Republic of the Philippines
LAGUNA STATE POLYTECHNIC UNIVERSITY
Province of Laguna

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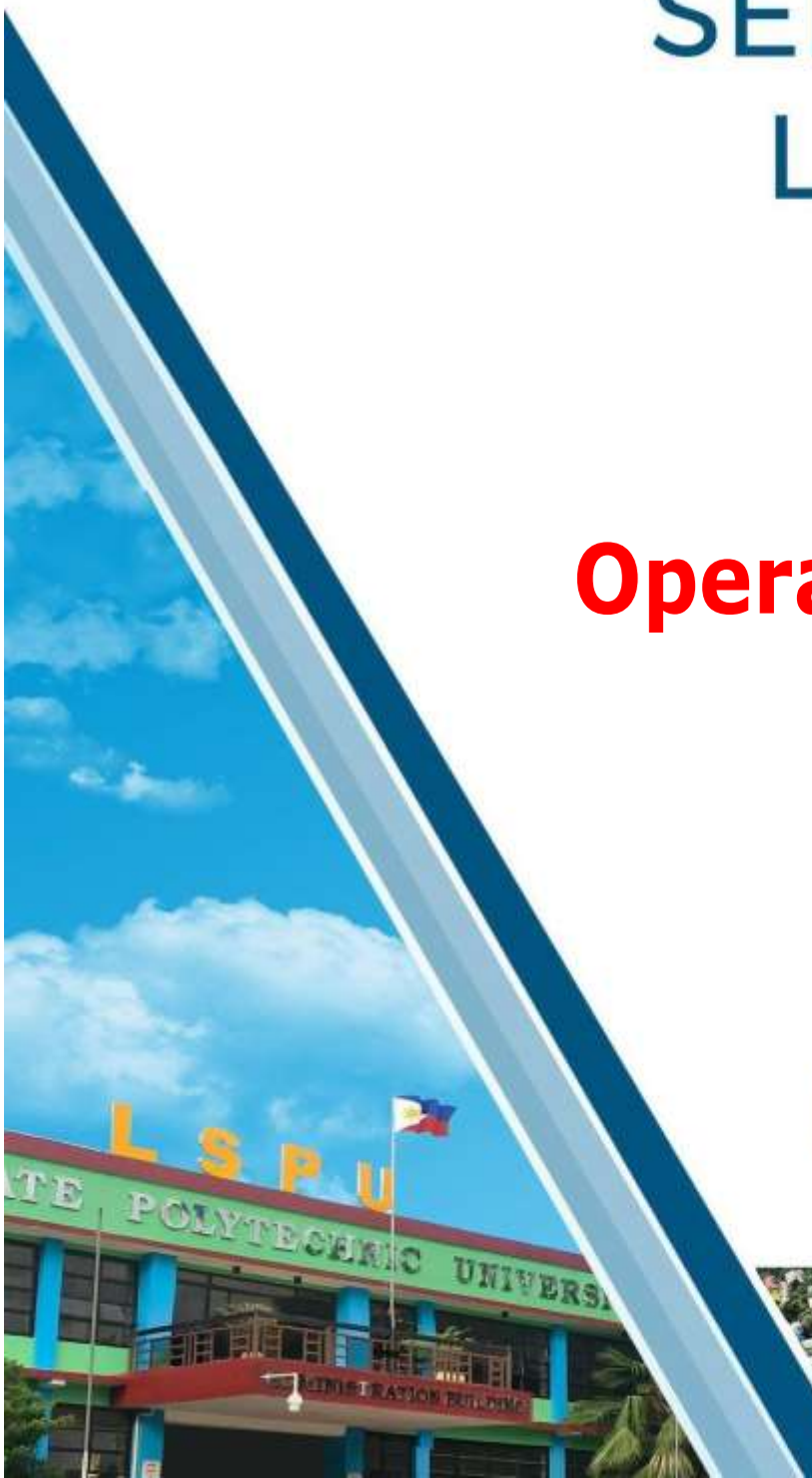
SELF-PACED LEARNING MODULE

FOR

Operating System

Module 1



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LSPU Self-Paced Learning Module (SLM)

Course	**CMSC 314- Operating System**
Sem/AY	Second Semester/2024-2025
Module No.	**1**
Lesson Title	**Introduction to Operating System**
Targets/ Objectives	At the end of the lesson, students should be able to: • Learn the important Operating System concepts. • Identify and differentiate the various typologies, as well as the features, advantages and disadvantages, of Operating Systems. • Appreciate the important role of Operating Systems in the operation of the computer system.

Module Contents

Take turns to ask and answer the following questions:

1. What is Operating System? Why it is important
2. What are the Components of Operating System?
3. What are the different types of Operating System?

Lecture Guide

Chapter 1
Operating System

Introduction

An operating system acts as an intermediary between the user of a computer and computer hardware. The purpose of an operating system is to provide an environment in which a user can execute programs conveniently and efficiently.

An operating system is a software that manages computer hardware. The hardware must provide appropriate mechanisms to ensure the correct operation of the computer system and to prevent user programs from interfering with the proper operation of the system.

Operating System

- May be defined as a computer program that acts as an intermediary or interface between the user of a computer and the computer hardware (Silberschartz, Galvin and Gagne, 2006).
- It is a set of system software routines that sits between the application programs and the hardware (Davis, Rajkumar, 2001).

