CHAPTER 1

INTRODUCTION

The most ventilated topic among IT specialists is distributed computing these days. The concept is getting fame and consideration as it ensures low cost resource sharing and fidelity. Distributed Systems are the Pivot of study in this field of computer science. Computer savvies consider Distributed Computing as a form of parallel computing. In Distributed Computing, Computational problems are solved through the use of Distributed Systems.

In Distributed Computing the program application taken into consideration is divided into several segments and these segments run concurrently on multiple computers communicating over a network to achieve a common goal [1]. For example, if there are ‘N’ systems connected in ‘X’ network, then distributed computing splits one program instruction into n different tasks and compute them synchronously.

Distributed Computing presents a solution of the problem of using limited resources optimally. It assures to perform jobs at fast speed which is a drastic requirement of present scenario. Several forms of distributed computing have come forth with the prelation in IT sector. The obvious benefits of these forms comprise resource sharing, data integration, expandability, dependability as well as virtualization [2].

Major classifications of Distributed computing are: Utility, Cloud, Grid as well as Cluster Computing.

Figure 1.1 displays the examples of Distributed System representing all basic aspects Systems Viz. Cloud, Cluster and Grid of Distributive System [3]. This figure also exhibits that all forms of Distributed systems are protruded by Grid Computing and depicting which technology is application oriented and which is service oriented.
Figure 1.1: Layout of Distributed System

The predominant instances as well as applications of Distributed Environment are as follow:

- Telecommunication Networks
- Network Application
- Real-time process control
- Parallel Computing

The main objective of Distributed Computing is economic and adequate usage of available resources. Users can access remote resources and share resources with
other users. Advanced level of throughput can be achieved by putting up resources together [4]. It can also be able to execute high scale computations. Grid and Cloud computing are fundamentally vital systems of Distributed System in today's era. Inspite of the fact that there is a long list of projects done in Grid and Cloud computing, yet some novel & unexplored fields can be worked upon in Distributed Computing for its betterment.

1.1 FEATURES OF DISTRIBUTED SYSTEMS

Distributed System has become the nerve system of today's age of Industrialization. With the advancement of internet, it has achieved more fame in whole world. Now it is used in several environs in diverse modes. Among the manifold features of Distributed Systems, the major can be discussed as follow:

- **Extensive Scale:** It refers to the ease of the increasing scale of the system (e.g. the number of processors). The number of systems or processors may range from just a few to billions. In order to meet the computational need of business sector, there was a dire need to create the network at cosmos level. Now, Cloud Computing a form of Distributed Computing is competent enough to cater the requirements of small scale firm to multinational companies [5].

- **Sharing of Resources:** It is the spirit of Distributed Systems. In order to curtail the expenditure, the resources of diverse organisations may be allowed to other business concerns to access them. Hence, Resource sharing is to use any software, hardware or any databases anywhere worldwide in a much resultant manner amid all computing devices [6]. The resources are co-ordinated in such a way that no discrepancy exists in database.

- **Divergence:** All types of resources viz. hardware or software can be utilized in Distributed system. They may be of divergent nature in terms of software
appliances/tools or programs or scientific apparatus, sensors, computers or any other mechanism that is needed in large scale computations [7].

- **Worldwide Geographical Access**: Distributed System enables to execute diverse computational tasks in collaboration with several network centres spread worldwide [8]. As the world is acknowledged as Global village, Distributed Systems play fundamental role to achieve the target of users.

- **Approachability**: Distributed Systems provide dynamic entree to feasible resources. It manages the system failures in heavy workload. It assures the effective rendition of services as per quality of Service needs selected by the client or service provider when it allows its scalability; it hides the heterogeneity of the resources [9].

- **Clear-cut access**: Any user can have right access to all the resources of Distributed Systems as a Distributed System is considered as a unique virtual computer [10]. It must be capable to conceal the heterogeneous nature of resources in term of scalability. It must handle the system failure in heavy workload. It must be equipped with standard services, protocols as interfaces.

- **QoS Needs**: User satisfaction is the prime purpose of every system. So, every system must give honest services to the users. QoS needs primarily are the criteria which assure the quality of service before the starting of system. These criteria are foreseen and achievable in accordance with system's capacity [11].

- **Insistent Access**: In Distributed System, standard services, interfaces and protocols are designed to achieve persistency in access [12]. Persistency is vital issue while sharing resources. The details of heterogeneousness are hidden in the system.

- **Sharing of Information**: In distributed computing Systems if one of the users generates information, it can be handily sliced by the other clients
engaged at other machines of the system worldwide. Hence, the circle of users works hand-in-hand which is termed as computer-supported cooperative working (CSCW) or groupware [13].

- **Extensibility:** In Distributed System, this is feasible to moderately boost the efficacy along with functionality by simply adding other resources in terms of software or hardware to the system when there any need occurs. This can be done without any type of disorder in normal existing system.

- **Better Price-Performance Ratio:** Distributed Systems likely possess a better price performance ratio in comparison with a single wide centralized system as they possess fast growing potential and decrement in price of the microprocessors connected with communication network [14].

