

# Cloud Computing

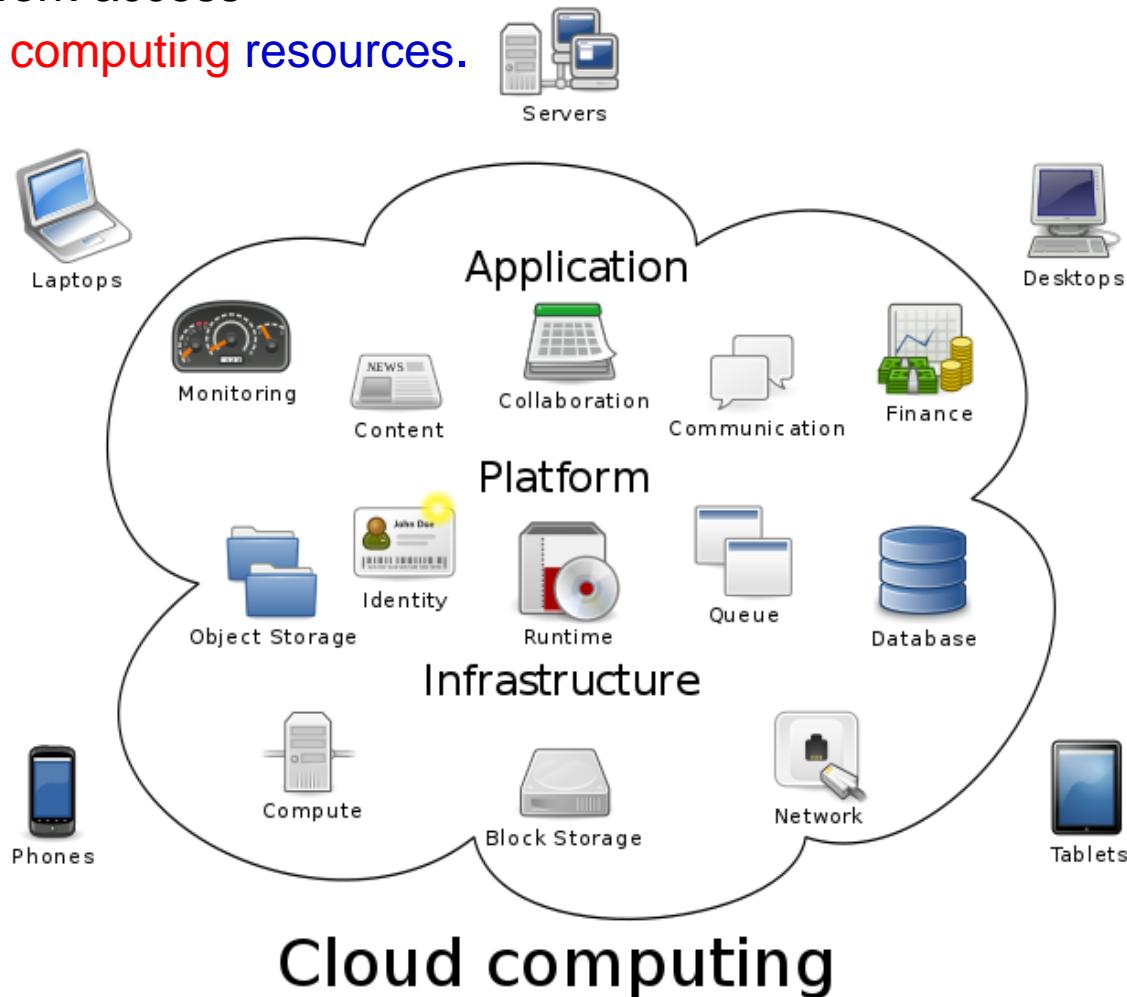
ACTS, CDAC Bangalore

# **Presentation Plan**

- **Introduction to Cloud computing**
  - **Evolution of Technologies: Computing, Networking**
  - **Definitions of Cloud Computing**
  - **Characteristics of Cloud Computing**
- **Deployment methods**
- **Service models**
- **Virtualization**
- **Private Cloud Setup using OpenStack**
- **Conclusions**

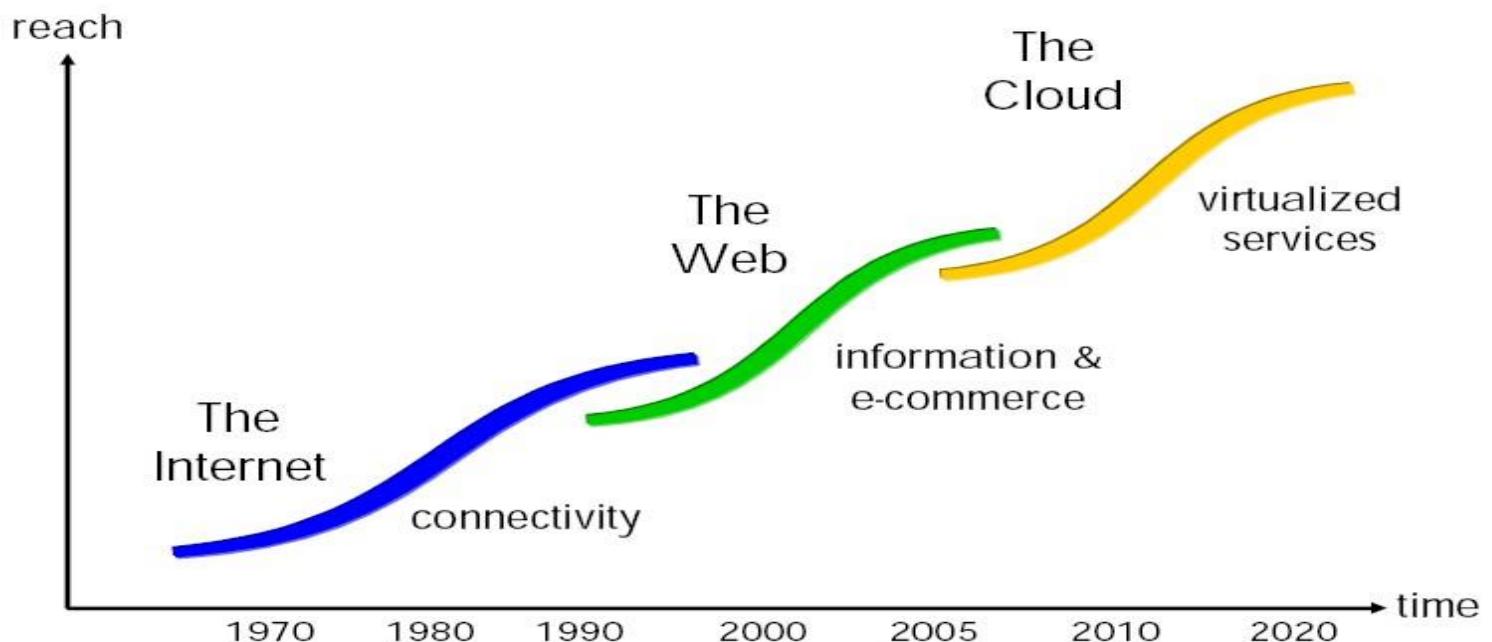
# Cloud computing - Introduction

- New **delivery model** for **on-demand access** to share pool of configured resources such as Server, Network, Storage
- Provide services such as **Data Storage, Software Applications, and email and file exchanges**
- **Ubiquitous** network access
- Promise **elastic computing resources.**



# Cloud Computing ?

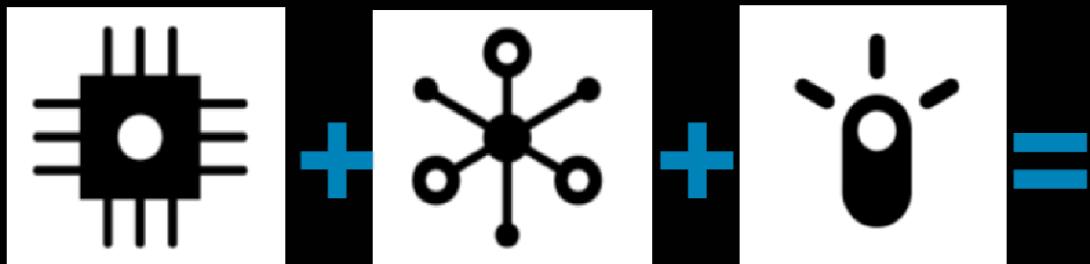
## Cloud - Third Generation of the Internet



# Cloud Computing.....



INSTRUMENTED    INTERCONNECTED    INTELLIGENT



An opportunity to think and act in new ways:

Service Creation  
Service Delivery  
Service Management

# The Next Revolution in IT?

# Classical Computing

- **Buy & Own**
    - Hardware, SystemSW, Applications: to meet peak needs.
  - **Install, Configure, Test, Verify, Evaluate**
  - **Manage**
  - ..
  - **Finally, use it**
  - **\$\$\$\$....\$(HighCapEx)**

Every 18 months?

# Cloud Computing

- **Subscribe**
  - **Use It**

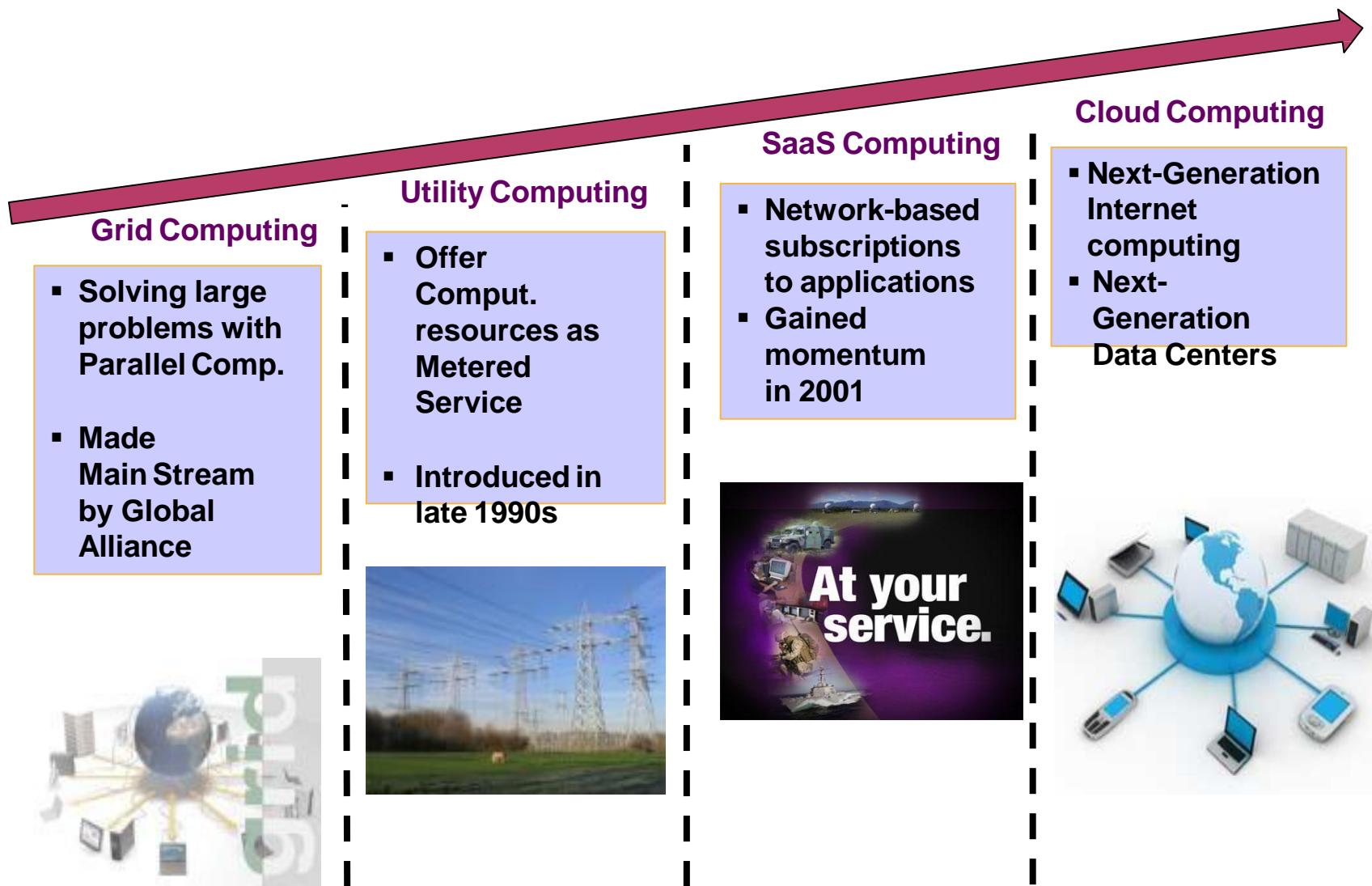


- \$ - Pay for what you use, based on QoS
  - No CapEx , Only OpEx

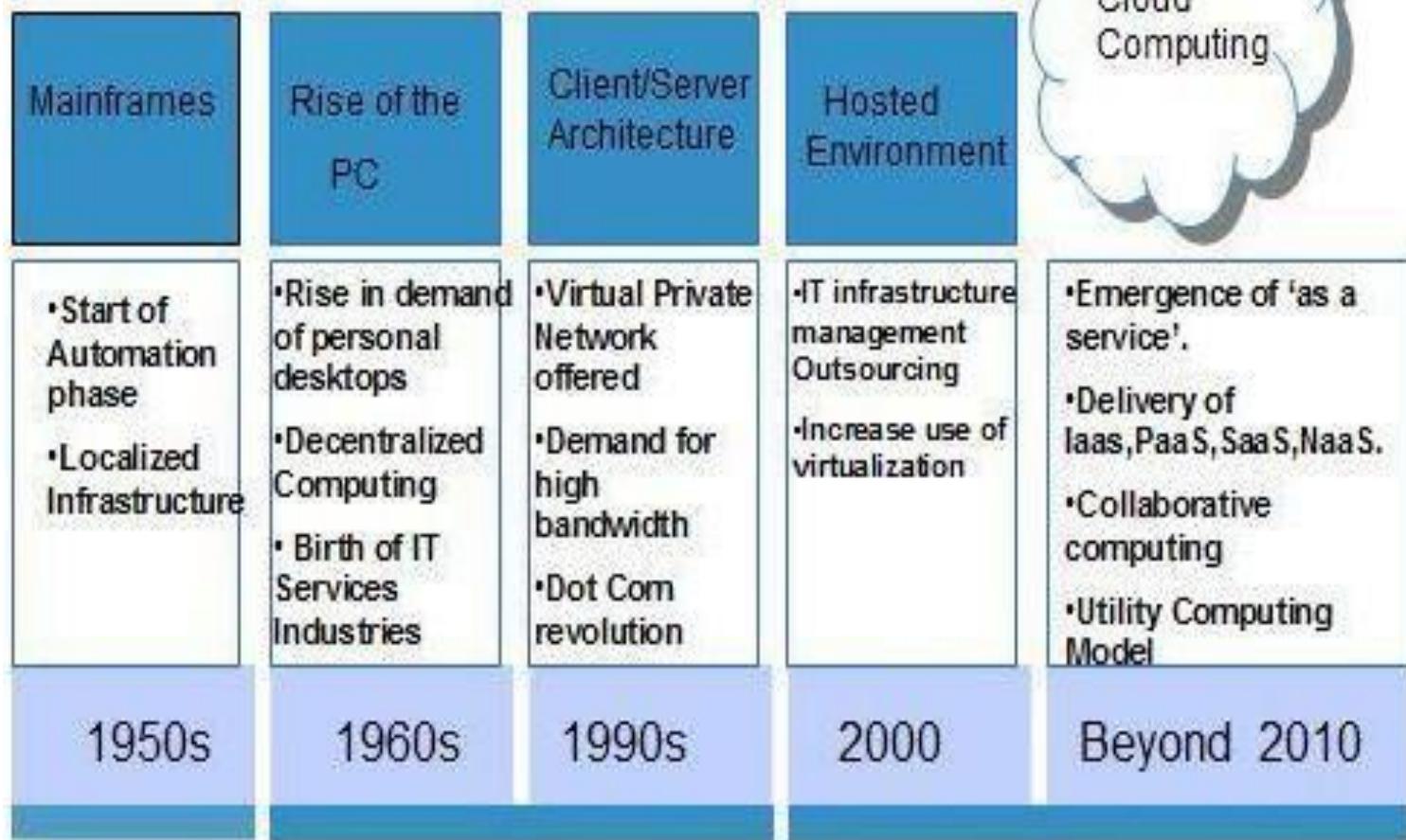
# New IT Trends

- **Ownership -> Leasing Model**
    - Infrastructure, platform, applications
  - **PC-> Internet Data Center**
    - Building applications for a single user → large number of concurrent consumers
  - **Web 2.0 & Virtualisation**
    - Building 3<sup>rd</sup> party IT services by composing multiple independent services

# Evolution of Cloud Computing



# History



# Properties and Characteristics





## Scalability & Elasticity



Give me the world  
without limitation!!



