

UNIT - I**CLOUD**

Cloud refers to a network or internet which is present at the remote location used to share, access, and store data.

The term "Cloud" came from a network design that was used by network engineers to represent the location of various network devices and their inter-connection. The shape of this network design was like a cloud.

The cloud is not a physical entity, but instead is a vast network of remote servers around the globe which are hooked together and meant to operate as a single ecosystem. These servers are designed to either store and manage data, run applications or deliver content or a service such as streaming videos, web mail, office productivity software or social media. Instead of accessing files and data from a local or personal computer, you are accessing them online from any Internet-capable device—the information will be available anywhere you go and anytime you need it. Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.

**COMPUTING**

Computing is the process of using computer technology to complete a given goal-oriented task. Computing refers to the process of using computer technology to design and develop the software and hardware for wide range of purposes- often structuring, processing and managing any kind of information.

Computing includes;

- Designing and building hardware and software
- Processing
- Structuring
- Managing various kinds of information
- Making computer systems behave intelligently
- Creating and using communications and entertainment media
- Finding and gathering information relevant to any particular purpose, and so on

Computing has also been defined as a branch of engineering science that deals with the systematic study of algorithmic processes, which are used to describe and transform information.

It also has specific meanings depending on the context and field in which it is used. For example, cloud computing, social computing, ubiquitous computing, parallel computing, and grid computing all fall under the umbrella of the general meaning of computing.

## RECENT TRENDS IN COMPUTING

In almost no field of technology are current developments as dramatic as in computing hardware and software and their applications in scientific research. Computing is any activity that uses computers to manage, process, and communicate information. It includes development of both hardware and software.

### Latest Trends in Computing:

1. Grid Computing
2. Cluster Computing
3. Distributed Computing
4. Utility Computing
5. Cloud Computing
6. Virtual Reality
7. Internet of Things
8. Machine Learning
9. Cognitive Technology
10. Touch Commerce

#### 1. Grid Computing:

Grid computing is a group of computers physically connected (over a network or with Internet) to perform a dedicated tasks together, such as analyzing e-commerce data and solve a complex problem. Grids are a form of "Virtual Organization" that solves a particular application. The grid size may vary from small to large enterprises network. Grid computing captures the basics of distributed computing that involves coordinating as well as sharing computing, data, application and storage or network resources across dynamic and geographically dispersed organization.

Grid Computing is a subset of distributed computing where a virtual super computer comprises of machines on a network connected by some bus, mostly Ethernet or sometimes the Internet. A Grid computing network mainly consists of these three types of machines;

##### 1. Control Node:

A computer, usually a server or a group of servers which administers the whole network and keeps the account of the resources in the network pool.

##### 2. Provider:

The computer which contributes its resources in the network resource pool.

##### 3. User:

The computer that uses the resources on the network.

#### 2. Cluster Computing:

Cluster computing or High-Performance computing is a form of computing in which bunch of computers (often called nodes) that are connected through a LAN (local area network) so that they behave like a single machine. A computer cluster help to solve complex operations more efficiently with much faster processing speed, better data integrity than a single computer and they only used for mission-critical applications.

In other words, A computer cluster is a set of loosely or tightly connected computers that work together so that, in many respects, they can be viewed as a single system.

Types of Cluster computing:

- 1✓ Load-balancing clusters
- 2✓ High availability (HA) clusters
- 3✓ High performance (HP) clusters

**3. Distributed Computing:**

Distributed computing refers to as multiple computer systems located at different places linked together over a network and use to solve higher level computation without having to use an expensive supercomputer.

In other words, Distributed Computing is the collection of autonomous computers that are connected using a communication network and they communicate with each other by passing messages. The different processors have their own local memory. They use a distribution middleware. They help in sharing different resources and capabilities to provide users with a single and integrated coherent network.

**4. Utility Computing:**

Utility computing is one of the most popular IT service models, primarily because of the flexibility and economy it provides. This model is based on that used by conventional utilities such as telephone services, electricity and gas.

Utility computing is the process of providing computing service through an on-demand, pay-per-use billing method. Utility computing is a computing business model, in which the provider governs, operates and manages the computing infrastructure and resources, and the subscribers accesses it over the internet or a virtual private network as and when required on a rental basis.

**5. Cloud Computing:**

Cloud Computing refers to manipulating, configuring, and accessing the hardware and software resources remotely. It offers online data storage, infrastructure, and application. Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications mobile and collaborative. Cloud computing uses client server architecture to deliver computing resources such as servers, storage, databases, and software over the cloud (Internet) with pay-as-you-go pricing. Cloud computing becomes a very popular option for organizations by providing various advantages, including cost-saving, increased productivity, efficiency, performance, data back-ups, disaster recovery, and security.

**6. Virtual Reality:**

Virtual Reality (VR) is the use of computer technology to create a simulated environment. Virtual Reality's most immediately-recognizable component is the

head-mounted display (HMD). Virtual reality has been a popular component of video games for several years and this trend is continuing to expand. In addition to video games, VR is likely to affect companies across the board as they adopt the technology to help them engage customers more effectively and optimize their sales and marketing efforts. It's also a potentially useful tool for learning and is increasingly being adopted by educational organizations.

#### 7. Internet of Things:

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

The Internet of Things is actually a pretty simple concept; it means taking all the things in the world and connecting them to the internet.

When something is connected to the internet that means it can send information or receive information, or both. This ability to send and/or receive information makes things smart and smart is good.

IoT provides businesses and people better insight into and control over the 99 percent of objects and environments that remain beyond the reach of the internet. And by doing so, IoT allows businesses and people to be more connected to the world around them and to do more meaningful, higher-level work.

#### 8. Machine Learning:

Another exciting emerging technology is machine learning, which is essentially a computer's ability to learn on its own by analyzing data and tracking repeating patterns. Machine Learning (ML) is a type of artificial intelligence that extracts patterns out of raw data by using an algorithm or method. It helps computer systems to sense the data in much the same way as human beings do. The main focus of ML is to allow computer systems learn from experience without being explicitly programmed or human intervention.

For example, social media platforms use machine learning to get a better understanding of how you're connected with those in your social network. They do this by analyzing your likes, shares and comments and then prioritizing content from your closest connections, serving you that content first.

#### 9. Cognitive Technology:

Cognitive technology is a subset of the broader field of artificial intelligence, which itself could be considered a subset of biomimetic. Although artificial intelligence has been the subject of research for a very long time, cognitive technology evolved mostly out of the internet (particularly the web and the cloud).

Cognitive technology is a field of computer science that mimics functions of the human brain through various means, including natural language processing, data mining and pattern recognition. It is expected to have a drastic effect on the way that humans interact with technology in coming years, particularly in the fields of automation, machine learning and information technology. For example, the cognitive technology umbrella includes things like natural language processing (NLP) and speech recognition. Combined, these different technologies are able to automate and optimize a lot of tasks that were previously done by people, including certain aspects of accounting and analytics.

