# Cloud Computing Architecture

cloud computing technology is used by both small and large organizations to **store the information** in cloud and **access** it from anywhere at anytime using the internet connection.

Cloud computing architecture is a combination of **service-oriented architecture** and **event-driven architecture**.

Cloud computing architecture is divided into the following two parts -

   o   Front End

   o   Back End

diagram shows the architecture of cloud computing –
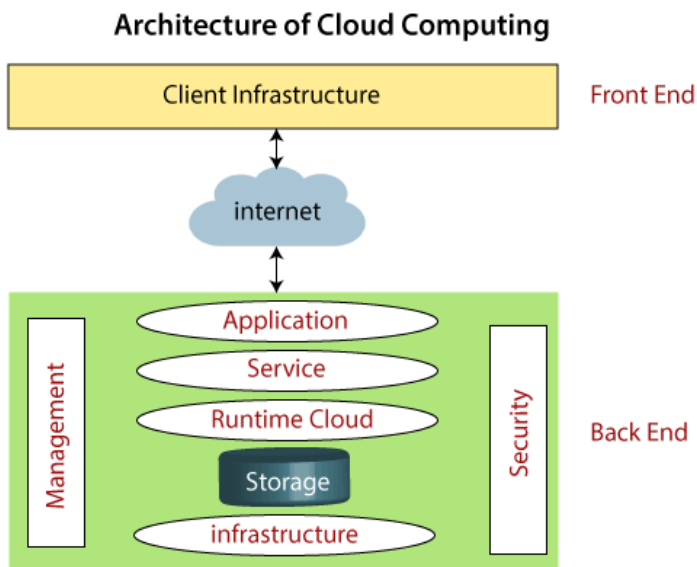
Front End

The front end is used by the client. It contains client-side interfaces and applications that are required to access the cloud computing platforms. The front end includes web servers (including Chrome, Firefox, internet explorer, etc.), thin & fat clients, tablets, and mobile devices.

Back End

The back end is used by the service provider. It manages all the resources that are required to provide cloud computing services. It includes a huge amount of data storage, security mechanism, virtual machines, deploying models, servers, traffic control mechanisms, etc.

Components of Cloud Computing Architecture

There are the following components of cloud computing architecture -

1. Client Infrastructure

Client Infrastructure is a Front end component. It provides GUI (Graphical User Interface) to interact with the cloud.

2. Application

The application may be any software or platform that a client wants to access.

3. Service

A Cloud Services manages that which type of service you access according to the client's requirement.

Cloud computing offers the following three type of services:

i. Software as a Service (SaaS) – It is also known as **cloud application services**. Mostly, SaaS applications run directly through the web browser means we do not require to download and install these applications. Some important example of SaaS is given below –

Example: Google Apps, Salesforce Dropbox, Slack, Hubspot, Cisco WebEx.

ii. Platform as a Service (PaaS) – It is also known as **cloud platform services**. It is quite similar to SaaS, but the difference is that PaaS provides a platform for software creation, but using SaaS, we can access software over the internet without the need of any platform.

Example: Windows Azure, Force.com, Magento Commerce Cloud, OpenShift.

iii. Infrastructure as a Service (IaaS) – It is also known as **cloud infrastructure services**. It is responsible for managing applications data, middleware, and runtime environments.

Example: Amazon Web Services (AWS) EC2, Google Compute Engine (GCE), Cisco Metapod.

4. Runtime Cloud

Runtime Cloud provides the **execution and runtime environment** to the virtual machines.

5. Storage

Storage is one of the most important components of cloud computing. It provides a huge amount of storage capacity in the cloud to store and manage data.

6. Infrastructure

It provides services on the **host level**, **application level**, and **network level**. Cloud infrastructure includes hardware and software components such as servers, storage, network devices, virtualization software, and other storage resources that are needed to support the cloud computing model.

7. Management

Management is used to manage components such as application, service, runtime cloud, storage, infrastructure, and other security issues in the backend and establish coordination between them.

8. Security

Security is an in-built back end component of cloud computing. It implements a security mechanism in the back end.

9. Internet

The Internet is medium through which front end and back end can interact and communicate with each other.

Cloud Computing Services and Technologies

1. Virtualization

Virtualization is the process of creating a virtual environment to run multiple applications and operating systems on the same server. The virtual environment can be anything, such as a single instance or a combination of many operating systems, storage devices, network application servers, and other environments.

The concept of Virtualization in cloud computing increases the use of virtual machines. A virtual machine is a software computer or software program that not only works as a physical computer but can also function as a physical machine and perform tasks such as running applications or programs as per the user's demand.

Types of Virtualization

A list of types of Virtualization is given below -

Hardware Virtualization: Multiple virtual machines (VMs) can run on a single physical server thanks to hardware virtualization, which abstracts away physical hardware resources. This makes it possible to consolidate servers and use resources effectively.

Server Virtualization: A physical server is divided into several virtual servers, or VMs, each of which can run its own operating system and applications. This process is known as server virtualization. It increases server efficiency and streamlines administration.
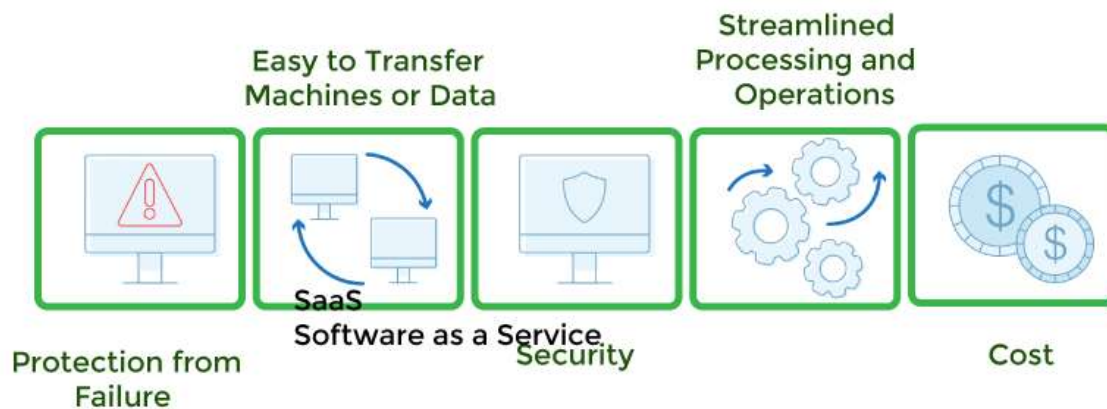
Storage Virtualization: It creates a virtualized storage pool by abstracting physical storage resources. This improves scalability and flexibility, centralizes provisioning, and simplifies management.

Operating System Virtualization: This technology enables a host operating system to host a number of segregated user-space instances, often known as containers. With quicker startup times and less overhead, it offers virtualization that is both lightweight and effective.

Data Virtualization: It creates a cohesive virtual picture by abstracting data from diverse sources. Data integration is facilitated, and real-time data access is made possible by the ability of users and programs to access and alter data as if it were kept in a single location.

These virtualization techniques enhance IT environments' resource utilization, scalability, flexibility, and management effectiveness.

Benefits of Virtualization in Cloud Computing

| Protection from Failure | Easy to Transfer Machines or Data | SaaS Software as a Service Security | Streamlined Processing and Operations | Cost |

2. Service-Oriented Architecture (SOA)

Service-Oriented Architecture (SOA) allows organizations to access on-demand cloud-based computing solutions according to the change in business needs. It can work without or with cloud computing. The advantages of using SOA are that it is easy to maintain, platform-independent, and highly scalable.

Service Providers and Service consumers are the two major roles within SOA.

Applications of Service-Oriented Architecture:

There are the following applications of Service-Oriented Architecture -

Mobile Applications and Games: SOA offers a flexible and scalable architecture that enables smooth integration with back-end services and effective data management for the development of mobile applications and games.

Defense and the Air Force: The implementation of situational awareness systems for the air force makes use of SOA infrastructure, enabling real-time data integration from many sources, boosting decision-making abilities, and better mission planning and execution.

