CSF2600505 Sistem Operasi
CSGE602055 Operating Systems
Week 00: Overview 1

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University of Indonesia

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

REV236 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	Concurrency: Processes & Threads	Ch. 3, 4
	29 Oct 2020	Maulid Nabi	
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**, 10^{th} 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. How to contact the Lecturer
5. Highlights
6. Week 00
7. Assessment
8. Week 00: Review
9. Week 00 Assignment #1: Public Repository "os202"
10. Week 00 Assignment #2: Start Week 00 Log
11. Week 00 Assignment #3: Create Your GitHub Page
12. Week 00 Assignment #4: Course Registration
13. TIPS
14. Week 00: Summary

Agenda (2)

15 Week 00: Check List
16 Week 00
17 Week 01
18 Week 02
19 Week 03
20 Week 04
21 Week 05
22 Week 06
23 Week 07
24 Week 08
25 Week 09
26 Week 10
27 The End

How to contact the Lecturer[2]

For Q & A, use WhatsApp Group **OperatingSystems** (info +62-881-456-**XXXX**)
Email (Subject:**[HELP]**) operatingsystems@vlsm.org State your "Name", "ID", and "OS class".
SCELE — (This enrollment key is **XXX**): https://scele.cs.ui.ac.id/course/view.php?id=3020.

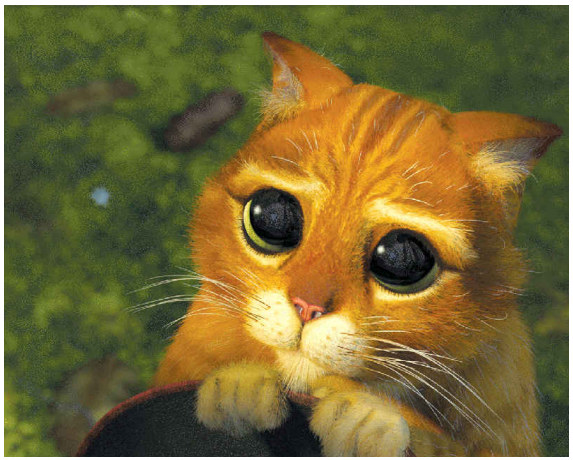


Figure: Never ever whine and pretend like this[1]!

[1] "Puss in Boot" is a DreamWorks/Paramount Picture character.

[2] FYI: King Goerge II founded the University of Goettingen in 1734.

Highlights

Coverage

This is an introduction to a modern operating systems course. It will cover general overview, computer architecture review, operating system overview, GNU/Linux CLI, scripting, C language overview, protection, security, privacy, systemd, I/O, addressing and pointers, memory management, processes and threads, virtual memory, synchronization, mutual exclusion, deadlock, CPU scheduling algorithms, file systems, and I/O programming.

Student-Centered

This course is student-centered where responsibility is in the hands of the students. Students are expected to be prepared for the class meeting.

GNU/Linux

Students will have a thorough understanding of how GNU/Linux provides services by using a Command Line Interface.

Week 00 Overview I: Topics[1]

- Role and purpose of the operating system
- Functionality of a typical operating system
- Mechanisms to support client-server models, hand-held devices
- Design issues (efficiency, robustness, flexibility, portability, security, compatibility)
- Influences of security, networking, multimedia, windowing systems
- Structuring methods (monolithic, layered, modular, micro-kernel models)
- Abstractions, processes, and resources
- Concepts of application program interfaces (APIs)
- The evolution of hardware/software techniques and application needs
- Device organization
- Interrupts: methods and implementations
- Concept of user/system state and protection, transition to kernel mode

[1] Source: ACM IEEE CS Curricula 2013

Week 00 Overview I: Learning Outcomes (1)[1]

- Explain the objectives and functions of modern operating systems [Familiarity]
- Analyze the tradeoffs inherent in operating system design [Usage]
- Describe the functions of a contemporary operating system with respect to convenience, efficiency, and the ability to evolve. [Familiarity]
- Discuss networked, client-server, distributed operating systems and how they differ from single user operating systems. [Familiarity]
- Identify potential threats to operating systems and the security features design to guard against them. [Familiarity]
- Explain the concept of a logical layer. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 00 Overview I: Learning Outcomes (2)[1]

- Explain the benefits of building abstract layers in hierarchical fashion. [Familiarity]
- Describe the value of APIs and middleware. [Assessment]
- Describe how computing resources are used by application software and managed by system software. [Familiarity]
- Contrast kernel and user mode in an operating system. [Usage]
- Discuss the advantages and disadvantages of using interrupt processing. [Familiarity]
- Explain the use of a device list and driver I/O queue. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Assessment part 1

85 - ... = A	80 - 85 = A-	75 - 80 = B+	70 - 75 = B
65 - 70 = B-	60 - 65 = C+	55 - 60 = C	50 - 55 = D or C[1]
40 - 50 = D	30 - 40 = E	20 - 30 = E	00 - 20 = E

- **4 SKS** (Units) means 12 hours per week!
- 11 (weekly) assigments @ 11 points.
  - Assignments will vary from week to week.
  - Final grade: the sum of the best 9 assignments.
- Deadline: before the next week starts.
- **C-2C:** upto 5 points.
  - Only if your grade is between 50.00 and 55.00 and you have a "good" track record.
- Check your points regularly at `https://academic.ui.ac.id/` and **DO NOT COMPLAIN** weeks after! See also, `https://os.vlsm.org/`.

[1] Terms and Conditions apply. Void where prohibited by law.

AIN'T DIFFICULT, lah!