#### **10. Touch Commerce:**

Being able to buy anything you want with the touch of a finger may have seemed like a fantasy a few years ago, but it's now a reality. Merging touch-screen technology with one-click shopping, touch commerce allows consumers to buy products easily from their phones. After linking their payment information to a general account and enabling the feature, customers are able to buy everything from clothes to furniture with just a fingerprint. Touch Commerce provides online interaction optimization solutions that enable enterprises to increase customer conversion. Touch Commerce Launches Touch Assist to Provide Enterprises with Optimal Combination of Virtual Assistant and Live Customer Interactions in Digital Channels.

#### **GRID COMPUTING**

Grid computing is a group of computers physically connected (over a network or with Internet) to perform a dedicated tasks together, such as analyzing e-commerce data and solve a complex problem. Grids are a form of "Virtual Organizations" that solve a particular application. The grid size may vary from small to large enterprises network. The **grid computing model** is a special kind of cost-effective distributed computing.

In Grid computing each node has heterogeneous and geographically dispersed (such as a WAN) and its own resource manager and perform a different task and are loosely connected by the Internet or low-speed networks.

In grid computing architecture, every computer in network turning into a powerful supercomputer that access to enormous processing power, memory and data storage capacity.

The main advantages of grid computing are that it increases user productivity by providing transparent access to resources, and work can be completed more quickly.

Grid computing and cloud computing are conceptually similar that can be easily confused us. But, In grid computing, resources are distributed over grids, whereas in cloud computing, resources are managed centrally.

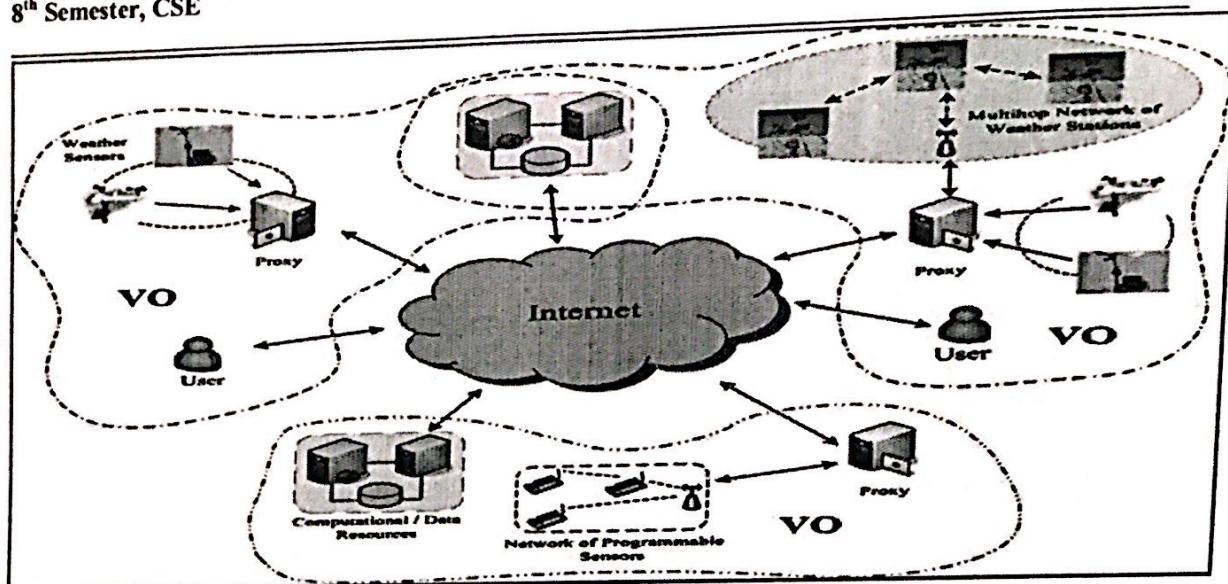


Figure: Grid Computing

#### Essential Characteristics of Grid Computing

- 1✓ Resource sharing
- 2✓ Geographical distribution
- 3✓ Heterogeneity
- 4✓ Large scale
- 5✓ Multiple administrations
- 6✓ Resource coordination
- 7✓ Transparent access
- 8✓ Dependable access
9. Consistent access
- 10✓ Pervasive access
- 11✓ Decentralization (Loosely coupled)
- 12✓ Distributed Job Management & scheduling

#### BENEFITS OF GRID COMPUTING

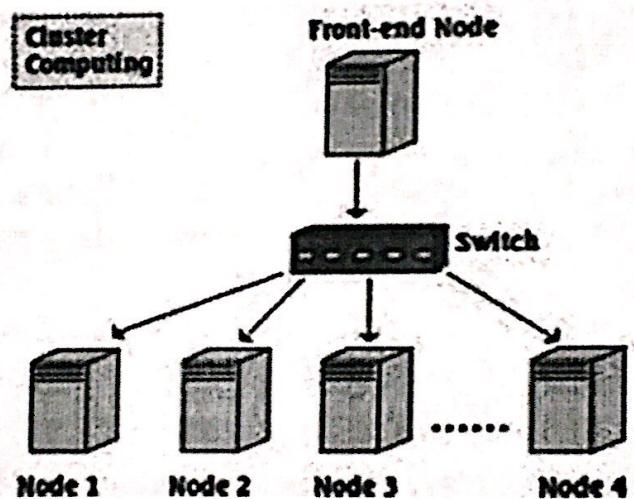
1. Enables applications to be easily scaled.
2. Better utilization of underused resources.
3. Enables the linking of computers together, instead of spending a lot of money on single machine.
4. Technologies being used are open source, trusted and transparent.
5. Increased reliability of computing.
6. Allows the sharing of computer resources across networks.
7. Parallelization of processing.
8. Resource balancing.

### **DRAWBACKS OF GRID COMPUTING**

1. Different Administrator Domains.
2. Trademarked approach should be eliminated.
3. Not Stable.
4. High Internet Connection Required.
5. Grid software and standards are still evolving.
6. Some applications cannot be parallelized.

### **CLUSTER COMPUTING**

Cluster computing (*High Performance computing*) is a form of computing in which bunch of computers (nodes) that are connected through a LAN (local area network) so that, they behave like a single machine. A computer cluster help to solve complex operations more efficiently with much faster processing speed, better data integrity than a single computer.



**Figure: Cluster Computing**

In other words, A computer cluster is a set of loosely or tightly connected computers that work together so that, in many respects, they can be viewed as a single system.

Clusters can be classified into two categories;

- ✓ **Open Cluster:** All nodes in Open Cluster are needed IPs, and that are accessible through internet or web, that cause more security concern.
- ✓ **Close Cluster:** On the other hand Close Cluster are hide behind the gateway node and provide better security.