Healthcare: SOA is used in healthcare systems to provide secure patient information sharing, promote interoperability between various healthcare providers, and enhance the effectiveness of clinical procedures.

E-commerce: To enable scalable and adaptable e-commerce operations, SOA is utilized in online shopping platforms, payment gateways, and inventory management systems.

Financial Services: Integrating stock trading, banking, and insurance systems using SOA enables secure transactions and real-time data processing.

Government Systems: In government organizations, SOA promotes information sharing, cross-departmental cooperation, and citizen-centric services.

Supply Chain Management: SOA improves coordination and response by linking suppliers, manufacturers, distributors, and retailers. These streamlines supply chain processes.

Enterprise Resource Planning (ERP): SOA combines different corporate processes, including accounting, human resources, sales, and inventory control, in ERP systems.

Telecommunications: SOA combines phone, data, and video services across several networks to improve service delivery and client satisfaction.

Logistics and Transportation: SOA enhances efficiency and lowers costs in logistics and transportation systems by optimizing routing, monitoring shipments, and managing fleet operations.

The service-oriented architecture is shown below:

3. Grid Computing

Grid computing is also known as distributed computing. It is a processor architecture that combines various different computing resources from multiple locations to achieve a common goal. In grid computing, the grid is connected by parallel nodes to form a computer cluster. These computer clusters are in different sizes and can run on any operating system.

Grid computing contains the following three types of machines -

Control Node: It is a group of servers that administrates the whole network.

Provider: It is a computer that contributes its resources to the network resource pool.

User: It is a computer that uses the resources on the network.

Mainly grid computing is used in ATMs, back-end infrastructures, and marketing research.

4. Utility Computing

Utility computing is the most trending IT service model. It provides on-demand computing resources (computation, storage, and programming services via API) and infrastructure based on the pay-per-use method. It minimizes the associated costs and maximizes the efficient use of resources. The advantage of utility computing is that it reduces IT costs, provides greater flexibility, and is easier to manage.

Large organizations such as Google and Amazon established their own utility services for computing storage and application.

How does cloud computing work

Assume that you are an executive at a very big corporation. Your particular responsibilities include to make sure that all of your employees have the right hardware and software they need to do their jobs. To buy computers for everyone is not enough. You also have to purchase software as well as software licenses and then provide these softwares to your employees as they require. Whenever you hire a new employee, you need to buy more software or make sure your current software license allows another user. It is so stressful that you have to spend lots of money.

But, there may be an alternative for executives like you. So, instead of installing a suite of software for each computer, you just need to load one application. That application will allow the employees to log-in into a Web-based service which hosts all the programs for the user that is required for his/her job. Remote servers owned by another company and that will run everything from e-mail to word processing to complex data analysis programs. It is called cloud computing, and it could change the entire computer industry.
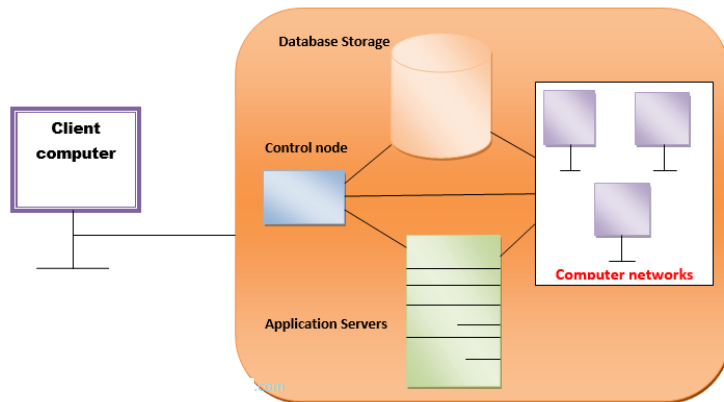
In a cloud computing system, there is a significant workload shift. Local computers have no longer to do all the heavy lifting when it comes to run applications. But cloud computing can handle that much heavy load easily and automatically. Hardware and software demands on the user's side decrease. The only thing the user's computer requires to be able to run is the cloud computing interface software of the system, which can be as simple as a Web browser and the cloud's network takes care of the rest.

Cloud Computing Applications

Cloud service providers provide various applications in the field of art, business, data storage and backup services, education, entertainment, management, social networking, etc.

1. Art Applications

Cloud computing offers various art applications for quickly and easily design **attractive cards, booklets,** and **images**. Some most commonly used cloud art applications are given below:

i Moo

Moo is one of the best cloud art applications. It is used for designing and printing business cards, postcards, and mini cards.

ii. Vistaprint

Vistaprint allows us to easily design various printed marketing products such as business cards, Postcards, Booklets, and wedding invitations cards.

iii. Adobe Creative Cloud

Adobe creative cloud is made for designers, artists, filmmakers, and other creative professionals. It is a suite of apps which includes PhotoShop image editing programming, Illustrator, InDesign, TypeKit, Dreamweaver, XD, and Audition.

2. Business Applications

Business applications are based on cloud service providers. Today, every organization requires the cloud business application to grow their business. It also ensures that business applications are 24*7 available to users.

There are the following business applications of cloud computing -

i. MailChimp

MailChimp is an **email publishing platform** which provides various options to **design, send,** and **save** templates for emails.

iii. Salesforce

Salesforce platform provides tools for sales, service, marketing, e-commerce, and more. It also provides a cloud development platform.

iv. Chatter

Chatter helps us to **share important information** about the organization in real time.

v. Bitrix24

Bitrix24 is a **collaboration** platform which provides communication, management, and social collaboration tools.

vi. Paypal

Paypal offers the simplest and easiest **online payment** mode using a secure internet account. Paypal accepts the payment through debit cards, credit cards, and also from Paypal account holders.

vii. Slack

Slack stands for **Searchable Log of all Conversation and Knowledge**. It provides a **user-friendly** interface that helps us to create public and private channels for communication.

viii. Quickbooks

Quickbooks works on the terminology "**Run Enterprise anytime, anywhere, on any device**." It provides online accounting solutions for the business. It allows more than 20 users to work simultaneously on the same system.

3. Data Storage and Backup Applications

Cloud computing allows us to store information (data, files, images, audios, and videos) on the cloud and access this information using an internet connection. As the cloud provider is

responsible for providing security, so they offer various backup recovery application for retrieving the lost data.

A list of data storage and backup applications in the cloud are given below -

i. Box.com

Box provides an online environment for **secure content management, workflow,** and **collaboration**. It allows us to store different files such as Excel, Word, PDF, and images on the cloud. The main advantage of using box is that it provides drag & drop service for files and easily integrates with Office 365, G Suite, Salesforce, and more than 1400 tools.

ii. Mozy

Mozy provides powerful **online backup solutions** for our personal and business data. It schedules automatically back up for each day at a specific time.

iii. Joukuu

Joukuu provides the simplest way to **share** and **track cloud-based backup files**. Many users use joukuu to search files, folders, and collaborate on documents.

iv. Google G Suite

Google G Suite is one of the best **cloud storage** and **backup** application. It includes Google Calendar, Docs, Forms, Google+, Hangouts, as well as cloud storage and tools for managing cloud apps. The most popular app in the Google G Suite is Gmail. Gmail offers free email services to users.

4. Education Applications

Cloud computing in the education sector becomes very popular. It offers various **online distance learning platforms** and **student information portals** to the students. The advantage of using cloud in the field of education is that it offers strong virtual classroom environments, Ease of accessibility, secure data storage, scalability, greater reach for the students, and minimal hardware requirements for the applications.

There are the following education applications offered by the cloud -

i. Google Apps for Education

Google Apps for Education is the most widely used platform for free web-based email, calendar, documents, and collaborative study.

ii. Chromebooks for Education

Chromebook for Education is one of the most important Google's projects. It is designed for the purpose that it enhances education innovation.

iii. Tablets with Google Play for Education

It allows educators to quickly implement the latest technology solutions into the classroom and make it available to their students.

iv. AWS in Education

AWS cloud provides an education-friendly environment to universities, community colleges, and schools.

