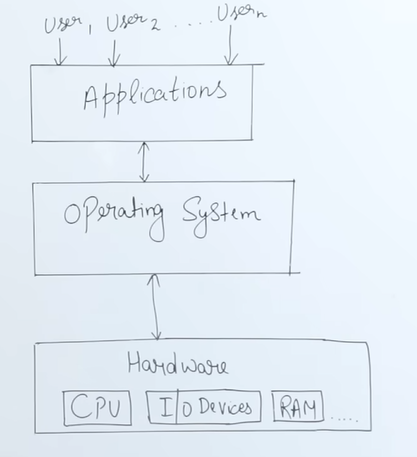
**Operating System :-**

1. Basic Introduction: - Type of OS, process diagram, System calls ,
2. Process Scheduling: - FIFOA, SJF, PReamtive, Round Robin Algorithms
3. Process Synchronization: - Semaphore,
4. Deadlock and Threads: - Bankers Algorithm
5. Memory Management: - Virtual Memory, Paging, Segmentation, Fragmentation, Page Replacement Algos.
6. Disk Scheduling: - SCAN, CSCNA, FCFS Algos
7. Unix Commands: - Sequential access, random access, linked access algos
8. File Management and Security.

**[LEC-1]**

**Introduction to Operating System and its Functions: -** An operating system is a piece of software that manages all the resources of a computer system, both hardware and software, and provides an environment in which the user can execute his/her programs in a convenient and efficient manner by hiding underlying complexity of the hardware and acting as a resource manager.

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**Why OS Important: -**

1. **What if there is no OS?**

**a. Bulky and complex app. (Hardware interaction code must be in app’s code base)**

**b. Resource exploitation by 1 App.**

**c. No memory protection.**

**2. What is an OS made up of?**

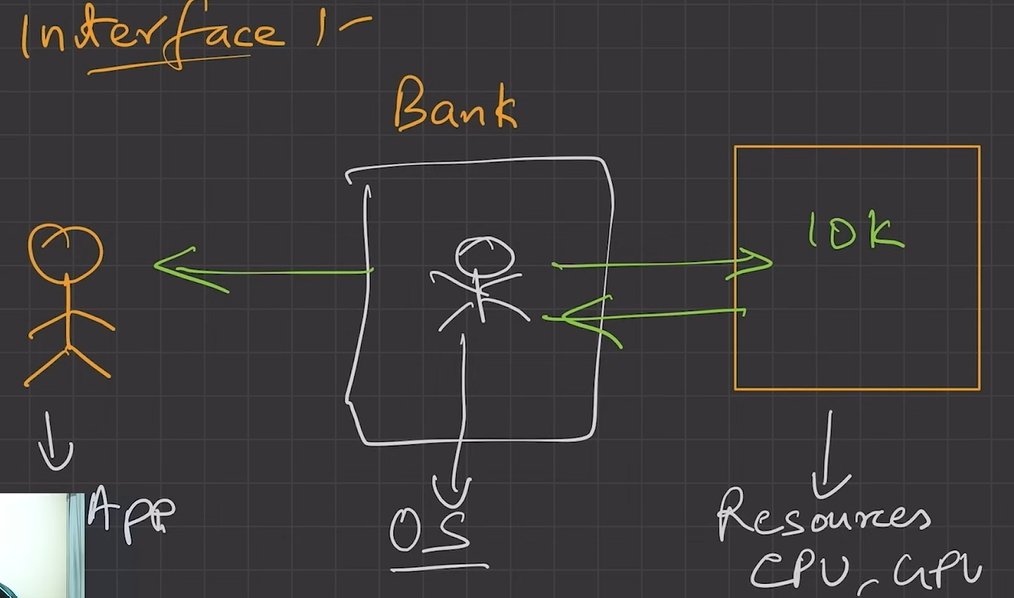
**a. Collection of system software.**

Let's take an example: Suppose we need to run an application like TikTok. To do this, we require CPU, GPU, memory, and disk resources.

