

Chapter 1

Operating Systems

-An Introduction

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Course Goal:

- Understand the fundamental concepts and basic principles of Operating System,
 - Demonstrate the understanding of fundamental Operating Systems concepts.
 - Understand the concept of process and thread management and apply the CPU scheduling algorithm to solve problems.
 - Explain and apply the concept of process synchronization, mutual exclusion and the deadlock.
 - Discuss various memory management techniques and apply memory page replacement algorithms to solve problems.
 - Understanding of the concepts of file management by Operating System.
 - Discuss the management of I/O devices by Operating System.

Reference Books:

Book	Author	Publisher
Modern Operating System, 4th Edition.	Andrew S. Tanenbaum & Herbert Bos	Pearson, ISBN-13: 9780133592221
Operating System Concepts, 9th Edition.	Abraham Silberschatz, Peter Baer Galvin and Greg Gagne	WILEY, ISBN 978-1-118-06333-0
Operating System: Internals and Design Principles, 8th Edition.	William Stallings	Prentice Hall, ISBN-10: 0-13-380591-3, ISBN-13: 978-0-13-380591-8
Operating Systems, 2nd Edition, October 2005	A Godbole	by Tata Mc Graw Hill, ISBN: 9780070591134.
The Design of the Unix Operating System, 1st Edition	Maurice J. Bach	Prentice Hall ISBN: 0-13-201799-7

Tentative topics:

- Introduction to Operating System,
- Processes and Process Management,
- Inter-process Communication and Synchronization, Deadlocks,
- Memory Management,
- File System,
- I/O Systems.

Roadmap of Chapter

- Introduction to Operating System
 - Introduction and need of an operating system,
 - Evolution of operating system,
 - Layered architecture/logical structure of an operating system,
 - OS services,
 - Types of OS,
 - Introduction to UNIX OS.

Introduction:

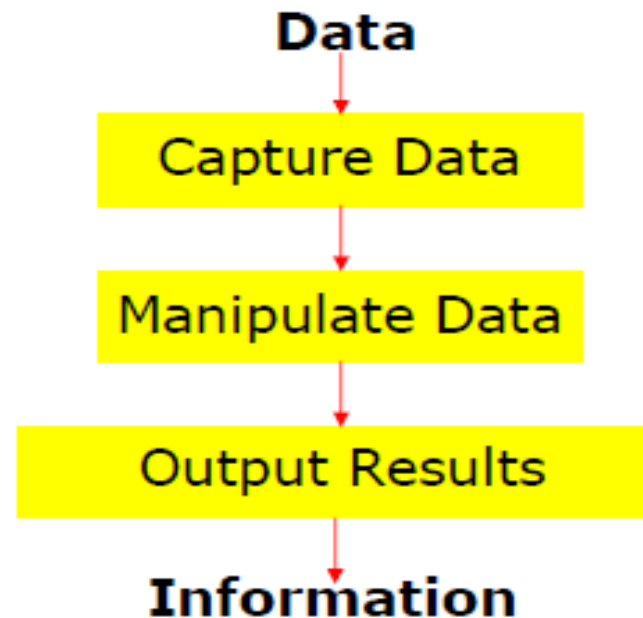
- **Computer:**

- The word computer comes from the word “compute”, which means, “to calculate”
- Thereby, a computer is an electronic device that can perform arithmetic operations at high speed
- A computer is also called a *data processor* because it can store, process, and retrieve data whenever desired

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- **Data Processing:**

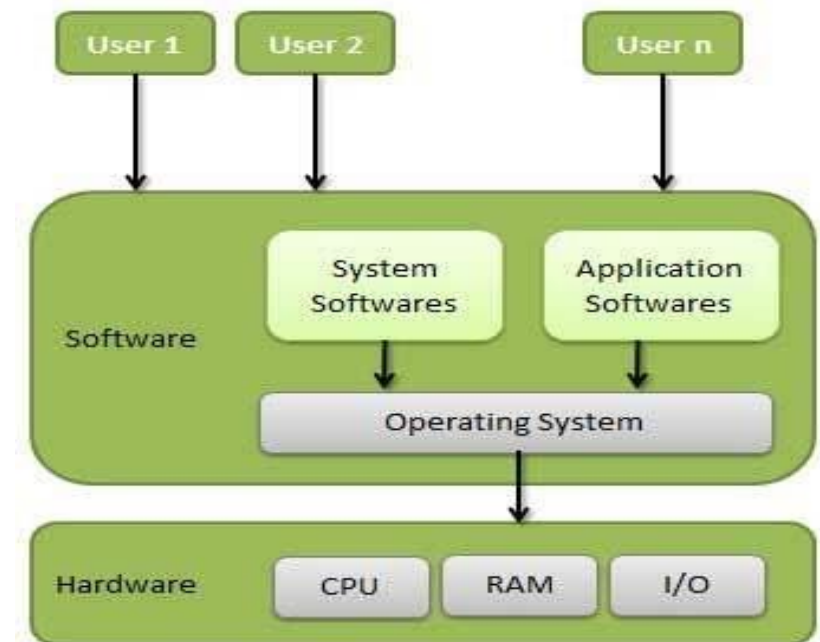
The activity of processing data using a computer is called *data processing*



Data is raw material used as input and *information* is processed data obtained as output of data processing

Operating System:

- A set of programs which acts as an interface between user interface and computer hardware and controls the execution of all kinds of programs.
- A software which performs all the basic tasks like **file management, memory management, process management, handling input and output, and controlling peripheral devices** such as disk drives and printers.
- Important functions of an operating System:
 - Memory Management,
 - Processor Management,
 - Device Management,
 - File Management,
 - Security,
 - Control over system performance,
 - Job accounting,
 - Error detecting aids,
 - Coordination between other software and users.



