Operating Systems

Module Introduction

- CCAT Exam
  - Operating Systems: 5 Questions
  - Computer Fundamentals + & Concepts of Programming: 10 Questions
- Quiz
  - Operating Systems: 4 Quizzes (10 marks)
  - Computer Fundamentals: 1 Quiz (10 marks)
  - Operating Systems: Module end quiz (20 marks)

- GitLab Repository
  - OS Galvin Slides
  - Practice MCQ
  - Notes/Diagrams (Daily)
  - Reference Book:
    Operating System Concepts - Galvin

Operating System Concepts

- **Introduction**
  - Introduction to Operating System, What is OS, Booting the System

- **System Architecture Design of OS**
  - System Calls, Dual Mode Operation: System mode and Kernel mode

- **Process Management**
  - What is Process & PCB?
  - States of the process
  - CPU scheduling & CPU scheduling algorithms
  - Inter Process Communication: Shared Memory Model & Message Passing Model
  - Process Synchronization/Co-ordination
  - Deadlocks & deadlock handling methods

Operating System Concepts

* **Memory Management**
  - Swapping
  - Memory Allocation Methods
  - Segmentation
  - Paging
  - Virtual Memory Management

Operating System Concepts

File Management

- What is file?
- What is filesystem & filesystem structure?
- Disk space allocation methods
- Disk scheduling algorithms

→ End User.

Editor | IDE | Web Browser | Media Player → appln software.

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① Interface.
② Resource allocate/manage.
③ Control Prog.
④ CD/DVD → core OS. + appln software + utilities.
⑤ Kernel → Core OS

Operating System (Kernel).

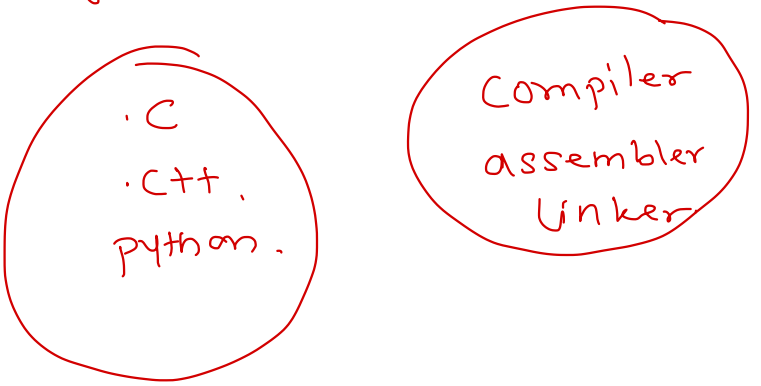
CPU | RAM | HDD | KBD | Monitor → Computer Hardware

Program → Set of Instn. given to computer system (executable file).

Software → Set of Program.

Utility → Prog with OS.

IDE → Integrated Development Environment.



Operating System Concepts

Introduction:

- Why there is need of an OS?
- What is an OS?
- History of OS- Multi-threading, multiprocessing etc
- Functions of an OS
- What is Process?
- States of Process

Q. Why there is a need of an OS?

- Computer is a machine/hardware does different tasks efficiently & accurately.
- Basic functions of computer:
  1. Data Storage
  2. Data Processing
  3. Data Movement
  4. Control

- As any user cannot communicates/interacts directly with computer hardware to do different tasks, and hence there is need of some interface between user and hardware.

Operating System Concepts

Q. What is an Operating System?

- An OS is a **system software** (i.e. collection of system programs) which acts as an interface between the user and hardware.
- An OS also acts as an interface between programs and hardware.
- An OS allocates resources like main memory, CPU time, i/o devices access etc... to all running programs, hence it is also called a **resource allocator.**
- An OS controls the execution of all programs and it also controls hardware devices which are connected to the computer system hence it is also called a **control program.**
- An OS manages limited available resources among all running programs, hence it is also called a **resource manager.**

Operating System Concepts

- From End User: An OS is software (i.e. collection of programs) that comes either in CD/DVD and has the following main components:

1. Kernel: It is a core program/part of an OS which runs continuously into the main memory and does basic minimal functionalities of it.

e.g. Linux: vmlinuz, Windows: ntoskrnl.exe

2. Utility Software: e.g. disk manager, Control panel, windows firewall, anti-virus software etc…

3. Application Software: e.g. google chrome, Shell, notepad, MS Office etc.

Operating System Concepts

Q. What is a Software?

-Software is a collection of programs.

Q. What is a Program?

- Program is a set of instructions written in any programming language (either low-level or high-level programming language) given to the machine to do a specific task.

- Three types of programs are there:

1. "user programs": programs defined by the programmer user/developers
e.g. main.c, hello.java, addition.cpp etc....

2. "application programs": programs which come with an OS/can be installed later

e.g. MS Office, Notepad, Compiler, IDE's, Google Chrome, Mozilla Firefox, Calculator, Games etc....

3. "System Programs": programs which are inbuilt into an OS/part of an OS.
e.g. Kernel, Loader, Scheduler, Memory Manager etc...