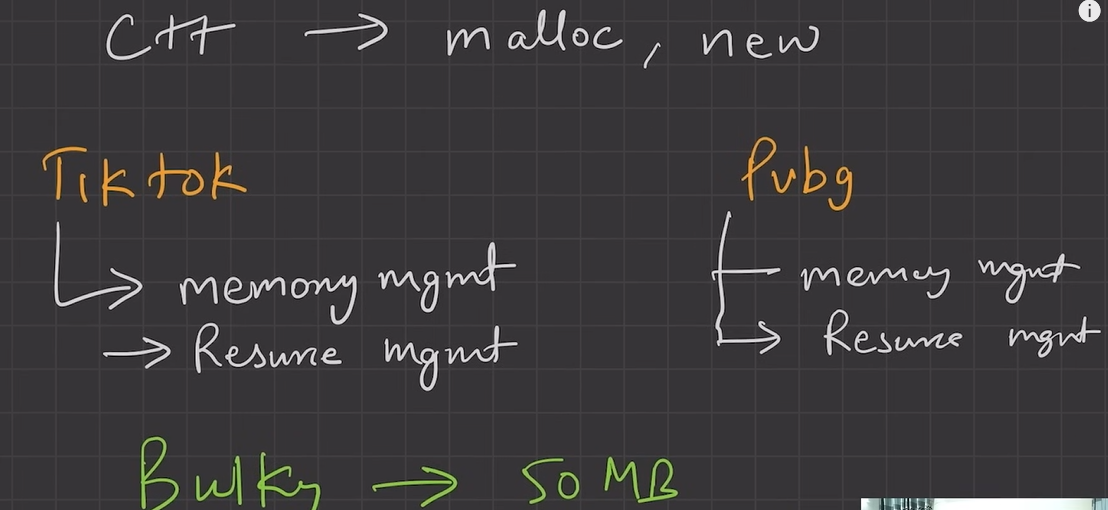
If there were no operating system (OS), TikTok would directly access the CPU, memory, GPU, and disk, consuming all available resources. Now, if we wanted to run another application, like PUBG, at the same time, it wouldn’t be possible because TikTok would have already occupied all the resources.

The OS solves this problem by allocating a specific portion of the CPU, memory, and GPU to TikTok while reserving some resources for other applications. This allows us to run PUBG simultaneously by distributing resources efficiently. This process is known as **resource management by the OS**.

The OS functions as an interface, similar to how a bank cashier facilitates cash withdrawals. When I go to a bank to withdraw money from my account, I first fill out a form and submit it to the cashier. The cashier then retrieves the cash from the bank and hands it over to me. In this scenario, the cashier acts as an interface between me and the bank, just as the OS serves as an interface between users and the computer's hardware.



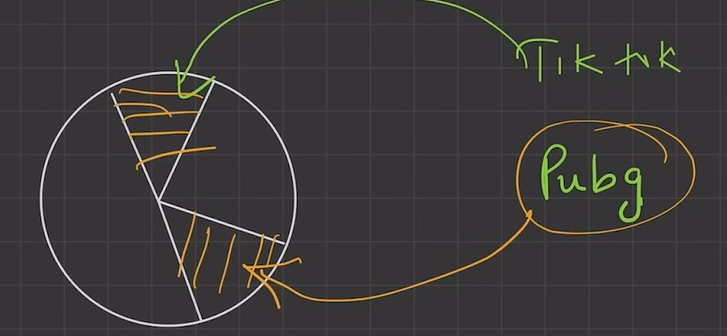
Without an OS, developers would need to write code for resource management, such as memory and CPU management, for applications like TikTok and PUBG. This would result in large, redundant code, as the same functionalities would have to be implemented repeatedly, violating the DRY (Don't Repeat Yourself) principle.

****

**Dry Principle: -** Do not repeat yourself: - The **DRY (Don't Repeat Yourself) Principle** is a software development concept that emphasizes reducing code duplication. It promotes reusability and maintainability by ensuring that a piece of logic or functionality is written only once and reused wherever needed (i.e Functions) . This helps prevent inconsistencies, reduces errors, and makes code easier to update and manage.

To stop DRY Principal violation, we need Operating System. We don’t need to write code for Resource management.