5. Entertainment Applications

Entertainment industries use a **multi-cloud strategy** to interact with the target audience. Cloud computing offers various entertainment applications such as online games and video conferencing.

i. Online games

Today, cloud gaming becomes one of the most important entertainment media. It offers various online games that run remotely from the cloud. The best cloud gaming services are Shaow, GeForce Now, Vortex, Project xCloud, and PlayStation Now.

ii. Video Conferencing Apps

Video conferencing apps provides a simple and instant connected experience. It allows us to communicate with our business partners, friends, and relatives using a cloud-based video conferencing. The benefits of using video conferencing are that it reduces cost, increases efficiency, and removes interoperability.

6. Management Applications

Cloud computing offers various cloud management tools which help admins to manage all types of cloud activities, such as resource deployment, data integration, and disaster recovery. These management tools also provide administrative control over the platforms, applications, and infrastructure.

Some important management applications are -

i. Toggl

Toggl helps users to track allocated time period for a particular project.

ii. Evernote

Evernote allows you to sync and save your recorded notes, typed notes, and other notes in one convenient place. It is available for both free as well as a paid version.

It uses platforms like Windows, macOS, Android, iOS, Browser, and Unix.

iii. Outright

Outright is used by management users for the purpose of accounts. It helps to track income, expenses, profits, and losses in real-time environment.

iv. GoToMeeting

GoToMeeting provides **Video Conferencing** and **online meeting apps**, which allows you to start a meeting with your business partners from anytime, anywhere using mobile phones or tablets. Using GoToMeeting app, you can perform the tasks related to the management such as join meetings in seconds, view presentations on the shared screen, get alerts for upcoming meetings, etc.

7. Social Applications

Social cloud applications allow a large number of users to connect with each other using social networking applications such as **Facebook, Twitter, Linkedln,** etc.

There are the following cloud based social applications -

i. Facebook

Facebook is a **social networking website** which allows active users to share files, photos, videos, status, more to their friends, relatives, and business partners using the cloud storage system. On Facebook, we will always get notifications when our friends like and comment on the posts.

ii. Twitter

Twitter is a **social networking** site. It is a **microblogging** system. It allows users to follow high profile celebrities, friends, relatives, and receive news. It sends and receives short posts called tweets.

iii. Yammer

Yammer is the **best team collaboration** tool that allows a team of employees to chat, share images, documents, and videos.

iv. LinkedIn

LinkedIn is a **social network** for students, freshers, and professionals.

<u>Security Challenges and Considerations in Cloud Computing</u>

A key component of cloud computing is security. Despite the numerous precautions that cloud providers take to ensure the security of their infrastructure and services, there are still some security issues and factors that businesses need to be aware of.

- o **Compliance:** Using cloud services may be subject to legal compliance regulations, depending on the industry. Organizations must make sure their cloud provider complies with these specifications and has access to the required paperwork.

- o **Data Loss:** Data loss is the most common cloud security risk of cloud computing. It is also known as data leakage. Data loss is the process in which data is deleted, corrupted, and unreadable by a user, software, or application. In a cloud computing environment, data loss occurs when our sensitive data is in somebody else's hands, one or more data elements can not be utilized by the data owner, the hard disk is not working properly, and the software is not updated.

- o **Data Breach:** It is the process in which confidential data is viewed, accessed, or stolen by a third party without any authorization, so the organization's data is hacked by hackers.

- o **Account Hijacking:** It is a serious security risk in cloud computing. It is the process in which individual users' or organizations' cloud account (bank account, e-mail account, and social media account) is stolen by hackers. The hackers use the stolen account to perform unauthorized activities.

- o **Spectre & Meltdown:** Spectre & Meltdown allows programs to view and steal data that is currently processed on the computer. It can run on personal computers, mobile devices, and in the cloud. It can store the password, and your personal information, such as images, e-mails, and business documents, in the memory of other running programs.

- o **Increased Complexity Strains IT Staff:** Migrating, integrating, and operating the cloud services is complex for the IT staff. IT staff must require the extra capability and skills to manage, integrate, and maintain the data in the cloud.

- o **Data Security and Privacy:** The security of sensitive data is one of the main issues with cloud computing. Access controls must be in place to restrict who can access the data, and organizations must make sure that their data is encrypted both in transit and at rest.

- o **Vendor Lock-In:** Switching cloud providers can be expensive and complex, which might result in vendor lock-in. When choosing a cloud provider, businesses should take this into account and make sure they have a plan in place in case switching providers becomes essential.

- o **DDoS:** Cloud service companies are a prime target for distributed denial of service (DDoS) attacks, which can cause downtime and data loss. Organizations should verify that the cloud provider has sufficient defenses against DDoS assaults in place.

- o **Identity and Access Management:** The security of cloud computing environments depends on effective identity and access management. To prevent unauthorized access to their data, organizations must make sure that they have robust authentication and authorization mechanisms in place.

- o **Monitoring and Logging:** Monitoring and logging services are frequently offered by cloud providers. These services can assist organizations in identifying and addressing security concerns. However, businesses must make sure they have the systems and procedures in place to analyze the data and take appropriate action.

- o **Shared Infrastructure:** Cloud service providers frequently employ this type of setup, which allows several businesses to use the same hardware and software resources. Organizations should make sure their cloud provider has proper isolation mechanisms in place because this could result in security issues like cross-tenant attacks.

Types of Cloud

Cloud computing is a revolutionary technology transforming how we store, access, and process data. It simply refers to delivering computing resources, such as servers, storage, databases, software, and applications, over the Internet. Cloud computing uses a network of remote computer systems housed on the net to save and process data rather than relying on physical infrastructure.

Cloud service companies use advanced security techniques, which include encryption, firewalls, and access restrictions, to secure your data from unauthorized access. Moreover, because your information is saved in the cloud, it is secure even if your nearby devices are damaged, misplaced, or stolen. Redundancy and cloud backups guarantee that your data may be restored promptly and effectively in case of any unexpected situations.
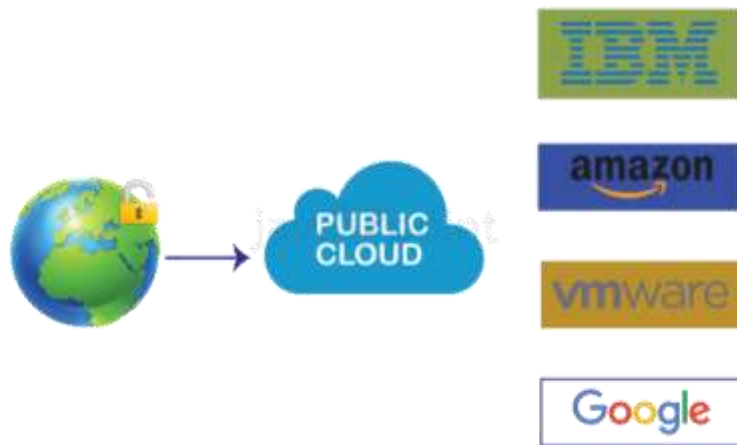
Public Cloud

Public cloud is open to all to store and access information via the Internet using the pay-per-usage method.

In public cloud, computing resources are managed and operated by the Cloud Service Provider (CSP). The CSP looks after the supporting infrastructure and ensures that the resources are accessible to and scalable for the users.

Due to its open architecture, anyone with an internet connection may use the public cloud, regardless of location or company size. Users can use the CSP's numerous services, store their

data, and run apps. By using a pay-per-usage strategy, customers can be assured that they will only be charged for the resources they actually use, which is a smart financial choice.

Example: Amazon elastic compute cloud (EC2), IBM SmartCloud Enterprise, Microsoft, Google App Engine, Windows Azure Services Platform.

Characteristics of Public Cloud

The public cloud has the following key characteristics:

- o **Accessibility:** Public cloud services are available to anyone with an internet connection. Users can access their data and programs at any time and from anywhere.

- o **Shared Infrastructure:** Several users share the infrastructure in public cloud settings. Cost reductions and effective resource use are made possible by this.

- o **Scalability:** By using the public cloud, users can easily adjust the resources they need based on their requirements, allowing for quick scaling up or down.

- o **Pay-per-Usage:** When using the public cloud, payment is based on usage, so users only pay for the resources they actually use. This helps optimize costs and eliminates the need for upfront investments.

