953214
Operating System and Computers Network

Chapter 2

Operating System Overview I

Lecturer: Parinya Suwansrikam, Dr. Phudinan Singkhamfu

College of Arts, Media and Technology
Chiang Mai University

Agenda

- What Operating Systems Do
- Computer-System Organization
- Computer-System Architecture
- Operating-System Operations
- Resource Management
- Security and Protection
- Virtualization
- Distributed Systems
- Kernel Data Structures
- Computing Environments
- Free/Libre and Open-Source Operating Systems

Objectives

- Describe the general organization of a computer system and the role of interrupts
- Describe the components in a modern, multiprocessor computer system
- Illustrate the transition from user mode to kernel mode
- Discuss how operating systems are used in various computing environments
- Provide examples of free and open-source operating systems

What Does the Term Operating System Mean?

- An operating system is “fill in the blanks”
- What about:
  - Car
  - Airplane
  - Printer
  - Washing Machine
  - Toaster
  - Compiler
  - etc.

Limitations

- Only a single user at a time
  - Who manages?
- Each user will need to be independent, and have full stack software
  - Drivers, all of them
  - Compilers
  - I/O
  - etc.
- Each user have full access!
  - Protection and security

What is an Operating System?

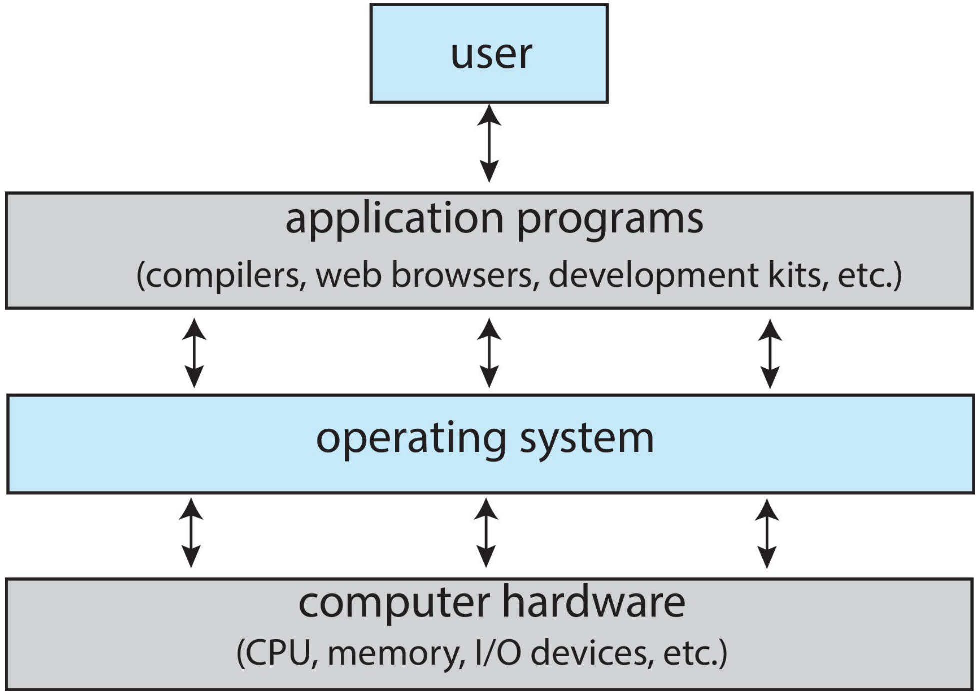
- A program that acts as an intermediary between a user of a computer and the computer hardware

- 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

Computer System Structure

- Computer system can be divided into four components:
  - 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

Abstract View of Components of Computer



What Operating Systems Do

- Depends on the point of view
- 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
  - Operating system is a resource allocator and control program making efficient use of HW and managing execution of user programs

What Operating Systems Do (Cont.)

- Users of dedicate systems such as workstations have dedicated resources but frequently use shared resources from servers
- Mobile devices like smartphones and tablets are resource poor, optimized for usability and battery life
  - Mobile user interfaces such as touch screens, voice recognition
- Some computers have little or no user interface, such as embedded computers in devices and automobiles
  - Run primarily without user intervention

Defining Operating Systems

- Term OS covers many roles
  - Because of myriad designs and uses of OSes
  - Present in toasters through ships, spacecraft, game machines, TVs and industrial control systems
  - Born when fixed use computers for military became more general purpose and needed resource management and program control

* myriad means a countless or extremely great number.

