CLOUD COMPUTING

AY:2024-25,SEM-2

Institute Vision -Mission

Institute Vision

"To be globally acclaimed Institute in Technical Education and Research for holistic Socio- economic development".

Institute Mission

- To ensure that 100% students are employable and employed in Industry, Higher Studies, become Entrepreneurs, Civil / Defense Services / Govt. Jobs and other areas like Sports and Theatre.
- To strengthen Academic Practices in terms of Curriculum, Pedagogy, Assessment and Faculty Competence.
- Promote Research Culture among Students and Faculty through Projects and Consultancy.
- To make students Socially Responsible Citizen.

Department Vision -Mission

Department Vision

"To provide student-centered state-of-the art academically enriched environment for productive careers in the world of computing through creativity and innovation art"

Department Mission

- To promote aspiring ethically conscious engineers demonstrating sustainable employability and entrepreneurship.
- To impart quality education with the focus on analytical and problem-solving skill development.
- To foster inspired scholarly environment through active student faculty participation in research and development resulting in new knowledge-base or insights.
- To prepare students to shoulder social responsibilities by application of their skill set for betterment of society.

Syllabus

- **Section-1**

- **UNIT I: Fundamentals of Cloud Computing [5 Hrs.]**
  - Origins and Influences, Basic Concepts and Terminology, Goals and Benefits, Risks and Challenges, Roles and Boundaries, Cloud Characteristics, Cloud Delivery Models, Cloud Deployment Models, Federated Cloud/Inter-cloud, Types of Clouds.
- **UNIT II: Cloud Enabling technology and Virtualization [5 Hrs.]**
  - Cloud-Enabling Technology: Broadband Networks and Internet Architecture, Data Center Technology, Virtualization Technology, Web Technology, Multitenant Technology, Service Technology.
  - Virtualization: Structures/Tools and Mechanisms, Types of Hypervisors, Virtualization of CPU, Memory, and I/O Devices, Virtual Clusters and Resource Management, Virtualization for Data-Center Automation.
- **UNIT III: Common Standards and Cloud Platforms [5 Hrs.]**
  - Common Standards: The Open Cloud Consortium, Open Virtualization Format, Standards for Application
  - Amazon web services: Compute services Storage Services Communication Services Additional services
  - Google AppEngine: Architecture and core concepts, Application life cycle, Cost model Microsoft Azure: Azure core concepts, SQL Azure, Windows Azure platform appliance

Syllabus

- **Section-2**
- **UNIT IV: Data Storage and Security in Cloud [5 Hrs.]**
  - Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo Cloud data stores: Datastore and Simple DB Gautam Shrauf, Cloud Storage-Overview, Cloud Storage Providers.
  - Securing the Cloud: General Security Advantages of Cloud-Based Solutions, Introducing Business Continuity and Disaster Recovery. Disaster Recovery-Understanding the Threats.
- **UNIT V: Ubiquitous Clouds and the Internet of Things [4 Hrs.]**
  - Performance of Distributed Systems and the Cloud, Enabling Technologies for the Internet of Things (RFID, Sensor Networks and ZigBee Technology, GPS), Innovative Applications of the Internet of Things
- **UNIT VI: Future of Cloud Computing [4 Hrs.]**
  - How the Cloud Will Change Operating Systems, Location-Aware Applications, The Future of Cloud TV, Future of Cloud-Based Smart Devices, Faster Time to Market for Software Applications, Home-Based Cloud Computing, Mobile Cloud, Autonomic Cloud Engine, Multimedia Cloud, Energy Aware Cloud Computing, Jungle Computing. Docker at a Glance

List of Practicals: (Any Six)

1. Install Google App Engine. Create hello world app and other simple web applications using python/java.
2. Use GAE launcher to launch the web applications.
3. Find a procedure to transfer the files from one virtual machine to another virtual machine.
4. Find a procedure to launch virtual machine using trystack (Online Openstack Demo Version)
5. Design and deploy a web application in a PaaS environment.
6. Design and develop custom Application (Mini Project) using Salesforce Cloud.
7. Design an Assignment to retrieve, verify, and store user credentials using Firebase Authentication, the Google App Engine standard environment, and Google Cloud Data store.

Course Outcomes:

CO	CO Statement	Level No
CO1	Articulate the main concepts, key technologies and fundamentals of cloud computing	2
CO2	Understand cloud enabling technologies and virtualization	2
CO3	Analyze various cloud programming models and apply them to solve problems on the cloud	3
CO4	Explain data storage and major security issues in the cloud	2
CO5	Understand trends in ubiquitous cloud and internet of things	2
CO6	Explore future trends of cloud computing	2

Programme Outcomes (PO)

PO1	**GA: 1 Engineering Knowledge**	**PO7**	**GA: 7: Environment and sustainability**
PO2	**GA: 2 Problem Analysis**	**PO8**	**GA: 8 : Ethics**
PO3	**GA: 3: Design/ Development of solution**	**PO9**	**GA: 9: Individual and Team Work**
PO4	**GA: 4: Conduct Investigation of ComplexProblems**	**PO10**	**GA: 10: Communication**
PO5	**GA: 5: Modern Tool Usage**	**PO11**	**GA: 11 : Project Management and Finance**
PO6	**GA: 6 : The Engineer and Society**	**PO12**	**GA: 12: Lifelong Learning**

Programme Specific Outcomes (PSO)

PSO	PSO Focus	PSO Statement
PSO1	**Engineering Foundation**	Apply information science theory, algorithmic and programming principles for comprehending technological trade-off in order to determine conceptual aspects of real world problems in information technology.
PSO2		Analyze and create problem frames in order to formulated composition structure of Information technology problem with correct resources, infrastructure and technology requirements determination for solution realization.
PSO3	**Engineering Application**	Compose technical design specifications using template based approaches for formally expressing the solution implementation by applying techniques and methods to create, enhance, and deliver IT tools with appropriate CASE tools selection.
PSO4		Exercise research and development aptitude focusing knowledge creation and dissemination through engineering artifacts construction, preparation and presentation of engineering evidences using procedures, techniques, guidelines, and standards Considering technology migration and evolution.

Unit I:Fundamentals of Cloud Computing

- Origins and Influences,
- Basic Concepts and Terminology,
- Goals and Benefits,
- Risks and Challenges,
- Roles and Boundaries,
- Cloud Characteristics,
- Cloud Delivery Models,
- Cloud Deployment Models,
- Federated Cloud/Inter-cloud,
- Types of Clouds.

Introduction

- Cloud Computing provides us a means by which we can access the applications as utilities, over the Internet. It allows us to create, configure, and customize applications online.

- With Cloud Computing users can access database resources via the internet from anywhere for as long as they need without worrying about any maintenance or management of actual resources.

What is Cloud

- The term **Cloud** refers to a **Network** or **Internet**. In other words, we can say that Cloud is something, which is present at remote location.

- Cloud can provide services over network, i.e., on public networks or on private networks, i.e., WAN, LAN or VPN.

- Applications such as **e-mail, web conferencing, customer relationship management (CRM),** all run in cloud.

Cloud Definitions

- Definition from ***NIST*** ***(National Institute of Standards and Technology)***
  - Cloud computing is a model for enabling 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.
  - This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.

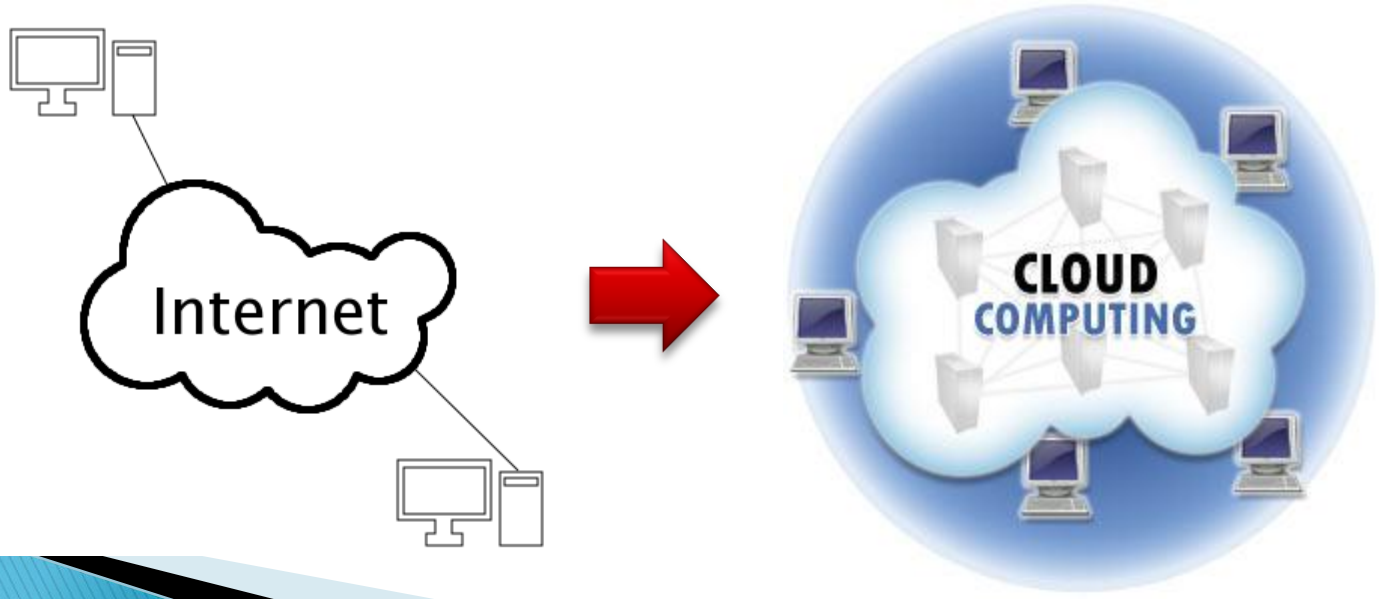
Cloud Definitions

- Definition from ***Wikipedia***
  - Cloud computing is Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid.
  - Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet.

WIKIPEDIA
The Free Encyclopedia

Cloud Definitions

- Definition from ***Whatis.com***
  - The name cloud computing was inspired by the cloud symbol that's often used to represent the Internet in flowcharts and diagrams. Cloud computing is a general term for anything that involves delivering hosted services over the Internet.



Cloud Definitions

- Definition from ***Berkeley***
  - Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services.
  - The services themselves have long been referred to as Software as a Service (SaaS), so we use that term. The datacenter hardware and software is what we will call a Cloud.
  - When a Cloud is made available in a pay-as-you-go manner to the public…… The service being sold is Utility Computing.

Computing??

- The term "computing" refers to the process of utilizing remote servers, networks, and data centers to perform computational tasks, store data, and deliver services over the internet, rather than relying on local servers or personal devices.

What is Cloud Computing?

- It is a combination of software and hardware based computing resources delivered as a network service

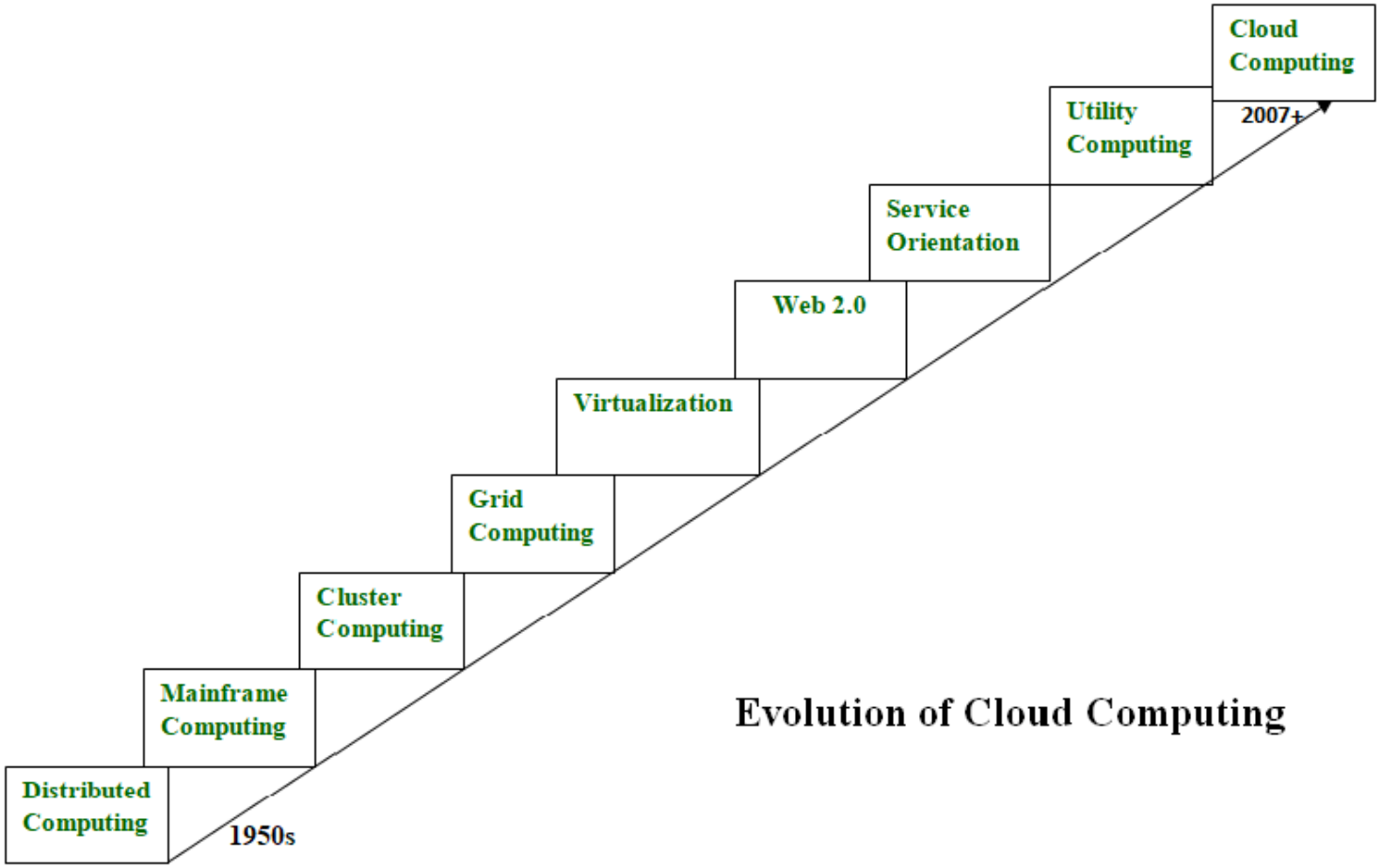
- It offers online data storage , infrastructure and application

What is Cloud Computing?

- **Cloud Computing** refers to **manipulating, configuring,** and **accessing** the applications online.
- It offers online data storage, infrastructure and application.

- **Cloud Computing** is both a combination of software and hardware based computing resources delivered as a network service.

Evolution of Cloud Computing



Evolution of Cloud Computing

Distributed computing

- Distributed computing is a powerful paradigm that allows complex problems to be solved by leveraging the combined capabilities of multiple machines, improving scalability, fault tolerance, and overall performance
- Transparency- refers to hiding the complexities of distribution from the end users.

