V Semester BCA

Subject: Cloud Computing

Syllabus:

Introduction: Different Computing Paradigms- Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing etc., Comparison of various Computing Technologies; Cloud Computing Basics- What is Cloud Computing? History, Characteristic Features, Advantages and Disadvantages, and Applications of Cloud Computing; Trends in Cloud Computing; Leading Cloud Platform Service Providers.

Cloud Architecture: Cloud Service Models- Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), Comparison of different Service Models; Cloud Deployment Models- Public Cloud; Private Cloud, Hybrid Cloud, Community Cloud; Cloud Computing Architecture- Layered Architecture of Cloud. Virtualization- Definition, Features of Virtualization; Types of Virtualizations- Hardware Virtualization, Server Virtualization, Application Virtualization, Storage Virtualization, Operating System Virtualization; Virtualization and Cloud Computing, Pros and Cons of Virtualization, Technology Examples- Xen: Paravirtualization, VMware: Full Virtualization, Microsoft Hyper-V.

Cloud Application Programming and the Aneka Platform: Aneka Cloud Application Platform-Framework Overview, Anatomy of theAneka Container; Building Aneka Clouds (Infrastructure Organization, Logical Organization, Private Cloud Deployment Mode, Public Cloud Deployment Mode, Hybrid Cloud Deployment Mode); Cloud Programming and Management- Aneka SDK (Application Model and Service Model); Management Tools (Infrastructure, Platform and Application management).

Cloud Platforms in Industry: Amazon Web Services- Compute Services, Storage Services, Communication Services, AdditionalServices; Google AppEngine- Architecture and Core Concepts, Application Life-Cycle, Cost Model, Observations;Microsoft AzureAzure Core Concepts (Compute, Storage, Core Infrastructure and Other Services), SQL Azure, Windows Azure Platform Appliance.

Cloud Applications: Scientific Applications- Healthcare (ECG Analysis in the Cloud) Biology (Protein Structure Prediction and Gene Expression Data Analysis for Cancer Diagnosis), Geoscience (Satellite Image Processing); Business and Consumer Applications- CRM and ERP, Productivity, Social Networking, Media Applications, Multiplayer Online Gaming.

Text Books:

1. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi: "Mastering CloudComputingFoundations and Applications Programming", Elsevier, 20
2. Barrie Sosinsky: "Cloud Computing Bible", Wiley-India, 2010
3. K Chandrashekaran: "Essentials of Cloud Computing", CRC Press, 2015
4. Derrick Rountree, Ileana Castrillo: "The Basics of Cloud Computing", Elsevier, 2014

V Semester BCA
Subject: Cloud Computing
Unit-1

Introduction: Different Computing Paradigms- Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing etc., Comparison of various Computing Technologies; Cloud Computing Basics- What is Cloud Computing? History, Characteristic Features, Advantages and Disadvantages, and Applications of Cloud Computing; Trends in Cloud Computing; Leading Cloud Platform Service Providers.

Different Computing Paradigms:

A computing paradigm refers to a fundamental approach or model used for performing computation, organizing data, designing systems, and solving problems with computers. It represents a specific way of thinking about and implementing computing tasks, influencing how problems are approached and solutions are developed.

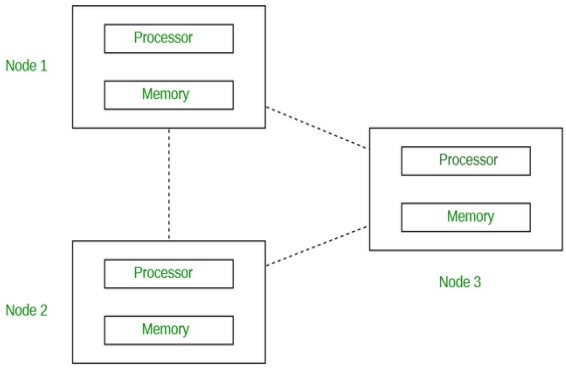
Over the years different computing paradigms have been developed and used. In fact different computing paradigms have existed before the cloud computing paradigm. Let us take a look at all the computing paradigms below.

1. Distributed Computing:

Distributed computing is defined as a type of computing where multiple computer systems work on a single problem. Here all the computer systems are linked together and the problem is divided into sub-problems where each part is solved by different computer systems. The goal of distributed computing is to increase the performance and efficiency of the systemand ensure fault tolerance.

Mobile and web applications are examples of distributed computing because several machines work together in the backend for the application to give you the correct information.

In the below diagram, each processor has its own local memory and all the processors communicate with each other over a network.



Example: How Google Search Works?

1. **Single Problem**: When you type a search query into Google, the single problem is "finding the best results for your query."
2. **Multiple Computer Systems**: Google has thousands of servers (computers) in data centers all around the world.

3. **Linked Together**: These servers are connected via high-speed networks, allowing them to work together seamlessly.
4. **Dividing the Problem**:
    - **Web Crawlers**: Some servers are responsible for scanning the entire internet and collecting data about web pages. This massive task is split among many servers, each responsible for different parts of the internet.
    - **Indexing**: The collected data is then processed and organized by another set of servers to create an index, much like a giant library catalog. Again, this task is divided among many servers.
    - **Query Processing**: When you enter a search query, it is sent to multiple servers, each responsible for searching a portion of the index to find relevant results.
5. **Solving Sub-Problems**:
    - One server might find pages that match the first part of your query.
    - Another server might find pages that match the second part of your query.
    - Other servers might rank the results based on relevance and popularity.
6. **Combining Results**: The results from different servers are combined and sent back to you as a single, coherent list of search results.

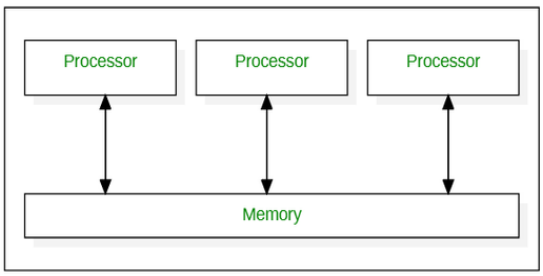
When you use Google Search, you are benefiting from distributed computing. The task of finding and delivering relevant search results is too big for a single computer, so Google divides this task among thousands of computers around the world. Each computer works on a small part of the problem, and together, they provide fast and accurate search results. This is a simple and familiar example of distributed computing in action.

2. Parallel Computing:

Parallel computing is defined as a type of computing where multiple computer systems are used simultaneously. Here a problem is broken into sub-problems and then further broken down into instructions. These instructions from each sub-problem are executed concurrently on different processors.

Parallel processing refers to the ability to deal with multiple stimuli simultaneously. Example is driving. When driving a car, we don't focus on driving exclusively, we also listen to music, carry on a conversation and look for the street where our destination is located.

In the below diagram you can see how the parallel computing system consists of multiple processors that communicate with each other and perform multiple tasks over a shared memory simultaneously. The goal of parallel computing is to save time and provide concurrency.



Example 1: Rendering a Video

1. **Single Problem**: Editing and rendering a high-definition video is a complex task that involves processing large amounts of data to produce the final video output.
2. **Breaking Down the Problem**:
   - **Sub-Problems**: The video is divided into smaller sections or scenes.
   - **Instructions**: Each section of the video needs various tasks, such as applying effects, adjusting colors, and rendering frames.
3. **Using Multiple Processors**:
   - **Divide the Work**: The video editing software breaks down each section into individual instructions (like processing a particular frame or applying an effect).
   - **Concurrent Execution**: Different processors (or cores within a multi-core processor) handle different parts of the video simultaneously. For example, one processor might work on rendering frames 1-100, while another processor works on frames 101-200.
4. **Communication**: The processors communicate with each other to ensure that all parts of the video are processed consistently. They share information to maintain the overall quality and coherence of the final output.
5. **Result**: By using multiple processors, the video editing software can render the final video much faster than if it were done sequentially on a single processor.

In video editing, parallel computing is used to speed up the process of rendering a high-definition video. By breaking the video into smaller sections and assigning tasks to multiple processors, each working simultaneously, the overall time required to complete the video is significantly reduced. This example illustrates how parallel computing allows complex tasks to be performed more efficiently by leveraging multiple processors working together.

Example 2: using a GPS navigation app on your phone.

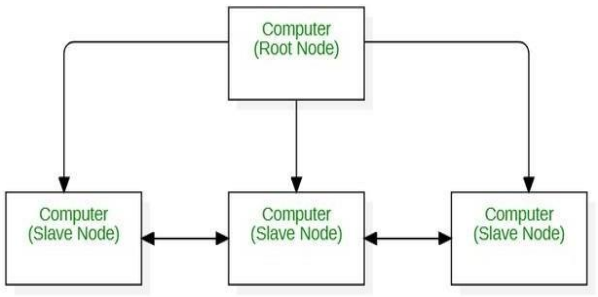
When you input a destination, the app calculates the best route by considering various factors such as traffic conditions, road closures, and route options. This calculation is done in parallel, as the app processes data from multiple sources simultaneously, such as live traffic updates, maps, and historical data, to provide you with the most accurate and efficient route in real time.

