

Introduction to systemd Basics

WHAT?

systemd is used to manage system settings and services. systemd organizes tasks into components called *units* and groups of units into *targets*.

WHY?

Learn about the basics of systemd, which include essential functionalities such as service management, dependency tracking, logging, resource management, socket activation and system control.

EFFORT

20 minutes of reading time.

REQUIREMENTS

- Basic understanding of Linux commands
- Basic understanding of Linux processes, daemons, and control groups

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Contents

- 1 What is systemd? 3
- 2 Structure of a unit file 3

3	Unit file types	5
4	Unit dependencies and order	6
5	Logging	7
6	systemd targets	7
7	Using systemd as a regular user	8
8	systemctl commands	9
9	systemd troubleshooting	10
10	systemd best practices	12
11	Legal Notice	13
A	GNU Free Documentation License	13

1 What is systemd?

`systemd` is a system and service manager for Linux operating systems. It is the default initialization system for major Linux distributions. `systemd` is not directly initiated by the user, but installed through the `/sbin/init` and started during the early boot. `systemd` acts as the init system that brings up and maintains user space services when run as the first process on boot (PID 1). PID 1 is known as *init* and is the first Linux user-mode process created. It runs until the system shutdown.

`systemd` owns PID 1, and is started directly by the kernel. All other processes are started directly by `systemd` or one of its child processes. `systemd` mounts the host's file system and manages temporary files. It is backward compatible with the SysV init scripts. SysV is an initialization system that predates `systemd`.

In `systemd`, a unit is a resource that the system knows how to operate on and manage. This is the primary object that the `systemd` tools use. These resources are defined with configuration files called unit files.

`systemctl` is the central management tool for controlling the init system. It is used to examine and control the state of the `systemd` system and service manager.

Targets in `systemd` are groups of related units that act as synchronization points during a system boot. Target unit files have a `.target` file extension. Target units group together various `systemd` units through a chain of dependencies.

For troubleshooting, you can use **`journalctl`**, which is used to query and display log messages from the `systemd` journal.

For more information on `systemd`, you can refer to <https://systemd.io> and **`man 1 systemd`**.

2 Structure of a unit file

In `systemd`, a unit refers to any resource that the system knows how to operate on and manage. This is the primary object that the `systemd` tools use. These resources are defined using configuration files called unit files. Administration is easier when you understand unit files when working with `systemd`. Unit files use a simple declarative syntax that allows you to see easily the purpose and effects of a unit upon activation. Unit files have sections with directives, for example:

[Section]

```
Directive1=value
Directive2=value
. . .
```

Unit file types include the following sections:

[Unit]

The first section found in most unit files is the [Unit] section. This section is used to define the metadata of the unit file and configure the relationship of the unit file to other unit files. This section is usually placed at the top because it provides an overview of the unit file.

[Automount] / [Mount] / [Path] / [Service] / [Slice] / [Socket] / [Swap] / [Timer]

Sections containing directives that are specific to the respective type. See [Section 3, “Unit file types”](#) for a list of available types. Note that the types device, target, snapshot and scope do not have a type-specific section.

[Install]

This is often the last section in the unit file and is optional. This section is used to define the behavior of a unit file when it is enabled or disabled. When you enable a unit file, it automatically starts at boot. Based on the specific unit, there could be a dependency on other related units to work properly. For example, chrony requires the directives After, Wants, and Before, which are all dependencies for chrony to work with.

