OPERATING SYSTEM (SEM-II)

By: Mrs. Nidhi Divecha (ME CMPN)

Modules at a Glance

- UNIT1 -- Introduction
- UNIT 2 -- Process management
- UNIT 3 -- Memory management

History of the Operating System

The First Generation (1940 to early 1950s)

- When the first electronic computer was developed in 1940, it was created **without any operating system.**
- The programmer can perform and solve **only simple mathematical calculations** during the computer generation, and this calculation does not require an operating system.

The Second Generation (1955 - 1965)

- The first operating system (OS) was created in the early 1950s and was known as **GMOS.**
- **General Motors** has developed OS for the **IBM** computer. The second-generation operating system was based on a single stream **batch processing system** because it collects all similar jobs in groups or batches and then submits the jobs to the operating system using a punch card to complete all jobs in a machine.
- After that, new machines were called **mainframes**, which were very big and used by professional operators.

The Third Generation (1965 - 1980)

- During the late 1960s, operating system designers were very capable of developing a new operating system that could simultaneously perform multiple tasks in a single computer program called **multiprogramming.**
- The introduction of **multiprogramming** plays a very important role in developing operating systems that allow a CPU to be busy every time by performing different tasks on a computer at the same time.
- During the third generation, there was a new development of **minicomputer's** phenomenal growth starting in 1961 with the DEC PDP-1. These PDP's leads to the creation of personal computers in the fourth generation.

The Fourth Generation (1980 - Present Day)

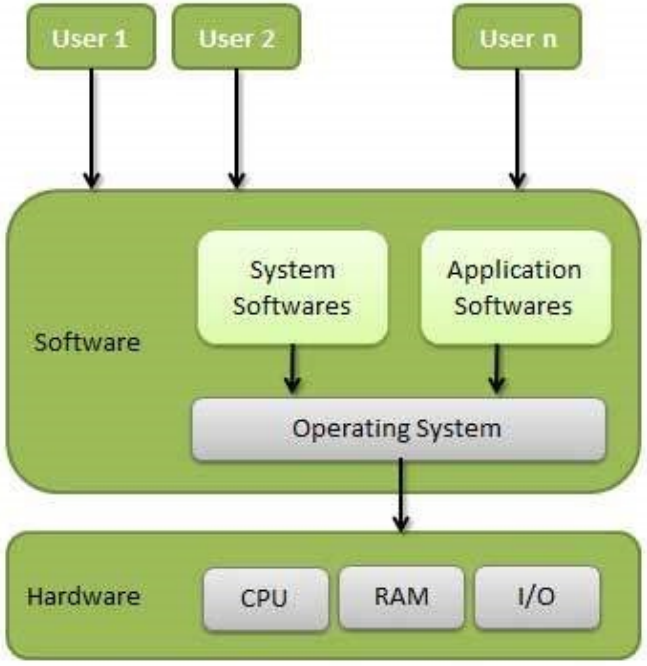
- The fourth generation of operating systems is related to the development of the **personal computer (PC).**
- However, the personal computer is very similar to the minicomputers that were developed in the third generation.
- Windows OS was created in 1975.
- They introduced MS-DOS in 1981. (**MS-DOS**, in full Microsoft **Disk Operating System**, the dominant **operating system** for the personal computer (PC) throughout the 1980s.)
- Today, Windows has become the most popular and most commonly used operating system technology.
- And then, Windows released various operating systems such as Windows 95, Windows 98, Windows XP and the latest operating system, Windows 7.
- Currently, most Windows users use the Windows 10 operating system.
- Besides the Windows operating system, Apple is another popular operating system built in the 1980s, and this operating system was developed by Steve Jobs, a co-founder of Apple. They named the operating system Macintosh OS or Mac OS.

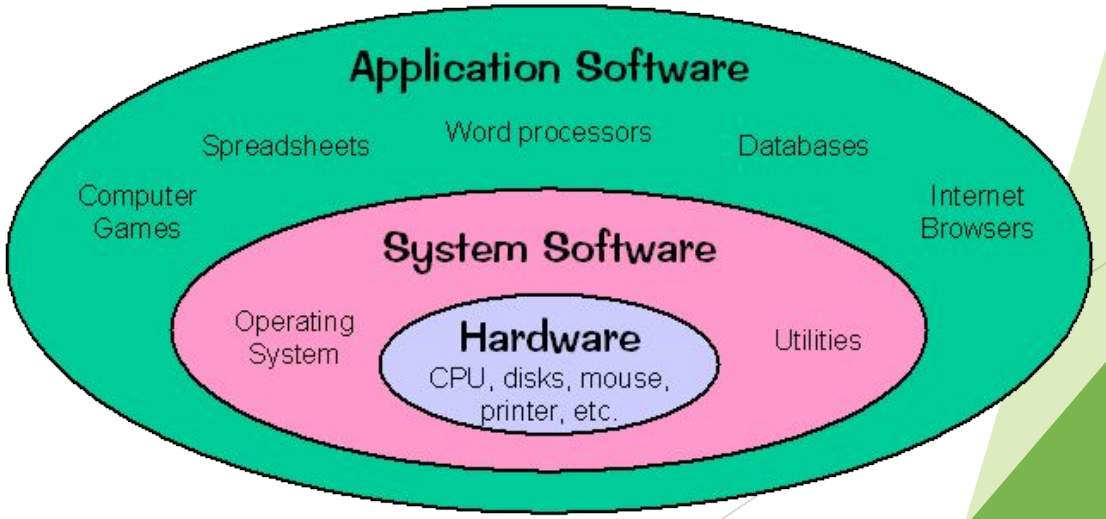
Operating System - Overview

- An Operating System (OS) is an interface between a computer user and computer hardware.
- An operating system is 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.
- E.g. of OS are –Windows, GNU/Linux, macOS (Macintosh) - used for Apple's personal computers and workstations (MacBook, iMac), Android (Google's Operating System for smartphones/tablets/smartwatches), iOS (Apple's OS for iPhone, iPad and iPod Touch)

Definition

- An operating system is a program that acts as an interface between the user and the computer hardware and controls the execution of all kinds of programs.





Advantages & Disadvantages of using Operating System

Advantages:

- Allows you to hide details of hardware by creating an abstraction
- Easy to use with a GUI
- Offers an environment in which a user may execute programs/applications
- Acts as an intermediator between all hardware's and software's of the system
- **Convenient:** The operating system makes sure that the computer system is convenient to use
- **Efficiency:** OS allows computer system resources to be used in an efficient manner.

