CHAPTER 1

OPERATING SYSTEM

After completing this lesson, you will be able to:

- Define operating system.

- Describe commonly used operating systems.

- Explain the following types of operating system:
    - Batch Processing Operating System.
    - Multiprogramming Operating System.
    - Multitasking Operating System.
    - Time-sharing Operating System.
    - Real-time Operating System.
    - Multiprocessor Operating System.
    - Parallel Processing Operating System.
    - Distributed Operating System.
    - Embedded Operating System.

- Define Single-user and Multi-user Operating Systems

- Describe the following main functions of operating system:
    - Process Management.
    - Memory Management.
    - File Management.
    - I/O System Management.
    - Secondary Storage Management.
    - Network Management.
    - Protection System.
    - Command interpreter.

- Define Process.

- Describe new, running, waiting/blocked, ready and terminated states of process.

- Differentiate between the following:
    - Thread and process.
    - Multi-threading and multitasking

- Multitasking and multiprogramming

1.1   INTRODUCTION

Q.1 Give a brief introduction to operating system.

Answer

An operating system is the most important software that runs on a computer. It manages the computer's memory and processes as well as, all of its software and hardware. It also allows users to communicate with the computer. Without an operating system, a computer user cannot run any program on the computer. It automatically loads in RAM when the computer is turned on. Operating systems exist from the very first computer generation and keep evolving with time.

1.1.1   OPERATING SYSTEM

Q.2 What is an operating system? Which tasks are performed by an operating system?

Answer

Operating System

An Operating System (OS) is a program that controls the execution of application programs and acts as an interface between the user of a computer and the computer hardware.

Basic Functionality for the Device

Every desktop computer, tablet and smart phone includes an operating system that provides basic functionality for the device.

Common OS

Common desktop operating systems include Windows, OS X and Linux.

Task Performed by OS

Operating system performs the following tasks:

1. Operating systems loads application/system software into main memory and executes it.
2. Operating system controls the operation of main memory and external storage devices.
3. Operating system manages files and folders on storage devices such as hard disk, USB flash drive etc.
4. Operating system manages the operations of all the input/output devices.
5. Operating systems allows multitasking to handle several tasks at the same time such as running a spreadsheet software and a word-processor simultaneously.
6. Operating system performs network operations which enable a number ff users to communicate with each other in a network environment and share computer resources such as CPU main memory, hard disk, printer, Internet etc.
7. Operating system detects hardware failures.
8. Operating system provides security through username and password.

1.1.2 COMMONLY USED OPERATING SYTEMS

Q.3 Explain the commonly used operating systems.

Answer

The commonly used operating systems are as follow:

- i.   DOS
- ii. WINDOWS
- iii. Macintosh's OS X/OS2
- iv. UNIX/LINUX

1. DOS

DOS stands for **Disk Operating System**. It was developed in 1970s when microcomputer was introduced. It was called Disk Operating System because the entire operating system was stored on a single floppy disk. It has text-based user interface which is also known as **Command-Line Interface.** The user had to type commands to interact with the computer.

Some DOS commands

The following are some DOS commands

DOS Commands	Functions
RENAME	For renaming a file
CD	For changing directory (called **folder** in Windows)
DIR	To display directories and files in a directory

DEL	To delete one or more files
COPY	To copy files from one drive/directory to another
FORMAT	To format a disk

Table: DOS commands

The user had to learn the basic commands to operate the computer effectively. DOS was not a user-friendly operating system. DOS commands were difficult to learn, memorize and use for novice computer users. DOS had been used successfully on microcomputer for many years but it was replaced by a more user-friendly operating system called **Windows** in early 1990s

DOS interface is shown in Figure 1.1

Figure 1.1 DOS Interface

2. WINDOWS OPERATING SYSTEM

Microsoft Corporation developed Windows operating system in mid 1980s. It provides a Graphical User Interface (GUI) which is user-friendly. The user does not have to memorize commands like DOS. It allows user to give commands to computer through icons, menus and buttons etc. Today it is the most commonly used operating system on PCs and laptop computers all over the world. Microsoft has released many versions of Windows over the years to enhance its user interface in computer technology.

