UNIT-II CLOUD COMPUTING FUNDAMENTALS

UNIT - II
Cloud Computing Fundamentals: Motivation for Cloud Computing, The Need   for Cloud Computing, Defining Cloud Computing, Definition of Cloud computing, Cloud Computing Is a Service, Cloud Computing Is a Platform, Principles of Cloud computing, Five Essential Characteristics, Four Cloud Deployment Models

Q1: 1. What is cloud computing? Why is it needed?
A1:

Motivation for Cloud Computing:
- Let us review the scenario of computing prior to the announcement and availability of cloud computing:
- The users who are in need of computing are expected to invest money on computing resources such as hardware, software, networking, and storage;
- This investment naturally costs a bulk currency to the users as they have to buy these computing resources, keep these in their premises, and maintain and make it operational—all these tasks would add cost.
- And, this is a particularly true and huge expenditure to the enterprises that require enormous computing power and resources, compared with classical academics and individuals
- On the other hand, it is easy and handy to get the required computing power and resources from some provider (or supplier) as and when it is needed and pay only for that usage.
- This would cost only a reasonable investment or spending, compared to the huge investment when buying the entire computing infrastructure.
- This phenomenon can be viewed as capital expenditure versus operational expenditure.
- As one can easily assess the huge lump sum required for capital expenditure (whole investment and maintenance for computing infrastructure) and compare it with the moderate or smaller lump sum required for the hiring or getting the computing infrastructure only to the tune of required time, and rest of the time free from that.
- Therefore, cloud computing is a mechanism of bringing–hiring or getting the services of the computing power or infrastructure to an organizational or individual level to the extent required and paying only for the consumed services.
- One can compare this situation with the usage of electricity (its services) from its producer-cum-distributor (in India, it is the state-/government-owned electricity boards that give electricity supply to all residences and organizations) to houses or organizations;
- Here, we do not generate electricity (comparable with electricity production–related tasks); rather, we use it only to tune up our requirements in our premises, such as for our

lighting and usage of other electrical appliances, and pay as per the electricity meter reading value.

- Therefore, cloud computing is needed in getting the services of computing resources.
- Thus, one can say as a one-line answer to the need for cloud computing that it eliminates a large computing investment without compromising the use of computing at the user level at an operational cost.
- Cloud computing is very economical and saves a lot of money.
- A blind benefit of this computing is that even if we lose our laptop or due to some crisis our personal computer—and the desktop system—gets damaged, still our data and files will stay safe and secured as these are not in our local machine (but remotely located at the provider's place—machine).
- In addition, one can think to add security while accessing these remote computing resources as depicted in Figure 2.1.
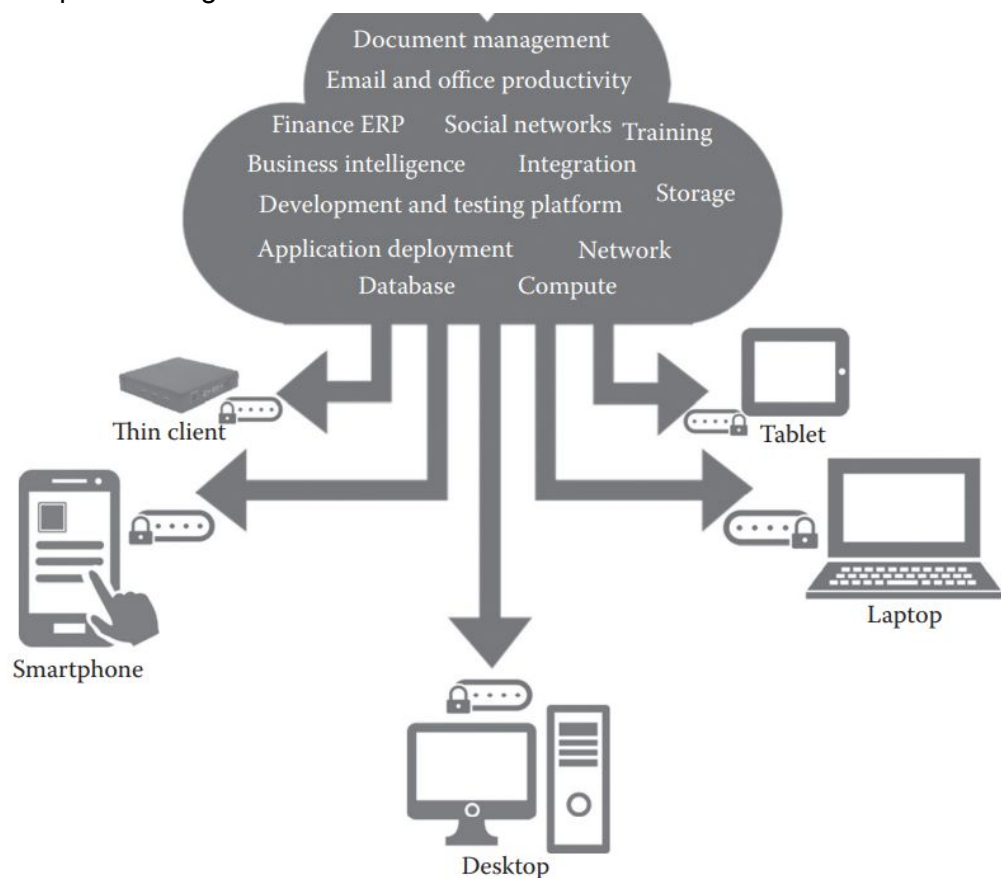

