Setting Up a `systemd` Service

Setting up a systemd service on SUSE Linux Enterprise Server for NVIDIA allows administrators to automate process execution, manage application lifecycles and configure custom background tasks. By defining declarative unit files, users can specify service dependencies, control startup behavior and apply security sandboxing features. This ensures reliable background operation, simplifies troubleshooting with systemctl and improves overall system stability across system reboots.

Prerequisites

- Basic understanding of Linux processes, daemons and control groups

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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 Creating a Linux service with `systemd`

Create an auto-start task or program that executes every time that you boot or reboot your system by creating a Linux service with `systemd`.

EXAMPLE 2: AUTOMATING TASK EXECUTION WITH `systemd`

Creating a custom `systemd` service, involves creating a service unit file, which defines the service and its behavior.

1. Create a new script at the specified location, that is used by the `systemd` service:

```
vi /usr/local/bin/FILE_NAME.sh
```

The `/usr/local/bin` is the standard location for installing custom scripts and executables specific to the system. By placing the script in this location, you make it accessible to all system users without a need to specify the full path.

2. Paste the following in the file:

```
#!/bin/bash
     echo "Hello, Everyone!"
```

3. Make the script executable:

```
> sudo  chmod +x /usr/local/bin/FILE_NAME.sh
```

4. Create a `systemd` unit file at the specified location:

```
vi /etc/systemd/system/FILE_NAME.service
```

5. Paste the following in the file:

```
[Unit]
Description= Name service

[Service]
ExecStart=/usr/local/bin/FILE_NAME.sh

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

   The `Unit` section gives you a description of the service. The `Service` section defines the service and its behavior. The `ExecStart` directive specifies the command to start the service. The `Install` section specifies when the service should start.

6. Save and exit the file.

7. To make `systemd` aware of the new service, run:

```
> sudo  systemctl SERVICE_NAME
```

8. Start,enable and check the status of the service:

```
systemctl start SERVICE_NAME
```

```
systemctl enable SERVICE_NAME
```

```
systemctl status SERVICE_NAME
```

6 The `sysctemctl edit` command

You can use the **`systemctl`** command to edit and modify an existing service file.

There are three main directories where unit files are stored on the system:

`/usr/lib/systemd/system/`
: When the RPM packages are installed, `systemd` unit files reside here.

`/run/systemd/system/`
: `systemd` unit files created at run time. This directory takes precedence over the directory with installed service unit files.

`/etc/systemd/system/`
: `systemd` unit files that are created by the **`systemctl enable`** command and also unit files added for extending a service. This directory takes precedence over the directory with unit files created at run time.

By default, the **`sysctemctl edit`** command opens a unit file snippet, for example:

```
> sudo  systemctl edit testhttp.service
```

This creates a blank file that is used to override or add directives to the unit file definition. A directory is created in `/etc/systemd/system`, which contains the name of the unit file with `.d` appended. For example, a directory called `testhttp.service.d` is created.

Within the directory, a snippet called `override.conf` is created. `systemd` merges the override snippet with the full unit file when the unit is loaded. This snippet's directives take precedence over those directives in the original unit file.

With the `--full` flag, you can edit the full unit file instead of creating a snippet. For example:

```
> sudo  systemctl edit --full testhttp.service
```

This loads the current unit file into the editor, allowing you to make modifications. When you save and exit the editor, the modified file is written to `/etc/systemd/system`, which takes precedence over the system's unit definition, usually located in `/lib/systemd/system`.

To remove any additions you have made, you can delete the unit's `.d` configuration directory or the the modified service file from `/etc/systemd/system`. After deleting the file or directory, reload the `systemd` process so that it reverts back to the initial system process.

7 Securing `systemd` services

Linux increases its security by separating privileges between individual components of the operating system. System services already have a default level of security. For example, their processes run under their own user ID, which limits the changes they can perform on the system.

The default level of privilege separation provides only a basic protection. Services can still perform as many changes as normal local users, though not as many as `root`. A higher level of system security requires limiting what services can perform and prevents them from certain privileges that normal users are allowed to use.

7.1 Why is securing `systemd` services important?

Securing `systemd` services increases the security of the whole operating system and protects sensitive data contained on its file system. With `systemd`, you can configure your system in many ways. `systemd` runs as the first process on boot (PID1) so it has a lot of power on your Linux environment.

`systemd` can apply additional restrictions to local services by using technologies included in the kernel. These restrictions are activated by adding specific options to the systemd service definition and restarting the service. `systemd` has a command-line tool **`systemd-analyze security`**. This command analyzes the services and checks whether the services are using its security options.

7.2 What is the **`systemd-analyze security`** command?

The command analyzes the security and sandboxing settings of the specified service units. A detailed analysis of the security settings is executed and displayed. If a service unit is not specified, all currently loaded, long-running service units are inspected and the results are displayed in a terse table.

Upon checking the security settings, the command assigns a numeric value , also known as *exposure level*. This value depends on how important a setting is. It then calculates the overall exposure level for the entire unit. This value ranges from 0.0 to 10.0, which is an indicator of how exposed a service is security-wise. High exposure levels indicate that the service might benefit from additional security settings. Low exposure levels indicate tight security restrictions.

7.3 Using the `systemd-analyze security` command

Use the **`systemd-analyze security`** command to analyze the security settings of a `systemd` service. The `security` option analyzes the security and the sandboxing settings of one or more specified services.

1. Create a `systemd` service in the `/etc/systemd/system`.
2. Reload the service files to include the new service:

```
> sudo  systemctl daemon-reload
```

3. Start, enable and check the status of the service:

```
> sudo  systemctl start SERVICE_NAME
```

```
> sudo systemctl enable SERVICE_NAME
```

```
> sudo  systemctl status SERVICE_NAME
```

4. Analyze the security settings of the service:

```
> sudo  systemd-analyze security SERVICE_NAME
```

   For example:

```
> sudo  systemd-analyze security test.service
  NAME                DESCRIPTION                                EXPOSURE
  ✗ PrivateNetwork=     Service has access to the host's network      0.5
  ✗ User=/DynamicUser=  Service runs as root user                     0.4
  ✗ DeviceAllow=        Service has no device ACL
  ...
  → Overall exposure level for test.service: 9.6 UNSAFE #
```

7.4 How to improve the overall exposure

If you get *9.6 UNSAFE*, you can use `[Service]` part of the service definition file to add any of the below options. For example:

```
[Service]
NoNewPrivileges=yes
PrivateTmp=yes
PrivateNetwork=yes
InaccessibleDirectories=/home
```

```
.....
```

NoNewPrivileges=yes

New privileges are not required.

PrivateTmp=yes

Private directory for temporary files. This option provides the service with a private `/tmp` isolated from the host system's `/tmp`. The shared host `/tmp` directory is a major source of security problems, such as symlink attacks and DoS `/tmp` temporary files.

PrivateNetwork=yes

This option isolates the service and its processes from networking. This prevents external network requests from reaching the protected service. Be aware that certain services require the network to be operational.

InaccessibleDirectories=/home

This option makes the specified directories inaccessible to the service. This option narrows the range of directories that can be read or modified by the service, for example, to secure users' private files.

ReadOnlyDirectories=/var

This option makes the specified directories inaccessible for writing to the service. The example configuration makes the whole tree below `/var` read-only. This option prevents the service from damaging the system files.

CapabilityBoundingSet=CAP_CHOWN CAP_KILL

This option restricts the kernel capabilities that a service can retain. In the example above, only the `CAP_CHOWN` and `CAP_KILL` capabilities are retained by the service, and the service and any processes it creates cannot obtain any other capabilities, not even via setuid binaries.



Tip: The **pscap** command tool

To easily identify which processes on your system retain which capabilities, use the **`pscap`** command tool from the `libcap-ng-utils` package.

The `~` prefix inverts the meaning of the option—. Instead of listing all capabilities that the service retains, you can list the ones it does not retain:

```
...
  [Service]
  CapabilityBoundingSet=~CAP_SYS_PTRACE
  ...
```

LimitNPROC=1, LimitFSIZE=0

You can use *resource limits* to apply security limits on services. Two of them can disable specific operating system features: `RLIMIT_NPROC=1` disables process forking, while `RLIMIT_FSIZE=0` disables creating non-empty files on the file system.

DeviceAllow=/dev/null rw

This option limits access to `/dev/null`, disallowing access to any other device nodes.

These are some options you can use.

EXAMPLE 3: `NoNewPrivileges=yes` OPTION EXAMPLE

This example shows a basic script configured to run as a specific user with privilege escalation strictly disabled.

```
[Unit]
Description=Simple Secure Service

[Service]
# Run as a non-root user
User=john
Group=john

# Disable gaining new privileges (setuid, setgid, etc.)
NoNewPrivileges=yes
```

8 Debugging a `systemd` service

Use the **`systemctl`** and **`journalctl`** commands to investigate the reasons for a failed system service.

When `systemd` fails to start a service, a generic error message is displayed, for example:

```
# systemctl start apache2
Job for apache2.service failed because the control process exited with error code.
See "systemctl status apache2.service" and "journalctl -xe" for details.
```

List all available services and their current status

```
# systemctl list-units -t service --all
```

For example:

```
# systemctl list-units -t service --all
```

```
  UNIT                                    LOAD      ACTIVE   SUB     DESCRIPTION>
  accounts-daemon.service                 loaded    active   running Accounts Se>
  apache2.service                         loaded    failed   failed  The Apache HTTP
 server>
\u25cf acpid.service                      not-found inactive dead    acpid.servi>
 after-local.service                     loaded    inactive dead    /etc/init.d>
  alsa-restore.service                    loaded    active   exited  Save/Restor>
  alsa-state.service                      loaded    inactive dead    Manage Soun>
\u25cf amavis.service                     not-found inactive dead    amavis.serv>
  apparmor.service                        loaded    active   exited  Load AppArm>
  appstream-sync-cache.service            loaded    inactive dead    Synchronize>
  auditd.service                          loaded    active   running Security Au>
  augenrules.service                      loaded    active   exited  auditd rule>
```

Check whether a specific service has failed

```
# systemctl is-failed apache2.service
              failed
```

Check the status of the failed service

```
# systemctl status --full --lines=50 apache2
  ● apache2.service - Apache HTTP Server
  Loaded: loaded (/usr/lib/systemd/system/apache2.service; enabled; vendor preset:
 disabled)
  Active: failed (Result: exit-code) since Fri 2021-08-20 10:24:15 CEST; 2min 24s
 ago
    Docs: https://httpd.apache.org/docs
 Process: 2491 ExecStart=/usr/bin/apache2 --add-runtime oci=/usr/sbin/apache-runc
 $DOCKER_NETWORK_OPTIONS $DOCKER_OPTS >
Main PID: 2491 (code=exited, status=1/FAILURE)
```

In the above example, the service ran as process ID 2491, but failed. Error messages give you a hint on what to do.

Check the logs of the failed service

```
#  journalctl --catalog --pager-end --unit=apache2
[...]
  Aug 20 10:24:15 localhost.localdomain dockerd[2479]: unable to configure the
 Docker daemon with file /etc/apache2/daemon.json:
cannot unmarshal string into Go value of type map[string]interface {}
```

The option `--unit` limits the log entries only to the failed Apache2 service. The error message suggests looking into the file `/etc/docker/daemon.json`. In this scenario, the error was caused by a wrong syntax. You can fix this and restart the Apache2 service.

9 `systemctl` commands overview

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.

9.1 Viewing `systemd` information

To view information about `systemd` components, you can use the following commands:

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.

9.2 Managing `systemd` services

The **`systemctl`** command enables you to perform the following tasks with 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/FOSSLinux.service → /dev/null.
```

systemctl unmask *SERVICE*

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

9.3 Managing system states

The **`systemctl`** command enables you to perform power management processes on your system, like restarting, shutting down and so on, as described below.

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`.

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