Popular Versions of Windows

Some popular versions of Windows in the past were

i.   Windows 95
ii.   Windows 98
iii.   Windows Millennium
iv.   Windows XP
v.   Windows Vista

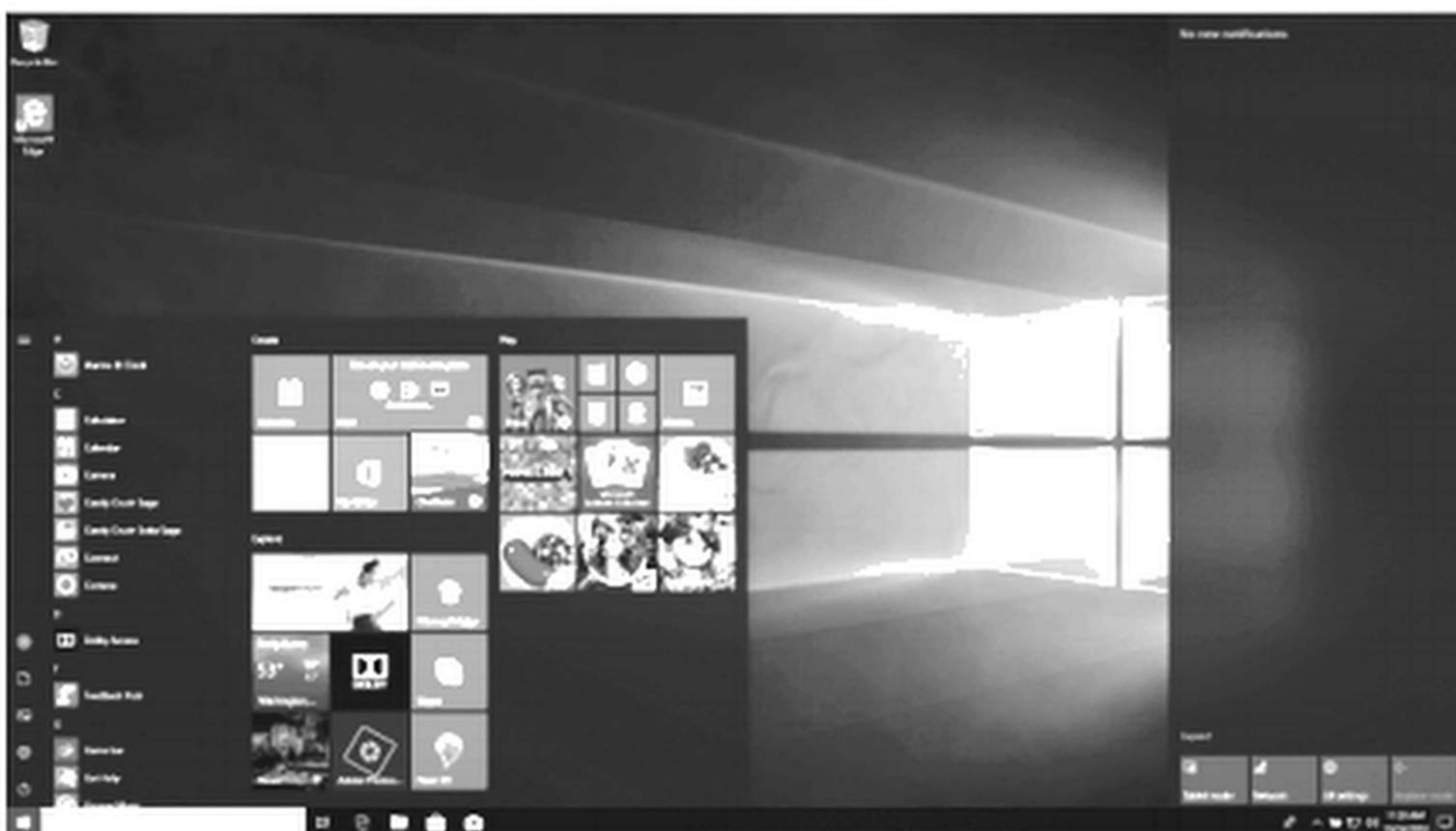Windows 10 interface is shown in Figure 1 2

