



# A RESEARCH STUDY ON DISTRIBUTED COMPUTING & IT'S APPLICATION WITH DEVELOPMENT TREND ANALYSIS

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**Abstract:** *Distributed computing is a field of computer science that deals with the computation of distributed systems. Distributed systems are by now very common, yet remains a difficult area of research. The results of new technologies coming up is that it's not only feasible, but easy, to hold together a computer system packed of multiple network computers, be they too large or too small. This paper focuses on distributed computing and its various applications in a research perspective. The idea is to have a deep research on distributed computing and an analysis on the development trends in distributed computing. This article also introduces the various application fields in distributed computing including real-time applications like GPS, ATC, IRA etc...*

**Keywords:** *GPS, Global Positioning System, ATC, Air Traffic Control System, IRA, Industrial Robotic Automation*

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## 1. Introduction

Distributed systems are by now very common, yet remains a difficult area of research. The results of new technologies coming up is that it's not only feasible, but easy, to hold together a computer system packed of multiple network computers, be they too large or too small. These computers are generally geographically dispersed, that reason they're usually said to make a distributed system. The size of a distributed system may vary from a couple of devices, to many computers. The interconnection network could also be wired, wireless, or a mixture of both. Moreover, distributed systems are often highly dynamic, within the sense that computers can join and leave, with the topology and performance of the underlying network almost continuously changing.

## 2. Distributed Computing Overview

Distributed computing as a department of computer science that deals with distributed systems. Distributed computing refers to multiple systems networked together with intent of allocating the same computing work. The main aim of distributed computing is to share the tasks between numerous systems [1]. The results of new technologies coming up is that it's not only feasible, but easy, to hold together a computer system packed of multiple network computers, be they too large or too small. These computers are generally geographically dispersed, that reason they're usually said to make a distributed system. The size of a distributed system may vary from a couple of devices, to many computers. The configuration of a distributed system is considered as decentralized if none of the participants in the system are more important than the others, in case that one amongst the participants fails, then it's neither additional nor less harmful to the system than caused by the failure of the other participant within the system. The major challenges for decentralized distributed systems are scheduling, authentication and privacy. The technologies used to implement a decentralized distributed system are Bellagio, Condor Flock P2P, Inter Grid, Legion Federation, Trader Federation, MOSIX Fed, Sharp, Tycoon, Amazon Ec2, Azure, and Eucalyptus [2].

## 2.1 Advantages of Distributed Computing

**Sharing Data:** User at one website could also be able to access the data from another website. Every website is in a position to retain a degree of management over information that square measure keeps domestically which results in autonomy.

**Availability:** If one website fails during a distributed system, the remaining sites could also be able to continue operating. Therefore failure of 1 website doesn't have an effect on the entire network.

**In distributed system** there's a world information administrator liable for the complete system. A Part of international information base administrator responsibilities is delegated to native information base administrator for every website.

## Disadvantages of Distributed Computing

**Complexity:** It needs correct coordination among all sites. If not so, it results in quality.

**Software Development Cost:** it's tougher to implement a distributed information system; so it's pricier.

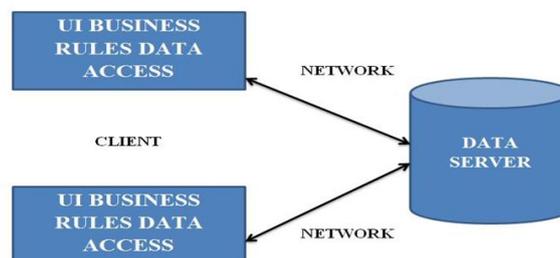
**Exaggerated process Overhead:** The exchange of information and extra computation needed to achieve co-ordination are a style of overhead that does not arise in centralized system.

## 2.2 Architecture

Distributed Systems are composed of varied hardware and software (collectively called components) that communicate with one another only by transfer of messages. These components are placed accordingly in a single network system. So, when we think about the architecture styles for distributed computing the main task would be to ensure that these can communicate with one another through a communication network. The distributed system architectures are classified into 4 types, client-server architecture, n-tier architecture, broker architecture and service oriented architecture.

