

CSGE602055 Operating Systems

CSF2600505 Sistem Operasi

Week 09: Storage, Firmware, Bootloader, & Systemd

Rahmat M. Samik-Ibrahim (ed.)

University of Indonesia

<https://os.vlsm.org/>

Always check for the latest revision!

REV238 13-Sep-2020

Operating Systems 2020-2 – (A, I, M) from HOME

A/M [Tu 10-12, ZOOM] — I [Tu 08-10, ZOOM]

Week	Schedule	Topic	OSC10
Week 00	15 Sep - 21 Sep 2020	Overview 1, Virtualization & Scripting	Ch. 1, 2, 18.
Week 01	22 Sep - 28 Sep 2020	Overview 2, Virtualization & Scripting	Ch. 1, 2, 18.
Week 02	29 Sep - 05 Oct 2020	Security, Protection, Privacy, & C-language	Ch. 16, 17
Week 03	06 Oct - 12 Oct 2020	File System & FUSE	Ch. 13, 14, 15
Week 04	13 Oct - 19 Oct 2020	Addressing, Shared Lib, & Pointer	Ch. 9
Week 05	20 Oct - 26 Oct 2020	Virtual Memory	Ch. 10
Week 06	27 Oct - 16 Nov 2020 29 Oct 2020	Concurrency: Processes & Threads Maulid Nabi	Ch. 3, 4
Week 07	17 Nov - 23 Nov 2020	Synchronization & Deadlock	Ch. 6, 7, 8
Week 08	24 Nov - 30 Nov 2020	Scheduling + W06/W07	Ch. 5
Week 09	01 Dec - 07 Dec 2020	Storage, Firmware, Bootldr, & Systemd	Ch. 11
Week 10	08 Dec - 16 Dec 2020	I/O & Programming	Ch. 12
	09 Dec 2020	Pil Kada	

STARTING POINT — <https://os.vlsm.org/>

- **Text Book** — Any recent/decent OS book. Eg. (**OSC10**) Silberschatz et. al.: **Operating System Concepts**, 10th Edition, 2018. See also <http://codex.cs.yale.edu/avi/os-book/OS10/>.
- **Resources**
 - **Extra Scele from Home** — <https://scele.cs.ui.ac.id/course/view.php?id=3020>.
 - **Download Slides and Demos from GitHub.com** <https://github.com/UI-FASILKOM-OS/SistemOperasi/>
 - **Problems** — <https://rms46.vlsm.org/2/>:
195.pdf (W00), 196.pdf (W01), 197.pdf (W02), 198.pdf (W03),
199.pdf (W04), 200.pdf (W05), 201.pdf (W06), 202.pdf (W07),
203.pdf (W08), 204.pdf (W09), 205.pdf (W10).
- **Build your own Virtual Guest**
<https://osp4diss.vlsm.org/>

Agenda

- 1 Start
- 2 Schedule
- 3 Agenda
- 4 Week 09
- 5 Storage, Firmware, Bootloader, & Systemd
- 6 Storage Management
- 7 RAID
- 8 Legacy BIOS
- 9 UEFI
- 10 Operating System (Boot) Loader
- 11 GRUB Map
- 12 init (SYSV legacy)
- 13 UpStart - Ubuntu
- 14 The All New "systemd"
- 15 systemctl
- 16 The End

Week 09 Storage, Firmware, Bootloader, & Systemd: Topics¹

- Storage
- Storage Arrays
- BIOS
- Loader
- Systemd

¹Source: ACM IEEE CS Curricula 2013

Week 09 Storage, Firmware, Bootloader, & Systemd: Learning Outcomes¹

- Storage [Usage]
- Storage Arrays [Usage]
- BIOS [Usage]
- Loader [Usage]
- Systemd [Usage]

