OPERATING SYSTEMS

Introduction, Computer System Organization

Suresh Jamadagni
Department of Computer Science

OPERATING SYSTEMS

Slides Credits for all the PPTs of this course

- The slides/diagrams in this course are an **adaptation**, **combination**, and **enhancement** of material from the following resources and persons:

1. Slides of Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne - 9th edition 2013 and some slides from 10th edition 2018
2. Some conceptual text and diagram from Operating Systems - Internals and Design Principles, William Stallings, 9th edition 2018
3. Some presentation transcripts from A. Frank – P. Weisberg
4. Some conceptual text from Operating Systems: Three Easy Pieces, Remzi Arpaci-Dusseau, Andrea Arpaci Dusseau

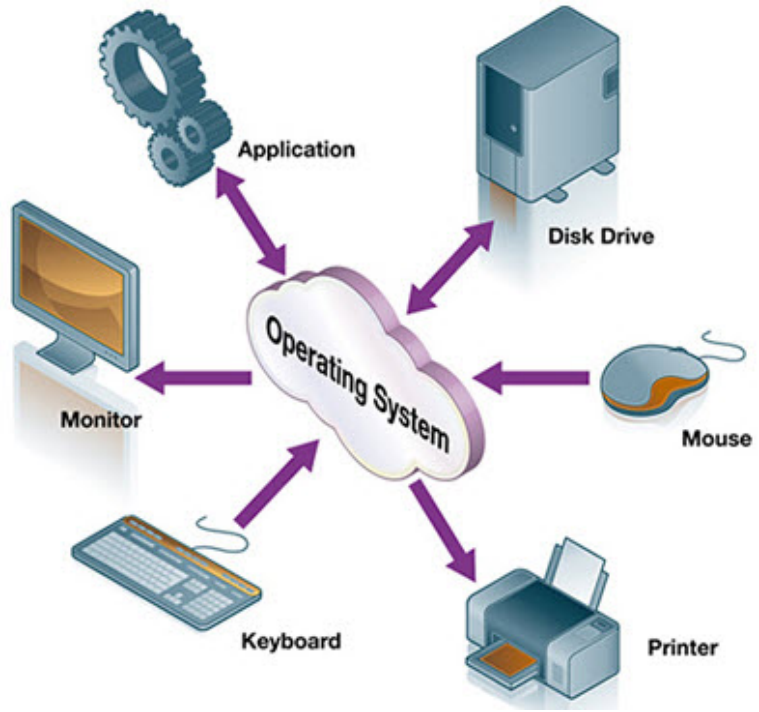
OPERATING SYSTEMS

Introduction, Computer System Organization

Suresh Jamadagni
Department of Computer Science

OPERATING SYSTEMS

Need for Operating System

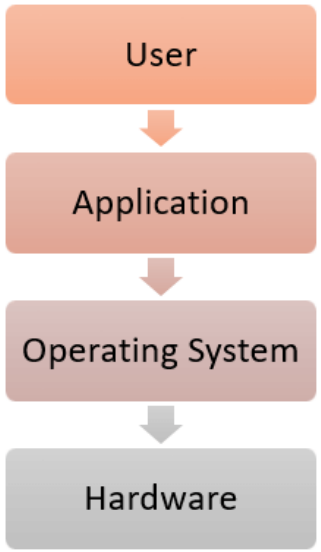


If OS is not developed then how will the application developers access the hardware?

