# Operating System

# Operating System

- 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.
- The purpose of an operating system is to provide an environment in which a user can execute programs in a convenient and efficient manner.
- An operating system is a software that manages the computer hardware. Which manages all the resources of computer system.

# Advantages

- User-Friendly Interface
- Resource Sharing
- Software Update
- Computing Source
- Multitasking

# Disadvantages

- Expensive
- System Failure
- Highly Complex
- Virus Threats

# Functions of Operating system

- Memory Management
- Processor Management
- Device Management
- File Management

**OTHER Activities**

- Security
- Control over system performance
- Job accounting
- Error detecting aids
- Coordination between other software and users

# Memory Management

- It keeps tracks of primary memory, i.e., which bytes of memory are used by which user program. The memory addresses that have already been allocated and the memory addresses of the memory that has not yet been used.
- 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

# Processor 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 perform 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.

# Device Management

- An OS manages device communication via their respective drivers. It performs the following activities for device management.
- Keeps tracks of all devices connected to system. designates a program responsible for every device known as the Input/Output controller.
- Decides which process gets access to a certain device and for how long. Allocates devices in an effective and efficient way. Deallocates devices when they are no longer required.

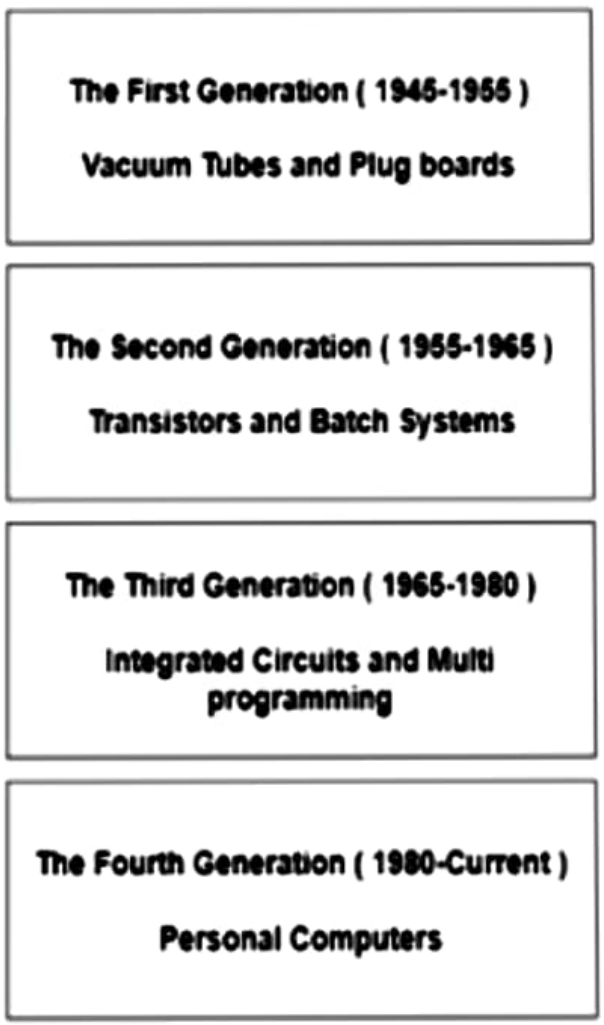
# File Management

- A file system is organized into directories for efficient or easy navigation and usage. These directories may contain other directories and other files.
- An Operating System carries out the following file management activities. It keeps track of where information is stored, user access settings and status of every file and more…
- These facilities are collectively known as the file system.

# OTHER Activities

- **Security** – By means of password and similar other techniques, it prevents unauthorized access to programs and data.
- **Control over system performance** – Recording delays between request for a service and response from the system.
- **Job accounting** – Keeping track of time and resources used by various jobs and users.
- **Error detecting aids** – Production of dumps, traces, error messages, and other debugging and error detecting aids.
- **Coordination between other softwares and users** – Coordination and assignment of compilers, interpreters, assemblers and other software to the various users of the computer systems.

# Operating System Generations




OPERATING SYSTEM GENERATIONS

# The First Generation ( 1945 - 1955 )
# Vacuum Tubes and Plugboards

- During this generation computers were generally used to solve simple math calculations, operating systems were not necessarily needed.
- Calculating engines with mechanical relays were built at that time. However, the mechanical relays were very slow and were later replaced with vacuum tubes. These machines were enormous but were still very slow.
- These early computers were designed, built and maintained by a single group of people. Programming languages were unknown and there were no operating systems so all the programming was done in machine language. All the problems were simple numerical calculations.
- By the 1950's punch cards were introduced and this improved the computer system. Instead of using plugboards, programs were written on cards and read into the system.

# The Second Generation ( 1955 - 1965 )
# Transistors and Batch Systems

- Transistors led to the development of the computer systems that could be manufactured and sold to paying customers. These machines were known as mainframes and were locked in air-conditioned computer rooms with staff to operate them.

- Operating systems in the 1950's were called single-stream batch processing systems because the data was submitted in groups. These new machines were called mainframes, and they were used by professional operators in large computer rooms. Since there was such as high price tag on these machines, only government agencies or large corporations were able to afford them.

# The Third Generation ( 1965 - 1980)
# Integrated Circuits and Multiprogramming

- Until the 1960's, there were two types of computer systems i.e the scientific and the commercial computers. These were combined by IBM in the System/360. This used integrated circuits and provided a major price and performance advantage over the second generation systems.

- The third generation operating systems also introduced multiprogramming. This meant that the processor was not idle while a job was completing its I/O operation. Another job was scheduled on the processor so that its time would not be wasted.

