Cloud delivery model

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Service Models

- Service Models are the reference models on which the Cloud Computing is based.
- These can be categorized into three basic service models as listed below:

1. Infrastructure as a Service (IaaS)
2. Platform as a Service (PaaS)
3. Software as a Service (SaaS)

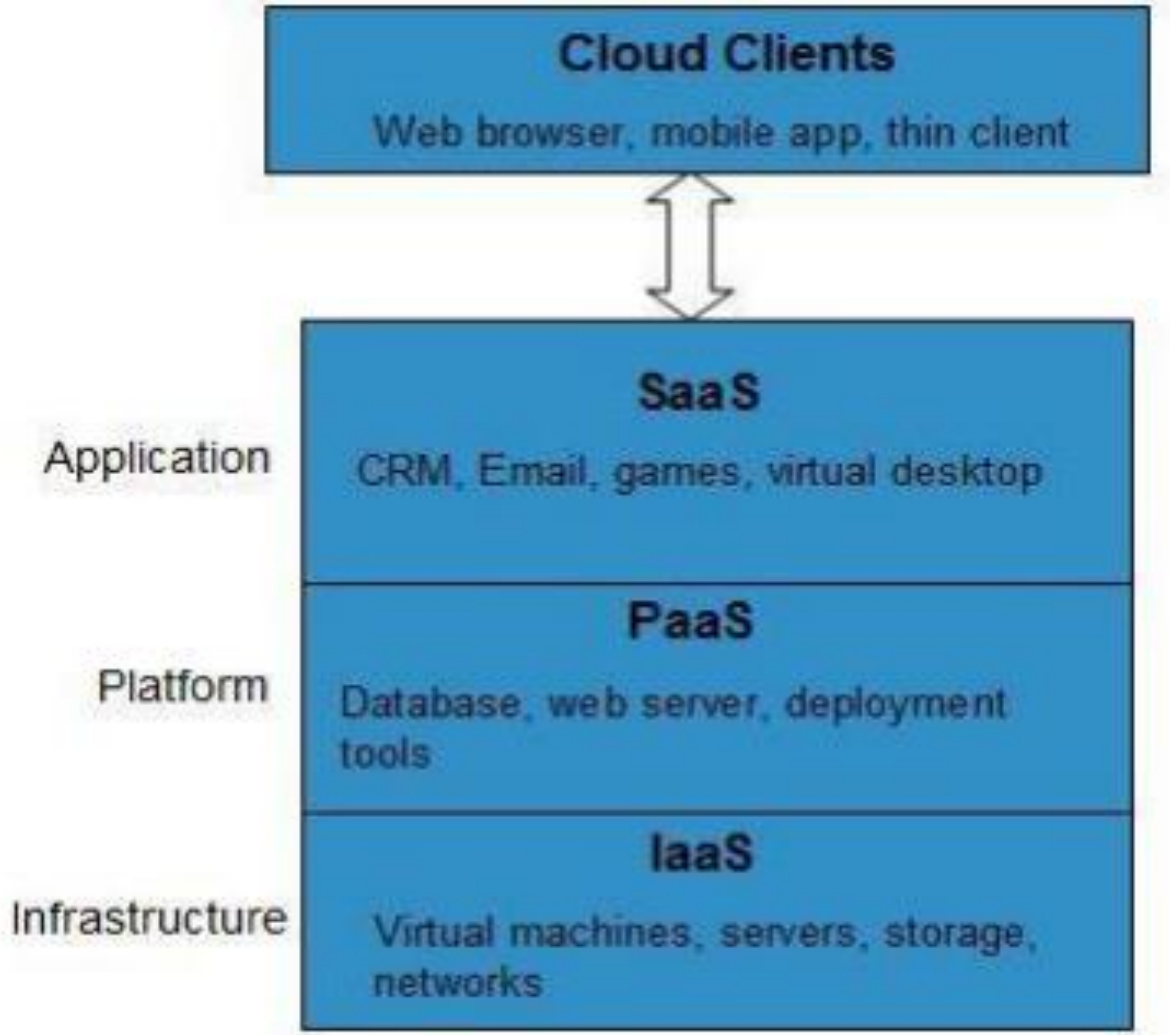
Service Models

- There are many other service models all of which can take the form like XaaS, i.e., Anything as a Service. This can be **Network as a Service, Business as a Service, Identity as a Service, Database as a Service or Strategy as a Service**.

Service Models

- The Infrastructure as a Service (IaaS) is the most basic level of service. Each of the service models make use of the underlying service model, i.e., each inherits the security and management mechanism from the underlying model, as shown in the following diagram:

Service Models



Service Models

- **Infrastructure as a Service (IAAS):** IaaS provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.
- **Platform as a Service (PAAS):** PaaS provides the runtime environment for applications, development & deployment tools, etc.
- **Software as a Service (SAAS):** SaaS model allows to use software applications as a service to end users.

Infrastructure as a Service (IAAS)

Infrastructure as a Service (IAAS)

- IaaS provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc., Apart from these resources, the IaaS also offers:

✓Virtual machine disk storage

✓Virtual local area network (VLANs)