3. Cluster Computing:

A cluster is a group of independent computers that work together to perform the tasks given. Cluster computing is defined as a type of computing that consists of two or more independent computers, referred to as nodes, that work together to execute tasks as a single machine. The goal of cluster computing is to increase the performance, scalability and simplicity of thesystem.

Some popular implementations of cluster computing are the Google search engine, Earthquake Simulation, Petroleum Reservoir Simulation, and Weather Forecasting systems.

As we can see in the below diagram, all the nodes, (irrespective of whether they are a parent node or child node), act as a single entity to perform the tasks.



Example 1: Cloud-Based File Storage Service

1. **Single Problem**: Storing and managing files for millions of users across the globe while ensuring that files are always accessible and secure.
2. **Cluster Setup**:
   - **Nodes**: A cluster consists of multiple storage servers (nodes) in data centers. Each server is an independent computer responsible for storing and managing part of the user data.
3. **How It Works**:
   - **File Distribution**: When a user uploads a file, it is divided into smaller chunks and distributed across multiple servers in the cluster. Each server stores a portion of the file.
   - **Redundancy and Backup**: To ensure data reliability, copies of file chunks are stored on different servers. If one server fails, other servers with copies of the data can provide access to the files.
   - **Access and Synchronization**: When a user accesses their files, the system retrieves the necessary chunks from various servers and reassembles them. Changes made to files are synchronized across all servers to keep data up-to-date.
4. **Benefits**:
   - **Performance**: The system can handle large volumes of file uploads, downloads, and access requests simultaneously because the workload is distributed across multiple servers.
   - **Scalability**: As more users store more files, additional servers can be added to the cluster to accommodate the increased demand.
   - **Reliability**: If one server goes down, the data is still accessible from other servers, ensuring high availability and reliability.
5. **Result**: Using a cluster of servers for file storage allows services like Dropbox or Google Drive to efficiently manage and access large amounts of data, provide quick file retrieval, and ensure that user data is protected and continuously available.

In cloud-based file storage services, cluster computing enables multiple storage servers to work together as a single entity to manage and store user files. This setup improves performance, scalability, and reliability, ensuring that files are accessible and secure, even under heavy usage or when individual servers fail.

Example 2: Streaming a Movie on Netflix

1. **Single Problem**: Delivering high-quality video streams to millions of users simultaneously around the world.

2. **Cluster Setup**:
- **Nodes**: A cluster consists of multiple servers located in data centers across different regions. Each server is an independent computer that stores and streams parts of Netflix's content library.
3. **How It Works**:
- **Content Distribution**: Netflix uses a content delivery network (CDN) that distributes video files across multiple servers. When you start streaming a movie, the video is delivered from a server that is geographically close to you to minimize latency and buffering.
- **Load Balancing**: Requests for video streams are distributed across the cluster of servers. This ensures that no single server becomes overloaded with too many requests.
- **Redundancy**: The content is replicated across multiple servers. If one server fails or is undergoing maintenance, other servers in the cluster can continue to deliver the video stream without interruption.
4. **Benefits**:
- **Performance**: By distributing video content across many servers, Netflix can provide a smooth streaming experience with minimal buffering, even during peak times.
- **Scalability**: As the number of viewers increases, Netflix can add more servers to the cluster to handle the additional demand without affecting performance.
- **Reliability**: If one server or data center encounters issues, the system can continue to deliver content from other servers, ensuring uninterrupted service.
5. **Result**: Netflix's use of a server cluster allows it to efficiently deliver high-quality video content to users worldwide. The cluster setup ensures that streaming is fast, scalable, and reliable, providing a seamless viewing experience.

In streaming services like Netflix, cluster computing enables multiple servers to work together as a unified system to handle and deliver video content. This approach enhances performance, scalability, and reliability, ensuring that users can stream movies and shows smoothly, even with high traffic or potential server failures.

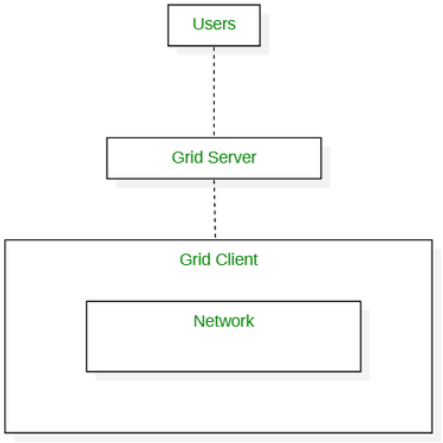
4. Grid Computing:

Grid computing is defined as a type of computing where it is constitutes a network of computers that work together to perform tasks that may be difficult for a single machine to handle. All the computers on that network work under the same umbrella and are termed as a virtual super computer.

The tasks they work on is of either high computing power and consist of large data sets. All communication between the computer systems in grid computing is done on the “data grid”.

The goal of grid computing is to solve more high computational problems in less time and improve productivity.

Organizations use grid computing to perform large tasks or solve complex problems that are difficult to do on a single computer. For example, meteorologists use grid computing for weather modeling. Weather modeling is a computation-intensive problem that requires complex data management and analysis.



Example: Online Multiplayer Gaming

Components in the Diagram

1. **Users**:
   - **Role**: Players who are participating in the online multiplayer game.
   - **Representation**: The top box labeled "Users."
2. **Grid Server**:
   - **Role**: The central game server that manages game state, player interactions, and distributes tasks to game clients.
   - **Representation**: The middle box labeled "Grid Server."
3. **Grid Client**:
   - **Role**: The individual gaming devices (computers, consoles, or smartphones) used by players to connect to the game. These devices handle local computations and communicate with the server.
   - **Representation**: The large box labeled "Grid Client."
4. **Network**:
   - **Role**: The internet or game network that connects all the gaming devices and the central server, allowing data and game state updates to be transferred.
   - **Representation**: The inner box labeled "Network" within the "Grid Client" box.

How It Works

1. **Task Submission**:
   - **Process**: Players (users) log into the game and perform actions (like moving their character, attacking, or chatting).
   - **Diagram**: Dashed line from "Users" to "Grid Server."
2. **Task Scheduling**:
   - **Process**: The central game server (Grid Server) receives these actions and determines how they affect the game state. It schedules tasks to update the game world and player interactions.
   - **Diagram**: This step is implied by the Grid Server's role.
3. **Task Distribution**:
   - **Process**: The game server sends updates to the game clients (the players' devices) about the game state and other players' actions.
   - **Diagram**: Dashed line from "Grid Server" to "Grid Client."
4. **Task Execution**:
   - **Process**: Each player's device (Grid Client) processes these updates locally to render the game world and animations. The devices also handle local actions and send them back to the server.

- **Diagram**: Inside the "Grid Client" box, the "Network" enables these devices to communicate and share updates.

5. **Result Collection**:
   - **Process**: The players' devices send their actions and state updates back to the central server.
   - **Diagram**: This step is implied by the connection between the Grid Server and Grid Clients.
6. **Result Delivery**:
   - **Process**: The central server aggregates these updates and delivers the new game state to all players, ensuring a consistent and synchronized game experience.
   - **Diagram**: This step completes the cycle, returning updated game states to the users.

Summary

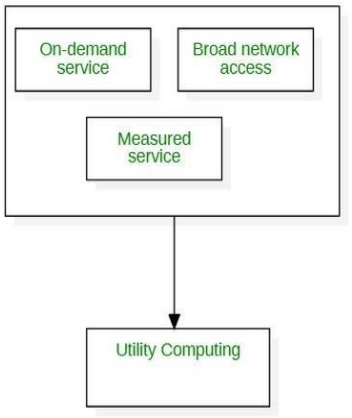
- **Users** (players) interact with the game.
- The **Grid Server** manages and distributes tasks (game state updates) to various **Grid Clients** (players' devices) through the **Network**.
- The **Grid Clients** execute local computations to render the game and handle player actions.
- Results (player actions) are sent back to the **Grid Server**, which then updates the game state and sends it to all players.

5. Utility Computing:

Utility computing is defined as the type of computing where the service provider provides the needed resources and services to the customer and charges them depending on the usage of these resources as per requirement and demand, but not of a fixed rate.

Utility computing involves the renting of resources such as hardware, software, etc. depending on the demand and the requirement. The goal of utility computing is to increase the usage of resources and be more cost-efficient.

Utility computing provides utmost flexibility in terms of availability of resources, on-demand usage, billing methods, and ease of accessing data anytime and anywhere.



