CLOUD AS A DISTRIBUTED ENVIRONMENT

The Vision of Cloud Computing

Defining a Cloud

A Cloud Computing Reference Model

Cloud Deployment Models: Public, Private,

Community, Hybrid Clouds

Cloud Delivery Models: IaaS, PaaS, SaaS

Characteristics and Benefits

Challenges Ahead

Historical Developments

Introduction

In 1969, Leonard Kleinrock, one of the chief scientists of the original Advanced Research Projects Agency Network (ARPANET), which seeded the Internet, said:

"As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of 'computer utilities' which, like present electric and telephone utilities, will service individual homes and offices across the country."

- **How computing transformed into a model consisting of services?**

Introduction

Cloud computing is a technological advancement that focuses on the way we design computing systems, develop applications, and leverage existing services for building software.

It is based on the concept of **dynamic provisioning**

Resources are made available through the Internet and offered on a pay-per-use basis from cloud computing vendors.

Utility computing or Cloud computing

Introduction

Cloud computing allows renting infrastructure, runtime environments, and services on a pay-
per-use basis.

This principle finds several practical applications and then gives different images of cloud computing to different people.

Cloud computing turns IT services into utilities - Such a delivery model is made possible by the effective composition of several technologies such as Web 2.0, Service orientation and Virtualization.

Vision of Cloud computing

Defining a Cloud

Cloud computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet

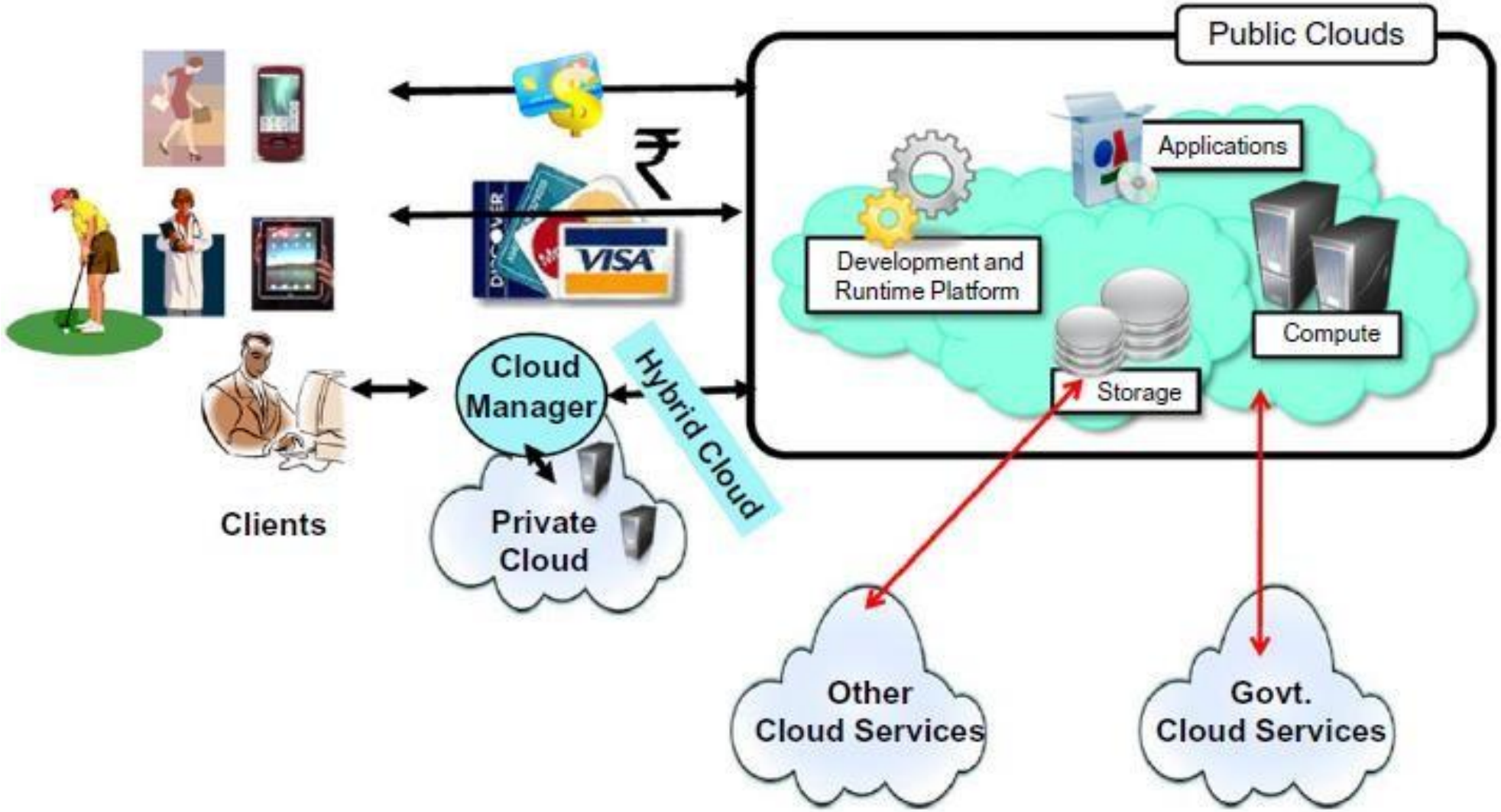
(or)

Cloud computing refers to both the applications delivered as services over the Internet and the hardware and system software in the datacenters that provide those services .

According to National Institute of Standards and Technology (NIST)

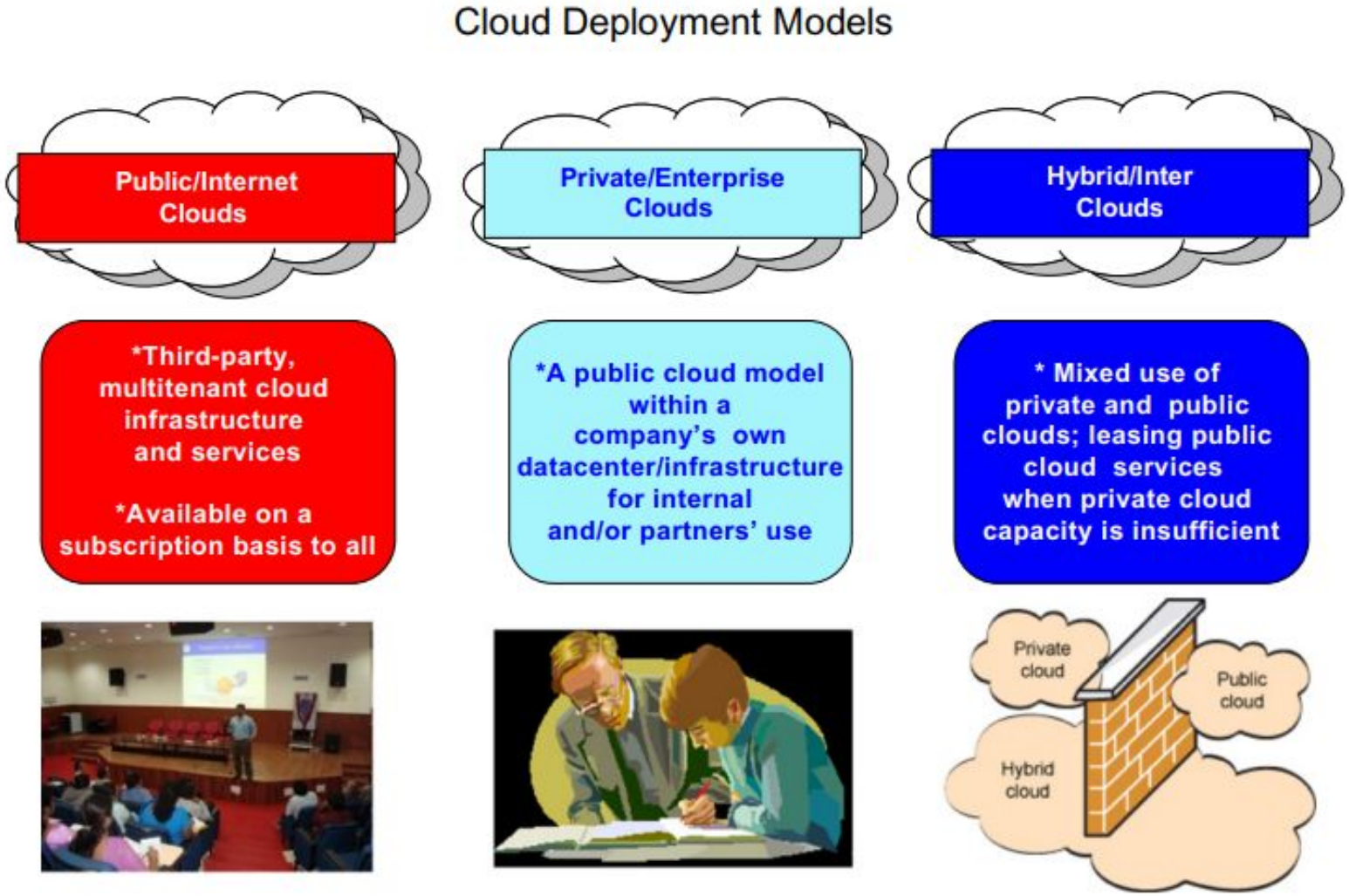
Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