Operating System Definition

- No universally accepted definition

- "Everything a vendor ships when you order an operating system" is a good approximation
  - But varies wildly

- "The one program running at all times on the computer" is the kernel, part of the operating system

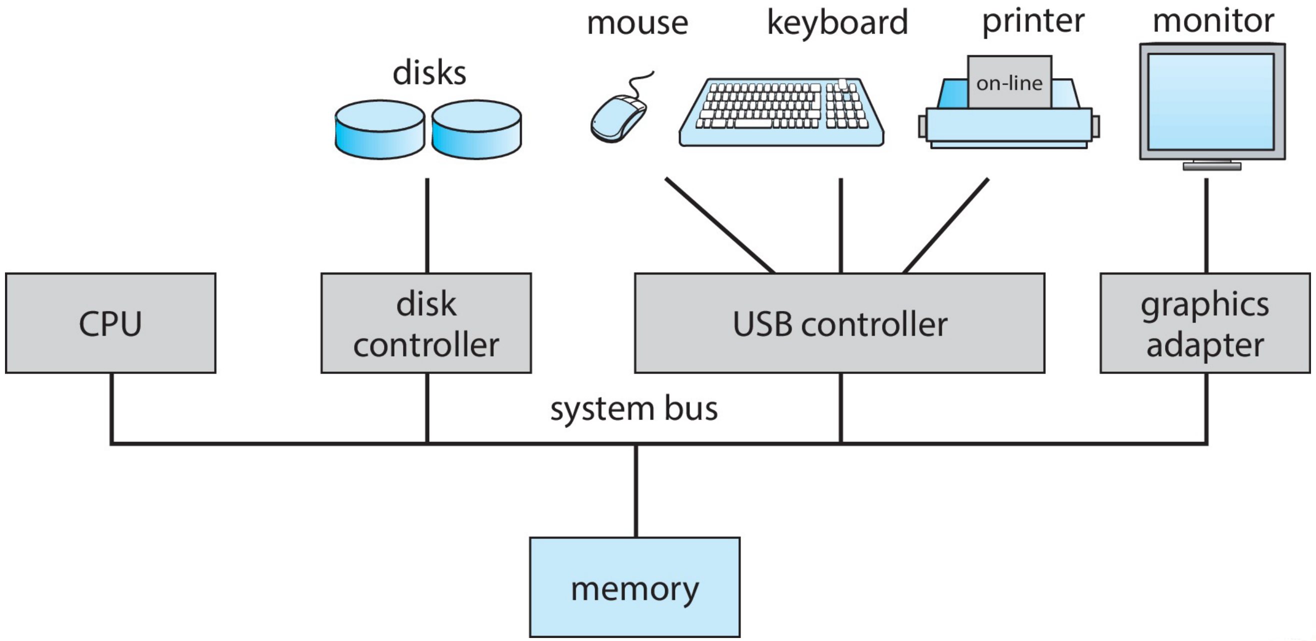
Operating System Definition (Cont.)

- Everything else is either
  - A *system program* (ships with the operating system, but not part of the kernel) , or
  - An *application program*, all programs not associated with the operating system
- Today's OSes for general purpose and mobile computing also include *middleware* – a set of software frameworks that provide additional services to application developers such as databases, multimedia, graphics

Overview of Computer System Structure

Computer System Organization

- Computer-system operation
  - One or more CPUs, device controllers connect through common bus providing access to shared memory
  - Concurrent execution of CPUs and devices competing for memory cycles