- o **Managed by Service Providers:** Cloud service providers manage and maintain public cloud infrastructure. They handle hardware maintenance, software updates, and security tasks, relieving users of these responsibilities.

- o **Reliability and Redundancy:** Public cloud providers ensure high reliability by implementing redundant systems and multiple data centers. By doing this, the probability of losing data and experiencing service disruptions is reduced.

- o **Security Measures:** Public cloud providers implement robust security measures to protect user data. These include encryption, access controls, and regular security audits.

Advantages of Public Cloud

There are the following advantages of Public Cloud -

- o Public cloud is owned at a lower cost than the private and hybrid cloud.

- o Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.

- o Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.

- o Public cloud is location independent because its services are delivered through the internet.

- o Public cloud is highly scalable as per the requirement of computing resources.

- o It is accessible by the general public, so there is no limit to the number of users.

- o Rapid deployment of services and applications.

- o Reduced time and effort in hardware procurement and setup.

- o The cloud provider offers a range of services and resources that you can avail of.

- o Built-in redundancy and resilience for enhanced reliability.

Disadvantages of Public Cloud

- o Public Cloud is less secure because resources are shared publicly.

- o Performance depends upon the high-speed internet network link to the cloud provider.

- o The data is not under the control of the client.

- o Dependency on the cloud service provider for availability and service level agreements.

- o Compliance challenges in meeting industry-specific regulations and standards.

- o Risk of vendor lock-in and limited portability of applications and data.

- o Concerns about data privacy and confidentiality.

- o Potential for unexpected costs with usage-based pricing models.

- o Lack of customization options and flexibility compared to private or hybrid cloud environments.

- o Reliance to the cloud provider's support and responsiveness for issue resolution.

Private Cloud

Private cloud is also known as an **internal cloud** or **corporate cloud**. It is used by organizations to build and manage their own data centers internally or by the third party. It can be deployed using Opensource tools such as Openstack and Eucalyptus.
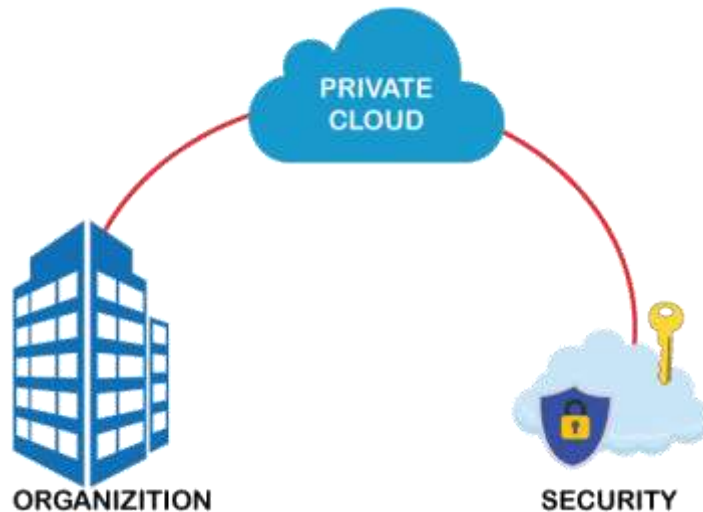
Examples: VMware vSphere, OpenStack, Microsoft Azure Stack, Oracle Cloud at Customer, and IBM Cloud Private.

Based on the location and management, National Institute of Standards and Technology (NIST) divide private cloud into the following two parts-

- o **On-premise private cloud:** An on-premise private cloud is situated within the physical infrastructure of the organization. It involves setting up and running a specific data center that offers cloud services just for internal usage by the company. The infrastructure is still completely under the hands of the organization, which gives them the freedom to modify and set it up in any way they see fit. Organizations can successfully manage security and compliance issues with this degree of control. However, on-premise private cloud setup and management necessitate significant hardware, software, and IT knowledge expenditures.

- o **Outsourced private cloud:** An outsourced private cloud involves partnering with a third-party service provider to host and manage the cloud infrastructure on behalf of the organization. The provider may operate the private cloud in their data center or a colocation facility. In this arrangement, the organization benefits from the expertise and resources of the service provider, alleviating the burden of infrastructure management. The outsourced private cloud model offers scalability, as the provider can adjust resources based on the organization's needs. Due to its flexibility, it is a desirable choice

for businesses that desire the advantages of a private cloud deployment without the initial capital outlay and ongoing maintenance expenses involved with an on-premise implementation.

Compared to public cloud options, both on-premise and external private clouds give businesses more control over their data, apps, and security. Private clouds are particularly suitable for organizations with strict compliance requirements, sensitive data, or specialized workloads that demand high levels of customization and security.

Characteristics of Private Cloud

The private cloud has the following key characteristics:

- o **Exclusive Use:** Private cloud is dedicated to a single organization, ensuring the resources and services are tailored to its needs. It is like having a personal cloud environment exclusively for that organization.

- o **Control and Security:** Private cloud offers organizations higher control and security than public cloud options. Organizations have more control over data governance, access controls, and security measures.

- o **Customization and Flexibility:** Private cloud allows organizations to customize the infrastructure according to their specific requirements. They can configure resources, networks, and storage to optimize performance and efficiency.

- o **Scalability and Resource Allocation:** The private cloud can scale and allocate resources. According to demand, businesses may scale up or down their infrastructure, effectively using their resources.

- o **Performance and dependability:** Private clouds give businesses more control over the infrastructure at the foundation, improving performance and dependability.

- o **Compliance and Regulatory Requirements:** Organizations may more easily fulfill certain compliance and regulatory standards using the private cloud. It provides the freedom to put in place strong security measures, follow data residency laws, and follow industry-specific norms.

- o **Hybrid Cloud Integration:** Private cloud can be integrated with public cloud services, forming a hybrid cloud infrastructure. This integration allows organizations to leverage the benefits of both private and public clouds.

Advantages of Private Cloud

There are the following advantages of the Private Cloud -

- o Private cloud provides a high level of security and privacy to the users.

- o Private cloud offers better performance with improved speed and space capacity.

- o It allows the IT team to quickly allocate and deliver on-demand IT resources.

- o The organization has full control over the cloud because it is managed by the organization itself. So, there is no need for the organization to depends on anybody.

- o It is suitable for organizations that require a separate cloud for their personal use and data security is the first priority.

- o Customizable to meet specific business needs and compliance regulations.

- o Higher reliability and uptime compared to public cloud environments.

- o Seamless integration with existing on-premises systems and applications.

- o Better compliance and governance capabilities for industry-specific regulations.

- o Enhanced flexibility in resource allocation and application deployment.

Disadvantages of Private Cloud

- o Skilled people are required to manage and operate cloud services.

- o Private cloud is accessible within the organization, so the area of operations is limited.

- o Private cloud is not suitable for organizations that have a high user base, and organizations that do not have the prebuilt infrastructure, sufficient manpower to maintain and manage the cloud.

- o Higher upfront costs and ongoing maintenance expenses.

- o Scaling resources can be challenging compared to public or hybrid cloud options.

- o Relies on internal IT staff for management and troubleshooting.

- o Slower deployment timelines and implementation compared to public cloud solutions.

- o Limited access to the latest advancements and innovations offered by public cloud providers.

- o Reduced flexibility and agility compared to public cloud options.

- o Challenges in keeping up with hardware and software upgrades and compatibility.

o Higher risks of technology becoming outdated and the need for regular infrastructure updates.

