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LCE510 - System Startup and Shutdown

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System Startup

Boot Loader

The most commonly used boot loader is called **GRUB** (**G**rand **U**nified **B**oot **L**oader), however historically there have been others:

- LILO (**LI**nux **LO**ader)
- SysLinux
- LoadLin
- ...

BIOS Systems

The Boot Loader is generally placed in the MBR (**M**aster **B**oot **Record**) of the disk on which the system to-be-booted resides. The MBR format is as follows:

- 446 bytes occupied by the boot loader,
- 64 bytes for the Partition Table. In other words 16 bytes per primary partition,
- 2 bytes with a fixed hexadecimal value of **AA55**.

Important - Note that you can also install the boot loader in what is known as the **PBR** (**P**artition **B**oot **R**ecord).

EFI Systems

Since 2011, the BIOS is being steadily replaced by **UEFI** (**U**nified **E**xtensible **F**irmware **I**nterface). Systems using a CPU other than the x86 or the x86-64 use non-BIOS software such as **OpenFirmware** or **EFI** .

EFI relies on boot loaders stored in a disk partition called the **EFI System Partition** or **ESP**. This partition is normally mounted by Linux at **/boot/efi**. The boot loaders reside in files having a .efi extension stored in subdirectories named after the OS to be booted.

The EFI firmware includes a boot manager that enables you to choose which OS to boot. In order for EFI to work each boot loader must be registered with the firmware.

GRUB 2

GRUB 2 is a complete rewrite of GRUB LEGACY.

GRUB 2 is modular in design.

The /boot/grub/grub.cfg File

Grub2 reads its entries from the **/boot/grub/grub.cfg** file:

```
<code>
[root@centos8 ~]# cat /boot/grub2/grub.cfg
#
```

```
# DO NOT EDIT THIS FILE
#
# It is automatically generated by grub2-mkconfig using templates
# from /etc/grub.d and settings from /etc/default/grub
#

### BEGIN /etc/grub.d/00_header ###
set pager=1

if [ -f ${config_directory}/grubenv ]; then
  load_env -f ${config_directory}/grubenv
elif [ -s $prefix/grubenv ]; then
  load_env
fi
if [ "${next_entry}" ] ; then
   set default="${next_entry}"
   set next_entry=
   save_env next_entry
   set boot_once=true
else
   set default="${saved_entry}"
fi

if [ x"${feature_menuentry_id}" = xy ]; then
  menuentry_id_option="--id"
else
  menuentry_id_option=""
fi

export menuentry_id_option

if [ "${prev_saved_entry}" ]; then
  set saved_entry="${prev_saved_entry}"
  save_env saved_entry
```

```
  set prev_saved_entry=
  save_env prev_saved_entry
  set boot_once=true
fi

function savedefault {
  if [ -z "${boot_once}" ]; then
    saved_entry="${chosen}"
    save_env saved_entry
  fi
}

function load_video {
  if [ x$feature_all_video_module = xy ]; then
    insmod all_video
  else
    insmod efi_gop
    insmod efi_uga
    insmod ieee1275_fb
    insmod vbe
    insmod vga
    insmod video_bochs
    insmod video_cirrus
  fi
}

terminal_output console
if [ x$feature_timeout_style = xy ] ; then
  set timeout_style=menu
  set timeout=5
# Fallback normal timeout code in case the timeout_style feature is
# unavailable.
else
  set timeout=5
```

```
fi
### END /etc/grub.d/00_header ###

### BEGIN /etc/grub.d/00_tuned ###
set tuned_params=""
set tuned_initrd=""
### END /etc/grub.d/00_tuned ###

### BEGIN /etc/grub.d/01_menu_auto_hide ###
if [ "${boot_success}" = "1" -o "${boot_indeterminate}" = "1" ]; then
  set last_boot_ok=1
else
  set last_boot_ok=0
fi

# Reset boot_indeterminate after a successful boot
if [ "${boot_success}" = "1" ] ; then
  set boot_indeterminate=0
# Avoid boot_indeterminate causing the menu to be hidden more then once
elif [ "${boot_indeterminate}" = "1" ]; then
  set boot_indeterminate=2
fi
set boot_success=0
save_env boot_success boot_indeterminate

if [ x$feature_timeout_style = xy ] ; then
  if [ "${menu_show_once}" ]; then
    unset menu_show_once
    save_env menu_show_once
    set timeout_style=menu
    set timeout=60
  elif [ "${menu_auto_hide}" -a "${last_boot_ok}" = "1" ]; then
    set orig_timeout_style=${timeout_style}
    set orig_timeout=${timeout}
```

```
    if [ "${fastboot}" = "1" ]; then
      # timeout_style=menu + timeout=0 avoids the countdown code keypress check
      set timeout_style=menu
      set timeout=0
    else
      set timeout_style=hidden
      set timeout=1
    fi
  fi
fi
### END /etc/grub.d/01_menu_auto_hide ###

### BEGIN /etc/grub.d/01_users ###
if [ -f ${prefix}/user.cfg ]; then
  source ${prefix}/user.cfg
  if [ -n "${GRUB2_PASSWORD}" ]; then
    set superusers="root"
    export superusers
    password_pbkdf2 root ${GRUB2_PASSWORD}
  fi
fi
### END /etc/grub.d/01_users ###

### BEGIN /etc/grub.d/10_linux ###
insmod part_msdos
insmod ext2
set root='hd0,msdos1'
if [ x$feature_platform_search_hint = xy ]; then
  search --no-floppy --fs-uuid --set=root --hint-bios=hd0,msdos1 --hint-efi=hd0,msdos1 --hint-
baremetal=ahci0,msdos1 --hint='hd0,msdos1'  2ae4c035-9244-458c-82c5-a49ae169cdb6
else
  search --no-floppy --fs-uuid --set=root 2ae4c035-9244-458c-82c5-a49ae169cdb6
fi
insmod part_msdos
```

```
insmod ext2
set boot='hd0,msdos1'
if [ x$feature_platform_search_hint = xy ]; then
  search --no-floppy --fs-uuid --set=boot --hint-bios=hd0,msdos1 --hint-efi=hd0,msdos1 --hint-
baremetal=ahci0,msdos1 --hint='hd0,msdos1'  2ae4c035-9244-458c-82c5-a49ae169cdb6
else
  search --no-floppy --fs-uuid --set=boot 2ae4c035-9244-458c-82c5-a49ae169cdb6
fi

# This section was generated by a script. Do not modify the generated file - all changes
# will be lost the next time file is regenerated. Instead edit the BootLoaderSpec files.
#
# The blscfg command parses the BootLoaderSpec files stored in /boot/loader/entries and
# populates the boot menu. Please refer to the Boot Loader Specification documentation
# for the files format: https://www.freedesktop.org/wiki/Specifications/BootLoaderSpec/.

set default_kernelopts="root=UUID=4c0cc28c-0d59-45be-bd73-d292b80be33c ro crashkernel=auto resume=UUID=c8bb3f47-
d67f-4b21-b781-766899dc83d4 rhgb quiet "

insmod blscfg
blscfg
### END /etc/grub.d/10_linux ###

### BEGIN /etc/grub.d/20_linux_xen ###
### END /etc/grub.d/20_linux_xen ###

### BEGIN /etc/grub.d/20_ppc_terminfo ###
### END /etc/grub.d/20_ppc_terminfo ###

### BEGIN /etc/grub.d/30_os-prober ###
### END /etc/grub.d/30_os-prober ###

### BEGIN /etc/grub.d/30_uefi-firmware ###
### END /etc/grub.d/30_uefi-firmware ###
```

```
### BEGIN /etc/grub.d/40_custom ###
# This file provides an easy way to add custom menu entries.  Simply type the
# menu entries you want to add after this comment.  Be careful not to change
# the 'exec tail' line above.
### END /etc/grub.d/40_custom ###

### BEGIN /etc/grub.d/41_custom ###
if [ -f  ${config_directory}/custom.cfg ]; then
  source ${config_directory}/custom.cfg
elif [ -z "${config_directory}" -a -f  $prefix/custom.cfg ]; then
  source $prefix/custom.cfg;
fi
### END /etc/grub.d/41_custom ###
</file>

==The /etc/default/grub file==

This file contains the default global configuration for GRUB 2:

<code>
[root@centos8 ~]# cat /etc/default/grub
GRUB_TIMEOUT=5
GRUB_DISTRIBUTOR="$(sed 's, release .*$,,g' /etc/system-release)"
GRUB_DEFAULT=saved
GRUB_DISABLE_SUBMENU=true
GRUB_TERMINAL_OUTPUT="console"
GRUB_CMDLINE_LINUX="crashkernel=auto resume=UUID=c8bb3f47-d67f-4b21-b781-766899dc83d4 rhgb quiet"
GRUB_DISABLE_RECOVERY="true"
GRUB_ENABLE_BLSCFG=true
```

Important : Any change made to this file requires the execution of the **grub2-mkconfig** command in order for the changes to become effective.

The most important directives in the above file are as follows:

Directive	Description
GRUB_TIMEOUT	Indicates the time to wait for user input prior to booting the default OS
GRUB_DISTRIBUTOR	Set by distributors of GRUB to their identifying name. This is used to generate more informative menu entry titles.
GRUB_DEFAULT	Indicates the default OS to boot. A value of 0 indicates the OS referenced by the first stanza commencing with the **menuentry** keyword
GRUB_CMDLINE_LINUX	Command-line arguments to add to menu entries for the Linux kernel.

Files in the /etc/grub.d directory

The files in this directory are executed in a numerical order and are used to build the stanzas in the **/boot/grub/grub.cfg** file:

```
[root@centos8 ~]#  ls -l /etc/grub.d
total 92
-rwxr-xr-x. 1 root root  8958 Mar  2 15:51 00_header
-rwxr-xr-x. 1 root root  1043 Jun 15  2020 00_tuned
-rwxr-xr-x. 1 root root   232 Mar  2 15:51 01_users
-rwxr-xr-x. 1 root root   832 Mar  2 15:51 08_fallback_counting
-rwxr-xr-x. 1 root root 14088 Mar  2 15:51 10_linux
-rwxr-xr-x. 1 root root   830 Mar  2 15:51 10_reset_boot_success
-rwxr-xr-x. 1 root root   889 Mar  2 15:51 12_menu_auto_hide
-rwxr-xr-x. 1 root root 11696 Mar  2 15:51 20_linux_xen
-rwxr-xr-x. 1 root root  2559 Mar  2 15:51 20_ppc_terminfo
-rwxr-xr-x. 1 root root 10670 Mar  2 15:51 30_os-prober
-rwxr-xr-x. 1 root root  1412 Mar  2 15:51 30_uefi-firmware
-rwxr-xr-x. 1 root root   214 Mar  2 15:51 40_custom
-rwxr-xr-x. 1 root root   216 Mar  2 15:51 41_custom
-rw-r--r--. 1 root root   483 Mar  2 15:51 README
```

Initramfs

The **Initramfs** *INITial Ram File System* file is a minimal system image which is initialised upon system boot.