- **Meet user's needs:** For diverse type of computing, performing at various types of computers is more suitable [15]. In DS, there is a pool of different types of resources. The most suitable is chosen for processing a user's need subjected to the sort of the task.

- **Openness:** It is related to extensions and improvements of DS. Interfaces help in connecting various components, so the detailed information of all these interfaces is published. If any new resource is added to the existing system, it must become the unified part of existing components [16]. The issue of heterogeneous components is resolved.

- **Dynamic and Comprehensive Access:** Dynamic and Comprehensive access to feasible resources is handy in Distributed system [17]. Distributed system can tackle the system failure in most desirable mode. If any type of prolixity occurs, it is maintained by scanning the failure level in the system without any deferment.
1.2 GENERIC ARCHITECTURE OF DISTRIBUTED ENVIRONMENT

Distributed System has its own generic architecture which is discussed as 'layers'. Each layer performs a distinct function as exhibited in Figure 1.2 [18]. Each layer uses previous layer to perform new functionality. The higher layers are user-oriented while the lower layers are hardware-oriented.

Figure 1.2: General Architecture of Distributed Environment
- **Network Layer:** This is bottom layer accountable for the congruence of feasible resources of the system. All sorts of tangible elements necessary to design the network such as switches etc. are contained in it [19].

- **Resource Layer:** It contains all the elements which are necessary to shape a Distributed Environment viz. computers, storage media and even sensors etc. used to design the DS.

- **Middleware Layer:** This layer is accountable to manage the security in DS [20]. The tools included in it allow the system elements to partake in a pooled Distributive environment.

- **Application Layer:** This is the top layer having face-to-face communication with end user. Conducive interface is given to the end user by concealing the complications of the system [21]. Different types of user applications for the domains of business as well as science etc. are included in it. There are different types of user-friendly web portals as well as development toolkits/apparatus supporting applications in it. These provide easy access to the user to Distributed System.

### 1.3 HISTORY, EVOLUTION & TRENDS IN DISTRIBUTED ENVIRONMENT

In present high computational scenario, more sophisticated DS has gained more attention. Its sojourn started in 1960 with the evolution of Mainframe Computer devised for scientific purposes. It has crossed many facets like ARPANET, CORBA et. al. before attaining the form of Grid and Cloud Computing. This segment gives the outline of all stages of Distributed System to ease the apprehension of Distributed System. Figure 1.3 is depicting the complete life span of the Distributed Computing from its inception phase to present scenario.
Figure 1.3: Evolution phases of Distributed Computing

- **Stage-I**
  - Main Frame IBM System
  - ARPANET

- **Stage-II**
  - ARPANET E-mail
  - Local Area Network
  - Host Based Hierarchy
  - Decentralized Stand Alone Systems.

- **Stage-III**
  - Workstation Server
  - Personal Computer

- **Stage-IV**
  - Client Server architecture
  - Common object Request Broker Architecture (CORBA)

- **Stage-V**
  - Peer to peer Computing
  - Internet Based Computing & Web Services
  - Distributed Computing Object Model
  - Cluster Computer

- **Stage-VI**
  - Present Time
  - Grid Computing
  - Ubiquitous Computing
  - Cloud Computing

- **Late 90's**
  - 1993

- **1980**
  - 1980

- **1970**
  - 1970

- **1960**
  - 1960
1.3.1. Early History: Stage 01 (1960s):

It is the starting stage when the origin of notion about Distributed Computing has come forth. This is often called the infancy stage of Distributed System. In this stage, the idea of Distributed System took the birth and its actual shape appeared with the development of IBM Mainframe Computer alongwith ARPANET.

- **IBM Mainframe Computer:** This was the first computer propounded in 1964 by IBM to execute complicated experiments of science as well as processing of trade associations [23]. At the time of declaration of this venture, the company got nearly one thousand orders which extended with time. This computer was capable to enforce communication for the first time. Through these computers, clients could interact by manually installing data into tape and relocating it from one computer to other. This basic idea originated the Distributed Computing. In simple words, the dispersion of complicated job in various computing gadget and execution of the process concurrently at a fast speed generated the concept of Distributed System.

- **ARPANET:** ARPANET is treated as the progenitor of the Internet of modern times and foremost instance of Distributed Computing [24]. No doubt, it was invented for military, yet not for bastille work. It was the result of that the country had limited influential research computers and many researchers to use them who were estranged topographically from them. On 29th October, 1969 the very first message was mailed through ARPANET by Charley Kline. 21st November, 1969 is considered a landmark date in the history of Internet as the very first continuous link was created on this date. The four prime locations were Universities of California and Utah [25]. Figure 1.4 is representing the first communication on ARPANET.
1.3.2. Stage II (1970):

In this phase, Distributed Computing became a toddler. It appeared in the view of existing cosmos by its activities viz. evolution of ARPANET, M-Email, LAN, Host based Hierarchy as well as Decentralized Stand Alone Systems. The Concoction of Local Area Network (LAN) in 1970's bestowed the idea of sharing resources [26]. This concept yielded wings to Distributed System.

