UNIT-1

CLOUD PARADIGMS

Cloud Computing

Cloud computing refers to the use of hosted services, such as data storage, servers, databases, networking, and software over the internet. The data is stored on physical servers, which are maintained by a cloud service provider. Computer system resources, especially data storage and computing power, are available on-demand, without direct management by the user in cloud computing.

Cloud Computing Uses

- **Well, it is used for many things like:**
- Data storage
- Data Backup
- Testing
- Flexibility
- Accessibility

- **It is basically needed for:**
- Scalability,
- Reduced risk of data loss
- Effective data management
- Less cost
- Serverless

Cloud Paradigms

- A computing paradigm refers to a fundamental approach or model for performing computation, organizing data, designing systems of higher levels, and solving problems using computers.
- Different types of cloud paradigms are as follows:

1. High performance computing
2. Parallel computing

3. Distributed computing
4. Cluster computing
5. Cloud computing
6. Bio computing
7. Mobile computing
8. Quantum computing
9. Optical computing
10. Nano computing
11. Grid computing

High performance computing

- High-performance computing (HPC) is the practice of using parallel data processing to improve computing performance and perform complex calculations. HPC achieves these goals by aggregating computing power, so even advanced applications can run efficiently, reliably and quickly as per user needs and expectations. It thus delivers much higher power and better performance than traditional computers, workstations and servers.

- **The need for high-performance computing (HPC)**
- In the modern world, groundbreaking discoveries and inventions can only happen with technology, data and advanced computing. As cutting-edge technologies like artificial intelligence (AI), machine learning (ML) and IoT evolve, they require huge amounts of data. They also need high-performance computing because HPC systems can perform quadrillions of calculations per second, compared to regular laptops or desktops that can perform at most 3 billion calculations per second (with a 3 GHz processor).

Benefits of HPC

- HPC helps overcome numerous computational barriers that conventional PCs and processors typically face. The benefits of HPC are many and include the following.
- **High speeds**
- HPC is mainly about lightning-fast processing, which means HPC systems can perform massive amounts of calculations very quickly. In comparison, regular processors and computing systems would take longer -- days, weeks or even months -- to perform these same calculations.

- **Lower cost**
- Because an HPC system can process faster, applications can run faster and yield answers quickly, saving time or money. Moreover, many such systems are available in "pay as you go" modes and can scale up or down as needed, further improving their cost-effectiveness.

- **How HPC works**
- Most HPC systems have three main components or resources:
- Compute
- Network
- Storage
- In an HPC architecture, multiple servers -- generally hundreds or thousands -- form a network or cluster. Each server is a node; and in each cluster, the nodes work in parallel to boost processing speeds and ensure HPC. Clusters are often created and removed automatically in the cloud to save time and reduce costs.

- Several software programs and algorithms run simultaneously on the cluster to support multiple HPC applications. Further, the cluster is networked to the storage components to capture and store the output of these programs.

