Necessary concepts of Operating Systems for a software engineer

What is it

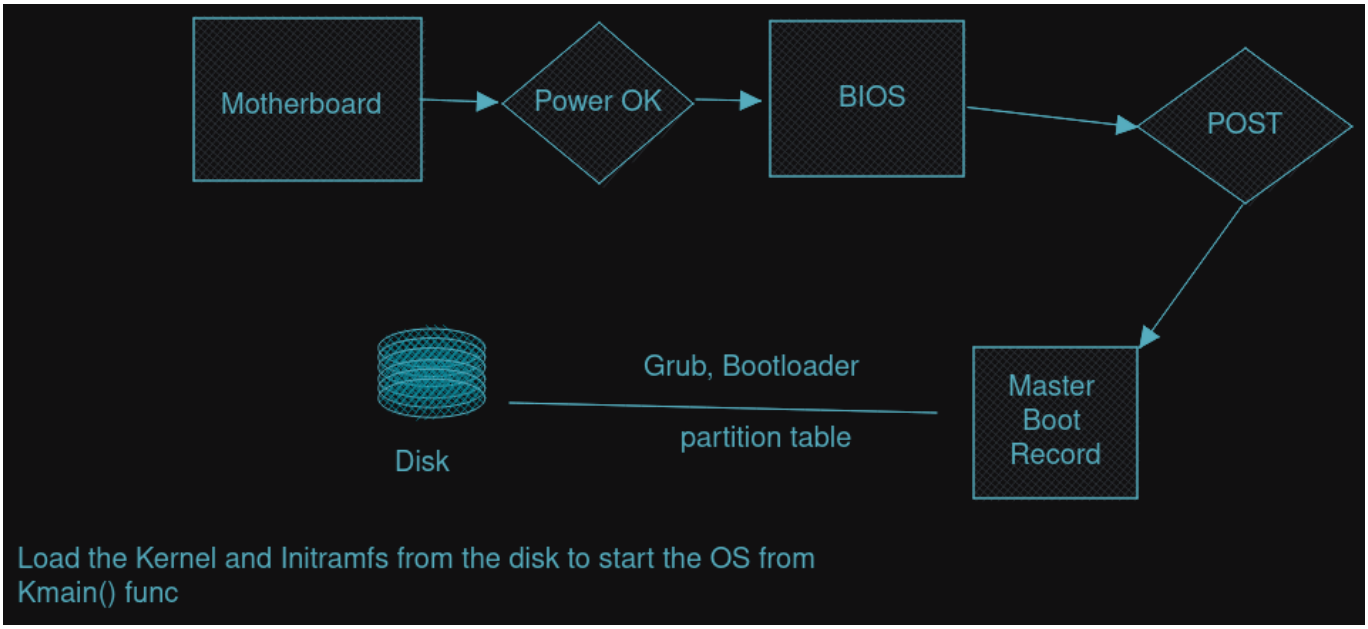
Operating system is a set of programs which acts as a interface between User and Hardware. it is neccessary to reduce complexity

Modes in a OS

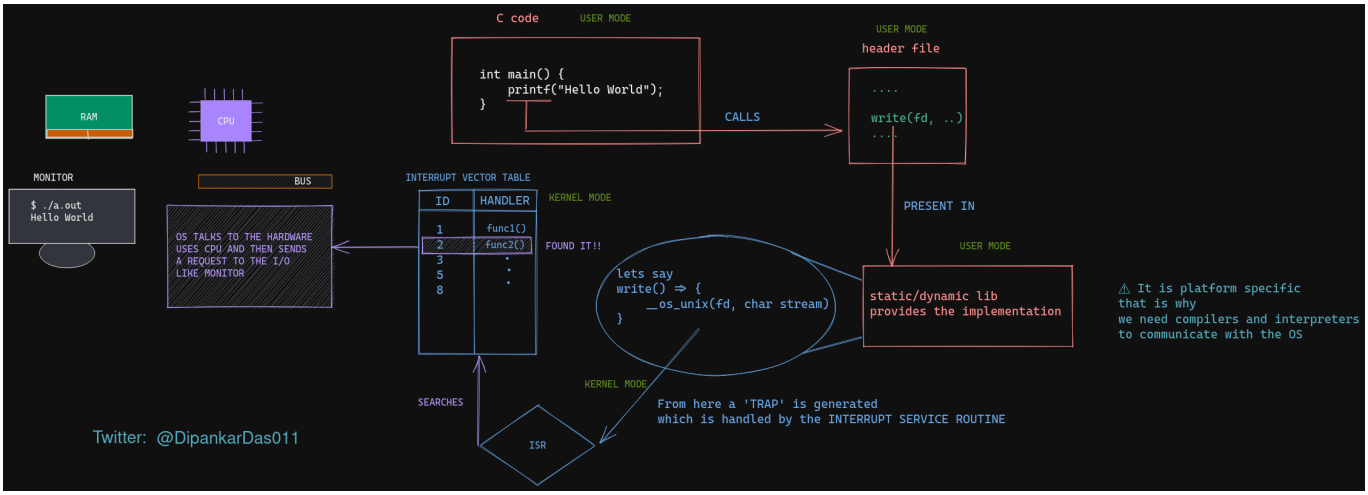
1. User mode
2. Supervisor mode (i.e. Kernel mode)

user application are provided API's by OS to talk with the hardware.

