

**Cloud Computing :** “Cloud is a model for enabling 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.”

### **Why Cloud Computing?**

Developing in the cloud enables users to get their applications to market quickly. Hardware failures do not result in data loss because of networked backups. Cloud computing uses remote resources, saving organizations the cost of servers and other equipment.

### **Characteristics of Cloud Computing**

There are basically 5 essential characteristics of Cloud Computing.

#### **On-demand self-services:**

The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.

#### **Broad network access:**

The Computing services are generally provided over standard networks and heterogeneous devices.

#### **Rapid elasticity:**

The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.

#### **Resource pooling:**

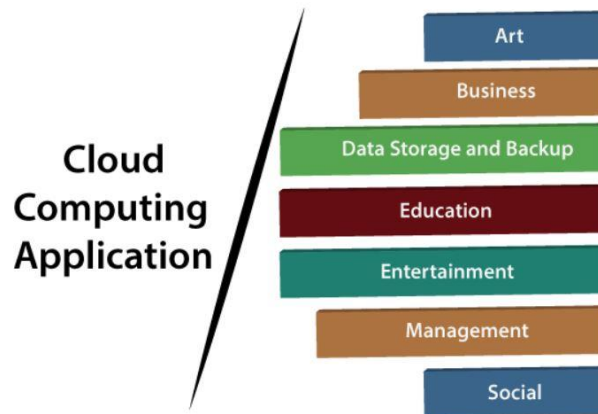
The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.

#### **Measured service:**

The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.

### **Cloud Computing Applications**

Cloud service providers provide various applications in the field of art, business, data storage and backup services, education, entertainment, management, social networking, etc.



## **1. Art Applications**

Cloud computing offers various art applications for quickly and easily design attractive cards, booklets, and images. Some most commonly used cloud art applications are given below:

### **i Moo**

Moo is one of the best cloud art applications. It is used for designing and printing business cards, postcards, and mini cards.

### **ii. Vistaprint**

Vistaprint allows us to easily design various printed marketing products such as business cards, Postcards, Booklets, and wedding invitations cards.

### **iii. Adobe Creative Cloud**

Adobe creative cloud is made for designers, artists, filmmakers, and other creative professionals. It is a suite of apps which includes PhotoShop image editing programming, Illustrator, InDesign, TypeKit, Dreamweaver, XD, and Audition.

## **2. Business Applications**

Business applications are based on cloud service providers. Today, every organization requires the cloud business application to grow their business. It also ensures that business applications are 24\*7 available to users.

There are the following business applications of cloud computing -

### **i. MailChimp**

MailChimp is an email publishing platform which provides various options to design, send, and save templates for emails.

### **iii. Salesforce**

Salesforce platform provides tools for sales, service, marketing, e-commerce, and more. It also provides a cloud development platform.

#### **iv. Chatter**

Chatter helps us to share important information about the organization in real time.

### **3. Data Storage and Backup Applications**

Cloud computing allows us to store information (data, files, images, audios, and videos) on the cloud and access this information using an internet connection. As the cloud provider is responsible for providing security, so they offer various backup recovery application for retrieving the lost data.

A list of data storage and backup applications in the cloud are given below -

#### **i. Box.com**

Box provides an online environment for secure content management, workflow, and collaboration. It allows us to store different files such as Excel, Word, PDF, and images on the cloud.

#### **ii. Mozy**

Mozy provides powerful online backup solutions for our personal and business data. It schedules automatically back up for each day at a specific time.

#### **iii. Joukuu**

Joukuu provides the simplest way to share and track cloud-based backup files. Many users use joukuu to search files, folders, and collaborate on documents.

### **4. Entertainment Applications**

Entertainment industries use a multi-cloud strategy to interact with the target audience. Cloud computing offers various entertainment applications such as online games and video conferencing.

#### **i. Online games**

Today, cloud gaming becomes one of the most important entertainment media. It offers various online games that run remotely from the cloud. The best cloud gaming services are Shaow, GeForce Now, Vortex, Project xCloud, and PlayStation Now.

