# Cloud Computing Models

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*Abstract*—**This study paper deals with various service models and deployment models provided by cloud. Cloud computing is the delivery of computer services such as databases, storage facilities, virtual machines, servers etc. Thus, cloud reduces the cost for infrastructure and maintenance, which in turn will allow the enterprises to focus on core business processes. Cloud also allows the users to pool the resources to its users effectively and efficiently. According to NIST, there are three recognized service models and three recognized deployment models. Service models include IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service). Deployment models include Public cloud, Private cloud, Community cloud and Hybrid cloud. This study paper discusses these models, along with the other models which are provided by the cloud and service providers who provide these kinds of services, in detail**.

*Keywords—Cloud Computing, Public Cloud, Infrastructure, Deployment Models, Benefits, Service Models*

## I.  EVOLUTION OF CLOUD COMPUTING
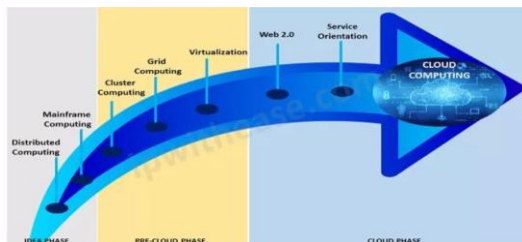


- Distributed Systems:
  It is a composition of multiple independent systems but all of them are depicted as a single entity to the users.The purpose of distributed systems is to share resources and also use them effectively and efficiently.
- Mainframe computing:
  Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines. These are responsible for handling large data such as massive input-output operations.
- Cluster computing:
  In the 1980s, cluster computing came as an alternative to mainframe computing. Each machine in the cluster was connected to each other by a network with high bandwidth. These were way cheaper than those mainframe systems.
- Grid computing:
  In the 1990s, the concept of grid computing was introduced. It means that different systems were placed at entirely different geographical locations and these all were connected via the internet. These systems belonged to different organizations and thus the grid consisted of heterogeneous nodes.
- 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.

- Web 2.0:
  It is the interface through which the cloud computing services interact with the clients. It is because of Web 2.0 that we have interactive and dynamic web pages. It also increases flexibility among web pages.
- Service orientation:
  It acts as a reference model for cloud computing.
- Utility computing:
  It is a computing model that defines service provisioning techniques for services such as compute services along with other major services such as storage, infrastructure, etc which are provisioned on a pay-per-use basis.

## II.  SERVICE MODELS

### A.  Infrastructure as a Service(IaaS)

This service model is the most comprehensive model of all. Here all the processing, network and additional required storage is provided by the supplier. Due to such ease of usage, the customer can run many sorts of softwares for different OS and environments. Such convenience is provided in this system that in spite of having no control over the CC system the customer has total power of the OS and the operating space. This model provides an accurate computer environment and infrastructure (both hardware and software) for maximum development efficiency

### B.  Platform as a Service (PaaS)

This service model is like a middleware offer which offers both a platform for computing and stack solution like service. It allows the customers to build their own software and maintain its deployment and other services provided by it. This model is mainly found only in business, as an average customer has no need to manage both software and hardware needed for the application to run smoothly. It therefore becomes successful in providing lower expenses for the application and giving a better control over both hardware and software provisioning capabilities

### C.  Software as a Service(SaaS)

Software as a Services or Software- as a Products well known as (SaaS) is the first layer of CC service models is the platform which enables various users at the same time via the used of object code and data. SaaS software is bought and installed into a personal computer, like a model of distribution where applications are accessible by vendors and providers of services, and provide the availability of the data to the end users via a typical platform, mostly the internet. It is appropriate a progressively predominant distribution

model since it underlined the technology that carries service-oriented architecture (SOA) and web services advanced and innovative developing methodologies start to become famous. Software as a Service is moreover frequently related to a licensing model such as pay-as-you-go subscription.

### D. Communication as a Service (CaaS)

This service model is responsible for managing hardware and software required for communication services such as Voice over IP (VoIP), Instant Messaging (IM), Collaboration and Video conferencing capabilities using fixed and mobile devices. This service model offers guaranteed Quality of Service (QoS), flexibility and expandability of small or medium -sized businesses which cannot afford the cost for devices or modes. This model allows the user/customer to select the types of communication services which are to be deployed by the organization for their core business processes.

