# 1.2 Cloud Deployment Model: Public cloud, Private cloud, Hybrid cloud, Community cloud.

1. **Enlist Cloud Deployment Model. Ans.: Cloud Deployment Model:**
	* Public cloud,
	* Private cloud,
	* Hybrid cloud.
	* Community cloud,

# Explain Cloud Deployment Model. Ans.: Cloud Deployment Model:

1. Clouds constitute the primary outcome of cloud computing. They are a type of parallel and distributed system harnessing physical and virtual computers presented as a unified computing resource.
2. Clouds build the infrastructure on top of which services are implemented and delivered to customers. Such infrastructures can be of different types and provide useful information about the nature and the services offered by the cloud.
3. A more useful classification is given according to the administrative domain of a cloud: It identifies the boundaries within which cloud computing services are implemented, provides hints on the underlying infrastructure adopted to support such services, and qualifies them.
4. It is then possible to differentiate four different types of cloud:
	* Public clouds. The cloud is open to the wider public.
	* Private clouds. The cloud is implemented within the private premises of an institution and generally made accessible to the members of the institution or a subset of them.
	* Hybrid or heterogeneous clouds. The cloud is a combination of the two previous solutions and most likely identifies a private cloud that has been augmented with resources or services hosted in a public cloud.
	* Community clouds: The cloud is characterized by a multi-administrative domain involving different deployment models (public, private, and hybrid), and it is specifically designed to address the needs of a specific industry. Almost all the implementations of clouds can be classified in it.
5. Following figure illustrates the Cloud Deployment Model.



# Figure: Cloud Deployment Model

**Public Cloud:**

1. Public clouds constitute the first expression of cloud computing. They are a realization of the canonical view of cloud computing in which the services offered are made available to anyone, from anywhere, and at any time through the Internet.
2. From a structural point of view they are a distributed system, most likely composed of one or more datacenters connected together, on top of which the specific services offered by the cloud are implemented. Any customer can easily sign in with the cloud provider, enter her credential and billing details, and use the services offered.
3. Historically, public clouds were the first class of cloud that were implemented and offered. They offer solutions for minimizing IT infrastructure costs and serve as a viable option for handling peak loads on the local infrastructure. They have become an interesting option for small enterprises, which are able to start their businesses without large up-front investments by completely relying on public infrastructure for their IT needs.
4. What made public clouds attractive compared to the reshaping of the private premises and the purchase of hardware and software was the ability to grow or shrink according to the needs of the related business.
5. By renting the infrastructure or subscribing to application services, customers were able to dynamically upsize or downsize their IT according to the demands of their business.
6. Currently, public clouds are used both to completely replace the IT infrastructure of enterprises and to extend it when it is required. A fundamental characteristic of public clouds is multi-tenancy.
7. A public cloud is meant to serve a multitude of users, not a single customer. Any customer requires a virtual computing environment that is separated, and most likely isolated, from other users. This is a fundamental requirement to provide effective monitoring of user activities and guarantee the desired performance and the other QoS attributes negotiated with users. QoS management is a very important aspect of public clouds.
8. For example, Amazon EC2 is a public cloud that provides infrastructure as a service; Google AppEngine is a public cloud that provides an application development platform as a service; and SalesForce.com is a public cloud that provides software as a service.

# Private clouds:

1. Having an infrastructure able to deliver IT services on demand can still be a winning solution, even when implemented within the private premises of an institution. This idea led to the diffusion of private clouds, which are similar to public clouds, but their resource-provisioning model is limited within the boundaries of an organization.
2. Private clouds are virtual distributed systems that rely on a private infrastructure and provide internal users with dynamic provisioning of computing resources. Instead of a pay-as-you-go model as in public clouds, there could be other schemes in place, taking into account the usage of the cloud and proportionally billing the different departments or sections of an enterprise.
3. Private clouds have the advantage of keeping the core business operations in-house by relying on the existing IT infrastructure and reducing the burden of maintaining it once the cloud has been set up. In this scenario, security concerns are less critical, since sensitive information does not flow out of the private infrastructure. Moreover, existing IT resources can be better utilized because the private cloud can provide services to a different range of users.
4. Another interesting opportunity that comes with private clouds is the possibility of testing applications and systems at a comparatively lower price rather than public clouds before deploying them on the public virtual infrastructure.

