Computer systems can be divided into four components: Hardware, Operating system, Application programs, Users

What is an Operating System (OS)? - Software that serves as the foundation for a computer system, providing essential functions and managing hardware and software resources. It acts as an intermediary between computer hardware and user applications.

The primary purpose of an operating system is to enable the execution of user programs while ensuring the efficient and secure allocation of system resources, such as memory, processing power, storage, and input/output devices.

Components of OS: 1. Kernel provides essential services and manages the system's resources; it acts as a **bridge** between the hardware and software layers of the system.

2. File System: The file system component manages the organization, storage, retrieval, and access of files on secondary storage devices such as hard drives or solid-state drives. It provides a hierarchical structure for organizing files and includes features like file permissions, directory management, and file metadata.

3. Device Drivers: Device drivers are software modules that facilitate communication between the operating system and hardware devices such as printers, keyboards, monitors, and network interfaces. They enable the operating system to control and interact with these devices.

4. User Interface: The user interface component provides a means for users to interact with the operating system. It can take the form of a command-line interface (CLI), where users enter text commands, or a graphical user interface (GUI), which presents a visual environment with icons, windows, and menus.

5. Networking: Networking components enable the operating system to support network connectivity and communication. They include protocols, drivers, and services that allow the system to connect to networks, access the internet, and transfer data.

6. Security: The security component ensures the protection of the system and its resources against unauthorized access, threats, and vulnerabilities. It includes features such as user authentication, access control, encryption, and firewall capabilities.

7. File and Data Management: This component includes utilities and services for managing files, directories, and data on the system. It handles tasks like file organization, recovery, and data integrity.

8. System Libraries: System libraries are collections of precompiled code that provide common functions and services to applications. They allow programmers to leverage existing functionality without having to develop everything from scratch

Key Features of an OS: Process management, Memory management, File system management, Device management, User interface

Big Pic of OS: User -> List of Services -> System Calls -> Kernel -> Interrupt -> CPU -> Processes -> Thread

Abstract view of Components of Computer: User -> Application programs -> OS -> Computer Hardware

Compiler Level Hierarchy (L0 –L6): Digital Logic Level, Control Level, Machine Level, System Software Level, Assembly Language Level, High-Level Language Level, The User Level

Why we require Interrupt? External devices are comparatively slower than CPU. So, if there is no interrupt CPU would waste a lot of time waiting for external devices to match their speed with that of CPU. This decreases the efficiency of CPU. Hence, interrupt is required to eliminate these limitations

Storage: Main memory – only large storage media that the CPU can access directly -> Random access, Typically volatile, Typically random-access memory in the form of Dynamic Random-access Memory

Secondary storage – extension of main memory that provides large nonvolatile storage capacity

Hard Disk Drives (HDD) – 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

Non-volatile memory (NVM) devices– faster than hard disks, nonvolatile -> Various technologies. -> Becoming more popular as capacity and performance increases, price drops

Storage systems organized in hierarchy: Speed, Cost, Volatility

Caching – copying information into faster storage system; main memory can be viewed as a cache for secondary storage

Device Driver for each device controller to manage I/O, -> Provides uniform interface between controller and

Multiprocessors: 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 2. Symmetric Multiprocessing

Clustered Systems: **1. Asymmetric clustering** has one machine in hot-standby mode **2. Symmetric clustering** has multiple nodes running applications, monitoring each other

User Mode: The system is in user mode when the operating system is running a user application such as handling a text editor.

The transition from user mode to kernel mode occurs when the application requests the help of the operating system or an interrupt or a system call occurs.

The mode bit is set to 1 in the user mode. It is changed from 1 to 0 when switching from user mode to kernel mode.

Kernel Mode: The system starts in kernel mode when it boots and after the operating system is loaded, it executes applications in user mode.

There are some privileged instructions that can only be executed in kernel mode.

These are interrupt instructions, input output management etc. If the privileged instructions are executed in user mode, it is illegal, and a trap is generated.

The mode bit is set to 0 in the kernel mode. It is changed from 0 to 1 when switching from kernel mode to user mode.

A **process** is a program in execution. It is a unit of work within the system. Program is a **passive entity**, process is an **active entity**

Process Management: 1. Single-threaded process has one program counter specifying location of next instruction to execute

- Process executes instructions sequentially, one at a time, until completion

2. Multi-threaded process has one program counter per thread

Typically system has many processes, some user, some operating system running concurrently on one or more CPUs

Memory Management: To execute a program, all (or part) of the instructions must be in memory.

Memory management determines what is in memory and when.

Optimizing CPU utilization and computer response to users.

File-system Management: OS provides a uniform, logical view of information storage. Files are usually organized into directories. Access control determines who can access what.

OS activities include Creating and deleting files and directories, Primitives to manipulate files and directories, Mapping files onto secondary storage, Backup files onto stable (non-volatile) storage media

Mass-Storage Management: Usually, disks are used to store data that does not fit in the main memory. Proper management is of central importance. The entire speed of computer operation hinges on disk subsystem and its algorithms. **OS activities include** Mounting and unmounting, Free-space management, Storage allocation, Disk scheduling, Partitioning, Protection

Caching: Important principle, performed at many levels in a computer. Information in use copied from slower to faster storage temporarily.

