# Operating Systems – 21CS44

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# Module 1 – Introduction to operating systems System structures

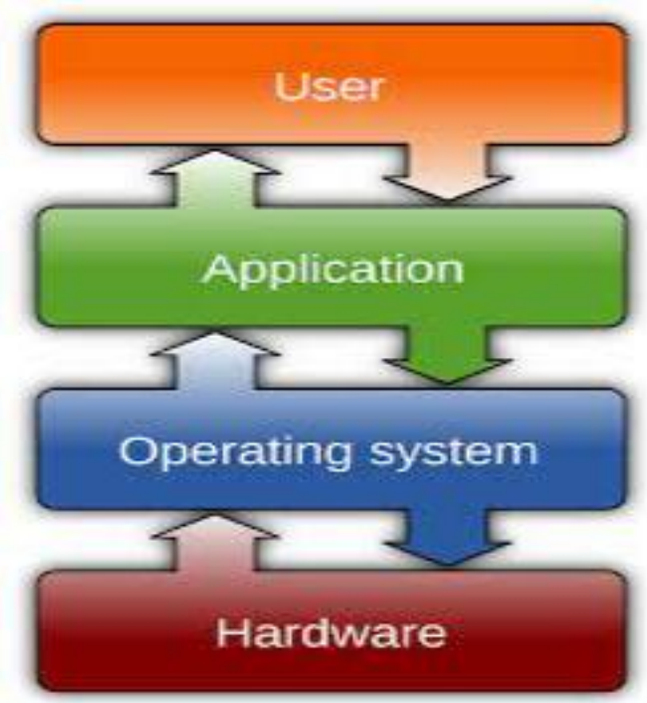
**Session 1**

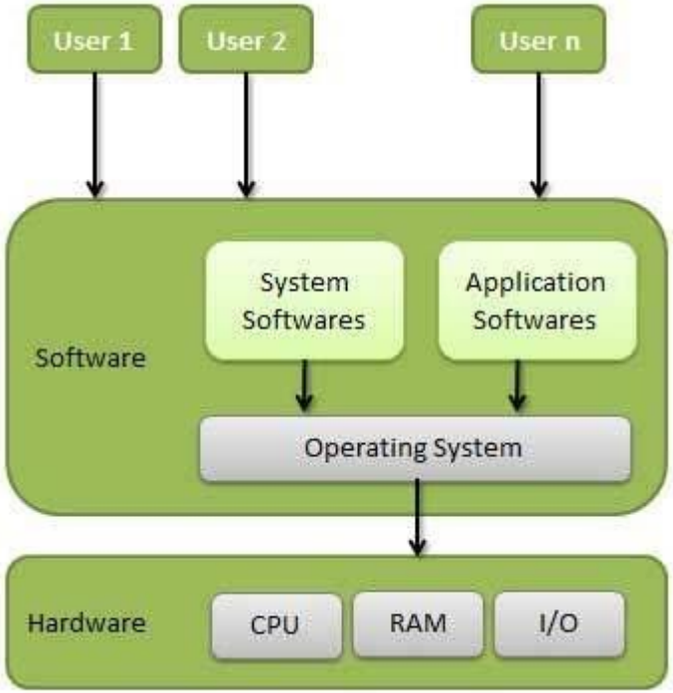
- Introduction
- What operating systems do
- Computer System organization

# Introduction

- An operating system is a program that acts as an interface between the user and the computer hardware and controls the execution of all kinds of programs.

- An operating system is a software which performs all the basic tasks like file management, memory management, process management, handling input and output, and controlling peripheral devices such as disk drives and printers.