# The Fourth Generation ( 1980 - Present ): Personal Computers

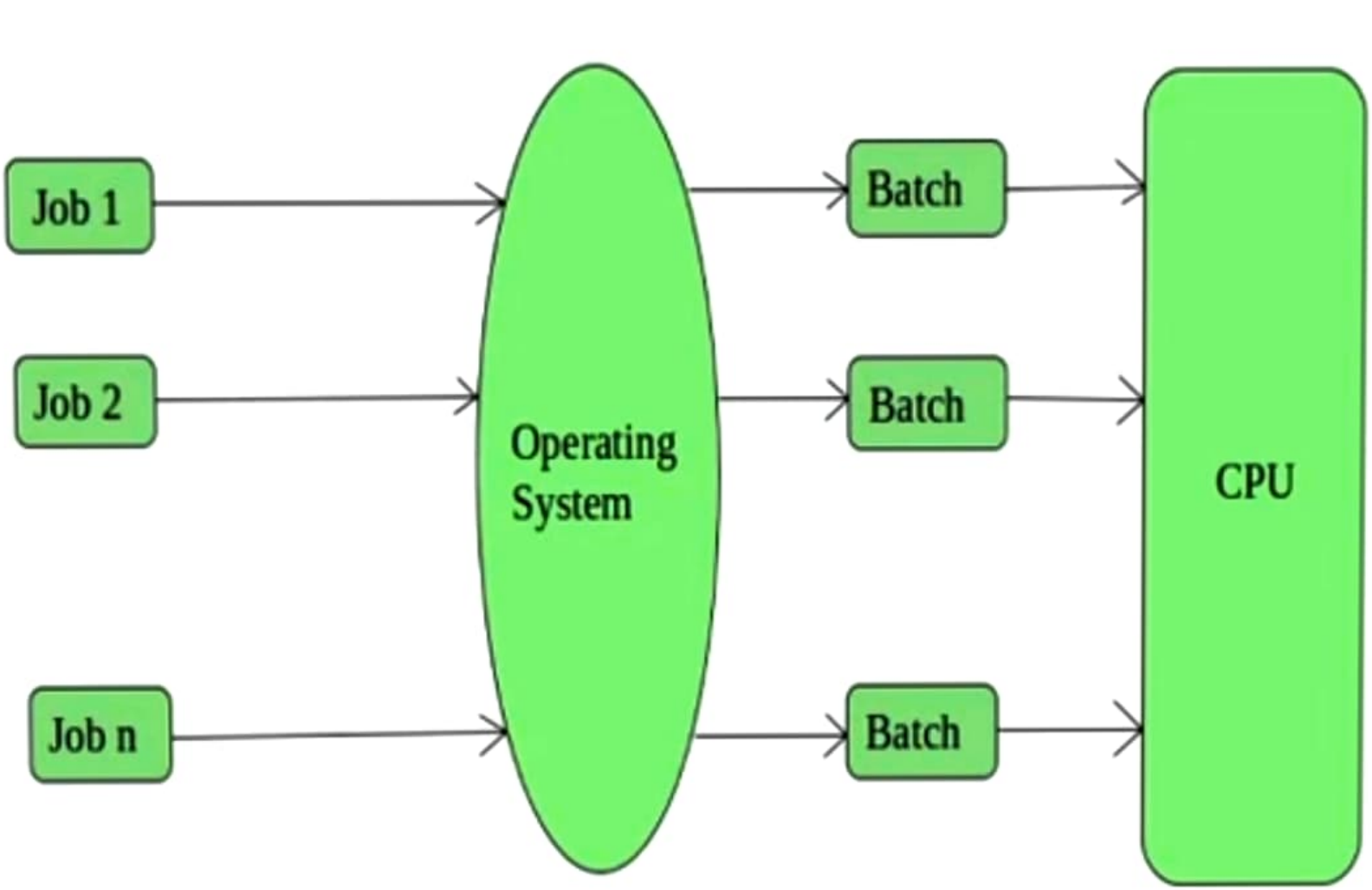
- Personal Computers were easy to create with the development of large-scale integrated circuits. These were chips containing thousands of transistors on a square centimeter of silicon. Because of these, microcomputers were much cheaper than minicomputers and that made it possible for a single individual to own one of them.

- The advent of personal computers also led to the growth of networks. This created network operating systems and distributed operating systems. The users were aware of a network while using a network operating system and could log in to remote machines and copy files from one machine to another.