### Client-Server Architecture

The client-server architecture is the one of the most common architecture in distributed systems. It has mainly two major subsystems which is the client and server. Client is first process from which a request is send to the second process/system known as server. Server is the second process/system which responds to the request received from the first process/system. This type of architecture, the application is modeled in such a way that servers provide a set of services and clients uses these services. The servers need not know about clients, but the clients must be aware about the server identity.



2-Tier Client-Server Architecture

### Advantages

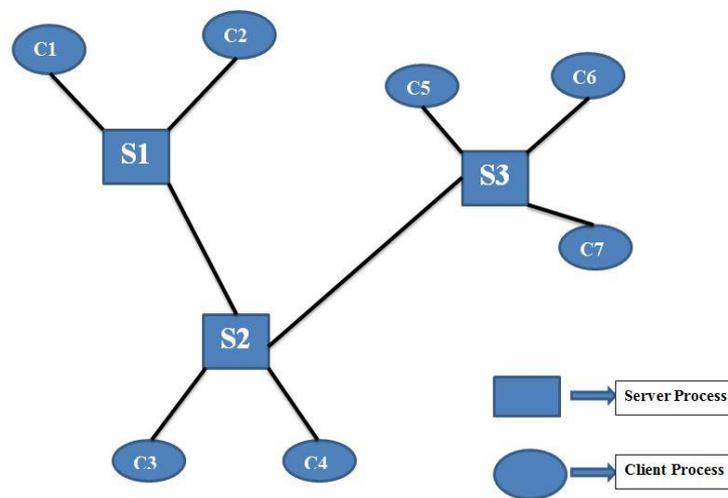
- Separation of responsibilities such as user interface presentation and business logic processing.
- It also makes effective use of resources when a large number of clients are accessing a high-performance server.

### Disadvantages

- Lack of heterogeneous infrastructure to deal with the requirement changes.
- Security complications.
- Limited server availability and reliability.

### Multi-Tier Architecture (n-tier Architecture)

Multi-tier architecture is a client-server similar architecture where the functions like presentation, application processing, and data management is physically separated into different modules. By separating an application into different modules/tiers, administrator will have an option to modify or add a certain layers if needed, instead of recreating the whole application. This provides a model by which developers can make flexible and reusable types of applications.



### Advantages

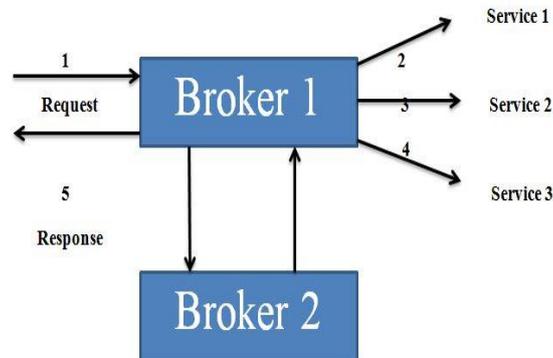
- Provides multi-threading support and also reduces network traffic.
- Provides maintainability and flexibility.

### Disadvantages

- Unsatisfactory Testability due to lack of testing tools.
- More critical server reliability and availability.

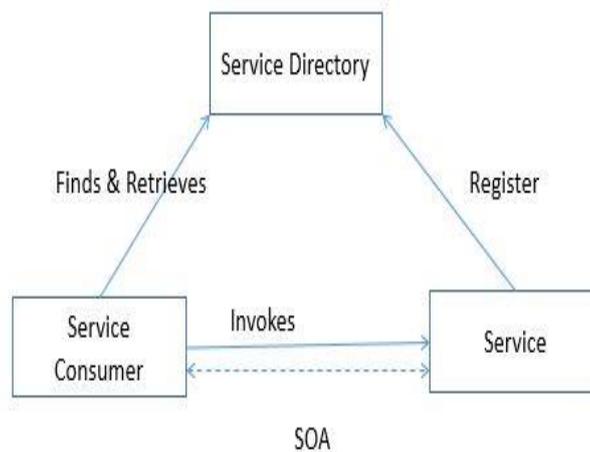
### Broker Architecture

It is a type of middleware architecture which is used commonly in distributed computing to coordinate and activate the proper server to client communications. In this architecture an object request broker (a software bus) is used as a middleware system on which the object communication takes place. The server and the client will never communicate directly with each other; they communicate mediator-broker known as proxy who passes the messages and requests. Services are provided by servers by registering and publishing their own interfaces with the broker, so that the clients can request those services provided by servers from the broker statically or dynamically. Common Object Request Broker Architecture (CORBA) is one of the best implemented instances of the broker architecture. Some of the components of broker architecture are broker, stub, skeleton and bridge.



