Enterprise Computing

Lecture slides – IV

UNIT 4

Cloud Concepts

4.1Cloud Computing (NIST Model), Properties, Characteristics, Benefits

4.2. Cloud Types; Private, Public and Hybrid Cloud.

4.3. Service Models: IaaS, PaaS, SaaS.

4.4. Role of Virtualization in Enabling the Cloud.

4.5. Application Availability, Performance, Security and Disaster

Cloud Computing (NIST Model), Properties, Characteristics, Benefits

- **National Institute of Standards and Technology (NIST)**

- 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"

Cloud

- The word cloud (also phrased as "the cloud") is used as a metaphor for "*the Internet.*

Cloud Computing

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet,

  - basically a step on from **Utility Computing**

  - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).

  - Using the Internet for communication and transport provides hardware, software and networking services to clients

Cloud Computing

- In addition, the platform provides **on demand services**, that are always on**, anywhere, anytime and   any place**.

- **Pay for use and as needed**, elastic scale up and down in capacity and functionalities

- The hardware and software services are available to **general public, enterprises, corporations and   businesses markets**

Cloud Summary

- Cloud computing is an umbrella term used to refer to Internet based development and services

- A number of characteristics define cloud data, applications services and infrastructure:

  - **Remotely hosted**: Services or data are hosted on remote infrastructure.

  - **Ubiquitous**: Services or data are available from anywhere.

  - **Commodified**: The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would want!
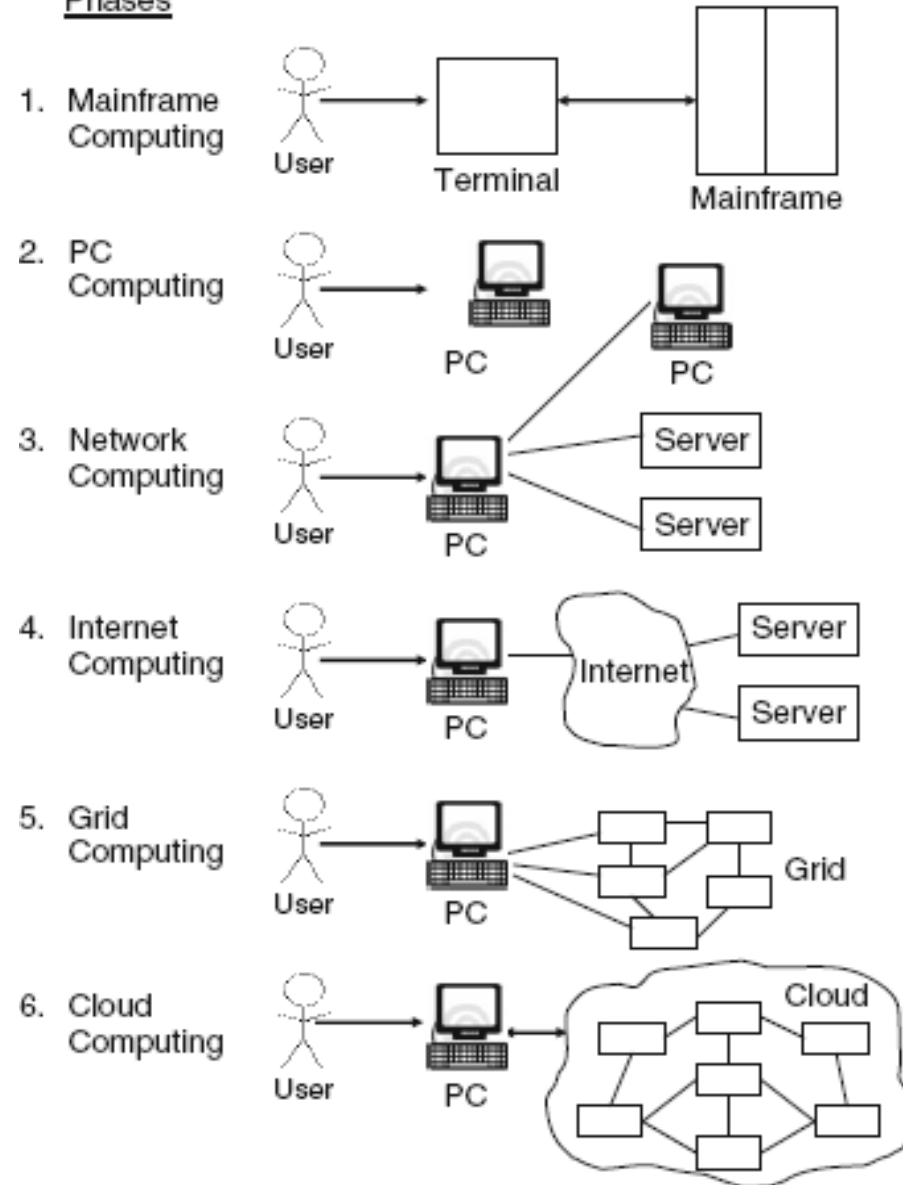
Pros and Cons

