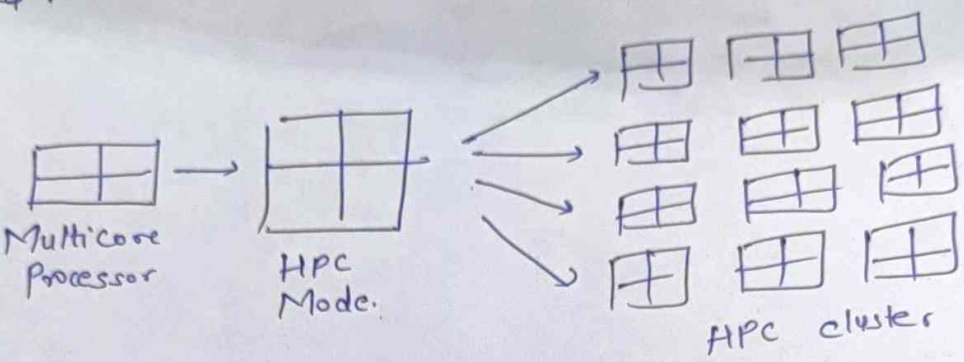
HPC

→ Refers to use the powerful computers & ||el processing techniques to solve complex computation problem at very high speed.



HPC Architecture

Need of HPC :-

1) Complete a time consuming operation in less time.
2) Peoform a high numbers of operations per sec.
3) Compute in ||el over lot of computation elements CPU, GPU etc. [fast computing]

Computational Thinking

~~→ It is the step tha~~

→ It is a problem-solving approach that involve breaking down problem into smaller, manageable parts & designing step by step soln

Components :- (1) Decomposition (Breaking Large problem into smaller part)
(2) Pattern recognization (Finding similarities in data or problem)
(3) Pattern Generalization
(4) Abstraction (focusing only essential details)
(5) Algorithmic design. (creating a clear step by step soln to solve the problem)

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Computing

→ It is a process of performing Large scale, complex Calcutions or data processing task at very high speed.

→ It uses the powerful computing resource like multi-core CPUs, GPUs & clusters of computers to perform computations in ||el, solving complex problem faster & more efficiently

Type of computing:-

1) ||el computing
2) distributed computing
3) GPU Computing
4) cluster computing

Parallel programming software & its significance

(3)

→ In parallel programming, task are parallelized so that they can be run at same time by using multiple computers (or) multiple cores within a CPU.

→ It is critical for Large scale projects in which speed & accuracy are needed.

Moore's Law is the observation that the no. of Tx'lor's in an Ic doubls about every two years.

In recent physical Limitation such as heat dissipation, power consumption & quantum effects have slowed down this trend.

Need of parallel programming :—

With the rise of multicore processor, simply writing sequential programs no longer fully utilize the hardware capabilities of Moodern systems.

llel programming allows us :—

1) divide Large problems into smaller subtasks.
2) Execute multiple task simultaneously.
3) Reduce execution time significantly.
4) Leverage multi-core, GPU & distributed architectures.

Task that benifit from parallelism :—

1) Scientific computing & simulations :—
   - Weather forecasting
   - Molecular dyam dynamics
   - Finite element analysis.

2) Big data & Machine learning
- Data processing in ||el.
- Training deep learning models on GPU's.
- Real time analytics over a Large datasets.

3) Image & signal processing
- Edge detection, filtering.
- Medical Image reconstruction.

4) Games & graphics
- physical simulations.
- AI behavior modeling.
- Rendering 3D scenes.

