

## 1. Definition

Cloud Computing is a technology that delivers computing services like storage, servers, databases, networking, and software over the internet ("the cloud").

Q1. Enlist essential characteristics of cloud computing

"Ohh Brother, Rutuja Runs Maggi Machine, Really Loud!"   

### Essential Characteristics of Cloud Computing (8 Points)

#### 1. On-Demand Self Service:

Users can provision resources like storage, servers, or apps automatically whenever required, without manual effort.

#### 2. Broad Network Access:

Cloud services are delivered over the internet and can be accessed on devices such as mobiles, laptops, and tablets.

#### 3. Resource Pooling:

Providers pool resources and serve multiple users, dynamically assigning servers, storage, and applications as per demand.

#### 4. Rapid Elasticity:

Resources can be scaled up or scaled down quickly, giving users the impression of having unlimited availability at any time.

#### 5. Measured Service:

The usage of cloud resources is continuously monitored, controlled, and billed in a transparent way based on actual consumption.

#### 6. Multi-Tenancy:

One cloud system serves multiple independent users securely, ensuring proper isolation of their data and applications.

#### 7. Resiliency & Fault Tolerance:

Cloud systems use backup and redundancy to maintain availability even during errors, failures, or outages.

#### 8. Location Independence:

Users can access data and services from anywhere, without knowing the exact physical location of servers.

Enlist phases of VM migration

### VM Migration –

*Process of moving a VM from one host to another with minimal downtime.*

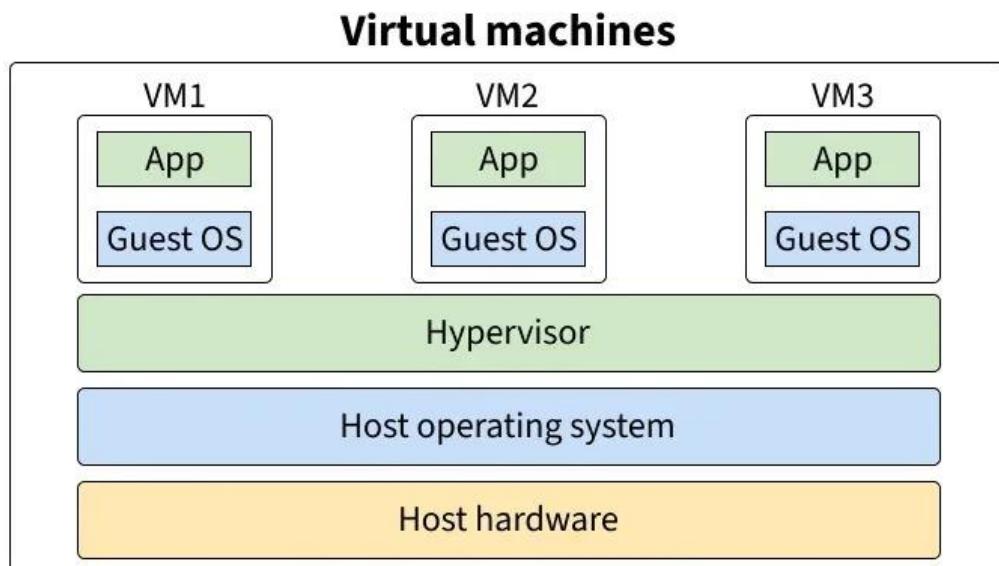
#### Phases of VM Migration (Common)

1. **Planning & Onboarding** – Choose which VM to move and decide the destination.
2. **Replication / Data Copy** – Copy or sync the VM data to the new system.
3. **Configuration** – Set CPU, RAM, storage, and network for target VM.
4. **Testing** – Start test VM and check if it runs correctly.
5. **Cut-Over** – Stop source VM, do final sync, and switch to the new VM.
6. **Finalization** – Clean up old VM and confirm migration is successful.

Differentiate between public and Private cloud

Public Cloud vs Private Cloud (5 Points + Examples)		
Aspect	Public Cloud	Private Cloud
1. Ownership	Owned & managed by third-party providers.	Owned & managed by a single organization.
2. Access	Services available to anyone on pay-as-you-go.	Restricted to one organization only.
3. Cost	Low upfront cost, subscription model.	High setup & maintenance cost.
4. Scalability	Highly scalable on demand.	Limited scalability (internal resources).
5. Security & Control	Less control, provider handles security.	More control, customized security policies.
Example	AWS, Microsoft Azure, Google Cloud.	VMware vSphere, OpenStack, Microsoft Private Cloud.

