UCS1402 Operating Systems

Operating Systems Overview

Unit-I

Lecture -1

Session Objectives

- To describe the basic organization of computer systems
- To provide an overview of the major components of operating systems

Session Outcomes

At the end of this session, participants will be able to

- Discuss structure and functions of OS

Agenda

Presentation Outline

Operating System

- A program that acts as an intermediary between a user of a computer and the computer hardware
- Operating system helps to:
  - Execute user programs and make solving user problems easier
  - Make the computer system convenient to use
  - Use the computer hardware in an efficient manner

Goals of an Operating System

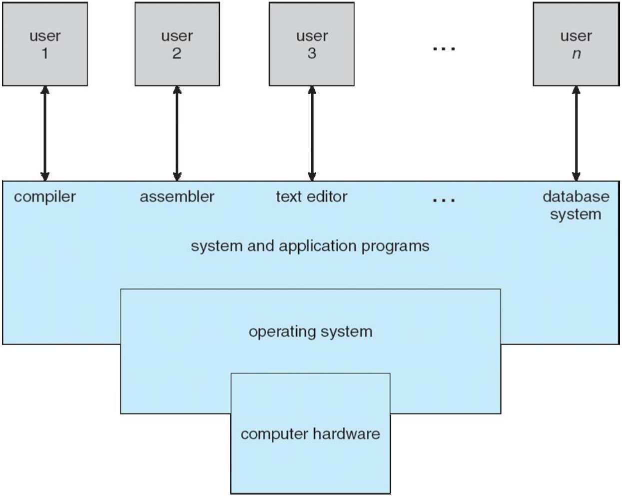
- Simplify the execution of user programs and make solving user problems easier.
- Use computer hardware efficiently.
- Allow sharing of hardware and software resources.
- Make application software portable and versatile.
- Provide isolation, security and protection among user programs.
- Improve overall system reliability error confinement, fault tolerance, reconfiguration.

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

Four Components of a Computer System



Operating System Definition

- 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
- **Definition**: "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 Startup

Bootstrap program is loaded at power-up or reboot

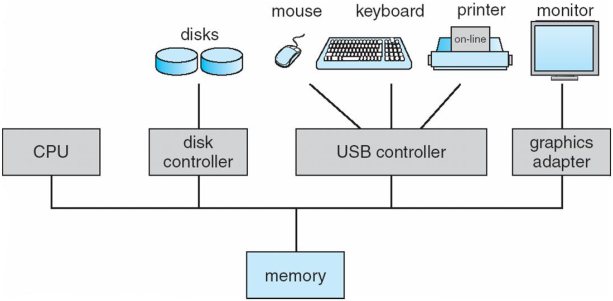
- Typically stored in ROM or EPROM, generally known as firmware
- Initializes all aspects of system
- Loads operating system kernel and starts execution

Presentation Outline

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
- 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**

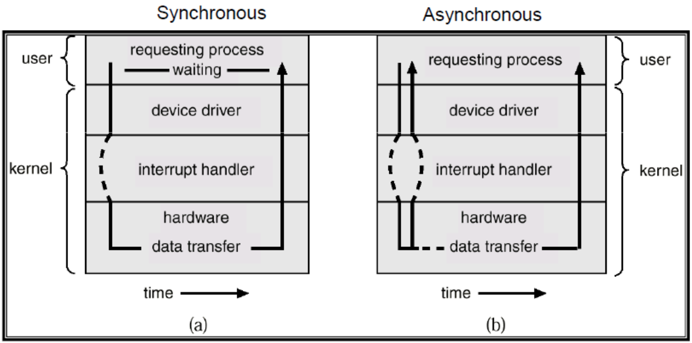
Common Functions of Interrupts

- 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**

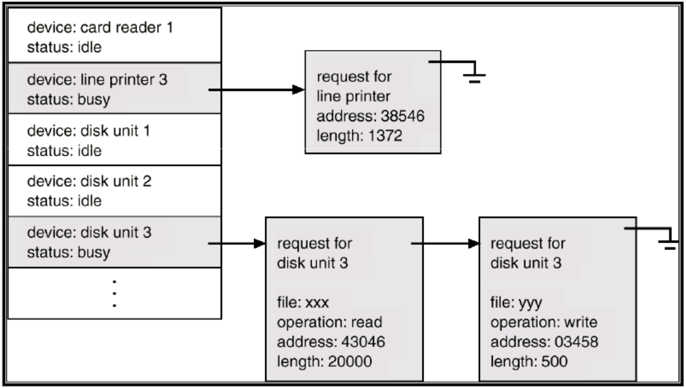
I/O Structure

- **Synchronous I/O**: 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
- **Asynchronous I/O**: 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