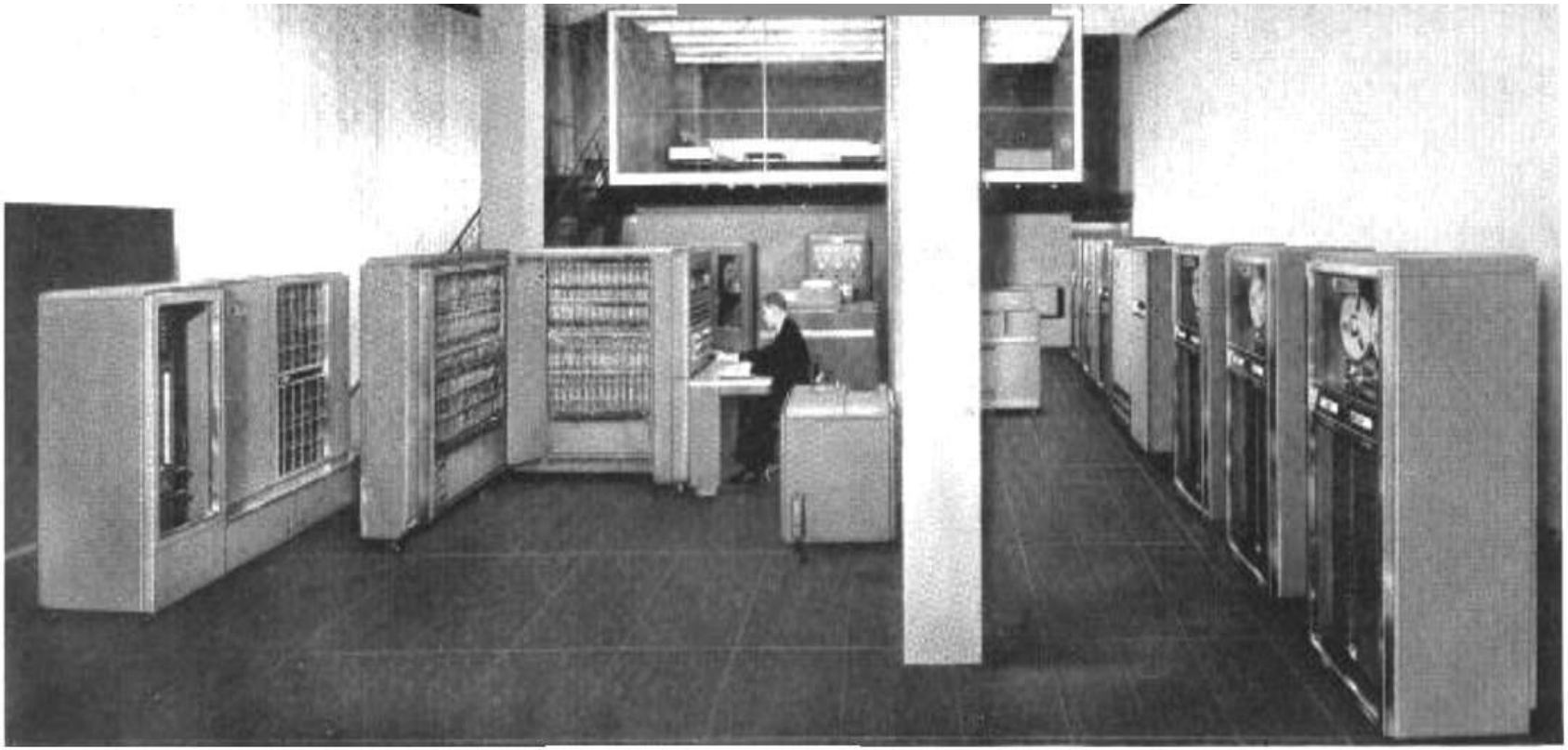
Figure: Even this Goat will get "C" at the end of the semester!

Prelude: Daisy Bell – Bicycle Built for Two

Daisy, Daisy,
Give me your answer, do!
I'm half crazy,
All for the love of you!
It won't be a stylish marriage,
I can't afford a carriage,
But you'll look sweet on the seat
Of a bicycle built for two!

See also https://youtu.be/TXK_cE9AqAI.

IBM 704 at Los Alamos National Laboratory in the 1950s



IBM 704 ELECTONIC DATA-PROCESSING MACHINES

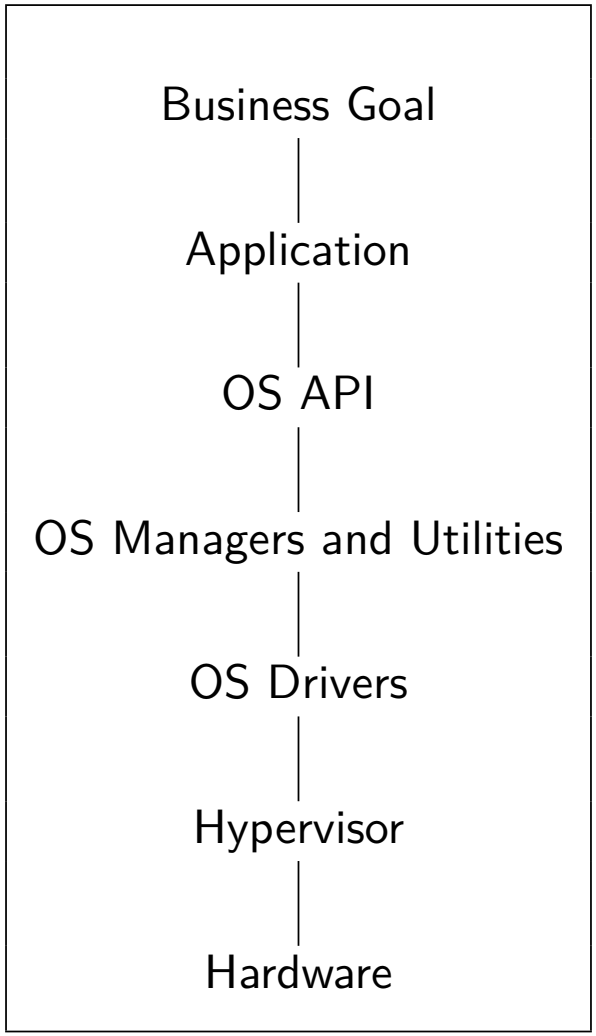
Estimate price (2020 value): USD 8,000,000.

QS855, 256GB, 12 GB, 48+12 MP, 6.4”, 4000 mAh

Estimate price (2020 value): Rp. 8,000,000.

Week 00: Review

- What is an Operating System?
- Why taking an Operating System class?



Computer Organization Review

- You should understand:
  - von Neumann Model.
  - Buses, Bridges, Transfer Rate, Clock.
  - Memory: DDR, DDR-2, DDR-3 ...
  - Cache, Buffer, Spool, & Pipelining.
  - Direct Memory Access (DMA).
  - Port & Memory Mapped I/O.
  - CPU: (privilege/kernel/supervisor mode) vs. (user mode).
  - Physical (Hardware) Limitation.
  - Priority: Read vs Write.
  - Interrupts: Polling & Vectored.
  - Multiprocessors: Symmetric vs. Asymmetric.
  - Multicore & Multithreading.
  - Clustered Systems.
  - Numbers: base 2, base 8, base 10, base 16.
    - Base 2: 110010101010_2
    - Base 8: $01234567_8 = 000\ 001\ 010\ 011\ 100\ 101\ 110\ 111_2$
    - Base 10: 012 345 679
    - Base 16: $9AB\ CDEF_{16} = 1001\ 1010\ 1011\ \ 1100\ 1101\ 1110\ 1111_2$

