Course Introduction: Operating Systems

Mainack Mondal and Saptarshi Ghosh

CS30002

Spring 2020-21

Today's class

- Resources and notes
- Introduction to operating systems

Instructors

- Mainack Mondal
  - Research interests: system security, large scale system measurement, privacy
  - Office: CSE 316
  - Will also be in your lab

Instructors

- Saptarshi Ghosh
  - Research interests: Social Networks, ML, NLP, IR
  - Office: CSE 207
  - Will also be in your lab

Teaching assistants

- Gunjan Balde (PhD)
- Anju Punuru (M.Tech.)
- Anmol Yadav (M.Tech.)
- Sankalp R (Dual)
- Manthan Parashar (Dual)
- Sai Saketh Aluru (Dual)
- Peruri Chandana (Dual)
- Ayan Zunaid (Dual)
- Abhishek Khari (M.Tech.)
- Shivam Kumar (M.Tech.)
- Madda Manjusha (M.Tech.)

Requirements

- Using computers and application software

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- How to write, compile and run C-programs

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- Using computers and application software
- How to write, compile and run C-programs
- Computer Organization and architecture (prerequisite)

Website / Books

- Website:
  - https://cse.iitkgp.ac.in/~mainack/courses/2020-spring/OS-course/index.html

- Textbooks / References:
  - Operating Systems Concepts, 9th ed. - A. Silverschatz, P.V. Galvin, and G. Gagne. Wiley
  - Some recent topics from research papers

Course logistics

- There will be three exams and some assignments
  - Dates will be announced later

Why should you attend class?

- Aside from the fact that slides are not complete and exam questions will come from class coverage?

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- Doubt clearing sessions

Last but not the least

- Ask questions in the class
  - You need to know how Operating Systems (OS) as computer scientist
  - It is best done via class - interaction

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- Do lab assignments & practice problems religiously
  - This is a systems course
  - There is no other way of learning how systems work than actually trying to build systems

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- Introduction to operating systems (OS)
  - What is an OS
  - What are the goals of an OS
  - Under the hood: the structure of OS
  - How does OS work?

What is an Operating System?

Let’s start with enumerating the actors

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- Users
    - might be one or multiple (using servers)

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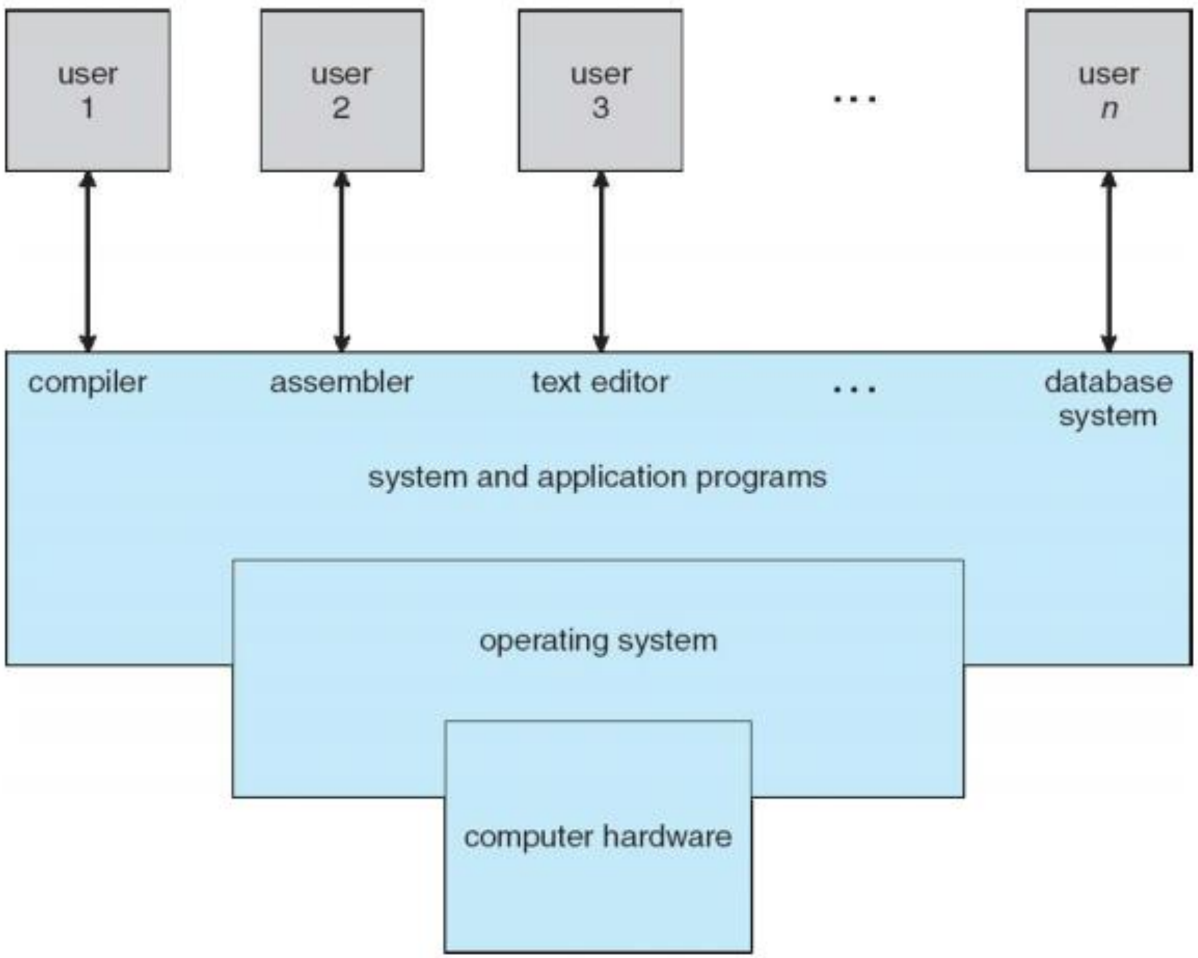
Operating system seats right in between applications and hardware

Putting it all together



Source: Silberschatz, Galvin and Gagne ©2013

OS: Definition

A program that acts as an intermediary between users of a computer system and hardware

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Goals of an Operating System

Primary goals

- Make the computer system convenient and easy to use (for the users)
- Ensure efficient utilization of resources (processor time, printer, RAM, ...)
  - Controls and co-ordinates the use of hardware resources among multiple users and applications

These goals might be conflicting across computing systems

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Mini computers and mainframes (1970 - 80)

Best utilization of resources

Cost: user experience (often no immediate result)

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Mini computers and mainframes (1970 - 80)	Workstations / terminals (1980 - now)
Best utilization of resources	Fast response time
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Mini computers and mainframes (1970 - 80)	Workstations / terminals (1980 - now)	Laptops
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These goals might be conflicting across computing systems

Mini computers and mainframes (1970 - 80)	Workstations / terminals (1980 - now)	Laptops	Mobile systems
Best utilization of resources	Fast response time	Flexible UI, easy to use	Optimized usability & battery life
Cost: user experience (often no immediate result)	Cost: Resource utilization is suboptimal	Cost: single user system	Cost: Severely constrained resources (your android cannot handle running full fledged game and browsing)

These goals might be conflicting across applications

Application A: I need 3 GB of memory, now!