Two I/O Methods



Device-Status Table



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 one interrupt per byte

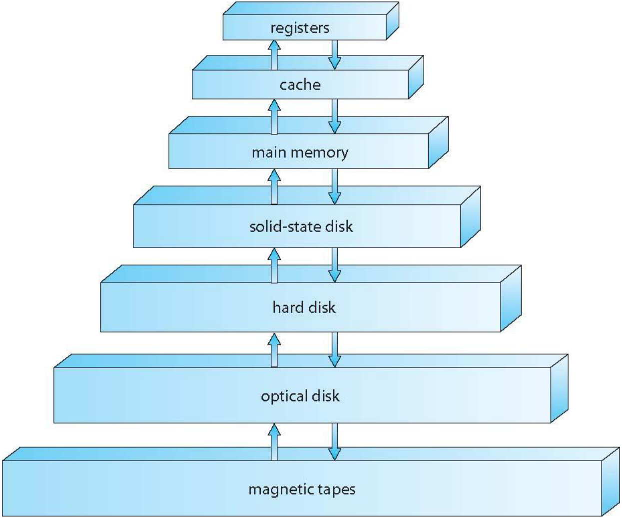
Storage Structure

- **Main memory** only large storage media that the CPU can access directly
  Typically **volatile**
- **Secondary storage** extension of main memory that provides large **non-volatile** 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, non-volatile
  Various technologies
  Becoming more popular

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

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

Evolution of OS

- Mainframe Systems
  - Batch Systems
  - Multiprogrammed Systems
  - Time sharing Systems
- Desktop Systems
- Multiprocessor Systems
- Distributed Systems
  - Client Server systems
  - Peer-to-Peer systems
- Clustered Systems
- Real-Time Systems
- Hand Held Systems

Evolution of OS

Mainframe Systems **Simple Batch Systems**:

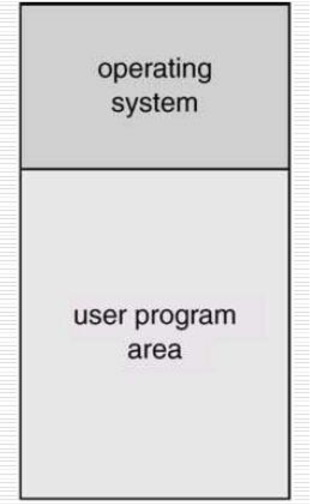
- User prepare a job and submit it to a computer operator, get output some time later
- No interaction between the user and the computer system
- Operator batches together jobs with similar needs to speedup processing

  Task of OS: automatically transfers control from one job to another.
- OS always resident in memory

Disadvantages of one job at a time:

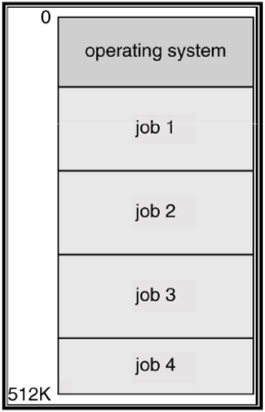
- CPU idle during I/O
- I/O devices idle when CPU busy
- OS is a resident monitor
  - initial control in monitor
  - control transfers to job
  - when job completes control transfers back to monitor

Memory Layout for a Simple Batch System



Multiprogrammed Batch Systems

- Several jobs are kept in main memory at the same time, and the
- CPU is multiplexed among them



OS Features in a Multiprogrammed System

- OS made decisions for users.
- **Job Scheduling**
  - Choose the jobs from the job pool to be loaded into Memory
- **CPU Scheduling**
  - Choosing the job to be run from a list of jobs ready to run at the same time.

Time-Sharing SystemsInteractive Computing

- Logical extension of Multiprogramming
- CPU executes multiple jobs by switching but the switching occurs so fast, that the user can interact with the program.
- Supports multiple users little CPU time for every
- User- illusion that the system is dedicated to a single user.
- **Process: program in execution**

Time-Sharing Systems

- Interactive (action/response)
  - when OS finishes execution of one command, it seeks the next control statement from user.
  - Eg: Switches jobs, when the current job needs input from the user who is slow.
- File systems
  - Resides on a collection of disks disk mgmt is necessary.
  - Virtual memory
  - Job is swapped in and out of memory to disk.

Desktop Systems

- Personal computers computer system **dedicated to a single user**.
- I/O devices keyboards, mouse, display screens, small printers.
- Single user systems may not need advanced CPU and peripheral utilization.
- So concentrates on **user convenience and responsiveness**.
- Due to the growth of intranets and internets, file protection feature was adopted.
- May run several different types of operating systems (**Windows, MacOS, UNIX, Linux**)

Multiprocessor Systems

- Also known as parallel systems or tightly coupled systems
- More than one processor in close communication, sharing computer bus, clock, memory, and usually peripheral devices
- Communication usually takes place through the shared memory.