Draw Reference model of Virtualization



Enlist essential characteristics of Virtualization

💡 "I Really Enjoy Having Some Fun Studying Machines"

#### 1. Definition

Virtualization is the process of creating **virtual versions of hardware** (servers, storage, OS, or networks) using a **hypervisor**, allowing **multiple virtual machines (VMs)** to run on a single physical system.

#### ❖ Characteristics of a Virtualized Environment (8 Points)

##### 1. Isolation

Each virtual machine (VM) runs in a completely isolated environment, so issues in one VM do not affect others.

##### 2. Resource Sharing

Physical resources such as CPU, memory, and storage are shared among multiple VMs for efficient utilization.

##### 3. Encapsulation

A VM is stored as a single file or package, making it easy to copy, move, backup, and restore.

##### 4. Hardware Independence

VMs are independent of the underlying hardware, so they can run on different physical machines without changes.

##### 5. Security

Virtualization provides strong separation of data and applications across VMs, reducing the chance of unauthorized access.

##### 6. Flexibility

New VMs can be quickly created, configured, or deleted, giving a highly adaptable IT environment.

##### 7. Scalability

Virtualized environments can scale easily by adding more VMs to meet increased workload demands.

##### 8. Manageability

Centralized management tools allow administrators to monitor, update, and control multiple VMs from one interface.

Write a note on Hypervisor with types

Hypervisor –

A hypervisor is a software that creates and manages multiple VMs by sharing and allocating resources like CPU, memory, and storage among them while keeping them isolated.

### ⚙️ Types of Hypervisors (with OS Control View)

#### 1. Type 1 Hypervisor (Bare-metal)

- **Definition:** Runs directly on hardware, no need for a host OS.
- **Advantage:** Has full control over the system without needing permission from an OS.
- **Disadvantage:** Harder to set up and manage.
- **Example:** VMware ESXi, Microsoft Hyper-V

---

#### 2. Type 2 Hypervisor (Hosted)

- **Definition:** Runs on top of a host OS like Windows or Linux.
- **Advantage:** Easy to install and good for personal/dev use.
- **Disadvantage:** Needs permission from the host OS to access hardware.
- **Example:** VirtualBox, VMware Workstation

---

#### 3. Guest-Host Concept 📈 –

- **Host** → The physical machine with hardware resources (CPU, memory, storage).
- **Guest** → The Virtual Machines created on top of the host using the hypervisor.

3 marks

a) Explain Storage virtualization

### Storage Virtualization (6 Points)

#### 1. Definition –

Storage virtualization is the process of combining multiple physical storage devices into one logical storage pool that appears as a single unified resource to users and applications.

#### 2. Purpose –

Allows storage to be accessed as a single resource, even though data is stored across multiple physical devices, making management easier and more efficient.

#### Types:

- **Block Storage** – Stores data in fixed-size blocks, ideal for high-speed systems.

*Example: SAN (Storage Area Network)*

- **File Storage** – Stores data as files in folders, used in most file servers.

*Example: Windows File Server, NAS*

- **Object Storage** – Stores data as objects with metadata, good for media files.

*Example: Amazon S3, Google Cloud Storage*

#### Advantages:

- **Resource Utilization** – Combines unused storage into a single usable pool.
- **Cost Efficiency** – Avoids buying separate storage systems for every use.
- **Isolation & Security** – Keeps data logically separated for each user or app.
- **Flexibility** – Supports block, file, and object types in the same setup.

#### Disadvantages:

- **Performance Overhead** – Extra layer may reduce access speed slightly.
- **Complex Setup** – Requires technical knowledge for proper setup.
- **Resource Limits** – May get overloaded if too many users access it.
- **Data Security Risks** – Misconfiguration can lead to data breaches in shared storage.

#### 6. Example –

Companies use tools like **VMware vSAN** to pool storage from different servers and present it as one shared drive.

Explain Server virtualization

### Server Virtualization (6 Points)

#### 1. Definition –

Server virtualization is the process of dividing a single physical server into multiple virtual servers (VMs), each capable of running its own operating system and applications independently.

#### 2. Purpose –

Allows each virtual server to act like an independent machine while sharing the same underlying physical hardware, improving efficiency and utilization.

#### 3. Types –

- **Full Virtualization:** Hypervisor fully simulates hardware; guest OS is unaware it's virtualized (e.g., VMware ESXi).
- **Para-Virtualization:** Guest OS is modified to work with hypervisor for better performance (e.g., Xen).
- **OS-Level Virtualization:** No hypervisor; containers run in isolated environments under same OS kernel (e.g., Docker, LXC).

