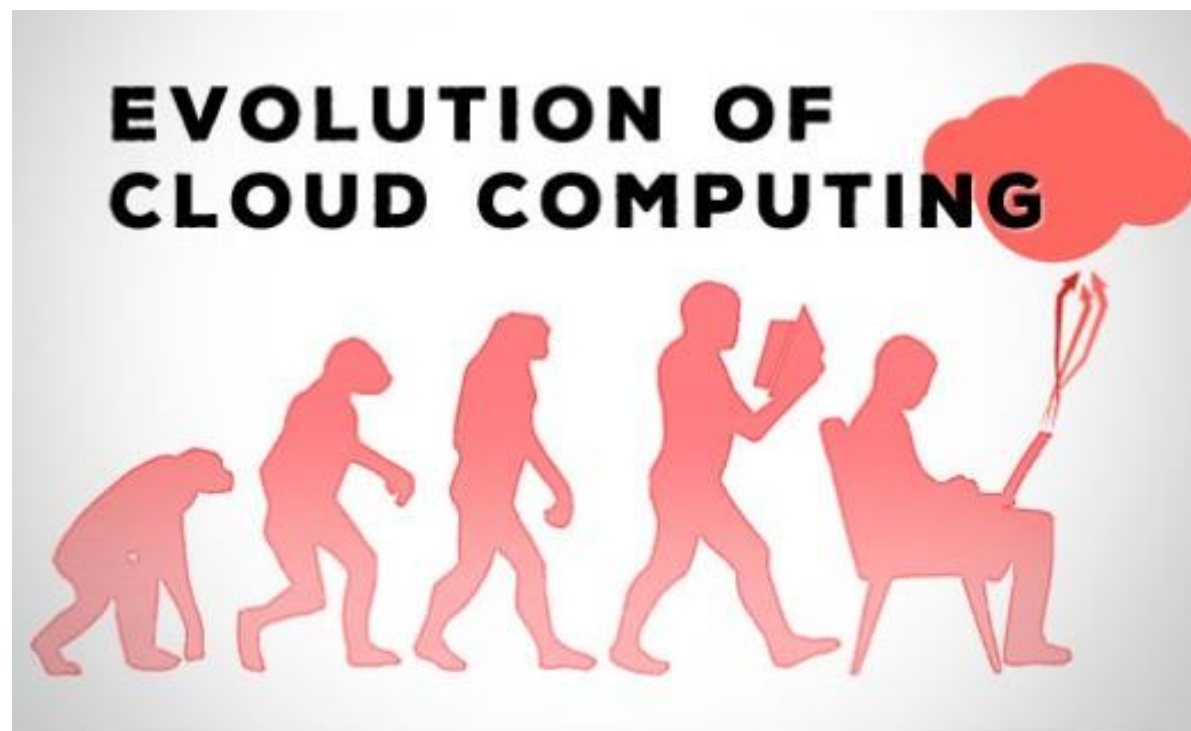

History and Evolution of Cloud Computing

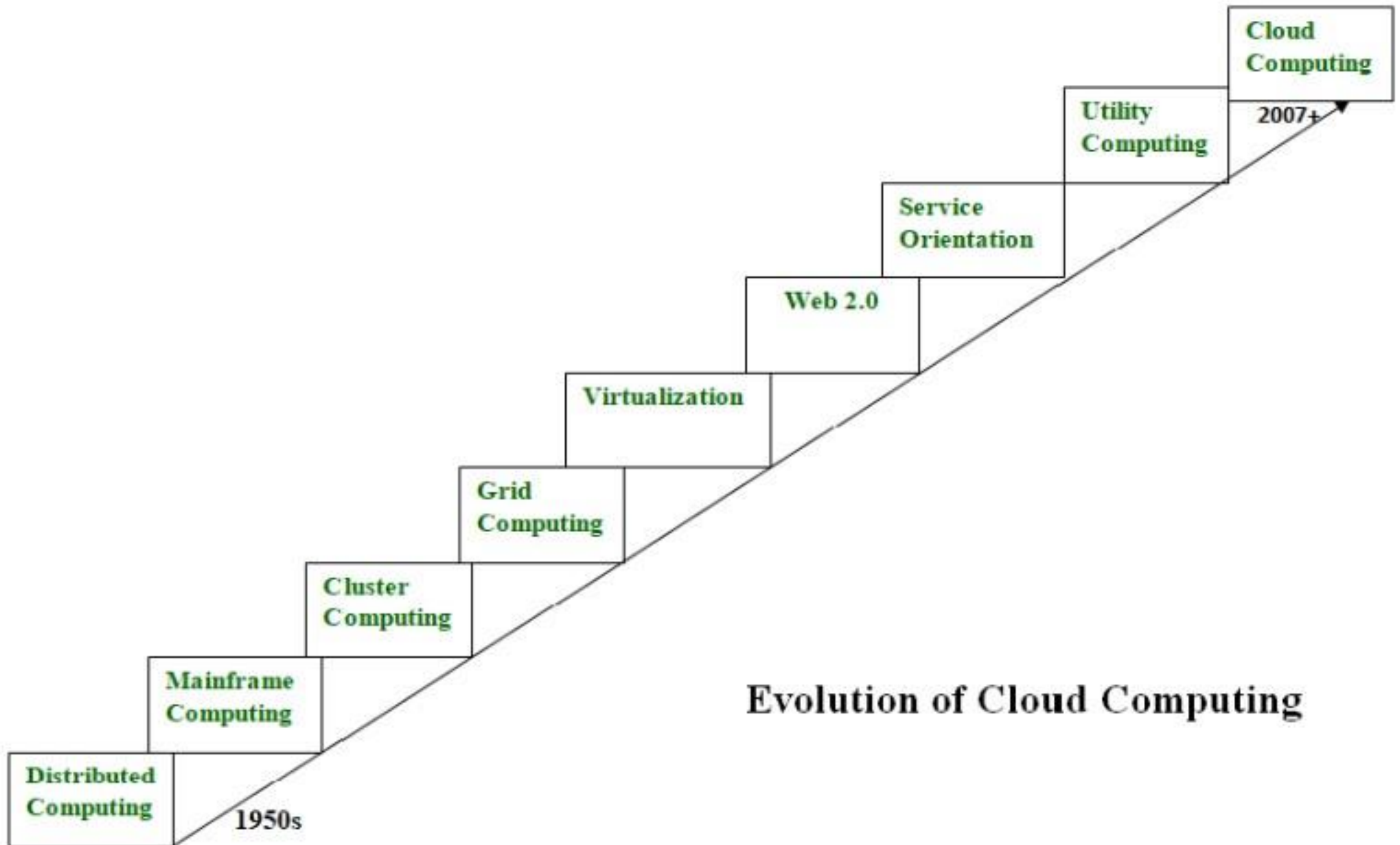
Prepared By: Bhesh Raj Pokhrel

1. Evolution of Cloud Computing

- The phrase "Cloud Computing" was **first introduced in the 1950s** to describe **internet-related services**, and it evolved from distributed computing to the modern technology known as **cloud computing**.
- The evolution of cloud computing is the **gradual development** of technologies and concepts **that led to the modern cloud** environment.
- Cloud computing **did not emerge suddenly**; instead, it evolved through **multiple stages of computing** models, **networking** advancements, and **virtualization** technologies. Today, cloud computing provides scalable, flexible, and on-demand computing resources over the Internet.