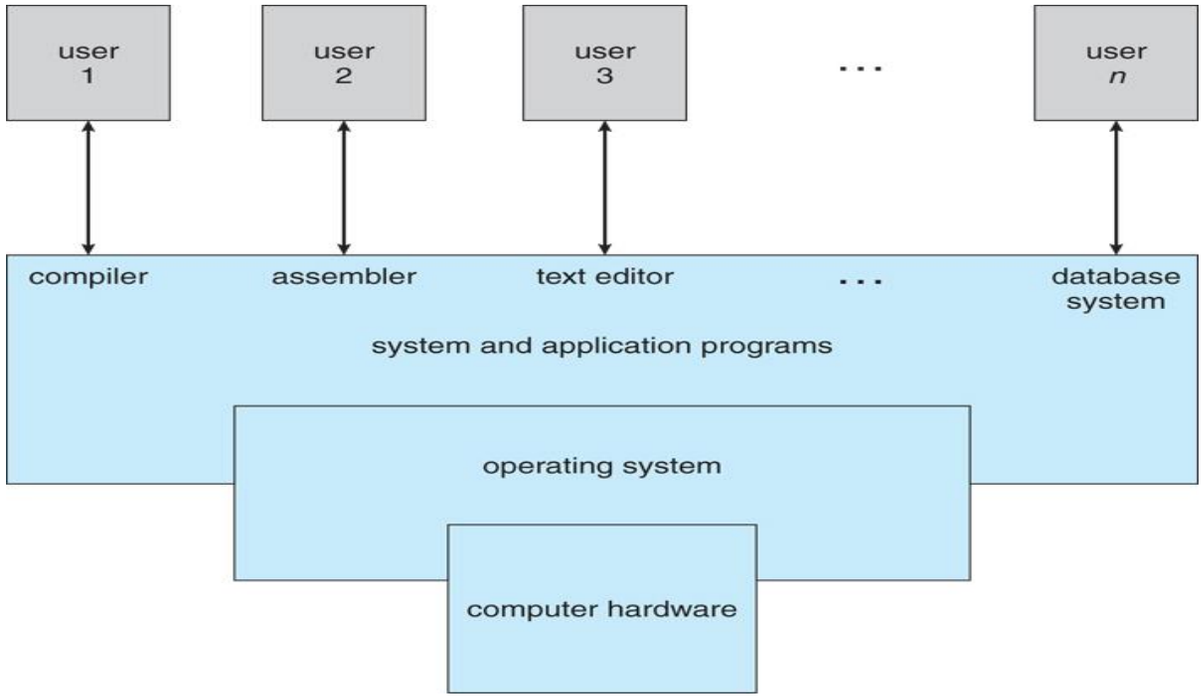


# What operating systems do

- Let us understand the operating system's role in overall computer system.

- Computer system can be divided into four components:
  1. Hardware
  2. Operating system
  3. Application programs
  4. Users



# What operating systems do

- **Hardware –** provides basic computing resources (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

# What operating systems do

- The computer system can also be viewed as consisting of hardware, software and data.
- The operating system provides the means for proper use of these resources in the operation of the computer systems.
- To understand the operating system's role better, let us consider the operating system from two viewpoints
  1. User
  2. System

# Operating system: System View

- OS is a **resource allocator**
  - Manages all resources
  - Decides between conflicting requests for efficient and fair resource use

- OS is a **control program**
  - Controls execution of programs to prevent errors and improper use of computer

# Operating system: User View

- Users want convenience, **ease of use –** some attention paid to **performance** and none paid to **resource utilization.**
- **Performance –** optimized for single user experience rather than the requirements of multiple users.
- Being considered as **mainframes** or **minicomputers –** resource utilization through shared resources.
- Users of dedicate systems such as **workstations** have dedicated resources but frequently use shared resources from **servers.** (connecting to networks).