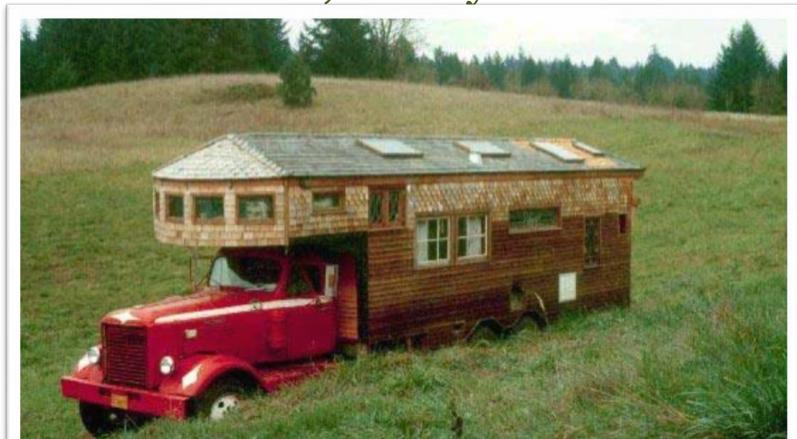
## Scalability & Elasticity

- What is scalability ?
  - A desirable property of a system, a network, or a process, which indicates its ability to either handle growing amounts of work in a graceful manner or to be readily enlarged.
- What is elasticity ?
  - The ability to apply a quantifiable methodology that allows for the basis of an adaptive introspection within a real time infrastructure.
- But how to achieve these properties ?
  - Dynamic provisioning
  - Multi-tenant design



## Dynamic Provisioning

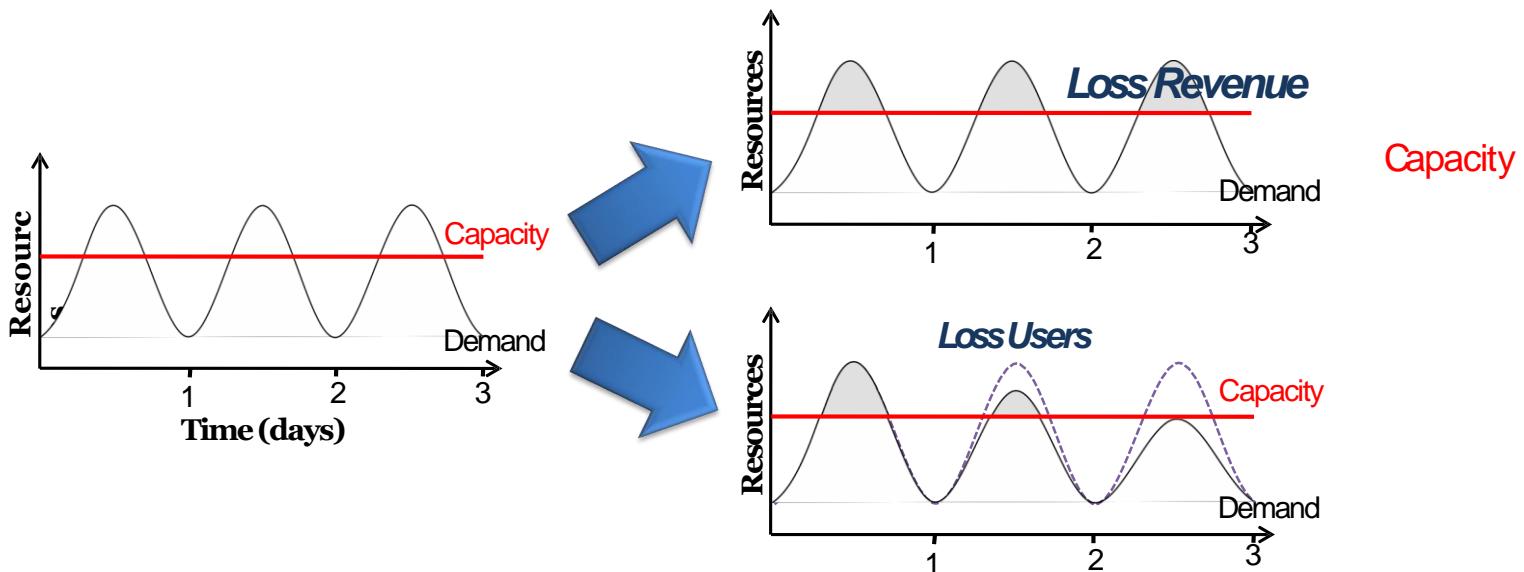
- What is dynamic provisioning ?
  - Dynamic Provisioning is a simplified way to explain a complex networked server computing environment where server computing instances are provisioned or deployed from a administrative console or client application by the server administrator, network administrator, or any other enabled user.





## Dynamic Provisioning

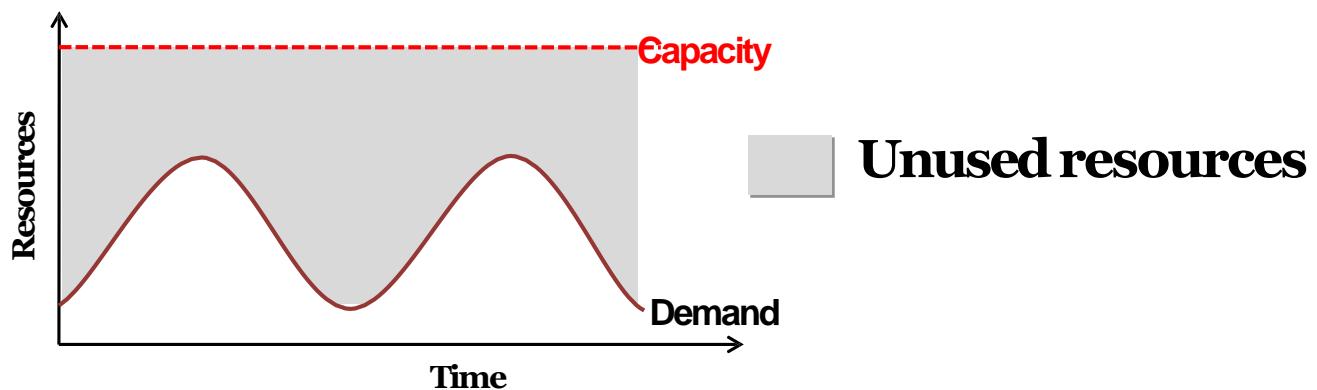
- In traditional computing model, two common problems :
  - Underestimate system utilization which result in under provision





## Dynamic Provisioning

- Overestimate system utilization which result in low utilization

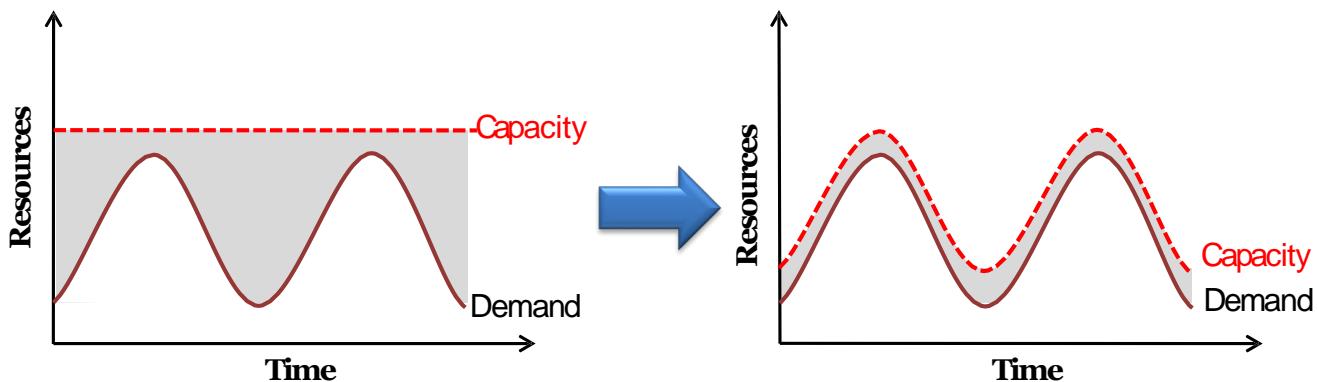


- How to solve this problem ??
  - Dynamically provision resources

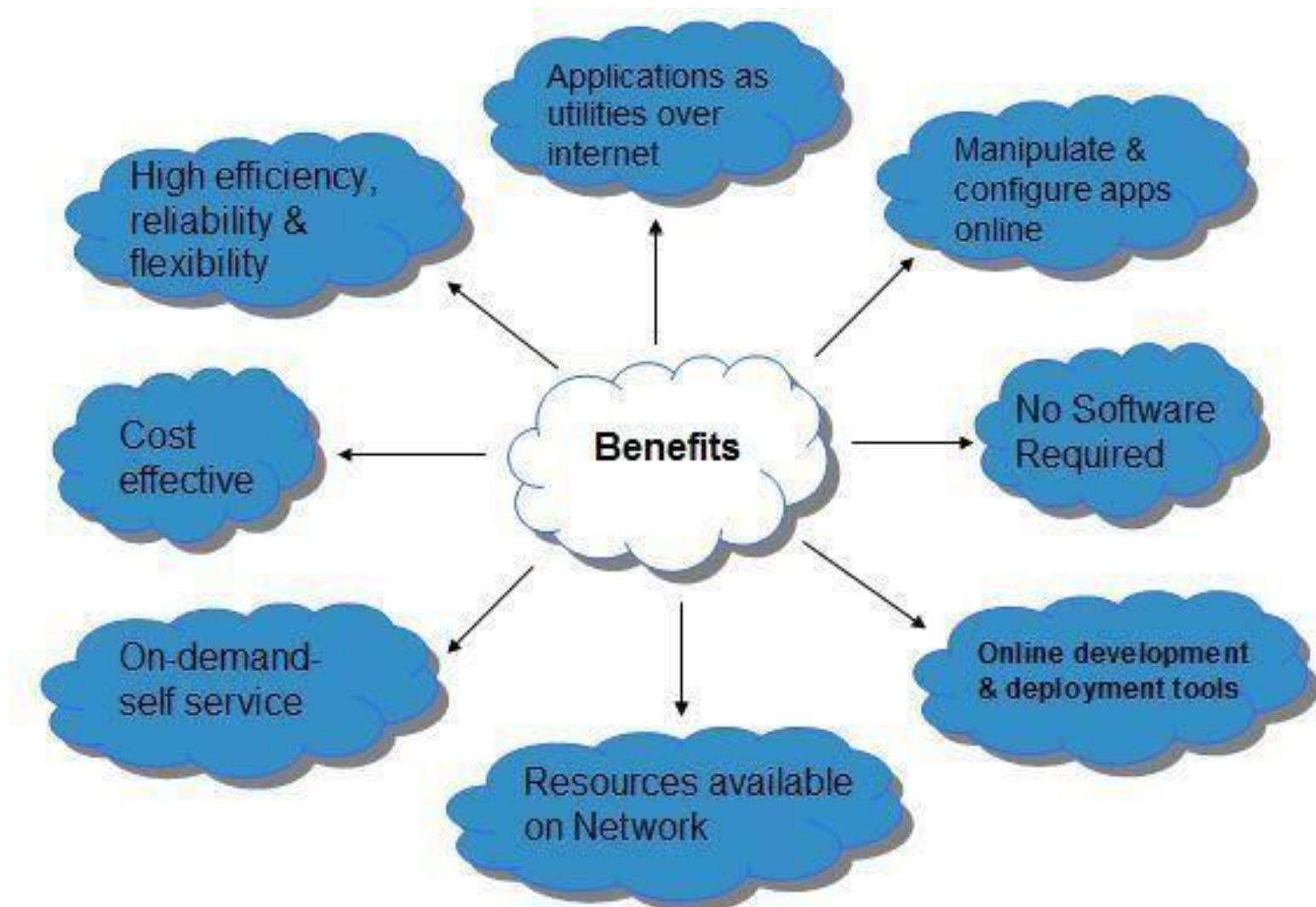


## Dynamic Provisioning

- Cloud resources should be provisioned dynamically
  - Meet seasonal demand variations
  - Meet demand variations between different industries
  - Meet burst demand for some extraordinary events



