

# CSGE602055 Operating Systems

## CSF2600505 Sistem Operasi

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

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

Always check for the latest revision!

REV240 14-Sep-2020

# Operating Systems 2020-2<sup>2</sup>) — PJJ from HOME

## ZOOM: International [Tue 08-10] — A/Matrix [Tue 10-12]

| Week    | Schedule                            | Topic   | OSC10 <sup>1</sup> ) |
|---------|-------------------------------------|---|----------------------|
| 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<br>29 Oct 2020 | Concurrency: Processes & Threads<br>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, Bootloader, & Systemd        | Ch. 11.              |
| Week 10 | 08 Dec - 16 Dec 2020                | I/O & Programming                               | Ch. 12.              |
|         | 09 Dec 2020                         | Pil Kada  |                      |

<sup>1</sup>Silberschatz et. al.: **Operating System Concepts**, 10<sup>th</sup> Edition, 2018.

<sup>2</sup>This information will be on **EVERY** page two (2) of this course material.

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

- **Text Book** — Any recent/decent OS book. Eg. (**OSC10**) Silberschatz et. al.: **Operating System Concepts**, 10<sup>th</sup> Edition, 2018. See also <http://codex.cs.yale.edu/avi/os-book/OS10/>.
- **Resources**
  - **SCELE** — <https://scele.cs.ui.ac.id/course/view.php?id=3020>.  
The enrollment key is **XXX**.
  - **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

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# Week 09 Storage, Firmware, Bootloader, & Systemd: Topics<sup>1</sup>

- Storage
- Storage Arrays
- BIOS
- Loader
- Systemd

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<sup>1</sup>Source: ACM IEEE CS Curricula 2013

# Week 09 Storage, Firmware, Bootloader, & Systemd: Learning Outcomes<sup>1</sup>

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

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<sup>1</sup>Source: ACM IEEE CS Curricula 2013

# Storage, Firmware, Bootloader, & Systemd

- Reference: (OSC10-ch11)
- Storage Capacity (2019)<sup>1</sup>
  - 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?

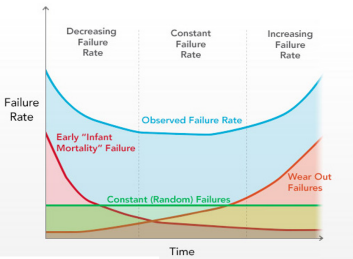
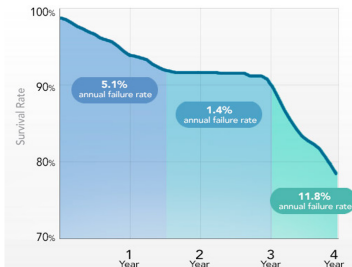
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<sup>1</sup>Subject to change

# 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).

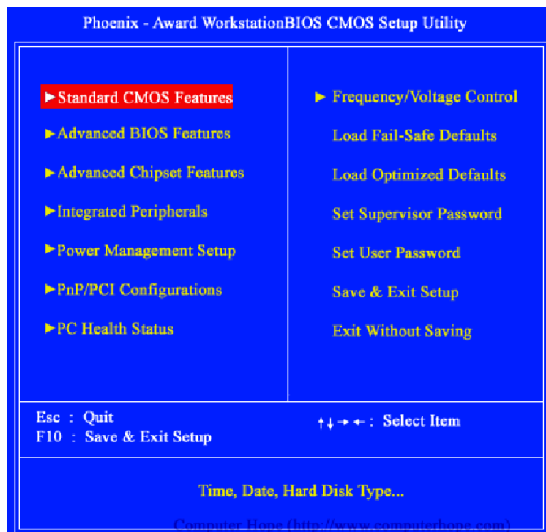


Figure: BIOS

- 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

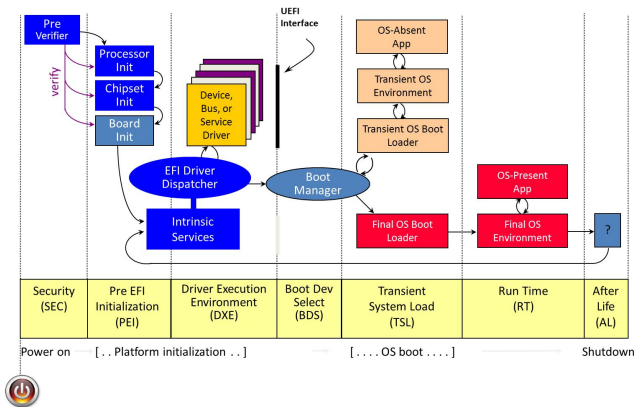


Figure: UEFI Boot Process<sup>1</sup>.

<sup>1</sup>Source Jarslstrom - 2014 - [www.tianocore.org](http://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: GRUB<sup>1</sup>.