# Operating system: User View

- **Handheld computers** such as mobiles and tablets are standalone units for individual users – OS is designed for individual usability and battery life.
- Some computers have little or no user interface, such as **embedded computers** in home devices and automobiles – OS is designed primarily to run without user intervention.
- With all these views – user and system, we can understand that the OS is designed for multiple purposes and cannot define the OS for a specific task – **No adequate definition for OS as the views are different.**

# Computer System Organization

- Computer-system operation
  - One or more CPUs, device controllers connect through common bus providing access to shared memory (as shown in fig. below)
  - Concurrent execution of CPUs and devices competing for memory cycles

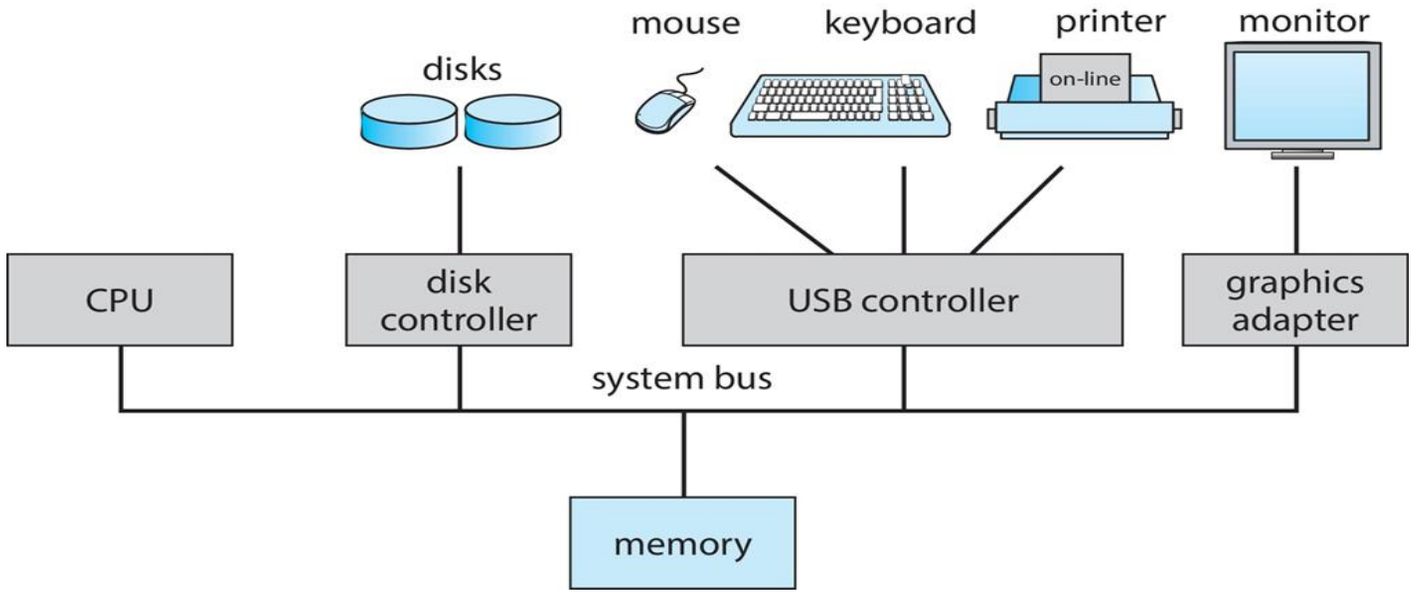



***Fig. A Modern Computer System***

# Computer System Organization

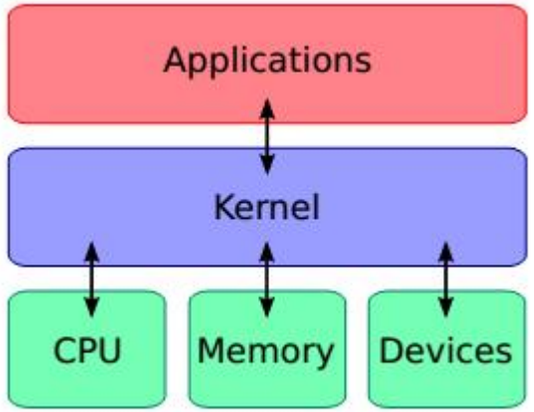
- When the system is switched ON, **Bootstrap** program is executed. It is the initial program to run in the system which is typically stored in ROM or EEPROM.
- It initializes all aspects of the system, from CPU registers to device controllers to memory contents. The bootstrap program must know how to load the operating system & how to start executing the system. To do this, the bootstrap program must locate the operating system **kernel** and load it into memory.
- The OS, then starts with the first process to be executed (i.e., **init** process) and then wait for the interrupt from the user.

