

Working with systemd timers

From running a backup script at regular intervals to starting a specific process as soon as the machine boots, there are plenty of tasks that require scheduling on a Linux system. `cron` has long been the go-to tool for all scheduling needs, but the switch to `systemd` introduced a modern way to schedule tasks: `systemd` timer units.

WHAT?

Learn how to set up, manage and operate `systemd` timers for scheduling tasks on Linux. Migrate to `systemd` timers as a modern replacement of `cron`.

WHY?

To give you a flexible mechanism for scheduling and managing jobs and services.

EFFORT?

It takes 10 minutes to create an example `systemd` timer. You will need up to 30 minutes to fully understand how `systemd` timers work.

GOAL!

Learn how to create `systemd` timers and understand how they work.

Requirements

- Basic understanding of systemd.
- root or sudo privileges. If you are planning to use systemd timers as a regular user, refer to *Section 8, “Using timers as a regular user”* first.

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1 The systemd timer concept

systemd timer units provide a modern mechanism for scheduling jobs on Linux, replacing cron.

Similar to cron, systemd timer units provide a mechanism for scheduling jobs on Linux. Although systemd timer units serve the same purpose as cron, they offer several advantages:

- Jobs scheduled using a timer unit can depend on other systemd services. Timer units are treated as regular systemd services, so can be managed with systemctl.
- Timers can be realtime (being triggered on calendar events) and monotonic being triggered at a specified time elapsed from a certain starting point.
- Time units are logged to the system journal, which makes it easier to monitor and troubleshoot them.
- Uses the centralized systemd management services.
- If the system is off during the expected execution time, the timer is executed once the system is running again.

systemd timer units are identified by the .timer file name extension. Each timer file requires a corresponding service file it controls. In other words, a timer file activates and manages the corresponding service file. For a full reference on systemd timers including advanced configuration options (like delays or handling clock or time zone changes) refer to man 5 systemd.timer.

2 Creating a timer

The following example shows how to set up a timer that triggers the hello-world.sh shell script after boot time and repeats its execution every 24 hours relative to its activation time. It also runs Monday to Friday at 10am.

2.1 "Hello World" example

1. Create the file /etc/systemd/system/helloworld.service with the following content:

```
[Unit]
Description="Hello World script"
```

```
[Service]
ExecStart=/usr/local/bin/helloworld.sh
```

This is a systemd service file that tells systemd which application to run.

2. Create the file /etc/systemd/system/helloworld.timer with the following content:

```
[Unit]
Description="Run helloworld.service 5min after boot and every 24 hours relative to
activation time"

[Timer]
OnBootSec=5min
OnUnitActiveSec=24h
OnCalendar=Mon..Fri 10:00
Unit=helloworld.service

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

This is the timer file that controls when to activate the respective service file.

3. Verify that the files you created above contain no errors:

```
systemd-analyze verify /etc/systemd/system/helloworld.*
```

If the command returns no output, the files have passed the verification successfully.

4. Start the timer:

```
sudo systemctl start helloworld.timer
```

This will activate the timer for the current session only.

5. To ensure the timer is automatically activated each time when booting the machine, you need to enable it:

```
sudo systemctl enable helloworld.timer
```

2.2 The example explained

EXAMPLE 1: THE SERVICE FILE

```
[Unit]
Description="Hello World script" ❶
```

```
[Service]
ExecStart=/usr/local/bin/helloworld.sh ❷
```

- ❶ A brief description explaining the service file's purpose.
- ❷ The application to execute.

Usually this is all you would need for a service file in this context. In case you require a more complex configuration refer to ??? for more information.



Note: Service files for timer do not require an **INSTALL** section

systemd service files usually contain an [Install] section determining with which target(s) a service is loaded. This section is not needed in service files for timers, since this information is provided with the timer file.

EXAMPLE 2: THE TIMER FILE

```
[Unit]
Description="Run helloworld.service 5min after boot and every 24 hours relative to
activation time" ❶

[Timer]
OnBootSec=5min ❷
OnUnitActiveSec=24h ❸
OnCalendar=Mon..Fri *-*-* 10:00 ❹
Unit=helloworld.service ❺

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

- ❶ A brief description explaining the timer file's purpose.
- ❷ Specifies a timer that triggers the service five minutes after the system boot.
- ❸ Specifies a timer that triggers the service 24 hours after the service has been activated (that is, the timer will trigger the service once a day).
- ❹ Specifies a timer that triggers the service at fixed points in time (here: Monday to Friday at 10 am).
- ❺ The service file that is to be executed.
- ❻ The system target in which the timer get activated. For more information on systemd targets refer to ???.