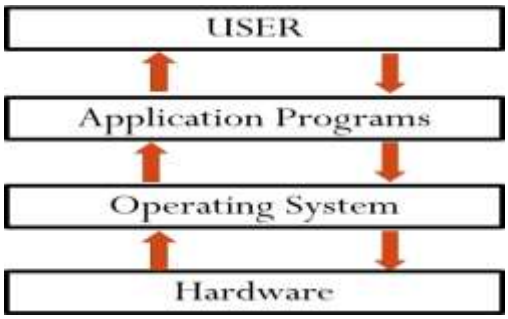

Figure 1.1 Operating System Depicted as interface between the application programs and hardware. (Adapted from Operating Systems: A systematic view by (William S. Davis and T.M. Rajkumar, 2001)

Every computer must have an operating system to run other programs. The operating system coordinates the use of the hardware among the various system programs and application programs for various users. It simply provides an environment within which other programs can do useful work.

The operating system is a set of special programs that run on a computer system that allows it to work properly. It performs basic tasks such as recognizing input from the keyboard, keeping track of files and directories on the disk, sending output to the display screen, and controlling peripheral devices.

OS is designed to serve two basic purposes:

- It controls the allocation and use of the computing System's resources among the various user and tasks.
- It provides an interface between the computer hardware and the programmer that simplifies and makes it feasible for coding, creation, debugging of application programs.

The Operating system must support the following tasks. The tasks are:

- Provides the facilities to create, modification of programs and data files using an editor.
- Access to the compiler for translating the user program from high-level language to machine language.
- Provide a loader program to move the compiled program code to the computer's memory for execution.
- Provide routines that handle the details of I/O programming.

Functions of Operating System

- According to Lister (1984), the operating system performs two unrelated functions in the computer system.

These are the following:

- Operating System as a Virtual Machine – the Operating system presents the user with an equivalent machine or virtual machine. With this, the OS hides from the user the complex and unfriendly truth about computer hardware and provides instead a nice view of named files.
- Operating System as a Resource Manager – in this view, the operating system acts as a resource allocator by managing the various parts of the computer system itself. These include various processes all competing for the processor, memory, I/O devices, etc.

The multiplexing techniques to facilitate Resource Management (Tanenbaum and Woodhull, 2006)

- **Time Multiplexing** – When a resource is time multiplexing it means that each of the different processes are given time to utilize a resource one after the other.
- **Space Multiplexing** – This type of multiplexing does not uphold the one at a time policy unlike in Time multiplexing. Rather, it simultaneously allocates free spaces to all processes that it can accommodate.

Components of the Operating System

- According to Flynn and Mchoes (2007), an Operating system is composed of five components:
- User Command Interface
- File Manager
- Device Manager
- Memory Manager

- Processor Manager

These are of course for standalone computer because another component, the (6) Network Manager is available for distributed systems.

User Command Interface

Also called the OS Shell, provides the human user with a visual tool for communication purposes. Through the OS shell the user can see if an error message occurred while printing a document or if the copying of files from one location to another was successful.

Other examples of command lines

There are other command lines in addition to the ones mentioned above, namely, Terminal, and the Linux command line.

History

The command-line user interface was the primary method of communicating with a computer from the first machines and through the 1980s. Although it may still be accessed in today's operating systems, it is utilized far less due to the ease of use and familiarity of the GUI (graphical user interface). The CUI, however, is still preferred by many advanced end users as its features provide them with more comprehensive control over an operating system's functions.

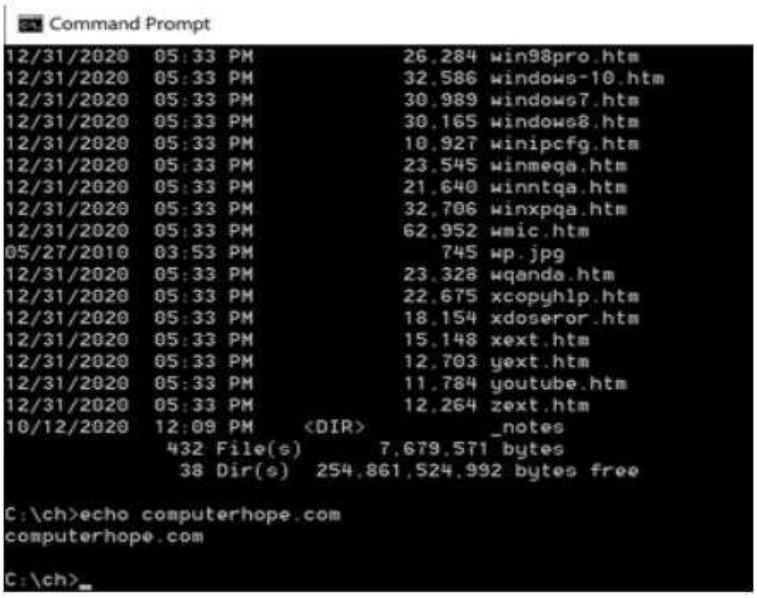

Figure 1.2 An Example of Output from the Command Prompt

The File Manager

Or File System pertains to the ability of the user to manipulate, add, edit and delete files named by the user. **Do you know how to name and rename your files in MS Word? How about copying your files from one folder location to another?** These activities are being handled by the File Manager component of your OS.

The Device Manager

Refers to the OS control over peripheral devices such as the mouse, disk drives, monitor, etc. When you save a file to a disk, the OS instructs the device drivers to write or store the file into the auxiliary storage device. The same is true when the user requests for a document to be printed, it is the OS and not the word processor which instructs the printer to accommodate the printing job request.

The device manager allows users to:

- Retrieve and install device drivers
- Disable or enable most devices

- Ignore selected devices when/if they malfunction
- View properties for each hardware device, such as manufacturer, model, type of device, etc.