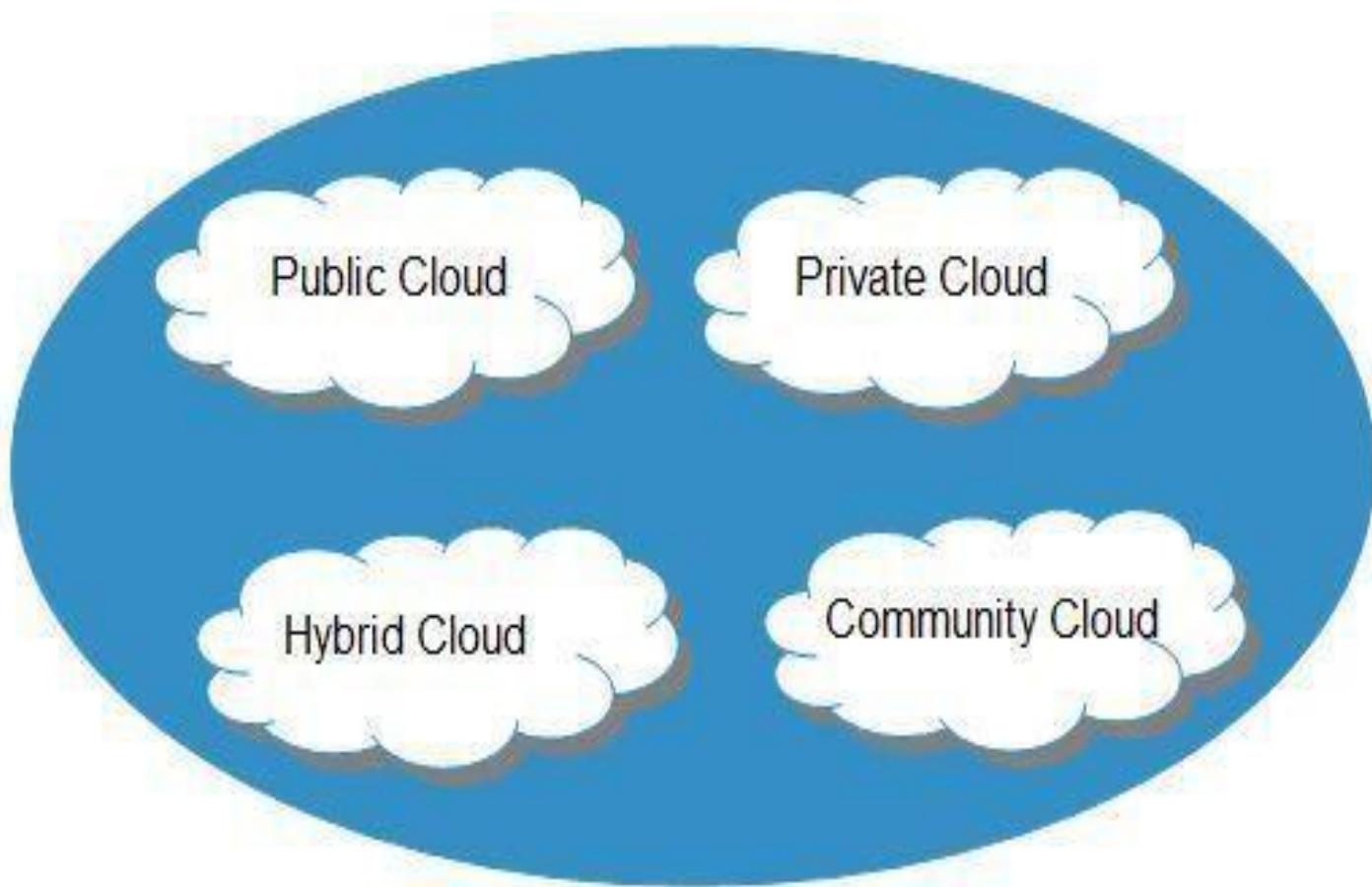
# Benefits

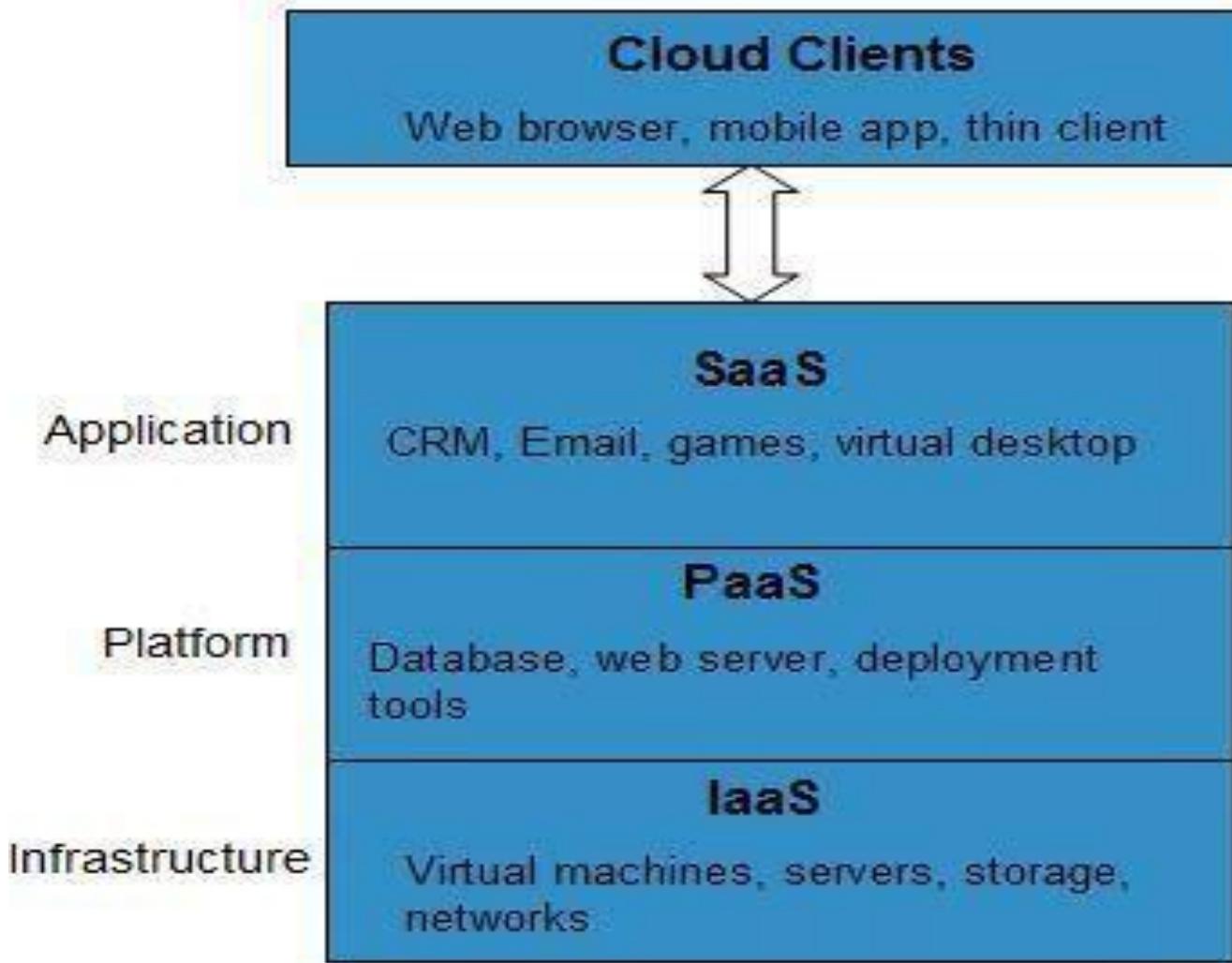


# Benefits

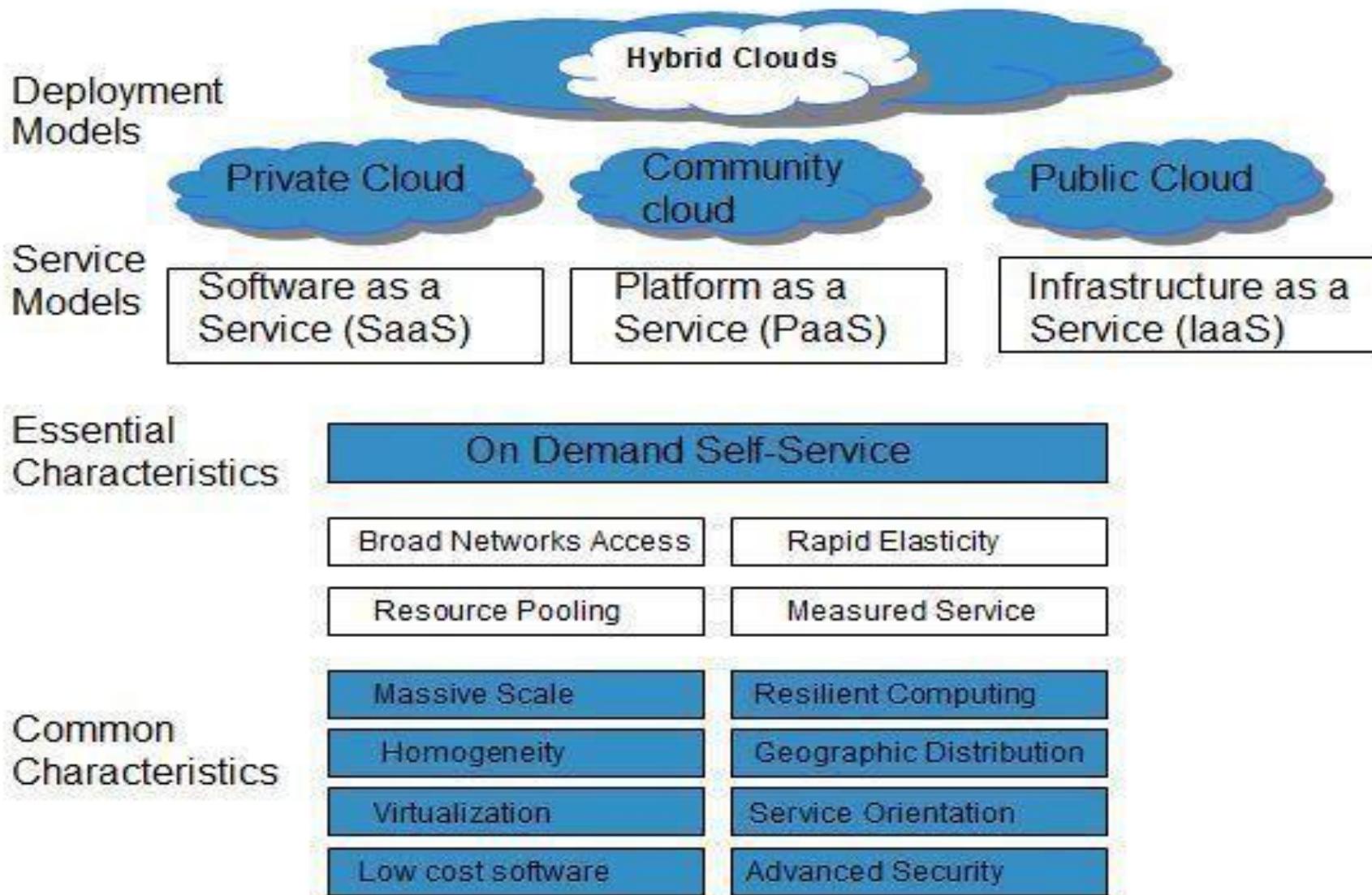
- One can access applications as utilities, over the Internet.
- Manipulate and configure the application online at any time.
- It does not require to install a specific piece of software to access or manipulate cloud application.
- Cloud Computing offers online development and deployment tools, programming runtime environment through **Platform as a Service model**.
- Cloud resources are available over the network in a manner that provides platform independent access to any type of clients.
- Cloud Computing offers **on-demand self-service**. The resources can be used without interaction with cloud service provider.
- Cloud Computing is highly cost effective because it operates at higher efficiencies with greater utilization. It just requires an Internet connection.
- Cloud Computing offers load balancing that makes it more reliable.

# Deployment Models





# Characteristics

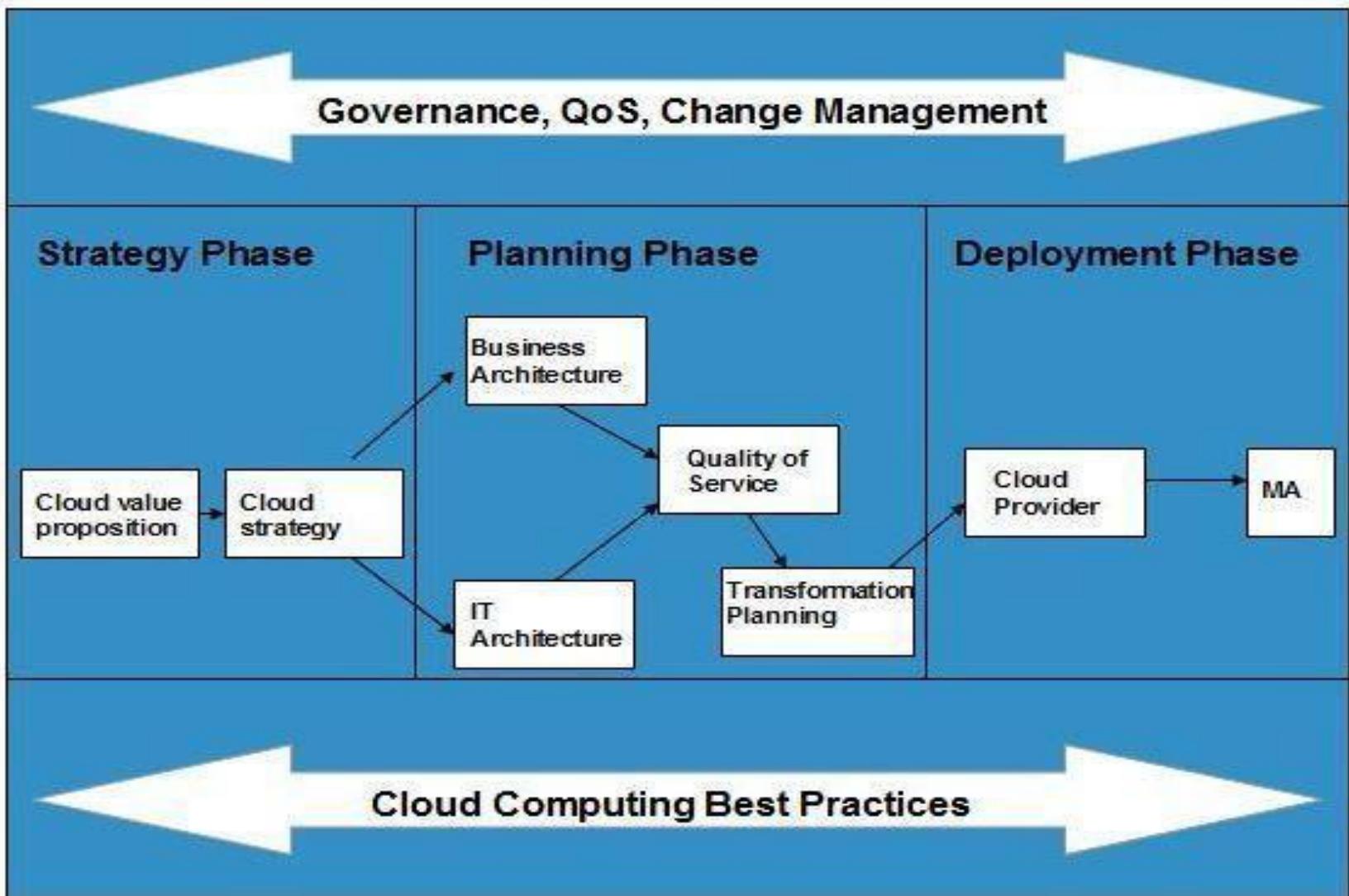


# Cloud computing - Planning

Before deploying applications to cloud, it is necessary to consider your business requirements. Following are the issues one must have to think about:

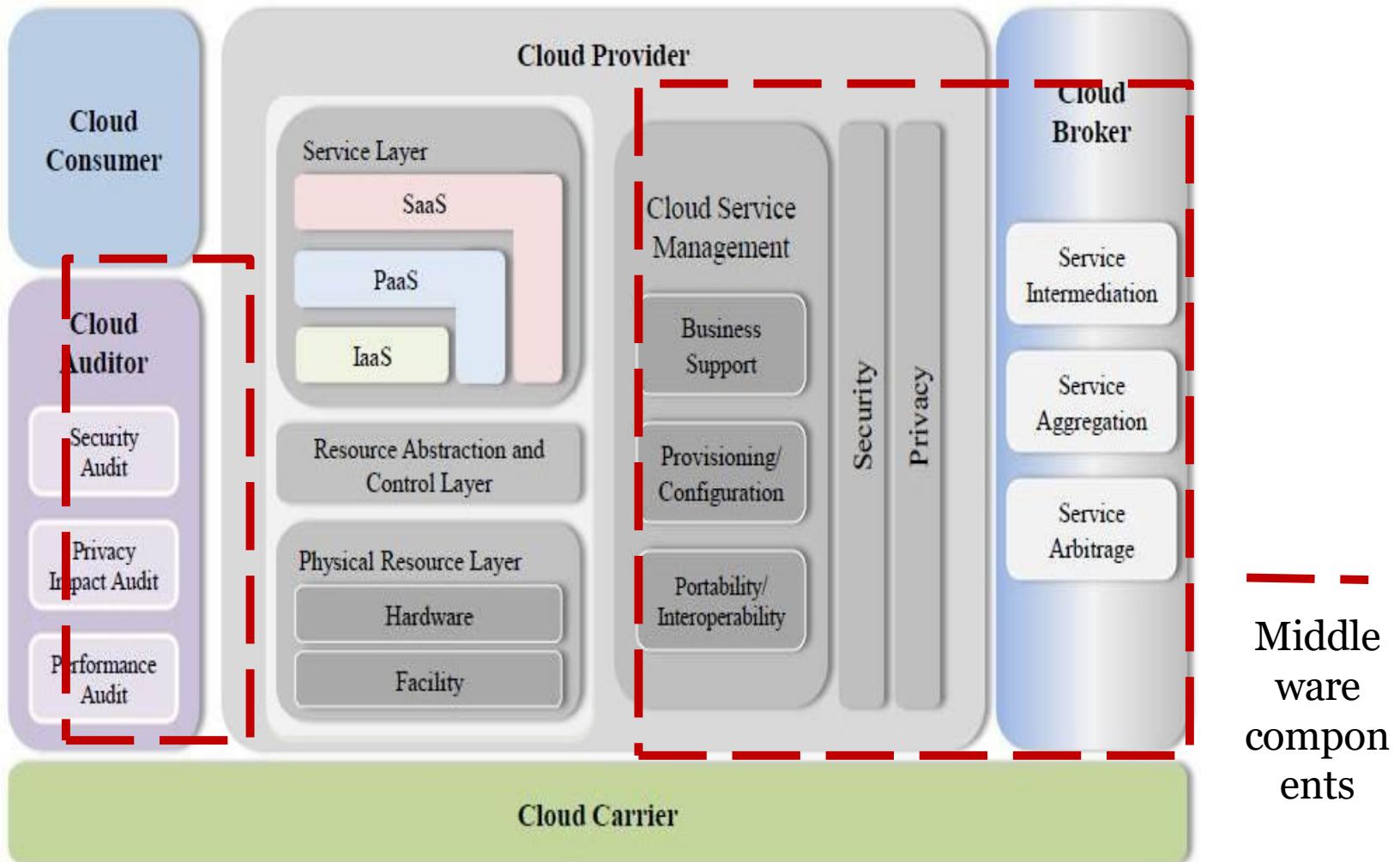
- Data Security and Privacy Requirement
- Budget Requirements
- Type of cloud - public, private or hybrid
- Data backup requirements
- Training requirements
- Dashboard and reporting requirements
- Client access requirements
- Data export requirements

