Lecture - 1, 2

Why we use Operating System?

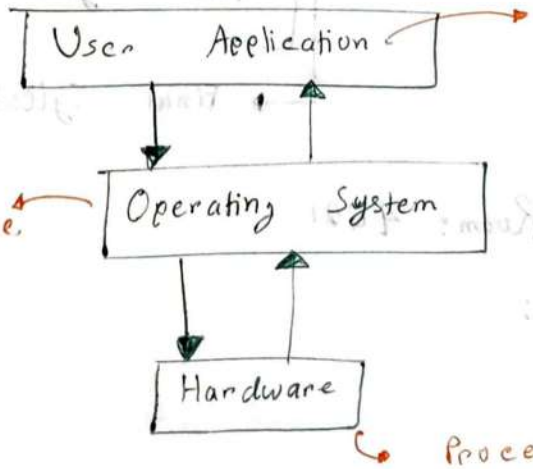
⇒ • Intermediary & negotiative between hardware and ~~software~~ user.

• To create a link between hardware and software.

What is an Operating System?

⇒ Operating system is a program/software that controls the execution of application programs and acts as an intermediary between a user of a computer and the computer hardware.

This is actually a bridge between the user of a computer and hardware



A program or application or interface. যেটা user use করে।

A system software.

Processor, Monitor, Keyboard, etc.

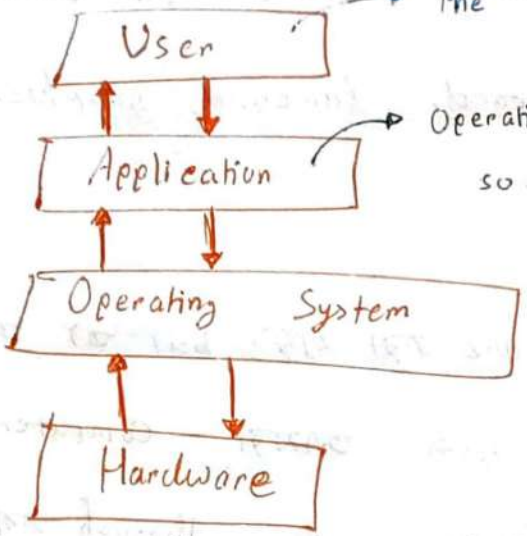
একটা Computer এ অনেক hardware থাকে। for example, CPU, Motherboard, Ram, sound card, lan card, graphics card, etc.

এই hardware গুলো directly use করা যায়; but এর অনেক complex. বিধায়, এই hardware গুলো আমরা Computer system এর একটা software এর through সবকিছু use করি,

example:

Suppose আমি, একটা browser এ যেকোনো একটা video দেখছি, তখন web-browser হচ্ছে system এর একটা application or user. , video দেখার সময় আমার, monitor, sound card, graphics controller, keyboard. mouse use করা লাগছে যা আমাদের hardware. Web browser আমার এই hardware গুলো use করছে.

OS একটা software ; যেটা আমার system এর user application এবং hardware এর থাকে middle man হিসাবে কাজ করে



→ The people that are using the PC.

→ Operating System এর case এ application software গুলো OS কে use করে। সব OS এর জন্য application software হলো- user.

System Software vs Application Software

দুই ধরনের software আছে। যেমন:

- System software
- Application software

- System Software:

- Operating System একধরনের System software.
- OS ছাড়াও আরো কিছু ধরনের program আমাদের computer এ থাকে যারা computer resource manage করে at low level..
- এরা hardware এর সাথে communicate করে উপরের layer এ যে application software আছে তাদের বিভিন্ন functionality provide করে,

- Compiler, loaders, linkers, debuggers → system softwares

" System softwares are the programs including operating system and other utility program that manages computer resources at low level."

example: Compiler, loaders, linkers, debuggers

Application Softwares:

application softwares are the programs that are designed for an end user.

example: word processor, database systems, spreadsheet program, web programms

(P.T.O).

Goals of Os:

Goals = উদ্দেশ্য ;
main motive কি

- Execute User ~~problem~~ programs and make solving user problems easier and make the computer system convenient to use.

↳ program (other programs) execute করা; manage বা control করা; Computer এর সব hardware নিয়ে build হয়, application software তো directly এই সব hardware কে use করতে পারে না; hardware কে সহজ করে use করতে পারে এজন্যে OS একটা interface provide করে, কঠিন, computer system use টা আরো convenient করে দেয়।

- Use the computer hardware in efficient manner.

↳ Os ; hardware এর feature গুলো provide করে through interface, ১ so, hardware efficient ভাবে use হচ্ছে কিনা তার দায়িত্ব OS এর।

- Manages and allocate all resource
- Control the execution of user programs and I/O devices

efficient ⇒ linux
Convenient ⇒ Windows.

↳ বিভিন্ন application software সমূহ use করি. এই application software computer system এর বিভিন্ন input- output device তাদের use করার প্রয়োজন হয়। তারা সাথে প্রত্যেকটা application ~~এরা~~ এই resource গুলোকে বিভিন্নভাবে us. করতে পারে এজন্য ঐ program গুলোর execution control করা important। তাই এই control করা OS এর one of the major goals

Primary functions of CPU :

- Process management
- Storage / Memory management
- Data file management
- Input / Output devices - i/o management
- Network management
- Protection & Security

function = কি কি কাজ করে

Four Components of Computer System.

- Computer System can be divided into four components.

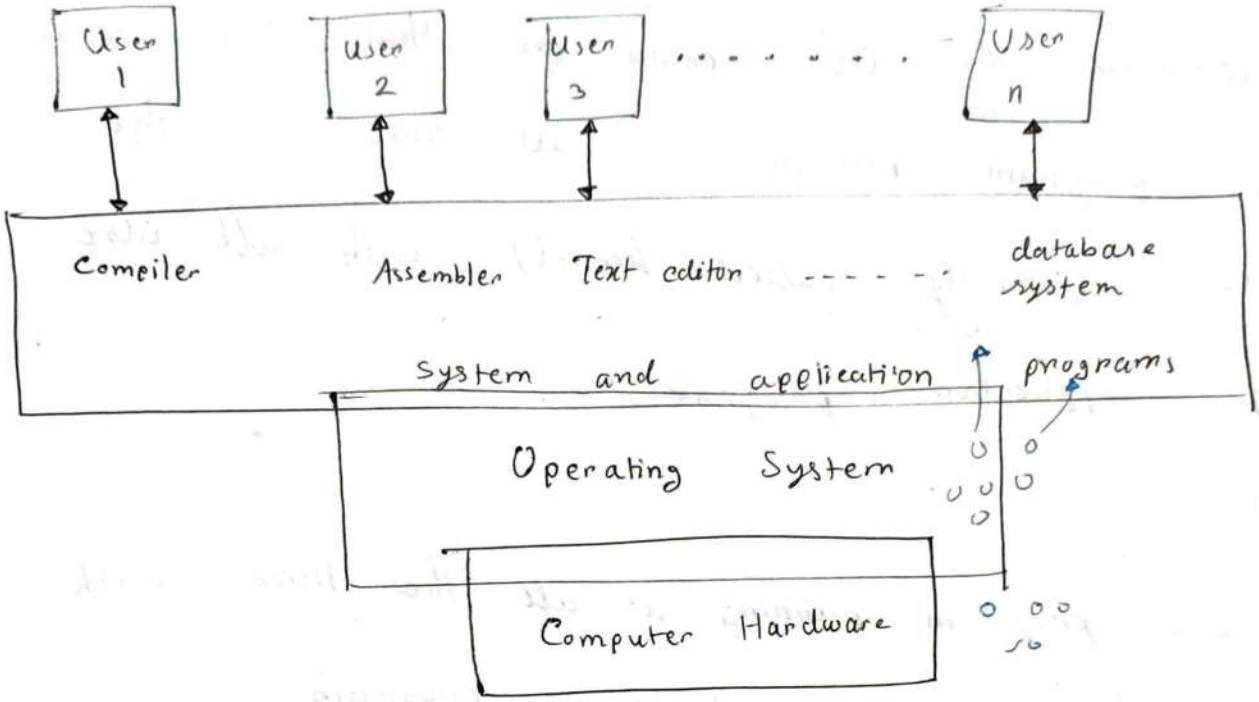
- **Hardware**
  - Provides basic computing resources.
  - example: CPU, memory, I/O devices.

- **Operating System:**
  - Controls & Co-ordinates use of hardware among various applications and user.

