Red Hat Enterprise Linux 8

Configuring and managing networking

A guide to configuring and managing networking in Red Hat Enterprise Linux 8

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Abstract

This document describes how to manage networking on Red Hat Enterprise Linux 8. The current version of the document contains only selected preview user stories.
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**Related information**
PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

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- For simple comments on specific passages, make sure you are viewing the documentation in the Multi-page HTML format. Highlight the part of text that you want to comment on. Then, click the Add Feedback pop-up that appears below the highlighted text, and follow the displayed instructions.

- For submitting more complex feedback, create a Bugzilla ticket:
  1. Go to the Bugzilla website.
  2. As the Component, use Documentation.
  3. Fill in the Description field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
  4. Click Submit Bug.
CHAPTER 1. OVERVIEW OF NETWORKING TOPICS

NOTE

The following sections mention some commands to be performed. The commands that need to be entered by the root user have ~# in the prompt, while the commands that can be performed by a regular user, have ~$ in their prompt.

1.1. IP VERSUS NON-IP NETWORKS

A network is a system of interconnected devices that can communicate sharing information and resources, such as files, printers, applications, and Internet connection. Each of these devices has a unique Internet Protocol (IP) address to send and receive messages between two or more devices using a set of rules called protocol.

Categories of network communication

IP networks

Networks that communicate through IP addresses. An IP network is implemented in the Internet and most internal networks. Ethernet, cable modems, DSL modems, dial-up modems, wireless networks, and VPN connections are typical examples.

non-IP networks

Networks that are used to communicate through a lower layer rather than the transport layer. Note that these networks are rarely used. InfiniBand is a non-IP network.

1.2. STATIC VERSUS DYNAMIC IP ADDRESSING

Static IP addressing

When a device is assigned a static IP address, the address does not change over time unless changed manually. Use static IP addressing if you want:

- To ensure network address consistency for servers such as DNS, and authentication servers.
- To use out-of-band management devices that work independently of other network infrastructure.

All the configuration tools listed in Section 4.1, “Selecting network configuration methods” allow assigning static IP addresses manually.

Dynamic IP addressing

When a device is assigned a dynamic IP address, the address changes over time. For this reason, it is recommended for devices that connect to the network occasionally because IP address might be changed after rebooting the machine.

Dynamic IP addresses are more flexible, easier to set up and administer. The Dynamic Host Control Protocol (DHCP) is a traditional method of dynamically assigning network configurations to hosts.

NOTE

There is no strict rule defining when to use static or dynamic IP address. It depends on user’s needs, preferences and the network environment.
1.3. CONFIGURING THE DHCP CLIENT BEHAVIOR

A Dynamic Host Configuration Protocol (DHCP) client requests the dynamic IP address and corresponding configuration information from a DHCP server each time a client connects to the network.

Configuring the DHCP timeout

When a DHCP connection is started, a dhcp client requests an IP address from a DHCP server. The time that a dhcp client waits for this request to be completed is 45 seconds by default. This procedure describes how you can configure the `ipv4.dhcp-timeout` property using the `nmcli` tool or the `IPV4_DHCP_TIMEOUT` option in the `/etc/sysconfig/network-scripts/ifcfg-ifname` file. For example, using `nmcli`:

```
~]# nmcli connection modify eth1 ipv4.dhcp-timeout 10
```

If an address cannot be obtained during this interval, the IPv4 configuration fails. The whole connection may fail, too, and this depends on the `ipv4.may-fail` property:

- If `ipv4.may-fail` is set to `yes` (default), the state of the connection depends on IPv6 configuration:
  - a. If the IPv6 configuration is enabled and successful, the connection is activated, but the IPv4 configuration can never be retried again.
  - b. If the IPv6 configuration is disabled or does not get configured, the connection fails.

- If `ipv4.may-fail` is set to `no` the connection is deactivated. In this case:
  - a. If the `autoconnect` property of the connection is enabled, `NetworkManager` retries to activate the connection as many times as set in the `autoconnect-retries` property. The default is 4.
  - b. If the connection still cannot acquire the dhcp address, auto-activation fails.

Note that after 5 minutes, the auto-connection process starts again and the dhcp client retries to acquire an address from the dhcp server.

Lease renewal and expiration

After a DHCP lease is acquired successfully, `NetworkManager` configures the interface with parameters received from the DHCP server for the given time, and tries to renew the lease periodically. When the lease expires and cannot be renewed, `NetworkManager` continues trying to contact the server up to 8 minutes. If the other IP configuration, either IPv4 or IPv6 is successful, DHCP requests continue as long as the connection is active.

1.3.1. Making DHCPv4 persistent

To make DHCPv4 persistent both at startup and during the lease renewal processes, set the `ipv4.dhcp-timeout` property either to the maximum for a 32-bit integer (MAXINT32), which is 2147483647, or to the `infinity` value:

```
~]# nmcli connection modify eth1 ipv4.dhcp-timeout infinity
```

As a result, `NetworkManager` never stops trying to get or renew a lease from a DHCP server until it is successful.
To ensure a DHCP persistent behavior only during the lease renewal process, you can manually add a static IP to the IPADDR property in the /etc/sysconfig/network-scripts/ifcfg-ethX configuration file or by using nmcli:

```
~$ nmcli connection modify eth0 ipv4.address 192.168.122.88/24
```

When an IP address lease expires, the static IP preserves the IP state as configured or partially configured - you can have an IP address, but you are not connected to the Internet.

### 1.4. SETTING THE WIRELESS REGULATORY DOMAIN

In Red Hat Enterprise Linux, the crda package contains the Central Regulatory Domain Agent that provides the kernel with the wireless regulatory rules for a given jurisdiction. It is used by certain udev scripts and should not be run manually unless debugging udev scripts. The kernel runs crda by sending a udev event upon a new regulatory domain change. Regulatory domain changes are triggered by the Linux wireless subsystem (IEEE-802.11). This subsystem uses the regulatory.bin file to keep its regulatory database information.

The `setregdomain` utility sets the regulatory domain for your system. `Setregdomain` takes no arguments and is usually called through system script such as udev rather than manually by the administrator. If a country code look-up fails, the system administrator can define the COUNTRY environment variable in the /etc/sysconfig/regdomain file.

**Additional resources**

See the following man pages for more information about the regulatory domain:

- `setregdomain(1)` man page — Sets regulatory domain based on country code.
- `crda(8)` man page — Sends to the kernel a wireless regulatory domain for a given ISO or IEC 3166 alpha2.
- `regulatory.bin(5)` man page — Shows the Linux wireless regulatory database.
- `iw(8)` man page — Shows or manipulates wireless devices and their configuration.

### 1.5. USING NETWORK KERNEL TUNABLES WITH SYSCTL

Using certain kernel tunables through the `sysctl` utility, you can adjust network configuration on a running system and directly affect the networking performance.

To change network settings, use the `sysctl` commands. For permanent changes that persist across system restarts, add lines to the `/etc/sysctl.conf` file.

To display a list of all available `sysctl` parameters, enter as `root`:

```
~# sysctl -a
```
CHAPTER 2. NETCONSOLE

The netconsole kernel module enables logging of kernel messages over the network to another computer. It allows kernel debugging when disk logging fails or when using the serial console is not possible.

2.1. CONFIGURING NETCONSOLE

This procedure describes how you can configure netconsole in Red Hat Enterprise Linux (RHEL) 8.

Prerequisites
The netconsole-service package is installed.

```
~]# yum install netconsole-service
```

Procedure

1. Set the SYSLOGADDR to the IP address of the syslogd server in the /etc/sysconfig/netconsole file to match the IP address of the syslogd server. For example:

   ```
   SYSLOGADDR=192.168.0.1
   ```

2. Restart the netconsole.service.

   ```
   ~]# systemctl restart netconsole.service
   ```

3. Enable netconsole.service to run after rebooting the system.

   ```
   ~]# systemctl enable netconsole.service
   ```

4. View the netconsole messages from the client in the /var/log/messages file (default) or in the file specified in rsyslog.conf.

   ```
   ~]# cat /var/log/messages
   ```

Additional resources
How to configure netconsole under Red Hat Enterprise Linux 8?
CHAPTER 3. GETTING STARTED WITH MANAGING NETWORKING WITH NETWORKMANAGER

3.1. OVERVIEW OF NETWORKMANAGER

Red Hat Enterprise Linux 8 uses the default networking service, NetworkManager, which is a dynamic network control and configuration daemon to keep network devices and connections up and active when they are available. The traditional ifcfg type configuration files are still supported.

Each network device corresponds to a NetworkManager device. The configuration of a network device is completely stored in a single NetworkManager connection. You can perform a network configuration applying a NetworkManager connection to a NetworkManager device.

3.1.1. Benefits of using NetworkManager

The main benefits of using NetworkManager are:

- Offering an API through D-Bus which allows to query and control network configuration and state. In this way, networking can be checked and configured by multiple applications ensuring a synced and up-to-date networking status. For example, the RHEL web console, which monitors and configures servers through a web browser, uses the NetworkManager D-BUS interface to configure networking, as well as the Gnome GUI, the nmcli and the nm-connection-editor tools. Each change made in one of these tools is detected by all the others.

- Making Network management easier: NetworkManager ensures that network connectivity works. When it detects that there is no network configuration in a system but there are network devices, NetworkManager creates temporary connections to provide connectivity.

- Providing easy setup of connection to the user: NetworkManager offers management through different tools — GUI, nmtui, nmcli.

- Supporting configuration flexibility. For example, configuring a WiFi interface, NetworkManager scans and shows the available wifi networks. You can select an interface, and NetworkManager displays the required credentials providing automatic connection after the reboot process. NetworkManager can configure network aliases, IP addresses, static routes, DNS information, and VPN connections, as well as many connection-specific parameters. You can modify the configuration options to reflect your needs.

- Maintaining the state of devices after the reboot process and taking over interfaces which are set into managed mode during restart.

- Handling devices which are not explicitly set unmanaged but controlled manually by the user or another network service.

Additional resources

- Section 3.5, “NetworkManager tools”

- For more information on installing and using the RHEL 8 web console, see Managing systems using the RHEL 8 web console.

3.2. INSTALLING NETWORKMANAGER

NetworkManager is installed by default on Red Hat Enterprise Linux 8. If it is not, enter as root:
-# yum install NetworkManager

Additional resources

- Section 3.1, “Overview of NetworkManager”
- Section 3.1.1, “Benefits of using NetworkManager”

3.3. CHECKING THE STATUS OF NETWORKMANAGER

To check whether NetworkManager is running:

-# systemctl status NetworkManager

NetworkManager.service - Network Manager
Loaded: loaded (/lib/systemd/system/NetworkManager.service; enabled)
Active: active (running) since Fri, 08 Mar 2013 12:50:04 +0100; 3 days ago

Note that the systemctl status command displays **Active: inactive (dead)** when NetworkManager is not running.

3.4. STARTING NETWORKMANAGER

To start NetworkManager:

-# systemctl start NetworkManager

To enable NetworkManager automatically at boot time:

-# systemctl enable NetworkManager

3.5. NETWORKMANAGER TOOLS

Table 3.1. A summary of NetworkManager tools and applications

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<tr>
<td>nmcli</td>
<td>A command-line tool which enables users and scripts to interact with NetworkManager. Note that nmcli can be used on systems without a GUI such as servers to control all aspects of NetworkManager. It provides a deeper functionality as GUI tools.</td>
</tr>
<tr>
<td>nmtui</td>
<td>A simple curses-based text user interface (TUI) for NetworkManager</td>
</tr>
<tr>
<td>nm-connection-editor</td>
<td>A graphical user interface tool for certain tasks not yet handled by the control-center utility such as configuring bonds and teaming connections. You can add, remove, and modify network connections stored by NetworkManager. To start it, enter nm-connection-editor in a terminal.</td>
</tr>
</tbody>
</table>
control-center

A graphical user interface tool provided by the GNOME Shell, available for desktop users. It incorporates a Network settings tool. To start it, press the **Super** key to enter the Activities Overview, type **Network** and then press **Enter**. The Network settings tool appears.

network connection icon

A graphical user interface tool provided by the GNOME Shell representing network connection states as reported by **NetworkManager**. The icon has multiple states that serve as visual indicators for the type of connection you are currently using.

Additional resources

- Chapter 5, Configuring IP networking with nmtui
- Chapter 6, Configuring networking with nmcli
- Chapter 7, Configuring networking with GNOME GUI

### 3.6. RUNNING DISPATCHER SCRIPTS

**NetworkManager** provides a way to run additional custom scripts to start or stop services based on the connection status. By default, the `/etc/NetworkManager/dispatcher.d/` directory exists and **NetworkManager** runs scripts there, in alphabetical order. Each script must be an executable file owned by **root** and must have **write permission** only for the file owner.

Additional resources

- For more information about running NetworkManager dispatcher scripts, see the Red Hat Knowledgebase solution [How to write a NetworkManager dispatcher script to apply ethtool commands](https://access.redhat.com/solutions/46084).

### 3.7. USING NETWORKMANAGER WITH SYSCONFIG FILES

The `/etc/sysconfig/` directory is a location for configuration files and scripts. Most network configuration information is stored there, with the exception of VPN, mobile broadband and PPPoE configuration, which are stored in the `/etc/NetworkManager/` subdirectories. For example, interface-specific information is stored in the `ifcfg` files in the `/etc/sysconfig/network-scripts/` directory.

Information for VPNs, mobile broadband and PPPoE connections is stored in `/etc/NetworkManager/system-connections/`.

In Red Hat Enterprise Linux 8, if you edit an `ifcfg` file, **NetworkManager** is not automatically aware of the change and has to be prompted to notice the change. If you use one of the tools to update **NetworkManager** profile settings, **NetworkManager** does not implement those changes until you reconnect using that profile. For example, if configuration files have been changed using an editor, **NetworkManager** must read the configuration files again.

To ensure this, enter as **root** to reload all connection profiles:
```bash
~$ nmcli connection reload
```

Alternatively, to reload only one changed file, `ifcfg-ifname`.

```bash
~$ nmcli con load /etc/sysconfig/network-scripts/ifcfg-ifname
```

Note that you can specify multiple file names using the above command.

To restart the connection after changes are made, use:

```bash
~$ nmcli con up connection-name
```

### 3.7.1. Legacy network scripts support

Network scripts are deprecated in Red Hat Enterprise Linux 8 and are no longer provided by default. The basic installation provides a new version of the `ifup` and `ifdown` scripts which call `NetworkManager` through the `nmcli` tool. In Red Hat Enterprise Linux 8, to run the `ifup` and the `ifdown` scripts, `NetworkManager` must be running.

**NOTE**

Custom commands in `/sbin/ifup-local`, `ifdown-pre-local` and `ifdown-local` scripts are not executed.

If any of these scripts are required, the installation of the deprecated network scripts in the system is still possible with the following command:

```bash
~$ yum install network-scripts
```

The `ifup` and the `ifdown` scripts link to the installed legacy network scripts.

Calling the legacy network scripts shows a warning about their deprecation.

**Additional resources**

- `NetworkManager(8)` man page – Describes the network management daemon.

- `NetworkManager.conf(5)` man page – Describes the `NetworkManager` configuration file.

- `/usr/share/doc/initscripts/sysconfig.txt` – Describes `ifcfg` configuration files and their directives as understood by the legacy network service.

- `ifcfg(8)` man page – Describes briefly the `ifcfg` command.
CHAPTER 4. OVERVIEW OF NETWORK CONFIGURATION METHODS

The following section provides an overview of network configuration methods that are available in Red Hat Enterprise Linux 8.

4.1. SELECTING NETWORK CONFIGURATION METHODS

- To configure a network interface using NetworkManager, use one of the following tools:
  - the text user interface tool, nmtui.
  - the command-line tool, nmcli.
  - the graphical user interface tools, GNOME GUI.
- To configure a network interface without using NetworkManager:
  - edit the ifcfg files manually.
- To configure the network settings when the root filesystem is not local:
  - use the kernel command-line.

Additional resources

- Chapter 5, Configuring IP networking with nmtui
- Chapter 6, Configuring networking with nmcli
- Chapter 7, Configuring networking with GNOME GUI
CHAPTER 5. CONFIGURING IP NETWORKING WITH NMTUI

The following section provides how you can configure a network interface using the NetworkManager’s tool, nmtui.

5.1. GETTING STARTED WITH NMTUI

nmtui is a simple curses-based text user interface (TUI) for NetworkManager.

This procedure describes how to start the text user interface tool, nmtui.

Prerequisites

- The nmtui tool is used in a terminal window. It is contained in the NetworkManager-tui package, but it is not installed along with NetworkManager by default. To install NetworkManager-tui:

  ~]$ yum install NetworkManager-tui

- To verify that NetworkManager is running, see Section 3.3, “Checking the status of NetworkManager”

Procedure

1. Start the nmtui tool:

  ~]$ nmtui

  The text user interface appears.

   Figure 5.1. The NetworkManager text user interface starting menu

2. To navigate, use the arrow keys or press Tab to step forwards and press Shift+Tab to step back through the options. Press Enter to select an option. The Space bar toggles the status of a check box.

5.1.1. Editing a connection with nmtui
Prerequisites

- Section 5.1, "Getting started with nmtui"

To edit a connection using nmtui, select the Edit a connection option in the NetworkManager TUI menu and press Enter.

5.1.2. Applying changes to a modified connection with nmtui

To apply changes after a modified connection which is already active requires a reactivation of the connection. In this case, follow the procedure below:

Prerequisites

- Section 5.1, “Getting started with nmtui”

Procedure

1. Select the Activate a connection menu entry.

Figure 5.2. Activating a connection with nmtui

2. Select the modified connection. On the right, click the Deactivate button.
3. Choose the connection again and click the **Activate** button.
The following commands are also available:

```bash
~$ nmtui edit connection-name
```

If no connection name is supplied, the selection menu appears. If the connection name is supplied and correctly identified, the relevant `Edit connection` screen appears.

```bash
~$ nmtui connect connection-name
```

If no connection name is supplied, the selection menu appears. If the connection name is supplied and correctly identified, the relevant connection is activated. Any invalid command prints a usage message.

Note that `nmtui` does not support all types of connections. In particular, you cannot edit VPNs, wireless network connections using WPA Enterprise, or Ethernet connections using 802.1X.

Additional resources

- For more information about the `NetworkManager`'s tools, see Section 3.5, "NetworkManager tools"
CHAPTER 6. CONFIGURING NETWORKING WITH NMCLI

The following section provides how you can configure a network interface using `nmcli`.

6.1. GETTING STARTED WITH NMCLI

`nmcli` (NetworkManager Command Line Interface) is the command-line utility to configure networking through `NetworkManager`. `nmcli` is used to create, display, edit, delete, activate, and deactivate network connections, as well as control and display network device status.

The `nmcli` utility can be used by both users and scripts:

- For servers, headless machines, and terminals, `nmcli` can be used to control `NetworkManager` directly, without GUI.
- For scripts, `nmcli` supports options to change the output to a format better suited for script processing.

Each network device corresponds to a `NetworkManager` device. The configuration of a network device is completely stored in a single `NetworkManager` connection. You can perform a network configuration applying a `NetworkManager` connection to a `NetworkManager` device.

To get started with `nmcli` the most common `nmcli` commands are `nmcli device` and `nmcli connection`:

- The `nmcli device` command lists the available network devices in the system.

A device can be:

1. **managed** - under the `NetworkManager` control. A `managed` device may be `connected`, meaning that it is activated and configured, or `disconnected`, meaning that it is not configured but ready to be activated again.

2. **unmanaged** - `NetworkManager` does not control it.

For more details on setting a `managed` or `unmanaged` device, see Section 6.4, "Setting a device managed or unmanaged with nmcli".

The `nmcli device` command can take many arguments. Most notable are: `status`, `show`, `set`, `connect`, `disconnect`, `modify`, `delete`, `wifi`. Enter the `nmcli device help` command to see the full list.

- The `nmcli connection` command lists the available connection profiles in `NetworkManager`.

Every connection that is active is displayed as green on top of the list. The inactive connections are displayed as white. The `DEVICE` field identifies the device on which the connection is applied on.

The `nmcli connection` command can take many arguments to manage connection profiles. Most notable are: `show`, `up`, `down`, `add`, `modify`, `delete`. Enter the `nmcli connection help` command to see the full list.
IMPORTANT

If you use the `nmcli` commands, it is recommended to type a partial `nmcli` command, and then press the Tab key to auto-complete the command sequence. If multiple completions are possible, then Tab lists them all. This helps users to type commands faster and easier. To enable the `nmcli` auto-complete feature be sure to install the `bash-completion` package:

```
~$# yum install bash-completion
```

After the package installation, `nmcli auto-complete` will be available next time you login into a console. To activate it also in the current console, enter:

```
~$ source /etc/profile.d/bash_completion.sh
```

The basic format of using `nmcli` is:

```
nmcli [OPTIONS] OBJECT { COMMAND | help }
```

- where [OPTIONS] can be optional options, such as:

  `-t`, terse
  
  This mode can be used for computer script processing as you can see a terse output displaying only the values.

  **Example 6.1. Viewing a terse output**

  ```
  ~$ nmcli -t device
  ens3:ethernet:connected:Profile 1
  lo:loopback:unmanaged:
  ```

  `-f`, field
  
  This option specifies what fields can be displayed in output. For example, NAME,UUID,TYPE,AUTOCONNECT,ACTIVE,DEVICE,STATE. You can use one or more fields. If you want to use more, do not use space after comma to separate the fields.

  **Example 6.2. Specifying fields in the output**

  ```
  ~$ nmcli -f DEVICE,TYPE device
  DEVICE  TYPE
  ens3    ethernet
  lo      loopback
  ```

  or even better for scripting:

  ```
  ~$ nmcli -t -f DEVICE,TYPE device
  ens3:ethernet
  lo:loopback
  ```

  `-p`, pretty
This option causes \texttt{nmcli} to produce human-readable output. For example, values are aligned and headers are printed.

**Example 6.3. Viewing an output in pretty mode**

```
$ nmcli -p device

Status of devices

DEVICE TYPE      STATE      CONNECTION
--------------------------------------------------------------
ens3    ethernet  connected  Profile 1
lo      loopback  unmanaged --
```

\textbf{-h, help}

Prints help information.

- where OBJECT can be one of the following options: \texttt{general}, \texttt{networking}, \texttt{radio}, \texttt{connection}, \texttt{device}, \texttt{agent}, and \texttt{monitor}.

\textbf{NOTE}

You can use any prefix of the above options in your commands. For example, \texttt{nmcli con help}, \texttt{nmcli c help}, \texttt{nmcli connection help} generate the same output.

- where COMMAND, the required \texttt{nmcli} command.

- where help is to list available actions related to a specified object:

```
$ nmcli OBJECT help
```

For example,

```
$ nmcli c help
```

Additional resources

- Section 3.5, “NetworkManager tools”
- the \texttt{nmcli(1)} man page.
- Section 6.3, “Brief selection of \texttt{nmcli} commands”
- Section 6.5, “Creating a connection profile with \texttt{nmcli}”

\section*{6.2. OVERVIEW OF NMCLI PROPERTY NAMES AND ALIASES}

\textbf{Prerequisites}

\textbf{Property} names are specific names that \texttt{NetworkManager} uses to identify a common option. Following are some of the important \texttt{nmcli property} names:

\texttt{connection.type}
A type of a specific connection. Allowed values are: adsl, bond, bond-slave, bridge, bridge-slave, bluetooth, cdma, ethernet, gsm, infiniband, olpc-mesh, team, team-slave, vlan, wifi, wimax. Each connection type has type-specific command options. You can see the TYPE_SPECIFIC_OPTIONS list in the nmcli(1) man page. For example, a gsm connection requires the access point name specified in an apn. A wifi device requires the service set identifier specified in a ssid.

connection.interface-name

A device name relevant for the connection. For example, eth0.

collection.id

A name used for the connection profile. If you do not specify a connection name, one will be generated as follows:

```
connection.type -connection.interface-name
```

The connection.id is the name of a connection profile and should not be confused with the interface name which denotes a device (wlan0, ens3, em1). However, users can name the connections after interfaces, but they are not the same thing. There can be multiple connection profiles available for a device. This is particularly useful for mobile devices or when switching a network cable back and forth between different devices. Rather than edit the configuration, create different profiles and apply them to the interface as needed. The id option also refers to the connection profile name.