#### 4. Advantages –

- **Resource Utilization:** Efficiently uses server hardware by running multiple VMs on one machine.
- **Cost Efficiency:** Reduces need to buy separate physical servers.
- **Isolation & Security:** Each VM runs separately, ensuring data safety.
- **Flexibility:** Supports different operating systems on the same machine.

#### 5. Disadvantages –

- **Performance Overhead:** May run slower than a dedicated server.
- **Hypervisor Dependency:** If hypervisor fails, all VMs are affected.
- **Complex Setup:** Requires skilled configuration and maintenance.
- **Resource Limits:** Too many VMs can overload the host server.

#### 6. Example –

A company can run **Windows Server**, **Linux Server**, and a **Database Server** on a single physical machine instead of buying three separate servers, saving cost and space.

Explain any 3 types of Virtualization

### Explain Any 3 Types of Virtualization (Server, Storage & Processor)

#### 1. Server Virtualization –

- **Definition:** Divides a single physical server into multiple virtual servers (VMs), each running its own OS and applications independently.
- **Types:**
  - **Full Virtualization:** Hypervisor fully simulates hardware (e.g., VMware ESXi).
  - **Para-Virtualization:** Guest OS is modified to work with hypervisor (e.g., Xen).
  - **OS-Level Virtualization:** Uses containers under same OS kernel (e.g., Docker, LXC).
- **Example:** Running Windows Server, Linux Server, and Database Server on one physical machine.

#### 2. Storage Virtualization –

- **Definition:** Combines multiple physical storage devices into a single logical storage pool that appears as one resource.
- **Types:**
  - **Block Storage:** Stores data in fixed-size blocks (e.g., SAN).
  - **File Storage:** Stores data as files (e.g., NAS).
  - **Object Storage:** Stores data as objects with metadata (e.g., Amazon S3).
- **Example:** VMware vSAN pooling disks from multiple servers into one shared storage system.

#### 3. Processor Virtualization –

- **Definition:** Splits one physical CPU into multiple virtual CPUs (vCPUs) allowing multiple OSs or VMs to share the same CPU power.
- **Hypervisor Use:** Hypervisor schedules CPU time for each VM, keeping them isolated from each other.
- **Advantages:**
  - **Resource Utilization:** Improves CPU usage by allowing full utilization.
  - **Cost Efficiency:** Runs multiple VMs on one processor, reducing hardware cost.
- **Example:** Intel Xeon processor split into 8 vCPUs, each running a different VM.

e) Write a note on Virtual Machine

### Virtual Machine (VM) – 5 Points

#### 1. Definition –

A Virtual Machine (VM) is a software-based, **simulated computer** that functions independently on a physical server, running its own operating system and applications.

#### 2. Components –

- **Host Hardware:** Physical server containing CPU, memory, storage, and network.
- **Host Operating System:** Base OS that controls the hardware.
- **Hypervisor:** Software layer that creates and manages multiple VMs by allocating resources.
- **Guest OS:** Operating system running inside each VM.
- **Application:** Programs that run on top of the guest OS.

#### 3. Isolation –

Each VM runs in its own isolated environment, so any crash or malware in one VM does not affect the host or other VMs.

#### 4. Portability –

Since VMs are stored as files, they can be easily moved or copied to another physical machine for migration or backup.

#### 5. Uses –

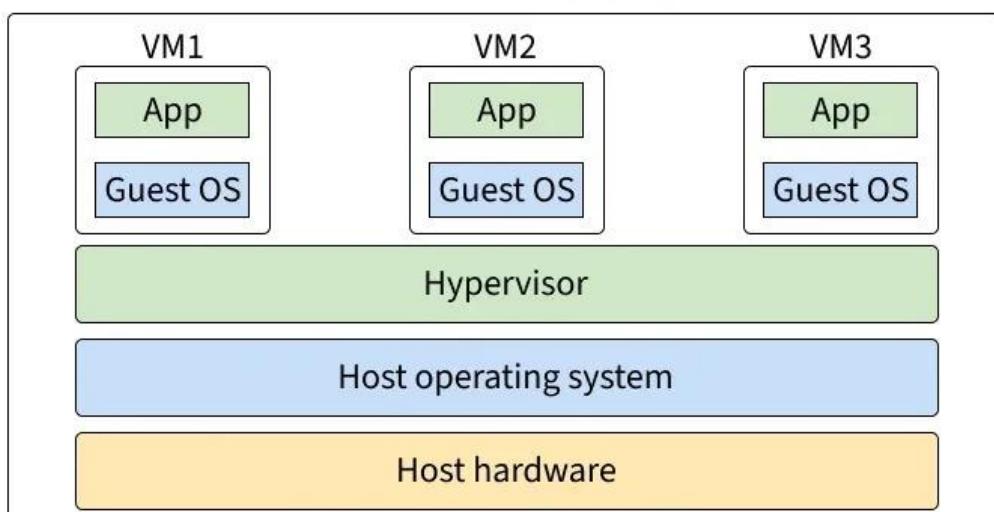
Ideal for server consolidation, software testing, running multiple OSs, and providing secure sandbox environments.

