UNIT-I

Introduction to Cloud Computing Fundamentals Cloud computing at a glance, defining a cloud, cloud computing reference model, types of services (IaaS, PaaS, SaaS), cloud deployment models (public, private, hybrid), utility computing, cloud computing characteristics and benefits, cloud service providers (Amazon Web Services, Microsoft Azure, Google AppEngine).

COURSE OUTCOMES

Course Outcomes		
Upon successful completion of the course, the student will be able to:		
CO1	**Understand** the fundamental concepts, service models, deployment models, and enabling technologies of cloud computing.	L2
CO2	**Apply** distributed computing, virtualization, and containerization techniques to demonstrate the functioning of cloud-based environments.	L3
CO3	**Implement** cloud service provisioning, container orchestration, and server less frameworks using suitable platforms and tools.	L3
CO4	**Analyze** cloud computing challenges related to scalability, interoperability, security, and advanced architectures such as IoT, fog, and edge computing.	L4

Text Books

1. Mastering Cloud Computing, 2nd edition, Rajkumar Buyya, Christian Vecchiola, Thamarai Selvi, Shivananda Poojara, Satish N. Srirama, Mc Graw Hill, 2024.
2. Distributed and Cloud Computing, Kai Hwang, Geoffery C. Fox, Jack J. Dongarra, Elsevier, 2012.

Introduction to Cloud Computing

Fundamentals of Cloud Computing

What is computing?

Computing is shifting from owning hardware to using services —

just like how we use water or electricity at home.

☞ This means we don't need to buy big computers or storage.
☞ Instead, we **use services from the cloud whenever you need them**.

Traditional Way (Before Cloud Computing)

Earlier, companies or individuals had to:

- Buy expensive computers and servers
- Maintain storage systems
- Install software on their own machines
- Pay for IT staff, power, and space

This was costly, difficult to scale, and often under-utilized.

Cloud Computing (Utility Model)

Cloud computing changed everything.

Now, computing is delivered like a **utility service**:

- You don't buy a server → you *rent* it from the cloud
- You don't buy storage → you *use* cloud storage
- You don't install software on your device → you use apps online

Just like we pay for electricity only for what we use, you pay the cloud provider only for:

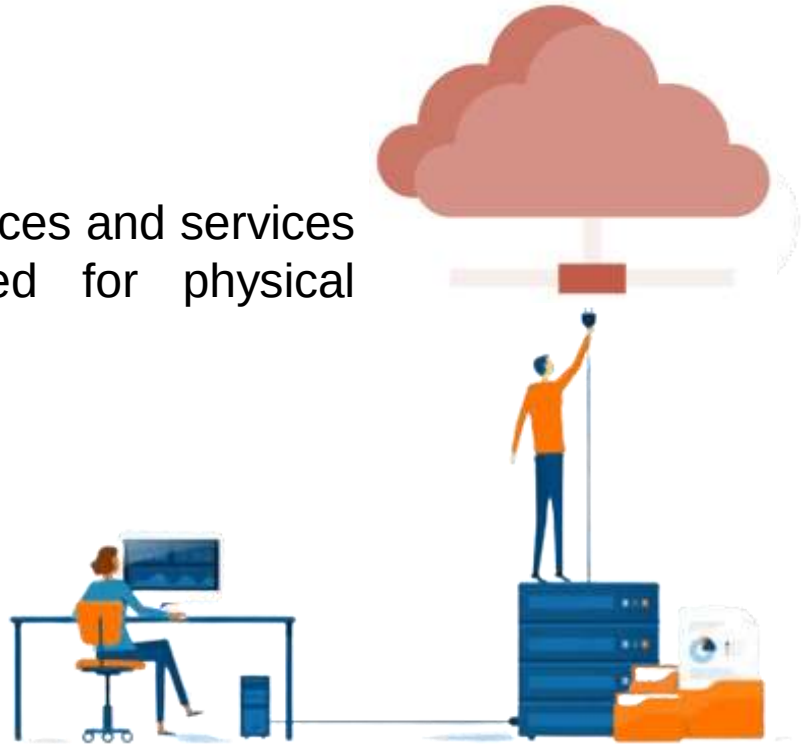
- How much data you store
- How long you run a virtual machine
- How many users access your application

Introduction

What is cloud computing?

Cloud computing refers to the delivery of computing services over the internet, including storage, processing power, and software applications.

It allows users to access resources and services on-demand, without the need for physical infrastructure or local servers.



What is Cloud Computing?

Cloud computing means **using the internet to access computing resources** such as:

- Servers
- Storage
- Databases
- Applications
- Networking

Why is it useful?

✓ Access from anywhere

Users can access cloud services anytime, anywhere.

✓ No need to worry about where it is stored

We don't need to know where the systems are located—the cloud provider manages everything.