The most important options for nmcli commands such as show, up, down are:

id

An identification string assigned by the user to a connection profile. Id can be used in nmcli connection commands to identify a connection. The NAME field in the command output always denotes the connection id. It refers to the same connection profile name that the con-name does.

uuid

A unique identification string assigned by the system to a connection profile. The uuid can be used in nmcli connection commands to identify a connection.

Aliases and property names

An alias is an alternative name for a property name — aliases are translated to properties internally in nmcli. Aliases are more readable but property names are preferable to use. Both can be used interchangeably.

<table>
<thead>
<tr>
<th>Alias</th>
<th>Example</th>
<th>Property</th>
<th>Example</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>type bond</td>
<td>connection.type</td>
<td>connection.type bond</td>
<td>type of a specific connection. Some of the connection types are: bond, bridge, ethernet, wifi, infiniband, vlan</td>
</tr>
<tr>
<td>ifname</td>
<td>ifname eth0</td>
<td>connection.interfa ce-name</td>
<td>connection.interface-name eth0</td>
<td>name of the device to which a connection belongs to</td>
</tr>
</tbody>
</table>
6.3. BRIEF SELECTION OF NMCLI COMMANDS

**IMPORTANT**

If you use the `nmcli` commands, it is recommended to type a partial `nmcli` command, and then press the Tab key to auto-complete the command sequence. If multiple completions are possible, then Tab lists them all. This helps users to type commands faster and easier. To enable the `nmcli` auto-complete feature be sure to install the `bash-completion` package:

```
~]$ yum install bash-completion
```

After the package installation, `nmcli auto-complete` will be available next time you login into a console. To activate it also in the current console, enter:

```
~]$ source /etc/profile.d/bash_completion.sh
```

The following examples show how to use `nmcli` in specific use cases:

**Example 6.4. Viewing all connections**

```
~]$ nmcli connection show
NAME       UUID                                  TYPE      DEVICE
Profile 1  db1060e9-c164-476f-b2b5-caec62dc1b05  ethernet    ens3
bond0       aaf6eb56-73e5-4746-9037-eed42caa8a65  ethernet    --
```

**Example 6.5. Viewing only currently active connections**

```
~]$ nmcli connection show --active
NAME       UUID                                  TYPE      DEVICE
Profile 1  db1060e9-c164-476f-b2b5-caec62dc1b05  ethernet    ens3
```

**Example 6.6. Activating a connection**

Use the `up` argument to activate a connection.

```
~]$ nmcli connection show
NAME       UUID                                  TYPE      DEVICE
Profile 1  db1060e9-c164-476f-b2b5-caec62dc1b05  ethernet    ens3
bond0       aaf6eb56-73e5-4746-9037-eed42caa8a65  ethernet    --
```
Example 6.7. Deactivating a specific active connection

Use the `down` argument to deactivate a specific active connection:

```bash
~$ nmcli connection down id bond0
```

```bash
~$ nmcli connection show
NAME       UUID                                  TYPE      DEVICE
Profile 1  db1060e9-c164-476f-b2b5-caec62dc1b05  ethernet    ens3
bond0      aaf6eb56-73e5-4746-9037-eed42caa8a65  ethernet    --
```

Example 6.8. Disconnecting a device preventing it from automatically started again

```bash
~$ nmcli device disconnect id bond0
```

**NOTE**

The `nmcli connection down` command, deactivates a connection from a device without preventing the device from further auto-activation. The `nmcli device disconnect` command, disconnects a device and prevent the device from automatically activating further connections without manual intervention. If the connection has the `connection.autoconnect` flag set to `yes`, the connection automatically starts on the disconnected device again. In this case, use the `nmcli device disconnect` command instead of the `nmcli connection down` command.

Example 6.9. Viewing only devices recognized by NetworkManager and their state

```bash
~$ nmcli device status
DEVICE  TYPE      STATE      CONNECTION
ens3    ethernet  connected  Profile 1
lo      loopback  unmanaged  --
```

Example 6.10. Viewing general information for a device

```bash
~$ nmcli device show
GENERAL.DEVICE: ens3
GENERAL.TYPE:   ethernet
```
Example 6.11. Checking the overall status of NetworkManager

~$ nmcli general status
STATE CONNECTIVITY WIFI-HW WIFI WWAN-HW WWAN
connected full enabled enabled enabled enabled

In terse mode:

~$ nmcli -t -f STATE general
connected

Example 6.12. Viewing NetworkManager logging status

~$ nmcli general logging
LEVEL DOMAINS
INFO PLATFORM,RFKILL,ETHER,WIFI,BT,MB,DHCP4,DHCP6,PPP,WIFI_SCAN,IP4,IP6,AUTOIP4,DNS,VPN,SHARING,SUPPLICANT,AGENTS,SETTINGS,SUSPEND,CORE,DEVICE,OLPC, WIMAX,INFINIBAND,FIREWALL,ADSL,BOND,VLAN,BRIDGE,DBUS_PROPS,TEAM,CONCHECK, DC, B, DISPATCH

You can also use the following abbreviations of the nmcli commands:

Table 6.1. Abbreviations of some nmcli commands

<table>
<thead>
<tr>
<th>nmcli command</th>
<th>abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>nmcli general status</td>
<td>nmcli g</td>
</tr>
<tr>
<td>nmcli general logging</td>
<td>nmcli g log</td>
</tr>
<tr>
<td>nmcli connection show</td>
<td>nmcli con show or nmcli c</td>
</tr>
<tr>
<td>nmcli connection show --active</td>
<td>nmcli con show -a or nmcli c -a</td>
</tr>
<tr>
<td>nmcli device status</td>
<td>nmcli dev or nmcli d</td>
</tr>
<tr>
<td>nmcli device show</td>
<td>nmcli dev show or nmcli d show</td>
</tr>
</tbody>
</table>

Additional resources
For more information on the comprehensive list of `nmcli` options, see the `nmcli(1)` man page.

For more examples, see the `nmcli-examples(5)` man page.

Section 6.5, “Creating a connection profile with nmcli”

6.4. SETTING A DEVICE MANAGED OR UNMANAGED WITH NMCLI

Prerequisites

- Section 6.1, “Getting started with nmcli”
- Section 6.2, “Overview of nmcli property names and aliases”

Procedure

1. To list the currently available network connections:

   ```
   ~]$ nmcli con show
   NAME    UUID                                  TYPE            DEVICE
   Auto Ethernet  9b7f2511-5432-40ae-b091-af2457dfd988  802-3-ethernet  --
   ens3     fb157a65-ad32-47ed-858c-102a48e064a2  802-3-ethernet  ens3
   MyWiFi   91451385-4eb8-4080-8b82-720aab8328dd  802-11-wireless wlan0
   ```

   Note that the `NAME` field in the output always denotes the connection ID (name). It is not the interface name even though it might look the same. In the second connection shown above, `ens3` in the `NAME` field is the connection ID given by the user to the profile applied to the interface `ens3`. In the last connection shown, the user has assigned the connection ID `MyWiFi` to the interface `wlan0`.

   Adding an Ethernet connection means creating a configuration profile which is then assigned to a device. Before creating a new profile, review the available devices as follows:

   ```
   ~]$ nmcli device status
   DEVICE  TYPE      STATE         CONNECTION
   ens3     ethernet  disconnected  --
   ens9     ethernet  disconnected  --
   lo       loopback  unmanaged     --
   ```

   For example, to set `eth2` unmanaged:

   ```
   ~]$ nmcli device set eth2 managed no
   ```

   For example, to set `eth2` unmanaged:

   ```
   ~]$ nmcli device status
   DEVICE  TYPE      STATE         CONNECTION
   bond0   bond       connected  bond0
   virbr0  bridge     connected  virbr0
   eth1    ethernet    connected  bond-slave-eth1
   eth2    ethernet    connected  bond-slave-eth2
   eth0    ethernet    unmanaged  --
   ```

   ```
   ~]$ nmcli device set eth2 managed no
   ```
```
$ nmcli device status
DEVICE   TYPE      STATE      CONNECTION
bond0     bond      connected  bond0
virbr0    bridge    connected  virbr0
eth1      ethernet  connected  bond-slave-eth1
eth2      ethernet  unmanaged  --
eth0      ethernet  unmanaged  --
```

**NOTE**

When you set the device unmanaged, **NetworkManager** does not control it. If the device you want to configure is listed as unmanaged, no **nmcli** command has any effect on this device. However, the device is still connected.

**Additional resources**

- For more information, see the **nmcli**(1) man page.

### 6.5. CREATING A CONNECTION PROFILE WITH NMCLI

You can create a connection profile to be associated with a device.

**Prerequisites**

- Section 6.1, “Getting started with nmcli”
- Section 6.2, “Overview of nmcli property names and aliases”

**IMPORTANT**

If you use the **nmcli** commands, it is recommended to type a partial **nmcli** command, and then press the **Tab** key to auto-complete the command sequence. If multiple completions are possible, then **Tab** lists them all. This helps users to type commands faster and easier. To enable the **nmcli** auto-complete feature be sure to install the **bash-completion** package:

```
~$ yum install bash-completion
```

After the package installation, **nmcli auto-complete** will be available next time you login into a console. To activate it also in the current console, enter:

```
~$ source /etc/profile.d/bash_completion.sh
```

**Procedure**

The basic format to create a new profile for **NetworkManager** using **nmcli**:  

```
nmcli c add {COMMON_OPTIONS} [IP_OPTIONS]/[NETMASK] [GATEWAY]
```

- **a.** where `{COMMON_OPTIONS}` are the aliases or property names, see **Aliases and Property names**.
- **b.** where `[IP_OPTIONS]` are the IP addresses:

---

---
For IPv4 addresses: `ip4`

For IPv6 addresses: `ip6`

c. where `[NETMASK]` is the network mask width. For example, `255.255.255.0` is the network mask for the prefix `198.51.100.0/24`.

d. where `[GATEWAY]` is the gateway information:

- For IPv4 addresses: `gw4`
- For IPv6 addresses: `gw6`

```
nmcli connection add type ethernet con-name connection-name ifname interface-name ip4 address/network mask gw4 address
```

1. To create a connection profile with an IPv4 address:

```
~]$ nmcli c add type ethernet ifname eth0 con-name "My Connection" ip4 192.168.2.100/24 gw4 192.168.2.1
Connection 'new-ens33' (f0c23472-1aec-4e84-8f1b-be8a2ecbeade) successfully added.
```

2. To activate the created connection:

```
~]$ nmcli c up _"My Connection"
```

3. To view the created connection:

```
~]$ nmcli c show _"My Connection"
```

Note that the `nmcli c show con-name` command displays all the properties present in the connection, even those that are empty or have a default value. If the output is longer than a terminal page, `nmcli` generates a pager to allow an easy navigation on the output. In the pager, use arrows to move up and down and the `q` key to quit.

For a more compact display of the connection, use the `-o` option:

```
~]$ nmcli -o c show _"My Connection"
```

The `nmcli -o c show con-name` command still displays the connection content, but omits empty properties or those that are set to a default value. This usually results in a shorter output that is more readable.

**Additional Resources**

- See the `nm-settings(5)` man page for more information on properties and their settings.

### 6.6. USING THE NMCLI INTERACTIVE CONNECTION EDITOR

The `nmcli` tool has an interactive connection editor. It allows you to change connection parameters according to your needs. To use it:

```
~]$ nmcli con edit
```
You should enter a valid **connection type** from the list displayed. Then, you are able to modify its parameters.

```bash
~]$ nmcli con edit
Valid connection types: generic, 802-3-ethernet (ethernet), pppoe, 802-11-wireless (wifi), wimax, gsm, cdma, infiniband, adsl, bluetooth, vpn, 802-11-olpc-mesh (olpc-mesh), vlan, bond, team, bridge, bond-slave, team-slave, bridge-slave, no-slave, tun, ip-tunnel, macsec, macvlan, vxlan, dummy
Enter connection type: **ethernet**

===| nmcli interactive connection editor |===
```

Adding a new '802-11-wireless' connection

Type 'help' or '?' for available commands.
Type 'describe [<setting>.<prop>]' for detailed property description.

You may edit the following settings: connection, 802-11-wireless (wifi), 802-11-wireless-security (wifi-sec), 802-1x, ipv4, ipv6, proxy

```
nmcli>
```

It is possible now to edit the **ethernet** connection settings. To get the list of available commands, type **help** or **?**:

```
nmcli> ?
```

---[ Main menu ]---
```
goto   [<setting> | <prop>]     :: go to a setting or property
remove  <setting>[.<prop>] | <prop> :: remove setting or reset property value
set     [<setting>.<prop> <value>]  :: set property value
describe [setting].<prop>       :: describe property
print   [all | <setting>[.<prop>]]  :: print the connection
verify  [all | fix]              :: verify the connection
save    [persistent|temporary]   :: save the connection
activate [<ifname>] [/<ap>|<nsp>]  :: activate the connection
back    :: go one level up (back)
help/?   [<command>]            :: print this help
nmcli   <conf-option> <value>   :: nmcli configuration
quit     :: exit nmcli
```

To exit, enter the **quit** command.

**Example 6.13. Adding a new Ethernet connection using the nmcli interactive connection editor**

```bash
~]$ nmcli con edit
Valid connection types: generic, 802-3-ethernet (ethernet), pppoe, 802-11-wireless (wifi), wimax, gsm, cdma, infiniband, adsl, bluetooth, vpn, 802-11-olpc-mesh (olpc-mesh), vlan, bond, team, bridge, bond-slave, team-slave, bridge-slave, no-slave, tun, ip-tunnel, macsec, macvlan, vxlan, dummy
Enter connection type: **ethernet**

===| nmcli interactive connection editor |===
```

Adding a new '802-3-ethernet' connection

---
Type 'help' or '?' for available commands.
Type 'describe [<setting>.<prop>]' for detailed property description.

You may edit the following settings: connection, 802-3-ethernet (ethernet), 802-1x, dcb, ipv4, ipv6, proxy

```bash
nmcli> set connection.id new_eth1
nmcli> set connection.interface-name eth1
nmcli> set connection.autoconnect yes
nmcli> save
```

Saving the connection with 'autoconnect=yes'. That might result in an immediate activation of the connection.

Do you still want to save? (yes/no) [yes] yes

Connection 'new_eth1' (34ac8f9a-e9d8-4e0b-9751-d5dc87cc0467) successfully saved.

```
nmcli> quit
```

A new network interface configuration file is created in the `/etc/sysconfig/network-scripts` directory:

```
~]# ls -lrt /etc/sysconfig/network-scripts/ifcfg *
-rw-r--r--. 1 root root 254 Aug 15  2017 /etc/sysconfig/network-scripts/ifcfg-lo
-rw-r--r--. 1 root root 304 Apr 26 22:14 /etc/sysconfig/network-scripts/ifcfg-ens3
-rw-r--r--. 1 root root 266 Aug  6 11:03 /etc/sysconfig/network-scripts/ifcfg-new_eth1
```

### 6.7. MODIFYING A CONNECTION PROFILE WITH NMCLI

You can modify the existing configuration of a connection profile.

**Prerequisites**

- Section 6.1, “Getting started with nmcli”
- Section 6.2, “Overview of nmcli property names and aliases”
- Section 6.5, “Creating a connection profile with nmcli”

**IMPORTANT**

If you use the `nmcli` commands, it is recommended to type a partial `nmcli` command, and then press the Tab key to auto-complete the command sequence. If multiple completions are possible, then Tab lists them all. This helps users to type commands faster and easier. To enable the `nmcli` auto-complete feature be sure to install the `bash-completion` package:

```
~]# yum install bash-completion
```

After the package installation, `nmcli auto-complete` will be available next time you login into a console. To activate it also in the current console, enter:

```
~]$ source /etc/profile.d/bash_completion.sh
```

Procedure
1. To modify one or more properties of a connection profile, use the following command:

```
$ nmcli c modify
```

For example, to change the connection.id from "My Connection" to "My favorite connection" and the connection.interface-name to eth1:

```
$ nmcli c modify "My Connection" connection.id "My favorite connection"
connection.interface-name eth1
```

2. To apply changes after a modified connection using `nmcli`, activate again the connection by entering:

```
$ nmcli con up "My favorite connection"
Connection successfully activated (D-Bus active path: /org/freedesktop/NetworkManager/ActiveConnection/16)
```

3. To view the modified connection, enter the `nmcli con show con-name` command.

### 6.8. CONFIGURING A STATIC ETHERNET CONNECTION

#### 6.8.1. Configuring a static Ethernet connection with `nmcli`

**Prerequisites**

- Section 6.1, “Getting started with `nmcli`”
- Section 6.5, “Creating a connection profile with `nmcli`”

**Procedure**

1. Setting two IPv4 DNS server addresses:

```
$ nmcli con mod test-lab ipv4.dns "8.8.8.8 8.8.4.4"
```

Note that this will replace any previously set DNS servers.

Alternatively, to set two IPv6 DNS server addresses:

```
$ nmcli con mod test-lab ipv6.dns "2001:4860:4860::8888 2001:4860:4860::8844"
```

Note that this will replace any previously set DNS servers.

2. To add additional DNS servers to any previously set, use the `+` prefix:

```
$ nmcli con mod test-lab +ipv4.dns "8.8.8.8 8.8.4.4"
```

```
$ nmcli con mod test-lab +ipv6.dns "2001:4860:4860::8888 2001:4860:4860::8844"
```

3. To activate the new Ethernet connection:
$ nmcli con up test-lab ifname ens9
Connection successfully activated (D-Bus active path: /org/freedesktop/NetworkManager/ActiveConnection/6)

4. To review the status of the devices and connections:

$ nmcli device status
DEVICE      TYPE      STATE      CONNECTION
ens3 ethernet connected my-office
ens9 ethernet connected test-lab
lo loopback unmanaged --

5. To view detailed information about the newly configured connection:

$ nmcli -p con show test-lab
Connection profile details (test-lab)
connection.id:                          test-lab
connection.uuid:                        05abfd5e-324e-4461-844e-8501ba704773
connection.interface-name:              ens9
connection.type:                        802-3-ethernet
connection.autoconnect:                 yes
connection.timestamp:                   1410428968
connection.read-only:                   no
connection.permissions:                 
connection.zone:                        --
connection.master:                      --
connection.slave-type:                  --
connection.secondaries:                 
connection.gateway-ping-timeout:        0

The use of the -p, --pretty option adds a title banner and section breaks to the output.

6.8.2. Configuring a static Ethernet connection using the nmcli interactive editor

To configure a static Ethernet connection using the nmcli interactive editor:

$ nmcli con edit type ethernet con-name ens3

Adding a new '802-3-ethernet' connection

Type 'help' or '?' for available commands.
Type 'describe [>setting<.>prop<]' for detailed property description.

You may edit the following settings: connection, 802-3-ethernet (ethernet), 802-1x, ipv4, ipv6, dcb

$ nmcli> set ipv4.addresses 192.168.122.88/24
Do you also want to set 'ipv4.method' to 'manual'? [yes]: yes
$ nmcli> save temporary
Saving the connection with 'autoconnect=yes'. That might result in an immediate activation of the connection.
Do you still want to save? [yes] yes
Connection 'ens3' (704a5666-8cbd-4d89-b5f9-fa65a3dbc916) successfully saved.
nmcli> quit

The default action is to save the connection profile as persistent. If required, the profile can be held in memory only, until the next restart, by means of the save temporary command.

Additional resources
- See the nm-settings(5) man page for more information on properties and their settings.

6.9. CONFIGURING A DYNAMIC ETHERNET CONNECTION

6.9.1. Configuring a dynamic Ethernet connection with nmcli

Prerequisites
- Section 6.1, “Getting started with nmcli”
- Section 6.5, “Creating a connection profile with nmcli”

Procedure

1. To change the host name sent by a host to a DHCP server, modify the dhcp-hostname property:

```bash
~$ nmcli con modify my-office my-office ipv4.dhcp-hostname host-name ipv6.dhcp-hostname host-name
```

2. To change the IPv4 client ID sent by a host to a DHCP server, modify the dhcp-client-id property:

```bash
~$ nmcli con modify my-office my-office ipv4.dhcp-client-id client-ID-string
```

There is no dhcp-client-id property for IPv6, dhclient to create an identifier for IPv6. See the dhclient(8) man page for details.

3. To ignore the DNS servers sent to a host by a DHCP server, modify the ignore-auto-dns property:

```bash
~$ nmcli con modify my-office my-office ipv4.ignore-auto-dns yes ipv6.ignore-auto-dns yes
```

6.9.2. Configuring a dynamic Ethernet connection using the interactive editor

To configure a dynamic Ethernet connection using the interactive editor:

```bash
~$ nmcli con edit type ethernet con-name ens3
```

Adding a new ‘802-3-ethernet’ connection
Type ‘help’ or ‘?’ for available commands.
Type ‘describe [<setting>.-<prop>]’ for detailed property description.

You may edit the following settings: connection, 802-3-ethernet (ethernet), 802-1x, ipv4, ipv6, dcb
nmcli> describe ipv4.method

=== [method] ===
[NM property description]
IPv4 configuration method. If ‘auto’ is specified then the appropriate automatic method (DHCP, PPP, etc) is used for the interface and most other properties can be left unset. If ‘link-local’ is specified, then a link-local address in the 169.254/16 range will be assigned to the interface. If ‘manual’ is specified, static IP addressing is used and at least one IP address must be given in the ‘addresses’ property. If ‘shared’ is specified (indicating that this connection will provide network access to other computers) then the interface is assigned an address in the 10.42.x.1/24 range and a DHCP and forwarding DNS server are started, and the interface is NAT-ed to the current default network connection. ‘disabled’ means IPv4 will not be used on this connection. This property must be set.

nmcli> set ipv4.method auto
nmcli> save
Saving the connection with ‘autoconnect=yes’. That might result in an immediate activation of the connection.
Do you still want to save? [yes] yes
Connection ‘ens3’ (090b61f7-540f-4dd6-bf1f-a905831fc287) successfully saved.
nmcli> quit

The default action is to save the connection profile as persistent. If required, the profile can be held in memory only, until the next restart, by means of the save temporary command.

Additional resources
- See the nm-settings(5) man page for more information on properties and their settings.

6.10. HOW TO USE THE NMCLI COMMAND TO CONFIGURE A STATIC ROUTE

To configure a static route, use the nmcli utility with the following syntax:

```
$ nmcli connection modify connection_name ipv4.routes "ip[/prefix] [next_hop] [metric] [attribute=value] [attribute=value] ...
```

The command supports the following route attributes:

- **table=n**
- **src=address**
- **tos=n**
- **onlink=true|false**
- **window=n**
- **cwnd=n**
- mtu=n
- lock-window=true/false
- lock-cwdn=true/false
- lock-mtu=true/false

If you use the `ipv4.routes` sub-command, `nmcli` overrides all current settings of this parameter. To add an additional route, use the `nmcli connection modify connection_name +ipv4.routes "..."` command. In a similar way, you can use `nmcli connection modify connection_name -ipv4.routes "..."` to remove a specific route.

### 6.11. CONFIGURING A STATIC ROUTE USING A NMCLI COMMAND

You can add a static route to the configuration of a network connection using the `nmcli connection modify` command.

The procedure in this section describes how to add a route to the `192.0.2.0/24` network that uses the gateway running on `198.51.100.1`, which is reachable through the `example` connection.

**Prerequisites**

- The network is configured
- The gateway for the static route must be directly reachable on the interface.
- If the user is logged in on a physical console, user permissions are sufficient. Otherwise, the command requires `root` permissions.