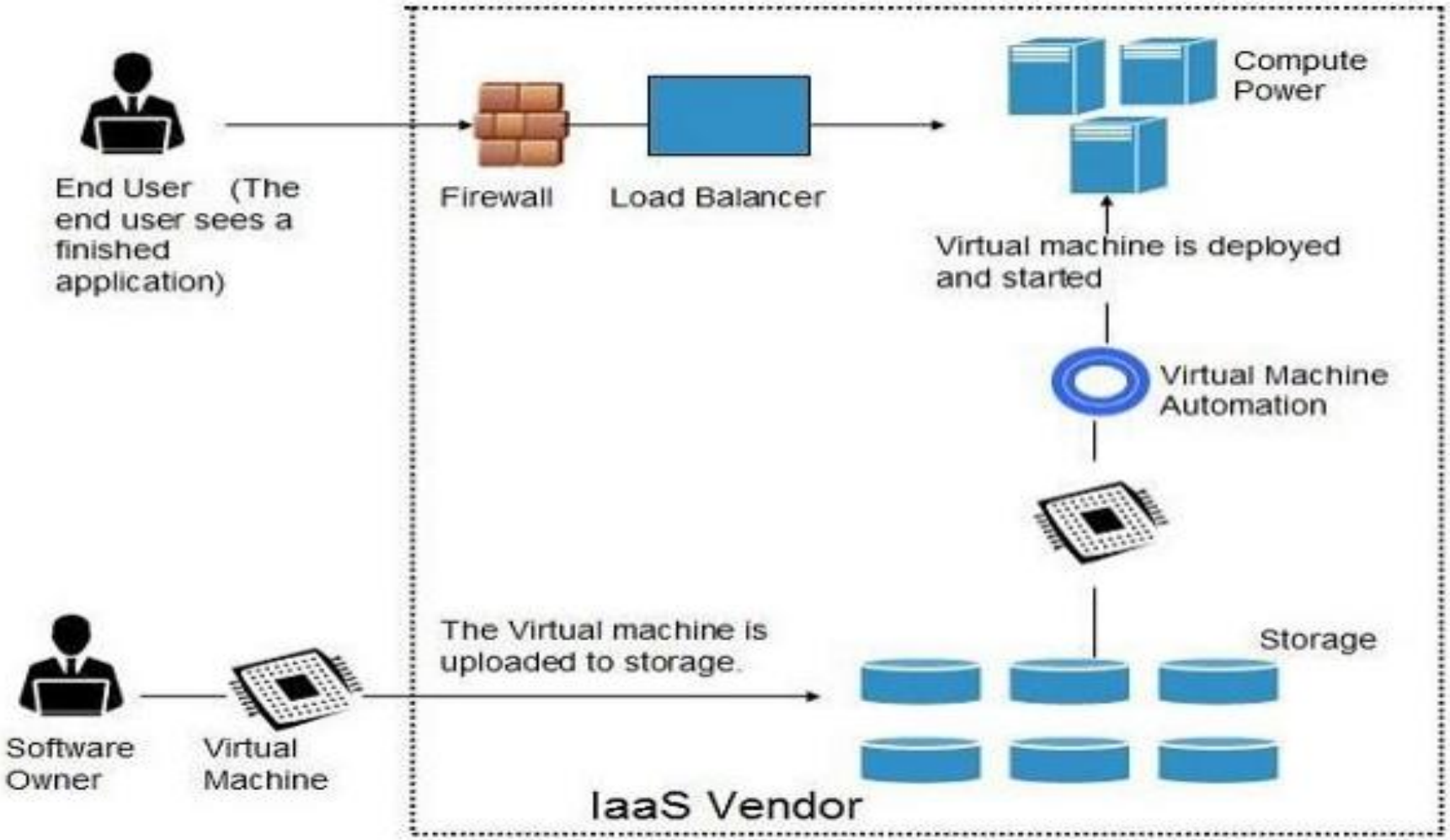
✓Load balancers

✓IP addresses

✓Software bundles

- All of the above resources are made available to end user via **server virtualization**. Moreover, these resources are accessed by the customers as if they own them.

Infrastructure as a Service (IAAS)



Infrastructure as a Service (IAAS)

- **Benefits**

IaaS allows the cloud provider to freely locate the infrastructure over the Internet in a cost-effective manner. Some of the key benefits of IaaS are listed below:

✓Full Control of the computing resources through Administrative Access to VMs.

✓Flexible and Efficient renting of Computer Hardware.

✓Portability, Interoperability with Legacy Applications.

Infrastructure as a Service (IAAS)

- **Full control over computing resources through administrative access to VMS**

IaaS allows the consumer to access computing resources through administrative access to virtual machines in the following manner:

✓ Consumer issues administrative command to cloud provider to run the virtual machine or to save data on cloud's server.

✓Consumer issues administrative command to virtual machines they owned to start web server or installing new applications.

Infrastructure as a Service (IAAS)

- **Flexible and efficient renting of computer hardware**

IaaS resources such as virtual machines, storages, bandwidth, IP addresses, monitoring services, firewalls, etc., all are made available to the consumers on rent. The consumer has to pay based the length of time a consumer retains a resource. Also with administrative access to virtual machines, the consumer can also run any software, even a custom operating system.

Infrastructure as a Service (IAAS)

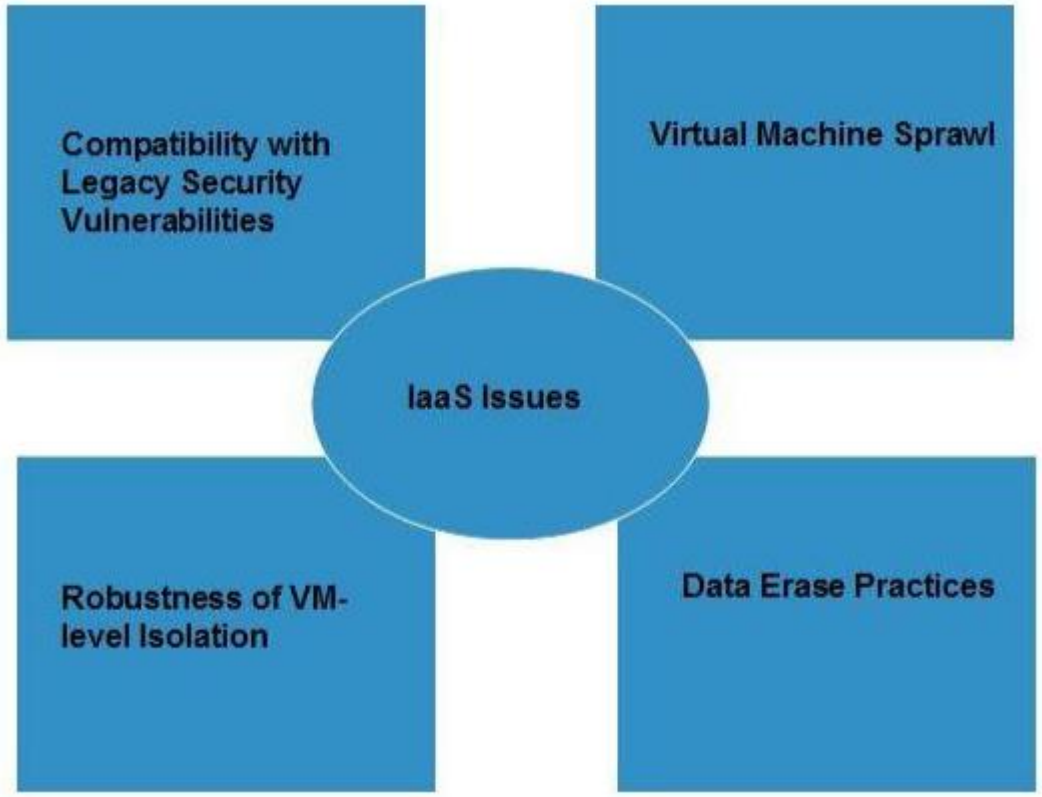
- **Portability, interoperability with legacy applications**

It is possible to maintain legacy between applications and workloads between IaaS clouds. For example, network applications such as web server, e-mail server that normally runs on consumer-owned server hardware can also be run from VMs in IaaS cloud.

Infrastructure as a Service (IAAS)

- **Issues**

IaaS shares issues with PaaS and SaaS, such as Network dependence and browser based risks. It also have some specific issues associated with it. These issues are mentioned in the following diagram:



Infrastructure as a Service (IAAS)

- **Compatibility with legacy security vulnerabilities:** Because IaaS offers the consumer to run legacy software in provider's infrastructure, therefore it exposes consumers to all of the security vulnerabilities of such legacy software.
- **virtual machine sprawl:** The VM can become out of date with respect to security updates because IaaS allows the consumer to operate the virtual machines in running, suspended and off state. However, the provider can automatically update such VMs, but this mechanism is hard and complex.

Infrastructure as a Service (IAAS)

- **Robustness of vm-level isolation:** IaaS offers an isolated environment to individual consumers through hypervisor. Hypervisor is a software layer that includes hardware support for virtualization to split a physical computer into multiple virtual machines.
- **Data erase practices:** The consumer uses virtual machines that in turn uses the common disk resources provided by the cloud provider. When the consumer releases the resource, the cloud provider must ensure that next consumer to rent the resource does not observe data residue from previous consumer.

Infrastructure as a Service (IAAS)

Characteristics

Here are the characteristics of IaaS service model:

✓ Virtual machines with pre-installed software.