Example: Using a Video Streaming Service (e.g., Netflix, Disney+)

1. **Requesting Resources**:
   - **Process**: Users (viewers) log into the streaming service and select a movie or TV show to watch

2. **Provisioning Resources**:
    - **Process**: The service provider allocates the necessary resources (server capacity, storage, network bandwidth) to stream the selected content to the user.
3. **Using Resources**:
    - **Process**: The user starts watching the selected movie or TV show. The service provider's resources are used to stream the content in real-time.
4. **Monitoring Usage**:
    - **Process**: The service provider continuously monitors how much content each user is streaming and the quality of the stream (e.g., HD, 4K).
5. **Billing Based on Usage**:
    - **Process**: Users are billed based on their subscription plan, which often depends on the amount of content they watch and the streaming quality.
6. **Adjusting Resources**:
    - **Process**: Users can upgrade or downgrade their subscription plan based on their needs (e.g., switching from standard to premium for more simultaneous streams or higher quality).

6. Edge Computing:

Edge computing is defined as the type of computing that is focused on decreasing the long distance communication between the client and the server. This is done by running fewer processes in the cloud and moving these processes onto a user's computer, IoT device or edge device/server.

The goal of edge computing is to bring computation to the network's edge which in turn builds less gap and results in better and closer interaction.

Edge computing is already in use all around us – from the wearable on your wrist to the computers parsing intersection traffic flow. Other examples include smart utility grid analysis, safety monitoring of oil rigs, streaming video optimization, and drone-enabled crop management.

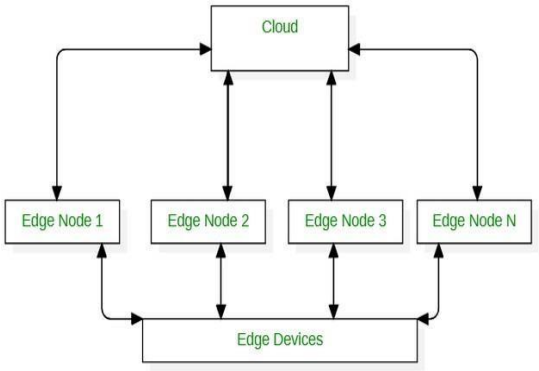


Diagram Explanation

- Cloud: Represents the central cloud servers where heavy processing and data storage typically occur.
- Edge Nodes: These are intermediary nodes that bring computing resources closer to the edge devices. Each edge node can handle specific tasks or processes, reducing the load on the central cloud.

- Edge Devices: These are the devices at the outermost edge of the network, such as smartphones, IoT devices, or local servers. They interact directly with the end-users and can perform computations locally.

Flow of Data

- Data from edge devices can be processed directly on the devices themselves or sent to the nearest edge node for further processing.
- Edge nodes communicate with each other and the central cloud to distribute the computational load efficiently.
- The central cloud is used for tasks that require more processing power or data storage than can be handled locally by edge nodes and devices.

Example: Smart Attendance System Example

In a smart attendance system using edge computing, each classroom might have its own smart device, such as a tablet or a biometric scanner, to record and process attendance data. For instance, when students check in using their ID cards or biometric information, the device processes the data locally to mark attendance and might even trigger immediate actions like notifying teachers if a student is absent. The data is recorded on the device and sent to the central system only if there's a need for further analysis or long-term storage.

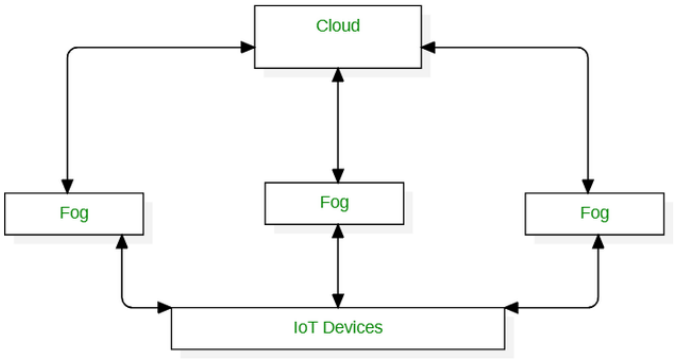
7. Fog Computing:

Fog computing is defined as the type of computing that acts a computational structure betweenthe cloud and the data producing devices. It is also called as "fogging".

This structure enables users to allocate resources, data, applications in locations at a closer range within each other. The goal of fog computing is to improve the overall network efficiency and performance.

Popular fog computing applications include smart grids, smart cities, smart buildings, vehicle networks and software-defined networks.

Real-world examples where fog computing is used are in IoT devices Devices with Sensors, Cameras (IIoT-Industrial Internet of Things), etc.



Example: Smart Attendance System Example at school level

In a smart attendance system using fog computing, there would be a local server or gateway at the school level that collects data from various devices across different classrooms. This local server processes and aggregates attendance data from all classrooms, performing tasks like generating daily attendance reports, identifying trends (e.g., frequent absences), and managing attendance

records. The aggregated data or reports are then sent to the cloud for further analysis, backup, or integration with other school management systems.

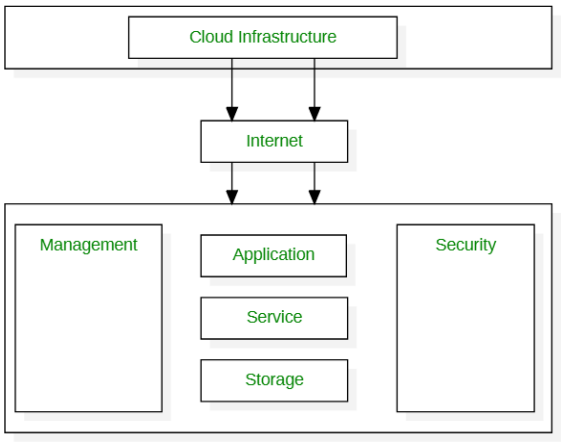
8. Cloud Computing:

Cloud is defined as the usage of someone else's server to host, process or store data. Cloud computing is defined as the type of computing where it is the delivery of on-demand computing services over the internet on a pay-as-you-go basis. It is widely distributed, network-based and used for storage.

There type of cloud are public, private, hybrid and community and some cloud providers are Google cloud, AWS, Microsoft Azure and IBM cloud.

Example: Dropbox, Gmail, Facebook

The number of cloud storage providers online seems to grow every day. Each competing over the amount of storage they can provide to clients.



Example: Gmail Email Service

Cloud Infrastructure:

- This is where all the physical hardware, such as servers and storage devices, are located.
- **Gmail** relies on Google's cloud infrastructure, which includes massive datacenters around the world. These datacenters contain the actual machines that store your emails and run the Gmail application.

Internet:

- The internet acts as the bridge between you (the user) and Gmail's cloud infrastructure.
- When you log in to Gmail, your request travels through the internet to reach Google's servers.

Application:

- This is where the Gmail application itself runs. It handles everything from displaying your inbox to composing new emails.
- The **application** layer processes your requests, like opening an email or sending a message.

Service:

- This layer includes additional services Gmail provides, such as spam filtering, calendar integration, and contact management.
- The **service** layer supports various functionalities that make Gmail more than just an email tool.

Storage:

- This is where all your emails, attachments, and other data are stored.
- The **storage** component ensures that when you save an email, it's securely stored in the cloud and can be accessed anytime.

Management:

- This layer manages the operation of Gmail, ensuring that it runs smoothly, scales with demand, and handles performance monitoring.
- **Management** oversees the entire Gmail service, making sure everything works efficiently.

Security:

- Security ensures that your emails and data are safe from unauthorized access, protecting your privacy and information.
- The **security** component is responsible for encryption, access control, and compliance with data protection regulations.

Summary:

When you use Gmail:

- Your device connects to the **cloud infrastructure** via the **internet**.
- The **application** layer runs Gmail, while **services** like spam filtering help manage your emails.
- Your emails are stored in the **storage** layer, managed by the **management** layer, and protected by **security**.