How does the Computer Boots



for example. How the print statement is evaluated in a Operating System



Components

1. Process management it manages the processes and there resources
2. File management it manages the file Read, Write, Execute, Permissions and sharing
3. Memory management it counts how much is free, makes memory available & dealloc, and memory isolation, mapping
4. I/O management it handles interrupts, device drivers, bus, buffers, etc

What is Process

a process is the instance of a computer program that is being executed by one or many threads. OS represents each process tracked with PCB(Process Control Block)

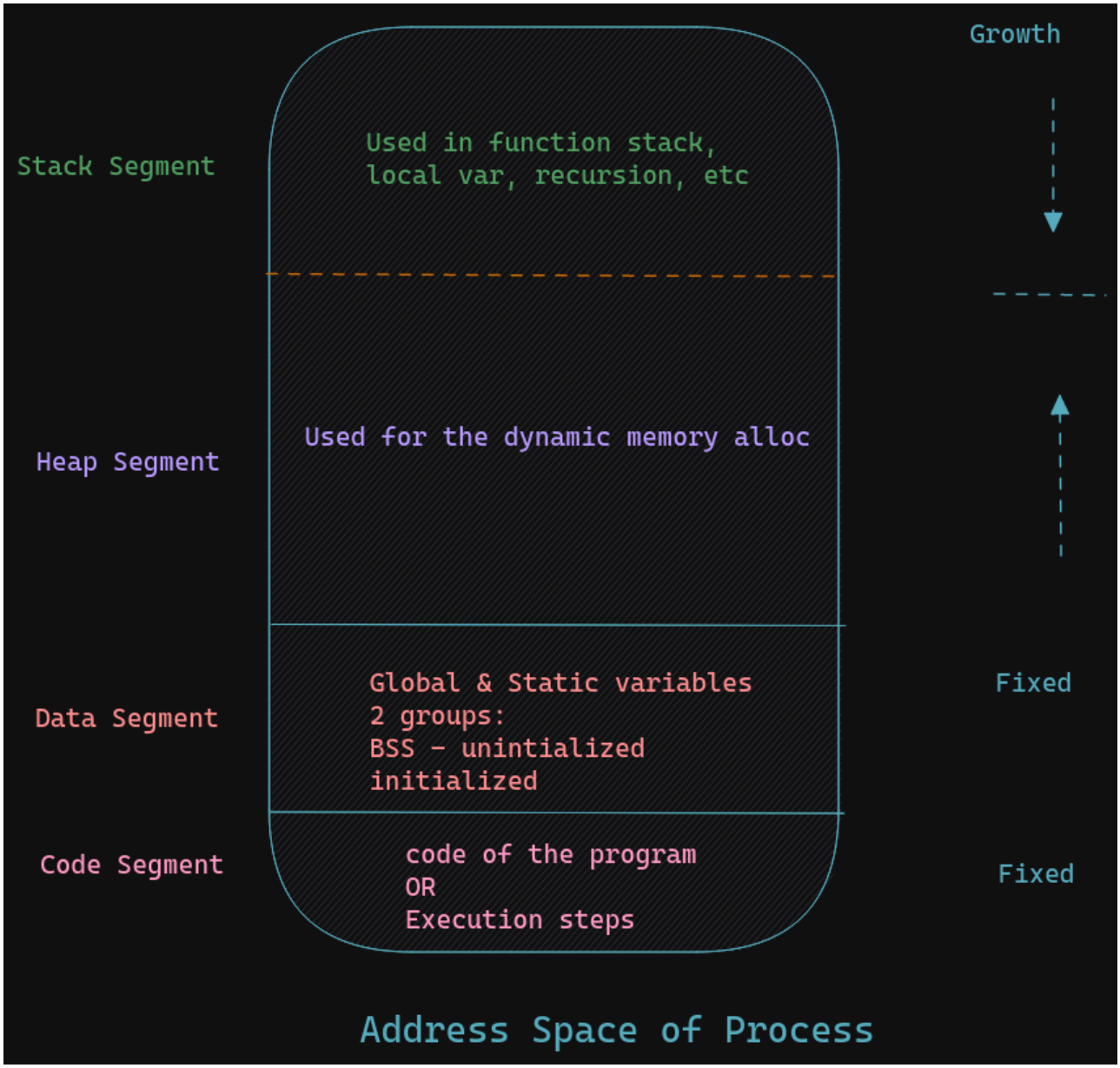
- Process ID (**Linux** it is represented by 16 bits)
- Parent process ID
- Process state
- CPU State
- Scheduling information
- Memory information
- Open file information

Components

1. OS Resources it contains the information

- open file information
- socket information
- scheduling algorithm to be used
- PID,etc.

2. Address Space



3. CPU State all the CPU register associated with the process it stores the current state PC=program Counter IP=Instruction pointer SP=stack pointer it is useful when there is a context switch as CPU stores the current state of process into this segment and after storing it then it switches to the new process

Creating of New Process

we can use `fork()` to create a child process its important to note that during fork() is invoked, the parent process address space is copied to the child process

Zombie & Orphan Processes

Orphan Process - When the parent process gets completed before the child process then child process control is transfered to the *init* process in linux kernel and so the child has a parent process id of 1 or in more recent linux kernel it is 2 or 3 Zombie Process - When the parent process is busy in some I/O or in sleeping/suspending state then if the child process gets completed then the parent process does not know about