Block Diagram

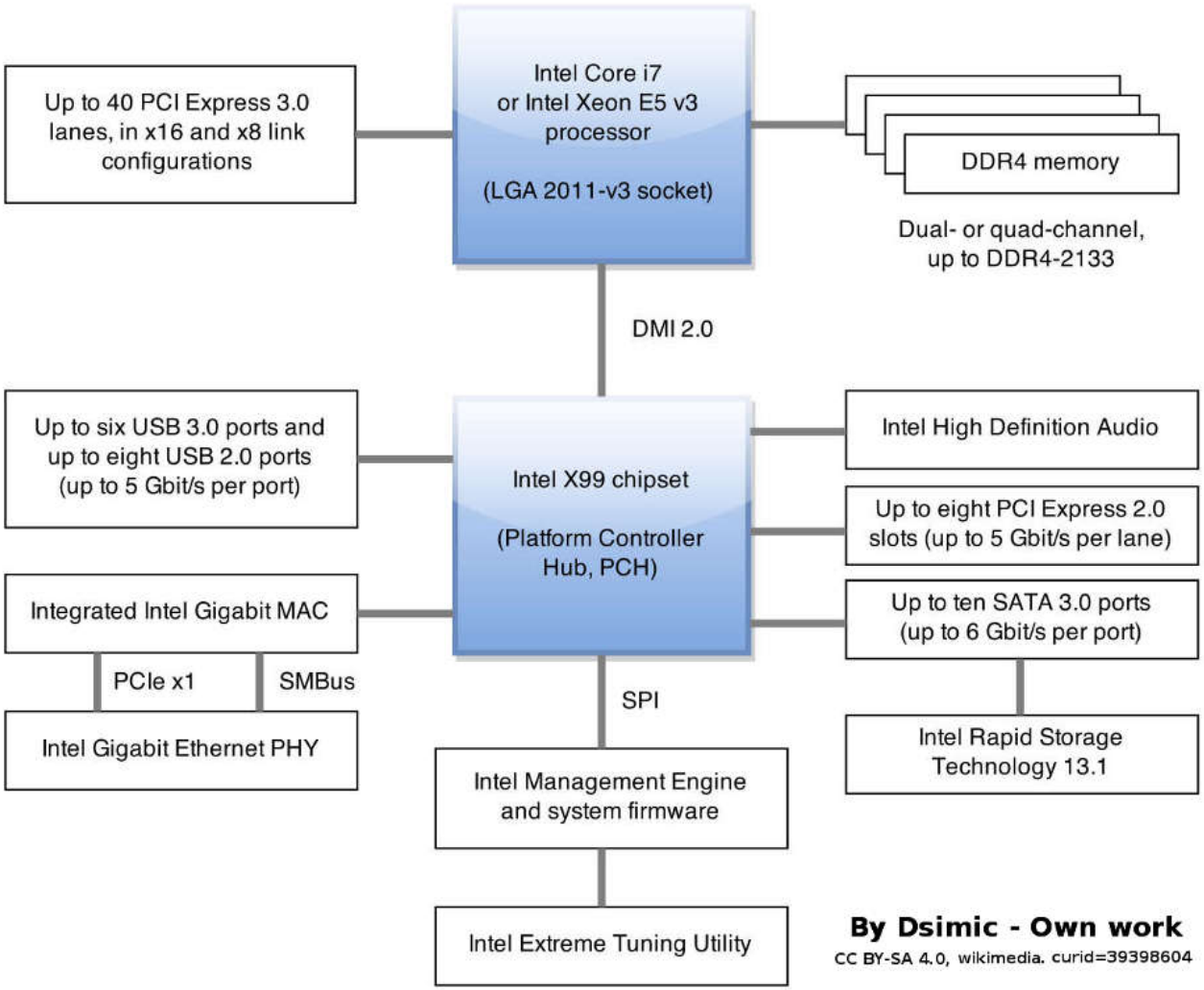


Figure: Block Diagram

APIC (Advanced Programmable Interrupt Controller)

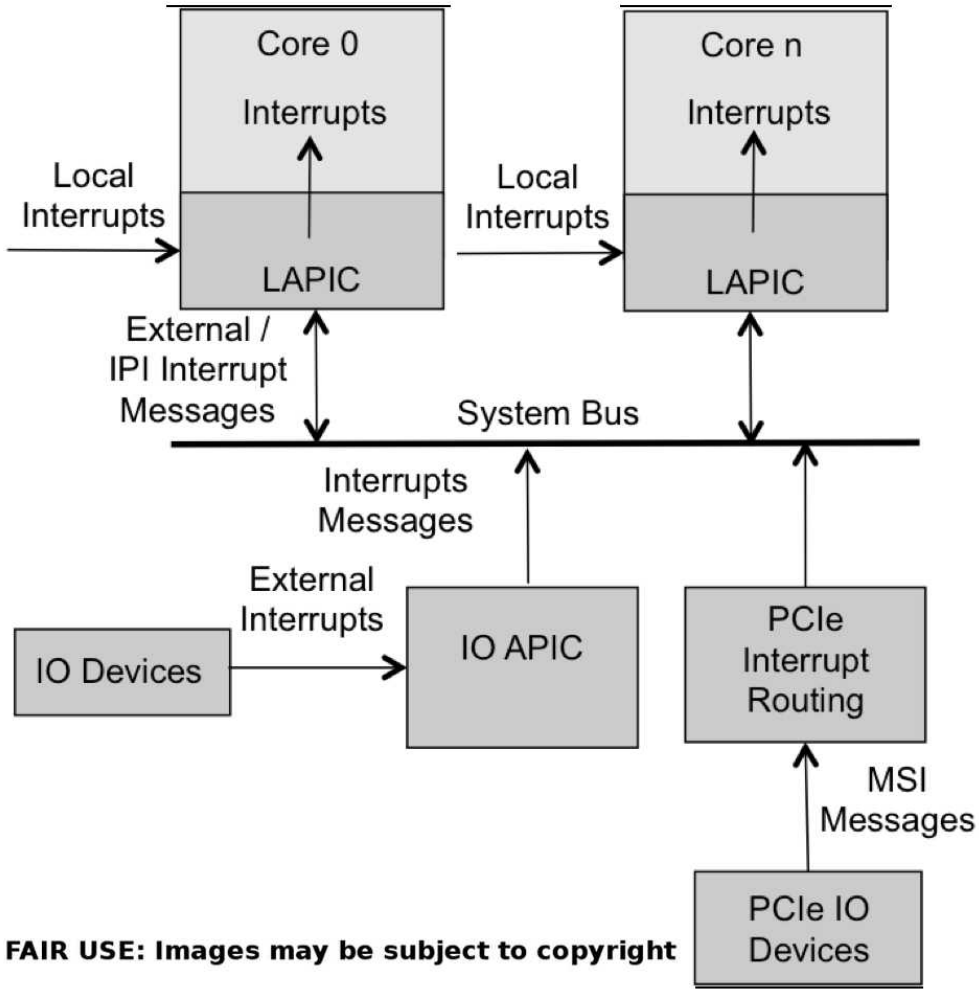


Figure: APIC (Advanced Programmable Interrupt Controller)