**Procedure**

1. Add the static route to the `example` connection:

   ```
   $ sudo nmcli connection modify example +ipv4.routes "192.0.2.0/24 198.51.100.1"
   ```

   To set multiple routes in one step, pass the individual routes comma-separated to the command. For example, to add a route to the `192.0.2.0/24` and `203.0.113.0/24` networks, both routed through the `198.51.100.1` gateway, enter:

   ```
   $ sudo nmcli connection modify example +ipv4.routes "192.0.2.0/24 198.51.100.1, 203.0.113.0/24 198.51.100.1"
   ```

2. Optionally, verify that the routes were added correctly to the configuration:

   ```
   $ nmcli connection show example
   ...
   ipv4.routes: { ip = 192.0.2.1/24, nh = 198.51.100.1 }
   ...
   ```

3. Restart the network connection:

   ```
   $ sudo nmcli connection up example
   ```
4. Optionally, verify that the route is active:

```
$ ip route
... 192.0.2.0/24 via 198.51.100.1 dev example proto static metric 100
```

Additional resources

- For further details about nmcli, see the nmcli(1) man page.

### 6.12. CONFIGURING A STATIC ROUTE USING THE NMCLI INTERACTIVE MODE

You can use the interactive mode of the nmcli utility to add a static route to the configuration of a network connection.

The procedure in this section describes how to add a route to the 192.0.2.0/24 network that uses the gateway running on 198.51.100.1, which is reachable through the example connection.

**Prerequisites**

- The network is configured
- The gateway for the static route must be directly reachable on the interface.
- If the user is logged in on a physical console, user permissions are sufficient. Otherwise, the command requires root permissions.

**Procedure**

1. Open the nmcli interactive mode for the example connection:

   ```
   $ sudo nmcli connection edit example
   ```

2. Add the static route:

   ```
   nmcli> set ipv4.routes 192.0.2.0/24 198.51.100.1
   ```

3. Optionally, verify that the routes were added correctly to the configuration:

   ```
   nmcli> print
   ...
   ipv4.routes: { ip = 192.0.2.1/24, nh = 198.51.100.1 }
   ...
   ```

   The ip attribute displays the network to route and the nh attribute the gateway (next hop).
4. Save the configuration:

   nmcli> save persistent

5. Restart the network connection:

   nmcli> activate example

   **WARNING**
   
   When you restart the connection, all connections currently using this connection will be temporarily interrupted.

6. Leave the nmcli interactive mode:

   nmcli> quit

7. Optionally, verify that the route is active:

   $ ip route
   ...
   192.0.2.0/24 via 198.51.100.1 dev example proto static metric 100

Additional resources

- For the list of commands available in the interactive mode, enter `help` in the interactive shell.

### 6.13. SETTING THE DEFAULT GATEWAY ON AN EXISTING CONNECTION USING NMCLI

In most situations, administrators set the default gateway when they create a connection as explained in, for example, Section 6.8.1, “Configuring a static Ethernet connection with `nmcli`”.

This section describes how to set or update the default gateway on a previously created connection using the `nmcli` utility.

**Prerequisites**

- At least one static IP address must be configured on the connection on which the default gateway will be set.

- If the user is logged in on a physical console, user permissions are sufficient. Otherwise, user must have `root` permissions.

**Procedure**

1. Set the IP address of the default gateway.
   
   For example, to set the IPv4 address of the default gateway on the `example` connection to 192.0.2.1:
For example, to set the IPv6 address of the default gateway on the `example` connection to `2001:db8::1`:

```
$ sudo nmcli connection modify example ipv6.gateway "2001:db8::1"
```

2. Restart the network connection for changes to take effect. For example, to restart the `example` connection using the command line:

```
$ sudo nmcli connection up example
```

---

**WARNING**

All connections currently using this network connection are temporarily interrupted during the restart.

---

3. Optionally, verify that the route is active.

To display the IPv4 default gateway:

```
$ ip -4 route
default via 192.0.2.1 dev example proto static metric 100
```

To display the IPv6 default gateway:

```
$ ip -6 route
default via 2001:db8::1 dev example proto static metric 100 pref medium
```

**Additional resources**

- Section 6.8.1, “Configuring a static Ethernet connection with `nmcli`”

---

### 6.14. Setting the Default Gateway on an Existing Connection Using the `nmcli` Interactive Mode

In most situations, administrators set the default gateway when they create a connection as explained in, for example, Section 6.8.2, “Configuring a static Ethernet connection using the `nmcli` interactive editor” .

This section describes how to set or update the default gateway on a previously created connection using the interactive mode of the `nmcli` utility.

**Prerequisites**

- At least one static IP address must be configured on the connection on which the default gateway will be set.
- If the user is logged in on a physical console, user permissions are sufficient. Otherwise, the user must have `root` permissions.
Procedure

1. Open the `nmcli` interactive mode for the required connection. For example, to open the `nmcli` interactive mode for the `example` connection:

   ```
   $ sudo nmcli connection edit example
   ```

2. Set the default gateway. For example, to set the IPv4 address of the default gateway on the `example` connection to `192.0.2.1`:

   ```
   nmcli> set ipv4.gateway 192.0.2.1
   ```

   For example, to set the IPv6 address of the default gateway on the `example` connection to `2001:db8::1`:

   ```
   nmcli> set ipv6.gateway 2001:db8::1
   ```

3. Optionally, verify that the default gateway was set correctly:

   ```
   nmcli> print
   ...
   ipv4.gateway: 192.0.2.1
   ...
   ipv6.gateway: 2001:db8::1
   ```

4. Save the configuration:

   ```
   nmcli> save persistent
   ```

5. Restart the network connection for changes to take effect:

   ```
   nmcli> activate example
   ```

   **WARNING**
   All connections currently using this network connection are temporarily interrupted during the restart.

6. Leave the `nmcli` interactive mode:

   ```
   nmcli> quit
   ```

7. Optionally, verify that the route is active. To display the IPv4 default gateway:
$ ip -4 route
default via 192.0.2.1 dev example proto static metric 100

To display the IPv6 default gateway:

$ ip -6 route
default via 2001:db8::1 dev example proto static metric 100 pref medium

Additional resources

- Section 6.8.2, “Configuring a static Ethernet connection using the nmcli interactive editor”

6.15. CONNECTING A WI-FI CONNECTION WITH NMCLI

This procedure describes how to connect to a wireless connection using the nmcli utility.

Prerequisites

- The nmcli utility to be installed.
- Make sure that the WiFi radio is on (default):

  ```
  ~]$ nmcli radio wifi on
  ```

Procedure

1. To refresh the available Wi-Fi connection list:

  ```
  ~]$ nmcli device wifi rescan
  ```

2. To view the available Wi-Fi access points:

  ```
  ~]$ nmcli dev wifi list
  ```
  
  IN-USE  SSID      MODE   CHAN  RATE        SIGNAL  BARS  SECURITY
  ...
      MyCafe    Infra  3     405 Mbit/s  85 ━━━━━━━━━━━ WPA1 WPA2
  
3. To connect to a Wi-Fi connection using nmcli:

  ```
  ~]$ `nmcli dev wifi connect _SSID-Name_ password _wireless-password_`
  ```

  For example:

  ```
  ~]$ nmcli dev wifi connect MyCafe password wireless-password
  ```

  Note that if you want to disable the Wi-Fi state:

  ```
  ~]$ nmcli radio wifi off
  ```

6.15.1. Configuring a Wi-Fi connection using nmcli
Prerequisites

- The `nmcli` utility to be installed.
- Make sure that the WiFi radio is on (default):

  ```bash
  ~$ nmcli radio wifi on
  ```

Procedure

1. To create a Wi-Fi connection profile with static IP configuration:

  ```bash
  ~$ nmcli con add con-name MyCafe ifname wlan0 type wifi ssid MyCafe ` `ip4 192.168.100.101/24 gw4 192.168.100.1
  ```

2. To check a specific property, for example `mtu`:

  ```bash
  ~$ nmcli connection show id MyCafe | grep mtu
  802-11-wireless.mtu: auto
  ```

3. To change the property of a setting:

  ```bash
  ~$ nmcli connection modify id MyCafe 802-11-wireless.mtu 1350
  ```

4. To verify the change:

  ```bash
  ~$ nmcli connection show id MyCafe | grep mtu
  802-11-wireless.mtu: 1350
  ```

Additional resources

See the `nm-settings(5)` man page for more information on properties and their settings.

6.15.2. Connecting to a hidden network using nmcli

All access points have a Service Set Identifier (SSID) to identify them. However, an access point may be configured not to broadcast its SSID, in which case it is hidden, and will not show up in NetworkManager's list of Available networks.

This procedure shows how you can connect to a hidden network using the `nmcli` tool.

Prerequisites

- The `nmcli` utility to be installed.
- To know the SSID, and password of the Wi-Fi connection.
- Make sure that the WiFi radio is on (default):

  ```bash
  ~$ nmcli radio wifi on
  ```

Procedure

Connect to the SSID that is hidden:
6.16. CONFIGURING 802.3 LINK SETTINGS

You can configure the 802.3 link settings of an Ethernet connection by modifying the following configuration parameters:

- 802-3-ethernet.auto-negotiate
- 802-3-ethernet.speed
- 802-3-ethernet.duplex

You can configure the 802.3 link settings to the following main modes:

- Ignore link negotiation
- Enforce the auto-negotiation activation
- Manually set the speed and duplex link settings

6.17. CONFIGURING 802.3 LINK SETTINGS WITH NMCLI TOOL

This procedure describes how to configure 802.3 link settings using the nmcli tool.

Prerequisites

- The NetworkManager must be installed and running.

Procedure

1. To ignore link negotiation, set the following parameters:

```shell
~]$ nmcli connection modify connection_name 802-3-ethernet.auto-negotiate no 802-3-ethernet.speed 0 802-3-ethernet.duplex ""
```

Note, that the auto-negotiation parameter is not disabled even if the speed and duplex parameters are not set and the auto-negotiation parameter is set to no.

2. To enforce the auto-negotiation activation, enter the following command:

```shell
~]$ nmcli connection modify connection_name 802-3-ethernet.auto-negotiate yes 802-3-ethernet.speed 0 802-3-ethernet.duplex ""
```

That allows to negotiate all the available speed and duplex modes supported by the NIC.

You can also enable auto-negotiation while advertising and allowing only one speed/duplex mode. This can be useful if you want to enforce 1000BASE-T and 10GBASE-T Ethernet link configuration, as these standards mandate auto-negotiation enabled. To enforce 1000BASE-T standard:

```shell
~]$ nmcli connection modify connection_name 802-3-ethernet.auto-negotiate yes 802-3-ethernet.speed 1000 802-3-ethernet.duplex full
```
3. To manually set the speed and duplex link settings, enter the following command:

```
~$ nmcli connection modify connection_name 802-3-ethernet.auto-negotiate no 802-3-ethernet.speed [speed in Mbit/s] 802-3-ethernet.duplex [full|half]
```

### 6.18. Configuring 802.1X Security for Wi-Fi and Wired with NMCLI

This procedure describes how to set the network security settings in a **wireless** or a **Wired** connection using the `nmcli` utility.

**Prerequisites**

- The `nmcli` utility is installed.

**Procedure**

1. For a **wireless** connection, set the authenticated **key-mgmt** (key management) protocol. It configures the keying mechanism for a secure **wifi** connection.

2. Configure the 802-1x authentication settings.

**Table 6.2. The 802-1x authentication settings**

<table>
<thead>
<tr>
<th>802-1x authentication setting</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>802-1x.identity</td>
<td>Identity</td>
</tr>
<tr>
<td>802-1x.ca-cert</td>
<td>CA certificate</td>
</tr>
<tr>
<td>802-1x.client-cert</td>
<td>User certificate</td>
</tr>
<tr>
<td>802-1x.private-key</td>
<td>Private key</td>
</tr>
<tr>
<td>802-1x.private-key-password</td>
<td>Private key password</td>
</tr>
</tbody>
</table>

For example, to configure WPA2 Enterprise using the EAP-TLS authentication method, apply the following settings:

```
~$ nmcli c add type wifi ifname wlan0 con-name 'My Wifi Network' \
    802-11-wireless.ssid 'My Wifi' \
    802-11-wireless-security.key-mgmt wpa-eap \
    802-1x.eap tls \
    802-1x.identity identity@example.com \
    802-1x.ca-cert /etc/pki/my-wifi/ca.crt \
    802-1x.client-cert /etc/pki/my-wifi/client.crt \
    802-1x.private-key /etc/pki/my-wifi/client.key \
    802-1x.private-key-password s3cr3t
```
To configure a wired connection using the `nmcli` tool, follow the same procedure as for a wireless connection, except the `802-11-wireless.ssid` and `802-11-wireless-security key-mgmt` settings.

### 6.19. CONFIGURING NETWORK BONDING USING NMCLI

This section describes the basics of network bonding, the differences between bonding and teaming, and how to configure a network bond on Red Hat Enterprise Linux 8 using the `nmcli` utility.

#### 6.19.1. Understanding network bonding

Network bonding is a method to combine or aggregate network interfaces to provide a logical interface with higher throughput or redundancy.

The `active-backup`, `balance-tlb`, and `balance-alb` modes do not require any specific configuration of the network switch. However, other bonding modes require configuring the switch to aggregate the links. For example, Cisco switches require `EtherChannel` for modes 0, 2, and 3, but for mode 4, the Link Aggregation Control Protocol (LACP) and `EtherChannel` are required.

For further details, see the documentation of your switch and [https://www.kernel.org/doc/Documentation/networking/bonding.txt](https://www.kernel.org/doc/Documentation/networking/bonding.txt).

#### IMPORTANT

Certain network bonding features, such as the fail-over mechanism, do not support direct cable connections without a network switch. For further details, see the Is bonding supported with direct connection using crossover cables? KCS solution.

#### 6.19.2. Understanding the default behavior of master and slave interfaces

Consider the following default behavior of, when managing or troubleshooting team or bond port interfaces using the `NetworkManager` service:

- Starting the master interface does not automatically start the port interfaces.
- Starting a port interface always starts the master interface.
- Stopping the master interface also stops the port interface.
- A master without ports can start static IP connections.
- A master without ports waits for ports when starting DHCP connections.
- A master with a DHCP connection waiting for ports completes when you add a port with a carrier.
- A master with a DHCP connection waiting for ports continues waiting when you add a port without carrier.

#### 6.19.3. Comparison of network teaming and bonding features

The following table compares features supported in network teams and network bonds:
<table>
<thead>
<tr>
<th>Feature</th>
<th>Network bond</th>
<th>Network team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Round-robin Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Active-backup Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP (802.3ad) support</td>
<td>Yes (active only)</td>
<td>Yes</td>
</tr>
<tr>
<td>Hash-based Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User can set hash function</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tx load-balancing support (TLB)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP hash port select</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Load-balancing for LACP support</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethtool link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ARP link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NS/NA (IPv6) link monitoring</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ports up/down delays</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Port priorities and stickiness (“primary” option enhancement)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Separate per-port link monitoring setup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple link monitoring setup</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Lockless Tx/Rx path</td>
<td>No (rwlock)</td>
<td>Yes (RCU)</td>
</tr>
<tr>
<td>VLAN support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User-space runtime control</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Logic in user-space</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Hard</td>
<td>Easy</td>
</tr>
<tr>
<td>Modular design</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### 6.19.4. Configuring a network bond using `nmcli` commands

This section describes how to configure a network bond using `nmcli` commands.

#### Prerequisites

- Two or more network cards are installed in the server.
- The network cards are connected to a switch.

#### Procedure

1. Create a bond interface. For example, to create a bond interface that uses the `active-backup` mode and both the interface and the connection are named `bond0`, enter:

   ```bash
   # nmcli connection add type bond con-name bond0 ifname bond0 bond.options "mode=active-backup"
   ``

   To additionally set a Media Independent Interface (MII) monitoring interval, add the `miimon=interval` option to the `bond.options` property. For example, to use the same command but, additionally, set the MII monitoring interval to 1000 milliseconds (1 second), enter:

   ```bash
   # nmcli connection add type bond con-name bond0 ifname bond0 bond.options "mode=active-backup,miimon=1000"
   ``

2. Configure the IPv4 settings. For example, to set a static IPv4 address, network mask, default gateway, and DNS server to the `bond0` connection, enter:

   ```bash
   # nmcli connection modify bond0 ipv4.addresses '192.0.2.1/24'
   # nmcli connection modify bond0 ipv4.gateway '192.0.2.254'
   # nmcli connection modify bond0 ipv4.dns '192.0.2.253'
   # nmcli connection modify bond0 ipv4.method manual
   ``

3. Configure the IPv6 settings. For example, to set a static IPv6 address, network mask, default gateway, and DNS server of the `bond0` connection, enter:

   ```bash
   # nmcli connection modify bond0 ipv6.addresses '2001:db8::1/32'
   # nmcli connection modify bond0 ipv6.gateway '2001:db8::fffe'
   # nmcli connection modify bond0 ipv6.dns '2001:db8::fffd'
   # nmcli connection modify bond0 ipv6.method manual
   ```
4. Optionally, display the network interfaces, and note names of interfaces you plan to add to the bond:

```
# nmcli device
DEVICE  TYPE      STATE         CONNECTION
enp1s0  ethernet  connected     enp1s0
enp7s0  ethernet  disconnected  --
enp8s0  ethernet  disconnected  --
lo      loopback unmanaged     --
```

5. Assign port interfaces to the bond’s connection. For example, to add the interfaces named enp7s0 and enp8s0 to the bond0 connection:

```
# nmcli connection add type ethernet slave-type bond con-name bond0-port1 ifname enp7s0 master bond0
# nmcli connection add type ethernet slave-type bond con-name bond0-port2 ifname enp8s0 master bond0
```

6. Activate the connection. For example, to activate the bond0 connection:

```
# nmcli connection up bond0
```

7. Verify that the slave devices are connected, and the CONNECTION column displays the slave’s connection name:

```
# nmcli device
DEVICE   TYPE      STATE      CONNECTION
...
enp7s0   ethernet  connected  bond0-port1
enp8s0   ethernet  connected  bond0-port2
```

Red Hat Enterprise Linux activates master and slave devices when the system boots. By activating any slave connection, the master is also activated. However, in this case, only one slave connection is activated. By default, activating the master does not automatically activate the slaves. However, you can enable this behavior by setting:

a. Enable the connection.autoconnect-slaves parameter of the bond’s connection:

```
# nmcli connection modify bond0 connection.autoconnect-slaves 1
```

b. Reactivate the bridge:

```
# nmcli connection up bond0
```

8. Optionally, display the status of the bond:

```
# cat /proc/net/bonding/bond0
Ethernet Channel Bonding Driver: v3.7.1 (April 27, 2011)
Bonding Mode: fault-tolerance (active-backup)
Primary Slave: None
Currently Active Slave: enp7s0
MII Status: up
MII Polling Interval (ms): 100
```
Up Delay (ms): 0
Down Delay (ms): 0
Slave Interface: enp7s0
MII Status: up
Speed: Unknown
Duplex: Unknown
Link Failure Count: 0
Permanent HW addr: 52:54:00:d5:e0:fb
Slave queue ID: 0
Slave Interface: enp8s0
MII Status: up
Speed: Unknown
Duplex: Unknown
Link Failure Count: 0
Permanent HW addr: 52:54:00:b2:e2:63
Slave queue ID: 0

In the example, both ports are up.

Additional resources
- For **nmcli** examples, see the **nmcli-examples(7)** man page.
- For a list of options you can set in the **bond.options** parameter of the **nmcli** command when you create a bond, see [https://www.kernel.org/doc/Documentation/networking/bonding.txt](https://www.kernel.org/doc/Documentation/networking/bonding.txt).

### 6.20. CONFIGURING A NETWORK BRIDGE USING NMCLI COMMANDS

This section explains how to configure a network bridge using the **nmcli** utility.

A network bridge is a link-layer device which forwards traffic between networks based on MAC addresses. The bridge device decides on forwarding packages based on a table of MAC addresses. The bridge builds the MAC addresses table by listening to network traffic and thereby learning what hosts are connected to each network.

For example, you can use a software bridge on a Red Hat Enterprise Linux 8 host:

- To emulate a hardware bridge
- In virtualization environments, to integrate virtual machines (VM) to the same network as the host

Due to the IEEE 802.11 standard which specifies the use of 3-address frames in Wi-Fi for the efficient use of airtime, you cannot configure a bridge over Wi-Fi networks operating in Ad-Hoc or Infrastructure modes.

**Prerequisites**

- Two or more physical or virtual network devices are installed in the server.
- You are logged in as the **root** user.

**Procedure**

1. Create a bridge interface. For example, to create the bridge interface named **bridge0**, enter:
2. Configure the IPv4 settings. For example, to set a static IPv4 address, network mask, default gateway, and DNS server of the bridge0 connection, enter:

```
# nmcli connection modify bridge0 ipv4.addresses '192.0.2.1/24'
# nmcli connection modify bridge0 ipv4.gateway '192.0.2.254'
# nmcli connection modify bridge0 ipv4.dns '192.0.2.253'
# nmcli connection modify bridge0 ipv4.method manual
```

3. Configure the IPv6 settings. For example, to set a static IPv6 address, network mask, default gateway, and DNS server of the bridge0 connection, enter:

```
# nmcli connection modify bridge0 ipv6.addresses '2001:db8::1/32'
# nmcli connection modify bridge0 ipv6.gateway '2001:db8::fffe'
# nmcli connection modify bridge0 ipv6.dns '2001:db8::fffd'
# nmcli connection modify bridge0 ipv6.method manual
```

4. Optionally, configure further properties of the bridge. For example, to set the Spanning Tree Protocol (STP) priority of bridge0 to 16384, enter:

```
# nmcli connection modify bridge0 bridge.priority '16384'
```

By default, STP is enabled.

5. Optionally, display the network interfaces, and note the names of the interfaces you want to add to the bridge as a slave in the next step:

```
# nmcli device
DEVICE  TYPE      STATE         CONNECTION
enp1s0  ethernet  connected     enp1s0
enp7s0  ethernet  disconnected  --
enp8s0  ethernet  disconnected  --
lo      loopback  unmanaged     --
```

6. Assign the port interfaces to the bridge’s connection. For example, to add the interfaces named enp7s0 and enp8s0 to the bridge0 connection, enter:

```
# nmcli connection add type ethernet slave-type bridge con-name bridge0-port1 ifname enp7s0 master bridge0
# nmcli connection add type ethernet slave-type bridge con-name bridge0-port2 ifname enp8s0 master bridge0
```

7. Activate the connection. For example, to activate the bridge0 connection, enter:

```
# nmcli connection up bridge0
```

8. Verify that the slave devices are connected, and the CONNECTION column displays the slave’s connection name:

```
# nmcli device
DEVICE  TYPE      STATE         CONNECTION
...
Red Hat Enterprise Linux activates master and slave devices when the system boots. By activating any slave connection, the master is also activated. However, in this case, only one slave connection is activated. By default, activating the master does not automatically activate the slaves. However, you can enable this behavior by setting:

a. Enable the `connection.autoconnect-slaves` parameter of the bridge connection:

```bash
# nmcli connection modify bridge0 connection.autoconnect-slaves 1
```

b. Reactivate the bridge:

```bash
# nmcli connection up bridge0
```

9. Optionally, use the following command to display the status of the bridge:

```bash
# bridge link show bridge0
3: enp7s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 master bridge0 state forwarding priority 32 cost 100
4: enp8s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 master bridge0 state listening priority 32 cost 100
```

Additional resources

- For `nmcli` examples, see the `nmcli-examples(7)` man page.
- For all bridge properties you can set, see the `bridge settings` section in the `nm-settings(5)` man page.
- For all bridge port properties you can set, see the `bridge-port settings` section in the `nm-settings(5)` man page.
- For details about the `bridge` utility, see the `bridge(8)` man page.

### 6.21. CONFIGURING NETWORK TEAMING USING NMCLI

This section describes the basics of network teaming, the differences between bonding and teaming, and how to configure a network team on Red Hat Enterprise Linux 8 using the `nmcli` utility.

#### Prerequisites

- Red Hat Enterprise Linux 8 is installed.
- The system has an active subscription assigned.

#### 6.21.1. Understanding network teaming

Network teaming is a feature that combines or aggregates network interfaces to provide a logical interface with higher throughput or redundancy.

Network teaming uses a kernel driver to implement fast handling of packet flows, as well as user-space libraries and services for other tasks. This way, network teaming is an easily extensible and scalable solution for load-balancing and redundancy requirements.
Note that in the context of network teaming, the term **port** is also known as **slave**. In the **teamd** service, the term **port** is preferred while in the **NetworkManager** service, the term **slave** refers to interfaces which create a team.