### E. Data as a Service (DaaS)

This service model provides data on demand to the customers, without any constraint of geographical or organizational distance between the customer and the service provider. This service primarily was started by web mashups in 2015, and now an extensively used feature by organizations such as UN. The primary reason for this service model to come into existence is the increasing costs for combined software and data customer packages, and the necessary EAI (Enterprise Application Integration) middleware, which act as an interface between the software and data. This service model separates the data cost and data usage from the cost of the software or the environment required to run it, making itself attractive to the customers

### F. Disaster Recovery as a Service (DRaaS)

It is also referred to as Recovery as a Service (RaaS), which provides protection of the application or data in the cloud at the times of natural or human disaster or interruption in the service at any location, and also ensuring the full recovery of the application or data to the customer when needed. The customer can pay for this service only when needed, which makes this service more efficient than the traditional sites for data recovery.

### G. Mobile Backend as a Service (MBaaS)

It is also referred to as Backend as a Service (BaaS), which delivers a model for the web and mobile applications developers for linking their applications to the backend cloud storage. It also provides application interfaces for other services such as push notifications, integration with social networking services and user management, in the backend.Firebase from Google, MBaaS services from Windows Azure, and Kumulos, are some of the vendors who provide MBaaS solutions.

### H. Monitoring as a Service (MaaS)

It is a service which is meant to monitor a certain part of an application, server or any other IT device. This service helps in monitoring many other applications and services running within the cloud. Online state monitoring is the most common service of the MaaS model. Flexibility and scalability is offered to all the available instances in the cloud effectively. Amazon Web Services and Monitis are some of

the vendors who provide MaaS solutions.provide MBaaS solutions.

## III. Deployment Models

There are four main categories of the deployment models are:
- Public
- Private
- Community
- Hybrid
- Distributed
- Inter Cloud
- Multi Cloud

### A. Public Cloud

The most popular and common deployment is the public cloud. The public cloud is accessible from anywhere in the globe and is easy to use for the general public. Any organization or enterprise or academic or a combination of them, may own and manage it. The entire infrastructure is located on the cloud provider's premises. It's a pay-per-use model and provides the services on demand according to service-level agreements. An end user can actually buy these resources on an hourly basis and utilize them as needed. In public cloud, users no need to maintain any infrastructure instead everything will be owned and operated by cloud public providers.



The public cloud is accessible from anywhere in the globe and is ease to use for the general public
The Public cloud model has the following benefits:
- Minimal Investment: This model eliminates the need for extra hardware expenditures.
- No startup costs: Users can rent the computing resources on pay-per-use, there is no need of establishing infrastructure from the user side which in turn reduces the startup costs.
- Infrastructure Management is not required: There is no need for any hardware to be set up from the user side but everything is operated and controlled by the service provider.
- Zero maintenance: The service provider is responsible for all maintenance work from infrastructure to software applications.
- Dynamic Scalability: On-demand resources are provisioned dynamically as per customer requirements

### B. Private Cloud

It is a cloud environment created specifically for a single enterprise. It is also known as onpremise cloud. It allows access to infrastructure and services inside the boundaries of

an organization or company. Private cloud is more secure when compared to similar models. Because the private cloud is usually owned, deployed and managed by the organization itself, the chance of data leakage is very less. Because all users are members of the same organization, there is no risk from anybody else. In private clouds, only authorized users have access, allowing organizations to better manage their data and security.



Private cloud is more secure when compared to similar models.

The Private cloud model has the following benefits:
- Better Control: Private cloud is managed by their own organization staff.
- Data Privacy: Data is accessed and managed by inside the boundaries of an organization.
- Security: Provides security for the data because only authorized users may access it.
- Customization: In contrast to a public cloud deployment, private cloud allows customization of resources to meet its specific needs.