- Define by Buyya [utility-oriented nature]
  - *"A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are **dynamically provisioned** and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers."*



A bird's-eye view of cloud computing.

The three major models for deploying and accessing cloud computing environments are public clouds, private/enterprise clouds, and hybrid clouds



Public Cloud	Private Cloud	Hybrid Cloud
Public clouds are the most common deployment models in which necessary IT infrastructure is established by a third-party service provider that makes it available to any consumer on a subscription basis.	Large organizations that own massive computing infrastructures by replicating the cloud IT service delivery model in-house.	Whenever private cloud resources are unable to meet users' quality-of-service requirements, hybrid computing systems are created to serve the organization's needs.
Such clouds are appealing to users because they allow users to quickly leverage compute, storage, and application services.	The use of cloud-based in-house solutions is also driven by the need to keep confidential information within an organization's premises.	It is partially composed of public cloud resources and privately owned infrastructures. Usage: stakeholders to start exploring the possibilities offered by cloud computing.
In this environment, users' data and applications are deployed on cloud datacenters on the vendor's premises.	Institutions such as governments and banks that have high security, privacy, and regulatory concerns prefer to build and use their own private or enterprise clouds.	Community clouds are a recent variation on the private cloud model that provide a complete cloud solution for specific business communities.

Need for Cloud Computing

Some practical scenarios to understand the need for Cloud Computing,

1. Large enterprises can offload some of their activities to cloud-based systems
2. Small enterprises and start-ups can afford to translate their ideas into business results more quickly, without excessive up-front costs
3. System developers can concentrate on the business logic rather than dealing with the Complexity of infrastructure management and scalability
4. End users can have their documents accessible from everywhere and any device.

Characteristics and Benefits

- Cloud computing has some interesting characteristics that bring benefits to both cloud service consumers (CSCs) and cloud service providers (CSPs).
- These characteristics are:
  - No up-front commitments
  - On-demand access
  - Nice pricing
  - Simplified application acceleration and scalability
  - Efficient resource allocation
  - Energy efficiency
  - Seamless creation and use of third-party services
  - broad network access, resource pooling, rapid elasticity, and measured service.

Business Benefits

- Increased economic return
- Business continuity
- Increases agility in defining and structuring software systems
- Ease of scalability
- Data / Resource availability (to employees)
- Collaboration efficiency
- Lot of new services to the customers
- Access to automatic updates

Challenges

1. Security

- Security, trust, and privacy issues are major obstacles for massive adoption of cloud computing
- The massive use of virtualization technologies exposes the existing system to new threats

2. Cloud Interoperability and Standards

- To fully realize cloud computing goal, introducing standards and allowing interoperability between solutions offered by different vendors are key objectives
- Vendor lock-in should be removed
- Presence of standards would give room for interoperability
- CCIF (Cloud Computing Interoperability Forum) + OCF (Open Connectivity Foundation's)

Challenges

3. Scalability and fault tolerance

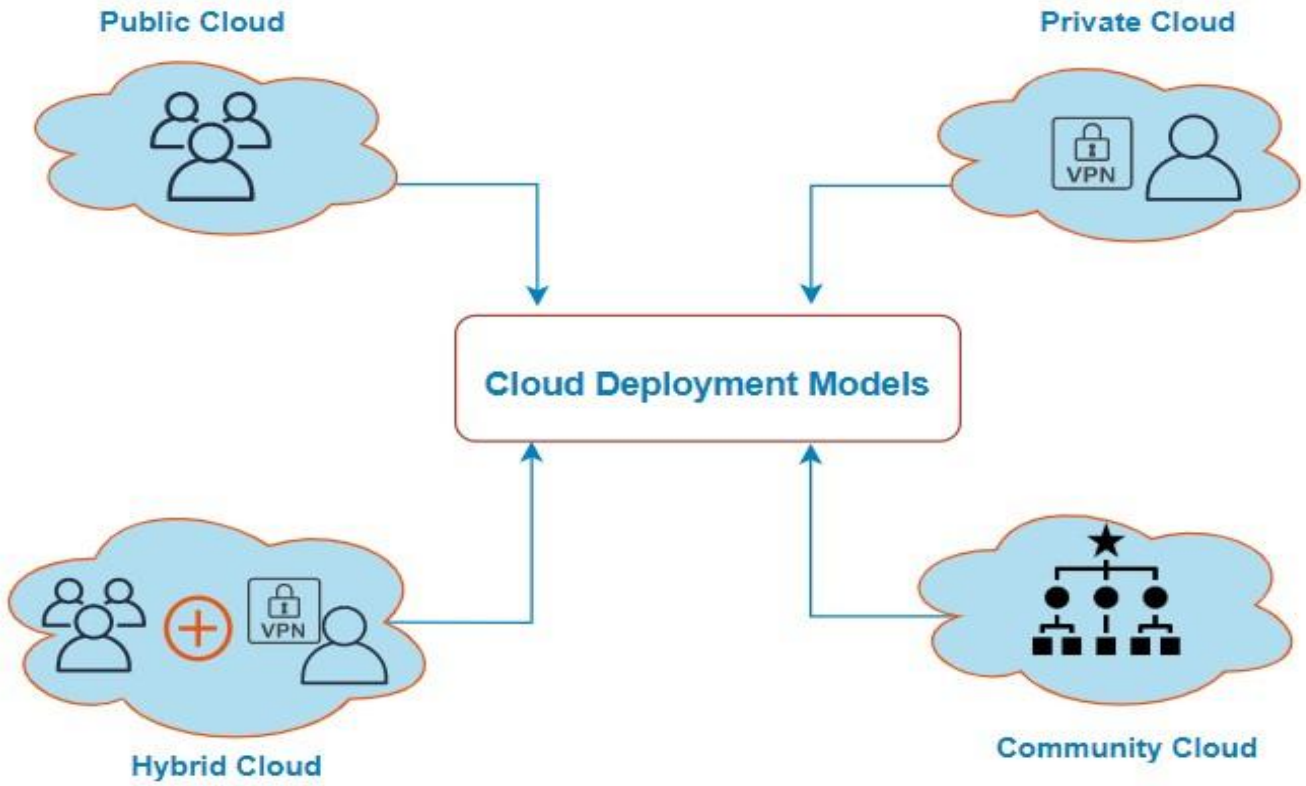
4. Dynamic provisioning of cloud computing resources