**IMPORTANT**

Certain network teaming features, such as the fail-over mechanism, do not support direct cable connections without a network switch. For further details, see [Is bonding supported with direct connection using crossover cables?](#).

### 6.21.2. Understanding the default behavior of master and slave interfaces

Consider the following default behavior of, when managing or troubleshooting team or bond port interfaces using the **NetworkManager** service:

- Starting the master interface does not automatically start the port interfaces.
- Starting a port interface always starts the master interface.
- Stopping the master interface also stops the port interface.
- A master without ports can start static IP connections.
- A master without ports waits for ports when starting DHCP connections.
- A master with a DHCP connection waiting for ports completes when you add a port with a carrier.
- A master with a DHCP connection waiting for ports continues waiting when you add a port without carrier.

### 6.21.3. Comparison of network teaming and bonding features

The following table compares features supported in network teams and network bonds:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Network bond</th>
<th>Network team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Round-robin Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Active-backup Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP (802.3ad) support</td>
<td>Yes (active only)</td>
<td>Yes</td>
</tr>
<tr>
<td>Hash-based Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User can set hash function</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tx load-balancing support (TLB)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Feature</td>
<td>Network bond</td>
<td>Network team</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>LACP hash port select</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Load-balancing for LACP support</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethtool link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ARP link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NS/NA (IPv6) link monitoring</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ports up/down delays</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Port priorities and stickiness (&quot;primary&quot; option enhancement)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Separate per-port link monitoring setup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple link monitoring setup</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Lockless Tx/Rx path</td>
<td>No (rwlock)</td>
<td>Yes (RCU)</td>
</tr>
<tr>
<td>VLAN support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User-space runtime control</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Logic in user-space</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Hard</td>
<td>Easy</td>
</tr>
<tr>
<td>Modular design</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Performance overhead</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>D-Bus interface</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple device stacking</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zero config using LLDP</td>
<td>No</td>
<td>(in planning)</td>
</tr>
<tr>
<td>NetworkManager support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

6.21.4. Understanding the teamd service, runners, and link-watchers
The team service, **teamd**, controls one instance of the team driver. This instance of the driver adds instances of a hardware device driver to form a team of network interfaces. The team driver presents a network interface, for example **team0**, to the kernel.

The **teamd** service implements the common logic to all methods of teaming. Those functions are unique to the different load sharing and backup methods, such as round-robin, and implemented by separate units of code referred to as **runners**. Administrators specify runners in JavaScript Object Notation (JSON) format, and the JSON code is compiled into an instance of **teamd** when the instance is created. Alternatively, when using **NetworkManager**, you can set the runner in the **team.runner** parameter, and **NetworkManager** auto-creates the corresponding JSON code.

The following runners are available:

- **broadcast**: Transmits data over all ports.
- **roundrobin**: Transmits data over all ports in turn.
- **activebackup**: Transmits data over one port while the others are kept as a backup.
- **loadbalance**: Transmits data over all ports with active Tx load balancing and Berkeley Packet Filter (BPF)-based Tx port selectors.
- **random**: Transmits data on a randomly selected port.
- **lacp**: Implements the 802.3ad Link Aggregation Control Protocol (LACP).

The **teamd** services uses a link watcher to monitor the state of subordinate devices. The following link-watchers are available:

- **ethtool**: The **libteam** library uses the **ethtool** utility to watch for link state changes. This is the default link-watcher.
- **arp_ping**: The **libteam** library uses the **arp_ping** utility to monitor the presence of a far-end hardware address using Address Resolution Protocol (ARP).
- **nsna_ping**: On IPv6 connections, the **libteam** library uses the Neighbor Advertisement and Neighbor Solicitation features from the IPv6 Neighbor Discovery protocol to monitor the presence of a neighbor’s interface.

Each runner can use any link watcher, with the exception of **lacp**. This runner can only use the **ethtool** link watcher.

### 6.21.5. Installing the teamd service

To configure a network team in **NetworkManager**, you require the **teamd** service and the team plug-in for **NetworkManager**. Both are installed on Red Hat Enterprise Linux 8 by default. This section describes how you install the required packages in case that you remove them.

**Prerequisites**

- An active Red Hat subscription is assigned to the host.

**Procedure**

1. Install the **teamd** and **NetworkManager-team** packages:

   ```bash
   # yum install teamd NetworkManager-team
   ```
6.21.6. Configuring a network team using nmcli commands

This section describes how you configure a network team using nmcli commands.

**Prerequisites**

- Two or more network cards are installed in the server.
- The network cards are connected to a switch.

**Procedure**

1. Create the team interface. For example, to create a team interface that uses the **activebackup** runner and both the interface and connection named **team0**, enter:

   ```
   # nmcli connection add type team con-name team0 ifname team0 team.runner activebackup
   ```

2. Optionally, set a link watcher. For example, to set the **ethtool** link watcher, modify the **team0** connection:

   ```
   # nmcli connection modify team0 team.link-watchers "name=ethtool"
   ```

   Link watchers support different parameters. To set parameters for a link watcher, specify them space-separated in the **name** property. Note that the name property must be surrounded by quotes. For example, to use the **ethtool** link watcher and set its **delay-up** parameter to 2500 milliseconds (2.5 seconds):

   ```
   # nmcli connection modify team0 team.link-watchers "name=ethtool delay-up=2500"
   ```

   To set multiple link watchers and each of them with specific parameters, the link watchers must be separated by a comma. The following example sets the **ethtool** link watcher with the **delay-up** parameter and the **arp_ping** link watcher with the **source-host** and **target-host** parameter:

   ```
   # nmcli connection modify team0 team.link-watchers "name=ethtool delay-up=2,
   name=arp_ping source-host=192.0.2.1 target-host=192.0.2.2"
   ```

3. Configure the IPv4 settings. For example, to set a static IPv4 address, network mask, default gateway, and DNS server of the **team0** connection, enter:

   ```
   # nmcli connection modify team0 ipv4.addresses '192.0.2.1/24'
   # nmcli connection modify team0 ipv4.gateway '192.0.2.254'
   # nmcli connection modify team0 ipv4.dns '192.0.2.253'
   # nmcli connection modify team0 ipv4.method manual
   ```

4. Configure the IPv6 settings. For example, to set a static IPv6 address, network mask, default gateway, and DNS server of the **team0** connection, enter:

   ```
   # nmcli connection modify team0 ipv6.addresses '2001:db8::1/32'
   # nmcli connection modify team0 ipv6.gateway '2001:db8::ffe'
   # nmcli connection modify team0 ipv6.dns '2001:db8::fffed'
   # nmcli connection modify team0 ipv6.method manual
   ```

5. Optionally, display the network interfaces, and note the names of the interfaces you want to add to the team in the next step:
# nmcli device

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>TYPE</th>
<th>STATE</th>
<th>CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>enp1s0</td>
<td>ethernet</td>
<td>connected</td>
<td>enp1s0</td>
</tr>
<tr>
<td>enp7s0</td>
<td>ethernet</td>
<td>disconnected</td>
<td>--</td>
</tr>
<tr>
<td>enp8s0</td>
<td>ethernet</td>
<td>disconnected</td>
<td>--</td>
</tr>
<tr>
<td>lo</td>
<td>loopback</td>
<td>unmanaged</td>
<td>--</td>
</tr>
</tbody>
</table>

**IMPORTANT**

You can only use network interfaces in a team that are not assigned to any connection. In the above example, you can only use the **enp7s0** and **enp8s0** interfaces.

6. Assign the port interfaces to the team’s connection. For example, to add the interfaces named **enp7s0** and **enp8s0** to the **team0** connection:

   ```
   # nmcli connection add type ethernet slave-type team con-name team0-port1 ifname enp7s0 master team0
   # nmcli connection add type ethernet slave-type team con-name team0-port2 ifname enp8s0 master team0
   ```

7. Activate the connection. For example, to activate the **team0** connection:

   ```
   # nmcli connection up team0
   ```

8. Optionally, display the status of the team:

   ```
   # teamdctl team0 state
   setup:
       runner: activebackup
   ports:
       enp7s0
           link watches:
               link summary: up
               instance[link_watch_0]:
                   name: ethtool
                   link: up
                   down count: 0
       enp8s0
           link watches:
               link summary: up
               instance[link_watch_0]:
                   name: ethtool
                   link: up
                   down count: 0
   runner:
       active port: enp7s0
   ```

   In the example, both ports are up.

**Additional resources**

- Section 6.21.4, “Understanding the teamd service, runners, and link-watchers”.

For **nmcli** examples, see the **nmcli-examples(7)** man page.

For all team properties you can set, see the **team** section in the **nm-settings(5)** man page.

For parameters you can set in the JSON configuration, as well as JSON examples, see the **teamd.conf(5)** man page.

### 6.22. CONFIGURING VLAN TAGGING USING NMCLI COMMANDS

This section describes how to configure Virtual Local Area Network (VLAN) tagging using **nmcli** commands. A VLAN is a logical network within a physical network. The VLAN interface tags packets with the VLAN ID as they pass through the interface, and removes tags of returning packets.

You create a VLAN interface on top of another interface, such as Ethernet, bond, team, or bridge. This interface is called the **parent interface**.

**Prerequisites**

- The interface you plan to use as a parent to the virtual VLAN interface supports VLAN tags.

- If you configure the VLAN on top of a bond interface:
  - The slaves of the bond are up.
  - The bond is not configured with the **fail_over_mac=follow** option. A VLAN virtual device cannot change its MAC address to match the parent’s new MAC address. In such a case, the traffic would still be sent with the then incorrect source MAC address.

- The switch the host is connected to is configured to support VLAN tags. For details, see the documentation of your switch.

**Procedure**

1. Optionally, display the available network interfaces:

   ```
   # ip address show
   1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
       link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
       inet 127.0.0.1/8 scope host lo
         valid_lft forever preferred_lft forever
       inet6 ::1/128 scope host
         valid_lft forever preferred_lft forever
   2: enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
      link/ether 52:54:00:d5:e0:fb brd ff:ff:ff:ff:ff:ff
   ```

2. Create the VLAN interface. For example, to create a VLAN interface named **vlan10** that uses **enp1s0** as its parent interface and that tags packets with VLAN ID **10**, enter:

   ```
   # nmcli connection add type vlan con-name vlan10 ifname vlan10 vlan.parent enp1s0 vlan.id 10
   ```

   Note that the VLAN must be within the range from **0** to **4094**.
3. By default, the VLAN connection inherits the maximum transmission unit (MTU) from the parent interface. Optionally, set a different MTU value:

```
# nmcli connection modify vlan10 802-3-ethernet.mtu 2000
```

4. Configure the IPv4 settings. For example, to set a static IPv4 address, network mask, default gateway, and DNS server to the `vlan10` connection, enter:

```
# nmcli connection modify vlan10 ipv4.addresses '192.0.2.1/24'
# nmcli connection modify vlan10 ipv4.gateway '192.0.2.254'
# nmcli connection modify vlan10 ipv4.dns '192.0.2.253'
# nmcli connection modify vlan10 ipv4.method manual
```

5. Configure the IPv6 settings. For example, to set a static IPv6 address, network mask, default gateway, and DNS server to the `vlan10` connection, enter:

```
# nmcli connection modify vlan10 ipv6.addresses '2001:db8::1/32'
# nmcli connection modify vlan10 ipv6.gateway '2001:db8::fffe'
# nmcli connection modify vlan10 ipv6.dns '2001:db8::fffd'
# nmcli connection modify vlan10 ipv6.method manual
```

6. Optionally, verify the settings:

```
# ip -d addr show vlan10
4: vlan10@enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
link/ether 52:54:00:d5:e0:fb brd ff:ff:ff:ff:ff:ff promiscuity 0
  vlan protocol 802.1Q id 10 <REORDER_HDR> numtxqueues 1 numrxqueues 1
  gso_max_size 65536 gso_max_segs 65535
  inet 192.0.2.1/24 brd 192.0.2.255 scope global noprefixroute vlan10
    valid_lft forever preferred_lft forever
  inet6 fe80::8dd7:9030:6f8e:89e6/64 scope link noprefixroute
    valid_lft forever preferred_lft forever
```

**Additional resources**

- For `nmcli` examples, see the `nmcli-examples(7)` man page.
- For all vlan properties you can set, see the `vlan setting` section in the `nm-settings(5)` man page.
CHAPTER 7. CONFIGURING NETWORKING WITH GNOME GUI

You can configure a network interface using the following Graphical User Interface (GUI) ways:

- the GNOME Shell network connection icon on the top right of the desktop
- the GNOME control-center application
- the GNOME nm-connection-editor application

7.1. CONNECTING TO A NETWORK USING THE GNOME SHELL NETWORK CONNECTION ICON

To access the Network settings, click on the GNOME Shell network connection icon in the top right-hand corner of the screen to open its menu:

Figure 7.1. The network connection icon menu

When you click on the GNOME Shell network connection icon, you can see:

- A list of categorized networks you are currently connected to (such as Wired and Wi-Fi).
- A list of all Available Networks that NetworkManager has detected. If you are connected to a network, this is indicated on the left of the connection name.
Options for connecting to any configured Virtual Private Networks (VPNs) and

An option for selecting the Network Settings menu entry.

7.2. CREATING A NETWORK CONNECTION USING CONTROL-CENTER

You can create a network connection through the GNOME control-center application, which is a graphical user interface that provides a view of available network devices and their current configuration.

This procedures describes how to create a new wired, wireless, vpn connection using control-center:

Procedure

1. Press the Super key to enter the Activities Overview, type Settings, and press Enter. Then, select the Network tab on the left-hand side, and the Network settings tool appears:

Figure 7.2. Opening the network settings window

2. Click the plus button to add a new connection:
   - For Wired connections, click the plus button next to Wired entry and configure the connection.
   - For VPN connections, click the plus button next to VPN entry. If you want to add an IPsec VPN, click on IPsec based VPN and configure the connection.
   - For Wi-Fi connections, click the Wi-Fi entry on the left-hand side in the Settings menu and configure the connection.
7.3. CONFIGURING A NETWORK CONNECTION USING CONTROL-CENTER

You can configure a network connection through the GNOME control-center application.

7.3.1. Configuring a Wired (Ethernet) connection using control-center

Procedure

1. Press the **Super** key to enter the Activities Overview, type **Settings** and press **Enter**. Then, select the **Network** menu entry on the left-hand side, and the **Network** settings tool appears, see Opening the Network Settings Window.

2. Select the **Wired** network interface
   The system creates and configures a single wired **connection profile** called **Wired** by default. More than one profile can be created for an interface and applied as needed. The default profile cannot be deleted but its settings can be changed.

3. Edit the default **Wired** profile by clicking the gear wheel icon to edit an existing connection or click the plus button and then set the configuration options for a new connection.

   **NOTE**

   When you add a new connection by clicking the plus button, **NetworkManager** creates a new configuration file for that connection and then opens the same dialog that is used for editing an existing connection. The difference between these dialogs is that an existing connection profile has a **Details** menu entry.

**Basic configuration options**

You can see the following configuration settings in the **Wired** dialog, by selecting the **Identity** menu entry:
**Name** – Enter a descriptive name for your network connection. This name will be used to list this connection in the menu of the **Network** window.

**MAC Address** – Select the MAC address of the interface this profile must be applied to.

**Cloned Address** – If required, enter a different MAC address to use.

**MTU** – If required, enter a specific *maximum transmission unit (MTU)* to use. The MTU value represents the size in bytes of the largest packet that the link layer will transmit. This value defaults to **1500** and does not generally need to be specified or changed.

### Configuring IPv4 settings for wired with control-center

You can further configure **IPv4** settings in a wired connection. In the **Wired** dialog, click the **IPv4** menu entry:
The **IPv4** menu entry allows you to configure:

- **IPv4 Method** used to connect to a network
- **DNS** and
- **Routes**

### IPv4 Method

**Automatic (DHCP)** – Choose this option if the network you are connecting to uses Router Advertisements (RA) or a DHCP server to assign dynamic IP addresses.

**Link-Local Only** – Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 3927 with prefix 169.254/16.

**Manual** – Choose this option if you want to assign IP addresses manually.

**Disable** – IPv4 is disabled for this connection.

### DNS

In the **DNS** section, when **Automatic** is **ON**, Switch Automatic to **OFF** to enter the IP address of a DNS server you want to use separating the IPs by comma.
NOTE

In the Routes section, when Automatic is ON, routes from Router Advertisements (RA) or DHCP are used, but you can also add additional static routes. When OFF, only static routes are used.

Address — Enter the IP address of a remote network, sub-net, or host.

Netmask — The netmask or prefix length of the IP address entered above.

Gateway — The IP address of the gateway leading to the remote network, sub-net, or host entered above.

Metric — A network cost, a preference value to give to this route. Lower values will be preferred over higher values.

Use this connection only for resources on its network

Select this check box to prevent the connection from becoming the default route. Typical examples are where a connection is a VPN tunnel or a leased line to a head office and you do not want any Internet-bound traffic to pass over the connection. Selecting this option means that only traffic specifically destined for routes learned automatically over the connection or entered here manually will be routed over the connection.

Configuring IPv6 settings for wired with control center

Alternatively, to configure IPv6 settings in a wired connection, click the IPv6 menu entry:
The **IPv6** menu entry allows you to configure:

- **IPv6 Method** used to connect to a network
- **DNS** and
- **Routes**

**IPv6 Method**

**Automatic** – Choose this option to use IPv6 Stateless Address AutoConfiguration (SLAAC) to create an automatic, stateless configuration based on the hardware address and Router Advertisements (RA).

**Automatic, DHCP only** – Choose this option to not use RA, but request information from DHCPv6 directly to create a stateful configuration.

**Link-Local Only** – Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 4862 with prefix FE80::0.

**Manual** – Choose this option if you want to assign IP addresses manually.

**Disabled** – IPv6 is disabled for this connection.

**Configuring 802.1X security for wired with control-center**
802.1X security is the name of the IEEE standard for port-based Network Access Control (PNAC). It is also called WPA Enterprise. 802.1X security is a way of controlling access to a logical network from a physical one. All clients who want to join the logical network must authenticate with the server (a router, for example) using the correct 802.1X authentication method.

To configure 802.1X Security settings in a wired connection, click the Security menu entry:

Figure 7.6. Configuring 802.1X security for a wired with control-center

![New Profile](image)

802.1X Security

To enable settings configuration, set the symbolic power button to ON, and select from one of following authentication methods:

- **TLS** for Transport Layer Security and proceed to Configuring TLS Settings
- **PWD** for Password and proceed to Configuring PWD Settings
- **FAST** for Flexible Authentication through Secure Tunneling and proceed to Configuring FAST Settings
- Select **Tunneled TLS** for Tunneled Transport Layer Security, otherwise known as TTLS, or EAP-TTLS and proceed to Configuring Tunneled TLS Settings
- Select **Protected EAP (PEAP)** for Protected Extensible Authentication Protocol and proceed to Configuring Protected EAP PEAP Settings

**Configuring TLS settings**

With Transport Layer Security (TLS), the client and server mutually authenticate using the TLS protocol.
Using TLS security requires the overhead of a public key infrastructure (PKI) to manage certificates. The benefit of using TLS security is that a compromised password does not allow access to the (W)LAN: an intruder must also have access to the authenticating client’s private key.

**NetworkManager** does not determine the version of TLS supported. **NetworkManager** gathers the parameters entered by the user and passes them to the daemon, **wpa_supplicant**, that handles the procedure. It in turn uses OpenSSL to establish the TLS tunnel. OpenSSL itself negotiates the SSL/TLS protocol version. It uses the highest version both ends support.

To configure TLS settings, follow the procedure described in Section 7.3.1, “Configuring a Wired (Ethernet) connection using control-center”. The following configuration settings are available:

**Identity**
- Provide the identity of this server.

**User certificate**
- Click to browse for, and select, a personal X.509 certificate file encoded with Distinguished Encoding Rules (DER) or Privacy Enhanced Mail (PEM).

**CA certificate**
- Click to browse for, and select, an X.509 certificate authority certificate file encoded with Distinguished Encoding Rules (DER) or Privacy Enhanced Mail (PEM).

**Private key**
- Click to browse for, and select, a private key file encoded with Distinguished Encoding Rules (DER), Privacy Enhanced Mail (PEM), or the Personal Information Exchange Syntax Standard (PKCS #12).

**Private key password**
- Enter the password for the private key in the Private key field. Select Show password to make the password visible as you type it.

**Configuring PWD settings**
With Password (PWD), you can specify the username and the password.

**Username**
- Enter the user name to be used in the authentication process.

**Password**
- Enter the password to be used in the authentication process.

**Configuring FAST settings**
To configure FAST settings, follow the procedure described in Section 7.3.1, “Configuring a Wired (Ethernet) connection using control-center”. The following configuration settings are available:

**Anonymous Identity**
- Provide the identity of this server.

**Allow automatic PAC provisioning**
- Select the check box to enable and then select from Anonymous, Authenticated, and Both.

**PAC file**
- Click to browse for, and select, a protected access credential (PAC) file.

**Inner authentication**
- GTC – Generic Token Card.
Username
Enter the user name to be used in the authentication process.

Password
Enter the password to be used in the authentication process.

Configuring tunneled TLS settings
To configure Tunneled TLS settings, follow the procedure described in Section 7.3.1, “Configuring a Wired (Ethernet) connection using control-center”. The following configuration settings are available:

Anonymous identity
This value is used as the unencrypted identity.

CA certificate
Click to browse for, and select, a Certificate Authority’s certificate.

Inner authentication
- MD5 – Message Digest 5, a cryptographic hash function.
- GTC – Generic Token Card.

Username
Enter the user name to be used in the authentication process.

Password
Enter the password to be used in the authentication process.

Configuring protected EAP (PEAP) settings
To configure Protected EAP (PEAP) settings, follow the procedure described in Section 7.3.1, “Configuring a Wired (Ethernet) connection using control-center”. The following configuration settings are available:

Anonymous Identity
This value is used as the unencrypted identity.

CA certificate
Click to browse for, and select, a Certificate Authority’s certificate.

PEAP version
The version of Protected EAP to use. Automatic, 0 or 1.

Inner authentication
- MD5 – Message Digest 5, a cryptographic hash function.
- GTC – Generic Token Card.
**7.4. CONNECTING TO A WI-FI NETWORK**

This procedure describes how you can connect to a wireless network to get access to the internet.

**Procedure**

1. Open the GNOME Shell network connection icon menu from the top right-hand corner of the screen.

2. Select **Wi-Fi Not Connected**.

3. Click the **Select Network** option.

4. Click the name of the network to which you want to connect, and then click **Connect**.
   Note that if you do not see the network, the network might be hidden.

5. If the network is protected by a password or encryption keys are required, enter the password and click **Connect**.
   Note that if you do not know the password, contact the administrator of the Wi-Fi network.

6. If the connection is successful, the name of the network is visible in the connection icon menu and the wireless indicator is on the top right-hand corner of the screen.

**Additional resources**

- Configuring a Wi-Fi connection using control center.

**7.5. CONFIGURING A WI-FI CONNECTION USING CONTROL-CENTER**

When you connect to a **Wi-Fi**, the network settings are prefilled depending on the current network connection. This means that the settings will be detected automatically when the interface connects to a network.

This procedure describes how to use **control-center** to manually configure the **Wi-Fi** settings.

**Prerequisites**

- Section 7.4, “Connecting to a Wi-Fi network”.

**Procedure**

1. Press the **Super** key to enter the **Activities Overview**, type **Wi-Fi** and press **Enter**. In the left-hand-side menu entry you see the list of available networks.

2. Select the gear wheel icon to the right of the **Wi-Fi** connection name that you want to edit, and the editing connection dialog appears. The **Details** menu window shows the connection details where you can make further configuration.

   **Options**

   a. If you select **Connect automatically**, **NetworkManager** auto-connects to this connection.
whenever NetworkManager detects that it is available. If you do not want NetworkManager to connect automatically, clear the check box. Note that when the check box is clear, you have to select that connection manually in the network connection icon’s menu to cause it to connect.

b. To make a connection available to other users, select the Make available to other users check box.

c. You can also control the background data usage. If you leave Restrict background data usage unspecified (default), then NetworkManager tries to download data that you are actively using. Otherwise, select the check box and NetworkManager sets the connection as metered, and applies restriction on the background data usage.