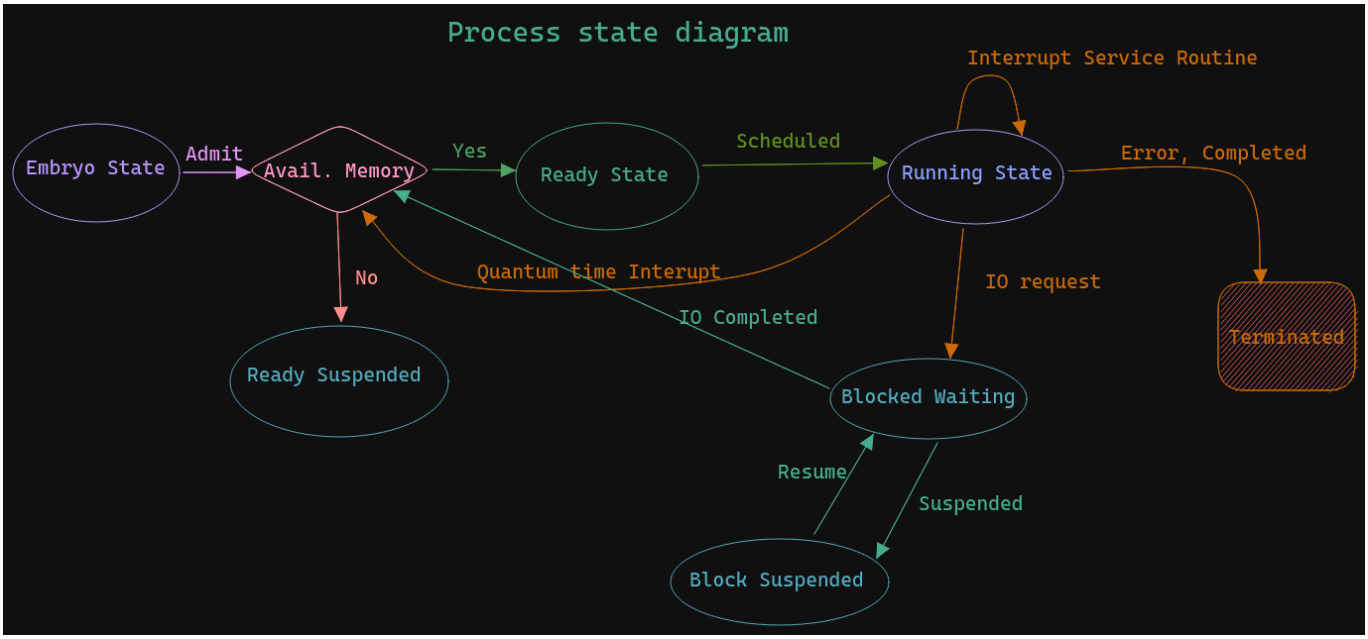
we can use the wait() in parent block so that parent waits for its child process to get terminated before it gets terminated

InterProcess Communication(IPC)

Here we use a pipe structure to communicate between processes it uses 2 heads a read and write

in Golang channel is used to communicate in a GoRoutine

process scheduling



the program that takes the responsibility of moving process from one queue to another

Types

1. Short Term Scheduler - it decides which process moves from Ready queue to Running state(CPU) it is called by:-

- Interrupt Service Routine
- When a process terminates
- I/O operation is invoked

1. Long Term Scheduler - it decides which process moves from Embryo State/Ready_Suspended state to Ready Queue
2. Mid Term Scheduler - used for swap area. but some dont use as logn term can be extended to fit its purpose

> Context switch - mechanism to change the control of the CPU from one process to another
> Premeptive - control can be transfered to another process even if the process is not completed Non-premeptive - control can be transfered to another process when the process is completed

Scheduling Algorithms

1. FCFS (First Come First Serve) [nonpremeptive] the process which comes first gets the CPU first (arrivial time)

2. SJF (Shortest Job First) [premptive/nonpremptive] it is not practical scheduler decides according to the burst time required by the process

3. Priority based [premptive/nonpremptive] each process is given priority the lower priority process is given the preference

to avoid starvation we can use the ageing method where at each clock cycle the priority of processes in queue are reduced

4. Round Robin [premptive] Here there is fixed Quantum time its like a circular queue where each process gets Qt amount of time, if not completed then it is reinserted at the back and the process after this is given to the CPU it has least waiting time. So used in interactive tasks (UI)

Hybrid of these are there

5. Round Robin with priority Here it compares the priority of runnnable process with other runnable processes
6. multilevel feedback Queue ready queue is divided into >= 2 queues 1st queue = Highest Priority (Interractive processes like UI) latest queue = Lowest priority (Background processes) and other queue for the (system process)

Thread

Its is lighweight process Every thread uses the address space of its parent it take significantly less time and resources as compared to creating a new child process each thread has its own:

- PC
- CPU state
- Stack

the stack is stored in parent process Heap address space

Types

- user thread - it is in user space and is handled by the programming language
- kernel thread - it is in kernel space and is handled by the Operating System to execute a user thread it is tranfer to kernel threads to execute it

Process Syncronization / Concurrency

There is problem when there are > 2 processes; excute simultaneously and using a common resources then there are inconsistencies This is Race Condition

there are 3 steps in each process

```
acuire_lock()
----
Critical section # where all the program logic happens
----
release_lock()
```

Solutions

1. Software Lock(Peterson's 2 process solution) If there are P0 and P1 processes then P0 gives chance to P1 and vice-versa therby maintaing consistency

```
// Process 0
flag[0] = True
turn = 1;

while (flag[1] == True && turn == 1);
```

```
// Process 1
flag[1] = True
turn = 0;

while (flag[0] == True && turn == 0);
```

limitations is only 2 process at a time

2. Semaphores Semaphore is a variable along with 2 operators called wait() and signal() to achieve synchronous

Types

- Binary - only one process at a time can enter the critical section
- Counting - more than one process at a time can enter the critical section If one or more processes are waiting to get there turn thereby cpu burst time is wasted to check them so it is a spin lock situation to overcome we need the waiting queue

Bakery using semaphore

multiple producer can put there item to the rack, and multiple consumer can eat item

```
// Producer
wait(empty)
  wait(mutex)
    insert(rack, p_item)
  signal(mutex)
signal(full)
```

```
// Consumer
wait(full)
  wait(mutex)
    remove(rack)
  signal(mutex)
signal(empty)
```

Reader & Writer method

When one or more process enters as read mode then no process can enter as write mode in the critical section and when write mode process is inside critical section no read mode process are allowed to enter only 1 write mode by N read mode

```
// writer
wait(wr)
  write()
signal(wr)

// reader
wait(mutex)
  count++
  if (count == 1)
    wait(wr)
signal(mutex)

read()

wait(mutex)
  count--
  if (count == 0)
    signal(wr)
signal(mutex)
```