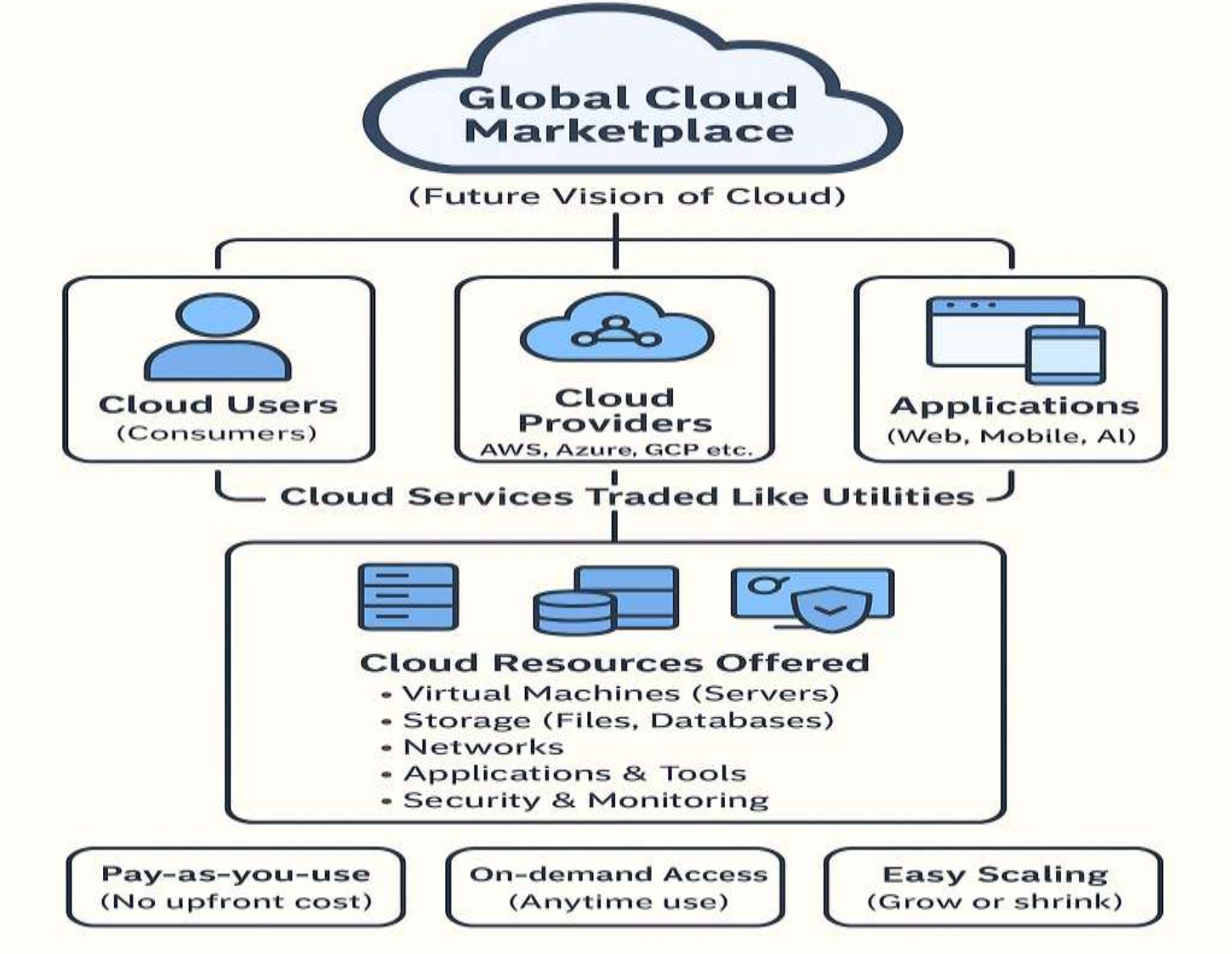
✓ Grows or shrinks based on need

If your app needs more storage or computing, the cloud **automatically increases** it.
If less is needed, it **reduces**, saving money.

Vision of Cloud Computing

- Anyone can create computing resources easily.
- Computing becomes like a utility.
- Cloud services are improving.
- Current limitation – stuck to one vendor
- Future vision – a global cloud marketplace
- Automatic discovery of cloud services
- Consumers can be providers too
- Benefits of using large datacenters.

Vision of Cloud Computing



Vision of Cloud Computing

FIGURE 1.1

Cloud computing vision.