These goals might be conflicting across applications

Application A: I need 3 GB of memory, now!

Application B: I need 2 GB of memory, now!

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Application A: I need 3 GB of memory, now!

Application B: I need 2 GB of memory, now!

Hardware: oops, total RAM is 4 GB

OS: goal-oriented definition

- A resource allocator
  - Manages all resources (processor time, RAM, display, ...) to ensure they are shared in an efficient and fair manner
  - Decides which application gets how much resources and when
- A control program
  - Controls execution of other programs / applications to prevent errors and improve usability (e.g., by giving faster response to users)
  - A faulty application should not disrupt other applications (or the OS itself)

OS: goal-oriented definition (contd.)

- Enabler of communication / coordination
  - One application may need to communicate to others, or share data / state / ...
- Enabler of easier development of applications
  - Offers a set of common services for applications (e.g., for I/O) - application developer does not need to worry about specifics of devices
  - Gives an illusion of infinite resources – dedicated processor, infinite memory, …

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Typical structure of OS (unix)

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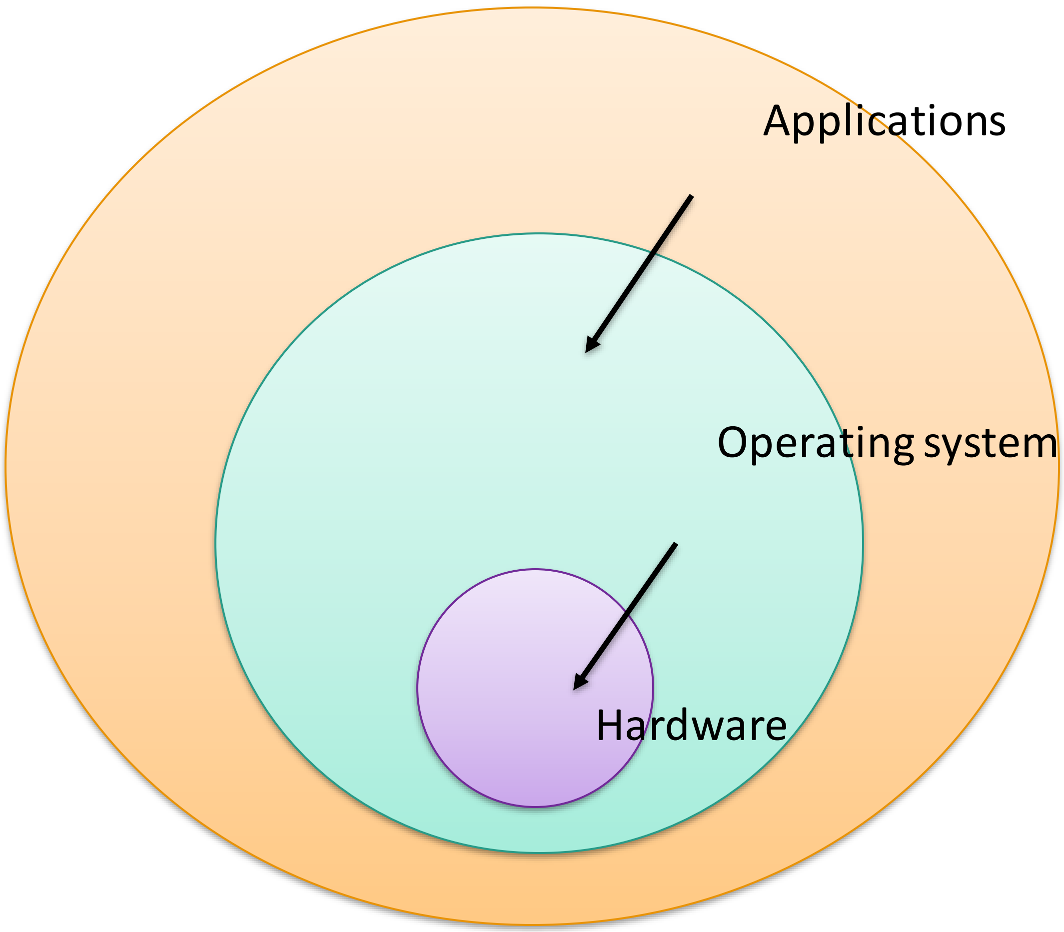

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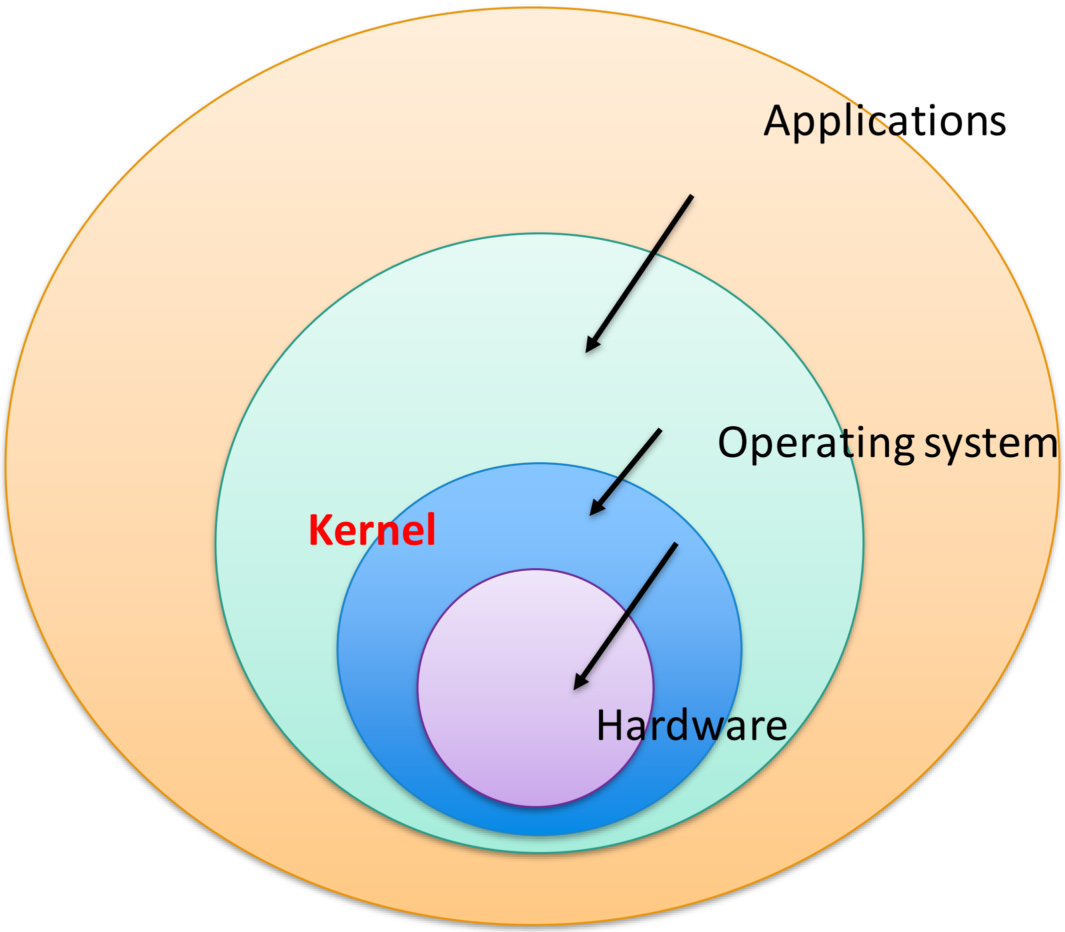

