OPERATING SYSTEM

- Prof. Ishani Saha

Program: B Tech /MBA Tech (Computer Engineering and Artificial Intelligence), B Tech (AI and DS, AI and ML, Computer Science)				**Semester:** III/ V	
Course: Operating Systems				**Code**: 702CO1C002	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Internal Continuous Assessment (ICA) (marks -50)**	**Term End Examinations (TEE) (marks -100)**
2	2	0	3	Marks Scaled to 50	Marks Scaled to 50

Prerequisite: Programming, Computer Organization and Architecture, Data Structures and Algorithms

Course Objective

The objective of this course is to provide an introduction to functions of the computer operating system.

Course Outcomes

After completion of the course, students will be able to -

1. Describe the fundamental concepts of Operating system
2. Apply process management strategies
3. Simulate memory management, I/O management and file management strategies.

Detailed Syllabus

Unit	Description	Duration
1	**Operating System Overview:** Operating system objectives and functions, evolution of operating system, basic concepts: Processes, Files, System Calls, Layered structure v/s Monolithic structure of OS	**02**
2	**Process and Process Scheduling:** Process Description, Process Control Block (PCB), Threads, Thread management, comparison between Processes and threads, Process Scheduling: Types, study and comparison of various scheduling algorithms	**06**
3	**Process Concurrency:** Principles of Concurrency, Mutual Exclusion-Hardware Approaches, Semaphores, Monitors, Message Passing, Classical IPC Problems: Reader's / Writer's Problem, Producer / Consumer Problem	**06**
4	**Deadlock:** Principles of Deadlock, Deadlock Prevention, Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery, Dining Philosopher Problem	**05**

Signature
(Prepared by Concerned Faculty/HOD)

SVKM's NMIMS
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5	**Memory Management:** Memory Management Requirements, Memory Partitioning, Paging, Segmentation, Page Replacement algorithms	**06**
6	**I/O Management and Disk Scheduling:** I/O devices, organization of I/O function, I/O buffering, Disk structure, Disk scheduling algorithms	**03**
7	**File Management:** Overview, File Organization, File Directories, File Sharing	**02**
	Total	**30**

Text Books

1. Silberschatz A. Galvin, *Operating Systems Principles*, 10th Edition, P Wiley Publications, 2018.
2. William Stallings, *Operating Systems: Internals and Design Principles*, 8th Edition, Pearson Education, 2015.

Reference Books

1. Andrew S. Tannenbaum, *Modern Operating System*, 4th Edition, PHI, 2014.

Laboratory Work:

8 to 10 experiments (and a practicum where applicable) based on the syllabus.