- **ARPANET E-MAIL:** At that time, E-Mail simply stood for delivering a message in another client's reference book or directory. He would get the message when he logged on his account. That was like delivering the letter or mail in the mailbox of any house. At that time, this was the most efficacious
application to deliver the data/information in the same network. When the networks flourished, each one realized the urgency to commutate the messages among other networks. So there appeared an urgency to decide an address of network where the information would be sent. Then in 1972, E-Mail was invented by Ray Tomlinson & was symbolized with @ to express the e-mail address of the clients of diverse networks where the client wished to deliver information [27]. Idea of E-Mail begot the technology of Internet.

- **Local Area Network (LAN):** It can be considered the new invention in the domain of Distributed Computing. It ascribes to the interconnected two or more computers to allocate the resources in a small area. As it interconnects different computers as well as apparatus, it endows the capacity to distribute computing power, which is considered as the spirit of Distributed Computing [28]. Two most LAN based technologies are Wi-Fi and Ethernet. Figure 1.5 representing the LAN establishment in the office.
• **Host Based Hierarchy:** It was the foremost data processing system after the unraveling of LAN. It is controlled by a Main or Central Computer. This system refers to hierarchical communication system which is handled by a primal computer for e.g. Mainframe Centralized host, Mini Computers etc. Hence the concept runs on Master-slave model [29]. Here, facts can be stashed at any plane. Figure 1.6 clearly demonstrates the Host based Hierarchy Architecture.

![Host based Hierarchy Architecture](image)

**Figure 1.6: Architecture of Host based Hierarchy**

• **Decentralized Stand Alone System:** Basically this can't be considered a sort of Distributed System yet it was put forth in companies to a wide extend in those days. As its title signifies, this system was capable to be operated
independently and was linked only at department level furthermore it could never be tied to new networks to partake the information. This was prototype of ERP Software as this software was brought out on the basis of this theory. Yet this system was entirely connected to execute diverse processes of contempo age [30].

1.3.3. Stage III (1980):

In this phase, Distributed Computing was in childhood. It was grown at very fast speed. The unraveling of personal computers took the computing concept from the reach of a few affluent and executives of diverse organisations. So, the evolution of workstation Server and Personal Computer helped the computing process to attain the summit of development day-by-day.

- **Workstation Server:** It was one of the productive advancement in the field of DS. They were high speed computers dispersed at varied locations but linked to one-another via. High speed Local Area Network. At one time, only one user could approach the server. The connected computers were diskless to cut down the cost of networking [31]. As the computers were very expensive at that time, so this technique became famous in large organisations, industries as well as in universities. Figure 1.7 clearly depicts the working of Workstation Model.

![Figure 1.7: Workstation Model](image-url)
- **Personal Computer**: As it has been mentioned above, the conception of Personal Computers proved a revolutionary turn in computing discipline. Earlier, the computer was in the reach of a few people. People generally perceived computers as large computing devices for computing tasks possessed by some businessmen only. Personal Computer was built for a single user. Now, it has been utilized for various tasks viz. for playing games, word processing as well as data management programs [32]. First PC was generated by Apple Company in 1977. The most well-known low cost computer was designed by IBM Company in 1981. It was named as IBM Personal Computer.

1.3.4. Stage IV (Early 1990):

During 1990's D.C. was like an adolescent comprehended its capability to carry out the computing tasks. The evolution of client-server Architecture and Common Object Request Broker Architecture (CORBA) provided the actual form and recognition to D.C. in the domain of computing.

- **Client Server Architecture**: This is basically a network architecture where each computer works as a dynamic terminal acting as a server or a client. Here, servers are predominant computers committed to running disk drives, printers or network traffic. For it, a separate server is set up, for e.g. printer servers for printers, file servers for disk drive and to handle network traffic, network server is set up. This was alias as two-tier architecture [33]. The chief level is punter having GUI background for user and other is server tier to handle complicated tasks of dealing out through the support of Database Management. At that point, servers could be reckoned by a few clients and they were incapable to interchange data from one-another. This concept empowered the employees and made the computing system more user-friendly. In those days, its expense was too high so it became a complicated information structure. Figure 1.8 perfectly exhibits the functioning of Client Server Architecture.
- **Common Object Request Broker Architecture (CORBA):** It was designed by a group of marketers named as Object Management Group (OMG) in 1991. This was the famous protocol designed for the communication on various machines/computers working on various languages [34]. In simple words, CORBA provides the potentiality to computers to induce multilingual interaction [35]. Apps accredited through CORBA likely to be operated on any type of hardware and created in language mapping with IDL. In this protocol, a client program can demand services from a server program even with no information of its whereabouts in Distributed Network. Figure 1.9 visibly displays the Architecture of CORBA.
1.3.5. Stage V (1993):

This is the phase of early adulthood in the life-cycle of D.C. At this stage, D.C. enacted an exclusive identification in the domain of computation alongwith the
advancing of Distributed Computing Object Model as well as Cluster Computing technique. Through Window based environment, Distributed Computing became more user-friendly.