¹Source: ACM IEEE CS Curricula 2013

Storage, Firmware, Bootloader, & Systemd

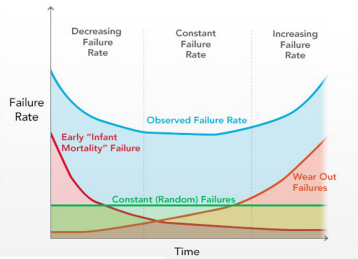
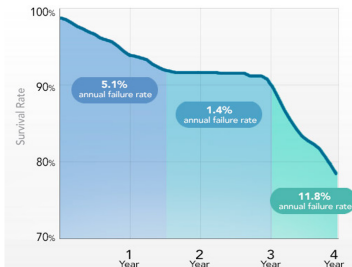
- Reference: (OSC10-ch11)
- Storage Capacity (2019)¹
 - Legacy 3.5" Floppy Disk (1.4MB) – obsolete?
 - SuperDisk (up to 240 MB) — never took off.
 - 4.7" Compact Disc (700MB) – obsolete?
 - 4.7" Digital Versatile Disc (up to 9GB) – ?
 - 4.7" Blu Ray (up to 128 GB) ⇒ DVD++.
 - Tape Cartridge (up to 15TB)
 - Robotic System (up to 250 PB per unit)
 - NASA, Google, Microsoft are still using this!
 - Cheap but slow.
 - Hard Disk Drives (up to 16 TB).
 - From Perpendicular Magnetic Recording to Shingled Magnetic Recording technology (+25% – writing problems).
 - Mechanical Disk Arm Scheduling (Until When?).
 - Solid-State Disks (up to 16 TB).
 - SSD Price > HDD Price.
 - Write Speed >> Read Speed.
 - (What is a) Flash Disk?

¹Subject to change

Storage Failure Rates

- MTDDL: Mean Time To Data Loss
- MTTF: Mean Time To Failure
- BackBlaze (Cloud Backup Services)

Drives Have 3 Distinct Failure Rates General Predicted Failure Rates
Hard Drive Survival Rates - Chart 1



<https://www.extremetech.com/computing/170748-how-long-do-hard-drives-actually-live-for>



Figure: BackBlaze — Failure Rates of 25000 DISKS

Storage Management

- Attached-Storage.
 - Host-Attached Storage: via I/O.
 - Network-Attached Storage (NAS): via distributed FileSystem.
 - Storage Area Network (SAN): dedicated Network.
- Formatting
 - Low Level (Physical)
 - High Level (FileSystem)
- Boot Block
- Disk Partition
 - "MBR"-scheme
 - upto 4 primary partition
 - upto 2 TB disk
 - "GPT"-scheme
 - "unlimited" partition
 - "unlimited" disk
 - redundancy
- Swap Space Management: On Partition or FileSystem?

RAID: Redundant Array of In* Disks

- RAID 0, 1, 5, 6, 10, 100
- Note (<http://www.commodore.ca/windows/raid5/raid5.htm>):
 - RAID was created to enhance data performance, reliability and availability.
 - Striping, parity checking and mirroring are three primary functions of RAID systems.
 - RAID performs its functions transparent to the operating system.
 - Systems are typically defined by ranks consisting of five disks each connected to one or two Disk Array Controllers.
 - Different RAID levels provide varying degrees of speed and data protection.
- Problems with RAID
- Stable-Storage Implementation

BIOS, Boot, & Systemd

- Firmware
 - BIOS: Basic Input Output System.
 - UEFI: Unified Extensible Firmware Interface.
 - ACPI: Advanced Configuration and Power Interface.
- Operating System (Boot) Loader
 - BOOTMGT: Windows Bootmanager / Bootloader.
 - LILO: Linux Loader.
 - GRUB: GRand Unified Bootloader.
- Operating System Initialization
 - Init (legacy)
 - UpStart
 - Systemd

- Check Settings.
- Initialize CPU & RAM.
- POST: Power-On Self-Test.
- Initialize ports, LANS, etc.
- Load a Boot Loader.
- Handover to the Boot Loader.
- Provides "Native" (obsolete) Drivers only (not loadable).
- Provides "INT" services .
- Limitation.
 - Technology of 1970s.
 - 16 bits software.
 - 20 bits address space (1 MB).
 - 31 bits disk space (2 TB).