EXAMPLE 1: A `systemd` SERVICE FILE

```
[Unit]
Description=usbguard ❶

[Service]
ExecStart=/usr/sbin/usb-daemon ❷

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

- ❶ A brief and meaningful description explaining the service file's purpose.
- ❷ Specifies the program to be executed when the service is started.
- ❸ Starts a multi-user system with networking, and no graphical environment. This directive allows you to specify a dependency relationship.

3 Unit file types

You can determine the type of unit by its file extension. `systemd` categorizes units according to the type of resource they describe.

Types of unit files available for `systemd`:

.service

Describes how to manage a service or application. This includes how to start or stop the service, reload its configuration file (if applicable), under what conditions the service starts automatically, and the dependency or the hierarchy information for related unit files.

.scope

This unit file is automatically created by `systemd` from the information received from the D-Bus interface and is used to manage sets of system processes that are created externally.

.path

Defines a path for path-based activation. By default, a `.service` unit file of the same base name is activated. `inotify` is a kernel API that is used by programs that want to be notified about changes to files.

.snapshot

The `systemctl snapshot` command automatically creates a `.snapshot` unit file. This command creates temporary snapshots of the current state of the system. You can modify the current state of the system after making changes. Snapshots are used for rolling back temporary states.

.timer

Defines a timer that is managed by `systemd`. This is similar to a cron job for delayed or scheduled activation. A unit file with the same name, but with file extension `.service` is started when the timer is reached.

.slice

Associate Linux Control Group nodes, which allow resources to be assigned or restricted to any processes associated with the slice. The name indicates the hierarchy within the control group tree. Units are placed in slices by default depending on their type.

.target

Provides synchronization for other units during a boot up or a change in state, or brings the system to a new state. Other units specify their relation to targets in order to sync with the target's operations.

.socket

Describes a network, an IPC socket, or a FIFO buffer that systemd uses for socket-based activation. There is an associated .service file that starts when an activity is seen on the socket that this unit defines.

.device

Defines a device that has been designated for systemd management by udev or sysfs file system. Not all devices have the .device file. This unit file is required when ordering, mounting, or accessing a device.

.swap

Defines the swap space on the system. The name of the unit file must reflect the device or file path of the space.

.mount

Defines a mount point on the system to be managed by systemd. This file is named after the mount path, with the slashes changed to dashes. Entries within /etc/fstab can have units created automatically.

.automount

Defines a mount point that is automatically mounted. Name the file after the mount point that it refers to. A matching .mount unit file is required to define the specifics of the mount.

4 Unit dependencies and order

systemd has two types of dependencies: requirement and order dependencies. Requirement dependencies specify which other units must be either started or stopped when activating a unit. Order dependencies specify the order in which units must be started.

Unit dependencies

Unit files have the dependencies feature. A unit may want or require one or more other units before it can run. These dependencies are set in unit files with the directives Wants and Requires.

Wants

For example, if unit A has Wants=unit B, when unit A is run, unit B runs as well. But if unit B starts successfully or not, does not have an influence on unit A running successfully.

Requires

If unit A has Requires=unit B, both units run but if unit B does not run successfully, unit A is deactivated. It does not matter if the processes of unit A would have run successfully.

Unit order

Without proper instructions, systemd can run a group of units at the same time. Starting services in the right order is important for a good functioning of the Linux system. You can arrange the order with the unit file directives Before and After.

Before

For example, if unit A has Before=unit B, when both units are run, unit A is executed fully before unit B.

After

If unit A has After=unit B, when both units are run, unit B is executed fully before unit A.

5 Logging

Log files and journals are important for system administration. They give in-depth information about a system and are very important for troubleshooting and auditing. Log files contain events and messages generated by the kernel, applications, and users that log into the system. You can use the journalctl command to query the journal. This command views logs collected by systemd. The systemd-journald service handles systemd's log collection. systemd-journald saves the events and messages in a binary format.

6 systemd targets

systemd uses units and targets. A systemd unit defines a service or action on the system, which consists of a name, type, and configuration file. A systemd target combines several units and defines which services have to be started to reach the target. On a server, for example, this is a state where the network is running and multiple users can log in. These files are identified by the suffix .target.

Similar to unit files, different targets may be nested via dependencies. For example, multi-user.target requires (among others) the targets that set up login and user session services.

Common systemd targets:

default.target

Boots by default. The default.target file is a symbolic link to the true target file, such as graphical.target for a desktop workstation. For a server, it is usually graphical.target.

poweroff.target

Shuts down and powers off the system.

rescue.target

Target unit that pulls the base system and starts a rescue shell session.

multi-user.target

Sets up a non-graphical (console) multi-user system.

graphical.target

Uses a graphical multi-user system with network services.

reboot.target

Shuts down and reboots the system.

For more information on systemd targets, refer to *man 5 systemd.target* and *man 7 systemd.special*.

7 Using systemd as a regular user

You can use systemd as a regular user and when you do not have root user privileges. In certain scenarios, it is more secure for a service to run with the privilege of a regular user. You can do this by creating a user service.

A user service is a systemd service that runs under the context of a regular user. Some points to note about user services:

- User service sessions are terminated when the user's session ends. This can be overridden by using the **loginctl enable-linger USERNAME**.
- User service files are located at /etc/systemd/user or \$HOME/.config/systemd/user/.
- You can control user services with the **systemctl --user** command.
- They run with the user's permissions.

8 **systemctl** commands

The **systemctl** command is used to examine and control the state of systemd and service manager.

You can use the following common **systemctl** commands and refer to the *man systemctl* page.

VIEWING systemd INFORMATION

systemctl list-units

Lists the systemd units. You can use the optional arguments: **--state=running** to show the active units and **--type=service** to show the exited and active units.

systemctl list-unit-files

Lists the systemd units and the status, such as static, generated, disabled, alias, masked, and enabled.

systemctl list-dependencies

Lists the dependency tree.

systemctl list-dependencies UNIT_FILE

Lists the dependencies of a unit file.

MANAGING systemd SERVICES

systemctl status SERVICE

Checks the status of the specific service.

systemctl show SERVICE

Displays the service information.

systemctl start SERVICE

Instead of manually starting the service, use the **start** command. When a change is made to the configuration file, the related service must be started again.

systemctl stop SERVICE

Stops a specific running service.

systemctl restart SERVICE

Instead of manually restarting the service, use the **restart** command. When a change is made to the configuration file, the related service must be restarted again.

systemctl enable SERVICE

Enables the service on boot.

systemctl disable SERVICE

Disables the service on boot.

systemctl reload-or-restart SERVICE

Reload the service if it supports reloading, otherwise it restarts the service. If the service is not running, it is restarted.

systemctl mask SERVICE

When a service is masked, this means the unit file is symlinked to `/dev/null`. A symlink for a masked service is created from `/etc/systemd/system` to point to `/dev/null`. This makes it impossible to load the service even if another enabled service requires it. It must be stopped manually, or it continues to run in the background. You can use **`--runtime`** option to only mask temporarily until the next reboot of the system.