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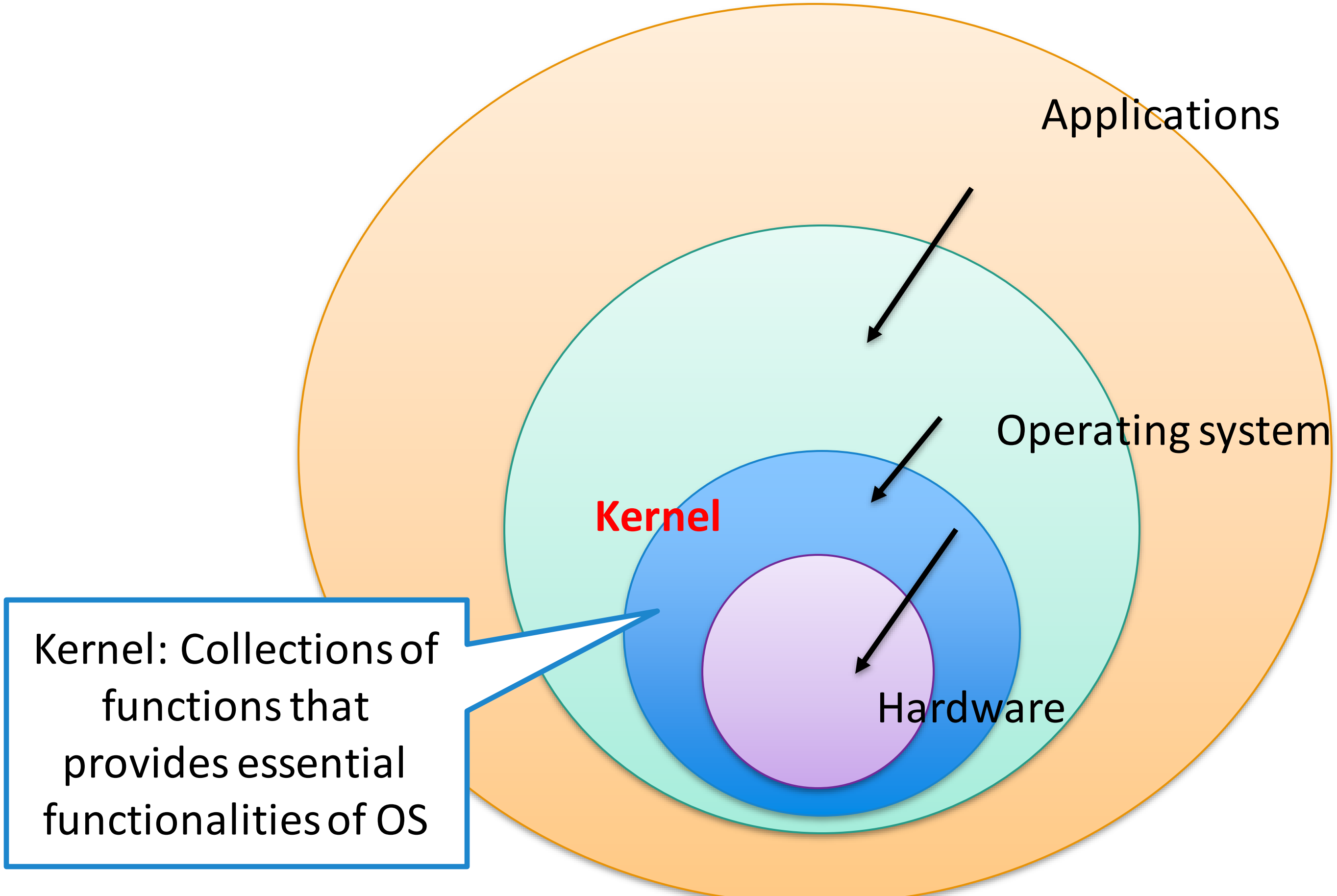