Figure: BIOS

- A Firmware Specification, not an Implementation!
- No (INT) service after boot.
- HII: Human Interface Infrastructure.
- Protected Mode.
- Flexible.
 - Technology of 2000s.
 - written in C.
 - (third party) loadable drivers and tools.
 - Emulate Legacy BIOS transition (MBR block, INT service).
 - UEFI Shell: environment shell for diagnostic (no need for DOS).
- Problems
 - Who controls the Hardware?
 - Is "Secure Boot" a good thing?
 - How about a **NASTY/LOCKING/TROJAN** UEFI implementation?
 - Different **DRIVERS**.

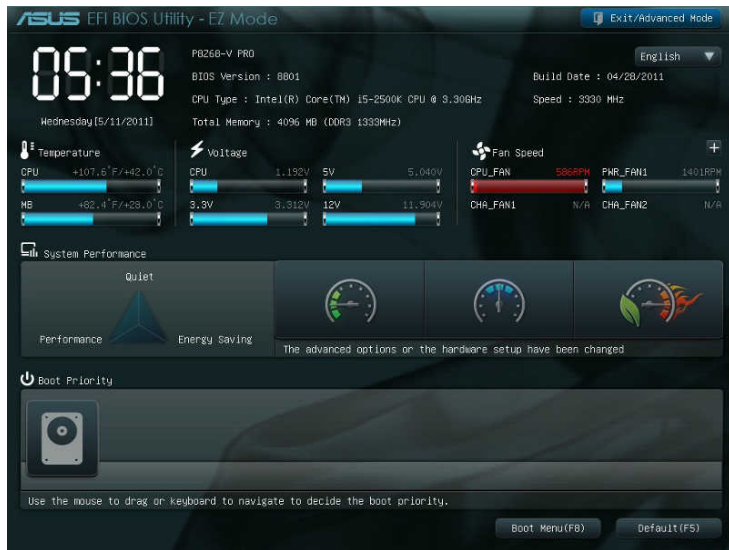


Figure: UEFI

Platform Initialization (PI) Boot Phases

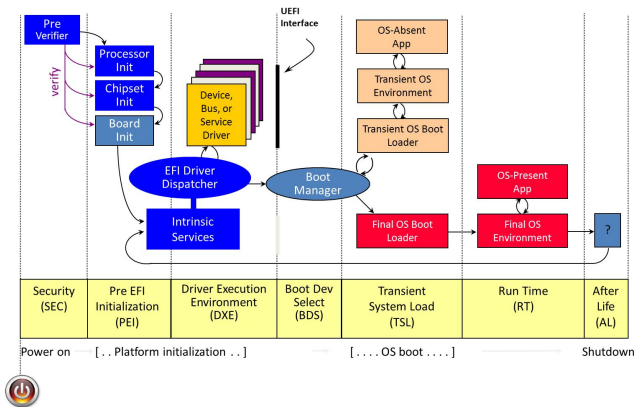


Figure: UEFI Boot Process¹.

¹Source Jarslstrom - 2014 - www.tianocore.org

Operating System (Boot) Loader

- General
 - How/Where to start the operating system?
 - What to do?
 - How many ways to boot?
 - How many types of OS?
- Disk Partition
 - MBR: Master Boot Record (1983).
 - GPT: GUID (Globally Unique Identifiers) Partition Table (2010s).
- GRUB: GRand Unified Boot system
 - Stage 1: a small boot.img inside the MBR.
 - Stage 1.5 (core.img): FileSystem drivers after MBR.
 - Stage 2: Kernel Selection: Windows, Linux, BSD, etc.
- GRUB2
 - More flexible than GRUB legacy.
 - More automated than GRUB legacy.
 - Accept MBR and GPT.
 - Stage 1.5 (core.img): generated from diskboot.img.
 - No 1024 cylinder restriction.