5. Management of large computing infrastructures and use of virtualization techniques

6. Organizational aspects

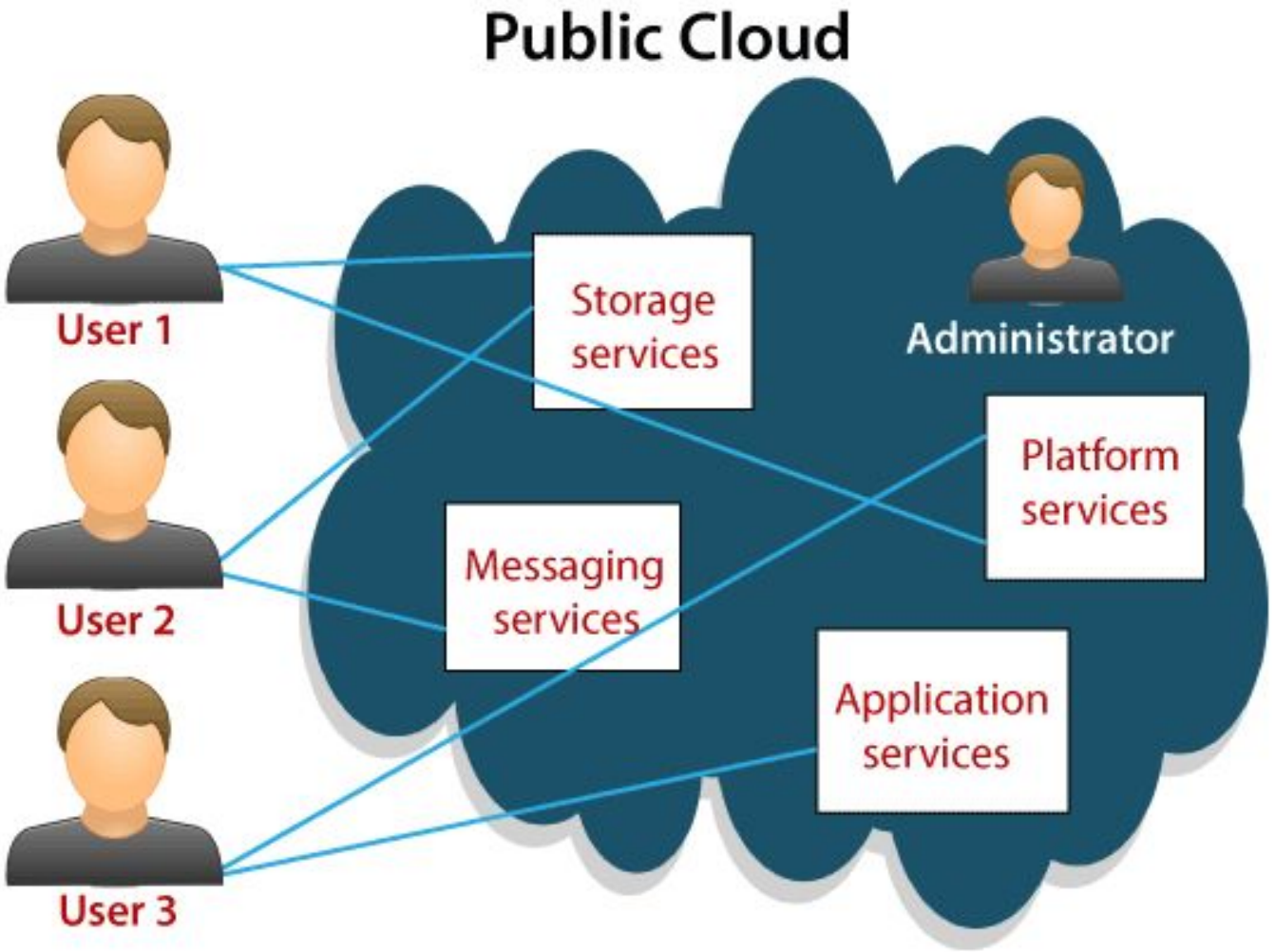
Deployment Models: Types of cloud - Public cloud - Private cloud - Hybrid cloud

Deployment Models



- Characterized by multi-administrative domain, involving different deployment models (Private, public and Hybrid)
- Designed to address the need for a specific Industry
- It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them

1. Public cloud



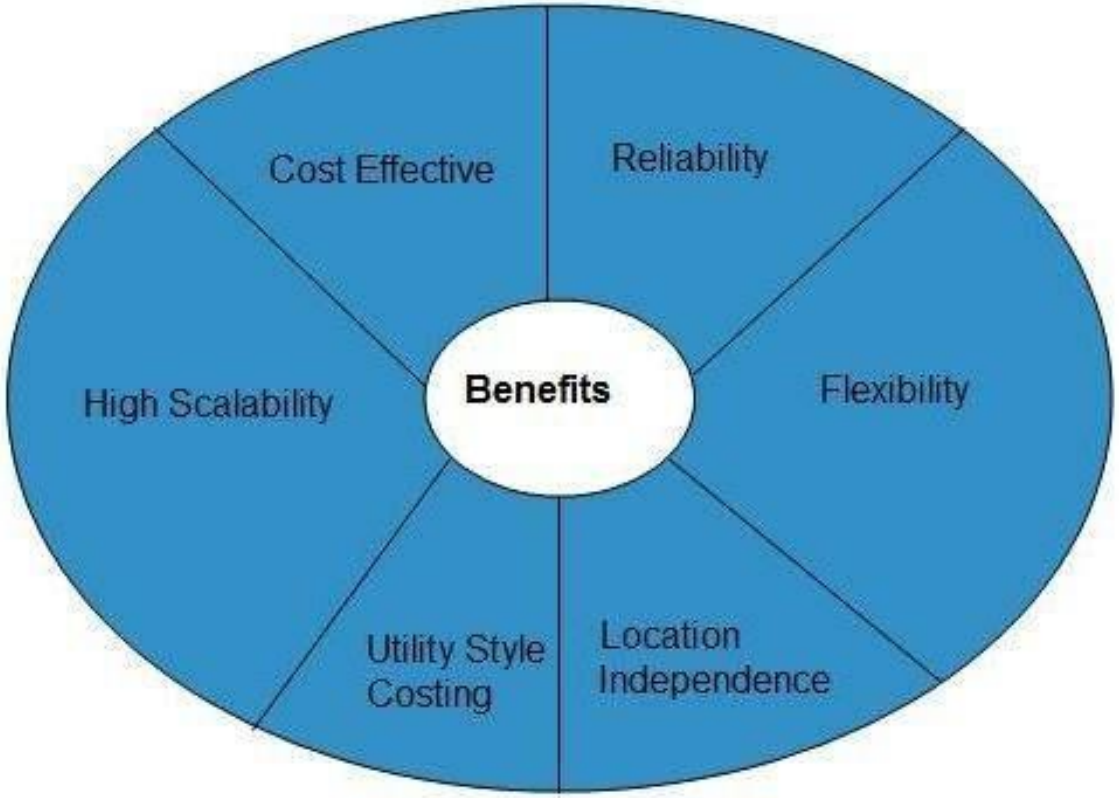
1. Public Cloud

- Public cloud is a cloud service that shares computing services among different customers through Internet
- Support for *Multitenancy* - Multitenancy is when multiple customers of a cloud provider are accessing the same server. Data from two different companies could be stored on the same server, or processes from two different applications could be running on the same server.
- Public clouds include SaaS, PaaS, and IaaS services.
- 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**