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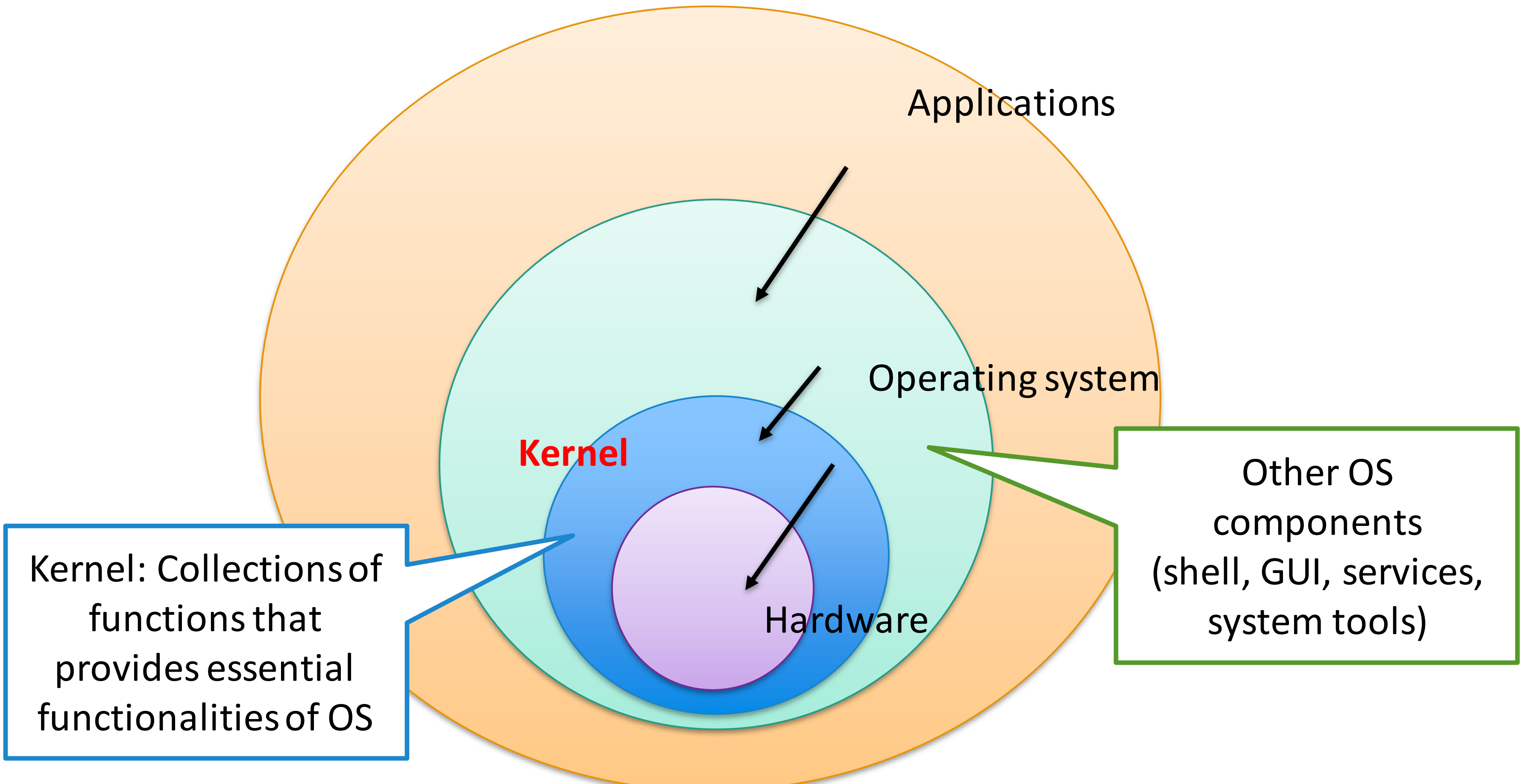

Function of Kernel

- Part of OS closest to the hardware, handles important functionalities
  - Managing memory, network, file, processes, system calls …

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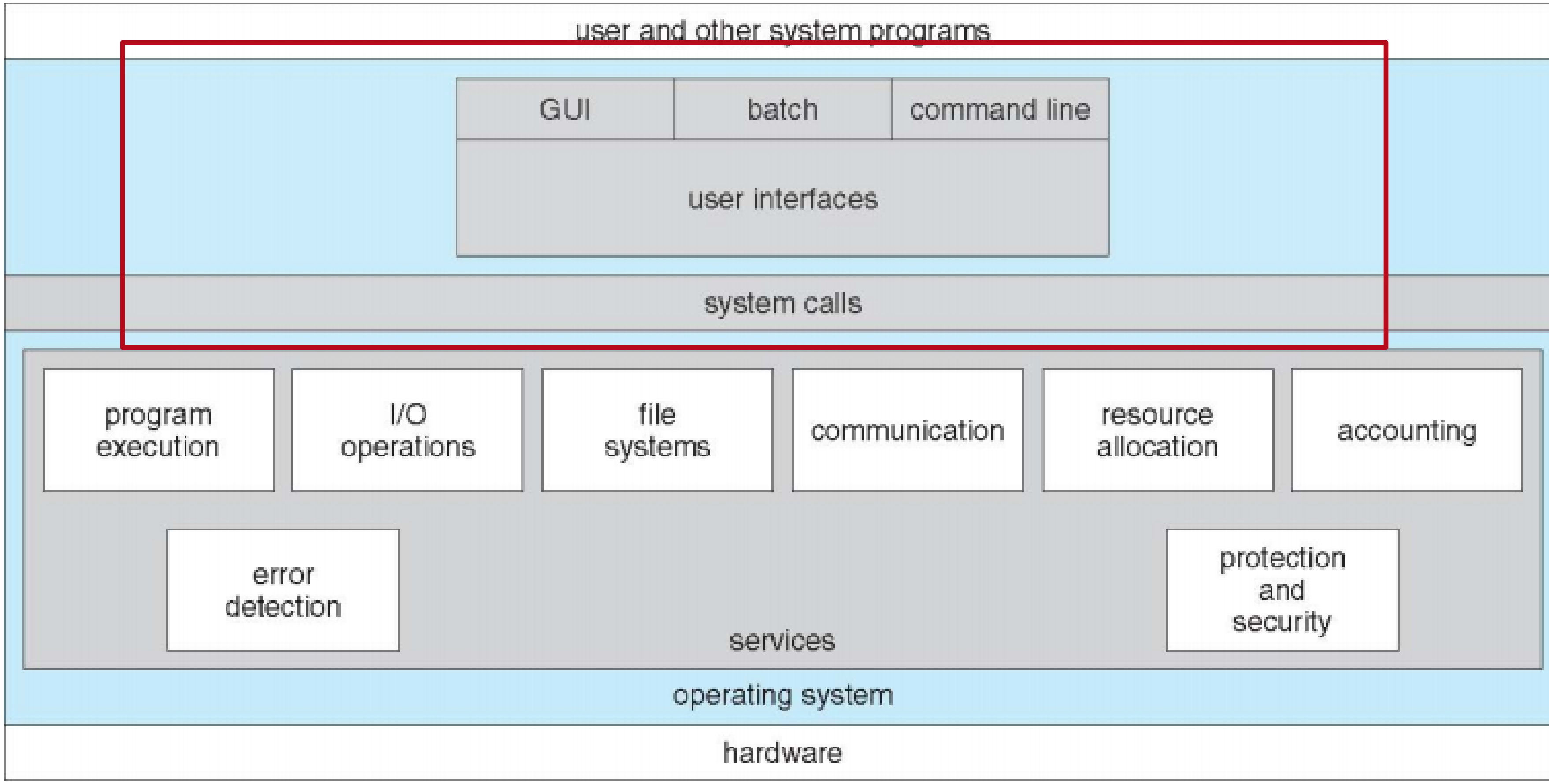
- Part of OS closest to the hardware, handles important functionalities
  - Managing memory, network, file, processes, system calls …
- Other parts of OS (e.g., the shell) and application programs can interact with kernel whenever they require these functionalities
  - E.g., need to read from keyboard (*scanf*), show something on display (*printf*), create directory (*mkdir*)

What other services?



