Unit 1: Introduction to Cloud Computing

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What is Cloud?

The term `cloud` refers to a **network** or the `Internet`. It represents computing resources that are located at remote locations. The cloud can provide services over both public and private networks (such as WAN, LAN, or VPN). Applications including email, web conferencing, and customer relationship management (CRM), all run in the cloud.

Network Types 🌐 ⋯ Cloud Computing ⋯ Remote Resources

Applications
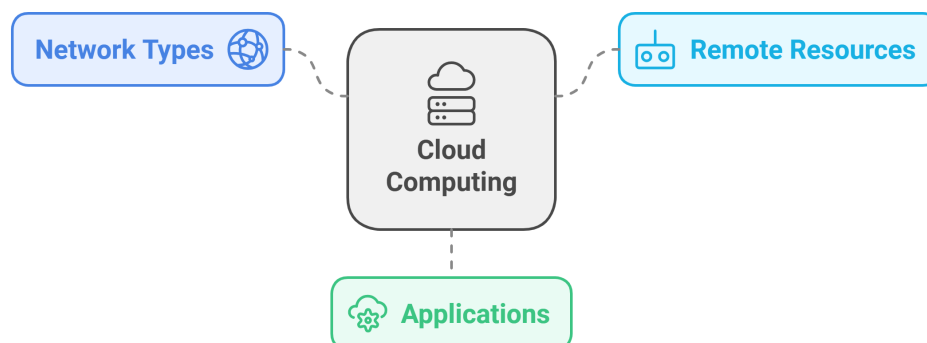
Cloud Computing:

Cloud computing is the delivery of **on-demand computing services** over the internet on a `pay-as-you-go-basis`.

Cloud computing is the use of computing resources (hardware and software) that are
delivered as a service over a network (typically the Internet). The name comes from
the use of a cloud-shaped symbol as an abstraction for the complex infrastructure it
contains in system diagrams. Cloud computing entrusts remote services with a

user's
data, software and computation
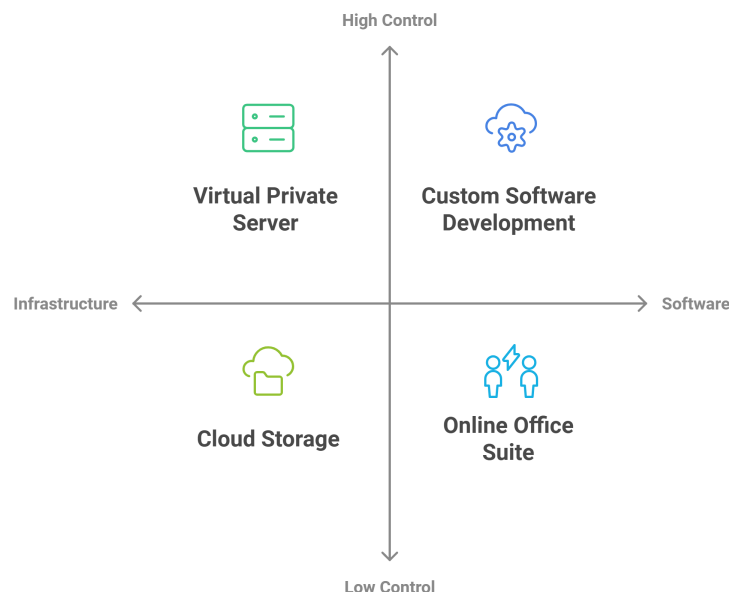
Cloud computing is a general term for anything that involves delivering hosted services over the Internet. These services are broadly divided into three categories:

`Infrastructure-as-a-Service (IaaS)` , `Platform-as-a-Service (PaaS)` and `Software-as-a-Service (SaaS)` . The name cloud computing was inspired by the cloud symbol that's often
used to represent the Internet in flowcharts and diagrams.