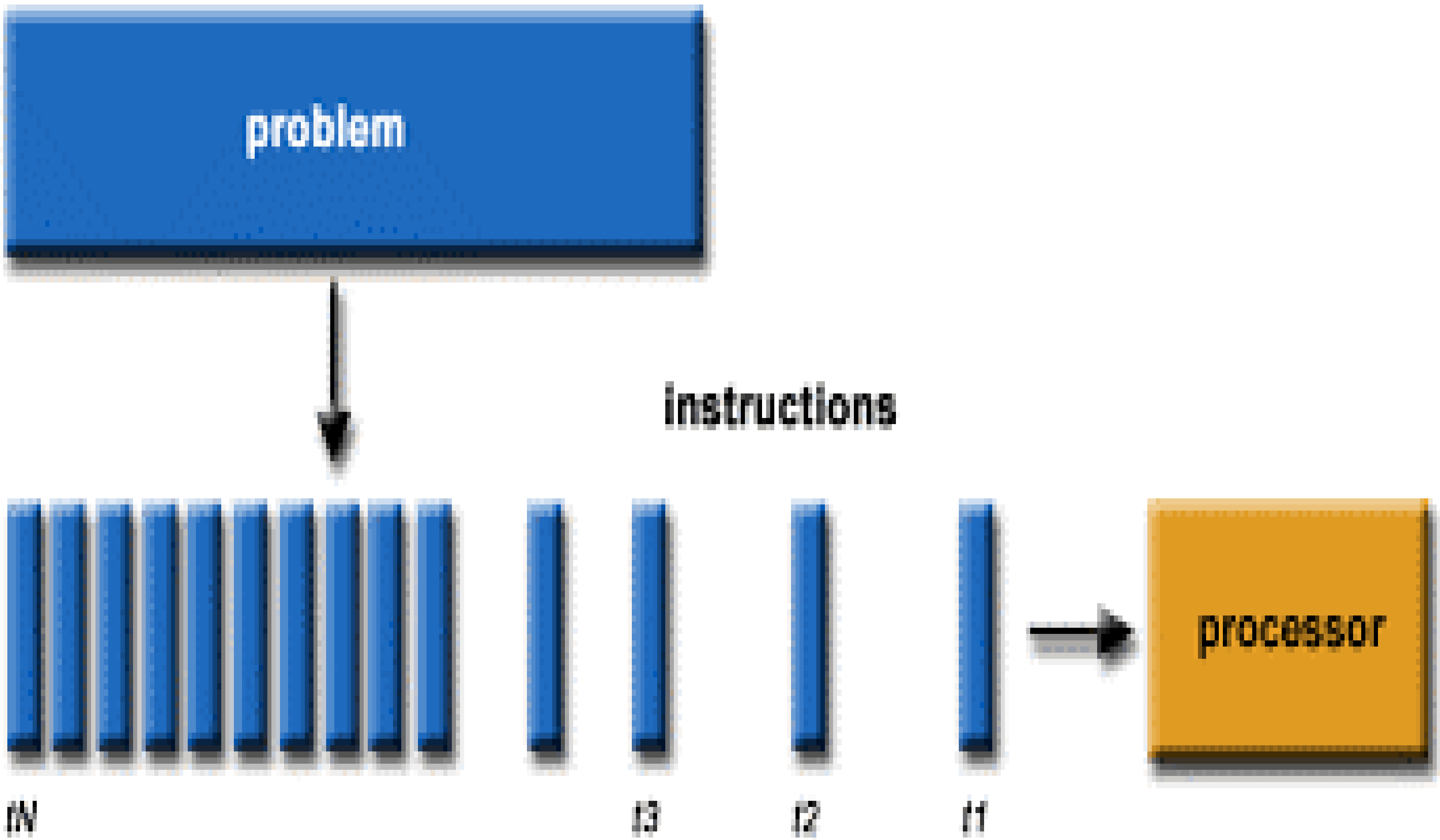
Applications of HPC

- HPC is used in many real-life scenarios to solve complex problems in science, business and engineering. Some academic institutions also use HPC systems. Some government agencies, particularly the military, rely on HPC for complex applications. As the demand for processing power and speed grows for real-world applications, HPC will likely interest businesses of all sizes, particularly for transaction processing, and data warehouses.

- HPC systems are also used in many other industries, including but not limited to the following:
- **Manufacturing.** To design, manufacture and test new products using simulations.
- **Healthcare.** To research and develop new vaccines, drugs and treatments for diseases; improve screening techniques; and to make more accurate patient diagnoses.
- **Media and entertainment.** To create animations and special effects, transcode media files, support high-speed video and live event streaming and create immersive entertainment using augmented reality

- **Aerospace.** For personnel training and to create critical simulations for airplane testing.
- A supercomputer is one of the best-known examples of HPC, in which one large computer is made up of many computers and processors that work together to achieve parallel processing and high performance.

Parallel Computing



- Parallel computing refers to the process of executing several processors an application or computation simultaneously. Generally, it is a kind of computing architecture where the large problems break into independent, smaller, usually similar parts that can be processed in one go. It is done by multiple CPUs communicating via shared memory, which combines results upon completion. It helps in performing large computations as it divides the large problem between more than one processor.