Working of Operating system:

- Operating System works in two roles:
 - **User View:**
 - In user view OS is designed for ease of use and resource utilization.
 - OS is designed to maximize resource utilization and to assure all available CPU time, memory and I/O are used efficiently.
 - OS are designed mostly for individual usability.
 - **System View:**
 - From computer's view, OS is the program involved with hardware.
 - For system point of view OS work as resource allocator.
 - The OS manage CPU time, memory space, file storage space and I/O devices.
 - The OS can act as a control program which manages the execution of the user program to prevent errors and improper use of the computer.

Important terms about operating system:

- **System Program:** Associated with operating system but are not part of kernel.
- **Application program:** Application programs includes all programs not associated with the operation of the system.
- **Kernel:** OS is one of the programs running at all times on the computer called as kernel.

Advantages of Operating System:

- **Convenience:**
 - As operating system provides easy-to-use commands and graphical user interface it makes computer system more convenient.
- **Efficiency:**
 - Operating system utilizes computer resources in efficient manner as well as it provides corrective actions when it becomes low.

Evolution of operating system:

- **Generation of Operating System**
 - Below are four generations of operating systems.
 - The First Generation
 - The Second Generation
 - The Third Generation
 - The Fourth Generation

Cont....

- **1. The First Generation (1940 to early 1950s)**
 - In 1940, an operating system was not included in the creation of the first electrical computer.
 - Vacuum tubes were used.
 - Early computer users had complete control over the device and wrote programs in pure **machine language** for every task.
 - During the computer generation, a programmer can merely execute and solve basic mathematical calculations.
 - An operating system is not needed for these computations.
 - No protection
 - Consume more electricity and generates lots of heats.

Cont....

- **2. The Second Generation (1955 – 1965)**
 - GMOSIS, the first operating system (OS) was developed in the early 1950s.
 - For the IBM Computer, General Motors has created the operating system.
 - Because it gathers all related jobs into groups or batches and then submits them to the operating system using a **punch card** to finish all of them, the second-generation operating system was built on a single-stream **batch processing system**.
 - Transistors were used
 - Minimum protection
 - I/O operation-processor had to remain **idle**
 - Base for multi-programming

Cont....

- **3. The Third Generation (1965 – 1980)**
 - Multi-programming and multi-tasking
 - Integrated circuits (IC) were used
 - No starvation

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- **4. The Fourth Generation (1980 – Present Day)**

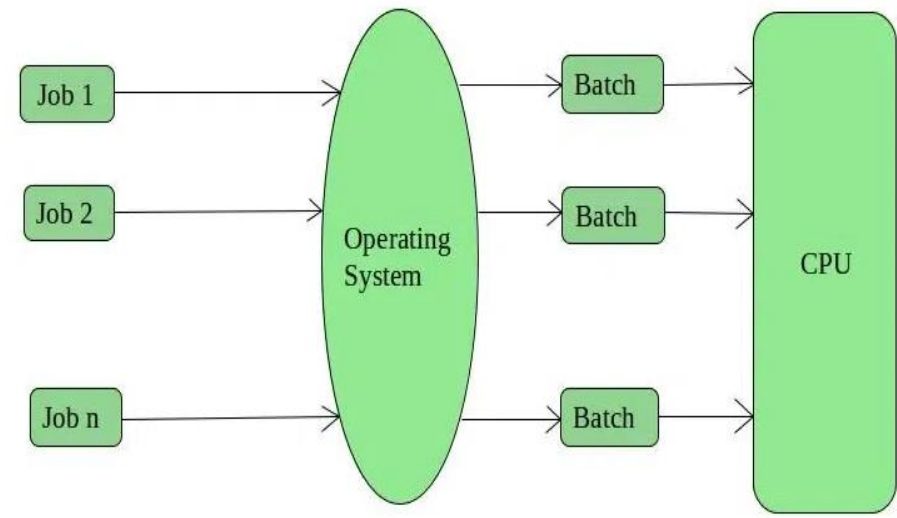
- The development of Microsoft and the Windows operating system was a significant influence in the creation of personal computers. In 1975, Microsoft developed the first Windows operating system. Bill Gates and Paul Allen had the idea to advance personal computers after releasing the Microsoft Windows OS. As a result, the MS-DOS was released in 1981, but users found it extremely challenging to decipher its complex commands. Windows is now the most widely used and well-liked operating system available. Following then, Windows released a number of operating systems, including Windows 95, Windows 98, Windows XP, and Windows 7, the most recent operating system. The majority of Windows users are currently running Windows 10. Apple is another well-known operating system in addition to Windows.
- Provided GIU
- No starvation
- Maximum CPU utilization
- Computer networking
- Provides high priority execution

Types of Operating System:

- Operating Systems have evolved in past years. It went through several changes before getting its original form. These changes in the operating system are known as the evolution of operating systems. OS improve itself with the invention of new technology. Basically, OS added the feature of new technology and making itself more powerful.
- Batch-idle
- Multi-programmed
 - non- pre-emptive-complete execution of the process
 - less-idleness
- Multi-tasking/time-sharing-responsive
 - preemptive
- Real time OS- YouTube
 - No delay
 - Hard-Live
 - Soft-Delayed
- Distributed
 - Many networks/global
- Clustered
 - One network/local
- Embedded
 - Fixed functionalities
 - Ex-AC, Wachine machine.

