UNIT 1

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- Functions of OS
- Features of OS
- OS Types
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  - o Concept of multithreads
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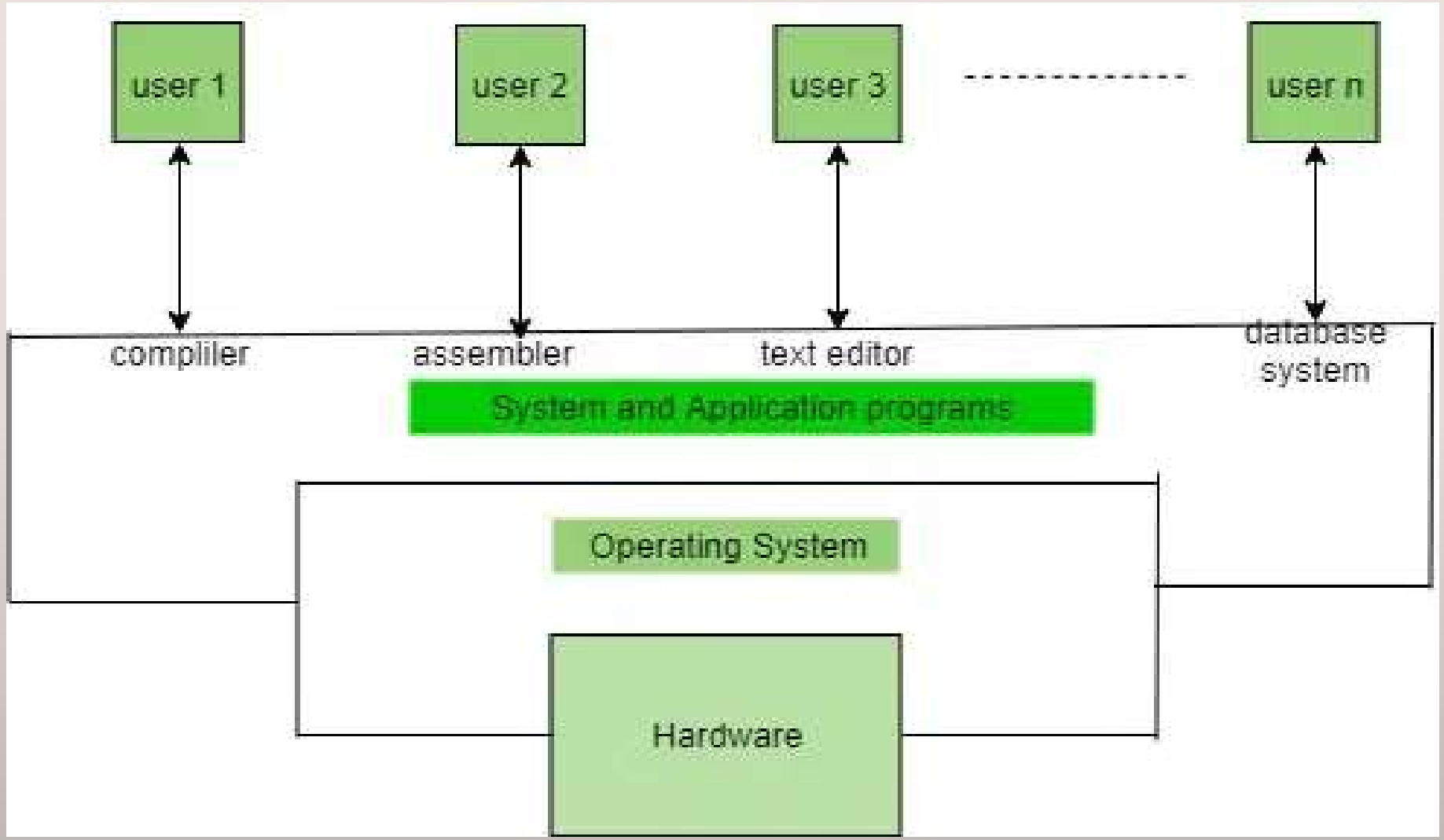
Meaning of OS

- An **Operating System** is a System software that manages all the resources of the computing deice.
- Acts as an interface between the software and different parts of the computer or the computer hardware.
- Manages the overall resources and operations of the computer.
- Controls and monitors the execution of all other programs that reside in the computer, which also includes application programs and other system software of the computer.
- Examples of Operating Systems are Windows, Linux, macOS, Android, iOS, etc.


user 1
user 2
user 3
user n
compliler
assembler
text editor
database system
System and Application programs
Operating System
Hardware

Functions of the Operating System

1. **Memory Management**

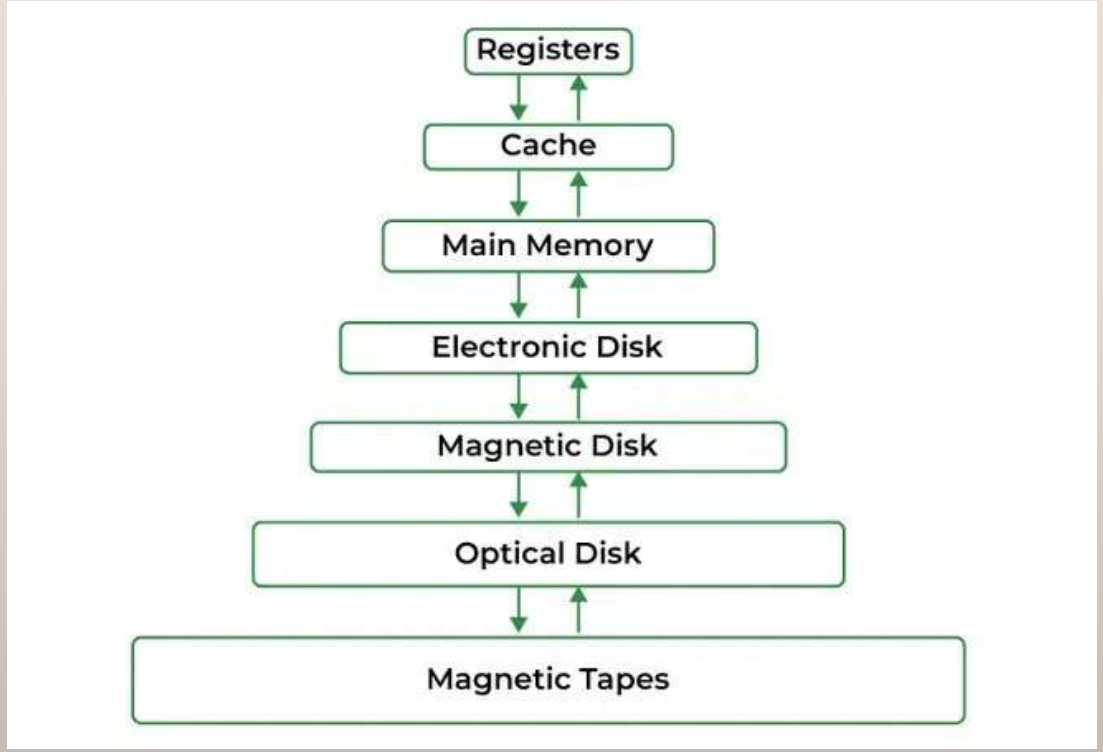
- The operating system manages the Primary Memory or Main Memory.
- Main memory is made up of a large array of bytes or words where each byte or word is assigned a certain address
- . Main memory is fast storage and it can be accessed directly by the CPU. For a program to be executed, it should be first loaded in the main memory.
- An operating system manages the allocation and deallocation of memory to various processes and ensures that the other process does not consume the memory allocated to one process.

- An Operating System performs the following activities for Memory Management:

It keeps track 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 multiprogramming, the OS decides the order in which processes are granted memory access, 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.


Registers
Cache
Main Memory
Electronic Disk
Magnetic Disk
Optical Disk
Magnetic Tapes

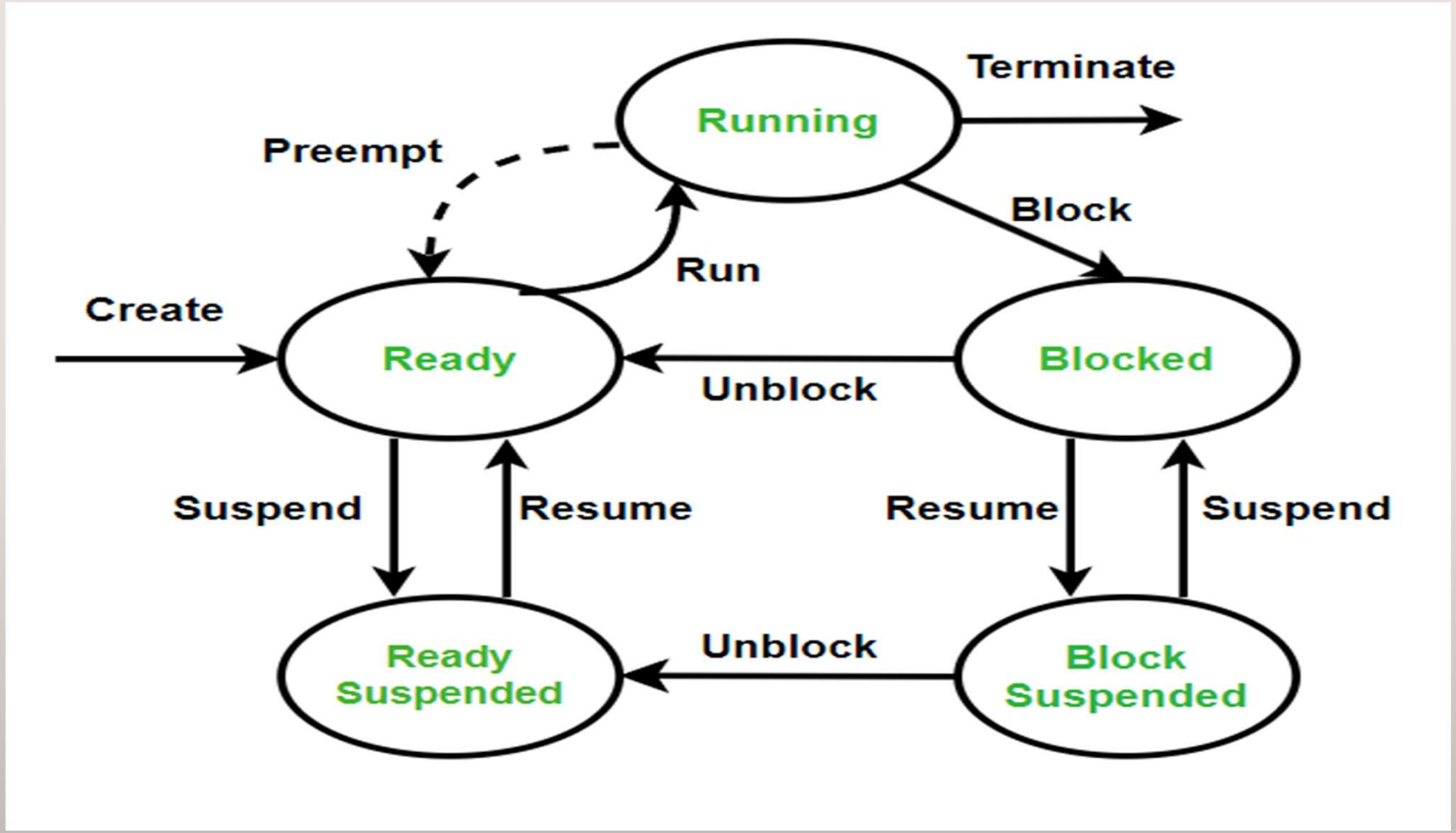
2. **Processor Management**

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.

An operating system manages the processor's work by allocating various jobs to it and ensuring that each process receives enough time from the processor to function properly.