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Food for thought

- A user might ask for *printf* any time
  - Does “Kernel run all the times”?

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- A user might ask for *printf* any time
  - Does “Kernel run all the times”?
- Possible problem
  - Kernel needs resources to run
- Insight
  - Kernel “only” needs to run when any of its functionalities are required

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    Kernel

Kernel is “interrupt” driven

- Think of interrupt as the “wake up call” to kernel
    - When interrupt comes, some function in Kernel is invoked

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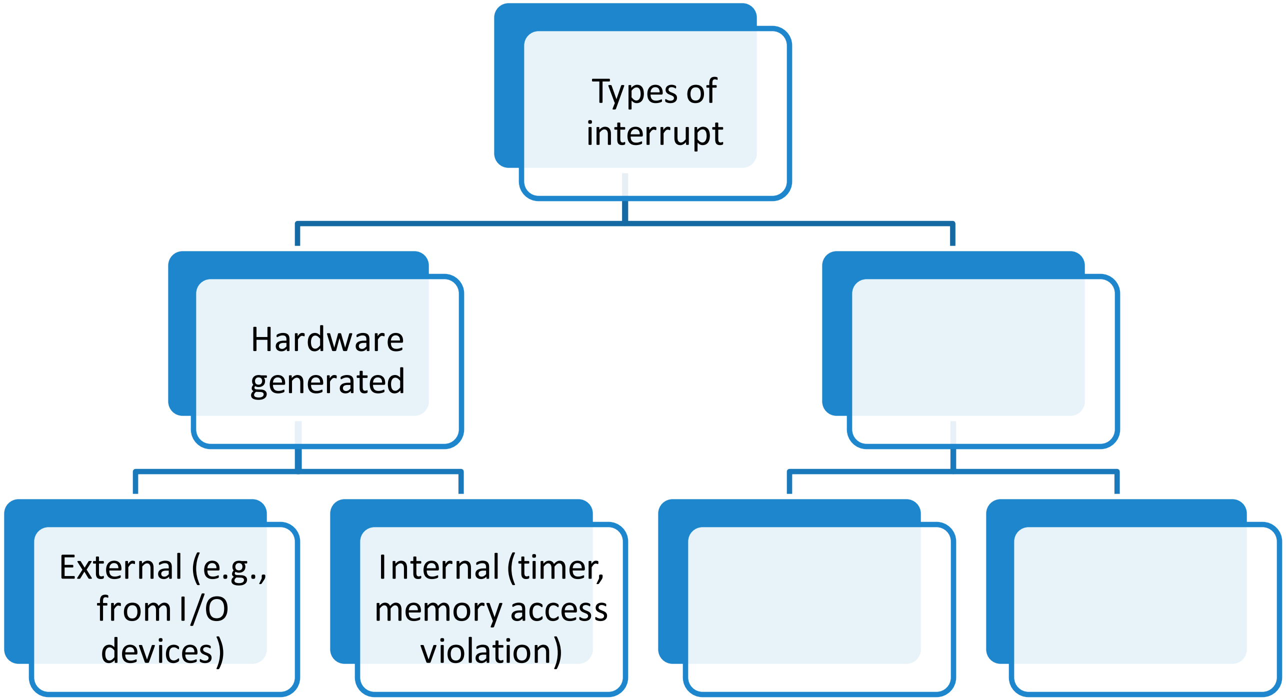
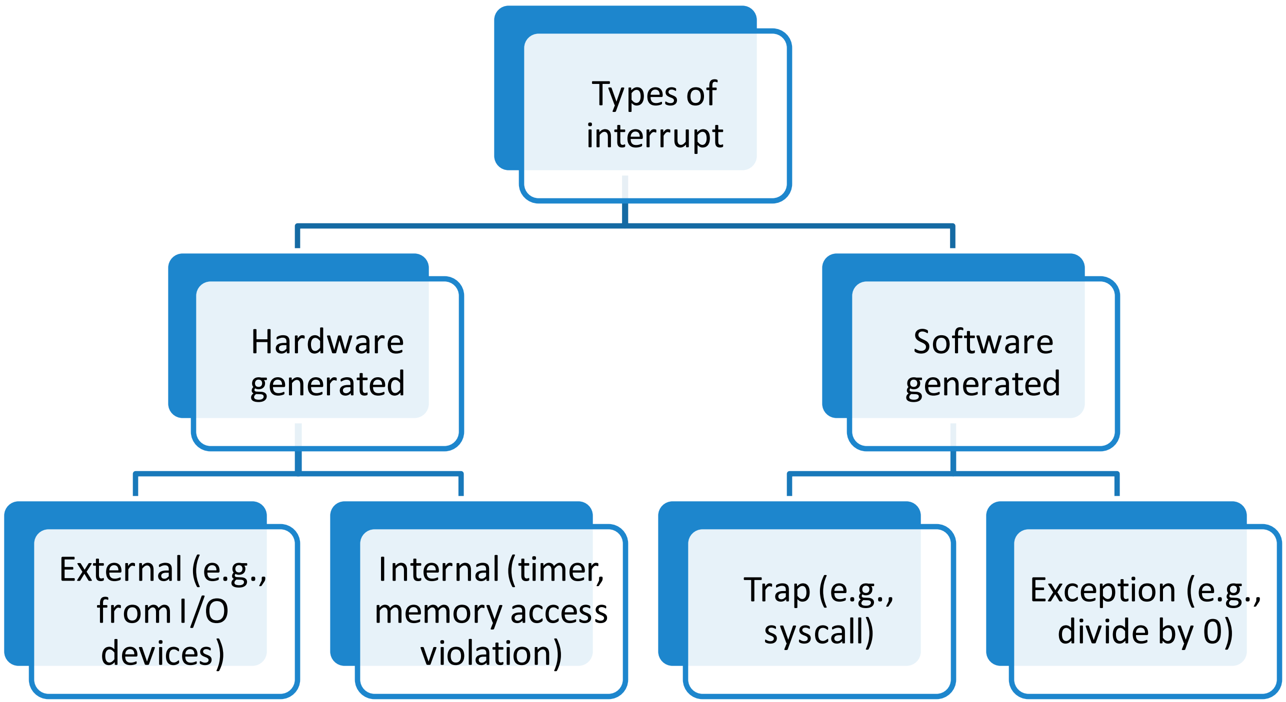
- Think of interrupt as the “wake up call” to kernel
    - When interrupt comes, some function in Kernel is invoked
- More technically
    - Interrupt is a signal (instruction), generated by hardware/software
    - The interrupt in turn activates appropriate kernel routine(s) depending on specific category of the interrupt