# Cloud computing - Planning



# Cloud Computing Reference Architecture

Courtesy: National Institute of Standards and Technology



# Cloud Architecture

User level

**Cloud Applications:**  
Social computing, Enterprise, ISV, Scientific, CDNs, ...

User-Level  
Middleware

**Cloud programming: environments and tools**

Web 2.0 Interfaces, Mashups, Concurrent and Distributed Programming, Workflows, Libraries, Scripting

Core  
Middleware

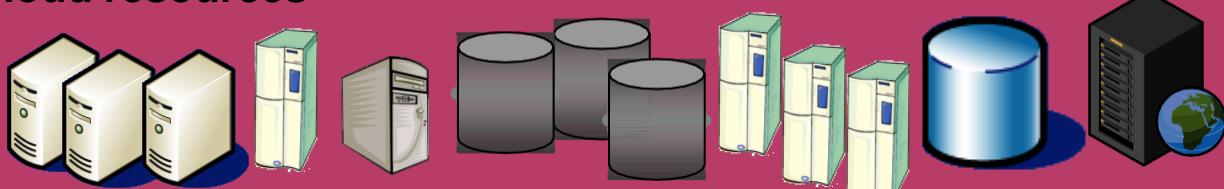
Apps Hosting Platforms

QoS Negotiation, Admission Control, Pricing, SLA Management, Monitoring, Execution Management, Metering, Accounting, Billing

System level

Virtual Machine (VM), VM Management and Deployment

Cloud resources



Adaptive Management

Autonomic / Cloud Economy

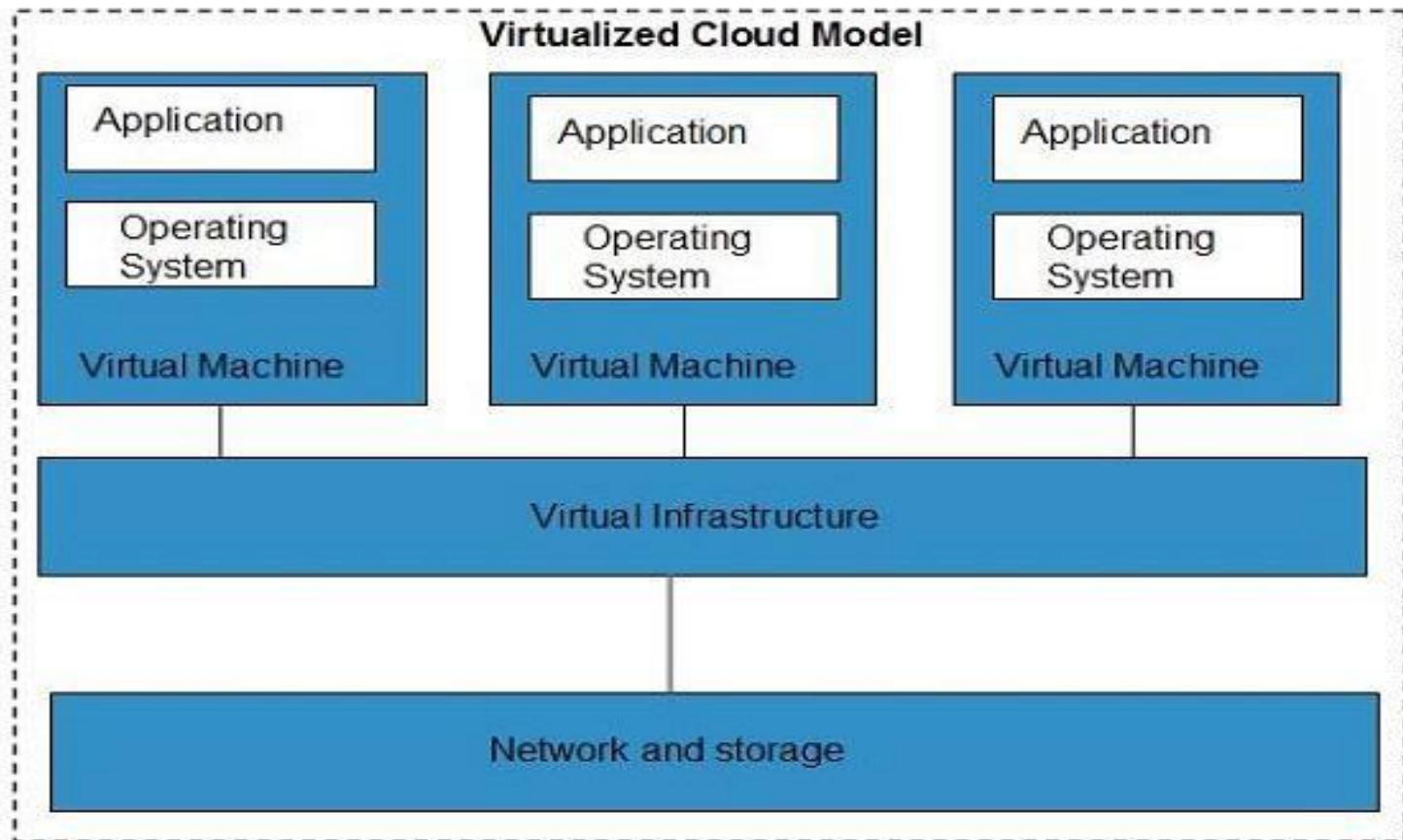
# Cloud computing - Technologies

There are certain technologies that are working behind the cloud computing platforms making cloud computing flexible, reliable, usable.

- Virtualization
- Service-Oriented Architecture (SOA)
- Grid Computing
- Utility Computing

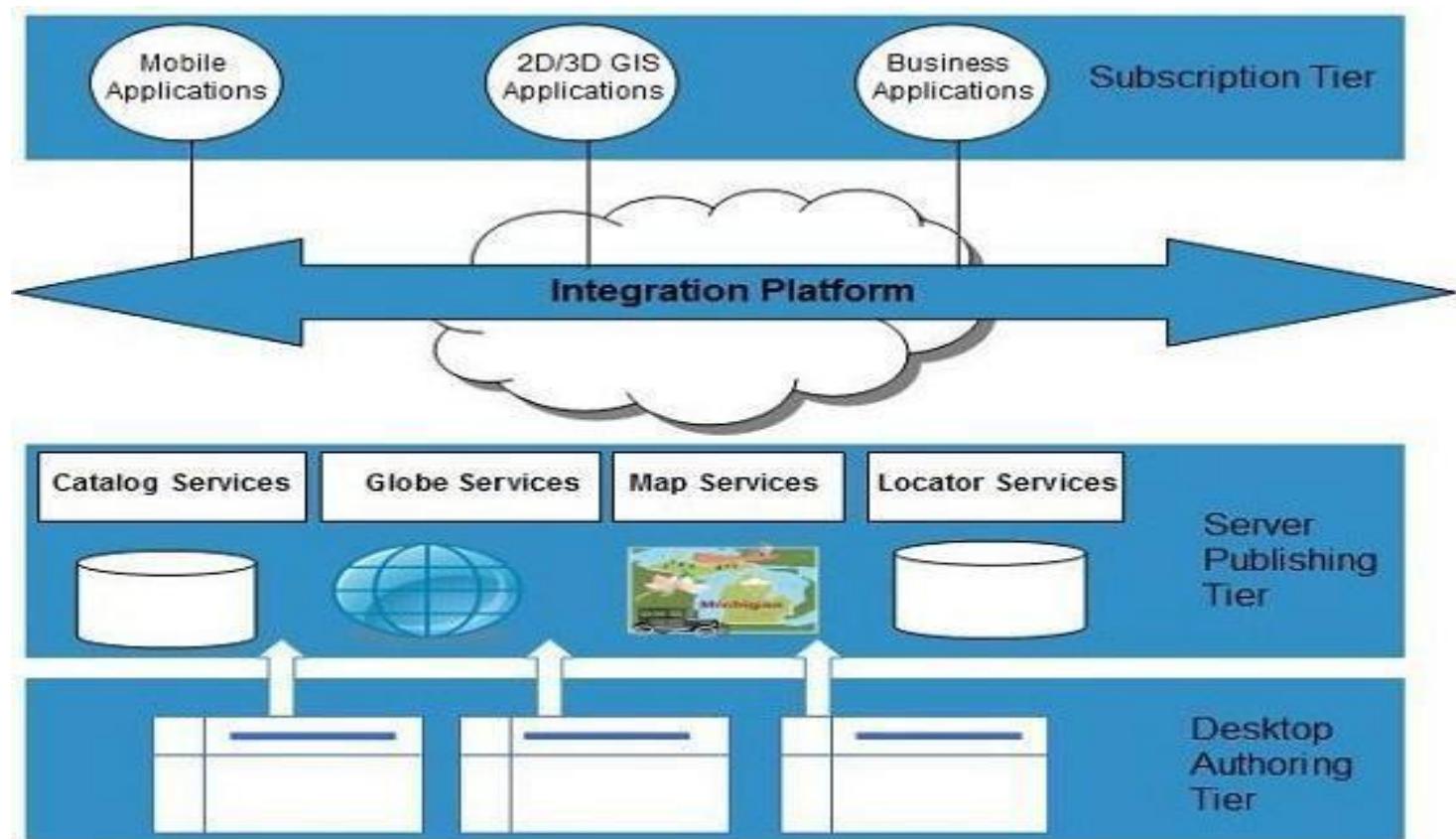
# Virtualization

- It is a technique, which allows to share single physical instance of an application or resource among multiple organizations or tenants
- It does so by assigning a logical name to a physical resource and providing a pointer to that physical resource when demanded.



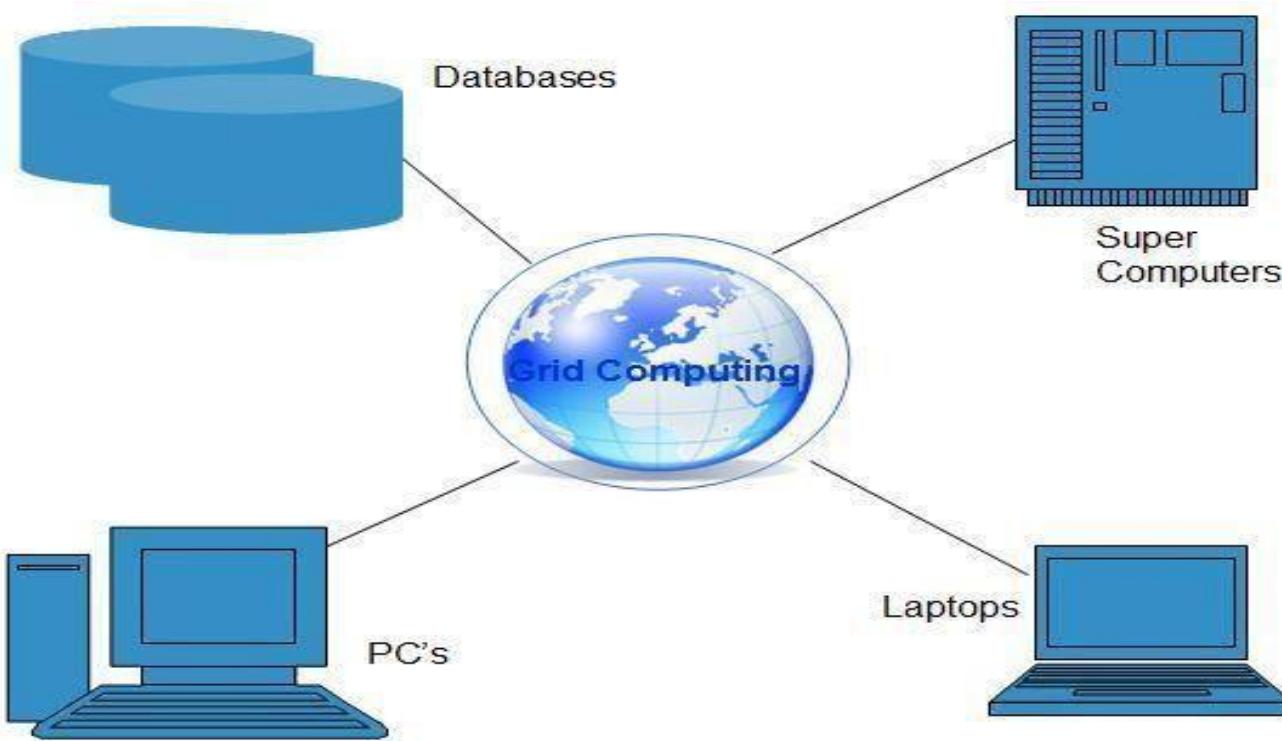
# Service-Oriented Architecture(SOA)

- Helps to use applications as a service for other applications regardless the type of vendor, product or technology
- It is possible to exchange of data between applications of different vendors without additional programming or making changes to services



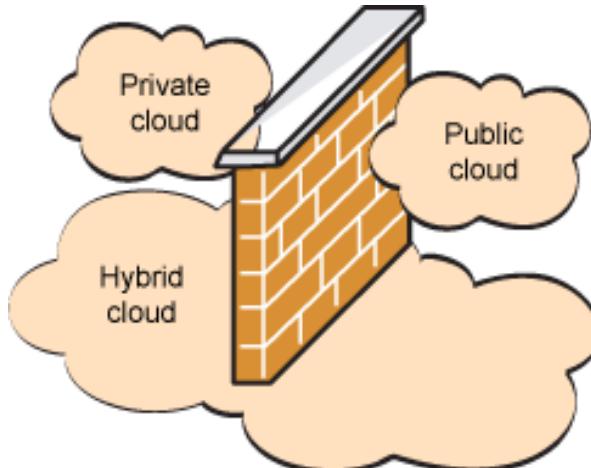
# Grid Computing

- Refers to distributed computing in which a group of computers from multiple locations are connected with each other to achieve common objective.
- These computer resources are heterogeneous and geographically dispersed



- **Utility computing** is based on **Pay per Use** model. It offers computational resources on demand as a metered service. Cloud computing, grid computing, and managed IT services are based on the concept of Utility computing.