- **Application Programs:**
  - Defines the ways in which the system resources are used to solve the computing problems of the users.
  - example: word processors, compilers, web-browsers database systems, games.

- **Users:**
  - People, machine & other users

Components of a Computer System



Operating system; application program এর hardware এর মধ্যে bridge হিসাবে কাজ করে, এরা Computer hardware এর যে facilities বা সুবিধা আছে বা যে feature provide করতে পারে ও feature যে module আকারে থাকে যে module দ্বারা create করা। Then এ module দ্বারাই application software use করে.

Another Definition of OS

Another definition for OS could be that, the OS is the one program running at all time on the computer. (usually called kernel) with all else being application program.

Kernel.

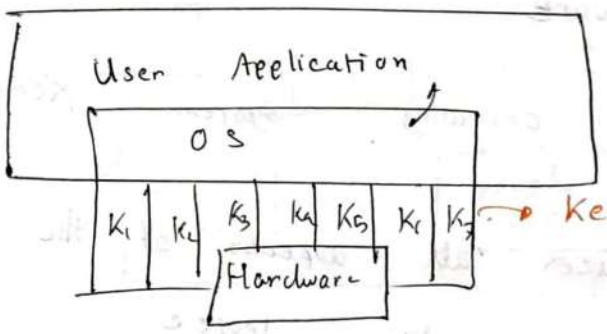
- The one program running at all the time; with all else being application program.
- The Kernel is the central module of an operating system.
- Part of the operating system that loads first and it remains in **main memory**

  - also known as primary memory.
  - main memory ~~को~~ basically ram को भुन्छ।
  - CPU can execute only from main memory.

- As small as possible.
- provides all the essential services required by other parts of operating system and application.

- Kernel code is usually located in a protected area of memory to prevent it from being overwritten by programms or other parts of the operating system.

→ যখন OS start হয় তখন OS এর যে part সবচেয়ে আগে load হয় তা kernel. যতক্ষণ পর্যন্ত system running অবস্থায় থাকে ততক্ষণ পর্যন্ত তা main memory তে execution এ থাকে. That's why এই Kernel টা যত ছোট possible তত ভালো.



প্রত্যেকটা Kernel OS এর একেক ধরনের service provide করছে।

Bootstrap Program

- একটা special kind of program. / initial program.
- একটা computer start হওয়ার সময় সময় এই initial program (bootstrap) start হয়,
- power up and reboot এ [redacted] bootstrap program execute হয়, (it's executed first)
- Stored in ROM or EEPROM, known as firmware
- Loads operating system, Kernel and start execution
- Initializes all aspects of the system, from CPU registers to device controllers to memory contents.
- Bootstrap program must know how to load operating system and how to start executing.
- Once the OS Kernel is loaded and executing; it can start providing services to the system and its users.

EEPROM /⇒ Electrically Erasable Programmable Read Only Memory.
EPROM

Computer System Organization

- One or More CPUs, device controllers connect through common bus providing access to shared Memory
- Each device control is in charge of a specific type of device.

Communicate, Transaction

- CPU and the device controllers can execute in parallel, competing for memory cycles.

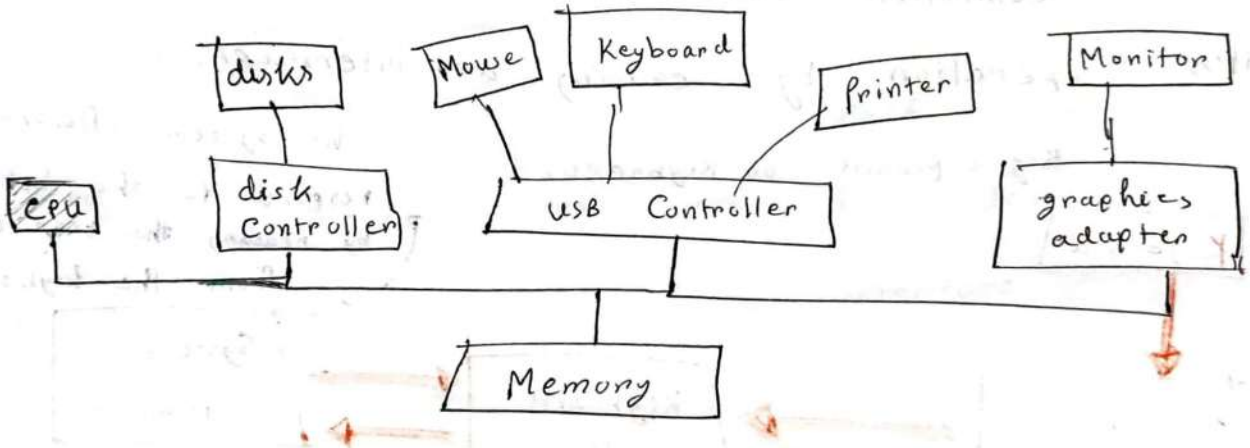


Figure: A modern Computer System

প্রত্যেকটা Computer এ CPU সাকবে এবং সবকটার device এর জন্য আলাদা আলাদা device controller থাকবে, এই device controller এর মাধ্যমে device গুলো এদের সাথে data আদান প্রদান করবে;

I/O device and CPU can execute concurrently

Each device controller ... change of a

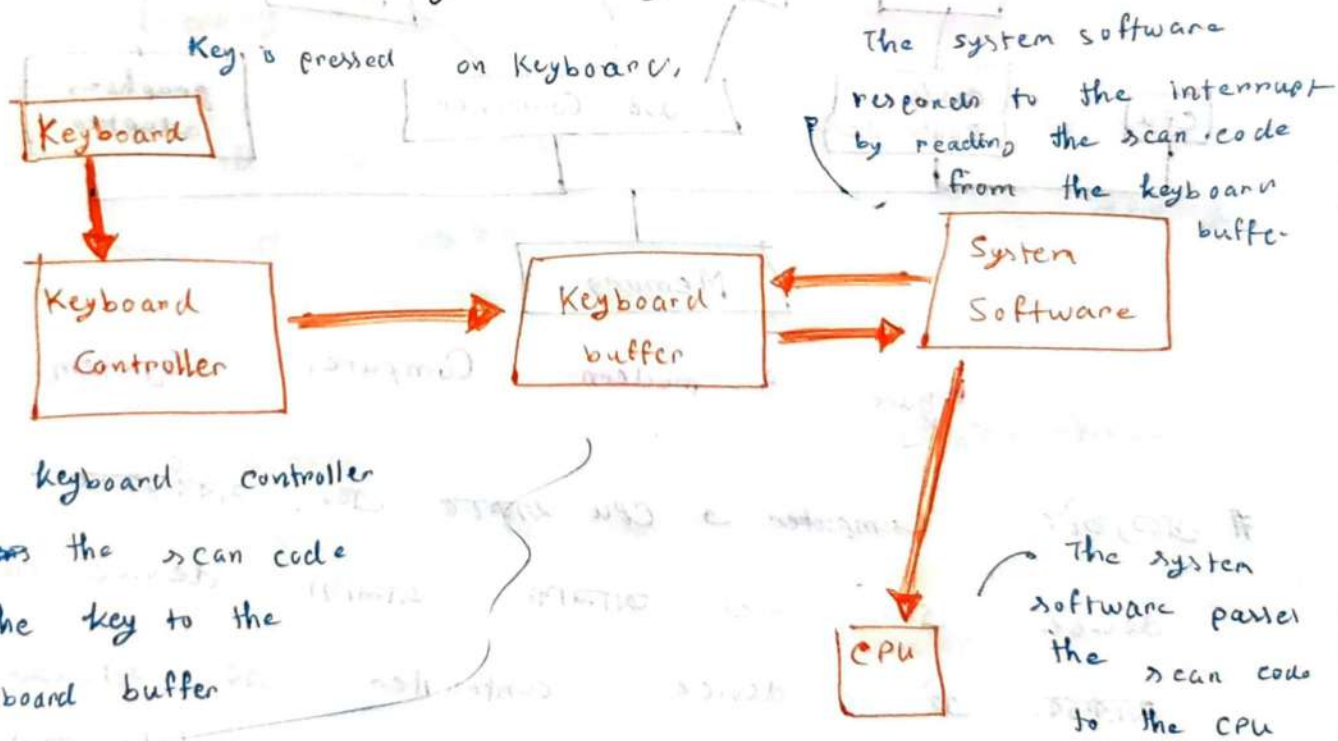
ration of a Controller:

- Controller এর কাজ কি কি?