Interupt Handling

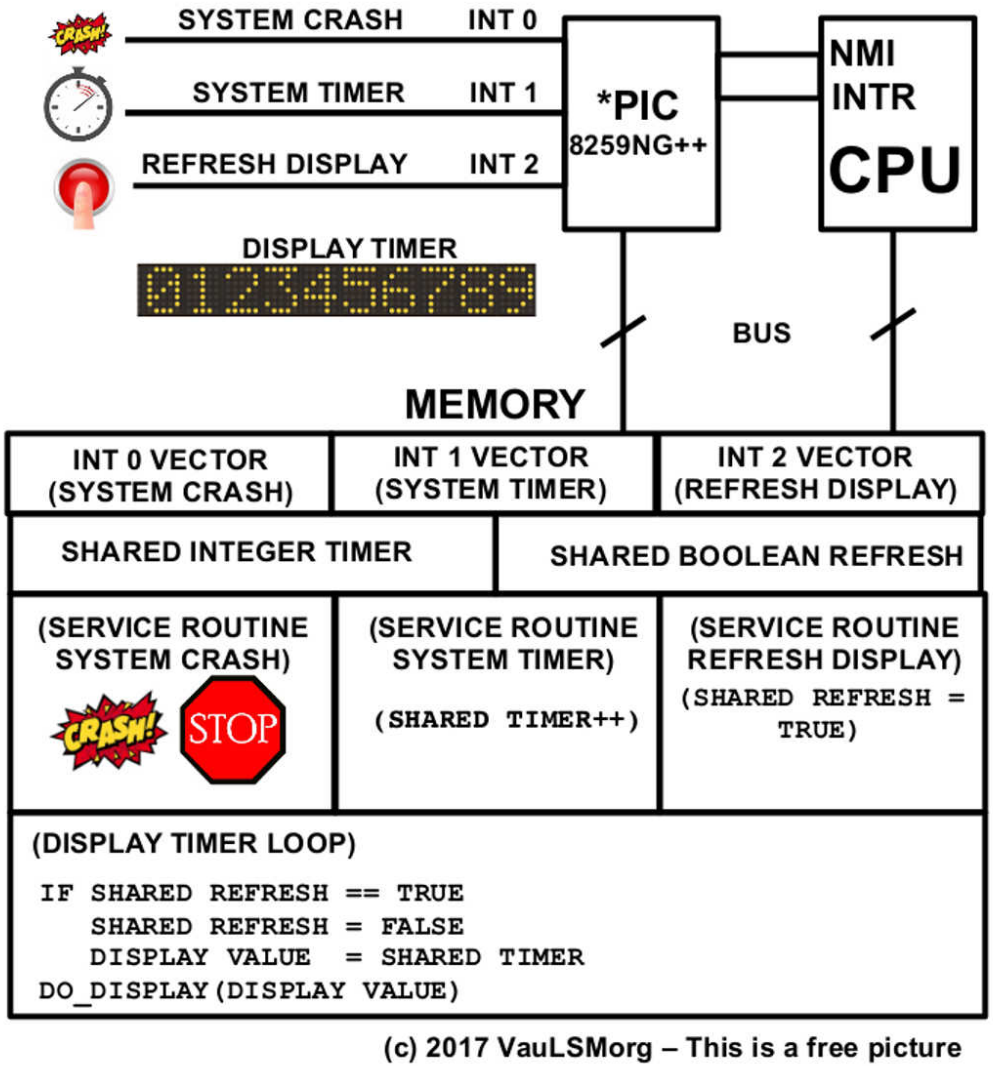


Figure: Interupt Handling with PIC (Programmable Interrupt Controller)

Managers Set

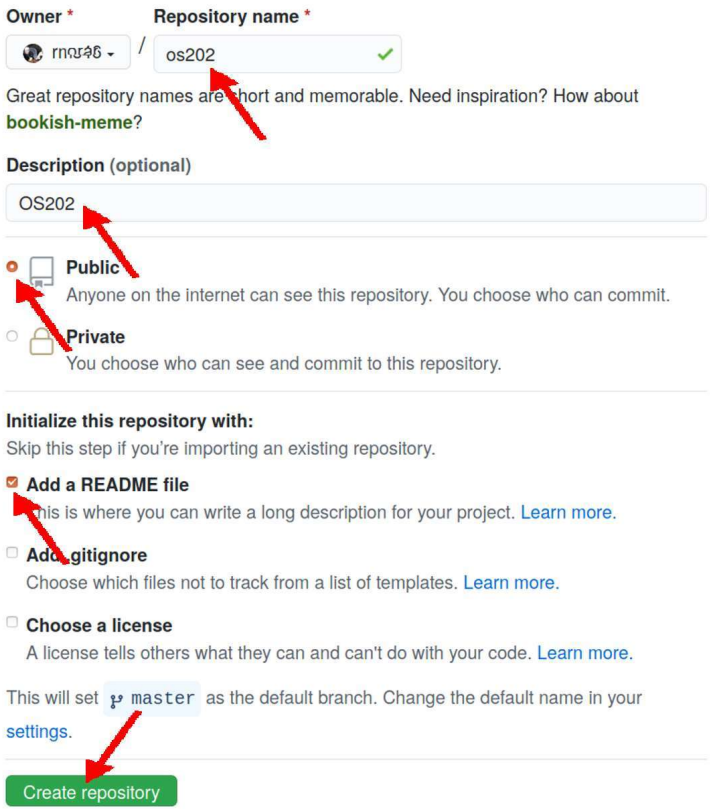
- Process:
  - Creating/Deleting; Suspending/Resuming; Synchronization; Communication; Schedulling
- Memory:
  - Tracking; Move In/Move Out; Allocating/Deallocating.
- Storage/File System:
  - Create/Delete; Open/Close; Read/Write.
- Mass Storage:
  - Schedulling; Allocating; Free Space.
- I/O:
  - Buffering; Caching; Spooling.
  - Interfacing (driving).
- Protecting & Security:
  - Protecting.
  - Security.

Make sure, to understand:

- Scripting: bash, regex, sed, awk?
- Security and Protection?
- File System?
- Data Structure in a (logical) Memory?
- Virtual Memory
- Concurrency
- Synchronization
- Mass Storage
- UEFI, GRUB, and systemd
- I/O
- I/O Programming

Week 00 Assignment #1: Public Repository "os202"

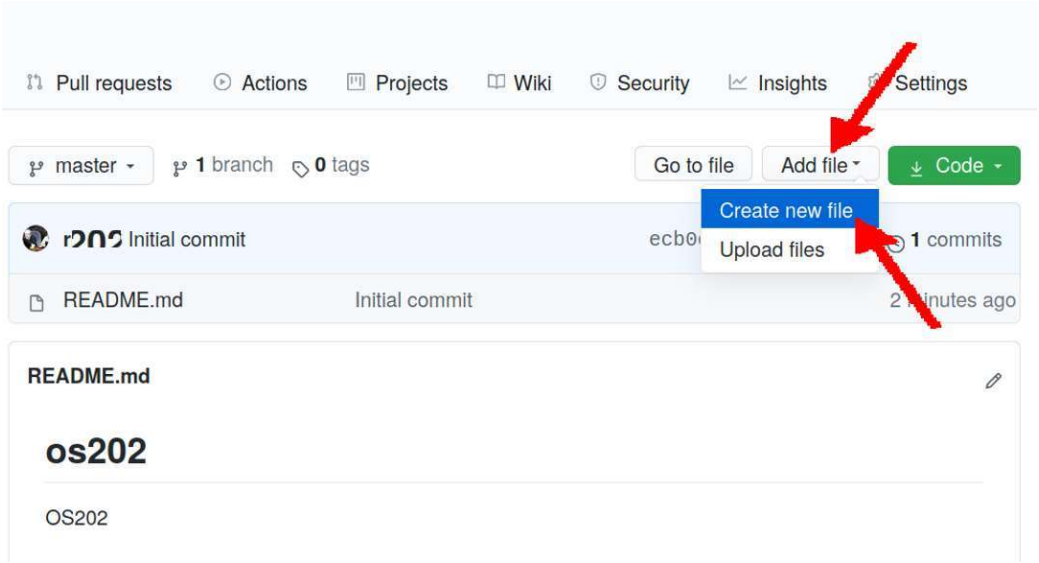
- Visit `github.com`
  - (IF NO ACCOUNT) **SIGN UP** (`https://github.com/join`).
  - (ELSE) **SIGN IN** (`https://github.com/login`).
  - Create a new repository ("os202"):



