Booting and System Management Daemons

Unix – Chapter 2

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January 15, 2026

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Boot process and configuration

Select boot device:

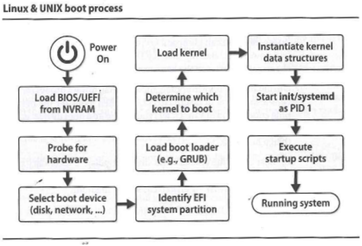
- Enable disk as boot device.
- Choose boot device.
- Specify boot device priorities.

Determine which kernel to boot:

- Select what kernel to load.
- Specify default kernel.

Execute startup scripts:

- Specify what init scripts to run.
- Run order or dependencies between init scripts.



Linux & UNIX boot process

Power On

Load BIOS/UEFI from NVRAM

Probe for hardware

Select boot device (disk, network, ...)

Identify EFI system partition

Load boot loader (e.g., GRUB)

Determine which kernel to boot

Load kernel

Instantiate kernel data structures

Start init/systemd as PID 1

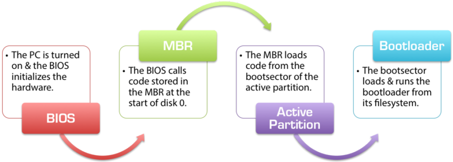
Execute startup scripts

Running system

BIOS and UEFI

- The acronyms:
  - BIOS = *Basic Input/Output System*
  - UEFI = *Unified Extensible Firmware Interface*
- BIOS and UEFI are firmware that is run when the computer starts.
  - CPU is hardwired to run the firmware.
- Usually stored in EEPROM on the motherboard.
- Typically includes a GUI to e.g. select the boot disk, or specify a disk priority for boot.
- Initializes the computer and runs the next stage of the bootstrapping code (e.g. GRUB).
- UEFI has replaced BIOS on modern PCs.
- UEFI firmwares usually implement some kind of BIOS compatibility.
  - UEFI can boot from a MBR (MBR on next slide).

BIOS



The PC is turned on & the BIOS initializes the hardware.
BIOS
MBR
The BIOS calls code stored in the MBR at the start of disk 0.
The MBR loads code from the bootsector of the active partition.
Active Partition
Bootloader
The bootsector loads & runs the bootloader from its filesystem.

- Boot disk must start with MBR (*Master Boot Record*) that contains:
  - First-stage boot loader, *boot block*.
  - Disk partition table.
- The second-stage boot loader, e.g. GRUB:
  - Includes the necessary file system drivers to load the OS.
  - Loads the OS.
- The second-stage boot loader is read either from:
  - The active partition, or
  - the dead zone before the first partition (64 disk blocks),
- All BIOS configurations are done inside the firmware.
  - BIOS has no concept of OS or file systems.

UEFI acronyms

- UEFI = Unified Extensible Firmware Interface
- GUID = Globally Unique Identifier
- GPT = GUID Partition Table
- ESP = EFI System Partition
- FAT = File Allocation Table (MS_DOS file system)
- NVRAM = Non-Volatile RAM

UEFI

- UEFI firmware can handle FAT partitions.
- ESP is a FAT partition that stores the target application, e.g. GRUB.
  - Usually mounted as "/boot/efi".
- UEFI parameters are stored in NVRAM, accessible by UEFI and OS.
  - Accessible as "/sys/firmware/efi/efivars", or "/sys/firmware/efi/vars".
- GPT identifies the ESP and the target application.
  - Stored as UEFI parameters.
  - Default target application is "/efi/boot/bootx64.efi".
- UEFI configurations can be modified in user space using e.g. the command **efibootmgr** or through the "/sys/firmware/" file system.

GRUB

- Default boot loader for Linux.
- Can boot multiple operating systems.
- GRUB code location:
  - UEFI – ESP
    - E.g. “EFI/almalinux/grubx64.efi”.
  - BIOS – Usually in the dead zone before the first partition.
- GRUB can read its configurations from a file.
  - Usually found as **grub.cfg** in the ESP or “/boot/grub2” partition.

Modify GRUB

- Modifications of **grub.cfg** do not survive updates.
  - Configuration file "/etc/default/grub".
  - Command grub2-editenv – modify GRUB parameters
- Transfer the changes to the **grub.cfg** file with the command:

```
grub2-mkconfig -o <path-to>/grub.cfg
```

  - Before using *grub2-mkconfig*, package "os-prober" must be installed.
- To specify a default kernel, see e.g. GRUB 2 - Fedora Project Wiki.