# Cloud Deployment Models



**Public/Internet  
Clouds**

**3rd party,  
multi-tenant Cloud  
infrastructure  
& services:**

**\* available on  
subscription basis  
(pay as you go)**

**Private/Enterprise  
Clouds**

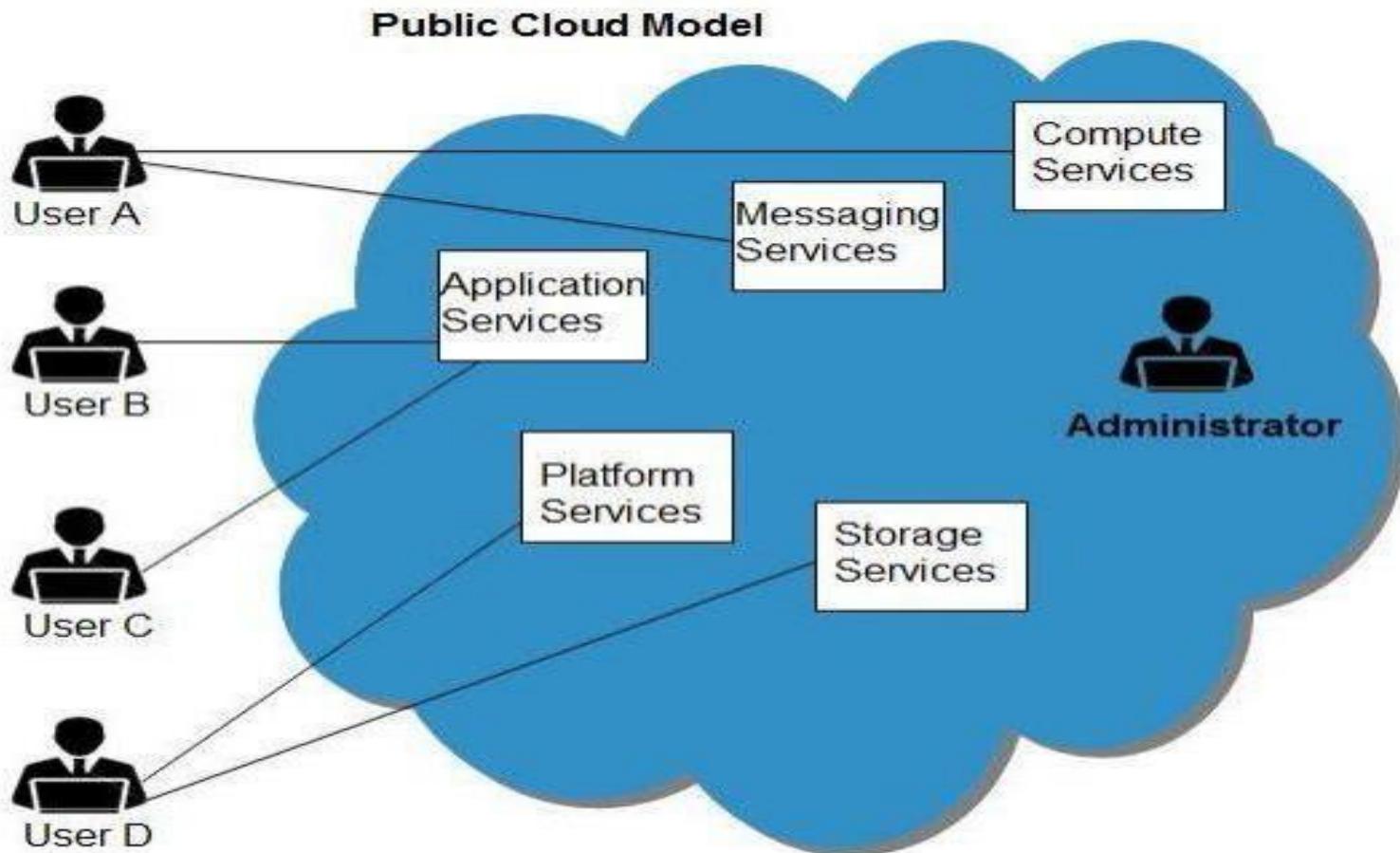
**Cloud computing  
model run  
within a company's  
own Data Center /  
infrastructure for  
internal and/or  
partners use.**

**Hybrid/Mixed Clouds**

**Mixed usage of  
private and public  
Clouds:  
Leasing public  
cloud services  
when private cloud  
capacity is  
insufficient**

# Public Cloud

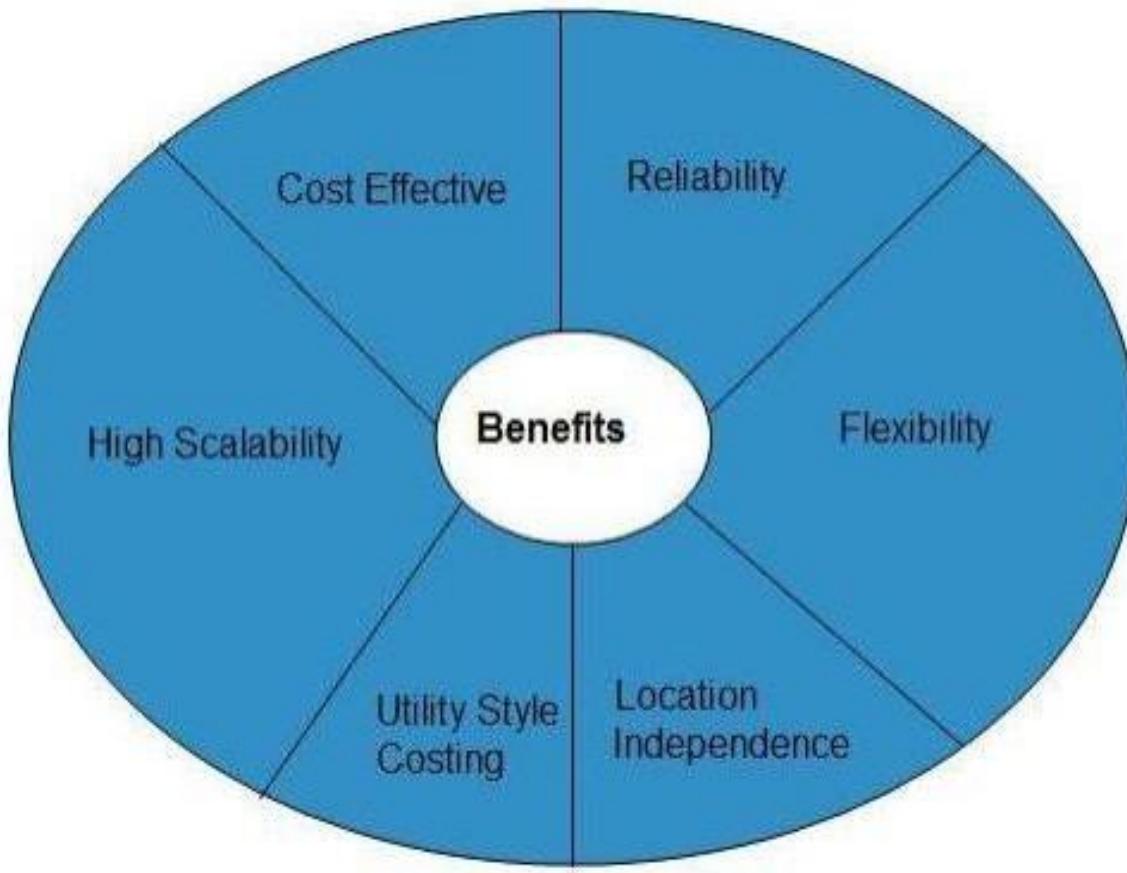
Allows systems and services to be easily accessible to general public, e.g., Google, Amazon, Microsoft offers cloud services via Internet.



# Promised Benefits of Public Clouds

- **No upfront infrastructure investment**
  - No procuring hardware, setup, hosting, power, etc
- **On demand access**
  - Lease what you need and when you need
- **Efficient Resource Allocation**
  - Globally shared infrastructure, can always be kept busy by serving users from different time zones/regions.
- **Nice Pricing**
  - Based on Usage, QoS, Supply and Demand, Loyalty
- **Application Acceleration**
  - Parallelism for large-scale data analysis, what-if scenarios studies
- **Highly Available, Scalable, and Energy Efficient**
- **Supports Creation of 3<sup>rd</sup> Party Services & Seamless offering**
  - Builds on infrastructure and follows similar Business model as Cloud

# Benefits...



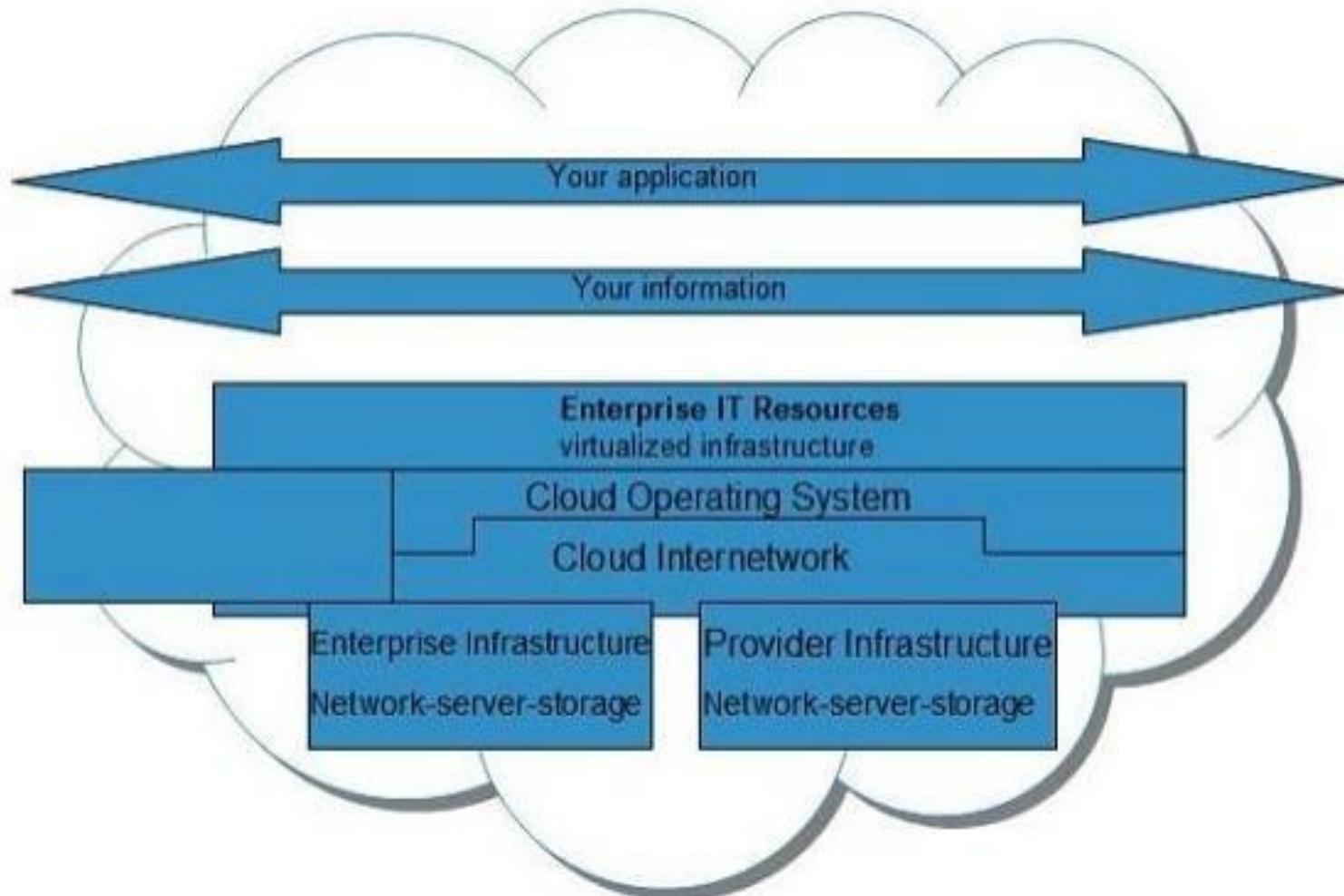
## Disadvantages

- **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.

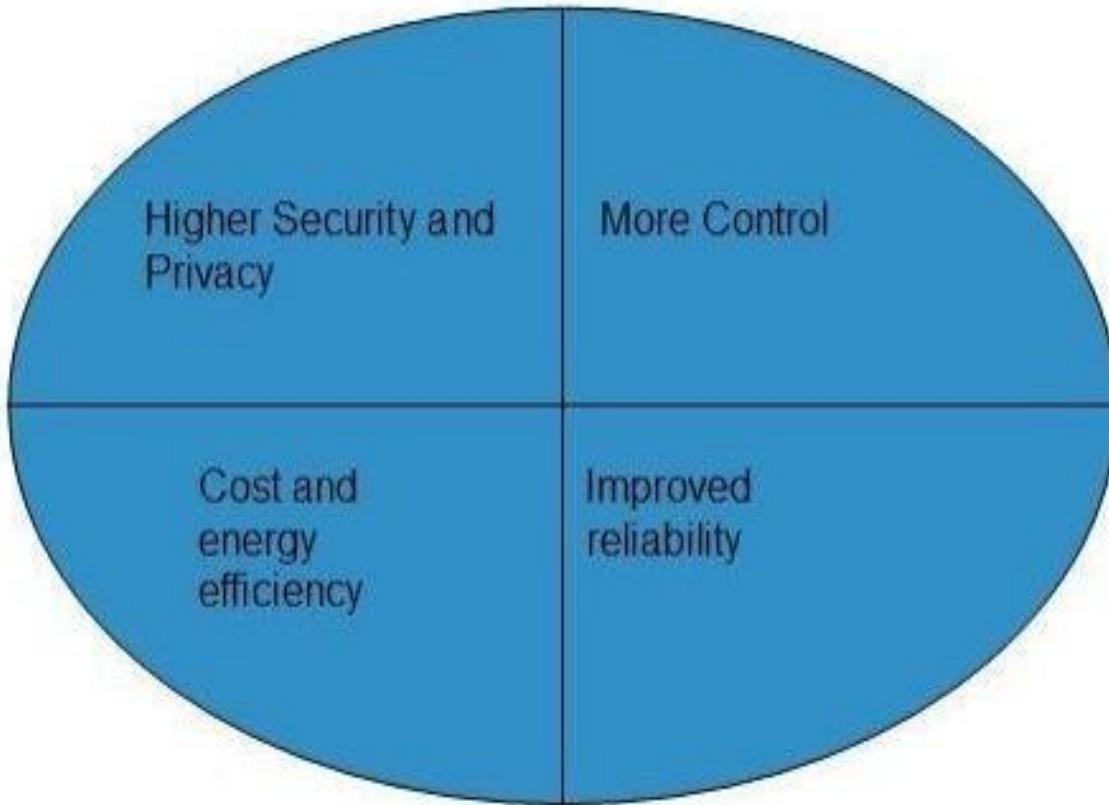
# Private Cloud

- Allows systems and services to be accessible within an organization. operated only within a single organization.
- It may be managed internally or by third-party.