Evolution of Cloud Computing

Phases

1. Mainframe Computing — User → Terminal ← Mainframe

2. PC Computing — User → PC

3. Network Computing — User → PC — PC, Server, Server

4. Internet Computing — User → PC — Internet — Server, Server

5. Grid Computing — User → PC — Grid

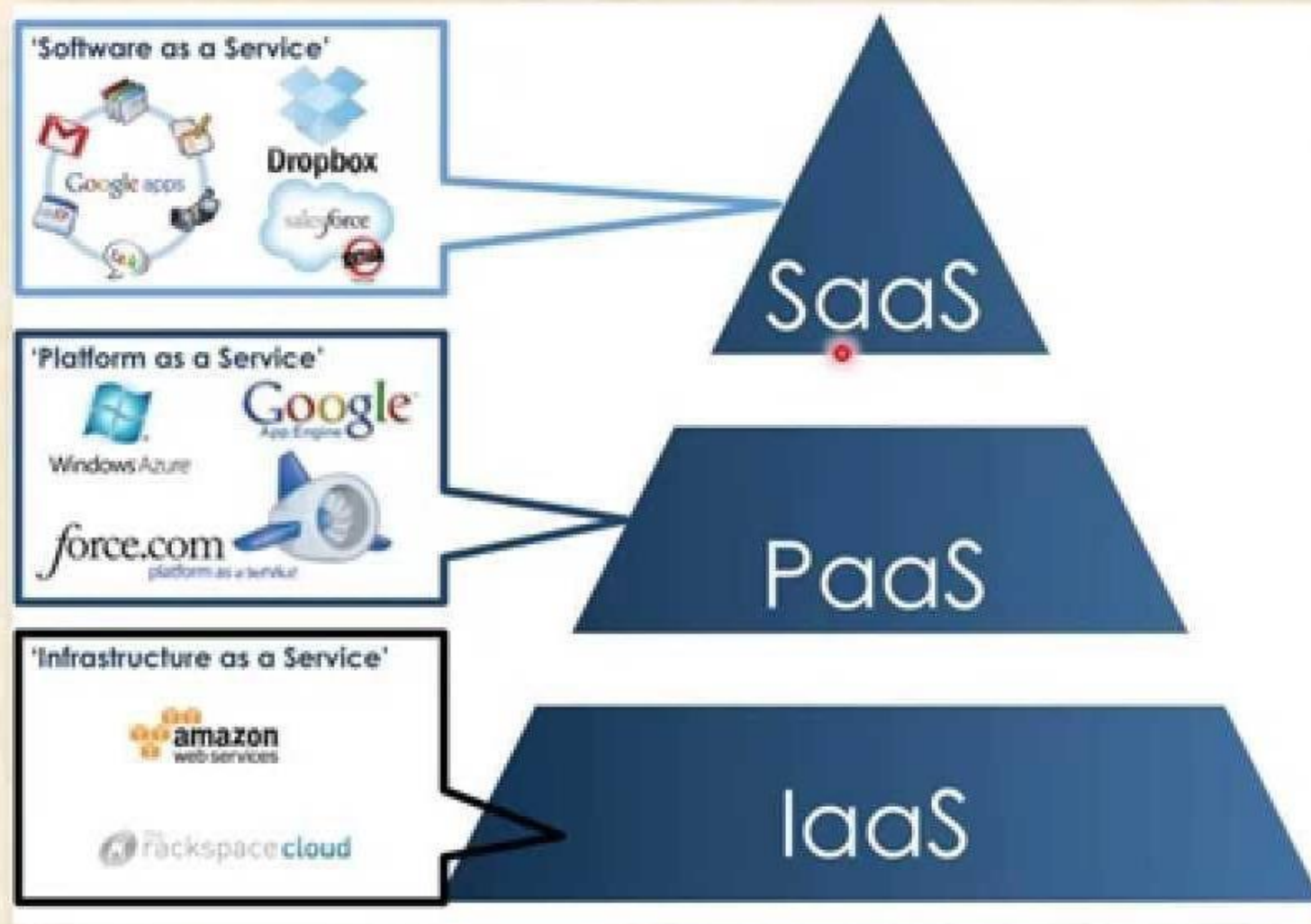6. Cloud Computing — User → PC ← Cloud

Type of cloud computing

- There are mainly three type of cloud computing service models

  - **Infrastructure as a service (Iaas)**
  - **Platform as a service (Pass)**
  - **Software as a service (Saas)**
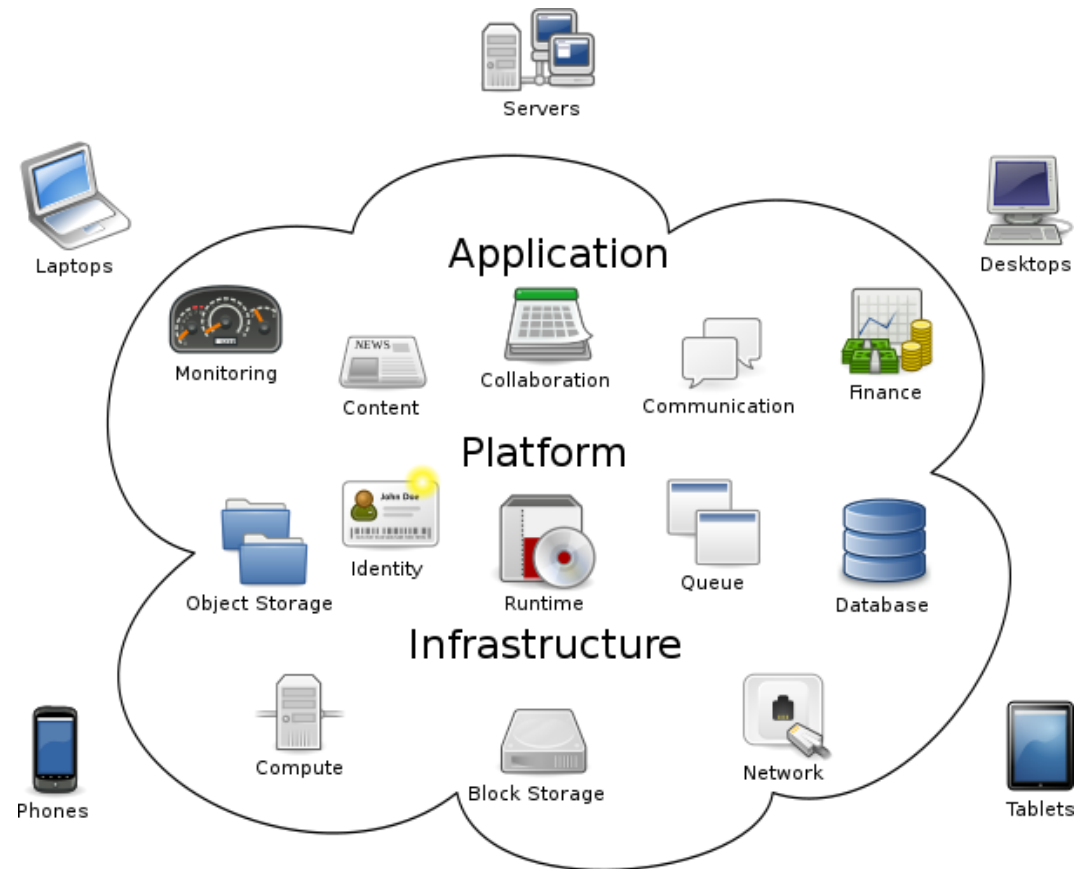
Cloud Services