Comparison of various Computing Technologies

Criteria	Peer-to-Peer Computing	Cluster Computing	Grid Computing	Cloud Computing
Virtualization	Limited	Limited	Half	Essential
Ownership	Shared Ownership	Single Ownership	Multiple Ownership	Single Ownership
Standards	No Standard	Virtual Interface Architecture	Some Open Grid Forum	Web Services (SOAP and REST)
Operating System	Windows or Mac OS or Linux	Windows or Linux	Any standard (dominated by UNIX)	A hypervisor runs multiple OS
Resource Management	Peer-to-peer	Centralized	Distributed	Centralized and Distributed
Application drivers	Content and file management and Instant messaging and games	Business and data centers and enterprise computing	High throughput scientific applications	Dynamically provisioned web applications
Capacity	Capacity increase automatically with popularity	Stable and guarantee capacity	Different, but large capacity	On demand dynamically provisioned capacity
Failure management	It handle failure by pro-viding special nodes, called relays, that store any updates temporarily until the destination reappears on the network	Limited (often failed task restarted)	Limited (usually failed jobs restarted)	Failover, content replication, migration of VMs supported
SLA	SLA Based	Limited	SLA Based	Essential
Security	Low	Very low- but typically high	High	Low

Comparison of the computing paradigms based on various characteristics:

1. Control

- **Distributed Computing:** Decentralized; each node operates independently.
- **Parallel Computing:** Centralized or tightly coupled; coordinated by a single system or tightly linked systems.
- **Cluster Computing:** Centralized; managed as a unified system.
- **Grid Computing:** Decentralized; resources are distributed across multiple locations.
- **Utility Computing:** Centralized; provided from a central cloud infrastructure.
- **Edge Computing:** Decentralized; processing happens at various edge devices.
- **Fog Computing:** Partially decentralized; intermediates between cloud and edge.
- **Cloud Computing:** Centralized; managed from central data centers.

2. Resources

- **Distributed Computing:** Uses independent computers across various locations.
- **Parallel Computing:** Relies on multiple processors or cores within a single system.
- **Cluster Computing:** Employs interconnected computers working as a single unit.
- **Grid Computing:** Uses diverse, distributed resources from multiple geographic locations.
- **Utility Computing:** Centralized data centers offering on-demand resources.
- **Edge Computing:** Utilizes edge devices close to the data source.
- **Fog Computing:** Employs nodes that bridge the gap between cloud and edge.
- **Cloud Computing:** Uses large-scale data centers with extensive cloud infrastructure.

3. Proximity to Data

- **Distributed Computing:** Varies; often involves data distributed across different locations.
- **Parallel Computing:** Local or within the same system; all tasks are processed close together.
- **Cluster Computing:** Local or closely situated nodes, providing high-speed access to data.
- **Grid Computing:** Distributed across large distances; data can be far from processing nodes.
- **Utility Computing:** Remote; data centers are often geographically distant from the user.
- **Edge Computing:** Very close to the data source, minimizing latency.
- **Fog Computing:** Intermediate; between the data source and cloud.
- **Cloud Computing:** Remote; data is stored and processed in central data centers far from the user.

4. Latency

- **Distributed Computing:** Can be high due to the communication overhead between nodes.
- **Parallel Computing:** Low, designed for high-speed processing within a single system.
- **Cluster Computing:** Low; nodes are usually physically close, reducing communication delays.
- **Grid Computing:** Variable; depends on the distance between distributed resources.
- **Utility Computing:** Depends on the location of data centers; can be moderate to high.
- **Edge Computing:** Very low, due to local data processing.
- **Fog Computing:** Lower than cloud but higher than edge computing.
- **Cloud Computing:** Higher, as data has to travel to centralized servers.

5. Scalability

- **Distributed Computing:** High; easily scalable by adding more nodes.

- **Parallel Computing:** Limited to system architecture; scalability is constrained by hardware design.
- **Cluster Computing:** High; can be scaled by adding more nodes to the cluster.
- **Grid Computing:** Very high; can integrate numerous systems across large distances.
- **Utility Computing:** Extremely high; virtually unlimited resources due to cloud infrastructure.
- **Edge Computing:** Moderate; limited by the number of available edge devices.
- **Fog Computing:** High; scales similar to cloud computing with added flexibility.
- **Cloud Computing:** Extremely high; resources are virtually unlimited due to the cloud infrastructure.

6. Resource Utilization

- **Distributed Computing:** Shared across distributed systems; often opportunistic.
- **Parallel Computing:** High efficiency within a single system; tasks are efficiently divided among processors.
- **Cluster Computing:** Shared within a managed cluster; provides high performance and availability.
- **Grid Computing:** Opportunistic use of idle resources; utilizes unused computing power from various sources.
- **Utility Computing:** Pay-as-you-go model; users are billed based on usage, which allows flexible and cost-effective resource utilization.
- **Edge Computing:** Localized, real-time processing; resources are used close to the data source.
- **Fog Computing:** Distributed between edge and cloud; balances processing between local and centralized resources.
- **Cloud Computing:** High elasticity; scalable resources provided on-demand with a pay-as-you-go model.

7. Use Cases

- **Distributed Computing:** Suitable for distributed databases, blockchain networks.
- **Parallel Computing:** Ideal for high-performance tasks like weather forecasting simulations and GPU-based tasks.
- **Cluster Computing:** Used for scientific research and high-performance computing tasks.
- **Grid Computing:** Effective for large-scale projects like SETI@home and collaborative research.
- **Utility Computing:** Perfect for flexible, on-demand computing needs like web hosting and cloud-based applications.
- **Edge Computing:** Suited for applications requiring real-time processing like autonomous vehicles and smart sensors.
- **Fog Computing:** Good for smart city infrastructure and IoT devices that need intermediate processing.
- **Cloud Computing:** Commonly used for a wide range of services, including data storage, applications, and large-scale computing power.

What is Cloud?

The term **Cloud** refers to a **Network** or **Internet.** In other words, we can say that Cloud is something, which is present at remote location.

The **cloud** is referred as **server of servers**.

The cloud is **a distributed collection of servers that host software and infrastructure, and it is accessed** over the Internet.

The cloud is an extensive network of remote servers around the world. These servers store and manage data, run applications, and deliver content and services like streaming videos, web mail, and office productivity software over the internet.

Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN (Virtual Private network).

The term "cloud" in computing refers to a model where services and resources are delivered over the internet. Instead of owning and maintaining physical servers, you use services provided by cloud providers like Amazon Web Services (AWS), Microsoft Azure, or Google Cloud Platform (GCP).

A cloud is a service that lets you access and store data or applications over the internet instead of on your local computer or server. Think of it as using a remote hard drive or software that you access online.

Other key terms:

Network: A system of interconnected computers and devices that can communicate with each other. It allows data to be shared between devices, whether it's a small local network (like in a home or office) or a larger network (like the internet).

Server: A powerful computer that provides resources, services, or data to other computers (clients) over a network. For example, a web server hosts websites, while an email server handles your email.

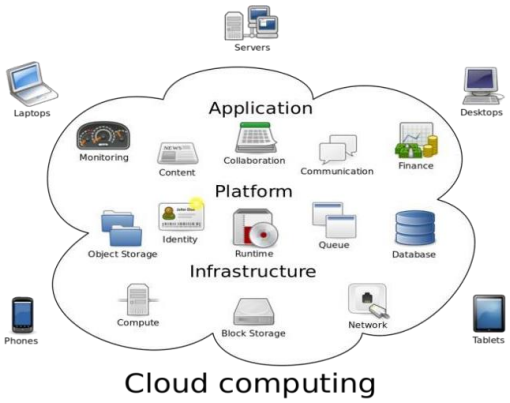
Internet: A global network of networks that connects millions of private, public, academic, and government networks. It allows people to access information, communicate, and share resources across the world.

What is Cloud Computing?

Cloud Computing refers to **manipulating, configuring,** and **accessing** the hardware andsoftware resources remotely.

Cloud Computing offers online **data storage, infrastructure, and application**.

Cloud computing offers **platform independency,** as the software is not required to be installedlocally on the PC. Hence, the Cloud Computing is making our business applications **mobile** and **collaborative.**



Why do we need Cloud Computing?

- One of the significant reasons why huge number of little scale and large scale business parts from everywhere throughout the world are utilizing cloud today, is because of huge impact on cost saving. Yes, cloud computing has also changed significantly in hardware and software costs and the lack of other server resources.
- We can run all our workload data of applications and procedures online over the internet remotely instead of utilizing physical hardware and software.
- Day to day issues related to server upkeep or installation of software/ hardware or whether it is renewal of license, each one of those variables are attempted by means of cloud computing

service providers.

- With the help of cloud we can get to any information, applications whenever andwherever we need to, over the internet. 100 pre-configured applications can be installed and updated.
- Cloud not only handles data storage remotely but it also protects and recovers all crashed or loss data, so we don't need to stress about crashed or loss of data, it gives you high security.
- With the upcoming new technology in cloud computing, numerous providers offers accessing and paying option with the ease of use, where clients can switch the applications effectively as indicated by the utilization and have pay just for the utilized resources.

  Ideally suitable for developing business, where the demand of bandwidth are high.

History of Cloud Computing:

Before emerging the cloud computing, there was Client/Server computing which is basically a centralized storage in which all the software applications, all the data and all the controls areresided on the server side. If a single user wants to access specific data or run a program, he/she need to connect to theserver and then gain appropriate access, and then he/she can do his/her business.

Then after, distributed computing came into picture, where all the computers are networkedtogether and share their resources when needed.

On the basis of above computing, there was emerged of cloud computing concepts that later implemented.

