

Evolution of Cloud Computing

Cloud computing allows users to access a wide range of services stored in the cloud or on the Internet. **Cloud Computing** services include computer resources, data storage, apps, servers, development tools, and **networking protocols**. They are most commonly used by IT companies and for business purposes.

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**. Cloud services include those provided by Amazon, Google, and Microsoft. Cloud computing allows users to access a wide range of services stored in the cloud or on the Internet. Cloud computing services include computer resources, data storage, apps, servers, development tools, and networking protocols.

1. Mainframe Computing(1950-1970)

Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines. These are responsible for handling large data such as massive input-output operations. Even today these are used for bulk processing tasks such as online transactions etc. These systems have almost no downtime with high fault tolerance. After distributed computing, these increased the processing capabilities of the system. But these were very expensive. To reduce this cost, cluster computing came as an alternative to mainframe technology.

2. Distributed Systems(1970-1980)

Distributed System is a composition of multiple independent systems but all of them are depicted as a single entity to the users. The purpose of distributed systems is to share resources and also use them effectively and efficiently. Distributed systems possess characteristics such as scalability, concurrency, continuous availability, heterogeneity, and independence in failures. But the main problem with this system was that all the systems were required to be present at the same geographical location. Thus to solve this problem, distributed computing led to three more types of computing and they were- Mainframe computing, cluster computing, and grid computing.

3. Cluster Computing(1980-1990)

In 1980s, cluster computing came as an alternative to mainframe computing. Each machine in the cluster was connected to each other by a network with high bandwidth. These were way cheaper than those mainframe systems. These were equally capable of high computations. Also, new nodes could easily be added to the cluster if it was required. Thus, the problem of the cost was solved to some extent but the problem related to geographical restrictions still pertained. To solve this, the concept of grid computing was introduced.

4. Grid Computing(1990-2000)

In 1990s, the concept of grid computing was introduced. It means that different systems were placed at entirely different geographical locations and these all were connected via the internet. These systems belonged to different organizations and thus the grid consisted of heterogeneous nodes. Although it solved some problems but new problems emerged as the distance between the nodes increased. The main problem which was encountered was the low availability of high bandwidth connectivity and

with its other network associated issues. Thus, cloud computing is often referred to as "Successor of grid computing".

5. Utility Computing(Late 1990-2000)

Utility Computing is a computing model that defines service provisioning techniques for services such as compute services along with other major services such as storage, infrastructure, etc which are provisioned on a pay-per-use basis.

6. Virtualization(1980-Present)

Virtualization was introduced nearly 40 years back. It refers to the process of creating a virtual layer over the hardware which allows the user to run multiple instances simultaneously on the hardware. It is a key technology used in cloud computing. It is the base on which major cloud computing services such as Amazon EC2, VMware vCloud, etc work on. Hardware virtualization is still one of the most common types of virtualization.

7. Web 2.0

Web 2.0 is the interface through which the cloud computing services interact with the clients. It is because of Web 2.0 that we have interactive and dynamic web pages. It also increases flexibility among web pages. Popular examples of web 2.0 include Google Maps, Facebook, Twitter, etc. Needless to say, social media is possible because of this technology only. It gained major popularity in 2004.

8. Service Orientation

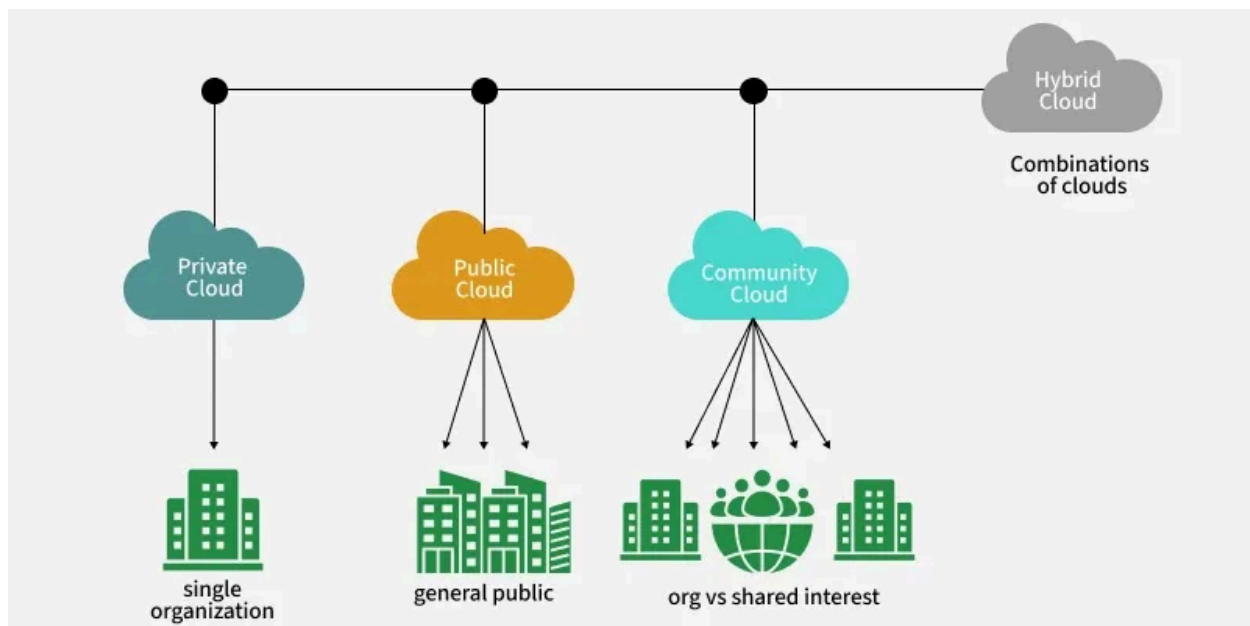
A service orientation acts as a reference model for cloud computing. It supports low-cost, flexible, and evolvable applications. Two important concepts were introduced in this computing model. These were Quality of Service (QoS) which also includes the SLA (Service Level Agreement) and Software as a Service (SaaS).