Signature

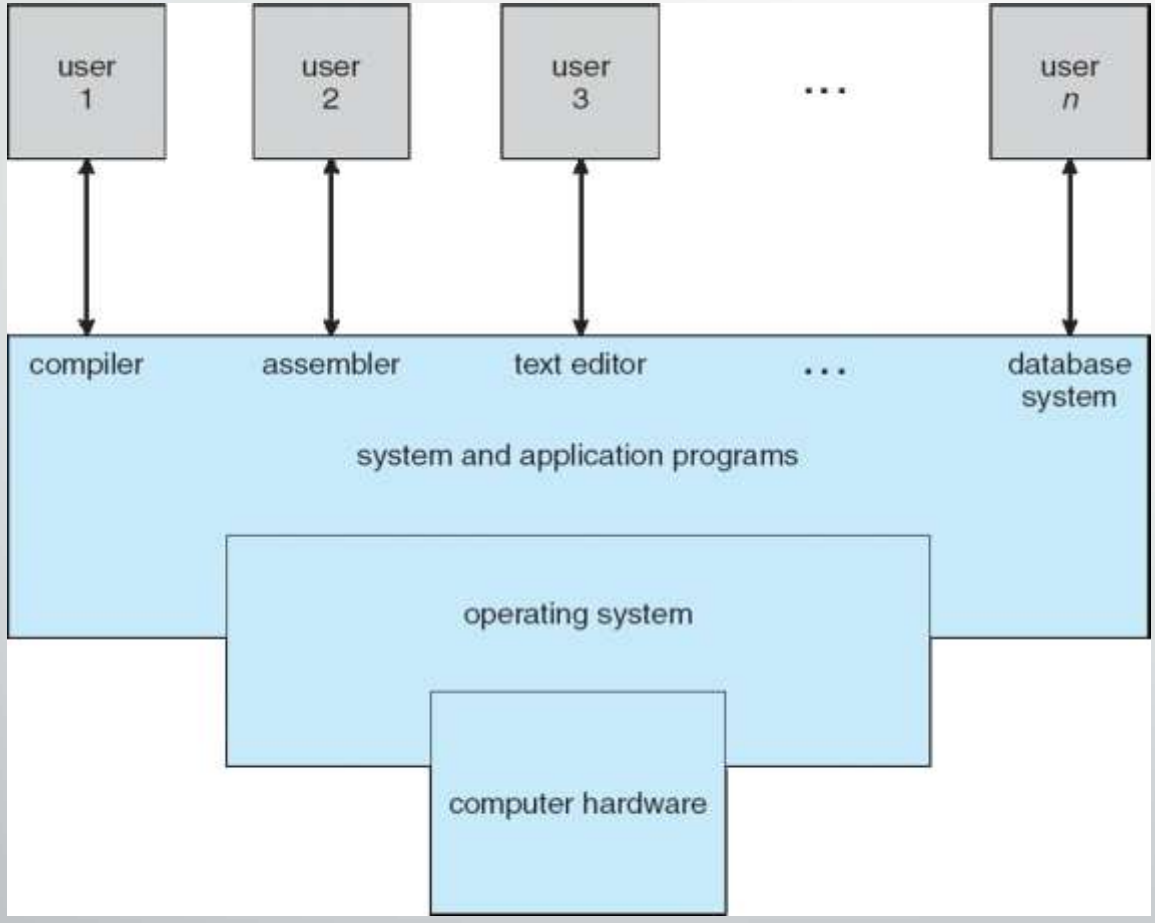
Chapter 1: Operating System Overview

What is an Operating System?

- A program that acts as an intermediary between a user of a computer and the computer hardware

- Operating system objectives:
  - Convenience
  - Efficiency
  - Ability to evolve

Four Components of a Computer System



Computer System Structure

- Computer system can be divided into four components:
  - Hardware – provides basic computing resources for the system
    - CPU, memory, I/O devices
  - Operating system
    - Controls and coordinates use of hardware among various applications and users
  - Application programs – define the ways in which the system resources are used to solve the computing problems of the users
    - Word processors, compilers, web browsers, database systems, video games
  - Users
    - People, machines, other computers

