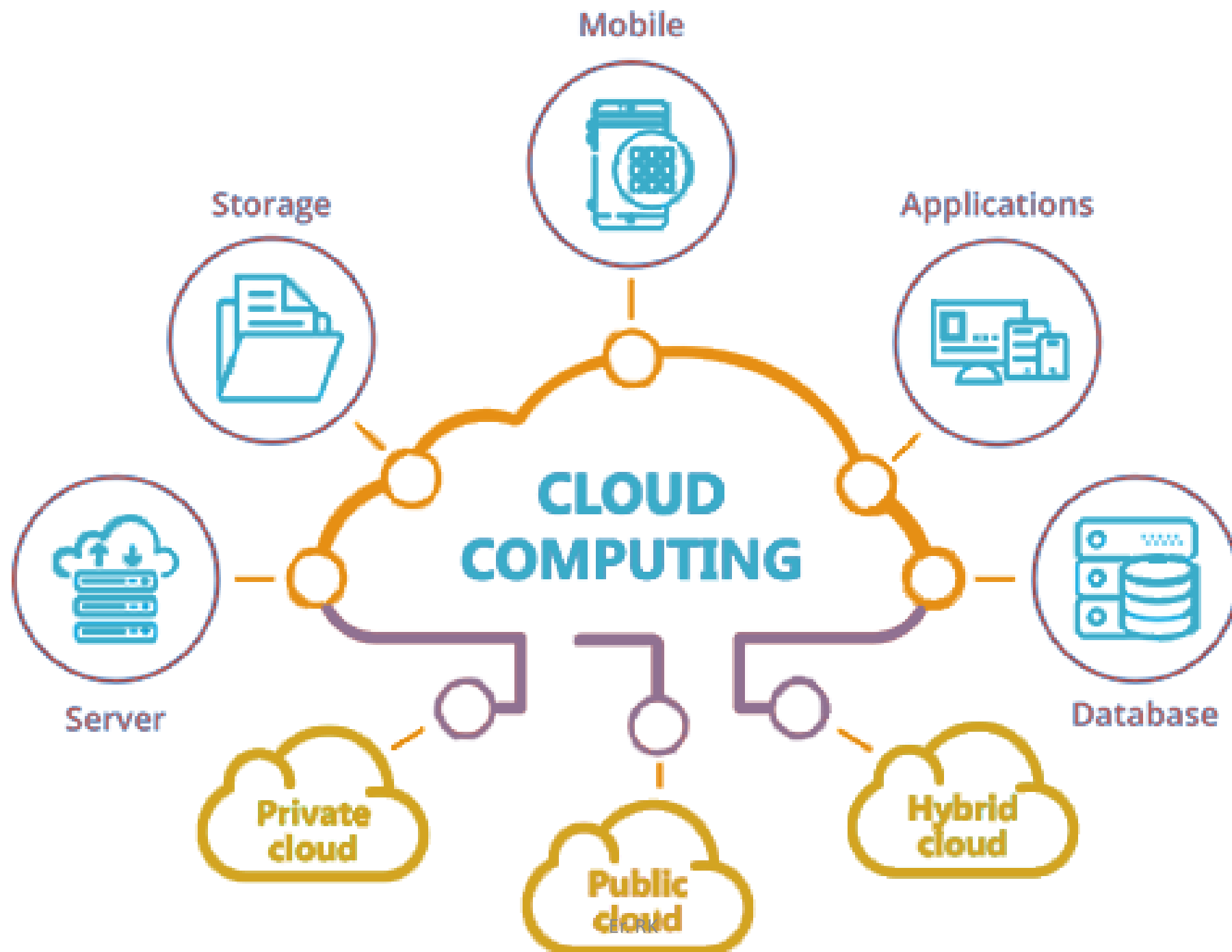# Introduction to Cloud Computing

Chapter_1

What is Cloud Computing?

- Delivering computing services (like storage, databases, software) over the internet ("the cloud").

- Accessible from anywhere with an internet connection.

- **Example**: Using Google Drive to store files online instead of on a personal hard drive.

