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

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https://os.vlsm.org/Slides/os09.pdf
Always check for the latest revision!

REV351 03-Oct-2021

OS212[4]): Operating Systems 2021 - 2

OS A	OS B	OS C	OS INT
Every first day of the Week, **Quiz#1:** (07:40-07:50) and **Quiz#2:** 07:20-07:40			
Monday/Thursday 13:00 — 14:40 14:00 — finish	Monday/Thursday 15:00 — 16:40[1] 16:00 — finish	Monday/Thursday 13:00 — 14:40 13:00 — 14:40	Monday/Wednesday 08:00 — 09:40 09:00 — finish

Week	**Schedule & Deadline[2])**	**Topic**	**OSC10[3])**
Week 00	30 Aug - 05 Sep 2021	Overview 1, Virtualization & Scripting	Ch. 1, 2, 18.
Week 01	06 Sep - 12 Sep 2021	Overview 2, Virtualization & Scripting	Ch. 1, 2, 18.
Week 02	13 Sep - 19 Sep 2021	Security, Protection, Privacy, & C-language.	Ch. 16, 17.
Week 03	20 Sep - 26 Sep 2021	File System & FUSE	Ch. 13, 14, 15.
Week 04	27 Sep - 03 Oct 2021	Addressing, Shared Lib, & Pointer	Ch. 9.
Week 05	04 Oct - 10 Oct 2021	Virtual Memory	Ch. 10.
Week 06	11 Oct - 17 Oct 2021	Concurrency: Processes & Threads	Ch. 3, 4.
Week 07	01 Nov - 07 Nov 2021	Synchronization & Deadlock	Ch. 6, 7, 8.
Week 08	08 Nov - 14 Nov 2021	Scheduling + W06/W07	Ch. 5.
Week 09	15 Nov - 21 Nov 2021	Storage, Firmware, Bootloader, & Systemd	Ch. 11.
Week 10	22 Nov - 28 Nov 2021	I/O & Programming	Ch. 12.

[1]) **OS B:** Week00-Week05 (RMS); Week06-Week10 (MAM).

[2]) The **DEADLINE** of Week 00 is 05 Sep 2021, whereas the **DEADLINE** of Week 01 is 12 Sep 2021, and so on...

[3]) Silberschatz et. al.: **Operating System Concepts**, 10^{th} Edition, 2018.

[4]) 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^{th} Edition, 2018. See also https://www.os-book.com/OS10/.
- **Resources**
  - **SCELE OS212** — https://scele.cs.ui.ac.id/course/view.php?id=3268. The enrollment key is **XXX**.
  - **Download Slides and Demos from GitHub.com** https://github.com/UI-FASILKOM-OS/SistemOperasi/: 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/
  - **OSP4DISS** — https://osp4diss.vlsm.org/
  - **DOIT** — https://doit.vlsm.org/001.html

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

Agenda (2)

11. GRUB Map
12. init (SYSV legacy)
13. UpStart - Ubuntu
14. The All New "systemd"
15. systemctl
16. Week 09: Check List
17. The End

Week 09 Storage, Firmware, Bootloader, & Systemd: Topics[1]

- Storage
- Storage Arrays
- BIOS
- Loader
- Systemd

[1] Source: ACM IEEE CS Curricula 2013

Week 09 Storage, Firmware, Bootloader, & Systemd: Learning Outcomes[1]

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

[1] Source: ACM IEEE CS Curricula 2013

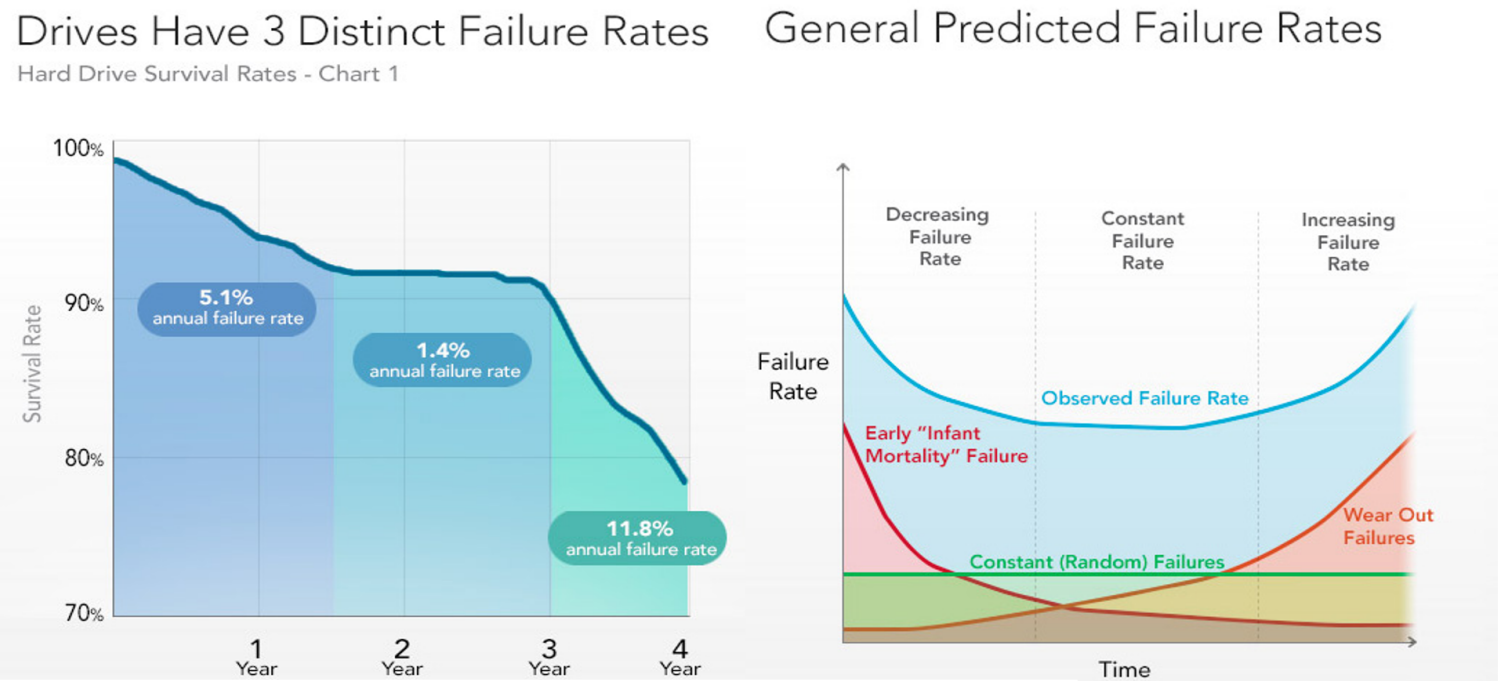
Storage, Firmware, Bootloader, & Systemd