- **Distributed Computing Object Model (DCOM):** This innovation was done by Microsoft Corporation. The purpose was to execute dispersed tasks on window based setting. Through this model, communication between a client application object and the server object could be done on whichever network was available [36]. DCOM was thoroughly conceptualized on the idea of Common Object Model. Common Object Model was competent for interaction of two objects in identical network. DCOM emerged as a component of windows operating systems acted on TCP/IP and Hyper Text Transfer Protocol (HTTP). DCOM and CORBA are comparable in terms of proffering a set of distributed services [37]. DCOM works with Remote Procedure Calls while interacting with Server Object although is confined merely to Microsoft applications.

- **Cluster Computing:** This was the amazing technology by Donald Becker and Thomas Sterling at NASA. In order to change the system of super computer for large complicated computing tasks, they had connected low capacity computer systems to construct the high efficiency Parallel Computing Cluster. This technique permitted allocating the tasks between the connected computers in such a way that computing could be executed on parallel basis. They could execute the task like a Super Computer by summatting the competencies of all these average computers [38]. At that time, this technique was named as Beowulf Cluster. Beowulf can be considered a tool of Clustering computers designing a parallel, virtual supercomputer. It was not an exclusive software package or an advanced network topology [39]. Figure 1.10 noticeably illustrates the Architecture of Cluster Computing.
1.3.6. Stage VI (Late 90s):

This was the phase of middle adulthood of D.C. The invention of Peer-to-Peer computing amid Internet based computation helped for enlarging Distributed Computing. Data distribution attribute of Peer-to-Peer technology and access to any devise through URL in Internet Based computing became the foundation of today's Distributed Computation mechanism.

- **Peer-to-Peer Computing:** This technology, innovated by Napster, eliminated the needs of servers. The structure of this technology was completely extrapolated form the concept of ARPANET and Cluster Computing even though they required powerful servers which were more powerful than Personal Computers. Any complicated processing of data can be executed on these types of servers [40]. Primarily there are main three kinds of Peer-to-Peer technique: Multiple, Distributed and Collaborative.
In the working of Multiple Peer Relationship Model, servers are used to connect Personal Computers with each-other. On same network, documents can be partaken and amassed from whichever personal computer is available yet security plus intellectual property matters constitute main faults of the above said model. Real life instances of this model are: Napster and Kazaa [41].

In model of Distributed Peer Relationship, different computers are allied in sync to add their computation & processing caliber to surf the internet or clear up the complications viz. Infrasearch etc. [42].

In the model of Collaborative Peer Relationship, very few people as a group share resources via. a worldwide interface for e.g. Chat rooms, on-line gaming, e-learning environment etc. Examples of this model include Jeopardy, Chat here, Horizon Live etc [43]. Figure 1.11 is illustrating peer-to-peer computing.

Figure 1.11: Portrayal of Peer-to-Peer Computing
• **Internet Based Computing and Web Services:** With the withdrawn of NSF Net from its services in 1995, the door of INTERNET was opened for commercial use. Before that Internet was only accessible for scientific and defense purposes. Internet initiated to bestow different services to the world after the removal of this constraint. It gave the people an opportunity and potency for remote computing. Then, the technique of URL was introduced to interchange the data at remote level. This brought an innovative transition in Internet Computing [44]. At that time, new designed technologies such as HTTP, XML, HTML etc. became the turning point in Distributed Computing. Later, these technologies were called web services [45]. These technologies made communication viable between applications. This concept of Internet Computing is regarded as the harbinger of the concept of Cloud Computing of today's world.

1.3.7. **Stage VII (Present Time):**

This phase depicts today's world when Distributed Computing has become mature adult. Distributed Computing has achieved new form with the development of Mobile Computing. With the help of Mobile Computing, Distributed Computing has begotten Grid Computing, Ubiquitous Computing and Cloud Computing which are three most famous techniques of present era [46]. These three technologies, especially Cloud Computing are playing a vital role in shifting the present world to a paperless environment.

• **Grid Computing:** The very first Grid application of international level was performed at Romania country for seven-hour duration in November 2002. Then in 2007, Monte Carlo Simulation was executed. This technology facilitated the skillful use of resources in Distributed Computing. As has been stated earlier, Distributed Computing ascribed to the sharing of available resources which are not perfect in their storage or processing capacity. Grid computing has some more features than that of Distributed Computing. It
involves the efficient arrangement of a group of dissimilar systems having best possible workload management. It facilitates the utilization of an organisation's total resources viz. networks, storage, servers as well as data etc. to act collectively to design new vast provisions of computing resources [47]. Grid Computing has no constraint in terms of users, departments or enterprises. In simple words, in Grid Computing, the individual user can access the computing resources when needed even though unaware of the actual physical location of these resources or what are vital mechanisms and so forth [48].