NOTE
To delete a Wi-Fi connection, click the Forget Connection red box.

3. Select the Identity menu entry to see the basic configuration options.
SSID — The Service Set Identifier (SSID) of the access point (AP).

BSSID — The Basic Service Set Identifier (BSSID) is the MAC address, also known as a hardware address, of the specific wireless access point you are connecting to when in Infrastructure mode. This field is blank by default, and you are able to connect to a wireless access point by SSID without having to specify its BSSID. If the BSSID is specified, it will force the system to associate to a specific access point only. For ad-hoc networks, the BSSID is generated randomly by the mac80211 subsystem when the ad-hoc network is created. It is not displayed by NetworkManager.

MAC address — The MAC address allows you to associate a specific wireless adapter with a specific connection (or connections).

Cloned Address — A cloned MAC address to use in place of the real hardware address. Leave blank unless required.

4. For further IP address configuration, select the IPv4 and IPv6 menu entries.
By default, both IPv4 and IPv6 are set to automatic configuration depending on current network settings. This means that addresses such as the local IP address, DNS address, and other settings will be detected automatically when the interface connects to a network. If a DHCP server assigns the IP configuration in this network, this is sufficient, but you can also provide static configuration in the IPv4 and IPv6 Settings. In the IPv4 and IPv6 menu entries, you can see the following settings:

- **IPv4 Method**
  - **Automatic (DHCP)** — Choose this option if the network you are connecting to uses Router Advertisements (RA) or a DHCP server to assign dynamic IP addresses. You can see the assigned IP address in the Details menu entry.
  - **Link-Local Only** — Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 3927 with prefix 169.254/16.
  - **Manual** — Choose this option if you want to assign IP addresses manually.
  - **Disable** — IPv4 is disabled for this connection.
• DNS
  If Automatic is ON, and no DHCP server is available that assigns DNS servers to this connection, switch it to OFF to enter the IP address of a DNS server separating the IPs by comma.

• Routes
  Note that in the Routes section, when Automatic is ON, routes from Router Advertisements (RA) or DHCP are used, but you can also add additional static routes. When OFF, only static routes are used.
  
  - Address – Enter the IP address of a remote network, sub-net, or host.
  - Netmask – The netmask or prefix length of the IP address entered above.
  - Gateway – The IP address of the gateway leading to the remote network, sub-net, or host entered above.
  - Metric – A network cost, a preference value to give to this route. Lower values will be preferred over higher values.

• Use this connection only for resources on its network
  Select this check box to prevent the connection from becoming the default route.

Alternatively, to configure IPv6 settings in a Wi-Fi connection, select the IPv6 menu entry:

• IPv6 Method
  
  - Automatic – Choose this option to use IPv6 Stateless Address AutoConfiguration (SLAAC) to create an automatic, stateless configuration based on the hardware address and Router Advertisements (RA).
  
  - Automatic, DHCP only – Choose this option to not use RA, but request information from DHCPv6 directly to create a stateful configuration.

  - Link-Local Only – Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 4862 with prefix FE80::0.
  
  - Manual – Choose this option if you want to assign IP addresses manually.
  
  - Disable – IPv6 is disabled for this connection.

• The DNS, Routes, Use this connection only for resources on its network fields are common to IPv4 settings.

5. To configure Security settings in a Wi-Fi connection, select the Security menu entry. The following configuration options are available:

• Security
  
  - None – Do not encrypt the Wi-Fi connection.

  - WEP 40/128-bit Key – Wired Equivalent Privacy (WEP), from the IEEE 802.11 standard. Uses a single pre-shared key (PSK).

  - WEP 128-bit Passphrase – An MD5 hash of the passphrase to derive a WEP key.
If the Wi-Fi use no encryption, WEP, or WPA, do not use the network because it is insecure and everyone can read the data you send over this network.

- **LEAP** – Lightweight Extensible Authentication Protocol, from Cisco Systems.
- **Dynamic WEP (802.1X)** – WEP keys are changed dynamically.
- **WPA & WPA2 Personal** – Wi-Fi Protected Access (WPA), from the draft IEEE 802.11i standard. A replacement for WEP. Wi-Fi Protected Access II (WPA2), from the 802.11i-2004 standard. Personal mode uses a pre-shared key (WPA-PSK).
- **WPA & WPA2 Enterprise** – WPA for use with a RADIUS authentication server to provide IEEE 802.1X network access control.

  - **Password** – Enter the password to be used in the authentication process.

6. Once you have finished the configuration, click the **Apply** button to save it.

**NOTE**

When you add a new connection by clicking the **plus** button, **NetworkManager** creates a new configuration file for that connection and then opens the same dialog that is used for editing an existing connection. The difference between these dialogs is that an existing connection profile has a **Details** menu entry.

## 7.6. CONFIGURING A VPN CONNECTION WITH CONTROL-CENTER

A Virtual Private Network (VPN) is a way of connecting to a local network over the internet. **IPsec**, provided by **Libreswan**, is the preferred method for creating a VPN. **Libreswan** is an open-source, user-space **IPsec** implementation for VPN. A Virtual Private Network (VPN) enables communication between your Local Area Network (LAN), and another, remote LAN. This is done by setting up a tunnel across an intermediate network such as the Internet. The VPN tunnel that is set up typically uses authentication and encryption.

This procedure describes how to configure a VPN connection using **control-center**.

**Prerequisites**

- The **NetworkManager-libreswan-gnome** package is installed.

- Start for adding a **VPN** connection as explained Section 7.2, “Creating a network connection using control-center”.

**Procedure**

1. Select the **Identity** menu entry to see the basic configuration options:
   
   **General**
**Gateway** – The name or **IP** address of the remote VPN gateway.

**Authentication**

**Type**

- **IKEv2 (Certificate)** – client is authenticated by certificate. It is more secure (default).

- **IKEv1 (XAUTH)** – client is authenticated by username and password, or secret (PSK).
  
  The following configuration settings are available under the **Advanced** section:
Figure 7.7. Advanced options of a VPN connection

[Image of IPsec Advanced Options window with fields for Identification, Security, and Connectivity options]
WARNING

When configuring an IPsec based VPN connection using the gnome-control-center application, the Advanced dialog will only display the configuration, but will not allow doing any change. As a consequence, users cannot change any advanced IPsec options. Use the nm-connection-editor or nmcli tools instead to perform configuration of the advanced properties.

Identification

Domain – If required, enter the Domain Name.

Security

• **Phase1 Algorithms** – corresponds to the ike Libreswan parameter – enter the algorithms to be used to authenticate and set up an encrypted channel.

• **Phase2 Algorithms** – corresponds to the esp Libreswan parameter – enter the algorithms to be used for the IPsec negotiations.
  
  ○ Check the Disable PFS field to turn off Perfect Forward Secrecy (PFS) to ensure compatibility with old servers that do not support PFS.

• **Phase1 Lifetime** – corresponds to the ikelifetime Libreswan parameter – how long the key used to encrypt the traffic will be valid.

• **Phase2 Lifetime** – corresponds to the salifetime Libreswan parameter – how long how long a particular instance of a connection should last before expiring.
  
  Note that the encryption key should be changed from time to time for security reasons.

• **Remote network** – corresponds to the rightsubnet Libreswan parameter – the destination private remote network that should be reached through the VPN.
  
  ○ Check the narrowing field to enable narrowing. Note that it is only effective in IKEv2 negotiation.

• **Enable fragmentation** – corresponds to the fragmentation Libreswan parameter – whether or not to allow IKE fragmentation. Valid values are yes (default), or no.

• **Enable Mobike** – corresponds to the mobike Libreswan parameter – whether to allow MOBIKE (RFC 4555) to enable a connection to migrate its endpoint without needing to restart the connection from scratch. This is used on mobile devices that switch between wired, wireless or mobile data connections. The values are no (default) or yes.

2. For further configuration, select the IPv4 menu entry:

• **IPv4 Method**
  
  ○ **Automatic (DHCP)** – Choose this option if the network you are connecting to uses Router Advertisements (RA) or a DHCP server to assign dynamic IP addresses.
- **Link-Local Only** – Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 3927 with prefix 169.254/16.

- **Manual** – Choose this option if you want to assign IP addresses manually.

- **Disable** – IPv4 is disabled for this connection.

- **DNS**
  In the DNS section, when **Automatic** is ON, switch it to OFF to enter the IP address of a DNS server you want to use separating the IPs by comma.

- **Routes**
  Note that in the Routes section, when **Automatic** is ON, routes from Router Advertisements (RA) or DHCP are used, but you can also add additional static routes. When OFF, only static routes are used.

  - **Address** – Enter the IP address of a remote network, sub-net, or host.
  
  - **Netmask** – The netmask or prefix length of the IP address entered above.

  - **Gateway** – The IP address of the gateway leading to the remote network, sub-net, or host entered above.

  - **Metric** – A network cost, a preference value to give to this route. Lower values will be preferred over higher values.

- **Use this connection only for resources on its network**
  Select this check box to prevent the connection from becoming the default route. Selecting this option means that only traffic specifically destined for routes learned automatically over the connection or entered here manually will be routed over the connection.

3. Alternatively, to configure IPv6 settings in a VPN connection, select the IPv6 menu entry:

- **IPv6 Method**
  
  - **Automatic** – Choose this option to use IPv6 Stateless Address AutoConfiguration (SLAAC) to create an automatic, stateless configuration based on the hardware address and Router Advertisements (RA).

  - **Automatic, DHCP only** – Choose this option to not use RA, but request information from DHCPv6 directly to create a stateful configuration.

  - **Link-Local Only** – Choose this option if the network you are connecting to does not have a DHCP server and you do not want to assign IP addresses manually. Random addresses will be assigned as per RFC 4862 with prefix FE80::0.

  - **Manual** – Choose this option if you want to assign IP addresses manually.

  - **Disable** – IPv6 is disabled for this connection.
  
  Note that DNS, Routes, Use this connection only for resources on its network are common to IPv4 settings.

4. Once you have finished editing the VPN connection, click the Add button to customize the configuration or the Apply button to save it for the existing one.

5. Switch the profile to ON to active the VPN connection.
NOTE

When you add a new connection by clicking the plus button, NetworkManager creates a new configuration file for that connection and then opens the same dialog that is used for editing an existing connection. The difference between these dialogs is that an existing connection profile has a Details menu entry.

Additional resources

- For more details on the supported Libreswan parameters, see the nm-settings-libreswan man page.

7.7. CONFIGURING A STATIC ROUTE USING CONTROL-CENTER

You can use control-center in GNOME to add a static route to the configuration of a network connection.

The procedure in this section describes how to add a route to the 192.0.2.0/24 network that uses the gateway running on 198.51.100.1.

Prerequisites

- The network is configured.
- The gateway for the static route must be directly reachable on the interface.
- The network configuration of the connection is opened in the control-center application. See Section 7.3, “Configuring a network connection using control-center”.

Procedure

1. Open the IPv4 tab.

2. Optionally, disable automatic routes by clicking the On button in the Routes section of the IPv4 tab to use only static routes. If automatic routes are enabled, Red Hat Enterprise Linux uses static routes and routes received from a DHCP server.

3. Enter the address, netmask, gateway, and optionally a metric value:

4. Click Apply.

5. Back in the Network window, disable and re-enable the connection by switching the button for the connection to Off and back to On for changes to take effect.
6. Optionally, verify that the route is active:

   ```
   $ ip route
   ...
   192.0.2.0/24 via 198.51.100.1 dev example proto static metric 100
   ```

7.8. CONFIGURING A STATIC ROUTE USING NM-CONNECTION-EDITOR

You can use the `nm-connection-editor` application to add a static route to the configuration of a network connection.

The procedure in this section describes how to add a route to the 192.0.2.0/24 network that uses the gateway running on 198.51.100.1, which is reachable through the `example` connection.

**Prerequisites**

- The network is configured.
- The gateway for the static route must be directly reachable on the interface.

**Procedure**

1. Open a terminal and enter `nm-connection-editor`:

   ```
   $ nm-connection-editor
   ```

2. Select the `example` connection and click the gear wheel icon to edit the existing connection.

3. Open the `IPv4` tab.

4. Click the `Routes` button.

5. Click the `Add` button and enter the address, netmask, gateway, and optionally a metric value.

   ![Editing IPv4 routes for example](image)

6. Click `OK`. 

---

**WARNING**

Restarting the connection briefly disrupts connectivity on that interface.
7. Click Save.

8. Restart the network connection for changes to take effect. For example, to restart the example connection using the command line:

```
$ sudo nmcli connection up example
```

9. Optionally, verify that the route is active:

```
$ ip route
... 192.0.2.0/24 via 198.51.100.1 dev example proto static metric 100
```

### 7.9. Setting the Default Gateway on an Existing Connection Using Control-Center

In most situations, administrators set the default gateway when they create a connection as explained in, for example, Section 7.3, “Configuring a network connection using control-center”. This section describes how to set or update the default gateway on a previously created connection using the control-center application.

**Prerequisites**

- At least one static IP address must be configured on the connection on which the default gateway will be set.
- The network configuration of the connection is open in the control-center application. See Section 7.3, “Configuring a network connection using control-center”.

**Procedure**

1. Set the IPv4 default gateway. For example, to set the IPv4 address of the default gateway on the connection to 192.0.2.1:
   a. Open the IPv4 tab.
   b. Enter the address in the gateway field next to the IP range the gateway’s address is within:

<table>
<thead>
<tr>
<th>Address</th>
<th>Netmask</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.0.2.123</td>
<td>255.255.255.0</td>
<td>192.0.2.1</td>
</tr>
</tbody>
</table>

2. Set the IPv6 default gateway. For example, to set the IPv6 address of the default gateway on the connection to 2001:db8::1:
   a. Open the IPv6 tab.
   b. Enter the address in the gateway field next to the IP range the gateway’s address is within:

<table>
<thead>
<tr>
<th>Address</th>
<th>Prefix</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001:db8::5</td>
<td>64</td>
<td>2001:db8::1</td>
</tr>
</tbody>
</table>
3. Click **Apply**.

4. Back in the **Network** window, disable and re-enable the connection by switching the button for the connection to **Off** and back to **On** for changes to take effect.

![WARNING]

All connections currently using this network connection are temporarily interrupted during the restart.

5. Optionally, verify that the route is active.
   
   To display the IPv4 default gateway:
   
   ```bash
   $ ip -4 route
default via 192.0.2.1 dev example proto static metric 100
   ```

   To display the IPv6 default gateway:
   
   ```bash
   $ ip -6 route
default via 2001:db8::1 dev example proto static metric 100 pref medium
   ```

**Additional resources**

- Section 7.3, “Configuring a network connection using control-center”

### 7.10. SETTING THE DEFAULT GATEWAY ON AN EXISTING CONNECTION USING NM-CONNECTION-EDITOR

In most situations, administrators set the default gateway when they create a connection as explained in, for example, Section 7.3, “Configuring a network connection using control-center”.

This section describes how to set or update the default gateway on a previously created connection using the **nm-connection-editor** application.

**Prerequisites**

- At least one static IP address must be configured on the connection on which the default gateway will be set.

**Procedure**

1. Open a terminal, and enter **nm-connection-editor**:

   ```bash
   $ nm-connection-editor
   ```

2. Select the connection to modify, and click the gear wheel icon to edit the existing connection.

3. Set the IPv4 default gateway. For example, to set the IPv4 address of the default gateway on the connection to **192.0.2.1**: 

   ```bash
   $ nm-connection-editor
   ```
a. Open the **IPv4 Settings** tab.

b. Enter the address in the **gateway** field next to the IP range the gateway’s address is within:

<table>
<thead>
<tr>
<th>Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>192.0.2.123</td>
</tr>
</tbody>
</table>

4. Set the IPv6 default gateway. For example, to set the IPv6 address of the default gateway on the connection to **2001:db8::1**:

a. Open the **IPv6** tab.

b. Enter the address in the **gateway** field next to the IP range the gateway’s address is within:

<table>
<thead>
<tr>
<th>Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>2001:db8::5</td>
</tr>
</tbody>
</table>

5. Click **OK**.

6. Click **Save**.

7. Restart the network connection for changes to take effect. For example, to restart the **example** connection using the command line:

```bash
$ sudo nmcli connection up example
```

**WARNING**

All connections currently using this network connection are temporarily interrupted during the restart.

8. Optionally, verify that the route is active.

To display the IPv4 default gateway:

```bash
$ ip -4 route
default via 192.0.2.1 dev example proto static metric 100
```

To display the IPv6 default gateway:

```bash
$ ip -6 route
default via 2001:db8::1 dev example proto static metric 100 pref medium
```

**Additional resources**

- Section 7.3, “Configuring a network connection using control-center”
7.11. CONFIGURING NETWORK BONDING USING NM-CONNECTION-EDITOR

This section describes the basics of network bonding, the differences between bonding and teaming, and how to configure a network bond on Red Hat Enterprise Linux 8 using the `nm-connection-editor` application.

7.11.1. Understanding network bonding

Network bonding is a method to combine or aggregate network interfaces to provide a logical interface with higher throughput or redundancy.

The `active-backup`, `balance-tlb`, and `balance-alb` modes do not require any specific configuration of the network switch. However, other bonding modes require configuring the switch to aggregate the links. For example, Cisco switches require `EtherChannel` for modes 0, 2, and 3, but for mode 4, the Link Aggregation Control Protocol (LACP) and `EtherChannel` are required.

For further details, see the documentation of your switch and https://www.kernel.org/doc/Documentation/networking/bonding.txt.

![IMPORTANT](image)

Certain network bonding features, such as the fail-over mechanism, do not support direct cable connections without a network switch. For further details, see the Is bonding supported with direct connection using crossover cables? KCS solution.

7.11.2. Understanding the default behavior of master and slave interfaces

Consider the following default behavior of, when managing or troubleshooting team or bond port interfaces using the `NetworkManager` service:

- Starting the master interface does not automatically start the port interfaces.
- Starting a port interface always starts the master interface.
- Stopping the master interface also stops the port interface.
- A master without ports can start static IP connections.
- A master without ports waits for ports when starting DHCP connections.
- A master with a DHCP connection waiting for ports completes when you add a port with a carrier.
- A master with a DHCP connection waiting for ports continues waiting when you add a port without carrier.

7.11.3. Comparison of network teaming and bonding features

The following table compares features supported in network teams and network bonds:
<table>
<thead>
<tr>
<th>Feature</th>
<th>Network bond</th>
<th>Network team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Round-robin Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Active-backup Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP (802.3ad) support</td>
<td>Yes (active only)</td>
<td>Yes</td>
</tr>
<tr>
<td>Hash-based Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User can set hash function</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tx load-balancing support (TLB)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP hash port select</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Load-balancing for LACP support</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethtool link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ARP link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NS/NA (IPv6) link monitoring</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ports up/down delays</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Port priorities and stickiness (&quot;primary&quot; option enhancement)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Separate per-port link monitoring setup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple link monitoring setup</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Lockless Tx/Rx path</td>
<td>No (rwlock)</td>
<td>Yes (RCU)</td>
</tr>
<tr>
<td>VLAN support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User-space runtime control</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Logic in user-space</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Hard</td>
<td>Easy</td>
</tr>
<tr>
<td>Modular design</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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86
<table>
<thead>
<tr>
<th>Feature</th>
<th>Network bond</th>
<th>Network team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance overhead</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>D-Bus interface</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple device stacking</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zero config using LLDP</td>
<td>No</td>
<td>(in planning)</td>
</tr>
<tr>
<td>NetworkManager support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

7.11.4. Configuring a network bond using nm-connection-editor

This section describes how to configure a network bond using the `nm-connection-editor` application.

**Prerequisites**

- Two or more network cards are installed in the server.
- The network cards are connected to a switch.

**Procedure**

1. Open a terminal, and enter `nm-connection-editor`:

   ```bash
   $ nm-connection-editor
   ```

2. Click the + button to add a new connection.

3. Select the **Bond** connection type, and click **Create**.

4. On the **Bond** tab:
   a. Optionally, set the name of the bond interface in the **Interface name** field.
   b. Click the **Add** button to add a network interface as a slave to the bond.
      i. Select the connection type of the interface. For example, select **Ethernet** for a wired connection.
      ii. Optionally, set a connection name for the slave device.
      iii. In the **Device** field on the **Ethernet** tab, select the network interface you want to add as a slave to the bond.

   **IMPORTANT**
   You can only use network interfaces in a bond that are not configured.

   iv. Click **Save**.
   
   c. Repeat the previous step for each interface you want to add to the bond:
Optional, set other options, such as the Media Independent Interface (MII) monitoring interval.

5. On the IPv4 Settings tab, configure the IPv4 settings. For example, set a static IPv4 address, network mask, default gateway, and DNS server:

6. On the IPv6 Settings tab, configure the IPv6 settings. For example, set a static IPv6 address, network mask, default gateway, and DNS server:
7. Click **Save** to save the bond connection.

8. Close **nm-connection-editor**.

9. Optionally, display the status of the bond:

```bash
$ cat /proc/net/bonding/_bond0_
Ethernet Channel Bonding Driver: v3.7.1 (April 27, 2011)

Bonding Mode: fault-tolerance (active-backup)
Primary Slave: None
Currently Active Slave: enp7s0
MII Status: up
MII Polling Interval (ms): 100
Up Delay (ms): 0
Down Delay (ms): 0

Slave Interface: enp7s0
MII Status: up
Speed: Unknown
Duplex: Unknown
Link Failure Count: 0
Permanent HW addr: 52:54:00:d5:e0:fb
Slave queue ID: 0

Slave Interface: enp8s0
MII Status: up
Speed: Unknown
Duplex: Unknown
```
7.12. CONFIGURING A NETWORK BRIDGE USING NM-CONNECTION-EDITOR

This section explains how to configure a network bridge using the `nm-connection-editor` application.

A network bridge is a link-layer device which forwards traffic between networks based on MAC addresses. The bridge device decides on forwarding packages based on a table of MAC addresses. The bridge builds the MAC addresses table by listening to network traffic and thereby learning what hosts are connected to each network.

For example, you can use a software bridge on a Red Hat Enterprise Linux 8 host:

- To emulate a hardware bridge
- In virtualization environments, to integrate virtual machines (VM) to the same network as the host

Due to the IEEE 802.11 standard which specifies the use of 3-address frames in Wi-Fi for the efficient use of airtime, you cannot configure a bridge over Wi-Fi networks operating in Ad-Hoc or Infrastructure modes.

Prerequisites

- Two or more physical or virtual network devices are installed in the server.

Procedure

1. Open a terminal, and enter `nm-connection-editor`:

   ```
   $ nm-connection-editor
   ```

2. Click the + button to add a new connection.

3. Select the Bridge connection type, and click Create.

   a. Optionally, set the name of the bridge interface in the Interface name field.

   b. Click the Add button to add a network interface as a slave to the bridge.

      i. Select the connection type of the interface. For example, select Ethernet for a wired connection.

      ii. Optionally, set a connection name for the slave device.

      iii. In the Device field on the Ethernet tab, select the network interface you want to add as a slave to the bridge.

        iv. Click Save.

   c. Repeat the previous step for each interface you want to add to the bridge.
i. Optionally, configure further bridge settings, such as Spanning Tree Protocol (STP) options.