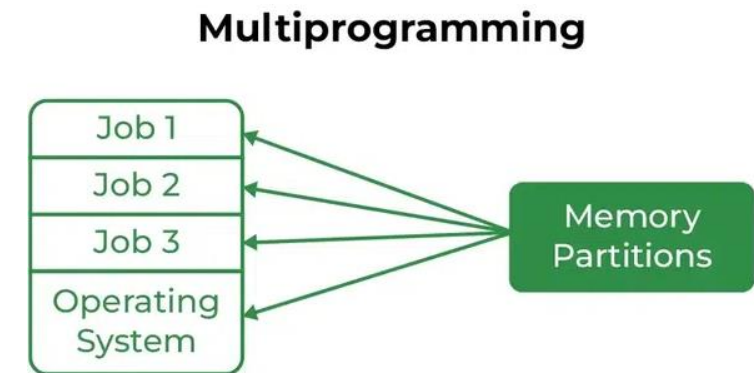
Batch Operating System:

- This type of operating system does not interact with the computer directly.
- There is an operator which takes similar jobs having the same requirements and groups them into batches.
- It is the responsibility of the operator to sort jobs with similar needs.
- Batch Operating System is designed to manage and execute a large number of jobs efficiently by processing them in groups.
- Advantages of Batch Operating System
 - Multiple users can share the batch systems.
 - The idle time for the batch system is very less.
 - It is easy to manage large work repeatedly in batch systems.
- Disadvantages of Batch Operating System
 - Batch systems are hard to debug.
 - It is sometimes costly.
 - The other jobs will have to wait for an unknown time if any job fails.
 - In batch operating system the processing time for jobs is commonly difficult to accurately predict while they are in the queue.
 - It is difficult to accurately predict the exact time required for a job to complete while it is in the queue.



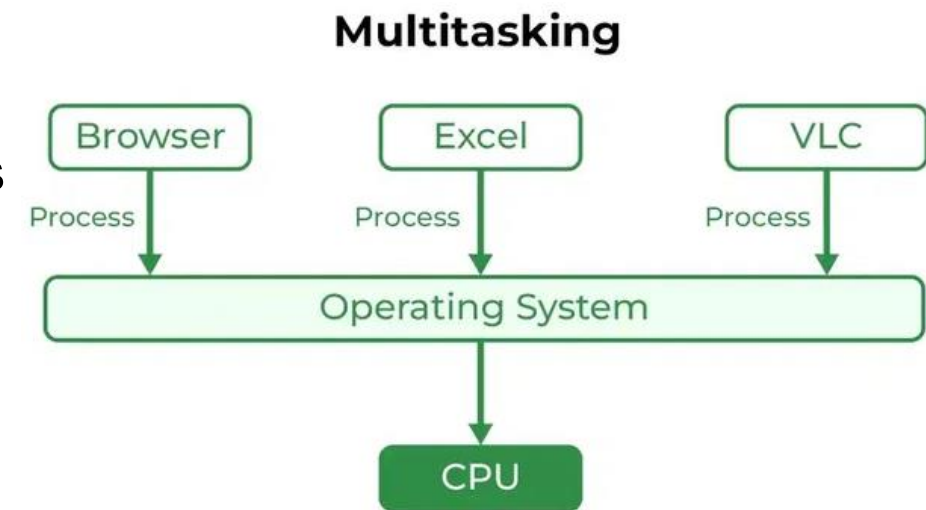
Multi-Programming Operating System:

- Multiprogramming Operating Systems can be simply illustrated as more than one program is present in the main memory and any one of them can be kept in execution.
- This is basically used for better execution of resources.
- In a multiprogramming environment, when a process does its I/O, The CPU can start the execution of other processes. Therefore, multiprogramming improves the efficiency of the system.
- **Advantages of Multi-Programming Operating System**
 - Multi Programming increases the Throughput of the System.
 - It helps in reducing the response time.
- **Disadvantages of Multi-Programming Operating System**
 - There is not any facility for user interaction of system resources with the system.