DEFINING A CLOUD

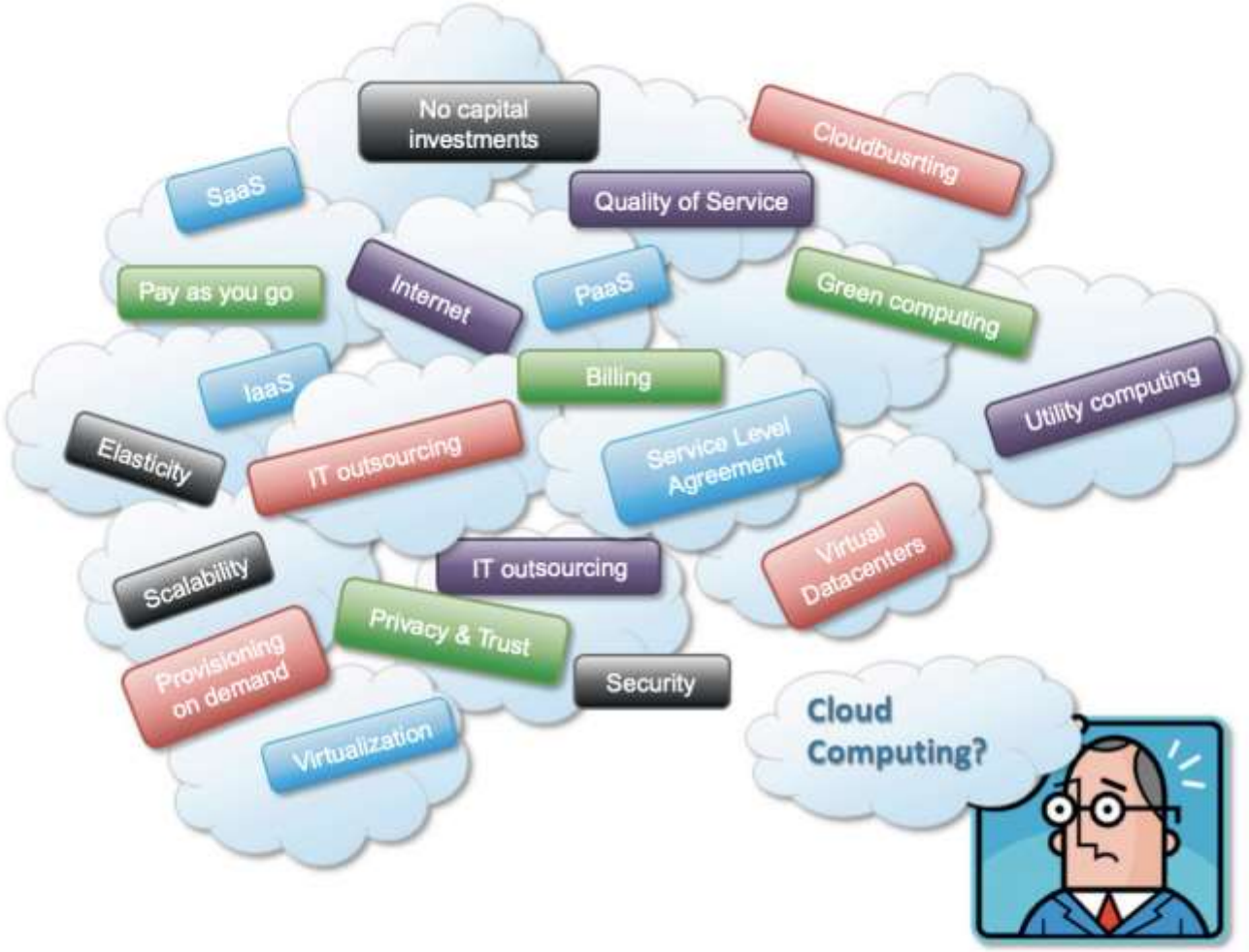


FIGURE 1.2

Cloud computing technologies, concepts, and ideas.

DEFINING A CLOUD

- **What does "Cloud Computing" really mean?**
- Cloud computing is a way of using computers, storage, and software **over the Internet** instead of buying and maintaining them yourself.
- **Why is it called "Cloud"?**

•Earlier, in network diagrams, the Internet was drawn as a **cloud symbol**.

•So "cloud computing" means **computing through the Internet**.

DEFINING A CLOUD

What does Cloud Computing include?

Cloud = Many things combined together such as:

✓ Virtual machines
✓ Servers
✓ Storage
✓ Databases
✓ Platforms
✓ Software
✓ Security services
✓ Developer tools

This idea is also called **XaaS – Everything as a Service**.

DEFINING A CLOUD

- As per National Institute of Standards and Technology

Cloud computing provides:

✓ Access from anywhere

✓ On-demand resources

✓ Shared pool of servers/storage

✓ Quick setup and release

✓ Minimal effort from users

A birds-eye view of cloud computing

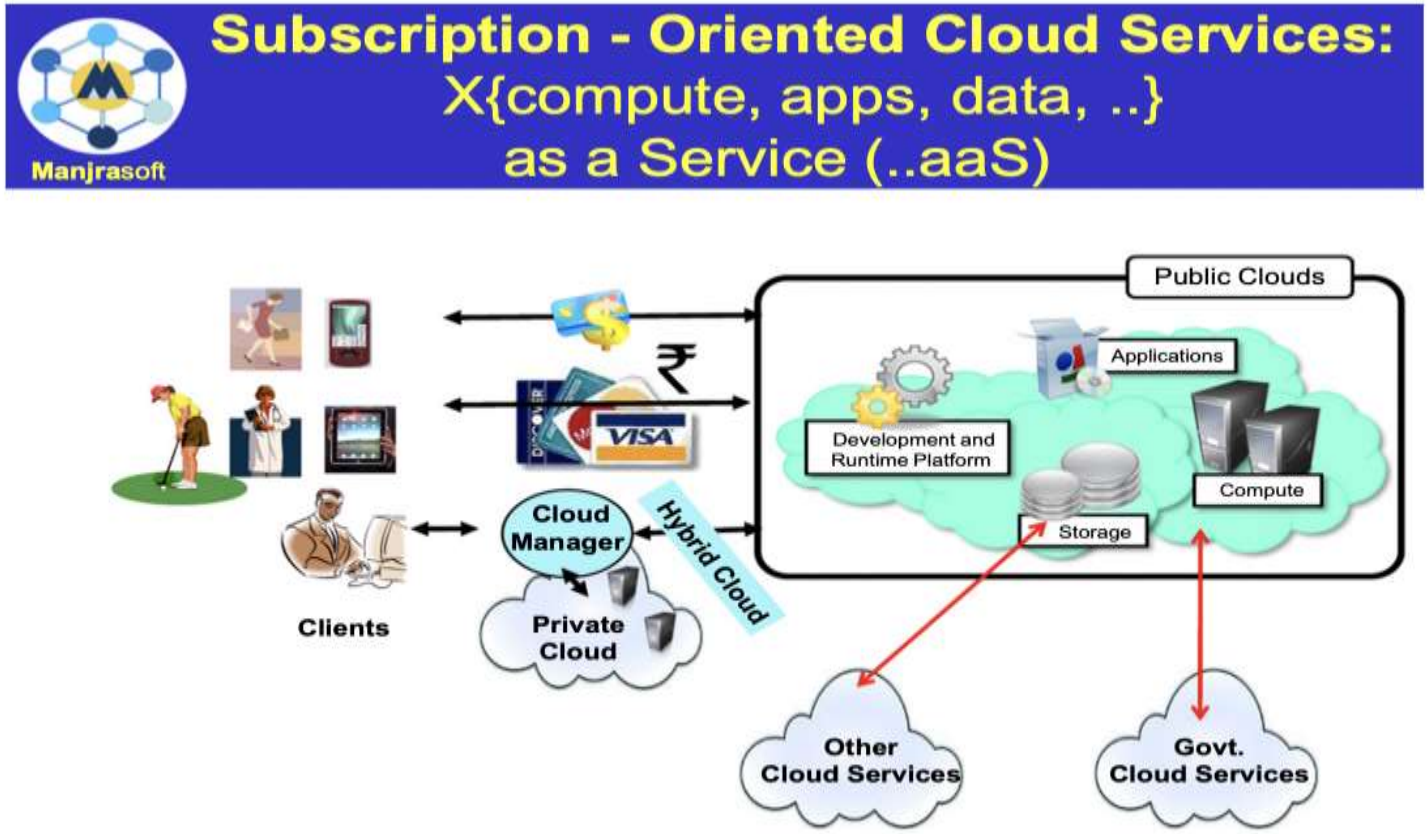


FIGURE 1.3
A bird's-eye view of cloud computing.