- Each device controller has a local buffer [which stores data in a buffer while it is being processed or transferred]

- CPU moves data from / to main memory to/from local buffers.

- Device Controller informs CPU that it has finished it's operation by causing an interrupt.



- The keyboard Controller sends an interrupt request to the system software

Device Driver VS Device Controller

Device Driver : (Kernel or software).

- A computer program that operates and control a particular type of device that is attached with the computer.

Device Controller (Hardware).

A part of computer hardware system system that makes sense of the signals going to and coming from CPU.

OS has a device driver for each driver controller,

Device driver understand the device controller and provides a uniform interface

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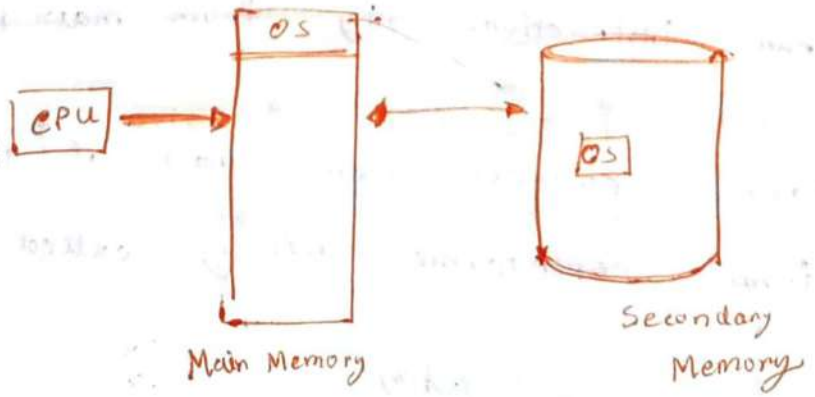
bootstrap program - OS কে মূলত load করে- এ OS এর Kernel টা load করে থাকে.

Secondary Memory তে OS কোথায় রাখা তার location রাখি,



Storage structure

Memory 2 ধরনের। যথা:

- Main Memory
- Secondary Mem

> Main Memory বলতে usually RAM কে বুঝায়। এগুলো Volatile হয়। যখন Computer on এ যা যা কাজ করছো save করছো। Computer off করলে তা সব মুছে যায়; store করে রাখে না.

Main Memory:

Only large storage media that the CPU can access directly

- Random access

- Typically Volatile. যতক্ষণ পর্যন্ত computer run হচ্ছে ততক্ষণ পর্যন্ত Main Memory তে যেসব data আছে সেটা ততক্ষণই থাকছে, PC off করে দিলে ঐ data remove হয়ে যাবে।

Secondary Memory.

Extension of main Memory that provides large non volatile storage capacity.

PC বন্ধ করার পরেও secondary memory বা-harddisk এ data থেকে যায়।

Important Points.

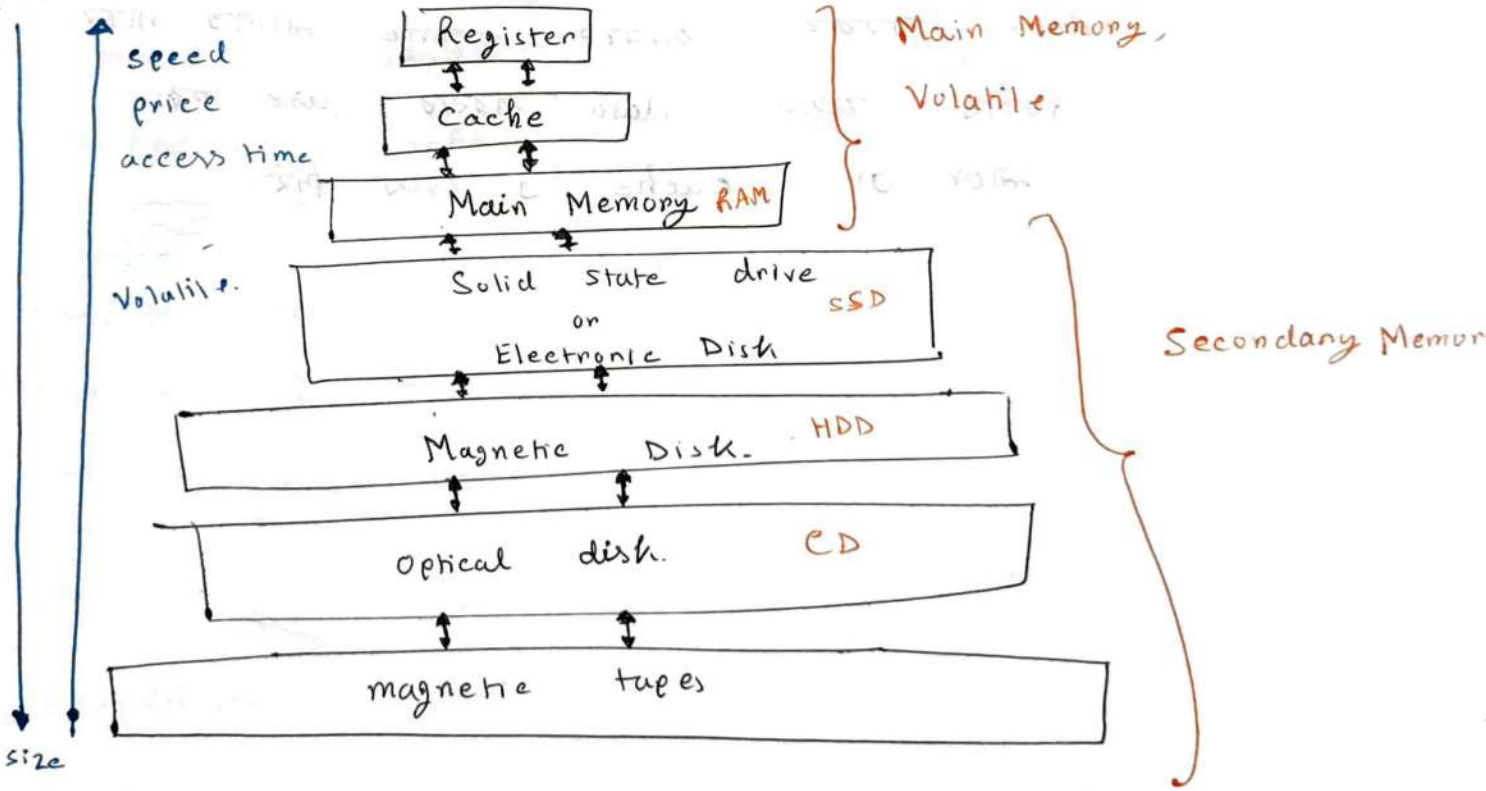
- CPU can run instructions only from main Memory.
- General purpose computers run most of their programs from rewriteable memory, called main memory (also called RAM)

- Computers use other forms as memory as well- Read only Memory (ROM) and electrically eraseable programmable read only memory (EEPROM)

- Only static programs, such as bootstrap program

" যখন ইঠাৎ program secondary memory থেকে primary memory ~~তে~~ আসতে হয় to get executed "

Storage device Hierarchy:



Speed ↑ price ↑ access time ↑ cost ↑ size ↓

Speed ↓ price ↓ access time ↓ cost ↓ size ↑

" Secondary Memory থেকে primary Memory এ data আনতে বেশি time লাগে, as secondary memory এর size অনেক বেশি, "

Cache
↳ buffer area
↳ Computer এ যা সবসময় use করি তা store রাখি,
↳ Caching:

- Information in use copied from slower to faster storage temporarily.
- Main memory থেকে cpu তে ~~data~~ repeated data বারবার আনতে time লাগতে পারে, বিধায় যেসব data বারবার use করা লাগে তা cache এ রাখা দিই,

Performance of Various level of storage

- Movement between ~~storage~~ levels of storage hierarchy can be explicit or implicit.

Level 1

Name: Registers.

Typical Size: < 1KB.

Implementation Technology: Custom Memory with Multiple Ports, CMOS

Access time (ns): 0.25 - 0.5.

Bandwidth (MB/sec): 20,000 - 100,000

Managed by: Compiler

Backed by: Cache.

Level 2:

Name: Cache

Typical Size: > 1GMB

Implementation Technology: on-chip or off-chip CMOS RAM

Access time (ns): 0.5 - 25.

Bandwidth (MB/sec): 5000 - 10,000

Managed by: Hardware

Backed by: Main Memory

Level 3:

Name: Main Memory.

Typical Size: > 1GB.