### Types of Cluster computing:

1. Load-balancing clusters
2. High availability (HA) clusters
3. High performance (HP) clusters

1. **Load-balancing clusters:** As the name implies, this system is used to distribute workload across multiple computers. That system distributes the processing load as possible across a cluster of computers.
2. **High availability (HA) clusters:** A high availability clusters (HA cluster) are the bunch of computers that can reliably utilize for redundant operations in the event of nodes failure in Cluster computing.
3. **High performance (HP) clusters:** This cluster model improves the availability and performance for applications, particularly large computational tasks like scientific computing or financial analysis, typical for the tasks requiring high processing power.

### BENEFITS OF CLUSTER COMPUTING

- ✓ High performance
- ✓ Greater scalability
- ✓ Simplified management
- ✓ High availability of resources
- ✓ Expandability

### DRABACKS OF CLUSTER COMPUTING

- High Cost
- Need more servers and hardware's
- Problem in finding the fault
- Difficult to Handle
- Difficult to develop programs for distributing systems

### APPLICATIONS OF CLUSTER COMPUTING:

There are a large number of applications provided by cluster computing. Some of these are

- Clusters can be used in weather modeling.
- Helps in automobile crash simulations and nuclear simulations.
- Supportive in image processing and electromagnetics.
- Ideal in data mining, aerodynamics, and astrophysics.
- Used in predicting life-threatening situations such as earthquakes or hurricanes. In the past, these applications would be run on vector or parallel supercomputers costing millions of dollars in order to calculate predictions.

- Cluster-based systems can be used to execute many Internet applications: Web servers, Search engines, Email, Security, Proxy and Database servers.
- Helpful in big computing projects having extremely complex computations.
- Can also be used to distribute a work load in the form of many small chunks of data, a technique known as grid computing. In this case, a single computer couldn't handle all the work, but many small computers can.

### DISTRIBUTED COMPUTING

Distributed Computing system is the collection of autonomous computers that are located at different places linked together over a network and they communicate with each other by passing messages.

Every node on the Distributed computing is autonomous machines (do not physically share memory or processors but thereby sharing resources such as printers and databases).

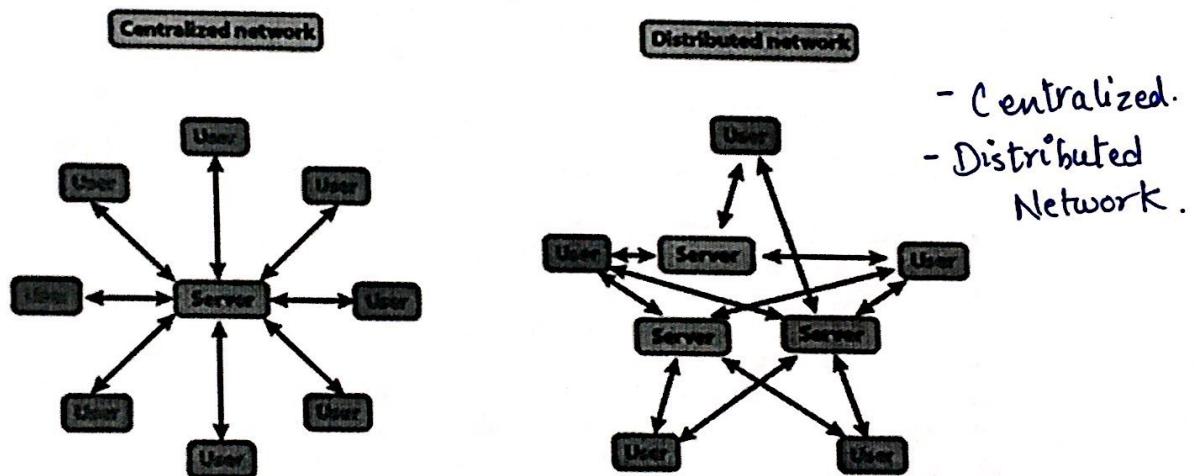


Figure: Distributed Network

A distributed system requires concurrent Components, communication network and a synchronization mechanism. A distributed system allows resource sharing, including software by systems connected to the network.

The ultimate goal of distributed computing is to maximize performance by connecting users and IT resources in a cost-effective, transparent and reliable manner. It also ensures fault tolerance and enables resource accessibility in the event that one of the components fails.

For example, in the typical distribution using the 3-tier model, user interface processing is performed in the PC at the user's location, business processing is done in a remote computer, and database access and processing is conducted in another computer that

provides centralized access for many business processes. The Distributed Computing Environment (DCE) is a widely-used industry standard that supports this kind of distributed computing. On the Internet, third-party service providers now offer some generalized services that fit into this model.

### **BENEFITS OF DISTRIBUTED COMPUTING**

- 1. Reliability
- 2. High fault tolerance
- 3. Scalability
- 4. Flexibility
- 5. Openness/Easily Accessible
- 6. High performance

### **DRAWBACKS OF DISTRIBUTED COMPUTING**

- 1. Difficult troubleshooting
- 2. Less software support
- 3. High network infrastructure costs
- 4. Security issues

### **APPLICATIONS OF DISTRIBUTED COMPUTING:**

Here are some examples/applications of distributed computing:

- Intranets, Internet, WWW, email.
- Telecommunication networks: Telephone networks and Cellular networks.
- Automatic processing of orders.
- Real-time process control: Aircraft control systems.
- Electronic banking.
- Airline reservation systems.
- Sensor networks.

### **UTILITY COMPUTING**

Utility computing is one of the most popular IT service models, primarily because of the flexibility and economy it provides. It is the process of providing computing service through an (on-demand, pay-per-use billing method in which the provider owns, operates and manages the computing infrastructure and resources.)

The principle of utility computing is very simple: One company pays another company for computing services. The services might include hardware rental, data storage space, use of specific computer applications or access to computer processing power. It all depends on what the client wants and what the utility computing company can offer.

The consumer has access to a virtually unlimited supply of computing solutions over the Internet. The back-end infrastructure and computing resources management and delivery is governed by the provider.

✓ IBM, HP and Microsoft were early leaders in the new field of utility computing, with their business units and researchers working on the architecture, payment and development challenges of the new computing model. Google, Amazon and others started to take the lead in 2008, as they established their own utility services for computing, storage and applications. Many utility computing companies offer bundles or packages of resources.

Utility computing can support grid computing which has the characteristic of very large computations or sudden peaks in demand which are supported via a large number of computers.