Dinning philosophere

philosophere

```
think()
# aquire_chopsticks
eat()
# release_chopsticks
```

```
enum STATE{
```

```
  HUNGARY, EATING, THINKING
}
semaphore p[5] = {0}
mutex = 1
int state[5]

void philosopherWork(int i) {
  while (1) {
    think(i)
    takeChopsticks(i)
    eat(i)
    releaseChopsticks(i)
  }
}

void takeChopsticks(int i) {
  wait(mutex)
    state[i] = HUNGARY
    test(i)
  signal(mutex)
  signal(p[i])
}
// 4 Philosopheres
void test(int i) {
  if (state[i] == HUNGARY && state[(i+1) % 5] != EATING && state[(i+4) % 5]
!= EATING) {
    state[i] = EATING
    signal(p[i])
  }
}

void releaseChopsticks(int i) {
  wait(mutex)
    state[i] = THINKING
    test((i+1) % 5)
    test((i+4) % 5)
  signal(mutex)
}
```

3. Monitors it is a high level programming language construct to achieve synchronous Block

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- lock
- shared variable
- atomic function
- conditional variables

Deadlock

a set of processes are said to be in deadlock if every process belongs to this set holds a resource and waiting for another resource which is currently held by other process belongs to this same set

handling

1. Deadlock prevention - prior to deadlock make anyone of the following true:

- no mutual exclusion
- no hold & wait
- no preemtion
- no circular wait

1. Deadlock avoidance - prior to deadlock dynamically verify the resource allocation state using Allocated resource count, available resources, need of that process

single instatnce resource - resource allocation graph multiple instance resource - bankers algorithm

1. Deadlock detection - deadlock occured system has to know information required to find deadlock

- allocation
- request
- availability
- single instance resource - Wait for graph
- Multiple instance resource - Banker's algo

1. Deadlock recovery - deadlock occured how to resolve it

- assume that there is no deadlock
    - resource preemption
    - process termination (all or some selected till it is deadlock free)

Memory management

functions of it:-

- keep track of free space
- allocation memory to process whenever they need it
- protection of memory of one process from another

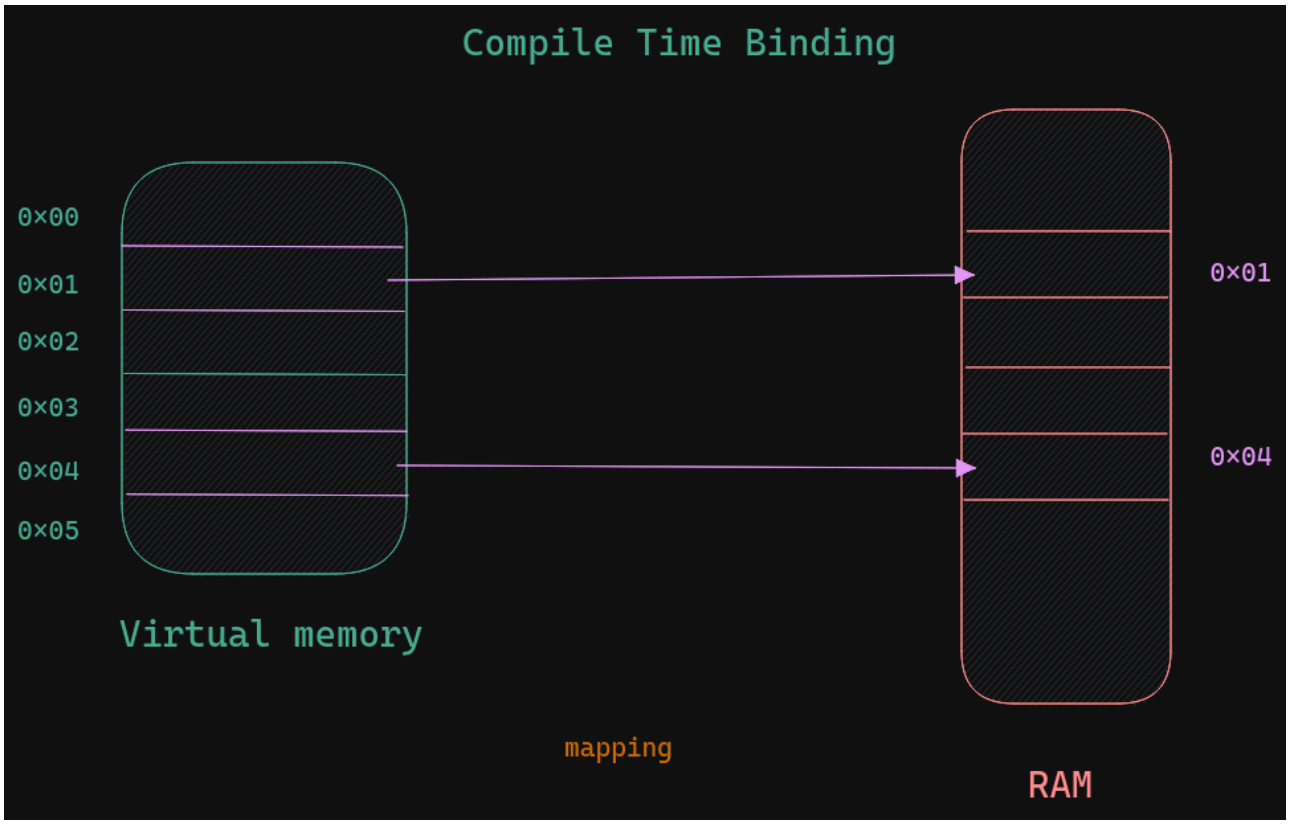
creation of executable file

- without linking
- with linking
    - static linking the libray files are added after linking process
    - dynamic linking the library file are fetches as needed during execution

