Red Hat Enterprise Linux 6

Deployment Guide

Deployment, Configuration and Administration of Red Hat Enterprise Linux 6

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Abstract

The Deployment Guide documents relevant information regarding the deployment, configuration and administration of Red Hat Enterprise Linux 6. It is oriented towards system administrators with a basic understanding of the system.

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PART I. BASIC SYSTEM CONFIGURATION

This part covers basic system administration tasks such as keyboard configuration, date and time configuration, managing users and groups, and gaining privileges.

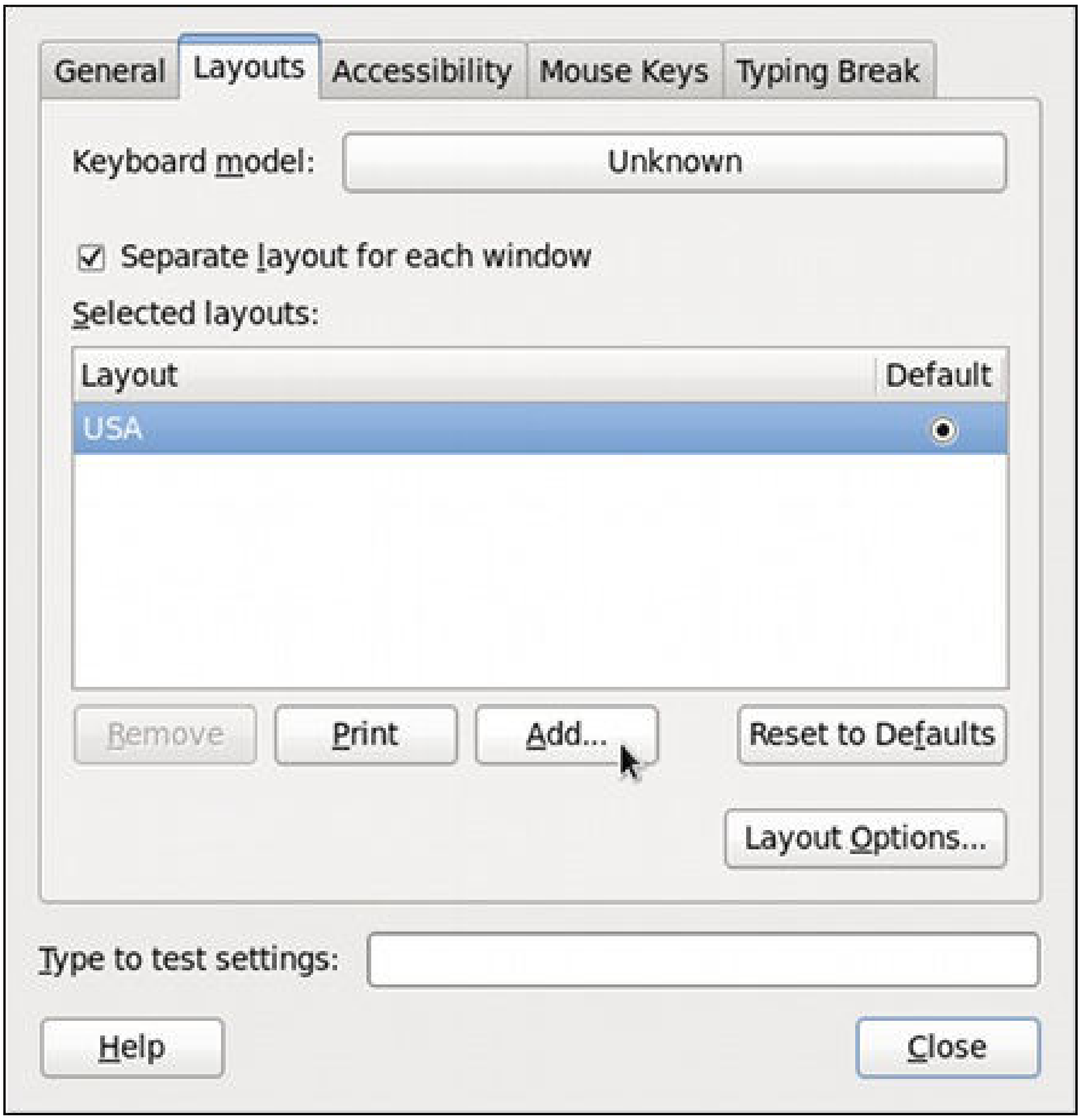
CHAPTER 1. KEYBOARD CONFIGURATION

This chapter describes how to change the keyboard layout, as well as how to add the **Keyboard Indicator** applet to the panel. It also covers the option to enforce a typing break, and explains both advantages and disadvantages of doing so.

1.1. CHANGING THE KEYBOARD LAYOUT

The installation program has allowed you to configure a keyboard layout for your system. However, the default settings may not always suit your current needs. To configure a different keyboard layout after the installation, use the **Keyboard Preferences** tool.

To open **Keyboard Layout Preferences**, select **System** → **Preferences** → **Keyboard** from the panel, and click the **`Layouts`** tab.



Keyboard model: Unknown

☑ Separate layout for each window

Selected layouts:

Layout	Default
USA	●

Figure 1.1. Keyboard Layout Preferences

You will be presented with a list of available layouts. To add a new one, click the **Add** button below the list, and you will be prompted to choose which layout you want to add.

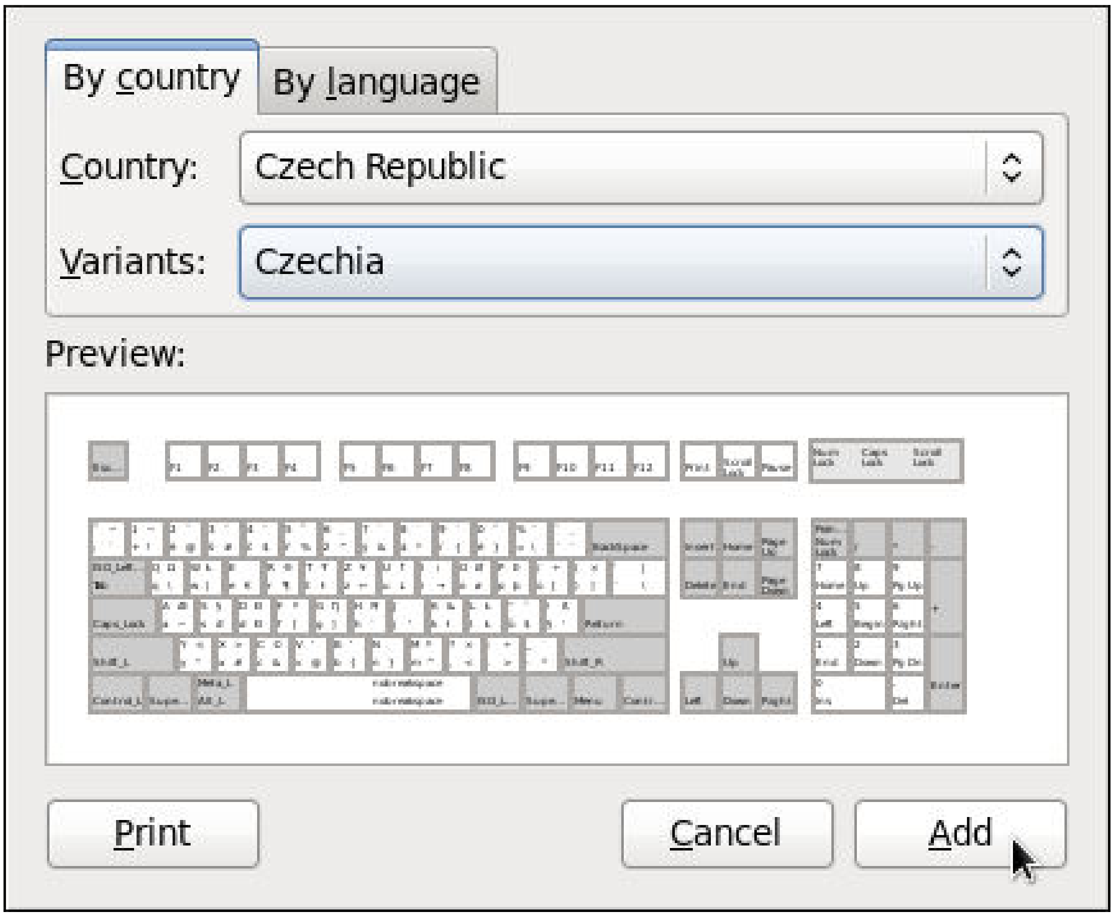


Figure 1.2. Choosing a layout

Currently, there are two ways how to choose the keyboard layout: you can either find it by the country it is associated with (the **`By country`** tab), or you can select it by language (the **`By language`** tab). In either case, first select the desired country or language from the **`Country`** or **`Language`** pulldown menu, then specify the variant from the **`Variants`** menu. The preview of the layout changes immediately. To confirm the selection, click **`Add`**.

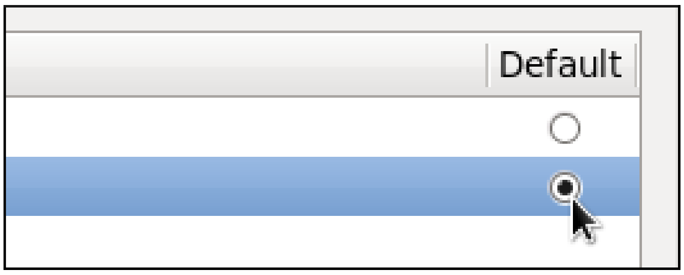


Figure 1.3. Selecting the default layout

The layout should appear in the list. To make it the default, select the radio button next to its name. The changes take effect immediately. Note that there is a text-entry field at the bottom of the window where you can safely test your settings. Once you are satisfied, click **`Close`** to close the window.

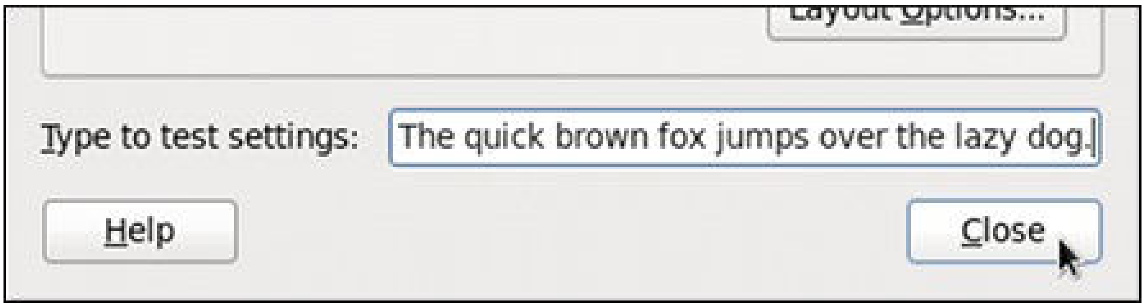
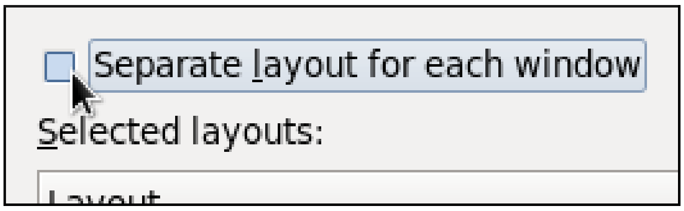


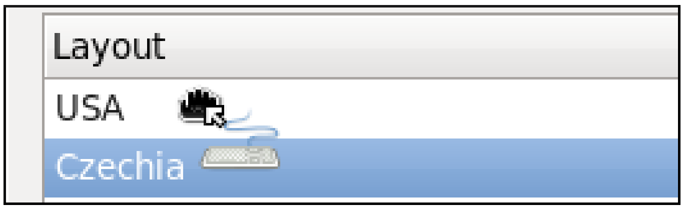
Figure 1.4. Testing the layout

NOTE

By default, changing the keyboard layout affects the active window only. This means that if you change the layout and switch to another window, this window will use the old one, which might be confusing. To turn this behavior off, clear the **`Separate layout for each window`** check box.



Doing this has its drawbacks though, as you will no longer be able to choose the default layout by selecting the radio button as shown in Figure 1.3, "Selecting the default layout". To make the layout the default, drag it to the beginning of the list.



1.2. ADDING THE KEYBOARD LAYOUT INDICATOR

If you want to see what keyboard layout you are currently using, or you would like to switch between different layouts with a single mouse click, add the **Keyboard Indicator** applet to the panel. To do so, right-click the empty space on the main panel, and select the **Add to Panel** option from the pulldown menu.

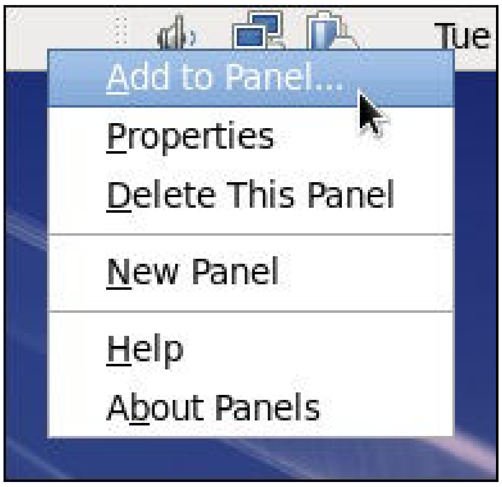
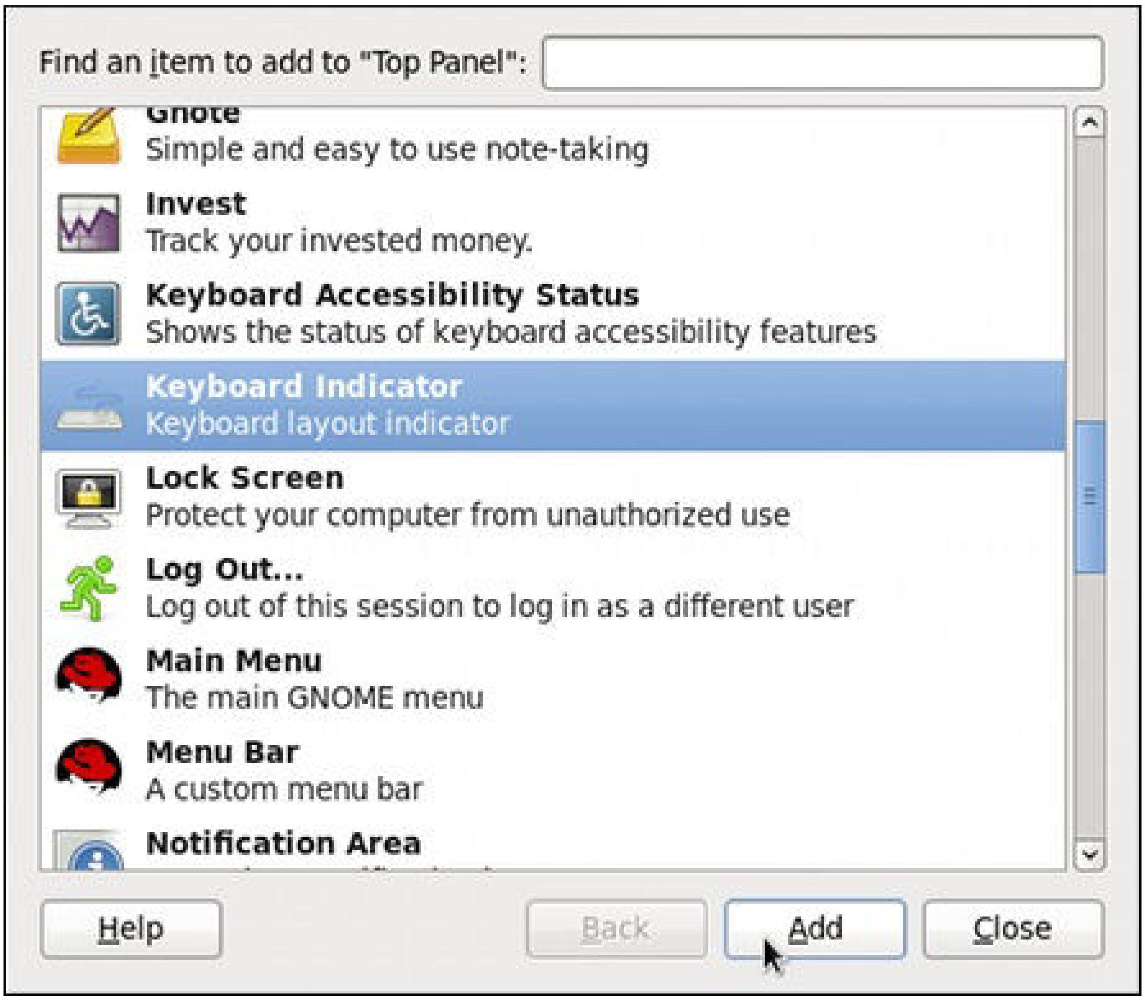


Figure 1.5. Adding a new applet

You will be presented with a list of available applets. Scroll through the list (or start typing “keyboard” into the search field at the top of the window), select **Keyboard Indicator**, and click the **Add** button.


Find an item to add to "Top Panel":

Gnote
Simple and easy to use note-taking

Invest
Track your invested money.

Keyboard Accessibility Status
Shows the status of keyboard accessibility features

Keyboard Indicator
Keyboard layout indicator

Lock Screen
Protect your computer from unauthorized use

Log Out...
Log out of this session to log in as a different user

Main Menu
The main GNOME menu

Menu Bar
A custom menu bar

Notification Area

Figure 1.6. Selecting the Keyboard Indicator

The applet appears immediately, displaying the shortened name of the country the current layout is associated with. To display the actual variant, hover the pointer over the applet icon.

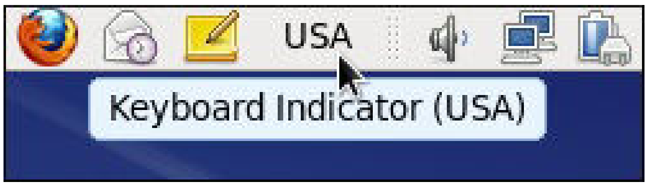
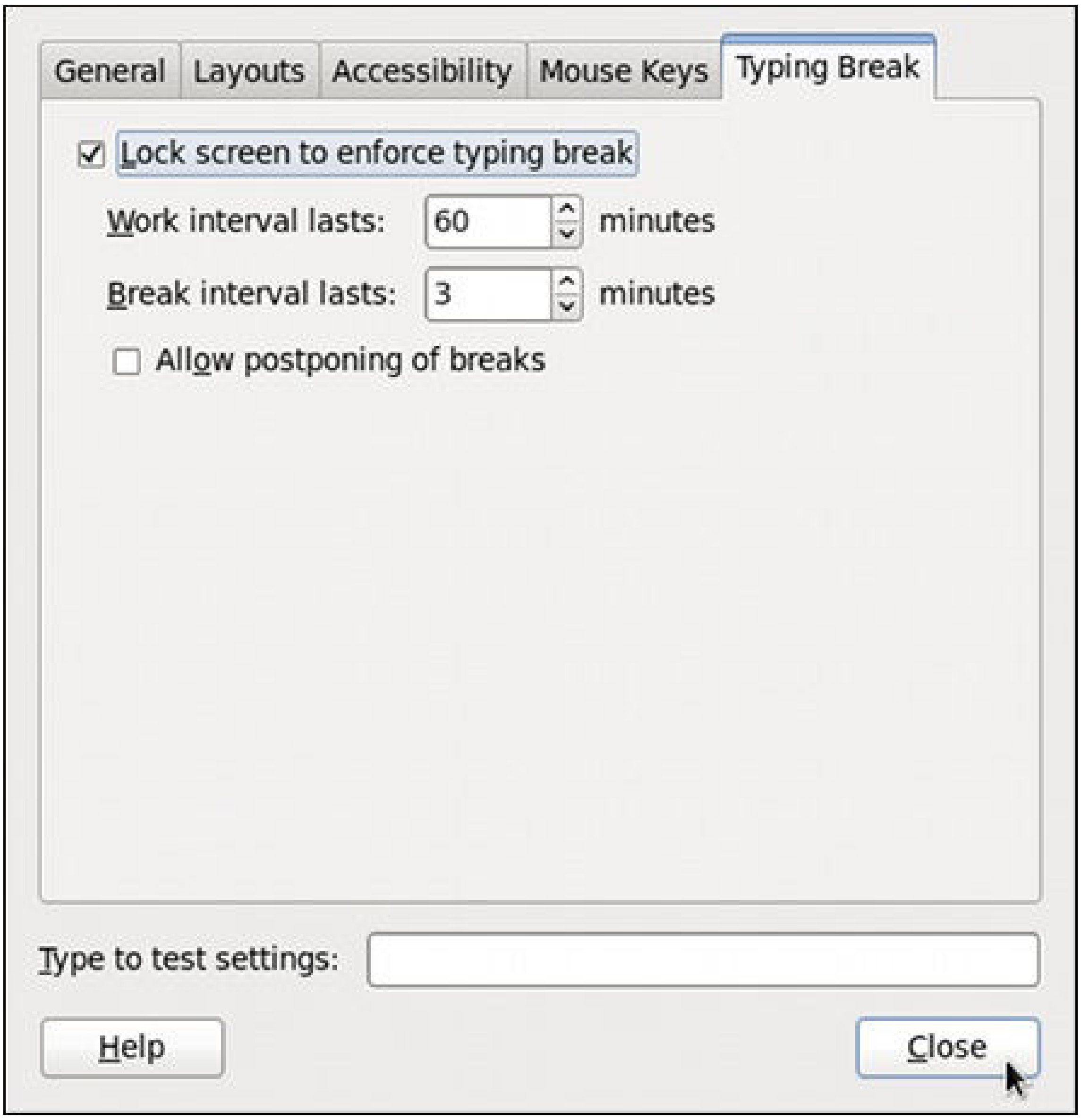


Figure 1.7. The Keyboard Indicator applet

1.3. SETTING UP A TYPING BREAK

Typing for a long period of time can be not only tiring, but it can also increase the risk of serious health problems, such as carpal tunnel syndrome. One way of preventing this is to configure the system to enforce typing breaks. To do so, select **System** → **Preferences** → **Keyboard** from the panel, click the **`Typing Break`** tab, and select the **`Lock screen to enforce typing break`** check box.



☑ Lock screen to enforce typing break

Work interval lasts: 60 minutes

Break interval lasts: 3 minutes

☐ Allow postponing of breaks

Figure 1.8. Typing Break Properties

To increase or decrease the allowed typing time before the break is enforced, click the up or down button next to the **`Work interval lasts`** label respectively. You can do the same with the **`Break interval lasts`** setting to alter the length of the break itself. Finally, select the **`Allow postponing`**

`of breaks` check box if you want to be able to delay the break in case you need to finish the work. The changes take effect immediately.

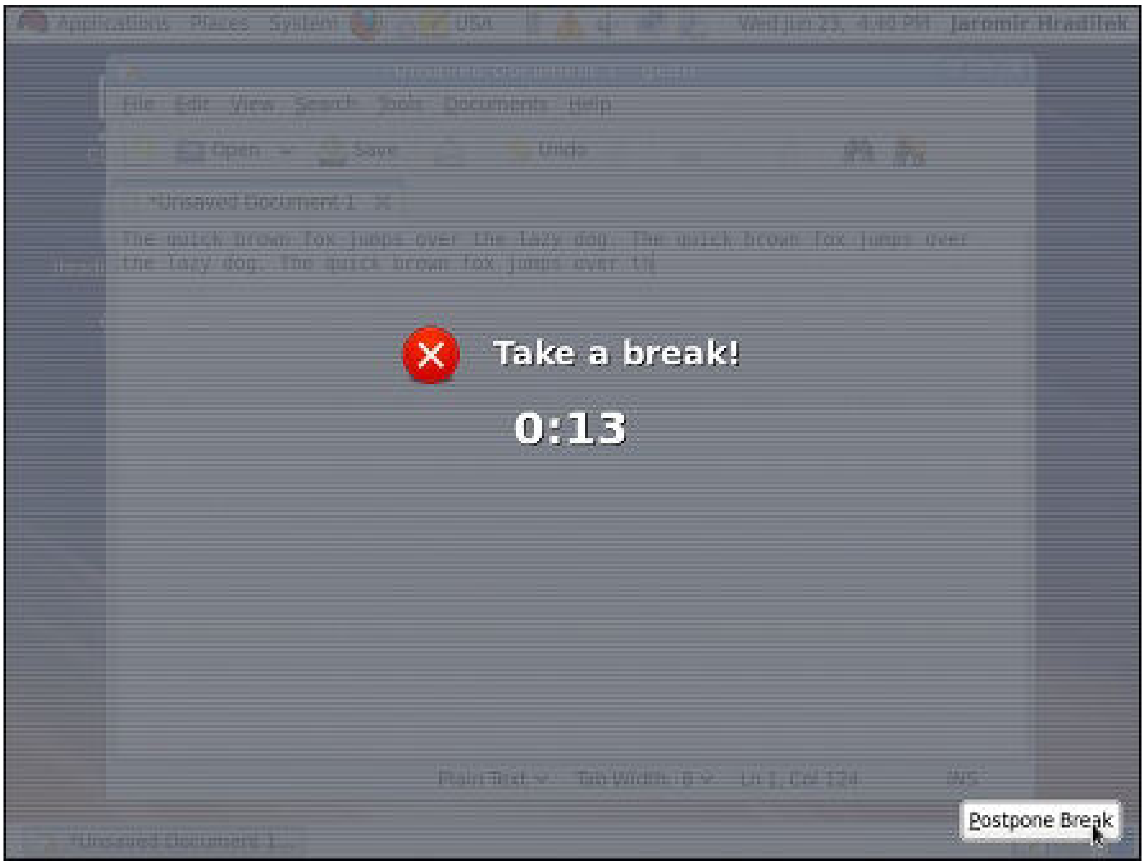


Figure 1.9. Taking a break

Next time you reach the time limit, you will be presented with a screen advising you to take a break, and a clock displaying the remaining time. If you have enabled it, the **`Postpone Break`** button will be located at the bottom right corner of the screen.

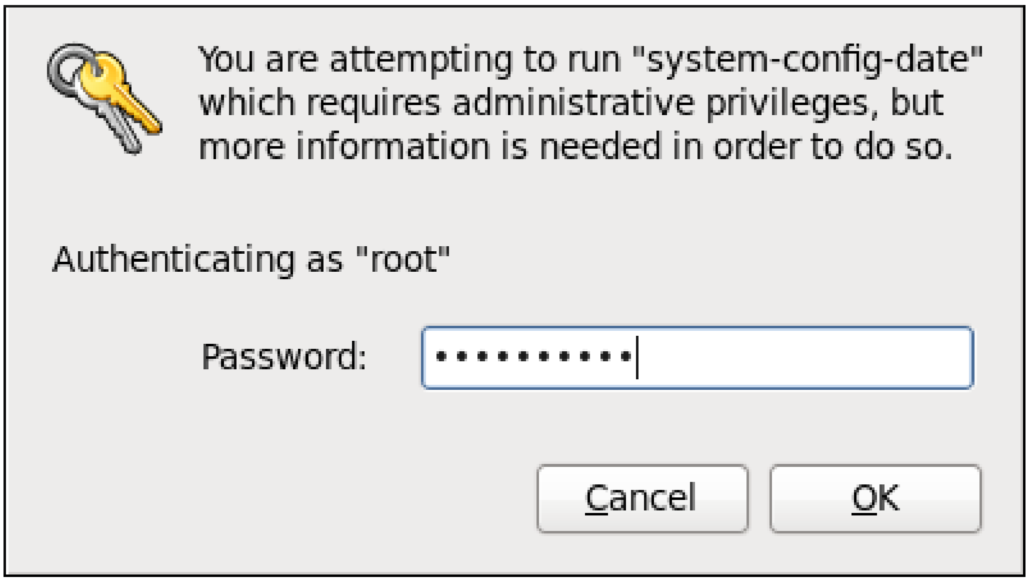
CHAPTER 2. DATE AND TIME CONFIGURATION

This chapter covers setting the system date and time in Red Hat Enterprise Linux, both manually and using the Network Time Protocol (NTP), as well as setting the adequate time zone. Two methods are covered: setting the date and time using the **Date/Time Properties** tool, and doing so on the command line.

2.1. DATE/TIME PROPERTIES TOOL

The **Date/Time Properties** tool allows the user to change the system date and time, to configure the time zone used by the system, and to set up the Network Time Protocol daemon to synchronize the system clock with a time server. Note that to use this application, you must be running the X Window System (see Appendix C, *The X Window System* for more information on this topic).

To start the tool, select **System** → **Administration** → **Date & Time** from the panel, or type the **`system-config-date`** command at a shell prompt (e.g., *xterm* or *GNOME Terminal*). Unless you are already authenticated, you will be prompted to enter the superuser password.


You are attempting to run "system-config-date" which requires administrative privileges, but more information is needed in order to do so.

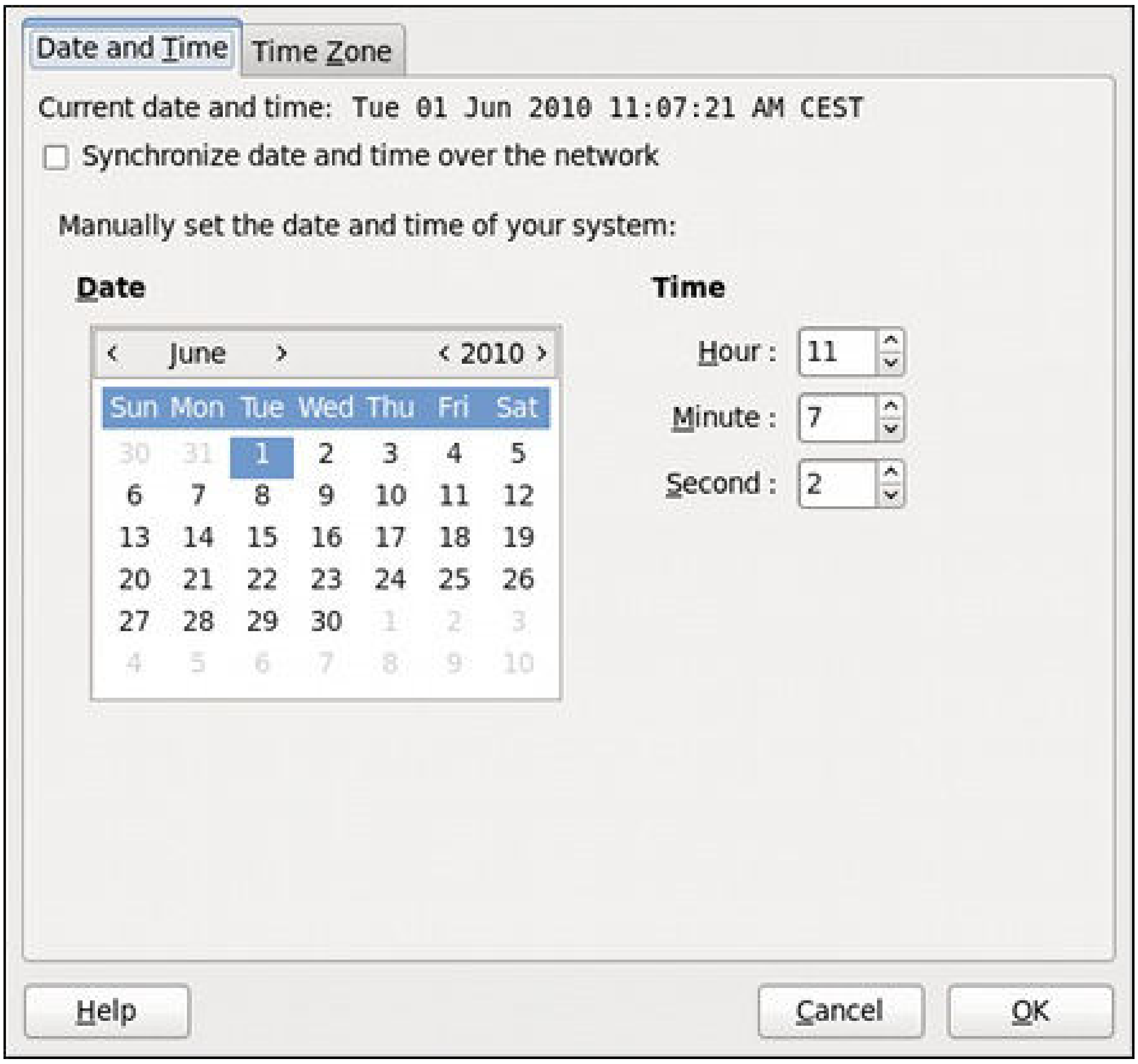
Authenticating as "root"

Password: ••••••••••

Figure 2.1. Authentication Query

2.1.1. Date and Time Properties

As shown in Figure 2.2, “Date and Time Properties”, the **Date/Time Properties** tool is divided into two separate tabs. The tab containing the configuration of the current date and time is shown by default.



Current date and time: Tue 01 Jun 2010 11:07:21 AM CEST

☐ Synchronize date and time over the network

Manually set the date and time of your system:

Date

June 2010

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10

Time

Hour : 11

Minute : 7

Second : 2

Figure 2.2. Date and Time Properties

To set up your system manually, follow these steps:

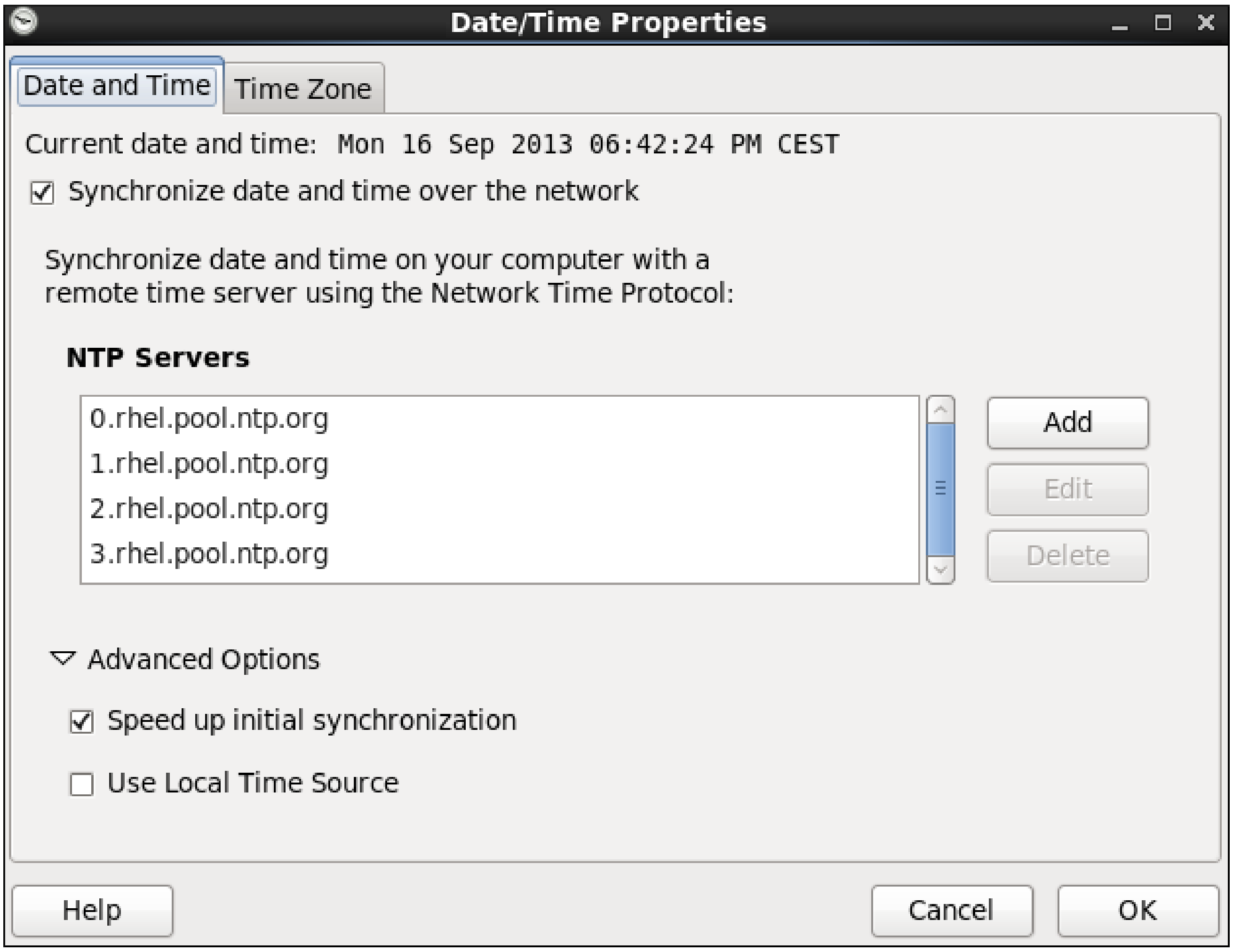
1. *Change the current date.* Use the arrows to the left and right of the month and year to change the month and year respectively. Then click inside the calendar to select the day of the month.

2. *Change the current time.* Use the up and down arrow buttons beside the **`Hour`**, **`Minute`**, and **`Second`**, or replace the values directly.

Click the **`OK`** button to apply the changes and exit the application.

2.1.2. Network Time Protocol Properties

If you prefer an automatic setup, select the check box labeled **`Synchronize date and time over the network`** instead. This will display the list of available NTP servers as shown in Figure 2.3, "Network Time Protocol Properties".



Current date and time: Mon 16 Sep 2013 06:42:24 PM CEST

☑ Synchronize date and time over the network

Synchronize date and time on your computer with a remote time server using the Network Time Protocol:

NTP Servers

0.rhel.pool.ntp.org
1.rhel.pool.ntp.org
2.rhel.pool.ntp.org
3.rhel.pool.ntp.org

Advanced Options

☑ Speed up initial synchronization

☐ Use Local Time Source

Figure 2.3. Network Time Protocol Properties

Here you can choose one of the predefined servers, edit a predefined server by clicking the **`Edit`** button, or add a new server name by clicking **`Add`**. In the **`Advanced Options`**, you can also select whether you want to speed up the initial synchronization of the system clock, or if you want to use a local time source.

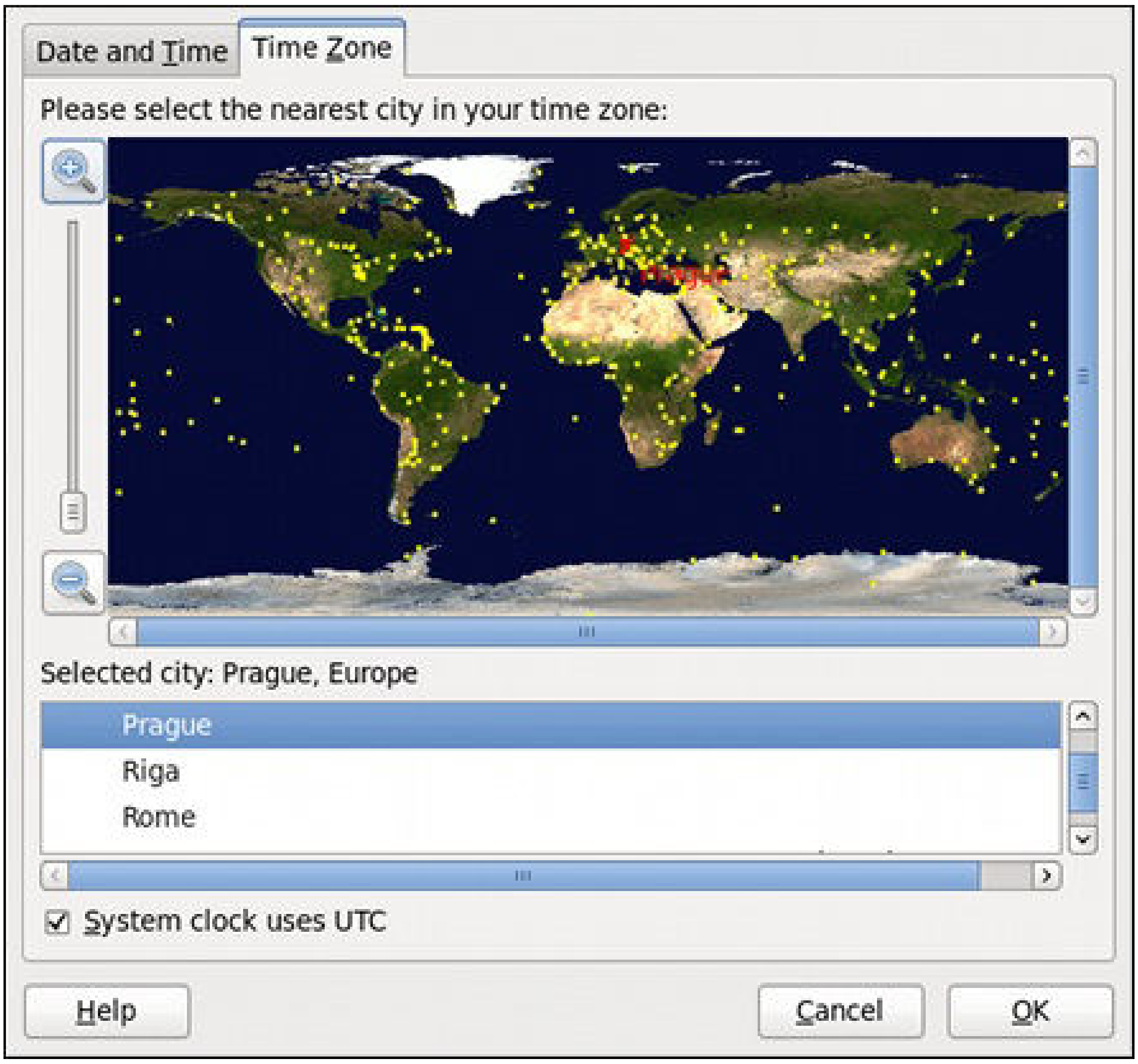
NOTE

Your system does not start synchronizing with the NTP server until you click the **`OK`** button at the bottom of the window to confirm your changes.

Click the **`OK`** button to apply any changes made to the date and time settings and exit the application.

2.1.3. Time Zone Properties

To configure the system time zone, click the **`Time Zone`** tab as shown in Figure 2.4, “Time Zone Properties”.



Selected city: Prague, Europe

Prague
Riga
Rome

☑ System clock uses UTC

Figure 2.4. Time Zone Properties

There are two common approaches to the time zone selection:

1. *Using the interactive map.* Click “zoom in” and “zoom out” buttons next to the map, or click on the map itself to zoom into the selected region. Then choose the city specific to your time zone. A red **X** appears and the time zone selection changes in the list below the map.

2. *Use the list below the map.* To make the selection easier, cities and countries are grouped within their specific continents. Note that non-geographic time zones have also been added to address needs in the scientific community.

If your system clock is set to use UTC, select the **`System clock uses UTC`** option. UTC stands for the *Universal Time, Coordinated*, also known as *Greenwich Mean Time* (GMT). Other time zones are determined by adding or subtracting from the UTC time.

Click **`OK`** to apply the changes and exit the program.

2.2. COMMAND LINE CONFIGURATION

In case your system does not have the **Date/Time Properties** tool installed, or the X Window Server is not running, you will have to change the system date and time on the command line. Note that in order to perform actions described in this section, you have to be logged in as a superuser:

```
~]$ su -
Password:
```

2.2.1. Date and Time Setup

The **`date`** command allows the superuser to set the system date and time manually:

1. *Change the current date.* Type the command in the following form at a shell prompt, replacing the *YYYY* with a four-digit year, *MM* with a two-digit month, and *DD* with a two-digit day of the month:

   ```
   ~]# date +%D -s YYYY-MM-DD
   ```

   For example, to set the date to 2 June 2010, type:

   ```
   ~]# date +%D -s 2010-06-02
   ```

2. *Change the current time.* Use the following command, where *HH* stands for an hour, *MM* is a minute, and *SS* is a second, all typed in a two-digit form:

   ```
   ~]# date +%T -s HH:MM:SS
   ```

   If your system clock is set to use UTC (Coordinated Universal Time), add the following option:

   ```
   ~]# date +%T -s HH:MM:SS -u
   ```

   For instance, to set the system clock to 11:26 PM using the UTC, type:

   ```
   ~]# date +%T -s 23:26:00 -u
   ```

You can check your current settings by typing **`date`** without any additional argument:

Example 2.1. Displaying the current date and time

```
~]$ date
Wed Jun  2 11:58:48 CEST 2010
```

2.2.2. Network Time Protocol Setup

As opposed to the manual setup described above, you can also synchronize the system clock with a remote server over the Network Time Protocol (NTP). For the one-time synchronization only, use the **ntpdate** command:

1. Firstly, check whether the selected NTP server is accessible:

   ```
   ~]# ntpdate -q server_address
   ```

   For example:

   ```
   ~]# ntpdate -q 0.rhel.pool.ntp.org
   ```

■

2. When you find a satisfactory server, run the **ntpdate** command followed by one or more server addresses:

   ```
   ~]# ntpdate server_address...
   ```

   For instance:

   ```
   ~]# ntpdate 0.rhel.pool.ntp.org 1.rhel.pool.ntp.org
   ```

   Unless an error message is displayed, the system time should now be set. You can check the current by setting typing **`date`** without any additional arguments as shown in Section 2.2.1, "Date and Time Setup".

3. In most cases, these steps are sufficient. Only if you really need one or more system services to always use the correct time, enable running the **ntpdate** at boot time:

   ```
   ~]# chkconfig ntpdate on
   ```

   For more information about system services and their setup, see Chapter 12, *Services and Daemons*.

   NOTE

   If the synchronization with the time server at boot time keeps failing, i.e., you find a relevant error message in the **`/var/log/boot.log`** system log, try to add the following line to **`/etc/sysconfig/network`**:

   ```
   NETWORKWAIT=1
   ```

However, the more convenient way is to set the **ntpd** daemon to synchronize the time at boot time automatically:

1. Open the NTP configuration file **`/etc/ntp.conf`** in a text editor such as **vi** or **nano**, or create a new one if it does not already exist:

   ```
   ~]# nano /etc/ntp.conf
   ```

2. Now add or edit the list of public NTP servers. If you are using Red Hat Enterprise Linux 6, the file should already contain the following lines, but feel free to change or expand these according to your needs:

   ```
   server 0.rhel.pool.ntp.org iburst
   server 1.rhel.pool.ntp.org iburst
   server 2.rhel.pool.ntp.org iburst
   server 3.rhel.pool.ntp.org iburst
   ```

   The **`iburst`** directive at the end of each line is to speed up the initial synchronization. As of Red Hat Enterprise Linux 6.5 it is added by default. If upgrading from a previous minor release, and your **`/etc/ntp.conf`** file has been modified, then the upgrade to Red Hat Enterprise Linux 6.5 will create a new file **`/etc/ntp.conf.rpmnew`** and will not alter the existing **`/etc/ntp.conf`** file.

3. Once you have the list of servers complete, in the same file, set the proper permissions, giving the unrestricted access to localhost only:

   ```
   restrict default kod nomodify notrap nopeer noquery
   restrict -6 default kod nomodify notrap nopeer noquery
   restrict 127.0.0.1
   restrict -6 ::1
   ```

4. Save all changes, exit the editor, and restart the NTP daemon:

   ```
   ~]# service ntpd restart
   ```

5. Make sure that **`ntpd`** is started at boot time:

   ```
   ~]# chkconfig ntpd on
   ```

CHAPTER 3. MANAGING USERS AND GROUPS

3.1. WHAT USERS AND GROUPS ARE

The control of users and groups is a core element of Red Hat Enterprise Linux system administration. The user of the system is either a human being or an account used by specific applications identified by a unique numerical identification number called *user ID* (UID). Users within a group can have read permissions, write permissions, execute permissions or any combination of read/write/execute permissions for files owned by that group.

Red Hat Enterprise Linux supports *access control lists* (ACLs) for files and directories which allow permissions for specific users outside of the owner to be set. For more information about this feature, see the *Access Control Lists* chapter of the *Red Hat Enterprise Linux 6 Storage Administration Guide*.

A group is an organization unit tying users together for a common purpose, which can be reading permissions, writing permission, or executing permission for files owned by that group. Similar to UID, each group is associated with a group ID (GID).

NOTE

Red Hat Enterprise Linux reserves user and group IDs below 500 for system users and groups. By default, the **User Manager** does not display the system users. Reserved user and group IDs are documented in the setup package. To view the documentation, use this command:

```
cat /usr/share/doc/setup-2.8.14/uidgid
```

The recommended practice is to assign non-reserved IDs starting at 5,000, as the reserved range can increase in the future. To make the IDs assigned to new users by default start at 5,000, change the **`UID_MIN`** and **`GID_MIN`** directives in the **`/etc/login.defs`** file:

```
[file contents truncated]
UID_MIN                  5000
[file contents truncated]
GID_MIN                  5000
[file contents truncated]
```

Even with new user and group IDs beginning with 5,000, it is recommended not to raise IDs reserved by system above 500 to avoid conflict with systems that retain the 500 limit.

Each user is a member of exactly one primary group and zero or more supplementary groups. By default, when a file is created, the file's owner is its creator and the file's group is the creator's primary group. A user can temporarily change what group is their primary group with the **`newgrp`** command, after which all newly created files are owned by the new group. A supplementary group serves to grant a certain set of users, its members, access to a certain set of files, those owned by this group.

The file is assigned separate read, write, and execute permissions for the owner, the group, and everyone else. The file owner can be changed only by **`root`**, and access permissions can be changed by both the **`root`** user and file owner.

By default, a file or directory can be modified only by its creator. The setting that determines what permissions are applied to a newly created file or directory is called a **`umask`** and can be configured in the **/etc/bashrc** file for all users, or in **~/.bashrc** for each user individually . The configuration in **~/.bashrc** overrides the configuration in **/etc/bashrc**. Additionally, the **umask** command overrides the default permissions for the duration of the shell session.

To authenticate, a user enters their password. A hash sum is generated from the entered string and compared to the hash sum of the user's password. If the hash sums match, the user authenticates successfully.

Hash sums of user passwords are stored in the **/etc/shadow** file, which is only readable by the **root** user. The file also stores information about password aging and policies for specific accounts. The default values for a newly created account are stored in the **/etc/login.defs** and **/etc/default/useradd** files. The *Red Hat Enterprise Linux 6 Security Guide* provides more security-related information about users and groups.

3.2. MANAGING USERS VIA THE USER MANAGER APPLICATION

The **User Manager** application allows you to view, modify, add, and delete local users and groups in the graphical user interface.

To start the User Manager application:

- From the toolbar, select **System** → **Administration** → **Users and Groups**.
- Or, type **system-config-users** at the shell prompt.

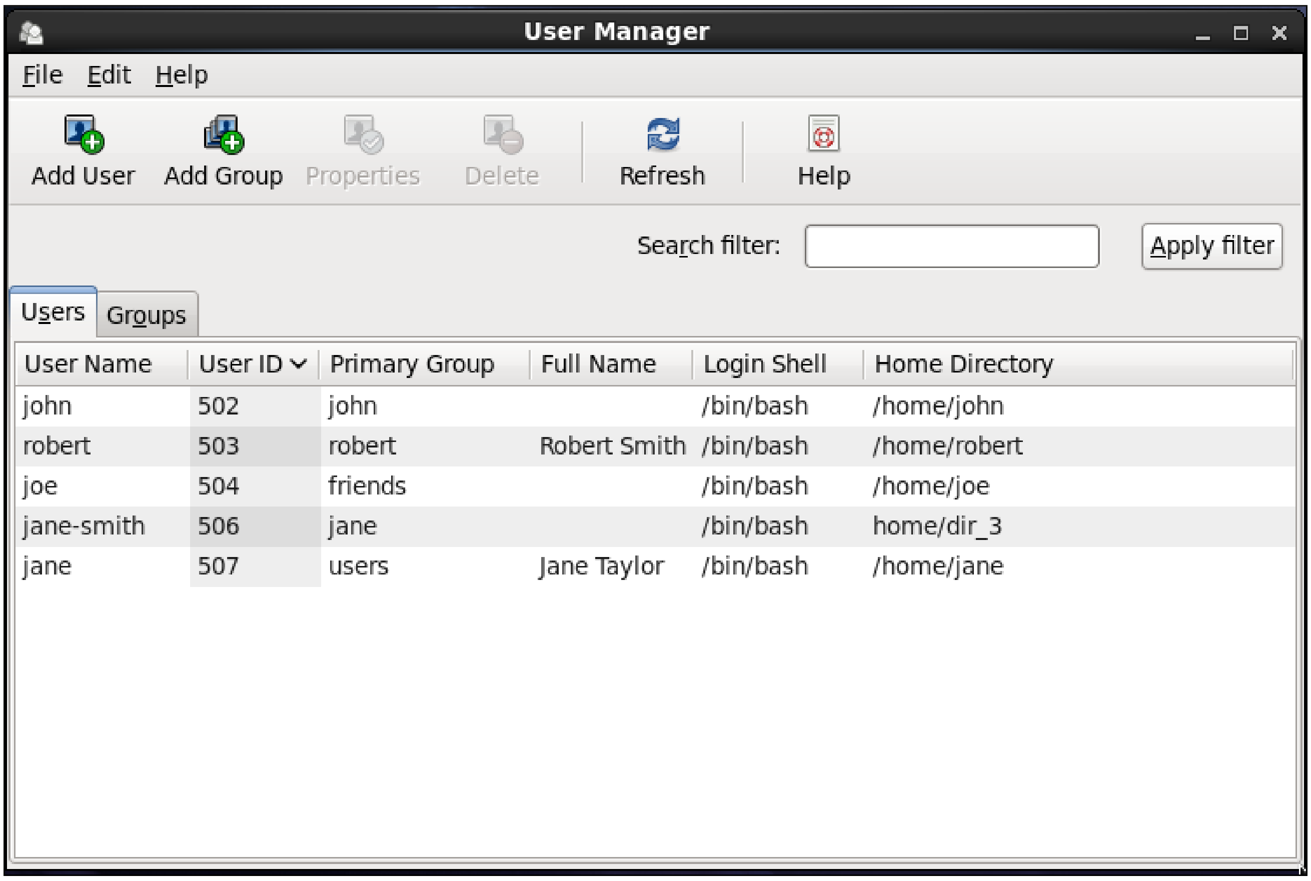
NOTE

Unless you have superuser privileges, the application will prompt you to authenticate as **root**.

3.2.1. Viewing Users

In order to display the main window of the **User Manager** to view users, from the toolbar of **User Manager** select **Edit** → **Preferences**. If you want to view *all* the users, that is including system users, clear the **Hide system users and groups** check box.

The **Users** tab provides a list of local users along with additional information about their user ID, primary group, home directory, login shell, and full name.



User Name	User ID	Primary Group	Full Name	Login Shell	Home Directory
john	502	john		/bin/bash	/home/john
robert	503	robert	Robert Smith	/bin/bash	/home/robert
joe	504	friends		/bin/bash	/home/joe
jane-smith	506	jane		/bin/bash	home/dir_3
jane	507	users	Jane Taylor	/bin/bash	/home/jane

Figure 3.1. Viewing Users

To find a specific user, type the first few letters of the name in the **`Search filter`** field and either press **`Enter`**, or click the **`Apply filter`** button. You can also sort the items according to any of the available columns by clicking the column header.

3.2.2. Adding a New User

If there is a new user you need to add to the system, follow this procedure:

1. Click the **`Add User`** button.

2. Enter the user name and full name in the appropriate fields

3. Type the user's password in the **`Password`** and **`Confirm Password`** fields. The password must be at least six characters long.

   NOTE

   For safety reasons, choose a long password not based on a dictionary term; use a combination of letters, numbers, and special characters.

4. Select a login shell for the user from the **`Login Shell`** drop-down list or accept the default value of /**bin**/**bash**.

5. Clear the **`Create home directory`** check box if you choose not to create the home directory for a new user in ***`/home/username/`***.

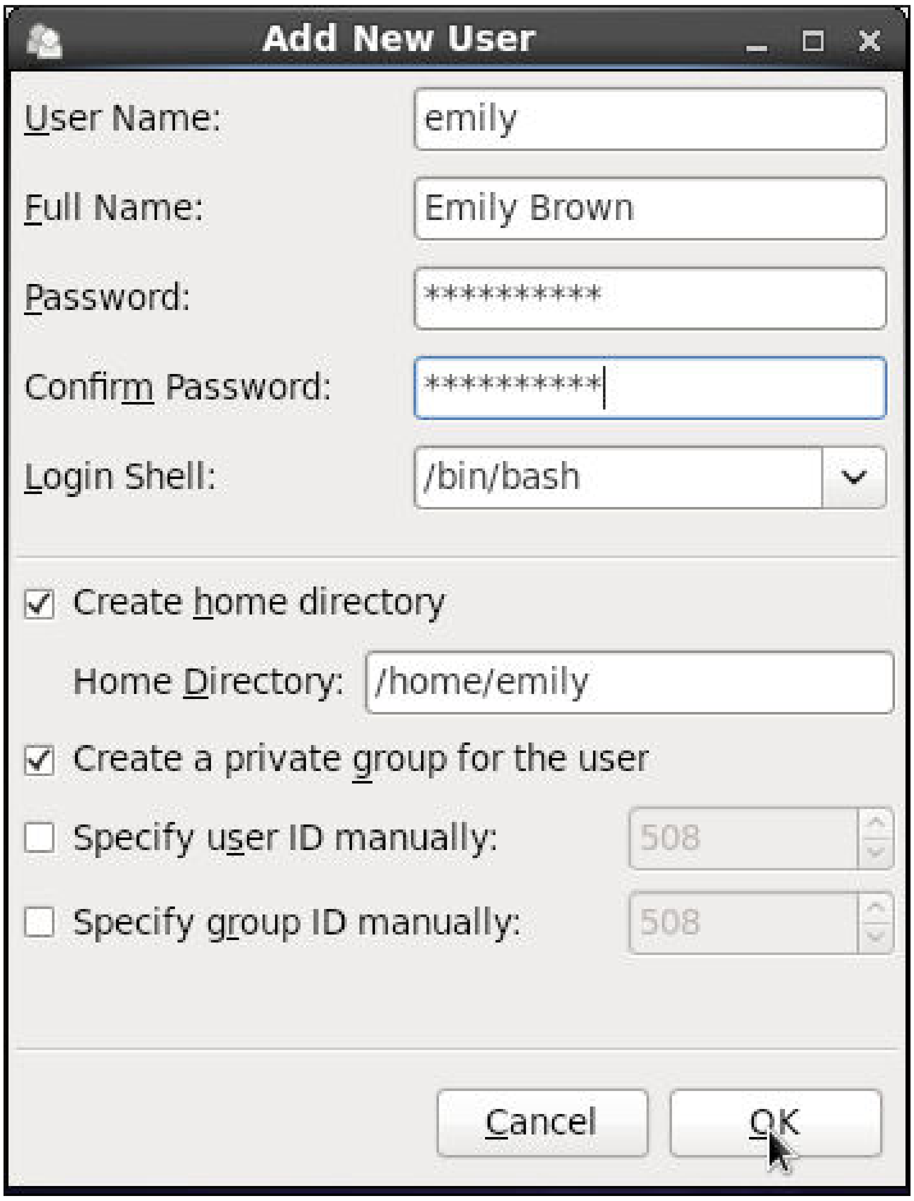
You can also change this home directory by editing the content of the **`Home Directory`** text box. Note that when the home directory is created, default configuration files are copied into it from the **`/etc/skel/`** directory.

6. Clear the **`Create a private group for the user`** check box if you do not want a unique group with the same name as the user to be created. User private group (UPG) is a group assigned to a user account to which that user exclusively belongs, which is used for managing file permissions for individual users.

7. Specify a user ID for the user by selecting **`Specify user ID manually`**. If the option is not selected, the next available user ID above 500 is assigned to the new user.

8. Click the **`OK`** button to complete the process.

Look at the sample **`Add New User`** dialog box configuration:



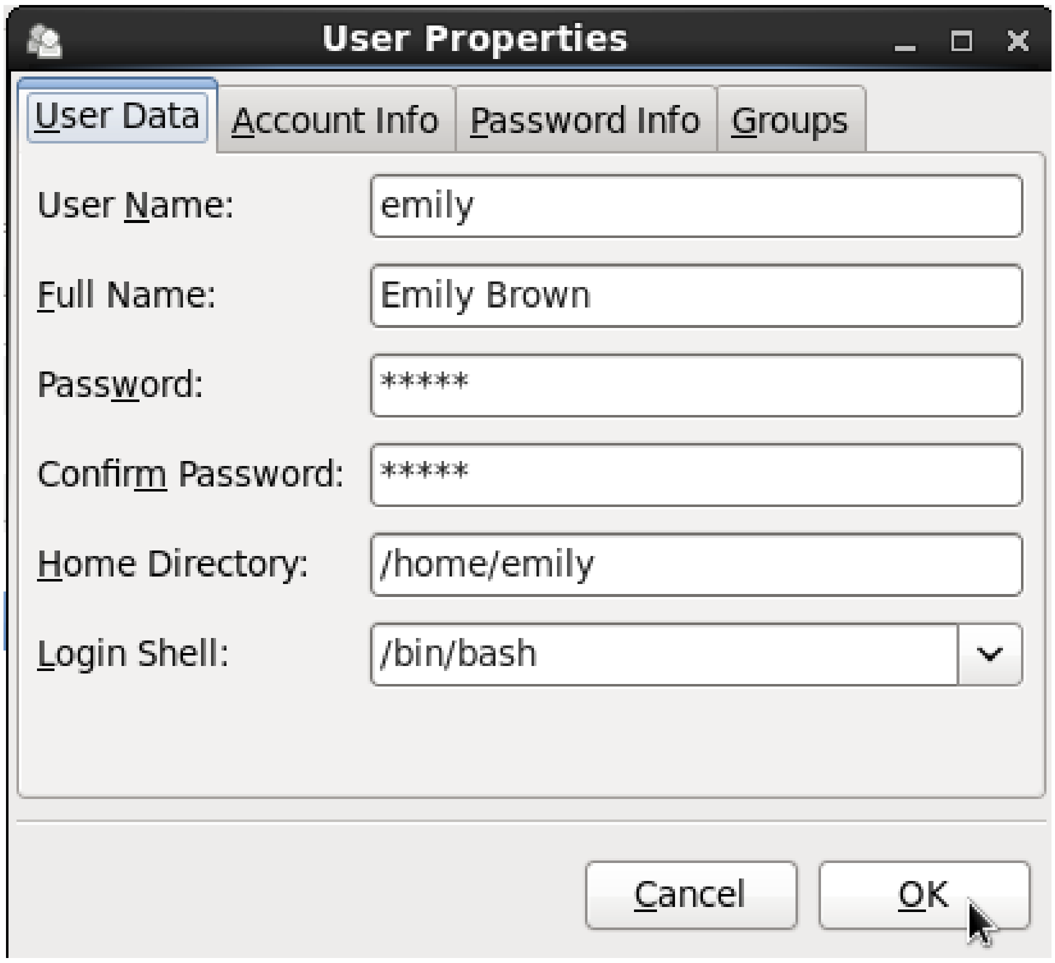
User Name: emily
Full Name: Emily Brown
Password: **********
Confirm Password: **********
Login Shell: /bin/bash
☑ Create home directory
Home Directory: /home/emily
☑ Create a private group for the user
☐ Specify user ID manually: 508
☐ Specify group ID manually: 508

To configure more advanced user properties, such as password expiration, modify the user's properties after adding the user.

3.2.3. Modifying User Properties

1. Select the user from the user list by clicking once on the user name.

2. Click **Properties** from the toolbar or choose **File** → **Properties** from the drop-down menu.



User Name: emily
Full Name: Emily Brown
Password: *****
Confirm Password: *****
Home Directory: /home/emily
Login Shell: /bin/bash

Figure 3.2. User Properties

3. There are four tabs you can update to your preferences. When you have finished, click the **`OK`** button to save your changes.

3.3. MANAGING GROUPS VIA THE USER MANAGER APPLICATION

3.3.1. Viewing Groups

In order to display the main window of **User Manager** to view groups, from the toolbar select **Edit** → **Preferences**. If you want to view *all* the groups, clear the **`Hide system users and groups`** check box.

The **`Groups`** tab provides a list of local groups with information about their group ID and group members as you can see in the picture below.

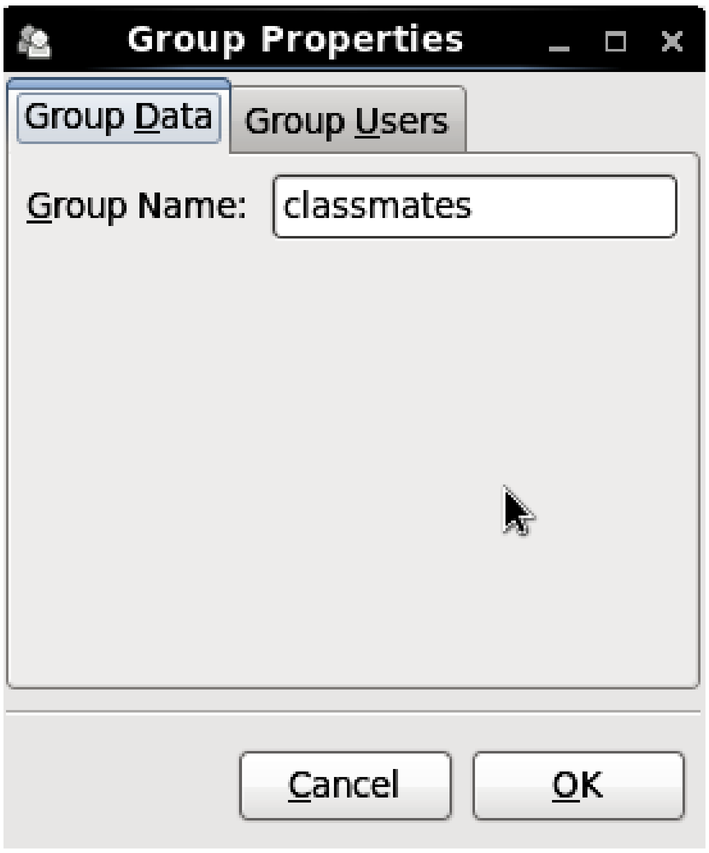


Figure 3.3. Viewing Groups

To find a specific group, type the first few letters of the name in the **`Search filter`** field and either press **`Enter`**, or click the **`Apply filter`** button. You can also sort the items according to any of the available columns by clicking the column header.

3.3.2. Adding a New Group

If there is a new group you need to add to the system, follow this procedure:

1. Select **`Add Group`** from the User Manager toolbar:

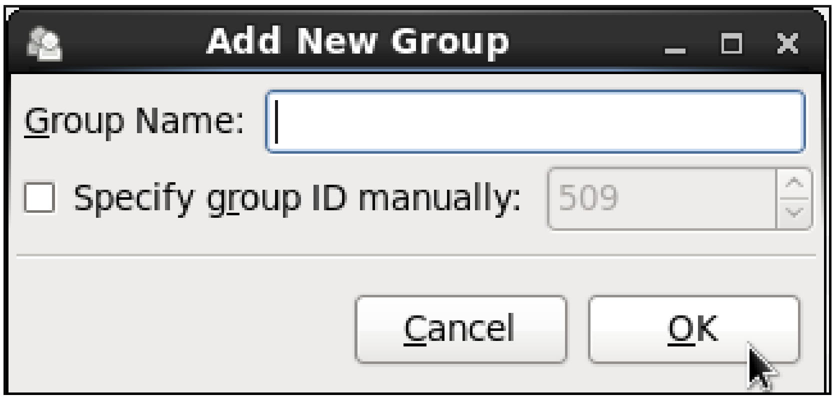


Figure 3.4. New Group

2. Type the name of the new group.

3. Specify the group ID (GID) for the new group by checking the **`Specify group ID manually`** check box.

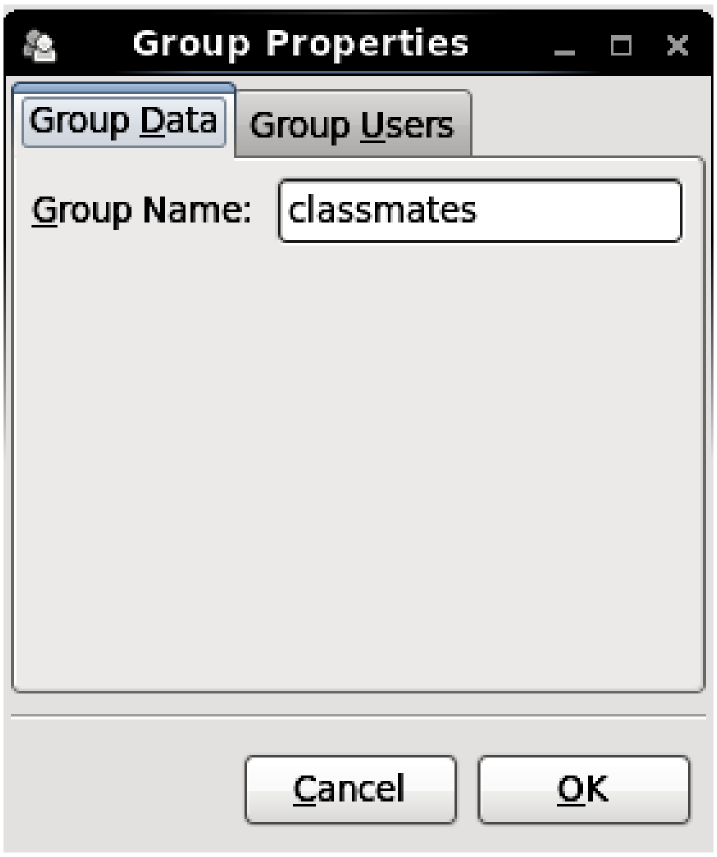
4. Select the GID. Note that Red Hat Enterprise Linux also reserves group IDs lower than 500 for system groups.

5. Click **OK** to create the group. The new group appears in the group list.

3.3.3. Modifying Group Properties

1. Select the group from the group list by clicking on its name.

2. Click **Properties** from the toolbar or choose **File** → **Properties** from the drop-down menu.



Group Name: classmates

Figure 3.5. Group Properties

3. The **`Group Users`** tab displays the list of group members. Use this tab to add or remove users from the group. Click **`OK`** to save your changes.

3.4. MANAGING USERS VIA COMMAND-LINE TOOLS

When managing users via command line, the following commands are used: **`useradd`**, **`usermod`**, **`userdel`**, or **`passwd`**. The files affected include **`/etc/passwd`** which stores user accounts information and **`/etc/shadow`**, which stores secure user account information.

3.4.1. Creating Users

The **`useradd`** utility creates new users and adds them to the system. Following the short procedure below, you will create a default user account with its UID, automatically create a home directory where default user settings will be stored, **`/home/`*`username`*`/`**, and set the default shell to **`/bin/bash`**.

1. Run the following command at a shell prompt as **`root`** substituting *username* with the name of your choice:

```
useradd username
```

2. By setting a password unlock the account to make it accessible. Type the password twice when the program prompts you to.

```
passwd
```

Example 3.1. Creating a User with Default Settings

```
~]# useradd robert
~]# passwd robert
Changing password for user robert
New password:
Re-type new password:
passwd: all authentication tokens updated successfully.
```

Running the **`useradd robert`** command creates an account named **`robert`**. If you run **`cat /etc/passwd`** to view the content of the **`/etc/passwd`** file, you can learn more about the new user from the line displayed to you:

```
robert:x:502:502::/home/robert:/bin/bash
```

`robert` has been assigned a UID of 502, which reflects the rule that the default UID values from 0 to 499 are typically reserved for system accounts. GID, group ID of **`User Private Group`**, equals to UID. The home directory is set to **`/home/robert`** and login shell to **`/bin/bash`**. The letter **`x`** signals that shadow passwords are used and that the hashed password is stored in **`/etc/shadow`**.

If you want to change the basic default setup for the user while creating the account, you can choose from a list of command-line options modifying the behavior of **`useradd`** (see the **`useradd`**(8) man page for the whole list of options). As you can see from the basic syntax of the command, you can add one or more options:

```
useradd [option(s)] username
```

As a system administrator, you can use the **`-c`** option to specify, for example, the full name of the user when creating them. Use **`-c`** followed by a string, which adds a comment to the user:

```
useradd -c "string" username
```

Example 3.2. Specifying a User's Full Name when Creating a User

```
~]# useradd -c "Robert Smith" robert
~]# cat /etc/passwd
robert:x:502:502:Robert Smith:/home/robert:/bin/bash
```

A user account has been created with user name **`robert`**, sometimes called the login name, and full name Robert Smith.

If you do not want to create the default ***/home/username/*** directory for the user account, set a different one instead of it. Execute the command below:

```
useradd -d home_directory
```

Example 3.3. Adding a User with non-default Home Directory

```
~]# useradd -d /home/dir_1 robert
```

robert's home directory is now not the default **/home/robert** but **/home/dir_1/**.

If you do not want to create the home directory for the user at all, you can do so by running **useradd** with the **-M** option. However, when such a user logs into a system that has just booted and their home directory does not exist, their login directory will be the root directory. If such a user logs into a system using the **su** command, their login directory will be the current directory of the previous user.

```
useradd -M username
```

If you need to copy a directory content to the **/home** directory while creating a new user, make use of the **-m** and **-k** options together followed by the path.

Example 3.4. Creating a User while Copying Contents to the Home Directory

The following command copies the contents of a directory named **/dir_1** to **/home/jane**, which is the default home directory of a new user **jane**:

```
~]# useradd -m -k /dir_1 jane
```

As a system administrator, you may need to create a temporary account. Using the **useradd** command, this means creating an account for a certain amount of time only and disabling it at a certain date. This is a particularly useful setting as there is no security risk resulting from forgetting to delete a certain account. For this, the **-e** option is used with the specified *expire_date* in the YYYY-MM-DD format.

NOTE

Do not confuse account expiration and password expiration. Account expiration is a particular date, after which it is impossible to log in to the account in any way, as the account no longer exists. Password expiration, the maximum password age and date of password creation or last password change, is the date, when it is not possible to log in using the password (but other ways exist, such as logging in using an SSH key).

```
useradd -e YYYY-MM-DD username
```

Example 3.5. Setting the Account Expiration Date

```
~]# useradd -e 2015-11-05 emily
```

The account **emily** will be created now and automatically disabled on 5 November, 2015.

- User's login shell defaults to **/bin/bash**, but can be changed by the **-s** option to any other shell different from bash, ksh, csh, tsh, for example.

```
useradd -s login_shell username
```

Example 3.6. Adding a User with Non-default Shell

```
~]# useradd -s /bin/ksh robert
```

This command creates the user **robert** which has the **/bin/ksh** shell.

The **-r** option creates a system account, which is an account for administrative use that has some, but not all, root privileges. Such accounts have a UID lower than the value of *UID_MIN* defined in **/etc/login.defs**, typically 500 and above for ordinary users.

```
useradd -r username
```

3.4.2. Attaching New Users to Groups

The **useradd** command creates a **User Private Group** (*UPG*, a group assigned to a user account to which that user exclusively belongs) whenever a new user is added to the system and names the group after the user. For example, when the account **robert** is created, an UPG named **robert** is created at the same time, the only member of which is the user **robert**.

If you do not want to create a **User Private Group** for a user for whatever reason, execute the **useradd** command with the following option:

```
useradd -N username
```

Instead of automatically creating UPG or not creating it at all, you can specify the user's group membership with **-g** and **-G** options. While the **-g** option specifies the primary group membership, **-G** refers to supplementary groups into which the user is also included. The group names you specify must already exist on the system.

Example 3.7. Adding a User to a Group

```
~]# useradd -g "friends" -G "family,schoolmates" emily
```

The **useradd -g "friends" -G "family,schoolmates" emily** command creates the user **emily** but **emily**'s primary group is set to **friends** as specified by the **-g** option. **emily** is also a group member of the supplementary groups **family** and **schoolmates**.

Provided the user already exists and you want to add them to certain supplementary group(s), use the **usermod** command with the **-G** option and a list of groups divided by commas, no spaces:

```
usermod -G group_1,group_2,group_3
```

3.4.3. Updating Users' Authentication

When running the basic **`useradd`** ***`username`*** command, the password is automatically set to never expire (see the **`/etc/shadow`** file).

If you want to change this, use **`passwd`**, the standard utility for administering the **`/etc/passwd`** file. The syntax of the **`passwd`** command look as follows:

```
passwd option(s) username
```

You can, for example, lock the specified account. The locking is performed by rendering the encrypted password into an invalid string by prefixing the encrypted string with an the exclamation mark (**`!`**). If you later find a reason to unlock the account, **`passwd`** has a reverse operation for locking. Only **`root`** can carry out these two operations.

```
passwd -l username
passwd -u username
```

Example 3.8. Unlocking a User Password

```
~]# passwd -l robert
Locking password for user robert.
passwd: Success
~]# passwd -u robert
passwd: Warning: unlocked password would be empty
passwd: Unsafe operation (use -f to force)
```

At first, the **`-l`** option locks **`robert`**'s account password successfully. However, running the **`passwd -u`** command does not unlock the password because by default **`passwd`** refuses to create a passwordless account.

If you want a password for an account to expire, run **`passwd`** with the **`-e`** option. The user will be forced to change the password during the next login attempt:

```
passwd -e username
```

As far as the password lifetime is concerned, setting the minimum time between password changes is useful for forcing the user to really change the password. The system administrator can set the minimum (the **`-n`** option) and the maximum (the **`-x`** option) lifetimes. To inform the user about their password expiration, use the **`-w`** option. All these options must be accompanied with the number of days and can be run as **`root`** only.

Example 3.9. Adjusting Aging Data for User Passwords

```
~]# passwd -n 10 -x 60 -w 3 jane
```

The above command has set the minimum password lifetime to 10 days, the maximum password lifetime to 60, and the number of days **`jane`** will begin receiving warnings in advance that her password will expire to 3 day.

Later, when you cannot remember the password setting, make use of the **`-S`** option which outputs a short information for you to know the status of the password for a given account:

```
~]# passwd -S jane
jane LK 2014-07-22 10 60 3 -1 (Password locked.)
```

You can also set the number of days after a password expires with the **`useradd`** command, which disables the account permanently. A value of **`0`** disables the account as soon as the password has expired, and a value of **`-1`** disables the feature, that is, the user will have to change his password when the password expires. The **`-f`** option is used to specify the number of days after a password expires until the account is disabled (but may be unblocked by system administrator):

```
useradd -f number-of-days username
```

For more information on the **`passwd`** command see the **`passwd`**(1) man page.

3.4.4. Modifying User Settings

When a user already exists and you need to specify any of the options now, use the **`usermod`** command. The logic of using **`usermod`** is identical to **`useradd`** as well as its syntax:

```
usermod option(s) username
```

If you need to change the user's user name, use the **`-l`** option with the new user name (or login).

Example 3.10. Changing User's Login

```
~]# usermod -l "emily-smith" emily
```

The **`-l`** option changes the name of the user from the login **`emily`** to the new login, **`emily-smith`**. Nothing else is changed. In particular, **`emily`**'s home directory name (**`/home/emily`**) remains the same unless it is changed manually to reflect the new user name.

In a similar way you can change the user's UID or user's home directory. See the example below:

NOTE

Find all files owned by the specified UID in system and change their owner. Do the same for Access Control List (ACL) referring to the UID. It is recommended to check there are no running processes as they keep running with the old UID.

Example 3.11. Changing User's UID and Home Directory

```
~]# usermod -a -u 699 -d /home/dir_2 robert
```

The command with **`-a -u`** and **`-d`** options changes the settings of user **`robert`**. Now, his ID is 699 instead of 501, and his home directory is no longer **`/home/robert`** but **`/home/dir_2`**.

With the **`usermod`** command you can also move the content of the user's home directory to a new location, or lock the account by locking its password.

Example 3.12. Changing User's

```
~]# usermod -m -d /home/jane -L jane
```

In this sample command, the **`-m`** and **`-d`** options used together move the content of **`jane`**'s home directory to the **`/home/dir_3`** directory. The **`-L`** option locks the access to **`jane`**'s account by locking its password.

For the whole list of options to be used with the **`usermod`** command, see the **`usermod`**(8) man page or run **`usermod --help`** on the command line.

3.4.5. Deleting Users

If you want to remove a user account from the system, use the **`userdel`** command on the command line as **`root`**.

```
userdel username
```

Combining **`userdel`** with the **`-r`** option removes files in the user's home directory along with the home directory itself and the user's mail spool. Files located in other file systems have to be searched for and deleted manually.

```
userdel -r username
```

NOTE

The **`-r`** option is relatively safer, and thus recommended, compared to **`-f`** which forces the removal of the user account even if the user is still logged in.

3.4.6. Displaying Comprehensive User Information

When administering users and groups on your system, you need a good tool to monitor their configuration and activity on the system. Red Hat Enterprise Linux 6 provides you with the **lslogins** command-line utility, which gives you a comprehensive overview of users and groups, not only regarding user or group account configuration but also their activity on the system.

The general syntax of **lslogins** is the following:

```
lslogins [OPTIONS]
```

where *OPTIONS* can be one or more available options and their related parameters. See the **`lslogins`**(1) manual page or the output of the **`lslogins --help`** command for the complete list of available options and their usage.

The **lslogins** utility gives versatile information in a variety of formats based on the chosen options. The following examples introduce the most basic as well as some of the most useful combinations.

Running the **`lslogins`** command without any options shows default information about all system and user accounts on the system. Specifically, their UID, user name, and GECOS information, as well as information about the user's last login to the system, and whether their password is locked or login by password disabled.

Example 3.13. Displaying basic information about all accounts on the system

```
~]# lslogins
  UID USER           PWD-LOCK PWD-DENY  LAST-LOGIN GECOS
    0 root                  0        0             root
    1 bin                   0        1             bin
    2 daemon                0        1             daemon
    3 adm                   0        1             adm
    4 lp                    0        1             lp
    5 sync                  0        1             sync
    6 shutdown              0        1 Jul21/16:20 shutdown
    7 halt                  0        1             halt
    8 mail                  0        1             mail
   10 uucp                  0        1             uucp
   11 operator              0        1             operator
   12 games                 0        1             games
   13 gopher                0        1             gopher
   14 ftp                   0        1             FTP User
   29 rpcuser               0        1             RPC Service User
   32 rpc                   0        1             Rpcbind Daemon
   38 ntp                   0        1
   42 gdm                   0        1
   48 apache                0        1             Apache
   68 haldaemon             0        1             HAL daemon
   69 vcsa                  0        1             virtual console
memory owner
   72 tcpdump               0        1
   74 sshd                  0        1             Privilege-separated
SSH
   81 dbus                  0        1             System message bus
   89 postfix               0        1
   99 nobody                0        1             Nobody
  113 usbmuxd               0        1             usbmuxd user
  170 avahi-autoipd         0        1             Avahi IPv4LL Stack
  173 abrt                  0        1
  497 pulse                 0        1             PulseAudio System
Daemon
  498 saslauth              0        1             Saslauthd user
  499 rtkit                 0        1             RealtimeKit
  500 jsmith                0        0    10:56:12 John Smith
  501 jdoe                  0        0    12:13:53 John Doe
  502 esmith                0        0    12:59:05 Emily Smith
  503 jeyre                 0        0    12:22:14 Jane Eyre
65534 nfsnobody             0        1             Anonymous NFS User
```

To display detailed information about a single user, run the **`lslogins`** ***`LOGIN`*** command, where *LOGIN* is either a UID or a user name. The following example displays detailed information about **`John Doe`**'s account and his activity on the system:

Example 3.14. Displaying detailed information about a single account

```
~]# lslogins jdoe
Username:                           jdoe
UID:                                501
```

```
Gecos field:                         John Doe
Home directory:                      /home/jdoe
Shell:                               /bin/bash
No login:                            no
Password is locked:                  no
Password no required:                no
Login by password disabled:          no
Primary group:                       jdoe
GID:                                 501
Supplementary groups:                users
Supplementary group IDs:             100
Last login:                          12:13:53
Last terminal:                       pts/3
Last hostname:                       192.168.100.1
Hushed:                              no
Password expiration warn interval:  7
Password changed:                    Aug01/02:00
Maximal change time:                 99999
Password expiration:                 Sep01/02:00
Selinux context:
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

If you use the **`--logins=`*`LOGIN`*** option, you can display information about a group of accounts that are specified as a list of UIDs or user names. Specifying the **`--output=`*`COLUMNS`*** option, where *COLUMNS* is a list of available output parameters, you can customize the output of the **`lslogins`** command. For example, the following command shows login activity of the users root, jsmith, jdoe, and esmith:

Example 3.15. Displaying specific information about a group of users

```
~]# lslogins --logins=0,500,jdoe,esmith \
> --output=UID,USER,LAST-LOGIN,LAST-TTY,FAILED-LOGIN,FAILED-TTY
UID USER   LAST-LOGIN LAST-TTY FAILED-LOGIN FAILED-TTY
  0 root
500 jsmith   10:56:12 pts/2
501 jdoe     12:13:53 pts/3
502 esmith   15:46:16 pts/3    15:46:09     ssh:notty
```

The **lslogins** utility also distinguishes between system and user accounts. To address system accounts in your query, use the **`--system-accs`** option. To address user accounts, use the **`--user-accs`**. For example, the following command displays information about supplementary groups and password expirations for all user accounts:

Example 3.16. Displaying information about supplementary groups and password expiration for all user accounts

```
~]# lslogins --user-accs --supp-groups --acc-expiration
  UID USER        GID GROUP     SUPP-GIDS SUPP-GROUPS PWD-WARN PWD-MIN
PWD-MAX PWD-CHANGE
PWD-EXPIR
    0 root          0 root                                   7
99999 Jul21/02:00
  500 jsmith      500 jsmith    1000,100  staff,users        7
```

```
99999 Jul21/02:00
  501 jdoe        501 jdoe      100       users             7
99999 Aug01/02:00
Sep01/02:00
  502 esmith      502 esmith    100       users             7
99999 Aug01/02:00
  503 jeyre       503 jeyre     1000,100  staff,users       7
99999 Jul28/02:00
Sep01/02:00
65534 nfsnobody 65534 nfsnobody
 Jul21/02:00
```

The ability to format the output of **`lslogins`** commands according to the user's needs makes **lslogins** an ideal tool to use in scripts and for automatic processing. For example, the following command returns a single string that represents the time and date of the last login. This string can be passed as input to another utility for further processing.

Example 3.17. Displaying a single piece of information without the heading

```
~]# lslogins --logins=jsmith --output=LAST-LOGIN --time-format=iso |
tail -1
2014-08-06T10:56:12+0200
```

3.5. MANAGING GROUPS VIA COMMAND-LINE TOOLS

Groups are a useful tool for permitting co-operation between different users. There is a set of commands for operating with groups such as **`groupadd`**, **`groupmod`**, **`groupdel`**, or **`gpasswd`**. The files affected include **`/etc/group`** which stores group account information and **`/etc/gshadow`**, which stores secure group account information.

3.5.1. Creating Groups

To add a new group to the system with default settings, the **`groupadd`** command is run at the shell prompt as **`root`**.

```
groupadd group_name
```

Example 3.18. Creating a Group with Default Settings

```
~]# groupadd friends
```

The **`groupadd`** command creates a new group called **`friends`**. You can read more information about the group from the newly-created line in the **`/etc/group`** file:

```
classmates:x:30005:
```

Automatically, the group **`friends`** is attached with a unique GID (group ID) of 30005 and is not attached with any users. Optionally, you can set a password for a group by running **`gpasswd`** ***`groupname`***.

-

Alternatively, you can add command options with specific settings.

```
groupadd option(s) groupname
```

If you, for example, want to specify the numerical value of the group's ID (GID) when creating the group, run the **groupadd** command with the **-g** option. Remember that this value must be unique (unless the **-o** option is used) and the value must be non-negative.

```
groupadd -g GID
```

Example 3.19. Creating a Group with Specified GID

The command below creates a group named **schoolmates** and sets GID of 60002 for it:

```
~]# groupadd -g 60002 schoolmates
```

When used with **-g** and *GID* already exists, **groupadd** refuses to create another group with existing GID. As a workaround, use the **-f** option, with which **groupadd** creates a group, but with a different *GID*.

```
groupadd -f GID
```

You may also create a system group by attaching the **-r** option to the **groupadd** command. System groups are used for system purposes, which practically means that GID is allocated from 1 to 499 within the reserved range of 999.

```
groupadd -r group_name
```

For more information on **groupadd**, see the groupadd(8) man pages.

3.5.2. Attaching Users to Groups

If you want to add an existing user to the named group, you can make use of the **gpasswd** command.

```
gpasswd -a username which_group_to_edit
```

To remove a user from the named group, run:

```
gpasswd -d username which_group_to_edit
```

To set the list of group members, write the user names after the **--members** option dividing them with commas and no spaces:

```
gpasswd --members username_1,username_2 which_group_to_edit
```

3.5.3. Updating Group Authentication

The **gpasswd** command administers **/etc/group** and **/etc/gshadow** files. Note that this command works only if run by a group administrator.

Who is a group administrator? A group administrator can add and delete users as well as set, change, or remove the group password. A group can have more than one group administrator. The **root** user can add group administrators with the **gpasswd -A *users groupname*** where *users* is a comma-separated list of existing users you want to be group administrators (without any spaces between commas).

For changing a group's password, run the **gpasswd** command with the relevant group name. You will be prompted to type the new password of the group.

```
gpasswd groupname
```

Example 3.20. Changing a Group Password

```
~]# gpasswd crowd
Changing password for group crowd
New password:
Re-enter new password:
```

The password for the group **crowd** has been changed.

You can also remove the password from the named group by using the **-r** option.

```
gpasswd -r schoolmates
```

3.5.4. Modifying Group Settings

When a group already exists and you need to specify any of the options now, use the **groupmod** command. The logic of using **groupmod** is identical to **groupadd** as well as its syntax:

```
groupmod option(s) groupname
```

To change the group ID of a given group, use the **groupmod** command in the following way:

```
groupmod -g GID_NEW which_group_to_edit
```

NOTE

Find all files owned by the specified GID in system and change their owner. Do the same for Access Control List (ACL) referring to the GID. It is recommended to check there are no running processes as they keep running with the old GID.

To change the name of the group, run the following on the command line. The name of the group will be changed from *GROUP_NAME* to *NEW_GROUP_NAME* name.

```
groupmod -n new_groupname groupname
```

Example 3.21. Changing a Group's Name

The following command changes the name of the group **schoolmates** to **crowd**:

```
~]# groupmod -n crowd schoolmates
```

3.5.5. Deleting Groups

The **groupdel** command modifies the system account files, deleting all entries that see the group. The named group must exist when you execute this command.

```
groupdel groupname
```

3.6. ADDITIONAL RESOURCES

See the following resources for more information about managing users and groups.

3.6.1. Installed Documentation

For information about various utilities for managing users and groups, see the following manual pages:

- **chage**(1) — A command to modify password aging policies and account expiration.
- **gpasswd**(1) — A command to administer the **/etc/group** file.
- **groupadd**(8) — A command to add groups.
- **grpck**(8) — A command to verify the **/etc/group** file.
- **groupdel**(8) — A command to remove groups.
- **groupmod**(8) — A command to modify group membership.
- **pwck**(8) — A command to verify the **/etc/passwd** and **/etc/shadow** files.
- **pwconv**(8) — A tool to convert standard passwords to shadow passwords.
- **pwunconv**(8) — A tool to convert shadow passwords to standard passwords.
- **useradd**(8) — A command to add users.
- **userdel**(8) — A command to remove users.
- **usermod**(8) — A command to modify users.

For information about related configuration files, see:

- **group**(5) — The file containing group information for the system.
- **passwd**(5) — The file containing user information for the system.
- **shadow**(5) — The file containing passwords and account expiration information for the system.
- **login.defs**(5) - The file containing shadow password suite configuration.

- **useradd**(8) - For **`/etc/default/useradd`**, section “Changing the default values” in manual page.

CHAPTER 4. GAINING PRIVILEGES

System administrators (and in some cases users) will need to perform certain tasks with administrative access. Accessing the system as **`root`** is potentially dangerous and can lead to widespread damage to the system and data. This chapter covers ways to gain administrative privileges using the **`su`** and **`sudo`** programs. These programs allow specific users to perform tasks which would normally be available only to the root user while maintaining a higher level of control and system security.

See the *Red Hat Enterprise Linux 6 Security Guide* for more information on administrative controls, potential dangers and ways to prevent data loss resulting from improper use of privileged access.

4.1. THE SU COMMAND

When a user executes the **`su`** command, they are prompted for the root password and, after authentication, are given a root shell prompt.

Once logged in via the **`su`** command, the user *is* the root user and has absolute administrative access to the system[1]. In addition, once a user has become root, it is possible for them to use the **`su`** command to change to any other user on the system without being prompted for a password.

Because this program is so powerful, administrators within an organization may want to limit who has access to the command.

One of the simplest ways to do this is to add users to the special administrative group called *wheel*. To do this, type the following command as root:

```
~]# usermod -a -G wheel username
```

In the previous command, replace *username* with the user name you want to add to the **`wheel`** group.

You can also use the **User Manager** to modify group memberships, as follows. Note: you need Administrator privileges to perform this procedure.

1. Click the **System** menu on the Panel, point to **Administration** and then click **Users and Groups** to display the User Manager. Alternatively, type the command **`system-config-users`** at a shell prompt.

2. Click the **`Users`** tab, and select the required user in the list of users.

3. Click **`Properties`** on the toolbar to display the User Properties dialog box (or choose **Properties** on the **File** menu).

4. Click the **`Groups`** tab, select the check box for the wheel group, and then click **`OK`**.

See Section 3.2, “Managing Users via the User Manager Application” for more information about the **User Manager**.

After you add the desired users to the **`wheel`** group, it is advisable to only allow these specific users to use the **`su`** command. To do this, you will need to edit the PAM configuration file for **`su`**: **`/etc/pam.d/su`**. Open this file in a text editor and remove the comment (#) from the following line:

```
#auth           required        pam_wheel.so use_uid
```

This change means that only members of the administrative group **wheel** can switch to another user using the **su** command.

NOTE

The **root** user is part of the **wheel** group by default.

4.2. THE SUDO COMMAND

The **sudo** command offers another approach to giving users administrative access. When trusted users precede an administrative command with **sudo**, they are prompted for *their own* password. Then, when they have been authenticated and assuming that the command is permitted, the administrative command is executed as if they were the root user.

The basic format of the **sudo** command is as follows:

```
sudo <command>
```

In the above example, *<command>* would be replaced by a command normally reserved for the root user, such as **mount**.

The **sudo** command allows for a high degree of flexibility. For instance, only users listed in the **/etc/sudoers** configuration file are allowed to use the **sudo** command and the command is executed in *the user's* shell, not a root shell. This means the root shell can be completely disabled as shown in the *Red Hat Enterprise Linux 6 Security Guide*.

Each successful authentication using the **sudo** is logged to the file **/var/log/messages** and the command issued along with the issuer's user name is logged to the file **/var/log/secure**. Should you require additional logging, use the **pam_tty_audit** module to enable TTY auditing for specified users by adding the following line to your **/etc/pam.d/system-auth** file:

```
session required pam_tty_audit.so disable=<pattern> enable=<pattern>
```

where *pattern* represents a comma-separated listing of users with an optional use of globs. For example, the following configuration will enable TTY auditing for the root user and disable it for all other users:

```
session required pam_tty_audit.so disable=* enable=root
```

Another advantage of the **sudo** command is that an administrator can allow different users access to specific commands based on their needs.

Administrators wanting to edit the **sudo** configuration file, **/etc/sudoers**, should use the **visudo** command.

To give someone full administrative privileges, type **visudo** and add a line similar to the following in the user privilege specification section:

```
juan ALL=(ALL) ALL
```

This example states that the user, **juan**, can use **sudo** from any host and execute any command.

The example below illustrates the granularity possible when configuring **sudo**:

–

```
%users localhost=/sbin/shutdown -h now
```

This example states that any user can issue the command **/sbin/shutdown -h now** as long as it is issued from the console.

The man page for **sudoers** has a detailed listing of options for this file.

IMPORTANT

There are several potential risks to keep in mind when using the **sudo** command. You can avoid them by editing the **/etc/sudoers** configuration file using **visudo** as described above. Leaving the **/etc/sudoers** file in its default state gives every user in the **wheel** group unlimited root access.

- By default, **sudo** stores the sudoer's password for a five minute timeout period. Any subsequent uses of the command during this period will not prompt the user for a password. This could be exploited by an attacker if the user leaves his workstation unattended and unlocked while still being logged in. This behavior can be changed by adding the following line to the **/etc/sudoers** file:

  ```
  Defaults    timestamp_timeout=<value>
  ```

  where *<value>* is the desired timeout length in minutes. Setting the *<value>* to 0 causes **sudo** to require a password every time.

- If a sudoer's account is compromised, an attacker can use **sudo** to open a new shell with administrative privileges:

  ```
  sudo /bin/bash
  ```

  Opening a new shell as root in this or similar fashion gives the attacker administrative access for a theoretically unlimited amount of time, bypassing the timeout period specified in the **/etc/sudoers** file and never requiring the attacker to input a password for **sudo** again until the newly opened session is closed.

4.3. ADDITIONAL RESOURCES

While programs allowing users to gain administrative privileges are a potential security risk, security itself is beyond the scope of this particular book. You should therefore see sources listed below for more information regarding security and privileged access.

Installed Documentation

- **su**(1) - the manual page for **su** provides information regarding the options available with this command.
- **sudo**(8) - the manual page for **sudo** includes a detailed description of this command as well as a list of options available for customizing **sudo**'s behavior.
- **pam**(8) - the manual page describing the use of Pluggable Authentication Modules for Linux.

Online Documentation

- Red Hat Enterprise Linux 6 Security Guide - The *Security Guide* describes in detail security risks and mitigating techniques related to programs for gaining privileges.
- Red Hat Enterprise Linux 6 Managing Single Sign-On and Smart Cards - This guide provides, among other things, a detailed description of *Pluggable Authentication Modules (PAM)*, their configuration and usage.

[1] This access is still subject to the restrictions imposed by SELinux, if it is enabled.

CHAPTER 5. CONSOLE ACCESS

When normal (non-root) users log into a computer locally, they are given two types of special permissions:

1. They can run certain programs that they otherwise cannot run.

2. They can access certain files that they otherwise cannot access. These files normally include special device files used to access diskettes, CD-ROMs, and so on.

Since there are multiple consoles on a single computer and multiple users can be logged into the computer locally at the same time, one of the users has to essentially win the race to access the files. The first user to log in at the console owns those files. Once the first user logs out, the next user who logs in owns the files.

In contrast, every user who logs in at the console is allowed to run programs that accomplish tasks normally restricted to the root user. If X is running, these actions can be included as menu items in a graphical user interface. As shipped, these console-accessible programs include **`halt`**, **`poweroff`**, and **`reboot`**.

5.1. DISABLING CONSOLE PROGRAM ACCESS FOR NON-ROOT USERS

Non-root users can be denied console access to any program in the **`/etc/security/console.apps/`** directory. To list these programs, run the following command:

```
~]$ ls /etc/security/console.apps
abrt-cli-root
config-util
eject
halt
poweroff
reboot
rhn_register
setup
subscription-manager
subscription-manager-gui
system-config-network
system-config-network-cmd
xserver
```

For each of these programs, console access denial can be configured using the program's *Pluggable Authentication Module* (PAM) configuration file. For information about PAMs and their usage, see chapter Pluggable Authentication Modules of the Red Hat Enterprise Linux 6 *Managing Single Sign-On and Smart Cards* guide.

PAM configuration file for each program in **`/etc/security/console.apps/`** resides in the **`/etc/pam.d/`** directory and is named the same as the program. Using this file, you can configure PAM to deny access to the program if the user is not root. To do that, insert line **`auth requisite pam_deny.so`** directly after the first uncommented line **`auth sufficient pam_rootok.so`**.

Example 5.1. Disabling Access to the Reboot Program

To disable non-root console access to **/etc/security/console.apps/reboot**, insert line **auth requisite pam_deny.so** into the **/etc/pam.d/reboot** PAM configuration file:

```
#%PAM-1.0
auth       sufficient   pam_rootok.so
auth        requisite   pam_deny.so
auth       required     pam_console.so
#auth       include     system-auth
account    required     pam_permit.so
```

With this setting, all non-root access to the **reboot** utility is disabled.

Additionally, several programs in **/etc/security/console.apps/** partially derive their PAM configuration from the **/etc/pam.d/config-util** configuration file. This allows to change configuration for all these programs at once by editing **/etc/pam.d/config-util**. To find all these programs, search for PAM configuration files that refer to the **config-util** file:

```
~]# grep -l "config-util" /etc/pam.d/*
/etc/pam.d/abrt-cli-root
/etc/pam.d/rhn_register
/etc/pam.d/subscription-manager
/etc/pam.d/subscription-manager-gui
/etc/pam.d/system-config-network
/etc/pam.d/system-config-network-cmd
```

Disabling console program access as described above may be useful in environments where the console is otherwise secured. Security measures may include password protection for BIOS and boot loader, disabling rebooting on pressing Ctrl+Alt+Delete, disabling the power and reset switches, and other. In these cases, you may want to restrict normal user's access to **halt**, **poweroff**, **reboot**, and other programs, which by default are accessible from the console.

5.2. DISABLING REBOOTING USING CTRL+ALT+DEL

The action that happens in response to pressing Ctrl+Alt+Del at console is specified in the **/etc/init/control-alt-delete.conf** file. By default, the **shutdown** utility with the **-r** option is used to shutdown and reboot the system.

To disable this action, create an overriding configuration file that specifies the **exec true** command, which does nothing. To do that, run the following command as root:

```
~]# echo "exec true" >> /etc/init/control-alt-delete.override
```

PART II. SUBSCRIPTION AND SUPPORT

To receive updates to the software on a Red Hat Enterprise Linux system it must be subscribed to the *Red Hat Content Delivery Network* (CDN) and the appropriate repositories enabled. This part describes how to subscribe a system to the Red Hat Content Delivery Network.

Red Hat provides support via the Customer Portal, and you can access this support directly from the command line using the **Red Hat Support Tool**. This part describes the use of this command-line tool.

CHAPTER 6. REGISTERING THE SYSTEM AND MANAGING SUBSCRIPTIONS

The subscription service provides a mechanism to handle Red Hat software inventory and allows you to install additional software or update already installed programs to newer versions using the **yum** or **PackageKit** package managers. In Red Hat Enterprise Linux 6 the recommended way to register your system and attach subscriptions is to use *Red Hat Subscription Management*.

NOTE

It is also possible to register the system and attach subscriptions after installation during the firstboot process. For detailed information about firstboot see the Firstboot chapter in the Installation Guide for Red Hat Enterprise Linux 6. Note that firstboot is only available on systems after a graphical installation or after a kickstart installation where a desktop and the X window system were installed and graphical login was enabled.

6.1. REGISTERING THE SYSTEM AND ATTACHING SUBSCRIPTIONS

Complete the following steps to register your system and attach one or more subscriptions using Red Hat Subscription Management. Note that all **`subscription-manager`** commands are supposed to be run as **`root`**.

1. Run the following command to register your system. You will be prompted to enter your user name and password. Note that the user name and password are the same as your login credentials for Red Hat Customer Portal.

   ```
   subscription-manager register
   ```

2. Determine the pool ID of a subscription that you require. To do so, type the following at a shell prompt to display a list of all subscriptions that are available for your system:

   ```
   subscription-manager list --available
   ```

   For each available subscription, this command displays its name, unique identifier, expiration date, and other details related to your subscription. To list subscriptions for all architectures, add the **`--all`** option. The pool ID is listed on a line beginning with **`Pool ID`**.

3. Attach the appropriate subscription to your system by entering a command as follows:

   ```
   subscription-manager attach --pool=pool_id
   ```

   Replace *pool_id* with the pool ID you determined in the previous step.

   To verify the list of subscriptions your system has currently attached, at any time, run:

   ```
   subscription-manager list --consumed
   ```

NOTE

If you use a firewall or a proxy, you may need additional configuration to allow **`yum`** and **`subscription-manager`** to work correctly. Refer to the "Setting Firewall Access for Content Delivery" section of the Red Hat Enterprise Linux 6 Subscription Management guide if you use a firewall and to the "Using an HTTP Proxy" section if you use a proxy.

For more details on how to register your system using Red Hat Subscription Management and associate it with subscriptions, see the designated solution article. For comprehensive information about subscriptions, see the Red Hat Subscription Management collection of guides.

6.2. MANAGING SOFTWARE REPOSITORIES

When a system is subscribed to the Red Hat Content Delivery Network, a repository file is created in the **`/etc/yum.repos.d/`** directory. To verify that, use **`yum`** to list all enabled repositories:

```
yum repolist
```

Red Hat Subscription Management also allows you to manually enable or disable software repositories provided by Red Hat. To list all available repositories, use the following command:

```
subscription-manager repos --list
```

The repository names depend on the specific version of Red Hat Enterprise Linux you are using and are in the following format:

```
rhel-variant-rhscl-version-rpms
rhel-variant-rhscl-version-debug-rpms
rhel-variant-rhscl-version-source-rpms
```

Where *variant* is the Red Hat Enterprise Linux system variant (**`server`** or **`workstation`**), and *version* is the Red Hat Enterprise Linux system version (**`6`** or **`7`**), for example:

```
rhel-server-rhscl-6-eus-rpms
rhel-server-rhscl-6-eus-source-rpms
rhel-server-rhscl-6-eus-debug-rpms
```

To enable a repository, enter a command as follows:

```
subscription-manager repos --enable repository
```

Replace *repository* with a name of the repository to enable.

Similarly, to disable a repository, use the following command:

```
subscription-manager repos --disable repository
```

Section 8.4, “Configuring Yum and Yum Repositories” provides detailed information about managing software repositories using **`yum`**.

6.3. REMOVING SUBSCRIPTIONS

To remove a particular subscription, complete the following steps.

1. Determine the serial number of the subscription you want to remove by listing information about already attached subscriptions:

   ```
   subscription-manager list --consumed
   ```

   The serial number is the number listed as **`serial`**. For instance, **`744993814251016831`** in the example below:

   ```
   SKU:                ES0113909
   Contract:           01234567
   Account:            1234567
   Serial:             744993814251016831
   Pool ID:            8a85f9894bba16dc014bccdd905a5e23
   Active:             False
   Quantity Used:      1
   Service Level:      SELF-SUPPORT
   Service Type:       L1-L3
   Status Details:
   Subscription Type: Standard
   Starts:             02/27/2015
   Ends:               02/27/2016
   System Type:        Virtual
   ```

2. Enter a command as follows to remove the selected subscription:

   ```
   subscription-manager remove --serial=serial_number
   ```

   Replace *serial_number* with the serial number you determined in the previous step.

To remove all subscriptions attached to the system, run the following command:

```
subscription-manager remove --all
```

6.4. ADDITIONAL RESOURCES

For more information on how to register your system using Red Hat Subscription Management and associate it with subscriptions, see the resources listed below.

Installed Documentation

- **`subscription-manager`**(8) — the manual page for Red Hat Subscription Management provides a complete list of supported options and commands.

Related Books

- Red Hat Subscription Management collection of guides — These guides contain detailed information how to use Red Hat Subscription Management.

- Installation Guide — see the Firstboot chapter for detailed information on how to register during the firstboot process.

Online Resources

- Red Hat Access Labs — The Red Hat Access Labs includes a “Registration Assistant”.

See Also

- Chapter 4, *Gaining Privileges* documents how to gain administrative privileges by using the **su** and **sudo** commands.
- Chapter 8, *Yum* provides information about using the **yum** packages manager to install and update software.
- Chapter 9, *PackageKit* provides information about using the **PackageKit** package manager to install and update software.

CHAPTER 7. ACCESSING SUPPORT USING THE RED HAT SUPPORT TOOL

The **Red Hat Support Tool**, in the redhat-support-tool package, can function as both an interactive shell and as a single-execution program. It can be run over **SSH** or from any terminal. It enables, for example, searching the Red Hat Knowledgebase from the command line, copying solutions directly on the command line, opening and updating support cases, and sending files to Red Hat for analysis.

7.1. INSTALLING THE RED HAT SUPPORT TOOL

The **Red Hat Support Tool** is installed by default on Red Hat Enterprise Linux. If required, to ensure that it is, enter the following command as **root**:

```
~]# yum install redhat-support-tool
```

7.2. REGISTERING THE RED HAT SUPPORT TOOL USING THE COMMAND LINE

To register the Red Hat Support Tool to the customer portal using the command line, proceed as follows:

1.
   ```
   ~]# redhat-support-tool config user username
   ```

   Where *username* is the user name of the Red Hat Customer Portal account.

2.
   ```
   ~]# redhat-support-tool config password
   Please enter the password for username:
   ```

7.3. USING THE RED HAT SUPPORT TOOL IN INTERACTIVE SHELL MODE

To start the tool in interactive mode, enter the following command:

```
~]$ redhat-support-tool
Welcome to the Red Hat Support Tool.
Command (? for help):
```

The tool can be run as an unprivileged user, with a consequently reduced set of commands, or as **root**.

The commands can be listed by entering the **?** character. The program or menu selection can be exited by entering the **q** or **e** character. You will be prompted for your Red Hat Customer Portal user name and password when you first search the Knowledgebase or support cases. Alternately, set the user name and password for your Red Hat Customer Portal account using interactive mode, and optionally save it to the configuration file.

7.4. CONFIGURING THE RED HAT SUPPORT TOOL

When in interactive mode, the configuration options can be listed by entering the command **config --help**:

```
~]# redhat-support-tool
```

```
Welcome to the Red Hat Support Tool.
Command (? for help): config --help

Usage: config [options] config.option <new option value>

Use the 'config' command to set or get configuration file values.
Options:
  -h, --help    show this help message and exit
  -g, --global  Save configuration option in /etc/redhat-support-
tool.conf.
  -u, --unset   Unset configuration option.

