

## # Operating System Concepts:

# DAY-01:

Q. Why there is a need of an OS?

- as any user cannot interact directly with any hardware device, hence there is need of some interface between user & hardware.

Q. What is an OS?

- An OS is a "system software" (i.e. collection of system programs) acts as an interface between user & hardware.

- It also acts as an interface between programs & hardware.

- As an OS allocates required resources like main memory, CPU time, IO devices access etc... for running programs, hence it is also called as a "resource allocator"

- As an OS manages limited available resources among all the running programs, it is also called as a "resource manager".

- an OS controls an execution of all programs as well it also controls hardware devices which are connected to the system, and hence an OS is also called as a "control program".

Q. What is an OS from end user point view:

- an OS is a software which comes either in a CD/DVD/PD.

- An OS is a software comes either in a CD/DVD/PD in a binary format, which mainly contains following three components:

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

e.g. Linux: vmlinuz

Windows: win32krnl.exe

2. Utility softwares: these are softwares comes with an OS which provides extra utility functionalities

e.g. file manager, task manager, shell etc...

3. Application softwares:

e.g. google chrome, browser application, notepad, MS Office etc....

+ Functions of an OS:

core functionalities/basic minimal functionalities/compulsory functionalities

"kernel" functionalities of an OS:

1. Process Management

2. Memory Management

3. CPU Scheduling

4. Hardware Abstraction

5. File & IO Management

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- extra utility functionalities/optional functionalities

6. Protection & Security

7. User Interfacing

8. Networking

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\$./program.out enter -> program gets loaded into the main memory

\$.\a.exe -> enter ---> executable file gets loaded into the main memory from the hdd.

Q. What is a Program?

- set of instructions given to the machine to do specific task

Q. What is a Process?

- program in execution i.e. when a program gets loaded into the main memory it becomes a process.

+ "loader": it is system program (part of an OS), which loads an executable file from hdd into the main memory.

- to starts an execution of a program --> OS (loader)

- to allocate CPU time for a process --> OS

- to give control of an IO device --> OS

- for any program to completes its execution following resources are required:

- main memory: RAM

- CPU time: 1

- input device access: KBD

- output device access: Monitor

etc...

+ "installation of OS": it is a process to store OS programs onto the hard disk drive.

+ "booting": it is a process in which bootstrap program locates a kernel which is onto the hard disk drive and load it into the main memory.

- bootstrap program is special program which is exists already into the hard disk drive in a boot sector (first sector of HDD ).

- "bootstrap program" gets loaded into the main memory by "bootstrap loader".  
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- in a single memory cell: we can store either 0 Or 1 -> bit

- bit: binary digit

- 1 byte = 8 bits = 8 memory cells

- smallest addressable unit = 1 byte -> if processor want to read/write data into the main memory min 8 bits/memory cells must be selected.

- there are two methods by which processor can write data into the main memory:

1. "big endian format": in this method, processor writes data into the memory in its binary equivalent format as it is.

2. "little endian format": in this method, processor writes data into the memory in the reverse order of its binary equivalent format.

```
int num = 300;
sizeof(int): 4 bytes = 32 bits
```

00000000 00000000 00000001 00101100

MSB

LSB

100101100

big endian format : 00000000 00000000 00000001 00101100

little endian format: 00101100 00000001 00000000 00000000

- "pentium family processor" use/follow little endian format.

16 bit compiler: sizeof(int): 2 bytes: 00000001 00101100

32 bit compiler: sizeof(int): 4 bytes: 00000000 00000000 00000001 00101100

300: 16 bit

- components of a computer hardware system are connected and does communications via a conducting wires referred as buses.

- 3 types of buses are there:

1. data bus/lines: carries data

2. addr bus/lines: addresses

3. control bus/lines: control signals

- control signals sent by the CPU to all devices are referred as a commands:

1. TEST: this command is used to check status of the device

2. READ:

3. WRITE:

4. CONTROL: to control operations on that device

- bus is a "shared communication pathway" i.e. data which is sent by one device can be recieved by any other device which is connected to the bus.

- bus which connects core components of a computer system is referred as a system bus.

- components of a computer system which are onto the motherboard are referred as core compeuter system.

e.g. processor, main memory, cache memory, ROM etc...

- devices which are connected to the motherboard externally through ports are referred as peripheral devices/peripherals.

e.g. io devices, hard disk drive --> external devices

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# DAY-02:

+ Everyone must follow the standard protocols while lecture:

1. You can chat only with the host while lecture is going on, if you are having doubts ask to the faculty.
2. Post your doubts only after finishing the current topic based on current topics only, after asked to post doubts.
3. Every doubt/question will be first explained and then its answer
4. Last 20 mins are reserved for your other doubts, and if you want that time chat settings will be public.
5. Still your doubt is unanswered you can ask it onto the whatsapp group.