Hybrid Cloud

Hybrid Cloud is a combination of the public cloud and the private cloud. we can say:
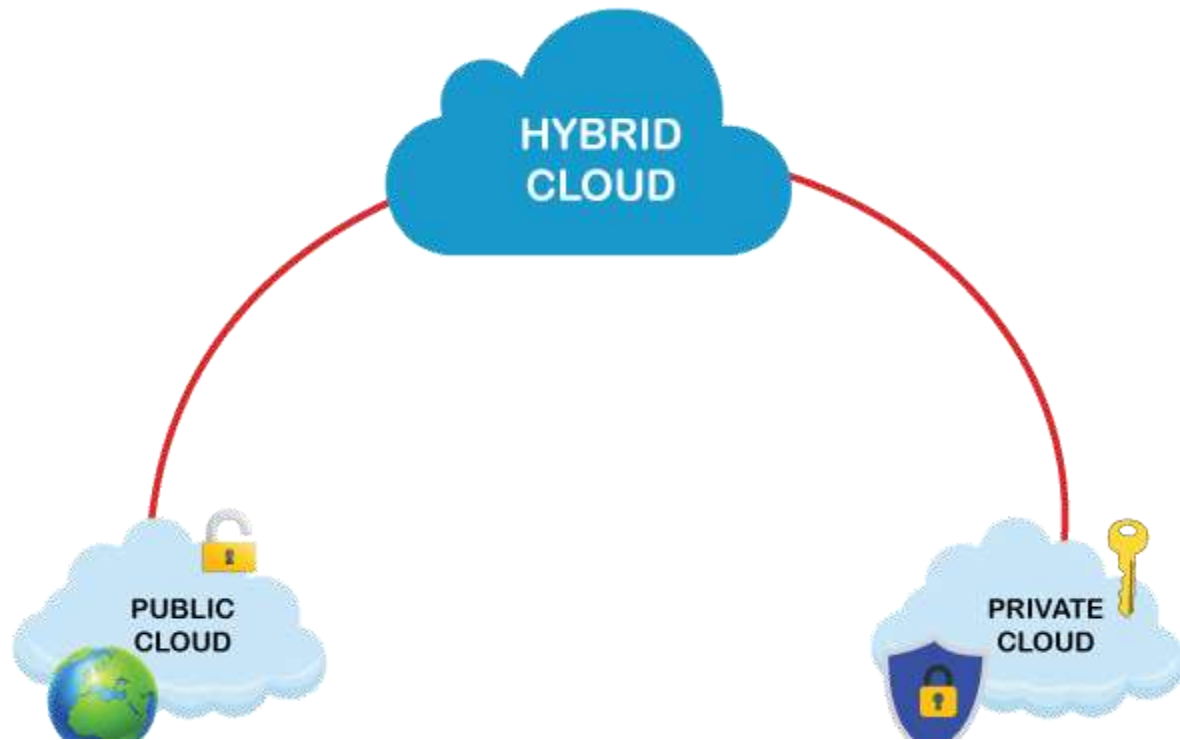
Hybrid Cloud = Public Cloud + Private Cloud

Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users. In a hybrid cloud setup, organizations can leverage the benefits of both public and private clouds to create a flexible and scalable computing environment. The public cloud portion allows using cloud services provided by third-party providers, accessible over the Internet.

Example: Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.

Characteristics of Hybrid Cloud

o **Integration of Public and Private Clouds:** Hybrid cloud seamlessly integrates public and private clouds, allowing organizations to leverage both advantages. It provides a unified platform where workloads and data can be deployed and managed across both environments.

- o **Flexibility and Scalability:** Hybrid cloud offers resource allocation and scalability flexibility. Organizations can dynamically scale their infrastructure by utilizing additional resources from the public cloud while maintaining control over critical workloads on the private cloud.

- o **Enhanced Security and Control:** Hybrid cloud allows organizations to maintain higher security and control over their sensitive data and critical applications. Private cloud components provide a secure and dedicated environment, while public cloud resources can be used for non-sensitive tasks, ensuring a balanced approach to data protection.

- o **Cost Optimization:** Hybrid cloud enables organizations to optimize costs by utilizing the cost-effective public cloud for non-sensitive workloads while keeping mission-critical applications and data on the more cost-efficient private cloud. This approach allows for efficient resource allocation and cost management.

- o **Data and Application Portability:** Organizations can move workloads and data between public and private clouds as needed with a hybrid cloud. This portability offers agility and the ability to adapt to changing business requirements, ensuring optimal performance and responsiveness.

- o **Compliance and Regulatory Compliance:** Hybrid cloud helps organizations address compliance and regulatory requirements more effectively. Sensitive data and applications can be kept within the private cloud, ensuring compliance with industry-specific regulations while leveraging the public cloud for other non-sensitive operations.

- o **Disaster Recovery and Business Continuity:** Hybrid cloud facilitates robust disaster recovery and business continuity strategies. Organizations can replicate critical data and applications between the private and public clouds, ensuring redundancy and minimizing the risk of data loss or service disruptions.

Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

- o Hybrid cloud is suitable for organizations that require more security than the public cloud.

- o Hybrid cloud helps you to deliver new products and services more quickly.

- o Hybrid cloud provides an excellent way to reduce the risk.

- o Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

- Hybrid facilitates seamless integration between on-premises infrastructure and cloud environments.

- Hybrid provides greater control over sensitive data and compliance requirements.

- Hybrid enables efficient workload distribution based on specific needs and performance requirements.

- Hybrid offers cost optimization by allowing organizations to choose the most suitable cloud platform for different workloads.

- Hybrid enhances business continuity and disaster recovery capabilities with private and public cloud resources.

- Hybrid supports hybrid cloud architecture, allowing applications and data to be deployed across multiple cloud environments based on their unique requirements.

Disadvantages of Hybrid Cloud

- In Hybrid Cloud, security feature is not as good as the private cloud.

- Managing a hybrid cloud is complex because it is difficult to manage more than one type of deployment model.

- In the hybrid cloud, the reliability of the services depends on cloud service providers.

- Potential challenges in data integration and ensuring seamless connectivity between different cloud platforms.

- Higher costs due to the need for managing and integrating multiple cloud environments.

- Increased complexity in data governance and compliance management across different cloud providers.

- Dependency on stable and high-bandwidth internet connections for efficient hybrid cloud operations.

- Potential compatibility issues between various cloud platforms and applications.

- Risk of vendor lock-in and limited portability of applications and data across different cloud providers.

- Requires skilled IT staff with expertise in managing hybrid cloud environments.

Community Cloud

Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.

In a community cloud setup, the participating organizations, which can be from the same industry, government sector, or any other community, collaborate to establish a shared cloud infrastructure. This infrastructure allows them to access shared services, applications, and data relevant to their community.
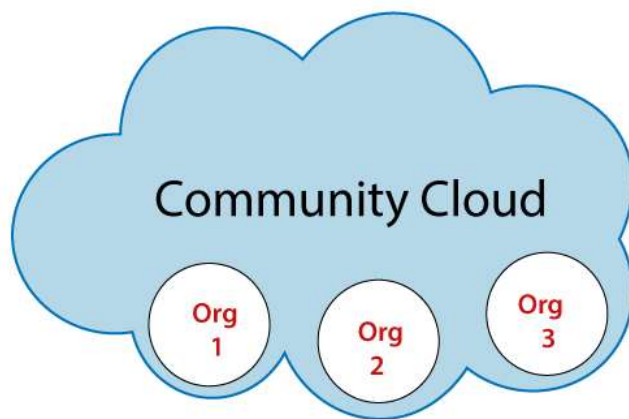
Example: Health Care community cloud

Characteristics of Community Cloud

- o **Shared Infrastructure:** Community cloud provides a shared infrastructure accessible to a specific community of organizations. The participating organizations can leverage this common cloud infrastructure to meet their shared computing needs and objectives.

- o **Community-specific Services:** The community cloud provides resources, apps, and services adapted to the participating organizations' demands. These services are created to meet the community's specific requirements and difficulties while promoting effective communication and information exchange.

- o **Community Ownership and Management:** The community cloud is owned, managed, and operated by one or more organizations from the community, a third party, or a combination of both. The involved organizations have a say in the governance and decision-making procedures to ensure that the cloud infrastructure meets their shared objectives.

- o **Enhanced Security and Compliance:** Community cloud emphasizes security and compliance measures relevant to the specific community. It allows for implementing robust security controls, access management, and compliance frameworks that meet the community's regulatory requirements and industry standards.

- o **Cost Sharing and Efficiency:** Participating organizations in a community cloud benefit from cost sharing. By sharing the infrastructure and resources, the costs associated with establishing and maintaining the cloud environment are distributed among the community members. This leads to cost efficiency and reduced financial burden for individual organizations.