GRUB command line

- Lets us modify the boot entries at boot time.
    - Changes are not saved.
- Modify a GRUB menu entry:
    - Locate the GRUB menu entry.
    - Press the “e” key.
    - Modify the kernel line.
    - Use “F-10” to boot from the modified GRUB stanza.
- See the book or Internet for details.

systemd

- Started by the kernel as process with pid equal to 1.
- Starts and stops system services and daemons.
- The systemd process is the top process in the process hierarchy.

systemd and init

- Most major distros uses systemd to initialize the system.
  - RedHat did use the init system of System V before RedHat 7.
- Startup sequence:
  - System V init – the scripts are run in a set sequence.
  - systemd – dependencies determine the startup sequence.
- Parallelism:
  - System V init – the scripts are run in a strict sequence, one at a time.
  - systemd – can run the startup scripts in parallel.
- systemd is a more complicated system.

systemd units and unit files

- A unit is an entity that is managed by systemd:
  - Can be a service started by a script.
  - Can be a target (more later).
  - And much more.
- A systemd unit is described by a unit file:
  - Path of executable.
  - Specify how to start and stop.
  - Specify dependencies.
- Unit files are read from:
  - “/etc/systemd/system” – Highest priority.
  - “/usr/local/lib/systemd/system”
  - “/usr/lib/systemd/system”
  - “/lib/systemd/system”
- Unit-file suffix specify unit type:
  - E.g. “.service”, “.target”, “.timer”, “.socket”, “.mount”, ...

Find systemd units

- List all loaded units:

```
systemctl list-units
```

- List loaded services only:

```
systemctl list-units --type=service
```

- List all service unit files:

```
systemctl list-unit-files --type=service
```

Enable/disable/mask

- An enabled service will be started at “boot” by systemd.

```
systemctl enable mariadb.service
```

- A disabled service will not be started at boot by systemd.
  - Can still be started manually.
  - Can also be started due to a depending enabled service.

```
systemctl disable mariadb.service
```

- A masked service can not be started.
  - Unit file is linked to “/dev/null”.

```
systemctl mask mariadb.service
```

Enabled unit and boot

An enabled unit is started if any of the *WantedBy* units are started.

Usually, this means that the unit is started at boot.

Start/stop/status

- A service can be started.

```
systemctl start mariadb.service
```

- A service can be stopped.

```
systemctl stop mariadb.service
```

- We can check the status of a service.

```
systemctl status -l mariadb.service
```

Enablement state

- States are e.g. *enabled*, *disabled* or *static*.
- Only unit files with an `Install` section can be *enabled* or *disabled*.
- The **list-unit-files** sub command list service and enablement state.
  - See the man page for all the enablement states.
- Services with state *static* have no `Install` section.
  - Can only be started by hand, or if named as a dependency by another service.

Targets

- Targets are used to gather units.
  - Action on target will act on all units of the target.
- List loaded targets:

```
systemctl list-units --type=target
```

- List all targets:

```
systemctl list-unit-files --type=target
```

- Some targets have special meaning.
  - Run automatically by systemd at specific events.

Some special targets

ctrl-alt-del.target: Run when Control+Alt+Del is pressed.

default.target: Default unit to start at boot.

emergency.target: Run if boot fails, e.g. due to a failing local disk mount.

- Play with this mode **before** you need it.

graphical.target: Sets up the graphical login screen.

multi-user.target: Sets up a multi-user system.

reboot.target: Shutdown and reboot the system.

shutdown.target: Shutdown the system.

rescue.target: Pulls in the base system for administrative purposes.

Using targets

- The sub command **isolate** changes the current mode:

```
systemctl isolate multi-user.target
```

  - Activate the target with its dependencies, and deactivate all others.

- Show the default target:

```
systemctl get-default
```

- Set the default target:

```
systemctl set-default multi-user.target
```

- Can also specify a target on the kernel boot line
  - Emergency mode: `systemd.unit=emergency.target`
    - Short form: `emergency`
  - Rescue mode: `systemd.unit=rescue.target`.
    - Short form: `rescue`

Unit dependencies

- Dependencies are specified in the unit files.
- Keywords are e.g. *Wants*, *Requires*, *Requisite*, *BindsTo*, *PartOf*, *Conflicts*
  - Does not imply any sequence for processing.
  - See the book page 51 and manual pages for their meaning.
- *Wants* are a weaker form of *Requires*.
  - Success of unit does not depend on sucess of *Wants*.
  - Success of unit does depend on sucess of *Requires*.
- Keywords to serialize processing are e.g. *After*, *Before*.
  - If no serializing keyword, systemd will try to run processes in parallel.
- Systemd assumes a default set of dependencies for units.
  - Turn off assumption with `DefaultDependencies=false`

Unit file

- New unit files can be created in an text editor.
- The systemctl sub command **edit** lets us modify an existing unit-file.

```
systemctl edit mariadb.service
```

  - Creates an override in "/etc/systemd/system/mariadb.service.d/".
- Do not modify existing unit-files.
  - Use an override, e.g. "/etc/systemd/system/mariadb.service.d/override.conf".
- Using unit-file overrides:
  - The original and the override will be merged by systemd at use.
  - If collisions, the override has higher priority.
- Install section can not be modified by an override.

Show unit properites

- List unit, with overrides:

```
systemctl cat mariadb.service
```

- List specfic property of unit:

```
systemctl show -p After mariadb.service
```

Some comments on logging

- Systemd has its own logging system, manged by the *journald* daemon.
- Systemd log messages are stored in the "/run" directory.
  - Typically, the rsyslog daemon will process also the systemd logs.
- Can be accessed with the command **journalctl**.
  - Show log of the Bluetooth unit:

```
journalctl -u bluetooth.service
```

- System logging will be covered later.