Implementation Technology: CMOS DRAM

Access time (ns): 80 - 250.

Bandwidth (MB/sec): 1000 - 5000

Managed by: OS.

Backed by: Disk

Level 4:

Name: Disk Storage

Typical Size: > 100 GB

Implementation Technology: Magnetic Disk

Access time (ns): 5,000,000

Bandwidth (MB/sec): 20 - 150

Managed by: OS

Backed by: CD or Tape.

Operating System Architectures

Based on the numbers of processors we can divide our OS in the three following ways.

(i) Single Processor System

(ii) Multiprocessor / Parallel / Multicore System

(iii) Clustered Systems

Single Processor System:

- One main CPU capable of executing a general purpose instruction set.
- Almost all single processor systems have other special purpose processors (device-specific processors), which run a limited instruction set.

"একটা single processor সবকিছুর কাজ পারে না, So, এমন single processor system এ special purpose processor থাকে, তাদের নাম কেউ হয়তো memory related কাজ করে, কেউবা input এর কাজ করে, কেউবা output এর কাজ করে।"

Multiprocessor System

- Such system have two or more processors in close communication, sharing the computer bus and sometimes the clock, memory and peripheral devices.

Clustered System

- Special kind of multiprocessor system which gathers together multiple CPUs. They are composed of two or more individual system - or nodes joined together.
- Clustered Computers share storage and are closely linked by a local area network (LAN) or a faster interconnect such as InfiniBand.
- One kind of multiprocessor system এরই cpu গুলো একসাথে আলাদা আলাদা system এর মতো, এরা system গুলো একে অপরের সাথে connected থাকে তাই এরা খুব fast communicate করে,

OS Structure

Multiprogramming System.

এই system টা কীভাবে OS develop করতে help করছে, কীভাবে user experience better করছে,

- Increases CPU Utilization by organizing jobs (code and data) so that CPU always has one to connect.

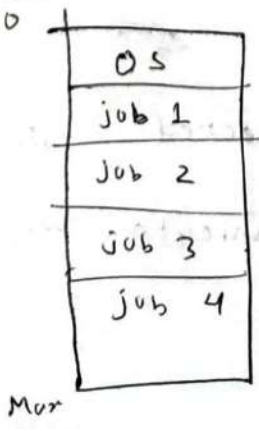
"System একসাথে অনেক program execute করতে পারছি, so, CPU utilization বেড়ে যায়, CPU কখনো idle হয়ে বসে থাকবে না, always কোনো না কোনো কাজ করতে থাকবে"

- OS keeps several jobs in memory simultaneously. As main memory is small, it keeps the job on the disk (job pool) which waits there to be allocated in the main memory.

"job pool হচ্ছে সেখানে কিছু process থাকবে যা job থাকবে; যা এখনো memory তে আসার জন্য ready."

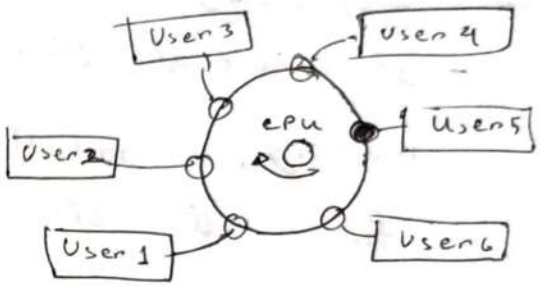
- OS picks and begins to execute one of the jobs in memory. Eventually, the job may have to wait for some task. OS picks another job from the pool to execute while the previous one waits.

"OS select করবে job pool থেকে কোন job memory তে load হবে-সেটা।



Time Sharing System aka Multitasking:

- CPU executes multiple jobs by switching among them.
- Switches occur so frequently that the user can interact with each program while it's running.
- Requires an interactive computer system, which provides direct communication between the user and system. (The system should be used by some users.)
- Response time should be short.



একটাই CPU থাকে এবং তা different user দের মধ্যে shared.

example: User 5 for a specific time (example: 1ms বা 1s (negligable amount of time)) gets the full access of the CPU, এই অবস্থায় আর কোন user এর access থাকে না এবং অন্য user গুলো system এর access পায়, প্রত্যেকটা user inturn খুবই অল্পসময়ের জন্য system টা use করতে পারে,

এই switching এতো first হয়, যে একজন user মনে system টা use করার সময় তখন তার user experience এমন হয় যে; অন্য কোনো user যে user use করছে এটা সে বুঝতে পারে না,

সুবিধা:

"Same system, same resource দিয়ে অনেকগুলো user কে একসাথে feature provide করতে পারি যাতে করে প্রত্যেক user এর কাছে মনে হয় যে single handedly পুরো system use করছে।"

Requirements of Multiprogramming:

- **Job Scheduling:**
  - If several jobs are ready to be brought into memory, and if there is not enough room for all of them, then the system must choose among them.
  - When OS selects a job from the job pool, it loads that job in the memory for execution. Having several programs in memory at the same time requires some form of memory managemen.

- **CPU scheduling:**
  - If several jobs are ready to run at the same time the system must choose which job will run fast.

- Running Multiple jobs concurrently requires their ability to affect one another be limited in all phases of the OS.

If processes don't fit in memory, swapping moves them in and out to run from main Memory achieving thu goal is virtual memory.

Operating System Operations:

OS এ কীভাবে কাজগুলো হয়,

- Modern OS are interrupt driven.
- Events are almost always signaled by the occurence of an interrupt or a trap.
- A trap (or an exception) is a software generated interrupt.
- For each type of interrupt, seperate segments of code determine what action should be taken.
- Errors can occur when an enormous program modify another program, the data of anothe. program or operating data itself.
- A properly designed OS must ensure thai- an incorrect (or malicious) program can't cause other programs to execute incorrectly.

H Trap একধরনের interrupt. But software generated interrupt.

Dual Mode Operation.

- Dual mode operation দিয়ে system এমনভাবে execution সুবিধা চালায়,
- Need to distinguish between Operating-system code and user defined code.
- A bit called the mode bit, is added to the hardware of the computer to indicate the current mode: Kernel (0) or User (1).
- Dual mode operation provides protection from of the OS from errant users.
- This protection is designated by some of the machine instructions that may cause harm as priviliged instructions that are only executed in kernel mode (0).

System Code ⇒ Operating System এর Code

User defined Code ⇒ নিজের বানানো user application, যেমন: word processor, web browser, ইত্যাদি

identify করতে পারা যে কোনটা System Code আর কোনটা user defined Code.

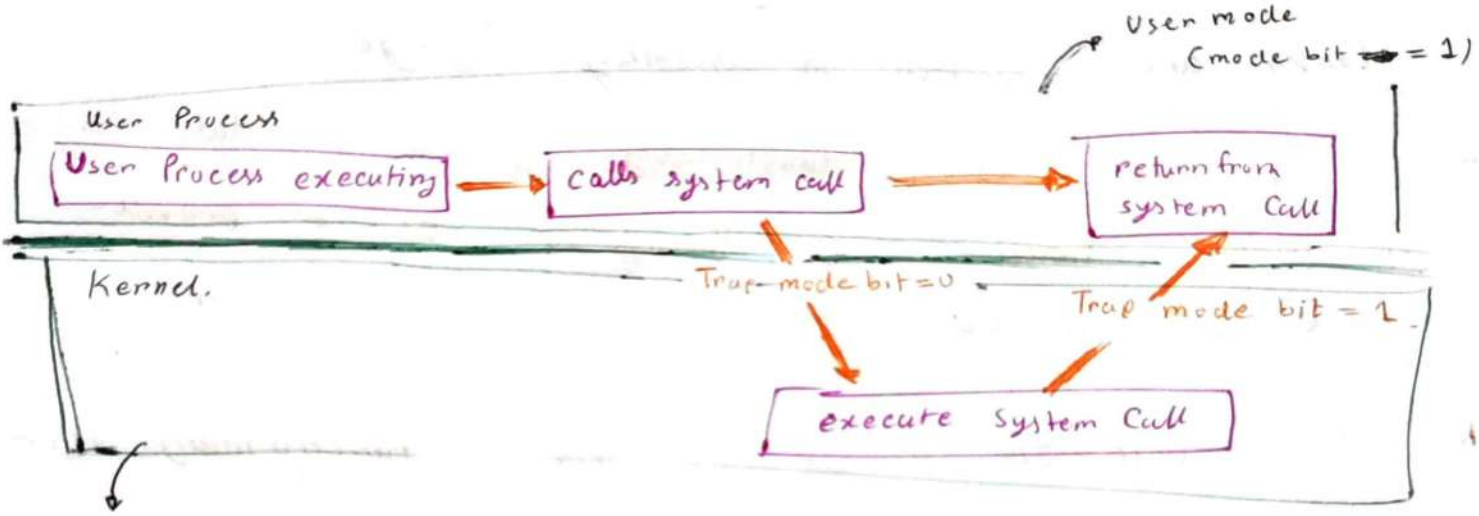


Figure: Transition from User to Kernel Mode

কিছু program এর line বা lines of code বেশ্যা খুব sensitive; যেখানে সামান্য system design এ system এর behaviour change করে দিতে পারে, so, ঐ line of code এ privileged instruction দিয়ে রাখতে দিবে না.