 # Functions of an OS:

Basic minimal functionalities/Kernel functionalities:

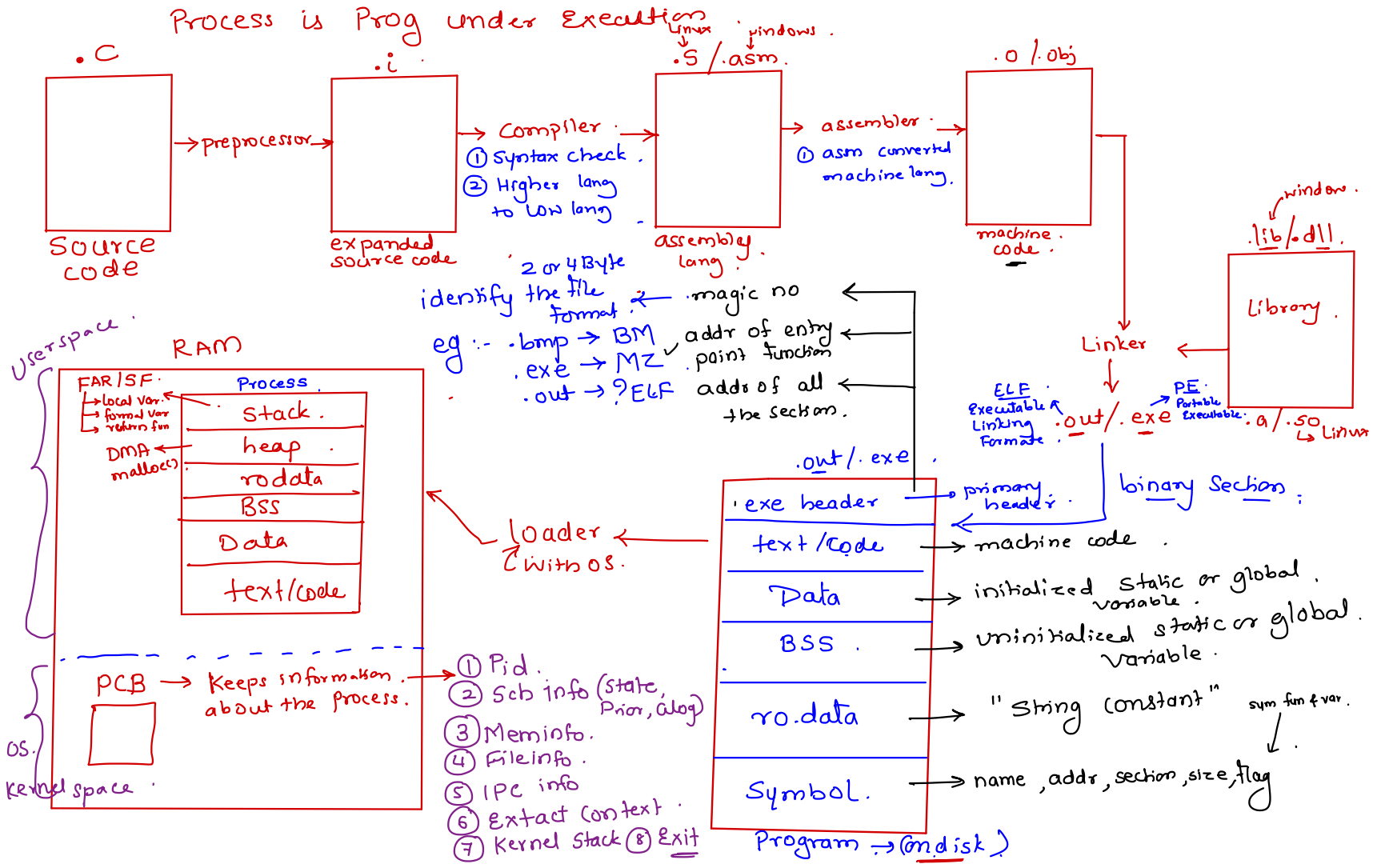
1. Process Management
2. Memory Management
3. Hardware Abstraction
4. CPU Scheduling
5. File & IO Management

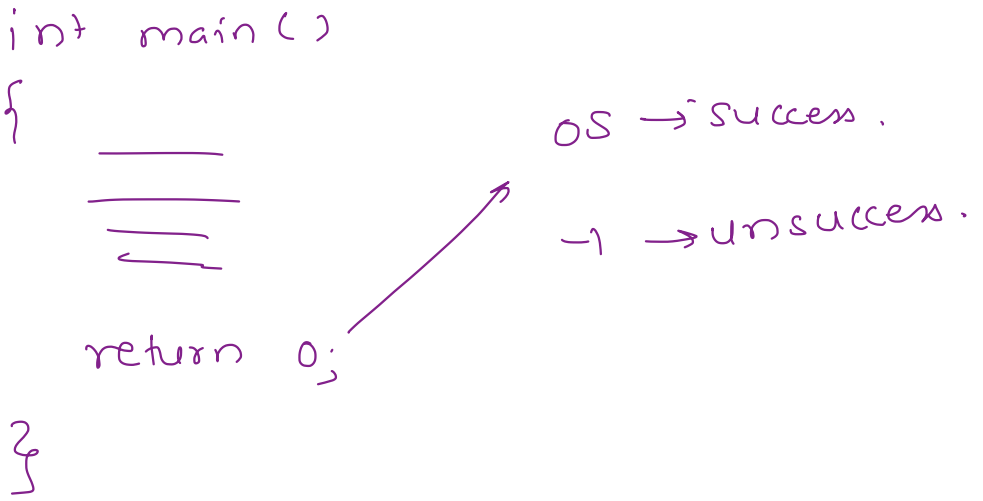
} Kernel.