- 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) $\Rightarrow$ 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?

[1] Subject to change

Storage Failure Rates

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



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

BACKBLAZE

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

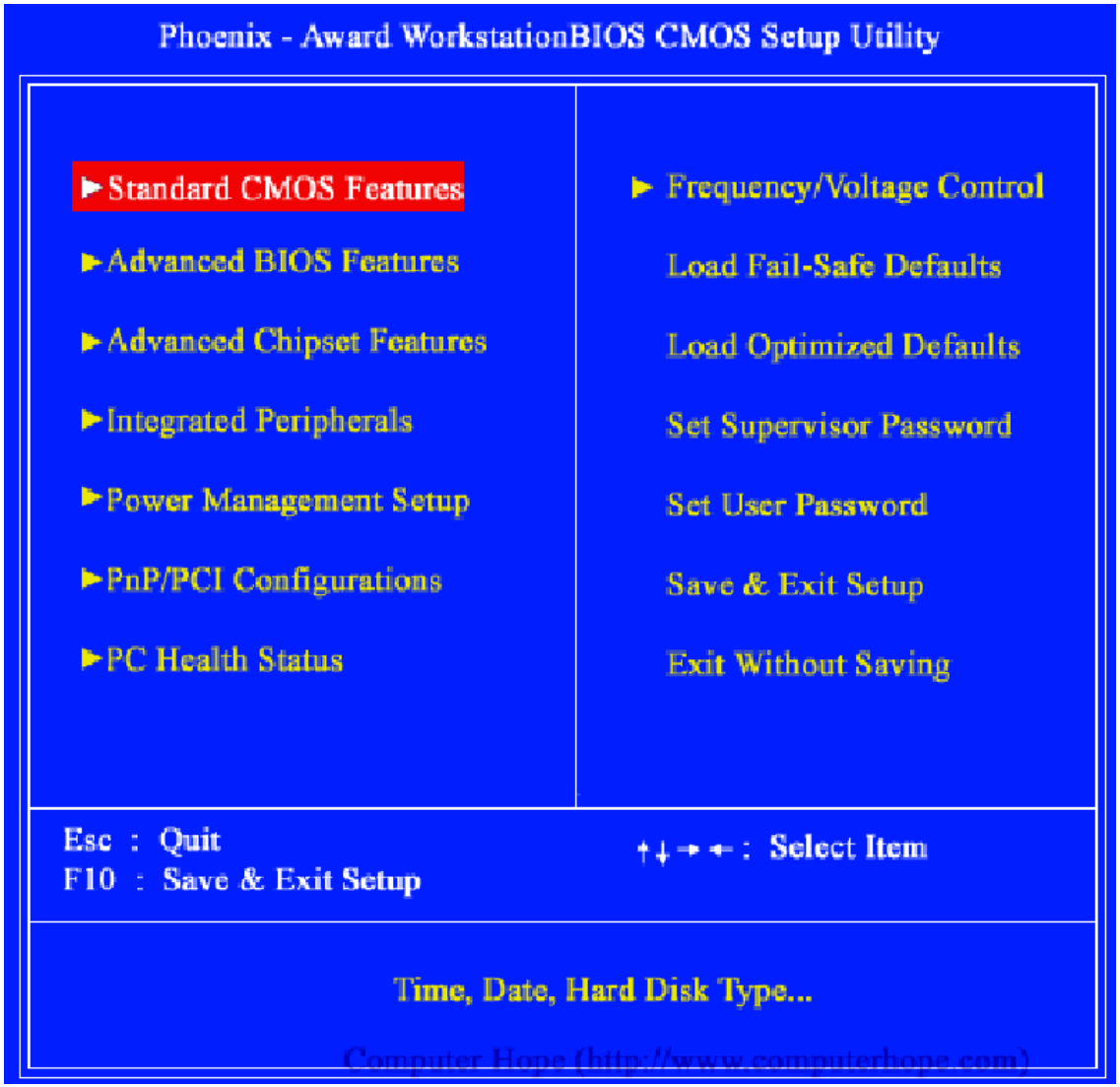


Figure: BIOS

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

UEFI Boot

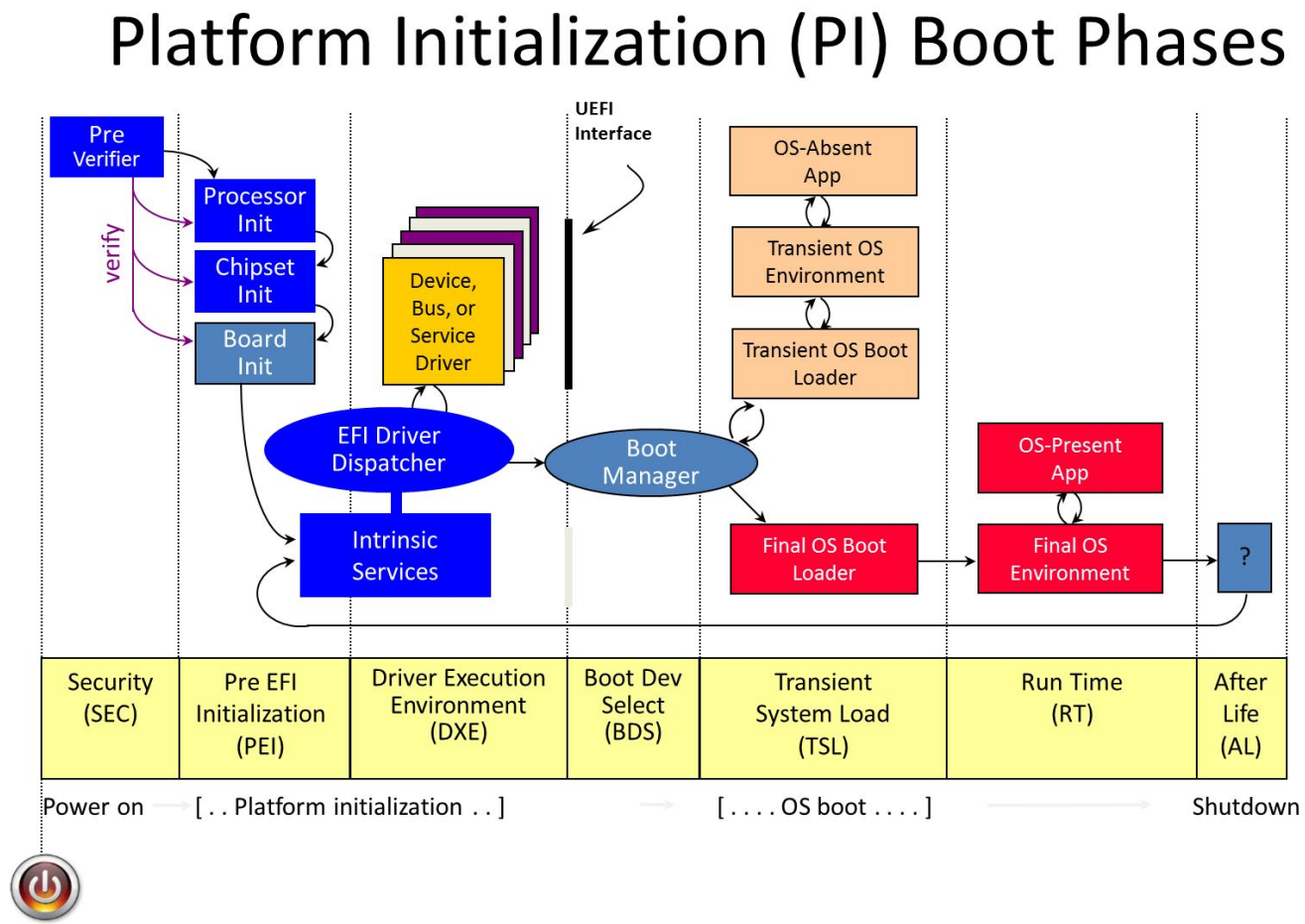


Figure: UEFI Boot Process[1].

[1] Source 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.