The file format is **cramFS** that is to say archived using **cpio** and compressed with **gzip**.

```
[root@centos8 ~]# cp /boot/initramfs-4.18.0-240.22.1.el8_3.x86_64.img /tmp/custom
[root@centos8 ~]# cd /tmp
[root@centos8 tmp]# ls
cpio.list
custom
dateref
incremental.tar
mbr.save
systemd-private-9af7a2f7444849578f55b306bfd9f820-chronyd.service-iQiNzF
tblpart.save
test.cpio
test.print
test.tar
tmp.iso
vg0_backup

[root@centos8 tmp]# mv custom custom.gz

[root@centos8 tmp]# gunzip custom.gz

[root@centos8 tmp]# mkdir initramfs

[root@centos8 tmp]# cd initramfs

[root@centos8 initramfs]# cpio -cid -I ../custom
216 blocks
[root@centos8 initramfs]# ls
```

```
bin  dev  etc  init  lib  lib64  proc  root  run  sbin  shutdown  sys  sysroot  tmp  usr  var
```

To examine the current image, you need to use the **lsinitrd** command:

```
[root@centos8 tmp]# lsinitrd custom | more
Image: custom: 25M
========================================================================
Early CPIO image
========================================================================
drwxr-xr-x   3 root     root            0 Feb 22 10:57 .
-rw-r--r--   1 root     root            2 Feb 22 10:57 early_cpio
drwxr-xr-x   3 root     root            0 Feb 22 10:57 kernel
drwxr-xr-x   3 root     root            0 Feb 22 10:57 kernel/x86
drwxr-xr-x   2 root     root            0 Feb 22 10:57 kernel/x86/microcode
-rw-r--r--   1 root     root       109568 Feb 22 10:57 kernel/x86/microcode/GenuineIntel.bin
========================================================================
Version: dracut-049-95.git20200804.el8_3.4

Arguments: -f --kver '4.18.0-240.22.1.el8_3.x86_64'

dracut modules:
bash
systemd
systemd-initrd
nss-softokn
rngd
i18n
network-legacy
network
ifcfg
drm
plymouth
prefixdevname
kernel-modules
```

```
kernel-modules-extra
kernel-network-modules
resume
rootfs-block
terminfo
udev-rules
biosdevname
dracut-systemd
usrmount
base
fs-lib
memstrack
microcode_ctl-fw_dir_override
shutdown
===============================================================================
drwxr-xr-x  12 root     root            0 Feb 22 10:57 .
crw-r--r--   1 root     root       5,   1 Feb 22 10:57 dev/console
crw-r--r--   1 root     root       1,  11 Feb 22 10:57 dev/kmsg
crw-r--r--   1 root     root       1,   3 Feb 22 10:57 dev/null
crw-r--r--   1 root     root       1,   8 Feb 22 10:57 dev/random
crw-r--r--   1 root     root       1,   9 Feb 22 10:57 dev/urandom
lrwxrwxrwx   1 root     root            7 Feb 22 10:57 bin -> usr/bin
drwxr-xr-x   2 root     root            0 Feb 22 10:57 dev
drwxr-xr-x  11 root     root            0 Feb 22 10:57 etc
-rw-r--r--   1 root     root           30 Nov 10  2020 etc/centos-release
drwxr-xr-x   2 root     root            0 Feb 22 10:57 etc/cmdline.d
drwxr-xr-x   2 root     root            0 Feb 22 10:57 etc/conf.d
-rw-r--r--   1 root     root          124 Feb 22 10:57 etc/conf.d/systemd.conf
--More--
```

The init Script

RHEL/CentOS 8 uses **systemd**. For this reason the init script is a soft link to **/usr/lib/systemd/systemd** :

```
[root@centos8 tmp]# lsinitrd custom | grep usr/lib/systemd/systemd | grep init
lrwxrwxrwx   1 root     root           23 Feb 22 10:57 init -> usr/lib/systemd/systemd
```

Kernel Booting Process

The Kernel Booting Process is divided into 6 stages:

Stage	Description
Kernel loader loading, setup and configuration	In this step, the bootsect.s file is loaded into the memory by the BIOS. When the bootsect.s file sets up, it loads the rest of the kernel into the memory.
Parameter setup and switch to 32-bit mode	When the kernel has been loaded, the boot.s file sets up a temporary **IDT** and **GDT** and handles the switch to 32-bit mode.
Kernel decompression	The head.s file decompresses the kernel.
Kernel setup	After the kernel is decompressed, the real GDT and IDT are created by the head.s (second file).
Kernel and memory initialisation	In this step, the kernel sets up all memory constraints and virtual memory is completely set up.
Init process creation	In the final step of booting, the init process is created, which switches a Linux computer to different runlevels.

The **init_post()** function then tries to execute one of the following in the order shown:

- /sbin/init ⇒ /usr/sbin/init ⇒ /usr/lib/systemd/systemd
- /etc/init
- /bin/init
- /bin/sh ⇒ /bin/bash ⇒ /usr/bin/bash

An error at this stage results in a **Kernel Panic**.

Systemd

Systemd uses Units and Targets. A unit can be:

- **.automount**
- **.device**
- **.mount**
- **.path**
- **.service**
- **.scope**
- **.slice**
- **.snapshot**
- **.socket**
- **.swap**
- **.timer**
- **.target**

Examples of Targets are:

- **halt.target**
- **poweroff.target**
- **shutdown.target**
- **rescue.target**
- **emergency.target**
- **multi-user.target**
- **graphical.target**
- **hibernate.target**
- **reboot.target**

Systemd uses Targets in a similar way to the use of run-levels by **SysVinit**. To facilitate the transition to Systemd, certain Targgets are soft links:

```
[root@centos8 ~]# ls -l /usr/lib/systemd/system/runlevel*
lrwxrwxrwx. 1 root root 15 Apr  7 16:55 /usr/lib/systemd/system/runlevel0.target -> poweroff.target
lrwxrwxrwx. 1 root root 13 Apr  7 16:55 /usr/lib/systemd/system/runlevel1.target -> rescue.target
lrwxrwxrwx. 1 root root 17 Apr  7 16:55 /usr/lib/systemd/system/runlevel2.target -> multi-user.target
lrwxrwxrwx. 1 root root 17 Apr  7 16:55 /usr/lib/systemd/system/runlevel3.target -> multi-user.target
lrwxrwxrwx. 1 root root 17 Apr  7 16:55 /usr/lib/systemd/system/runlevel4.target -> multi-user.target
lrwxrwxrwx. 1 root root 16 Apr  7 16:55 /usr/lib/systemd/system/runlevel5.target -> graphical.target
```

```
lrwxrwxrwx. 1 root root 13 Apr  7 16:55 /usr/lib/systemd/system/runlevel6.target -> reboot.target

/usr/lib/systemd/system/runlevel1.target.wants:
total 0

/usr/lib/systemd/system/runlevel2.target.wants:
total 0

/usr/lib/systemd/system/runlevel3.target.wants:
total 0

/usr/lib/systemd/system/runlevel4.target.wants:
total 0

/usr/lib/systemd/system/runlevel5.target.wants:
total 0
```

LAB #1 - The systemctl Command

To list unit files, use the **systemctl** command with the **list-units** sub-command:

```
[root@centos8 ~]# systemctl list-units
UNIT                                                                    LOAD   ACTIVE SUB
DESCRIPTION
proc-sys-fs-binfmt_misc.automount                                       loaded active waiting
Arbitrary Executable File Formats File System Automount Point
sys-devices-pci0000:00-0000:00:01.1-ata2-host1-target1:0:0-1:0:0:0-block-sr0.device      loaded active plugged
CD-ROM
sys-devices-pci0000:00-0000:00:03.0-net-enp0s3.device                   loaded active plugged
82540EM Gigabit Ethernet Controller (PRO/1000 MT Desktop Adapter)
sys-devices-pci0000:00-0000:00:05.0-sound-card0.device                  loaded active plugged
82801AA AC'97 Audio Controller
sys-devices-pci0000:00-0000:00:0d.0-ata3-host2-target2:0:0-2:0:0:0-block-sda-sda1.device  loaded active plugged
```

```
VBOX_HARDDISK 1
sys-devices-pci0000:00-0000:00:0d.0-ata3-host2-target2:0:0-2:0:0:0-block-sda-sda2.device  loaded active plugged
VBOX_HARDDISK 2
sys-devices-pci0000:00-0000:00:0d.0-ata3-host2-target2:0:0-2:0:0:0-block-sda-sda3.device  loaded active plugged
VBOX_HARDDISK 3
sys-devices-pci0000:00-0000:00:0d.0-ata3-host2-target2:0:0-2:0:0:0-block-sda.device       loaded active plugged
VBOX_HARDDISK
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb1.device  loaded active plugged
VBOX_HARDDISK 1
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb10.device loaded active plugged
VBOX_HARDDISK 10
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb11.device loaded active plugged
VBOX_HARDDISK my_ext4
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb12.device loaded active plugged
VBOX_HARDDISK 12
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb2.device  loaded active plugged
VBOX_HARDDISK 2
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb3.device  loaded active plugged
VBOX_HARDDISK 3
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb4.device  loaded active plugged
VBOX_HARDDISK 4
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb5.device  loaded active plugged
VBOX_HARDDISK 5
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb6.device  loaded active plugged
VBOX_HARDDISK 6
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb7.device  loaded active plugged
VBOX_HARDDISK 7
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb8.device  loaded active plugged
VBOX_HARDDISK 8
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb-sdb9.device  loaded active plugged
VBOX_HARDDISK 9
sys-devices-pci0000:00-0000:00:0d.0-ata4-host3-target3:0:0-3:0:0:0-block-sdb.device       loaded active plugged
VBOX_HARDDISK
sys-devices-platform-serial8250-tty-ttyS0.device                                          loaded active plugged
```

```
/sys/devices/platform/serial8250/tty/ttyS0
sys-devices-platform-serial8250-tty-ttyS1.device                                    loaded active plugged
/sys/devices/platform/serial8250/tty/ttyS1
sys-devices-platform-serial8250-tty-ttyS2.device                                    loaded active plugged
/sys/devices/platform/serial8250/tty/ttyS2
sys-devices-platform-serial8250-tty-ttyS3.device                                    loaded active plugged
/sys/devices/platform/serial8250/tty/ttyS3
sys-devices-virtual-block-dm\x2d0.device                                            loaded active plugged
/sys/devices/virtual/block/dm-0
sys-devices-virtual-block-dm\x2d1.device                                            loaded active plugged
/sys/devices/virtual/block/dm-1
sys-devices-virtual-net-virbr0.device                                               loaded active plugged
/sys/devices/virtual/net/virbr0
sys-devices-virtual-net-virbr0\x2dnic.device                                        loaded active plugged
/sys/devices/virtual/net/virbr0-nic
sys-module-configfs.device                                                          loaded active plugged
/sys/module/configfs
sys-subsystem-net-devices-enp0s3.device                                             loaded active plugged
82540EM Gigabit Ethernet Controller (PRO/1000 MT Desktop Adapter)
sys-subsystem-net-devices-virbr0.device                                             loaded active plugged
/sys/subsystem/net/devices/virbr0
sys-subsystem-net-devices-virbr0\x2dnic.device                                      loaded active plugged
/sys/subsystem/net/devices/virbr0-nic
-.mount                                                                             loaded active mounted
Root Mount
boot.mount                                                                          loaded active mounted
/boot
dev-hugepages.mount                                                                 loaded active mounted
Huge Pages File System
dev-mqueue.mount                                                                    loaded active mounted
POSIX Message Queue File System
run-user-1000.mount                                                                 loaded active mounted
/run/user/1000
sys-kernel-config.mount                                                             loaded active mounted
```

```
Kernel Configuration File System
sys-kernel-debug.mount                                                    loaded active mounted
Kernel Debug File System
sys-kernel-tracing.mount                                                  loaded active mounted
/sys/kernel/tracing
var-lib-nfs-rpc_pipefs.mount                                              loaded active mounted
RPC Pipe File System
cups.path                                                                 loaded active running
CUPS Scheduler
systemd-ask-password-plymouth.path                                        loaded active waiting
Forward Password Requests to Plymouth Directory Watch
systemd-ask-password-wall.path                                            loaded active waiting
Forward Password Requests to Wall Directory Watch
init.scope                                                                loaded active running
System and Service Manager
session-96.scope                                                          loaded active running
Session 96 of user trainee
atd.service                                                               loaded active running
Job spooling tools
auditd.service                                                            loaded active running
Security Auditing Service
avahi-daemon.service                                                      loaded active running
Avahi mDNS/DNS-SD Stack
chronyd.service                                                           loaded active running
NTP client/server
crond.service                                                             loaded active running
Command Scheduler
cups.service                                                              loaded active running
CUPS Scheduler
dbus.service                                                              loaded active running
D-Bus System Message Bus
dracut-shutdown.service                                                   loaded active exited
Restore /run/initramfs on shutdown
firewalld.service                                                         loaded active running
```

```
firewalld - dynamic firewall daemon
lines 1-57
```