Extra utility functionalities/optional:

6. Protection & Security
7. User Interfacing
8. Networking

}


Process is Prog under Execution
.C
Source code
preprocessor
.i
expanded source code
Compiler
① Syntax check
② Higher lang to Low lang
.S / .asm
assembly lang
assembler
① asm converted machine lang.
.o / .obj
machine code
.lib / .dll
window
Library
Linker
.out / .exe
ELF Executable Linking Format
PE Portable Executable
.a / .so
Linux
2 or 4 Byte
identify the file format
magic no
addr of entry point function
addr of all the section
eg :- .bmp → BM
.exe → MZ
.out → ?ELF
.out / .exe
exe header
primary header
text / Code
machine code
Data
initialized static or global variable
BSS
uninitialized static or global variable
ro.data
" String constant "
Symbol
sum fun & var.
name, addr, section, size, flag
binary Section :
Program → (on disk)
loader
(with os)
Userspace
RAM
FAR / SF
local var.
formal var
return fun
Process
Stack
heap
DMA
malloc()
rodata
BSS
Data
text / Code
PCB → Keeps information about the process.
OS.
Kernel space
① Pid
② Pcb info (state, Prior, Along)
③ Meminfo
④ Fileinfo
⑤ IPC info
⑥ Extact context
⑦ Kernel Stack ⑧ Exit


int main()
{
return 0;
}
OS → success.
→ unsuccess.

Q. What is an IDE (Integrated Development Environment) ?

- It is an application software i.e. collection of tools/programs like **source code editor, preprocessor, compiler, linker, debugger** etc... required for **faster software development.**

e.g. VS code editor, MS Visual Studio, NetBeans, Android Studio, Turbo C etc....

1. "Editor": it is an application program used for to write a source code.

e.g. notepad, vi editor, gedit etc...

2. "Preprocessor": it is an application program gets executes before compilation and does two jobs - it executes all preprocessor directives and removes all comments from the source code.

e.g. cpp

3. "Compiler": it is an application program which convert high level programming language code into low level programming language code i.e. human understandable language code into the machine understandable language code.

e.g. gcc, tc, visual c etc...

4. "Assembler": it is an application program which converts assembly language code into machine language code/object code.

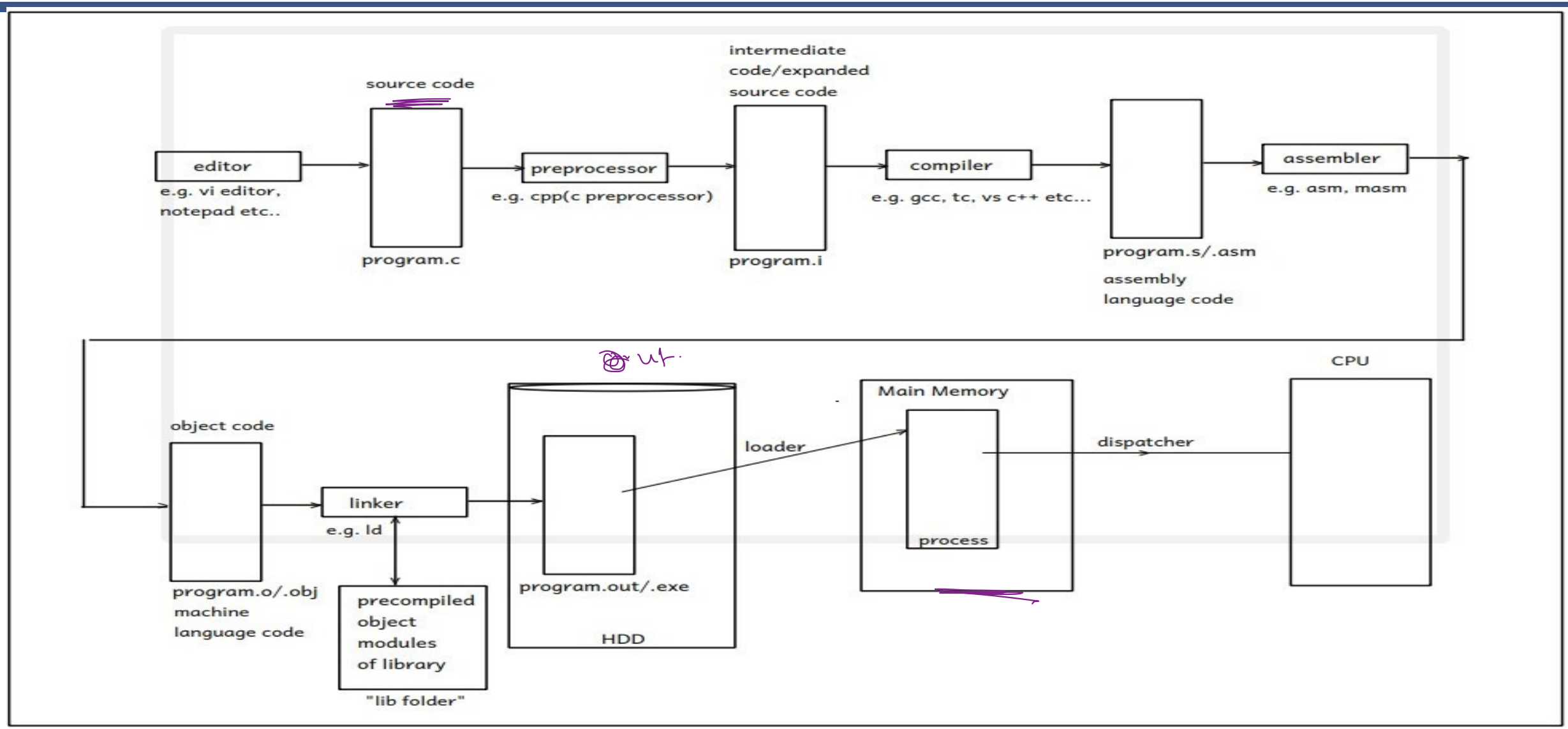
e.g. masm, tasm etc...