The Memory Manager

A **memory manager** is a software utility that operates in conjunction with the operating system. It helps manage memory more efficiently and provides additional features such as flushing out unused segments of memory. All modern operating systems provide memory management.

Below is a listing of other examples of memory managers.

- Cacheman
- Freemem
- Quarterdeck MagnaRAM
- RamDisk
- WinRAM

Process Manager

The process management component is a procedure for managing the many processes that are running simultaneously on the operating system. Every software application program has one or more processes associated with them when they are running.

For example, when you use a browser like Google Chrome, there is a process running for that browser program. The OS also has many processes running, which performing various functions.

All these processes should be managed by process management, which keeps processes for running efficiently. It also uses memory allocated to them and shutting them down when needed.

The execution of a process must be sequential so, at least one instruction should be executed on behalf of the process.

Functions of process management in OS:

The following are functions of process management.

- Process creation and deletion.
- Suspension and resumption.
- Synchronization process
- Communication process

The Network Manager

Network management is the process of administering and managing computer networks. It includes performance management, fault analysis, provisioning of networks, and maintaining the quality of service.

A distributed system is a collection of computers/processors that never share their own memory or a clock. In this type of system, all the processors have their local Memory, and the processors communicate with each other using different communication lines, like fiber optics or telephone lines.

The computers in the network are connected through a communication network, which can be configured in a number of different ways. With the help of network management, the network can be fully or partially connected, which helps users to design routing and connection strategies that overcome connection and security issues.

Functions of Network management:

- Distributed systems help you to various computing resources in size and function. They

  may involve microprocessors, minicomputers, and many general-purpose computer systems.

- A distributed system also offers the user access to the various resources the network shares.
- It helps to access shared resources that help computation to speed-up or offers data availability and reliability.

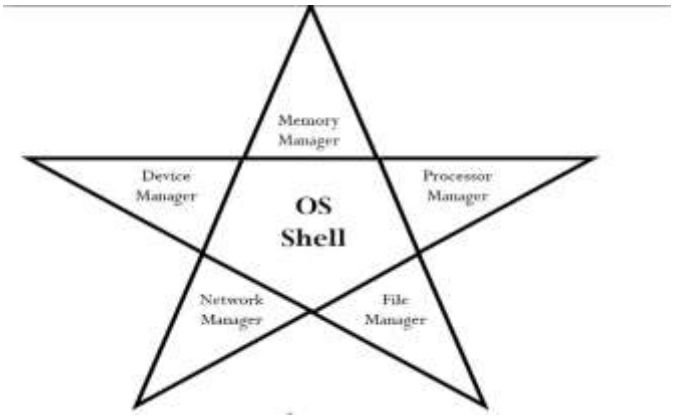

Figure 1.3 Components of an Operating System

Historical Revolution of Operating Systems

The first computers did not have operating systems. Each program that was running on these first computers had to include all the code needed to run on the computer, communicate with the connected hardware and perform the calculation that the program was intended to perform. This situation made even the simplest programs become very complex.

In response to this problem, the owners of the central computers began to develop system software that facilitated the writing and execution of the programs included in the computer, and thus the first operating systems were born.

- The Zeroth Generation (1940s)
- The First Generation (1950s)
- The Second Generation (mid 1950s to early 1960s)
- The Third Generation (mid 1960s to late 1970s)
- The Fourth Generation (late 1970s to present)

The Zeroth Generation (1940s)

- The first computer systems were run without operating systems (dietel, 1984)
- It was in this period that Charles Babbage conceptualizes his 'analytical engine' after his

  first difference engine.
- The analytical engine was purely mechanical and made use of Jacquard looms technology.

Figure 1.4 Show the illustration of Jacquard looms

- His failure to make this invention work properly was attributed mostly to the lack of needed parts, which was not manufactured at the time (Tanenbaum and Woodhull, 2006; Albano.et.al., 2008).

The First Generation (1950s)

- The period saw improvements after World War II.
- Bulky computers, usually capable of filling up an entire room, initially made use of mechanical relays but was later replaced by vacuum tubes.
- Originally announced on February 14, 1946, the Electronic Numerical Integrator and Computer (ENIAC), was the first general-purpose electronic computer.

Figure 1.5 Show the actual image of ENIAC

During this period, computer time is wasted primarily on job set-up time. **Job set-up time** occurs as a result of changing compiler tapes and loading of punch cards. This led to the birth of batch processing systems or the grouping of similar jobs into batches. This procedure lessened the idle time of the computer processor but it still was not enough to maximize computer time.

It must be understood at this point that the rarity of computer during this period made it very expensive and available only to big companies.

The Second Generation (mid 1950s to early 1960s)

- Ushered (make the start of) in the replacement of vacuum tubes with the transistors.
- During this period, the solution of performing batch processing proved its worth but only up to a certain extent.

Figure 1.6 Second generation main component - transistor

- Brilliant solution was the development of a system software known as the monitor, also called resident monitor. This piece of software is the forerunner (root) of our modern-day OS. It was termed resident monitor because it is the first "resident software" in the computer. It is invoked the moment power is turned.

- The resident monitor performs what is known as automatic job sequencing by simply transferring control to a program. When a program terminates, execution control is returned to the monitor, which loads the next program to which control would then again be transferred. This cycle is repeated until all programs are executed.

- However, the resident monitor by itself would be at a quandary (difficult situation) as to which job would be next. To solve this problem of the resident monitor control cards were used (Peterson and Silberschatz, 1983).