Private Cloud Model



# Benefits



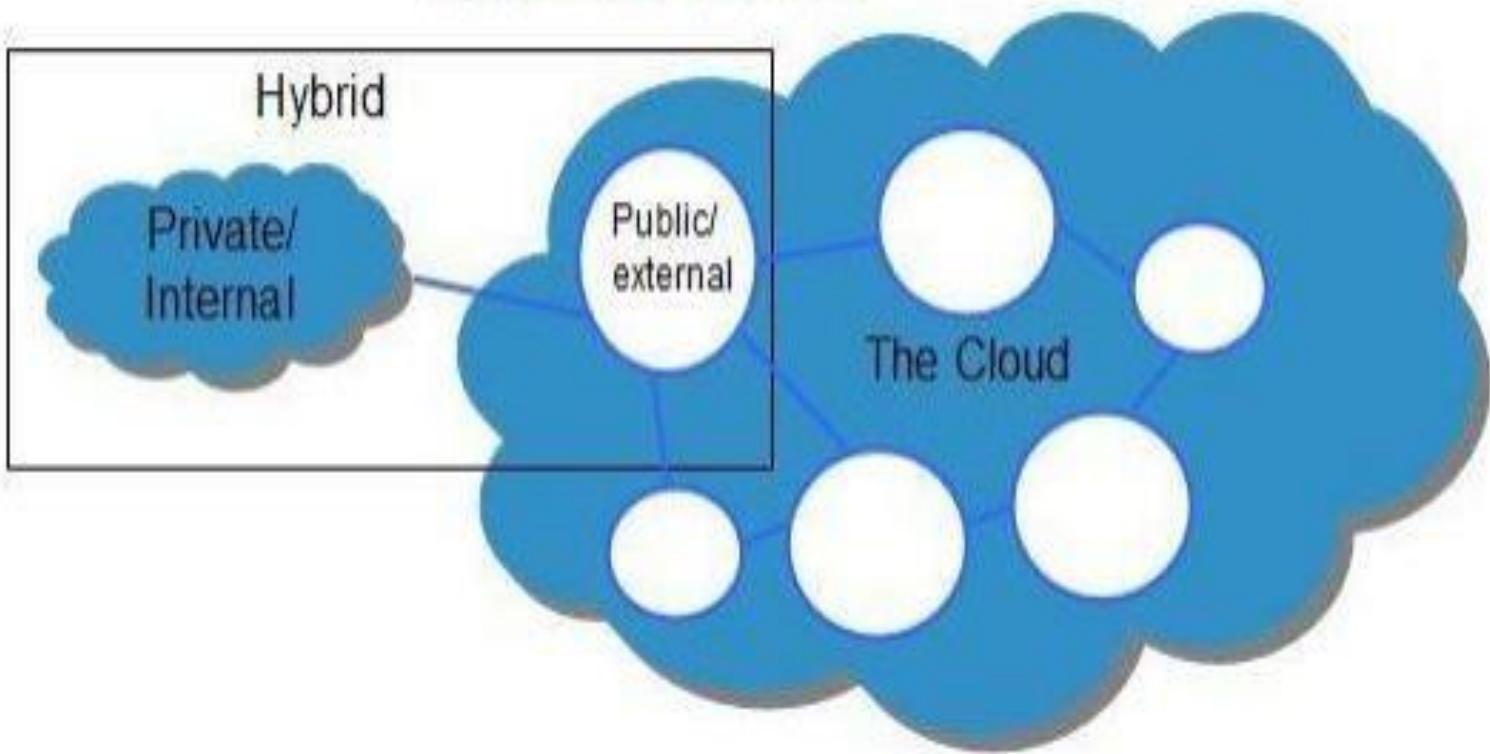
## Disadvantages

- 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

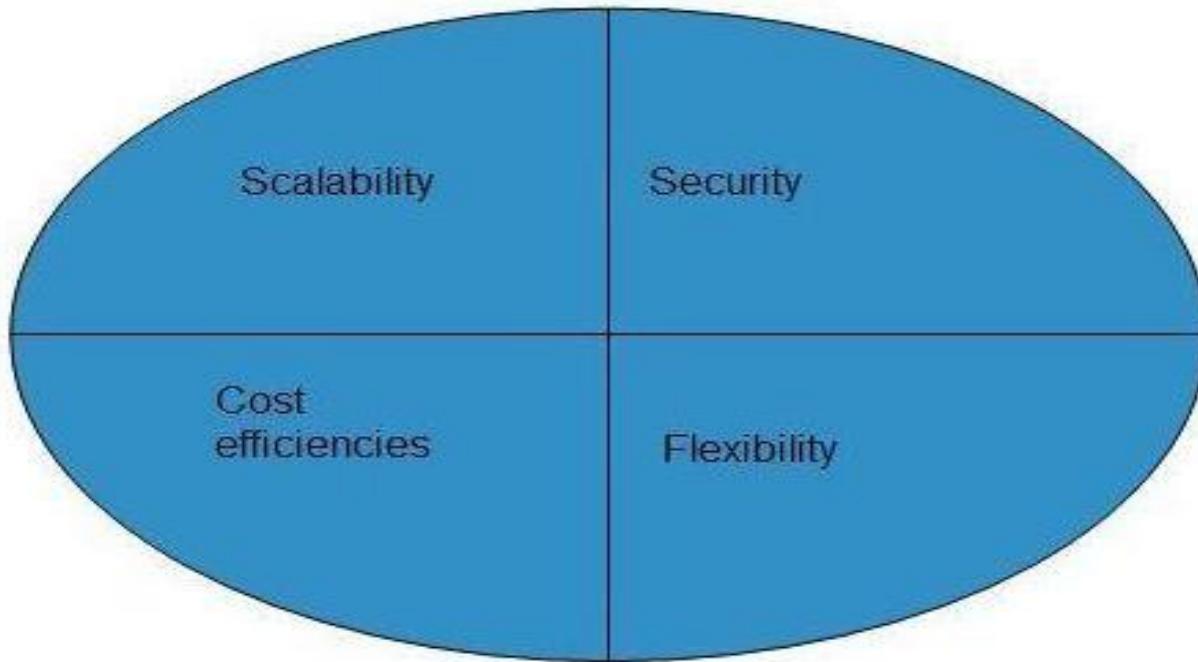
# Hybrid Cloud

- It 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

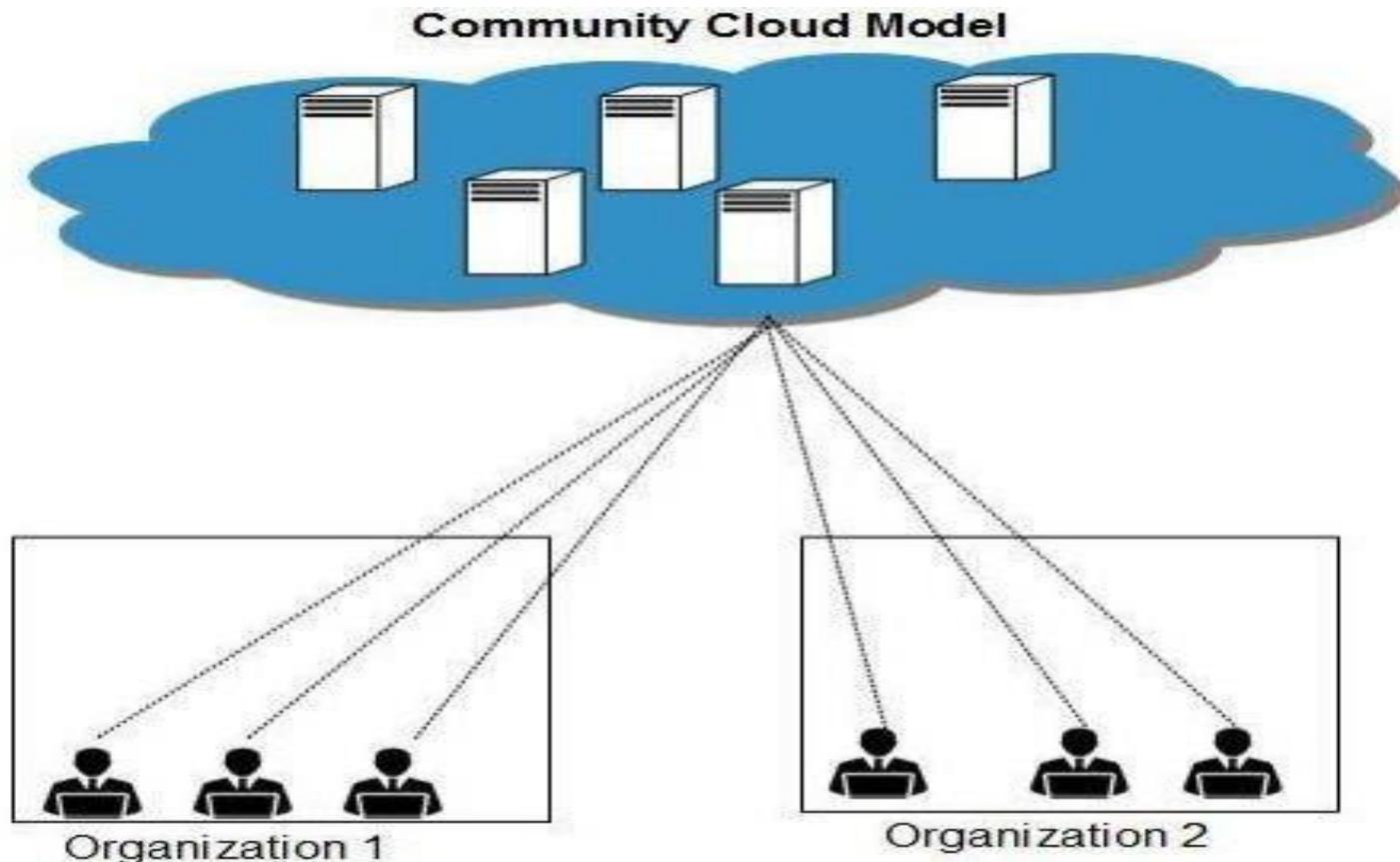


## Disadvantages

- **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.
- **TUTORIALS POINT** Simply Easy Learning
- **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

- 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.



## 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
- SECURITY Community cloud is comparatively more secure than the public cloud.

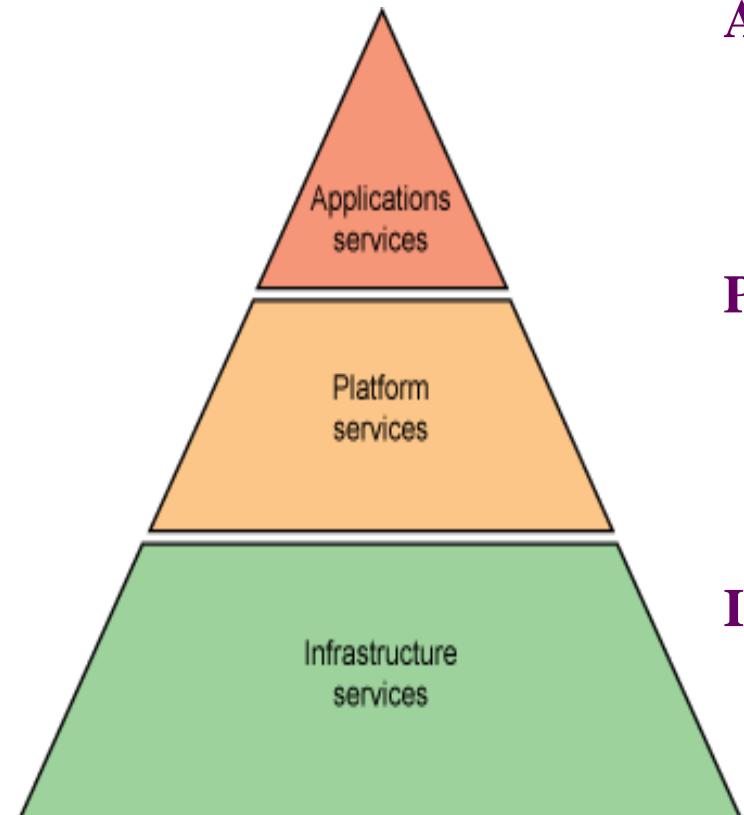
## Issues

- 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..

- **IaaS – Infrastructure as a Service**
  - Basic Computing System is provided
  - E.g., Amazon EC2
- **PaaS – Platform as a Service**
  - Development and Deployment Platform is provided
  - E.g., Google AppEngine
- **SaaS – Software as a Service**
  - Software is provided
  - E.g., SalesForce CRM Software
- **Storage as a Service**
  - Storage is provided
  - E.g., Amazon S3, C-DAC Cloud Vault

# Cloud Anatomy

Three models based on the type of service offered to the user



## Application Services (Services on Demand)

Gmail, GoogleCalender

Payroll, HR, CRMetc

SugarCRM, IBM Lotus Live

## Platform Services (Resources on Demand)

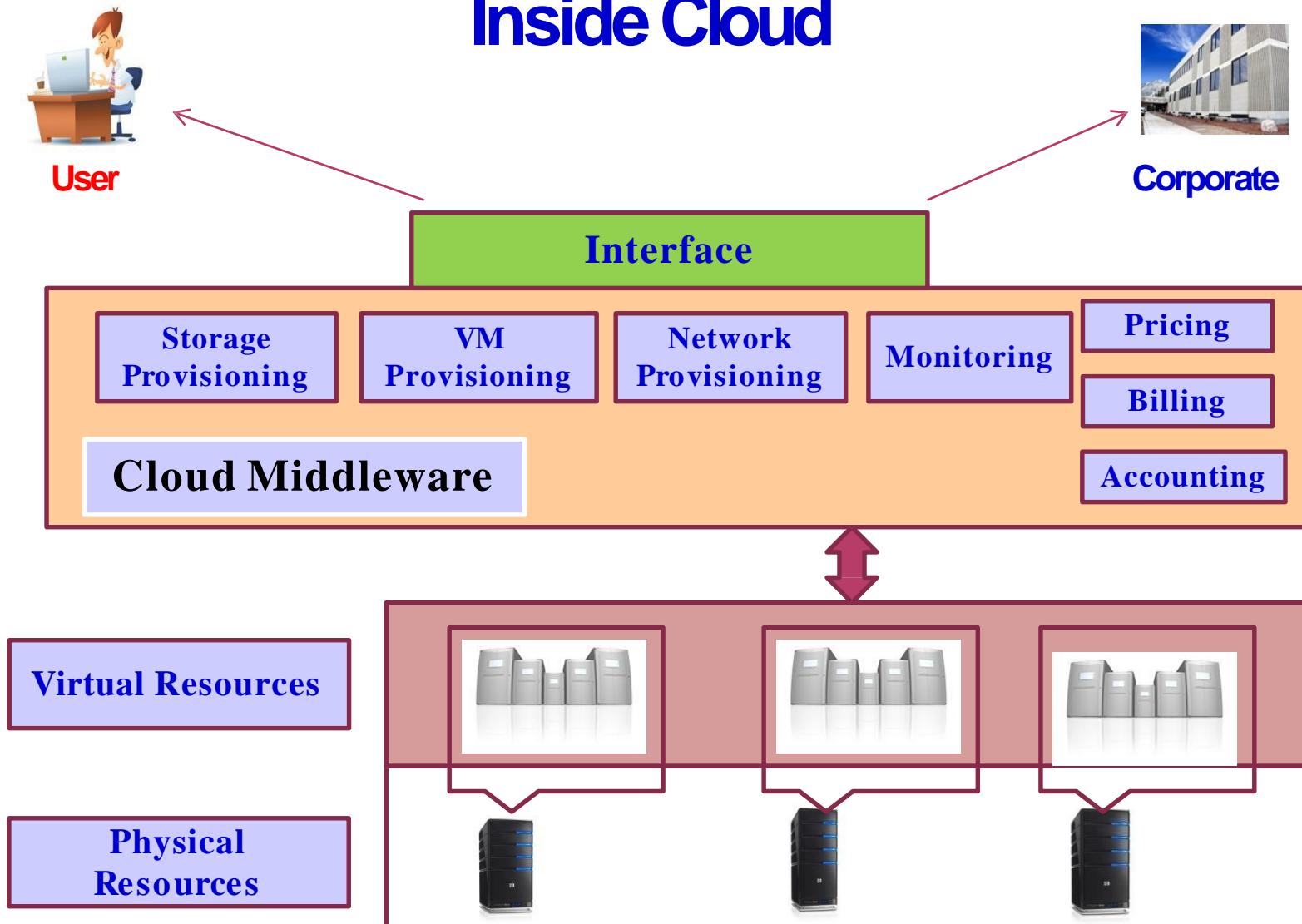
Middleware, Integration, Messaging,  
Information, connectivity etc

AWS, IBM Virtual images, Boomi, CastIron,  
Google Appengine

## Infrastructure as services (Physical Assets)

IBM BlueHouse, VMWare, Amazon EC2,  
Microsoft Azure, Sun Parascale ...

# Inside Cloud

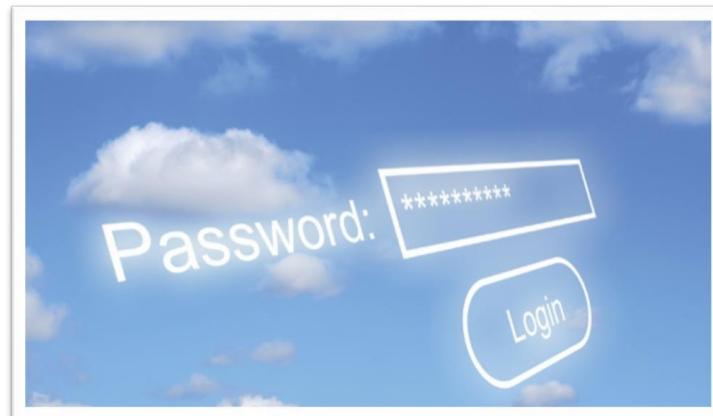




## System Security

- **Security issue in Cloud Computing :**

- Cloud security is an evolving sub-domain of computer security, network security, and, more broadly, information security.
- It refers to a broad set of policies, technologies, and controls deployed to protect data, applications, and the associated infrastructure of cloud computing.