Disadvantages:

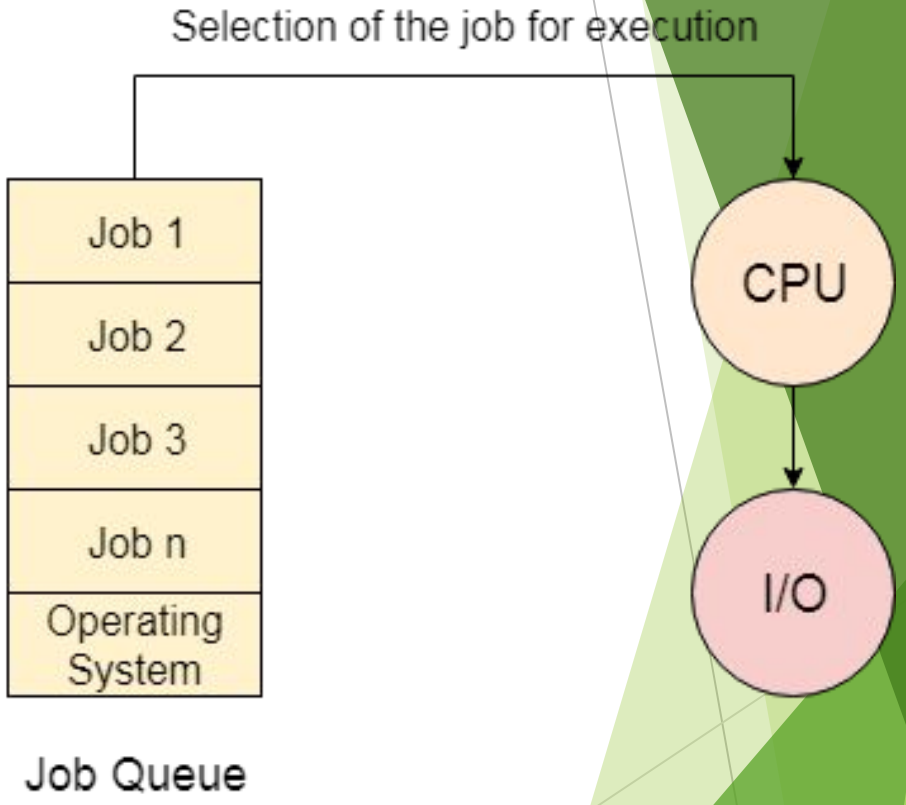
- If any issue occurs in OS, you may lose all the contents which have been stored in your system
- Operating system's software is quite expensive for small size organization which adds burden on them. Example Windows
- It is never entirely secure as a threat can occur at any time

Types of Operating System

- Batch Operating System
- Multitasking/Time Sharing OS
- Multiprocessing OS
- Real Time OS
- Distributed OS
- Network OS
- Mobile OS

Batch Operating System

- Some computer processes are very lengthy and time-consuming.
- To speed the same process, a job with a similar type of needs is batched together and run as a group.
- Batch OS groups jobs that perform similar type of functions. These groups are called as batch and are executed at the same time.
- The user of a batch operating system never directly interacts with the computer.
- In this type of OS, every user prepares his or her job on an offline device like a punch card and submit it to the computer operator.
- The system put all the jobs in a queue on the basis of first come first serve and then executes the jobs one by one. The users collect their respective output when all the jobs get executed.



The **problems** with Batch Systems are as follows –

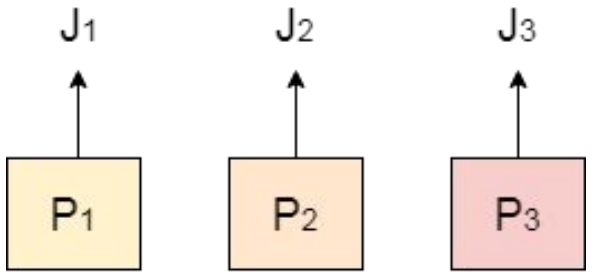
- **Lack of interaction** between the user and the job.
- **CPU is often idle**, because the speed of the mechanical I/O devices is slower than the CPU.
- Batch processing suffers from starvation. If there are five jobs J1, J2, J3, J4, J4 and J5 present in the batch. If the execution time of J1 is very high, then other four jobs will never be going to get executed or they will have to wait for a very high time. Hence the other processes get starved.

Multiprogramming Operating System

- Multiprogramming is an extension to the batch processing where the CPU is kept always busy.
- Each process needs two types of system time: CPU time and I/O time.
- In multiprogramming environment, for the time a process does its I/O, The CPU can start the execution of other processes.
- Therefore, multiprogramming improves the efficiency of the system.

Multiprocessing Operating System

- In Multiprocessing, Parallel computing is achieved.
- There are more than one processor present in the system which can execute more than one process at the same time. This will increase the throughput of the system.



Multi Processing

Real time OS

- 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 then it will be completely useless.
- The time taken by the system to respond to an input and display of required updated information is termed as the **response time**. So, in this method, the response time is very less as compared to online processing.
- 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 certain precision.
- For example, Scientific experiments, medical imaging systems, industrial control systems, weapon systems, robots, air traffic control systems, etc.
- There are two types of real-time operating systems.

Hard real-time systems

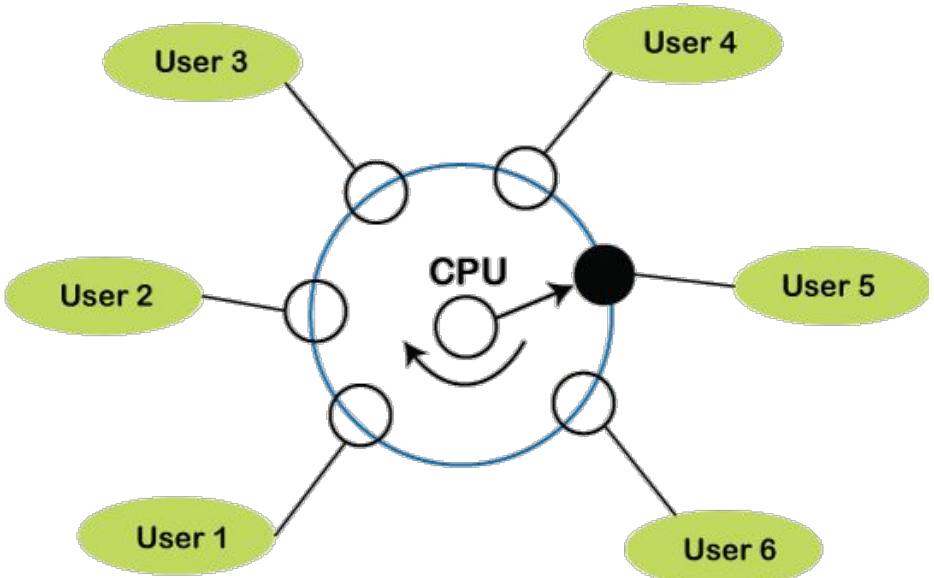
- In Hard RTOS, the deadline is handled very strictly which means that given task must start executing on specified scheduled time and must be completed within the assigned time duration.
- Example: Medical critical care system, Aircraft systems, etc.