✓ Virtual machines with pre-installed Operating Systems such as Windows, Linux, and Solaris.

✓ On-demand availability of resources.

✓ Allows to store copies of particular data in different locations.

✓The computing resources can be easily scaled up and down.

Platform-as-a-Service(PAAS)

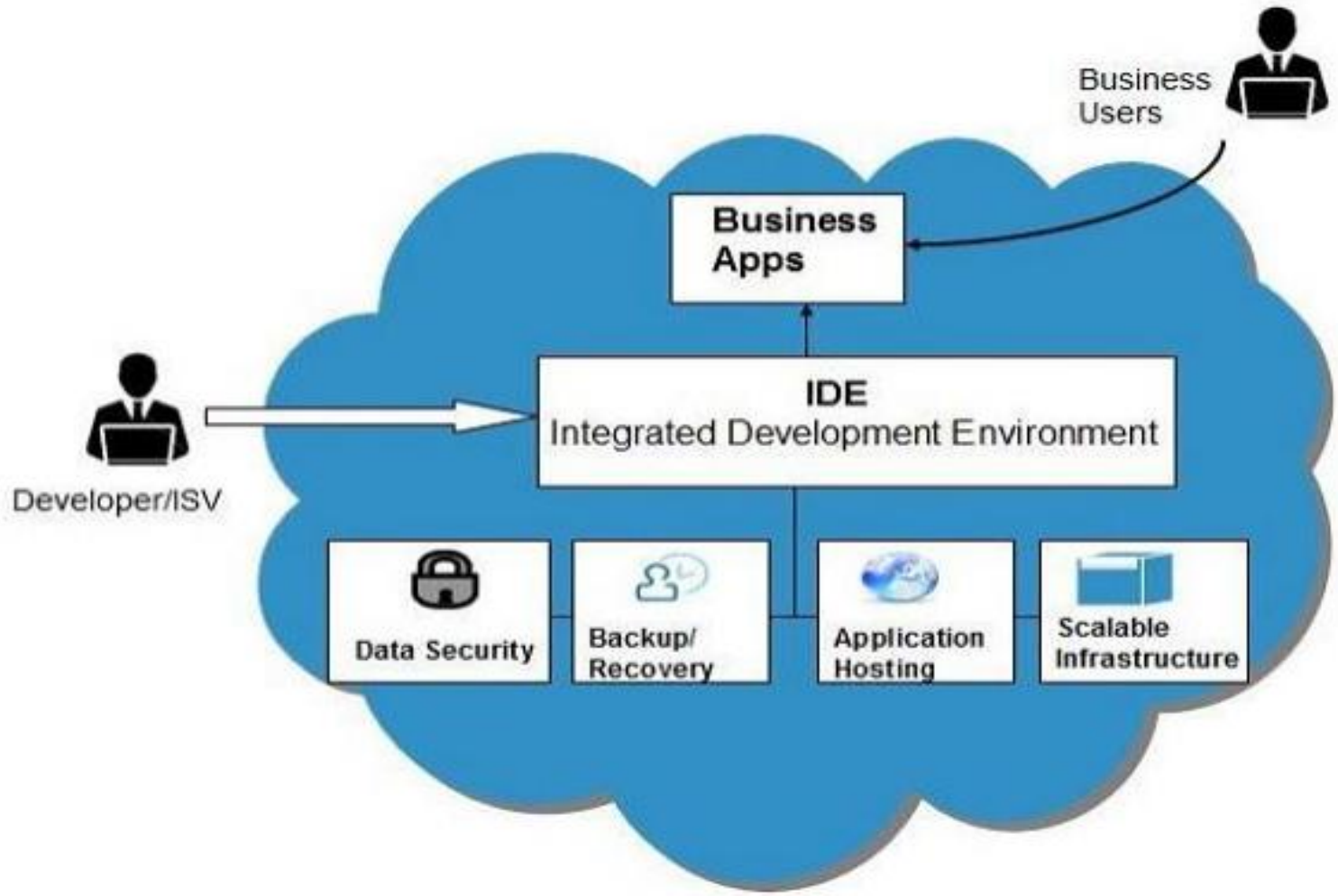
Platform-as-a-Service(PAAS)

- **PaaS** offers the runtime environment for applications. It also offers development & deployment tools, required to develop applications. PaaS has a feature of **point-and-click** tools that enables non-developers to create web applications.
- **Google's App Engine, Force.com** are examples of PaaS offering vendors. Developer may log on to these websites and use the built-in API to create web-based applications.

Platform-as-a-Service(PAAS)

- But the disadvantage of using PaaS is that the developer **lock-in** with a particular vendor. For example, an application written in Python against Google's API using Google's App Engine is likely to work only in that environment. Therefore, the vendor lock-in is the biggest problem in PaaS.
- The following diagram shows how PaaS offers an API and development tools to the developers and how it helps the end user to access business applications.

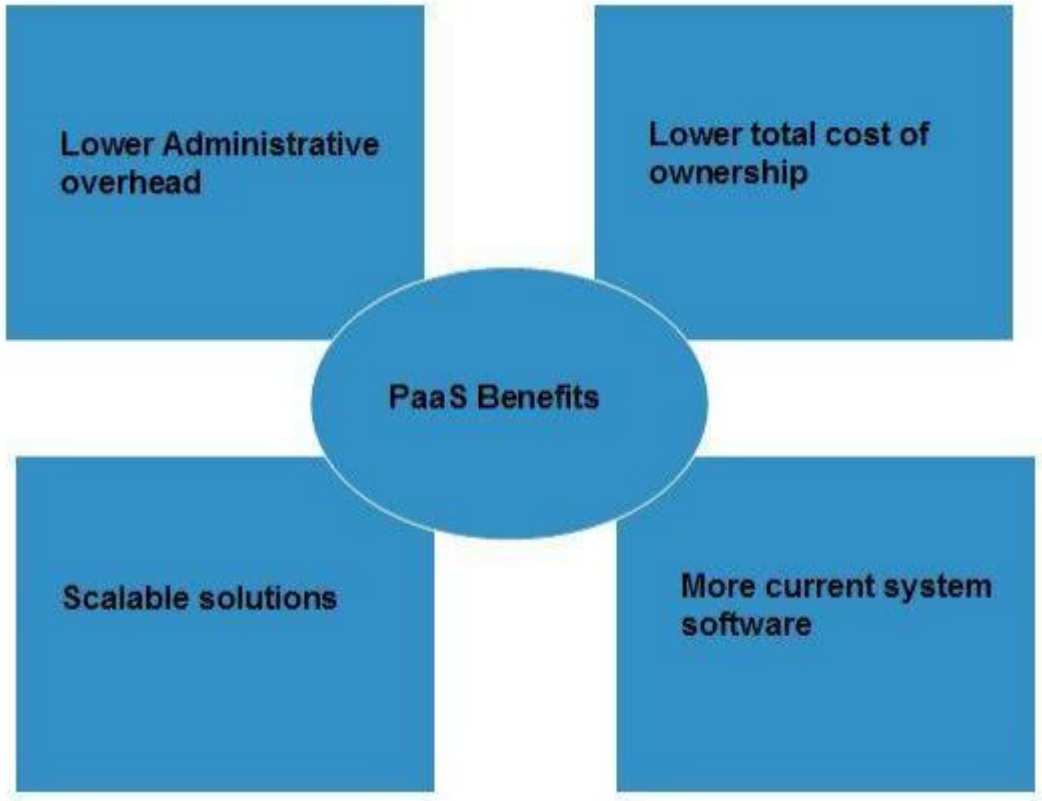
Platform-as-a-Service(PAAS)