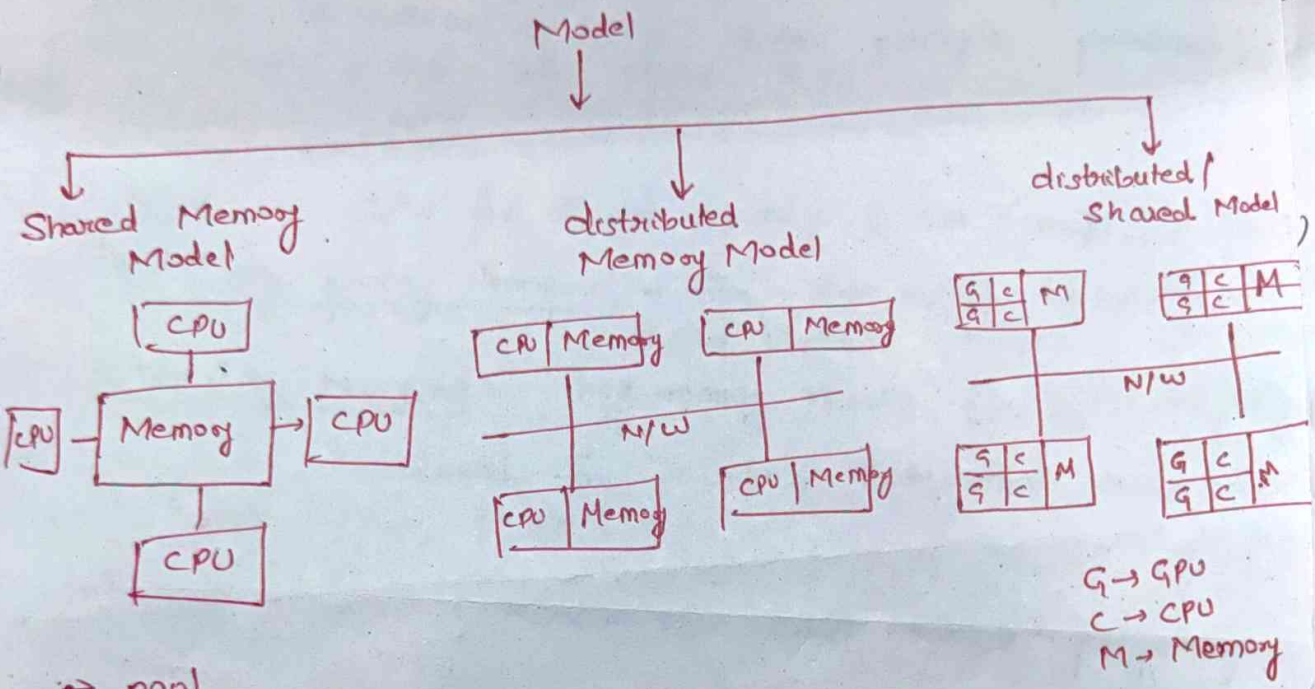
5) Search & optimization.
- ||el graph algorithms.
- Genetic algorithm.
- Large scale data mining.

Key benifits of ||el programming :-

1) speed up.
2) Scalability :- Efficient use of hardware with ↑sing data & problem size.
3) Resource Utilization :- Maximize CPU, GPU & memory B.W.
4) Responsiveness :- Enable real time systems to respond faster.

How parallel computation Works :-

llel computation connects multiple processor to memory that is either pooled connected via high speed Network.



⇒ pool

Tools :- Open MP
MPI

Parallel Programming software & its significance

Ilel program s/w refers to tools, Languages (or) frameworks that allow a program to execute multiple tasks (or) instruction simultaneously by using multiple processors, CPU core, threads (or) GPU.

1) OpenMP (multiprocessing) → API for shared memory Ilelism (multicore CPUs)
2) MPI (Msg passing Interface) → For distributed computing across multiple system.
3) CUDA (by NVIDIA) :- Programming model for GPU computing.
4) OpenCL → Framework for writing code that runs on computing Language both CPUs & GPUs.
5) Pthreads → POSIX threads (low level thread program)

Significance :—

1) Faster Execution.
2) Efficient use of multicore processor.
3) Scalability
4) High performance for complex applications)
5) Energy & cost efficient.

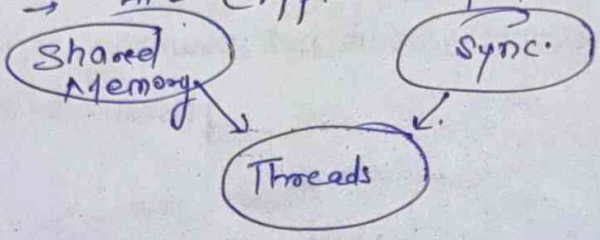
MPI :- For process level parallelism across diff. machine (Msg passing interface) & processor.

OpenMP :- For thread level llelism inside each CPU procm. (Open Multithread) → Shared Memory

CUDA :- For massive data llelism inside GPU. (Compute unified device architecture)

:- llel computing plateform ; C, C++, Fortan

→ API (Application program Interface)



Cloud computing

→ Means delivering computing services like storage, ~~services~~ servers, databases, N/w'ing & software - over the internet (the cloud)

→ Cost efficient, scalability, accessibility from anywhere & reduced hardware requirement

e.g:- Google drive / dropbox, Streaming services (Netflix, Spotify) etc.