OPERATING SYSTEMS

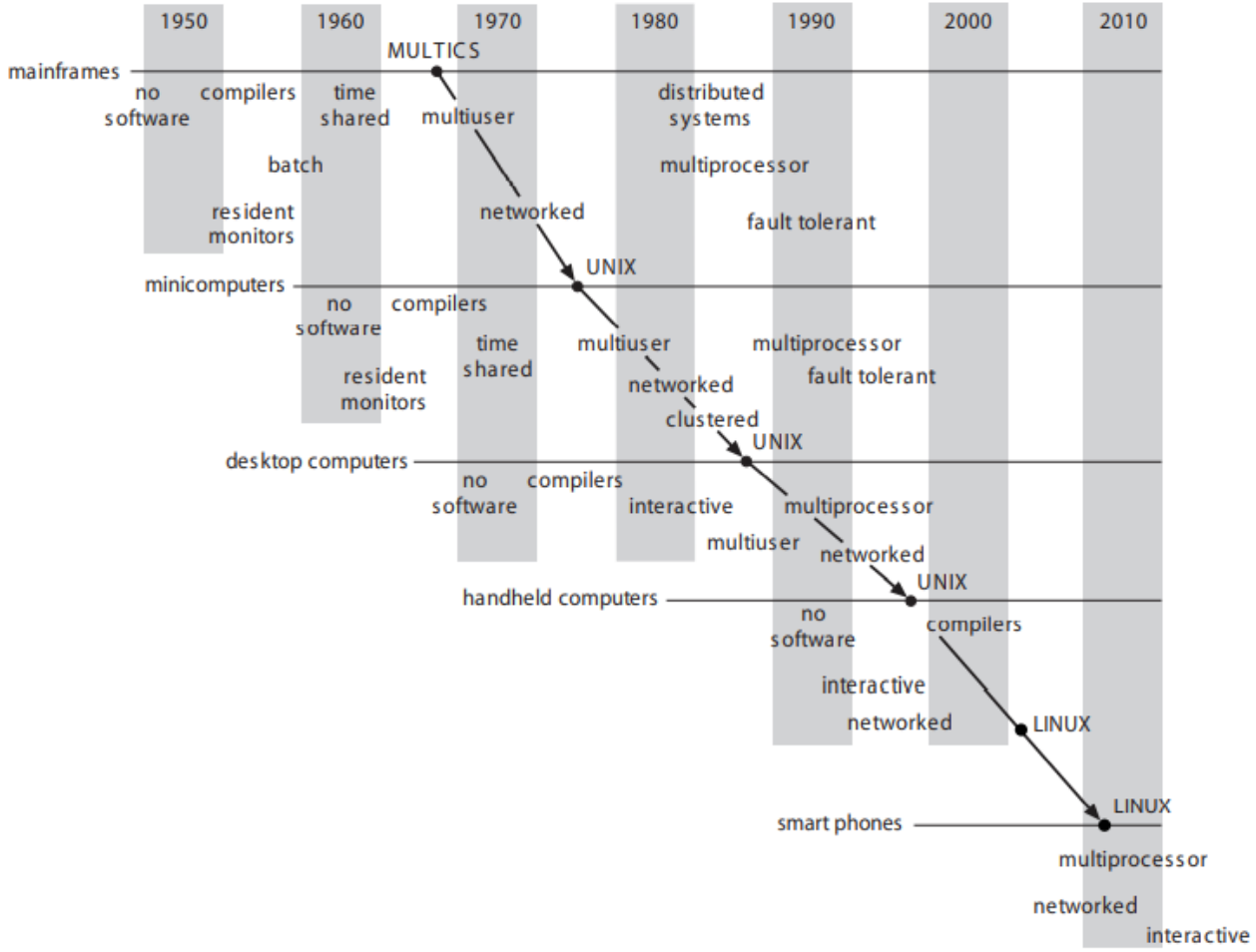
General Definition

- An Operating System is a program that acts as an intermediary between a user of a computer and the computer hardware
- It provides a user-friendly environment in which a user may easily develop and execute programs. Otherwise, hardware knowledge would be mandatory for computer programming.