```
Created symlink /etc/systemd/system/F0SSLinux.service → /dev/null.
```

systemctl unmask SERVICE

Unmasks the service. It is effective when the system is started or restarted manually.

MANAGING SYSTEM STATES

systemctl reboot

Reboots the system `reboot.target`.

systemctl poweroff

Powers off the system `poweroff.target`.

systemctl emergency

Goes into the emergency mode `emergency.target`.

systemctl default

Goes back to default target `multi-user.target`.

9 systemd troubleshooting

You can use the following troubleshooting tips to identify and resolve issues with `systemd` services and ensure a smooth system operation.

Check the syntax of your systemd unit file with the systemd-analyze verify SERVICE

Before starting or enabling a systemd service, check the syntax of the unit file to ensure there are no errors. For example:

```
> sudo systemd-analyze verify /etc/systemd/system/my-custom-service.service
```

The command analyzes the unit file and reports any syntax errors, missing files, or other issues. You must fix any reported issues before enabling and starting the service.

Check the logs for your service with the journalctl -u SERVICE command

If you experience any issue with a systemd service, check the service's log. For example:

```
> sudo journalctl -u my-custom-service.service
```

The command displays logs for the specified service, including any error messages, warnings, or other relevant information. You can use these logs to identify and fix issues with the service.

Use the systemd-analyze plot command to visualize the boot process

If a service is causing issues during the boot process, you can use the systemd-analyze plot command to visualize the boot process and identify issues. For example:

```
> sudo systemd-analyze plot > boot-plot.svg
```

The command creates an SVG file called `boot-plot.svg` that contains a graphical representation of the boot process and potential issues. This includes the start and stop time of each service. You can open this file in an SVG-compatible image viewer or Web browser to analyze services that are causing issues during the boot process.

Troubleshoot failed services

To find out which services have failed and to inspect the log output:

```
> sudo systemctl --state=failed
```

Check the runtime status of a service

To find out the current runtime status of a service:

```
> sudo systemctl status SERVICE
```

Shutdown or reboot takes long

If the shutdown or reboot takes long, it could be a service that is not exiting. systemd waits for some time for each service to exit before trying to terminate it. A common issue is a suspended service or a stalled shutdown. To find out, use the following:

```
> sudo systemctl poweroff
```

```
Failed to power off system via logind: There's already a shutdown or sleep operation in progress
```

```
> sudo systemctl list-jobs
```

You can cancel the running and waiting jobs, and again shut down or reboot:

```
> sudo systemctl cancel
```

```
> sudo systemctl stop systemd-suspend.service
```

10 systemd best practices

You can follow some of the best practices to ensure efficient systemd services that are equipped to handle different situations.

Check the runtime status of a service

To find out the current runtime status of a service:

```
> sudo systemctl status SERVICE
```

Use absolute path in your systemd unit file

Use an absolute path for executable files and required files, such as configuration files or scripts in your systemd unit file. systemd does not rely on the user's environment variables like \$PATH to locate files.

Use the ExecReload directive

Use the ExecReload directive in the [SERVICE] section when you want to define a specific command that should be executed when you reload a service with the **systemctl reload** command. This is useful for services that can dynamically reload their configuration without a restart.

```
[Service]
ExecStart=PATH_TO_EXECUTABLE
ExecReload=PATH_TO_RELOAD_SCRIPT
```

Use the RestartSec directive

Use the RestartSec directive in the [SERVICE] section when you want to define a delay (in seconds) before the service is restarted after a failure. This is useful for services that require a specified time to release resources or prevent rapid restart loops that can cause high system load.

```
[Service]
ExecStart=PATH_TO_EXECUTABLE
Restart=on-failure
RestartSec=5
```

Disable emergency mode on a remote machine

You can disable emergency mode on a remote machine, for example, a virtual machine hosted on Google Cloud. If this mode is enabled, the machine is blocked from connecting to the network. For example:


```
> sudo systemctl mask emergency.service
```

```
> sudo systemctl mask emergency.target
```

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