- **Control Cards** – are cards specially designed to instruct the resident monitor which program should be selected next for processing. These cards are fed into the computer by the operator along with other punch cards. The operator relies on a special marking on the card to distinguish it from the other data or program cards. The special marking is denoted by a dollar sign ($)

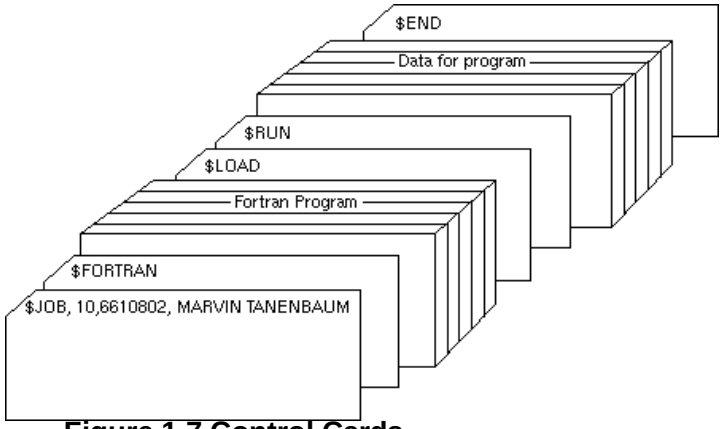

Figure 1.7 Control Cards

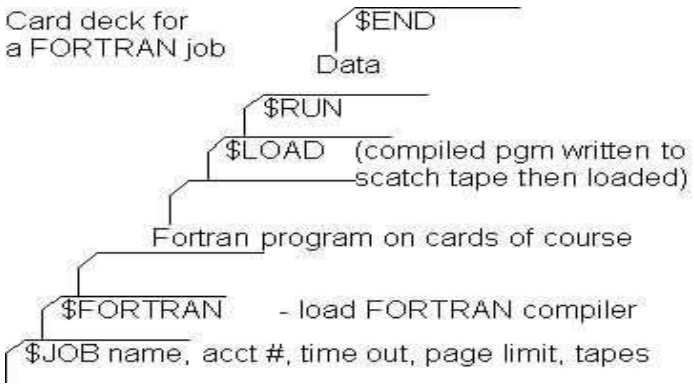

Figure 1.8 Process of Control Cards

Although the automatic job sequencing technique in a simple batch system proved to be much faster than the manual human operations it still kept the CPU idle most of the time. The culprit for such is blamed on slow I/O devices which are not capable of keeping at pace with the development of faster CPU. Assuming the processor has a processing speed of 10 jobs per minute and the card reader has 5 jobs per minute, on the first minute the first batch of jobs (jobs 1-10). Halfway through the second minute, while the input device has just finished jobs 11-15, the processor is already done with jobs 1-10. It would therefore have to wait for 30 seconds for the input device to finish the remaining half of the second batch of jobs (jobs 16-20).

- This generation ushered in the coming of general-purpose computers for the use of the public and businesses.
- Simultaneous Peripheral Operation On-line or Spooling makes use of magnetic disk storage for reading input jobs in advance and temporary storing them into disk until the CPU can process them. Likewise, jobs already processed by the CPU are maintained in
  the disk until an output device e.g. A printer is ready to accommodate the job.

- This technique introduced the concept of overlapping tasks. This means that while a job is being read by an input device another job is being output by the printer.

Figure 1.9 Simultaneous Peripheral Operation On-line or Spooling

- Spooling introduced what is known as a **Job Pool** (Silberschatz and Galvin, 1998). It is a combination of jobs waiting for CPU processing and jobs already processed waiting for an output device. Since these jobs are stored on a direct accessed storage device (DASD), commonly a magnetic disk, accessing the jobs randomly can be facilitated unlike in magnetic tapes, which required sequential access.

The Third Generation (mid 1960s to late 1970s)

Multiprogramming, it is very important concept in modern operating system for it enables multiple programs or processes to simultaneously be present inside the computer system by alternating on the CPU. In order to facilitate such scheme, the OS exploits the alternating CPU and I/O burst of each program in the computer system. A program having a CPU burst simply means that it is doing CPU processing while an I/O burst refers to the program doing input/output activity. CPU and I/O burst of a process can be likened to the inhale of oxygen and exhale of carbon dioxide. Both essential for man to live.

- Multiprogramming, also known as multitasking, is not limited to just two jobs or processes.
- Time-sharing systems may be considered as an interactive version of multiprogramming.
- Another major development during the third generation was the phenomenal growth of minicomputers, starting with the DEC PDP-1 in 1961. The PDP-1 had only 4K of 18-bit words, but at $120,000 per machine (less than 5 percent of the price of a 7094), it sold like hotcakes. These microcomputers help create a whole new industry and the development of more PDP's. These PDP's helped lead to the creation of personal computers which are created in the fourth generation.

The Fourth Generation (late 1970s to present)

- This computer era saw the emergence (that the computer is becoming important) and proliferation (its rapid increase in numbers) of microcomputers or personal computers.
- This period is known for the development of **graphical user interface (GUI)**, which made the computer friendly users.

Types of Operating Systems

1. Multi-user Operating Systems
2. Network or Distributed Operating Systems
3. Multiprocessor Operating Systems
4. Single-User Operating Systems
5. Real-Time Operating Systems
6. Embedded Operating Systems
7. Smart Card Operating Systems

Multi-user Operating Systems

A Multi-user operating system is a computer operating system which allows multiple users to access the single system with one operating system on it. It is generally used on large mainframe computers.

Figure 1.10 Multi-user Operating Systems

Example: Linux, Unix, Windows 2000, Ubuntu, Mac OS etc., In the multi-user operating system, different users connected at different terminals and we can access, these users through the network as shown in the diagram.