- Program written in any programming language is called as a **"source code".**

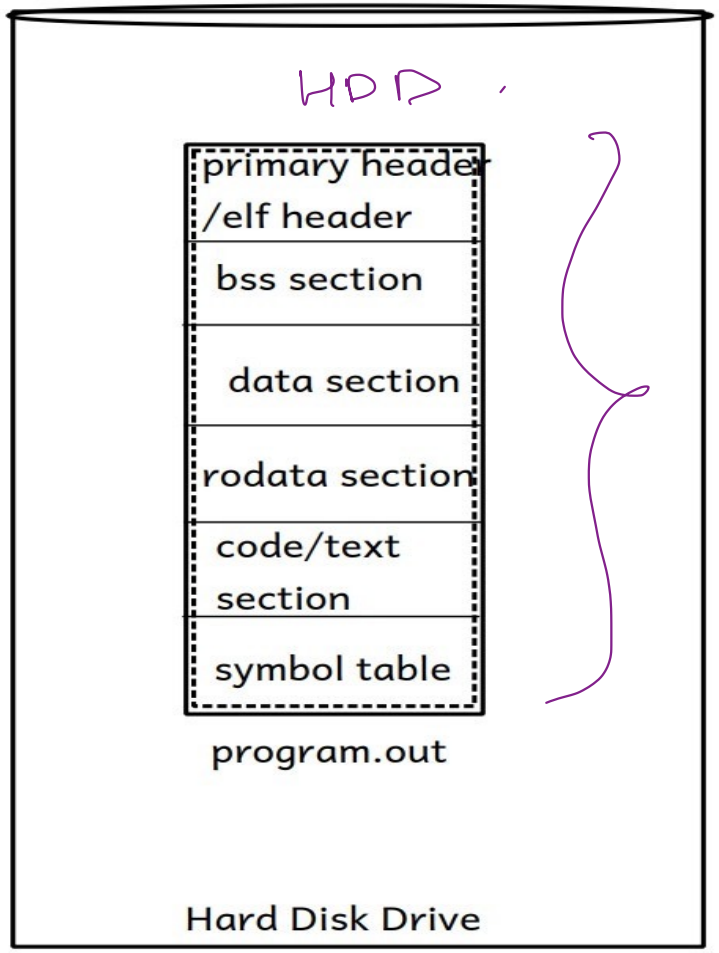
5. "Linker": it is an application program which links object file/s in a program with precompiled object modules of library functions exists in a lib folder and creates final single executable file.

e.g. ld. link editor in Linux.