OPERATING SYSTEMS

Genesis



Operating System Goals

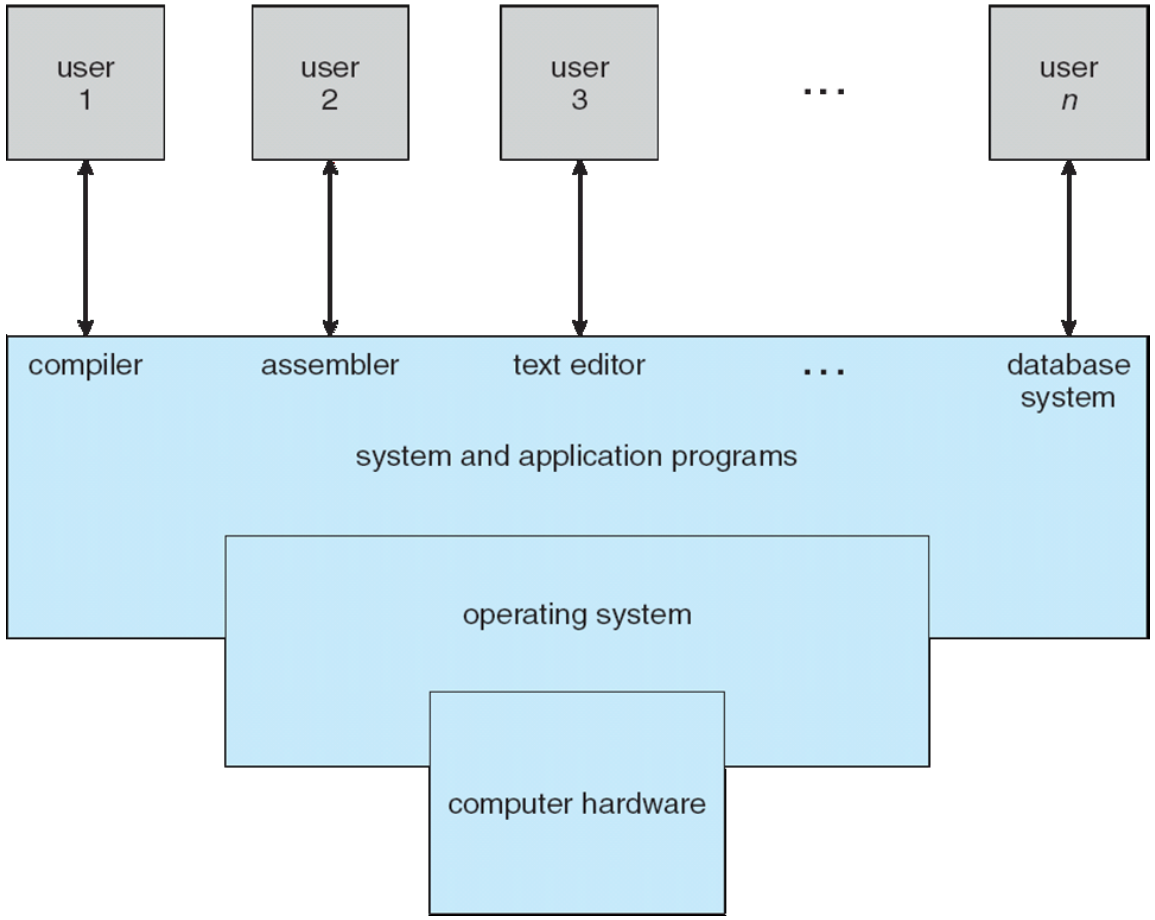
- Execute user programs and make solving user problems easier
- Make the computer system convenient to use
- Use the computer hardware in an efficient manner
- Manage resources such as
  - Memory
  - Processor(s)
  - I/O Devices

Why Study Operating Systems?

- Only a small percentage of computer practitioners will be involved in the creation or modification of an operating system.
- However almost all code runs on top of an operating system, and thus knowledge of how operating systems work is crucial to proper, efficient, effective, and secure programming.
- Understanding the fundamentals of operating systems

OPERATING SYSTEMS

Four Components of a Computer System (Abstract view)



OPERATING SYSTEMS

Computer System Structure

- 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

- Depends on the point of view user and system
- Users want convenience, **ease of use** and **good performance**
  - Don’t care about **resource utilization**
- But shared computer such as **mainframe** or **minicomputer** must keep all users happy.
  - Maximize resource utilization.
  - Available CPU time, memory, and I/O are used efficiently and that no individual user takes more than her fair share

What Operating Systems Do

- Users of dedicated systems such as workstations have dedicated resources but frequently use shared resources from servers.
  - resources like file, compute, and print servers are shared.
  - operating system is designed to compromise between individual usability and resource utilization
- Handheld computers are resource poor, optimized for usability and battery life.
- Some computers have little or no user interface, such as embedded computers in devices and automobiles