Features of the Multi-user Operating System

- Multi-tasking- Using multi-user operating system we can perform multiple tasks at a time, i.e. we can run more than one program at a time.
  Example: we can edit a word document while browsing the internet.
- Resource sharing- we can share different peripherals like printers, hard drives or we can share a file or data. For this, each user is given a small time slice of CPU time
- Background processing- It means that when commands are not processed firstly, then they are executed in the background while another programs are interacting with the system in the real time.

Advantages of the Multi-user Operating System

- When one computer in the network gets affected, then it does not affect another computer in the network. So, the system can be handled efficiently.
- Also, different users can access the same document on their computer. Example: if one computer contains the pdf file which the other user wants to access, then the other user can access that file.
- We use the multi-user operating system in the printing process so that different users can access the same printer and regular operating system can not do this process.
- Airlines also use this operating system for ticket reservation.
- We make use of the multi-user operating system in teachers and library staff for handling and searching for books. In this, the book record is stored in one computer while the other systems which are connected can access that computer for querying of books.

Disadvantages of the Multi-user Operating System

- Sometimes sharing your data becomes dangerous for you as your private Data also gets shared.
- Virus attacking takes place on all computer simultaneously as the computers are shared. So if one computer is affected then other also gets affected.
- Also, computer information is shared.

Network or Distributed Operating Systems

- A type of operating system which allows interconnected or networked computers to communicate with each other.
- In this environment, each computer in the network has its own processing capabilities. Aside from allowing the different computers to communicate with each other, the OS enables these computers to share limited resources such as printers, flatbed scanners, etc.
- Another interesting feature found in a distributed system is the distribution of software

applications.

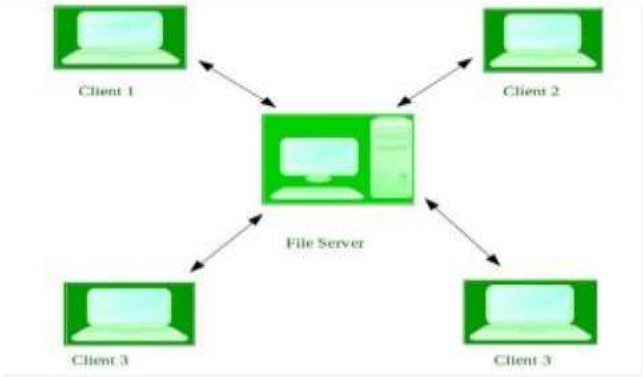

Figure 1.11 Network or Distributed Operating Systems

Advantages of Network Operating System:

- Highly stable centralized servers
- Security concerns are handled through servers
- New technologies and hardware up-gradation are easily integrated into the system
- Server access is possible remotely from different locations and types of systems

Disadvantages of Network Operating System:

- Servers are costly
- User has to depend on a central location for most operations
- Maintenance and updates are required regularly

Examples of Network Operating System are: Microsoft Windows Server 2003, Microsoft Windows Server 2008, UNIX, Linux, Mac OS X, Novell NetWare, and BSD, etc.

Multiprocessor Operating Systems

In operating systems, to improve the performance of more than one CPU can be used within one computer system called Multiprocessor operating system.

Multiple CPUs are interconnected so that a job can be divided among them for faster execution. When a job finishes, results from all CPUs are collected and compiled to give the final output.

Jobs needed to share main memory and they may also share other system resources among themselves. Multiple CPUs can also be used to run multiple jobs simultaneously.

For Example: UNIX Operating system is one of the most widely used multiprocessing systems.

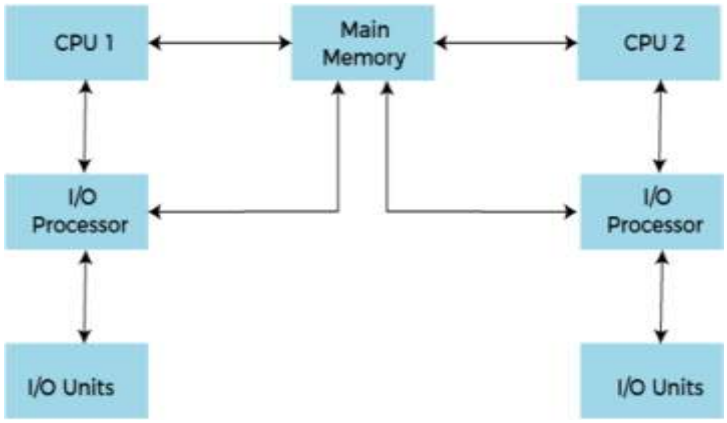

Figure 1.12 Multiprocessor Operating Systems

To employ a multiprocessing operating system effectively, the computer system must have the following things:

- A motherboard is capable of handling multiple processors in a multiprocessing operating system.
- Processors are also capable of being used in a multiprocessing system.

Advantages of multiprocessing operating system are:

- **Increased reliability:** Due to the multiprocessing system, processing tasks can be distributed among several processors. This increases reliability as if one processor fails; the task can be given to another processor for completion.
- **Increased throughout:** As several processors increase, more work can be done in less
- **The economy of Scale:** As multiprocessors systems share peripherals, secondary storage devices, and power supplies, they are relatively cheaper than single-processor systems.

Disadvantages of Multiprocessing operating System

- Operating system of multiprocessing is more complex and sophisticated as it takes care of multiple CPUs at the same time.