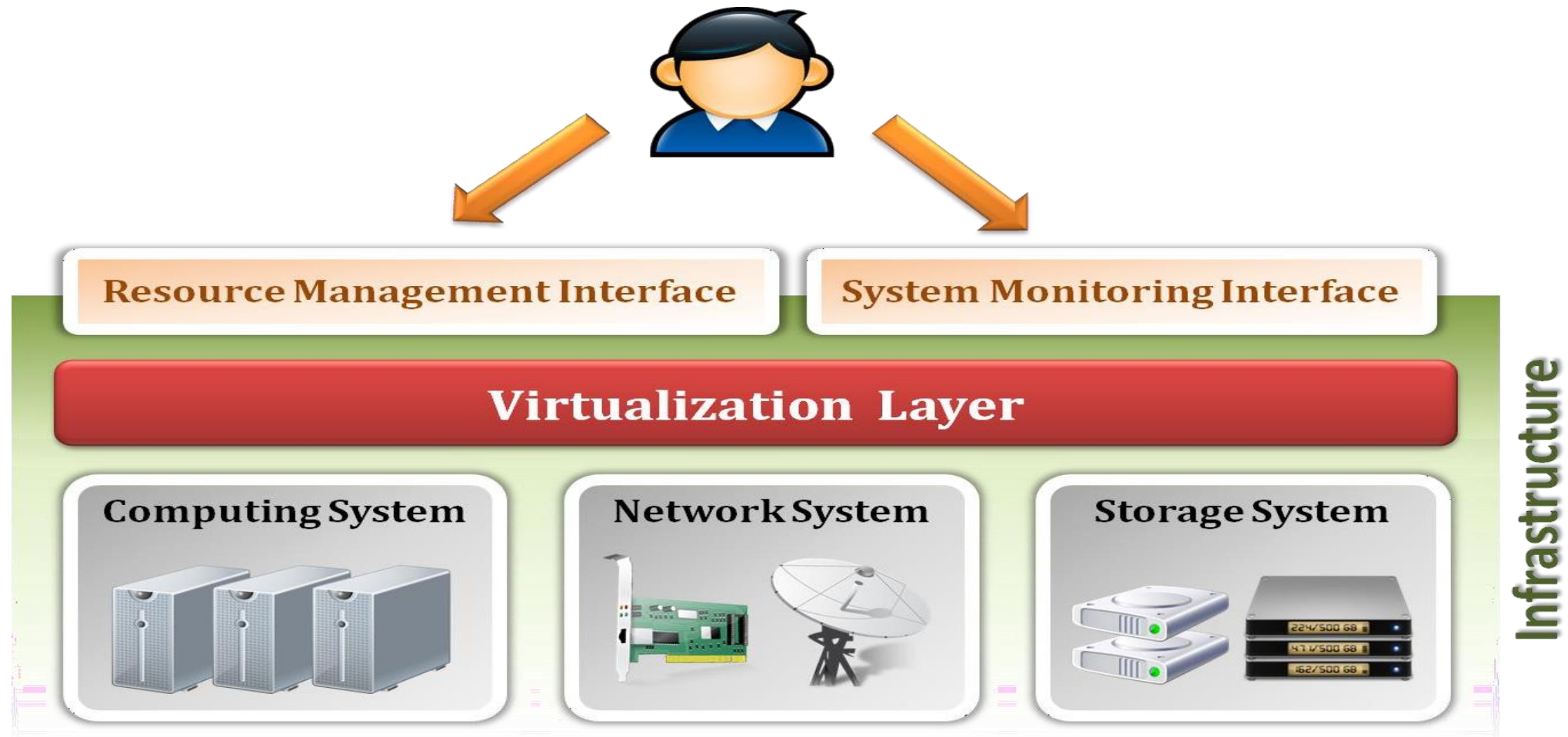# Infrastructure as a Service

- **Infrastructure as a Service - IaaS**
  - Thecapability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer 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 operating systems, storage, deployed applications, and possibly limited control of select networking components .
- Examples :
 - Amazon EC2
  - OpenNebula
  - RackSpace cloud
  - … etc
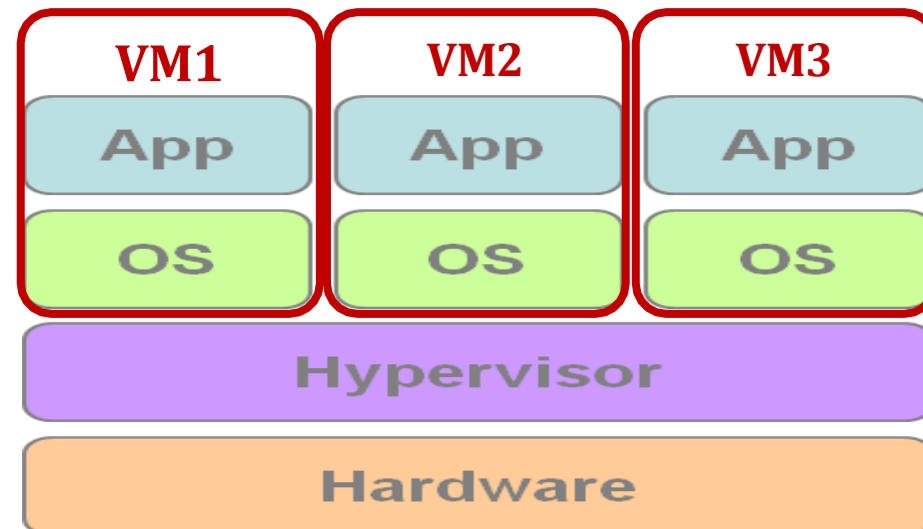
Infrastructure as a Service

- System architecture :

Infrastructure as a Service

- Enabling technique - *Virtualization*
    - Virtualization is an abstraction of logical resources, away from underlying physical resources.
        - Virtualization technique shift OS onto hypervisor.
        - Multiple OS share the physical hardware and provide different services.
        - Improve utilization, availability, security and convenience.
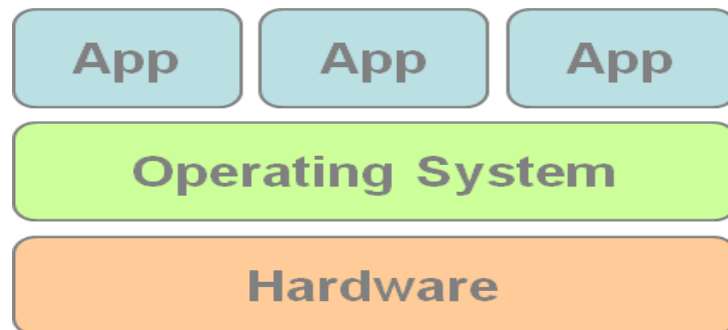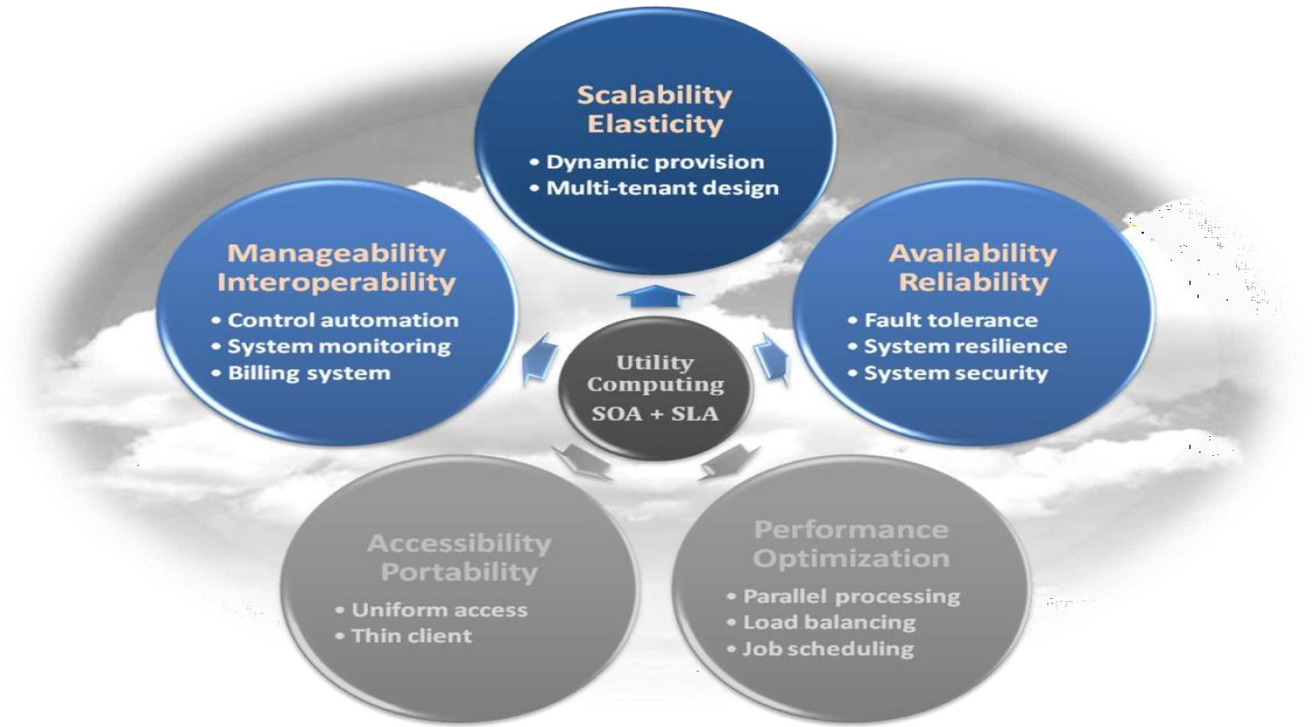

Traditional Stack

Virtualized Stack

Infrastructure as a Service

- Properties supported by virtualization technique :
    - Manageability and Interoperability
    - Availability and Reliability
    - Scalability and Elasticity

Infrastructure as a Service

- Provide service – **Resource Management Interface**
  - Several types of virtualized resource :
    - *Virtual Machine* – As an IaaS provider, we should be able to provide the basic virtual machine operations, such as *creation*, *suspension*, *resumption* and *termination*, …etc.

    - *Virtual Storage* – As an IaaS provider, we should be able to provide the basic virtual storage operations, such as *space allocation*, *space release*, *data writing* and *data reading*, …etc.

    - *Virtual Network* – As an IaaS provider, we should be able to provide the basic virtual network operations, such as *IP address allocation*, *domain name register*, *connection establishment* and *bandwidth provision*, …etc.