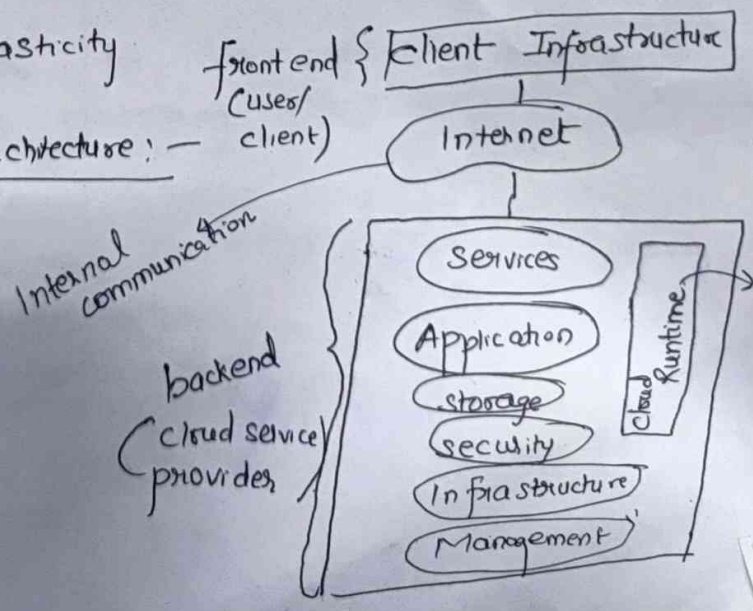
Major cloud providers

1) Amazon web services (AWS)
2) Microsoft Azure
3) Google cloud platform (GCP)
4) Saleforce
5) Alibaba cloud
6) IBM cloud
7) Oracle cloud

Key characteristics :-

1) on-demand self service
2) Pay as you go pricing
3) Broad N/w access
4) Resource pooling
5) Scalability & elasticity

Cloud Computing Architecture :-



Iaas :- (Infrastructure as a service)

→ Provide access to IT tools like virtual computers, storage & N/w through Internet
- → operating System
- → virtual machine & storage
- → IP addresses
- → Provides Infrastructures
- → Enhanced Scalability
- → Flexible

e.g :-
AWS Login
↓
compute
↓
EC 2

Paas (Plateform as a service)

→ 3rd party provider offers the s/w & hardware tools needed to develop, test & Run
- → Developers use it
- → No access of OS, Middleware, virtual machine.
- → access of user Inteoface provided.
- → offers development & deployment tools.
- → No need to purchase expensive H/w & s/w.

e.g :- Google app engine.

Saas (software as a service)

→ Like s/w over internet
- → on demand
- → end users / clients
- → No need to install on PC
- → Server / Resources Managed by vendor
- → Plateform independance. (window, Linux)

e.g :- Google Workplace, Saleforce, Google Doc

Faas (funcn as a service) :-

→ allows customers to run code in response to event, without managing the complex infrastructure.

e.g :- AWS Lambda, Resizing the Image

Cloud deployment Models

↓

- Private cloud
- Public cloud
  - → pay as you go
- Hybrid cloud

Model

Public

→ servers, storage & applications are owned by 3rd party provider (e.g:- AWS, Microsoft Azure, google cloud) & deliver over Internet

Private

→ used exclusively by one organization

→ It can be hosted either on-premises (or) by a third-party provider, but Infrastructure is dedicated to a single customer

e.g:- NASA

Hybrid

→ combination of public & private clouds

e.g:- IBM

Grid computing

→ It is a distributed architecture that combines computer resources from different locations to achieves a common goal.

→ It break-down task into smaller subtasks, allowing concurrent process.

→ It can be defined as N/w of computers working together to perform a task that would be difficult for a single machine. & it is a subset of distributed computing.

→ All machine on the N/w work under the some protocol to act as a virtual supercomputer.

Importance of grid computing:-

1) Scalability
2) Resource ultilization.
3) complex problem solving
4) Collabration
5) Cost saving

Working of grid computing:-

3 main parts of grid computing N/w

1) Control Node
2) Provider
3) User.

Control Node:- group of servers / powerful computer.
- Manage the whole N/w.
- Keep track of all available resource in the N/w.

Provider :— A computer the - Share its resources like processing power storage etc to the N/w.

User :- A computer that uses the shared resource from the N/w.

Working :—

→ When user computer Need extra resources, it send a request to control Node.

→ The control Node allows it to use available resources from the N/w.

→ When computer is not using resources from the N/w, it can act as a provider based on its needs.

Network in grid computer :—

Homogenous N/w

→ All machines have same hardware/ OS

Hetrogenous N/w

→ Machine have different hardwar & OS

→ Middleware (special computer. s/w the connects different computer in grid, manages resource & make them work together smoothly) ~~controls & m~~ is used for execution.

Application :—

Genomic research
Drug discovery
Cancer Research.
Risk Analysis
Animation & visual effects.
Collaborative project.

Advantages :—

→ High Resource ultization.
→ Hel processing
→ Scalable.

Disadvantage :—

→ Introduced complexity.
→ Limited flexibility
→ Security Risk.