- "Computer Memory Hierarchy":

1. "CPU Registers": it contains currently executing data & instructions by the CPU temporarily.

- MBR: Memory Buffer Register: main memory contents (data/instructions)
- MAR: Memory Address Register: main memory addresses of the contents which are in MBR
- IOBR: InputOutput Buffer Register
- IOAR: InputOutput Address Register
- PC: Program Counter: addr of next instruction to be executed etc....

2. One or more levels of cache memory i.e. L1 cache & L2 cache

3. Cache Memory

4. RAM Memory/Main Memory

5. Magnetic Disk Memory

6. Optical Disk Memory

Q. What do you mean by Internal & External memory?

- "Internal Memory": memory which is internal to the motherboard  
e.g. cpu registers, L1 cache & L2 cache, Cache Memory, RAM etc...

- "External Memory": memory which is external to the motherboard  
e.g. hard disk drive (magnetic disk memory), optical memory etc...

Q. What do you mean by Primary memory & Secondary memory?

- "Primary Memory": memory which can be accessible directly by the CPU  
e.g. cpu registers, L1 cache & L2 cache, Cache Memory, RAM etc...

- "Secondary Memory": memory which cannot be accessible directly by the CPU  
e.g. hard disk drive (magnetic disk memory), optical disk memory etc...

Q. Why RAM Memory is also called Main Memory?

- for an execution of any program RAM memory is must, and hence RAM memory is also called as main memory.

- RAM: Random Access Memory - volatile -> i.e. contents of this memory remains sustains only till power supply is there, when we switched off power supply main memory contents gets lost.

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Q. Why there is a need of cache memory?

- due to the speed mismatch between the CPU and main memory overall system performance gets decreased, and hence to reduce this speed mismatch cache memory can be added between the CPU & Main Memory.

Q. What is Cache Memory?

- cache memory is "faster" memory, which is type of RAM memory, in which most recently accessed main memory contents can be kept in an "associative" manner i.e. in a key-value pairs.

- there are two types of RAM:

SRAM: Static RAM - memory cells are made up of capacitors --> e.g. main memory

DRAM: Dynamic RAM - memory cells are made up of flip-flop gates -> e.g. cache memory

- "word": it is a unit of memory from system point view.

- word length = 8 bits/16 bits/32 bits/64 bits

- on few processor, word length may vary or on few process it is fixed.

- "cache hit"

- "cache miss"

- one or more levels of cache memory i.e. L1 cache & L2 cache can be added between the CPU and Cache Memory, to reduce speed mismatch between them.

$res = n1 + n2;$

$n1=10$

$n2=20$

registers:

accumulator:

- the rate at which the CPU can execute instructions is much faster than the rate at which data can be fetched from the HDD, so there is a huge speed mismatch, and hence to reduce this speed mismatch disk cache can be used.

- "disk cache": it is purely a software technique in which portion of the main memory can be used as a cache memory in which most recently accessed disk contents can be kept in an associative manner.

- there are four methods by which data can be accessed from computer memory:

1. sequential access: e.g. magnetic tape - data used to stored in record

2. direct access: e.g. magnetic disk - hdd

3. random access: e.g. RAM Memory

4. associative access: e.g. cache memory

Book of => 1000 pages

access page no.: 755 -> sequential access

direct access:

Book of => 1000 pages => 5 blocks having same size

Block1: 1-200

Block2: 201-400

Block3: 401-600

Block4: 601-800

Block5: 801-1000

circular platter - book of 1000 pages

hundreds of concentric rings: 200 = tracks --> 5 blocks

each track is divided into thousands equal size of blocks : 1000 sectors -> each block 200 pages

usually the size of sector = 512 bytes

- if we want to access (sector no.: 455 + track no.: 125)
- this request will be sent to the "disk controller", and disk controller controls movement the "head"
- "head" is a conducting coil exists in hdd which can be used to access data from one sector at a time i.e. head has the capacity to write/to read data into/from the sector at a time.
- head can access 512 bytes of data at once - block by block
- data access can be done block by block - hdd is also called as a "block device".

- seek time: time required for the disk controller to move head from its current position to the desired track is referred "seek time".

- time required for rotation of a platter till desired sector will not gets aligned with the head is referred as "rotational latency".

- access time = seek time + rotational latency.

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+ "IO Devices/External Device/Peripheral Devices":

Core Computer System: CPU, RAM, Cache Memory etc...