Timeline in History of Cloud Computing:

To really understand the history of cloud computing, it is rather crucial to understand the key developments and their schedule. The following section will help you in understanding the timeline in the history of cloud computing:

History of Cloud Computing in 1960s:

- At around in 1961, **John MacCharty** suggested in a speech at MIT that computing can be sold like a utility, just like a water or electricity. It was a brilliant idea, but like all brilliant ideas, it was ahead if its time, as for the next few decades, despite interest in the model, the technologysimply was not ready for it.
- Initial concepts of time-sharing become popularized via Remote Job Entry (RJE).
- The "data center" model, where users submitted jobs to operators to run on mainframes, was predominantly used during this era.

History of Cloud Computing in 1994:

- The term "cloud" is used by General Magic to describe the universe of "places" that mobile agents in the Telescript environment could go. This metaphor is credited to David Hoffman, a General Magic communications employee.

History of Cloud Computing in 1996:

- Compaq Computer Corporation draws up a business plan for future computing and the Internet, introducing the concept of "cloud computing-enabled applications."

In 1999, **Salesforce.com** started delivering of applications to users using a simple website. The applications were delivered to enterprises over the Internet, and this way the dream of computing sold as utility were true.

History of Cloud Computing in 2000s:

- Amazon Web Services (AWS) is established in 2002, allowing developers to build applications independently.
- In 2006, the beta version of Google Docs is released, and Amazon Simple Storage Service (Amazon S3) and Amazon Elastic Compute Cloud (EC2) are introduced.
- In 2008, NASA develops the first open-source software for deploying private and hybrid clouds.
- In 2009, **Google Apps** also started to provide cloud computing enterprise applications.

History of Cloud Computing in 2010s:

- Microsoft launches Microsoft Azure in 2010.
- Rackspace Hosting and NASA initiate the open-source cloud-software project, OpenStack.
- IBM introduces the IBM SmartCloud framework in 2011.
- Oracle announces the Oracle Cloud in 2012.
- In December 2019, Amazon launches AWS Outposts, a service that extends AWS infrastructure to customer data centers, co-location spaces, or on-premises facilities.

History of Cloud Computing in 2020s:

- Cloud technology surges in popularity in 2020 due to the global pandemic, offering data security and flexibility for remote workers.

Characteristics of Cloud Computing

1. **On-demand self-services:** The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
2. **Broad network access:** The Computing services are generally provided over standard networks and heterogeneous devices.
3. **Rapid elasticity:** The Computing services should have IT resources that are able to scale out and in quickly and on a need basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.
4. **Resource pooling:** The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.
5. **Measured service:** The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.
6. **Multi-tenancy:** Cloud computing providers can support multiple tenants (users or organizations) on a single set of shared resources.
7. **Virtualization:** Cloud computing providers use virtualization technology to abstract underlying hardware resources and present them as logical resources to users.
8. **Resilient computing:** Cloud computing services are typically designed with redundancy and fault tolerance in mind, which ensures high availability and reliability.
9. **Flexible pricing models:** Cloud providers offer a variety of pricing models, including pay- per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.

10. **Security:** Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
11. **Automation:** Cloud computing services are often highly automated, allowing users to deploy and manage resources with minimal manual intervention.
12. **Sustainability:** Cloud providers are increasingly focused on sustainable practices, such as energy-efficient data centers and the use of renewable energy sources, to reduce their environmental impact.

Advantages of Cloud Computing:

1. **Cost saving**
   The services are free from capital expenditure. There are no huge costs of hardware in cloud computing. You just have to pay as you operate it and enjoy the model based on your subscription plan.
2. **24 X 7 Availability**
   Most of the cloud providers are truly reliable in offering their services, with most of them maintaining an uptime of 99.9%. The workers can get onto the applications needed basically from anywhere. Some of the applications even function off-line.
3. **Flexibility in Capacity**

   It offers flexible facility which could be turned off, up or down as per the circumstances of the user. For instance, a promotion of sales is very popular, capacity can be immediately and quickly added to it for the avoidance of losing sales and crashing servers. When those sales are done, the capacity can also be shrunk for the reduction ofcosts.
4. **All over Functioning**

   Cloud computing offers yet another advantage of working from anywhere across theglobe, as long as you have an internet connection. Even while using the critical cloudservices that offer mobile apps, there is no limitation of the device used.
5. **Automated Updates on Software**

   In cloud computing, the server suppliers regularly update your software including the updates on security, so that you do not need to agonize on wasting your crucial time on maintaining the system. You find extra time to focus on the important things like 'How to grow your businesses.
6. **Security**

   Cloud computing offers great security when any sensitive data has been lost. As the datais stored in the system, it can be easily accessed even if something happens to your computer. You can even remotely wipe out data from the lost machines for avoiding it getting in the wrong hands.
7. **Carbon Footprint**

   Cloud computing is helping out organizations to reduce their carbon footprint. Organizations utilize only the amount of resources they need, which helps them to avoidany over-provisioning. Hence, no waste of resources and thus energy.

8. Enhanced Collaboration

Cloud applications enhance collaboration by authorizing diverse groups of people virtually meet and exchange information with the help of shared storage. Such capability helps in improving the customer service and product development and alsoreducing the marketing time.

9. Control on the Documents

Before cloud came into being, workers needed to send files in and out as the email attachments for being worked on by a single user at one time ultimately ending up witha mess of contrary titles, formats, and file content. Moving to cloud computing has facilitated central file storage.

10. Easily Manageable

Cloud computing offers simplified and enhanced IT maintenance and management capacities by agreements backed by SLA, central resource administration and managedinfrastructure. You get to enjoy a basic user interface without any requirement for installation. Plus you are assured guaranteed and timely management, maintenance, and delivery of the IT services.

Risks related to Cloud Computing:

Although cloud Computing is a promising innovation with various benefits in the world of computing, it comes with risks. Some of them are discussed below:

1. Security and Privacy

It is the biggest concern about cloud computing. Since data management and infrastructure management in cloud is provided by third-party, it is always a risk to handoverthe sensitive information to cloud service providers.

Although the cloud computing vendors ensure highly secured password protectedaccounts, any sign of security breach may result in loss of customers and businesses.

2. Lock In

It is very difficult for the customers to switch from one **Cloud Service Provider (CSP)** to another. It results in dependency on a particular CSP for service.

3. Isolation Failure

This risk involves the failure of isolation mechanism that separates storage, memory,and routing between the different tenants.

4. Management Interface Compromise

In case of public cloud provider, the customer management interfaces are accessiblethrough the Internet.

5. Insecure or Incomplete Data Deletion

It is possible that the data requested for deletion may not get deleted. It happensbecause either of the following reasons:

- Extra copies of data are stored but are not available at the time of deletion
- Disk that stores data of multiple tenants is destroyed.

Applications of Cloud Computing:

1. Art related application

Cloud computing applications offer a variety of art-related applications for various designing purposes, assisting in the development of eye-catching designs for cards, books, and other visuals. Examples of cloud computing applications for the arts include Moo, Adobe Creative Cloud, and Vistaprint. These programs facilitate quick card creation, printing, and design. Additionally, programs like Adobe Creative Cloud, a cloud-based program that offers first-rate professional editing services, are available.

2. Image-editing application

There are several applications available today that offer free image editing. These cloud computing services offer a variety of functions, such as graphic user interfaces and image editing, resizing, cropping, and special effects (GUI). Additionally, these programs include customizable brightness and contrast options. Additionally, they offer highly sophisticated functions that are simple to use. Famous examples include Fotor and Adobe Creative Cloud.

3. Data Storage

Computer programs for data storage are another choice for cloud computing applications. It is also one among the many cloud applications that let you save data, files, photos, and other types of material in the cloud. It facilitates using the applications of the cloud to obtain information. These cloud computing applications are designed for security and to guarantee that data is safely backed up. Word, Excel, PDF, Excel, and other file types can all be used to restore and convert data. Applications like Box, Mozy, Jouks, and Google Suite are excellent examples of cloud storage.

- **Box.com**

  For secure management of content, workflow, as well as collaboration, Box offers an online environment. It enables us to store various files on the cloud, including Excel, Word, PDFs, and photos. The key benefit of using Box.com is that it offers drag-and-drop file sharing and has simple integrations with over 1400 apps, including Salesforce, G Suite, Office 365, and more.

- One of the greatest cloud storage as well as backup programs is Google G Suite. Along with cloud storage and management features, it offers Google docs, Calendar, Forms, hangouts, Google+, and cloud storage. Gmail is the most used application in the Google G Suite. Users of Gmail can access free email services.

4. Business applications

Applications for businesses rely on cloud-based service providers. Today, every corporation needs a cloud-based business application to expand. Additionally, it makes sure users can access corporate applications around-the-clock.