### Service-Oriented Architecture

A service could be a part of business practicality that's well-defined, self-contained, freelance, published, and on the market to be used via a typical programming interface. The connections between services are conducted by common and universal message-oriented protocols like the SOAP net service protocol, which might deliver requests and responses between services loosely. Service-oriented design could be a client/server style that support business-driven IT approach during which associate degree application consists of code services and code service customers (also known as clients or service requesters). A service-oriented architecture provides features like Distributed Deployment, Computability, Interoperability and Reusability.



### 2.3 Applications of Distributed Systems

The terribly nature of an application might need the utilization of a communication network that connects many computers: for instance, information made in one physical location and needed in another location. There are several cases during which the utilization of one pc would be doable in essence; however the utilization of a distributed system is helpful for sensible reasons. For instance, it should be additional efficient to get the specified level of performance by employing a cluster of many low-end computers, as compared with one high-end pc. A distributed system will give additional responsibility than a non-distributed system, as there's no single purpose of failure. Moreover, a distributed system is also easier to expand and manage than a monolithic uniprocessor system. Applications mentioned during this paper square measure usually classified



into 3 main elements like telecommunication network applications, network applications and also the real time process control applications and its subparts also are explained.

### **Telecommunication Networks**

The telecommunication business in Asian country is quickly growing and witnessing several developments. It's seasoned many transformations that have led to severe competition within the business. The telecommunications business in India has witnessed several developments and undergone tremendous changes. It one among the quickest growing industries within the world and has established to be a global success story. India has developed because the second largest telecommunication market with 898 million subscribers as on March, 2013. Indian telecommunication sector has undergone a serious method of transformation through many policy reforms and laws. The world is turning into additional competitive day-by-day, with the introduction of latest players and has actually revolutionized the manner we tend to communicate and share info [4].

### **Telephone Networks and Cellular Networks**

The major changes in the industry occurred due to factors like technological developments, declining tariffs, changing customer demands, values added services (VAS), mobile number portability, Telecom Commercial Communications Customer Preference Regulations, Foreign direct Investments and competitions. The industry in the coming years is estimated to be very competitive and aggressive with establishment of new technology and it will be interesting to see how the market leads adapt themselves and change strategies with the oscillating environment [4]. There is an emphasized importance of using a good simulator for network simulation and modeling tasks. A credible simulator offers additional flexibility in model development, modification and validation, and incorporates acceptable analysis of simulation output information, pseudo-random variety generators, and applied mathematics accuracy of the simulation results. There are mainly three specific recommendations specifically, network researchers should: (1) select a reputable network machine for simulation tasks; (2) build valid and credible simulation models; and (3) use applied math approaches to improve credibleness of simulation results. Adopting these suggestions can facilitate to provide a sound, scientific underpinning for network analysis [5]. Teleworking as a system includes inputs, activities, outputs and feedbacks. The aim of the interaction between these components is to achieve several benefits for employers, employees and society. There are mainly 4 points as the recommendation for the teleworking like materials and work equipment, manual of procedures, technology platforms, code of ethics and code of conduct [6]. Unified Research on 5G is being carried on and is contemplated to come in utilization commercially by 2020. The birth of 5G technology can be a finest gel to the various problems that we are cladding in the current technologies nowadays. 5G will come out as an intelligent technology that will narrow down the number of different technologies to a single entity of a global standard [10]. Wireless Technology is a method of transmission of data or information from one place to another without wire. It is more flexible and expensive when compared with the wired one. Now day's wireless technologies have become so prominent that the development in that area is increasing greatly. Paper brings methodologies used for 5g wireless system. Concept called MIMO which is multiple inputs and multiple outputs with multiple antennas used directly to meet the goals of 5G by increasing the data rate and decreasing the latency. The highlight features of 5G which includes high resolution, greater speed, higher quality Services to avoid error and so on. Comparative study of the various generation starting from 1g followed by 2G ,3G,4G and currently 5G which is not officially used but has proven to be fast and reliable. To conclude 5G Technology will be soon released giving us a better experience a wireless Technology [16].