Privileged instruction Kernel mode এ run হয়, আর normal instruction user mode এ.

System Call

- System Calls provide an interface to the services made available by an operating system.
- These calls are generally available as routines.
- Routines are written in C or C++. Some low level tasks are written in assembly language.

OS, hardware এর functionality গুলোকে module আকারে বিভিন্ন function এর through এ OS যে provide করে ঐ module গুলোকে বলে system call.

System call হচ্ছে OS এর সেই functionality গুলো বা সেই module গুলো যেগুলো আবার computer system এ hardware এর সেই functionality গুলো user application কে provide করার কাজ করে provide করার scope করে দেয়,

"System call interface maintains a table indexed according to this number."

System Call Interface

- Serves as link to the system calls made available by the users
- A number is associated with each system call, the system call interface maintains a table indexed according to those numbers
- Invokes the intended system call in the operating system kernel and returns the status of the system call and any return values

User application কোনো particular command run করাতে চাইলে, then ঐ command টা system call interface এ পাঠায় এবং সে তখন ঐ resource দরকার request করে। Then system call interface তার particular index table থেকে ঐ particular command এর জন্য যে code আছে তা execute করে এর result টা পরবর্তীতে user কে return করে।

normally সব application use হয় যা user mode এ execute হচ্ছে। But যখনই যে কোনো System Call এর Call করছে তখনই mode টা change হয়ে Kernel mode এ যায়, System Call will be executed in Kernel Mode

Types of System Call

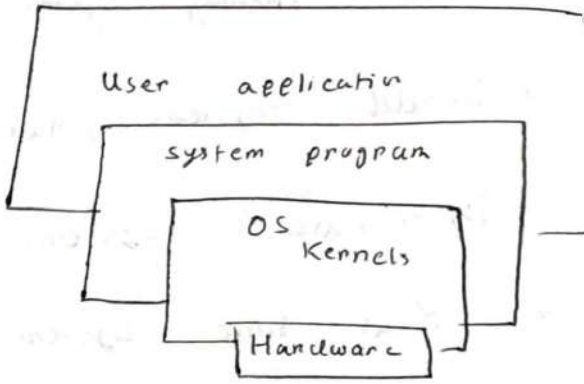
Type	Windows OS	Linux OS
Process Control	Create Process () Exit Process () Wait For Single Object ()	fork () exit () wait ()
File Manipulation	Create File () Read File () Write File () Close Handle ()	open () read () write () close ()
Device Manipulation	Set Console Mode () Read Console () Write Console ()	ioctl () read () write ()
Information Maintenance	Get Current Process ID Set Timer () Sleep ()	getpid () alarm () sleep ()
Communication	Create Pipe () Create File Mapping () Map View Of File ()	pipe () shm_open () mmap ()
Protection	Set File Security () Initialize Security Deseriptor () Set Security Descriptor Group ()	chmod () umask () chown ()

System Programs

⇒ aka system utilities

⇒ provides a convenient environment for program development & execution

⇒ One kind of program



⇒ OS এর kernel কে use করে easy way তে যাতে user application use করতে পারে তা convenient করে দেয়।

⇒ They provide

- File management
- Status information
- File modification
- Programming Language support
- Program loading & execution
- Communications
- Background Service

History of OS / Type of OS

- Simple Batch Systems. → Unit Process
- Multiprogramming Systems → Unit Processor
- Time Sharing Systems / Multitasking system → Unit Processor
- Parallel Systems / Multiprocessing system
- Distributed Systems
- Real time Systems. IRTOS

> # CPU can only execute from main memory.

Simple Batch System:

- Automatically transfers control from one job to another.

Multiprogrammed System:

- Several jobs are kept in main memory at same time, and the CPU is multiplexed among them.

Time Sharing System:

- Logical extension of multi-programming.

Parallel System:

- Multiprocessor system with more than one CPU.

Distributed System.

- Distribute the computation among several physical processors.

- **Loosely coupled system:**
  - each processor has it's own local memory; processors communicate with one another through various communications lines, such as high speed buses or telephone lines

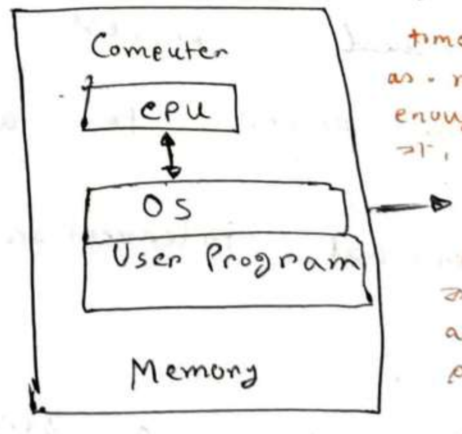
Real Time Systems:

- Often used as a control device in a dedicated application such as controlling scientific experiments, medical imaging systems, industrial control systems, and some display systems

Simple Batch System

- Automatically transfers control from one job to another.
- Common I/O device are card-readers and tape drivers
- User prepare a job consisted of program, input data and control instruction

main mem অনেক limited ছিলো times এ একটি job কে load করে একটা একটা execute হতো। i/o এর সময় cpu idle বসে ছিল।



* input, output time এ cpu idle. as main mem এ enough space ছিল না। তখন একাধিক process কে accomodate করানো যায়নি, at a time একটা process accomodate হতো তখন cpu I/O এ সময় idle বসে থাকতো। তাই properly used হয়নি।

job execution instead of program execution

Program
↓
Input Data
↓
Control Instruction
Job

Similar type এর job কে একসাথে করে।

একসাথে job operator এর কাছে দেয়া নিতান্ত,
Operator, similar type এর job গুলোকে একত্রে batch আকারে produce করে batch আকারে input নিতো।

এখানে সময় OS এ "মুর্দ্ধিমান একটা job শেষ হলে তৎ job এ automatic switch করার ছিল এ সমস্যা OS এর intelligence.

example: User prepares his job on an offline device like punch cards and submits it to the computer operator. To speed up processing, jobs with similar needs are batched together and run as a group.

Advantage:
- Saves time that was being wasted earlier for each individual process in context switch from one environment to another.
- No manual intervention needed.

Disadvantage:
- Executing a series of non-interactive jobs all at one time.

- The output is obtained only after all the jobs are executed.
- Priority can't be implemented if a certain job has to be executed on urgent.

Limitations:

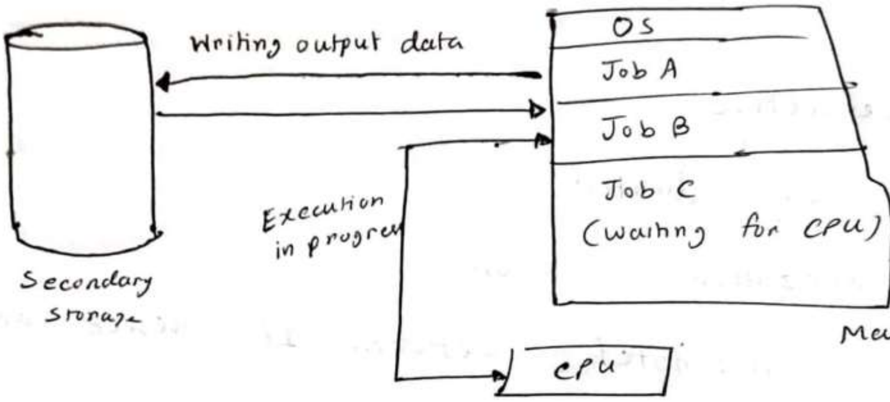
- Not interactive
- Memory was limited
- CPU utilization poor.
- Speed mismatch between I/o device and CPU

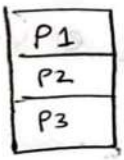
Multi-Programmed Operating System

Mechanical I/o device were very slow than the CPU. Even a slow CPU working in micro second rate. was very fast than I/o device.