- **Ubiquitous Computing:** In this arena of technology, it has entered into the backdrop of our lives. This has been defined as "Third Paradigm Computing" by Alan Kay of APPLE Computing [49]. As nowadays one user has multiple computers to execute the computing process. Previously, one computer was ingressed by numerous users viz. Main Frame computer or a single person had only single Personal Computer to execute the computing. This latest technology can also be called as Pervasive Computing. The idea of Ubiquitous Computing is entirely established on installed technique where many microprocessors are interspersed on a particular or undersized chip. The users keep ample computing processors to execute the parallel processing at an agile rate. This technology cuts down the memory as well as storage needs as it is based on the use of thrifty processors [50]. This technique amalgamates current network techniques along with Wireless Computing, Facility of Internet, Artificial Intelligence and so on etc. The main aim of this technology is to form a domain where the congruence of equipments can be installed in a shape so that the connectivity can be unnoticeable as well as accessible beyond any deferment at 24x7 [51]. Figure 1.12 evidently points up the Ubiquitous retailing pattern.
Cloud Computing: Such type of technology has been prevalent in modern age. Nowadays, people are not ready to pay big amount to buy full version of the hardware or application they need. They are willing to invest for the hardware/application for the time period they require them. In that case, Cloud Computing bestows the alternate to people to invest as per usage [52]. In other words, Cloud Computing is a technique of applying a connection of unique servers entartined on the Internet in place of a local server or personal Computer [53]. By using this connection, user can store manage or process data. The term Cloud Computing obtained its name from the sketch commonly used to enact the Internet. For IT services, Cloud Computing can be considered a most recent utilisation plus delivery model. This concept acts as a swing in our imagination that the users have no need to comprehend the particulars of a detailed technology. The provider himself administers the service; users will procure the service as per their needs and bear the cost as per the usage only. The architecture of Cloud depends on its types: Public, Private and Hybrid. Cloud Computing services are being given by many noteworthy companies viz. IBM, Google, Microsoft, Yahoo, Amazon etc. [54]. More and more companies like Facebook, YouTube, MySpace, SalesForce etc. have also initiated to give all kinds of Cloud Computing services for Internet customers in present times.

Figure 1.12: Ubiquitous retailing pattern
1.4 APPLICATIONS ARENA OF DISTRIBUTED ENVIRONMENT

Distributed Computing has gravid potency in today’s world as Cloud Computing and Grid Computing have emerged from Distributed Computing. One can see its subsistence in every domain, comprising business, industry or at customer plane [55]. Some of them can be listed as follow:

- **Telecom Industry:**

Telecommunication is the result of idea that information can interchanged at distant region. It is much dilated than the concept of telephone. The invention of telegraph gave the feathers to this concept [56]. In the sphere, Distributive System proved as crucial factor in establishing telephone and cellular networks, computer network as well as wireless sensor networks [57] [58]. Figure 1.13 undoubted depicted the Architecture of Wireless Sensor Network & role of DS in the wireless Sensor Network.

![Architecture of Wireless Sensor Network depicting the role of Distributed System](image)

*Figure 1.13: Architecture of Wireless Sensor Network depicting the role of Distributed System*
Distributed system acted as a cardinal element in establishing exchanges in different cities to handle the telephonic calls. In the today’s cellular age, Distributive System provides the foundation for the concept of cellular networks. Even the concept of Internet reached its summit by distributed system’s trait of network of networks [59].

Wireless sensor networks are basically autonomous sensors which act as geographically distributed wireless sensors. Due to the capability of these sensors, they are used not only for environment forecast but for military applications like battlefield surveillance, Industrial process monitoring, and health industry also [60].

- **Role in Networking:**

  Distributed System with its features of parallel processing and sharing of resources has enabled the idea of networking to be grown up [61]. In whole networking concepts viz. World Wide Web, peer to peer networks, Multiplayer online games, Virtual reality etc., applications are currently functioning with the dispersion of tasks in various modules to execute computations at fast rate and usage of resources optimally [62].

  World Wide Web is a set of broad distributed network. Earlier it was acknowledged as an extensive client-server system which was later on delineated with the idea of peer-to-peer network [63]. Even though this technology supersedes the requirements of servers yet is founded on Distributed System to form the knowledge depot. Hence, it is cognized as real distributed system.

  Centralized Distributed Architecture helps in Multiplayer, Online Role-playing Games by distributing the game on various game servers to get the abated computational burden [64]. Further Virtual Reality, based on Distributing Computing, reckons the amazing attribute in the arena of online gaming [65].
Even the Network File Systems (NFS), foundation of every network for interchanging data, is a distributed file system protocol which empowers the client to approach any data residing in same or a distant server [66]. Distributed Information Processing System has emerged as the life force of banking as well as online reservation systems as it bestows the attribute to end user to approach the data at any location as well as suffice the prolixity of data when needed in order to protect the data from system breakdown [67].

- **Real-time process Control:**

These systems are ever activated. They have capacity to reciprocate the user request within specified time. In this situation, different control systems depend on the idea of distributed systems [68]. Aircraft control and Industrial control system work in this environment. Distributed Flight Controls System is a power plunge in the emergence of Aircraft Flight Control System designing [69]. Even the concept of unmanned Aircraft is based on Distributed Flight Control Systems. Figure 1.14 portrays Air Traffic Control System.