To see inactive units, use the following command:

```
[root@centos8 ~]# systemctl list-units --all | grep inactive | more
● boot.automount
not-found inactive dead      boot.automount
  proc-fs-nfsd.mount
loaded    inactive dead      NFSD configuration filesystem
  proc-sys-fs-binfmt_misc.mount
loaded    inactive dead      Arbitrary Executable File Formats File System
  sys-fs-fuse-connections.mount
loaded    inactive dead      FUSE Control File System
● sysroot.mount
not-found inactive dead      sysroot.mount
  tmp.mount
loaded    inactive dead      Temporary Directory (/tmp)
  var-lib-machines.mount
loaded    inactive dead      Virtual Machine and Container Storage
  systemd-ask-password-console.path
loaded    inactive dead      Dispatch Password Requests to Console Directory Watch
● apparmor.service
not-found inactive dead      apparmor.service
  auth-rpcgss-module.service
loaded    inactive dead      Kernel Module supporting RPCSEC_GSS
  cpupower.service
loaded    inactive dead      Configure CPU power related settings
● display-manager.service
not-found inactive dead      display-manager.service
  dm-event.service
loaded    inactive dead      Device-mapper event daemon
  dnf-makecache.service
loaded    inactive dead      dnf makecache
```

```
  dracut-cmdline.service
loaded    inactive dead      dracut cmdline hook
  dracut-initqueue.service
loaded    inactive dead      dracut initqueue hook
  dracut-mount.service
loaded    inactive dead      dracut mount hook
  dracut-pre-mount.service
loaded    inactive dead      dracut pre-mount hook
  dracut-pre-pivot.service
loaded    inactive dead      dracut pre-pivot and cleanup hook
  dracut-pre-trigger.service
loaded    inactive dead      dracut pre-trigger hook
  dracut-pre-udev.service
loaded    inactive dead      dracut pre-udev hook
  ebtables.service
loaded    inactive dead      Ethernet Bridge Filtering tables
  emergency.service
loaded    inactive dead      Emergency Shell
  initrd-cleanup.service
loaded    inactive dead      Cleaning Up and Shutting Down Daemons
  initrd-parse-etc.service
loaded    inactive dead      Reload Configuration from the Real Root
  initrd-switch-root.service
loaded    inactive dead      Switch Root
  initrd-udevadm-cleanup-db.service
loaded    inactive dead      Cleanup udevd DB
● ip6tables.service
not-found inactive dead      ip6tables.service
● ipset.service
not-found inactive dead      ipset.service
● iptables.service
not-found inactive dead      iptables.service
  iscsi-onboot.service
loaded    inactive dead      Special handling of early boot iSCSI sessions
```

```
  iscsi.service
loaded    inactive dead      Login and scanning of iSCSI devices
  iscsid.service
loaded    inactive dead      Open-iSCSI
  iscsiuio.service
loaded    inactive dead      iSCSI UserSpace I/O driver
  ldconfig.service
loaded    inactive dead      Rebuild Dynamic Linker Cache
  libvirt-guests.service
loaded    inactive dead      Suspend/Resume Running libvirt Guests
  libvirtd.service
loaded    inactive dead      Virtualization daemon
  loadmodules.service
loaded    inactive dead      Load legacy module configuration
● lvm2-activation.service
not-found inactive dead      lvm2-activation.service
  lvm2-lvmpolld.service
loaded    inactive dead      LVM2 poll daemon
  mdmonitor.service
loaded    inactive dead      Software RAID monitoring and management
  microcode.service
loaded    inactive dead      Load CPU microcode update
● network.service
not-found inactive dead      network.service
  nfs-blkmap.service
loaded    inactive dead      pNFS block layout mapping daemon
  nfs-convert.service
loaded    inactive dead      Preprocess NFS configuration convertion
  nfs-idmapd.service
loaded    inactive dead      NFSv4 ID-name mapping service
  nfs-mountd.service
loaded    inactive dead      NFS Mount Daemon
  nfs-server.service
loaded    inactive dead      NFS server and services
```

```
  nfs-utils.service
loaded    inactive dead      NFS server and client services
  nfsdcld.service
loaded    inactive dead      NFSv4 Client Tracking Daemon
  nftables.service
loaded    inactive dead      Netfilter Tables
● ntpd.service
not-found inactive dead      ntpd.service
● ntpdate.service
not-found inactive dead      ntpdate.service
  plymouth-switch-root.service
loaded    inactive dead      Plymouth switch root service
  rc-local.service
loaded    inactive dead      /etc/rc.d/rc.local Compatibility
  rescue.service
loaded    inactive dead      Rescue Shell
  rpc-gssd.service
loaded    inactive dead      RPC security service for NFS client and server
--More--
```

The black dots above are white on the screen. These dots mean that the unit has not been found on the system. For example:

```
[root@centos8 ~]# systemctl status ntpd
Unit ntpd.service could not be found.
```

To see unit status data, use the following command:

```
[root@centos8 ~]# systemctl list-unit-files | more
UNIT FILE                                                                  STATE
proc-sys-fs-binfmt_misc.automount                                          static
-.mount                                                                    generated
boot.mount                                                                 generated
dev-hugepages.mount                                                        static
dev-mqueue.mount                                                           static
```

```
proc-fs-nfsd.mount                                  static
proc-sys-fs-binfmt_misc.mount                       static
sys-fs-fuse-connections.mount                       static
sys-kernel-config.mount                             static
sys-kernel-debug.mount                              static
tmp.mount                                           disabled
var-lib-machines.mount                              static
var-lib-nfs-rpc_pipefs.mount                        static
cups.path                                           enabled
systemd-ask-password-console.path                   static
systemd-ask-password-plymouth.path                  static
systemd-ask-password-wall.path                      static
session-96.scope                                    transient
arp-ethers.service                                  disabled
atd.service                                         enabled
auditd.service                                      enabled
auth-rpcgss-module.service                          static
autovt@.service                                     enabled
avahi-daemon.service                                enabled
blk-availability.service                            disabled
chrony-dnssrv@.service                              static
chrony-wait.service                                 disabled
chronyd.service                                     enabled
cockpit-motd.service                                static
cockpit-wsinstance-http-redirect.service            static
cockpit-wsinstance-http.service                     static
cockpit-wsinstance-https-factory@.service           static
cockpit-wsinstance-https@.service                   static
cockpit.service                                     static
console-getty.service                               disabled
container-getty@.service                            static
cpupower.service                                    disabled
crond.service                                       enabled
cups-browsed.service                                disabled
```

```
cups.service                                                enabled
dbus-org.fedoraproject.FirewallD1.service                   enabled
dbus-org.freedesktop.Avahi.service                          enabled
dbus-org.freedesktop.hostname1.service                      static
dbus-org.freedesktop.import1.service                        static
dbus-org.freedesktop.locale1.service                        static
dbus-org.freedesktop.login1.service                         static
dbus-org.freedesktop.machine1.service                       static
dbus-org.freedesktop.nm-dispatcher.service                  enabled
dbus-org.freedesktop.portable1.service                      static
dbus-org.freedesktop.timedate1.service                      enabled
dbus.service                                                static
debug-shell.service                                         disabled
dm-event.service                                            static
dnf-makecache.service                                       static
dnsmasq.service                                             disabled
dracut-cmdline.service                                      static
--More--
```

To see units of a specific type, use the **-t** switch:

```
[root@centos8 ~]# systemctl list-unit-files -t mount
UNIT FILE                      STATE
-.mount                        generated
boot.mount                     generated
dev-hugepages.mount            static
dev-mqueue.mount               static
proc-fs-nfsd.mount             static
proc-sys-fs-binfmt_misc.mount  static
sys-fs-fuse-connections.mount  static
sys-kernel-config.mount        static
sys-kernel-debug.mount         static
tmp.mount                      disabled
var-lib-machines.mount         static
```

```
var-lib-nfs-rpc_pipefs.mount  static

12 unit files listed.
```

In the STATE column you can see the **static** and **generated** terms.