A cloud service has three distinct characteristics that differentiate it from traditional
hosting:

- It is `sold on demand` , typically by the minute or the hour;

- It is `elastic` : a user can have as much or as little of a service as they want at any
    given time; and

- The service is fully managed by the provider (the consumer needs nothing but a
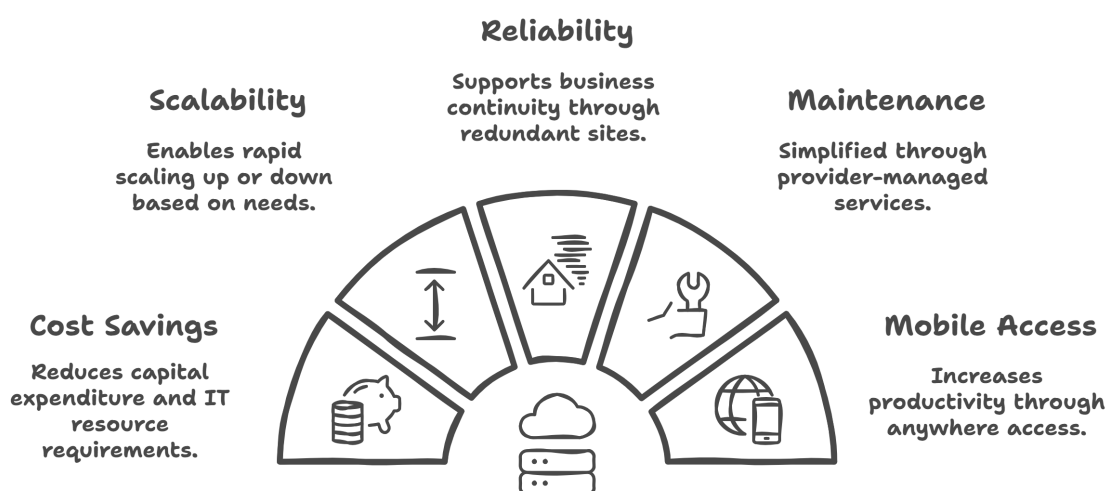   personal computer and Internet access). Significant innovations in virtualization

and distributed computing, as well as improved access to high-speed Internet and a
weak economy, have accelerated interest in cloud computing.

Benefits of using cloud models:

In cloud computing, customers pay only for the resources they use, avoiding large upfront infrastructure costs. The shared computing model improves resource utilization and reduces costs while accelerating application development.

This model also provides increased computing capacity without requiring customers to plan for peak loads. The widespread adoption of cloud computing has been facilitated by improved high-speed internet access, though legal considerations remain important.

Cloud Computing Benefits

Scalability

Enables rapid scaling up or down based on needs.

Reliability

Supports business continuity through redundant sites.

Maintenance

Simplified through provider-managed services.

Cost Savings

Reduces capital expenditure and IT resource requirements.

Mobile Access

Increases productivity through anywhere access.

- **Cost Savings:** Reduces capital expenditure and IT resource requirements
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Evolution of cloud computing:

Cloud computing can be seen as an innovation in different ways. From a technological
perspective it is an advancement of computing, applying virtualization concepts to utilize
hardware more efficiently. Yet a different point of view is to look at cloud computing from
an IT deployment perspective. In this sense cloud computing has the potential to
revolutionize the way, how computing resources and applications are provided, breaking
up traditional value chains and making room for new business models. In the following
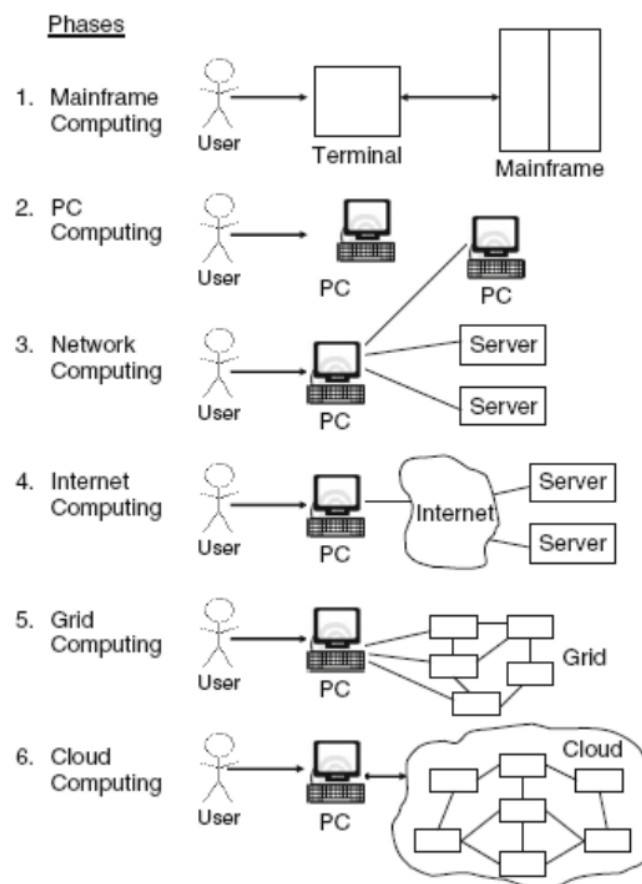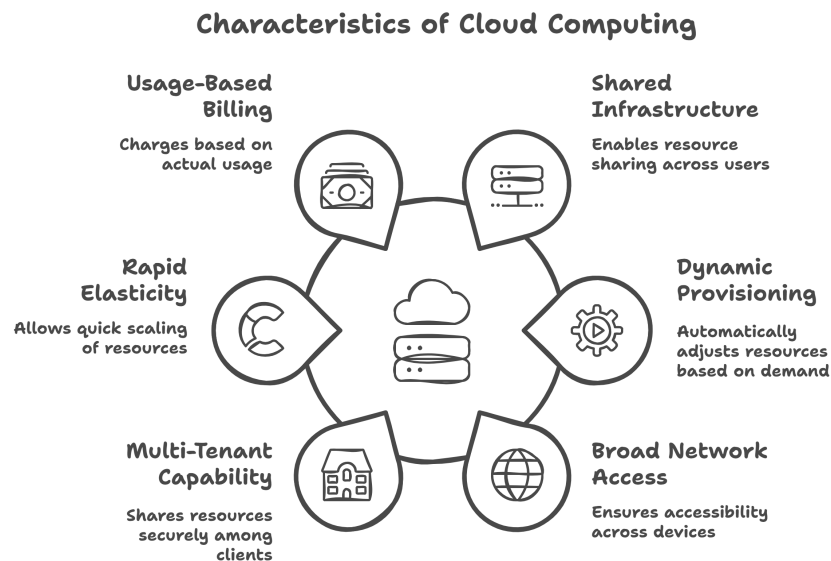section we are going to describe the emergence of cloud computing from both perspectives.

Fig: Evolution of Computing Paradigms from mainframe to cloud computing

Characteristics of Cloud Computing:

Cloud computing has several key characteristics:

Characteristics of Cloud Computing

Usage-Based Billing
Charges based on actual usage

Shared Infrastructure
Enables resource sharing across users

Rapid Elasticity
Allows quick scaling of resources

Dynamic Provisioning
Automatically adjusts resources based on demand

Multi-Tenant Capability
Shares resources securely among clients

Broad Network Access
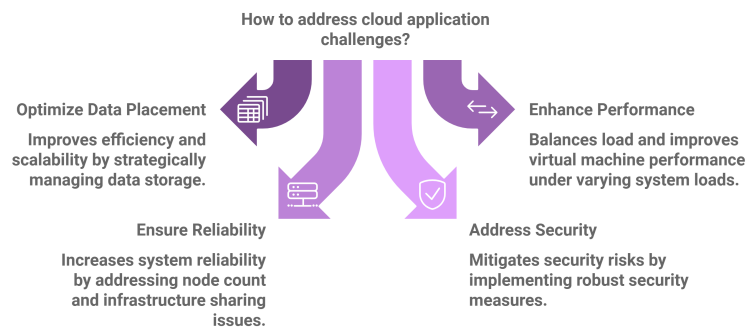Ensures accessibility across devices

- **Shared Infrastructure:** Uses a virtualized software model that enables sharing of physical services, storage, and networking capabilities. The cloud infrastructure maximizes resource utilization across users, regardless of deployment model.

- **Dynamic Provisioning / On-Demand Self-Service:** Automatically provisions services based on current demand through software automation. This allows for flexible scaling of service capabilities while maintaining high reliability and security.

- **Broad Network Access:** Provides access through the internet across diverse devices (PCs, laptops, mobile devices) using standards-based APIs like HTTP. Cloud services range from business applications to smartphone apps.

- **Multi-Tenant Capability:** Shares resources (network, storage, compute power) among multiple enterprise clients to reduce costs. Uses resource virtualization for security and isolation.

- **Rapid Elasticity:** Enables users to quickly and often automatically scale computing resources up or down as needed.