- o **Collaboration and Knowledge Sharing:** The community cloud encourages communication and information exchange amongst participating businesses. It gives community members a forum for project collaboration, information sharing, and resource exploitation. This encourages creativity, education, and effectiveness within the neighborhood.

- o **Scalability and Flexibility:** Community cloud enables organizations to scale up or reduce their resources in response to demand. This allows the community to adjust to shifting computing requirements and efficiently use cloud resources as needed.

Advantages of Community Cloud

There are the following advantages of Community Cloud -

- o Community cloud is cost-effective because the whole cloud is being shared by several organizations or communities.

- o Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.

- o It provides better security than the public cloud.

- o It provdes collaborative and distributive environment.

- o Community cloud allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

- o Offers customization options to meet the unique needs and requirements of the community.

- o Simplifies compliance with industry-specific regulations and standards through shared security measures.

- o Provides scalability and flexibility, allowing organizations to scale resources based on changing demands.

- o Promotes efficient resource utilization, reducing wastage, and optimizing performance within the community.

- o Enables organizations to leverage shared expertise and experiences, leading to improved decision-making and problem-solving.

Disadvantages of Community Cloud

- o Community cloud is not a good choice for every organization.

- o Security features are not as good as the private cloud.

- o It is not suitable if there is no collaboration.

- o The fixed amount of data storage and bandwidth is shared among all community members.

- o Challenges in ensuring consistent performance and availability when multiple organizations share the same resources.

- o Limited scalability options as the shared resources determine the community cloud's capacity.

- o Potential conflicts of interest among community members regarding resource allocation and usage.

- o Transparent governance and agreement frameworks are required to address potential disputes and ensure fair resource distribution.

- o Inadequate technical support and service level agreements (SLAs) compared to private or public cloud options.

Difference between public cloud, private cloud, hybrid cloud, and community cloud -

Parameter	Public Cloud	Private Cloud	Hybrid Cloud	Community Cloud	Multi-Cloud
Host	Service provider	Enterprise (Third party)	Enterprise (Third party)	Community (Third party)	Multiple cloud providers
Users	General public	Selected users	Selected users	Community members	Multiple organizations
Access	Internet	Internet, VPN	Internet, VPN	Internet, VPN	Internet, VPN
Owner	Service provider	Enterprise	Enterprise	Community	Multiple organizations
Cost	Pay-per-usage	Infrastructure investment	Mixed (variable)	Shared cost among members	Variable depending on usage
Security	Provider's responsibility	Enhanced control	Varied (depends on setup)	Varied (depends on setup)	Varied (depends on setup)
Scalability	Highly scalable	Scalable within resources	Scalable within resources	Scalable within resources	Scalable within resources
Customization	Limited control	High control	Varied (depends on setup)	Varied (depends on setup)	Varied (depends on setup)
Resource Sharing	Not shared	Not shared	Varied (depends on setup)	Shared among community	Shared among providers

Cloud Service Models

Infrastructure as a Service | IaaS

Iaas is also known as Hardware as a Service (HaaS). It is one of the layers of the cloud computing platform. It allows customers to outsource their IT infrastructures, such as servers, networking, processing, storage, virtual machines, and other resources. Customers access these resources on the Internet using a pay-as-per-use model.

In traditional hosting services, IT infrastructure was rented out for a specific period of time, with pre-determined hardware configuration. The client paid for the configuration and time, regardless of the actual use. With the help of the IaaS cloud computing platform layer, clients can dynamically scale the configuration to meet changing requirements and are billed only for the services actually used.

The IaaS cloud computing platform layer eliminates the need for every organization to maintain its IT infrastructure.

IaaS is offered in three models: public, private, and hybrid cloud. The private cloud implies that the infrastructure resides at the customer's premise. In the case of the public cloud, it is located at the cloud computing platform vendor's data center, and the hybrid cloud is a combination of the two in which the customer selects the best of both public cloud and private cloud.

Some of the Primary Characteristics of IaaS are:

o   Scalability: IaaS enables users to adjust computing capacity according to their demands without requiring long lead times or up-front hardware purchases.

o   Virtualization: IaaS uses virtualization technology to generate virtualized instances that can be managed and delivered on-demand by abstracting physical computer resources.

o   Resource Pooling: This feature enables users to share computer resources, such as networking and storage, among a number of users, maximizing resource utilization and cutting costs.

o   Elasticity: IaaS allows users to dynamically modify their computing resources in response to shifting demand, ensuring optimum performance and financial viability.

o   Self-Service: IaaS offers consumers "self-service" portals that let them independently deploy, administer, and monitor their computing resources without the assistance of IT employees.

o   Availability: To ensure the high availability and reliability of services, IaaS providers often run redundant and geographically dispersed data centers.

- o Security: To safeguard their infrastructure and client data, IaaS companies adopt security measures, including data encryption, firewalls, access controls, and threat detection.

- o Customization: IaaS enables users to alter the operating systems, application stacks, and security settings of their virtualized instances to suit their unique requirements.

IaaS, or infrastructure as a service, is a cloud computing model that offers users virtualized computer resources on a pay-per-use basis.

Users can scale their resources up or down in accordance with their demands while taking advantage of high availability, security, and customization possibilities.

IaaS provider provides the following services -

Computing: To provision virtual machines (VMs) for end users, IaaS providers offer virtual central processing units (CPUs) and virtual main memory. As a result, users may run their workloads and apps on the provider's infrastructure without having to worry about managing the underlying hardware.

Storage: Back-end storage services are provided by IaaS providers, enabling users to store and access their files and data. This offers scalable and trustworthy storage solutions for a variety of use cases and can include block storage, object storage, or file storage alternatives.

Network: IaaS providers provide networking tools, including routers, switches, and bridges for the VMs through Network as a Service (NaaS). This enables connectivity and communication between VMs and other resources while also allowing customers to create and maintain their network architecture within the IaaS environment.

Load balancers: Infrastructure-layer load balancing services are provided by IaaS providers. Incoming network traffic is split up among many virtual machines (VMs) or resources by load balancers, resulting in effective resource management and excellent application and service availability.

Security: Security features and services are frequently offered by IaaS providers as part of their offering. To safeguard data and resources housed on the IaaS platform, this can include network security, firewall configurations, access controls, encryption, and other security measures.

Backup and disaster recovery services are provided by some IaaS providers, enabling customers to create backup copies of their data and software and put recovery plans in place in the event of data loss or system problems. This promotes business continuity and data security.

Monitoring and Management: IaaS suppliers provide tools and services for monitoring and controlling the resources and infrastructure. This can involve managing VMs, storage, and network configurations using management panels or APIs, as well as measuring resource utilization, automating scaling, and monitoring performance.

It's vital to remember that depending on the provider and their offerings, the precise services offered by IaaS providers may change. The list above illustrates some typical IaaS providers' common services.

Virtualized Computing Resources:

o Cloud computing's Infrastructure as a Service (IaaS) model must include virtualized computer resources. IaaS enables users to rent computer infrastructure from cloud service providers over the internet, including virtual machines (VMs), virtual networks, and storage.

o In IaaS, virtual machines (VMs) are a crucial type of virtualized computing resource. Multiple operating systems and applications can operate on a single physical host machine thanks to virtual machines (VMs), which are software simulations of real hardware. Customers can select the VM that best matches their needs from a variety of VM types that IaaS providers normally offer, each with a different CPU, memory, and storage configuration.

o Virtual Networks: Another virtualized computing resource in IaaS is virtual networks. Customers can design and maintain network topologies in the cloud, including subnets, IP addresses, and routing tables, using virtual networks. Virtual networks offer clients' applications and data a secure, decoupled environment and make it simple to integrate them with on-premises networks.

o A crucial virtualized computing resource in IaaS is storage. IaaS providers frequently offer various storage options, including block, object, and file storage, each with its own performance, pricing, and cost-effectiveness features. Because storage resources are highly scalable, clients can alter their storage capacity as needed without having to change their actual hardware.

o In comparison to conventional on-premises hardware architecture, virtualized computing resources have better scalability, flexibility, and cost-effectiveness. Without making expensive hardware investments or taking care of their own data centers, customers may rent the computing capabilities they require on demand and only pay for what they use.