Keeps track of the status of processes. The program which performs this task is known as a traffic controller. Allocates the CPU that is a processor to a process. De-allocates processor when a process is no longer required.

- There is various type of scheduling techniques that are used by the operating systems:
- **Shortest Job First(SJF)**: The process which needs the shortest CPU time is scheduled first.
- **Round Robin Scheduling:** Each process is assigned a fixed CPU execution time in a cyclic way.
- **Priority-Based Scheduling (**Non-Preemptive**):** In this scheduling, processes are scheduled according to their priorities, i.e., the highest priority process is scheduled first. If the priorities of the two processes match, then schedule according to arrival time.

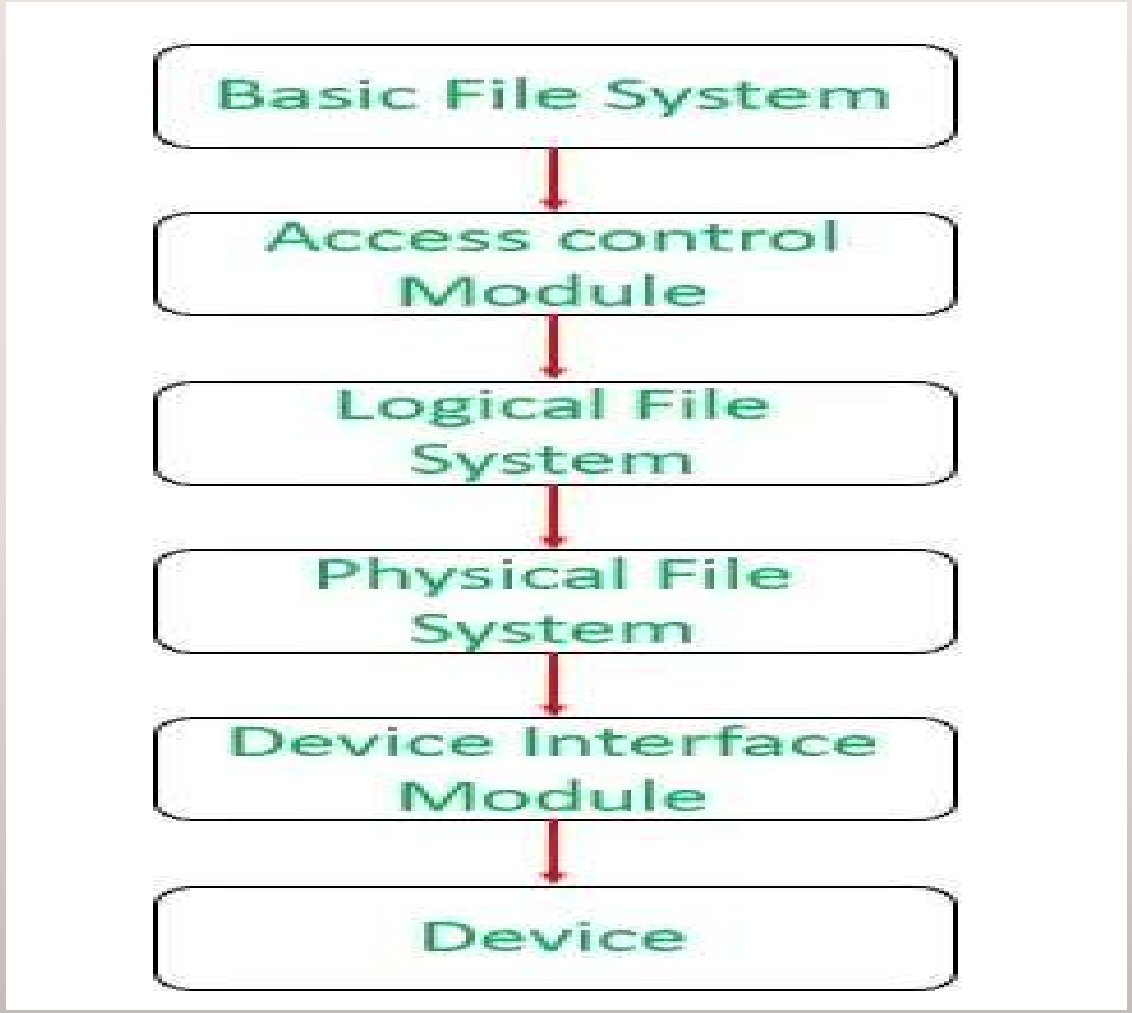

Running
Terminate
Preempt
Block
Run
Create
Ready
Blocked
Unblock
Suspend
Resume
Resume
Suspend
Ready
Suspended
Unblock
Block
Suspended

3 Device Management

- An OS manages device communication via its respective drivers. It performs the following activities for device management.
- Keeps track of all devices connected to the system. Designates a program responsible for every device known as the Input/Output controller.
- Decide which process gets access to a certain device and for how long.
- Allocates devices effectively and efficiently. Deallocates devices when they are no longer required.
- There are various input and output devices. An OS controls the working of these input-output devices.
- It receives the requests from these devices, performs a specific task, and communicates back to the requesting process.

4 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, the status of every file, and more.
- These facilities are collectively known as the file system. An OS keeps track of information regarding the creation, deletion, transfer, copy, and storage of files in an organized way.
- It also maintains the integrity of the data stored in these files, including the file directory structure, by protecting against unauthorized access.


Basic File System
Access control Module
Logical File System
Physical File System
Device Interface Module
Device

5. **I/O Management**

/O management is the important function of operating system refers to how the OS handles **input** and **output** operations between the computer and external devices, such as keyboards, mice, printers, hard drives, and monitors.

6. **User Interface or Command Interpreter**

The user interacts with the computer system through the operating system. Hence OS acts as an interface between the user and the computer hardware. This user interface is offered through a set of commands or a graphical user interface (GUI). Through this interface, the user makes interacts with the applications and the machine hardware.

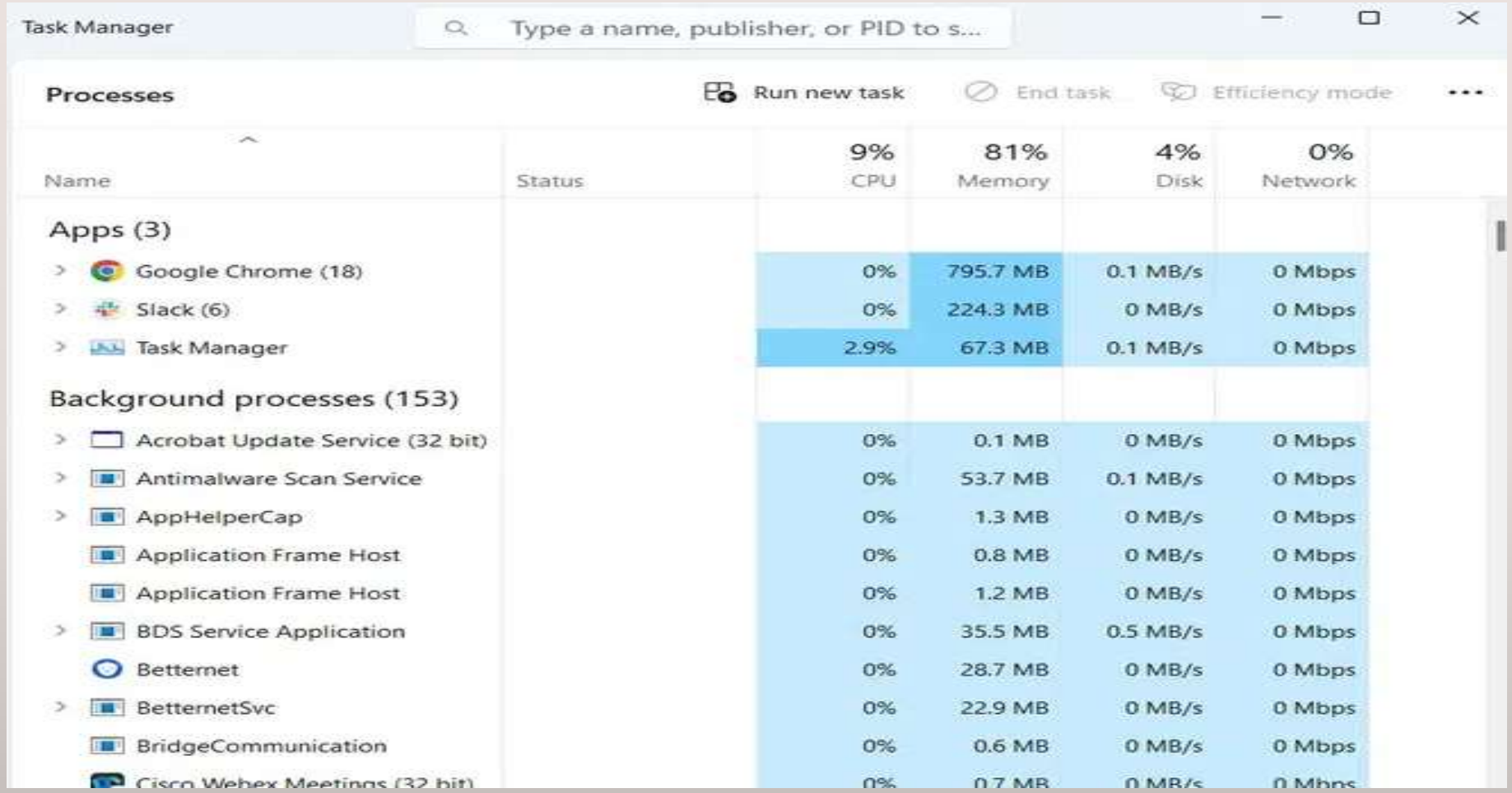
7. Security

- The operating system uses password protection to protect user data and similar other techniques. it also prevents unauthorized access to programs and user data. The operating system provides various techniques which assure the integrity and confidentiality of user data. The following security measures are used to protect user data:
- Protection against unauthorized access through login.
- Protection against intrusion by keeping the firewall active.
- Protecting the system memory against malicious access.
- Displaying messages related to system vulnerabilities.

8 **Control Over System Performance**

Operating systems play a pivotal role in controlling and optimizing system performance.

They act as intermediaries between hardware and software, ensuring that computing resources are efficiently utilized. One fundamental aspect is resource allocation, where the OS allocates CPU time, memory, and I/O devices to different processes, striving to provide fair and optimal resource utilization. Process scheduling, a critical function, helps decide which processes or threads should run when preventing any single task from monopolizing the CPU and enabling effective multitasking.


Task Manager
Type a name, publisher, or PID to s...
Processes
Run new task
End task
Efficiency mode
Name
Status
9%
CPU
81%
Memory
4%
Disk
0%
Network
Apps (3)
Google Chrome (18) 0% 795.7 MB 0.1 MB/s 0 Mbps
Slack (6) 0% 224.3 MB 0 MB/s 0 Mbps
Task Manager 2.9% 67.3 MB 0.1 MB/s 0 Mbps
Background processes (153)
Acrobat Update Service (32 bit) 0% 0.1 MB 0 MB/s 0 Mbps
Antimalware Scan Service 0% 53.7 MB 0.1 MB/s 0 Mbps
AppHelperCap 0% 1.3 MB 0 MB/s 0 Mbps
Application Frame Host 0% 0.8 MB 0 MB/s 0 Mbps
Application Frame Host 0% 1.2 MB 0 MB/s 0 Mbps
BDS Service Application 0% 35.5 MB 0.5 MB/s 0 Mbps
Betternet 0% 28.7 MB 0 MB/s 0 Mbps
BetternetSvc 0% 22.9 MB 0 MB/s 0 Mbps
BridgeCommunication 0% 0.6 MB 0 MB/s 0 Mbps
Cisco Webex Meetings (32 bit) 0% 0.7 MB 0 MB/s 0 Mbps

Features of the Operating System

Memory Control

- It is the control of the primary or main memory. Furthermore, the main memory must contain the program that is being run. Consequently, more than one program may be active at once. Consequently, managing memory is necessary. operating system memory is allocated and released. keeps track of who uses which area of primary memory and how often.enables memory distribution while multiprocessing.