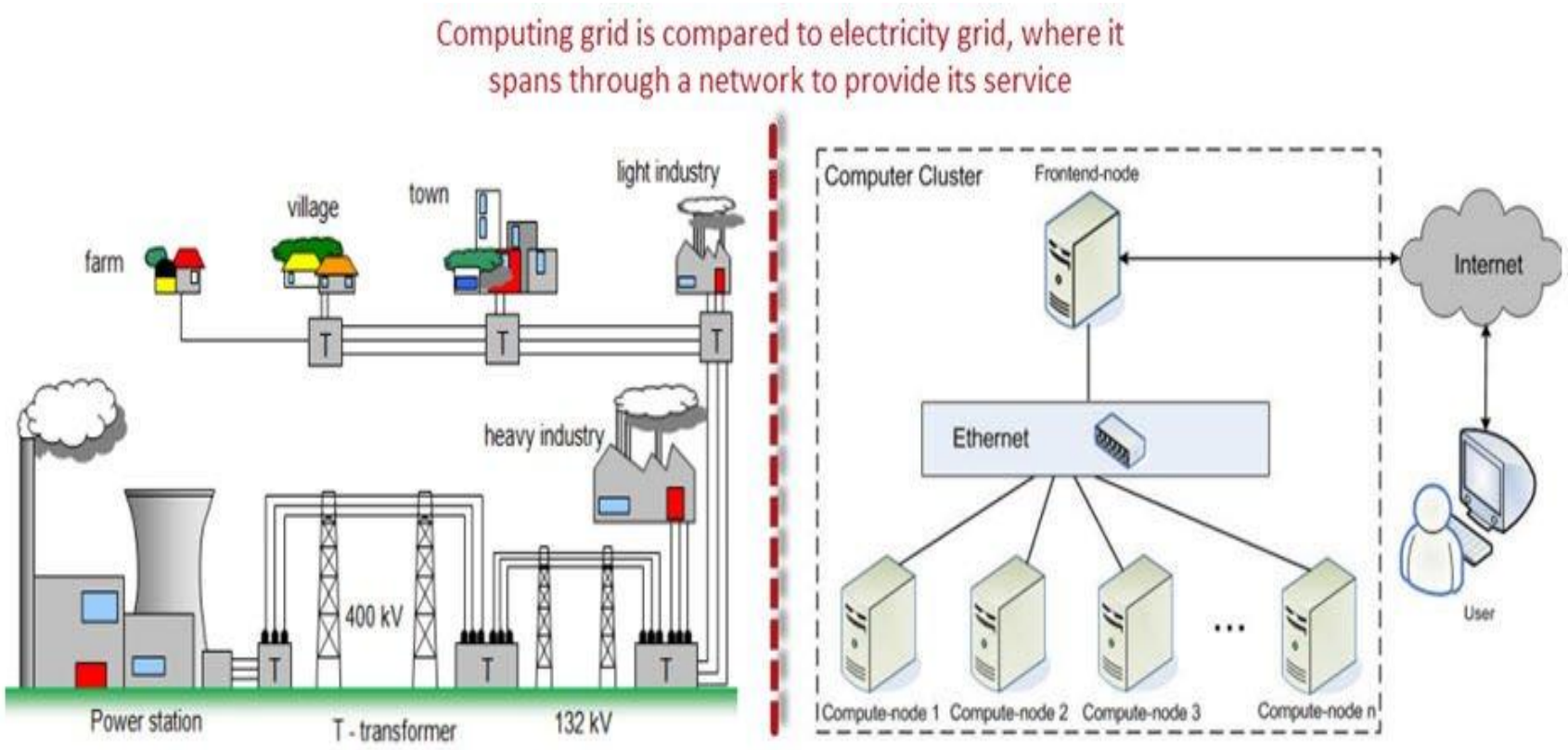
Mainframe computing:

- came into existence in 1951
- used for bulk processing tasks such as online transactions
- almost no downtime with high fault tolerance
- very expensive
- To reduce this cost- cluster computing

Cluster computing

- **Cluster computing** is a form of distributed computing where a group of interconnected computers (or nodes) work together as a single system to perform computational tasks.
- These nodes are typically located in close physical proximity (often within the same data center), and they communicate over a high-speed local network to share processing power, storage, and resources.
- Designed to provide high availability, fault tolerance, and improved computational power compared to a single computer.

Grid Computing?



Grid computing

- Grid computing is a distributed computing architecture where resources such as processing power, storage, and applications are pooled and shared across multiple locations to solve large-scale computation problems.
- The grid consists of interconnected computers, often geographically dispersed, working together as a virtual supercomputer.

What is Cloud Computing?

- Cloud computing is a paradigm of computing, a new way of thinking about IT industry but not any specific technology.
  - Central ideas
    - ***Utility Computing***
    - ***SOA*** - Service Oriented Architecture
    - ***SLA*** - Service Level Agreement
  - Properties and characteristics
    - High ***scalability*** and ***elasticity***
    - High ***availability*** and ***reliability***
    - High ***manageability*** and ***interoperability***
    - High ***accessibility*** and ***portability***
    - High ***performance*** and ***optimization***
  - Enabling techniques
    - Hardware virtualization
    - Parallelized and distributed computing
    - Web service

Cloud computing has five fundamental characteristics

On-demand self-service

No human intervention needed to get resources

Broad network access

Access from anywhere

Resource pooling

Provider shares resources to consumers

Rapid elasticity

Get more resources quickly as needed

Measured service

Pay only for what you consume

Essential Characteristics

- **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. ,completely automated

•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.

Using a multi-tenant model, computing resources are pooled to serve multiple consumers; cloud **resources are dynamically assigned and reassigned, according to demand, without customers needing** to concern themselves with the physical location of these resources.

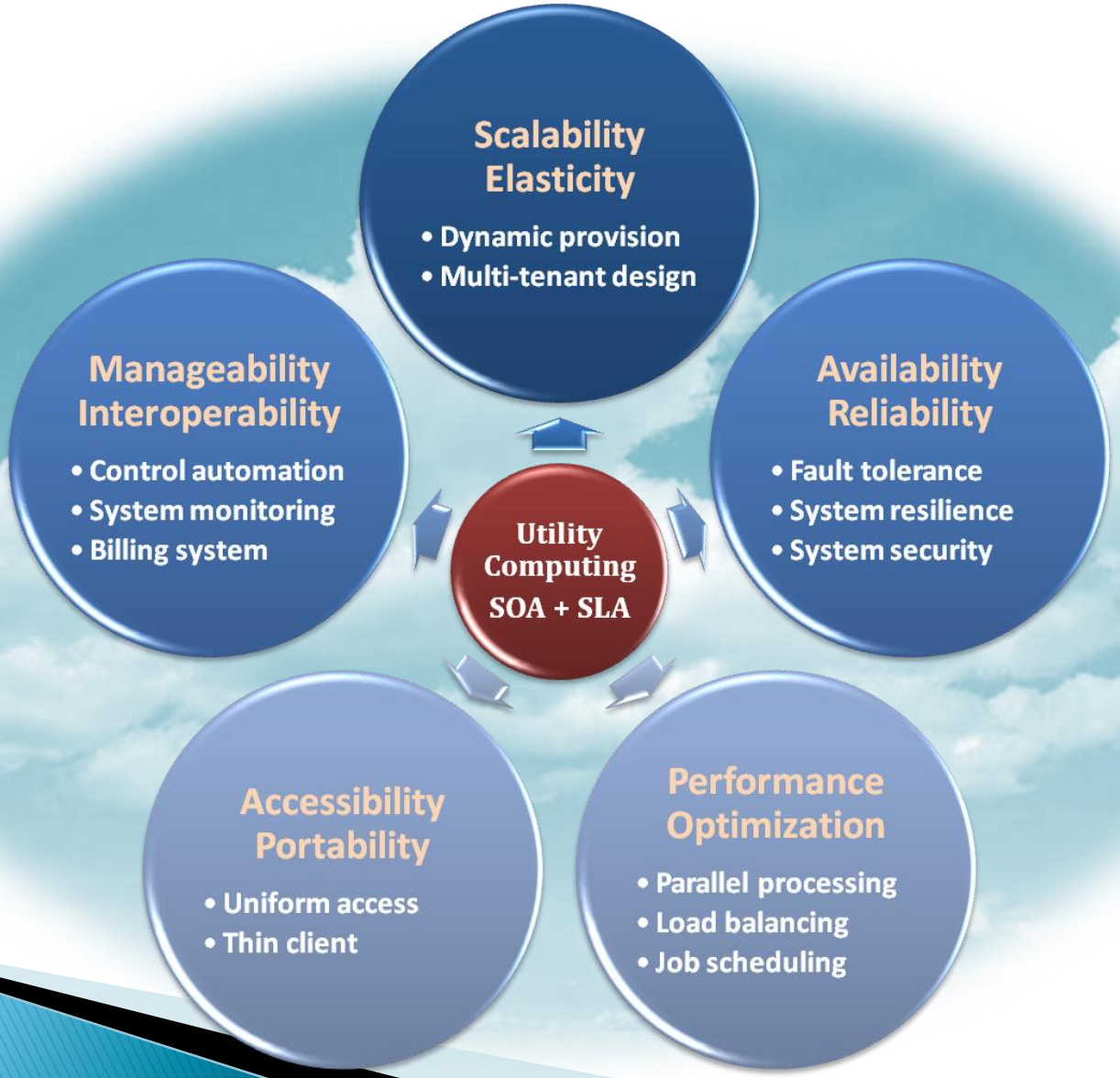
- **Measured Service**

–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 both the provider and consumer of the utilized service.

•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.

Properties and Characteristics



Central Ideas

- Perspective from user :
  - Users do not care about how the works are done
    - Instead, they only concern about what they can get
  - Users do not care about what the provider actually did
    - Instead, they only concern about their quality of service
  - Users do not want to own the physical infrastructure
    - Instead, they only want to pay as many as they used

- What dose user really care ?
  - They only care about their “Service”

Utility Computing

- One service provisioning model
  - Service provider makes computing resources and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate.
  - Like other types of on-demand computing , the utility model seeks to maximize the efficient use of resources and/or minimize associated costs.

Basic Concepts and Terminology

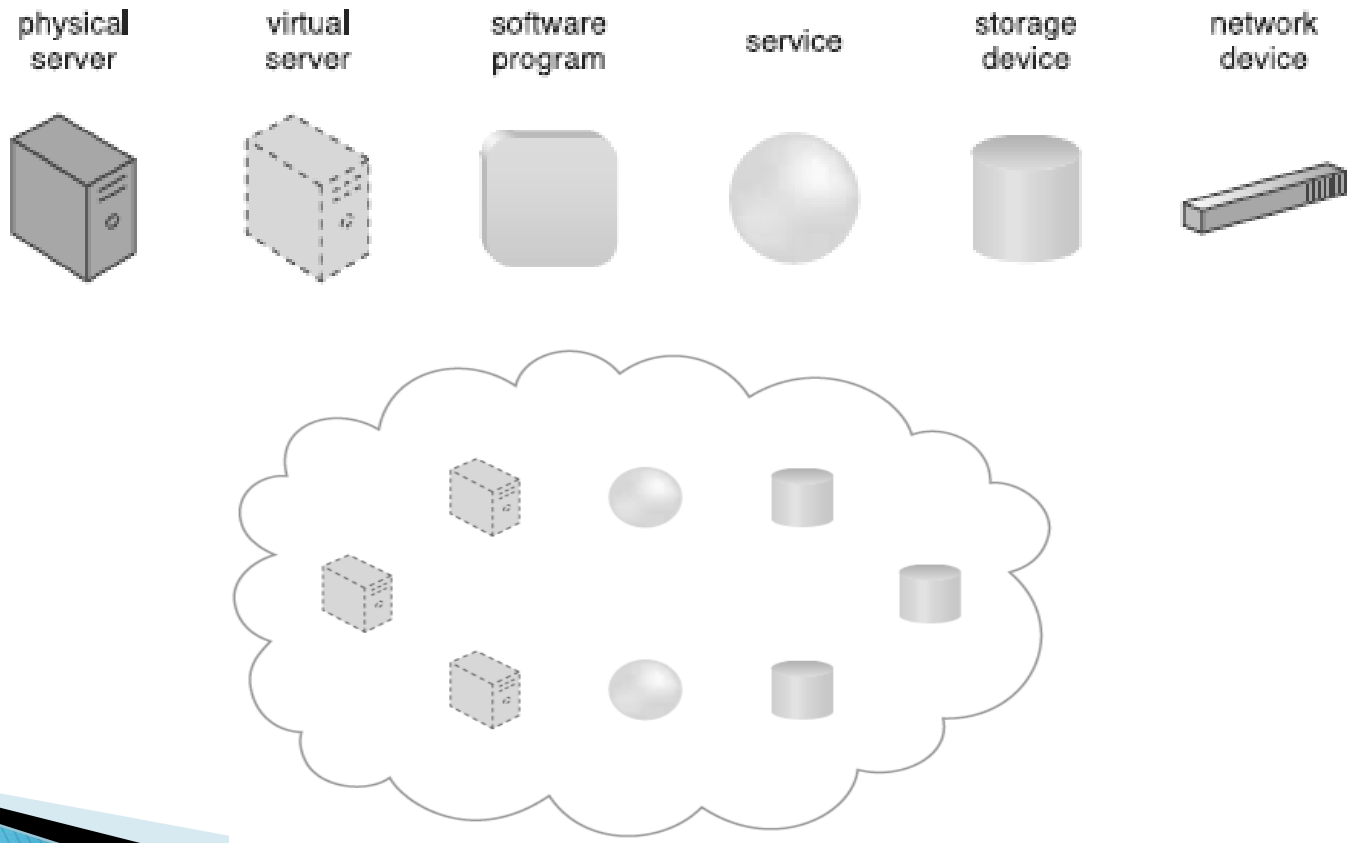
- Cloud
- IT Resources
- On-Premise
- Cloud Consumer & cloud Providers
- Scaling
- Cloud Service
- Cloud Service Consumer

Cloud

- Cloud refers to a distinct IT environment that is designed for the purpose of remotely provisioning scalable and measured IT resources.

IT Resources

- An IT resource is a physical or virtual IT related artifact that can be either software based or hardware based



On-Premise

- An IT resource that is hosted in a conventional IT enterprise within an organizational boundary is considered to be located on the premises of the IT enterprise, or *on-premise* for short.

- "on-premise" is another way of stating "on the premises of a controlled IT environment that is not cloud-based."

Cloud Consumer & cloud Provider

- The party that provides cloud-based IT resources is the *cloud provider*.
- The party that uses cloud-based IT resources is the *cloud consumer*.