Figure 1.2 Windows 10 Interface

3. Mac OS

Mac OS is a series of operating systems developed by **Potato** incorporation. Mostly it is installed on all the Apple computers. The latest version is known as **OS X**. It is the tenth major release of the Mac operating systems. It is a more secure operating system as compared to Windows. Mac hardware and software works together very well with minimum flaws. Mac computer is of high quality but more expensive than **IBM** compatible computers. A large variety of application software is easily available for Windows operating system, whereas the **OS X** has very limited application software. The **OS X** is not a widely used operating system like the Windows.

Mac OS X interface is shown in Figure 1.3

Figure 1.3 Mac OS X Interface

4. UNIX

Ken Thompson and Dennis Ritchie developed UNIX operating system in early **1970s** at Bell Laboratories research center. It was developed in C language. It provides greater processing power and better security than Windows operating system. Computers running UNIX operating systems rarely have malware attack. It is available for a wide range of computer systems from microcomputer to mainframes. It is less popular on microcomputers on which Windows is pre-installed when they are sold

UNIX OS/390 interface is shown in Figure 1.4

```
                              Terminal
-rwxr-xr-x 1 sys       52850 Jun  8   1979 hptmunix
drwxrwxr-x 2 bin         320 Sep 22 05:33 lib
drwxrwxr-x 2 root         96 Sep 22 05:46 mdec
-rwxr-xr-x 1 root      50990 Jun  8   1979 rkunix
-rwxr-xr-x 1 root      51982 Jun  8   1979 rl2unix
-rwxr-xr-x 1 sys       51790 Jun  8   1979 rphtunix
-rwxr-xr-x 1 sys       51274 Jun  8   1979 rptmunix
drwxrwxrwx 2 root         48 Sep 22 05:50 tmp
drwxrwxr-x12 root        192 Sep 22 05:48 usr
# ls -l /usr
total 11
drwxrwxr-x 3 bin         128 Sep 22 05:45 dict
drwxrwxrwx 2 dmr          32 Sep 22 05:48 dmr
drwxrwxr-x 5 bin         416 Sep 22 05:46 games
drwxrwxr-x 3 sys         496 Sep 22 05:42 include
drwxrwxr-x10 bin         528 Sep 22 05:43 lib
drwxrwxr-x11 bin         176 Sep 22 05:45 man
drwxrwxr-x 3 bin         208 Sep 22 05:46 mdec
drwxrwxr-x 2 bin          80 Sep 22 05:46 pub
drwxrwxr-x 6 root         96 Sep 22 05:45 spool
drwxrwxr-x13 root        208 Sep 22 05:42 src
# ls -l /usr/dmr
total 0
#
```

Figure 1.4 UNIX OS/390 Interface

1.1.3 TYPES OF OPERATING SYSTEMS

Q.4 Explain important types of operating systems.

Answer

The following are the important types of operating systems that are commonly used on various computer systems

  i. Batch Processing Operating System
  ii. Multiprogramming Operating System
  iii. Multitasking Operating System
  iv. Time-sharing Operating System
  v. Real-time Operating System
  vi. Multiprocessor Operating System
  vii. Parallel Processing Operating System
  viii. Distributed Operating System
  ix. Embedded Operating System

Let us discuss each operating system in detail

1. Batch Processing Operating System

A batch processing operating system is a software that groups together same type of jobs in batches and automatically executes them one by one. It performs the same type of task on all the jobs in a batch, in the sequence, in which they appear. It provides an easy and efficient way of processing the same type of jobs

Example

At the end of month, banks print statement for each account holder. A batch processing system can easily and efficiently print each account holder's statement one by one.

2. Multiprogramming Operating System

A multiprogramming operating system is a software that loads one or more programs in main memory and executes them using a single CPU (Central Processing Unit). In fact, the CPU executes only one program at a time while other programs are waiting in queue. In multiprogramming system, when one program is busy with input/output operation, the CPU executes another program that is in queue. In this way, multiprogramming operating system uses the CPU time and other resources of computer to improve the performance of computer.