FIGURE 2.1
Cloud computing.

- Figure 2.1 shows several cloud computing applications.
- The cloud represents the Internet-based computing resources, and the accessibility is through some secure support of connectivity.
- It is a computing solution growing in popularity, especially among individuals and small- and medium-sized companies (SMEs).

- In the cloud computing model, an organization's core computer power resides offsite and is essentially subscribed to rather than owned.
- Thus, cloud computing comes into focus and is much needed only when we think about what computing resources and information technology (IT) solutions are required.
- This need caters to a way to increase capacity or add capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software.
- Cloud computing encompasses the subscription based or pay-per-use service model of offering computing to end users or customers over the Internet and thereby extending the IT's existing capabilities.

The Need for Cloud Computing:
- The main reasons for the need and use of cloud computing are convenience and reliability.
- In the past, if we wanted to bring a file, we would have to save it to a Universal Serial Bus (USB) flash drive, external hard drive, or compact disc (CD) and bring that device to a different place.
- Instead, saving a file to the cloud (e.g., use of cloud application Dropbox) ensures that we will be able to access it with any computer that has an Internet connection.
- The cloud also makes it much easier to share a file with friends, making it possible to collaborate over the web.
- While using the cloud, losing our data/file is much less likely.
- However, just like anything online, there is always a risk that someone may try to gain access to our personal data, and therefore, it is important to choose an access control with a strong password and pay attention to any privacy settings for the cloud service that we are using.

Q2:. Distinguish between the definitions of cloud computing is a service and cloud computing is a platform.?
A2:
Defining Cloud Computing:
- In the simplest terms, cloud computing means storing and accessing data and programs over the Internet from a remote location or computer instead of our computer's hard drive.
- This so-called remote location has several properties such as scalability, elasticity etc., which is significantly different from a simple remote machine.
- The cloud is just a metaphor for the Internet. When we store data on or run a program from the local computer's hard drive, that is called local storage and computing.
- For it to be considered cloud computing, we need to access our data or programs over the Internet.
- The end result is the same; however, with an online connection, cloud computing can be done anywhere, anytime, and by any device.

