Introduction to Operating System

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General Information

- Textbook:
  - Operating System Concepts, 8th or 9th Ed, by Silberschatz, Galvin, and Gagne
- Reference Books:
  - Operating Systems: Principles and Practice by Anderson and Dahlin
  - Modern Operating Systems by Andrew Tanenbaum
- Programming assignments will be covered in associated E-Lab.

Computer System

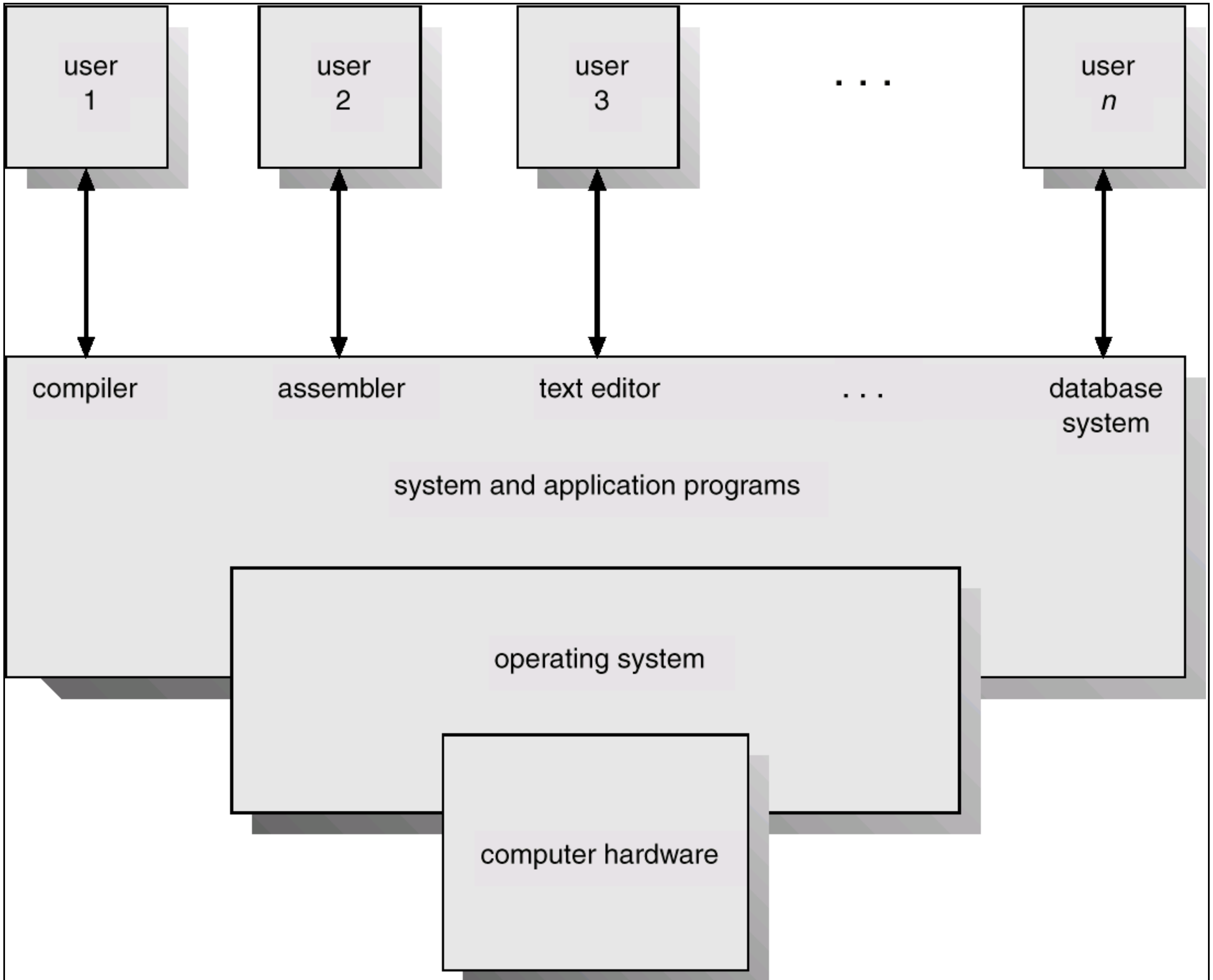
- Can be divided roughly into four components:
  - Hardware
  - Operating System
  - Application Program
  - Users
- Hardware constitutes of:
  - CPU
  - Memory
  - I/O Devices
- Application Programs: Word Processors, spreadsheets, compilers, browsers……
- Operating System provides the means for proper use of these resources.
- Operating System provides an environment within which other programs can do useful work.