Single-User Operating Systems

An operating system that allows a single user to perform only one task at a time is called a Single- User Single-Tasking Operating System. Functions like printing a document, downloading images, etc., can be performed only one at a time. Examples include MS-DOS, Palm OS, etc.

Advantages

- This operating system occupies less space in memory.

Disadvantages

- It can perform only a single task at a time.

Real-Time Operating Systems

Real-time operating system (RTOS) is an operating system intended to serve real time application that process data as it comes in, mostly without buffer delay. The full form of RTOS is Real time operating system.

In a RTOS, Processing time requirement are calculated in tenths of seconds increments of time. It is time-bound system that can be defined as fixed time constraints. In this type of system, processing must be done inside the specified constraints. Otherwise, the system will fail.

Why use an RTOS?

Here are important reasons for using RTOS:

- It offers priority-based scheduling, which allows you to separate analytical processing from non-critical processing.
- The Real time OS provides API functions that allow cleaner and smaller application code.
- Abstracting timing dependencies and the task-based design results in fewer interdependencies between modules.

- RTOS offers modular task-based development, which allows modular task-based testing.
- The task-based API encourages modular development as a task, will typically have a clearly defined role. It allows designers/teams to work independently on their parts of the project.
- An RTOS is event-driven with no time wastage on processing time for the event which is not occur.

Embedded Operating Systems

An embedded operating system is a small-scale computer of an embedded system with a limited number of features. It is designed to carry out a function or a set of functions of an electronic end product. Akin to a desktop PC that requires an OS like Windows, Linux, or Mac OS to run basic apps, embedded systems also need an operating system to facilitate and expedite their functionality.

For instance, all mobile phones have an integrated embedded operating system software like Android or iOS that starts up when the phone is switched on. Without the OS, implementing an app into every single mobile phone with different hardware would have been a nightmare for developers. It allows them to bridge all the gaps and build a unified app specifically for the OS. The embedded operating system is also known as a real-time operating system (RTOS) in some cases, which we will discuss in another section.

Here are some common characteristics of an embedded OS:

- Power efficient
- Fewer storage capabilities
- Smaller processing power
- Fast and lightweight
- I/O device flexibility
- Real-time operation

- Tailored to the intended use case

How Does an Embedded System Work?

People often wonder how an embedded system works because there is a high demand for sophisticated product technology, and as a result there are excellent opportunities for embedded software developers. Unlike a desktop PC that loads or executes applications, an embedded operating system is configured for fewer purposes, typically handling a single application on a device.

Though the scope of operating system functions is limited, it must be reliable and operate seamlessly even with constraints on size, processing power, and memory because that specific application is crucial for the functionality of the end product. Some of the examples of the best embedded OSs for commercial and industrial applications are Embedded Linux and Android, Wind River VxWorks, Green Hills Integrity, and QNX.

Are you wondering if embedded operating systems can be updated or not? Yes, embedded OSs can be updated if the product is designed with flash memory and if the chip it is implemented on is flashable. For instance, your smart TV might contain an embedded operating system and a plethora of features as well as complexities. The more features, the more bugs and security vulnerabilities that must be managed. The operating systems of such devices are designed to be updated to eliminate bugs or add new features and offer the best customer experience.

Smart Card Operating Systems

- A more unique type of operating system.
- It makes use of a plastic material to hold the computer chip. Like the Disc Operating System (DOS) which was previously very popular for computers without any installed OS, the Smart Card OS works in the same fashion.

Chapter 2
Computer System Structure

The computer system structure consists of interrupt mechanism for I/O devices, memory unit to run programs, memory protection, and disk storage to save program and data files.

Computer-system operations

A modern general-purpose computer has CPU and device controllers for devices such as disk, audio devices, and video display devices connected to a common system bus. Each controller is for a specific device only and it has a local buffer.

The CPU and device controllers can run concurrently and compete for memory. A memory controller synchronizes access to shared memory.

Figure 2.1 Computer System Structure

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

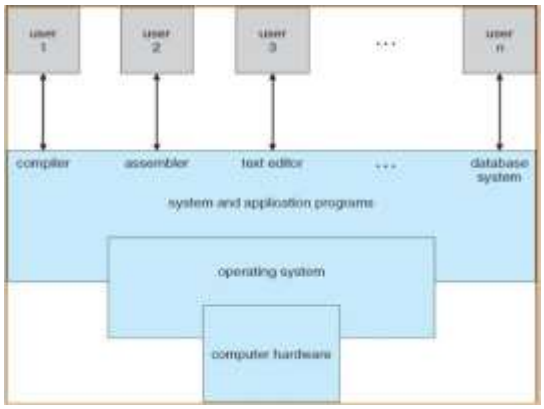

Figure 2.2 Computer System

Computer System Organization

The computer system is a combination of many parts such as peripheral devices, secondary memory, CPU etc. This can be explained more clearly using a figure.