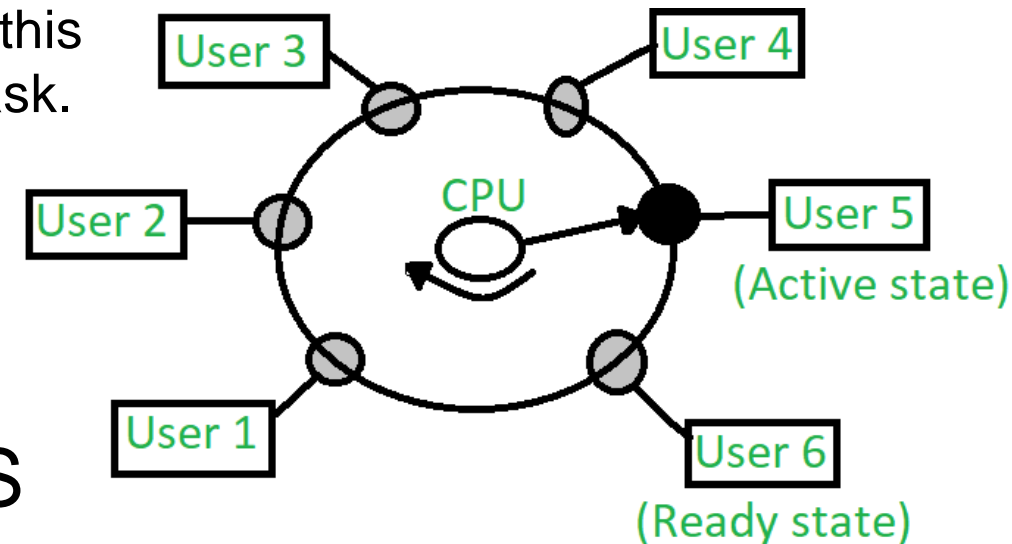
Multi-Tasking Operating System:

- Multitasking Operating System is simply a multiprogramming Operating System with having facility of a Round-Robin Scheduling Algorithm. It can run multiple programs simultaneously.
- The multitasking operating system is a logical extension of a multiprogramming system that enables multiple programs simultaneously. It allows a user to perform more than one computer task at the same time.
- There are two types of Multi-Tasking Systems which are listed below.
 - Preemptive Multi-Tasking
 - Cooperative Multi-Tasking
- Advantages of Multi-Tasking Operating System
 - Multiple Programs can be executed simultaneously in Multi-Tasking Operating System.
 - It comes with proper memory management.
- Disadvantages of Multi-Tasking Operating System
 - The system gets heated in case of heavy programs multiple times.



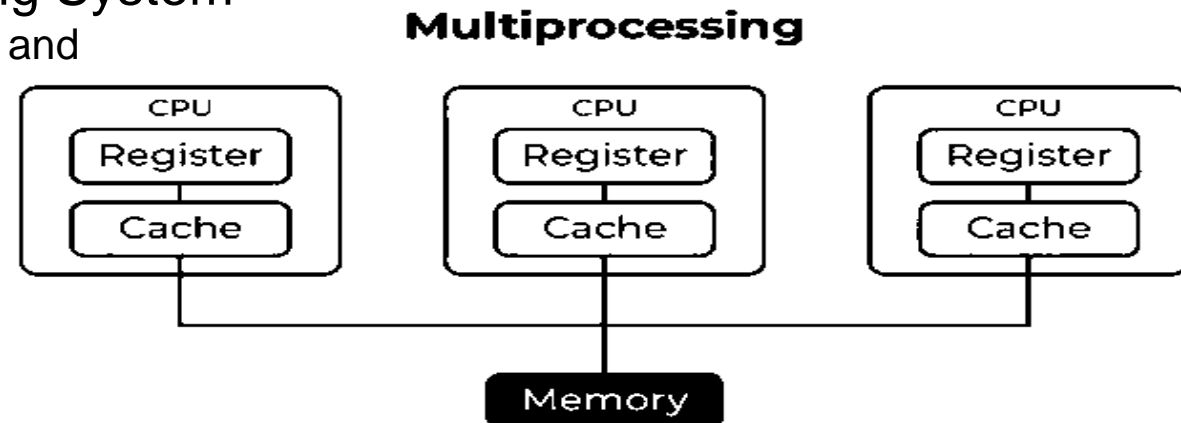
Time-Sharing Operating System:

- Each task is given some time to execute so that all the tasks work smoothly. Each user gets the time of the CPU as they use a single system. These systems are also known as **Multitasking** Systems. The task can be from a single user or different users also. The time that each task gets to execute is called **quantum**. After this time interval is over OS switches over to the next task.
- Advantages of Time-Sharing OS
 - Each task gets an equal opportunity.
 - Fewer chances of duplication of software.
 - CPU idle time can be reduced.
 - Resource Sharing, Improved Productivity, Improved User Experience
- Disadvantages of Time-Sharing OS
 - Reliability problem.
 - One must have to take care of the security and integrity of user programs and data.
 - Data communication problem.
 - High Overhead, Complexity, Security Risks.



Multi-Processing Operating System:

- Multi-Processing Operating System is a type of Operating System in which more than one CPU is used for the execution of resources.
- Parallel computing is achieved. There are more than one processors present in the system which can execute more than one process at the same time.
- It better the throughput of the System.
- Advantages of Multi-Processing Operating System
 - It increases the throughput of the system.
 - As it has several processors, so, if one processor fails, we can proceed with another processor.
- Disadvantages of Multi-Processing Operating System
 - Due to the multiple CPU, it can be more complex and somehow difficult to understand.