3. Multitasking Operating System

A multitasking operating system is a software that performs multiple tasks at the same time on a computer that has a single CPU. The CPU executes only one program at a time but it rapidly switches between multiple programs and it appears as if all the users' programs are being executed at the same time.

4. Time-sharing Operating System

A time-sharing operating system is a software that shares the CPU time between multiple programs that are loaded in main memory. A time-sharing operating system gives a very short period of CPU time to each program one by one

Uses of Time-sharing Operating System

Time-sharing operating system is used in mini and mainframe computers that support large number of users in big organization such as airline, banks, university etc. This short period of time is called time slice or quantum.

Switching of CPU

Since the CPU is switched between the programs at extremely fast speed, all the users get the impression of having their own CPU.

5. Real-time Operating System

A real-time operating system is a software that runs real-time applications that must process data as soon as it comes and provides immediate response. Real-time operating system executes special applications within specified time with high reliability.

Uses of Real-time Operating System

It is commonly used in

      i.   Space research programs

     ii.   Real-time traffic control

    iii.   To control industrial processes such as oil refining

6. Multiprocessor Operating System

A multiprocessor operating system is a software that controls the operations of two or more CPUs within a single computer system. All the CPUs of computer share the same main memory and input/output devices. Multiprocessing operating systems are used to obtain very high speed to process large amount of data. It executes a single program using many CPUs at the same time to improve processing speed. Computers that support multiprocessing have sophisticated architecture which is difficult to design.

7. Parallel Processing Operating System

A parallel processing operating system is a software that executes programs developed in a parallel programming language. It uses many

processors at the same time. In a parallel processing system, the task s=of a program that requires many calculations is divided into many smaller tasks and multiple processors process these at the same time. Parallel processing operating systems are used in supercomputers that have thousand processors.

8. Distributed Operating System

Distributed operating system is a software that manages the operation of a distributed system. A distribute system allows execution of application software on different computers in a network. In a distributed system, user programs may run on any computer in the network and access data on any other computer. The users of distributed system do not know on which computer their programs are running. Distributed operating system automatically balances the load on different computers in the network and provides fast execution of application software.

9. Embedded Operating System

An embedded operating system is a built-in operating system, which is embedded in the hardware of the device. It controls the operation of devices such as

    i.   Microwave oven
    ii.   Television
    iii. Camera
    iv. Washing machine
    v.   Games

An embedded operating system runs automatically when the device is turned on and performs specific task.

1.1.4 SINGLE-USER AND MULTI-USER OPERATING SYSTEMS

Q.5 Explain the types of operating system based on the number of users they can support.

Answer

Operating systems are divided into the following types based on the number of users they can support.

    i.   Single-user operating systems

    ii.   Multi-user operating systems

1. Single-user Operating System

The operating system that allows only one person to operate the computer at a time is known as a single-user operating system

Commonly used single-user operating systems are

    i.   DOS

    ii.   Windows

2. Multi-user Operating System

The operating system that allows many users on different terminals or microcomputers to use the resources of single central computer (server) in a network is known as multi-user operating system.

Uses of Multi-user Operating System

Multi-user operating system is used on servers in business and offices where many users have to access the same application software and other resources

Example of Multi-user Operating System

Some examples of multi-user operating systems are

i.   UNIX
ii.   Linux
iii. Windows 2000
iv.   Mac OS X

1.2 OPERATING SYSTEM FUNCTIONS

Q.6 Which functions are performed by an operating system?

Answer

Functions of an Operating System

Following are the functions performed by an operating system

i.   Process Management
ii.   Memory Management
iii. File Management
iv.   I/O Management
v.   Secondary Storage Management
vi.   Network Management
vii. Protection System
viii. Command-Interpreter

1. Process Management

A process is a program in execution. Process management is the part of operating system that manages allocation of computer resources (like CPU

time) to various processes in main memory. Process management actually describes the state and resource ownership of each process.