#### Example of VM:

Running Windows OS on a Mac using VirtualBox —

You can install VirtualBox on your Mac (host machine), create a VM, and install Windows as the **guest OS** inside it. This lets you run Windows apps on your Mac **without affecting the MacOS**.

## Virtual machines



f) Explain benefits of Cloud Computing

Cute Sky Always Has Amazing Dreams ☁

### 1. Definition

Cloud Computing is a technology that delivers computing services like storage, servers, databases, networking, and software over the internet ("the cloud").

### Benefits of Cloud Computing (6 Points)

#### 1. Cost Efficiency –

No need to buy or maintain expensive hardware and software; you pay only for the resources you actually use.

#### 2. Scalability –

Computing power, storage, and services can be scaled up or down quickly based on changing business demand.

#### 3. Accessibility –

Cloud services can be accessed securely from anywhere, anytime, using an internet connection and supported device.

#### 4. High Availability –

Leading cloud providers offer guaranteed uptime and redundancy, ensuring services stay available even during failures.

#### 5. Automatic Updates –

Software, security patches, and infrastructure updates are handled automatically by the provider, saving admin time.

#### 6. Disaster Recovery –

Cloud offers easy data backup and quick recovery options, protecting against major data loss or system failures.

c) Draw and Explain Cloud computing Architecture

## Cloud Computing Architecture (6 Layers)

### Definition –

Cloud computing architecture shows how different layers work together to deliver computing, storage, networking, and application services over the internet.

### Explanation (6 Layers):

#### 1. Frontend & Backend:

Frontend is the client-side interface (browsers, apps, dashboards) that allows users to send requests and see responses.

Backend is the provider side where requests are processed, resources managed, and results sent back.

#### 2. Internet Layer:

Secure bridge transferring requests and responses between frontend and backend using protocols like HTTP/HTTPS.

#### 3. Application Layer:

Hosts cloud apps like Gmail, Google Docs, and Zoom which work without local installation.

#### 4. Service Layer:

Provides SaaS, PaaS, and IaaS models for applications, platforms, and infrastructure.

#### 5. Runtime & Storage Layers:

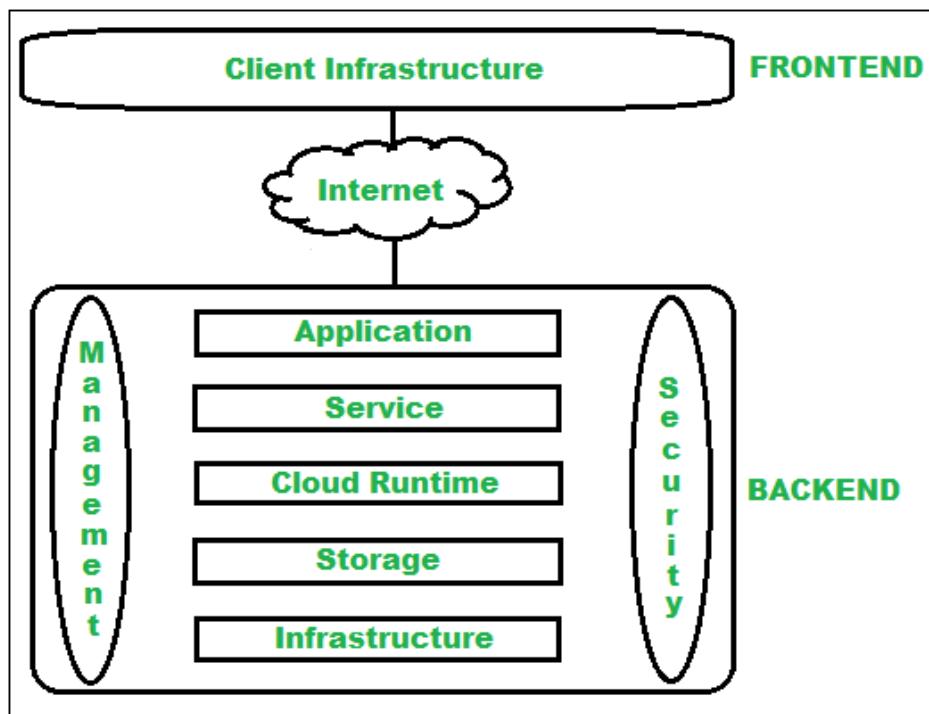
**Runtime** provides the execution environment for applications with virtual machines (VMs), containers, and APIs to run code smoothly.