1. Evolution of Cloud Computing



1.1. Evolution : Mainframe Computing Era (1950s–1960s)

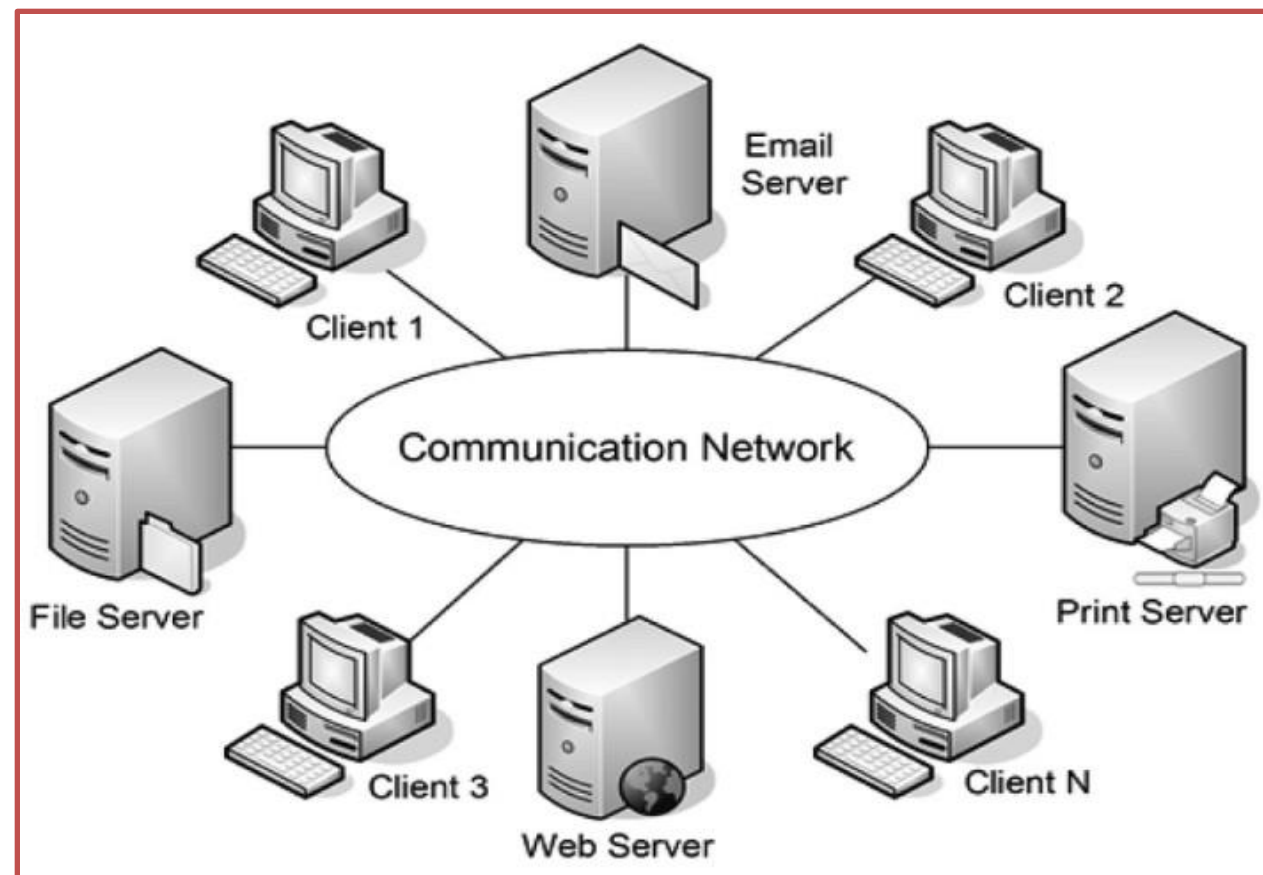
- The **mainframe computer** was the **first step in the evolution of cloud computing**. During the 1950s and 1960s, computers were very **large, powerful, and expensive**, so only big organizations like **banks, governments, and research centers** could afford them.
- Mainframe computers used a **centralized computing model**. All data storage and processing were done at one central machine.
- Many users could work on the same mainframe at the same time. The system **shared resources** such as CPU time, memory, and storage among users. This made computing more efficient and cost-effective than providing separate computers for each user.
- This era introduced the key ideas **of centralized management and shared resources**, which later became the **basic principles of cloud computing**.
- Although mainframe systems were costly and complex, they proved that computing power could be delivered as a **shared service**, laying the foundation for modern cloud technology.

1.2. Evolution : Distributed Systems (1970–1980)

- During the **1970s and 1980s**, the concept of **distributed systems** emerged as an important step in the evolution of cloud computing.
- In distributed system **multiple independent computers that work together** and appear as **a single system to users**.
- The main goal of distributed systems was to **share resources** such as processing power(CPU), memory, and data, and to use them **efficiently and effectively**.
- Each computer in the system **performed its own tasks**, but all systems were **connected** and coordinated through software and networks.
- Distributed systems introduced several important features, including:
 - **Scalability** – the ability to add more systems easily
 - **Concurrency** – multiple users or processes working at the same time
 - **Continuous availability** – services remain available even if one system fails
 - **Heterogeneity** – different types of hardware and software can work together
 - **Fault tolerance** – failure of one system does not stop the entire system

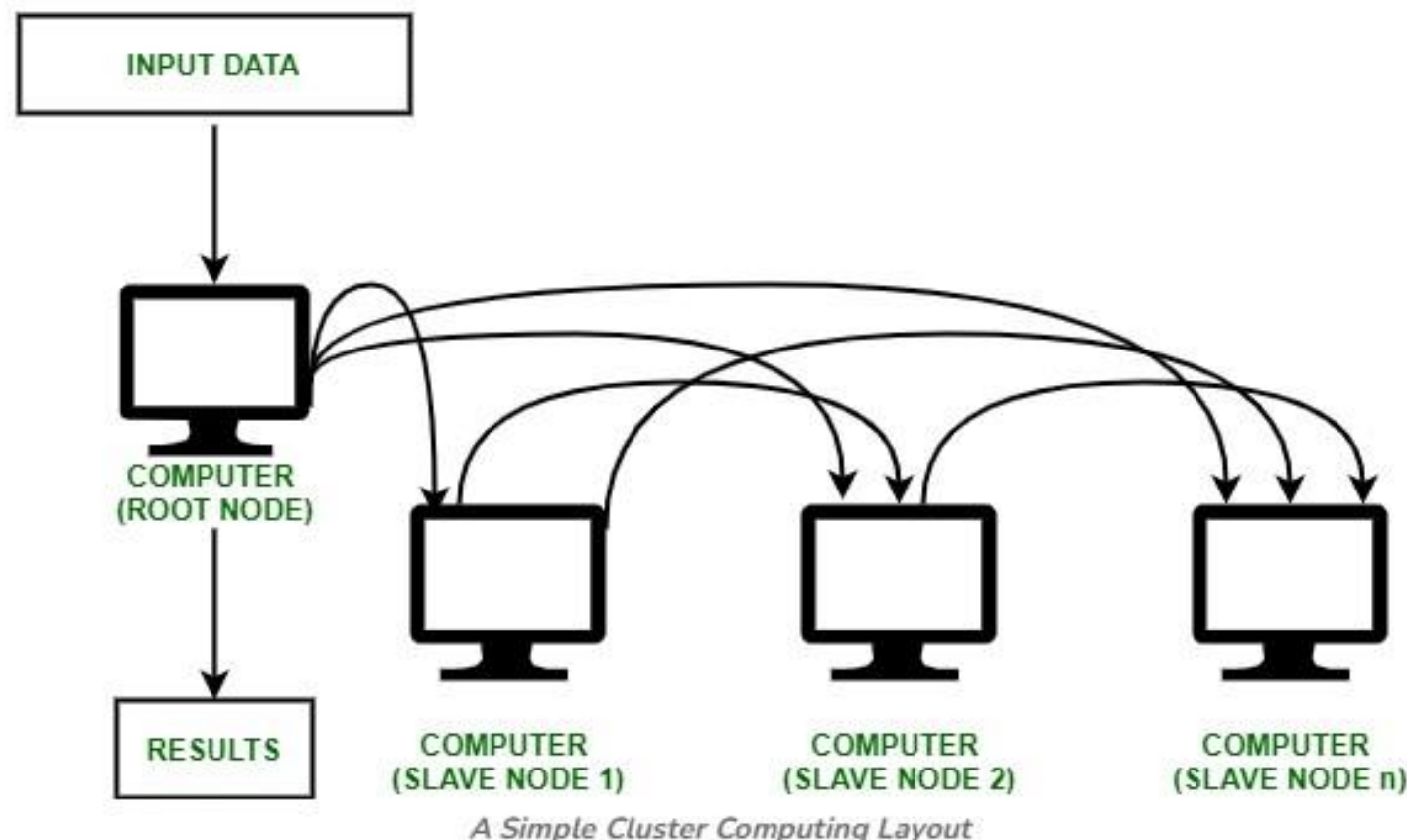
1.2. Evolution : Distributed Systems (1970–1980)

