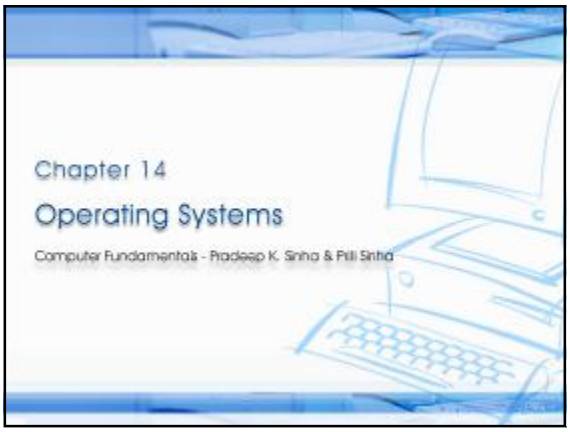


Learning Objectives

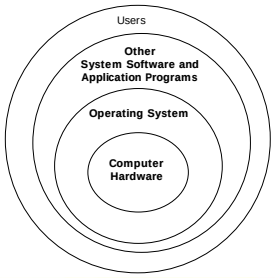
In this chapter you will learn about:

- Definition and need for operating system
- Main functions of an operating system
- Commonly used mechanisms for:
  - Process management
  - Memory management
  - File management
  - Security
  - Command interpretation module
- Some commonly used OS capability enhancement software
- Some popular operating systems

Definition and Need for OS

- Integrated set of programs that controls the resources (the CPU, memory, I/O devices, etc.) of a computer system
- Provides its users with an interface or virtual machine that is more convenient to use than the bare machine
- Two primary objectives of an OS are:
  - Making a computer system convenient to use
  - Managing the resources of a computer system

Logical Architecture of a Computer System



The operating system layer hides the details of the hardware from the programmer and provides the programmer with convenient interface for using the system

Main Functions of an OS

- Process management
- Memory management
- File management
- Security
- Command interpretation

Parameters for Measuring System Performance

- **Throughput:** Amount of work that the system is able to do per unit time
- **Turnaround time:** Interval from the time of submission of a job to the system for processing to the time of completion of the job
- **Response time:** Interval from the time of submission of a job to the system for processing to the time the first response for the job is produced by the system

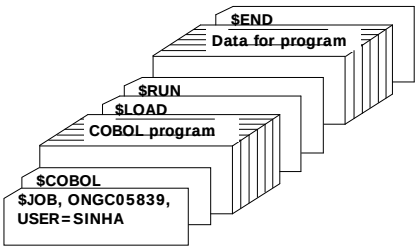
Process Management

- A process (also called job) is a program in execution
- Process management manages the processes submitted to a system in a manner to minimize *idle time* of processors (CPUs, I/O processors, etc.) of the system

Process Management Mechanisms in Early Systems

- Manual loading mechanism: Jobs were manually loaded one after another in a computer by the computer operator
- Batch processing mechanism: Batch of jobs was submitted together to the computer and job-to-job transition was done automatically by the operating system
- Job Control Language (JCL): Control statements were used to facilitate job loading and unloading

Use of Job Control Statements in Batch Processing (An Example)



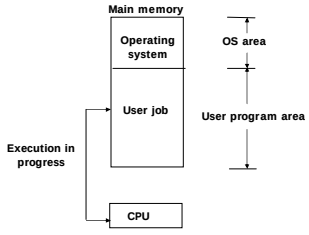
Multiprogramming

- **Uniprogramming:** Only one job is processed at a time and all system resources are available exclusively for the job until its completion
- **Multiprogramming:** Interleaved execution of two or more different and independent programs by a computer
- Types of Multiprogramming:
  - *Multiprogramming with fixed tasks (MFT)*: Fixed number of jobs can be processed concurrently
  - *Multiprogramming with variable tasks (MVT)*: Number of jobs can vary
- Area occupied by each job residing simultaneously in the main memory is known as a **memory partition**

Job

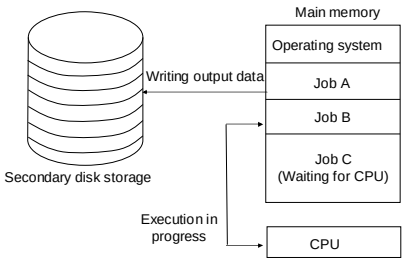
- **CPU bound:** Mostly perform computations with little I/O operations. Scientific and engineering computations usually fall in this category
- **I/O bound:** Mostly perform I/O operations with little computation. Commercial data processing applications usually fall in this category