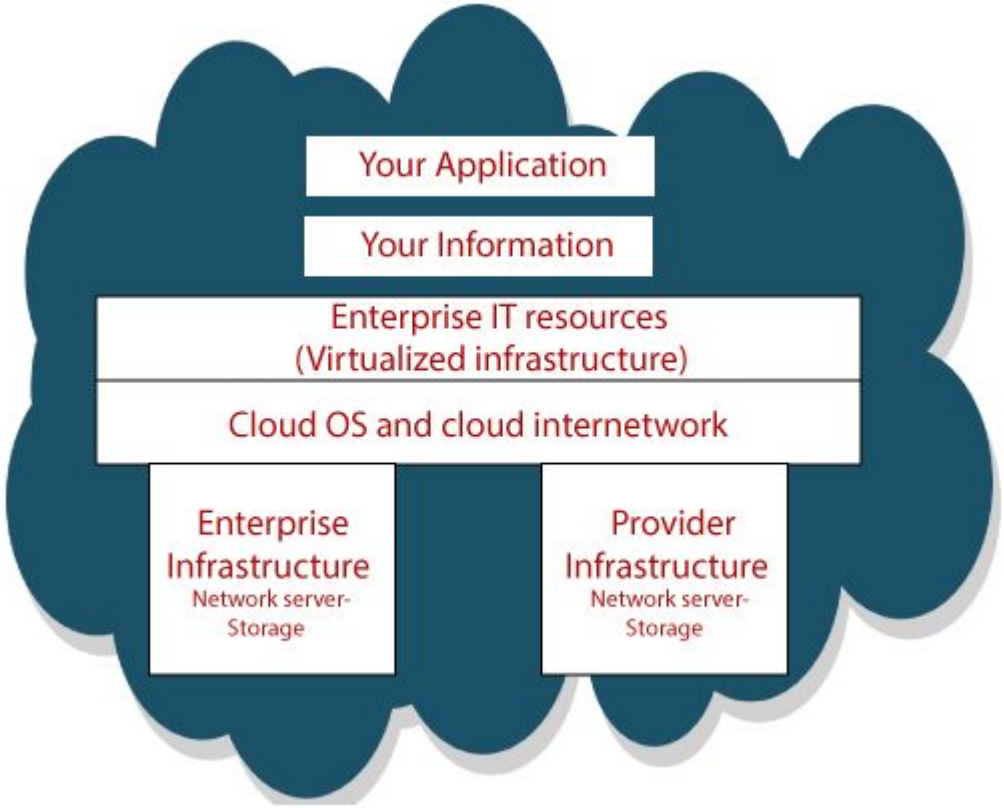
1. Public Cloud

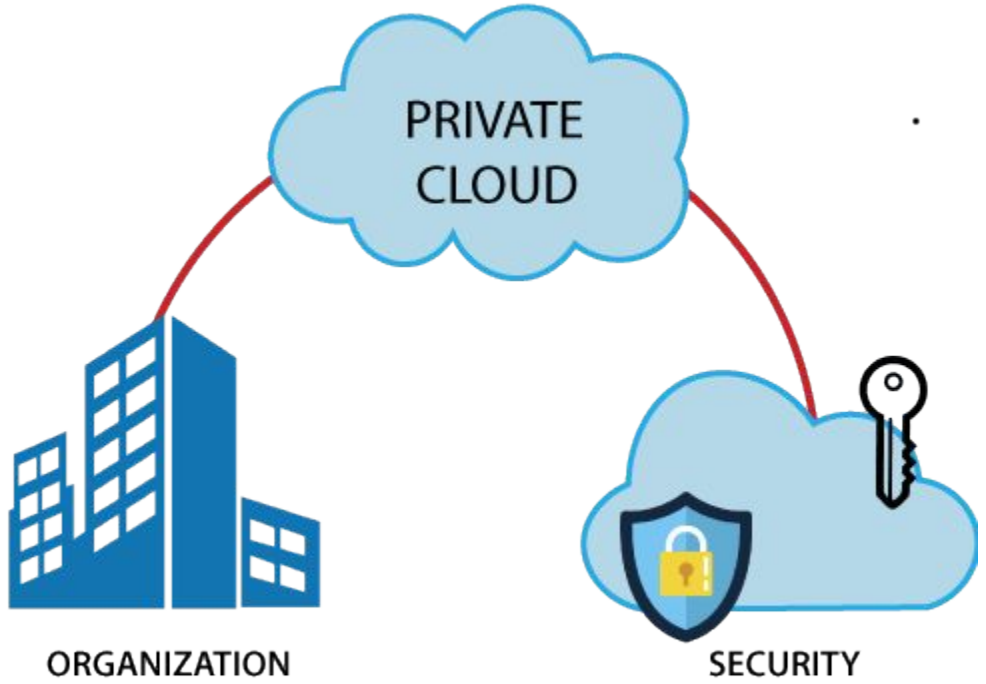
- For public cloud, one or more datacenters constitute the physical infrastructure on top of which the services are implemented and delivered
- Public clouds can be composed of geographically dispersed datacenters to share the load of users and better serve them according to their locations.
- For example, Amazon Web Services has datacenters installed in the United States, Europe, Singapore, and Australia; they allow their customers to choose between three different regions
- Advantages and Disadvantages

1. Public cloud - Benefits



2. Private Cloud





2. Private Cloud

Need for private cloud (i.e. drawbacks in public cloud)

- loss of control-Provider is in control of infrastructure and customers core logic and sensitive data- perceived as thread or as an unacceptable risk
- Security aspects
- Regulations based on infrastructure region

Private clouds are virtual distributed systems that rely on a private infrastructure and provide internal users with dynamic provisioning of computing resources.

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.