The configuration file options which can be set are:
 user      : The Red Hat Customer Portal user.
 password  : The Red Hat Customer Portal password.
 debug     : CRITICAL, ERROR, WARNING, INFO, or DEBUG
 url       : The support services URL.
Default=https://api.access.redhat.com
 proxy_url : A proxy server URL.
 proxy_user: A proxy server user.
 proxy_password: A password for the proxy server user.
 ssl_ca    : Path to certificate authorities to trust during
communication.
 kern_debug_dir: Path to the directory where kernel debug symbols should
be downloaded and cached. Default=/var/lib/redhat-support-
tool/debugkernels

Examples:
- config user
- config user my-rhn-username
- config --unset user
```

Procedure 7.1. Registering the Red Hat Support Tool Using Interactive Mode

To register the Red Hat Support Tool to the customer portal using interactive mode, proceed as follows:

1. Start the tool by entering the following command:

   ```
   ~]# redhat-support-tool
   ```

2. Enter your Red Hat Customer Portal user name:

   ```
   Command (? for help): config user username
   ```

   To save your user name to the global configuration file, add the **-g** option.

3. Enter your Red Hat Customer Portal password:

   ```
   Command (? for help): config password
   Please enter the password for username:
   ```

7.4.1. Saving Settings to the Configuration Files

The **Red Hat Support Tool**, unless otherwise directed, stores values and options locally in the home directory of the current user, using the **`~/.redhat-support-tool/redhat-support-tool.conf`** configuration file. If required, it is recommended to save passwords to this file because it is only readable by that particular user. When the tool starts, it will read values from the global configuration file **`/etc/redhat-support-tool.conf`** and from the local configuration file. Locally stored values and options take precedence over globally stored settings.

WARNING

It is recommended **not** to save passwords in the global **`/etc/redhat-support-tool.conf`** configuration file because the password is just **`base64`** encoded and can easily be decoded. In addition, the file is world readable.

To save a value or option to the global configuration file, add the **`-g, --global`** option as follows:

```
Command (? for help): config setting -g value
```

NOTE

In order to be able to save settings globally, using the **`-g, --global`** option, the **Red Hat Support Tool** must be run as **`root`** because normal users do not have the permissions required to write to **`/etc/redhat-support-tool.conf`**.

To remove a value or option from the local configuration file, add the **`-u, --unset`** option as follows:

```
Command (? for help): config setting -u value
```

This will clear, unset, the parameter from the tool and fall back to the equivalent setting in the global configuration file, if available.

NOTE

When running as an unprivileged user, values stored in the global configuration file cannot be removed using the **`-u, --unset`** option, but they can be cleared, unset, from the current running instance of the tool by using the **`-g, --global`** option simultaneously with the **`-u, --unset`** option. If running as **`root`**, values and options can be removed from the global configuration file using **`-g, --global`** simultaneously with the **`-u, --unset`** option.

7.5. OPENING AND UPDATING SUPPORT CASES USING INTERACTIVE MODE

Procedure 7.2. Opening a New Support Case Using Interactive Mode

To open a new support case using interactive mode, proceed as follows:

1. Start the tool by entering the following command:

```
~]# redhat-support-tool
```

2. Enter the **opencase** command:

   ```
   Command (? for help): opencase
   ```

3. Follow the on screen prompts to select a product and then a version.

4. Enter a summary of the case.

5. Enter a description of the case and press **Ctrl**+**D** on an empty line when complete.

6. Select a severity of the case.

7. Optionally chose to see if there is a solution to this problem before opening a support case.

8. Confirm you would still like to open the support case.

   ```
   Support case 0123456789 has successfully been opened
   ```

9. Optionally chose to attach an SOS report.

10. Optionally chose to attach a file.

Procedure 7.3. Viewing and Updating an Existing Support Case Using Interactive Mode

To view and update an existing support case using interactive mode, proceed as follows:

1. Start the tool by entering the following command:

   ```
   ~]# redhat-support-tool
   ```

2. Enter the **getcase** command:

   ```
   Command (? for help): getcase case-number
   ```

   Where *case-number* is the number of the case you want to view and update.

3. Follow the on screen prompts to view the case, modify or add comments, and get or add attachments.

Procedure 7.4. Modifying an Existing Support Case Using Interactive Mode

To modify the attributes of an existing support case using interactive mode, proceed as follows:

1. Start the tool by entering the following command:

   ```
   ~]# redhat-support-tool
   ```

2. Enter the **modifycase** command:

   ```
   Command (? for help): modifycase case-number
   ```

Where *case-number* is the number of the case you want to view and update.

3. The modify selection list appears:

```
Type the number of the attribute to modify or 'e' to return to the
previous menu.
 1 Modify Type
 2 Modify Severity
 3 Modify Status
 4 Modify Alternative-ID
 5 Modify Product
 6 Modify Version
End of options.
```

   Follow the on screen prompts to modify one or more of the options.

4. For example, to modify the status, enter **3**:

```
Selection: 3
 1   Waiting on Customer
 2   Waiting on Red Hat
 3   Closed
Please select a status (or 'q' to exit):
```

7.6. VIEWING SUPPORT CASES ON THE COMMAND LINE

Viewing the contents of a case on the command line provides a quick and easy way to apply solutions from the command line.

To view an existing support case on the command line, enter a command as follows:

```
~]# redhat-support-tool getcase case-number
```

Where *case-number* is the number of the case you want to download.

7.7. ADDITIONAL RESOURCES

The Red Hat Knowledgebase article *Red Hat Support Tool* has additional information, examples, and video tutorials.

PART III. INSTALLING AND MANAGING SOFTWARE

All software on a Red Hat Enterprise Linux system is divided into RPM packages, which can be installed, upgraded, or removed. This part focuses on product subscriptions and entitlements, and describes how to manage packages on Red Hat Enterprise Linux using both **Yum** and the **PackageKit** suite of graphical package management tools.

CHAPTER 8. YUM

Yum is the Red Hat package manager that is able to query for information about available packages, fetch packages from repositories, install and uninstall them, and update an entire system to the latest available version. Yum performs automatic dependency resolution on packages you are updating, installing, or removing, and thus is able to automatically determine, fetch, and install all available dependent packages.

Yum can be configured with new, additional repositories, or *package sources*, and also provides many plug-ins which enhance and extend its capabilities. Yum is able to perform many of the same tasks that **RPM** can; additionally, many of the command-line options are similar. Yum enables easy and simple package management on a single machine or on groups of them.

The following sections assume your system was registered with Red Hat Subscription Management during installation as described in the Red Hat Enterprise Linux 6 Installation Guide. If your system is not subscribed, see Chapter 6, *Registering the System and Managing Subscriptions*.

IMPORTANT

Yum provides secure package management by enabling GPG (Gnu Privacy Guard; also known as GnuPG) signature verification on GPG-signed packages to be turned on for all package repositories (i.e. package sources), or for individual repositories. When signature verification is enabled, Yum will refuse to install any packages not GPG-signed with the correct key for that repository. This means that you can trust that the **RPM** packages you download and install on your system are from a trusted source, such as Red Hat, and were not modified during transfer. See Section 8.4, “Configuring Yum and Yum Repositories” for details on enabling signature-checking with Yum, or Section B.3, “Checking a Package's Signature” for information on working with and verifying GPG-signed **RPM** packages in general.

Yum also enables you to easily set up your own repositories of **RPM** packages for download and installation on other machines.

Learning Yum is a worthwhile investment because it is often the fastest way to perform system administration tasks, and it provides capabilities beyond those provided by the **PackageKit** graphical package management tools. See Chapter 9, *PackageKit* for details on using **PackageKit**.

NOTE

You must have superuser privileges in order to use **yum** to install, update or remove packages on your system. All examples in this chapter assume that you have already obtained superuser privileges by using either the **su** or **sudo** command.

8.1. CHECKING FOR AND UPDATING PACKAGES

8.1.1. Checking For Updates

To see which installed packages on your system have updates available, use the following command:

```
yum check-update
```

For example:

```
~]# yum check-update
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
PackageKit.x86_64                  0.5.8-2.el6                rhel
PackageKit-glib.x86_64             0.5.8-2.el6                rhel
PackageKit-yum.x86_64              0.5.8-2.el6                rhel
PackageKit-yum-plugin.x86_64       0.5.8-2.el6                rhel
glibc.x86_64                       2.11.90-20.el6             rhel
glibc-common.x86_64                2.10.90-22                 rhel
kernel.x86_64                      2.6.31-14.el6              rhel
kernel-firmware.noarch             2.6.31-14.el6              rhel
rpm.x86_64                         4.7.1-5.el6                rhel
rpm-libs.x86_64                    4.7.1-5.el6                rhel
rpm-python.x86_64                  4.7.1-5.el6                rhel
udev.x86_64                        147-2.15.el6               rhel
yum.noarch                         3.2.24-4.el6               rhel
```

The packages in the above output are listed as having updates available. The first package in the list is **PackageKit**, the graphical package manager. The line in the example output tells us:

- **`PackageKit`** — the name of the package
- **`x86_64`** — the CPU architecture the package was built for
- **`0.5.8`** — the version of the updated package to be installed
- **`rhel`** — the repository in which the updated package is located

The output also shows us that we can update the kernel (the kernel package), Yum and RPM themselves (the yum and rpm packages), as well as their dependencies (such as the kernel-firmware, rpm-libs, and rpm-python packages), all using **`yum`**.

8.1.2. Updating Packages

You can choose to update a single package, multiple packages, or all packages at once. If any dependencies of the package (or packages) you update have updates available themselves, then they are updated too.

Updating a Single Package

To update a single package, run the following command as **`root`**:

```
yum update package_name
```

For example, to update the udev package, type:

```
~]# yum update udev
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Setting up Update Process
Resolving Dependencies
--> Running transaction check
---> Package udev.x86_64 0:147-2.15.el6 set to be updated
--> Finished Dependency Resolution
```

```
Dependencies Resolved

================================================================================
=
 Package        Arch            Version                    Repository
Size
================================================================================
=
Updating:
 udev           x86_64          147-2.15.el6               rhel           337
k

Transaction Summary
================================================================================
=
Install       0 Package(s)
Upgrade       1 Package(s)

Total download size: 337 k
Is this ok [y/N]:
```

This output contains several items of interest:

1. **`Loaded plugins: product-id, refresh-packagekit, subscription-manager`** — **`yum`** always informs you which Yum plug-ins are installed and enabled. See Section 8.5, “Yum Plug-ins” for general information on Yum plug-ins, or to Section 8.5.3, “Plug-in Descriptions” for descriptions of specific plug-ins.

2. **`udev.x86_64`** — you can download and install new udev package.

3. **`yum`** presents the update information and then prompts you as to whether you want it to perform the update; **`yum`** runs interactively by default. If you already know which transactions the **`yum`** command plans to perform, you can use the **`-y`** option to automatically answer **`yes`** to any questions that **`yum`** asks (in which case it runs non-interactively). However, you should always examine which changes **`yum`** plans to make to the system so that you can easily troubleshoot any problems that might arise.

   If a transaction does go awry, you can view Yum's transaction history by using the **`yum history`** command as described in Section 8.3, “Working with Transaction History”.

IMPORTANT

`yum` always *installs* a new kernel in the same sense that **RPM** installs a new kernel when you use the command **`rpm -i kernel`**. Therefore, you do not need to worry about the distinction between *installing* and *upgrading* a kernel package when you use **`yum`**: it will do the right thing, regardless of whether you are using the **`yum update`** or **`yum install`** command.

When using **RPM**, on the other hand, it is important to use the **`rpm -i kernel`** command (which installs a new kernel) instead of **`rpm -u kernel`** (which *replaces* the current kernel). See Section B.2.2, “Installing and Upgrading” for more information on installing/upgrading kernels with **RPM**.

Updating All Packages and Their Dependencies

To update all packages and their dependencies, enter **`yum update`** (without any arguments):

```
yum update
```

Updating Security-Related Packages

Discovering which packages have security updates available and then updating those packages quickly and easily is important. Yum provides the plug-in for this purpose. The **security** plug-in extends the **`yum`** command with a set of highly-useful security-centric commands, subcommands and options. See Section 8.5.3, “Plug-in Descriptions” for specific information.

Updating Packages Automatically

It is also possible to set up periodical automatic updates for your packages. For this purpose, Red Hat Enterprise Linux 6 uses the yum-cron package. It provides a Yum interface for the **`cron`** daemon and downloads metadata from your package repositories. With the **yum-cron** service enabled, the user can schedule an automated daily Yum update as a cron job.

NOTE

The yum-cron package is provided by the Optional subscription channel. See Section 8.4.8, “Adding the Optional and Supplementary Repositories” for more information on Red Hat additional channels.

To install **yum-cron** issue the following command:

```
~]# yum install yum-cron
```

By default, the **yum-cron** service is disabled and needs to be activated and started manually:

```
~]# chkconfig yum-cron on
```

```
~]# service yum-cron start
```

To verify the status of the service, run the following command:

```
~]# service yum-cron status
```

The script included in the yum-cron package can be configured to change the extent and frequency of the updates, as well as to send notifications to e-mail. To customize **yum-cron**, edit the **`/etc/sysconfig/yum-cron`** file.

Additional details and instructions for **`yum-cron`** can be found in the comments within **`/etc/sysconfig/yum-cron`** and at the **yum-cron**(8) manual page.

8.1.3. Preserving Configuration File Changes

You will inevitably make changes to the configuration files installed by packages as you use your Red Hat Enterprise Linux system. **RPM**, which Yum uses to perform changes to the system, provides a mechanism for ensuring their integrity. See Section B.2.2, “Installing and Upgrading” for details on how to manage changes to configuration files across package upgrades.

8.1.4. Upgrading the System Off-line with ISO and Yum

For systems that are disconnected from the Internet or Red Hat Network, using the **`yum update`** command with the Red Hat Enterprise Linux installation ISO image is an easy and quick way to upgrade systems to the latest minor version. The following steps illustrate the upgrading process:

1. Create a target directory to mount your ISO image. This directory is not automatically created when mounting, so create it before proceeding to the next step. As **`root`**, type:

   ```
   mkdir mount_dir
   ```

   Replace *mount_dir* with a path to the mount directory. Typically, users create it as a subdirectory in the **`/media/`** directory.

2. Mount the Red Hat Enterprise Linux 6 installation ISO image to the previously created target directory. As **`root`**, type:

   ```
   mount -o loop iso_name mount_dir
   ```

   Replace *iso_name* with a path to your ISO image and *mount_dir* with a path to the target directory. Here, the **`-o loop`** option is required to mount the file as a block device.

3. Copy the **`media.repo`** file from the mount directory to the **`/etc/yum.repos.d/`** directory. Note that configuration files in this directory must have the *.repo* extension to function properly.

   ```
   cp mount_dir/media.repo /etc/yum.repos.d/new.repo
   ```

   This creates a configuration file for the yum repository. Replace *new.repo* with the filename, for example *rhel6.repo*.

4. Edit the new configuration file so that it points to the Red Hat Enterprise Linux installation ISO. Add the following line into the **`/etc/yum.repos.d/new.repo`** file:

   ```
   baseurl=file:///mount_dir
   ```

   Replace *mount_dir* with a path to the mount point.

5. Update all yum repositories including **`/etc/yum.repos.d/new.repo`** created in previous steps. As **`root`**, type:

   ```
   yum update
   ```

   This upgrades your system to the version provided by the mounted ISO image.

6. After successful upgrade, you can unmount the ISO image. As **`root`**, type:

   ```
   umount mount_dir
   ```

   where *mount_dir* is a path to your mount directory. Also, you can remove the mount directory created in the first step. As **`root`**, type:

   ```
   rmdir mount_dir
   ```

7. If you will not use the previously created configuration file for another installation or update, you can remove it. As **`root`**, type:

```
rm /etc/yum.repos.d/new.repo
```

Example 8.1. Upgrading from Red Hat Enterprise Linux 6.3 to 6.4

Imagine you need to upgrade your system without access to the Internet. To do so, you want to use an ISO image with the newer version of the system, called for instance **RHEL6.4-Server-20130130.0-x86_64-DVD1.iso**. A target directory created for mounting is **/media/rhel6/**. As **root**, change into the directory with your ISO image and type:

```
~]# mount -o loop RHEL6.4-Server-20130130.0-x86_64-DVD1.iso
/media/rhel6/
```

Then set up a yum repository for your image by copying the **media.repo** file from the mount directory:

```
~]# cp /media/rhel6/media.repo /etc/yum.repos.d/rhel6.repo
```

To make yum recognize the mount point as a repository, add the following line into the **/etc/yum.repos.d/rhel6.repo** copied in the previous step:

```
baseurl=file:///media/rhel6/
```

Now, updating the yum repository will upgrade your system to a version provided by **RHEL6.4-Server-20130130.0-x86_64-DVD1.iso**. As **root**, execute:

```
~]# yum update
```

When your system is successfully upgraded, you can unmount the image, remove the target directory and the configuration file:

```
~]# umount /media/rhel6/
```

```
~]# rmdir /media/rhel6/
```

```
~]# rm /etc/yum.repos.d/rhel6.repo
```

8.2. PACKAGES AND PACKAGE GROUPS

8.2.1. Searching Packages

You can search all RPM package names, descriptions and summaries by using the following command:

```
yum search term…
```

Replace *term* with a package name you want to search.

Example 8.2. Searching for packages matching a specific string

To list all packages that match “vim”, “gvim”, or “emacs”, type:

```
~]$ yum search vim gvim emacs
Loaded plugins: langpacks, product-id, search-disabled-repos,
subscription-manager
============================= N/S matched: vim
==============================
vim-X11.x86_64 : The VIM version of the vi editor for the X Window
System
vim-common.x86_64 : The common files needed by any version of the VIM
editor
[output truncated]

============================ N/S matched: emacs
=============================
emacs.x86_64 : GNU Emacs text editor
emacs-auctex.noarch : Enhanced TeX modes for Emacs
[output truncated]

  Name and summary matches mostly, use "search all" for everything.
Warning: No matches found for: gvim
```

The **`yum search`** command is useful for searching for packages you do not know the name of, but for which you know a related term. Note that by default, **`yum search`** returns matches in package name and summary, which makes the search faster. Use the **`yum search all`** command for a more exhaustive but slower search.

8.2.2. Listing Packages

`yum list` and related commands provide information about packages, package groups, and repositories.

All of Yum's list commands allow you to filter the results by appending one or more *glob expressions* as arguments. Glob expressions are normal strings of characters which contain one or more of the wildcard characters **`*`** (which expands to match any character multiple times) and **`?`** (which expands to match any one character).

NOTE

Be careful to escape the glob expressions when passing them as arguments to a **`yum`** command, otherwise the Bash shell will interpret these expressions as *pathname expansions*, and potentially pass all files in the current directory that match the globs to **`yum`**. To make sure the glob expressions are passed to **`yum`** as intended, either:

- escape the wildcard characters by preceding them with a backslash character
- double-quote or single-quote the entire glob expression.

See Example 8.3, “Listing all ABRT add-ons and plug-ins using glob expressions”and Example 8.5, “Listing available packages using a single glob expression with escaped wildcard characters” for an example usage of both these methods.

`yum list` ***`glob_expression`***…

Lists information on installed and available packages matching all glob expressions.

Example 8.3. Listing all ABRT add-ons and plug-ins using glob expressions

Packages with various ABRT add-ons and plug-ins either begin with “abrt-addon-”, or “abrt-plugin-”. To list these packages, type the following at a shell prompt:

```
~]# yum list abrt-addon\* abrt-plugin\*
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Installed Packages
abrt-addon-ccpp.x86_64                          1.0.7-5.el6
@rhel
abrt-addon-kerneloops.x86_64                    1.0.7-5.el6
@rhel
abrt-addon-python.x86_64                        1.0.7-5.el6
@rhel
abrt-plugin-bugzilla.x86_64                     1.0.7-5.el6
@rhel
abrt-plugin-logger.x86_64                       1.0.7-5.el6
@rhel
abrt-plugin-sosreport.x86_64                    1.0.7-5.el6
@rhel
abrt-plugin-ticketuploader.x86_64               1.0.7-5.el6
@rhel
```

`yum list all`

Lists all installed *and* available packages.

`yum list installed`

Lists all packages installed on your system. The rightmost column in the output lists the repository from which the package was retrieved.

Example 8.4. Listing installed packages using a double-quoted glob expression

To list all installed packages that begin with “krb” followed by exactly one character and a hyphen, type:

```
~]# yum list installed "krb?-*"
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Installed Packages
krb5-libs.x86_64                           1.8.1-3.el6
@rhel
krb5-workstation.x86_64                    1.8.1-3.el6
@rhel
```

`yum list available`

Lists all available packages in all enabled repositories.

Example 8.5. Listing available packages using a single glob expression with escaped wildcard characters

To list all available packages with names that contain “gstreamer” and then “plugin”, run the following command:

```
~]# yum list available gstreamer\*plugin\*
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Available Packages
gstreamer-plugins-bad-free.i686              0.10.17-4.el6
rhel
gstreamer-plugins-base.i686                  0.10.26-1.el6
rhel
gstreamer-plugins-base-devel.i686            0.10.26-1.el6
rhel
gstreamer-plugins-base-devel.x86_64          0.10.26-1.el6
rhel
gstreamer-plugins-good.i686                  0.10.18-1.el6
rhel
```

`yum grouplist`

Lists all package groups.

`yum repolist`

Lists the repository ID, name, and number of packages it provides for each *enabled* repository.

8.2.3. Displaying Package Information

To display information about one or more packages (glob expressions are valid here as well), use the following command:

`yum info` *`package_name…`*

For example, to display information about the abrt package, type:

```
~]# yum info abrt
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Installed Packages
Name       : abrt
Arch       : x86_64
Version    : 1.0.7
Release    : 5.el6
Size       : 578 k
Repo       : installed
From repo  : rhel
Summary    : Automatic bug detection and reporting tool
URL        : https://fedorahosted.org/abrt/
```

```
License    : GPLv2+
Description: abrt is a tool to help users to detect defects in
applications
           : and to create a bug report with all informations needed by
           : maintainer to fix it. It uses plugin system to extend its
           : functionality.
```

The **yum info *package_name*** command is similar to the **rpm -q --info *package_name*** command, but provides as additional information the ID of the Yum repository the RPM package is found in (look for the **From repo:** line in the output).

You can also query the Yum database for alternative and useful information about a package by using the following command:

```
yumdb info package_name
```

This command provides additional information about a package, including the check sum of the package (and algorithm used to produce it, such as SHA-256), the command given on the command line that was invoked to install the package (if any), and the reason that the package is installed on the system (where **user** indicates it was installed by the user, and **dep** means it was brought in as a dependency). For example, to display additional information about the yum package, type:

```
~]# yumdb info yum
Loaded plugins: product-id, refresh-packagekit, subscription-manager
yum-3.2.27-4.el6.noarch
     checksum_data =
23d337ed51a9757bbfbdceb82c4eaca9808ff1009b51e9626d540f44fe95f771
     checksum_type = sha256
     from_repo = rhel
     from_repo_revision = 1298613159
     from_repo_timestamp = 1298614288
     installed_by = 4294967295
     reason = user
     releasever = 6.1
```

For more information on the **yumdb** command, see the **yumdb**(8) manual page.

Listing Files Contained in a Package

repoquery is a program for querying information from yum repositories similarly to rpm queries. You can query both package groups and individual packages. To list all files contained in a specific package, type:

```
repoquery --list package_name
```

Replace *package_name* with a name of the package you want to inspect. For more information on the **repoquery** command, see the **repoquery** manual page.

To find out which package provides a specific file, you can use the **yum provides** command, described in Finding which package owns a file

8.2.4. Installing Packages

Yum allows you to install both a single package and multiple packages, as well as a package group of your choice.

Installing Individual Packages

To install a single package and all of its non-installed dependencies, enter a command in the following form:

```
yum install package_name
```

You can also install multiple packages simultaneously by appending their names as arguments:

```
yum install package_name package_name…
```

If you are installing packages on a *multilib* system, such as an AMD64 or Intel 64 machine, you can specify the architecture of the package (as long as it is available in an enabled repository) by appending *.arch* to the package name. For example, to install the sqlite package for **`i686`**, type:

```
~]# yum install sqlite.i686
```

You can use glob expressions to quickly install multiple similarly-named packages:

```
~]# yum install perl-Crypt-\*
```

In addition to package names and glob expressions, you can also provide file names to **`yum install`**. If you know the name of the binary you want to install, but not its package name, you can give **`yum install`** the path name:

```
~]# yum install /usr/sbin/named
```

`yum` then searches through its package lists, finds the package which provides **`/usr/sbin/named`**, if any, and prompts you as to whether you want to install it.

NOTE

If you know you want to install the package that contains the **`named`** binary, but you do not know in which **`bin`** or **`sbin`** directory is the file installed, use the **`yum provides`** command with a glob expression:

```
~]# yum provides "*bin/named"
Loaded plugins: product-id, refresh-packagekit, subscription-
manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
32:bind-9.7.0-4.P1.el6.x86_64 : The Berkeley Internet Name
Domain (BIND)
                              : DNS (Domain Name System)
server
Repo        : rhel
Matched from:
Filename    : /usr/sbin/named
```

`yum provides "*/`*`file_name`*`"` is a common and useful trick to find the package(s) that contain *file_name*.

Installing a Package Group

A package group is similar to a package: it is not useful by itself, but installing one pulls a group of dependent packages that serve a common purpose. A package group has a name and a *groupid*. The **`yum grouplist -v`** command lists the names of all package groups, and, next to each of them, their groupid in parentheses. The groupid is always the term in the last pair of parentheses, such as **`kde-desktop`** in the following example:

```
~]# yum -v grouplist kde\*
Loading "product-id" plugin
Loading "refresh-packagekit" plugin
Loading "subscription-manager" plugin
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Config time: 0.123
Yum Version: 3.2.29
Setting up Group Process
Looking for repo options for [rhel]
rpmdb time: 0.001
group time: 1.291
Available Groups:
   KDE Desktop (kde-desktop)
Done
```

You can install a package group by passing its full group name (without the groupid part) to **`groupinstall`**:

```
yum groupinstall group_name
```

You can also install by groupid:

```
yum groupinstall groupid
```

You can even pass the groupid (or quoted name) to the **`install`** command if you prepend it with an @-symbol (which tells **`yum`** that you want to perform a **`groupinstall`**):

```
yum install @group
```

For example, the following are alternative but equivalent ways of installing the **`KDE Desktop`** group:

```
~]# yum groupinstall "KDE Desktop"
~]# yum groupinstall kde-desktop
~]# yum install @kde-desktop
```

8.2.5. Removing Packages

Similarly to package installation, Yum allows you to uninstall (remove in **RPM** and Yum terminology) both individual packages and a package group.

Removing Individual Packages

To uninstall a particular package, as well as any packages that depend on it, run the following command as **`root`**:

```
yum remove package_name…
```

As when you install multiple packages, you can remove several at once by adding more package names to the command. For example, to remove totem, rhythmbox, and sound-juicer, type the following at a shell prompt:

```
~]# yum remove totem rhythmbox sound-juicer
```

Similar to **`install`**, **`remove`** can take these arguments:

- package names
- glob expressions
- file lists
- package provides

WARNING

Yum is not able to remove a package without also removing packages which depend on it. This type of operation can only be performed by **RPM**, is not advised, and can potentially leave your system in a non-functioning state or cause applications to misbehave and/or crash. For further information, see Section B.2.4, “Uninstalling” in the **RPM** chapter.

Removing a Package Group

You can remove a package group using syntax congruent with the **`install`** syntax:

```
yum groupremove group
```

```
yum remove @group
```

The following are alternative but equivalent ways of removing the **`KDE Desktop`** group:

```
~]# yum groupremove "KDE Desktop"
~]# yum groupremove kde-desktop
~]# yum remove @kde-desktop
```

IMPORTANT

When you tell **yum** to remove a package group, it will remove every package in that group, even if those packages are members of other package groups or dependencies of other installed packages. However, you can instruct **yum** to remove only those packages which are not required by any other packages or groups by adding the **`groupremove_leaf_only=1`** directive to the **`[main]`** section of the **`/etc/yum.conf`** configuration file. For more information on this directive, see Section 8.4.1, “Setting [main] Options”.

8.3. WORKING WITH TRANSACTION HISTORY

The **yum history** command allows users to review information about a timeline of Yum transactions, the dates and times they occurred, the number of packages affected, whether transactions succeeded or were aborted, and if the RPM database was changed between transactions. Additionally, this command can be used to undo or redo certain transactions.

8.3.1. Listing Transactions

To display a list of twenty most recent transactions, as **root**, either run **yum history** with no additional arguments, or type the following at a shell prompt:

```
yum history list
```

To display all transactions, add the **all** keyword:

```
yum history list all
```

To display only transactions in a given range, use the command in the following form:

```
yum history list start_id..end_id
```

You can also list only transactions regarding a particular package or packages. To do so, use the command with a package name or a glob expression:

```
yum history list glob_expression…
```

For example, the list of the first five transactions looks as follows:

```
~]# yum history list 1..5
Loaded plugins: product-id, refresh-packagekit, subscription-manager
ID     | Login user               | Date and time    | Action(s)      |
Altered
----------------------------------------------------------------------
---------
     5 | Jaromir ... <jhradilek>  | 2011-07-29 15:33 | Install        |
1
     4 | Jaromir ... <jhradilek>  | 2011-07-21 15:10 | Install        |
1
     3 | Jaromir ... <jhradilek>  | 2011-07-16 15:27 | I, U           |
73
     2 | System <unset>           | 2011-07-16 15:19 | Update         |
1
     1 | System <unset>           | 2011-07-16 14:38 | Install        |
1106
history list
```

All forms of the **yum history list** command produce tabular output with each row consisting of the following columns:

- **ID** — an integer value that identifies a particular transaction.
- **Login user** — the name of the user whose login session was used to initiate a transaction.

This information is typically presented in the ***Full Name <username>*** form. For transactions that were not issued by a user (such as an automatic system update), **System <unset>** is used instead.

- **Date and time** — the date and time when a transaction was issued.
- **Action(s)** — a list of actions that were performed during a transaction as described in Table 8.1, “Possible values of the Action(s) field”.
- **Altered** — the number of packages that were affected by a transaction, possibly followed by additional information as described in Table 8.2, “Possible values of the Altered field”.

Table 8.1. Possible values of the Action(s) field

Action	Abbreviation	Description
Downgrade	**D**	At least one package has been downgraded to an older version.
Erase	**E**	At least one package has been removed.
Install	**I**	At least one new package has been installed.
Obsoleting	**O**	At least one package has been marked as obsolete.
Reinstall	**R**	At least one package has been reinstalled.
Update	**U**	At least one package has been updated to a newer version.

Table 8.2. Possible values of the Altered field

Symbol	Description
<	Before the transaction finished, the **rpmdb** database was changed outside Yum.
>	After the transaction finished, the **rpmdb** database was changed outside Yum.
*****	The transaction failed to finish.
#	The transaction finished successfully, but **yum** returned a non-zero exit code.
E	The transaction finished successfully, but an error or a warning was displayed.
P	The transaction finished successfully, but problems already existed in the **rpmdb** database.
s	The transaction finished successfully, but the **--skip-broken** command-line option was used and certain packages were skipped.

Yum also allows you to display a summary of all past transactions. To do so, run the command in the following form as **root**:

```
yum history summary
```

To display only transactions in a given range, type:

```
yum history summary start_id..end_id
```

Similarly to the **yum history list** command, you can also display a summary of transactions regarding a certain package or packages by supplying a package name or a glob expression:

```
yum history summary glob_expression…
```

For instance, a summary of the transaction history displayed above would look like the following:

```
~]# yum history summary 1..5
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Login user                 | Time                 | Action(s)        |
Altered
----------------------------------------------------------------------
---------
Jaromir ... <jhradilek>    | Last day             | Install          |
1
Jaromir ... <jhradilek>    | Last week            | Install          |
1
Jaromir ... <jhradilek>    | Last 2 weeks         | I, U             |
73
System <unset>             | Last 2 weeks         | I, U             |
1107
history summary
```

All forms of the **yum history summary** command produce simplified tabular output similar to the output of **yum history list**.

As shown above, both **yum history list** and **yum history summary** are oriented towards transactions, and although they allow you to display only transactions related to a given package or packages, they lack important details, such as package versions. To list transactions from the perspective of a package, run the following command as **root**:

```
yum history package-list glob_expression…
```

For example, to trace the history of subscription-manager and related packages, type the following at a shell prompt:

```
~]# yum history package-list subscription-manager\*
Loaded plugins: product-id, refresh-packagekit, subscription-manager
ID     | Action(s)      | Package
----------------------------------------------------------------------
---------
     3 | Updated        | subscription-manager-0.95.11-1.el6.x86_64
     3 | Update         |                      0.95.17-1.el6_1.x86_64
     3 | Updated        | subscription-manager-firstboot-0.95.11-
1.el6.x86_64
```

```
     3 | Update         |                                0.95.17-
1.el6_1.x86_64
     3 | Updated        | subscription-manager-gnome-0.95.11-1.el6.x86_64
     3 | Update         |                            0.95.17-
1.el6_1.x86_64
     1 | Install        | subscription-manager-0.95.11-1.el6.x86_64
     1 | Install        | subscription-manager-firstboot-0.95.11-
1.el6.x86_64
     1 | Install        | subscription-manager-gnome-0.95.11-1.el6.x86_64
history package-list
```

In this example, three packages were installed during the initial system installation: subscription-manager, subscription-manager-firstboot, and subscription-manager-gnome. In the third transaction, all these packages were updated from version 0.95.11 to version 0.95.17.

8.3.2. Examining Transactions

To display the summary of a single transaction, as **root**, use the **yum history summary** command in the following form:

```
yum history summary id
```

To examine a particular transaction or transactions in more detail, run the following command as **root**:

```
yum history info id…
```

The *id* argument is optional and when you omit it, **yum** automatically uses the last transaction. Note that when specifying more than one transaction, you can also use a range:

```
yum history info start_id..end_id
```

The following is sample output for two transactions, each installing one new package:

```
~]# yum history info 4..5
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Transaction ID : 4..5
Begin time     : Thu Jul 21 15:10:46 2011
Begin rpmdb    : 1107:0c67c32219c199f92ed8da7572b4c6df64eacd3a
End time       :            15:33:15 2011 (22 minutes)
End rpmdb      : 1109:1171025bd9b6b5f8db30d063598f590f1c1f3242
User           : Jaromir Hradilek <jhradilek>
Return-Code    : Success
Command Line   : install screen
Command Line   : install yum-plugin-security
Transaction performed with:
    Installed     rpm-4.8.0-16.el6.x86_64
    Installed     yum-3.2.29-17.el6.noarch
    Installed     yum-metadata-parser-1.1.2-16.el6.x86_64
Packages Altered:
    Install screen-4.0.3-16.el6.x86_64
    Install yum-plugin-security-1.1.30-17.el6.noarch
history info
```

You can also view additional information, such as what configuration options were used at the time of the transaction, or from what repository and why were certain packages installed. To determine what additional information is available for a certain transaction, type the following at a shell prompt as **root**:

```
yum history addon-info id
```

Similarly to **yum history info**, when no *id* is provided, **yum** automatically uses the latest transaction. Another way to see the latest transaction is to use the **last** keyword:

```
yum history addon-info last
```

For instance, for the first transaction in the previous example, the **yum history addon-info** command would provide the following output:

```
~]# yum history addon-info 4
Loaded plugins: product-id, refresh-packagekit, subscription-manager
Transaction ID: 4
Available additional history information:
  config-main
  config-repos
  saved_tx

history addon-info
```

In this example, three types of information are available:

- **config-main** — global Yum options that were in use during the transaction. See Section 8.4.1, “Setting [main] Options” for information on how to change global options.
- **config-repos** — options for individual Yum repositories. See Section 8.4.2, “Setting [repository] Options” for information on how to change options for individual repositories.
- **saved_tx** — the data that can be used by the **yum load-transaction** command in order to repeat the transaction on another machine (see below).

To display selected type of additional information, run the following command as **root**:

```
yum history addon-info id information
```

8.3.3. Reverting and Repeating Transactions

Apart from reviewing the transaction history, the **yum history** command provides means to revert or repeat a selected transaction. To revert a transaction, type the following at a shell prompt as **root**:

```
yum history undo id
```

To repeat a particular transaction, as **root**, run the following command:

```
yum history redo id
```

Both commands also accept the **last** keyword to undo or repeat the latest transaction.

Note that both **yum history undo** and **yum history redo** commands only revert or repeat the steps that were performed during a transaction. If the transaction installed a new package, the **yum history undo** command will uninstall it, and if the transaction uninstalled a package the command will again install it. This command also attempts to downgrade all updated packages to their previous version, if these older packages are still available.

When managing several identical systems, Yum also allows you to perform a transaction on one of them, store the transaction details in a file, and after a period of testing, repeat the same transaction on the remaining systems as well. To store the transaction details to a file, type the following at a shell prompt as **root**:

```
yum -q history addon-info id saved_tx > file_name
```

Once you copy this file to the target system, you can repeat the transaction by using the following command as **root**:

```
yum load-transaction file_name
```

Note, however that the **rpmdb** version stored in the file must be identical to the version on the target system. You can verify the **rpmdb** version by using the **yum version nogroups** command.

8.3.4. Completing Transactions

An unexpected situation, such as power loss or system crash, can prevent you from completing your yum transaction. When such event occurs in the middle of your transaction, you can try to resume it later with the following command as **root**:

```
yum-complete-transaction
```

The **yum-complete-transaction** tool searches for incomplete or aborted yum transactions on a system and attempts to complete them. By default, these transactions are listed in the **/var/lib/yum/transaction-all** and **/var/lib/yum/transaction-done** files. If there are more unfinished transactions, **yum-complete-transaction** attempts to complete the most recent one first.

To clean transaction journal files without attempting to resume the aborted transactions, use the **--cleanup-only** option:

```
yum-complete-transaction --cleanup-only
```

8.3.5. Starting New Transaction History

Yum stores the transaction history in a single SQLite database file. To start new transaction history, run the following command as **root**:

```
yum history new
```

This will create a new, empty database file in the **/var/lib/yum/history/** directory. The old transaction history will be kept, but will not be accessible as long as a newer database file is present in the directory.

8.4. CONFIGURING YUM AND YUM REPOSITORIES

The configuration file for **yum** and related utilities is located at **/etc/yum.conf**. This file contains one mandatory **[main]** section, which allows you to set Yum options that have global effect, and can also contain one or more **[*repository*]** sections, which allow you to set repository-specific options. However, it is recommended to define individual repositories in new or existing **.repo** files in the **/etc/yum.repos.d/** directory. The values you define in individual **[*repository*]** sections of the **/etc/yum.conf** file override values set in the **[main]** section.

This section shows you how to:

- set global Yum options by editing the **[main]** section of the **/etc/yum.conf** configuration file;
- set options for individual repositories by editing the **[*repository*]** sections in **/etc/yum.conf** and **.repo** files in the **/etc/yum.repos.d/** directory;
- use Yum variables in **/etc/yum.conf** and files in the **/etc/yum.repos.d/** directory so that dynamic version and architecture values are handled correctly;
- add, enable, and disable Yum repositories on the command line; and,
- set up your own custom Yum repository.

8.4.1. Setting [main] Options

The **/etc/yum.conf** configuration file contains exactly one **[main]** section, and while some of the key-value pairs in this section affect how **yum** operates, others affect how Yum treats repositories. You can add many additional options under the **[main]** section heading in **/etc/yum.conf**.

A sample **/etc/yum.conf** configuration file can look like this:

```
[main]
cachedir=/var/cache/yum/$basearch/$releasever
keepcache=0
debuglevel=2
logfile=/var/log/yum.log
exactarch=1
obsoletes=1
gpgcheck=1
plugins=1
installonly_limit=3

[comments abridged]

# PUT YOUR REPOS HERE OR IN separate files named file.repo
# in /etc/yum.repos.d
```

The following are the most commonly-used options in the **[main]** section:

assumeyes=*value*

…where *value* is one of:

0 — **yum** should prompt for confirmation of critical actions it performs. This is the default.

1 — Do not prompt for confirmation of critical **yum** actions. If **assumeyes=1** is set, **yum** behaves in the same way that the command-line option **-y** does.

`cachedir=`*`directory`*

…where *directory* is an absolute path to the directory where Yum should store its cache and database files. By default, Yum's cache directory is **`/var/cache/yum/$basearch/$releasever`**.

See Section 8.4.3, “Using Yum Variables” for descriptions of the **`$basearch`** and **`$releasever`** Yum variables.

`debuglevel=`*`value`*

…where *value* is an integer between **`1`** and **`10`**. Setting a higher **`debuglevel`** value causes **`yum`** to display more detailed debugging output. **`debuglevel=0`** disables debugging output, while **`debuglevel=2`** is the default.

`exactarch=`*`value`*

…where *value* is one of:

`0` — Do not take into account the exact architecture when updating packages.

`1` — Consider the exact architecture when updating packages. With this setting, **`yum`** will not install an i686 package to update an i386 package already installed on the system. This is the default.

`exclude=`*`package_name`* [*`more_package_names`*]

This option allows you to exclude packages by keyword during installation/updates. Listing multiple packages for exclusion can be accomplished by quoting a space-delimited list of packages. Shell globs using wildcards (for example, **`*`** and **`?`**) are allowed.

`gpgcheck=`*`value`*

…where *value* is one of:

`0` — Disable GPG signature-checking on packages in all repositories, including local package installation.

`1` — Enable GPG signature-checking on all packages in all repositories, including local package installation. **`gpgcheck=1`** is the default, and thus all packages' signatures are checked.

If this option is set in the **`[main]`** section of the **`/etc/yum.conf`** file, it sets the GPG-checking rule for all repositories. However, you can also set **`gpgcheck=`*`value`*** for individual repositories instead; that is, you can enable GPG-checking on one repository while disabling it on another. Setting **`gpgcheck=`*`value`*** for an individual repository in its corresponding **`.repo`** file overrides the default if it is present in **`/etc/yum.conf`**.

For more information on GPG signature-checking, see Section B.3, “Checking a Package's Signature”.

`grouppremove_leaf_only=`*`value`*

…where *value* is one of:

`0` — **`yum`** should *not* check the dependencies of each package when removing a package group. With this setting, **`yum`** removes all packages in a package group, regardless of whether those packages are required by other packages or groups. **`groupremove_leaf_only=0`** is the default.

`1` — **yum** should check the dependencies of each package when removing a package group, and remove only those packages which are not required by any other package or group.

For more information on removing packages, see Intelligent package group removal.

`installonlypkgs=`*space separated list of packages*

Here you can provide a space-separated list of packages which **yum** can *install*, but will never *update*. See the **yum.conf**(5) manual page for the list of packages which are install-only by default.

If you add the **`installonlypkgs`** directive to **`/etc/yum.conf`**, you should ensure that you list *all* of the packages that should be install-only, including any of those listed under the **`installonlypkgs`** section of **yum.conf**(5). In particular, kernel packages should always be listed in **`installonlypkgs`** (as they are by default), and **`installonly_limit`** should always be set to a value greater than **`2`** so that a backup kernel is always available in case the default one fails to boot.

`installonly_limit=`*value*

…where *value* is an integer representing the maximum number of versions that can be installed simultaneously for any single package listed in the **`installonlypkgs`** directive.

The defaults for the **`installonlypkgs`** directive include several different kernel packages, so be aware that changing the value of **`installonly_limit`** will also affect the maximum number of installed versions of any single kernel package. The default value listed in **`/etc/yum.conf`** is **`installonly_limit=3`**, and it is not recommended to decrease this value, particularly below **`2`**.

`keepcache=`*value*

…where *value* is one of:

`0` — Do not retain the cache of headers and packages after a successful installation. This is the default.

`1` — Retain the cache after a successful installation.

`logfile=`*file_name*

…where *file_name* is an absolute path to the file in which **yum** should write its logging output. By default, **yum** logs to **`/var/log/yum.log`**.

`multilib_policy=`*value*

…where *value* is one of:

`best` — install the best-choice architecture for this system. For example, setting **`multilib_policy=best`** on an AMD64 system causes **yum** to install 64-bit versions of all packages.

`all` — always install every possible architecture for every package. For example, with **`multilib_policy`** set to **`all`** on an AMD64 system, **yum** would install both the i686 and AMD64 versions of a package, if both were available.

`obsoletes=`*value*

…where *value* is one of:

`0` — Disable **yum**'s obsoletes processing logic when performing updates.

`1` — Enable **`yum`**'s obsoletes processing logic when performing updates. When one package declares in its spec file that it *obsoletes* another package, the latter package will be replaced by the former package when the former package is installed. Obsoletes are declared, for example, when a package is renamed. **`obsoletes=1`** the default.

`plugins=`*`value`*

…where *value* is one of:

`0` — Disable all Yum plug-ins globally.

IMPORTANT

Disabling all plug-ins is not advised because certain plug-ins provide important **`Yum`** services. In particular, **rhnplugin** provides support for **`RHN Classic`**, and **product-id** and **subscription-manager** plug-ins provide support for the certificate-based **`Content Delivery Network`** (CDN). Disabling plug-ins globally is provided as a convenience option, and is generally only recommended when diagnosing a potential problem with **`Yum`**.

`1` — Enable all Yum plug-ins globally. With **`plugins=1`**, you can still disable a specific Yum plug-in by setting **`enabled=0`** in that plug-in's configuration file.

For more information about various Yum plug-ins, see Section 8.5, “Yum Plug-ins”. For further information on controlling plug-ins, see Section 8.5.1, “Enabling, Configuring, and Disabling Yum Plug-ins”.

`reposdir=`*`directory`*

…where *directory* is an absolute path to the directory where **`.repo`** files are located. All **`.repo`** files contain repository information (similar to the **`[`*`repository`*`]`** sections of **`/etc/yum.conf`**). **`yum`** collects all repository information from **`.repo`** files and the **`[`*`repository`*`]`** section of the **`/etc/yum.conf`** file to create a master list of repositories to use for transactions. If **`reposdir`** is not set, **`yum`** uses the default directory **`/etc/yum.repos.d/`**.

`retries=`*`value`*

…where *value* is an integer **`0`** or greater. This value sets the number of times **`yum`** should attempt to retrieve a file before returning an error. Setting this to **`0`** makes **`yum`** retry forever. The default value is **`10`**.

For a complete list of available **`[main]`** options, see the **`[main] OPTIONS`** section of the **yum.conf**(5) manual page.

8.4.2. Setting [repository] Options

The **`[`*`repository`*`]`** sections, where *repository* is a unique repository ID such as **`my_personal_repo`** (spaces are not permitted), allow you to define individual Yum repositories. To avoid conflicts, custom repositories should not use names used by Red Hat repositories.

The following is a bare-minimum example of the form a **`[`*`repository`*`]`** section takes:

```
[repository]
name=repository_name
baseurl=repository_url
```

Every **`[repository]`** section must contain the following directives:

`name=`*repository_name*

…where *repository_name* is a human-readable string describing the repository.

`baseurl=`*repository_url*

…where *repository_url* is a URL to the directory where the **`repodata`** directory of a repository is located:

- If the repository is available over HTTP, use: **`http://path/to/repo`**
- If the repository is available over FTP, use: **`ftp://path/to/repo`**
- If the repository is local to the machine, use: **`file:///path/to/local/repo`**
- If a specific online repository requires basic HTTP authentication, you can specify your user name and password by prepending it to the URL as ***`username`*`:`*`password`*`@`*`link`***. For example, if a repository on http://www.example.com/repo/ requires a user name of “user” and a password of “password”, then the **`baseurl`** link could be specified as **`http://user:password@www.example.com/repo/`**.

Usually this URL is an HTTP link, such as:

```
baseurl=http://path/to/repo/releases/$releasever/server/$basearch/os/
```

Note that Yum always expands the **`$releasever`**, **`$arch`**, and **`$basearch`** variables in URLs. For more information about Yum variables, see Section 8.4.3, “Using Yum Variables”.

Another useful **`[repository]`** directive is the following:

`enabled=`*value*

…where *value* is one of:

`0` — Do not include this repository as a package source when performing updates and installs. This is an easy way of quickly turning repositories on and off, which is useful when you desire a single package from a repository that you do not want to enable for updates or installs.

`1` — Include this repository as a package source.

Turning repositories on and off can also be performed by passing either the **`--enablerepo=`*`repo_name`*** or **`--disablerepo=`*`repo_name`*** option to **`yum`**, or through the **`Add/Remove Software`** window of the **PackageKit** utility.

Many more **`[repository]`** options exist. For a complete list, see the **`[repository] OPTIONS`** section of the **yum.conf**(5) manual page.

Example 8.6. A sample /etc/yum.repos.d/redhat.repo file

The following is a sample **`/etc/yum.repos.d/redhat.repo`** file:

```
#
# Red Hat Repositories
# Managed by (rhsm) subscription-manager
#

[red-hat-enterprise-linux-scalable-file-system-for-rhel-6-entitlement-
rpms]
name = Red Hat Enterprise Linux Scalable File System (for RHEL 6
Entitlement) (RPMs)
baseurl = https://cdn.redhat.com/content/dist/rhel/entitlement-
6/releases/$releasever/$basearch/scalablefilesystem/os
enabled = 1
gpgcheck = 1
gpgkey = file:///etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release
sslverify = 1
sslcacert = /etc/rhsm/ca/redhat-uep.pem
sslclientkey = /etc/pki/entitlement/key.pem
sslclientcert = /etc/pki/entitlement/11300387955690106.pem

[red-hat-enterprise-linux-scalable-file-system-for-rhel-6-entitlement-
source-rpms]
name = Red Hat Enterprise Linux Scalable File System (for RHEL 6
Entitlement) (Source RPMs)
baseurl = https://cdn.redhat.com/content/dist/rhel/entitlement-
6/releases/$releasever/$basearch/scalablefilesystem/source/SRPMS
enabled = 0
gpgcheck = 1
gpgkey = file:///etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release
sslverify = 1
sslcacert = /etc/rhsm/ca/redhat-uep.pem
sslclientkey = /etc/pki/entitlement/key.pem
sslclientcert = /etc/pki/entitlement/11300387955690106.pem

[red-hat-enterprise-linux-scalable-file-system-for-rhel-6-entitlement-
debug-rpms]
name = Red Hat Enterprise Linux Scalable File System (for RHEL 6
Entitlement) (Debug RPMs)
baseurl = https://cdn.redhat.com/content/dist/rhel/entitlement-
6/releases/$releasever/$basearch/scalablefilesystem/debug
enabled = 0
gpgcheck = 1
gpgkey = file:///etc/pki/rpm-gpg/RPM-GPG-KEY-redhat-release
sslverify = 1
sslcacert = /etc/rhsm/ca/redhat-uep.pem
sslclientkey = /etc/pki/entitlement/key.pem
sslclientcert = /etc/pki/entitlement/11300387955690106.pem
```

8.4.3. Using Yum Variables

You can use and reference the following built-in variables in **`yum`** commands and in all Yum configuration files (that is, **`/etc/yum.conf`** and all **`.repo`** files in the **`/etc/yum.repos.d/`** directory):

`$releasever`

You can use this variable to reference the release version of Red Hat Enterprise Linux. Yum obtains the value of **`$releasever`** from the **`distroverpkg=`*`value`*** line in the **`/etc/yum.conf`** configuration file. If there is no such line in **`/etc/yum.conf`**, then **`yum`** infers the correct value by deriving the version number from the redhat-release-server package. The value of **`$releasever`** typically consists of the major release number and the variant of Red Hat Enterprise Linux, for example **`6Client`**, or **`6Server`**.

`$arch`

You can use this variable to refer to the system's CPU architecture as returned when calling Python's **`os.uname()`** function. Valid values for **`$arch`** include **`i686`** and **`x86_64`**.

`$basearch`

You can use **`$basearch`** to reference the base architecture of the system. For example, i686 machines have a base architecture of **`i386`**, and AMD64 and Intel 64 machines have a base architecture of **`x86_64`**.

`$YUM0-9`

These ten variables are each replaced with the value of any shell environment variables with the same name. If one of these variables is referenced (in **`/etc/yum.conf`** for example) and a shell environment variable with the same name does not exist, then the configuration file variable is not replaced.

To define a custom variable or to override the value of an existing one, create a file with the same name as the variable (without the “**`$`**” sign) in the **`/etc/yum/vars/`** directory, and add the desired value on its first line.

For example, repository descriptions often include the operating system name. To define a new variable called **`$osname`**, create a new file with “Red Hat Enterprise Linux” on the first line and save it as **`/etc/yum/vars/osname`**:

```
~]# echo "Red Hat Enterprise Linux" > /etc/yum/vars/osname
```

Instead of “Red Hat Enterprise Linux 6”, you can now use the following in the **`.repo`** files:

```
name=$osname $releasever
```

8.4.4. Viewing the Current Configuration

To display the current values of global Yum options (that is, the options specified in the **`[main]`** section of the **`/etc/yum.conf`** file), run the **`yum-config-manager`** with no command-line options:

```
yum-config-manager
```

To list the content of a different configuration section or sections, use the command in the following form:

```
yum-config-manager section…
```

You can also use a glob expression to display the configuration of all matching sections:

–

```
yum-config-manager glob_expression…
```

For example, to list all configuration options and their corresponding values, type the following at a shell prompt:

```
~]$ yum-config-manager main \*
Loaded plugins: product-id, refresh-packagekit, subscription-manager
================================== main
===================================
[main]
alwaysprompt = True
assumeyes = False
bandwith = 0
bugtracker_url = https://bugzilla.redhat.com/enter_bug.cgi?
product=Red%20Hat%20Enterprise%20Linux%206&component=yum
cache = 0
[output truncated]
```

8.4.5. Adding, Enabling, and Disabling a Yum Repository

Section 8.4.2, “Setting [repository] Options” described various options you can use to define a Yum repository. This section explains how to add, enable, and disable a repository by using the **`yum-config-manager`** command.

IMPORTANT

When the system is registered with the certificate-based **`Red Hat Network`**, the Red Hat Subscription Manager tools are used to manage repositories in the **`/etc/yum.repos.d/redhat.repo`** file. See Chapter 6, *Registering the System and Managing Subscriptions* for more information how to register a system with **`Red Hat Network`** and use the Red Hat Subscription Manager tools to manage subscriptions.

Adding a Yum Repository

To define a new repository, you can either add a **`[`*`repository`*`]`** section to the **`/etc/yum.conf`** file, or to a **`.repo`** file in the **`/etc/yum.repos.d/`** directory. All files with the **`.repo`** file extension in this directory are read by **`yum`**, and it is recommended to define your repositories here instead of in **`/etc/yum.conf`**.

WARNING

Obtaining and installing software packages from unverified or untrusted software sources other than Red Hat Network constitutes a potential security risk, and could lead to security, stability, compatibility, and maintainability issues.

Yum repositories commonly provide their own **`.repo`** file. To add such a repository to your system and enable it, run the following command as **`root`**:

```
yum-config-manager --add-repo repository_url
```

…where *repository_url* is a link to the **.repo** file. For example, to add a repository located at http://www.example.com/example.repo, type the following at a shell prompt:

```
~]# yum-config-manager --add-repo http://www.example.com/example.repo
Loaded plugins: product-id, refresh-packagekit, subscription-manager
adding repo from: http://www.example.com/example.repo
grabbing file http://www.example.com/example.repo to
/etc/yum.repos.d/example.repo
example.repo                                             |  413 B
00:00
repo saved to /etc/yum.repos.d/example.repo
```

Enabling a Yum Repository

To enable a particular repository or repositories, type the following at a shell prompt as **root**:

```
yum-config-manager --enable repository…
```

…where *repository* is the unique repository ID (use **yum repolist all** to list available repository IDs). Alternatively, you can use a glob expression to enable all matching repositories:

```
yum-config-manager --enable glob_expression…
```

For example, to enable repositories defined in the **[example]**, **[example-debuginfo]**, and **[example-source]** sections, type:

```
~]# yum-config-manager --enable example\*
Loaded plugins: product-id, refresh-packagekit, subscription-manager
============================== repo: example
==============================
[example]
bandwidth = 0
base_persistdir = /var/lib/yum/repos/x86_64/6Server
baseurl = http://www.example.com/repo/6Server/x86_64/
cache = 0
cachedir = /var/cache/yum/x86_64/6Server/example
[output truncated]
```

When successful, the **yum-config-manager --enable** command displays the current repository configuration.

Disabling a Yum Repository

To disable a Yum repository, run the following command as **root**:

```
yum-config-manager --disable repository…
```

…where *repository* is the unique repository ID (use **yum repolist all** to list available repository IDs). Similarly to **yum-config-manager --enable**, you can use a glob expression to disable all matching repositories at the same time:

```
yum-config-manager --disable glob_expression…
```

When successful, the **`yum-config-manager --disable`** command displays the current configuration.

8.4.6. Creating a Yum Repository

To set up a Yum repository, follow these steps:

1. Install the createrepo package. To do so, type the following at a shell prompt as **`root`**:

   ```
   yum install createrepo
   ```

2. Copy all packages that you want to have in your repository into one directory, such as **`/mnt/local_repo/`**.

3. Change to this directory and run the following command:

   ```
   createrepo --database /mnt/local_repo
   ```

   This creates the necessary metadata for your Yum repository, as well as the **sqlite** database for speeding up **`yum`** operations.

IMPORTANT

Compared to Red Hat Enterprise Linux 5, RPM packages for Red Hat Enterprise Linux 6 are compressed with the XZ lossless data compression format and can be signed with newer hash algorithms like SHA-256. Consequently, it is not recommended to use the **`createrepo`** command on Red Hat Enterprise Linux 5 to create the package metadata for Red Hat Enterprise Linux 6.

8.4.7. Working with Yum Cache

By default, **yum** deletes downloaded data files when they are no longer needed after a successful operation. This minimizes the amount of storage space that **yum** uses. However, you can enable caching, so that the package files downloaded by **yum** stay in cache directories. By using cached data, you can carry out certain operations without a network connection, you can also copy packages stored in the caches and reuse them elsewhere.

Yum stores temporary files in the **`/var/cache/yum/$basearch/$releasever/`** directory, where **`$basearch`** and **`$releasever`** are Yum variables referring to base architecture of the system and the release version of Red Hat Enterprise Linux. Each configured repository has one subdirectory. For example, the directory **`/var/cache/yum/$basearch/$releasever/development/packages/`** holds packages downloaded from the development repository. You can find the values for the *$basearch* and *$releasever* variables in the output of the **`yum version`** command.

To change the default cache location, modify the **`cachedir`** option in the **`[main]`** section of the **`/etc/yum.conf`** configuration file. See Section 8.4, "Configuring Yum and Yum Repositories" for more information on configuring **yum**.

Enabling the Caches

To retain the cache of packages after a successful installation, add the following text to the **`[main]`** section of **`/etc/yum.conf`**.

```
keepcache = 1
```

Once you enabled caching, every yum operation may download package data from the configured repositories.

To download and make usable all the metadata for the currently enabled yum repositories, type:

```
yum makecache
```

This is useful if you want to make sure that the cache is fully up to date with all metadata. To set the time after which the metadata will expire, use the `metadata-expire` setting in `/etc/yum.conf`.

Using yum in Cache-only Mode

To carry out a **yum** command without a network connection, add the `-C` or `--cacheonly` command-line option. With this option, **yum** proceeds without checking any network repositories, and uses only cached files. In this mode, **yum** may only install packages that have been downloaded and cached by a previous operation.

For instance, to list packages that use the currently cached data with names that contain “gstreamer”, enter the following command:

```
yum -C list gstreamer*
```

Clearing the yum Caches

It is often useful to remove entries accumulated in the `/var/cache/yum/` directory. If you remove a package from the cache, you do not affect the copy of the software installed on your system. To remove all entries for currently enabled repositories from the cache, type the following as a `root`:

```
yum clean all
```

There are various ways to invoke `yum` in `clean` mode depending on the type of cached data you want to remove. See Table 8.3, “Available `yum clean` options” for a complete list of available configuration options.

Table 8.3. Available `yum clean` options

Option	Description
expire-cache	eliminates time records of the metadata and mirrorlists download for each repository. This forces yum to revalidate the cache for each repository the next time it is used.
packages	eliminates any cached packages from the system
headers	eliminates all header files that previous versions of yum used for dependency resolution
metadata	eliminates all files that yum uses to determine the remote availability of packages. These metadata are downloaded again the next time yum is run.

Option	Description
dbcache	eliminates the sqlite cache used for faster access to metadata. Using this option will force yum to download the sqlite metadata the next time it is run. This does not apply for repositories that contain only .xml data, in that case, sqlite data are deleted but without subsequent download
rpmdb	eliminates any cached data from the local rpmdb
plugins	enabled plugins are forced to eliminate their cached data
all	removes all of the above

The **expire-cache** option is most preferred from the above list. In many cases, it is a sufficient and much faster replacement for **clean all**.

8.4.8. Adding the Optional and Supplementary Repositories

Optional and Supplementary subscription channels provide additional software packages for Red Hat Enterprise Linux that cover open source licensed software (in the Optional channel) and proprietary licensed software (in the Supplementary channel).

Before subscribing to the Optional and Supplementary channels see the Scope of Coverage Details. If you decide to install packages from these channels, follow the steps documented in the article called How to access Optional and Supplementary channels, and -devel packages using Red Hat Subscription Manager (RHSM)? on the Red Hat Customer Portal.

8.5. YUM PLUG-INS

Yum provides plug-ins that extend and enhance its operations. Certain plug-ins are installed by default. Yum always informs you which plug-ins, if any, are loaded and active whenever you call any **yum** command. For example:

```
~]# yum info yum
Loaded plugins: product-id, refresh-packagekit, subscription-manager
[output truncated]
```

Note that the plug-in names which follow **Loaded plugins** are the names you can provide to the **--disableplugins=*plugin_name*** option.

8.5.1. Enabling, Configuring, and Disabling Yum Plug-ins

To enable Yum plug-ins, ensure that a line beginning with **plugins=** is present in the **[main]** section of **/etc/yum.conf**, and that its value is **1**:

```
plugins=1
```

You can disable all plug-ins by changing this line to **plugins=0**.

IMPORTANT

Disabling all plug-ins is not advised because certain plug-ins provide important **`Yum`** services. In particular, **rhnplugin** provides support for **`RHN Classic`**, and **product-id** and **subscription-manager** plug-ins provide support for the certificate-based **`Content Delivery Network`** (CDN). Disabling plug-ins globally is provided as a convenience option, and is generally only recommended when diagnosing a potential problem with **`Yum`**.

Every installed plug-in has its own configuration file in the **`/etc/yum/pluginconf.d/`** directory. You can set plug-in specific options in these files. For example, here is the **refresh-packagekit** plug-in's **`refresh-packagekit.conf`** configuration file:

```
[main]
enabled=1
```

Plug-in configuration files always contain a **`[main]`** section (similar to Yum's **`/etc/yum.conf`** file) in which there is (or you can place if it is missing) an **`enabled=`** option that controls whether the plug-in is enabled when you run **`yum`** commands.

If you disable all plug-ins by setting **`enabled=0`** in **`/etc/yum.conf`**, then all plug-ins are disabled regardless of whether they are enabled in their individual configuration files.

If you merely want to disable all Yum plug-ins for a single **`yum`** command, use the **`--noplugins`** option.

If you want to disable one or more Yum plug-ins for a single **`yum`** command, add the **`--disableplugin=`*`plugin_name`*** option to the command. For example, to disable the **presto** plug-in while updating a system, type:

```
~]# yum update --disableplugin=presto
```

The plug-in names you provide to the **`--disableplugin=`** option are the same names listed after the **`Loaded plugins`** line in the output of any **`yum`** command. You can disable multiple plug-ins by separating their names with commas. In addition, you can match multiple plug-in names or shorten long ones by using glob expressions:

```
~]# yum update --disableplugin=presto,refresh-pack*
```

8.5.2. Installing Additional Yum Plug-ins

Yum plug-ins usually adhere to the **`yum-plugin-`*`plugin_name`*** package-naming convention, but not always: the package which provides the **presto** plug-in is named **`yum-presto`**, for example. You can install a Yum plug-in in the same way you install other packages. For instance, to install the **security** plug-in, type the following at a shell prompt:

```
~]# yum install yum-plugin-security
```

8.5.3. Plug-in Descriptions

The following list provides descriptions and usage instructions for several useful yum plug-ins. Plug-ins are listed by names, brackets contain the name of the package.

search-disabled-repos (subscription-manager)

The **search-disabled-repos** plug-in allows you to temporarily or permanently enable disabled repositories to help resolve dependencies. With this plug-in enabled, when Yum fails to install a package due to failed dependency resolution, it offers to temporarily enable disabled repositories and try again. If the installation succeeds, Yum also offers to enable the used repositories permanently. Note that the plug-in works only with the repositories that are managed by **subscription-manager** and not with custom repositories.

IMPORTANT

If **`yum`** is executed with the **`--assumeyes`** or **`-y`** option, or if the **`assumeyes`** directive is enabled in **`/etc/yum.conf`**, the plug-in enables disabled repositories, both temporarily and permanently, without prompting for confirmation. This may lead to problems, for example, enabling repositories that you do not want enabled.

To configure the **search-disabled-repos** plug-in, edit the configuration file located in **`/etc/yum/pluginconf.d/search-disabled-repos.conf`**. For the list of directives you can use in the **`[main]`** section, see the table below.

Table 8.4. Supported `search-disabled-repos.conf` directives

Directive	Description
`enabled`=*value*	Allows you to enable or disable the plug-in. The *value* must be either **`1`** (enabled), or **`0`** (disabled). The plug-in is enabled by default.
`notify_only`=*value*	Allows you to restrict the behavior of the plug-in to notifications only. The *value* must be either **`1`** (notify only without modifying the behavior of Yum), or **`0`** (modify the behavior of Yum). By default the plug-in only notifies the user.
`ignored_repos`=*repositories*	Allows you to specify the repositories that will not be enabled by the plug-in.

kabi (kabi-yum-plugins)

The **kabi** plug-in checks whether a driver update package conforms with official Red Hat *kernel Application Binary Interface* (kABI). With this plug-in enabled, when a user attempts to install a package that uses kernel symbols which are not on a whitelist, a warning message is written to the system log. Additionally, configuring the plug-in to run in enforcing mode prevents such packages from being installed at all.

To configure the **kabi** plug-in, edit the configuration file located in **`/etc/yum/pluginconf.d/kabi.conf`**. See Table 8.5, “Supported **`kabi.conf`** directives” for a list of directives that can be used in the **`[main]`** section.

Table 8.5. Supported `kabi.conf` directives

Directive	Description

Directive	Description
`enabled`=*value*	Allows you to enable or disable the plug-in. The *value* must be either `1` (enabled), or `0` (disabled). When installed, the plug-in is enabled by default.
`whitelists`=*directory*	Allows you to specify the *directory* in which the files with supported kernel symbols are located. By default, the **kabi** plug-in uses files provided by the kernel-abi-whitelists package (that is, the `/lib/modules/kabi/` directory).
`enforce`=*value*	Allows you to enable or disable enforcing mode. The *value* must be either `1` (enabled), or `0` (disabled). By default, this option is commented out and the **kabi** plug-in only displays a warning message.

presto (yum-presto)

The **presto** plug-in adds support to Yum for downloading *delta RPM* packages, during updates, from repositories which have **presto** metadata enabled. Delta RPMs contain only the differences between the version of the package installed on the client requesting the RPM package and the updated version in the repository.

Downloading a delta RPM is much quicker than downloading the entire updated package, and can speed up updates considerably. Once the delta RPMs are downloaded, they must be rebuilt to apply the difference to the currently-installed package and thus create the full, updated package. This process takes CPU time on the installing machine. Using delta RPMs is therefore a compromise between time-to-download, which depends on the network connection, and time-to-rebuild, which is CPU-bound. Using the **presto** plug-in is recommended for fast machines and systems with slower network connections, while slower machines on very fast connections benefit more from downloading normal RPM packages, that is, by disabling **presto**.

product-id (subscription-manager)

The **product-id** plug-in manages product identity certificates for products installed from the Content Delivery Network. The **product-id** plug-in is installed by default.

refresh-packagekit (PackageKit-yum-plugin)

The **refresh-packagekit** plug-in updates metadata for **PackageKit** whenever **`yum`** is run. The **refresh-packagekit** plug-in is installed by default.

rhnplugin (yum-rhn-plugin)

The **rhnplugin** provides support for connecting to **`RHN Classic`**. This allows systems registered with **`RHN Classic`** to update and install packages from this system. Note that **`RHN Classic`** is only provided for older Red Hat Enterprise Linux systems (that is, Red Hat Enterprise Linux 4.x, Red Hat Enterprise Linux 5.x, and Satellite 5.x) in order to migrate them over to Red Hat Enterprise Linux 6. The **rhnplugin** is installed by default.

See the **rhnplugin**(8) manual page for more information about the plug-in.

security (yum-plugin-security)

Discovering information about and applying security updates easily and often is important to all system administrators. For this reason Yum provides the **security** plug-in, which extends **yum** with a set of highly-useful security-related commands, subcommands and options.

You can check for security-related updates as follows:

```
~]# yum check-update --security
Loaded plugins: product-id, refresh-packagekit, security, subscription-
manager
Updating Red Hat repositories.
INFO:rhsm-app.repolib:repos updated: 0
Limiting package lists to security relevant ones
Needed 3 of 7 packages, for security
elinks.x86_64                   0.12-0.13.el6             rhel
kernel.x86_64                   2.6.30.8-64.el6           rhel
kernel-headers.x86_64           2.6.30.8-64.el6           rhel
```

You can then use either **`yum update --security`** or **`yum update-minimal --security`** to update those packages which are affected by security advisories. Both of these commands update all packages on the system for which a security advisory has been issued. **`yum update-minimal --security`** updates them to the latest packages which were released as part of a security advisory, while **`yum update --security`** will update all packages affected by a security advisory *to the latest version of that package available*.

In other words, if:

- the kernel-2.6.30.8-16 package is installed on your system;
- the kernel-2.6.30.8-32 package was released as a security update;
- then kernel-2.6.30.8-64 was released as a bug fix update,

...then **`yum update-minimal --security`** will update you to kernel-2.6.30.8-32, and **`yum update --security`** will update you to kernel-2.6.30.8-64. Conservative system administrators probably want to use **`update-minimal`** to reduce the risk incurred by updating packages as much as possible.

See the **yum-security**(8) manual page for usage details and further explanation of the enhancements the **security** plug-in adds to **yum**.

subscription-manager (subscription-manager)

The **subscription-manager** plug-in provides support for connecting to **`Red Hat Network`**. This allows systems registered with **`Red Hat Network`** to update and install packages from the certificate-based Content Delivery Network. The **subscription-manager** plug-in is installed by default.

See Chapter 6, *Registering the System and Managing Subscriptions* for more information how to manage product subscriptions and entitlements.

yum-downloadonly (yum-plugin-downloadonly)

The **yum-downloadonly** plug-in provides the **`--downloadonly`** command-line option which can be used to download packages from Red Hat Network or a configured Yum repository without installing the packages.

To install the package, follow the instructions in Section 8.5.2, “Installing Additional Yum Plug-ins”. After the installation, see the contents of the **`/etc/yum/pluginconf.d/downloadonly.conf`** file to ensure that the plug-in is enabled:

```
~]$ cat /etc/yum/pluginconf.d/downloadonly.conf
[main]
enabled=1
```

In the following example, the **`yum install --downloadonly`** command is run to download the latest version of the httpd package, without installing it:

```
~]# yum install httpd --downloadonly
Loaded plugins: downloadonly, product-id, refresh-packagekit, rhnplugin,
              : subscription-manager
Updating Red Hat repositories.
Setting up Install Process
Resolving Dependencies
--> Running transaction check
---> Package httpd.x86_64 0:2.2.15-9.el6_1.2 will be updated
---> Package httpd.x86_64 0:2.2.15-15.el6_2.1 will be an update
--> Processing Dependency: httpd-tools = 2.2.15-15.el6_2.1 for package:
httpd-2.2.15-15.el6_2.1.x86_64
--> Running transaction check
---> Package httpd-tools.x86_64 0:2.2.15-9.el6_1.2 will be updated
---> Package httpd-tools.x86_64 0:2.2.15-15.el6_2.1 will be an update
--> Finished Dependency Resolution

Dependencies Resolved

========================================================================
========
 Package        Arch      Version                 Repository
Size
========================================================================
========
Updating:
 httpd          x86_64    2.2.15-15.el6_2.1       rhel-x86_64-server-6
812 k
Updating for dependencies:
 httpd-tools    x86_64    2.2.15-15.el6_2.1       rhel-x86_64-server-6
70 k

Transaction Summary
========================================================================
========
Upgrade       2 Package(s)

Total download size: 882 k
Is this ok [y/N]: y
Downloading Packages:
(1/2): httpd-2.2.15-15.el6_2.1.x86_64.rpm                | 812 kB
00:00
(2/2): httpd-tools-2.2.15-15.el6_2.1.x86_64.rpm          |  70 kB
00:00
--------------------------------------------------------------------
```

```
------------
Total                                                301 kB/s | 882 kB
00:02


exiting because --downloadonly specified
```

By default, packages downloaded using the **`--downloadonly`** option are saved in one of the subdirectories of the **`/var/cache/yum`** directory, depending on the Red Hat Enterprise Linux variant and architecture.

If you want to specify an alternate directory to save the packages, pass the **`--downloaddir`** option along with **`--downloadonly`**:

```
~]# yum install --downloadonly --downloaddir=/path/to/directory httpd
```

NOTE

As an alternative to the **yum-downloadonly** plugin — to download packages without installing them — you can use the **yumdownloader** utility that is provided by the yum-utils package.

8.6. ADDITIONAL RESOURCES

For more information on how to manage software packages on Red Hat Enterprise Linux, see the resources listed below.

Installed Documentation

- **`yum`**(8) — The manual page for the **`yum`** command-line utility provides a complete list of supported options and commands.
- **`yumdb`**(8) — The manual page for the **`yumdb`** command-line utility documents how to use this tool to query and, if necessary, alter the yum database.
- **`yum.conf`**(5) — The manual page named **`yum.conf`** documents available yum configuration options.
- **`yum-utils`**(1) — The manual page named **`yum-utils`** lists and briefly describes additional utilities for managing yum configuration, manipulating repositories, and working with yum database.

Online Resources

- Yum Guides — The *Yum Guides* page on the project home page provides links to further documentation.
- Red Hat Access Labs — The Red Hat Access Labs includes a “Yum Repository Configuration Helper”.

See Also

- Chapter 4, *Gaining Privileges* documents how to gain administrative privileges by using the **su** and **sudo** commands.
- Appendix B, *RPM* describes the **RPM Package Manager** (RPM), the packaging system used by Red Hat Enterprise Linux.

CHAPTER 9. PACKAGEKIT

Red Hat provides **PackageKit** for viewing, managing, updating, installing and uninstalling packages compatible with your system. PackageKit consists of several graphical interfaces that can be opened from the GNOME panel menu, or from the Notification Area when PackageKit alerts you that updates are available. For more information on **PackageKit's** architecture and available front ends, see Section 9.3, “PackageKit Architecture”.

9.1. UPDATING PACKAGES WITH SOFTWARE UPDATE

PackageKit displays a starburst icon in the Notification Area whenever updates are available to be installed on your system.

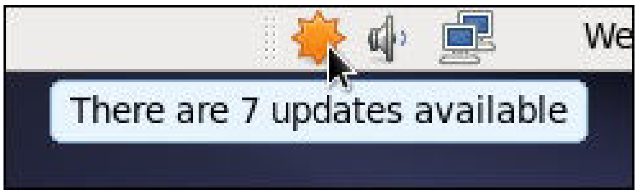
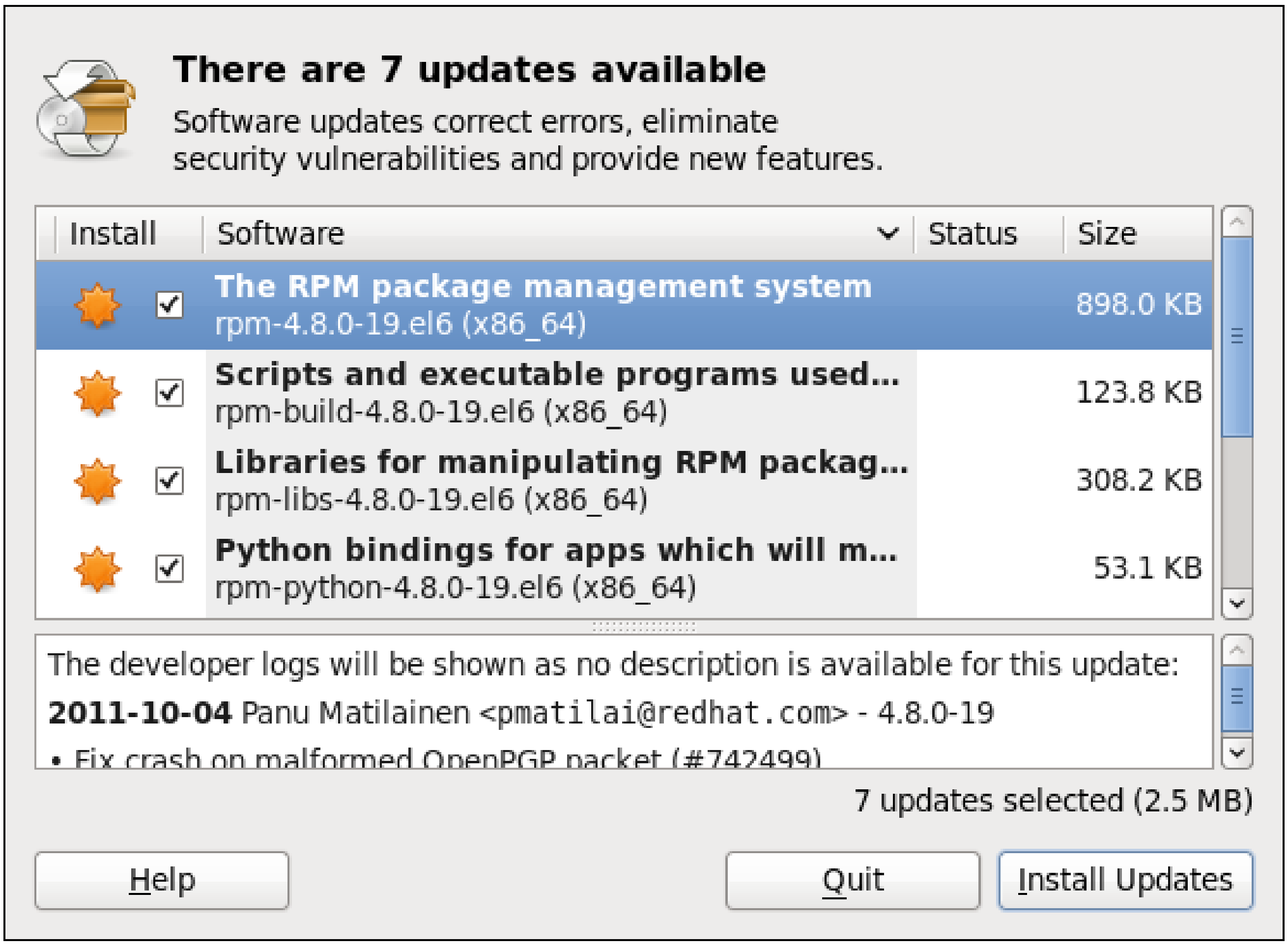

There are 7 updates available

Figure 9.1. PackageKit's icon in the Notification Area

Clicking on the notification icon opens the **`Software Update`** window. Alternatively, you can open **`Software Updates`** by clicking **System** → **Administration** → **Software Update** from the GNOME panel, or running the **`gpk-update-viewer`** command at the shell prompt. In the **`Software Updates`** window, all available updates are listed along with the names of the packages being updated (minus the **`.rpm`** suffix, but including the CPU architecture), a short summary of the package, and, usually, short descriptions of the changes the update provides. Any updates you do not want to install can be de-selected here by unchecking the check box corresponding to the update.


There are 7 updates available

Software updates correct errors, eliminate security vulnerabilities and provide new features.

Install	Software	Status	Size
✓	**The RPM package management system** rpm-4.8.0-19.el6 (x86_64)		898.0 KB
✓	**Scripts and executable programs used...** rpm-build-4.8.0-19.el6 (x86_64)		123.8 KB
✓	**Libraries for manipulating RPM packag...** rpm-libs-4.8.0-19.el6 (x86_64)		308.2 KB
✓	**Python bindings for apps which will m...** rpm-python-4.8.0-19.el6 (x86_64)		53.1 KB

The developer logs will be shown as no description is available for this update:

2011-10-04 Panu Matilainen <pmatilai@redhat.com> - 4.8.0-19

• Fix crash on malformed OpenPGP packet (#742499)

7 updates selected (2.5 MB)

Figure 9.2. Installing updates with Software Update

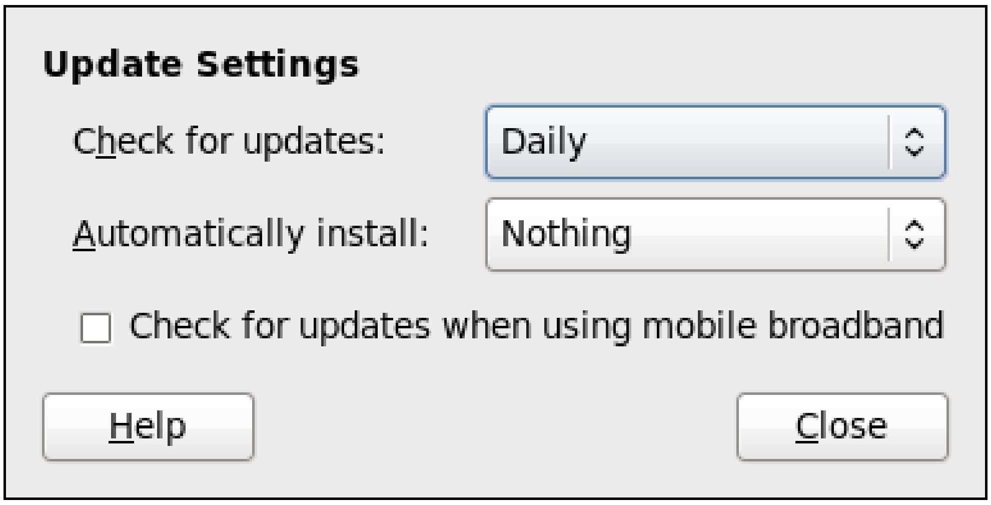
The updates presented in the **`Software Updates`** window only represent the currently-installed packages on your system for which updates are available; dependencies of those packages, whether they are existing packages on your system or new ones, are not shown until you click **`Install Updates`**.

PackageKit utilizes the fine-grained user authentication capabilities provided by the **PolicyKit** toolkit whenever you request it to make changes to the system. Whenever you instruct PackageKit to update, install or remove packages, you will be prompted to enter the superuser password before changes are made to the system.

If you instruct PackageKit to update the kernel package, then it will prompt you after installation, asking you whether you want to reboot the system and thereby boot into the newly-installed kernel.

Setting the Update-Checking Interval

Right-clicking on PackageKit's Notification Area icon and clicking **Preferences** opens the **`Software Update Preferences`** window, where you can define the interval at which PackageKit checks for package updates, as well as whether or not to automatically install all updates or only security updates. Leaving the **`Check for updates when using mobile broadband`** box unchecked is handy for avoiding extraneous bandwidth usage when using a wireless connection on which you are charged for the amount of data you download.


Update Settings

Check for updates: Daily

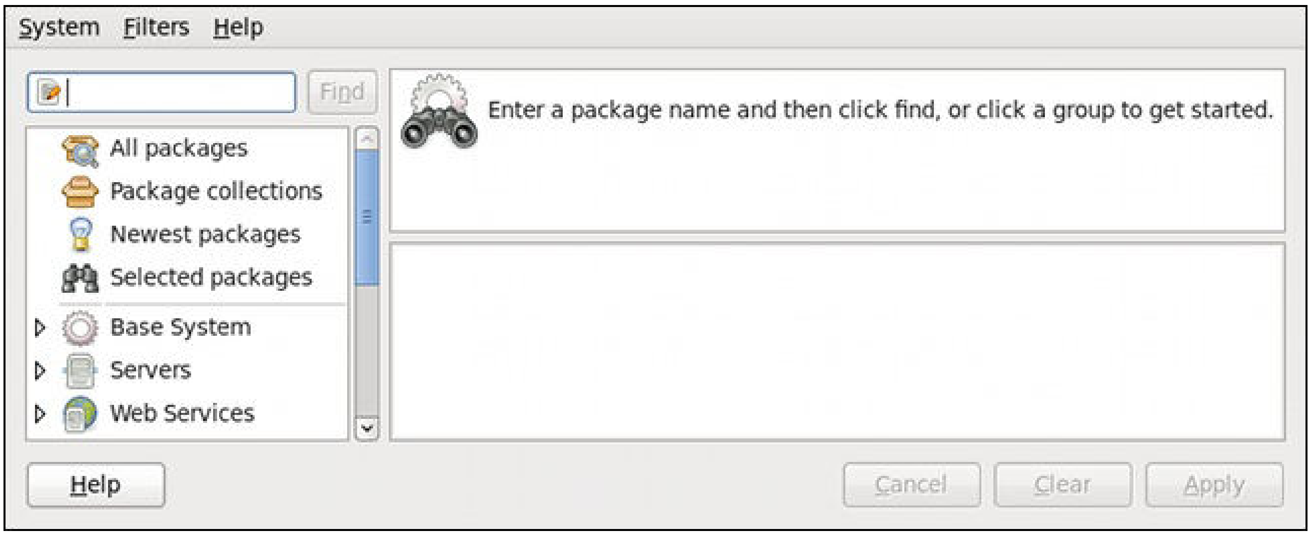
Automatically install: Nothing

☐ Check for updates when using mobile broadband

Figure 9.3. Setting PackageKit's update-checking interval

9.2. USING ADD/REMOVE SOFTWARE

To find and install a new package, on the GNOME panel click on **System** → **Administration** → **Add/Remove Software**, or run the **`gpk-application`** command at the shell prompt.



Enter a package name and then click find, or click a group to get started.

Figure 9.4. PackageKit's Add/Remove Software window

9.2.1. Refreshing Software Sources (Yum Repositories)

PackageKit refers to **Yum** repositories as software sources. It obtains all packages from enabled software sources. You can view the list of all *configured* and unfiltered (see below) Yum repositories by opening **`Add/Remove Software`** and clicking **System** → **Software sources**. The **`Software Sources`** dialog shows the repository name, as written on the **`name=<`*`My Repository Name`*`>`** field of all [*repository*] sections in the **`/etc/yum.conf`** configuration file, and in all ***`repository`*`.repo`** files in the **`/etc/yum.repos.d/`** directory.

Entries which are checked in the **`Enabled`** column indicate that the corresponding repository will be used to locate packages to satisfy all update and installation requests (including dependency resolution). You can enable or disable any of the listed Yum repositories by selecting or clearing the check box. Note that doing so causes **PolicyKit** to prompt you for superuser authentication.

The **`Enabled`** column corresponds to the **`enabled=<`*`1 or 0`*`>`** field in [*repository*] sections. When you click the check box, PackageKit inserts the **`enabled=<1 or 0>`** line into the correct [*repository*] section if it does not exist, or changes the value if it does. This means that enabling or disabling a repository through the **`Software Sources`** window causes that change to persist after closing the window or rebooting the system.

Note that it is not possible to add or remove Yum repositories through PackageKit.

NOTE

Checking the box at the bottom of the **`Software Sources`** window causes PackageKit to display source RPM, testing and debuginfo repositories as well. This box is unchecked by default.

After making a change to the available Yum repositories, click on **System** → **Refresh package lists** to make sure your package list is up-to-date.

9.2.2. Finding Packages with Filters

Once the software sources have been updated, it is often beneficial to apply some filters so that PackageKit retrieves the results of our **`Find`** queries faster. This is especially helpful when performing many package searches. Four of the filters in the **Filters** drop-down menu are used to split results by matching or not matching a single criterion. By default when PackageKit starts, these filters are all unapplied (**`No filter`**), but once you do filter by one of them, that filter remains set until you either change it or close PackageKit.

Because you are usually searching for available packages that are *not* installed on the system, click **Filters** → **Installed** and select the **Only available** radio button.

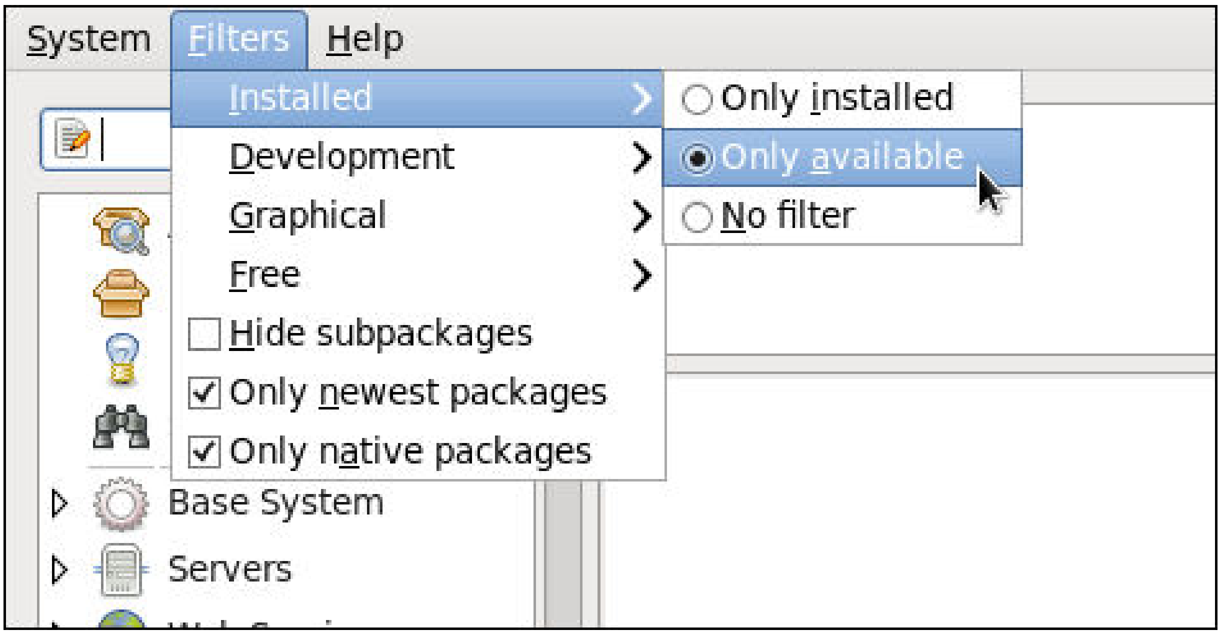


Figure 9.5. Filtering out already-installed packages

Also, unless you require development files such as C header files, click **Filters** → **Development** and select the **Only end user files** radio button. This filters out all of the **`<package_name>-devel`** packages we are not interested in.

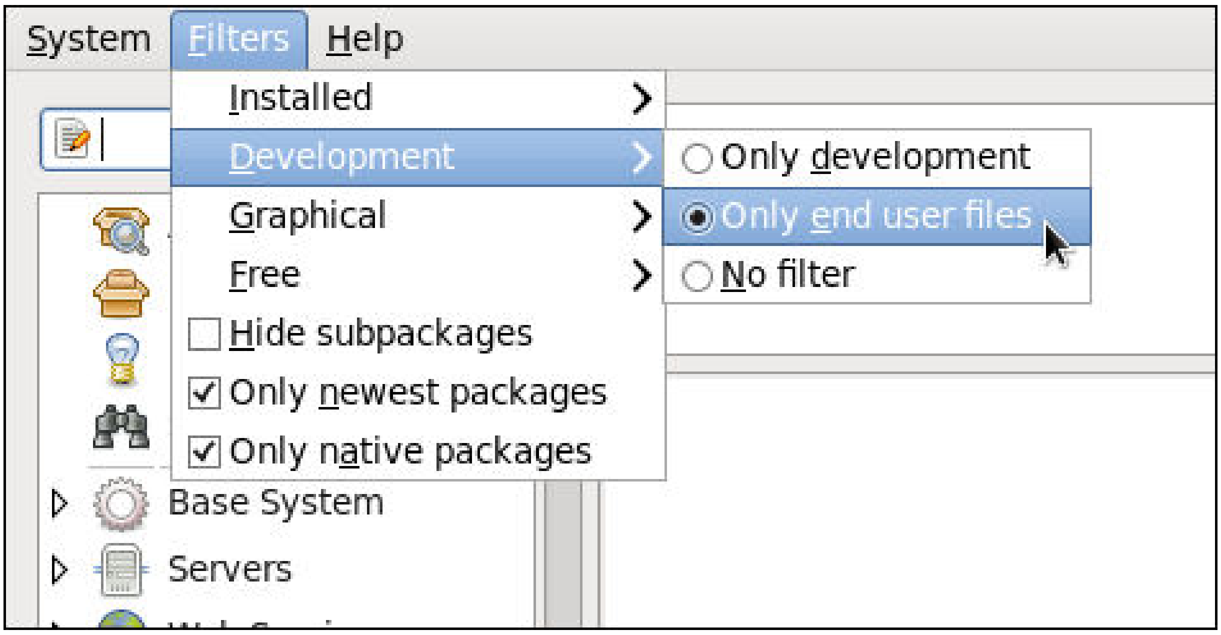


Figure 9.6. Filtering out development packages from the list of Find results

The two remaining filters with submenus are:

Graphical

Narrows the search to either applications which provide a GUI interface (**`Only graphical`**) or those that do not. This filter is useful when browsing for GUI applications that perform a specific function.

Free

Search for packages which are considered to be free software. See the Fedora Licensing List for details on approved licenses.

The remaining filters can be enabled by selecting the check boxes next to them:

Hide subpackages

Checking the **Hide subpackages** check box filters out generally-uninteresting packages that are typically only dependencies of other packages that we want. For example, checking **Hide subpackages** and searching for ***<package>*** would cause the following related packages to be filtered out of the **`Find`** results (if it exists):

- ***<package>*`-devel`**
- ***<package>*`-libs`**
- ***<package>*`-libs-devel`**
- ***<package>*`-debuginfo`**

Only newest packages

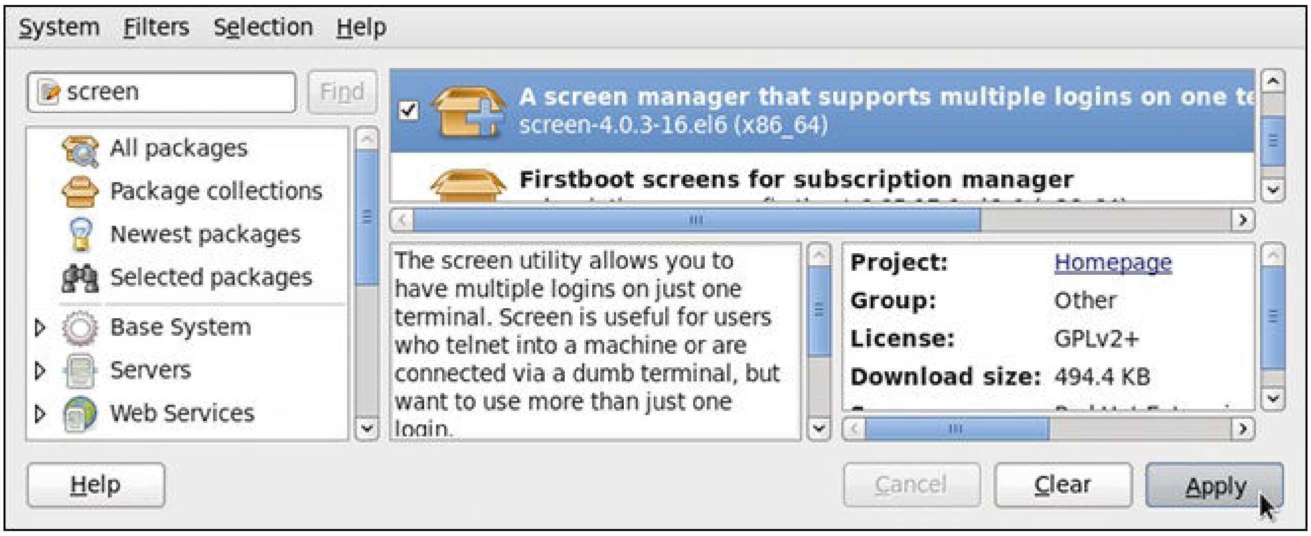
Checking **Only newest packages** filters out all older versions of the same package from the list of results, which is generally what we want. Note that this filter is often combined with the **Only available** filter to search for the latest available versions of new (not installed) packages.

Only native packages

Checking the **Only native packages** box on a multilib system causes PackageKit to omit listing results for packages compiled for the architecture that runs in *compatibility mode*. For example, enabling this filter on a 64-bit system with an AMD64 CPU would cause all packages built for the 32-bit x86 CPU architecture not to be shown in the list of results, even though those packages are able to run on an AMD64 machine. Packages which are architecture-agnostic (i.e. *noarch* packages such as **`crontabs-1.10-32.1.el6.noarch.rpm`**) are never filtered out by checking **Only native packages**. This filter has no affect on non-multilib systems, such as x86 machines.

9.2.3. Installing and Removing Packages (and Dependencies)

With the two filters selected, **`Only available`** and **`Only end user files`**, search for the **screen** window manager for the command line and highlight the package. You now have access to some very useful information about it, including: a clickable link to the project homepage; the Yum package group it is found in, if any; the license of the package; a pointer to the GNOME menu location from where the application can be opened, if applicable; and the size of the package, which is relevant when we download and install it.



A screen manager that supports multiple logins on one te
screen-4.0.3-16.el6 (x86_64)
Firstboot screens for subscription manager

The screen utility allows you to have multiple logins on just one terminal. Screen is useful for users who telnet into a machine or are connected via a dumb terminal, but want to use more than just one login.

Project:	Homepage
Group:	Other
License:	GPLv2+
Download size:	494.4 KB

Figure 9.7. Viewing and installing a package with PackageKit's Add/Remove Software window

When the check box next to a package or group is checked, then that item is already installed on the system. Checking an unchecked box causes it to be *marked* for installation, which only occurs when the **`Apply`** button is clicked. In this way, you can search for and select multiple packages or package groups before performing the actual installation transactions. Additionally, you can remove installed packages by unchecking the checked box, and the removal will occur along with any pending installations when **`Apply`** is pressed. Dependency resolution, which may add additional packages to be installed or removed, is performed after pressing **`Apply`**. PackageKit will then display a window listing those additional packages to install or remove, and ask for confirmation to proceed.

Select **screen** and click the **`Apply`** button. You will then be prompted for the superuser password; enter it, and PackageKit will install **screen**. After finishing the installation, PackageKit sometimes presents you with a list of your newly-installed applications and offers you the choice of running them immediately. Alternatively, you will remember that finding a package and selecting it in the **`Add/Remove Software`** window shows you the **`Location`** of where in the GNOME menus its application shortcut is located, which is helpful when you want to run it.

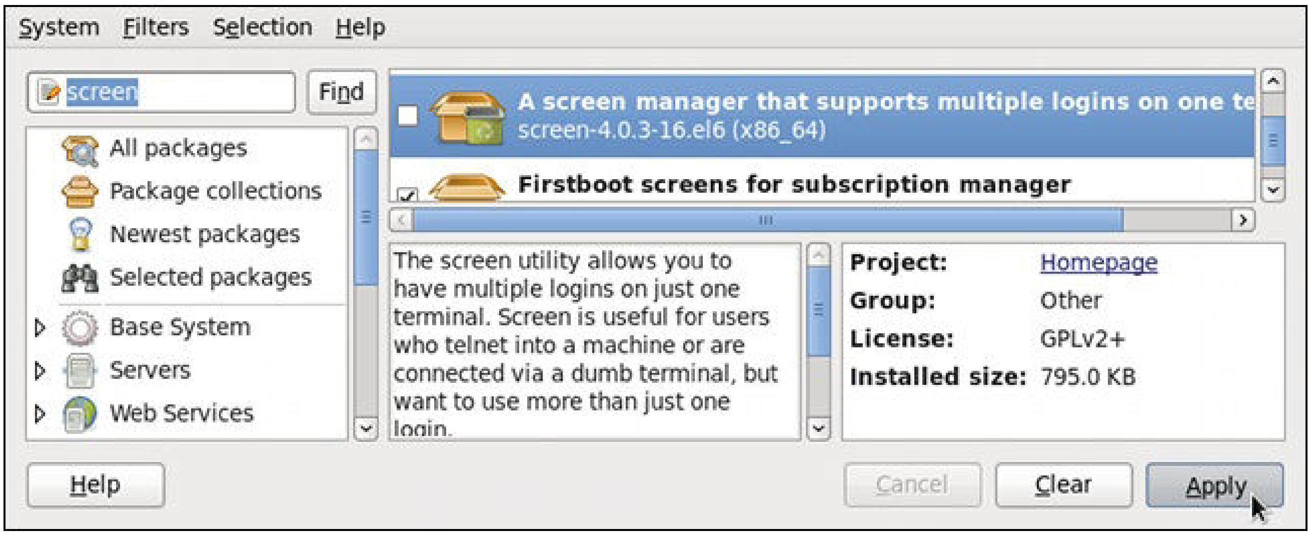
Once it is installed, you can run **`screen`**, a screen manager that allows you to have multiple logins on one terminal, by typing **`screen`** at a shell prompt.

screen is a very useful utility, but we decide that we do not need it and we want to uninstall it.

Remembering that we need to change the **`Only available`** filter we recently used to install it to **`Only installed`** in **Filters** → **Installed**, we search for **screen** again and uncheck it. The program did not install any dependencies of its own; if it had, those would be automatically removed as well, as long as they were not also dependencies of any other packages still installed on our system.

WARNING

Although PackageKit automatically resolves dependencies during package installation and removal, it is unable to remove a package without also removing packages which depend on it. This type of operation can only be performed by **RPM**, is not advised, and can potentially leave your system in a non-functioning state or cause applications to behave erratically and/or crash.



A screen manager that supports multiple logins on one te
screen-4.0.3-16.el6 (x86_64)
Firstboot screens for subscription manager

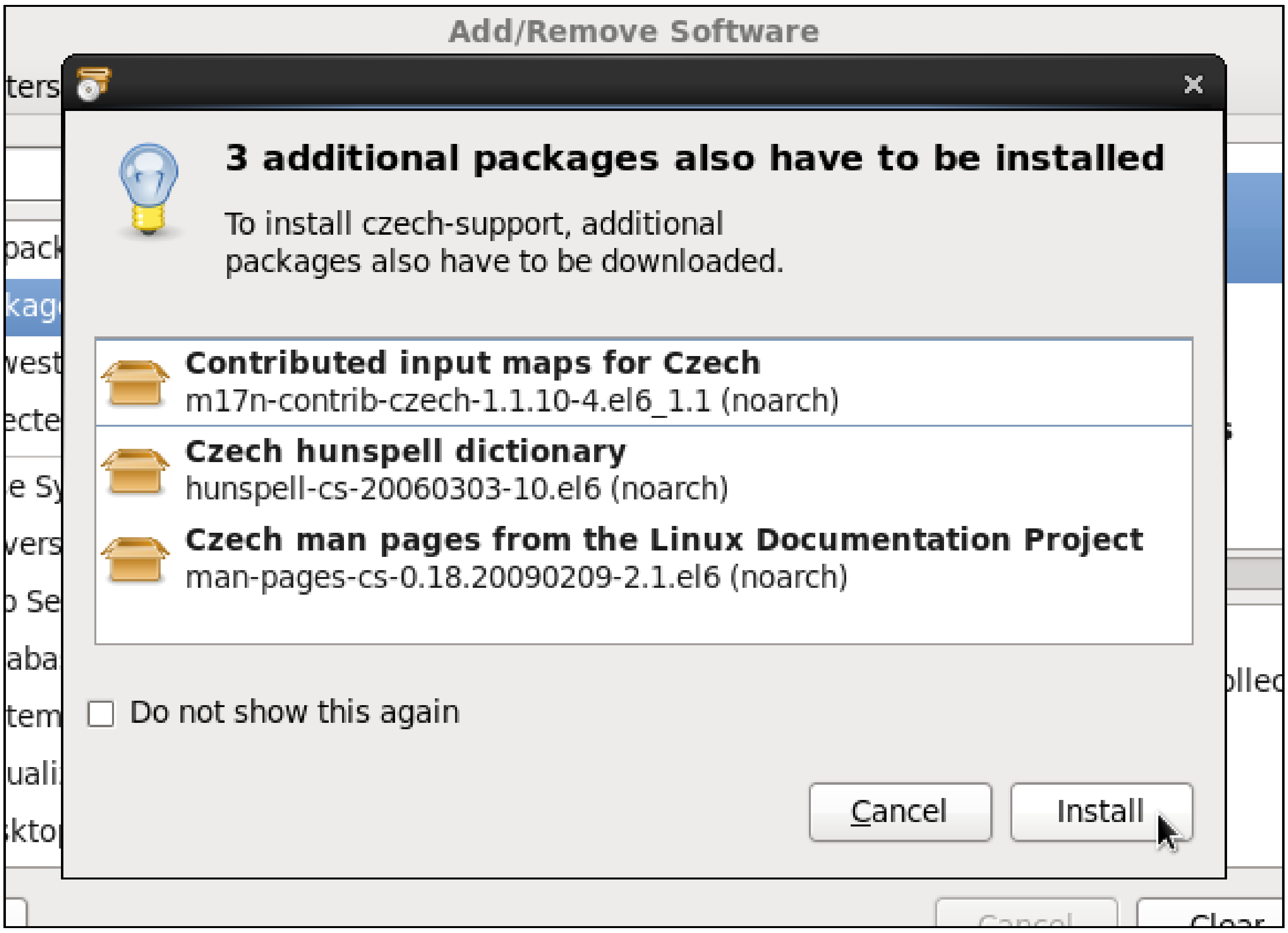
The screen utility allows you to have multiple logins on just one terminal. Screen is useful for users who telnet into a machine or are connected via a dumb terminal, but want to use more than just one login.

Project: Homepage
Group: Other
License: GPLv2+
Installed size: 795.0 KB

Figure 9.8. Removing a package with PackageKit's Add/Remove Software window

9.2.4. Installing and Removing Package Groups

PackageKit also has the ability to install Yum package groups, which it calls **`Package collections`**. Clicking on **`Package collections`** in the top-left list of categories in the **`Software Updates`** window allows us to scroll through and find the package group we want to install. In this case, we want to install Czech language support (the **`Czech Support`** group). Checking the box and clicking **`apply`** informs us how many *additional* packages must be installed in order to fulfill the dependencies of the package group.



3 additional packages also have to be installed

To install czech-support, additional packages also have to be downloaded.

Contributed input maps for Czech
m17n-contrib-czech-1.1.10-4.el6_1.1 (noarch)

Czech hunspell dictionary
hunspell-cs-20060303-10.el6 (noarch)

Czech man pages from the Linux Documentation Project
man-pages-cs-0.18.20090209-2.1.el6 (noarch)

Do not show this again

Figure 9.9. Installing the Czech Support package group

Similarly, installed package groups can be uninstalled by selecting **`Package collections`**, unchecking the appropriate check box, and applying.

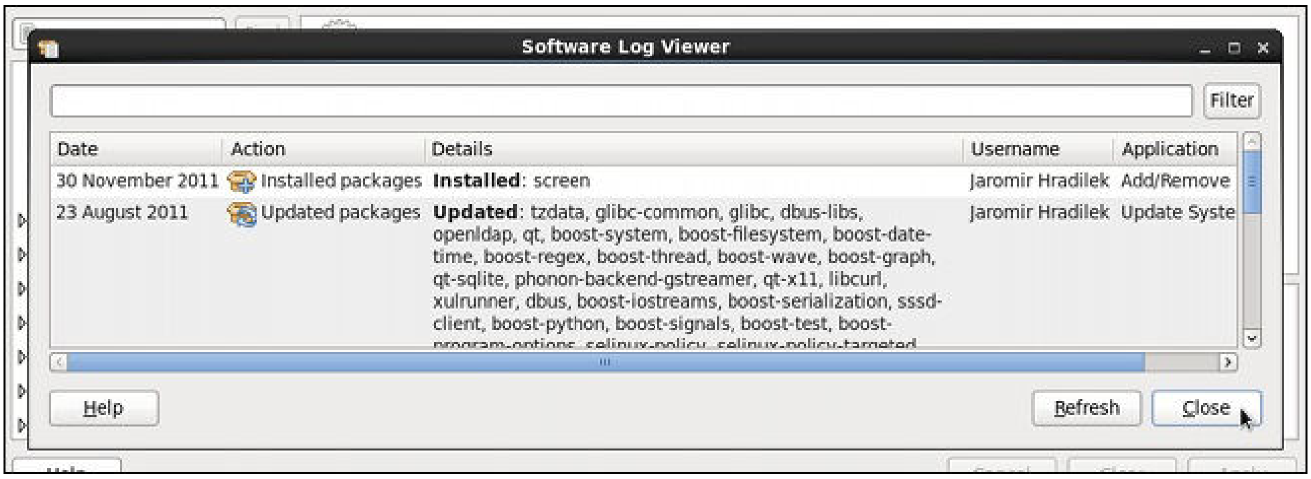
9.2.5. Viewing the Transaction Log

PackageKit maintains a log of the transactions that it performs. To view the log, from the **`Add/Remove Software`** window, click **System** → **Software log**, or run the **`gpk-log`** command at the shell prompt.

The **`Software Log Viewer`** shows the following information:

- **`Date`** — the date on which the transaction was performed.
- **`Action`** — the action that was performed during the transaction, for example **`Updated packages`** or **`Installed packages`**.
- **`Details`** — the transaction type such as **`Updated`**, **`Installed`**, or **`Removed`**, followed by a list of affected packages.
- **`Username`** — the name of the user who performed the action.
- **`Application`** — the front end application that was used to perform the action, for example **`Update System`**.

Typing the name of a package in the top text entry field filters the list of transactions to those which affected that package.



Date	Action	Details	Username	Application
30 November 2011	Installed packages	**Installed**: screen	Jaromir Hradilek	Add/Remove
23 August 2011	Updated packages	**Updated**: tzdata, glibc-common, glibc, dbus-libs, openldap, qt, boost-system, boost-filesystem, boost-date-time, boost-regex, boost-thread, boost-wave, boost-graph, qt-sqlite, phonon-backend-gstreamer, qt-x11, libcurl, xulrunner, dbus, boost-iostreams, boost-serialization, sssd-client, boost-python, boost-signals, boost-test, boost-program-options, selinux-policy, selinux-policy-targeted	Jaromir Hradilek	Update Syste

Figure 9.10. Viewing the log of package management transactions with the Software Log Viewer

9.3. PACKAGEKIT ARCHITECTURE

Red Hat provides the PackageKit suite of applications for viewing, updating, installing and uninstalling packages and package groups compatible with your system. Architecturally, PackageKit consists of several graphical front ends that communicate with the **`packagekitd`** daemon back end, which communicates with a package manager-specific back end that utilizes Yum to perform the actual transactions, such as installing and removing packages, etc.

Table 9.1, “PackageKit GUI windows, menu locations, and shell prompt commands” shows the name of the GUI window, how to start the window from the GNOME desktop or from the **`Add/Remove Software`** window, and the name of the command-line application that opens that window.

Table 9.1. PackageKit GUI windows, menu locations, and shell prompt commands

Window Title	Function	How to Open	Shell Command
Add/Remove Software	Install, remove or view package info	From the GNOME panel: **System** → **Administration** → **Add/Remove Software**	gpk-application
Software Update	Perform package updates	From the GNOME panel: **System** → **Administration** → **Software Update**	gpk-update-viewer
Software Sources	Enable and disable Yum repositories	From **`Add/Remove Software`**: **System** → **Software Sources**	gpk-repo
Software Log Viewer	View the transaction log	From **`Add/Remove Software`**: **System** → **Software Log**	gpk-log
Software Update Preferences	Set PackageKit preferences		gpk-prefs

Window Title	Function	How to Open	Shell Command
(Notification Area Alert)	Alerts you when updates are available	From the GNOME panel: **System** → **Preferences** → **Startup Applications**, the **`Startup Programs`** tab	gpk-update-icon

The **`packagekitd`** daemon runs outside the user session and communicates with the various graphical front ends. The **`packagekitd`** daemon[2] communicates via the **DBus** system message bus with another back end, which utilizes Yum's Python API to perform queries and make changes to the system. On Linux systems other than Red Hat Enterprise Linux and Fedora, **`packagekitd`** can communicate with other back ends that are able to utilize the native package manager for that system. This modular architecture provides the abstraction necessary for the graphical interfaces to work with many different package managers to perform essentially the same types of package management tasks. Learning how to use the PackageKit front ends means that you can use the same familiar graphical interface across many different Linux distributions, even when they utilize a native package manager other than Yum.

In addition, PackageKit's separation of concerns provides reliability in that a crash of one of the GUI windows—or even the user's X Window session—will not affect any package management tasks being supervised by the **`packagekitd`** daemon, which runs outside of the user session.

All of the front end graphical applications discussed in this chapter are provided by the gnome-packagekit package instead of by PackageKit and its dependencies.

Finally, PackageKit also comes with a console-based front end called **`pkcon`**.

9.4. ADDITIONAL RESOURCES

For more information about PackageKit, see the resources listed below.

Installed Documentation

- **`gpk-application(1)`** — The manual page containing information about the **`gpk-application`** command.
- **`gpk-backend-status(1)`** — The manual page containing information about the **`gpk-backend-status`** command.
- **`gpk-install-local-file(1)`** — The manual page containing information about the **`gpk-install-local-file`** command.
- **`gpk-install-mime-type(1)`** — The manual page containing information about the **`gpk-install-mime-type`** command.
- **`gpk-install-package-name(1)`** — The manual page containing information about the **`qpk-install-package-name`** command.
- **`gpk-install-package-name(1)`** — The manual page containing information about the **`gpk-install-package-name`** command.

- **`gpk-prefs(1)`** — The manual page containing information about the **`gpk-prefs`** command.
- **`gpk-repo(1)`** — The manual page containing information about the **`gpk-repo`** command.
- **`gpk-update-icon(1)`** — The manual page containing information about the **`gpk-update-icon`** command.
- **`gpk-update-viewer(1)`** — The manual page containing information about the **`gpk-update-viewer`** command.
- **`pkcon(1)`** and **`pkmon(1)`** — The manual pages containing information about the PackageKit console client.
- **`pkgenpack(1)`** — The manual page containing information about the PackageKit Pack Generator.

Online Documentation

- PackageKit home page — The PackageKit home page listing detailed information about the PackageKit software suite.
- PackageKit FAQ — An informative list of Frequently Asked Questions for the PackageKit software suite.

See Also

- Chapter 8, *Yum* documents Yum, the Red Hat package manager.

[2] System daemons are typically long-running processes that provide services to the user or to other programs, and which are started, often at boot time, by special initialization scripts (often shortened to *init scripts*). Daemons respond to the **`service`** command and can be turned on or off permanently by using the **`chkconfig on`** or **`chkconfig off`** commands. They can typically be recognized by a "*d*" appended to their name, such as the **`packagekitd`** daemon. See Chapter 12, *Services and Daemons* for information about system services.

PART IV. NETWORKING

This part describes how to configure the network on Red Hat Enterprise Linux.

CHAPTER 10. NETWORKMANAGER

NetworkManager is a dynamic network control and configuration system that attempts to keep network devices and connections up and active when they are available. **NetworkManager** consists of a core daemon, a GNOME Notification Area applet that provides network status information, and graphical configuration tools that can create, edit and remove connections and interfaces. **NetworkManager** can be used to configure the following types of connections: Ethernet, wireless, mobile broadband (such as cellular 3G), and **`DSL`** and **`PPPoE`** (Point-to-Point over Ethernet). In addition, **NetworkManager** allows for the configuration of network aliases, static routes, DNS information and VPN connections, as well as many connection-specific parameters. Finally, **NetworkManager** provides a rich API via D-Bus which allows applications to query and control network configuration and state.

Previous versions of Red Hat Enterprise Linux included the **Network Administration Tool**, which was commonly known as **`system-config-network`** after its command-line invocation. In Red Hat Enterprise Linux 6, **NetworkManager** replaces the former **Network Administration Tool** while providing enhanced functionality, such as user-specific and mobile broadband configuration. It is also possible to configure the network in Red Hat Enterprise Linux 6 by editing interface configuration files; see Chapter 11, *Network Interfaces* for more information.

NetworkManager may be installed by default on your version of Red Hat Enterprise Linux. To ensure that it is, run the following command as **`root`**:

```
~]# yum install NetworkManager
```

10.1. THE NETWORKMANAGER DAEMON

The **NetworkManager** daemon runs with **`root`** privileges and is usually configured to start up at boot time. You can determine whether the **NetworkManager** daemon is running by entering this command as **`root`**:

```
~]# service NetworkManager status
    NetworkManager (pid  1527) is running...
```

The **`service`** command will report **`NetworkManager is stopped`** if the **NetworkManager** service is not running. To start it for the current session:

```
~]# service NetworkManager start
```

Run the **`chkconfig`** command to ensure that **NetworkManager** starts up every time the system boots:

```
~]# chkconfig NetworkManager on
```

For more information on starting, stopping and managing services and runlevels, see Chapter 12, *Services and Daemons*.

10.2. INTERACTING WITH NETWORKMANAGER

Users do not interact with the **NetworkManager** system service directly. Instead, you can perform network configuration tasks via **NetworkManager**'s Notification Area applet. The applet has multiple states that serve as visual indicators for the type of connection you are currently using. Hover the pointer over the applet icon for tooltip information on the current connection state.

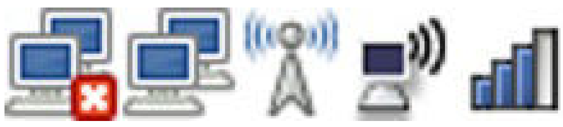


Figure 10.1. NetworkManager applet states

If you do not see the **NetworkManager** applet in the GNOME panel, and assuming that the **NetworkManager** package is installed on your system, you can start the applet by running the following command as a normal user (not **`root`**):

```
~]$ nm-applet &
```

After running this command, the applet appears in your Notification Area. You can ensure that the applet runs each time you log in by clicking **System** → **Preferences** → **Startup Applications** to open the **`Startup Applications Preferences`** window. Then, select the **`Startup Programs`** tab and check the box next to **NetworkManager**.

10.2.1. Connecting to a Network

When you left-click on the applet icon, you are presented with:

- a list of categorized networks you are currently connected to (such as **`Wired`** and **`Wireless`**);
- a list of all **`Available Networks`** that **NetworkManager** has detected;
- options for connecting to any configured Virtual Private Networks (VPNs); and,
- options for connecting to hidden or new wireless networks.

If you are connected to a network, its name is presented in bold typeface under its network type, such as **`Wired`** or **`Wireless`**. When many networks are available, such as wireless access points, the **`More networks`** expandable menu entry appears.

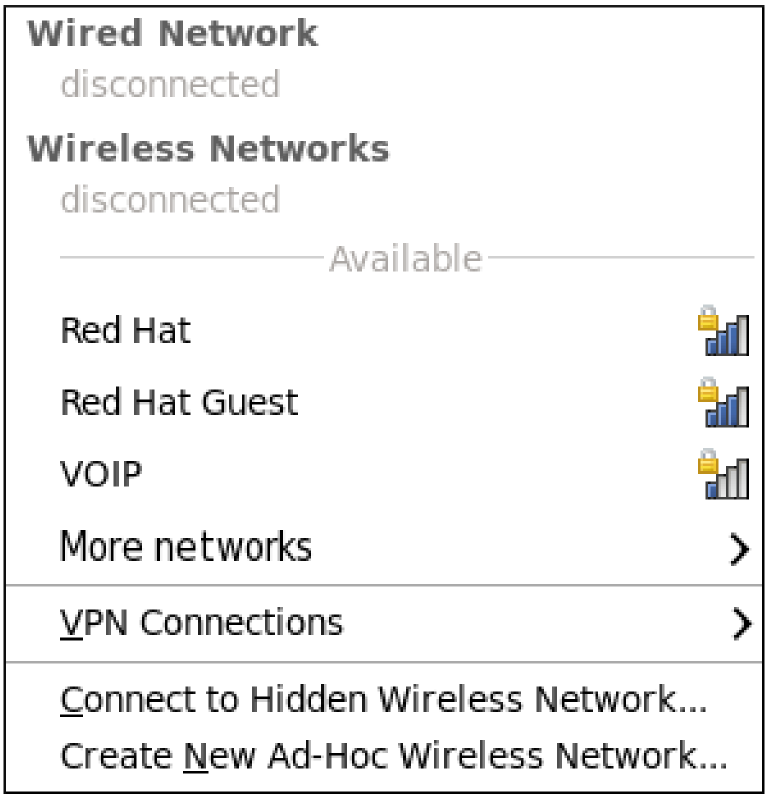


Figure 10.2. The NetworkManager applet's left-click menu, showing all available and connected-to networks

10.2.2. Configuring New and Editing Existing Connections

Next, right-click on the **NetworkManager** applet to open its context menu, which is the main point of entry for interacting with **NetworkManager** to configure connections.

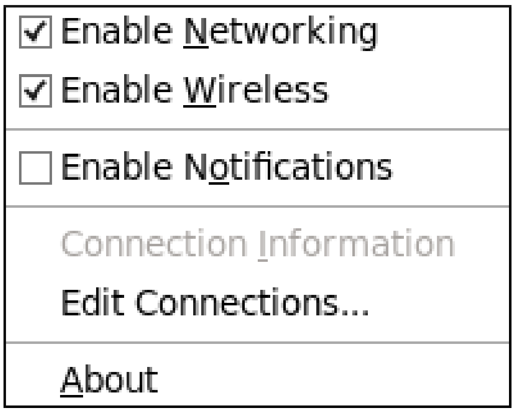


Figure 10.3. The NetworkManager applet's context menu

Ensure that the **`Enable Networking`** box is checked. If the system has detected a wireless card, then you will also see an **`Enable Wireless`** menu option. Check the **`Enable Wireless`** check box as well. **NetworkManager** notifies you of network connection status changes if you check the **`Enable Notifications`** box. Clicking the **`Connection Information`** entry presents an informative **`Connection Information`** window that lists the connection type and interface, your IP address and routing details, and so on.

Finally, clicking on **`Edit Connections`** opens the **`Network Connections`** window, from where you can perform most of your network configuration tasks. Note that this window can also be opened by running, as a normal user:

```
~]$ nm-connection-editor &
```

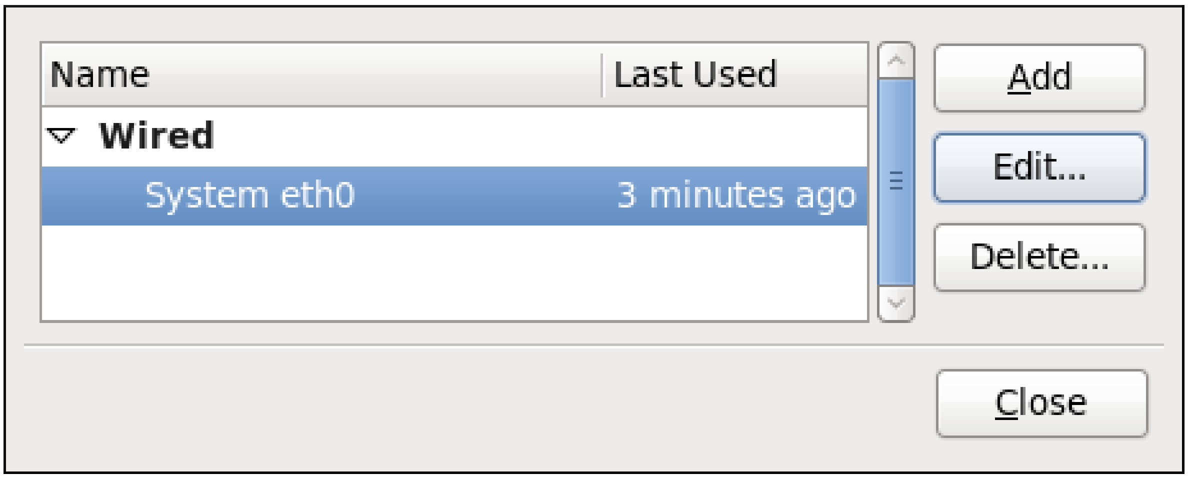


Figure 10.4. Configure networks using the Network Connections window

There is an arrow head symbol to the left which can be clicked to hide and reveal entries as needed. To create a new connection, click the **`Add`** button to view the selection list, select the connection type and click the **`Create`** button. Alternatively, to edit an existing connection select the interface name from the list and click the **`Edit`** button.

Then, to configure:

- wired Ethernet connections, proceed to Section 10.3.1, "Establishing a Wired (Ethernet) Connection";
- wireless connections, proceed to Section 10.3.2, "Establishing a Wireless Connection"; or,
- mobile broadband connections, proceed to Section 10.3.3, "Establishing a Mobile Broadband Connection"; or,
- VPN connections, proceed to Section 10.3.4, "Establishing a VPN Connection".

10.2.3. Connecting to a Network Automatically

For any connection type you add or configure, you can choose whether you want **NetworkManager** to try to connect to that network automatically when it is available.

Procedure 10.1. Configuring NetworkManager to Connect to a Network Automatically When Detected

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.
2. Click the arrow head if necessary to reveal the list of connections.
3. Select the specific connection that you want to configure and click **`Edit`**.
4. Check **`Connect automatically`** to cause **NetworkManager** to auto-connect to the connection whenever **NetworkManager** detects that it is available. Uncheck the check box if you do not want **NetworkManager** to connect automatically. If the box is unchecked, you will have to select that connection manually in the **NetworkManager** applet's left-click menu to cause it to connect.

10.2.4. User and System Connections

NetworkManager connections are always either *user connections* or *system connections*. Depending on the system-specific policy that the administrator has configured, users may need **`root`** privileges to create and modify system connections. **NetworkManager**'s default policy enables users to create and modify user connections, but requires them to have **`root`** privileges to add, modify or delete system connections.

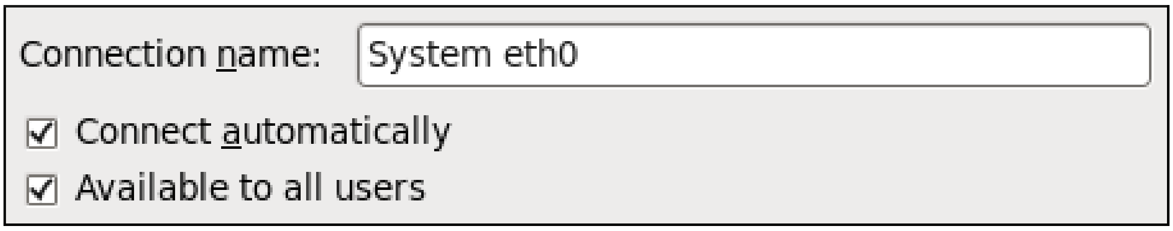
User connections are so-called because they are specific to the user who creates them. In contrast to system connections, whose configurations are stored under the **`/etc/sysconfig/network-scripts/`** directory (mainly in **`ifcfg-<network_type>`** interface configuration files), user connection settings are stored in the GConf configuration database and the GNOME keyring, and are only available during login sessions for the user who created them. Thus, logging out of the desktop session causes user-specific connections to become unavailable.

NOTE

Because **NetworkManager** uses the GConf and GNOME keyring applications to store user connection settings, and because these settings are specific to your desktop session, it is highly recommended to configure your personal VPN connections as user connections. If you do so, other Non-**`root`** users on the system cannot view or access these connections in any way.

System connections, on the other hand, become available at boot time and can be used by other users on the system without first logging in to a desktop session.

NetworkManager can quickly and conveniently convert user to system connections and vice versa. Converting a user connection to a system connection causes **NetworkManager** to create the relevant interface configuration files under the **`/etc/sysconfig/network-scripts/`** directory, and to delete the GConf settings from the user's session. Conversely, converting a system to a user-specific connection causes **NetworkManager** to remove the system-wide configuration files and create the corresponding GConf/GNOME keyring settings.


Connection name: System eth0

☑ Connect automatically

☑ Available to all users

Figure 10.5. The `Available to all users` check box controls whether connections are user-specific or system-wide

Procedure 10.2. Changing a Connection to be User-Specific instead of System-Wide, or Vice-Versa

NOTE

Depending on the system's policy, you may need **`root`** privileges on the system in order to change whether a connection is user-specific or system-wide.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. If needed, select the arrow head (on the left hand side) to hide and reveal the types of available network connections.

3. Select the specific connection that you want to configure and click **`Edit`**.

4. Check the **`Available to all users`** check box to ask **NetworkManager** to make the connection a system-wide connection. Depending on system policy, you may then be prompted for the **`root`** password by the **PolicyKit** application. If so, enter the **`root`** password to finalize the change.

   Conversely, uncheck the **`Available to all users`** check box to make the connection user-specific.

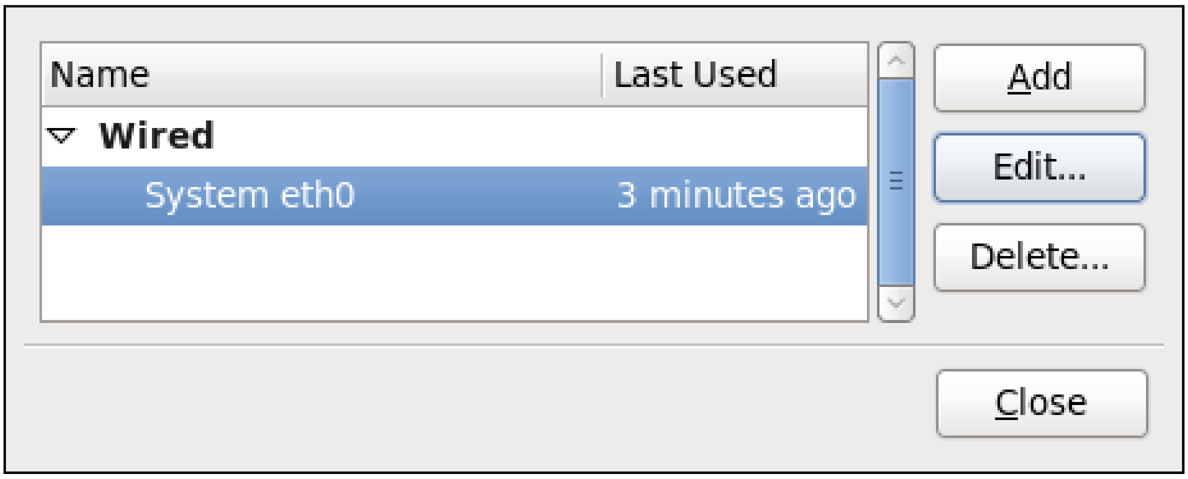
10.3. ESTABLISHING CONNECTIONS

10.3.1. Establishing a Wired (Ethernet) Connection

To establish a wired network connection, Right-click on the **NetworkManager** applet to open its context menu, ensure that the **`Enable Networking`** box is checked, then click on **`Edit Connections`**. This opens the **`Network Connections`** window. Note that this window can also be opened by running, as a normal user:

```
~]$ nm-connection-editor &
```

You can click on the arrow head to reveal and hide the list of connections as needed.



Name	Last Used
Wired	
System eth0	3 minutes ago

Figure 10.6. The Network Connections window showing the newly created System eth0 connection

The system startup scripts create and configure a single wired connection called **`System eth0`** by default on all systems. Although you can edit **`System eth0`**, creating a new wired connection for your custom settings is recommended. You can create a new wired connection by clicking the **`Add`** button, selecting the **`Wired`** entry from the list that appears and then clicking the**`Create`** button.

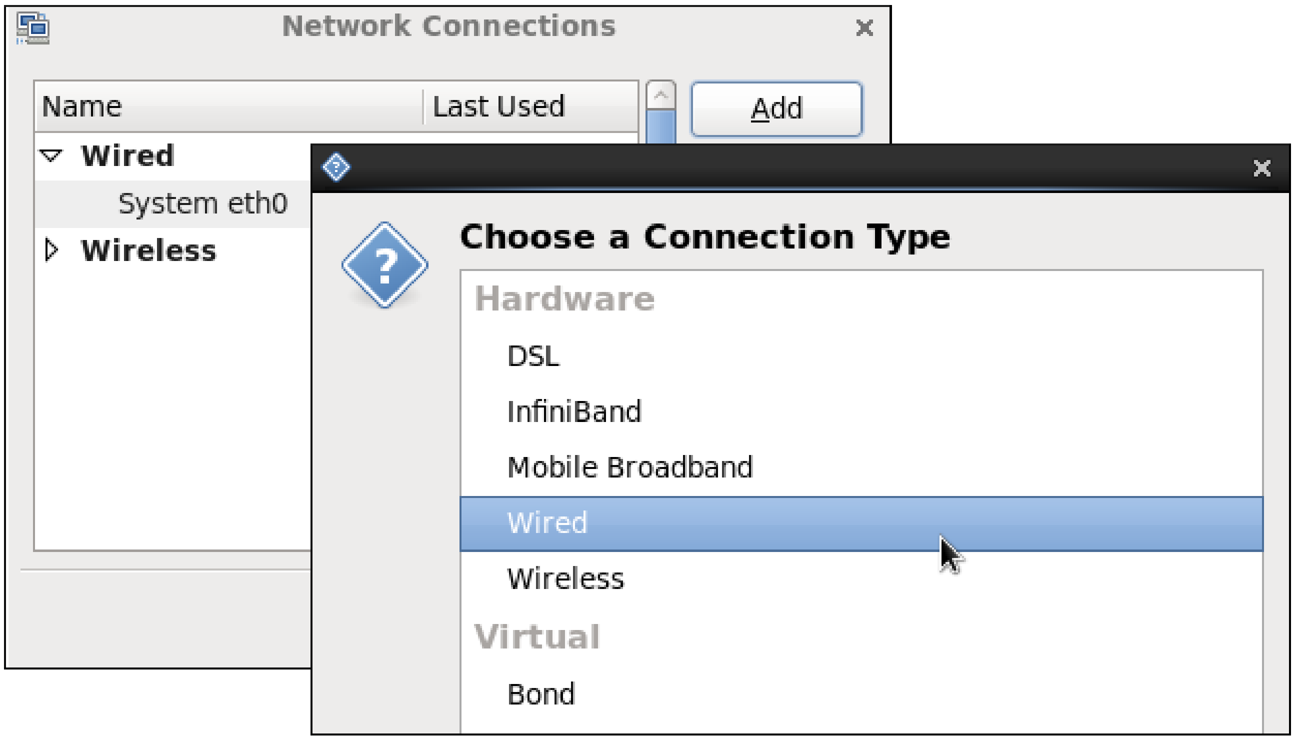
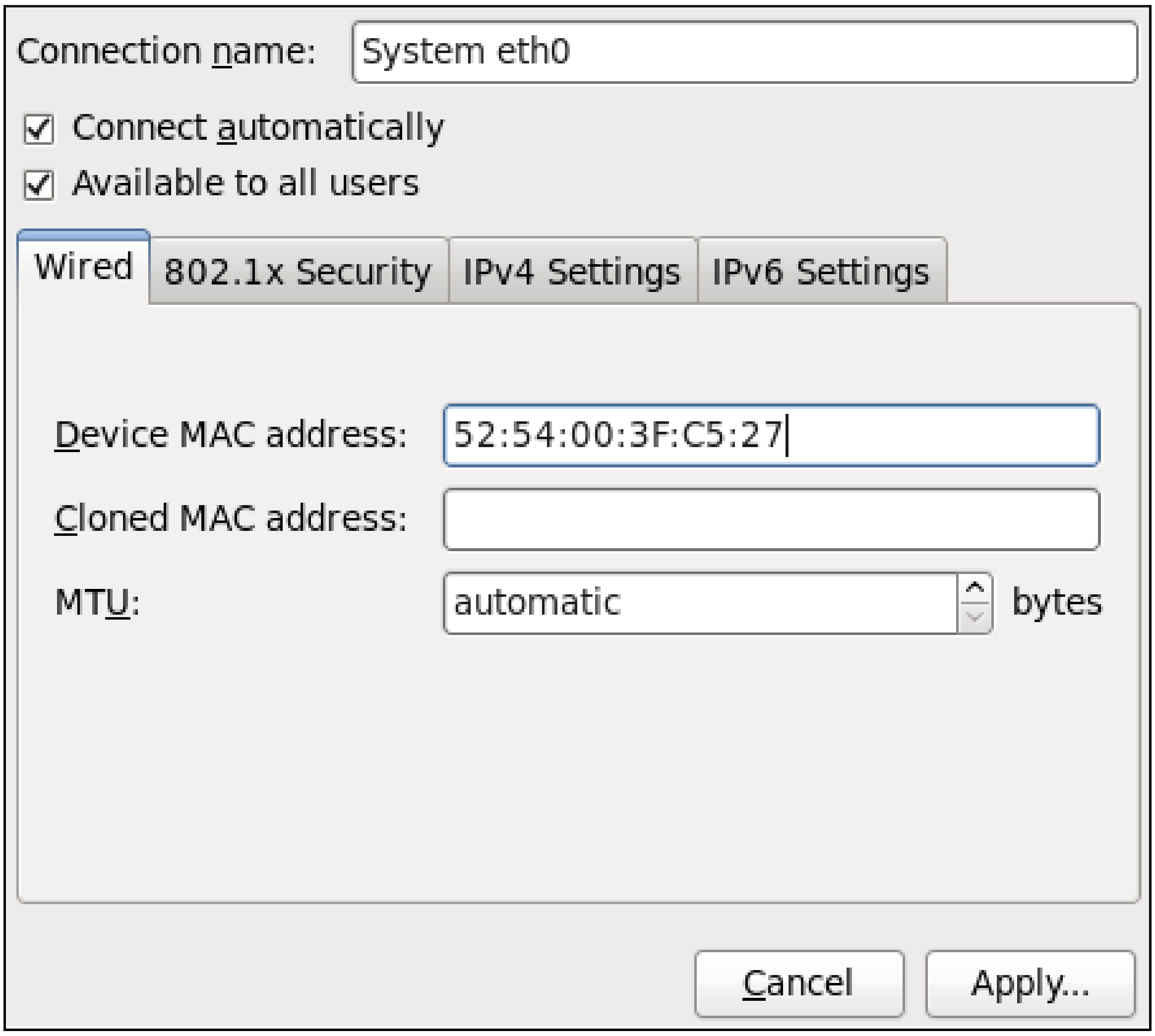


Figure 10.7. Selecting a new connection type from the "Choose a Connection Type" list

NOTE

When you add a new connection by clicking the **Add** button, a list of connection types appears. Once you have made a selection and clicked on the **`Create`** button, **NetworkManager** creates a new configuration file for that connection and then opens the same dialog that is used for editing an existing connection. There is no difference between these dialogs. In effect, you are always editing a connection; the difference only lies in whether that connection previously existed or was just created by **NetworkManager** when you clicked **`Create`**.


Connection name: System eth0

☑ Connect automatically

☑ Available to all users

Device MAC address: 52:54:00:3F:C5:27

Cloned MAC address:

MTU: automatic bytes

Figure 10.8. Editing the newly created Wired connection System eth0

Configuring the Connection Name, Auto-Connect Behavior, and Availability Settings

Three settings in the **`Editing`** dialog are common to all connection types:

- **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`Wired`** section of the **`Network Connections`** window.
- **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, "Connecting to a Network Automatically" for more information.
- **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, "User and System Connections" for details.

Configuring the Wired Tab

The final three configurable settings are located within the **`Wired`** tab itself: the first is a text-entry field where you can specify a MAC (Media Access Control) address, and the second allows you to specify a cloned MAC address, and third allows you to specify the MTU (Maximum Transmission Unit) value. Normally, you can leave the **`MAC address`** field blank and the **`MTU`** set to **`automatic`**. These defaults will suffice unless you are associating a wired connection with a second or specific NIC, or performing advanced networking. In such cases, see the following descriptions:

`MAC Address`

Network hardware such as a Network Interface Card (NIC) has a unique MAC address (Media Access Control; also known as a *hardware address*) that identifies it to the system. Running the **`ip addr`** command will show the MAC address associated with each interface. For example, in the following **`ip addr`** output, the MAC address for the **`eth0`** interface (which is **`52:54:00:26:9e:f1`**) immediately follows the **`link/ether`** keyword:

```
~]# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UNKNOWN qlen 1000
    link/ether 52:54:00:26:9e:f1 brd ff:ff:ff:ff:ff:ff
    inet 192.168.122.251/24 brd 192.168.122.255 scope global eth0
    inet6 fe80::5054:ff:fe26:9ef1/64 scope link
       valid_lft forever preferred_lft forever
```

A single system can have one or more NICs installed on it. The **`MAC address`** field therefore allows you to associate a specific NIC with a specific connection (or connections). As mentioned, you can determine the MAC address using the **`ip addr`** command, and then copy and paste that value into the **`MAC address`** text-entry field.

The cloned MAC address field is mostly for use in such situations were a network service has been restricted to a specific MAC address and you need to emulate that MAC address.

`MTU`

The MTU (Maximum Transmission Unit) value represents the size in bytes of the largest packet that the connection will use to transmit. This value defaults to **`1500`** when using IPv4, or a variable number **`1280`** or higher for IPv6, and does not generally need to be specified or changed.

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your wired connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, “Connecting to a Network” for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- port-based Network Access Control (PNAC), click the **`802.1X Security`** tab and proceed to Section 10.3.9.1, “Configuring 802.1X Security”;
- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”; or,
- IPv6 settings for the connection, click the **`IPv6 Settings`** tab and proceed to Section 10.3.9.5, “Configuring IPv6 Settings”.

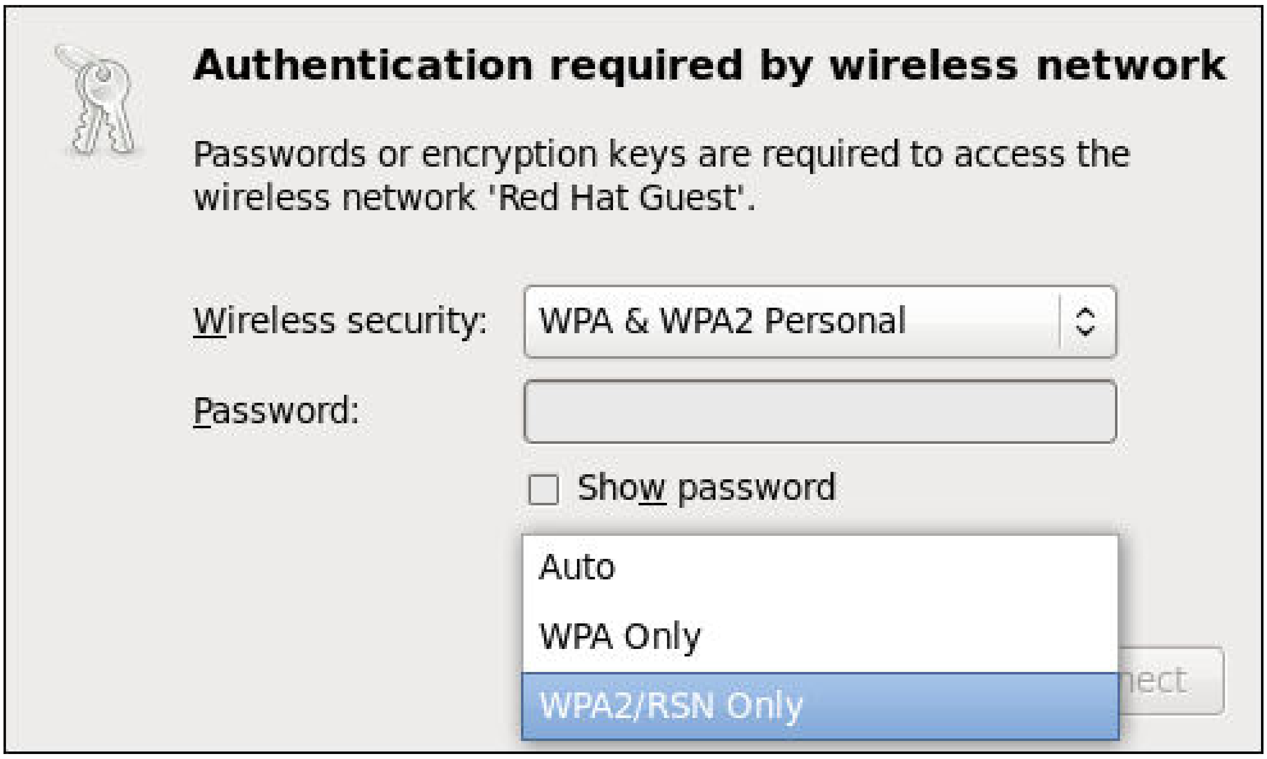
10.3.2. Establishing a Wireless Connection

This section explains how to use **NetworkManager** to configure a wireless (also known as Wi-Fi or 802.11*a/b/g/n*) connection to an Access Point.

To configure a mobile broadband (such as 3G) connection, see Section 10.3.3, "Establishing a Mobile Broadband Connection".

Quickly Connecting to an Available Access Point

The easiest way to connect to an available access point is to left-click on the **NetworkManager** applet, locate the *Service Set Identifier* (SSID) of the access point in the list of `Available` networks, and click on it. If the access point is secured, a dialog prompts you for authentication.



Authentication required by wireless network

Passwords or encryption keys are required to access the wireless network 'Red Hat Guest'.

Wireless security: WPA & WPA2 Personal

Password:

Figure 10.9. Authenticating to a wireless access point

NetworkManager tries to auto-detect the type of security used by the access point. If there are multiple possibilities, **NetworkManager** guesses the security type and presents it in the `Wireless security` dropdown menu. To see if there are multiple choices, click the `Wireless security` dropdown menu and select the type of security the access point is using. If you are unsure, try connecting to each type in turn. Finally, enter the key or passphrase in the `Password` field. Certain password types, such as a 40-bit WEP or 128-bit WPA key, are invalid unless they are of a requisite length. The `Connect` button will remain inactive until you enter a key of the length required for the selected security type. To learn more about wireless security, see Section 10.3.9.2, "Configuring Wireless Security".

NOTE

In the case of WPA and WPA2 (Personal and Enterprise), an option to select between Auto, WPA and WPA2 has been added. This option is intended for use with an access point that is offering both WPA and WPA2. Select one of the protocols if you would like to prevent roaming between the two protocols. Roaming between WPA and WPA2 on the same access point can cause loss of service.

If **NetworkManager** connects to the access point successfully, its applet icon will change into a graphical indicator of the wireless connection's signal strength.

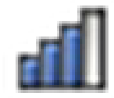
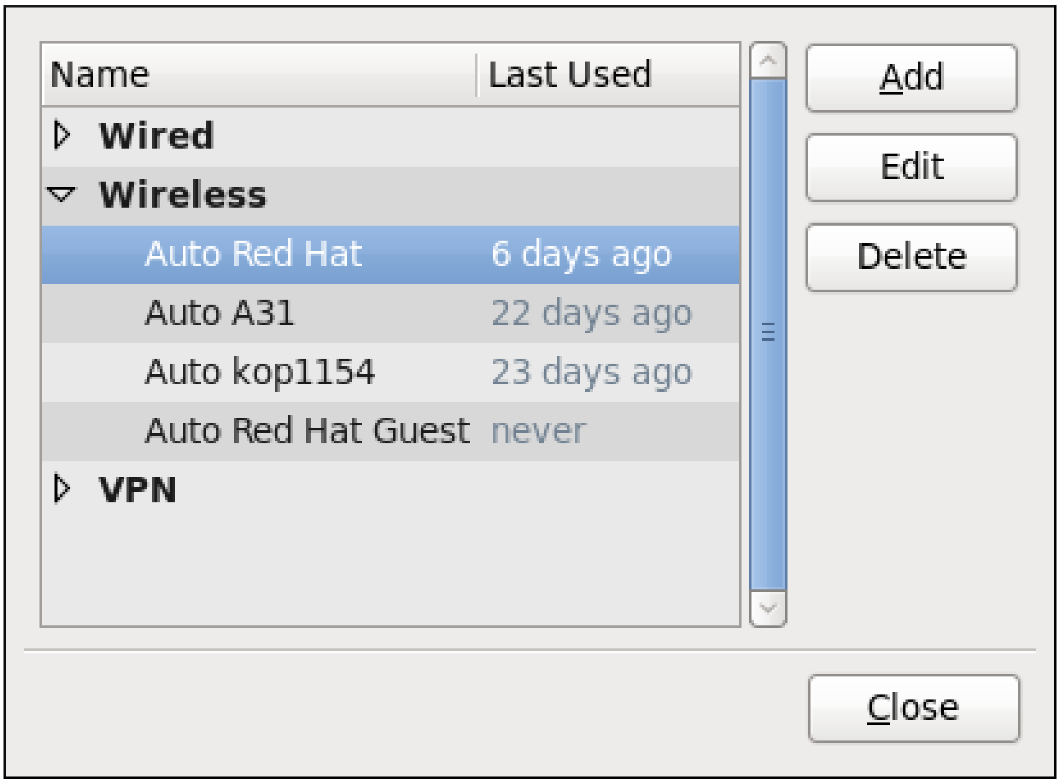


Figure 10.10. Applet icon indicating a wireless connection signal strength of 75%

You can also edit the settings for one of these auto-created access point connections just as if you had added it yourself. The **`Wireless`** tab of the **`Network Connections`** window lists all of the connections you have ever tried to connect to: **NetworkManager** names each of them **`Auto <SSID>`**, where SSID is the *Service Set identifier* of the access point.



Name	Last Used
Wired	
Wireless	
Auto Red Hat	6 days ago
Auto A31	22 days ago
Auto kop1154	23 days ago
Auto Red Hat Guest	never
VPN	

Figure 10.11. An example of access points that have previously been connected to

Connecting to a Hidden Wireless Network

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. You can still connect to a wireless access point that is hiding its SSID as long as you know its SSID, authentication method, and secrets.

To connect to a hidden wireless network, left-click **NetworkManager**'s applet icon and select **`Connect to Hidden Wireless Network`** to cause a dialog to appear. If you have connected to the hidden network before, use the **`Connection`** dropdown to select it, and click **`Connect`**. If you have not, leave the **`Connection`** dropdown as **New**, enter the SSID of the hidden network, select its **`Wireless security`** method, enter the correct authentication secrets, and click **`Connect`**.

For more information on wireless security settings, see Section 10.3.9.2, “Configuring Wireless Security”.

Editing a Connection, or Creating a Completely New One

You can edit an existing connection that you have tried or succeeded in connecting to in the past by opening the **`Wireless`** tab of the **`Network Connections`**, selecting the connection by name (words which follow **`Auto`** refer to the SSID of an access point), and clicking **`Edit`**.

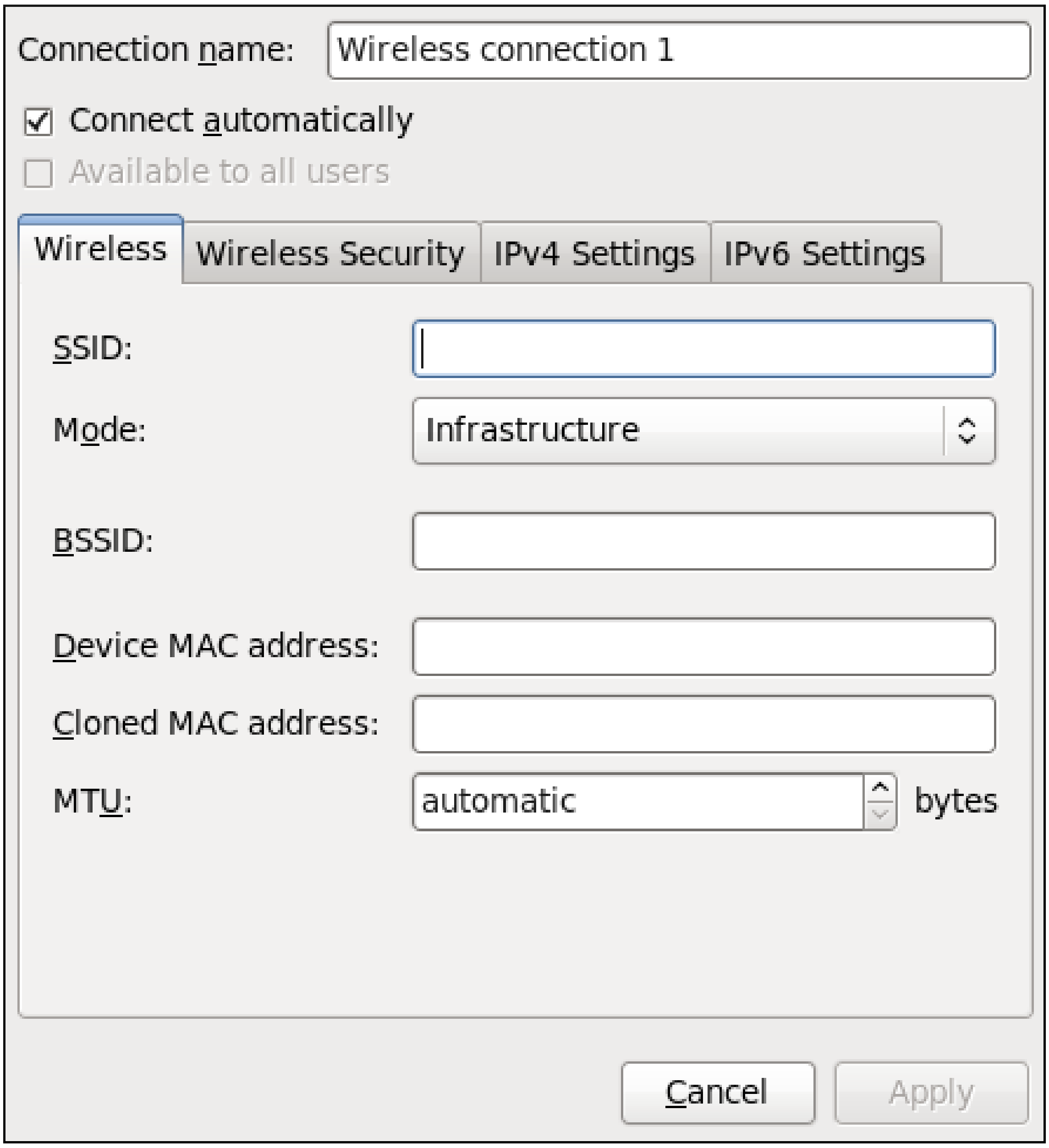
You can create a new connection by opening the **`Network Connections`** window, clicking the **`Add`** button, selecting **`Wireless`**, and clicking the **`Create`** button.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Click the **`Add`** button.

3. Select the **`Wireless`** entry from the list.

4. Click the **`Create`** button.



Connection name: Wireless connection 1

☑ Connect automatically

☐ Available to all users

Wireless tab:

SSID:

Mode: Infrastructure

BSSID:

Device MAC address:

Cloned MAC address:

MTU: automatic bytes

Figure 10.12. Editing the newly created Wireless connection 1

Configuring the Connection Name, Auto-Connect Behavior, and Availability Settings

Three settings in the **`Editing`** dialog are common to all connection types:

- **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`Wireless`** section of the **`Network Connections`** window. By default, wireless connections are named the same as the *SSID* of the wireless access point.

You can rename the wireless connection without affecting its ability to connect, but it is recommended to retain the SSID name.

- **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, "Connecting to a Network Automatically" for more information.

- **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, "User and System Connections" for details.

Configuring the Wireless Tab

`SSID`

All access points have a *Service Set identifier* 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. You can still connect to a wireless access point that is hiding its SSID as long as you know its SSID (and authentication secrets).

For information on connecting to a hidden wireless network, see the section called "Connecting to a Hidden Wireless Network".

`Mode`

Infrastructure — Set **`Mode`** to **Infrastructure** if you are connecting to a dedicated wireless access point or one built into a network device such as a router or a switch.

Ad-hoc — Set **`Mode`** to **Ad-hoc** if you are creating a peer-to-peer network for two or more mobile devices to communicate directly with each other. If you use **Ad-hoc** mode, referred to as *Independent Basic Service Set* (IBSS) in the 802.11 standard, you must ensure that the same **`SSID`** is set for all participating wireless devices, and that they are all communicating over the same channel.

`BSSID`

The Basic Service Set Identifier (BSSID) is the MAC 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`

Like an Ethernet Network Interface Card (NIC), a wireless adapter has a unique MAC address (Media Access Control; also known as a *hardware address*) that identifies it to the system. Running the **`ip addr`** command will show the MAC address associated with each interface. For example, in the following **`ip addr`** output, the MAC address for the **`wlan0`** interface (which is **`00:1c:bf:02:f8:70`**) immediately follows the **`link/ether`** keyword:

```
~]# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
```

```
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UNKNOWN qlen 1000
    link/ether 52:54:00:26:9e:f1 brd ff:ff:ff:ff:ff:ff
    inet 192.168.122.251/24 brd 192.168.122.255 scope global eth0
    inet6 fe80::5054:ff:fe26:9ef1/64 scope link
       valid_lft forever preferred_lft forever
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP
qlen 1000
    link/ether 00:1c:bf:02:f8:70 brd ff:ff:ff:ff:ff:ff
    inet 10.200.130.67/24 brd 10.200.130.255 scope global wlan0
    inet6 fe80::21c:bfff:fe02:f870/64 scope link
       valid_lft forever preferred_lft forever
```

A single system could have one or more wireless network adapters connected to it. The **`MAC address`** field therefore allows you to associate a specific wireless adapter with a specific connection (or connections). As mentioned, you can determine the MAC address using the **`ip addr`** command, and then copy and paste that value into the **`MAC address`** text-entry field.

`MTU`

The MTU (Maximum Transmission Unit) value represents the size in bytes of the largest packet that the connection will use to transmit. If set to a non-zero number, only packets of the specified size or smaller will be transmitted. Larger packets are broken up into multiple Ethernet frames. It is recommended to leave this setting on **automatic**.

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing the wireless connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can successfully connect to your the modified connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, “Connecting to a Network” for details on selecting and connecting to a network.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- security authentication for the wireless connection, click the **`Wireless Security`** tab and proceed to Section 10.3.9.2, “Configuring Wireless Security”;
- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”; or,
- IPv6 settings for the connection, click the **`IPv6 Settings`** tab and proceed to Section 10.3.9.5, “Configuring IPv6 Settings”.

10.3.3. Establishing a Mobile Broadband Connection

You can use **NetworkManager**'s mobile broadband connection abilities to connect to the following *2G* and *3G* services:

- 2G — *GPRS* (*General Packet Radio Service*) or *EDGE* (*Enhanced Data Rates for GSM Evolution*)

- 3G — *UMTS* (*Universal Mobile Telecommunications System*) or *HSPA* (*High Speed Packet Access*)

Your computer must have a mobile broadband device (modem), which the system has discovered and recognized, in order to create the connection. Such a device may be built into your computer (as is the case on many notebooks and netbooks), or may be provided separately as internal or external hardware. Examples include PC card, USB Modem or Dongle, mobile or cellular telephone capable of acting as a modem.

Procedure 10.3. Adding a New Mobile Broadband Connection

You can configure a mobile broadband connection by opening the **`Network Connections`** window, clicking **`Add`**, and selecting **`Mobile Broadband`** from the list.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Click the **`Add`** button to open the selection list. Select **`Mobile Broadband`** and then click **`Create`**. The **`Set up a Mobile Broadband Connection`** assistant appears.

3. Under **`Create a connection for this mobile broadband device`**, choose the 2G- or 3G-capable device you want to use with the connection. If the dropdown menu is inactive, this indicates that the system was unable to detect a device capable of mobile broadband. In this case, click **`Cancel`**, ensure that you do have a mobile broadband-capable device attached and recognized by the computer and then retry this procedure. Click the **`Forward`** button.

4. Select the country where your service provider is located from the list and click the **`Forward`** button.

5. Select your provider from the list or enter it manually. Click the **`Forward`** button.

6. Select your payment plan from the dropdown menu and confirm the *Access Point Name* (APN) is correct. Click the **`Forward`** button.

7. Review and confirm the settings and then click the **`Apply`** button.

8. Edit the mobile broadband-specific settings by referring to the *Configuring the Mobile Broadband Tab* description below .

Procedure 10.4. Editing an Existing Mobile Broadband Connection

Follow these steps to edit an existing mobile broadband connection.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **`Edit`** button.

3. Select the **`Mobile Broadband`** tab.

4. Configure the connection name, auto-connect behavior, and availability settings.

   Three settings in the **`Editing`** dialog are common to all connection types:

    - **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`Mobile Broadband`** section of the **`Network Connections`** window.

    - **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, “Connecting to a Network Automatically” for more information.

    - **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, “User and System Connections” for details.

5. Edit the mobile broadband-specific settings by referring to the *Configuring the Mobile Broadband Tab* description below .

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your mobile broadband connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, “Connecting to a Network” for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- Point-to-point settings for the connection, click the **`PPP Settings`** tab and proceed to Section 10.3.9.3, “Configuring PPP (Point-to-Point) Settings”;

- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”; or,

- IPv6 settings for the connection, click the **`IPv6 Settings`** tab and proceed to Section 10.3.9.5, “Configuring IPv6 Settings”.

Configuring the Mobile Broadband Tab

If you have already added a new mobile broadband connection using the assistant (see Procedure 10.3, “Adding a New Mobile Broadband Connection” for instructions), you can edit the **`Mobile Broadband`** tab to disable roaming if home network is not available, assign a network ID, or instruct **NetworkManager** to prefer a certain technology (such as 3G or 2G) when using the connection.

`Number`

The number that is dialed to establish a PPP connection with the GSM-based mobile broadband network. This field may be automatically populated during the initial installation of the broadband device. You can usually leave this field blank and enter the **`APN`** instead.

`Username`

Enter the user name used to authenticate with the network. Some providers do not provide a user name, or accept any user name when connecting to the network.

`Password`

Enter the password used to authenticate with the network. Some providers do not provide a password, or accept any password.

`APN`

Enter the *Access Point Name* (APN) used to establish a connection with the GSM-based network. Entering the correct APN for a connection is important because it often determines:

- how the user is billed for their network usage; and/or
- whether the user has access to the Internet, an intranet, or a subnetwork.

`Network ID`

Entering a **`Network ID`** causes **NetworkManager** to force the device to register only to a specific network. This can be used to ensure the connection does not roam when it is not possible to control roaming directly.

`Type`

`Any` — The default value of **`Any`** leaves the modem to select the fastest network.

`3G (UMTS/HSPA)` — Force the connection to use only 3G network technologies.

`2G (GPRS/EDGE)` — Force the connection to use only 2G network technologies.

`Prefer 3G (UMTS/HSPA)` — First attempt to connect using a 3G technology such as HSPA or UMTS, and fall back to GPRS or EDGE only upon failure.

`Prefer 2G (GPRS/EDGE)` — First attempt to connect using a 2G technology such as GPRS or EDGE, and fall back to HSPA or UMTS only upon failure.

`Allow roaming if home network is not available`

Uncheck this box if you want **NetworkManager** to terminate the connection rather than transition from the home network to a roaming one, thereby avoiding possible roaming charges. If the box is checked, **NetworkManager** will attempt to maintain a good connection by transitioning from the home network to a roaming one, and vice versa.

`PIN`

If your device's *SIM* (*Subscriber Identity Module*) is locked with a *PIN* (*Personal Identification Number*), enter the PIN so that **NetworkManager** can unlock the device. **NetworkManager** must unlock the SIM if a PIN is required in order to use the device for any purpose.

10.3.4. Establishing a VPN Connection

Establishing an encrypted Virtual Private Network (VPN) enables you to communicate securely between your Local Area Network (LAN), and another, remote LAN. After successfully establishing a VPN connection, a VPN router or gateway performs the following actions upon the packets you transmit:

1. it adds an *Authentication Header* for routing and authentication purposes;
2. it encrypts the packet data; and,
3. it encloses the data with an Encapsulating Security Payload (ESP), which constitutes the decryption and handling instructions.

The receiving VPN router strips the header information, decrypts the data, and routes it to its intended destination (either a workstation or other node on a network). Using a network-to-network connection, the receiving node on the local network receives the packets already decrypted and ready for processing. The encryption/decryption process in a network-to-network VPN connection is therefore transparent to clients.

Because they employ several layers of authentication and encryption, VPNs are a secure and effective means of connecting multiple remote nodes to act as a unified intranet.

Procedure 10.5. Adding a New VPN Connection

1. You can configure a new VPN connection by opening the **`Network Connections`** window, clicking the **`Add`** button and selecting a type of VPN from the **`VPN`** section of the new connection list.

2. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

3. Click the **`Add`** button.

4. The **`Choose a Connection Type`** list appears.

5. **NOTE**

   The appropriate **NetworkManager** VPN plug-in for the VPN type you want to configure must be installed (see Section 8.2.4, “Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux 6).

   The **`VPN`** section in the **`Choose a Connection Type`** list will **not** appear if you do not have a suitable plug-in installed.

6. Select the VPN protocol for the gateway you are connecting to from the **`Choose a Connection Type`** list. The VPN protocols available for selection in the list correspond to the **NetworkManager** VPN plug-ins installed. For example, if NetworkManager-openswan, the **NetworkManager** VPN plug-in for libreswan, is installed, then the IPsec based VPN will be selectable from the **`Choose a Connection Type`** list.

   NOTE

   In Red Hat Enterprise Linux 6.8, openswan has been obsoleted by libreswan. NetworkManager-openswan has been modified to support both openswan and libreswan.

   After selecting the correct one, press the **`Create`** button.

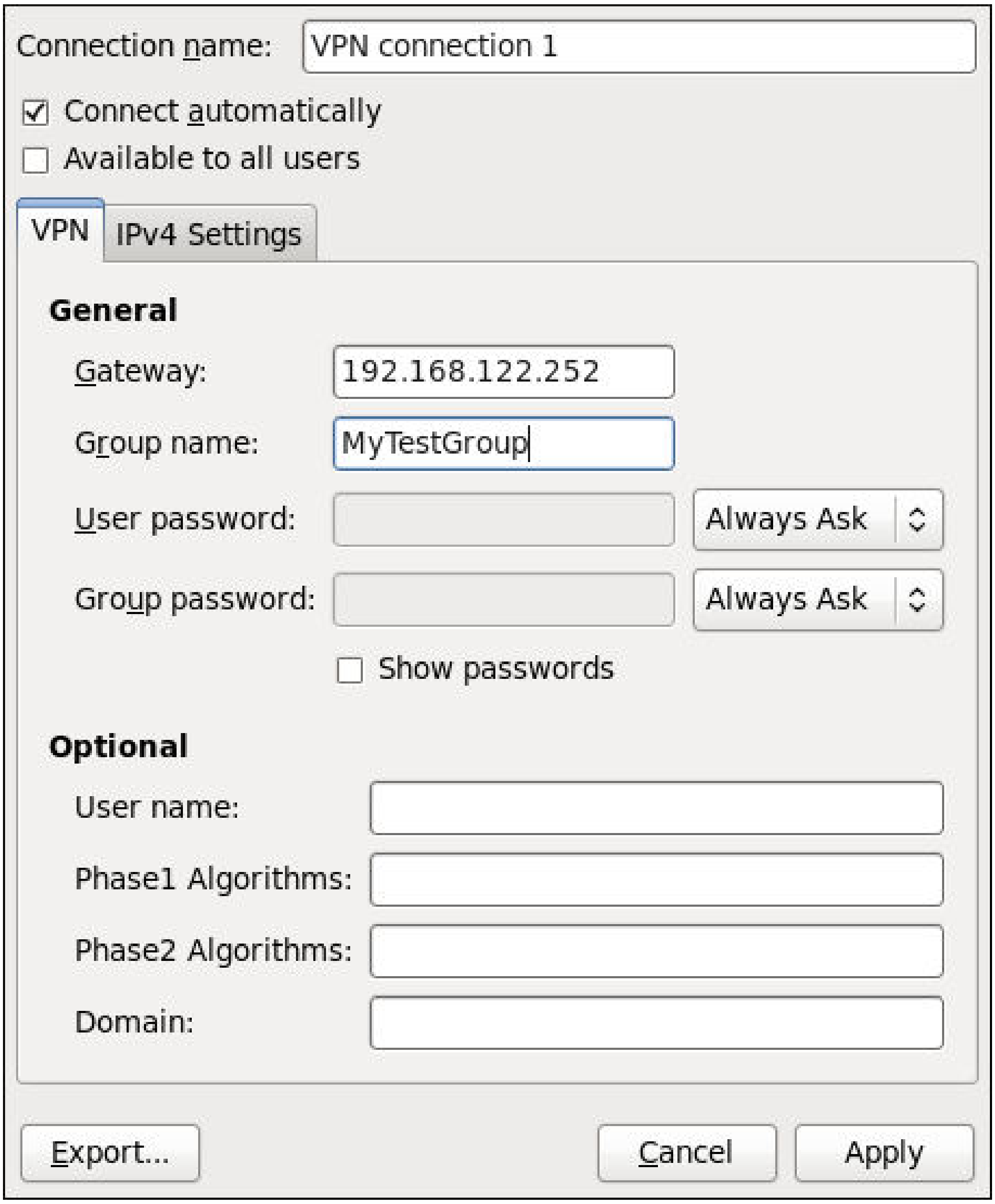
7. The **`Editing VPN Connection`** ***`1`*** window then appears. This window presents settings customized for the type of VPN connection you selected in Step 6.

Procedure 10.6. Editing an Existing VPN Connection

You can configure an existing VPN connection by opening the **`Network Connections`** window and selecting the name of the connection from the list. Then click the **`Edit`** button.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **Edit** button.



Connection name: VPN connection 1

☑ Connect automatically

☐ Available to all users

General

Gateway: 192.168.122.252

Group name: MyTestGroup

User password: Always Ask

Group password: Always Ask

☐ Show passwords

Optional

User name:

Phase1 Algorithms:

Phase2 Algorithms:

Domain:

Figure 10.13. Editing the newly created IPsec VPN connection 1

Configuring the Connection Name, Auto-Connect Behavior, and Availability Settings

Three settings in the `Editing` dialog are common to all connection types:

- **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`VPN`** section of the **`Network Connections`** window.

- **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, “Connecting to a Network Automatically” for more information.

- **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, “User and

System Connections" for details.

Configuring the VPN Tab

`Gateway`

The name or IP address of the remote VPN gateway.

`Group name`

The name of a VPN group configured on the remote gateway.

`User password`

If required, enter the password used to authenticate with the VPN.

`Group password`

If required, enter the password used to authenticate with the VPN.

`User name`

If required, enter the user name used to authenticate with the VPN.

`Phase1 Algorithms`

If required, enter the algorithms to be used to authenticate and set up an encrypted channel.

`Phase2 Algorithms`

If required, enter the algorithms to be used for the IPsec negotiations.

`Domain`

If required, enter the Domain Name.

`NAT traversal`

Cisco UDP (default) — IPsec over UDP.

NAT-T — ESP encapsulation and IKE extensions are used to handle NAT Traversal.

Disabled — No special NAT measures required.

`Disable Dead Peer Detection` — Disable the sending of probes to the remote gateway or endpoint.

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your new VPN connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, "Connecting to a Network" for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”.

10.3.5. Establishing a DSL Connection

This section is intended for those installations which have a DSL card fitted within a host rather than the external combined DSL modem router combinations typical of private consumer or SOHO installations.

Procedure 10.7. Adding a New DSL Connection

You can configure a new DSL connection by opening the **`Network Connections`** window, clicking the **`Add`** button and selecting **`DSL`** from the **`Hardware`** section of the new connection list.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Click the **`Add`** button.

3. The **`Choose a Connection Type`** list appears.

4. Select **`DSL`** and press the **`Create`** button.

5. The **`Editing DSL Connection`** ***`1`*** window appears.

Procedure 10.8. Editing an Existing DSL Connection

You can configure an existing DSL connection by opening the **`Network Connections`** window and selecting the name of the connection from the list. Then click the **`Edit`** button.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **`Edit`** button.

Configuring the Connection Name, Auto-Connect Behavior, and Availability Settings

Three settings in the **`Editing`** dialog are common to all connection types:

- **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`DSL`** section of the **`Network Connections`** window.

- **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, “Connecting to a Network Automatically” for more information.

- **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, “User and System Connections” for details.

Configuring the DSL Tab

`Username`

Enter the user name used to authenticate with the service provider.

`Service`

Leave blank unless otherwise directed.

`Password`

Enter the password supplied by the service provider.

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your DSL connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, “Connecting to a Network” for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- The MAC address and MTU settings, click the **`Wired`** tab and proceed to the section called “Configuring the Wired Tab”;
- Point-to-point settings for the connection, click the **`PPP Settings`** tab and proceed to Section 10.3.9.3, “Configuring PPP (Point-to-Point) Settings”;
- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”.

10.3.6. Establishing a Bond Connection

You can use **NetworkManager** to create a Bond from two or more Wired or Infiniband connections. It is not necessary to create the connections to be bonded first. They can be configured as part of the process to configure the bond. You must have the MAC addresses of the interfaces available in order to complete the configuration process.

NOTE

NetworkManager support for bonding must be enabled by means of the **`NM_BOND_VLAN_ENABLED`** directive and then **NetworkManager** must be restarted. See Section 11.2.1, “Ethernet Interfaces” for an explanation of **`NM_CONTROLLED`** and the **`NM_BOND_VLAN_ENABLED`** directive. See Section 12.3.4, “Restarting a Service” for an explanation of restarting a service such as **NetworkManager** from the command line. Alternatively, for a graphical tool see Section 12.2.1, “Using the Service Configuration Utility”.

Procedure 10.9. Adding a New Bond Connection

You can configure a Bond connection by opening the **`Network Connections`** window, clicking **`Add`**, and selecting **`Bond`** from the list.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Click the **`Add`** button to open the selection list. Select **`Bond`** and then click **`Create`**. The **`Editing Bond connection *1*`** window appears.

3. On the **Bond** tab, click **Add** and select the type of interface you want to use with the bond connection. Click the **Create** button. Note that the dialog to select the slave type only comes up when you create the first slave; after that, it will automatically use that same type for all further slaves.

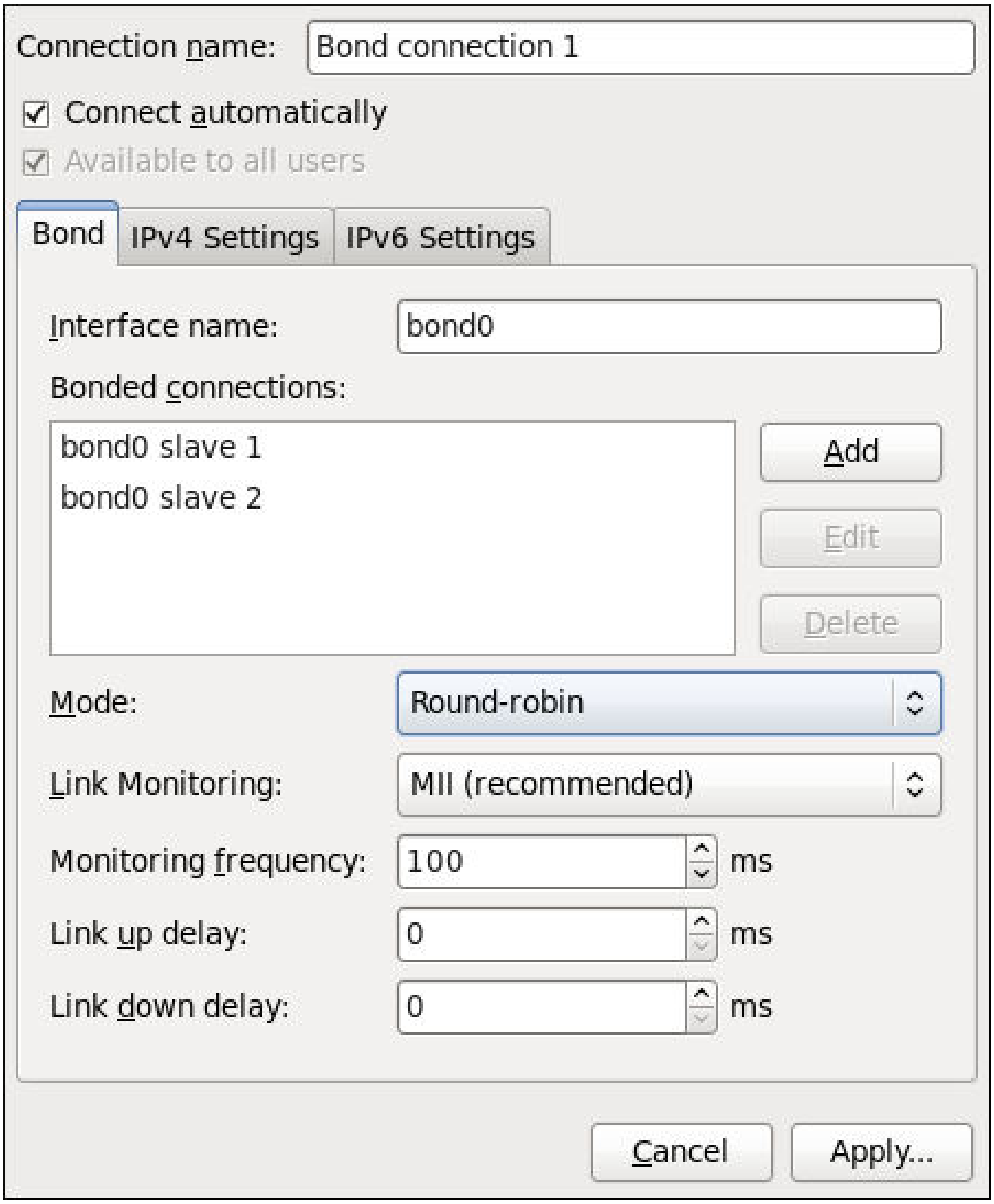
4. The **Editing bond0 slave 1** window appears. Fill in the MAC address of the first interface to be bonded. The first slave's MAC address will be used as the MAC address for the bond interface. If required, enter a clone MAC address to be used as the bond's MAC address. Click the **Apply** button.

5. The **Authenticate** window appears. Enter the **root** password to continue. Click the **Authenticate** button.

6. The name of the bonded slave appears in the **Bonded Connections window**. Click the **Add** button to add further slave connections.

7. Review and confirm the settings and then click the **Apply** button.

8. Edit the bond-specific settings by referring to the section called “Configuring the Bond Tab” below.


Connection name: Bond connection 1

☑ Connect automatically

☑ Available to all users

Interface name: bond0

Bonded connections:

bond0 slave 1

bond0 slave 2

Mode: Round-robin

Link Monitoring: MII (recommended)

Monitoring frequency: 100 ms

Link up delay: 0 ms

Link down delay: 0 ms

Figure 10.14. Editing the newly created Bond connection 1

Procedure 10.10. Editing an Existing Bond Connection

Follow these steps to edit an existing bond connection.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **`Edit`** button.

3. Select the **Bond** tab.

4. Configure the connection name, auto-connect behavior, and availability settings.

   Three settings in the **`Editing`** dialog are common to all connection types:

- **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **Bond** section of the **`Network Connections`** window.

- **`Connect automatically`** — Select this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, "Connecting to a Network Automatically" for more information.

- **`Available to all users`** — Select this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, "User and System Connections" for details.

5. Edit the bond-specific settings by referring to the section called "Configuring the Bond Tab" below.

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your bond connection, click the **`Apply`** button to save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, "Connecting to a Network" for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, "Configuring IPv4 Settings"; or,

- IPv6 settings for the connection, click the **`IPv6 Settings`** tab and proceed to Section 10.3.9.5, "Configuring IPv6 Settings".

Configuring the Bond Tab

If you have already added a new bond connection (see Procedure 10.9, "Adding a New Bond Connection" for instructions), you can edit the **`Bond`** tab to set the load sharing mode and the type of link monitoring to use to detect failures of a slave connection.

`Mode`

The mode that is used to share traffic over the slave connections which make up the bond. The default is **`Round-robin`**. Other load sharing modes, such as **`802.3ad`**, can be selected by means of the drop-down list.

`Link Monitoring`

The method of monitoring the slaves ability to carry network traffic.

The following modes of load sharing are selectable from the **`Mode`** drop-down list:

`Round-robin`

Sets a round-robin policy for fault tolerance and load balancing. Transmissions are received and sent out sequentially on each bonded slave interface beginning with the first one available. This mode might not work behind a bridge with virtual machines without additional switch configuration.

`Active backup`

Sets an active-backup policy for fault tolerance. Transmissions are received and sent out via the first available bonded slave interface. Another bonded slave interface is only used if the active bonded slave interface fails. Note that this is the only mode available for bonds of InfiniBand devices.

`XOR`

Sets an XOR (exclusive-or) policy. Transmissions are based on the selected hash policy. The default is to derive a hash by XOR of the source and destination MAC addresses multiplied by the modulo of the number of slave interfaces. In this mode traffic destined for specific peers will always be sent over the same interface. As the destination is determined by the MAC addresses this method works best for traffic to peers on the same link or local network. If traffic has to pass through a single router then this mode of traffic balancing will be suboptimal.

`Broadcast`

Sets a broadcast policy for fault tolerance. All transmissions are sent on all slave interfaces. This mode might not work behind a bridge with virtual machines without additional switch configuration.

`802.3ad`

Sets an IEEE **`802.3ad`** dynamic link aggregation policy. Creates aggregation groups that share the same speed and duplex settings. Transmits and receives on all slaves in the active aggregator. Requires a network switch that is **`802.3ad`** compliant.

`Adaptive transmit load balancing`

Sets an adaptive Transmit Load Balancing (TLB) policy for fault tolerance and load balancing. The outgoing traffic is distributed according to the current load on each slave interface. Incoming traffic is received by the current slave. If the receiving slave fails, another slave takes over the MAC address of the failed slave. This mode is only suitable for local addresses known to the kernel bonding module and therefore cannot be used behind a bridge with virtual machines.

`Adaptive load balancing`

Sets an Adaptive Load Balancing (ALB) policy for fault tolerance and load balancing. Includes transmit and receive load balancing for **`IPv4`** traffic. Receive load balancing is achieved through **`ARP`** negotiation. This mode is only suitable for local addresses known to the kernel bonding module and therefore cannot be used behind a bridge with virtual machines.

The following types of link monitoring can be selected from the **`Link Monitoring`** drop-down list. It is a good idea to test which channel bonding module parameters work best for your bonded interfaces.

`MII (Media Independent Interface)`

The state of the carrier wave of the interface is monitored. This can be done by querying the driver, by querying MII registers directly, or by using **ethtool** to query the device. Three options are available:

`Monitoring Frequency`

The time interval, in milliseconds, between querying the driver or MII registers.

`Link up delay`

The time in milliseconds to wait before attempting to use a link that has been reported as up. This delay can be used if some gratuitous **`ARP`** requests are lost in the period immediately following the link being reported as “up”. This can happen during switch initialization for example.

`Link down delay`

The time in milliseconds to wait before changing to another link when a previously active link has been reported as “down”. This delay can be used if an attached switch takes a relatively long time to change to backup mode.

`ARP`

The address resolution protocol (**`ARP`**) is used to probe one or more peers to determine how well the link-layer connections are working. It is dependent on the device driver providing the transmit start time and the last receive time.

Two options are available:

`Monitoring Frequency`

The time interval, in milliseconds, between sending **`ARP`** requests.

`ARP targets`

A comma separated list of **`IP`** addresses to send **`ARP`** requests to.

10.3.7. Establishing a VLAN Connection

You can use **NetworkManager** to create a VLAN using an existing interface. Currently, at time of writing, you can only make VLANs on Ethernet devices.

Procedure 10.11. Adding a New VLAN Connection

You can configure a VLAN connection by opening the **`Network Connections`** window, clicking **`Add`**, and selecting **`VLAN`** from the list.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Click the **`Add`** button to open the selection list. Select **`VLAN`** and then click **`Create`**. The **`Editing VLAN Connection`** ***`1`*** window appears.

3. On the **`VLAN`** tab, select the parent interface from the drop-down list you want to use for the VLAN connection.

4. Enter the VLAN ID

5. Enter a VLAN interface name. This is the name of the VLAN interface that will be created. For example, "eth0.1" or "vlan2". (Normally this is either the parent interface name plus "." and the VLAN ID, or "vlan" plus the VLAN ID.)

6. Review and confirm the settings and then click the **`Apply`** button.

7. Edit the VLAN-specific settings by referring to the *Configuring the VLAN Tab* description below .

Procedure 10.12. Editing an Existing VLAN Connection

Follow these steps to edit an existing VLAN connection.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **`Edit`** button.

3. Select the **`VLAN`** tab.

4. Configure the connection name, auto-connect behavior, and availability settings.

   Three settings in the **`Editing`** dialog are common to all connection types:

   - **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`VLAN`** section of the **`Network Connections`** window.

   - **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, "Connecting to a Network Automatically" for more information.

   - **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, "User and System Connections" for details.

5. Edit the VLAN-specific settings by referring to the *Configuring the VLAN Tab* description below .

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your VLAN connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, "Connecting to a Network" for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, "Configuring IPv4 Settings".

Configuring the VLAN Tab

If you have already added a new VLAN connection (see Procedure 10.11, "Adding a New VLAN Connection" for instructions), you can edit the **`VLAN`** tab to set the parent interface and the VLAN ID.

`Parent Interface`

A previously configured interface can be selected in the drop-down list.

`VLAN ID`

The identification number to be used to tag the VLAN network traffic.

`VLAN interface name`

The name of the VLAN interface that will be created. For example, "eth0.1" or "vlan2".

`Cloned MAC address`

Optionally sets an alternate MAC address to use for identifying the VLAN interface. This can be used to change the source MAC address for packets sent on this VLAN.

`MTU`

Optionally sets a Maximum Transmission Unit (MTU) size to be used for packets to be sent over the VLAN connection.

10.3.8. Establishing an IP-over-InfiniBand (IPoIB) Connection

You can use **NetworkManager** to create an InfiniBand connection.

Procedure 10.13. Adding a New InfiniBand Connection

You can configure an InfiniBand connection by opening the **`Network Connections`** window, clicking **`Add`**, and selecting **`InfiniBand`** from the list.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

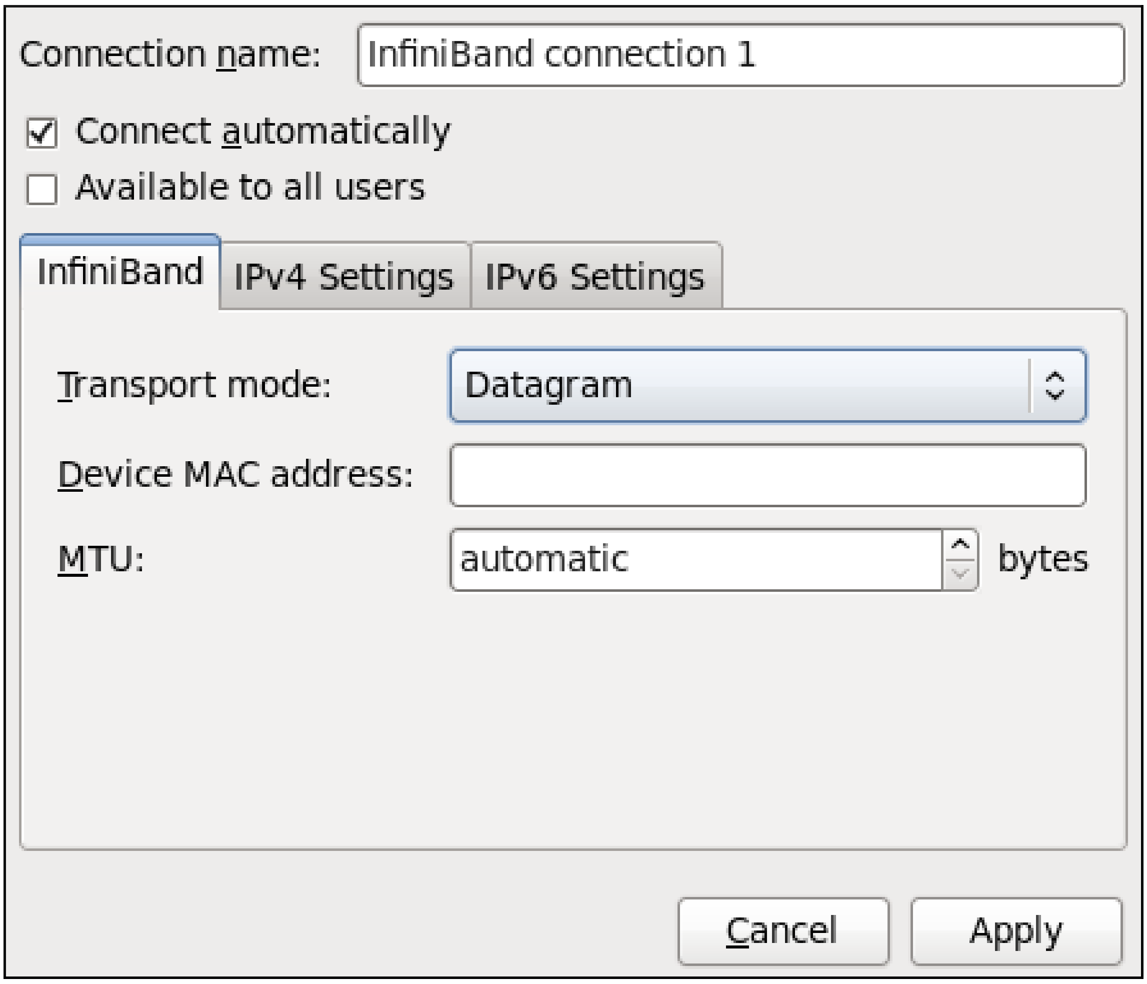
2. Click the **`Add`** button to open the selection list. Select **`InfiniBand`** and then click **`Create`**. The **`Editing InfiniBand Connection`** ***`1`*** window appears.

3. On the **`InfiniBand`** tab, select the transport mode from the drop-down list you want to use for the InfiniBand connection.

4. Enter the InfiniBand MAC address.

5. Review and confirm the settings and then click the **`Apply`** button.

6. Edit the InfiniBand-specific settings by referring to the *Configuring the InfiniBand Tab* description below .



Connection name: InfiniBand connection 1

☑ Connect automatically

☐ Available to all users

Transport mode: Datagram

Device MAC address:

MTU: automatic bytes

Figure 10.15. Editing the newly created InfiniBand connection 1

Procedure 10.14. Editing an Existing InfiniBand Connection

Follow these steps to edit an existing InfiniBand connection.

1. Right-click on the **NetworkManager** applet icon in the Notification Area and click **`Edit Connections`**. The **`Network Connections`** window appears.

2. Select the connection you want to edit and click the **`Edit`** button.

3. Select the **`InfiniBand`** tab.

4. Configure the connection name, auto-connect behavior, and availability settings.

   Three settings in the **`Editing`** dialog are common to all connection types:

   - **`Connection name`** — Enter a descriptive name for your network connection. This name will be used to list this connection in the **`InfiniBand`** section of the **`Network Connections`** window.

   - **`Connect automatically`** — Check this box if you want **NetworkManager** to auto-connect to this connection when it is available. See Section 10.2.3, “Connecting to a Network Automatically” for more information.

    - **`Available to all users`** — Check this box to create a connection available to all users on the system. Changing this setting may require **`root`** privileges. See Section 10.2.4, “User and System Connections” for details.

5. Edit the InfiniBand-specific settings by referring to the *Configuring the InfiniBand Tab* description below .

Saving Your New (or Modified) Connection and Making Further Configurations

Once you have finished editing your InfiniBand connection, click the **`Apply`** button and **NetworkManager** will immediately save your customized configuration. Given a correct configuration, you can connect to your new or customized connection by selecting it from the **NetworkManager** Notification Area applet. See Section 10.2.1, “Connecting to a Network” for information on using your new or altered connection.

You can further configure an existing connection by selecting it in the **`Network Connections`** window and clicking **`Edit`** to return to the **`Editing`** dialog.

Then, to configure:

- IPv4 settings for the connection, click the **`IPv4 Settings`** tab and proceed to Section 10.3.9.4, “Configuring IPv4 Settings”; or,

- IPv6 settings for the connection, click the **`IPv6 Settings`** tab and proceed to Section 10.3.9.5, “Configuring IPv6 Settings”.

Configuring the InfiniBand Tab

If you have already added a new InfiniBand connection (see Procedure 10.13, “Adding a New InfiniBand Connection” for instructions), you can edit the **`InfiniBand`** tab to set the parent interface and the InfiniBand ID.

`Transport mode`

Datagram or Connected mode can be selected from the drop-down list. Select the same mode the rest of your IPoIB network is using.

`Device MAC address`

The MAC address of the InfiniBand capable device to be used for the InfiniBand network traffic.This hardware address field will be pre-filled if you have InfiniBand hardware installed.

`MTU`

Optionally sets a Maximum Transmission Unit (MTU) size to be used for packets to be sent over the InfiniBand connection.

10.3.9. Configuring Connection Settings

10.3.9.1. Configuring 802.1X Security

802.1X security is the name of the IEEE standard for port-based Network Access Control (PNAC). Simply put, 802.1X security is a way of defining a *logical network* out of 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.

802.1X security is most often associated with securing wireless networks (WLANs), but can also be used to prevent intruders with physical access to the network (LAN) from gaining entry. In the past, DHCP servers were configured not to lease IP addresses to unauthorized users, but for various reasons this practice is both impractical and insecure, and thus is no longer recommended. Instead, 802.1X security is used to ensure a logically-secure network through port-based authentication.

802.1X provides a framework for WLAN and LAN access control and serves as an envelope for carrying one of the Extensible Authentication Protocol (EAP) types. An EAP type is a protocol that defines how WLAN security is achieved on the network.

You can configure 802.1X security for a wired or wireless connection type by opening the **`Network Connections`** window (see Section 10.2.2, “Configuring New and Editing Existing Connections”) and following the applicable procedure:

Procedure 10.15. For a wired connection...

1. Either click **`Add`**, select a new network connection for which you want to configure 802.1X security and then click **`Create`**, or select an existing connection and click **`Edit`**.

2. Then select the **`802.1X Security`** tab and check the **`Use 802.1X security for this connection`** check box to enable settings configuration.

3. Proceed to Section 10.3.9.1.1, “Configuring TLS (Transport Layer Security) Settings”

Procedure 10.16. For a wireless connection...

1. Either click on **`Add`**, select a new network connection for which you want to configure 802.1X security and then click **`Create`**, or select an existing connection and click **`Edit`**.

2. Select the **`Wireless Security`** tab.

3. Then click the **`Security`** dropdown and choose one of the following security methods: **LEAP**, **Dynamic WEP (802.1X)**, or **WPA & WPA2 Enterprise**.

4. See Section 10.3.9.1.1, “Configuring TLS (Transport Layer Security) Settings” for descriptions of which EAP types correspond to your selection in the **`Security`** dropdown.

10.3.9.1.1. Configuring TLS (Transport Layer Security) Settings

With Transport Layer Security, the client and server mutually authenticate using the TLS protocol. The server demonstrates that it holds a digital certificate, the client proves its own identity using its client-side certificate, and key information is exchanged. Once authentication is complete, the TLS tunnel is no longer used. Instead, the client and server use the exchanged keys to encrypt data using AES, TKIP or WEP.

The fact that certificates must be distributed to all clients who want to authenticate means that the EAP-TLS authentication method is very strong, but also more complicated to set up. 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.

`Identity`
: Identity string for EAP authentication methods, such as a user name or login name.

`User certificate`
: Click to browse for, and select, a user's certificate.

`CA certificate`
: Click to browse for, and select, a Certificate Authority's certificate.

`Private key`
: Click to browse for, and select, a user's private key file. Note that the key must be password protected.

`Private key password`
: Enter the user password corresponding to the user's private key.

10.3.9.1.2. Configuring Tunneled TLS Settings

`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`
: **PAP** — Password Authentication Protocol.

  MSCHAP — Challenge Handshake Authentication Protocol.

  MSCHAPv2 — Microsoft Challenge Handshake Authentication Protocol version 2.

  CHAP — Challenge Handshake Authentication Protocol.

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

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

10.3.9.1.3. Configuring Protected EAP (PEAP) Settings

`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`

MSCHAPv2 — Microsoft Challenge Handshake Authentication Protocol version 2.

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.

10.3.9.2. Configuring Wireless Security

`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 will be used to derive a WEP key.

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).

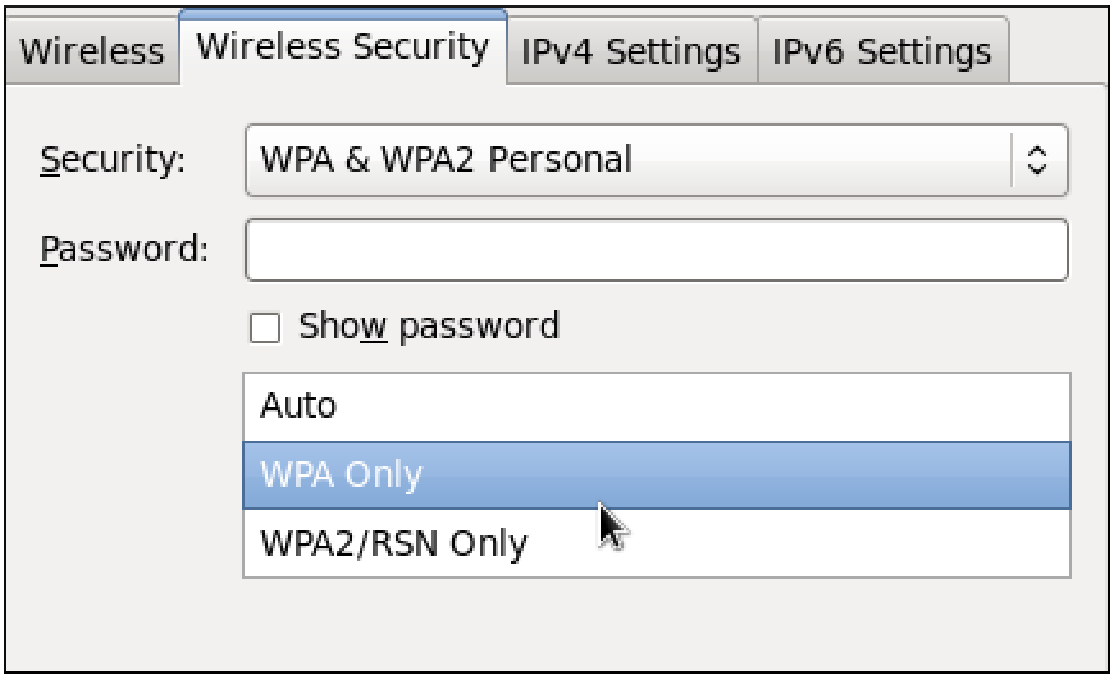
WPA & WPA2 Enterprise — WPA for use with a RADIUS authentication server to provide IEEE 802.1X network access control.

Password

Enter the password to be used in the authentication process.

NOTE

In the case of WPA and WPA2 (Personal and Enterprise), an option to select between Auto, WPA and WPA2 has been added. This option is intended for use with an access point that is offering both WPA and WPA2. Select one of the protocols if you would like to prevent roaming between the two protocols. Roaming between WPA and WPA2 on the same access point can cause loss of service.


Wireless | Wireless Security | IPv4 Settings | IPv6 Settings

Security: WPA & WPA2 Personal

Password:

☐ Show password

Auto

WPA Only

WPA2/RSN Only

Figure 10.16. Editing the Wireless Security tab and selecting the WPA protocol

10.3.9.3. Configuring PPP (Point-to-Point) Settings

`Configure Methods`

`Use point-to-point encryption (MPPE)`

Microsoft Point-To-Point Encryption protocol (RFC 3078).

`Allow BSD data compression`

PPP BSD Compression Protocol (RFC 1977).

`Allow Deflate data compression`

PPP Deflate Protocol (RFC 1979).

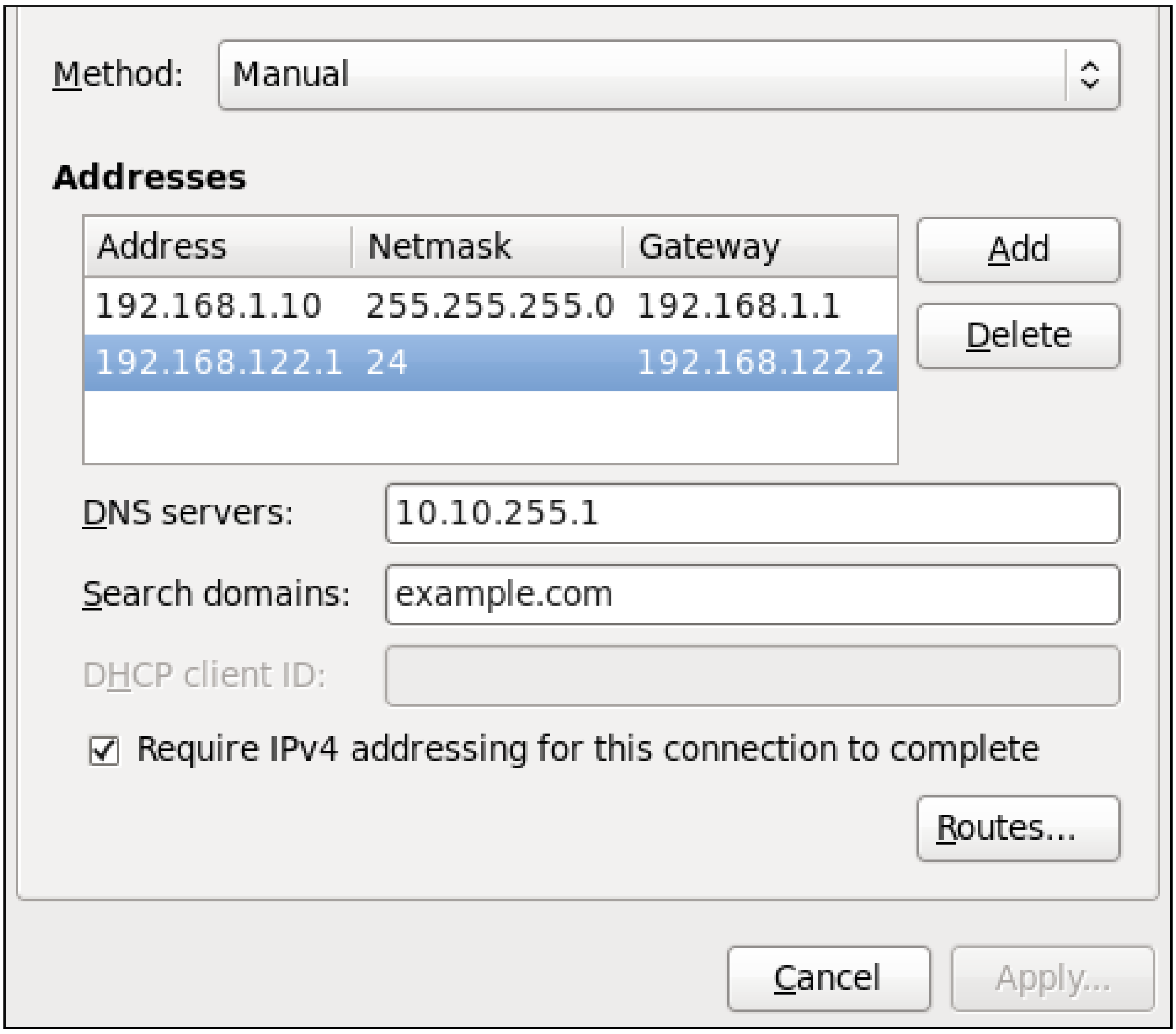
`Use TCP header compression`

Compressing TCP/IP Headers for Low-Speed Serial Links (RFC 1144).

`Send PPP echo packets`

LCP Echo-Request and Echo-Reply Codes for loopback tests (RFC 1661).

10.3.9.4. Configuring IPv4 Settings



Method: Manual

Addresses

Address	Netmask	Gateway
192.168.1.10	255.255.255.0	192.168.1.1
192.168.122.1	24	192.168.122.2

DNS servers: 10.10.255.1

Search domains: example.com

DHCP client ID:

☑ Require IPv4 addressing for this connection to complete

Figure 10.17. Editing the IPv4 Settings Tab

The **`IPv4 Settings`** tab allows you to configure the method by which you connect to the Internet and enter IP address, route, and DNS information as required. The **`IPv4 Settings`** tab is available when you create and modify one of the following connection types: wired, wireless, mobile broadband, VPN or DSL.

If you are using DHCP to obtain a dynamic IP address from a DHCP server, you can set **`Method`** to **Automatic (DHCP)**.

Setting the Method

Available IPv4 Methods by Connection Type

When you click the **`Method`** dropdown menu, depending on the type of connection you are configuring, you are able to select one of the following IPv4 connection methods. All of the methods are listed here according to which connection type or types they are associated with.

`Method`

Automatic (DHCP) — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses. You do not need to fill in the **`DHCP client ID`** field.

Automatic (DHCP) addresses only — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses but you want to assign DNS servers manually.

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 selected as per RFC 3927.

Shared to other computers — Choose this option if the interface you are configuring is for sharing an Internet or WAN connection.

Wired, Wireless and DSL Connection Methods

Manual — Choose this option if the network you are connecting to does not have a DHCP server and you want to assign IP addresses manually.

Mobile Broadband Connection Methods

Automatic (PPP) — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses.

Automatic (PPP) addresses only — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses but you want to assign DNS servers manually.

VPN Connection Methods

Automatic (VPN) — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses.

Automatic (VPN) addresses only — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses but you want to assign DNS servers manually.

DSL Connection Methods

Automatic (PPPoE) — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses.

Automatic (PPPoE) addresses only — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses but you want to assign DNS servers manually.

PPPoE Specific Configuration Steps

If more than one NIC is installed, and PPPoE will only be run over one NIC but not the other, then for correct PPPoE operation it is also necessary to lock the connection to the specific Ethernet device PPPoE is supposed to be run over. To lock the connection to one specific NIC, do **one** of the following:

- Enter the MAC address in **nm-connection-editor** for that connection. Optionally select **`Connect automatically`** and **`Available to all users`** to make the connection come up without requiring user login after system start.

- Set the hardware-address in the [802-3-ethernet] section in the appropriate file for that connection in **`/etc/NetworkManager/system-connections/`** as follows:

  ```
  [802-3-ethernet]
  mac-address=00:11:22:33:44:55
  ```

  Mere presence of the file in **`/etc/NetworkManager/system-connections/`** means that it is “available to all users”. Ensure that **`autoconnect=true`** appears in the [connection] section for the connection to be brought up without requiring user login after system start.

For information on configuring static routes for the network connection, go to Section 10.3.9.6, “Configuring Routes”.

10.3.9.5. Configuring IPv6 Settings

`Method`

Ignore — Choose this option if you want to disable IPv6 settings.

Automatic — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses.

Automatic, addresses only — Choose this option if the network you are connecting to uses a DHCP server to assign IP addresses but you want to assign DNS servers manually.

Manual — Choose this option if the network you are connecting to does not have a DHCP server and you want to assign IP addresses manually.

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 selected as per RFC 4862.

Shared to other computers — Choose this option if the interface you are configuring is for sharing an Internet or WAN connection.

`Addresses`

DNS servers — Enter a comma separated list of DNS servers.

Search domains — Enter a comma separated list of domain controllers.

For information on configuring static routes for the network connection, go to Section 10.3.9.6, “Configuring Routes”.

10.3.9.6. Configuring Routes

A host's routing table will be automatically populated with routes to directly connected networks. The routes are learned by observing the network interfaces when they are “up”. This section is for entering static routes to networks or hosts which can be reached by traversing an intermediate network or connection, such as a VPN or leased line.

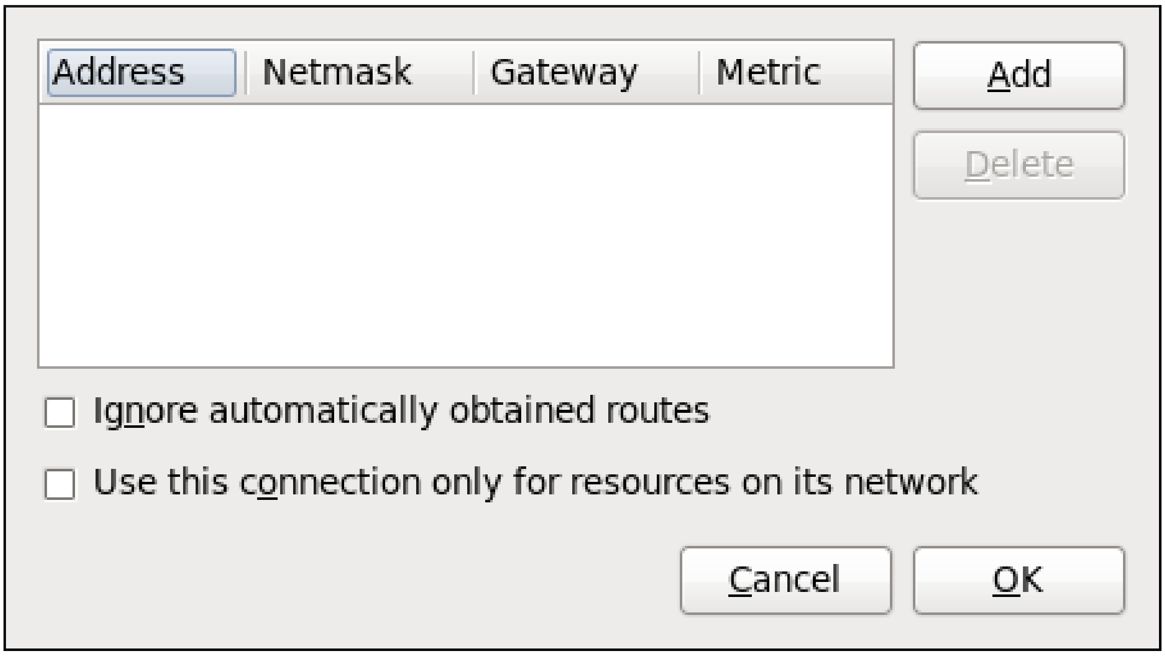

Address
Netmask
Gateway
Metric
Add
Delete
Ignore automatically obtained routes
Use this connection only for resources on its network
Cancel
OK

Figure 10.18. Configuring static network routes

`Addresses`

Address — The IP address of a network, sub-net or host.

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

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

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

`Ignore automatically obtained routes`

Select this check box to only use manually entered routes for this connection.

`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 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.

CHAPTER 11. NETWORK INTERFACES

Under Red Hat Enterprise Linux, all network communications occur between configured software *interfaces* and *physical networking devices* connected to the system.

The configuration files for network interfaces are located in the **`/etc/sysconfig/network-scripts/`** directory. The scripts used to activate and deactivate these network interfaces are also located here. Although the number and type of interface files can differ from system to system, there are three categories of files that exist in this directory:

1. *Interface configuration files*
2. *Interface control scripts*
3. *Network function files*

The files in each of these categories work together to enable various network devices.

This chapter explores the relationship between these files and how they are used.

11.1. NETWORK CONFIGURATION FILES

Before delving into the interface configuration files, let us first itemize the primary configuration files used in network configuration. Understanding the role these files play in setting up the network stack can be helpful when customizing a Red Hat Enterprise Linux system.

The primary network configuration files are as follows:

`/etc/hosts`

The main purpose of this file is to resolve host names that cannot be resolved any other way. It can also be used to resolve host names on small networks with no **`DNS`** server. Regardless of the type of network the computer is on, this file should contain a line specifying the **`IP`** address of the loopback device (**`127.0.0.1`**) as **`localhost.localdomain`**. For more information, see the **`hosts(5)`** manual page.

`/etc/resolv.conf`

This file specifies the **`IP`** addresses of **`DNS`** servers and the search domain. Unless configured to do otherwise, the network initialization scripts populate this file. For more information about this file, see the **`resolv.conf(5)`** manual page.

`/etc/sysconfig/network`

This file specifies routing and host information for all network interfaces. It is used to contain directives which are to have global effect and not to be interface specific. For more information about this file and the directives it accepts, see Section D.1.13, “/etc/sysconfig/network”.

`/etc/sysconfig/network-scripts/ifcfg-`*`interface-name`*

For each network interface, there is a corresponding interface configuration script. Each of these files provide information specific to a particular network interface. See Section 11.2, “Interface Configuration Files” for more information on this type of file and the directives it accepts.

IMPORTANT

Network interface names may be different on different hardware types. See Appendix A, *Consistent Network Device Naming* for more information.

WARNING

The **`/etc/sysconfig/networking/`** directory is used by the now deprecated **Network Administration Tool** (**`system-config-network`**). Its contents should **not** be edited manually. Using only one method for network configuration is strongly encouraged, due to the risk of configuration deletion. For more information about configuring network interfaces using graphical configuration tools, see Chapter 10, *NetworkManager*.

11.1.1. Setting the Host Name

To permanently change the static host name, change the HOSTNAME directive in the **`/etc/sysconfig/network`** file. For example:

```
HOSTNAME=penguin.example.com
```

Red Hat recommends the static host name matches the *fully qualified domain name* (FQDN) used for the machine in DNS, such as host.example.com. It is also recommended that the static host name consists only of 7 bit ASCII lower-case characters, no spaces or dots, and limits itself to the format allowed for DNS domain name labels, even though this is not a strict requirement. Older specifications do not permit the underscore, and so their use is not recommended. Changes will only take effect when the networking service, or the system, is restarted.

Note that the FQDN of the host can be supplied by a DNS resolver, by settings in **`/etc/sysconfig/network`**, or by the **`/etc/hosts`** file. The default setting of **`hosts: files dns`** in **`/etc/nsswitch.conf`** causes the configuration files to be checked before a resolver. The default setting of **`multi on`** in the **`/etc/host.conf`** file means that all valid values in the **`/etc/hosts`** file are returned, not just the first.

Sometimes you may need to use the host table in the **`/etc/hosts`** file instead of the HOSTNAME directive in **`/etc/sysconfig/network`**, for example, when DNS is not running during system bootup.

To change the host name using the **`/etc/hosts`** file, add lines to it in the following format:

```
192.168.1.2 penguin.example.com penguin
```

11.2. INTERFACE CONFIGURATION FILES

Interface configuration 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 *name* refers to the name of the device that the configuration file controls.

11.2.1. Ethernet Interfaces

One of the most common interface files is **`/etc/sysconfig/network-scripts/ifcfg-eth0`**, which controls the first Ethernet *network interface card* or NIC in the system. In a system with multiple NICs, there are multiple **`ifcfg-eth`*`X`*** files (where *X* is a unique number corresponding to a specific interface). Because each device has its own configuration file, an administrator can control how each interface functions individually.

The following is a sample **`ifcfg-eth0`** file for a system using a fixed **`IP`** address:

```
DEVICE=eth0
BOOTPROTO=none
ONBOOT=yes
NETMASK=255.255.255.0
IPADDR=10.0.1.27
USERCTL=no
```

The values required in an interface configuration file can change based on other values. For example, the **`ifcfg-eth0`** file for an interface using **`DHCP`** looks different because **`IP`** information is provided by the **`DHCP`** server:

```
DEVICE=eth0
BOOTPROTO=dhcp
ONBOOT=yes
```

NetworkManager is graphical configuration tool which provides an easy way to make changes to the various network interface configuration files (see Chapter 10, *NetworkManager* for detailed instructions on using this tool).

However, it is also possible to manually edit the configuration files for a given network interface.

Below is a listing of the configurable parameters in an Ethernet interface configuration file:

`BONDING_OPTS=`*`parameters`*

sets the configuration parameters for the bonding device, and is used in **`/etc/sysconfig/network-scripts/ifcfg-bond`*`N`*** (see Section 11.2.4, "Channel Bonding Interfaces"). These parameters are identical to those used for bonding devices in **`/sys/class/net/`*`bonding_device`*`/bonding`**, and the module parameters for the bonding driver as described in ***`bonding`** Module Directives*.

This configuration method is used so that multiple bonding devices can have different configurations. In Red Hat Enterprise Linux 6, place all interface-specific bonding options after the **`BONDING_OPTS`** directive in **`ifcfg-`*`name`*** files. See Where to specify bonding module parameters for more information.

`BOOTPROTO=`*`protocol`*

where *protocol* is one of the following:

- **`none`** — No boot-time protocol should be used.
- **`bootp`** — The **`BOOTP`** protocol should be used.
- **`dhcp`** — The **`DHCP`** protocol should be used.

BROADCAST=*address*

where *address* is the broadcast address. This directive is deprecated, as the value is calculated automatically with **ipcalc**.

DEVICE=*name*

where *name* is the name of the physical device (except for dynamically-allocated **PPP** devices where it is the *logical name*).

DHCP_HOSTNAME=*name*

where *name* is a short host name to be sent to the **DHCP** server. Use this option only if the **DHCP** server requires the client to specify a host name before receiving an **IP** address.

DHCPV6C=*answer*

where *answer* is one of the following:

- **yes** — Use **DHCP** to obtain an **IPv6** address for this interface.
- **no** — Do not use **DHCP** to obtain an **IPv6** address for this interface. This is the default value.

An **IPv6** link-local address will still be assigned by default. The link-local address is based on the MAC address of the interface as per *RFC 4862*.

DHCPV6C_OPTIONS=*answer*

where *answer* is one of the following:

- **-P** — Enable **IPv6** prefix delegation.
- **-S** — Use **DHCP** to obtain stateless configuration only, not addresses, for this interface.
- **-N** — Restore normal operation after using the **-T** or **-P** options.
- **-T** — Use **DHCP** to obtain a temporary **IPv6** address for this interface.
- **-D** — Override the default when selecting the type of *DHCP Unique Identifier* (DUID) to use.

  By default, the **DHCP** client (dhclient) creates a *DHCP Unique Identifier* (DUID) based on the link-layer address (DUID-LL) if it is running in stateless mode (with the **-S** option, to not request an address), or it creates an identifier based on the link-layer address plus a timestamp (DUID-LLT) if it is running in stateful mode (without **-S**, requesting an address). The **-D** option overrides this default, with a value of either **LL** or **LLT**.

DNS*{1,2}*=*address*

where *address* is a name server address to be placed in **/etc/resolv.conf** provided that the **PEERDNS** directive is not set to **no**.

ETHTOOL_OPTS=*options*

where *options* are any device-specific options supported by **ethtool**. For example, if you wanted to force 100Mb, full duplex:

```
ETHTOOL_OPTS="autoneg off speed 100 duplex full"
```

Instead of a custom initscript, use **`ETHTOOL_OPTS`** to set the interface speed and duplex settings. Custom initscripts run outside of the network init script lead to unpredictable results during a post-boot network service restart.

IMPORTANT

Changing speed or duplex settings almost always requires disabling auto-negotiation with the **`autoneg off`** option. This option needs to be stated first, as the option entries are order-dependent.

See Section 11.8, “Ethtool” for more **ethtool** options.

`HOTPLUG=`*answer*

where *answer* is one of the following:

- **`yes`** — This device should be activated when it is hot-plugged (this is the default option).
- **no** — This device should *not* be activated when it is hot-plugged.

The **`HOTPLUG=no`** option can be used to prevent a channel bonding interface from being activated when a bonding kernel module is loaded.

See Section 11.2.4, “Channel Bonding Interfaces” for more information about channel bonding interfaces.

`HWADDR=`*MAC-address*

where *MAC-address* is the hardware address of the Ethernet device in the form *AA:BB:CC:DD:EE:FF*. This directive must be used in machines containing more than one NIC to ensure that the interfaces are assigned the correct device names regardless of the configured load order for each NIC's module. This directive should **not** be used in conjunction with **`MACADDR`**.

NOTE

- Persistent device names are now handled by **`/etc/udev/rules.d/70-persistent-net.rules`**.
- **`HWADDR`** must not be used with System z network devices.
- See Section 25.3.3, "Mapping subchannels and network device names", in the *Red Hat Enterprise Linux 6 Installation Guide*.

`IPADDR`*n*=*address*

where *address* is the **`IPv4`** address and the *n* is expected to be consecutive positive integers starting from 0 (for example, IPADDR0). It is used for configurations with multiple IP addresses on an interface. It can be omitted if there is only one address being configured.

`IPV6ADDR=`*address*

where *address* is the first static, or primary, **`IPv6`** address on an interface.

The format is Address/Prefix-length. If no prefix length is specified, **`/64`** is assumed. Note that this setting depends on **`IPV6INIT`** being enabled.

`IPV6ADDR_SECONDARIES=`*address*

where *address* is one or more, space separated, additional **`IPv6`** addresses.

The format is Address/Prefix-length. If no prefix length is specified, **`/64`** is assumed. Note that this setting depends on **`IPV6INIT`** being enabled.

`IPV6INIT=`*answer*

where *answer* is one of the following:

- **`yes`** — Initialize this interface for **`IPv6`** addressing.
- **`no`** — Do not initialize this interface for **`IPv6`** addressing. This is the default value.

  This setting is required for **`IPv6`** static and **`DHCP`** assignment of **`IPv6`** addresses. It does not affect *IPv6 Stateless Address Autoconfiguration* (SLAAC) as per *RFC 4862*.

  See Section D.1.13, "/etc/sysconfig/network" for information on disabling **`IPv6`**.

`IPV6_AUTOCONF=`*answer*

where *answer* is one of the following:

- **`yes`** — Enable **`IPv6`** autoconf configuration for this interface.
- **`no`** — Disable **`IPv6`** autoconf configuration for this interface.

If enabled, an **`IPv6`** address will be requested using *Neighbor Discovery* (ND) from a router running the **`radvd`** daemon.

Note that the default value of **`IPV6_AUTOCONF`** depends on **`IPV6FORWARDING`** as follows:

- If **`IPV6FORWARDING`**=**`yes`**, then **`IPV6_AUTOCONF`** will default to **`no`**.
- If **`IPV6FORWARDING`**=**`no`**, then **`IPV6_AUTOCONF`** will default to **`yes`** and **`IPV6_ROUTER`** has no effect.

`IPV6_MTU=`*value*

where *value* is an optional dedicated MTU for this interface.

`IPV6_PRIVACY=`*rfc3041*

where *rfc3041* optionally sets this interface to support *RFC 3041 Privacy Extensions for Stateless Address Autoconfiguration in IPv6*. Note that this setting depends on **`IPV6INIT`** option being enabled.

The default is for *RFC 3041* support to be disabled. Stateless Autoconfiguration will derive addresses based on the MAC address, when available, using the modified **`EUI-64`** method. The address is appended to a prefix but as the address is normally derived from the MAC address it is globally unique even when the prefix changes. In the case of a link-local address the prefix is **`fe80::/64`** as per *RFC 2462 IPv6 Stateless Address Autoconfiguration*.

`LINKDELAY=`*time*

where *time* is the number of seconds to wait for link negotiation before configuring the device. The default is 5 secs. Delays in link negotiation, caused by **`STP`** for example, can be overcome by increasing this value.

`MACADDR=`*MAC-address*

where *MAC-address* is the hardware address of the Ethernet device in the form *AA:BB:CC:DD:EE:FF*.

This directive is used to assign a MAC address to an interface, overriding the one assigned to the physical NIC. This directive should **not** be used in conjunction with the **`HWADDR`** directive.

`MASTER=`*bond-interface*

where *bond-interface* is the channel bonding interface to which the Ethernet interface is linked.

This directive is used in conjunction with the **`SLAVE`** directive.

See Section 11.2.4, “Channel Bonding Interfaces” for more information about channel bonding interfaces.

`NETMASK`*n*`=`*mask*

where *mask* is the netmask value and the *n* is expected to be consecutive positive integers starting from 0 (for example, NETMASK0). It is used for configurations with multiple IP addresses on an interface. It can be omitted if there is only one address being configured.

`NETWORK=`*address*

where *address* is the network address. This directive is deprecated, as the value is calculated automatically with **`ipcalc`**.

`NM_CONTROLLED=`*answer*

where *answer* is one of the following:

- **`yes`** — **NetworkManager** is permitted to configure this device. This is the default behavior and can be omitted.
- **`no`** — **NetworkManager** is not permitted to configure this device.

NOTE

The **`NM_CONTROLLED`** directive is now, as of Red Hat Enterprise Linux 6.3, dependent on the **`NM_BOND_VLAN_ENABLED`** directive in **`/etc/sysconfig/network`**. If and only if that directive is present and is one of **`yes`**, **`y`**, or **`true`**, will **NetworkManager** detect and manage bonding and VLAN interfaces.

`ONBOOT=`*answer*

where *answer* is one of the following:

- **`yes`** — This device should be activated at boot-time.
- **`no`** — This device should not be activated at boot-time.

`PEERDNS=`*`answer`*

where *answer* is one of the following:

- **`yes`** — Modify **`/etc/resolv.conf`** if the **`DNS`** directive is set, if using **`DHCP`**, or if using Microsoft's *RFC 1877* **`IPCP`** extensions with **`PPP`**. In all cases **`yes`** is the default.
- **`no`** — Do not modify **`/etc/resolv.conf`**.

`SLAVE=`*`answer`*

where *answer* is one of the following:

- **`yes`** — This device is controlled by the channel bonding interface specified in the **`MASTER`** directive.
- **`no`** — This device is *not* controlled by the channel bonding interface specified in the **`MASTER`** directive.

This directive is used in conjunction with the **`MASTER`** directive.

See Section 11.2.4, “Channel Bonding Interfaces” for more about channel bonding interfaces.

`SRCADDR=`*`address`*

where *address* is the specified source **`IP`** address for outgoing packets.

`USERCTL=`*`answer`*

where *answer* is one of the following:

- **`yes`** — Non-**`root`** users are allowed to control this device.
- **`no`** — Non-**`root`** users are not allowed to control this device.

11.2.2. Specific ifcfg Options for Linux on System z

`SUBCHANNELS=`*`<read_device_bus_id>, <write_device_bus_id>, <data_device_bus_id>`*

where *<read_device_bus_id>*, *<write_device_bus_id>*, and *<data_device_bus_id>* are the three device bus IDs representing a network device.

`PORTNAME=`*`myname;`*

where *myname* is the Open Systems Adapter (OSA) portname or LAN Channel Station (LCS) portnumber.

`CTCPROT=`*`answer`*

where *answer* is one of the following:

- **`0`** — Compatibility mode, TCP/IP for Virtual Machines (used with non-Linux peers other than IBM S/390 and IBM System z operating systems). This is the default mode.
- **`1`** — Extended mode, used for Linux-to-Linux Peers.
- **`3`** — Compatibility mode for S/390 and IBM System z operating systems.

This directive is used in conjunction with the NETTYPE directive. It specifies the CTC protocol for NETTYPE='ctc'. The default is 0.

`OPTION=`*'answer'*

where *'answer'* is a quoted string of any valid sysfs attributes and their value. The Red Hat Enterprise Linux installer currently uses this to configure the layer mode, (layer2), and the relative port number, (portno), of QETH devices. For example:

```
OPTIONS='layer2=1 portno=0'
```

11.2.3. Required ifcfg Options for Linux on System z

`NETTYPE=`*answer*

where *answer* is one of the following:

- **`ctc`** — Channel-to-Channel communication. For point-to-point TCP/IP or TTY.
- **`lcs`** — LAN Channel Station (LCS).
- **`qeth`** — QETH (QDIO Ethernet). This is the default network interface. It is the preferred installation method for supporting real or virtual OSA cards and HiperSockets devices.

11.2.4. Channel Bonding Interfaces

Red Hat Enterprise Linux allows administrators to bind multiple network interfaces together into a single channel using the **`bonding`** kernel module and a special network interface called a *channel bonding interface*. Channel bonding enables two or more network interfaces to act as one, simultaneously increasing the bandwidth and providing redundancy.

WARNING

The use of direct cable connections without network switches is not supported for bonding. The failover mechanisms described here will not work as expected without the presence of network switches. See the Red Hat Knowledgebase article *Why is bonding in not supported with direct connection using crossover cables?* for more information.

NOTE

The active-backup, balance-tlb and balance-alb modes do not require any specific configuration of the switch. Other bonding modes require configuring the switch to aggregate the links. For example, a Cisco switch requires EtherChannel for Modes 0, 2, and 3, but for Mode 4 LACP and EtherChannel are required. See the documentation supplied with your switch and the **`bonding.txt`** file in the kernel-doc package (see Section 31.9, “Additional Resources”).

11.2.4.1. Check if Bonding Kernel Module is Installed

In Red Hat Enterprise Linux 6, the bonding module is not loaded by default. You can load the module by issuing the following command as **root**:

```
~]# modprobe --first-time bonding
```

No visual output indicates the module was not running and has now been loaded. This activation will not persist across system restarts. See Section 31.7, "Persistent Module Loading" for an explanation of persistent module loading. Note that given a correct configuration file using the **BONDING_OPTS** directive, the bonding module will be loaded as required and therefore does not need to be loaded separately.

To display information about the module, issue the following command:

```
~]$ modinfo bonding
```

See the **modprobe(8)** man page for more command options and see Chapter 31, *Working with Kernel Modules* for information on loading and unloading modules.

11.2.4.2. Create a Channel Bonding Interface

To create a channel bonding interface, create a file in the **/etc/sysconfig/network-scripts/** directory called **ifcfg-bond*N***, replacing *N* with the number for the interface, such as **0**.

The contents of the file can be identical to whatever type of interface is getting bonded, such as an Ethernet interface. The only difference is that the **DEVICE** directive is **bond*N***, replacing *N* with the number for the interface. The **NM_CONTROLLED** directive can be added to prevent **NetworkManager** from configuring this device.

Example 11.1. Example ifcfg-bond0 interface configuration file

The following is an example of a channel bonding interface configuration file:

```
DEVICE=bond0
IPADDR=192.168.1.1
NETMASK=255.255.255.0
ONBOOT=yes
BOOTPROTO=none
USERCTL=no
NM_CONTROLLED=no
BONDING_OPTS="bonding parameters separated by spaces"
```

The MAC address of the bond will be taken from the first interface to be enslaved. It can also be specified using the HWADDR directive if required. If you want **NetworkManager** to control this interface, remove the **NM_CONTROLLED=no** directive, or set it to **yes**, and add **TYPE=Bond** and **BONDING_MASTER=yes**.

After the channel bonding interface is created, the network interfaces to be bound together must be configured by adding the **MASTER** and **SLAVE** directives to their configuration files. The configuration files for each of the channel-bonded interfaces can be nearly identical.

Example 11.2. Example ifcfg-ethX bonded interface configuration file

If two Ethernet interfaces are being channel bonded, both **eth0** and **eth1** can be as follows:

```
DEVICE=ethX
BOOTPROTO=none
ONBOOT=yes
MASTER=bond0
SLAVE=yes
USERCTL=no
NM_CONTROLLED=no
```

In this example, replace *X* with the numerical value for the interface.

Once the interfaces have been configured, restart the network service to bring the bond up. As **root**, issue the following command:

```
~]# service network restart
```

To view the status of a bond, view the **/proc/** file by issuing a command in the following format:

```
 cat /proc/net/bonding/bondN
```

For example:

```
~]$ cat /proc/net/bonding/bond0
Ethernet Channel Bonding Driver: v3.6.0 (September 26, 2009)

Bonding Mode: load balancing (round-robin)
MII Status: down
MII Polling Interval (ms): 0
Up Delay (ms): 0
Down Delay (ms): 0
```

For further instructions and advice on configuring the bonding module and to view the list of bonding parameters, see Section 31.8.1, “Using Channel Bonding”.

Support for bonding was added to **NetworkManager** in Red Hat Enterprise Linux 6.3. See Section 11.2.1, “Ethernet Interfaces” for an explanation of **NM_CONTROLLED** and the **NM_BOND_VLAN_ENABLED** directive.

IMPORTANT

In Red Hat Enterprise Linux 6, interface-specific parameters for the bonding kernel module must be specified as a space-separated list in the **`BONDING_OPTS="`*`bonding parameters`*`"`** directive in the **`ifcfg-bond`*`N`*** interface file. Do **not** specify options specific to a bond in **`/etc/modprobe.d/`*`bonding`*`.conf`**, or in the deprecated **`/etc/modprobe.conf`** file.

The **`max_bonds`** parameter is not interface specific and therefore, if required, should be specified in **`/etc/modprobe.d/bonding.conf`** as follows:

```
options bonding max_bonds=1
```

However, the **`max_bonds`** parameter should **not** be set when using **`ifcfg-bond`*`N`*** files with the **`BONDING_OPTS`** directive as this directive will cause the network scripts to create the bond interfaces as required.

Note that any changes to **`/etc/modprobe.d/bonding.conf`** will not take effect until the module is next loaded. A running module must first be unloaded. See Chapter 31, *Working with Kernel Modules* for more information on loading and unloading modules.

11.2.4.2.1. Creating Multiple Bonds

In Red Hat Enterprise Linux 6, for each bond a channel bonding interface is created including the **`BONDING_OPTS`** directive. This configuration method is used so that multiple bonding devices can have different configurations. To create multiple channel bonding interfaces, proceed as follows:

- Create multiple **`ifcfg-bond`*`N`*** files with the **`BONDING_OPTS`** directive; this directive will cause the network scripts to create the bond interfaces as required.
- Create, or edit existing, interface configuration files to be bonded and include the **`SLAVE`** directive.
- Assign the interfaces to be bonded, the slave interfaces, to the channel bonding interfaces by means of the **`MASTER`** directive.

Example 11.3. Example multiple ifcfg-bondN interface configuration files

The following is an example of a channel bonding interface configuration file:

```
DEVICE=bondN
IPADDR=192.168.1.1
NETMASK=255.255.255.0
ONBOOT=yes
BOOTPROTO=none
USERCTL=no
NM_CONTROLLED=no
BONDING_OPTS="bonding parameters separated by spaces"
```

In this example, replace *N* with the number for the bond interface. For example, to create two bonds create two configuration files, **`ifcfg-bond0`** and **`ifcfg-bond1`**.

Create the interfaces to be bonded as per Example 11.2, "Example ifcfg-ethX bonded interface configuration file" and assign them to the bond interfaces as required using the **MASTER=bond*N*** directive. For example, continuing on from the example above, if two interfaces per bond are required, then for two bonds create four interface configuration files and assign the first two using **MASTER=bond*0*** and the next two using **MASTER=bond*1***.

11.2.5. Configuring a VLAN over a Bond

This section will show configuring a VLAN over a bond consisting of two Ethernet links between a server and an Ethernet switch. The switch has a second bond to another server. Only the configuration for the first server will be shown as the other is essentially the same apart from the **IP** addresses.

WARNING

The use of direct cable connections without network switches is not supported for bonding. The failover mechanisms described here will not work as expected without the presence of network switches. See the Red Hat Knowledgebase article *Why is bonding in not supported with direct connection using crossover cables?* for more information.

NOTE

The active-backup, balance-tlb and balance-alb modes do not require any specific configuration of the switch. Other bonding modes require configuring the switch to aggregate the links. For example, a Cisco switch requires EtherChannel for Modes 0, 2, and 3, but for Mode 4 LACP and EtherChannel are required. See the documentation supplied with your switch and the **bonding.txt** file in the kernel-doc package (see Section 31.9, "Additional Resources").

Check the available interfaces on the server:

```
~]$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast state DOWN qlen
1000
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
3: eth1: <BROADCAST,MULTICAST> mtu 1500 qdisc pfifo_fast state DOWN qlen
1000
    link/ether 52:54:00:f6:63:9a brd ff:ff:ff:ff:ff:ff
```

Procedure 11.1. Configuring the Interfaces on the Server

1. Configure a slave interface using **eth0**:

```
~]# vi /etc/sysconfig/network-scripts/ifcfg-eth0
NAME=bond0-slave0
```

```
DEVICE=eth0
TYPE=Ethernet
BOOTPROTO=none
ONBOOT=yes
MASTER=bond0
SLAVE=yes
NM_CONTROLLED=no
```

The use of the NAME directive is optional. It is for display by a GUI interface, such as **nm-connection-editor** and **nm-applet**.

2. Configure a slave interface using **`eth1`**:

```
~]# vi /etc/sysconfig/network-scripts/ifcfg-eth1
NAME=bond0-slave1
DEVICE=eth1
TYPE=Ethernet
BOOTPROTO=none
ONBOOT=yes
MASTER=bond0
SLAVE=yes
NM_CONTROLLED=no
```

The use of the NAME directive is optional. It is for display by a GUI interface, such as **nm-connection-editor** and **nm-applet**.

3. Configure a channel bonding interface **`ifcfg-bond0`**:

```
~]# vi /etc/sysconfig/network-scripts/ifcfg-bond0
NAME=bond0
DEVICE=bond0
BONDING_MASTER=yes
TYPE=Bond
IPADDR=192.168.100.100
NETMASK=255.255.255.0
ONBOOT=yes
BOOTPROTO=none
BONDING_OPTS="mode=active-backup miimon=100"
NM_CONTROLLED=no
```

The use of the NAME directive is optional. It is for display by a GUI interface, such as **nm-connection-editor** and **nm-applet**. In this example MII is used for link monitoring, see the Section 31.8.1.1, “Bonding Module Directives” section for more information on link monitoring.

4. Check the status of the interfaces on the server:

```
~]$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP qlen 1000
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
    inet6 fe80::5054:ff:fe19:28fe/64 scope link
```

```
       valid_lft forever preferred_lft forever
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
state UP qlen 1000
    link/ether 52:54:00:f6:63:9a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::5054:ff:fef6:639a/64 scope link
       valid_lft forever preferred_lft forever
```

Procedure 11.2. Resolving Conflicts with Interfaces

The interfaces configured as slaves should not have **`IP`** addresses assigned to them apart from the **`IPv6`** link-local addresses (starting **`fe80`**). If you have an unexpected **`IP`** address, then there may be another configuration file with ONBOOT set to **`yes`**.

1. If this occurs, issue the following command to list all **`ifcfg`** files that may be causing a conflict:

   ```
   ~]$ grep -r "ONBOOT=yes" /etc/sysconfig/network-scripts/ | cut -f1 -
   d":" | xargs grep -E "IPADDR|SLAVE"
   /etc/sysconfig/network-scripts/ifcfg-lo:IPADDR=127.0.0.1
   ```

   The above shows the expected result on a new installation. Any file having both the ONBOOT directive as well as the IPADDR or SLAVE directive will be displayed. For example, if the **`ifcfg-eth1`** file was incorrectly configured, the display might look similar to the following:

   ```
   ~]# grep -r "ONBOOT=yes" /etc/sysconfig/network-scripts/ | cut -f1 -
   d":" | xargs grep -E "IPADDR|SLAVE"
   /etc/sysconfig/network-scripts/ifcfg-lo:IPADDR=127.0.0.1
   /etc/sysconfig/network-scripts/ifcfg-eth1:SLAVE=yes
   /etc/sysconfig/network-scripts/ifcfg-eth1:IPADDR=192.168.55.55
   ```

2. Any other configuration files found should be moved to a different directory for backup, or assigned to a different interface by means of the HWADDR directive. After resolving any conflict set the interfaces “down” and “up” again or restart the network service as **`root`**:

   ```
   ~]# service network restart
   Shutting down interface bond0:                             [  OK
   ]
   Shutting down loopback interface:                          [  OK  ]
   Bringing up loopback interface:                            [  OK
   ]
   Bringing up interface bond0:  Determining if ip address
   192.168.100.100 is already in use for device bond0...
                                                              [  OK
   ]
   ```

   If you are using **NetworkManager**, you might need to restart it at this point to make it forget the unwanted **`IP`** address. As **`root`**:

   ```
   ~]# service NetworkManager restart
   ```

Procedure 11.3. Checking the bond on the Server

1. Bring up the bond on the server as **`root`**:

```
~]# ifup /etc/sysconfig/network-scripts/ifcfg-bond0
Determining if ip address 192.168.100.100 is already in use for
device bond0...
```

2. Check the status of the interfaces on the server:

```
~]$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc
pfifo_fast master bond0 state UP qlen 1000
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
3: eth1: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc
pfifo_fast master bond0 state UP qlen 1000
    link/ether 52:54:00:f6:63:9a brd ff:ff:ff:ff:ff:ff
4: bond0: <BROADCAST,MULTICAST,MASTER,UP,LOWER_UP> mtu 1500 qdisc
noqueue state UP
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.100/24 brd 192.168.100.255 scope global bond0
    inet6 fe80::5054:ff:fe19:28fe/64 scope link
       valid_lft forever preferred_lft forever
```

Notice that **eth0** and **eth1** have **master bond0 state UP** and **bond0** has status of **MASTER,UP**.

3. View the bond configuration details:

```
~]$ cat /proc/net/bonding/bond0
Ethernet Channel Bonding Driver: v3.6.0 (September 26, 2009)

Bonding Mode: transmit load balancing
Primary Slave: None
Currently Active Slave: eth0
MII Status: up
MII Polling Interval (ms): 100
Up Delay (ms): 0
Down Delay (ms): 0

Slave Interface: eth0
MII Status: up
Speed: 100 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 52:54:00:19:28:fe
Slave queue ID: 0

Slave Interface: eth1
MII Status: up
Speed: 100 Mbps
Duplex: full
```

```
Link Failure Count: 0
Permanent HW addr: 52:54:00:f6:63:9a
Slave queue ID: 0
```

4. Check the routes on the server:

```
~]$ ip route
192.168.100.0/24 dev bond0  proto kernel  scope link  src
192.168.100.100
169.254.0.0/16 dev bond0  scope link  metric 1004
```

Procedure 11.4. Configuring the VLAN on the Server

IMPORTANT

At the time of writing, it is important that the bond has slaves and that they are “up” before bringing up the VLAN interface. At the time of writing, adding a VLAN interface to a bond without slaves does not work. In Red Hat Enterprise Linux 6, setting the ONPARENT directive to **`yes`** is important to ensure that the VLAN interface does not attempt to come up before the bond is up. This is because a VLAN virtual device takes the MAC address of its parent, and when a NIC is enslaved, the bond changes its MAC address to that NIC's MAC address.

NOTE

A VLAN slave cannot be configured on a bond with the **`fail_over_mac=follow`** option, because the VLAN virtual device cannot change its MAC address to match the parent's new MAC address. In such a case, traffic would still be sent with the now incorrect source MAC address.

Some older network interface cards, loopback interfaces, Wimax cards, and some Infiniband devices, are said to be *VLAN challenged*, meaning they cannot support VLANs. This is usually because the devices cannot cope with VLAN headers and the larger MTU size associated with VLANs.

1. Create a VLAN interface file **`bond0.192`**:

```
~]# vi /etc/sysconfig/network-scripts/ifcfg-bond0.192
DEVICE=bond0.192
NAME=bond0.192
BOOTPROTO=none
ONPARENT=yes
IPADDR=192.168.10.1
NETMASK=255.255.255.0
VLAN=yes
NM_CONTROLLED=no
```

2. Bring up the VLAN interface as **`root`**:

```
~]# ifup /etc/sysconfig/network-scripts/ifcfg-bond0.192
Determining if ip address 192.168.10.1 is already in use for device
bond0.192...
```

3. Enabling VLAN tagging on the network switch. Consult the documentation for the switch to see what configuration is required.

4. Check the status of the interfaces on the server:

```
~]# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc
pfifo_fast master bond0 state UP qlen 1000
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
3: eth1: <BROADCAST,MULTICAST,SLAVE,UP,LOWER_UP> mtu 1500 qdisc
pfifo_fast master bond0 state UP qlen 1000
    link/ether 52:54:00:f6:63:9a brd ff:ff:ff:ff:ff:ff
4: bond0: <BROADCAST,MULTICAST,MASTER,UP,LOWER_UP> mtu 1500 qdisc
noqueue state UP
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.100/24 brd 192.168.100.255 scope global bond0
    inet6 fe80::5054:ff:fe19:28fe/64 scope link
       valid_lft forever preferred_lft forever
5: bond0.192@bond0: <BROADCAST,MULTICAST,MASTER,UP,LOWER_UP> mtu
1500 qdisc noqueue state UP
    link/ether 52:54:00:19:28:fe brd ff:ff:ff:ff:ff:ff
    inet 192.168.10.1/24 brd 192.168.10.255 scope global bond0.192
    inet6 fe80::5054:ff:fe19:28fe/64 scope link
       valid_lft forever preferred_lft forever
```

Notice there is now **`bond0.192@bond0`** in the list of interfaces and the status is **`MASTER,UP`**.

5. Check the route on the server:

```
~]$ ip route
192.168.100.0/24 dev bond0  proto kernel  scope link  src
192.168.100.100
192.168.10.0/24 dev bond0.192  proto kernel  scope link  src
192.168.10.1
169.254.0.0/16 dev bond0  scope link  metric 1004
169.254.0.0/16 dev bond0.192  scope link  metric 1005
```

Notice there is now a route for the **`192.168.10.0/24`** network pointing to the VLAN interface **`bond0.192`**.

Configuring the Second Server

Repeat the configuration steps for the second server, using different **`IP`** addresses but from the same subnets respectively.

Test the bond is up and the network switch is working as expected:

```
~]$ ping -c4 192.168.100.100
PING 192.168.100.100 (192.168.100.100) 56(84) bytes of data.
64 bytes from 192.168.100.100: icmp_seq=1 ttl=64 time=1.35 ms
64 bytes from 192.168.100.100: icmp_seq=2 ttl=64 time=0.214 ms
64 bytes from 192.168.100.100: icmp_seq=3 ttl=64 time=0.383 ms
```

```
64 bytes from 192.168.100.100: icmp_seq=4 ttl=64 time=0.396 ms

--- 192.168.100.100 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3002ms
rtt min/avg/max/mdev = 0.214/0.586/1.353/0.448 ms
```

Testing the VLAN
To test that the network switch is configured for the VLAN, try to ping the first servers' VLAN interface:

```
~]# ping -c2 192.168.10.1
PING 192.168.10.1 (192.168.10.1) 56(84) bytes of data.
64 bytes from 192.168.10.1: icmp_seq=1 ttl=64 time=0.781 ms
64 bytes from 192.168.10.1: icmp_seq=2 ttl=64 time=0.977 ms
--- 192.168.10.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.781/0.879/0.977/0.098 ms
```

No packet loss suggests everything is configured correctly and that the VLAN and underlying interfaces are “up”.

Optional Steps

- If required, perform further tests by removing and replacing network cables one at a time to verify that failover works as expected. Make use of the **ethtool** utility to verify which interface is connected to which cable. For example:

  ```
  ethtool --identify ifname integer
  ```

  Where *integer* is the number of times to flash the LED on the network interface.

- The bonding module does not support **`STP`**, therefore consider disabling the sending of BPDU packets from the network switch.

- If the system is not linked to the network except over the connection just configured, consider enabling the switch port to transition directly to sending and receiving. For example on a Cisco switch, by means of the **`portfast`** command.

11.2.6. Network Bridge

A network bridge is a Link Layer device which forwards traffic between networks based on MAC addresses and is therefore also referred to as a Layer 2 device. It makes forwarding decisions based on tables of MAC addresses which it builds by learning what hosts are connected to each network. A software bridge can be used within a Linux host in order to emulate a hardware bridge, for example in virtualization applications for sharing a NIC with one or more virtual NICs. This case will be illustrated here as an example.

To create a network bridge, create a file in the **`/etc/sysconfig/network-scripts/`** directory called **`ifcfg-br`*****`N`***, replacing *N* with the number for the interface, such as **`0`**.

The contents of the file is similar to whatever type of interface is getting bridged to, such as an Ethernet interface. The differences in this example are as follows:

- The **`DEVICE`** directive is given an interface name as its argument in the format **`br`*****`N`***, where *N* is replaced with the number of the interface.

- The **TYPE** directive is given an argument **Bridge**. This directive determines the device type and the argument is case sensitive.
- The bridge interface configuration file now has the **IP** address and the physical interface has only a MAC address.
- An extra directive, **DELAY=0**, is added to prevent the bridge from waiting while it monitors traffic, learns where hosts are located, and builds a table of MAC addresses on which to base its filtering decisions. The default delay of 15 seconds is not needed if no routing loops are possible.
- The **NM_CONTROLLED=no** should be added to the Ethernet interface to prevent **NetworkManager** from altering the file. It can also be added to the bridge configuration file in case future versions of **NetworkManager** support bridge configuration.

The following is a sample bridge interface configuration file using a static **IP** address:

Example 11.4. Sample ifcfg-br0 interface configuration file

```
DEVICE=br0
TYPE=Bridge
IPADDR=192.168.1.1
NETMASK=255.255.255.0
ONBOOT=yes
BOOTPROTO=none
NM_CONTROLLED=no
DELAY=0
```

To complete the bridge another interface is created, or an existing interface is modified, and pointed to the bridge interface. The following is a sample Ethernet interface configuration file pointing to a bridge interface. Configure your physical interface in **/etc/sysconfig/network-scripts/ifcfg-eth*X***, where *X* is a unique number corresponding to a specific interface, as follows:

Example 11.5. Sample ifcfg-ethX interface configuration file

```
DEVICE=ethX
TYPE=Ethernet
HWADDR=AA:BB:CC:DD:EE:FF
BOOTPROTO=none
ONBOOT=yes
NM_CONTROLLED=no
BRIDGE=br0
```

NOTE

For the **DEVICE** directive, almost any interface name could be used as it does not determine the device type. Other commonly used names include **tap**, **dummy** and **bond** for example. **TYPE=Ethernet** is not strictly required. If the **TYPE** directive is not set, the device is treated as an Ethernet device (unless its name explicitly matches a different interface configuration file.)

You can see Section 11.2, “Interface Configuration Files” for a review of the directives and options used in network interface config files.

WARNING

If you are configuring bridging on a remote host, and you are connected to that host over the physical NIC you are configuring, please consider the implications of losing connectivity before proceeding. You will lose connectivity when restarting the service and may not be able to regain connectivity if any errors have been made. Console, or out-of-band access is advised.

Restart the networking service, in order for the changes to take effect, as follows:

```
service network restart
```

11.2.6.1. Network Bridge with Bond

An example of a network bridge formed from two or more bonded Ethernet interfaces will now be given as this is another common application in a virtualization environment. If you are not very familiar with the configuration files for bonded interfaces then please see Section 11.2.4, “Channel Bonding Interfaces”

Create or edit two or more Ethernet interface configuration files, which are to be bonded, as follows:

```
DEVICE=ethX
TYPE=Ethernet
USERCTL=no
SLAVE=yes
MASTER=bond0
BOOTPROTO=none
HWADDR=AA:BB:CC:DD:EE:FF
NM_CONTROLLED=no
```

NOTE

Using ***ethX*** as the interface name is common practice but almost any name could be used. Names such as **tap**, **dummy** and **bond** are commonly used.

Create or edit one interface configuration file, **/etc/sysconfig/network-scripts/ifcfg-bond0**, as follows:

```
DEVICE=bond0
ONBOOT=yes
BONDING_OPTS='mode=1 miimon=100'
BRIDGE=br0
NM_CONTROLLED=no
```

For further instructions and advice on configuring the bonding module and to view the list of bonding parameters, see Section 31.8.1, “Using Channel Bonding”.

Create or edit one interface configuration file, **`/etc/sysconfig/network-scripts/ifcfg-br0`**, as follows:

```
DEVICE=br0
ONBOOT=yes
TYPE=Bridge
IPADDR=192.168.1.1
NETMASK=255.255.255.0
NM_CONTROLLED=no
```

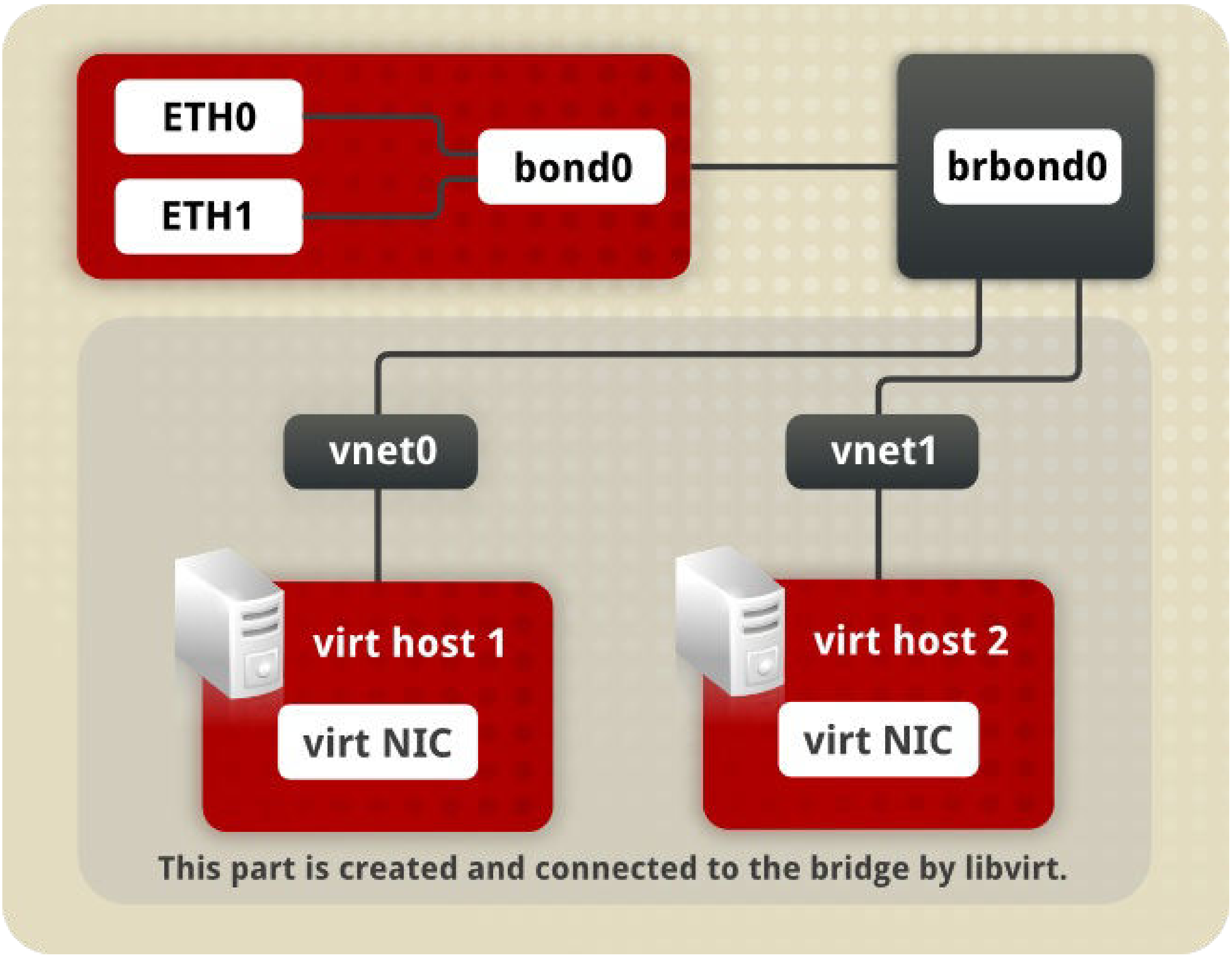


Figure 11.1. A network bridge consisting of two bonded Ethernet interfaces.

We now have two or more interface configuration files with the **`MASTER=bond0`** directive. These point to the configuration file named **`/etc/sysconfig/network-scripts/ifcfg-bond0`**, which contains the **`DEVICE=bond0`** directive. This **`ifcfg-bond0`** in turn points to the **`/etc/sysconfig/network-scripts/ifcfg-br0`** configuration file, which contains the **`IP`** address, and acts as an interface to the virtual networks inside the host.

To bring up the new or recently configured interfaces, issue a command as **`root`** in the following format:

```
ifup device
```

Alternatively, restart the networking service, in order for the changes to take effect, as follows:

```
~]# service network restart
```

11.2.6.2. Network Bridge with Bonded VLAN

Virtualization servers that intend to have distinct subnets for its guests while still ensuring availability in the event of a NIC failure will often combine bonds, VLANs, and bridges. An example of this configuration will now be given. By creating a bridge on the VLAN instead of the underlying device we allow VLAN tagging to be handled entirely through the host with no need to configure the guests' interfaces.

1. Ensure the bond and VLAN have been configured as outlined in Section 11.2.5, “Configuring a VLAN over a Bond”.

2. Create the bridge's configuration file, **`ifcfg-br0`**:

   ```
   ~]# vi /etc/sysconfig/network-scripts/ifcfg-br0
   DEVICE=br0
   ONBOOT=yes
   TYPE=Bridge
   IPADDR=192.168.10.1
   NETMASK=255.255.255.0
   NM_CONTROLLED=no
   ```

3. Adjust the VLAN's configuration file, **`ifcfg-bond0.192`** from the earlier example, to use the newly created **`br0`** as its master:

   ```
   ~]# vi /etc/sysconfig/network-scripts/ifcfg-bond0.192
   DEVICE=bond0.192
   BOOTPROTO=none
   ONPARENT=yes
   #IPADDR=192.168.10.1
   #NETMASK=255.255.255.0
   VLAN=yes
   NM_CONTROLLED=no
   BRIDGE=br0
   ```

4. To bring up the new or recently configured interfaces, issue a command as **`root`** in the following format:

   ```
   ifup device
   ```

   Alternatively, restart the networking service, in order for the changes to take effect, as follows:

   ```
   ~]# service network restart
   ```

11.2.7. Setting Up 802.1Q VLAN Tagging

1. If required, start the VLAN 8021q module by issuing the following command as **`root`**:

   ```
   ~]# modprobe --first-time 8021q
   ```

   No visual output indicates the module was not running and has now been loaded. Note that given a correct configuration file, the VLAN 8021q module will be loaded as required and therefore does not need to be loaded separately.

2. Configure your physical interface in **`/etc/sysconfig/network-scripts/ifcfg-eth`*`X`***, where *X* is a unique number corresponding to a specific interface, as follows:

```
DEVICE=ethX
TYPE=Ethernet
BOOTPROTO=none
ONBOOT=yes
```

3. Configure the VLAN interface configuration in **`/etc/sysconfig/network-scripts`**. The configuration filename should be the physical interface plus a **`.`** character plus the VLAN ID number. For example, if the VLAN ID is 192, and the physical interface is **`eth0`**, then the configuration filename should be **`ifcfg-eth0.192`**:

   ```
   DEVICE=ethX.192
   BOOTPROTO=none
   ONBOOT=yes
   IPADDR=192.168.1.1
   NETMASK=255.255.255.0
   USERCTL=no
   NETWORK=192.168.1.0
   VLAN=yes
   ```

   If there is a need to configure a second VLAN, with for example, VLAN ID 193, on the same interface, **`eth0`** , add a new file with the name **`eth0.193`** with the VLAN configuration details.

4. Restart the networking service, in order for the changes to take effect. Issue the following command as **`root`**:

   ```
   ~]# service network restart
   ```

11.2.8. Alias and Clone Files

Two lesser-used types of interface configuration files are *alias* and *clone* files. As the **ip** utility now supports assigning multiple addresses to the same interface it is no longer necessary to use this method of binding multiple addresses to the same interface. The **ip** command to assign an address can be repeated multiple times in order to assign multiple address. For example:

```
~]# ip address add 192.168.2.223/24 dev eth1
~]# ip address add 192.168.4.223/24 dev eth1
~]# ip addr
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state
UP qlen 1000
    link/ether 52:54:00:fb:77:9e brd ff:ff:ff:ff:ff:ff
    inet 192.168.2.223/24 scope global eth1
    inet 192.168.4.223/24 scope global eth1
```

The commands for the **ip** utility, sometimes referred to as **iproute2** after the upstream package name, are documented in the **`man ip(8)`** page. The package name in Red Hat Enterprise Linux 6 is iproute.

NOTE

In Red Hat Enterprise Linux 6, **NetworkManager** now reads **`ifcfg`** alias files and assigns the addresses in them to their master interface, using the alias name as the address label. For example, if **`ifcfg-eth0`** and **`ifcfg-eth0:1`** files are present, **NetworkManager** reads the alias file's DEVICE line and stores this as an address label. The use of secondary addresses rather than alias is still preferred.

For new installations, users should select the **`Manual`** method on the **`IPv4`** or **`IPv6`** tab in **NetworkManager** to assign multiple **`IP`** address to the same interface. For more information on using this tool, see Chapter 10, *NetworkManager*.

Alias interface configuration files, which are used to bind multiple addresses to a single interface, use the **`ifcfg-`*`if-name`*`:`*`alias-value`*** naming scheme.

For example, an **`ifcfg-eth0:0`** file could be configured to specify **`DEVICE=eth0:0`** and a static **`IP`** address of **`10.0.0.2`**, serving as an alias of an Ethernet interface already configured to receive its **`IP`** information via **`DHCP`** in **`ifcfg-eth0`**. Under this configuration, **`eth0`** is bound to a dynamic **`IP`** address, but the same physical network card can receive requests via the fixed, **`10.0.0.2 IP`** address.

WARNING

Alias interfaces do not support **`DHCP`**.

A clone interface configuration file should use the following naming convention: **`ifcfg-`*`if-name`*`-`*`clone-name`***. While an alias file allows multiple addresses for an existing interface, a clone file is used to specify additional options for an interface. For example, a standard **`DHCP`** Ethernet interface called **`eth0`**, may look similar to this:

```
DEVICE=eth0
ONBOOT=yes
BOOTPROTO=dhcp
```

Since the default value for the **`USERCTL`** directive is **no** if it is not specified, users cannot bring this interface up and down. To give users the ability to control the interface, create a clone by copying **`ifcfg-eth0`** to **`ifcfg-eth0-user`** and add the following line to **`ifcfg-eth0-user`**:

```
USERCTL=yes
```

This way a user can bring up the **`eth0`** interface using the **`/sbin/ifup eth0-user`** command because the configuration options from **`ifcfg-eth0`** and **`ifcfg-eth0-user`** are combined. While this is a very basic example, this method can be used with a variety of options and interfaces.

It is no longer possible to create alias and clone interface configuration files using a graphical tool. However, as explained at the beginning of this section, it is no longer necessary to use this method as it is now possible to directly assign multiple **`IP`** address to the same interface. For new installations, users should select the **`Manual`** method on the **`IPv4`** or **`IPv6`** tab in **NetworkManager** to assign multiple **`IP`** address to the same interface. For more information on using this tool, see Chapter 10, *NetworkManager*.

11.2.9. Dialup Interfaces

If you are connecting to the Internet via a dialup connection, a configuration file is necessary for the interface.

`PPP` interface files are named using the following format:

`ifcfg-ppp`*`X`*

where *X* is a unique number corresponding to a specific interface.

The **`PPP`** interface configuration file is created automatically when **`wvdial`**, or **Kppp** is used to create a dialup account. It is also possible to create and edit this file manually.

The following is a typical **`/etc/sysconfig/network-scripts/ifcfg-ppp0`** file:

```
DEVICE=ppp0
NAME=test
WVDIALSECT=test
MODEMPORT=/dev/modem
LINESPEED=115200
PAPNAME=test
USERCTL=true
ONBOOT=no
PERSIST=no
DEFROUTE=yes
PEERDNS=yes
DEMAND=no
IDLETIMEOUT=600
```

Serial Line Internet Protocol (SLIP) is another dialup interface, although it is used less frequently. **`SLIP`** files have interface configuration file names such as **`ifcfg-sl0`**.

Other options that may be used in these files include:

`DEFROUTE=`*answer*

where *answer* is one of the following:

- **`yes`** — Set this interface as the default route.
- **`no`** — Do not set this interface as the default route.

`DEMAND=`*answer*

where *answer* is one of the following:

- **`yes`** — This interface allows **`pppd`** to initiate a connection when someone attempts to use it.
- **`no`** — A connection must be manually established for this interface.

`IDLETIMEOUT=`*value*

where *value* is the number of seconds of idle activity before the interface disconnects itself.

`INITSTRING=`*string*

where *string* is the initialization string passed to the modem device. This option is primarily used in conjunction with **`SLIP`** interfaces.

`LINESPEED=`*value*

where *value* is the baud rate of the device. Possible standard values include **`57600`**, **`38400`**, **`19200`**, and **`9600`**.

`MODEMPORT=`*`device`*

where *device* is the name of the serial device that is used to establish the connection for the interface.

`MTU=`*`value`*

where *value* is the *Maximum Transfer Unit* (MTU) setting for the interface. The MTU refers to the largest number of bytes of data a frame can carry, not counting its header information. In some dialup situations, setting this to a value of **`576`** results in fewer packets dropped and a slight improvement to the throughput for a connection.

`NAME=`*`name`*

where *name* is the reference to the title given to a collection of dialup connection configurations.

`PAPNAME=`*`name`*

where *name* is the user name given during the *Password Authentication Protocol* (PAP) exchange that occurs to allow connections to a remote system.

`PERSIST=`*`answer`*

where *answer* is one of the following:

- **`yes`** — This interface should be kept active at all times, even if deactivated after a modem hang up.
- **`no`** — This interface should not be kept active at all times.

`REMIP=`*`address`*

where *address* is the **`IP`** address of the remote system. This is usually left unspecified.

`WVDIALSECT=`*`name`*

where *name* associates this interface with a dialer configuration in **`/etc/wvdial.conf`**. This file contains the phone number to be dialed and other important information for the interface.

11.2.10. Other Interfaces

Other common interface configuration files include the following:

`ifcfg-lo`

A local *loopback interface* is often used in testing, as well as being used in a variety of applications that require an **`IP`** address pointing back to the same system. Any data sent to the loopback device is immediately returned to the host's network layer.

WARNING

The loopback interface script, **`/etc/sysconfig/network-scripts/ifcfg-lo`**, should never be edited manually. Doing so can prevent the system from operating correctly.

`ifcfg-irlan0`

An *infrared interface* allows information between devices, such as a laptop and a printer, to flow over an infrared link. This works in a similar way to an Ethernet device except that it commonly occurs over a peer-to-peer connection.

`ifcfg-plip0`

A *Parallel Line Interface Protocol* (PLIP) connection works much the same way as an Ethernet device, except that it utilizes a parallel port.

Interface configuration files for Linux on System z include the following:

`ifcfg-hsiN`

A *HiperSockets* interface is an interface for high-speed TCP/IP communication within and across z/VM guest virtual machines and logical partitions (LPARs) on an IBM System z mainframe.

11.3. INTERFACE CONTROL SCRIPTS

The interface control scripts activate and deactivate system interfaces. There are two primary interface control scripts that call on control scripts located in the **`/etc/sysconfig/network-scripts/`** directory: **`/sbin/ifdown`** and **`/sbin/ifup`**.

The **`ifup`** and **`ifdown`** interface scripts are symbolic links to scripts in the **`/sbin/`** directory. When either of these scripts are called, they require the value of the interface to be specified, such as:

```
ifup eth0
```

WARNING

The **`ifup`** and **`ifdown`** interface scripts are the only scripts that the user should use to bring up and take down network interfaces.

The following scripts are described for reference purposes only.

Two files used to perform a variety of network initialization tasks during the process of bringing up a network interface are **`/etc/rc.d/init.d/functions`** and **`/etc/sysconfig/network-scripts/network-functions`**. See Section 11.7, “Network Function Files” for more information.

After verifying that an interface has been specified and that the user executing the request is allowed to control the interface, the correct script brings the interface up or down. The following are common interface control scripts found within the **`/etc/sysconfig/network-scripts/`** directory:

`ifup-aliases`
: Configures **`IP`** aliases from interface configuration files when more than one **`IP`** address is associated with an interface.

`ifup-ippp` and **`ifdown-ippp`**
: Brings ISDN interfaces up and down.

`ifup-ipv6` and **`ifdown-ipv6`**
: Brings **`IPv6`** interfaces up and down.

`ifup-plip`
: Brings up a **`PLIP`** interface.

`ifup-plusb`
: Brings up a USB interface for network connections.

`ifup-post` and **`ifdown-post`**
: Contains commands to be executed after an interface is brought up or down.

`ifup-ppp` and **`ifdown-ppp`**
: Brings a **`PPP`** interface up or down.

`ifup-routes`
: Adds static routes for a device as its interface is brought up.

`ifdown-sit` and **`ifup-sit`**
: Contains function calls related to bringing up and down an **`IPv6`** tunnel within an **`IPv4`** connection.

`ifup-wireless`
: Brings up a wireless interface.

WARNING

Removing or modifying any scripts in the **`/etc/sysconfig/network-scripts/`** directory can cause interface connections to act irregularly or fail. Only advanced users should modify scripts related to a network interface.

The easiest way to manipulate all network scripts simultaneously is to use the **`/sbin/service`** command on the network service (**`/etc/rc.d/init.d/network`**), as illustrated by the following command:

```
/sbin/service network action
```

Here, *action* can be either **`start`**, **`stop`**, or **`restart`**.

To view a list of configured devices and currently active network interfaces, use the following command:

```
/sbin/service network status
```

11.4. STATIC ROUTES AND THE DEFAULT GATEWAY

Static routes are for traffic that must not, or should not, go through the default gateway. Routing is often handled by devices on the network dedicated to routing (although any device can be configured to perform routing). Therefore, it is often not necessary to configure static routes on Red Hat Enterprise Linux servers or clients. Exceptions include traffic that must pass through an encrypted VPN tunnel or traffic that should take a specific route for reasons of cost or security. The default gateway is for any and all traffic which is not destined for the local network and for which no preferred route is specified in the routing table. The default gateway is traditionally a dedicated network router.

Configuring Static Routes Using the Command Line

If static routes are required, they can be added to the routing table by means of the **`ip route add`** command and removed using the **`ip route del`** command. The more frequently used **`ip route`** commands take the following form:

```
ip route [ add | del | change | append | replace ] destination-address
```

See the **`ip-route(8)`** man page for more details on the options and formats.

Use the **`ip route`** command without options to display the **`IP`** routing table. For example:

```
~]$ ip route
default via 192.168.122.1 dev eth0  proto static  metric 1024
192.168.122.0/24 dev ens9  proto kernel  scope link  src 192.168.122.107
192.168.122.0/24 dev eth0  proto kernel  scope link  src 192.168.122.126
```

To add a static route to a host address, in other words to a single **`IP`** address, issue a command as **`root`**:

```
~]# ip route add 192.0.2.1 via 10.0.0.1 [dev ifname]
```

Where *192.0.2.1* is the **IP** address of the host in dotted decimal notation, *10.0.0.1* is the next hop address and *ifname* is the exit interface leading to the next hop.

To add a static route to a network, in other words to an **IP** address representing a range of **IP** addresses, issue the following command as **root**:

```
~]# ip route add 192.0.2.0/24 via 10.0.0.1 [dev ifname]
```

where *192.0.2.0* is the **IP** address of the destination network in dotted decimal notation and */24* is the network prefix. The network prefix is the number of enabled bits in the subnet mask. This format of network address slash network prefix length is sometimes referred to as *classless inter-domain routing* (CIDR) notation.

Static route configuration can be stored per-interface in a **/etc/sysconfig/network-scripts/route-*interface*** file. For example, static routes for the eth0 interface would be stored in the **/etc/sysconfig/network-scripts/route-eth0** file. The **route-*interface*** file has two formats: **ip** command arguments and network/netmask directives. These are described below.

See the **ip-route(8)** man page for more information on the **ip route** command.

Configuring The Default Gateway

The default gateway is determined by the network scripts which parse the **/etc/sysconfig/network** file first and then the network interface **ifcfg** files for interfaces that are “up”. The **ifcfg** files are parsed in numerically ascending order, and the last GATEWAY directive to be read is used to compose a default route in the routing table.

The default route can thus be indicated by means of the GATEWAY directive and can be specified either globally or in interface-specific configuration files. Specifying the gateway globally has certain advantages in static networking environments, especially if more than one network interface is present. It can make fault finding simpler if applied consistently. There is also the GATEWAYDEV directive, which is a global option. If multiple devices specify GATEWAY, and one interface uses the GATEWAYDEV directive, that directive will take precedence. This option is not recommend as it can have unexpected consequences if an interface goes down and it can complicate fault finding.

In dynamic network environments, where mobile hosts are managed by **NetworkManager**, gateway information is likely to be interface specific and is best left to be assigned by **DHCP**. In special cases where it is necessary to influence **NetworkManager**'s selection of the exit interface to be used to reach a gateway, make use of the **DEFROUTE=no** command in the **ifcfg** files for those interfaces which do not lead to the default gateway.

Global default gateway configuration is stored in the **/etc/sysconfig/network** file. This file specifies gateway and host information for all network interfaces. For more information about this file and the directives it accepts, see Section D.1.13, “/etc/sysconfig/network”.

11.5. CONFIGURING STATIC ROUTES IN IFCFG FILES

Static routes set using **ip** commands at the command prompt will be lost if the system is shutdown or restarted. To configure static routes to be persistent after a system restart, they must be placed in per-interface configuration files in the **/etc/sysconfig/network-scripts/** directory. The file name should be of the format **route-*ifname***. There are two types of commands to use in the configuration files; **ip** commands as explained in Section 11.5.1, “Static Routes Using the IP Command Arguments Format” and the *Network/Netmask* format as explained in Section 11.5.2, “Network/Netmask Directives Format”.

11.5.1. Static Routes Using the IP Command Arguments Format

If required in a per-interface configuration file, for example **`/etc/sysconfig/network-scripts/route-eth0`**, define a route to a default gateway on the first line. This is only required if the gateway is not set via **`DHCP`** and is not set globally in the **`/etc/sysconfig/network`** file:

```
default via 192.168.1.1 dev interface
```

where *192.168.1.1* is the **`IP`** address of the default gateway. The *interface* is the interface that is connected to, or can reach, the default gateway. The **`dev`** option can be omitted, it is optional. Note that this setting takes precedence over a setting in the **`/etc/sysconfig/network`** file.

If a route to a remote network is required, a static route can be specified as follows. Each line is parsed as an individual route:

```
10.10.10.0/24 via 192.168.1.1 [dev interface]
```

where *10.10.10.0/24* is the network address and prefix length of the remote or destination network. The address *192.168.1.1* is the **`IP`** address leading to the remote network. It is preferably the *next hop address* but the address of the exit interface will work. The“next hop” means the remote end of a link, for example a gateway or router. The **`dev`** option can be used to specify the exit interface *interface* but it is not required. Add as many static routes as required.

The following is an example of a **`route-`*`interface`*** file using the **ip** command arguments format. The default gateway is **`192.168.0.1`**, interface eth0 and a leased line or WAN connection is available at **`192.168.0.10`**. The two static routes are for reaching the **`10.10.10.0/24`** network and the **`172.16.1.10/32`** host:

```
default via 192.168.0.1 dev eth0
10.10.10.0/24 via 192.168.0.10 dev eth0
172.16.1.10/32 via 192.168.0.10 dev eth0
```

In the above example, packets going to the local **`192.168.0.0/24`** network will be directed out the interface attached to that network. Packets going to the **`10.10.10.0/24`** network and **`172.16.1.10/32`** host will be directed to **`192.168.0.10`**. Packets to unknown, remote, networks will use the default gateway therefore static routes should only be configured for remote networks or hosts if the default route is not suitable. Remote in this context means any networks or hosts that are not directly attached to the system.

Specifying an exit interface is optional. It can be useful if you want to force traffic out of a specific interface. For example, in the case of a VPN, you can force traffic to a remote network to pass through a tun0 interface even when the interface is in a different subnet to the destination network.

IMPORTANT

If the default gateway is already assigned from **`DHCP`**, the **`IP`** command arguments format can cause one of two errors during start-up, or when bringing up an interface from the down state using the **`ifup`** command: "RTNETLINK answers: File exists" or 'Error: either "to" is a duplicate, or "*X.X.X.X*" is a garbage.', where *X.X.X.X* is the gateway, or a different **`IP`** address. These errors can also occur if you have another route to another network using the default gateway. Both of these errors are safe to ignore.

11.5.2. Network/Netmask Directives Format

You can also use the network/netmask directives format for **route-*interface*** files. The following is a template for the network/netmask format, with instructions following afterwards:

```
ADDRESS0=10.10.10.0
NETMASK0=255.255.255.0
GATEWAY0=192.168.1.1
```

- **ADDRESS0=*10.10.10.0*** is the network address of the remote network or host to be reached.
- **NETMASK0=*255.255.255.0*** is the netmask for the network address defined with **ADDRESS0=*10.10.10.0***.
- **GATEWAY0=*192.168.1.1*** is the default gateway, or an **IP** address that can be used to reach **ADDRESS0=*10.10.10.0***

The following is an example of a **route-*interface*** file using the network/netmask directives format. The default gateway is **192.168.0.1** but a leased line or WAN connection is available at **192.168.0.10**. The two static routes are for reaching the **10.10.10.0/24** and **172.16.1.0/24** networks:

```
ADDRESS0=10.10.10.0
NETMASK0=255.255.255.0
GATEWAY0=192.168.0.10
ADDRESS1=172.16.1.10
NETMASK1=255.255.255.0
GATEWAY1=192.168.0.10
```

Subsequent static routes must be numbered sequentially, and must not skip any values. For example, **ADDRESS0**, **ADDRESS1**, **ADDRESS2**, and so on.

11.6. CONFIGURING IPV6 TOKENIZED INTERFACE IDENTIFIERS

In a network, servers are generally given static addresses and these are usually configured manually to avoid relying on a **DHCP** server which may fail or run out of addresses. The **IPv6** protocol introduced *Stateless Address Autoconfiguration* (SLAAC) which enables clients to assign themselves an address without relying on a **DHCPv6** server. SLAAC derives the **IPv6** address based on the interface hardware, therefore it should not be used for servers in case the hardware is changed and the associated SLAAC generated address changes with it. In an **IPv6** environment, if the network prefix is changed, or the system is moved to a new location, any manually configured static addresses would have to be edited due to the changed prefix.

To address these problems, the IETF draft *Tokenised IPv6 Identifiers* has been implemented in the kernel together with corresponding additions to the **ip** utility. This enables the lower 64 bit interface identifier part of the **IPv6** address to be based on a token, supplied by the administrator, leaving the network prefix, the higher 64 bits, to be obtained from *router advertisements* (RA). This means that if the network interface hardware is changed, the lower 64 bits of the address will not change, and if the system is moved to another network, the network prefix will be obtained from router advertisements automatically, thus no manual editing is required.

To configure an interface to use a tokenized **IPv6** identifier, issue a command in the following format as **root** user:

```
~]# ip token set ::1a:2b:3c:4d/64 dev eth4
```

Where **`::1a:2b:3c:4d/64`** is the token to be used. This setting is not persistent. To make it persistent, add the command to an init script. See Section 11.3, “Interface Control Scripts”.

Using a memorable token is possible, but is limited to the range of valid hexadecimal digits. For example, for a **`DNS`** server, which traditionally uses port **`53`**, a token of **`::53/64`** could be used.

To view all the configured **`IPv6`** tokens, issue the following command:

```
~]$ ip token
     token :: dev eth0
     token :: dev eth1
     token :: dev eth2
     token :: dev eth3
     token ::1a:2b:3c:4d dev eth4
```

To view the configured **`IPv6`** token for a specific interface, issue the following command:

```
~]$ ip token get dev eth4
     token ::1a:2b:3c:4d dev eth4
```

Note that adding a token to an interface will replace a previously allocated token, and in turn invalidate the address derived from it. Supplying a new token causes a new address to be generated and applied, but this process will leave any other addresses unchanged. In other words, a new tokenized identifier only replaces a previously existing tokenized identifier, not any other **`IP`** address.

NOTE

Take care not to add the same token to more than one system or interface as the duplicate address detection (DAD) mechanism will not be able to resolve the problem. Once a token is set, it cannot be cleared or reset, except by rebooting the machine.

11.7. NETWORK FUNCTION FILES

Red Hat Enterprise Linux makes use of several files that contain important common functions used to bring interfaces up and down. Rather than forcing each interface control file to contain these functions, they are grouped together in a few files that are called upon when necessary.

The **`/etc/sysconfig/network-scripts/network-functions`** file contains the most commonly used **`IPv4`** functions, which are useful to many interface control scripts. These functions include contacting running programs that have requested information about changes in the status of an interface, setting host names, finding a gateway device, verifying whether or not a particular device is down, and adding a default route.

As the functions required for **`IPv6`** interfaces are different from **`IPv4`** interfaces, a **`/etc/sysconfig/network-scripts/network-functions-ipv6`** file exists specifically to hold this information. The functions in this file configure and delete static **`IPv6`** routes, create and remove tunnels, add and remove **`IPv6`** addresses to an interface, and test for the existence of an **`IPv6`** address on an interface.

11.8. ETHTOOL

Ethtool is a utility for configuration of *Network Interface Cards* (NICs). This utility allows querying and changing settings such as speed, port, auto-negotiation, PCI locations and checksum offload on many network devices, especially Ethernet devices.

We present here a short selection of often used **ethtool** commands together with some useful commands that are not well known. For a full list of commands type **`ethtool -h`** or see the man page, **`ethtool(8)`**, for a more comprehensive list and explanation. The first two examples are information queries and show the use of the different formats of the command.

But first, the command structure:

```
ethtool [option...] devname
```

where *option* is none or more options, and *devname* is your Network Interface Card (NIC). For example eth0 or em1.

`ethtool`

The **`ethtool`** command with only a device name as an option is used to print the current settings of the specified device. It takes the following form:

```
ethtool devname
```

where *devname* is your NIC. For example eth0 or em1.

Some values can only be obtained when the command is run as **`root`**. Here is an example of the output when the command is run as **`root`**:

```
~]# ethtool em1
Settings for em1:
 Supported ports: [ TP ]
 Supported link modes:   10baseT/Half 10baseT/Full
                         100baseT/Half 100baseT/Full
                         1000baseT/Full
 Supported pause frame use: No
 Supports auto-negotiation: Yes
 Advertised link modes:  10baseT/Half 10baseT/Full
                         100baseT/Half 100baseT/Full
                         1000baseT/Full
 Advertised pause frame use: No
 Advertised auto-negotiation: Yes
 Speed: 1000Mb/s
 Duplex: Full
 Port: Twisted Pair
 PHYAD: 2
 Transceiver: internal
 Auto-negotiation: on
 MDI-X: on
 Supports Wake-on: pumbg
 Wake-on: g
 Current message level: 0x00000007 (7)
          drv probe link
 Link detected: yes
```

Issue the following command, using the short or long form of the argument, to query the specified network device for associated driver information:

```
ethtool -i, --driver devname
```

where *devname* is your Network Interface Card (NIC). For example eth0 or em1.

Here is an example of the output:

```
~]$ ethtool -i em1
driver: e1000e
version: 2.0.0-k
firmware-version: 0.13-3
bus-info: 0000:00:19.0
supports-statistics: yes
supports-test: yes
supports-eeprom-access: yes
supports-register-dump: yes
```

Here follows a list of command options to query, identify or reset the device. They are in the usual **`-short`** and **`--long`** form:

`--statistics`

The **`--statistics`** or **`-S`** queries the specified network device for NIC and driver statistics. It takes the following form:

```
-S, --statistics devname
```

where *devname* is your NIC.

`--identify`

The **`--identify`** or **`-p`** option initiates adapter-specific action intended to enable an operator to easily identify the adapter by sight. Typically this involves blinking one or more LEDs on the specified network port. It takes the following form:

```
-p, --identify devname integer
```

where *integer* is length of time in seconds to perform the action,

and *devname* is your NIC.

`--show-time-stamping`

The **`--show-time-stamping`** or **`-T`** option queries the specified network device for time stamping parameters. It takes the following form:

```
-T, --show-time-stamping devname
```

where *devname* is your NIC.

`--show-offload`

The **--show-features**, or **--show-offload**, or **-k** option queries the specified network device for the state of protocol offload and other features. It takes the following form:

```
-k, --show-features, --show-offload devname
```

where *devname* is your NIC.

--test

The **--test** or **-t** option is used to perform tests on a Network Interface Card. It takes the following form:

```
-t, --test devname word
```

where *word* is one of the following:

- **offline** — Perform a comprehensive set of tests. Service will be interrupted.
- **online** — Perform a reduced set of tests. Service should not be interrupted.
- **external_lb** — Perform full set of tests including loopback tests while fitted with a loopback cable.

and *devname* is your NIC.

Changing some or all settings of the specified network device requires the **-s** or **--change** option. All the following options are only applied if the **-s** or **--change** option is also specified. For the sake of clarity we will omit it here.

To make these settings permanent you can make use of the **ETHTOOL_OPTS** directive. It can be used in interface configuration files to set the desired options when the network interface is brought up. See Section 11.2.1, “Ethernet Interfaces” for more details on how to use this directive.

--offload

The **--features**, or **--offload**, or **-K** option changes the offload parameters and other features of the specified network device. It takes the following form:

```
-K, --features, --offload devname feature boolean
```

where *feature* is a built-in or kernel supplied feature,

boolean is one of **ON** or **OFF**,

and *devname* is your NIC.

The **ethtool(8)** man page lists most features. As the feature set is dependent on the NIC driver, you should consult the driver documentation for features not listed in the man page.

--speed

The **--speed** option is used to set the speed in megabits per second (Mb/s). Omitting the speed value will show the supported device speeds. It takes the following form:

```
--speed number devname
```

where *number* is the speed in megabits per second (Mb/s),

and *devname* is your NIC.

--duplex

The **--duplex** option is used to set the transmit and receive mode of operation. It takes the following form:

```
--duplex word devname
```

where *word* is one of the following:

- **half** — Sets half-duplex mode. Usually used when connected to a hub.
- **full** — Sets full-duplex mode. Usually used when connected to a switch or another host.

and *devname* is your NIC.

--port

The **--port** option is used to select the device port . It takes the following form:

```
--port value devname
```

where *value* is one of the following:

- **tp** — An Ethernet interface using Twisted-Pair cable as the medium.
- **aui** — Attachment Unit Interface (AUI). Normally used with hubs.
- **bnc** — An Ethernet interface using BNC connectors and co-axial cable.
- **mii** — An Ethernet interface using a Media Independent Interface (MII).
- **fibre** — An Ethernet interface using Optical Fibre as the medium.

and *devname* is your NIC.

--autoneg

The **--autoneg** option is used to control auto-negotiation of network speed and mode of operation (full-duplex or half-duplex mode). If auto-negotiation is enabled you can initiate re-negotiation of network speeds and mode of operation by using the **-r, --negotiate** option. You can display the auto-negotiation state using the **--a, --show-pause** option.

It takes the following form:

```
--autoneg value devname
```

where *value* is one of the following:

- **yes** — Allow auto-negotiating of network speed and mode of operation.
- **no** — Do not allow auto-negotiating of network speed and mode of operation.

and *devname* is your NIC.

--advertise

The **--advertise** option is used to set what speeds and modes of operation (duplex mode) are advertised for auto-negotiation. The argument is one or more hexadecimal values from Table 11.1, “Ethtool advertise options: speed and mode of operation”.

It takes the following form:

```
--advertise option devname
```

where *option* is one or more of the hexadecimal values from the table below and *devname* is your NIC.

Table 11.1. Ethtool advertise options: speed and mode of operation

Hex Value	Speed	Duplex Mode	IEEE standard?
0x001	10	Half	Yes
0x002	10	Full	Yes
0x004	100	Half	Yes
0x008	100	Full	Yes
0x010	1000	Half	No
0x020	1000	Full	Yes
0x8000	2500	Full	Yes
0x1000	10000	Full	Yes
0x20000	20000MLD2	Full	No
0x20000	20000MLD2	Full	No
0x40000	20000KR2	Full	No

--phyad

The **--phyad** option is used to change the physical address. Often referred to as the MAC or hardware address but in this context referred to as the physical address.

It takes the following form:

```
--phyad physical_address devname
```

where *physical_address* is the physical address in hexadecimal format and *devname* is your NIC.

--xcvr

The **--xcvr** option is used to select the transceiver type. Currently only “internal” and “external” can be specified. In the future other types might be added.

It takes the following form:

```
--xcvr word devname
```

where *word* is one of the following:

- **internal** — Use internal transceiver.
- **external** — Use external transceiver.

and *devname* is your NIC.

--wol

The **--wol** option is used to set “Wake-on-LAN” options. Not all devices support this. The argument to this option is a string of characters specifying which options to enable.

It takes the following form:

```
--wol value devname
```

where *value* is one or more of the following:

- **p** — Wake on PHY activity.
- **u** — Wake on unicast messages.
- **m** — Wake on multicast messages.
- **b** — Wake on broadcast messages.
- **g** — Wake-on-Lan; wake on receipt of a "magic packet".
- **s** — Enable security function using password for Wake-on-Lan.
- **d** — Disable Wake-on-Lan and clear all settings.

and *devname* is your NIC.

--sopass

The **--sopass** option is used to set the “SecureOn” password. The argument to this option must be 6 bytes in Ethernet MAC hexadecimal format (xx:yy:zz:aa:bb:cc).

It takes the following form:

```
--sopass xx:yy:zz:aa:bb:cc devname
```

where *xx:yy:zz:aa:bb:cc* is the password in the same format as a MAC address and *devname* is your NIC.

`--msglvl`

The **`--msglvl`** option is used to set the driver message-type flags by name or number. The precise meanings of these type flags differ between drivers.

It takes the following form:

```
--msglvl message_type devname
```

where *message_type* is one of:

- message type name in plain text.
- hexadecimal number indicating the message type.

and *devname* is your NIC.

The defined message type names and numbers are shown in the table below:

Table 11.2. Driver message type

Message Type	Hex Value	Description
drv	0x0001	General driver status
probe	0x0002	Hardware probing
link	0x0004	Link state
timer	0x0008	Periodic status check
ifdown	0x0010	Interface being brought down
ifup	0x0020	Interface being brought up
rx_err	0x0040	Receive error
tx_err	0x0080	Transmit error
intr	0x0200	Interrupt handling
tx_done	0x0400	Transmit completion
rx_status	0x0800	Receive completion
pktdata	0x1000	Packet contents
hw	0x2000	Hardware status
wol	0x4000	Wake-on-LAN status

11.9. CONFIGURING 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.

Configuring a Listening Machine

To enable receiving **netconsole** logging messages, install the rsyslog package:

```
]# yum install rsyslog
```

To configure **rsyslogd** to listen on the 514/UDP port and receive messages from the network, uncomment the following lines in the **MODULES** section of **/etc/rsyslog.conf**:

```
$ModLoad imudp
$UDPServerRun 514
```

Restart the **rsyslogd** service for the changes to take effect:

```
]# service rsyslog restart
```

To verify that **rsyslogd** is listening on the 514/udp port, use the following command:

```
]# netstat -l | grep syslog
udp        0      0 *:syslog                    *:*
udp        0      0 *:syslog                    *:*
```

The **0 *:syslog** value in the **netstat -l** output mean that **rsyslogd** is listening on default **netconsole** port, which is defined in the **/etc/services** file:

```
]$ cat /etc/services | grep syslog
syslog          514/udp
syslog-conn     601/tcp                 # Reliable Syslog Service
syslog-conn     601/udp                 # Reliable Syslog Service
syslog-tls      6514/tcp                # Syslog over TLS
```

Configuring a Sending Machine

In Red Hat Enterprise Linux 6, **netconsole** is configured using the file **/etc/sysconfig/netconsole**, which is part of the initscripts package. This package is installed by default and it also provides the **netconsole** service.

To configure a sending machine, set the value of the **SYSLOGADDR** variable in the **/etc/sysconfig/netconsole** file to match the IP address of the **syslogd** server, for example:

```
SYSLOGADDR=192.168.0.1
```

Restart the **netconsole** service so the changes take effect. Then, use the **chkconfig** command to ensure **netconsole** service starts automatically after next reboot:

```
]# service netconsole restart
Initializing netconsole                                   [  OK  ]
]# chkconfig netconsole on
```

–

By default, the **rsyslogd** server writes the **netconsole** messages from the client in **/var/log/messages** or in the file specified in **rsyslog.conf**.

NOTE

To set **rsyslogd** and **netconsole** to use a different port, change the following line in **/etc/rsyslog.conf** to the desired port number:

```
$UDPServerRun <PORT>
```

On the sending machine, uncomment and edit the following line in the **/etc/sysconfig/netconsole** file:

```
SYSLOGPORT=514
```

For more information about **netconsole** configuration and troubleshooting tips, see Netconsole Kernel Documentation.

11.10. ADDITIONAL RESOURCES

The following are resources which explain more about network interfaces.

Installed Documentation

- **/usr/share/doc/initscripts-*version*/sysconfig.txt** — A guide to available options for network configuration files, including **IPv6** options not covered in this chapter.

Online Resources

- http://linux-ip.net/gl/ip-cref/ — This document contains a wealth of information about the **ip** command, which can be used to manipulate routing tables, among other things.
- Red Hat Access Labs — The Red Hat Access Labs includes a "Network Bonding Helper".

See Also

- Appendix E, *The proc File System* — Describes the **sysctl** utility and the virtual files within the **/proc/** directory, which contain networking parameters and statistics among other things.

PART V. INFRASTRUCTURE SERVICES

This part provides information how to configure services and daemons, configure authentication, and enable remote logins.

CHAPTER 12. SERVICES AND DAEMONS

Maintaining security on your system is extremely important, and one approach for this task is to manage access to system services carefully. Your system may need to provide open access to particular services (for example, **`httpd`** if you are running a web server). However, if you do not need to provide a service, you should turn it off to minimize your exposure to possible bug exploits.

This chapter explains the concept of runlevels, and describes how to set the default one. It also covers the setup of the services to be run in each of these runlevels, and provides information on how to start, stop, and restart the services on the command line using the **service** command.

IMPORTANT

When you allow access for new services, always remember that both the firewall and **SELinux** need to be configured as well. One of the most common mistakes committed when configuring a new service is neglecting to implement the necessary firewall configuration and SELinux policies to allow access for it. For more information, see the Red Hat Enterprise Linux 6 *Security Guide*.

12.1. CONFIGURING THE DEFAULT RUNLEVEL

A *runlevel* is a state, or *mode*, defined by services that are meant to be run when this runlevel is selected. Seven numbered runlevels exist (indexed from *0*):

Table 12.1. Runlevels in Red Hat Enterprise Linux

Runlevel	Description
`0`	Used to halt the system. This runlevel is reserved and cannot be changed.
`1`	Used to run in a single-user mode. This runlevel is reserved and cannot be changed.
`2`	Not used by default. You are free to define it yourself.
`3`	Used to run in a full multi-user mode with a command-line user interface.
`4`	Not used by default. You are free to define it yourself.
`5`	Used to run in a full multi-user mode with a graphical user interface.
`6`	Used to reboot the system. This runlevel is reserved and cannot be changed.

To check in which runlevel you are operating, type the following:

```
~]$ runlevel
N 5
```

The **`runlevel`** command displays previous and current runlevel. In this case it is number *5*, which means the system is running in a full multi-user mode with a graphical user interface.

The default runlevel can be changed by modifying the **`/etc/inittab`** file, which contains a line near the end of the file similar to the following:

```
id:5:initdefault:
```

To do so, edit this file as **`root`** and change the number on this line to the desired value. The change will take effect the next time you reboot the system.

12.2. CONFIGURING THE SERVICES

To allow you to configure which services are started at boot time, Red Hat Enterprise Linux is shipped with the following utilities: the **Service Configuration** graphical application, the **ntsysv** text user interface, and the **chkconfig** command-line tool.

IMPORTANT

To ensure optimal performance on POWER architecture, it is recommended that the **`irqbalance`** service is enabled. In most cases, this service is installed and configured to run during the Red Hat Enterprise Linux 6 installation. To verify that **`irqbalance`** is running, as **`root`**, type the following at a shell prompt:

```
~]# service irqbalance status
irqbalance (pid  1234) is running...
```

For information on how to enable and run a service using a graphical user interface, see Section 12.2.1, “Using the Service Configuration Utility”. For instructions on how to perform these task on the command line, see Section 12.2.3, “Using the chkconfig Utility” and Section 12.3, “Running Services” respectively.

12.2.1. Using the Service Configuration Utility

The **Service Configuration** utility is a graphical application developed by Red Hat to configure which services are started in a particular runlevel, as well as to start, stop, and restart them from the menu. To start the utility, select **System** → **Administration** → **Services** from the panel, or type the command **`system-config-services`** at a shell prompt.

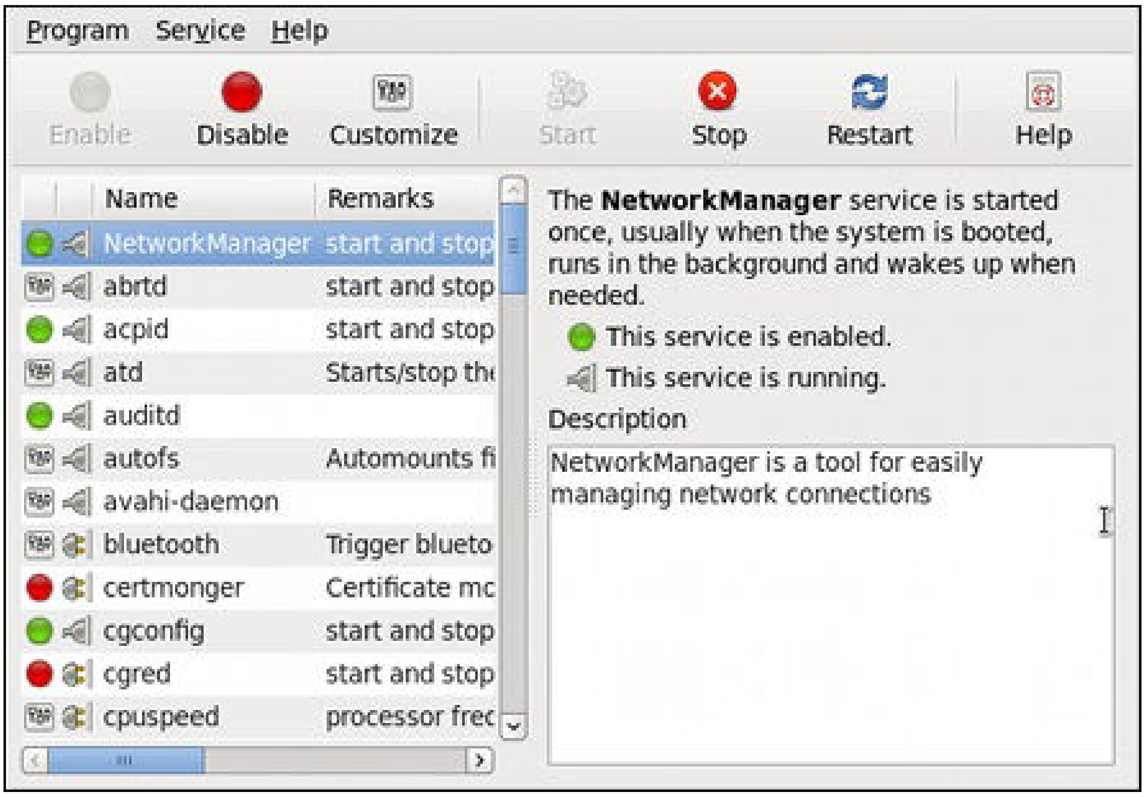
NOTE

The **`system-config-services`** utility is provided by the system-config-services package, which may not be installed by default on your version of Red Hat Enterprise Linux. To ensure that, first run the following command:

```
~]$ rpm -q system-config-services
```

If the package is not installed by default, install it manually by running the following command as root:

```
~]# yum install system-config-services
```



Name	Remarks
NetworkManager	start and stop
abrtd	start and stop
acpid	start and stop
atd	Starts/stop th
auditd	
autofs	Automounts fi
avahi-daemon	
bluetooth	Trigger blueto
certmonger	Certificate mc
cgconfig	start and stop
cgred	start and stop
cpuspeed	processor frec

The **NetworkManager** service is started once, usually when the system is booted, runs in the background and wakes up when needed.

This service is enabled.

This service is running.

Description

NetworkManager is a tool for easily managing network connections

Figure 12.1. The Service Configuration utility

The utility displays the list of all available services (services from the **`/etc/rc.d/init.d/`** directory, as well as services controlled by **xinetd**) along with their description and the current status. For a complete list of used icons and an explanation of their meaning, see Table 12.2, “Possible service states”.

Note that unless you are already authenticated, you will be prompted to enter the superuser password the first time you make a change.

Table 12.2. Possible service states

Icon	Description
🟢	The service is enabled.
🔴	The service is disabled.
▦	The service is enabled for selected runlevels only.
◀	The service is running.
◧	The service is stopped.
⚠	There is something wrong with the service.

Icon	Description
◈	The status of the service is unknown.

12.2.1.1. Enabling and Disabling a Service

To enable a service, select it from the list and either click the `Enable` button on the toolbar, or choose **Service** → **Enable** from the main menu.

To disable a service, select it from the list and either click the `Disable` button on the toolbar, or choose **Service** → **Disable** from the main menu.

12.2.1.2. Starting, Restarting, and Stopping a Service

To start a service, select it from the list and either click the `Start` button on the toolbar, or choose **Service** → **Start** from the main menu. Note that this option is not available for services controlled by **xinetd**, as they are started by it on demand.

To restart a running service, select it from the list and either click the `Restart` button on the toolbar, or choose **Service** → **Restart** from the main menu. Note that this option is not available for services controlled by **xinetd**, as they are started and stopped by it automatically.

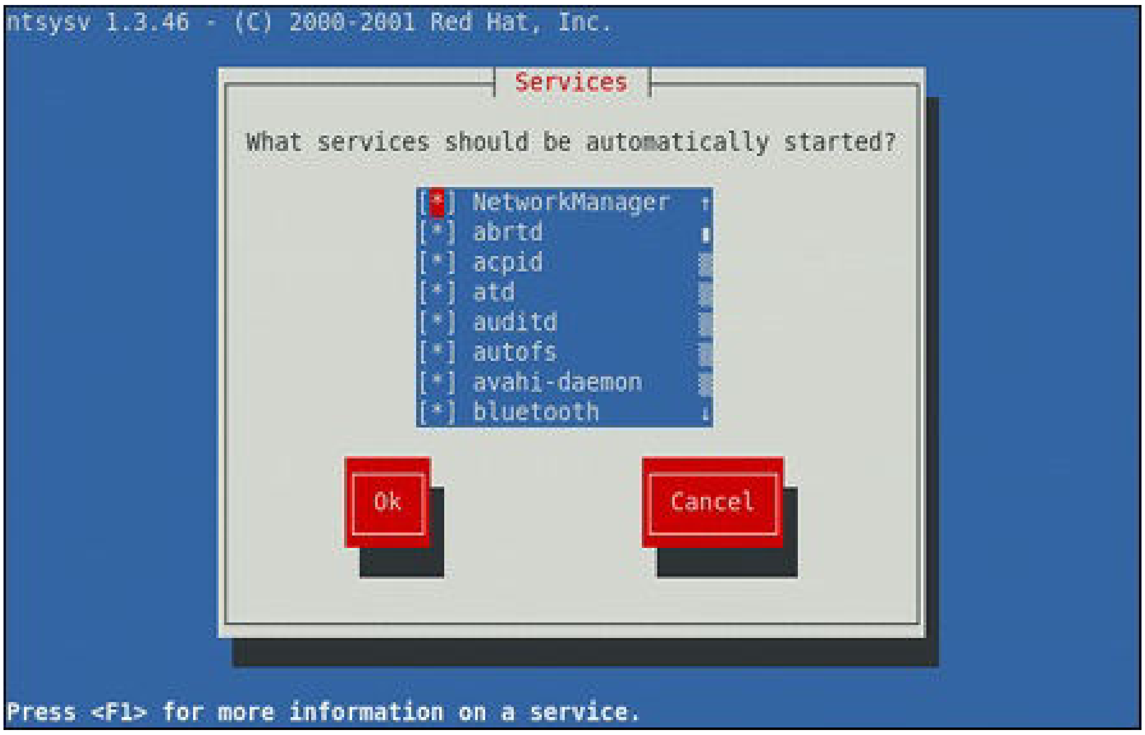
To stop a service, select it from the list and either click the `Stop` button on the toolbar, or choose **Service** → **Stop** from the main menu. Note that this option is not available for services controlled by **xinetd**, as they are stopped by it when their job is finished.

12.2.1.3. Selecting Runlevels

To enable the service for certain runlevels only, select it from the list and either click the `Customize` button on the toolbar, or choose **Service** → **Customize** from the main menu. Then select the check box beside each runlevel in which you want the service to run. Note that this option is not available for services controlled by **xinetd**.

12.2.2. Using the ntsysv Utility

The **ntsysv** utility is a command-line application with a simple text user interface to configure which services are to be started in selected runlevels. To start the utility, type `ntsysv` at a shell prompt as `root`.



```
ntsysv 1.3.46 - (C) 2000-2001 Red Hat, Inc.

                       Services

   What services should be automatically started?

              [*] NetworkManager
              [*] abrtd
              [*] acpid
              [*] atd
              [*] auditd
              [*] autofs
              [*] avahi-daemon
              [*] bluetooth

           Ok                     Cancel

Press <F1> for more information on a service.
```

Figure 12.2. The ntsysv utility

The utility displays the list of available services (the services from the **`/etc/rc.d/init.d/`** directory) along with their current status and a description obtainable by pressing **`F1`**. For a list of used symbols and an explanation of their meaning, see Table 12.3, “Possible service states”.

Table 12.3. Possible service states

Symbol	Description
`[*]`	The service is enabled.
`[ ]`	The service is disabled.

12.2.2.1. Enabling and Disabling a Service

To enable a service, navigate through the list using the **`Up`** and **`Down`** arrows keys, and select it with the **`Spacebar`**. An asterisk (**`*`**) appears in the brackets.

To disable a service, navigate through the list using the **`Up`** and **`Down`** arrows keys, and toggle its status with the **`Spacebar`**. An asterisk (**`*`**) in the brackets disappears.

Once you are done, use the **`Tab`** key to navigate to the **`Ok`** button, and confirm the changes by pressing **`Enter`**. Keep in mind that **ntsysv** does not actually start or stop the service. If you need to start or stop the service immediately, use the **`service`** command as described in Section 12.3.2, “Starting a Service”.

12.2.2.2. Selecting Runlevels

By default, the **ntsysv** utility only affects the current runlevel. To enable or disable services for other runlevels, as **`root`**, run the command with the additional **`--level`** option followed by numbers from 0 to 6 representing each runlevel you want to configure:

```
ntsysv --level runlevels
```

For example, to configure runlevels 3 and 5, type:

```
~]# ntsysv --level 35
```

12.2.3. Using the chkconfig Utility

The **chkconfig** utility is a command-line tool that allows you to specify in which runlevel to start a selected service, as well as to list all available services along with their current setting. Note that with the exception of listing, you must have superuser privileges to use this command.

12.2.3.1. Listing the Services

To display a list of system services (services from the **`/etc/rc.d/init.d/`** directory, as well as the services controlled by **xinetd**), either type **`chkconfig --list`**, or use **`chkconfig`** with no additional arguments. You will be presented with an output similar to the following:

```
~]# chkconfig --list
NetworkManager  0:off   1:off   2:on    3:on    4:on    5:on    6:off
abrtd           0:off   1:off   2:off   3:on    4:off   5:on    6:off
acpid           0:off   1:off   2:on    3:on    4:on    5:on    6:off
anamon          0:off   1:off   2:off   3:off   4:off   5:off   6:off
atd             0:off   1:off   2:off   3:on    4:on    5:on    6:off
auditd          0:off   1:off   2:on    3:on    4:on    5:on    6:off
avahi-daemon    0:off   1:off   2:off   3:on    4:on    5:on    6:off
... several lines omitted ...
wpa_supplicant  0:off   1:off   2:off   3:off   4:off   5:off   6:off

xinetd based services:
        chargen-dgram:  off
        chargen-stream: off
        cvs:            off
        daytime-dgram:  off
        daytime-stream: off
        discard-dgram:  off
... several lines omitted ...
        time-stream:    off
```

Each line consists of the name of the service followed by its status (*on* or *off*) for each of the seven numbered runlevels. For example, in the listing above, **NetworkManager** is enabled in runlevel 2, 3, 4, and 5, while **abrtd** runs in runlevel 3 and 5. The **xinetd** based services are listed at the end, being either *on*, or *off*.

To display the current settings for a selected service only, use **`chkconfig --list`** followed by the name of the service:

```
chkconfig --list service_name
```

For example, to display the current settings for the **sshd** service, type:

```
~]# chkconfig --list sshd
sshd            0:off   1:off   2:on    3:on    4:on    5:on    6:off
```

You can also use this command to display the status of a service that is managed by **xinetd**. In that case, the output will only contain the information whether the service is enabled or disabled:

```
~]# chkconfig --list rsync
rsync           off
```

12.2.3.2. Enabling a Service

To enable a service in runlevels 2, 3, 4, and 5, type the following at a shell prompt as **root**:

```
chkconfig service_name on
```

For example, to enable the **httpd** service in these four runlevels, type:

```
~]# chkconfig httpd on
```

To enable a service in certain runlevels only, add the **--level** option followed by numbers from 0 to 6 representing each runlevel in which you want the service to run:

```
chkconfig service_name on --level runlevels
```

For instance, to enable the **abrtd** service in runlevels 3 and 5, type:

```
~]# chkconfig abrtd on --level 35
```

The service will be started the next time you enter one of these runlevels. If you need to start the service immediately, use the **service** command as described in Section 12.3.2, “Starting a Service”.

Do *not* use the **--level** option when working with a service that is managed by **xinetd**, as it is not supported. For example, to enable the **rsync** service, type:

```
~]# chkconfig rsync on
```

If the **xinetd** daemon is running, the service is immediately enabled without having to manually restart the daemon.

12.2.3.3. Disabling a Service

To disable a service in runlevels 2, 3, 4, and 5, type the following at a shell prompt as **root**:

```
chkconfig service_name off
```

For instance, to disable the **httpd** service in these four runlevels, type:

```
~]# chkconfig httpd off
```

To disable a service in certain runlevels only, add the **--level** option followed by numbers from 0 to 6 representing each runlevel in which you do *not* want the service to run:

```
chkconfig service_name off --level runlevels
```

For instance, to disable the **abrtd** in runlevels 2 and 4, type:

```
~]# chkconfig abrtd off --level 24
```

The service will be stopped the next time you enter one of these runlevels. If you need to stop the service immediately, use the **service** command as described in Section 12.3.3, “Stopping a Service”.

Do *not* use the **--level** option when working with a service that is managed by **xinetd**, as it is not supported. For example, to disable the **rsync** service, type:

```
~]# chkconfig rsync off
```

If the **xinetd** daemon is running, the service is immediately disabled without having to manually restart the daemon.

12.3. RUNNING SERVICES

The **service** utility allows you to start, stop, or restart the services from the **/etc/init.d/** directory.

12.3.1. Determining the Service Status

To determine the current status of a service, type the following at a shell prompt:

```
service service_name status
```

For example, to determine the status of the **httpd** service, type:

```
~]# service httpd status
httpd (pid  7474) is running...
```

To display the status of all available services at once, run the **service** command with the **--status-all** option:

```
~]# service --status-all
abrt (pid  1492) is running...
acpid (pid  1305) is running...
atd (pid  1540) is running...
auditd (pid  1103) is running...
automount (pid 1315) is running...
Avahi daemon is running
cpuspeed is stopped
... several lines omitted ...
wpa_supplicant (pid  1227) is running...
```

Note that you can also use the **Service Configuration** utility as described in Section 12.2.1, “Using the Service Configuration Utility”.

12.3.2. Starting a Service

To start a service, type the following at a shell prompt as **root**:

```
service service_name start
```

For example, to start the **httpd** service, type:

```
~]# service httpd start
Starting httpd:                                             [  OK  ]
```

12.3.3. Stopping a Service

To stop a running service, type the following at a shell prompt as **root**:

```
service service_name stop
```

For example, to stop the **httpd** service, type:

```
~]# service httpd stop
Stopping httpd:                                             [  OK  ]
```

12.3.4. Restarting a Service

To restart the service, type the following at a shell prompt as **root**:

```
service service_name restart
```

For example, to restart the **httpd** service, type:

```
~]# service httpd restart
Stopping httpd:                                             [  OK  ]
Starting httpd:                                             [  OK  ]
```

12.4. ADDITIONAL RESOURCES

12.4.1. Installed Documentation

- **chkconfig**(8) — a manual page for the **chkconfig** utility.
- **ntsysv**(8) — a manual page for the **ntsysv** utility.
- **service**(8) — a manual page for the **service** utility.
- **system-config-services**(8) — a manual page for the **system-config-services** utility.

12.4.2. Related Books

Red Hat Enterprise Linux 6 Security Guide

A guide to securing Red Hat Enterprise Linux 6. It contains valuable information on how to set up the firewall, as well as the configuration of **SELinux**.

CHAPTER 13. CONFIGURING AUTHENTICATION

Authentication is the way that a user is identified and verified to a system. The authentication process requires presenting some sort of identity and credentials, like a user name and password. The credentials are then compared to information stored in some data store on the system. In Red Hat Enterprise Linux, the Authentication Configuration Tool helps configure what kind of data store to use for user credentials, such as LDAP.

For convenience and potentially part of single sign-on, Red Hat Enterprise Linux can use a central daemon to store user credentials for a number of different data stores. The System Security Services Daemon (SSSD) can interact with LDAP, Kerberos, and external applications to verify user credentials. The Authentication Configuration Tool can configure SSSD along with NIS, Winbind, and LDAP, so that authentication processing and caching can be combined.

13.1. CONFIGURING SYSTEM AUTHENTICATION

When a user logs into a Red Hat Enterprise Linux system, that user presents some sort of *credential* to establish the user identity. The system then checks those credentials against the configured authentication service. If the credentials match and the user account is active, then the user is *authenticated*. (Once a user is authenticated, then the information is passed to the access control service to determine what the user is permitted to do. Those are the resources the user is *authorized* to access.)

The information to verify the user can be located on the local system or the local system can reference a user database on a remote system, such as LDAP or Kerberos.

The system must have a configured list of valid account databases for it to check for user authentication. On Red Hat Enterprise Linux, the Authentication Configuration Tool has both GUI and command-line options to configure any user data stores.

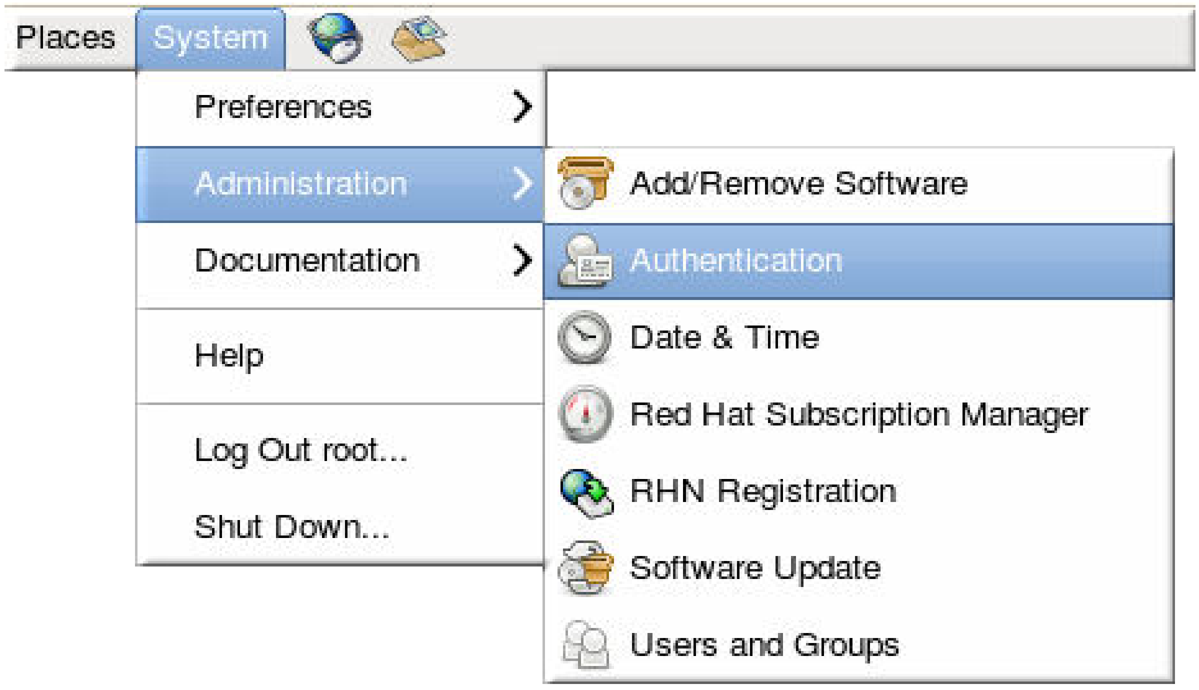
A local system can use a variety of different data stores for user information, including Lightweight Directory Access Protocol (LDAP), Network Information Service (NIS), and Winbind. Additionally, both LDAP and NIS data stores can use Kerberos to authenticate users.

IMPORTANT

If a medium or high security level is set during installation or with the Security Level Configuration Tool, then the firewall prevents NIS authentication. For more information about firewalls, see the "Firewalls" section of the *Security Guide*.

13.1.1. Launching the Authentication Configuration Tool UI

1. Log into the system as root.
2. Open the **System**.
3. Select the **Administration** menu.
4. Select the **Authentication** item.



Alternatively, run the **`system-config-authentication`** command.

IMPORTANT

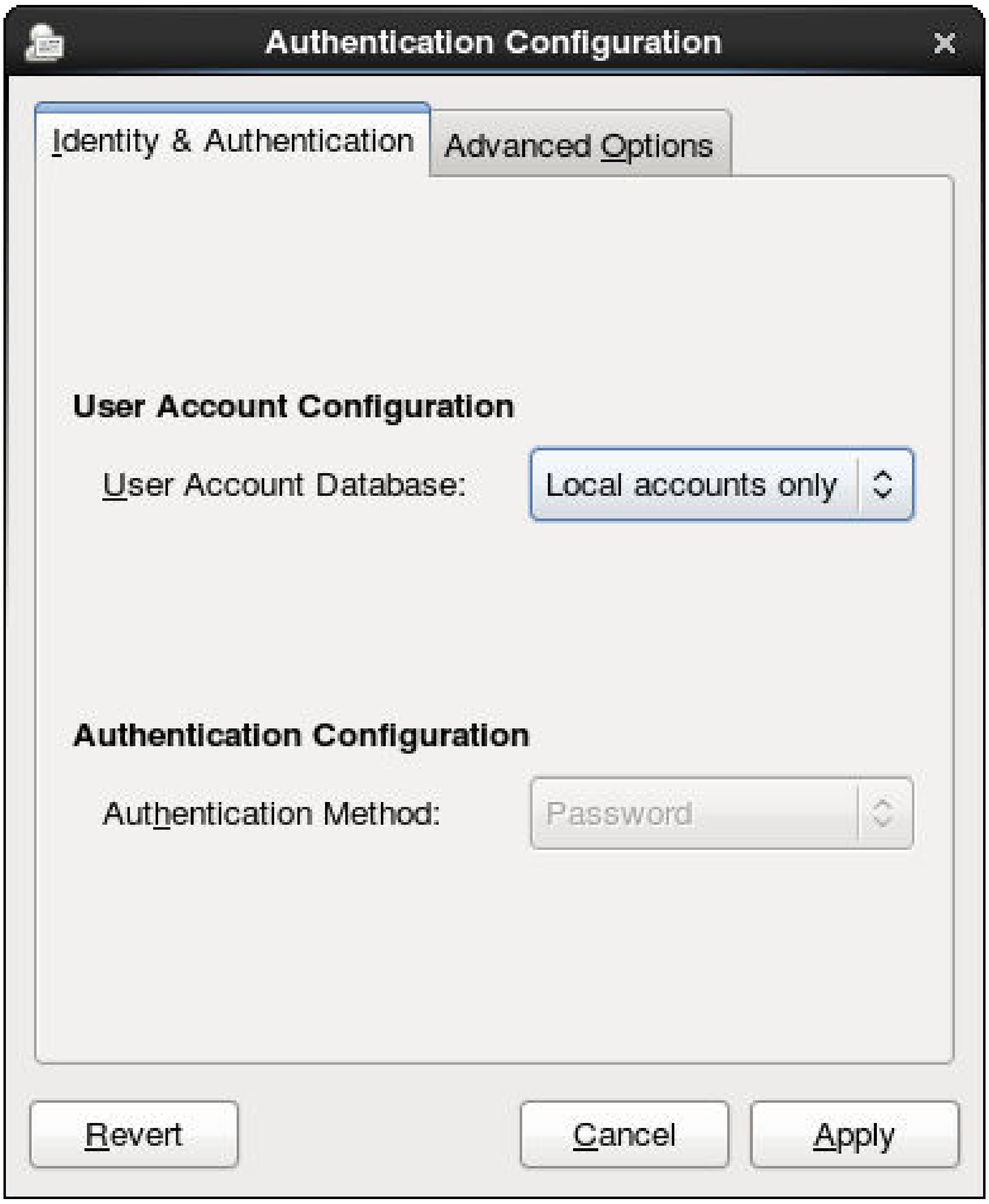
Any changes take effect immediately when the Authentication Configuration Tool UI is closed.

There are two configuration tabs in the **`Authentication`** dialog box:

- **`Identity & Authentication`**, which configures the resource used as the identity store (the data repository where the user IDs and corresponding credentials are stored).
- **`Advanced Options`**, which allows authentication methods other than passwords or certificates, like smart cards and fingerprint.

13.1.2. Selecting the Identity Store for Authentication

The **`Identity & Authentication`** tab sets how users should be authenticated. The default is to use local system authentication, meaning the users and their passwords are checked against local system accounts. A Red Hat Enterprise Linux machine can also use external resources which contain the users and credentials, including LDAP, NIS, and Winbind.



User Account Configuration

User Account Database: Local accounts only

Authentication Configuration

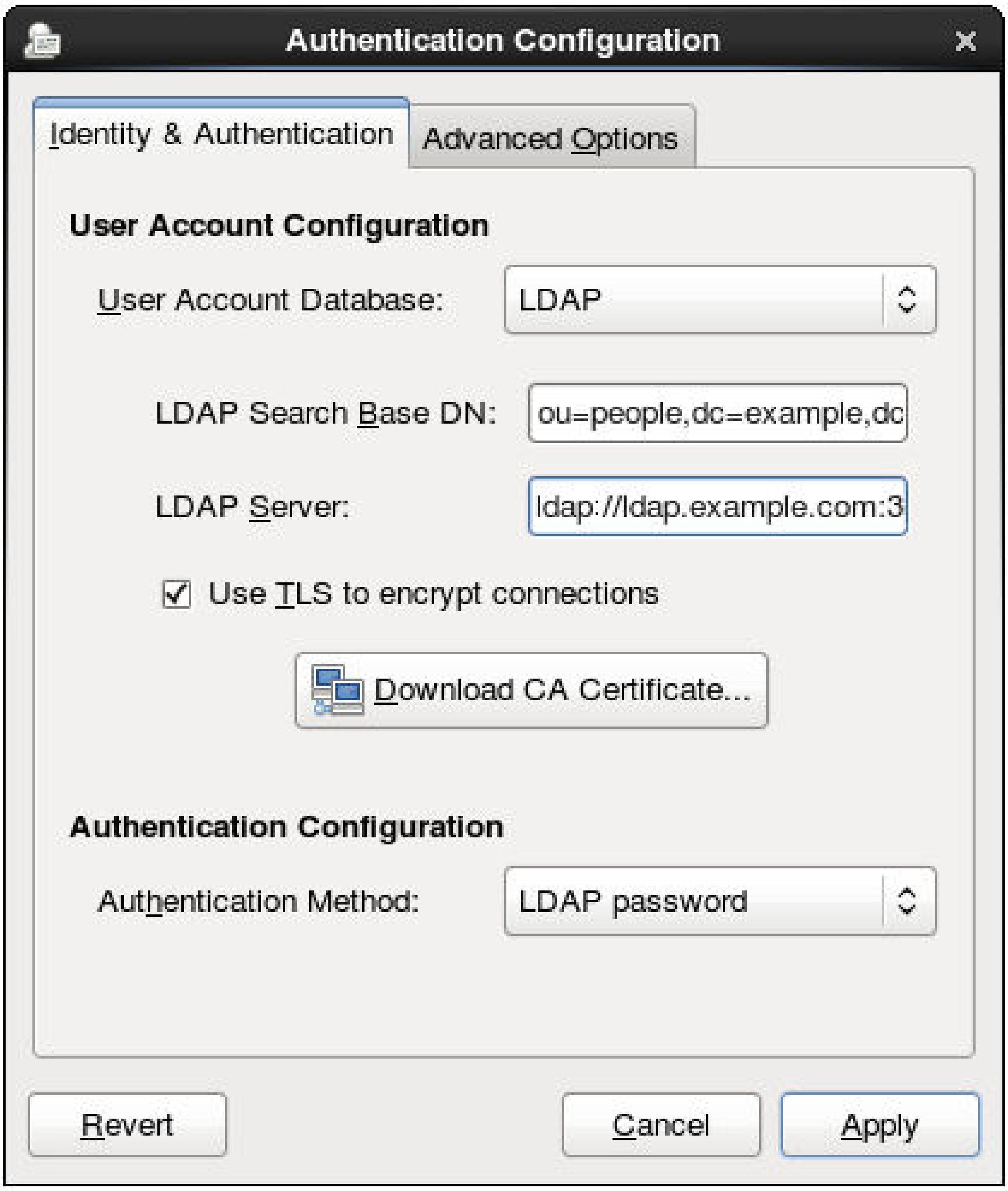
Authentication Method: Password

Figure 13.1. Local Authentication

13.1.2.1. Configuring LDAP Authentication

Either the openldap-clients package or the sssd package is used to configure an LDAP server for the user database. Both packages are installed by default.

1. Open the Authentication Configuration Tool, as in Section 13.1.1, “Launching the Authentication Configuration Tool UI”.
2. Select **LDAP** in the **`User Account Database`** drop-down menu.


Authentication Configuration

Identity & Authentication | Advanced Options

User Account Configuration

User Account Database: LDAP

LDAP Search Base DN: ou=people,dc=example,dc

LDAP Server: ldap://ldap.example.com:3

☑ Use TLS to encrypt connections

Authentication Configuration

Authentication Method: LDAP password

3. Set the information that is required to connect to the LDAP server.

   - **`LDAP Search Base DN`** gives the root suffix or *distinguished name* (DN) for the user directory. All of the user entries used for identity/authentication will exist below this parent entry. For example, *ou=people,dc=example,dc=com*.

     This field is optional. If it is not specified, then the System Security Services Daemon (SSSD) attempts to detect the search base using the ***`namingContexts`*** and ***`defaultNamingContext`*** attributes in the LDAP server's configuration entry.

   - **`LDAP Server`** gives the URL of the LDAP server. This usually requires both the host name and port number of the LDAP server, such as *ldap://ldap.example.com:389*.

     Entering the secure protocol in the URL, **`ldaps://`**, enables the **`Download CA Certificate`** button.

   - **`Use TLS to encrypt connections`** sets whether to use Start TLS to encrypt the connections to the LDAP server. This enables a secure connection over a standard port.

     Selecting TLS enables the **`Download CA Certificate`** button, which retrieves the issuing CA certificate for the LDAP server from whatever certificate authority issued it. The CA certificate must be in the privacy enhanced mail (PEM) format.

IMPORTANT

Do not select **`Use TLS to encrypt connections`** if the server URL uses a secure protocol (**`ldaps`**). This option uses Start TLS, which initiates a secure connection over a standard port; if a secure port is specified, then a protocol like SSL must be used instead of Start TLS.

4. Select the authentication method. LDAP allows simple password authentication or Kerberos authentication.

   Using Kerberos is described in Section 13.1.2.4, “Using Kerberos with LDAP or NIS Authentication”.

   The **`LDAP password`** option uses PAM applications to use LDAP authentication. This option requires either a secure (**`ldaps://`**) URL or the TLS option to connect to the LDAP server.

13.1.2.2. Configuring NIS Authentication

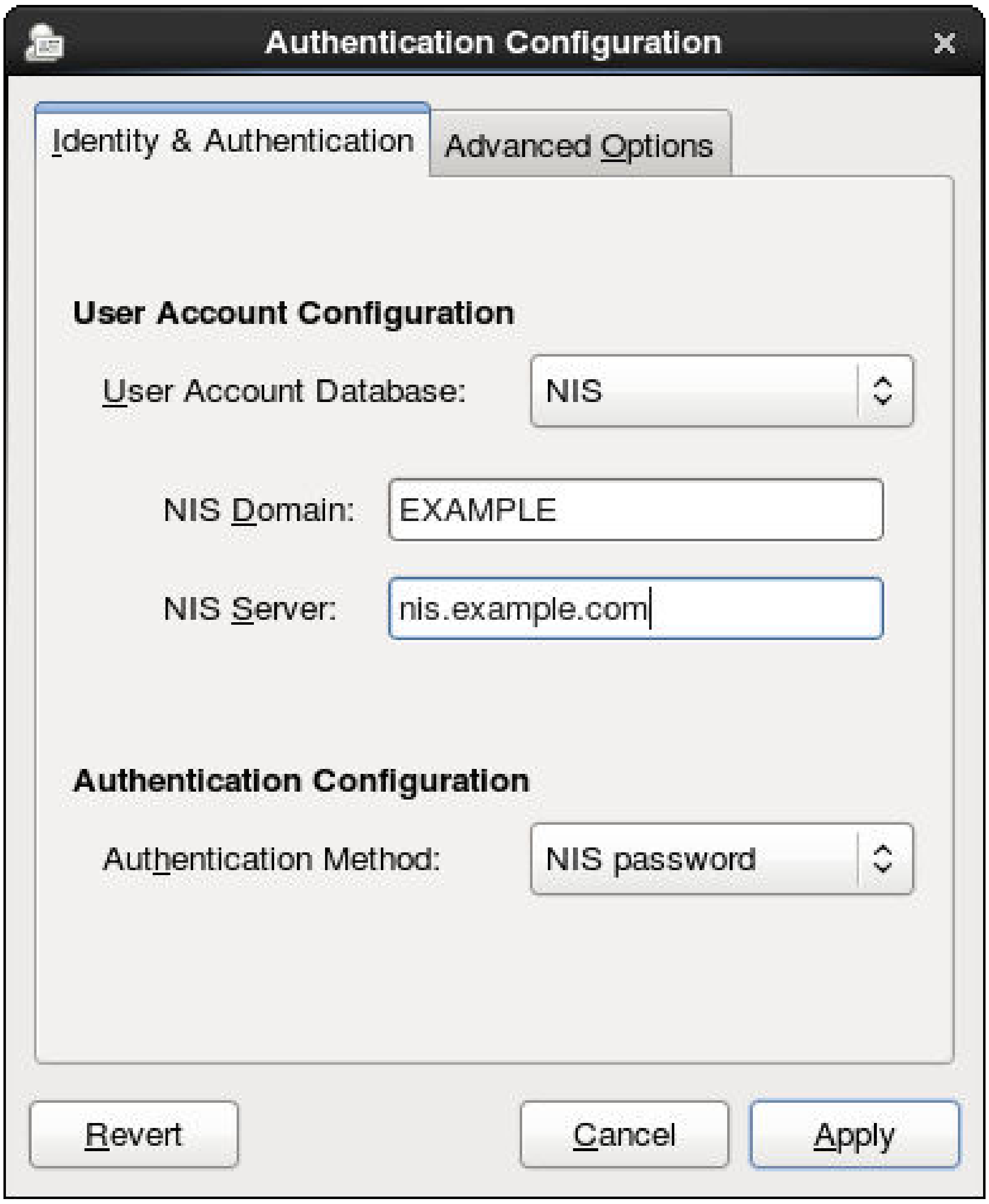
1. Install the ypbind package. This is required for NIS services, but is not installed by default.

   ```
   ~]# yum install ypbind
   ```

   When the **`ypbind`** service is installed, the **`portmap`** and **`ypbind`** services are started and enabled to start at boot time.

2. Open the Authentication Configuration Tool, as in Section 13.1.1, “Launching the Authentication Configuration Tool UI”.

3. Select **NIS** in the **`User Account Database`** drop-down menu.



User Account Configuration

User Account Database: NIS

NIS Domain: EXAMPLE

NIS Server: nis.example.com

Authentication Configuration

Authentication Method: NIS password

4. Set the information to connect to the NIS server, meaning the NIS domain name and the server host name. If the NIS server is not specified, the **`authconfig`** daemon scans for the NIS server.

5. Select the authentication method. NIS allows simple password authentication or Kerberos authentication.

   Using Kerberos is described in Section 13.1.2.4, “Using Kerberos with LDAP or NIS Authentication”.

For more information about NIS, see the "Securing NIS" section of the *Security Guide*.

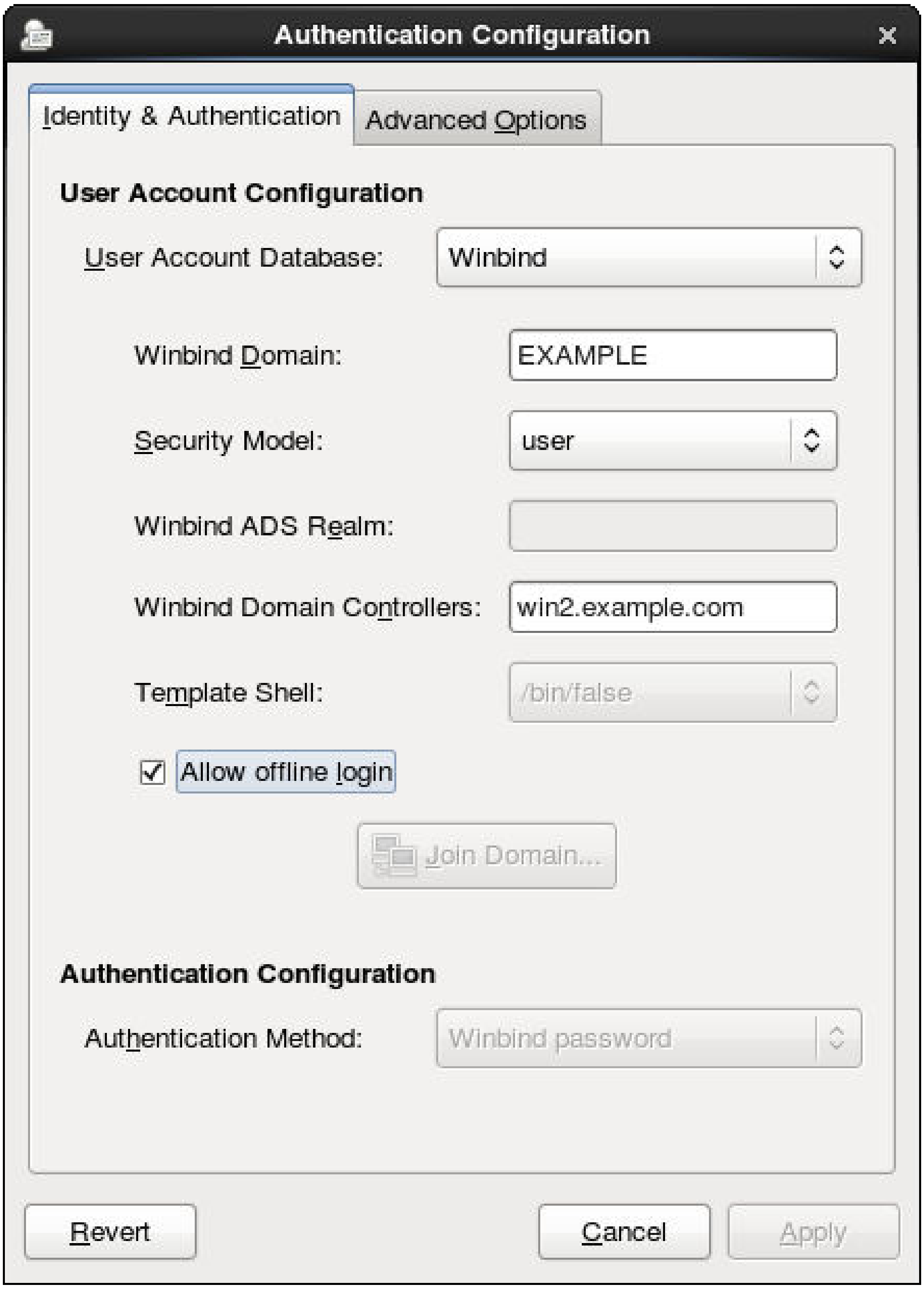
13.1.2.3. Configuring Winbind Authentication

1. Install the samba-winbind package. This is required for Windows integration features in Samba services, but is not installed by default.

   ```
   ~]# yum install samba-winbind
   ```

2. Open the Authentication Configuration Tool, as in Section 13.1.1, “Launching the Authentication Configuration Tool UI”.

3. Select **Winbind** in the **`User Account Database`** drop-down menu.



User Account Configuration

User Account Database: Winbind

Winbind Domain: EXAMPLE

Security Model: user

Winbind ADS Realm:

Winbind Domain Controllers: win2.example.com

Template Shell: /bin/false

☑ Allow offline login

Authentication Configuration

Authentication Method: Winbind password

4. Set the information that is required to connect to the Microsoft Active Directory domain controller.

   - **`Winbind Domain`** gives the Windows domain to connect to.

     This should be in the Windows 2000 format, such as **`DOMAIN`**.

   - **`Security Model`** sets the security model to use for Samba clients. **`authconfig`** supports four types of security models:

- **`ads`** configures Samba to act as a domain member in an Active Directory Server realm. To operate in this mode, the krb5-server package must be installed and Kerberos must be configured properly. Also, when joining to the Active Directory Server using the command line, the following command must be used:

  ```
  net ads join
  ```

- **`domain`** has Samba validate the user name/password by authenticating it through a Windows primary or backup domain controller, much like a Windows server.

- **`server`** has a local Samba server validate the user name/password by authenticating it through another server, such as a Windows server. If the server authentication attempt fails, the system then attempts to authenticate using **`user`** mode.

- **`user`** requires a client to log in with a valid user name and password. This mode does support encrypted passwords.

  The user name format must be *domain\user*, such as **`EXAMPLE\jsmith`**.

  NOTE

  When verifying that a given user exists in the Windows domain, always use Windows 2000-style formats and escape the backslash (\) character. For example:

  ```
  ~]# getent passwd domain\\user
  DOMAIN\user:*:16777216:16777216:Name
  Surname:/home/DOMAIN/user:/bin/bash
  ```

  This is the default option.

- **`Winbind ADS Realm`** gives the Active Directory realm that the Samba server will join. This is only used with the **`ads`** security model.

- **`Winbind Domain Controllers`** gives the domain controller to use. For more information about domain controllers, see Section 21.1.6.3, “Domain Controller”.

- **`Template Shell`** sets which login shell to use for Windows user account settings.

- **`Allow offline login`** allows authentication information to be stored in a local cache. The cache is referenced when a user attempts to authenticate to system resources while the system is offline.

For more information about the **`Winbind`** service, see Section 21.1.2, “Samba Daemons and Related Services”.

For additional information about configuring **`Winbind`** and troubleshooting tips, see the Knowledgebase on the Red Hat Customer Portal.

Also, the Red Hat Access Labs page includes the **`Winbind Mapper`** utility that generates a part of the **`smb.conf`** file to help you connect a Red Hat Enterprise Linux to an Active Directory.

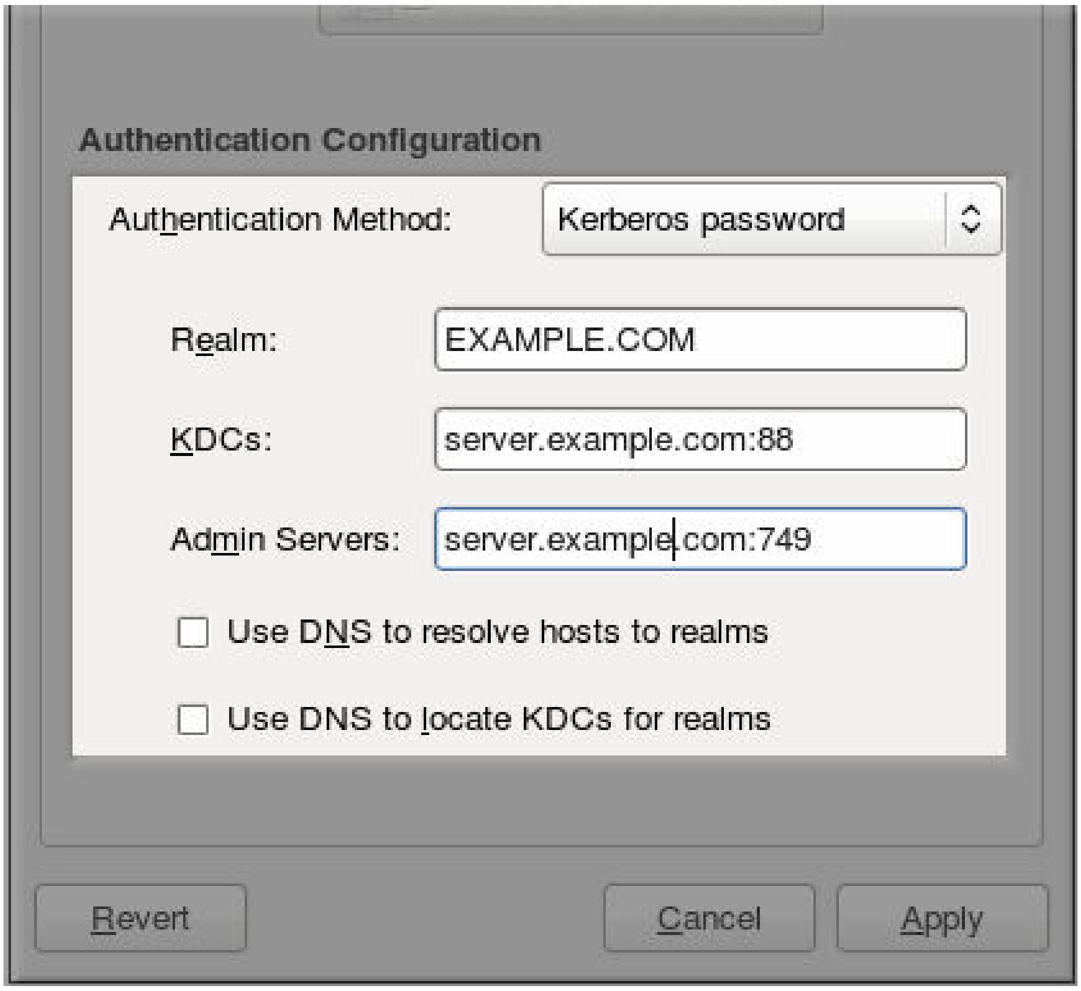
13.1.2.4. Using Kerberos with LDAP or NIS Authentication

Both LDAP and NIS authentication stores support Kerberos authentication methods. Using Kerberos has a couple of benefits:

- It uses a security layer for communication while still allowing connections over standard ports.
- It automatically uses credentials caching with SSSD, which allows offline logins.

Using Kerberos authentication requires the krb5-libs and krb5-workstation packages.

The **Kerberos password** option from the **`Authentication Method`** drop-down menu automatically opens the fields required to connect to the Kerberos realm.



Authentication Method: Kerberos password

Realm: EXAMPLE.COM

KDCs: server.example.com:88

Admin Servers: server.example.com:749

☐ Use DNS to resolve hosts to realms

☐ Use DNS to locate KDCs for realms

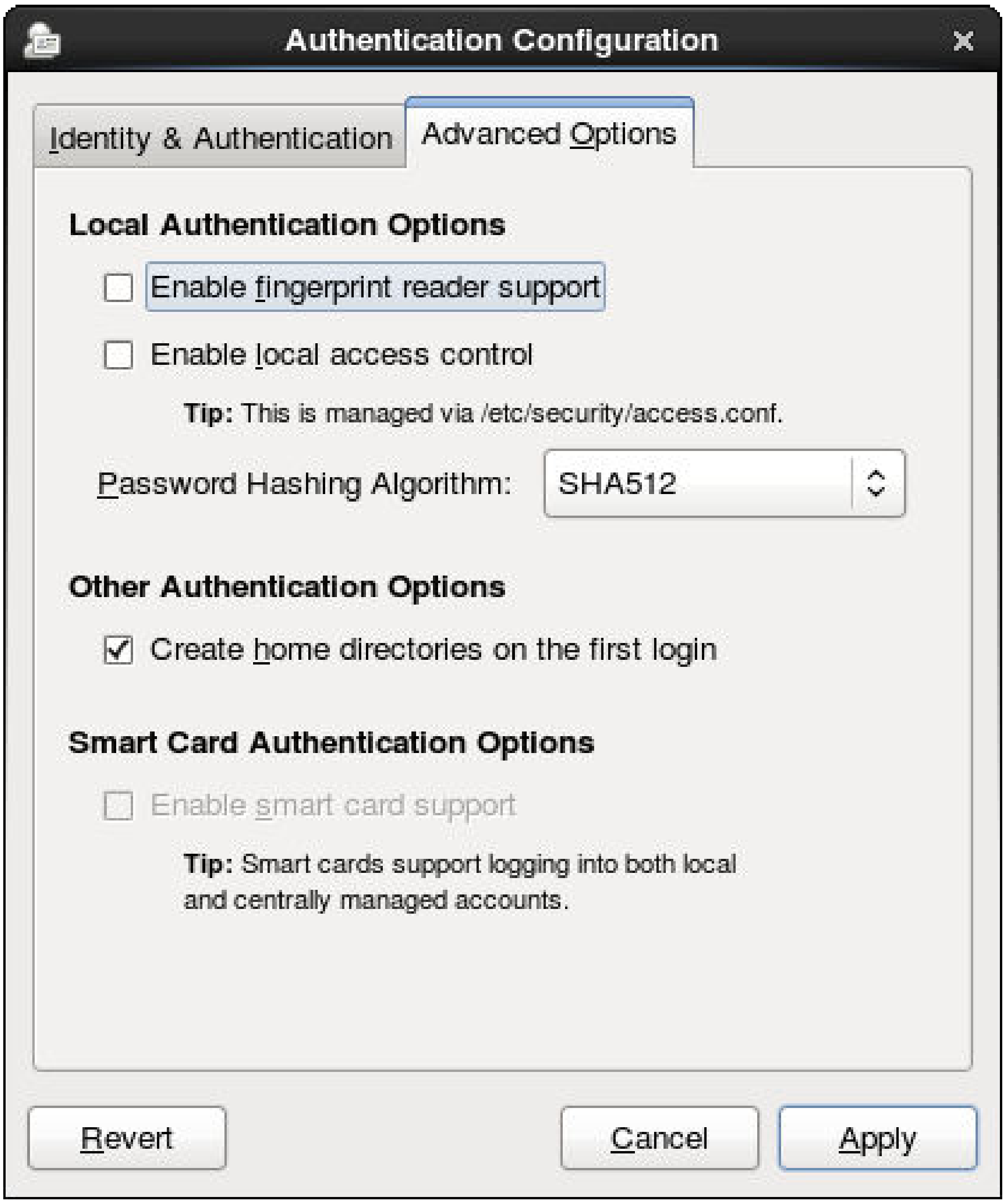
Figure 13.2. Kerberos Fields

- **`Realm`** gives the name for the realm for the Kerberos server. The realm is the network that uses Kerberos, composed of one or more *key distribution centers* (KDC) and a potentially large number of clients.
- **`KDCs`** gives a comma-separated list of servers that issue Kerberos tickets.
- **`Admin Servers`** gives a list of administration servers running the **`kadmind`** process in the realm.
- Optionally, use DNS to resolve server host name and to find additional KDCs within the realm.

For more information about Kerberos, see section "Using Kerberos" of the Red Hat Enterprise Linux 6 *Managing Single Sign-On and Smart Cards* guide.

13.1.3. Configuring Alternative Authentication Features

The Authentication Configuration Tool also configures settings related to authentication behavior, apart from the identity store. This includes entirely different authentication methods (fingerprint scans and smart cards) or local authentication rules. These alternative authentication options are configured in the **`Advanced Options`** tab.



Local Authentication Options

☐ Enable fingerprint reader support

☐ Enable local access control

Tip: This is managed via /etc/security/access.conf.

Password Hashing Algorithm: SHA512

Other Authentication Options

☑ Create home directories on the first login

Smart Card Authentication Options

☐ Enable smart card support

Tip: Smart cards support logging into both local and centrally managed accounts.

Figure 13.3. Advanced Options

13.1.3.1. Using Fingerprint Authentication

When there is appropriate hardware available, the **`Enable fingerprint reader support`** option allows fingerprint scans to be used to authenticate local users in addition to other credentials.

13.1.3.2. Setting Local Authentication Parameters

There are two options in the **`Local Authentication Options`** area which define authentication behavior on the local system:

- **`Enable local access control`** instructs the **`/etc/security/access.conf`** file to check for local user authorization rules.
- **`Password Hashing Algorithm`** sets the hashing algorithm to use to encrypt locally-stored passwords.

13.1.3.3. Enabling Smart Card Authentication

When there are appropriate smart card readers available, a system can accept smart cards (or *tokens*) instead of other user credentials to authenticate.

Once the **`Enable smart card support`** option is selected, then the behaviors of smart card authentication can be defined:

- **`Card Removal Action`** tells the system how to respond when the card is removed from the card reader during an active session. A system can either ignore the removal and allow the user to access resources as normal, or a system can immediately lock until the smart card is supplied.
- **`Require smart card login`** sets whether a smart card is required for logins or allowed for logins. When this option is selected, all other methods of authentication are immediately blocked.

WARNING

Do not select this option until you have successfully authenticated to the system using a smart card.

Using smart cards requires the pam_pkcs11 package.

13.1.3.4. Creating User Home Directories

There is an option (**`Create home directories on the first login`**) to create a home directory automatically the first time that a user logs in.

This option is beneficial with accounts that are managed centrally, such as with LDAP. However, this option should not be selected if a system like automount is used to manage user home directories.

13.1.4. Configuring Authentication from the Command Line

The **`authconfig`** command-line tool updates all of the configuration files and services required for system authentication, according to the settings passed to the script. Along with allowing all of the identity and authentication configuration options that can be set through the UI, the **`authconfig`** tool can also be used to create backup and kickstart files.

For a complete list of **`authconfig`** options, check the help output and the man page.

13.1.4.1. Tips for Using authconfig

There are some things to remember when running **`authconfig`**:

- With every command, use either the **`--update`** or **`--test`** option. One of those options is required for the command to run successfully. Using **`--update`** writes the configuration changes. **`--test`** prints the changes to stdout but does not apply the changes to the configuration.

- Each enable option has a corresponding disable option.

13.1.4.2. Configuring LDAP User Stores

To use an LDAP identity store, use the **`--enableldap`**. To use LDAP as the authentication source, use **`--enableldapauth`** and then the requisite connection information, like the LDAP server name, base DN for the user suffix, and (optionally) whether to use TLS. The **`authconfig`** command also has options to enable or disable RFC 2307bis schema for user entries, which is not possible through the Authentication Configuration UI.

Be sure to use the full LDAP URL, including the protocol (**`ldap`** or **`ldaps`**) and the port number. Do *not* use a secure LDAP URL (**`ldaps`**) with the **`--enableldaptls`** option.

```
authconfig --enableldap --enableldapauth --
ldapserver=ldap://ldap.example.com:389,ldap://ldap2.example.com:389 --
ldapbasedn="ou=people,dc=example,dc=com" --enableldaptls --
ldaploadcacert=https://ca.server.example.com/caCert.crt --update
```

Instead of using **`--ldapauth`** for LDAP password authentication, it is possible to use Kerberos with the LDAP user store. These options are described in Section 13.1.4.5, “Configuring Kerberos Authentication”.

13.1.4.3. Configuring NIS User Stores

To use a NIS identity store, use the **`--enablenis`**. This automatically uses NIS authentication, unless the Kerberos parameters are explicitly set, so it uses Kerberos authentication (Section 13.1.4.5, “Configuring Kerberos Authentication”). The only parameters are to identify the NIS server and NIS domain; if these are not used, then the **`authconfig`** service scans the network for NIS servers.

```
authconfig --enablenis --nisdomain=EXAMPLE --nisserver=nis.example.com --
update
```

13.1.4.4. Configuring Winbind User Stores

Windows domains have several different security models, and the security model used in the domain determines the authentication configuration for the local system.

For user and server security models, the Winbind configuration requires only the domain (or workgroup) name and the domain controller host names.

```
authconfig --enablewinbind --enablewinbindauth --smbsecurity=user|server
--enablewinbindoffline --smbservers=ad.example.com --smbworkgroup=EXAMPLE
--update
```

NOTE

The user name format must be *domain\user*, such as **`EXAMPLE\jsmith`**.

When verifying that a given user exists in the Windows domain, always use Windows 2000-style formats and escape the backslash (\) character. For example:

```
~]# getent passwd domain\\user
DOMAIN\user:*:16777216:16777216:Name
Surname:/home/DOMAIN/user:/bin/bash
```

For ads and domain security models, the Winbind configuration allows additional configuration for the template shell and realm (ads only). For example:

```
authconfig --enablewinbind --enablewinbindauth --smbsecurity ads  --
enablewinbindoffline --smbservers=ad.example.com --smbworkgroup=EXAMPLE --
smbrealm EXAMPLE.COM --winbindtemplateshell=/bin/sh --update
```

There are a lot of other options for configuring Windows-based authentication and the information for Windows user accounts, such as name formats, whether to require the domain name with the user name, and UID ranges. These options are listed in the **`authconfig`** help.

13.1.4.5. Configuring Kerberos Authentication

Both LDAP and NIS allow Kerberos authentication to be used in place of their native authentication mechanisms. At a minimum, using Kerberos authentication requires specifying the realm, the KDC, and the administrative server. There are also options to use DNS to resolve client names and to find additional admin servers.

```
authconfig NIS or LDAP options --enablekrb5 --krb5realm EXAMPLE --krb5kdc
kdc.example.com:88,server.example.com:88 --krb5adminserver
server.example.com:749 --enablekrb5kdcdns --enablekrb5realmdns --update
```

13.1.4.6. Configuring Local Authentication Settings

The Authentication Configuration Tool can also control some user settings that relate to security, such as creating home directories, setting password hash algorithms, and authorization. These settings are done independently of identity/user store settings.

For example, to create user home directories:

```
authconfig --enablemkhomedir --update
```

To set or change the hash algorithm used to encrypt user passwords:

```
authconfig --passalgo=sha512 --update
```

13.1.4.7. Configuring Fingerprint Authentication

There is one option to enable support for fingerprint readers. This option can be used alone or in conjunction with other **`authconfig`** settings, like LDAP user stores.

```
~]# authconfig --enablefingerprint --update
```

13.1.4.8. Configuring Smart Card Authentication

All that is required to use smart cards with a system is to set the **`--enablesmartcard`** option:

```
~]# authconfig --enablesmartcard --update
```

There are other configuration options for smart cards, such as changing the default smart card module, setting the behavior of the system when the smart card is removed, and requiring smart cards for login.

For example, this command instructs the system to lock out a user immediately if the smart card is removed (a setting of 1 ignores it if the smart card is removed):

```
~]# authconfig --enablesmartcard --smartcardaction=0 --update
```

Once smart card authentication has been successfully configured and tested, then the system can be configured to require smart card authentication for users rather than simple password-based authentication.

```
~]# authconfig --enablerequiresmartcard --update
```

WARNING

Do not use the **`--enablerequiresmartcard`** option until you have successfully authenticated to the system using a smart card. Otherwise, users may be unable to log into the system.

13.1.4.9. Managing Kickstart and Configuration Files

The **`--update`** option updates all of the configuration files with the configuration changes. There are a couple of alternative options with slightly different behavior:

- **`--kickstart`** writes the updated configuration to a kickstart file.
- **`--test`** prints the full configuration, with changes, to stdout but does not edit any configuration files.

Additionally, **`authconfig`** can be used to back up and restore previous configurations. All archives are saved to a unique subdirectory in the **`/var/lib/authconfig/`** directory. For example, the **`--savebackup`** option gives the backup directory as **`2011-07-01`**:

```
~]# authconfig --savebackup=2011-07-01
```

This backs up all of the authentication configuration files beneath the **`/var/lib/authconfig/backup-2011-07-01`** directory.

Any of the saved backups can be used to restore the configuration using the **--restorebackup** option, giving the name of the manually-saved configuration:

```
~]# authconfig --restorebackup=2011-07-01
```

Additionally, **authconfig** automatically makes a backup of the configuration before it applies any changes (with the **--update** option). The configuration can be restored from the most recent automatic backup, without having to specify the exact backup, using the **--restorelastbackup** option.

13.1.5. Using Custom Home Directories

If LDAP users have home directories that are not in **/home** and the system is configured to create home directories the first time users log in, then these directories are created with the wrong permissions.

1. Apply the correct SELinux context and permissions from the **/home** directory to the home directory that is created on the local system. For example:

   ```
   ~]# semanage fcontext -a -e /home /home/locale
   ```

2. Install the oddjob-mkhomedir package on the system.

   This package provides the **pam_oddjob_mkhomedir.so** library, which the Authentication Configuration Tool uses to create home directories. The **pam_oddjob_mkhomedir.so** library, unlike the default **pam_mkhomedir.so** library, can create SELinux labels.

   The Authentication Configuration Tool automatically uses the **pam_oddjob_mkhomedir.so** library if it is available. Otherwise, it will default to using **pam_mkhomedir.so**.

3. Make sure the **oddjobd** service is running.

4. Re-run the Authentication Configuration Tool and enable home directories, as in Section 13.1.3, “Configuring Alternative Authentication Features”.

If home directories were created before the home directory configuration was changed, then correct the permissions and SELinux contexts. For example:

```
~]# semanage fcontext -a -e /home /home/locale
# restorecon -R -v /home/locale
```

13.2. USING AND CACHING CREDENTIALS WITH SSSD

The System Security Services Daemon (SSSD) provides access to different identity and authentication providers.

13.2.1. About SSSD

Most system authentication is configured locally, which means that services must check with a local user store to determine users and credentials. What SSSD does is allow a local service to check with a local cache in SSSD, but that cache may be taken from any variety of *remote* identity providers — an LDAP directory, an Identity Management domain, Active Directory, possibly even a Kerberos realm.

SSSD also caches those users and credentials, so if the local system *or* the identity provider go offline, the user credentials are still available to services to verify.

SSSD is an intermediary between local clients and any configured data store. This relationship brings a number of benefits for administrators:

- *Reducing the load on identification/authentication servers.* Rather than having every client service attempt to contact the identification server directly, all of the local clients can contact SSSD which can connect to the identification server or check its cache.
- *Permitting offline authentication.* SSSD can optionally keep a cache of user identities and credentials that it retrieves from remote services. This allows users to authenticate to resources successfully, even if the remote identification server is offline or the local machine is offline.
- *Using a single user account.* Remote users frequently have two (or even more) user accounts, such as one for their local system and one for the organizational system. This is necessary to connect to a virtual private network (VPN). Because SSSD supports caching and offline authentication, remote users can connect to network resources by authenticating to their local machine and then SSSD maintains their network credentials.

Additional Resources

While this chapter covers the basics of configuring services and domains in SSSD, this is not a comprehensive resource. Many other configuration options are available for each functional area in SSSD; check out the man page for the specific functional area to get a complete list of options.

Some of the common man pages are listed in Table 13.1, “A Sampling of SSSD Man Pages”. There is also a complete list of SSSD man pages in the "See Also" section of the **`sssd(8)`** man page.

Table 13.1. A Sampling of SSSD Man Pages

Functional Area	Man Page
General Configuration	sssd.conf(8)
sudo Services	sssd-sudo
LDAP Domains	sssd-ldap
Active Directory Domains	sssd-ad sssd-ldap
Identity Management (IdM or IPA) Domains	sssd-ipa sssd-ldap
Kerberos Authentication for Domains	sssd-krb5
OpenSSH Keys	sss_ssh_authorizedkeys sss_ssh_knownhostsproxy

Functional Area	Man Page
Cache Maintenance	sss_cache (cleanup) sss_useradd, sss_usermod, sss_userdel, sss_seed (user cache entry management)

13.2.2. Setting up the sssd.conf File

SSSD services and domains are configured in a **`.conf`** file. By default, this is **`/etc/sssd/sssd.conf`** — although that file must be created and configured manually, since SSSD is not configured after installation.

13.2.2.1. Creating the sssd.conf File

There are three parts of the SSSD configuration file:

- **`[sssd]`**, for general SSSD process and operational configuration; this basically lists the configured services, domains, and configuration parameters for each
- *[service_name]*, for configuration options for each supported system service, as described in Section 13.2.4, "SSSD and System Services"
- *[domain_type/DOMAIN_NAME]*, for configuration options for each configured identity provider

IMPORTANT

While services are optional, at least one identity provider domain must be configured before the SSSD service can be started.

Example 13.1. Simple sssd.conf File

```
[sssd]
domains = LOCAL
services = nss
config_file_version = 2

[nss]
filter_groups = root
filter_users = root

[domain/LOCAL]
id_provider = local
auth_provider = local
access_provider = permit
```

The **`[sssd]`** section has three important parameters:

- **domains** lists all of the domains, configured in the **sssd.conf**, which SSSD uses as identity providers. If a domain is not listed in the **domains** key, it is not used by SSSD, even if it has a configuration section.
- **services** lists all of the system services, configured in the **sssd.conf**, which use SSSD; when SSSD starts, the corresponding SSSD service is started for each configured system service. If a service is not listed in the **services** key, it is not used by SSSD, even if it has a configuration section.
- **config_file_version** sets the version of the configuration file to set file format expectations. This is version 2, for all recent SSSD versions.

NOTE

Even if a service or domain is configured in the **sssd.conf** file, SSSD does not interact with that service or domain unless it is listed in the **services** or **domains** parameters, respectively, in the **[sssd]** section.

Other configuration parameters are listed in the **sssd.conf** man page.

Each service and domain parameter is described in its respective configuration section in this chapter and in their man pages.

13.2.2.2. Using a Custom Configuration File

By default, the **sssd** process assumes that the configuration file is **/etc/sssd/sssd.conf**.

An alternative file can be passed to SSSD by using the **-c** option with the **sssd** command:

```
~]# sssd -c /etc/sssd/customfile.conf --daemon
```

13.2.3. Starting and Stopping SSSD

IMPORTANT

Configure at least one domain before starting SSSD for the first time. See Section 13.2.10, “SSSD and Identity Providers (Domains)”.

Either the **service** command or the **/etc/init.d/sssd** script can start SSSD. For example:

```
~]# service sssd start
```

By default, SSSD is not configured to start automatically. There are two ways to change this behavior:

- Enabling SSSD through the **authconfig** command:

  ```
  ~]# authconfig --enablesssd --enablesssdauth --update
  ```

- Adding the SSSD process to the start list using the **chkconfig** command:

  ```
  ~]# chkconfig sssd on
  ```

–

13.2.4. SSSD and System Services

SSSD and its associated services are configured in the **sssd.conf** file. The **[sssd]** section also lists the services that are active and should be started when **sssd** starts within the **services** directive.

SSSD can provide credentials caches for several system services:

- A Name Service Switch (NSS) provider service that answers name service requests from the **sssd_nss** module. This is configured in the **[nss]** section of the SSSD configuration.

  This is described in Section 13.2.5, “Configuring Services: NSS”.

- A PAM provider service that manages a PAM conversation through the **sssd_pam** module. This is configured in the **[pam]** section of the configuration.

  This is described in Section 13.2.6, “Configuring Services: PAM”.

- An SSH provider service that defines how SSSD manages the **known_hosts** file and other key-related configuration. Using SSSD with OpenSSH is described in Section 13.2.9, “Configuring Services: OpenSSH and Cached Keys”.

- An **autofs** provider service that connects to an LDAP server to retrieve configured mount locations. This is configured as part of an LDAP identity provider in a **[domain/NAME]** section in the configuration file.

  This is described in Section 13.2.7, “Configuring Services: autofs”.

- A **sudo** provider service that connects to an LDAP server to retrieve configured **sudo** policies. This is configured as part of an LDAP identity provider in a **[domain/NAME]** section in the configuration file.

  This is described in Section 13.2.8, “Configuring Services: sudo”.

- A PAC responder service that defines how SSSD works with Kerberos to manage Active Directory users and groups. This is specifically part of managing Active Directory identity providers with domains, as described in Section 13.2.13, “Creating Domains: Active Directory”.

13.2.5. Configuring Services: NSS

SSSD provides an NSS module, **sssd_nss**, which instructs the system to use SSSD to retrieve user information. The NSS configuration must include a reference to the SSSD module, and then the SSSD configuration sets how SSSD interacts with NSS.

About NSS Service Maps and SSSD

The Name Service Switch (NSS) provides a central configuration for services to look up a number of configuration and name resolution services. NSS provides one method of mapping system identities and services with configuration sources.

SSSD works with NSS as a provider services for several types of NSS maps:

- Passwords (**passwd**)

- User groups (**shadow**)

- Groups (**groups**)

- Netgroups (**netgroups**)
- Services (**services**)

Procedure 13.1. Configuring NSS Services to Use SSSD

NSS can use multiple identity and configuration providers for any and all of its service maps. The default is to use system files for services; for SSSD to be included, the **nss_sss** module has to be included for the desired service type.

1. Use the Authentication Configuration tool to enable SSSD. This automatically configured the **nsswitch.conf** file to use SSSD as a provider.

   ```
   ~]# authconfig --enablesssd --update
   ```

   This automatically configures the password, shadow, group, and netgroups services maps to use the SSSD module:

   ```
   passwd:     files sss
   shadow:     files sss
   group:      files sss

   netgroup:   files sss
   ```

2. The services map is not enabled by default when SSSD is enabled with **authconfig**. To include that map, open the **nsswitch.conf** file and add the **sss** module to the **services** map:

   ```
   ~]# vim /etc/nsswitch.conf

   ...
   services: file sss
   ...
   ```

Procedure 13.2. Configuring SSSD to Work with NSS

The options and configuration that SSSD uses to service NSS requests are configured in the SSSD configuration file, in the **[nss]** services section.

1. Open the **sssd.conf** file.

   ```
   ~]# vim /etc/sssd/sssd.conf
   ```

2. Make sure that NSS is listed as one of the services that works with SSSD.

   ```
   [sssd]
   config_file_version = 2
   reconnection_retries = 3
   sbus_timeout = 30
   services = nss, pam
   ```

3. In the **[nss]** section, change any of the NSS parameters. These are listed in Table 13.2, “SSSD [nss] Configuration Parameters”.

```
[nss]
filter_groups = root
filter_users = root
reconnection_retries = 3
entry_cache_timeout = 300
entry_cache_nowait_percentage = 75
```

4. Restart SSSD.

```
~]# service sssd restart
```

Table 13.2. SSSD [nss] Configuration Parameters

Parameter	Value Format	Description
entry_cache_nowait_percentage	integer	Specifies how long **`sssd_nss`** should return cached entries before refreshing the cache. Setting this to zero (**`0`**) disables the entry cache refresh. This configures the entry cache to update entries in the background automatically if they are requested if the time before the next update is a certain percentage of the next interval. For example, if the interval is 300 seconds and the cache percentage is 75, then the entry cache will begin refreshing when a request comes in at 225 seconds — 75% of the interval. The allowed values for this option are 0 to 99, which sets the percentage based on the **`entry_cache_timeout`** value. The default value is 50%.
entry_negative_timeout	integer	Specifies how long, in seconds, **`sssd_nss`** should cache *negative* cache hits. A negative cache hit is a query for an invalid database entries, including non-existent entries.
filter_users, filter_groups	string	Tells SSSD to exclude certain users from being fetched from the NSS database. This is particularly useful for system accounts such as **`root`**.
filter_users_in_groups	Boolean	Sets whether users listed in the **`filter_users`** list appear in group memberships when performing group lookups. If set to **FALSE**, group lookups return all users that are members of that group. If not specified, this value defaults to **`true`**, which filters the group member lists.
debug_level	integer, 0 - 9	Sets a debug logging level.

NSS Compatibility Mode

NSS *compatibility (compat) mode* provides the support for additional entries in the **`/etc/passwd`** file to ensure that users or members of netgroups have access to the system.

To enable NSS compatibility mode to work with SSSD, add the following entries to the **`/etc/nsswitch.conf`** file:

```
passwd: compat
passwd_compat: sss
```

Once NSS compatibility mode is enabled, the following **`passwd`** entries are supported:

- ***`+user`* *`-user`***

  Include (**+**) or exclude (**-**) a specified *user* from the Network Information System (NIS) map.

- ***`+@netgroup`* *`-@netgroup`***

  Include (**+**) or exclude (**-**) all users in the given *netgroup* from the NIS map.

- **`+`**

  Exclude all users, except previously excluded ones from the NIS map.

For more information about NSS compatibility mode, see the **`nsswitch.conf(5)`** manual page.

13.2.6. Configuring Services: PAM

WARNING

A mistake in the PAM configuration file can lock users out of the system completely. Always back up the configuration files before performing any changes, and keep a session open so that any changes can be reverted.

SSSD provides a PAM module, **`sssd_pam`**, which instructs the system to use SSSD to retrieve user information. The PAM configuration must include a reference to the SSSD module, and then the SSSD configuration sets how SSSD interacts with PAM.

Procedure 13.3. Configuring PAM

1. Use **`authconfig`** to enable SSSD for system authentication.

   ```
   # authconfig --update --enablesssd --enablesssdauth
   ```

   This automatically updates the PAM configuration to reference all of the SSSD modules:

   ```
   #%PAM-1.0
   # This file is auto-generated.
   # User changes will be destroyed the next time authconfig is run.
   auth        required      pam_env.so
   auth        sufficient    pam_unix.so nullok try_first_pass
   auth        requisite     pam_succeed_if.so uid >= 500 quiet
   auth sufficient pam_sss.so use_first_pass
   auth        required      pam_deny.so

   account     required      pam_unix.so
   ```

```
account     sufficient    pam_localuser.so
account     sufficient    pam_succeed_if.so uid < 500 quiet
account [default=bad success=ok user_unknown=ignore] pam_sss.so
account     required      pam_permit.so

password    requisite     pam_cracklib.so try_first_pass retry=3
password    sufficient    pam_unix.so sha512 shadow nullok
try_first_pass use_authtok
password sufficient pam_sss.so use_authtok
password    required      pam_deny.so

session     optional      pam_keyinit.so revoke
session     required      pam_limits.so
session     [success=1 default=ignore] pam_succeed_if.so service in
crond quiet use_uid
session sufficient pam_sss.so
session     required      pam_unix.so
```

These modules can be set to **include** statements, as necessary.

2. Open the **sssd.conf** file.

```
# vim /etc/sssd/sssd.conf
```

3. Make sure that PAM is listed as one of the services that works with SSSD.

```
[sssd]
config_file_version = 2
reconnection_retries = 3
sbus_timeout = 30
services = nss, pam
```

4. In the **[pam]** section, change any of the PAM parameters. These are listed in Table 13.3, “SSSD [pam] Configuration Parameters”.

```
[pam]
reconnection_retries = 3
offline_credentials_expiration = 2
offline_failed_login_attempts = 3
offline_failed_login_delay = 5
```

5. Restart SSSD.

```
~]# service sssd restart
```

Table 13.3. SSSD [pam] Configuration Parameters

Parameter	Value Format	Description
offline_credentials_expiration	integer	Sets how long, in days, to allow cached logins if the authentication provider is offline. This value is measured from the last successful online login. If not specified, this defaults to zero (**0**), which is unlimited.

Parameter	Value Format	Description
offline_failed_login_attempts	integer	Sets how many failed login attempts are allowed if the authentication provider is offline. If not specified, this defaults to zero (**0**), which is unlimited.
offline_failed_login_delay	integer	Sets how long to prevent login attempts if a user hits the failed login attempt limit. If set to zero (**0**), the user cannot authenticate while the provider is offline once he hits the failed attempt limit. Only a successful online authentication can re-enable offline authentication. If not specified, this defaults to five (**5**).

13.2.7. Configuring Services: autofs

About Automount, LDAP, and SSSD

Automount maps are commonly flat files, which define a relationship between a map, a mount directory, and a fileserver. (Automount is described in the Storage Administration Guide.)

For example, let's say that there is a fileserver called **nfs.example.com** which hosts the directory **pub**, and automount is configured to mount directories in the **/shares/** directory. So, the mount location is **/shares/pub**. All of the mounts are listed in the **auto.master** file, which identifies the different mount directories and the files which configure them. The **auto.shares** file then identifies each file server and mount directory which goes into the **/shares/** directory. The relationships could be viewed like this:

```
        auto.master
   _________|__________
   |                  |
   |                  |
/shares/        auto.shares
                      |
       |
       |
            nfs.example.com:pub
```

Every mount point, then, is defined in two different files (at a minimum): the **auto.master** and **auto.***whatever* file, and those files have to be available to each local automount process.

One way for administrators to manage that for large environments is to store the automount configuration in a central LDAP directory, and just configure each local system to point to that LDAP directory. That means that updates only need to be made in a single location, and any new maps are automatically recognized by local systems.

For automount-LDAP configuration, the automount files are stored as LDAP entries, which are then translated into the requisite automount files. Each element is then translated into an LDAP attribute.

The LDAP entries look like this:

```
# container entry
dn: cn=automount,dc=example,dc=com
objectClass: nsContainer
objectClass: top
cn: automount

# master map entry
dn: automountMapName=auto.master,cn=automount,dc=example,dc=com
objectClass: automountMap
objectClass: top
automountMapName: auto.master

# shares map entry
dn: automountMapName=auto.shares,cn=automount,dc=example,dc=com
objectClass: automountMap
objectClass: top
automountMapName: auto.shares

# shares mount point
dn:
automountKey=/shares,automountMapName=auto.master,cn=automount,dc=example,
dc=com
objectClass: automount
objectClass: top
automountKey: /shares
automountInformation: auto.shares

# pub mount point
dn:
automountKey=pub,automountMapName=auto.shares,cn=automount,dc=example,dc=c
om
objectClass: automount
objectClass: top
automountKey: pub
automountInformation: filer.example.com:/pub
description: pub
```

The schema elements, then, match up to the structure like this (with the RFC 2307 schema):

```
               auto.master
                      objectclass: automountMap
                      filename attribute: automountMapName
   _______________________|__________________________
   |                                                |
   |                                                |
/shares/                                       auto.shares
objectclass: automount                         objectclass: automountMap
mount point name attribute: automountKey       filename attribute:
automountMapName
map name attribute: automountInformation            |
                                     |
                                                    |
                                          nfs.example.com:pub
                                          objectclass: automount
                                          mount point name attribute:
automountKey
```

```
                                                    fileserver attribute:
automountInformation
```

autofs uses those schema elements to derive the automount configuration. The **/etc/sysconfig/autofs** file identifies the LDAP server, directory location, and schema elements used for automount entities:

```
LDAP_URI=ldap://ldap.example.com
SEARCH_BASE="cn=automount,dc=example,dc=com"
MAP_OBJECT_CLASS="automountMap"
ENTRY_OBJECT_CLASS="automount"
MAP_ATTRIBUTE="automountMapName"
ENTRY_ATTRIBUTE="automountKey"
VALUE_ATTRIBUTE="automountInformation"
```

Rather than pointing the automount configuration to the LDAP directory, it can be configured to point to SSSD. SSSD, then, stores all of the information that automount needs, and as a user attempts to mount a directory, that information is cached into SSSD. This offers several advantages for configuration — such as failover, service discovery, and timeouts — as well as performance improvements by reducing the number of connections to the LDAP server. Most important, using SSSD allows all mount information to be cached, so that clients can still successfully mount directories *even if the LDAP server goes offline*.

Procedure 13.4. Configuring autofs Services in SSSD

1. Make sure that the autofs and sssd-common packages are installed.

2. Open the **sssd.conf** file.

   ```
   ~]# vim /etc/sssd/sssd.conf
   ```

3. Add the **autofs** service to the list of services that SSSD manages.

   ```
   [sssd]
   services = nss,pam,autofs
   ....
   ```

4. Create a new **[autofs]** service configuration section. This section can be left blank; there is only one configurable option, for timeouts for negative cache hits.

   This section is required, however, for SSSD to recognize the **autofs** service and supply the default configuration.

   ```
   [autofs]
   ```

5. The automount information is read from a configured LDAP domain in the SSSD configuration, so an LDAP domain must be available. If no additional settings are made, then the configuration defaults to the RFC 2307 schema and the LDAP search base (**ldap_search_base**) for the automount information. This can be customized:

   - The directory type, **autofs_provider**; this defaults to the **id_provider** value; a value of *none* explicitly disables autofs for the domain.

- The search base, **`ldap_autofs_search_base`**.
- The object class to use to recognize map entries, **`ldap_autofs_map_object_class`**
- The attribute to use to recognize map names, **`ldap_autofs_map_name`**
- The object class to use to recognize mount point entries, **`ldap_autofs_entry_object_class`**
- The attribute to use to recognize mount point names, **`ldap_autofs_entry_key`**
- The attribute to use for additional configuration information for the mount point, **`ldap_autofs_entry_value`**

For example:

```
[domain/LDAP]
...
autofs_provider=ldap
ldap_autofs_search_base=cn=automount,dc=example,dc=com
ldap_autofs_map_object_class=automountMap
ldap_autofs_entry_object_class=automount
ldap_autofs_map_name=automountMapName
ldap_autofs_entry_key=automountKey
ldap_autofs_entry_value=automountInformation
```

6. Save and close the **`sssd.conf`** file.

7. Configure **`autofs`** to look for the automount map information in SSSD by editing the **`nsswitch.conf`** file and changing the location from **`ldap`** to **`sss`**:

```
# vim /etc/nsswitch.conf

automount: files sss
```

8. Restart SSSD.

```
# service sssd restart
```

13.2.8. Configuring Services: sudo

About sudo, LDAP, and SSSD

`sudo` rules are defined in the **`sudoers`** file, which must be distributed separately to every machine to maintain consistency.

One way for administrators to manage that for large environments is to store the **`sudo`** configuration in a central LDAP directory, and just configure each local system to point to that LDAP directory. That means that updates only need to be made in a single location, and any new rules are automatically recognized by local systems.

For **`sudo`**-LDAP configuration, each **`sudo`** rule is stored as an LDAP entry, with each component of the **`sudo`** rule defined in an LDAP attribute.

The **`sudoers`** rule looks like this:

```
Defaults    env_keep+=SSH_AUTH_SOCK
...
%wheel        ALL=(ALL)       ALL
```

The LDAP entry looks like this:

```
# sudo defaults
dn: cn=defaults,ou=SUDOers,dc=example,dc=com
objectClass: top
objectClass: sudoRole
cn: defaults
description: Default sudoOptions go here
sudoOption: env_keep+=SSH_AUTH_SOCK

# sudo rule
dn: cn=%wheel,ou=SUDOers,dc=example,dc=com
objectClass: top
objectClass: sudoRole
cn: %wheel
sudoUser: %wheel
sudoHost: ALL
sudoCommand: ALL
```

NOTE

SSSD only caches **sudo** rules which apply to the local system, depending on the value of the ***sudoHost*** attribute. This can mean that the ***sudoHost*** value is set to ALL, uses a regular expression that matches the host name, matches the systems netgroup, or matches the systems host name, fully qualified domain name, or IP address.

The **sudo** service can be configured to point to an LDAP server and to pull its rule configuration from those LDAP entries. Rather than pointing the **sudo** configuration to the LDAP directory, it can be configured to point to SSSD. SSSD, then, stores all of the information that **sudo** needs, and every time a user attempts a **sudo**-related operation, the latest **sudo** configuration can be pulled from the LDAP directory (through SSSD). SSSD, however, also caches all of the **sudo** riles, so that users can perform tasks, using that centralized LDAP configuration, *even if the LDAP server goes offline*.

Procedure 13.5. Configuring sudo with SSSD

All of the SSSD **sudo** configuration options are listed in the **sssd-ldap(5)** man page.

1. Make sure that the sssd-common package is installed.

   ```
   ~]$ rpm -q sssd-common
   ```

2. Open the **sssd.conf** file.

   ```
   ~]# vim /etc/sssd/sssd.conf
   ```

3. Add the **sudo** service to the list of services that SSSD manages.

```
[sssd]
services = nss,pam,sudo
....
```

4. Create a new **[sudo]** service configuration section. This section can be left blank; there is only one configurable option, for evaluating the sudo not before/after period.

   This section is required, however, for SSSD to recognize the **sudo** service and supply the default configuration.

   ```
   [sudo]
   ```

5. The **sudo** information is read from a configured LDAP domain in the SSSD configuration, so an LDAP domain must be available. For an LDAP provider, these parameters are required:

   - The directory type, **sudo_provider**; this is always **ldap**.
   - The search base, **ldap_sudo_search_base**.
   - The URI for the LDAP server, **ldap_uri**.

   For example:

   ```
   [domain/LDAP]
   id_provider = ldap

   sudo_provider = ldap
   ldap_uri = ldap://example.com
   ldap_sudo_search_base = ou=sudoers,dc=example,dc=com
   ```

   For an Identity Management (IdM or IPA) provider, there are additional parameters required to perform Kerberos authentication when connecting to the server.

   ```
   [domain/IDM]
   id_provider = ipa
   ipa_domain = example.com
   ipa_server = ipa.example.com
   ldap_tls_cacert = /etc/ipa/ca.crt

   sudo_provider = ldap
   ldap_uri = ldap://ipa.example.com
   ldap_sudo_search_base = ou=sudoers,dc=example,dc=com
   ldap_sasl_mech = GSSAPI
   ldap_sasl_authid = host/hostname.example.com
   ldap_sasl_realm = EXAMPLE.COM
   krb5_server = ipa.example.com
   ```

   NOTE

   The **sudo_provider** type for an Identity Management provider is still **ldap**.

6. Set the intervals to use to refresh the **sudo** rule cache.

The cache *for a specific system user* is always checked and updated whenever that user performs a task. However, SSSD caches all rules which relate to the local system. That complete cache is updated in two ways:

- Incrementally, meaning only changes to rules since the last full update (**ldap_sudo_smart_refresh_interval**, the time in seconds); the default is 15 minutes,
- Fully, which dumps the entire caches and pulls in all of the current rules on the LDAP server(**ldap_sudo_full_refresh_interval**, the time in seconds); the default is six hours.

These two refresh intervals are set separately. For example:

```
[domain/LDAP]
...
ldap_sudo_full_refresh_interval=86400
ldap_sudo_smart_refresh_interval=3600
```

NOTE

SSSD only caches **sudo** rules which apply to the local system. This can mean that the ***sudoHost*** value is set to ALL, uses a regular expression that matches the host name, matches the systems netgroup, or matches the systems host name, fully qualified domain name, or IP address.

7. Optionally, set any values to change the schema used for **sudo** rules.

   Schema elements are set in the **ldap_sudorule_*** attributes. By default, all of the schema elements use the schema defined in sudoers.ldap; these defaults will be used in almost all deployments.

8. Save and close the **sssd.conf** file.

9. Configure **sudo** to look for rules configuration in SSSD by editing the **nsswitch.conf** file and adding the **sss** location:

```
~]# vim /etc/nsswitch.conf

sudoers: files sss
```

10. Restart SSSD.

```
~]# service sssd restart
```

13.2.9. Configuring Services: OpenSSH and Cached Keys

OpenSSH creates secure, encrypted connections between two systems. One machine authenticates to another machine to allow access; the authentication can be of the machine itself for server connections or of a user on that machine. OpenSSH is described in more detail in Chapter 14, *OpenSSH*.

This authentication is performed through *public-private key pairs* that identify the authenticating user or machine. The remote machine or user attempting to access the machine presents a key pair. The local machine then elects whether to trust that remote entity; if it is trusted, the public key for that remote machine is stored in the **known_hosts** file or for the remote user in **authorized_keys**. Whenever that remote machine or user attempts to authenticate again, the local system checks the **known_hosts** or **authorized_keys** file first to see if that remote entity is recognized and trusted. If it is, then access is granted.

The first problem comes in verifying those identities reliably.

The **known_hosts** file is a triplet of the machine name, its IP address, and its public key:

```
server.example.com,255.255.255.255 ssh-rsa
AbcdEfg1234ZYX098776/AbcdEfg1234ZYX098776/AbcdEfg1234ZYX098776=
```

The **known_hosts** file can quickly become outdated for a number of different reasons: systems using DHCP cycle through IP addresses, new keys can be re-issued periodically, or virtual machines or services can be brought online and removed. This changes the host name, IP address, and key triplet.

Administrators have to clean and maintain a current **known_hosts** file to maintain security. (Or system users get in the habit of accepting any machine and key presented, which negates the security benefits of key-based security.)

Additionally, a problem for both machines and users is distributing keys in a scalable way. Machines can send their keys as part of establishing an encrypted session, but users have to supply their keys in advance. Simply propagating and then updating keys consistently is a difficult administrative task.

Lastly, SSH key and machine information are only maintained locally. There may be machines or users on the network which are recognized and trusted by some systems and not by others because the **known_hosts** file has not been updated uniformly.

The goal of SSSD is to server as a credentials cache. This includes working as a credentials cache for SSH public keys for machines and users. OpenSSH is configured to reference SSSD to check for cached keys; SSSD uses Red Hat Linux's Identity Management (IPA) domain as an identity, and Identity Management actually stores the public keys and host information.

NOTE

Only Linux machines enrolled, or joined, in the Identity Management domain can use SSSD as a key cache for OpenSSH. Other Unix machines and Windows machines must use the regular authentication mechanisms with the **known_hosts** file.

Configuring OpenSSH to Use SSSD for Host Keys

OpenSSH is configured in either a user-specific configuration file (**~/.ssh/config**) or a system-wide configuration file (**/etc/ssh/ssh_config**). The user file has precedence over the system settings and the first obtained value for a parameter is used. The formatting and conventions for this file are covered in Chapter 14, *OpenSSH*.

In order to manage host keys, SSSD has a tool, **sss_ssh_knownhostsproxy**, which performs two operations:

1. Asks SSSD to retrieve the public host key from the Identity Management server and store it in the **/var/lib/sss/pubconf/known_hosts** file.

2. Establishes a connection with the host machine, using either a socket (the default) or a proxy command.

This tool has the format:

```
sss_ssh_knownhostsproxy [-d sssd_domain] [-p ssh_port] HOST
[PROXY_COMMAND]
```

Table 13.4. sss_ssh_knownhostsproxy Options

Short Argument	Long Argument	Description
	HOSTNAME	Gives the host name of the host to check and connect to. In the OpenSSH configuration file, this can be a token, **%h**.
	PROXY_COMMAND	Passes a proxy command to use to connect to the SSH client. This is similar to running **`ssh -o ProxyCommand=`***value*. This option is used when running **`sss_ssh_knownhostsproxy`** from the command line or through another script, but is not necessary in the OpenSSH configuration file.
-d *sssd_domain*	--domain *sssd_domain*	Only searches for public keys in entries in the specified domain. If not given, SSSD searches for keys in all configured domains.
-p *port*	--port *port*	Uses this port to connect to the SSH client. By default, this is port 22.

To use this SSSD tool, add or edit two parameters to the **`ssh_config`** or **`~/.ssh/config`** file:

- Specify the command to use to connect to the SSH client (**`ProxyCommand`**). This is the **`sss_ssh_knownhostsproxy`**, with the desired arguments and host name.
- Specify the location of the SSSD hosts file (**`GlobalKnownHostsFile`**).

For example, this looks for public keys in all configured SSSD domains and connects over whatever port and host are supplied:

```
ProxyCommand /usr/bin/sss_ssh_knownhostsproxy -p %p %h
GlobalKnownHostsFile /var/lib/sss/pubconf/known_hosts
```

Configuring OpenSSH to Use SSSD for User Keys

SSSD can provide user public keys to OpenSSH. The keys are read by the SSH daemon, **`sshd`**, directly from the output of the **`sss_ssh_authorizedkeys`** tool and are not stored in a file.

To configure **`sshd`** to read a user's public keys from an external program, in this case the **`sss_ssh_authorizedkeys`** tool, use the AuthorizedKeysCommand directive in the **`/etc/ssh/sshd_config`** file.

The **`sss_ssh_authorizedkeys`** tool can be used to acquire SSH public keys from the user entries in the Identity Management (IPA) domain and output them in OpenSSH **`authorized_keys`** format. The command has the following format:

```
sss_ssh_authorizedkeys [-d sssd_domain] USER
```

Table 13.5. sss_ssh_authorizedkeys Options

Short Argument	Long Argument	Description
	USER	The user name or account name for which to obtain the public key. In the OpenSSH configuration file, this can be represented by a token, **%u**.
-d *sssd_domain*	--domain *sssd_domain*	Only search for public keys in entries in the specified domain. If not given, SSSD searches for keys in all configured domains.

This feature is configured in **`/etc/ssh/sshd_config`** as follows:

```
AuthorizedKeysCommand /usr/bin/sss_ssh_authorizedkeys
AuthorizedKeysCommandRunAs nobody
```

These and further options are documented in the **`sshd_config(5)`** man page. Note that the **`sshd`** service must be restarted for any changes to take effect.

13.2.10. SSSD and Identity Providers (Domains)

SSSD recognizes *domains*, which are entries within the SSSD configuration file associated with different, external data sources. Domains are a combination of an identity provider (for user information) and, optionally, other providers such as authentication (for authentication requests) and for other operations, such as password changes. (The identity provider can also be used for all operations, if all operations are performed within a single domain or server.)

SSSD works with different LDAP identity providers (including OpenLDAP, Red Hat Directory Server, and Microsoft Active Directory) and can use native LDAP authentication, Kerberos authentication, or provider-specific authentication protocols (such as Active Directory).

A domain configuration defines the *identity provider*, the *authentication provider*, and any specific configuration to access the information in those providers. There are several types of identity and authentication providers:

- LDAP, for general LDAP servers
- Active Directory (an extension of the LDAP provider type)
- Identity Management (an extension of the LDAP provider type)
- Local, for the local SSSD database
- Proxy
- Kerberos (authentication provider only)

The identity and authentication providers can be configured in different combinations in the domain entry. The possible combinations are listed in Table 13.6, “Identity Store and Authentication Type Combinations”.

Table 13.6. Identity Store and Authentication Type Combinations

Identification Provider	Authentication Provider
Identity Management (LDAP)	Identity Management (LDAP)
Active Directory (LDAP)	Active Directory (LDAP)
Active Directory (LDAP)	Kerberos
LDAP	LDAP
LDAP	Kerberos
proxy	LDAP
proxy	Kerberos
proxy	proxy

Along with the domain entry itself, the domain name must be added to the list of domains that SSSD will query. For example:

```
[sssd]
domains = LOCAL,Name
...

[domain/Name]
id_provider = type
auth_provider = type
provider_specific = value
global = value
```

global attributes are available to any type of domain, such as cache and time out settings. Each identity and authentication provider has its own set of required and optional configuration parameters.

Table 13.7. General [domain] Configuration Parameters

Parameter	Value Format	Description

Parameter	Value Format	Description
id_provider	string	Specifies the data back end to use for this domain. The supported identity back ends are: • ldap • ipa (Identity Management in Red Hat Enterprise Linux) • ad (Microsoft Active Directory) • proxy, for a legacy NSS provider, such as **`nss_nis`**. Using a proxy ID provider also requires specifying the legacy NSS library to load to start successfully, set in the **`proxy_lib_name`** option. • local, the SSSD internal local provider
auth_provider	string	Sets the authentication provider used for the domain. The default value for this option is the value of **`id_provider`**. The supported authentication providers are ldap, ipa, ad, krb5 (Kerberos), proxy, and none.
min_id,max_id	integer	*Optional.* Specifies the UID and GID range for the domain. If a domain contains entries that are outside that range, they are ignored. The default value for **`min_id`** is **`1`**; the default value for **`max_id`** is **`0`**, which is unlimited. **IMPORTANT** The default **`min_id`** value is the same for all types of identity provider. If LDAP directories are using UID numbers that start at one, it could cause conflicts with users in the local **`/etc/passwd`** file. To avoid these conflicts, set **`min_id`** to **`1000`** or higher as possible.
cache_credentials	Boolean	*Optional.* Specifies whether to store user credentials in the local SSSD domain database cache. The default value for this parameter is **`false`**. Set this value to **`true`** for domains other than the LOCAL domain to enable offline authentication.
entry_cache_timeout	integer	*Optional.* Specifies how long, in seconds, SSSD should cache *positive* cache hits. A positive cache hit is a successful query.

Parameter	Value Format	Description
use_fully_qualified_names	Boolean	*Optional.* Specifies whether requests to this domain require fully qualified domain names. If set to **`true`**, all requests to this domain must use fully qualified domain names. It also means that the output from the request displays the fully-qualified name. Restricting requests to fully qualified user names allows SSSD to differentiate between domains with users with conflicting user names. If ***`use_fully_qualified_names`*** is set to **`false`**, it is possible to use the fully-qualified name in the requests, but only the simplified version is displayed in the output. SSSD can only parse names based on the domain name, not the realm name. The same name can be used for both domains and realms, however.

13.2.11. Creating Domains: LDAP

An LDAP domain means that SSSD uses an LDAP directory as the identity provider (and, optionally, also as an authentication provider). SSSD supports several major directory services:

- Red Hat Directory Server
- OpenLDAP
- Identity Management (IdM or IPA)
- Microsoft Active Directory 2008 R2

NOTE

All of the parameters available to a general LDAP identity provider are also available to Identity Management and Active Directory identity providers, which are subsets of the LDAP provider.

Parameters for Configuring an LDAP Domain

An LDAP directory can function as both an identity provider and an authentication provider. The configuration requires enough information to identify and connect to the user directory in the LDAP server, but the way that those connection parameters are defined is flexible.

Other options are available to provide more fine-grained control, like specifying a user account to use to connect to the LDAP server or using different LDAP servers for password operations. The most common options are listed in Table 13.8, “LDAP Domain Configuration Parameters”.

NOTE

Server-side password policies always take precedence over the policy enabled from the client side. For example, when setting the **`ldap_pwd_policy=shadow`** option, the policies defined with the ***`shadow`*** LPAD attributes for a user have no effect on whether the password policy is enabled on the OpenLDAP server.

NOTE

Many other options are listed in the man page for LDAP domain configuration, **`sssd-ldap(5)`**.

Table 13.8. LDAP Domain Configuration Parameters

Parameter	Description
ldap_uri	Gives a comma-separated list of the URIs of the LDAP servers to which SSSD will connect. The list is given in order of preference, so the first server in the list is tried first. Listing additional servers provides failover protection. This can be detected from the DNS SRV records if it is not given.
ldap_search_base	Gives the base DN to use for performing LDAP user operations. **IMPORTANT** If used incorrectly, ***`ldap_search_base`*** might cause SSSD lookups to fail. With an AD provider, setting ***`ldap_search_base`*** is not required. The AD provider automatically discovers all the necessary information. Red Hat recommends not to set the parameter in this situation and instead rely on what the AD provider discovers.
ldap_tls_reqcert	Specifies how to check for SSL server certificates in a TLS session. There are four options: • *never* disables requests for certificates. • *allow* requests a certificate, but proceeds normally even if no certificate is given or a bad certificate is given. • *try* requests a certificate and proceeds normally if no certificate is given, If a bad certificate is given, the session terminates. • *demand* and *hard* are the same option. This requires a valid certificate or the session is terminated. The default is *hard*.
ldap_tls_cacert	Gives the full path and file name to the file that contains the CA certificates for all of the CAs that SSSD recognizes. SSSD will accept any certificate issued by these CAs. This uses the OpenLDAP system defaults if it is not given explicitly.

Parameter	Description
ldap_referrals	Sets whether SSSD will use LDAP referrals, meaning forwarding queries from one LDAP database to another. SSSD supports database-level and subtree referrals. For referrals within the same LDAP server, SSSD will adjust the DN of the entry being queried. For referrals that go to different LDAP servers, SSSD does an exact match on the DN. Setting this value to **`true`** enables referrals; this is the default. Referrals can negatively impact overall performance because of the time spent attempting to trace referrals. Disabling referral checking can significantly improve performance.

ldap_schema	Sets what version of schema to use when searching for user entries. This can be **`rfc2307`**, **`rfc2307bis`**, **`ad`**, or **`ipa`**. The default is **`rfc2307`**.
	In RFC 2307, group objects use a multi-valued attribute, ***`memberuid`***, which lists the names of the users that belong to that group. In RFC 2307bis, group objects use the ***`member`*** attribute, which contains the full distinguished name (DN) of a user or group entry. RFC 2307bis allows nested groups using the ***`member`*** attribute. Because these different schema use different definitions for group membership, using the wrong LDAP schema with SSSD can affect both viewing and managing network resources, even if the appropriate permissions are in place.
	
	For example, with RFC 2307bis, all groups are returned when using nested groups or primary/secondary groups.
	
	`$ id`
	`uid=500(myserver) gid=500(myserver)`
	`groups=500(myserver),510(myothergroup)`
	
	If SSSD is using RFC 2307 schema, only the primary group is returned.
	
	This setting only affects how SSSD determines the group members. It does not change the actual user data.

ldap_search_timeout	Sets the time, in seconds, that LDAP searches are allowed to run before they are canceled and cached results are returned. When an LDAP search times out, SSSD automatically switches to offline mode.
ldap_network_timeout	Sets the time, in seconds, SSSD attempts to poll an LDAP server after a connection attempt fails. The default is six seconds.
ldap_opt_timeout	Sets the time, in seconds, to wait before aborting synchronous LDAP operations if no response is received from the server. This option also controls the timeout when communicating with the KDC in case of a SASL bind. The default is five seconds.

LDAP Domain Example

The LDAP configuration is very flexible, depending on your specific environment and the SSSD behavior. These are some common examples of an LDAP domain, but the SSSD configuration is not limited to these examples.

NOTE

Along with creating the domain entry, add the new domain to the list of domains for SSSD to query in the **sssd.conf** file. For example:

```
domains = LOCAL,LDAP1,AD,PROXYNIS
```

Example 13.2. A Basic LDAP Domain Configuration

An LDAP domain requires three things:

- An LDAP server
- The search base
- A way to establish a secure connection

The last item depends on the LDAP environment. SSSD requires a secure connection since it handles sensitive information. This connection can be a dedicated TLS/SSL connection or it can use Start TLS.

Using a dedicated TLS/SSL connection uses an LDAPS connection to connect to the server and is therefore set as part of the **ldap_uri** option:

```
# An LDAP domain
[domain/LDAP]
cache_credentials = true

id_provider = ldap
auth_provider = ldap

ldap_uri = ldaps://ldap.example.com:636
ldap_search_base = dc=example,dc=com
```

Using Start TLS requires a way to input the certificate information to establish a secure connection dynamically over an insecure port. This is done using the **ldap_id_use_start_tls** option to use Start TLS and then **ldap_tls_cacert** to identify the CA certificate which issued the SSL server certificates.

```
# An LDAP domain
[domain/LDAP]
cache_credentials = true

id_provider = ldap
auth_provider = ldap

ldap_uri = ldap://ldap.example.com
ldap_search_base = dc=example,dc=com
ldap_id_use_start_tls = true
ldap_tls_reqcert = demand
ldap_tls_cacert = /etc/pki/tls/certs/ca-bundle.crt
```

13.2.12. Creating Domains: Identity Management (IdM)

The Identity Management (IdM or IPA) identity provider is an extension of a generic LDAP provider. All of the configuration options for an LDAP provider are available to the IdM provider, as well as some additional parameters which allow SSSD to work as a client of the IdM domain and extend IdM functionality.

Identity Management can work as a provider for identities, authentication, access control rules, and passwords, all of the ***_provider** parameters for a domain. Additionally, Identity Management has configuration options within its own domain to manage SELinux policies, automount information, and host-based access control. All of those features in IdM domains can be tied to SSSD configuraiton, allowing those security-related policies to be applied and cached for system users.

Example 13.3. Basic IdM Provider

An IdM provider, like an LDAP provider, can be set to serve several different services, including identity, authentication, and access control

For IdM servers, there are two additional settings which are very useful (although not required):

- Use the specific IdM schema rather than the default RFC 2307 schema.
- Set SSSD to update the Identity Management domain's DNS server with the IP address of this client when the client first connects to the IdM domain.

```
[sssd]
domains = local,example.com
...

[domain/example.com]
id_provider = ipa
ipa_server = ipaserver.example.com
ipa_hostname = ipa1.example.com
auth_provider = ipa
access_provider = ipa
chpass_provider = ipa

# set which schema to use
ldap_schema = ipa

# automatically update IdM DNS records
ipa_dyndns_update = true
```

Identity Management defines and maintains security policies and identities for users across a Linux domain. This includes access control policies, SELinux policies, and other rules. Some of these elements in the IdM domain interact directly with SSSD, using SSSD as an IdM client — and those features can be managed in the IdM domain entry in **sssd.conf**.

Most of the configuration parameters relate to setting schema elements (which is not relevant in most deployments because IdM uses a fixed schema) and never need to be changed. In fact, none of the features in IdM require client-side settings. But there may be circumstances where tweaking the behavior is helpful.

Example 13.4. IdM Provider with SELinux

IdM can define SELinux user policies for system users, so it can work as an SELinux provider for SSSD. This is set in the **`selinux_provider`** parameter. The provider defaults to the **`id_provider`** value, so this is not necessary to set explicitly to *support* SELinux rules. However, it can be useful to explicitly *disable* SELinux support for the IdM provider in SSSD.

```
selinux_provider = ipa
```

Example 13.5. IdM Provider with Host-Based Access Control

IdM can define host-based access controls, restricting access to services or entire systems based on what host a user is using to connect or attempting to connect to. This rules can be evaluated and enforced by SSSD as part of the access provider behavior.

For host-based access controls to be in effect, the Identity Management server must be the access provider, at a minimum.

There are two options which can be set for how SSSD evaluates host-based access control rules:

- SSSD can evaluate what machine (source host) the user is using to connect to the IdM resource; this is disabled by default, so that only the target host part of the rule is evaluated.
- SSSD can refresh the host-based access control rules in its cache at a specified interval.

For example:

```
access_provider = ipa
ipa_hbac_refresh = 120

# check for source machine rules; disabled by default
ipa_hbac_support_srchost = true
```

Example 13.6. Identity Management with Cross-Realm Kerberos Trusts

Identity Management (IdM or IPA) can be configured with trusted relationships between Active Directory DNS domains and Kerberos realms. This allows Active Directory users to access services and hosts on Linux systems.

There are two configuration settings in SSSD that are used with cross-realm trusts:

- A service that adds required data to Kerberos tickets
- A setting to support subdomains

Kerberos Ticket Data

Microsoft uses a special authorization structure called *privileged access certificates* or MS-PAC. A PAC is embedded in a Kerberos ticket as a way of identifying the entity to other Windows clients and servers in the Windows domain.

SSSD has a special PAC service which generates the additional data for Kerberos tickets. When using an Active Directory domain, it may be necessary to include the PAC data for Windows users. In that case, enable the **pac** service in SSSD:

```
[sssd]
services = nss, pam, pac
...
```

Windows Subdomains

Normally, a domain entry in SSSD corresponds directly to a single identity provider. However, with IdM cross-realm trusts, the IdM domain can trust another domain, so that the domains are transparent to each other. SSSD can follow that trusted relationship, so that if an IdM domain is configured, any Windows domain is also automatically searched and supported by SSSD — without having to be configured in a domain section in SSSD.

This is configured by adding the **`subdomains_provider`** parameter to the IdM domain section. This is actually an optional parameter; if a subdomain is discovered, then SSSD defaults to using the **`ipa`** provider type. However, this parameter can also be used to disable subdomain fetches by setting a value of **none**.

```
[domain/IDM]
...
subdomains_provider = ipa
get_domains_timeout = 300
```

13.2.13. Creating Domains: Active Directory

The Active Directory identity provider is an extension of a generic LDAP provider. All of the configuration options for an LDAP provider are available to the Active Directory provider, as well as some additional parameters related to user accounts and identity mapping between Active Directory and system users.

There are some fundamental differences between standard LDAP servers and an Active Directory server. When configuring an Active Directory provider, there are some configuration areas, then, which require specific configuration:

- Identities using a Windows security ID must be mapped to the corresponding Linux system user ID.
- Searches must account for the range retrieval extension.
- There may be performance issues with LDAP referrals.

Mapping Active Directory Securiy IDs and Linux User IDs

There are inherent structural differences between how Windows and Linux handle system users and in the user schemas used in Active Directory and standard LDAPv3 directory services. When using an Active Directory identity provider with SSSD to manage system users, it is necessary to reconcile the Active Directory-style user to the new SSSD user. There are two ways to do this:

- Using Services for Unix to insert POSIX attributes on Windows user and group entries, and then having those attributes pulled into PAM/NSS
- Using ID mapping on SSSD to create a map between Active Directory security IDs (SIDs) and the generated UIDs on Linux

ID mapping is the simplest option for most environments because it requires no additional packages or configuration on Active Directory.

The Mechanism of ID Mapping

Linux/Unix systems use a local user ID number and group ID number to identify users on the system. These UID:GID numbers are a simple integer, such as *501:501*. These numbers are simple because they are always created and administered locally, even for systems which are part of a larger Linux/Unix domain.

Microsoft Windows and Active Directory use a different user ID structure to identify users, groups, and machines. Each ID is constructed of different segments that identify the security version, the issuing authority type, the machine, and the identity itself. For example:

```
S-1-5-21-3623811015-3361044348-30300820-1013
```

The third through sixth blocks are the machine identifier:

```
S-1-5-21-3623811015-3361044348-30300820-1013
```

The last block is the *relative identifier* (RID) which identifies the specific entity:

```
S-1-5-21-3623811015-3361044348-30300820-1013
```

A range of possible ID numbers are always assigned to SSSD. (This is a local range, so it is the same for every machine.)

```
|______________________________|
|                              |
minimum ID                     max ID
```

This range is divided into 10,000 sections (by default), with each section allocated 200,000 IDs.

```
| slice 1 | slice 2 |   ...   |
|_________|_________|_________|
|         |         |         |
minimum ID                    max ID
```

When a new Active Directory domain is detected, the SID is hashed. Then, SSSD takes the modulus of the hash and the number of available sections to determine which ID section to assign to the Active Directory domain. This is a reliably consistent means of assigning ID sections, so the same ID range is assigned to the same Active Directory domain on most client machines.

```
| Active  | Active  |         |
|Directory|Directory|         |
|domain 1 |domain 2 |   ...   |
|         |         |         |
| slice 1 | slice 2 |   ...   |
|_________|_________|_________|
|         |         |         |
minimum ID                    max ID
```

NOTE

While the method of assigning ID sections is consistent, **ID mapping is based on the order that an Active Directory domain is encountered on a client machine** — so it may not result in consistent ID range assignments on all Linux client machines. If consistency is required, then consider disabling ID mapping and using explicit POSIX attributes.

ID Mapping Parameters

ID mapping is enabled in two parameters, one to enable the mapping and one to load the appropriate Active Directory user schema:

```
ldap_id_mapping = True
ldap_schema = ad
```

NOTE

When ID mapping is enabled, the ***`uidNumber`*** and ***`gidNumber`*** attributes are ignored. This prevents any manually-assigned values. If *any* values must be manually assigned, then *all* values must be manually assigned, and ID mapping should be disabled.

Mapping Users

When an Active Directory user attempts to log into a local system service for the first time, an entry for that user is created in the SSSD cache. The remote user is set up much like a system user:

- A system UID is created for the user based on his SID and the ID range for that domain.
- A GID is created for the user, which is identical to the UID.
- A private group is created for the user.
- A home directory is created, based on the home directory format in the **`sssd.conf`** file.
- A shell is created, according to the system defaults or the setting in the **`sssd.conf`** file.
- If the user belongs to any groups in the Active Directory domain, then, using the SID, SSSD adds the user to those groups on the Linux system.

Active Directory Users and Range Retrieval Searches

Microsoft Active Directory has an attribute, ***`MaxValRange`***, which sets a limit on how many values for a multi-valued attribute will be returned. This is the *range retrieval* search extension. Essentially, this runs multiuple mini-searches, each returning a subset of the results within a given range, until all matches are returned.

For example, when doing a search for the ***`member`*** attribute, each entry could have multiple values, and there can be multiple entries with that attribute. If there are 2000 matching results (or more), then ***`MaxValRange`*** limits how many are displayed at once; this is the value range. The given attribute then has an additional flag set, showing which range in the set the result is in:

```
attribute:range=low-high:value
```

For example, results 100 to 500 in a search:

```
member;range=99-499: cn=John Smith...
```

This is described in the Microsoft documentation at http://msdn.microsoft.com/en-us/library/cc223242.aspx.

SSSD supports range retrievals with Active Directory providers as part of user and group management, without any additional configuration.

However, some LDAP provider attributes which are available to configure searches — such as **`ldap_user_search_base`** — are not performant with range retrievals. Be cautious when configuring search bases in the Active Directory provider domain and consider what searches may trigger a range retrieval.

Performance and LDAP Referrals

Referrals can negatively impact overall performance because of the time spent attempting to trace referrals. There is particularly bad performance degradation when referral chasing is used with an Active Directory identity provider. Disabling referral checking can significantly improve performance.

LDAP referrals are enabled by default, so they must be explicitly disabled in the LDAP domain configuration. For example:

```
ldap_referrals = false
```

Active Directory as Other Provider Types

Active Directory can be used as an identity provider and as an access, password, and authentication provider.

There are a number of options in the generic LDAP provider configuration which can be used to configure an Active Directory provider. Using the **`ad`** value is a short-cut which automatically pulls in the parameters and values to configure a given provider for Active Directory. For example, using **`access_provider = ad`** to configure an Active Directory access provider expands to this configuration using the explicit LDAP provider parameters:

```
access_provider = ldap
ldap_access_order = expire
ldap_account_expire_policy = ad
```

Procedure 13.6. Configuring an Active Directory Identity Provider

Active Directory can work as a provider for identities, authentication, access control rules, and passwords, all of the ***`*_provider`*** parameters for a domain. Additionally, it is possible to load the native Active Directory schema for user and group entries, rather than using the default RFC 2307.

1. Make sure that both the Active Directory and Linux systems have a properly configured environment.

   - Name resolution must be properly configured, particularly if service discovery is used with SSSD.

   - The clocks on both systems must be in sync for Kerberos to work properly.

2. Set up the Linux system as an Active Directory client and enroll it within the Active Directory domain. This is done by configuring the Kerberos and Samba services on the Linux system.

   a. Set up Kerberos to use the Active Directory Kerberos realm.

i. Open the Kerberos client configuration file.

```
~]# vim /etc/krb5.conf
```

ii. Configure the **`[logging]`** and **`[libdefaults]`** sections so that they connect to the Active Directory realm.

```
[logging]
 default = FILE:/var/log/krb5libs.log

[libdefaults]
 default_realm = EXAMPLE.COM
 dns_lookup_realm = true
 dns_lookup_kdc = true
 ticket_lifetime = 24h
 renew_lifetime = 7d
 rdns = false
 forwardable = false
```

If autodiscovery is not used with SSSD, then also configure the **`[realms]`** and **`[domain_realm]`** sections to explicitly define the Active Directory server.

b. Configure the Samba server to connect to the Active directory server.

i. Open the Samba configuration file.

```
~]# vim /etc/samba/smb.conf
```

ii. Set the Active Directory domain information in the **`[global]`** section.

```
[global]
   workgroup = EXAMPLE
   client signing = yes
   client use spnego = yes
   kerberos method = secrets and keytab
   log file = /var/log/samba/%m.log
   password server = AD.EXAMPLE.COM
   realm = EXAMPLE.COM
   security = ads
```

c. Add the Linux machine to the Active Directory domain.

i. Obtain Kerberos credentials for a Windows administrative user.

```
~]# kinit Administrator
```

ii. Add the machine to the domain using the **`net`** command.

```
~]# net ads join -k
Joined 'server' to dns domain 'example.com'
```

This creates a new keytab file, **`/etc/krb5.keytab`**.

List the keys for the system and check that the host principal is there.

```
~]# klist -k
```

3. Use **`authconfig`** to enable SSSD for system authentication.

```
# authconfig --update --enablesssd --enablesssdauth
```

4. Set the Active Directory domain as an identity provider in the SSSD configuration, as shown in Example 13.7, “An Active Directory 2008 R2 Domain” and Example 13.8, “An Active Directory 2008 R2 Domain with ID Mapping”.

5. Restart the SSH service to load the new PAM configuration.

```
~]# service sshd restart
```

6. Restart SSSD after changing the configuration file.

```
~]# service sssd restart
```

Example 13.7. An Active Directory 2008 R2 Domain

```
~]# vim /etc/sssd/sssd.conf

[sssd]
config_file_version = 2
domains = ad.example.com
services = nss, pam

...

[domain/ad.example.com]
id_provider = ad
ad_server = ad.example.com
ad_hostname = ad.example.com
auth_provider = ad
chpass_provider = ad
access_provider = ad

# defines user/group schema type
ldap_schema = ad

# using explicit POSIX attributes in the Windows entries
ldap_id_mapping = False

# caching credentials
cache_credentials = true

# access controls
ldap_access_order = expire
ldap_account_expire_policy = ad
ldap_force_upper_case_realm = true
```

```
# performance
ldap_referrals = false
```

There are two parameters that are critical for ID mapping: the Active Directory schema must be loaded (**`ldap_schema`**) and ID mapping must be explicitly enabled (**`ldap_id_mapping`**).

Example 13.8. An Active Directory 2008 R2 Domain with ID Mapping

```
~]# vim /etc/sssd/sssd.conf

[sssd]
config_file_version = 2
domains = ad.example.com
services = nss, pam

...

[domain/ad.example.com]
id_provider = ad
ad_server = ad.example.com
ad_hostname = ad.example.com
auth_provider = ad
chpass_provider = ad
access_provider = ad

# defines user/group schema type
ldap_schema = ad

# for SID-UID mapping
ldap_id_mapping = True

# caching credentials
cache_credentials = true

# access controls
ldap_access_order = expire
ldap_account_expire_policy = ad
ldap_force_upper_case_realm = true

# performance
ldap_referrals = false
```

All of the potential configuration attributes for an Active Directory domain are listed in the **`sssd-ldap(5)`** and **`sssd-ad(5)`** man pages.

13.2.14. Configuring Domains: Active Directory as an LDAP Provider (Alternative)

While Active Directory can be configured as a type-specific identity provider, it can also be configured as a pure LDAP provider with a Kerberos authentication provider.

Procedure 13.7. Configuring Active Directory as an LDAP Provider

1. It is recommended that SSSD connect to the Active Directory server using SASL, which means that the local host must have a service keytab *for the Windows domain* on the Linux host.

   This keytab can be created using Samba.

   a. Configure the **/etc/krb5.conf** file to use the Active Directory realm.

   ```
   [logging]
    default = FILE:/var/log/krb5libs.log

   [libdefaults]
    default_realm = AD.EXAMPLE.COM
    dns_lookup_realm = true
    dns_lookup_kdc = true
    ticket_lifetime = 24h
    renew_lifetime = 7d
    rdns = false
    forwardable = false

   [realms]
   # Define only if DNS lookups are not working
   # AD.EXAMPLE.COM = {
   #  kdc = server.ad.example.com
   #  admin_server = server.ad.example.com
   #  master_kdc = server.ad.example.com
   # }

   [domain_realm]
   # Define only if DNS lookups are not working
   # .ad.example.com = AD.EXAMPLE.COM
   # ad.example.com = AD.EXAMPLE.COM
   ```

   b. Set the Samba configuration file, **/etc/samba/smb.conf**, to point to the Windows Kerberos realm.

   ```
   [global]
      workgroup = EXAMPLE
      client signing = yes
      client use spnego = yes
      kerberos method = secrets and keytab
      log file = /var/log/samba/%m.log
      password server = AD.EXAMPLE.COM
      realm = EXAMPLE.COM
      security = ads
   ```

   c. To initialize Kerberos, type the following command as **root**:

   ```
   ~]# kinit Administrator@EXAMPLE.COM
   ```

   d. Then, run the **net ads** command to log in as an administrator principal. This administrator account must have sufficient rights to add a machine to the Windows domain, but it does not require domain administrator privileges.

   ```
   ~]# net ads join -U Administrator
   ```

   e. Run **`net ads`** again to add the host machine to the domain. This can be done with the host principal (*host/FQDN*) or, optionally, with the NFS service (*nfs/FQDN*).

      ```
      ~]# net ads join createupn="host/rhel-
      server.example.com@AD.EXAMPLE.COM" -U Administrator
      ```

2. Make sure that the Services for Unix package is installed on the Windows server.

3. Set up the Windows domain which will be used with SSSD.

   a. On the Windows machine, open **`Server Manager`**.

   b. Create the Active Directory Domain Services role.

   c. Create a new domain, such as **`ad.example.com`**.

   d. Add the Identity Management for UNIX service to the Active Directory Domain Services role. Use the Unix NIS domain as the domain name in the configuration.

4. On the Active Directory server, create a group for the Linux users.

   a. Open **`Administrative Tools`** and select **`Active Directory Users and Computers`**.

   b. Select the Active Directory domain, **`ad.example.com`**.

   c. In the **`Users`** tab, right-click and select **Create a New Group**.

   d. Name the new group **`unixusers`**, and save.

   e. Double-click the **`unixusers`** group entry, and open the **`Users`** tab.

   f. Open the **`Unix Attributes`** tab.

   g. Set the NIS domain to the NIS domain that was configured for **`ad.example.com`** and, optionally, set a group ID (GID) number.

5. Configure a user to be part of the Unix group.

   a. Open **`Administrative Tools`** and select **`Active Directory Users and Computers`**.

   b. Select the Active Directory domain, **`ad.example.com`**.

   c. In the **`Users`** tab, right-click and select **Create a New User**.

   d. Name the new user **`aduser`**, and make sure that the **`User must change password at next logon`** and **`Lock account`** check boxes are *not* selected.

      Then save the user.

   e. Double-click the **`aduser`** user entry, and open the **`Unix Attributes`** tab. Make sure that the Unix configuration matches that of the Active Directory domain and the **`unixgroup`** group:

      - The NIS domain, as created for the Active Directory domain

- The UID
- The login shell, to **`/bin/bash`**
- The home directory, to **`/home/aduser`**
- The primary group name, to **`unixusers`**

NOTE

Password lookups on large directories can take several seconds per request. The initial user lookup is a call to the LDAP server. Unindexed searches are much more resource-intensive, and therefore take longer, than indexed searches because the server checks every entry in the directory for a match. To speed up user lookups, index the attributes that are searched for by SSSD:

- uid
- uidNumber
- gidNumber
- gecos

6. On the Linux system, configure the SSSD domain.

```
~]# vim /etc/sssd/sssd.conf
```

For a complete list of LDAP provider parameters, see the **`sssd-ldap(5)`** man pages.

Example 13.9. An Active Directory 2008 R2 Domain with Services for Unix

```
[sssd]
config_file_version = 2
domains = ad.example.com
services = nss, pam

...

[domain/ad.example.com]
cache_credentials = true

# for performance
ldap_referrals = false

id_provider = ldap
auth_provider = krb5
chpass_provider = krb5
access_provider = ldap

ldap_schema = rfc2307bis

ldap_sasl_mech = GSSAPI
ldap_sasl_authid = host/rhel-server.example.com@AD.EXAMPLE.COM
```

```
#provide the schema for services for unix
ldap_schema = rfc2307bis

ldap_user_search_base = ou=user accounts,dc=ad,dc=example,dc=com
ldap_user_object_class = user
ldap_user_home_directory = unixHomeDirectory
ldap_user_principal = userPrincipalName

# optional - set schema mapping
# parameters are listed in sssd-ldap
ldap_user_object_class = user
ldap_user_name = sAMAccountName

ldap_group_search_base = ou=groups,dc=ad,dc=example,dc=com
ldap_group_object_class = group

ldap_access_order = expire
ldap_account_expire_policy = ad
ldap_force_upper_case_realm = true
ldap_referrals = false

krb5_realm = AD-REALM.EXAMPLE.COM
# required
krb5_canonicalize = false
```

7. Restart SSSD.

```
~]# service sssd restart
```

13.2.15. Domain Options: Setting Username Formats

One of the primary actions that SSSD performs is mapping a local system user to an identity in the remote identity provider. SSSD uses a combination of the user name and the domain back end name to create the login identity.

As long as they belong to different domains, SSSD can recognize different users with the same user name. For example, SSSD can successfully authenticate both **`jsmith`** in the **`ldap.example.com`** domain and **`jsmith`** in the **`ldap.otherexample.com`** domain.

The name format used to construct full user name is (optionally) defined universally in the **`[sssd]`** section of the configuration and can then be defined individually in each domain section.

Usernames for different services — LDAP, Samba, Active Directory, Identity Management, even the local system — all have different formats. The expression that SSSD uses to identify user name/domain name sets must be able to interpret names in different formats. This expression is set in the **`re_expression`** parameter.

In the global default, this filter constructs a name in the form *name@domain*:

```
(?P<name>[^@]+)@?(?P<domain>[^@]*$)
```

NOTE

The regular expression format is Python syntax.

The domain part may be supplied automatically, based on the domain name of the identity provider. Therefore, a user can log in as **`jsmith`** and if the user belongs to the LOCAL domain (for example), then his user name is interpreted by SSSD as **`jsmith@LOCAL`**.

However, other identity providers may have other formats. Samba, for example, has a very strict format so that user name must match the form *DOMAIN\username*. For Samba, then, the regular expression must be:

```
(?P<domain>[^\\]*?)\\?(?P<name>[^\\]+$)
```

Some providers, such as Active Directory, support multiple different name formats. Active Directory and Identity Management, for example, support three different formats by default:

- *username*
- *username@domain.name*
- *DOMAIN\username*

The default value for Active Directory and Identity Management providers, then, is a more complex filter that allows all three name formats:

```
(((?P<domain>[^\\]+)\\(?P<name>.+$))|((?P<name>[^@]+)@(?P<domain>.+$))|(^(?
P<name>[^@\\]+)$))
```

NOTE

Requesting information with the fully-qualified name, such as **`jsmith@ldap.example.com`**, always returns the proper user account. If there are multiple users with the same user name in different domains, specifying only the user name returns the user for whichever domain comes first in the lookup order.

While **`re_expression`** is the most important method for setting user name formats, there are two other options which are useful for other applications.

Default Domain Name Value

The first sets a default domain name to be used with all users, **`default_domain_suffix`**. (This is a global setting, available in the **`[sssd]`** section only.) There may be a case where multiple domains are configured but only one stores user data and the others are used for host or service identities. Setting a default domain name allows users to log in with only their user name, not specifying the domain name (which would be required for users outside the primary domain).

```
[sssd]
...
default_domain_suffix = USERS.EXAMPLE.COM
```

Full Name Format for Output

The other parameter is related to **`re_expression`**, only instead of defining how to *interpret* a user name, it defines how to *print* an identified name. The **`full_name_format`** parameter sets how the user name and domain name (once determined) are displayed.

```
full_name_format = %1$s@%2$s
```

13.2.16. Domain Options: Enabling Offline Authentication

User identities are always cached, as well as information about the domain services. However, user *credentials* are not cached by default. This means that SSSD always checks with the back end identity provider for authentication requests. If the identity provider is offline or unavailable, there is no way to process those authentication requests, so user authentication could fail.

It is possible to enable *offline credentials caching*, which stores credentials (after successful login) as part of the user account in the SSSD cache. Therefore, even if an identity provider is unavailable, users can still authenticate, using their stored credentials. Offline credentials caching is primarily configured in each individual domain entry, but there are some optional settings that can be set in the PAM service section, because credentials caching interacts with the local PAM service as well as the remote domain.

```
[domain/EXAMPLE]
cache_credentials = true
```

There are optional parameters that set when those credentials expire. Expiration is useful because it can prevent a user with a potentially outdated account or credentials from accessing local services indefinitely.

The credentials expiration itself is set in the PAM service, which processes authentication requests for the system.

```
[sssd]
services = nss,pam
...

[pam]
offline_credentials_expiration = 3
...

[domain/EXAMPLE]
cache_credentials = true
...
```

`offline_credentials_expiration` sets the number of days after a successful login that a single credentials entry for a user is preserved in cache. Setting this to zero (0) means that entries are kept forever.

While not related to the credentials cache specifically, each domain has configuration options on when individual user and service caches expire:

- **`account_cache_expiration`** sets the number of days after a successful login that the entire user account entry is removed from the SSSD cache. This must be equal to or longer than the individual offline credentials cache expiration period.

- **`entry_cache_timeout`** sets a validity period, in seconds, for all entries stored in the cache before SSSD requests updated information from the identity provider. There are also individual cache timeout parameters for group, service, netgroup, sudo, and autofs entries; these are listed in the **sssd.conf** man page. The default time is 5400 seconds (90 minutes).

For example:

```
[sssd]
services = nss,pam
...

[pam]
offline_credentials_expiration = 3
...

[domain/EXAMPLE]
cache_credentials = true
account_cache_expiration = 7
entry_cache_timeout = 14400
...
```

13.2.17. Domain Options: Setting Password Expirations

Password policies generally set an expiration time, after which passwords expire and must be replaced. Password expiration policies are evaluated on the server side through the identity provider, then a warning can be processed and displayed in SSSD through its PAM service.

There are two ways to display password expiration warnings:

- The ***pam_pwd_expiration_warning*** parameter defines the global default setting for all domains on how far in advance of the password expiration to display a warning. This is set for the PAM service.

- The ***pwd_expiration_warning*** parameter defines the per-domain setting on how far in advance of the password expiration to display a warning.

  When using a domain-level password expiration warning, an authentication provider (**auth_provider**) must also be configured for the domain.

For example:

```
[sssd]
services = nss,pam
...

[pam]
pam_pwd_expiration_warning = 3
...

[domain/EXAMPLE]
id_provider = ipa
auth_provider = ipa
pwd_expiration_warning = 7
```

The password expiration warning must be sent from the server to SSSD for the warning to be displayed. If no password warning is sent from the server, no message is displayed through SSSD, even if the password expiration time is within the period set in SSSD.

If the password expiration warning is not set in SSSD or is set to **0**, then the SSSD password warning filter is not applied and the server-side password warning is automatically displayed.

NOTE

As long as the password warning is sent from the server, the PAM or domain password expirations in effect override the password warning settings on the back end identity provider. For example, consider a back end identity provider that has the warning period set at 28 days, but the PAM service in SSSD has it set to 7 days. The provider sends the warning to SSSD starting at 28 days, but the warning is not displayed locally until 7 days, according to the password expiration set in the SSSD configuration.

Password Expiration Warnings for Non-Password Authentication

By default, password expiration is verified only if the user enters the password during authentication. However, you can configure SSSD to perform the expiration check and display the warning even when a non-password authentication method is used, for example, during SSH login.

To enable password expiration warnings with non-password authentication methods:

1. Make sure the **access_provider** parameter is set to **ldap** in the **sssd.conf** file.

2. Make sure the **ldap_pwd_policy** parameter is set in **sssd.conf**. In most situations, the appropriate value is **shadow**.

3. Add one of the following **pwd_expire_*** values to the **ldap_access_order** parameter in **sssd.conf**. If the password is about to expire, each one of these values only displays the expiration warning. In addition:

   - **pwd_expire_policy_reject** prevents the user from logging in if the password is already expired.

   - **pwd_expire_policy_warn** allows the user to log in even if the password is already expired.

   - **pwd_expire_policy_renew** prompts the user to immediately change the password if the user attempts to log in with an expired password.

   For example:

   ```
   [domain/EXAMPLE]
   access_provider = ldap
   ldap_pwd_policy = shadow
   ldap_access_order = pwd_expire_policy_warn
   ```

For more details on using **ldap_access_order** and its values, see the sssd-ldap(5) man page.

13.2.18. Domain Options: Using DNS Service Discovery

DNS service discovery, defined in RFC 2782, allows applications to check the SRV records in a given domain for certain services of a certain type; it then returns any servers discovered of that type.

With SSSD, the identity and authentication providers can either be explicitly defined (by IP address or host name) or they can be discovered dynamically, using service discovery. If no provider server is listed — for example, if **id_provider = ldap** is set without a corresponding **ldap_uri** parameter — then discovery is automatically used.

The DNS discovery query has this format:

```
_service._protocol.domain
```

For example, a scan for an LDAP server using TCP in the **`example.com`** domain looks like this:

```
_ldap._tcp.example.com
```

NOTE

For every service with which to use service discovery, add a special DNS record to the DNS server:

```
_service._protocol._domain TTL priority weight port hostname
```

For SSSD, the service type is LDAP by default, and almost all services use TCP (except for Kerberos, which starts with UDP). For service discovery to be enabled, the only thing that is required is the domain name. The default is to use the domain portion of the machine host name, but another domain can be specified (using the **`dns_discovery_domain`** parameter).

So, by default, no additional configuration needs to be made for service discovery — with one exception. The password change provider has server discovery disabled by default, and it must be explicitly enabled by setting a service type.