Cloud computing allows companies to use IT resources like servers and storage on demand—just like utilities—scaling instantly as needed and paying only for what they use.

Cloud Deployment Models

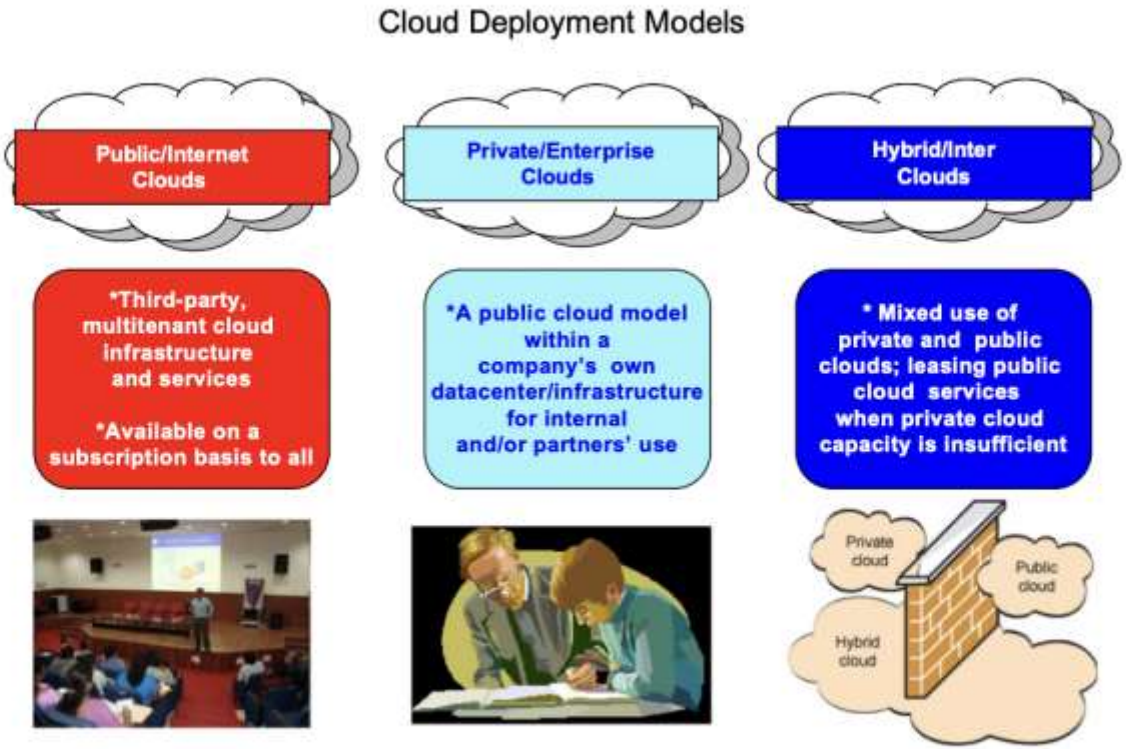


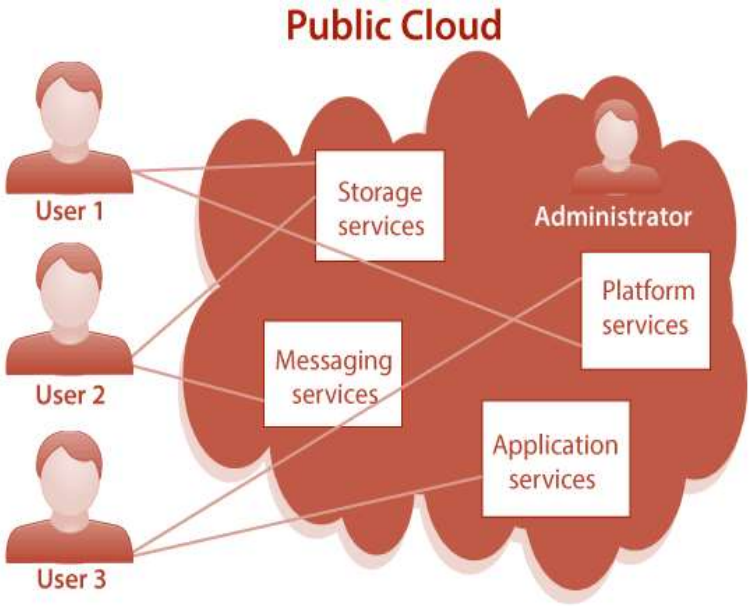
FIGURE 1.4

Major deployment models for cloud computing.

Cloud Deployment Models

Public Cloud

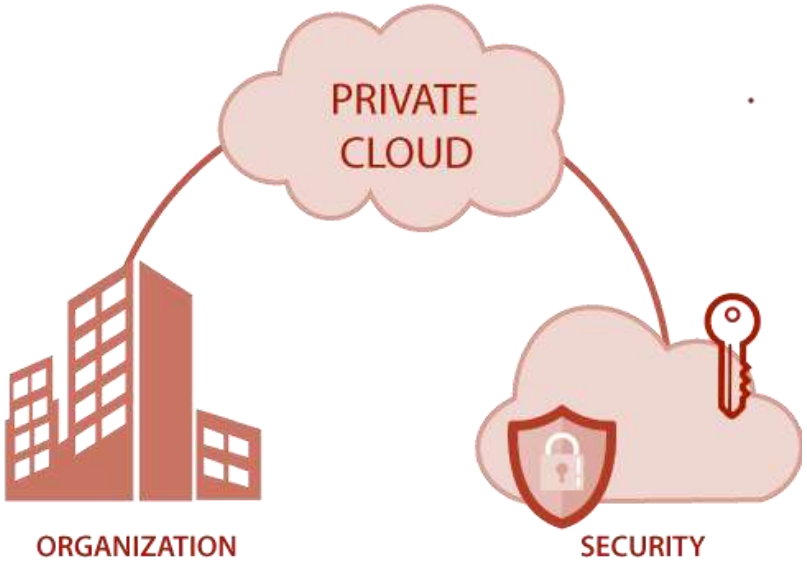
- Services are provided over a public network and available to anyone who wants to use them.
- It is a cost-effective option for businesses and individuals looking for scalability and flexibility.
- Public cloud providers, such as AWS, Azure, and GCP, offer a wide range of services accessible to the general public.