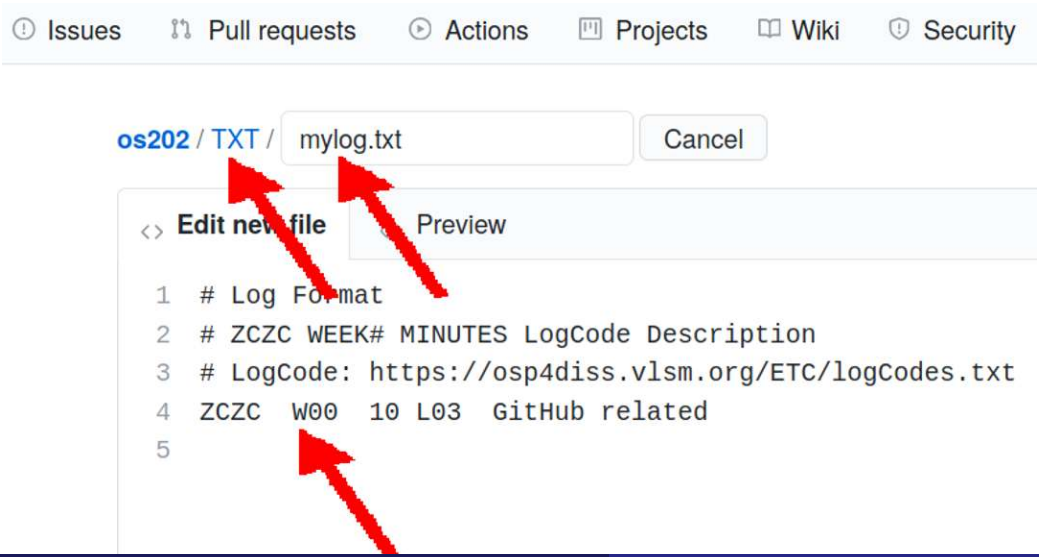
    - **Repository name**: "os202" (all small).
    - **Public**: Anyone can see this repository.

Week 00 Assignment #2: Start Week 00 Log (1)

`Add file` → `Create new file`

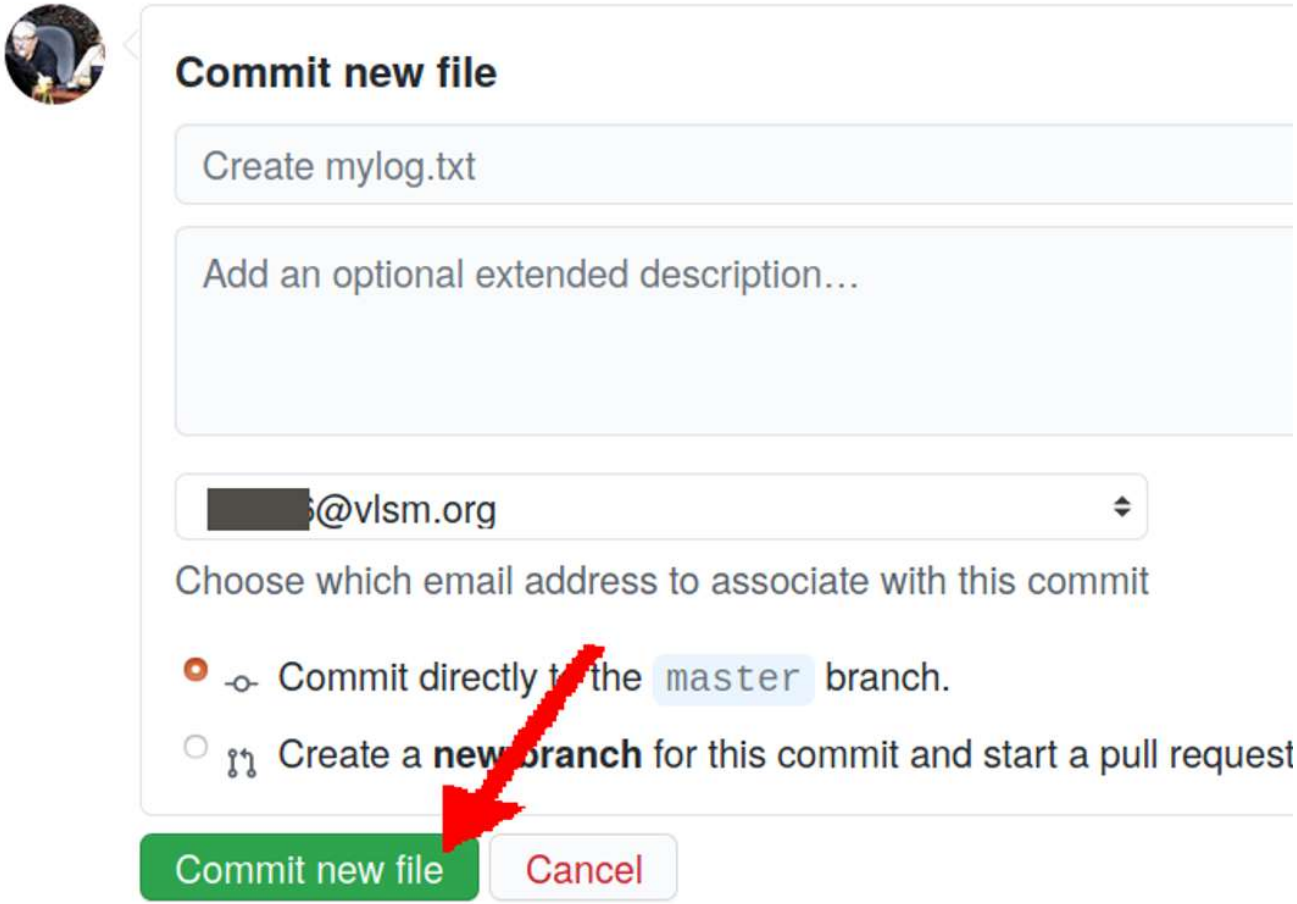


Folder/File: `"TXT/mylog.txt"` (Eg. Week-00 10 minutes doing GitHub (L03))