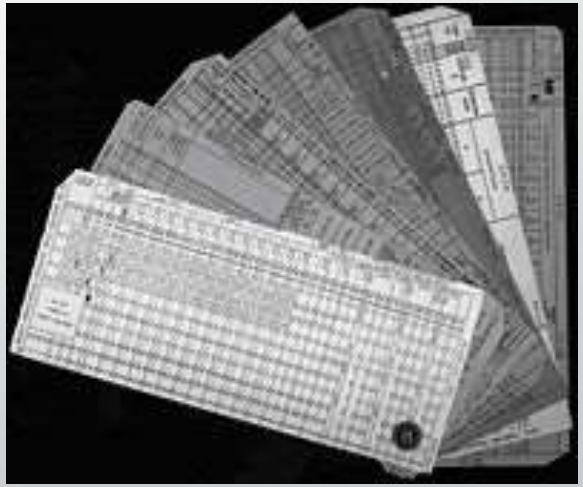
Operating System Evolution

- Batch Systems
- Multi-Programmed Batch Systems
- Time Sharing Systems

✓Simple Batch Systems

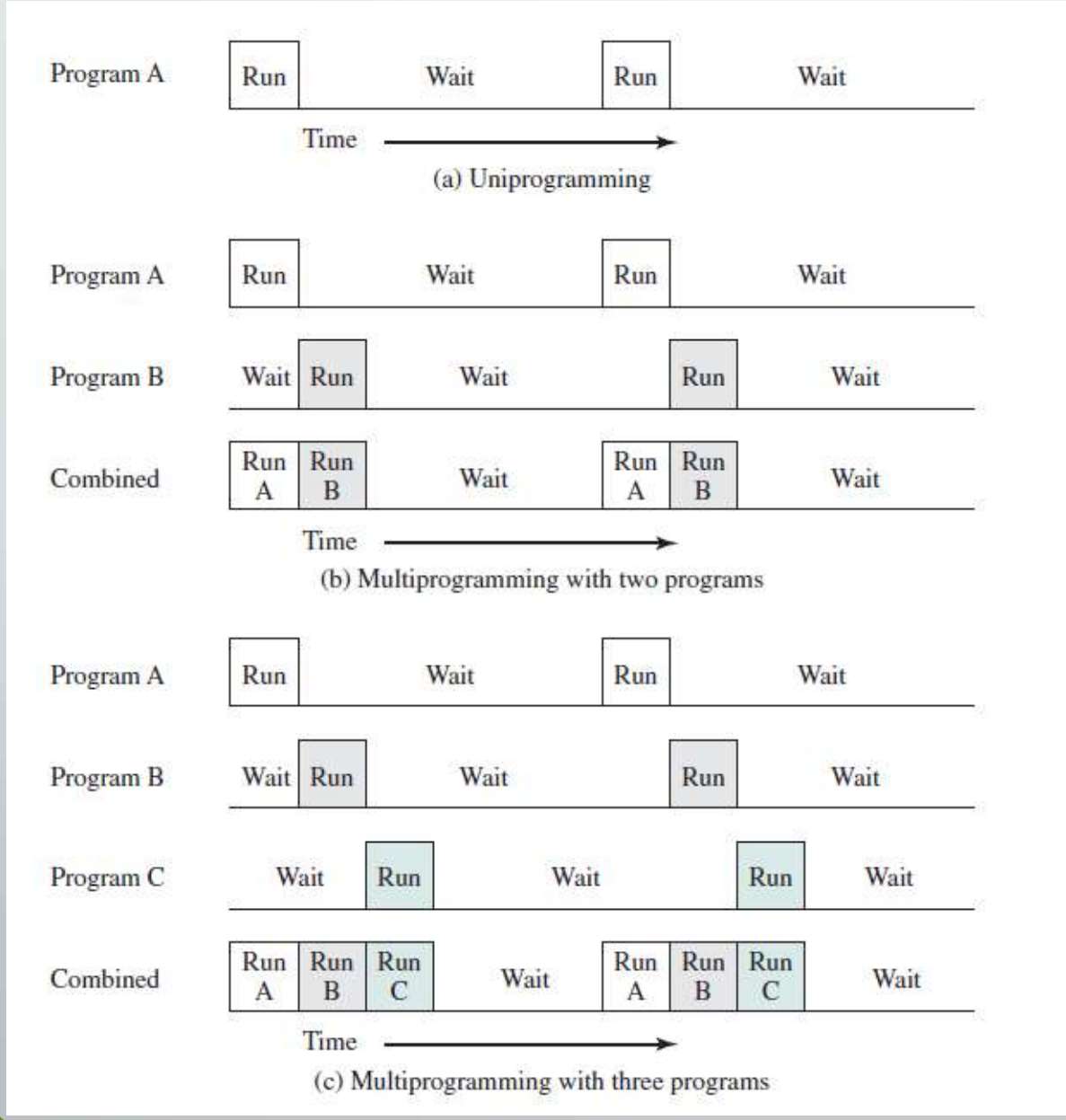
- A batch operating system is a type of operating system that processes a collection of similar jobs or tasks in a batch without user intervention
- In a batch processing environment, users submit their jobs to the operating system as a batch, and the system executes them one after another, without requiring constant user interaction.