Cloud Computing

Cloud computing delivers on-demand IT services—like servers, storage, databases, software, analytics—over the internet, allowing businesses and individuals to access resources from remote data centers instead of owning physical hardware, paying only for what they use (pay-as-you-go)

OR

Cloud Computing means storing and accessing the data and programs on remote servers that are hosted on the internet instead of the computer's hard drive or local server. Cloud computing is also referred to as Internet-based computing, it is a technology where the resource is provided as a service through the Internet to the user. The data that is stored can be files, images, documents, or any other storable document.



Cloud computing is categorized into three main models based on accessibility and ownership:

1. Public Cloud

- Hosted by third-party providers like AWS, Google Cloud, and Microsoft Azure.
- Cost-effective but may pose security concerns.

2. Private Cloud

- Used exclusively by a single organization for better security and customization.
- More expensive but provides greater control.

3. Hybrid Cloud

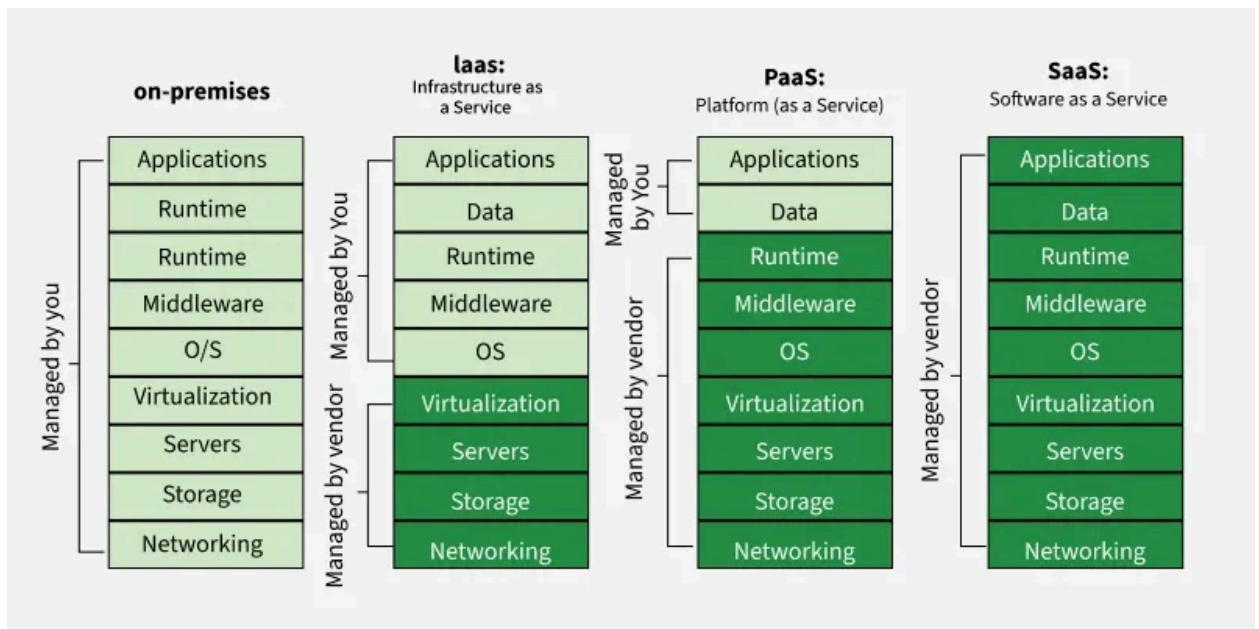
- A combination of public and private clouds, balancing cost-efficiency with security.
- Ideal for businesses needing scalability and data protection.

4. Community Cloud

- A community cloud is a shared cloud infrastructure which is designed to meet the shared needs of multiple organizations like security, compliance or performance.