GNU GRUB 2

Locations of *boot.img*, *core.img* and the */boot/grub* directory

Example 1: an MBR-partitioned harddisc with sector size of 512 or 4096Bytes



Example 2: a GPT-partitioned harddisc with sector size of 512 or 4096Bytes



Figure: GRUB¹.

¹Source Shmuel Csaba Otto Traian 2013

init (SYSV legacy)

- File: `/etc/inittab`.
- Folders: `/etc/rcX.d` — `X` = runlevel.
 - Seven (7) different runlevels:
 - 0 (shutdown).
 - 1 (single-user/admin).
 - 2 (multi-user non net).
 - 3 (standard).
 - 4 (N/A).
 - 5 (3+GUI).
 - 6 (reboot).
 - SXX-YYY: Start
 - KXX-YYY: Kill.
- One script at a time in order.
- dependency is set manually.

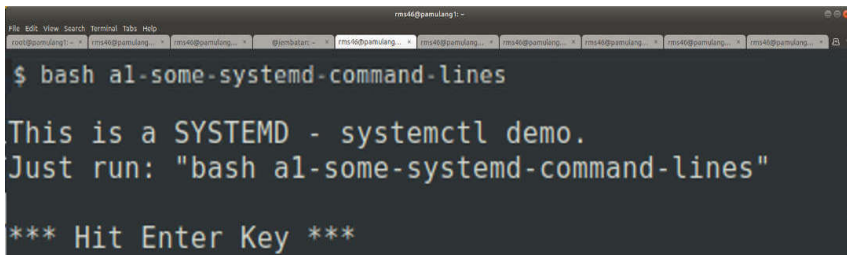
- Developer: Ubuntu.
- Folder: `/etc/init/`.
- Control: `initctl`.
 - `initctl list` – listing all processes managed by upstart.
- better support for hotplug devices.
- cleaner service management.
- faster service management.
- asynchronous.

The All New "systemd"

- Replaces (SYSV) init and UpStart.
 - better concurrency handling: Faster!
 - better dependencies handling: No more "S(tarts)" and "K(ills)".
 - better crash handling: automatic restart option.
 - better security: group protection from anyone including superusers.
 - simpler config files: reliable and clean scripts.
 - hotplug: dynamic start/stop.
 - supports legacy systems (init).
 - overhead reducing.
 - unified management way for all distros.
 - bloated: doing more with more resources.
 - linux specific: NOT portable.

systemctl 01

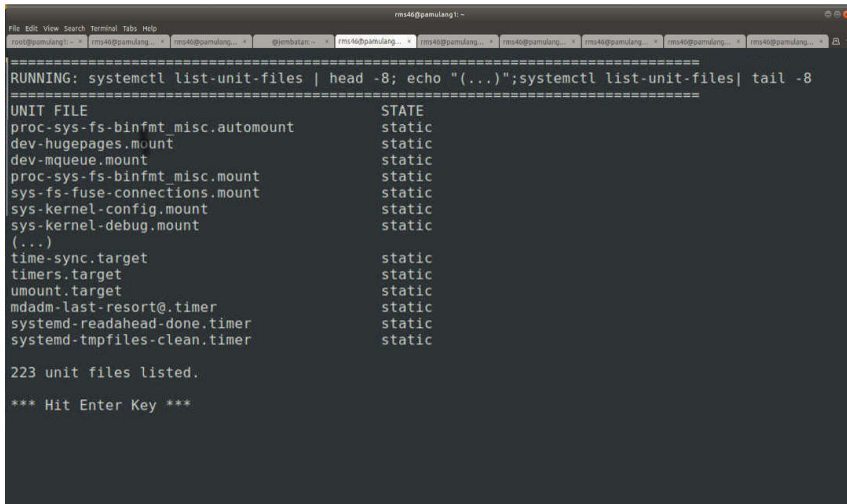
```
for II in \
'systemctl list-unit-files | head -8; echo "(...)";
  systemctl list-unit-files| tail -8' \
'systemd-analyze blame | wc -l; echo "===";
  systemd-analyze blame | head -15' \
'systemctl --full | wc -l; echo "===";
  systemctl --full | head -10' \
'systemctl list-units | wc -l; echo "===";
  systemctl list-units | head -10' \
'systemctl list-units |grep .service|wc -l;echo "===";
  systemctl list-units|grep .service|head -10' \
'systemctl list-units | grep ssh.service' \
'systemctl status ssh.service' \
'systemctl is-enabled ssh' \
'journalctl' \
'journalctl -b' \
do
...
```