Advantages of IaaS Cloud Computing Layer

There are the following advantages of the IaaS computing layer -

1. Shared infrastructure

IaaS allows multiple users to share the same physical infrastructure.

2. Web access to the resources

Iaas allows IT users to access resources over the internet.

3. Pay-as-per-use model

IaaS providers provide services based on a pay-as-per-use basis. The users are required to pay for what they have used.

4. Focus on the core business

IaaS providers focus on the organization's core business rather than on IT infrastructure.

5. On-demand scalability

On-demand scalability is one of the biggest advantages of IaaS. Using IaaS, users do not worry about upgrading software and troubleshooting issues related to hardware components.

Disadvantages of IaaS Cloud Computing Layer

Security: In the IaaS context, security is still a major problem. Although IaaS companies have security safeguards in place, it is difficult to achieve 100% protection. To safeguard their data and applications, customers must verify that the necessary security configurations and controls are in place.

Maintenance and Upgrade: The underlying infrastructure is maintained by IaaS service providers, but they are not required to automatically upgrade the operating systems or software used by client applications. Compatibility problems could come from this, making it harder for customers to maintain their current software.

Interoperability Issues: Interoperability Problems: Because of interoperability problems, moving virtual machines (VMs) from one IaaS provider to another can be difficult. As a result, consumers may find it challenging to transfer providers or integrate their IaaS resources with other platforms or services. This may result in vendor lock-in.

Performance Variability: Due to shared resources and multi-tenancy, the performance of VMs in the IaaS system can change. During times of high demand or while sharing resources with other users on the same infrastructure, customers' performance may fluctuate.

Dependency on Internet Connectivity: Internet access is crucial to IaaS, which is largely dependent on it. Any interruptions or connectivity problems could hinder access to cloud infrastructure and services, which would have an impact on productivity and business operations.

Learning Curve and Complexity: Learning Curve and Complexity: Using and administering IaaS calls for a certain amount of technical know-how and comprehension of cloud computing principles. To efficiently use and manage the IaaS resources, organizations may need to spend money on IT employee training or turn to outside experts.

Cost Management: Cost Control: IaaS provides scalability and flexibility, but it can also result in difficult cost control. In order to prevent unforeseen charges, customers must keep an eye on and manage their resource utilization. Higher costs may be the result of inefficient use of resources or improper resource allocation.

Platform as a Service | PaaS

Platform as a Service (PaaS) provides a runtime environment. It allows programmers to easily create, test, run, and deploy web applications. You can purchase these applications from a cloud service provider on a pay-as-per-use basis and access them using an Internet connection. In PaaS, back-end scalability is managed by the cloud service provider, so end-users do not need to worry about managing the infrastructure.

PaaS includes infrastructure (servers, storage, and networking) and platform (middleware, development tools, database management systems, business intelligence, and more) to support the web application life cycle.

Examples: Google App Engine, Force.com, Joyent, Azure.

Some of the Services Provided by PaaS are:

Programming Languages: A variety of programming languages are supported by PaaS providers, allowing developers to choose their favorite language to create apps. Languages including Java, Python, Ruby,.NET, PHP, and Node.js are frequently supported.

Application Frameworks: Pre-configured application frameworks are offered by PaaS platforms, which streamline the development process. These frameworks include features like libraries, APIs, and tools for quick development, laying the groundwork for creating scalable and reliable applications. Popular application frameworks include Laravel, Django, Ruby on Rails, and Spring Framework.

Databases: Managed database services are provided by PaaS providers, making it simple for developers to store and retrieve data. These services support relational databases (like MySQL, PostgreSQL, and Microsoft SQL Server) and NoSQL databases (like MongoDB, Cassandra, and Redis). For its database services, PaaS platforms often offer automated backups, scalability, and monitoring tools.

Additional Tools and Services: PaaS providers provide a range of extra tools and services to aid in the lifecycle of application development and deployment. These may consist of the following:

o   Development Tools: to speed up the development process, these include integrated development environments (IDEs), version control systems, build and deployment tools, and debugging tools.

- o   Collaboration and Communication: PaaS platforms frequently come with capabilities for team collaboration, including chat services, shared repositories, and project management software.

- o   Analytics and Monitoring: PaaS providers may give tools for tracking application performance, examining user behavior data, and producing insights to improve application behavior and address problems.

- o   Security and Identity Management: PaaS systems come with built-in security features like access control, encryption, and mechanisms for authentication and authorization to protect the privacy of applications and data.

- o   Scalability and load balancing: PaaS services frequently offer automatic scaling capabilities that let applications allocate more resources as needed to manage a spike in traffic or demand. To improve performance and availability, load balancing features divide incoming requests among various instances of the application.

Because of the services offered by PaaS platforms, developers may concentrate on creating applications rather than worrying about the infrastructure, middleware, or database management that supports them. A streamlined and effective environment is provided by PaaS for developing, deploying, and managing applications.

Advantages of PaaS

There are the following advantages of PaaS -

1) Simplified Development

PaaS allows developers to focus on development and innovation without worrying about infrastructure management.

2) Lower risk

No need for up-front investment in hardware and software. Developers only need a PC and an internet connection to start building applications.

3) Prebuilt business functionality

Some PaaS vendors also provide already defined business functionality so that users can avoid building everything from very scratch and hence can directly start the projects only.

4) Instant community

PaaS vendors frequently provide online communities where the developer can get ideas, share experiences, and seek advice from others.

5) Scalability

Applications deployed can scale from one to thousands of users without any changes to the applications.

Disadvantages of PaaS Loud Computing Layer

1) Vendor lock-in

One has to write the applications according to the platform provided by the PaaS vendor, so the migration of an application to another PaaS vendor would be a problem.

2) Data Privacy

Corporate data, whether it can be critical or not, will be private, so if it is not located within the walls of the company, there can be a risk in terms of privacy of data.

3) Integration with the rest of the systems applications

It may happen that some applications are local, and some are in the cloud. So there will be chances of increased complexity when we want to use data in the cloud with the local data.

4) Limited Customization and Control: The degree of customization and control over the underlying infrastructure is constrained by PaaS platforms' frequent provision of pre-configured services and their relative rigidity.

Organizations can evaluate the viability of PaaS solutions for their unique requirements by taking into account these characteristics, as well as the trade-offs and potential difficulties involved in implementing such platforms.

Popular PaaS Providers

The below table shows some popular PaaS providers and services that are provided by them -
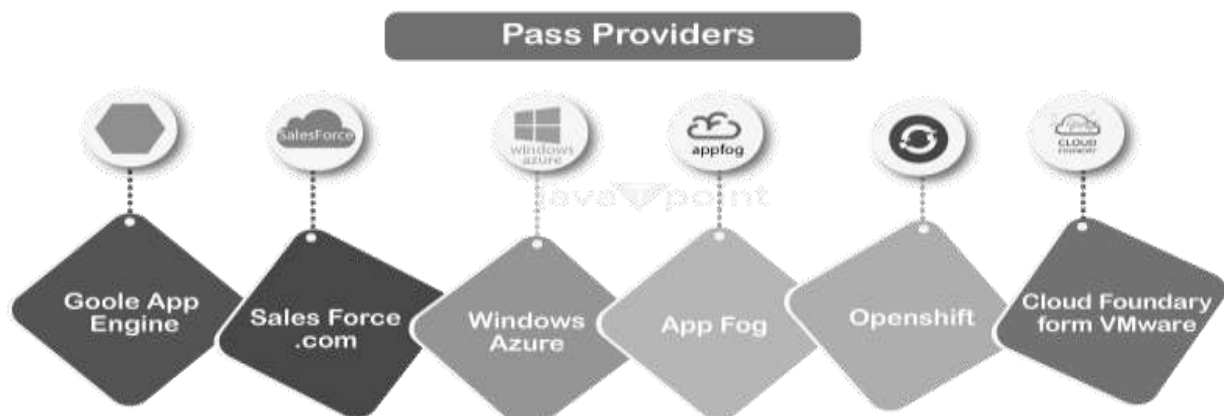
Providers	Services
Google App Engine (GAE)	App Identity, URL Fetch, Cloud storage client library, Logservice
Salesforce.com	Faster implementation, Rapid scalability, CRM Services, Sales cloud, Mobile connectivity, Chatter.
Windows Azure	Compute, security, IoT, Data Storage.
AppFog	Justcloud.com, SkyDrive, GoogleDocs
Openshift	RedHat, Microsoft Azure.
Cloud Foundry from VMware	Data, Messaging, and other services.