Scaling

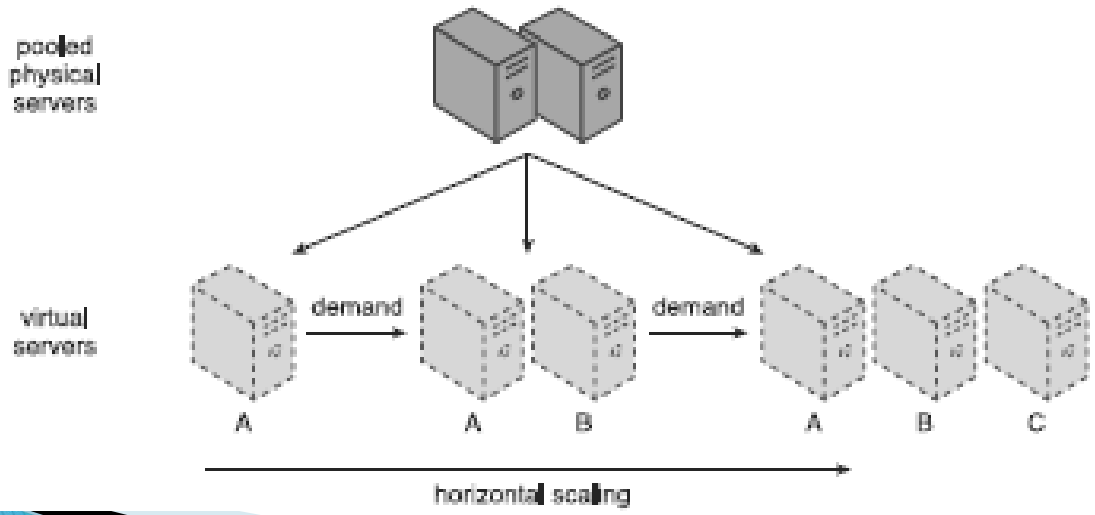
- Scaling represents the ability of the IT resource to handle increased or decreased usages demands

- Two types of scaling:-
  - Horizontal Scaling-scaling out and scaling in
  - Vertical Scaling-scaling up and scaling down

Horizontal Scaling

- The allocating or releasing of IT resources that are of the same type is referred to as *horizontal scaling*

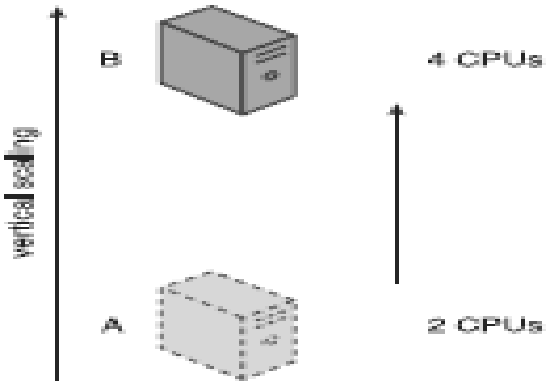
- The horizontal allocation of resources is referred to as *scaling out* and the horizontal releasing of resources is referred to as *scaling in*.



Vertical Scaling

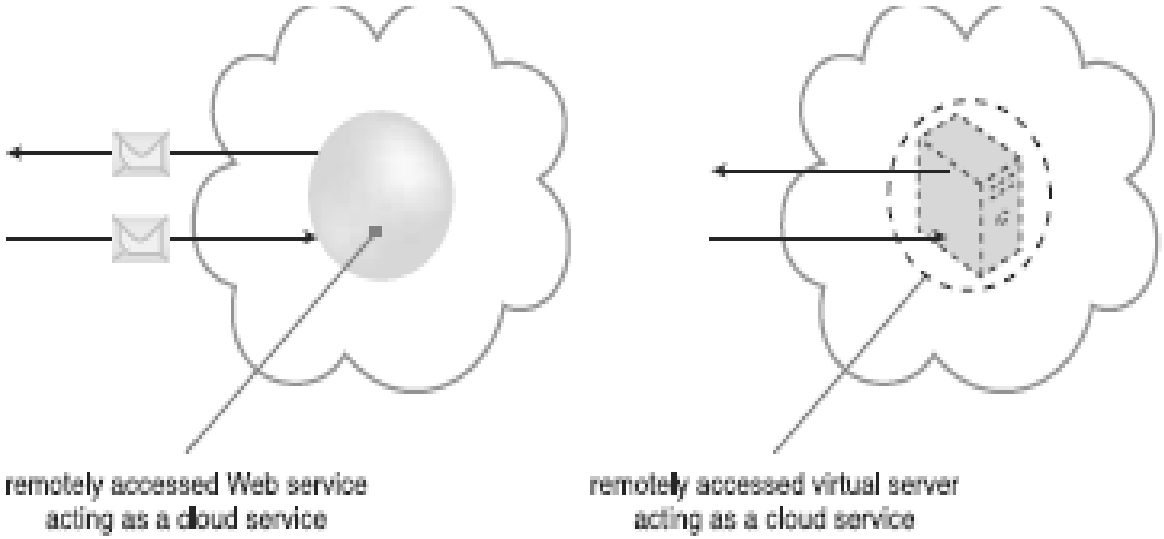
- When an existing IT resource is replaced by another with higher or lower capacity is vertical scaling

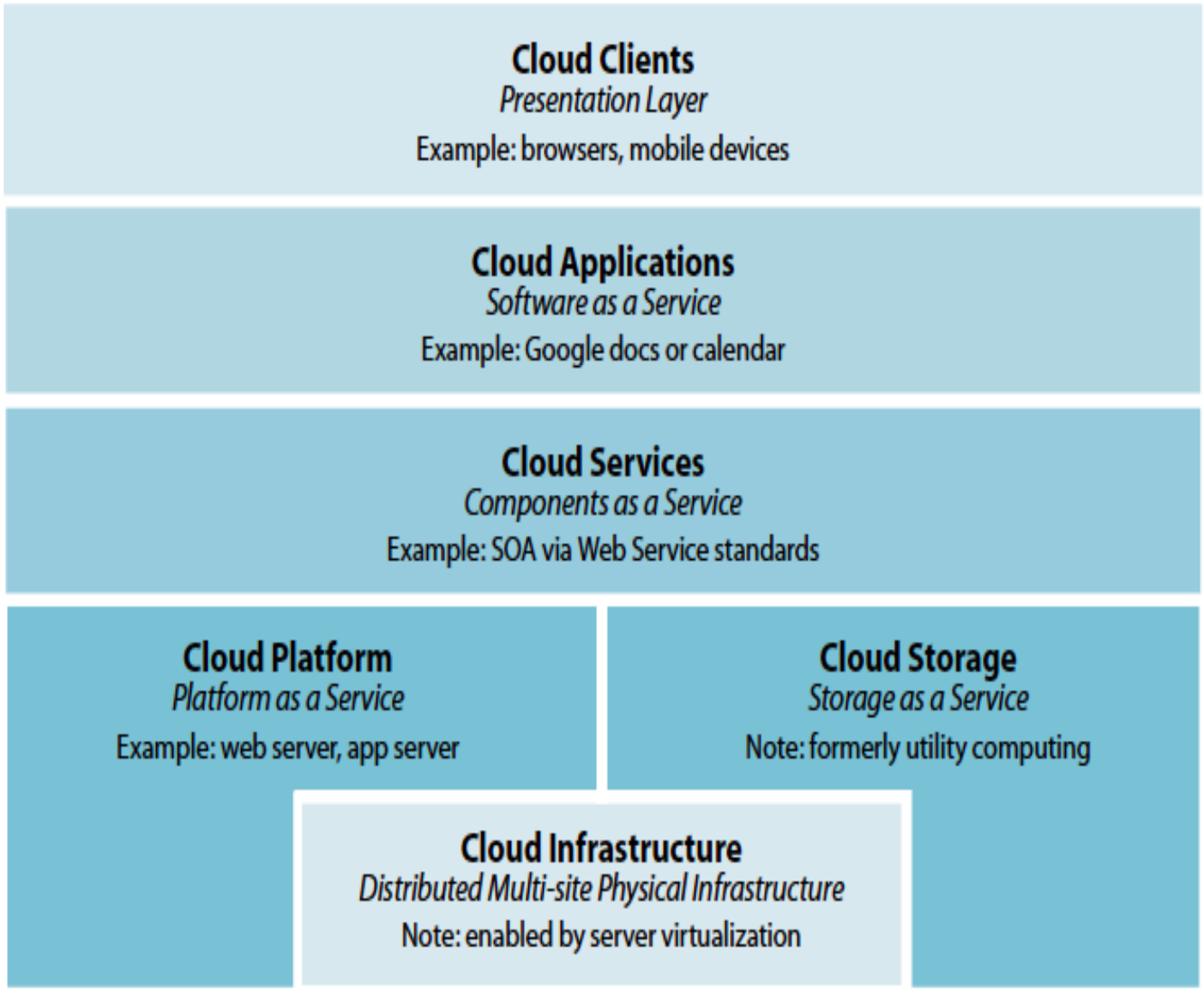
- The replacing of an IT resource with another that has a higher capacity is referred to as *scaling up* and with another that has a lower capacity is considered *scaling down*.



Cloud Service

- Cloud Service is any IT resource that is made remotely accessible via a cloud




Cloud Clients
Presentation Layer
Example: browsers, mobile devices
Cloud Applications
Software as a Service
Example: Google docs or calendar
Cloud Services
Components as a Service
Example: SOA via Web Service standards
Cloud Platform
Platform as a Service
Example: web server, app server
Cloud Storage
Storage as a Service
Note: formerly utility computing
Cloud Infrastructure
Distributed Multi-site Physical Infrastructure
Note: enabled by server virtualization

What Is Service?

- Service is what you connect together using Web Services.
- Service is the endpoint of a connection.
- A service is a software component that **performs a specific task** or business function and can be **reused across multiple applications** or systems.
- A service is a reusable component that can be used as a building block to form larger, more complex business-application functionality.
- A service may be as simple as “get me some person data,” or as complex as “process a disbursement.”

- Functionalities of service :
  - A service should be well-defined
  - A service should be self-contained
  - A service should not depend on the context or sta
  - Streaming service: netflix,spotify
  - Google Drive-Saas,Storage

What Is Web Service?

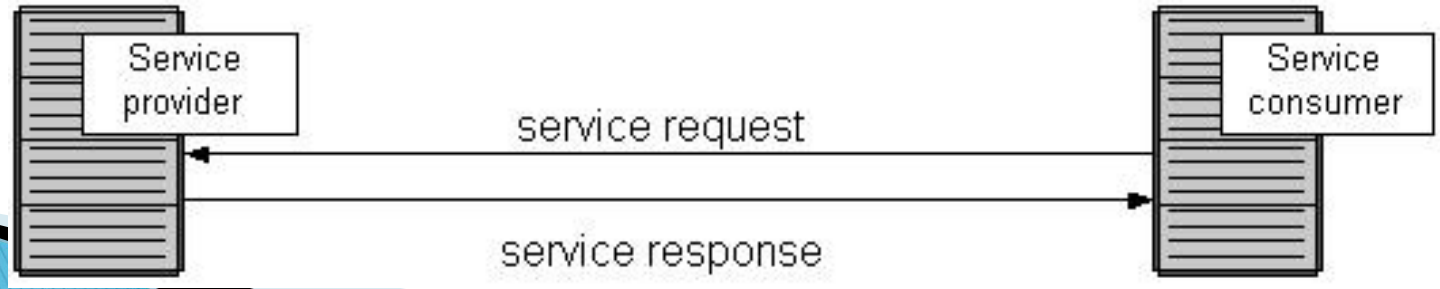
- Definition :
  - Web service is self-describing and stateless modules that perform discrete units of work and are available over the network
  - Web service providers offer APIs that enable developers to exploit functionality over the Internet, rather than delivering full-blown applications
  - standardized way of enabling communication and data exchange between applications or systems over the internet using open protocols such as HTTP, XML, or JSON
  - Eq: A weather forecasting web service accessed via an API.
  - Google Map APIs
  - A payment gateway (e.g., PayPal API).

Service Vs Web Service

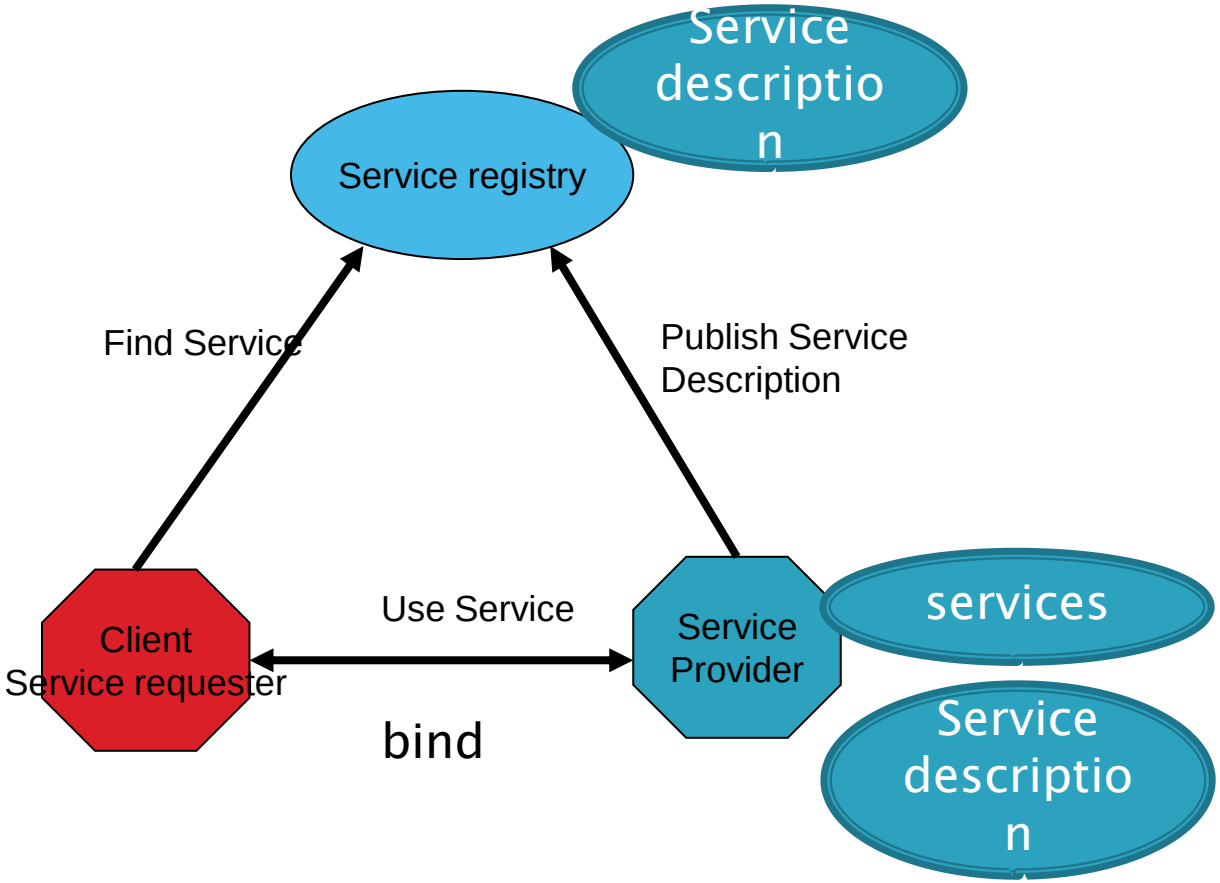
Aspect	Service	Web Service
Scope	General term for a reusable functionality.	A type of service specifically designed to be accessed over the web.
Communication Protocol	Can use any protocol (e.g., TCP, RPC).	Uses web-based protocols (e.g., HTTP, SOAP, REST).
Access	Can operate within a local system or private network.	Accessible only via a network (internet or intranet).
Interoperability	May not guarantee cross-platform compatibility.	Built to ensure interoperability across platforms.
Standards	No strict adherence to web standards	Follows web-specific standards like XML, JSON, WSDL.
Examples	A service to calculate taxes within an ERP system.	A REST API that provides currency exchange rates.