#### **ii. Video Conferencing Apps**

Video conferencing apps provides a simple and instant connected experience. It allows us to communicate with our business partners, friends, and relatives using a cloud-based video conferencing.

## **5. Management Applications**

Cloud computing offers various cloud management tools which help admins to manage all types of cloud activities, such as resource deployment, data integration, and disaster recovery. These management tools also provide administrative control over the platforms, applications, and infrastructure.

Some important management applications are -

### **i. Toggl**

Toggl helps users to track allocated time period for a particular project.

### **ii. Evernote**

Evernote allows you to sync and save your recorded notes, typed notes, and other notes in one convenient place. It is available for both free as well as a paid version.

It uses platforms like Windows, macOS, Android, iOS, Browser, and Unix.

### **iii. Outright**

Outright is used by management users for the purpose of accounts. It helps to track income, expenses, profits, and losses in real-time environment.

## **6. Social Applications**

Social cloud applications allow a large number of users to connect with each other using social networking applications such as Facebook, Twitter, LinkedIn, etc.

There are the following cloud based social applications -

### **i. Facebook**

Facebook is a social networking website which allows active users to share files, photos, videos, status, more to their friends, relatives, and business partners using the cloud storage system. On Facebook, we will always get notifications when our friends like and comment on the posts.

### **ii. Twitter**

Twitter is a social networking site. It is a microblogging system. It allows users to follow high profile celebrities, friends, relatives, and receive news. It sends and receives short posts called tweets.

### iii. Yammer

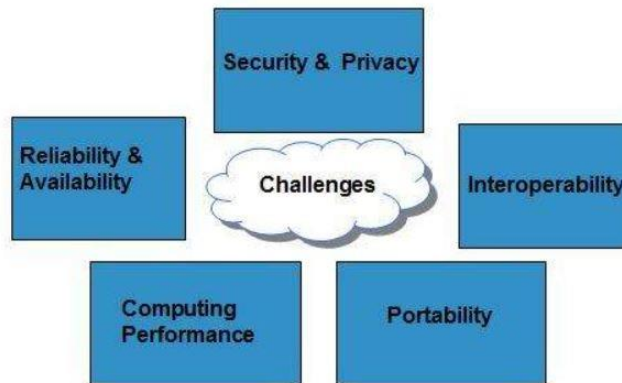
Yammer is the best team collaboration tool that allows a team of employees to chat, share images, documents, and videos.

### iv. LinkedIn

LinkedIn is a social network for students, fresher, and professionals.

## Cloud Computing Challenges

Cloud computing, an emergent technology, has placed many challenges in different aspects of data and information handling. Some of these are shown in the following diagram:



### Security and Privacy

Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications.

### Portability

This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in. However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

### Interoperability

It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

### Computing Performance

Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

## **Reliability and Availability**

It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

## **Advantages of Cloud Computing**

- Lower computer costs
- Instant software updates
- Unlimited storage capacity
- Increased data reliability
- Device independent
- Easier group collaboration

## **Disadvantages of Cloud Computing**

- Requires a constant Internet Connection
- Does not work well with low-speed connections
- Stored data might not be secured

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## **5 Real-World Examples of Cloud Computing**

- Ex: Dropbox, Gmail, Facebook.
- Ex: Maropost for Marketing, Hubspot, Adobe Marketing Cloud.
- Ex: SlideRocket, Ratatype, Amazon Web Services.
- Ex: ClearDATA, Dell's Secure Healthcare Cloud, IBM Cloud.
- Uses: IT consolidation, shared services, citizen services

## **Evolution of Cloud Computing**

Cloud computing is all about renting computing services. This idea first came in the 1950s. In making cloud computing what it is today, five technologies played a vital role. These are distributed systems and its peripherals, virtualization, web 2.0, service orientation, and utility computing.