Evolution of Cloud Computing

Early Days: Traditional IT Infrastructure

- **On-Premises Servers**: Companies owned physical servers for data storage and computing.

- **High Costs and Maintenance**: Required space, power, and IT staff to manage.

- **Example**: A company would buy several servers and set up an entire room just to manage its data.

Virtualization (1990s)

- **What It Brought**: Enabled multiple "virtual" servers on a single physical machine, saving costs.

- **Key Benefit**: Increased efficiency by sharing resources on the same hardware.

- **Example**: Instead of needing separate servers for each task, companies could create multiple virtual servers on one physical server.

Grid Computing and Utility Computing (Late 1990s - Early 2000s)

- **Grid Computing**: Connected computers to work together on large tasks (like data analysis).

- **Utility Computing**: Pay-as-you-go model, similar to paying for utilities like electricity.

- **Example**: NASA used grid computing to analyze large datasets by linking multiple computers.

Difference between

CLOUD COMPUTING & GRID COMPUTING

CLOUD COMPUTING

- Centralised user management
- High Scalability
- Hardware & software platforms
- Client-server architecture

GRID COMPUTING

- Decentralised user management
- Normal Scalability
- Data & computing resources
- Distributed computing architecture

Rise of **Cloud** Providers (Mid-2000s)

- **Amazon Web Services (AWS)** launched in 2006, followed by Google Cloud, Microsoft Azure.
- **New Era**: Businesses could rent IT resources (like storage and servers) instead of buying them.
- **Example**: Startups no longer needed to buy expensive servers—they could rent space on AWS instead.

The "as-a-Service" Model (2010s)

- **IaaS, PaaS, SaaS**: Infrastructure, platform, and software available on-demand.

- **Focus on Flexibility**: Businesses could choose the service level that suited them best.

- **Example**: Microsoft 365 (SaaS) allows users to access Word, Excel, and other apps online without needing to install them.

Modern Cloud Computing (Present)

- **Hybrid and Multi-Cloud Solutions**: Organizations combine public, private, and multiple cloud providers.
- **Edge Computing**: Extending cloud services closer to users for faster access and lower latency.
- **AI and ML Integration**: Cloud providers offer machine learning tools and resources to build AI applications.
- **Example**: Today's companies can use a mix of AWS, Azure, and Google Cloud to balance costs, availability, and capabilities.

Characteristics of Cloud Computing

- **On-Demand Self-Service**: Users can access computing resources as needed without requiring human interaction with service providers.

- Example: A developer can spin up a virtual server in minutes on AWS or Google Cloud.

- **Broad Network Access**: Services are accessible over the internet, making them available on any device connected to the web.

- Example: Google Drive and Dropbox allow users to access files from any device with an internet connection.

Characteristics of Cloud Computing

- •	**Resource Pooling**: Cloud providers pool resources to serve multiple users with a multi-tenant model, using virtualized resources that dynamically allocate based on demand.

- 	Example: AWS provides scalable storage and processing power to thousands of customers globally.

- •	**Rapid Elasticity and Scalability**: Cloud services can be scaled up or down automatically or manually based on demand.

- o	Example: E-commerce sites like Amazon handle increased traffic during sales events by scaling their cloud resources.

- •	**Measured Service**: Resource usage is monitored, measured, and billed based on actual consumption, often in a pay-as-you-go model.

- 	Example: Google Cloud bills users for the exact amount of storage or computing power they consume.

Benefits and Challenges of Cloud Computing

Benefits

- • Cost Savings: Reduces capital expenses (CapEx) as there is no need for physical hardware, only operating expenses (OpEx) based on usage.

Example: Startups use cloud services to avoid large upfront investments in infrastructure.

- • Scalability: Cloud resources can be easily scaled to accommodate growth or downscaled during low-demand periods.

Example: Netflix scales its resources during new series releases to handle increased viewer traffic.

- • Flexibility and Mobility: Cloud enables access from any device, supporting remote work and real-time collaboration.

Example: Microsoft 365 allows teams to collaborate on documents simultaneously from different locations.

- • Disaster Recovery and Data Backup: Data stored in the cloud is backed up by providers, ensuring data availability even in case of local failures.