Advantages

- **Increased throughput**
- Economy of scale: **cheaper** than multiple single-processor systems
- Increased reliability: **graceful degradation**, fault tolerant

Multiprocessor Systems

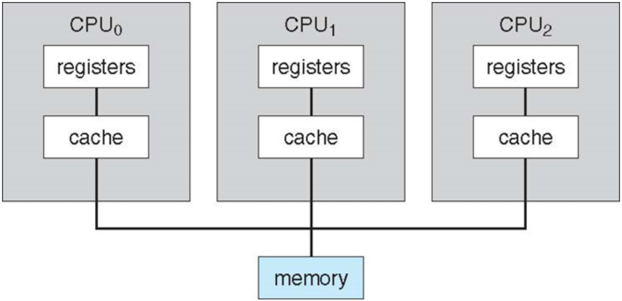
Symmetric multiprocessing (SMP)

- Each processor runs an identical copy of the operating system.
- All processors are peers: any processor can work on any task
- OS can distribute load evenly over the processors.
- Most modern operating systems support SMP

Asymmetric multiprocessing

- Master-slave relationship: a master processor controls the system, assigns works to other processors
- Each processor is assigned a specific task. Don't have the flexibility to assign processes to the least loaded CPU
- More common in extremely large systems

Symmetric Multiprocessing Architecture



Distributed Systems

- Based on the concept of networking
- Distribute the computation among several physical processors.
- **Loosely coupled system** each processor has its own local memory; processors communicate with one another through various communications lines, such as high-speed buses or telephone lines.

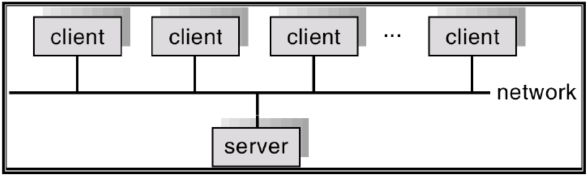
Advantages of distributed systems

- Resource Sharing
- Computation speed up load sharing
- Reliability

Distributed Systems

- Requires networking infrastructure.
- Local area networks (LAN) or Wide area networks (WAN)
- Two types:
  - client-server
  - Compute severs
  - File-servers
- peer-to-peer systems.

General Structure of Client-Server



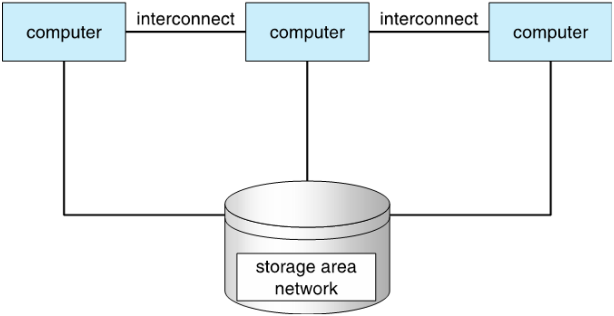
Clustered Systems

- Multiple CPUs to accomplish work but two or more systems are coupled together.
- Provides high reliability.
- **Asymmetric clustering:** one server runs the application while the other server is in hot standby mode monitoring.
- **Symmetric clustering:** all N hosts are running the application and monitoring each other.

Clustered Systems

- Like multiprocessor systems, but multiple systems working together
- Usually sharing storage via a storage-area network (SAN)
- Provides a high-availability service which survives failures
  - Asymmetric clustering has one machine in hot-standby mode
  - Symmetric clustering has multiple nodes running applications, monitoring each other
- Some clusters are for high-performance computing (HPC) Applications must be written to use parallelization
- Some have distributed lock manager (DLM) to avoid conflicting operations

Clustered Systems



Presentation Outline

Operating System Structure

- Multiprogramming (Batch system) needed for efficiency
  - Single user cannot keep CPU and I/O devices busy at all times
  - 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 it has to wait (for I/O), OS switches to another job
- Timesharing (multitasking) is logical extension where 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
  - 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

Presentation Outline

Operating-System Operations

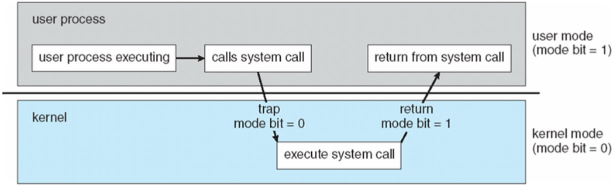
- Interrupt driven (hardware and software)
- Hardware interrupt by one of the devices
    - Software interrupt (exception or trap):
    - Software error (e.g., division by zero)
    - Request for operating system service
    - Other process problems include infinite loop, processes modifying each other or the operating system

Operating-System Operations

- 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
  - Some instructions designated as privileged, only executable in kernel mode
  - System call changes mode to kernel, return from call resets it to user
- Increasingly CPUs support multi-mode operations
- i.e. virtual machine manager (VMM) mode for guest VMs

Transition from User to Kernel Mode

- Timer to prevent infinite loop / 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



Summary

- What is an Operating Systems
- Computer-System Organization - components
- Computer-System Architecture Evolution of OS
- Operating-System Structure Two modes

Check your understanding

- What are the three main purposes of an operating system?
- Which of the following instructions should be privileged?
  - Set value of timer.
  - Read the clock.
  - Clear memory.
  - Issue a trap instruction.
  - Turn off interrupts.
  - Modify entries in device-status table.
  - Switch from user to kernel mode.
  - Access I/O device.
- Some CPUs provide for more than two modes of operation. What are two possible uses of these multiple modes?