IaaS - Summary

- **IaaS is the deployment platform that abstract the infrastructure.**

- IaaS enabling technique
  - Virtualization
    - Server Virtualization
    - Storage Virtualization
    - Network Virtualization

- IaaS provided services
  - Resource Management Interface
  - System Monitoring Interface

Platform as a Service

- Platform as a Service - PaaS
  - The **capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created** or acquired applications created using programming languages and tools supported by the provider.
  - The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.
- Examples :
  - Microsoft Windows Azure
 - Google App Engine
  - Hadoop
  - Force.com
  - … etc

Platform as a Service

- System architecture :
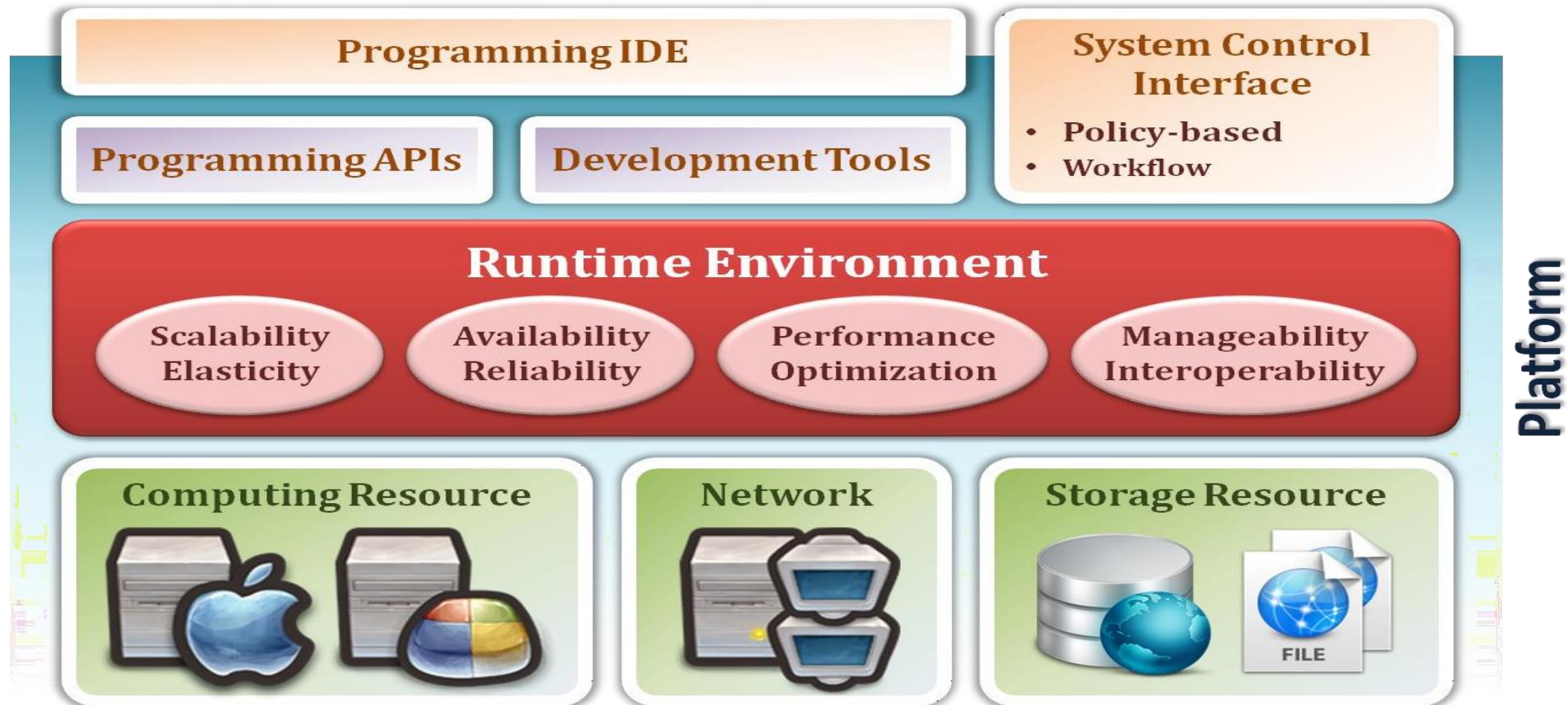
Platform as a Service

- Enabling technique – **Runtime Environment Design**
  - Runtime environment refers to collection of software services available. Usually implemented by a collection of program libraries.
- Common properties in Runtime Environment :
  - Manageability and Interoperability
  - Performance and Optimization
  - Availability and Reliability
  - Scalability and Elasticity
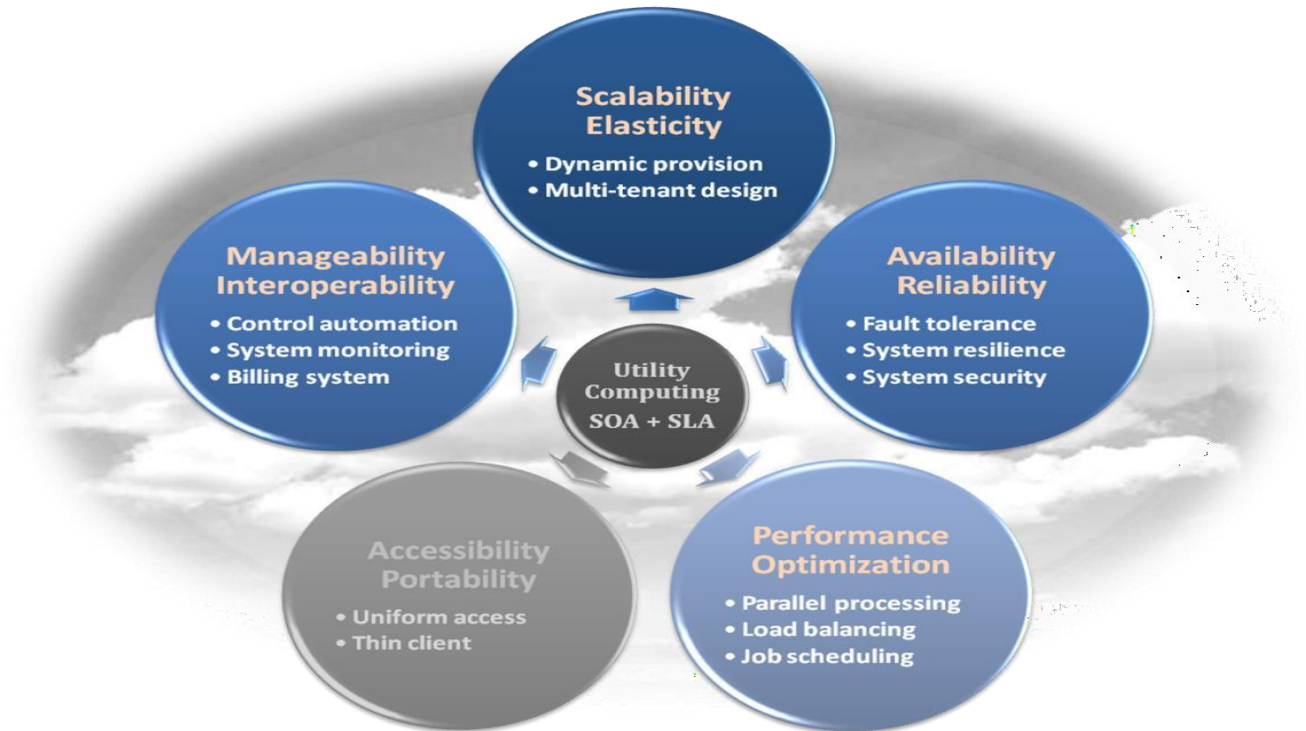
Platform as a Service

- Provide service – **Programming IDE**
  - Users make use of programming IDE to develop their service among PaaS.
    - This IDE should integrate the full functionalities which supported from the underling runtime environment.
    - This IDE should also provide some development tools, such as profiler, debugger and testing environment.
  - The programming APIs supported from runtime environment may be various between different cloud providers, but there are still some common operating functions.
    - Computation, storage and communication resource operation