Cloud Deployment Models

Private Cloud

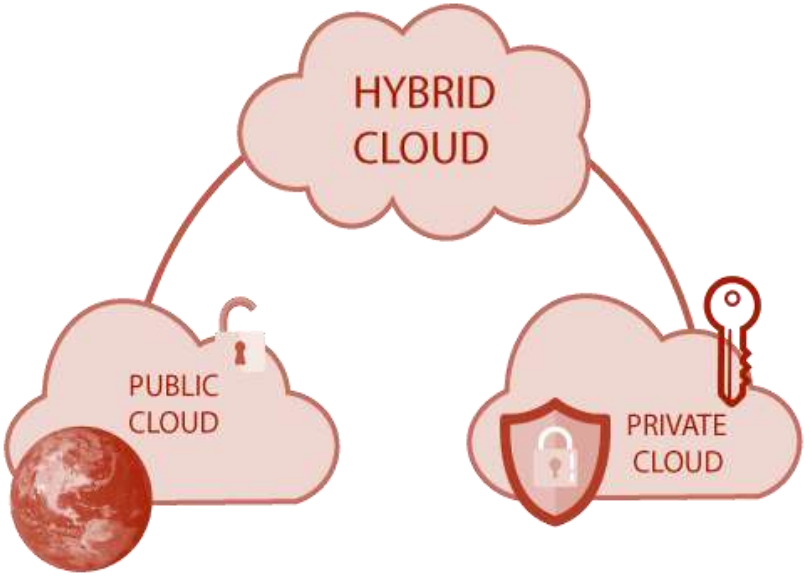
- Infrastructure is dedicated to a single organization and may be located on-premises or off-premises.
- Private cloud environments are designed to meet specific security, compliance, or performance requirements.
- They offer enhanced control, customization, and privacy but require significant upfront investment.



Cloud Deployment Models

Hybrid Cloud

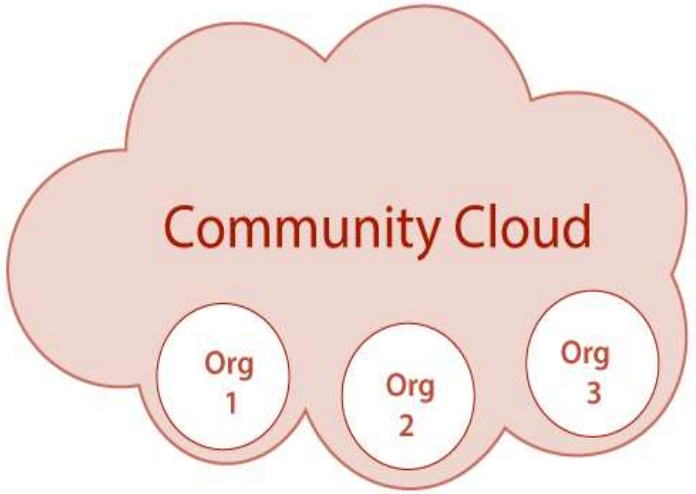
- Combines public and private cloud environments, allowing for flexibility and data sharing between the two.
- Organizations can leverage the benefits of both public and private clouds, ensuring optimal resource allocation.
- Hybrid cloud deployments enable workload portability and seamless integration between different environments.



Cloud Deployment Models

Community Cloud

- Community cloud is a deployment model where infrastructure and services are shared among a specific community or group of organizations.
- It caters to the needs of a particular community, such as government agencies, educational institutions, or research organizations.
- Community cloud provides a cost-effective solution while addressing specific requirements and compliance standards of the community.