### **□ Distributed Systems:**

It is a composition of multiple independent systems but run as a single system. The purpose of distributed systems is to share resources and also use them effectively and efficiently. Distributed systems possess characteristics such as scalability, concurrency, continuous availability, heterogeneity, and independence in failures. The main problem with this system was that, all the systems were required to be present at the same geographical location. Thus to solve this problem, distributed computing led to three more types of computing and they were-Mainframe computing, cluster computing, and grid computing.

#### □ **Mainframe computing:**

Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines. These are responsible for handling large data such as massive input-output operations. These systems have almost no downtime with high fault tolerance. After distributed computing, these increased the processing capabilities of the system. But these were very expensive. To reduce this cost, cluster computing came as an alternative to mainframe technology.

#### □ **Cluster computing:**

In 1980s, cluster computing came. Each machine in the cluster was connected to each other by a network with high bandwidth. These were way cheaper than those mainframe systems. These were equally capable of high computations. Also, new nodes could easily be added to the cluster if it was required. Thus, the problem of the cost was solved to some extent but the problem related to geographical restrictions still pertained. To solve this, the concept of grid computing was introduced.

#### □ **Grid computing:**

In 1990s, the concept of grid computing was introduced. It means that different systems(heterogeneous nodes) were placed at entirely different geographical locations and these all were connected via the internet. Although it solved some problems but new problems emerged as the distance between the nodes increased. The main problem was the low availability of high bandwidth connectivity and with it other network associated issues. Thus, cloud computing is often referred to as “Successor of grid computing”.

#### □ **Virtualization:**

It was introduced nearly 40 years back. It refers to the process of creating a virtual layer over the hardware which allows the user to run multiple instances simultaneously on the hardware. It is a key technology used in cloud computing. It is the base on which major cloud computing services such as Amazon EC2, VMware vCloud, etc work on.

#### □ **Web 2.0:**

It is the interface through which the cloud computing services interact with the clients. Popular examples of web 2.0 include Google Maps, Facebook, Twitter, etc.

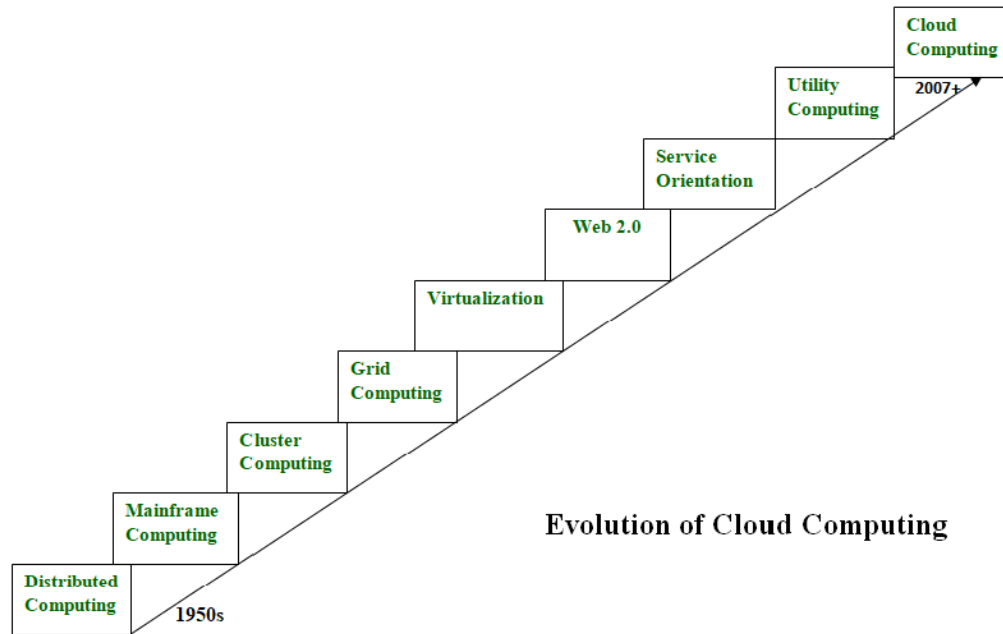
#### □ **Service orientation:**

It acts as a reference model for cloud computing. It supports low-cost, flexible, and evolvable applications. Two important concepts were introduced in this computing model. These were Quality of Service (QoS) which also includes the SLA (Service Level Agreement) and Software as a Service (SaaS).