A terminal window titled 'rms46@pamulang1: ~' with multiple tabs. The active tab shows the command '\$ bash a1-some-systemd-command-lines' being executed. The output text reads: 'This is a SYSTEMD - systemctl demo. Just run: "bash a1-some-systemd-command-lines" *** Hit Enter Key ***'.

```
rms46@pamulang1: ~  
File Edit View Search Terminal Tabs Help  
root@pamulang1: ~ * rms46@pamulang... rms46@pamulang... @jimbatan: ~ rms46@pamulang... rms46@pamulang... rms46@pamulang... rms46@pamulang... rms46@pamulang... rms46@pamulang...  
$ bash a1-some-systemd-command-lines  
This is a SYSTEMD - systemctl demo.  
Just run: "bash a1-some-systemd-command-lines"  
*** Hit Enter Key ***
```

Figure: bash a1-some-systemd-command-lines

systemctl 03



```
rms46@pamulang: ~  
File Edit View Search Terminal Tabs Help  
root@pamulang: ~ * rms46@pamulang: ~ @jembatan: ~ rms46@pamulang: ~ rms46@pamulang: ~ rms46@pamulang: ~ rms46@pamulang: ~ rms46@pamulang: ~ rms46@pamulang: ~ rms46@pamulang: ~  
===== RUNNING: systemctl list-unit-files | head -8; echo "...";systemctl list-unit-files| tail -8 =====  
===== UNIT FILE STATE =====  
proc-sys-fs-binfmt_misc.automount static  
dev-hugepages.mount static  
dev-mqueue.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  
(...)  
time-sync.target static  
timers.target static  
umount.target static  
mdadm-last-resort@.timer static  
systemd-readahead-done.timer static  
systemd-tmpfiles-clean.timer static  
  
223 unit files listed.  
  
*** Hit Enter Key ***
```

Figure: systemctl list-unit-files

systemctl 04



```
rms46@pamulang1: ~  
File Edit View Search Terminal Tabs Help  
root@pamulang1: ~ * rms46@pamulang... * rms46@pamulang... * @jembar: ~ * rms46@pamulang... * rms46@pamulang... * rms46@pamulang... * rms46@pamulang... * rms46@pamulang... * rms46@pamulang... *  
===== RUNNING: systemd-analyze blame | wc -l; echo "===";systemd-analyze blame | head -10 =====  
34  
===  
2.374s keyboard-setup.service  
963ms systemd-logind.service  
957ms rsyslog.service  
954ms ssh.service  
954ms rc-local.service  
954ms systemd-user-sessions.service  
928ms postfix.service  
589ms networking.service  
519ms snmpd.service  
322ms systemd-tmpfiles-setup-dev.service  
*** Hit Enter Key ***
```