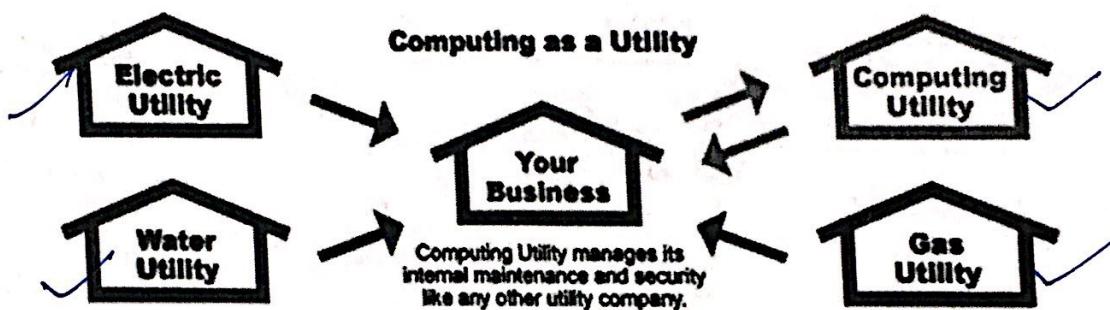


Figure: Utility Computing

#### ADVANTAGES OF UTILITY COMPUTING:

1. The client doesn't have to buy all the hardware, software and licenses.
2. Utility computing gives companies the option to subscribe to a single service and use the same suite of software throughout the entire client organization.
3. Utility computing gives companies the option to subscribe to a single service and use the same suite of software throughout the entire client organization.

#### DISADVANTAGES OF UTILITY COMPUTING:

1. Utility computing systems can also be attractive targets for hackers.
2. Awareness of utility computing isn't very widespread. It's hard to sell a service to a client if the client has never heard of it.
3. If a utility computing company is in financial trouble or any other problems, clients could get cut off from the services for which they're paying.

## CLOUD COMPUTING

Cloud Computing is on demand delivery of IT resources over the internet with pay as you go. Instead of buying, owning and maintaining physical data centers and servers, one can access technology services such as computing power, storage and databases on as per need basis from cloud provider.

Organizations of every field are using the cloud for a wide variety of use cases such as data backup, disaster recovery, email, virtual desktops, software development and testing, big data analytics and customer related web applications. Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications mobile and collaborative.

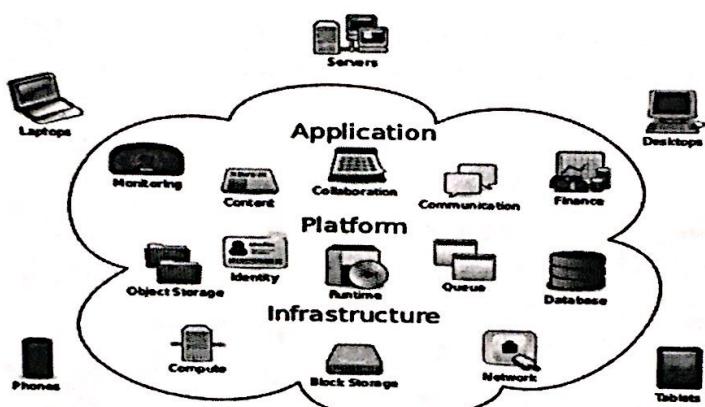
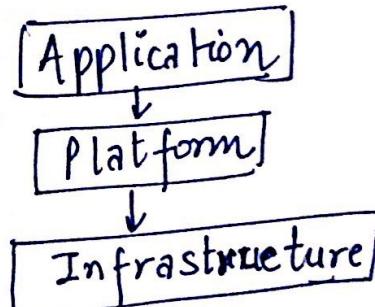


Figure: Cloud Computing



#### Cloud Computing involves:

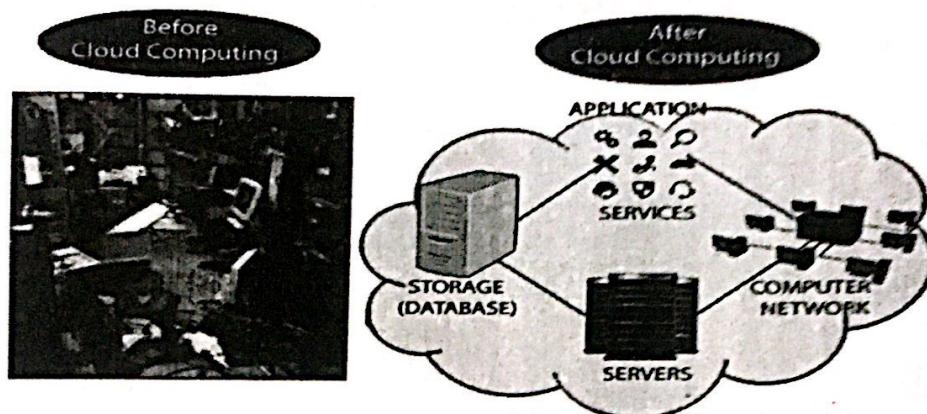
- 1. Servers
- 2. Database
- 3. Platform
- 4. Storage
- 5. Infrastructures
- 6. Applications

#### WHY CLOUD COMPUTING?

With increase in computer and Mobile user's, data storage has become a priority in all fields. Large and small scale businesses today thrive on their data & they spent a huge amount of money to maintain this data. It requires a strong IT support and a storage hub. Not all businesses can afford high cost of in-house IT infrastructure and back up support services. For them Cloud Computing is a cheaper solution. Cloud computing decreases the hardware and software demand from the user's side.

Earlier, Small as well as large IT companies, follow the traditional methods to provide the IT infrastructure. That means for any IT company, we need a Server Room that is the basic need of IT companies.

In that server room, there should be a database server, mail server, networking, firewalls, routers, modem, switches, configurable system, high speed internet, and the maintenance engineers. To establish such IT infrastructure, we need to spend lots of money. To overcome all these problems and to reduce the IT infrastructure cost, Cloud Computing comes into existence.



**Figure: Why Cloud Computing?**

There are the following operations that we can do using cloud computing:

- Developing new applications and services
- Storage, back up, and recovery of data
- Hosting blogs and websites
- Delivery of software on demand
- Analysis of data
- Streaming videos and audios

### **EVOLUTION OF CLOUD COMPUTING**

We have been using cloud computing unknowingly through Gmail and Google docs, yet we never thought that these were cloud computing services.

The term "cloud" was actually derived from telephony. The telecommunication companies offered Virtual Private Network with good quality at affordable prices. The symbol of the cloud represented the isolation point which was the sole responsibility of the provider. Cloud computing manages servers and network infrastructure management.

Cloud computing has essentially evolved from various computing technologies like grid computing, utility computing, parallel computing, and virtualization. The most recent development of cloud computing has evolved from the Web2.0 technology which caters to web applications that facilitate participatory information sharing, interoperability & user-centered design, etc. Examples of Web 2.0 include wikis, blogs, social networking & video sharing sites, etc.