Week 00 Assignment #2: Start Week 00 Log (2)

Commit a new file

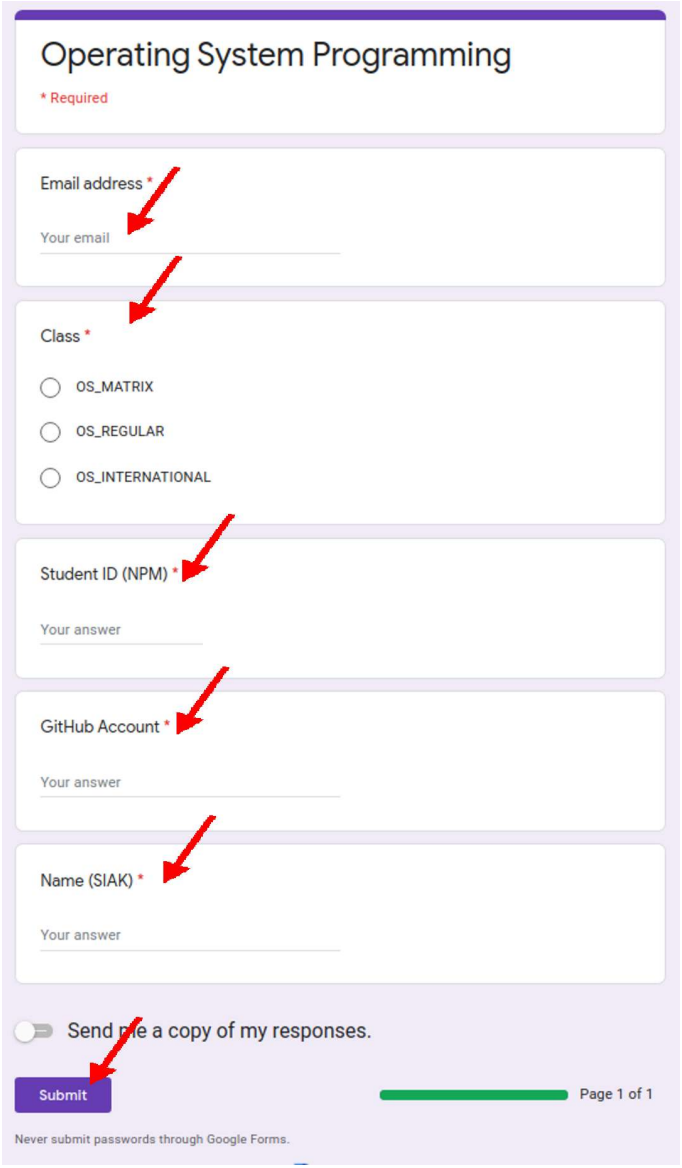


Week 00 Assignment #3: Create Your GitHub Page

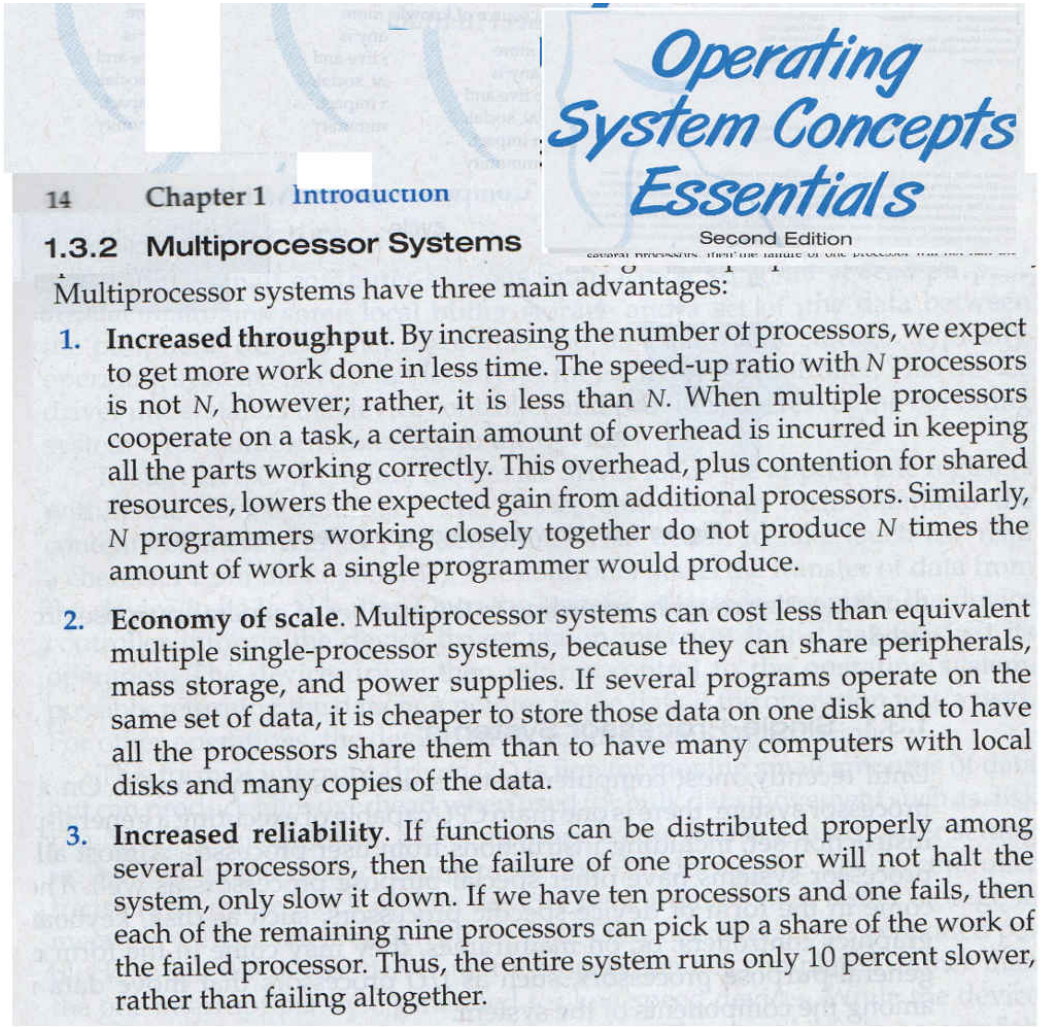
- Find out how to create your GitHub Page!
- If your Github Repository is:
  - `https://github.com/akunGitHub/os202`,
- your GitHub Page will be:
  - `https://akunGitHub.github.io/os202`.

