Cloud Computing

UNIT-1

- ⇒ High Performance Computing
- ⇒ Parallel Computing
- ⇒ Distributed Computing
- ⇒ cloud Computing
- ⇒ Bio Computing
- ⇒ Quantum Computing
- ⇒ Mobile Computing
- ⇒ Optical and Nano Computing
- ⇒ Difference Between parallel and Distributed Computing
- ⇒ Advantages of Distributed Systems over Centralized Systems
- ⇒ Distributed System models
- ⇒ cluster Computing, Principles and Objectives
- ⇒ Grid Computing

High Performance Computing

High performance Computing (HPC) refers to the use of multiple processors (CPUs) working together with resources such as memory, storage, input/output devices to solve complex and large-scale problems.

⇒ In high performance Computing, processors can either be the same type (homogeneous processors) or different type (heterogeneous processors).

⇒ In the past, when we talked about high performance Computing, we usually meant Super Computers, which are very powerful machines used for heavy calculations

⇒ Now, high performance Computing also includes Smaller Systems like regular Computers (like desktop PCs) these can be found in places like Schools, offices, etc...

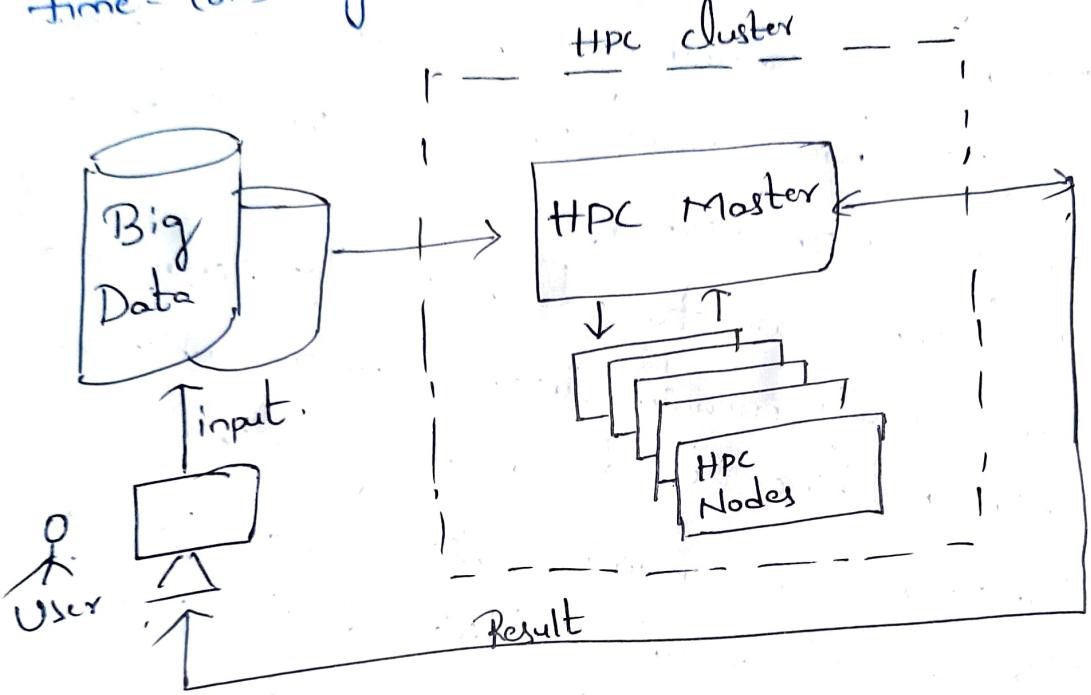
⇒ In Science, there are very Complicated tasks that need a lot of Calculations. For example:

Protein Folding:- This is the process of how Proteins take Shape. Understanding this can help Scientists develop new medicines.

Nuclear Fusion Models:- Scientists Study how to Create energy from nuclear fusion (the process that powers the Sun) to find better energy Sources. this involves lots of data and Complex Calculations.

Regular Computers may not have enough power to handle these Complex tasks quickly. High performance Computing Systems are Designed to work on large problems by Splitting the work across multiple processors.

⇒ HPC enables faster and more efficient problem-Solving by Using the Combined power of multiple Computers to handle tasks that would be too large or time-Consuming for a Single Computer to manage.



Parallel Computing

Parallel Computing is when many processors (CPUs) work together at the same time to solve one big problem. All the processors are usually similar and connected to each other.

Serial Computing is like doing things step by steps.. A single processor does one instruction after another. Serial Computing is also known as Sequential Computing.

⇒ Parallel Computing is a part of High-Performance Computing (HPC). In parallel Computing, many processors (CPUs) work together to solve one big problem. these processors are usually the same type (homogeneous). This setup can include Super Computers with hundreds or thousands of processors connected to each other.