- Ideal for Healthcare services, Educational Collaboration, Government Agencies, Financial Institutions etc.

Types of Cloud Computing Services



Cloud services are divided into three categories based on functionality:

1. Infrastructure as a Service (IaaS)

- Provides virtualized computing resources over the internet.

- Example: AWS EC2, Google Compute Engine, Microsoft Azure Virtual Machines.

2. Platform as a Service (PaaS)

- Offers a managed platform with built-in tools for developers.
- Example: AWS Elastic Beanstalk, Google App Engine, Heroku.

3. Software as a Service (SaaS)

- Delivers ready-to-use software applications over the internet.
- Example: Google Drive, Dropbox, Salesforce.

Advantages of Cloud Computing

- Cost Saving
- Data Redundancy and Replication
- Ransomware/Malware Protection
- Flexibility
- Reliability
- High Accessibility
- Scalable

Disadvantages of Cloud Computing

- Internet Dependency

- Issues in Security and Privacy
 - Data Breaches
 - Limitations on Control
-

Centralized vs Distributed System

It is essential to understand the differences between centralized and distributed systems. Centralized systems have a single, central point of control, like a hub controlling all the activities. For instance, a school administration office manages all the classrooms and teachers. On the other hand, distributed systems are like a team of equals, with no single point of control. Each part of the system can operate independently, yet they work together seamlessly, like computers connected to each other. This article highlights their importance in various applications and their differences in effective system design and management.



What is a Centralized System?

A centralized system is a type of system where all the important tasks like processing data, storing information, and making decisions are done by a single main computer or server. This means that there is one central place that controls and manages all the resources and important choices for the whole system. In such systems, all resources, data, and functionalities are managed and controlled from this central point.

Characteristics of Centralized Systems

- **Single Point of Control:** In a centralized system, there is a single point of control and authority. This central entity typically makes all decisions and manages all resources.
- **Centralized Data Management:** All data and resources are stored and managed centrally. This means that all data processing, storage, and retrieval activities occur within the central system.
- **Hierarchical Structure:** Centralized systems often have a hierarchical structure, with lower-level nodes or entities reporting to and receiving instructions from the central authority.
- **Communication Flow:** Communication within a centralized system typically flows from peripheral nodes or entities to the central node.
- **Simplicity in Management:** Centralized systems are relatively simpler to manage and administer since all control and

decision-making are centralized. This can lead to efficient coordination and streamlined operations.

For Example:

Many businesses operate with centralized IT infrastructures where data centers or servers centrally manage resources such as file storage, application hosting, and network services.

Use Cases of Centralized Systems

- **Small Office Network:** Many offices use one main computer to run things. This main computer stores files for all workers. It also helps computers access the network. The main computer checks workers are who they say. Using one main computer makes it simpler to manage everything. It also allows all workers to use things the same way.
- **Traditional Client-Server Architecture:** A lot of older programs like email, websites, and databases work one way. Clients talk to one main server to get what they need. This setup has a center. Computers connect to the main spot to get services or info.
- **Standalone Applications:** Apps running on one machine do everything locally. They process and store things without needing

other machines. This is a centralized system. All the work happens on the single machine you are using.

What is a Distributed System?

In a distributed system, different parts of a computer system are located on different computers or devices that are connected together. Each computer or device can work by itself, but they all work together to do things like process information, store data, or provide services.

- It's kind of like having a team of people working on the same project, but each person is in a different place and has their own task to do.
- But they all communicate and share information with each other to make sure the whole project gets done correctly and efficiently.

Characteristics of Distributed Systems

- **Decentralized Control:** In a distributed system, control and decision-making authority are decentralized. Each node in the system has a degree of autonomy and can make decisions independently based on local information.
- **Distributed Data Management:** Data and resources are distributed across multiple nodes in the system. Each node may store a subset of the data or perform specific tasks, contributing to the overall functionality of the system.

- **Peer-to-Peer Communication:** Communication in a distributed system can occur directly between nodes without the need for a central intermediary. Nodes can exchange information, coordinate actions, and collaborate to achieve shared objectives.
- **Fault Tolerance:** Distributed systems are often designed to be resilient to failures. Since there is no single point of failure, the system can continue to operate even if individual nodes experience issues or failures.
- **Scalability:** Distributed systems can be highly scalable, allowing for the addition of new nodes to accommodate increased workload or user demand. This scalability is achieved through the parallelization of tasks across multiple nodes.

For Example:

Content Delivery Networks(CDNs) distribute content such as web pages, images, and videos across geographically dispersed servers. By caching content closer to end-users, CDNs improve performance, reduce latency, and increase reliability.

Use Cases of Distributed Systems

- **Cloud Computing Platforms:** Cloud services share resources over data centers. This lets them offer computing on demand. AWS, Azure, GCP are examples.