Tip: Migrating from cron

The equivalent of the helloworld example above in cron would be the following lines:

```
@reboot sleep 300 && /usr/local/bin/helloworld.sh
0 10 * * * 1-5 /usr/local/bin/helloworld.sh
```

Note that there is now equivalent for OnUnitActiveSec in cron.

3 Managing timers

Timers can be managed with general systemd commands using the **systemctl** command. In addition to that, **systemctl list-timers** shows you all timers available on a host.

Starting and stopping timers

```
# systemctl start TIMER.timer
# systemctl restart TIMER.timer
# systemctl stop TIMER.timer
```

Enabling and disabling timers

```
# systemctl enable TIMER.timer
# systemctl disable TIMER.timer
```

Showing the timer file contents

```
# systemctl cat TIMER.timer
```

Checking on a specific timer

```
# systemctl status helloworld.timer
● helloworld.timer - "Run helloworld.service 5min after boot and every 24 hours
relative to activation time" ❶
Loaded: loaded (/etc/systemd/system/helloworld.timer; disabled; vendor preset:
disabled) ❷
Active: active (waiting) since Tue 2022-10-26 18:35:41 CEST; 6s ago ❸
Trigger: Wed 2022-10-27 18:35:41 CEST; 23h left ❹
Triggers: ● helloworld.service ❺
❻
```

```
Oct 26 18:35:41 neo systemd[1]: Started "Run helloworld.service 5min after boot and every 24 hours relative to activation time". ⑦
```

- ① The timer's file name and it's description.
- ② Lists whether a timer has been successfully parsed and is kept in memory (loaded), shows the full path to the timer file, Last it shows wether the timer is being started at boot time (enabled) or not (disabled). The first value shows the current system configuration, the second value the vendor preset.
- ③ Indicates whether the timer is active (waiting to trigger events) or inactive. If active, it also shows the time that has passed since the last activation (6 seconds in this example).
- ④ Date and time the timer will be triggered next.
- ⑤ Name of the service file the timer will trigger.
- ⑥ Optional line pointing to documenattion (for example man pages). If not available shows an empty line (as in this example).
- ⑦ Latest journal entry created by the timer.

To list all timers available on the system, use **`systemctl list-timers`**. The following options are available:

List all active timers:

```
# systemctl list-timers
```

List all timers including inactive ones:

```
# systemctl list-timers --all
```

List all timers matching a pattern:

```
# systemctl list-timers hello*
# systemctl list-timers --all hello*
```

The pattern can be a name or a shell globbing expression as above. The operators `*`, `?`, and `[]` may be used.

List timers matching a certain state:

```
# systemctl list-timers --state=failed
```

`--state=` takes the following values: `active`, `failed`, `load`, `sub`, see **`man systemctl`** for details.

EXAMPLE 3: LISTING TIMERS

Running **systemctl list-timers** will result in a table similar to this example.

```
# systemctl list-timers snapp*
NEXT                                LEFT      LAST                                PASSED    UNIT
                                ACTIVATES
-----
Tue 2022-10-26 19:00:00 CEST 39min left Tue 2022-10-26 18:00:29 CEST 19min ago
snapper-timeline.timer snapper-timeline.service
Wed 2022-10-27 08:33:04 CEST 14h left Tue 2022-10-26 08:33:04 CEST 9h ago
snapper-cleanup.timer snapper-cleanup.service
```

- NEXT shows the next time the timer will run.
- LEFT shows how long till the next time the timer runs.
- LAST shows the last time the timer ran.
- PASSED shows how long has passed since the timer last ran.
- UNIT shows the name of the timer.
- ACTIVATES shows the name the service the timer activates when it runs.

4 Timer types

systemd supports two types of timers: realtime (based on calendar) and monotonic (based on events). Although timers are usually persistent, **systemd** also allows to set up transient timers, that are only valid for the current session.

Realtime timer

Similar to cronjobs, realtime timers are triggered on calendar events. Realtime timers are defined using the option `OnCalendar=`.

Using a syntax similar to cron, you can specify when to trigger an event based on date and time. the following general syntax applies:

```
OnCalendar=DayOfWeek Year-Month-Day Hour:Minute:Second
```

`DayOfWeek` is optional, each value in `Year-Month-Day` can be replaced by the wildcard `*` to match every occurrence. Continuous ranges can be specified using `..`, a list of separated values needs to be delimited by `,`.