Soft real-time systems

- Soft Real time RTOS, accepts some delays by the Operating system. In this type of RTOS, there is a deadline assigned for a specific job, but a delay for a small amount of time is acceptable. So, deadlines are handled softly by this type of RTOS.
- Example: Online Transaction system and Livestock price quotation System.

Multi-Tasking/Time-sharing Operating systems

- Multitasking is multiprogramming with time sharing.
- In multitasking OS, each process is executed for a fixed time period.
- After that fixed time, CPU is switched to other process.
- Switching is so fast that the user gets illusion that all the process is running at the same time, but this does not happen because we have only one CPU.
- This fixed time period is called **time quantum**. It is also called **Time -sharing OS.**
- Multiple jobs are executed by the CPU by switching between them, but the switches occur so frequently. Thus, the user can receive an **immediate response**. For example, in a transaction processing, the processor executes each user program in a short burst or quantum of computation. That is, if **n** users are present, then each user can get a time quantum. When the user submits the command, the response time is in few seconds at most.



Advantages

- Provides the advantage of quick response.
- Avoids duplication of software.
- Reduces CPU idle time.

Disadvantages

- Problem of reliability.
- Question of security and integrity of user programs and data.
- Problem of data communication.

Distributed Operating System

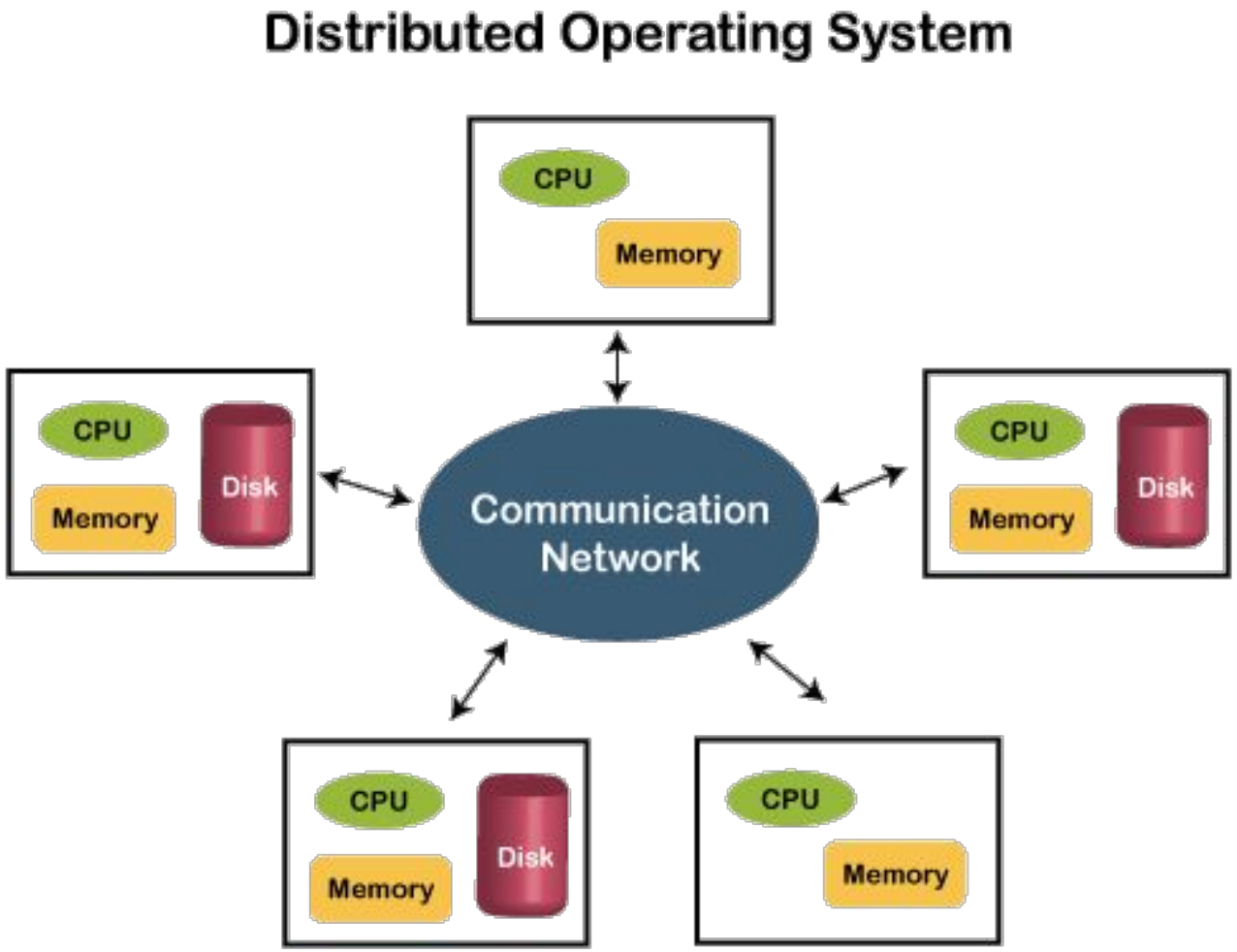
- It is a collection of independent computers, interconnected via a computer network, capable of collaborating on a task.
- Distributed Operating System use multiple CPU to execute multiple processes.
- In Distributed systems, Data processing jobs are distributed among the processors accordingly.
- The processors communicate with one another through various communication lines (such as high-speed buses or telephone lines).
- These are referred as **loosely coupled systems** or **distributed systems**. Processors in a distributed system may vary in size and function. These processors are referred as sites, nodes, computers.
- Examples: Telephone network, mobile computing, ATM machine etc.