# Types of Operating Systems

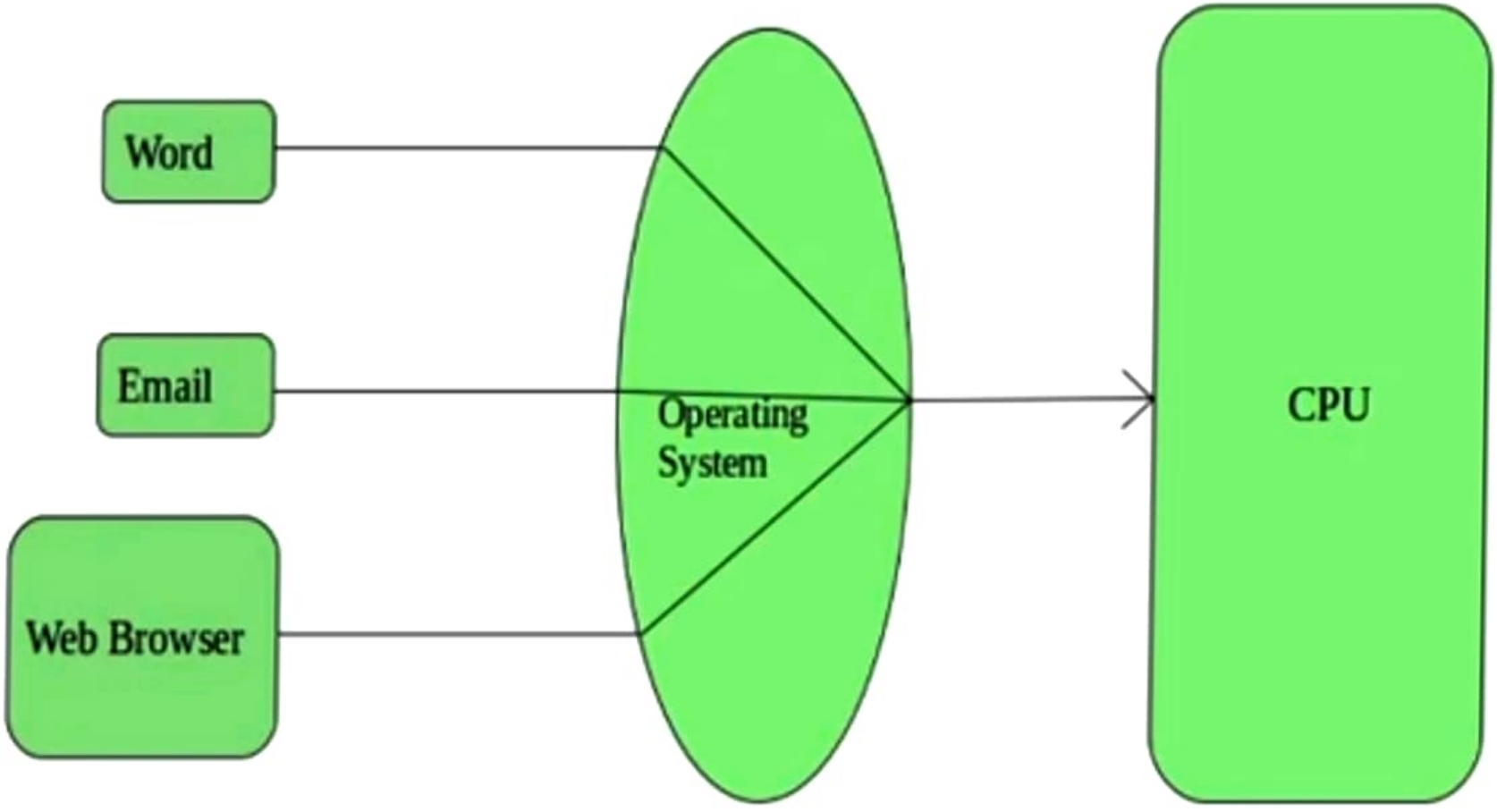
1. **Batch Operating System**

   This type of operating system does not interact with the computer directly. There is an operator which takes similar jobs having same requirement and group them into batches. It is the responsibility of operator to sort the jobs with similar needs


Job 1
Job 2
Job n
Operating System
Batch
Batch
Batch
CPU

## 2. Time-Sharing Operating Systems

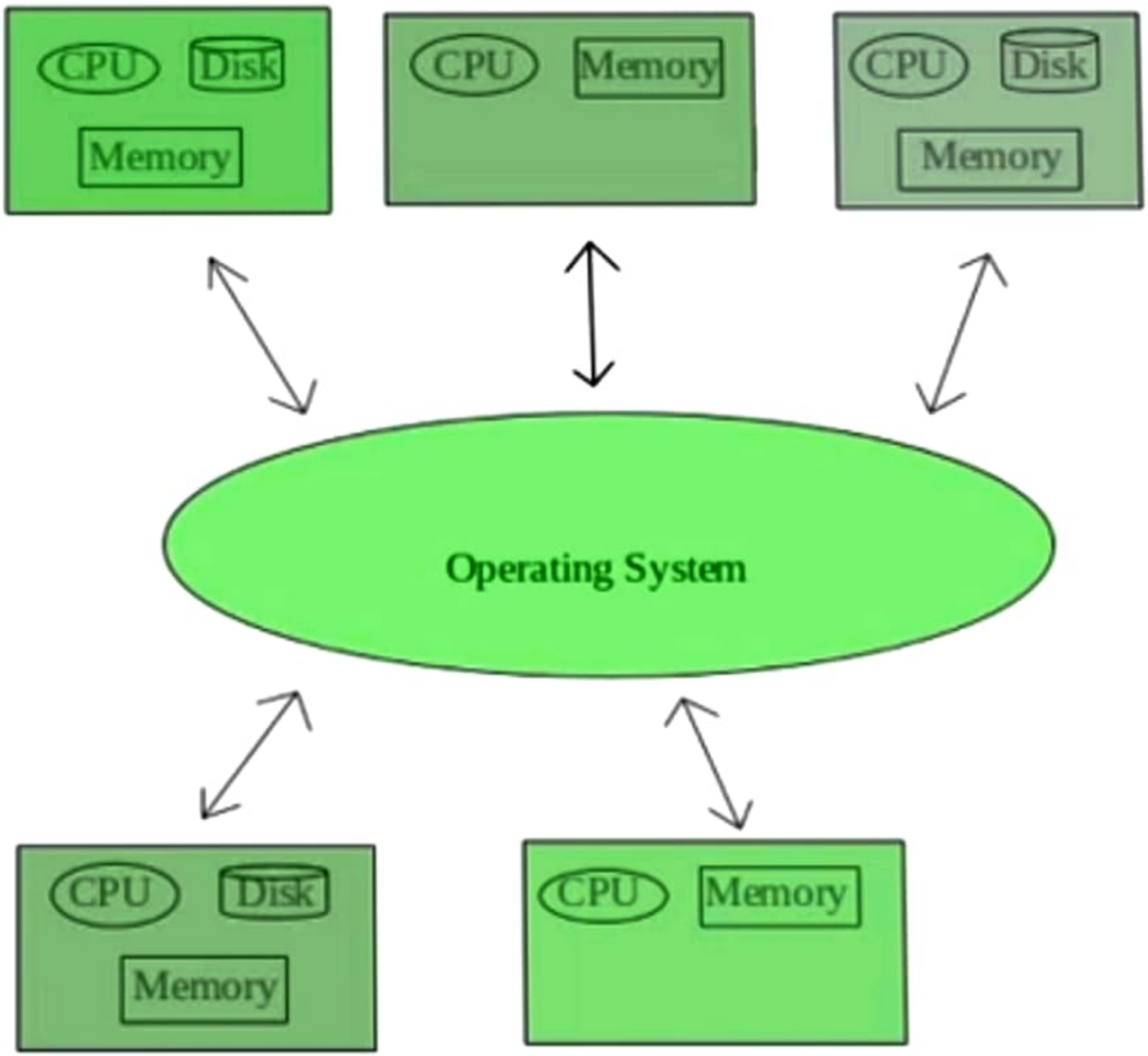
Each task is given some time to execute, so that all the tasks work smoothly. Each user gets time of CPU as they use single system. These systems are also known as Multitasking Systems. The task can be from single user or from different users also. The time that each task gets to execute is called quantum. After this time interval is over OS switches over to next task.