Example: Businesses use Google Cloud or AWS for data backup to ensure continuity during power outages or data loss.
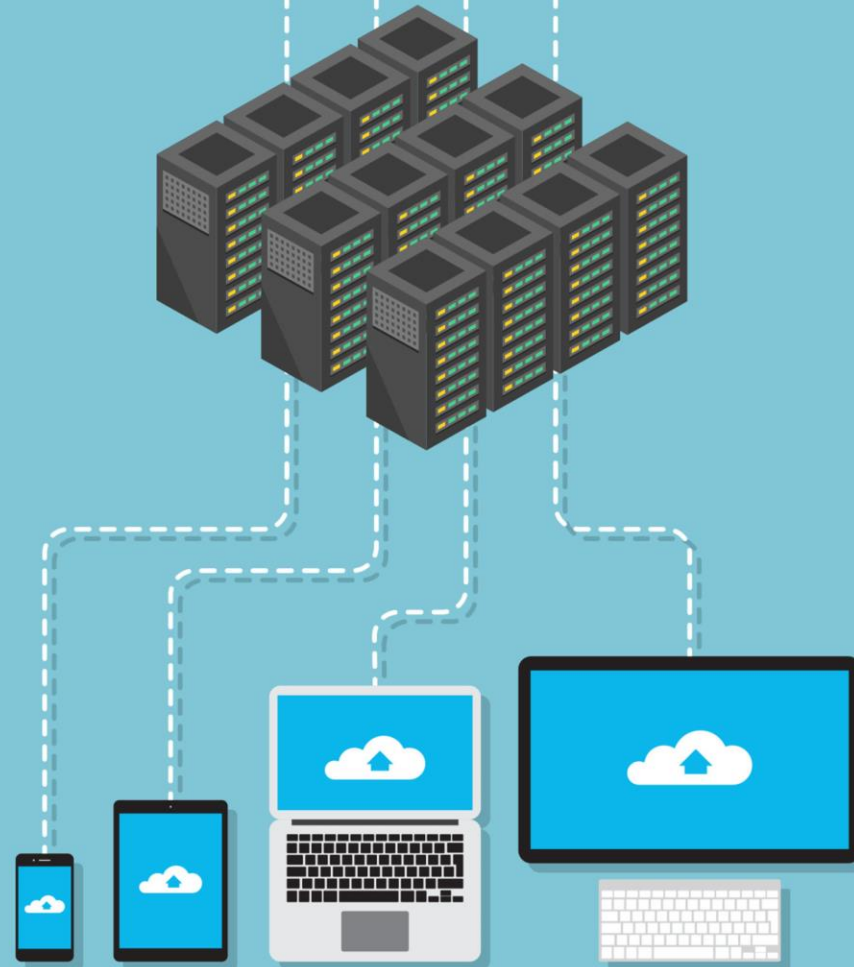
Challenges

- •   Security and Privacy: Storing sensitive data on the cloud raises concerns about unauthorized access and data breaches.

- o   Example: Banks using cloud services must adhere to strict data security regulations to protect customer information.

- •   Downtime and Reliability: Cloud services can experience outages, leading to disruptions in service availability.

- o   Example: AWS outages have affected high-profile services like Slack, which rely on cloud resources for uptime.

- •   Vendor Lock-In: Once a business invests in a specific cloud provider's ecosystem, it can be challenging to migrate to another provider due to compatibility issues.

- o   Example: Moving a database from AWS to Google Cloud requires significant effort, leading some companies to remain locked in.

- •   Limited Control: Cloud users have limited control over the underlying infrastructure, which can restrict specific configurations.

- o   Example: A business may not have full control over hardware setups as it would with an on-premises solution.

Cloud Storage

- **Cloud storage is a data deposit model in which digital information such as documents, photos, videos and other forms of media are stored on virtual or cloud servers hosted by third parties.**

- **It allows you to transfer data on an offsite storage system and access them whenever needed.**

- A service that allows users to save data on remote servers accessible via the internet.