Types of interrupt



Hardware interrupts: generated by external device (e.g., a printer) OR internal hardware unit

Types of interrupt

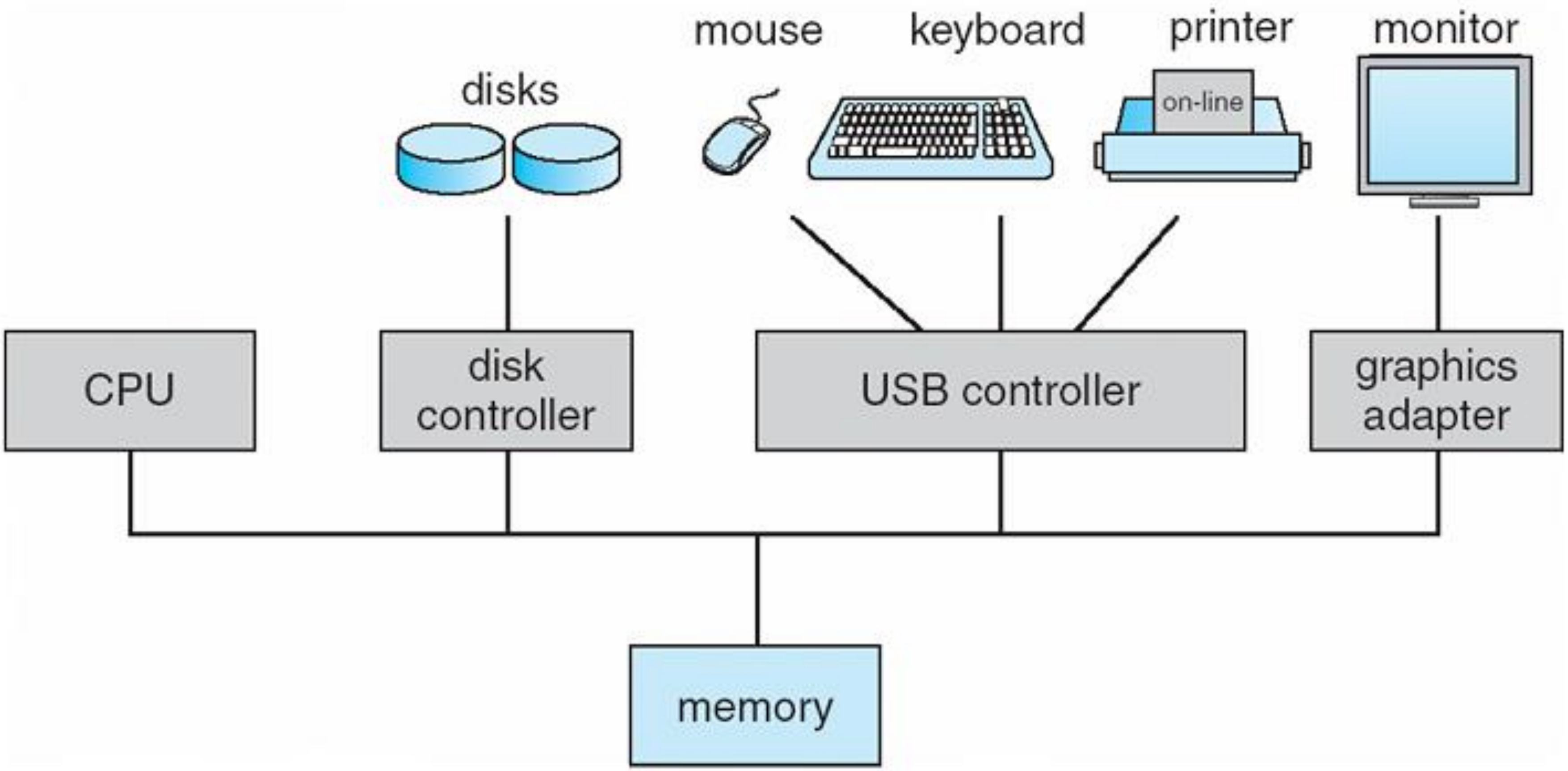


Hardware interrupts: generated by external device (e.g., a printer) OR internal hardware unit

Software interrupts: Generated by a running program

Case study: Handling Input/Output (I/O) requests

The setup



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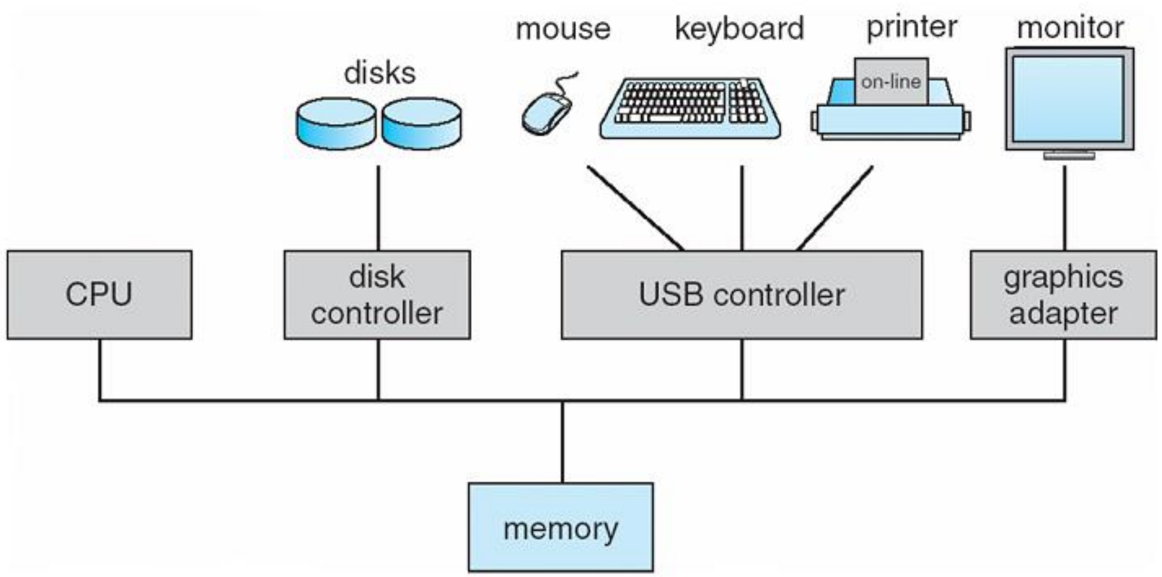
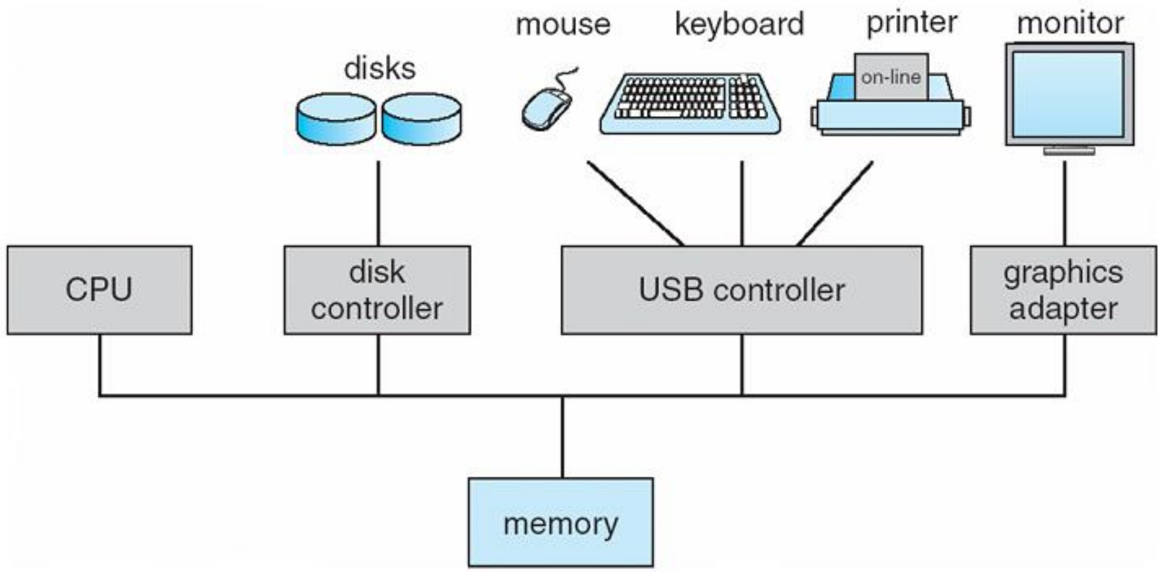
The setup (contd.)