- However, a major limitation of early distributed systems was that **all computers had to be located in the same geographical area**. This reduced flexibility and limited large-scale expansion.
- To overcome this limitation and improve resource sharing across locations, distributed computing evolved further and gave rise to advanced computing models such as **cluster computing, and grid computing**.
- These developments played a key role in shaping modern cloud computing by introducing concepts like **resource pooling, scalability, and fault tolerance**.



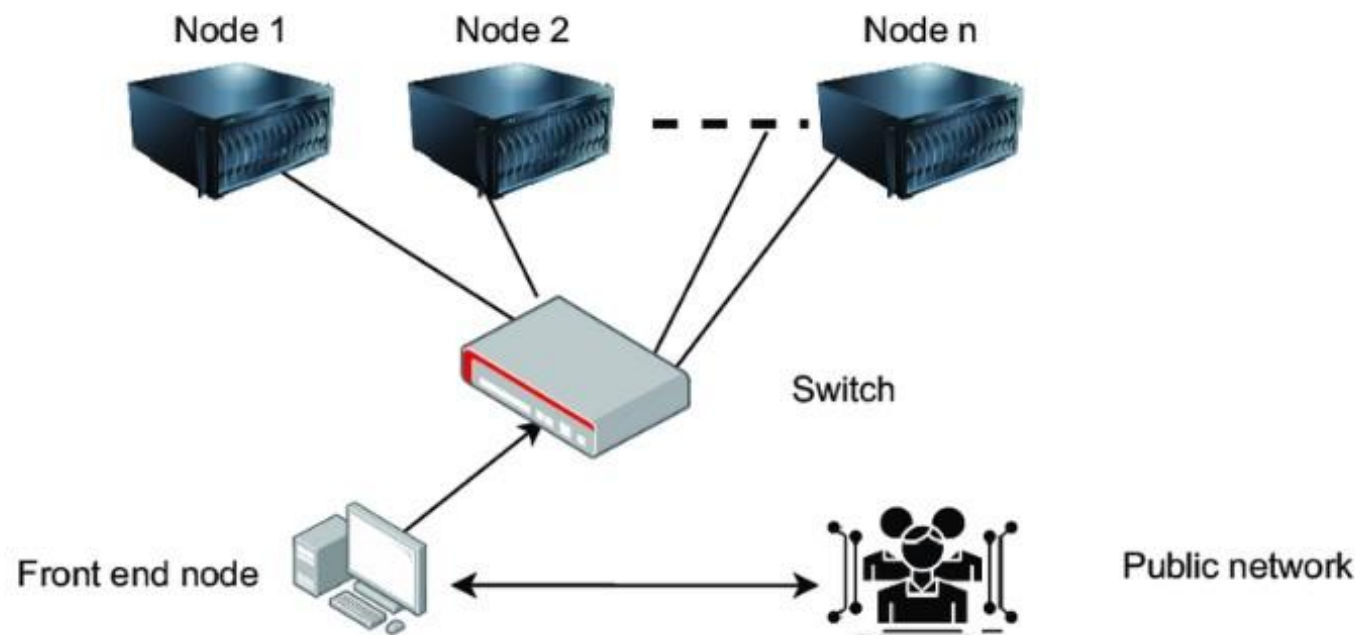
1.3. Evolution : Cluster Computing (1980–1990)

- During the **1980s**, **cluster computing** emerged as an important stage in the evolution of cloud computing and as a **cost-effective alternative to mainframe computers**. Instead of using one large and expensive machine, cluster computing combined **multiple smaller and cheaper computers** to work together as a single system.
- In a cluster, all machines (called **nodes**) were connected through a **high-speed network**. These connected systems shared computing tasks, making the cluster capable of performing **high-level computations** similar to mainframe systems. Because of this, organizations could achieve high performance at a **much lower cost**.



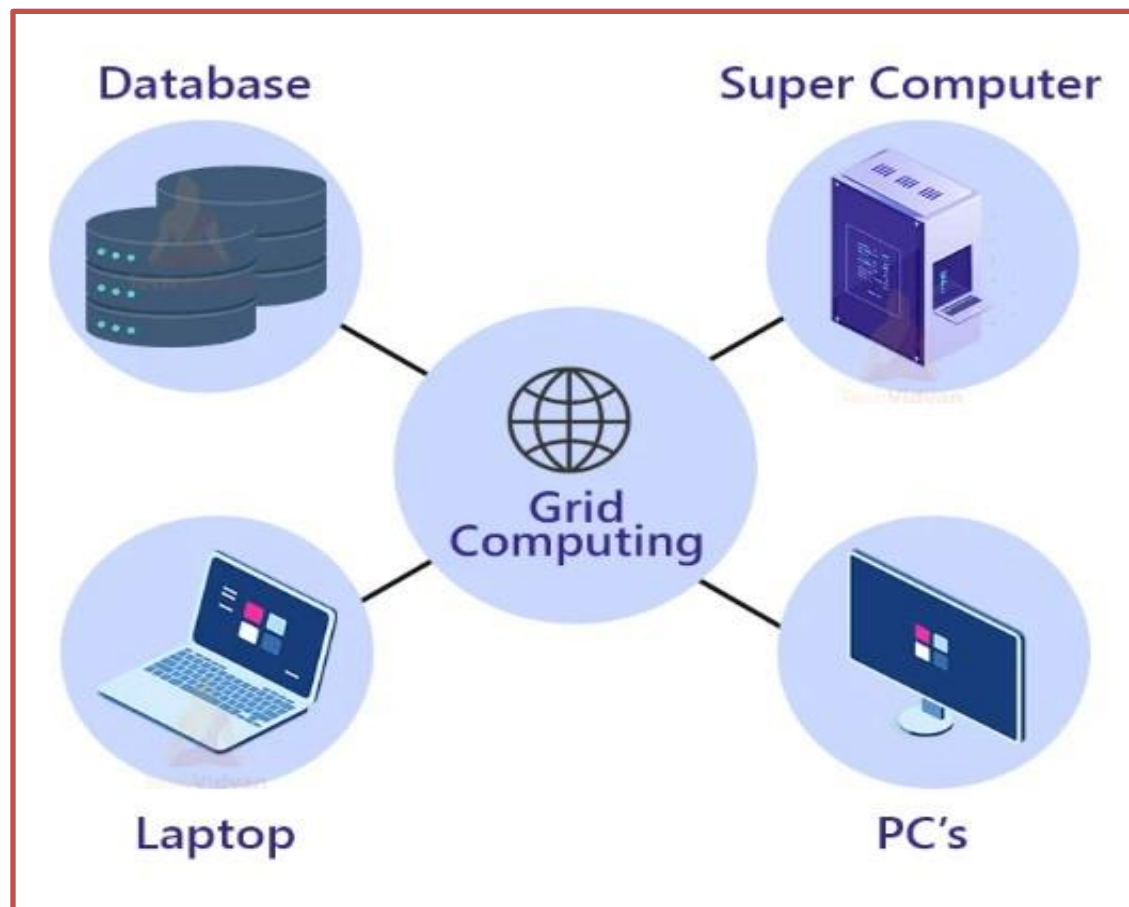
1.3. Evolution : Cluster Computing (1980–1990)