**Storage** manages data, backup, and retrieval with high availability.

#### 6. Infrastructure, Management & Security:

Infrastructure provides physical servers and network.

Management & Security handle monitoring, billing, encryption, and access control.



4 marks

Explain Cloud Deployment Models

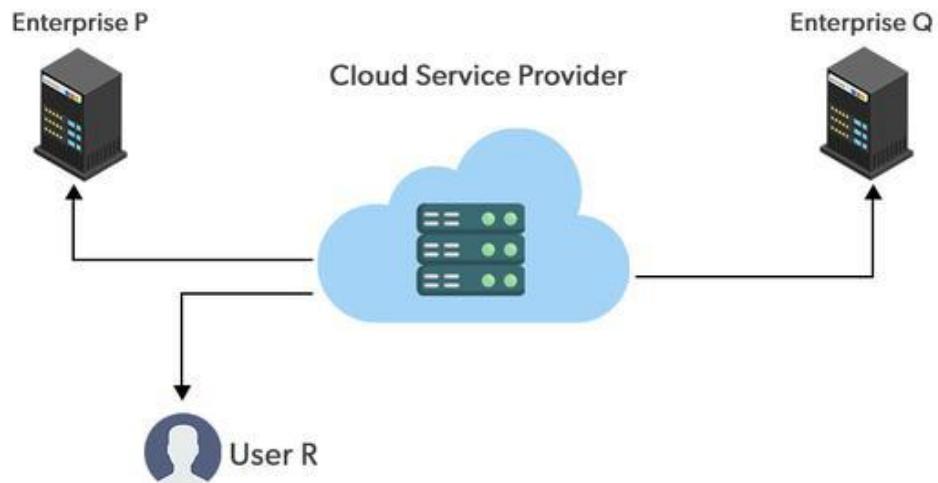
## Cloud Deployment Models (4 Models)

**Definition –**

Cloud Deployment Models describe **how cloud infrastructure is deployed, owned, and accessed** by users.

### 1. Public Cloud –

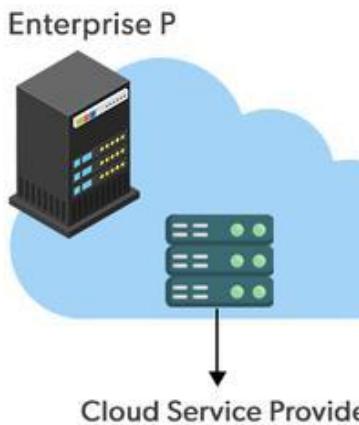
- **Ownership:** Owned and managed by third-party providers.
- **Access:** Open to the general public over the internet.
- **Example:** AWS, Microsoft Azure, Google Cloud.



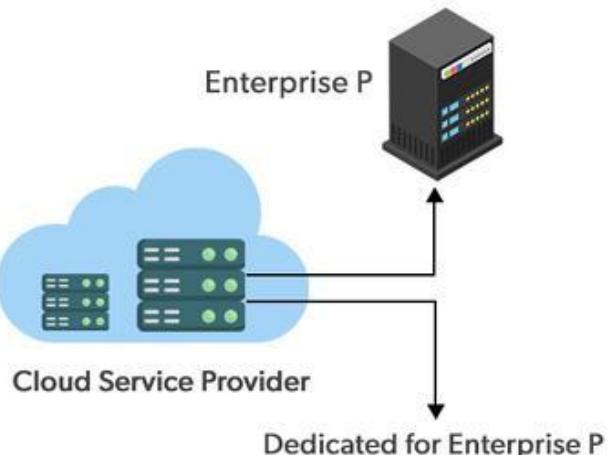
## 2. Private Cloud –

- **Ownership:** Dedicated to a single organization, managed internally or by a trusted vendor.
- **Access:** Restricted to that organization's authorized users only.
- **Example:** VMware Private Cloud, OpenStack.