Service Oriented Architecture

- Definition
  - Service Oriented Architecture (SOA) is essentially a collection of services which communicate with each other
  - Contain a flexible set of design principles used during the phases of systems development and integration
  - Provide a loosely-integrated suite of services that can be used within multiple business domains
- Approach
  - Usually implemented by Web Service model



Service Oriented Architecture



Quality Of Service

- Original definition
  - Quality of Service (QoS) is a set of technologies for managing network traffic in a cost effective manner to enhance user experiences for home and enterprise environments.
  - Refers to the ability of a system, network, or service to guarantee specific performance levels to meet the requirements of its users or applications.
- Now QoS becomes to a broad term that is used following areas :
  - Customer care evaluations
  - Technological evaluations

Quality Of Service

- Customer care evaluations
  - QoS is usually measured in terms of issues that have a direct impact on the experience of the customer
  - Only issues that produce a negative effect on the goods and services received by the customer come under scrutiny **Example: Telecom Service Provider**
  - negative issues: network outages, slow response times, inaccurate billing, and unresolved complaints.

Quality Of Service

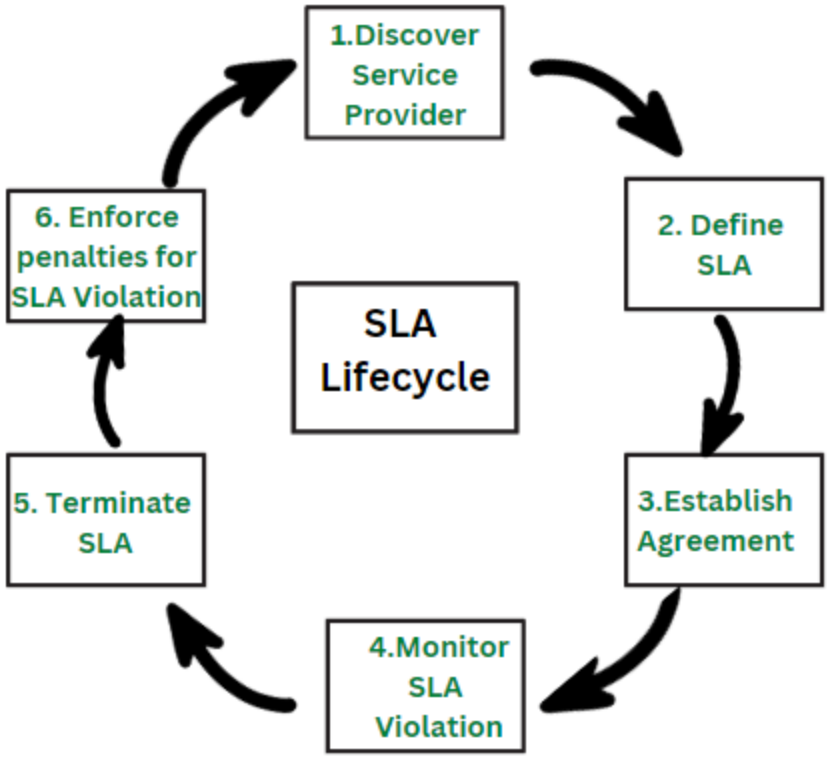
- Technological evaluations
  - QoS has to do with the efficient operation of various systems
  - This can lead to adjusting procedures or adapting software programs and code to achieve the desired effect while making a more efficient use of available resources
  - Example: Consider a **web hosting company** that provides online services to businesses through a cloud-based platform. The company is evaluating its **Quality of Service (QoS)** based on system performance, specifically the responsiveness of its **web servers** and **resource utilization** during peak traffic periods.

Service Level Agreement

- Definition
  - A service-level agreement (SLA) is a contract between a network service provider and a customer that specifies, usually in measurable terms (QoS), what services the network service provider will furnish

- Common content in contract
  - Performance guarantee metrics
    - Up-time and down-time ratio
    - System throughput
    - Response time
  - Problem management detail
  - Penalties for non-performance
  - Documented security capabilities

Steps in SLA Lifecycle



Cloud Service Consumer

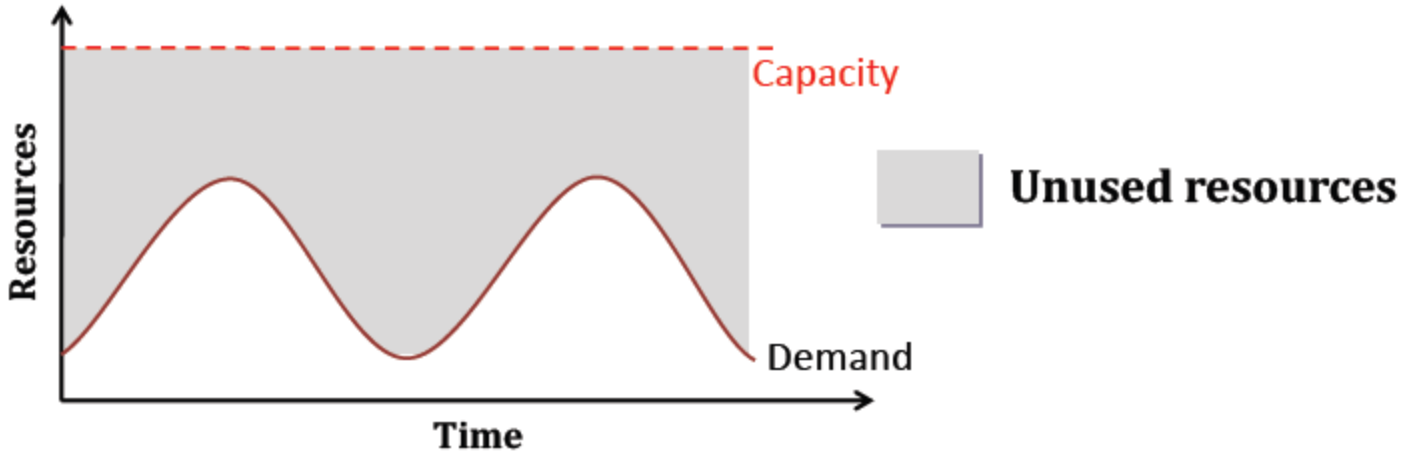
- The cloud service consumer is a temporary runtime role assumed by a software program when it accesses a cloud service
- any individual(Google Drive, Dropbox, or iCloud), organization(Microsoft 365, or application(AWS) that uses cloud services provided by a cloud service provider.

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 grow or shrink infrastructure resources dynamically as needed to adapt to workload changes in an autonomic manner, maximizing the use of resources. This can result in savings in infrastructure costs overall.
- But how to achieve these properties ?
  - Dynamic provisioning
  - Multi-tenant design

Static Provisioning

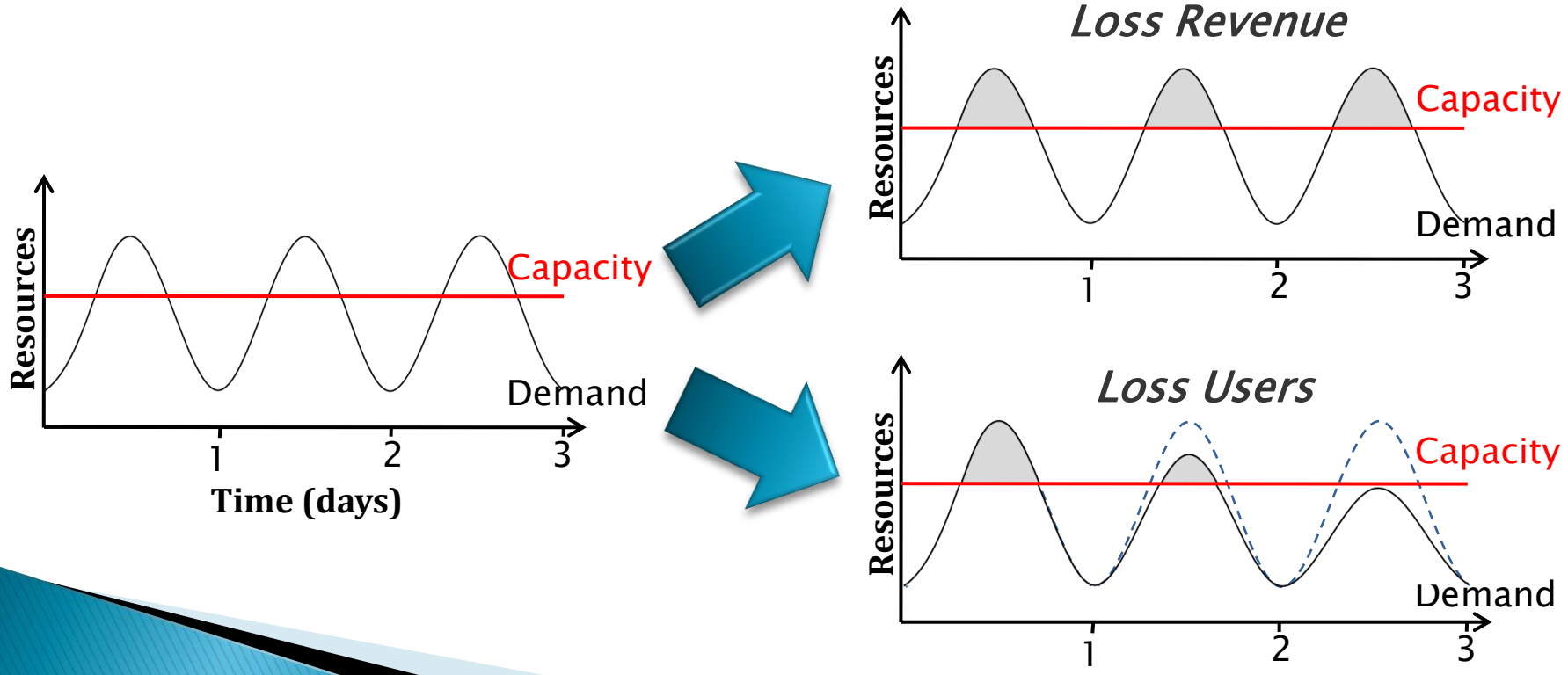
- Overestimate system capacity which result in low utilization



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

Dynamic Provisioning

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

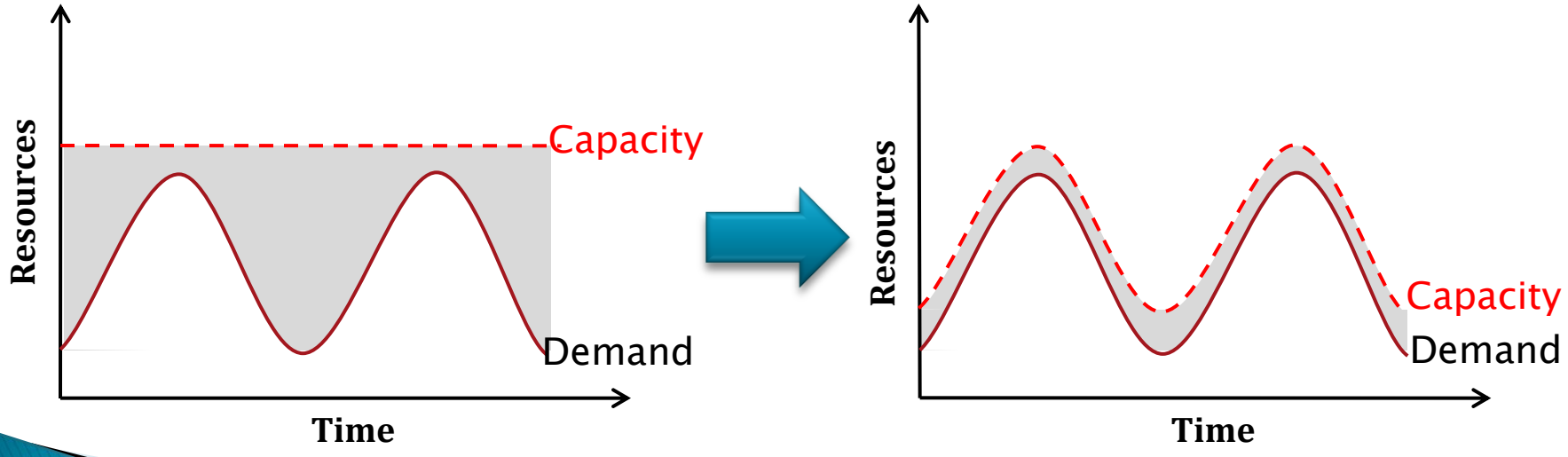


Dynamic Provisioning

- What is dynamic provisioning ?
  - automatic allocation or deallocation of resources (like compute power, storage, or network bandwidth) based on real-time demand
  - 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.
  - Ex: Netflix-
    - **Peak hours**: Evening times and weekends
    - **Off-peak hours**: Early mornings

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



Traditional infrastructure

Deployment in the cloud

Multi-tenant Design

- What is multi-tenant design ?
  - Multi-tenant refers to a principle in software architecture where a single instance of the software runs on a server, serving multiple client organizations.
  - With a multi-tenant architecture, a software application is designed to virtually partition its data and configuration thus each client organization works with a customized virtual application instance.

- Client oriented requirements :
  - Customization
    - Multi-tenant applications are typically required to provide a high degree of customization to support each target organization's needs.
  - Quality of service
    - Multi-tenant applications are expected to provide adequate levels of security and robustness.

Availability & Reliability

- What is availability ?
  - The degree to which a system, subsystem, or equipment is in a specified operable and committable state at the start of a mission, when the mission is called for at an unknown time.
  - Cloud system usually require high availability
    - Ex. “Five Nines” system would statistically provide 99.999% availability
- What is reliability ?
  - The ability of a system or component to perform its required functions under stated conditions for a specified period of time.
- But how to achieve these properties ?
  - Fault tolerance system-No SPF
  - Require system resilience-provide acceptable level of service,recovery
  - Reliable system security-data protection, app security,

Manageability & Interoperability

- What is manageability ?
  - Enterprise-wide administration of cloud computing systems. Systems manageability is strongly influenced by network management initiatives in telecommunications.
- What is interoperability ?
  - Interoperability is a property of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, without any restricted access or implementation.
- But how to achieve these properties ?
  - System control automation
  - System state monitoring

Control Automation

- Four functional areas :
  - Self-Configuration
    - Automatic configuration of components.
  - Self-Healing
    - Automatic discovery, and correction of faults.
  - Self-Optimization
    - Automatic monitoring and control of resources to ensure the optimal functioning with respect to the defined requirements.
  - Self-Protection
    - Proactive identification and protection from arbitrary attacks.