The cloud computing reference model

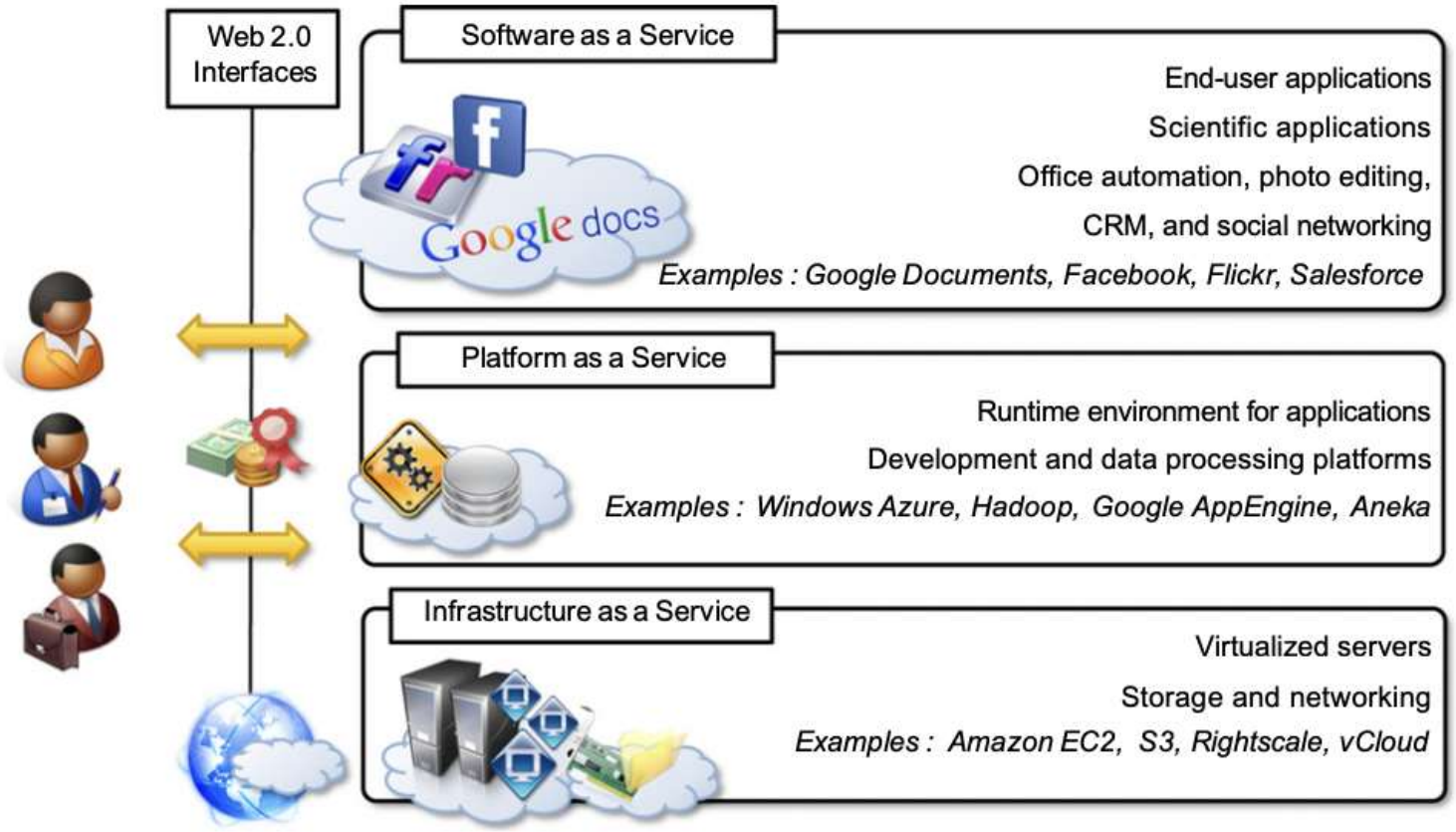


FIGURE 1.5

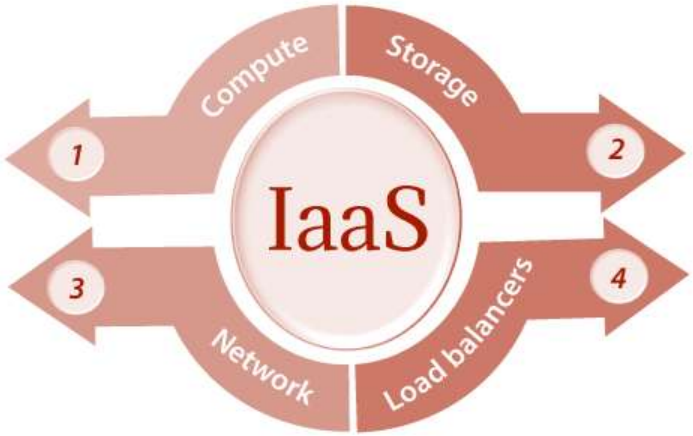
The Cloud Computing Reference Model.

Service Models

Infrastructure as a Service (IaaS)

- IaaS provides virtualized computing resources over the internet. Users have control over the operating systems, storage, and networking components.

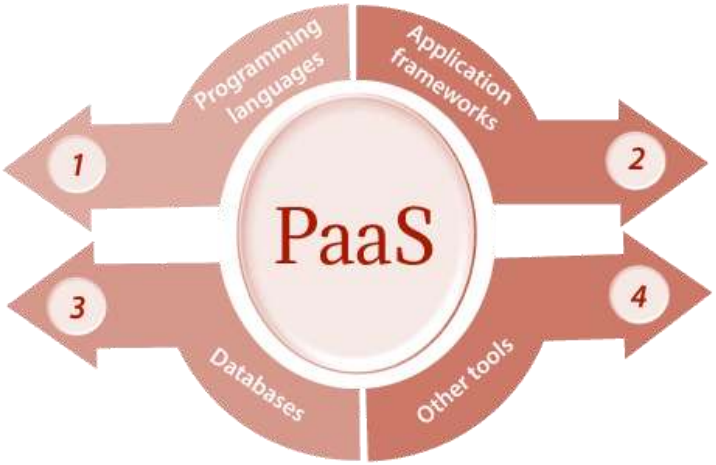
- They can provision and manage virtual machines (VMs), storage, and networks according to their requirements. Examples of IaaS providers include AWS EC2, Azure Virtual Machines, and Google Compute Engine.



Service Models

Platform as a Service (PaaS)

- PaaS offers a platform for developing, testing, and deploying applications.
- Users can focus on application development without worrying about infrastructure management.
- PaaS providers manage the underlying infrastructure, including servers, storage, and networking.
- Developers can leverage pre-configured environments, development frameworks, and deployment tools.
- Examples of PaaS providers include Heroku, Google App Engine, and AWS Elastic Beanstalk.