- 6pm on every Friday: `OnCalendar=Fri *-*-* 18:00:00`
- 5am every day: `OnCalendar=Mon..Sun *-*-* 5:00:00`
- 1am and 3am on Sundays and Tuesdays: `OnCalendar=Tue,Sun *-*-* 01,03:00:00`
- Single date: `OnCalendar=Mo..Sun 2023-09-23 00:00:01`

To specify triggers at different times, you may create more than one `OnCalendar` entries in a single timer file:

- 10am on week days and at 10pm on weekends:

```
OnCalendar=Mon..Fri *-*-* 10:00
OnCalendar=Sat,Sun *-*-* 22:00
```

The syntax is very flexible and offers many more advanced features. Refer to `man 7 systemd.time` to, among others, learn how to:

- shorten the syntax and use abbreviations..
- specify repetitions.
- find specific days in a month (last day of month, last Sunday,...).
- apply time zones.

Monotonic timers

Monotonic timers are triggered at a specified time elapsed from a certain event. The latter could be a system boot or system unit activation event. There are several options for defining monotonic timers:

- `OnActiveSec`: time after unit activation

```
OnActiveSec=50minutes
```

- `OnBootSec`: time after system boot.

```
OnBootSec=10hours
```

- `OnStartupSec`: timer after service manager is started. For `systemd` services this is almost equal to `OnActiveSec`. Use this for user services, where the service manager is started at user login.

```
OnStartupSec=5minutes 20seconds
```

- OnUnitActiveSec: time after the corresponding service was last activated

```
OnUnitActiveSec=10seconds
```

- OnUnitInactiveSec: time after the corresponding service was last deactivated

```
OnUnitInactiveSec=2hours 15minutes 18 seconds
```

Values are to be defined as a time. Minutes, hours, days, month, years etc. may be used. If no unit is specified, seconds are assumed. The following units can be used:

- usec
- msec
- seconds
- minutes
- hours
- days
- weeks
- months
- years

Transient timers

Transient timers are temporary timers only valid for the current session. Using these timers you can either use an existing service file or directly start a program. Transient timers are invoked by running **systemd-run**.

The following example runs the helloworld.service unit every two hours:

```
systemd-run --on-active="2hours" --unit="helloworld.service"
```

To run a command directly use the following syntax. In this example the script /usr/local/bin/helloworld.sh is called directly:

```
systemd-run --on-active="2hours" /usr/local/bin/helloworld.sh
```

In case the command takes parameters, add them space-separated:

```
systemd-run --on-active="2hours" /usr/local/bin/helloworld.sh --language=pt_BR"
```

Transient timers can be of types monotonic or real time. The following switches, working as described above, are supported:

- --on-active
- --on-startup
- --on-unit-active
- --on-unit-inactive
- --on-calendar

For more information refer to man 1 systemd-run.

5 Testing calendar entries

systemd provides a tool for testing and creating calendar timer entries for realtime timers

When it comes to creating complex date entries for realtime timers, systemd provides you with a tool that will help you with this task: **systemd-analyze calendar**. It accepts the same argument than the OnCalendar entry required to set up realtime timers.

Here are some examples. You can concatenate several arguments separated by space. If the term to test is correct, the output will show you when the timer is triggered next (in local time and UTC). It will also show the string in Normalized form, it is recommended to use that string in the timer file.

```
> sudo systemd-analyze calendar "Tue,Sun *-*- * 01,03:00:00"
Normalized form: Tue,Sun *-*- * 01,03:00:00
Next elapse: Sun 2021-10-31 01:00:00 CEST
(in UTC): Sat 2021-10-30 23:00:00 UTC
From now: 3 days left

> sudo systemd-analyze calendar "Mon..Fri *-*- * 10:00" "Sat,Sun *-*- * 22:00"
Original form: Mon..Fri *-*- * 10:00
Normalized form: Mon..Fri *-*- * 10:00:00
Next elapse: Thu 2021-10-28 10:00:00 CEST
(in UTC): Thu 2021-10-28 08:00:00 UTC
```

```
From now: 19h left

Original form: Sat,Sun *-.* 22:00
Normalized form: Sat,Sun *-.* 22:00:00
Next elapse: Sat 2021-10-30 22:00:00 CEST
(in UTC): Sat 2021-10-30 20:00:00 UTC
From now: 3 days left
```