- One major advantage of cluster computing was **scalability**. New nodes could be **easily added** to the cluster whenever more processing power was needed. This made the system flexible and efficient.
- Although cluster computing solved the **high cost problem** of mainframes, it still had a limitation. All the computers in a cluster needed to be located in the **same geographical area**. This restriction limited wider resource sharing.
- To overcome this geographical limitation, the concept of **grid computing** was later introduced. Cluster computing, however, played a key role in cloud evolution by introducing ideas such as **scalability, resource pooling, and parallel processing**, which are essential features of modern cloud computing.



1.4. Evolution : Grid Computing (1990–2000)

- In the 1990s, **grid computing** expanded computing across locations.
- In grid computing, **multiple computers in different geographical areas** were connected via the Internet to work together.
- These systems often belonged to **different organizations**, so a grid was made up of **heterogeneous nodes** (different hardware, software, and operating systems).
- The main purpose of grid computing was to **share computing resources across long distances** and solve large and complex problems that could not be handled by a single system.

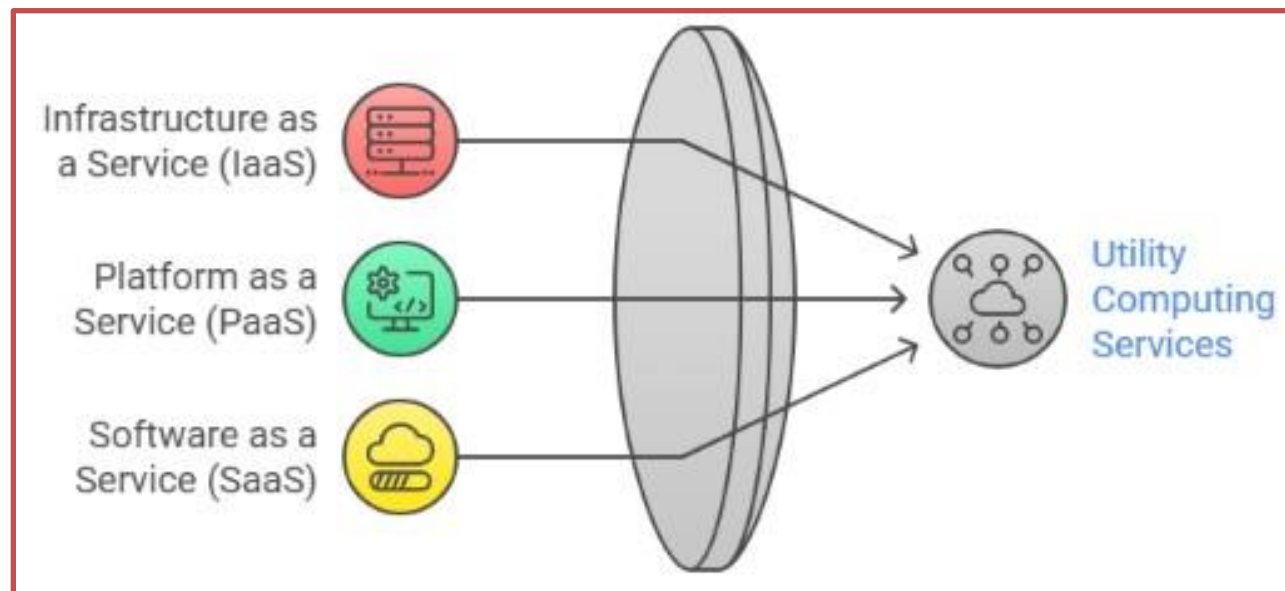


1.4. Evolution : Grid Computing (1990–2000)

- Grid computing successfully **removed geographical limitations** found in cluster computing and allowed global resource sharing.
- However, as the distance between systems increased, **new challenges** appeared. The most serious problem was the **lack of high-bandwidth and reliable network connections**. Other issues such as **network latency, low availability, and management complexity** also affected performance.
- Because of these limitations, grid computing could not always provide fast, reliable, and on-demand services. To overcome these problems, **cloud computing evolved as an improved model**, offering better scalability, high-speed connectivity, centralized management, and reliable services.
- For this reason, cloud computing is often described as the “**successor of grid computing**”, as it builds upon grid concepts while solving many of its limitations

1.5. Evolution : Utility Computing (Late 1990s–2000)

- Utility computing provides **on-demand** computing resources and infrastructure management, similar to utilities **like electricity or water**.
- Organizations can access computing power, storage, and applications from a service provider **without maintaining their own infrastructure**.
- Users **do not need to buy** or maintain **expensive hardware**. Instead, **they pay only for the resources they use**, which is known as the **pay-per-use** model.
- **In short:**
 - Utility computing introduced the idea of **pay-per-use**.
 - Users paid only for the resources they used.
 - Computing services were provided like electricity.
 - Reduced the need to buy expensive hardware.
- Utility computing Introduced the **concept of renting** computing resources.



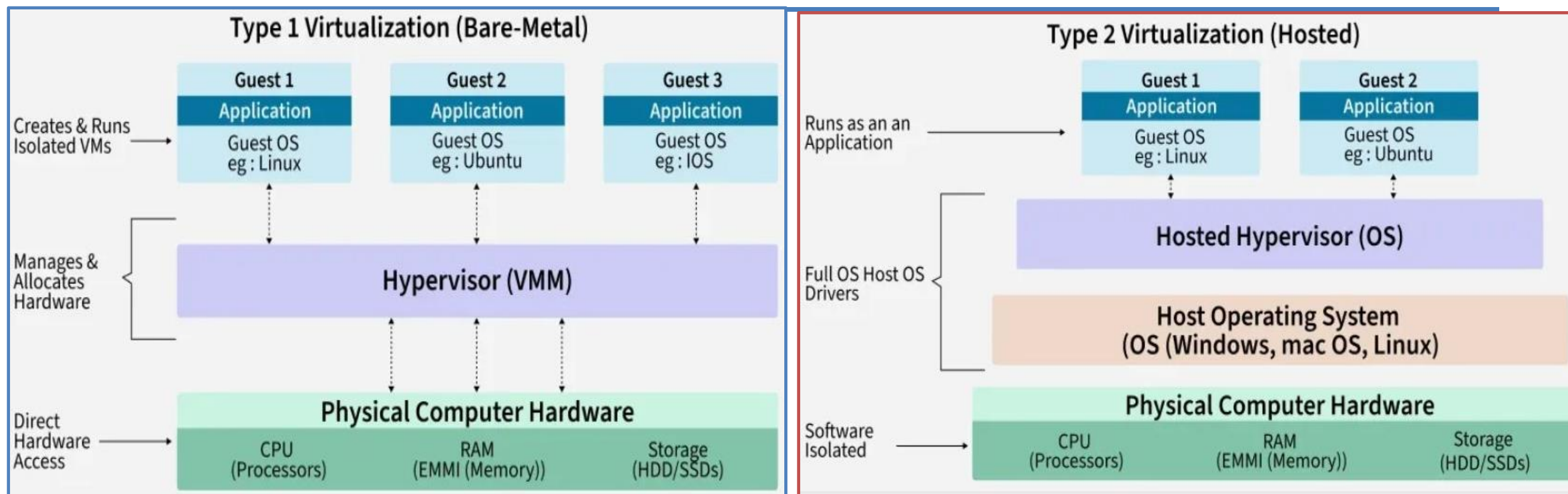
1.5. Evolution : Utility Computing (Late 1990s–2000)