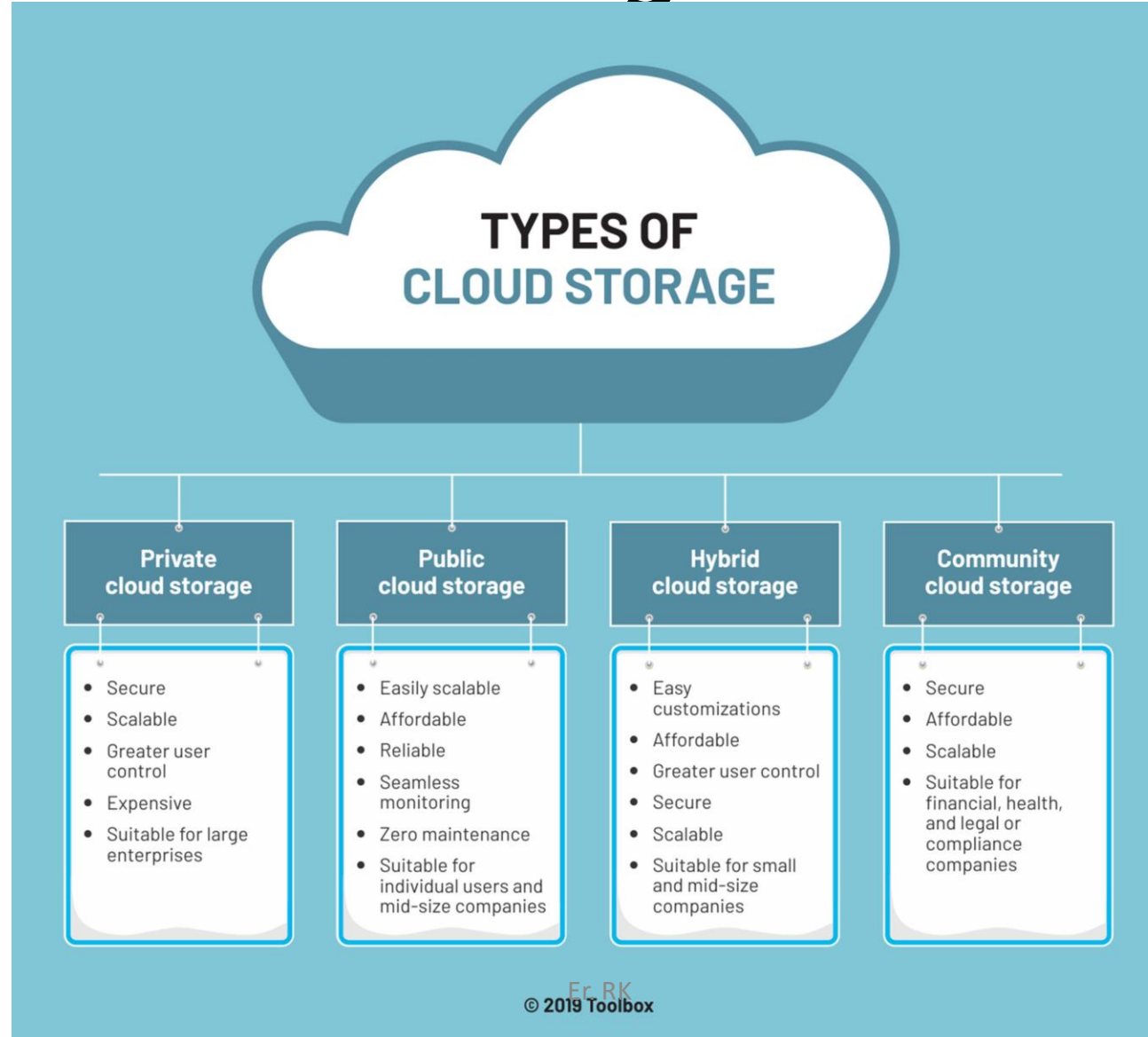- Managed and maintained by cloud providers.

Cloud Storage

- Cloud storage works as a virtual data center. It offers end users and applications virtual storage infrastructure that can be scaled to the application's requirements.

- It generally operates via a web-based API implemented remotely through its interaction with in-house cloud storage infrastructure.