Platform-as-a-Service(PAAS)

- **Benefits**

Following are the benefits of PaaS model:



Platform-as-a-Service(PAAS)

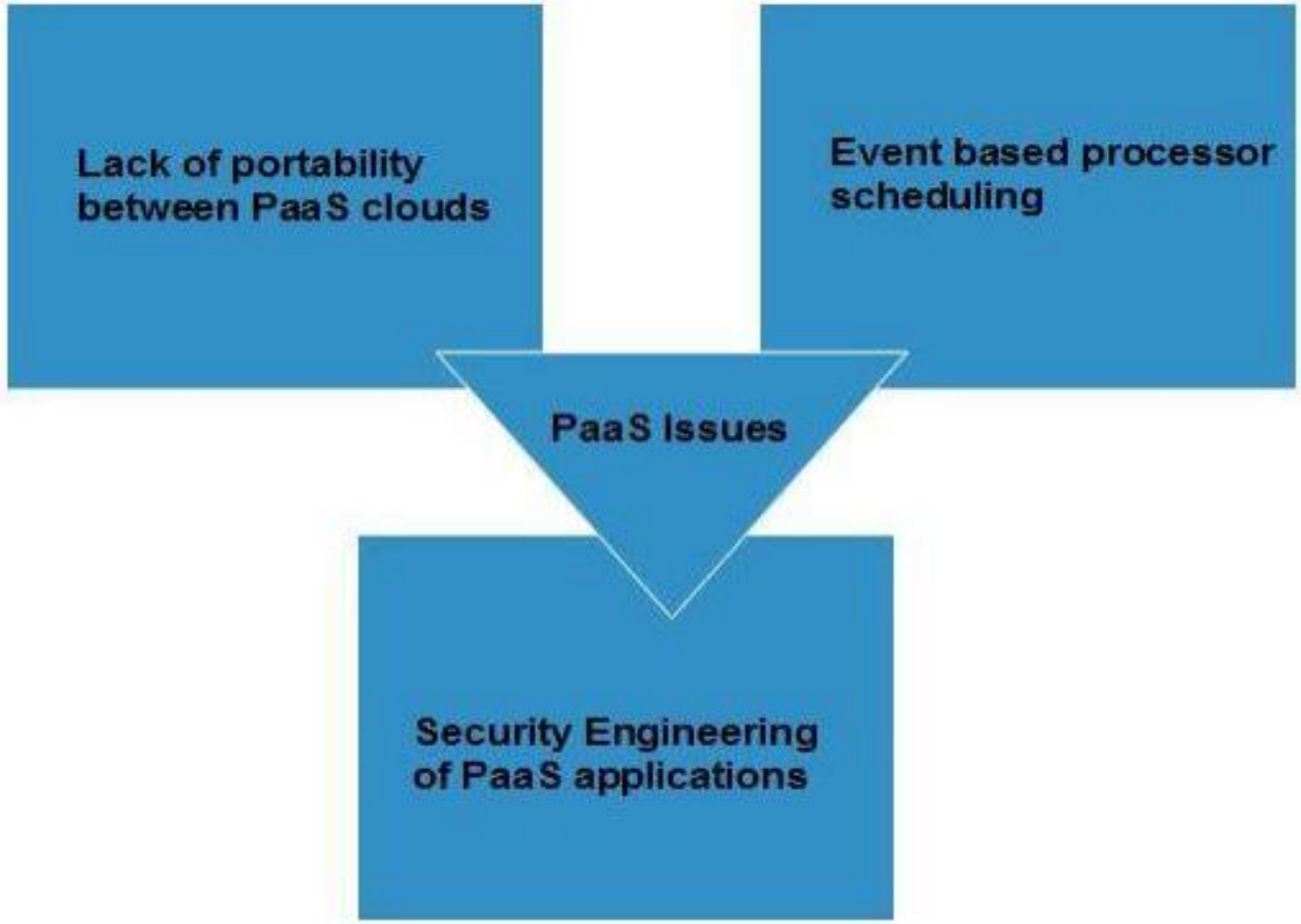
- **Lower administrative overhead:** consumer need not to bother much about the administration because it's the responsibility of cloud provider.
- **Lower total cost of ownership:** consumer need not purchase expensive hardware, servers, power and data storage.
- **Scalable solutions:** it is very easy to scale up or down automatically based on application resource demands.
- **More current system software:** it is the responsibility of the cloud provider to maintain software versions and patch installations.

Platform-as-a-Service(PAAS)

Issues

- Like SaaS, PaaS also place significant burdens on consumer's browsers to maintain reliable and secure connections to the provider systems. Therefore, PaaS shares many of the issues of SaaS. However, there are some specific issues associated with PaaS as shown in the following diagram:

Platform-as-a-Service(PAAS)



Platform-as-a-Service(PAAS)

- **Lack of portability between PaaS clouds:** Although standard languages are used yet the implementations of platforms services may vary. For example, file, queue, or hash table interfaces of one platform may differ from another, making it difficult to transfer workloads from one platform to another.
- **Event based processor scheduling:** The PaaS applications are event oriented which poses resource constraints on applications, i.e., they have to answer a request in a given interval of time.

Platform-as-a-Service(PAAS)

- **Security engineering of PaaS applications:** Since the PaaS applications are dependent on network, PaaS applications must explicitly use cryptography and manage security exposures.

Characteristics

- Here are the characteristics of PaaS service model:

✓PaaS offers browser based development environment. It allows the developer to create database and edit the application code either via Application Programming Interface or point-and-click tools.

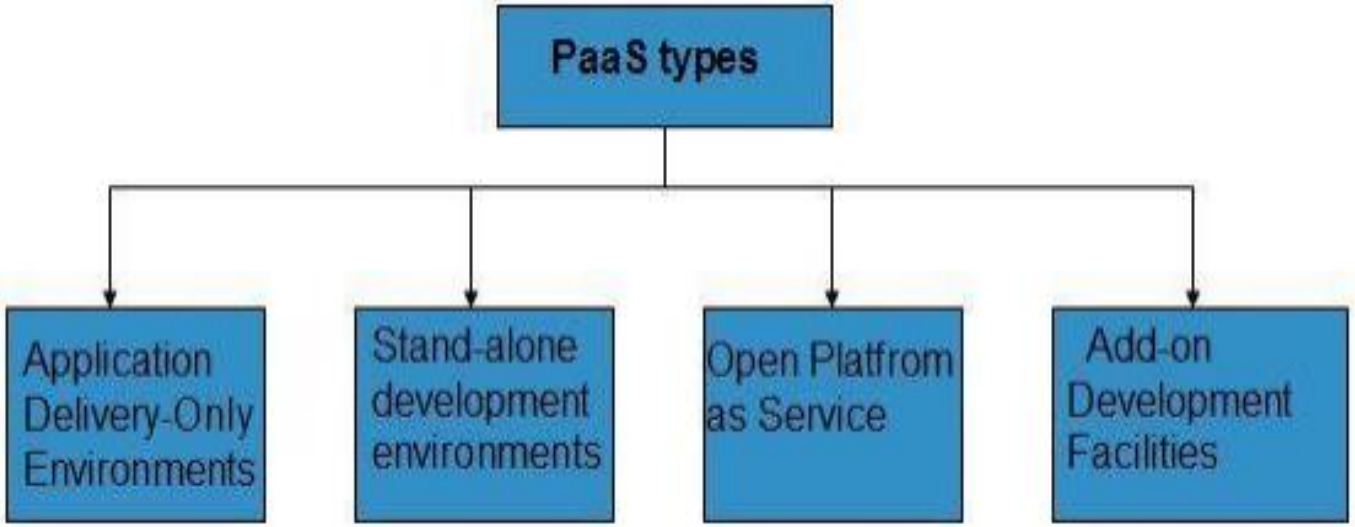
Platform-as-a-Service(PAAS)