#### □ **Utility computing:**

It is a service provisioning model in which a service provider makes computing resources and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate.

Thus, the above technologies contributed to the making of cloud computing.



## Cloud Computing Architecture

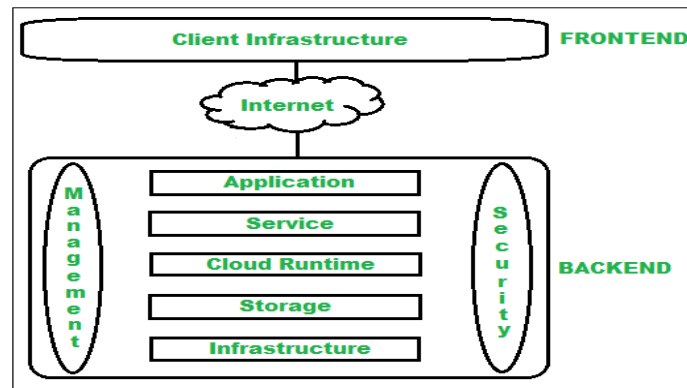
Cloud computing architecture is a combination of service-oriented architecture and event-driven architecture.

Cloud computing architecture is divided into the following two parts -

- Front End
- Back End

The below diagram shows the architecture of cloud computing –





### Front End

The front end is used by the client. It contains client-side interfaces and applications that are required to access the cloud computing platforms. The front end includes web servers (including Chrome, Firefox, internet explorer, etc.), thin & fat clients, tablets, and mobile devices.

### Back End

The back end is used by the service provider. It manages all the resources that are required to provide cloud computing services. It includes a huge amount of data storage, security mechanism, virtual machines, deploying models, servers, traffic control mechanisms, etc.

### Components of Cloud Computing Architecture

There are the following components of cloud computing architecture -

#### 1. Client Infrastructure

Client Infrastructure is a Front end component. It provides GUI (Graphical User Interface) to interact with the cloud.

#### 2. Application

The application may be any software or platform that a client wants to access.

#### 3. Service

A Cloud Services manages that which type of service you access according to the client's requirement.

**Cloud computing offers the following three type of services:**

**Software as a Service (SaaS)** – It is also known as cloud application services. Mostly, SaaS applications run directly through the web browser means we do not require to download and install these applications. Some important example of SaaS is given below –

**Example: Google Apps, Salesforce Dropbox, Slack, Hubspot, Cisco WebEx.**

**ii. Platform as a Service (PaaS)** – It is also known as cloud platform services. It is quite similar to SaaS, but the difference is that PaaS provides a platform for software creation, but using SaaS, we can access software over the internet without the need of any platform.

**Example: Windows Azure, Force.com, Magento Commerce Cloud, OpenShift.**

**iii. Infrastructure as a Service (IaaS)** – It is also known as cloud infrastructure services. It is responsible for managing applications data, middleware, and runtime environments.

**Example: Amazon Web Services (AWS) EC2, Google Compute Engine (GCE), Cisco Metapod.**

#### **4. Runtime Cloud**

Runtime Cloud provides the execution and runtime environment to the virtual machines.

#### **5. Storage**

Storage is one of the most important components of cloud computing. It provides a huge amount of storage capacity in the cloud to store and manage data.

#### **6. Infrastructure**

It provides services on the host level, application level, and network level. Cloud infrastructure includes hardware and software components such as servers, storage, network devices, virtualization software, and other storage resources that are needed to support the cloud computing model.

#### **7. Management**

Management is used to manage components such as application, service, runtime cloud, storage, infrastructure, and other security issues in the backend and establish coordination between them.