- STATE = static
  - This implies that only the system can stop and start the unit. Generally these are dependencies of other units.
- STATE = generated
  - This indicates that the file is generated automatically from the information in the **/etc/fstab** file when the system starts. In the case of a mount point, the binary responsable for this is **/lib/systemd/system-generators/systemd-fstab-generator** :

```
[root@centos8 ~]# ls -l /lib/systemd/system-generators/systemd-fstab-generator
-rwxr-xr-x. 1 root root 46096 Apr  7 16:56 /lib/systemd/system-generators/systemd-fstab-generator
```

Other binaries exist to automatically generate other types of unit files:

```
[root@centos8 ~]# ls -l /lib/systemd/system-generators
total 508
-rwxr-xr-x. 1 root root    504 Jan  4 11:25 kdump-dep-generator.sh
-r-xr-xr-x. 1 root root 134976 Aug 17  2020 lvm2-activation-generator
-rwxr-xr-x. 1 root root  67792 Jul 20  2020 nfs-server-generator
-rwxr-xr-x. 1 root root  38216 Jul 20  2020 rpc-pipefs-generator
-rwxr-xr-x. 1 root root    743 Apr 23  2020 selinux-autorelabel-generator.sh
-rwxr-xr-x. 1 root root  33504 Apr  7 16:56 systemd-cryptsetup-generator
-rwxr-xr-x. 1 root root  16648 Apr  7 16:56 systemd-debug-generator
-rwxr-xr-x. 1 root root  46096 Apr  7 16:56 systemd-fstab-generator
-rwxr-xr-x. 1 root root  17064 Apr  7 16:56 systemd-getty-generator
-rwxr-xr-x. 1 root root  29432 Apr  7 16:56 systemd-gpt-auto-generator
-rwxr-xr-x. 1 root root  12568 Apr  7 16:56 systemd-hibernate-resume-generator
-rwxr-xr-x. 1 root root  12368 Apr  7 16:56 systemd-rc-local-generator
-rwxr-xr-x. 1 root root  12408 Apr  7 16:56 systemd-system-update-generator
-rwxr-xr-x. 1 root root  33544 Apr  7 16:56 systemd-sysv-generator
```

```
-rwxr-xr-x. 1 root root  17024 Apr  7 16:56 systemd-veritysetup-generator
```

Commande Line Switches

Command line switches of the **systemctl** command are as follows:

```
[root@centos8 ~]# systemctl --help
systemctl [OPTIONS...] {COMMAND} ...

Query or send control commands to the systemd manager.

  -h --help           Show this help
     --version        Show package version
     --system         Connect to system manager
     --user           Connect to user service manager
  -H --host=[USER@]HOST
                      Operate on remote host
  -M --machine=CONTAINER
                      Operate on local container
  -t --type=TYPE      List units of a particular type
     --state=STATE    List units with particular LOAD or SUB or ACTIVE state
  -p --property=NAME  Show only properties by this name
  -a --all            Show all properties/all units currently in memory,
                      including dead/empty ones. To list all units installed on
                      the system, use the 'list-unit-files' command instead.
     --failed         Same as --state=failed
  -l --full           Don't ellipsize unit names on output
  -r --recursive      Show unit list of host and local containers
     --reverse        Show reverse dependencies with 'list-dependencies'
     --job-mode=MODE  Specify how to deal with already queued jobs, when
                      queueing a new job
     --show-types     When showing sockets, explicitly show their type
     --value          When showing properties, only print the value
```

```
  -i --ignore-inhibitors
                       When shutting down or sleeping, ignore inhibitors
     --kill-who=WHO    Who to send signal to
  -s --signal=SIGNAL   Which signal to send
     --now             Start or stop unit in addition to enabling or disabling it
     --dry-run         Only print what would be done
  -q --quiet           Suppress output
     --wait            For (re)start, wait until service stopped again
     --no-block        Do not wait until operation finished
     --no-wall         Don't send wall message before halt/power-off/reboot
     --no-reload       Don't reload daemon after en-/dis-abling unit files
     --no-legend       Do not print a legend (column headers and hints)
     --no-pager        Do not pipe output into a pager
     --no-ask-password
                       Do not ask for system passwords
     --global          Enable/disable/mask unit files globally
     --runtime         Enable/disable/mask unit files temporarily until next
                       reboot
  -f --force           When enabling unit files, override existing symlinks
                       When shutting down, execute action immediately
     --preset-mode=    Apply only enable, only disable, or all presets
     --root=PATH       Enable/disable/mask unit files in the specified root
                       directory
  -n --lines=INTEGER   Number of journal entries to show
  -o --output=STRING   Change journal output mode (short, short-precise,
                              short-iso, short-iso-precise, short-full,
                              short-monotonic, short-unix,
                              verbose, export, json, json-pretty, json-sse, cat)
     --firmware-setup Tell the firmware to show the setup menu on next boot
     --plain           Print unit dependencies as a list instead of a tree

lines 1-57
```

LAB #2 - Configuration Files

2.1 - Default Configuration Files

These files can be found in the **/usr/lib/systemd/system** directory:

```
[root@centos8 ~]# pkg-config systemd --variable=systemdsystemunitdir
/usr/lib/systemd/system
```

```
[root@centos8 ~]# ls -l /usr/lib/systemd/system | more
total 1464
-rw-r--r--. 1 root root  275 Apr 26  2020 arp-ethers.service
-rw-r--r--. 1 root root  222 May 11  2019 atd.service
-rw-r--r--. 1 root root 1512 Apr 23  2020 auditd.service
-rw-r--r--. 1 root root  628 Jul 20  2020 auth-rpcgss-module.service
lrwxrwxrwx. 1 root root   14 Apr  7 16:55 autovt@.service -> getty@.service
-rw-r--r--. 1 root root 1044 Nov 16  2020 avahi-daemon.service
-rw-r--r--. 1 root root  870 Nov 16  2020 avahi-daemon.socket
-rw-r--r--. 1 root root  956 Apr  7 16:54 basic.target
drwxr-xr-x. 2 root root    6 Apr  7 16:55 basic.target.wants
-r--r--r--. 1 root root  408 Aug 17  2020 blk-availability.service
-rw-r--r--. 1 root root  419 Jun 22  2018 bluetooth.target
-rw-r--r--. 1 root root  455 Apr  7 16:54 boot-complete.target
-rw-r--r--. 1 root root  209 Nov 19  2019 chrony-dnssrv@.service
-rw-r--r--. 1 root root  138 Nov 19  2019 chrony-dnssrv@.timer
-rw-r--r--. 1 root root  491 Nov 19  2019 chronyd.service
-rw-r--r--. 1 root root  472 May 10  2019 chrony-wait.service
-rw-r--r--. 1 root root  222 Aug 24  2020 cockpit-motd.service
-rw-r--r--. 1 root root  835 Aug 24  2020 cockpit.service
-rw-r--r--. 1 root root  373 Aug 24  2020 cockpit.socket
-rw-r--r--. 1 root root  251 Aug 24  2020 cockpit-wsinstance-http-redirect.service
-rw-r--r--. 1 root root  233 Aug 24  2020 cockpit-wsinstance-http-redirect.socket
```

```
-rw-r--r--. 1 root root  221 Aug 24  2020 cockpit-wsinstance-http.service
-rw-r--r--. 1 root root  165 Aug 24  2020 cockpit-wsinstance-https-factory@.service
-rw-r--r--. 1 root root  244 Aug 24  2020 cockpit-wsinstance-https-factory.socket
-rw-r--r--. 1 root root  215 Aug 24  2020 cockpit-wsinstance-http.socket
-rw-r--r--. 1 root root  264 Aug 24  2020 cockpit-wsinstance-https@.service
-rw-r--r--. 1 root root  478 Aug 24  2020 cockpit-wsinstance-https@.socket
-rw-r--r--. 1 root root 1082 Apr  7 16:55 console-getty.service
-rw-r--r--. 1 root root 1263 Apr  7 16:55 container-getty@.service
-rw-r--r--. 1 root root  294 Apr  8 15:21 cpupower.service
-rw-r--r--. 1 root root  356 Nov  8  2019 crond.service
-rw-r--r--. 1 root root  465 Jun 22  2018 cryptsetup-pre.target
-rw-r--r--. 1 root root  412 Jun 22  2018 cryptsetup.target
lrwxrwxrwx. 1 root root   13 Apr  7 16:55 ctrl-alt-del.target -> reboot.target
-rw-r--r--. 1 root root  234 Oct  4  2017 cups-browsed.service
-r--r--r--. 1 root root  142 Jun 15  2020 cups.path
-r--r--r--. 1 root root  248 Jun 15  2020 cups.service
-r--r--r--. 1 root root  136 Jun 15  2020 cups.socket
lrwxrwxrwx. 1 root root   25 Apr  7 16:55 dbus-org.freedesktop.hostname1.service -> systemd-hostnamed.service
lrwxrwxrwx. 1 root root   23 Apr  7 16:55 dbus-org.freedesktop.import1.service -> systemd-importd.service
lrwxrwxrwx. 1 root root   23 Apr  7 16:55 dbus-org.freedesktop.locale1.service -> systemd-localed.service
lrwxrwxrwx. 1 root root   22 Apr  7 16:55 dbus-org.freedesktop.login1.service -> systemd-logind.service
lrwxrwxrwx. 1 root root   24 Apr  7 16:55 dbus-org.freedesktop.machine1.service -> systemd-machined.service
lrwxrwxrwx. 1 root root   25 Apr  7 16:55 dbus-org.freedesktop.portable1.service -> systemd-portabled.service
lrwxrwxrwx. 1 root root   25 Apr  7 16:55 dbus-org.freedesktop.timedate1.service -> systemd-timedated.service
-rw-r--r--. 1 root root  380 Apr  7 12:08 dbus.service
-rw-r--r--. 1 root root  102 Apr  7 12:08 dbus.socket
drwxr-xr-x. 2 root root    6 Apr  7 16:55 dbus.target.wants
-rw-r--r--. 1 root root 1084 Apr  7 16:55 debug-shell.service
lrwxrwxrwx. 1 root root   16 Apr  7 16:55 default.target -> graphical.target
drwxr-xr-x. 2 root root    6 Apr  7 16:55 default.target.wants
-rw-r--r--. 1 root root  750 Jun 22  2018 dev-hugepages.mount
-rw-r--r--. 1 root root  665 Jun 22  2018 dev-mqueue.mount
-r--r--r--. 1 root root  345 Aug 17  2020 dm-event.service
-r--r--r--. 1 root root  248 Aug 17  2020 dm-event.socket
```

```
-rw-r--r--. 1 root root  457 Jun  2  2020 dnf-makecache.service
--More--
```

Certain configuration files are dynamically created and placed in the **/run/systemd/system** directory to then be deleted upon system reboot:

```
[root@centos8 ~]# ls -l /run/systemd/system/
total 0
```

User created unit files must be placed in the **/usr/lib/systemd/user** directory:

```
[root@centos8 ~]# pkg-config systemd --variable=systemduserunitdir
/usr/lib/systemd/user
```

> **Important** : This means that files in **/usr/lib/systemd/user** overload by files in **/run/systemd/system** which in turn overload files in **/usr/lib/systemd/system**.