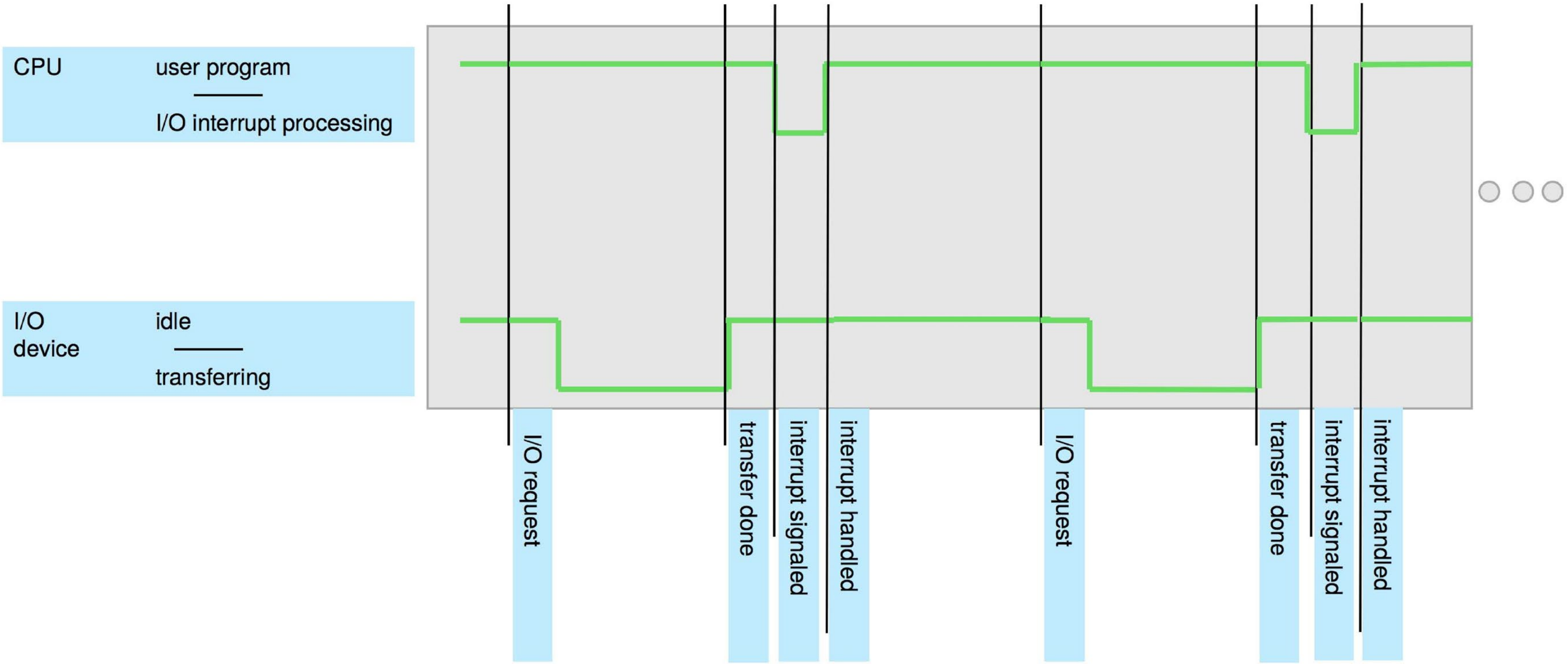
Computer-System Operation

- 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



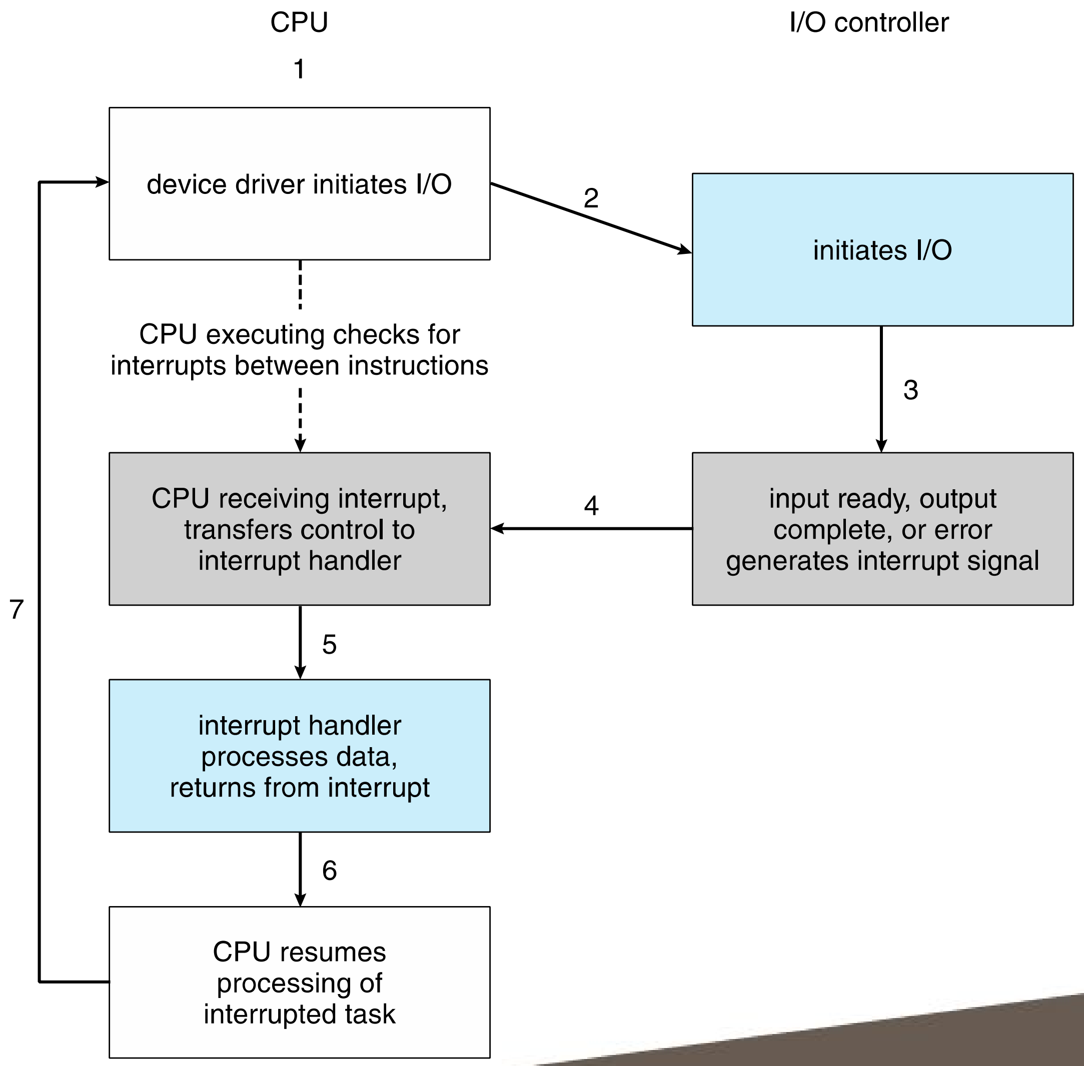
Interrupt Handling

- The operating system preserves the state of the CPU by storing the registers and the program counter

- Determines which type of interrupt has occurred:

- Separate segments of code determine what action should be taken for each type of interrupt

Interrupt-drive I/O Cycle



I/O Structure

- Two methods for handling I/O
  - After I/O starts, control returns to user program only upon I/O completion
  - After I/O starts, control returns to user program without waiting for I/O completion

I/O Structure (Cont.)

- 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

Computer Startup

- Bootstrap program is loaded at power-up or reboot
  - Typically stored in ROM or EPROM, generally known as firmware
  - Initializes all aspects of system
  - Loads operating system kernel and starts execution

Storage Structure

Storage Structure

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

Storage Structure (Cont.)

- 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 Definitions and Notation Review

The basic unit of computer storage is the bit. A bit can contain one of two values, 0 and 1. All other storage in a computer is based on collections of bits. Given enough bits, it is amazing how many things a computer can represent: numbers, letters, images, movies, sounds, documents, and programs, to name a few. A byte is 8 bits, and on most computers it is the smallest convenient chunk of storage. For example, most computers don't have an instruction to move a bit but do have one to move a byte. A less common term is word, which is a given computer architecture's native unit of data. A word is made up of one or more bytes. For example, a computer that has 64-bit registers and 64-bit memory addressing typically has 64-bit (8-byte) words. A computer executes many operations in its native word size rather than a byte at a time.