Operating System Concepts

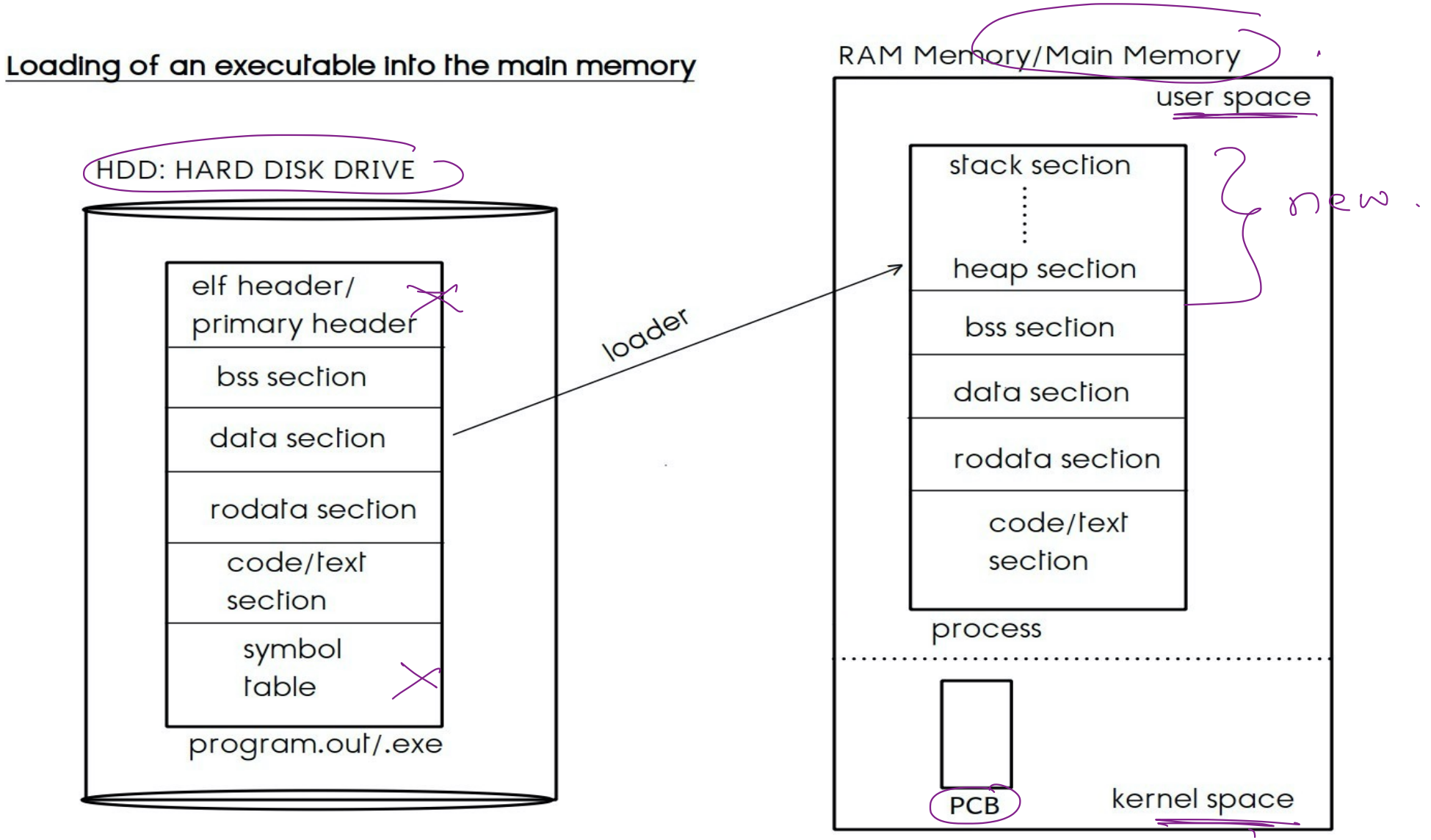


Structure of an executable file
ELF file format in Linux



1. **primary header/exe header:** it contains information which is required to starts an execution of the program.
   e.g. - addr of an entry point function --> main() function
   - **magic number:** it is constant number generated by the compiler which is file format specific.
     - magic number in Linux starts with ELF in its eq **hexadecimal format**.
     - info about remaining sections.
2. **bss(block started by symbol) section:** it contains uninitialized global & static vars
3. **data section:** it contains initialized global & static vars
4. **rodata (readonly data) section:** it contains string literals and constants.
5. **code/text section:** it contains an executable instructions
6. **symbol table:** it contains info about functions and its vars in a tabular format.

Operating System Concepts



Process

- Program under execution.
- Process execute in RAM.
- The process control block contains information about the process (required for the execution of the process).
  - Process id
  - Exit status
  - Scheduling information (State, Priority, Sched algorithm, Time, ...)
  - Memory information (Base & Limit, Segment table, or Page table)
  - File information (Open files, Current directory, ...)
  - IPC information (Signals, ...)
  - Execution context
  - Kernel stack
- PCB is also called process descriptor (PD), uarea (UNIX), or task_struct (Linux).

Q. What is a Process? User view:

- A program in execution is called a process.
- Running a program is called a process.
- When a program gets loaded into the main memory it is referred to as a process.
- Running an instance of a program is referred to as a process.

System view:

- The process is a file loaded into the main memory which has got bss section, rodata section, code section, and two new sections gets added for the process:
- **stack section:** contains function activation records of called functions.
- **heap section:** dynamically allocated memory

- file format of an executable file in Windows is **PE** (Portable Executable),

whereas the file format of an executable file in Linux is **ELF (Executable & Linkable Format).**

- The file format is a specific way to store data & instructions of a program inside an executable file, and it is different in diff OS.

- ELF file format divides an executable file logically into sections and inside each section specific contents can be kept in an organized manner:

1. elf header
2. bss section (block started by symbol)
3. data section
4. rodata (read-only data)section
5. code/text section
6. symbol table

Memory Layout of Program and Process

Program Consist of
exe header/primary header
Block started by symbol (bss) section (un initialized static / global variables)
Data section (initialized static / global variables)
Rodata Section(Constant/literals)
code/text section (contains executable instructions)
Symbol Table

Process Consist of
Skipped
Block started by symbol (bss) section (un initialized static / global variables)
Data section (initialized static / global variables)
Rodata Section(Constant/literals)
code/text section (contains executable instructions)
Skipped
Stack Section
Heap Section

Process and Program

- A **process** is an instance of a program in execution.
- Running a program is also known as **Process.**
- When a program gets loaded into memory is also known as **Process.**
- A **Program** is a set of instructions given to the machine to do a specific task.

Interaction with an OS : Two Types of Interface (CUI and GUI)

1. CUI/CLI : Command User Interface/Command Line Interface

- By using this kind of interface user can interacts with an OS by means entering commands onto the terminal/command line in a text format.

e.g. In Windows name of the program which provide CUI => cmd.exe command prompt

In Linux name of an application program which provides CUI => shell/terminal

In MSDOS name of the program which provides CUI => command.com (MicroSoft Disk Operating System).

2. GUI : Graphical User Interface

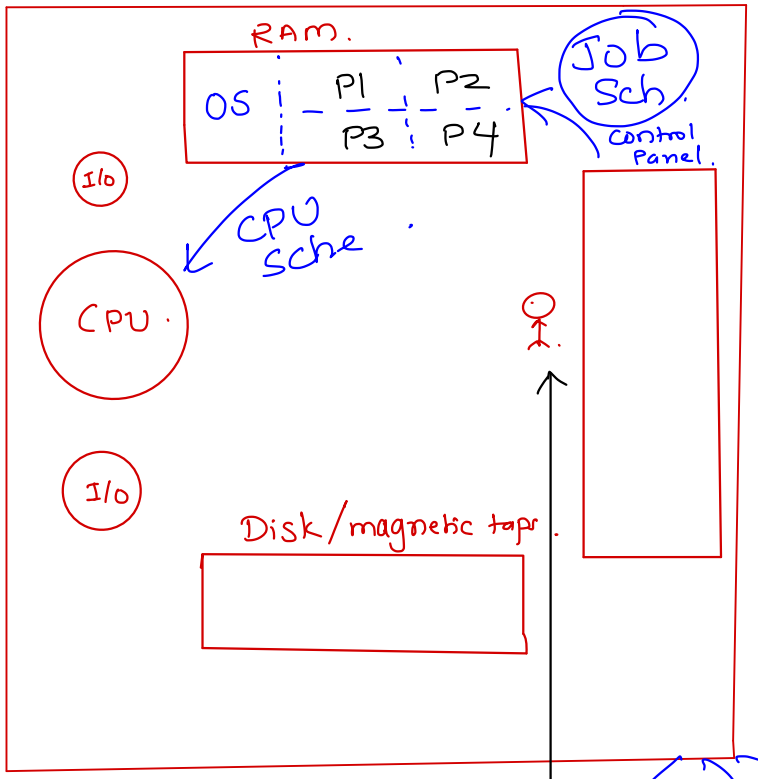
- by using this kind of interface user can interacts with an OS by means making an events like click on buttons, left click/rigyht click/double click, menu bar, menu list etc.....