- **Peer-to-Peer (P2P) Networks:** Peer-to-peer networks are special kinds of computer networks that allow direct communication between computers without needing a central server. These networks work by letting each computer share its resources and services with other computers on the network
- **Distributed Databases:** Distributed databases are computer systems that store information across several computers or nodes linked together in a network. Having data spread out like this makes the database highly available, fault-tolerant, and scalable. This means the database can handle many users and requests without crashing or slowing down. It also allows the system to keep working even if some parts fail.

Difference between Cloud Computing and Distributed Computing :

S.No.	CLOUD COMPUTING	DISTRIBUTED COMPUTING

<p>01.</p>	<p>Cloud computing refers to providing on demand IT resources/services like server, storage, database, networking, analytics, software etc. over internet.</p>	<p>Distributed computing refers to solve a problem over distributed autonomous computers and they communicate between them over a network.</p>
<p>02.</p>	<p>In simple cloud computing can be said as a computing technique that delivers hosted services over the internet to its users/customers.</p>	<p>In simple distributed computing can be said as a computing technique which allows to multiple computers to communicate and work to solve a single problem.</p>
<p>03.</p>	<p>It is classified into 4 different types such as Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud.</p>	<p>It is classified into 3 different types such as Distributed Computing Systems, Distributed Information Systems and Distributed Pervasive Systems.</p>

04.	<p>There are many benefits of cloud computing like cost effective, elasticity and reliable, economies of Scale, access to the global market etc.</p>	<p>There are many benefits of distributed computing like flexibility, reliability, improved performance etc.</p>
05.	<p>Cloud computing provides services such as hardware, software, networking resources through internet.</p>	<p>Distributed computing helps to achieve computational tasks more faster than using a single computer as it takes a lot of time.</p>
06.	<p>The goal of cloud computing is to provide on demand computing services over internet on pay per use model.</p>	<p>The goal of distributed computing is to distribute a single task among multiple computers and to solve it quickly by maintaining coordination between them.</p>

Characteristics as per NIST

Cloud computing's core characteristics, defined by NIST, include On-Demand Self-Service, Broad Network Access, Resource Pooling, Rapid Elasticity, and Measured Service, enabling users to provision resources instantly, access services from anywhere, share provider resources, scale up/down automatically, and pay based on usage, leading to flexibility, cost savings, and efficiency.

Here's a breakdown of the key characteristics:

On-Demand Self-Service:

Users can automatically get computing resources (like server time, storage, networking) as needed, without human intervention from the provider.

Broad Network Access:

Services are available over the network (internet) and accessible via standard mechanisms on various devices (laptops, phones, tablets).

Resource Pooling:

The provider's resources (servers, storage, etc.) are pooled to serve multiple customers (multi-tenant model), with resources dynamically assigned and reassigned as demand changes.

Rapid Elasticity:

Capabilities can be scaled out (up) and in (down) quickly and elastically, appearing unlimited to the consumer, matching demand automatically.

Measured Service:

Resource usage (storage, processing, bandwidth) is automatically monitored, controlled, and optimized, allowing for pay-per-use billing.

DEPLOYMENT MODELS

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid and Community.

PUBLIC CLOUD

The **Public Cloud** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness, e.g., e-mail.

PRIVATE CLOUD

The **Private Cloud** allows systems and services to be accessible within an organization. It offers increased security because of its private nature.

COMMUNITY CLOUD

The **Community Cloud** allows systems and services to be accessible by group of organizations.

HYBRID CLOUD

The **Hybrid Cloud** is mixture of public and private cloud. However, the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.

SERVICE MODELS / Reference Models

Service Models are the reference models on which the Cloud Computing is based. These can be categorized into three basic service models as listed below:

1. Infrastructure as a Service (IaaS)
2. Platform as a Service (PaaS)
3. Software as a Service (SaaS)

There are many other service models all of which can take the form like **XaaS**, i.e., **Anything as a Service**. This can be **Network as a Service**, **Business as a Service**, **Identity as a Service**, **Database as a Service** or **Strategy as a Service**. The **Infrastructure as a Service (IaaS)** is the most basic level of service. Each of the service models make use of the underlying service model, i.e., each inherits the

security and management mechanism from the underlying model, as shown in the following diagram:

INFRASTRUCTURE AS A SERVICE (IAAS)

IaaS provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.

PLATFORM AS A SERVICE (PAAS)

PaaS provides the runtime environment for applications, development & deployment tools, etc.

SOFTWARE AS A SERVICE (SAAS)

SaaS model allows to use software applications as a service to end users.

Cloud Environment

A cloud environment in cloud computing is a virtualized, on-demand space where users access shared or dedicated computing resources (servers, storage, networks, software) over the internet from remote data centers, rather than owning physical hardware, enabling scalability, flexibility, and pay-as-you-go cost models. These environments are categorized by deployment (Public, Private, Hybrid, Multi-cloud) and service type (IaaS, PaaS, SaaS).