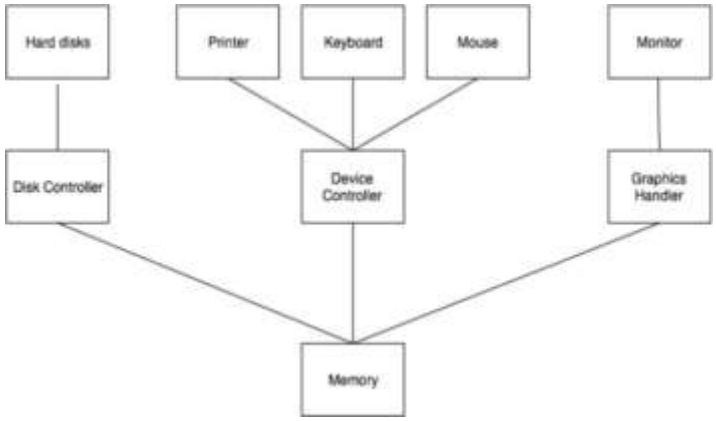

Figure 2.3 Computer System Organization

The salient points about the above figure displaying Computer System Organization is −

- The I/O devices and the CPU both execute concurrently. Some of the processes are scheduled for the CPU and at the same time, some are undergoing input/output operations.
- There are multiple device controllers, each in charge of a particular device such as keyboard, mouse, printer etc.
- There is buffer available for each of the devices. The input and output data can be stored in these buffers.
- The data is moved from memory to the respective device buffers by the CPU for I/O operations and then this data is moved back from the buffers to memory.
- The device controllers use an interrupt to inform the CPU that I/O operation is completed.

Interrupt Handling

An interrupt is a necessary part of Computer System Organization as it is triggered by hardware and software parts when they need immediate attention.

An interrupt can be generated by a device or a program to inform the operating system to halt its current activities and focus on something else. The types of interrupts are better explained using the following

figure 2.4.

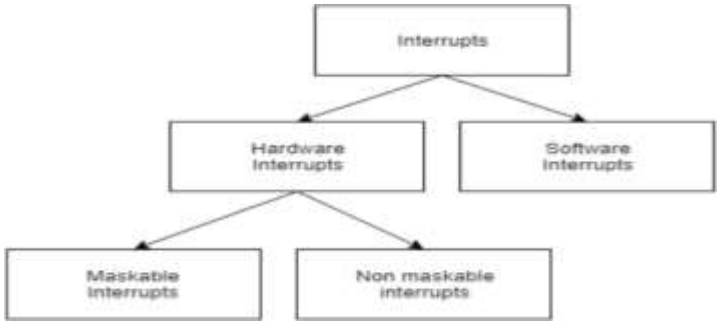

Figure 2.4 Interrupt Handling

Hardware and software interrupts are two types of interrupts. Hardware interrupts are triggered by hardware peripherals while software interrupts are triggered by software function calls.

Hardware interrupts are of further two types. Maskable interrupts can be ignored or disabled by the CPU while this is not possible for non-maskable interrupts.

How Computer Boot-Up?

As soon as the power or reset button on our computer is pressed a special program is evoked called the **bootstrap program**. It is stored in a ROM found on a known secondary storage location. It contains a program loader which is tasked to find and load the OS loader and transfer control to the latter. Once the OS is loaded it then loads other programs to initialize in the computer system. This process is known as **booting or bootstrapping**. In the booting process the bootstrap loader makes a thorough inspection of the computer components such as checking the presence of the keyboard, monitor, hard drives, etc.

The boot up process primarily starts when the power button on a CPU or computer system is manually pressed by a human operator. The computer is then activated and performs a series of boot time tests and checks before normal operations can be performed by the user. These checks

include the power on self test (POST), which ensures that the computer has enough electrical

power to proceed, peripheral devices check and the initiation of the boot loader, which loads and executes the startup sequence and the operating system.

I/O Operation Techniques

- **Programmed I/O-** this method is done by copying data from the user space to the kernel to avoid a more complex operation should the access be done at the user level.
- **Interrupt Driven I/O-as** stated earlier I/O device triggered a hardware interrupt from the I/O device to the CPU. This process of issuing an interrupt frees the CPU from its busy waiting status and work on other process.
- **Direct Memory Access-** it assigns the work of output of data to a DMA Controller instead of generating an interrupt every time a character needs an output. The process of executing interrupts take time which result to a certain amount of CPU time wastage.

Storage Structure

- Main memory – only large storage media that the CPU can access directly.
- Secondary storage (Auxiliary or External Storage) – extension of main memory that provides large nonvolatile storage capacity.
- Magnetic 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.

Storage Hierarchy

- Storage systems organized in hierarchy.
    - Speed
    - Cost
    - Capacity
- *Caching* – copying information into faster storage system; main memory can be viewed as a last *cache* for secondary storage.

Storage Hierarchy

The hierarchy shows the different classification and characteristics of the different storage media that can be summarized as follows:

- The higher the device is in the hierarchy the faster is the access time
- The higher the device is found in the hierarchy the more expensive it gets.
- The lower the device is in the hierarchy the bigger is the capacity of the device.
- The higher the device is in the hierarchy the more it is accessed by the CPU.

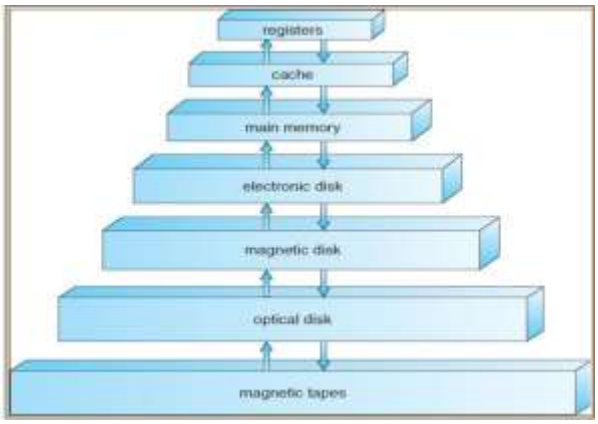

Figure 2.5 Storage Hierarchy

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

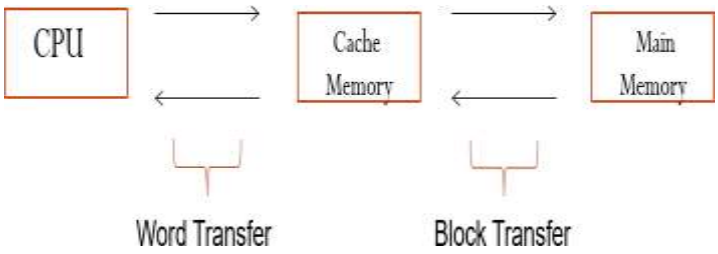

Figure 2.6 How caching works

The caching technique is used to speed-up the transfer of data between main memory and the CPU. It must be clarified at this point that, unlike the register which is within the CPU, the memory is connected to the CPU through the system bus. Thus, communication between the two is done through the system bus and consequently the travel of data takes quite some time from the main memory.

