linuxptp` package, is using hardware timestamping on an interface. Multiple `hwtimestamp` directives are allowed in the chrony configuration file.

Example 13.3. Enabling hardware timestamping by using the `hwtimestamp` directive

```
hwtimestamp eth0
hwtimestamp eth1
hwtimestamp *
```

13.3.3. Configuring client polling interval

The default range of a polling interval (64–1024 seconds) is recommended for servers on the Internet. For local servers and hardware timestamping, a shorter polling interval needs to be configured in order to minimize offset of the system clock.

The following directive in `/etc/chrony.conf` specifies a local NTP server using one second polling interval:

```
server ntp.local minpoll 0 maxpoll 0
```

13.3.4. Enabling interleaved mode

NTP servers that are not hardware NTP appliances, but rather general purpose computers running a software NTP implementation, like `chrony`, will get a hardware transmit timestamp only after sending a packet. This behavior prevents the server from saving the timestamp in the packet to which it corresponds. In order to enable NTP clients receiving transmit timestamps that were generated after the transmission, configure the clients to use the NTP interleaved mode by adding the `xleave` option to the server directive in `/etc/chrony.conf`:

```
server ntp.local minpoll 0 maxpoll 0 xleave
```

13.3.5. Configuring server for large number of clients

The default server configuration allows a few thousands of clients at most to use the interleaved mode concurrently. To configure the server for a larger number of clients, increase the `clientloglimit` directive in `/etc/chrony.conf`. This directive specifies the maximum size of memory allocated for logging of clients’ access on the server:

```
clientloglimit 100000000
```
13.3.6. Verifying hardware timestamping

To verify that the interface has successfully enabled hardware timestamping, check the system log. The log should contain a message from `chronyd` for each interface with successfully enabled hardware timestamping.

Example 13.4. Log messages for interfaces with enabled hardware timestamping

```plaintext
chronyd[4081]: Enabled HW timestamping on eth0
chronyd[4081]: Enabled HW timestamping on eth1
```

When `chronyd` is configured as an NTP client or peer, you can have the transmit and receive timestamping modes and the interleaved mode reported for each NTP source by the `chronyc ntpdata` command:

Example 13.5. Reporting the transmit, receive timestamping and interleaved mode for each NTP source

```plaintext
# chronyc ntpdata

Remote address : 203.0.113.15 (CB00710F)
Remote port : 123
Local address : 203.0.113.74 (CB00714A)
Leap status : Normal
Version : 4
Mode : Server
Stratum : 1
Poll interval : 0 (1 seconds)
Precision : -24 (0.000000060 seconds)
Root delay : 0.000015 seconds
Root dispersion : 0.000015 seconds
Reference ID : 47505300 (GPS)
Reference time : Wed May 03 13:47:45 2017
Offset : -0.000000134 seconds
Peer delay : 0.000005396 seconds
Peer dispersion : 0.000002329 seconds
Response time : 0.000152073 seconds
Jitter asymmetry: +0.00
NTP tests : 111 111 1111
Interleaved : Yes
Authenticated : No
TX timestamping : Hardware
RX timestamping : Hardware
Total TX : 27
Total RX : 27
Total valid RX : 27
```

Example 13.6. Reporting the stability of NTP measurements
With hardware timestamping enabled, stability of NTP measurements should be in tens or hundreds of nanoseconds, under normal load. This stability is reported in the Std Dev column of the output of the `chronyc sourcestats` command:

```
210 Number of sources = 1
Name/IP Address NP NR Span Frequency Freq Skew Offset Std Dev
ntp.local 12 7 11 +0.000 0.019 +0ns 49ns
```

### 13.3.7. Configuring PTP-NTP bridge

If a highly accurate Precision Time Protocol (PTP) primary timeserver is available in a network that does not have switches or routers with PTP support, a computer may be dedicated to operate as a PTP client and a stratum-1 NTP server. Such a computer needs to have two or more network interfaces, and be close to the primary timeserver or have a direct connection to it. This will ensure highly accurate synchronization in the network.

Configure the `ptp4l` and `phc2sys` programs from the `linuxptp` packages to use one interface to synchronize the system clock using PTP.

Configure `chronyd` to provide the system time using the other interface:

```
bindaddress 203.0.113.74
hwtimestamp eth1
local stratum 1
```

### 13.4. OVERVIEW OF NETWORK TIME SECURITY (NTS) IN CHRONY

Network Time Security (NTS) is an authentication mechanism for Network Time Protocol (NTP), designed to scale substantial clients. It verifies that the packets received from the server machines are unaltered while moving to the client machine. Network Time Security (NTS) includes a Key Establishment (NTS-KE) protocol that automatically creates the encryption keys used between the server and its clients.