Uses of parallel Computing

(1) **Saves time and money**:- By using more CPUs at the same time, a task can be finished faster. This can also save money, especially since you can build parallel Computers using cheap parts.

(2) **Solves bigger problems**:- Some problems are too big or complicated for one Computer to handle, especially if it doesn't have enough memory. Parallel Computing helps solve these big problems.

(3) **Does multiple things at Once**:- A single Computer can only do one thing at a time. But with parallel Computing multiple Computers can work on different tasks at the same time.

(4) **Uses resources from different places**:- if your local Computers are busy, you can use Computers from other places (using internet) to help get the work done.

Computational grid :-

A Computational grid is a System made of both hardware and Software that allows many Computers to work together. It gives reliable, Consistent, and low-Cost access to powerful Computing.

Reliable :- If one Computer fails, others keep working, So the task gets done.

Consistent :- you get the Same performance each time because the work is shared across many Computers.

Low-Cost :- Instead of buying an expensive Computer, you use many cheaper Computers working together, Saving money.

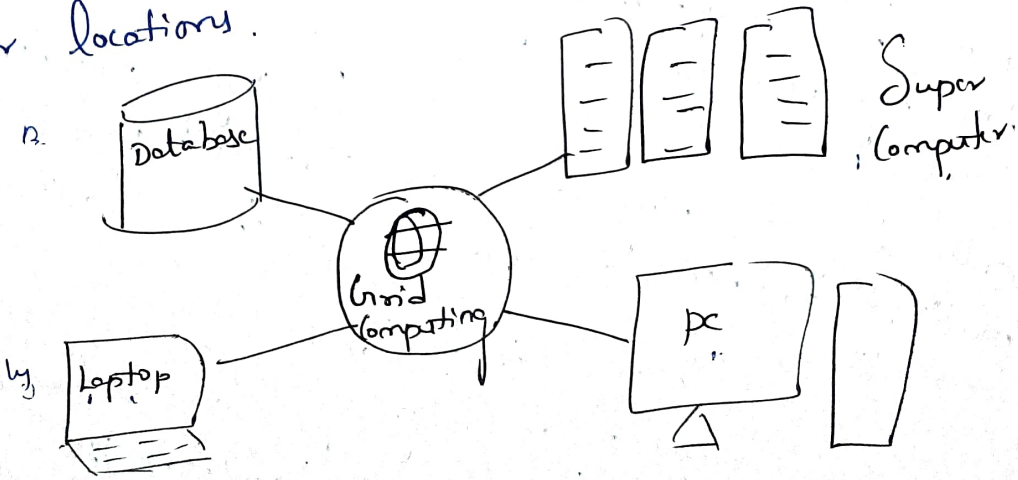
In a Computational grid :

→ Many Computers are Connected in a network to share the work.

→ A big task is broken into Smaller tasks, and each Computer (called a node) works on one part of the task at the Same time.

→ After finishing, each Computer Sends its result back to the main Computer.

→ These Computers may also belong to different Organizations or locations.



Distributed Computing

⇒ Distributed Computing is a System where multiple Computers work together as if they are like one Single Computer. These Computers can be close together, Connected by a local network, or far apart, Connected through the internet. they can be different types of Computers, Such as desktops, laptops, or large machines like Servers.

⇒ The main goal of distributed Computing is to make all these Computers work together to Solve tasks faster and more efficiently. It's like dividing a big task among a group of people instead of having one person to do all the work.

Two key benefits of distributed Computing are :-

1) Scalability :- You can easily add or remove Computers from the System Without distrubing the Current work. It makes it easier to handle more work as the System grows.

2) Redundancy :- Multiple Computers can perform the Same tasks, So if one fails, the others can continue working, ensuring that the System keeps running Smoothly.

This Setup helps make Computing more flexible, reliable and faster.

↳ dependable
↳ no other Computers if one fails

↳ add or remove Systems based on needs.

Difference Between Parallel and Distributed Computing

Parallel Computing

→ Different types of processes can be done simultaneously.

→ A single computer can be used for parallel computing

→ Parallel system consists of multiple processors which help in the performance of multiple operations

→ parallel computing supports shared or distributed memory.

→ Bus communication is used within a computer to allow different processors or components to communicate with each other

→ System performance can be improved easily through parallel computing

→ Scalability and fault tolerance is limited

→ A single thread can be used to manage all the tasks

Distributed Computing

→ a single task is distributed among the systems.

→ A distributed computing system needs a lot of computers.

→ Multiple operations are performed by multiple computers in distributed computing.

→ Distributed computing has distributed memory.

→ Message passing is a method used in distributed systems for communication. Computers sends messages to each other over a network to coordinate or share data

→ Fault tolerance, System Scalability, Resource sharing capabilities improves through Distributed computing

→ High Scalability and fault tolerance is comparatively much more

→ Computers in distributed system coordinates with each other by using advanced mechanisms.