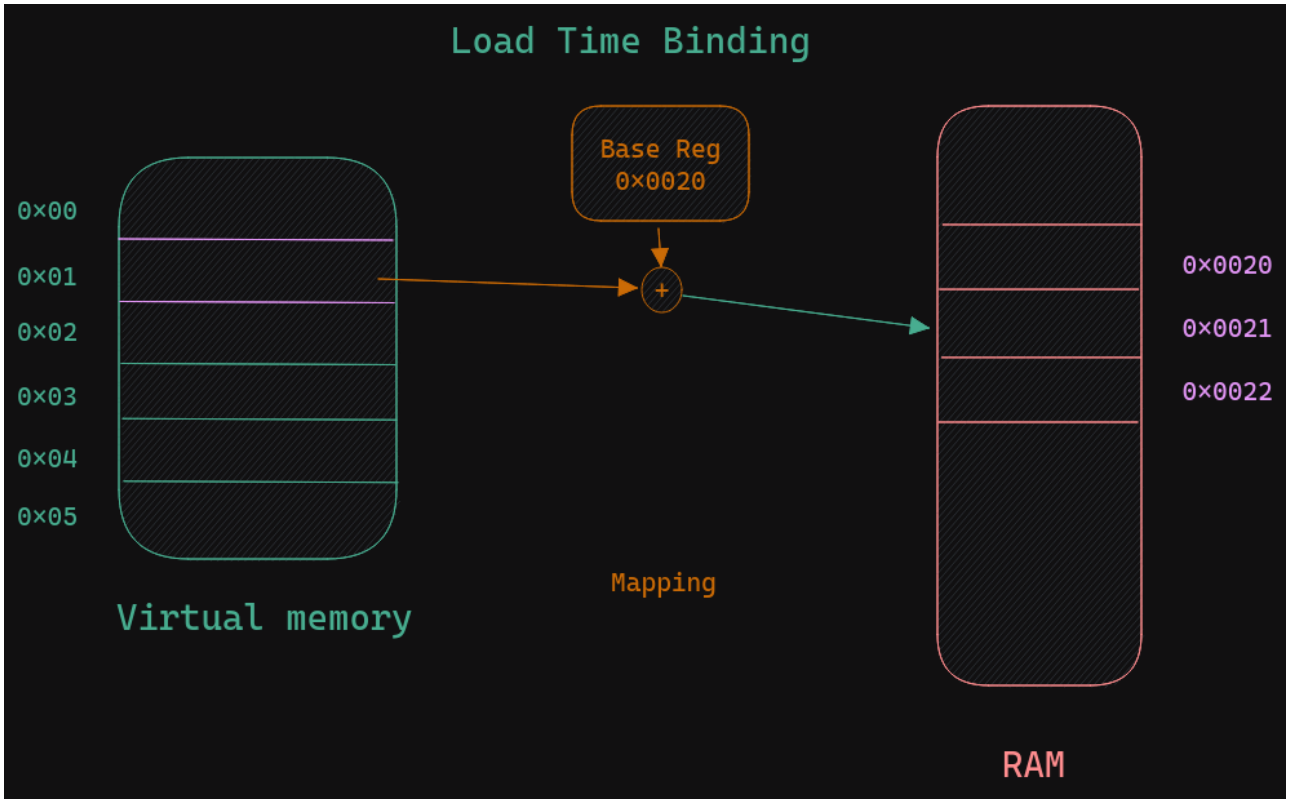
> Virtual Memory - it is used to expanded the available memory resource than it is.

Mapping of instructions

1. Compile time binding each line mapped to the physical memory Compiler must know where the space is available



2. Load time binding Base register is provided by the OS and Base register + index gives the physical memory



3. Execution time binding during the execution the instruction can move from one memory location to another

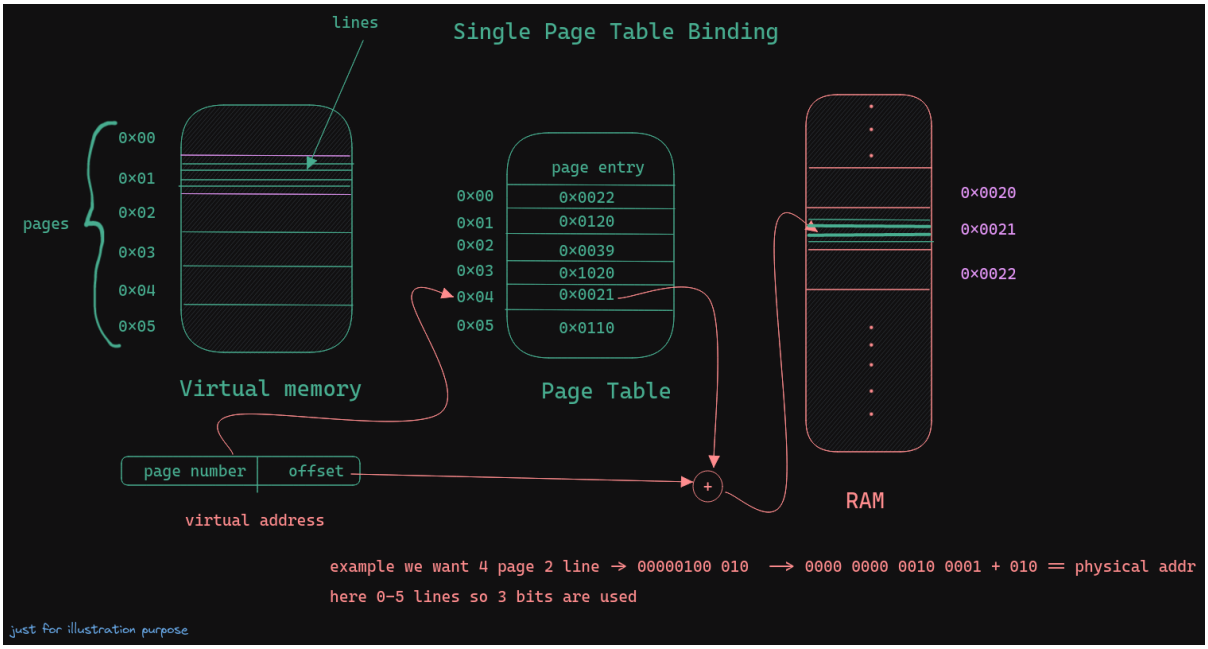
Types of allocation

- Monoprogramming systems (compile time binding)
- multiprogramming
    - Contigous
        1. fixed partioning whole memory is divided in fixed sized chunks it causes internal fragmentation
        2. variable partioning it is not divied but the program is stored in continuous memory location of its size it causes external fragmentation
    - Non contiguous it solves the external fragmenation