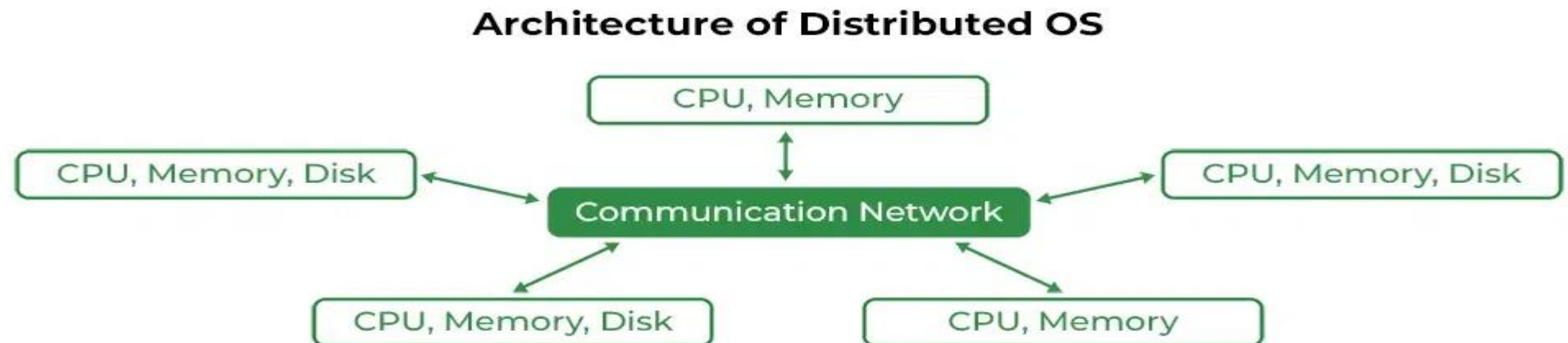


Real-Time Operating System:

- In Real-Time Systems, each job carries a certain deadline within which the job is supposed to be completed, otherwise, the huge loss will be there, or even if the result is produced, it will be completely useless.
- The Application of a Real-Time system exists in the case of military applications, if you want to drop a missile, then the missile is supposed to be dropped with a certain precision.
- Types of Real-Time Operating Systems
 - Hard Real-Time Systems: Hard Real-Time OSs are meant for applications where time constraints are very strict and even the shortest possible delay is not acceptable. These systems are built for saving life like automatic parachutes or airbags which are required to be readily available in case of an accident. Virtual memory is rarely found in these systems.
 - Soft Real-Time Systems: These OSs are for applications where time-constraint is less strict.
- Advantages of Real-time operating system:
 - Easy to layout, develop and execute real-time applications under the real-time operating system.
 - In a Real-time operating system, the maximum utilization of devices and systems.
- Disadvantages of Real-time operating system:
 - Real-time operating systems are very costly to develop.
 - Real-time operating systems are very complex and can consume critical CPU cycles.

Distributed Operating System:

- The Distributed Operating system is not installed on a single machine, it is divided into parts, and these parts are loaded on different machines.
- A part of the distributed Operating system is installed on each machine to make their communication possible.
- Distributed Operating systems are much more complex, large, and sophisticated than Network operating systems because they also have to take care of varying networking protocols.

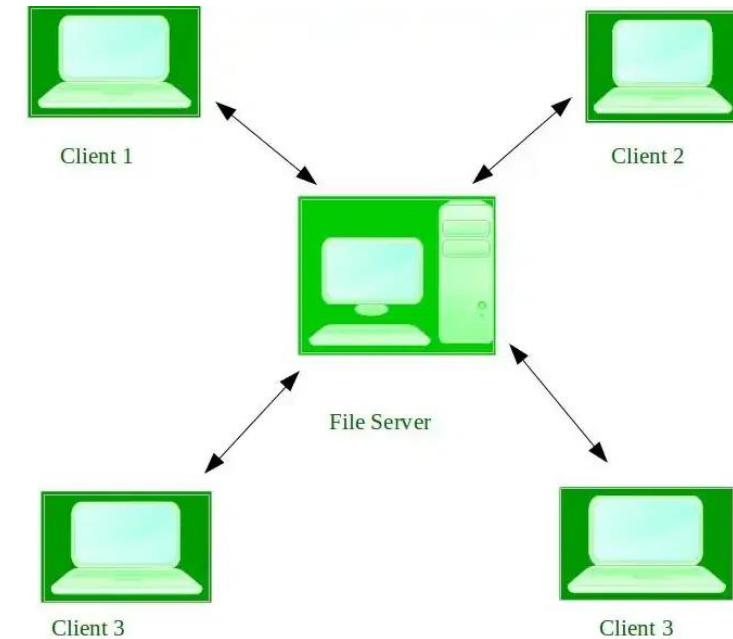


Distributed Operating System:

- Advantages of Distributed Operating System
 - Failure of one will not affect the other network communication, as all systems are independent of each other.
 - Electronic mail increases the data exchange speed.
 - Since resources are being shared, computation is highly fast and durable.
 - Load on host computer reduces.
 - These systems are easily scalable as many systems can be easily added to the network.
 - Delay in data processing reduces.
- Disadvantages of Distributed Operating System
 - Failure of the main network will stop the entire communication.
 - To establish distributed systems the language is used not well-defined yet.
 - These types of systems are not readily available as they are very expensive. Not only that the underlying software is highly complex and not understood well yet.

Network Operating System:

- 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.