Peripheral Devices : HDD, IO devices

Input Devices: KBD, joystick, bar code reader, scanner, webcam, mic, etc...

Output Devices: Monitor, Printer, Plotter, Projector etc...

- whenever there is a transfer of data either from core computer system to an external devices or vice-versa it is referred as an "IO", and this io can be done via "io modules" i.e. through "io ports", as core computer system cannot directly interacts with any external device.

- io modules/io ports acts as an interface between core computer system and an external devices.

- structure of external device (input device/output device/memory device):

e.g. keyboard

- each external device has got three important blocks:

1. "control logic block": "controller" -> this block controls all the operations of that device.

2. "buffer": each device has got its own memory in which data can be stored temporarily

3. "transducer": this block is used to do communication with the outside world.

- this block converts one form energy into another form of energy.

- in i/p devices transducer convert any other form of energy an electrical energy,

whereas in an o/p device transducer converts an electrical energy into any other form of energy.

- "QWERTY" keyboard -> keyboard layout

- there are three io techniques:

1. "Program driven io":

- in this type of io all the steps/logic which is required for an io is there inside one program, and by means of executing that program by the CPU io can be done.

- in this method the CPU fully remains involved in an io, there is a less utilization of the CPU, because by the time an io modules does communication with io devices, CPU has to remain idle.

2. "Interrupt io":

Q. What is an interrupt?

- an interrupt is a "signal" which is sent by any io device to the CPU, due to which it stops an execution of one job/process and starts executing another job/process.

in other words:

- an interrupt is a signal received by the CPU from any io device, due to which it stops an execution of one job/process and starts executing another job/process.

- control signals sent by the CPU to an io devices are called as "commands"

e.g. TEST, READ, WRITE, CONTROL

- by the time an io modules does communication with an io devices, the CPU can complete part of another job/process, instead of remaining idle, and it can takes part again in an io by means of sending an interrupt, and hence due to an interrupt involvement of the CPU in an io has beed reduced and its utilization gets maximized.

3. DMA (Direct Memory Access): this is an io technique in which DMA controller can be added onto the system bus which takes cares about an io between main memory and hard disk drive.

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# DAY-03:

- UNIX: UNICS

- "File has Space and Process has Life".

- from UNIX point of vei w whatever that can be stored is considered as a file and whatever which is in a running state is considered as a process.

- UNIX treats all devices as a file.

- UNIX system catagories devices into two catagories:

1. "character device": character special device files

- devices from which data gets transfered char by char

e.g. keyboard, monitor, printer etc...

"buffer": file in a main memory area in which temporarily data can be kept.

stdin : standard input buffer which is associated with standard i/p device - KBD  
stdout : standard output buffer which is associated with standard o/p device - Monitor  
stderr : standard error buffer which is associated with standard o/p device - Monitor

2. "block devices": block special device files

- devices from which data gets transferred block by block i.e. sector by sector

e.g. all storage devices

\$/program.out - press enter --> to execute a program

- double click executable file

- Loader/OS creates a process implicitly
- to exit a process
- to open file a file or to create a new file

- sir can we create a process from our program explicitly

\* kernel: program -> functions

+ "system calls": are the functions (of kernel program) defined in C, C++ & assembly language which provides interface of services made available by the kernel for programmer user.

- In UNIX 64 system calls
- In Linux more 300 system calls
- In Windows more than 3000 system calls

- there are 6 categories of system calls:

exit() --> \_exit()  
fopen() --> open()  
fclose() --> close()  
printf(), fprintf(), fputc(), fputs(), fwrite() --> write()  
scanf(), fscanf(), fgetc(), fgets(), fread() --> read()  
fseek() --> lseek()  
etc...

//user defined code

#include<stdio.h>

//entry point function

int main(void)

{



```

int n1, n2, res;

printf("enter the values of n1 & n2: "); //write() - system defined code
scanf("%d %d", &n1, &n2); //read() - system defined code

res = n1 + n2;

printf("res: %d\n", res); //write() - system defined code

return 0; //successful termination
}

```

- whenever system call occurs the CPU switched from user defined code to the system defined code, and hence system calls are also called as "software interrupts".

- throughout an execution of any program the CPU keeps switched in between user defined code and system defined code, and system runs in two modes

1. "kernel mode"/system mode/monitor mode/privileged mode: when the CPU executes system defined code instructions

2. "user mode"/privileged mode: when the CPU executes user defined code instructions

- there is one bit onto the CPU referred as a "mode bit" which is maintained by an OS/kernel.

mode bit = 0 --> kernel mode

mode bit = 1 --> user mode

- "dual mode operation" of a system.