Advantages of distributed systems are as follows –

- With resource sharing facility, a user at one site may be able to use the resources available at another.
- Speedup the exchange of data with one another via electronic mail.
- If one site fails in a distributed system, the remaining sites can potentially continue operating.
- Better service to the customers.
- Reduction of the load on the host computer.

Disadvantages of Distributed Operating System:

•Failure of the main network will stop the entire communication



Network Operating System

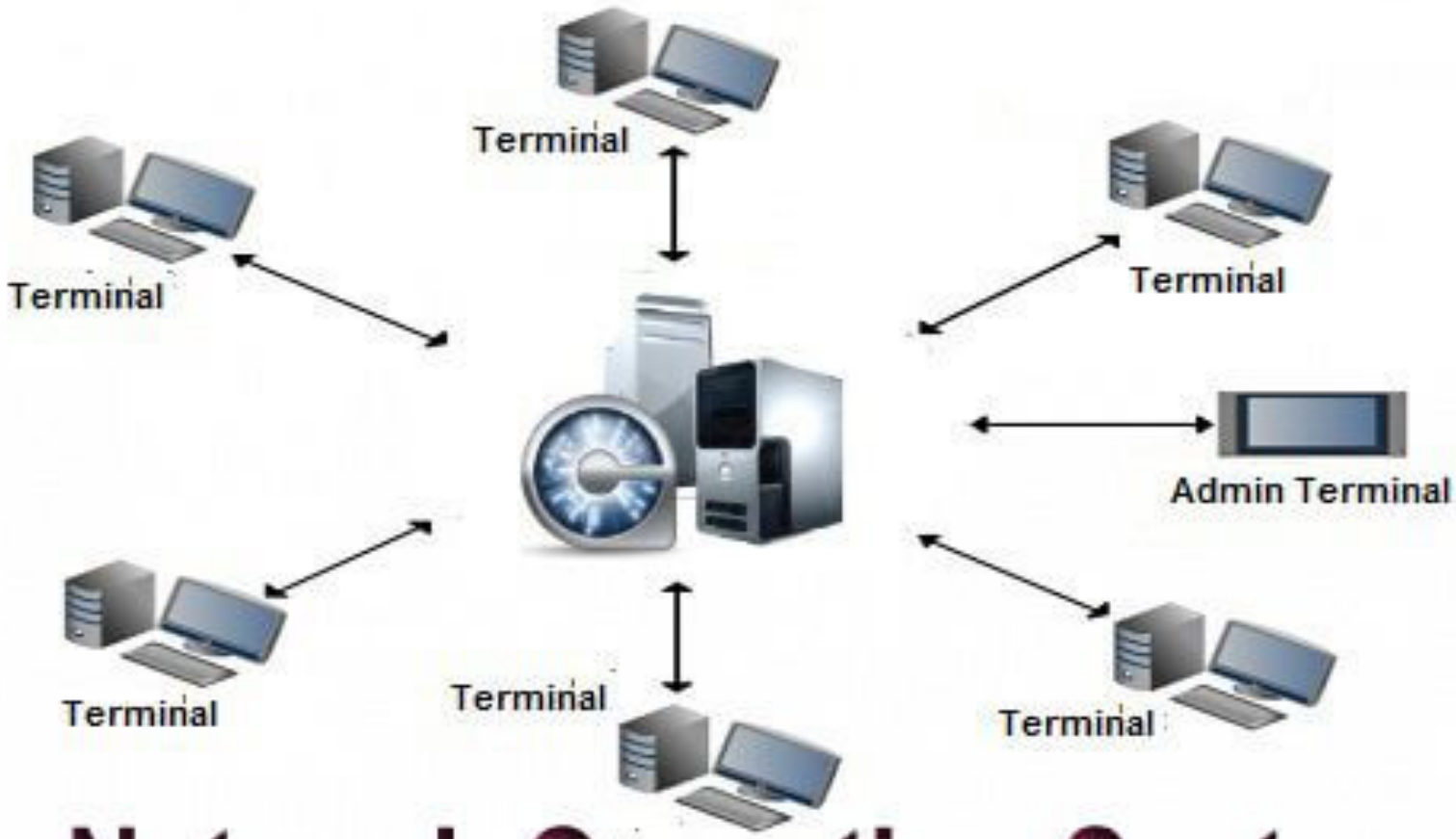
- A Network Operating System **runs on a server** and provides the server the capability to manage data, users, groups, security, applications, and other networking functions.
- The primary purpose of the network operating system is to allow shared file and printer access among multiple computers in a network.
- Examples of network operating systems include Microsoft Windows Server 2003, Microsoft Windows Server 2008, UNIX, Linux, Mac OS X, Novell NetWare, and BSD.

Advantages:

- Centralized servers are highly stable.
- Security is server managed.
- Upgrades to new technologies and hardware can be easily integrated into the system.
- Remote access to servers is possible from different locations and types of systems.

Disadvantages:

- High cost of buying and running a server.
- Dependency on a central location for most operations.
- Regular maintenance and updates are required.

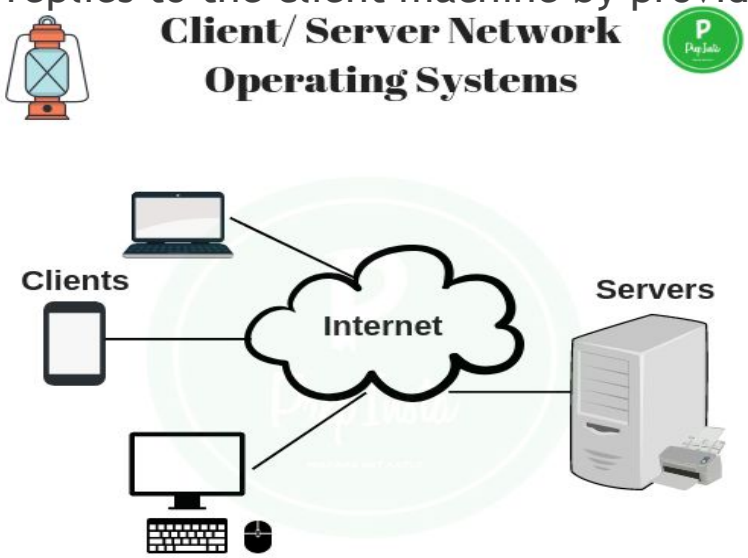


Network Operating System

There are mainly two types of Network O.S., they are:

Client-Server

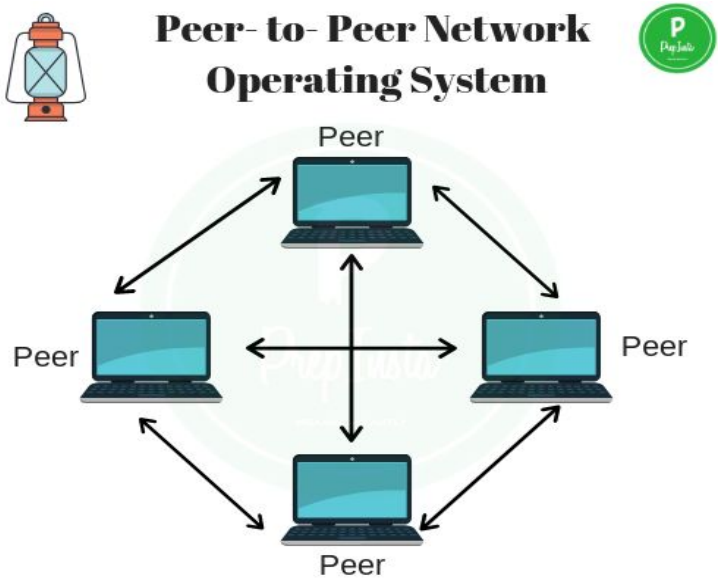
- The Client-Server Networking Operating System operates with a single server and multiple client computers in the network.
- Whenever computers share resources with client machines they are considered as servers.
- Servers waits for requests to arrive from client machines and then respond to them.
- The server machine is a centralized hub for all the client machines.
- The client machines generate a request for information or some resource and forward it to the server machine.
- The server machine, in turn, replies to the client machine by providing appropriate services to it in a secure manner.



There are mainly two types of Network O.S., they are:

Peer-to-Peer

- Peers are the computer systems which are connected to each other.
- Files can be shared directly between systems on the network without the need of a central server.
- In other words, each computer on a P2P network becomes a file server as well a client.
- Using the Network O.S., they can connect and communicate with each other. They can also share data and resources with one another.
- One node can also communicate and share data and resources with a remote node in the network by using the authentication feature of the Network O.S.
- The nodes are directly connected with each other in the network with the help of a **switch or a hub.**
- Peer to peer networks is more common in small offices or within a single department of a larger organization.



Mobile OS

- A mobile operating system is an operating system that helps to run other application software on mobile devices.
- Much like the Linux or Windows operating system controls your desktop or laptop computer, a mobile operating system is the software platform on top of which other programs can run on mobile devices.
- Some most famous mobile operating systems are Android and iOS, but others include BlackBerry, Web, and watchOS.

Popular platforms of the Mobile OS

- **Android OS:** The Android operating system is the most popular operating system today. It is a mobile OS based on the Linux Kernel and open-source software. The android operating system was developed by **Google**. The first Android device was launched in **2008**.
- **Bada (Samsung Electronics):** Bada is a Samsung mobile operating system that was launched in 2010. The Samsung was the first mobile to use the bada operating system. The bada operating system offers many mobile features, such as 3-D graphics, application installation, and multipoint-touch.
- **iPhone OS / iOS:** The iOS was developed by the Apple for the use on its device. The iOS operating system is the most popular operating system today. It is a very secure operating system.
- **Windows Mobile OS:** The window mobile OS is a mobile operating system that was developed by **Microsoft**. It was designed for the pocket PCs and smart mobiles.

System Software

- Software required to run the hardware parts of the computer and other application software.
- Acts as an interface between hardware and user applications.
- Interface is needed because hardware devices and humans speak in different languages.
- English is the pre-dominant language of interacting with computers.
- System software converts all human instructions into machine understandable instructions.

Types of System Software

- Operating system
- Language Processor
- Device drivers

Operating System

- System software or (OS) is responsible for functioning of all the hardware parts and their inter-operability to carry out tasks successfully.
- First software to be loaded into computer memory.
- Manages a computers basic functions like storing data in memory, retrieving files from storage devices, scheduling tasks based on priority.

Language processors

- Converts all user instructions into machine understandable language.
- In terms of human machine interactions, languages are of three types:
- 1) **Machine level language** – a string of 0's and 1's that the machine can understand.
- 2) **Assembly level language** – defines mnemonics
- 3) **High level language** – uses English like statements and is completely independent of machines (programming language)
- Program written in high level programming level like java, c++, etc is called a source code.
- System software that converts source code to object code is called language processors.

Three types of language interpreters:

1) Assembler – converts assembly level programs into machine level program.
2) Interpreter – converts high level programs into machine level line by line.
3) Compiler – converts high level programs into machine level programs at go rather than line by line.

Device Drivers

- System software that controls and monitors functioning of a specific device on a computer.
- Each device that needs to be attached externally to the system has a specific driver associated with it.
- When you attach a new device, you need to install its driver so that the OS knows it needs to be managed.