> logical address - it is the address generated by the CPU which is the virtual memory location page table - it is used for mapping virtual page number <-> physical frame number

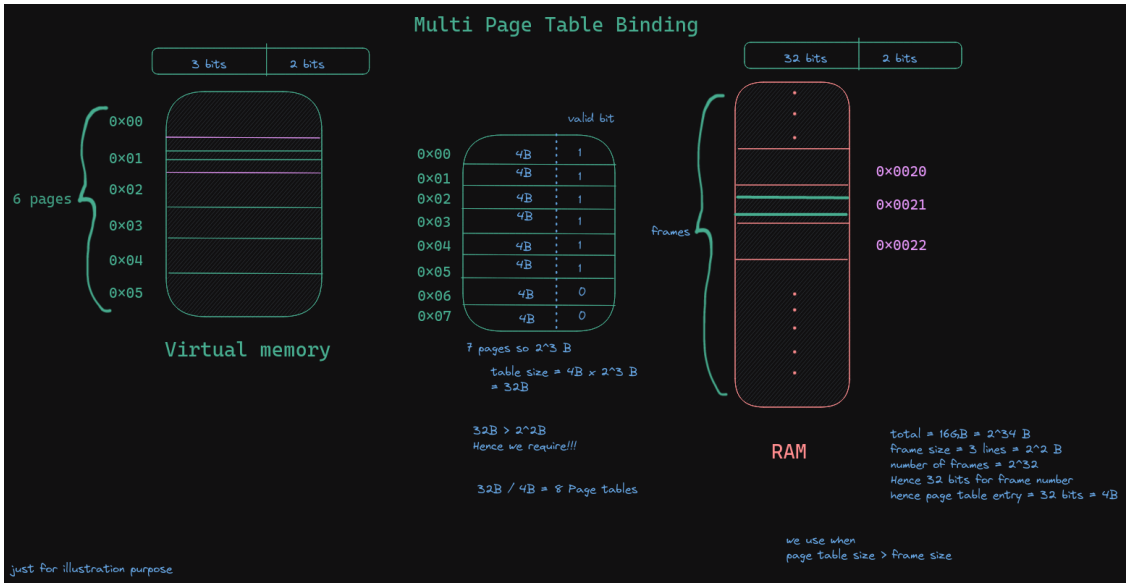
1. paging
2. Single page table

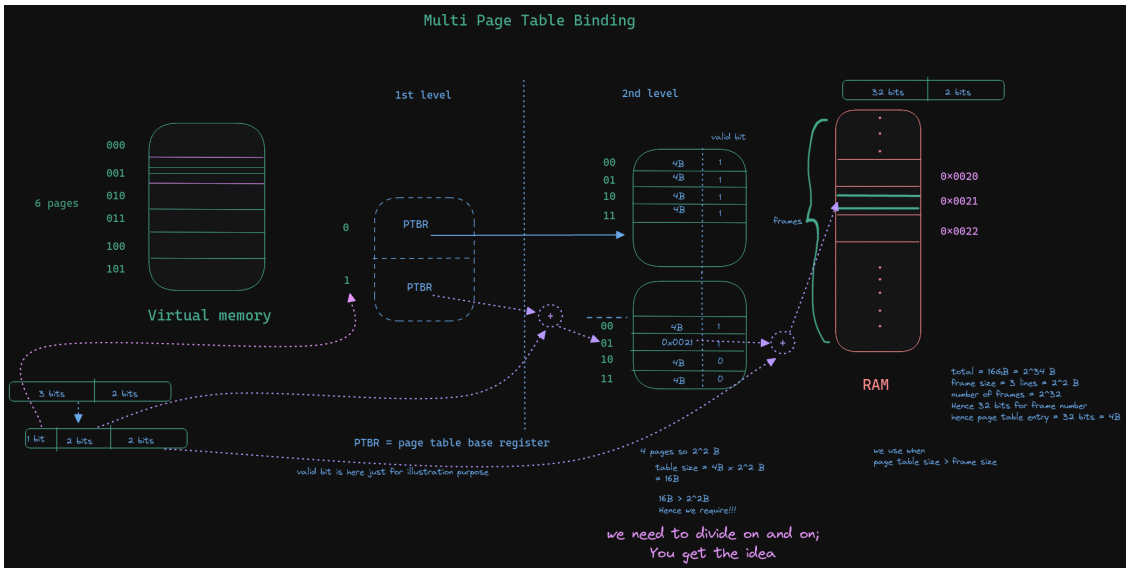
> number of bits to represent page number = number of pages ; same for the offset where number of lines or size of each page each page size == each frame size