2. Private Cloud

Key advantages

- Customer information protection
- Infrastructure ensuring Service Level Agreement(SLA)-
- Compliance with standard procedures and operations-

- Private clouds can be implemented on more heterogeneous hardware.
- 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
- **Drawback:** limited scalability, price

2. Private Cloud

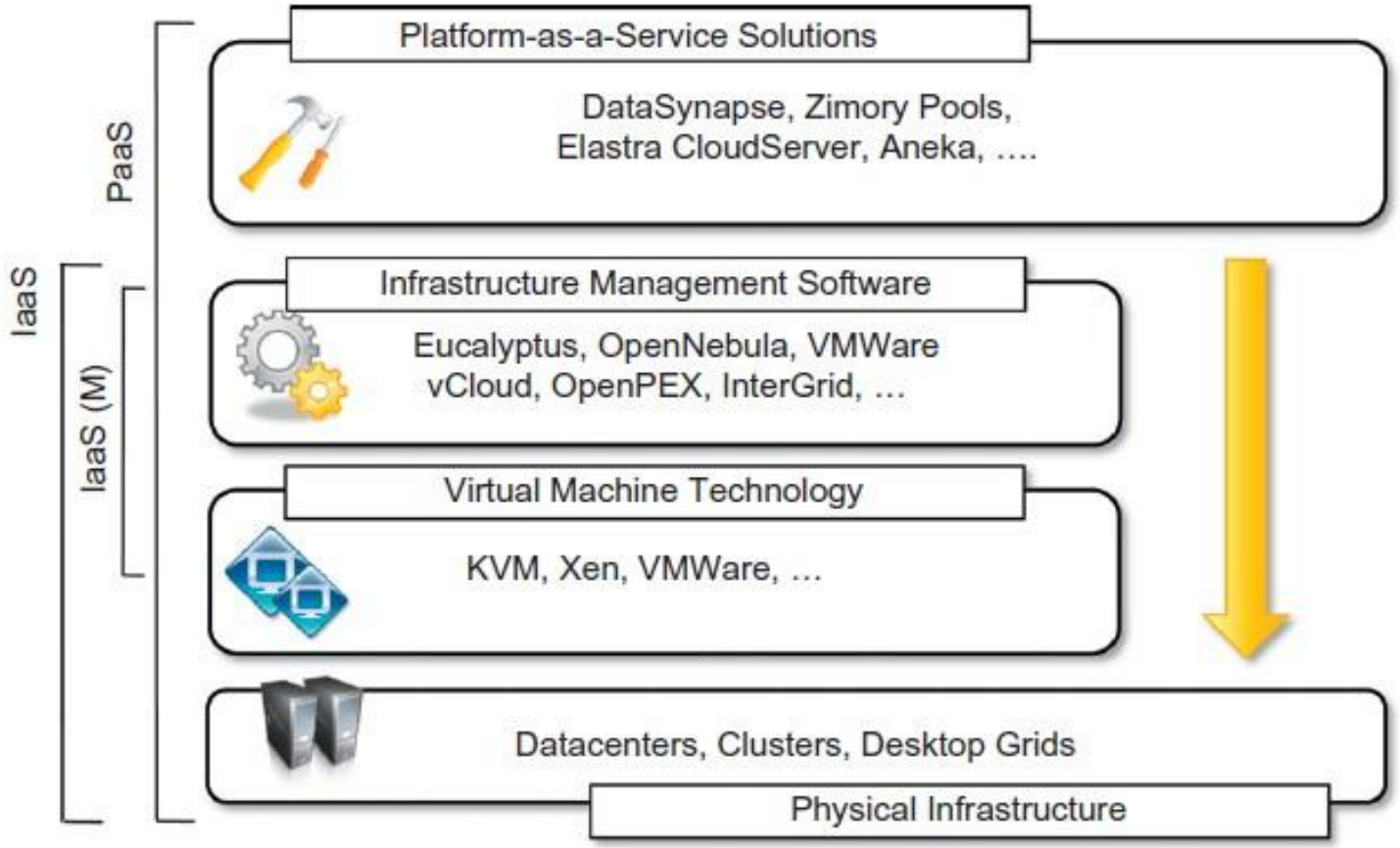
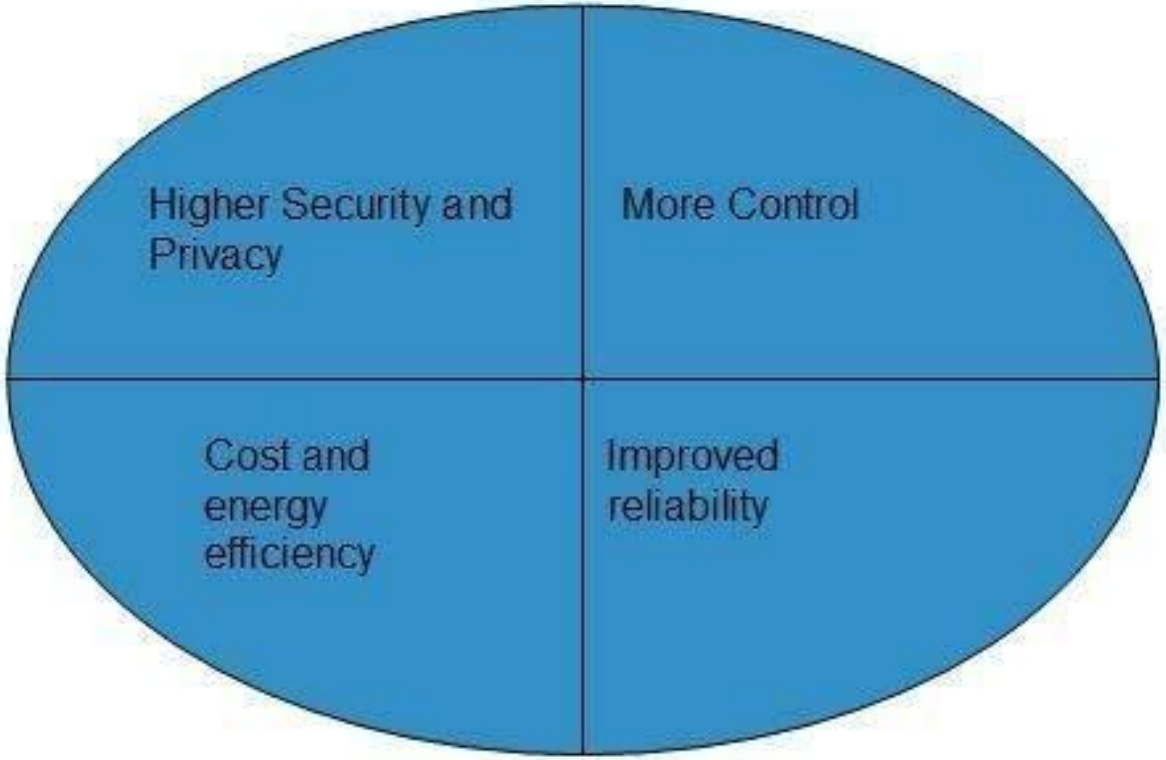
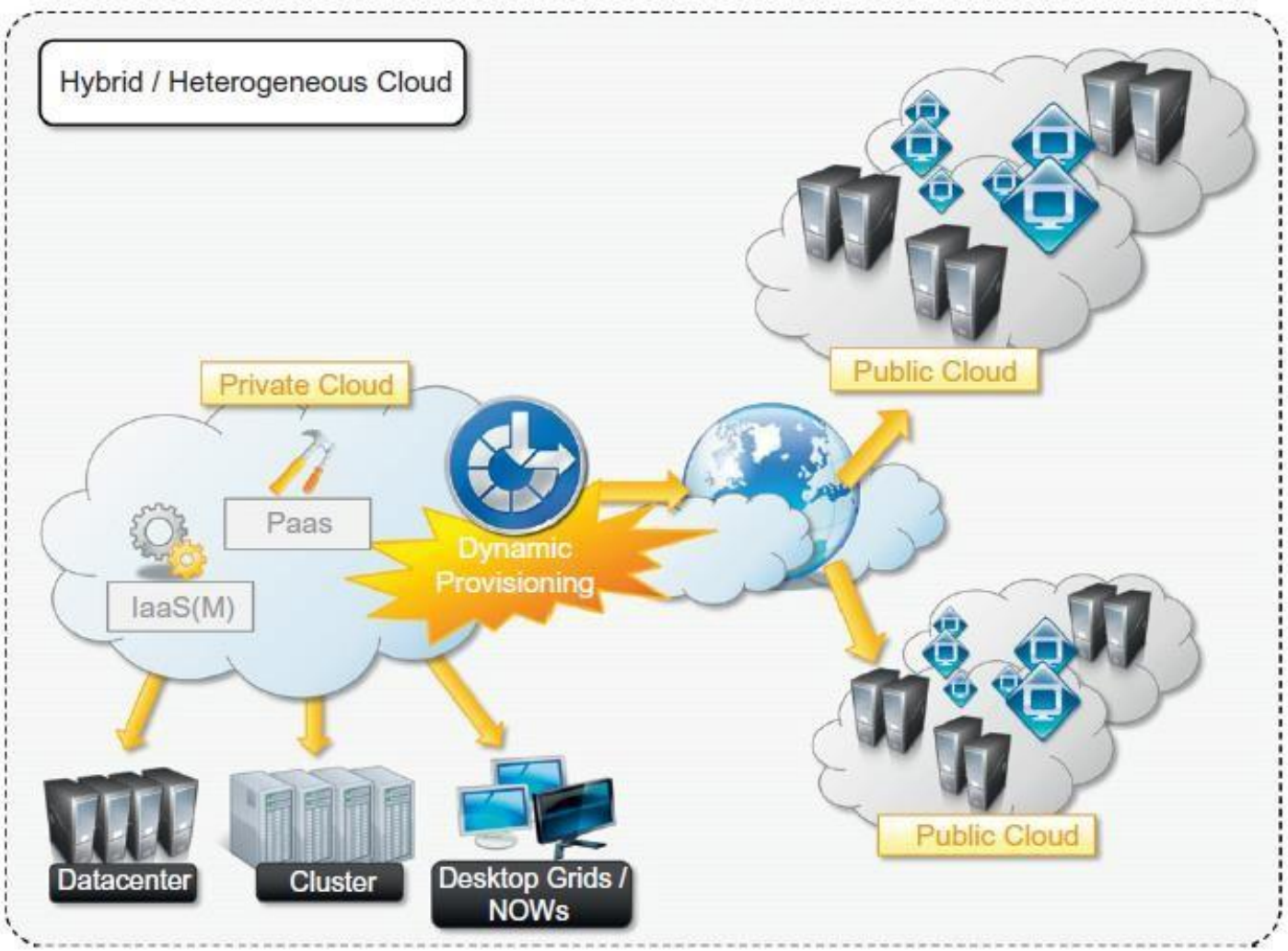