Take the case of the **/usr/lib/systemd/system/sshd.service** file:

```
[root@centos8 ~]# cat /usr/lib/systemd/system/sshd.service
[Unit]
Description=OpenSSH server daemon
Documentation=man:sshd(8) man:sshd_config(5)
After=network.target sshd-keygen.target
Wants=sshd-keygen.target

[Service]
Type=notify
EnvironmentFile=-/etc/crypto-policies/back-ends/opensshserver.config
EnvironmentFile=-/etc/sysconfig/sshd
ExecStart=/usr/sbin/sshd -D $OPTIONS $CRYPTO_POLICY
ExecReload=/bin/kill -HUP $MAINPID
```

```
KillMode=process
Restart=on-failure
RestartSec=42s

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

To see **all** of the values of the configuration directives, use **systemctl show** and specify the unit file:

```
[root@centos8 ~]# systemctl show sshd
Type=notify
Restart=on-failure
NotifyAccess=main
RestartUSec=42s
TimeoutStartUSec=1min 30s
TimeoutStopUSec=1min 30s
RuntimeMaxUSec=infinity
WatchdogUSec=0
WatchdogTimestamp=Thu 2021-06-03 15:09:54 EDT
WatchdogTimestampMonotonic=12502561
PermissionsStartOnly=no
RootDirectoryStartOnly=no
RemainAfterExit=no
GuessMainPID=yes
MainPID=902
ControlPID=0
FileDescriptorStoreMax=0
NFileDescriptorStore=0
StatusErrno=0
Result=success
UID=[not set]
GID=[not set]
NRestarts=0
ExecMainStartTimestamp=Thu 2021-06-03 15:09:54 EDT
```

```
ExecMainStartTimestampMonotonic=12446178
ExecMainExitTimestampMonotonic=0
ExecMainPID=902
ExecMainCode=0
ExecMainStatus=0
ExecStart={ path=/usr/sbin/sshd ; argv[]=/usr/sbin/sshd -D $OPTIONS $CRYPTO_POLICY ; ignore_errors=no ;
start_time=[n/a] ; stop_time=[n/a] ; pid=0 ; code=(null) ; status=0/0 }
ExecReload={ path=/bin/kill ; argv[]=/bin/kill -HUP $MAINPID ; ignore_errors=no ; start_time=[n/a] ;
stop_time=[n/a] ; pid=0 ; code=(null) ; status=0/0 }
Slice=system.slice
ControlGroup=/system.slice/sshd.service
MemoryCurrent=6270976
CPUUsageNSec=[not set]
EffectiveCPUs=
EffectiveMemoryNodes=
TasksCurrent=1
IPIngressBytes=18446744073709551615
IPIngressPackets=18446744073709551615
IPEgressBytes=18446744073709551615
IPEgressPackets=18446744073709551615
Delegate=no
CPUAccounting=no
CPUWeight=[not set]
StartupCPUWeight=[not set]
CPUShares=[not set]
StartupCPUShares=[not set]
CPUQuotaPerSecUSec=infinity
CPUQuotaPeriodUSec=infinity
AllowedCPUs=
AllowedMemoryNodes=
IOAccounting=no
IOWeight=[not set]
StartupIOWeight=[not set]
BlockIOAccounting=no
```

```
BlockIOWeight=[not set]
lines 1-57
```

To see unit dependencies, use the **systemctl list-dependancies** command and specify the unit:

```
[root@centos8 ~]# systemctl list-dependencies sshd.service
sshd.service
● ├─system.slice
● ├─sshd-keygen.target
● │ ├─sshd-keygen@ecdsa.service
● │ ├─sshd-keygen@ed25519.service
● │ └─sshd-keygen@rsa.service
● └─sysinit.target
●   ├─dev-hugepages.mount
●   ├─dev-mqueue.mount
●   ├─dracut-shutdown.service
●   ├─import-state.service
●   ├─iscsi-onboot.service
●   ├─kmod-static-nodes.service
●   ├─ldconfig.service
●   ├─loadmodules.service
●   ├─lvm2-lvmpolld.socket
●   ├─lvm2-monitor.service
●   ├─nis-domainname.service
●   ├─plymouth-read-write.service
●   ├─plymouth-start.service
●   ├─proc-sys-fs-binfmt_misc.automount
●   ├─rngd.service
●   ├─selinux-autorelabel-mark.service
●   ├─sys-fs-fuse-connections.mount
●   ├─sys-kernel-config.mount
●   ├─sys-kernel-debug.mount
●   ├─systemd-ask-password-console.path
●   ├─systemd-binfmt.service
```

```
●   ├─systemd-firstboot.service
●   ├─systemd-hwdb-update.service
●   ├─systemd-journal-catalog-update.service
●   ├─systemd-journal-flush.service
●   ├─systemd-journald.service
●   ├─systemd-machine-id-commit.service
●   ├─systemd-modules-load.service
●   ├─systemd-random-seed.service
●   ├─systemd-sysctl.service
●   ├─systemd-sysusers.service
●   ├─systemd-tmpfiles-setup-dev.service
●   ├─systemd-tmpfiles-setup.service
●   ├─systemd-udev-trigger.service
●   ├─systemd-udevd.service
●   ├─systemd-update-done.service
●   ├─systemd-update-utmp.service
●   ├─cryptsetup.target
●   ├─local-fs.target
●   │ ├─-.mount
●   │ ├─boot.mount
●   │ └─systemd-remount-fs.service
●   └─swap.target
●     └─dev-disk-by\x2duuid-c8bb3f47\x2dd67f\x2d4b21\x2db781\x2d766899dc83d4.swap
```

2.2 - Overloading Default Configuration Files

Default configuration files can be overloaded by files in other directories:

```
[root@centos8 ~]# pkg-config systemd --variable=systemdsystemunitpath
/etc/systemd/system:/etc/systemd/system:/run/systemd/system:/usr/local/lib/systemd/system:/usr/lib/systemd/system
:/usr/lib/systemd/system:/lib/systemd/system
```

```
[root@centos8 ~]# ls -l /etc/systemd/system
```

```
total 4
drwxr-xr-x. 2 root root   31 May  8  2020 basic.target.wants
lrwxrwxrwx. 1 root root   41 May  8  2020 dbus-org.fedoraproject.FirewallD1.service ->
/usr/lib/systemd/system/firewalld.service
lrwxrwxrwx. 1 root root   44 Jun  3 14:02 dbus-org.freedesktop.Avahi.service -> /usr/lib/systemd/system/avahi-
daemon.service
lrwxrwxrwx. 1 root root   57 May  8  2020 dbus-org.freedesktop.nm-dispatcher.service ->
/usr/lib/systemd/system/NetworkManager-dispatcher.service
lrwxrwxrwx. 1 root root   41 May  8  2020 dbus-org.freedesktop.timedate1.service ->
/usr/lib/systemd/system/timedatex.service
lrwxrwxrwx. 1 root root   37 May  8  2020 default.target -> /lib/systemd/system/multi-user.target
drwxr-xr-x. 2 root root   32 May  8  2020 getty.target.wants
drwxr-xr-x. 2 root root 4096 Jun  3 14:02 multi-user.target.wants
drwxr-xr-x. 2 root root   48 May  8  2020 network-online.target.wants
drwxr-xr-x. 2 root root   33 Apr 19 12:07 nfs-blkmap.service.requires
drwxr-xr-x. 2 root root   33 Apr 19 12:07 nfs-idmapd.service.requires
drwxr-xr-x. 2 root root   33 Apr 19 12:07 nfs-mountd.service.requires
drwxr-xr-x. 2 root root   33 Apr 19 12:07 nfs-server.service.requires
drwxr-xr-x. 2 root root   26 Jun  3 14:02 printer.target.wants
drwxr-xr-x. 2 root root   52 Apr 19 12:07 remote-fs.target.wants
drwxr-xr-x. 2 root root   33 Apr 19 12:07 rpc-gssd.service.requires
drwxr-xr-x. 2 root root   33 Apr 19 12:07 rpc-statd-notify.service.requires
drwxr-xr-x. 2 root root   33 Apr 19 12:07 rpc-statd.service.requires
drwxr-xr-x. 2 root root  260 Jun  3 14:02 sockets.target.wants
drwxr-xr-x. 2 root root  235 Apr 19 12:07 sysinit.target.wants
lrwxrwxrwx. 1 root root   39 May  8  2020 syslog.service -> /usr/lib/systemd/system/rsyslog.service
lrwxrwxrwx. 1 root root    9 May 11  2019 systemd-timedated.service -> /dev/null
drwxr-xr-x. 2 root root   34 May  8  2020 timers.target.wants
```

LAB #3 - The systemd-analyze Command

To see the startup duration, use the following command:

```
[root@centos8 ~]# systemd-analyze
Startup finished in 1.665s (kernel) + 6.977s (initrd) + 8.458s (userspace) = 17.101s
multi-user.target reached after 5.528s in userspace
```

THe **blame** sub-command is used to see which units are the slowest:

```
[root@centos8 ~]# systemd-analyze blame
          4.080s dracut-initqueue.service
          3.257s kdump.service
          1.727s tuned.service
          1.415s initrd-switch-root.service
          1.393s NetworkManager-wait-online.service
          1.116s systemd-machined.service
          1.111s dracut-cmdline.service
           850ms sssd.service
           791ms vdo.service
           713ms firewalld.service
           622ms lvm2-monitor.service
           605ms polkit.service
           508ms chronyd.service
           434ms avahi-daemon.service
           426ms systemd-logind.service
           417ms netcf-transaction.service
           410ms dracut-pre-udev.service
           295ms libvirtd.service
           275ms dnf-makecache.service
           243ms systemd-udevd.service
           221ms systemd-journald.service
           196ms systemd-tmpfiles-setup.service
           151ms dracut-pre-pivot.service
           139ms sysroot.mount
           139ms systemd-update-utmp-runlevel.service
           122ms systemd-vconsole-setup.service
           110ms lvm2-pvscan@8:25.service
```

```
             98ms systemd-udev-trigger.service
             82ms gssproxy.service
             81ms cups.service
             79ms initrd-parse-etc.service
             77ms NetworkManager.service
             72ms lvm2-pvscan@8:23.service
             69ms systemd-user-sessions.service
             68ms lvm2-pvscan@8:22.service
             67ms unbound-anchor.service
             66ms rsyslog.service
             62ms boot.mount
             56ms sshd.service
             54ms smartd.service
             54ms systemd-fsck@dev-disk-by\x2duuid-2ae4c035\x2d9244\x2d458c\x2d82c5\x2da49ae169cdb6.service
             53ms user@1000.service
             52ms auditd.service
             51ms plymouth-quit.service
             49ms rngd-wake-threshold.service
             46ms import-state.service
             46ms systemd-tmpfiles-setup-dev.service
             43ms ksmtuned.service
             42ms plymouth-quit-wait.service
             42ms var-lib-nfs-rpc_pipefs.mount
             42ms rpc-statd-notify.service
             38ms plymouth-switch-root.service
             37ms systemd-remount-fs.service
             37ms plymouth-start.service
             33ms dev-disk-by\x2duuid-c8bb3f47\x2dd67f\x2d4b21\x2db781\x2d766899dc83d4.swap
             33ms systemd-tmpfiles-clean.service
             31ms dev-hugepages.mount
lines 1-57
```

The **critical-chain** sub-command shows the startup process of a specific unit:

```
[root@centos8 ~]# systemd-analyze critical-chain sshd.service
The time after the unit is active or started is printed after the "@" character.
The time the unit takes to start is printed after the "+" character.

sshd.service +56ms
└─network.target @3.799s
  └─NetworkManager.service @3.719s +77ms
    └─network-pre.target @3.718s
      └─firewalld.service @3.004s +713ms
        └─polkit.service @2.397s +605ms
          └─basic.target @2.392s
            └─sockets.target @2.392s
              └─sssd-kcm.socket @2.391s
                └─sysinit.target @2.379s
                  └─systemd-update-utmp.service @2.370s +8ms
                    └─auditd.service @2.317s +52ms
                      └─systemd-tmpfiles-setup.service @2.118s +196ms
                        └─import-state.service @2.070s +46ms
                          └─local-fs.target @2.069s
                            └─boot.mount @2.006s +62ms
                              └─systemd-fsck@dev-disk-
by\x2duuid-2ae4c035\x2d9244\x2d458c\x2d82c5\x2da49ae169cdb6.service @1.943s +54ms
                                └─local-fs-pre.target @1.942s
                                  └─lvm2-monitor.service @1.319s +622ms
                                    └─dm-event.socket @1.317s
                                      └─-.mount
                                        └─system.slice
                                          └─-.slice
```

Commande Line Switches

Command line switches of the **systemd-analyze** command are as follows:

```
[root@centos7 ~]# systemd-analyze --help
systemd-analyze [OPTIONS...] {COMMAND} ...