**ISOLATION & PROTECTION: -** The OS ensures isolation and protection. Without an OS, if applications like TikTok and PUBG are running and consuming memory, they could accidentally overwrite another application's memory, compromising security and leading to potential system instability.

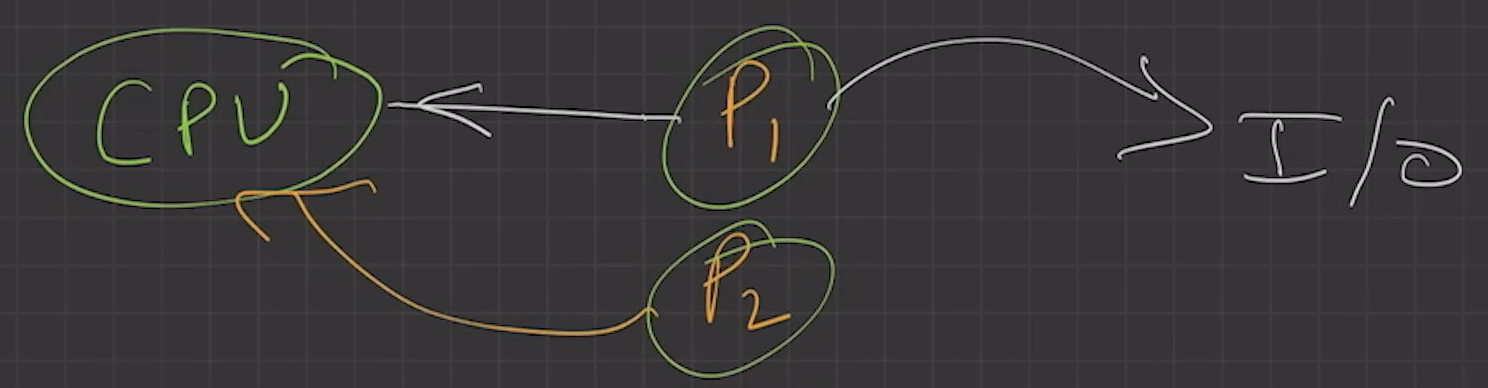
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Imagine you are playing PUBG with your player's health at 100%. Suddenly, TikTok runs and accidentally changes your health to 0%, instantly killing your player. This happens because there’s no OS to keep applications separate, allowing one app to interfere with another, which is a security breach.