OPERATING SYSTEMS

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 the computer

OPERATING SYSTEMS

Defining Operating System

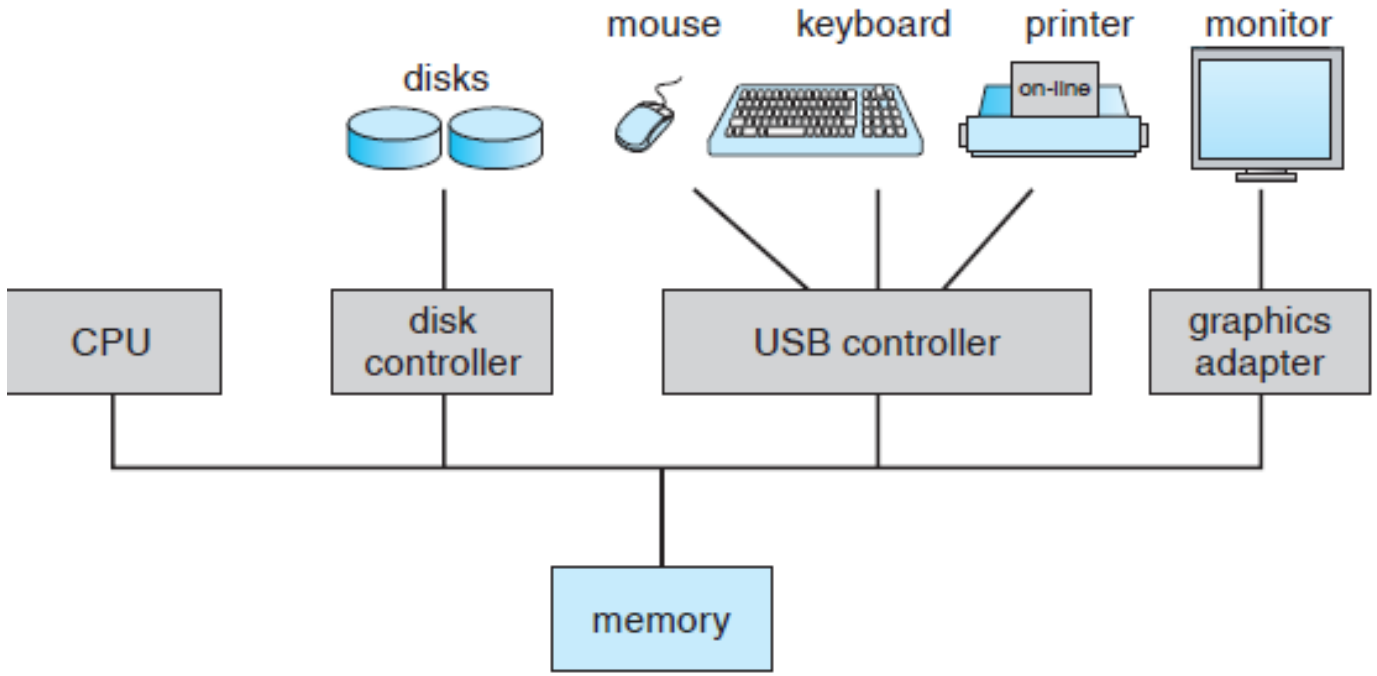
- The OS has many roles and functions
- The fundamental goal of computer systems is to execute user programs and to make solving user problems easier.
- The common functions of controlling and allocating resources are then brought together into one piece of software: the **operating system**
- “The one program running at all times on the computer” is the **kernel**.
- Everything else is either
  - a system program (ships with the operating system) , or
  - an application program.

Computer System Organization

- Computer-system consists of,
  - One or more CPUs, device controllers connect through common bus providing access to shared memory
  - The CPU and the device controllers can execute concurrently, competing for memory cycles.
    - memory controller is provided to synchronize access to the memory.

OPERATING SYSTEMS

Computer System Organization



A modern computer system

OPERATING SYSTEMS

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 has registers for action (like “read character from keyboard”) to take
- 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

OPERATING SYSTEMS

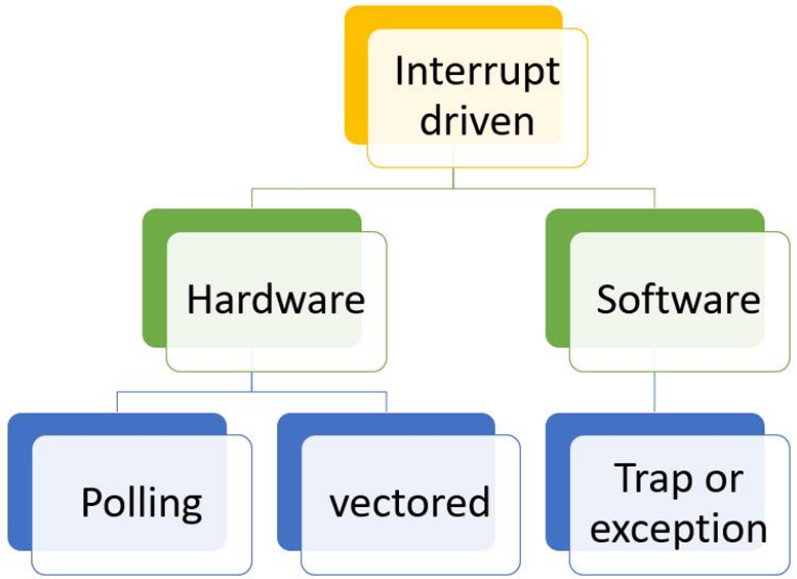
Computer System Organization

- When the system is booted, the first program that starts running is a Boostrap.
- It is stored in read-only memory (ROM) or electrically erasable programmable read-only memory (EEPROM).
- Bootstrap is known by the general term firmware, within the computer hardware.
- 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 and how to start executing that system.
- The bootstrap program must locate and load into memory the operating system kernel.
- The first program that is created is **init**, after the OS is booted. It waits for the occurrence of event.