Management and Scheduling of Processors

- When a system has multiple processes running, the OS determines how and when each process will use the CPU. So, CPU Scheduling is another name for it.

File Management

- The files on a system are stored in different directories. The OS:
- Keeps records of the status and locations of files.
- Responsible for the Allocation and deallocation of resources.

Protected and Supervisor Mode

- User mode is limited, whereas supervisor mode or kernel mode is unrestricted mode. All hardware instructions are legitimate in this mode of execution. When operating in kernel mode, you have total and (nearly) unrestricted control over your OS's hardware and software components.

Error Handling

- The reaction and recovery processes from error situations that are present in a software application are referred to as an OS error handling feature. The operating system continuously scans for potential mistakes.

Information and Resource Protection

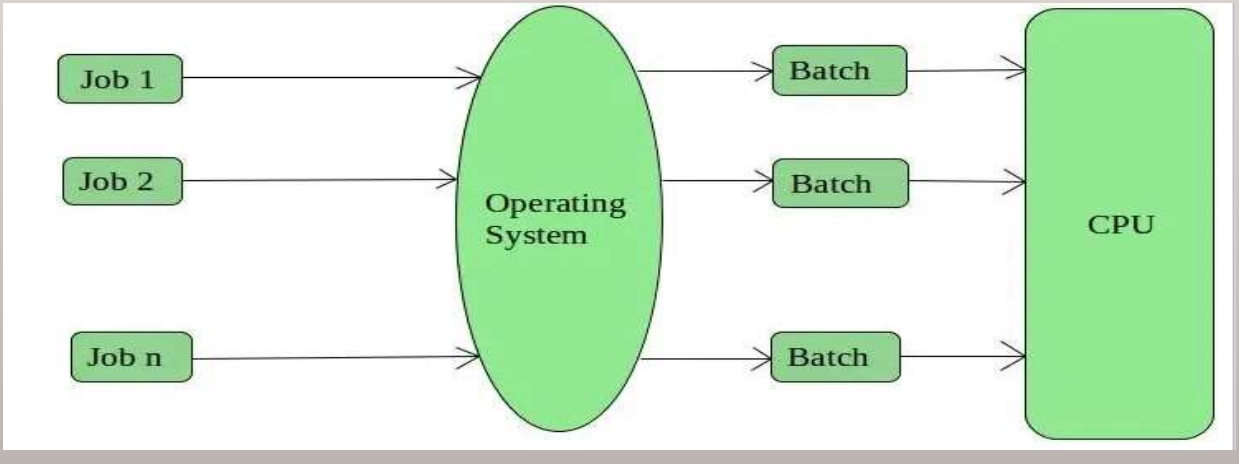
- The operating system protects the information and resources saved on the system by providing strong authorised keys to the user, securing the system against malware attacks.

Types of Operating Systems

- **1. Batch Operating System**
- **2. Time Sharing Operating System**
- **3. Distributed Operating System**
- **4. Network Operating System**
- **5. Real-Time Operating System**
- **6. Multi-Programming Operating System**
- 7. **Multi-Processing Operating System**

1. Batch Operating System (BOS)

- 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.
- Example : Bank Statement



Advantages of Batch Operating System

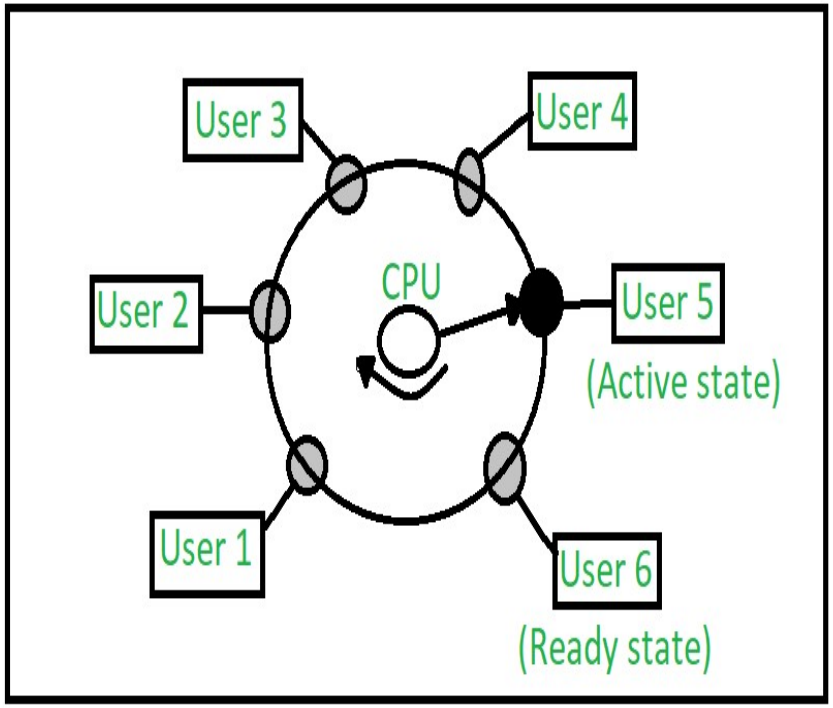
- Multiple users can share the batch systems.
- The idle time for the batch system is very less.
- It is easy to manage large work repeatedly in batch systems.

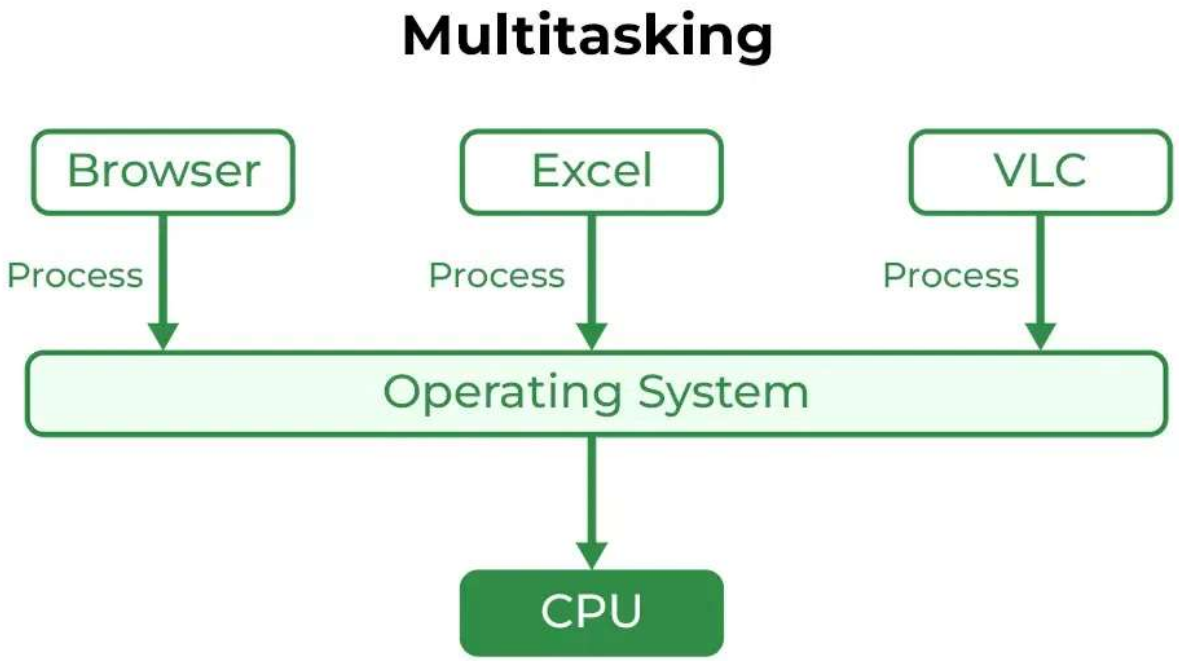
Disadvantages of Batch Operating System

- CPU is not used efficiently. When the current process is doing IO, CPU is free and could be utilized by other processes waiting.
- The other jobs will have to wait for an unknown time if any job fails.
- In batch operating system, average response time increases as all processes are processed one by one.

2. Time-Sharing / Multitasking Operating Systems

- It is a type of Multiprogramming system with every process running in round robin manner.
- 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.
- Example : Linux, Windows, ..


User 3
User 4
CPU
User 2
User 5
(Active state)
User 1
User 6
(Ready state)


Multitasking
Browser
Excel
VLC
Process
Process
Process
Operating System
CPU

Advantages of Time-Sharing OS

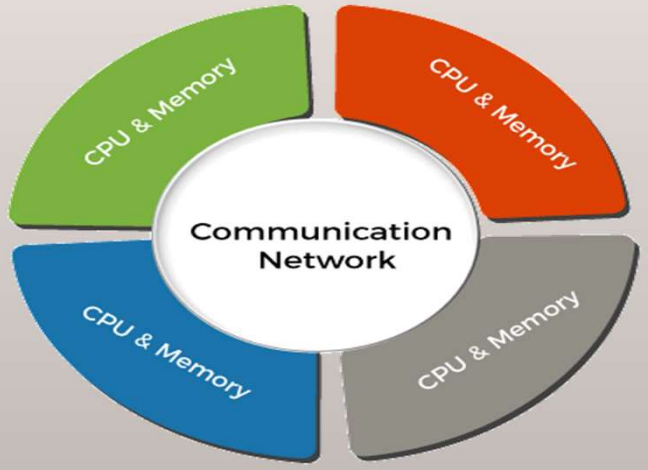
- Each task gets an equal opportunity.Fewer chances of duplication of software.CPU idle time can be reduced.
- Resource Sharing: Time-sharing systems allow multiple users to share hardware resources such as the CPU, memory, and peripherals, reducing the cost of hardware and increasing efficiency.
- Improved Productivity: Time-sharing allows users to work concurrently, thereby reducing the waiting time for their turn to use the computer. This increased productivity translates to more work getting done in less time.
- Improved User Experience: Time-sharing provides an interactive environment that allows users to communicate with the computer in real time, providing a better user experience than batch processing.

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: Time-sharing systems have a higher overhead than other operating systems due to the need for scheduling, context switching, and other overheads that come with supporting multiple users.
- Complexity: Time-sharing systems are complex and require advanced software to manage multiple users simultaneously. This complexity increases the chance of bugs and errors.
- Security Risks: With multiple users sharing resources, the risk of security breaches increases. Time-sharing systems require careful management of user access, authentication, and authorization to ensure the security of data and software.