What is operating system?

- User-centric definition
  - A program that acts as an intermediary between a user of a computer and the computer hardware
  - Defines an interface for the user to use services provided by the system
  - Provides a “view” of the system to the user Converts what the hardware gives to what the user wants
  - The view can hide many details of the hardware that the user does not need to know
  - Can even give a very different view of the operating environment to the user than what is actually there

- System-centric definition
  - Efficiently manages and allocates resources to users
  - Controls the execution of user programs and operations of I/O devices
  - Provides isolation/protection between different user programs

Abstract View of System Components



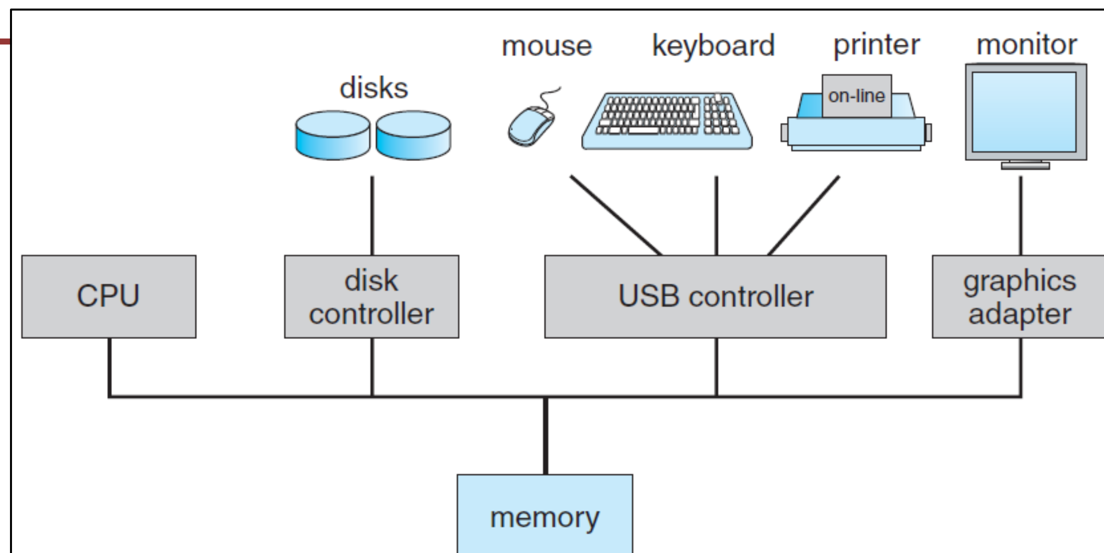
Types of System

- Batch Systems
  - Multiple jobs, but only one job in memory at one time and executed (till completion) before the next one starts
- Multiprogrammed Batch Systems
  - Multiple jobs in memory, CPU is multiplexed between them
  - CPU-bound vs I/O bound jobs
- Time-sharing Systems
  - Multiple jobs in memory and on disk, CPU is multiplexed among jobs in memory, jobs swapped between disk and memory
  - Allows interaction with users

- Personal Computers
  - Dedicated to a single user at one time
- Multiprocessing Systems
  - More than one CPU in a single machine to allocate jobs to
  - Symmetric Multiprocessing, NUMA machines …
  - Multicore
- Other Parallel Systems, Distributed Systems, Clusters…
  - Different types of systems with multiple CPUs/Machines
- Real Time Systems
  - Systems to run jobs with time guarantees
- Many other types
  - Embedded systems, mobiles/smartphones, ….