- ✓PaaS provides built-in security, scalability, and web service interfaces.
- ✓PaaS provides built-in tools for defining workflow and approval processes and defining business rules.
- ✓It is easy to integrate with other applications on the same platform.
- ✓PaaS also provides web services interfaces that allow us to connect the applications outside the platform.

Platform-as-a-Service(PAAS)

PaaS Types

- Based on the functions, the PaaS can be classified into four types as shown in the following diagram:



Platform-as-a-Service(PAAS)

- **Stand-alone development environments:** The Stand-alone PaaS works as an independent entity for a specific function. It does not include licensing, technical dependencies on specific SaaS applications.
- **Application delivery-only environments:** The Application Delivery PaaS includes on-demand scaling and application security.
- **Open platform as a service:** Open PaaS offers an open source software that helps a PaaS provider to run applications.
- **Add-on development facilities:** The Add-on PaaS allows to customize the existing SaaS platform.

Software-as-a-Service(SAAS)

Software-as-a-Service(SAAS)

- **Software as a Service(SaaS)** model allows to provide software application as a service to the end users. It refers to a software that is deployed on a hosted service and is accessible via Internet. There are several SaaS applications, some of them are listed below:

✓Billing and Invoicing System

✓Customer Relationship Management (CRM) applications

✓Help Desk Applications

✓Human Resource (HR) Solutions

Software-as-a-Service(SAAS)

- Some of the SaaS applications are not customizable such as an **Office Suite**. But SaaS provides us **Application Programming Interface (API)**, which allows the developer to develop a customized application.

Software-as-a-Service(SAAS)

- **Characteristics**

Here are the characteristics of SaaS service model:

✓SaaS makes the software available over the Internet.

✓The Software are maintained by the vendor rather than where they are running.

✓The license to the software may be subscription based or usage based. And it is billed on recurring basis.

✓SaaS applications are cost effective since they do not require any maintenance at end user side.

Software-as-a-Service(SAAS)

- ✓They are available on demand.
- ✓They can be scaled up or down on demand.
- ✓They are automatically upgraded and updated.
- ✓SaaS offers share data model. Therefore, multiple users can share single instance of infrastructure. It is not required to hard code the functionality for individual users.
- ✓All users are running same version of the software

Software-as-a-Service(SAAS)

- **Benefits**

Using SaaS has proved to be beneficial in terms of scalability, efficiency, performance and much more. Some of the benefits are listed below:

✓Modest Software Tools

✓Efficient use of Software Licenses

✓Centralized Management & Data

✓Platform responsibilities managed by provider

✓Multitenant solutions

Software-as-a-Service(SAAS)

- **Modest software tools:** The SaaS application deployment requires a little or no client side software installation which results in the following benefits:

✓No requirement for complex software packages at client side

✓Little or no risk of configuration at client side

✓Low distribution cost

- **Efficient use of software licenses:** The client can have single license for multiple computers running at different locations which reduces the licensing cost. Also, there is no requirement for license servers because the software runs in the provider's infrastructure.

Software-as-a-Service(SAAS)

- **Centralized management & data:** The data stored by the cloud provider is centralized. However, the cloud providers may store data in a decentralized manner for sake of redundancy and reliability.
- **Platform responsibilities managed by providers:** All platform responsibilities such as backups, system maintenance, security, hardware refresh, power management, etc., are performed by the cloud provider. The consumer need not to bother about them.
- **Multitenant solutions:** Multitenancy allows multiple users to share single instance of resources in virtual isolation. Consumers can customize their application without affecting the core functionality.

Software-as-a-Service(SAAS)

- **Issues**

There are several issues associated with SaaS, some of them are listed below:

✓Browser based risks

✓Network dependence

✓Lack of portability between SaaS clouds

Software-as-a-Service(SAAS)

- **Browser based risks:** If the consumer visits malicious website and browser becomes infected, and the subsequent access to SaaS application might compromise the consumer's data. To avoid such risks, the consumer can use multiple browsers and dedicate a specific browser to access SaaS applications or can use virtual desktop while accessing the SaaS applications.
- **Network dependence:** The SaaS application can be delivered only when network is continuously available. Also network should be reliable but the network reliability cannot be guaranteed either by cloud provider or the consumer

Software-as-a-Service(SAAS)

- **Lack of portability between SaaS clouds:** Transferring workloads from one SaaS cloud to another is not so easy because work flow, business logics, user interfaces, support scripts can be provider specific.

Software-as-a-Service(SAAS)

- **Open SaaS**: Open SaaS uses SaaS applications that are developed using open source programming language. These SaaS applications can run on any open source operating system and database. Open SaaS has several benefits, some of these are listed below:

✓No License Required

✓Low Deployment Cost

✓Less Vendor Lock-in

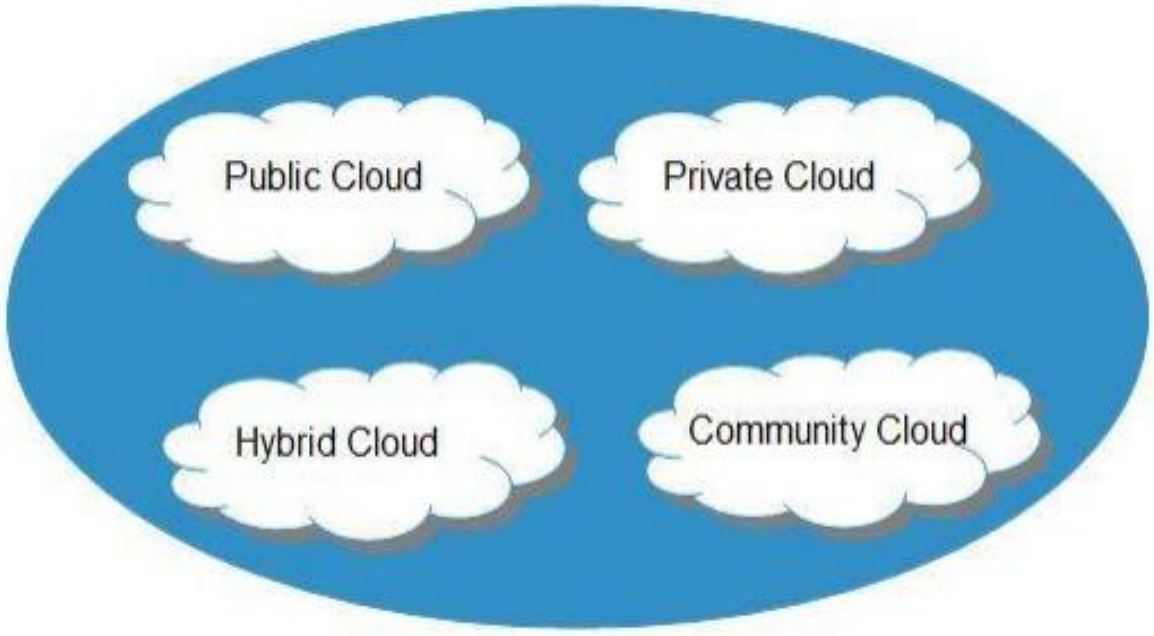
✓More portable applications

✓More Robust Solution

DEPLOYMENT MODELS

Deployment models

- **Deployment models** define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid and Community.