Figure: systemd-analyze blame

systemctl 05

```
rms40@pamulang1: ~
File Edit View Search Terminal Tabs Help
rms40@pamulang1: ~
RUNNING: systemctl --full | wc -l; echo "===";systemctl --full | head -6
=====
97
UNIT
proc-sys-fs-binfmt-misc.automount                                loaded active waiting Arbitrary Executable File Formats File System Automount Point
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sda-sda1.device loaded active plugged QEMU_HARDDISK 1
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sda-sda2.device loaded active plugged QEMU_HARDDISK 2
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sdb.device loaded active plugged QEMU_HARDDISK
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:1:0:0:1-black-sdb-sdb1.device loaded active plugged QEMU_HARDDISK 1
*** Hit Enter Key ***

RUNNING: systemctl list-units | wc -l; echo "===";systemctl list-units | head -6
=====
97
UNIT
proc-sys-fs-binfmt-misc.automount                                loaded active waiting Arbitrary Executable File Formats File System Automount Point
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sda-sda1.device loaded active plugged QEMU_HARDDISK 1
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sda-sda2.device loaded active plugged QEMU_HARDDISK 2
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:0:0:0-black-sdb.device loaded active plugged QEMU_HARDDISK
sys-devices-pci0000:00:0000:00:05:0-host0-target0:0:1:0:0:1-black-sdb-sdb1.device loaded active plugged QEMU_HARDDISK 1
*** Hit Enter Key ***

RUNNING: systemctl list-units | grep .service | wc -l; echo "===";systemctl list-units | grep .service | head -6
=====
12
UNIT
ssct.service                                                    loaded active exited LSB: process and login accounting
icpidd.service                                                  loaded active running ACPI event daemon
console-setup.service                                           loaded active exited Set console font and keymap
cron.service                                                    loaded active running Regular background program processing daemon
dbus.service                                                    loaded active running D-Bus System Message Bus
jetty@tty1.service                                              loaded active running Getty on tty1
*** Hit Enter Key ***
```

Figure: systemctl --full; systemctl list-units

systemctl 06

```
rms46@pamulang1: ~
File Edit View Search Terminal Tabs Help
rms46@pamulang1 ~
=====
RUNNING: systemctl list-units | grep ssh.service
=====
ssh.service                                loaded active running    OpenBSD Secure Shell server
*** Hit Enter Key ***
=====
RUNNING: systemctl status ssh.service
=====
● ssh.service - OpenBSD Secure Shell server
   Loaded: loaded (/lib/systemd/system/ssh.service; enabled)
   Active: active (running) since Sun 2020-04-26 03:00:24 WIB; 3h 33min ago
   Process: 653 ExecStartPre=/usr/sbin/sshd -t (code=exited, status=0/SUCCESS)
   Main PID: 686 (sshd)
   CGroup: /system.slice/ssh.service
           └─ 686 /usr/sbin/sshd -D
              └─ 3247 sshd: demo [priv]
                 └─ 3253 sshd: demo@pts/0
                    └─ 3254 -bash
                       └─ 3391 bash a1-some-systemd-command-lines
                          └─ 3550 systemctl status ssh.service
*** Hit Enter Key ***
```

Figure: systemctl status ssh.service

A terminal window with a dark background and light-colored text. The window title is 'rms46@pamulang1: ~'. The terminal shows the output of the command 'systemctl status ssh'. The output is enclosed in a box of equals signs. The text inside the box reads: 'RUNNING: systemctl is-enabled ssh' followed by 'enabled' on the next line. Below the box, it says '*** Hit Enter Key ***'. The terminal has several tabs open at the top, all with the same title 'rms46@pamulang1: ~'. The menu bar at the top of the terminal window includes 'File', 'Edit', 'View', 'Search', 'Terminal', 'Tabs', and 'Help'.

```
rms46@pamulang1: ~  
File Edit View Search Terminal Tabs Help  
root@pamulang1: ~ * rms46@pamulang1: ~ rms46@pamulang1: ~ @jembaran: ~ rms46@pamulang1: ~ rms46@pamulang1: ~ rms46@pamulang1: ~ rms46@pamulang1: ~ rms46@pamulang1: ~ rms46@pamulang1: ~  
=====  
RUNNING: systemctl is-enabled ssh  
=====  
enabled  
  
*** Hit Enter Key ***
```

Figure: systemctl is-enabled ssh

The End

- ☐ This is the end of the presentation.
- ☒ This is the end of the presentation.
 - This is the end of the presentation.