- One of the most significant advantages of utility computing is its **ability to provide on-demand access to resources**. Users can quickly scale their computing power up or down based on their requirements without the need for significant upfront investment.
- This scalability is particularly beneficial for businesses with **fluctuating workloads**, as it allows them to handle peak demands efficiently without over-provisioning resources.
- Utility computing follows a **metered billing model**, where **users are charged** based on their actual **resource consumption**. This **pay-as-you-go** approach ensures that businesses only pay for what they use, avoiding the costs associated with over-provisioning.
- Metered billing provides transparency and helps organizations manage their IT budgets more effectively.

1.6. Evolution : Virtualization (1980–Present)

- Virtualization is **one of the most important technologies** in the evolution of cloud computing. It was introduced around **40 years ago** and has continued to develop until the present day.
- Virtualization refers to **the process of creating a virtual layer over physical hardware**, which allows **multiple operating systems and applications** to run at the same time on a single physical machine.
- With virtualization, one physical **server can be divided into multiple virtual machines (VMs)**. Each virtual machine **works like a separate computer** with its own operating system, memory, and storage. This improves **hardware utilization** and reduces the need for multiple physical servers.
- **Before virtualization**, a physical server could only run **one Operating System (OS) and often one task**. This wasted massive amounts of resources if our app **only used 10%** of the CPU, the other **90% was idle**. Virtualization solves this by allowing one physical server to host dozens of virtual servers, each running its own OS and apps isolated from the others.

1.6. Evolution : Virtualization (1980–Present)

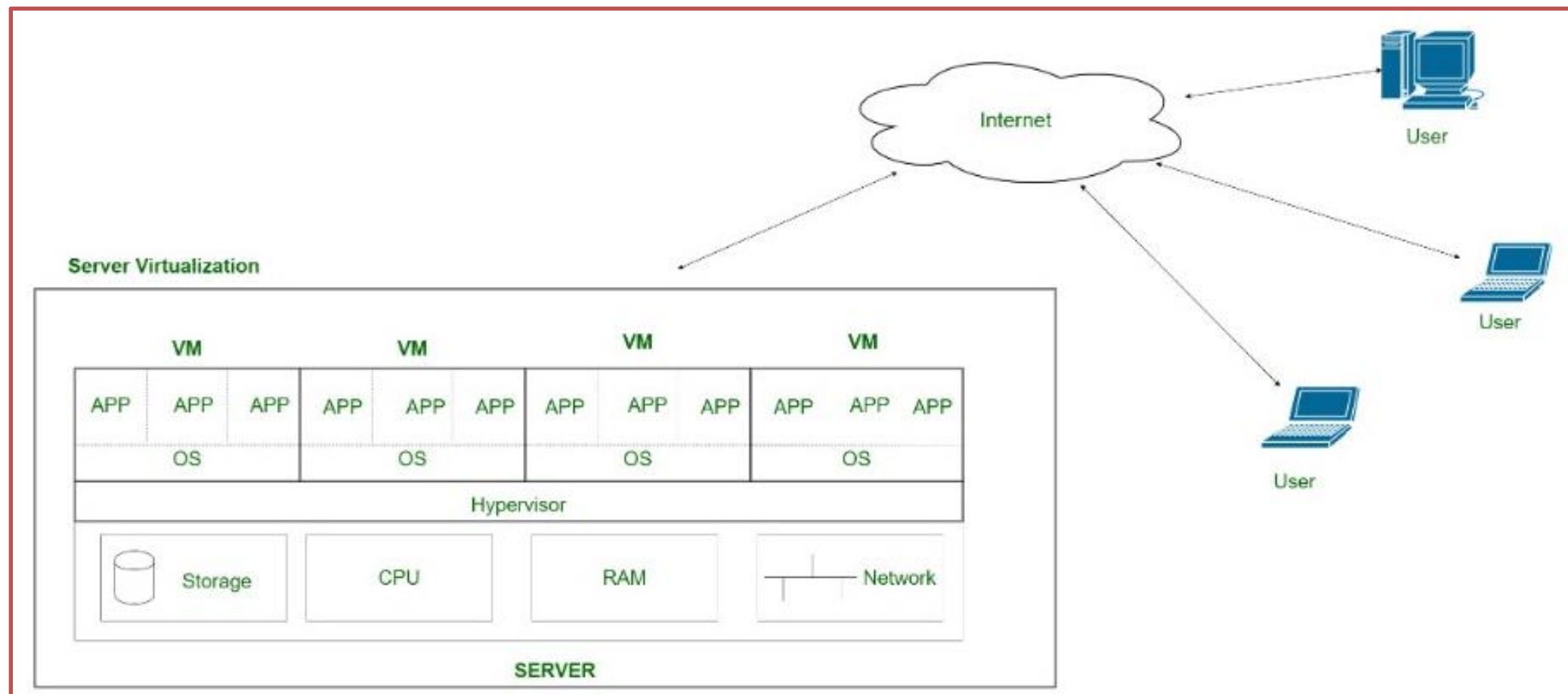


The Core Architecture

- At the heart of virtualization is a piece of software called the **Hypervisor**.
- **Physical Hardware (Host):** The actual server (CPU, RAM, Disk).
- **Hypervisor:** A lightweight software layer that sits between the hardware and the virtual machines. It allocates resources (e.g., "Give VM1 2GB of RAM") and manages the VMs.
- **Virtual Machine (Guest):** A software-based computer that runs like a physical one. It has its own OS, libraries, and applications.

1.6. Evolution : Virtualization (1980–Present)

- Virtualization is the **core foundation of cloud computing**. Most cloud services are built on this technology. Popular cloud platforms such as **Amazon EC2, VMware vCloud, and Microsoft Azure** use virtualization to provide **scalable and flexible computing** resources to users.
- Among different types of virtualization, **hardware virtualization** is the most widely used. It allows cloud providers to create and manage virtual servers efficiently.
- Because of virtualization, cloud computing can offer **on-demand resources, scalability, isolation, and cost efficiency**.
- Virtualization transformed **traditional computing into modern cloud computing** by enabling resource sharing, flexibility, and efficient infrastructure management.



1.7. Evolution : Web 2.0 (Around 2004)

- **Web 2.0** is an important stage in the evolution of cloud computing because it provides the **user interface** through which users interact with cloud services.
- It refers to the second generation of the **World Wide Web** that focuses on **interactive, dynamic, and user-friendly web applications**.
- Before Web 2.0, web pages were mostly **static** and allowed users **only to read information**. With Web 2.0, users can **create, share, and interact with content** in real time. This made web applications more flexible, responsive, and engaging.