Computer System Architecture

- Computer system consists of one or more CPUs and a number of device controllers, which execute in parallel.
- Each device controller is in charge of a specific type of device.
- For orderly access to the shared memory, a memory controller synchronizes access to the memory



- Bootstrap program
  - Once computer is powered on, to start running a initial program: Bootstrap Program
  - Initializes all aspects of the system, from CPU registers to device controllers to memory contents.
  - Stored within the computer hardware in read-only memory (**ROM**)
  - Bootstrap program locates the operating-system kernel and loads it into memory
  - A loaded and executing kernel provides services of the system to the user.
- Some services are provided outside of the kernel, by system programs that are loaded into memory at boot time to become **system processes**

Homework

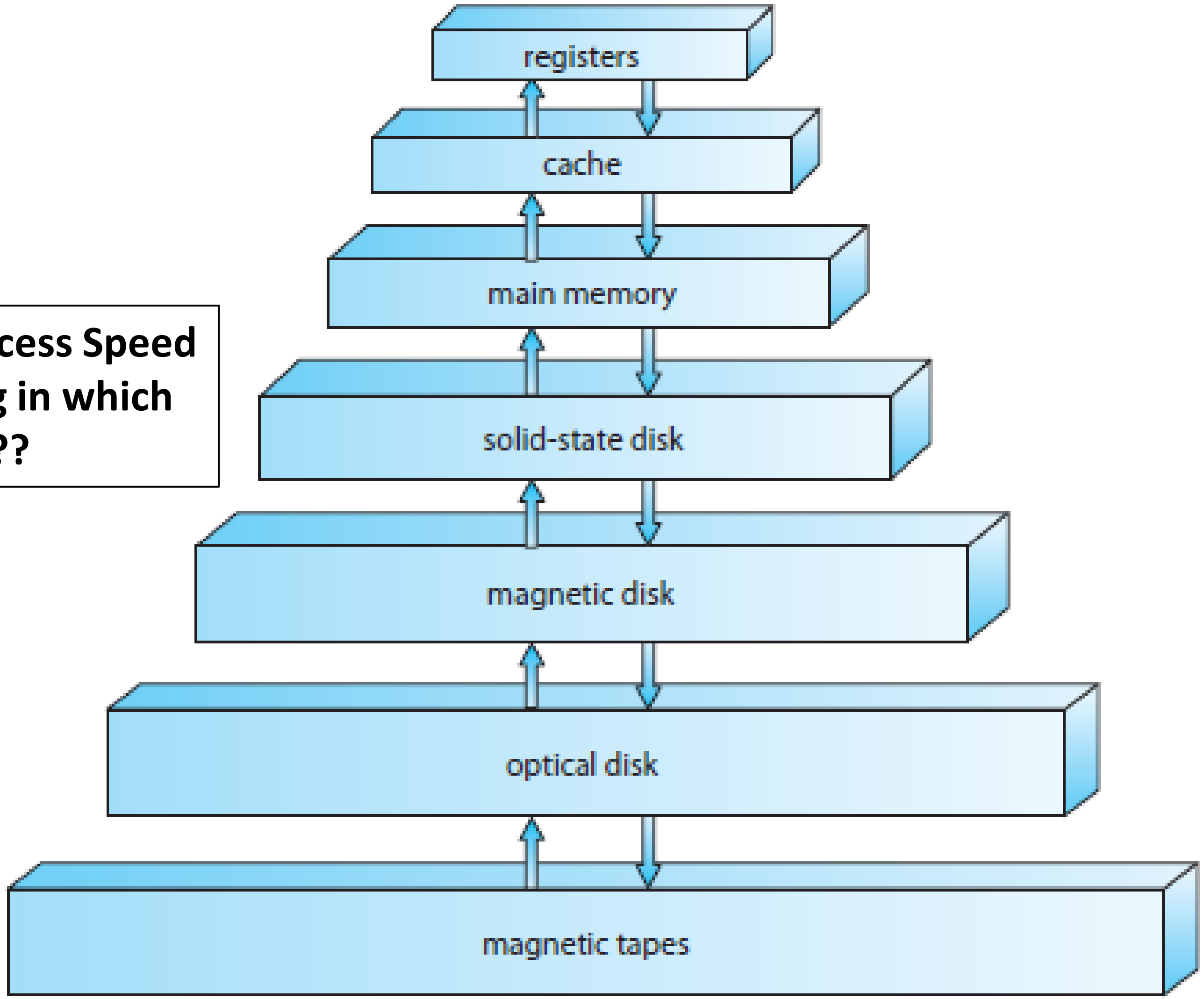
Case Study 1: Study the Unix bootstrap process