Batch System



Punch Cards

✓ Multiprogrammed Systems



✓ Time Sharing Systems

- Processor time shared between multiple users
- OS interleaves execution of each user in time slices
- Compatible Time Sharing System (CTSS) – first time sharing OS
- CTSS is preemptive
- Interrupts were generated at every 0.2 seconds i.e. Time slice – 0.2 seconds
- At each clock interrupt, the OS regained control and could assign the processor to another user
- Thus, at regular time intervals, the current user would be preempted and another user loaded in.
- To preserve the old user program status for later resumption, the old user programs and data were written out to disk before the new user programs and data were read in.
- Subsequently, the old user program code and data were restored in main memory when that program was next given a turn.

Operating System Services

- User Interface
  - Command Line Interface
  - Graphical user interface
- Program Execution
- I/O Operations
- File System Manipulation
- Communication
- Error Detection

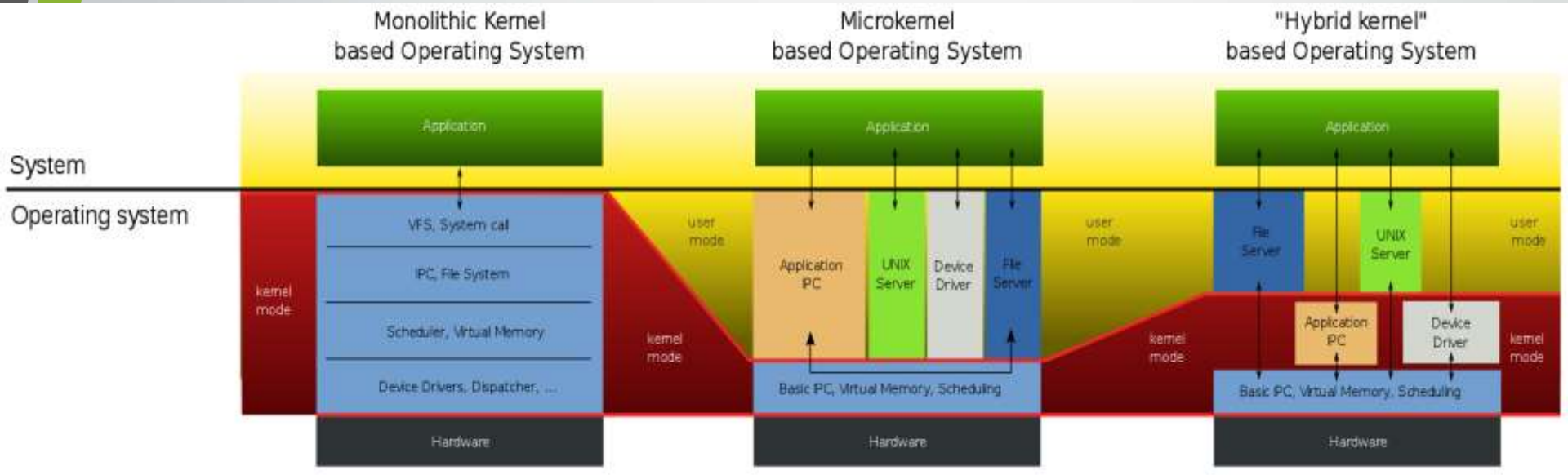
User View

- Resource Allocation
- Accounting
- Protection and Security

System View

Terminologies used in OS

1. Kernel
    1. Microkernel
    2. Monolithic
    3. Hybrid



Terminologies used in OS

- ✓ User Space and Kernel Space

RAM (Main memory) is divided into two distinct regions- the user space and the kernel space.