Difference between Multi-cloud and Hybrid Cloud

Hybrid cloud combines private (on-premises) infrastructure with public cloud services, focusing on integrating different types of environments for control and flexibility, while multi-cloud uses services from multiple public cloud providers (like AWS, Azure, Google Cloud) to leverage best-of-breed services, avoid lock-in, and enhance resilience, essentially using different vendors of the same type. The key difference: Hybrid integrates public+private; multi-cloud uses multiple public clouds, sometimes within a hybrid setup.

Feature	Hybrid Cloud	Multi-Cloud
Composition	Private + Public Cloud(s)	Multiple Public Clouds (e.g., AWS, Azure, GCP)
Primary Goal	Control, compliance, extending on-prem	Flexibility, avoiding lock-in, best-of-breed services
Integration	Tightly integrated (public/private work together)	Can be independent or loosely coupled
Management	Complex integration of different environments	Complex management of different vendor tools
Data Sharing	Data and applications can move between private and public cloud	Data sharing between clouds is optional

Security	Sensitive data kept in private cloud	Security depends on each cloud provider
Example	Running a database on your private cloud but using AWS for a web application	Using Google Cloud for AI/ML and Azure for Microsoft workloads

Service Oriented Computing

Service-oriented computing (SOC) is defined as a software design and architectural approach that emphasizes the creation of distributed, reusable, and interoperable services that are independently deployable and loosely coupled, allowing for specific functionalities to be provided to clients over a network using standardized communication protocols.

Core Concepts

- **Service:** A self-contained, discrete unit of business functionality (e.g., credit check, order processing) with a specified outcome, accessed remotely.

- **Loose Coupling:** Services are independent; changes to one don't break others, as long as the interface remains consistent.
- **Interoperability:** Services use common standards (like web services protocols) to communicate across different platforms and technologies.
- **Discoverability & Reusability:** Services are published so developers can easily find and use them, often assembling them into larger applications.
- **Composition:** Combining multiple simple services to create more complex, composite services.

How it Works (SOA)

Service Provider: Offers a service (e.g., payment processing).

Service Requestor/Consumer: Needs a service (e.g., an e-commerce site).

Service Broker/Registry (Optional but common): A directory where providers publish services and requestors find them.

Communication: Requestor finds the service and communicates with it (often via web services) using standardized messages.

Key Benefits & Applications

Business Agility: Quickly adapt to market changes by rearranging services.

Efficiency: Reuse existing services instead of building from scratch.

Integration: Connect disparate systems more easily.

Cloud Computing: Forms the basis for cloud services, enabling models like Software as a Service (SaaS)

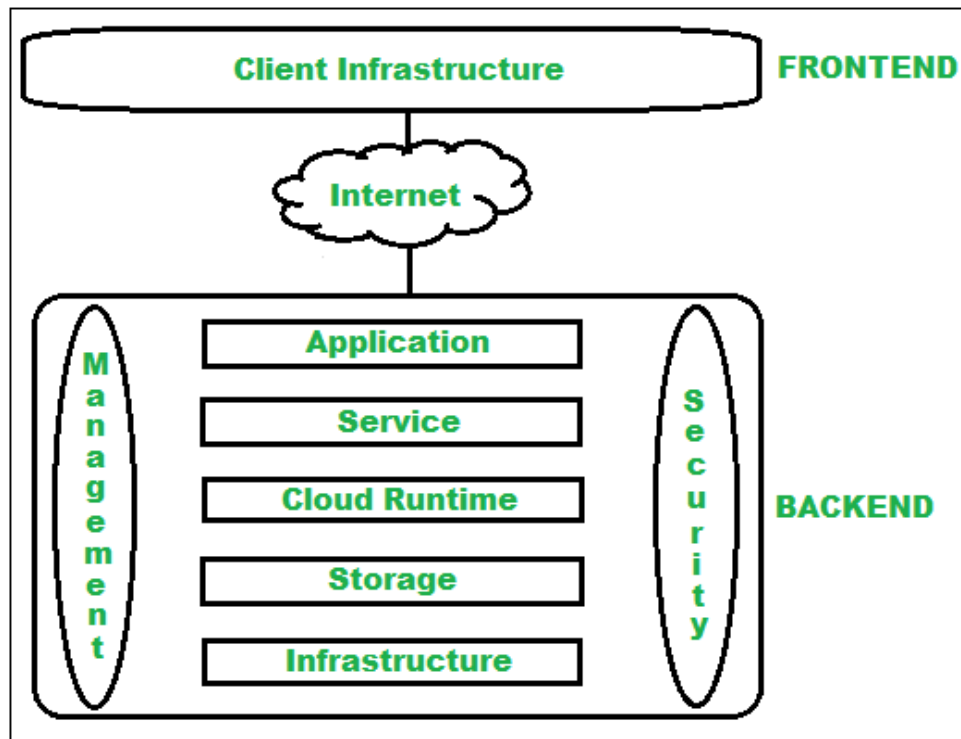
Cloud Computing Architecture

Architecture of cloud computing is the combination of both SOA (Service Oriented Architecture) and EDA (Event Driven Architecture). Client infrastructure, application, service, runtime cloud, storage, infrastructure, management and security all these are the components of cloud computing architecture.