Multi-Programmed OS:

- Multi programming needed for efficiency and CPU utilization.
- Means more than one process in main memory which are ready to execute.





Currently CPU, P1 execute হচ্ছে। P1 execute হবার P1 যখন output দিবে তখন P1 এর সময় লাগবে। তখন CPU P2 কে access করতে পারে। তখন CPU idle হয়ে থাকবে না, main mem এ space বাড়ার জন্য CPU এর কাছে সবসময় কোনো না কোনো কাজ execute করার জন্য থাকে,

Main mem size বাড়ানো হয়েছে এবং secondary mem concept add করা হয়েছে। as a result main mem এ অনেকগুলো job কে রাখা সম্ভব হয়েছে

- Single user can't keep CPU and I/O devices busy at all times.

- Multiprogramming organizes jobs (code & data) so CPU always has one to execute.

- A subset of total jobs in system is keep in memory.

- Process generally require CPU time and I/O time, when CPU has to wait (for I/O for example), OS switches to another job and this idea will continue.

multiprogramming system এর approach হলো ~~non primitive~~ non-preemptive approach হলো,

ধরে নিই, CPU currently job A execute করছে, এখন job এর input দরকার বা কিছু input file থেকে read করা প্রয়োজন, যখন সে input/output নিতে ব্যস্ত CPU idle বসে থাকবে না, তখন যেহেতু Job A input/output নিয়ে ব্যস্ত; তার মানে তার CPU দরকার নাই, তখন CPU switch করে M.M এর মধ্যে যে অন্য কোনো job আছে তাদের মধ্যে অন্য job এ switch করে ঐ job execute শুরু করবে, multiprogramming এই approach এ কাজ করে,

প্রত্যেকটা process তার lifetime এ 2 ধরনের জিনিসের দরকার হয়,

- CPU Time → লাগাতার কাজ টা execute করার জন্য.
- I/O Time → Input নিতে পারতে হবে ও output দিতে পারতে হবে,

CPU bound process হলো সেইসব process যার সমস্ত কাজ শুধু CPU তে হয়

maximum process এর CPU time & I/O time লাগে,

Several jobs are kept in the main memory at the same time, and the CPU is multiplexed among them.

"same time এ অনেক job mem এ ready অবস্থায় রাখা হয় CPU তাদের মধ্যে multiplexed করে কাজ করে।"

☐ CPU কোন অবস্থায় এক proc থেকে অন্য proc এ যাচ্ছে?

⇒ যখন একটা job এ CPU এর ~~[illegible]~~ দরকার নাই; তখন CPU ঐ job থেকে switch করে অন্য job এ যাবে। এই approach known as non-preemptive approach। That means কোনো এক job execute হচ্ছে; তার কাছে CPU আছে; execute করার পর CPU লাগবে এইসময়ে CPU অন্য process এর কাছে- চলে যায় না, যতক্ষণ পর্যন্ত এই job এর CPU লাগবে ততক্ষণ পর্যন্ত সে CPU কে hold করবে, যখন they don't need CPU at that time then switch to another process

#P2 কে কখন execute start করছে তা হলো তার response time

Advantages:

- High CPU Utilization.
- It appears that many programs are alloted CPU almost concurrently
- Response time is shorter.

Disadvantage.

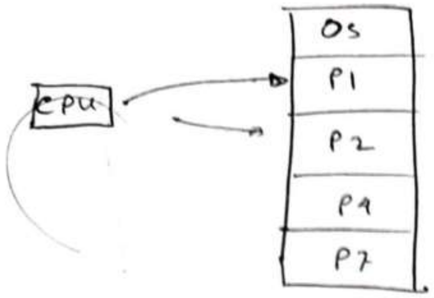
- CPU Scheduling is required
- To accomodate several jobs in memory, memory management is essential

Multi-programmed systems provide an environment in which the various system resources (like CPU, memory and peripheral devices) are utilized effectively but they do not provide for user interaction with the computer system.

> "Job 1 এর যখন I/O দরকার তখন CPU পরবর্তীতে Job 2 কে যাবে না Job 3 কে যাবে এই decision নেওয়া tough।"

Multitasking / Time - Sharing Systems - Interactive Computn.

- Multitasking is multiprogramming with time sharing where CPU executes multiple jobs by switching among them
- Timesharing (multitasking) is logical extension of ~~multiple~~ multiprogramming, in which CPU switches jobs so frequently that user can interact with each job while its running, creating interactive computing.
- OS is able to keep track of where you are in the tasks and go from one to other without losing information.
- Response time < 1 second.
- Requires interactive computer system, which provide direct communication between the user and the systems
- Multitasked OS allows many users to share the computer simultaneously.



M.M

Processes are executed by CPU in preemptive approach

for examele cpu যখন প্রথমে P1 কে 2 second execute করবে then P2 কে 2 second then P3 কে 2 second তারপর P7 then আবার serially P1, P2, P4, P7 এ switch করতে থাকবে 2 second অন্তর অ,

∴ সবার মধ্যে equally time share হচ্ছে, diff. process এর মধ্যে switch করে করে execute করে,

Multiple programming এ interactive ছিল না বা এখন interactive.

এত fast switching হয় যে মনে করে cpu মনে হয় ও কাজই করছে,

Multitasking system এ preemptive approach ফলো করে. cpu কোন process execute করতে করতে তোমার cpu কে লাগবে but তাও যে cpu কে switch করানো অন্য process এ চলে যায়, (forcefully)

"একটা নির্দিষ্ট সময় পরপর cpu must switch. একটা process এর কাজ শেষ হল কি হল না তা তার মাথাব্যথা না."

এখন আমরা single processor architecture নিয়ে।

Advantage:

- Create interactive computer environment.
- Response time is less than 1 second.

- Each user has at least one seperate program for executing in memory.

- **Process**

  A program loaded into memory and executing is called a process

  ⇒ Job scheduling
  ⇒ CPU scheduling
  } Multitasking এ হয়ে থাকে

  একটা program secondary mem. থেকে যখন main mem. এ load হয়ে আসবে তখন তাকে process বলে।

- If process doesn't fit in memory : swapping moves them in and out to run from main memory to achieving goal is virtual memory.

Computer System Architecture

- Single Processor System
- Multiprocessor / Parallel System
- Clustered System

Single Processor System.

- Only one general purpose CPU
- Other special purpose processors are also present- which perform device specific task.

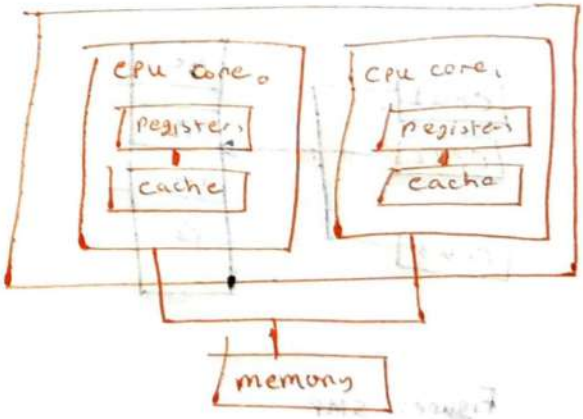
Multiprocessor / Parallel System :

- More than one CPU in close communication
- All the CPU can work parallely.

computer → multiple processor

Tightly Coupled System.

- Processors share memory and a clock;
- Communication usually takes place through the shared memory.



- **Advantages**
  - increased throughput (working capability)
  - economy of scale
  - increased reliablity.

Two type of multiprocessing system.

(i) Symmetric Multiprocessing (SMP)

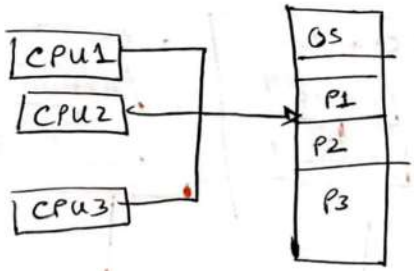
(ii) Asymmetric Multiprocessing (ASMP)

Symmetric Multiprocessing (SMP)

- each processor runs an identical copy of the OS.
- Most modern operating system supports SMP.

Asymmetric Multiprocessing (ASMP)

- each processor assigned for specific task.
- master processor schedules and allocate work to slave processor.