NIST Definition of Cloud Computing:

- The formal definition of cloud computing comes from the National Institute of Standards and Technology (NIST): "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.
- This cloud model is composed of five essential characteristics, three service models, and four deployment models .
- It means that the computing resource or infrastructure—be it server hardware, storage, network, or application software—all available from the cloud vendor or provider's site/premises, can be accessible over the Internet from any remote location and by any local computing device.
- In addition, the usage or accessibility is to cost only to the level of usage to the customers based on their needs and demands, also known as the pay-as-you-go or pay-as-per-use model.
- If the need is more, more quantum computing resources are made available (provisioning with elasticity) by the provider.
- Minimal management effort implies that at the customer's side, the maintenance of computing systems is very minimal as they will have to look at these tasks only for their local computing devices used for accessing cloud-based resources, not for those computing resources managed at the provider's side.

Cloud Computing Is a Service :
- The simplest thing that any computer does is allow us to store and retrieve information.
- We can store our family photographs, our favorite songs, or even save movies on it, which is also the most basic service offered by cloud computing.
- Let us look at the example of a popular application called Flickr to illustrate the meaning of this section.
- While Flickr started with an emphasis on sharing photos and images, it has emerged as a great place to store those images.
- **In many ways, it is superior to storing the images on your computer:**
- 1. First, Flickr allows us to easily access our images no matter where we are or what type of device we are using. While we might upload the photos of our vacation from our home computer, later, we can easily access them from our laptop at the office.
- 2. Second, Flickr lets us share the images. There is no need to burn them to a CD or save them on a flash drive. We can just send someone our Flickr address to share these photos or images.
- 3. Third, Flickr provides data security. By uploading the images to Flickr, we are providing ourselves with data security by creating a backup on the web. And, while it is always best to keep a local copy— either on a computer, a CD, or a flash drive—the truth is that we are far more likely to lose the images that we store locally than Flickr is of losing our images.

Cloud Computing Is a Platform:
- The World Wide Web (WWW) can be considered as the operating system for all our Internet-based applications.

- However, one has to understand that we will always need a local operating system in our computer to access web based applications.
- The basic meaning of the term platform is that it is the support on which applications run or give results to the users.
- For example, Microsoft Windows is a platform. But, a platform does not have to be an operating system.
- Java is a platform even though it is not an operating system.
- Through cloud computing, the web is becoming a platform. With trends (applications) such as Office 2.0, more and more applications that were originally available on desktop computers are now being converted into web–cloud applications.
- Word processors like Buzzword and office suites like Google Docs are now available in the cloud as their desktop counterparts.
- All these kinds of trends in providing applications via the cloud are turning cloud computing into a platform or to act as a platform.

Q3:Is it true that all essential characteristic features of the cloud are necessary to completely describe it?

A3:

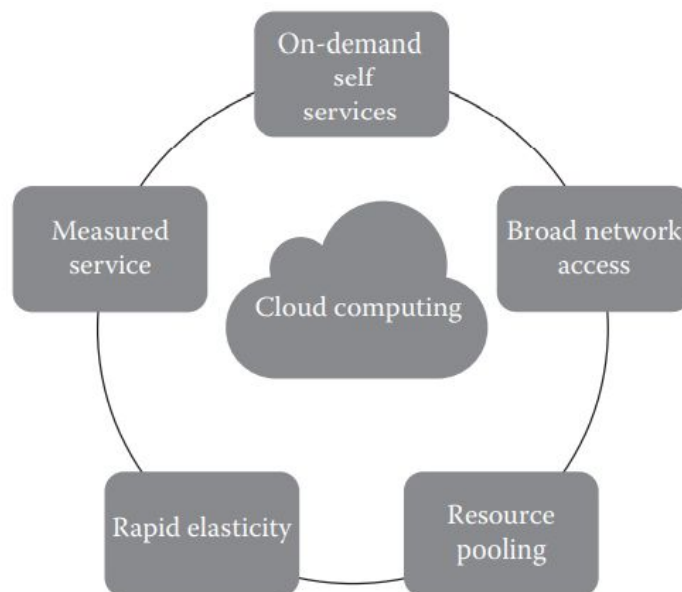**Five Essential Characteristics of Cloud Computing:**

FIGURE 2.2
The essential characteristics of cloud computing.