GRUB Map

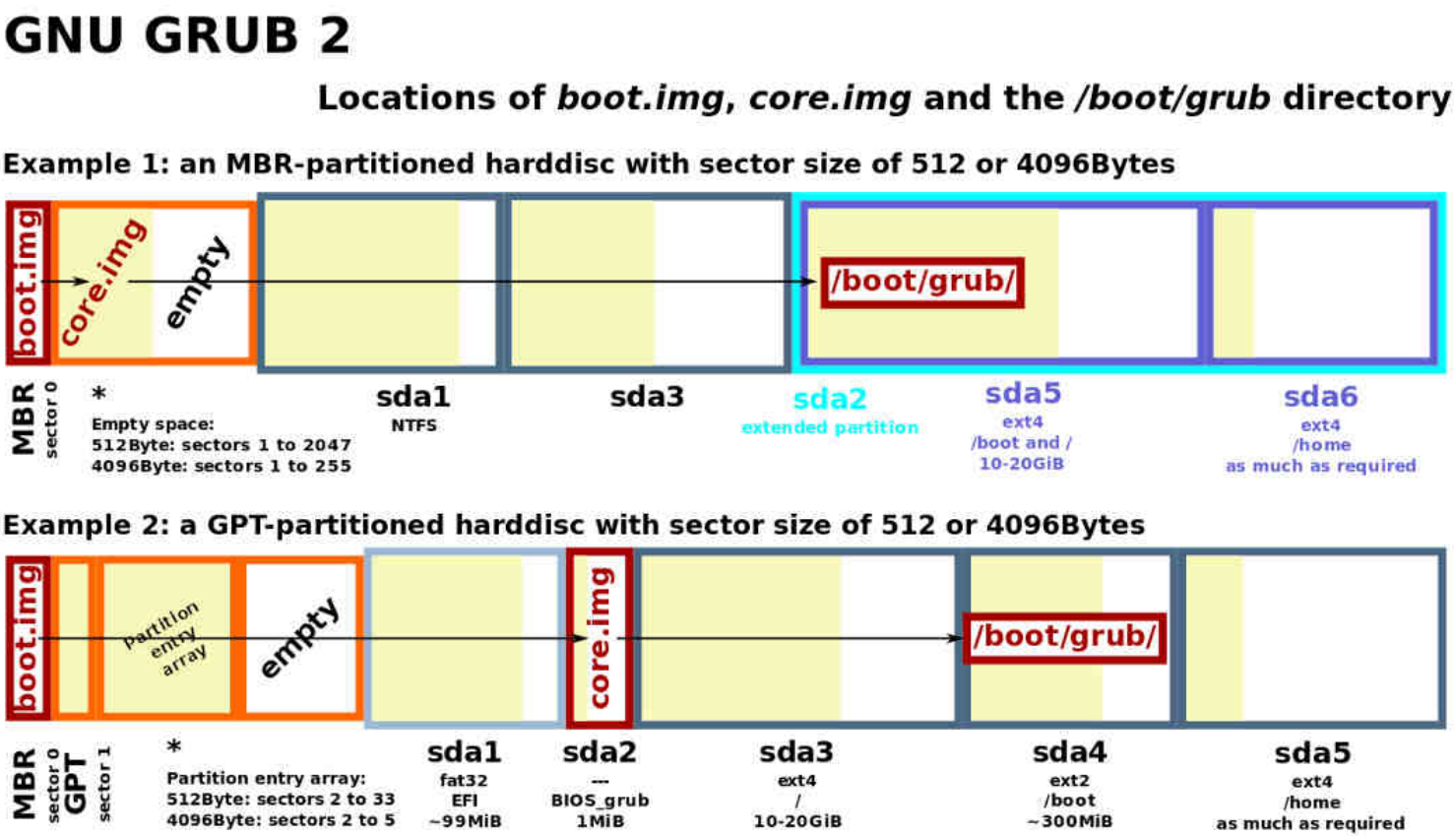


Figure: GRUB[1].