- **Salesforce:** The Salesforce platform offers solutions for e-commerce, marketing, sales, and other functions. Additionally, a cloud development platform is offered.
- **MailChimp:** A platform for publishing emails called MailChimp offers a number of tools for creating, sending, and storing email templates.
- **Quickbooks:** The phrase “Run Enterprise anywhere, anytime on any device” is how Quickbooks operates. The firm, it offers online accounting solutions. More than 20 persons can collaborate on the very same system at once.

5. Education based applications

The use of cloud computing in education is growing rapidly. It provides students with a variety of online distance learning platforms and student information websites. Strong virtual classrooms, easy

accessibility, safe data storage, scalability, better reach for the students, and minimum hardware requirements for the apps are all benefits of using the cloud in the field of education.

The cloud provides the following educational applications:

- **Google Apps for Education:** The most popular platform for free web-based email, calendar, documents, and group study is Google Apps for Education.
- **Tablets:** It enables teachers to give pupils access to the newest technological solutions in the classroom rapidly.
- **AWS:** Universities, community institutions, and schools can access an environment that is conducive to learning thanks to AWS cloud.

6. Big Data Analysis

The use of cloud computing for in-depth data analysis is one of its most significant uses. Big data cannot be stored using conventional data management solutions due to its enormous volume. Big data can now be stored and analysed by enterprises to produce priceless business insights thanks to the cloud's limitless storage capacity.

7. Testing

Applications for cloud computing offer the simplest method for product testing and development. Such environment would've been time-consuming, costly to set up in terms of IT resources as well as infrastructure, and labor-intensive using conventional approaches. Organizations may employ scalable and adaptable cloud services for product creation, testing, and deployment thanks to cloud computing.

8. Entertainment Application

The entertainment sector employs a multi-cloud approach to engage the target audience. V and video conference and Online games are just a couple of the leisure applications available with cloud computing.

- **Online gaming:** Cloud gaming is one of the most significant forms of entertainment nowadays. It provides a variety of online games that are remote-controlled by the cloud. GeForce Now, Vortex, Project xCloud, Shaow, and PlayStation Now are the top cloud gaming providers.
- **Video Conference:** Apps for video conferencing offer a quick and easy way to connect. We can use cloud-based video conferencing to speak with our friends, family, and business colleagues. The advantages of adopting video conferencing include cost savings, increased productivity, and elimination of interoperability.

9. E-commerce Applications

Ecommerce customers and e-businesses can react swiftly to possibilities as they arise thanks to cloud-based ecommerce solutions. It offers business leaders a fresh method for getting things done quickly and efficiently. They manage product data, customer data, as well as other operational systems in cloud settings.

10. Social Media Applications

Many users can connect with one another via social networking services like Facebook, Twitter, LinkedIn, etc. thanks to social cloud applications.

The following are some cloud-based social applications:

- **Facebook:** Facebook is a social networking site that enables active users to share documents, pictures, videos, status updates, and more with their friends, family members, and business associates using a cloud storage system. We always receive notifications on Facebook when our friends like and comment on the posts.
- **LinkedIn:** LinkedIn is a famous social media platform for professionals, new graduates, and students.
- **Yammer:** The ideal technology for team collaboration is Yammer, which enables a group of workers to communicate and exchange files, videos, and photographs.

11. Antivirus Application

There are also numerous antivirus programmes accessible for support. These cloud application services guarantee the system's efficient operation. They provide numerous advantages to consumers, including system cleaning, malware detection, and virus removal. This antivirus is free of charge and is considered the best antivirus for your personal computer. By sending the information to the cloud data centre and repairing it, this application's main purpose is to detect malware. Some of the most widely used cloud antivirus programmes include Kaspersky Endpoint Security and Sophos Endpoint Protection.

12. URL conversion application

There are a number of social media programmes, one of which is connected to Twitter and aids in the reduction of long URLs to shorter ones. The function of a programme like bitly is to shorten lengthy URLs, which then refers users back to the initial website. In addition to protecting the application from malware and hacking activity, it facilitates microblogging.

13. Presentation Application

For presentation services, there is software available that enables the importation of PowerPoint Presentations by making slides. One such programme that assists the user in making professional presentations is called "Sliderocket." Anywhere in the planet can access these cloud computing applications. It offers both a free and a paid version of the programme.

14. GPS application

GPS, another innovation of cloud computing and its uses, is made available to users. These programmes assist users in discovering destinations online and in following directions from a map. Websites like Google Maps, Yahoo Maps, and others are examples of such cloud computing applications. Millions of users utilise these applications, which are also available for free.

15. Accounting application

One of the real-time cloud computing apps that supports management in the accounting area of the firm is accounting software. One such tool utilised by larger businesses to provide real-time daily accounting services is Outright. You may keep track of spending, earnings, and losses in real time. Other cloud accounting software examples are Kash Flow and Zoho Books.

Trends in Cloud Computing:

Many cloud service providers like **Google**, **Microsoft**, **IBM**, **Amazon**, etc. are working on these cloud trends so that more cost-effective services can be provided to users with high efficiency.

1. AI and ML

One of the most trending technologies that are close to cloud computing is **Artificial Intelligence** and **Machine Learning**. They are cost-effective technologies as they require high computational power and storage for the collection of data and training. Major trends that will grow in this sector in the upcoming years are self-automation, self-learning, personalized cloud, high data security, and privacy. Many cloud service provider companies such as **Amazon**, **Google**, **IBM**, etc are investing a lot in artificial intelligence and machine learning.

Amazon's AWS DeepLens camera and Google Lens are two such examples of their products based on machine learning.

2. Data Security

When it comes to data security, no business or organization wants to compromise. Security of the organization's data is a top priority. Threats such as data leaks, data deletion, and unauthorized amendments to the data need to be minimized. Certain steps can be taken to minimize the losses and ensure high data security.

Data breaches can be minimized with the help of encryption and authentication. Data losses can be reduced with the help of backups, reviewing privacy policies, and data recovery systems. Security testing will be done thoroughly to detect any loopholes and patches. High-security measures should be taken during storage and transfer of data. Cloud service providers secure the data with many security protocols and data encryption algorithms.

3. Multi and Hybrid Cloud Deployment

The use of multi-cloud and hybrid solutions is increasing. Many organizations like banks, insurance companies, etc are using hybrid cloud service that offers a combination of both private and public clouds to store their data.

Now, businesses are dividing their workload among multiple cloud service providers to control their data and resources as well as utilize the strength of each cloud service provider. The use of multi-cloud minimizes the potential risks and failure points and provides cost-effectiveness. In multi-cloud, you can choose a particular service of a particular cloud service provider that meets your requirements instead of deploying your entire application on that cloud. This will also ignite the cloud service provider**s** to embed new services.

4. Low Code and No Code Cloud Solutions

Those days are gone when users need to write hundreds of lines of code to create applications and solve real-world problems and have deep technical knowledge. Businesses can create applications and make use of AI and its subdomains with low-code and no-code cloud solutions. These solutions can help in the development of website**s,** app**s,** services, etc without having any technical knowledge.

This helps in reducing the time and cost involved to create these solutions. These solutions increase product development speed and result in a smaller number of errors. Tools such as **Figma** and **Zoho** enable users to design and develop websites, apps, and services without any computing infrastructure and coding knowledge involved.

5. Edge computing

Edge computing includes storage of data**,** data processing**,** data analytics which is done geographically nearer to the source. It means that the computation and storage of data are brought closer to the source sensors and devices. It provides many benefits like reduced latency, enhanced efficiency, increased privacy, security, and a high rate of data transmission. It works in real-time

and processes data that is not bounded by time.

As the use of 5G is increasing, it is easy to achieve fast processing and reduced latency. Also, many telecom and IT organizations are uniting, resulting in the rise in edge computing. With the rise in IoT devices, edge computing will play a huge role in providing real-time data and data analysis.

6. IoT

The Internet of Things (IoT) is a trend that is becoming popular day by day. IoT involves the use of many sensors that generate huge amounts of data which gets storage on cloud servers. IoT makes use of many sensors, and actuators and performs analysis on the data collected to yield results that will help in taking business decisions. It involves connectivity among computers, networks, and servers. It can remotely collect data and communicate with the devices.

IoT collects data from various sensors and devices and acts as an intermediator between remote systems and smart device management. Smart connectivity plays a major role in making IoT a trend in cloud computing**.**

7. Kubernetes and Docker

Kubernetes and Docker are among the trending and evolving technologies in cloud computing**.** They are an open-source platform that manages services and workloads from a single location while running applications from a single source. They provide scalability and efficiency to many large-scale deployments. As the use of cloud computing services is increasing, Kubernetes and Docker play a major role in managing cloud deployments of cloud users and organizations.

8. Serverless architecture/computing

Serverless computing is a methodology that provides backend services on a per-user basis. There is no need for developers to manage the servers while running their code. **Code execution** is managed by the cloud service provider. Cloud users will pay as per the pay-as-you-go format which means that users will only pay when their code runs instead for a fixed server. There is no need to purchase the servers as a third party will manage the cost for you. This will help in reducing infrastructure costs and will enhance scalability.