Word
Email
Web Browser
Operating System
CPU

# 3. Distributed Operating System

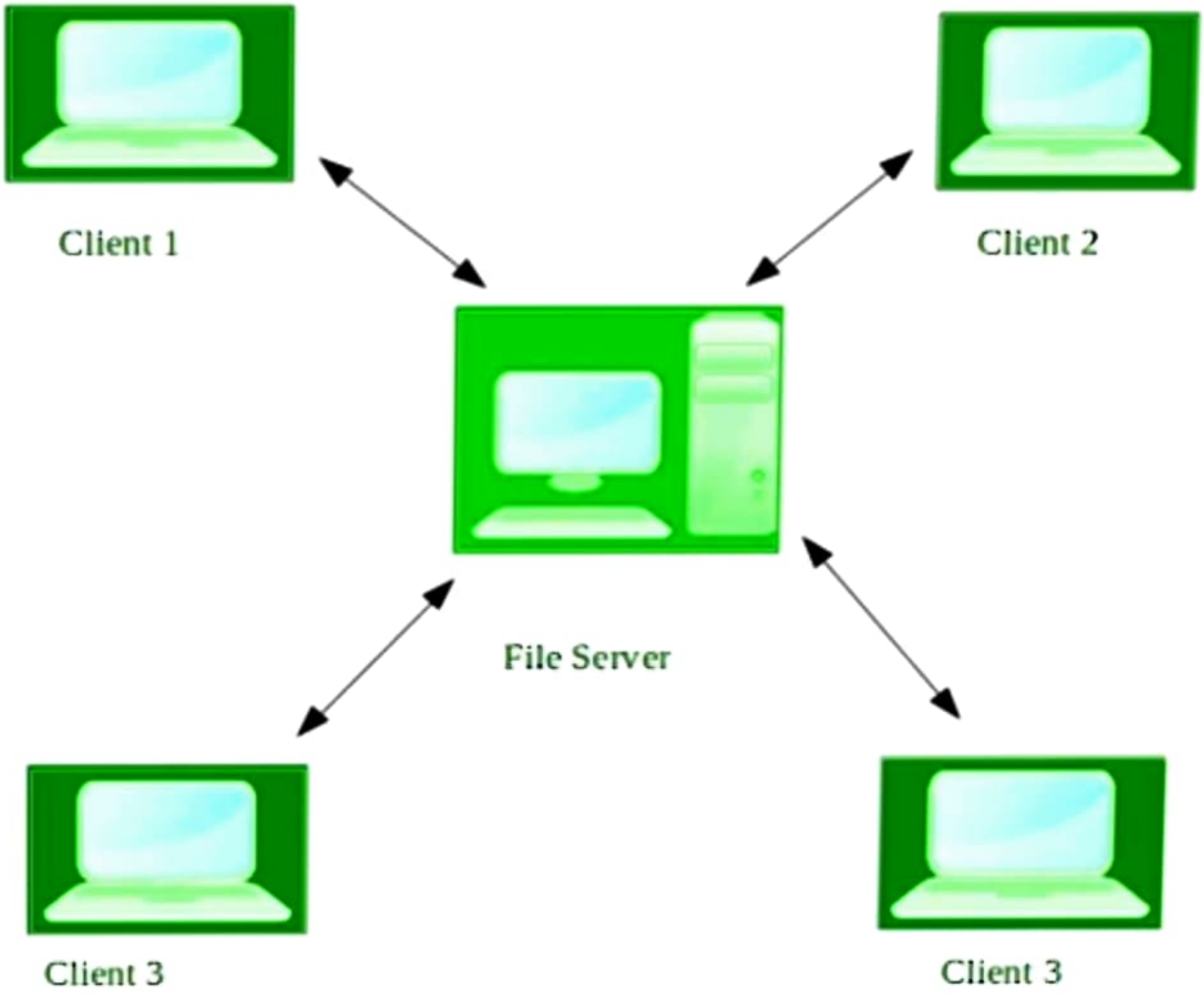
- These types of operating system is a recent advancement in the world of computer technology and are being widely accepted all-over the world and, that too, with a great pace. Various autonomous interconnected computers communicate each other using a shared communication network. Independent systems possess their own memory unit and CPU.

- These are referred as **loosely coupled systems** or distributed systems. These system's processors differ in size and function. The major benefit of working with these types of operating system is that it is always possible that one user can access the files or software which are not actually present on his system but on some other system connected within this network i.e., remote access is enabled within the devices connected in that network.


CPU
Disk
Memory
CPU
Memory
CPU
Disk
Memory
Operating System
CPU
Disk
Memory
CPU
Memory

# 4. Network Operating System

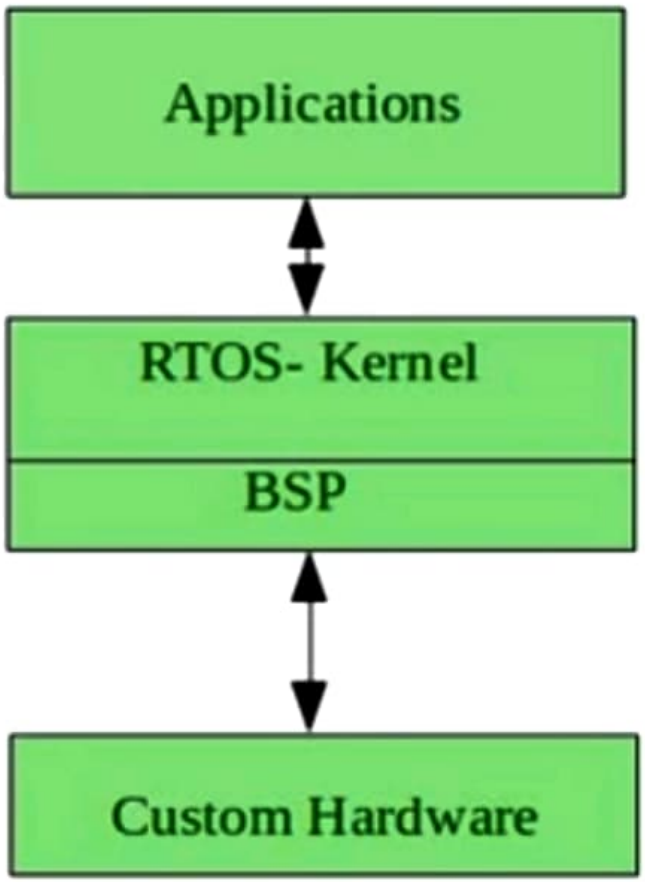
- These systems run on a server and provide the capability to manage data, users, groups, security, applications, and other networking functions. These type of operating systems allow shared access of files, printers, security, applications, and other networking functions over a small private network.
- One more important aspect of Network Operating Systems is that all the users are well aware of the underlying configuration, of all other users within the network, their individual connections etc. and that's why these computers are popularly known as **tightly coupled systems**.