- Windows = User friendly GUI.

e.g. In Windows name of an application program which provides GUI => explorer.exe

In Linux name of an application program which provides GUI => GNOME/KDE (GNU Network Object Model Environment / Common Desktop Environment).

old computer → Mainframe.

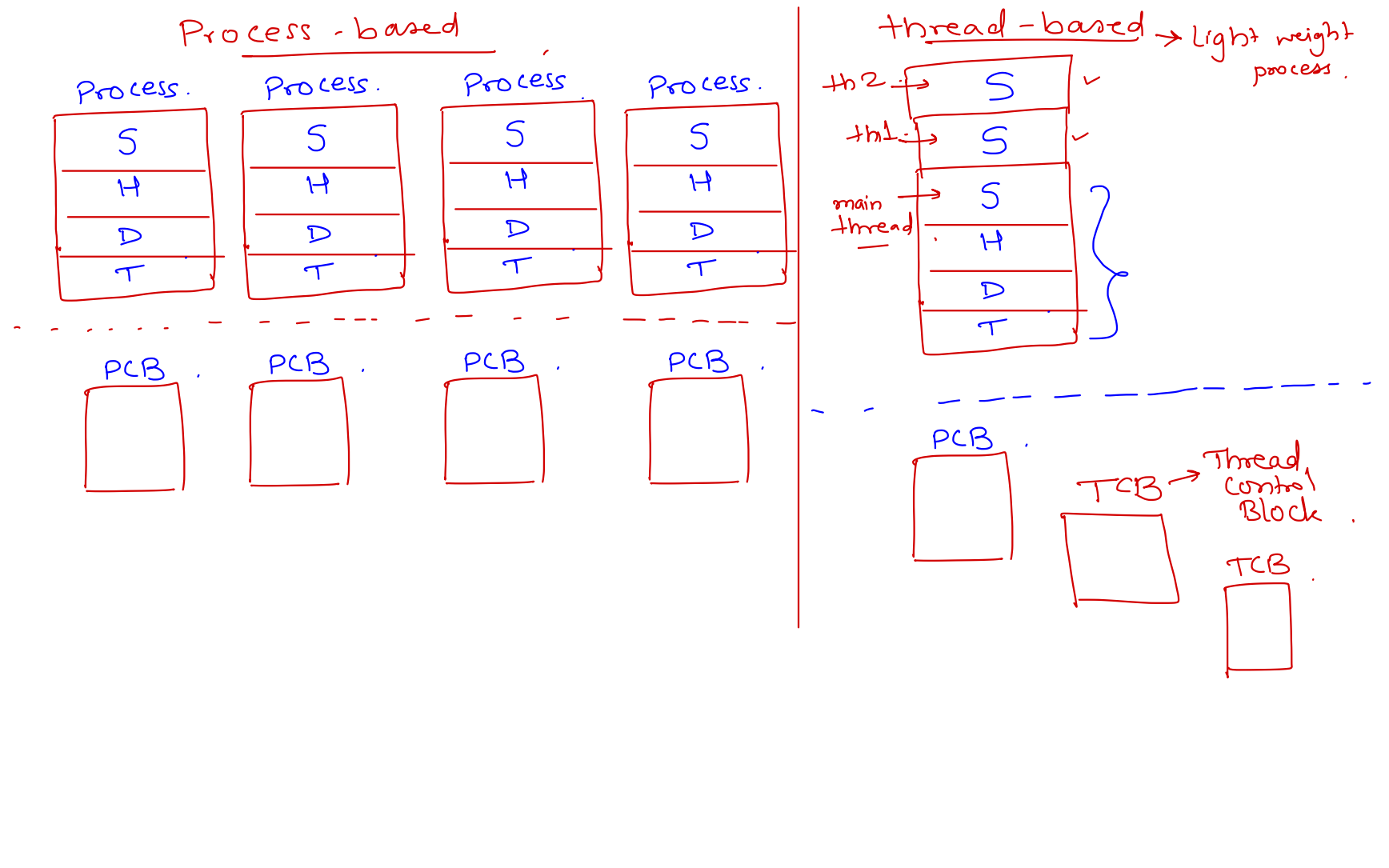


Prog. → CPU Burst time + IO Burst time.