Advantages of Distributed Systems over Centralized Systems

① **Economics**:- Using many small computers is usually cheaper and gives you better performance than using one big computer.

② **Speed**:- A distributed system can have more total computing power than a single mainframe computer, so it can handle tasks faster.

③ **Inherent Distribution**:- Some applications are naturally spread out over many locations. For example, a supermarket chain needs to manage stores in different places making a distributed system a good fit.

④ **Reliability**:- If one computer in a distributed system crashes or fails, the whole system can keep running.

⑤ **Incremental Growth**:- you can add computers if needed.

Disadvantages:

① **Software**:- it can be more difficult to develop software for distributed systems because you have to manage multiple computers working together instead of single.

(2) Network Issues:

Problems can occur with the network, like slowdowns or data getting lost during transmission. This can affect performance and reliability.

(3) Security:

Because many computers are connected, it is more challenging to keep data secure in a distributed system.

Distributed System Models:

Distributed systems are made up of many independent computers (called nodes) that work together. These nodes are connected through different types of networks, like:

- SANs (Storage Area Networks)
- LANs (Local Area Networks)
- WANs (Wide Area Networks)

This setup allows them to communicate and share resources effectively.

How LANs and WANs are Connected:

LANs :- A few LAN switches can easily connect hundreds of computers to form a working group, known as cluster.

WANs :- A WAN can connect multiple local clusters, creating a much larger network that can have millions of computers working together.

There are different models for how these distributed systems can be organized:

① clusters of Cooperative Computers:

This is a group of Standalone Computers that work together like a Single Computer. they share resources like Storage and are Connected by high-Speed networks (like SANs or LANs)

② Grid Computing:

Grid Computing Combines resources from different Organizations to provide Computing power or data Services. it Can be divided into two types. (WAN)

① Computational Grids: these focus on providing Computing resources.

② Data Grids: these focus on sharing and managing large amount of data.

③ Peer to peer (P2P) Networks:

→ In a P2P System, every Computer acts both as a Client and as a Server. All machines Can join or leave the network freely.

4) Overlay network:

An Overlay network is a Virtual network Created on top of an existing network.

(4) Cloud Computing:

Cloud Computing is a type of distributed System that allows users to access Computing resources over the internet. It can be able to grow easily, Self recovering and highly flexible.

Cluster Computing

A Computer Cluster or cluster Computing is when Several Computers (called nodes) are Connected together to work as one powerful System. These Computers are Usually the Same type, and they are linked through a network. They share resources like files and have special Software that helps them work together on the Same task.

This type of Setup is part of high-performance Computing (HPC) because the Computers work together to Solve big problems that one Computer alone Cannot handle. For them to Cooperate, they need to Communicate with each other through the network.

If the cluster has Computers of different types (called a heterogeneous cluster), it becomes a more Specialized Version of cluster Computing, but it's Still mostly used for research or experiments.

Design Principles of Computer clusters :-

① Single-System Image (SSI) :-

when you use a cluster (a group of Computers working together), it looks and behaves like one Single System to Users, even though it has many processors and Computers.

② Single Job Management System:-

All the jobs (tasks) in the cluster are handled by one Central System, and you can submit tasks from any Computer in the cluster.

③ Single User Interface:

you access the cluster Using a Single, easy-to-use graphical interface (like the desktop on your Computer).

④ Reliability, Availability, Serviceability:

- **Reliability**: how long the cluster can run without failing or breaking down
- **Availability**: the percentage of time the System is working and available for use
- **Serviceability**: how easy to fix, maintain, or upgrade the cluster.

Design Objectives of Computer clusters:

① **Scalability**: you can grow or expand the cluster by adding more Computers (nodes) to it.

② **Packaging**: the Computers in the cluster can be packed tightly together in one location. but it may require more cooling to control heat. and Sometime Computers are placed in different locations to reduce heat, but Connecting the Computers might be Complex.

③ **Control**:
- **Centralized Control**: one System or person Controls all the Computers in the cluster
- **Decentralized Control**: Different Computers in the cluster are owned and Controlled by different people.

④ **Homogeneity**: All the Computers in the cluster are the Same in terms of hardware and Software.

⑤ **Security**: How the Computers in the cluster Communicates with each other, it can be exposed cluster or Secure cluster.

Grid Computing

Grid Computing is a distributed Computing model that Connects multiple Computers or Servers across different locations to work together as a Virtual Supercomputer.

⇒ Many Organizations have Computers that aren't being used fully all the time. Grid Computing takes this unused power from different Computers and allows other Organizations or Users to borrow it to perform tasks. this increases the value of their investment.

How Grid Computing works:

Middleware:- A Special Software Called middleware Connects many Computers or Servers across different locations.