The cloud architecture is divided into 2 parts:

- Frontend
- Backend

The below figure represents an internal architectural view of cloud computing.



Architecture of Cloud Computing

1. Frontend

Frontend of the cloud architecture refers to the client side of the cloud computing system. Means it contains all the user interfaces and applications which are used by the client to access the cloud computing services/resources. For example, use of a web browser to access the cloud platform.

2. Backend

Backend refers to the cloud itself which is used by the service provider. It contains the resources as well as manages the resources and provides security mechanisms. Along with this, it includes huge storage, virtual applications, virtual machines, traffic control mechanisms, deployment models, etc.

Components of Cloud Computing Architecture

Following are the components of Cloud Computing Architecture

1. **Client Infrastructure:** Client Infrastructure is a part of the frontend component. It contains the applications and user interfaces which are required to access the cloud platform. In other words, it provides a GUI(Graphical User Interface) to interact with the cloud.
2. **Application :** Application is a part of a backend component that refers to a software or platform to which client accesses. Means it provides the service in the backend as per the client requirement.
3. **Service:** Service in backend refers to the major three types of cloud based services like [SaaS](#), [PaaS](#) and [IaaS](#). Also manages which type of service the user accesses.
4. **Runtime Cloud:** Runtime cloud in backend provides the execution and Runtime platform/environment to the Virtual machine.
5. **Storage:** Storage in the backend provides flexible and scalable storage service and management of stored data.
6. **Infrastructure:** Cloud Infrastructure in backend refers to the hardware and software components of cloud like it includes servers, storage, network devices, virtualization software etc.

7. **Management:** Management in backend refers to management of backend components like application, service, runtime cloud, storage, infrastructure, and other security mechanisms etc.
8. **Security:** Security in backend refers to implementation of different security mechanisms in the backend for secure cloud resources, systems, files, and infrastructure to end-users.
9. **Internet:** Internet connection acts as the medium or a bridge between frontend and backend and establishes the interaction and communication between frontend and backend.
10. **Database:** Database in backend refers to a database for storing structured data, such as SQL and NOSQL databases. Examples of Database services include Amazon RDS, Microsoft Azure SQL database and Google CCloud SQL.
11. **Networking:** Networking in backend services that provide networking infrastructure for application in the cloud, such as load balancing, DNS and virtual private networks.
12. **Analytics:** Analytics in backend service that provides analytics capabilities for data in the cloud, such as warehousing, business intelligence and machine learning.

Benefits of Cloud Computing Architecture

The following are the benefits of cloud computing architecture:

- Makes the overall cloud computing system simpler.
- Improves data processing requirements.
- Helps in providing high security.
- Makes it more modularized.
- Results in better disaster recovery.
- Gives good user accessibility.
- Reduces IT operating costs.
- Provides high level reliability.
- Scalability.

Functioning of Cloud Computing

Cloud computing works on the principle of **delivering computing services over the Internet** instead of using local machines or personal servers. These services include **storage, processing power, software, networking, and databases**.

1. User Request

- The user accesses cloud services using a **web browser or application**.
- Example: Opening Google Drive, AWS console, or Microsoft Azure portal.

2. Front End

- This is the **client side** of cloud computing.
- It includes devices like **PCs, laptops, mobiles**, and applications used to access the cloud.
- The front end sends requests to the cloud via the Internet.

3. Internet / Network

- Acts as the **communication medium** between the user and the cloud service provider.
- Ensures fast and secure data transfer.

4. Back End (Cloud Infrastructure)

The back end consists of powerful resources managed by the cloud provider:

- **Servers** – Perform computation and processing
- **Storage systems** – Store data securely
- **Databases** – Manage structured data
- **Virtualization** – Allows multiple users to share resources efficiently
- **Management software** – Controls resource allocation and monitoring

5. Virtualization

- A key technology in cloud computing.
- It divides physical resources into **virtual machines (VMs)**.

- Multiple users can run different applications on the same hardware safely.

6. Resource Allocation

- Cloud dynamically allocates resources based on demand.
- If demand increases, more resources are provided automatically (**scalability**).

7. Service Models

Cloud services are delivered in different models:

- **IaaS (Infrastructure as a Service)** – Virtual machines, storage, networks
- **PaaS (Platform as a Service)** – Development platforms and tools
- **SaaS (Software as a Service)** – Ready-to-use applications

8. Pay-As-You-Go Model

- Users pay **only for the resources they use**.
- Reduces hardware and maintenance costs.

9. Security and Monitoring

- Cloud providers ensure **data security, backups, access control, and monitoring**.
- Includes encryption, authentication, and firewalls.

What is cloud storage?