Client 1
Client 2
File Server
Client 3
Client 3

# 5. Real-Time Operating System

- These types of OSs serves the real-time systems. The time interval required to process and respond to inputs is very small. This time interval is called **response time**.

- **Real-time systems** are used when there are time requirements are very strict like missile systems, air traffic control systems, robots etc


Applications
RTOS- Kernel
BSP
Custom Hardware

# Operating System Services

- An Operating System provides services to both the users and to the programs.
- It provides programs an environment to execute
- It provides users the services to execute the programs in a convenient manner.

- Following are a few common services provided by an operating system:

- Program execution
- I/O operations
- File System manipulation
- Communication
- Error Detection
- Resource Allocation
- Protection

# 1.Program Execution

- Operating systems handle many kinds of activities from user programs to system programs like printer spooler, name servers, file server, etc. Each of these activities is encapsulated as a process.
- A process includes the complete execution context (code to execute, data to manipulate, registers, OS resources in use). Following are the major activities of an operating system with respect to program management

- Loads a program into memory.
- Executes the program.
- Handles program's execution.
- Provides a mechanism for process synchronization.
- Provides a mechanism for process communication.
- Provides a mechanism for deadlock handling.

# 2. I/O Operation

- An I/O subsystem comprises of I/O devices and their corresponding driver software. Drivers hide the peculiarities of specific hardware devices from the users.
- An Operating System manages the communication between user and device drivers.
- I/O operation means read or write operation with any file or any specific I/O device.
- Operating system provides the access to the required I/O device when required.

# 3. File system manipulation

- A file represents a collection of related information. Computers can store files on the disk (secondary storage), for long-term storage purpose. Examples of storage media include magnetic tape, magnetic disk and optical disk drives like CD, DVD. Each of these media has its own properties like speed, capacity, data transfer rate and data access methods.

- A file system is normally organized into directories for easy navigation and usage. These directories may contain files and other directions. Following are the major activities of an operating system with respect to file management

- Program needs to read a file or write a file.
- The operating system gives the permission to the program for operation on file.
- Permission varies from read-only, read-write, denied and so on.
- Operating System provides an interface to the user to create/delete files.
- Operating System provides an interface to the user to create/delete directories.
- Operating System provides an interface to create the backup of file system.

# 4. Communication

- In case of distributed systems which are a collection of processors that do not share memory, peripheral devices, or a clock, the operating system manages communications between all the processes. Multiple processes communicate with one another through communication lines in the network.
- The OS handles routing and connection strategies, and the problems of contention and security. Following are the major activities of an operating system with respect to communication

- Two processes often require data to be transferred between them
- Both the processes can be on one computer or on different computers, but are connected through a computer network.
- Communication may be implemented by two methods, either by Shared Memory or by Message Passing.

# 5. Error handling

- Errors can occur anytime and anywhere. An error may occur in CPU, in I/O devices or in the memory hardware. Following are the major activities of an operating system with respect to error handling –

- The OS constantly checks for possible errors.

- The OS takes an appropriate action to ensure correct and consistent computing.

# 6. Resource Management

- In case of multi-user or multi-tasking environment, resources such as main memory, CPU cycles and files storage are to be allocated to each user or job. Following are the major activities of an operating system with respect to resource management −

- The OS manages all kinds of resources using schedulers.

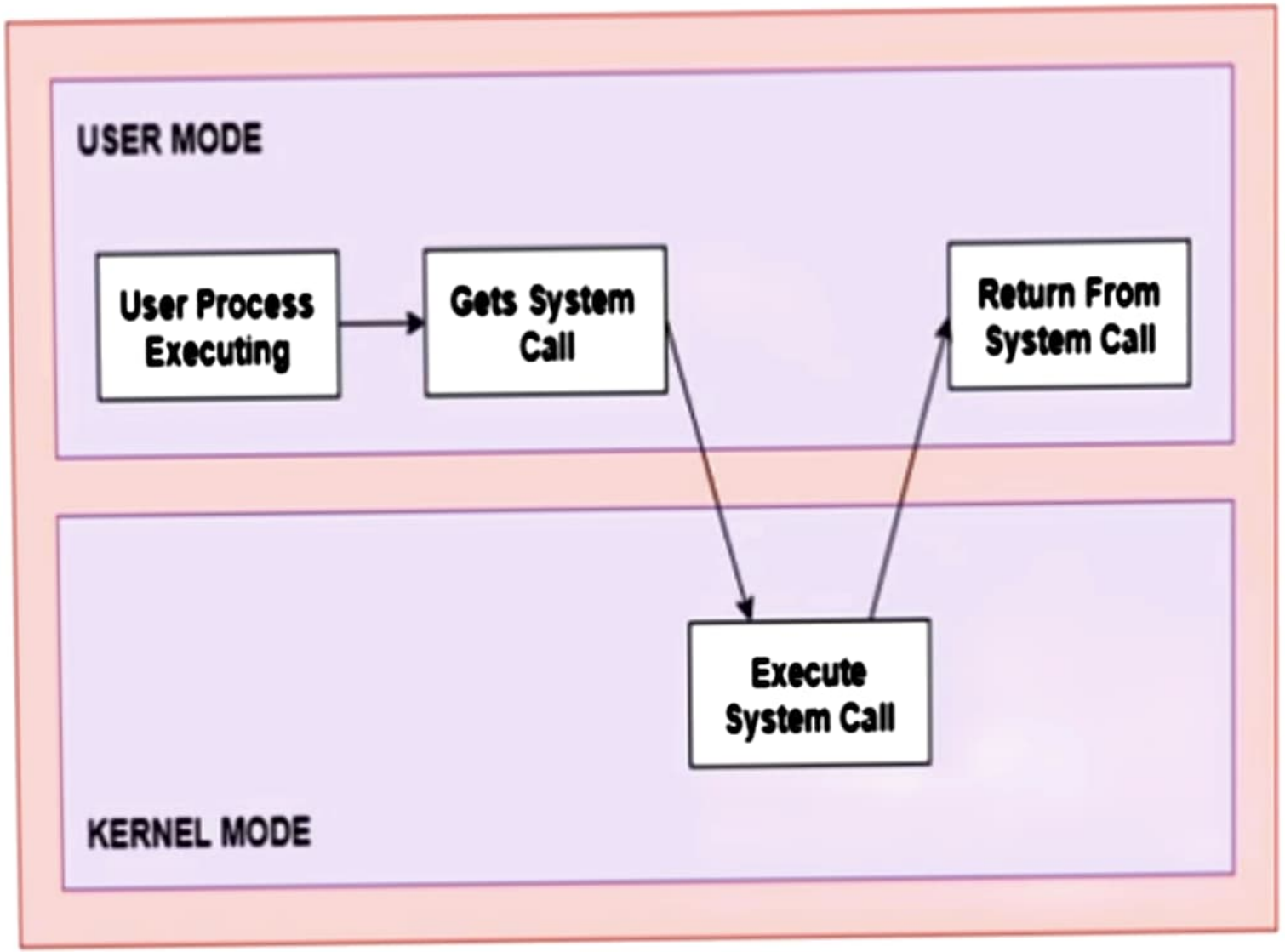
- CPU scheduling algorithms are used for better utilization of CPU.