Process systemd profiling information

  -h --help           Show this help
     --version        Show package version
     --system         Connect to system manager
     --user           Connect to user service manager
     --order          When generating a dependency graph, show only order
     --require        When generating a dependency graph, show only requirement
     --from-pattern=GLOB, --to-pattern=GLOB
                      When generating a dependency graph, filter only origins
                      or destinations, respectively
     --fuzz=TIMESPAN  When printing the tree of the critical chain, print also
                      services, which finished TIMESPAN earlier, than the
                      latest in the branch. The unit of TIMESPAN is seconds
                      unless specified with a different unit, i.e. 50ms
     --no-pager       Do not pipe output into a pager

Commands:
  time               Print time spent in the kernel before reaching userspace
  blame              Print list of running units ordered by time to init
  critical-chain     Print a tree of the time critical chain of units
  plot               Output SVG graphic showing service initialization
  dot                Output dependency graph in dot(1) format
  set-log-level LEVEL Set logging threshold for systemd
  dump               Output state serialization of service manager
```

LAB #4 - Targets

Each Target has a configuration file:

```
[root@centos8 ~]# cat /usr/lib/systemd/system/graphical.target
#  SPDX-License-Identifier: LGPL-2.1+
#
#  This file is part of systemd.
#
#  systemd is free software; you can redistribute it and/or modify it
#  under the terms of the GNU Lesser General Public License as published by
#  the Free Software Foundation; either version 2.1 of the License, or
#  (at your option) any later version.

[Unit]
Description=Graphical Interface
Documentation=man:systemd.special(7)
Requires=multi-user.target
Wants=display-manager.service
Conflicts=rescue.service rescue.target
After=multi-user.target rescue.service rescue.target display-manager.service
AllowIsolate=yes
```

4.1 - Checking the Target Dependencies

Target dependencies are shown by the **systemctl list-dependencies** command:

```
[root@centos8 ~]# systemctl list-dependencies multi-user.target
multi-user.target
● ├─atd.service
● ├─auditd.service
● ├─avahi-daemon.service
● ├─chronyd.service
● ├─crond.service
● ├─cups.path
● ├─cups.service
```

```
● ├─dbus.service
● ├─dnf-makecache.timer
● ├─firewalld.service
● ├─irqbalance.service
● ├─kdump.service
● ├─ksm.service
● ├─ksmtuned.service
● ├─libstoragemgmt.service
● ├─libvirtd.service
● ├─mcelog.service
● ├─mdmonitor.service
● ├─netcf-transaction.service
● ├─NetworkManager.service
● ├─plymouth-quit-wait.service
● ├─plymouth-quit.service
● ├─rpcbind.service
● ├─rsyslog.service
● ├─smartd.service
● ├─sshd.service
● ├─sssd.service
● ├─systemd-ask-password-wall.path
● ├─systemd-logind.service
● ├─systemd-update-utmp-runlevel.service
● ├─systemd-user-sessions.service
● ├─tuned.service
● ├─vdo.service
● ├─basic.target
● │ ├─-.mount
● │ ├─microcode.service
● │ ├─paths.target
● │ ├─slices.target
● │ │ ├─-.slice
● │ │ └─system.slice
● │ ├─sockets.target
```

```
● │ │ ├─avahi-daemon.socket
● │ │ ├─cups.socket
● │ │ ├─dbus.socket
● │ │ ├─dm-event.socket
● │ │ ├─iscsid.socket
● │ │ ├─iscsiuio.socket
● │ │ ├─libvirtd-ro.socket
● │ │ ├─libvirtd.socket
● │ │ ├─rpcbind.socket
● │ │ ├─sssd-kcm.socket
● │ │ ├─systemd-coredump.socket
● │ │ ├─systemd-initctl.socket
● │ │ ├─systemd-journald-dev-log.socket
● │ │ ├─systemd-journald.socket
● │ │ ├─systemd-udevd-control.socket
lines 1-57
```

The black dots above are coloured on-screen:

- **Green** implies that the service, target or unit is active and started.
- **White** implies that the service, target or unit is inactive.
- **Red** implies that the service, target or unit has not started due to a fatal error.

To see failed units, use **systemctl –failed** :

```
[root@centos8 ~]# systemctl --failed
0 loaded units listed. Pass --all to see loaded but inactive units, too.
To show all installed unit files use 'systemctl list-unit-files'.
```

Target dependencies are soft-links in **/etc/systemd/system/multi-user.target.wants** and **/usr/lib/systemd/system/multi-user.target.wants**:

```
[root@centos8 ~]# ls -l /etc/systemd/system/multi-user.target.wants
total 0
lrwxrwxrwx. 1 root root 35 May  8  2020 atd.service -> /usr/lib/systemd/system/atd.service
```

```
lrwxrwxrwx. 1 root root 38 May  8  2020 auditd.service -> /usr/lib/systemd/system/auditd.service
lrwxrwxrwx. 1 root root 44 Jun  3 14:02 avahi-daemon.service -> /usr/lib/systemd/system/avahi-daemon.service
lrwxrwxrwx. 1 root root 39 May  8  2020 chronyd.service -> /usr/lib/systemd/system/chronyd.service
lrwxrwxrwx. 1 root root 37 May  8  2020 crond.service -> /usr/lib/systemd/system/crond.service
lrwxrwxrwx. 1 root root 33 Jun  3 14:02 cups.path -> /usr/lib/systemd/system/cups.path
lrwxrwxrwx. 1 root root 36 Jun  3 14:02 cups.service -> /usr/lib/systemd/system/cups.service
lrwxrwxrwx. 1 root root 43 May  8  2020 dnf-makecache.timer -> /usr/lib/systemd/system/dnf-makecache.timer
lrwxrwxrwx. 1 root root 41 May  8  2020 firewalld.service -> /usr/lib/systemd/system/firewalld.service
lrwxrwxrwx. 1 root root 42 May  8  2020 irqbalance.service -> /usr/lib/systemd/system/irqbalance.service
lrwxrwxrwx. 1 root root 37 May  8  2020 kdump.service -> /usr/lib/systemd/system/kdump.service
lrwxrwxrwx. 1 root root 35 Apr 19 12:07 ksm.service -> /usr/lib/systemd/system/ksm.service
lrwxrwxrwx. 1 root root 40 Apr 19 12:07 ksmtuned.service -> /usr/lib/systemd/system/ksmtuned.service
lrwxrwxrwx. 1 root root 46 May  8  2020 libstoragemgmt.service -> /usr/lib/systemd/system/libstoragemgmt.service
lrwxrwxrwx. 1 root root 40 Apr 19 12:07 libvirtd.service -> /usr/lib/systemd/system/libvirtd.service
lrwxrwxrwx. 1 root root 38 May  8  2020 mcelog.service -> /usr/lib/systemd/system/mcelog.service
lrwxrwxrwx. 1 root root 41 May  8  2020 mdmonitor.service -> /usr/lib/systemd/system/mdmonitor.service
lrwxrwxrwx. 1 root root 49 Apr 19 12:07 netcf-transaction.service -> /usr/lib/systemd/system/netcf-
transaction.service
lrwxrwxrwx. 1 root root 46 May  8  2020 NetworkManager.service -> /usr/lib/systemd/system/NetworkManager.service
lrwxrwxrwx. 1 root root 41 Apr 19 12:07 nfs-client.target -> /usr/lib/systemd/system/nfs-client.target
lrwxrwxrwx. 1 root root 40 May  8  2020 remote-fs.target -> /usr/lib/systemd/system/remote-fs.target
lrwxrwxrwx. 1 root root 39 Apr 19 12:07 rpcbind.service -> /usr/lib/systemd/system/rpcbind.service
lrwxrwxrwx. 1 root root 39 May  8  2020 rsyslog.service -> /usr/lib/systemd/system/rsyslog.service
lrwxrwxrwx. 1 root root 38 May  8  2020 smartd.service -> /usr/lib/systemd/system/smartd.service
lrwxrwxrwx. 1 root root 36 May  8  2020 sshd.service -> /usr/lib/systemd/system/sshd.service
lrwxrwxrwx. 1 root root 36 May  8  2020 sssd.service -> /usr/lib/systemd/system/sssd.service
lrwxrwxrwx. 1 root root 37 May  8  2020 tuned.service -> /usr/lib/systemd/system/tuned.service
lrwxrwxrwx. 1 root root 35 May  8  2020 vdo.service -> /usr/lib/systemd/system/vdo.service

[root@centos8 ~]# ls -l /usr/lib/systemd/system/multi-user.target.wants
total 0
lrwxrwxrwx. 1 root root 15 Apr  7 12:08 dbus.service -> ../dbus.service
lrwxrwxrwx. 1 root root 15 Apr  7 16:55 getty.target -> ../getty.target
```

```
lrwxrwxrwx. 1 root root 29 Oct  6  2020 plymouth-quit-wait.service -> ../plymouth-quit-wait.service
lrwxrwxrwx. 1 root root 33 Apr  7 16:55 systemd-ask-password-wall.path -> ../systemd-ask-password-wall.path
lrwxrwxrwx. 1 root root 25 Apr  7 16:55 systemd-logind.service -> ../systemd-logind.service
lrwxrwxrwx. 1 root root 39 Apr  7 16:55 systemd-update-utmp-runlevel.service -> ../systemd-update-utmp-
runlevel.service
lrwxrwxrwx. 1 root root 32 Apr  7 16:55 systemd-user-sessions.service -> ../systemd-user-sessions.service
```

4.2 - The Default Target

Checking the Default Target

To check the defauylt target, use the **systemctl get-default** command:

```
[root@centos8 ~]# systemctl get-default
multi-user.target
```

The default target is in fact a symbolic link:

```
[root@centos8 ~]# ls -l /etc/systemd/system/default.target
lrwxrwxrwx. 1 root root 37 May  8  2020 /etc/systemd/system/default.target -> /lib/systemd/system/multi-
user.target
```

Changing the Default Target

To change the default traget for the **next** boot process, use the **systemctl set-default** command:

```
[root@centos8 ~]# systemctl set-default graphical.target
Removed /etc/systemd/system/default.target.
Created symlink /etc/systemd/system/default.target → /usr/lib/systemd/system/graphical.target.
[root@centos8 ~]# ls -l /etc/systemd/system/default.target
```

```
lrwxrwxrwx. 1 root root 40 Jun  6 08:11 /etc/systemd/system/default.target ->
/usr/lib/systemd/system/graphical.target
[root@centos8 ~]# systemctl set-default multi-user.target
Removed /etc/systemd/system/default.target.
Created symlink /etc/systemd/system/default.target → /usr/lib/systemd/system/multi-user.target.
[root@centos8 ~]# ls -l /etc/systemd/system/default.target
lrwxrwxrwx. 1 root root 41 Jun  6 08:11 /etc/systemd/system/default.target -> /usr/lib/systemd/system/multi-
user.target
```

Changing the Default Target for the Current Session

This can be done by using the **systemctl isolate** command:

```
[root@centos8 ~]# systemctl isolate rescue
[root@centos8 ~]# systemctl list-units --type target | egrep "eme|res|gra|mul" | head -1
rescue.target       loaded active active Rescue Mode
[root@centos8 ~]# runlevel
3 1
[root@centos8 ~]# who -r
         run-level 1  2021-06-15 04:22                   last=3
```

```
[root@centos8 ~]# systemctl isolate multi-user
[root@centos8 ~]# systemctl list-units --type target | egrep "eme|res|gra|mul" | head -1
multi-user.target      loaded active active Multi-User System
[root@centos8 ~]# runlevel
1 3
[root@centos8 ~]# who -r
         run-level 3  2021-06-15 04:24                   last=1
```

LAB #5 - Managing Services

5.1 - Single Service Instances

Start by installing **httpd** :

```
[root@centos8 ~]# dnf install httpd
```

To obtain information about a specific service, use the **systemctl status** command:

```
[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled; vendor preset: disabled)
   Active: inactive (dead)
     Docs: man:httpd.service(8)
```

In the above output you can see that the service is **disabled**. The status can have one of two values:

- **disabled**.
- **enabled**.

You can also check if a service is enabled with the **systemctl is-enabled** command:

```
[root@centos8 ~]# systemctl is-enabled httpd.service
disabled
```

To configure the status as **enabled**, use the **systemctl enable** command:

```
[root@centos8 ~]# systemctl enable httpd.service
Created symlink /etc/systemd/system/multi-user.target.wants/httpd.service →
/usr/lib/systemd/system/httpd.service.