- **Usage-Based Billing:**Employs metering to manage and optimize services while tracking usage for billing. Customers pay only for their actual usage, accessing scalable services from any location.
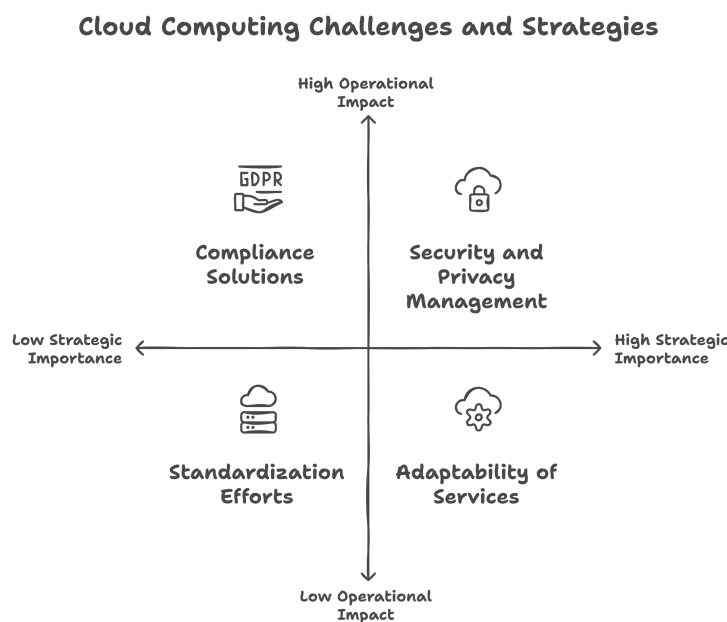
Challenges for cloud computing

Cloud applications face challenges due to imbalances in computing resources and communication bandwidth. While cloud infrastructures handle load balancing automatically, developers must optimize data placement and storage solutions.

Performance can be affected by shared infrastructure and imperfect isolation. Virtual machine performance varies with system load, and reliability concerns increase with node count. Developers must balance performance, reliability, and security with cost considerations.

Multi-stage applications present additional challenges with parallel processing and cross-system communication, affecting efficiency and scalability.

How to address cloud application challenges?

Optimize Data Placement

Improves efficiency and scalability by strategically managing data storage.

Enhance Performance

Balances load and improves virtual machine performance under varying system loads.

Ensure Reliability

Increases system reliability by addressing node count and infrastructure sharing issues.

Address Security

Mitigates security risks by implementing robust security measures.

These challenges can become opportunities when properly addressed during planning.

Cloud Computing Challenges and Strategies

High Operational Impact

Compliance Solutions

Security and Privacy Management

Low Strategic Importance ← → High Strategic Importance

Standardization Efforts

Adaptability of Services

Low Operational Impact

- **Security and Privacy:** Organizations can mitigate security concerns by keeping sensitive data internal while using cloud services through hybrid deployment.

- **Lack of Standards:** Limited interoperability due to absence of universal standards, though industry groups are working on standardization.

- **Continuously Evolving:** Cloud services must adapt to changing user needs and technical requirements.

- **Compliance Concerns:** Cloud computing must address various regulations, often leading to hybrid solutions for sensitive data management.

Types of Cloud Computing: Service and Deployment Models

Cloud computing has revolutionized the way businesses and individuals access and manage technology resources. This document outlines the various types of cloud computing, focusing on both service models and deployment models. Understanding these models is crucial for organizations looking to leverage cloud technology effectively.
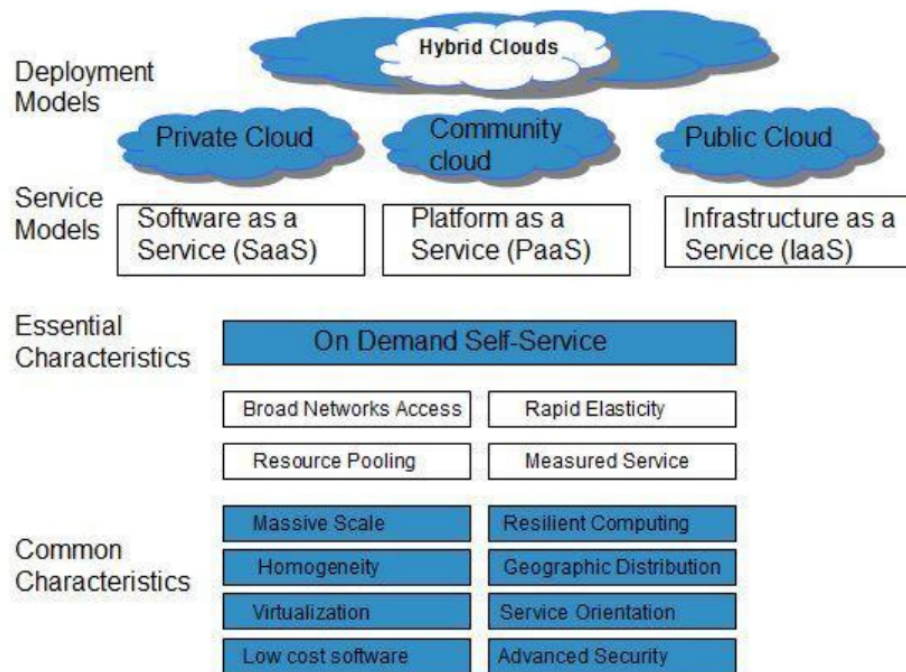
Service Models