System Monitoring

- What is system monitor ?
  - A System Monitor in systems engineering is a process within a distributed system for collecting and storing state data.
- What should be monitored in the Cloud ?
  - Physical and virtual hardware state
  - Resource performance metrics
  - Network access patterns
  - System logs
  - … etc
- Anything more ?
  - Billing system

Accessibility & Portability

- What is accessibility ?
  - Accessibility is a general term used to describe the degree to which a product, device, service, or environment is accessible by as many people as possible.
- • What is service portability ?
  - Service portability is the ability to access services using any device, anywhere, continuously with mobility support and dynamic adaptation to resource variations.
- But how to achieve these properties ?
  - Uniform access
  - Thin client

Accessibility & Portability

- web browser technique is one of the most widespread platform in almost any intelligent electronic devices.
- Cloud service take this into concern, and delivery their services with web-based interface through the Internet
- End user can access cloud service via plenty of various electronic devices, which include mobile phones and smart TV.

Benefits From Cloud

- Cloud computing brings many benefits :
  - For the market and enterprises
    - Reduce initial investment
    - Reduce capital expenditure
    - Improve industrial specialization
    - Improve resource utilization
  - For the end user and individuals
    - Reduce local computing power
    - Reduce local storage power
    - Variety of thin client devices in daily life

What does cloud computing achieve ?

	Traditional	With Cloud Computing
Business focus	*Need to own its IT department*	*Cloud provider takes care everything*
Payment	*Pay for all investment and human resource*	*Enterprise pays as the service used*
Time duration	*Long establish time*	*Fast to business ready*

Reduce Local Computing Power

- What does cloud computing achieve ?

	Traditional	With Cloud Computing
Hardware Requirement	*User needs to buy powerful hardware*	*Only basic hardware to connect to internet*
Software Requirement	*Install application in local computer*	*No local installation requirement*
Portability	*Hard to be portable*	*Natively portable*

Reduce Local Storage Power

- What does cloud computing achieve ?

	Traditional	With Cloud Computing
Storage Space	*Limited to local disk, may be underutilized*	*Dynamically allocated on demand*
Storage Data Consistency	*Difficult to maintain data consistency*	*Data consistency maintained by cloud*
Availability	*Regular user backup*	*Cloud service guarantee*

Variety of End Devices

- What does cloud computing achieve ?

	Traditional	With Cloud Computing
Computing Power	*Only accessed through desktop computer*	*Accessed through small smart devices*
Small Device Intelligence	*Functionalities were limited due to their power consumption*	*Shift computing intensive jobs into cloud, and then wait for results*

Goals and Benefits

- Reduced Investment & Proportional costs
- Increased Scalability
- Increased Availability & Reliability

Basic Concepts

- There are certain services and models working behind the scene making the cloud computing feasible and accessible to end users. Following are the working models for cloud computing:

- Deployment Models
- Services Models

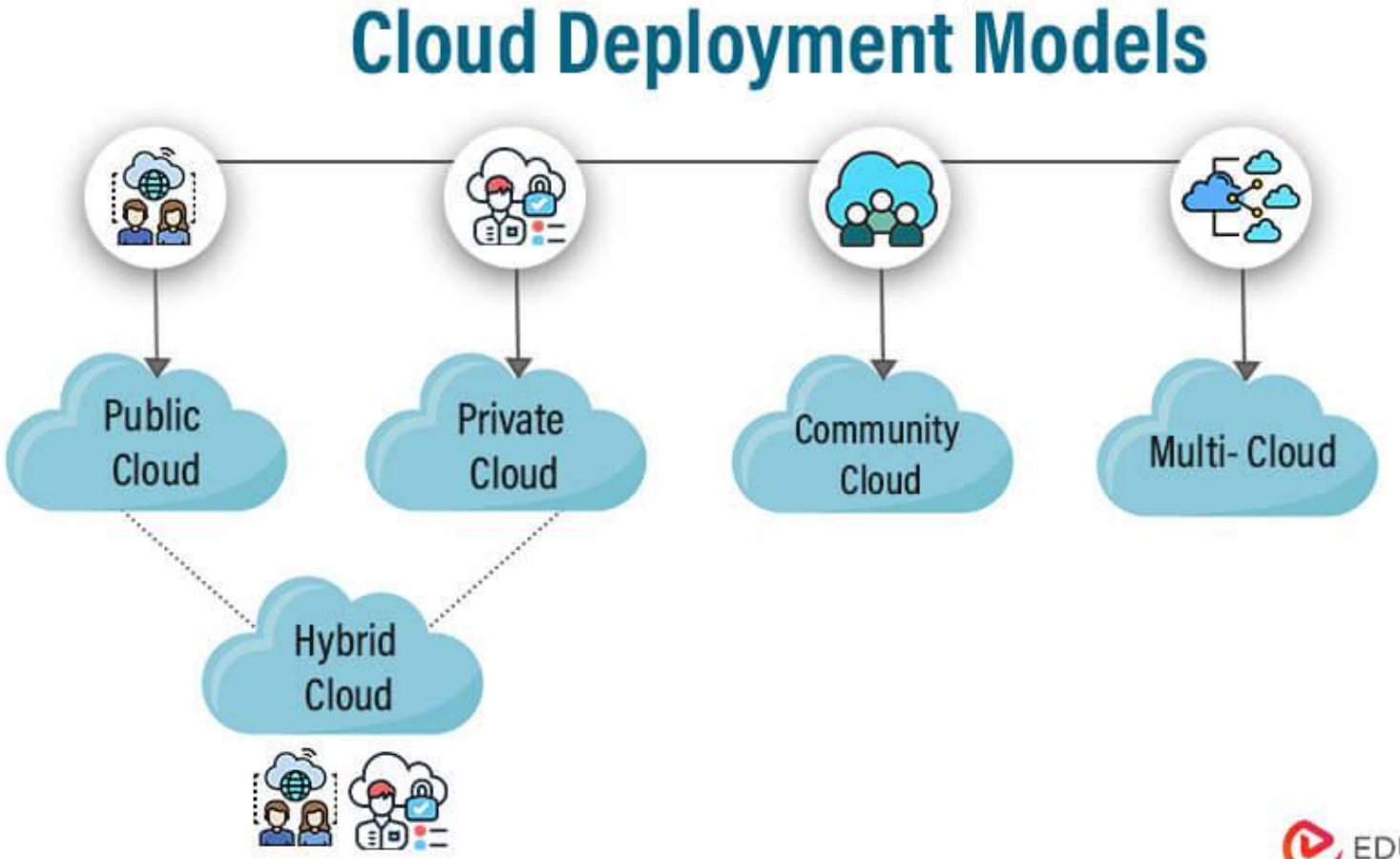
Deployment Models

- 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 Model

- There are four primary cloud deployment models :
  - Public Cloud
  - Private Cloud
  - Community Cloud
  - Hybrid Cloud
- Each can exhibit the previously discussed characteristics; their differences lie primarily in the scope and access of published cloud services, as they are made available to service consumers.

Deployment Models



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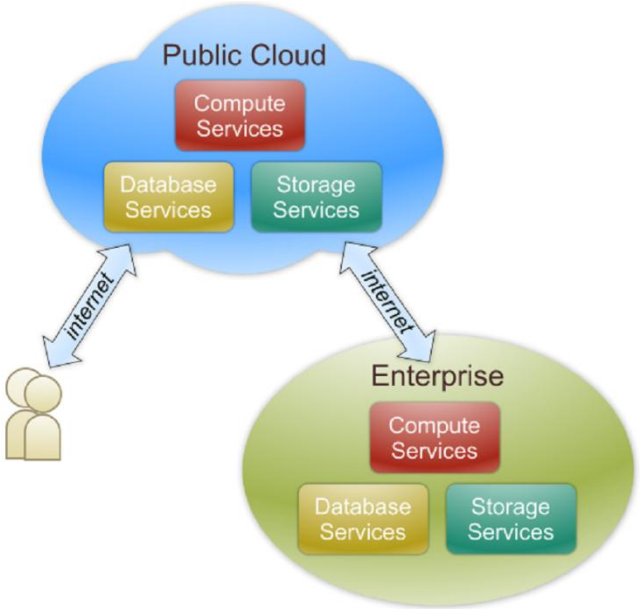
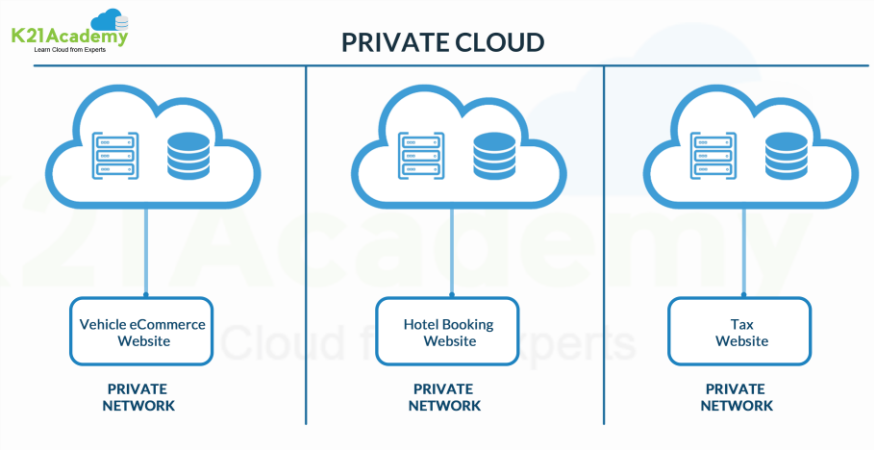
Public Cloud

- 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



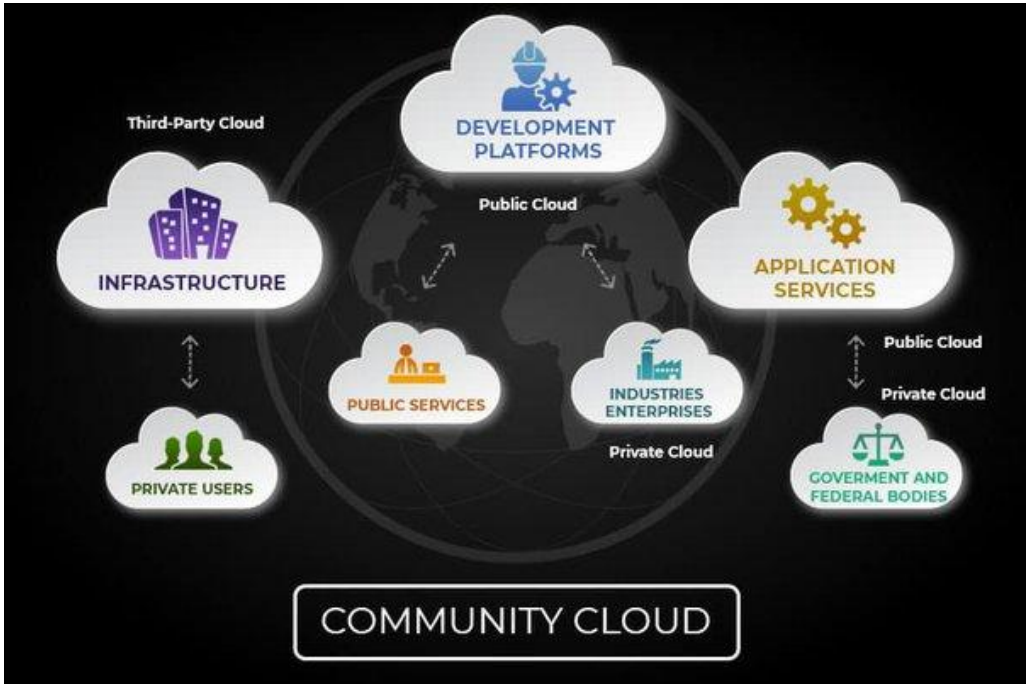
Public vs. Private

- 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*

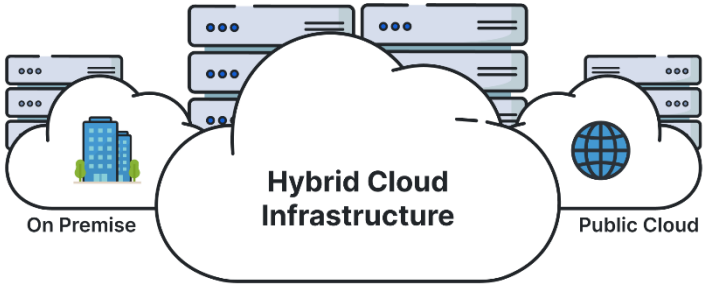
Community Cloud

- 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).



Hybrid Cloud

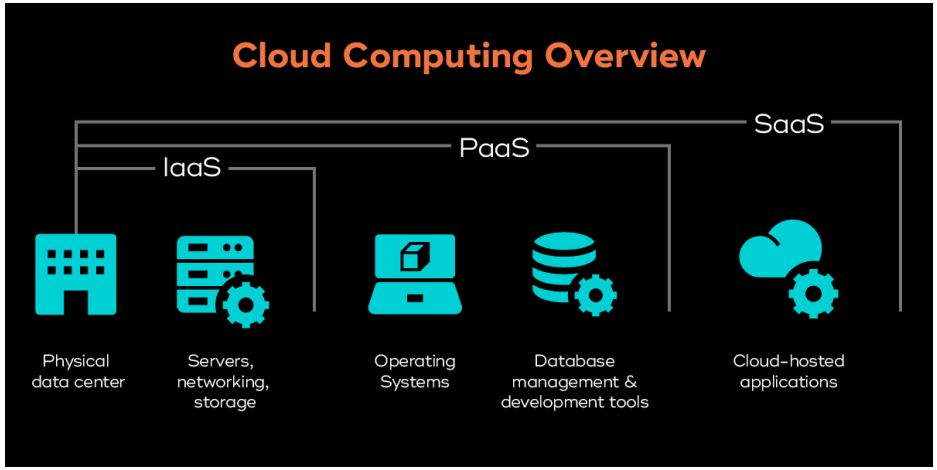
- Hybrid cloud definition
  - The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).



