CSGE602055 Operating Systems
CSF2600505 Sistem Operasi
Week 09: Storage, Firmware, Bootloader, & Systemd

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REV425: Thu 12 Sep 2024 08:00

OS242[3]): Operating Systems Schedule 2024 - 2

Week	Topic[1])	OSC10[2])
Week 00	Overview (1), Assignment of Week 00	Ch. 1, 2
Week 01	Overview (2), Virtualization & Scripting	Ch. 1, 2, 18.
Week 02	Security, Protection, Privacy, & C-language.	Ch. 16, 17.
Week 03	File System & FUSE	Ch. 13, 14, 15.
Week 04	Addressing, Shared Lib, & Pointer	Ch. 9.
Week 05	Virtual Memory	Ch. 10.
Week 06	Concurrency: Processes & Threads	Ch. 3, 4.
Week 07	Synchronization & Deadlock	Ch. 6, 7, 8.
Week 08	Scheduling + W06/W07	Ch. 5.
Week 09	Storage, Firmware, Bootloader, & Systemd	Ch. 11.
Week 10	I/O & Programming	Ch. 12.

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[1]) For schedule, see https://os.vlsm.org/#idx02
[2]) Silberschatz et. al.: **Operating System Concepts**, 10th Edition, 2018.
[3]) This information will be on **EVERY** page two (2) of this course material.

- ☐ **Text Book** — Any recent/decent OS book. Eg. (**OSC10**) Silberschatz et. al.: **Operating System Concepts**, 10th Edition, 2018. (See `https://codex.cs.yale.edu/avi/os-book/OS10/`).
- ☐ **Resources (`https://os.vlsm.org/#idx03`)**
  - ☐ **SCELE** — `https://scele.cs.ui.ac.id/course/view.php?id=3841`. The enrollment key is **XXX**.
  - ☐ **Download Slides and Demos from GitHub.com** — (`https://github.com/os2xx/docos/`)
    `os00.pdf (W00)`, `os01.pdf (W01)`, `os02.pdf (W02)`, `os03.pdf (W03)`, `os04.pdf (W04)`, `os05.pdf (W05)`, `os06.pdf (W06)`, `os07.pdf (W07)`, `os08.pdf (W08)`, `os09.pdf (W09)`, `os10.pdf (W10)`.
  - ☐ **Problems**
    `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)`.
  - ☐ **LFS** — `http://www.linuxfromscratch.org/lfs/view/stable/`
  - ☐ **This is How Me Do It!** — `https://doit.vlsm.org/`
    - ☐ PS: "Me" rhymes better than "I", duh!

Agenda

- Storage
- Storage Arrays
- BIOS
- Loader
- Systemd

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[1]Source: ACM IEEE CS Curricula

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

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[1]Source: ACM IEEE CS Curricula

- OSC10 Chapter 11: Mass-Storage Systems
  - Overview of Mass Storage Structure
  - HDD Scheduling
  - NVM Scheduling
  - Error Detection and Correction
  - Storage Device Management
  - Swap-Space Management
  - Storage Attachment
  - RAID Structure

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) $\Rightarrow$ 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?

Storage Capacity

|			
Floppy Disk	1.4MB	Hard Drive	5TB
USB Drive	64GB	Angry GF remembering all of my past mistakes	1,000,000 TB

Figure: Source: https://linktr.ee/hackingarticles

Storage Failure Rates

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

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

General Predicted Failure Rates

https://www.extremetech.com/computing/
170748-how-long-do-hard-drives-actually-live-for
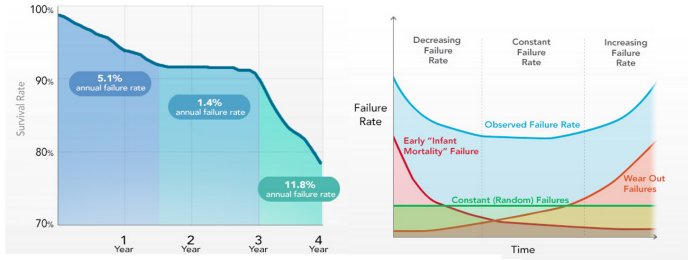
Figure: BackBlaze — Failure Rates of 25000 DISKS

Storage Management

- Attached-Storage.
  - Host-Attached Storage: via I/O.
  - Network-Attached Storage (NAS): via distributed FileSystem.
  - Storage Area Network (SAN): dedicated Network.
- Formating
  - 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

Legacy BIOS

- 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).