# Hybrid clouds:

1. Hybrid Clouds combine both Public Clouds and Private Clouds. A hybrid solution could be an interesting opportunity for taking advantage of the best of the private and public worlds. This led to the development and diffusion of hybrid clouds.
2. Hybrid clouds address scalability issues by leveraging external resources for exceeding capacity demand. These resources or services are temporarily leased for the time required and then released. This practice is also known as cloudbusting.

# Few Points can be taken from Q.(d). (1)

**Community clouds**:

1. Community clouds are distributed systems created by integrating the services of different clouds to address the specific needs of an industry, a community, or a business sector.
2. The National Institute of Standards and Technologies (NIST) characterizes community clouds as follows: “The 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.”
3. Community cloud is most likely implemented over multiple administrative domains. This means that different organizations such as government bodies, Private Users Public Services Industries Enterprises Third-Party Cloud Infrastructure.
4. Candidate sectors for community clouds are like the Media industry, Healthcare industry, Energy and other core industries, Public sector, Scientific research.
5. The term community cloud can also identify a more specific type of cloud that arises from concern over the controls of vendors in cloud computing and that aspire to combine the principles of digital ecosystems with the case study of cloud computing.
6. A community cloud is formed by harnessing the underutilized resources of user machines [45] and providing an infrastructure in which each can be at the same time a consumer, a producer, or a coordinator of the services offered by the cloud.

# Explain Following Cloud Deployment Model.

**(1) Public Clouds (2) Private Clouds Ans.:**

1. **Public Clouds:**
	1. Public clouds constitute the first expression of cloud computing. They are a realization of the canonical view of cloud computing in which the services offered are made available to anyone, from anywhere, and at any time through the Internet.
	2. From a structural point of view they are a distributed system, most likely composed of one or more datacenters connected together, on top of which the specific services offered by the cloud are implemented. Any customer can easily sign in with the cloud provider, enter her credential and billing details, and use the services offered.
	3. Historically, public clouds were the first class of cloud that were implemented and offered. They offer solutions for minimizing IT infrastructure costs and serve as a viable option for handling peak loads on the local infrastructure.
	4. They have become an interesting option for small enterprises, which are able to start their businesses without large up-front investments by completely relying on public infrastructure for their IT needs. What made attractive public clouds compared to the reshaping of the private premises and the purchase of hardware and software was the ability to grow or shrink according to the needs of the related business.
	5. By renting the infrastructure or subscribing to application services, customers were able to dynamically upsize or downsize their IT according to the demands of their business. Currently, public clouds are used both to completely replace the IT infrastructure of enterprises and to extend it when it is required.

# Fundamental characteristic of public clouds :

1. **Multitenancy:** A public cloud is meant to serve a multitude of users, not a single customer. Any customer requires a virtual computing environment that is separated, and most likely isolated, from other users. This is a fundamental requirement to provide effective monitoring of user activities and guarantee the desired performance and the other QoS attributes negotiated with users.
2. **QoS Management:** It is a very important aspect of public clouds. Hence, a significant portion of the software infrastructure is devoted to monitoring the cloud resources, to bill them according to the contract made with the user, and to keep a complete history of cloud usage for each customer. **These features are fundamental to public clouds because they help providers offer services to users with full accountability.**

# Services offered by public clouds :

1. A public cloud can offer any kind of service: infrastructure, platform, or applications.
2. For example,
	1. **Amazon EC2** is a public cloud that provides infrastructure as a service;
	2. **Google AppEngine** is a public cloud that provides an application development platform as a service; and
	3. **SalesForce.com** is a public cloud that provides software as a service.

# Advantages:

1. What makes public clouds peculiar is the way they are consumed: They are available to everyone and are generally architected to support a large quantity of users.
2. What characterizes them is their natural ability to scale on demand and sustain peak loads.
3. Public clouds can be composed of geographically dispersed datacenters to share the load of users and better serve them according to their locations. For example, Amazon Web Services has datacenters installed in the United States, Europe, Singapore, and Australia;
4. They allow their customers to choose between three different regions: us-west-1, us-east-1, or eu-west-1. Such regions are priced differently and are further divided into availability zones, which map to specific datacenters.
5. According to the specific class of services delivered by the cloud, a different software stack is installed to manage the infrastructure: virtual machine managers, distributed middleware, or distributed applications.