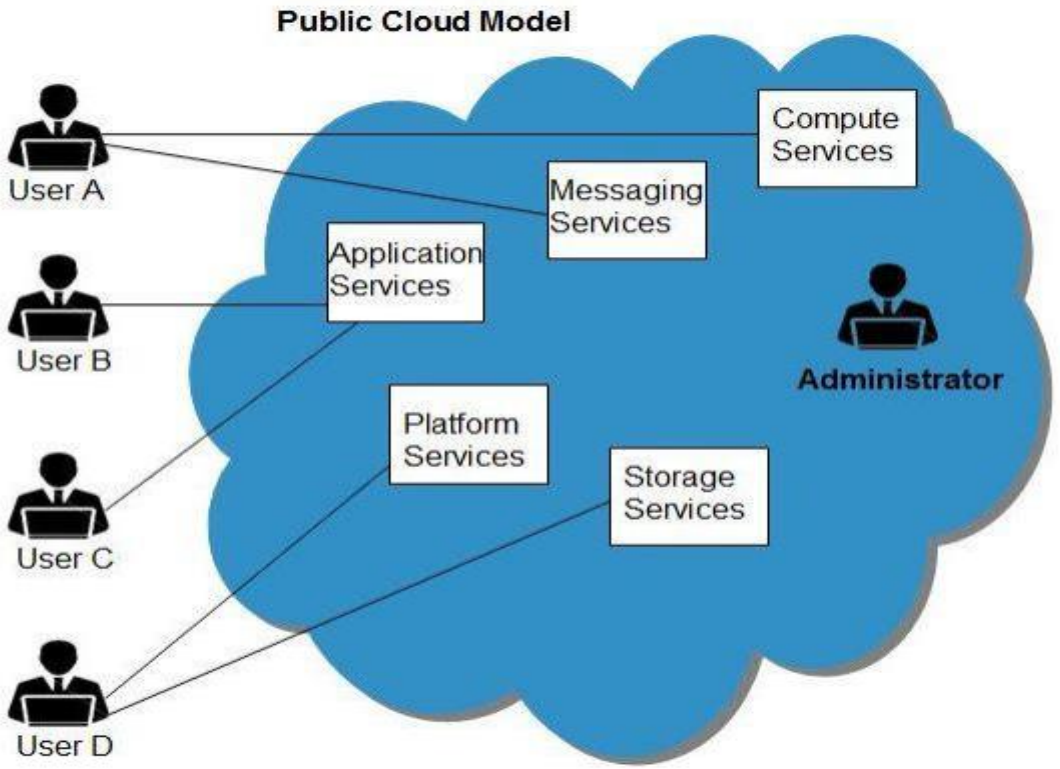


Deployment models

- **Public cloud:** The Public Cloud allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness, e.g., e-mail.
- **Private cloud:** The Private Cloud allows systems and services to be accessible within an organization. It offers increased security because of its private nature.
- **Community cloud:** The Community Cloud allows systems and services to be accessible by group of organizations.
- **Hybrid cloud:** The Hybrid Cloud is mixture of public and private cloud. However, the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.

Public Cloud Model

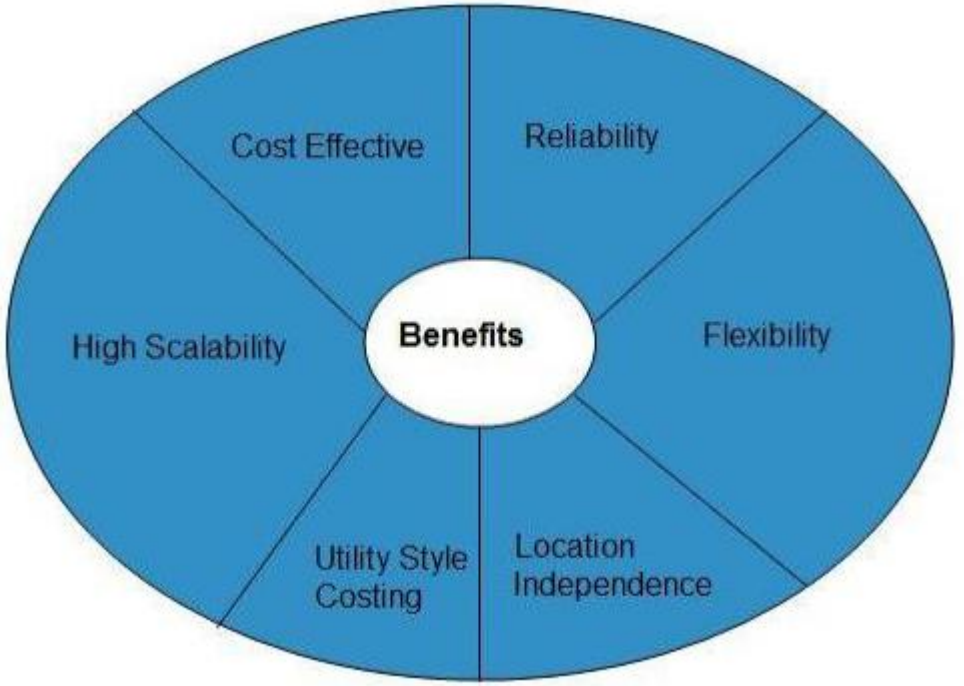
- The **Public Cloud** allows systems and services to be easily accessible to general public, e.g., Google, Amazon, Microsoft offers cloud services via Internet.



Public Cloud Model

- **Benefits**

There are many benefits of deploying cloud as public cloud model. The following diagram shows some of those benefits:



Public Cloud Model

- **Cost effective:** Since public cloud share same resources with large number of consumer, it has low cost.
- **Reliability:** Since public cloud employs large number of resources from different locations, if any of the resource fail, public cloud can employ another one.
- **Flexibility:** It is also very easy to integrate public cloud with private cloud, hence gives consumers a flexible approach.

Public Cloud Model

- **Location independence:** Since, public cloud services are delivered through Internet, therefore ensures location independence.
- **Utility style costing:** Public cloud is also based on pay-per-use model and resources are accessible whenever consumer needs it.
- **High scalability:** Cloud resources are made available on demand from a pool of resources, i.e., they can be scaled up or down according the requirement.