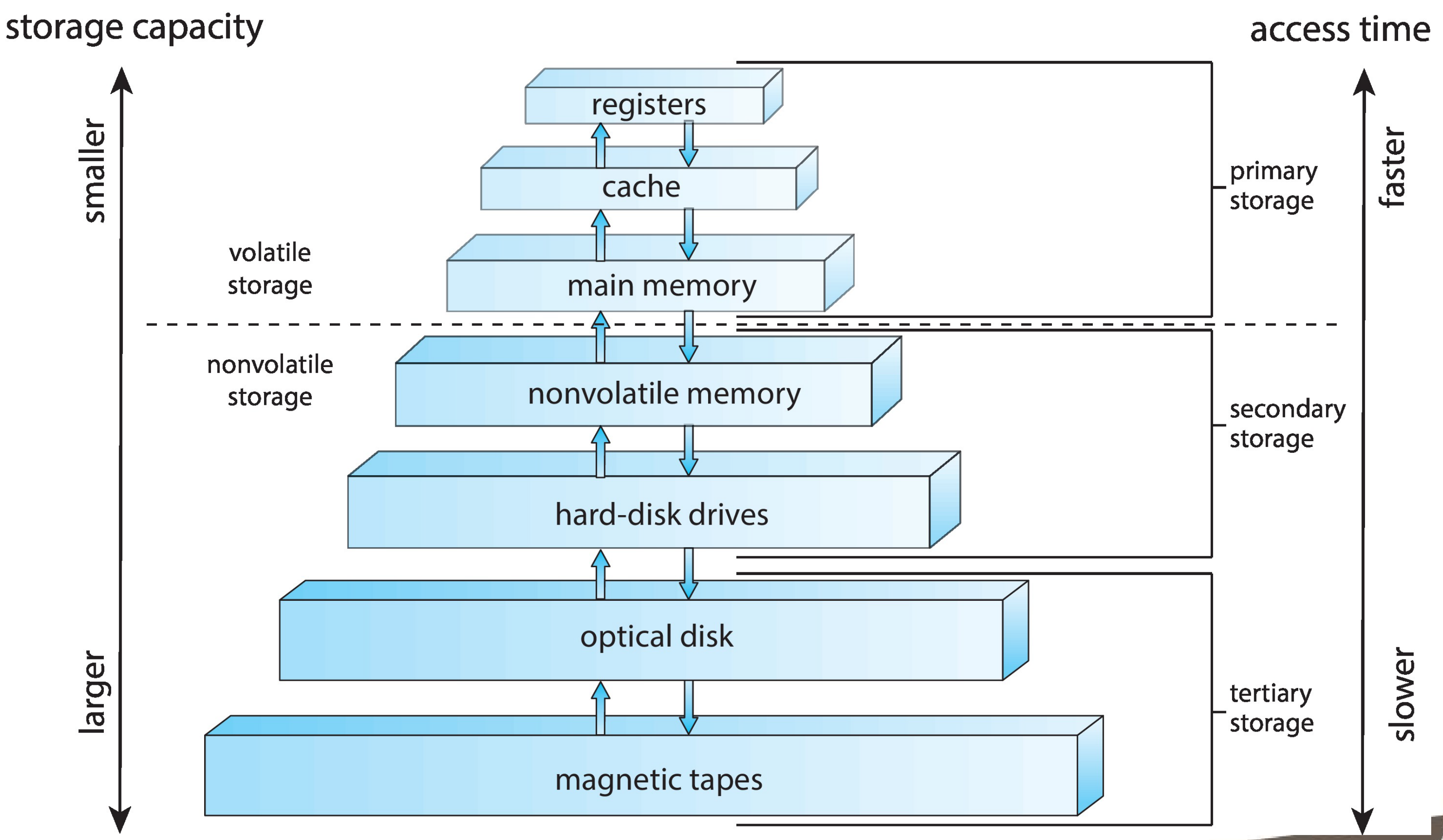
Computer storage, along with most computer throughput, is generally measured and manipulated in bytes and collections of bytes. A kilobyte, or KB , is 1,024 bytes; a megabyte, or MB, is $1{,}024^2$ bytes; a gigabyte, or GB, is $1{,}024^3$ bytes; a terabyte, or TB, is $1{,}024^4$ bytes; and a petabyte, or PB, is $1{,}024^5$ bytes. Computer manufacturers often round off these numbers and say that a megabyte is 1 million bytes and a gigabyte is 1 billion bytes. Networking measurements are an exception to this general rule; they are given in bits (because networks move data a bit at a time).