- User Space
- Kernel Space

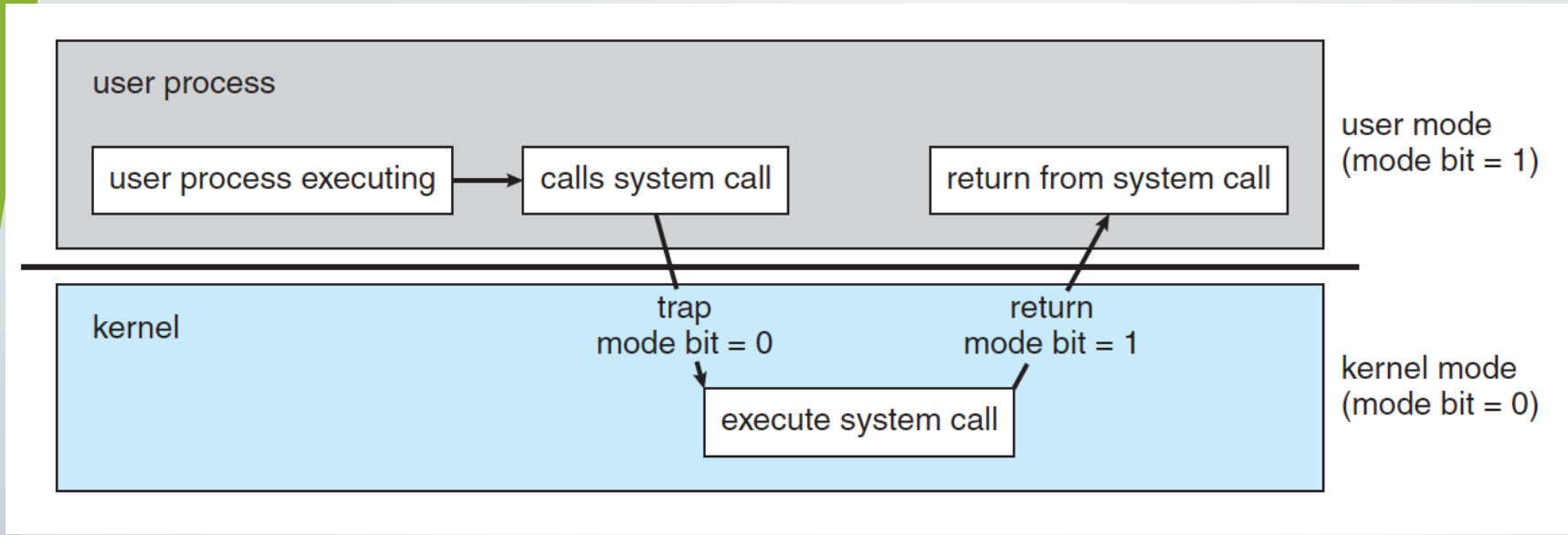
Terminologies used in OS

- ✓ User Mode and Kernel Mode
  - A processor in a computer running Windows has two different modes: user mode and kernel mode. The processor switches between the two modes depending on what type of code is running on the processor. Applications run in user mode, and core operating system components run in kernel mode.
  - In Kernel mode, the executing code has complete and unrestricted access to the underlying hardware. It can execute any CPU instruction and reference any memory address. Kernel mode is generally reserved for the lowest-level, most trusted functions of the operating system. Crashes in kernel mode are catastrophic; they will halt the entire PC.
  - In User mode, the executing code has no ability to directly access hardware or reference memory. Code running in user mode must delegate to system APIs to access hardware or memory. Due to the protection afforded by this sort of isolation, crashes in user mode are always recoverable. Most of the code running on your computer will execute in user mode.

Terminologies used in OS

2. System Calls

- Interface between OS and User programs (processes)
- Used to request service from the kernel
- At the very least, we need to separate modes of operation: user mode and kernel mode. At system boot time, the hardware starts in kernel mode. The operating system is then loaded and starts user applications in user mode.
- Whenever a trap or interrupt occurs, the hardware switches from user mode to kernel mode. Thus, whenever the operating system gains control of the computer, it is in kernel mode.
- Control is switched back to the operating system via an interrupt, a trap, or a system call. System calls provide the means for a user program to ask the operating system to perform tasks reserved for the operating system on the user program's behalf. When a system call is executed, it is treated by the hardware as a software interrupt. Control passes through the interrupt vector to a service routine in the operating system, and the mode bit is set to kernel mode.