# Disadvantages:

1. **Loss of control:** Public clouds are appealing and provide a viable option to cut IT costs and reduce capital expenses, but they are not applicable in all scenarios. For example, a very common critique to the use of cloud computing in its canonical implementation is the loss of control.
2. **Sensitive Information:** In particular, institutions such as government and military agencies will not consider public clouds as an option for processing or storing their sensitive data.
3. **Security infrastructure:** The risk of a breach in the security infrastructure of the provider could expose such information to others; this could simply be considered unacceptable.
4. **Private clouds**
	1. Having an infrastructure able to deliver IT services on demand can still be a winning solution, even when implemented within the private premises of an institution. This idea led to the diffusion of private clouds, which are similar to public clouds, but their resource-provisioning model is limited within the boundaries of an organization.
	2. Private clouds are virtual distributed systems that rely on a private infrastructure and provide internal users with dynamic provisioning of computing resources. Instead of a pay-as-you-go model as in public clouds, there could be other schemes in place, taking into account the usage of the cloud and proportionally billing the different departments or sections of an enterprise.
	3. Private clouds have the advantage of keeping the core business operations in-house by relying on the existing IT infrastructure and reducing the burden of maintaining it once the cloud has been set up. In this scenario, security concerns are less critical, since sensitive information does not flow out of the private infrastructure. Moreover, existing IT resources can be better utilized because the private cloud can provide services to a different range of users.
	4. Another interesting opportunity that comes with private clouds is the possibility of testing applications and systems at a comparatively lower price rather than public clouds before deploying them on the public virtual infrastructure.
	5. Following figure illustrate Private Clouds:



Figure: Private clouds hardware and software stack.

# From an architectural point of view, private clouds can be implemented on more heterogeneous hardware:

1. They generally rely on the existing IT infrastructure already deployed on the private premises. This could be a datacenter, a cluster, an enterprise desktop grid, or a combination of them.
2. The physical layer is complemented with infrastructure management software (i.e., IaaS (M); or a PaaS solution, according to the service delivered to the users of the cloud. Different options can be adopted to implement private clouds.
3. Figure provides a comprehensive view of the solutions together with some reference to the most popular software used to deploy private clouds. At the bottom layer of the software stack, virtual machine technologies such as Xen [35], KVM [36], and VMware serve as the foundations of the cloud.
4. Virtual machine management technologies such as VMware vCloud, Eucalyptus, and OpenNebula can be used to control the virtual infrastructure and provide an IaaS solution. VMware vCloud is a proprietary solution, but Eucalyptus provides full compatibility with Amazon Web Services interfaces and supports different virtual machine technologies such as Xen, KVM, and VMware. Like Eucalyptus, OpenNebula is an open-source solution for virtual infrastructure management that supports KVM, Xen, and VMware, which has been designed to easily integrate third-party IaaS providers.
5. Its modular architecture allows extending the software with additional features such as the capability of reserving virtual machine instances by using Haizea as scheduler.
6. Solutions that rely on the previous virtual machine managers and provide added value are OpenPEX and InterGrid OpenPEX is Web-based system that allows the reservation of virtual machine instances and is designed to support different back ends (at the moment only the support for Xen is implemented).
7. InterGrid provides added value on top of OpenNebula and Amazon EC2 by allowing the reservation of virtual machine instances and managing multi administrative domain clouds. PaaS solutions can provide an additional layer and deliver a high level service for private clouds.