Resource Abstraction

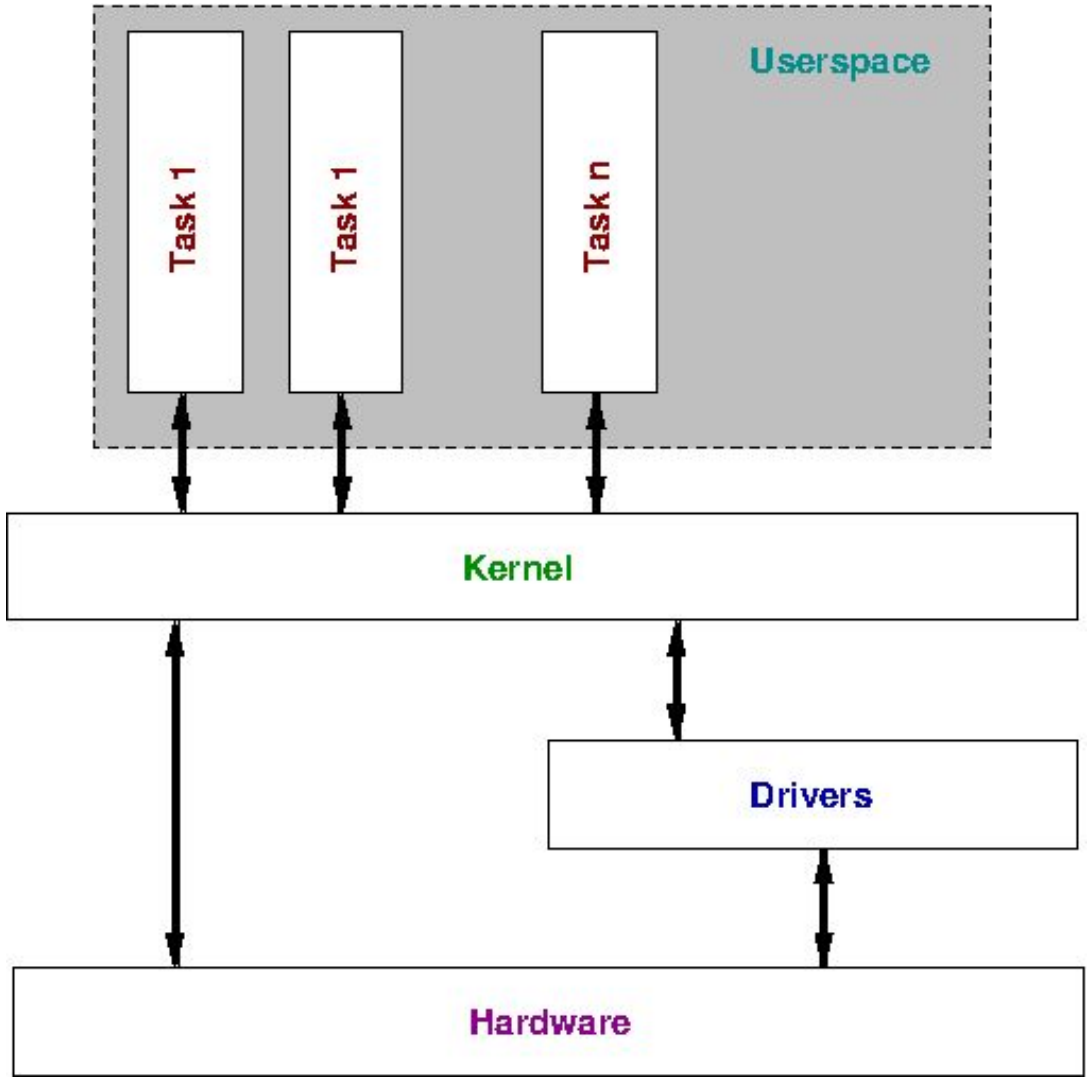
- Resource abstraction is used to **hide the details of hardware** by creating abstraction.
- An abstraction is software that hides lower-level details and provides a set of higher-level functions.
- An operating system transforms the physical world of devices, instructions, memory, and time into virtual world that is the result of abstractions built by the operating system. **There are several reasons for abstraction.**
- ***First***, the code needed to control peripheral devices is not standardized. Operating systems provide subroutines called **device drivers** that perform operations on behalf of programs for example, input/output operations.
- ***Second***, the operating system introduces new functions as it abstracts the hardware. For instance, operating system introduces the **file abstraction** so that programs do not have to deal with disks.
- ***Third***, the operating system transforms the computer hardware into multiple virtual computers, each belonging to a different program. Each program that is running is called a process. Each process views the hardware through the lens of abstraction.
- ***Fourth***, the operating system can enforce **security** through abstraction

OS Strategies for Providing Services

- Depending on the needs of its users, a computer's operating system may be designed to use different strategies to serve the users' needs best.

- **Batch Processing Systems**
- **Time share**
- **Multi-Tasking Operating Systems**
- **Multi-User Operating Systems**
- **Multi-Processor Operating Systems**
- **Real-Time Operating Systems**
- **Network Operating Systems**

Operating System Organisation



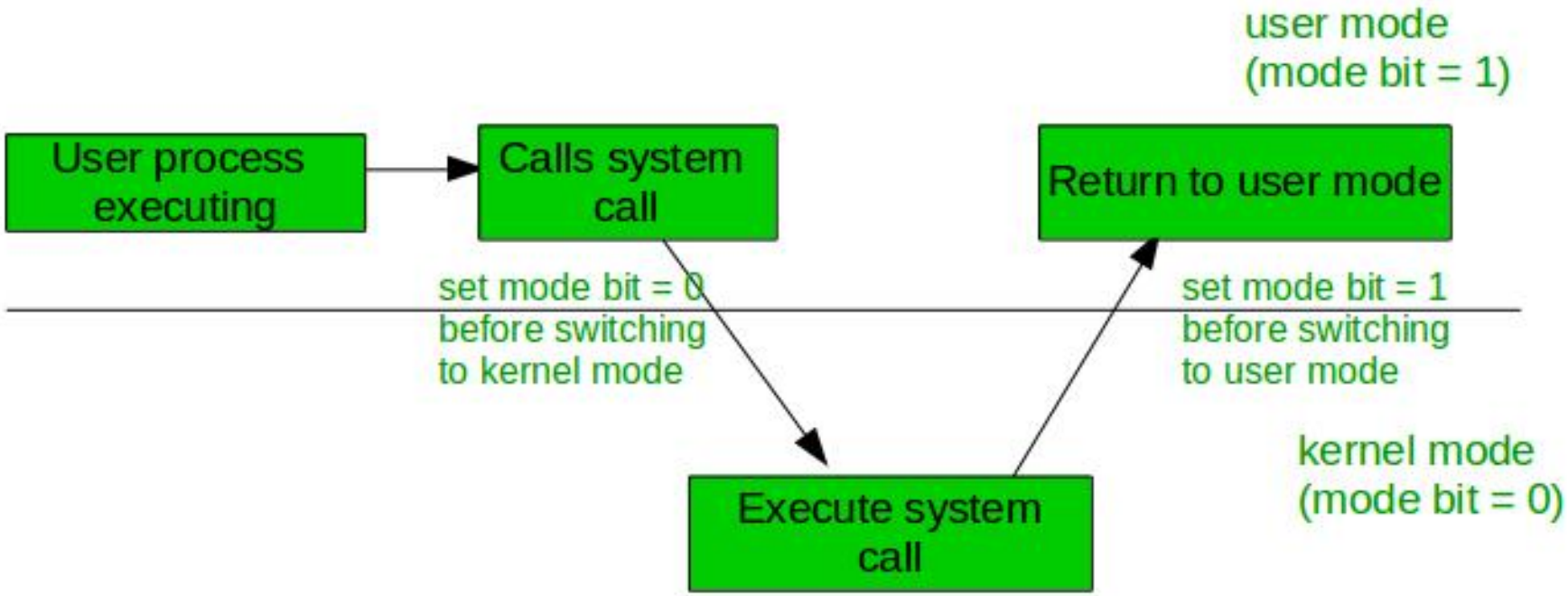
- There are two modes of operation in the operating system to make sure it works correctly. These are **user mode and kernel mode.**
- There are certain instructions that need to be executed by Kernel only. So, the CPU executes these instructions in the Kernel Mode only.
- For example, memory management should be done in Kernel-Mode only.
- While in the User Mode, the CPU executes the processes that are given by the user in the User Space.