OPERATING SYSTEMS

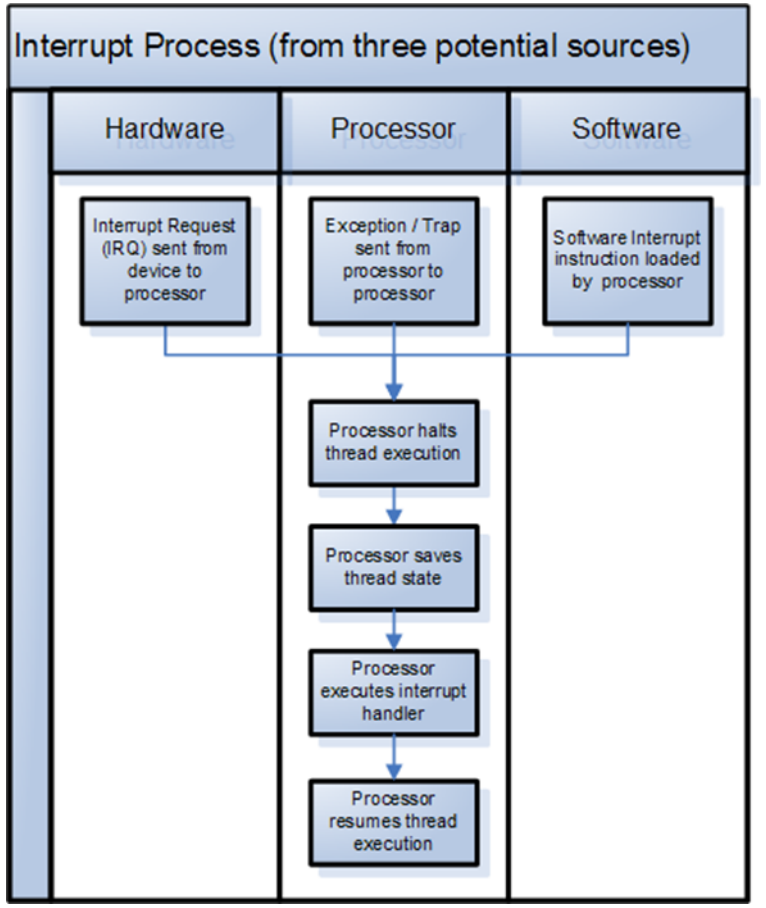
Common Functions of Interrupts

- An operating system is **interrupt driven**
- 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