### On premise Private cloud



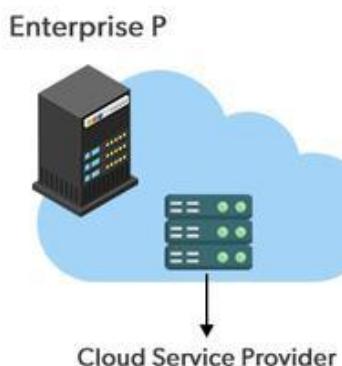
### Externally hosted Private cloud



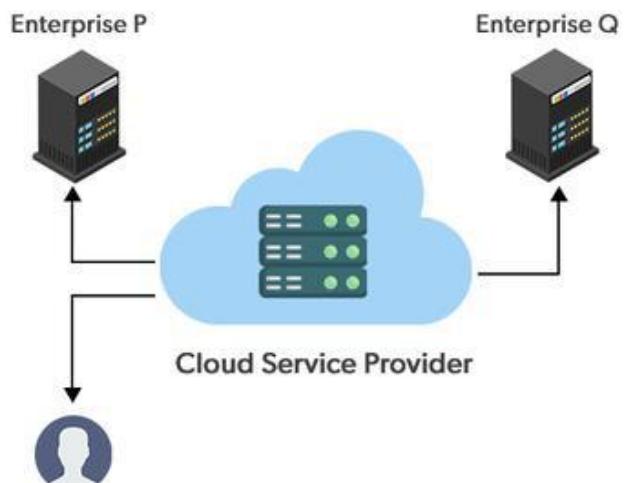
## Hybrid Cloud –

- **Definition:** Combination of public and private clouds used together for flexibility and security.
- **Access:** Some resources are public while sensitive data stays private.
- **Example:** IBM Hybrid Cloud, Microsoft Azure Stack.

### Private cloud



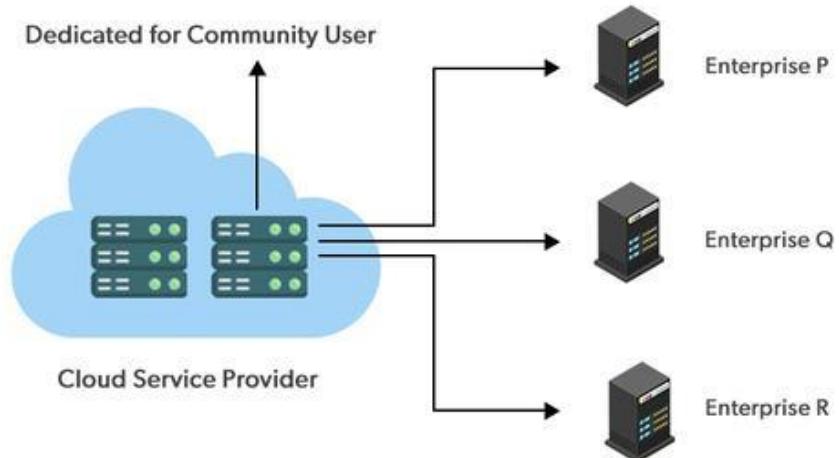
### Public cloud



#### 4. Community Cloud –

- **Ownership:** Shared by several organizations with common goals or policies.
- **Access:** Members share and use the same cloud resources collaboratively.
- **Example:** Government cloud, Healthcare cloud systems.

### Community Users



b) Draw and Explain Virtualization reference model

#### **Virtualization Reference Model –**

Explains how virtualization divides a physical system into multiple layers so that several virtual machines (VMs) can run on the same hardware simultaneously using shared resources efficiently.

#### **2. Layers of Virtualization Model (Refer Diagram):**

- **Host Hardware:** Physical CPU, memory, storage, network.
- **Host OS:** OS on physical machine managing hardware.
- **Virtualization Layer:** Hypervisor creating and managing VMs.
- **Virtual Machines (VMs):** Software-based computers using shared resources.
- **Guest OS:** OS running inside each VM independently.
- **Applications:** Programs running on top of Guest OS.

#### **3. Hypervisor & Types –**

Hypervisor is software that creates and manages VMs by allocating resources.

##### **Types:**

- **Type 1:** Runs directly on hardware (e.g., ESXi, Hyper-V).
- **Type 2:** Runs on top of a host OS (e.g., VirtualBox).

#### **4. Examples / Tools –**

VMware, Hyper-V, KVM, Xen.

#### **5. Purpose –**

Reduce hardware cost, improve efficiency, run multiple isolated systems.

#### **6. Role in Cloud Computing –**

Forms the foundation of cloud computing; used by AWS, Azure, GCP to offer scalable virtual servers.