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)**



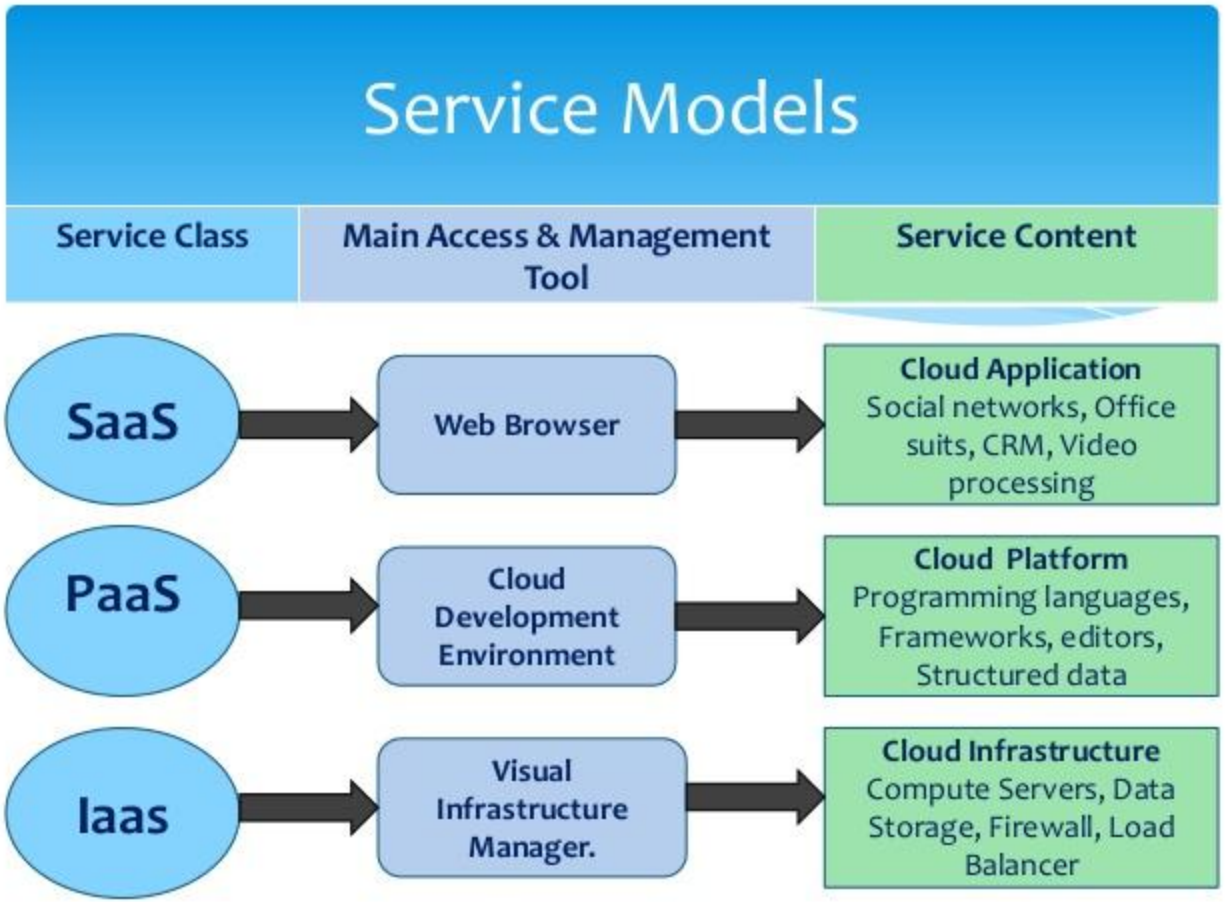
Service Models

- Moved to a city and looking for a place to live
  - build a new house
  - buy an empty house
  - live in a hotel

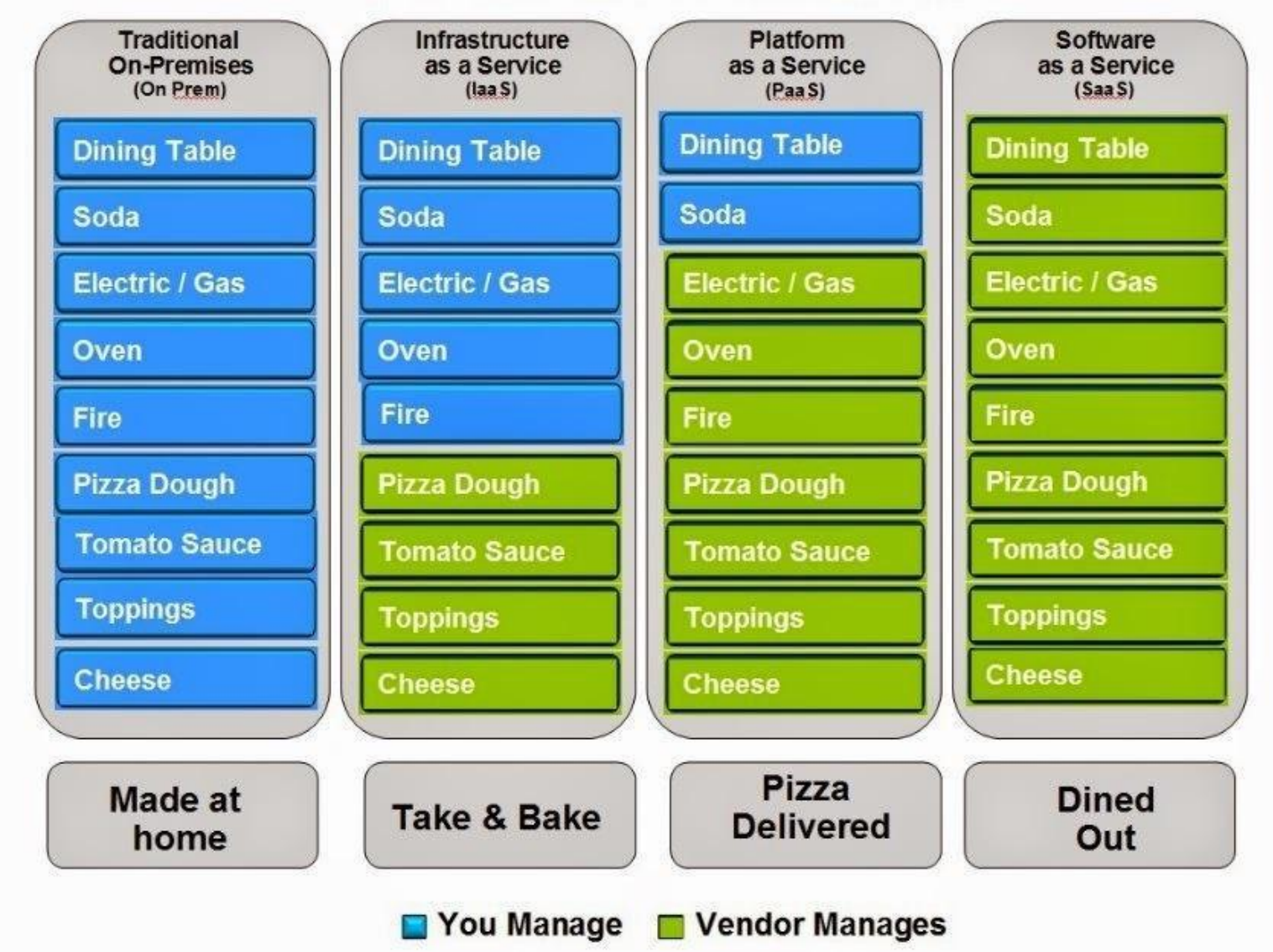
Service Models Overview

- What if you want to have an IT department ?
  - Similar to ***build a new house*** in previous analogy
    - You can rent some virtualized infrastructure and build up your own IT system among those resources, which may be fully controlled.
    - Technical speaking, use the ***Infrastructure as a Service (IaaS)*** solution.
  - Similar to ***buy an empty house*** in previous analogy
    - You can directly develop your IT system through one cloud platform, and do not care about any lower level resource management.
    - Technical speaking, use the ***Platform as a Service (PaaS)*** solution.
  - Similar to ***live in a hotel*** in previous analogy
    - You can directly use some existed IT system solutions, which were provided by some cloud application service provider, without knowing any detail technique about how these service was achieved.
    - Technical speaking, use the ***Software as a Service (SaaS)*** solution.

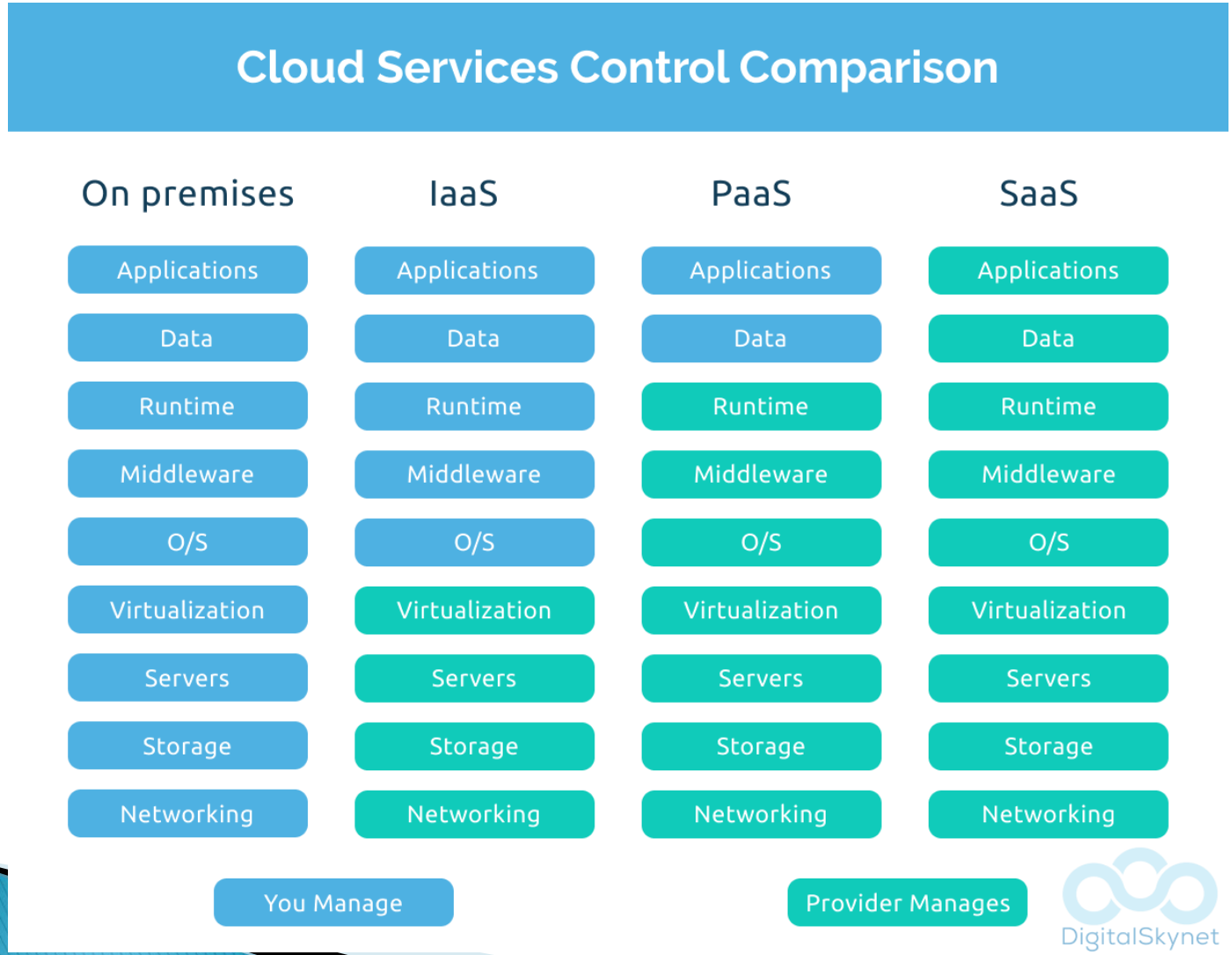
Service Model Overview



Pizza Service Models



Cloud Service Models



Infrastructure as a Service (IaaS)

- **IaaS** is the delivery of technology infrastructure as an on demand scalable service.
- **IaaS** provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.

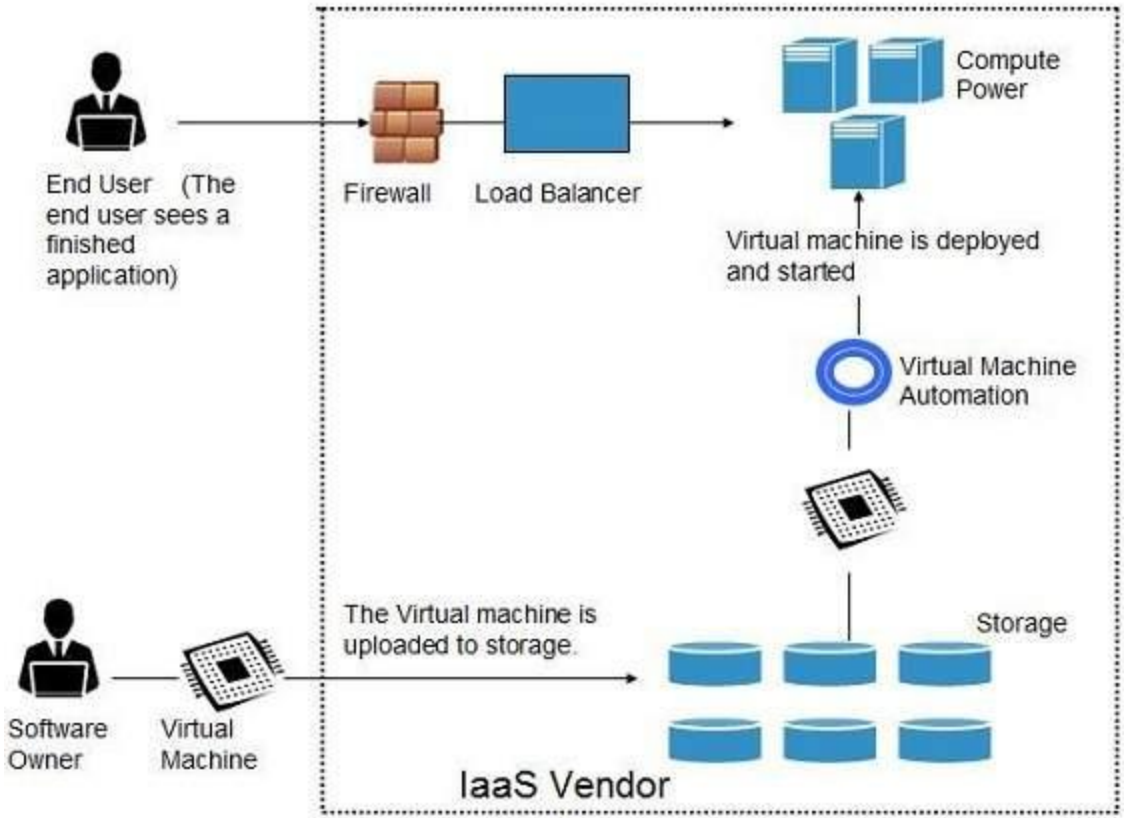
- Usually billed based on usage
- Usually multi tenant virtualized environment
- Can be coupled with Managed Services for OS and application support

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
  - Eucalyputs
  - OpenNebula
  - … etc

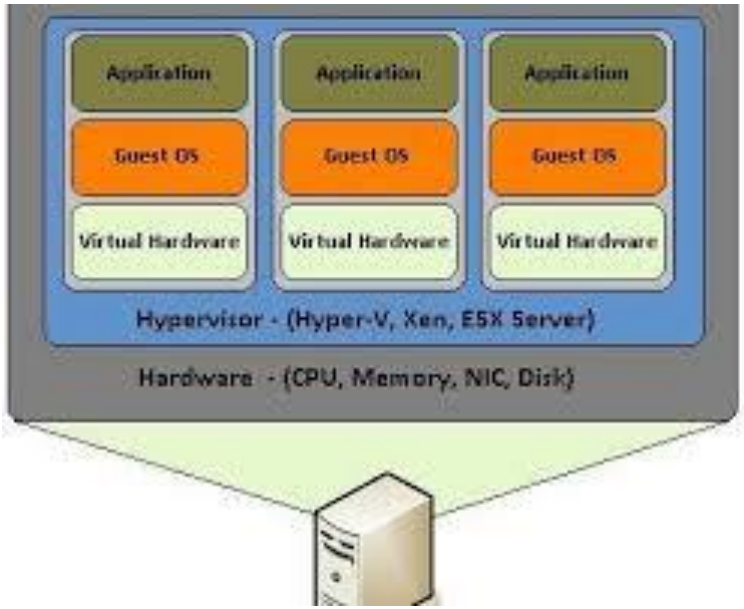
Infrastructure as a Service

- 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

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.