Cloud computing service models can be categorized into three primary types:

1. **Infrastructure as a Service (IaaS)**

IaaS provides virtualized computing resources over the internet. Users can rent IT infrastructure such as `servers`, `storage`, `databases` and `networking` on a `pay-as-you-go` basis. This model offers flexibility and scalability, allowing businesses to scale resources up or down based on demand.

Examples include `Amazon Web Services (AWS) EC2` and `Microsoft Azure`.

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

PaaS offers a platform allowing developers to build, deploy, and manage applications without the complexity of managing the underlying infrastructure. This model provides tools and services for application development, including databases, middleware, and development frameworks. `Examples` include `Google App Engine` and `Heroku`.

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

SaaS delivers software applications over the internet on a subscription basis. Users can access software applications from any device with an internet connection, eliminating the need for installation and maintenance. This model is ideal for applications like email, customer relationship management (CRM), and collaboration tools. **Examples** include `Salesforce`, `Google Workspace`, and `Microsoft 365`.

Deployment Models

Cloud computing deployment models define how cloud services are made available to users. The main deployment models include:

1. **Public Cloud**

In a public cloud model, services are delivered over the internet and shared across multiple organizations. This model is cost-effective and scalable, as resources are managed by third-party providers. However, it may raise concerns regarding data security and compliance.

Examples include `AWS`, `Microsoft Azure`, and `Google Cloud Platform`.

2. **Private Cloud**

A private cloud is dedicated to a single organization, providing greater control over resources and security. This model can be hosted on-premises or by a third-party provider. Private clouds are ideal for businesses with strict regulatory requirements or those needing enhanced security.

3. **Hybrid Cloud**

The hybrid cloud model combines public and private clouds, allowing data and applications to be shared between them. This model offers flexibility, enabling organizations to scale resources as needed while maintaining control over sensitive data. It is suitable for businesses that require both the scalability of public clouds and the security of private clouds.

4. **Community Cloud**

A community cloud is shared among several organizations with similar interests or requirements, such as compliance or security needs. This model allows for cost-sharing and collaboration while maintaining a level of privacy and control. It is often managed by one of the organizations or a third-party provider.

Cloud service requirements

1. Cost Efficiency: Cloud infrastructure eliminates large upfront expenses for equipment purchase and maintenance.

2. Data Security: Cloud platforms provide advanced security features for data protection, including authentication, access control, and encryption. These baseline protections ensure secure data storage and handling.

3. Scalability: Cloud services adapt to diverse business needs—from startups to large enterprises with 1000+ employees. Organizations can efficiently scale resources up or down based on demand.

4. Mobility: Cloud computing enables secure access to corporate data through smartphones and devices. This keeps teams connected and up-to-date with clients and colleagues, regardless of location or schedule.

5. Disaster Recovery: Cloud storage ensures data availability even if local equipment fails. Cloud-based services offer rapid data recovery solutions for

various emergency scenarios, addressing a major organizational concern.

6. Control: Cloud platforms provide complete visibility and control over data, allowing administrators to set precise user access levels.