Operating System structure:

- Operating system can be implemented with the help of various structures.
- The structure of the OS depends mainly on how the various common components of the operating system are interconnected and melded into the kernel.
- Depending on this we have following structures of the operating system:
 - Simple structure
 - Monolithic structure
 - Micro-kernel
 - Hybrid-Kernel Structure
 - Exo-Kernel Structure
 - Layered structure
 - Modular structure
 - Virtual Machines

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- **Simple structure:**

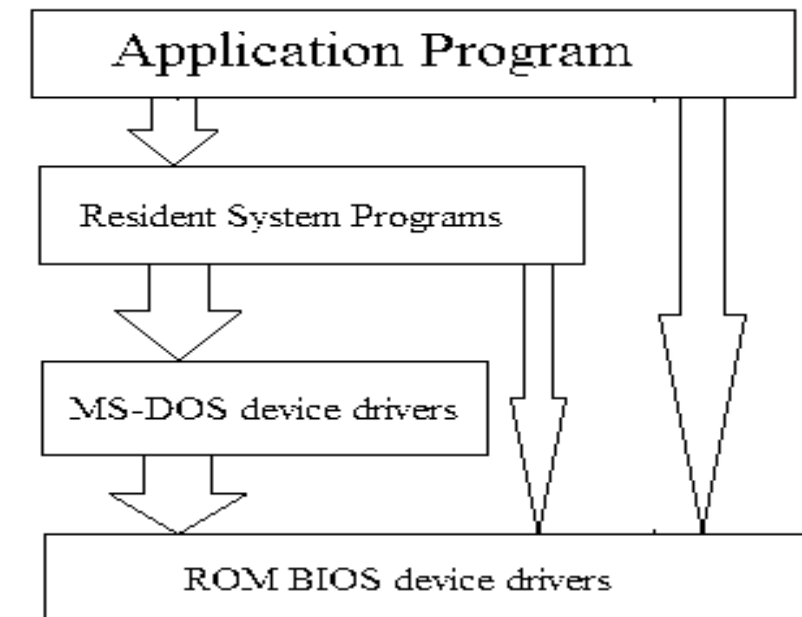
- Such operating systems do not have well defined structure and are small, simple and limited systems.
- The interfaces and levels of functionality are not well separated. MS-DOS is an example of such operating system.
- In MS-DOS application programs are able to access the basic I/O routines.
- These types of operating system cause the entire system to crash if one of the user programs fails.

- **Advantages:**

- It delivers better application performance because of the few interfaces between the application program and the hardware.
- Easy for kernel developers to develop such an operating system.

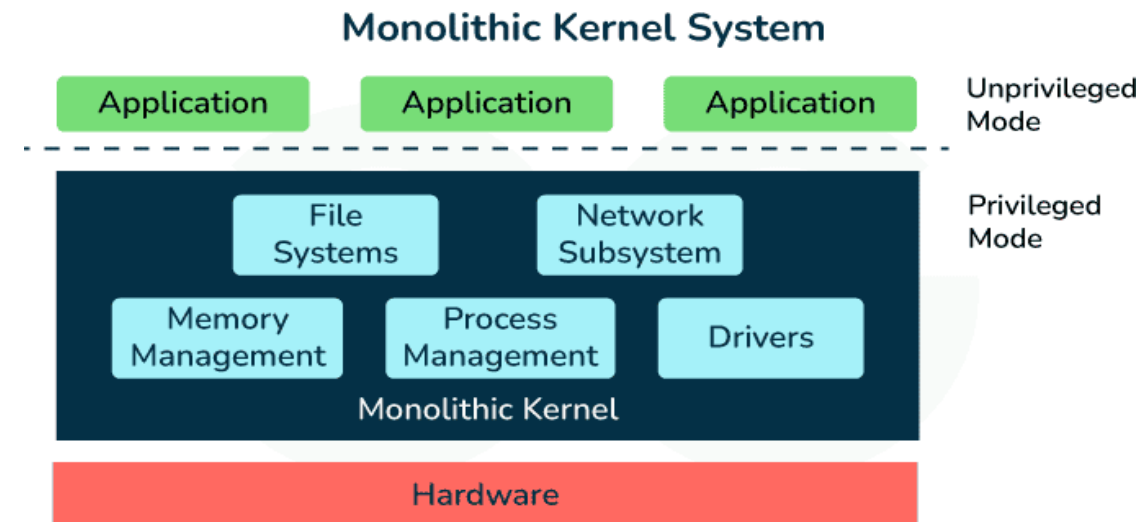
- **Disadvantages:**

- The structure is very complicated as no clear boundaries exists between modules.
- It does not enforce data hiding in the operating system.



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- **Monolithic structure: UNIX OS**
 - In a monolithic architecture, the operating system kernel is designed to provide all operating system services, including memory management, process scheduling, device drivers, and file systems, in a single, large binary. This means that all code runs in kernel space, with no separation between kernel and user-level processes.
- **Advantages:**
 - The main advantage of a monolithic architecture is that it can provide high performance, since system calls can be made directly to the kernel without the overhead of message passing between user-level processes. Additionally, the design is simpler, since all operating system services are provided by a single binary.
- **Disadvantages:**
 - One major disadvantage is that it can lead to a less secure and less stable operating system. Since all code runs in kernel space, any vulnerabilities or bugs in the kernel can potentially affect the entire system. Additionally, if a user-level process crashes, it can bring down the entire system, since there is no separation between kernel and user-level processes.



Cont....