- Cloud computing has five essential characteristics, which are shown in Figure 2.2. Readers can note the word essential, which means that if any of these characteristics is missing, then it is not cloud computing:
- 1. On-demand self-service: A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

- 2. Broad network access: Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and personal digital assistants [PDAs])
- 3. Elastic resource pooling: The provider's computing resources are pooled to serve multiple consumers using a multi tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify the location at a higher level of abstraction (e.g., country, state, or data center). Examples of resources include storage, processing, memory, and network bandwidth.
- 4. Rapid elasticity: Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.
- 5. Measured service: 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 both the provider and consumer of the utilized service.

Q4:What are the services offering models of the cloud?
A4:
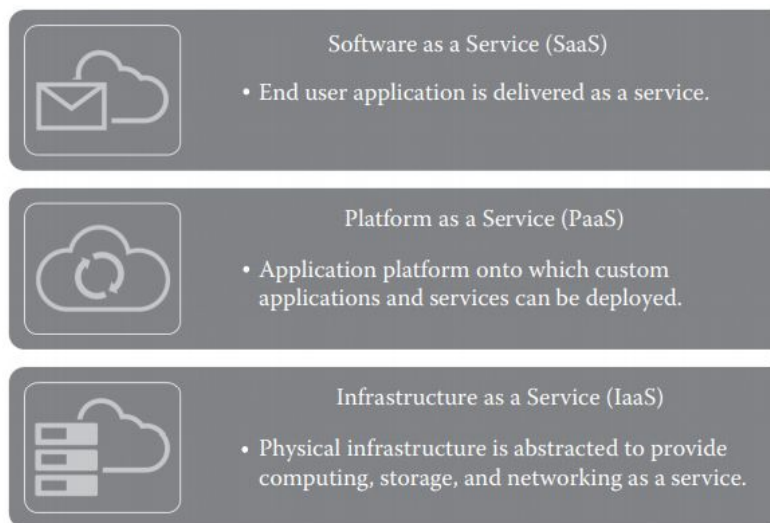**Three Service Offering Models :**

FIGURE 2.3
SPI—service offering model of the cloud.

- The three kinds of services with which the cloud-based computing resources are available to end customers are as follows: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).
- It is also known as the service–platform–infrastructure (SPI) model of the cloud and is shown in Figure 2.3.
- SaaS is a software distribution model in which applications (software, which is one of the most important computing resources) are hosted by a vendor or service provider and made available to customers over a network, typically the Internet.
- PaaS is a paradigm for delivering operating systems and associated services (e.g., computer aided software engineering [CASE] tools, integrated development environments [IDEs] for developing software solutions) over the Internet without downloads or installation.
- IaaS involves outsourcing the equipment used to support operations, including storage, hardware, servers, and networking components.
- **1. Cloud SaaS:** The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure, including network, servers, operating systems, storage, and even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based e-mail), or a program interface.
- The consumer does not manage or control the underlying cloud infrastructure.
- Typical applications offered as a service include customer relationship management (CRM), business intelligence analytics, and online accounting software.
- **2. Cloud PaaS:** The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.
- The consumer does not manage or control the underlying cloud infrastructure but has control over the deployed applications and possibly configuration settings for the application-hosting environment.
- In other words, it is a packaged and ready-to-run development or operating framework.
- The PaaS vendor provides the networks, servers, and storage and manages the levels of scalability and maintenance.
- The client typically pays for services used. Examples of PaaS providers include Google App Engine and Microsoft Azure Services.
- **3. Cloud IaaS:** The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources on a pay-per-use basis where he or she is able to deploy and run arbitrary software, which can include operating systems and applications.
- The consumer does not manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications and possibly limited control of select networking components (e.g., host firewalls).
- The service provider owns the equipment and is responsible for housing, cooling operation, and maintenance.
- Amazon Web Services (AWS) is a popular example of a large IaaS provider.

- The major difference between PaaS and IaaS is the amount of control that users have.
- In essence, PaaS allows vendors to manage everything, while IaaS requires more management from the customer side.
- Generally speaking, organizations that already have a software package or application for a specific purpose and want to install and run it in the cloud should opt to use IaaS instead of PaaS.