# The benefits of delivering in-house cloud computing solutions for enterprises highlighted some of the key advantages of using a private cloud computing infrastructure:

1. Customer information protection. Despite assurances by the public cloud leaders about security, few provide satisfactory disclosure or have long enough histories with their cloud offerings to provide warranties about the specific level of security put in place on their systems. In-house security is easier to maintain and rely on.
2. Infrastructure ensuring SLAs. Quality of service implies specific operations such as appropriate clustering and failover, data replication, system monitoring and maintenance, and disaster recovery, and other uptime services can be commensurate to the application needs. Although public cloud vendors provide some of these features, not all of them are available as needed.
3. Compliance with standard procedures and operations. If organizations are subject to third-party compliance standards, specific procedures have to be put in place when deploying and executing applications. This could be not possible in the case of the virtual public infrastructure. All these aspects make the use of cloud-based infrastructures in private premises an interesting option.

# The major drawbacks of private deployments:

1. The inability to scale on demand
2. To efficiently address peak loads. In this case, it is important to leverage capabilities of public clouds as needed.

# Explain Following Cloud Deployment Model.

**(1) Hybrid Clouds (2) Community Clouds Ans.: (1) Hybrid Clouds:**

1. Public clouds are large software and hardware infrastructures that have a capability that is huge enough to serve the needs of multiple users, but they suffer from security threats and administrative pitfalls. Although the option of completely relying on a public virtual infrastructure is appealing for companies that did not incur IT capital costs and have just started considering their IT needs (i.e., start-ups), in most cases the private cloud option prevails because of the existing IT infrastructure.
2. Private clouds hardware and software stack. 128 CHAPTER 4 Cloud Computing Architecture Private clouds are the perfect solution when it is necessary to keep the processing of information within an enterprise’s premises or it is necessary to use the existing hardware and software infrastructure. One of the major drawbacks of private deployments is the inability to scale on demand and to efficiently address peak loads. In this case, it is important to leverage capabilities of public clouds as needed.
3. Hence, a hybrid solution could be an interesting opportunity for taking advantage of the best of the private and public worlds. This led to the development and diffusion of hybrid clouds.
4. Hybrid clouds allow enterprises to exploit existing IT infrastructures, maintain sensitive information within the premises, and naturally grow and shrink by provisioning external resources and releasing them when they’re no longer needed. Security concerns are then only limited to the public portion of the cloud that can be used to perform operations with less stringent constraints but that are still part of the system workload.
5. Following Figure illustrates :



# Figure: Hybrid/heterogeneous cloud overview.

1. Figure provides a general overview of a hybrid cloud: It is a heterogeneous distributed system resulting from a private cloud that integrates additional services or resources from one or more public clouds. For this reason they are also called heterogeneous clouds.
2. As depicted in the diagram, dynamic provisioning is a fundamental component in this scenario. Hybrid clouds address scalability issues by leveraging external resources for exceeding capacity demand. These resources or services are temporarily leased for the time required and then released. This practice is also known as cloudbusting.
3. Whereas the concept of hybrid cloud is general, it mostly applies to IT infrastructure rather than software services. Service-oriented computing already introduces the concept of integration of paid software services with existing application deployed in the private premises. In an IaaS scenario, dynamic provisioning refers to the ability to acquire on demand virtual machines in order to increase the capability of the resulting distributed system and then release them.
4. Infrastructure management software and PaaS solutions are the building blocks for deploying and managing hybrid clouds. In particular, with respect to private clouds, dynamic provisioning introduces a more complex scheduling algorithm and policies, the goal of which is also to optimize the budget spent to rent public resources.
5. Dynamic provisioning is most commonly implemented in PaaS solutions that support hybrid clouds. One of the fundamental components of PaaS middleware is the mapping of distributed applications onto the cloud infrastructure. In this scenario, the role of dynamic provisioning becomes fundamental to ensuring the execution of applications under the QoS agreed on with the user.
6. For example, Aneka provides a provisioning service that leverages different IaaS providers for scaling the existing cloud infrastructure. The provisioning service cooperates with the scheduler, which is in charge of guaranteeing a specific QoS for applications. In particular, each user application has a budget attached, and the scheduler uses that budget to optimize the execution of the application by renting virtual nodes if needed.
7. Other PaaS implementations support the deployment of hybrid clouds and provide dynamic provisioning capabilities. Among those discussed for the implementation and management of private clouds we can cite Elastra CloudServer and Zimory Pools.