#### **8. Security**

Security is an in-built back end component of cloud computing. It implements a security mechanism in the back end.

#### **9. Internet**

The Internet is medium through which front end and back end can interact and communicate with each other.

## Cloud Deployment Model

### Different Types of Cloud Computing Deployment Models

- Public
- Private
- Community
- Hybrid

### What Is A Cloud Deployment Model?

It works as your virtual computing environment with a choice of deployment model depending on how much data you want to store and who has access to the infrastructure.

#### 1. Public Cloud

The public cloud makes it possible for anybody to access systems and services. The public cloud may be less secure as it is open for everyone. The public cloud is one in which cloud infrastructure services are provided over the internet to the general people or major industry groups. The infrastructure in this cloud model is owned by the entity that delivers the cloud services, not by the consumer. It is a type of cloud hosting that allows customers and users to easily access systems and services. This form of cloud computing is an excellent example of cloud hosting, in which service providers supply services to a variety of customers. In this arrangement, storage backup and retrieval services are given for free, as a subscription, or on a per-use basis. Example: Google App Engine etc.

#### Benefits of Public Cloud

**Minimal Investment** – As a pay-per-use service, there is no large upfront cost and is ideal for businesses who need quick access to resources

**No Hardware Set-up** – The entire infrastructure is fully funded by the cloud service providers

**No Infrastructure Management** – Does not require an in-house team to utilize the public cloud

#### Limitations of Public Cloud

**Data Security and Privacy Concerns** – Since it is accessible to all, it does not fully protect against cyber-attacks and could lead to vulnerabilities

**Reliability Issues** – Since the same server network is open to a wide range of users, it can lead to malfunction and outages

**Service/License Limitation** – While there are many resources that you can exchange with tenants, there is a cap on usage

#### Private Cloud

The private cloud deployment model is the exact opposite of the public cloud deployment model. It's a one-on-one environment for a single user (customer). There is no need to share your hardware

with anyone else. The distinction between private and public cloud is in how you handle all of the hardware. It is also called the “internal cloud” & it refers to the ability to access systems and services within a given border or organization. The cloud platform is implemented in a cloud-based secure environment that is protected by powerful firewalls and under the supervision of an organization’s IT department.

The private cloud gives the greater flexibility of control over cloud resources.

### **Benefits of Private Cloud**

**Data Privacy** - It is ideal for storing corporate data where only authorized personnel gets access

**Security** - Segmentation of resources within the same Infrastructure can help with better access and higher levels of security.

**Supports Legacy Systems** - This model supports legacy systems that cannot access the public cloud.

### **Limitations of Private Cloud**

**Higher Cost** - With the benefits you get, the investment will also be larger than the public cloud. Here, you will pay for software, hardware, and resources for staff and training.

**Fixed Scalability** - The hardware you choose will accordingly help you scale in a certain direction

**High Maintenance** - Since it is managed in-house, the maintenance costs also increase.

### **Community cloud**

It allows systems and services to be accessible by a group of organizations. It is a distributed system that is created by integrating the services of different clouds to address the specific needs of a community, industry, or business. The infrastructure of the community could be shared between the organization which has shared concerns or tasks. It is generally managed by a third party or by the combination of one or more organizations in the community.

### **Benefits of Community Cloud**

**Smaller Investment** - A community cloud is much cheaper than the private & public cloud and provides great performance

**Setup Benefits** - The protocols and configuration of a community cloud must align with industry standards, allowing customers to work much more efficiently.

### **Limitations of Community Cloud**

**Shared Resources** - Due to restricted bandwidth and storage capacity, community resources often pose challenges.

**Not as Popular** - Since this is a recently introduced model, it is not that popular or available across industries.

## Hybrid Cloud

As the name suggests, a hybrid cloud is a combination of two or more cloud architectures. While each model in the hybrid cloud functions differently, it is all part of the same architecture. Further, as part of this deployment of the cloud computing model, the internal or external providers can offer resources.