# Computer System Organization

Switch on ⟶ 'Bootstrap' program

- Initializes the registers, memory and I/O devices
- Locates & loads kernel into memory
- Starts with 'init' process
- Waits for interrupt from user.

**Kernel** is central component of an operating system that manages operations of computer and hardware. It basically manages operations of memory and CPU time. It is core component of an operating system. Kernel acts as a bridge between applications and data processing performed at hardware level using inter-process communication and system calls.



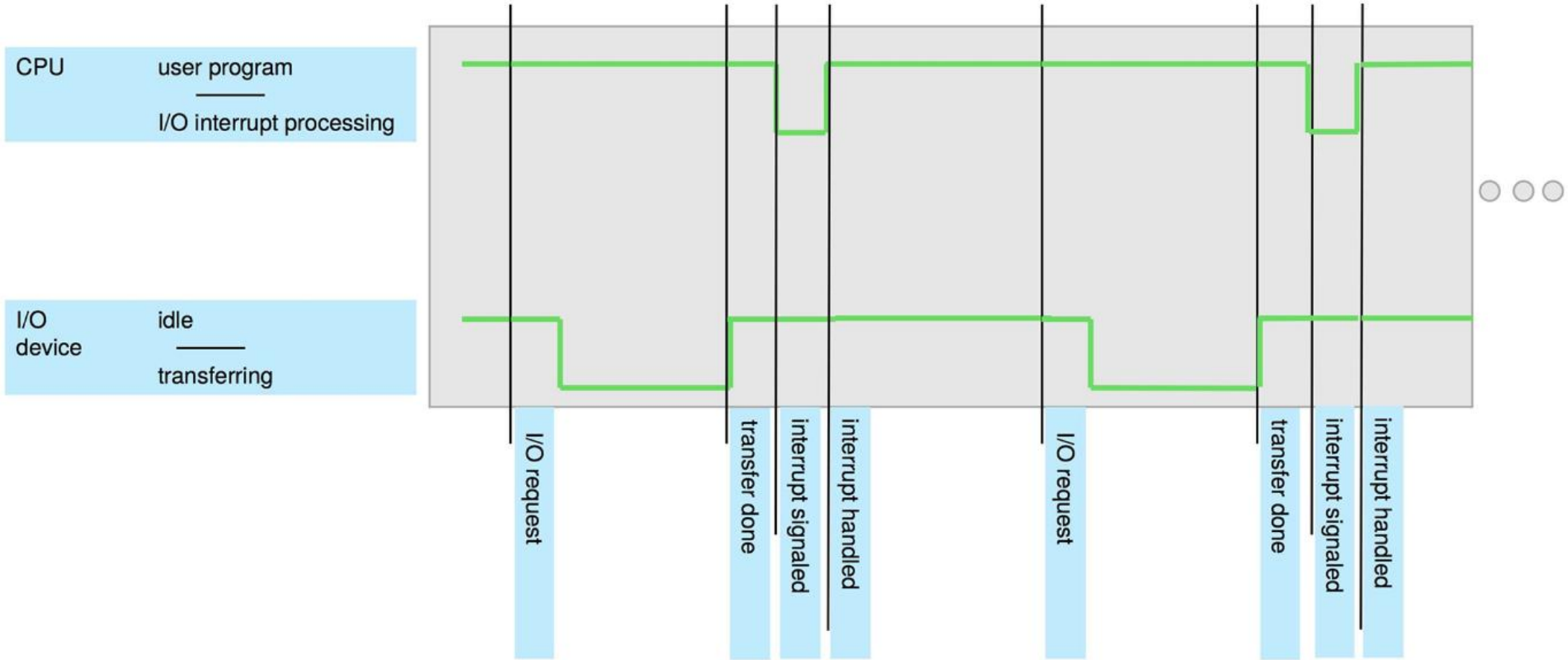
# Computer System Operation

- 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
- Each device controller type has an operating system device driver to manage it
- 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**