# 7. Protection

- Considering a computer system having multiple users and concurrent execution of multiple processes, the various processes must be protected from each other's activities.
- Protection refers to a mechanism or a way to control the access of programs, processes, or users to the resources defined by a computer system. Following are the major activities of an operating system with respect to protection −
- The OS ensures that all access to system resources is controlled.
- The OS ensures that external I/O devices are protected from invalid access attempts.
- The OS provides authentication features for each user by means of passwords.

# system calls

- The interface between a process and an operating system is provided by system calls. In general, system calls are available as assembly language instructions.
- They are also included in the manuals used by the assembly level programmers. 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.


USER MODE
User Process Executing
Gets System Call
Return From System Call
Execute System Call
KERNEL MODE

- As can be seen from this diagram, the processes execute normally in the user mode until a system call interrupts this. Then the system call is executed on a priority basis in the kernel mode. After the execution of the system call, the control returns to the user mode and execution of user processes can be resumed.

- 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.

# Types of System Calls

- Process Control
- File Management
- Device Management
- Information Maintenance
- Communications

# 1. Process Control

- These system calls deal with processes such as process creation, process termination etc.
- End and Abort
- Load and Execute
- Create Process and Terminate Process
- Wait and Signed Event
- Allocate and free memory

## 2. File Management

- These system calls are responsible for file manipulation such as creating a file, reading a file, writing into a file etc.
- Create a file
- Delete file
- Open and close file
- Read, write, and reposition
- Get and set file attributes

## 3. Device Management

- Device management does the job of device manipulation like reading from device buffers, writing into device buffers, etc.

- Request and release device
- Logically attach/ detach devices
- Get and Set device attributes

## 4. Information Maintenance

- It handles information and its transfer between the OS and the user program.

- Functions:
- Get or set time and date
- Get process and device attributes

## 5. Communication:

- These types of system calls are specially used for interprocess communications.

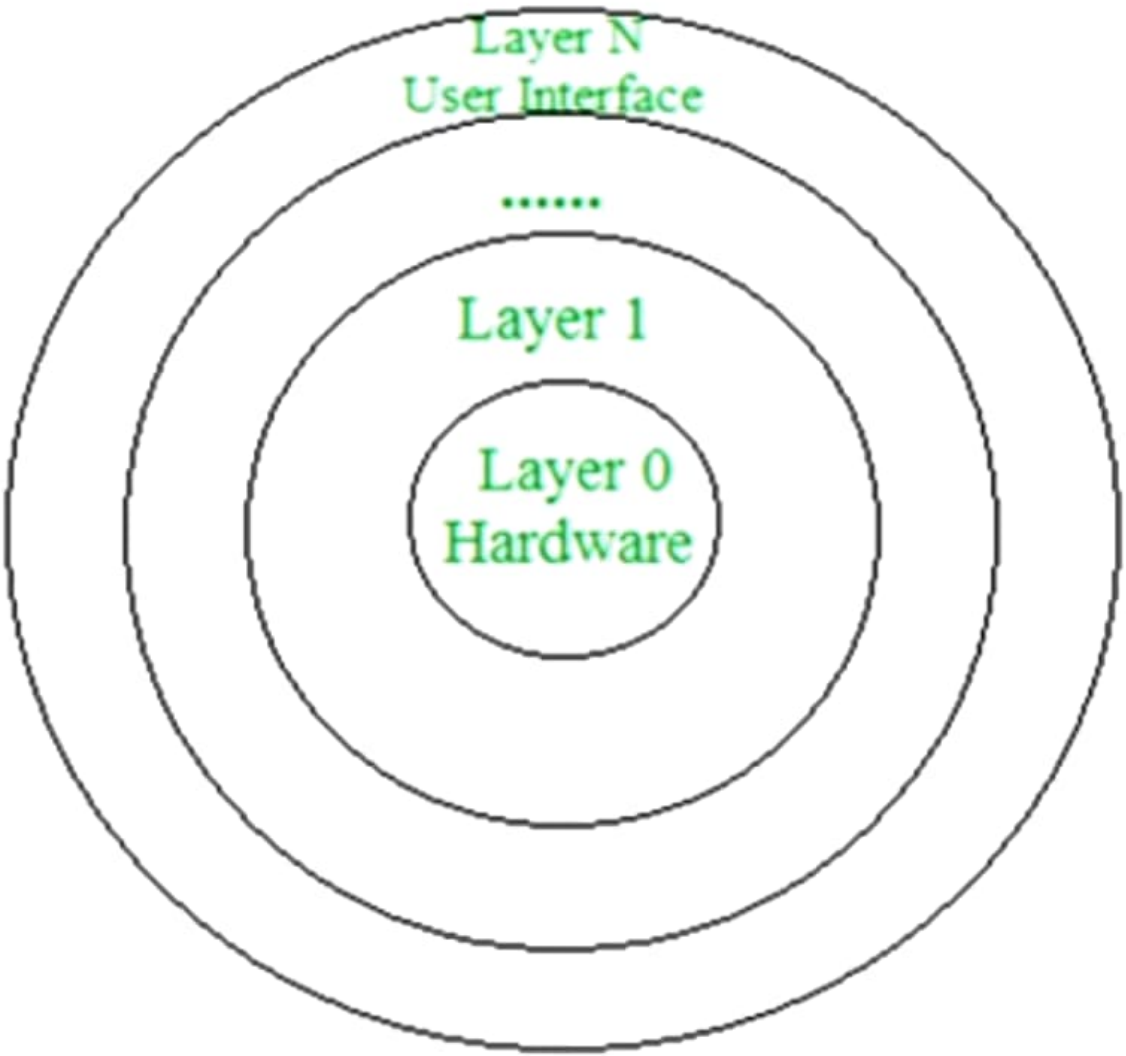
- Create, delete communications connections
- Send, receive message
- Help OS to transfer status information
- Attach or detach remote devices