BIOS

Figure: BIOS

UEFI
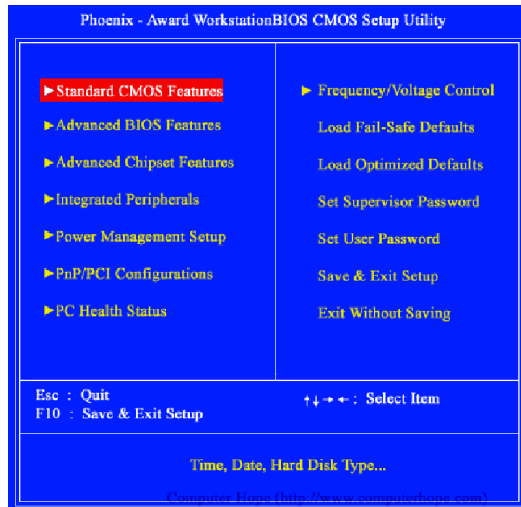
- A Firmware Specification, not an Implementation!
- No (INT) service after boot.
- HII: Human Interface Infrastructure.
- Protected Mode.
- Flexible.
    - Technology of 2000s.
    - writen in C.
    - (third party) loadable drivers and tools.
    - Emulate Legacy BIOS transition (MBR block, INT service).
    - 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**.
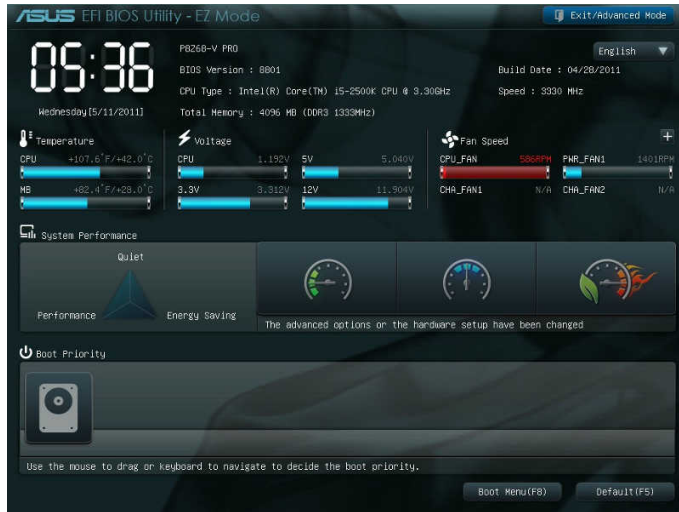
UEFI

Figure: UEFI

Platform Initialization (PI) Boot Phases
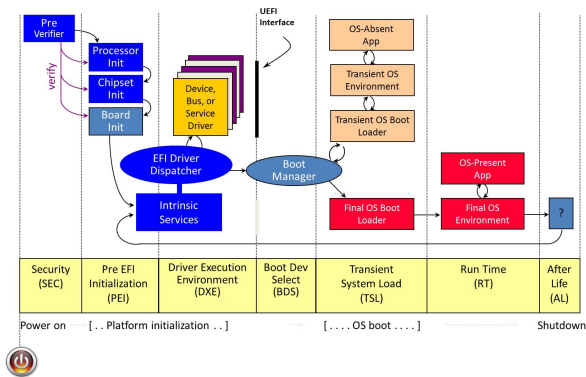
Figure: UEFI Boot Process[1].

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.
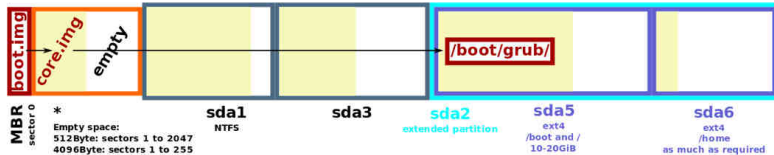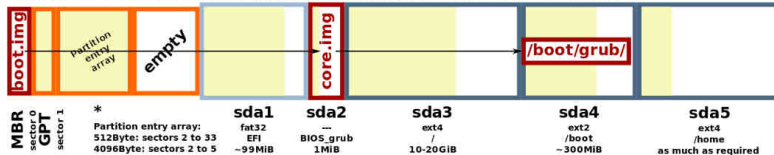
Figure: GRUB[1].