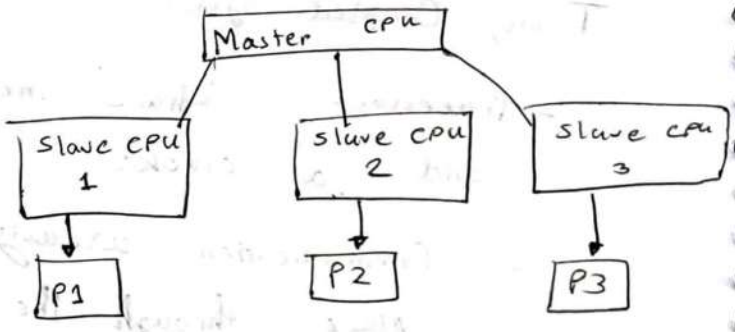


Figure: SMP

processor, main mem.

process

pick

execute

independent of each other

বর্তমানে SMP use করা হয়,

Distributed System:

- A Distributed Operating System is the software over a collection of independent, networked, communicating and physically seperate computational nodes

- is a model where the distributed applications running on networked computers communicate and co-ordinate their action by simply passing messages.

- The application ~~[illegible]~~ on this networked computer work toward achieving common goal

- Load balancing, Computation Speed Up, Remote Data Access possible.

- Goals are: connecting user and resources, transparency and reliablity

different computers একটা network এর মাধ্যমে connected থাকবে এবং একটা central System (Central Computer, Central Server) থাকবে, তার OS ~~[illegible]~~ দিয়ে প্রত্যেকটা computer ও distributed ভাবে কাজ করবে।

Clustered Systems.

- Cluster Computing is the process of sharing the computation tasks among multiple computers and those computers or machines form the cluster.

- It works on the distributed system with networks.

- Popular implementation of Cluster Computing.
  - Google Search engine
  - Earthquake Simulation

- Composed of two or more individuals systems coupled together share common storage and are closely linked through LAN.

- Can be structured asymmetric or symmetric.

- Several type of clustered computing are used based on the business implementation, performance optimization and architectural preference, such as
  - load balancing clusters
  - high availability Clusters (HA).
  - high performance (HP) Clusters.

Advantages:

- Processing speed
- Cost efficiency
- Scalability
- High availability of resources

... device ... they are connected to each other. sharing storage

Difference between Cluster & Distributed

Cluster System ... distributed system ... network ... connected

Cluster System - sharing common storage device

Distributed - sharing common OS working under a common system

Real time System (RTOS):

⇒ also known as. RTOS

- RTOS is an operating system. it's a brain of the real time System. and it response to inputs immediately
- In RTOS, the task will be completed by specified time and its responses in a predictable way to unpredictable events

Real Time System:

- Often used as control device in a dedicated application such as controlling scientific experiments, medical imaging systems, industrial control systems, and some

display systems. Mostly used in Real time application

কাজ হচ্ছে.

- immediate বা Quick action দেওয়া.
- যেকোনো একটা হওয়া মানে immediately and quickly decision নিতে হবে. no option for delay.
- you can't afford delay in operation.

OS Service.

- OS provide an environment for execution of program and services to programs and users.

- One set of OS services provides functions that are helpful to the user.

- **User Interface.**

  Command Line (CLI) Interface, Graphics user Interface (e.g. GUI), Batch interface in which commands and directives to control those commands are entered into files and those files are executed.

- **Program execution**

  The system must be able to load program into memory and to run that program, end execution either normally or abnormally

- **I/O operations.**

  A running program may require I/O, which may involve a file or an I/O device.

- **File System Manipulation:**

  Programs need to

  - read and write file directories,
  - Create and delete them,
  - Search them.
  - list file info,
  - permission management

- Communication..

- may exchange info on same compute or between computers connected through a network.

- Communicat.. may be via shared memory or through message passing

- Error Detector:

- OS needs to be constantly aware of possible errors,

- may occur in CPU and memory hardware, in I/O devices, in user program

- for each type of error, OS should take appropriate action to ensure correct and consistent computing

- Debugging facilities can greatly enhance the users and programmer's abilities to efficiently use the system

- Another set of OS function exists for ensuring the efficient operation of the system itself via resource sharing.

- Resource Allocation:

When multiple users or jobs running concurrently resources must be allocated to each of them.

many types of resources — CPU cycles, main memory, file storage, I/O devices

- Accounting:

To keep track of which users use how much and what kinds of computer resources

- Protection and Security:

The owners of information stored in a multiuser or networked computer system may want to control use of that information, concurrent processes should not interfere with each other.

- Protection involves ensuring that all access to system resources is controlled.
- Security of the system from outsiders requires user authentication, extends to defending external I/O devices from invalid access attempts

OS Structure

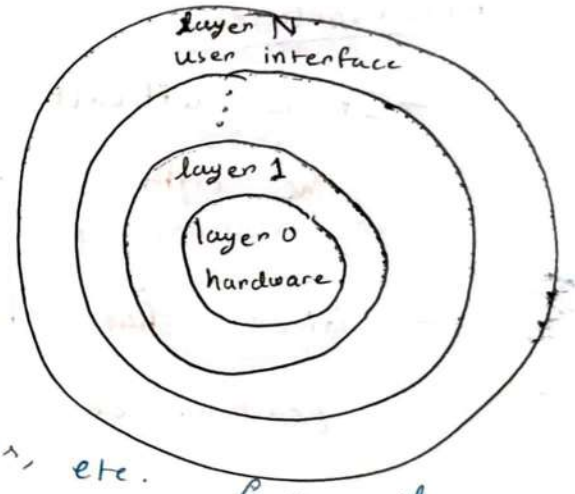
- An operating system is a ~~structure~~ construct that allows the user application program to interact with the system hardware. Since it's to complex so it must be created with utmost care. so it can be used and modified easily. An easy way to do this is creating the OS in parts. Each of these parts should be well defined with clear inputs, output and functions.
- General Purpose OS is very large program
- Various way to structure ones
  - Simple Structure / Monolithic kernel (MS-DOS)
  - Layered (an Abstractions)
  - Micro kernel (Mach)

Simple / Monolithic Structure

- Earliest and most common architecture
- Every component of OS is in the kernel and can communicate with each other individually. (directly)
- Complex and large (million lines of codes), hard to maintain

Layered Structure

- Bottom layer is hardware & topmost layer is user interface



- Each upper layer is built upon the bottom layer. All the layers hide some structures, operations, etc. from them

✓ - Each layer can use services of its lower layers.

- All the layers can be defined seperately and interact with one another as required

∴ Disadvantage is that each layer needs to be carefully defined.

✓ - Easy to debug and develop.

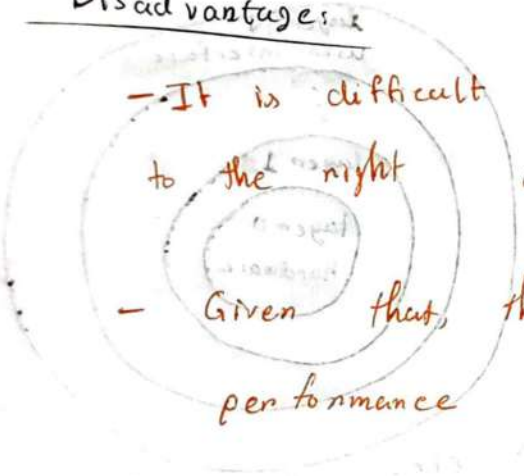
- less efficient as layer adds some overhead

Advantages:

- easier to create, maintain and update the system if it's done in the form of layers.
- Change in one layer specification doesn't affect the rest of the layers.