1.7. Evolution : Web 2.0 (Around 2004)

- Web 2.0 technologies made it possible for cloud-based applications to run smoothly through **web browsers**, without the need to install software locally.
- Popular Web 2.0 applications include **Google Maps, Facebook, Twitter, YouTube**, and other social media platforms.
- The rise of Web 2.0 around **2004** greatly increased the use of cloud computing. It enabled services like online collaboration, social networking, and real-time data sharing.
- In short, **Web 2.0 made cloud computing practical and widely accessible** by providing an interactive platform for users to access cloud services easily.

1.8. Evolution : Service-Oriented Computing

- Services were delivered as reusable components.
- Introduced **Software as a Service (SaaS)**.
- Included Quality of Service (QoS) and SLAs.
- Improved flexibility and reliability.
- Service-Oriented Computing defined how cloud services are delivered.

1.9. Evolution : Modern Cloud Computing (2006–Present)

- **Cloud computing** is the final and most advanced stage in the evolution of computing technologies.
- It refers to the practice of **storing, managing, and accessing data and applications on remote servers** that are hosted on the **Internet**, instead of on a computer's local hard drive or local server.
- In cloud computing, users do not need to own or maintain physical hardware or software. Computing resources such as **storage, processing power, applications, and infrastructure** are provided to users as **services over the Internet**. This is why cloud computing is also called **Internet-based computing**.
- The data stored in the cloud can include **files, images, documents, videos, and other digital content**. Users can access this data from **any device, at any time, and from any location**, as long as they have an Internet connection.

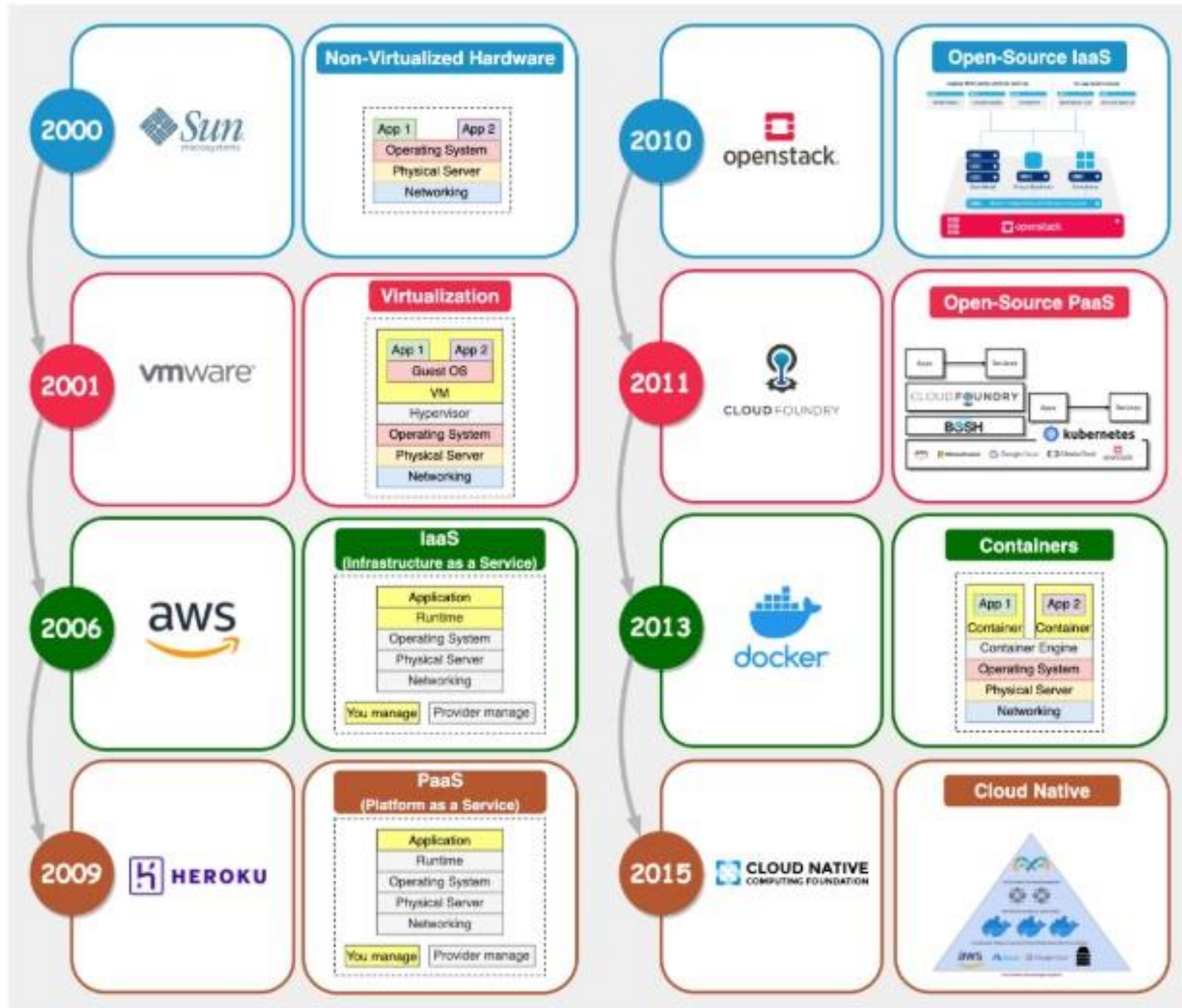
1.9. Evolution : Modern Cloud Computing (2006–Present)

- Cloud computing combines ideas from earlier technologies such as **mainframe computing, distributed systems, virtualization, utility computing, Web 2.0, and service orientation.**
- By integrating these concepts, cloud computing offers **scalability, flexibility, cost efficiency, high availability, and ease of use.**
- Cloud computing represents the successful evolution of computing into a **service-based, on-demand, and globally accessible model**, making it one of the most important technologies in modern information systems.

1.9. Evolution : Modern Cloud Computing (2006–Present)

2 Decades of Cloud Evolution

blog.bytebytego.com



2. What is Cloud Computing?

- The cloud computing is the **delivery of computing services** such as **database, storage, networking, software** etc. **over the internet**. It helps for **lowering the costs** and increases the efficiency of business.
- **Cloud computing** is a modern computing model in which **users rent computing resources** such as storage, software, servers, and processing power from a service provider over the **Internet**, instead of buying and maintaining their own hardware and software.
- In cloud computing, data and programs are stored and run on **remote servers (the cloud)**. Users access these services through the Internet and **pay only for what they use**, just like paying for electricity or water.
- Cloud computing transforms **IT infrastructure into** a **utility (pay-per-use basis)** i.e. it lets us '**plug into**' infrastructure via the internet, and use computing resources **without installing** and maintaining them on-premises.

2. What is Cloud Computing?

- To clearly understand cloud computing, it is important to separate the two concepts **Cloud and Computing** :

1. What is “Cloud”?

- The **cloud** refers to a **network of remote servers and data centers** located in different parts of the world. These servers are owned and managed by cloud service providers.
- The cloud stores data and applications.
- Users do not know or care about the physical location of servers.
- All maintenance, security, and upgrades are handled by the provider.

Example:

When you save a file in **Google Drive**, the file is stored on Google’s cloud servers, not on your computer.

2. What is “Computing Services”?

- **Computing services** are the **resources and functions** provided by the cloud. These include:
- Storage (for files and data), Processing power (CPU and memory), Software applications, Networking and databases.
- These services are **rented**, not owned. Users can **increase** or **decrease** usage anytime based on their needs.

Example:

A company rents virtual servers from **Amazon EC2** instead of buying physical servers.