## The Cloud Evolution

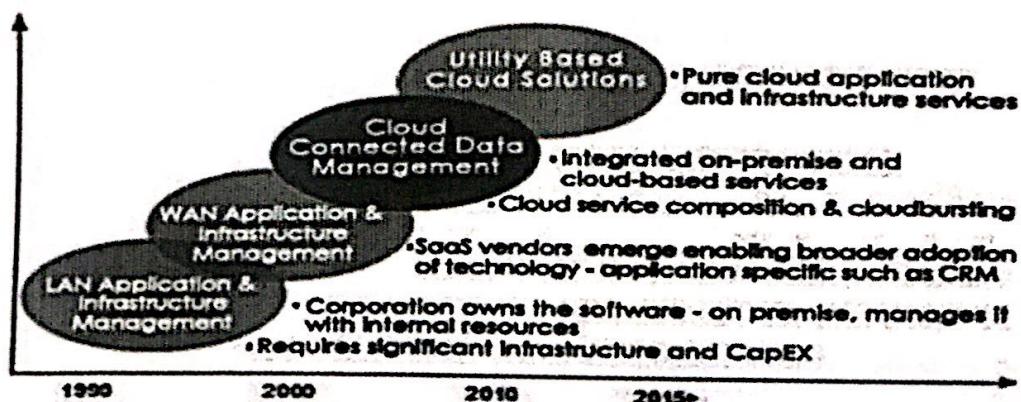


Figure: Cloud Evolution

The evolution of cloud computing can be categorized into three basic phases:

- 1. The Idea Phase-** This phase inceptioned in the early 1960s with the emergence of utility and grid computing and lasted till pre-internet bubble era. Joseph Carl Robnett Licklider was the founder of cloud computing.
- 2. The Pre-cloud Phase-** The pre-cloud phase originated in the 1999 and extended to 2006. In this phase internet as the mechanism to provide Application as Service.
- 3. The Cloud Phase-** The much talked about real cloud phase started in the year 2007 when the classification of IaaS, PaaS, and SaaS got formalized. The history of cloud computing has witnessed some very interesting breakthroughs launched by some of the leading computer/web organizations of the world.

### BUSINESS DRIVER FOR ADOPTING CLOUD COMPUTING

In recent years, Cloud migration has progressed beyond development and testing, and there has been a tremendous improvement in adoption of Cloud services among IT organizations. Enterprises, all over the world, have unique requirements and challenges when it comes to Cloud computing. Especially for startups and small and midsize businesses (SMBs), Cloud has emerged extremely advantageous as personnel and financial resources are limited.

Cloud provides enterprises the flexibility to focus on their core competencies and reduce cost to a great extent. Although there are security concerns associated with Cloud adoption, the rapid adoption of enterprise-class cloud computing implies that the concerns are being met.

With the amount of interest Cloud has managed to build up among startups, SMBs (small and midsize businesses), and Chief Information Officer (CIOs), we have tried to analyze and compile the most important drivers of Cloud services adoption. There are only six drivers for cloud adoption: Three business-focused drivers (business growth, productivity and experience) and three technology-focused drivers (agility, cost and mobility). Here's what you need to know about each one:

1. **Reducing cost** - This is definitely one of the key drivers behind Cloud adoption. Many enterprises have witnessed a considerable reduction in license and services spend by adopting Cloud services, compared to legacy systems. In many cases it has been found that the cost of replatforming to the cloud is actually much lower than the license renewal of their legacy apps. For SMBs, this benefit leads to a very healthy return on investment (ROI) after one year. Cloud computing enables organizations to reduce cost through server consolidation, thin clients and community cost sharing.
2. **Enforcing mobility** - An increasing number of enterprises are driven towards Cloud technology, because it is global, self-configurable and cost effective. With remote working gaining popularity among organizations, Cloud computing is enabling employees to work at any place, at any time, and on any device. In recent years, the way smart mobile devices market has matured and got acceptance has made mobility a key driver behind Cloud adoption. In the days ahead, more and more enterprises are expected to join the race to launch new Cloud computing solutions of all sizes to be more efficient and gain competitive advantage.
3. **Improving productivity** - Every organization is concerned about improving productivity and Cloud computing is seen as an ideal option by many organizations. Use of Cloud-based tools for email, instant messaging, voice communication, information sharing and development, event scheduling, and conferencing is becoming an increasingly common feature of business life.
4. **Creating new business avenues** - An enterprise can get new business opportunities as a provider of cloud services or added services. Organizations that have good track record of its own IT can become a public Infrastructure-as-a-Service (IaaS) or Platform-as-a-Service (PaaS) provider. One business opportunity could be, if a company implements a private cloud and has spare capacity, it can sell that additional capacity as public Cloud to another company. On the other hand, software companies can expand their market by providing cloud services in the form of Software-as-a-Service (SaaS).
5. **Increasing business agility** - Business agility is undoubtedly the main benefit and key driver behind Cloud adoption among enterprises. It has been found that enterprises who have adopted Cloud have gained competitive advantage by reducing complexity and increasing business agility. Even for SMBs and independent software vendors (ISVs), business agility has been the main reason for moving to Cloud. Enterprises that have adopted Cloud have observed improved agility due to on-demand self-service and rapid elasticity. Moreover, IT

resources can be acquired and deployed more quickly and, once deployed, they can be increased or decreased as needed to meet the demand.

6. **Experience** - Next among the business drivers is improving the quality of the customer experience, which 45% of enterprises worldwide rank as a top cloud driver. Two of the most common ways organizations are achieving this goal with cloud technology are by introducing new channels of engagement and improving workplace productivity. However, the experience driver can come into direct conflict with goals around cost and efficiency. For example, if you introduce an automated phone tree for customer service, you might cut costs and increase efficiency, but your customer experience will suffer.

### CLOUD COMPUTING (NIST MODEL)

With all the opinion-based cloud computing definitions out there, it is hard to come to an agreement about what "the Cloud" or a 'cloud service' is. The US National Institute of Standards and Technology (NIST) has developed a clear and concise definition of what "Cloud" is that has been broadly adopted, both nationally and internationally.

In 2011, according to the official NIST definition, "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.")

The definition is intended to serve as a means for broad comparisons of cloud services and deployment strategies, and to provide a baseline for discussion from what is cloud computing to how to best use cloud computing.

The NIST definition for cloud computing includes:

- Essential Characteristics:
  - On-demand self-service.
  - Resource pooling.
  - Rapid elasticity.
  - Measured Service.
  - Broad network access.
- Service Models:
  - Software as a service (SaaS).
  - Platform as a Service (PaaS).
  - Infrastructure as a service (IaaS).
- Deployment Models:
  - Public Cloud.
  - Private Cloud.
  - Community Cloud
  - Hybrid Cloud.