If you have reoccurring timers, you can use the `--iterations N` switch to list trigger times and test whether they met your expectations. The argument *N* specifies the number of iterations you would like to test. The following example string triggers every 8 hours (starting at 00:00:00) on Sundays:

```
> sudo systemd-analyze calendar --iterations 5 "Sun *-.* 0/08:00:00"
Original form: Sun *-.* 0/08:00:00
Normalized form: Sun *-.* 00/8:00:00
Next elapse: Sun 2021-10-31 00:00:00 CEST
(in UTC): Sat 2021-10-30 22:00:00 UTC
From now: 3 days left
Iter. #2: Sun 2021-10-31 08:00:00 CET
(in UTC): Sun 2021-10-31 07:00:00 UTC
From now: 3 days left
Iter. #3: Sun 2021-10-31 16:00:00 CET
(in UTC): Sun 2021-10-31 15:00:00 UTC
From now: 4 days left
Iter. #4: Sun 2021-11-07 00:00:00 CET
(in UTC): Sat 2021-11-06 23:00:00 UTC
From now: 1 week 3 days left
Iter. #5: Sun 2021-11-07 08:00:00 CET
(in UTC): Sun 2021-11-07 07:00:00 UTC
From now: 1 week 3 days left
```

6 Catching up on missed runs

With `systemd` timers you can make leeway for missed timer events.

If a `systemd` timer was inactive or the system was off during the expected execution time, missed events can optionally be triggered immediately when the timer is activated again. To enable this, add the configuration option `Persisten=true` to the Timer section:

```
[Timer]
OnCalendar=Mon..Fri 10:00
Persistent=true
Unit=helloworld.service
```

7 Getting notified by email if a timer fails

Cron comes with the MAILTO feature, where you only have to specify an email address with MAILTO to get an email notification with the output of the respective script(s). systemd does not offer such functionality out of the box. The following procedure describes a workaround to get email notifications when a timer fails.

You need to

1. create a script that sends an e-mail.
2. create systemd service file running the email script.
3. test the service file.
4. call this service file via `OnFailure` within the service that is run by the timer.

1. Create the script `/usr/local/bin/send_systemd_email`. In the following example we are using the `mailx` command from package `mailx`. Note that the script requires two parameters: `$1`, the email address, and `$2`, the name of the unit file used by the timer. Both parameters will be provided by the unit file running the mail script.

```
#!/bin/sh
systemctl status --full "$2" | mailx -S sendwait\
-s "Timer failure for $2" -r root@$HOSTNAME $1
```

Make sure the script you just created is executable:

```
sudo chmod 755 /usr/local/bin/send_systemd_email
```



Note: Requires Postfix

Note that in order to send emails you need to install and configure the email server Postfix on your system. The latter can be done via *YaST > Network Services > Mail Server*.

2. Create the file `/etc/systemd/system/send_email_to_user@.service`. Note that you need to replace `user` in the file name with the login of the user that should receive the email.

```
[Unit]
```

```
Description=Send systemd status information by email for %i to user

[Service]
Type=oneshot
ExecStart=/usr/local/bin/send_systemd_email e-mail_address %i
User=root
Group=systemd-journal
```

Note that you need to replace user and e-mail_address in the file with the login and the e-mail address of the user that should receive the email. %i is the name of the service that has failed (it will be passed on to the e-mail service (by the %n parameter)).

3. To make sure the service file works correctly, verify it and fix any errors that may be reported:

```
systemd-analyze verify /etc/systemd/system/send_email_to_user@.service
```

If the command returns no output, the file has passed the verification successfully.

Now start the service using the dbus instance for testing (you may use any other service that is currently running. We are using dbus here, because this service is guaranteed to run on any installation).

```
sudo systemctl start send_email_to_user@dbus.service
```

If successful, e-mail_address will receive an e-mail with the subject Timer failure for dbus containing dbus status messages in the body. (Note that this is just a test, there is no problem with the dbus service. You can safely delete the mail, no action is required). If the test e-mail has been successfully send, proceed by integrating it into your timer file(s).

4. To add e-mail notification to your timer, add an OnFailure option to the Unit section of the *service* file that is started by the timer:

```
[Unit]
Description="Hello World script"
OnFailure❶=send_email_to_user❷@%n❸.service

[Service]
ExecStart=/usr/local/bin/helloworld.sh
```

- ❶ The OnFailure option takes a service as a argument.
- ❷ Replace with the login name part of the service unit's file name.

- ③ Provides the name of the service (helloworld in this example). This name is available in the e-mail service file as %i.