- Interrupts
  - Occurrence of an event is usually signalled by an **interrupt** from either the hardware or the software.
  - When the CPU is interrupted, it stops what it is doing and immediately transfers execution to a fixed location.
  - Fixed location usually contains the starting address where the service routine for the interrupt is located.
  - On completion of service routine the CPU resumes the interrupted computation.

Storage Structure

- CPU can load instructions only from memory, so any programs to run must be stored there.
- Mostly computer access there programs from Random Access Memory (RAM)
- Static programs such as Bootstrap are stored in ROM.
- All forms of memory provide an array of bytes, each byte having its own address.
- Sequence of load or store instructions maintains the execution.
- Load instruction moves a byte or word from main memory to an internal register within the CPU.
- Store instruction moves the content of a register to main memory

Memory Access Speed is increasing in which direction????



Storage-device hierarchy

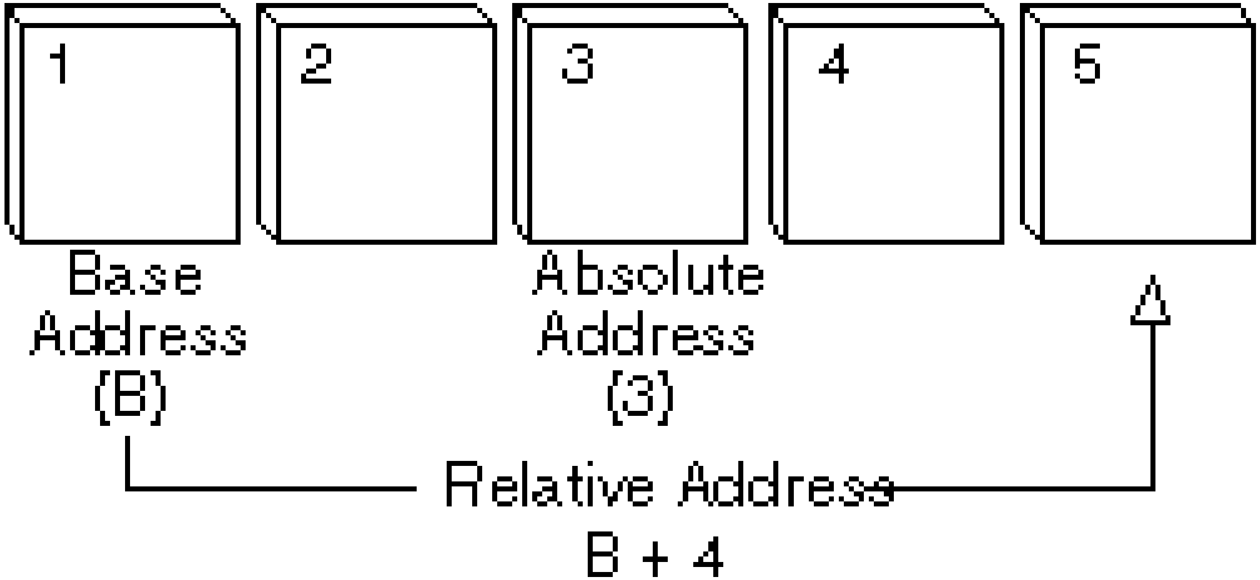
I/O Structure

- A large portion of operating system code is dedicated to managing I/O.
- Device controller who is in charge of a specific type of device, maintains some local buffer storage and a set of special-purpose registers.
- To start an I/O operation, the device driver loads the appropriate registers within the device controller.
- Device driver then informs the operating system that the data is loaded and is ready.