#### WARNING

NTS is not compatible with the FIPS and OSPP profile. When you enable the FIPS and OSPP profile, `chronyd` that is configured with NTS can abort with a fatal message. You can disable the OSPP profile and FIPS mode for `chronyd` service by adding the `GNUTLS_FORCE_FIPS_MODE=0` to the `/etc/sysconfig/chronyd` file.
13.4.1. Enabling Network Time Security (NTS) in the client configuration file

By default, Network Time Security (NTS) is not enabled. You can enable NTS in the /etc/chrony.conf. For that, perform the following steps:

Prerequisites

- Server with the NTS support

Procedure

In the client configuration file:

1. Specify the server with the nts option in addition to the recommended iburst option.

   For example:
   
   server time.example.com iburst nts
   server nts.netnod.se iburst nts
   server ptbtime1.ptb.de iburst nts

2. To avoid repeating the Network Time Security-Key Establishment (NTS-KE) session during system boot, add the following line to chrony.conf, if it is not present:

   ntsdumpdir /var/lib/chrony

3. To disable synchronization with Network Time Protocol (NTP) servers provided by DHCP, comment out or remove the following line in chrony.conf, if it is present:

   sourcedir /run/chrony-dhcp

4. Save your changes.

5. Restart the chronyd service:

   systemctl restart chronyd

Verification

- Verify if the NTS keys were successfully established:

  # chronyc -N authdata

  Name/IP address  Mode KeyID Type KLen Last Atmp  NAK Cook CLen
  ==============================================================
  time.example.com  NTS  1  15  256  33m    0    0    8  100
  nts.sth1.ntp.se   NTS  1  15  256  33m    0    0    8  100
  nts.sth2.ntp.se   NTS  1  15  256  33m    0    0    8  100

  The KeyID, Type, and KLen should have non-zero values. If the value is zero, check the system log for error messages from chronyd.

- Verify the client is making NTP measurements:

  # chronyc -N sources
The `Reach` column should have a non-zero value; ideally 377. If the value rarely gets 377 or never gets to 377, it indicates that NTP requests or responses are getting lost in the network.

**Additional resources**

- `chrony.conf(5)` man page

**13.4.2. Enabling Network Time Security (NTS) on the server**

If you run your own Network Time Protocol (NTP) server, you can enable the server Network Time Security (NTS) support to facilitate its clients to synchronize securely.

If the NTP server is a client of other servers, that is, it is not a Stratum 1 server, it should use NTS or symmetric key for its synchronization.

**Prerequisites**

- Server private key in **PEM** format
- Server certificate with required intermediate certificates in **PEM** format

**Procedure**

1. Specify the private key and the certificate file in `chrony.conf`. For example:

   ```
   ntsserverkey /etc/pki/tls/private/<ntp-server.example.net>.key
   ntsservercert /etc/pki/tls/certs/<ntp-server.example.net>.crt
   ```

2. Ensure that both the key and certificate files are readable by the chrony system user, by setting the group ownership. For example:

   ```
   # chown :chrony /etc/pki/tls//<ntp-server.example.net>.
   ```

3. Ensure the `ntsdumpdir /var/lib/chrony` directive is present in the `chrony.conf`.

4. Restart the `chronyd` service:

   ```
   # systemctl restart chronyd
   ```

**IMPORTANT**

If the server has a firewall, it needs to allow both the **UDP 123** and **TCP 4460** ports for NTP and Network Time Security-Key Establishment (NTS-KE).

**Verification**
Perform a quick test from a client machine with the following command:

```
$ chronyd -Q -t 3 'server

ntp-server.example.net iburst nts maxsamples 1'
```

2021-09-15T13:45:26Z chronyd version 4.1 starting (+CMDMON +NTP +REFCLOCK +RTC +PRIVDROP +SCFILTER +SIGND +ASYNCDNS +NTS +SECHASH +IPV6 +DEBUG)
2021-09-15T13:45:26Z Disabled control of system clock
2021-09-15T13:45:28Z System clock wrong by 0.002205 seconds (ignored)
2021-09-15T13:45:28Z chronyd exiting

The **System clock wrong** message indicates the NTP server is accepting NTS-KE connections and responding with NTS-protected NTP messages.

Verify the NTS-KE connections and authenticated NTP packets observed on the server:

```
# chronyc serverstats

NTP packets received : 7
NTP packets dropped  : 0
Command packets received: 22
Command packets dropped : 0
Client log records dropped : 0
NTS-KE connections accepted: 1
NTS-KE connections dropped : 0
Authenticated NTP packets: 7
```

If the value of the **NTS-KE connections accepted** and **Authenticated NTP packets** field is a non-zero value, it means that at least one client was able to connect to the NTS-KE port and send an authenticated NTP request.
CHAPTER 14. RECOVERING AND RESTORING A SYSTEM

To recover and restore a system using an existing backup, Red Hat Enterprise Linux provides the Relax-and-Recover (ReaR) utility.