Platform as a Service

- Provide service – **System Control Interface**
    - **Policy-Based Control**
        - Typically described as a principle or rule to guide decisions and achieve rational outcome(s)
        - Make the decision according to some requirements
    - **Workflow Control**
        - Describe the flow of installation and configuration of resources
        - Workflow processing daemon delivers speedy and efficient construction and management of cloud resources

PaaS - Summary

- **PaaS is the development platform that abstract the infrastructure, OS, and middleware to drive developer productivity.**

- PaaS enabling technique
  - Runtime Environment

- PaaS provide services
  - Programming IDE
    - Programming APIs
    - Development tools
  - System Control Interface
    - Policy based approach
    - Workflow based approach

Software as a Service
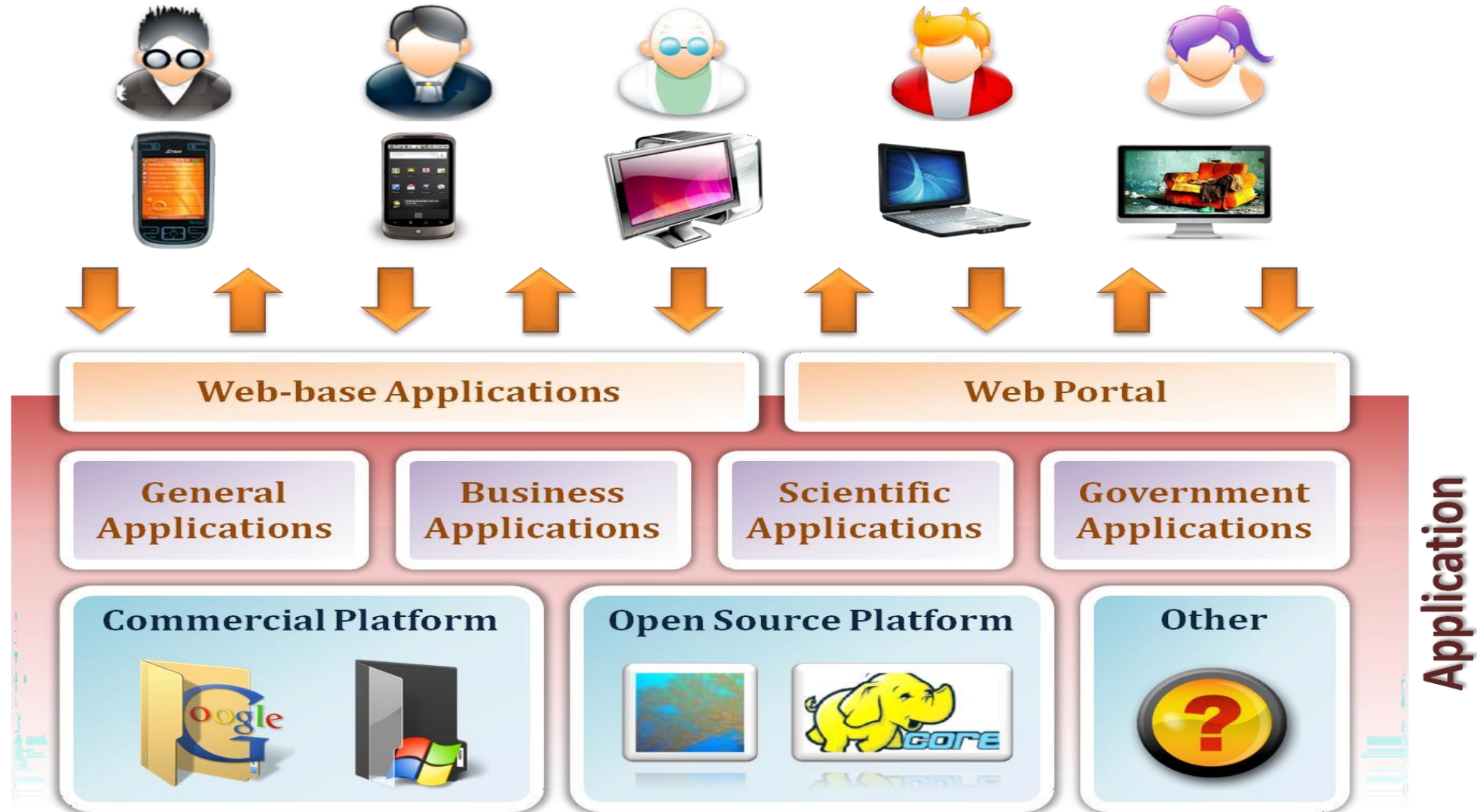
- **Software as a Service - SaaS**
  - The **capability provided to the consumer is to use the provider's applications running on a cloud infrastructure**. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web- based email).
  - The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- Examples :
  - Google Apps (e.g., Gmail, Google Docs, Google sites, …etc)
 - SalesForce.com
  - EyeOS
  - … etc

Software as a Service

Software as a Service

- Enabling Technique – **Web Service**
  - Web 2.0 is the trend of using the full potential of the web
    - Viewing the Internet as a computing platform
    - Running interactive applications through a web browser
    - Leveraging interconnectivity and mobility of devices
    - Enhanced effectiveness with greater human participation
- Properties provided by Internet :
  - **Accessibility and Portability**
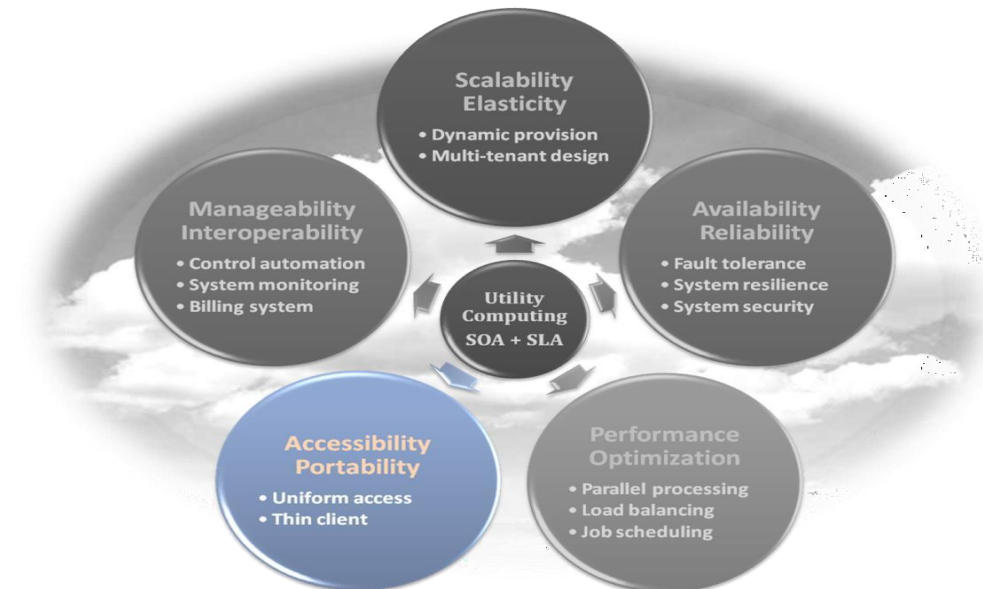
Software as a Service

- Provide service – **Web-based Applications**
    - Conventional applications should translate their access interface onto web-based platform.
    - Applications in different domains
        - *General Applications* – Applications which are designed for general propose, such as office suit, *multimedia* and *instant message*, …etc.
        - *Business Applications* – Application which are designed for business propose, such as *ERP*, *CRM* and *market trading system*, …etc.
        - *Scientific Applications* – Application which are designed for scientific propose, such as *aerospace simulation* and *biochemistry simulation*, …etc.
        - *Government Applications* – Applications which are designed for government propose, such as *national medical system* and *public transportation system service*, …etc.