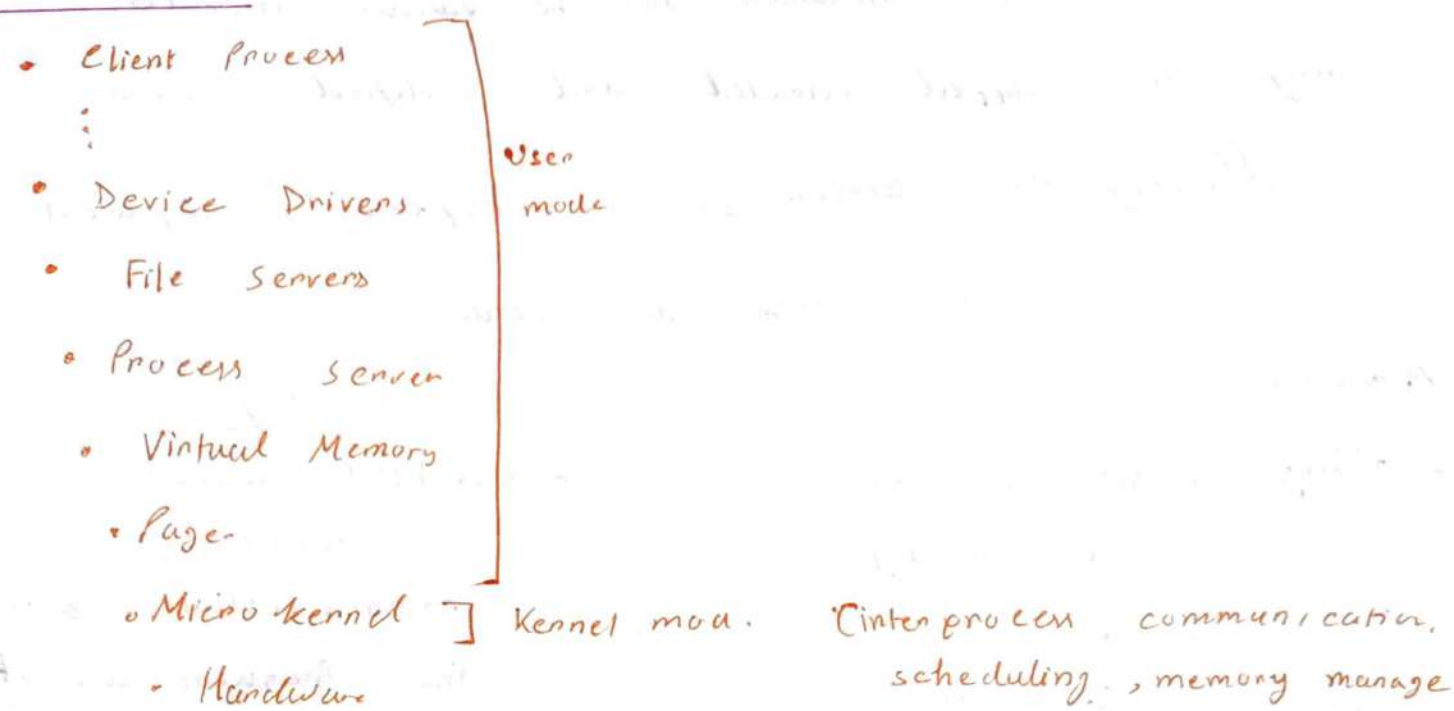
Disadvantages:

- It is difficult to precisely assign the function to the right and the appropriate layers.
- Given that, there are too many layers, performance on the system can be degraded



- User } User Mode
- File Systems
- Inter process Communications.
- I/O and device management.
- Virtual memory.
- Primitive process management. } Kernel Mode
- Hardware

Micro kernel :



- Moves as much from kernel to user space.
- Communication takes place between user modules using message passing.
- Easier to extend a micro kernel.
- More reliable (less code running in kernel mode) and secure.
- Performance Overhead.
- Ideally kernel is so small that it fits in first level Cache.

Micro kernels are modulars and the various modules may be swapped, reloaded and modified without affecting the kernel. It is expensive compared to monolithic system architecture.

Advantages

- Adding a new service doesn't require modifying the kernel
- More secure as more operation are done in user mode than in kernel mode.
- Simpler kernel design and functionality typically results in a more reliable operating system

Disadvantages

- Overheads associated with interprocess communications and the frequent use of the operating systems messaging function in order to enable the user process and the system service to interact with each other.

A view of operating system Service

- User interface
  - GUI
  - Batch
  - Command line
- System Calls
- Services
  - Program execution
  - I/O operation
  - error detection
  - file systems
  - Communication
  - Resource Allocation
  - Accounting.
  - Protection and Security

OS Operation

- OS is interrupt driven
  - Hardware interrupts
    - Occurs by one of the device
  - Software interrupts (exception or trap)
    - Request for OS service.
    - Software error
    - A trap is a software generated interrupt caused either by an error or a user request

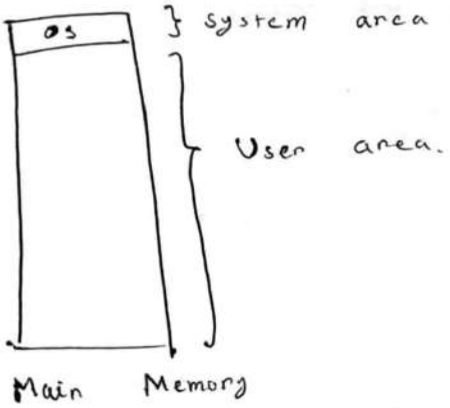
☑ We know modern OS are interrupt driven

- Hardware generates input.
  - Many errors detected by hardware can be handled by OS.
- Software error handled by exception or trap.
  - A trap (or an exception) is a software generated interrupt caused either by an error (for example, divison by zero. or invalid memory access) or by a specific request from a user program that an OS service need to be provided

"With sharing many processes could be adversely affected by a bug in one program. Since the operating system and the user program share the hardware & software resources of the computer system. A properly designed OS must ensure that an incorrect program can't run and also cant cause other programs to execute incorrectly.

OS Operation protection

- in order to ensure the proper execution of OS, we must be able to distinguish between the execution of OS code and user defined code.



- OS এর code সবসময় main mem এ থাকে।
- User area এর সাথে system area distinguish থাকে।
- System area টা locked access.
- System code সবসময় run হয়, User দরকার হলে user mode এ কাজ করে, সবসময় না.

- না হয় User — kernel mode এ কাজ করে OS cracked হয়ে destroyed হয়ে যায়.

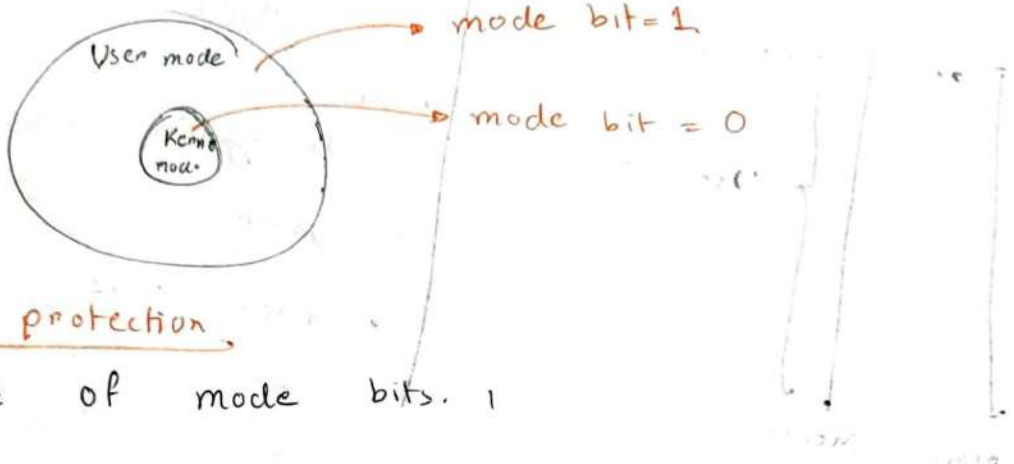
interrupt driven বলতে বোঝানো হবে interrupt handle করতে পারা বুঝায়।

Hardware Protection

- The approach taken by most computer system is to provide hardware support that allows us to differentiate among various models of execution.

Why we need dual mode operation ?

⇒ " We need dual mode operations as it ~~provide~~ allows security to the OS to protect itself and other system components. (hardware resources.)



Dual mode protection

2 type of mode bits.

- User mode / Safer mode
- Kernel mode / priviledge mode

mode bit provided by hardware.

- provides ability to distinguish when system is running user code or system code.
- Some instructions designated as priviledged, only executable in system mode.
- System call changes mode to kernel, return from call resets it to use.

Why Kernel mode is priviledge mode?

⇒ resource use করতে Kernel mode এ লাগে, যেকোনো resource use করতে চাইলে kernel mode এ কাজ হয়। then সেই আবার user mode এ চলে যাবে। তাই kernel mode is also called priviledged mode.

Why user mode is Safe mode?

⇒ User mode এ থাকা অবস্থায় system crash করলে তাহলে তা Overall computer এর উপর কোনো effect করবে না; তাই user mode is also called safer mode.

System Calls

- A system call is a way for programs to interact with the OS.
- A computer ~~makes~~ program makes a system call when it makes a request to the OS Kernel. System call provides the services of the operating system to the user program via Application program interface (API).