### **Internet**

The comparative assessment of survivability in the distributed information is widely discussed. Some ways also are delineate upon the comparative assessment of distributed information-telecommunication networks as to their ability to provide information exchange between correspondents in conditions of occasional and intentional software interferences. The results of mistreatment of the ways are increase of liableness of assessment of structures of distributed integrated information-telecommunication networks upon variation of the quantity of communication nodes and lines of the network. The strategies account security of



communication lines, which, not like the communication nodes, cannot be isolated from impacts of the atmosphere [7].

### **Wireless Sensor Network**

Grid Habitat monitoring is described as a driver application for wireless sensor network. The Intel Research Laboratory deployed a mote based tiered sensor network on Great Duck Island (GDI) to monitor the behavior of storm petrel. The Mica Weather Board, stacked to the processor board via the 51 pin extension connector, includes temperature, photo resistor, barometer, and humidity and thermopile sensors. To protect from the varying climatic condition on GDI, the Mica mote is packed in acrylic enclosure, which will not clog the functionality of sensing and radio communication of the motes. Two types of sensor data are collected, weather data are collected every ten minutes and image data are collected once per hour, users can use Internet to access the data from a server. The sensor placement strategy is evaluated on the basis of 3 major goals: resilience to single point of failure, area of interest is covered by at least one sensor, minimum number of nodes. Environment Observation and Forecasting System (EOFS) is large distributed system that widens large geographic areas and monitor, model and forecast physical processes, like environmental pollution, flooding etc. The major 3 components are: sensor stations, a distribution network, centralized processing farm [13].

### **Routing Algorithms**

A routing algorithm is taken as a tool for creating an analysis over the research work done in network algorithms. An analysis is concluded over the routing algorithms such as between the adoptive routing algorithms and the non-adoptive routing algorithms. The results endorse to the adoptive routing algorithms in which the researchers can simply trace the best routing path in traffic over the network since it adjusts to network when compared with non-adoptive routing algorithms. The adoptive routing algorithms give best routing path when compared with the non-adoptive routing algorithms in the networks [8]. Multiple routing protocols for MANET, which are broadly categorized as proactive and reactive and Hybrid protocols. The classification of routing protocols like Proactive Routing Protocols, Dynamic Destination-Sequenced Distance-Vector Routing Protocol, Wireless Routing Protocol, Cluster Gateway Switch Routing Protocol, Reactive Routing Protocols, Dynamic Source Routing, Ad Hoc On-Demand Distance Vector Routing, Associativity-Based Routing, Signal Stability-Based Adaptive Routing Protocol, Temporarily Ordered Routing Algorithm, Hybrid Routing Protocol, Zone Routing Protocol and Sharp Hybrid Adaptive Routing Protocol are also widely discussed. There are several challenges that need to be met, so these networks are going to have extensive applications in the future [9].

### **Network Applications**

A network may be an assortment or set of computing devices connected to one another to determine communication and conjointly share offered resources. A network can comprise package and hardware devices. You'll have a network even if you're not connected to the web. Laptop networks create it doable for individuals to transfer files from one place to a different and to speak taking the shortest time doable. Computer network applications are network package applications that utilize the net or alternative network hardware infrastructure to perform helpful functions for instance file transfers at intervals a network. They assist United States to transfer knowledge from one purpose to a different at intervals the network.

### **WWW and Peer-Peer Networks**

Grid According to the number of criteria grouped under the headings Simulator Architecture, Usability, Scalability, Underlying Network Simulation and System Limitations, the simulators will be assessed. P2PSim is a discrete event packet level simulator that simulates structured overlays. It contains implementations of six candidate protocols. The P2PSim code is for a range of radical network topologies such as end-to-end time graph, G2 graph, GT-ITM, random graph and Euclidean graph. Planets are a discrete-event overlay network simulator, written in Java. It supports both structured and unstructured overlays, and is packaged with ChordSIGCOMM and Symphony implementations. PeerSim is an event-based P2P simulator written in Java, partly developed in the BISON project and released under the GPL open source license. It is designed specifically for epidemic protocols with very high scalability and support for dynamicity. It can be used to