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+ Process Management:

Q. What is Program:

- from OS point of view the program is nothing but an executable file (.exe, .out) which has got different sections like exe header, bss section, data section, rodata section, code/text section & symbol table.

- What Process?

+ features of an OS:

- "multi-programming": system in which more than one processes can be submitted at a time.

- "degree of multi-programming": no. of processes that can be submitted into the system at a time.

- "multi-tasking": system in which it seems that the CPU can execute multiple processes concurrently or simultaneously.

- "the CPU can execute only one process at a time".

Q. What is a thread?

- thread is the smallest execution unit of a process
- thread is the smallest indivisible part of a process
- thread is a lightweight process

- "multi-threading": system in which it seems that the CPU can execute multiple threads which are of either same process or different processes concurrently or simultaneously.

"the CPU can execute only one thread of any one process at a time".

- "multi-processor": system can run on such a machine in which more than one CPU's are connected in a closed circuit.

- "uni-processor"

- "multi-user": system in which it seems that the CPU can execute processes of more than one users concurrently.

- to keep control on all running programs kernel maintains few data structures:

1. "job queue": it contains list of PCB's of all submitted processes

2. "ready queue": it contains list of PCB's of processes which are in the main memory and waiting for the CPU time.

- an OS maintains device queue/waiting queue per device

3. "waiting queue"/"device queue": it contains list of PCB's of processes which are requesting for that device.

- "job scheduler": it is a system program which schedules jobs/processes from job queue to load them onto the ready queue.

- "cpu scheduler": it is a system program which schedules job/process from ready queue to load it onto the CPU.

- "dispatcher": it is a system program which copies an execution context of process which is scheduled by cpu scheduler from its PCB into the CPU registers.

- in following four cases CPU scheduler must gets called:

1. running --> terminated

2. running --> waiting

3. running --> ready

4. waiting --> ready

- there are two types of CPU scheduling:

1. "non-preemptive":

- control of the CPU released by the process by its own, i.e. voluntarily  
e.g. above case 1 & case 2

2. "preemptive":

- control of the CPU taken away forcefully from the process  
e.g. above case 3 & case 4

+ CPU scheduling algorithms:

1. FCFS (First Come First Served) CPU Scheduling
2. SJF (Shortest Job First) CPU Scheduling
3. Priority CPU Scheduling
4. Round Robin CPU Scheduling

- there is need to decide which algo is efficient and which algo is best suited at which situation, there are certain criterias, called as "CPU scheduling criterias":

1. "CPU utilization": one need to select such an algo in which utilization of the CPU must be as max as possible.

2. "throughput": total work done per unit time

one need to select such an algo in which throughput must be as max as possible.

3. "waiting time": total amount of time spent by the process into the ready queue for waiting to get control of the CPU from its time of submission.

- one need to select such an algo in which waiting time must be as min as possible.

4. "response time": time required for the process to get first response from the CPU from its time of submission.

- one need to select such an algo in which response time must be as min as possible.

5. "turn-around-time": total amount of time required for the process to complete its execution from its time of submission.

- it is sum of periods spent by the process into the ready queue for waiting and onto the CPU for execution.

turn-around-time = waiting time + execution time.

- one need to select such an algo in which turn-around-time must be as min as possible.

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# DAY-04:

+ CPU scheduling algorithms:

1. FCFS (First Come First Served) CPU Scheduling

- "gant chart": bar chart presentation of CPU allocation for processes in terms of CPU cycle numbers.

- non-preemptive

2. SJF (Shortest Job First) CPU Scheduling

- non-preemptive as well preemptive

3. Priority CPU Scheduling:

P1 - 2 - 20

P2 - 1 - 12

P3 - 4 - 5

P2 -> P1 -> P3

- preemptive
- "starvation/indefinite blocking"
- "aging"
- shmget()

"related processes": processes which are of same parent

"non-related processes": processes which are of different parent

#### 4. Round Robin CPU Scheduling

- when we shutdown the machine an OS sends "SIGTERM" signal to all running programs due to which processes get terminated normally, but there are such processes which do not get terminated even after receiving SIGTERM signal from an OS, in that case an OS sends SIGKILL signal

SIGTERM: normal termination

SIGKILL: forceful termination

SIGSEGV: process gets terminated with printing message as "segmentation fault"

SIGSTOP: to suspend a process

SIGCONT: to resume suspended process

etc...

pipe

message queue

signals

socket

- by using socket process running on one machine can communicate with process which is running on another machine, whereas both the machines are at remote distance, provide connected in a network (LAN/WAN/Internet).