Q5:. What are the deployment models of the cloud?
A5:
Four Cloud Deployment Models:
- Deployment models describe the ways with which the cloud services can be deployed or made available to its customers, depending on the organizational structure and the provisioning location.
- One can understand it in this manner too: cloud (Internet)-based computing resources—that is, the locations where data and services are acquired and provisioned to its customers— can take various forms.
- **Four deployment models are usually distinguished, namely, public, private, community, and hybrid cloud service usage:**
- **1. Private cloud:**
- The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units).
- It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
- **2. Public cloud:**
- The cloud infrastructure is provisioned for open use by the general public.
- It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.
- It exists on the premises of the cloud provider.
- **3. Community cloud:**
- The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations).
- It may be managed by the organizations or a third party and may exist on premise or off premise.
- **4. Hybrid cloud:**
- The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

Q6:. Compare and contrast public and private clouds?
A6:
Private Cloud:

- According to the National Institute of Standards and Technology (NIST), private cloud can be defined as the cloud infrastructure that is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units).
- It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises .
- The private cloud in simple terms is the cloud environment created for a single organization.
- It is usually private to the organization but can be managed by the organization or any other third party.
- Private cloud can be deployed using Open Source tools such as Openstack , Eucalyptus .
- The private cloud is small in size as compared to other cloud models. Here, the cloud is deployed and maintained by the organizations itself.

Characteristics:
- Certain characteristics of the private cloud are as follows:
- **1. Secure:** The private cloud is secure.
- This is because usually the private cloud is deployed and managed by the organization itself, and hence there is least chance of data being leaked out of the cloud.
- In the case of outsourced cloud, the service provider may view the cloud (though governed by SLAs), but there is no other risk from anybody else as all the users belong to the same organization.
- **2. Central control:** The organization mostly has full control over the cloud as usually the private cloud is managed by the organization itself.
- Thus, when managed by the organization itself, there is no need for the organization to rely on anybody.
- **3. Weak SLAs:** Formal SLAs may or may not exist in a private cloud.
- But if they exist they are weak as it is between the organization and the users of the same organization.
- Thus, high availability and good service may or may not be available. This depends on the organization that is controlling the cloud.

Suitability:
- Suitability refers to the instances where this cloud model can be used.
- **It also signifies the most suitable conditions and environment where this cloud model can be used, such as the following:**
- • The organizations or enterprises that require a separate cloud for their personal or official use.
- • The organizations or enterprises that have a sufficient amount of funds as managing and maintaining a cloud is a costly affair.
- • The organizations or enterprises that consider data security to be important.
- • The organizations that want autonomy and complete control over the cloud.
- • The organizations that have a less number of users.
- • The organizations that have pre-built infrastructure for deploying the cloud and are ready for timely maintenance of the cloud for efficient functioning.
- • Special care needs to be taken and resources should be available for troubleshooting.

- **The private cloud platform is not suitable for the following**:
- • The organizations that have high user base
- • The organizations that have financial constraints
- • The organizations that do not have pre built infrastructure
- • The organizations that do not have sufficient manpower to maintain and manage the cloud

Advantages:
• The cloud is small in size and is easy to maintain.
• It provides a high level of security and privacy to the user.
• It is controlled by the organization.