**[EC-2: Types of OS]**

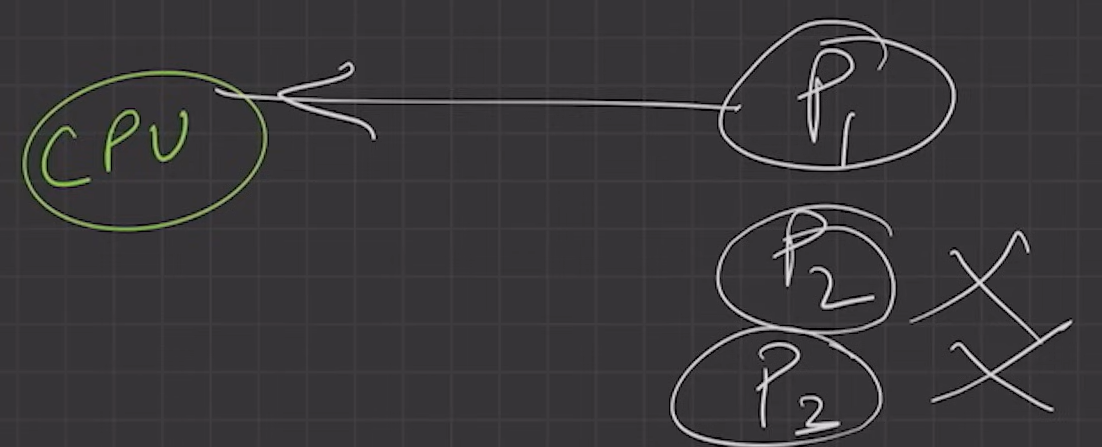
**OS goals –**

* **Maximum CPU utilization: -**

****

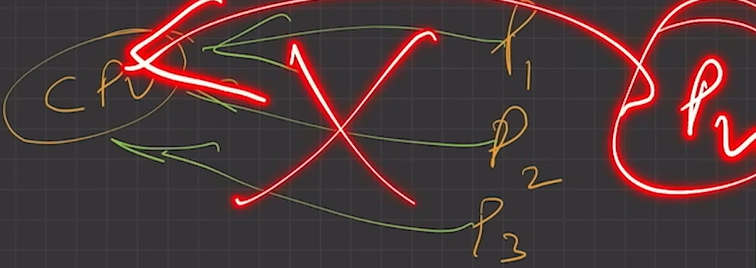
There are two processes, P1 and P2. When P1 is using the CPU and later needs to perform input/output (I/O) operations, the CPU switches to P2 so that it doesn't sit idle. This helps in making the best use of the CPU.

* **Less process starvation: -**

****

If P1 keeps using the CPU for a long time and P2 and P3 don’t get a turn, it is called process starvation. This means some processes are stuck waiting while one process keeps running.

* **Higher priority job execution: -**



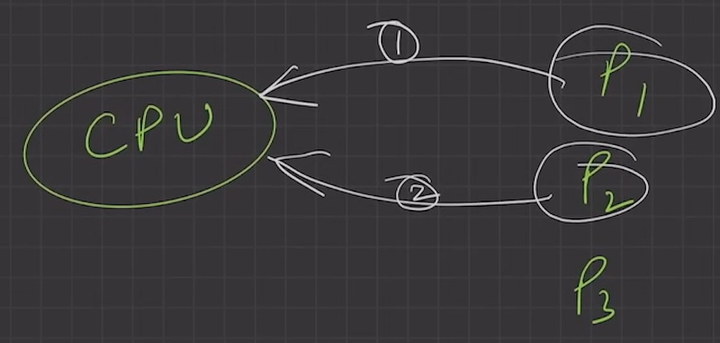
If multiple processes are running on the CPU and a high-priority task arrives, the CPU should pause the others and run the high-priority task first.

**Types of operating systems –**

* Single process operating system
* Batch-processing operating system
* Multiprogramming operating system
* Multitasking operating system
* Multi-processing operating system
* Distributed system
* Real time OS

1. **Single process OS**, only 1 process executes at a time from the ready queue. [Oldest – MS DOS]

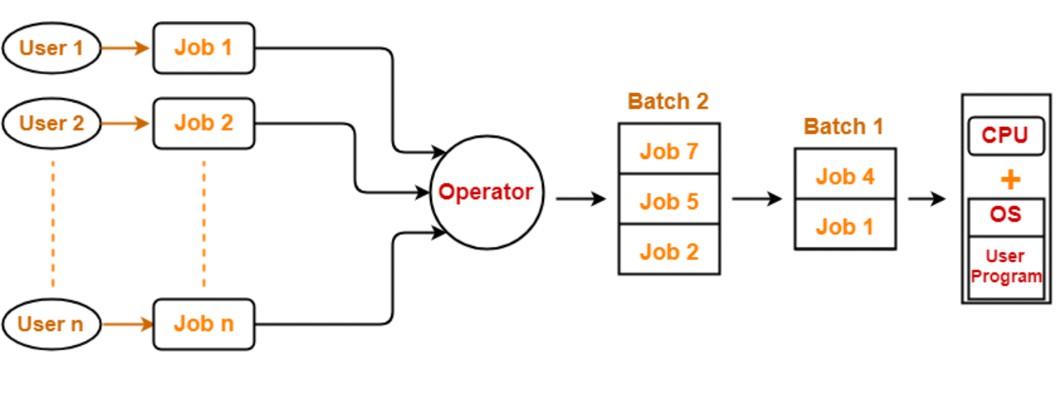
### In a single-process OS, only one process runs at a time. For example, if there are three processes—P1, P2, and P3—first, P1 runs. After P1 finishes, P2 starts. Once P2 is done, P3 begins.



The disadvantage of this OS is that it doesn’t fully utilize the CPU, can cause process starvation, and doesn’t allow high-priority tasks to run first.