simulate both structured and unstructured overlays. GPS is a message level discrete event simulator with a built-in protocol implementation of Bit Torrent. GPS comes with a tool which provides a method for automatic generation of events in the context of the implemented Bit Torrent protocol [14]. World-Wide Web (WWW) provides a unified client image to an enormous range and variety of information services on the Internet. World-Wide Web (WWW) can be defined as an interface to all the different Internet services, which is user-friendly. It is useful for all types of networked communication. Hypertext is defined as text with —level references. The World-Wide Web was designed not only to browse through purpose-built hyper documents, but also to use most of the existing Internet services. FTP is a protocol for transferring files to and from computers on the internet. Gopher is similar to WWW in the sense that no opening of connections is needed: it suffices to select a menu item referring to a file on a different computer in order to get that file. News: the Usenet newsgroups form a system of world-wide bulletin boards on different subjects, reachable through many different computers so as to spread the effort of storing and transmitting the huge amount of information they produce. Each day new messages are added and messages older than a pre- defined period are deleted. WAIS: is a very powerful and flexible text retrieval system which is accessed by typing in a list of keywords. Telnet is very inefficient and not user- friendly. A physical network connection and some implementation of the TCP/IP protocol which defines Internet communication [15].

### **Distributed databases and DDMS**

Distributed database management system (DDMS) is the software that manages the DDB, and provides an access mechanism that makes this distribution transparent to the user. Distributed database system is the integration of DDB and DDBMS. This integration is achieved by combining the database and networking technologies together. Distributed data base is the collection of multiple, logically interrelated databases distributed over a computer network. A distributed database management system is a software system that allows managing distributed databases and making that distribution transparent to the users. The difference in functionality and structure are: distributed file system allow user to access files that are located on machines other than their own and it provides a simple interface to users which allows them to open and close files [12]. The distributed database is one of upcoming technology in the field of research and business organization. Mainly there are two specific rules which were proposed by Date and Stonebreakers are compared and they are merged to draw out a standard that follow can help in any distributed database system to build a new model for distributed storage environment. The problem areas declared in the paper are very useful while implementing distributed database so that concurrency, deadlock, replication control, security, and privacy is easily managed. The distributed database architectures are drawn out and explained for the purpose of better performance and enhancement in developing a distributed database system [20].

Issues of distributed database are: replica synchronization, synchronous and asynchronous replication, cost function for network or server loads and low amount of data. In DBMS there's only one internal method of accessing data. For the data grid, a single access method is not optimal depending on number of objects to be accessed from a file. There are many tools for monitoring applications and network parameters in grid. Access to data is important for data analysis in HEP. And access to replicated data requires specific data and Meta data structures. The management of replicas requires Meta data structures that store information about the distribution of and access to data [11].

### **Network File System**

A method for implementing Network File System [NFS] protocol for larger block or network packets transfer over to NAS from available clients. A method of inducing NFS to communicate onto storage for highly available application, which can be implemented in any data center where data guarantee is more admitted than the speed of the data, since the data that flows via NFS; whenever a client/ server goes and comes back, during the recovery time the data travel is delayed. More over single lock file function is tolerated in this method [19].

### **Real Time Process Control Applications**

### **Air Traffic Control Systems**



A major problem within the ATC system that is aircraft sequencing and scheduling (ASS). The problem is tackled using a genetic algorithm with uniform crossover in a multi runway system. With the proper use of multiple genetic algorithms, uniform crossover technique and proper construction and use of chromosomes made to efficiently tackle the problem. The results illustrate a clear upper hand advantages with this proposed systems over the existing ones [28].

During initial coaching traffic management students acquire theoretical data in varied fields including traffic management, craft performance, air traffic control instrumentation and systems, navigation and others. The goal of the machine is to realistically implement all the key functionalities required to hide the topics that were conferred in class. The machine offers user friendly, distributed, and multi-role surroundings that may be deployed on regular PCs. By using this simulator the user will have more knowledge about the system, its functionalities and tools to get a better understanding about the aircraft view point and their limitations. A user can also test and increase his/her skills in radar, coordination, teamwork and environment [29].