Infrastructure as a Service

- Provide service – **System Monitoring Interface**
  - Several types of monitoring metrics :
    - ***Virtual Machine*** – As an IaaS provider, we should be able to monitor some system states of each virtual machine, such as *CPU loading*, *memory utilization*, *IO loading* and *internal network loading*, …etc.
    - ***Virtual Storage*** – As an IaaS provider, we should be able to monitor some storage states of each virtual storage, such as *virtual space utilization*, *data duplication* and *storage device access bandwidth*, …etc.
    - ***Virtual Network*** – As an IaaS provider, we should be able to monitor some network states of each virtual network, such as *virtual network bandwidth*, *network connectivity* and *network load balancing*, …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 (PaaS)

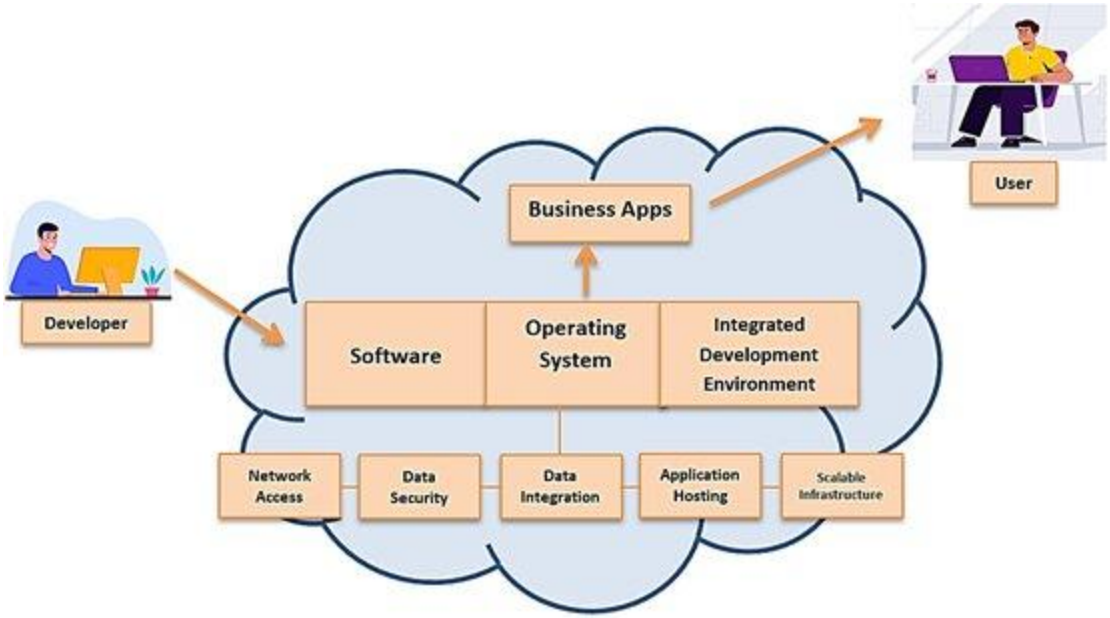
- PaaS provides the runtime environment for applications, development & deployment tools, etc.
- PaaS provides all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely from the Internet.
- Typically applications must be developed with a particular platform in mind
- •Multi tenant environments
- •Highly scalable multi tier architecture

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

Platform as a Service

- Provide service – **System Control Interface**
  - Police-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

PaaS Examples

Software as a Service (SaaS)

SaaS model allows to use software applications as a service to end users.

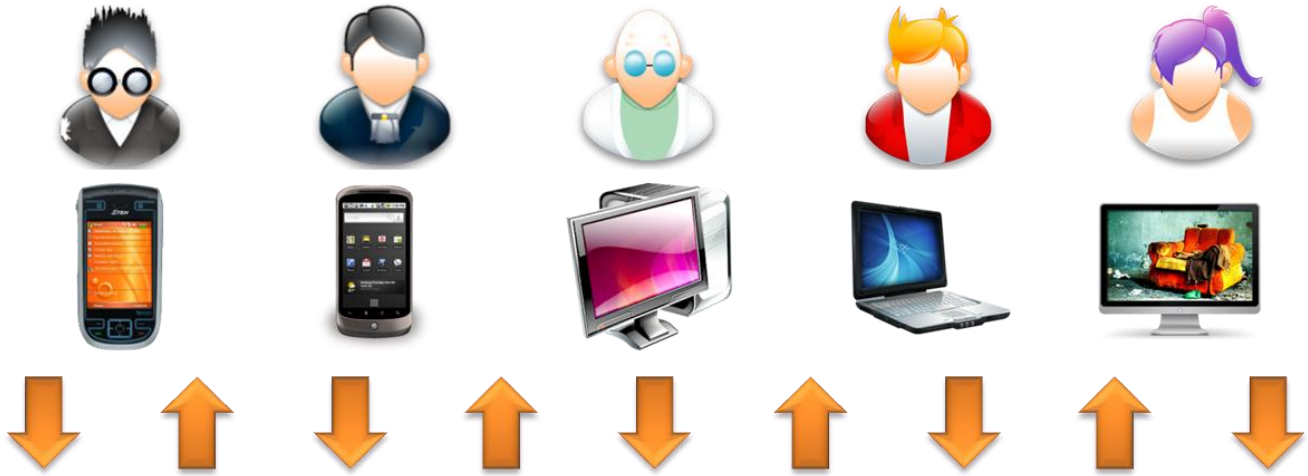
SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service.

- Usually billed based on usage
- Usually multi tenant environment
- Highly scalable architecture

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



Web-base Applications

Web Portal

General Applications

Business Applications

Scientific Applications

Government Applications

Commercial Platform

Open Source Platform

Other

Application

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

SaaS Examples

salesforce.com
Success On Demand.

NETSUITE
ONE SYSTEM. NO LIMITS.

postini

Microsoft Online Services: Business Productivity Online Suite
SharePoint Online
Office Communications Online
Exchange Online
Office Live Meeting

facebook

IaaS	Paas	SaaS
It provides a virtual data center to store information and create platforms for app development, testing, and deployment.	It provides virtual platforms and tools to create, test, and deploy apps.	It provides web software and apps to complete business tasks.
It provides access to resources such as virtual machines, virtual storage, etc.	It provides runtime environments and deployment tools for applications.	It provides software as a service to the end-users.
It is used by network architects.	It is used by developers.	It is used by end users.
IaaS provides only **Infrastructure.**	PaaS provides **Infrastructure+Platform.**	SaaS provides **Infrastructure+Platform +Software.**
Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.	AWS Elastic Beanstalk, Windows Azure, Heroku, Force.com, Google App Engine, Apache Stratos, Magento Commerce Cloud, and OpenShift.	BigCommerce, Google Apps, Salesforce, Dropbox, ZenDesk, Cisco WebEx, ZenDesk, Slack, and GoToMeeting.

Benefits of Cloud Hosting

- **Scalability:** With Cloud hosting, it is easy to grow and shrink the number and size of servers based on the need. This is done by either increasing or decreasing the resources in the cloud. This ability to alter plans due to fluctuation in business size and needs is a superb benefit of cloud computing especially when experiencing a sudden growth in demand.

- **Instant:** Whatever you want is instantly available in the cloud.

Benefits of Cloud Hosting

- **Save Money:** An advantage of cloud computing is the reduction in hardware cost. Instead of purchasing in-house equipment, hardware needs are left to the vendor.

- For companies that are growing rapidly, new hardware can be a large, expensive, and inconvenience. Cloud computing alleviates these issues because resources can be acquired quickly and easily. Even better, the cost of repairing or replacing equipment is passed to the vendors.

Benefits of Cloud Hosting

- Along with purchase cost, off-site hardware cuts internal power costs and saves space.

- Large data centers can take up precious office space and produce a large amount of heat. Moving to cloud applications or storage can help maximize space and significantly cut energy expenditures.

Benefits of Cloud Hosting

- **Reliability:** Rather than being hosted on one single instances of a physical server, hosting is delivered on a virtual partition which draws its resource, such as disk space, from an extensive network of underlying physical servers.

- If one server goes offline it will have no effect on availability, as the virtual servers will continue to pull resource from the remaining network of servers.

Benefits of Cloud Hosting

- **Physical Security:** The underlying physical servers are still housed within data centres and so benefit from the security measures that those facilities implement to prevent people accessing or disrupting them on-site

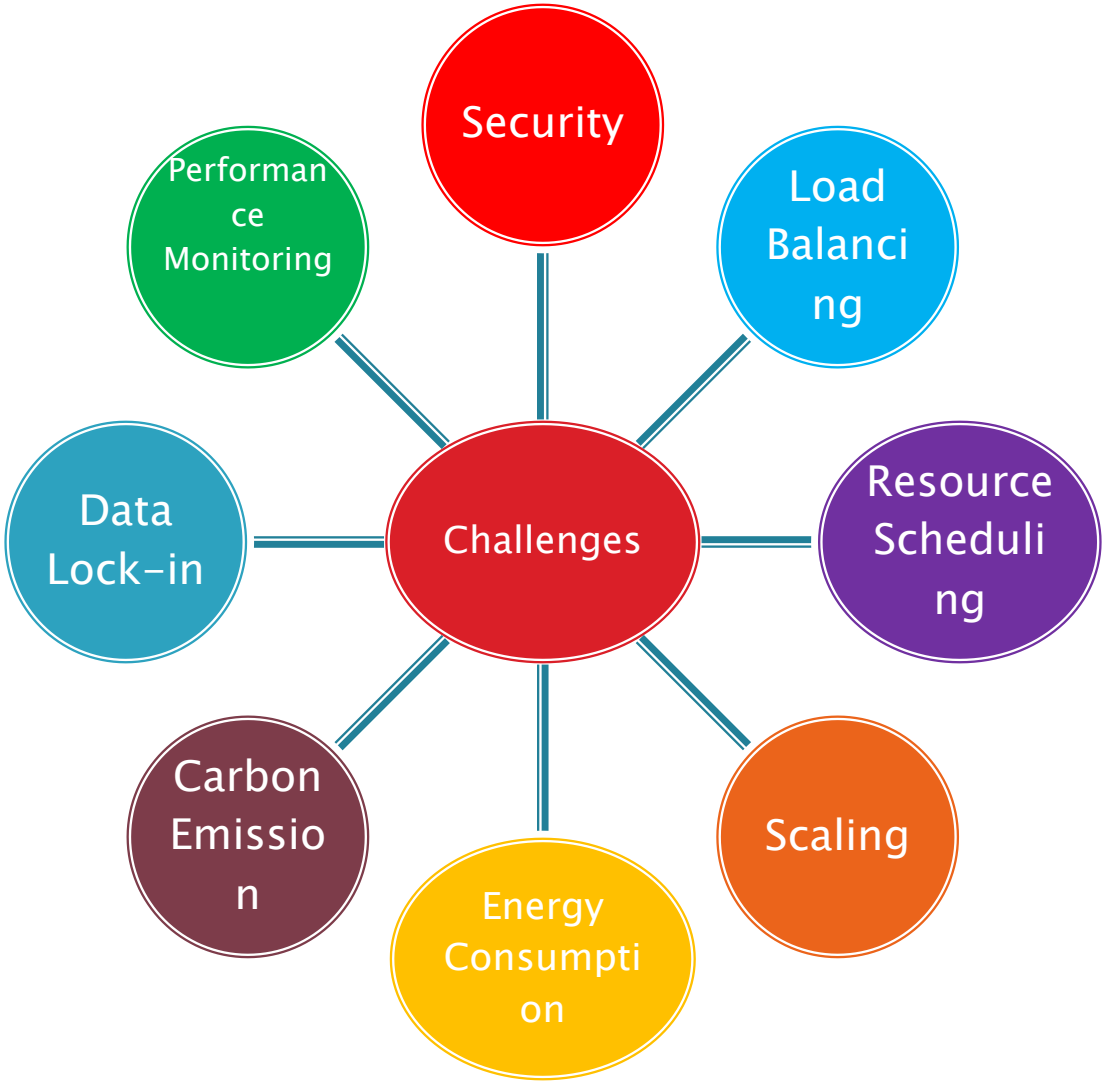
List of Advantages

- Improved performance
- Reduced software costs
- Instant software updates
- Improved document format compatibility
- Unlimited storage capacity
- Increased data reliability
- Universal document access
- Latest version availability
- Easier group collaboration
- Device independence

List of Disadvantages

- Requires a constant Internet connection
- Does not work well with low-speed connections
- Features might be limited
- Can be slow
- Stored data can be lost
- Stored data might not be secure

Challenges in Cloud Computing



Challenges of Cloud

1. Data Security and Privacy
2. Cost Management
3. Multi-Cloud Environments
4. Performance Challenges
5. Interoperability and Flexibility
6. High Dependence on Network
7. Lack of Knowledge and Expertise

1. Data Security and Privacy

- Data security is a major concern when switching to cloud computing. User or organizational data stored in the cloud is critical and private.

- Even if the cloud service provider assures data integrity, it is your responsibility to carry out user authentication and authorization, identity management, data encryption, and access control.

1. Data Security and Privacy

- Security issues on the cloud include identity theft, data breaches, malware infections, and a lot more which eventually decrease the trust amongst the users of your applications.

- This can in turn lead to potential loss in revenue alongside reputation and stature. Also, dealing with cloud computing requires sending and receiving huge amounts of data at high speed, and therefore is susceptible to data leaks.

2. Cost Management

- Even as almost all cloud service providers have a “Pay As You Go” model, which reduces the overall cost of the resources being used, there are times when there are huge costs incurred to the enterprise using cloud computing.

- When there is under optimization of the resources, let’s say that the servers are not being used to their full potential, add up to the hidden costs.

2. Cost Management

- If there is a degraded application performance or sudden spikes or overages in the usage, it adds up to the overall cost.

- Unused resources are one of the other main reasons why the costs go up. If you turn on the services or an instance of cloud and forget to turn it off during the weekend or when there is no current use of it, it will increase the cost without even using the resources.

3. Multi Cloud Environments

- Due to an increase in the options available to the companies, enterprises not only use a single cloud but depend on multiple cloud service providers.

- Most of these companies use hybrid cloud tactics and close to 84% are dependent on multiple clouds. This often ends up being hindered and difficult to manage for the infrastructure team.

- The process most of the time ends up being highly complex for the IT team due to the differences between multiple cloud providers.

4. Performance Challenges

- Performance is an important factor while considering cloud-based solutions. If the performance of the cloud is not satisfactory, it can drive away users and decrease profits.

- Even a little latency while loading an app or a web page can result in a huge drop in the percentage of users. This latency can be a product of inefficient load balancing, which means that the server cannot efficiently split the incoming traffic so as to provide the best user experience.

- Challenges also arise in the case of fault tolerance, which means the operations continue as required even when one or more of the components fail.

4. Interoperability and Flexibility

- When an organization uses a specific cloud service provider and wants to switch to another cloud-based solution, it often turns up to be a tedious procedure since applications written for one cloud with the application stack are required to be re-written for the other cloud.