<sup>1</sup>Source 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.

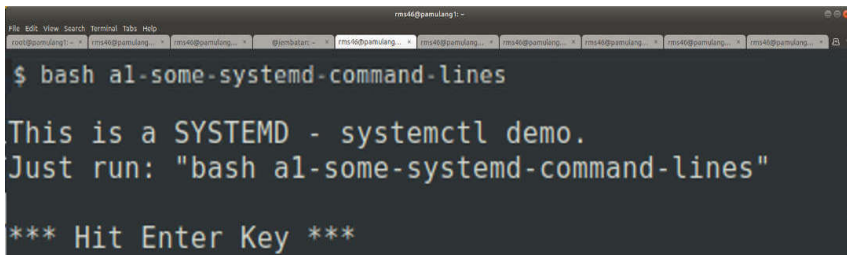
- Developer: Ubuntu.
- Folder: `/etc/init/`.
- Control: `initctl`.
  - `initctl list` – listing all processes managed by upstart.
- better support for hotplug devices.
- cleaner service management.
- faster service management.
- asynchronous.

# 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
...
```

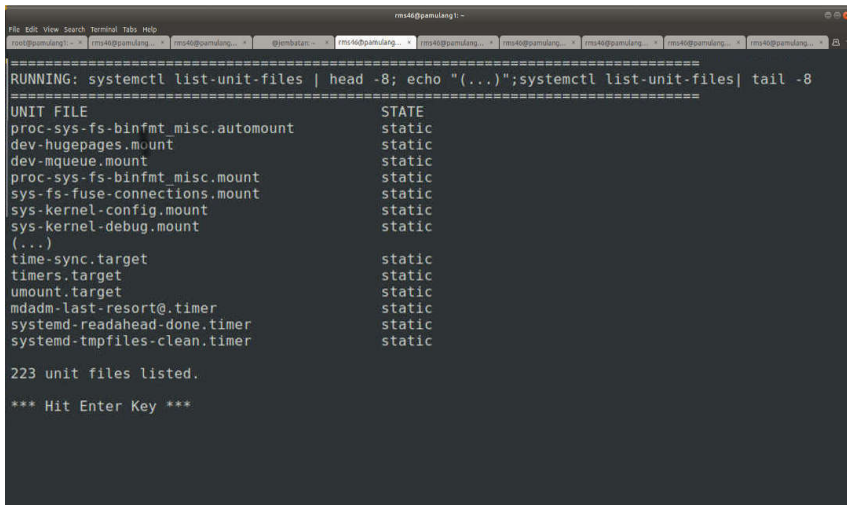


A terminal window titled 'rms46@pamulang1: ~' with multiple tabs open. The active tab shows the command '\$ bash a1-some-systemd-command-lines' being executed. The output of the command is displayed in the terminal:

```
$ 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@pamulang1: ~  
File Edit View Search Terminal Tabs Help  
root@pamulang1: ~ * rms46@pamulang... * rms46@pamulang... * @jembatan: ~ * 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

A terminal window titled 'rms46@pamulang1: ~' showing the output of the 'systemd-analyze blame' command. The output lists various system services and their boot times. The command was executed with a pipe to 'wc -l' and 'echo' to show the command being run. The output is preceded by a '34' and '==='.

```
File Edit View Search Terminal Tabs Help
rms46@pamulang1: ~
=====
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 titled 'rms46@pamulang1: ~' with multiple tabs open. The active tab shows the output of 'systemctl status ssh'. The output is displayed in a monospaced font with yellow and green text on a dark background. It shows 'RUNNING: systemctl is-enabled ssh' followed by 'enabled' and '\*\*\* Hit Enter Key \*\*\*'.

```
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: systemctl is-enabled ssh  
=====  
enabled  
  
*** Hit Enter Key ***
```

Figure: systemctl is-enabled ssh

# Week 09: Check List

- ☐ Check this out:
  - ☐ **Starting Point:** <https://os.vlsm.org/>
    - This page is <https://os.vlsm.org/Slides/check09.pdf>.
  - ☐ **SCELE:** <https://scele.cs.ui.ac.id/course/view.php?id=3020>
  - ☐ **OSP4DISS:** <https://osp4diss.vlsm.org/>
- ☐ **Read any** recent and decent Operating Systems TextBook chapter(s) that are related to this week topic. Write a **TOP 10 LIST** about what you think is important.
- ☐ Week 09: Assignment (more details in **os09.pdf**).
  - ① TBA.
- ☐ TBA.
- ☐ The "Assignment Day" is every Thursday morning.
- ☐ The "Deadline Day" will be the begining of the week after.
- ☐ Revisit/add your own Weekly Log.
- ☐ **Study Hard!** No more TABULA RASA. Jolan Tru!

# The End

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