Week 00 Assignment #2: Course Registration

Fill in your Email Address, Class, Student ID, GitHub Account, and Name. See also **SCELE**



Week 00: Problem Example (from OSC2e)



Operating System Concepts Essentials
Second Edition

14 Chapter 1 Introduction

1.3.2 Multiprocessor Systems

Multiprocessor systems have three main advantages:

1. **Increased throughput**. By increasing the number of processors, we expect to get more work done in less time. The speed-up ratio with N processors is not N, however; rather, it is less than N. When multiple processors cooperate on a task, a certain amount of overhead is incurred in keeping all the parts working correctly. This overhead, plus contention for shared resources, lowers the expected gain from additional processors. Similarly, N programmers working closely together do not produce N times the amount of work a single programmer would produce.
2. **Economy of scale**. Multiprocessor systems can cost less than equivalent multiple single-processor systems, because they can share peripherals, mass storage, and power supplies. If several programs operate on the same set of data, it is cheaper to store those data on one disk and to have all the processors share them than to have many computers with local disks and many copies of the data.
3. **Increased reliability**. If functions can be distributed properly among several processors, then the failure of one processor will not halt the system, only slow it down. If we have ten processors and one fails, then each of the remaining nine processors can pick up a share of the work of the failed processor. Thus, the entire system runs only 10 percent slower, rather than failing altogether.

Figure: **T / F** The advantages of a multiprocessor system include: increased throughput, economy of scale, and increased reliability (Week00 2016-1).

TIPS (1)

- For any administrative issues, contact SEKRE at building B, 2^{nd} floor – especially for absences, illness, sick letters, follow-up exams, etc. Please do not contact the **Lecturer** (RMS).
- Please complete the follow-up / paper work within 6 working days (RMS).
- Prepare the weekly MEMO as completely as possible. You should have mastered the material at the beginning of the week (RMS).
- Study the Operating System Concept book which deals with the material will be discussed that week (MIM). Make a summary of material in your Memo (IP).
- You should understand every single problem of the past examinations. Write down all hints in your "**MEMO**" (MHP).
- You are allowed to bring up to 6 sheets of MEMOs for the midterm (UTS) and up to 5 sheets of MEMOs for the final term (UAS) (RMS).
- You should understand every single line of the "**DEMOS**" (MHP).

TIPS (2)

- You should ask **the lecturer** or anyone, anything you do not understand (TA).

Special Thanks

Special thanks for the early version of this writing to:

Anisha Inas Izdihar (AII), Benedictus Alvin (BA), Ibnu Sofian Firdaus (ISF), Irmanpen Panjaitan (IP), Ivana Irene Thomas (IIT), Michael Giorgio Wirawan (MGW), Muhammad Afkar (MA), Muhammad Hanif Pratama (MHP), Muhammad Iqbal Mahendra (MIM), M. Ikhsan Kurniawan (MIK), Nixi Sendya Putri (NSP), Raihan Mahendra Sutanto (RM), Rizki Leonardo (RL), Shavira Adeva (SA), Stefan Mayer Sianturi (SMS), Thrisnadevany Amalia (TA), Zhelia Alifa (ZA);

See also `https://rms46.vlsm.org/2/221.pdf`.

Week 00: Summary

- What is an Operating Systems?
  - Definition: Resource Allocator & Control Program.
  - Why taking an Operating System class?
- Computer Organization Review
- The Manager Set
  - Process Manager, Memory Manager, I/O Manager, Storage Manager.
- Security and Protection
- Virtualization
  - Hypervisor type 0, 1, 2
  - Paravirtualization, Emulators, Containers.
  - VCPU: Virtual CPU
  - Virtualization Implementation:
    - Trap-and-Emulate mode
    - Binary Translation mode

Week 00: Check List

- ☐ Check this out: `https://os.vlsm.org/Slides/os00.pdf` and `https://os.vlsm.org/Slides/check00.pdf`.
- ☐ Also visit **OSP4DISS** and **SCELE**: `https://osp4diss.vlsm.org/` `https://scele.cs.ui.ac.id/course/view.php?id=3020`
- ☐ **Read any** recent and decent Operating System Book (ch. 1 & 2).
- ☐ Week 00: Assignment #1: Create GitHub Public Repository "os202".
- ☐ Week 00: Assignment #2: Start Week 00 Log.
- ☐ Week 00: Assignment #3: Create your "os202" GitHub Page.
- ☐ Week 00: Assignment #4: Course Registration.
- ☐ Assignment Day is every Thursday morning.
- ☐ Create a **TOP 10 LIST** about what you should know about **OS**.
- ☐ Revisit/add your own Weekly Log.
- ☐ Starting next week **(Week 01)**: TABULA RASA is not accepted anymore!

Week 00 Overview I: Topics[1]

- Role and purpose of the operating system
- Functionality of a typical operating system
- Mechanisms to support client-server models, hand-held devices
- Design issues (efficiency, robustness, flexibility, portability, security, compatibility)
- Influences of security, networking, multimedia, windowing systems
- Structuring methods (monolithic, layered, modular, micro-kernel models)
- Abstractions, processes, and resources
- Concepts of application program interfaces (APIs)
- The evolution of hardware/software techniques and application needs
- Device organization
- Interrupts: methods and implementations
- Concept of user/system state and protection, transition to kernel mode

[1] Source: ACM IEEE CS Curricula 2013

Week 00 Overview I: Learning Outcomes (1)[1]

- Explain the objectives and functions of modern operating systems [Familiarity]
- Analyze the tradeoffs inherent in operating system design [Usage]
- Describe the functions of a contemporary operating system with respect to convenience, efficiency, and the ability to evolve. [Familiarity]
- Discuss networked, client-server, distributed operating systems and how they differ from single user operating systems. [Familiarity]
- Identify potential threats to operating systems and the security features design to guard against them. [Familiarity]
- Explain the concept of a logical layer. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 00 Overview I: Learning Outcomes (2)[1]

- Explain the benefits of building abstract layers in hierarchical fashion. [Familiarity]
- Describe the value of APIs and middleware. [Assessment]
- Describe how computing resources are used by application software and managed by system software. [Familiarity]
- Contrast kernel and user mode in an operating system. [Usage]
- Discuss the advantages and disadvantages of using interrupt processing. [Familiarity]
- Explain the use of a device list and driver I/O queue. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 01 Overview II: Topics[1]

- Types of virtualization (including Hardware/Software, OS, Server, Service, Network)
- Paging and virtual memory
- Virtual file systems
- Hypervisors
- Portable and cost of virtualization; emulation vs. isolation
- Cloud services: IAAS, PAAS and Platform APIs, SAAS
- Introduction to Scripting and REGEX.