## 6. Advantages

- **Resource Utilization** → Uses hardware more efficiently by sharing resources.
- **Cost Efficiency** → Reduces hardware and maintenance costs.
- **Isolation & Security** → Each VM is isolated, reducing risk of attacks.
- **Flexibility** → Supports multiple OS and apps on one system.
- **Easy Management** → Centralized control and backups.
- **Improved Efficiency** → Faster deployment and better use of IT resources.

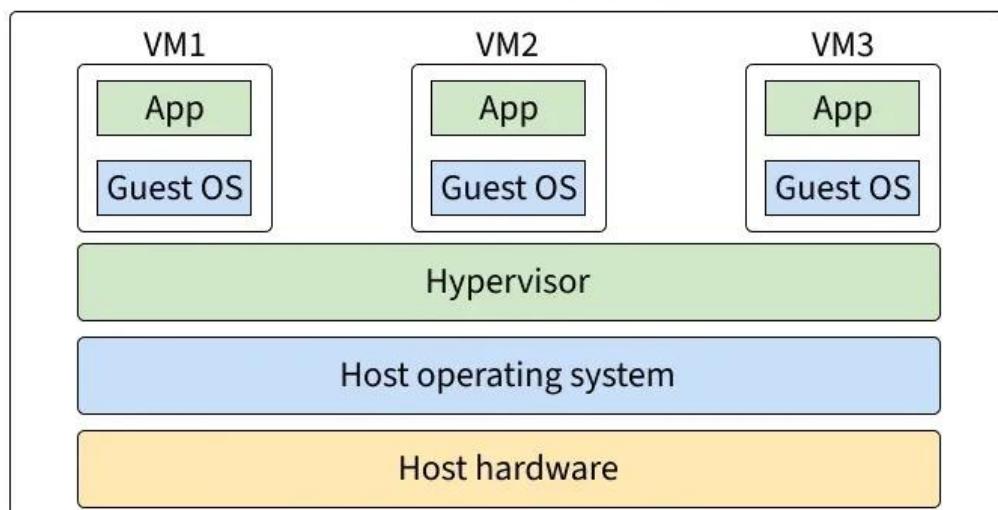
## 7. Disadvantages

- **Performance Overhead** → Slightly slower due to resource sharing.
- **Hypervisor Dependency** → If hypervisor fails, all VMs stop.
- **Complex Setup** → Needs expert configuration and monitoring.
- **Resource Limits** → Too many VMs on one host may cause bottlenecks.
- **Data Security Risks** → Shared resources may cause **data leakage or breaches**.

## 2. Examples / Tools

Common virtualization tools include **VMware**, **Hyper-V**, **KVM**, and **Xen**. These are used to create, run, and manage virtual machines for cloud and system environments.

## Virtual machines



## ★ VM Migration and Its Types

### 1. Definition

VM Migration is the process of moving a virtual machine (VM) from one physical host to another. It helps in balancing workloads, performing maintenance, and ensuring continuous service.

### 2. Purpose

The main goals are to improve resource utilization, reduce downtime, ensure high availability, and provide fault tolerance.

### 4. Types of VM Migration:

#### a) Cold Migration (Offline Migration)

- **Definition:** VM is powered off before migration.
- **Process:** Disk + configuration data are copied to target host.
- **Advantage:** Simple, requires fewer resources.
- **Disadvantage:** Causes downtime as VM is unavailable during move.
- **Application:** Suitable for **non-critical sectors** such as **education labs, software testing, R&D, and small businesses** where downtime is acceptable.

#### b) Hot Migration (Live Migration)

- **Definition:** VM is moved while running with memory sync.
- **Process:** Transfers memory, disk, and CPU state to new host.
- **Advantage:** Ensures near-zero downtime, ideal for production apps.
- **Disadvantage:** Requires high bandwidth and may slightly impact performance.
- **Application:** Suitable for **critical sectors** like **banking, healthcare, telecom, and e-commerce** where 24x7 uptime is required.

### 4. Use Case

Cloud providers such as AWS, Azure, and VMware use VM migration for load balancing, hardware maintenance, and disaster recovery without affecting end users.

### 8. Importance in Cloud

VM migration forms the backbone of IaaS, allowing cloud providers to manage workloads efficiently across datacenters.

Advantage:

#### Improved Load Balancing:

Move VMs from busy servers to free servers so no single server gets overloaded.

#### — Additional Disadvantage (Overall):

- **Complex Configuration:** Requires proper setup of network/storage; misconfiguration can cause failure or data loss.

## Cloud Computing Infrastructure (7 Points)

### **Definition –**

It is the foundation of cloud services that provides **hardware, software, network, and virtualization resources** for computing.