# Structures of Operating Systems

- 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:

# 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.

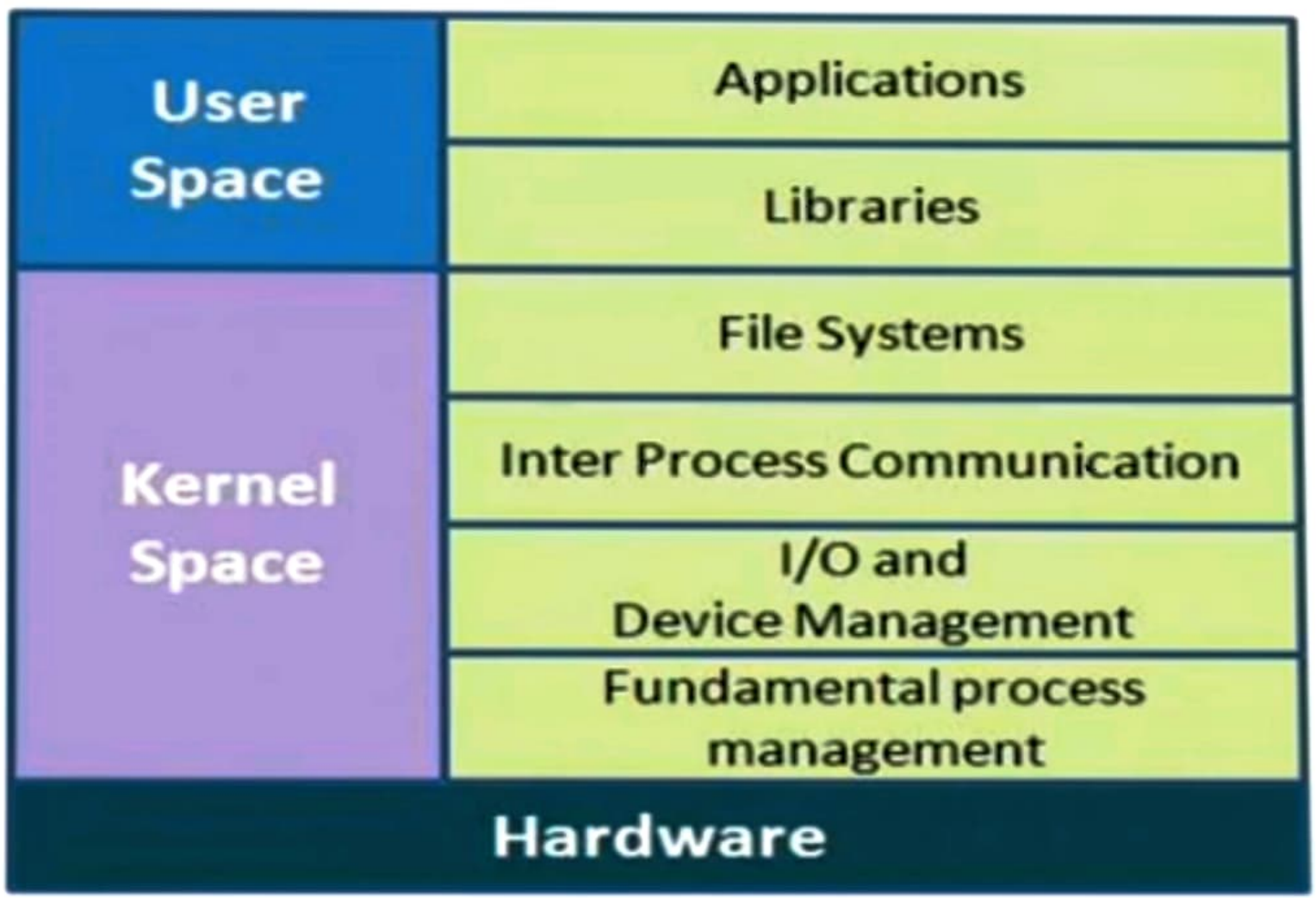

Layer N
User Interface
.....
Layer 1
Layer 0
Hardware

- The main disadvantage of this structure is that at each layer, the data needs to be modified and passed on which adds overhead to the system. Moreover careful planning of the layers is necessary as a layer can use only lower level layers. UNIX is an example of this structure.

# Monolithic Structure

- The entire operating system works in the kernel space in the monolithic system. This increases the size of the kernel as well as the operating system.
- This is different than the microkernel system where the minimum software that is required to correctly implement an operating system is kept in the kernel.

# Monolithic Kernel



- The kernel provides various services such as memory management, file management, process scheduling etc. using function calls.
- This makes the execution of the operating system quite fast as the services are implemented under the same address space.
- The monolithic operating system is also known as the monolithic kernel. This is an old type of operating system. They were used to perform small tasks like batch processing, time sharing tasks in banks. Monolithic kernel acts as a virtual machine which controls all hardware parts.