[root@centos8 ~]# systemctl is-enabled httpd.service
enabled
```

```
[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled; vendor preset: disabled)
   Active: inactive (dead)
     Docs: man:httpd.service(8)
```

In the above output, you can now see that the status is **inactive (dead)**. The status can have one of 7 values:

- **inactive (dead)**
- **active(running**
- **active(exited)**
- **active(waiting)**
- **activating**
- **deactivating**
- **failed**

You can also check if a service is active with the **systemctl is-active** command:

```
[root@centos8 ~]# systemctl is-active httpd.service
inactive
```

To set the service to **active(running)**, use the following command:

```
[root@centos8 ~]# systemctl start httpd.service
```

Now check the service status:

```
[root@centos8 ~]# systemctl is-active httpd.service
active

[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled; vendor preset: disabled)
   Active: active (running) since Sun 2021-06-06 15:33:06 EDT; 14s ago
```

```
     Docs: man:httpd.service(8)
 Main PID: 34382 (httpd)
   Status: "Running, listening on: port 80"
    Tasks: 213 (limit: 23719)
   Memory: 36.3M
   CGroup: /system.slice/httpd.service
           ├─34382 /usr/sbin/httpd -DFOREGROUND
           ├─34383 /usr/sbin/httpd -DFOREGROUND
           ├─34384 /usr/sbin/httpd -DFOREGROUND
           ├─34385 /usr/sbin/httpd -DFOREGROUND
           └─34386 /usr/sbin/httpd -DFOREGROUND

Jun 06 15:33:05 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 06 15:33:06 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 06 15:33:06 centos8.ittraining.loc httpd[34382]: Server configured, listening on: port 80
```

To stop a service use the following command:

```
[root@centos8 ~]# systemctl stop httpd.service
[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled; vendor preset: disabled)
   Active: inactive (dead) since Sun 2021-06-06 23:58:04 EDT; 8s ago
     Docs: man:httpd.service(8)
  Process: 34382 ExecStart=/usr/sbin/httpd $OPTIONS -DFOREGROUND (code=exited, status=0/SUCCESS)
 Main PID: 34382 (code=exited, status=0/SUCCESS)
   Status: "Running, listening on: port 80"

Jun 06 15:33:05 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 06 15:33:06 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 06 15:33:06 centos8.ittraining.loc httpd[34382]: Server configured, listening on: port 80
Jun 06 23:58:02 centos8.ittraining.loc systemd[1]: Stopping The Apache HTTP Server...
Jun 06 23:58:04 centos8.ittraining.loc systemd[1]: httpd.service: Succeeded.
```

```
Jun 06 23:58:04 centos8.ittraining.loc systemd[1]: Stopped The Apache HTTP Server.
```

To disable a service for the next boot sequence, use the **disable** sub-command:

```
[root@centos8 ~]# systemctl disable httpd.service
Removed /etc/systemd/system/multi-user.target.wants/httpd.service.
[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled; vendor preset: disabled)
   Active: inactive (dead)
     Docs: man:httpd.service(8)

Jun 06 15:33:05 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 06 15:33:06 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 06 15:33:06 centos8.ittraining.loc httpd[34382]: Server configured, listening on: port 80
Jun 06 23:58:02 centos8.ittraining.loc systemd[1]: Stopping The Apache HTTP Server...
Jun 06 23:58:04 centos8.ittraining.loc systemd[1]: httpd.service: Succeeded.
Jun 06 23:58:04 centos8.ittraining.loc systemd[1]: Stopped The Apache HTTP Server.
```

5.2 - Multiple Instance Services

Systemd permits the use of unit configuration file templates. In this way, multiple service instances can co-exist. A template can be recognised by it's name which contains the **@** character:

```
[root@centos8 ~]# cat /usr/lib/systemd/system/httpd@.service
# This is a template for httpd instances.
# See httpd@.service(8) for more information.

[Unit]
Description=The Apache HTTP Server
After=network.target remote-fs.target nss-lookup.target
Documentation=man:httpd@.service(8)
```

```
[Service]
Type=notify
Environment=LANG=C
Environment=HTTPD_INSTANCE=%i
ExecStartPre=/bin/mkdir -m 710 -p /run/httpd/instance-%i
ExecStartPre=/bin/chown root.apache /run/httpd/instance-%i
ExecStart=/usr/sbin/httpd $OPTIONS -DFOREGROUND -f conf/%i.conf
ExecReload=/usr/sbin/httpd $OPTIONS -k graceful -f conf/%i.conf
# Send SIGWINCH for graceful stop
KillSignal=SIGWINCH
KillMode=mixed
PrivateTmp=true

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

An instance created form this template must have a name of the following format:

```
httpd@<nom_instance>.service
```

In the configuration file you can see an **%i** which is called an **identifier**. Identifiers can be of two types - **escaped** where alphanumeric non-ASCII characters are replaced with C langauge **escapes** whilst the other type is **non-escaped**:

- %n : is replaced by the escaped or non-escaped name of the unit.
- %N : is replaced by unit's complete non-escaped name.
- %p : is replaced by the prefix - the part of the name before the **@** of an escaped unit.
- %P : is replaced by the prefix - part of the name before the **@** of a non-escaped unit.
- %i : is replaced by the part of the name after the **@** and before the **.** of an escaped unit.
- %I : is replaced by the part of the name after the **@** and before the **.** of an non-escaped unit.
- %f : is replaced by a **/** character followed by the prefix of the name of a non-escaped unit.
- %c : is replaced by unit's CGroup without /sys/fs/cgroup/systemd/.
- %u : is replaced by the name of the user responsible for the execution of the unit.
- %U : is replaced by the UID of the user responsible for the execution of the unit.
- %H : is replaced by the hostname of the system on which the unit is executed.

- %% : is replaced by **%** character.

Now create **two** copies of the **/usr/lib/systemd/system/httpd@.service** file:

```
[root@centos8 ~]# cp /usr/lib/systemd/system/httpd@.service /usr/lib/systemd/system/httpd@instance01.service
[root@centos8 ~]# cp /usr/lib/systemd/system/httpd@.service /usr/lib/systemd/system/httpd@instance02.service
```

Create **two** copies of the **/etc/httpd/conf/httpd.conf** file:

```
[root@centos8 ~]# cp /etc/httpd/conf/httpd.conf /etc/httpd/conf/instance01.conf
[root@centos8 ~]# cp /etc/httpd/conf/httpd.conf /etc/httpd/conf/instance02.conf
```

Change the value of the **Listen** directive and **add* the** PidFile **directive in the** /etc/httpd/conf/instance01.conf **file: <code> [root@centos8 ~]# vi /etc/httpd/conf/instance01.conf [root@centos8 ~]# more /etc/httpd/conf/instance01.conf # # This is the main Apache HTTP server configuration file. It contains the # configuration directives that give the server its instructions. # See <URL:http://httpd.apache.org/docs/2.4/> for detailed information. # In particular, see # <URL:http://httpd.apache.org/docs/2.4/mod/directives.html> # for a discussion of each configuration directive. # # See the httpd.conf(5) man page for more information on this configuration, # and httpd.service(8) on using and configuring the httpd service. # # Do NOT simply read the instructions in here without understanding # what they do. They're here only as hints or reminders. If you are unsure # consult the online docs. You have been warned. # # Configuration and logfile names: If the filenames you specify for many # of the server's control files begin with “/” (or “drive:/” for Win32), the # server will use that explicit path. If the filenames do *not* begin # with “/”, the value of ServerRoot is prepended – so 'log/access_log' # with ServerRoot set to '/www' will be interpreted by the # server as '/www/log/access_log', where as '/log/access_log' will be # interpreted as '/log/access_log'. # # ServerRoot: The top of the directory tree under which the server's # configuration, error, and log files are kept. # # Do not add a slash at the end of the directory path. If you point # ServerRoot at a non-local disk, be sure to specify a local disk on the # Mutex directive, if file-based mutexes are used. If you wish to share the # same ServerRoot for multiple httpd daemons, you will need to change at # least PidFile. # ServerRoot “/etc/httpd” # # Listen: Allows you to bind Apache to specific IP addresses and/or # ports, instead of the default. See also the <VirtualHost> # directive. # # Change this to Listen on specific IP addresses as shown below to # prevent Apache from glomming onto all bound IP addresses. # #Listen 12.34.56.78:80 Listen 8008 PidFile /var/run/httpd/instance01.pid # # Dynamic Shared Object (DSO) Support # # To be able to use the functionality of a module which was built as a DSO you # have to place corresponding `LoadModule' lines at this location so the # directives contained in it are actually available _before_ they are used. # Statically compiled modules (those listed by `httpd -l') do not need # to be loaded here. # # Example: # LoadModule foo_module modules/mod_foo.so –More–(19%) </code> Change the value of the** Listen **directive and** add* the **PidFile** directive in the **/etc/httpd/conf/instance02.conf** file:

```
[root@centos8 ~]# vi /etc/httpd/conf/instance02.conf
[root@centos8 ~]# more /etc/httpd/conf/instance02.conf
#
# This is the main Apache HTTP server configuration file.  It contains the
# configuration directives that give the server its instructions.
# See <URL:http://httpd.apache.org/docs/2.4/> for detailed information.
# In particular, see
# <URL:http://httpd.apache.org/docs/2.4/mod/directives.html>
# for a discussion of each configuration directive.
#
# See the httpd.conf(5) man page for more information on this configuration,
# and httpd.service(8) on using and configuring the httpd service.
#
# Do NOT simply read the instructions in here without understanding
# what they do.  They're here only as hints or reminders.  If you are unsure
# consult the online docs. You have been warned.
#
# Configuration and logfile names: If the filenames you specify for many
# of the server's control files begin with "/" (or "drive:/" for Win32), the
# server will use that explicit path.  If the filenames do *not* begin
# with "/", the value of ServerRoot is prepended -- so 'log/access_log'
# with ServerRoot set to '/www' will be interpreted by the
# server as '/www/log/access_log', where as '/log/access_log' will be
# interpreted as '/log/access_log'.

#
# ServerRoot: The top of the directory tree under which the server's
# configuration, error, and log files are kept.
#
# Do not add a slash at the end of the directory path.  If you point
# ServerRoot at a non-local disk, be sure to specify a local disk on the
# Mutex directive, if file-based mutexes are used.  If you wish to share the
# same ServerRoot for multiple httpd daemons, you will need to change at
# least PidFile.
```

```
#
ServerRoot "/etc/httpd"

#
# Listen: Allows you to bind Apache to specific IP addresses and/or
# ports, instead of the default. See also the <VirtualHost>
# directive.
#
# Change this to Listen on specific IP addresses as shown below to
# prevent Apache from glomming onto all bound IP addresses.
#
#Listen 12.34.56.78:80
Listen 8009
PidFile /var/run/httpd/instance02.pid
#
# Dynamic Shared Object (DSO) Support
#
# To be able to use the functionality of a module which was built as a DSO you
# have to place corresponding `LoadModule' lines at this location so the
# directives contained in it are actually available _before_ they are used.
# Statically compiled modules (those listed by `httpd -l') do not need
# to be loaded here.
#
# Example:
# LoadModule foo_module modules/mod_foo.so
--More--(19%)
```