Software as a Service

- Provide service – **Web Portal**
  - Apart from the standard search engine feature, web portals offer other services such as e-mail, news, stock prices, information, databases and entertainment.

  - Portals provide a way for enterprises to provide a consistent look and feel with access control and procedures for multiple applications and databases, which otherwise would have been different entities altogether.

  - Some examples :
    - iGoogle
    - MSNBC
    - Netvibes
    - Yahoo!

SaaS - Summary

- **SaaS is the finished applications that you rent and customize.**

- SaaS enabling technique
  - Web Service

- SaaS provide services
  - Web-based Applications
    - General applications
    - Business applications
    - Scientific applications
    - Government applications
  - Web Portal

Cloud computing Types contd.

- Based on Cloud location or **Deployment model**, there are mainly four of them.
  - **Private Cloud**
  - **Public Cloud**
  - **Hybrid Cloud**
  - **Community Cloud**

Cloud Computing Deployment models

|	Type	Properties
1.	Private cloud	• Outsource or own • Lease or buy • Separate or virtual data center
2.	Community cloud	• Private cloud for a set of users with specific demands • Several stakeholders
3.	Public cloud	• Mega scaleable infrastructure • Available for all
4.	Hybrid cloud	• Combination of two clouds • Usually private for sensitive data and strategic applications

Public Cloud

- **Public cloud definition**
    - The cloud infrastructure is made available to the **general public or a large industry group** and is owned by an organization selling cloud services.
    - Also known as **external cloud or multi-tenant cloud**, this model essentially represents a cloud environment that is openly accessible.
    - **Basic characteristics** :
        - Homogeneous infrastructure
        - Common policies
        - Shared resources and multi-tenant
        - Leased or rented infrastructure
   - Economies of scale
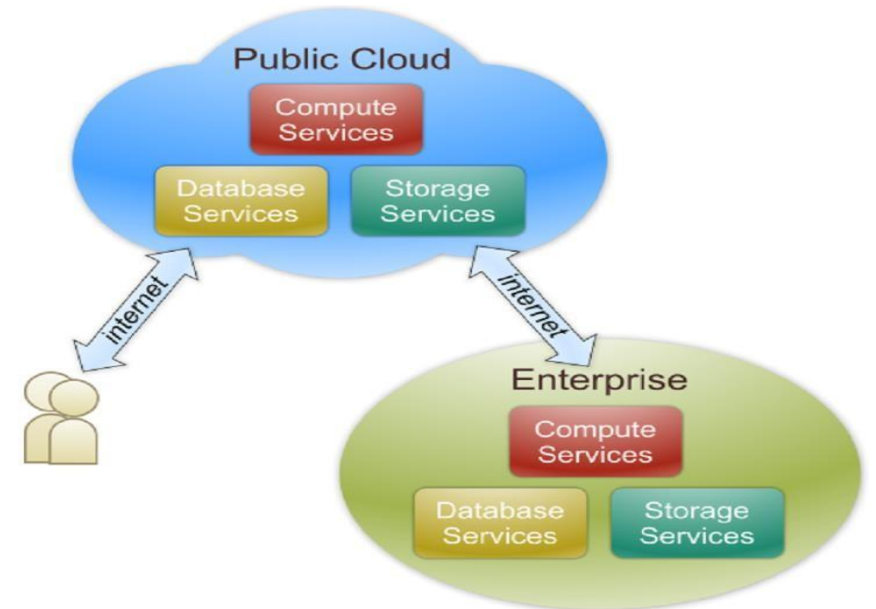
Private Cloud

- **Private cloud definition**
  - The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

  - Also referred to as internal cloud or on-premise cloud, a private cloud intentionally limits access to its resources to service consumers that belong to the same organization that owns the cloud.
  - **Basic characteristics :**
    - Heterogeneous infrastructure
    - Customized and tailored policies
    - Dedicated resources
    - In-house infrastructure
    - End-to-end control
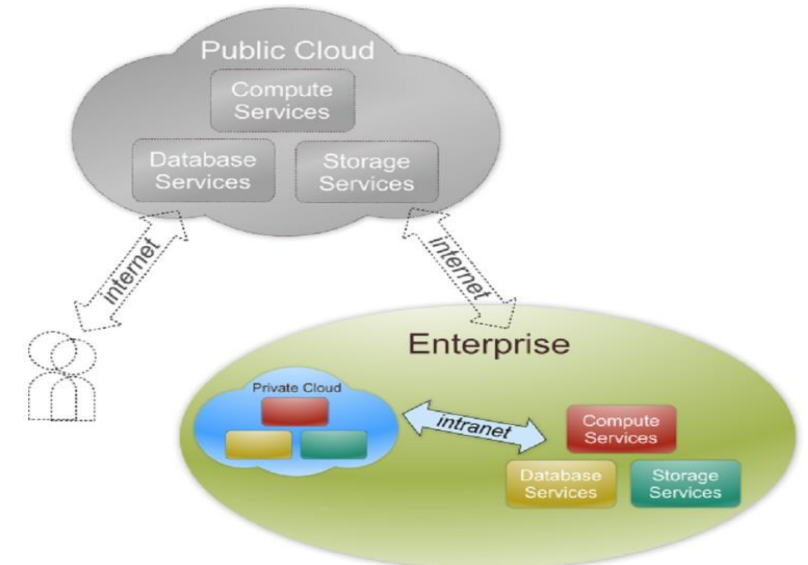
Public vs. Private

Comparison :

	Public Cloud	Private Cloud
Infrastructure	Homogeneous	Heterogeneous
Policy Model	Common defined	Customized & Tailored
Resource Model	Shared & Multi-tenant	Dedicated
Cost Model	Operational expenditure	Capital expenditure
Economy Model	Large economy of scale	End-to-end control

Community Cloud

- Community cloud definition
  - 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).
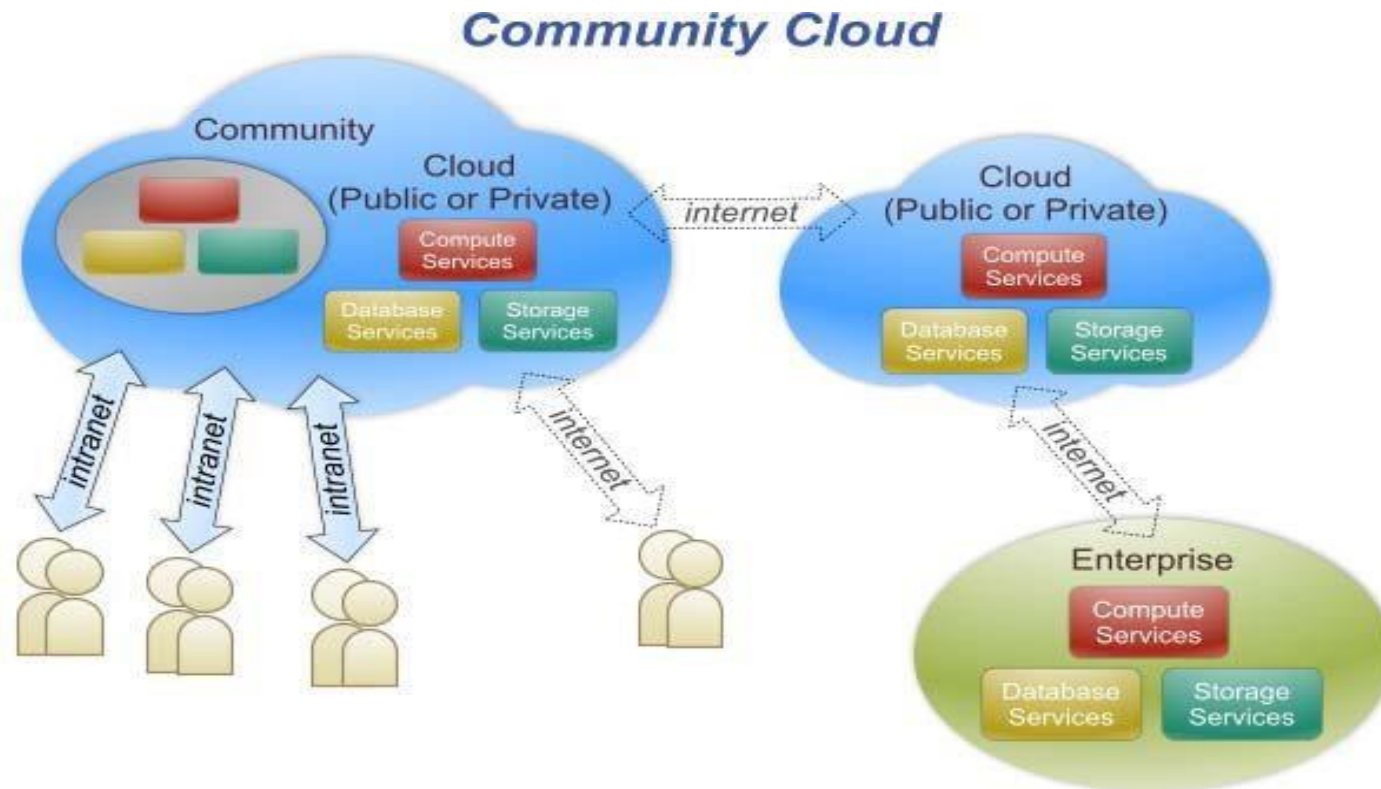
Community Cloud