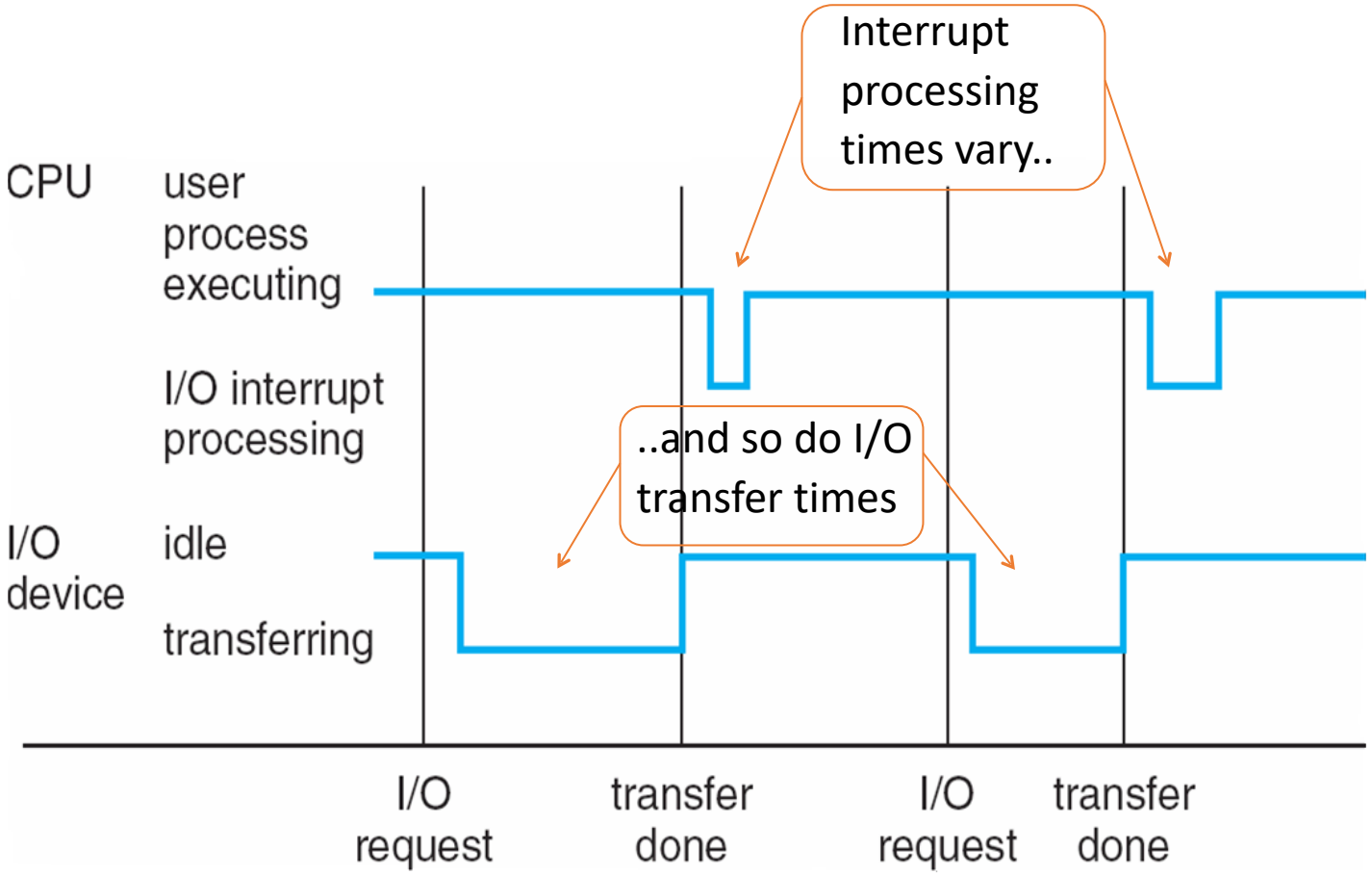


Interrupt Handling

- The operating system saves the state of the CPU by storing registers and the program counter
- Determines which type of interrupt has occurred:
  - polling
  - vectored interrupt system
- Separate segments of code determine what action should be taken for each type of interrupt



Interrupt Timeline for a single process doing output



OPERATING SYSTEMS

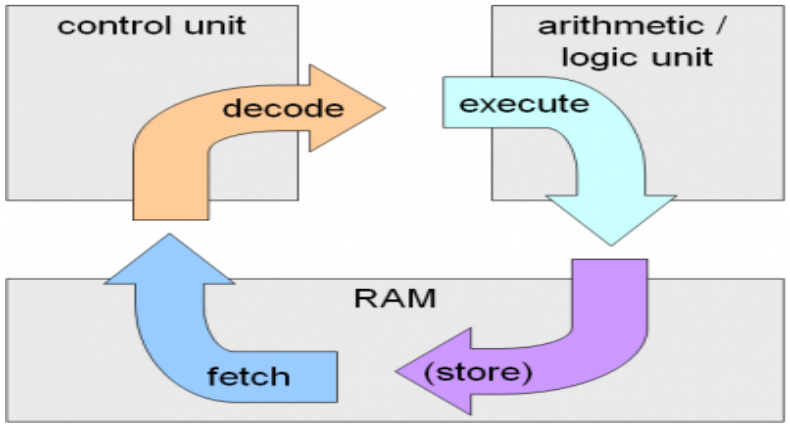
Storage Structure

- Main memory – only large storage media that the CPU can access directly (**Random access memory** and typically **volatile)**
  - Implemented with semiconductor technology called DRAM
- Computers use other forms of memory like ROM, EEPROM
- Smart phones have EEPROM to store factory installed programs.

OPERATING SYSTEMS

Program Execution Model

- Typical instruction execution



- The processor fetches instructions from memory, decodes and executes them.
- The Fetch, Decode and Execute cycles are repeated until the program terminates.
- This is called the Von Neumann model of computing.