This trend can be automatically scaled as per its demand. Serverless architecture offers many advantages such as no requirement for system administration, low cost and liability, easy management of operations, and enhanced user experience even in case of no internet.

9. DevSecOps

Cloud computing provides many benefits to its customers in managing their data but along with that, many security issues are sometimes faced by the users. Risks involving network invasion, **Denial of Service** (**DoS**) attacks, issues in virtualization, unauthorized use of data, etc. This can be minimized with the help of DevSecOps.

DevSecOps is an integration of security with the ongoing development process. It embeds many processes in its workflow to ensure secure task automation. Many cloud service providers provide various tools and services to help businesses apply DevSecOps methods. It will provide all the required security to provide a secure system to the users.

10. Disaster recovery and backup

Disaster recovery plays a crucial role in the restoration of critical data and systems in case of any kind of disaster. Many organizations have faced huge losses of unsaved data due to server

crashes. With the help of cloud computing, a backup of critical data of businesses can be stored to quickly recover from disruptions such as data loss, power outages, natural disasters, cyberattacks, or hardware failures. For any organization, a strong disaster recovery and backup plan with the help of cloud computing can save them from a huge loss. Many enterprises keep electronic records and files and upload those documents on an external cloud server automatically.

Leading Cloud Platform Service providers:

Cloud Computing has revolutionized IT solutions, replacing traditional hard drive storage with accessible services delivered over the Internet.

From storage to **processing, networking,** and **software, cloud computing** offers a range of solutions. Whether updating **social media** or **banking online**, chances are, cloud computing is involved. Many businesses invest heavily in cloud migration to address challenges and stay competitive.

List of Top 10 Cloud Platform Service Providers in 2024

1. Amazon Web Services (AWS)

Launched in 2006, AWS is the best cloud service provider **leading in the market**. It becomes a major player in AI, database, machine learning, 5G cloud, multi-cloud and serverless deployments. AWS operates in **20 geographical regions** across the world. The company reported a revenue of **9 billion dollars** in Q3 2019.

- AWS offers **175 fully-featured services** to meet any kind of business requirements. These services are database storage, computing power, networking and many more
- You can virtually host any applications, including networks like firewall, DNS, Load balancing, or even you can have your virtual private cloud.
- AWS applications are scalable, flexible, reliable, secure and trustworthy.
- Easy sign-up and fast deployment. The best thing is there is no upfront cost and you pay for what you use. It also offers a FREE tier for some of their popular services.

Top Companies using Amazon Web Services (AWS)

- Netflix
- Spotify
- Airbnb
- Uber
- Peloton
- Expedia
- Pinterest
- Samsung
- Sony
- Novartis

2. Microsoft Azure

Microsoft Azure was launched in 2010 as Windows Azure, and later in 2014, it was renamed, Microsoft Azure. It was launched years after the release of AWS and Google cloud but still, it is the fastest-growing cloud and giving tough competition to AWS and other cloud service providers. There is a five-year partnership between Microsoft and Disney. In this partnership, the new method will be developed to move production content to the cloud. Azure has **54 data**

centers regions across the world available in **140 countries**.

- Azure offers hundreds of services including **AI + Machine Learning**, **Analytics,** Blockchain, Compute, Containers, Databases, Developer Tools, DevOps, Identity, Integration, Internet of Things, Management, Media, Microsoft Azure Stack, Migration, Mixed Reality, Mobile, Networking, Security, Storage, Web, and Windows Virtual Desktop.
- Microsoft Azure is available with public or private cloud service or hybrid cloud service consists of both private and public.
- Scalability, consistency, security, flexibility, and cost-effectiveness.
- Azure supports various operating systems, databases, tools, programming languages and frameworks.
- It's easier for users to move their application or framework without any hassle and recoding them again.
- 24/7 cooperative team paying attention to their customers. A free trial version of Microsoft Azure is available for 30 days.

Top Companies using Microsoft Azure

- Walmart
- Macy's
- The Home Depot
- Starbucks
- Coca-Cola
- Bank of America
- JPMorgan Chase
- Citigroup
- Fidelity Investments
- Standard Chartered

3. Google Cloud Platform (GCP)

Google cloud platform(GCP) is another set of solutions for users to get the benefit of cloud services. If you are serious about latency to build performance-oriented applications then Google cloud is the best choice because it includes **GCP & G Suite**. According to Gardner, the public cloud services market is forecast to grow **17% in 2020 to $266.4 billion**, up from **$227.8 billion in 2019.** Google cloud has a firm grip over the banking and finance sector. **eBay, Snapdeal, and HSBC** are some major clients of Google. In July 2019 **VMWare** also announced a partnership with Google cloud which is the biggest collaboration of last year. As of Q1 2020, Google Cloud Platform is available in **22 regions, 61 zones and 200+ countries**.

- It offers a variety of products and services including AI and Machine Learning, API Management, Compute, Containers**,** Data Analytics**,** Databases**,** Developer Tools, Healthcare and Life Scienctes, Hybrid and Multi-cloud, Internet of Things, Management Tools, Media and Gaming, Migration, Networking, Security and Identity, Serverless Computing**,** and Storage. Google products are also offered in the cloud, including G Suite**,** Google Maps Platform, Google Hardware, Google Identity**,** Chrome Enterprise, Android Enterprise, Apigee, Firebase, and Orbitera.
- Security, stability, flexibility, scalability and trustworthy.
- GCP offers the cheapest cloud services in the market. It offers $300 in credit to be used in 60 days as a free trial.

- Flexible payment plans based on **Pay-As-You-Go (PAYG)**. Also, the cost only applies if the codes given by a user run accurately if not, it doesn't cost any amount.
- Easy migration of data without touching or rewriting any codes.
- Machine learning and the use of API are very easy.

Top Companies using Google Cloud Platform (GCP)

- Verizon
- Twitch
- CenturyLink
- LinkedIn
- NewsCorp
- SAP
- Facebook
- Intel
- Yahoo
- Marriott

4. Alibaba Cloud

Alibaba Cloud, also known as Aliyun, is the cloud computing arm of Alibaba Group, one of the world's largest e-commerce and technology conglomerates based in China. It offers a comprehensive suite of cloud computing services to support businesses worldwide, including:

Market Presence:

- Currently holding the **third largest global market share** in cloud computing, following Amazon Web Services (AWS) and Microsoft Azure.
- **Dominates the Asian market**, particularly in China.

Service Portfolio:

- Offers a **diverse and comprehensive suite** of cloud solutions, including:
    - **Compute:** Elastic Compute Service (ECS) for virtual machines, Serverless Computing, Container Services.
    - **Storage:** Object Storage Service (OSS), File Storage Service (NAS), Block Storage Service (ESSD).
    - **Networking:** Virtual Private Cloud (VPC), Elastic Network Interface (ENI), Global Accelerator.
    - **Databases:** Alibaba Cloud Database Service (RDS), NoSQL databases, Graph Database.
    - **AI & ML:** AI Platform, pre-trained models, Big Data Analytics.
    - **Security & Identity:** Security Center, Anti-DDoS, Key Management Service.
    - **Developer Tools:** API Gateway, Serverless Application Model (SAM), CodePipeline.
    - **Industry-Specific Solutions:** Tailored solutions for retail, manufacturing, finance, and more.
- While offering various AI & ML tools, its **strength lies in e-commerce and financial services solutions**, leveraging expertise from its parent company, Alibaba Group.
- Actively develops **industry-specific cloud solutions** for various sectors.

- Known for **aggressive pricing, often competing with lower costs** compared to rivals.

Top Companies using Alibaba Cloud

- ABS-CBN
- PrestoMall (formerly 11street Malaysia)
- Hang Seng Bank
- Chow Tai Fook *Jewellery Group*

5. Oracle Cloud

Oracle Cloud is an **ERP(Enterprise Resource Planning)** based cloud service that helps you to build, deploy, and manage workloads in the cloud or on-premises. Oracle has approximately **4, 30, 000** huge numbers of clients around the world. The total revenue generated by Oracle was around **6.81 billion dollars** in 2019.

- Oracle IaaS offerings are Compute, Storage, Networking, Governance, Database, Load Balancing, DNS Monitoring, Ravello, and FastConnect.IaaS help to run any kind of workload of an Enterprise.
- Oracle PaaS offerings are Data Management, Application Development, Integration, Business Analytics, Security, Management, and Content and Enterprise. PaaS helps developers to develop, connect, secure and share data across the applications.
- Oracle SaaS offerings are CX, HCM, ERP, SCM, EPM, IoT, Analytics, Data, and Blockchain Applications. SaaS provides a complete data-driven and secure cloud environment.
- The best thing about this cloud services provider is its **chatbot** option which can help customers 24/7 whenever they face difficulties.
- Data analytics by users that help decision-makers in planning for the company's financial condition.
- Secure and better visibility to unsanctioned apps and protects against sophisticated cyberattacks.
- Payment according to the usage.