- I/O devices and CPU can execute in parallel
  - Each device controller is in charge of a particular device type
  - Each device controller has a local buffer
  - Data transfers between local buffer and main memory
  - Device controller sends an interrupt to the CPU to indicate I/O completion

The setup (contd.)



Question: How would an I/O request be handled in this setup?

- Each device controller has a local buffer
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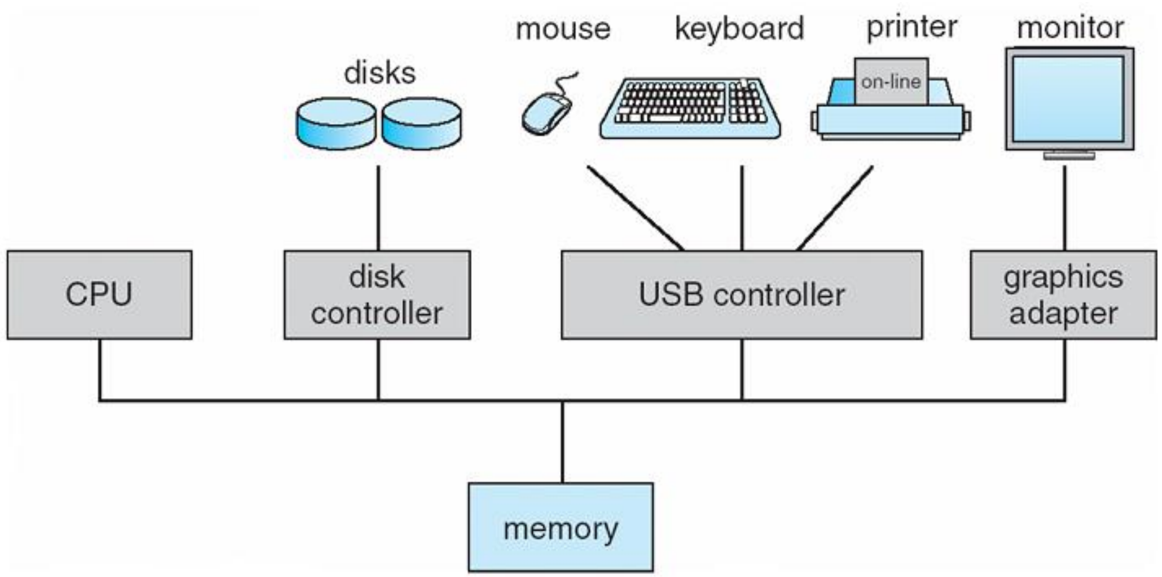
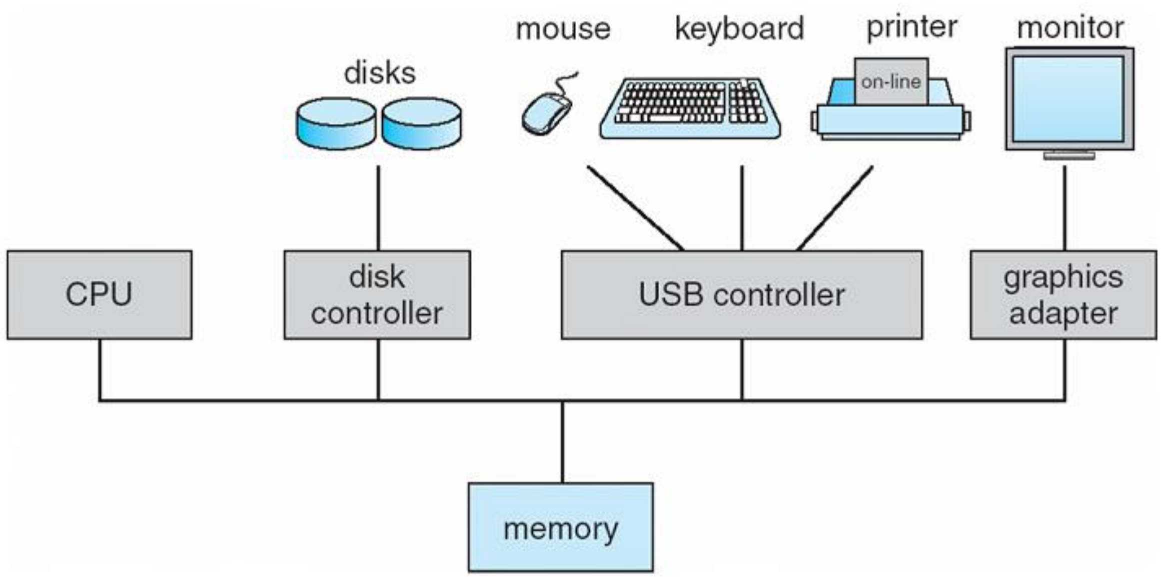
- Device controller sends an interrupt to the CPU to indicate I/O completion