Image source :https://computersciencewiki.org/index.php/The_machine_instruction_cycle

OPERATING SYSTEMS

Storage Structure

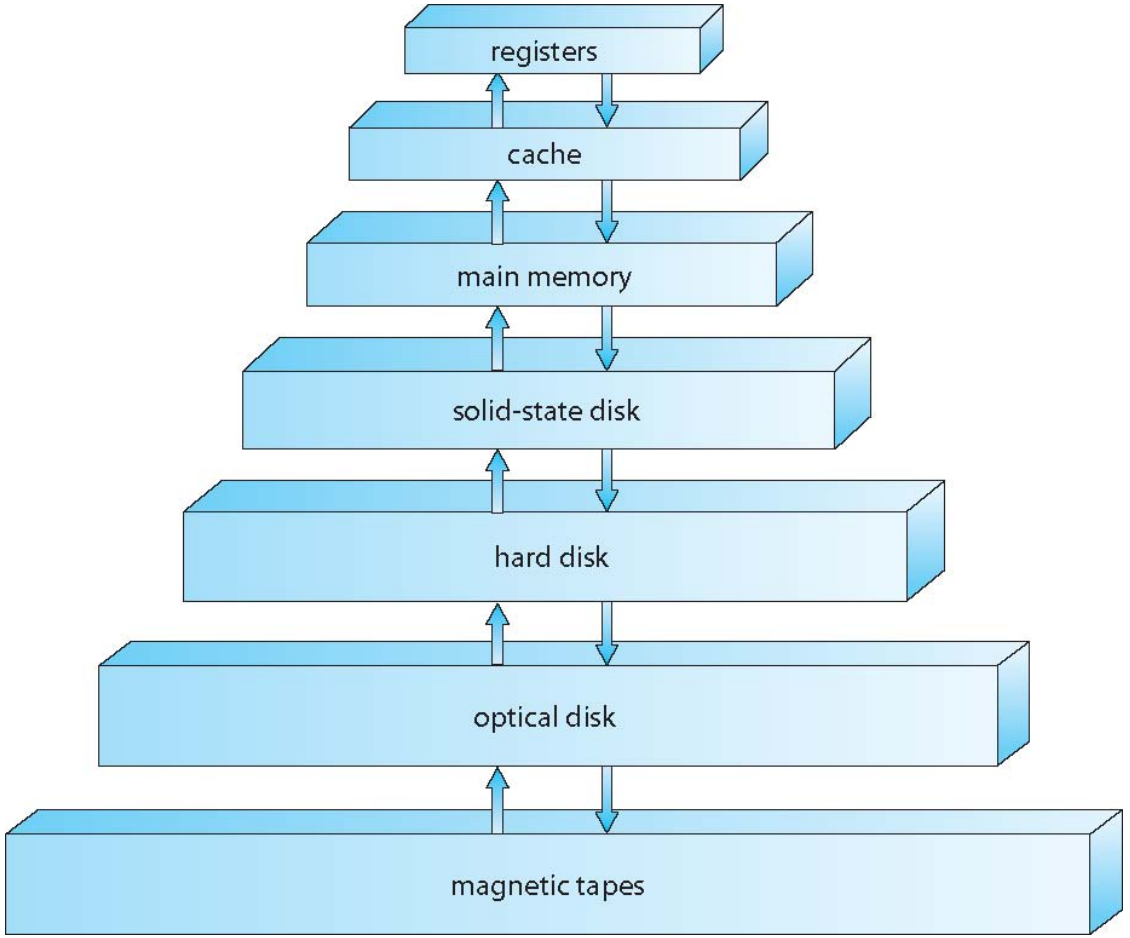
- Secondary storage – extension of main memory that provides large **nonvolatile** storage capacity
- Hard disks – rigid metal or glass platters covered with magnetic recording material
  - Disk surface is logically divided into **tracks**, which are subdivided into **sectors**
  - The **disk controller** determines the logical interaction between the device and the computer
- **Solid-state disks** – faster than hard disks, nonvolatile
  - Various technologies and becoming more popular
  - Flash memory used in camera's PDA's

Storage Hierarchy

- 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

OPERATING SYSTEMS

Storage-Device Hierarchy



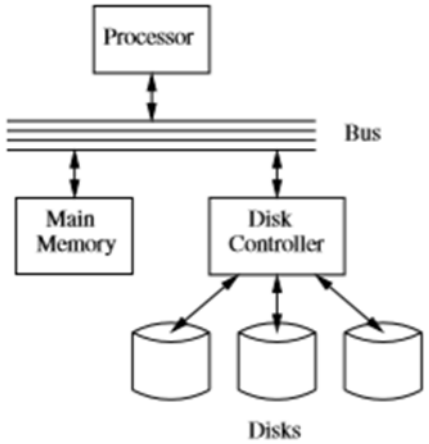
Caching

- Important principle, performed at many levels in a computer (in hardware, operating system, software)
- Information in use copied from slower to faster storage temporarily
- Faster storage (cache) checked first to determine if information is there
  - If it is, information used directly from the cache (fast)
  - If not, data copied to cache and used there
- Cache smaller than storage being cached
  - Cache management important design problem
  - Cache size and replacement policy