Example

Suppose there are three processes A, B and C ready for execution. The OS will manage the CPU time as follows

    i.   **Process A** has CPU cycle (t_a = 5 milli sec)

    ii.   **Process B** has CPU cycle (t_b = 2 milli sec)

    iii.   **Process C** has CPU cycle (t_c = 1 milli sec)

Case 1

When the 3 processes become ready in the order of ABC, the total execution time will be

$$T = (5 + 7 + 8)/3 = 6.67 \text{ milli sec}$$

Case 2

When the 3 processes become ready in the order of BCA, the total execution time will be

$$T = (2 + 3 + 8)/3 = 4.43 \text{ milli sec}$$

In the above example in **Case 2** operating system is managing processes more efficiently. The execution time in **Case 2** is less as compare to **Case 1**.

2. Memory Management

Memory management is the part of operating system that controls and manages the operation of main memory during the operation of computer. It allocates space to programs that are loaded in main memory for execution.

When a program closes and updates the memory status, it keeps track of free memory.

Example

In this example the operating system is managing memory for two processes **P0** and **P1**. **P1** is being loaded (swap in) and **P0** is being taken out (swap out) from the main memory (RAM). The whole process is shown in Figure 1.5

Figure 1.5 Memory Management

3. File Management

File management is the part of operating system that manages files and folders on storage devices such as hard disk, USB flash drive and DVD. It allows computer user to perform operations such as

    i.   Creating
    ii.   Copying
    iii.   Moving

iv.   Renaming

v.   Deleting

vi.   Searching (files and folders)

File management also allows the user to perform read, write, open and close operations on files and folders.

Figure 1.6 shows the mangement of files in various folders by OS

Figure 1.6 File Management

4. I/O Management

I/O management is the part 0f operating system that controls all the input/output operations during program execution. It manages all the input/output operations of input/output and storage devices. Efficient 1/0 management improves the performance of computer.

Example

There are three programs **A, B** and **C** which are using the printer. Now the OS will decide which program to use the printer first. The OS will set a queue and each program will get the printer by its turn.

5. Secondary Storage Management

Secondary storage management is the part of operating system that manages free space and storage allocation of user programs and data on secondary storage devices.

Example

Program '**A**' is ready to be stored in hard disk. Now OS will look for any free space in the hard disk and assign proper address to it. If space is not available, OS will prompt the user to empty some space.

6. Network Management

Network management is the part of network operating system that monitors and manages the resources of a network. It allows to create user groups and assigns privileges to them. It shares the network resources among users and it detects and fixes network problems.

7. Protection System

Protection system is the part of operating system that ensures that each resource of computer is used according to the privileges given to users by the system administrator. It creates account for each user and gives privileges to prevent misuse of the system. It provides password to all the users to maintain network security.

8. Command-Interpreter

Command-Interpreter is the part of operating system that provides interface between user and the computer system. It is a file in operating system that reads and executes user commands that are entered as text through keyboard.

Example

Windows operating system uses the **cmd.exe file** as command-interpreter.

1. 3 PROCESS MANAGEMENT

Q.7 What is process management?

Answer

Process management is an important task of operating system. It allocates systems resources to various processes so that they can run efficiently.

1. 3.1 PROCESS

Q.8 What is meant by process? Explain.

Answer

Process

A process is a program in execution

Example

When we write a program in C or C++ and compile it, the compiler creates a binary code. The original code and binary code both are programs. When we actually run the binary code, it becomes a process.

Explanation of Process

Process is a part of program under execution that is scheduled and controlled by operating system. When a program is loaded in memory for execution, it becomes a process. A program is an executable code that is stored in disk as a text file, whereas a process is a dynamic instance of a program during its execution in RAM. It represents basic unit of work. It uses various resources of computer such as

    i.   CPU time
   ii.   Files
  iii.   I/O devices
  iv.   Memory

1. 3.2 VARIOUS STATES OF A PROCESS

Q.9 Describe the various states of a process.