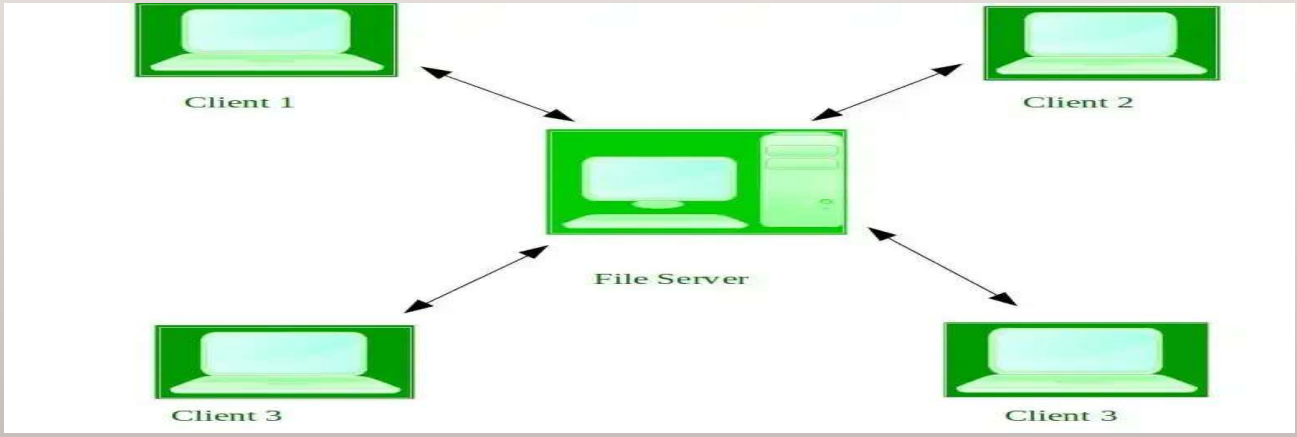
3. Distributed Operating System

- A distributed operating system **(DOS)** is an essential type of operating system. Distributed systems use many central processors to serve multiple real-time applications and users. As a result, data processing jobs are distributed between the processors.
- Example : Cloud computing, Distributed Databases



4. Network Operating System

- A network operating system(NOS) is software that connects multiple devices and computers on the network and allows them to share resources on the network. Let's see what are the functions of the network operating system.
- Example : Linux / Unix, Windows server



Advantages of Network Operating Systems

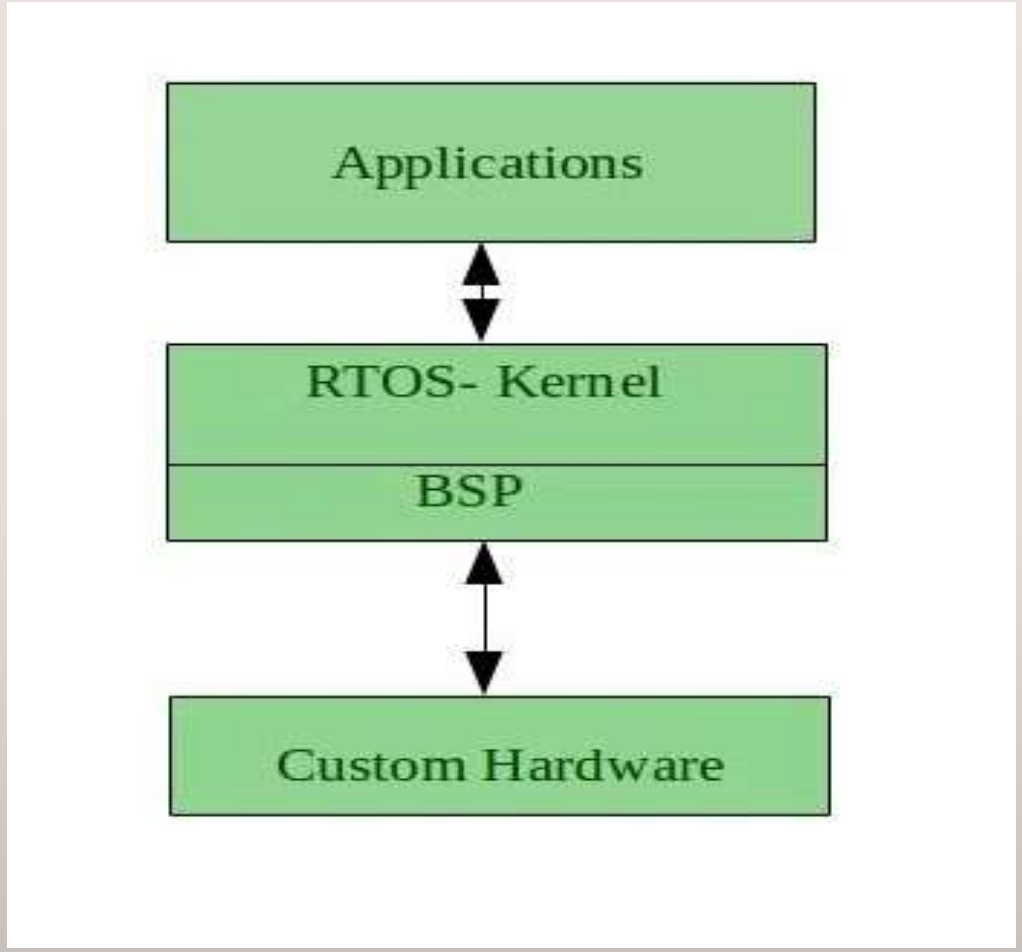
- Highly stable due to central server.
- Provide good security.
- Upgradation of new technology and hardware can be easily implemented in the network.
- Provide remote access to servers from different locations.

Disadvantages of Network Operating Systems

- Depend on the central location to perform the operations.
- High cost to buying server.
- Regular updating and maintenance are required.

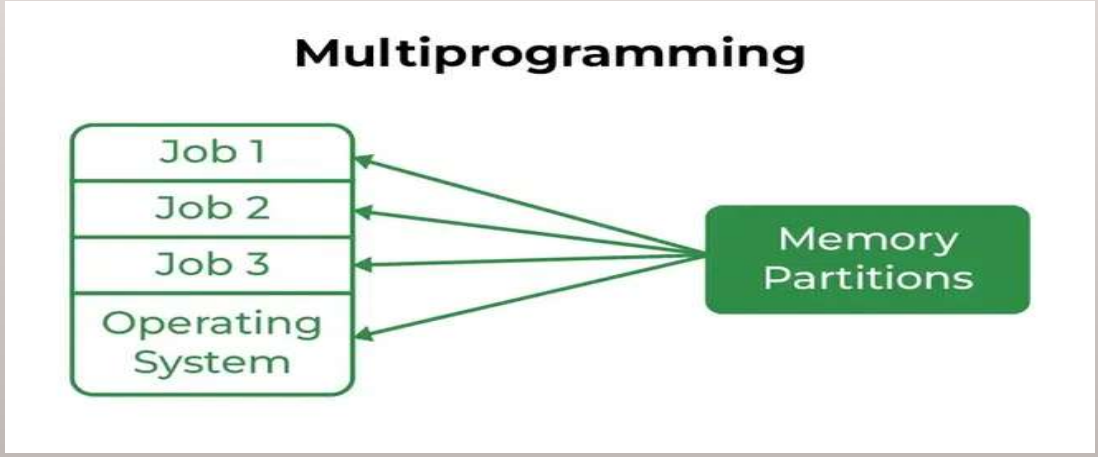
5. Real-Time Operating System

- **A real-time operating system (RTOS)** is a special-purpose operating system used in computers that has strict time constraints for any job to be performed.
- It is employed mostly in those systems in which the results of the computations are used to influence a process while it is executing. Whenever an event external to the computer occurs, it is communicated to the computer with the help of some sensor used to monitor the event.
- The sensor produces the signal that is interpreted by the operating system as an interrupt. On receiving an interrupt, the operating system invokes a specific process or a set of processes to serve the interrupt.
- Example : Medical Device, Cellular system, Telecommunication


Applications
RTOS- Kernel
BSP
Custom Hardware

6. 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 utilization of resources.
- Example: Download software, Transfer Data, Google Chrome, Ms-Excel, …



Advantages of Multi-Programming Operating System

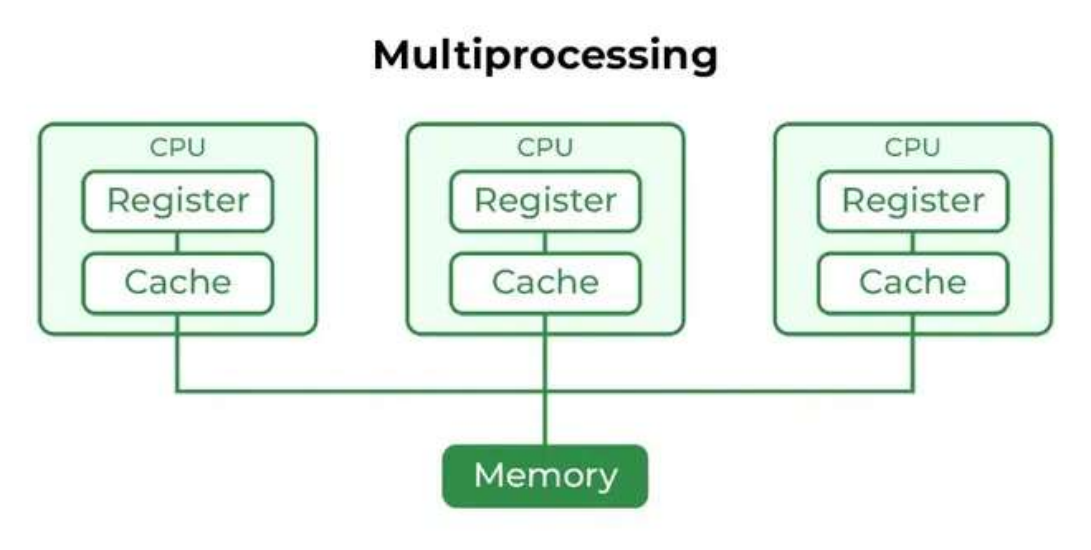
- It provides less response time.
- It may help to run various jobs in a single application simultaneously.
- It helps to optimize the total job throughput of the computer.
- Various users may use the multiprogramming system at once.
- Short-time jobs are done quickly in comparison to long-time jobs.
- It may help to improve turnaround time for short-time tasks.
- It helps in improving CPU utilization and never gets idle.
- The resources are utilized smartly.

Disadvantages of Multi-Programming Operating System

- It is highly complicated and sophisticated.
- The CPU scheduling is required.
- Memory management is needed in the operating system because all types of tasks are stored in the main memory.
- The harder task is to handle all processes and tasks.
- If it has a large number of jobs, then long-term jobs will require a long wait.

7. Multi-Processing Operating System

- **Multiprocessing** is a system that has two or more processors. In this, CPUs are added to increase the computing speed of the system. Because of Multiprocessing, many processes are executed simultaneously.
- Example : Unix, Linux, …..



Advantages of Multi-Processing Operating System

- It increases the throughput of the system as processes can be parallelized.
- As it has several processors, so, if one processor fails, we can proceed with another processor.

Disadvantages of Multi-Processing Operating System

- Multiprocessing operating systems have a more complex architecture when compared to a single processor OS.
- It may require a bigger memory as multiple processors share the same main memory.
- The system crashes if the processor in charge of a particular task fails.

Process

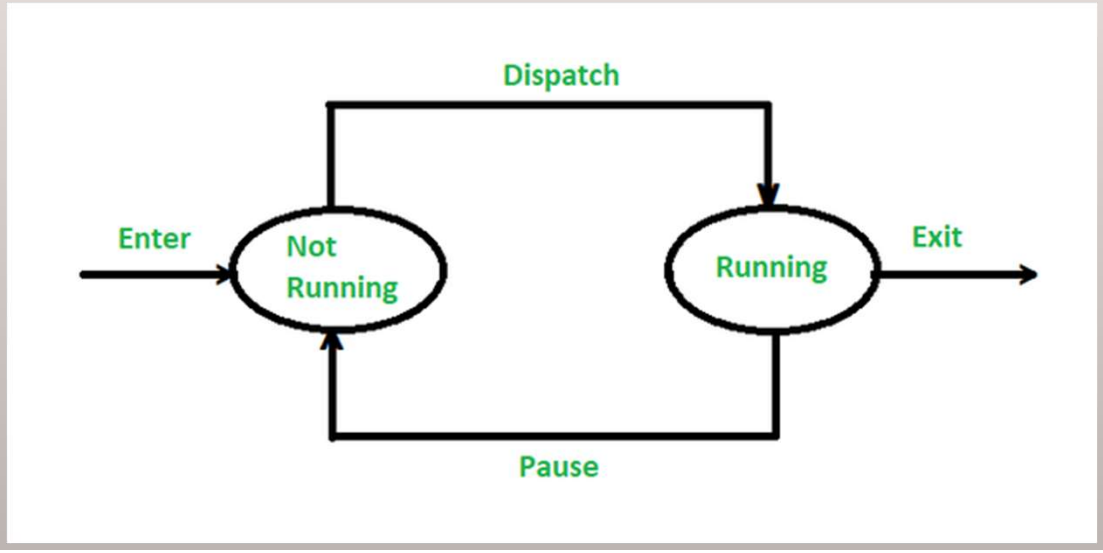
- An active program which running now on the Operating System is known as the process. Process is created during the execution and it is loaded directly into the main memory
- An active program which running now on the OS is known as the process.
- Example : When you want to search something on web then you start browser

Process State

Two State Model

Running: It is the current process state in which the process is running.