- There is a lack of flexibility from switching from one cloud to another due to the complexities involved. Handling data movement, setting up the security from scratch and network also add up to the issues encountered when changing cloud solutions, thereby reducing flexibility.

4. High Dependence on Network

- Since cloud computing deals with provisioning resources in real-time, it deals with enormous amounts of data transfer to and from the servers. This is only made possible due to the availability of the high-speed network.

- Although these data and resources are exchanged over the network, this can prove to be highly vulnerable in case of limited bandwidth or cases when there is a sudden outage.

4. High Dependence on Network

- Even when the enterprises can cut their hardware costs, they need to ensure that the internet bandwidth is high as well there are zero network outages, or else it can result in a potential business loss.

- It is therefore a major challenge for smaller enterprises that have to maintain network bandwidth that comes with a high cost.

4. Lack of Knowledge and Expertise

- Due to the complex nature and the high demand for research working with the cloud often ends up being a highly tedious task.

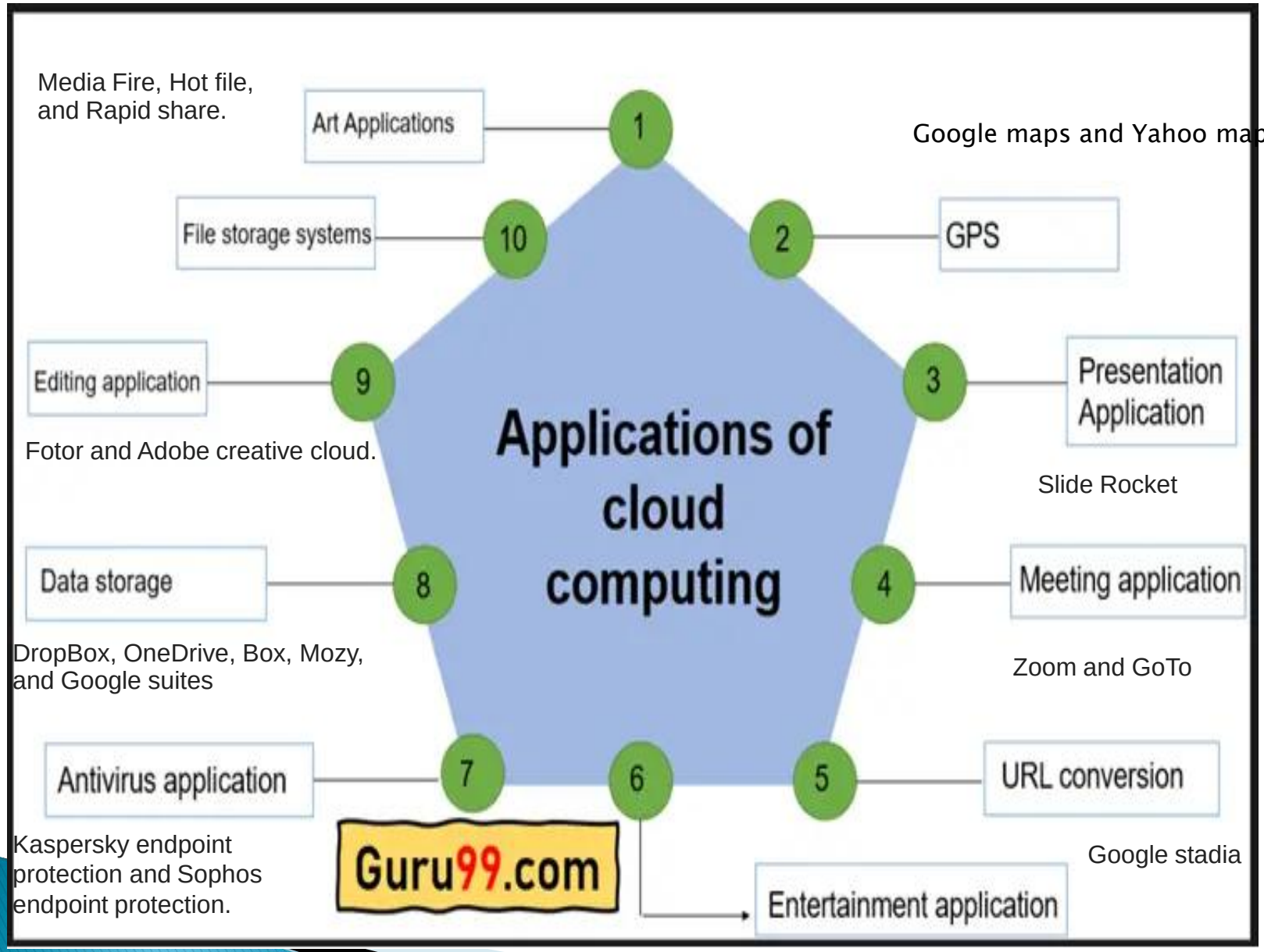
- It requires immense knowledge and wide expertise on the subject. Although there are a lot of professionals in the field they need to constantly update themselves. Cloud computing is a highly paid job due to the extensive gap between demand and supply.

4. Lack of Knowledge and Expertise

- There are a lot of vacancies but very few talented cloud engineers, developers, and professionals.

- Therefore, there is a need for upskilling so these professionals can actively understand, manage and develop cloud-based applications with minimum issues and maximum reliability.

Vistaprint and Adobe Creative

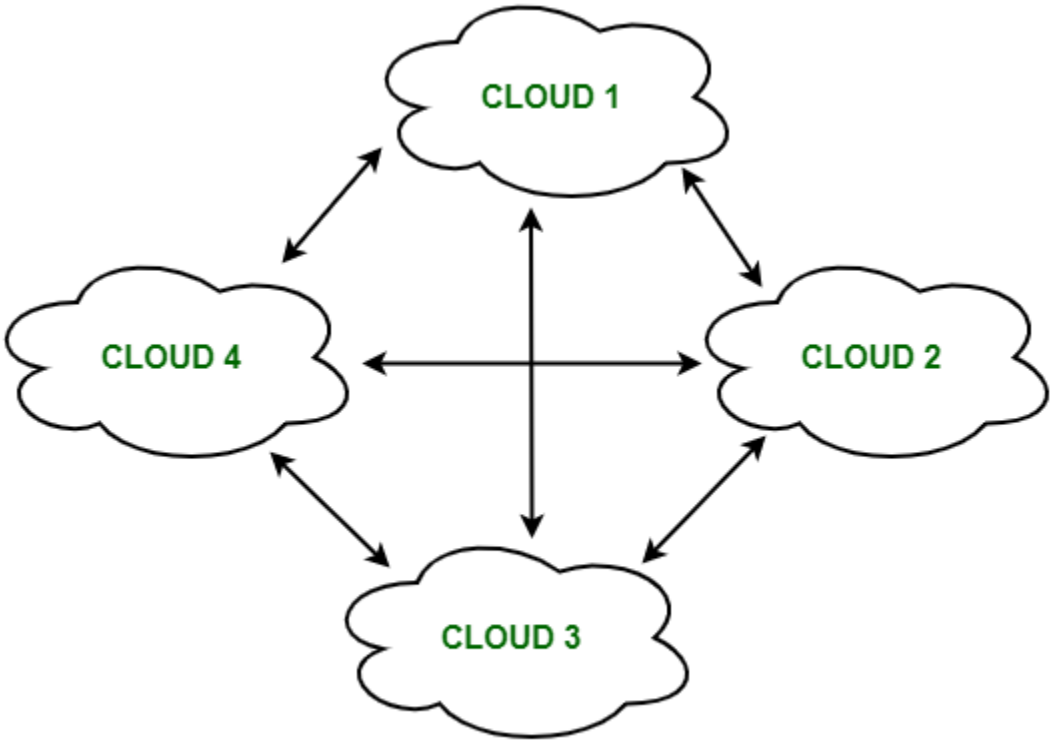


Federated Cloud

- Cloud Federation, also known as Federated Cloud is the deployment and management of several external and internal cloud computing services to match business needs.

- It is a multi-national cloud system that integrates private, community, and public clouds into scalable computing platforms. Federated cloud is created by connecting the cloud environment of different cloud providers using a common standard.

Federated Cloud



Federated Cloud

Architecture of Federated Cloud

- **1. Cloud Exchange**
- **2. Cloud Coordinator**
- **3. Cloud Broker**

Cloud Exchange

- The Cloud Exchange acts as a mediator between cloud coordinator and cloud broker.
- The demands of the cloud broker are mapped by the cloud exchange to the available services provided by the cloud coordinator.
- The cloud exchange has a track record of what is the present cost, demand patterns, and available cloud providers, and this information is periodically reformed by the cloud coordinator.

Cloud Coordinator

- The cloud coordinator assigns the resources of the cloud to the remote users based on the quality of service they demand and the credits they have in the cloud bank.

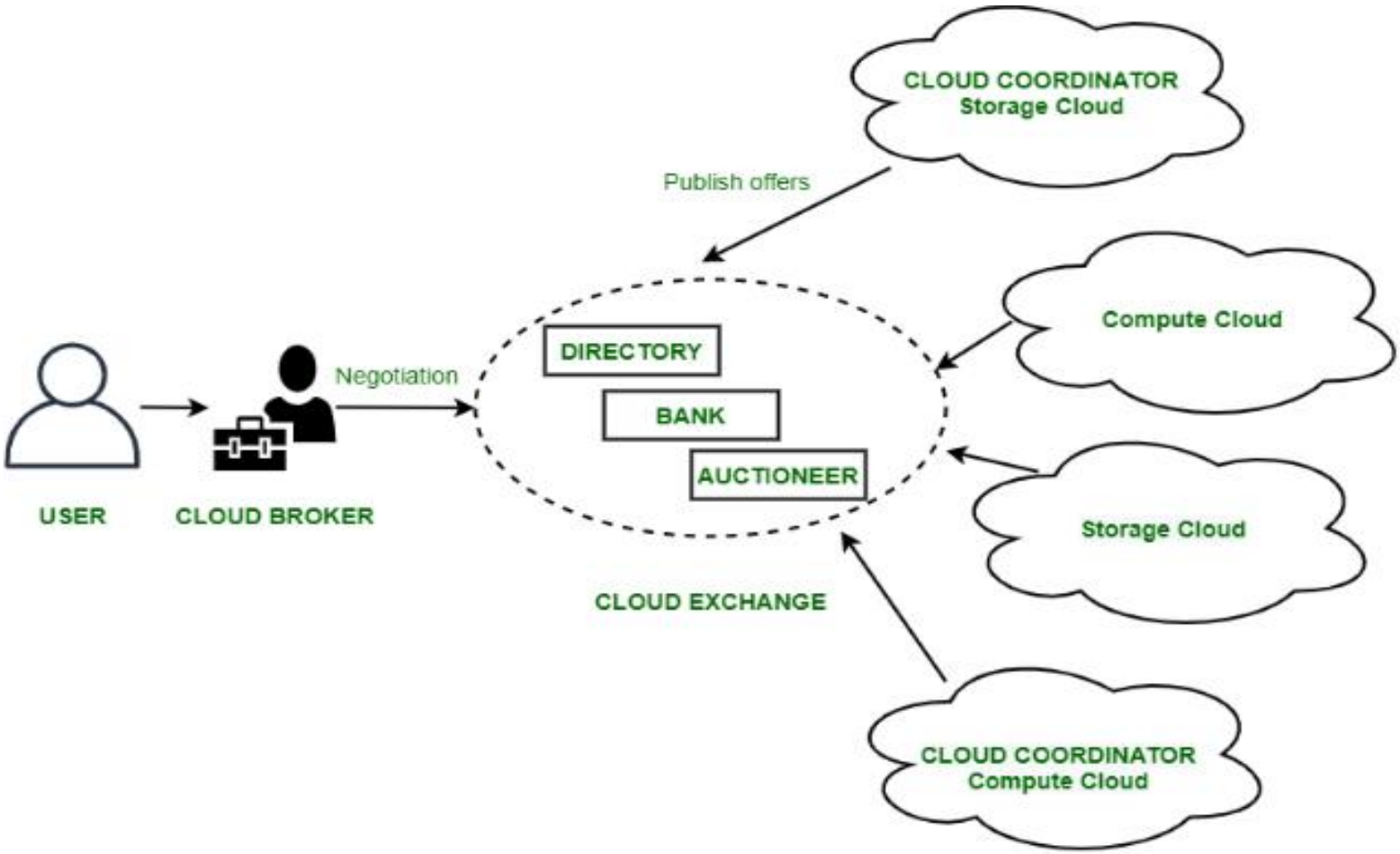
- The cloud enterprises and their membership are managed by the cloud controller.

Cloud Broker

- The cloud broker interacts with the cloud coordinator, analyzes the Service-level agreement and the resources offered by several cloud providers in cloud exchange.

- Cloud broker finalizes the most suitable deal for their client.

Architecture of Federated Cloud



Federal Cloud Architecture

Properties of Federated Cloud

- In the federated cloud, the users can interact with the architecture either centrally or in a decentralized manner.
- In centralized interaction, the user interacts with a broker to mediate between them and the organization. Decentralized interaction permits the user to interact directly with the clouds in the federation.
- Federated cloud can be practiced with various niches like commercial and non-commercial.

Properties of Federated Cloud

- The visibility of a federated cloud assists the user to interpret the organization of several clouds in the federated environment.

- Federated cloud can be monitored in two ways. MaaS (Monitoring as a Service) provides information that aids in tracking contracted services to the user. Global monitoring aids in maintaining the federated cloud.

Properties of Federated Cloud

- The providers who participate in the federation publish their offers to a central entity. The user interacts with this central entity to verify the prices and propose an offer.

- The marketing objects like infrastructure, software, and platform have to pass through federation when consumed in the federated cloud.

Benefits of Federated Cloud

- It minimizes the consumption of energy.
- It increases reliability.
- It minimizes the time and cost of providers due to dynamic scalability.
- It connects various cloud service providers globally. The providers may buy and sell services on demand.
- It provides easy scaling up of resources.

Challenges of Federated Cloud

- In cloud federation, it is common to have more than one provider for processing the incoming demands.
- In such cases, there must be a scheme needed to distribute the incoming demands equally among the cloud service providers.
- The increasing requests in cloud federation have resulted in more heterogeneous infrastructure, making interoperability an area of concern.

Challenges of Federated Cloud

- It becomes a challenge for cloud users to select relevant cloud service providers and therefore, it ties them to a particular cloud service provider.

- A federated cloud means constructing a seamless cloud environment that can interact with people, different devices, several application interfaces, and other entities.

Federated Cloud technologies

- OpenNebula
- Aneka coordinator
- Eucalyptus

1. OpenNebula

- It is a cloud computing platform for managing heterogeneous distributed data center infrastructures.

- It can use the resources of its interoperability, leveraging existing information technology assets, protecting the deals, and adding the application programming interface (API).

2. Aneka Coordinator

- The Aneka coordinator is a proposition of the Aneka services and Aneka peer components (network architectures) which give the cloud ability and performance to interact with other cloud services.

3. Eucalyptus

- Eucalyptus defines the pooling computational, storage, and network resources that can be measured scaled up or down as application workloads change in the utilization of the software.

- It is an open-source framework that performs the storage, network, and many other computational resources to access the cloud environment.

THANK YOU!