![Figure 1.14: Air Traffic Control System](image)
Also the Industrial Control System is term as Distributed Control System. In this System, all controlling components are dispersed geographically while processing is going on. All controlling elements are designed in a hierarchy. They are connected by communication networks for observation and control.

- **Parallel Computing:**

With the distinct traits of parallel computation and allocation of resources, Distributed Computing has gained much fame in the arena of computing. Parallel Computing is form of Distributed Computing. In Distributed Computing, the task is assigned to various machines which work concurrently and allocate the resources to hasten the computation process while in parallel Computing, one computer has various processes to execute the single task [71].

In this age of agility, Parallel Computing has gained the actual lift with the evolution of Cluster, Grid and Cloud Computing. Nowadays, Scientific Computing with assistance of Computer Science is at its best to tackle the obstacles of science as well as engineering. Rightly it has been called “**Third Pillar of Science**” [72]. The platform of simulation is playing a major role in obtaining real results at low expense and to construct optimal structure. Simulation has become the spine of Grid as well as Cloud Computing. Figure 1.15 mentions that theory, experiment and simulation are three pillars of science for scientific problems.

One of the Major techniques of Parallel Computing and Distributed System is distributed rendering for computing jobs on computer graphics. Rendering Graphics need huge computing resources to create typical scenes viz. visualization in Science or Medical, Virtual Reality etc. [73]. Then in the rendering an object has much workload in various domains like frames, pixels etc. In that case, Distributed rendering is used.
1.5 DISPOSITION OF GRID COMPUTING

Grid computing manipulates intensive as well as large scale data related problems. Basically it is a framework consisting the joining of computers, databases as well as available network resources [74]. In today’s world of scientific & technological advancements, the exponentiation of computational problems is on increasing. It has compelled the IT specialists to engulf the organizational line to achieve targeted data handling. In this situation, the allocation of the different problems over multiple computers is the best reasonable resolution. Figure 1.16 representing General Architecture of Grid.
On the basis of usage, Grid computing can be categorized as:

- **Computational Grids**: Such kind of grids are used to impart protected access to computational resources, adequate enough to implement processing of computational complications which otherwise would have demanded high computing power machines [75].

- **Collaboration Grids**: These types of Grids cater the best possible desired collaboration in internet Services and network resources as their advancement demands better collusion.

- **Utility Grids**: CPU cycles as well as other software & special units viz. sensors can be shared in such type of grids.
• **Network Grids:** One of the obstacles in handling computational machines having sufficient computational power is poor network communication. It hinders in using machines most desirably. In that case, network grid imparts effusive performance communication by using data caching between nodes there by hastening communication with each cache nodes which act as router.

• **Data Grids:** Primarily there are two things: data and calculation over that data. Data grid proffers the base for data repository and other data related services viz. Data discovery, handling, publication etc. Figure 1.17 representing various kinds of Grids.

![Figure 1.17: Various kinds of Grids](image)

### 1.6 APPLICATIONS BASED ON GRID

On the basis of our prior discussion, we can adjust grid based computing applications to get common requirements which are mentioned in the following points:
• Application segmenting that comprises breaking the problem into distinct sections.
• Detection as well as listing of undertakings and workflow
• Input communications aggravating the problem data when and where it is needed.
• Providing as well as diffusing application codes to particular system nodes.
• Results Management supporting in the decision processes of the domain.
• Unrestrained constituent’s viz. self-configuration, self-accretion, self-reformation as well as self-administration [76].

1.7 DISPOSITION OF CLOUD COMPUTING

When the services as well as applications run on an allocated network exerting virtualized resources, it is called Cloud Computing. Such resources can be determined by same Internet and Networking protocols. Such virtualized resources are confined. Even the physical resources used for executing software stay isolated from the end user [77]. Hence, Cloud Computing pertains to the services and applications, hardware as well as system software reachable through the Internet in the data centers that bestow those services.

Two most essential notions of the word ‘Cloud’ are:

• Abstraction

The technicalities of system exertion from every type of user are abstracted in Cloud Computing. Data storage sites persist hidden. Physical systems on which applications run are not described. System Administration can distribute the job to different outsourced companies so that users can access the information at the earliest level when they require.
• **Virtualization**

Pooling and sharing of resources makes the virtualized systems. Computers as well as storage can be arranged as needed from a systematize framework. Expenditure is based on usage; multi-tenancy is permitted as well as resources are adaptable with deftness.

The origin of the term Cloud Computing may be from the use of the image of cloud which represents the internet or massive networked domain. One never bothers what is in it or else what is going inside apart from one relies for communicating info from it [78]. Nowadays, Cloud Computing is related to abstraction of larger plane. Now it has services besides data pipes, routers etc. However, there are still latent hardware alongwith software networking, yet higher level service facilities are procurable now that can be used for building applications. Behind these available services, there are data and computational resources [78].