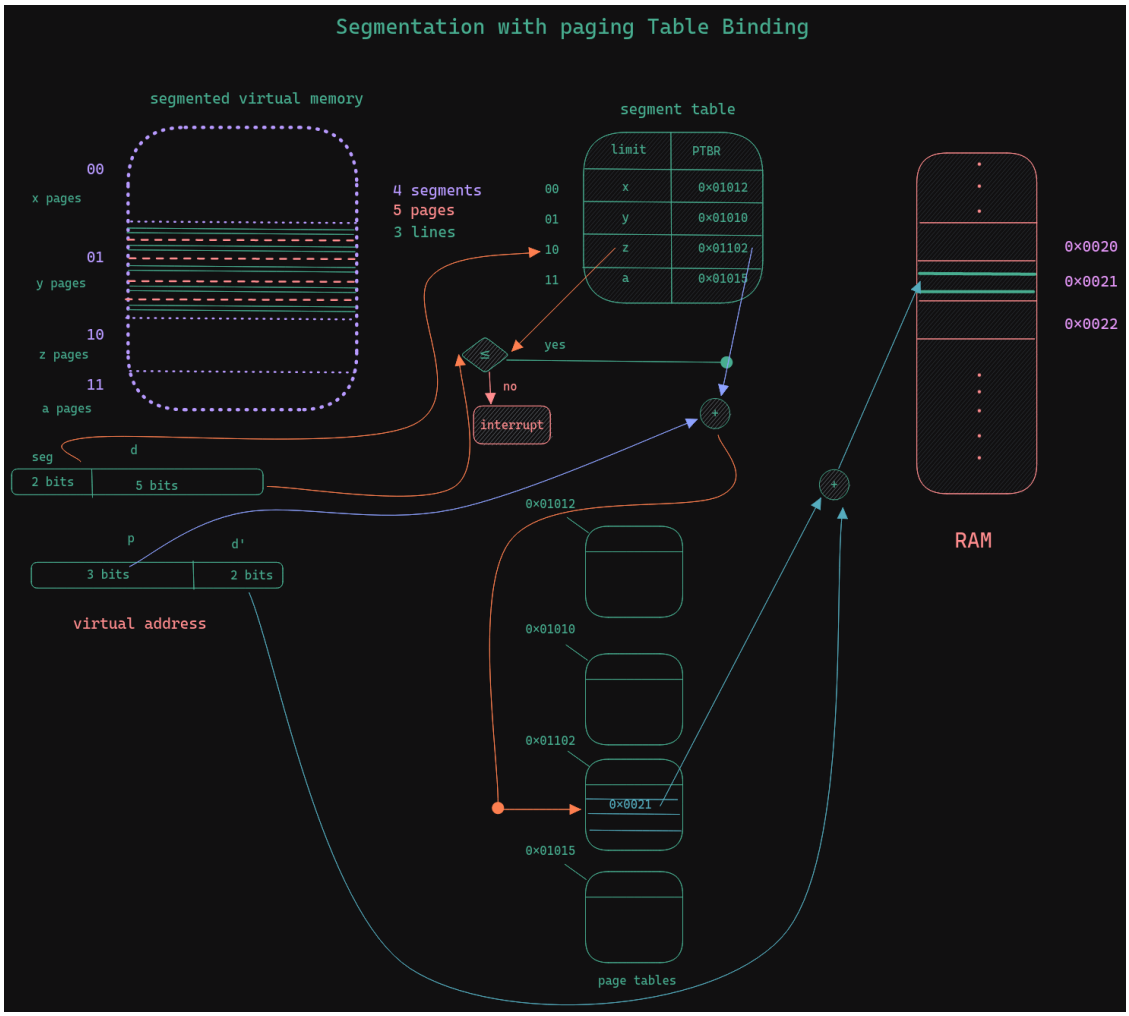
page table is typically stored in the RAM and most recent in the MMU TLB (Translation Look-Aside Buffer) it act as a fastest cache for page number with corresponding frame number it reduces the access time Very fast cache directly on the CPU that caches most recent virtual to physical address translations. Implemented as fully associative cache

1. Multiple page table





2. segmentation with paging as the process address block is segmented into 4 seg and each segment is divided into pages and each page into lines



additional bits of Page table

- valid bit 1 -> valid if the page is used by the program otherwise 0
- protection bit read, write, execute code segment must be read, execute data segment must be read, write
- Reference bit whether this page is curently accessed in CPU or not even reading or writing is known here as refered
- dirty bit if that page is modified in in the ram but not written back to the virtual memory then dirty bit is set to 1 so when the page has to be removed from the ram then: if the dirty bit == 1 then it is saved to the swap area else it is saved to the hard drive

Replacement algo

it happens in demand paging when during the segmentation paging the page is not present in the ram then "PAGE FAULT" exception is thrown OS handles the exception by bringing that page from the disk / swap -> RAM