# NIST Cloud Computing Model

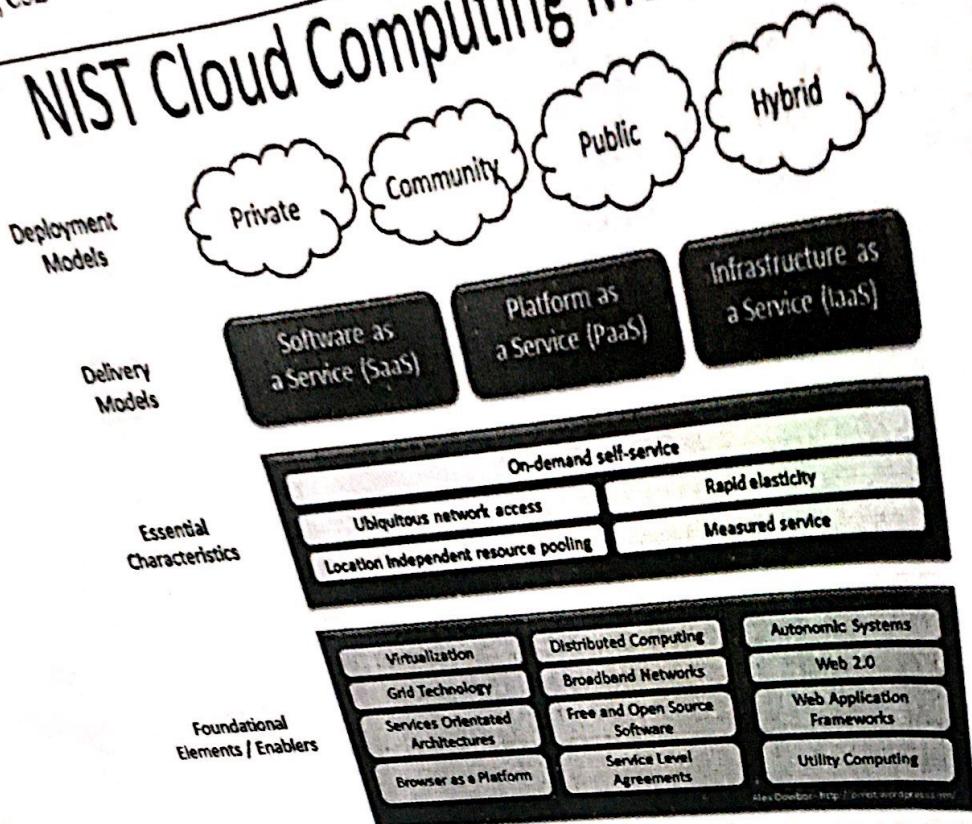


Figure: NIST Model of Cloud Computing

## HISTORY OF CLOUD COMPUTING

At the beginning era of technology, the Client-Server architecture was popular along with the mainframe and terminal application. At that time, storing data in CPU was very expensive, and hence the mainframe connected both types of resources and served them to a small client-terminal. With the revolution in the mass storage capacity, the file servers gained the popularity for storing vast amount of information.

- Cloud computing has its roots as far back in 1950s when mainframe computers came into existence. At that time, several users accessed the central computer via dummy terminals. That was the time when the idea of provision of shared access to a single computer occurred to the companies to save costs.
- In the mid-1960s, a major advancement in cloud computing came when American computer scientist J.C.R. Licklider conceptualized an interconnected system of computers. In 1969, "Lick", he helped to develop a very primitive version of the Internet, known as the **Advanced Research Projects Agency Network (ARPANET)**. ARPANET was the first network that allowed digital sources to be shared among computers that were not in the same physical location.

- Over the decades that followed, much further advancement in cloud technology came into being. In 1972, for example, IBM released an operating system (OS) called the Virtual Machine (VM) operating system. The concept evolved with the Internet, and businesses began offering “virtual” private networks as a rentable service, eventually leading to the development of the modern cloud computing infrastructure.

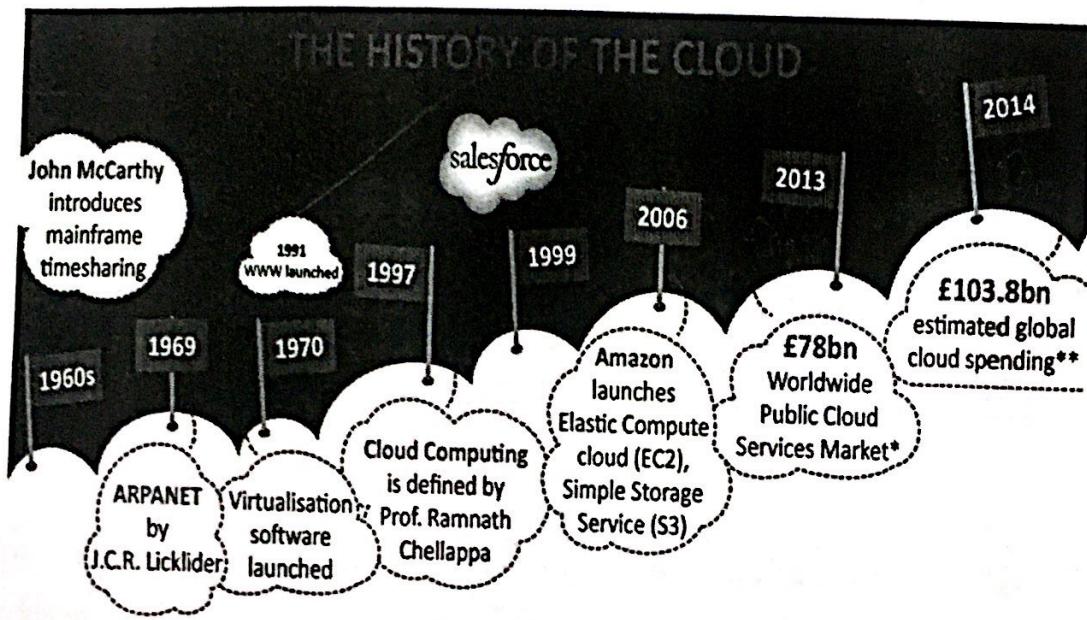


Figure: History of Cloud

- The first known definition of the term “Cloud Computing” seems to be by Prof. Ramnath Chellappa in Dallas in 1997 – “A computing paradigm where the boundaries of computing will be determined by economic rationale rather than technical limits alone.”
- In the early 2000s, Amazon Web Services (AWS) emerged, and Amazon launched Elastic Compute Cloud (EC2) in 2006, allowing companies and individuals to rent virtual computers through which they could use their own programs and applications. In the same year, Google launched its Google Docs services, allowing users to save, edit and transfer documents in the cloud.
- In 2007, IBM, Google, and several universities joined forces to develop a server farm for research projects. It was also the year that Netflix launched its video streaming service, using the cloud to stream movies and other video content into the homes and onto the computers of thousands (and eventually millions) of subscribers worldwide.

- The Worldwide Public Cloud Services Market totalled £78bn, up 18.5 per cent on 2012, with IaaS (infrastructure-as-a-service) the fastest growing market service.
- In 2014, global business spending for infrastructure and services related to the cloud will reach an estimated £103.8bn, up 20% from the amount spent in 2013 (Constellation Research).
- Today the global cloud computing market is worth \$180bn in vendor revenues for SaaS, PaaS and IaaS with the market growing by 24 per cent annually.
- The cloud computing market is forecast to reach \$411bn by 2020 according to new research from global communications provider CenturyLink and Statista.