Operation System Operations

- Process Management
  - A program in execution, as mentioned, is a process.
  - A word-processing program being run by an individual user on a PC is a process.
  - A process needs certain resources—CPU time, memory, files, and I/O devices.
  - Activities in connection with process management:
    - Scheduling processes and threads on the CPUs
    - Creating and deleting both user and system processes
    - Suspending and resuming processes
    - Providing mechanisms for process synchronization

- Memory Management
  - Main memory is central to the operation of a modern computer system
  - Main memory is a repository of quickly accessible data shared by the CPU and I/O devices.
  - For a program to be executed, it must be mapped to absolute addresses and loaded into memory.
  - Program executes by accessing program instructions from memory by their absolute addresses.
  - Program terminates and its memory space is declared available
  - Activities in connection with memory management:
    - Keeping track of which parts of memory are currently being used and who is using them
    - Deciding which processes (or parts of processes) and data to move into and out of memory.
    - Allocating and deallocating memory space as needed.



- Absolute Address:
  - A fixed address in memory
  - Is not a relative address
  - Also called real addressess

- Storage Management
  - Operating system provides a uniform, logical view of information storage, a logical unit, the **file**
  - OS maps files onto physical media and accesses these files via the storage devices.
  - Activities in connection with storage management:
    - File System Management
    - Mass storage management
    - Caching
    - I/O Systems
  - File system management:
    - Creating and deleting files
    - Creating and deleting directories to organize files
    - Supporting primitives for manipulating files and directories
    - Mapping files onto secondary storage
    - Backing up files on stable (nonvolatile) storage media

- Storage Management
  - Mass-Storage Management
    - Free-space management
    - Storage allocation
    - Disk scheduling
  - Caching
  - I/O Systems
    - A memory-management component that includes buffering, caching, and spooling
    - A general device-driver interface
    - Drivers for specific hardware devices

- Protection and Security
  - Protection, then, is any mechanism for controlling the access of processes or users to the resources defined by a computer system.
  - Job of **security** is to defend a system from external and internal attacks which may include viruses and worms, denial-of service attacks, identity theft and theft of service.

Modes of Operating System

- Operating System is interface between applications and the underlying hardware.
- At the same time to maintain systems integrity, it needs to prevent system integrity from application accessing hardware directly.
- To enforce this protection, CPU provides two modes of operation:
  - Kernel Mode
  - User Mode

- User Mode
  - Direct access to the hardware is prohibited, and so is any arbitrary switching to kernel mode.
  - For a user-mode application, Windows creates a process for the application.
  - Process provides the application with a private virtual address space and a private handle table.
  - As virtual address space is private, one application cannot alter data that belongs to another application.
  - If an application crashes, the crash is limited to that one application

- Kernel Mode
  - Known as supervisor mode or privileged mode.
  - Has complete access to all of the computer's hardware and can control the switching between the CPU modes.
  - Code that runs in kernel mode shares a single virtual address space
  - If a kernel-mode driver accidentally writes to the wrong virtual address, data that belongs to the operating system or another driver could be compromised
  - If a kernel-mode driver crashes, the entire operating system crashes

Operating system classification

Operating Systems can be classified as:

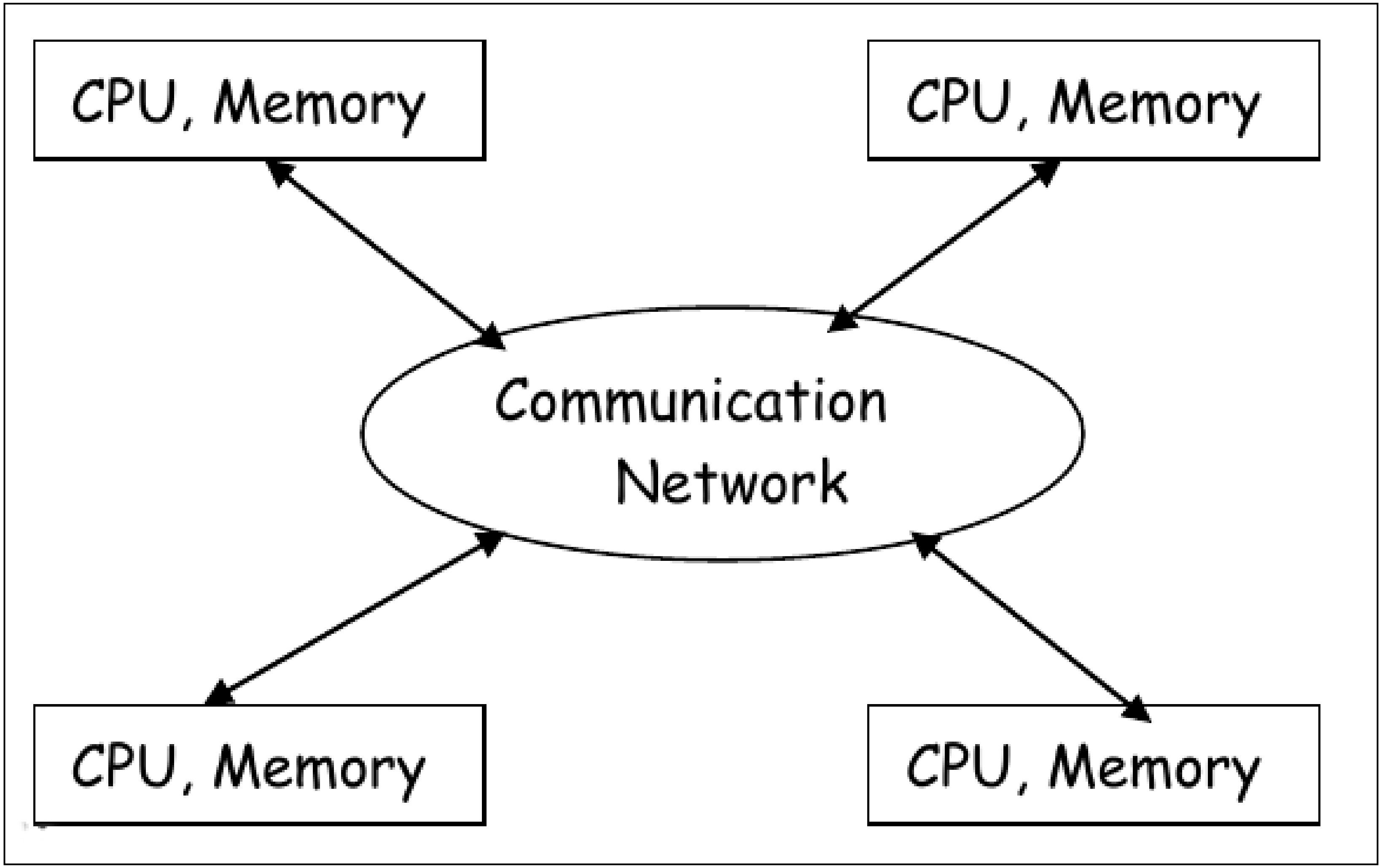
- *GUI:* Graphical User Interface operating systems are operating systems that have the capability of using a mouse and are graphical
- *Multi user:* allows multiple users to utilize the computer and run programs at the same time
- *Multi processing*: allows multiple processors to be utilized
- *Multi tasking*: allows multiple software processes to be run at the same time
- *Multi threading:* allows different parts of a software program to run concurrently