You can use the utility as a disaster recovery solution and also for system migration.

The utility enables you to perform the following tasks:

- Produce a bootable image and restore the system from an existing backup, using the image.
- Replicate the original storage layout.
- Restore user and system files.
- Restore the system to a different hardware.

Additionally, for disaster recovery, you can also integrate certain backup software with ReaR.

Setting up ReaR involves the following high-level steps:

1. Install ReaR.
3. Create rescue system.
4. Generate backup files.

14.1. SETTING UP REAR

Use the following steps to install the package for using the Relax-and-Recover (ReaR) utility, create a rescue system, configure and generate a backup.

Prerequisites

- Necessary configurations as per the backup restore plan are ready.
  Note that you can use the NETFS backup method, a fully-integrated and built-in method with ReaR.

Procedure

1. Install the ReaR utility by running the following command:

   # dnf install rear

2. Modify the ReaR configuration file in an editor of your choice, for example:

   # vi /etc/rear/local.conf

3. Add the backup setting details to /etc/rear/local.conf. For example, in the case of the NETFS backup method, add the following lines:

   BACKUP=NETFS
   BACKUP_URL=backup.location
Replace `backup.location` by the URL of your backup location.

4. To configure ReaR to keep the previous backup archive when the new one is created, also add the following line to the configuration file:

   ```
   NETFS_KEEP_OLD_BACKUP_COPY=y
   ```

5. To make the backups incremental, meaning that only the changed files are backed up on each run, add the following line:

   ```
   BACKUP_TYPE=incremental
   ```

6. Create a rescue system:

   ```
   # rear mkrescue
   ```

7. Take a backup as per the restore plan. For example, in the case of the NETFS backup method, run the following command:

   ```
   # rear mkbackuponly
   ```

   Alternatively, you can create the rescue system and the backup in a single step by running the following command:

   ```
   # rear mkbackup
   ```

   This command combines the functionality of the `rear mkrescue` and `rear mkbackuponly` commands.

### 14.2. USING A REAR RESCUE IMAGE ON THE 64-BIT IBM Z ARCHITECTURE

Basic Relax and Recover (ReaR) functionality is now available on the 64-bit IBM Z architecture as a Technology Preview. You can create a ReaR rescue image on IBM Z only in the z/VM environment. Backing up and recovering logical partitions (LPARs) has not been tested.

**IMPORTANT**

ReaR on the 64-bit IBM Z architecture is supported only with the `rear` package version 2.6-17.el9 or later. Earlier versions are available as a Technology Preview feature only. For more information about the support scope of Red Hat Technology Preview features, see [https://access.redhat.com/support/offerings/techpreview](https://access.redhat.com/support/offerings/techpreview).

The only output method currently available is Initial Program Load (IPL). IPL produces a kernel and an initial RAM disk (initrd) that can be used with the `ziPL` boot loader.

**Prerequisites**

- ReaR is installed.
  - To install ReaR, run the `dnf install rear` command
Procedure

Add the following variables to the `/etc/rear/local.conf` to configure ReaR for producing a rescue image on the 64-bit IBM Z architecture:

1. To configure the `IPL` output method, add `OUTPUT=IPL`.

2. To configure the backup method and destination, add `BACKUP` and `BACKUP_URL` variables. For example:

   ```
   BACKUP=NETFS
   BACKUP_URL=nfs://<nfsserver name>/<share path>
   ```

   **IMPORTANT**
   The local backup storage is currently not supported on the 64-bit IBM Z architecture.

3. Optionally, you can also configure the `OUTPUT_URL` variable to save the kernel and `initrd` files. By default, the `OUTPUT_URL` is aligned with `BACKUP_URL`.

4. To perform backup and rescue image creation:

   ```
   # rear mkbackup
   ```

5. This creates the kernel and initrd files at the location specified by the `BACKUP_URL` or `OUTPUT_URL` (if set) variable, and a backup using the specified backup method.

6. To recover the system, use the ReaR kernel and initrd files created in step 3, and boot from a Direct Attached Storage Device (DASD) or a Fibre Channel Protocol (FCP)-attached SCSI device prepared with the `zipl` boot loader, kernel, and `initrd`. For more information, see Using a Prepared DASD.

7. When the rescue kernel and `initrd` get booted, it starts the ReaR rescue environment. Proceed with system recovery.

   **WARNING**
   Currently, the rescue process reformats all the DASDs (Direct Attached Storage Devices) connected to the system. Do not attempt a system recovery if there is any valuable data present on the system storage devices. This also includes the device prepared with the zipl boot loader, ReaR kernel, and initrd that were used to boot into the rescue environment. Ensure to keep a copy.

Additional resources

- Installing under z/VM
- Using a Prepared DASD