Uniprogramming System

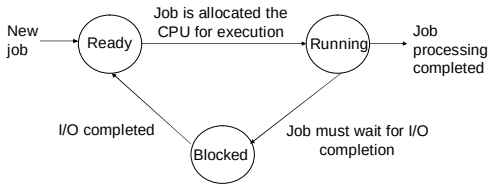


Only one job is processed by the system at a time and all the system resources are exclusively available for the job until it completes

Multiprogramming System



Process States in Multiprogramming



Requirements of Multiprogramming Systems

- **Large memory**
- **Memory protection**
- **Job status preservation**
- **Proper job mix (CPU and I/O bound jobs)**
- **CPU scheduling**

Process Control Block (PCB)

process identifier
process state
program counter
values of various CPU registers
accounting and scheduling information
I/O status information
⋮

PCB is used to preserve the job status of each loaded process in a multiprogramming system

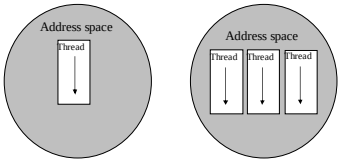
Multitasking

- Interleaved execution of multiple jobs (often referred to as *tasks* of same user) in a single-user system
- Computer systems used for multitasking are uniprocessor systems (having only one CPU)
- Treated differently from multiprogramming that refers to interleaved execution of multiple jobs in a multi-user system

Multithreading

- Thread is basic unit of CPU utilization. Threads share a CPU in the same way as processes do
- All threads of a process also share the same set of operating system resources
- All threads of a process inherit parent's address space and security parameters
- Each thread of a process has its own program counter, its own register states, and its own stack
- Referred as mini-process or lightweight process

Multithreading System

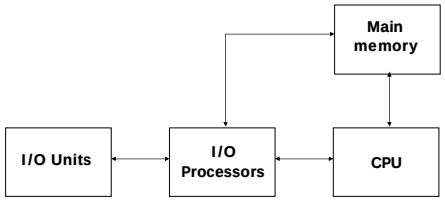


(a) Single-threaded and (b) multithreaded processes. A single-threaded process corresponds to a process of a traditional operating system. [Reproduced with permission, from the book titled Distributed Operating Systems: Concepts and Design by Pradeep K. Sinha. © 1997 IEEE, USA].

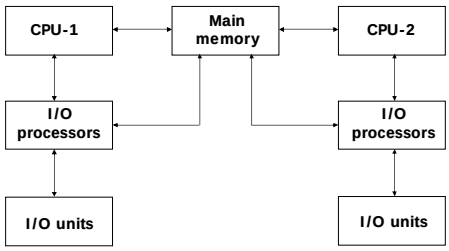
Multiprocessing

- System with two or more CPUs having ability to execute multiple processes concurrently
- Multiple CPUs are used to process either instructions from different and independent programs or different instructions from the same program simultaneously
- Types of multiprocessing:
  - *Tightly-coupled:* Single system-wide primary memory shared by all processors
  - *Loosely-coupled:* Each processor has its own local memory

CPU, Memory, and I/O Processors of a Computer System



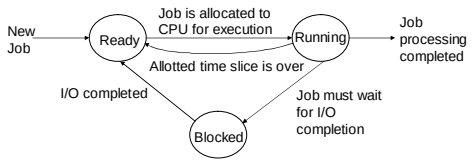
Multiprocessing System



Time-sharing

- Simultaneous interactive use of a computer system by many users in such a way that each one feels that he/she is the sole user of the system
- User terminals connected to the same computer simultaneously
- Uses multiprogramming with a special CPU scheduling algorithm
- Short period during which a user process gets to use CPU is known as time slice, time slot, or quantum
- CPU is taken away from a running process when the allotted time slice expires

Process State Diagram for a Time-Sharing System



Advantages of Time-sharing Systems

- Reduces CPU idle time
- Provides advantages of quick response time
- Offers good computing facility to small users

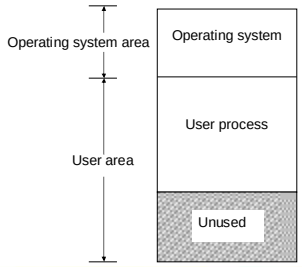
Memory Management

- Memory is important resource of a computer system that must be properly managed for the overall system performance
- Memory management module:
  - Keeps track of parts of memory in use and parts not in use
  - Allocates memory to processes as needed and deallocates when no longer needed

Uniprogramming Memory Model

- Used in systems that process one job only at a time, and all system resources are available exclusively for the job until it completes
- Simple and easy to implement
- Does not lead to proper utilization of the main memory as unoccupied memory space by the currently active user process remains unused
- Used only on very small or dedicated computer systems