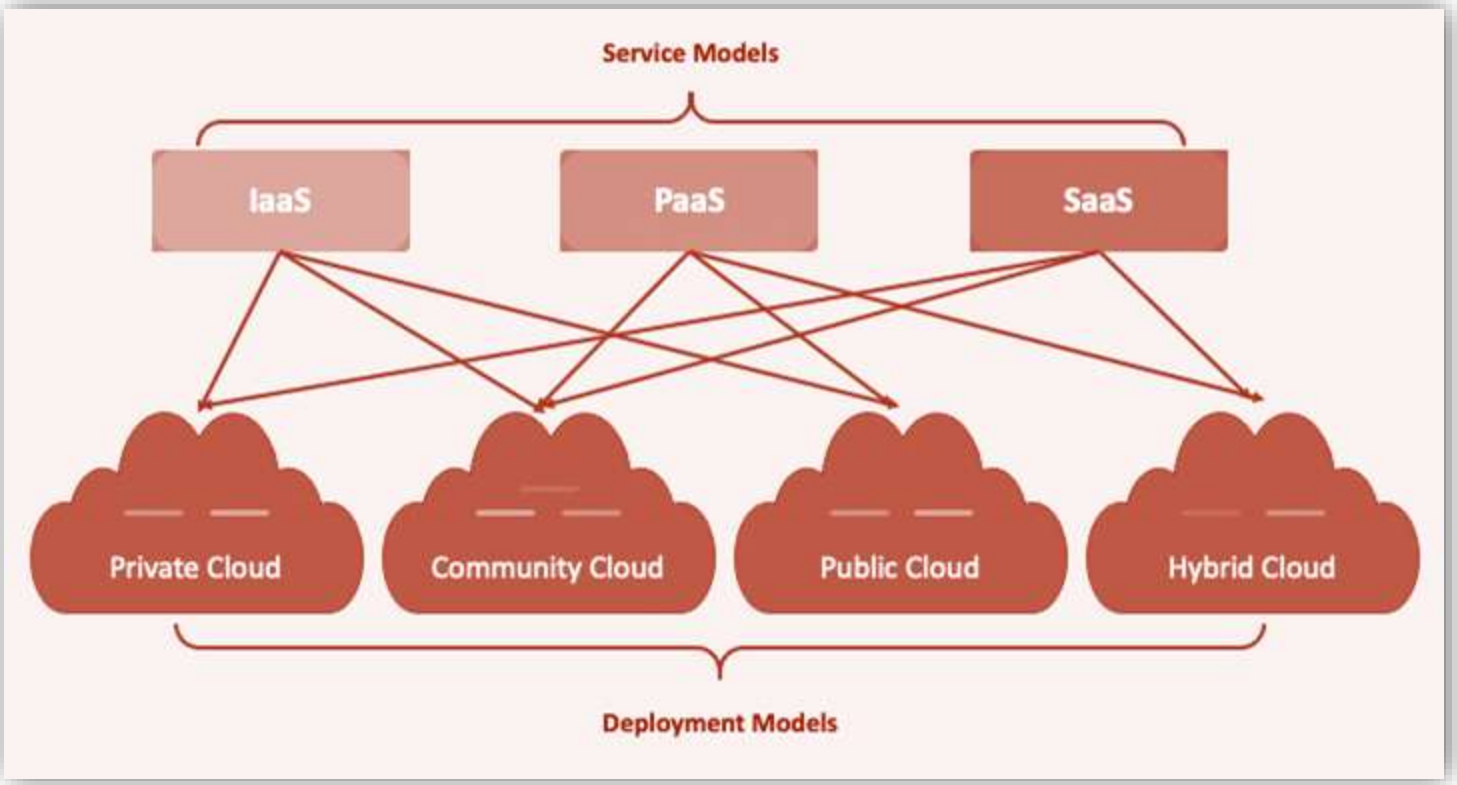


Service Models

Software as a Service (SaaS)

- SaaS delivers software applications over the internet on a subscription basis.
- Users can access and use applications directly through a web browser or APIs.
- The provider hosts and manages the underlying infrastructure, application, and data.
- Users can typically customize certain aspects of the application to fit their needs.
- Examples of SaaS include Salesforce, Microsoft Office 365, and Google Workspace.

Cloud Deployment & Service Models

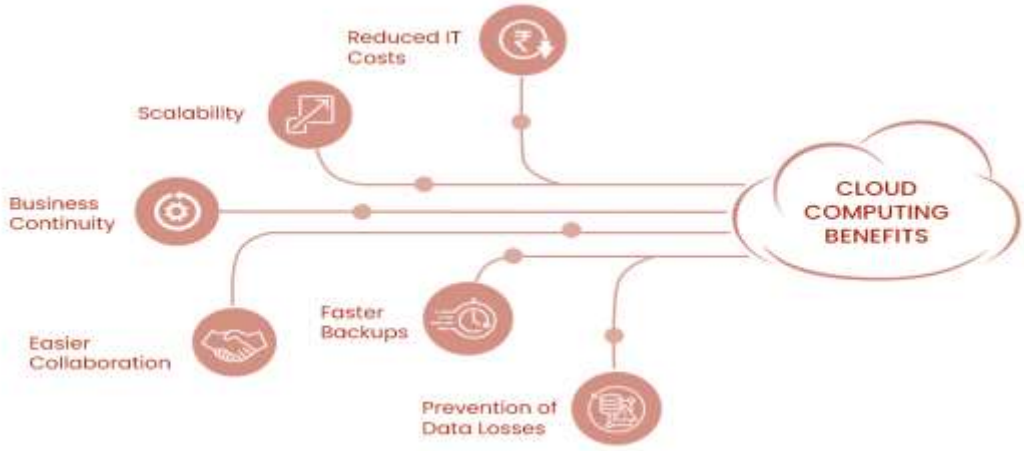


Characteristics of Cloud Computing

- On-Demand Self-Service: Users can provision resources and services as needed, without requiring human interaction with service providers.
- Broad Network Access: Services are accessible over the internet via standard protocols and devices.
- Resource Pooling: Computing resources are pooled together to serve multiple users, allowing for efficient utilization and scalability.
- Rapid Elasticity: Resources can be scaled up or down quickly to meet changing demands.
- Measured Service: Cloud service usage is measured, monitored, and billed based on actual consumption.