Top Companies using Oracle Cloud

- Labcorp
- Diebold Nixdorf
- CVS Health
- Universal Studios
- Zurich
- UnitedHealth Group
- Hitachi
- Ahold Delhaize
- Bank of America

6. IBM Cloud (Kyndryl)

Developed by IBM, this cloud service offers another set of solutions to the users to deploy their applications on the cloud. It offers IaaS, SaaS, and PaaS services via **public, private, hybrid and multi-cloud** models. IBM generated **5.3 billion dollars** of revenues according to Q3 2019 which is 6.4 percent higher than the previous quarter. IBM cloud offers approximately 170 products and services to meet the customer's business demands. IBM's best bets come in the form of the **Internet of Things, Cognitive Computing and Blockchain**. Recently IBM has **Red Hat**, for

the delivery of hybrid solutions efficiently. The cloud service is helping home appliance manufacturers, retailers, and medical supply businesses.

- Computer Network, Storage, Cloud Packs, Management, Security, Database, Analytics, AI, IoT, Mobile, Dev Tools, Blockchain, Integration, Migration, Private Cloud, and VMware are some services offered by IBM cloud.
- Freedom to select and unite the desired tools, data models and delivery models in designing/creating the next-generation services or applications.
- Users can manage their applications in many coding languages such as Java, Python, Swift, Php, etc.
- IBM AI helps with its multifunctional ability such as text to speech, detecting language, machine learning, classification of natural language, etc.
- Costs depends on the usage but free in its lite mode with free access to more than 40 services by IBM Cloud.
- You can incorporate **highly performing cloud communications and services** into your IT environment with the help of **IBM Bluemix** Cloud platform.

Top Companies using IBM Cloud (Kyndryl)

- City Furniture, Inc.
- Chevron Phillips Chemical (CPChem)
- Carrefour Belgium
- Canadian Malartic
- Bord Gáis Energy
- Blue NAP Americas
- Bank of Ayudhya Public Company Ltd (Krungsri)
- Arizona Department of Transportation

7. Tencent Cloud

DigitalOcean is a well-known cloud hosting provider that currently holds the **fourth largest global market share** in cloud computing, following Alibaba Cloud, AWS, and Microsoft Azure. It Has a **strong presence in China and Southeast Asia**, with growing international reach.

Service Portfolio:

- Offers a **comprehensive range of cloud solutions**, including:
  - **Compute: Cloud Virtual Machines (CVM)** for traditional VMs, **Serverless Functions (SCF)** for serverless computing, and Container Orchestration (TKE) for managing containerized applications.
  - **Storage:** Cloud Object Storage (COS) for highly scalable object storage, Cloud Block Storage (CBS) for high-performance block storage, and Cloud File Storage (CFS) for network-attached storage.
  - **Networking: Cloud Virtual Private Cloud (VPC)** for creating isolated virtual networks, Cloud Private Line (CPL) for dedicated connections, and Global Transit Gateway (GTW) for managing complex network environments.
  - **Databases: Cloud Database Service (TDSQL)** for managed databases, various managed NoSQL databases, and Data Aggregation Storage (DAS) for big data analytics.
  - **AI & ML:** Tencent AI Platform provides tools for building, training, and deploying AI models, and offers pre-trained models for various tasks.

- **Security & Identity:** Cloud Security (Tencent Cloud Security) offers various security solutions, including **Anti-DDoS protection, Web Application Firewall (WAF**), and **Key Management Service (KMS).**
- **Developer Tools:** API Gateway for managing APIs, Serverless Application Model (SAM) for developing serverless applications, and Cloud Code for integrated development and deployment.
- **Industry-Specific Solutions:** Tailored solutions for gaming, media, healthcare, finance, and more.

- Known for its **expertise in gaming and media industry solutions**, leveraging the experience of its parent company, Tencent.
- Has a strong focus on **AI and machine learning**, offering a diverse range of AI tools and pre-trained models.
- Offers **competitive pricing with various flexible payment options**, including pay-as-you-go and reserved instances.

Top Companies using Tencent Cloud

- ChangYou
- SINA Corporation
- OS – Learning Fun
- Q-See
- NBA Media Ventures, LLC

8. OVHcloud

DigitalOcean is a well-known cloud hosting provider that currently holds the **sixth largest global market share** in cloud computing, following Alibaba Cloud, AWS, Microsoft Azure, Tencent Cloud, and Google Cloud Platform. Known as a **strong player in Europe**, particularly in France, and is expanding its global presence.

Service Portfolio:

- Offers a **diverse range of cloud solutions**, including:
  - **Compute:** Dedicated servers (bare metal), Public Cloud with various VM options, Web Hosting solutions, and Private Cloud for on-premises infrastructure.
  - **Storage:** Dedicated storage solutions, Public Cloud Object Storage, Backup solutions, and High Availability storage.
  - **Networking:** Dedicated network solutions, Public Cloud Virtual Private Cloud (vRack), and managed network services.
  - **Databases:** Managed database solutions for various engines like MySQL, PostgreSQL, and MongoDB.
  - **AI & ML:** AI Marketplace with pre-trained models and solutions, and access to various AI and ML frameworks.
  - **Security & Identity:** Security solutions for various needs, including anti-DDoS protection, web application firewall, and vulnerability management.
  - **Developer Tools:** Various DevOps tools, API Gateway, and code repositories.
  - **Industry-Specific Solutions:** Tailored solutions for healthcare, media, e-commerce, and more.

- Known for its expertise in bare metal server solutions, offering high performance and customization.
- Has a strong commitment to data privacy and security, compliant with various European regulations.
- Places emphasis on open-source technologies and partnerships.
- Offers transparent and competitive pricing with various flexible options, including pay-as-you-go and commitment plans.

Top Companies using OVHcloud

- Emisora Escuela M21 Radio
- H&R Block, Inc
- Collège Boréal
- VMware Inc
- VMware Tanzu ***Observability***

9. DigitalOcean

DigitalOcean is a well-known cloud hosting provider that primarily caters to **startups, small and medium-sized businesses (SMBs), and individual developers**, holding a smaller market share compared to larger cloud providers. Known for its **strong presence in developer communities**.

Service Portfolio:

- Offers a **focused set of essential cloud solutions**, including:
  - **Compute:** Droplets (virtual machines) with various configurations and operating systems.
  - **Storage:** Block storage options for data persistence.
  - **Networking:** Private networking capabilities and additional networking add-ons.
  - **Databases:** Managed databases for popular engines like MySQL, PostgreSQL, and MariaDB.
  - **Containerization:** Managed Kubernetes platform for deploying containerized applications.
  - **App Platform:** Serverless platform for deploying web applications without managing infrastructure.
  - **Marketplace:** Additional tools and services from third-party partners.
- Prioritizes **simplicity and developer experience**, offering a user-friendly interface and APIs.
- Provides **transparent and predictable pricing**, making it cost-effective for smaller projects.
- Offers **extensive documentation and community support**, catering to developers' needs.
- Operates on a **pay-as-you-go model** with clear pricing tiers based on resource usage.
- Offers **free tier for experimentation and learning**.

Top Companies using DigitalOcean

- Shopify
- GitHub
- Airbnb

10. Linode (owned by Akamai)

Linode, which is now part of **Akamai**, is a cloud platform primarily caters to **developers, startups, and SMBs**, holding a smaller market share compared to major cloud providers. Known for its **strong developer community and focus on simplicity**.

Service Portfolio:

1. Offers a **focused set of cloud hosting solutions**, including:
   - **Nanode** and **Linode**: Virtual machines (VMs) with various configurations and operating systems.
   - **LKE**: Managed Kubernetes platform for deploying containerized applications.
   - **Managed Databases**: Managed options for popular databases like MySQL, PostgreSQL, and MongoDB.
   - **Block Storage**: Additional storage options for data persistence.
   - **Marketplace**: Additional tools and services from third-party partners.
2. Similar to DigitalOcean, Linode prioritizes **simplicity and developer experience**, offering a user-friendly interface and APIs.
3. Provides **transparent and predictable pricing**, making it cost-effective for smaller projects.
4. Offers **extensive documentation and community support**, catering to developers' needs.
5. Integrates with **Akamai's content delivery network (CDN) and security services** after the acquisition, potentially offering enhanced performance and protection.
6. Operates on a **pay-as-you-go model** with clear pricing tiers based on resource usage.
7. Offers **free tier for experimentation and learning**.

Top Companies using Linode (owned by Akamai)

- Heroku
- GitLab
- Authy
- Postmates

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