- Types of System Calls
  1. Process Control
  2. File Management
  3. Device Management
  4. Communication
  5. Memory Management

Terminologies used in OS

3. Bootstrap Program

- **bootstrap program** is loaded at power-up or reboot
- Typically stored in ROM
- Initializes all aspects of system
- Locates and loads operating system kernel and starts execution

Terminologies used in OS

4. Interrupt

- Occurrence of an event is signalled by an interrupt from h/w or s/w
- h/w triggers interrupt by sending signal to CPU
- s/w triggers by executing system call or monitor call
- When CPU is interrupted it stops what it is doing and transfers the control to Interrupt Service Routine.
- ISR executes the interrupt and on completion returns the control back to CPU

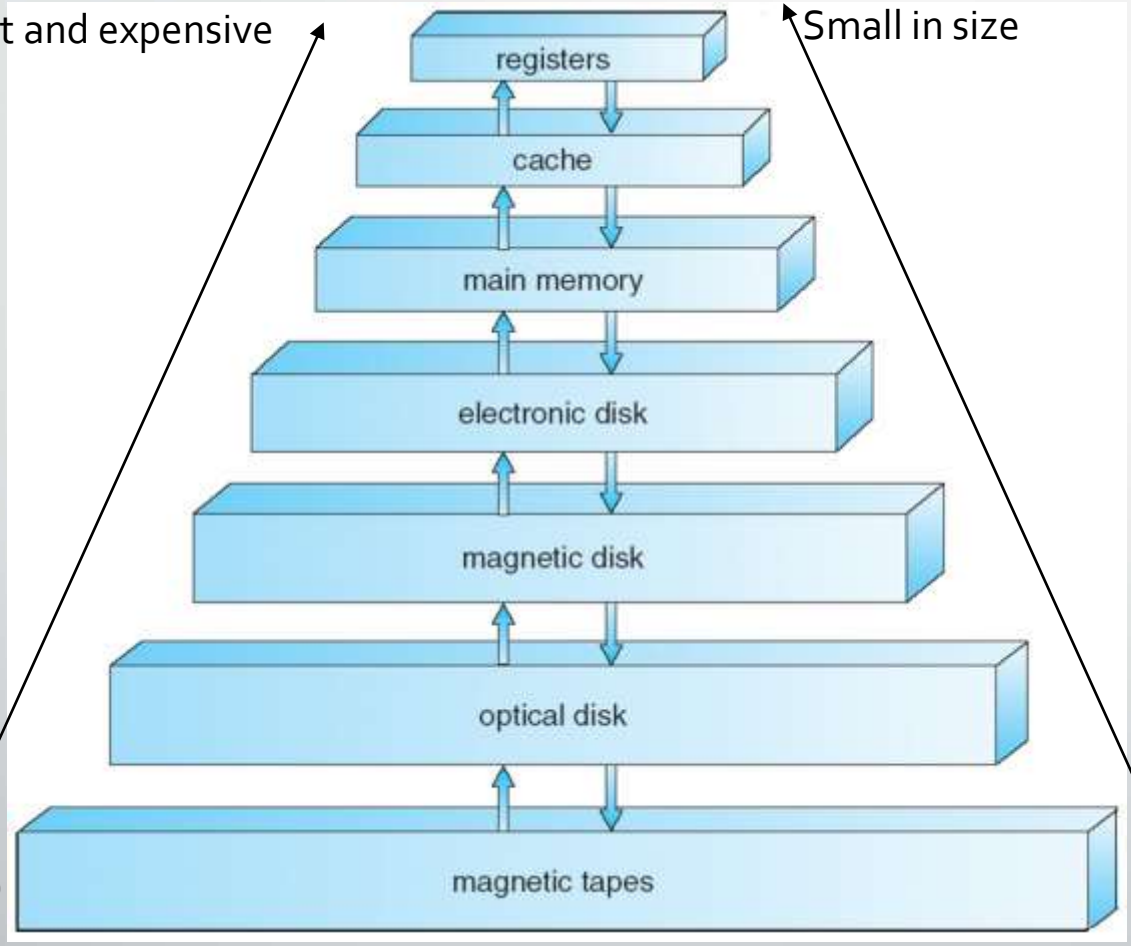
Terminologies used in OS

5. Storage Device Hierarchy

- Main memory – Programs should be in main memory or RAM to be executed
  - **Random access**
  - Typically **volatile**
  - Interacts through sequence of **load and store instructions**
  - **Too small**
- Secondary storage – extension of main memory that provides large **nonvolatile** storage capacity
- Magnetic disks – rigid metal or glass platters covered with magnetic recording material
  - Disk surface is logically divided into **tracks**, which are subdivided into **sectors**
  - The **disk controller** determines the logical interaction between the device and the computer

Fastest and expensive

Small in size



Speed and cost / bit increases

Access time and size increases

Slow and Cheap

Larger in size

Terminologies in OS

6. Computer-System Operation

- I/O devices and the CPU can execute concurrently
- Each device controller is in charge of a particular device type
- Each device controller has a local buffer
- CPU moves data from/to main memory to/from local buffers
- I/O is from the device to local buffer of controller
- Device controller informs CPU that it has finished its operation by causing an interrupt