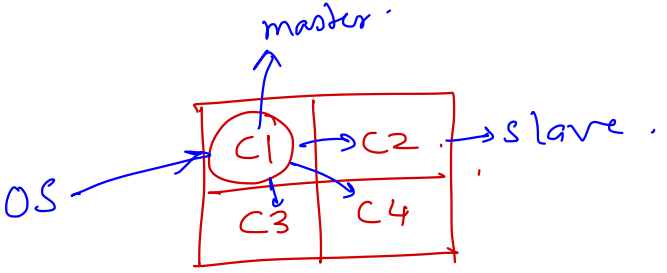
History of OS

1. Resident monitor.
2. Batch Prog.
3. multi-programming
   - ↳ multiple prog loaded in main mem.
   - ↳ Ultization of CPU
4. Multi-tasking/time-sharing
   - Process base
   - thread base

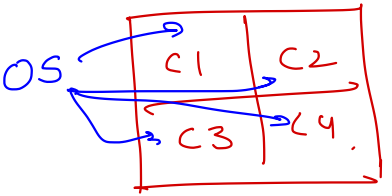
   resp time < 1 sec.
5. multi-user.
6. multi-core processing.


Process - based
Process.
Process.
Process
Process.
S
H
D
T
PCB
PCB
PCB
PCB
thread - based
Light weight process.
th2
th1
main thread
S
H
D
T
PCB
TCB
Thread Control Block
TCB

Multi-core processing.



Assymmetric multi-core.



Symmetric multi-core.

Operating System Concepts

- **History of Operating System**

1. **Resident monitor**
2. **Batch System**
   - The batch/group of similar programs is loaded in the computer, from which OS loads one program in the memory and execute it. The programs are executed one after another.
   - In this case, if any process is performing IO, CPU will wait for that process and hence not utilized efficiently.
3. **Multi-programming**
   - Better utilization of CPU
   - Loading multiple Programs in memory
   - Mixed program(CPU bound + IO bound)
4. **Time-sharing/Multitasking**
   - Sharing CPU time among multiple process/task present in main memory and ready for execution
   - Any process should have response time should be less then 1sec
   - Multi-tasking is divided into two types
     - Process based multitasking
     - Thread based multitasking

- Process based multitasking: Multiple independent processes are executing concurrently. Processes running on multiple processors called as "multi-processing".
- Thread based multi-tasking OR multi-threading: Multiple parts/functions in a process are executing concurrently.

Thread is a light weight process

- When new thread is created a new stack and new TCB is created.
- Thread Share text, data, heap sections with the parent process

Process vs thread

- In modern OS, process is a container holding resources required for execution, while thread is unit of execution/scheduling.
  Process holds resources like memory, open files, IPC (e.g. signal table, shared memory, pipe, etc.).
  PCB contains resources information like pid, exit status, open files, signals/ipc, memory info, etc.
- CPU time is allocated to the threads. Thread is unit of execution.
- TCB contains execution information like tid, scheduling info (priority, sched algo, time left, ...), Execution context, Kernel stack, etc.
- For each process one thread is created by default it is called as main thread.

5. Multi-user system

Multiple users runs multiple programs concurrently

6. **Multi-processor/Multi-core system**

System can run on a machine in which more than one CPU's are connected in a closed circuit.

Multiprocessing Advantage is it increased throughput (amount of work done in unit time)

- There are two types of multiprocessor systems:
- Asymmetric Multi-processing Symmetric Multi-processing

- **Asymmetric Multi-processing**

OS treats one of the processor as master processor and schedule task for it. The task is in turn divided into smaller tasks and get them done from other processors.

- **Symmetric Multi-processing**

OS considers all processors at same level and schedule tasks on each processor individually. All modern desktop systems are SMP.

Process — PCB

- ① Pid.
- ② Sch inf
  - ⓐ State.
  - ⓑ Priority
  - ⓒ Alg

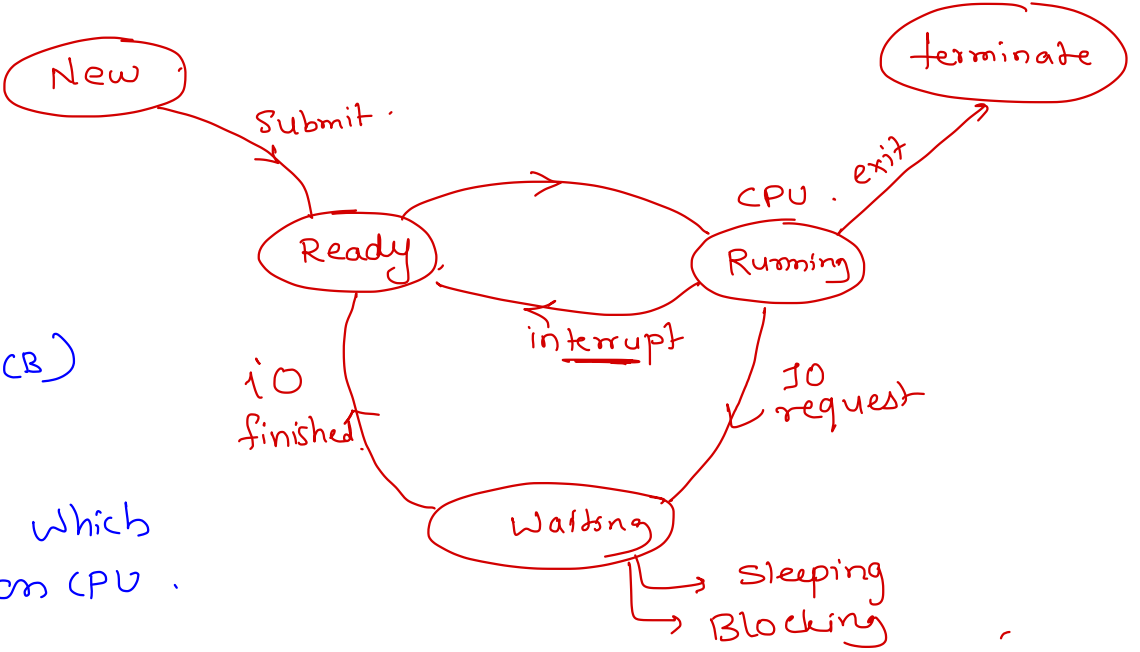
OS data structure.