OPERATING SYSTEMS

I/O Structure

- Storage is a type of I/O device
- A large portion of operating-system code is dedicated to managing I/O
    - As reliability and performance of a system is the main concern.
- General-purpose computer system consists of CPUs and multiple device controllers that are connected through a common bus.
- Each device controller is in charge of a specific type of device.
- **Device Driver** for each device controller to manage I/O
    - Provides uniform interface between controller and kernel
- **Small Computer-Systems Interface (SCSI)** controller enables to connect more devices.



I/O Structure

- A device controller maintains some local buffer storage and a set of special-purpose registers.
- The device controller is responsible for moving the data between the peripheral devices.

OPERATING SYSTEMS

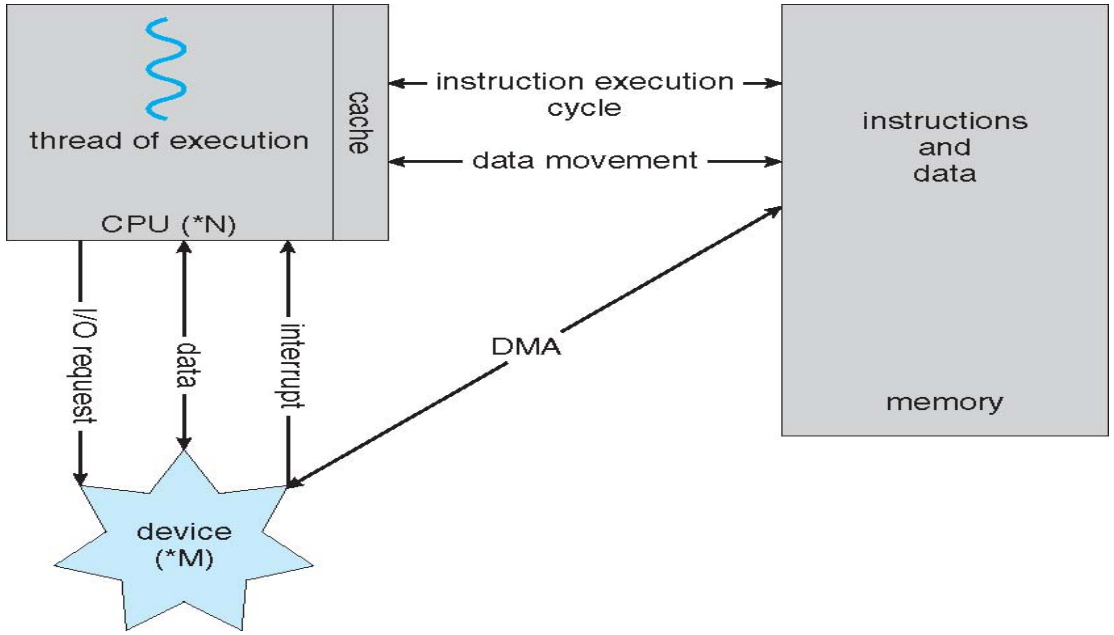
I/O Structure

- After I/O starts, control returns to user program only upon I/O completion
  - Wait instruction idles the CPU until the next interrupt
  - Wait loop (contention for memory access)
  - At most one I/O request is outstanding at a time, no simultaneous I/O processing
- After I/O starts, control returns to user program without waiting for I/O completion
  - **System call** – request to the OS to allow user to wait for I/O completion
  - **Device-status table** contains entry for each I/O device indicating its type, address, and state
  - OS indexes into I/O device table to determine device status and to modify table entry to include interrupt.

OPERATING SYSTEMS

Direct Memory Access Structure

- Used for high-speed I/O devices able to transmit information at close to memory speeds
- Device controller transfers blocks of data from buffer storage directly to main memory without CPU intervention
- Only one interrupt is generated per block, rather than the one interrupt per byte



THANK YOU

Suresh Jamadagni
Department of Computer Science Engineering

sureshjamadagni@pes.edu