[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
...
```

systemctl 02

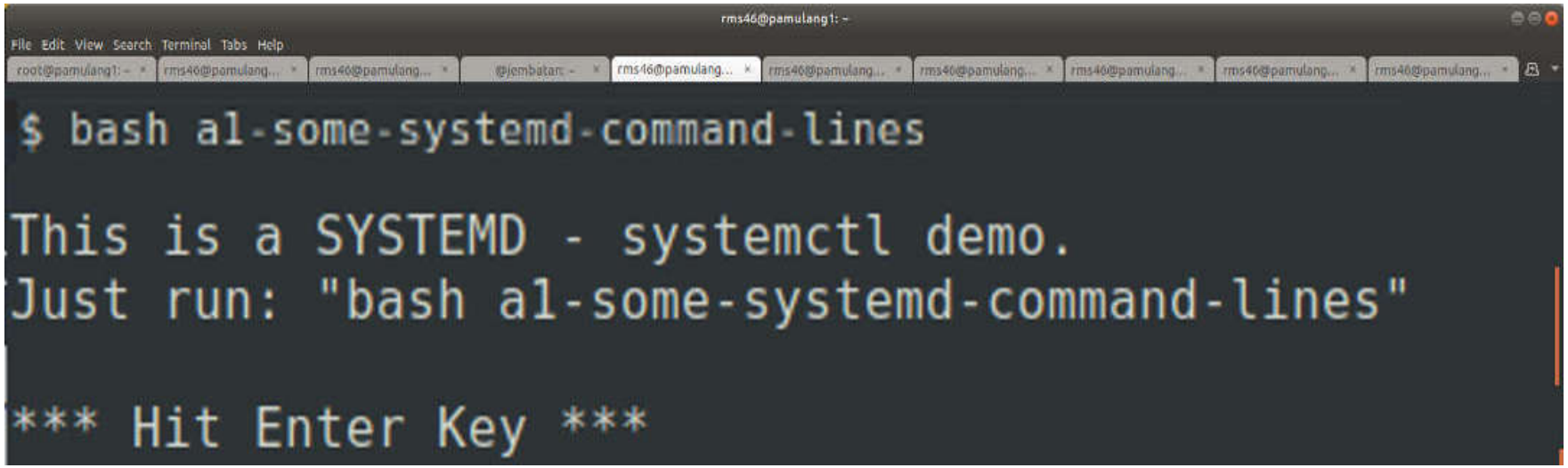


Figure: bash a1-some-systemd-command-lines

systemctl 03

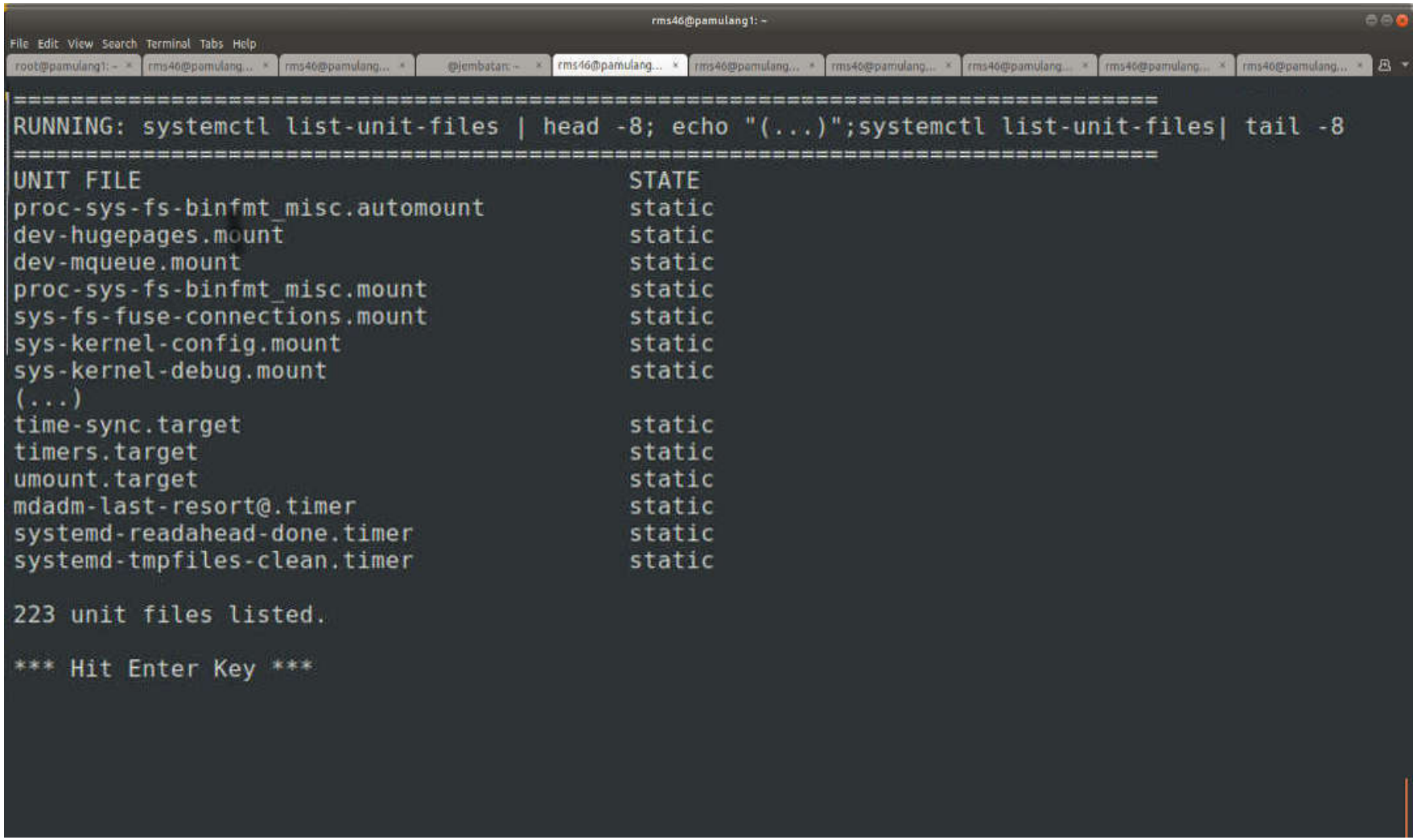


Figure: systemctl list-unit-files

systemctl 04

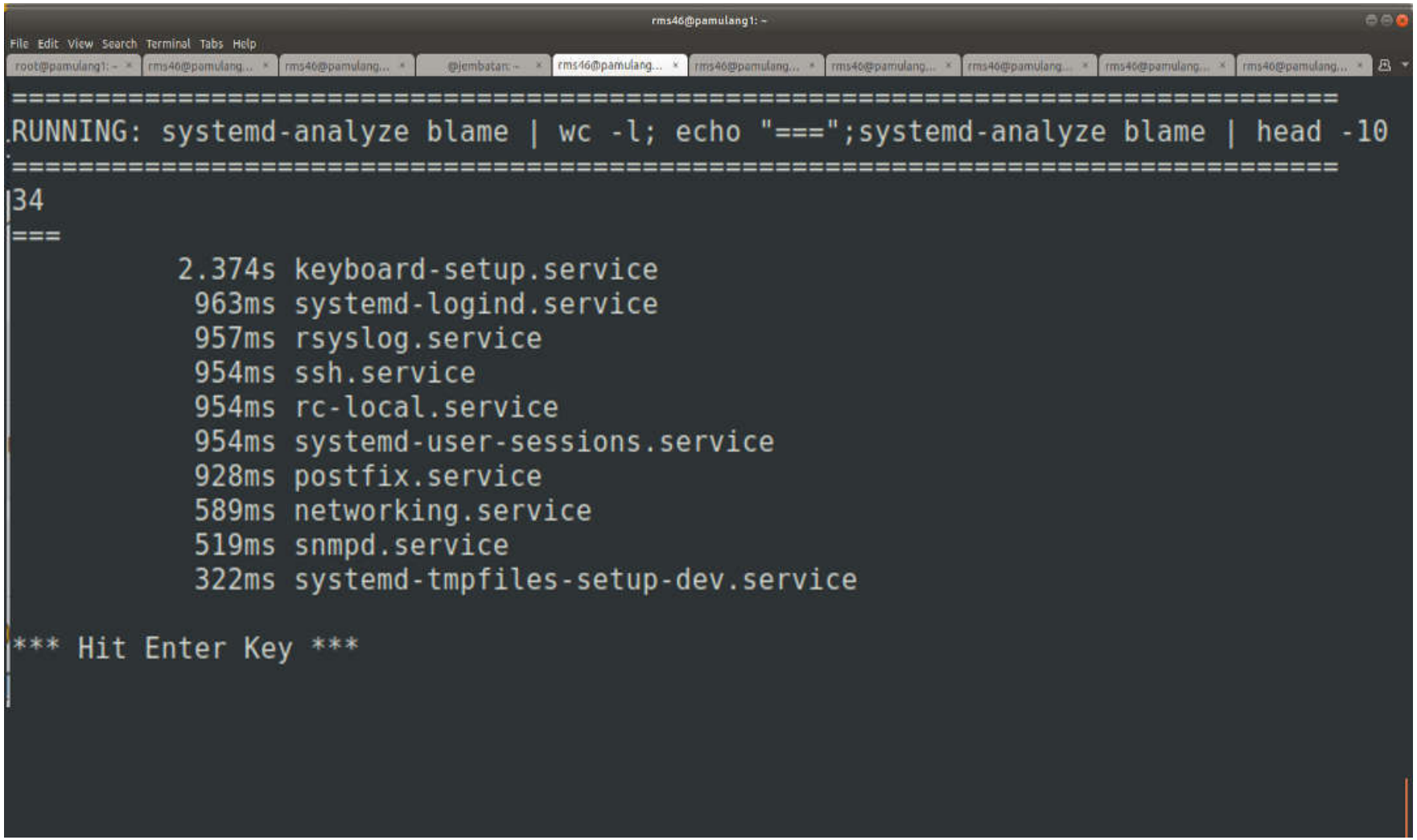


Figure: systemd-analyze blame

systemctl 05

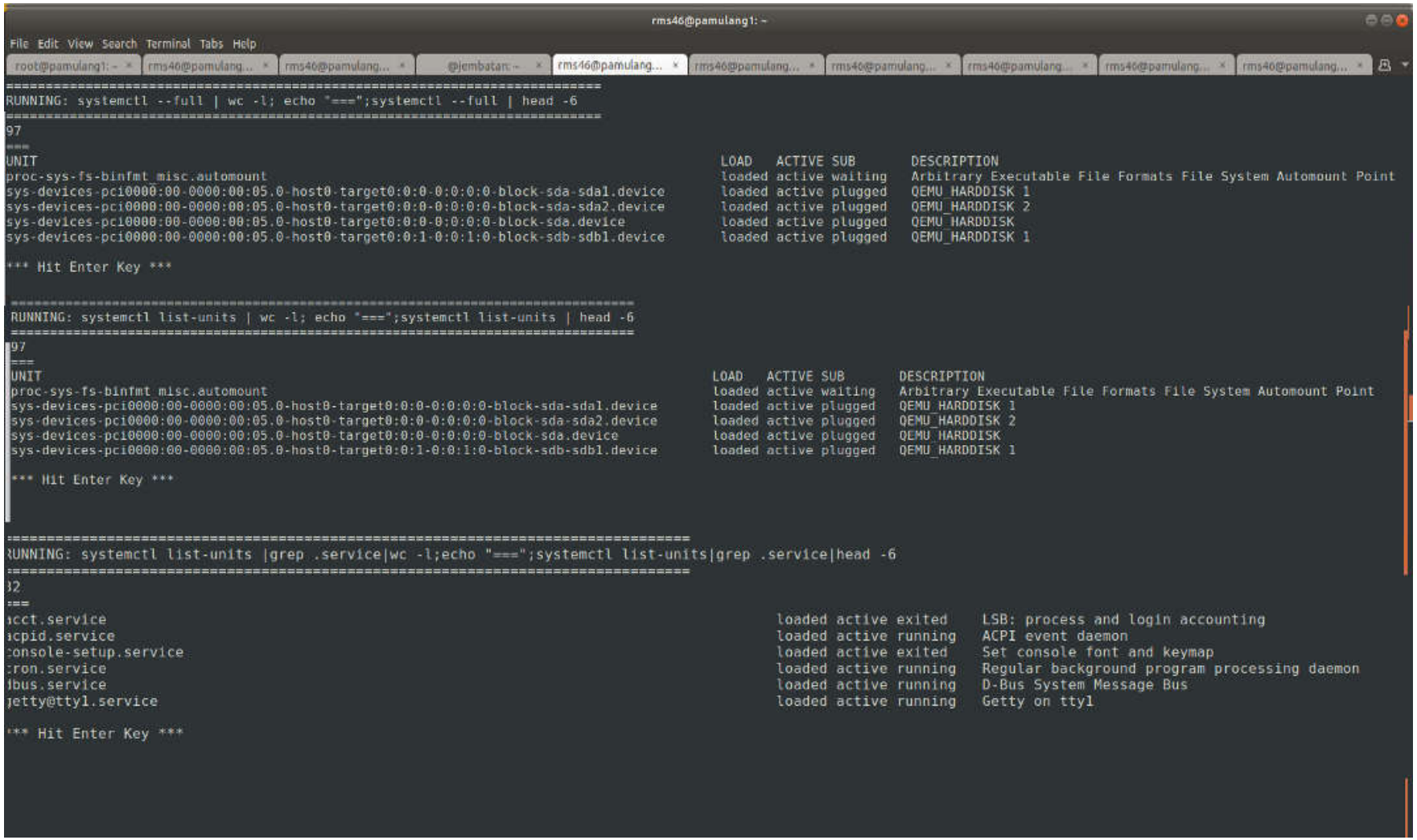