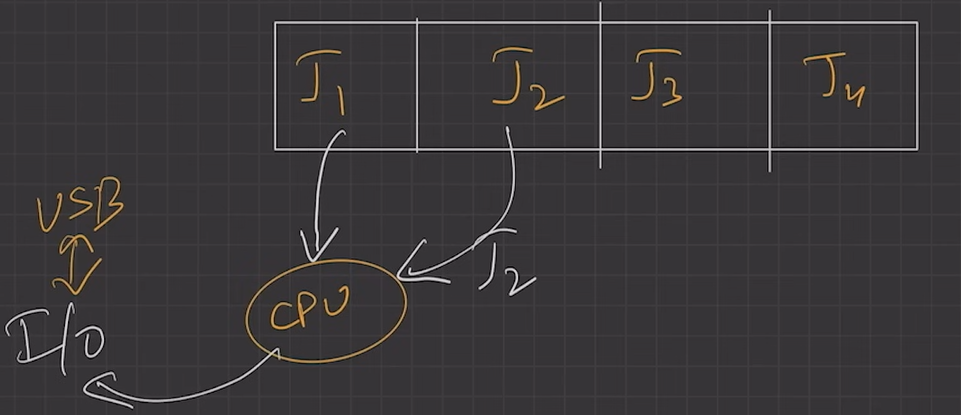
### **Batch-processing OS,**

1. Firstly, user prepares his job using **punch cards**.
2. Then, he submits the job to the computer operator.
3. Operator collects the jobs from different users and sort the jobs into batches with similar needs.
4. Then, operator submits the batches to the processor one by one.
5. All the jobs of one batch are exec uted together.
   * Priorities cannot be set, if a job comes with some higher priority.
   * May lead to starvation. (A batch may take more time to complete)
   * CPU may become idle in case of I/O operations.



1. **Multiprogramming** increases CPU utilization by keeping multiple jobs (code and data) in the memory so that the CPU always has one to execute in case some job gets busy with I/O.
   * Single CPU
   * Context switching for processes.
   * Switch happens when current process goes to wait state.
   * CPU idle time reduced.

In a multiprogramming OS, there is only one CPU, but it uses a **ready queue** to hold multiple jobs. If one process goes into waiting or needs I/O, the CPU picks another job to run, keeping the system active.



* + **Context switching for processes. :-**

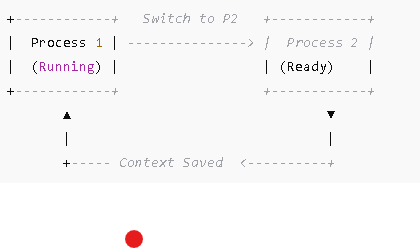
Context switching is when the CPU switches from one process to another. This happens when multiple processes are running, and the CPU needs to stop one process and start another. The OS saves the state of the current process and loads the state of the next process so it can continue from where it left off.

Example:

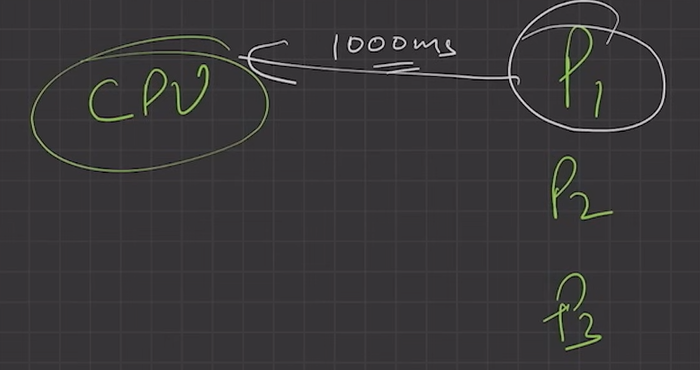
Imagine you are watching a video on your phone, and suddenly you get a call. Your phone pauses the video (saves its state) and switches to the call. After the call, you go back to the video, and it resumes from where it stopped.