Types of Cloud Storage

Benefits and Challenges of Cloud Storage Adoption

- The cloud is rapidly becoming the storage environment of choice for enterprises.
- [30%Opens a new window](#) of all corporate data was stored on the cloud in 2015, which increased to 50% in 2020.
- The cloud storage market has also grown in tandem and is expected to be worth $137.3 billion by 2025, as per MarketsandMarkets.
- This is because the cloud offers several benefits over traditional on-premise storage systems.

Benefits of cloud storage

- **Flexibility and ease of access**: Cloud storage means that your data is not tied down to any one location.

- **Remote management support**: Cloud storage also paves the way for remote management either by internal IT teams or by [managed service providers (MSPs)](#).

- **Fast scalability**: A major benefit of cloud storage is that you can provision new resources with only a few clicks without the need for any additional infrastructure

- **Redundancy for backup**: Data redundancy (i.e., replicating the same data in multiple locations) is essential for an effective backup mechanism.

Benefits of cloud storage

- **Long-term cost savings**: In the long-term, cloud storage can save you significantly in the costs of [hardware equipment](#), storage facilities, power supply, and personnel, which are sure to multiply as your organization grows.

Challenges of cloud storage

- **Risk of vendor lock-in**: If all your data is stored in a single public cloud platform, there's a risk of vendor lock-in and potential inflexibilities.

- **Security issues around multi-tenancy**: Public cloud environments are shared by multiple tenants, which can multiply your security vulnerabilities.

- **Fragmentation of IT landscape**: Unplanned cloud storage adoption can cause your IT landscape to become fragmented over time.

Challenges of cloud storage

- **Outage and downtime risk**: Cloud platforms managed by external providers could suffer from an outage, rendering the data and applications stored in these environments inaccessible.

- **Short-term budget overruns**: Cloud cost worries are extremely common, where data storage and storage processes occupy more space than estimated.

Selecting the right cloud storage provider

- **Storage space:** The amount of data a business processes determines the requirement for storage space. A small organization (around 250 employees) could opt for public cloud storage services, which offer employees storage space of over 15 GB each.

- **Maintenance & uptime:** Cloud servers need to be maintained to make sure the data stored is secure. However, downtimes and network failures can occur anytime.

Selecting the right cloud storage provider

- **Security:** If data is compromised, then cloud storage comes in handy as a useful backup. There is no guarantee, however, that cloud storage providers are safe from [security threats](#).

- **Speed:** The speed of downloads from the cloud has a major impact on businesses and their ability to process critical data. If cloud storage providers place a cap on the download speed, retrieving data and running applications will take longer.

Cloud service requirements

1. Efficiency / cost reduction

2. Data security

3. Scalability

4. Mobility

5. Disaster recovery

6. Control

7. Market reach

8. Automatic Software Updates

Cloud service requirements

- **1. Efficiency / cost reduction**

- By using cloud infrastructure, you don't have to spend huge amounts of money on purchasing and maintaining equipment.

- **2. Data security**

- Cloud offers many advanced security features that guarantee that data is securely stored and handled. Cloud storage providers implement baseline protections for their platforms and the data they process, such authentication, access control, and encryption.

Cloud service requirements

- **3. Scalability**
- Different companies have different IT needs — a large enterprise of 1000+ employees won't have the same IT requirements as a start-up.Using cloud is a great solution because it enables enterprise to efficiently — and quickly — scale up/down according to business demands.
- **4. Mobility**
- Cloud computing allows mobile access to corporate data via smartphones and devices, which is a great way to ensure that no one is ever left out of the loop. Staff with busy schedules, or who live a long way away from the corporate office, can use this feature to keep instantly up-to-date with clients and coworkers.

Cloud service requirements

- **5. Disaster recovery**
- Data loss is a major concern for all organizations, along with data security. Storing your data in the cloud guarantees that data is always available, even if your equipment like laptops or PCs, is damaged. Cloud-based services provide quick data recovery for all kinds of emergency scenarios.
- **6. Control**
- Cloud enables you complete visibility and control over your data. You can easily decide which users have what level of access to what data.