## CLOUD SERVICE PROVIDERS

Cloud Computing Services providers are the vendors which provide Information Technology (IT) as a service over the Internet. Cloud computing is a term which is used for storing and accessing data over the internet. It doesn't store any data on the hard disk of your PC. Cloud computing helps you to access your data from a remote server.

Cloud computing services range from full applications and development platforms to servers, storage, and virtual desktops. There are various types of cloud computing services available in the market.

**Generally, cloud computing services are categorized into three types.**

**1) Infrastructure as a Service (IaaS):** This service provides the infrastructure like Servers, Operating Systems, Virtual Machines, Networks, and Storage etc on rent basis.

**Eg:** Amazon Web Service, Microsoft Azure

**2) Platform as a Service (PaaS):** This service is used in developing, testing and maintaining of software. PaaS is same as IaaS but also provides the additional tools like DBMS services etc.

**Eg:** Red Hat OpenShift

**3) Software as a Service (SaaS):** This service makes the users connect to the applications through the Internet on a subscription basis.

**Eg:** Google Applications, Salesforce

Few Companies offer such computing services, hence named as "Cloud Computing Providers". They charge its users for utilizing such services and the charges are based on their usage of services.

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**Here is the list of Cloud Computing Companies:**

**Amazon Web Services:-**

- AWS is the safest and protected platform of cloud service which offers a wide set of infrastructure services like database storage, computing power, networking etc.
- Using this AWS one can host the static websites.
- By using such services, users are able to build complicated applications that are trustworthy, scalable and flexible.
- One can have the hands-on experience of AWS for free.

**Microsoft Azure:-**

- Microsoft Azure is used for deploying, designing and managing the applications through a worldwide network.
- Previously Microsoft Azure was known as Windows Azure.
- This Cloud computing service supports various operating systems, databases, tools, programming languages and frameworks etc.
- A free trial version of Microsoft Azure is available for 30 days.

**Google Cloud Platform:-**

- Google Cloud Platform uses resources such as computers, virtual machines, hard disks etc located at Google data centres.
- Google Cloud Platform is an integrated storage used by developers and enterprises for live data.
- Apart from the free trial, this service is available at various flexible payment plans based on Pay-As-You-Go (PAYG).

**Adobe:-**

- Adobe offers many products that provide cloud services. Few among them are Adobe Creative Cloud, Adobe Experience Cloud and Adobe Document Cloud etc.
- Adobe Creative Cloud service is a SaaS, that offers its users to access the tools offered by Adobe like editing the videos, photography, graphic designing etc.
- Adobe Document Cloud is a complete solution for digital documentation.

**VMware:-**

- VMware is a universal leader in virtualization and Cloud Infrastructure.
- VMware's cloud computing is exclusive and helps in reducing the IT intricacy, lower the expenses, provides flexible agile services etc.
- VMware vCloud Air is a safe and protected public cloud platform that offers networking, storage, disaster recovery and computing etc.

**IBM Cloud:-**

- IBM Cloud offers IaaS, PaaS, and SaaS through all the available cloud delivery models.
- Using IBM Cloud one can have the freedom to select and unite your desired tools, data models and delivery models in designing/creating your next-generation services or applications.

- With IBM Bluemix Cloud platform one can incorporate highly performing cloud communications and services into your IT environment.

**Red Hat:-**

- Red Hat is an Open Cloud technology used by IT organizations to deliver agile and flexible solutions.
- Using Red Hat Cloud we can modernize the apps, update and manage them from a single place and integrate all the desired parts into a single solution.
- Red Hat Cloud Infrastructure helps us to build and manage an open cum private cloud at low cost.

**Oracle Cloud:-**

- Oracle Cloud is available as SaaS, PaaS, and IaaS. Oracle Cloud helps the companies in transforming their business quickness and reducing the IT Complexity.
- Oracle Cloud SaaS provides a complete data-driven and secure cloud environment.
- Oracle Cloud PaaS helps IT Enterprises and Independent developers to develop, connect, secure and share data across the applications.

**Dropbox:-**

- Dropbox is a refined cloud storage service used by small businesses and customers to store files or documents virtually on remote cloud servers.
- Generally, Dropbox serves as an online or cloud personal hard drive.
- Dropbox allows its users to access any saved data or content from any device through an internet connection.
- Dropbox is available as a desktop app, where users can download it and save the files directly in the Dropbox folder located on your desktop.

## **PROPERTIES OF CLOUD COMPUTING**

Cloud Computing is gaining more and more popularity day by day. The reason behind this is the gradual growth of the companies which are in need of the place to store their data. Therefore, companies are in competition to provide large space to store data along with the various features and quality service. It has been found that cloud computing is a model for enabling ubiquitous, convenient, on-demand network access the computing resources. There are many services and features of cloud computing.

The key properties of Cloud computing are

- User centric:** This means once a user is connected to cloud any data there, such as images, videos, applications, becomes his property. Not only the data but the devices connected also become his and he can share it with other users.
- Task Centric:** Cloud computing focus on what one need and how application can do it for us. Here documents are given more priority than the applications which create them.

- User centric
- Task centric
- Powerful
- Self-Healing
- Multi-tenancy
- Programmable
- Flexible

3. **Powerful:** Powerful in the sense that as there are large computers more computing power and mass data storage possible.
4. **Self-Healing:** Is called Self-healing because hot backups are available for every document in the cloud. Hence if one document crashes there will be its duplicate ready to run.
5. **Multi-tenancy & Intelligence:** Multi-tenancy refers to sharing of data and costs across a large pool of users. As various data are stored in cloud data mining and analysis are necessary for accessing information in an intelligent manner.
6. **Programmable:** Many processes in cloud computing shall be automate such as backing up crashed data with its duplicate. Hence programming is associated with cloud computing.
7. **Flexible:** Flexible as the users may be of different varieties and hence it has to match with their needs.

## CHARACTERISTICS OF CLOUD COMPUTING

As cloud computing services mature both commercially and technologically, it will be easier for companies to maximize the potential benefits. Knowing what cloud computing is and what it does, however, is just as important. The National Institute of Standards and Technology (NIST) defines cloud computing as it is known today through five essential characteristics.

### **1. On-Demand Self-Service**

On-demand self-service means that a consumer can request and receive access to a service offering, without an administrator or some sort of support staff having to fulfill the request manually. The request processes and fulfillment processes are all automated.

In other words, a manufacturing organization can provision additional computing resources as needed without going through the cloud service provider. This can be a storage space, virtual machine instances, database instances, and so on. Manufacturing organizations can use a web self-service portal as an interface to access their cloud accounts to see their cloud services, their usage, and also to provision and de-provision services as they need to.

### **2. Broad Network Access**

Broad network access is one of the fundamental aspects of cloud computing. People must be able to take the data information required from any place, and from any device. In Broad network access the resources which are hosted in a "private cloud" made available to access from a "wide range of devices, like PCs, tablets, Macs, and smartphones". Cloud computing resources are available over the network and can be accessed by diverse customer platforms.