Now start both services:

```
[root@centos8 ~]# systemctl start httpd@instance01.service
[root@centos8 ~]# systemctl status httpd@instance01.service
● httpd@instance01.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd@instance01.service; disabled; vendor preset: disabled)
   Active: active (running) since Mon 2021-06-07 01:40:43 EDT; 7s ago
```

```
     Docs: man:httpd@.service(8)
  Process: 43854 ExecStartPre=/bin/chown root.apache /run/httpd/instance-instance01 (code=exited,
status=0/SUCCESS)
  Process: 43852 ExecStartPre=/bin/mkdir -m 710 -p /run/httpd/instance-instance01 (code=exited, status=0/SUCCESS)
 Main PID: 43856 (httpd)
   Status: "Started, listening on: port 8008"
    Tasks: 213 (limit: 23719)
   Memory: 43.6M
   CGroup: /system.slice/system-httpd.slice/httpd@instance01.service
           ├─43856 /usr/sbin/httpd -DFOREGROUND -f conf/instance01.conf
           ├─43857 /usr/sbin/httpd -DFOREGROUND -f conf/instance01.conf
           ├─43858 /usr/sbin/httpd -DFOREGROUND -f conf/instance01.conf
           ├─43859 /usr/sbin/httpd -DFOREGROUND -f conf/instance01.conf
           └─43860 /usr/sbin/httpd -DFOREGROUND -f conf/instance01.conf

Jun 07 01:40:43 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 07 01:40:43 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 07 01:40:43 centos8.ittraining.loc httpd[43856]: Server configured, listening on: port 8008
[root@centos8 ~]# systemctl start httpd@instance02.service
[root@centos8 ~]# systemctl status httpd@instance02.service
● httpd@instance02.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd@instance02.service; disabled; vendor preset: disabled)
   Active: active (running) since Mon 2021-06-07 01:36:45 EDT; 4min 24s ago
     Docs: man:httpd@.service(8)
  Process: 43568 ExecStartPre=/bin/chown root.apache /run/httpd/instance-instance02 (code=exited,
status=0/SUCCESS)
  Process: 43566 ExecStartPre=/bin/mkdir -m 710 -p /run/httpd/instance-instance02 (code=exited, status=0/SUCCESS)
 Main PID: 43569 (httpd)
   Status: "Running, listening on: port 8009"
    Tasks: 213 (limit: 23719)
   Memory: 43.6M
   CGroup: /system.slice/system-httpd.slice/httpd@instance02.service
           ├─43569 /usr/sbin/httpd -DFOREGROUND -f conf/instance02.conf
           ├─43571 /usr/sbin/httpd -DFOREGROUND -f conf/instance02.conf
```

```
           ├─43572 /usr/sbin/httpd -DFOREGROUND -f conf/instance02.conf
           ├─43573 /usr/sbin/httpd -DFOREGROUND -f conf/instance02.conf
           └─43574 /usr/sbin/httpd -DFOREGROUND -f conf/instance02.conf

Jun 07 01:36:45 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 07 01:36:45 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 07 01:36:45 centos8.ittraining.loc httpd[43569]: Server configured, listening on: port 8009
```

5.3 - Disallowing Modifications to a Service Status

It is possible to disallow modifications to a service status by using the **systemctl mask**command:

```
[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled; vendor preset: disabled)
   Active: inactive (dead)
     Docs: man:httpd.service(8)

Jun 07 18:27:25 centos8.ittraining.loc httpd[58535]: Server configured, listening on: port 80
Jun 07 18:27:29 centos8.ittraining.loc systemd[1]: Stopping The Apache HTTP Server...
Jun 07 18:27:30 centos8.ittraining.loc systemd[1]: httpd.service: Succeeded.
Jun 07 18:27:30 centos8.ittraining.loc systemd[1]: Stopped The Apache HTTP Server.
Jun 07 18:27:32 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 07 18:27:32 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
Jun 07 18:27:32 centos8.ittraining.loc httpd[58760]: Server configured, listening on: port 80
Jun 07 18:27:34 centos8.ittraining.loc systemd[1]: Stopping The Apache HTTP Server...
Jun 07 18:27:36 centos8.ittraining.loc systemd[1]: httpd.service: Succeeded.
Jun 07 18:27:36 centos8.ittraining.loc systemd[1]: Stopped The Apache HTTP Server.

[root@centos8 ~]# systemctl mask httpd.service
Created symlink /etc/systemd/system/httpd.service → /dev/null.

[root@centos8 ~]# systemctl enable httpd.service
```

```
Failed to enable unit: Unit file /etc/systemd/system/httpd.service is masked.

[root@centos8 ~]# systemctl start httpd.service
Failed to start httpd.service: Unit httpd.service is masked.
```

To once again allow modifications, use the **systemctl unmask** command:

```
[root@centos8 ~]# systemctl unmask httpd.service
Removed /etc/systemd/system/httpd.service.

[root@centos8 ~]# systemctl enable httpd.service
Created symlink /etc/systemd/system/multi-user.target.wants/httpd.service →
/usr/lib/systemd/system/httpd.service.

[root@centos8 ~]# systemctl start httpd.service

[root@centos8 ~]# systemctl status httpd.service
● httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled; vendor preset: disabled)
   Active: active (running) since Mon 2021-06-07 18:30:59 EDT; 5s ago
     Docs: man:httpd.service(8)
 Main PID: 59101 (httpd)
   Status: "Started, listening on: port 80"
    Tasks: 213 (limit: 23719)
   Memory: 39.4M
   CGroup: /system.slice/httpd.service
           ├─59101 /usr/sbin/httpd -DFOREGROUND
           ├─59102 /usr/sbin/httpd -DFOREGROUND
           ├─59103 /usr/sbin/httpd -DFOREGROUND
           ├─59104 /usr/sbin/httpd -DFOREGROUND
           └─59105 /usr/sbin/httpd -DFOREGROUND

Jun 07 18:30:59 centos8.ittraining.loc systemd[1]: Starting The Apache HTTP Server...
Jun 07 18:30:59 centos8.ittraining.loc systemd[1]: Started The Apache HTTP Server.
```

```
Jun 07 18:31:00 centos8.ittraining.loc httpd[59101]: Server configured, listening on: port 80
```

LAB #6 - System Shutdown

Using RHEL / CentOS 8 the **halt**, **poweroff**, **reboot** and **shutdown** commands are all soft links pointing to **/bin/systemctl** :

```
[root@centos8 ~]# ls -l /usr/sbin/shutdown /usr/sbin/halt /usr/sbin/poweroff /usr/sbin/reboot
lrwxrwxrwx. 1 root root 16 Apr  7 16:55 /usr/sbin/halt -> ../bin/systemctl
lrwxrwxrwx. 1 root root 16 Apr  7 16:55 /usr/sbin/poweroff -> ../bin/systemctl
lrwxrwxrwx. 1 root root 16 Apr  7 16:55 /usr/sbin/reboot -> ../bin/systemctl
lrwxrwxrwx. 1 root root 16 Apr  7 16:55 /usr/sbin/shutdown -> ../bin/systemctl
```

The correct way to use these four commands is now:

- systemctl halt
- systemctl poweroff
- systemctl reboot
- systemctl shutdown

However you can still use the **halt**, **poweroff**, **reboot** and **shutdown** commands without specifying systemctl.

6.1 - The shutdown Command

The shutdown command's procedure includes :

- informing all connected users that the machine will shutdown,
- stopping all started services,
- committing all data to disk,
- unmounting all mounted filesystems.

shutdown's command line switches are as follows:

```
[root@centos8 ~]# shutdown --help
shutdown [OPTIONS...] [TIME] [WALL...]

Shut down the system.

     --help      Show this help
  -H --halt      Halt the machine
  -P --poweroff  Power-off the machine
  -r --reboot    Reboot the machine
  -h             Equivalent to --poweroff, overridden by --halt
  -k             Don't halt/power-off/reboot, just send warnings
     --no-wall   Don't send wall message before halt/power-off/reboot
  -c             Cancel a pending shutdown
```

The **time** argument can take several values:

Value	Description
hh:mm	The time at which to shutdown
+m	Shutdown the system in m minutes
now	Shutdown immediately

Important : If a shutdown is programmed for less than 5 minutes in the future any future connections are rejected, including those for root.

6.2 - The reboot command

This command calls the **shutdown -r** command.

reboot's command line switches are as follows:

```
[root@centos8 ~]# reboot --help
reboot [OPTIONS...] [ARG]

Reboot the system.

     --help      Show this help
     --halt      Halt the machine
  -p --poweroff  Switch off the machine
     --reboot    Reboot the machine
  -f --force     Force immediate halt/power-off/reboot
  -w --wtmp-only Don't halt/power-off/reboot, just write wtmp record
  -d --no-wtmp   Don't write wtmp record
     --no-wall   Don't send wall message before halt/power-off/reboot
```

6.3 - The halt Command

This command calls the **shutdown -h** command.

halt's command line switches are as follows:

```
[root@centos8 ~]# halt --help
halt [OPTIONS...]

Halt the system.

     --help      Show this help
     --halt      Halt the machine
  -p --poweroff  Switch off the machine
     --reboot    Reboot the machine
  -f --force     Force immediate halt/power-off/reboot
  -w --wtmp-only Don't halt/power-off/reboot, just write wtmp record
  -d --no-wtmp   Don't write wtmp record
```

```
     --no-wall   Don't send wall message before halt/power-off/reboot
```

6.4 - The poweroff Command

This command calls the **shutdown -hP** command.

halt's command line switches are as follows:

```
[root@centos8 ~]# poweroff --help
poweroff [OPTIONS...]

Power off the system.

     --help      Show this help
     --halt      Halt the machine
  -p --poweroff  Switch off the machine
     --reboot    Reboot the machine
  -f --force     Force immediate halt/power-off/reboot
  -w --wtmp-only Don't halt/power-off/reboot, just write wtmp record
  -d --no-wtmp   Don't write wtmp record
     --no-wall   Don't send wall message before halt/power-off/reboot
```