2. What is Cloud Computing?

- One of the most important ideas in cloud computing is **renting instead of owning**.

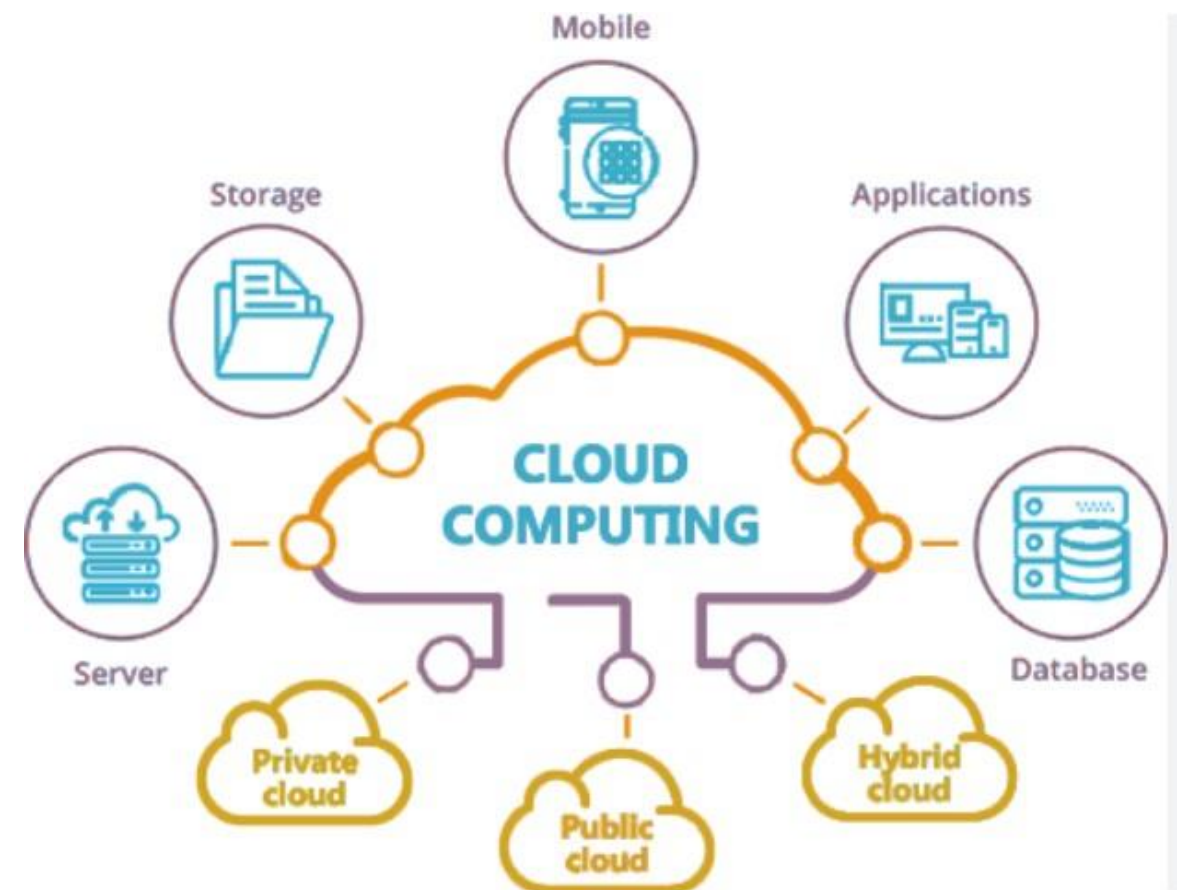
Traditional Computing:

- Buy servers and software
- High initial cost
- Maintenance and upgrades are the user's responsibility

Cloud Computing:

- Rent computing services
- No upfront investment
- Pay-as-you-use model
- Provider handles maintenance
- This model makes cloud computing **cost-effective and flexible**.

- Cloud computing is a **kind of outsourcing of resources** such as software, data storage, processing etc. Users access applications and files by logging in from any device that has an internet connection.
- The idea of computing in a "cloud" was originated by **scientist John McCarthy in 1961**



2.1. Advantages of Cloud Computing

- Cloud computing is a modern computing model in which users **rent computing services such as servers, storage, software, and processing power over the Internet**. Instead of buying and maintaining physical infrastructure, users **access resources on demand**.
- This approach provides several **technical, financial, and operational** advantages.

1. Cost Efficiency (Reduced IT Costs)

- One of the main advantages of cloud computing is cost efficiency, as it **eliminates the need for expensive** hardware, software installation, and maintenance.
- Users **pay only for the resources they use**, which helps organizations reduce operational expenses.

2. Scalability and Elasticity

- Another important advantage of cloud computing is scalability and flexibility.
- Cloud resources **can be increased or decreased easily** according to **user demand**.
- This makes cloud **computing suitable for growing organizations** and applications with **fluctuating usage**.

3. Accessibility and Global Reach

- Cloud computing also provides **easy accessibility** and global reach.
- Data and **applications stored in the cloud can be accessed from anywhere in the world** using an Internet connection.

2.1. Advantages of Cloud Computing

4. Automatic Maintenance and Updates

- Cloud **providers take care** of system maintenance.
- Cloud service providers handle **software updates**, security **patches**, and hardware maintenance, which **reduces the workload of IT staff** and ensures that systems remain up to date and secure.

5. Data Backup and Disaster Recovery

- Data backup and disaster recovery are greatly improved through cloud computing. Cloud providers **store data in multiple locations** and **create regular backups**, ensuring that data can be recovered quickly in case of system failure, accidental deletion, or natural disasters.

6. High Availability and Reliability

- High availability and reliability are also key advantages of cloud computing. Cloud services **run on multiple servers**, so if **one server fails, another continues** to provide the service.

7. Enhanced Collaboration and Productivity

- Cloud platforms support real-time collaboration.
- Cloud computing enhances collaboration and productivity **by allowing multiple users to work on the same documents or projects at the same time**. Changes are saved automatically and can be viewed instantly, improving teamwork and efficiency.

2.1. Advantages of Cloud Computing

8. Strong Security Measures

- Security is another significant advantage of cloud computing.
- Cloud **providers use advanced security measures** such as data **encryption**, **authentication**, **access control**, and **regular security audits** to protect user data.
- In many cases, **cloud security is stronger** than traditional local systems.

9. Performance and Speed

- Cloud computing **also improves performance and speed** by using high-performance data centers and optimized networks.
- Applications **run faster and data access is quicker**, especially when cloud providers use servers located close to users.