A service user needn’t bother how it is put into action or how it is managed or what are the technologies used in it. The level of reliability essential to meet the application fundamentals is the only crucial thing. In fact, Cloud Computing means accessing resources as well as services required to carry out targets with vehemently changing requirements. Instead of a specific end point or named resource, cloud can be assessed by an application or service developer. Different frameworks across several organisations are managed by what goes on in the cloud. It comprises one or more infrastructures coated on top of the infrastructures confining them together. Figure 1.18 is representing components of Cloud Environment.

Cloud Computing is categorized in two well-defined sets of following models:

- **Service models:** It comprises peculiar kinds of services that one can approach on a cloud computing podium.

- **Deployment models:** It ascribes to the location & management of the cloud’s framework.
1.7.1 SERVICE MODELS

During the development phase of Cloud Computing many vendors with clouds that are providing different services are easily available. These service portfolios accumulate a new set of definitions. They are called Service Models.

- **Infrastructure as a Service:** It imparts virtual storage, Virtual machines, Virtual framework as well as other hardware goods as resources which applicant can choose. The responsibility of entire infrastructure is taken by the IaaS service provider. The applicant handles other facets of the arrangement including applications, user communications with the system as well as operating system [77].

- **Platform as a Service:** It bestows operating systems, virtual machines, development frameworks, transactions, services, applications as well as control structures. The applicant can implement its applications on the cloud
framework. It can utilize those applications which were programmed supported by the PaaS service provider.

The cloud framework, the operating systems as well as the accredited software are managed by the service provider. The responsibility for the deployment of application’s installation and maintenance is of client’s.

- **Software as a Service:**

  It includes applications, management as well as the user interface which makes a complete operating environment. In this model, the application to the client is provided by a thin client interface, usually a browser. Then the responsibility of client starts and ends with handling its data as well as user interaction. Business person is responsible for everything from the application down to the infrastructure.

SPI model of Cloud Computing came in existence when these three service models are taken collectively.

The other service models can be listed as: IdaaS, CmaaS, StaaS acronyms of Identity as a service, Compliance as a service as well as Storage as a service respectively [79].

1.7.2 **DEPLOYMENT MODEL**

A well reputed Institute of Technology (NIST) has illustrated four deployment models which are as follow:

- **Public cloud:** This infrastructure is retained by an organisation for vending its services and entirely accessible for civil use preferably for a large industry group.
• **Private Cloud**: This structure is exclusively built pro the usage of a company national or international itself, however that possibly will be handled through that firm itself or a third party. These clouds may operate from on the premises or off the premises of the organisation [77].

• **Hybrid cloud**: It is the combination of several clouds viz. public, private or community. These Clouds are found together as a unit even though they possess exclusive identities. This cloud may allow standardized or proprietary approach to data and applications along with application movability [77].

• **Community Cloud**: This cloud has been formed to provide a common function or goal which may be related to one or more firms or companies having common goals viz. their security, mission, policies, regulatory compliance requirements etc.

Such type of cloud can be tackled by the fundamental organisation(s) or by any third party which is shown in figure 1.19 [77].

![Figure 1.19: Deployment Models](image-url)
On the other hands, the SPI services circumscribe all other prospects. Cloud Computing services can be taken into consideration in the form of a hardware or software assemblage. At the bottom of the stack network comprises the infrastructure or hardware. Moving upward in the stack, every service model obtains the potentialities of the service model below it. There are the least levels of unified process and the lowest level of unification in IaaS.

In the present era, various multinational companies have started to provide the services as cloud service provider and many of the big ventures are in the planning to gain the profit from the continuously booming area.

1.8 RESEARCH ISSUES IN DISTRIBUTED SYSTEM

From the above illustration, It is clear that there is a complete life cycle of Distributed System. With the development of IBM Main frame Computer, it has begun its sojourn. Now it is in the appearance of Grid Computing, Cloud Computing et. al.

Nowadays, the approach of Grid as well as Cloud Computing being executing adeptly. Yet there are numerous spheres such as load balancing, task scheduling, security et. al where research process is still going on. This segment exhibits the leading issues of contemporary era for doing research in Distributive Environment as follows: Figure 1.20 depicting various types of research issues which can be considered as Open Challenges for research Community.

- **Task Scheduling:** It is a crucial issue in the sphere of Distributive Environment which has great influence on the performance of system at large extent. In present competitive environment, expectations of users are increasing at rapid speed about the services provided by Cloud and Grid. Even lot of infrastructure has been provided by the various multinational companies and government of different countries at their own. But as compare to the demand the resources are always limited so scheduling of resources is always a complicated problem [1].
Task scheduling algorithms are technique by which a task is allocated to the specific machine to get the optimum. Due to contradictory objective functions, no technique can be considered as prefect scheduling algorithm. Normally the efficiency of algorithm is evaluated on the basis of execution time required to implement it.