Fig. Private clouds hardware and software stack.

2. Private Cloud- Benefits



3. Hybrid Cloud



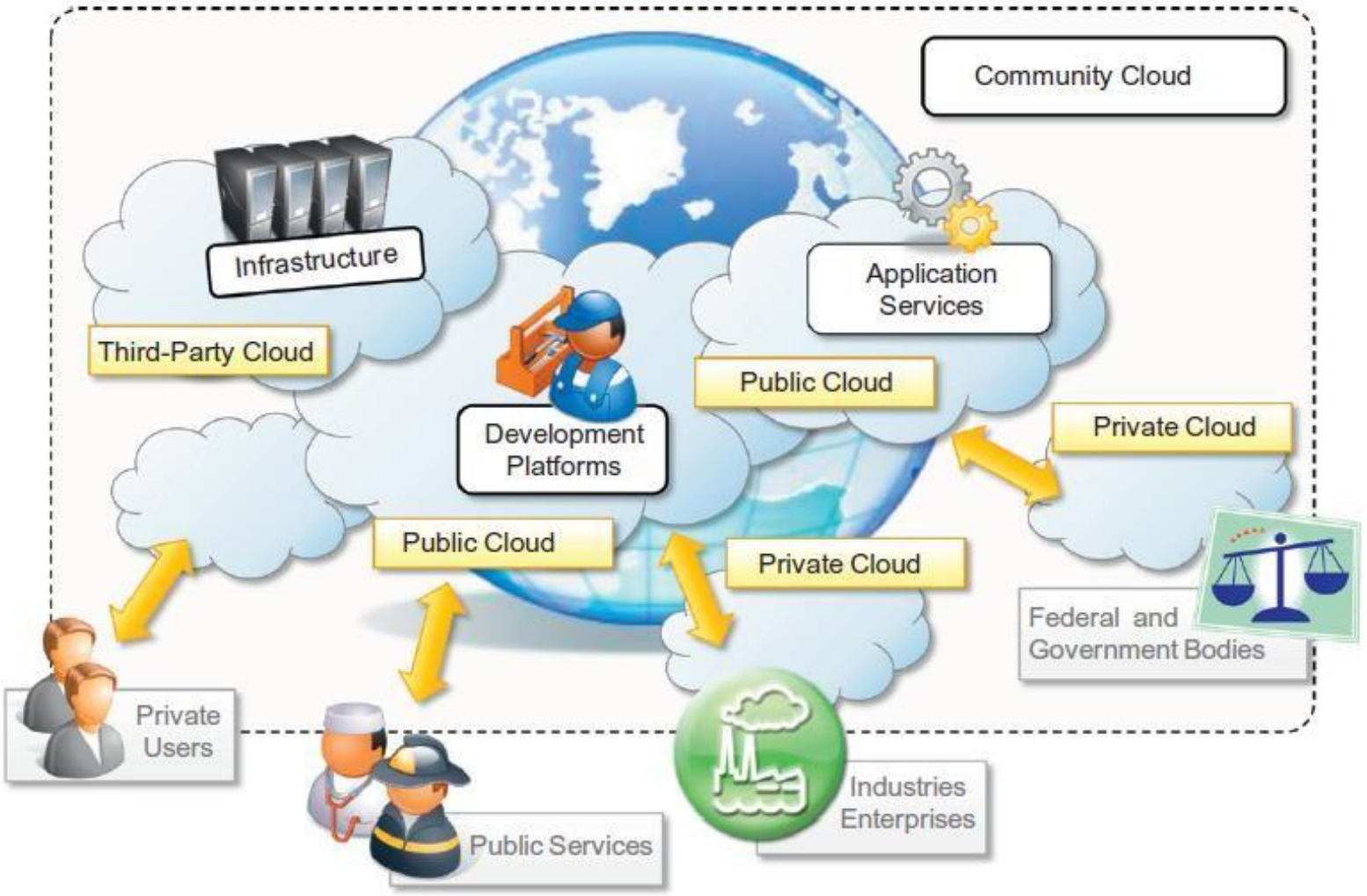
3. Hybrid Cloud

- ***Drawbacks in public and private clouds***
- 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
- It is a heterogeneous distributed system resulting from a private cloud that integrates additional services or resources from one or more public clouds.
- They are also called as heterogeneous clouds.
- Dynamic provisioning is a fundamental component in hybrid cloud
- 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

- The resources or services are temporarily leased for the time required and then released. This practice is also known as **cloud bursting**

4. Community Cloud



4. Community Cloud

The purpose of community cloud is to allow **multiple customers to work on joint projects and applications** that belong to the community, where it is necessary to have a centralized cloud infrastructure.