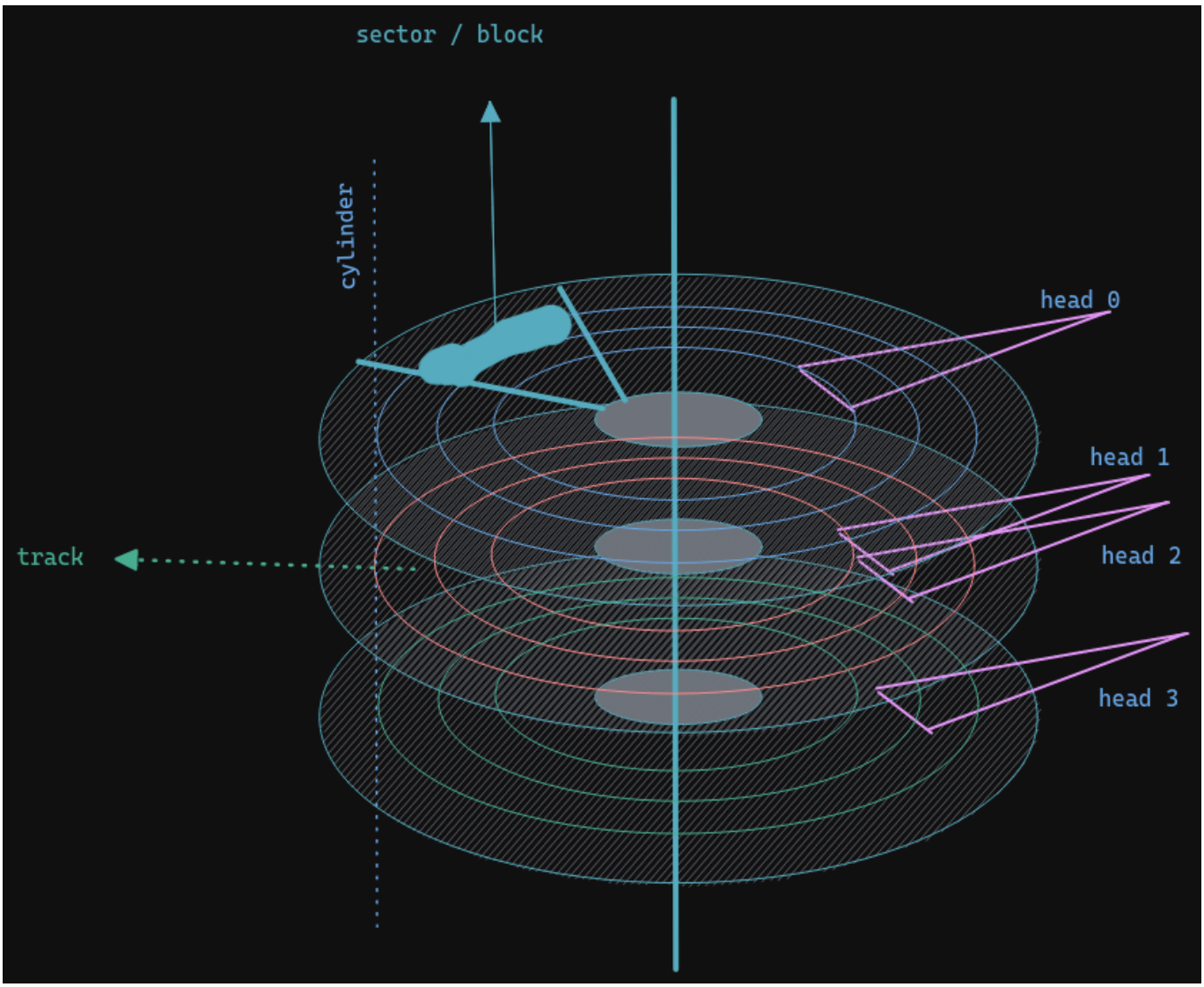
1. FIFO - the first one in has to be replaced
2. optimal - in the near future whichever page is not going to be used
3. LRU - replace with the page which has not been used recently
4. Approx LRU

- uses the reference bit
- if reference bit = 0 then replace it; otherwise not

1. additional refernce bit algo
2. second chance algo
3. Counting Algo

IO

Disk



1. sector/block - A sector is the basic unit of data storage on a hard disk
2. Head
3. track
4. cylinder - all the tracks under the head at a given point on all surface

Scheduling in Disk

Disk Latency = Seek Time + Rotation Time + Transfer Time goal is to Reducing seek time Scheduling technique:

1. FCFS first request is served
2. SSTF least movement of the disk arm from its current position
3. SCAN start scanning in same direction till 0 and then scan in reverse direction
4. LOOK like scan but does not go to the extreme ends.
5. C-SCAN similar to SCAN but moves in one direction L->R or R->L
6. C-LOOK similar to LOOK but moves in one direction L->R or R->L

How files are stored (Linux File System)

it uses inode where singleIndirect doubleIndirect, tripleIndirect is by multi level indexing

```
struct prem {
  int read, write, exec;
};

struct file {
  struct prem mode;
  String owner;
  time timestamps;
  int block_size;
  int count;
  struct fs *directBlock;
  struct fs_1 *singleIndirect;
  struct fs_2 *doubleIndirect;
  struct fs_3 *tripleIndirect;
};

struct fs {};
struct fs_1 {
  struct fs **data; // array of pointers for the implementation of m binary
tree
};
struct fs_2 {
  struct fs_1 **data; // array of pointers
};
struct fs_3 {
  struct fs_2 **data; // array of pointers
};
```

now the directory structure is acyclic graph

- 2 or more directory entry can point to the same file or sub directory
- can create links(symbolic & hard)

Hard Link

gives different names to the existing file that all refer to the same content

cons cannot link across file systems

Soft Link

a symbloic link is a file that contains the name of another file or directory OS searches the inode of the original file based on the gile name

cons deletion or moving the file causes the links to break

Components

- I/O device
- I/O controller - interface between the I/O devices and the internal system components; CPU, memory, etc
- I/O bus

CPU interact with the I/O controller through a set of interface registered called I/O port. I/O port – consists of four registers, called the status , control, data-in, and data-out registers. – Control register

- The control register can be used give the command. – Status Register
- whether the current command has completed or not
- whether a byte is available to be read or not
- Indication of device error. – Data-in register
- read by the host to get input. – Data-out register
- written by the host to send output.

DMA (Direct Memory Access) - DMA module controls the exchange of data between main memory and an I/O module

Device Driver - it is usually part of the OS kernel that contains the device specific code to control an I/O device, which is usually written by device manufacturer

Buffers

Buffer is used to speed up the process because the I/O significantly slower compared to the CPU so CPU had to wait.

- Single buffer
- Double Buffer
- circular buffer

Protections & security

Protection happens inside a computer where as Security considers external threats.

Components involved in protection

- Subjects

    - user, process, procedure, etc.
- Objects
    - files, printer, Disk writer, etc.
- Operations
    - read, write, etc.

reference monitor validates access to objects by authorized subjects

Protection domain

- user
- supervisor

access matrix is used it is a set of operations that a process executing in demain(i) can perform on Object(i)

Conclusion

Hope this blog gives you the basic overall idea of Operating System Happy learning 📖