7. Market Agility: Cloud development accelerates application deployment and market entry.

8. Automatic Updates: Cloud-based applications maintain themselves through automatic updates and refreshes.

Applications cloud computing

Cloud computing provides a wide range of applications across various sectors, enabling users to access services and data remotely. Here's a summary of key cloud-based applications:

1. Art Applications

Cloud tools help in designing and creating graphics. Notable examples include:

- **Moo** and **Vistaprint** for creating business cards and marketing materials.
- **Adobe Creative Cloud** for professional design, offering tools like Photoshop, Illustrator, and InDesign.

2. Business Applications

Cloud services are essential for modern businesses, offering solutions for communication, marketing, sales, and more:

- **MailChimp** for email marketing.
- **Salesforce** for CRM and business operations.
- **Slack** for team communication.
- **QuickBooks** for online accounting.

3. Data Storage and Backup Applications

Cloud storage allows secure, scalable file storage and backup:

- **Box.com** for file management and collaboration.
- **Mozy** for data backup.
- **Google G Suite** for storage and productivity tools (e.g., Gmail, Docs).

4. Education Applications

Cloud-based platforms support online learning and student management:

- **Google Apps for Education** offers email, docs, and collaborative tools.
- **AWS in Education** provides cloud infrastructure for schools and universities.

5. Entertainment Applications

Cloud computing supports gaming and video streaming:

- **Cloud gaming services** like GeForce Now and PlayStation Now.
- **Video conferencing apps** like Zoom and Skype.

6. Management Applications

Cloud tools assist with project management, time tracking, and organization:

- **Toggl** for time tracking.
- **Evernote** for note-taking and organization.
- **GoToMeeting** for virtual meetings.

7. Social Applications

Cloud-based social networks allow users to connect and share content:

- **Facebook**, **Twitter**, **LinkedIn**, and **Yammer** enable social interaction and professional networking.

Cloud computing makes these applications accessible from anywhere, supporting collaboration, productivity, and creativity across industries.

Following are some of the real-time applications of cloud computing:

- Data Storage
- Backup and Recovery
- Testing and Development
- Entertainment Applications
- Social Media Applications

Cloud Storage

Cloud Storage is a service that allows users to store data on remote servers, managed by a cloud provider. It offers secure, scalable, and cost-effective storage without the need for physical infrastructure. Cloud storage can be accessed anytime, anywhere, and is particularly useful for businesses of all sizes.

Key Benefits:

- **Cost-Effective**: Pay only for what you use, with no need for hardware maintenance.

- **Scalable**: Easily adjust storage as needed, without worrying about capacity.

- **Agile & Efficient**: Fast deployment and management, freeing up resources for other tasks.

- **Data Security**: Stored data is encrypted and protected, ensuring business continuity.

- **Business Continuity**: Cloud providers ensure high availability and disaster recovery options.

Types of Cloud Storage:

- **Object Storage**: Best for large amounts of unstructured data (e.g., videos, images).

- **File Storage**: Used for data stored in a hierarchical folder format, often via NAS.

- **Block Storage**: Suitable for databases and high-performance applications requiring low latency.

Cloud storage is widely used for applications like data backup, disaster recovery, analytics, and software development, offering a secure and flexible solution for managing data at scale.

Cloud and Dynamic infrastructure

Cloud and Dynamic Infrastructure Summary:

Cloud Infrastructure refers to the essential components needed for cloud computing, which include hardware, storage, virtualization, and network

resources. These elements are integrated into a unified system that supports business applications and services.

Key components of cloud infrastructure:

1. **Hardware:** Includes physical resources like servers, storage arrays, networking equipment (routers, switches), and backup devices, often spread across multiple data centers.

2. **Virtualization:** Uses a hypervisor to abstract and allocate physical resources (such as memory, CPU, storage) into virtual resources, enabling dynamic cloud environments.

3. **Storage:** Cloud storage abstracts physical storage into scalable virtual resources, allowing easy management of data, backup, and recovery without manual intervention.

4. **Network:** Built on physical hardware (wires, routers, switches) and virtual networks, which provide secure access to cloud resources via internet or intranet.

Dynamic Infrastructure is a key feature of cloud environments that allows resources to respond dynamically to fluctuating demand.

This concept involves:

- **Provisioning resources on demand** (e.g., storage and computing power) to meet surges in user needs.

- **Automation and scaling**: The infrastructure can adjust itself based on real-time data and demands, ensuring efficient resource usage and responsiveness.

- **Service-oriented**: Designed to support business needs with agility, such as optimizing energy usage, enhancing user experience, or maintaining disaster recovery readiness.