Not Running : This process state may be created anytime, whether a process is running or not



Five State Model

1. New

- It refers to a new process that has been created but has not yet been approved for execution by the operating system. Although a new process has not been loaded into the main memory, its process control block has been created.

2. Ready

- After a new state process, a process moves from a new to a ready state. When a process is in the ready state, it signifies it has been loaded into the main memory and is ready to run. In the ready state, the process must wait for the processor to respond; once the processor responds, the process advances to the processor for execution. It's worth noting that several processes in a multi-programming environment can remain in the ready state.

3. Running

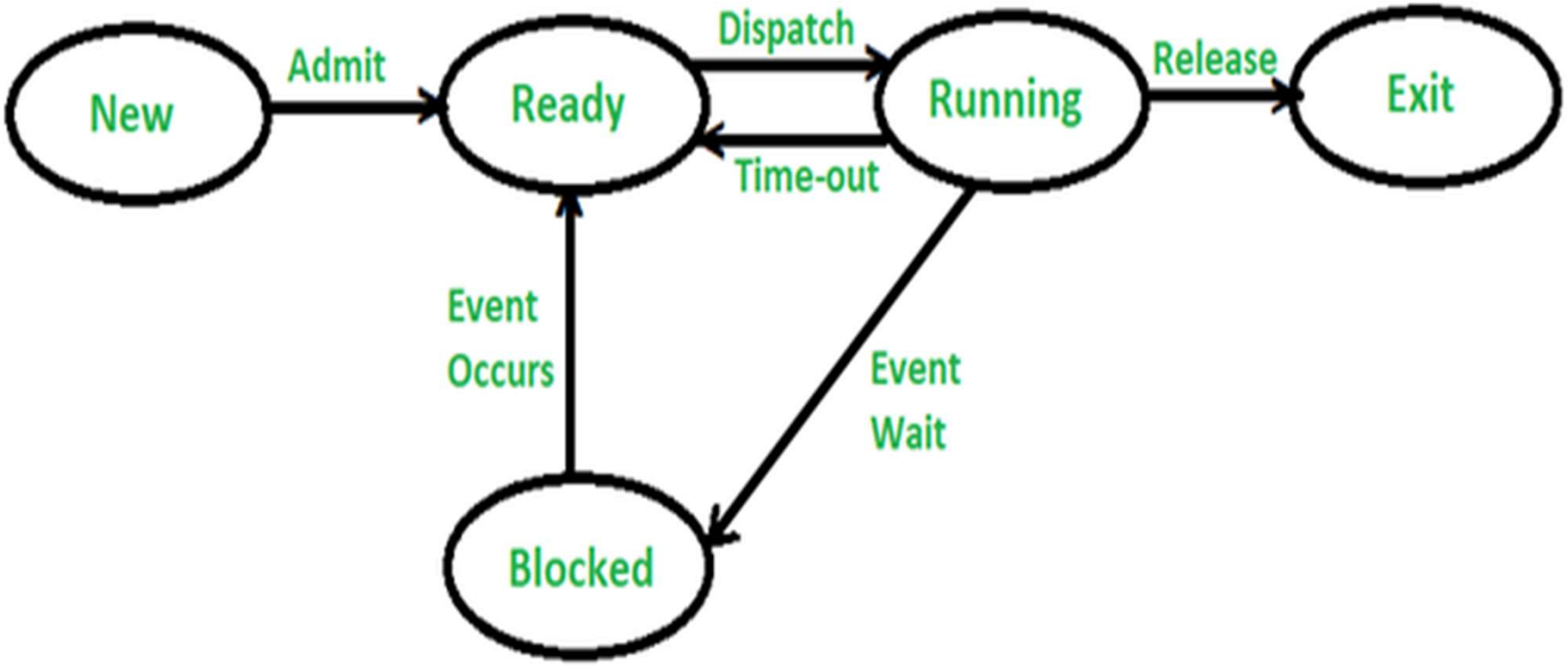
- All of the processes that are executing on the CPU are in the running state.
- The running state indicates that the procedure is starting from a new and ready state. If the process is in its critical section, other processes must wait in the Ready state.

4. Blocked/Waiting

- The blocked state applies to all processes that quit the CPU and enter the waiting state. When the CPU becomes available, processes in the blocked state are moved to the ready state and then to the running state.

5. Exit/Terminated

- The exit state refers to a process that has been terminated from the CPU and the main memory.


New
Admit
Ready
Dispatch
Running
Release
Exit
Time-out
Event
Occurs
Event
Wait
Blocked

Seven State Model

1. New : A program which is going to be picked up by the OS into the main memory is called a new process.

2. Ready : Whenever a process is created, it directly enters in the ready state, in which, it waits for the CPU to be assigned. The OS picks the new processes from the secondary memory and put all of them in the main memory.

- The processes which are ready for the execution and reside in the main memory are called ready state processes. There can be many processes present in the ready state.

3. Running : One of the processes from the ready state will be chosen by the OS depending upon the scheduling algorithm. Hence, if we have only one CPU in our system, the number of running processes for a particular time will always be one. If we have n processors in the system then we can have n processes running simultaneously.

4. Block or wait : From the Running state, a process can make the transition to the block or wait state depending upon the scheduling algorithm or the intrinsic behavior of the process.

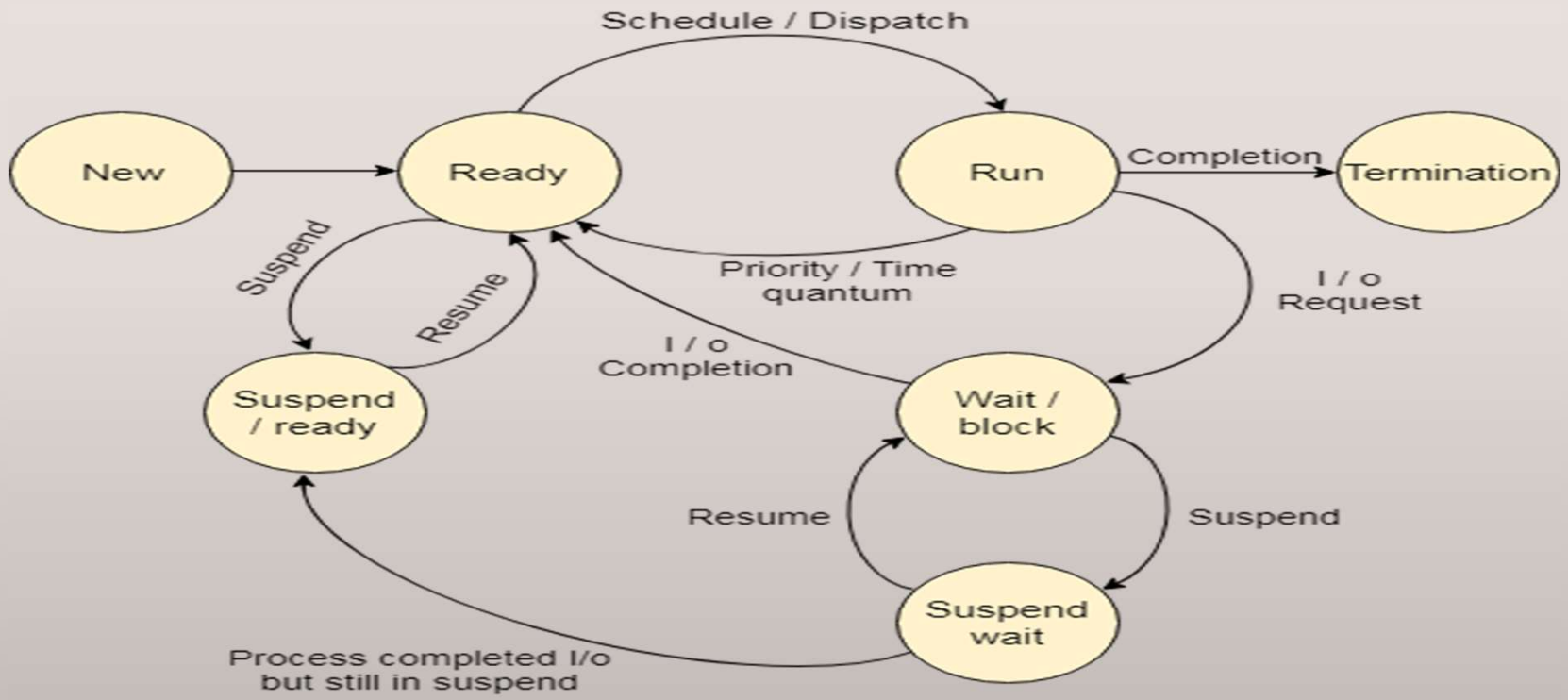
- When a process waits for a certain resource to be assigned or for the input from the user then the OS move this process to the block or wait state and assigns the CPU to the other processes.

5. Completion or termination : When a process finishes its execution, it comes in the termination state. All the context of the process (Process Control Block) will also be deleted the process will be terminated by the Operating system.

6. Suspend ready : A process in the ready state, which is moved to secondary memory from the main memory due to lack of the resources (mainly primary memory) is called in the suspend ready state.

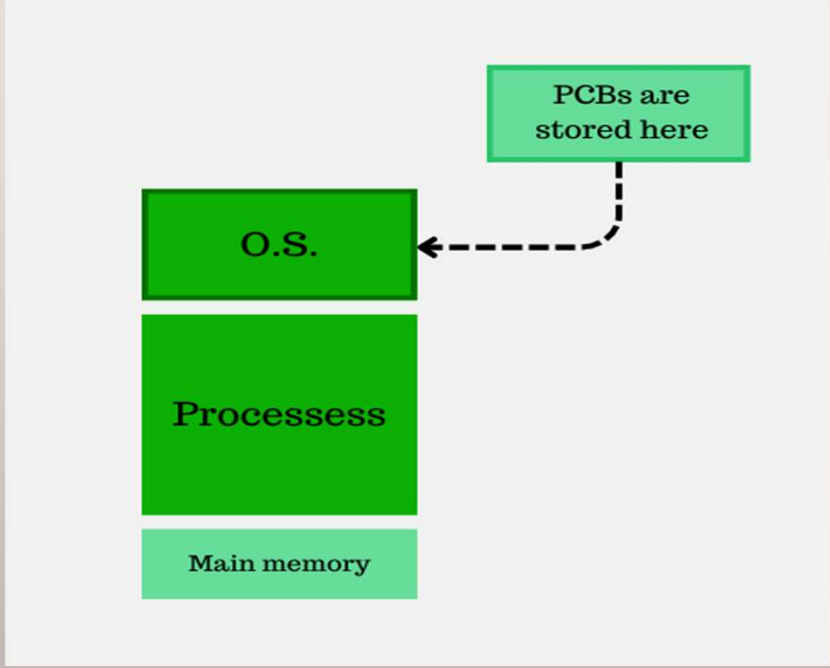
- If the main memory is full and a higher priority process comes for the execution then the OS have to make the room for the process in the main memory by throwing the lower priority process out into the secondary memory. The suspend ready processes remain in the secondary memory until the main memory gets available.

7. Suspend wait : Instead of removing the process from the ready queue, it's better to remove the blocked process which is waiting for some resources in the main memory. Since it is already waiting for some resource to get available hence it is better if it waits in the secondary memory and make room for the higher priority process. These processes complete their execution once the main memory gets available and their wait is finished.