# Common Functions of Interrupts

- Interrupt transfers control to the interrupt service routine generally, through the **interrupt vector**, which contains the addresses of all the service routines
- Interrupt architecture must save the address of the interrupted instruction
- A **trap or exception** is a software-generated interrupt caused either by an error or a user request
- An operating system is **interrupt driven**

# Interrupt Timeline



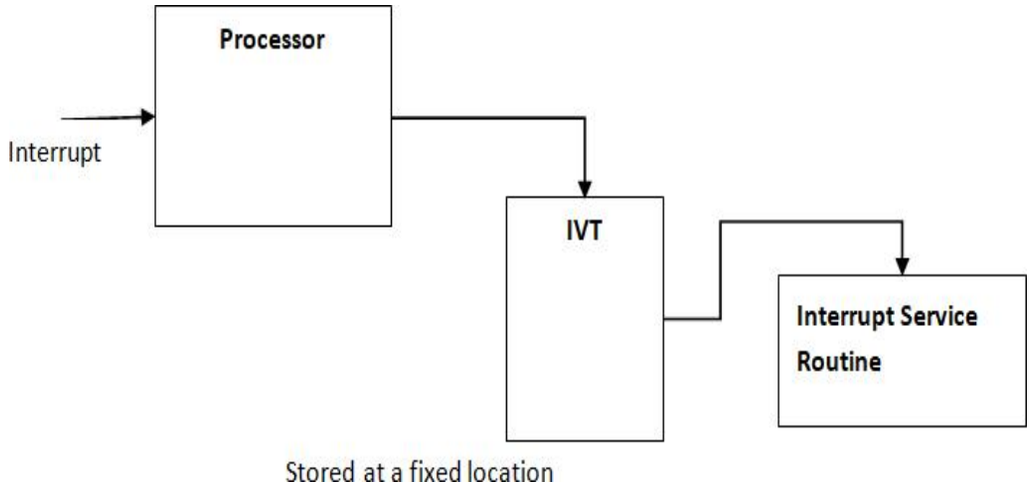
# Interrupt Handling

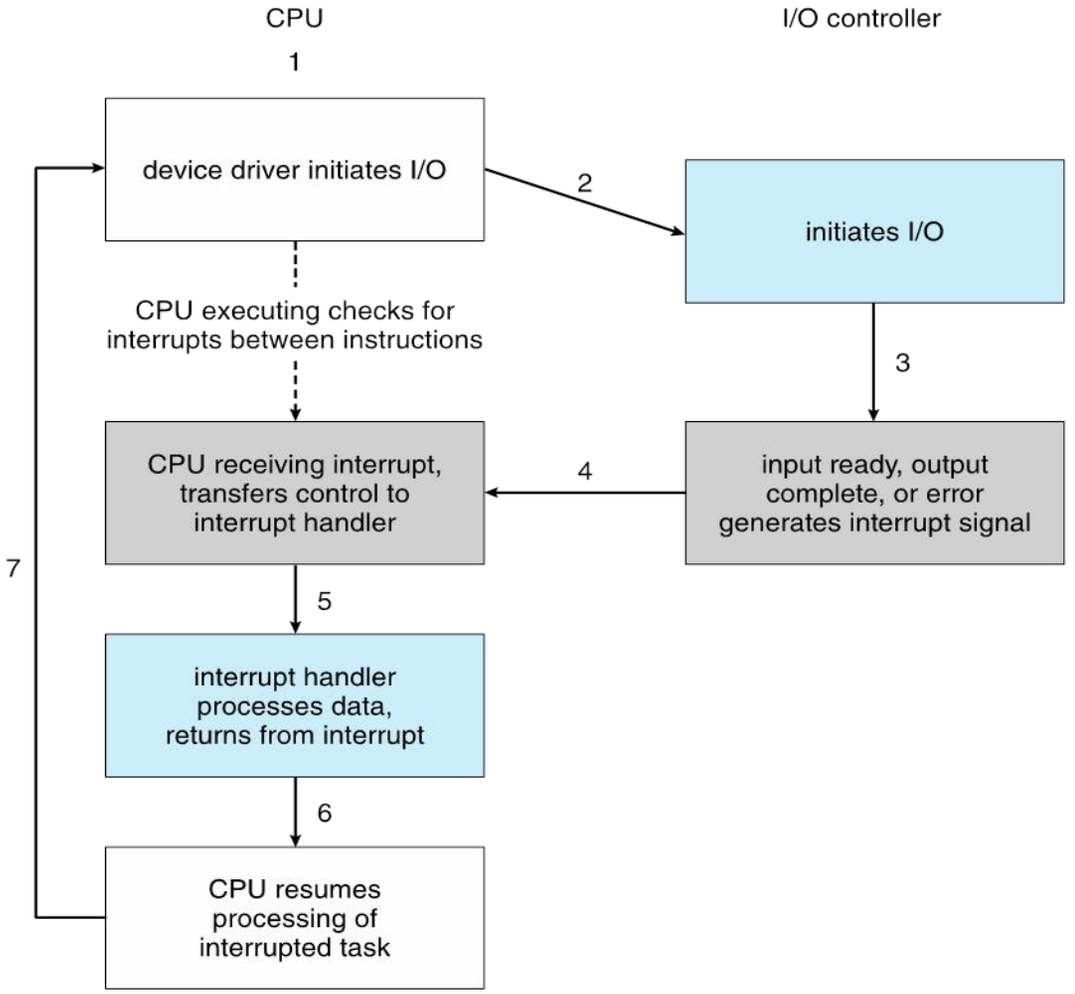
- The occurrence of an event is usually signaled by an interrupt. The interrupt can either be from the hardware or the software. Hardware may trigger an interrupt at any time by sending a signal to the CPU. Software triggers an interrupt by executing a special operation called a system call (also called a monitor call).

- When the CPU is interrupted, it stops what it is doing and immediately transfers execution to a fixed location. The fixed location (Interrupt Vector Table) contains the starting address where the service routine for the interrupt is located. After the execution of interrupt service routine, the CPU resumes the interrupted computation.

- Interrupts are an important part of computer architecture. Each computer design has its own interrupt mechanism, but several functions are common. The interrupt must transfer control to the appropriate interrupt service routine.

# Interrupt-driven I/O Cycle



# I/O Structure

- A large portion of operating system code is dedicated to managing I/O, both because of its importance to the reliability and performance of a system and because of the varying nature of the devices.

- Every device has a **device controller**, maintains some local buffer and a set of special- purpose registers. The device controller is responsible for moving the data between the peripheral devices. The operating systems have a **device driver** for each device controller.

- **Interrupt-driven I/O** is well suited for moving small amounts of data but can produce high overhead when used for bulk data movement such as disk I/O. To solve this problem, **direct memory access (DMA)** is used.

# I/O Structure

- After setting up buffers, pointers, and counters for the I/O device, the device controller transfers an entire block of data directly to or from its own buffer storage to memory, with no intervention by the CPU. Only one interrupt is generated per block, to tell the device driver that the operation has completed.