### **Industrial Control Systems**

Industrial automation using GSM is a trending distributed computing application. A GSM server is implemented with PSOC mixed signal chip, sensors and relays. The GSM modem can produce the needed data which is linked to industry and a maintenance officer who is located at somewhere at any time. The officer will take some action according to the data received by the process of sending commands to PSOC chip using GSM modem. The PSOC microcontroller is needed for the implementation of very complex systems such as controlling multiple systems in a nuclear plant. It can also be implemented in a system where there is a requirement of instrumentation, inverting and non-inverting amplifiers [25].

The pervasive introduction of the web into Robotics and Automation systems pushes forward an evolution that began once the pc was introduced within the enterprise in the middle of the last century which continued with the interconnection of shop-floor workstations in native networks in the 80's. Nowadays the web represents a challenge each for research and development within the space of distributed AI and Automation. So as to achieve a much better understanding and evaluation of recent ends up in Distributed Computing, this paper classifies the foremost promising technological approaches, provides examples of however they're applied in AI and Automation, and discusses accessible standards and business solutions. Decentralized management is changing into a necessity in process management and enterprise integration. Flexibility and ability square measure of elementary importance for cooperative style support. Robust communication characterizes robotic teleportation. Measurability and autonomous execution square measure obligatory for multirobot teams [23].

### **Global Positioning Systems**

Distributed architectures for autonomous vehicles in a real-time environment are commonly discussed topic in the field of computing. Some components of real time autonomous vehicles like the architecture of embedded systems, fieldbus related communication links and some important modules of the GVS (Global navigation system) which in brief explains the solution for the problems based on the autonomous vehicle architecture. The major problem occurs with the integration of all these components together with current technologies with a goal on achieving real-time behavior [21].

Global Positioning System (GPS) application is a highlighted to distributed systems and networks application. Certain principles are applied to get the accurate positioning, current applications, network applications, protocols used, limitations of the system and the real-time application and trending products [30].

There are 3 different basic stages of GPS, GPS security and anti-spoofing methods. It stretches out the spoofing methods like Open-Loop Signal Simulator Attack; Spoofer with Known Geometry Relative to Victim, Meaconing Attack, True-Signal Nulling Attack, Receiver-based spoofing, sophisticated receiver based spoofing, Spoofing in Signal Processing, Spoofing by changing Data Frame and Spoofing by changing Navigation and Position levels and some of the anti-spoofing techniques. The combination of anti-spoofing and anti-jamming techniques could increase accuracy and efficiency of the system. Higher number of attacks and more susceptibility needs high quality research and advance methods to counter them [31].

The major problem of tracking a moving vehicle using GPS is solved with n number of efficient algorithms. As a solution and to increase the accuracy of the moving vehicle a statistical model is proposed. For the



improvement in GPS positioning the author proposes to use a combined version of map matching algorithms, nearest location available and the moving angle. With the increase in the above mentioned aspects, the vehicle tracking efficiency is improved [32]. Algorithms like dijkstra, a\* heuristic, bellman ford algorithms are used to calculate the shortest path for travelling using a GPS technology.

## 2.4 Development Trend

Stand-alone workstations delivering multiple tens of operations per second are commonplace, and continued will increase in power are expected. Once these laptop systems are interconnected by associate degree applicable high-speed network, their combined machine power is applied to unravel a spread of computationally intensive applications. Indeed, network computing could even offer supercomputer-level machine power.

Over the years, technologies like CORBA and DCOM have provided the suggests that to build distributed component-based systems. Such technologies permit systems to interoperate at the element level, by providing a code layer and protocols that offer the ability required for elements developed in totally different programming languages to exchange messages.

Web Services area unit supported XML and give a way to develop distributed systems that follow a Service orientated design (SOA). Services area unit delineate in associate XML- based accent (WSDL).

Along with net Services, Grid computing is another rising paradigm for making wide-area distributed applications. Net Services square measure foundation technologies that will be used in building several sorts of distributed systems and applications as well as Grid systems.

Ethernet - the name given to the favored native space packet-switched network technology fictitious by Xerox PARC. The Ethernet is a ten Mbit/s broadcast bus technology with distributed access management.

FDDI - the Fiber Distributed information Interface. FDDI may be a 100-Mbit/sec token-passing ring that uses optic fiber for transmission between stations and has twin counter-rotating rings to supply redundant information methods.