Schedule / Dispatch
New
Ready
Run
Completion
Termination
Suspend
Resume
Priority / Time quantum
I / o Request
I / o Completion
Suspend / ready
Wait / block
Resume
Suspend
Suspend wait
Process completed I/o but still in suspend

Process Control Block

- A 'Process Control Block' (PCB) is a dedicated data structure that represents each process being managed by an operating system.



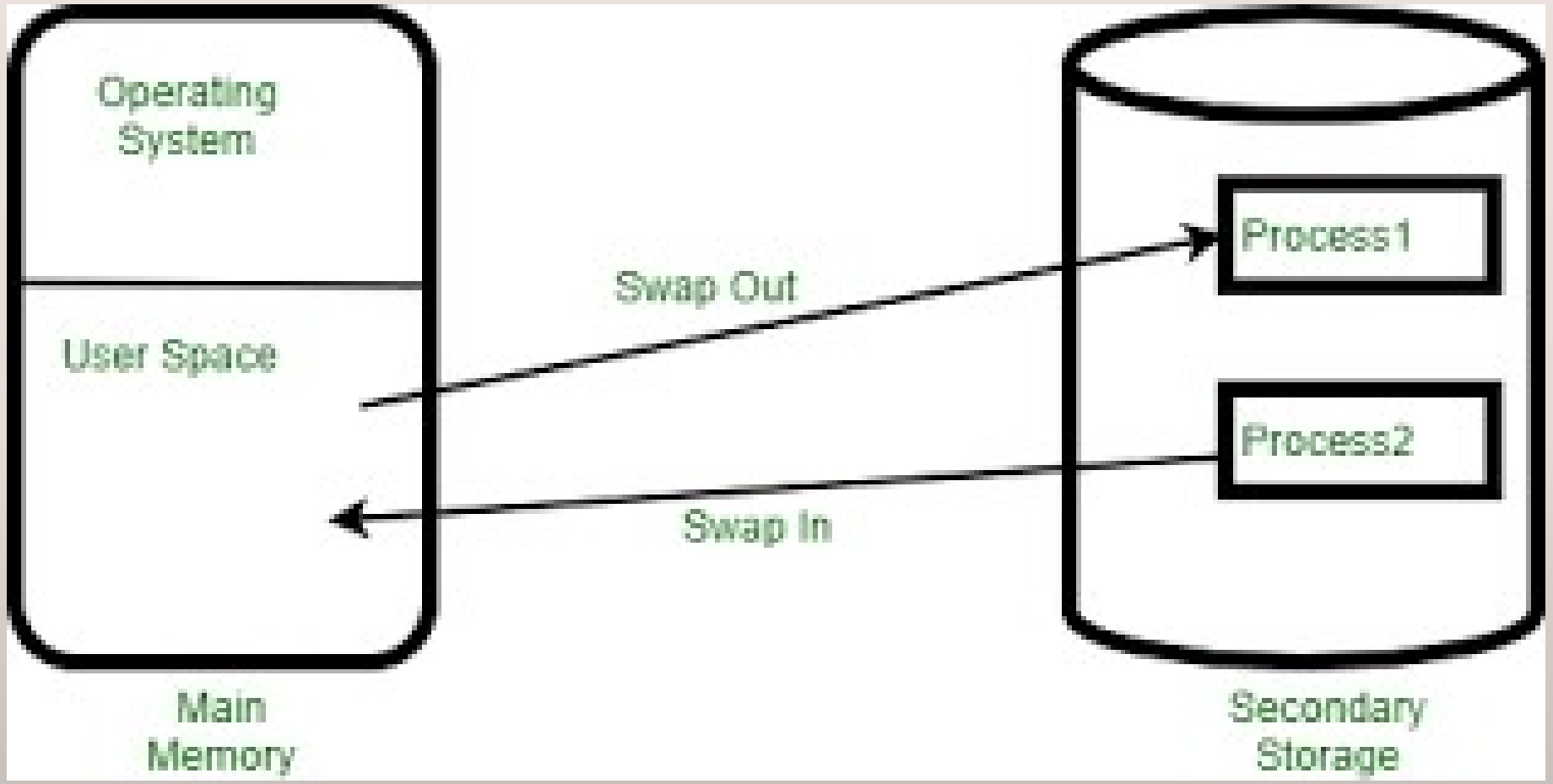
- **A Process Control Block (PCB)** is a data structure that is used by an Operating System to manage and regulate how processes are carried out. In operating systems, managing the process and scheduling them properly play the most significant role in the efficient usage of memory and other system resources.
- Process number : Each process is identified by its unique process number, called
- process-ID. Priority: Priority of process.
- Process State (Transition): Each process may be in any of these
- states: new, ready, running, waiting, terminated.
- Program Counter: It indicates the address of the text instruction to be executed for this process.
- Registers: They include machine registers like accumulator, general purpose registers, index registers etc. They also include priority of a process, and register address to scheduling queues and any other registers.
- PCB Pointer: it is a pointer to the next PCB in the process scheduling list.

Context Switching Block

The Context switching is a technique or method used by the operating system to switch a process from one state to another to execute its function using CPUs in the system. When switching perform in the system, it stores the old running process's status in the form of registers and assigns the CPU to a new process to execute its tasks.

While a new process is running in the system, the previous process must wait in a ready queue. The execution of the old process starts at that point where another process stopped it.

It defines the characteristics of a multitasking operating system in which multiple processes shared the same CPU to perform multiple tasks without the need for additional processors in the system.


Operating System
User Space
Main Memory
Swap Out
Swap In
Process1
Process2
Secondary Storage

Threads

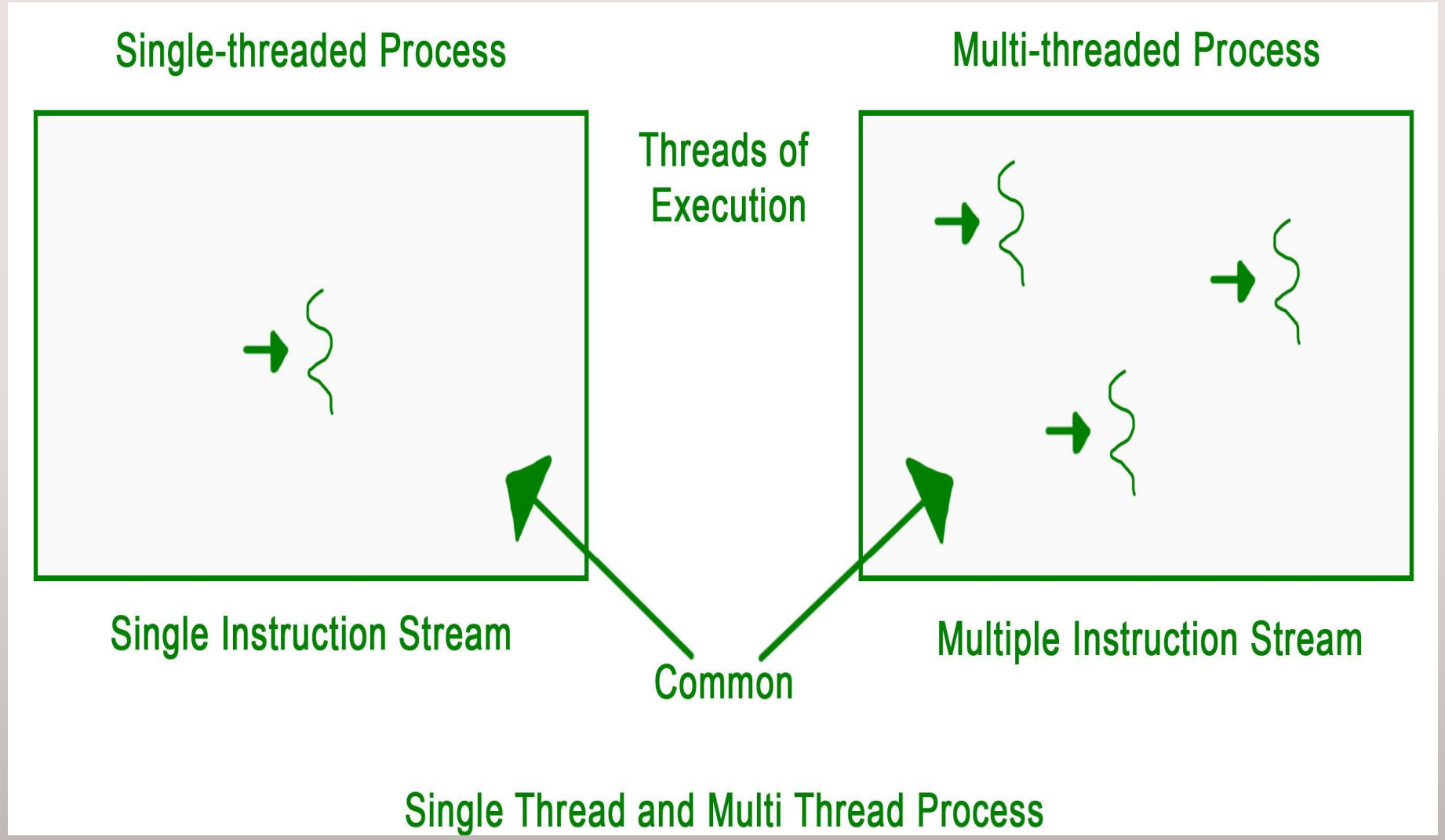
- A thread is a single sequential flow of execution of tasks of a process so it is also known as thread of execution or thread of control. There is a way of thread execution inside the process of any operating system

Multithreading

Running multiple threads within a single program simultaneously.

Multithreading is a feature in operating systems that allows a program to do several tasks at the same time. Think of it like having multiple hands working together to complete different parts of a job faster. Each “hand” is called a thread, and they help make programs run more efficiently.

Multithreading makes your computer work better by using its resources more effectively, leading to quicker and smoother performance for applications like web browsers, games, and many other programs you use every day.



Single Thread and Multi Thread Process

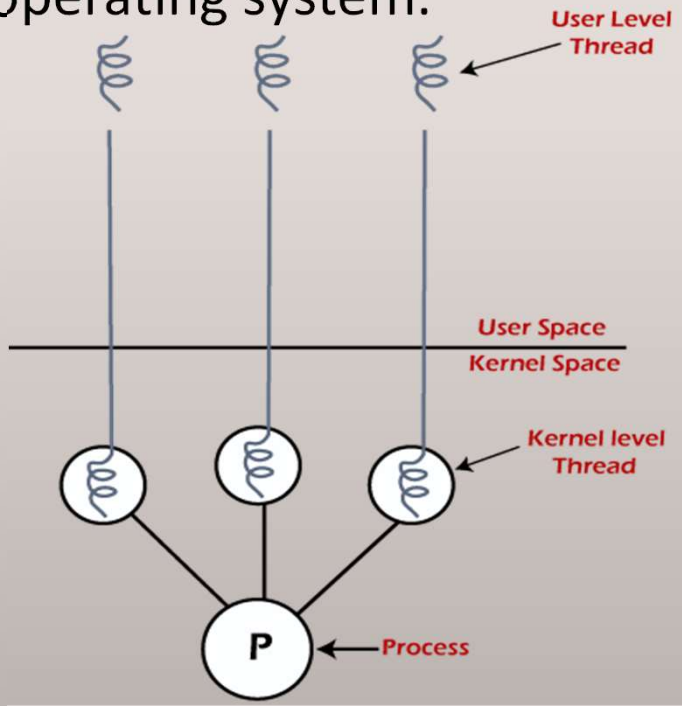
Benefits of Threads

- Takes less time to create a new thread than a process
- Less time to terminate a thread than a process
- Less time to switch between two threads within the same process
- Since threads within the same process share memory and files, they can communicate with each other without invoking the kernel

Types Of Thread

1. Kernel level thread

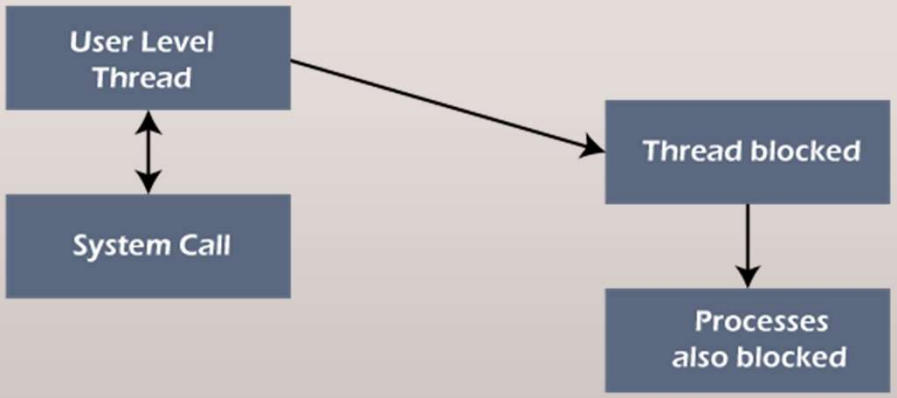
- The kernel thread recognizes the operating system. There is a thread control block and process control block in the system for each thread and process in the kernel-level thread. The kernel-level thread is implemented by the operating system.