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[1]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.
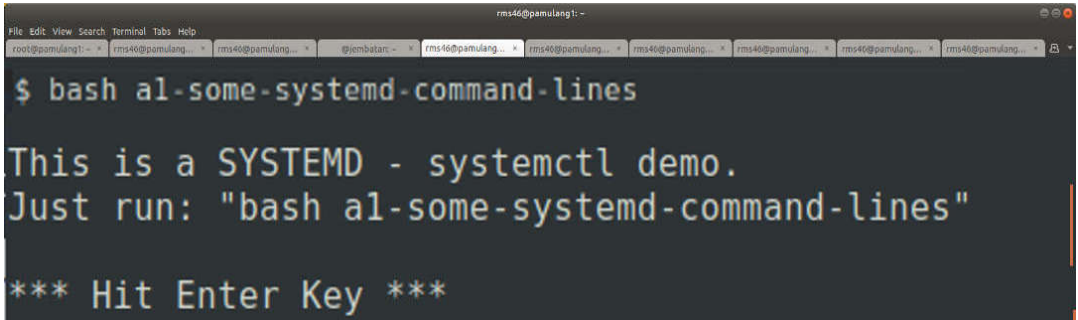
UpStart - Ubuntu

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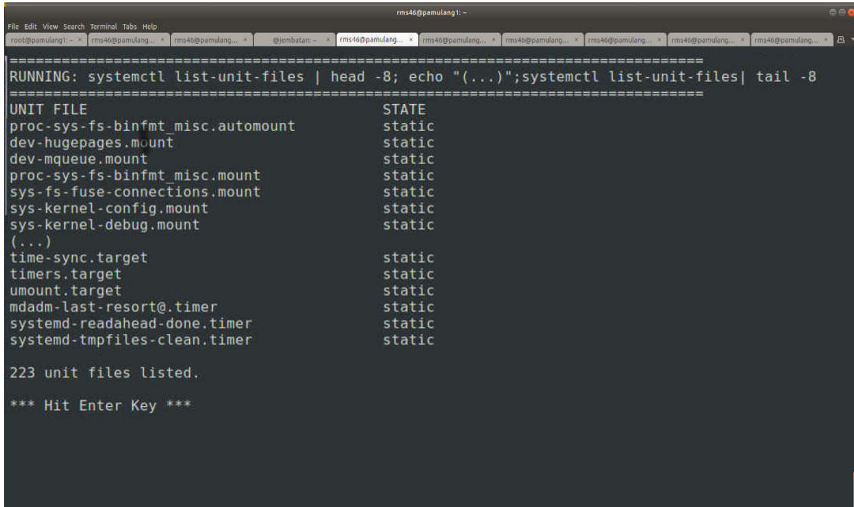
Figure: bash a1-some-systemd-command-lines

Figure: systemctl list-unit-files

Figure: systemd-analyze blame
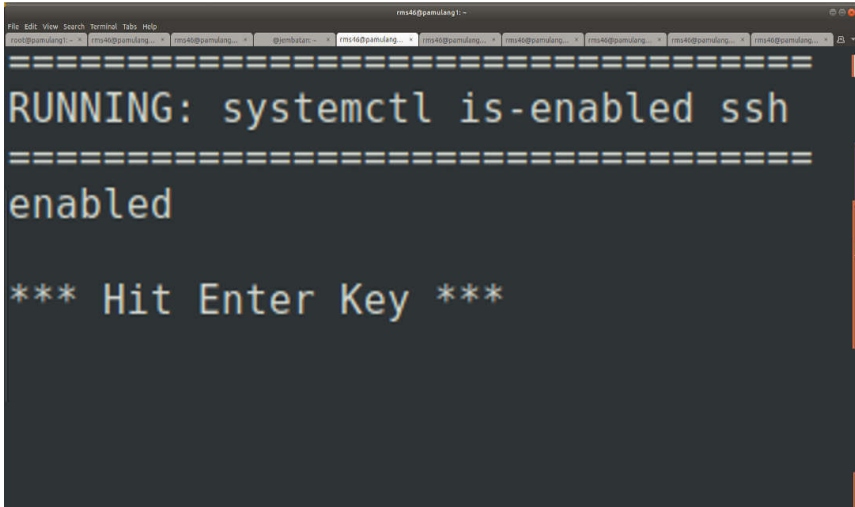
Figure: systemctl –full; systemctl list-units

Figure: systemctl status ssh.service

Figure: systemctl is-enabled ssh