Let's understand the hybrid model better. A company with critical data will prefer storing on a private cloud, while less sensitive data can be stored on a public cloud. The hybrid cloud is also frequently used for 'cloud bursting'. It means, supposes an organization runs an application on-premises, but due to heavy load, it can burst into the public cloud.

### Benefits of Hybrid Cloud

**Cost-Effectiveness** - The overall cost of a hybrid solution decreases since it majorly uses the public cloud to store data.

**Security** - Since data is properly segmented, the chances of data theft from attackers are significantly reduced.

**Flexibility** - With higher levels of flexibility, businesses can create custom solutions that fit their exact requirements

### Limitations of Hybrid Cloud

**Complexity** - It is complex setting up a hybrid cloud since it needs to integrate two or more cloud architectures

**Specific Use Case** - This model makes more sense for organizations that have multiple use cases or need to separate critical and sensitive data.

### A Comparative Analysis of Cloud Deployment Models

Important Factors to Consider	Public	Private	Community	Hybrid
Setup and ease of use	Easy	Requires professional IT Team	Requires professional IT Team	Requires professional IT Team
Data Security and Privacy	Low	High	Very High	High
Scalability and flexibility	High	High	Fixed requirements	High
Cost-Effectiveness	Most affordable	Most expensive	Cost is distributed among members	Cheaper than private but more expensive than public
Reliability	Low	High	Higher	High

# Service Models Of Cloud Computing

Cloud computing makes it possible to render several services, which can be defined according to the roles, service providers and user companies. Cloud computing models and services are broadly classified as below:

## **IAAS: Changing Its Hardware Infrastructure on Demand**

The Infrastructure As A Service (IAAS) means the hiring & utilizing of the physical infrastructure of IT (network, storage, and servers) from a third-party provider. The IT resources are hosted on external servers and users can access them via an internet connection.

### **Benefits**

**Time and cost savings:** No installation and maintenance of IT hardware in-house,

**Better flexibility:** On-demand hardware resources that can be tailored to your needs,

**Remote access and resource management.**

### **For Who?**

This cloud computing service model is ideal for large accounts, enterprises, or organizations capable of building and managing their own IT platforms. However, they want the flexibility to amend their infrastructure according to their needs.

## **PAAS: Providing a Flexible Environment for Your Software Applications**

PaaS is a category of cloud computing that provides a platform and environment to allow developers to build applications and services over the internet. PaaS services are hosted in the cloud and accessed by users simply via their web browser.

A PaaS provider hosts the hardware and software on its own infrastructure. As a result, PaaS frees users from having to install in-house hardware and software to develop or run a new application. Thus, the development and deployment of the application take place independent of the hardware.

### **The Benefits**

Focus on development: Mastering the installation and development of software applications.

Time saving and flexibility: no need to manage the implementation of the platform, instant production.

Data security: You control the distribution, protection, and backup of your business data.

### **For Who?**

It is ideal for companies wanting to maintain control over their business applications. However, they wish to get rid of constraints to manage the hardware infrastructure and software environment.

## SAAS: Releasing the User Experience of Management Constraints

Software-as-a-Service (SaaS) is a way of delivering services and applications over the Internet. Instead of installing and maintaining software, we simply access it via the Internet, freeing ourselves from the complex software and hardware management. It removes the need to install and run applications on our own computers or in the data centers eliminating the expenses of hardware as well as software maintenance.

SaaS provides a complete software solution that you purchase on a pay-as-you-go basis from a cloud service provider. Most SaaS applications can be run directly from a web browser without any downloads or installations required. The SaaS applications are sometimes called Web-based software, on-demand software, or hosted software.

### The Benefits

- You are entirely free from the infrastructure management and aligning software environment: no installation or software maintenance.
- You benefit from automatic updates with the guarantee that all users have the same software version.
- It enables easy and quicker testing of new software solutions.

### For Who?

SAAS model accounts for 60% of sales of cloud solutions. Hence, it is applicable and preferred by most companies.