Terminologies in OS

7. Computer-System Architecture

- Most systems use a single general-purpose processor
- Most systems have special-purpose processors as well
- Based on no. of general purpose processors used, computer systems are classified as
    1. Single Processor Systems
    2. Multi Processor Systems
    3. Clustered Systems

- **Singleprocessor systems** uses only 1 general purpose processor
  - Also have other special purpose processors.
  - OS can only communicate with general purpose processor and not with special purpose processors
- **Multiprocessor systems** have 2 or more general purpose processors.
  - Also known as parallel systems, tightly-coupled systems
  - Advantages include:
    1. Increased throughput
    2. Economy of scale
    3. Increased reliability – graceful degradation or fault tolerance
  - Two types:
    1. Asymmetric Multiprocessing – Master Slave
    2. Symmetric Multiprocessing - Peers

- **Clustered** systems – Multiple CPUs are gathered together.
  - 2 or more individual systems coupled together.
  - Shared storage and connected through LAN
  - Advantage – high availability
  - Two Types
    1. Asymmetric clustering
    2. Symmetric clustering

Terminologies in OS

8. Processes

- Key concept in all OS
- **Program in execution**
- Each process has – an address space, some memory locations, set of registers, stack pointer and other h/w registers
- Communication between related processes is called as **interprocess communication**

Terminologies in OS

9. Files

- Systems Calls are required to carry out file operations
- Directories group files together
- Each file can be specified by giving path name

Terminologies in OS

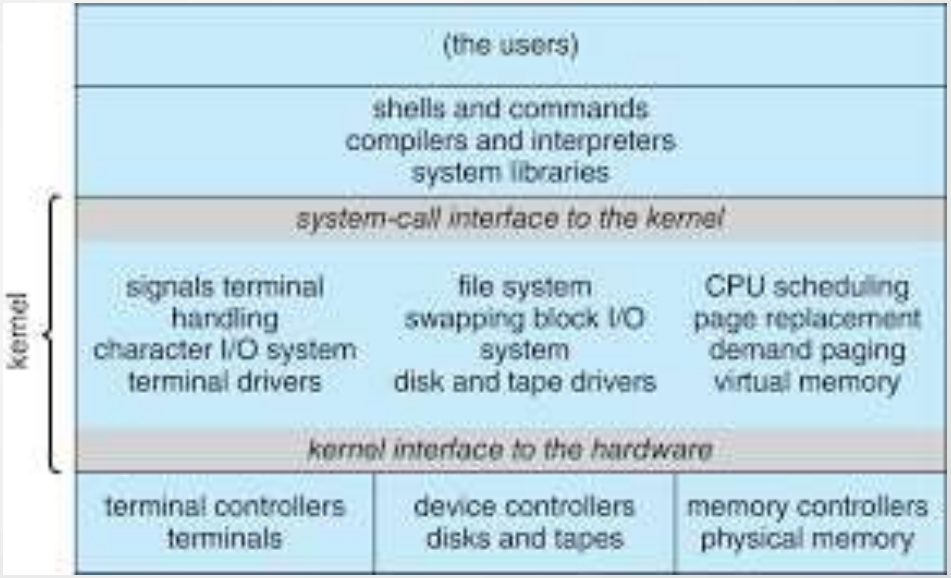
10. Shell

- Unix command interpreter
- Primary interface between user and OS
- Different types of shells - sh, csh, bash
- Terminal for i/p and o/p
- Begins with $ prompt to accept i/p from user