Hybrid Cloud

- Hybrid cloud definition
  - The cloud infrastructure is a composition of **two or more clouds (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).
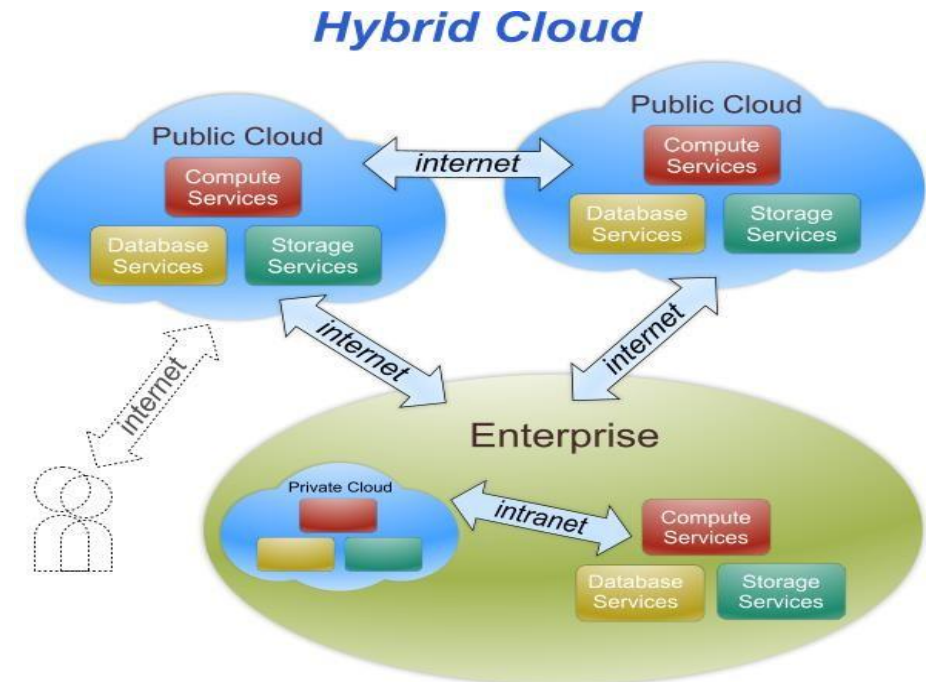
Cloud Ecosystem
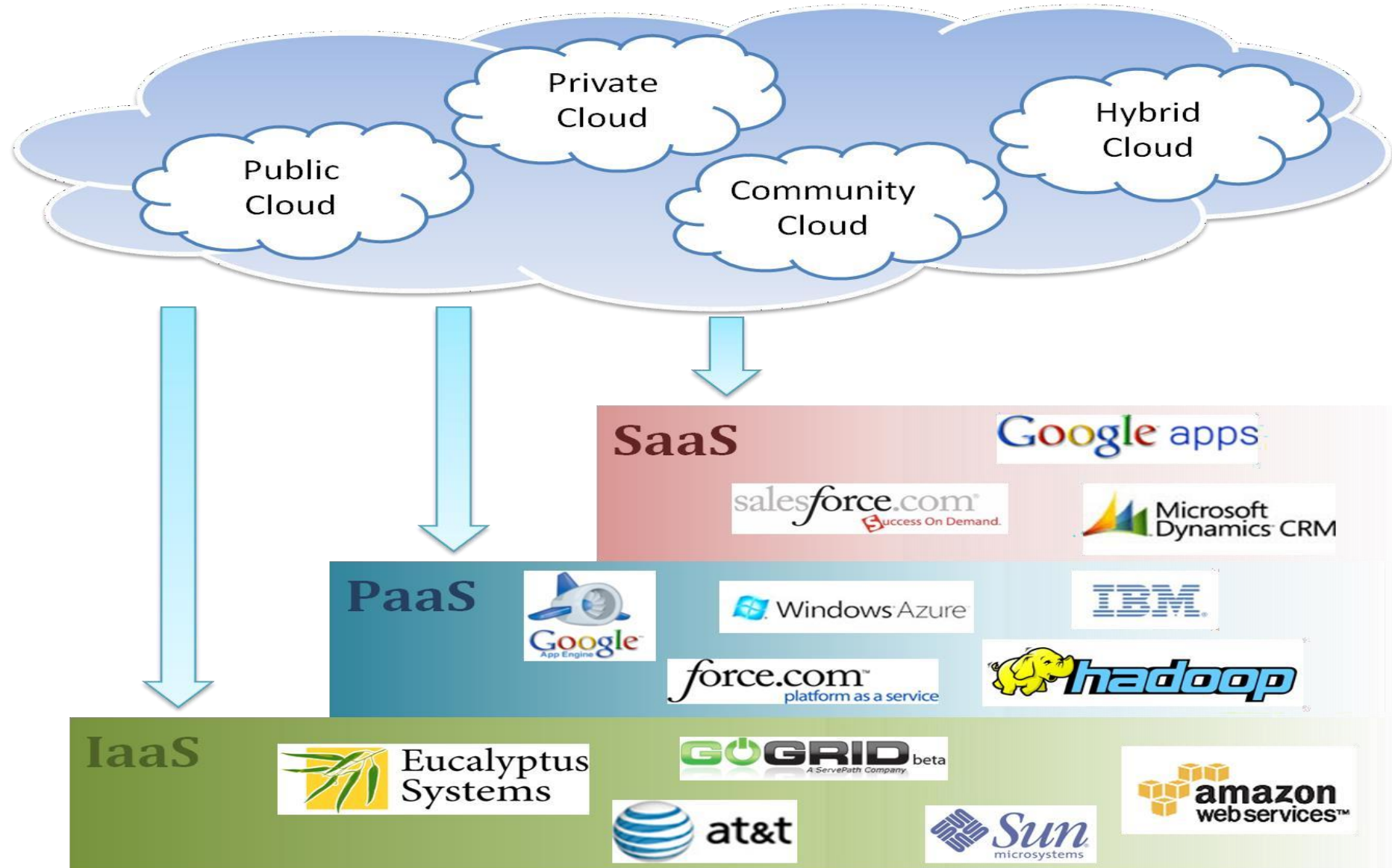
Components of Cloud computing

- Basic Components of Cloud Computing
  - Clients
  - Data center
  - Distributed servers

Components of Cloud computing

Clients : End Users

- **Mobile :** Mobile includes PDA, Smartphones, or any other portable devices which can access internet.