Faster storage (cache) checked first to determine if information is there.

Types of Cache Memory: L1 cache, or primary cache, is extremely fast but small, usually embedded in the processor. **L2 cache** is often more capacious than L1, may be embedded on the CPU or on a separate chip. **L3 cache** is specialized memory developed to improve the performance of L1 and L2.

- With multicore processors, each core can have dedicated L1 and L2 caches but share an L3 cache.

Transition from User to Kernel Mode: -> Timer to prevent infinite loop / process hogging resources. ->Timer is set to interrupt the computer after some time. -> Keep a counter that is decremented by the physical clock. -> Operating system set the counter (privileged instruction). -> When counter zero generate an interrupt ->Set up before scheduling process to regain control or terminate program that exceeds allotted time

IMPORTANT STATEMENTS:

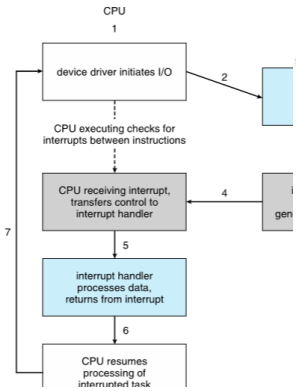
- CPU moves data from/to main memory to/from local buffers
- Each device controller has a local buffer
- After I/O starts, control returns to user program only upon I/O completion
- Cache memory is fast and expensive. Traditionally, it is categorized as "levels" that describe its closeness and accessibility to the microprocessor.
- The one program always running on the computer" is the kernel, part of the operating system

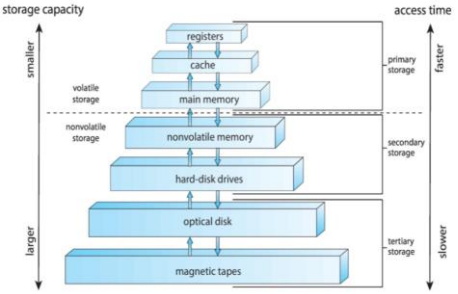
REVIEW PAPER#1

1. **OS** - Operating System is system software that manages all computer resources.
2. **HPC** - High Performance Computing
3. **Asymmetric Multiprocessing:** Each processor performs a specific/particular task.
4. **Symmetric Multiprocessing:** Each processor performs all tasks.
5. **RAM:** 1) RAM is Volatile memory, 2) Access speed of RAM is faster, 3) High Storage Capacity
   ROM: 1) ROM is Non-volatile memory, 2) Access speed of ROM is slower than the RAM, 3) Low Storage Capacity
6. **Interrupt** is a hardware mechanism in which the device notices that it requires its attention.
7. **Polling** is a protocol in which the CPU steadily checks whether the device needs attention.
8. **Interrupt Advantages:** 1) It Increases the efficiency of CPU 2) It decreases the waiting time of CPU
9. **Interrupt Disadvantage:** Workload on CPU increases due to handling of the interrupt.
10. Interrupt: 1) An interrupt is not a protocol; it's a hardware mechanism. 2) In interrupt, the device is serviced by interrupt handler. 3) An Interrupt can take place at any time.
    Polling: 1) Polling isn't a hardware mechanism, it's a protocol. 2) In polling, the device is serviced by CPU. 3) Whereas CPU steadily polls the device at regular intervals.
11. **Big Pic of OS:** User -> List of Services -> System Calls -> Kernel -> Interrupt -> CPU -> Processes -> Thread
12. **components of the von Neumann** system:1) Memory, 2) Control Unit, 3) Arithmetic Logic Unit, 4) Processor, 5) Accumulator, 6) Input/Output Devices
13. **Computer architecture** is the logical design of a computer while **computer organizaion** is the physical structure of the system.
14. Two **Modes of OS:** 1) User Mode, 2) Kernel Mode
15. A **process** is a program in execution.

Abbreviations:

GUI - Graphical User Interface
CLI - Command line Interface
ISA - Instruction Set Architecture
HDD - Dynamic Random-access Memory
DRAM - Hard Disk Drives
NVM - Hard Disk Drives
SAN - Storage Area Network
HPC - High Performance Computing
DLM - distributed lock manager





Level	1	2	3	4	5
Name	registers	cache	main memory	solid-state disk	magnetic disk
Typical size	< 1 KB	< 16MB	< 64GB	< 1 TB	< 10 TB
Implementation technology	custom memory with multiple ports CMOS	on-chip or off-chip CMOS SRAM	CMOS SRAM	flash memory	magnetic disk
Access time (ns)	0.25-0.5	0.5-25	80-250	25,000-50,000	5,000,000
Bandwidth (MB/sec)	20,000-100,000	5,000-10,000	1,000-5,000	500	20-150
Managed by	compiler	hardware	operating system	operating system	operating system
Backed by	cache	main memory	disk	disk	disk or tape