Grid Services: The middleware also Controls access to these Shared Computers, provide Security and gives Users access to files, data and large Storage remotely.

Advantages:

1. **Cost effective:-** Make use of idle Computers, So no need for extra investment.
2. **High performance:** Can Solve Complex problems by using multiple Computers together
3. **Collaboration:** Different Computers Can work together Smoothly to Solve Comman task.

Cloud Computing

Cloud Computing is the delivery of IT resources like Servers, Storage, databases, networking, Software and over the internet. Instead of buying and managing physical hardware or Software, Users access these resources remotely from cloud providers like Amazon web Services (AWS), MicroSoft Azure, or Google Cloud. It's like renting Services when you need them, and you pay only for what you use.

Cloud Computing Services are broadly divided into three main Categories.

(1) Infrastructure as a Service (IaaS):-

provides Virtualized Computing resources like Servers, Storage, and network.
you get Complete Control over the infrastructure but need to manage Operating Systems and applications.

(2) platform as a Service (Paas):- → Primarily for developers and IT team

platform as a Service (Paas) provides a platform that includes the underlying infrastructure and also Operating System and tools to facilitate Coding, testing and deployment.

(3) Software as a Service (Saas):- → end-users

Provides ready to use Software applications like gmail, microSoft office, Zoom etc. Over the internet. Users dont need to install or maintain any Software, just use it.

Grid Computing focuses on many computers solving one big tasks, while cloud Computing delivers services like storage, software or services to users as needed through the internet.

Bio Computing:

Bio Computing is an area of Science that Combines biology and Computing to Solve problems using biological materials or models.

⇒ Bio Computing Uses molecules found in nature, Such as DNA and proteins. these molecules acts as tools to help Scientists develop Computer programs that Can perform Various tasks related to biology.

⇒ One important goal of bio Computing is to understand how diseases develop at a molecular level. This knowledge Can lead to better treatments and therapies for Various health conditions.

⇒ Bio Computing enables the Creation of new Solutions in healthcare and other Scientific areas by using biological Concepts to Solve Complex Computational challenges.

Mobile Computing

⇒ Mobile Computing means using Small devices like Smartphones or tablets to perform tasks, Such as Sending or receiving information, without needing wires. It relies on wireless Communication like the internet or cellular networks.

⇒ One common example is mobile phones, which started with voice calls but now allow more advanced things like sending messages, video calls, or even online meetings. Using apps, people can do many things remotely, like chatting, working, attending meetings even when they are far away from their home or office.

⇒ With improving technology, these mobile-based services are growing quickly and becoming essential for everyone.

Quantum Computing

⇒ Quantum computing is a new type of computing that could solve problems much faster than the computers we use today.

⇒ In regular computers, tiny switches called transistors are used to control the flow of electricity and process information. The more transistors a computer chip has, the faster it can work. For a long time, engineers kept making transistors smaller, so they could fit more of them on a chip. This allowed computers to become faster every 18 months, following a pattern called 'Moore's Law'.

⇒ But now, the transistors are already so tiny that it's getting very hard to make them any smaller. As a result, computers are not becoming faster as quickly as they used to. This is why scientists are looking for new solutions, like quantum computing, which works in a different way to handle complex tasks.

⇒ Quantum Computers works in a totally different way by using the strange rules of tiny particles called quantum mechanics. They process information much faster than even the worlds' best Super Computers.

⇒ However, quantum Computers are still in development. Although Scientists have made some test versions, they are not yet ready to replace the Computers we use today. But in the future, they could help Solve very Complex problems much faster.

Optical Computing

⇒ Optical Computing is a new way of building Computers that uses light (like Visible light or infrared) instead of electricity to process information.

⇒ In regular Computers, electric Signals travel through wires, but they move much slower than light. this is why data transfer over long distance can be slow, and why technology like Optical fibers (which use light) were invented for faster Communication.

⇒ If we use light to perform Calculations inside Computers, they could work 10 times or more faster than todays electronic Computers. Optical Computing is still being developed, but it has the potential to make future Computers much faster and more efficient.

Nano Computing

⇒ Nano Computing means building computers using extremely tiny parts, much smaller than what we use today. Regular computers rely on Silicon transistors (small switches) but in nano computing, these may be replaced by even smaller switches made from Carbon nanotubes (tiny tubes of carbon, much thinner than a human hair).

⇒ the main challenges in nano computing are:

① Size:- These components are only a few nanometers in size, making them very difficult to work with

② manufacturing:
It's hard and expensive to create complex designs with so many tiny parts.

③ Integration: Since nano computers will need huge numbers of these tiny parts, figuring out how to connect them all is another challenge.

⇒ Researchers are working to solve these problems, and if they succeed, nano computing could make computers even smaller, faster, and more powerful than today's machines.