Community Cloud is a distributed infrastructure that solves the specific issues of business sectors by integrating the services provided by different types of cloud solutions.

- 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.
- Community cloud's are mostly implemented over multiple administrative domains

Benefits:

- Openness – Dependencies on cloud vendors are removed
- Community- Collectively providing resources and services-infrastructure turns out to be more scalable
- Graceful failures (No Single point of failure)
- Convenience and control
- Environmental Sustainability- based on the demand of community the cloud grows or shrinks

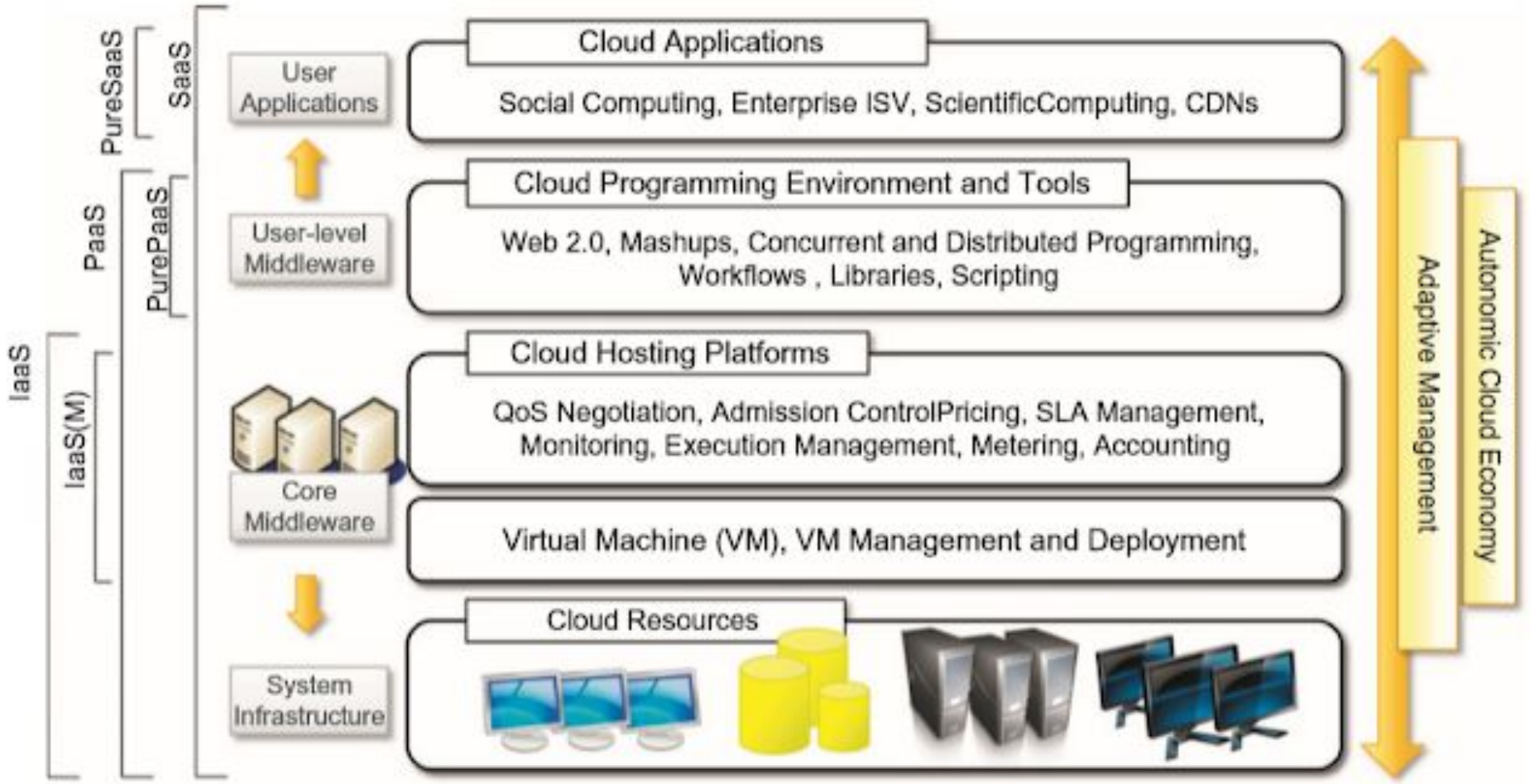
The cloud computing reference model

Cloud Delivery Models: IaaS, PaaS, SaaS

(Organic View of Cloud Computing)

Cloud Computing Architecture

Cloud computing is a utility-oriented and Internet-centric way of delivering IT services on demand



Cloud Computing Architecture

Cloud Computing Architecture

User applications:

1. It includes cloud applications through which end user get interact.
2. There may be different types of user applications, like scientific, gaming, social etc.
3. Some of the examples are Gmail, Facebook.com, etc.

User-level middleware:

1. It includes cloud programming environment and tools.
2. There may be different types of programming environments and tools depends on the user applications.
3. Some of the examples of user level middleware are **web 2.0, libraries, scripting**.

Core middleware:

1. It includes cloud hosting platforms.
2. It manage quality of service.
3. Execution management.
4. Accounting, metering etc.
5. Virtual machines are the part of core middleware.

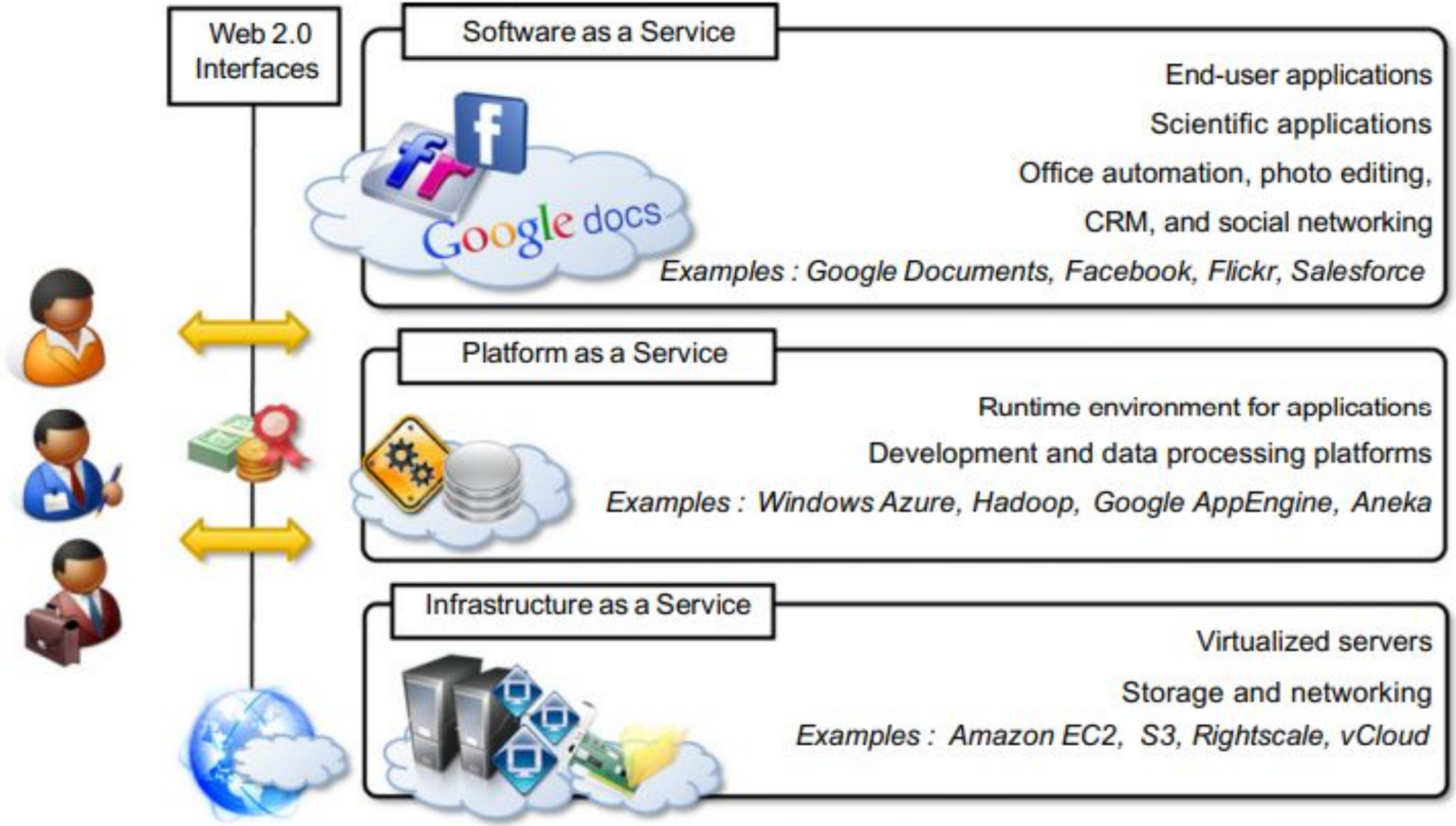
System infrastructure:

1. It includes cloud resources.
2. Storage hardware
3. Servers, databases are part of it.

The cloud computing reference model

The reference model for cloud computing is an **abstract model that characterizes and standardizes a cloud computing environment** by partitioning it into abstraction layers and cross-layer functions.

IaaS, PaaS and SaaS are the three most popular types of cloud service offerings.


Web 2.0 Interfaces
Software as a Service
End-user applications
Scientific applications
Office automation, photo editing,
CRM, and social networking
Examples : Google Documents, Facebook, Flickr, Salesforce
Google docs
Platform as a Service
Runtime environment for applications
Development and data processing platforms
Examples : Windows Azure, Hadoop, Google AppEngine, Aneka
Infrastructure as a Service
Virtualized servers
Storage and networking
Examples : Amazon EC2, S3, Rightscale, vCloud

Infrastructure-as-a-Service

- Deliver infrastructure on demand in the form of virtual hardware, storage, and networking.
- Virtual hardware is utilized to provide compute on demand in the form of virtual machine instances.
- These are created at user request on the provider infrastructure so that users are given with necessary tools or interfaces to configure the software stack installed in the virtual machine.
- Virtual storage is delivered in the form of raw disk space or object store.

Infrastructure-as-a-Service

IaaS Characteristics:

- Resources are available as a service
- Cost varies depending on consumption
- Services are highly scalable
- Multiple users on a single piece of hardware
- Organization retain complete control of the infrastructure
- Dynamic and flexible

When to Use IaaS

- **Startups and small companies** may prefer IaaS to avoid spending time and money on purchasing and creating hardware and software.
- **Larger companies** may prefer to retain complete control over their applications and infrastructure, but they want to purchase only what they actually consume or need.
- **Companies experiencing rapid growth** like the scalability of IaaS, and they can change out specific hardware and software easily as their needs evolve.

Platform-as-a-Service

- PaaS, or platform as a service, is on-demand access to a complete, ready-to-use, cloud-hosted platform for developing, running, maintaining and managing applications.
- They deliver scalable and elastic runtime environments on demand and host the execution of applications.
- These services are backed by a core middleware platform that is responsible for creating the abstract environment where applications are deployed and executed.
- It is the responsibility of the service provider to provide scalability and to manage fault tolerance, while users are requested to focus on the logic of the application developed by leveraging the provider's APIs and libraries.
- This approach increases the level of abstraction at which cloud computing is leveraged but also constrains the user in a more controlled environment.

Platform-as-a-Service

- Hardware and software tools available over the internet
- The cloud services provider hosts, manages and maintains all the hardware and software included in the platform - servers (for development, testing and deployment), operating system (OS) software, storage, networking, databases, middleware, runtimes, frameworks, development tools - as well as related services for security, operating system and software upgrades, backups and more.
- Examples of PaaS solutions include AWS Elastic Beanstalk, Google App Engine, Microsoft Windows Azure, and Red Hat OpenShift on IBM Cloud.

Platform-as-a-Service

PaaS Characteristics:

- Builds on virtualization technology, so resources can easily be scaled up or down as your business changes
- Provides a variety of services to assist with the development, testing, and deployment of apps
- Accessible to numerous users via the same development application
- Integrates web services and databases

When to Use PaaS

Utilizing PaaS is beneficial, sometimes even necessary, in several situations. **For example**, PaaS can streamline workflows when multiple developers are working on the same development project. If other vendors must be included, PaaS can provide great speed and flexibility to the entire process. PaaS is particularly beneficial if you need to create customized applications.

Software -as-a-Service

- Software that's available via a third-party over the internet
- Provide applications and services on demand.
- Most of the common functionalities of desktop applications—such as office automation, document management, photo editing, and customer relationship management (CRM) software—are replicated on the provider's infrastructure and made more scalable and accessible through a browser on demand.
- These applications are shared across multiple users whose interaction is isolated from the other users.
- The SaaS layer is also the area of social networking Websites, which leverage cloud-based infrastructures to sustain the load generated by their popularity.

Software -as-a-Service

- Users pay a monthly or annual fee to use a complete application from within a web browser, desktop client or mobile app.
- The application and all of the infrastructure required to deliver it - servers, storage, networking, middleware, application software, data storage - are hosted and managed by the SaaS vendor.
- The vendor manages all upgrades and patches to the software, usually invisibly to customers.
- The vendor ensures a level of availability, performance and security as part of a Service Level Agreement (SLA). Customers can add more users and data storage on demand at additional cost.

Software -as-a-Service

SaaS Characteristics:

- ❑Managed from a central location
- ❑Hosted on a remote server
- ❑Accessible over the internet
- ❑Users not responsible for hardware or software updates

When to Use SaaS:

- ❑Startups or small companies that need to launch e-commerce quickly and don't have time for server issues or software
- ❑Short-term projects that require quick, easy, and affordable collaboration
- ❑Applications that aren't needed too often, such as tax software
- ❑Applications that need both web and mobile access

Some examples:

- ✔Gmail
- ✔Google drive
- ✔Dropbox
- ✔WhatsApp

Summary

- IaaS solutions are sought by users who want to leverage cloud computing from building dynamically scalable computing systems requiring a specific software stack.
- IaaS services are therefore used to develop scalable Websites or for background processing.
- PaaS solutions provide scalable programming platforms for developing applications and are more appropriate when new systems have to be developed.
- SaaS solutions target mostly end users who want to benefit from the elastic scalability of the cloud without doing any software development, installation, configuration, and maintenance.
- This solution is appropriate when there are existing SaaS services that fit users needs (such as email, document management, CRM, etc.) and a minimum level of customization is needed.