5. You successfully set up failure notification for systemd services.



Tip: Scope of usage

Using the e-mail for systemd service failure notification is not restricted to systemd timers. It can be used with any systemd service. The e-mailing service created above can be also used with multiple service files simultaneously.



Tip: Sending e-mail notifications to multiple users

While the e-mail script is generic, the email service file has the recipient's e-mail address hard-coded. In order to send notification emails to a different user, copy the e-mail service file and replace the user login in the file name and the e-mail address within the copy.

To send a failure notification to several people at the same time, add the respective service files space-separated to the service file:

```
OnFailure=send_email_to_tux@%n.service send_email_to_wilber@%n.service
```

8 Using timers as a regular user

systemd timers can also be used by regular users to, for example, automate reoccurring tasks.

Similar to cron, you can also use systemd timers as a regular users. It will help you to automate reoccurring tasks like regular backups, processing images, or moving data to the cloud. The same procedures and tasks as mentioned above are valid, however the following differences apply:

- Timer and service files need to be placed in ~/.config/systemd/user/.
- All **systemctl** and **journalctl** command need to be run with the --user switch. Note that **systemd-analyze** does *not* support this option.

```
> systemctl --user start ~/.config/systemd/user/helloworld.timer
```

```
> systemctl --user enable ~/.config/systemd/user/helloworld.timer
> systemctl --user list-timers
> journalctl --user -u helloworld.*
> systemctl-analyze ~/.config/systemd/user/helloworld.timer
```



Note: Provide the path for the unit files

As a regular user, you should provide the path to the unit files as in the examples above, to avoid confusion with system unit files with the same name.



Important: User timers only run during an active session

As with other systemd services started as a regular user, user timers only run when the user is logged in. In case you want to start user timers at boot time and continue them after log out, enable lingering for each affected user:

```
sudo loginctl enable-linger USER
```

For more information refer to [**man 1 loginctl**](#).



Important: Environment variables are not inherited

The `systemd` user instance does not inherit environment variables set by scripts like `~/.profile` or `~/.bashrc`. To check the systemd environment run **`systemctl --user show-environment`**.

To import any variables missing in the `systemd` environment, specify the following command at the end of your `~/.bashrc`:

```
systemctl --user import-environment VARIABLE1 VARIABLE2
```

9 Troubleshooting

Learn how to find and troubleshoot systemd timers that have failed.

9.1 Avoiding errors

To avoid errors with `systemd` timers make sure to

- Verify the executable you specify in the service with `ExecStart` runs without problems.
- check the syntax of the service and timer files by running `systemd-analyze verify FILE`.
- check execution times of calendar entries by running `systemd-analyze calendar CALENDER_ENTRY`.

9.2 Event is not triggered

When you activate a timer that contains non-fatal errors `systemd` will silently ignore these errors. Given is the following example:

EXAMPLE 4: `systemd` TIMER FILE CUTOUT CONTAINING A NON-FATAL ERROR

```
[Timer]
OnBootSec=5min
OnClendar=Mon..Fri 10:00
Unit=helloworld.service
```

Line 3 contains a syntax error (`OnClendar` instead of `OnCalendar`). Since the `[Timer]` section contains a second timer entry (`OnBoot`) this error is not fatal and will silently be ignored. As a consequence the Monday to Friday trigger would not be executed. The only way to detect the error is via `systemd-analyze verify`:

```
# systemd-analyze verify /etc/systemd/system/helloworld.timer
/etc/systemd/system/helloworld.timer:7: Unknown key name 'OnClendar' in section
'Timer', ignoring.
```

9.3 Checking the system journal

As with every `systemd` service, events and actions triggered by timers are logged with the system journal. In case a trigger does not behave as expected, check the log messages with `journalctl`. To filter the journal for what matters, use the `-u` switch to specify the `systemd` timers and service files. You should use it in a way that it shows the log entries for the timer *and* the corresponding service file:

```
sudo journalctl -u helloworld.timer -u helloworld.service
```

or shorter (if applicable):

```
sudo journalctl -u helloworld.*
```

journalctl is a tool that supports many options and filters. Please refer to `man journalctl` for in-depth information. The following options will be helpful when troubleshooting timers:

- `-b`: Only show entries for the current boot.
- `-S today`: only show entries from today.
- `-x`: Show explanatory help texts alongside the log entry.
- `-f`: Start with the most recent entries and continuously print the log as new entries get added. Useful to check triggers that occur in short intervals. Exit with `Ctrl - C`.

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