College of Arts, Media and Technology
Chiang Mai University

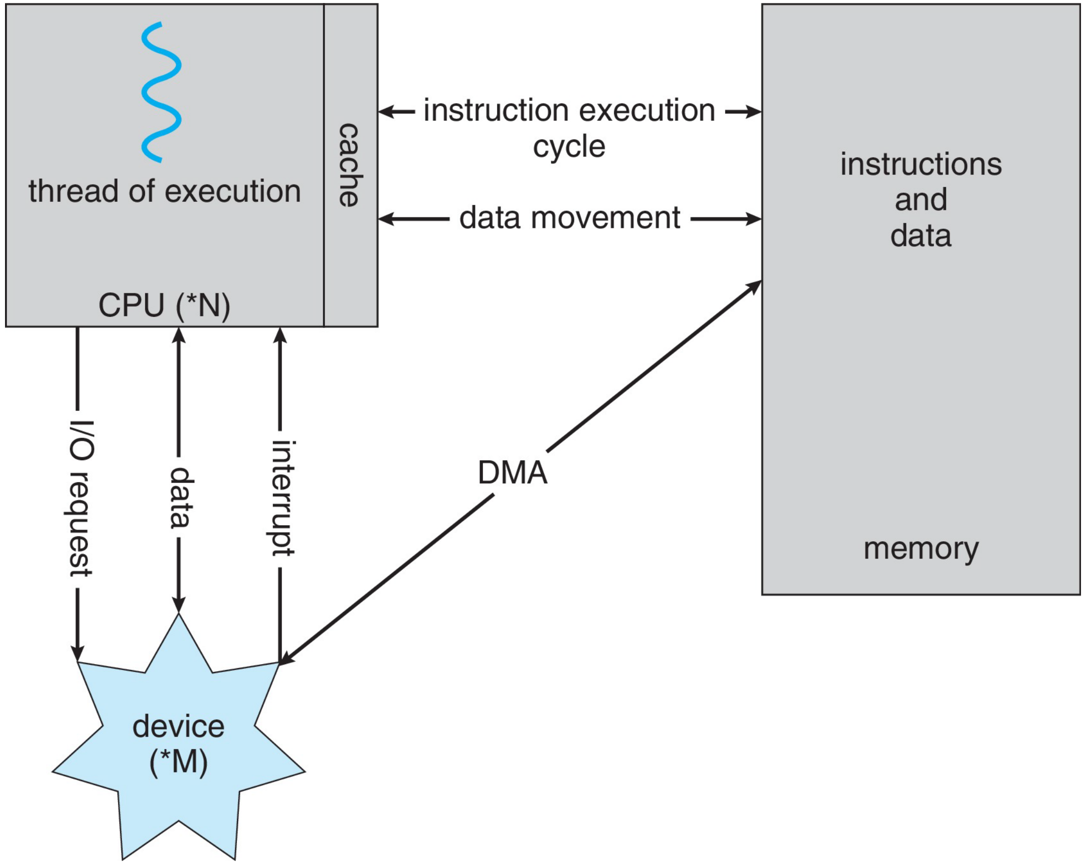
Storage Hierarchy

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

Storage-Device Hierarchy



How a Modern Computer Works



A von Neumann architecture

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

Operating-System Operations

- Bootstrap program – simple code to initialize the system, load the kernel
- Kernel loads
- Starts system daemons (services provided outside of the kernel)
- Kernel interrupt driven (hardware and software)
  - Hardware interrupt by one of the devices
  - Software interrupt (exception or trap):
    - Software error (e.g., division by zero)
    - Request for operating system service – system call
    - Other process problems include infinite loop, processes modifying each other or the operating system

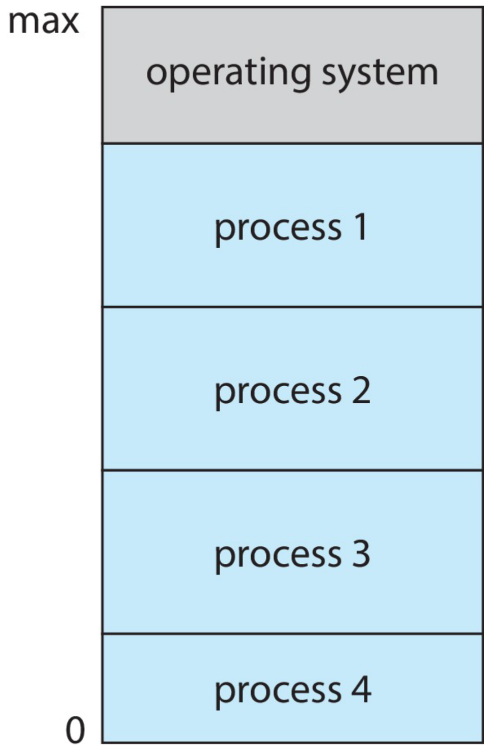
Multiprogramming (Batch system)