4. On the IPv4 Settings tab, configure the IPv4 settings. For example, set a static IPv4 address, network mask, default gateway, and DNS server:

<table>
<thead>
<tr>
<th>Address</th>
<th>Netmask</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.0.2.1</td>
<td>24</td>
<td>192.0.2.254</td>
</tr>
</tbody>
</table>

DNS servers: 192.0.2.1
5. On the **IPv6 Settings** tab, configure the IPv6 settings. For example, set a static IPv6 address, network mask, default gateway, and DNS server:

![Editing Bridge connection 1](image)

<table>
<thead>
<tr>
<th>Connection name:</th>
<th>Bridge connection 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Bridge</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Proxy</strong></td>
<td></td>
</tr>
<tr>
<td><strong>IPv4 Settings</strong></td>
<td></td>
</tr>
<tr>
<td><strong>IPv6 Settings</strong></td>
<td></td>
</tr>
<tr>
<td>Method:</td>
<td>Manual</td>
</tr>
<tr>
<td><strong>Addresses</strong></td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td>Prefix</td>
</tr>
<tr>
<td>2001:db8:1</td>
<td>32</td>
</tr>
<tr>
<td>DNS servers:</td>
<td>2001:db8::fffd</td>
</tr>
</tbody>
</table>

6. Save the bridge connection.

7. Close **nm-connection-editor**.

8. Optionally, use the following command to display the status of the bridge:

   ```
   # bridge link show bridge0
   3: enp7s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 master bridge0 state forwarding priority 32 cost 100
   4: enp8s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 master bridge0 state listening priority 32 cost 100
   ```

### 7.13. CONFIGURING A NETWORK TEAM USING NM-CONNECTION-EDITOR

This section describes the basics of network teaming, the differences between bonding and teaming, and how to configure a network team on Red Hat Enterprise Linux 8 using the **nm-connection-editor** application.

**Prerequisites**

- Red Hat Enterprise Linux 8 is installed.
- The system has an active subscription assigned.

#### 7.13.1. Understanding network teaming

Network teaming is a feature that combines or aggregates network interfaces to provide a logical interface with higher throughput or redundancy.

Network teaming uses a kernel driver to implement fast handling of packet flows, as well as user-space libraries and services for other tasks. This way, network teaming is an easily extensible and scalable solution for load-balancing and redundancy requirements.
Note that in the context of network teaming, the term **port** is also known as **slave**. In the **teamd** service, the term **port** is preferred while in the **NetworkManager** service, the term **slave** refers to interfaces which create a team.

**IMPORTANT**

Certain network teaming features, such as the fail-over mechanism, do not support direct cable connections without a network switch. For further details, see Is bonding supported with direct connection using crossover cables?

### 7.13.2. Understanding the default behavior of master and slave interfaces

Consider the following default behavior of, when managing or troubleshooting team or bond port interfaces using the **NetworkManager** service:

- Starting the master interface does not automatically start the port interfaces.
- Starting a port interface always starts the master interface.
- Stopping the master interface also stops the port interface.
- A master without ports can start static IP connections.
- A master without ports waits for ports when starting DHCP connections.
- A master with a DHCP connection waiting for ports completes when you add a port with a carrier.
- A master with a DHCP connection waiting for ports continues waiting when you add a port without carrier.

### 7.13.3. Comparison of network teaming and bonding features

The following table compares features supported in network teams and network bonds:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Network bond</th>
<th>Network team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Round-robin Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Active-backup Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LACP (802.3ad) support</td>
<td>Yes (active only)</td>
<td>Yes</td>
</tr>
<tr>
<td>Hash-based Tx policy</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User can set hash function</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Tx load-balancing support (TLB)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Feature</td>
<td>Network bond</td>
<td>Network team</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>LACP hash port select</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
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<td>No</td>
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</tr>
<tr>
<td>Ethtool link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ARP link monitoring</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NS/NA (IPv6) link monitoring</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Ports up/down delays</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Port priorities and stickiness (“primary” option enhancement)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Separate per-port link monitoring setup</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple link monitoring setup</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Lockless Tx/Rx path</td>
<td>No (rwlock)</td>
<td>Yes (RCU)</td>
</tr>
<tr>
<td>VLAN support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User-space runtime control</td>
<td>Limited</td>
<td>Yes</td>
</tr>
<tr>
<td>Logic in user-space</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Hard</td>
<td>Easy</td>
</tr>
<tr>
<td>Modular design</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Performance overhead</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>D-Bus interface</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multiple device stacking</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Zero config using LLDP</td>
<td>No</td>
<td>(in planning)</td>
</tr>
<tr>
<td>NetworkManager support</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### 7.13.4. Understanding the teamd service, runners, and link-watchers
The team service, **teamd**, controls one instance of the team driver. This instance of the driver adds instances of a hardware device driver to form a team of network interfaces. The team driver presents a network interface, for example **team0**, to the kernel.

The **teamd** service implements the common logic to all methods of teaming. Those functions are unique to the different load sharing and backup methods, such as round-robin, and implemented by separate units of code referred to as **runners**. Administrators specify runners in JavaScript Object Notation (JSON) format, and the JSON code is compiled into an instance of **teamd** when the instance is created. Alternatively, when using **NetworkManager**, you can set the runner in the **team.runner** parameter, and **NetworkManager** auto-creates the corresponding JSON code.

The following runners are available:

- **broadcast**: Transmits data over all ports.
- **roundrobin**: Transmits data over all ports in turn.
- **activebackup**: Transmits data over one port while the others are kept as a backup.
- **loadbalance**: Transmits data over all ports with active Tx load balancing and Berkeley Packet Filter (BPF)-based Tx port selectors.
- **random**: Transmits data on a randomly selected port.
- **lacp**: Implements the 802.3ad Link Aggregation Control Protocol (LACP).

The **teamd** services uses a link watcher to monitor the state of subordinate devices. The following link-watchers are available:

- **ethtool**: The **libteam** library uses the **ethtool** utility to watch for link state changes. This is the default link-watcher.
- **arp_ping**: The **libteam** library uses the **arp_ping** utility to monitor the presence of a far-end hardware address using Address Resolution Protocol (ARP).
- **nsna_ping**: On IPv6 connections, the **libteam** library uses the Neighbor Advertisement and Neighbor Solicitation features from the IPv6 Neighbor Discovery protocol to monitor the presence of a neighbor’s interface.

Each runner can use any link watcher, with the exception of **lacp**. This runner can only use the **ethtool** link watcher.

### 7.13.5. Installing the teamd service

To configure a network team in **NetworkManager**, you require the **teamd** service and the team plug-in for **NetworkManager**. Both are installed on Red Hat Enterprise Linux 8 by default. This section describes how you install the required packages in case that you remove them.

#### Prerequisites

- An active Red Hat subscription is assigned to the host.

#### Procedure

1. Install the **teamd** and **NetworkManager-team** packages:

   ```bash
   # yum install teamd NetworkManager-team
   ```
7.13.6. Configuring a network team using nm-connection-editor

This section describes how you configure a network team using the nm-connection-editor application.

Prerequisites

- Two or more network cards are installed in the server.
- The network cards are connected to a switch.

Procedure

1. Open a terminal, and enter nm-connection-editor:

   ```bash
   $ nm-connection-editor
   ```

2. Click the + button to add a new connection.

3. Select the Team connection type, and click Create.

4. On the Team tab:
   a. Optionally, set the name of the team interface in the Interface name field.
   b. Click the Add button to add a network interface as a slave to the team.
      i. Select the connection type of the interface. For example, select Ethernet for a wired connection.
      ii. Optionally, set a connection name for the slave device.
      iii. In the Device field on the Ethernet tab, select the network interface you want to add as a slave to the team.

      **IMPORTANT**

      You can only use network interfaces in a team that are not configured.

   iv. Click Save.
   c. Repeat the previous step for each interface you want to add to the team.
d. Click the **Advanced** button to set advanced options to the team connection.
   
i. On the **Runner** tab, select the runner.
   
ii. On the **Link Watcher** tab, set the link link watcher and its optional settings.
   
iii. Click **OK**.

5. On the **IPv4 Settings** tab, configure the IPv4 settings. For example, set a static IPv4 address, network mask, default gateway, and DNS server:
6. On the IPv6 Settings tab, configure the IPv6 settings. For example, set a static IPv6 address, network mask, default gateway, and DNS server:

![IPv6 Settings tab](image)

6. Click **Save** to save the team connection.

7. Close **nm-connection-editor**.

8. Optionally, display the status of the team:

```
# teamdctl team0 state
setup:
 runner: activebackup
ports:
enp7s0
  link watches:
    link summary: up
   instance[link_watch_0]:
     name: ethtool
     link: up
down count: 0
enp8s0
  link watches:
    link summary: up
   instance[link_watch_0]:
     name: ethtool
     link: up
down count: 0
runner:
active port: enp7s0
```

9. **Additional resources**

   - Section 7.13.4, "Understanding the teamd service, runners, and link-watchers".
7.14. CONFIGURING VLAN TAGGING USING NM-CONNECTION-EDITOR

This section describes how to configure Virtual Local Area Network (VLAN) tagging using the nm-connection-editor application. A VLAN is a logical network within a physical network. The VLAN interface tags packets with the VLAN ID as they pass through the interface, and removes tags of returning packets.

You create a VLAN interface on top of another interface, such as Ethernet, bond, team, or bridge. This interface is called the parent interface.

Prerequisites

- The interface you plan to use as a parent to the virtual VLAN interface supports VLAN tags.
- If you configure the VLAN on top of a bond interface:
  - The slaves of the bond are up.
  - The bond is not configured with the fail_over_mac=follow option. A VLAN virtual device cannot change its MAC address to match the parent’s new MAC address. In such a case, the traffic would still be sent with the then incorrect source MAC address.
- The switch the host is connected to is configured to support VLAN tags. For details, see the documentation of your switch.

Procedure

1. Open a terminal, and enter nm-connection-editor:

```
$ nm-connection-editor
```

2. Click the + button to add a new connection.

3. Select the VLAN connection type, and click Create.

4. On the VLAN tab:
   a. Select the parent interface.
   b. Select the VLAN id. Note that the VLAN must be within the range from 0 to 4094.
   c. By default, the VLAN connection inherits the maximum transmission unit (MTU) from the parent interface. Optionally, set a different MTU value.
   d. Optionally, set the name of the VLAN interface and further VLAN-specific options.
5. On the **IPv4 Settings** tab, configure the IPv4 settings. For example, set a static IPv4 address, network mask, default gateway, and DNS server:

```
<table>
<thead>
<tr>
<th>Address</th>
<th>Netmask</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.0.2.1</td>
<td>24</td>
<td>192.0.2.254</td>
</tr>
</tbody>
</table>
```

DNS servers: 192.0.2.253
6. On the **IPv6 Settings** tab, configure the IPv6 settings. For example, set a static IPv6 address, network mask, default gateway, and DNS server:

![Editing VLAN connection 1](image)

- Addresses:
  - Address: 2001:db8::1, Prefix: 32, Gateway: 2001:db8::ffe

**DNS servers:** 2001:db8::fffd

7. Click **Save** to save the VLAN connection.

8. Close **nm-connection-editor**.

9. Optionally, verify the settings:

```
# ip -d addr show vlan10
4: vlan10@enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
  state UP group default qlen 1000
    link/ether 52:54:00:d5:e0:fb brd ff:ff:ff:ff:ff:ff promiscuity 0
    vlan protocol 802.1Q id 10 <REORDER_HDR> numtxqueues 1 numrxqueues 1
    gso_max_size 65536 gso_max_segs 65535
    inet 192.0.2.1/24 brd 192.0.2.255 scope global noprefixroute vlan10
      valid_lft forever preferred_lft forever
    inet6 fe80::8dd7:9030:6f8e:89e6/64 scope link noprefixroute
      valid_lft forever preferred_lft forever
```
CHAPTER 8. CONFIGURING IP NETWORKING WITH IFCFG FILES

This section describes how to configure a network interface manually by editing the ifcfg files.

Interface configuration (ifcfg) files control the software interfaces for individual network devices. As the system boots, it uses these files to determine what interfaces to bring up and how to configure them. These files are usually named ifcfg-name, where the suffix name refers to the name of the device that the configuration file controls. By convention, the ifcfg file’s suffix is the same as the string given by the DEVICE directive in the configuration file itself.

Note, that in RHEL 8 ifcfg files demand NetworkManager running to use the functionality of the current solution.

8.1. CONFIGURING AN INTERFACE WITH STATIC NETWORK SETTINGS USING IFCFG FILES

This procedure describes how to configure a network interface using ifcfg files.

Prerequisites

- NetworkManager running.

Procedure

To configure an interface with static network settings using ifcfg files, for an interface with the name eth0, create a file with the name ifcfg-eth0 in the /etc/sysconfig/network-scripts/ directory that contains:

- For IPv4 configuration:
  
  ```
  DEVICE=eth0
  BOOTPROTO=None
  ONBOOT=yes
  PREFIX=24
  IPADDR=10.0.1.27
  GATEWAY=10.0.1.1
  ```

- For IPv6 configuration:
  
  ```
  DEVICE=eth0
  BOOTPROTO=None
  ONBOOT=yes
  IPV6INIT=yes
  IPV6ADDR=2001:db8::2/48
  ```

  For more IPv6 ifcfg configuration options, see nm-settings-ifcfg-rh(5) man page.

8.2. CONFIGURING AN INTERFACE WITH DYNAMIC NETWORK SETTINGS USING IFCFG FILES

This procedure describes how to configure a network interface with dynamic network settings using ifcfg files.
Prerequisites

- NetworkManager running.

Procedure

1. To configure an interface named em1 with dynamic network settings using ifcfg files, create a file with the name ifcfg-em1 in the /etc/sysconfig/network-scripts/ directory that contains:

   ```
   DEVICE=em1
   BOOTPROTO=dhcp
   ONBOOT=yes
   ```

2. To configure an interface to send a different host name to the DHCP server, add the following line to the ifcfg file:

   ```
   DHCP_HOSTNAME=hostname
   ```

3. To configure an interface to send a different fully qualified domain name (FQDN) to the DHCP server, add the following line to the ifcfg file:

   ```
   DHCP_FQDN=fully.qualified.domain.name
   ```

   **NOTE**

   Only one directive, either DHCP_HOSTNAME or DHCP_FQDN, should be used in a given ifcfg file. In case both DHCP_HOSTNAME and DHCP_FQDN are specified, only the latter is used.

4. To configure an interface to use particular DNS servers, add the following lines to the ifcfg file:

   ```
   PEERDNS=no
   DNS1=ip-address
   DNS2=ip-address
   ```

   where ip-address is the address of a DNS server. This will cause the network service to update /etc/resolv.conf with the specified DNS servers specified. Only one DNS server address is necessary, the other is optional.

8.3. MANAGING SYSTEM-WIDE AND PRIVATE CONNECTION PROFILES WITH IFCFG FILES

This procedure describes how to configure ifcfg files to manage the system-wide and private connection profiles.

Prerequisites

- NetworkManager running.

Procedure

The permissions correspond to the USERS directive in the ifcfg files. If the USERS directive is not present, the network profile will be available to all users.
1. As an example, modify the `ifcfg` file with the following row, which will make the connection available only to the users listed:

```bash
users="joe bob alice"
```
CHAPTER 9. CONFIGURING MACSEC

The following section provides information on how to configure Media Control Access Security (MACsec), which is an 802.1AE IEEE standard security technology for secure communication in all traffic on Ethernet links.

9.1. INTRODUCTION TO MACSEC

Media Access Control Security (MACsec, IEEE 802.1AE) encrypts and authenticates all traffic in LANs with the GCM-AES-128 algorithm. MACsec can protect not only IP but also Address Resolution Protocol (ARP), Neighbor Discovery (ND), or DHCP. While IPsec operates on the network layer (layer 3) and SSL or TLS on the application layer (layer 7), MACsec operates in the data link layer (layer 2). Combine MACsec with security protocols for other networking layers to take advantage of different security features that these standards provide.

9.2. USING MACSEC WITH NMCLI TOOL

This procedure shows how to configure MACsec with nmcli tool.

Prerequisites

- The NetworkManager must be running.
- You already have a 16-byte hexadecimal CAK ($MKA_CAK) and a 32-byte hexadecimal CKN ($MKA_CKN).

Procedure

```bash
~]$ nmcli connection add type macsec \
    con-name test-macsec+ ifname macsec0 \
    connection.autoconnect no \
    macsec.parent eth0 macsec.mode psk \
    macsec.mka-cak $MKA_CAK \
    macsec.mka-ckn $MKA_CKN
```

After this step, the macsec0 device is configured and can be used for networking.

9.3. USING MACSEC WITH WPA_SUPPLICANT

This procedure shows how to enable MACsec with a switch that performs authentication using a pre-shared Connectivity Association Key/CAK Name (CAK/CKN) pair.

Procedure

1. Create a CAK/CKN pair. For example, the following command generates a 16-byte key in hexadecimal notation:

   ```bash
   ~]$ dd if=/dev/urandom count=16 bs=1 2>/dev/null | hexdump -e '1/2 "%02x"'
   ```

2. Create the wpa_supplicant.conf configuration file and add the following lines to it:

   ```
   ctrl_interface=/var/run/wpa_supplicant
   ```
Use the values from the previous step to complete the `mka_cak` and `mka_ckn` lines in the `wpa_supplicant.conf` configuration file.

For more information, see the `wpa_supplicant.conf(5)` man page.

3. Assuming you are using `eth0` to connect to your network, start `wpa_supplicant` using the following command:

```
~# wpa_supplicant -i eth0 -Dmacsec_linux -c wpa_supplicant.conf
```

9.4. RELATED INFORMATION

For more details, see the What’s new in MACsec: setting up MACsec using wpa_supplicant and (optionally) NetworkManager article. In addition, see the MACsec: a different solution to encrypt network traffic article for more information about the architecture of a MACsec network, use case scenarios, and configuration examples.
CHAPTER 10. GETTING STARTED WITH IPVLAN

This document describes the IPVLAN driver.

10.1. IPVLAN OVERVIEW

IPVLAN is a driver for a virtual network device that can be used in container environment to access the host network. IPVLAN exposes a single MAC address to the external network regardless the number of IPVLAN device created inside the host network. This means that a user can have multiple IPVLAN devices in multiple containers and the corresponding switch reads a single MAC address. IPVLAN driver is useful when the local switch imposes constraints on the total number of MAC addresses that it can manage.

10.2. IPVLAN MODES

The following modes are available for IPVLAN:

- **L2 mode**
  In IPVLAN L2 mode, virtual devices receive and respond to Address Resolution Protocol (ARP) requests. The netfilter framework runs only inside the container that owns the virtual device. No netfilter chains are executed in the default namespace on the containerized traffic. Using **L2 mode** provides good performance, but less control on the network traffic.

- **L3 mode**
  In **L3 mode**, virtual devices process only **L3** traffic and above. Virtual devices do not respond to ARP request and users must configure the neighbour entries for the IPVLAN IP addresses on the relevant peers manually. The egress traffic of a relevant container is landed on the netfilter POSTROUTING and OUTPUT chains in the default namespace while the ingress traffic is threaded in the same way as **L2 mode**. Using **L3 mode** provides good control but decreases the network traffic performance.

- **L3S mode**
  In **L3S mode**, virtual devices process the same way as in **L3 mode**, except that both egress and ingress traffics of a relevant container are landed on netfilter chain in the default namespace. **L3S mode** behaves in a similar way to **L3 mode** but provides greater control of the network.

**NOTE**

The IPVLAN virtual device does not receive broadcast and multicast traffic in case of **L3** and **L3S modes**.

10.3. OVERVIEW OF MACVLAN

The MACVLAN driver allows to create multiple virtual network devices on top of a single NIC, each of them identified by its own unique MAC address. Packets which land on the physical NIC are demultiplexed towards the relevant MACVLAN device via MAC address of the destination. MACVLAN devices do not add any level of encapsulation.

10.4. COMPARISON OF IPVLAN AND MACVLAN

The following table shows the major differences between MACVLAN and IPVLAN.
### Table: MACVLAN vs IPVLAN

<table>
<thead>
<tr>
<th>MACVLAN</th>
<th>IPVLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses MAC address for each MACVLAN device. The overlimit of MAC addresses of MAC table in switch might cause loosing the connectivity.</td>
<td>Uses single MAC address which does not limit the number of IPVLAN devices.</td>
</tr>
<tr>
<td>Netfilter rules for global namespace cannot affect traffic to or from MACVLAN device in a child namespace.</td>
<td>It is possible to control traffic to or from IPVLAN device in <strong>L3 mode</strong> and <strong>L3S mode</strong>.</td>
</tr>
</tbody>
</table>

Note that both IPVLAN and MACVLAN do not require any level of encapsulation.

### 10.5. CONFIGURING IPVLAN NETWORK

#### 10.5.1. Creating and configuring the IPVLAN device using iproute2

This procedure shows how to set up the IPVLAN device using iproute2.

**Procedure**

1. To create an IPVLAN device, enter the following command:

   ```
   ~]$ ip link add link real_NIC_device name IPVLAN_device type ipvlan mode l2
   ```

   Note that network interface controller (NIC) is a hardware component which connects a computer to a network.

   **Example 10.1. Creating an IPVLAN device**

   ```
   ~]$ ip link add link enp0s31f6 name my_ipvlan type ipvlan mode l2
   ~]$ ip link
   47: my_ipvlan@enp0s31f6: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT group default qlen 1000 link/ether e8:6a:6e:8a:a2:44 brd ff:ff:ff:ff:ff:ff
   ```

2. To assign an **IPv4** or **IPv6** address to the interface, enter the following command:

   ```
   ~]$ ip addr add dev IPVLAN_device IP_address/subnet_mask_prefix
   ```

3. In case of configuring an IPVLAN device in **L3 mode** or **L3S mode**, make the following setups:

   a. Configure the neighbor setup for the remote peer on the remote host:

      ```
      ~]$ ip neigh add dev peer_device IPVLAN_device IP_address lladdr MAC_address
      ```

      where **MAC_address** is the MAC address of the real NIC on which an IPVLAN device is based on.

   b. Configure an IPVLAN device for **L3 mode** with the following command:
For L3S mode:

```bash
~$ ip neigh add dev real_NIC_device peer_IP_address lladdr peer_MAC_address
```

where IP-address represents the address of the remote peer.

4. To set an IPVLAN device active, enter the following command:

```bash
~$ ip link set dev IPVLAN_device up
```

5. To check if the IPVLAN device is active, execute the following command on the remote host:

```bash
~$ ping IP_address
```

where the IP_address uses the IP address of the IPVLAN device.
CHAPTER 11. GETTING STARTED WITH VRF

With Virtual routing and forwarding (VRF), Administrators can use multiple routing tables simultaneously on the same host. For that, VRF partitions a network at layer 3. This enables the administrator to isolate traffic using separate and independent route tables per VRF domain. This technique is similar to virtual LANs (VLAN), which partitions a network at layer 2, where the operating system uses different VLAN tags to isolate traffic sharing the same physical medium.

One benefit of VRF over partitioning on layer 2 is that routing scales better with respect to the number of peers involved.

Red Hat Enterprise Linux uses a virtual vrt device for each VRF domain and adds routes to a VRF domain by enslaving existing network devices to a VRF device. Addresses and routes previously attached to the enslaved device will be moved inside the VRF domain.

Note that each VRF domain is isolated from each other.

Related information

CHAPTER 12. USING AND CONFIGURING FIREWALLS

A firewall is a way to protect machines from any unwanted traffic from outside. It enables users to control incoming network traffic on host machines by defining a set of firewall rules. These rules are used to sort the incoming traffic and either block it or allow through.

12.1. GETTING STARTED WITH FIREWALLD

12.1.1. firewalld

firewalld is a firewall service daemon that provides a dynamic customizable host-based firewall with a D-Bus interface. Being dynamic, it enables creating, changing, and deleting the rules without the necessity to restart the firewall daemon each time the rules are changed.

firewalld uses the concepts of zones and services, that simplify the traffic management. Zones are predefined sets of rules. Network interfaces and sources can be assigned to a zone. The traffic allowed depends on the network your computer is connected to and the security level this network is assigned. Firewall services are predefined rules that cover all necessary settings to allow incoming traffic for a specific service and they apply within a zone.

Services use one or more ports or addresses for network communication. Firewalls filter communication based on ports. To allow network traffic for a service, its ports must be open. firewalld blocks all traffic on ports that are not explicitly set as open. Some zones, such as trusted, allow all traffic by default.

Additional resources

- firewalld(1) man page

12.1.2. Zones

firewalld can be used to separate networks into different zones according to the level of trust that the user has decided to place on the interfaces and traffic within that network. A connection can only be part of one zone, but a zone can be used for many network connections.