Cloud storage is the abstraction, pooling, and sharing of storage resources through the internet. Cloud storage is facilitated by IT environments known as clouds, which enable cloud computing—the act of running workloads within a cloud environment. Access cloud storage doesn't require an intranet connection (that's known as network-attached storage) or a direct connection to storage hardware (that's known as direct-attached storage).

How does cloud storage work?

Data can be acted upon as short-term memory or archived as long-term memory. The short-term memory is handled by random-access memory (RAM), which is responsible for processing and remembering all requests and actions during the time a computer processes specific computations (known as tasks). Once all computations are complete, the data can be stored as long-term memory among different storage volumes, some of which may exist as clouds.

At the base of every cloud storage volume are storage resources abstracted from physical hardware. [Virtualization technology](#) is one way of abstraction, and it can take a dozen different servers (commodity or proprietary) and abstract the storage space from all of them. All this virtual storage space can be pooled together into something called a [data lake](#) that users can access as a single repository. If those data lakes are connected to the internet, then you've created cloud storage.

Cloud storage formats

Block Storage

Block storage splits a single storage volume (like a cloud storage node) into individual instances known as blocks. It's a fast, low latency storage system ideal for high performance workloads.

Object Storage

Object storage involves pairing a piece of data with unique identifiers known as metadata. Since objects are uncompressed and unencrypted, they can be accessed very quickly at huge scale—making them ideal for cloud-native applications.

File storage

File storage is the dominant technology used on NAS systems and is responsible for organizing data and representing it to users. Its hierarchical structure allows us to navigate data from top to bottom easily, but increases processing time.

Types of cloud storage

Public cloud storage

Public cloud storage is the storage of data among pools of resources that are abstracted from hardware not owned by the end user. Since

there are certain innate risks that come with not owning or managing the systems that are storing your data, many organizations are using [containers](#) to move workloads and applications among public cloud environments. Persistent storage solutions (like [Red Hat® OpenShift® Data Foundation](#)) help keep stateful applications from failing and losing all their data.

Private cloud storage

Private cloud storage is the storage of data among pools of resources abstracted from resources solely dedicated to the end user—usually within the user’s firewall and sometimes on premise. Since setting up an enterprise-scale private cloud manually can be less efficient in the long run than using existing software, companies are using platforms like [OpenStack®](#) to digitally transform pools of virtual resources into private clouds.

Hybrid cloud storage

Hybrid cloud storage is the storage of data among multiple cloud environments with some degree of workload portability, orchestration, and management among them. While the public and private cloud environments that make up a hybrid cloud are separate entities, migrating data between them is facilitated by a complex network of local-area networks (LANs), wide area networks (WANs), [application programming interfaces \(APIs\)](#), virtual private networks (VPNs), or containers. This separate—yet connected—architecture allows

enterprises to store data in any environment and move data between them as desired.

What are cloud services?

Cloud services are infrastructure, platforms, or software that are hosted by third-party providers and made available to users through the internet.

Cloud services facilitate the flow of user data from front-end clients (e.g., users' servers, tablets, desktops, laptops—anything on the users' ends), through the internet, to the provider's systems, and back. Cloud services promote the building of [cloud-native applications](#) and the flexibility of working in the cloud. Users can access cloud services with nothing more than a computer, operating system, and internet connectivity.

What are examples of cloud services?

All [infrastructure](#), platforms, software, or technologies that users access through the internet without requiring additional software downloads can be considered [cloud computing](#) services—including the following as-a-Service solutions.

[Infrastructure-as-a-Service \(IaaS\)](#) provides users with compute, networking, and storage resources.

[Platforms-as-a-Service \(PaaS\)](#) provides users with a platform on which applications can run, as well as all the IT infrastructure required for it to run.

[Software-as-a-Service \(SaaS\)](#) provides users with—essentially—a [cloud application](#), the platform on which it runs, and the platform's underlying infrastructure.

[Function-as-a-Service \(FaaS\)](#), an [event-driven](#) execution model, lets developers build, run, and [manage](#) app packages as functions without maintaining the infrastructure.

Clouds are IT environments that abstract, pool, and share scalable resources across a network. Clouds enable cloud computing, which is the act of running workloads within a cloud environment. Clouds are a type of PaaS, because hardware and an application software platform is provided by another party.

How do cloud services work?

Like all other IT solutions, cloud services rely on hardware and software. However, unlike traditional hardware and software solutions, users don't need anything other than a computer, network connection, and [operating system](#) to access cloud services.

Cloud infrastructure

When supplying users with a [cloud infrastructure](#), cloud services providers detach computing capabilities from hardware components, such as separating:

- Processing power from central processing units (CPUs)
- Active memory from random access memory (RAM) chips
- Graphics processing from the graphics processing units (GPUs)
- Data storage availability from datacenters or hard drives

This abstraction is typically accomplished through [virtualization](#) and [virtual machines](#). Once separated, the storage, compute, and networking components are provided to users through the internet as infrastructure—or IaaS. This kind of cloud service has led to the rise of [cloud storage](#), which stores [big data](#) as part of the [Internet of Things \(IOT\)](#). [RackSpace](#) is an example of an IaaS provider.