## C. Community Clouds

The community cloud is the extension of private cloud and this kind of model is sharing cloud infrastructure among multiple organizations in the same community or area. Organizations, businesses, financial institutions and banks etc. are examples of this category. The infrastructure is provided for exclusive usage by a group of users from companies with similar computing requirements in a community cloud environment. The following Fig. 2.2.3 represents the community cloud.
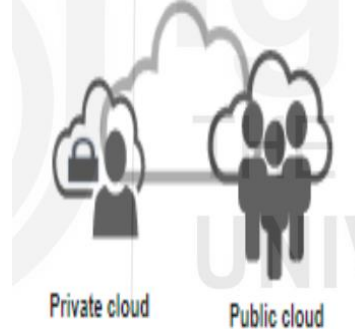


The Community cloud model has the following benefits:
- Cost-effective: Community cloud is cost-effective since its infrastructure cost is shared among number of enterprises or communities.
- Security: The community cloud is more secure compared to public cloud
- Shared resources: Infrastructure and other resources shared with multiple organizations.
- Data sharing and collaboration: It is excellent for both data sharing and collaboration.
- Setup Benefits: Customers may be able to work more efficiently as a consequence of these shared resources.

- Smaller investment: Investment on infrastructure is shared among organizations in the community

## D. Hybrid Cloud

It is a kind of integrated cloud computing, which means that it may be a combination of private, public, and community cloud, all of which are integrated into a single architecture but remain independent entities inside the overall system. This aims to combine the benefits of both private and public clouds. The most common way to use the hybrid cloud is to start with a private cloud and then use the public cloud for more resources. It is possible to utilize the public cloud for non-critical tasks like development and testing. On the other hand, critical tasks such as processing company data are carried out on a private cloud.



Private cloud          Public cloud

The Hybrid cloud model has the following benefits:
- Flexibility and control: Companies with greater flexibility may create customized solutions to match their specific requirements.
- Cost: Cost is less compared to public cloud users paid only for additional resources used from public cloud.
- Partial Security: The hybrid cloud is generally a mix of public and private clouds. Although the private cloud is considered as secure and the hybrid cloud includes public cloud, poses a significant chance of security breach. As a result, it can only be described as partially secure

## E. Distributed Cloud

If a cloud computing platform is distributed across different locations on different machines, then that kind of cloud model is called a distributed model. There are two types of distributed clouds- public resource cloud and volunteer cloud. This model can provide fast and responsive communication services globally.

## F. Inter Cloud

It is known as cloud of clouds. Here each cloud can use the computational capacity and other infrastructure resources of other clouds simultaneously for generating effective and productive solutions. Cisco uses Inter Cloud.

## G. Multi Cloud

It is the use of multiple cloud computing resources under a single heterogeneous architecture. These kinds of clouds are used to minimize the loss of data or any other component in the cloud. This kind of cloud improves overall performance of the cloud.

## IV. CHOOSING APPROPRIATE DEPLOYMENT MODELS

### A. Suitability of Public Cloud

- The public cloud model is appropriate in the following circumstances:
- There is a high demand for resources, resulting in a large user base.
- There is a dynamic change of resources based on customer requirements.
- No physical infrastructure exists. A company's finances are limited.

The public cloud model is not appropriate in the following circumstances:

- It is critical to maintain a high level of security.
- Autonomy is expected by the organization.
- Reliability from a third party is not recommended.

### B. Suitability of Private Cloud

The term suitability in terms of cloud refers to the conditions under which this cloud model is appropriate. It also denotes the best circumstances and environment in which to use this cloud model, such as the following:

- Enterprises or businesses that demand their own cloud for personal or business purposes.
- Business organizations have appropriate financial resources, since operating and sustaining a cloud is an expensive effort.
- Business organizations consider data security to be important.
- Enterprises want to get complete control and autonomy over cloud resources.
- Private cloud is suitable for organizations with less number of employees.
- Organizations that already have a pre-built infrastructure will choose a private cloud for managing resources efficiently.

The private cloud model is not appropriate in the following circumstances:

- An organization consists of more users..
- Enterprises that have constraints on finance.
- Organizations that do not have a pre-existing infrastructure
- Organizations with insufficient operational staff to maintain and administer the cloud

### C. Suitability of Commuity Cloud

The Community cloud is suitable for the organizations with the following concerns:

- Wish to build a private cloud but lack of financial support.
- Don't want to take complete control of maintenance responsibility of the cloud
- Desire to work in collaboration for effective outcome.
- provides more security when compared to public cloud

### D. Suitability of Hybrid Clouds

The hybrid cloud model is appropriate in the following circumstances:

- Organizations that desire a private cloud environment with public cloud scalability
- Businesses that demand greater protection compared to the public cloud.