Figure: systemctl –full; systemctl list-units

systemctl 06

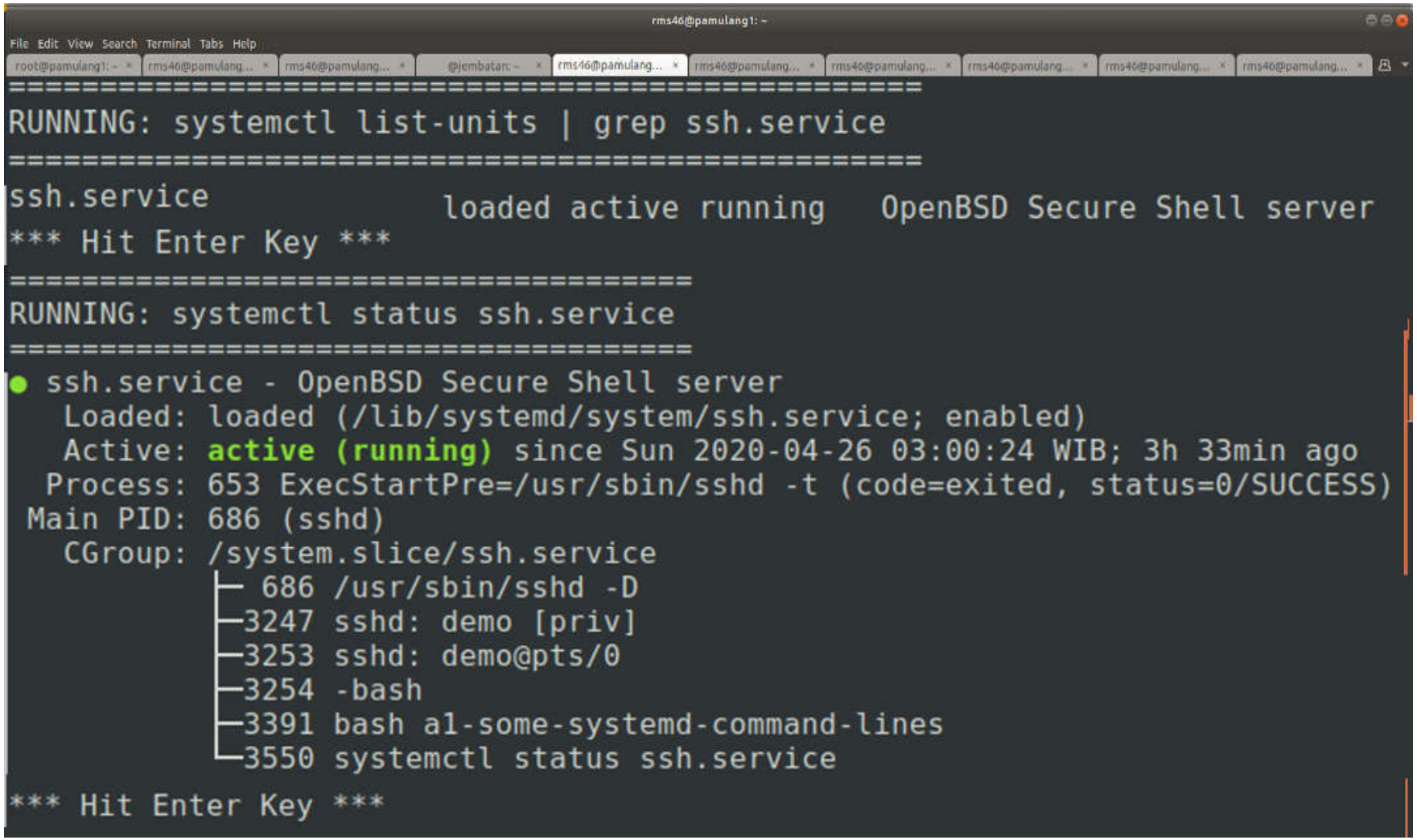


Figure: systemctl status ssh.service

systemctl 07

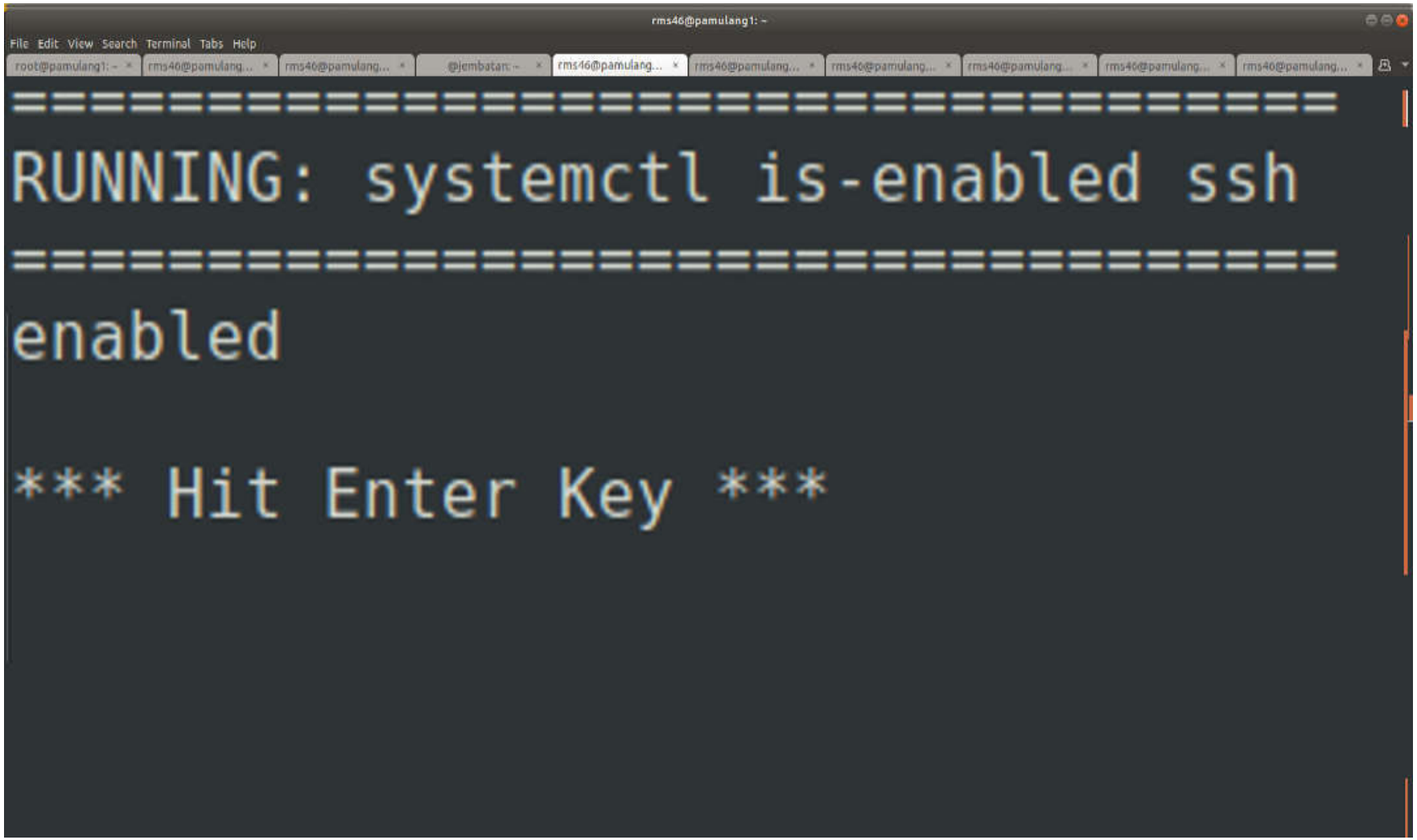


Figure: systemctl is-enabled ssh

Week 09: Check List (Deadline: 21 Nov 2021).

- Week 09 Input Token: AkunGitHubW09 Eg. **cbkadalW09**
- This page is https://os.vlsm.org/Slides/check09.pdf.
- More details: https://osp4diss.vlsm.org/W09.html.
- Assignment Check List:
  1. Read: (OSC10 chapter 11)
  2. Visit https://os.vlsm.org/GitHubPages/. Review **Last Week TOP 10 List** and pick at least 3 out of your 10 next neighbors. See https://cbkadal.github.io/os212/TXT/myrank.txt.
  3. Create your **TOP 10 List** of Week 09. **Do not use lecture material. Please be more creative!** (E.g. https://cbkadal.github.io/os212/W09/).
  4. Week 09 will be about Linux From Scratch (LFS) chapter 5-7.
  5. The report should be placed into a "W09/" folder and tarballed as "myW09.tar.bz2.asc"
  6. Update your log (e.g. https://cbkadal.github.io/os212/TXT/mylog.txt).
  7. Make SHA256SUM and sign it (detached, armor) as SHA256SUM.asc.

The End

- ☐ This is the end of the presentation.
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