- Parallel computing also helps in faster application processing and task resolution by increasing the available computation power of systems. The parallel computing principles are used by most supercomputers employ to operate. The operational scenarios that need massive processing power or computation, generally, parallel processing is commonly used there.
- Typically, this infrastructure is housed where various processors are installed in a server rack; the application server distributes the computational requests into small chunks then the requests are processed simultaneously on each server.

- The earliest computer software is written for serial computation as they are able to execute a single instruction at one time, but parallel computing is different where it executes several processors an application or computation in one time.
- There are many reasons to use parallel computing, such as save time and money, provide concurrency, solve larger problems, etc. Furthermore, parallel computing reduces complexity. In the real-life example of parallel computing, there are two queues to get a ticket of anything; if two cashiers are giving tickets to 2 persons simultaneously, it helps to save time as well as reduce complexity.

- Applications of Parallel Computing
- There are various applications of Parallel Computing, which are as follows:
- One of the primary applications of parallel computing is Databases and Data mining.
- The real-time simulation of systems is another use of parallel computing.
- The technologies, such as Networked videos and Multimedia.
- Science and Engineering.
- Collaborative work environments.
- The concept of parallel computing is used by augmented reality, advanced graphics, and virtual reality.

Why parallel computing?

- There are various reasons why we need parallel computing, such are discussed below:
- Parallel computing deals with larger problems. In the real world, there are multiple things that run at a certain time but at numerous places simultaneously, which is difficult to manage. In this case, parallel computing helps to manage this kind of extensively huge data.
- Parallel computing is the key to make data more modeling, dynamic simulation and for achieving the same. Therefore, parallel computing is needed for the real world too.

- With the help of serial computing, parallel computing is not ideal to implement real-time systems; also, it offers concurrency and saves time and money.
- Only the concept of parallel computing can organize large datasets, complex, and their management.
- The parallel computing approach provides surety the use of resources effectively and guarantees the effective use of hardware, whereas only some parts of hardware are used in serial computation, and some parts are rendered idle.

Distributed Computing

- **Distributed cloud computing** is the distribution of public cloud services across multiple geographic locations. In distributed clouds, the operations and governance—as well as updates—continue to remain under the purview of the primary public cloud provider.
- In distributed computing, computation workload is spread across several connected servers.

- Distributed cloud computing takes the cloud computing model and distributes it to different geographic locations in a connected manner. It creates an execution environment where application components look at specific geographical locations that are chosen based on application needs. Some application requirements are:
- **Locational**: To help enhance responsiveness and performance in delivery of applications, particularly those where latency is critical and transferring bulk data to a single cloud proves to be an expensive affair.

- **Regulatory**: There are some countries where regulations stipulate that data must not leave the country. Distributed cloud computing helps in such cases.
- Security and control of Data: To make sure that an enterprise has the ability to retain specific data and processes in its private cloud, within its integrated public cloud.

How Distributed Cloud computing Works

- Distributed computing networks can be connected as local networks or through a wide area network if the machines are in different geographic locations. Processors in distributed computing systems typically run in parallel.
- Common functions involved in distributed computing include the following:
- **Task distribution.** A central algorithm distributes a large task into smaller subtasks. These sub-tasks are then assigned to different nodes within the system to distribute the workload.

- **Parallel execution**. Once the nodes are assigned, they independently execute their assigned subtask concurrently with other nodes. This parallel processing enables faster computation of complex tasks compared to sequential processing.
- **Communication**. Nodes in a distributed system communicate with one another to share resources, coordinate tasks and maintain synchronization. This communication can take place through a variety of network protocols.

- **Aggregation of results.** After completing their respective sub-tasks, nodes often send their results back to a central node or aggregator. The aggregator combines these results to produce the final output or result of the overall computation.
- **Fault tolerance.** Distributed systems are designed to handle failures gracefully. They often incorporate redundancy, replication of data and mechanisms for detecting and recovering from failures of individual nodes or communication channels.

Benefits of Distributed computing

- Enhanced performance. Distributed computing can help improve performance by having each computer in a cluster handle different parts of a task simultaneously.
- Scalability. ...
- Resilience and redundancy. ...
- Cost-effectiveness. ...
- Efficiency. ...
- Flexibility. ...
- Transparency.