- **Advantages of Kernel-level threads**
- The kernel-level thread is fully aware of all threads.
- The scheduler may decide to spend more CPU time in the process of threads being large numerical.
- The kernel-level thread is good for those applications that block the frequency.
- **Disadvantages of Kernel-level threads**
- The kernel thread manages and schedules all threads.
- The implementation of kernel threads is difficult than the user thread.
- The kernel-level thread is slower than user-level threads.

2. **User-level thread**

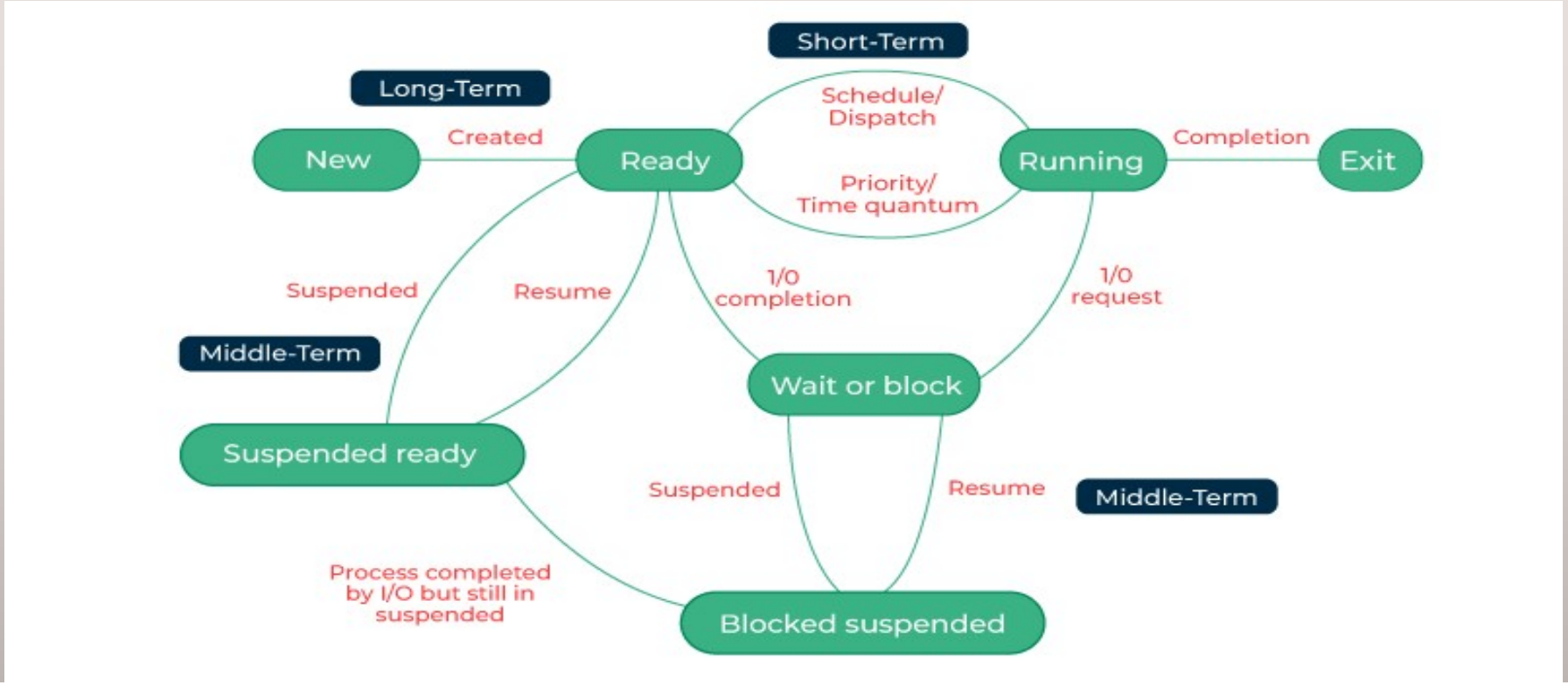
- The operating system does not recognize the user-level thread. User threads can be easily implemented and it is implemented by the user. If a user performs a user-level thread blocking operation, the whole process is blocked.



- **Advantages of User-level threads**
- The user threads can be easily implemented than the kernel thread.
- User-level threads can be applied to such types of operating systems that do not support threads at the kernel-level.
- It is faster and efficient.
- Context switch time is shorter than the kernel-level threads.
- It does not require modifications of the operating system.
- User-level threads representation is very simple. The register, PC, stack, and mini thread control blocks are stored in the address space of the user-level process.
- It is simple to create, switch, and synchronize threads without the intervention of the process.
- **Disadvantages of User-level threads**
- User-level threads lack coordination between the thread and the kernel.
- If a thread causes a page fault, the entire process is blocked.

Process Scheduling

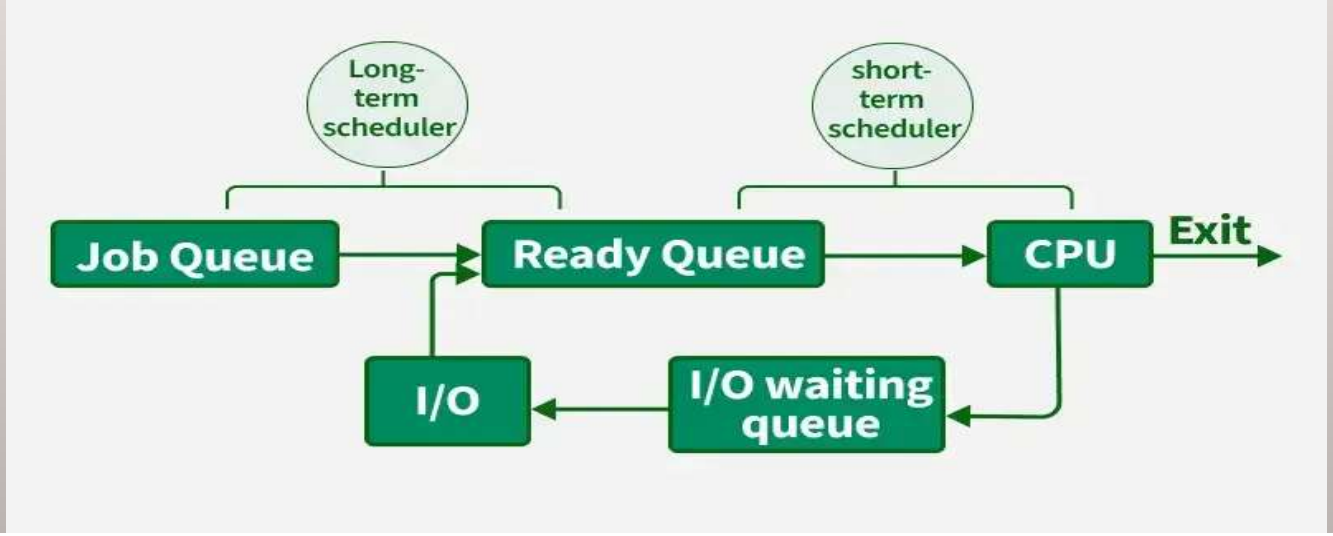
- Process scheduling is the activity of the process manager that handles the removal of the running process from the CPU and the selection of another process based on a particular strategy.



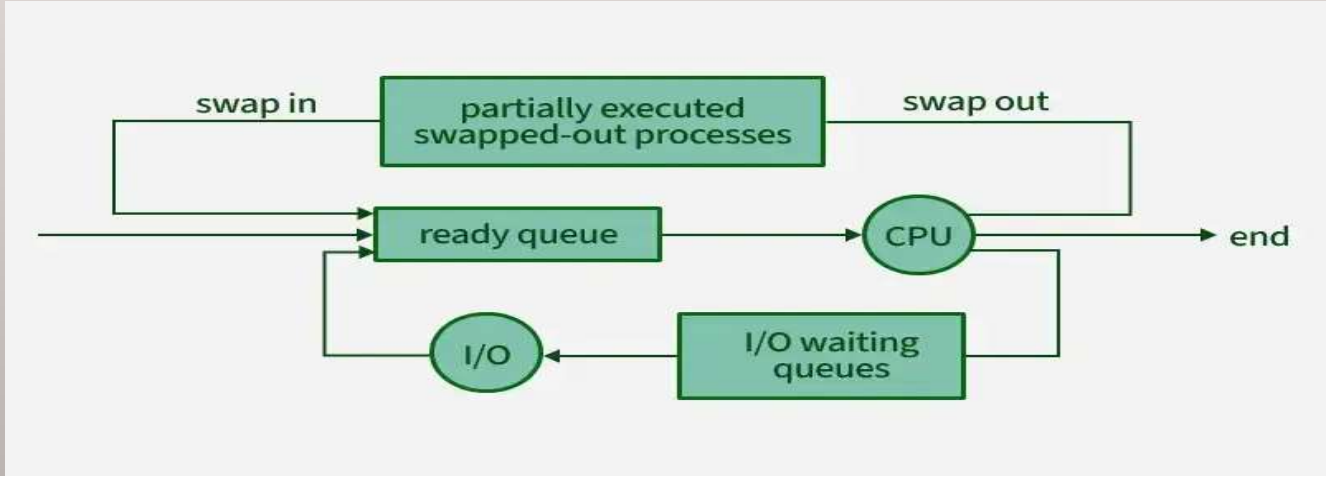
Types of Process Schedulers

- 1. Long term scheduler
- Long term scheduler is also known as job scheduler. It chooses the processes from the pool (secondary memory) and keeps them in the ready queue maintained in the primary memory.
- Long Term scheduler mainly controls the degree of Multiprogramming. The purpose of long term scheduler is to choose a perfect mix of IO bound and CPU bound processes among the jobs present in the pool.
- If the job scheduler chooses more IO bound processes then all of the jobs may reside in the blocked state all the time and the CPU will remain idle most of the time. This will reduce the degree of Multiprogramming. Therefore, the Job of long term scheduler is very critical and may affect the system for a very long time.

- 2. Short term scheduler
- Short term scheduler is also known as CPU scheduler. It selects one of the Jobs from the ready queue and dispatch to the CPU for the execution.
- A scheduling algorithm is used to select which job is going to be dispatched for the execution. The Job of the short term scheduler can be very critical in the sense that if it selects job whose CPU burst time is very high then all the jobs after that, will have to wait in the ready queue for a very long time.
- This problem is called starvation which may arise if the short term scheduler makes some mistakes while selecting the job.