Steps in Context Switching:

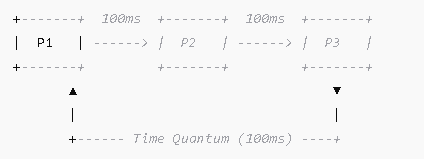
1. **Save the current process state (PCB – Process Controll Block) .**
2. **Load the new process state from memory.**
3. **Start executing the new process.**



1. **Multitasking** is a logical extension of multiprogramming.
   1. Single CPU
   2. Time Sharing (Time Quantum i.e 100 ms)
   3. Able to run more than one task simultaneously.
   4. Context switching and time sharing used.
   5. Increases responsiveness.
   6. CPU idle time is further reduced.



In this diagram, we show **time-sharing**, where each process gets a fixed amount of time to execute. Suppose **P1** starts running and gets **100 ms** to complete its work. After **100 ms**, the CPU switches to **P2** for another **100 ms**, and then to **P3**. This fixed time slice is called a **time quantum**.

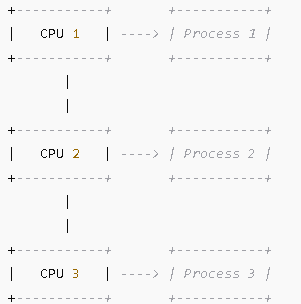


1. **Multi-processing OS,** more than 1 CPU in a single computer.

A **multiprocessing OS** is an operating system that uses **more than one CPU** in a single computer. This allows multiple processes to run **at the same time**, improving performance and efficiency.

**Key Concepts:**

1. **Increases Reliability** – If one CPU fails, the other can still work, preventing system failure.
2. **Context Switching** – The OS can switch between processes when needed, ensuring smooth execution.
3. **Time Sharing** – Multiple CPUs handle different tasks, giving each process a fair share of execution time.
4. **Better Throughput** – Since more processes run in parallel, the system completes tasks faster.
5. **Less Process Starvation** – If one CPU is busy with a process, another CPU can handle other tasks, reducing waiting time.

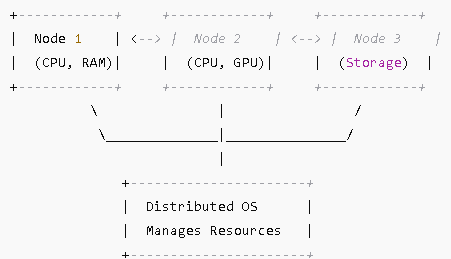


### **Distributed OS,**

A **Distributed Operating System** is an OS that manages multiple resources like **CPUs, memory, GPUs, and storage** across different computers (nodes) that are connected over a network. It allows multiple computers to work together as a **single system**, even though they are **physically separate and loosely connected**.

**Key Concepts:**

1. **Manages Many Resources** – The OS controls multiple CPUs, memory units, and GPUs across different machines.
2. **Loosely Connected & Autonomous** – Each computer (node) operates independently but works together as a system.
3. **Interconnected Computer Nodes** – These nodes communicate with each other over a network.
4. **Independent & Networked Nodes** – Unlike a single system, these computers are physically separate but communicate to share workloads.



### **RTOS**

* Real time error free, computations within tight-time boundaries.
* Air Traffic control system, ROBOTS etc.

**Types of Operating Systems with Simple Explanation & Examples**

**1. Single-Process Operating System**

* **Definition:** Runs only one process at a time. The next process starts only after the current one is completed.
* **Example:** **MS-DOS, Palm OS (used in old PDAs)**
* **Scenario:** If you open a text editor in MS-DOS, you can’t do anything else until you close it.

**2. Batch-Processing Operating System**

* **Definition:** Processes multiple tasks in batches without user interaction. Jobs are grouped and executed sequentially.
* **Example:** **IBM OS/360, Windows Batch Scripts, UNIX Batch Processing**
* **Scenario:** In a bank, salary payments for all employees are processed in a batch at the end of the month.

**3. Multiprogramming Operating System**

* **Definition:** Multiple processes are kept in memory, and the CPU switches between them to improve efficiency.
* **Example:** **IBM OS/360, UNIX**
* **Scenario:** While a program is waiting for user input, the CPU switches to another program to keep the system busy.

**4. Multitasking Operating System**

* **Definition:** Supports multiple tasks running at the same time by switching between them rapidly.
* **Example:** **Windows, macOS, Linux**
* **Scenario:** You are listening to music, browsing the internet, and editing a document at the same time.