- **Layered structure:**

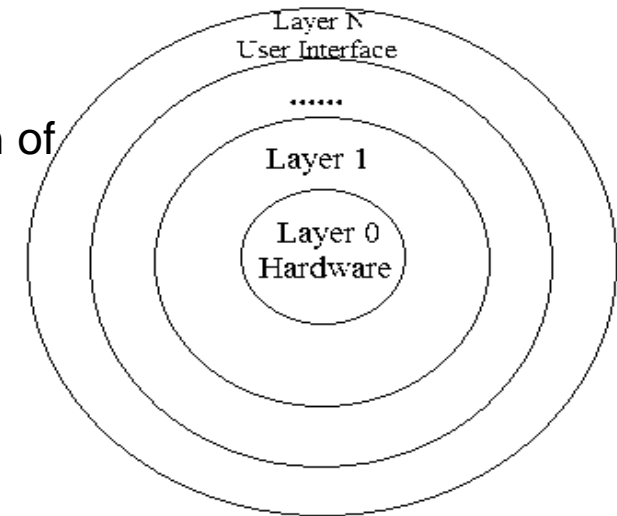
- An OS can be broken into pieces and retain much more control on system.
- In this structure the OS is broken into number of layers (levels).
- The bottom layer (layer 0) is the hardware and the topmost layer (layer N) is the user interface.
- These layers are so designed that each layer uses the functions of the lower level layers only.
- This simplifies the debugging process as if lower level layers are debugged and an error occurs during debugging then the error must be on that layer only as the lower level layers have already been debugged.

- **Advantages:**

- Layering makes it easier to enhance the operating system as implementation of a layer can be changed easily without affecting the other layers.
- It is very easy to perform debugging and system verification.

- **Disadvantages:**

- In this structure the application performance is degraded as compared to simple structure.
- It requires careful planning for designing the layers as higher layers use the functionalities of only the lower layers.



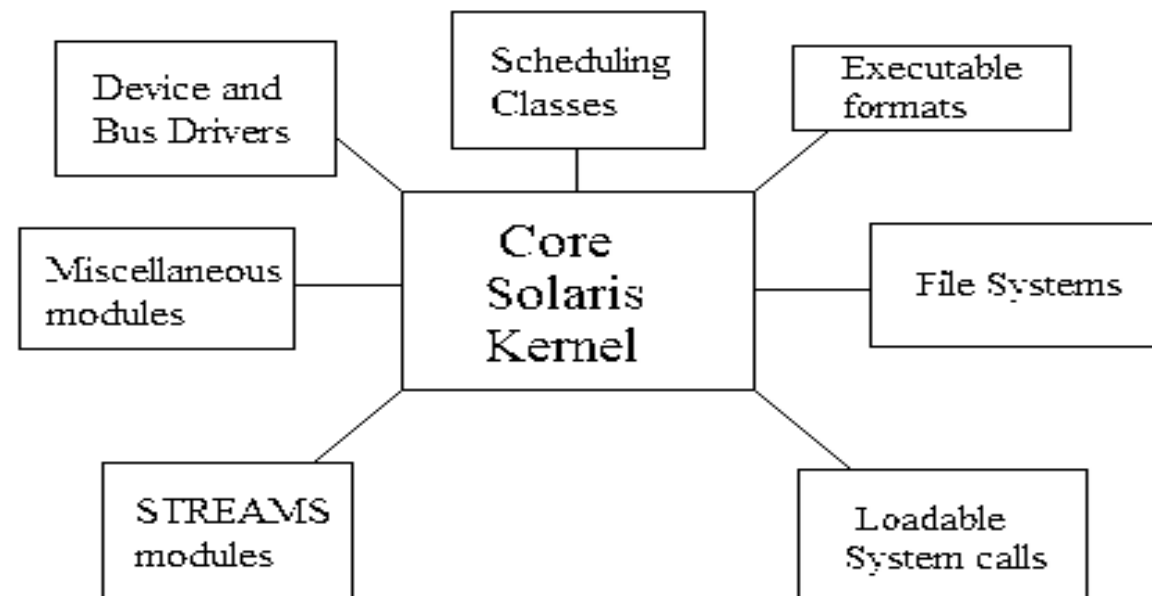
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- **Micro-kernel:**
 - An OS can be broken into pieces and retain much more control on This structure designs the operating system by removing all non-essential components from the kernel and implementing them as system and user programs.
 - This result in a smaller kernel called the micro-kernel.
 - Advantages of this structure are that all new services need to be added to user space and does not require the kernel to be modified.
 - Thus it is more secure and reliable as if a service fails then rest of the operating system remains untouched. Mac OS is an example of this type of OS.
- **Advantages:**
 - It makes the operating system portable to various platforms.
 - As microkernels are small so these can be tested effectively.
- **Disadvantages:**
 - Increased level of inter module communication degrades system performance.

Cont....

- **Modular structure or approach:**

- It is considered as the best approach for an OS.
- It involves designing of a modular kernel.
- The kernel has only set of core components and other services are added as dynamically loadable modules to the kernel either during run time or boot time.
- It resembles layered structure due to the fact that each kernel has defined and protected interfaces but it is more flexible than the layered structure as a module can call any other module.



Cont....