Distributed Operating Systems

- Distributed systems are loosely coupled systems
- A Distributed computer system is a collection of autonomous computer systems
- Distributed systems communicate with one another through various communication lines like high speed buses or telephone lines
- The processors in a distributed system may vary in size and function
- Example: small microprocessors, workstations , minicomputer and large general purpose computers

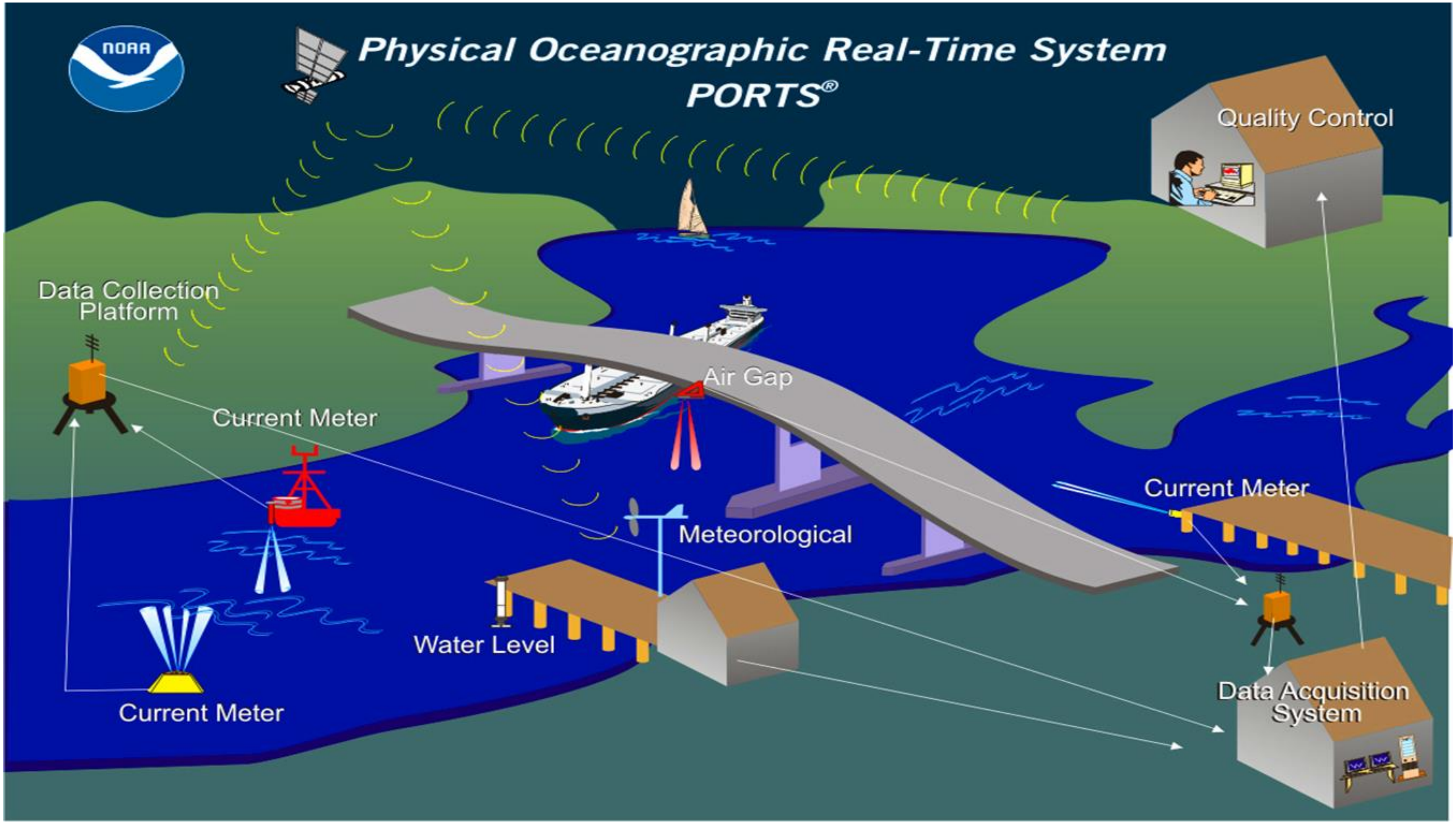
Distributed Operating Systems

- Processors in distributed systems are referred by no. of different names like, sites, nodes, computers, etc.
- Important reasons for building distributed systems are
  - Resource sharing
  - Computation speedup
  - Reliability
  - Communication
- The key objective of a distributed operating system is transparency
- Ideally, component and resource distribution should be hidden from users and applications programs unless they explicitly demand


CPU, Memory
CPU, Memory
Communication Network
CPU, Memory
CPU, Memory

Real Time Operating System

- Real-time systems has well defined, fixed time constraints
- Processing must be done with in the defined constraints, or the system will fail
- For example:
  - Weather Forecasting, Self driving Cars, Earthquake warning systems, wireless sensor networks


Physical Oceanographic Real-Time System
PORTS®
NOAA
Quality Control
Data Collection Platform
Current Meter
Air Gap
Current Meter
Meteorological
Water Level
Current Meter
Data Acquisition System

Real Time Operating System

- Real-time system is used as a control device in a dedicated application
- Sensors bring data to computers
- Computer analyze data and adjust controls to modify the sensor inputs
- Example:
  - Scientific experiments, medical imaging systems, industrial control systems etc..
- Real-time system functions correctly only if it returns the correct result within its time constraints

Real Time Operating System

- A primary objective of real-time systems is to provide quick event - response times, thus meet the scheduling dead lines
- User convenience and resource utilization are of secondary concern to real- time system designers
- Real-time operating systems usually rely on some specific policies and techniques for doing their job