Uniprogramming Memory Model

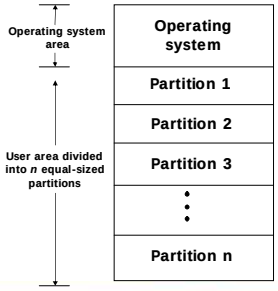


Multiprogramming Memory Models

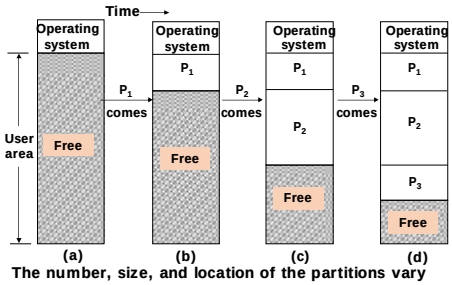
Two memory management schemes used to facilitate this are:

- ***Multiprogramming with fixed number of memory partitions*: User area of the memory is divided into a number of fixed-sized partitions**
- ***Multiprogramming with variable number of memory partitions*: Number, size and location of the partitions vary dynamically as processes come and go**

Multiprogramming with Fixed Number of Memory Partition

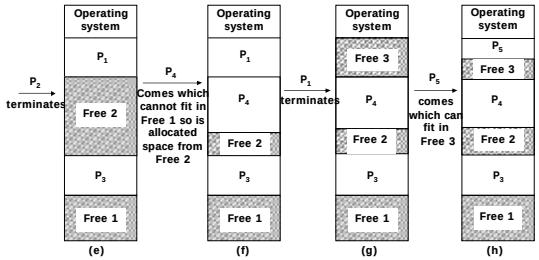


Multiprogramming with Variable Number of Memory Partitions



The number, size, and location of the partitions vary dynamically as processes come and go. (contd...)

Multiprogramming with Variable Number of Memory Partitions



The number, size, and location of the partitions vary dynamically as processes come and go.

Virtual Memory

Memory management scheme that allows execution of processes that might not be completely loaded in the main memory.

It does not require the entire process to be in memory before the process can execute

Virtual Memory Realization

Three basic concepts used for its realization are:

- **On-line secondary storage:** Used to keep a process's address space ready to be loaded into the memory
- **Swapping:** Process of transferring a block of data from the on-line secondary storage to main memory (swapping in) or vice-versa (swapping out)
- **Demand paging:** Scheme of swapping in of pages of a process as and when needed during execution of the process, rather than loading all the pages before starting the process's execution

Advantages of Virtual Memory

- Provides a large virtual memory to programmers on a system having smaller physical memory
- Enables execution of a process on a system whose main memory size is less than the total memory required by the process
- Enables a process's execution to be started even when sufficient free memory for loading the entire process is not available
- Makes programming easier there no longer need to worry about the memory size limitations
- Often leads to less I/O activity resulting in better throughput, turnaround time, and response time

Disadvantages of Virtual Memory

- Difficult to implement because it requires algorithms to support demand paging
- If used carelessly, it may substantially decrease performance due to high page fault rate

File Management

- A file is a collection of related information
- Every file has a name, its data and attributes
- File's name uniquely identifies it in the system and is used by its users to access it
- File's data is its contents
- File's attributes contain information such as date & time of its creation, date & time of last access, date & time of last update, its current size, its protection features, etc.
- File management module of an operating system takes care of file-related activities such as structuring, accessing, naming, sharing, and protection of files

File Access Methods

Two commonly supported file access methods are:

- Sequential access: Information stored in a file can be accessed sequentially (in the order in which they are stored, starting at the beginning)
- Random access: Information stored in a file can be accessed randomly irrespective of the order in which the bytes or records are stored

File Operations

- Set of commands provided by an operating system to deal with files and their contents
- Typical file operations include create, delete, open, close, read, write, seek, get attributes, set attributes, rename, and copy

File Naming

File naming deals with the rules for naming files in an operating system. This may include such rules as:

- Maximum number of characters that a file name may have
- Special characters allowed in a file name
- Distinction between upper case and lower case letters
- Multi-part file names allow file extensions to be part of a file name. File extensions indicate something about the file and its content
- Used by applications to check for the intended type of file before operating on it

File Extensions (Example)

File extension	Its meaning
.bas	Basic source program file
.c	C source program file
.ftn	Fortran source program file
.pas	Pascal source program file
.obj	Object file (compiler output, not yet linked)
.bin	Executable binary program file
.lib	Library of .obj files used by the linker
.dat	Data file
.hlp	Text file for HELP command
.man	Online manual page file

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File Extensions (Example)

(Continued from previous slide)