[1] Source: ACM IEEE CS Curricula 2013

Week 01 Overview II: Learning Outcomes[1]

- Explain the concept of virtual memory and how it is realized in hardware and software. [Familiarity]
- Discuss hypervisors and the need for them in conjunction with different types of hypervisors. [Usage]
- Differentiate emulation and isolation. [Familiarity]
- Evaluate virtualization trade-offs. [Assessment]
- Discuss the importance of elasticity and resource management in cloud computing. [Familiarity]
- Explain the advantages and disadvantages of using virtualized infrastructure. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 02 Security & Protection: Topics[1]

- Overview of system security
- Policy/mechanism separation
- Security methods and devices
- Protection, access control, and authentication
- Backups

[1] Source: ACM IEEE CS Curricula 2013

Week 02 Security & Protection: Learning Outcomes[1]

- Articulate the need for protection and security in an OS (cross-reference IAS/Security Architecture and Systems Administration/Investigating Operating Systems Security for various systems). [Assessment]
- Summarize the features and limitations of an operating system used to provide protection and security [Familiarity]
- Explain the mechanisms available in an OS to control access to resources [Familiarity]
- Carry out simple system administration tasks according to a security policy, for example creating accounts, setting permissions, applying patches, and arranging for regular backups [Usage]

[1] Source: ACM IEEE CS Curricula 2013

Week 03 File System & FUSE: Topics[1]

- Files: data, metadata, operations, organization, buffering, sequential, nonsequential
- Directories: contents and structure
- File systems: partitioning, mount/unmount, virtual file systems
- Standard implementation techniques
- Memory-mapped files
- Special-purpose file systems
- Naming, searching, access, backups
- Journaling and log-structured file systems

[1] Source: ACM IEEE CS Curricula 2013

Week 03 File System & FUSE: Learning Outcomes[1]

- Describe the choices to be made in designing file systems. [Familiarity]
- Compare and contrast different approaches to file organization, recognizing the strengths and weaknesses of each. [Usage]
- Summarize how hardware developments have led to changes in the priorities for the design and the management of file systems. [Familiarity]
- Summarize the use of journaling and how log-structured file systems enhance fault tolerance. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 04 Addressing: Topics[1]

- Bits, bytes, and words
- Numeric data representation and number bases
- Representation of records and arrays

[1] Source: ACM IEEE CS Curricula 2013

Week 04 Addressing: Learning Outcomes[1]

- Explain why everything is data, including instructions, in computers. [Familiarity]
- Explain the reasons for using alternative formats to represent numerical data. [Familiarity]
- Describe the internal representation of non-numeric data, such as characters, strings, records, and arrays. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 05 Virtual Memory: Topics[1]

- Review of physical memory and memory management hardware
- Virtual Memory
- Caching
- Memory Allocation
- Memory Performance
- Working sets and thrashing

[1] Source: ACM IEEE CS Curricula 2013

Week 05 Virtual Memory: Learning Outcomes[1]

- Explain memory hierarchy and cost-performance trade-offs. [Familiarity]
- Summarize the principles of virtual memory as applied to caching and paging. [Familiarity]
- Describe the reason for and use of cache memory (performance and proximity, different dimension of how caches complicate isolation and VM abstraction). [Familiarity]
- Defend the different ways of allocating memory to tasks, citing the relative merits of each. [Assessment]
- Evaluate the trade-offs in terms of memory size (main memory, cache memory, auxiliary memory) and processor speed. [Assessment]
- Discuss the concept of thrashing, both in terms of the reasons it occurs and the techniques used to recognize and manage the problem. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 06 Concurrency: Topics[1]

- States and state diagrams
- Structures (ready list, process control blocks, and so forth)
- Dispatching and context switching
- The role of interrupts
- Managing atomic access to OS objects
- Implementing synchronization primitives
- Multiprocessor issues (spin-locks, reentrancy)

[1] Source: ACM IEEE CS Curricula 2013

Week 06 Concurrency: Learning Outcomes (1)[1]

- Describe the need for concurrency within the framework of an operating system. [Familiarity]
- Demonstrate the potential run-time problems arising from the concurrent operation of many separate tasks. [Usage]
- Summarize the range of mechanisms that can be employed at the operating system level to realize concurrent systems and describe the benefits of each. [Familiarity]
- Explain the different states that a task may pass through and the data structures needed to support the management of many tasks. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 06 Concurrency: Learning Outcomes (2)[1]

- Summarize techniques for achieving synchronization in an operating system (e.g., describe how to implement a semaphore using OS primitives). [Familiarity]
- Describe reasons for using interrupts, dispatching, and context switching to support concurrency in an operating system. [Familiarity]
- Create state and transition diagrams for simple problem domains. [Usage]

[1] Source: ACM IEEE CS Curricula 2013

Week 07 Synchronization & Deadlock: Topics[1]

- Shared Memory and Critical Section
- Consistency, and its role in programming language guarantees for data-race-free programs
- Message passing: PtPo vs Multicast, Blocking vs non-blocking, buffering.

[1] Source: ACM IEEE CS Curricula 2013

Week 07 Synchronization & Deadlock: Learning Outcomes[1]

- Use mutual exclusion to avoid a given race condition. [Usage]
- Give an example of an ordering of accesses among concurrent activities (e.g., program with a data race) that is not sequentially consistent. [Familiarity]
- Use semaphores to block threads [Usage]

[1] Source: ACM IEEE CS Curricula 2013

Week 08 Scheduling: Topics[1]

- Preemptive and non-preemptive scheduling
- Schedulers and policies
- Processes and threads
- Deadlines and real-time issues

[1] Source: ACM IEEE CS Curricula 2013

Week 08 Scheduling: Learning Outcomes[1]

- Compare and contrast the common algorithms used for both preemptive and non-preemptive scheduling of tasks in operating systems, such as priority, performance comparison, and fair-share schemes. [Usage]
- Describe relationships between scheduling algorithms and application domains. [Familiarity]
- Discuss the types of processor scheduling such as short-term, medium-term, long-term, and I/O. [Familiarity]
- Describe the difference between processes and threads. [Usage]
- Compare and contrast static and dynamic approaches to real-time scheduling. [Usage]
- Discuss the need for preemption and deadline scheduling. [Familiarity]
- Identify ways that the logic embodied in scheduling algorithms are applicable to other domains, such as disk I/O, network scheduling, project scheduling, and problems beyond computing. [Usage]

[1] Source: ACM IEEE CS Curricula 2013

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

Week 10 I/O & Programming: Topics[1]

- Characteristics of serial and parallel devices
- Abstracting device differences
- Buffering strategies
- Direct memory access
- Recovery from failures
- I/O Programming
- Network Programming

[1] Source: ACM IEEE CS Curricula 2013

Week 10 I/O & Programming: Learning Outcomes[1]

- Explain the key difference between serial and parallel devices and identify the conditions in which each is appropriate. [Familiarity]
- Identify the relationship between the physical hardware and the virtual devices maintained by the operating system. [Usage]
- Explain buffering and describe strategies for implementing it. [Familiarity]
- Differentiate the mechanisms used in interfacing a range of devices (including hand-held devices, networks, multimedia) to a computer and explain the implications of these for the design of an operating system. [Usage]
- Describe the advantages and disadvantages of direct memory access and discuss the circumstances in which its use is warranted. [Usage]
- Identify the requirements for failure recovery. [Familiarity]
- Implement a simple device driver for a range of possible devices. [Usage]
- I/O Programming [Usage]
- Network Programming [Usage]

The End

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