HiPPI - the superior interface. HiPPI may be a copper-based information communications standard capable of transferring information at 800 Mbit/sec over thirty two parallel lines or one.6 Gbit/sec over half dozen4 parallel lines.

ATM - Asynchronous Transfer Mode. ATM is that the technique for transport, multiplexing, and shift that has a high degree of flexibility needed by B-ISDN. ATM may be a connection-oriented protocol using fixed-size packets with a 5-byte header and forty eight bytes of knowledge.

These advances in high-speed networking promise high output with low latency and create it attainable to utilize distributed computing for years to return. Consequently, increasing numbers of universities, government and industrial laboratories, and Money Corporation's area unit turning to distributed computing to unravel their machine issues. The target of PVM is to alter these establishments to use distributed computing expeditiously.

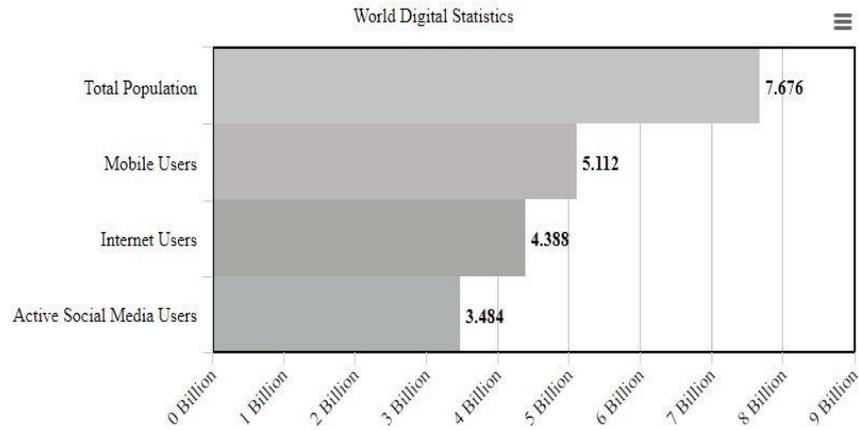
Spark is a remarkable recent development that would be seen as seminal in distributed systems - primarily because of its ability to method information in-memory and with a robust purposeful abstraction. A lot of here: Apache Spark™ - Lightning-Fast Cluster Computing.

The work done on Graph Lab, particularly Power Graph (or Graph Lab 2) may even be seen as important therein it helps in resolution sure machine learning or improvement issues that need communication among the computing entities, one thing that even Spark might struggle to unravel.

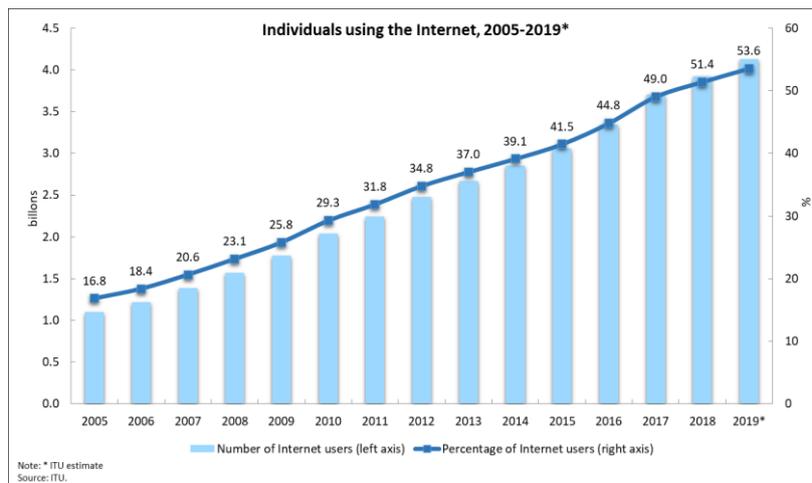
Google's paper on clock synchronization, called the hand tool that solves the oldest downside within the distributed systems literature is additionally important. It solves the matter by exploitation satellite (GPS) and atomic clocks and exposing the inaccuracy/uncertainty through its True Time API.