The Hybrid cloud model is not appropriate in the following circumstances:

- Organizations that prefer security as a top priority
- Organizations that are unable to handle complex hybrid cloud infrastructures

## V. BENEFITS OF CLOUD COMPUTING
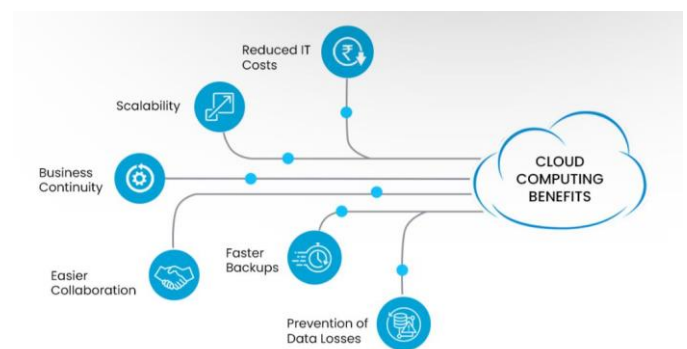


### A. Reduced IT Costs

With Cloud, there is no need to purchase expensive systems and equipment, as the users utilize their Cloud Computing Provider resources.

### B. Scalable Solution

With Cloud Computing, businesses can quickly scale up or down their operation and storage-based needs on the go.

### C. Ensures Business Continuity

Protection of data and applications is an inevitable component of business continuity planning. Cloud Computing becomes handy in any unforeseen disasters as the data and applications are stored in a safe place.

### D. Easier Collaboration

Cloud Computing offers enhanced collaboration between the business entities, present within and outside the organization. Cloud Computing provides seamless collaboration in geographically scattered users as the changes are reflected in near-time.

### E. Easier Backup & Data Restoration

Data can be easily stored on the Cloud without considering any constraints related to capacity. In the absence of such capacity constraints, it becomes easier

for the Cloud users to backup and restore their application & data.

### F. Prevention of Data Losses

When data is stored on Cloud, it remains available, even in case of hardware failures. To access the online data on Cloud, one requires a desktop/computer device with an active Internet connection.

## VI. New Trends In Service Space

- The abstraction of infrastructure, platforms and software were initially offered as services (IaaS, PaaS and SaaS) on the cloud.
- However, the service space is becoming richer with a wide variety of services.
- For example, to offer acceleration provided by GPUs to applications Acceleration-as-a-Service (AaaS) has been proposed.
- In the future, as more applications make use of hardware accelerators the AaaS space is expected to become more mature. Currently, GPU virtualisation technologies, such as rCUDA facilitate the use of GPU services
- However, most AaaS services still require applications to be specifically written for an accelerator.
- Further, a wider variety of accelerators, such as coprocessors, FPGAs and ASICs (such as Tensor Processing Units (TPUs) need to be integrated in future clouds to enable computing in device rich environments, such as fog computing and IoT.
- Another area in the service space that is gaining significant traction is Container-as-a-Service (CaaS)
- The benefits of deploying containers have been investigated for a variety of applications (although they are not applicable for all workloads).
- Consequently, containers are starting to be adopted as an alternate virtualisation technology.
- CaaS offers the deployment and management of containers, which will be required for workload execution in ad hoc clouds and micro clouds for enabling volunteer computing and fog computing, respectively.
- The security aspects of containers due to weak isolation relative to cloud VMs needs to be further understood.
- With the adoption of event-based platforms for enabling serverless computing, more applications will make use of Function-as-a-Service (FaaS).

- The aim will be to execute functions on the cloud platform that are initiated by events. This is in contrast to current execution models in which an application is constantly running on the server to furnish a client request and is billed even when the server application remains idle when it is not servicing requests

## VII. Conclusion

The services and deployment models provided by cloud form the basic functionality of cloud. Cloud computing, thus, provides the benefits of resources at economical scale, with flexibility, scalability and multi-tenancy. Cloud can be the platform for executing all the crucial and core business processes

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