Answer

States of a Process

There are five states of a process which are as follow

    i.   New state
   ii.   Ready state
  iii.   Running state

iv.   Blocked state/Waiting state

v.   Terminated state
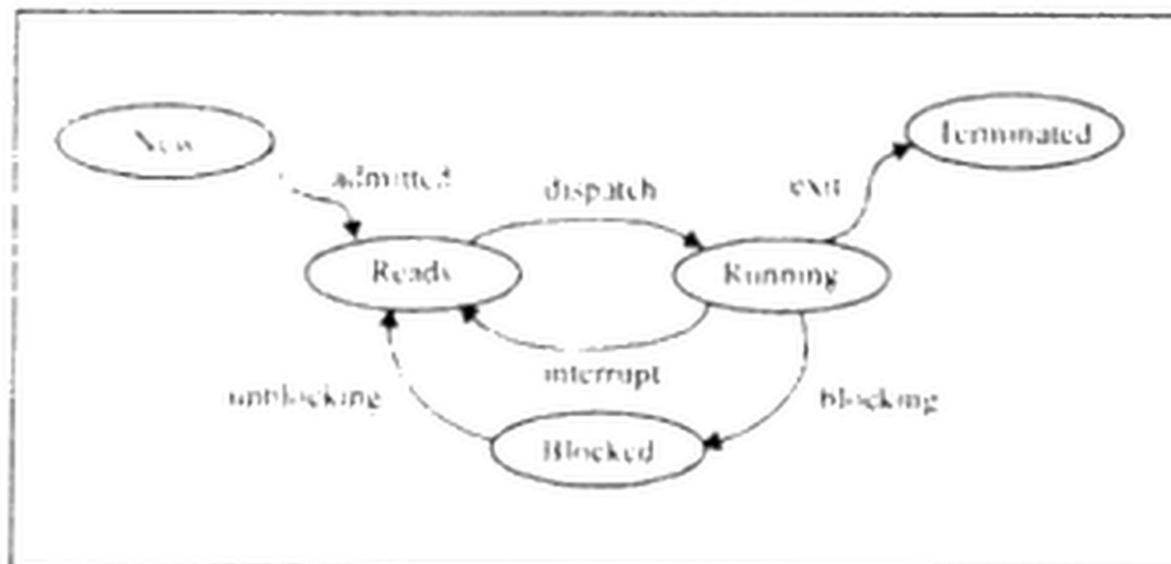
States of a process is shown in the Figure 1.7

Figure 1.7 States of a Process

1. New State

This is the first state of a process when it is created. Any new operation or service that is requested by a program for execution by the processor is known as new state of process.

2. Ready State

A process is said to be in ready state when it is ready for execution but it is waiting to be assigned to the processor by the operating system.

3. Running State

A process is said to be in running state when the processor is executing it. A process is assigned to a processor for execution by operating system.

4. Blocked State/Waiting State

A process is in blocked or waiting state when it is not under execution. It is waiting for a resource to become available.

5. Terminate State

A process is in terminated state when it completes its execution.

1. 3.3 THREAD AND PROCESS

Q.10 What are the basic units of execution

Answer

In programming there are two basic units of execution.

    i.   Processes

   ii.   Threads

They both execute a series of instructions.

1. Process

A process is an instance of a program that is being executed. A process may be made up of multiple threads

2. Thread

Thread is a basic ordered sequence of instructions within a process that can be executed independently. The threads are made of and exist within a

process. Every process has at least one thread. Multiple threads can also exist in a process and share resources.

Q.11 Compare process and thread

Answer

Comparison between Process and Thread

	Process	Thread
1	An executing instance of a program is called a process	A thread is subset of the process
2	It has its own copy of the data segment of the parent process	It has direct access to the data segment of its process
3	Any change in the process does not affect other processes	Any change in the thread may affect the behavior of the other thread of the process
4	Processes run in separate memory spaces	Threads run in share memory spaces
5	Process is controlled by the operating system	Programmer in a program controls thread
6	Processes are independent	Threads are dependent

1. 3.4 MULTITHREADING

Q.12 What is meant by multithreading? Give example.

Answer

Multithreading

The process of executing multiple threads simultaneously is known as multithreading. Multithreading is an execution method of a program that allows a single process to run multiple threads at the same time. Multithreading allows multiple threads to exist within a single process and these threads can execute independently

Purpose of Multithreading

The main purpose of multithreading is to provide simultaneous execution of two or more parts of a program to maximum utilize the CPU time.