Public Cloud Model

- **Disadvantages**

Here are the disadvantages of public cloud model:

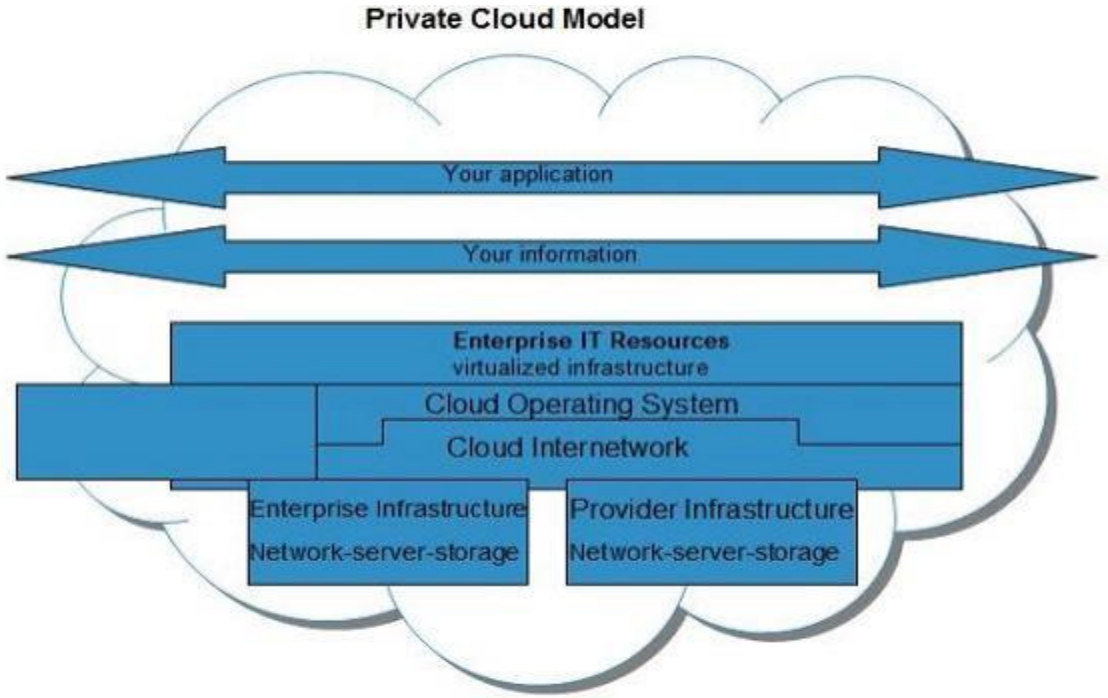
✓**Low security:** In public cloud model, data is hosted off-site and resources are shared publicly, therefore does not ensure higher level of security.

✓**Less customizable:** It is comparatively less customizable than private cloud.

Private Cloud Model

Private Cloud Model

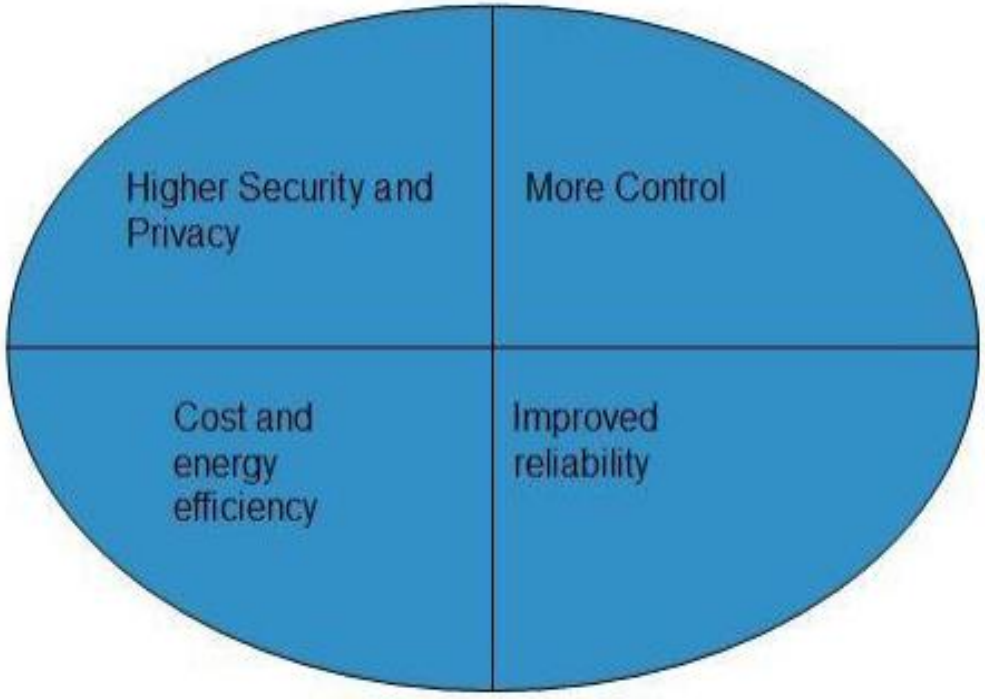
- The Private Cloud allows systems and services to be accessible with in an organization. The Private Cloud is operated only within a single organization. However, It may be managed internally or by third-party.



Private Cloud Model

- **Benefits**

There are many benefits of deploying cloud as private cloud model. The following diagram shows some of those benefits:



Private Cloud Model

- **Higher security and privacy:** Private cloud operations are not available to general public and resources are shared from distinct pool of resources, therefore, ensures high security and privacy.
- **More control:** Private clouds have more control on its resources and hardware than public cloud because it is accessed only within an organization.
- **Cost and energy efficiency:** Private cloud resources are not as cost effective as public clouds but they offer more efficiency than public cloud.

Private Cloud Model

- **Disadvantages**

Here are the disadvantages of using private cloud model:

✓**Restricted area:** Private cloud is only accessible locally and is very difficult to deploy globally.

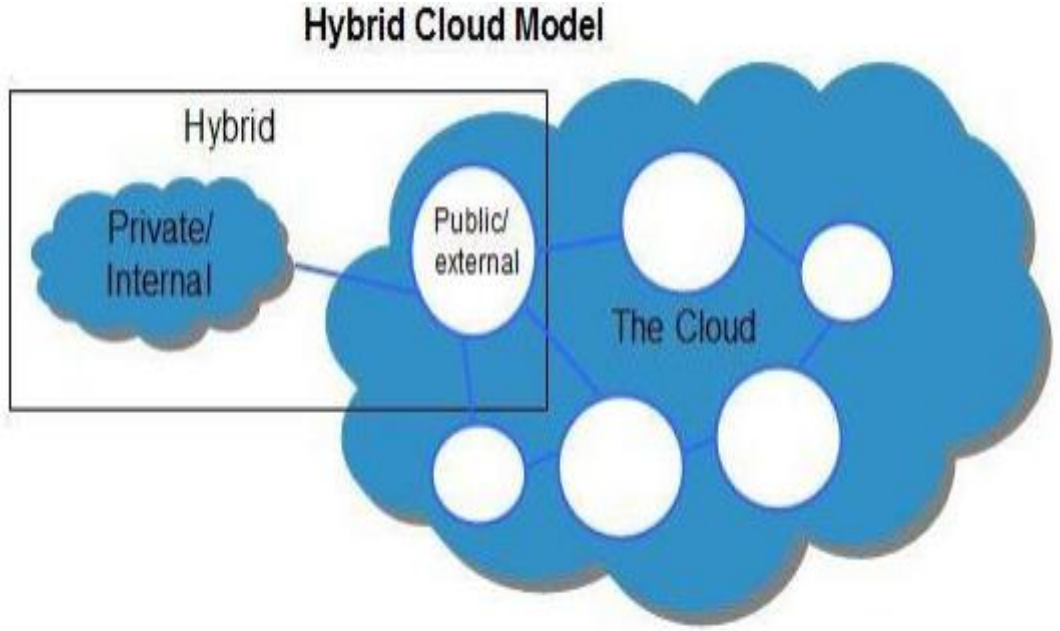
✓**Inflexible pricing:** In order to fulfill demand, purchasing new hardware is very costly.