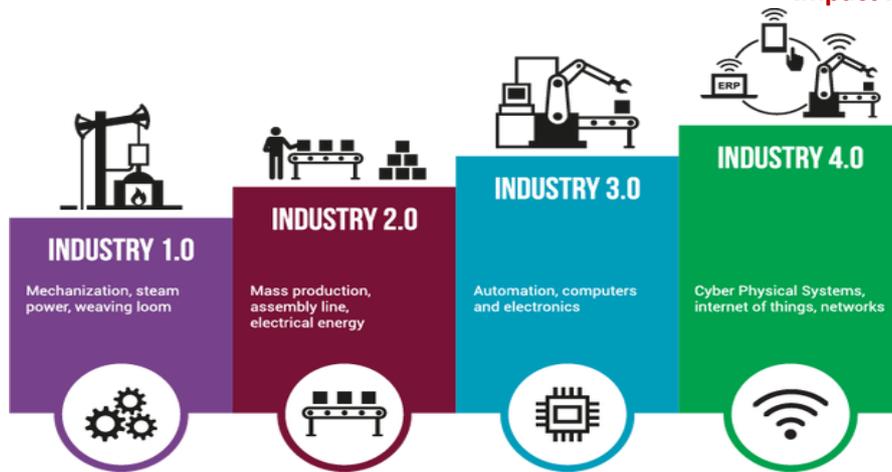
## 2.5 Graphical & Data Analysis Digital Around The World (as per 2019)



## Individuals Using Internet (2005-2019)

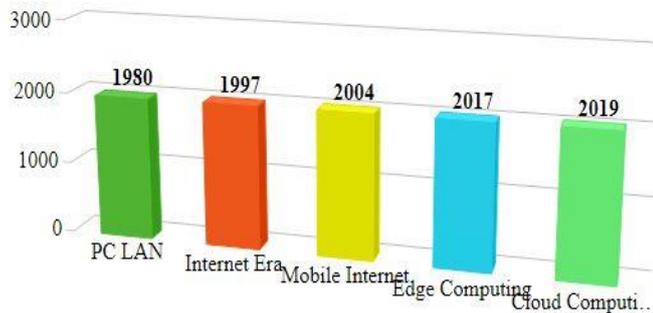


## Industrial Updates



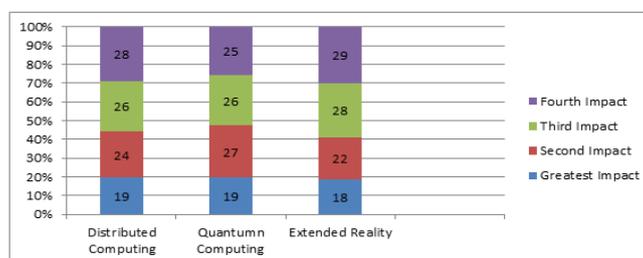
### Evolution of Distributed Systems

Evolution of distributed systems



### Distributed Computing Trend

Distributed Computing Trend Percentage (as per 2019)





### Network Evolution

		4G LTE • 3GPP Rel 11	5G Rel 15
Traffic Density	Mbps/km <sup>2</sup>	-	1000 x
Throughput (Mbps)	Peak	75	3000
	Typical	20	1000
	Change	-	50 x
Latency	Round Trip	12 ms	1 ms
	Change	-	12 x
Reliability	Availability	95%	99.99%
	Downtime	4320 sec/day	< 8 sec/day
	Change	-	550 x

### 3. Future Scope

Some mobile devices additionally used the distributed technology resources to form such applications for mobile devices. An open supply computer code platform for supporting Grid systems and applications Amoeba: A distributed software package that is designed for distributed computing tasks. Green Tea Software: A java primarily based P2P generic distributed network computing platform that transmits code and knowledge on-demand to run on heterogeneous OS. There square measure some future prospects of Distributed computing in technological World.

### 4. Conclusion

As we've got noted so far, distributed systems are a crucial a part of peoples' lives as a results of innovations within the recent past within the space of Web-based applications, and can still build a heavy impact within the future. With the speedy development of varied rising distributed computing technologies like net services, Grid computing, and Cloud computing, pc networks become the integrant of consequent generation distributed computing systems. Rising technologies like Grids can drive the next wave of innovation enabling the creation of applications that deliver IT because the fifth utility once water, electricity, gas, and also the phone. Lastly, distributed computing is a terribly broad space potential to improve efficiency of business processes and quality of life. Therefore, integration of networking and distributed computing systems becomes a crucial research downside for building the next-generation high performance distributed data infrastructure.

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