- **Advantages of Monolithic Kernel**

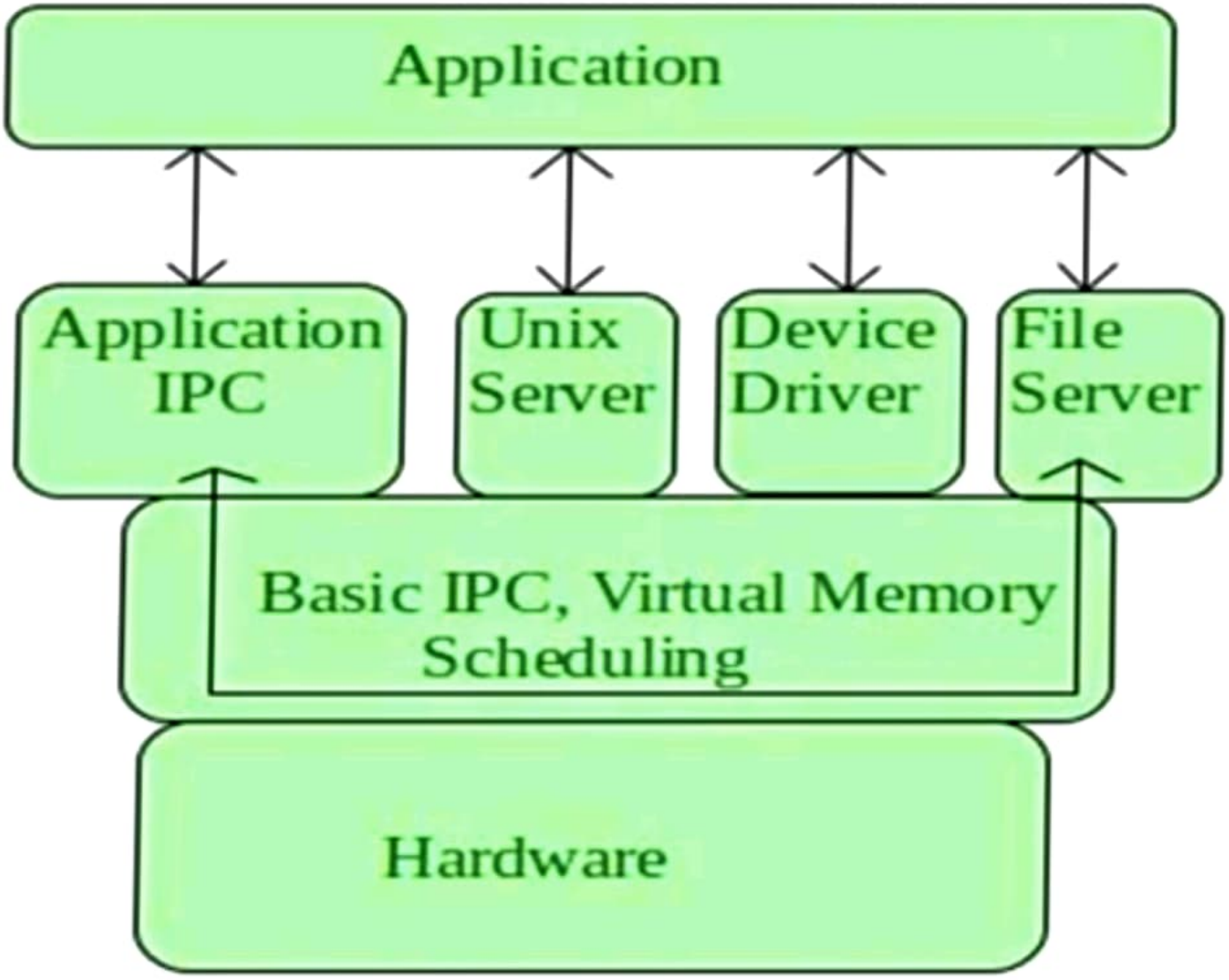
- The execution of the monolithic kernel is quite fast as the services such as memory management, file management, process scheduling etc.are implemented under the same address space.
- A process runs completely in a single address space in the monolithic kernel.
- The monolithic kernel is a static single binary file.

## Disadvantages of Monolithic Kernel

- If any service fails in the monolithic kernel, it leads to the failure of the entire system.
- To add any new service, the entire operating system needs to be modified by the user.

# Microkernel in Operating Systems

- Microkernel is one of the classification of the kernel. Being a kernel it manages all system resources. But in a microkernel, the **user services** and **kernel services** are implemented in different address space.
- The user services are kept in **user address space**, and kernel services are kept under **kernel address space**, thus also reduces the size of kernel and size of operating system as well


Application
Application IPC
Unix Server
Device Driver
File Server
Basic IPC, Virtual Memory Scheduling
Hardware

- Since kernel is the core part of the operating system, so it is meant for handling the most important services only. Thus in this architecture only the most important services are inside kernel and rest of the OS services are present inside system application program. Thus users are able to interact with those not-so important services within the system application. And the microkernel is solely responsible for the most important services of operating system they are named as follows:
- Inter process-Communication
- Memory Management
- CPU-Scheduling

- It provides minimal services of process and memory management. The communication between client program/application and services running in user address space is established through message passing, reducing the speed of execution microkernel.
- The Operating System **remains unaffected** as user services and kernel services are isolated so if any user service fails it does not affect kernel service.
- Thus it adds to one of the advantages in a microkernel. It is easily **extendable** i.e. if any new services are to be added they are added to user address space and hence requires no modification in kernel space. It is also portable, secure and reliable.

- **Advantages of Microkernel –**
- The architecture of this kernel is small and isolated hence it can function better.
- Expansion of the system is easier, it is simply added in the system application without disturbing the kernel.
- Extending the operating system becomes much easier.
- Any changes to the kernel tend to be fewer, since the kernel is smaller.
- The microkernel also provides more security and reliability.

# Virtual Machines in Operating System

- **Virtual Machine** abstracts the hardware of our personal computer such as CPU, disk drives, memory, NIC (Network Interface Card) etc, into many different execution environments as per our requirements, hence giving us a feel that each execution environment is a single computer. For example, VirtualBox.
- When we run different processes on an operating system, it creates an illusion that each process is running on a different processor having its own virtual memory, with the help of CPU scheduling and virtual-memory techniques.
- There are additional features of a process that cannot be provided by the hardware alone like system calls and a file system. The virtual machine approach does not provide these additional functionalities but it only provides an interface that is same as basic hardware. Each process is provided with a virtual copy of the underlying computer system

- We can create a virtual machine for several reasons, all of which are fundamentally related to the ability to share the same basic hardware yet can also support different execution environments, i.e., different operating systems simultaneously.
- The main drawback with the virtual-machine approach involves disk systems. Let us suppose that the physical machine has only three disk drives but wants to support seven virtual machines.
- Obviously, it cannot allocate a disk drive to each virtual machine, because virtual-machine software itself will need substantial disk space to provide virtual memory and spooling. The solution is to provide virtual disks.

- Users are thus given their own virtual machines. After which they can run any of the operating systems or software packages that are available on the underlying machine.
- The virtual-machine software is concerned with multi-programming multiple virtual machines onto a physical machine, but it does not need to consider any user-support software.
- This arrangement can provide a useful way to divide the problem of designing a multi-user interactive system, into two smaller pieces.