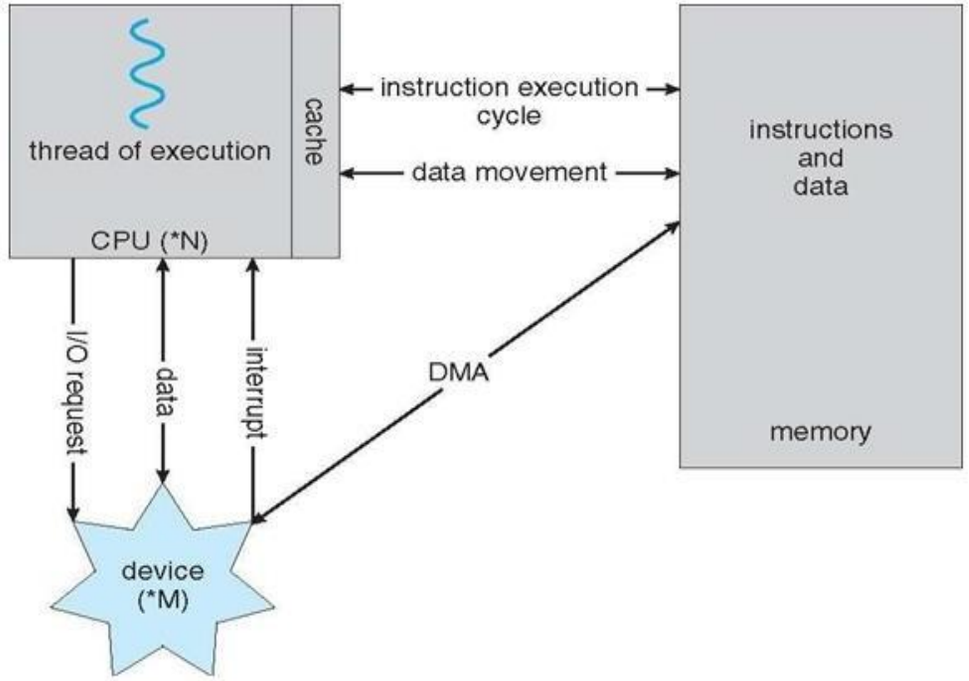



***Fig. How a Modern Computer System Works***

# Storage Structure

- Computer programs must be in **main memory (RAM)** to be executed.
- **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 (DRAM)

- All forms of memory provide an array of **memory words.** Each word has its own **address.** Interaction is achieved through a sequence of **load or store instructions** to specific memory addresses.

- A typical instruction-execution cycle, as executed on a system with a **Von Neumann architecture**, first fetches an instruction from memory and stores that instruction in the instruction register.

# Storage Structure

- The instruction is then decoded and may cause operands to be fetched from memory and stored in some internal register. After the instruction on the operands has been executed, the result may be stored back in memory.

- Ideally, we want the programs and data to reside in main memory permanently. This arrangement usually is not possible for the following two reasons:

  1. ***Main memory is usually too small to store all needed programs and data permanently.***
  2. ***Main memory is a volatile storage device that loses its contents when power is turned off.***

- Thus, most computer systems provide secondary storage as an extension of main memory. The main requirement for secondary storage is that it will be able to hold large quantities of data permanently.