Cloud service requirements

- **7. Market reach**

- Developing in the cloud enables users to get their applications to market quickly.

- **8. Automatic Software Updates**

- Cloud-based applications automatically refresh and update themselves.

NIST Definition

- The National Institute of Standards and Technology (NIST) proposed a definition of cloud computing in its NIST Special Publication 800-145 as:

- "A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models."

NIST Architecture

- The Cloud Reference Model is based on the National Institute of Standards and Technology (NIST) definition of cloud computing and helps establish a common language and understanding among stakeholders in the cloud ecosystem.

- It provides a high-level view of cloud computing and assists in identifying and classifying different cloud services and deployment models.

NIST Architecture

- The NIST Cloud Computing Reference Architecture consists of five core components:
- **Cloud Auditor:**

  - The cloud auditor monitors and assesses the cloud environment's security, performance, and compliance.
  - They evaluate the cloud provider's operations and ensure that the cloud services adhere to relevant policies, standards, and regulations.
  - Cloud auditors play a crucial role in ensuring transparency and trustworthiness in cloud computing.

NIST Architecture

- **Cloud Provider:**

  - The cloud provider is responsible for delivering cloud services to the cloud consumer.
  - This can be a public cloud provider, a private cloud operator, or a hybrid cloud provider.
  - Cloud providers offer infrastructure, platforms, or software services, and they manage the underlying cloud infrastructure and resources.

NIST Architecture

- **Cloud Broker:**

  - The cloud broker acts as an intermediary between cloud consumers and cloud providers.
  - They help cloud consumers select appropriate cloud services based on their requirements and negotiate contracts with cloud providers.
  - Brokers tend to handle three cloud categories:

    - Intermediation – Enhancing access, performance monitoring, identity management, etc.
    - Aggregation – Integrating a provider's cloud services into a comprehensive cloud suite
    - Arbitrage – Integrating services from multiple providers into a uniform service suite
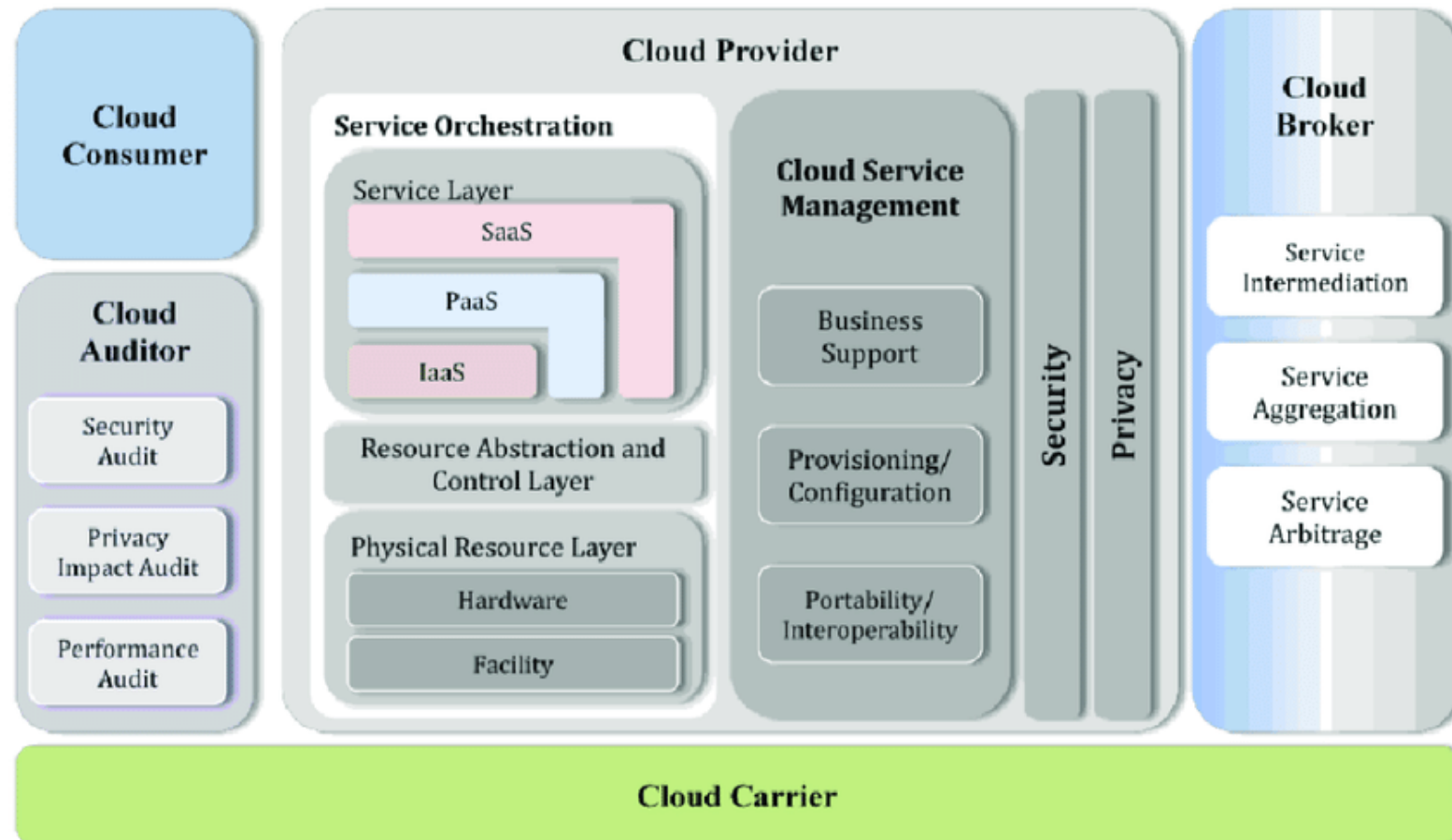
NIST Architecture