Disadvantages:
• For the private cloud, budget is a constraint.
• The private clouds have loose SLAs.
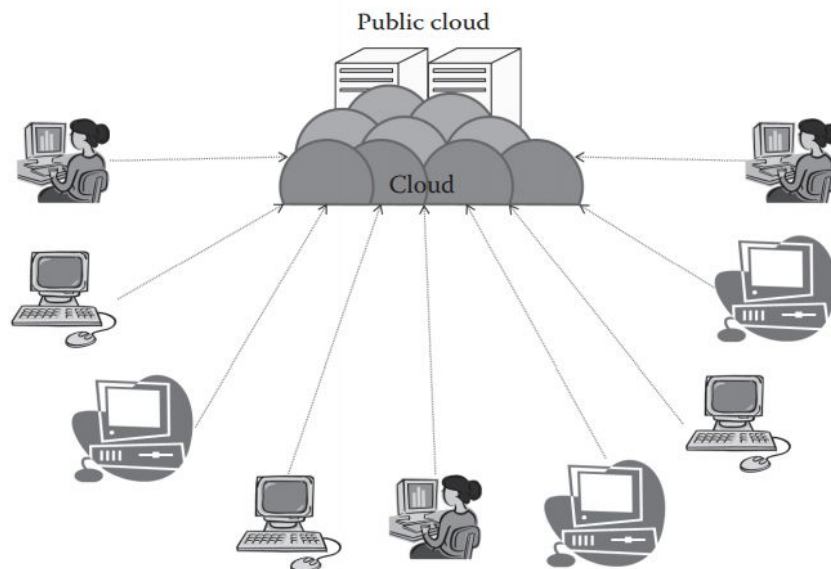
Public Cloud:

FIGURE 4.4
Public cloud.

- According to NIST, the public cloud is the cloud infrastructure that is provisioned for open use by the general public.
- It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.
- It exists on the premises of the cloud provider.
- The typical public cloud is depicted in Figure 4.4.
- Public cloud consists of users from all over the world.
- A user can simply purchase resources on an hourly basis and work with the resources.
- There is no need for any pre-built infrastructure for using the public cloud.
- These resources are available in the cloud provider's premises

- Usually, cloud providers accept all the requests, and hence, the resources in the service providers' end are considered infinite in one aspect. Some of the well-known examples of the public cloud are Amazon AWS , Microsoft Azure , etc.

Characteristics:

- **1. Highly scalable:**
- The public cloud is highly scalable.
- The resources in the public cloud are large in number and the service providers make sure that all the requests are granted.
- Hence, the public cloud is considered to be scalable.
- **2. Affordable:**
- The public cloud is offered to the public on a pay-as-you go basis;
- hence, the user has to pay only for what he or she is using (usually on a per-hour basis).
- And, this does not involve any cost related to the deployment.
- **3. Less secure:**
- The public cloud is less secure out of all the four deployment models.
- This is because the public cloud is offered by a third party and they have full control over the cloud.
- Though the SLAs ensure privacy, still there is a high risk of data being leaked.
- **4. Highly available:**
- The public cloud is highly available because anybody from any part of the world can access the public cloud with proper permission, and this is not possible in other models as geographical or other access restrictions might be there.
- **5. Stringent SLAs:**
- SLA is very stringent in the case of the public cloud.
- As the service provider's business reputation and customer strength are totally dependent on the cloud services, they follow the SLA strictly and violations are avoided. These SLAs are very competitive.

Suitability:

- **There are several occasions and environments where the public cloud is suitable.**
- Thus, the suitability of the public cloud is described.
- The public cloud can be used whenever the following applies:
- • The requirement for resources is large, that is, there is large user base.
- • The requirement for resources is varying.
- • There is no physical infrastructure available.
- • An organization has financial constraints.
- **The public cloud is not suitable, where the following applies:**
- • Security is very important.
- • Organization expects autonomy.
- • Third-party reliability is not preferred.

Advantages :

• There is no need of establishing infrastructure for setting up a cloud.

 • There is no need for maintaining the cloud.

• They are comparatively less costly than other cloud models.

• Strict SLAs are followed.
• There is no limit for the number of users.
• The public cloud is highly scalable.
 Disadvantages:
• Security is an issue.
 • Privacy and organizational autonomy are not possible.