User Mode

- The system is in user mode when the operating system is running a user application such as handling a text editor.
- The transition from user mode to kernel mode occurs when the application requests the help of operating system or an interrupt or a **system call occurs.**
- The mode bit is set to 1 in the user mode. It is changed from 1 to 0 when switching from user mode to kernel mode.

Kernel Mode

- The system starts in kernel mode when it boots and after the operating system is loaded, it executes applications in user mode.
- There are some privileged instructions that can only be executed in kernel mode.
- These are interrupt instructions, input output management etc. If the privileged instructions are executed in user mode, it is illegal and a trap is generated.
- The mode bit is set to 0 in the kernel mode. It is changed from 0 to 1 when switching from kernel mode to user mode.



In the above image, the user process executes in the user mode until it gets a system call. Then a system trap is generated, and the mode bit is set to zero. The system call gets executed in kernel mode. After the execution is completed, again a system trap is generated, and the mode bit is set to 1. The system control returns to kernel mode and the process execution continues.

The Kernel

- A kernel is an important part of an OS that manages system resources.
- It also acts as a bridge between the software and hardware of the computer.
- It is one of the first program which is loaded on start-up after the bootloader.
- The Kernel is also responsible for offering secure access to the machine's hardware for various programs.
- The Kernel is responsible for low-level tasks such as disk management, memory management, task management, etc.
- It also decides when and how long a certain application uses specific hardware.
- When a process makes a request to the Kernel, then it is called **System Call.**

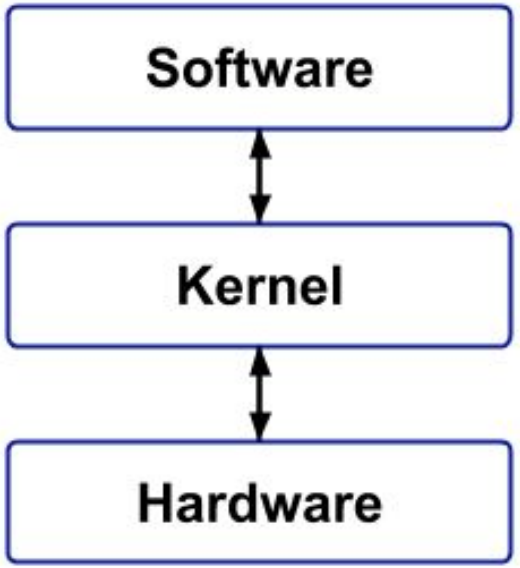
Functions of a Kernel

- **Access Computer resource:** A Kernel can access various computer resources like the CPU, I/O devices and other resources. It acts as a bridge between the user and the resources of the system.
- **Resource Management:** It is the duty of a Kernel to share the resources between various process in such a way that there is uniform access to the resources by every process.
- **Memory Management:** Every process needs some memory space. So, memory must be allocated and deallocated for its execution. All these memory management is done by a Kernel.
- **Device Management:** The peripheral devices connected in the system are used by the processes. So, the allocation of these devices is managed by the Kernel.

Types of Kernel

1. Monolithic Kernels

- Monolithic Kernels are those Kernels where the user services and the kernel services are implemented in the **same memory space** i.e. different memory for user services and kernel services are not used in this case.
- By doing so, the size of the Kernel is increased and this, in turn, increases the size of the Operating System.
- As there is no separate User Space and Kernel Space, so the **execution of the process will be faster in Monolithic Kernels.**



Advantages:

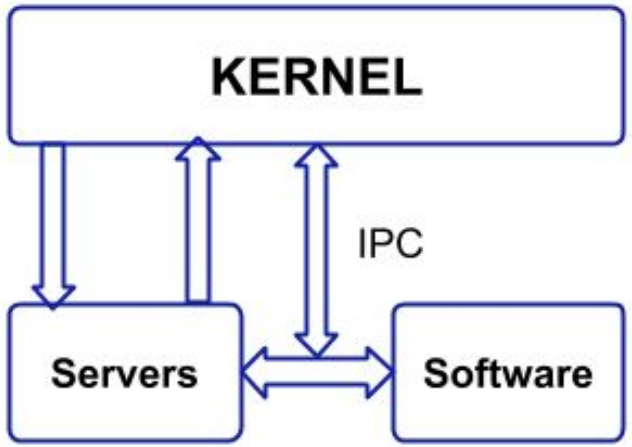
- It provides CPU scheduling, memory scheduling, file management through System calls only.
- Execution of the process is fast because there is no separate memory space for user and kernel.

Disadvantages:

- If any service fails, then it leads to system failure.
- If new services are to be added, then the entire Operating System needs to be modified.

2. Microkernel

- A Microkernel is different from Monolithic kernel because in a Microkernel, the user services and kernel services are **implemented into different spaces** i.e. we use User Space and Kernel Space in case of Microkernels.
- As we are using User Space and Kernel Space separately, so it **reduces the size** of the Kernel and this, in turn, reduces the size of Operating System.
- As we are using different spaces for user services and kernel service, so the communication between application and services is done with the help of message passing and this, in turn, reduces the speed of execution.



Advantages:

- If **new services** are to be added, then it can be **easily added.**

Disadvantages:

- Since we are using User Space and Kernel Space separately, so the **communication** between these can **reduce the overall execution time.**

Factors in Operating System Design

- Performance
- Protection and Security
- Correctness
- Maintainability
- Commercial factors
- Standard and open systems

Strategies for open system

Strategies	Explanation
Portability	Application programs could be build so that they can be moved easily from one type of hardware to another
Application integrated	All application programs could be built so that they present a common interface to users
Interoperability	Facilities could be provide in a network environment to standardize access to remote facilities

Basic OS functions

Device Management

- Operating System manages device communication via their respective drivers.
- It does the following activities for device management −
- Keeps tracks of all devices. I/O controller is responsible for this task
- Decides which process gets the device when and for how much time.
- Allocates the device in an efficient way.
- De-allocates devices.

File Management

- The operating system allocates and de-allocates resources. It regulates which process gets the file and for what duration. Also, it keeps track of information, location, uses, status etc.
- It manages all the file-related activities such as organization storage, retrieval, naming, sharing, and protection of files.
- OS also performs tasks like creating directories and files, copying/moving them and renaming/deleting files.