- **Cloud Auditor:**

  - The cloud auditor monitors and assesses the cloud environment's security, performance, and compliance.
  - They evaluate the cloud provider's operations and ensure that the cloud services adhere to relevant policies, standards, and regulations.
  - Cloud auditors play a crucial role in ensuring transparency and trustworthiness in cloud computing.

NIST Architecture

- **Cloud Carrier:**

  - The cloud carrier provides the underlying network infrastructure that connects cloud consumers and cloud providers.
  - This can include network service providers, internet service providers, or telecommunications companies.
  - Cloud carriers ensure the secure and reliable transport of data and communications between cloud consumers and cloud providers.

NIST Architecture

Cloud Adoption

Cloud Adoption

- Cloud adoption is the act of moving traditional on-premises computing services or facilities to cloud-based or remote infrastructure.

- In most cases, it's a gradual and complex process to ensure no downtime for the organization.

How does cloud adoption work?

- Cloud adoption works by moving critical computing services, applications, and/or stored data to remote, cloud-based servers.

- These cloud-based servers can be private or shared, and are often a cost-effective way to manage compute power as a company grows.

- Once the data and apps are set up in the cloud, they are accessed through an internet-connected browser.

Who needs cloud adoption? Why?

- Cloud adoption can be beneficial for companies or organizations of any size.

- For smaller companies, it represents a cost-effective way to manage growth or recession without the cost of on-premises, hardware-based computing.

- For larger companies, cloud adoption also provides scalability benefits, as well as zero-downtime security for organizations that store sensitive consumer data.

Advantages of cloud adoption

- For the **IT department**, cloud adoption allows for constant software updates with little to no downtime, and robust security services that protect the sensitive data of both the organization and its customers.

- • For the **operations and procurement** teams, cloud adoption represents significant cost savings as the services are most often pay-as-you-go and scalable as the company sees increased or decreased profits.

- • For the **management** team, cloud adoption provides the framework for collaboration across locations and hardware, making any employee and a wide variety of hardware devices part of the team.

- • For the **marketing** team, cloud adoption provides the ability to cost-effectively increase computing power, which can open doors of AI-driven marketing efforts that increase personalization for their consumers and improve the overall customer experience.

Challenges

- One of the challenges of cloud adoption is the culture of the business that is moving forward with cloud-based services.

- Cloud services, like many other products, provide benefits regardless of how they're purchased.