Q7:Differentiate community cloud and hybrid cloud based on their properties.?
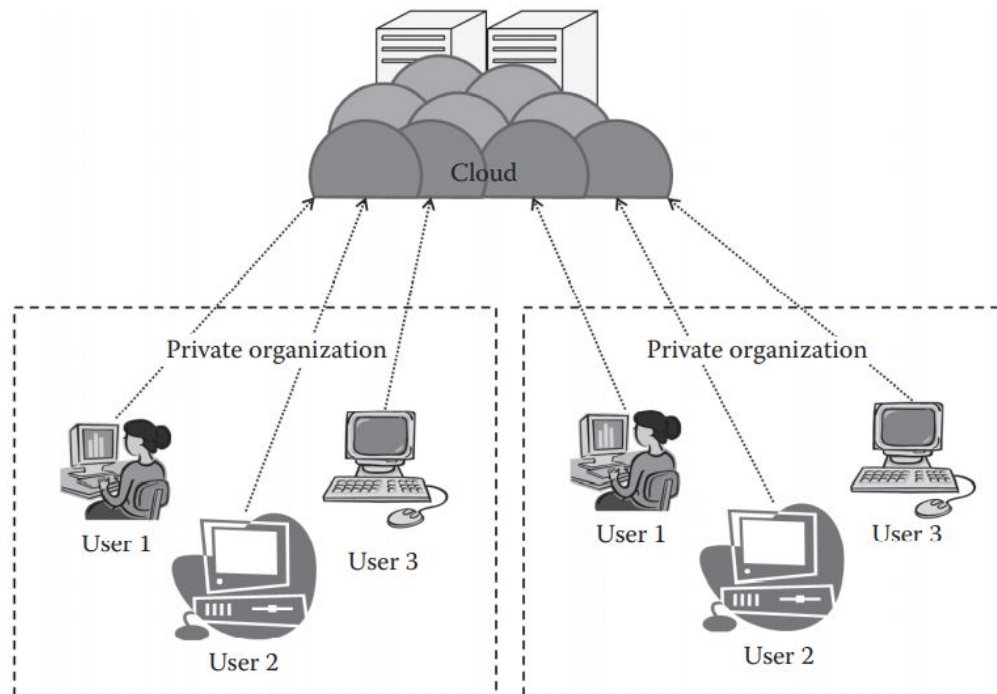**A7:**
Community Cloud:

FIGURE 4.5
Community cloud.

- According to NIST, the community cloud is the cloud infrastructure that is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations).
- It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises .
- It is a further extension of the private cloud. Here, a private cloud is shared between several organizations.
- Either the organizations or a single organization may collectively maintain the cloud.
- The main advantage of the public cloud is that the organizations are able to share the resources among themselves based on specific concerns.

- Thus, here the organizations are able to extract the power of the cloud, which is much bigger than the private cloud, and at the same time, they are able to use it at a usually less cost.
- The community is formed based on any common cause, but eventually, all the members of the community are benefitted.
- This model is very suitable for organizations that cannot afford a private cloud and cannot rely on the public cloud either.

Characteristics:

1. Collaborative and distributive maintenance:
- The community cloud is wholly collaborative, and usually no single party has full control over the whole cloud (in some cases, it may be controlled by one party).
- This is usually distributive, and hence, better cooperation gives better results.
- Even though it may be outsourced, collaboration based on purpose always proves to be beneficial.

2. Partially secure:
- Partially secure refers to the property of the community cloud where few organizations share the cloud, so there is a possibility that the data can be leaked from one organization to another, though it is safe from the outside world.

3. Cost effective:
- The community cloud is cost effective as the whole cloud is being shared by several organizations or a community.
- Usually, not only cost but every other sharable responsibilities are also shared or divided among the groups.

Suitability :
- **This kind of cloud is suitable for organizations that**
- • Want to establish a private cloud but have financial constraint
- • Do not want to complete maintenance responsibility of the cloud
- • Want to establish the cloud in order to collaborate with other clouds
- • Want to have a collaborative cloud with more security features than the public cloud
  This cloud is not suitable for organizations that
- • Prefer autonomy and control over the cloud
- • Does not want to collaborate with other organizations
-

Advantages:
 • It allows establishing a low-cost private cloud.
 • It allows collaborative work on the cloud.
• It allows sharing of responsibilities among the organization.
 • It has better security than the public cloud.