File extension	Its meaning
.man	Online manual page file
.txt	General text file
.bak	Backup file
.doc	Microsoft word document file
.wav	Microsoft windows sound file
.wk4	Lotus 1-2-3 spreadsheet file
.xls	Microsoft Excel spreadsheet file
.jpg	JPEG graphics file
.gif	GIF graphics file

Security

- Deals with protecting the various resources and information of a computer system against destruction and unauthorized access
- **External security:** Deals with securing computer against external factors such as fires, floods, earthquakes, stolen disks/tapes, etc. by maintaining adequate backup, using security guards, allowing access to sensitive information to only trusted employees/users, etc.
- **Internal security:** Deals with user authentication, access control, and cryptography mechanisms

Security

- **User authentication:** Deals with the problem of verifying the identity of a user (person or program) before permitting access to the requested resource
- **Access Control:** Once authenticated, access control mechanisms prohibit a user/process from accessing those resources/information that he/she/it is not authorized to access
- **Cryptography:** Means of encrypting private information so that unauthorized access cannot use information

Command Interpretation

- Provides a set of commands using which the user can give instructions to the computer for getting some job done by it
- Commands supported by the command interpretation module are known as system calls

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Command Interpretation

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Two types of user interfaces supported by various operating systems are:

- **Command-line interface:** User gives instructions to the computer by typing the commands
- **Graphical User Interface (GUI):** User gives commands to the system by selecting icon or menu item displayed on the screen with the use of a point-and-draw device

OS Capability Enhancement Software

- Perform several tasks of routine nature, frequently needed by users but are not provided as part of the OS
- They are primarily grouped into three categories:
  - **Translating programs:** Translate a source program into an object program
  - **Library programs:** Consist of frequently used functions and operations
  - **Utility programs:** Assist users with system maintenance tasks such as disk formatting, data compression, data backups, antivirus utilities

UNIX OS

- Developed in the early 1970s at Bell Laboratories by Ken Thompson and Dennis Ritchie
- Written in C high-level language, hence, highly portable
- Multi-user, time-sharing OS
- Used on a wide variety of computers ranging from notebook computers to super computers
- Especially prevalent on RISC workstations such as those from Sun Microsystems, Hewlett-Packard, IBM, and Silicon Graphics
- Structured in three layers – kernel, shell, and utilities

MS-DOS

- Stands for Microsoft Disk Operating System.
- Single-user OS for IBM and IBM-compatible personal computers (PC)
- Structured in three layers – BIOS (Basic Input Output System), kernel, and shell
- Very popular in the 1980s, now not in much use and development with the launch of Microsoft Windows OS in 1990s

Microsoft Windows

- Developed by Microsoft to overcome limitations of MS-DOS operating system
- Single-user, multitasking OS
- Native interface is a GUI
- Designed to be not just an OS but also a complete operating environment
- OS of choice for most PCs after 1990

Microsoft Windows NT

- Multi-user, time-sharing OS developed by Microsoft
- Designed to have UNIX-like features so that it can be used for powerful workstations, network, and database servers
- Supports multiprogramming and is designed to take advantage of multiprocessing on systems having multiple processors
- Native interface is a GUI
- Built-in networking and communications features
- Provides strict system security
- Rich set of tools for software development

Linux

- Open-source OS enhanced and backed by thousands of programmers world-wide
- Multi-tasking, multiprocessing OS, originally designed to be used in PCs
- Name "Linux" is derived from its inventor Linus Torvalds
- Several Linux distributions available (Red Hat, SuSE). Difference in distribution is mostly set of tools, number and quality of applications, documentation, support, and service

Keywords / Phrases

- Access control
- Batch processing
- Command interpretation
- Command-line interface (CLI)
- CPU-bound jobs
- Cryptography
- Demand paging
- External security
- File
- File attributes
- File extensions
- File management
- Graphical User Interface (GUI)
- I/O-bound jobs
- Internal security
- Job control language (JCL)
- Library programs
- Linux
- Loosely coupled system
- Memory management
- Memory partition
- Microsoft Windows
- Microsoft Windows NT
- MS-DOS
- Multiprocessing
- Multiprogramming
- Multiprogramming with fixed tasks (MFT)
- Multiprogramming with variable tasks (MVT)
- Operating systems
- Multithreading
- Process
- Process Control Block (PCB) Multitasking
- Process management
- Random access files
- Response time
- Security
- Sequential access files
- Swapping

(Continued on next slide)

Keywords / Phrases

(Continued from previous slide)

- Throughput
- Tightly coupled system
- Time-sharing
- Time slice
- Time slot
- Translating programs
- Turnaround time
- Unix
- User authentication
- Utility programs
- Virtual machine
- Virtual memory