① Job queue.
list of all process (PCB)

② Ready queue.
list of process (PCB) which are ready to run on CPU.

③ Waiting queue.
list of PCB. which are ready of IO device.

Process-state.



Process life Cycle

- **Process States:**

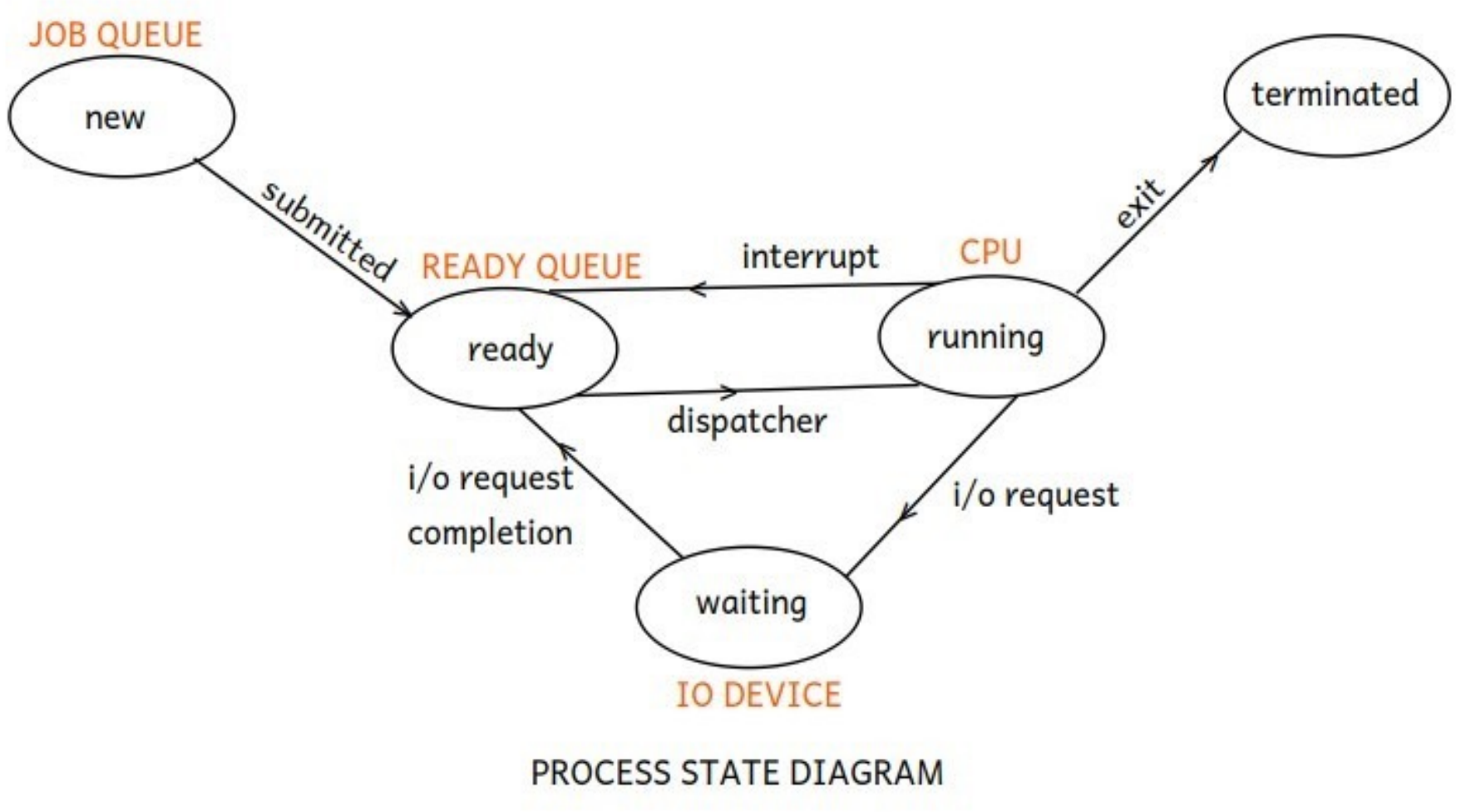
To keep track on all running programs, an OS maintains few **data structures** reffered as **OS data Structure**

1. Job queue: it contains list of all the processes(PCB).

2. Ready queue: it contains list of PCB's of processes which are ready to run on CPU (not for io)

3. Waiting queue: it contains list of PCB's of processes waiting for io device or for synchronization

Five State Process Diagram



Five State Process Diagram

 # Process States:

- Throughout execution, process goes through different states out of which at a time it can be only in a one state.

- **States of the process:**

1. New state: upon submission or when a PCB for a process gets created into the main memory process is in a new state.

2. Ready state: after submission, if process is in the main memory and waiting for the CPU time, it is in a ready state.

3. Running state: if currently the CPU is executing any process then state of that process is considered as a running state.

4. Waiting state: if a process is requesting for any i/o device then state of that process is considered as a waiting state.

5. Terminated state: upon exit, process goes into terminated state and its PCB gets destroyed from the main memory.