Handling I/O in the setup



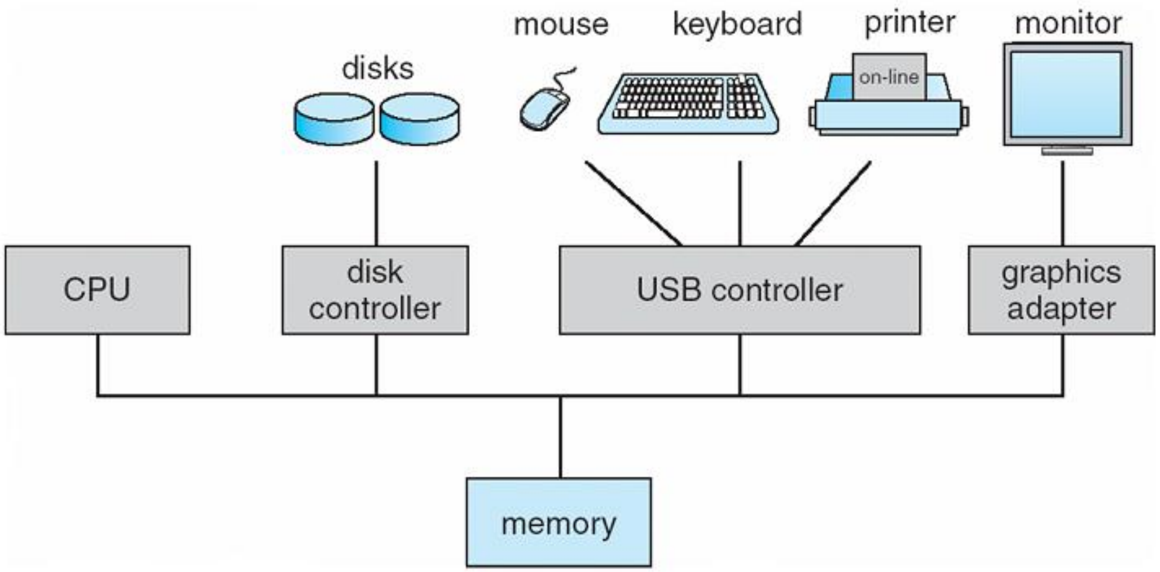
- Option 1
  - User program makes I/O request - transfers data from memory to buffer of device controller and initiates I/O
  - CPU remains idle as long as device controller handles request
  - Upon I/O completion, device controller sends interrupt, then execution of user program resumes
  - "Busy waiting" - under-utilization of CPU

Handling I/O in the setup



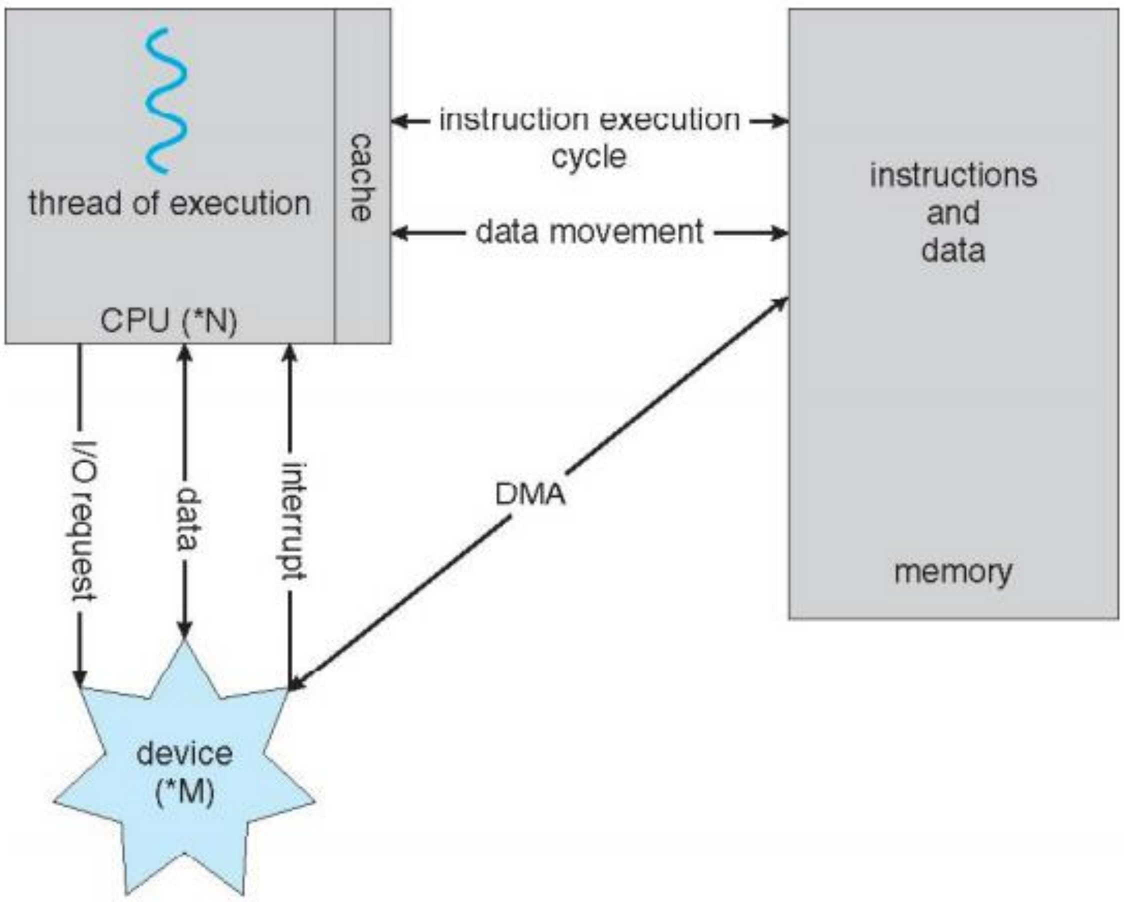
- Option 2: use OS
  - User program makes I/O request through a "system call"
  - OS transfers data from memory to buffer of device controller and initiates I/O
  - OS can allocate CPU to other programs during I/O of one program
  - Upon I/O completion, device controller sends interrupt, then OS may resume this particular user program (according to some scheduling

Handling I/O in the setup



- Previous scheme of interrupt-driven I/O is fine for small amounts of data, but high overhead for bulk data transfer such as disk I/O
- Hence option 3 – Direct Memory Access (DMA)
  - Once OS initiates I/O, DMA manages transfer of data between memory and device controller with no intervention by the CPU

I/O handling in von Neumann architecture



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