- 3. Medium term scheduler
- Medium term scheduler takes care of the swapped out processes.If the running state processes needs some IO time for the completion then there is a need to change its state from running to waiting.
- Medium term scheduler is used for this purpose. It removes the process from the running state to make room for the other processes. Such processes are the swapped out processes and this procedure is called swapping. The medium term scheduler is responsible for suspending and resuming the processes.
- It reduces the degree of multiprogramming. The swapping is necessary to have a perfect mix of processes in the ready queue.



CPU Scheduling Algorithms

- CPU scheduling is a fundamental operating system function that decides which processes or program gets to run on the CPU and in what order
- It helps to manage the execution of multiple task on a computer
- **Terminologies Used in CPU Scheduling**
- **Arrival Time:** The time at which the process arrives in the ready queue.
- **Completion Time:** The time at which the process completes its execution.
- **Burst Time:** Time required by a process for CPU execution.
- **Turn Around Time:** Time Difference between completion time and arrival time.
- **Waiting Time(W.T):** Time Difference between turn around time and burst time.

First Come First Serve (FCFS) CPU Scheduling [Non-Preemptive]

- First Come First Serve CPU Scheduling Algorithm shortly known as FCFS is the first algorithm of CPU Process Scheduling Algorithm. In First Come First Serve Algorithm what we do is to allow the process to execute in linear manner.
- This means that whichever process enters process enters the ready queue first is executed first. This shows that First Come First Serve Algorithm follows First In First Out (FIFO) principle.

BT : Burst Time

CT : Completion Time

AT : Arrival Time

TAT : Turn Around Time

WT : Waiting Time

RT : Response Time

TAT = CT – AT

WT = TAT – BT

R.T = (First Arrival Time) – (Arrival Time)

Example

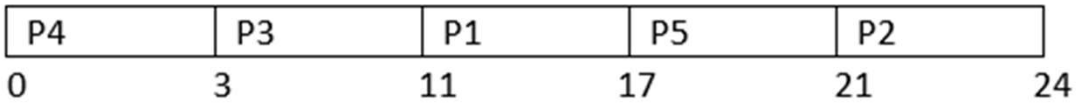
Process	Arrival Time	Burst Time
p1	0	5
p2	0	3
p3	0	8

Process	Completion Time (CT)	Turnaround Time (TAT = CT – AT)	Waiting Time (WT = TAT – BT)
P2	3 ms	3 ms	0 ms
P1	8 ms	6 ms	1 ms
P3	12 ms	8 ms	4 ms

Example 2

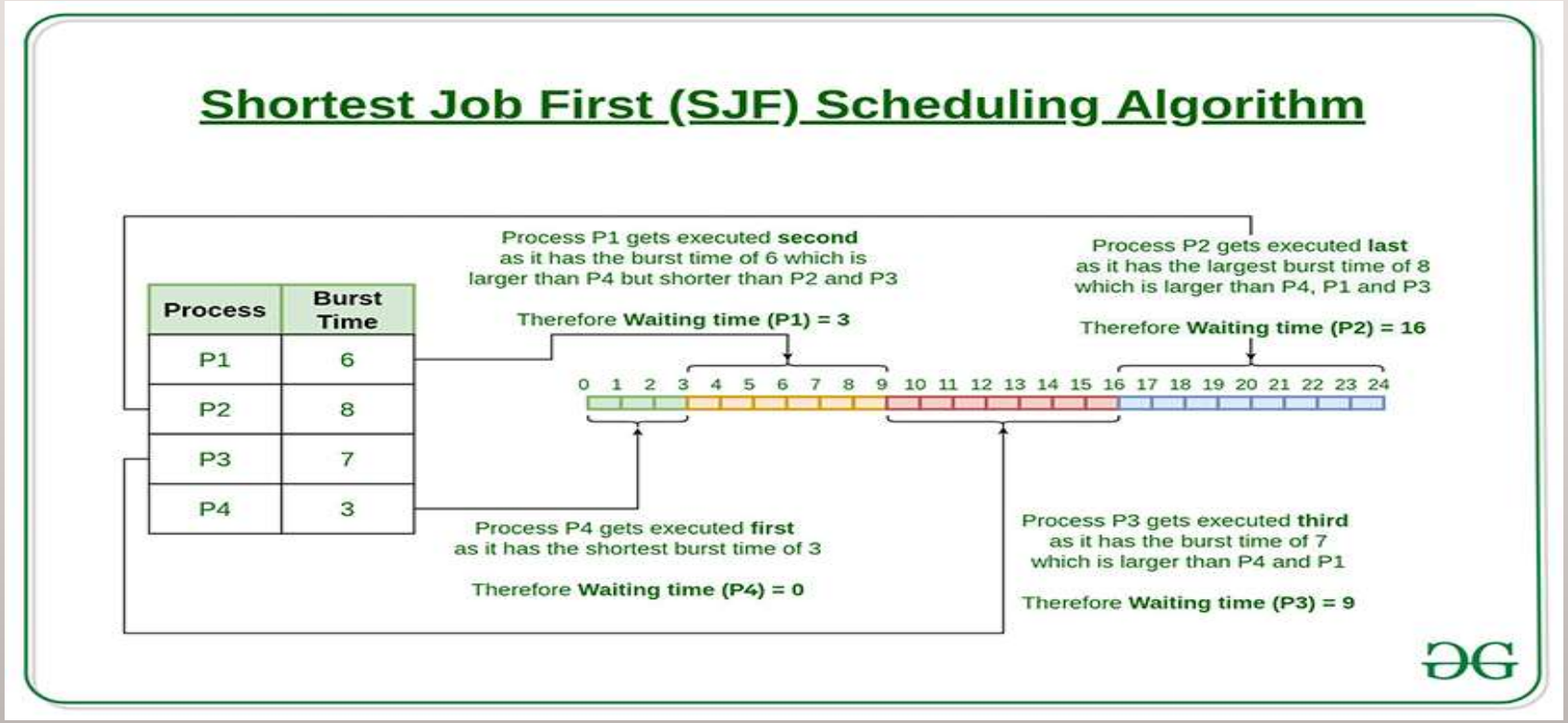
Process ID	AT	BT	CT	TAT	WT	RT
P1	2	6	17	15	09	09
P2	5	3	24	19	16	16
P3	1	8	11	10	02	02
P4	0	3	3	03	00	00
P5	4	4	21	17	13	13

Gantt Chart



Shortest Job First (or SJF) CPU Scheduling (Non-preemptive)

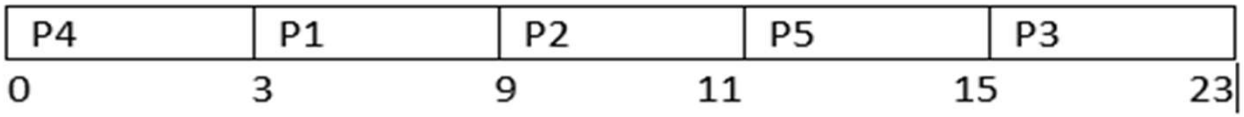
- The shortest job first (SJF) or shortest job next, is a scheduling policy that selects the waiting process with the smallest execution time to execute next. SJN, also known as Shortest Job Next (SJN)



Example

Process ID	AT	BT	CT	TAT	WT	RT
P1	2	6	09	07	01	01
P2	5	3	11	06	04	04
P3	1	8	23	22	14	14
P4	0	3	3	03	00	00
P5	4	4	15	11	07	07

Gantt Chart



Round Robin

- **Round Robin Scheduling** is a method used by operating systems to manage the execution time of multiple processes that are competing for CPU attention. It is called "round robin" because the system rotates through all the processes, allocating each of them a fixed time slice or "quantum", regardless of their priority.
- Round Robin is a CPU scheduling algorithm where each process is cyclically assigned a fixed time slot. It is the preemptive version of the First come First Serve CPU Scheduling algorithm.

Example

- Consider the following table of arrival time and burst time for three processes P1, P2 and P3 and given **Time Quantum = 2 ms**

Process	Burst Time	Arrival Time
P1	4 ms	0 ms
P2	5 ms	0 ms
P3	3 ms	0 ms

- **Step-by-Step Execution:**
- **Time 0-2 (P1)**: P1 runs for 2 ms (total time left: 2 ms).
- **Time 2-4 (P2)**: P2 runs for 2 ms (total time left: 3 ms).
- **Time 4-6 (P3)**: P3 runs for 2 ms (total time left: 1 ms).
- **Time 6-8 (P1)**: P1 finishes its last 2 ms.
- **Time 8-10 (P2)**: P2 runs for another 2 ms (total time left: 1 ms).
- **Time 10-11 (P3)**: P3 finishes its last 1 ms.
- **Time 11-12 (P2)**: P2 finishes its last 1 ms.

Turnaround Time = Completion Time - Arrival Time
Waiting Time = Turnaround Time - Burst Time

Processes	AT	BT	CT	TAT	WT
P1	0	4	8	8-0 = 8	8-4 = 4
P2	0	5	12	12-0 = 12	12-5 = 7
P3	0	3	11	11-0 = 11	11-3 = 8

- **Average Turn around time** = (8 + 12 + 11)/3 = 31/3 = 10.33 ms
- **Average waiting time** = (4 + 7 + 8)/3 = 19/3 = 6.33 ms

Priority Base Non-Preemptive

- If a new process of higher priority than the currently running process arrives, then the currently executing process is not disturbed.
- Rather, the newly arrived process is put at the head of the ready queue, i.e. according to its priority in the queue. And when the execution of the currently running process is complete, the newly arrived process will be given the CPU.

Advantages

- Processes having higher priority need not wait for a longer time due to other processes running.
- The relative importance of processes can be defined.
- The application in which the requirement of time and resources fluctuate are useful.

Example

(Lower Number of high priority)

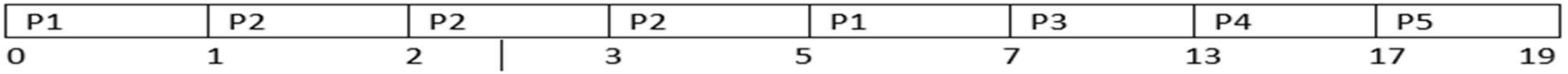
Process ID	Priority	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time	Response Time
P1	2	0	3	3	3	0	0
P2	6	2	5	18	16	11	13
P3	3	1	4	7	6	2	3
P4	5	4	2	13	9	7	11
P5	7	6	9	27	21	12	18
P6	4	5	4	11	6	2	7
P7	10	7	10	37	30	20	27

Priority Base Preemptive

- A scheduling system commonly used in real-time systems. With fixed priority preemptive scheduling, the scheduler ensures that at any given time, the processor executes the highest priority task of all those tasks that are currently ready to execute.
- (Lower Number is high priority)

Process ID	AT	Priority	BT	CT	TAT	WT	RT
P1	0	3	3	7	7	4	0
P2	1	2	4	5	4	0	0
P3	2	4	6	13	11	5	5
P4	3	6	4	17	14	10	10
P5	5	10	2	19	14	12	12

Gantt Chart



Full Form

- Operating System (OS)
- Shortest Job First (SJF)
- Graphical user interface (GUI)
- Batch Operating System (BOS)
- Time-Sharing Operating System (TSOS)
- Distributed operating system (DOS)
- network operating system(NOS)
- real-time operating system (RTOS)
- Process Control Block(PCB)
- First In First Out (FIFO)
- First Come First Serve (FCFS)
- Simultaneous multithreading (SMT)
- Round Robbin (RR)

Assignment 1

(Introduction, Process and Thread, Process Scheduling)

1. Explain Five State Process Model
2. Explain Function of OS
3. Explain Round Robbin with example
4. Explain SJF with example
5. Explain FCFS with example
6. List types of OS and Explain Batch OS
7. Explain Time Sharing OS
8. Write Note on priority based scheduling techniques