- "socket": ip addr + port number

"chatting application"

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A - 1

B - 2

C - 3

e-dbda

- to write something at a time on the same notebook, on same page and on the same line

"race condition":

"data inconsistency"

Process A

- open a file

- to connect a printer

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Process B

- to connect a printer

- to open a file

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- deadlock:

- there are four necc & suff conditions:

1. "mutual exclusion": at a time resource can be acquired by only one process

2. "hold & wait":

3. "circular wait":

4. "no preemption": control of the resource cannot be taken away forcefully from any process.

- deadlock handling methods:

1. "deadlock prevention": deadlocks can be prevented by discarding any one condition out of 4 necc & suff conditions.

2. "deadlock detection & avoidance":

- in this method before allocating resources for processes in advanced all the input can be given to the deadlock detection algorithm, and it will get checked whether there are chances to occur deadlock or not, if there are chances to occur deadlock

it can be avoided by doing necc changes.

- there are two deadlock detection & avoidance algorithms:

1. resource allocation graph algorithm

2. banker's algorithm

3. "deadlock recovery": system can be recovered from deadlocks by using two methods:  
1. "process termination": in this method, any one process gets selected and gets terminated, such process is referred a "victim" process.

2. "resource preemption": in this method, control the resource taken away forcefully from any process.

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#DAY-05:

- Main Memory : 2GB/4GB/8GB/16GB/32GB - limited
- Main Memory: Kernel Space & User Space
- Main Memory 4GB => "swap area = 8 GB

8 GB RAM + Core i5 -

"relocation registers:"

1. base register : (dynamic) : 10 K
2. limit register:(fixed) : 5 K

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- there are two methods by which memory gets allocated for processes:

1. "contiguous memory allocation":

- in this method, process can complete its execution only if memory gets allocated for a process in only contiguous manner.

- A. fixed size partitioning
2. variable/dynamic size partitioning

+ external fragmentation:

1. "compaction":

2. "non-contiguous memory allocation":

- in this method, process can complete its execution even for it memory gets allocated in a non-contiguous manner.

- this memory allocation can be implemented by two "memory management techniques":

1. segmentation
2. paging

+ Main Memory: 4 GB -> 1 GB(Kernel) + 3 GB(User Processes)

Swap Area: 8 GB

Process: 6 GB --> Main Memory(Physical Memory) + Swap Area(Virtual Memory) = 12 GB

"Virtual Memory Management": Paging + Swapping

- big size process is divided into pages: few pages of running process can be kept inside the RAM and few pages of the same process can be kept into the swap area

- active pages of running programs --> main memory

- inactive pages of running programs --> swap area

page in

page out

- "lazy swapper": it is a system program which does swapping of pages between main memory and swap area, as this program swapped in any page into the main memory only after it is requested by the process, and this type of paging is called as demand paging, page which is never requested will never gets loaded into the main memory is called as "pure demand paging".

- no. pages >> no. of frames ==> all frames becomes full.

"page fault": if requested page by the process is not exists into the main memory it is referred as a "page fault".

- "page replacement algorithms:"

1. FIFO page replacement: page which was inserted first can be replaced by the requested page.

2. "Optimal Page replacement": page which will not used in a near future will get replaced.

3. "LRU"(Least Recently Used): least recently used page gets replaced

4. "LFU": Least Frequently Used

5. "MFU": Most Frequently Used

5 PreCAT batches - 10 mins each ==> 50 mins

if i spent 2 hrs on scheduling ==> 120 mins

- if process spent more time on paging rather than its execution, this high paging activity ie referred as "thrashing".

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# File Management:

Q What is file?

user view:

- it is a named collection of logically related data/information.
- file is a basic storage unit
- file is a container which contains logically related data/information.

system view:

- file is a stream of bits/bytes.

- file = data + metadata

1. data = file contents --> inside the file

2. metadata = information about the file --> FCB(File Control Block)

- filesystem maintains one structure per file inside which information about that file can be kept, this structure is referred as "FCB"/"iNode".

- FCB/iNode contains mainly:

- iNode number: unique identifier
- name of the file
- parent folder location

- time stamps
- access perms
- size of the file
- other info about the file
- etc.....

- no. of inodes = no. of files

no. of file = 1000 --> no. of inodes = 1000  
1000 files -> millions of bytes of data

+ "filesystem": it is way to store data onto the disk in an organized manner so that it can be accessed efficiently.

Linux: "ext" - ext, ext2, ext3, ext4 - extended filesystem

Windows: NTFS, FAT, FAT16, FAT32

UNIX: UFS

MAC OS X: HFS

etc...

- filesystem can be created at the time installation of an OS  
"format" - to create a new filesystem