✓**Limited scalability:** Private cloud can be scaled only within capacity of internal hosted resources.

Hybrid Cloud Model

Hybrid Cloud Model

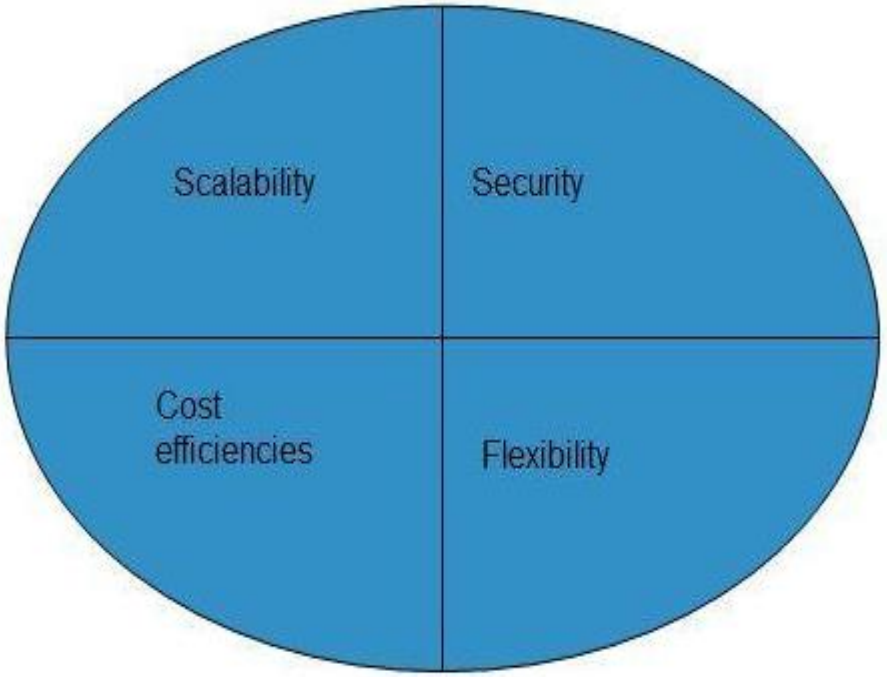
- The **Hybrid Cloud** is a mixture of public and private cloud. Non-critical activities are performed using public cloud while the critical activities are performed using private cloud.



Hybrid Cloud Model

- **Benefits**

There are many benefits of deploying cloud as hybrid cloud model. The following diagram shows some of those benefits:



Hybrid Cloud Model

- **Scalability:** It offers both features of public cloud scalability and private cloud scalability.
- **Flexibility:** It offers both secure resources and scalable public resources.
- **Cost efficiencies:** Public cloud are more cost effective than private, therefore hybrid cloud can have this saving.
- **Security:** Private cloud in hybrid cloud ensures higher degree of security.

Hybrid Cloud Model

Disadvantages

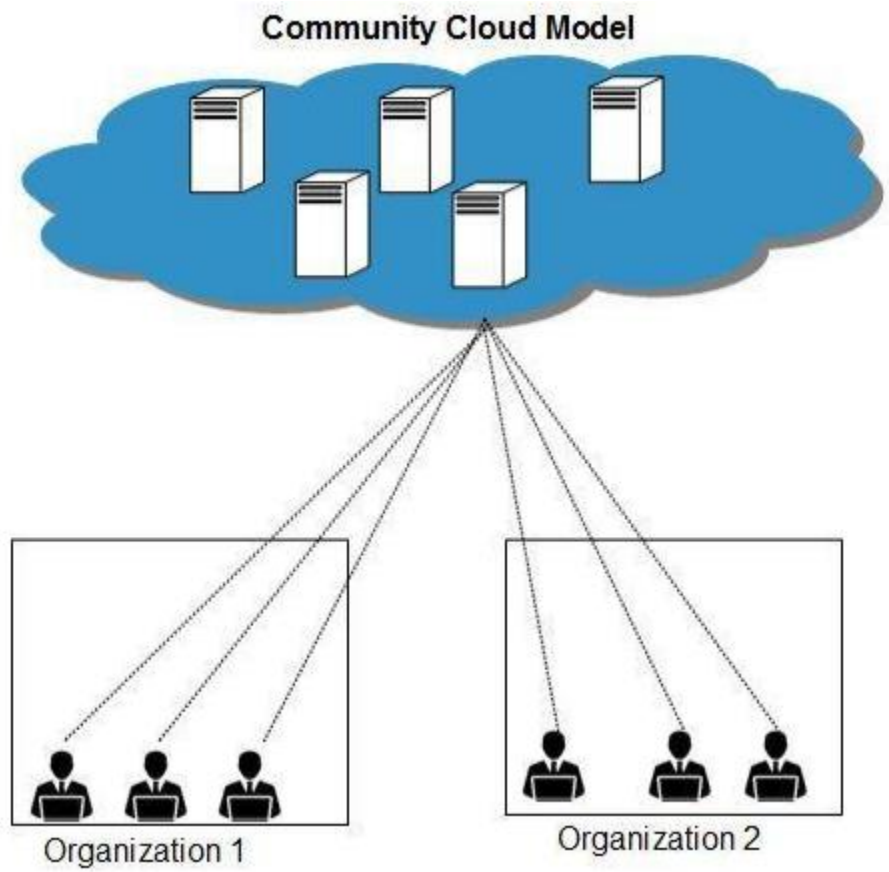
- **Networking issues:** Networking becomes complex due to presence of private and public cloud.
- **Security compliance:** It is necessary to ensure that cloud services are compliant with organization's security policies.
- **Infrastructural dependency:** The hybrid cloud model is dependent on internal IT infrastructure, therefore it is necessary to ensure redundancy across data centers.

Community Cloud Model

Community Cloud Model

- The **Community Cloud** allows system and services to be accessible by group of organizations. It shares the infrastructure between several organizations from a specific community. It may be managed internally or by the third-party.

Community Cloud Model



Community Cloud Model

- **Benefits**

There are many benefits of deploying cloud as community cloud model. The following diagram shows some of those benefits:

✓**Cost effective:** Community cloud offers same advantage as that of private cloud at low cost. Sharing Between Organizations Community cloud provides an infrastructure to share cloud resources and capabilities among several organizations.

Community Cloud Model

- **Security:** Community cloud is comparatively more secure than the public cloud.

Issues

✓Since all data is housed at one location, one must be careful in storing data in community cloud because it might be accessible by others.

✓ It is also challenging to allocate responsibilities of governance, security and cost

Thank You