Cluster Computing

- A computer cluster is a set of connected computers that perform as a single system. These computers are basic units of a much larger system called a node.
- A computing cluster can range from a simple two-node setup with personal computers to complex supercomputers with advanced architectures.

- All units in the system are the same kind of machines. These computers are interconnected through fast and efficient local area networks (LANs) and generally use the same hardware. Their connection can be tight or loose, but they share one home directory.

How does Cluster Computing work

- At its most fundamental level, cluster computing uses a LAN to connect multiple, independent computers in a network. In the architecture of the cluster, each computer on the network is referred to as a “node” and is controlled by middleware, software that enables communication between each machine. Users of the cluster can use each computer’s resources as though they were a single machine, rather than individual machines connected via a LAN.

- A computing cluster can connect as few as two nodes or as many as thousands. For example, a Beowulf cluster typically uses commercial grade PCs connected via a LAN and can be a relatively affordable alternative to a supercomputer for certain tasks.
- Kubernetes, on the other hand—a container-related, cluster-adjacent technology that's essential to cloud computing—supports clusters of up to 5,000 separate but connected nodes. Kubernetes is used in many kinds of cloud deployments, including hybrid cloud and multicloud architectures, as well as DevOps and application modernization

Types of Cluster computing :

- **1. High performance (HP) clusters :**
  HP clusters use computer clusters and supercomputers to solve advance computational problems. They are used to performing functions that need nodes to communicate as they perform their jobs. They are designed to take benefit of the parallel processing power of several nodes.

- **2. Load-balancing clusters :**
- Incoming requests are distributed for resources among several nodes running similar programs or having similar content. This prevents any single node from receiving a disproportionate amount of task. This type of distribution is generally used in a web-hosting environment.

- **3. High Availability (HA) Clusters :**
- HA clusters are designed to maintain redundant nodes that can act as backup systems in case any failure occurs. Consistent computing services like business activities, complicated databases, customer services like e-websites and network file distribution are provided. They are designed to give uninterrupted data availability to the customers.

Bio Computing

- Biocomputers use biologically derived materials to perform computational functions. A biocomputer consists of a pathway or series of metabolic pathways involving biological materials that are engineered to behave in a certain manner based upon the conditions (input) of the system.

- The resulting pathway of reactions that takes place constitutes an output, which is based on the engineering design of the biocomputer and can be interpreted as a form of computational analysis. Three distinguishable types of biocomputers include biochemical computers, biomechanical computers, and bioelectronic computers.

- The behavior of biologically derived computational systems such as these relies on the particular molecules that make up the system, which are primarily proteins but may also include DNA molecules. Nanobiotechnology provides the means to synthesize the multiple chemical components necessary to create such a system.The chemical nature of a protein is dictated by its sequence of amino acids—the chemical building blocks of proteins.

- This sequence is in turn dictated by a specific sequence of DNA nucleotides—the building blocks of DNA molecules. Proteins are manufactured in biological systems through the translation of nucleotide sequences by biological molecules called ribosomes, which assemble individual amino acids into polypeptides that form functional proteins based on the nucleotide sequence that the ribosome interprets

Mobile computing

- Mobile Computing is a technology that provides an environment that enables users to transmit data from one device to another device without the use of any physical link or cables.
- In other words, you can say that mobile computing allows transmission of data, voice and video via a computer or any other wireless-enabled device without being connected to a fixed physical link.

- In this technology, data transmission is done wirelessly with the help of wireless devices such as mobiles, laptops etc.
- This is only because of Mobile Computing technology that you can access and transmit data from any remote locations without being present there physically. Mobile computing technology provides a vast coverage diameter for communication. It is one of the fastest and most reliable sectors of the computing technology field.

- The concept of Mobile Computing can be divided into three parts:

1. Mobile Communication
2. Mobile Hardware
3. Mobile Software

- Mobile Communication specifies a framework that is responsible for the working of mobile computing technology. In this case, mobile communication refers to an infrastructure that ensures seamless and reliable communication among wireless devices. This framework ensures the consistency and reliability of communication between wireless devices. The mobile communication framework consists of communication devices such as protocols, services, bandwidth, and portals necessary to facilitate and support the stated services. These devices are responsible for delivering a smooth communication process.