Cloud platforms

Cloud service providers can also use their hardware resources to create cloud platforms, which are online environments where users can develop code or run apps. Building a cloud platform requires more than just abstracting a computer's capabilities from its hardware components—like when providing cloud infrastructure. Providing a cloud platform requires additional levels of development to incorporate

technologies like [containerization](#), orchestration, [application programming interfaces \(APIs\)](#), routing, security, management, and [automation](#). User experience design (UX) is also an important consideration in order to create a navigable online experience.

Cloud platforms are a type of PaaS. And if the infrastructural components holding up the PaaS are highly scalable and sharable, it might be considered a cloud. The best examples of PaaS clouds include public clouds and managed private clouds.

Cloud software

The final widely accepted cloud service that providers can offer is a full web application—known as cloud software or SaaS. This requires the highest development investment because the cloud provider is literally offering an online app to customers.

Cloud software can be provided using a [cloud-native](#) approach, which is an [application architecture](#) combining small, independent, and loosely coupled [microservices](#). Multiple microservices can be packaged into individual [Linux®](#) containers managed by a [container orchestration](#) engine like [Kubernetes](#) or [Red Hat® OpenShift®](#). The final product is a cloud app that can be optimized by the microservice without impacting other microservices that—together—make up the whole app.

What Are the Advantages/Benefits of Cloud Computing?

[Cloud computing](#) offers numerous benefits, which is why businesses of all sizes – from corporate giants to small start-ups - are adopting it with such enthusiasm. The top benefits of cloud computing are:

1. Lower Costs

It is expensive to establish and run in-house computing infrastructure. Purchasing and maintaining equipment and hiring trained IT experts come at a cost. By switching to cloud computing, businesses only need to pay for the services they procure. This results in significant cost savings.

2. Mobility

Cloud-based technology offers mobility, ensuring workers can access resources in the cloud in real-time from any location or device.

3. Scalability

Businesses using cloud computing can scale up or down their IT features based on business requirements.

4. Disaster Recovery

There's no need for a disaster recovery data backup plan in cloud systems. There's no permanent data loss in case of a disaster.

5. Data Security

Cloud computing offers many advanced data security features to guarantee data safety and security.

6. Unlimited Storage Capacity

The cloud has unlimited storage capacity for all types of data.

7. Automatic Software Updates

Software and security are regularly managed by software vendors on behalf of the users.

8. Better Collaboration

Cloud environments allow easy sharing of real-time data across teams within an organization, which improves collaboration and team performance.

Top Applications of Cloud Computing

Cloud technology offers several applications in various fields like business, data storage, entertainment, management, social networking, education, art, GPS, to name a few.

The major types of cloud computing service models available are Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Software as a Service (SaaS). Plus, there are platforms like Public Cloud, Private Cloud, Hybrid Cloud, and Community Cloud.

Let's start elaborating on the top 7 applications of cloud computing.

1. Online Data Storage

Cloud Computing allows storage and access to data like files, images, audio, and videos on the cloud storage. In this age of big data, storing huge volumes of business data locally requires more and more space and escalating costs. This is where cloud storage comes into play, where businesses can store and access data using multiple devices.

The interface provided is easy to use, convenient, and has the benefits of high speed, scalability, and integrated security.

2. Backup and Recovery

Cloud service providers offer safe storage and backup facility for data and resources on the cloud. In a traditional computing system, data backup is a complex problem, and often, in case of a disaster, data can be permanently lost. But with cloud computing, data can be easily recovered with minimal damage in case of a disaster.

3. Big Data Analysis

One of the most important applications of cloud computing is its role in extensive data analysis. The extremely large volume of [big data](#) makes it impossible to store using traditional data management systems. Due to the unlimited storage capacity of the cloud, businesses can now store and analyze big data to gain valuable business insights.

4. Testing and Development

Cloud computing applications provide the easiest approach for testing and development of products. In traditional methods, such an environment would be time-consuming, expensive due to the setting up of IT resources and infrastructure, and needed manpower. However, with cloud computing, businesses get scalable and flexible cloud services, which they can use for product development, testing, and deployment.

5. Antivirus Applications

With Cloud Computing comes cloud antivirus software which is stored in the cloud from where they monitor viruses and malware in the organization's system and fixes them. Earlier, organizations had to

install antivirus software within their system and detect security threats.

6. E-commerce Application

Ecommerce applications in the cloud enable users and e-businesses to respond quickly to emerging opportunities. It offers a new approach to business leaders to make things done with minimum amount and minimal time. They use cloud environments to manage customer data, product data, and other operational systems.

7. Cloud Computing in Education

E-learning, online distance learning programs, and student information portals are some of the key changes brought about by applications of cloud computing in the education sector. In this new learning environment, there's an attractive environment for learning, teaching, experimenting provided to students, teachers, and researchers so they can connect to the cloud of their establishment and access data and information.