Memory Management

- The operating system manages the Primary Memory or Main Memory.
- Main memory is made up of a large array of bytes or words where each byte or word is assigned a certain address. Main memory is a fast storage and it can be accessed directly by the CPU.
- For a program to be executed, it should be first loaded in the main memory.
- An Operating System performs the following activities for memory management:
- It keeps tracks of primary memory, i.e., which bytes of memory are used by which user program.
- In multi programming, the OS decides the order in which process are granted access to memory, and for how long.
- It Allocates the memory to a process when the process requests it and deallocates the memory when the process has terminated or is performing an I/O operation

Process Management

- In a multi programming environment, the OS decides the order in which processes have access to the processor, and how much processing time each process has.
- This function of OS is called process scheduling.
- An Operating System performs the following activities for processor management.
- Keeps tracks of the status of processes.
- The program which performs this task is known as traffic controller.
- Allocates the CPU that is processor to a process.
- De-allocates processor when a process is no more required.

Security

- The operating system uses password protection to protect user data and similar other techniques.
- It also prevents unauthorized access to programs and user data.

Control over system performance

- Monitors overall system health to help improve performance.
- Records the response time between service requests and system response to have a complete view of the system health.
- This can help improve performance by providing important information needed to troubleshoot problems.

Job accounting

- Keeping track of time & resource used by various job and users.

Networking:

- A distributed system is a group of processors which do not share memory, hardware devices, or a clock. The processors communicate with one another through the network.

Error detecting aids

- Production of dumps, traces, error messages, and other debugging and error detecting aids.

Communication management:

- Coordination and assignment of compilers, interpreters, and another software resource of the various users of the computer systems.

Basic Implementation consideration

- 3 basic implementation mechanisms are used in every OS design.

1) Processor modes

- The mode bit is used to distinguish between execution on behalf of an **OS(supervisor mode)** and execution on behalf of a **user(user mode).**

2) Kernels

- Kernel is designed as a **trusted software module** that supports correct operation all over the software.

3) Method of requesting system device

- This issue is concerned with the way user processes request services from the operating system by calling a system function or message passing to a system.

1) Processor modes

2 types of modes in processor

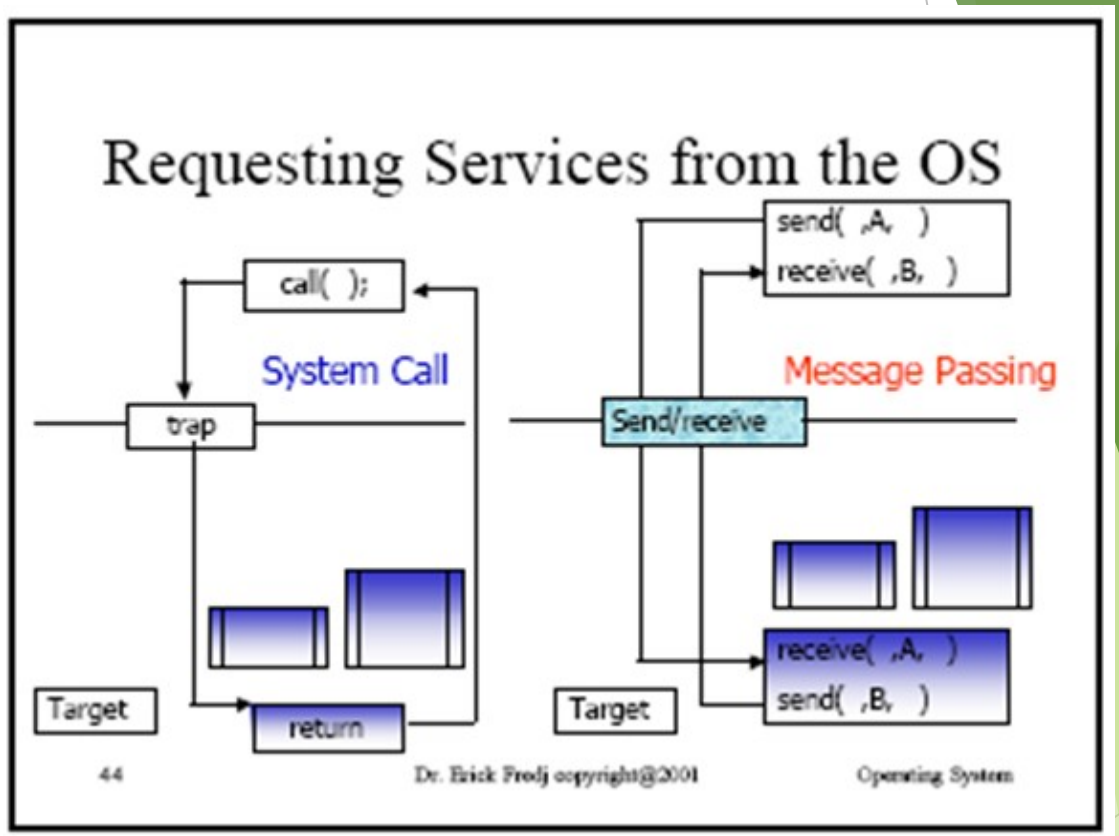
- **Supervisor mode:** processor executes every instruction in hardware.
- **User mode:** executes only a subset of instructions.
- Supervisor mode also known as **supervisor, privileged, protected mode**.
- The mode bit is set by the user mode trap instruction, also called supervisor call instruction.

Kernels

- The critical part of the system software that executes in supervisor mode.
- All application program execute in user mode.
- Operated as trusted software, means implement protection mechanisms that could not be changed actions of untrusted software executing in user mode.

Requesting services from OS

- Two techniques by which a program executing in user mode can request the kernels services:
- **System call-** a program that requests service from kernel and provide the interface between process and OS.
- **Message passing-** uses a common mailbox to pass messages between processes



System call in OS

- A program that requests service from kernel and provide the interface between process and OS.
- System calls are usually made when a process in user mode requires access to a resource. Then it requests the kernel to provide the resource via a system call.
- System calls are the only entry points for the kernel system.

In general, system calls are required in the following situations −

- If a file system requires the creation or deletion of files. Reading and writing from files also require a system call.
- Creation and management of new processes.
- Network connections also require system calls. This includes sending and receiving packets.
- Access to a hardware devices such as a printer, scanner etc. requires a system call.