- **Thin Clients** : Now thin computers are that do not have internal hard drives or very low internal configuration, but rather the server do all there work and then display the information.

- **Thick Client :** Regular computers, Devices that has own capabilities to do some computing.

Components of Cloud computing

Data Center

- Now datacentre is collection of server where application to which you subscribe is housed,
- It could be a large room in basement, or room full of server which you access through internet.
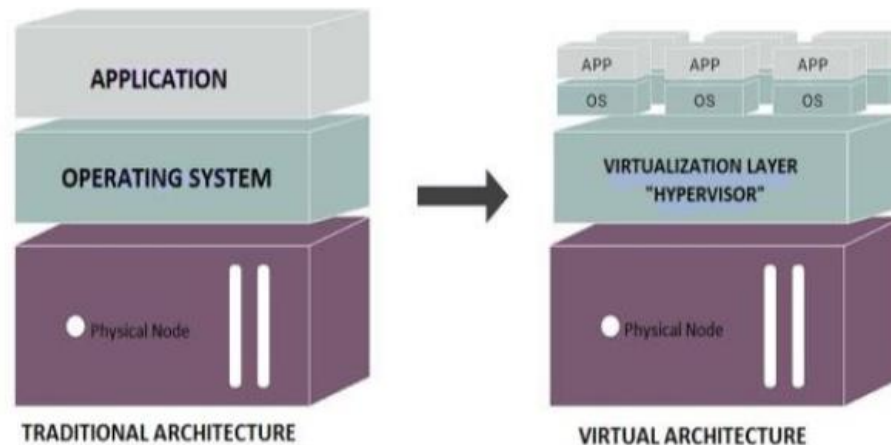
Components of Cloud computing

Distributed Severs

- Server don't have to be housed in same location often   server are in dispersed geographically location but to you   the   cloud   subscriber, these server acts if they are humming   right away next to each other.

- This gives the service provider more flexibility in option and security.

Role of virtualization in enabling the cloud.

- Virtualization is the Key component of Cloud Computing.

- it is the enabling technology allowing the creation of an intelligent abstraction layer which hides the complexity of underlying hardware or software.

- Virtualization is the ability to run "**Virtual machines**' on top of a "**hypviso**r".

- A hypervisor Provides a uniform abstraction of the underlying physical machine

APPLICATION

OPERATING SYSTEM

Physical Node

TRADITIONAL ARCHITECTURE

APP   APP   APP

OS   OS   OS

VIRTUALIZATION LAYER "HYPERVISOR"

Physical Node

VIRTUAL ARCHITECTURE

What Virtual Machines provide (characteristics)

Hardware Independence

- VM sees the same hardware regardless of the host hardware

Isolation

- VM's operating system is isolated from the host operating system

Encapsulation

- Entire VM encapsulated into a single file

Types of virtualization in Cloud

Hardware Virtualization:- With the help of Hypervisor one can divide processor, memory and other hardware resources. VMM (Virtual Machine Manager) installed on the hardware

OS Virtualization:- Multiple guest OS can be run over a single host OS. VMM installed on Host OS. Quicker than Server Virtualization

Server Virtualization:- One physical server divided into multiple servers. VMM installed on the server system.

Storage Virtualization:- Multiple physical storage is grouped to act as single large storage. One server sees multiple storages as one (due to virtualization) and storages see the server they are attached to.

Network Virtualization:- Combine the available resources in a network by splitting up the bandwidth into separate channels.

Software Virtualization:- Under the SaaS model instances of the same software installed are provided to multiple users.

Cloud Computing Characteristics

Common Characteristics:

Massive Scale	Resilient Computing
Homogeneity	Geographic Distribution
Virtualization	Service Orientation
Low Cost Software	Advanced Security

Essential Characteristics:

On Demand Self-Service

Broad Network Access	Rapid Elasticity
Resource Pooling	Measured Service

Characteristics of Cloud computing

- Five **essential characteristics** **(NIST model)** of cloud computing:
  - ❑ **O**n demand self-service
  - ❑ **B**road network access
  - ❑ **R**esource pooling
  - ❑ **R**apid Elasticity
  - ❑ **M**easured service

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 provider.

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, tablets, laptops and workstations).

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 location at a higher level of abstraction (e.g., country, state or datacenter).

- Examples of resources include storage, processing, memory and network bandwidth.

Rapid elasticity:

- Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand.

- To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

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 the provider and consumer.

Challenges of Cloud Computing

- **Security and Privacy**
  - Data security and privacy has been always the challenge in cloud computing.
  - there may be some data or applications that your organization will never feel comfortable letting out of sight.
- **Lack of Standards**
  - There is no standard associated with cloud computing.
  - The Open Grid Forum is developing an Open Cloud Computing Interface to resolve this issue and the Open Cloud Consortium is working on cloud computing standards and practices

Challenges of Cloud Computing

- **Continuously Evolving**
  - User requirements are continuously evolving, as are the requirements for interfaces, networking, and storage. So Cloud has to grow accordingly to meet all the requirements for interfaces, networking, storages etc.
- **Integration with Existing Infrastructure**:
  - This is a difficult yet essential piece of maximizing the value of cloud services.
- **Vendor Transparency:**
  - "Trust me" is not what you want to hear from your service provider.

Application Availability, Performance, Security and Disaster

Application Availability

➢ A measure used to evaluate if an application is functioning properly and meets the business requirements

➢ Cloud provides high availability with a high degree of performance.

➢ Available 24/7 with nodes in major parts of the world

➢ **Determined based on:**

▪ Application uptime/downtime

▪ Number of complete transactions

▪ Timeouts, errors, missing resources

➢ **Uses different techniques to guarantee high availability:-**

▪ Load balancer

▪ Concept of availability zones

▪ Health checks

Application Availability, Performance, Security and Disaster

➤ A measure used to monitor and ensure effective operations
➤ Guarantee a certain degree of performance under SLA
➤ Determined based on:
  ○ Input/Output Operations per Second (IOPS)
  ○ File system performance
  ○ Caching
➤ Uses different techniques to guarantee Performance:
  ○ Data backup
  ○ Disaster recovery
  ○ Fault tolerance
  ○ Load balancer
  ○ Autoscaling
  ○ Easy maintenance
  ○ Using appropriate infrastructure

Types of performance testing:
  ○ Stress testing
  ○ Load testing
  ○ Latency testing
  ○ Failover testing

Application Availability, Performance, Security and Disaster

Security

- Consists of a set of policies, controls, procedures that work together to protect the cloud-based system
- Configured to protect cloud data and customer privacy under SLA
- CSP is responsible for the physical security of the server and provides various measures to clients to implement on their end. like Firewall, **Virtual Private Cloud (VPC), Multi-Factor Authentication (MFA), Access Control List (ACL),** Identity Access Management (IAM), Server and client-side Encryption
- Data backup

Application Availability, Performance, Security and Disaster

Disaster
- An unpredictable event that causes an interruption in services
- Cloud provide an effective and cheap Disaster recovery plan (DRP) facility
- If the current functioning server fails then it is the responsibility of CSP to spin another server within a certain time frame and continue its operation.

CSP employs features like :
- ❑ Data backup
- ❑ Automation in server deployment and recovery
- ❑ Rapid elasticity to minimize downtime
- ❑ Availability zone to redirect traffic to other AZ in the region in case of a disaster in one.