- Single user cannot always keep CPU and I/O devices busy
- Multiprogramming organizes jobs (code and data) so CPU always has one to execute
- A subset of total jobs in system is kept in memory
- One job selected and run via job scheduling
- When job has to wait (for I/O for example), OS switches to another job

Multitasking (Timesharing)

- A logical extension of Batch systems– the CPU switches jobs so frequently that users can interact with each job while it is running, creating **interactive** computing
  - **Response time** should be < 1 second
  - Each user has at least one program executing in memory ⇨ **process**
  - If several jobs ready to run at the same time ⇨ **CPU scheduling**
  - If processes don't fit in memory, **swapping** moves them in and out to run
  - **Virtual memory** allows execution of processes not completely in memory

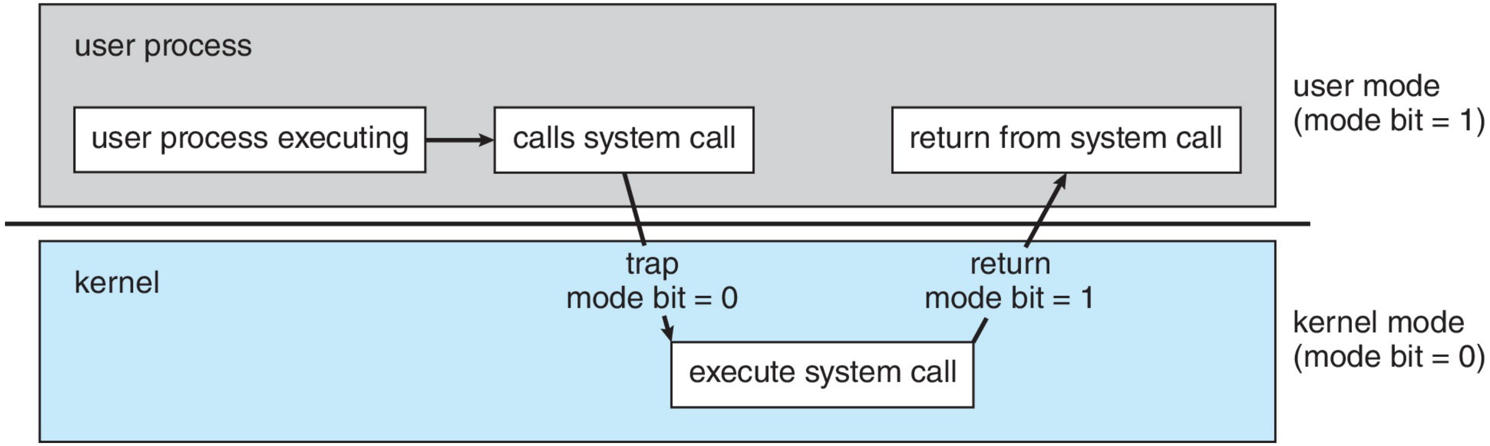
Memory Layout for Multiprogrammed System



Dual-mode Operation

- Dual-mode operation allows OS to protect itself and other system components
  - User mode and kernel mode
- Mode bit provided by hardware
  - Provides ability to distinguish when system is running user code or kernel code.
  - When a user is running ⇨ mode bit is “user”
  - When kernel code is executing ⇨ mode bit is “kernel”
- How do we guarantee that user does not explicitly set the mode bit to “kernel”?
  - System call changes mode to kernel, return from call resets it to user
- Some instructions designated as privileged, only executable in kernel mode

Transition from User to Kernel Mode



Timer

- Timer to prevent infinite loop (or process hogging resources)
  - Timer is set to interrupt the computer after some time period
  - 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

End of Presentation

- Questions and Answers