Software as a Service | SaaS

SaaS is also known as "On-Demand Software." It is a software distribution model in which services are hosted by a cloud service provider. These services are available to end-users over the internet, so the end-users do not need to install any software on their devices to access these services.

Characteristics of SaaS:

- o **Web-based Delivery:** SaaS apps can be accessed from anywhere with an internet connection because they are supplied over the internet, often through a web browser. Users no longer need to install and maintain software programs on their local machines as a result.

- o **Multiple Users** or "tenants" can access SaaS applications from a single instance of the program thanks to the concept of multi-tenancy. As a result, the provider can serve several clients with the same application without administering unique program instances for every client.

- o **Automatic Updates:** SaaS providers are in charge of keeping the software up to date and making sure that everyone has access to the newest features and security patches. Users are no longer required to manually install updates or fixes as a result.

- o **Scalable:** SaaS systems are scalable, which can readily grow or shrink in response to user demand. This frees up enterprises from worrying about infrastructure or licensing fees and lets them add or remove users as needed.

- o **Pricing on a Subscription Basis:** SaaS programs are frequently sold using a subscription-based pricing model, in which customers pay a monthly or yearly price to access the program. As a result, companies won't need to invest significantly in software licenses upfront.

- o **Data Security**, including data encryption, access restrictions, and backups, is the responsibility of SaaS providers. Users no longer need to handle their own data security because of this.

Access to Software Applications Over the Internet:

- o The majority of the time, SaaS companies host software programs on their own servers and provide them online. Using their login information, users can access the software through a web browser or mobile app, authenticating and gaining access to it.

- o Users don't need to install or maintain any software on their local machines because the provider hosts and maintains it. As a result, users may easily access the program from any location with an internet connection and on any device that can run mobile apps or web surfing.

- o All users have access to the most recent features and security updates because the provider is in charge of keeping the program updated and maintained. Users are no longer required to manually install updates or fixes as a result.

- o Users often pay a monthly or yearly charge to access the software through subscription-based SaaS providers. Because they don't have to make a significant upfront investment in software licenses, businesses are able to budget for their software costs more effectively as a result.

- o In general, SaaS gives enterprises a practical way to use and access software programs without having to worry about infrastructure or software upkeep. Providers are in charge of keeping the software up to date so that all users have access to the newest features and security patches. Users can access the software from any location with an internet connection.

Pricing Models: Subscription or User-Based

- o Most SaaS companies use a subscription-based pricing structure; however, some may also provide a usage-based pricing structure. Users that choose a subscription-based pricing model for their software access pay a set monthly or yearly charge.

- o The cost may vary according to the usage of the software's capabilities or the number of users. Businesses benefit from predictability and consistency thanks to this strategy because they can more efficiently budget for their software expenses.

- o In a usage-based pricing model, the costs are determined by how the program is actually used, such as the volume of data processed, the number of API requests, or the number of transactions.

- o For companies with erratic usage patterns or those that only want the program sometimes, this model may be more adaptable and economical.

- o According to their business strategy and the demands of their clients, SaaS providers may offer either a subscription-based or a usage-based pricing plan. SaaS offers organizations a cost-effective option to access and use software products without having to worry about infrastructure or software maintenance, regardless of the price model.

Services Provided by SaaS:

Business Services - SaaS Provider provides various business services to start up the business. The SaaS business services include ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), billing, and sales.

Document Management - SaaS document management is a software application offered by a third party (SaaS provider) to create, manage, and track electronic documents.

Examples: Slack, Samepage, Box, and Zoho Forms.

Social Networks - As we all know, social networking sites are used by the general public, so social networking service providers use SaaS for their convenience and handle the general public's information.

Mail Services - To handle the unpredictable number of users and load on e-mail services, many e-mail providers offer their services using SaaS.

Collaboration Tools: SaaS companies provide collaboration solutions that let teams collaborate effectively no matter where they are physically located. Platforms for project management, apps for team communication, and file-sharing services are some of these resources.

Examples include Slack, Microsoft Office 365, and Google Workspace (formerly G Suite).

Human Resources Management: SaaS-based HR management systems give companies tools to simplify key HR procedures, such as employee onboarding, payroll administration, timekeeping, performance reviews, and employee self-service portals.

Workday, BambooHR, and ADP Workforce Now, as examples.

Customer Support and Help Desk: SaaS platforms provide customer support and help desk solutions that enable firms to manage customer inquiries, track support tickets, and promptly address customer issues.

For instance, Salesforce Service Cloud, Freshdesk, and Zendesk.

Marketing and Sales Automation: To increase productivity and boost income, firms can automate marketing campaigns, lead generation, customer relationship management, and sales activities using SaaS marketing and sales automation technologies.

Examples include Marketo, Pardot, and HubSpot.

E-commerce Platforms: SaaS-based e-commerce platforms make it simpler for businesses to launch and run online storefronts, maintain product catalogs, handle payments, and keep track of orders.

Examples include WooCommerce (a WordPress plugin), BigCommerce, and Shopify.

Advantages of SaaS Cloud Computing Layer

1. SaaS is easy to buy

SaaS pricing is based on a monthly fee or annual fee subscription, so it allows organizations to access business functionality at a low cost, which is less than licensed applications.

Unlike traditional software, which is sold as a licensed base with an up-front cost (and often an optional ongoing support fee), SaaS providers are generally pricing the applications using a subscription fee, most commonly a monthly or annual fee.

2. One to Many

SaaS services are offered as a one-to-many model means a single instance of the application is shared by multiple users.

3. Less hardware required for SaaS

The software is hosted remotely, so organizations do not need to invest in additional hardware.

4. Low maintenance required for SaaS

Software as a service removes the need for installation, set-up, and daily maintenance for organizations. The initial set-up cost for SaaS is typically less than the enterprise software. SaaS vendors are pricing their applications based on some usage parameters, such as the number of users using the application. So SaaS does easy to monitor and automatic updates.

5. No special software or hardware versions are required

All users will have the same version of the software and typically access it through the web browser. SaaS reduces IT support costs by outsourcing hardware and software maintenance and support to the IaaS provider.

6. Multidevice support

SaaS services can be accessed from any device, such as desktops, laptops, tablets, phones, and thin clients.

7. API Integration

SaaS services easily integrate with other software or services through standard APIs.

8. No client-side installation

SaaS services are accessed directly from the service provider using an internet connection, so they do not need to require any software installation.

Disadvantages of SaaS Cloud Computing Layer:

1) Security

Actually, data is stored in the cloud, so security may be an issue for some users. However, cloud computing is not more secure than in-house deployment.

2) Latency issue

Since data and applications are stored in the cloud at a variable distance from the end-user, there is a possibility that there may be greater latency when interacting with the application compared to local deployment. Therefore, the SaaS model is not suitable for applications whose demand response time is in milliseconds.

3) Total Dependency on the Internet

Without an internet connection, most SaaS applications are not usable.

4) Switching between SaaS vendors is difficult

Switching SaaS vendors involves the difficult and slow task of transferring very large data files over the internet and then converting and importing them into another SaaS also.

Popular SaaS Providers

The below table shows some popular SaaS providers and services that are provided by them -

Provider	Services
Salseforce.com	On-demand CRM solutions
Microsoft Office 365	Online office suite
Google Apps	Gmail, Google Calendar, Docs, and sites
NetSuite	ERP, accounting, order management, CRM, Professionals Services Automation (PSA), and e-commerce applications.
GoToMeeting	Online meeting and video-conferencing software
Constant Contact	E-mail marketing, online survey, and event marketing
Oracle CRM	CRM applications
Workday, Inc	Human capital management, payroll, and financial management.