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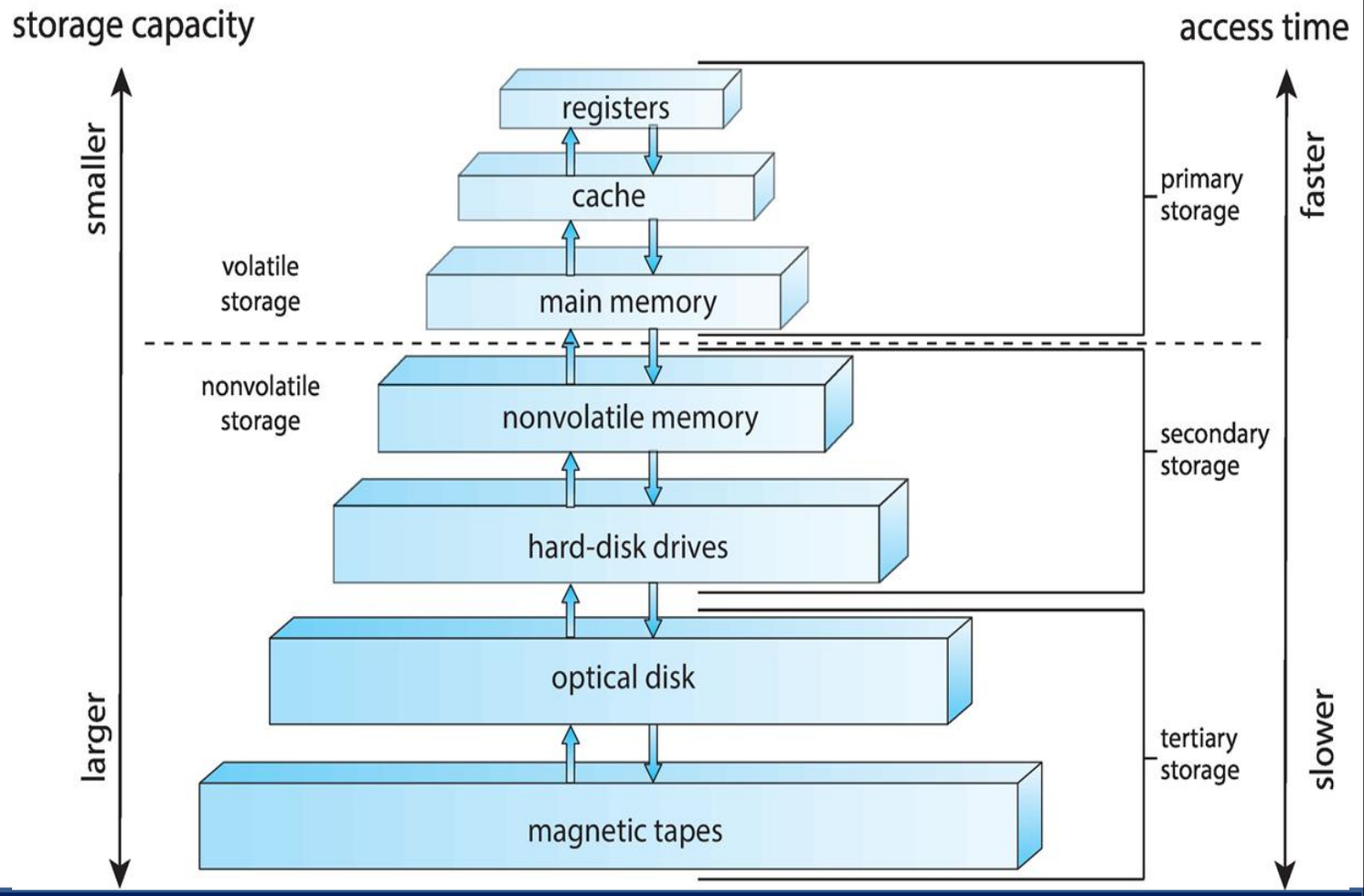
# Storage Structure & Hierarchy

- The most common secondary-storage device is a **magnetic disk**, which provides storage for both programs and data.
- The wide variety of storage systems in a computer system can be organized in a hierarchy as shown in the figure, according to speed, cost and capacity.



# Storage Hierarchy

- The higher levels are expensive, but they are fast.
- As we move down the hierarchy, the cost per bit generally decreases, whereas the access time and the capacity of storage generally increases.
- In addition to differing in speed and cost, the various storage systems are either volatile or nonvolatile.
- Volatile storage loses its contents when the power to the device is removed.
- In the absence of expensive battery and generator backup systems, data must be written to nonvolatile storage for safekeeping.

# Summary

- In today's session, you all have gone through the following topics
  - Introduction
  - What operating systems do
  - Computer System organization

# Discussion and Interaction

# Topics for Next Session

**Module 1: Introduction to operating systems, System structures**

**Session 2**

- Computer System structures
- Operating Systems Structure


Thank
you