NetworkManager notifies firewalld of the zone of an interface. You can assign zones to interfaces with:

- NetworkManager
- firewall-config tool
- firewall-cmd command-line tool
- The RHEL web console

The latter three can only edit the appropriate NetworkManager configuration files. If you change the zone of the interface using the web console, firewall-cmd or firewall-config, the request is forwarded to NetworkManager and is not handled by firewalld.

The predefined zones are stored in the /usr/lib/firewalld/zones/ directory and can be instantly applied to any available network interface. These files are copied to the /etc/firewalld/zones/ directory only after they are modified. The default settings of the predefined zones are as follows:

- block
Any incoming network connections are rejected with an icmp-host-prohibited message for IPv4 and icmp6-adm-prohibited for IPv6. Only network connections initiated from within the system are possible.

**dmz**

For computers in your demilitarized zone that are publicly-accessible with limited access to your internal network. Only selected incoming connections are accepted.

**drop**

Any incoming network packets are dropped without any notification. Only outgoing network connections are possible.

**external**

For use on external networks with masquerading enabled, especially for routers. You do not trust the other computers on the network to not harm your computer. Only selected incoming connections are accepted.

**home**

For use at home when you mostly trust the other computers on the network. Only selected incoming connections are accepted.

**internal**

For use on internal networks when you mostly trust the other computers on the network. Only selected incoming connections are accepted.

**public**

For use in public areas where you do not trust other computers on the network. Only selected incoming connections are accepted.

**trusted**

All network connections are accepted.

**work**

For use at work where you mostly trust the other computers on the network. Only selected incoming connections are accepted.

One of these zones is set as the default zone. When interface connections are added to **NetworkManager**, they are assigned to the default zone. On installation, the default zone in **firewalld** is set to be the **public** zone. The default zone can be changed.

**NOTE**

The network zone names have been chosen to be self-explanatory and to allow users to quickly make a reasonable decision. To avoid any security problems, review the default zone configuration and disable any unnecessary services according to your needs and risk assessments.

Additional resources

`firewalld.zone(5)` man page

### 12.1.3. Predefined services

A service can be a list of local ports, protocols, source ports, and destinations, as well as a list of firewall helper modules automatically loaded if a service is enabled. Using services saves users time because they can achieve several tasks, such as opening ports, defining protocols, enabling packet forwarding and more, in a single step, rather than setting up everything one after another.

Service configuration options and generic file information are described in the **firewalld.service(5)** man...
The services are specified by means of individual XML configuration files, which are named in the following format: `service-name.xml`. Protocol names are preferred over service or application names in `firewalld`.

Services can be added and removed using the graphical `firewall-config` tool, `firewall-cmd`, and `firewall-offline-cmd`.

Alternatively, you can edit the XML files in the `/etc/firewalld/services/` directory. If a service is not added or changed by the user, then no corresponding XML file is found in `/etc/firewalld/services/`. The files in the `/usr/lib/firewalld/services/` directory can be used as templates if you want to add or change a service.

Additional resources

- `firewalld.service(5)` man page

### 12.2. INSTALLING THE `FIREWALL-CONFIG` GUI CONFIGURATION TOOL

To use the `firewall-config` GUI configuration tool, install the `firewall-config` package.

**Procedure**

1. Enter the following command as `root`:

   ```sh
   # yum install firewall-config
   ```

   Alternatively, in `GNOME`, use the Super key and type `Software` to launch the `Software Sources` application. Type `firewall` to the search box, which appears after selecting the search button in the top-right corner. Select the `Firewall` item from the search results, and click on the `Install` button.

2. To run `firewall-config`, use either the `firewall-config` command or press the Super key to enter the Activities Overview, type `firewall`, and press Enter.

### 12.3. VIEWING THE CURRENT STATUS AND SETTINGS OF `FIREWALLD`

#### 12.3.1. Viewing the current status of `firewalld`

The firewall service, `firewalld`, is installed on the system by default. Use the `firewalld` CLI interface to check that the service is running.

**Procedure**

1. To see the status of the service:

   ```sh
   # firewall-cmd --state
   ```

2. For more information about the service status, use the `systemctl status` sub-command:

   ```sh
   # systemctl status firewalld
   firewalld.service - firewalld - dynamic firewall daemon
   Loaded: loaded (/usr/lib/systemd/system/firewalld.service; enabled; vendor provided)
   Active: active (running) since Mon 2017-12-18 16:05:15 CET; 50min ago
   Docs: man:firewalld(1)
   ```
Main PID: 705 (firewalld)  
Tasks: 2 (limit: 4915)  
CGroup: /system.slice/firewalld.service  
└── 705 /usr/bin/python3 -E /usr/sbin/firewalld --nofork --nopid

Additional resources
It is important to know how firewalld is set up and which rules are in force before you try to edit the settings. To display the firewall settings, see Section 12.3.2, “Viewing current firewalld settings”

12.3.2. Viewing current firewalld settings

12.3.2.1. Viewing allowed services using GUI

To view the list of services using the graphical firewall-config tool, press the Super key to enter the Activities Overview, type firewall, and press Enter. The firewall-config tool appears. You can now view the list of services under the Services tab.

Alternatively, to start the graphical firewall configuration tool using the command-line, enter the following command:

```
$ firewall-config
```

The Firewall Configuration window opens. Note that this command can be run as a normal user, but you are prompted for an administrator password occasionally.

12.3.2.2. Viewing firewalld settings using CLI

With the CLI client, it is possible to get different views of the current firewall settings. The --list-all option shows a complete overview of the firewalld settings.

firewalld uses zones to manage the traffic. If a zone is not specified by the --zone option, the command is effective in the default zone assigned to the active network interface and connection.

To list all the relevant information for the default zone:

```
# firewall-cmd --list-all
public
target: default
icmp-block-inversion: no
interfaces:
sources:
services: ssh dhcpv6-client
ports:
protocols:
masquerade: no
forward-ports:
source-ports:
icmp-blocks:
rich rules:
```

To specify the zone for which to display the settings, add the --zone=zone-name argument to the firewall-cmd --list-all command, for example:

```
# firewall-cmd --list-all --zone=home
```
To see the settings for particular information, such as services or ports, use a specific option. See the `firewalld` manual pages or get a list of the options using the command help:

```
# firewall-cmd --help
```

Usage: firewall-cmd [OPTIONS...]

General Options
- `h`, `--help` Prints a short help text and exists
- `V`, `--version` Print the version string of firewalld
- `q`, `--quiet` Do not print status messages

Status Options
- `--state` Return and print firewalld state
- `--reload` Reload firewall and keep state information

For example, to see which services are allowed in the current zone:

```
# firewall-cmd --list-services
ssh dhcpv6-client
```

**NOTE**

Listing the settings for a certain subpart using the CLI tool can sometimes be difficult to interpret. For example, you allow the SSH service and firewalld opens the necessary port (22) for the service. Later, if you list the allowed services, the list shows the SSH service, but if you list open ports, it does not show any. Therefore, it is recommended to use the `--list-all` option to make sure you receive a complete information.

### 12.4. STARTING FIREWALLD

**Procedure**

1. To start firewalld, enter the following command as `root`:

   ```
   # systemctl unmask firewalld
   # systemctl start firewalld
   ```

2. To ensure firewalld starts automatically at system start, enter the following command as `root`:

   ```
   # systemctl enable firewalld
   ```

### 12.5. STOPPING FIREWALLD
Procedure

1. To stop **firewalld**, enter the following command as **root**:
   
   ```bash
   # systemctl stop firewalld
   ```

2. To prevent **firewalld** from starting automatically at system start:
   
   ```bash
   # systemctl disable firewalld
   ```

3. To make sure firewalld is not started by accessing the **firewalld D-Bus** interface and also if other services require **firewalld**:
   
   ```bash
   # systemctl mask firewalld
   ```

12.6. RUNTIME AND PERMANENT SETTINGS

Any changes committed in **runtime** mode only apply while **firewalld** is running. When **firewalld** is restarted, the settings revert to their **permanent** values.

To make the changes persistent across reboots, apply them again using the **--permanent** option. Alternatively, to make changes persistent while **firewalld** is running, use the **--runtime-to-permanent** `firewall-cmd` option.

If you set the rules while **firewalld** is running using only the **--permanent** option, they do not become effective before **firewalld** is restarted. However, restarting **firewalld** closes all open ports and stops the networking traffic.

Modifying settings in runtime and permanent configuration using CLI

Using the CLI, you do not modify the firewall settings in both modes at the same time. You only modify either runtime or permanent mode. To modify the firewall settings in the permanent mode, use the **--permanent** option with the `firewall-cmd` command.

```bash
# firewall-cmd --permanent <other options>
```

Without this option, the command modifies runtime mode.

To change settings in both modes, you can use two methods:

1. Change runtime settings and then make them permanent as follows:

   ```bash
   # firewall-cmd <other options>
   # firewall-cmd --runtime-to-permanent
   ```

2. Set permanent settings and reload the settings into runtime mode:

   ```bash
   # firewall-cmd --permanent <other options>
   # firewall-cmd --reload
   ```

The first method allows you to test the settings before you apply them to the permanent mode.
NOTE

It is possible, especially on remote systems, that an incorrect setting results in a user locking themselves out of a machine. To prevent such situations, use the `--timeout` option. After a specified amount of time, any change reverts to its previous state. Using this option excludes the `--permanent` option.

For example, to add the SSH service for 15 minutes:

```
# firewall-cmd --add-service=ssh --timeout 15m
```

12.7. CONTROLLING NETWORK TRAFFIC USING FIREWALLD

12.7.1. Disabling all traffic in case of emergency using CLI

In an emergency situation, such as a system attack, it is possible to disable all network traffic and cut off the attacker.

**Procedure**

1. To immediately disable networking traffic, switch panic mode on:

```
# firewall-cmd --panic-on
```

**IMPORTANT**

Enabling panic mode stops all networking traffic. From this reason, it should be used only when you have the physical access to the machine or if you are logged in using a serial console.

Switching off panic mode reverts the firewall to its permanent settings. To switch panic mode off:

```
# firewall-cmd --panic-off
```

To see whether panic mode is switched on or off, use:

```
# firewall-cmd --query-panic
```

12.7.2. Controlling traffic with predefined services using CLI

The most straightforward method to control traffic is to add a predefined service to `firewalld`. This opens all necessary ports and modifies other settings according to the service definition file.

**Procedure**

1. Check that the service is not already allowed:

```
# firewall-cmd --list-services
```

   ssh  dhcpv6-client

2. List all predefined services:
3. Add the service to the allowed services:

   # firewall-cmd --add-service=<service-name>

4. Make the new settings persistent:

   # firewall-cmd --runtime-to-permanent

12.7.3. Controlling traffic with predefined services using GUI

To enable or disable a predefined or custom service:

1. Start the firewall-config tool and select the network zone whose services are to be configured.
2. Select the Services tab.
3. Select the check box for each type of service you want to trust or clear the check box to block a service.

To edit a service:

1. Start the firewall-config tool.
2. Select Permanent from the menu labeled Configuration. Additional icons and menu buttons appear at the bottom of the Services window.
3. Select the service you want to configure.

The Ports, Protocols, and Source Port tabs enable adding, changing, and removing of ports, protocols, and source port for the selected service. The modules tab is for configuring Netfilter helper modules. The Destination tab enables limiting traffic to a particular destination address and Internet Protocol (IPv4 or IPv6).

**NOTE**

It is not possible to alter service settings in Runtime mode.

12.7.4. Adding new services

Services can be added and removed using the graphical firewall-config tool, firewall-cmd, and firewall-offline-cmd. Alternatively, you can edit the XML files in /etc/firewalld/services/. If a service is not added or changed by the user, then no corresponding XML file are found in /etc/firewalld/services/. The files /usr/lib/firewalld/services/ can be used as templates if you want to add or change a service.

**Procedure**

To add a new service in a terminal, use firewall-cmd, or firewall-offline-cmd in case of not active firewalld.
1. Enter the following command to add a new and empty service:

   $ firewall-cmd --new-service=service-name

2. To add a new service using a local file, use the following command:

   $ firewall-cmd --new-service-from-file=service-name.xml

   You can change the service name with the additional --name=service-name option.

3. As soon as service settings are changed, an updated copy of the service is placed into

   /etc/firewalld/services/

   As root, you can enter the following command to copy a service manually:

   # cp /usr/lib/firewalld/services/service-name.xml /etc/firewalld/services/service-name.xml

firewalld loads files from /usr/lib/firewalld/services in the first place. If files are placed in

/etc/firewalld/services and they are valid, then these will override the matching files from

/usr/lib/firewalld/services. The overridden files in /usr/lib/firewalld/services are used as soon as the
matching files in /etc/firewalld/services have been removed or if firewalld has been asked to load the
defaults of the services. This applies to the permanent environment only. A reload is needed to get
these fallbacks also in the runtime environment.

### 12.7.5. Controlling ports using CLI

Ports are logical devices that enable an operating system to receive and distinguish network traffic and
forward it accordingly to system services. These are usually represented by a daemon that listens on the
port, that is it waits for any traffic coming to this port.

Normally, system services listen on standard ports that are reserved for them. The httpd daemon, for
example, listens on port 80. However, system administrators by default configure daemons to listen on
different ports to enhance security or for other reasons.

#### 12.7.5.1. Opening a port

Through open ports, the system is accessible from the outside, which represents a security risk.
Generally, keep ports closed and only open them if they are required for certain services.

**Procedure**

To get a list of open ports in the current zone:

1. List all allowed ports:

   # firewall-cmd --list-ports

2. Add a port to the allowed ports to open it for incoming traffic:

   # firewall-cmd --add-port=port-number/port-type

3. Make the new settings persistent:

   # firewall-cmd --runtime-to-permanent
The port types are either \texttt{tcp}, \texttt{udp}, \texttt{sctp}, or \texttt{dccp}. The type must match the type of network communication.

\subsection*{12.7.5.2. Closing a port}

When an open port is no longer needed, close that port in \texttt{firewalld}. It is highly recommended to close all unnecessary ports as soon as they are not used because leaving a port open represents a security risk.

\textbf{Procedure}

To close a port, remove it from the list of allowed ports:

1. List all allowed ports:

   \begin{verbatim}
   # firewall-cmd --list-ports
   [WARNING]
   ====
   This command will only give you a list of ports that have been opened as ports. You will not be able to see any open ports that have been opened as a service. Therefore, you should consider using the --list-all option instead of --list-ports.
   ====
   \end{verbatim}

2. Remove the port from the allowed ports to close it for the incoming traffic:

   \begin{verbatim}
   # firewall-cmd --remove-port=port-number/port-type
   \end{verbatim}

3. Make the new settings persistent:

   \begin{verbatim}
   # firewall-cmd --runtime-to-permanent
   \end{verbatim}

\subsection*{12.7.6. Opening ports using GUI}

To permit traffic through the firewall to a certain port:

1. Start the \texttt{firewall-config} tool and select the network zone whose settings you want to change.

2. Select the \texttt{Ports} tab and click the \texttt{Add} button on the right-hand side. The \texttt{Port and Protocol} window opens.

3. Enter the port number or range of ports to permit.

4. Select \texttt{tcp} or \texttt{udp} from the list.

\subsection*{12.7.7. Controlling traffic with protocols using GUI}

To permit traffic through the firewall using a certain protocol:

1. Start the \texttt{firewall-config} tool and select the network zone whose settings you want to change.

2. Select the \texttt{Protocols} tab and click the \texttt{Add} button on the right-hand side. The \texttt{Protocol} window opens.

3. Either select a protocol from the list or select the \texttt{Other Protocol} check box and enter the protocol in the field.
12.7.8. Opening source ports using GUI

To permit traffic through the firewall from a certain port:

1. Start the firewall-config tool and select the network zone whose settings you want to change.
2. Select the Source Port tab and click the Add button on the right-hand side. The Source Port window opens.
3. Enter the port number or range of ports to permit. Select tcp or udp from the list.

12.8. WORKING WITH FIREWALLD ZONES

Zones represent a concept to manage incoming traffic more transparently. The zones are connected to networking interfaces or assigned a range of source addresses. You manage firewall rules for each zone independently, which enables you to define complex firewall settings and apply them to the traffic.

12.8.1. Listing zones

Procedure

1. To see which zones are available on your system:

   # firewall-cmd --get-zones

   The firewall-cmd --get-zones command displays all zones that are available on the system, but it does not show any details for particular zones.

2. To see detailed information for all zones:

   # firewall-cmd --list-all-zones

3. To see detailed information for a specific zone:

   # firewall-cmd --zone=zone-name --list-all

12.8.2. Modifying firewalld settings for a certain zone

The Section 12.7.2, “Controlling traffic with predefined services using CLI” and Section 12.7.5, “Controlling ports using CLI” explain how to add services or modify ports in the scope of the current working zone. Sometimes, it is required to set up rules in a different zone.

Procedure

1. To work in a different zone, use the --zone=zone-name option. For example, to allow the SSH service in the zone public:

   # firewall-cmd --add-service=ssh --zone=public

12.8.3. Changing the default zone
System administrators assign a zone to a networking interface in its configuration files. If an interface is not assigned to a specific zone, it is assigned to the default zone. After each restart of the `firewalld` service, `firewalld` loads the settings for the default zone and makes it active.

**Procedure**

To set up the default zone:

1. Display the current default zone:
   
   ```
   # firewall-cmd --get-default-zone
   ```

2. Set the new default zone:

   ```
   # firewall-cmd --set-default-zone zone-name
   ```

**NOTE**

Following this procedure, the setting is a permanent setting, even without the `--permanent` option.

12.8.4. Assigning a network interface to a zone

It is possible to define different sets of rules for different zones and then change the settings quickly by changing the zone for the interface that is being used. With multiple interfaces, a specific zone can be set for each of them to distinguish traffic that is coming through them.

**Procedure**

To assign the zone to a specific interface:

1. List the active zones and the interfaces assigned to them:

   ```
   # firewall-cmd --get-active-zones
   ```

2. Assign the interface to a different zone:

   ```
   # firewall-cmd --zone=zone-name --change-interface=<interface-name>
   ```

**NOTE**

You do not have to use the `--permanent` option to make the setting persistent across restarts. If you set a new default zone, the setting becomes permanent.

12.8.5. Assigning a default zone to a network connection

When the connection is managed by `NetworkManager`, it must be aware of a zone that it uses. For every network connection, a zone can be specified, which provides the flexibility of various firewall settings according to the location of the computer with portable devices. Thus, zones and settings can be specified for different locations, such as company or home.

**Procedure**
To set a default zone for an Internet connection, use either the NetworkManager GUI or edit the `/etc/sysconfig/network-scripts/ifcfg-connection-name` file and add a line that assigns a zone to this connection:

```
ZONE=zone-name
```

### 12.8.6. Creating a new zone

To use custom zones, create a new zone and use it just like a predefined zone. New zones require the `--permanent` option, otherwise the command does not work.

**Procedure**

To create a new zone:

1. Create a new zone:

   ```
   # firewall-cmd --new-zone=zone-name
   ```

2. Check if the new zone is added to your permanent settings:

   ```
   # firewall-cmd --get-zones
   ```

3. Make the new settings persistent:

   ```
   # firewall-cmd --runtime-to-permanent
   ```

### 12.8.7. Zone configuration files

Zones can also be created using a zone configuration file. This approach can be helpful when you need to create a new zone, but want to reuse the settings from a different zone and only alter them a little.

A `firewalld` zone configuration file contains the information for a zone. These are the zone description, services, ports, protocols, icmp-blocks, masquerade, forward-ports and rich language rules in an XML file format. The file name has to be `zone-name.xml` where the length of `zone-name` is currently limited to 17 chars. The zone configuration files are located in the `/usr/lib/firewalld/zones/` and `/etc/firewalld/zones/` directories.

The following example shows a configuration that allows one service (`SSH`) and one port range, for both the TCP and UDP protocols:

```xml
<?xml version="1.0" encoding="utf-8"?>
<zone>
  <short>My zone</short>
  <description>Here you can describe the characteristic features of the zone.</description>
  <service name="ssh"/>
  <port port="1025-65535" protocol="tcp"/>
  <port port="1025-65535" protocol="udp"/>
</zone>
```

To change settings for that zone, add or remove sections to add ports, forward ports, services, and so on.

**Additional resources**
12.8.8. Using zone targets to set default behavior for incoming traffic

For every zone, you can set a default behavior that handles incoming traffic that is not further specified. Such behavior is defined by setting the target of the zone. There are three options - default, ACCEPT, REJECT, and DROP. By setting the target to ACCEPT, you accept all incoming packets except those disabled by a specific rule. If you set the target to REJECT or DROP, you disable all incoming packets except those that you have allowed in specific rules. When packets are rejected, the source machine is informed about the rejection, while there is no information sent when the packets are dropped.

Procedure

To set a target for a zone:

1. List the information for the specific zone to see the default target:

   $ firewall-cmd --zone=zone-name --list-all

2. Set a new target in the zone:

   # firewall-cmd --zone=zone-name --set-target=default|ACCEPT|REJECT|DROP>

12.9. USING ZONES TO MANAGE INCOMING TRAFFIC DEPENDING ON A SOURCE

12.9.1. Using zones to manage incoming traffic depending on a source

You can use zones to manage incoming traffic based on its source. That enables you to sort incoming traffic and route it through different zones to allow or disallow services that can be reached by that traffic.

If you add a source to a zone, the zone becomes active and any incoming traffic from that source will be directed through it. You can specify different settings for each zone, which is applied to the traffic from the given sources accordingly. You can use more zones even if you only have one network interface.

12.9.2. Adding a source

To route incoming traffic into a specific source, add the source to that zone. The source can be an IP address or an IP mask in the Classless Inter-domain Routing (CIDR) notation.

- To set the source in the current zone:

  # firewall-cmd --add-source=<source>

- To set the source IP address for a specific zone:

  # firewall-cmd --zone=zone-name --add-source=<source>

The following procedure allows all incoming traffic from 192.168.2.15 in the trusted zone:

Procedure

1. List all available zones:
# firewall-cmd --get-zones

2. Add the source IP to the trusted zone in the permanent mode:

# firewall-cmd --zone=trusted --add-source=192.168.2.15

3. Make the new settings persistent:

# firewall-cmd --runtime-to-permanent

12.9.3. Removing a source

Removing a source from the zone cuts off the traffic coming from it.

Procedure

1. List allowed sources for the required zone:

# firewall-cmd --zone=zone-name --list-sources

2. Remove the source from the zone permanently:

# firewall-cmd --zone=zone-name --remove-source=<source>

3. Make the new settings persistent:

# firewall-cmd --runtime-to-permanent

12.9.4. Adding a source port

To enable sorting the traffic based on a port of origin, specify a source port using the `--add-source-port` option. You can also combine this with the `--add-source` option to limit the traffic to a certain IP address or IP range.

Procedure

1. To add a source port:

# firewall-cmd --zone=zone-name --add-source-port=<port-name>/<tcp|udp|sctp|dccp>

12.9.5. Removing a source port

By removing a source port you disable sorting the traffic based on a port of origin.

Procedure

1. To remove a source port:

# firewall-cmd --zone=zone-name --remove-source-port=<port-name>/<tcp|udp|sctp|dccp>

12.9.6. Using zones and sources to allow a service for only a specific domain
To allow traffic from a specific network to use a service on a machine, use zones and source. The following procedure allows traffic from 192.168.1.0/24 to be able to reach the HTTP service while any other traffic is blocked.

**Procedure**

1. List all available zones:

   ```bash
   # firewall-cmd --get-zones
   block dmz drop external home internal public trusted work
   ```

2. Add the source to the trusted zone to route the traffic originating from the source through the zone:

   ```bash
   # firewall-cmd --zone=trusted --add-source=192.168.1.0/24
   ```

3. Add the http service in the trusted zone:

   ```bash
   # firewall-cmd --zone=trusted -add-service=http
   ```

4. Make the new settings persistent:

   ```bash
   # firewall-cmd --runtime-to-permanent
   ```

5. Check that the trusted zone is active and that the service is allowed in it:

   ```bash
   # firewall-cmd --zone=trusted --list-all
   trusted (active)
   target: ACCEPT
   sources: 192.168.1.0/24
   services: http
   ```

**12.9.7. Configuring traffic accepted by a zone based on a protocol**

You can allow incoming traffic to be accepted by a zone based on a protocol. All traffic using the specified protocol is accepted by a zone, in which you can apply further rules and filtering.