# (2) Community Clouds

1. Community clouds are distributed systems created by integrating the services of different clouds to address the specific needs of an industry, a community, or a business sector.
2. The National Institute of Standards and Technologies (NIST) [43] characterizes community clouds as follows: “The 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.”
3. In community cloud, focusing more on the social aspect of the clouds that are formed as an aggregation of resources of community members.
4. The idea of a heterogeneous infrastructure built to serve the needs of a community of people is also reflected in the previous definition, but in that case the attention is focused on the commonality of interests that aggregates the users of the cloud into a community. In both cases, the concept of community is fundamental.
5. The term community cloud can also identify a more specific type of cloud that arises from concern over the controls of vendors in cloud computing and that aspire to combine the principles of digital ecosystems with the case study of cloud computing.
6. A community cloud is formed by harnessing the underutilized resources of user machines and providing an infrastructure in which each can be at the same time a consumer, a producer, or a coordinator of the services offered by the cloud.

# Figure:



**Figure: Community Clouds**

1. Figure provides a general view of the usage scenario of community clouds, together with reference architecture. The users of a specific community cloud fall into a well-identified community, sharing the same concerns or needs; they can be government bodies, industries, or even simple users, but all of them focus on the same issues for their interaction with the cloud.
2. This is a different scenario than public clouds, which serve a multitude of users with different needs. Community clouds are also different from private clouds, where the services are generally delivered within the institution that owns the cloud.
3. From an architectural point of view, a community cloud is most likely implemented over multiple administrative domains. This means that different organizations such as government bodies,private enterprises, research organizations, and even public virtual infrastructure providers contribute with their resources to build the cloud infrastructure.

# Candidate sectors for community clouds are as follows:

1. **Media industry:** In the media industry, companies are looking for low-cost, agile, and simple solutions to improve the efficiency of content production. Most media productions involve an extended ecosystem of partners. In particular, the creation of digital content is the outcome of a collaborative process that includes movement of large data, massive compute-intensive rendering tasks, and complex workflow executions. Community clouds can provide a shared environment where services can facilitate business-to-business collaboration and offer the horsepower in terms of aggregate bandwidth, CPU, and storage required to efficiently support media production.
2. **Healthcare industry:** In the healthcare industry, there are different scenarios in which community clouds could be of use. In particular, community clouds can provide a global platform on which to share information and knowledge without revealing sensitive data maintained within the private infrastructure. The naturally hybrid deployment model of community clouds can easily support the storing of patient-related data in a private cloud while using the shared infrastructure for noncritical services and automating processes within hospitals.
3. **Energy and other core industries:** In these sectors, community clouds can bundle the comprehensive set of solutions that together vertically address management, deployment, and orchestration of services and operations. Since these industries involve different providers, vendors, and organizations, a community cloud can provide the right type of infrastructure to create an open and fair market.
4. **Public sector:** Legal and political restrictions in the public sector can limit the adoption of public cloud offerings. Moreover, governmental processes involve several institutions and agencies and are aimed at providing strategic solutions at local, national, and international administrative levels. They involve

business-to-administration, citizen-to-administration, and possibly business-to-business processes. Some examples include invoice approval, infrastructure planning, and public hearings. A community cloud can constitute the optimal venue to provide a distributed environment in which to create a communication platform for performing such operations.

1. **Scientific research:** Science clouds are an interesting example of community clouds. In this case, the common interest driving different organizations sharing a large distributed infrastructure is scientific computing.

# The benefits of these community clouds are the following:

1. **Openness:** By removing the dependency on cloud vendors, community clouds are open systems in which fair competition between different solutions can happen.
2. **Community:** Being based on a collective that provides resources and services, the infrastructure turns out to be more scalable because the system can grow simply by expanding its user base.
3. **Graceful failures:** Since there is no single provider or vendor in control of the infrastructure, there is no single point of failure.
4. **Convenience and control:** Within a community cloud there is no conflict between convenience and control because the cloud is shared and owned by the community, which makes all the decisions through a collective democratic process.
5. **Environmental sustainability:** The community cloud is supposed to have a smaller carbon footprint because it harnesses underutilized resources. Moreover, these clouds tend to be more organic by growing and shrinking in a symbiotic relationship to support the demand of the community, which in turn sustains it.