Unlike architecture, it focuses on **components**, not design.

---

#### **1. Hypervisor (Virtualization Layer):**

Software that creates and manages VMs, dividing cloud resources among users efficiently.

Also called **VMM (Virtual Machine Monitor)**.

- **Type 1 (Bare Metal):** Runs directly on hardware (AWS, Azure).
- **Type 2 (Hosted):** Runs over host OS (e.g., VirtualBox).

#### **2. Management Software:**

Monitors, maintains, and configures cloud resources, tracks usage in real time, optimizes performance, and sends alerts.

#### **3. Deployment Software:**

Automates deployment, scaling, updates, and integration of applications, creating a smooth virtual computing environment.

#### **4. Network:**

Connects servers, storage, and users securely via routers, switches, and firewalls, ensuring fast and reliable data transfer.

#### **5. Server:**

Physical/virtual machines that run cloud applications, manage virtual machines, and deliver services while maintaining security.

#### **6. Storage:**

Stores user and app data securely with backup and redundancy, enabling recovery and high availability of resources.

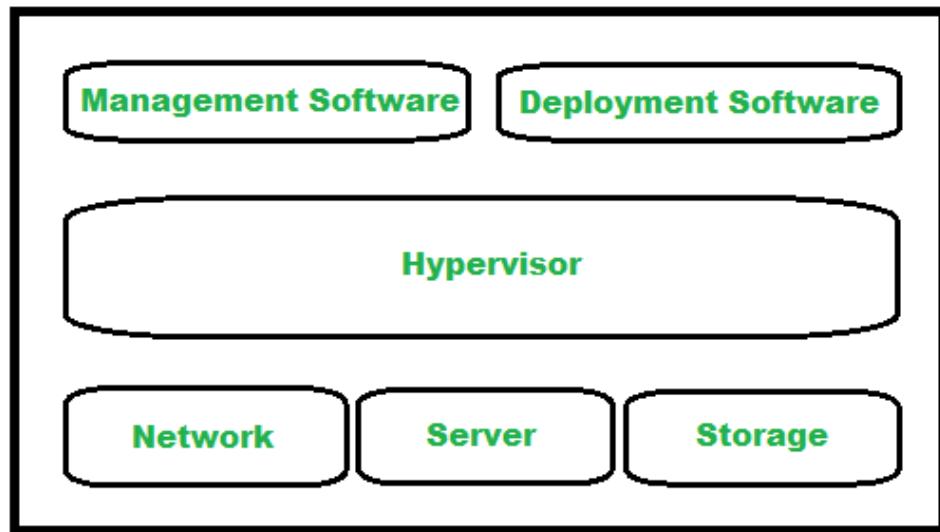
#### **7. Example:**

Used by major providers like **AWS, Microsoft Azure, and Google Cloud** to deliver scalable cloud services worldwide.

Write a note on Hypervisor with types

**Hypervisor –**

*A hypervisor is a software that creates and manages multiple VMs by sharing and allocating resources like CPU, memory, and storage among them while keeping them isolated.*



f) Explain Cloud Service Models

**Cloud Service Models** are standardized frameworks for delivering computing resources over the internet, defining the level of control and management between provider and user.

### 💡 **Cloud Service Models: IaaS, PaaS, SaaS**

- ◆ **1. Infrastructure as a Service (IaaS)**
- **Definition:** IaaS is a cloud service model that provides virtualized computing resources such as servers, storage, and networking over the internet.
- **User Control:** In this model, the user installs and manages their own operating system, middleware, and applications.
- **Advantage:** It offers high flexibility and scalability while reducing the need for physical hardware.
- **Example:** Amazon EC2 and Microsoft Azure Virtual Machines.

### ◆ **2. Platform as a Service (PaaS)**

- **Definition:** PaaS is a cloud service model that provides a complete platform with operating system, middleware, and development tools for building and deploying applications.
- **Developer Focus:** It allows developers to concentrate only on coding and deployment while the provider manages infrastructure.
- **Advantage:** This model enables faster application development and ensures automatic scalability.
- **Example:** Google App Engine and Heroku.

### ◆ **3. Software as a Service (SaaS)**

- **Definition:** SaaS is a cloud service model that delivers fully functional software applications over the internet to end users.
- **Accessibility:** Applications are accessed directly through web browsers or mobile apps without installation.
- **Maintenance:** All updates, security, and maintenance are handled entirely by the provider.
- **Example:** Gmail, Google Docs, and Microsoft Office 365.