**12.9.7.1. Adding a protocol to a zone**

By adding a protocol to a certain zone, you allow all traffic with this protocol to be accepted by this zone.

**Procedure**

1. To add a protocol to a zone:

   ```bash
   # firewall-cmd --zone=zone-name --add-protocol=port-name/tcp|udp|sctp|dccp|igmp
   ```

**NOTE**

To receive multicast traffic, use the `igmp` value with the `--add-protocol` option.

**12.9.7.2. Removing a protocol from a zone**
By removing a protocol from a certain zone, you stop accepting all traffic based on this protocol by the zone.

Procedure

1. To remove a protocol from a zone:

   # firewall-cmd --zone=zone-name --remove-protocol=port-name/tcp|udp|sctp|dccp|igmp

12.10. CONFIGURING IP ADDRESS MASQUERADING

The following procedure describes how to enable IP masquerading on your system. IP masquerading hides individual machines behind a gateway when accessing the Internet.

Procedure

1. To check if IP masquerading is enabled (for example, for the external zone), enter the following command as root:

   # firewall-cmd --zone=external --query-masquerade

   The command prints yes with exit status 0 if enabled. It prints no with exit status 1 otherwise. If zone is omitted, the default zone will be used.

2. To enable IP masquerading, enter the following command as root:

   # firewall-cmd --zone=external --add-masquerade

3. To make this setting persistent, repeat the command adding the --permanent option.

To disable IP masquerading, enter the following command as root:

   # firewall-cmd --zone=external --remove-masquerade --permanent

12.11. PORT FORWARDING

Redirecting ports using this method only works for IPv4-based traffic. For IPv6 redirecting setup, you must use rich rules.

To redirect to an external system, it is necessary to enable masquerading. For more information, see Configuring IP address masquerading.

12.11.1. Adding a port to redirect

Using firewalld, you can set up ports redirection so that any incoming traffic that reaches a certain port on your system is delivered to another internal port of your choice or to an external port on another machine.

Prerequisites

- Before you redirect traffic from one port to another port, or another address, you have to know three things: which port the packets arrive at, what protocol is used, and where you want to redirect them.
Procedure
To redirect a port to another port:

```
# firewall-cmd --add-forward-port=port=port-number:proto=tcp|udp|sctp|dccp:toport=port-number
```

To redirect a port to another port at a different IP address:

1. Add the port to be forwarded:

```
# firewall-cmd --add-forward-port=port=port-number:proto=tcp|udp:toport=port-number:toaddr=IP/mask
```

2. Enable masquerade:

```
# firewall-cmd --add-masquerade
```

12.11.2. Redirecting TCP port 80 to port 88 on the same machine

Follow the steps to redirect the TCP port 80 to port 88.

Procedure

1. Redirect the port 80 to port 88 for TCP traffic:

```
# firewall-cmd --add-forward-port=port=80:proto=tcp:toport=88
```

2. Make the new settings persistent:

```
# firewall-cmd --runtime-to-permanent
```

3. Check that the port is redirected:

```
# firewall-cmd --list-all
```

12.11.3. Removing a redirected port

To remove a redirected port:

```
~]# firewall-cmd --remove-forward-port=port=port-number:proto=<tcp|udp>:toport=port-number:toaddr=<IP/mask>
```

To remove a forwarded port redirected to a different address, use the following procedure.

Procedure

1. Remove the forwarded port:

```
~]# firewall-cmd --remove-forward-port=port=port-number:proto=<tcp|udp>:toport=port-number:toaddr=<IP/mask>
```

2. Disable masquerade:
12.11.4. Removing TCP port 80 forwarded to port 88 on the same machine

To remove the port redirection:

**Procedure**

1. List redirected ports:

```
~]# firewall-cmd --list-forward-ports
port=80:proto=tcp:toport=88:toaddr=
```

2. Remove the redirected port from the firewall:

```
~]# firewall-cmd --remove-forward-port=port=80:proto=tcp:toport=88:toaddr=
```

3. Make the new settings persistent:

```
~]# firewall-cmd --runtime-to-permanent
```

12.12. MANAGING ICMP REQUESTS

The **Internet Control Message Protocol (ICMP)** is a supporting protocol that is used by various network devices to send error messages and operational information indicating a connection problem, for example, that a requested service is not available. **ICMP** differs from transport protocols such as **TCP** and **UDP** because it is not used to exchange data between systems.

Unfortunately, it is possible to use the **ICMP** messages, especially **echo-request** and **echo-reply**, to reveal information about your network and misuse such information for various kinds of fraudulent activities. Therefore, **firewalld** enables blocking the **ICMP** requests to protect your network information.

12.12.1. Listing and blocking ICMP requests

**Listing ICMP requests**

The **ICMP** requests are described in individual XML files that are located in the `/usr/lib/firewalld/icmptypes/` directory. You can read these files to see a description of the request. The **firewall-cmd** command controls the **ICMP** requests manipulation.

- To list all available **ICMP** types:

  ```
  # firewall-cmd --get-icmptypes
  ```

- The **ICMP** request can be used by IPv4, IPv6, or by both protocols. To see for which protocol the **ICMP** request is used:

  ```
  # firewall-cmd --info-icmptype=<icmptype>
  ```

- The status of an **ICMP** request shows **yes** if the request is currently blocked or **no** if it is not. To see if an **ICMP** request is currently blocked:

  ```
  # firewall-cmd --info-icmptype=<icmptype>
  ```
Blocking or unblocking ICMP requests

When your server blocks ICMP requests, it does not provide the information that it normally would. However, that does not mean that no information is given at all. The clients receive information that the particular ICMP request is being blocked (rejected). Blocking the ICMP requests should be considered carefully, because it can cause communication problems, especially with IPv6 traffic.

- To see if an ICMP request is currently blocked:
  ```
  # firewall-cmd --query-icmp-block=<icmptype>
  ```

- To block an ICMP request:
  ```
  # firewall-cmd --add-icmp-block=<icmptype>
  ```

- To remove the block for an ICMP request:
  ```
  # firewall-cmd --remove-icmp-block=<icmptype>
  ```

Blocking ICMP requests without providing any information at all

Normally, if you block ICMP requests, clients know that you are blocking it. So, a potential attacker who is sniffing for live IP addresses is still able to see that your IP address is online. To hide this information completely, you have to drop all ICMP requests.

- To block and drop all ICMP requests:
  1. Set the target of your zone to DROP:
     ```
     # firewall-cmd --set-target=DROP
     ```
  2. Make the new settings persistent:
     ```
     # firewall-cmd --runtime-to-permanent
     ```

Now, all traffic, including ICMP requests, is dropped, except traffic which you have explicitly allowed.

- To block and drop certain ICMP requests and allow others:
  1. Set the target of your zone to DROP:
     ```
     # firewall-cmd --set-target=DROP
     ```
  2. Add the ICMP block inversion to block all ICMP requests at once:
     ```
     # firewall-cmd --add-icmp-block-inversion
     ```
  3. Add the ICMP block for those ICMP requests that you want to allow:
     ```
     # firewall-cmd --add-icmp-block=<icmptype>
     ```
4. Make the new settings persistent:

```
# firewall-cmd --runtime-to-permanent
```

The **block inversion** inverts the setting of the **ICMP** requests blocks, so all requests, that were not previously blocked, are blocked. Those that were blocked are not blocked. Which means that if you need to unblock a request, you must use the blocking command.

- To revert the block inversion to a fully permissive setting:
  1. Set the target of your zone to **default** or **ACCEPT**:
     
     ```
     # firewall-cmd --set-target=default
     ```
  2. Remove all added blocks for **ICMP** requests:
     
     ```
     # firewall-cmd --remove-icmp-block=<icmptype>
     ```
  3. Remove the **ICMP** block inversion:
     
     ```
     # firewall-cmd --remove-icmp-block-inversion
     ```
  4. Make the new settings persistent:
     
     ```
     # firewall-cmd --runtime-to-permanent
     ```

12.12.2. Configuring the **ICMP** filter using GUI

- To enable or disable an **ICMP** filter, start the **firewall-config** tool and select the network zone whose messages are to be filtered. Select the **ICMP Filter** tab and select the check box for each type of **ICMP** message you want to filter. Clear the check box to disable a filter. This setting is per direction and the default allows everything.

- To edit an **ICMP** type, start the **firewall-config** tool and select **Permanent** mode from the menu labeled **Configuration**. Additional icons appear at the bottom of the **Services** window. Select **Yes** in the following dialog to enable masquerading and to make forwarding to another machine working.

- To enable inverting the **ICMP Filter**, click the **Invert Filter** check box on the right. Only marked **ICMP** types are now accepted, all other are rejected. In a zone using the **DROP** target, they are dropped.

12.13. SETTING AND CONTROLLING IP SETS USING **FIREWALLD**

To see the list of IP set types supported by **firewalld**, enter the following command as root.

```
~ ]*# firewall-cmd --get-ipset-types
```

12.13.1. Configuring IP set options using CLI
IP sets can be used in `firewalld` zones as sources and also as sources in rich rules. In Red Hat Enterprise Linux, the preferred method is to use the IP sets created with `firewalld` in a direct rule.

- To list the IP sets known to `firewalld` in the permanent environment, use the following command as root:

  ```
  # firewall-cmd --permanent --get-ipsets
  ```

- To add a new IP set, use the following command using the permanent environment as root:

  ```
  # firewall-cmd --permanent --new-ipset=test --type=hash:net
  success
  ```

  The previous command creates a new IP set with the name `test` and the `hash:net` type for IPv4. To create an IP set for use with IPv6, add the `--option=family=inet6` option. To make the new setting effective in the runtime environment, reload `firewalld`.

- List the new IP set with the following command as root:

  ```
  # firewall-cmd --permanent --get-ipsets
  test
  ```

- To get more information about the IP set, use the following command as root:

  ```
  # firewall-cmd --permanent --info-ipset=test
  test
  type: hash:net
  options:
  entries:
  ```

  Note that the IP set does not have any entries at the moment.

- To add an entry to the `test` IP set, use the following command as root:

  ```
  # firewall-cmd --permanent --ipset=test --add-entry=192.168.0.1
  success
  ```

  The previous command adds the IP address `192.168.0.1` to the IP set.

- To get the list of current entries in the IP set, use the following command as root:

  ```
  # firewall-cmd --permanent --ipset=test --get-entries
  192.168.0.1
  ```

- Generate a file containing a list of IP addresses, for example:

  ```
  # cat > iplist.txt <<EOL
  192.168.0.2
  192.168.0.3
  192.168.1.0/24
  192.168.2.254
  EOL
  ```
The file with the list of IP addresses for an IP set should contain an entry per line. Lines starting with a hash, a semi-colon, or empty lines are ignored.

- To add the addresses from the iplist.txt file, use the following command as root:

```
# firewall-cmd --permanent --ipset=test --add-entries-from-file=iplist.txt
```

- To see the extended entries list of the IP set, use the following command as root:

```
# firewall-cmd --permanent --ipset=test --get-entries
192.168.0.1
192.168.0.2
192.168.0.3
192.168.1.0/24
192.168.2.254
```

- To remove the addresses from the IP set and to check the updated entries list, use the following commands as root:

```
# firewall-cmd --permanent --ipset=test --remove-entries-from-file=iplist.txt
success
# firewall-cmd --permanent --ipset=test --get-entries
192.168.0.1
```

- You can add the IP set as a source to a zone to handle all traffic coming in from any of the addresses listed in the IP set with a zone. For example, to add the test IP set as a source to the drop zone to drop all packets coming from all entries listed in the test IP set, use the following command as root:

```
# firewall-cmd --permanent --zone=drop --add-source=ipset:test
success
```

The ipset: prefix in the source shows firewalld that the source is an IP set and not an IP address or an address range.

Only the creation and removal of IP sets is limited to the permanent environment, all other IP set options can be used also in the runtime environment without the --permanent option.

---

**WARNING**

Red Hat does not recommend using IP sets that are not managed through firewalld. To use such IP sets, a permanent direct rule is required to reference the set, and a custom service must be added to create these IP sets. This service needs to be started before firewalld starts, otherwise firewalld is not able to add the direct rules using these sets. You can add permanent direct rules with the /etc/firewalld/direct.xml file.

---

12.14. CONFIGURING FIREWALL LOCKDOWN
Local applications or services are able to change the firewall configuration if they are running as root (for example, libvirt). With this feature, the administrator can lock the firewall configuration so that either no applications or only applications that are added to the lockdown whitelist are able to request firewall changes. The lockdown settings default to disabled. If enabled, the user can be sure that there are no unwanted configuration changes made to the firewall by local applications or services.


- To query whether lockdown is enabled, use the following command as root:

  ```
  # firewall-cmd --query-lockdown
  ```

  The command prints yes with exit status 0 if lockdown is enabled. It prints no with exit status 1 otherwise.

- To enable lockdown, enter the following command as root:

  ```
  # firewall-cmd --lockdown-on
  ```

- To disable lockdown, use the following command as root:

  ```
  # firewall-cmd --lockdown-off
  ```

12.14.2. Configuring lockdown whitelist options using CLI

The lockdown whitelist can contain commands, security contexts, users and user IDs. If a command entry on the whitelist ends with an asterisk "*", then all command lines starting with that command will match. If the "*" is not there then the absolute command including arguments must match.

- The context is the security (SELinux) context of a running application or service. To get the context of a running application use the following command:

  ```
  $ ps -e --context
  ```

  That command returns all running applications. Pipe the output through the grep tool to get the application of interest. For example:

  ```
  $ ps -e --context | grep example_program
  ```

- To list all command lines that are on the whitelist, enter the following command as root:

  ```
  # firewall-cmd --list-lockdown-whitelist-commands
  ```

- To add a command command to the whitelist, enter the following command as root:

  ```
  # firewall-cmd --add-lockdown-whitelist-command='/usr/bin/python3 -Es /usr/bin/command'
  ```

- To remove a command command from the whitelist, enter the following command as root:

  ```
  # firewall-cmd --remove-lockdown-whitelist-command='/usr/bin/python3 -Es /usr/bin/command'
  ```
To query whether the command command is on the whitelist, enter the following command as root:

```
# firewall-cmd --query-lockdown-whitelist-command='/usr/bin/python3 -Es /usr/bin/command'
```

The command prints yes with exit status 0 if true. It prints no with exit status 1 otherwise.

To list all security contexts that are on the whitelist, enter the following command as root:

```
# firewall-cmd --list-lockdown-whitelist-contexts
```

To add a context context to the whitelist, enter the following command as root:

```
# firewall-cmd --add-lockdown-whitelist-context=context
```

To remove a context context from the whitelist, enter the following command as root:

```
# firewall-cmd --remove-lockdown-whitelist-context=context
```

To query whether the context context is on the whitelist, enter the following command as root:

```
# firewall-cmd --query-lockdown-whitelist-context=context
```

Prints yes with exit status 0, if true, prints no with exit status 1 otherwise.

To list all user IDs that are on the whitelist, enter the following command as root:

```
# firewall-cmd --list-lockdown-whitelist-uids
```

To add a user ID uid to the whitelist, enter the following command as root:

```
# firewall-cmd --add-lockdown-whitelist-uid=uid
```

To remove a user ID uid from the whitelist, enter the following command as root:

```
# firewall-cmd --remove-lockdown-whitelist-uid=uid
```

To query whether the user ID uid is on the whitelist, enter the following command:

```
$ firewall-cmd --query-lockdown-whitelist-uid=uid
```

Prints yes with exit status 0, if true, prints no with exit status 1 otherwise.

To list all user names that are on the whitelist, enter the following command as root:

```
# firewall-cmd --list-lockdown-whitelist-users
```

To add a user name user to the whitelist, enter the following command as root:

```
# firewall-cmd --add-lockdown-whitelist-user=user
```

To remove a user name user from the whitelist, enter the following command as root:
To query whether the user name user is on the whitelist, enter the following command:

```
$ firewall-cmd --query-lockdown-whitelist-user=user
```

Prints yes with exit status 0, if true, prints no with exit status 1 otherwise.

### 12.14.3. Configuring lockdown whitelist options using configuration files

The default whitelist configuration file contains the NetworkManager context and the default context of libvirt. The user ID 0 is also on the list.

```xml
<whitelist>
  <selinux context="system_u:system_r:NetworkManager_t:s0"/>
  <selinux context="system_u:system_r:virtd_t:s0-s0:c0.c1023"/>
  <user id="0"/>
</whitelist>
```

Following is an example whitelist configuration file enabling all commands for the firewall-cmd utility, for a user called user whose user ID is 815:

```xml
<whitelist>
  <command name="/usr/libexec/platform-python -s /bin/firewall-cmd"/>
  <selinux context="system_u:system_r:NetworkManager_t:s0"/>
  <user id="815"/>
  <user name="user"/>
</whitelist>
```

This example shows both user id and user name, but only one option is required. Python is the interpreter and is prepended to the command line. You can also use a specific command, for example:

```
/usr/bin/python3 /bin/firewall-cmd --lockdown-on
```

In that example, only the --lockdown-on command is allowed.

In Red Hat Enterprise Linux, all utilities are placed in the /usr/bin/ directory and the /bin/ directory is sym-linked to the /usr/bin/ directory. In other words, although the path for firewall-cmd when entered as root might resolve to /bin/firewall-cmd, /usr/bin/firewall-cmd can now be used. All new scripts should use the new location. But be aware that if scripts that run as root are written to use the /bin/firewall-cmd path, then that command path must be whitelisted in addition to the /usr/bin/firewall-cmd path traditionally used only for non-root users.

The * at the end of the name attribute of a command means that all commands that start with this string match. If the * is not there then the absolute command including arguments must match.

### 12.15. LOG FOR DENIED PACKETS

With the LogDenied option in the firewalld, it is possible to add a simple logging mechanism for denied packets. These are the packets that are rejected or dropped. To change the setting of the logging, edit the /etc/firewalld/firewalld.conf file or use the command-line or GUI configuration tool.
If `LogDenied` is enabled, logging rules are added right before the reject and drop rules in the INPUT, FORWARD and OUTPUT chains for the default rules and also the final reject and drop rules in zones. The possible values for this setting are: all, unicast, broadcast, multicast, and off. The default setting is off. With the unicast, broadcast, and multicast setting, the `pkttype` match is used to match the link-layer packet type. With all, all packets are logged.

To list the actual `LogDenied` setting with firewall-cmd, use the following command as root:

```bash
# firewall-cmd --get-log-denied
off
```

To change the `LogDenied` setting, use the following command as root:

```bash
# firewall-cmd --set-log-denied=all
success
```

To change the `LogDenied` setting with the `firewalld` GUI configuration tool, start `firewall-config`, click the Options menu and select Change Log Denied. The LogDenied window appears. Select the new LogDenied setting from the menu and click OK.

### 12.16. RELATED INFORMATION

The following sources of information provide additional resources regarding `firewalld`.

**Installed documentation**

- `firewalld(1)` man page – describes command options for `firewalld`
- `firewall.conf(5)` man page – contains information to configure `firewalld`
- `firewall-cmd(1)` man page – describes command options for the `firewalld` command-line client.
- `firewall-config(1)` man page – describes settings for the `firewall-config` tool.
- `firewall-offline-cmd(1)` man page – describes command options for the `firewalld` offline command-line client.
- `firewalld.icmptype(5)` man page – describes XML configuration files for ICMP filtering.
- `firewalld.ipset(5)` man page – describes XML configuration files for the `firewalld` IP sets.
- `firewalld.service(5)` man page – describes XML configuration files for `firewalld` service.
- `firewalld.zone(5)` man page – describes XML configuration files for `firewalld` zone configuration.
- `firewalld.direct(5)` man page – describes the `firewalld` direct interface configuration file.
- `firewalld.lockdown-whitelist(5)` man page – describes the `firewalld` lockdown whitelist configuration file.
- `firewalld.richlanguage(5)` man page – describes the `firewalld` rich language rule syntax.
- `firewalld.zones(5)` man page – general description of what zones are and how to configure them.
- `firewalld.dbus(5)` man page – describes the D-Bus interface of `firewalld`.

Online documentation

CHAPTER 13. GETTING STARTED WITH NFTABLES

The nftables framework enables administrators to configure packet-filtering rules used by the Linux kernel firewall.

13.1. INTRODUCTION TO NFTABLES

The nftables framework provides packet classification facilities and it is the designated successor to the iptables, ip6tables, arptables, and ebttables tools. It offers numerous improvements in convenience, features, and performance over previous packet-filtering tools, most notably:

- lookup tables instead of linear processing
- a single framework for both the IPv4 and IPv6 protocols
- rules all applied atomically instead of fetching, updating, and storing a complete ruleset
- support for debugging and tracing in the ruleset (nftrace) and monitoring trace events (in the nft tool)
- more consistent and compact syntax, no protocol-specific extensions
- a Netlink API for third-party applications

Similarly to iptables, nftables use tables for storing chains. The chains contain individual rules for performing actions. The nft tool replaces all tools from the previous packet-filtering frameworks. The libnftnl library can be used for low-level interaction with nftables Netlink API over the libmnl library.

In RHEL 8, nftables serve as the default firewalld back end. Although the nftables back end is backward-compatible with the previous iptables backend in firewall configurations, you can switch back to iptables by setting the FirewallBackend option to the iptables value in the /etc/firewalld/firewalld.conf file.

Effect of the modules on the nftables ruleset can be observed using the nft list ruleset command. Since these tools add tables, chains, and rules to the nftables ruleset, be aware that nftables rule-set operations, such as the nft flush ruleset command, might affect rule sets installed using the formerly separate legacy commands.

To quickly identify which variant of the tool is present, version information has been updated to include the back-end name. In RHEL 8, the nftables-based iptables tool prints the following version string:

```
$ iptables --version
iptables v1.8.0 (nf_tables)
```

For comparison, the following version information is printed if legacy iptables tool is present:

```
$ iptables --version
iptables v1.8.0 (legacy)
```

Additional resources

- The nft(8) man page provides a comprehensive reference documentation for configuring and inspecting packet filtering with nftables using the nft command-line tool.
13.2. CONVERTING IPTABLES TO NFTABLES

Red Hat Enterprise Linux 8 provides the `iptables-translate` and `ip6tables-translate` tools to convert the existing `iptables` or `ip6tables` rules into the equivalent ones for `nftables`.

Note that some extensions lack translation support. If such an extension exists, the tool prints the untranslated rule prefixed with the `#` sign. For example:

```
| % iptables-translate -A INPUT -j CHECKSUM --checksum-fill
| nft # -A INPUT -j CHECKSUM --checksum-fill
```

Additionally, users can use the `iptables-restore-translate` and `ip6tables-restore-translate` tools to translate a dump of rules. Note that before that, users can use the `iptables-save` or `ip6tables-save` commands to print a dump of current rules. For example:

```
| % sudo iptables-save >/tmp/iptables.dump
| % iptables-restore-translate -f /tmp/iptables.dump
| # Translated by iptables-restore-translate v1.8.0 on Wed Oct 17 17:00:13 2018
| add table ip nat
| ...
```

For more information and a list of possible options and values, enter the `iptables-translate --help` command.

13.3. RELATED INFORMATION


- The [Firewalld: The Future is nftables](#) article provides additional information on `nftables` as a default back end for `firewalld`. 
CHAPTER 14. GETTING STARTED WITH DPDK

The Data Plane Development Kit (DPDK) provides libraries and network drivers to accelerate package processing in user space.

Administrators use DPDK, for example, in virtual machines to use Single Root I/O Virtualization (SR-IOV) to reduce latencies and increase I/O throughput.

14.1. INSTALLING THE DPDK PACKAGE

This section describes how to install the dpdk package.

Prerequisites

- Red Hat Enterprise Linux is installed.
- A valid subscription is assigned to the host.

Procedure

1. Use the yum utility to install the dpdk package:

   ```bash
   # yum install dpdk
   ```

Related information

- For a list of network adapters that support SR-IOV on Red Hat Enterprise Linux 8, see Network Adapter Fast Datapath Feature Support Matrix.