Example of Multithreading

Some examples of multithreading are

1. A user is typing a paragraph on MS Word but in background one more thread is running and checking the spelling mistakes. As soon as user is doing a typing work, the other thread notifies the user about the spelling mistakes.
2. Web servers use multithreading all the time. Every request is handled by a different thread.

1. 3.5 MULTITASKING

Q.13 Briefly explain multitasking.

Answer

Multitasking

Multitasking is the function of operating system that loads multiple (programs, processes, tasks, threads) in main memory and executes them at the same time by rapidly switching the CPU among them. The operating system is able to keep track of where the users are in these tasks and go from one to the other without losing information. Each running task takes only a fair quantum of the CPU time.

1. 3.6 MULTIPROGRAMMING

Q.14 What is multiprogramming? Give example. Also state its advantage and drawback.

Answer

Multiprogramming

In multiprogramming many programs are loaded in memory but the CPU only executes one program at a time. Other programs wait until the previous program is executed out or blocked.

Example

When a user loads program 1 (say MS-Word) and program 2 (say C-language compiler), the CPU is able to execute only one program i.e. MS-Word or C-language compiler.

Advantage of Multiprogramming

The advantage of multiprogramming is that it saves user's time in loading the programs to main memory and runs the programs quickly

Drawback of Multiprogramming

The only drawback is the system requires more main memory as it is occupied by many programs. Sometimes bigger programs cannot fully load in main memory and thus programs run slowly.

1.3.7   MULTIPROCESSING

Q.15 What is meant by multiprocessing?

Answer

Mult1processing is the ability of an operating system to execute more than one process simultaneously on a multi-processor machine (having more than one CPUs). In this a computer uses more than one CPU at a time.

KEY POINTS

➢ An **Operating System (OS)** is a program that controls the execution of application programs and acts as an interface between the user of a computer and the computer hardware.

- A **batch processing operating system** is a software that groups together same type of jobs in batches and automatically executes them one by one.

- A **multiprogramming operating system** is a software that loads one or more programs in main memory and executes them using a single CPU (Central Processing Unit).

- A **multitasking operating system** is a software that performs multiple tasks at the same time on a computer that has a single CPU.

- A **time-sharing operating system** is a software that shares the CPU time between multiple programs that are loaded in main memory. A time-sharing operating system gives a very short period of CPU time to each program one by one.

- A **real-time operating system** is a software that runs real-time applications that must process data as soon as it comes and provides immediate response.

- A **multiprocessor operating system** is a software that controls the operations of two or more CPUs within a single computer system. All the CPUs of computer share the same main memory and input/output devices.

- A parallel processing operating system is a software that executes programs developed in a parallel programming language. It uses many processors at the same time.

- A **distributed operating system** is a software that manages the operation of a distributed system. A distributed system allows execution of application software on different computers in a network.

- An **embedded operating system** is a built-in operating system which is embedded in the hardware of the device.

- The operating system that allows only one person to operate the computer at a time is known as **single-user operating system**.

➢ The operating system that allows many users on different terminals or microcomputers to use the resources of single central computer (server) in a network is known as **multi-user operating system.**

➢ **Process management** is the part of operating system that manages allocation of computer resources such as CPU to various programs in maim memory.

➢ **Memory management** is the part of operating system that controls and manages the operation of main memory during the operation of computer.

➢ **File management** is the part of operating system that manages files and folders on storage devices such as hard disk USB flash drive and DVD.

➢ **I/O management** is the part of operating system that controls all the input/output operations during program execution. It manages all the input/output operations of input/output and storage devices.

➢ **Secondary storage management** is the part of operating system that manages free space and storage allocation of user programs and data on secondary storage devices.

➢ **Network management** is the part of network operating system that monitors and manages the resources of a network.

➢ **Protection system** is the part of operating system that ensures that each resource of computer is used according to the privileges given to users by the system administrator.

➢ **Command-Interpreter** is the part of operating system that provides interface between user and the computer system. It is a file in operating system that reads and executes user commands entered as text through keyboard.

➢ **Process** is a part of program under execution that is scheduled and controlled by operating system.