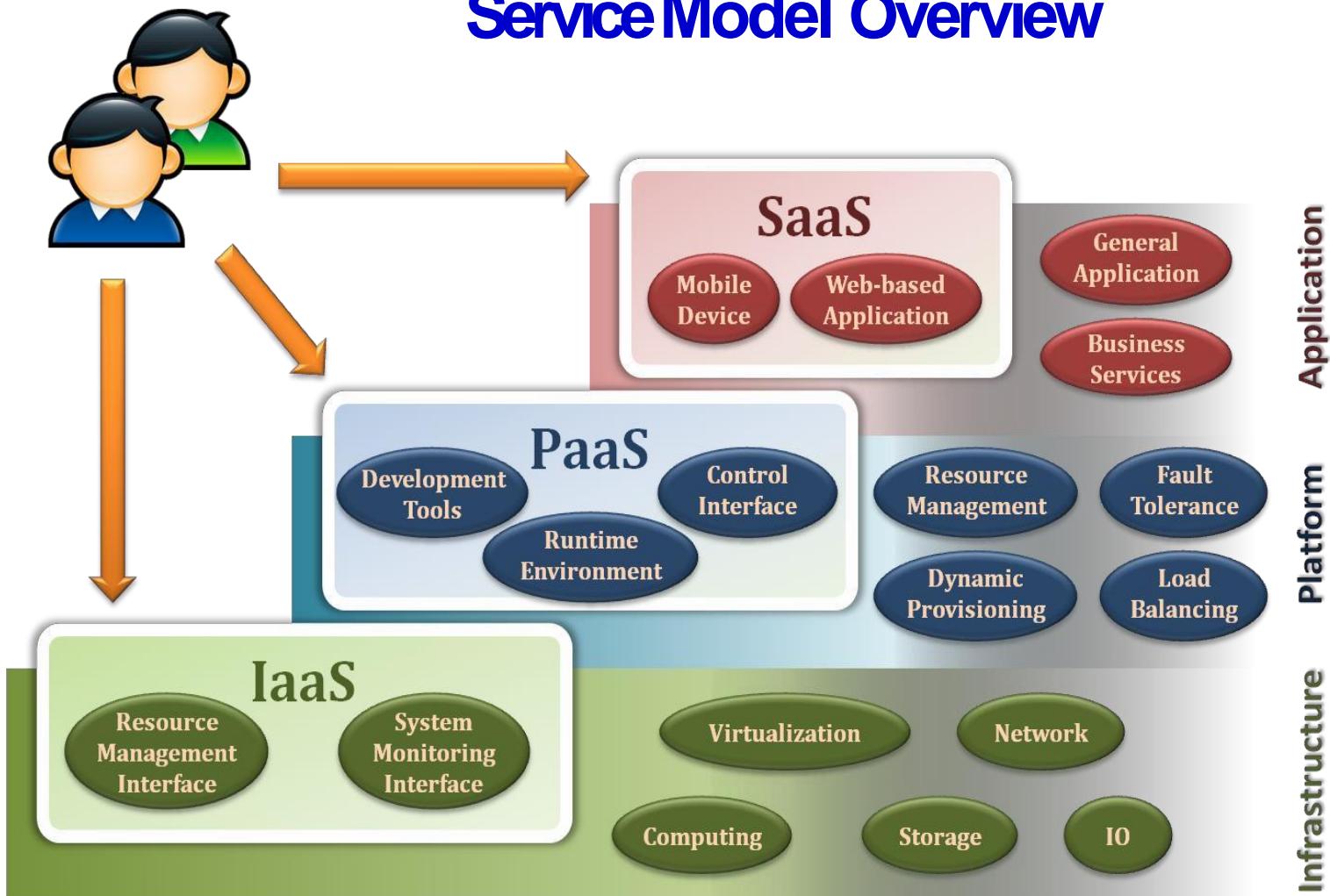


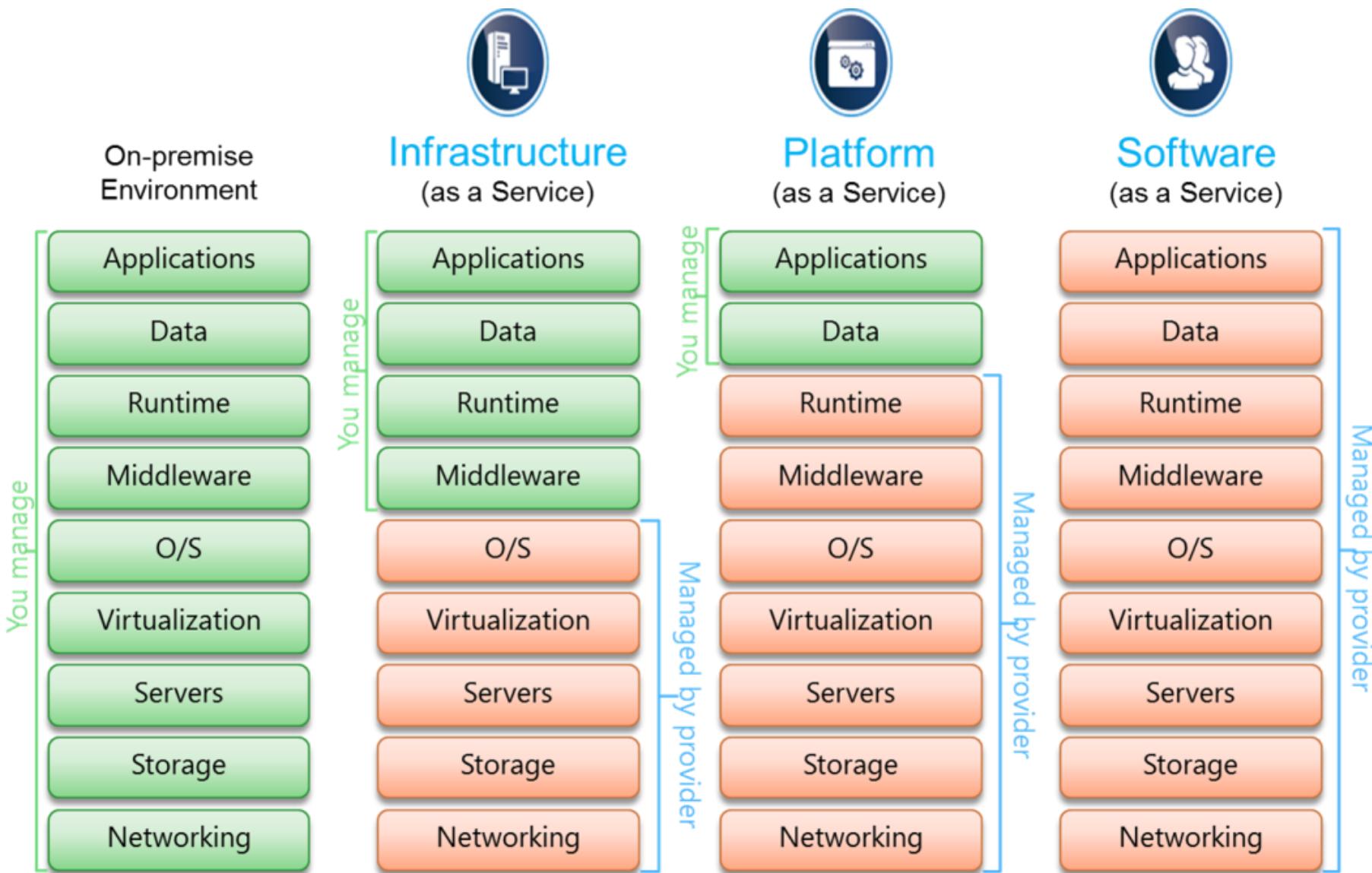


## System Security

- Important security and privacy issues :
  - Data Protection
    - To be considered protected, data from one customer must be properly segregated from that of another.
  - Identity Management
    - Every enterprise will have its own identity management system to control access to information and computing resources.
  - Application Security
    - Cloud providers should ensure that applications available as a service via the cloud are secure.
  - Privacy
    - Providers ensure that all critical data are masked and that only authorized users have access to data in its entirety.

# Service Model Overview



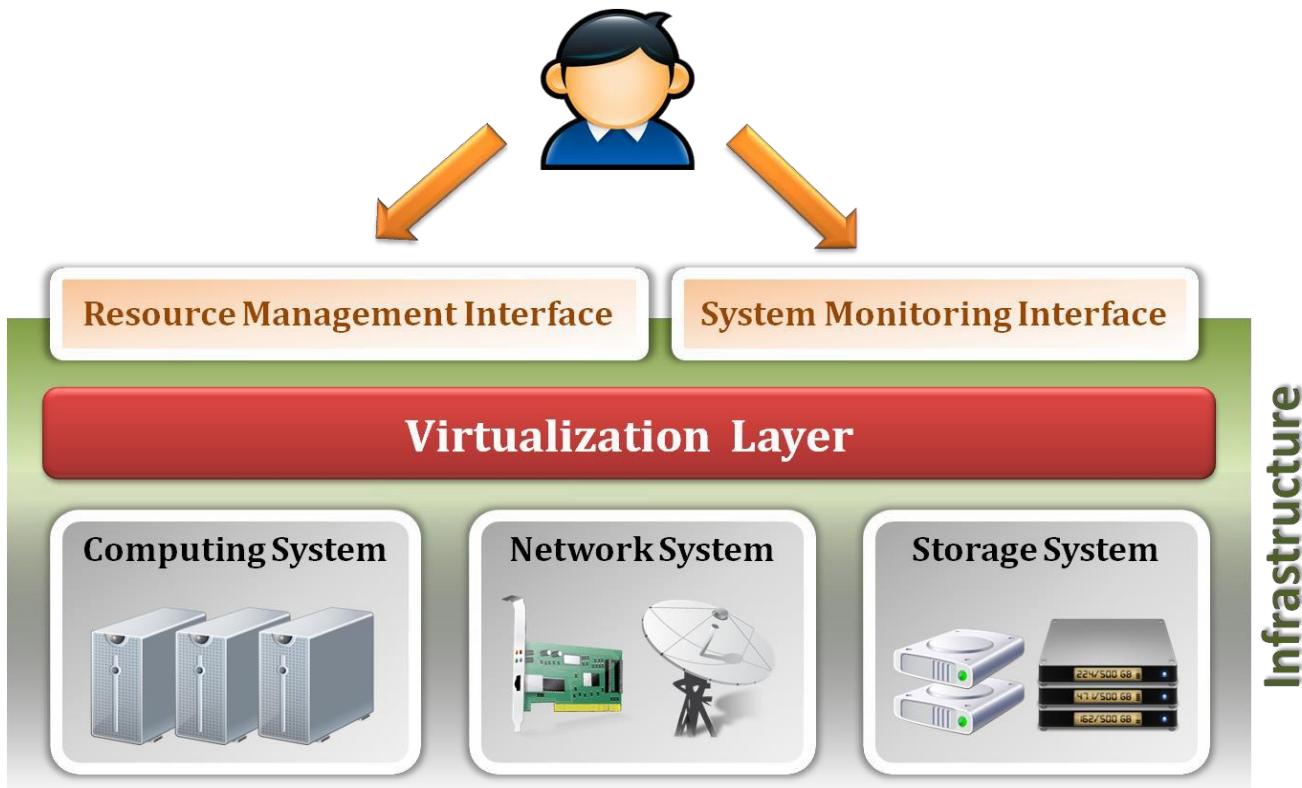


## Infrastructure as a Service

- Infrastructure as a Service - IaaS
  - The capability 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
  - Eucalyptus
  - OpenNebula
  - ... etc

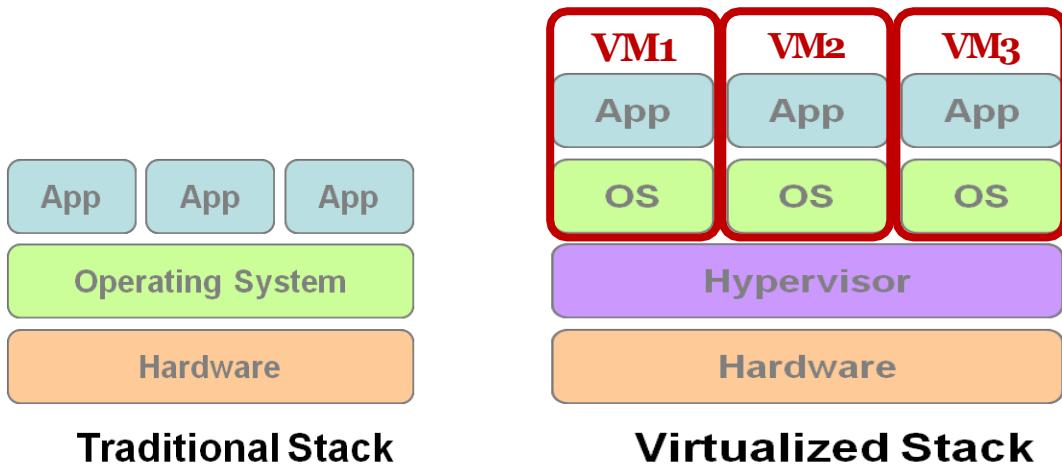
# Infrastructure as a Service

- 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.



## Infrastructure as a Service

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



## IaaS - Summary

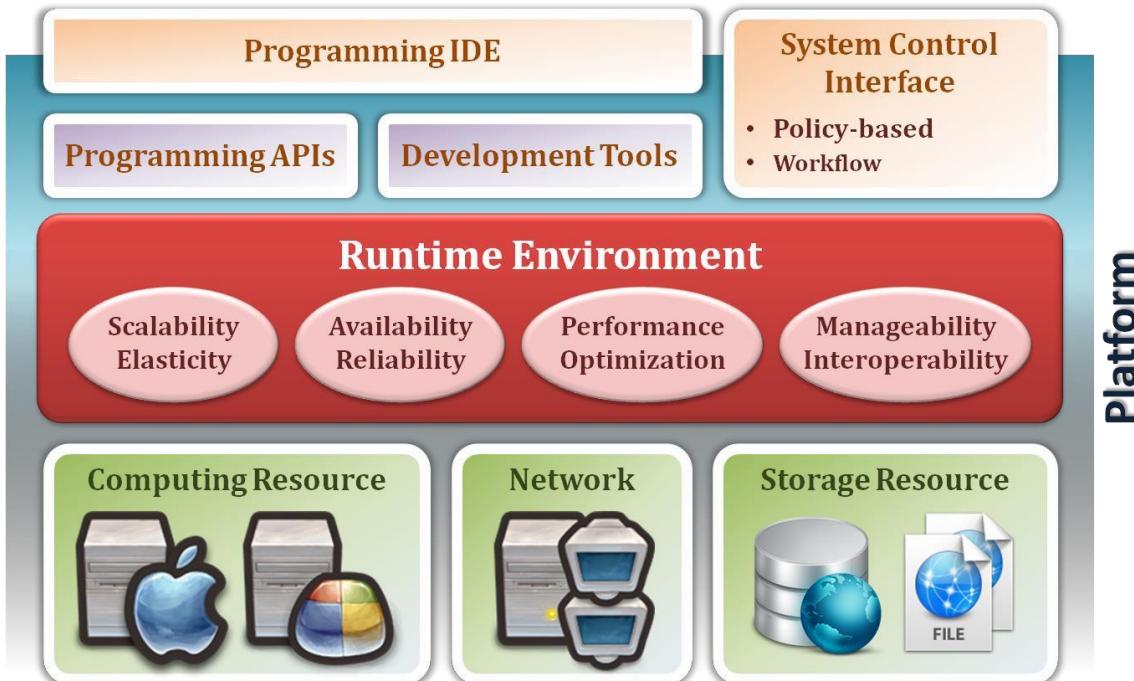
- IaaS is the deployment platform that abstract the infrastructure.
- IaaS enabling technique
  - Virtualization
    - Server Virtualization
    - Storage Virtualization
    - Network Virtualization
- IaaS provided services
  - Resource Management Interface
  - System Monitoring Interface