```
[domain/EXAMPLE]
...
chpass_provider = ldap
ldap_chpass_dns_service_name = ldap
```

While no configuration is necessary, it is possible for server discovery to be customized by using a different DNS domain (**`dns_discovery_domain`**) or by setting a different service type to scan for. For example:

```
[domain/EXAMPLE]
id _provider = ldap

dns_discovery_domain = corp.example.com
ldap_dns_service_name = ldap

chpass_provider = krb5
ldap_chpass_dns_service_name = kerberos
```

Lastly, service discovery is never used with backup servers; it is only used for the primary server for a provider. What this means is that discovery can be used initially to locate a server, and then SSSD can fall back to using a backup server. To use discovery for the primary server, use **`_srv_`** as the primary server value, and then list the backup servers. For example:

```
[domain/EXAMPLE]
id _provider = ldap
ldap_uri = _srv_
```

```
ldap_backup_uri = ldap://ldap2.example.com

auth_provider = krb5
krb5_server = _srv_
krb5_backup_server = kdc2.example.com

chpass_provider = krb5
ldap_chpass_dns_service_name = kerberos
ldap_chpass_uri = _srv_
ldap_chpass_backup_uri = kdc2.example.com
```

NOTE

Service discovery cannot be used with backup servers, only primary servers.

If a DNS lookup fails to return an IPv4 address for a host name, SSSD attempts to look up an IPv6 address before returning a failure. This only ensures that the asynchronous resolver identifies the correct address.

The host name resolution behavior is configured in the ***`lookup family order`*** option in the **`sssd.conf`** configuration file.

13.2.19. Domain Options: Using IP Addresses in Certificate Subject Names (LDAP Only)

Using an IP address in the **`ldap_uri`** option instead of the server name may cause the TLS/SSL connection to fail. TLS/SSL certificates contain the server name, not the IP address. However, the *subject alternative name* field in the certificate can be used to include the IP address of the server, which allows a successful secure connection using an IP address.

Procedure 13.8. Using IP Addresses in Certificate Subject Names

1. Convert an existing certificate into a certificate request. The signing key (**`-signkey`**) is the key of the issuer of whatever CA originally issued the certificate. If this is done by an external CA, it requires a separate PEM file; if the certificate is self-signed, then this is the certificate itself. For example:

   ```
   openssl x509 -x509toreq -in old_cert.pem -out req.pem -signkey
   key.pem
   ```

   With a self-signed certificate:

   ```
   openssl x509 -x509toreq -in old_cert.pem -out req.pem -signkey
   old_cert.pem
   ```

2. Edit the **`/etc/pki/tls/openssl.cnf`** configuration file to include the server's IP address under the ***`[ v3_ca ]`*** section:

   ```
   subjectAltName = IP:10.0.0.10
   ```

3. Use the generated certificate request to generate a new self-signed certificate with the specified IP address:

```
openssl x509 -req -in req.pem -out new_cert.pem -extfile
./openssl.cnf -extensions v3_ca -signkey old_cert.pem
```

The **-extensions** option sets which extensions to use with the certificate. For this, it should be v3_ca to load the appropriate section.

4. Copy the private key block from the **old_cert.pem** file into the **new_cert.pem** file to keep all relevant information in one file.

When creating a certificate through the **certutil** utility provided by the nss-tools package, note that **certutil** supports DNS subject alternative names for certificate creation only.

13.2.20. Creating Domains: Proxy

A proxy with SSSD is just a relay, an intermediary configuration. SSSD connects to its proxy service, and then that proxy loads the specified libraries. This allows SSSD to use some resources that it otherwise would not be able to use. For example, SSSD only supports LDAP and Kerberos as authentication providers, but using a proxy allows SSSD to use alternative authentication methods like a fingerprint scanner or smart card.

Table 13.9. Proxy Domain Configuration Parameters

Parameter	Description
proxy_pam_target	Specifies the target to which PAM must proxy as an authentication provider. The PAM target is a file containing PAM stack information in the default PAM directory, **/etc/pam.d/**. This is used to proxy an authentication provider. **IMPORTANT** Ensure that the proxy PAM stack does *not* recursively include **pam_sss.so**.
proxy_lib_name	Specifies which existing NSS library to proxy identity requests through. This is used to proxy an identity provider.

Example 13.10. Proxy Identity and Kerberos Authentication

The proxy library is loaded using the **proxy_lib_name** parameter. This library can be anything as long as it is compatible with the given authentication service. For a Kerberos authentication provider, it must be a Kerberos-compatible library, like NIS.

```
[domain/PROXY_KRB5]
auth_provider = krb5
krb5_server = kdc.example.com
krb5_realm = EXAMPLE.COM

id_provider = proxy
proxy_lib_name = nis
cache_credentials = true
```

Example 13.11. LDAP Identity and Proxy Authentication

The proxy library is loaded using the **`proxy_pam_target`** parameter. This library must be a PAM module that is compatible with the given identity provider. For example, this uses a PAM fingerprint module with LDAP:

```
[domain/LDAP_PROXY]
id_provider = ldap
ldap_uri = ldap://example.com
ldap_search_base = dc=example,dc=com

auth_provider = proxy
proxy_pam_target = sssdpamproxy
cache_credentials = true
```

After the SSSD domain is configured, make sure that the specified PAM files are configured. In this example, the target is **`sssdpamproxy`**, so create a **`/etc/pam.d/sssdpamproxy`** file and load the PAM/LDAP modules:

```
auth          required      pam_frprint.so
account       required      pam_frprint.so
password      required      pam_frprint.so
session       required      pam_frprint.so
```

Example 13.12. Proxy Identity and Authentication

SSSD can have a domain with both identity and authentication proxies. The only configuration given then are the proxy settings, **`proxy_pam_target`** for the authentication PAM module and **`proxy_lib_name`** for the service, like NIS or LDAP.

This example illustrates a possible configuration, but this is not a realistic configuration. If LDAP is used for identity and authentication, then both the identity and authentication providers should be set to the LDAP configuration, not a proxy.

```
[domain/PROXY_PROXY]
auth_provider = proxy
id_provider = proxy
proxy_lib_name = ldap
proxy_pam_target = sssdproxyldap
cache_credentials = true
```

Once the SSSD domain is added, then update the system settings to configure the proxy service:

1. Create a **`/etc/pam.d/sssdproxyldap`** file which requires the **`pam_ldap.so`** module:

   ```
   auth          required      pam_ldap.so
   account       required      pam_ldap.so
   password      required      pam_ldap.so
   session       required      pam_ldap.so
   ```

2. Make sure the nss-pam-ldapd package is installed.

```
~]# yum install nss-pam-ldapd
```

3. Edit the **/etc/nslcd.conf** file, the configuration file for the LDAP name service daemon, to contain the information for the LDAP directory:

```
uid nslcd
gid ldap
uri ldaps://ldap.example.com:636
base dc=example,dc=com
ssl on
tls_cacertdir /etc/openldap/cacerts
```

13.2.21. Creating Domains: Kerberos Authentication

Both LDAP and proxy identity providers can use a separate Kerberos domain to supply authentication. Configuring a Kerberos authentication provider requires the *key distribution center* (KDC) and the Kerberos domain. All of the principal names must be available in the specified identity provider; if they are not, SSSD constructs the principals using the format *username@REALM*.

NOTE

Kerberos can only provide authentication; it cannot provide an identity database.

SSSD assumes that the Kerberos KDC is also a Kerberos kadmin server. However, production environments commonly have multiple, read-only replicas of the KDC and only a single kadmin server. Use the **krb5_kpasswd** option to specify where the password changing service is running or if it is running on a non-default port. If the **krb5_kpasswd** option is not defined, SSSD tries to use the Kerberos KDC to change the password.

The basic Kerberos configuration options are listed in Table 13.10, “Kerberos Authentication Configuration Parameters”. The **sssd-krb5(5)** man page has more information about Kerberos configuration options.

Example 13.13. Basic Kerberos Authentication

```
# A domain with identities provided by LDAP and authentication by
Kerberos
[domain/KRBDOMAIN]
id_provider = ldap
chpass_provider = krb5
ldap_uri = ldap://ldap.example.com
ldap_search_base = dc=example,dc=com
ldap-tls_reqcert = demand
ldap_tls_cacert = /etc/pki/tls/certs/ca-bundle.crt

auth_provider = krb5
krb5_server = kdc.example.com
krb5_backup_server = kerberos.example.com
krb5_realm = EXAMPLE.COM
krb5_kpasswd = kerberos.admin.example.com
krb5_auth_timeout = 15
```

Example 13.14. Setting Kerberos Ticket Renewal Options

The Kerberos authentication provider, among other tasks, requests ticket granting tickets (TGT) for users and services. These tickets are used to generate other tickets dynamically for specific services, as accessed by the ticket principal (the user).

The TGT initially granted to the user principal is valid only for the lifetime of the ticket (by default, whatever is configured in the configured KDC). After that, the ticket cannot be renewed or extended. However, not renewing tickets can cause problems with some services when they try to access a service in the middle of operations and their ticket has expired.

Kerberos tickets are not renewable by default, but ticket renewal can be enabled using the **`krb5_renewable_lifetime`** and **`krb5_renew_interval`** parameters.

The lifetime for a ticket is set in SSSD with the **`krb5_lifetime`** parameter. This specifies how long a single ticket is valid, and overrides any values in the KDC.

Ticket renewal itself is enabled in the **`krb5_renewable_lifetime`** parameter, which sets the maximum lifetime of the ticket, counting all renewals.

For example, the ticket lifetime is set at one hour and the renewable lifetime is set at 24 hours:

```
krb5_lifetime = 1h
krb5_renewable_lifetime = 1d
```

This means that the ticket expires every hour and can be renewed continually up to one day.

The lifetime and renewable lifetime values can be in seconds (s), minutes (m), hours (h), or days (d).

The other option — which must also be set for ticket renewal — is the **`krb5_renew_interval`** parameter, which sets how frequently SSSD checks to see if the ticket needs to be renewed. At half of the ticket lifetime (whatever that setting is), the ticket is renewed automatically. (This value is always in seconds.)

```
krb5_lifetime = 1h
krb5_renewable_lifetime = 1d
krb5_renew_interval = 60s
```

NOTE

If the **`krb5_renewable_lifetime`** value is not set or the **`krb5_renew_interval`** parameter is not set or is set to zero (0), then ticket renewal is disabled. Both **`krb5_renewable_lifetime`** and **`krb5_renew_interval`** are required for ticket renewal to be enabled.

Table 13.10. Kerberos Authentication Configuration Parameters

Parameter	Description

Parameter	Description
chpass_provider	Specifies which service to use for password change operations. This is assumed to be the same as the authentication provider. To use Kerberos, set this to *krb5*.
krb5_server	Gives the primary Kerberos server, by IP address or host names, to which SSSD will connect.
krb5_backup_server	Gives a comma-separated list of IP addresses or host names of Kerberos servers to which SSSD will connect if the primary server is not available. The list is given in order of preference, so the first server in the list is tried first. After an hour, SSSD will attempt to reconnect to the primary service specified in the ***`krb5_server`*** parameter. When using service discovery for KDC or kpasswd servers, SSSD first searches for DNS entries that specify UDP as the connection protocol, and then falls back to TCP.
krb5_realm	Identifies the Kerberos realm served by the KDC.
krb5_lifetime	Requests a Kerberos ticket with the specified lifetime in seconds (s), minutes (m), hours (h) or days (d).
krb5_renewable_lifetime	Requests a renewable Kerberos ticket with a total lifetime that is specified in seconds (s), minutes (m), hours (h) or days (d).
krb5_renew_interval	Sets the time, in seconds, for SSSD to check if tickets should be renewed. Tickets are renewed automatically once they exceed half their lifetime. If this option is missing or set to zero, then automatic ticket renewal is disabled.
krb5_store_password_if_offline	Sets whether to store user passwords if the Kerberos authentication provider is offline, and then to use that cache to request tickets when the provider is back online. The default is **`false`**, which does not store passwords.
krb5_kpasswd	Lists alternate Kerberos kadmin servers to use if the change password service is not running on the KDC.

Parameter	Description
krb5_ccname_template	Gives the directory to use to store the user's credential cache. This can be templatized, and the following tokens are supported: • *%u*, the user's login name • *%U*, the user's login UID • *%p*, the user's principal name • *%r*, the realm name • *%h*, the user's home directory • *%d*, the value of the **`krb5ccache_dir`** parameter • *%P*, the process ID of the SSSD client. • *%%*, a literal percent sign (%) • *XXXXXX*, a string at the end of the template which instructs SSSD to create a unique filename safely For example: `krb5_ccname_template = FILE:%d/krb5cc_%U_XXXXXX`
krb5_ccachedir	Specifies the directory to store credential caches. This can be templatized, using the same tokens as **`krb5_ccname_template`**, except for **`%d`** and **`%P`**. If **`%u`**, **`%U`**, **`%p`**, or **`%h`** are used, then SSSD creates a private directory for each user; otherwise, it creates a public directory.
krb5_auth_timeout	Gives the time, in seconds, before an online authentication or change password request is aborted. If possible, the authentication request is continued offline. The default is 15 seconds.

13.2.22. Creating Domains: Access Control

SSSD provides a rudimentary access control for domain configuration, allowing either simple user allow/deny lists or using the LDAP back end itself.

Using the Simple Access Provider

The *Simple Access Provider* allows or denies access based on a list of user names or groups.

The Simple Access Provider is a way to restrict access to certain, specific machines. For example, if a company uses laptops, the Simple Access Provider can be used to restrict access to only a specific user or a specific group, even if a different user authenticated successfully against the same authentication provider.

The most common options are **`simple_allow_users`** and **`simple_allow_groups`**, which grant access explicitly to specific users (either the given users or group members) and deny access to everyone else. It is also possible to create deny lists (which deny access only to explicit people and implicitly allow everyone else access).

The Simple Access Provider adheres to the following four rules to determine which users should or should not be granted access:

- If both the allow and deny lists are empty, access is granted.
- If any list is provided, allow rules are evaluated first, and then deny rules. Practically, this means that deny rules supersede allow rules.
- If an allowed list is provided, then all users are denied access unless they are in the list.
- If only deny lists are provided, then all users are allowed access unless they are in the list.

This example grants access to two users and anyone who belongs to the IT group; implicitly, all other users are denied:

```
[domain/example.com]
access_provider = simple
simple_allow_users = jsmith,bjensen
simple_allow_groups = itgroup
```

NOTE

The LOCAL domain in SSSD does not support **`simple`** as an access provider.

Other options are listed in the **`sssd-simple`** man page, but these are rarely used.

Using the Access Filters

An LDAP, Active Directory, or Identity Management server can provide access control rules for a domain. The associated options (**`ldap_access_filter`** for LDAP and IdM and **`ad_access_filter`** for AD) specify which users are granted access to the specified host. The user filter must be used or all users are denied access. See the examples below:

```
[domain/example.com]
access_provider = ldap
ldap_access_filter = memberOf=cn=allowedusers,ou=Groups,dc=example,dc=com
```

```
[domain/example.com]
access_provider = ad
ad_access_filter = memberOf=cn=allowedusers,ou=Groups,dc=example,dc=com
```

NOTE

Offline caching for LDAP access providers is limited to determining whether the user's last online login attempt was successful. Users that were granted access during their last login will continue to be granted access while offline.

SSSD can also check results by the ***`authorizedService`*** or ***`host`*** attribute in an entry. In fact, all options — LDAP filter, ***`authorizedService`***, and ***`host`*** — can be evaluated, depending on the user entry and the configuration. The **`ldap_access_order`** parameter lists all access control methods to use, in order of how they should be evaluated.

```
[domain/example.com]
```

```
access_provider = ldap
ldap_access_filter = memberOf=cn=allowedusers,ou=Groups,dc=example,dc=com
ldap_access_order = filter, host, authorized_service
```

The attributes in the user entry to use to evaluate authorized services or allowed hosts can be customized. Additional access control parameters are listed in the **`sssd-ldap(5)`** man page.

13.2.23. Creating Domains: Primary Server and Backup Servers

Identity and authentication providers for a domain can be configured for automatic failover. SSSD attempts to connect to the specified, primary server first. If that server cannot be reached, then SSSD then goes through the listed backup servers, in order.

NOTE

SSSD tries to connect to the primary server every 30 seconds, until the connection can be re-established, and then switches from the backup to the primary.

All of the major service areas have optional settings for primary and backup servers[3].

Table 13.11. Primary and Secondary Server Parameters

Service Area	Primary Server Attribute	Backup Server Attribute
LDAP identity provider	ldap_uri	ldap_backup_uri
Active Directory identity provider	ad_server	ad_backup_server
Identity Management (IdM or IPA) identity provider	ipa_server	ipa_backup_server
Kerberos authentication provider	krb5_server	krb5_backup_server
Kerberos authentication provider	krb5_server	krb5_backup_server
Password change provider	ldap_chpass_uri	ldap_chpass_backup_uri

One and only one server can be set as the primary server. (And, optionally, the primary server can be set to service discovery, using **`_srv_`** rather than a host name.) Multiple backup servers can be set, in a comma-separated list. The backup server list is in order of preference, so the first server listed is tried first.

```
[domain/EXAMPLE]
id_provider = ad
ad_server = ad.example.com
ad_backup_server = ad1.example.com, ad-backup.example.com
```

13.2.24. Installing SSSD Utilities

Additional tools to handle the SSSD cache, user entries, and group entries are contained in the sssd-tools package. This package is not required, but it is useful to install to help administer user accounts.

```
~]# yum install sssd-tools
```

NOTE

The sssd-tools package is provided by the Optional subscription channel. See Section 8.4.8, “Adding the Optional and Supplementary Repositories” for more information on Red Hat additional channels.

13.2.25. SSSD and UID and GID Numbers

When a user is created — using system tools such as **useradd** or through an application such as Red Hat Identity Management or other client tools — the user is automatically assigned a user ID number and a group ID number.

When the user logs into a system or service, SSSD caches that user name with the associated UID/GID numbers. The UID number is then used as the identifying key for the user. If a user with the same name but a different UID attempts to log into the system, then SSSD treats it as two different users with a name collision.

What this means is that SSSD does not recognize UID number changes. It interprets it as a different and new user, not an existing user with a different UID number. If an existing user changes the UID number, that user is prevented from logging into SSSD and associated services and domains. This also has an impact on any client applications which use SSSD for identity information; the user with the conflict will not be found or accessible to those applications.

IMPORTANT

UID/GID changes are not supported in SSSD.

If a user for some reason has a changed UID/GID number, then the SSSD cache must be cleared for that user before that user can log in again. For example:

```
~]# sss_cache -u jsmith
```

Cleaning the SSSD cache is covered in the section called “Purging the SSSD Cache”.

13.2.26. Creating Local System Users

There can be times when it is useful to seed users into the SSSD database rather than waiting for users to login and be added.

NOTE

Adding user accounts manually requires the sssd-tools package to be installed.

When creating new system users, it is possible to create a user within the SSSD local identity provider domain. This can be useful for creating new system users, for troubleshooting SSSD configuration, or for creating specialized or nested groups.

New users can be added using the **sss_useradd** command.

At its most basic, the **sss_useradd** command only requires the new user name.

```
~]# sss_useradd jsmith
```

There are other options (listed in the **sss_useradd(8)** man page) which can be used to set attributes on the account, like the UID and GID, the home directory, or groups which the user belongs to.

```
~]# sss_useradd --UID 501 --home /home/jsmith --groups admin,dev-group
jsmith
```

13.2.27. Seeding Users into the SSSD Cache During Kickstart

NOTE

Adding user accounts manually requires the sssd-tools package to be installed.

With SSSD, users in a remote domain are not available in a local system until that identity is retrieved from the identity provider. However, some network interfaces are not available until a user has logged in — which is not possible if the user identity is somewhere over the network. In that case, it is possible to seed the SSSD cache with that user identity, associated with the appropriate domain, so that the user can log in locally and active the appropriate interfaces.

This is done using the **sss_seed** utility:

```
sss_seed --domain EXAMPLE.COM --username testuser --password-file
/tmp/sssd-pwd.txt
```

This utility requires options that identify, at a minimum, the user name, domain name, and password.

- **--domain** gives the domain name from the SSSD configuration. This domain must already exist in the SSSD configuration.
- **--username** for the short name of the user account.
- **--password-file** for the path and name of a file containing a temporary password for the seed entry. If the user account already exists in the SSSD cache, then the temporary password in this file overwrites the stored password in the SSSD cache.

Additional account configuration options are listed in the **sss_seed(8)** man page.

This would almost always be run as part of a kickstart or automated setup, so it would be part of a larger set of scripts, which would also enable SSSD, set up an SSSD domain, and create the password file. For example:

```
function make_sssd {
cat <<- _EOF_
[sssd]
domains = LOCAL
services = nss,pam

[nss]
[pam]

[domain/LOCAL]
id_provider = local
auth_provider = local
access_provider = permit

_EOF_
}

make_sssd >> /etc/sssd/sssd.conf

authconfig --enablesssd --enablesssdauth --update

function make_pwdfile {
cat <<1 _EOF_
password
_EOF_
}

make_pwdfile >> /tmp/sssd-pwd.txt

sss_seed --domain EXAMPLE.COM --username testuser --password-file
/tmp/sssd-pwd.txt
```

13.2.28. Managing the SSSD Cache

SSSD can define multiple domains of the same type and different types of domain. SSSD maintains a separate database file for each domain, meaning each domain has its own cache. These cache files are stored in the **`/var/lib/sss/db/`** directory.

Purging the SSSD Cache

As LDAP updates are made to the identity provider for the domains, it can be necessary to clear the cache to reload the new information quickly.

The cache purge utility, **`sss_cache`**, invalidates records in the SSSD cache for a user, a domain, or a group. Invalidating the current records forces the cache to retrieve the updated records from the identity provider, so changes can be realized quickly.

NOTE

This utility is included with SSSD in the sssd package.

Most commonly, this is used to clear the cache and update all records:

```
~]# sss_cache -E
```

The **`sss_cache`** command can also clear all cached entries for a particular domain:

```
~]# sss_cache -Ed LDAP1
```

If the administrator knows that a specific record (user, group, or netgroup) has been updated, then **`sss_cache`** can purge the records for that specific account and leave the rest of the cache intact:

```
~]# sss_cache -u jsmith
```

Table 13.12. Common sss_cache Options

Short Argument	Long Argument	Description
-E	--everything	Invalidates all cached entries with the exception of sudo rules.
-d *name*	--domain *name*	Invalidates cache entries for users, groups, and other entries only within the specified domain.
-G	--groups	Invalidates all group records. If **`-g`** is also used, **`-G`** takes precedence and **`-g`** is ignored.
-g *name*	--group *name*	Invalidates the cache entry for the specified group.
-N	--netgroups	Invalidates cache entries for all netgroup cache records. If **`-n`** is also used, **`-N`** takes precedence and **`-n`** is ignored.
-n *name*	--netgroup *name*	Invalidates the cache entry for the specified netgroup.
-U	--users	Invalidates cache entries for all user records. If the **`-u`** option is also used, **`-U`** takes precedence and **`-u`** is ignored.
-u *name*	--user *name*	Invalidates the cache entry for the specified user.

Deleting Domain Cache Files

All cache files are named for the domain. For example, for a domain named **`exampleldap`**, the cache file is named **`cache_exampleldap.ldb`**.

Be careful when you delete a cache file. This operation has significant effects:

- Deleting the cache file deletes all user data, both identification and cached credentials. Consequently, do not delete a cache file unless the system is online and can authenticate with a user name against the domain's servers. Without a credentials cache, offline authentication will fail.

- If the configuration is changed to reference a different identity provider, SSSD will recognize users from both providers until the cached entries from the original provider time out.

  It is possible to avoid this by purging the cache, but the better option is to use a different domain name for the new provider. When SSSD is restarted, it creates a new cache file with the new name and the old file is ignored.

13.2.29. Downgrading SSSD

When downgrading — either downgrading the version of SSSD or downgrading the operating system itself — then the existing SSSD cache needs to be removed. If the cache is not removed, then SSSD process is dead but a PID file remains. The SSSD logs show that it cannot connect to any of its associated domains because the cache version is unrecognized.

```
(Wed Nov 28 21:25:50 2012) [sssd] [sysdb_domain_init_internal] (0x0010):
Unknown DB version [0.14], expected [0.10] for domain AD!
```

Users are then no longer recognized and are unable to authenticate to domain services and hosts.

After downgrading the SSSD version:

1. Delete the existing cache database files.

   ```
   ~]# rm -rf /var/lib/sss/db/*
   ```

2. Restart the SSSD process.

   ```
   ~]# service sssd restart
   Stopping sssd:
   [FAILED]
   Starting sssd:                                              [  OK
   ]
   ```

13.2.30. Using NSCD with SSSD

SSSD is not designed to be used with the NSCD daemon. Even though SSSD does not directly conflict with NSCD, using both services can result in unexpected behavior, especially with how long entries are cached.

The most common evidence of a problem is conflicts with NFS. When using Network Manager to manage network connections, it may take several minutes for the network interface to come up. During this time, various services attempt to start. If these services start before the network is up and the DNS servers are available, these services fail to identify the forward or reverse DNS entries they need. These services will read an incorrect or possibly empty **`resolv.conf`** file. This file is typically only read once, and so any changes made to this file are not automatically applied. This can cause NFS locking to fail on the machine where the NSCD service is running, unless that service is manually restarted.

To avoid this problem, enable caching for hosts and services in the **`/etc/nscd.conf`** file and rely on the SSSD cache for the **`passwd`**, **`group`**, and **`netgroup`** entries.

Change the **`/etc/nscd.conf`** file:

```
enable-cache hosts yes
enable-cache passwd no
enable-cache group no
enable-cache netgroup no
```

With NSCD answering hosts requests, these entries will be cached by NSCD and returned by NSCD during the boot process. All other entries are handled by SSSD.

13.2.31. Troubleshooting SSSD

- the section called “Setting Debug Logs for SSSD Domains”
- the section called “Checking SSSD Log Files”
- the section called “Problems with SSSD Configuration”

Setting Debug Logs for SSSD Domains

Each domain sets its own debug log level. Increasing the log level can provide more information about problems with SSSD or with the domain configuration.

To change the log level, set the ***debug_level*** parameter for each section in the **sssd.conf** file for which to produce extra logs. For example:

```
[domain/LDAP]
cache_credentials = true
debug_level = 9
```

Table 13.13. Debug Log Levels

Level	Description
0	Fatal failures. Anything that would prevent SSSD from starting up or causes it to cease running.
1	Critical failures. An error that doesn't kill the SSSD, but one that indicates that at least one major feature is not going to work properly.
2	Serious failures. An error announcing that a particular request or operation has failed.
3	Minor failures. These are the errors that would percolate down to cause the operation failure of 2.
4	Configuration settings.
5	Function data.
6	Trace messages for operation functions.
7	Trace messages for internal control functions.
8	Contents of function-internal variables that may be interesting.
9	Extremely low-level tracing information.

NOTE

In versions of SSSD older than 1.8, debug log levels could be set globally in the **[sssd]** section. Now, each domain and service must configure its own debug log level.

To copy the global SSSD debug log levels into each configuration area in the SSSD configuration file, use the **sssd_update_debug_levels.py** script.

```
python -m SSSDConfig.sssd_update_debug_levels.py
```

Checking SSSD Log Files

SSSD uses a number of log files to report information about its operation, located in the **/var/log/sssd/** directory. SSSD produces a log file for each domain, as well as an **sssd_pam.log** and an **sssd_nss.log** file.

Additionally, the **/var/log/secure** file logs authentication failures and the reason for the failure.

Problems with SSSD Configuration

Q: SSSD fails to start

A: SSSD requires that the configuration file be properly set up, with all the required entries, before the daemon will start.

SSSD requires at least one properly configured domain before the service will start. Without a domain, attempting to start SSSD returns an error that no domains are configured:

```
# sssd -d4

[sssd] [ldb] (3): server_sort:Unable to register control with
rootdse!
[sssd] [confdb_get_domains] (0): No domains configured, fatal
error!
[sssd] [get_monitor_config] (0): No domains configured.
```

Edit the **/etc/sssd/sssd.conf** file and create at least one domain.

SSSD also requires at least one available service provider before it will start. If the problem is with the service provider configuration, the error message indicates that there are no services configured:

```
[sssd] [get_monitor_config] (0): No services configured!
```

Edit the **/etc/sssd/sssd.conf** file and configure at least one service provider.

IMPORTANT

SSSD requires that service providers be configured as a comma-separated list in a single ***services*** entry in the **/etc/sssd/sssd.conf** file. If services are listed in multiple entries, only the last entry is recognized by SSSD.

Q: I don't see any groups with 'id' or group members with 'getent group'.

A: This may be due to an incorrect **ldap_schema** setting in the **[domain/DOMAINNAME]** section of **sssd.conf**.

SSSD supports RFC 2307 and RFC 2307bis schema types. By default, SSSD uses the more common RFC 2307 schema.

The difference between RFC 2307 and RFC 2307bis is the way which group membership is stored in the LDAP server. In an RFC 2307 server, group members are stored as the multi-valued ***memberuid*** attribute, which contains the name of the users that are members. In an RFC2307bis server, group members are stored as the multi-valued ***member*** or ***uniqueMember*** attribute which contains the DN of the user or group that is a member of this group. RFC2307bis allows nested groups to be maintained as well.

If group lookups are not returning any information:

1. Set **ldap_schema** to **rfc2307bis**.
2. Delete **/var/lib/sss/db/cache_DOMAINNAME.ldb**.
3. Restarting SSSD.

If that doesn't work, add this line to **sssd.conf**:

```
ldap_group_name = uniqueMember
```

Then delete the cache and restart SSSD again.

Q: Authentication fails against LDAP.

A: To perform authentication, SSSD requires that the communication channel be encrypted. This means that if **sssd.conf** is configured to connect over a standard protocol (**ldap://**), it attempts to encrypt the communication channel with Start TLS. If **sssd.conf** is configured to connect over a secure protocol (**ldaps://**), then SSSD uses SSL.

This means that the LDAP server must be configured to run in SSL or TLS. TLS must be enabled for the standard LDAP port (389) or SSL enabled on the secure LDAPS port (636). With either SSL or TLS, the LDAP server must also be configured with a valid certificate trust.

An invalid certificate trust is one of the most common issues with authenticating against LDAP. If the client does not have proper trust of the LDAP server certificate, it is unable to validate the connection, and SSSD refuses to send the password. The LDAP protocol requires that the password be sent in plaintext to the LDAP server. Sending the password in plaintext over an unencrypted connection is a security problem.

If the certificate is not trusted, a **syslog** message is written, indicating that TLS encryption could not be started. The certificate configuration can be tested by checking if the LDAP server is accessible apart from SSSD. For example, this tests an anonymous bind over a TLS connection to **test.example.com**:

```
$ ldapsearch -x -ZZ -h test.example.com -b dc=example,dc=com
```

If the certificate trust is not properly configured, the test fails with this error:

```
ldap_start_tls: Connect error (-11) additional info: TLS error -
8179:Unknown code ___f 13
```

To trust the certificate:

1. Obtain a copy of the public CA certificate for the certificate authority used to sign the LDAP server certificate and save it to the local system.
2. Add a line to the **sssd.conf** file that points to the CA certificate on the filesystem.

```
ldap_tls_cacert = /path/to/cacert
```

3. If the LDAP server uses a self-signed certificate, remove the **ldap_tls_reqcert** line from the **sssd.conf** file.

   This parameter directs SSSD to trust any certificate issued by the CA certificate, which is a security risk with a self-signed CA certificate.

Q: **Connecting to LDAP servers on non-standard ports fail.**

A: When running SELinux in enforcing mode, the client's SELinux policy has to be modified to connect to the LDAP server over the non-standard port. For example:

```
# semanage port -a -t ldap_port_t -p tcp 1389
```

Q: **NSS fails to return user information**

A: This usually means that SSSD cannot connect to the NSS service.

Ensure that NSS is running:

```
# service sssd status
```

If NSS is running, make sure that the provider is properly configured in the **[nss]** section of the **/etc/sssd/sssd.conf** file. Especially check the ***filter_users*** and ***filter_groups*** attributes.

Make sure that NSS is included in the list of services that SSSD uses.

Check the configuration in the **/etc/nsswitch.conf** file.

Q: **NSS returns incorrect user information**

A: If searches are returning the incorrect user information, check that there are not conflicting user names in separate domains. When there are multiple domains, set the ***use_fully_qualified_domains*** attribute to **true** in the **/etc/sssd/sssd.conf** file. This differentiates between different users in different domains with the same name.

Q: **Setting the password for the local SSSD user prompts twice for the password**

A: When attempting to change a local SSSD user's password, it may prompt for the password twice:

```
[root@clientF11 tmp]# passwd user1000
Changing password for user user1000.
New password:
Retype new password:
New Password:
Reenter new Password:
passwd: all authentication tokens updated successfully.
```

This is the result of an incorrect PAM configuration. Ensure that the ***use_authtok*** option is correctly configured in your **/etc/pam.d/system-auth** file.

Q: I am trying to use sudo rules with an Identity Management (IPA) provider, but no sudo rules are being found, even though sudo is properly configured.

A: The SSSD client can successfully authenticate to the Identity Management server, and it is properly searching the LDAP directory for sudo rules. However, it is showing that no rules exist. For example, in the logs:

```
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sdap_sudo_load_sudoers_process] (0x0400): Receiving sudo rules with
base [ou=sudoers,dc=ipa,dc=test]
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sdap_sudo_load_sudoers_done] (0x0400): Received 0 rules
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sdap_sudo_purge_sudoers] (0x0400): Purging SUDOers cache of user's
[admin] rules
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sysdb_sudo_purge_byfilter] (0x0400): No rules matched
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sysdb_sudo_purge_bysudouser] (0x0400): No rules matched
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[sdap_sudo_load_sudoers_done] (0x0400): Sudoers is successfuly stored
in cache
(Thu Jun 21 10:37:47 2012) [sssd[be[ipa.test]]]
[be_sudo_handler_reply] (0x0200): SUDO Backend returned: (0, 0,
Success)
```

When using an Identity Management provider for SSSD, SSSD attempts to connect to the underlying LDAP directory using Kerberos/GSS-API. However, by default, SSSD uses an anonymous connection to an LDAP server to retrieve sudo rules. This means that SSSD cannot retrieve the sudo rules from the Identity Management server with its default configuration.

To support retrieving sudo rules with a Kerberos/GSS-API connection, enable GSS-API as the authentication mechanism in the identity provider configuration in **sssd.conf**. For example:

```
[domain/ipa.example.com]
id_provider = ipa
ipa_server = ipa.example.com
ldap_tls_cacert = /etc/ipa/ca.crt

sudo_provider = ldap
ldap_uri = ldap://ipa.example.com
ldap_sudo_search_base = ou=sudoers,dc=ipa,dc=example,dc=com
ldap_sasl_mech = GSSAPI
ldap_sasl_authid = host/hostname.ipa.example.com
ldap_sasl_realm = IPA.EXAMPLE.COM
krb5_server = ipa.example.com
```

Q: Password lookups on large directories can take several seconds per request. How can this be improved?

A: The initial user lookup is a call to the LDAP server. Unindexed searches are much more resource-intensive, and therefore take longer, than indexed searches because the server checks every entry in the directory for a match. To speed up user lookups, index the attributes that are searched for by

uid

uidNumber

gidNumber

gecos

Q: An Active Directory identity provider is properly configured in my `sssd.conf` file, but SSSD fails to connect to it, with GSS-API errors.

A: SSSD can only connect with an Active Directory provider using its host name. If the host name is not given, the SSSD client cannot resolve the IP address to the host, and authentication fails.

For example, with this configuration:

```
[domain/ADEXAMPLE]
debug_level = 0xFFF0
id_provider = ad
ad_server = 255.255.255.255
ad_domain = example.com
krb5_canonicalize = False
```

The SSSD client returns this GSS-API failure, and the authentication request fails:

```
(Fri Jul 27 18:27:44 2012) [sssd[be[ADTEST]]] [sasl_bind_send]
(0x0020): ldap_sasl_bind failed (-2)[Local error]
(Fri Jul 27 18:27:44 2012) [sssd[be[ADTEST]]] [sasl_bind_send]
(0x0080): Extended failure message: [SASL(-1): generic failure: GSSAPI
Error: Unspecified GSS failure.  Minor code may provide more
information (Cannot determine realm for numeric host address)]
```

To avoid this error, set the ***`ad_server`*** to the name of the Active Directory host.

Q: I configured SSSD for central authentication, but now several of my applications (such as Firefox or Adobe) will not start.

A: Even on 64-bit systems, 32-bit applications require a 32-bit version of SSSD to use to access the password and identity cache. If a 32-bit version of SSSD is not available, but the system is configured to use the SSSD cache, then 32-bit applications can fail to start.

For example, Firefox can fail with permission denied errors:

```
Failed to contact configuration server. See
http://www.gnome.org/projects/gconf/
for information. (Details -  1: IOR file '/tmp/gconfd-
somebody/lock/ior'
not opened successfully, no gconfd located: Permission denied 2: IOR
file '/tmp/gconfd-somebody/lock/ior' not opened successfully, no
gconfd
located: Permission denied)
```

For Adobe Reader, the error shows that the current system user is not recognized:

```
~]$ acroread
(acroread:12739): GLib-WARNING **: getpwuid_r(): failed due to unknown
user id (366)
```

Other applications may show similar user or permissions errors.

Q: SSSD is showing an automount location that I removed.

A: The SSSD cache for the automount location persists even if the location is subsequently changed or removed. To update the autofs information in SSSD:

1. Remove the autofs cache, as described in the section called “Purging the SSSD Cache”.
2. Restart SSSD, as in Section 13.2.3, “Starting and Stopping SSSD”.

[3] Most services default to the identity provider server if a specific server for that service is not set.

CHAPTER 14. OPENSSH

`SSH` (Secure Shell) is a protocol which facilitates secure communications between two systems using a client-server architecture and allows users to log into server host systems remotely. Unlike other remote communication protocols, such as **`FTP`**, **`Telnet`**, or **`rlogin`**, SSH encrypts the login session, rendering the connection difficult for intruders to collect unencrypted passwords.

The **ssh** program is designed to replace older, less secure terminal applications used to log into remote hosts, such as **`telnet`** or **`rsh`**. A related program called **`scp`** replaces older programs designed to copy files between hosts, such as **`rcp`**. Because these older applications do not encrypt passwords transmitted between the client and the server, avoid them whenever possible. Using secure methods to log into remote systems decreases the risks for both the client system and the remote host.

Red Hat Enterprise Linux includes the general OpenSSH package, openssh, as well as the OpenSSH server, openssh-server, and client, openssh-clients, packages.

14.1. THE SSH PROTOCOL

14.1.1. Why Use SSH?

Potential intruders have a variety of tools at their disposal enabling them to disrupt, intercept, and re-route network traffic in an effort to gain access to a system. In general terms, these threats can be categorized as follows:

Interception of communication between two systems

The attacker can be somewhere on the network between the communicating parties, copying any information passed between them. He may intercept and keep the information, or alter the information and send it on to the intended recipient.

This attack is usually performed using a *packet sniffer*, a rather common network utility that captures each packet flowing through the network, and analyzes its content.

Impersonation of a particular host

Attacker's system is configured to pose as the intended recipient of a transmission. If this strategy works, the user's system remains unaware that it is communicating with the wrong host.

This attack can be performed using a technique known as *DNS poisoning*, or via so-called *IP spoofing*. In the first case, the intruder uses a cracked DNS server to point client systems to a maliciously duplicated host. In the second case, the intruder sends falsified network packets that appear to be from a trusted host.

Both techniques intercept potentially sensitive information and, if the interception is made for hostile reasons, the results can be disastrous. If SSH is used for remote shell login and file copying, these security threats can be greatly diminished. This is because the SSH client and server use digital signatures to verify their identity. Additionally, all communication between the client and server systems is encrypted. Attempts to spoof the identity of either side of a communication does not work, since each packet is encrypted using a key known only by the local and remote systems.

14.1.2. Main Features

The SSH protocol provides the following safeguards:

No one can pose as the intended server

After an initial connection, the client can verify that it is connecting to the same server it had connected to previously.

No one can capture the authentication information

The client transmits its authentication information to the server using strong, 128-bit encryption.

No one can intercept the communication

All data sent and received during a session is transferred using 128-bit encryption, making intercepted transmissions extremely difficult to decrypt and read.

Additionally, it also offers the following options:

It provides secure means to use graphical applications over a network

Using a technique called *X11 forwarding*, the client can forward *X11* (*X Window System*) applications from the server. Note that if you set the **`ForwardX11Trusted`** option to **`yes`** or you use SSH with the **`-Y`** option, you bypass the X11 SECURITY extension controls, which can result in a security threat.

It provides a way to secure otherwise insecure protocols

The SSH protocol encrypts everything it sends and receives. Using a technique called *port forwarding*, an SSH server can become a conduit to securing otherwise insecure protocols, like POP, and increasing overall system and data security.

It can be used to create a secure channel

The OpenSSH server and client can be configured to create a tunnel similar to a virtual private network for traffic between server and client machines.

It supports the Kerberos authentication

OpenSSH servers and clients can be configured to authenticate using the GSSAPI (Generic Security Services Application Program Interface) implementation of the Kerberos network authentication protocol.

14.1.3. Protocol Versions

Two varieties of SSH currently exist: version 1 and version 2. The OpenSSH suite under Red Hat Enterprise Linux uses SSH version 2, which has an enhanced key exchange algorithm not vulnerable to the known exploit in version 1. However, for compatibility reasons, the OpenSSH suite does support version 1 connections as well, although version 1 is disabled by default and needs to be enabled in the configuration files.

IMPORTANT

For maximum security, avoid using SSH version 1 and use SSH version 2-compatible servers and clients whenever possible.

14.1.4. Event Sequence of an SSH Connection

The following series of events help protect the integrity of SSH communication between two hosts.

1. A cryptographic handshake is made so that the client can verify that it is communicating with the correct server.

2. The transport layer of the connection between the client and remote host is encrypted using a symmetric cipher.

3. The client authenticates itself to the server.

4. The client interacts with the remote host over the encrypted connection.

14.1.4.1. Transport Layer

The primary role of the transport layer is to facilitate safe and secure communication between the two hosts at the time of authentication and during subsequent communication. The transport layer accomplishes this by handling the encryption and decryption of data, and by providing integrity protection of data packets as they are sent and received. The transport layer also provides compression, speeding the transfer of information.

Once an SSH client contacts a server, key information is exchanged so that the two systems can correctly construct the transport layer. The following steps occur during this exchange:

- Keys are exchanged
- The public key encryption algorithm is determined
- The symmetric encryption algorithm is determined
- The message authentication algorithm is determined
- The hash algorithm is determined

During the key exchange, the server identifies itself to the client with a unique *host key*. If the client has never communicated with this particular server before, the server's host key is unknown to the client and it does not connect. OpenSSH notifies the user that the authenticity of the host cannot be established and prompts the user to accept or reject it. The user is expected to independently verify the new host key before accepting it. In subsequent connections, the server's host key is checked against the saved version on the client, providing confidence that the client is indeed communicating with the intended server. If, in the future, the host key no longer matches, the user must remove the client's saved version before a connection can occur.

WARNING

Always verify the integrity of a new SSH server. During the initial contact, an attacker can pretend to be the intended SSH server to the local system without being recognized. To verify the integrity of a new SSH server, contact the server administrator before the first connection or if a host key mismatch occurs.

SSH is designed to work with almost any kind of public key algorithm or encoding format. After an initial key exchange creates a hash value used for exchanges and a shared secret value, the two systems immediately begin calculating new keys and algorithms to protect authentication and future data sent over the connection.

After a certain amount of data has been transmitted using a given key and algorithm (the exact amount depends on the SSH implementation), another key exchange occurs, generating another set of hash values and a new shared secret value. Even if an attacker is able to determine the hash and shared secret value, this information is only useful for a limited period of time.

14.1.4.2. Authentication

Once the transport layer has constructed a secure tunnel to pass information between the two systems, the server tells the client the different authentication methods supported, such as using a private key-encoded signature or typing a password. The client then tries to authenticate itself to the server using one of these supported methods.

SSH servers and clients can be configured to allow different types of authentication, which gives each side the optimal amount of control. The server can decide which encryption methods it supports based on its security model, and the client can choose the order of authentication methods to attempt from the available options.

14.1.4.3. Channels

After a successful authentication over the SSH transport layer, multiple channels are opened via a technique called *multiplexing*[4]. Each of these channels handles communication for different terminal sessions and for forwarded X11 sessions.

Both clients and servers can create a new channel. Each channel is then assigned a different number on each end of the connection. When the client attempts to open a new channel, the clients sends the channel number along with the request. This information is stored by the server and is used to direct communication to that channel. This is done so that different types of sessions do not affect one another and so that when a given session ends, its channel can be closed without disrupting the primary SSH connection.

Channels also support *flow-control*, which allows them to send and receive data in an orderly fashion. In this way, data is not sent over the channel until the client receives a message that the channel is open.

The client and server negotiate the characteristics of each channel automatically, depending on the type of service the client requests and the way the user is connected to the network. This allows great flexibility in handling different types of remote connections without having to change the basic infrastructure of the protocol.

14.2. CONFIGURING OPENSSH

14.2.1. Configuration Files

There are two different sets of configuration files: those for client programs (that is, **`ssh`**, **`scp`**, and **`sftp`**), and those for the server (the **`sshd`** daemon).

System-wide SSH configuration information is stored in the **`/etc/ssh/`** directory as described in Table 14.1, “System-wide configuration files”. User-specific SSH configuration information is stored in **`~/.ssh/`** within the user's home directory as described in Table 14.2, “User-specific configuration files”.

Table 14.1. System-wide configuration files

File	Description
`/etc/ssh/moduli`	Contains Diffie-Hellman groups used for the Diffie-Hellman key exchange which is critical for constructing a secure transport layer. When keys are exchanged at the beginning of an SSH session, a shared, secret value is created which cannot be determined by either party alone. This value is then used to provide host authentication.
`/etc/ssh/ssh_config`	The default SSH client configuration file. Note that it is overridden by **`~/.ssh/config`** if it exists.
`/etc/ssh/sshd_config`	The configuration file for the **`sshd`** daemon.
`/etc/ssh/ssh_host_dsa_key`	The DSA private key used by the **`sshd`** daemon.
`/etc/ssh/ssh_host_dsa_key.pub`	The DSA public key used by the **`sshd`** daemon.
`/etc/ssh/ssh_host_key`	The RSA private key used by the **`sshd`** daemon for version 1 of the SSH protocol.
`/etc/ssh/ssh_host_key.pub`	The RSA public key used by the **`sshd`** daemon for version 1 of the SSH protocol.
`/etc/ssh/ssh_host_rsa_key`	The RSA private key used by the **`sshd`** daemon for version 2 of the SSH protocol.
`/etc/ssh/ssh_host_rsa_key.pub`	The RSA public key used by the **`sshd`** daemon for version 2 of the SSH protocol.
`/etc/pam.d/sshd`	The PAM configuration file for the **`sshd`** daemon.
`/etc/sysconfig/sshd`	Configuration file for the **`sshd`** service.

Table 14.2. User-specific configuration files

File	Description
`~/.ssh/authorized_keys`	Holds a list of authorized public keys for servers. When the client connects to a server, the server authenticates the client by checking its signed public key stored within this file.
`~/.ssh/id_dsa`	Contains the DSA private key of the user.
`~/.ssh/id_dsa.pub`	The DSA public key of the user.

File	Description
`~/.ssh/id_rsa`	The RSA private key used by **ssh** for version 2 of the SSH protocol.
`~/.ssh/id_rsa.pub`	The RSA public key used by **ssh** for version 2 of the SSH protocol.
`~/.ssh/identity`	The RSA private key used by **ssh** for version 1 of the SSH protocol.
`~/.ssh/identity.pub`	The RSA public key used by **ssh** for version 1 of the SSH protocol.
`~/.ssh/known_hosts`	Contains DSA host keys of SSH servers accessed by the user. This file is very important for ensuring that the SSH client is connecting the correct SSH server.

For information concerning various directives that can be used in the SSH configuration files, see the **ssh_config**(5) and **sshd_config**(5) manual pages.

14.2.2. Starting an OpenSSH Server

In order to run an OpenSSH server, you must have the openssh-server installed (see Section 8.2.4, “Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux 6).

To start the **sshd** daemon, type the following at a shell prompt:

```
~]# service sshd start
```

To stop the running **sshd** daemon, use the following command:

```
~]# service sshd stop
```

If you want the daemon to start automatically at the boot time, type:

```
~]# chkconfig sshd on
```

This will enable the service for levels 2, 3, 4, and 5. For more configuration options, see Chapter 12, *Services and Daemons* for the detailed information on how to manage services.

Note that if you reinstall the system, a new set of identification keys will be created. As a result, clients who had connected to the system with any of the OpenSSH tools before the reinstall will see the following message:

```
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@    WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED!     @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
Someone could be eavesdropping on you right now (man-in-the-middle
attack)!
It is also possible that the RSA host key has just been changed.
```

–

To prevent this, you can backup the relevant files from the **`/etc/ssh/`** directory (see Table 14.1, “System-wide configuration files” for a complete list), and restore them whenever you reinstall the system.

14.2.3. Requiring SSH for Remote Connections

For SSH to be truly effective, using insecure connection protocols should be prohibited. Otherwise, a user's password may be protected using SSH for one session, only to be captured later while logging in using Telnet. Some services to disable include **`telnet`**, **`rsh`**, **`rlogin`**, and **`vsftpd`**.

To disable these services, type the following commands at a shell prompt:

```
~]# chkconfig telnet off
~]# chkconfig rsh off
~]# chkconfig rlogin off
~]# chkconfig vsftpd off
```

For more information on runlevels and configuring services in general, see Chapter 12, *Services and Daemons*.

14.2.4. Using Key-Based Authentication

To improve the system security even further, you can enforce key-based authentication by disabling the standard password authentication. To do so, open the **`/etc/ssh/sshd_config`** configuration file in a text editor such as **vi** or **nano**, and change the **`PasswordAuthentication`** option as follows:

```
PasswordAuthentication no
```

To be able to use **`ssh`**, **`scp`**, or **`sftp`** to connect to the server from a client machine, generate an authorization key pair by following the steps below. Note that keys must be generated for each user separately.

Red Hat Enterprise Linux 6 uses SSH Protocol 2 and RSA keys by default (see Section 14.1.3, “Protocol Versions” for more information).

IMPORTANT

Do not generate key pairs as **`root`**, as only **`root`** would be able to use those keys.

NOTE

Before reinstalling your system, back up the **`~/.ssh/`** directory to keep the generated key pair. Copy the backed-up data to the home directory in the new system for any user you require, including root.

14.2.4.1. Generating Key Pairs

To generate an RSA key pair for version 2 of the SSH protocol, follow these steps:

1. Generate an RSA key pair by typing the following at a shell prompt:

```
~]$ ssh-keygen -t rsa
Generating public/private rsa key pair.
Enter file in which to save the key (/home/john/.ssh/id_rsa):
```

2. Press **`Enter`** to confirm the default location (that is, **`~/.ssh/id_rsa`**) for the newly created key.

3. Enter a passphrase, and confirm it by entering it again when prompted to do so. For security reasons, avoid using the same password as you use to log in to your account.

   After this, you will be presented with a message similar to this:

```
Your identification has been saved in /home/john/.ssh/id_rsa.
Your public key has been saved in /home/john/.ssh/id_rsa.pub.
The key fingerprint is:
e7:97:c7:e2:0e:f9:0e:fc:c4:d7:cb:e5:31:11:92:14
john@penguin.example.com
The key's randomart image is:
+--[ RSA 2048]----+
|             E.  |
|            . .  |
|             o . |
|              . .|
|        S .    . |
|         + o o ..|
|          * * +oo|
|           O +..=|
|           o*  o.|
+-----------------+
```

4. Change the permissions of the **`~/.ssh/`** directory:

```
~]$ chmod 700 ~/.ssh
```

5. Copy the content of **`~/.ssh/id_rsa.pub`** into the **`~/.ssh/authorized_keys`** on the machine to which you want to connect, appending it to its end if the file already exists.

6. Change the permissions of the **`~/.ssh/authorized_keys`** file using the following command:

```
~]$ chmod 600 ~/.ssh/authorized_keys
```

To generate a DSA key pair for version 2 of the SSH protocol, follow these steps:

1. Generate a DSA key pair by typing the following at a shell prompt:

```
~]$ ssh-keygen -t dsa
Generating public/private dsa key pair.
Enter file in which to save the key (/home/john/.ssh/id_dsa):
```

2. Press **`Enter`** to confirm the default location (that is, **`~/.ssh/id_dsa`**) for the newly created key.

3. Enter a passphrase, and confirm it by entering it again when prompted to do so. For security reasons, avoid using the same password as you use to log in to your account.

   After this, you will be presented with a message similar to this:

   ```
   Your identification has been saved in /home/john/.ssh/id_dsa.
   Your public key has been saved in /home/john/.ssh/id_dsa.pub.
   The key fingerprint is:
   81:a1:91:a8:9f:e8:c5:66:0d:54:f5:90:cc:bc:cc:27
   john@penguin.example.com
   The key's randomart image is:
   +--[ DSA 1024]----+
   |   .oo*o.        |
   |  ...o Bo        |
   | .. . + o.       |
   |.  .   E o       |
   | o..o   S        |
   |. o= .           |
   |. +              |
   | .               |
   |                 |
   +-----------------+
   ```

4. Change the permissions of the **~/.ssh/** directory:

   ```
   ~]$ chmod 700 ~/.ssh
   ```

5. Copy the content of **~/.ssh/id_dsa.pub** into the **~/.ssh/authorized_keys** on the machine to which you want to connect, appending it to its end if the file already exists.

6. Change the permissions of the **~/.ssh/authorized_keys** file using the following command:

   ```
   ~]$ chmod 600 ~/.ssh/authorized_keys
   ```

To generate an RSA key pair for version 1 of the SSH protocol, follow these steps:

1. Generate an RSA key pair by typing the following at a shell prompt:

   ```
   ~]$ ssh-keygen -t rsa1
   Generating public/private rsa1 key pair.
   Enter file in which to save the key (/home/john/.ssh/identity):
   ```

2. Press **Enter** to confirm the default location (that is, **~/.ssh/identity**) for the newly created key.

3. Enter a passphrase, and confirm it by entering it again when prompted to do so. For security reasons, avoid using the same password as you use to log into your account.

   After this, you will be presented with a message similar to this:

   ```
   Your identification has been saved in /home/john/.ssh/identity.
   Your public key has been saved in /home/john/.ssh/identity.pub.
   The key fingerprint is:
   cb:f6:d5:cb:6e:5f:2b:28:ac:17:0c:e4:62:e4:6f:59
   ```

```
john@penguin.example.com
The key's randomart image is:
+--[RSA1 2048]----+
|                 |
|     . .         |
|    o o          |
|     + o E       |
|    . o S        |
|       = +   .   |
|      . = . o . .|
|       . = o o..o|
|       .o o  o=o.|
+-----------------+
```

4. Change the permissions of the **`~/.ssh/`** directory:

   ```
   ~]$ chmod 700 ~/.ssh
   ```

5. Copy the content of **`~/.ssh/identity.pub`** into the **`~/.ssh/authorized_keys`** on the machine to which you want to connect, appending it to its end if the file already exists.

6. Change the permissions of the **`~/.ssh/authorized_keys`** file using the following command:

   ```
   ~]$ chmod 600 ~/.ssh/authorized_keys
   ```

See Section 14.2.4.2, “Configuring ssh-agent” for information on how to set up your system to remember the passphrase.

IMPORTANT

Never share your private key with anybody; it is for your personal use only.

14.2.4.2. Configuring ssh-agent

To store your passphrase so that you do not have to enter it each time you initiate a connection with a remote machine, you can use the **`ssh-agent`** authentication agent. If you are running GNOME, you can configure it to prompt you for your passphrase whenever you log in and remember it during the whole session. Otherwise you can store the passphrase for a certain shell prompt.

To save your passphrase during your GNOME session, follow these steps:

1. Make sure you have the openssh-askpass package installed. If not, see Section 8.2.4, “Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux.

2. Select **System** → **Preferences** → **Startup Applications** from the panel. The **Startup Applications Preferences** will be started, and the tab containing a list of available startup programs will be shown by default.

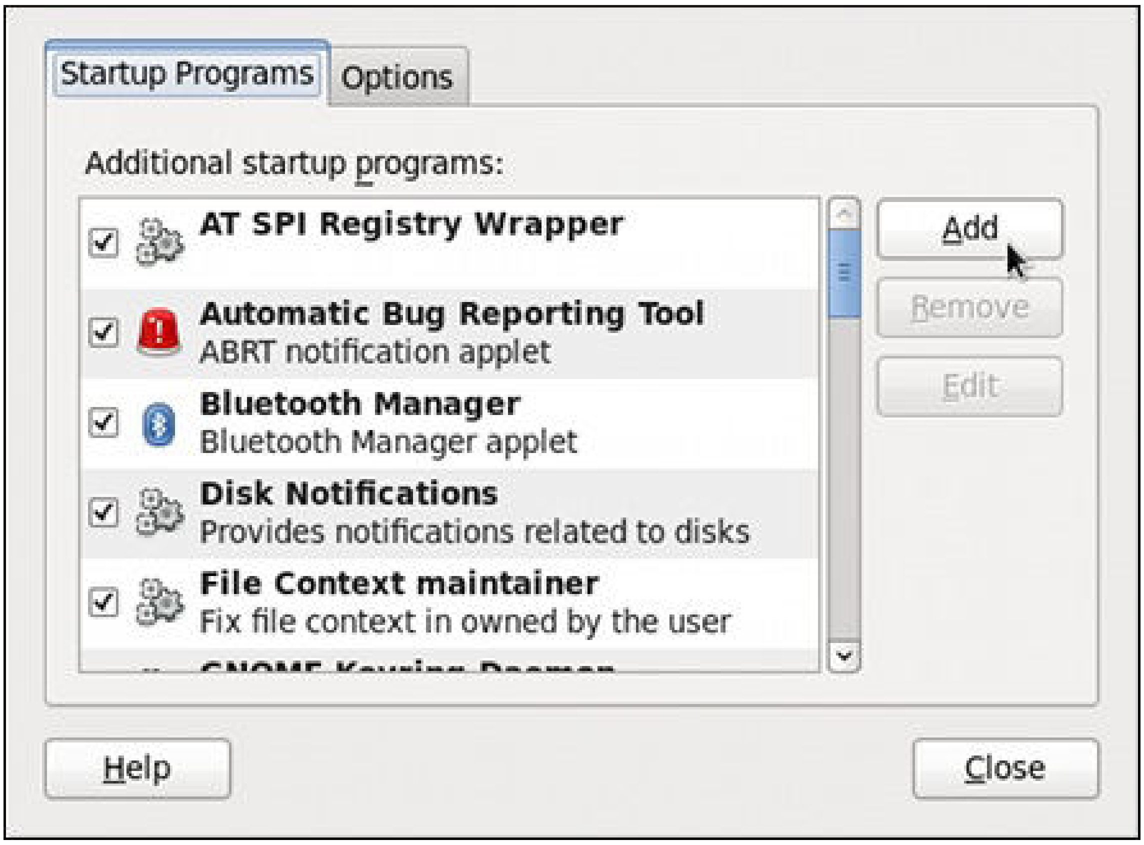
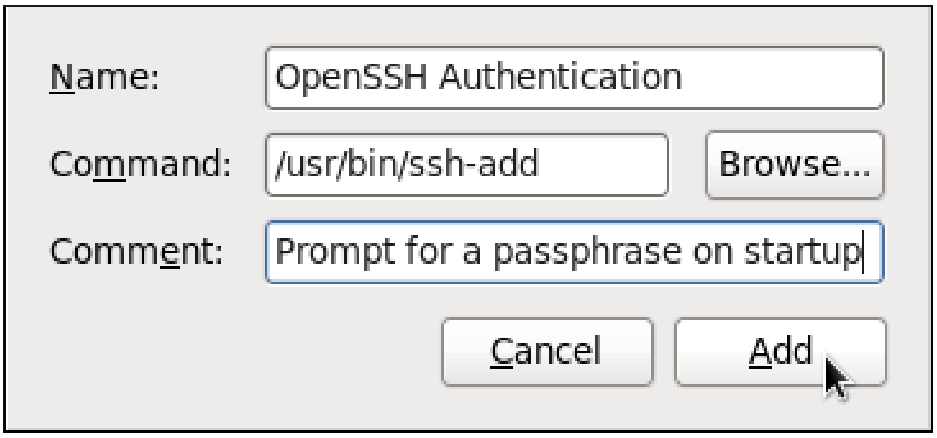


Figure 14.1. Startup Applications Preferences

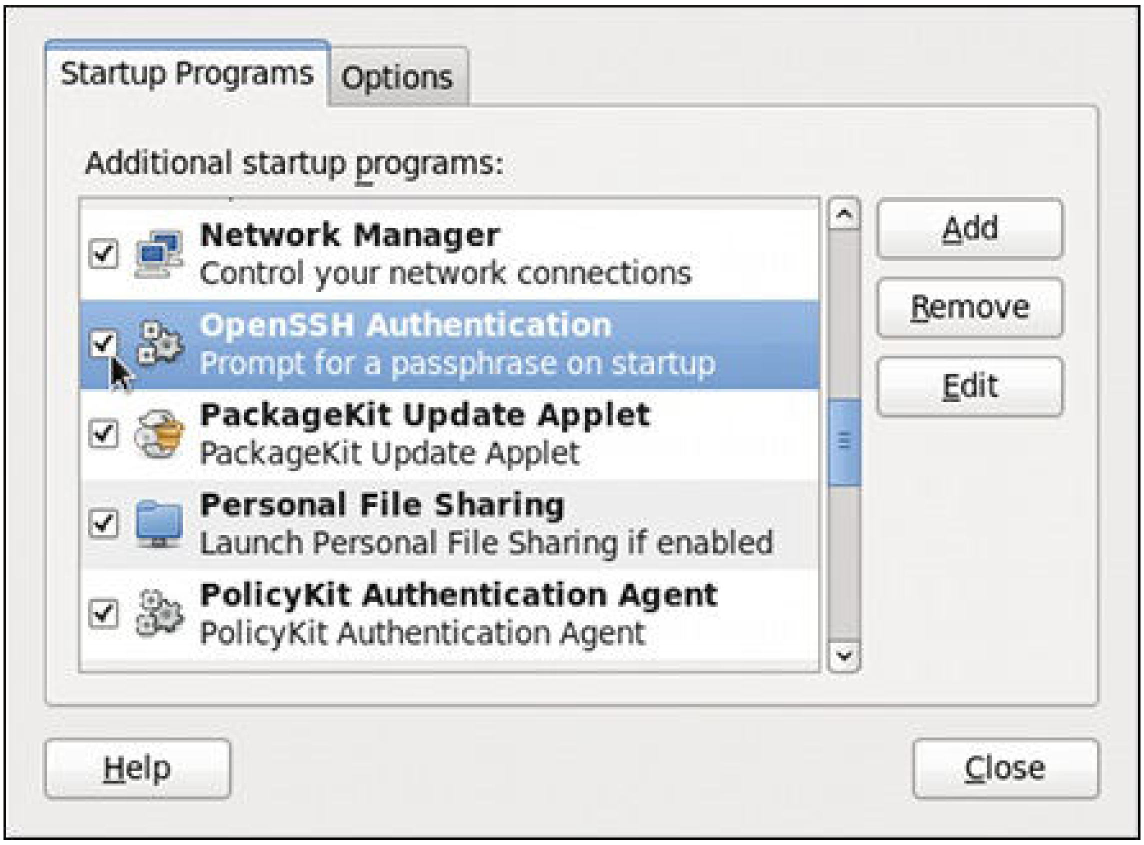
3. Click the **Add** button on the right, and enter **`/usr/bin/ssh-add`** in the **`Command`** field.



Name: OpenSSH Authentication
Command: /usr/bin/ssh-add
Comment: Prompt for a passphrase on startup

Figure 14.2. Adding new application

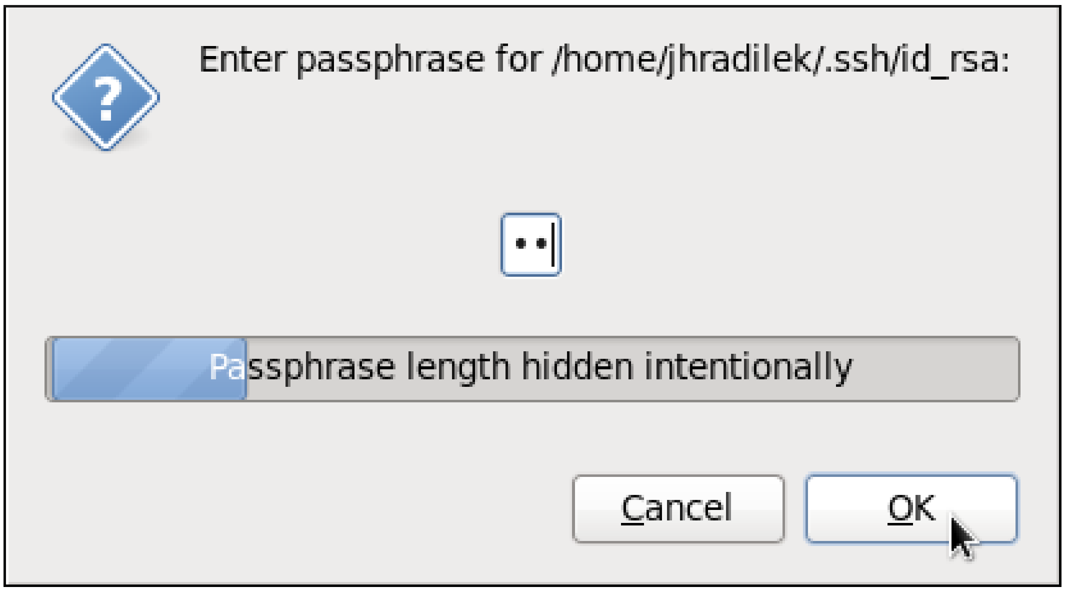
4. Click **Add** and make sure the check box next to the newly added item is selected.



- [✓] **Network Manager** Control your network connections
- [✓] **OpenSSH Authentication** Prompt for a passphrase on startup
- [✓] **PackageKit Update Applet** PackageKit Update Applet
- [✓] **Personal File Sharing** Launch Personal File Sharing if enabled
- [✓] **PolicyKit Authentication Agent** PolicyKit Authentication Agent

Figure 14.3. Enabling the application

5. Log out and then log back in. A dialog box will appear prompting you for your passphrase. From this point on, you should not be prompted for a password by **`ssh`**, **`scp`**, or **`sftp`**.


Enter passphrase for /home/jhradilek/.ssh/id_rsa:

Passphrase length hidden intentionally

Figure 14.4. Entering a passphrase

To save your passphrase for a certain shell prompt, use the following command:

```
~]$ ssh-add
Enter passphrase for /home/john/.ssh/id_rsa:
```

Note that when you log out, your passphrase will be forgotten. You must execute the command each time you log in to a virtual console or a terminal window.

14.2.4.3. Multiple required methods of authentication for sshd

For higher security, SSH can require multiple methods of authentication to log in successfully, for example both a passphrase and a public key. Set the **RequiredAuthentications2** option in the **/etc/ssh/sshd_config** file as desired, for example by running:

```
~]# echo "RequiredAuthentications2 publickey,password" >>
/etc/ssh/sshd_config
```

For more information on the available options, see the **sshd_config(5)** manual page.

14.3. USING OPENSSH CERTIFICATE AUTHENTICATION

14.3.1. Introduction to SSH Certificates

Using public key cryptography for authentication requires copying the public key from every client to every server that the client intends to log into. This system does not scale well and can be an administrative burden. Using a public key from a *certificate authority* (CA) to authenticate client certificates removes the need to copy keys between multiple systems. While the X.509 Public Key Infrastructure Certificate system provides a solution to this issue, there is a submission and validation process, with associated fees, to go through in order to get a certificate signed. As an alternative, OpenSSH supports the creation of simple certificates and associated CA infrastructure.

OpenSSH certificates contain a public key, identity information, and validity constraints. They are signed with a standard SSH public key using the **ssh-keygen** utility. The format of the certificate is described in **/usr/share/doc/openssh-*version*/PROTOCOL.certkeys**.

The **ssh-keygen** utility supports two types of certificates: user and host. User certificates authenticate users to servers, whereas host certificates authenticate server hosts to users. For certificates to be used for user or host authentication, **sshd** must be configured to trust the CA public key.

14.3.2. Support for SSH Certificates

Support for certificate authentication of users and hosts using the new OpenSSH certificate format was introduced in Red Hat Enterprise Linux 6.5, in the openssh-5.3p1-94.el6 package. If required, to ensure the latest OpenSSH package is installed, enter the following command as **root**:

```
~]# yum install openssh
Package openssh-5.3p1-104.el6_6.1.i686 already installed and latest
version
Nothing to do
```

14.3.3. Creating SSH CA Certificate Signing Keys

Two types of certificates are required, host certificates and user certificates. It is considered better to have two separate keys for signing the two certificates, for example **ca_user_key** and **ca_host_key**, however it is possible to use just one CA key to sign both certificates. It is also easier to follow the procedures if separate keys are used, so the examples that follow will use separate keys.

The basic format of the command to sign user's public key to create a user certificate is as follows:

```
ssh-keygen -s ca_user_key -I certificate_ID id_rsa.pub
```

Where **-s** indicates the private key used to sign the certificate, **-I** indicates an identity string, the *certificate_ID*, which can be any alpha numeric value. It is stored as a zero terminated string in the certificate. The *certificate_ID* is logged whenever the certificate is used for identification and it is also used when revoking a certificate. Having a long value would make logs hard to read, therefore using the host name for host certificates and the user name for user certificates is a safe choice.

To sign a host's public key to create a host certificate, add the **-h** option:

```
ssh-keygen -s ca_host_key -I certificate_ID -h ssh_host_rsa_key.pub
```

Host keys are generated on the system by default, to list the keys, enter a command as follows:

```
~]# ls -l /etc/ssh/ssh_host*
-rw-------. 1 root root  668 Jul  9  2014 /etc/ssh/ssh_host_dsa_key
-rw-r--r--. 1 root root  590 Jul  9  2014 /etc/ssh/ssh_host_dsa_key.pub
-rw-------. 1 root root  963 Jul  9  2014 /etc/ssh/ssh_host_key
-rw-r--r--. 1 root root  627 Jul  9  2014 /etc/ssh/ssh_host_key.pub
-rw-------. 1 root root 1671 Jul  9  2014 /etc/ssh/ssh_host_rsa_key
-rw-r--r--. 1 root root  382 Jul  9  2014 /etc/ssh/ssh_host_rsa_key.pub
```

IMPORTANT

It is recommended to create and store CA keys in a safe place just as with any other private key. In these examples the **root** user will be used. In a real production environment using an offline computer with an administrative user account is recommended. For guidance on key lengths see *NIST Special Publication 800-131A*.

Procedure 14.1. Generating SSH CA Certificate Signing Keys

1. On the server designated to be the CA, generate two keys for use in signing certificates. These are the keys that all other hosts need to trust. Choose suitable names, for example **ca_user_key** and **ca_host_key**. To generate the user certificate signing key, enter the following command as **root**:

   ```
   ~]# ssh-keygen -t rsa -f ~/.ssh/ca_user_key
   Generating public/private rsa key pair.
   Created directory '/root/.ssh'.
   Enter passphrase (empty for no passphrase):
   Enter same passphrase again:
   Your identification has been saved in /root/.ssh/ca_user_key.
   Your public key has been saved in /root/.ssh/ca_user_key.pub.
   The key fingerprint is:
   11:14:2f:32:fd:5d:f5:e4:7a:5a:d6:b6:a0:62:c9:1f
   root@host_name.example.com
   The key's randomart image is:
   +--[ RSA 2048]----+
   |       .+.      o|
   |       . o     +.|
   |      o + .   . o|
   |       o + . . ..|
   |        S . ... *|
   |        . . . .*.|
   |         = E  .. |
   ```

```
|        . o .    |
|           .     |
+-----------------+
```

Generate a host certificate signing key, **`ca_host_key`**, as follows:

```
~]# ssh-keygen -t rsa -f ~/.ssh/ca_host_key
Generating public/private rsa key pair.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/ca_host_key.
Your public key has been saved in /root/.ssh/ca_host_key.pub.
The key fingerprint is:
e4:d5:d1:4f:6b:fd:a2:e3:4e:5a:73:52:91:0b:b7:7a
root@host_name.example.com
The key's randomart image is:
+--[ RSA 2048]----+
|             ..  |
|            . ....|
|        . . o +oo|
|       o .   o *o|
|        S      = .|
|             o. .|
|            *.E. |
|           +o=   |
|          .oo.   |
+-----------------+
```

If required, confirm the permissions are correct:

```
~]# ls -la ~/.ssh
total 40
drwxrwxrwx. 2 root root 4096 May 22 13:18 .
dr-xr-x---. 3 root root 4096 May  8 08:34 ..
-rw-------. 1 root root 1743 May 22 13:15 ca_host_key
-rw-r--r--. 1 root root  420 May 22 13:15 ca_host_key.pub
-rw-------. 1 root root 1743 May 22 13:14 ca_user_key
-rw-r--r--. 1 root root  420 May 22 13:14 ca_user_key.pub
-rw-r--r--. 1 root root  854 May  8 05:55 known_hosts
-r--------. 1 root root 1671 May  6 17:13 ssh_host_rsa
-rw-r--r--. 1 root root 1370 May  7 14:30 ssh_host_rsa-cert.pub
-rw-------. 1 root root  420 May  6 17:13 ssh_host_rsa.pub
```

2. Create the CA server's own host certificate by signing the server's host public key together with an identification string such as the host name, the CA server's *fully qualified domain name* (FQDN) but without the trailing `.`, and a validity period. The command takes the following form:

```
ssh-keygen -s ~/.ssh/ca_host_key -I certificate_ID -h -Z
host_name.example.com -V -start:+end /etc/ssh/ssh_host_rsa.pub
```

The **`-Z`** option restricts this certificate to a specific host within the domain. The **`-V`** option is for adding a validity period; this is highly recommend. Where the validity period is intended to be one year, fifty two weeks, consider the need for time to change the certificates and any holiday periods around the time of certificate expiry.

For example:

```
~]# ssh-keygen -s ~/.ssh/ca_host_key -I host_name -h -Z
host_name.example.com -V -1w:+54w5d /etc/ssh/ssh_host_rsa.pub
Enter passphrase:
Signed host key /root/.ssh/ssh_host_rsa-cert.pub: id "host_name"
serial 0 for host_name.example.com valid from 2015-05-15T13:52:29 to
2016-06-08T13:52:29
```

14.3.4. Distributing and Trusting SSH CA Public Keys

Hosts that are to allow certificate authenticated log in from users must be configured to trust the CA's public key that was used to sign the user certificates, in order to authenticate user's certificates. In this example that is the **`ca_user_key.pub`**.

Publish the **`ca_user_key.pub`** key and download it to all hosts that are required to allow remote users to log in. Alternately, copy the CA user public key to all the hosts. In a production environment, consider copying the public key to an administrator account first. The secure copy command can be used to copy the public key to remote hosts. The command has the following format:

```
scp ~/.ssh/ca_user_key.pub root@host_name.example.com:/etc/ssh/
```

Where *host_name* is the host name of a server the is required to authenticate user's certificates presented during the login process. Ensure you copy the public key not the private key. For example, as **`root`**:

```
~]# scp ~/.ssh/ca_user_key.pub root@host_name.example.com:/etc/ssh/
The authenticity of host 'host_name.example.com (10.34.74.56)' can't be
established.
RSA key fingerprint is fc:23:ad:ae:10:6f:d1:a1:67:ee:b1:d5:37:d4:b0:2f.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'host_name.example.com,10.34.74.56' (RSA) to
the list of known hosts.
root@host_name.example.com's password:
ca_user_key.pub                                     100%  420
0.4KB/s   00:00
```

For remote user authentication, CA keys can be marked as trusted per-user in the **`~/.ssh/authorized_keys`** file using the **`cert-authority`** directive or for global use by means of the **`TrustedUserCAKeys`** directive in the **`/etc/ssh/sshd_config`** file. For remote host authentication, CA keys can be marked as trusted globally in the **`/etc/ssh/known_hosts`** file or per-user in the **`~/.ssh/ssh_known_hosts`** file.

Procedure 14.2. Trusting the User Signing Key

- For user certificates which have one or more principles listed, and where the setting is to have global effect, edit the **`/etc/ssh/sshd_config`** file as follows:

  ```
  TrustedUserCAKeys /etc/ssh/ca_user_key.pub
  ```

  Restart **sshd** to make the changes take effect:

  ```
  ~]# service sshd restart
  ```

To avoid being presented with the warning about an unknown host, a user's system must trust the CA's public key that was used to sign the host certificates. In this example that is **`ca_host_key.pub`**.

Procedure 14.3. Trusting the Host Signing Key

1. Extract the contents of the public key used to sign the host certificate. For example, on the CA:

   ```
   cat ~/.ssh/ca_host_key.pub
   ssh-rsa  AAAAB5Wm.== root@ca-server.example.com
   ```

2. To configure client systems to trust servers' signed host certificates, add the contents of the **`ca_host_key.pub`** into the global **`known_hosts`** file. This will automatically check a server's host advertised certificate against the CA public key for all users every time a new machine is connected to in the domain **`*.example.com`**. Login as **`root`** and configure the **`/etc/ssh/ssh_known_hosts`** file, as follows:

   ```
   ~]# vi /etc/ssh/ssh_known_hosts
   # A CA key, accepted for any host in *.example.com
   @cert-authority *.example.com ssh-rsa AAAAB5Wm.
   ```

   Where **`ssh-rsa`** ***`AAAAB5Wm.`*** is the contents of **`ca_host_key.pub`**. The above configures the system to trust the CA servers host public key. This enables global authentication of the certificates presented by hosts to remote users.

14.3.5. Creating SSH Certificates

A certifcate is a signed public key. The user's and host's public keys must be copied to the CA server for signing by the CA server's private key.

IMPORTANT

Copying many keys to the CA to be signed can create confusion if they are not uniquely named. If the default name is always used then the latest key to be copied will overwrite the previously copied key, which may be an acceptable method for one administrator. In the example below the default name is used. In a production environment, consider using easily recognizable names. It is recommend to have a designated directory on the CA server owned by an administrative user for the keys to be copied into. Copying these keys to the **`root`** user's **`/etc/ssh/`** directory is not recommend. In the examples below an account named **`admin`** with a directory named **`keys/`** will be used.

Create an administrator account, in this example **`admin`**, and a directory to receive the user's keys. For example:

```
~]$ mkdir keys
```

Set the permissions to allow keys to be copied in:

```
~]$ chmod o+w keys
ls -la keys
total 8
drwxrwxrwx. 2 admin admin 4096 May 22 16:17 .
drwx------. 3 admin admin 4096 May 22 16:17 ..
```

14.3.5.1. Creating SSH Certificates to Authenticate Hosts

The command to sign a host certificate has the following format:

```
ssh-keygen -s ca_host_key -I host_name -h ssh_host_rsa_key.pub
```

The host certificate will named **`ssh_host_rsa_key-cert.pub`**.

Procedure 14.4. Generating a Host Certificate

To authenticate a host to a user, a public key must be generated on the host, passed to the CA server, signed by the CA, and then passed back to be stored on the host to present to a user attempting to log into the host.

1. Host keys are generated automatically on the system. To list them enter the following command:

   ```
   ~]# ls -l /etc/ssh/ssh_host*
   -rw-------. 1 root root  668 May  6 14:38 /etc/ssh/ssh_host_dsa_key
   -rw-r--r--. 1 root root  590 May  6 14:38
   /etc/ssh/ssh_host_dsa_key.pub
   -rw-------. 1 root root  963 May  6 14:38 /etc/ssh/ssh_host_key
   -rw-r--r--. 1 root root  627 May  6 14:38 /etc/ssh/ssh_host_key.pub
   -rw-------. 1 root root 1679 May  6 14:38 /etc/ssh/ssh_host_rsa_key
   -rw-r--r--. 1 root root  382 May  6 14:38
   /etc/ssh/ssh_host_rsa_key.pub
   ```

2. Copy the chosen public key to the server designated as the CA. For example, from the host:

   ```
   ~]# scp /etc/ssh/ssh_host_rsa_key.pub admin@ca-
   server.example.com:~/keys/ssh_host_rsa_key.pub
   The authenticity of host 'ca-server.example.com (10.34.74.58)' can't
   be established.
   RSA key fingerprint is
   b0:e5:ea:b8:75:e2:f0:b1:fe:5b:07:39:7f:58:64:d9.
   Are you sure you want to continue connecting (yes/no)? yes
   Warning: Permanently added 'ca-server.example.com,10.34.74.58' (RSA)
   to the list of known hosts.
   admin@ca-server.example.com's password:
   ssh_host_rsa_key.pub                              100%  382
   0.4KB/s   00:00
   ```

   Alternately, from the CA:

   ```
   ~]$ scp root@host_name.example.com:/etc/ssh/ssh_host_rsa_key.pub
   ~/keys/ssh_host_rsa_key.pub
   ```

3. On the CA server, sign the host's public key. For example, as **`root`**:

   ```
   ~]# ssh-keygen -s ~/.ssh/ca_host_key -I host_name -h -Z
   host_name.example.com -V -1d:+54w
   /home/admin/keys/ssh_host_rsa_key.pub
   Enter passphrase:
   ```

```
Signed host key /home/admin/keys/ssh_host_rsa_key-cert.pub: id
"host_name" serial 0 for host_name.example.com valid from 2015-05-
26T12:21:54 to 2016-06-08T12:21:54
```

Where *host_name* is the host name of the system requiring the certificate.

4. Copy the certificate to the host. For example, from the CA:

```
~]# scp /home/admin/keys/ssh_host_rsa_key-cert.pub
root@host_name.example.com:/etc/ssh/
root@host_name.example.com's password:
ssh_host_rsa_key-cert.pub                      100% 1384
1.5KB/s   00:00
```

5. Configure the host to present the certificate to a user's system when a user initiates the login process. As **root**, edit the **/etc/ssh/sshd_config** file as follows:

```
HostCertificate /etc/ssh/ssh_host_rsa_key-cert.pub
```

6. Restart **sshd** to make the changes take effect:

```
~]# service sshd restart
```

7. On user's systems. remove keys belonging to hosts from the **~/.ssh/known_hosts** file if the user has previously logged into the host configured above. When a user logs into the host they should no longer be presented with the warning about the hosts authenticity.

To test the host certificate, on a client system, ensure the client has set up the global **/etc/ssh/known_hosts** file, as described in Procedure 14.3, “Trusting the Host Signing Key”, and that the server's public key is not in the **~/.ssh/known_hosts** file. Then attempt to log into the server over SSH as a remote user. You should not see a warning about the authenticity of the host. If required, add the **-v** option to the SSH command to see logging information.

14.3.5.2. Creating SSH Certificates for Authenticating Users

To sign a user's certificate, use a command in the following format:

```
ssh-keygen -s ca_user_key -I user_name -Z user_name -V -start:+end
id_rsa.pub
```

The resulting certificate will be named **id_rsa-cert.pub**.

The default behavior of OpenSSH is that a user is allowed to log in as a remote user if one of the principals specified in the certificate matches the remote user's name. This can be adjusted in the following ways:

- Add more user's names to the certificate during the signing process using the **-Z** option:

```
-Z "name1[,name2,...]"
```

- On the user's system, add the public key of the CA in the **~/.ssh/authorized_keys** file using the **cert-authority** directive and list the principals names as follows:

```
~]# vi ~/.ssh/authorized_keys
```

```
# A CA key, accepted for any host in *.example.com
@cert-authority principals="name1,name2" *.example.com ssh-rsa
AAAAB5Wm.
```

- On the server, create an **AuthorizedPrincipalsFile** file, either per user or glabally, and add the principles' names to the file for those users allowed to log in. Then in the **/etc/ssh/sshd_config** file, specify the file using the **AuthorizedPrincipalsFile** directive.

Procedure 14.5. Generating a User Certificate

To authenticate a user to a remote host, a public key must be generated by the user, passed to the CA server, signed by the CA, and then passed back to be stored by the user for use when logging in to a host.

1. On client systems, login as the user who requires the certificate. Check for available keys as follows:

   ```
   ~]$ ls -l ~/.ssh/
   ```

   If no suitable public key exists, generate one and set the directory permissions if the directory is not the default directory. For example, enter the following command:

   ```
   ~]$ ssh-keygen -t rsa
   Generating public/private rsa key pair.
   Enter file in which to save the key (/home/user1/.ssh/id_rsa):
   Created directory '/home/user1/.ssh'.
   Enter passphrase (empty for no passphrase):
   Enter same passphrase again:
   Your identification has been saved in /home/user1/.ssh/id_rsa.
   Your public key has been saved in /home/user1/.ssh/id_rsa.pub.
   The key fingerprint is:
   b1:f8:26:a7:46:87:c3:60:54:a3:6d:85:0d:60:fe:ce
   user1@host1.example.com
   The key's randomart image is:
   +--[ RSA 2048]----+
   |    oo++.        |
   |   o.o.o.        |
   |   .o o .        |
   |    oo . o       |
   |   . oo.S        |
   |     o=..        |
   |     .Eo+        |
   |      .=         |
   |     ..          |
   +-----------------+
   ```

   By default the directory permissions for a user's keys are **drwx------.**, or octal 0700. If required, confirm the permissions are correct:

   ```
   ~]$ ls -la ~/.ssh
   total 16
   drwx------. 2 user1 user1 4096 May  7 12:37 .
   ```

```
drwx------. 3 user1 user1 4096 May  7 12:37 ..
-rw-------. 1 user1 user1 1679 May  7 12:37 id_rsa
-rw-r--r--. 1 user1 user1  421 May  7 12:37 id_rsa.pub
```

See Section 14.2.4, “Using Key-Based Authentication” for more examples of key generation and for instructions on setting the correct directory permissions.

2. The chosen public key must be copied to the server designated as the CA, in order to be signed. The secure copy command can be used to do this, the command has the following format:

```
scp ~/.ssh/id_protocol.pub admin@ca_server.example.com:~/keys/
```

Where *protocol* is the part of the file name indicating the protocol used to generate the key, for example **rsa**, *admin* is an account on the CA server, and */keys/* is a directory setup to receive the keys to be signed.

Copy the chosen public key to the server designated as the CA. For example:

```
~]$ scp ~/.ssh/id_rsa.pub admin@ca-server.example.com:~/keys/
admin@ca-server.example.com's password:
id_rsa.pub                                  100%  421     0.4KB/s
00:00
```

If you have configured the client system to trust the host signing key as described in Procedure 14.3, “Trusting the Host Signing Key” then you should not see a warning about the authenticity of the remote host.

3. On the CA server, sign the user's public key. For example, as **root**:

```
~]# ssh-keygen -s ~/.ssh/ca_user_key -I user1 -Z user1 -V -1d:+54w
/home/admin/keys/id_rsa.pub
Enter passphrase:
Signed user key /home/admin/keys/id_rsa-cert.pub: id "user1" serial
0 for host_name.example.com valid from 2015-05-21T16:43:17 to 2016-
06-03T16:43:17
```

4. Copy the resulting certificate to the user's **~/.ssh/** directory on their system. For example:

```
~]# scp /home/admin/keys/id_rsa-cert.pub
user1@host_name.example.com:~/.ssh/
user1@host_name.example.com's password:
id_rsa-cert.pub                             100%  1498    1.5KB/s
00:00
```

5. If using the standard file names and location then no further configuration is required as the SSH daemon will search for user certificates ending in **-cert.pub** and use them automatically if it finds them. Note that the default location and file names for for SSH version 2 keys are: **~/.ssh/id_dsa**, **~/.ssh/id_ecdsa** and **~/.ssh/id_rsa** as explained in the **ssh_config(5)** manual page. If you use these locations and naming conventions then there is no need for editing the configuration files to enable **sshd** to present the certificate. They will be used automatically when logging in to a remote system. In this is the case then skip to step 6.

If required to use a non-default directory or file naming convention, then as **root**, add the following line to the **/etc/ssh/ssh_config** or **~/.ssh/config** files:

```
IdentityFile ~/path/key_file
```

Note that this must be the private key name, do not had **.pub** or **-cert.pub**. Ensure the file permission are correct. For example:

```
~]$ ls -la ~/.ssh/config
-rw-rw-r--. 1 user1 user1 36 May 27 21:49 /home/user1/.ssh/config
chmod 700 ~/.ssh/config
~]$ ls -la ~/.ssh/config
-rwx------. 1 user1 user1 36 May 27 21:49 /home/user1/.ssh/config
```

This will enable the user of this system to be authenticated by a user certificate when logging into a remote system configured to trust the CA user certificate signing key.

6. To test the user certificate, attempt to log into a server over SSH from the user's account. You should do this as the user listed as a principle in the certificate, if any are specified. You should not be prompted for a password. If required, add the **-v** option to the SSH command to see logging information.

14.3.6. Signing an SSH Certificate Using a PKCS#11 Token

It is possible to sign a host key using a CA key stored in a PKCS#11 token by providing the token library using the **-D** and identifying the CA key by providing its public half as an argument to the **-s** option:

```
ssh-keygen -s ca_host_key.pub -D libpkcs11.so -I certificate_ID
host_key.pub
```

In all cases, *certificate_ID* is a “key identifier” that is logged by the server when the certificate is used for authentication.

Certificates may be configured to be valid only for a set of users or host names, the principals. By default, generated certificates are valid for all users or hosts. To generate a certificate for a specified set of principals, use a comma separated list with the **-Z** option as follows:

```
ssh-keygen -s ca_user_key.pub -D libpkcs11.so -I certificate_ID -Z
user1,user2 id_rsa.pub
```

and for hosts:

```
ssh-keygen -s ca_host_key.pub -D libpkcs11.so -I certificate_ID -h -Z
host.domain ssh_host_rsa_key.pub
```

Additional limitations on the validity and use of user certificates may be specified through certificate options. A certificate option may disable features of the SSH session, may be valid only when presented from particular source addresses or may force the use of a specific command. For a list of valid certificate options, see the **ssh-keygen(1)** manual page for the **-O** option.

Certificates may be defined to be valid for a specific lifetime. The **-V** option allows specifying a certificates start and end times. For example:

```
ssh-keygen -s ca_user_key -I certificate_ID id_rsa.pub -V "-1w:+54w5d"
```

A certificate that is presented at a time outside this range will not be considered valid. By default, certificates are valid indefinitely starting from UNIX Epoch.

14.3.7. Viewing an SSH CA Certificate

To view a certificate, use the **-L** to list the contents. For example, for a user's certificate:

```
~]$ ssh-keygen -L -f ~/.ssh/id_rsa-cert.pub
/home/user1/.ssh/id_rsa-cert.pub:
        Type: ssh-rsa-cert-v01@openssh.com user certificate
        Public key: RSA-CERT
3c:9d:42:ed:65:b6:0f:18:bf:52:77:c6:02:0e:e5:86
        Signing CA: RSA b1:8e:0b:ce:fe:1b:67:59:f1:74:cd:32:af:5f:c6:e8
        Key ID: "user1"
        Serial: 0
        Valid: from 2015-05-27T00:09:16 to 2016-06-09T00:09:16
        Principals:
                user1
        Critical Options: (none)
        Extensions:
                permit-X11-forwarding
                permit-agent-forwarding
                permit-port-forwarding
                permit-pty
                permit-user-rc
```

To vew a host certificate:

```
~]# ssh-keygen -L -f /etc/ssh/ssh_host_rsa_key-cert.pub
/etc/ssh/ssh_host_rsa_key-cert.pub:
        Type: ssh-rsa-cert-v01@openssh.com host certificate
        Public key: RSA-CERT
1d:71:61:50:05:9b:ec:64:34:27:a5:cc:67:24:03:23
        Signing CA: RSA e4:d5:d1:4f:6b:fd:a2:e3:4e:5a:73:52:91:0b:b7:7a
        Key ID: "host_name"
        Serial: 0
        Valid: from 2015-05-26T17:19:01 to 2016-06-08T17:19:01
        Principals:
                host_name.example.com
        Critical Options: (none)
        Extensions: (none)
```

14.3.8. Revoking an SSH CA Certificate

If a certificate is stolen, it should be revoked. Although OpenSSH does not provide a mechanism to distribute the revocation list it is still easier to create the revocation list and distribute it by other means then to change the CA keys and all host and user certificates previously created and distributed.

Keys can be revoked by adding them to the **revoked_keys** file and specifying the file name in the **sshd_config** file as follows:

```
RevokedKeys /etc/ssh/revoked_keys
```

Note that if this file is not readable, then public key authentication will be refused for all users.

To test if a key has been revoked, query the revocation list for the presence of the key. Use a command as follows:

```
ssh-keygen -Qf /etc/ssh/revoked_keys ~/.ssh/id_rsa.pub
```

A user can revoke a CA certificate by changing the **cert-authority** directive to **revoke** in the **known_hosts** file.

14.4. OPENSSH CLIENTS

To connect to an OpenSSH server from a client machine, you must have the openssh-clients and openssh packages installed (see Section 8.2.4, “Installing Packages” for more information on how to install new packages in Red Hat Enterprise Linux).

14.4.1. Using the ssh Utility

The **ssh** utility allows you to log in to a remote machine and execute commands there. It is a secure replacement for the **rlogin**, **rsh**, and **telnet** programs.

Similarly to the **telnet** command, log in to a remote machine by using the following command:

```
ssh hostname
```

For example, to log in to a remote machine named **penguin.example.com**, type the following at a shell prompt:

```
~]$ ssh penguin.example.com
```

This will log you in with the same user name you are using on the local machine. If you want to specify a different user name, use a command in the following form:

```
ssh username@hostname
```

For example, to log in to **penguin.example.com** as **john**, type:

```
~]$ ssh john@penguin.example.com
```

The first time you initiate a connection, you will be presented with a message similar to this:

```
The authenticity of host 'penguin.example.com' can't be established.
RSA key fingerprint is 94:68:3a:3a:bc:f3:9a:9b:01:5d:b3:07:38:e2:11:0c.
Are you sure you want to continue connecting (yes/no)?
```

Type **yes** to confirm. You will see a notice that the server has been added to the list of known hosts, and a prompt asking for your password:

```
Warning: Permanently added 'penguin.example.com' (RSA) to the list of
known hosts.
john@penguin.example.com's password:
```

IMPORTANT

Update the host key of an SSH server if the key changes. The client notifies the user that the connection cannot proceed until the server's host key is deleted from the **~/.ssh/known_hosts** file. Contact the system administrator of the SSH server to verify the server is not compromised, then remove the line with the name of the remote machine at the beginning.

After entering the password, you will be provided with a shell prompt for the remote machine.

Alternatively, the **ssh** program can be used to execute a command on the remote machine without logging in to a shell prompt:

```
ssh [username@]hostname command
```

For example, the **/etc/redhat-release** file provides information about the Red Hat Enterprise Linux version. To view the contents of this file on **penguin.example.com**, type:

```
~]$ ssh john@penguin.example.com cat /etc/redhat-release
john@penguin.example.com's password:
Red Hat Enterprise Linux Server release 6.2 (Santiago)
```

After you enter the correct password, the user name will be displayed, and you will return to your local shell prompt.

14.4.2. Using the scp Utility

scp can be used to transfer files between machines over a secure, encrypted connection. In its design, it is very similar to **rcp**.

To transfer a local file to a remote system, use a command in the following form:

```
scp localfile username@hostname:remotefile
```

For example, if you want to transfer **taglist.vim** to a remote machine named **penguin.example.com**, type the following at a shell prompt:

```
~]$ scp taglist.vim john@penguin.example.com:.vim/plugin/taglist.vim
john@penguin.example.com's password:
taglist.vim                                   100%  144KB 144.5KB/s
00:00
```

Multiple files can be specified at once. To transfer the contents of **.vim/plugin/** to the same directory on the remote machine **penguin.example.com**, type the following command:

```
~]$ scp .vim/plugin/* john@penguin.example.com:.vim/plugin/
john@penguin.example.com's password:
closetag.vim                                  100%   13KB  12.6KB/s
00:00
snippetsEmu.vim                               100%   33KB  33.1KB/s
00:00
taglist.vim                                   100%  144KB 144.5KB/s
00:00
```

- To transfer a remote file to the local system, use the following syntax:

```
scp username@hostname:remotefile localfile
```

For instance, to download the **.vimrc** configuration file from the remote machine, type:

```
~]$ scp john@penguin.example.com:.vimrc .vimrc
john@penguin.example.com's password:
.vimrc                                        100% 2233     2.2KB/s
00:00
```

14.4.3. Using the sftp Utility

The **sftp** utility can be used to open a secure, interactive FTP session. In its design, it is similar to **ftp** except that it uses a secure, encrypted connection.

To connect to a remote system, use a command in the following form:

```
sftp username@hostname
```

For example, to log in to a remote machine named **penguin.example.com** with **john** as a user name, type:

```
~]$ sftp john@penguin.example.com
john@penguin.example.com's password:
Connected to penguin.example.com.
sftp>
```

After you enter the correct password, you will be presented with a prompt. The **sftp** utility accepts a set of commands similar to those used by **ftp** (see Table 14.3, “A selection of available sftp commands”).

Table 14.3. A selection of available sftp commands

Command	Description
ls [*directory*]	List the content of a remote *directory*. If none is supplied, a current working directory is used by default.
cd *directory*	Change the remote working directory to *directory*.
mkdir *directory*	Create a remote *directory*.
rmdir *path*	Remove a remote *directory*.
put *localfile* [*remotefile*]	Transfer *localfile* to a remote machine.
get *remotefile* [*localfile*]	Transfer *remotefile* from a remote machine.

For a complete list of available commands, see the **sftp**(1) manual page.

14.5. MORE THAN A SECURE SHELL

A secure command-line interface is just the beginning of the many ways SSH can be used. Given the proper amount of bandwidth, X11 sessions can be directed over an SSH channel. Or, by using TCP/IP forwarding, previously insecure port connections between systems can be mapped to specific SSH channels.

14.5.1. X11 Forwarding

To open an X11 session over an SSH connection, use a command in the following form:

```
ssh -Y username@hostname
```

For example, to log in to a remote machine named **`penguin.example.com`** with **`john`** as a user name, type:

```
~]$ ssh -Y john@penguin.example.com
john@penguin.example.com's password:
```

When an X program is run from the secure shell prompt, the SSH client and server create a new secure channel, and the X program data is sent over that channel to the client machine transparently.

X11 forwarding can be very useful. For example, X11 forwarding can be used to create a secure, interactive session of the **Printer Configuration** utility. To do this, connect to the server using **ssh** and type:

```
~]$ system-config-printer &
```

The **Printer Configuration Tool** will appear, allowing the remote user to safely configure printing on the remote system.

Please note that X11 Forwarding does not distinguish between trusted and untrusted forwarding.

14.5.2. Port Forwarding

SSH can secure otherwise insecure **`TCP/IP`** protocols via port forwarding. When using this technique, the SSH server becomes an encrypted conduit to the SSH client.

Port forwarding works by mapping a local port on the client to a remote port on the server. SSH can map any port from the server to any port on the client. Port numbers do not need to match for this technique to work.

NOTE

If you want to use reserved port numbers, please note that setting up port forwarding to listen on ports below 1024 requires **`root`** level access.

To create a TCP/IP port forwarding channel which listens for connections on the **`localhost`**, use a command in the following form:

```
ssh -L local-port:remote-hostname:remote-port username@hostname
```

For example, to check email on a server called **`mail.example.com`** using **`POP3`** through an encrypted connection, use the following command:

```
~]$ ssh -L 1100:mail.example.com:110 mail.example.com
```

Once the port forwarding channel is in place between the client machine and the mail server, direct a POP3 mail client to use port **`1100`** on the **`localhost`** to check for new email. Any requests sent to port **`1100`** on the client system will be directed securely to the **`mail.example.com`** server.

If **`mail.example.com`** is not running an SSH server, but another machine on the same network is, SSH can still be used to secure part of the connection. However, a slightly different command is necessary:

```
~]$ ssh -L 1100:mail.example.com:110 other.example.com
```

In this example, POP3 requests from port **`1100`** on the client machine are forwarded through the SSH connection on port **`22`** to the SSH server, **`other.example.com`**. Then, **`other.example.com`** connects to port **`110`** on **`mail.example.com`** to check for new email. Note that when using this technique, only the connection between the client system and **`other.example.com`** SSH server is secure.

Port forwarding can also be used to get information securely through network firewalls. If the firewall is configured to allow SSH traffic via its standard port (that is, port 22) but blocks access to other ports, a connection between two hosts using the blocked ports is still possible by redirecting their communication over an established SSH connection.

IMPORTANT

The connection is only as secure as the client system because forwarding connections in this way allows any user on the client system to connect to that service. If the client system becomes compromised, an attacker can also access the forwarded services.

If preferred, disable this functionality on the server by specifying a **`No`** parameter for the **`AllowTcpForwarding`** line in the **`/etc/ssh/sshd_config`** file and restarting the **`sshd`** service.

14.6. ADDITIONAL RESOURCES

For more information about OpenSSH and OpenSSL, see the resources listed below.

14.6.1. Installed Documentation

- **sshd**(8) — a manual page for the **sshd** daemon.
- **ssh**(1) — a manual page for the **ssh** client.
- **scp**(1) — a manual page for the **scp** utility.
- **sftp**(1) — a manual page for the **sftp** utility.
- **ssh-keygen**(1) — a manual page for the **ssh-keygen** utility.
- **ssh_config**(5) — a manual page with a full description of available SSH client configuration options.

- **sshd_config**(5) — a manual page with a full description of available SSH daemon configuration options.
- **`/usr/share/doc/openssh-`*`version`*`/`** Contains detailed information on the protocols supported by OpenSSH.

14.6.2. Useful Websites

http://www.openssh.com/
: The OpenSSH home page containing further documentation, frequently asked questions, links to the mailing lists, bug reports, and other useful resources.

http://www.openssl.org/
: The OpenSSL home page containing further documentation, frequently asked questions, links to the mailing lists, and other useful resources.

[4] A multiplexed connection consists of several signals being sent over a shared, common medium. With SSH, different channels are sent over a common secure connection.

CHAPTER 15. TIGERVNC

`TigerVNC` (Tiger Virtual Network Computing) is a system for graphical desktop sharing which allows you to remotely control other computers.

`TigerVNC` works on the client-server principle: a **server** shares its output (**`vncserver`**) and a **client** (**`vncviewer`**) connects to the server.

15.1. VNC SERVER

`vncserver` is a utility which starts a VNC (Virtual Network Computing) desktop. It runs **`Xvnc`** with appropriate options and starts a window manager on the VNC desktop. **`vncserver`** allows users to run separate sessions in parallel on a machine which can then be accessed by any number of clients from anywhere.

15.1.1. Installing VNC Server

To install the **TigerVNC** server, run the following command as **`root`**:

```
~]# yum install tigervnc-server
```

15.1.2. Configuring VNC Server

The VNC server can be configured to start a display for one or more users, provided that accounts for the users exist on the system, with optional parameters such as for display settings, network address and port, and security settings.

Procedure 15.1. Configuring a VNC Display for a Single User

- Specify the user name and the display number by editing **`/etc/sysconfig/vncservers`** and adding a line in the following format:

  ```
  VNCSERVERS="display_number:user"
  ```

  The VNC user names must correspond to users of the system.

  Example 15.1. Setting the Display Number for a User

  For example, to configure display number **3** for user **`joe`**, open the configuration file for editing:

  ```
  ~]# vi /etc/sysconfig/vncservers
  ```

  Add a line as follows:

  ```
  VNCSERVERS="3:joe"
  ```

  Save and close the file.

  In the example above, display number **3** and the user **joe** are set. Do not use **0** as the display number since the main X display of a workstation is usually indicated as 0.

Procedure 15.2. Configuring a VNC Display for Multiple Users

- To set a VNC display for more than one user, specify the user names and display numbers by editing **`/etc/sysconfig/vncservers`** and adding a line in the following format:

```
VNCSERVERS="display_number:user display_number:user"
```

The VNC user names must correspond to users of the system.

Example 15.2. Setting the Display Numbers for Two Users

For example, to configure two users, open the configuration file for editing:

```
~]# vi /etc/sysconfig/vncservers
```

Add a line as follows:

```
VNCSERVERS="3:joe 4:jill"
```

Procedure 15.3. Configuring VNC Display Arguments

- Specify additional settings in the **`/etc/sysconfig/vncservers`** file by adding arguments using the VNCSERVERARGS directive as follows:

```
VNCSERVERS="display_number:user display_number:user"
VNCSERVERARGS[display_number]="arguments"
```

Table 15.1. Frequently Used VNC Server Parameters

VNCSERVERARGS	Definition
-geometry	specifies the size of the VNC desktop to be created, default is 1024x768.
-nolisten tcp	prevents connections to your VNC server through TCP (Transmission Control Protocol)
-localhost	prevents remote VNC clients from connecting except when doing so through a secure tunnel

See the **`Xvnc(1)`** man page for further options.

Example 15.3. Setting vncserver Arguments

Following on from the example above, to add arguments for two users, edit the **`/etc/sysconfig/vncservers`** file as follows:

```
VNCSERVERS="3:joe 4:jill"
VNCSERVERARGS[1]="-geometry 800x600 -nolisten tcp -localhost"
VNCSERVERARGS[2]="-geometry 1920×1080 -nolisten tcp -localhost"
```

Procedure 15.4. Configuring VNC User Passwords

- To set the VNC password for all users defined in the **`/etc/sysconfig/vncservers`** file, enter the following command as **`root`**:

  ```
  ~]# vncpasswd
  Password:
  Verify:
  ```

  To set the VNC password individually for a user:

  ```
  ~]# su - user
  ~]$ vncpasswd
  Password:
  Verify:
  ```

  IMPORTANT

  The stored password is not encrypted; anyone who has access to the password file can find the plain-text password.

15.1.3. Starting VNC Server

In order to start a VNC desktop, the **`vncserver`** utility is used. It is a Perl script which simplifies the process of starting an Xvnc server. It runs Xvnc with appropriate options and starts a window manager on the VNC desktop. There are three ways to start **`vncserver`**:

- You can allow **`vncserver`** to choose the first available display number, start Xvnc with that display number, and start the default window manager in the Xvnc session. All these steps are provided by one command:

  ```
  ~]$ vncserver
  ```

  You will be prompted to enter a VNC password the first time the command is run if no VNC password has been set.

- Alternately, you can specify a specific display number:

  ```
  vncserver :display_number
  ```

  `vncserver` attempts to start Xvnc with that display number and exits if the display number is not available.

  For example:

  ```
  ~]$ vncserver :20
  ```

- Alternately, to start VNC server with displays for the users configured in the **`/etc/sysconfig/vncservers`** configuration file, as **`root`** enter:

  ```
  ~]# service vncserver start
  ```

You can enable the **vncserver** service automatically at system start. Every time you log in, **vncserver** is automatically started. As **root**, run

```
~]# chkconfig vncserver on
```

15.1.4. Terminating a VNC Session

Similarly to enabling the **vncserver** service, you can disable the automatic start of the service at system start:

```
~]# chkconfig vncserver off
```

Or, when your system is running, you can stop the service by issuing the following command as **root**:

```
~]# service vncserver stop
```

To terminate a specific display, terminate **vncserver** using the **-kill** option along with the display number.

Example 15.4. Terminating a Specific Display

For example, to terminate display number 2, run:

```
~]# vncserver -kill :2
```

Example 15.5. Terminating an Xvnc process

If it is not possible to terminate the VNC service or display, terminate the Xvnc session using the process ID (PID). To view the processes, enter:

```
~]$ service vncserver status
Xvnc (pid 4290 4189) is running...
```

To terminate process **4290**, enter as **root**:

```
~]# kill -s 15 4290
```

15.2. SHARING AN EXISTING DESKTOP

By default a logged in user has a desktop provided by X Server on display **0**. A user can share their desktop using the **TigerVNC** server **x0vncserver**.

Procedure 15.5. Sharing an X Desktop

To share the desktop of a logged in user, using the **x0vncserver**, proceed as follows:

1. Enter the following command as **root**

   ```
   ~]# yum install tigervnc-server
   ```

■

2. Set the VNC password for the user:

```
~]$ vncpasswd
Password:
Verify:
```

3. Enter the following command as that user:

```
~]$ x0vncserver -PasswordFile=.vnc/passwd -AlwaysShared=1
```

Provided the firewall is configured to allow connections to port **5900**, the remote viewer can now connect to display **0**, and view the logged in users desktop. See Section 15.3.2.1, “Configuring the Firewall for VNC” for information on how to configure the firewall.

15.3. USING A VNC VIEWER

A VNC viewer is a program which shows the graphical user interface created by the VNC server and can control the VNC server remotely. The desktop that is shared is not by default the same as the desktop that is displayed to a user directly logged into the system. The VNC server creates a unique desktop for every display number. Any number of clients can connect to a VNC server.

15.3.1. Installing the VNC Viewer

To install the **TigerVNC** client, **vncviewer**, as **root**, run the following command:

```
~]# yum install tigervnc
```

The **TigerVNC** client has a graphical user interface (GUI) which can be started by entering the command **vncviewer**. Alternatively, you can operate **vncviewer** through the command-line interface (CLI). To view a list of parameters for **vncviewer** enter **vncviewer -h** on the command line.

15.3.2. Connecting to a VNC Server

Once the VNC server is configured, you can connect to it from any VNC viewer.

Procedure 15.6. Connecting to a VNC Server Using a GUI

1. Enter the **vncviewer** command with no arguments, the **VNC Viewer: Connection Details** utility appears. It prompts for a VNC server to connect to.

2. If required, to prevent disconnecting any existing VNC connections to the same display, select the option to allow sharing of the desktop as follows:

   a. Select the **Options** button.

   b. Select the **Misc.** tab.

   c. Select the **Shared** button.

   d. Press **OK** to return to the main menu.

3. Enter an address and display number to connect to:

```
address:display_number
```

4. Press **Connect** to connect to the VNC server display.

5. You will be prompted to enter the VNC password. This will be the VNC password for the user corresponding to the display number unless a global default VNC password was set.

   A window appears showing the VNC server desktop. Note that this is not the desktop the normal user sees, it is an Xvnc desktop.

Procedure 15.7. Connecting to a VNC Server Using the CLI

1. Enter the **viewer** command with the address and display number as arguments:

   ```
   vncviewer address:display_number
   ```

   Where *address* is an **IP** address or host name.

2. Authenticate yourself by entering the VNC password. This will be the VNC password for the user corresponding to the display number unless a global default VNC password was set.

3. A window appears showing the VNC server desktop. Note that this is not the desktop the normal user sees, it is the Xvnc desktop.

15.3.2.1. Configuring the Firewall for VNC

When using a non-encrypted connection, the firewall might block your connection. The VNC protocol is *remote framebuffer* (RFB), which is transported in **TCP** packets. If required, open a port for the **TCP** protocol as described below. When using the **-via** option, traffic is redirected over **SSH** which is enabled by default.

NOTE

The default port of VNC server is 5900. To reach the port through which a remote desktop will be accessible, sum the default port and the user's assigned display number. For example, for the second display: 2 + 5900 = 5902.

Procedure 15.8. Opening a Port Using lokkit

The **lokkit** command provides a way to quickly enable a port using the command line.

1. To enable a specific port, for example port **5902** for **TCP**, issue the following command as **root**:

   ```
   ~]# lokkit --port=5902:tcp --update
   ```

   Note that this will restart the firewall as long as it has not been disabled with the **--disabled** option. Active connections will be terminated and time out on the initiating machine.

2. Verify whether the chosen port is open. As **root**, enter:

   ```
   ~]# iptables -L -n | grep 'tcp.*59'
   ACCEPT     tcp  --  0.0.0.0/0     0.0.0.0/0    state NEW tcp
   dpt:5902
   ```

3. If you are unsure of the port numbers in use for VNC, as **root**, enter:

   ```
   ~]# netstat -tnlp
   tcp    0    0 0.0.0.0:6003    0.0.0.0:*    LISTEN    4290/Xvnc
   tcp    0    0 0.0.0.0:5900    0.0.0.0:*    LISTEN
   7013/x0vncserver
   tcp    0    0 0.0.0.0:5902    0.0.0.0:*    LISTEN    4189/Xvnc
   tcp    0    0 0.0.0.0:5903    0.0.0.0:*    LISTEN    4290/Xvnc
   tcp    0    0 0.0.0.0:6002    0.0.0.0:*    LISTEN    4189/Xvnc
   ```

   Ports starting **59XX** are for the VNC **RFB** protocol. Ports starting **60XX** are for the X windows protocol.

   To list the ports and the Xvnc session's associated user, as **root**, enter:

   ```
   ~]# lsof -i -P | grep vnc
   Xvnc      4189    jane    0u  IPv6  27972    0t0  TCP *:6002
   (LISTEN)
   Xvnc      4189    jane    1u  IPv4  27973    0t0  TCP *:6002
   (LISTEN)
   Xvnc      4189    jane    6u  IPv4  27979    0t0  TCP *:5902
   (LISTEN)
   Xvnc      4290     joe    0u  IPv6  28231    0t0  TCP *:6003
   (LISTEN)
   Xvnc      4290     joe    1u  IPv4  28232    0t0  TCP *:6003
   (LISTEN)
   Xvnc      4290     joe    6u  IPv4  28244    0t0  TCP *:5903
   (LISTEN)
   x0vncserv 7013     joe    4u  IPv4  47578    0t0  TCP *:5900
   (LISTEN)
   ```

Procedure 15.9. Configuring the Firewall Using an Editor

When preparing a configuration file for multiple installations using administration tools, it is useful to edit the firewall configuration file directly. Note that any mistakes in the configuration file could have unexpected consequences, cause an error, and prevent the firewall settings from being applied. Therefore, check the **/etc/sysconfig/system-config-firewall** file thoroughly after editing.

1. To check what the firewall is configured to allow, issue the following command as **root** to view the firewall configuration file:

   ```
   ~]# less /etc/sysconfig/system-config-firewall
   # Configuration file for system-config-firewall

   --enabled
   --service=ssh
   ```

   In this example taken from a default installation, the firewall is enabled but VNC ports have not been configured to pass through.

2. Open **/etc/sysconfig/system-config-firewall** for editing as **root** and add lines in the following format to the firewall configuration file:

   ```
   --port=port_number:tcp
   ```

For example, to add port **5902** :

```
~]# vi /etc/sysconfig/system-config-firewall
  # Configuration file for system-config-firewall

--enabled
--service=ssh
--port=5902:tcp
```

3. Note that these changes will not take effect even if the firewall is reloaded or the system rebooted. To apply the settings in **/etc/sysconfig/system-config-firewall**, issue the following command as **root**:

```
~]# lokkit --update
```

15.3.3. Connecting to VNC Server Using SSH

VNC is a clear text network protocol with no security against possible attacks on the communication. To make the communication secure, you can encrypt your server-client connection by using the **-via** option. This will create an **SSH** tunnel between the VNC server and the client.

The format of the command to encrypt a VNC server-client connection is as follows:

```
vncviewer -via user@host:display_number
```

Example 15.6. Using the -via Option

1. To connect to a VNC server using **SSH**, enter a command as follows:

   ```
   $ vncviewer -via joe@192.168.2.101 127.0.0.1:3
   ```

2. When you are prompted to, type the password, and confirm by pressing **Enter**.

3. A window with a remote desktop appears on your screen.

For more information on using **SSH**, see Chapter 14, *OpenSSH*.

15.4. ADDITIONAL RESOURCES

For more information about TigerVNC, see the resources listed below.

Installed Documentation

- **vncserver(1)** — The manual page for the VNC server utility.
- **vncviewer(1)** — The manual page for the VNC viewer.
- **vncpasswd(1)** — The manual page for the VNC password command.
- **Xvnc(1)** — The manual page for the Xvnc server configuration options.
- **x0vncserver(1)** — The manual page for the **TigerVNC** server for sharing existing X servers.

PART VI. SERVERS

This part discusses various topics related to servers such as how to set up a Web server or share files and directories over the network.

CHAPTER 16. DHCP SERVERS

Dynamic Host Configuration Protocol (DHCP) is a network protocol that automatically assigns TCP/IP information to client machines. Each DHCP client connects to the centrally located DHCP server, which returns the network configuration (including the IP address, gateway, and DNS servers) of that client.

16.1. WHY USE DHCP?

DHCP is useful for automatic configuration of client network interfaces. When configuring the client system, you can choose DHCP instead of specifying an IP address, netmask, gateway, or DNS servers. The client retrieves this information from the DHCP server. DHCP is also useful if you want to change the IP addresses of a large number of systems. Instead of reconfiguring all the systems, you can just edit one configuration file on the server for the new set of IP addresses. If the DNS servers for an organization changes, the changes happen on the DHCP server, not on the DHCP clients. When you restart the network or reboot the clients, the changes go into effect.

If an organization has a functional DHCP server correctly connected to a network, laptops and other mobile computer users can move these devices from office to office.

16.2. CONFIGURING A DHCPV4 SERVER

The dhcp package contains an Internet Systems Consortium (ISC) DHCP server. First, install the package as the superuser:

```
~]# yum install dhcp
```

Installing the dhcp package creates a file, **`/etc/dhcp/dhcpd.conf`**, which is merely an empty configuration file:

```
~]# cat /etc/dhcp/dhcpd.conf
#
# DHCP Server Configuration file.
#   see /usr/share/doc/dhcp*/dhcpd.conf.sample
```

The sample configuration file can be found at **`/usr/share/doc/dhcp-<version>/dhcpd.conf.sample`**. You should use this file to help you configure **`/etc/dhcp/dhcpd.conf`**, which is explained in detail below.

DHCP also uses the file **`/var/lib/dhcpd/dhcpd.leases`** to store the client lease database. See Section 16.2.2, “Lease Database” for more information.

16.2.1. Configuration File

The first step in configuring a DHCP server is to create the configuration file that stores the network information for the clients. Use this file to declare options and global options for client systems.

The configuration file can contain extra tabs or blank lines for easier formatting. Keywords are case-insensitive and lines beginning with a hash sign (#) are considered comments.

There are two types of statements in the configuration file:

- Parameters — State how to perform a task, whether to perform a task, or what network configuration options to send to the client.

- Declarations — Describe the topology of the network, describe the clients, provide addresses for the clients, or apply a group of parameters to a group of declarations.

The parameters that start with the keyword option are referred to as *options*. These options control DHCP options; whereas, parameters configure values that are not optional or control how the DHCP server behaves.

Parameters (including options) declared before a section enclosed in curly brackets ({ }) are considered global parameters. Global parameters apply to all the sections below it.

IMPORTANT

If the configuration file is changed, the changes do not take effect until the DHCP daemon is restarted with the command **`service dhcpd restart`**.

NOTE

Instead of changing a DHCP configuration file and restarting the service each time, using the **`omshell`** command provides an interactive way to connect to, query, and change the configuration of a DHCP server. By using **`omshell`**, all changes can be made while the server is running. For more information on **`omshell`**, see the **`omshell`** man page.

In Example 16.1, “Subnet Declaration”, the **`routers`**, **`subnet-mask`**, **`domain-search`**, **`domain-name-servers`**, and **`time-offset`** options are used for any **`host`** statements declared below it.

For every **`subnet`** which will be served, and for every **`subnet`** to which the DHCP server is connected, there must be one **`subnet`** declaration, which tells the DHCP daemon how to recognize that an address is on that **`subnet`**. A **`subnet`** declaration is required for each **`subnet`** even if no addresses will be dynamically allocated to that **`subnet`**.

In this example, there are global options for every DHCP client in the subnet and a **`range`** declared. Clients are assigned an IP address within the **`range`**.

Example 16.1. Subnet Declaration

```
subnet 192.168.1.0 netmask 255.255.255.0 {
        option routers                  192.168.1.254;
        option subnet-mask              255.255.255.0;
        option domain-search              "example.com";
        option domain-name-servers       192.168.1.1;
        option time-offset              -18000;     # Eastern Standard
Time
 range 192.168.1.10 192.168.1.100;
}
```

To configure a DHCP server that leases a dynamic IP address to a system within a subnet, modify Example 16.2, “Range Parameter” with your values. It declares a default lease time, maximum lease time, and network configuration values for the clients. This example assigns IP addresses in the **`range`** 192.168.1.10 and 192.168.1.100 to client systems.

Example 16.2. Range Parameter

```
default-lease-time 600;
max-lease-time 7200;
option subnet-mask 255.255.255.0;
option broadcast-address 192.168.1.255;
option routers 192.168.1.254;
option domain-name-servers 192.168.1.1, 192.168.1.2;
option domain-search "example.com";
subnet 192.168.1.0 netmask 255.255.255.0 {
   range 192.168.1.10 192.168.1.100;
}
```

To assign an IP address to a client based on the MAC address of the network interface card, use the **`hardware ethernet`** parameter within a **`host`** declaration. As demonstrated in Example 16.3, "Static IP Address Using DHCP", the **`host apex`** declaration specifies that the network interface card with the MAC address 00:A0:78:8E:9E:AA always receives the IP address 192.168.1.4.

Note that you can also use the optional parameter **`host-name`** to assign a host name to the client.

Example 16.3. Static IP Address Using DHCP

```
host apex {
   option host-name "apex.example.com";
   hardware ethernet 00:A0:78:8E:9E:AA;
   fixed-address 192.168.1.4;
}
```

All subnets that share the same physical network should be declared within a **`shared-network`** declaration as shown in Example 16.4, "Shared-network Declaration". Parameters within the **`shared-network`**, but outside the enclosed **`subnet`** declarations, are considered to be global parameters. The name of the **`shared-network`** must be a descriptive title for the network, such as using the title 'test-lab' to describe all the subnets in a test lab environment.

Example 16.4. Shared-network Declaration

```
shared-network name {
    option domain-search            "test.redhat.com";
    option domain-name-servers      ns1.redhat.com, ns2.redhat.com;
    option routers                  192.168.0.254;
    #more parameters for EXAMPLE shared-network
    subnet 192.168.1.0 netmask 255.255.252.0 {
        #parameters for subnet
        range 192.168.1.1 192.168.1.254;
    }
    subnet 192.168.2.0 netmask 255.255.252.0 {
        #parameters for subnet
        range 192.168.2.1 192.168.2.254;
    }
}
```

As demonstrated in Example 16.5, “Group Declaration”, the **`group`** declaration is used to apply global parameters to a group of declarations. For example, shared networks, subnets, and hosts can be grouped.

Example 16.5. Group Declaration

```
group {
   option routers                  192.168.1.254;
   option subnet-mask              255.255.255.0;
   option domain-search              "example.com";
   option domain-name-servers       192.168.1.1;
   option time-offset              -18000;     # Eastern Standard Time
   host apex {
      option host-name "apex.example.com";
      hardware ethernet 00:A0:78:8E:9E:AA;
      fixed-address 192.168.1.4;
   }
   host raleigh {
      option host-name "raleigh.example.com";
      hardware ethernet 00:A1:DD:74:C3:F2;
      fixed-address 192.168.1.6;
   }
}
```

NOTE

You can use the provided sample configuration file as a starting point and add custom configuration options to it. To copy this file to the proper location, use the following command as **`root`**:

```
~]# cp /usr/share/doc/dhcp-<version_number>/dhcpd.conf.sample
/etc/dhcp/dhcpd.conf
```

... where *<version_number>* is the DHCP version number.

For a complete list of option statements and what they do, see the **`dhcp-options`** man page.

16.2.2. Lease Database

On the DHCP server, the file **`/var/lib/dhcpd/dhcpd.leases`** stores the DHCP client lease database. Do not change this file. DHCP lease information for each recently assigned IP address is automatically stored in the lease database. The information includes the length of the lease, to whom the IP address has been assigned, the start and end dates for the lease, and the MAC address of the network interface card that was used to retrieve the lease.

All times in the lease database are in Coordinated Universal Time (UTC), not local time.

The lease database is recreated from time to time so that it is not too large. First, all known leases are saved in a temporary lease database. The **`dhcpd.leases`** file is renamed **`dhcpd.leases~`** and the temporary lease database is written to **`dhcpd.leases`**.

The DHCP daemon could be killed or the system could crash after the lease database has been renamed to the backup file but before the new file has been written. If this happens, the **`dhcpd.leases`** file does not exist, but it is required to start the service. Do not create a new lease file. If you do, all old leases are lost which causes many problems. The correct solution is to rename the **`dhcpd.leases~`** backup file to **`dhcpd.leases`** and then start the daemon.

16.2.3. Starting and Stopping the Server

IMPORTANT

When the DHCP server is started for the first time, it fails unless the **`dhcpd.leases`** file exists. Use the command **`touch /var/lib/dhcpd/dhcpd.leases`** to create the file if it does not exist.

If the same server is also running BIND as a DNS server, this step is not necessary, as starting the **named** service automatically checks for a **`dhcpd.leases`** file.

To start the DHCP service, use the command **`/sbin/service dhcpd start`**. To stop the DHCP server, use the command **`/sbin/service dhcpd stop`**.

By default, the DHCP service does not start at boot time. For information on how to configure the daemon to start automatically at boot time, see Chapter 12, *Services and Daemons*.

If more than one network interface is attached to the system, but the DHCP server should only be started on one of the interfaces, configure the DHCP server to start only on that device. In **`/etc/sysconfig/dhcpd`**, add the name of the interface to the list of**`DHCPDARGS`**:

```
# Command line options here
DHCPDARGS=eth0
```

This is useful for a firewall machine with two network cards. One network card can be configured as a DHCP client to retrieve an IP address to the Internet. The other network card can be used as a DHCP server for the internal network behind the firewall. Specifying only the network card connected to the internal network makes the system more secure because users can not connect to the daemon via the Internet.

Other command-line options that can be specified in **`/etc/sysconfig/dhcpd`** include:

- **`-p <portnum>`** — Specifies the UDP port number on which **dhcpd** should listen. The default is port 67. The DHCP server transmits responses to the DHCP clients at a port number one greater than the UDP port specified. For example, if the default port 67 is used, the server listens on port 67 for requests and responds to the client on port 68. If a port is specified here and the DHCP relay agent is used, the same port on which the DHCP relay agent should listen must be specified. See Section 16.2.4, “DHCP Relay Agent” for details.

- **`-f`** — Runs the daemon as a foreground process. This is mostly used for debugging.

- **`-d`** — Logs the DHCP server daemon to the standard error descriptor. This is mostly used for debugging. If this is not specified, the log is written to **`/var/log/messages`**.

- **`-cf <filename>`** — Specifies the location of the configuration file. The default location is **`/etc/dhcp/dhcpd.conf`**.

- **`-lf <filename>`** — Specifies the location of the lease database file. If a lease database file already exists, it is very important that the same file be used every time the DHCP server is started. It is strongly recommended that this option only be used for debugging purposes on non-production machines. The default location is **`/var/lib/dhcpd/dhcpd.leases`**.

- **`-q`** — Do not print the entire copyright message when starting the daemon.

16.2.4. DHCP Relay Agent

The DHCP Relay Agent (**`dhcrelay`**) allows for the relay of DHCP and BOOTP requests from a subnet with no DHCP server on it to one or more DHCP servers on other subnets.

When a DHCP client requests information, the DHCP Relay Agent forwards the request to the list of DHCP servers specified when the DHCP Relay Agent is started. When a DHCP server returns a reply, the reply is broadcast or unicast on the network that sent the original request.

The DHCP Relay Agent listens for DHCP requests on all interfaces unless the interfaces are specified in **`/etc/sysconfig/dhcrelay`** with the **`INTERFACES`** directive.

To start the DHCP Relay Agent, use the command **`service dhcrelay start`**.

16.3. CONFIGURING A DHCPV4 CLIENT

To configure a DHCP client manually, modify the **`/etc/sysconfig/network`** file to enable networking and the configuration file for each network device in the **`/etc/sysconfig/network-scripts`** directory. In this directory, each device should have a configuration file named **`ifcfg-eth0`**, where **`eth0`** is the network device name.

Make sure that the **`/etc/sysconfig/network-scripts/ifcfg-eth0`** file contains the following lines:

```
DEVICE=eth0
BOOTPROTO=dhcp
ONBOOT=yes
```

To use DHCP, set a configuration file for each device.

Other options for the network script include:

- **`DHCP_HOSTNAME`** — Only use this option if the DHCP server requires the client to specify a host name before receiving an IP address.
- **`PEERDNS=<answer>`**, where **`<answer>`** is one of the following:
  - **`yes`** — Modify **`/etc/resolv.conf`** with information from the server. This is the default.
  - **`no`** — Do not modify **`/etc/resolv.conf`**.

If you prefer using a graphical interface, see Chapter 10, *NetworkManager* for instructions on using **NetworkManager** to configure a network interface to use DHCP.

NOTE

For advanced configurations of client DHCP options such as protocol timing, lease requirements and requests, dynamic DNS support, aliases, as well as a wide variety of values to override, prepend, or append to client-side configurations, see the **`dhclient`** and **`dhclient.conf`** man pages.

16.4. CONFIGURING A MULTIHOMED DHCP SERVER

A multihomed DHCP server serves multiple networks, that is, multiple subnets. The examples in these sections detail how to configure a DHCP server to serve multiple networks, select which network interfaces to listen on, and how to define network settings for systems that move networks.

Before making any changes, back up the existing **`/etc/sysconfig/dhcpd`** and **`/etc/dhcp/dhcpd.conf`** files.

The DHCP daemon listens on all network interfaces unless otherwise specified. Use the **`/etc/sysconfig/dhcpd`** file to specify which network interfaces the DHCP daemon listens on. The following **`/etc/sysconfig/dhcpd`** example specifies that the DHCP daemon listens on the **`eth0`** and **`eth1`** interfaces:

```
DHCPDARGS="eth0 eth1";
```

If a system has three network interfaces cards — **`eth0`**, **`eth1`**, and **`eth2`** — and it is only desired that the DHCP daemon listens on the **`eth0`** card, then only specify **`eth0`** in **`/etc/sysconfig/dhcpd`**:

```
DHCPDARGS="eth0";
```

The following is a basic **`/etc/dhcp/dhcpd.conf`** file, for a server that has two network interfaces, **`eth0`** in a 10.0.0.0/24 network, and **`eth1`** in a 172.16.0.0/24 network. Multiple **`subnet`** declarations allow you to define different settings for multiple networks:

```
default-lease-time 600;
max-lease-time 7200;
subnet 10.0.0.0 netmask 255.255.255.0 {
 option subnet-mask 255.255.255.0;
 option routers 10.0.0.1;
 range 10.0.0.5 10.0.0.15;
}
subnet 172.16.0.0 netmask 255.255.255.0 {
 option subnet-mask 255.255.255.0;
 option routers 172.16.0.1;
 range 172.16.0.5 172.16.0.15;
}
```

`subnet` ***`10.0.0.0`*** **`netmask`** ***`255.255.255.0`*****`;`**

A **`subnet`** declaration is required for every network your DHCP server is serving. Multiple subnets require multiple **`subnet`** declarations. If the DHCP server does not have a network interface in a range of a **`subnet`** declaration, the DHCP server does not serve that network.

If there is only one **`subnet`** declaration, and no network interfaces are in the range of that subnet, the DHCP daemon fails to start, and an error such as the following is logged to **`/var/log/messages`**:

```
dhcpd: No subnet declaration for eth0 (0.0.0.0).
dhcpd: ** Ignoring requests on eth0.  If this is not what
dhcpd:    you want, please write a subnet declaration
dhcpd:    in your dhcpd.conf file for the network segment
dhcpd:    to which interface eth1 is attached. **
dhcpd:
dhcpd:
dhcpd: Not configured to listen on any interfaces!
```

`option subnet-mask` ***`255.255.255.0`*****`;`**

The **`option subnet-mask`** option defines a subnet mask, and overrides the **`netmask`** value in the **`subnet`** declaration. In simple cases, the subnet and netmask values are the same.

`option routers` ***`10.0.0.1`*****`;`**

The **`option routers`** option defines the default gateway for the subnet. This is required for systems to reach internal networks on a different subnet, as well as external networks.

`range` ***`10.0.0.5 10.0.0.15`*****`;`**

The **`range`** option specifies the pool of available IP addresses. Systems are assigned an address from the range of specified IP addresses.

For further information, see the **`dhcpd.conf(5)`** man page.

16.4.1. Host Configuration

Before making any changes, back up the existing **`/etc/sysconfig/dhcpd`** and **`/etc/dhcp/dhcpd.conf`** files.

Configuring a Single System for Multiple Networks

The following **`/etc/dhcp/dhcpd.conf`** example creates two subnets, and configures an IP address for the same system, depending on which network it connects to:

```
default-lease-time 600;
max-lease-time 7200;
subnet 10.0.0.0 netmask 255.255.255.0 {
 option subnet-mask 255.255.255.0;
 option routers 10.0.0.1;
 range 10.0.0.5 10.0.0.15;
}
subnet 172.16.0.0 netmask 255.255.255.0 {
 option subnet-mask 255.255.255.0;
 option routers 172.16.0.1;
 range 172.16.0.5 172.16.0.15;
}
host example0 {
 hardware ethernet 00:1A:6B:6A:2E:0B;
 fixed-address 10.0.0.20;
}
host example1 {
 hardware ethernet 00:1A:6B:6A:2E:0B;
 fixed-address 172.16.0.20;
}
```

host *example0*

The **host** declaration defines specific parameters for a single system, such as an IP address. To configure specific parameters for multiple hosts, use multiple **host** declarations.

Most DHCP clients ignore the name in **host** declarations, and as such, this name can be anything, as long as it is unique to other **host** declarations. To configure the same system for multiple networks, use a different name for each **host** declaration, otherwise the DHCP daemon fails to start. Systems are identified by the **hardware ethernet** option, not the name in the **host** declaration.

hardware ethernet *00:1A:6B:6A:2E:0B*;

The **hardware ethernet** option identifies the system. To find this address, run the **ip link** command.

fixed-address *10.0.0.20*;

The **fixed-address** option assigns a valid IP address to the system specified by the **hardware ethernet** option. This address must be outside the IP address pool specified with the **range** option.

If **option** statements do not end with a semicolon, the DHCP daemon fails to start, and an error such as the following is logged to **/var/log/messages**:

```
/etc/dhcp/dhcpd.conf line 20: semicolon expected.
dhcpd: }
dhcpd: ^
dhcpd: /etc/dhcp/dhcpd.conf line 38: unexpected end of file
dhcpd:
dhcpd: ^
dhcpd: Configuration file errors encountered -- exiting
```

Configuring Systems with Multiple Network Interfaces

The following **host** declarations configure a single system, which has multiple network interfaces, so that each interface receives the same IP address. This configuration will not work if both network interfaces are connected to the same network at the same time:

```
host interface0 {
 hardware ethernet 00:1a:6b:6a:2e:0b;
 fixed-address 10.0.0.18;
}
host interface1 {
 hardware ethernet 00:1A:6B:6A:27:3A;
 fixed-address 10.0.0.18;
}
```

For this example, **interface0** is the first network interface, and **interface1** is the second interface. The different **hardware ethernet** options identify each interface.

If such a system connects to another network, add more **host** declarations, remembering to:

- assign a valid **fixed-address** for the network the host is connecting to.
- make the name in the **host** declaration unique.

When a name given in a **host** declaration is not unique, the DHCP daemon fails to start, and an error such as the following is logged to **/var/log/messages**:

```
dhcpd: /etc/dhcp/dhcpd.conf line 31: host interface0: already exists
dhcpd: }
dhcpd: ^
dhcpd: Configuration file errors encountered -- exiting
```

This error was caused by having multiple **host interface0** declarations defined in **/etc/dhcp/dhcpd.conf**.

16.5. DHCP FOR IPV6 (DHCPV6)

The ISC DHCP includes support for IPv6 (DHCPv6) since the 4.x release with a DHCPv6 server, client and relay agent functionality. The server, client and relay agents support both IPv4 and IPv6. However, the client and the server can only manage one protocol at a time — for dual support they must be started separately for IPv4 and IPv6.

16.5.1. Configuring a DHCPv6 Server

The DHCPv6 server configuration file is installed together with the dhcp package and it can be found at **/etc/dhcp/dhcpd6.conf**.

The sample server configuration file can be found at **/usr/share/doc/dhcp-<version>/dhcpd6.conf.sample**, in Red Hat Enterprise Linux 6 at **/usr/share/doc/dhcp-4.1.1/dhcpd6.conf.sample**.

A simple DHCPv6 server configuration file can look like this:

```
subnet6 2001:db8:0:1::/64 {
        range6 2001:db8:0:1::129 2001:db8:0:1::254;
        option dhcp6.name-servers fec0:0:0:1::1;
        option dhcp6.domain-search "domain.example";
}
```

For more examples, see the **dhcpd.conf(5)** man page.

To start the DHCPv6 service, enter the command **service dhcpd6 start** as root. To stop the DHCPv6 server, use the command **service dhcpdv6 stop**.

To pass command-line options to **dhcpd** daemon when the DHCPv6 service starts, use the **/etc/sysconfig/dhcpd6** file. This file uses the same structure like the **/etc/sysconfig/dhcpd**:

```
# cat /etc/sysconfig/dhcpd6
# Command line options here
DHCPDARGS=
```

The value added to the **DHCPDARGS** option is passed to the DHCPv6 service, which passes it to the **dhcpd** daemon. For more information, see the **STANDARD DHCPV6 OPTIONS** section in the **dhcpd-options(5)** man page. For additional examples, see the Dynamic IPv6 configuration on the Fedora Project wiki.

16.5.2. Configuring a DHCPv6 Client

The default configuration of the DHCPv6 client works fine in the most cases. However, to configure a DHCP client manually, create and modify the **`/etc/dhcp/dhclient.conf`** file. See the **`/usr/share/doc/dhclient-4.1.1/dhclient6.conf.sample`** for a client configuration file example.

For advanced configurations of DHCPv6 client options such as protocol timing, lease requirements and requests, dynamic DNS support, aliases, as well as a wide variety of values to override, prepend, or append to client-side configurations, see the **`dhclient.conf(5)`** man page and the **`STANDARD DHCPV6 OPTIONS`** section in the **`dhcpd-options(5)`** man page.

IMPORTANT

In Red Hat Enterprise Linux 6, a DHCPv6 client is correctly handled only by **NetworkManager** and should not generally be run separately. That is because DHCPv6, unlike DHCPv4, is not a standalone network configuration protocol but is always supposed to be used together with router discovery.

16.6. ADDITIONAL RESOURCES

For additional information, see *The DHCP Handbook; Ralph Droms and Ted Lemon; 2003* or the following resources.

16.6.1. Installed Documentation

- **`dhcpd`** man page — Describes how the DHCP daemon works.
- **`dhcpd.conf`** man page — Explains how to configure the DHCP configuration file; includes some examples.
- **`dhcpd.leases`** man page — Describes a persistent database of leases.
- **`dhcp-options`** man page — Explains the syntax for declaring DHCP options in **`dhcpd.conf`**; includes some examples.
- **`dhcrelay`** man page — Explains the DHCP Relay Agent and its configuration options.
- **`/usr/share/doc/dhcp-<version>/`** — Contains sample files, README files, and release notes for current versions of the DHCP service.

CHAPTER 17. DNS SERVERS

DNS (Domain Name System), also known as a *nameserver*, is a network system that associates host names with their respective IP addresses. For users, this has the advantage that they can refer to machines on the network by names that are usually easier to remember than the numerical network addresses. For system administrators, using the nameserver allows them to change the IP address for a host without ever affecting the name-based queries, or to decide which machines handle these queries.

17.1. INTRODUCTION TO DNS

DNS is usually implemented using one or more centralized servers that are authoritative for certain domains. When a client host requests information from a nameserver, it usually connects to port 53. The nameserver then attempts to resolve the name requested. If it does not have an authoritative answer, or does not already have the answer cached from an earlier query, it queries other nameservers, called *root nameservers*, to determine which nameservers are authoritative for the name in question, and then queries them to get the requested name.

17.1.1. Nameserver Zones

In a DNS server such as BIND (Berkeley Internet Name Domain), all information is stored in basic data elements called *resource records* (RR). The resource record is usually a *fully qualified domain name* (FQDN) of a host, and is broken down into multiple sections organized into a tree-like hierarchy. This hierarchy consists of a main trunk, primary branches, secondary branches, and so on.

Example 17.1. A simple resource record

```
bob.sales.example.com
```

Each level of the hierarchy is divided by a period (that is, `.`). In Example 17.1, “A simple resource record”, **com** defines the *top-level domain*, **example** its subdomain, and **sales** the subdomain of **example**. In this case, **bob** identifies a resource record that is part of the **sales.example.com** domain. With the exception of the part furthest to the left (that is, **bob**), each of these sections is called a *zone* and defines a specific *namespace*.

Zones are defined on authoritative nameservers through the use of *zone files*, which contain definitions of the resource records in each zone. Zone files are stored on *primary nameservers* (also called *master nameservers*), where changes are made to the files, and *secondary nameservers* (also called *slave nameservers*), which receive zone definitions from the primary nameservers. Both primary and secondary nameservers are authoritative for the zone and look the same to clients. Depending on the configuration, any nameserver can also serve as a primary or secondary server for multiple zones at the same time.

17.1.2. Nameserver Types

There are two nameserver configuration types:

authoritative

Authoritative nameservers answer to resource records that are part of their zones only. This category includes both primary (master) and secondary (slave) nameservers.

recursive

Recursive nameservers offer resolution services, but they are not authoritative for any zone. Answers for all resolutions are cached in a memory for a fixed period of time, which is specified by the retrieved resource record.

Although a nameserver can be both authoritative and recursive at the same time, it is recommended not to combine the configuration types. To be able to perform their work, authoritative servers should be available to all clients all the time. On the other hand, since the recursive lookup takes far more time than authoritative responses, recursive servers should be available to a restricted number of clients only, otherwise they are prone to distributed denial of service (DDoS) attacks.

17.1.3. BIND as a Nameserver

BIND consists of a set of DNS-related programs. It contains a nameserver called **`named`**, an administration utility called **`rndc`**, and a debugging tool called **`dig`**. See Chapter 12, *Services and Daemons* for more information on how to run a service in Red Hat Enterprise Linux.

17.2. BIND

This chapter covers **`BIND`** (Berkeley Internet Name Domain), the DNS server included in Red Hat Enterprise Linux. It focuses on the structure of its configuration files, and describes how to administer it both locally and remotely.

17.2.1. Configuring the named Service

When the **named** service is started, it reads the configuration from the files as described in Table 17.1, “The named service configuration files”.

Table 17.1. The named service configuration files

Path	Description
`/etc/named.conf`	The main configuration file.
`/etc/named/`	An auxiliary directory for configuration files that are included in the main configuration file.

The configuration file consists of a collection of statements with nested options surrounded by opening and closing curly brackets. Note that when editing the file, you have to be careful not to make any syntax error, otherwise the **named** service will not start. A typical **`/etc/named.conf`** file is organized as follows:

```
statement-1 ["statement-1-name"] [statement-1-class] {
  option-1;
  option-2;
  option-N;
};
statement-2 ["statement-2-name"] [statement-2-class] {
  option-1;
  option-2;
  option-N;
};
statement-N ["statement-N-name"] [statement-N-class] {
  option-1;
  option-2;
  option-N;
};
```

NOTE

If you have installed the bind-chroot package, the BIND service will run in the **/var/named/chroot** environment. In that case, the initialization script will mount the above configuration files using the **mount --bind** command, so that you can manage the configuration outside this environment. There is no need to copy anything into the **/var/named/chroot** directory because it is mounted automatically. This simplifies maintenance since you do not need to take any special care of **BIND** configuration files if it is run in a **chroot** environment. You can organize everything as you would with **BIND** not running in a **chroot** environment.

The following directories are automatically mounted into **/var/named/chroot** if they are empty in the **/var/named/chroot** directory. They must be kept empty if you want them to be mounted into **/var/named/chroot**:

- **/var/named**
- **/etc/pki/dnssec-keys**
- **/etc/named**
- **/usr/lib64/bind** or **/usr/lib/bind** (architecture dependent).

The following files are also mounted if the target file does not exist in **/var/named/chroot**.

- **/etc/named.conf**
- **/etc/rndc.conf**
- **/etc/rndc.key**
- **/etc/named.rfc1912.zones**
- **/etc/named.dnssec.keys**
- **/etc/named.iscdlv.key**
- **/etc/named.root.key**

17.2.1.1. Common Statement Types

The following types of statements are commonly used in **/etc/named.conf**:

acl

The **acl** (Access Control List) statement allows you to define groups of hosts, so that they can be permitted or denied access to the nameserver. It takes the following form:

```
acl acl-name {
  match-element;
  ...
};
```

The *acl-name* statement name is the name of the access control list, and the*match-element* option is usually an individual IP address (such as **10.0.1.1**) or a CIDR (Classless Inter-Domain Routing) network notation (for example, **10.0.1.0/24**). For a list of already defined keywords, see Table 17.2, “Predefined access control lists”.

Table 17.2. Predefined access control lists

Keyword	Description
any	Matches every IP address.
localhost	Matches any IP address that is in use by the local system.
localnets	Matches any IP address on any network to which the local system is connected.
none	Does not match any IP address.

The **acl** statement can be especially useful in conjunction with other statements such as **options**. Example 17.2, “Using acl in conjunction with options” defines two access control lists, **black-hats** and **red-hats**, and adds **black-hats** on the blacklist while granting **red-hats** a normal access.

Example 17.2. Using acl in conjunction with options

```
acl black-hats {
  10.0.2.0/24;
  192.168.0.0/24;
  1234:5678::9abc/24;
};
acl red-hats {
  10.0.1.0/24;
};
options {
  blackhole { black-hats; };
  allow-query { red-hats; };
  allow-query-cache { red-hats; };
};
```

include

The **include** statement allows you to include files in the **/etc/named.conf**, so that potentially sensitive data can be placed in a separate file with restricted permissions. It takes the following form:

```
include "file-name"
```

The *file-name* statement name is an absolute path to a file.

Example 17.3. Including a file to /etc/named.conf

```
include "/etc/named.rfc1912.zones";
```

`options`

The **`options`** statement allows you to define global server configuration options as well as to set defaults for other statements. It can be used to specify the location of the **named** working directory, the types of queries allowed, and much more. It takes the following form:

```
options {
  option;
  ...
};
```

For a list of frequently used *option* directives, see Table 17.3, “Commonly used options” below.

Table 17.3. Commonly used options

Option	Description
`allow-query`	Specifies which hosts are allowed to query the nameserver for authoritative resource records. It accepts an access control list, a collection of IP addresses, or networks in the CIDR notation. All hosts are allowed by default.
`allow-query-cache`	Specifies which hosts are allowed to query the nameserver for non-authoritative data such as recursive queries. Only **`localhost`** and **`localnets`** are allowed by default.
`blackhole`	Specifies which hosts are *not* allowed to query the nameserver. This option should be used when particular host or network floods the server with requests. The default option is **none**.
`directory`	Specifies a working directory for the **named** service. The default option is **`/var/named/`**.
`dnssec-enable`	Specifies whether to return DNSSEC related resource records. The default option is **`yes`**.
`dnssec-validation`	Specifies whether to prove that resource records are authentic via DNSSEC. The default option is **`yes`**.
`forwarders`	Specifies a list of valid IP addresses for nameservers to which the requests should be forwarded for resolution.

Option	Description
`forward`	Specifies the behavior of the **`forwarders`** directive. It accepts the following options: • **`first`** — The server will query the nameservers listed in the **`forwarders`** directive before attempting to resolve the name on its own. • **`only`** — When unable to query the nameservers listed in the **`forwarders`** directive, the server will not attempt to resolve the name on its own.
`listen-on`	Specifies the IPv4 network interface on which to listen for queries. On a DNS server that also acts as a gateway, you can use this option to answer queries originating from a single network only. All IPv4 interfaces are used by default.
`listen-on-v6`	Specifies the IPv6 network interface on which to listen for queries. On a DNS server that also acts as a gateway, you can use this option to answer queries originating from a single network only. All IPv6 interfaces are used by default.
`max-cache-size`	Specifies the maximum amount of memory to be used for server caches. When the limit is reached, the server causes records to expire prematurely so that the limit is not exceeded. In a server with multiple views, the limit applies separately to the cache of each view. The default option is **`32M`**.
`notify`	Specifies whether to notify the secondary nameservers when a zone is updated. It accepts the following options: • **`yes`** — The server will notify all secondary nameservers. • **`no`** — The server will *not* notify any secondary nameserver. • **`master-only`** — The server will notify primary server for the zone only. • **`explicit`** — The server will notify only the secondary servers that are specified in the **`also-notify`** list within a zone statement.
`pid-file`	Specifies the location of the process ID file created by the **`named`** service.
`recursion`	Specifies whether to act as a recursive server. The default option is **`yes`**.
`statistics-file`	Specifies an alternate location for statistics files. The **`/var/named/named.stats`** file is used by default.

IMPORTANT

To prevent distributed denial of service (DDoS) attacks, it is recommended that you use the **`allow-query-cache`** option to restrict recursive DNS services for a particular subset of clients only.

See the *BIND 9 Administrator Reference Manual* referenced in Section 17.2.7.1, “Installed Documentation”, and the **named.conf** manual page for a complete list of available options.

Example 17.4. Using the options statement

```
options {
  allow-query       { localhost; };
  listen-on port    53 { 127.0.0.1; };
  listen-on-v6 port 53 { ::1; };
  max-cache-size    256M;
  directory         "/var/named";
  statistics-file   "/var/named/data/named_stats.txt";

  recursion         yes;
  dnssec-enable     yes;
  dnssec-validation yes;
};
```

zone

The **zone** statement allows you to define the characteristics of a zone, such as the location of its configuration file and zone-specific options, and can be used to override the global **options** statements. It takes the following form:

```
zone zone-name [zone-class] {
  option;
  ...
};
```

The *zone-name* attribute is the name of the zone, *zone-class* is the optional class of the zone, and *option* is a **zone** statement option as described in Table 17.4, “Commonly used options”.

The *zone-name* attribute is particularly important, as it is the default value assigned for the **$ORIGIN** directive used within the corresponding zone file located in the **/var/named/** directory. The **named** daemon appends the name of the zone to any non-fully qualified domain name listed in the zone file. For example, if a **zone** statement defines the namespace for **example.com**, use **example.com** as the *zone-name* so that it is placed at the end of host names within the **example.com** zone file.

For more information about zone files, see Section 17.2.2, “Editing Zone Files”.

Table 17.4. Commonly used options

Option	Description
allow-query	Specifies which clients are allowed to request information about this zone. This option overrides global **allow-query** option. All query requests are allowed by default.
allow-transfer	Specifies which secondary servers are allowed to request a transfer of the zone's information. All transfer requests are allowed by default.

Option	Description
`allow-update`	Specifies which hosts are allowed to dynamically update information in their zone. The default option is to deny all dynamic update requests. Note that you should be careful when allowing hosts to update information about their zone. Do not set IP addresses in this option unless the server is in the trusted network. Instead, use TSIG key as described in Section 17.2.5.3, “Transaction SIGnatures (TSIG)”.
`file`	Specifies the name of the file in the **`named`** working directory that contains the zone's configuration data.
`masters`	Specifies from which IP addresses to request authoritative zone information. This option is used only if the zone is defined as **`type slave`**.
`notify`	Specifies whether to notify the secondary nameservers when a zone is updated. It accepts the following options: • **`yes`** — The server will notify all secondary nameservers. • **`no`** — The server will *not* notify any secondary nameserver. • **`master-only`** — The server will notify primary server for the zone only. • **`explicit`** — The server will notify only the secondary servers that are specified in the **`also-notify`** list within a zone statement.
`type`	Specifies the zone type. It accepts the following options: • **`delegation-only`** — Enforces the delegation status of infrastructure zones such as COM, NET, or ORG. Any answer that is received without an explicit or implicit delegation is treated as **`NXDOMAIN`**. This option is only applicable in TLDs (Top-Level Domain) or root zone files used in recursive or caching implementations. • **`forward`** — Forwards all requests for information about this zone to other nameservers. • **`hint`** — A special type of zone used to point to the root nameservers which resolve queries when a zone is not otherwise known. No configuration beyond the default is necessary with a **`hint`** zone. • **`master`** — Designates the nameserver as authoritative for this zone. A zone should be set as the **`master`** if the zone's configuration files reside on the system. • **`slave`** — Designates the nameserver as a slave server for this zone. Master server is specified in **`masters`** directive.

Most changes to the **`/etc/named.conf`** file of a primary or secondary nameserver involve adding, modifying, or deleting **`zone`** statements, and only a small subset of **`zone`** statement options is usually needed for a nameserver to work efficiently.

In Example 17.5, “A zone statement for a primary nameserver”, the zone is identified as

example.com, the type is set to **master**, and the **named** service is instructed to read the **/var/named/example.com.zone** file. It also allows only a secondary nameserver (**192.168.0.2**) to transfer the zone.

Example 17.5. A zone statement for a primary nameserver

```
zone "example.com" IN {
  type master;
  file "example.com.zone";
  allow-transfer { 192.168.0.2; };
};
```

A secondary server's **zone** statement is slightly different. The type is set to **slave**, and the **masters** directive is telling **named** the IP address of the master server.

In Example 17.6, “A zone statement for a secondary nameserver”, the **named** service is configured to query the primary server at the **192.168.0.1** IP address for information about the **example.com** zone. The received information is then saved to the **/var/named/slaves/example.com.zone** file. Note that you have to put all slave zones to **/var/named/slaves** directory, otherwise the service will fail to transfer the zone.

Example 17.6. A zone statement for a secondary nameserver

```
zone "example.com" {
  type slave;
  file "slaves/example.com.zone";
  masters { 192.168.0.1; };
};
```

17.2.1.2. Other Statement Types

The following types of statements are less commonly used in **/etc/named.conf**:

controls

The **controls** statement allows you to configure various security requirements necessary to use the **rndc** command to administer the **named** service.

See Section 17.2.3, “Using the rndc Utility” for more information on the **rndc** utility and its usage.

key

The **key** statement allows you to define a particular key by name. Keys are used to authenticate various actions, such as secure updates or the use of the **rndc** command. Two options are used with **key**:

- **algorithm *algorithm-name*** — The type of algorithm to be used (for example, **hmac-md5**).
- **secret "*key-value*"** — The encrypted key.

See Section 17.2.3, “Using the rndc Utility” for more information on the **rndc** utility and its usage.

logging

The **logging** statement allows you to use multiple types of logs, so called *channels*. By using the **channel** option within the statement, you can construct a customized type of log with its own file name (**file**), size limit (**size**), versioning (**version**), and level of importance (**severity**). Once a customized channel is defined, a **category** option is used to categorize the channel and begin logging when the **named** service is restarted.

By default, **named** sends standard messages to the **rsyslog** daemon, which places them in **/var/log/messages**. Several standard channels are built into BIND with various severity levels, such as **default_syslog** (which handles informational logging messages) and **default_debug** (which specifically handles debugging messages). A default category, called **default**, uses the built-in channels to do normal logging without any special configuration.

Customizing the logging process can be a very detailed process and is beyond the scope of this chapter. For information on creating custom BIND logs, see the *BIND 9 Administrator Reference Manual* referenced in Section 17.2.7.1, “Installed Documentation”.

server

The **server** statement allows you to specify options that affect how the **named** service should respond to remote nameservers, especially with regard to notifications and zone transfers.

The **transfer-format** option controls the number of resource records that are sent with each message. It can be either **one-answer** (only one resource record), or **many-answers** (multiple resource records). Note that while the **many-answers** option is more efficient, it is not supported by older versions of BIND.

trusted-keys

The **trusted-keys** statement allows you to specify assorted public keys used for secure DNS (DNSSEC). See Section 17.2.5.4, “DNS Security Extensions (DNSSEC)” for more information on this topic.

view

The **view** statement allows you to create special views depending upon which network the host querying the nameserver is on. This allows some hosts to receive one answer regarding a zone while other hosts receive totally different information. Alternatively, certain zones may only be made available to particular trusted hosts while non-trusted hosts can only make queries for other zones.

Multiple views can be used as long as their names are unique. The **match-clients** option allows you to specify the IP addresses that apply to a particular view. If the **options** statement is used within a view, it overrides the already configured global options. Finally, most **view** statements contain multiple **zone** statements that apply to the **match-clients** list.

Note that the order in which the **view** statements are listed is important, as the first statement that matches a particular client's IP address is used. For more information on this topic, see Section 17.2.5.1, “Multiple Views”.

17.2.1.3. Comment Tags

Additionally to statements, the **/etc/named.conf** file can also contain comments. Comments are ignored by the **named** service, but can prove useful when providing additional information to a user. The following are valid comment tags:

//

Any text after the **//** characters to the end of the line is considered a comment. For example:

```
notify yes;  // notify all secondary nameservers
```

#

Any text after the # character to the end of the line is considered a comment. For example:

```
notify yes;  # notify all secondary nameservers
```

/* and */

Any block of text enclosed in **/*** and ***/** is considered a comment. For example:

```
notify yes;  /* notify all secondary nameservers */
```

17.2.2. Editing Zone Files

As outlined in Section 17.1.1, “Nameserver Zones”, zone files contain information about a namespace. They are stored in the **named** working directory located in **/var/named/** by default, and each zone file is named according to the **file** option in the **zone** statement, usually in a way that relates to the domain in question and identifies the file as containing zone data, such as **example.com.zone**.

Table 17.5. The named service zone files

Path	Description
/var/named/	The working directory for the **named** service. The nameserver is *not* allowed to write to this directory.
/var/named/slaves/	The directory for secondary zones. This directory is writable by the **named** service.
/var/named/dynamic/	The directory for other files, such as dynamic DNS (DDNS) zones or managed DNSSEC keys. This directory is writable by the **named** service.
/var/named/data/	The directory for various statistics and debugging files. This directory is writable by the **named** service.

A zone file consists of directives and resource records. Directives tell the nameserver to perform tasks or apply special settings to the zone, resource records define the parameters of the zone and assign identities to individual hosts. While the directives are optional, the resource records are required in order to provide name service to a zone.

All directives and resource records should be entered on individual lines.

17.2.2.1. Common Directives

Directives begin with the dollar sign character followed by the name of the directive, and usually appear at the top of the file. The following directives are commonly used in zone files:

`$INCLUDE`

The **`$INCLUDE`** directive allows you to include another file at the place where it appears, so that other zone settings can be stored in a separate zone file.

Example 17.7. Using the $INCLUDE directive

```
$INCLUDE /var/named/penguin.example.com
```

`$ORIGIN`

The **`$ORIGIN`** directive allows you to append the domain name to unqualified records, such as those with the host name only. Note that the use of this directive is not necessary if the zone is specified in **`/etc/named.conf`**, since the zone name is used by default.

In Example 17.8, “Using the $ORIGIN directive”, any names used in resource records that do not end in a trailing period are appended with **`example.com`**.

Example 17.8. Using the $ORIGIN directive

```
$ORIGIN example.com.
```

`$TTL`

The **`$TTL`** directive allows you to set the default *Time to Live* (TTL) value for the zone, that is, how long is a zone record valid. Each resource record can contain its own TTL value, which overrides this directive.

Increasing this value allows remote nameservers to cache the zone information for a longer period of time, reducing the number of queries for the zone and lengthening the amount of time required to propagate resource record changes.

Example 17.9. Using the $TTL directive

```
$TTL 1D
```

17.2.2.2. Common Resource Records

The following resource records are commonly used in zone files:

`A`

The *Address* record specifies an IP address to be assigned to a name. It takes the following form:

```
hostname IN A IP-address
```

If the *hostname* value is omitted, the record will point to the last specified *hostname*.

In Example 17.10, “Using the A resource record”, the requests for **`server1.example.com`** are pointed to **`10.0.1.3`** or **`10.0.1.5`**.

Example 17.10. Using the A resource record

```
server1  IN  A  10.0.1.3
         IN  A  10.0.1.5
```

`CNAME`

The *Canonical Name* record maps one name to another. Because of this, this type of record is sometimes referred to as an *alias record*. It takes the following form:

```
alias-name IN CNAME real-name
```

`CNAME` records are most commonly used to point to services that use a common naming scheme, such as **`www`** for Web servers. However, there are multiple restrictions for their usage:

- CNAME records should not point to other CNAME records. This is mainly to avoid possible infinite loops.
- CNAME records should not contain other resource record types (such as A, NS, MX, etc.). The only exception are DNSSEC related records (that is, RRSIG, NSEC, etc.) when the zone is signed.
- Other resource record that point to the fully qualified domain name (FQDN) of a host (that is, NS, MX, PTR) should not point to a CNAME record.

In Example 17.11, “Using the CNAME resource record”, the **`A`** record binds a host name to an IP address, while the **`CNAME`** record points the commonly used **`www`** host name to it.

Example 17.11. Using the CNAME resource record

```
server1  IN  A      10.0.1.5
www      IN  CNAME  server1
```

`MX`

The *Mail Exchange* record specifies where the mail sent to a particular namespace controlled by this zone should go. It takes the following form:

```
IN MX preference-value email-server-name
```

The *email-server-name* is a fully qualified domain name (FQDN). The *preference-value* allows numerical ranking of the email servers for a namespace, giving preference to some email systems over others. The **`MX`** resource record with the lowest *preference-value* is preferred over the others. However, multiple email servers can possess the same value to distribute email traffic evenly among them.

In Example 17.12, “Using the MX resource record”, the first **`mail.example.com`** email server is preferred to the **`mail2.example.com`** email server when receiving email destined for the **`example.com`** domain.

Example 17.12. Using the MX resource record

```
example.com.  IN  MX  10  mail.example.com.
              IN  MX  20  mail2.example.com.
```

NS

The *Nameserver* record announces authoritative nameservers for a particular zone. It takes the following form:

```
IN NS nameserver-name
```

The *nameserver-name* should be a fully qualified domain name (FQDN). Note that when two nameservers are listed as authoritative for the domain, it is not important whether these nameservers are secondary nameservers, or if one of them is a primary server. They are both still considered authoritative.

Example 17.13. Using the NS resource record

```
IN  NS  dns1.example.com.
IN  NS  dns2.example.com.
```

PTR

The *Pointer* record points to another part of the namespace. It takes the following form:

```
last-IP-digit IN PTR FQDN-of-system
```

The *last-IP-digit* directive is the last number in an IP address, and the *FQDN-of-system* is a fully qualified domain name (FQDN).

PTR records are primarily used for reverse name resolution, as they point IP addresses back to a particular name. See Section 17.2.2.4.2, “A Reverse Name Resolution Zone File” for more examples of **PTR** records in use.

SOA

The *Start of Authority* record announces important authoritative information about a namespace to the nameserver. Located after the directives, it is the first resource record in a zone file. It takes the following form:

```
@  IN  SOA  primary-name-server hostmaster-email (
       serial-number
       time-to-refresh
       time-to-retry
       time-to-expire
       minimum-TTL )
```

The directives are as follows:

- The @ symbol places the **$ORIGIN** directive (or the zone's name if the**$ORIGIN** directive is not set) as the namespace being defined by this **SOA** resource record.
- The *primary-name-server* directive is the host name of the primary nameserver that is authoritative for this domain.
- The *hostmaster-email* directive is the email of the person to contact about the namespace.
- The *serial-number* directive is a numerical value incremented every time the zone file is altered to indicate it is time for the **named** service to reload the zone.
- The *time-to-refresh* directive is the numerical value secondary nameservers use to determine how long to wait before asking the primary nameserver if any changes have been made to the zone.
- The *time-to-retry* directive is a numerical value used by secondary nameservers to determine the length of time to wait before issuing a refresh request in the event that the primary nameserver is not answering. If the primary server has not replied to a refresh request before the amount of time specified in the *time-to-expire* directive elapses, the secondary servers stop responding as an authority for requests concerning that namespace.
- In BIND 4 and 8, the *minimum-TTL* directive is the amount of time other nameservers cache the zone's information. In BIND 9, it defines how long negative answers are cached for. Caching of negative answers can be set to a maximum of 3 hours (that is, **3H**).

When configuring BIND, all times are specified in seconds. However, it is possible to use abbreviations when specifying units of time other than seconds, such as minutes (**M**), hours (**H**), days (**D**), and weeks (**W**). Table 17.6, “Seconds compared to other time units” shows an amount of time in seconds and the equivalent time in another format.

Table 17.6. Seconds compared to other time units

Seconds	Other Time Units
60	**1M**
1800	**30M**
3600	**1H**
10800	**3H**
21600	**6H**
43200	**12H**
86400	**1D**
259200	**3D**

Seconds	Other Time Units
604800	**1W**
31536000	**365D**

Example 17.14. Using the SOA resource record

```
@  IN  SOA  dns1.example.com.  hostmaster.example.com. (
       2001062501  ; serial
       21600       ; refresh after 6 hours
       3600        ; retry after 1 hour
       604800      ; expire after 1 week
       86400 )     ; minimum TTL of 1 day
```

17.2.2.3. Comment Tags

Additionally to resource records and directives, a zone file can also contain comments. Comments are ignored by the **named** service, but can prove useful when providing additional information to the user. Any text after the semicolon character to the end of the line is considered a comment. For example:

```
604800  ; expire after 1 week
```

17.2.2.4. Example Usage

The following examples show the basic usage of zone files.

17.2.2.4.1. A Simple Zone File

Example 17.15, “A simple zone file” demonstrates the use of standard directives and **SOA** values.

Example 17.15. A simple zone file

```
$ORIGIN example.com.
$TTL 86400
@         IN  SOA  dns1.example.com.  hostmaster.example.com. (
              2001062501  ; serial
              21600       ; refresh after 6 hours
              3600        ; retry after 1 hour
              604800      ; expire after 1 week
              86400 )     ; minimum TTL of 1 day
;
;
          IN  NS     dns1.example.com.
          IN  NS     dns2.example.com.
dns1      IN  A      10.0.1.1
          IN  AAAA   aaaa:bbbb::1
dns2      IN  A      10.0.1.2
          IN  AAAA   aaaa:bbbb::2
```

```
;
;
@          IN   MX     10  mail.example.com.
           IN   MX     20  mail2.example.com.
mail       IN   A      10.0.1.5
           IN   AAAA   aaaa:bbbb::5
mail2      IN   A      10.0.1.6
           IN   AAAA   aaaa:bbbb::6
;
;
; This sample zone file illustrates sharing the same IP addresses
; for multiple services:
;
services   IN   A      10.0.1.10
           IN   AAAA   aaaa:bbbb::10
           IN   A      10.0.1.11
           IN   AAAA   aaaa:bbbb::11

ftp        IN   CNAME  services.example.com.
www        IN   CNAME  services.example.com.
;
;
```

In this example, the authoritative nameservers are set as **`dns1.example.com`** and **`dns2.example.com`**, and are tied to the **`10.0.1.1`** and **`10.0.1.2`** IP addresses respectively using the **`A`** record.

The email servers configured with the **`MX`** records point to **`mail`** and **`mail2`** via **`A`** records. Since these names do not end in a trailing period, the **`$ORIGIN`** domain is placed after them, expanding them to **`mail.example.com`** and **`mail2.example.com`**.

Services available at the standard names, such as **`www.example.com`** (WWW), are pointed at the appropriate servers using the **`CNAME`** record.

This zone file would be called into service with a **`zone`** statement in the **`/etc/named.conf`** similar to the following:

```
zone "example.com" IN {
  type master;
  file "example.com.zone";
  allow-update { none; };
};
```

17.2.2.4.2. A Reverse Name Resolution Zone File

A reverse name resolution zone file is used to translate an IP address in a particular namespace into an fully qualified domain name (FQDN). It looks very similar to a standard zone file, except that the **`PTR`** resource records are used to link the IP addresses to a fully qualified domain name as shown in Example 17.16, “A reverse name resolution zone file”.

Example 17.16. A reverse name resolution zone file

```
$ORIGIN 1.0.10.in-addr.arpa.
```

```
$TTL 86400
@  IN  SOA  dns1.example.com.  hostmaster.example.com. (
       2001062501  ; serial
       21600       ; refresh after 6 hours
       3600        ; retry after 1 hour
       604800      ; expire after 1 week
       86400 )     ; minimum TTL of 1 day
;
@  IN  NS   dns1.example.com.
;
1  IN  PTR  dns1.example.com.
2  IN  PTR  dns2.example.com.
;
5  IN  PTR  server1.example.com.
6  IN  PTR  server2.example.com.
;
3  IN  PTR  ftp.example.com.
4  IN  PTR  ftp.example.com.
```

In this example, IP addresses **10.0.1.1** through **10.0.1.6** are pointed to the corresponding fully qualified domain name.

This zone file would be called into service with a **zone** statement in the **/etc/named.conf** file similar to the following:

```
zone "1.0.10.in-addr.arpa" IN {
  type master;
  file "example.com.rr.zone";
  allow-update { none; };
};
```

There is very little difference between this example and a standard **zone** statement, except for the zone name. Note that a reverse name resolution zone requires the first three blocks of the IP address reversed followed by **.in-addr.arpa**. This allows the single block of IP numbers used in the reverse name resolution zone file to be associated with the zone.

17.2.3. Using the rndc Utility

The **rndc** utility is a command-line tool that allows you to administer the **named** service, both locally and from a remote machine. Its usage is as follows:

```
rndc [option...] command [command-option]
```

17.2.3.1. Configuring the Utility

To prevent unauthorized access to the service, **named** must be configured to listen on the selected port (that is, **953** by default), and an identical key must be used by both the service and the **rndc** utility.

Table 17.7. Relevant files

Path	Description
/etc/named.conf	The default configuration file for the **named** service.
/etc/rndc.conf	The default configuration file for the **rndc** utility.
/etc/rndc.key	The default key location.

The **rndc** configuration is located in **/etc/rndc.conf**. If the file does not exist, the utility will use the key located in **/etc/rndc.key**, which was generated automatically during the installation process using the **rndc-confgen -a** command.

The **named** service is configured using the **controls** statement in the **/etc/named.conf** configuration file as described in Section 17.2.1.2, "Other Statement Types". Unless this statement is present, only the connections from the loopback address (that is, **127.0.0.1**) will be allowed, and the key located in **/etc/rndc.key** will be used.

For more information on this topic, see manual pages and the *BIND 9 Administrator Reference Manual* listed in Section 17.2.7, "Additional Resources".

IMPORTANT

To prevent unprivileged users from sending control commands to the service, make sure only root is allowed to read the **/etc/rndc.key** file:

```
~]# chmod o-rwx /etc/rndc.key
```

17.2.3.2. Checking the Service Status

To check the current status of the **named** service, use the following command:

```
~]# rndc status
version: 9.7.0-P2-RedHat-9.7.0-5.P2.el6
CPUs found: 1
worker threads: 1
number of zones: 16
debug level: 0
xfers running: 0
xfers deferred: 0
soa queries in progress: 0
query logging is OFF
recursive clients: 0/0/1000
tcp clients: 0/100
server is up and running
```

17.2.3.3. Reloading the Configuration and Zones

To reload both the configuration file and zones, type the following at a shell prompt:

```
~]# rndc reload
server reload successful
```

This will reload the zones while keeping all previously cached responses, so that you can make changes to the zone files without losing all stored name resolutions.

To reload a single zone, specify its name after the **`reload`** command, for example:

```
~]# rndc reload localhost
zone reload up-to-date
```

Finally, to reload the configuration file and newly added zones only, type:

```
~]# rndc reconfig
```

NOTE

If you intend to manually modify a zone that uses Dynamic DNS (DDNS), make sure you run the **`freeze`** command first:

```
~]# rndc freeze localhost
```

Once you are finished, run the **`thaw`** command to allow the DDNS again and reload the zone:

```
~]# rndc thaw localhost
The zone reload and thaw was successful.
```

17.2.3.4. Updating Zone Keys

To update the DNSSEC keys and sign the zone, use the **`sign`** command. For example:

```
~]# rndc sign localhost
```

Note that to sign a zone with the above command, the **`auto-dnssec`** option has to be set to **`maintain`** in the zone statement. For instance:

```
zone "localhost" IN {
  type master;
  file "named.localhost";
  allow-update { none; };
  auto-dnssec maintain;
};
```

17.2.3.5. Enabling the DNSSEC Validation

To enable the DNSSEC validation, type the following at a shell prompt:

```
~]# rndc validation on
```

Similarly, to disable this option, type:

```
~]# rndc validation off
```

See the **options** statement described in Section 17.2.1.1, “Common Statement Types” for information on how to configure this option in **/etc/named.conf**.

17.2.3.6. Enabling the Query Logging

To enable (or disable in case it is currently enabled) the query logging, run the following command:

```
~]# rndc querylog
```

To check the current setting, use the **status** command as described in Section 17.2.3.2, “Checking the Service Status”.

17.2.4. Using the dig Utility

The **dig** utility is a command-line tool that allows you to perform DNS lookups and debug a nameserver configuration. Its typical usage is as follows:

```
dig [@server] [option...] name type
```

See Section 17.2.2.2, “Common Resource Records” for a list of common *type*s.

17.2.4.1. Looking Up a Nameserver

To look up a nameserver for a particular domain, use the command in the following form:

```
dig name NS
```

In Example 17.17, “A sample nameserver lookup”, the **dig** utility is used to display nameservers for **example.com**.

Example 17.17. A sample nameserver lookup

```
~]$ dig example.com NS

; <<>> DiG 9.7.1-P2-RedHat-9.7.1-2.P2.fc13 <<>> example.com NS
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 57883
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;example.com.                   IN      NS

;; ANSWER SECTION:
example.com.            99374   IN      NS      a.iana-servers.net.
example.com.            99374   IN      NS      b.iana-servers.net.

;; Query time: 1 msec
;; SERVER: 10.34.255.7#53(10.34.255.7)
;; WHEN: Wed Aug 18 18:04:06 2010
;; MSG SIZE  rcvd: 77
```

17.2.4.2. Looking Up an IP Address

To look up an IP address assigned to a particular domain, use the command in the following form:

```
dig name A
```

In Example 17.18, “A sample IP address lookup”, the **dig** utility is used to display the IP address of **example.com**.

Example 17.18. A sample IP address lookup

```
~]$ dig example.com A

; <<>> DiG 9.7.1-P2-RedHat-9.7.1-2.P2.fc13 <<>> example.com A
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 4849
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 0

;; QUESTION SECTION:
;example.com.                   IN      A

;; ANSWER SECTION:
example.com.            155606  IN      A       192.0.32.10

;; AUTHORITY SECTION:
example.com.            99175   IN      NS      a.iana-servers.net.
example.com.            99175   IN      NS      b.iana-servers.net.

;; Query time: 1 msec
;; SERVER: 10.34.255.7#53(10.34.255.7)
;; WHEN: Wed Aug 18 18:07:25 2010
;; MSG SIZE  rcvd: 93
```

17.2.4.3. Looking Up a Hostname

To look up a host name for a particular IP address, use the command in the following form:

```
dig -x address
```

In Example 17.19, “A sample host name lookup”, the **dig** utility is used to display the host name assigned to **192.0.32.10**.

Example 17.19. A sample host name lookup

```
~]$ dig -x 192.0.32.10

; <<>> DiG 9.7.1-P2-RedHat-9.7.1-2.P2.fc13 <<>> -x 192.0.32.10
;; global options: +cmd
;; Got answer:
```

```
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 29683
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 5, ADDITIONAL: 6

;; QUESTION SECTION:
;10.32.0.192.in-addr.arpa.      IN      PTR

;; ANSWER SECTION:
10.32.0.192.in-addr.arpa. 21600 IN      PTR     www.example.com.

;; AUTHORITY SECTION:
32.0.192.in-addr.arpa.  21600   IN      NS      b.iana-servers.org.
32.0.192.in-addr.arpa.  21600   IN      NS      c.iana-servers.net.
32.0.192.in-addr.arpa.  21600   IN      NS      d.iana-servers.net.
32.0.192.in-addr.arpa.  21600   IN      NS      ns.icann.org.
32.0.192.in-addr.arpa.  21600   IN      NS      a.iana-servers.net.

;; ADDITIONAL SECTION:
a.iana-servers.net.     13688   IN      A       192.0.34.43
b.iana-servers.org.     5844    IN      A       193.0.0.236
b.iana-servers.org.     5844    IN      AAAA    2001:610:240:2::c100:ec
c.iana-servers.net.     12173   IN      A       139.91.1.10
c.iana-servers.net.     12173   IN      AAAA    2001:648:2c30::1:10
ns.icann.org.           12884   IN      A       192.0.34.126

;; Query time: 156 msec
;; SERVER: 10.34.255.7#53(10.34.255.7)
;; WHEN: Wed Aug 18 18:25:15 2010
;; MSG SIZE  rcvd: 310
```

17.2.5. Advanced Features of BIND

Most BIND implementations only use the **named** service to provide name resolution services or to act as an authority for a particular domain. However, BIND version 9 has a number of advanced features that allow for a more secure and efficient DNS service.

IMPORTANT

Before attempting to use advanced features like DNSSEC, TSIG, or IXFR (Incremental Zone Transfer), make sure that the particular feature is supported by all nameservers in the network environment, especially when you use older versions of BIND or non-BIND servers.

All of the features mentioned are discussed in greater detail in the *BIND 9 Administrator Reference Manual* referenced in Section 17.2.7.1, “Installed Documentation”.

17.2.5.1. Multiple Views

Optionally, different information can be presented to a client depending on the network a request originates from. This is primarily used to deny sensitive DNS entries from clients outside of the local network, while allowing queries from clients inside the local network.

To configure multiple views, add the **view** statement to the **/etc/named.conf** configuration file. Use the **match-clients** option to match IP addresses or entire networks and give them special options and zone data.

17.2.5.2. Incremental Zone Transfers (IXFR)

Incremental Zone Transfers (*IXFR*) allow a secondary nameserver to only download the updated portions of a zone modified on a primary nameserver. Compared to the standard transfer process, this makes the notification and update process much more efficient.

Note that IXFR is only available when using dynamic updating to make changes to master zone records. If manually editing zone files to make changes, *Automatic Zone Transfer* (*AXFR*) is used.

17.2.5.3. Transaction SIGnatures (TSIG)

Transaction SIGnatures (TSIG) ensure that a shared secret key exists on both primary and secondary nameserver before allowing a transfer. This strengthens the standard IP address-based method of transfer authorization, since attackers would not only need to have access to the IP address to transfer the zone, but they would also need to know the secret key.

Since version 9, BIND also supports *TKEY*, which is another shared secret key method of authorizing zone transfers.

IMPORTANT

When communicating over an insecure network, do not rely on IP address-based authentication only.

17.2.5.4. DNS Security Extensions (DNSSEC)

Domain Name System Security Extensions (*DNSSEC*) provide origin authentication of DNS data, authenticated denial of existence, and data integrity. When a particular domain is marked as secure, the **SERFVAIL** response is returned for each resource record that fails the validation.

Note that to debug a DNSSEC-signed domain or a DNSSEC-aware resolver, you can use the **dig** utility as described in Section 17.2.4, “Using the dig Utility”. Useful options are **+dnssec** (requests DNSSEC-related resource records by setting the DNSSEC OK bit), **+cd** (tells recursive nameserver not to validate the response), and **+bufsize=512** (changes the packet size to 512B to get through some firewalls).

17.2.5.5. Internet Protocol version 6 (IPv6)

Internet Protocol version 6 (*IPv6*) is supported through the use of **AAAA** resource records, and the **listen-on-v6** directive as described in Table 17.3, “Commonly used options”.

17.2.6. Common Mistakes to Avoid

The following is a list of recommendations on how to avoid common mistakes users make when configuring a nameserver:

Use semicolons and curly brackets correctly

An omitted semicolon or unmatched curly bracket in the **/etc/named.conf** file can prevent the **named** service from starting.

Use period correctly

In zone files, a period at the end of a domain name denotes a fully qualified domain name. If omitted, the **`named`** service will append the name of the zone or the value of **`$ORIGIN`** to complete it.

Increment the serial number when editing a zone file

If the serial number is not incremented, the primary nameserver will have the correct, new information, but the secondary nameservers will never be notified of the change, and will not attempt to refresh their data of that zone.

Configure the firewall

If a firewall is blocking connections from the **`named`** service to other nameservers, the recommended practice is to change the firewall settings.

WARNING

According to the recent research in DNS security, using a fixed UDP source port for DNS queries is a potential security vulnerability that could allow an attacker to conduct cache-poisoning attacks more easily. To prevent this, configure your firewall to allow queries from a random UDP source port.

17.2.7. Additional Resources

The following sources of information provide additional resources regarding BIND.

17.2.7.1. Installed Documentation

BIND features a full range of installed documentation covering many different topics, each placed in its own subject directory. For each item below, replace *version* with the version of the bind package installed on the system:

`/usr/share/doc/bind-`*`version`*`/`

The main directory containing the most recent documentation.

`/usr/share/doc/bind-`*`version`*`/arm/`

The directory containing the *BIND 9 Administrator Reference Manual* in HTML and SGML formats, which details BIND resource requirements, how to configure different types of nameservers, how to perform load balancing, and other advanced topics. For most new users of BIND, this is the best place to start.

`/usr/share/doc/bind-`*`version`*`/draft/`

The directory containing assorted technical documents that review issues related to the DNS service, and propose some methods to address them.

`/usr/share/doc/bind-`*`version`*`/misc/`

The directory designed to address specific advanced issues. Users of BIND version 8 should consult the **`migration`** document for specific changes they must make when moving to BIND 9. The **`options`** file lists all of the options implemented in BIND 9 that are used in **`/etc/named.conf`**.

`/usr/share/doc/bind-`*`version`*`/rfc/`

The directory providing every RFC document related to BIND.

There is also a number of man pages for the various applications and configuration files involved with BIND:

`man rndc`

The manual page for **`rndc`** containing the full documentation on its usage.

`man named`

The manual page for **`named`** containing the documentation on assorted arguments that can be used to control the BIND nameserver daemon.

`man lwresd`

The manual page for **`lwresd`** containing the full documentation on the lightweight resolver daemon and its usage.

`man named.conf`

The manual page with a comprehensive list of options available within the **`named`** configuration file.

`man rndc.conf`

The manual page with a comprehensive list of options available within the **`rndc`** configuration file.

17.2.7.2. Useful Websites

http://www.isc.org/software/bind

The home page of the BIND project containing information about current releases as well as a PDF version of the *BIND 9 Administrator Reference Manual*.

17.2.7.3. Related Books

***DNS and BIND* by Paul Albitz and Cricket Liu; O'Reilly & Associates**

A popular reference that explains both common and esoteric BIND configuration options, and provides strategies for securing a DNS server.

***The Concise Guide to DNS and BIND* by Nicolai Langfeldt; Que**

Looks at the connection between multiple network services and BIND, with an emphasis on task-oriented, technical topics.

CHAPTER 18. WEB SERVERS

HTTP (Hypertext Transfer Protocol) server, or a *web server*, is a network service that serves content to a client over the web. This typically means web pages, but any other documents can be served as well.

18.1. THE APACHE HTTP SERVER

This section focuses on the **Apache HTTP Server 2.2**, a robust, full-featured open source web server developed by the Apache Software Foundation, that is included in Red Hat Enterprise Linux 6. It describes the basic configuration of the **httpd** service, and covers advanced topics such as adding server modules, setting up virtual hosts, or configuring the secure HTTP server.

There are important differences between the Apache HTTP Server 2.2 and version 2.0, and if you are upgrading from a previous release of Red Hat Enterprise Linux, you will need to update the **httpd** service configuration accordingly. This section reviews some of the newly added features, outlines important changes, and guides you through the update of older configuration files.

18.1.1. New Features

The Apache HTTP Server version 2.2 introduces the following enhancements:

- Improved caching modules, that is, **mod_cache** and **mod_disk_cache**.
- Support for proxy load balancing, that is, the **mod_proxy_balancer** module.
- Support for large files on 32-bit architectures, allowing the web server to handle files greater than 2GB.
- A new structure for authentication and authorization support, replacing the authentication modules provided in previous versions.

18.1.2. Notable Changes

Since version 2.0, few changes have been made to the default **httpd** service configuration:

- The following modules are no longer loaded by default: **mod_cern_meta** and **mod_asis**.
- The following module is newly loaded by default: **mod_ext_filter**.

18.1.3. Updating the Configuration

To update the configuration files from the Apache HTTP Server version 2.0, take the following steps:

1. Make sure all module names are correct, since they may have changed. Adjust the **LoadModule** directive for each module that has been renamed.
2. Recompile all third party modules before attempting to load them. This typically means authentication and authorization modules.
3. If you use the **mod_userdir** module, make sure the **UserDir** directive indicating a directory name (typically **public_html**) is provided.
4. If you use the Apache HTTP Secure Server, see Section 18.1.9, “Enabling the mod_ssl Module” for important information on enabling the Secure Sockets Layer (SSL) protocol.

Note that you can check the configuration for possible errors by using the following command:

```
~]# service httpd configtest
Syntax OK
```

For more information on upgrading the Apache HTTP Server configuration from version 2.0 to 2.2, see http://httpd.apache.org/docs/2.2/upgrading.html.

18.1.4. Running the httpd Service

This section describes how to start, stop, restart, and check the current status of the Apache HTTP Server. To be able to use the **`httpd`** service, make sure you have the httpd installed. You can do so by using the following command:

```
~]# yum install httpd
```

For more information on the concept of runlevels and how to manage system services in Red Hat Enterprise Linux in general, see Chapter 12, *Services and Daemons*.

18.1.4.1. Starting the Service

To run the **`httpd`** service, type the following at a shell prompt as **`root`**:

```
~]# service httpd start
Starting httpd:                                            [  OK  ]
```

If you want the service to start automatically at the boot time, use the following command:

```
~]# chkconfig httpd on
```

This will enable the service for runlevel 2, 3, 4, and 5. Alternatively, you can use the **Service Configuration** utility as described in Section 12.2.1.1, “Enabling and Disabling a Service”.

NOTE

If running the Apache HTTP Server as a secure server, a password may be required after the machine boots if using an encrypted private SSL key.

18.1.4.2. Stopping the Service

To stop the running **`httpd`** service, type the following at a shell prompt as **`root`**:

```
~]# service httpd stop
Stopping httpd:                                            [  OK  ]
```

To prevent the service from starting automatically at the boot time, type:

```
~]# chkconfig httpd off
```

This will disable the service for all runlevels. Alternatively, you can use the **Service Configuration** utility as described in Section 12.2.1.1, “Enabling and Disabling a Service”.

18.1.4.3. Restarting the Service

There are three different ways to restart a running **`httpd`** service:

1. To restart the service completely, enter the following command as **`root`**:

   ```
   ~]# service httpd restart
   Stopping httpd:                                            [  OK
   ]
   Starting httpd:                                            [  OK
   ]
   ```

   This stops the running **`httpd`** service and immediately starts it again. Use this command after installing or removing a dynamically loaded module such as PHP.

2. To only reload the configuration, as **`root`**, type:

   ```
   ~]# service httpd reload
   ```

   This causes the running **`httpd`** service to reload its configuration file. Any requests being currently processed will be interrupted, which may cause a client browser to display an error message or render a partial page.

3. To reload the configuration without affecting active requests, enter the following command as **`root`**:

   ```
   ~]# service httpd graceful
   ```

   This causes the running **`httpd`** service to reload its configuration file. Any requests being currently processed will use the old configuration.

Alternatively, you can use the **Service Configuration** utility as described in Section 12.2.1.2, “Starting, Restarting, and Stopping a Service”.

18.1.4.4. Verifying the Service Status

To verify that the **`httpd`** service is running, type the following at a shell prompt:

```
~]# service httpd status
httpd (pid 19014) is running...
```

Alternatively, you can use the **Service Configuration** utility as described in Section 12.2.1, “Using the Service Configuration Utility”.

18.1.5. Editing the Configuration Files

When the **`httpd`** service is started, by default, it reads the configuration from locations that are listed in Table 18.1, “The httpd service configuration files”.

Table 18.1. The httpd service configuration files

Path	Description
`/etc/httpd/conf/httpd.conf`	The main configuration file.
`/etc/httpd/conf.d/`	An auxiliary directory for configuration files that are included in the main configuration file.

Although the default configuration should be suitable for most situations, it is a good idea to become at least familiar with some of the more important configuration options. Note that for any changes to take effect, the web server has to be restarted first. See Section 18.1.4.3, “Restarting the Service” for more information on how to restart the **`httpd`** service.

To check the configuration for possible errors, type the following at a shell prompt:

```
~]# service httpd configtest
Syntax OK
```

To make the recovery from mistakes easier, it is recommended that you make a copy of the original file before editing it.

18.1.5.1. Common httpd.conf Directives

The following directives are commonly used in the **`/etc/httpd/conf/httpd.conf`** configuration file:

`<Directory>`

The **`<Directory>`** directive allows you to apply certain directives to a particular directory only. It takes the following form:

```
<Directory directory>
  directive
  …
</Directory>
```

The *directory* can be either a full path to an existing directory in the local file system, or a wildcard expression.

This directive can be used to configure additional **`cgi-bin`** directories for server-side scripts located outside the directory that is specified by **`ScriptAlias`**. In this case, the **`ExecCGI`** and **`AddHandler`** directives must be supplied, and the permissions on the target directory must be set correctly (that is, **`0755`**).

Example 18.1. Using the <Directory> directive

```
<Directory /var/www/html>
  Options Indexes FollowSymLinks
  AllowOverride None
  Order allow,deny
  Allow from all
</Directory>
```

`<IfDefine>`

The **`IfDefine`** directive allows you to use certain directives only when a particular parameter is supplied on the command line. It takes the following form:

```
<IfDefine [!]parameter>
  directive
  …
</IfDefine>
```

The *parameter* can be supplied at a shell prompt using the **`-D`***parameter* command-line option (for example, **`httpd -DEnableHome`**). If the optional exclamation mark (that is, **`!`**) is present, the enclosed directives are used only when the parameter is *not* specified.

Example 18.2. Using the <IfDefine> directive

```
<IfDefine EnableHome>
  UserDir public_html
</IfDefine>
```

`<IfModule>`

The **`<IfModule>`** directive allows you to use certain directive only when a particular module is loaded. It takes the following form:

```
<IfModule [!]module>
  directive
  …
</IfModule>
```

The *module* can be identified either by its name, or by the file name. If the optional exclamation mark (that is, **`!`**) is present, the enclosed directives are used only when the module is *not* loaded.

Example 18.3. Using the <IfModule> directive

```
<IfModule mod_disk_cache.c>
  CacheEnable disk /
  CacheRoot /var/cache/mod_proxy
</IfModule>
```

`<Location>`

The **`<Location>`** directive allows you to apply certain directives to a particular URL only. It takes the following form:

```
<Location url>
  directive
  …
</Location>
```

The *url* can be either a path relative to the directory specified by the**`DocumentRoot`** directive (for example, **`/server-info`**), or an external URL such as **`http://example.com/server-info`**.

Example 18.4. Using the <Location> directive

```
<Location /server-info>
  SetHandler server-info
  Order deny,allow
  Deny from all
  Allow from .example.com
</Location>
```

`<Proxy>`

The **`<Proxy>`** directive allows you to apply certain directives to the proxy server only. It takes the following form:

```
<Proxy pattern>
  directive
  …
</Proxy>
```

The *pattern* can be an external URL, or a wildcard expression (for example, **`http://example.com/*`**).

Example 18.5. Using the <Proxy> directive

```
<Proxy *>
  Order deny,allow
  Deny from all
  Allow from .example.com
</Proxy>
```

`<VirtualHost>`

The **`<VirtualHost>`** directive allows you apply certain directives to particular virtual hosts only. It takes the following form:

```
<VirtualHost address[:port]…>
  directive
  …
</VirtualHost>
```

The *address* can be an IP address, a fully qualified domain name, or a special form as described in Table 18.2, “Available <VirtualHost> options”.

Table 18.2. Available <VirtualHost> options

Option	Description
`*`	Represents all IP addresses.
`_default_`	Represents unmatched IP addresses.

Example 18.6. Using the <VirtualHost> directive

```
<VirtualHost *:80>
  ServerAdmin webmaster@penguin.example.com
  DocumentRoot /www/docs/penguin.example.com
  ServerName penguin.example.com
  ErrorLog logs/penguin.example.com-error_log
  CustomLog logs/penguin.example.com-access_log common
</VirtualHost>
```

`AccessFileName`

The **`AccessFileName`** directive allows you to specify the file to be used to customize access control information for each directory. It takes the following form:

```
AccessFileName filename…
```

The *filename* is a name of the file to look for in the requested directory. By default, the server looks for **`.htaccess`**.

For security reasons, the directive is typically followed by the **`Files`** tag to prevent the files beginning with **`.ht`** from being accessed by web clients. This includes the **`.htaccess`** and **`.htpasswd`** files.

Example 18.7. Using the AccessFileName directive

```
AccessFileName .htaccess

<Files ~ "^\.ht">
  Order allow,deny
  Deny from all
  Satisfy All
</Files>
```

`Action`

The **`Action`** directive allows you to specify a CGI script to be executed when a certain media type is requested. It takes the following form:

```
Action content-type path
```

The *content-type* has to be a valid MIME type such as **`text/html`**, **`image/png`**, or **`application/pdf`**. The *path* refers to an existing CGI script, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/cgi-bin/process-image.cgi`**).

Example 18.8. Using the Action directive

```
Action image/png /cgi-bin/process-image.cgi
```

`AddDescription`

The **`AddDescription`** directive allows you to specify a short description to be displayed in server-generated directory listings for a given file. It takes the following form:

```
AddDescription "description" filename…
```

The *description* should be a short text enclosed in double quotes (that is, **`"`**). The *filename* can be a full file name, a file extension, or a wildcard expression.

Example 18.9. Using the AddDescription directive

```
AddDescription "GZIP compressed tar archive" .tgz
```

`AddEncoding`

The **`AddEncoding`** directive allows you to specify an encoding type for a particular file extension. It takes the following form:

```
AddEncoding encoding extension…
```

The *encoding* has to be a valid MIME encoding such as **`x-compress`**, **`x-gzip`**, etc. The *extension* is a case sensitive file extension, and is conventionally written with a leading dot (for example, **`.gz`**).

This directive is typically used to instruct web browsers to decompress certain file types as they are downloaded.

Example 18.10. Using the AddEncoding directive

```
AddEncoding x-gzip .gz .tgz
```

`AddHandler`

The **`AddHandler`** directive allows you to map certain file extensions to a selected handler. It takes the following form:

```
AddHandler handler extension…
```

The *handler* has to be a name of a previously defined handler. The *extension* is a case sensitive file extension, and is conventionally written with a leading dot (for example, **`.cgi`**).

This directive is typically used to treat files with the **`.cgi`** extension as CGI scripts regardless of the directory they are in. Additionally, it is also commonly used to process server-parsed HTML and image-map files.

Example 18.11. Using the AddHandler option

```
AddHandler cgi-script .cgi
```

`AddIcon`

The **`AddIcon`** directive allows you to specify an icon to be displayed for a particular file in server-generated directory listings. It takes the following form:

```
AddIcon path pattern…
```

The *path* refers to an existing icon file, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/icons/folder.png`**). The *pattern* can be a file name, a file extension, a wildcard expression, or a special form as described in the following table:

Table 18.3. Available AddIcon options

Option	Description
`^^DIRECTORY^^`	Represents a directory.
`^^BLANKICON^^`	Represents a blank line.

Example 18.12. Using the AddIcon directive

```
AddIcon /icons/text.png .txt README
```

`AddIconByEncoding`

The **`AddIconByEncoding`** directive allows you to specify an icon to be displayed for a particular encoding type in server-generated directory listings. It takes the following form:

```
AddIconByEncoding path encoding…
```

The *path* refers to an existing icon file, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/icons/compressed.png`**). The *encoding* has to be a valid MIME encoding such as **`x-compress`**, **`x-gzip`**, etc.

Example 18.13. Using the AddIconByEncoding directive

```
AddIconByEncoding /icons/compressed.png x-compress x-gzip
```

`AddIconByType`

The **`AddIconByType`** directive allows you to specify an icon to be displayed for a particular media type in server-generated directory listings. It takes the following form:

```
AddIconByType path content-type…
```

The *path* refers to an existing icon file, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/icons/text.png`**). The *content-type* has to be either a valid MIME type (for example, **`text/html`** or **`image/png`**), or a wildcard expression such as **`text/*`**, **`image/*`**, etc.

Example 18.14. Using the AddIconByType directive

```
AddIconByType /icons/video.png video/*
```

`AddLanguage`

The **`AddLanguage`** directive allows you to associate a file extension with a specific language. It takes the following form:

```
AddLanguage language extension…
```

The *language* has to be a valid MIME language such as **`cs`**, **`en`**, or **`fr`**. The *extension* is a case sensitive file extension, and is conventionally written with a leading dot (for example, **`.cs`**).

This directive is especially useful for web servers that serve content in multiple languages based on the client's language settings.

Example 18.15. Using the AddLanguage directive

```
AddLanguage cs .cs .cz
```

`AddType`

The **`AddType`** directive allows you to define or override the media type for a particular file extension. It takes the following form:

```
AddType content-type extension…
```

The *content-type* has to be a valid MIME type such as **`text/html`**, **`image/png`**, etc. The *extension* is a case sensitive file extension, and is conventionally written with a leading dot (for example, **`.cs`**).

Example 18.16. Using the AddType directive

```
AddType application/x-gzip .gz .tgz
```

`Alias`

The **`Alias`** directive allows you to refer to files and directories outside the default directory specified by the **`DocumentRoot`** directive. It takes the following form:

```
Alias url-path real-path
```

The *url-path* must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/images/`**). The *real-path* is a full path to a file or directory in the local file system.

This directive is typically followed by the **`Directory`** tag with additional permissions to access the target directory. By default, the **`/icons/`** alias is created so that the icons from **`/var/www/icons/`** are displayed in server-generated directory listings.

Example 18.17. Using the Alias directive

```
Alias /icons/ /var/www/icons/

<Directory "/var/www/icons">
  Options Indexes MultiViews FollowSymLinks
  AllowOverride None
  Order allow,deny
  Allow from all
<Directory>
```

`Allow`

The **`Allow`** directive allows you to specify which clients have permission to access a given directory. It takes the following form:

```
Allow from client…
```

The *client* can be a domain name, an IP address (both full and partial), a *network*/*netmask* pair, or **`all`** for all clients.

Example 18.18. Using the Allow directive

```
Allow from 192.168.1.0/255.255.255.0
```

`AllowOverride`

The **`AllowOverride`** directive allows you to specify which directives in a **`.htaccess`** file can override the default configuration. It takes the following form:

```
AllowOverride type…
```

The *type* has to be one of the available grouping options as described in Table 18.4, “Available AllowOverride options”.

Table 18.4. Available AllowOverride options

Option	Description
`All`	All directives in **`.htaccess`** are allowed to override earlier configuration settings.

Option	Description
`None`	No directive in **`.htaccess`** is allowed to override earlier configuration settings.
`AuthConfig`	Allows the use of authorization directives such as **`AuthName`**, **`AuthType`**, or **`Require`**.
`FileInfo`	Allows the use of file type, metadata, and **`mod_rewrite`** directives such as **`DefaultType`**, **`RequestHeader`**, or **`RewriteEngine`**, as well as the **`Action`** directive.
`Indexes`	Allows the use of directory indexing directives such as **`AddDescription`**, **`AddIcon`**, or **`FancyIndexing`**.
`Limit`	Allows the use of host access directives, that is, **`Allow`**, **`Deny`**, and **`Order`**.
`Options` [=*option*,…]	Allows the use of the **`Options`** directive. Additionally, you can provide a comma-separated list of options to customize which options can be set using this directive.

Example 18.19. Using the AllowOverride directive

```
AllowOverride FileInfo AuthConfig Limit
```

`BrowserMatch`

The **`BrowserMatch`** directive allows you to modify the server behavior based on the client's web browser type. It takes the following form:

```
BrowserMatch pattern variable…
```

The *pattern* is a regular expression to match the User-Agent HTTP header field. The *variable* is an environment variable that is set when the header field matches the pattern.

By default, this directive is used to deny connections to specific browsers with known issues, and to disable keepalives and HTTP header flushes for browsers that are known to have problems with these actions.

Example 18.20. Using the BrowserMatch directive

```
BrowserMatch "Mozilla/2" nokeepalive
```

`CacheDefaultExpire`

The **`CacheDefaultExpire`** option allows you to set how long to cache a document that does not have any expiration date or the date of its last modification specified. It takes the following form:

```
CacheDefaultExpire time
```

The *time* is specified in seconds. The default option is **`3600`** (that is, one hour).

Example 18.21. Using the CacheDefaultExpire directive

```
CacheDefaultExpire 3600
```

`CacheDisable`

The **`CacheDisable`** directive allows you to disable caching of certain URLs. It takes the following form:

```
CacheDisable path
```

The *path* must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/files/`**).

Example 18.22. Using the CacheDisable directive

```
CacheDisable /temporary
```

`CacheEnable`

The **`CacheEnable`** directive allows you to specify a cache type to be used for certain URLs. It takes the following form:

```
CacheEnable type url
```

The *type* has to be a valid cache type as described in Table 18.5, “Available cache types”. The *url* can be a path relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/images/`**), a protocol (for example, **`ftp://`**), or an external URL such as **`http://example.com/`**.

Table 18.5. Available cache types

Type	Description
`mem`	The memory-based storage manager.
`disk`	The disk-based storage manager.
`fd`	The file descriptor cache.

Example 18.23. Using the CacheEnable directive

```
CacheEnable disk /
```

–

`CacheLastModifiedFactor`

The **`CacheLastModifiedFactor`** directive allows you to customize how long to cache a document that does not have any expiration date specified, but that provides information about the date of its last modification. It takes the following form:

```
CacheLastModifiedFactor number
```

The *number* is a coefficient to be used to multiply the time that passed since the last modification of the document. The default option is **`0.1`** (that is, one tenth).

Example 18.24. Using the CacheLastModifiedFactor directive

```
CacheLastModifiedFactor 0.1
```

`CacheMaxExpire`

The **`CacheMaxExpire`** directive allows you to specify the maximum amount of time to cache a document. It takes the following form:

```
CacheMaxExpire time
```

The *time* is specified in seconds. The default option is **`86400`** (that is, one day).

Example 18.25. Using the CacheMaxExpire directive

```
CacheMaxExpire 86400
```

`CacheNegotiatedDocs`

The **`CacheNegotiatedDocs`** directive allows you to enable caching of the documents that were negotiated on the basis of content. It takes the following form:

```
CacheNegotiatedDocs option
```

The *option* has to be a valid keyword as described in Table 18.6, “Available CacheNegotiatedDocs options”. Since the content-negotiated documents may change over time or because of the input from the requester, the default option is **`Off`**.

Table 18.6. Available CacheNegotiatedDocs options

Option	Description
`On`	Enables caching the content-negotiated documents.
`Off`	Disables caching the content-negotiated documents.

Example 18.26. Using the CacheNegotiatedDocs directive

```
CacheNegotiatedDocs On
```

`CacheRoot`

The **`CacheRoot`** directive allows you to specify the directory to store cache files in. It takes the following form:

```
CacheRoot directory
```

The *directory* must be a full path to an existing directory in the local file system. The default option is **`/var/cache/mod_proxy/`**.

Example 18.27. Using the CacheRoot directive

```
CacheRoot /var/cache/mod_proxy
```

`CustomLog`

The **`CustomLog`** directive allows you to specify the log file name and the log file format. It takes the following form:

```
CustomLog path format
```

The *path* refers to a log file, and must be relative to the directory that is specified by the**`ServerRoot`** directive (that is, **`/etc/httpd/`** by default). The *format* has to be either an explicit format string, or a format name that was previously defined using the **`LogFormat`** directive.

Example 18.28. Using the CustomLog directive

```
CustomLog logs/access_log combined
```

`DefaultIcon`

The **`DefaultIcon`** directive allows you to specify an icon to be displayed for a file in server-generated directory listings when no other icon is associated with it. It takes the following form:

```
DefaultIcon path
```

The *path* refers to an existing icon file, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/icons/unknown.png`**).

Example 18.29. Using the DefaultIcon directive

```
DefaultIcon /icons/unknown.png
```

`DefaultType`

The **`DefaultType`** directive allows you to specify a media type to be used in case the proper MIME type cannot be determined by the server. It takes the following form:

```
DefaultType content-type
```

The *content-type* has to be a valid MIME type such as **`text/html`**, **`image/png`**, **`application/pdf`**, etc.

Example 18.30. Using the DefaultType directive

```
DefaultType text/plain
```

`Deny`

The **`Deny`** directive allows you to specify which clients are denied access to a given directory. It takes the following form:

```
Deny from client…
```

The *client* can be a domain name, an IP address (both full and partial), a *network*/*netmask* pair, or **`all`** for all clients.

Example 18.31. Using the Deny directive

```
Deny from 192.168.1.1
```

`DirectoryIndex`

The **`DirectoryIndex`** directive allows you to specify a document to be served to a client when a directory is requested (that is, when the URL ends with the **`/`** character). It takes the following form:

```
DirectoryIndex filename…
```

The *filename* is a name of the file to look for in the requested directory. By default, the server looks for **`index.html`**, and **`index.html.var`**.

Example 18.32. Using the DirectoryIndex directive

```
DirectoryIndex index.html index.html.var
```

`DocumentRoot`

The **`DocumentRoot`** directive allows you to specify the main directory from which the content is served. It takes the following form:

```
DocumentRoot directory
```

The *directory* must be a full path to an existing directory in the local file system. The default option is **`/var/www/html/`**.

Example 18.33. Using the DocumentRoot directive

```
DocumentRoot /var/www/html
```

`ErrorDocument`

The **`ErrorDocument`** directive allows you to specify a document or a message to be displayed as a response to a particular error. It takes the following form:

```
ErrorDocument error-code action
```

The *error-code* has to be a valid code such as **`403`** (Forbidden), **`404`** (Not Found), or **`500`** (Internal Server Error). The *action* can be either a URL (both local and external), or a message string enclosed in double quotes (that is, **`"`**).

Example 18.34. Using the ErrorDocument directive

```
ErrorDocument 403 "Access Denied"
ErrorDocument 404 /404-not_found.html
```

`ErrorLog`

The **`ErrorLog`** directive allows you to specify a file to which the server errors are logged. It takes the following form:

```
ErrorLog path
```

The *path* refers to a log file, and can be either absolute, or relative to the directory that is specified by the **`ServerRoot`** directive (that is, **`/etc/httpd/`** by default). The default option is **`logs/error_log`**

Example 18.35. Using the ErrorLog directive

```
ErrorLog logs/error_log
```

`ExtendedStatus`

The **`ExtendedStatus`** directive allows you to enable detailed server status information. It takes the following form:

```
ExtendedStatus option
```

The *option* has to be a valid keyword as described in Table 18.7, “Available ExtendedStatus options”. The default option is **`Off`**.

Table 18.7. Available ExtendedStatus options

Option	Description
`On`	Enables generating the detailed server status.
`Off`	Disables generating the detailed server status.

Example 18.36. Using the ExtendedStatus directive

```
ExtendedStatus On
```

`Group`

The **`Group`** directive allows you to specify the group under which the **`httpd`** service will run. It takes the following form:

```
Group group
```

The *group* has to be an existing UNIX group. The default option is **`apache`**.

Note that **`Group`** is no longer supported inside **`<VirtualHost>`**, and has been replaced by the **`SuexecUserGroup`** directive.

Example 18.37. Using the Group directive

```
Group apache
```

`HeaderName`

The **`HeaderName`** directive allows you to specify a file to be prepended to the beginning of the server-generated directory listing. It takes the following form:

```
HeaderName filename
```

The *filename* is a name of the file to look for in the requested directory. By default, the server looks for **`HEADER.html`**.

Example 18.38. Using the HeaderName directive

```
HeaderName HEADER.html
```

`HostnameLookups`

The **`HostnameLookups`** directive allows you to enable automatic resolving of IP addresses. It takes the following form:

```
HostnameLookups option
```

The *option* has to be a valid keyword as described in Table 18.8, “Available HostnameLookups options”. To conserve resources on the server, the default option is **`Off`**.

Table 18.8. Available HostnameLookups options

Option	Description
`On`	Enables resolving the IP address for each connection so that the host name can be logged. However, this also adds a significant processing overhead.
`Double`	Enables performing the double-reverse DNS lookup. In comparison to the above option, this adds even more processing overhead.
`Off`	Disables resolving the IP address for each connection.

Note that when the presence of host names is required in server log files, it is often possible to use one of the many log analyzer tools that perform the DNS lookups more efficiently.

Example 18.39. Using the HostnameLookups directive

```
HostnameLookups Off
```

`Include`

The **`Include`** directive allows you to include other configuration files. It takes the following form:

```
Include filename
```

The **`filename`** can be an absolute path, a path relative to the directory specified by the**`ServerRoot`** directive, or a wildcard expression. All configuration files from the **`/etc/httpd/conf.d/`** directory are loaded by default.

Example 18.40. Using the Include directive

```
Include conf.d/*.conf
```

`IndexIgnore`

The **`IndexIgnore`** directive allows you to specify a list of file names to be omitted from the server-generated directory listings. It takes the following form:

```
IndexIgnore filename…
```

The *filename* option can be either a full file name, or a wildcard expression.

Example 18.41. Using the IndexIgnore directive

```
IndexIgnore .??* *~ *# HEADER* README* RCS CVS *,v *,t
```

▪

`IndexOptions`

The **`IndexOptions`** directive allows you to customize the behavior of server-generated directory listings. It takes the following form:

```
IndexOptions option…
```

The *option* has to be a valid keyword as described in Table 18.9, “Available directory listing options”. The default options are **`Charset=UTF-8`**, **`FancyIndexing`**, **`HTMLTable`**, **`NameWidth=*`**, and **`VersionSort`**.

Table 18.9. Available directory listing options

Option	Description
`Charset`=*encoding*	Specifies the character set of a generated web page. The *encoding* has to be a valid character set such as **`UTF-8`** or **`ISO-8859-2`**.
`Type`=*content-type*	Specifies the media type of a generated web page. The *content-type* has to be a valid MIME type such as **`text/html`** or **`text/plain`**.
`DescriptionWidth`=*value*	Specifies the width of the description column. The *value* can be either a number of characters, or an asterisk (that is, **`*`**) to adjust the width automatically.
`FancyIndexing`	Enables advanced features such as different icons for certain files or possibility to re-sort a directory listing by clicking on a column header.
`FolderFirst`	Enables listing directories first, always placing them above files.
`HTMLTable`	Enables the use of HTML tables for directory listings.
`IconsAreLinks`	Enables using the icons as links.
`IconHeight`=*value*	Specifies an icon height. The *value* is a number of pixels.
`IconWidth`=*value*	Specifies an icon width. The *value* is a number of pixels.
`IgnoreCase`	Enables sorting files and directories in a case-sensitive manner.
`IgnoreClient`	Disables accepting query variables from a client.
`NameWidth`=*value*	Specifies the width of the file name column. The *value* can be either a number of characters, or an asterisk (that is, **`*`**) to adjust the width automatically.
`ScanHTMLTitles`	Enables parsing the file for a description (that is, the **`title`** element) in case it is not provided by the **`AddDescription`** directive.

Option	Description
`ShowForbidden`	Enables listing the files with otherwise restricted access.
`SuppressColumnSorting`	Disables re-sorting a directory listing by clicking on a column header.
`SuppressDescription`	Disables reserving a space for file descriptions.
`SuppressHTMLPreamble`	Disables the use of standard HTML preamble when a file specified by the **`HeaderName`** directive is present.
`SuppressIcon`	Disables the use of icons in directory listings.
`SuppressLastModified`	Disables displaying the date of the last modification field in directory listings.
`SuppressRules`	Disables the use of horizontal lines in directory listings.
`SuppressSize`	Disables displaying the file size field in directory listings.
`TrackModified`	Enables returning the **`Last-Modified`** and **`ETag`** values in the HTTP header.
`VersionSort`	Enables sorting files that contain a version number in the expected manner.
`XHTML`	Enables the use of XHTML 1.0 instead of the default HTML 3.2.

Example 18.42. Using the IndexOptions directive

```
IndexOptions FancyIndexing VersionSort NameWidth=* HTMLTable
Charset=UTF-8
```

`KeepAlive`

The **`KeepAlive`** directive allows you to enable persistent connections. It takes the following form:

```
KeepAlive option
```

The *option* has to be a valid keyword as described in Table 18.10, “Available KeepAlive options”. The default option is **`Off`**.

Table 18.10. Available KeepAlive options

Option	Description

Option	Description
`On`	Enables the persistent connections. In this case, the server will accept more than one request per connection.
`Off`	Disables the keep-alive connections.

Note that when the persistent connections are enabled, on a busy server, the number of child processes can increase rapidly and eventually reach the maximum limit, slowing down the server significantly. To reduce the risk, it is recommended that you set **`KeepAliveTimeout`** to a low number, and monitor the **`/var/log/httpd/logs/error_log`** log file carefully.

Example 18.43. Using the KeepAlive directive

```
KeepAlive Off
```

`KeepAliveTimeout`

The **`KeepAliveTimeout`** directive allows you to specify the amount of time to wait for another request before closing the connection. It takes the following form:

```
KeepAliveTimeout time
```

The *time* is specified in seconds. The default option is **`15`**.

Example 18.44. Using the KeepAliveTimeout directive

```
KeepAliveTimeout 15
```

`LanguagePriority`

The **`LanguagePriority`** directive allows you to customize the precedence of languages. It takes the following form:

```
LanguagePriority language…
```

The *language* has to be a valid MIME language such as **`cs`**, **`en`**, or **`fr`**.

This directive is especially useful for web servers that serve content in multiple languages based on the client's language settings.

Example 18.45. Using the LanguagePriority directive

```
LanguagePriority sk cs en
```

`Listen`

The *Listen* directive allows you to specify IP addresses or ports to listen to. It takes the following form:

```
Listen [ip-address:]port [protocol]
```

The *ip-address* is optional and unless supplied, the server will accept incoming requests on a given *port* from all IP addresses. Since the *protocol* is determined automatically from the port number, it can be usually omitted. The default option is to listen to port **80**.

Note that if the server is configured to listen to a port under 1024, only superuser will be able to start the **httpd** service.

Example 18.46. Using the Listen directive

```
Listen 80
```

LoadModule

The **LoadModule** directive allows you to load a *Dynamic Shared Object* (DSO) module. It takes the following form:

```
LoadModule name path
```

The *name* has to be a valid identifier of the required module. The *path* refers to an existing module file, and must be relative to the directory in which the libraries are placed (that is, **/usr/lib/httpd/** on 32-bit and **/usr/lib64/httpd/** on 64-bit systems by default).

See Section 18.1.6, “Working with Modules” for more information on the Apache HTTP Server's DSO support.

Example 18.47. Using the LoadModule directive

```
LoadModule php5_module modules/libphp5.so
```

LogFormat

The *LogFormat* directive allows you to specify a log file format. It takes the following form:

```
LogFormat format name
```

The *format* is a string consisting of options as described in Table 18.11, “Common LogFormat options”. The *name* can be used instead of the format string in the **CustomLog** directive.

Table 18.11. Common LogFormat options

Option	Description
%b	Represents the size of the response in bytes.
%h	Represents the IP address or host name of a remote client.

Option	Description
`%l`	Represents the remote log name if supplied. If not, a hyphen (that is, **`-`**) is used instead.
`%r`	Represents the first line of the request string as it came from the browser or client.
`%s`	Represents the status code.
`%t`	Represents the date and time of the request.
`%u`	If the authentication is required, it represents the remote user. If not, a hyphen (that is, **`-`**) is used instead.
`%{field}`	Represents the content of the HTTP header *field*. The common options include **`%{Referer}`** (the URL of the web page that referred the client to the server) and **`%{User-Agent}`** (the type of the web browser making the request).

Example 18.48. Using the LogFormat directive

```
LogFormat "%h %l %u %t \"%r\" %>s %b" common
```

`LogLevel`

The **`LogLevel`** directive allows you to customize the verbosity level of the error log. It takes the following form:

```
LogLevel option
```

The *option* has to be a valid keyword as described in Table 18.12, “Available LogLevel options”. The default option is **`warn`**.

Table 18.12. Available LogLevel options

Option	Description
`emerg`	Only the emergency situations when the server cannot perform its work are logged.
`alert`	All situations when an immediate action is required are logged.
`crit`	All critical conditions are logged.
`error`	All error messages are logged.
`warn`	All warning messages are logged.
`notice`	Even normal, but still significant situations are logged.

Option	Description
info	Various informational messages are logged.
debug	Various debugging messages are logged.

Example 18.49. Using the LogLevel directive

```
LogLevel warn
```

MaxKeepAliveRequests

The **MaxKeepAliveRequests** directive allows you to specify the maximum number of requests for a persistent connection. It takes the following form:

```
MaxKeepAliveRequests number
```

A high *number* can improve the performance of the server. Note that using **0** allows unlimited number of requests. The default option is **100**.

Example 18.50. Using the MaxKeepAliveRequests option

```
MaxKeepAliveRequests 100
```

NameVirtualHost

The **NameVirtualHost** directive allows you to specify the IP address and port number for a name-based virtual host. It takes the following form:

```
NameVirtualHost ip-address[:port]
```

The *ip-address* can be either a full IP address, or an asterisk (that is, *****) representing all interfaces. Note that IPv6 addresses have to be enclosed in square brackets (that is, **[** and **]**). The *port* is optional.

Name-based virtual hosting allows one Apache HTTP Server to serve different domains without using multiple IP addresses.

IMPORTANT

Name-based virtual hosts *only* work with non-secure HTTP connections. If using virtual hosts with a secure server, use IP address-based virtual hosts instead.

Example 18.51. Using the NameVirtualHost directive

```
NameVirtualHost *:80
```

`Options`

The **`Options`** directive allows you to specify which server features are available in a particular directory. It takes the following form:

```
Options option…
```

The *option* has to be a valid keyword as described in Table 18.13, “Available server features”.

Table 18.13. Available server features

Option	Description
`ExecCGI`	Enables the execution of CGI scripts.
`FollowSymLinks`	Enables following symbolic links in the directory.
`Includes`	Enables server-side includes.
`IncludesNOEXEC`	Enables server-side includes, but does not allow the execution of commands.
`Indexes`	Enables server-generated directory listings.
`MultiViews`	Enables content-negotiated “MultiViews”.
`SymLinksIfOwnerMatch`	Enables following symbolic links in the directory when both the link and the target file have the same owner.
`All`	Enables all of the features above with the exception of **`MultiViews`**.
`None`	Disables all of the features above.

IMPORTANT

The **`SymLinksIfOwnerMatch`** option is not a security feature as it can be bypassed by an attacker.

Example 18.52. Using the Options directive

```
Options Indexes FollowSymLinks
```

`Order`

The **`Order`** directive allows you to specify the order in which the **`Allow`** and **`Deny`** directives are evaluated. It takes the following form:

```
Order option
```

The *option* has to be a valid keyword as described in Table 18.14, “Available Order options”. The default option is **`allow,deny`**.

Table 18.14. Available Order options

Option	Description
`allow,deny`	**`Allow`** directives are evaluated first.
`deny,allow`	**`Deny`** directives are evaluated first.

Example 18.53. Using the Order directive

```
Order allow,deny
```

`PidFile`

The **`PidFile`** directive allows you to specify a file to which the *process ID* (PID) of the server is stored. It takes the following form:

```
PidFile path
```

The *path* refers to a pid file, and can be either absolute, or relative to the directory that is specified by the **`ServerRoot`** directive (that is, **`/etc/httpd/`** by default). The default option is **`run/httpd.pid`**.

Example 18.54. Using the PidFile directive

```
PidFile run/httpd.pid
```

`ProxyRequests`

The **`ProxyRequests`** directive allows you to enable forward proxy requests. It takes the following form:

```
ProxyRequests option
```

The *option* has to be a valid keyword as described in Table 18.15, “Available ProxyRequests options”. The default option is **`Off`**.

Table 18.15. Available ProxyRequests options

Option	Description
`On`	Enables forward proxy requests.
`Off`	Disables forward proxy requests.

Example 18.55. Using the ProxyRequests directive

```
ProxyRequests On
```

`ReadmeName`

The **`ReadmeName`** directive allows you to specify a file to be appended to the end of the server-generated directory listing. It takes the following form:

```
ReadmeName filename
```

The *filename* is a name of the file to look for in the requested directory. By default, the server looks for **`README.html`**.

Example 18.56. Using the ReadmeName directive

```
ReadmeName README.html
```

`Redirect`

The **`Redirect`** directive allows you to redirect a client to another URL. It takes the following form:

```
Redirect [status] path url
```

The *status* is optional, and if provided, it has to be a valid keyword as described in Table 18.16, “Available status options”. The *path* refers to the old location, and must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/docs`**). The *url* refers to the current location of the content (for example, **`http://docs.example.com`**).

Table 18.16. Available status options

Status	Description
`permanent`	Indicates that the requested resource has been moved permanently. The **`301`** (Moved Permanently) status code is returned to a client.
`temp`	Indicates that the requested resource has been moved only temporarily. The **`302`** (Found) status code is returned to a client.
`seeother`	Indicates that the requested resource has been replaced. The **`303`** (See Other) status code is returned to a client.
`gone`	Indicates that the requested resource has been removed permanently. The **`410`** (Gone) status is returned to a client.

Note that for more advanced redirection techniques, you can use the **`mod_rewrite`** module that is part of the Apache HTTP Server installation.

Example 18.57. Using the Redirect directive

```
Redirect permanent /docs http://docs.example.com
```

`ScriptAlias`

The **`ScriptAlias`** directive allows you to specify the location of CGI scripts. It takes the following form:

```
ScriptAlias url-path real-path
```

The *url-path* must be relative to the directory specified by the **`DocumentRoot`** directive (for example, **`/cgi-bin/`**). The *real-path* is a full path to a file or directory in the local file system.

This directive is typically followed by the **`Directory`** tag with additional permissions to access the target directory. By default, the **`/cgi-bin/`** alias is created so that the scripts located in the **`/var/www/cgi-bin/`** are accessible.

The **`ScriptAlias`** directive is used for security reasons to prevent CGI scripts from being viewed as ordinary text documents.

Example 18.58. Using the ScriptAlias directive

```
ScriptAlias /cgi-bin/ /var/www/cgi-bin/

<Directory "/var/www/cgi-bin">
  AllowOverride None
  Options None
  Order allow,deny
  Allow from all
</Directory>
```

`ServerAdmin`

The **`ServerAdmin`** directive allows you to specify the email address of the server administrator to be displayed in server-generated web pages. It takes the following form:

```
ServerAdmin email
```

The default option is **`root@localhost`**.

This directive is commonly set to **`webmaster@`*`hostname`***, where *hostname* is the address of the server. Once set, alias **`webmaster`** to the person responsible for the web server in **`/etc/aliases`**, and as superuser, run the **`newaliases`** command.

Example 18.59. Using the ServerAdmin directive

```
ServerAdmin webmaster@penguin.example.com
```

`ServerName`

The **ServerName** directive allows you to specify the host name and the port number of a web server. It takes the following form:

```
ServerName hostname[:port]
```

The *hostname* has to be a *fully qualified domain name* (FQDN) of the server. The *port* is optional, but when supplied, it has to match the number specified by the **Listen** directive.

When using this directive, make sure that the IP address and server name pair are included in the **/etc/hosts** file.

Example 18.60. Using the ServerName directive

```
ServerName penguin.example.com:80
```

ServerRoot

The **ServerRoot** directive allows you to specify the directory in which the server operates. It takes the following form:

```
ServerRoot directory
```

The *directory* must be a full path to an existing directory in the local file system. The default option is **/etc/httpd/**.

Example 18.61. Using the ServerRoot directive

```
ServerRoot /etc/httpd
```

ServerSignature

The **ServerSignature** directive allows you to enable displaying information about the server on server-generated documents. It takes the following form:

```
ServerSignature option
```

The *option* has to be a valid keyword as described in Table 18.17, “Available ServerSignature options”. The default option is **On**.

Table 18.17. Available ServerSignature options

Option	Description
On	Enables appending the server name and version to server-generated pages.
Off	Disables appending the server name and version to server-generated pages.

Option	Description
`EMail`	Enables appending the server name, version, and the email address of the system administrator as specified by the **`ServerAdmin`** directive to server-generated pages.

Example 18.62. Using the ServerSignature directive

```
ServerSignature On
```

`ServerTokens`

The **`ServerTokens`** directive allows you to customize what information is included in the Server response header. It takes the following form:

```
ServerTokens option
```

The *option* has to be a valid keyword as described in Table 18.18, “Available ServerTokens options”. The default option is **`OS`**.

Table 18.18. Available ServerTokens options

Option	Description
`Prod`	Includes the product name only (that is, **`Apache`**).
`Major`	Includes the product name and the major version of the server (for example, **`2`**).
`Minor`	Includes the product name and the minor version of the server (for example, **`2.2`**).
`Min`	Includes the product name and the minimal version of the server (for example, **`2.2.15`**).
`OS`	Includes the product name, the minimal version of the server, and the type of the operating system it is running on (for example, **`Red Hat`**).
`Full`	Includes all the information above along with the list of loaded modules.

Note that for security reasons, it is recommended to reveal as little information about the server as possible.

Example 18.63. Using the ServerTokens directive

```
ServerTokens Prod
```

`SuexecUserGroup`

The **`SuexecUserGroup`** directive allows you to specify the user and group under which the CGI scripts will be run. It takes the following form:

```
SuexecUserGroup user group
```

The *user* has to be an existing user, and the *group* must be a valid UNIX group.

For security reasons, the CGI scripts should not be run with root privileges. Note that in **`<VirtualHost>`**, **`SuexecUserGroup`** replaces the **`User`** and **`Group`** directives.

Example 18.64. Using the SuexecUserGroup directive

```
SuexecUserGroup apache apache
```

`Timeout`

The **`Timeout`** directive allows you to specify the amount of time to wait for an event before closing a connection. It takes the following form:

```
Timeout time
```

The *time* is specified in seconds. The default option is **`60`**.

Example 18.65. Using the Timeout directive

```
Timeout 60
```

`TypesConfig`

The **`TypesConfig`** allows you to specify the location of the MIME types configuration file. It takes the following form:

```
TypesConfig path
```

The *path* refers to an existing MIME types configuration file, and can be either absolute, or relative to the directory that is specified by the **`ServerRoot`** directive (that is, **`/etc/httpd/`** by default). The default option is **`/etc/mime.types`**.

Note that instead of editing **`/etc/mime.types`**, the recommended way to add MIME type mapping to the Apache HTTP Server is to use the **`AddType`** directive.

Example 18.66. Using the TypesConfig directive

```
TypesConfig /etc/mime.types
```

`UseCanonicalName`

The **`UseCanonicalName`** allows you to specify the way the server refers to itself. It takes the following form:

```
UseCanonicalName option
```

The *option* has to be a valid keyword as described in Table 18.19, “Available UseCanonicalName options”. The default option is **`Off`**.

Table 18.19. Available UseCanonicalName options

Option	Description
`On`	Enables the use of the name that is specified by the **`ServerName`** directive.
`Off`	Disables the use of the name that is specified by the **`ServerName`** directive. The host name and port number provided by the requesting client are used instead.
`DNS`	Disables the use of the name that is specified by the **`ServerName`** directive. The host name determined by a reverse DNS lookup is used instead.

Example 18.67. Using the UseCanonicalName directive

```
UseCanonicalName Off
```

`User`

The **`User`** directive allows you to specify the user under which the **`httpd`** service will run. It takes the following form:

```
User user
```

The *user* has to be an existing UNIX user. The default option is **`apache`**.

For security reasons, the **`httpd`** service should not be run with root privileges. Note that **`User`** is no longer supported inside **`<VirtualHost>`**, and has been replaced by the **`SuexecUserGroup`** directive.

Example 18.68. Using the User directive

```
User apache
```

`UserDir`

The **`UserDir`** directive allows you to enable serving content from users' home directories. It takes the following form:

```
UserDir option
```

The *option* can be either a name of the directory to look for in user's home directory (typically **`public_html`**), or a valid keyword as described in Table 18.20, “Available UserDir options”. The default option is **`disabled`**.

Table 18.20. Available UserDir options

Option	Description
`enabled` *user*…	Enables serving content from home directories of given *user*s.
`disabled` [*user*…]	Disables serving content from home directories, either for all users, or, if a space separated list of *user*s is supplied, for given users only.

NOTE

In order for the web server to access the content, the permissions on relevant directories and files must be set correctly. Make sure that all users are able to access the home directories, and that they can access and read the content of the directory specified by the **`UserDir`** directive. For example:

```
~]# chmod a+x /home/username/
~]# chmod a+rx /home/username/public_html/
```

All files in this directory must be set accordingly.

Example 18.69. Using the UserDir directive

```
UserDir public_html
```

18.1.5.2. Common ssl.conf Directives

The *Secure Sockets Layer* (SSL) directives allow you to customize the behavior of the Apache HTTP Secure Server, and in most cases, they are configured appropriately during the installation. Be careful when changing these settings, as incorrect configuration can lead to security vulnerabilities.

The following directive is commonly used in **`/etc/httpd/conf.d/ssl.conf`**:

`SetEnvIf`

The **`SetEnvIf`** directive allows you to set environment variables based on the headers of incoming connections. It takes the following form:

```
SetEnvIf option pattern [!]variable[=value]…
```

The *option* can be either a HTTP header field, a previously defined environment variable name, or a valid keyword as described in Table 18.21, “Available SetEnvIf options”. The *pattern* is a regular expression. The *variable* is an environment variable that is set when the option matches the pattern. If the optional exclamation mark (that is, **`!`**) is present, the variable is removed instead of being set.

Table 18.21. Available SetEnvIf options

Option	Description
`Remote_Host`	Refers to the client's host name.
`Remote_Addr`	Refers to the client's IP address.
`Server_Addr`	Refers to the server's IP address.
`Request_Method`	Refers to the request method (for example, **`GET`**).
`Request_Protocol`	Refers to the protocol name and version (for example, **`HTTP/1.1`**).
`Request_URI`	Refers to the requested resource.

The **`SetEnvIf`** directive is used to disable HTTP keepalives, and to allow SSL to close the connection without a closing notification from the client browser. This is necessary for certain web browsers that do not reliably shut down the SSL connection.

Example 18.70. Using the SetEnvIf directive

```
SetEnvIf User-Agent ".*MSIE.*" \
         nokeepalive ssl-unclean-shutdown \
         downgrade-1.0 force-response-1.0
```

Note that for the **`/etc/httpd/conf.d/ssl.conf`** file to be present, the mod_ssl needs to be installed. See Section 18.1.8, “Setting Up an SSL Server” for more information on how to install and configure an SSL server.

18.1.5.3. Common Multi-Processing Module Directives

The *Multi-Processing Module* (MPM) directives allow you to customize the behavior of a particular MPM specific server-pool. Since its characteristics differ depending on which MPM is used, the directives are embedded in **`IfModule`**. By default, the server-pool is defined for both the **`prefork`** and **`worker`** MPMs.

The following MPM directives are commonly used in **`/etc/httpd/conf/httpd.conf`**:

`MaxClients`

The **`MaxClients`** directive allows you to specify the maximum number of simultaneously connected clients to process at one time. It takes the following form:

```
MaxClients number
```

A high *number* can improve the performance of the server, although it is not recommended to exceed **`256`** when using the **`prefork`** MPM.

Example 18.71. Using the MaxClients directive

```
MaxClients 256
```

`MaxRequestsPerChild`

The **`MaxRequestsPerChild`** directive allows you to specify the maximum number of request a child process can serve before it dies. It takes the following form:

```
MaxRequestsPerChild number
```

Setting the *number* to **`0`** allows unlimited number of requests.

The **`MaxRequestsPerChild`** directive is used to prevent long-lived processes from causing memory leaks.

Example 18.72. Using the MaxRequestsPerChild directive

```
MaxRequestsPerChild 4000
```

`MaxSpareServers`

The **`MaxSpareServers`** directive allows you to specify the maximum number of spare child processes. It takes the following form:

```
MaxSpareServers number
```

This directive is used by the **`prefork`** MPM only.

Example 18.73. Using the MaxSpareServers directive

```
MaxSpareServers 20
```

`MaxSpareThreads`

The **`MaxSpareThreads`** directive allows you to specify the maximum number of spare server threads. It takes the following form:

```
MaxSpareThreads number
```

The *number* must be greater than or equal to the sum of **`MinSpareThreads`** and **`ThreadsPerChild`**. This directive is used by the **`worker`** MPM only.

Example 18.74. Using the MaxSpareThreads directive

```
MaxSpareThreads 75
```

`MinSpareServers`

The **`MinSpareServers`** directive allows you to specify the minimum number of spare child processes. It takes the following form:

```
MinSpareServers number
```

Note that a high *number* can create a heavy processing load on the server. This directive is used by the **`prefork`** MPM only.

Example 18.75. Using the MinSpareServers directive

```
MinSpareServers 5
```

`MinSpareThreads`

The **`MinSpareThreads`** directive allows you to specify the minimum number of spare server threads. It takes the following form:

```
MinSpareThreads number
```

This directive is used by the **`worker`** MPM only.

Example 18.76. Using the MinSpareThreads directive

```
MinSpareThreads 75
```

`StartServers`

The **`StartServers`** directive allows you to specify the number of child processes to create when the service is started. It takes the following form:

```
StartServers number
```

Since the child processes are dynamically created and terminated according to the current traffic load, it is usually not necessary to change this value.

Example 18.77. Using the StartServers directive

```
StartServers 8
```

`ThreadsPerChild`

The **`ThreadsPerChild`** directive allows you to specify the number of threads a child process can create. It takes the following form:

```
ThreadsPerChild number
```

This directive is used by the **`worker`** MPM only.

Example 18.78. Using the ThreadsPerChild directive

```
ThreadsPerChild 25
```

18.1.6. Working with Modules

Being a modular application, the **`httpd`** service is distributed along with a number of *Dynamic Shared Objects* (DSOs), which can be dynamically loaded or unloaded at runtime as necessary. By default, these modules are located in **`/usr/lib/httpd/modules/`** on 32-bit and in **`/usr/lib64/httpd/modules/`** on 64-bit systems.

18.1.6.1. Loading a Module

To load a particular DSO module, use the **`LoadModule`** directive as described in Section 18.1.5.1, “Common httpd.conf Directives”. Note that modules provided by a separate package often have their own configuration file in the **`/etc/httpd/conf.d/`** directory.

Example 18.79. Loading the mod_ssl DSO

```
LoadModule ssl_module modules/mod_ssl.so
```

Once you are finished, restart the web server to reload the configuration. See Section 18.1.4.3, “Restarting the Service” for more information on how to restart the **`httpd`** service.

18.1.6.2. Writing a Module

If you intend to create a new DSO module, make sure you have the httpd-devel package installed. To do so, enter the following command as **`root`**:

```
~]# yum install httpd-devel
```

This package contains the include files, the header files, and the **APache eXtenSion** (**`apxs`**) utility required to compile a module.

Once written, you can build the module with the following command:

```
~]# apxs -i -a -c module_name.c
```

If the build was successful, you should be able to load the module the same way as any other module that is distributed with the Apache HTTP Server.

18.1.7. Setting Up Virtual Hosts

The Apache HTTP Server's built in virtual hosting allows the server to provide different information based on which IP address, host name, or port is being requested.

To create a name-based virtual host, find the virtual host container provided in **`/etc/httpd/conf/httpd.conf`** as an example, remove the hash sign (that is, #) from the beginning of each line, and customize the options according to your requirements as shown in Example 18.80, “Example virtual host configuration”.

Example 18.80. Example virtual host configuration

```
NameVirtualHost *:80

<VirtualHost *:80>
    ServerAdmin webmaster@penguin.example.com
    DocumentRoot /www/docs/penguin.example.com
    ServerName penguin.example.com
    ServerAlias www.penguin.example.com
    ErrorLog logs/penguin.example.com-error_log
    CustomLog logs/penguin.example.com-access_log common
</VirtualHost>
```

Note that **`ServerName`** must be a valid DNS name assigned to the machine. The **`<VirtualHost>`** container is highly customizable, and accepts most of the directives available within the main server configuration. Directives that are *not* supported within this container include **`User`** and **`Group`**, which were replaced by **`SuexecUserGroup`**.

NOTE

If you configure a virtual host to listen on a non-default port, make sure you update the **`Listen`** directive in the global settings section of the **`/etc/httpd/conf/httpd.conf`** file accordingly.

To activate a newly created virtual host, the web server has to be restarted first. See Section 18.1.4.3, “Restarting the Service” for more information on how to restart the **`httpd`** service.

18.1.8. Setting Up an SSL Server

Secure Sockets Layer (SSL) is a cryptographic protocol that allows a server and a client to communicate securely. Along with its extended and improved version called *Transport Layer Security* (TLS), it ensures both privacy and data integrity. The Apache HTTP Server in combination with **`mod_ssl`**, a module that uses the OpenSSL toolkit to provide the SSL/TLS support, is commonly referred to as the *SSL server*. Red Hat Enterprise Linux also supports the use of Mozilla NSS as the TLS implementation. Support for Mozilla NSS is provided by the **`mod_nss`** module.

Unlike an HTTP connection that can be read and possibly modified by anybody who is able to intercept it, the use of SSL/TLS over HTTP, referred to as HTTPS, prevents any inspection or modification of the transmitted content. This section provides basic information on how to enable this module in the Apache HTTP Server configuration, and guides you through the process of generating private keys and self-signed certificates.

18.1.8.1. An Overview of Certificates and Security

Secure communication is based on the use of keys. In conventional or *symmetric cryptography*, both ends of the transaction have the same key they can use to decode each other's transmissions. On the other hand, in public or *asymmetric cryptography*, two keys co-exist: a *private key* that is kept a secret, and a *public key* that is usually shared with the public. While the data encoded with the public key can only be decoded with the private key, data encoded with the private key can in turn only be decoded with the public key.

To provide secure communications using SSL, an SSL server must use a digital certificate signed by a *Certificate Authority* (CA). The certificate lists various attributes of the server (that is, the server host name, the name of the company, its location, etc.), and the signature produced using the CA's private key. This signature ensures that a particular certificate authority has signed the certificate, and that the certificate has not been modified in any way.

When a web browser establishes a new SSL connection, it checks the certificate provided by the web server. If the certificate does not have a signature from a trusted CA, or if the host name listed in the certificate does not match the host name used to establish the connection, it refuses to communicate with the server and usually presents a user with an appropriate error message.

By default, most web browsers are configured to trust a set of widely used certificate authorities. Because of this, an appropriate CA should be chosen when setting up a secure server, so that target users can trust the connection, otherwise they will be presented with an error message, and will have to accept the certificate manually. Since encouraging users to override certificate errors can allow an attacker to intercept the connection, you should use a trusted CA whenever possible. For more information on this, see Table 18.22, “Information about CA lists used by common web browsers”.

Table 18.22. Information about CA lists used by common web browsers

Web Browser	Link
Mozilla Firefox	Mozilla root CA list.
Opera	Information on root certificates used by Opera .
Internet Explorer	Information on root certificates used by Microsoft Windows .
Chromium	Information on root certificates used by the Chromium project .

When setting up an SSL server, you need to generate a certificate request and a private key, and then send the certificate request, proof of the company's identity, and payment to a certificate authority. Once the CA verifies the certificate request and your identity, it will send you a signed certificate you can use with your server. Alternatively, you can create a self-signed certificate that does not contain a CA signature, and thus should be used for testing purposes only.

18.1.9. Enabling the mod_ssl Module

If you intend to set up an SSL or HTTPS server using **`mod_ssl`**, you **cannot** have another application or module, such as **`mod_nss`** configured to use the same port. Port **`443`** is the default port for HTTPS.

To set up an SSL server using the **`mod_ssl`** module and the OpenSSL toolkit, install the mod_ssl and openssl packages. Enter the following command as **`root`**:

```
~]# yum install mod_ssl openssl
```

This will create the **`mod_ssl`** configuration file at **`/etc/httpd/conf.d/ssl.conf`**, which is included in the main Apache HTTP Server configuration file by default. For the module to be loaded, restart the **`httpd`** service as described in Section 18.1.4.3, “Restarting the Service”.

IMPORTANT

Due to the vulnerability described in *POODLE: SSLv3 vulnerability (CVE-2014-3566)*, Red Hat recommends disabling **`SSL`**, if it is enabled, and using only **`TLSv1.1`** or **`TLSv1.2`**. Backwards compatibility can be achieved using **`TLSv1.0`**. Many products Red Hat supports have the ability to use **`SSLv2`** or **`SSLv3`** protocols. However, the use of **`SSLv2`** or **`SSLv3`** is now strongly recommended against.

18.1.9.1. Enabling and Disabling SSL and TLS in mod_ssl

To disable and enable specific versions of the SSL and TLS protocol, either do it globally by adding the **`SSLProtocol`** directive in the "## SSL Global Context" section of the configuration file and removing it everywhere else, or edit the default entry under "# SSL Protocol support" in all "VirtualHost" sections. If you do not specify it in the per-domain VirtualHost section then it will inherit the settings from the global section. To make sure that a protocol version is being disabled the administrator should either **only** specify **`SSLProtocol`** in the "SSL Global Context" section, or specify it in **all** per-domain VirtualHost sections.

Note that in Red Hat Enterprise Linux 6.8 SSLv2 is disabled by default.

Procedure 18.1. Disable SSLv2 and SSLv3

To disable SSL version 2 and SSL version 3, which implies enabling everything except SSL version 2 and SSL version 3, in all VirtualHost sections, proceed as follows:

1. As **`root`**, open the **`/etc/httpd/conf.d/ssl.conf`** file and search for **all** instances of the **`SSLProtocol`** directive. By default, the configuration file contains one section that looks as follows:

   ```
   ~]# vi /etc/httpd/conf.d/ssl.conf
   #   SSL Protocol support:
   # List the enable protocol levels with which clients will be able to
   # connect.  Disable SSLv2 access by default:
   SSLProtocol all -SSLv2
   ```

   This section is within the VirtualHost section.

2. Edit the **`SSLProtocol`** line as follows:

   ```
   #   SSL Protocol support:
   # List the enable protocol levels with which clients will be able to
   # connect.  Disable SSLv2 access by default:
   SSLProtocol all -SSLv2 -SSLv3
   ```

   Repeat this action for all VirtualHost sections. Save and close the file.

3. Verify that all occurrences of the **`SSLProtocol`** directive have been changed as follows:

   ```
   ~]# grep SSLProtocol /etc/httpd/conf.d/ssl.conf
   SSLProtocol all -SSLv2 -SSLv3
   ```

   This step is particularly important if you have more than the one default VirtualHost section.

4. Restart the Apache daemon as follows:

```
~]# service httpd restart
```

Note that any sessions will be interrupted.

Procedure 18.2. Disable All SSL and TLS Protocols Except TLS 1 and Up

To disable all SSL and TLS protocol versions except TLS version 1 and higher, proceed as follows:

1. As **`root`**, open the **`/etc/httpd/conf.d/ssl.conf`** file and search for **all** instances of **`SSLProtocol`** directive. By default the file contains one section that looks as follows:

   ```
   ~]# vi /etc/httpd/conf.d/ssl.conf
   #   SSL Protocol support:
   # List the enable protocol levels with which clients will be able to
   # connect.  Disable SSLv2 access by default:
   SSLProtocol all -SSLv2
   ```

2. Edit the **`SSLProtocol`** line as follows:

   ```
   #   SSL Protocol support:
   # List the enable protocol levels with which clients will be able to
   # connect.  Disable SSLv2 access by default:
   SSLProtocol -all +TLSv1 +TLSv1.1 +TLSv1.2
   ```

   Save and close the file.

3. Verify the change as follows:

   ```
   ~]# grep SSLProtocol /etc/httpd/conf.d/ssl.conf
   SSLProtocol -all +TLSv1 +TLSv1.1 +TLSv1.2
   ```

4. Restart the Apache daemon as follows:

   ```
   ~]# service httpd restart
   ```

   Note that any sessions will be interrupted.

Procedure 18.3. Testing the Status of SSL and TLS Protocols

To check which versions of SSL and TLS are enabled or disabled, make use of the **`openssl s_client -connect`** command. The command has the following form:

```
openssl s_client -connect hostname:port -protocol
```

Where *port* is the port to test and *protocol* is the protocol version to test for. To test the SSL server running locally, use **`localhost`** as the host name. For example, to test the default port for secure HTTPS connections, port **443** to see if SSLv3 is enabled, issue a command as follows:

1.
   ```
   ~]# openssl s_client -connect localhost:443 -ssl3
   CONNECTED(00000003)
   139809943877536:error:14094410:SSL routines:SSL3_READ_BYTES:sslv3
   alert handshake failure:s3_pkt.c:1257:SSL alert number 40
   139809943877536:error:1409E0E5:SSL routines:SSL3_WRITE_BYTES:ssl
   ```

```
handshake failure:s3_pkt.c:596:
output omitted
New, (NONE), Cipher is (NONE)
Secure Renegotiation IS NOT supported
Compression: NONE
Expansion: NONE
SSL-Session:
    Protocol  : SSLv3
output truncated
```

The above output indicates that the handshake failed and therefore no cipher was negotiated.

2.

```
~]$ openssl s_client -connect localhost:443 -tls1_2
CONNECTED(00000003)
depth=0 C = --, ST = SomeState, L = SomeCity, O = SomeOrganization,
OU = SomeOrganizationalUnit, CN = localhost.localdomain,
emailAddress = root@localhost.localdomain
output omitted
New, TLSv1/SSLv3, Cipher is ECDHE-RSA-AES256-GCM-SHA384
Server public key is 2048 bit
Secure Renegotiation IS supported
Compression: NONE
Expansion: NONE
SSL-Session:
    Protocol  : TLSv1.2
output truncated
```

The above output indicates that no failure of the handshake occurred and a set of ciphers was negotiated.

The **`openssl s_client`** command options are documented in the **`s_client(1)`** manual page.

For more information on the SSLv3 vulnerability and how to test for it, see the Red Hat Knowledgebase article *POODLE: SSLv3 vulnerability (CVE-2014-3566)*.

18.1.10. Enabling the mod_nss Module

If you intend to set up an HTTPS server using **`mod_nss`**, the HTTPS server **cannot** simultaneously use **`mod_ssl`** with its default settings as **`mod_ssl`** will use port **`443`** by default, however this is the default HTTPS port. If is recommend to remove the package if it is not required.

To remove mod_ssl, enter the following command as **`root`**:

```
~]# yum remove mod_ssl
```

NOTE

If **`mod_ssl`** is required for other purposes, modify the **`/etc/httpd/conf.d/ssl.conf`** file to use a port other than **`443`** to prevent **`mod_ssl`** conflicting with **`mod_nss`** when its port to listen on is changed to **`443`**.

For a specific VirtualHost where HTTPS is required, **`mod_nss`** and **`mod_ssl`** can only co-exist at the same time if they use unique ports. For this reason **`mod_nss`** by default uses **`8443`**, but the default port for HTTPS is port **`443`**. The port is specified by the **`Listen`** directive as well as in the VirtualHost name or address.

Everything in NSS is associated with a "token". The software token exists in the NSS database but you can also have a physical token containing certificates. With OpenSSL, discrete certificates and private keys are held in PEM files. With NSS, these are stored in a database. Each certificate and key is associated with a token and each token can have a password protecting it. This password is optional, but if a password is used then the Apache HTTP server needs a copy of it in order to open the database without user intervention at system start.

Procedure 18.4. Configuring mod_nss

1. Install mod_nss as **`root`**:

   ```
   ~]# yum install mod_nss
   ```

   This will create the **`mod_nss`** configuration file at **`/etc/httpd/conf.d/nss.conf`**. The **`/etc/httpd/conf.d/`** directory is included in the main Apache HTTP Server configuration file by default. For the module to be loaded, restart the **`httpd`** service as described in Section 18.1.4.3, "Restarting the Service".

2. As **`root`**, open the **`/etc/httpd/conf.d/nss.conf`** file and search for **all** instances of the **`Listen`** directive.

   Edit the **`Listen 8443`** line as follows:

   ```
   Listen 443
   ```

   Port **`443`** is the default port for **`HTTPS`**.

3. Edit the default **`VirtualHost _default_:8443`** line as follows:

   ```
   VirtualHost _default_:443
   ```

   Edit any other non-default virtual host sections if they exist. Save and close the file.

4. Mozilla NSS stores certificates in a *server certificate database* indicated by the **`NSSCertificateDatabase`** directive in the **`/etc/httpd/conf.d/nss.conf`** file. By default the path is set to **`/etc/httpd/alias`**, the NSS database created during installation.

   To view the default NSS database, issue a command as follows:

   ```
   ~]# certutil -L -d /etc/httpd/alias

   Certificate Nickname                                         Trust
   Attributes
   ```

```
SSL,S/MIME,JAR/XPI

cacert
CTu,Cu,Cu
Server-Cert
u,u,u
alpha
u,pu,u
```

In the above command output, **`Server-Cert`** is the default **`NSSNickname`**. The **`-L`** option lists all the certificates, or displays information about a named certificate, in a certificate database. The **`-d`** option specifies the database directory containing the certificate and key database files. See the **`certutil(1)`** man page for more command line options.

5. To configure mod_nss to use another database, edit the **`NSSCertificateDatabase`** line in the **`/etc/httpd/conf.d/nss.conf`** file. The default file has the following lines within the VirtualHost section.

```
#   Server Certificate Database:
#   The NSS security database directory that holds the certificates
and
#   keys. The database consists of 3 files: cert8.db, key3.db and
secmod.db.
#   Provide the directory that these files exist.
NSSCertificateDatabase /etc/httpd/alias
```

   In the above command output, **`alias`** is the default NSS database directory, **`/etc/httpd/alias/`**.

6. To apply a password to the default NSS certificate database, use the following command as **`root`**:

```
~]# certutil -W -d /etc/httpd/alias
Enter Password or Pin for "NSS Certificate DB":
Enter a password which will be used to encrypt your keys.
The password should be at least 8 characters long,
and should contain at least one non-alphabetic character.

Enter new password:
Re-enter password:
Password changed successfully.
```

7. Before deploying the HTTPS server, create a new certificate database using a certificate signed by a certificate authority (CA).

Example 18.81. Adding a Certificate to the Mozilla NSS database

The **`certutil`** command is used to add a CA certificate to the NSS database files:

```
certutil -d /etc/httpd/nss-db-directory/ -A -n "CA_certificate" -
t CT,, -a -i certificate.pem
```

The above command adds a CA certificate stored in a PEM-formatted file named *certificate.pem*. The **-d** option specifies the NSS database directory containing the certificate and key database files, the **-n** option sets a name for the certificate, **-t CT,,** means that the certificate is trusted to be used in TLS clients and servers. The **-A** option adds an existing certificate to a certificate database. If the database does not exist it will be created. The **-a** option allows the use of ASCII format for input or output, and the **-i** option passes the **certificate.pem** input file to the command.

See the **certutil(1)** man page for more command line options.

8. The NSS database should be password protected to safeguard the private key.

Example 18.82. Setting_a_Password_for_a_Mozilla_NSS_database

The **certutil** tool can be used to set a password for an NSS database as follows:

```
certutil -W -d /etc/httpd/nss-db-directory/
```

For example, for the default database, issue a command as **root** as follows:

```
~]# certutil -W -d /etc/httpd/alias
Enter Password or Pin for "NSS Certificate DB":
Enter a password which will be used to encrypt your keys.
The password should be at least 8 characters long,
and should contain at least one non-alphabetic character.

Enter new password:
Re-enter password:
Password changed successfully.
```

9. Configure **mod_nss** to use the NSS internal software token by changing the line with the **NSSPassPhraseDialog** directive as follows:

```
~]# vi /etc/httpd/conf.d/nss.conf
NSSPassPhraseDialog file:/etc/httpd/password.conf
```

This is to avoid manual password entry on system start. The software token exists in the NSS database but you can also have a physical token containing your certificates.

10. If the SSL Server Certificate contained in the NSS database is an RSA certificate, make certain that the **NSSNickname** parameter is uncommented and matches the nickname displayed in step 4 above:

```
~]# vi /etc/httpd/conf.d/nss.conf
NSSNickname Server-Cert
```

If the SSL Server Certificate contained in the NSS database is an ECC certificate, make certain that the **NSSECCNickname** parameter is uncommented and matches the nickname displayed in step 4 above:

```
~]# vi /etc/httpd/conf.d/nss.conf
NSSECCNickname Server-Cert
```

Make certain that the **`NSSCertificateDatabase`** parameter is uncommented and points to the NSS database directory displayed in step 4 or configured in step 5 above:

```
~]# vi /etc/httpd/conf.d/nss.conf
NSSCertificateDatabase /etc/httpd/alias
```

Replace **`/etc/httpd/alias`** with the path to the certificate database to be used.

11. Create the **`/etc/httpd/password.conf`** file as **`root`**:

```
~]# vi /etc/httpd/password.conf
```

Add a line with the following form:

```
internal:password
```

Replacing *password* with the password that was applied to the NSS security databases in step 6 above.

12. Apply the appropriate ownership and permissions to the **`/etc/httpd/password.conf`** file:

```
~]# chgrp apache /etc/httpd/password.conf
~]# chmod 640 /etc/httpd/password.conf
~]# ls -l /etc/httpd/password.conf
-rw-r-----. 1 root apache 10 Dec  4 17:13 /etc/httpd/password.conf
```

13. To configure **`mod_nss`** to use the NSS the software token in **`/etc/httpd/password.conf`**, edit **`/etc/httpd/conf.d/nss.conf`** as follows:

```
~]# vi /etc/httpd/conf.d/nss.conf
```

14. Restart the Apache server for the changes to take effect as described in Section 18.1.4.3, “Restarting the Service”

IMPORTANT

Due to the vulnerability described in *POODLE: SSLv3 vulnerability (CVE-2014-3566)*, Red Hat recommends disabling **`SSL`**, if it is enabled, and using only **`TLSv1.1`** or **`TLSv1.2`**. Backwards compatibility can be achieved using **`TLSv1.0`**. Many products Red Hat supports have the ability to use **`SSLv2`** or **`SSLv3`** protocols. However, the use of **`SSLv2`** or **`SSLv3`** is now strongly recommended against.

18.1.10.1. Enabling and Disabling SSL and TLS in mod_nss

To disable and enable specific versions of the SSL and TLS protocol, either do it globally by adding the **`NSSProtocol`** directive in the “## SSL Global Context” section of the configuration file and removing it everywhere else, or edit the default entry under “# SSL Protocol” in all “VirtualHost” sections. If you do not specify it in the per-domain VirtualHost section then it will inherit the settings from the global section. To make sure that a protocol version is being disabled the administrator should either **only** specify **`NSSProtocol`** in the “SSL Global Context” section, or specify it in **all** per-domain VirtualHost sections.

Note that in Red Hat Enterprise Linux 6.8 SSLv2 is disabled by default.

Procedure 18.5. Disable All SSL and TLS Protocols Except TLS 1 and Up in mod_nss

To disable all SSL and TLS protocol versions except TLS version 1 and higher, proceed as follows:

1. As **root**, open the **/etc/httpd/conf.d/nss.conf** file and search for **all** instances of the **NSSProtocol** directive. By default, the configuration file contains one section that looks as follows:

   ```
   ~]# vi /etc/httpd/conf.d/nss.conf
   #   SSL Protocol:
   output omitted
   #   Since all protocol ranges are completely inclusive, and no
   protocol in the
   #   middle of a range may be excluded, the entry "NSSProtocol
   SSLv3,TLSv1.1"
   #   is identical to the entry "NSSProtocol SSLv3,TLSv1.0,TLSv1.1".
   NSSProtocol TLSv1.0,TLSv1.1,TLSv1.2
   ```

   This section is within the VirtualHost section.

2. Edit the **NSSProtocol** line as follows:

   ```
   #   SSL Protocol:
   NSSProtocol TLSv1.0,TLSv1.1,TLSv1.2
   ```

   Repeat this action for all VirtualHost sections.

3. Edit the **Listen 8443** line as follows:

   ```
   Listen 443
   ```

4. Edit the default **VirtualHost _default_:8443** line as follows:

   ```
   VirtualHost _default_:443
   ```

   Edit any other non-default virtual host sections if they exist. Save and close the file.

5. Verify that all occurrences of the **NSSProtocol** directive have been changed as follows:

   ```
   ~]# grep NSSProtocol /etc/httpd/conf.d/nss.conf
   #   middle of a range may be excluded, the entry "NSSProtocol
   SSLv3,TLSv1.1"
   #   is identical to the entry "NSSProtocol SSLv3,TLSv1.0,TLSv1.1".
   NSSProtocol TLSv1.0,TLSv1.1,TLSv1.2
   ```

   This step is particularly important if you have more than one VirtualHost section.

6. Restart the Apache daemon as follows:

   ```
   ~]# service httpd restart
   ```

   Note that any sessions will be interrupted.

Procedure 18.6. Testing the Status of SSL and TLS Protocols in mod_nss

To check which versions of SSL and TLS are enabled or disabled in **mod_nss**, make use of the **`openssl s_client -connect`** command. Install the openssl package as **`root`**:

```
~]# yum install openssl
```

The **`openssl s_client -connect`** command has the following form:

```
openssl s_client -connect hostname:port -protocol
```

Where *port* is the port to test and *protocol* is the protocol version to test for. To test the SSL server running locally, use **`localhost`** as the host name. For example, to test the default port for secure HTTPS connections, port **`443`** to see if SSLv3 is enabled, issue a command as follows:

1.
   ```
   ~]# openssl s_client -connect localhost:443 -ssl3
   CONNECTED(00000003)
   3077773036:error:1408F10B:SSL routines:SSL3_GET_RECORD:wrong version
   number:s3_pkt.c:337:
   output omitted
   New, (NONE), Cipher is (NONE)
   Secure Renegotiation IS NOT supported
   Compression: NONE
   Expansion: NONE
   SSL-Session:
       Protocol  : SSLv3
   output truncated
   ```

   The above output indicates that the handshake failed and therefore no cipher was negotiated.

2.
   ```
   ~]$ openssl s_client -connect localhost:443 -tls1_2
   CONNECTED(00000003)
   depth=1 C = US, O = example.com, CN = Certificate Shack
   output omitted
   New, TLSv1/SSLv3, Cipher is AES256-SHA
   Server public key is 1024 bit
   Secure Renegotiation IS supported
   Compression: NONE
   Expansion: NONE
   SSL-Session:
       Protocol  : TLSv1.2
       Cipher    : AES256-SHA
   output truncated
   ```

   The above output indicates that no failure of the handshake occurred and a set of ciphers was negotiated.

The **`openssl s_client`** command options are documented in the **`s_client(1)`** manual page.

For more information on the SSLv3 vulnerability and how to test for it, see the Red Hat Knowledgebase article *POODLE: SSLv3 vulnerability (CVE-2014-3566)*.

18.1.11. Using an Existing Key and Certificate

If you have a previously created key and certificate, you can configure the SSL server to use these files instead of generating new ones. There are only two situations where this is not possible:

1. *You are changing the IP address or domain name.*

   Certificates are issued for a particular IP address and domain name pair. If one of these values changes, the certificate becomes invalid.

2. *You have a certificate from VeriSign, and you are changing the server software.*

   VeriSign, a widely used certificate authority, issues certificates for a particular software product, IP address, and domain name. Changing the software product renders the certificate invalid.

In either of the above cases, you will need to obtain a new certificate. For more information on this topic, see Section 18.1.12, "Generating a New Key and Certificate".

If you want to use an existing key and certificate, move the relevant files to the **/etc/pki/tls/private/** and **/etc/pki/tls/certs/** directories respectively. You can do so by issuing the following commands as **root**:

```
~]# mv key_file.key /etc/pki/tls/private/hostname.key
~]# mv certificate.crt /etc/pki/tls/certs/hostname.crt
```

Then add the following lines to the **/etc/httpd/conf.d/ssl.conf** configuration file:

```
SSLCertificateFile /etc/pki/tls/certs/hostname.crt
SSLCertificateKeyFile /etc/pki/tls/private/hostname.key
```

To load the updated configuration, restart the **httpd** service as described in Section 18.1.4.3, "Restarting the Service".

Example 18.83. Using a key and certificate from the Red Hat Secure Web Server

```
~]# mv /etc/httpd/conf/httpsd.key
/etc/pki/tls/private/penguin.example.com.key
~]# mv /etc/httpd/conf/httpsd.crt
/etc/pki/tls/certs/penguin.example.com.crt
```

18.1.12. Generating a New Key and Certificate

In order to generate a new key and certificate pair, the crypto-utils package must be installed on the system. In Red Hat Enterprise Linux 6, the mod_ssl package is required by the **genkey** utility. To install these, enter the following command as **root**:

```
~]# yum install crypto-utils mod_ssl
```

This package provides a set of tools to generate and manage SSL certificates and private keys, and includes **genkey**, the Red Hat Keypair Generation utility that will guide you through the key generation process.

IMPORTANT

If the server already has a valid certificate and you are replacing it with a new one, specify a different serial number. This ensures that client browsers are notified of this change, update to this new certificate as expected, and do not fail to access the page. To create a new certificate with a custom serial number, use the following command instead of **genkey**:

```
~]# openssl req -x509 -new -set_serial number -key hostname.key
-out hostname.crt
```

NOTE

If there already is a key file for a particular host name in your system, **genkey** will refuse to start. In this case, remove the existing file using the following command as **root**:

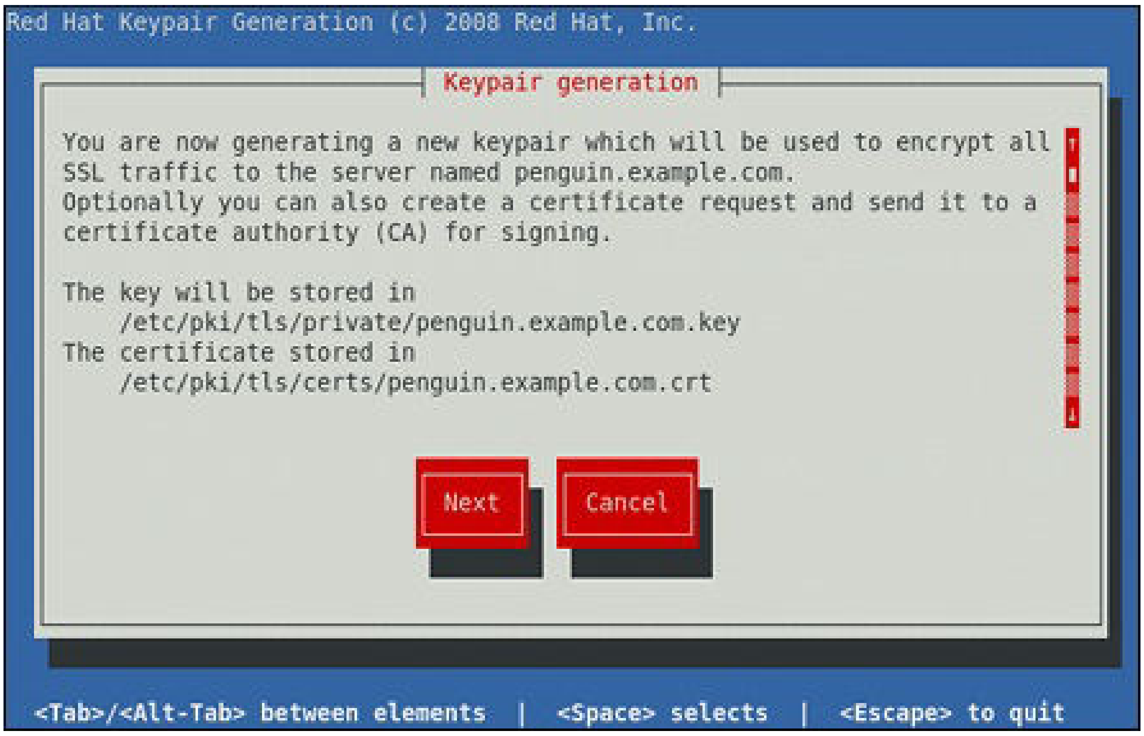
```
~]# rm /etc/pki/tls/private/hostname.key
```

To run the utility enter the **genkey** command as **root**, followed by the appropriate host name (for example, **penguin.example.com**):

```
~]# genkey hostname
```

To complete the key and certificate creation, take the following steps:

1. Review the target locations in which the key and certificate will be stored.

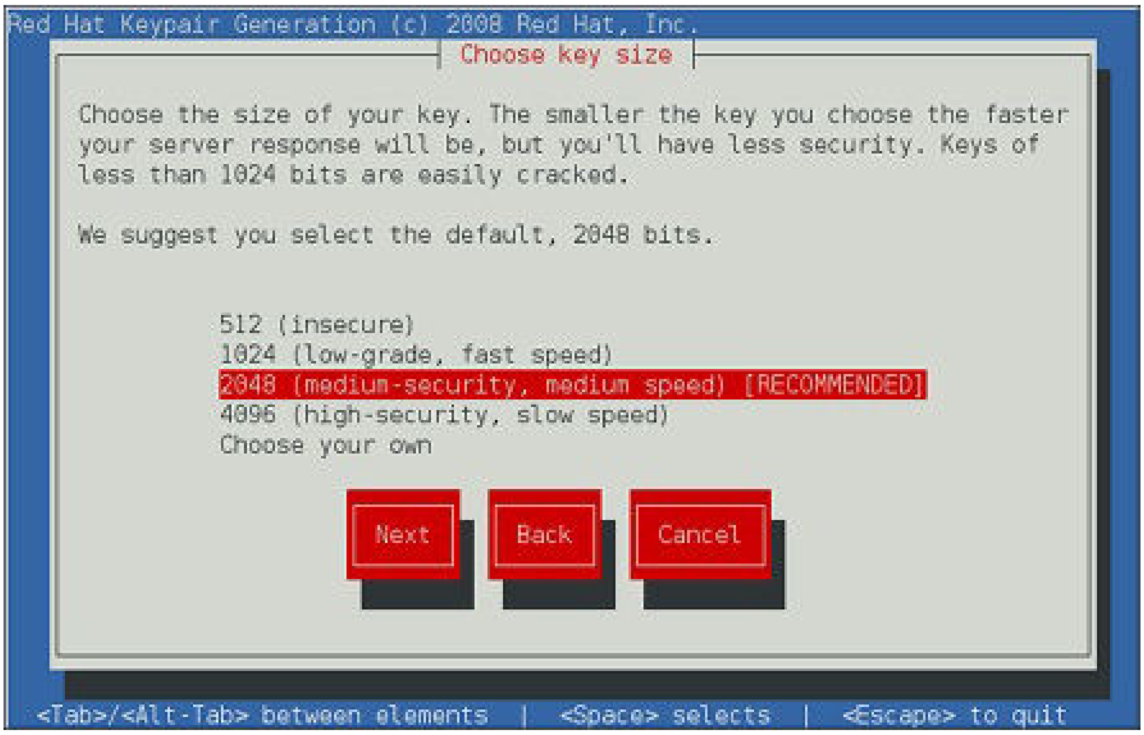


```
Red Hat Keypair Generation (c) 2008 Red Hat, Inc.

Keypair generation

You are now generating a new keypair which will be used to encrypt all
SSL traffic to the server named penguin.example.com.
Optionally you can also create a certificate request and send it to a
certificate authority (CA) for signing.

The key will be stored in
    /etc/pki/tls/private/penguin.example.com.key
The certificate stored in
    /etc/pki/tls/certs/penguin.example.com.crt

                    Next      Cancel

<Tab>/<Alt-Tab> between elements   |  <Space> selects  |  <Escape> to quit
```

Figure 18.1. Running the genkey utility

Use the **Tab** key to select the **Next** button, and press **Enter** to proceed to the next screen.

2. Using the **up** and **down** arrow keys, select a suitable key size. Note that while a larger key increases the security, it also increases the response time of your server. The NIST recommends using **`2048 bits`**. See *NIST Special Publication 800-131A*.

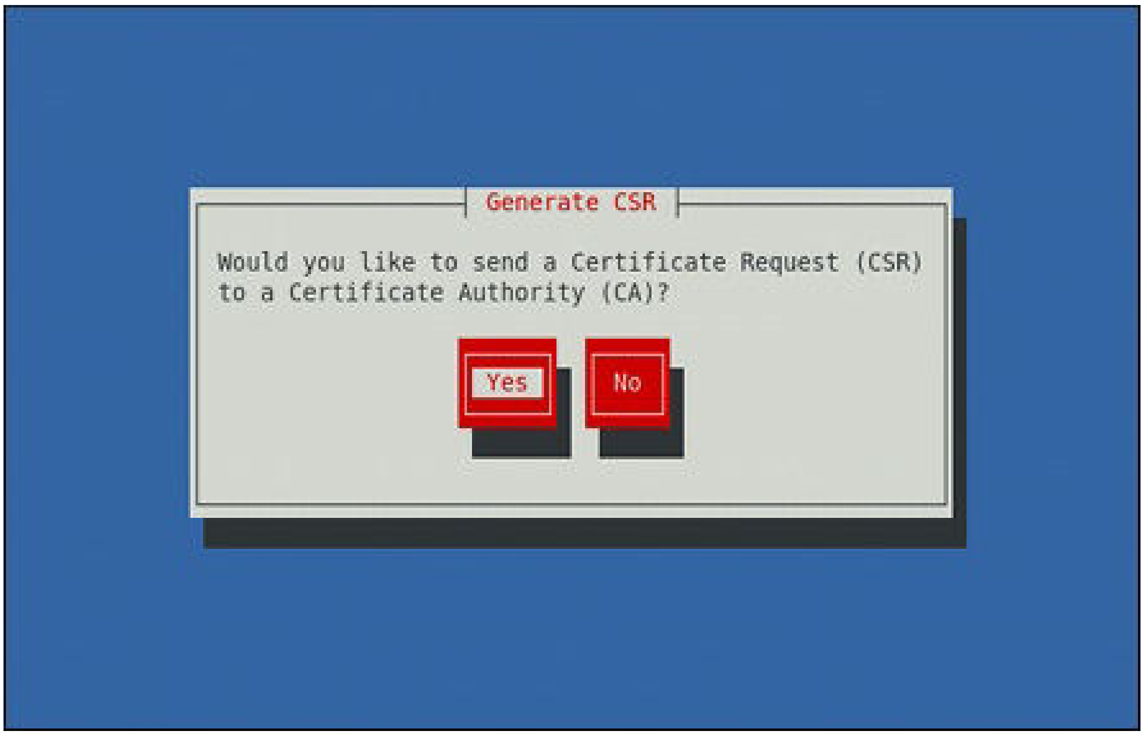


```
Red Hat Keypair Generation (c) 2008 Red Hat, Inc.
                          Choose key size

  Choose the size of your key. The smaller the key you choose the faster
  your server response will be, but you'll have less security. Keys of
  less than 1024 bits are easily cracked.

  We suggest you select the default, 2048 bits.


            512 (insecure)
            1024 (low-grade, fast speed)
            2048 (medium-security, medium speed) [RECOMMENDED]
            4096 (high-security, slow speed)
            Choose your own

                     Next      Back      Cancel

  <Tab>/<Alt-Tab> between elements  |  <Space> selects  |  <Escape> to quit
```

Figure 18.2. Selecting the key size

Once finished, use the **`Tab`** key to select the **`Next`** button, and press **`Enter`** to initiate the random bits generation process. Depending on the selected key size, this may take some time.

3. Decide whether you want to send a certificate request to a certificate authority.

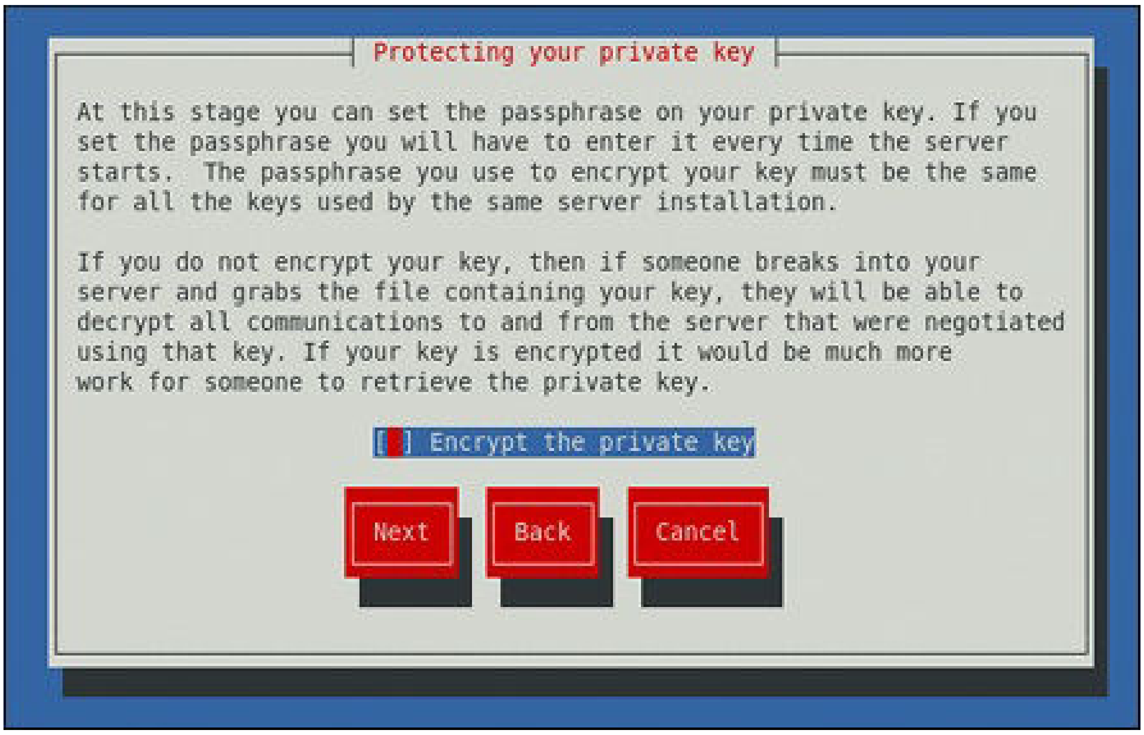


```
                 Generate CSR

  Would you like to send a Certificate Request (CSR)
  to a Certificate Authority (CA)?

                 Yes      No
```

Figure 18.3. Generating a certificate request

Use the **Tab** key to select **Yes** to compose a certificate request, or **No** to generate a self-signed certificate. Then press **Enter** to confirm your choice.

4. Using the **Spacebar** key, enable (**[*]**) or disable (**[ ]**) the encryption of the private key.

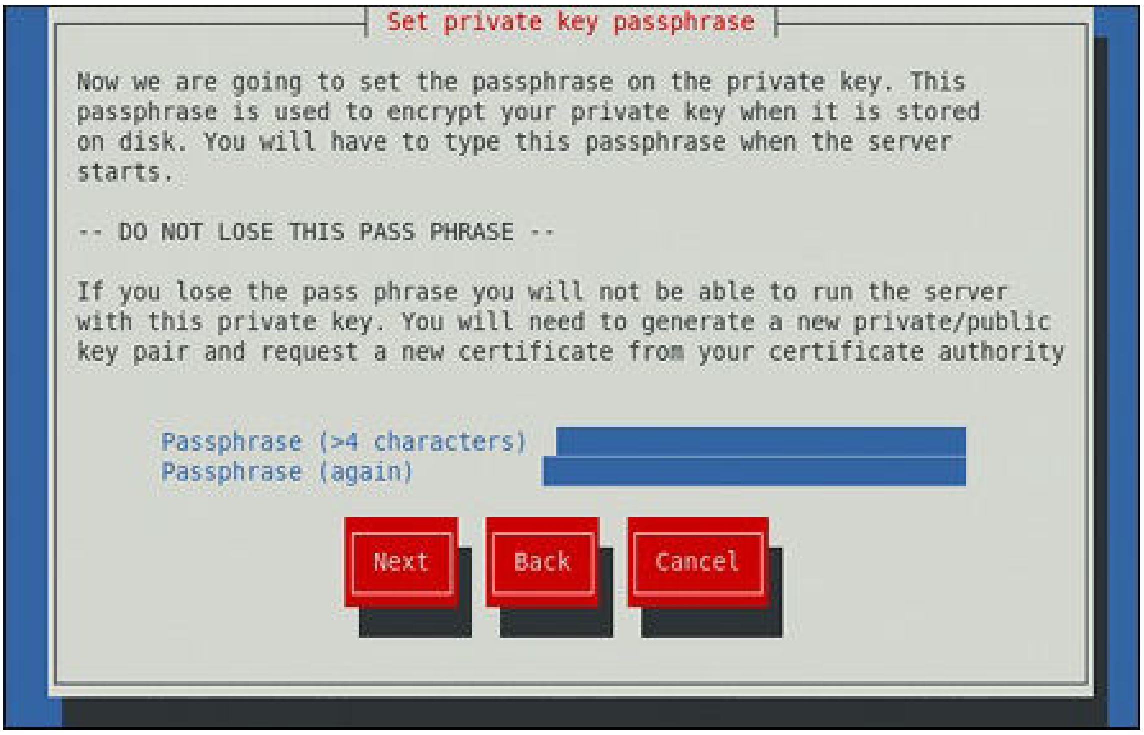


```
Protecting your private key

At this stage you can set the passphrase on your private key. If you
set the passphrase you will have to enter it every time the server
starts.  The passphrase you use to encrypt your key must be the same
for all the keys used by the same server installation.

If you do not encrypt your key, then if someone breaks into your
server and grabs the file containing your key, they will be able to
decrypt all communications to and from the server that were negotiated
using that key. If your key is encrypted it would be much more
work for someone to retrieve the private key.

[ ] Encrypt the private key

Next    Back    Cancel
```

Figure 18.4. Encrypting the private key

Use the **Tab** key to select the **Next** button, and press **Enter** to proceed to the next screen.

5. If you have enabled the private key encryption, enter an adequate passphrase. Note that for security reasons, it is not displayed as you type, and it must be at least five characters long.



```
Set private key passphrase

Now we are going to set the passphrase on the private key. This
passphrase is used to encrypt your private key when it is stored
on disk. You will have to type this passphrase when the server
starts.

-- DO NOT LOSE THIS PASS PHRASE --

If you lose the pass phrase you will not be able to run the server
with this private key. You will need to generate a new private/public
key pair and request a new certificate from your certificate authority

Passphrase (>4 characters)
Passphrase (again)

Next    Back    Cancel
```

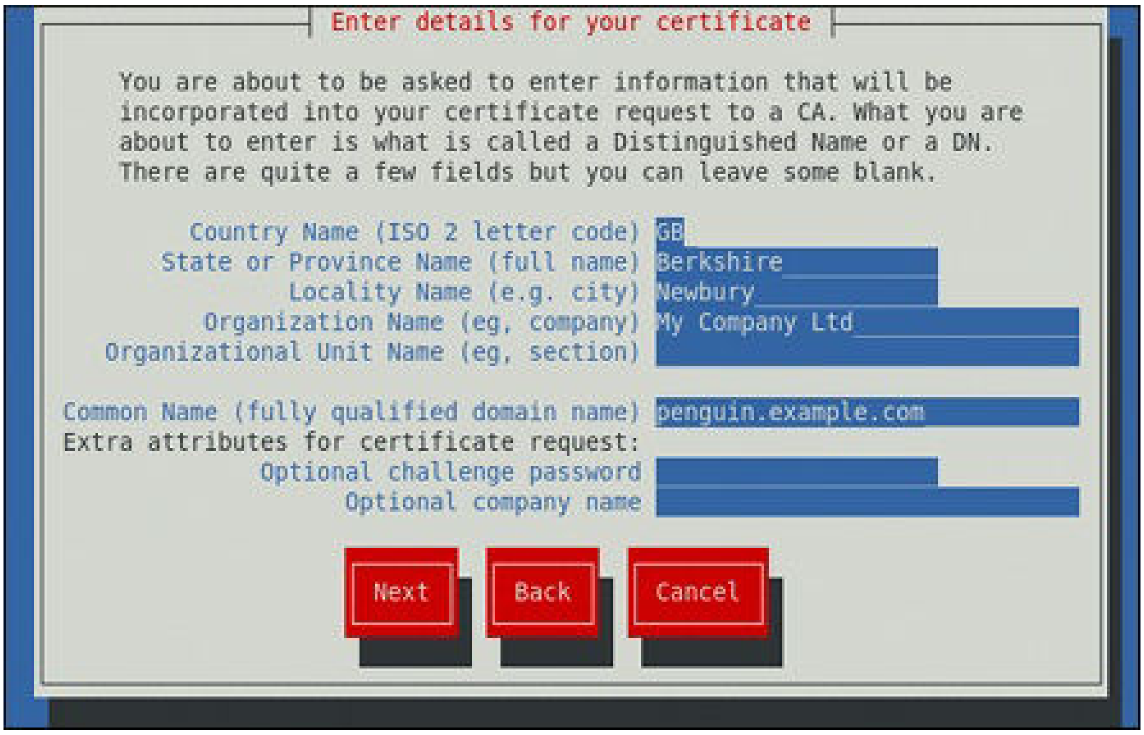
Figure 18.5. Entering a passphrase

Use the **`Tab`** key to select the **`Next`** button, and press **`Enter`** to proceed to the next screen.

IMPORTANT

Entering the correct passphrase is required in order for the server to start. If you lose it, you will need to generate a new key and certificate.

6. Customize the certificate details.

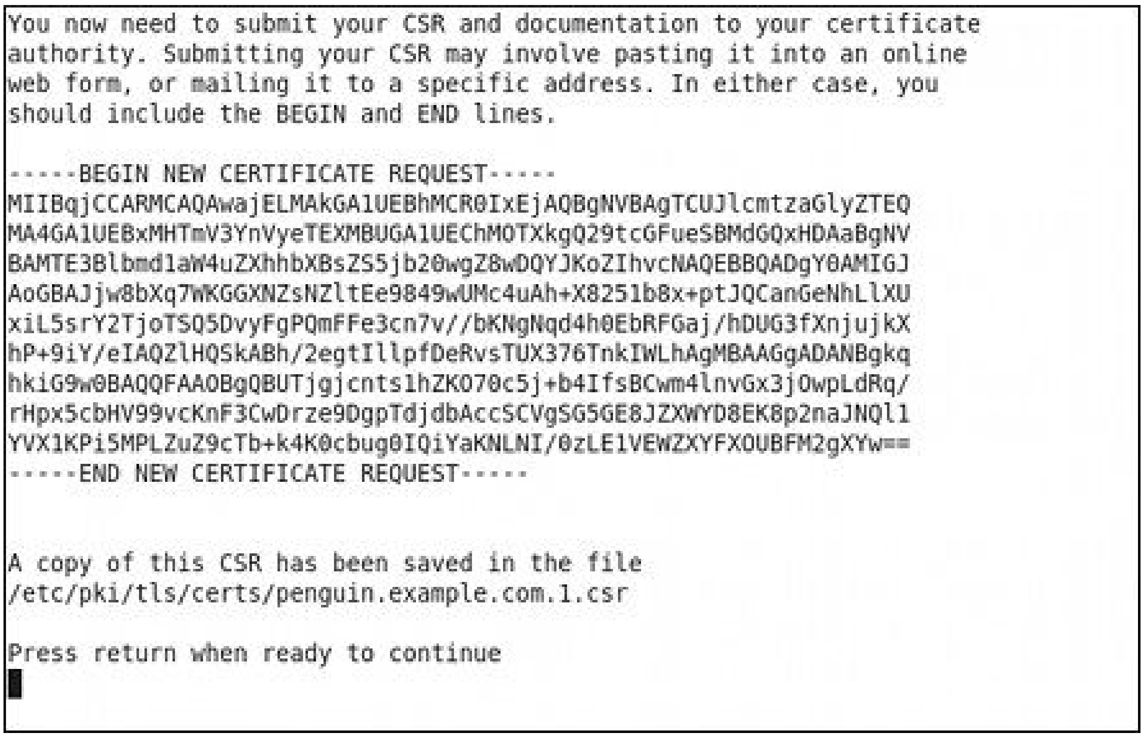


```
Enter details for your certificate

  You are about to be asked to enter information that will be
  incorporated into your certificate request to a CA. What you are
  about to enter is what is called a Distinguished Name or a DN.
  There are quite a few fields but you can leave some blank.

       Country Name (ISO 2 letter code) GB
      State or Province Name (full name) Berkshire
             Locality Name (e.g. city) Newbury
        Organization Name (eg, company) My Company Ltd
    Organizational Unit Name (eg, section)

Common Name (fully qualified domain name) penguin.example.com
Extra attributes for certificate request:
            Optional challenge password
                  Optional company name
```

Figure 18.6. Specifying certificate information

Use the **`Tab`** key to select the **`Next`** button, and press **`Enter`** to finish the key generation.

7. If you have previously enabled the certificate request generation, you will be prompted to send it to a certificate authority.



```
You now need to submit your CSR and documentation to your certificate
authority. Submitting your CSR may involve pasting it into an online
web form, or mailing it to a specific address. In either case, you
should include the BEGIN and END lines.

-----BEGIN NEW CERTIFICATE REQUEST-----
MIIBqjCCARMCAQAwajELMAkGA1UEBhMCR0IxEjAQBgNVBAgTCUJlcmtzaGlyZTEQ
MA4GA1UEBxMHTmV3YnVyeTEXMBUGA1UEChMOTXkgQ29tcGFueSBMdGQxHDAaBgNV
BAMTE3BlbmdlaW4uZXhhbXBsZS5jb20wgZ8wDQYJKoZIhvcNAQEBBQADgY0AMIGJ
AoGBAJjw8bXq7WKGGXNZsNZltEe9849wUMc4uAh+X8251b8x+ptJQCanGeNhLlXU
xiL5srY2TjoTSQ5DvyFgPQmFFe3cn7v//bKNgNqd4h0EbRFGaj/hDUG3fXnjujkX
hP+9iY/eIAQZlHQSkABh/2egtIllpfDeRvsTUX376TnkIWLhAgMBAAGgADANBgkq
hkiG9w0BAQQFAAOBgQBUTjgjcnts1hZKO70c5j+b4IfsBCwm4lnvGx3jOwpLdRq/
rHpx5cbHV99vcKnF3CwDrze9DgpTdjdbAccSCVgSG5GE8JZXWYD8EK8p2naJNQl1
YVX1KPi5MPLZuZ9cTb+k4K0cbug0IQiYaKNLNI/0zLE1VEWZXYFXOUBFM2gXYw==
-----END NEW CERTIFICATE REQUEST-----


A copy of this CSR has been saved in the file
/etc/pki/tls/certs/penguin.example.com.1.csr

Press return when ready to continue
```

Figure 18.7. Instructions on how to send a certificate request

Press **`Enter`** to return to a shell prompt.

Once generated, add the key and certificate locations to the **`/etc/httpd/conf.d/ssl.conf`** configuration file:

```
SSLCertificateFile /etc/pki/tls/certs/hostname.crt
SSLCertificateKeyFile /etc/pki/tls/private/hostname.key
```

Finally, restart the **`httpd`** service as described in Section 18.1.4.3, “Restarting the Service”, so that the updated configuration is loaded.

18.1.13. Configure the Firewall for HTTP and HTTPS Using the Command Line

Red Hat Enterprise Linux does not allow **`HTTP`** and **`HTTPS`** traffic by default. To enable the system to act as a web server, enable ports and protocols as required. The default port for **`HTTP`** is **`80`** and the default port for **`HTTPS`** is **`443`**. In both cases the **`TCP`** should be allowed to pass through the firewall.

To enable port **`80`** for **`HTTP`** using the command line, issue the following command as **`root`**:

```
~]# lokkit --port=80:tcp --update
```

Note that this will restart the firewall as long as it has not been disabled with the **`--disabled`** option. Active connections will be terminated and time out on the initiating machine. Use the **`lokkit --help`** command to view the built in help.

To enable port **`443`** for **`HTTPS`** using the command line, issue the following command as **`root`**:

```
~]# lokkit --port=443:tcp --update
```

Note that this will restart the firewall as long as it has not been disabled with the **`--disabled`** option. Active connections will be terminated and time out on the initiating machine. See the **`/etc/services`** file for list of services and their associated ports.

When preparing a configuration file for multiple installations using administration tools, it is useful to edit the firewall configuration file directly. Note that any mistakes in the configuration file could have unexpected consequences, cause an error, and prevent the firewall settings from being applied. Therefore, check the **`/etc/sysconfig/system-config-firewall`** file thoroughly after editing. To apply the settings in **`/etc/sysconfig/system-config-firewall`**, issue the following command as **`root`**:

```
~]# lokkit --update
```

For example, to enable **`HTTPS`** to pass through the firewall, by editing the configuration file, become the **`root`** user and add the following line to **`/etc/sysconfig/system-config-firewall`**:

```
 --port=443:tcp
```

Note that these changes will not take effect even if the firewall is reloaded or the system rebooted. To apply the changes in **`/etc/sysconfig/system-config-firewall`**, issue the following command as **`root`**:

```
~]# lokkit --update
```

18.1.13.1. Checking Network Access for Incoming HTTPS and HTTPS Using the Command Line

To check what the firewall is configured to allow, using the command line, issue the following command as **`root`**:

```
~]# less /etc/sysconfig/system-config-firewall
# Configuration file for system-config-firewall

--enabled
--service=ssh
```

In this example taken from a default installation, the firewall is enabled but **`HTTP`** and **`HTTPS`** have not been allowed to pass through.

Once the default port for **`HTTP`** is enabled, the following line appears as output in addition to the lines shown above:

```
--port=80:tcp
```

To check if the firewall is currently allowing incoming **`HTTP`** traffic for clients, issue the following command as **`root`**:

```
~]# iptables -L -n | grep 'tcp.*80'
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW
tcp dpt:80
```

Once the default port for **`HTTPS`** is enabled, the following line appears as output in addition to the lines shown above:

```
--port=443:tcp
```

To check if the firewall is currently allowing incoming **HTTPS** traffic for clients, issue the following command as **root**:

```
~]# iptables -L -n | grep 'tcp.*443'
ACCEPT     tcp  --  0.0.0.0/0            0.0.0.0/0           state NEW
tcp dpt:443
```

18.1.14. Additional Resources

To learn more about the Apache HTTP Server, see the following resources.

Installed Documentation

- **httpd(8)** — The manual page for the **httpd** service containing the complete list of its command-line options.
- **genkey(1)** — The manual page for **genkey** utility, provided by the crypto-utils package.

Installable Documentation

- http://localhost/manual/ — The official documentation for the Apache HTTP Server with the full description of its directives and available modules. Note that in order to access this documentation, you must have the httpd-manual package installed, and the web server must be running.

  Before accessing the documentation, issue the following commands as **root**:

  ```
  ~]# yum install httpd-manual
  ~]# service httpd graceful
  ```

Online Documentation

- http://httpd.apache.org/ — The official website for the Apache HTTP Server with documentation on all the directives and default modules.
- http://www.openssl.org/ — The OpenSSL home page containing further documentation, frequently asked questions, links to the mailing lists, and other useful resources.

CHAPTER 19. MAIL SERVERS

Red Hat Enterprise Linux offers many advanced applications to serve and access email. This chapter describes modern email protocols in use today, and some of the programs designed to send and receive email.

19.1. EMAIL PROTOCOLS

Today, email is delivered using a client/server architecture. An email message is created using a mail client program. This program then sends the message to a server. The server then forwards the message to the recipient's email server, where the message is then supplied to the recipient's email client.

To enable this process, a variety of standard network protocols allow different machines, often running different operating systems and using different email programs, to send and receive email.

The following protocols discussed are the most commonly used in the transfer of email.

19.1.1. Mail Transport Protocols

Mail delivery from a client application to the server, and from an originating server to the destination server, is handled by the *Simple Mail Transfer Protocol* (*SMTP*).

19.1.1.1. SMTP

The primary purpose of SMTP is to transfer email between mail servers. However, it is critical for email clients as well. To send email, the client sends the message to an outgoing mail server, which in turn contacts the destination mail server for delivery. For this reason, it is necessary to specify an SMTP server when configuring an email client.

Under Red Hat Enterprise Linux, a user can configure an SMTP server on the local machine to handle mail delivery. However, it is also possible to configure remote SMTP servers for outgoing mail.

One important point to make about the SMTP protocol is that it does not require authentication. This allows anyone on the Internet to send email to anyone else or even to large groups of people. It is this characteristic of SMTP that makes junk email or *spam* possible. Imposing relay restrictions limits random users on the Internet from sending email through your SMTP server, to other servers on the internet. Servers that do not impose such restrictions are called *open relay* servers.

Red Hat Enterprise Linux provides the Postfix and Sendmail SMTP programs.

19.1.2. Mail Access Protocols

There are two primary protocols used by email client applications to retrieve email from mail servers: the *Post Office Protocol* (*POP*) and the *Internet Message Access Protocol* (*IMAP*).

19.1.2.1. POP

The default POP server under Red Hat Enterprise Linux is **Dovecot** and is provided by the dovecot package.

NOTE

In order to use **Dovecot**, first ensure the dovecot package is installed on your system by running, as **`root`**:

```
~]# yum install dovecot
```

For more information on installing packages with Yum, see Section 8.2.4, “Installing Packages”.

When using a **`POP`** server, email messages are downloaded by email client applications. By default, most **`POP`** email clients are automatically configured to delete the message on the email server after it has been successfully transferred, however this setting usually can be changed.

`POP` is fully compatible with important Internet messaging standards, such as *Multipurpose Internet Mail Extensions* (*MIME*), which allow for email attachments.

`POP` works best for users who have one system on which to read email. It also works well for users who do not have a persistent connection to the Internet or the network containing the mail server. Unfortunately for those with slow network connections, **`POP`** requires client programs upon authentication to download the entire content of each message. This can take a long time if any messages have large attachments.

The most current version of the standard **`POP`** protocol is **`POP3`**.

There are, however, a variety of lesser-used **`POP`** protocol variants:

- *APOP* — **`POP3`** with **`MD5`** authentication. An encoded hash of the user's password is sent from the email client to the server rather than sending an unencrypted password.
- *KPOP* — **`POP3`** with Kerberos authentication.
- *RPOP* — **`POP3`** with **`RPOP`** authentication. This uses a per-user ID, similar to a password, to authenticate POP requests. However, this ID is not encrypted, so **`RPOP`** is no more secure than standard **`POP`**.

For added security, it is possible to use *Secure Socket Layer* (*SSL*) encryption for client authentication and data transfer sessions. This can be enabled by using the **`pop3s`** service, or by using the **`stunnel`** application. For more information on securing email communication, see Section 19.5.1, “Securing Communication”.

19.1.2.2. IMAP

The default **`IMAP`** server under Red Hat Enterprise Linux is **Dovecot** and is provided by the dovecot package. See Section 19.1.2.1, “POP” for information on how to install **Dovecot**.

When using an **`IMAP`** mail server, email messages remain on the server where users can read or delete them. **`IMAP`** also allows client applications to create, rename, or delete mail directories on the server to organize and store email.

`IMAP` is particularly useful for users who access their email using multiple machines. The protocol is also convenient for users connecting to the mail server via a slow connection, because only the email header information is downloaded for messages until opened, saving bandwidth. The user also has the ability to delete messages without viewing or downloading them.

For convenience, **IMAP** client applications are capable of caching copies of messages locally, so the user can browse previously read messages when not directly connected to the **IMAP** server.

IMAP, like **POP**, is fully compatible with important Internet messaging standards, such as MIME, which allow for email attachments.

For added security, it is possible to use **SSL** encryption for client authentication and data transfer sessions. This can be enabled by using the **imaps** service, or by using the **stunnel** program. For more information on securing email communication, see Section 19.5.1, “Securing Communication”.

Other free, as well as commercial, IMAP clients and servers are available, many of which extend the IMAP protocol and provide additional functionality.

19.1.2.3. Dovecot

The **imap-login** and **pop3-login** processes which implement the **IMAP** and **POP3** protocols are spawned by the master **dovecot** daemon included in the dovecot package. The use of **IMAP** and **POP** is configured through the **/etc/dovecot/dovecot.conf** configuration file; by default **dovecot** runs **IMAP** and **POP3** together with their secure versions using **SSL**. To configure **dovecot** to use **POP**, complete the following steps:

1. Edit the **/etc/dovecot/dovecot.conf** configuration file to make sure the **protocols** variable is uncommented (remove the hash sign (#) at the beginning of the line) and contains the **pop3** argument. For example:

   ```
   protocols = imap pop3 lmtp
   ```

   When the **protocols** variable is left commented out, **dovecot** will use the default values as described above.

2. Make the change operational for the current session by running the following command:

   ```
   ~]# service dovecot restart
   ```

3. Make the change operational after the next reboot by running the command:

   ```
   ~]# chkconfig dovecot on
   ```

   NOTE

   Please note that **dovecot** only reports that it started the **IMAP** server, but also starts the **POP3** server.

Unlike **SMTP**, both **IMAP** and **POP3** require connecting clients to authenticate using a user name and password. By default, passwords for both protocols are passed over the network unencrypted.

To configure **SSL** on **dovecot**:

- Edit the **/etc/dovecot/conf.d/10-ssl.conf** configuration to make sure the **ssl_cipher_list** variable is uncommented, and append **:!SSLv3**:

  ```
  ssl_cipher_list = ALL:!LOW:!SSLv2:!EXP:!aNULL:!SSLv3
  ```

These values ensure that **dovecot** avoids SSL versions 2 and also 3, which are both known to be insecure. This is due to the vulnerability described in *POODLE: SSLv3 vulnerability (CVE-2014-3566)*. See *Resolution for POODLE SSL 3.0 vulnerability (CVE-2014-3566) in Postfix and Dovecot* for details.

- Edit the **/etc/pki/dovecot/dovecot-openssl.cnf** configuration file as you prefer. However, in a typical installation, this file does not require modification.
- Rename, move or delete the files **/etc/pki/dovecot/certs/dovecot.pem** and **/etc/pki/dovecot/private/dovecot.pem**.
- Execute the **/usr/libexec/dovecot/mkcert.sh** script which creates the **dovecot** self signed certificates. These certificates are copied in the **/etc/pki/dovecot/certs** and **/etc/pki/dovecot/private** directories. To implement the changes, restart **dovecot**:

```
~]# service dovecot restart
```

More details on **dovecot** can be found online at http://www.dovecot.org.

19.2. EMAIL PROGRAM CLASSIFICATIONS

In general, all email applications fall into at least one of three classifications. Each classification plays a specific role in the process of moving and managing email messages. While most users are only aware of the specific email program they use to receive and send messages, each one is important for ensuring that email arrives at the correct destination.

19.2.1. Mail Transport Agent

A *Mail Transport Agent* (*MTA*) transports email messages between hosts using **SMTP**. A message may involve several MTAs as it moves to its intended destination.

While the delivery of messages between machines may seem rather straightforward, the entire process of deciding if a particular MTA can or should accept a message for delivery is quite complicated. In addition, due to problems from spam, use of a particular MTA is usually restricted by the MTA's configuration or the access configuration for the network on which the MTA resides.

Many modern email client programs can act as an MTA when sending email. However, this action should not be confused with the role of a true MTA. The sole reason email client programs are capable of sending email like an MTA is because the host running the application does not have its own MTA. This is particularly true for email client programs on non-UNIX-based operating systems. However, these client programs only send outbound messages to an MTA they are authorized to use and do not directly deliver the message to the intended recipient's email server.

Since Red Hat Enterprise Linux offers two MTAs, *Postfix* and *Sendmail*, email client programs are often not required to act as an MTA. Red Hat Enterprise Linux also includes a special purpose MTA called *Fetchmail*.

For more information on Postfix, Sendmail, and Fetchmail, see Section 19.3, “Mail Transport Agents”.

19.2.2. Mail Delivery Agent

A *Mail Delivery Agent* (*MDA*) is invoked by the MTA to file incoming email in the proper user's mailbox. In many cases, the MDA is actually a *Local Delivery Agent* (*LDA*), such as **mail** or Procmail.

Any program that actually handles a message for delivery to the point where it can be read by an email client application can be considered an MDA. For this reason, some MTAs (such as Sendmail and Postfix) can fill the role of an MDA when they append new email messages to a local user's mail spool file. In general, MDAs do not transport messages between systems nor do they provide a user interface; MDAs distribute and sort messages on the local machine for an email client application to access.

19.2.3. Mail User Agent

A *Mail User Agent* (*MUA*) is synonymous with an email client application. An MUA is a program that, at a minimum, allows a user to read and compose email messages. Many MUAs are capable of retrieving messages via the **`POP`** or **`IMAP`** protocols, setting up mailboxes to store messages, and sending outbound messages to an MTA.

MUAs may be graphical, such as **Evolution**, or have simple text-based interfaces, such as **pine**.

19.3. MAIL TRANSPORT AGENTS

Red Hat Enterprise Linux offers two primary MTAs: Postfix and Sendmail. Postfix is configured as the default MTA, although it is easy to switch the default MTA to Sendmail. To switch the default MTA to Sendmail, you can either uninstall Postfix or use the following command to switch to Sendmail:

```
~]# alternatives --config mta
```

You can also use a command in the following format to enable or disable the desired service:

```
chkconfig service_name on | off
```

19.3.1. Postfix

Originally developed at IBM by security expert and programmer Wietse Venema, Postfix is a Sendmail-compatible MTA that is designed to be secure, fast, and easy to configure.

To improve security, Postfix uses a modular design, where small processes with limited privileges are launched by a *master* daemon. The smaller, less privileged processes perform very specific tasks related to the various stages of mail delivery and run in a changed root environment to limit the effects of attacks.

Configuring Postfix to accept network connections from hosts other than the local computer takes only a few minor changes in its configuration file. Yet for those with more complex needs, Postfix provides a variety of configuration options, as well as third party add-ons that make it a very versatile and full-featured MTA.

The configuration files for Postfix are human readable and support upward of 250 directives. Unlike Sendmail, no macro processing is required for changes to take effect and the majority of the most commonly used options are described in the heavily commented files.

19.3.1.1. The Default Postfix Installation

The Postfix executable is **`/usr/sbin/postfix`**. This daemon launches all related processes needed to handle mail delivery.

Postfix stores its configuration files in the **`/etc/postfix/`** directory. The following is a list of the more commonly used files:

- **`access`** — Used for access control, this file specifies which hosts are allowed to connect to Postfix.
- **`main.cf`** — The global Postfix configuration file. The majority of configuration options are specified in this file.
- **`master.cf`** — Specifies how Postfix interacts with various processes to accomplish mail delivery.
- **`transport`** — Maps email addresses to relay hosts.

The **`aliases`** file can be found in the **`/etc/`** directory. This file is shared between Postfix and Sendmail. It is a configurable list required by the mail protocol that describes user ID aliases.

IMPORTANT

The default **`/etc/postfix/main.cf`** file does not allow Postfix to accept network connections from a host other than the local computer. For instructions on configuring Postfix as a server for other clients, see Section 19.3.1.2, “Basic Postfix Configuration”.

Restart the **`postfix`** service after changing any options in the configuration files under the **`/etc/postfix`** directory in order for those changes to take effect:

```
~]# service postfix restart
```

19.3.1.2. Basic Postfix Configuration

By default, Postfix does not accept network connections from any host other than the local host. Perform the following steps as **`root`** to enable mail delivery for other hosts on the network:

- Edit the **`/etc/postfix/main.cf`** file with a text editor, such as **`vi`**.
- Uncomment the **`mydomain`** line by removing the hash sign (`#`), and replace *domain.tld* with the domain the mail server is servicing, such as **`example.com`**.
- Uncomment the **`myorigin = $mydomain`** line.
- Uncomment the **`myhostname`** line, and replace *host.domain.tld* with the host name for the machine.
- Uncomment the **`mydestination = $myhostname, localhost.$mydomain`** line.
- Uncomment the **`mynetworks`** line, and replace *168.100.189.0/28* with a valid network setting for hosts that can connect to the server.
- Uncomment the **`inet_interfaces = all`** line.
- Comment the **`inet_interfaces = localhost`** line.
- Restart the **`postfix`** service.

Once these steps are complete, the host accepts outside emails for delivery.

Postfix has a large assortment of configuration options. One of the best ways to learn how to configure

Postfix is to read the comments within the **/etc/postfix/main.cf** configuration file. Additional resources including information about Postfix configuration, SpamAssassin integration, or detailed descriptions of the **/etc/postfix/main.cf** parameters are available online at http://www.postfix.org/.

19.3.1.2.1. Configuring Postfix to Use Transport Layer Security

Configuring postfix to use *transport layer security* (TLS) is described in the Red Hat Knowledgebase solution *How to configure postfix with TLS?*

IMPORTANT

Due to the vulnerability described in *Resolution for POODLE SSL 3.0 vulnerability (CVE-2014-3566) in Postfix and Dovecot*, Red Hat recommends disabling **SSL**, if it is enabled, and using only **TLSv1.1** or **TLSv1.2**. Backwards compatibility can be achieved using **TLSv1.0**. Many products Red Hat supports have the ability to use **SSLv2** or **SSLv3** protocols. However, the use of **SSLv2** or **SSLv3** is now strongly recommended against.

19.3.1.3. Using Postfix with LDAP

Postfix can use an **LDAP** directory as a source for various lookup tables (e.g.: **aliases**, **virtual**, **canonical**, etc.). This allows **LDAP** to store hierarchical user information and Postfix to only be given the result of **LDAP** queries when needed. By not storing this information locally, administrators can easily maintain it.

19.3.1.3.1. The /etc/aliases lookup example

The following is a basic example for using **LDAP** to look up the **/etc/aliases** file. Make sure your **/etc/postfix/main.cf** file contains the following:

```
alias_maps = hash:/etc/aliases, ldap:/etc/postfix/ldap-aliases.cf
```

Create a **/etc/postfix/ldap-aliases.cf** file if you do not have one already and make sure it contains the following:

```
server_host = ldap.example.com
search_base = dc=example, dc=com
```

where ***ldap.example.com***, ***example***, and ***com*** are parameters that need to be replaced with specification of an existing available **LDAP** server.

NOTE

The **/etc/postfix/ldap-aliases.cf** file can specify various parameters, including parameters that enable **LDAP SSL** and **STARTTLS**. For more information, see the **ldap_table(5)** man page.

For more information on **LDAP**, see Section 20.1, "OpenLDAP".

19.3.2. Sendmail

Sendmail's core purpose, like other MTAs, is to safely transfer email among hosts, usually using the

SMTP protocol. However, Sendmail is highly configurable, allowing control over almost every aspect of how email is handled, including the protocol used. Many system administrators elect to use Sendmail as their MTA due to its power and scalability.

19.3.2.1. Purpose and Limitations

It is important to be aware of what Sendmail is and what it can do, as opposed to what it is not. In these days of monolithic applications that fulfill multiple roles, Sendmail may seem like the only application needed to run an email server within an organization. Technically, this is true, as Sendmail can spool mail to each users' directory and deliver outbound mail for users. However, most users actually require much more than simple email delivery. Users usually want to interact with their email using an MUA, that uses **POP** or **IMAP**, to download their messages to their local machine. Or, they may prefer a Web interface to gain access to their mailbox. These other applications can work in conjunction with Sendmail, but they actually exist for different reasons and can operate separately from one another.

It is beyond the scope of this section to go into all that Sendmail should or could be configured to do. With literally hundreds of different options and rule sets, entire volumes have been dedicated to helping explain everything that can be done and how to fix things that go wrong. See the Section 19.6, “Additional Resources” for a list of Sendmail resources.

This section reviews the files installed with Sendmail by default and reviews basic configuration changes, including how to stop unwanted email (spam) and how to extend Sendmail with the *Lightweight Directory Access Protocol (LDAP)*.

19.3.2.2. The Default Sendmail Installation

In order to use Sendmail, first ensure the sendmail package is installed on your system by running, as **root**:

```
~]# yum install sendmail
```

In order to configure Sendmail, ensure the sendmail-cf package is installed on your system by running, as **root**:

```
~]# yum install sendmail-cf
```

For more information on installing packages with Yum, see Section 8.2.4, “Installing Packages”.

Before using Sendmail, the default MTA has to be switched from Postfix. For more information how to switch the default MTA see Section 19.3, “Mail Transport Agents”.

The Sendmail executable is **/usr/sbin/sendmail**.

Sendmail's lengthy and detailed configuration file is **/etc/mail/sendmail.cf**. Avoid editing the **sendmail.cf** file directly. To make configuration changes to Sendmail, edit the **/etc/mail/sendmail.mc** file, back up the original **/etc/mail/sendmail.cf** file, and use the following alternatives to generate a new configuration file:

- Use the included makefile in **/etc/mail/** to create a new **/etc/mail/sendmail.cf** configuration file:

  ```
  ~]# make all -C /etc/mail/
  ```

All other generated files in **/etc/mail** (db files) will be regenerated if needed. The old makemap commands are still usable. The make command is automatically used whenever you start or restart the **sendmail** service.

- Alternatively you may use the **m4** macro processor to create a new **/etc/mail/sendmail.cf**. The **m4** macro processor is not installed by default. Before using it to create **/etc/mail/sendmail.cf**, install the m4 package as root:

  ```
  ~]# yum install m4
  ```

More information on configuring Sendmail can be found in Section 19.3.2.3, "Common Sendmail Configuration Changes".

Various Sendmail configuration files are installed in the **/etc/mail/** directory including:

- **access** — Specifies which systems can use Sendmail for outbound email.
- **domaintable** — Specifies domain name mapping.
- **local-host-names** — Specifies aliases for the host.
- **mailertable** — Specifies instructions that override routing for particular domains.
- **virtusertable** — Specifies a domain-specific form of aliasing, allowing multiple virtual domains to be hosted on one machine.

Several of the configuration files in **/etc/mail/**, such as **access**, **domaintable**, **mailertable** and **virtusertable**, must actually store their information in database files before Sendmail can use any configuration changes. To include any changes made to these configurations in their database files, run the following command, as **root**:

```
~]# makemap hash /etc/mail/<name> < /etc/mail/<name>
```

where *<name>* represents the name of the configuration file to be updated. You may also restart the **sendmail** service for the changes to take effect by running:

```
~]# service sendmail restart
```

For example, to have all emails addressed to the **example.com** domain delivered to **bob@other-example.com**, add the following line to the **virtusertable** file:

```
@example.com bob@other-example.com
```

To finalize the change, the **virtusertable.db** file must be updated:

```
~]# makemap hash /etc/mail/virtusertable < /etc/mail/virtusertable
```

Sendmail will create an updated **virtusertable.db** file containing the new configuration.

19.3.2.3. Common Sendmail Configuration Changes

When altering the Sendmail configuration file, it is best not to edit an existing file, but to generate an entirely new **/etc/mail/sendmail.cf** file.

WARNING

Before replacing or making any changes to the **`sendmail.cf`** file, create a backup copy.

To add the desired functionality to Sendmail, edit the **`/etc/mail/sendmail.mc`** file as root. Once you are finished, restart the **`sendmail`** service and, if the m4 package is installed, the **`m4`** macro processor will automatically generate a new **`sendmail.cf`** configuration file:

```
~]# service sendmail restart
```

IMPORTANT

The default **`sendmail.cf`** file does not allow Sendmail to accept network connections from any host other than the local computer. To configure Sendmail as a server for other clients, edit the **`/etc/mail/sendmail.mc`** file, and either change the address specified in the **`Addr=`** option of the **`DAEMON_OPTIONS`** directive from **`127.0.0.1`** to the IP address of an active network device or comment out the **`DAEMON_OPTIONS`** directive all together by placing **`dnl`** at the beginning of the line. When finished, regenerate **`/etc/mail/sendmail.cf`** by restarting the service

```
~]# service sendmail restart
```

The default configuration in Red Hat Enterprise Linux works for most **`SMTP`**-only sites. However, it does not work for *UUCP* (*UNIX-to-UNIX Copy Protocol*) sites. If using UUCP mail transfers, the **`/etc/mail/sendmail.mc`** file must be reconfigured and a new **`/etc/mail/sendmail.cf`** file must be generated.

Consult the **`/usr/share/sendmail-cf/README`** file before editing any files in the directories under the **`/usr/share/sendmail-cf`** directory, as they can affect the future configuration of the **`/etc/mail/sendmail.cf`** file.

19.3.2.4. Masquerading

One common Sendmail configuration is to have a single machine act as a mail gateway for all machines on the network. For example, a company may want to have a machine called **`mail.example.com`** that handles all of their email and assigns a consistent return address to all outgoing mail.

In this situation, the Sendmail server must masquerade the machine names on the company network so that their return address is **`user@example.com`** instead of **`user@host.example.com`**.

To do this, add the following lines to **`/etc/mail/sendmail.mc`**:

```
FEATURE(always_add_domain)dnl
FEATURE(`masquerade_entire_domain')dnl
FEATURE(`masquerade_envelope')dnl
FEATURE(`allmasquerade')dnl
```

```
MASQUERADE_AS(`example.com.')dnl
MASQUERADE_DOMAIN(`example.com.')dnl
MASQUERADE_AS(example.com)dnl
```

After generating a new **sendmail.cf** file using the **m4** macro processor, this configuration makes all mail from inside the network appear as if it were sent from **example.com**.

19.3.2.5. Stopping Spam

Email spam can be defined as unnecessary and unwanted email received by a user who never requested the communication. It is a disruptive, costly, and widespread abuse of Internet communication standards.

Sendmail makes it relatively easy to block new spamming techniques being employed to send junk email. It even blocks many of the more usual spamming methods by default. Main anti-spam features available in sendmail are *header checks*, *relaying denial* (default from version 8.9), *access database and sender information checks*.

For example, forwarding of **SMTP** messages, also called relaying, has been disabled by default since Sendmail version 8.9. Before this change occurred, Sendmail directed the mail host (**x.edu**) to accept messages from one party (**y.com**) and sent them to a different party (**z.net**). Now, however, Sendmail must be configured to permit any domain to relay mail through the server. To configure relay domains, edit the **/etc/mail/relay-domains** file and restart Sendmail

```
~]# service sendmail restart
```

However users can also be sent spam from from servers on the Internet. In these instances, Sendmail's access control features available through the **/etc/mail/access** file can be used to prevent connections from unwanted hosts. The following example illustrates how this file can be used to both block and specifically allow access to the Sendmail server:

```
badspammer.com ERROR:550 "Go away and do not spam us anymore"
tux.badspammer.com OK 10.0 RELAY
```

This example shows that any email sent from **badspammer.com** is blocked with a 550 RFC-821 compliant error code, with a message sent back. Email sent from the **tux.badspammer.com** sub-domain, is accepted. The last line shows that any email sent from the 10.0.*.* network can be relayed through the mail server.

Because the **/etc/mail/access.db** file is a database, use the **makemap** command to update any changes. Do this using the following command as **root**:

```
~]# makemap hash /etc/mail/access < /etc/mail/access
```

Message header analysis allows you to reject mail based on header contents. **SMTP** servers store information about an email's journey in the message header. As the message travels from one MTA to another, each puts in a **Received** header above all the other **Received** headers. It is important to note that this information may be altered by spammers.

The above examples only represent a small part of what Sendmail can do in terms of allowing or blocking access. See the **/usr/share/sendmail-cf/README** file for more information and examples.

Since Sendmail calls the Procmail MDA when delivering mail, it is also possible to use a spam filtering program, such as SpamAssassin, to identify and file spam for users. See Section 19.4.2.6, “Spam Filters” for more information about using SpamAssassin.

19.3.2.6. Using Sendmail with LDAP

Using **`LDAP`** is a very quick and powerful way to find specific information about a particular user from a much larger group. For example, an **`LDAP`** server can be used to look up a particular email address from a common corporate directory by the user's last name. In this kind of implementation, **`LDAP`** is largely separate from Sendmail, with **`LDAP`** storing the hierarchical user information and Sendmail only being given the result of **`LDAP`** queries in pre-addressed email messages.

However, Sendmail supports a much greater integration with **`LDAP`**, where it uses **`LDAP`** to replace separately maintained files, such as **`/etc/aliases`** and **`/etc/mail/virtusertables`**, on different mail servers that work together to support a medium- to enterprise-level organization. In short, **`LDAP`** abstracts the mail routing level from Sendmail and its separate configuration files to a powerful **`LDAP`** cluster that can be leveraged by many different applications.

The current version of Sendmail contains support for **`LDAP`**. To extend the Sendmail server using **`LDAP`**, first get an **`LDAP`** server, such as **OpenLDAP**, running and properly configured. Then edit the **`/etc/mail/sendmail.mc`** to include the following:

```
LDAPROUTE_DOMAIN('yourdomain.com')dnl
FEATURE('ldap_routing')dnl
```

NOTE

This is only for a very basic configuration of Sendmail with **`LDAP`**. The configuration can differ greatly from this depending on the implementation of **`LDAP`**, especially when configuring several Sendmail machines to use a common **`LDAP`** server.

Consult **`/usr/share/sendmail-cf/README`** for detailed **`LDAP`** routing configuration instructions and examples.

Next, recreate the **`/etc/mail/sendmail.cf`** file by running the **`m4`** macro processor and again restarting Sendmail. See Section 19.3.2.3, “Common Sendmail Configuration Changes” for instructions.

For more information on **`LDAP`**, see Section 20.1, “OpenLDAP”.

19.3.3. Fetchmail

Fetchmail is an MTA which retrieves email from remote servers and delivers it to the local MTA. Many users appreciate the ability to separate the process of downloading their messages located on a remote server from the process of reading and organizing their email in an MUA. Designed with the needs of dial-up users in mind, Fetchmail connects and quickly downloads all of the email messages to the mail spool file using any number of protocols, including **`POP3`** and **`IMAP`**. It can even forward email messages to an **`SMTP`** server, if necessary.

NOTE

In order to use **Fetchmail**, first ensure the fetchmail package is installed on your system by running, as **`root`**:

```
~]# yum install fetchmail
```

For more information on installing packages with Yum, see Section 8.2.4, “Installing Packages”.

Fetchmail is configured for each user through the use of a **`.fetchmailrc`** file in the user's home directory. If it does not already exist, create the **`.fetchmailrc`** file in your home directory

Using preferences in the **`.fetchmailrc`** file, Fetchmail checks for email on a remote server and downloads it. It then delivers it to port **`25`** on the local machine, using the local MTA to place the email in the correct user's spool file. If Procmail is available, it is launched to filter the email and place it in a mailbox so that it can be read by an MUA.

19.3.3.1. Fetchmail Configuration Options

Although it is possible to pass all necessary options on the command line to check for email on a remote server when executing Fetchmail, using a **`.fetchmailrc`** file is much easier. Place any desired configuration options in the **`.fetchmailrc`** file for those options to be used each time the **`fetchmail`** command is issued. It is possible to override these at the time Fetchmail is run by specifying that option on the command line.

A user's **`.fetchmailrc`** file contains three classes of configuration options:

- *global options* — Gives Fetchmail instructions that control the operation of the program or provide settings for every connection that checks for email.
- *server options* — Specifies necessary information about the server being polled, such as the host name, as well as preferences for specific email servers, such as the port to check or number of seconds to wait before timing out. These options affect every user using that server.
- *user options* — Contains information, such as user name and password, necessary to authenticate and check for email using a specified email server.

Global options appear at the top of the **`.fetchmailrc`** file, followed by one or more server options, each of which designate a different email server that Fetchmail should check. User options follow server options for each user account checking that email server. Like server options, multiple user options may be specified for use with a particular server as well as to check multiple email accounts on the same server.

Server options are called into service in the **`.fetchmailrc`** file by the use of a special option verb, **`poll`** or **`skip`**, that precedes any of the server information. The **`poll`** action tells Fetchmail to use this server option when it is run, which checks for email using the specified user options. Any server options after a **`skip`** action, however, are not checked unless this server's host name is specified when Fetchmail is invoked. The **`skip`** option is useful when testing configurations in the **`.fetchmailrc`** file because it only checks skipped servers when specifically invoked, and does not affect any currently working configurations.

The following is an example of a **`.fetchmailrc`** file:

```
set postmaster "user1"
set bouncemail

poll pop.domain.com proto pop3
    user 'user1' there with password 'secret' is user1 here

poll mail.domain2.com
    user 'user5' there with password 'secret2' is user1 here
    user 'user7' there with password 'secret3' is user1 here
```

In this example, the global options specify that the user is sent email as a last resort (**`postmaster`** option) and all email errors are sent to the postmaster instead of the sender (**`bouncemail`** option). The **`set`** action tells Fetchmail that this line contains a global option. Then, two email servers are specified, one set to check using **`POP3`**, the other for trying various protocols to find one that works. Two users are checked using the second server option, but all email found for any user is sent to **`user1`**'s mail spool. This allows multiple mailboxes to be checked on multiple servers, while appearing in a single MUA inbox. Each user's specific information begins with the **`user`** action.

NOTE

Users are not required to place their password in the **`.fetchmailrc`** file. Omitting the **`with password '<password>'`** section causes Fetchmail to ask for a password when it is launched.

Fetchmail has numerous global, server, and local options. Many of these options are rarely used or only apply to very specific situations. The **`fetchmail`** man page explains each option in detail, but the most common ones are listed in the following three sections.

19.3.3.2. Global Options

Each global option should be placed on a single line after a **`set`** action.

- **`daemon`** ***`seconds`*** — Specifies daemon-mode, where Fetchmail stays in the background. Replace *seconds* with the number of seconds Fetchmail is to wait before polling the server.
- **`postmaster`** — Specifies a local user to send mail to in case of delivery problems.
- **`syslog`** — Specifies the log file for errors and status messages. By default, this is **`/var/log/maillog`**.

19.3.3.3. Server Options

Server options must be placed on their own line in **`.fetchmailrc`** after a **`poll`** or **`skip`** action.

- **`auth`** ***`auth-type`*** — Replace *auth-type* with the type of authentication to be used. By default, **`password`** authentication is used, but some protocols support other types of authentication, including **`kerberos_v5`**, **`kerberos_v4`**, and **`ssh`**. If the **`any`** authentication type is used, Fetchmail first tries methods that do not require a password, then methods that mask the password, and finally attempts to send the password unencrypted to authenticate to the server.
- **`interval`** ***`number`*** — Polls the specified server every ***`number`*** of times that it checks for email on all configured servers. This option is generally used for email servers where the user rarely receives messages.

- **`port`** ***`port-number`*** — Replace *port-number* with the port number. This value overrides the default port number for the specified protocol.
- **`proto`** ***`protocol`*** — Replace *protocol* with the protocol, such as **`pop3`** or **`imap`**, to use when checking for messages on the server.
- **`timeout`** ***`seconds`*** — Replace *seconds* with the number of seconds of server inactivity after which Fetchmail gives up on a connection attempt. If this value is not set, a default of **`300`** seconds is used.

19.3.3.4. User Options

User options may be placed on their own lines beneath a server option or on the same line as the server option. In either case, the defined options must follow the **`user`** option (defined below).

- **`fetchall`** — Orders Fetchmail to download all messages in the queue, including messages that have already been viewed. By default, Fetchmail only pulls down new messages.
- **`fetchlimit`** ***`number`*** — Replace *number* with the number of messages to be retrieved before stopping.
- **`flush`** — Deletes all previously viewed messages in the queue before retrieving new messages.
- **`limit`** ***`max-number-bytes`*** — Replace *max-number-bytes* with the maximum size in bytes that messages are allowed to be when retrieved by Fetchmail. This option is useful with slow network links, when a large message takes too long to download.
- **`password '`*`password`*`'`** — Replace *password* with the user's password.
- **`preconnect "`*`command`*`"`** — Replace *command* with a command to be executed before retrieving messages for the user.
- **`postconnect "`*`command`*`"`** — Replace *command* with a command to be executed after retrieving messages for the user.
- **`ssl`** — Activates SSL encryption. At the time of writing, the default action is to use the best available from **`SSL2`**, **`SSL3`**, **`SSL23`**, **`TLS1`**, **`TLS1.1`** and **`TLS1.2`**. Note that **`SSL2`** is considered obsolete and due to the POODLE: SSLv3 vulnerability (CVE-2014-3566), **`SSLv3`** should not be used. However there is no way to force the use of TLS1 or newer, therefore ensure the mail server being connected to is configured **not** to use **`SSLv2`** and **`SSLv3`**. Use **`stunnel`** where the server cannot be configured **not** to use **`SSLv2`** and **`SSLv3`**.
- **`sslproto`** — Defines allowed SSL or TLS protocols. Possible values are **`SSL2`**, **`SSL3`**, **`SSL23`**, and **`TLS1`**. The default value, if **`sslproto`** is omitted, unset, or set to an invalid value, is **`SSL23`**. The default action is to use the best from **`SSLv3`**, **`TLSv1`**, **`TLS1.1`** and **`TLS1.2`**. Note that setting any other value for SSL or TLS will disable all the other protocols. Due to the POODLE: SSLv3 vulnerability (CVE-2014-3566), it is recommend to omit this option, or set it to **`SSLv23`**, and configure the corresponding mail server **not** to use **`SSLv2`** and **`SSLv3`**. Use **`stunnel`** where the server cannot be configured **not** to use **`SSLv2`** and **`SSLv3`**.
- **`user "`*`username`*`"`** — Replace *username* with the username used by Fetchmail to retrieve messages. *This option must precede all other user options.*

19.3.3.5. Fetchmail Command Options