- **Hybrid-Kernel Structure:**

- Hybrid-kernel structure is nothing but just a combination of both monolithic-kernel structure and micro-kernel structure. Basically, it combines properties of both monolithic and micro-kernel and make a more advance and helpful approach. It implement speed and design of monolithic and modularity and stability of micro-kernel structure.
- Advantages of Hybrid-Kernel Structure
 - It offers good performance as it implements the advantages of both structure in it.
 - It supports a wide range of hardware and applications.
 - It provides better isolation and security by implementing micro-kernel approach.
 - It enhances overall system reliability by separating critical functions into micro-kernel for debugging and maintenance.
- Disadvantages of Hybrid-Kernel Structure
 - It increases overall complexity of system by implementing both structure (monolithic and micro) and making the system difficult to understand.
 - The layer of communication between micro-kernel and other component increases time complexity and decreases performance compared to monolithic kernel.

OS services:

- Program execution
- Input Output Operations
- Communication between Process
- File Management
- Memory Management
- Process Management
- Security and Privacy
- Resource Management
- User Interface
- Networking
- Error handling
- Time Management

Cont....

- **Program Execution:**

- It is the Operating System that manages how a program is going to be executed.
- It loads the program into the memory after which it is executed.
- The order in which they are executed depends on the CPU Scheduling Algorithms.
- A few are FCFS, SJF, etc. When the program is in execution, the Operating System also handles deadlock i.e. no two processes come for execution at the same time.
- The Operating System is responsible for the smooth execution of both user and system programs.
- The Operating System utilizes various resources available for the efficient running of all types of functionalities.

Cont....

- **Input Output Operations:**
 - Operating System manages the input-output operations and establishes communication between the user and device drivers.
 - Device drivers are software that is associated with hardware that is being managed by the OS so that the sync between the devices works properly.
 - It also provides access to input-output devices to a program when needed.

Cont....

- **Communication Between Processes:**
 - The Operating system manages the communication between processes.
 - Communication between processes includes data transfer among them.
 - If the processes are not on the same computer but connected through a computer network, then also their communication is managed by the Operating System itself.

Cont....

- **File Management:**
 - The operating system helps in managing files also.
 - If a program needs access to a file, it is the operating system that grants access.
 - These permissions include read-only, read-write, etc.
 - It also provides a platform for the user to create, and delete files.
 - The Operating System is responsible for making decisions regarding the storage of all types of data or files, i.e, floppy disk/hard disk/pen drive, etc.
 - The Operating System decides how the data should be manipulated and stored.

Cont....

- **Memory Management**

- OS first check whether the upcoming program fulfil all requirement to get memory space or not ,if all things good, it checks how much memory space will be sufficient for program and then load the program into memory at certain location. And thus, it prevents program from using unnecessary memory.
- Let's understand memory management by OS in simple way. Imagine a cricket team with limited number of player . The team manager (OS) decide whether the upcoming player will be in playing 11 ,playing 15 or will not be included in team, based on his performance.

Cont....

- **Process Management:**

- Let's understand the process management in unique way. Imagine, our kitchen stove as the (CPU) where all cooking(execution) is really happen and chef as the (OS) who uses kitchen-stove(CPU) to cook different dishes(program).
- The chef(OS) has to cook different dishes(programs) so he ensure that any particular dish(program) does not take long time(unnecessary time) and all dishes(programs) gets a chance to cooked(execution) .
- The chef(OS) basically scheduled time for all dishes(programs) to run kitchen(all the system) smoothly and thus cooked(execute) all the different dishes(programs) efficiently.

Cont....

- **Security and Privacy:**

- **Security** : OS keep our computer safe from an unauthorized user by adding security layer to it.
- Basically, Security is nothing but just a layer of protection which protect computer from bad guys like viruses and hackers.
- OS provide us defenses like firewalls and anti-virus software and ensure good safety of computer and personal information.
- **Privacy** : OS give us facility to keep our essential information hidden like having a lock on our door, where only you can enter and other are not allowed . Basically, it respect our secrets and provide us facility to keep it safe.

Cont....

- **Resource Management:**
 - System resources are shared between various processes.
 - It is the Operating system that manages resource sharing.
 - It also manages the CPU time among processes using CPU Scheduling Algorithms.
 - It also helps in the memory management of the system.
 - It also controls input-output devices.
 - The OS also ensures the proper use of all the resources available by deciding which resource to be used by whom.

Cont....

- **User Interface:**

- User interface is essential and all operating systems provide it. Users either interface with the operating system through the command-line interface or graphical user interface or GUI. The command interpreter executes the next user-specified command.
- A GUI offers the user a mouse-based window and menu system as an interface.

- **Networking:**

- This service enables communication between devices on a network, such as connecting to the internet, sending and receiving data packets, and managing network connections.

Cont....

- **Error Handling:**

- The Operating System also handles the error occurring in the CPU, in Input-Output devices, etc. It also ensures that an error does not occur frequently and fixes the errors. It also prevents the process from coming to a deadlock. It also looks for any type of error or bugs that can occur while any task. The well-secured OS sometimes also acts as a countermeasure for preventing any sort of breach of the Computer System from any external source and probably handling them.

- **Time Management:**

- Imagine traffic light as (OS), which indicates all the cars(programs) whether it should be stop(red)=>(simple queue), start(yellow)=>(ready queue),move(green)=>(under execution) and this light (control) changes after a certain interval of time at each side of the road(computer system) so that the cars(program) from all side of road move smoothly without traffic.

Thank You !!!