10. Environment Friendly (Green Computing)

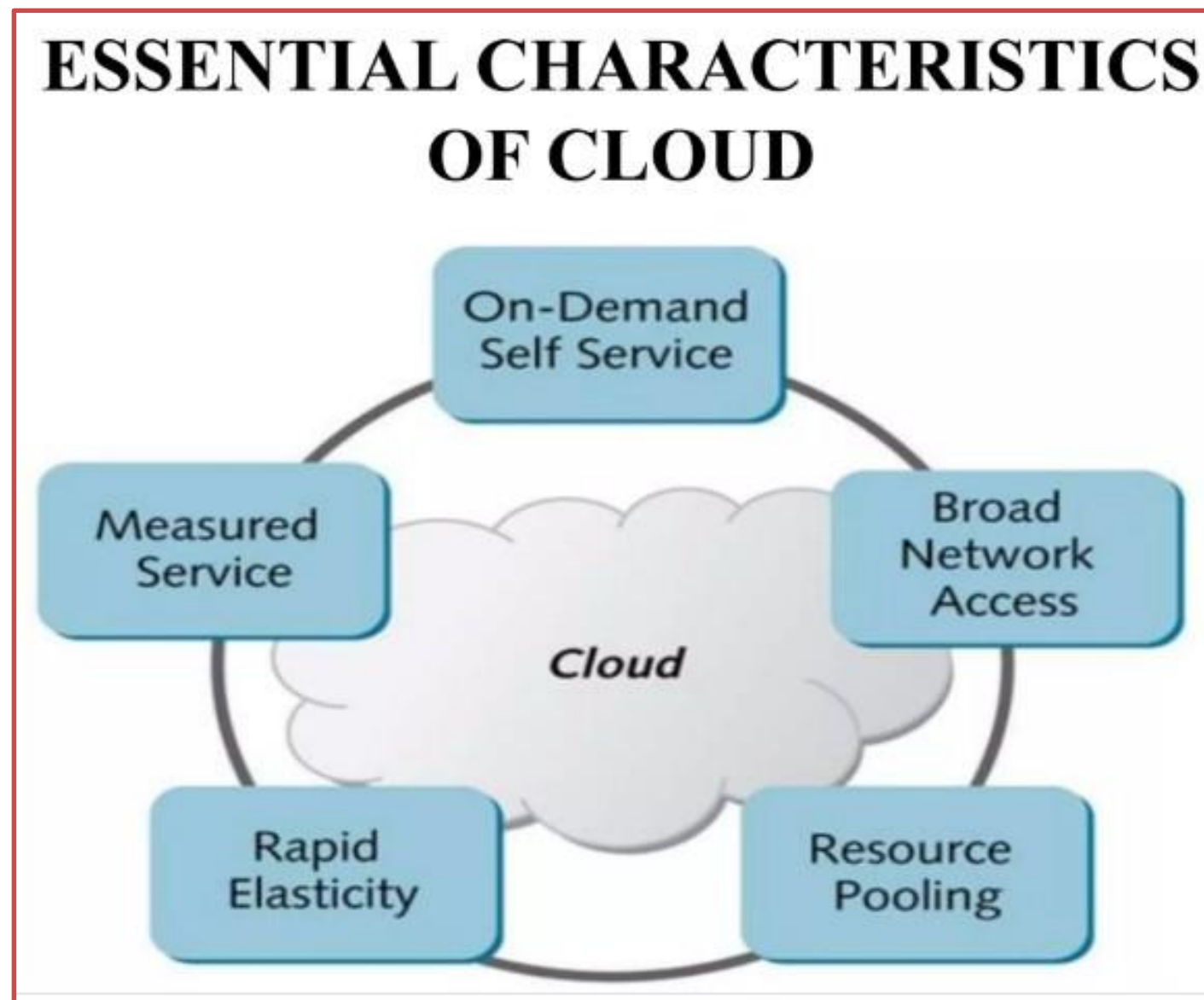
- Cloud computing supports **environmental sustainability** by **reducing the number of physical servers** and optimizing resource usage.
- This **leads to lower energy consumption** and a reduced carbon footprint.

2.2. Disadvantages of Cloud Computing

- Cloud computing **depends heavily on a stable Internet connection**, and without Internet access, cloud services cannot be used.
- **Data security and privacy** are major concerns because data is stored on third-party servers, increasing the risk of **unauthorized access or data breaches**.
- **Service downtime and outages** may occur due to technical failures, maintenance, or cyber attacks, which can interrupt business operations.
- Users have **limited control and customization** over cloud infrastructure since services are managed by the cloud provider.
- **Vendor lock-in** can make it difficult and **expensive to switch** from one cloud provider to another.
- **Performance issues** may arise **due to shared resources**, network latency, or heavy traffic on cloud servers.
- **Long-term costs** may increase if cloud resources are not managed properly, especially for large-scale or continuous usage.
- **Compliance and legal issues** can occur because **cloud data** may be stored in different countries with varying data protection laws.

2.3. Characteristics of Cloud Computing

- Cloud computing has **several important features** that make it different from traditional computing systems. These **characteristics** help users store data, run applications, and use computing resources efficiently over the internet.
- All cloud services share **five fundamental characteristics** that define them:



2.3. Characteristics of Cloud Computing

1. On-Demand Self-Service

- One of the **most important** characteristics of cloud computing is **on-demand self-service**.
- This means **users can use cloud services whenever they want** without needing help from the service provider. Users **can create** servers, **increase** storage, or **use** applications automatically through an *online dashboard*.
- **For example**, when a user creates an **email account** or cloud **storage account**, the service becomes available immediately **without contacting the company**.

2. Broad Network Access

- Cloud computing **services are available through the internet** and can be accessed using standard devices such as computers, laptops, tablets, and smartphones.
- This allows users to **work from different places** using different devices.
- **For example**, a student can **open** Google Classroom **from home, school, or a cyber café** using any internet-enabled device.

2.3. Characteristics of Cloud Computing

3. Resource Pooling

- In cloud computing, the **service provider pools** computing resources such as **servers, storage, and networks** to serve multiple users at the same time.
- These **resources are dynamically allocated** and reallocated according to user demand. Users **do not know the exact physical location** of the resources.
- **For example**, many companies use the **same cloud data center**, but each company's data remains private and secure.

4. Rapid Elasticity and Scalability

- Cloud computing **allows resources to be increased or decreased quickly** based on demand. This **flexibility** is called scalability and elasticity.
- Users can **easily scale up** resources during high demand and **scale down** when demand is low.
- **For example**, an e-commerce website can **increase server capacity** during festivals or sales and reduce it after the sale period ends.

5. Measured Service (Pay-As-You-Use)

- Cloud computing uses a **measured service model** where users **pay only for the resources they consume**.
- The usage is **monitored**, controlled, and reported **by the cloud provider**. This helps reduce unnecessary costs.
- **For example**, a user **pays only for the amount of cloud storage**, bandwidth, or computing power used in a month.

2.3. Characteristics of Cloud Computing

6. High Availability and Reliability

- Cloud computing systems are **designed** to provide **high availability and reliability**. Data is stored in **multiple locations** and **backup** servers are used to **ensure continuous service** even if one system fails.
- **For example**, if one cloud server goes down, another server **automatically takes over** without affecting the user.

7. Automatic Maintenance and Updates

- In cloud computing, the **service provider is responsible** for **maintaining** the hardware and software. Updates, **security patches**, and system upgrades are performed automatically.
- Users always get the **latest version of services** without manual installation.
- **For example**, Google Docs updates itself without the user needing to download or install anything.

8. Data Backup and Disaster Recovery

- Cloud computing provides **automatic data backup and recovery features**. In case of system **failure**, accidental **deletion**, or natural **disaster**, data can be **restored easily from backups**.
- **For example**, cloud storage services **allow users to recover deleted** files within a specific time period.

2.3. Characteristics of Cloud Computing

9. Cost Effectiveness

- Cloud computing **reduces the need for expensive hardware, software, and maintenance.**
- Users do not need to **invest heavily in infrastructure.** This makes cloud computing **cost-effective**, especially for small businesses and startups.
- **For example**, a small company **can rent** cloud servers **instead of buying** and maintaining physical servers.

10. Location Independence

- Cloud computing **allows users to access data and applications from anywhere** in the world as long as there is an internet connection. The user's physical location does not affect access to cloud services.
- **For example**, an employee can work remotely and access company files stored in the cloud.

11. Virtualization:

- Cloud computing providers use virtualization technology to abstract underlying hardware resources and present them as logical resources to users.

12. Security:

- Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