Benefits of Cloud

- **Cost Savings**: Pay for what you use, with no upfront infrastructure costs.
- **Scalability**: Easily scale resources up or down based on demand.
- **Flexibility**: Access resources and applications from anywhere with an internet connection.
- **Reliability**: Cloud providers typically offer high uptime and data redundancy.
- **Collaboration**: Enable seamless collaboration and data sharing among teams.



Challenges Ahead in Cloud Computing

1. Technical Challenges

- Deciding how many cloud resources to use and for how long.
- Managing large data centers and virtualization efficiently.
- Integrating physical (real) and virtual systems smoothly.

2. Security Challenges

- Organizations don't own the cloud infrastructure, so protecting sensitive data is difficult.
- Data must be decrypted while processing, creating a weak point for attacks.
- Need strong security standards and guaranteed data confidentiality.

3. Legal Challenges

- Cloud data is stored across different countries with different privacy laws.
- Conflicts may arise about who has the right to access data.
- Example: U.S. vs European privacy laws can complicate data access for investigations.

Utility Computing

- A billing model where users pay only for the computing resources they consume.
- Focuses mainly on *pricing and billing* (pay-per-use).

Utility Computing

Cloud Computing Vs Utility Computing

Feature	Cloud Computing	Utility Computing
Meaning	Delivery of computing services over the Internet	Computing resources billed based on usage
Purpose	Provide scalable, flexible IT services	Reduce cost by using pay-per-use billing
Focus	Service delivery (SaaS, PaaS, IaaS)	Pricing and metered usage
Usage Type	Access services anytime from anywhere	Pay only for what you consume
Ownership	No need to own hardware/software	Ownership not important; consumption-based
Examples	AWS, Azure, Google Cloud, Office 365	Paying for CPU hours, RAM usage, storage used
Relationship	Cloud uses utility computing for billing	Utility computing is part of cloud computing

CLOUD SERVICE PROVIDERS

- A **Cloud Service Provider (CSP)** is a company that offers **computing services over the internet**.
- Instead of buying and maintaining your own computers, servers, or storage, you can **rent** these from a CSP and pay only for what you use.

Cloud Service Provider provide:

✓ Compute Power
(virtual machines, servers)

✓ Storage
(save files, databases, backups online)

✓ Applications / Software
(run apps like email, analytics, AI tools)

✓ Networking
(internet connectivity, security tools, firewalls)

CLOUD SERVICE PROVIDERS

CLOUD SERVICE PROVIDERS

1. Amazon Web Services (AWS)

•AWS is the **largest and most popular cloud provider** in the world.

•It offers more than **200+ cloud services**, including storage, computing power, databases, machine learning, and security.

•Common services:

- **EC2** → Virtual servers
- **S3** → Cloud storage
- **Lambda** → Serverless computing

•AWS is known for **high reliability, global availability, and pay-as-you-go pricing**.

CLOUD SERVICE PROVIDERS

2. Microsoft Azure

•Azure is Microsoft's cloud platform.

•It integrates very well with **Windows, Office 365, and other Microsoft tools**, making it popular for companies using Microsoft products.

•Common services:

- **Virtual Machines** → Computing
- **Azure Blob Storage** → Storage
- **Azure SQL Database** → Managed database

•Azure is widely used by **enterprises and government organizations**.

CLOUD SERVICE PROVIDERS

3. Google App Engine (Google Cloud Platform – GCP)

•Google App Engine (part of GCP) allows developers to **build and deploy applications** without managing servers.

•Google Cloud is known for **big data, AI, and machine learning tools** (like TensorFlow).

•Common services:

- **App Engine** → Serverless application hosting
- **Compute Engine** → Virtual machines
- **Cloud Storage** → File storage

•It is popular among **startups and data-driven companies**.

CLOUD SERVICE PROVIDERS

Cloud Model	What It Provides	AWS Example	Azure Example	GCP Example
IaaS (Infrastructure)	We can rent **servers**, **storage**, **networking**	**Server:** EC2 **Storage:** S3 **Network:** VPC	**Server:** Azure VM **Storage:** Blob Storage **Network:** Virtual Network	**Server:** Compute Engine **Storage:** Cloud Storage **Network:** VPC Network
PaaS (Platform)	We can rent a **platform** to build & deploy apps (no server management)	**App Hosting:** Elastic Beanstalk **Database:** RDS **Serverless:** Lambda	**App Hosting:** App Service **Database:** SQL Database **Serverless:** Azure Functions	**App Hosting:** App Engine **Database:** Cloud SQL **Serverless:** Cloud Functions
SaaS (Software)	Use **ready-made software** online	**Software:** Amazon WorkMail Amazon Chime	**Software:** Microsoft 365 Microsoft Teams	**Software:** Gmail, Google Docs Google Meet

CLOUD SERVICE PROVIDERS

Feature	AWS (Amazon Web Services)	Microsoft Azure	Google App Engine / Google Cloud Platform (GCP)
Parent Company	Amazon	Microsoft	Google
Launch Year	2006	2010	2008
Strength / Specialty	Largest number of services, strong IaaS (servers, storage), global reach	Best for enterprise / corporate use, integrates with Windows tools	Best for AI, Machine Learning, Big Data, App development
Popular Services	EC2 (compute), S3 (storage), RDS (database)	Virtual Machines, Azure SQL, Azure Functions	App Engine, Compute Engine, BigQuery
Ease of Use	Complex but very powerful	Easy for companies already using Microsoft	Simple for developers and app hosting
Pricing	Pay-as-you-go, sometimes higher for enterprise	Competitive and affordable for Windows systems	Very cost-effective for workloads using AI & data
Best For	Large businesses, flexible cloud systems	Companies using Windows, .NET, Office tools	Developers, startups, AI/ML projects, mobile/web apps


THANK YOU