- **Mobile communication can be divided in the following four types:**

- Fixed and Wired
- Fixed and Wireless
- Mobile and Wired
- Mobile and Wireless
- **Fixed and Wired:** In Fixed and Wired

configuration, the devices are fixed at a position, and they are connected through a physical link to communicate with other devices.

- **For Example**, Desktop Computer.

- **Fixed and Wireless:** In Fixed and Wireless configuration, the devices are fixed at a position, and they are connected through a wireless link to make communication with other devices.

- **For Example**, Communication Towers, WiFi router

- **Mobile and Wired:** In Mobile and Wired configuration, some devices are wired, and some are mobile. They altogether make communication with other devices.

- **For Example**, Laptops.

- **Mobile and Wireless:** In Mobile and Wireless configuration, the devices can communicate with each other irrespective of their position. They can also connect to any network without the use of any wired device.

- **For Example**, WiFi Dongle.

2.Mobile Hardware

- Mobile hardware consists of mobile devices or device components that can be used to receive or access the service of mobility. Examples of mobile hardware can be smart phones, laptops, portable PCs, tablet PCs, Personal Digital Assistants, etc.

3.Mobile Software

- Mobile software is a program that runs on mobile hardware. This is designed to deal capably with the characteristics and requirements of mobile applications. This is the operating system for the appliance of mobile devices. In other words, you can say it the heart of the mobile systems. This is an essential component that operates the mobile device.

Applications of Mobile Computing

- Following is a list of some significant fields in which mobile computing is generally applied:
- Web or Internet access.
- Global Position System (GPS).
- Emergency services.
- Entertainment services.
- Educational services.

Quantum computing

- Quantum computing is a multidisciplinary field comprising aspects of computer science, physics, and mathematics that utilizes quantum mechanics to solve complex problems faster than on classical computers. The field of quantum computing includes hardware research and application development. Quantum computers are able to solve certain types of problems faster than classical computers by taking advantage of quantum mechanical effects, such as superposition and quantum interference.

- Some applications where quantum computers can provide such a speed boost include machine learning (ML), optimization, and simulation of physical systems. Eventual use cases could be portfolio optimization in finance or the simulation of chemical systems, solving problems that are currently impossible for even the most powerful supercomputers on the market.

What are the components of a quantum computer?

- Quantum computers have hardware and software, similar to a classical computer.
- Quantum hardware
- Quantum hardware has three main components.
- Quantum data plane
- The quantum data plane is the core of the quantum computer and includes the physical qubits and the structures required to hold them in place.
- Control and measurement plane

- The control and measurement plane converts digital signals into analog or wave control signals. These analog signals perform the operations on the qubits in the quantum data plane.
- Quantum software
- Quantum software implements unique quantum algorithms using quantum circuits. A quantum circuit is a computing routine that defines a series of logical quantum operations on the underlying qubits. Developers can use various software development tools and libraries to code quantum algorithms.

Optical Computing

Optical computing (also known as *optoelectronic computing* and *photonic computing*) is a computation paradigm that uses photons (small packets of light energy) produced by laser/ diodes for digital computation. Photons have proved to give us a higher bandwidth than the electrons we use in conventional computer systems. The optical computers, would give us a higher performance and hence be faster than the electronic ones.

- The speed of computation depends on **two factors**: how fast the information can be transferred and how fast that information can be processed that is data computation. Photons basically use wave propagation and the interference pattern of waves to determine outputs. This allows for instantaneous computation without inducing latency. Data is processed while it’s propagating. There is no need to stop the data movement and flow for its processing. This speed factor would transform the computer industry.

- The building block of any conventional electronic computer is a transistor. For optical computing, we achieve an equivalent optical transistor by making use of materials with non-linear refractive indices. Such materials can be used for making optical logic gates, which go into the CPU. An optical logic gate is simply a switch that controls one light beam by another. It is “ON” when light is being transmitted, and it is “OFF” when it blocks the light.