Operating System Structure

- Two Types of OS - Monolithic Systems and Layered Systems

1. Monolithic Systems

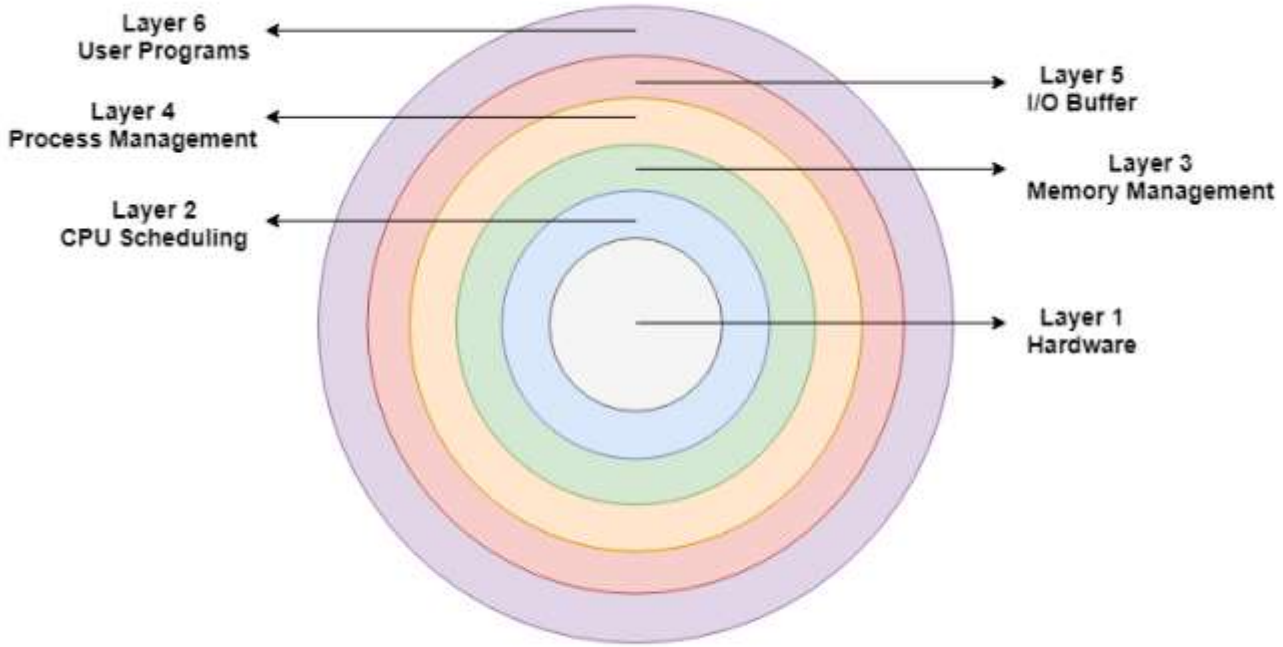


- Big Mess
- No structure
- Collection of procedures
- No information hiding
- Working :
  - User mode program calls a system service
  - Processor traps the call and switches the calling thread to kernel mode
  - On completion of system service, the thread switches back to user mode.
- One service procedure for each system call
- Utility procedures do things that are needed by several service procedures like fetching user data.

Operating System Structure

2. Layered Systems

- OS organized as hierarchy of layers
- First layered OS – 'THE' system
- There are 6 layers in Layered OS.



LAYERED OPERATING SYSTEM