### 3. Resource Pooling

Resource pooling means that multiple customers are serviced from the same physical resources. Providers' resource pool should be very large and flexible enough to service multiple client requirements and to provide for economy of scale. When it comes to resource pooling, resource allocation must not impact performances of critical manufacturing applications.

Resource pooling allows cloud providers to pool large-scale IT resources to serve multiple cloud consumers. Different physical and virtual IT resources are dynamically assigned and reassigned according to cloud consumer demand, typically followed by execution through statistical multiplexing. Resource pooling is commonly achieved through multi-tenancy technology.

Multi-tenancy allows multiple customers to share the same applications or the same physical infrastructure while retaining privacy and security over their information. It's similar to people living in an apartment building, sharing the same building infrastructure but they still have their own apartments and privacy within that infrastructure. That is how cloud multi-tenancy works.

### 4. Rapid Elasticity

Elasticity is basically a 'rename' of scalability, which has been a known non-functional requirement in IT architectures for many years already. Scalability is the ability to add or remove capacity, mostly processing, memory, or both, to or from an IT environment when this is needed.

Elasticity is a landmark of cloud computing and it implies that manufacturing organizations can rapidly provision and de-provision any of the cloud computing resources. Rapid provisioning and de-provisioning might apply to storage or virtual machines or customer applications. Cloud computing resources can scale up or down rapidly and, in some cases, automatically, in response to business demands. It is a key feature of cloud computing. The usage, capacity, and therefore cost, can be scaled up or down with no additional contract or penalties.

Just-in-time (JIT) service is the notion of requiring cloud elasticity either to provision more resources in the cloud or less. Another feature available for rapid elasticity and scalability in the cloud is related to testing of manufacturing applications.

### 5. Measured Service

Cloud computing resources usage is metered and manufacturing organizations pay accordingly for what they have used. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth and active user accounts). Resource usage can be monitored, controlled and reported, providing transparency for the provider and consumer. The cost model is based on "pay for what you use"—the payment is variable based on the actual consumption by the manufacturing organization.

## PROS AND CONS OF CLOUD COMPUTING

Cloud computing is evolving like never before, with companies of all shapes and sizes adapting to this new technology. Industry experts believe that this trend will only continue to grow and develop even further in the coming few years. While cloud computing is undoubtedly beneficial for mid-size to large companies, it is not without its downsides, especially for smaller businesses. Working with data in the cloud can vastly benefit all types of businesses.

Mentioned below are some of the advantages/pros of this technology.

### 1. Cost Efficient

Cloud computing is probably the most cost-efficient method to use, maintain and upgrade. Traditional desktop software costs companies a lot in terms of finance. The cloud, on the other hand, is available at much cheaper rates and hence, can significantly lower the company's IT expenses. Besides, there are many one-time-payment, pay-as-you-go and other scalable options available, which makes it very reasonable for the company.

### 2. Unlimited Storage

Storing information in the cloud gives you almost unlimited storage capacity. Hence, you no more need to worry about running out of storage space or increasing your current storage space availability. Most cloud services provide you a free, secure and huge storage space to store all your valuable information.

### 3. Backup and Recovery

Since all your data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device. Furthermore, most cloud service providers are usually competent enough to handle the recovery of information. Hence, this makes the entire process of backup and recovery much simpler than other traditional methods of data storage.

### 4. Accessibility

Access your data anywhere, anytime. An Internet cloud infrastructure maximizes enterprise productivity and efficiency by ensuring your application is always accessible. This allows for easy collaboration and sharing among users in multiple locations.

### 5. Quick Deployment

Cloud computing gives you the advantage of quick deployment. Once you opt for this method of functioning, your entire system can be fully functional in a matter of a few minutes. Of course, the amount of time taken here will depend on the exact kind of technology that you need for your business.

## 6. Automatic Software Integration

In the cloud, software integration is usually something that occurs automatically. This means that you do not need to take additional efforts to customize and integrate your applications as per your preferences. This aspect usually takes care of itself. Not only that, cloud computing allows you to customize your options with great ease.

## 7. Maintenance

Maintenance of cloud computing applications is easier, since they do not need to be installed on each user's computer and can be accessed from different places. So, it reduces the cost also.

## 8. Improved collaboration

Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

Cloud computing has benefited many enterprises by reducing costs and enabling a focus on one's core business competence, rather than IT and infrastructure issues. Despite the general hype on the subject across the IT world, there can be disadvantages to cloud computing. Businesses, especially smaller ones, need to be aware of these cons before going in for this technology.

Mentioned below are some of the disadvantages/cons of this technology.

### 1. Security in the Cloud

The other major issue while in the cloud is that of security issues. Before adopting this technology, you should know that you will be surrendering all your company's sensitive information to a third-party cloud service provider. This could potentially put your company at great risk.

### 2. Vulnerability to Attacks

With your business information stored in the cloud, there is a vulnerability to external hack attacks. The internet is not completely secure, and for this reason, there is always the possibility of theft of sensitive data.

### 3. Limited control of infrastructure

Since you are not the owner of the infrastructure of the cloud, hence you don't have any control or have limited access to the cloud infra.

### 4. Ongoing cost

Although you save your cost of spending on whole infrastructure and its management, on the cloud, you need to keep paying for services as long as you use them. But in traditional methods, you only need to invest once.

### 5. Downtime

Downtime is often cited as one of the biggest disadvantages of cloud computing. Since cloud computing systems are internet-based, service outages are always an unfortunate possibility and can occur for any reason.

#### **6. Vendor lock-in**

Vendor lock-in is another perceived disadvantage of cloud computing. Easy switching between cloud services is a service that hasn't yet completely evolved, and organizations may find it difficult to migrate their services from one vendor to another. Differences between vendor platforms may create difficulties in migrating from one cloud platform to another.

#### **7. Bandwidth limitations**

Depending on what service you choose, there may be a bandwidth allowance. If your business exceeds the allowance, then charges could be costly. Some vendors provide unlimited bandwidth and this is something to think about when choosing the right provider. To access your cloud services, you need to have a good internet connection always with good bandwidth to upload or download files to/from the cloud.

### **BENEFITS OF CLOUD COMPUTING**

Cloud computing offers your business/industry many benefits. It allows you to set up what is essentially a virtual office to give you the flexibility of connecting to your business anywhere, any time. With the growing number of web-enabled devices used in today's business environment (e.g. smartphones, tablets), access to your data is even easier.

There are many benefits to moving your business to the cloud:

1. Higher availability of resources
2. On demand self service
3. Automatic Software Updates
4. Quick Deployment
5. Unlimited Storage capacity
6. Location and device independence
7. Pay per use
8. Less maintenance
9. Resource pooling/sharing
10. Cost Savings
11. Security
12. Flexibility
13. Mobility
14. Increased Collaboration
15. Quality Control
16. Disaster Recovery
17. Sustainability
18. Fast and effective virtualization
19. Regular updates