Nano Computing

- Nanocomputing describes computing that uses extremely small, or nanoscale, devices (one nanometer [nm] is one billionth of a meter). In 2001, state-of-the-art electronic devices could be as small as about 100 nm, which is about the same size as a virus. The **integrated circuits** (IC) industry, however, looks to the future to determine the smallest electronic devices possible within the limits of computing technology

- Until the mid-1990s, the term "nanoscale" generally denoted circuit features smaller than 100 nm. As the IC industry started to build commercial devices at such size scales since the beginning of the 2000s, the term "nanocomputing" has been reserved for device features well below 50 nm to even the size of individual molecules, which are only a few nm. Scientists and engineers are only beginning to conceive new ways to approach computing using extremely small devices and individual molecules.

- All computers must operate by basic physical processes. Contemporary digital computers use currents and voltages in tens of millions of complementary metal oxide semiconductor (CMOS) **transistors** covering a few square centimeters of silicon. If device dimensions could be scaled down by a factor of 10 or even 100, then circuit functionality would increase 100 to 10,000 times.

- Furthermore, if such a new device or computer architecture were to be developed, this might lead to millionfold increases in computing power. Such circuits would consume far less power per function, increasing battery life and shrinking boxes and fans necessary to cool circuits. Also, they would be remarkably fast and able to perform calculations that are not yet possible on any computer. Benefits of significantly faster computers include more accuracy in predicting weather patterns, recognizing complex figures in images, and developing **artificial intelligence (AI)** .

- Potentially, **single-chip** memories containing thousands of **gigabytes** of data will be developed, capable of holding entire libraries of books, music, or movies.
- Current nanocomputing research involves the study of very small electronic devices and molecules, their fabrication, and architectures that can benefit from their inherent electrical properties. Nanostructures that have been studied include semiconductor quantum dots, single electron structures, and various molecules.

- Very small particles of material confine electrons in ways that large ones do not, so that the **quantum mechanical** nature of the electrons becomes important.

Grid Computing

- **Grid computing** is a distributed architecture that combines computer resources from different locations to achieve a common goal. It breaks down tasks into smaller subtasks, allowing concurrent processing. In this article, we are going to discuss grid computing.

- **Grid Computing** can be defined as a network of computers working together to perform a task that would rather be difficult for a single machine. All machines on that network work under the same protocol to act as a virtual supercomputer. The tasks that they work on may include analyzing huge datasets or simulating situations that require high computing power. Computers on the network contribute resources like processing power and storage capacity to the network.

- Grid Computing is a subset of distributed computing, where a virtual supercomputer comprises machines on a network connected by some bus, mostly Ethernet or sometimes the Internet. It can also be seen as a form of Parallel Computing where instead of many CPU cores on a single machine, it contains multiple cores spread across various locations. The concept of grid computing isn’t new, but it is not yet perfected as there are no standard rules and protocols established and accepted by people.

Working of Grid Computing

- A Grid computing network mainly consists of these three types of machines
- **Control Node:** A computer, usually a server or a group of servers which administrates the whole network and keeps the account of the resources in the network pool.
- **Provider:** The computer contributes its resources to the network resource pool.
- **User:** The computer that uses the resources on the network

- When a computer makes a request for resources to the control node, the control node gives the user access to the resources available on the network. When it is not in use it should ideally contribute its resources to the network. Hence a normal computer on the node can swing in between being a user or a provider based on its needs. The nodes may consist of machines with similar platforms using the same OS called homogeneous networks, else machines with different platforms running on various different OSs called heterogeneous networks.

- This is the distinguishing part of grid computing from other distributed computing architectures. For controlling the network and its resources a software/networking protocol is used generally known as **Middleware**. This is responsible for administrating the network and the control nodes are merely its executors. As a grid computing system should use only unused resources of a computer, it is the job of the control node that any provider is not overloaded with tasks.

- The meaning of the term Grid Computing has changed over the years, according to “The Grid: Blueprint for a new computing infrastructure” by Ian Foster and Carl Kesselman published in 1999, the idea was to consume computing power like electricity is consumed from a power grid. This idea is similar to the current concept of cloud computing, whereas now grid computing is viewed as a distributed collaborative network. Currently, grid computing is being used in various institutions to solve a lot of mathematical, analytical, and physics problems.