## 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
  - ... etc

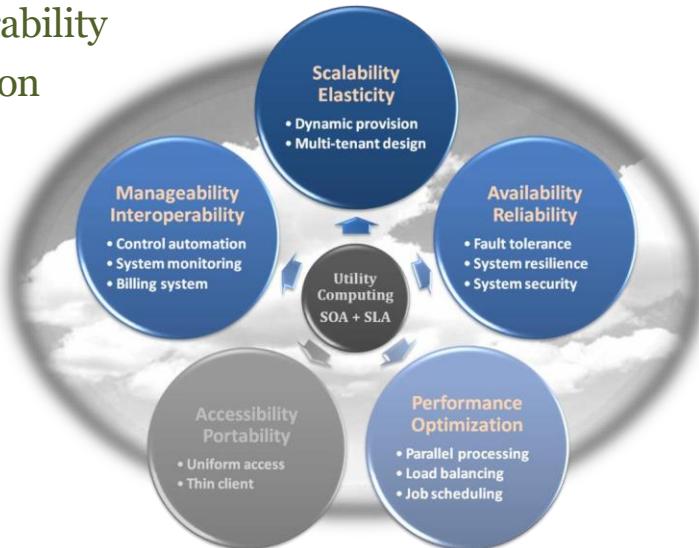
# Platform as a Service

- 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

## 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

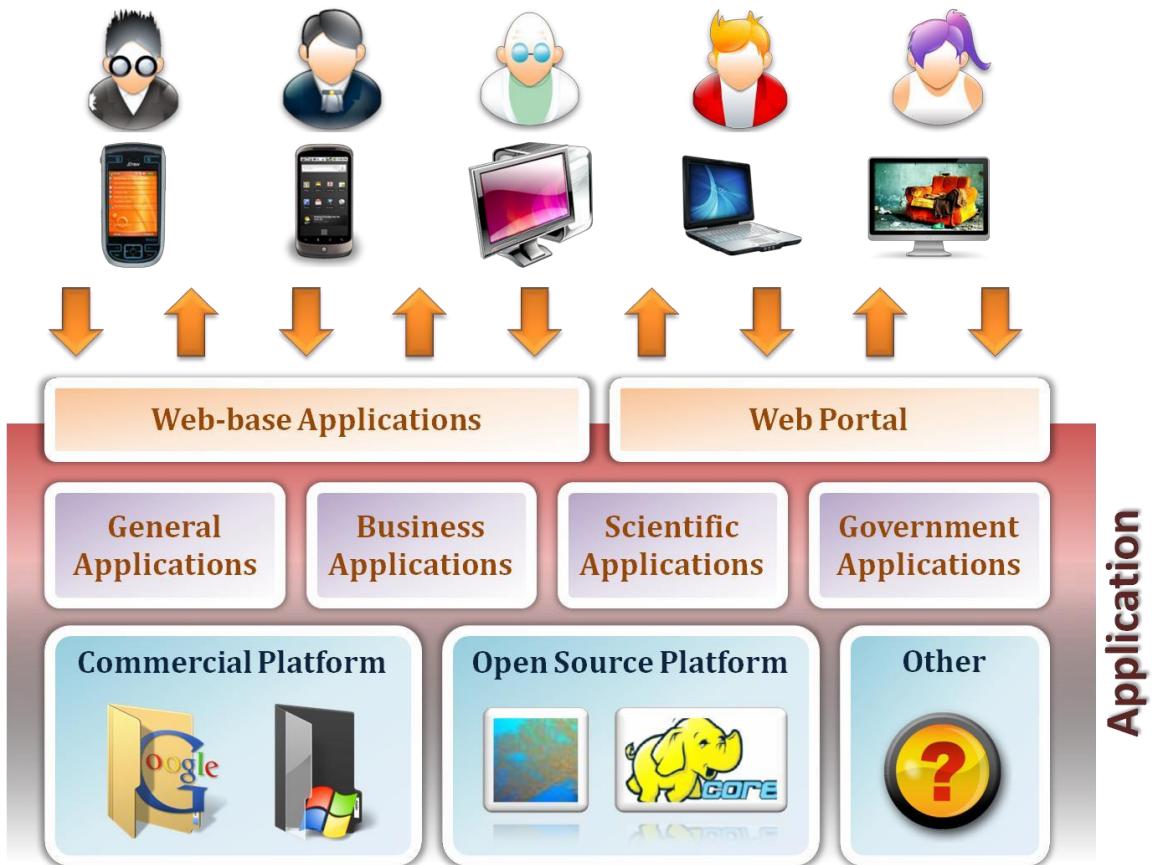
- **Software as a Service - SaaS**

- 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 :**

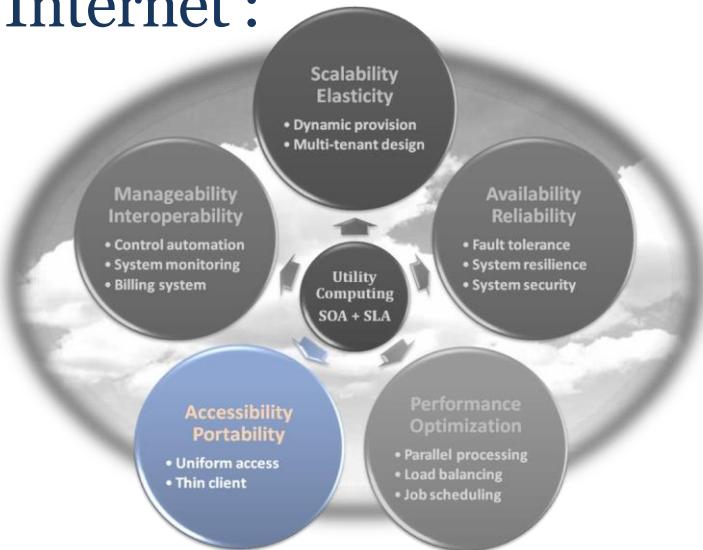
- Google Apps (e.g., Gmail, Google Docs, Google sites, ...etc)
- SalesForce.com
- EyeOS
- ... etc

## 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



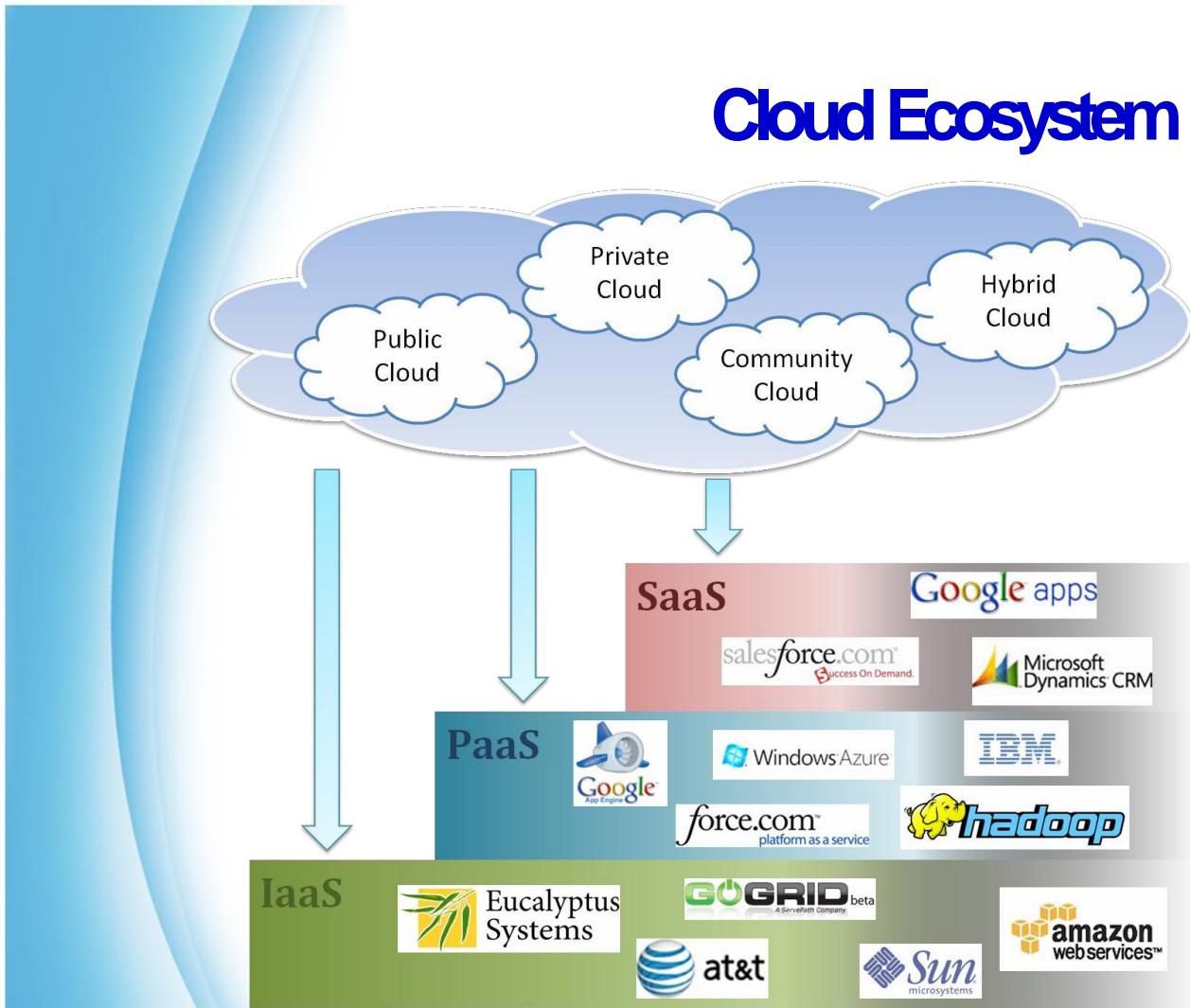
## Software as a Service

- Provide service – **Web 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



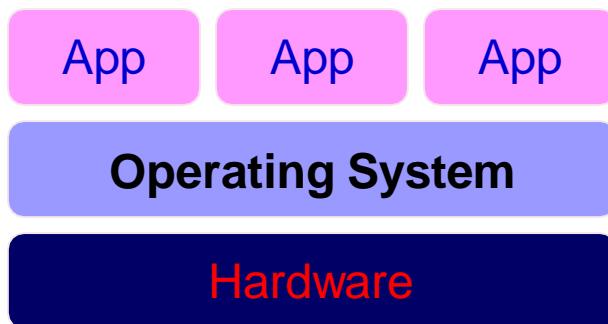
## Summary

- What is cloud computing in your mind
  - Clear or Cloudy?
- Cloud computing is a new paradigm shift of computing
- Cloud computing can provide high quality of properties and characteristics based on essentially central ideas
- Service models and deployment models provide services that can be used to
  - Rent fundamental computing resources
  - Deploy and develop customer-created applications on clouds
  - Access provider's applications over network (wired or wireless)

# Traditional Arch. Vs Virtualization Arch.

## Traditional Architecture

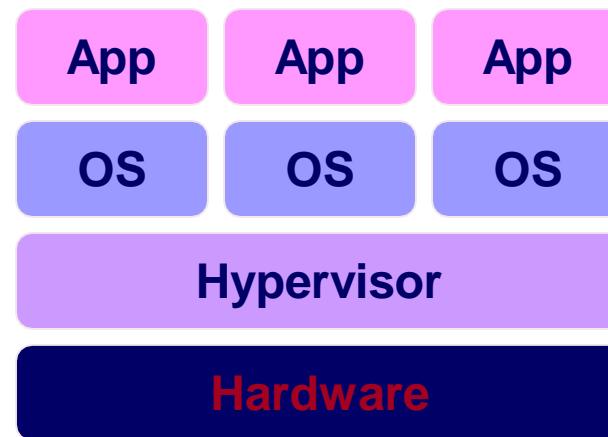
- One OS on one Server
- Tightly coupled HW and SW
- One Application on One Server
- Typical load on server is 5 –15 %



Traditional Stack

## Virtual Architecture

- Many OS to one server
- Separation between SW and HW
- Many applications on one server
- Typical load on server is 80 –95%
- Dynamically optimized resources



Virtualized Stack

# CLOUD STACK

Application

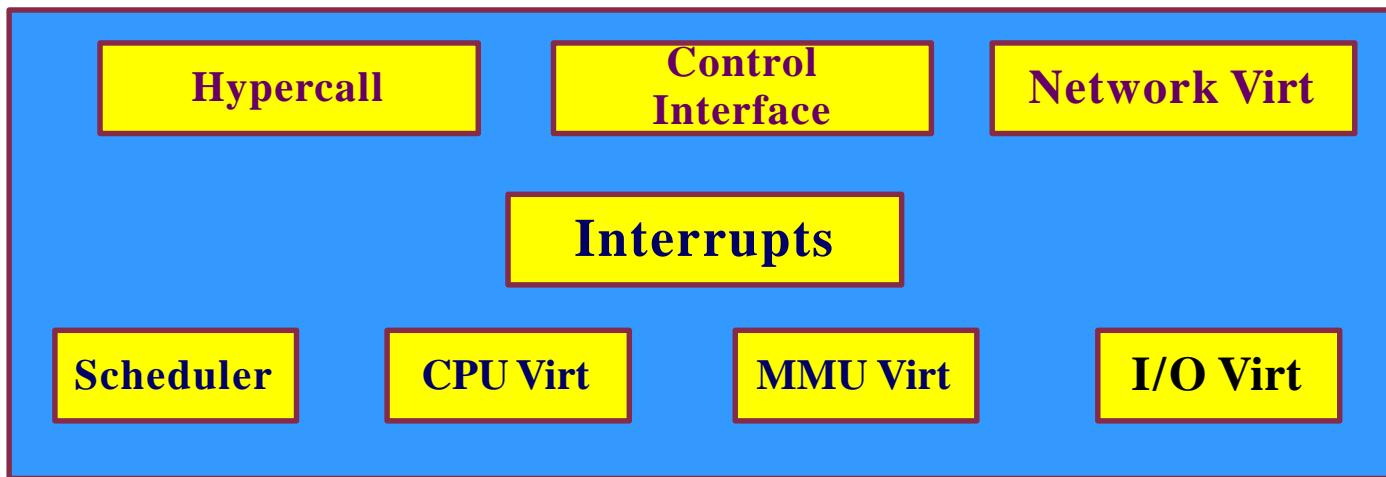
Middleware

Hypervisor

Hardware Resources

# Hypervisors

- **Most Important Component.**
- **Thin Layer Software**
- **Allow Multiple OS's to run Concurrently.**
- **Dynamically Partitioning and Sharing the physical resources such as CPU, storage, memory and I/O devices.**
- **Abstraction of the Hardware from the VM's.**



**Hypervisor Components**

# Cloud Middleware

**Cloud Middleware** A software used to integrate services, applications and content available on the cloud.

## Key Features:

**Management and monitoring**

**Resource Scheduler**

**Data management**

**Identity / security management**

**Service hosting, mediation and management**

**User interfaces and portals**

**Billing and metering**

# Open Source Cloud Middleware



1. **OpenStack:** is Python based open source cloud computing platform that provides Compute & Storage services for Public & Hybrid Clouds
2. **Nimbus:** is Java & Python based open source cloud computing platform that provides compute & storage services for public clouds
3. **Eucalyptus:** is a Linux-based software architecture that implements scalable, efficiency-enhancing private and hybrid clouds
4. **Open Cirrus** is an open cloud-computing research testbed
5. **StratusLab:** project aims to create a private cloud distribution that permits resource center administrators to deploy Grid services over the cloud's virtualized resources of high performance compute and data intensive distributed applications for real-time Big Data processing
6. **GridGain:** application enabler for HPC and Data Intensive Distributed applications for real-time Big Data processing

# Cloud computing security

- **Cloud computing security is sometimes referred to simply as "cloud security"**
  - **Is an evolving sub-domain of computer security, network security, and, more broadly, information security.**
  - **Security issues in Cloud fall into two broad categories:**
    - **Security issues faced by cloud providers (organizations providing software-, platform-, or infrastructure-as-a-service via the cloud)**
    - **Security issues faced by their customers.**

# Cloud Computing Security Fundamentals

- Confidentiality , Integrity and availability are important pillars of cloud s/w assurance.
- Confidentiality :
  - It refers to the prevention of intentional or unintentional unauthorized disclosure of information.
- Integrity :
  - The concept of cloud information integrity requires that the following two principles are met :
    - Modifications are not made to data by unauthorized personnel.
    - The data is internally or externally consistent - the internal information is consistent both among all sub-entities and with the real world.
- Availability :
  - It enables the reliable and timely access to cloud data or cloud computing resources by the appropriate personnel.
  - It guarantees that the systems are functioning properly when needed.

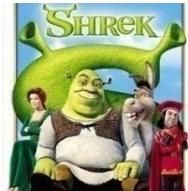
# Cloud Applications

- **Scientific/Tech Applications**
- **Business Applications**
- **Consumer/Social Applications**

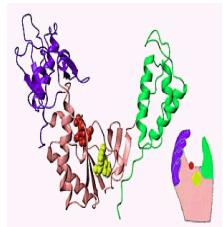
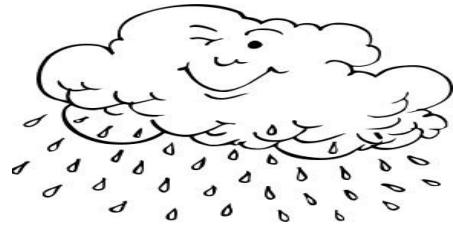
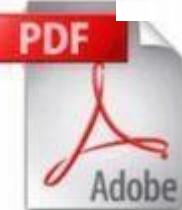


**Business Applications**

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36300 DJ INTERBANK FOR  
INDU -195.14 VOLU 1.13  
INDP 9646.26 UVOL 288,  
UTIL +1.90 DVOL 823,  
TRAN -84.40 TRIN 1.13



**Consumer/Social Applications**



**Science and Technical Applications**