Disadvantages:
 • Autonomy of an organization is lost.
 • Security features are not as good as the private cloud.
• It is not suitable if there is no collaboration.
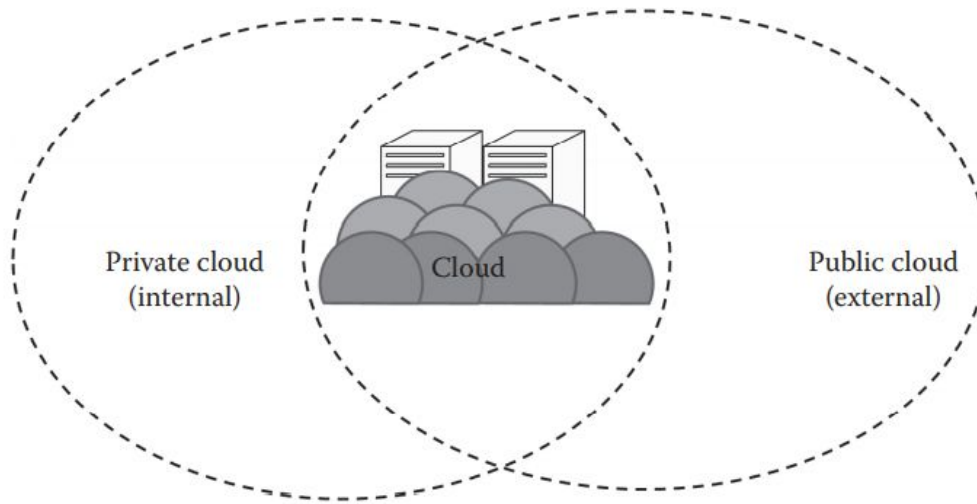
Hybrid Cloud:

FIGURE 4.6
Hybrid cloud.

- According to NIST, the hybrid cloud can be defined as the cloud infrastructure that is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.
- The hybrid cloud usually is a combination of both public and private clouds.
- This is aimed at combining the advantages of private and public clouds.
- The usual method of using the hybrid cloud is to have a private cloud initially, and then for additional resources, the public cloud is used.
- There are several advantages of the hybrid cloud.
- The hybrid cloud can be regarded as a private cloud extended to the public cloud.
- This aims at utilizing the power of the public cloud by retaining the properties of the private cloud.
- One of the popular examples for the hybrid cloud is Eucalyptus .
- Eucalyptus was initially designed for the private cloud and is basically a private cloud, but now it also supports hybrid cloud.

Characteristics :
1. Scalable:
- The hybrid cloud is a combination of one or more deployment models.
- Usually, the private with public cloud gives hybrid cloud.
- The main reason for having a hybrid cloud is to use the property of a public cloud with a private cloud environment.
- The public cloud is used whenever needed; hence, as the public cloud is scalable, the hybrid cloud with the help of its public counterpart is also scalable.

2. Partially secure:
- The hybrid cloud usually is a combination of public and private.

- The private cloud is considered to be secured, but as the hybrid cloud also uses the public cloud, there is high risk of security breach.
- Thus, it cannot be fully termed as secure but as partially secure.

3. Stringent SLAs:
- As the hybrid cloud involves a public cloud intervention, the SLAs are stringent and might as per the public cloud service provider.
- But overall, the SLAs are more stringent than the private cloud.

4. Complex cloud management:
- Cloud management is complex and is a difficult task in the hybrid cloud as it involves more than one type of deployment models and also the numbers of users are high.

Suitability :

The hybrid cloud environment is suitable for

• Organizations that want the private cloud environment with the scalability of the public cloud

• Organizations that require more security than the public cloud

The hybrid cloud is not suitable for

• Organizations that consider security as a prime objective

• Organizations that will not be able to handle hybrid cloud management

Advantages:

• It gives the power of both the private and public clouds.

• It is highly scalable.

• It provides better security than the public cloud.

Disadvantages:

• The security features are not as good as the public cloud.

• Managing a hybrid cloud is complex.

• It has stringent SLAs.