- **Load Balancing:** As has been defined above, task scheduling is an important element to achieve the efficient environment, while scheduling the task the balance load between different Physical machines is also an important factor. For this purpose, VM migration can be performed by identifying the idle
virtual machines. After scheduling the task based on any algorithm to the appropriate Virtual Machine as per their capacity and objective function. Some time, few VMs are remain unmanaged or idle, they can cause to waste of energy. To manage this situation a dedicated algorithm is required which can perform the VM migration at low cost. Design of such algorithm is critical issue in the present era [80]. Normally, to design such algorithm two modules are created one is responsible to find the overloaded and Under loaded Physical Machine and second one lead to the VM migration as per mapping to get the balance load on the system.

- **Security:** In the present sphere, when everyone is connected to each other. Security has become the prime function for every system. Security is important to maintain the privacy of users and provide the access of system to the authorized person. As the cloud getting popularity among the society for storage of their confidential document and other services of cloud. It has also become soft target for hackers. They are always try to find the vulnerability in the system or hack API interface to stole the financial information, business secrets of users of cloud service providers. So there is need to design a trust based model and security algorithm which can manage the system from these types of attacks [81].

- **QoS Parameters:** Basically Quality of Service (QoS) is the skill to give various priorities to diverse applications, users, or data flows, or to promise a certain plane of efficiency. In the current sphere, users are increasing at rapid speed and expectations of users are different as per their profile. There are various technique to manage the QoS Parameters are Scheduling, admission control, traffic control, dynamic resource provisioning [82]. Figure 1.21 explains the QoS parameters for cloud.
At last, we can conclude that Clouds will be shared clouds driven by economical constraints and for some applications, availability of resources along with isolation are of prime importance. So, the QoS for clouds is already a necessary and hot topic in research community.

- **Cost Management and Energy Efficiency**: From the decade to decade, when a service is introduced in the real world, the first step is to reduce its cost so that user can access the services at lowest cost. Due to ever increasing demand of cloud computing, the operational cost of datacenters has increased many folds and is of major concern for the cloud providers [83]. The reduction in the energy consumption of the servers and communication networks can
significantly improve the overall operational cost of datacenters. The efficient virtual machine (VM) placement can optimize the utilization of server and network resources resulting in energy efficient datacenters. So in the present scenario energy management for the cost reduction is prime issue for the researchers.

1.9 PROBLEM DEFINITION

Even a lot of work has been done in the field of task scheduling in Distributive Environment and various eminent authors have given various techniques to schedule the task in the Distributive Environment but after the extensive critical survey of various task scheduling techniques reveal that a lot of more dimensions are yet to be explored in terms of datacenter cost, Virtual machine migration, energy consumption and Service Level Agreement. Instead of managing these parameters, the most important factor is lagging behind i.e. security in the task scheduling and Design of Trust model which can assure the various factors related to the security in the Distributive Environment. The gist of this research work is to critically observe, analyze, investigate the task scheduling parameters, security challenges and finally develops most efficient and secure task scheduling technique for Distributive Environment in terms of minimum execution time, energy consumption and better resource utilization with trust model for security of system.

1.10 ORGANIZATION OF THESIS

Rest of the thesis is divided into eight chapters as mentioned below:

Chapter 2: Comprises the extensive literature review of Task Scheduling Techniques independent with security feature especially in the independent task scheduling. Critical review of workflow task scheduling to find the possibilities in the improvement of these scheduling techniques. The complete survey of Trust model in the sphere of Cloud computing so that we can propose a new Trust model for the security management in the system. At the last a extensive critical survey has
been performed in the field of energy aware task scheduling and frame work for real
world applications to trace out the unfold and untouched areas so that a new
technique which can provide minimum energy consumption for cloud environment
can be proposed.

Chapter 3: Comprises the Aims and objectives of thesis based on the research
issues chosen for research purpose.

Chapter 4: Comprises of development process of proposed Modified Genetic
Algorithm for the independent tasks. This chapter shows that it outperform as
compare to the standard Genetic Algorithm. This chapter also comprises the security
feature in the task scheduling algorithm by adding up the security overhead in the
technique.

Chapter 5: This chapter comprised the proposed algorithm based on Genetic
algorithm for the interdependent tasks. Workflow based task scheduling consider the
dependency factor to task and resource and communication cost, while calculating
the makespan and resource utilization. It also outperform as compared to standard
Genetic Algorithm.

Chapter 6: In this chapter an extensive critical review of meta-heuristic task
scheduling technique has been performed. The survey also includes the close
examination of the performance of hybrid metaheuristics. An extensive review of
recent proposals for scheduling techniques to reveal that is there is any scope in
terms of datacenter cost, virtual machine migration, energy consumption and
Service-Level Agreement etc.

Chapter 7: Proposed a trust model for Cloud Environment, designed with the help
of fuzzy system and Simulink. Cloud analyst used as simulator to get the results
based on the user inputs. In this chapter, a framework for the Trust model also has
been proposed.
Chapter 8: Proposed an Energy aware Task scheduling algorithm for Cloud Environment based on the Genetic algorithm for the cost reduction. This chapter also presents the results of proposed algorithm as compared to the First Fit Algorithm. It outperform as compared to First Fit Algorithm.

Chapter 9: This is the concluding chapter which presents the distinctive offerings of whole research work and the future scope in this area.