System Calls

- The mechanism used by an application program to request service from the operating system.
- System calls often use a special machine code instruction which causes the processor to change mode (Protected or Supervisor mode)
- This allows the OS to perform restricted actions such as accessing hardware devices or the memory management unit

Types of System Call

Process management

Call	Description
pid = fork( )	Create a child process identical to the parent
pid = waitpid(pid, &statloc, options)	Wait for a child to terminate
s = execve(name, argv, environp)	Replace a process' core image
exit(status)	Terminate process execution and return status

File management

Call	Description
fd = open(file, how, ...)	Open a file for reading, writing or both
s = close(fd)	Close an open file
n = read(fd, buffer, nbytes)	Read data from a file into a buffer
n = write(fd, buffer, nbytes)	Write data from a buffer into a file
position = lseek(fd, offset, whence)	Move the file pointer
s = stat(name, &buf)	Get a file's status information

Types of System Call

Directory and file system management

Call	Description
s = mkdir(name, mode)	Create a new directory
s = rmdir(name)	Remove an empty directory
s = link(name1, name2)	Create a new entry, name2, pointing to name1
s = unlink(name)	Remove a directory entry
s = mount(special, name, flag)	Mount a file system
s = umount(special)	Unmount a file system

Miscellaneous

Call	Description
s = chdir(dirname)	Change the working directory
s = chmod(name, mode)	Change a file's protection bits
s = kill(pid, signal)	Send a signal to a process
seconds = time(&seconds)	Get the elapsed time since Jan. 1, 1970

System Calls Vs API Call

- Processes in a system runs in different modes, process running in user mode have no access to the privileged instructions.
- If process want perform any privileged instruction or need of any services they request kernel for that service through **System Calls**.
- API is generic term used to identify the functions exposed by any libraries.
- These functions are implemented as part of libraries, or SDK.
- System call is when you call the kernel, whereas a System API are used to invoke system call.

Homework

Case Study 2: Diagrammatically draw and explain steps involved in making a system call.

Thank You