Dynamic infrastructure in cloud computing helps businesses quickly scale up or down based on demand, ensuring cost efficiency, flexibility, and improved performance.

Cloud Adoption

Cloud Adoption is a strategic move by organizations of reducing cost, mitigating risk and achieving scalability of data base capabilities. Cloud

adoption may be up to various degrees in an organization, depending on the depth of adoption.

Cloud adoption means adopting a service or technology from another cloud service provide.
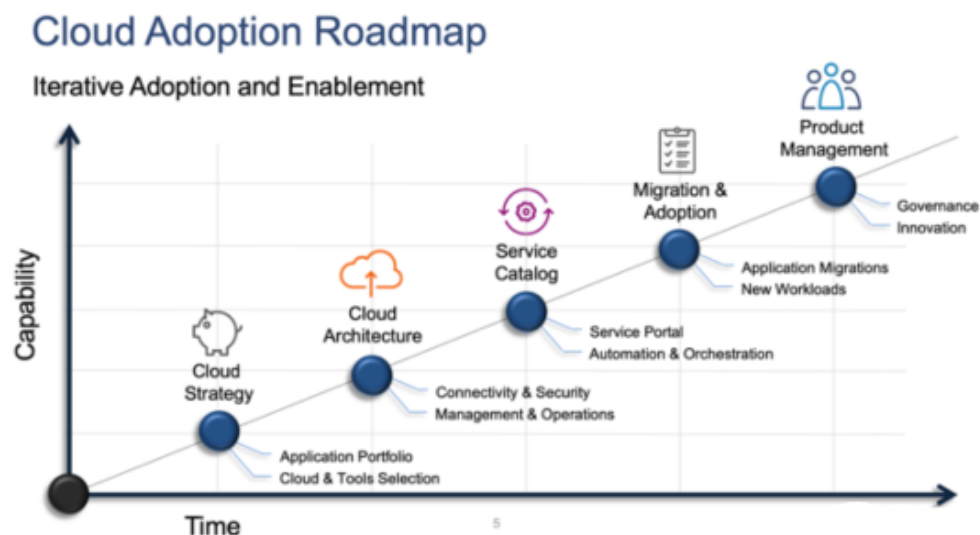
1. Here `Cloud` means the environment of cloud where the cloud services are being operated.

2. Adoption term states that accepting the services of new Technology.

3. Adoption means following some kind of new trend or existing trend or a technology.

4. This Cloud adoption is suitable for low priority business applications.

5. It supports some interactive applications that combines two or more data sources.

6. **For example:** if a marketing company requires to grow his business in the whole country in a short span of time then it must need a quick promotion or short promotion across the country

7. Cloud Adoption is useful when the recovery management, backup recovery based implementations are required.

8. By considering the above key points we conclude that it is only suitable for the applications that are modular and loosely coupled.

9. It will work well with research and development projects.

10. It means the testing of new services ,design models and also the applications that can be get adjusted on small servers.

11. Applications which requires different level of infrastructure throughout the day or throughout the month should be deployed Through the cloud.

12. The applications whose demand is unknown can also be deployed using clouds.

Benefits of cloud adoption:

- Data security

- Increased resource sharing

- Flexibility

- Business agility

- Facilitates innovation

- Great efficiency at lower price

- Better collaboration

- Better backup

Summary of Cloud Computing Concepts

1. Fundamental Concepts

- Cloud computing delivers on-demand computing services over the internet using a pay-as-you-go model

- It provides remote access to computing resources through public and private networks

2. Key Applications

- Art and Design (Adobe Creative Cloud, Vistaprint)

- Business Solutions (Salesforce, Slack, QuickBooks)

- Data Storage (Box.com, Google G Suite)

- Education Platforms

- Entertainment Services

- Management Tools

- Social Applications

3. Cloud Storage

- Offers secure, scalable remote data storage

- Includes object, file, and block storage types

- Provides cost-effective and efficient data management

4. Cloud Infrastructure

- Comprises hardware, virtualization, storage, and network components

- Features dynamic infrastructure that adapts to demand

- Enables automatic scaling and resource optimization

5. Cloud Adoption

- Strategic approach for cost reduction and scalability

- Suitable for various business applications and testing environments

- Offers benefits like enhanced security, collaboration, and efficiency