**5. Multi-Processing Operating System**

* **Definition:** Uses multiple CPUs to execute multiple processes at the same time, improving speed and reliability.
* **Example:** **Windows (on multi-core processors), Linux, UNIX SMP (Symmetric Multiprocessing)**
* **Scenario:** A **gaming PC with a multi-core processor** runs a video game while streaming and performing background tasks efficiently.

**6. Distributed Operating System**

* **Definition:** Manages multiple interconnected computers working together as a single system.
* **Example:** **Google Cloud OS, Apache Hadoop, Microsoft Azure, IBM AIX**
* **Scenario:** A **Google search request** is processed across multiple servers instead of just one computer.

**7. Real-Time Operating System (RTOS)**

* **Definition:** Executes tasks within a fixed time limit, ensuring timely responses for critical systems.
* **Example:** **VxWorks, QNX, FreeRTOS, RTLinux**
* **Scenario:** **Airplane autopilot systems** need immediate responses to sensor inputs to ensure safety.

**[LEC-3: Multi-Tasking vs multi-threading]**

**Program**: A Program is an executable file which contains a certain set of instructions written to complete the specific job or operation on your computer.

* + It’s a compiled code. Ready to be executed.
  + Stored in Disk

**Process**: Program under execution. Resides in Computer’s primary memory (RAM).

## **Thread: For Threading Concept the pre-requisite we should have greater then 1 CPU.**

A **thread** is the **smallest unit of execution** in a process. A process can have **one or multiple threads** running simultaneously, sharing the same memory and resources but executing different tasks.

**Types of Threads:**

1. **Single-Threaded Process:** Only one thread runs in a process at a time.
2. **Multi-Threaded Process:** Multiple threads run within the same process, improving performance and efficiency.

**Example :-**

**1. Single-Threaded Process Example: A Fast-Food Counter 🍔**

Imagine you go to a fast-food restaurant where there is **only one cashier** taking orders **one by one**.

🔹 **Steps:**

1. The cashier takes your order.
2. They process your payment.
3. They prepare the food.
4. Once completed, they move to the next customer.

**Problem?** This is **slow** because only **one task is executed at a time**. If one order takes too long, others must wait.

**2. Multi-Threaded Process Example: A Fast-Food Chain with Multiple Counters 🍕**

Now imagine **McDonald's** where multiple cashiers are available, each taking orders simultaneously.

🔹 **Steps:**

1. One cashier takes an order while another processes a different order.
2. The kitchen staff prepares food for multiple customers at the same time.
3. One order delay doesn’t affect others.

This is how **multi-threading** works! Instead of waiting for one process to finish before starting another, multiple tasks run in parallel, improving speed and efficiency.

* + Single sequence stream within a process.
  + An independent path of execution in a process.
  + Light-weight process.
  + Used to achieve parallelism by dividing a process’s tasks which are independent path of execution.
  + E.g., Multiple tabs in a browser, text editor (When you are typing in an editor, spell- checking, formatting of text and saving the text are done concurrently by multiple threads.)

|  |  |
| --- | --- |
| **Multi-Tasking** | **Multi-Threading** |
| The execution of more than one task simultaneously is called as multitasking. | A process is divided into several different sub-tasks called as threads, which has its own path of execution. This concept is  called as multithreading. |
| Concept of more than 1 processes being context switched. | Concept of more than 1 thread. Threads are context switched. |
| No. of CPU 1. | No. of CPU >= 1. (Better to have more than 1) |
| **Isolation and memory protection** exists. OS must allocate separate memory and resources to each program that CPU is executing. | **No isolation and memory protection**, resources are shared among threads of that process.  OS allocates memory to a process; multiple threads of that process share the same memory and resources allocated to the  process. |

## **Thread Scheduling:**

Threads are scheduled for execution based on their priority. Even though threads are executing within the runtime, all threads are assigned processor time slices by the operating system.

## **Difference between Thread Context Switching and Process Context Switching:**

|  |  |
| --- | --- |
| Thread Context switching | Process context switching |
| OS saves current state of thread & switches to another thread of same process. | OS saves current state of process & switches to another process by restoring its  state. |