Caching serves as a temporary storage facility located between the main memory and the CPU so that when the latter needs data it first checks from the cache if the word is available. Otherwise, a block containing the request is loaded from main memory.

Magnetic Disk

- Magnetic disk have different types of R/W head. A fixed head disk has a read/write head per track. A movable head disk or hard disk, on the other hand, uses a retractable access arm to move the read/write head from one track to another.
- Another type of magnetic disk is the floppy disk. One unique characteristic of this disk is that it has no mounted read/write head on it, much like optical disk. In order for data to be read/written, it must be inserted into a slot or disk drive which contains the spindle of the write/read head.

Direct Access Storage Device (DASD)

- DASD is the optical disk. It is highly characterized by the use of laser beams for data encoding. One of the earliest optical disk is the layer disk which is extremely large when compared to a DVD.
- Magneto Optical Disk is a storage device which combines the laser recording technology of an optical disk and the magnetic recording technology of magnetic disks.

Magnetic tape Cartridges

- The oldest secondary storage device is the magnetic type. It was developed earlier than the magnetic disk and was the most sought after permanent storage device in the early days of computer technology.
- The latest in storage devices are flash memory which gained popularity due to the advent of portable, digital gadgets such as digital camera, cellular phone, etc. These is considered electronic disk due to the electronic circuitry used in the storage of data.

Hardware Protection

It is one of the central themes in computer system structures. From very simple architecture, the computer has evolved into a highly dynamic, interactive and complex machine. The earliest computer systems are simple in the sense that an individual performs both tasks as programmer and operator of the machine. Under this situation, he has complete control over the computer system and all the resources needed in the operation. With the advent of the resident memory, multiprogramming and resource sharing, the manual human control over the computer system became obsolete. The computer necessitated protection schemes to secure the systems' proper operation.

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

Operating System Structure

- Multiprogramming 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 for example), OS switches to another job
- Timesharing (multitasking) is logical extension in which 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

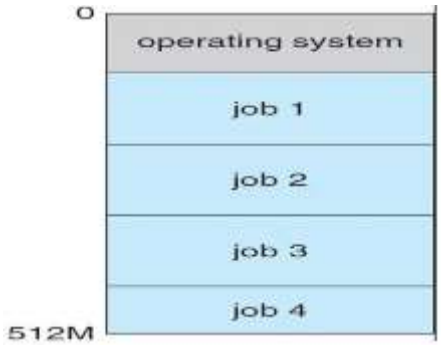

Figure 2.7 Memory Layout for Multiprogrammed System

Performance Tasks

A. Multiple Choice

1. It controls the allocation and use of the computing System's resources among the various user and
   tasks.
   a. File Manager
   b. Operating System
   c. Process manager
2. This type of multiplexing does not uphold the one at a time policy unlike in Time multiplexing. Rather, it simultaneously allocates free spaces to all processes that it can accommodate.
   a. Space Multiplexing
   b. Time Multiplexing
3. Pertains to the ability of the user to manipulate, add, edit and delete files named by the user.
   a. File Manager
   b. Operating System
   c. Process manager
4. Process of administering and managing computer networks. It includes performance management, fault analysis, provisioning of networks, and maintaining the quality of service.
   a. Memory Manager
   b. Network manager
   c. Device Manager
5. Is a software utility that operates in conjunction with the operating system.
   a. Memory Manager
   b. Network manager
   c. Device Manager
6. During this period, the solution of performing batch processing proved its worth but only up to a certain extent
   a. First Generation
   b. Second Generation
   c. Third Generation

7. Cards specially designed to instruct the resident monitor which program should be selected next for processing.
   a. Memory card
   b. Process Card
   c. Control card

8. Computer operating system which allows multiple users to access the single system with one operating system on it.
   a. Multi-user Operating Systems
   b. Network or Distributed Operating Systems
   c. Multiprocessor Operating Systems

9. An operating system that allows a single user to perform only one task at a time.
   a. Real-Time Operating Systems
   b. Single-User Operating Systems
   c. Embedded Operating Systems

10. Operating system we can perform multiple tasks at a time, i.e. we can run more than one program at a time.
    a. Multi-user Operating Systems
    b. Network or Distributed Operating Systems
    c. Multiprocessor Operating Systems

B. Essay

1. How does an Operating System works?

2. What is the Difference between Network or Distributed Operating Systems and Multi-user Operating Systems?

3. How does an Embedded Operating works?

Learning Resources

- Operating System:
- User Command Interface: searchwindowsserver.techtarget.com / computerhope.com
- Multi-user Operating Systems: ecomputernotes.com
- Network or Distributed Operating Systems: geeksforgeeks.org
- Multiprocessing operating System: javatpoint.com
- Single-User Operating Systems:
- tutorialspoint.com Real-Time Operating
- Systems: guru99.com Embedded Operating
- Systems: digi.com