UNIT-I

Syllabus: Introduction to Cloud Computing, Characteristics of Cloud Computing, Cloud Models, Cloud Services Examples, Cloud based services and Applications, Cloud Concepts and Technologies, Virtualization, Load Balancing, Scalability and Elasticity, Deployment, Replication, Monitoring, Software defined networking, Network function virtualization, Map Reduce, Identity and Access Management, Service Level Agreements, Billing.

Introduction to Cloud Computing:

Cloud Computing:

The term **Cloud** refers to a **Network** or **Internet.** It is a technology that uses remote servers on the internet to store, manage, and access data online rather than local drives.

The data can be anything such as files, images, documents, audio, video, and more.

Cloud Computing is the delivery of computing services such as servers, storage, databases, networking, software, analytics, intelligence, and more, over the Cloud (Internet).

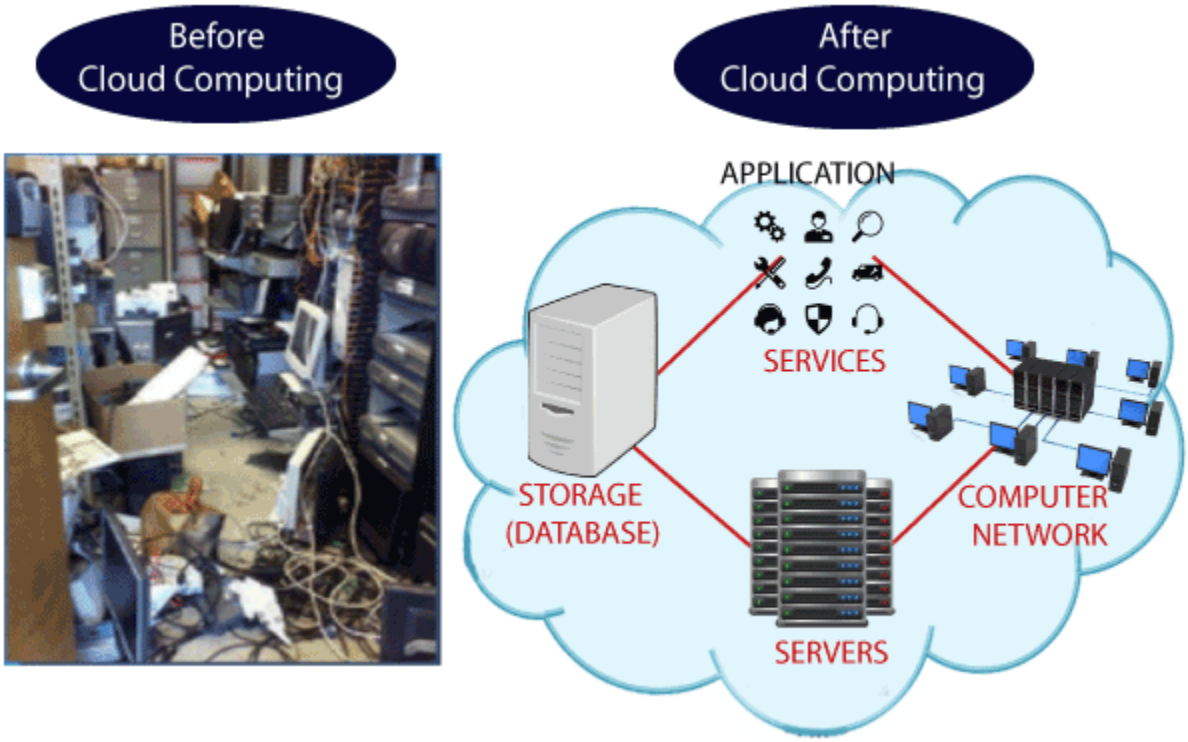
Cloud computing offers **platform independency,** as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications **mobile** and **collaborative.**

Why Cloud Computing?

Small as well as large IT companies, follow the traditional methods to provide the IT infrastructure. That means **for any IT company, we need a Server Room that is the basic need of IT companies**.

In that server room, there should be a database server, mail server, networking, firewalls, routers, modem, switches, QPS (Query Per Second means how much queries or load will be handled by the server), configurable system, high net speed, and the maintenance engineers.

To establish such IT infrastructure, we need to spend lots of money. To overcome all these problems and to reduce the IT infrastructure cost, Cloud Computing comes into existence.



Cloud Computing Applications:

Cloud Computing has its applications in almost all the fields such as business, entertainment, data storage, social networking, management, entertainment, education, art and **global positioning system,** etc. Some of the widely famous cloud computing applications are:

Business Applications:

Cloud computing has made businesses more collaborative and easy by incorporating various apps such as **Mail Chimp, Chatter, Google Apps for business,** and **Quick books.**

SN	Application Description
1	**Mail Chimp** It offers an **e-mail publishing platform.** It is widely employed by the businesses to design and send their e-mail campaigns.
2	**Chatter**

	Chatter app helps the employee to share important information about organization in real time. One can get the instant feed regarding any issue.
3	**Google Apps for Business** **Google** offers **creating text documents, spreadsheets, presentations,** etc., on **Google Docs** which allows the business users to share them in collaborating manner.
4	**Quick books** It offers **online accounting solutions** for a business. It helps in **monitoring cash flow, creating VAT returns** and **creating business reports.**

Data Storage and Backup

Box.com, Mozy, Joukuu are the applications offering data storage and backup services in cloud.

SN	Application Description
1	**Box.com** **Box.com** offers drag and drop service for files. The users need to drop the files into Box and access from anywhere.
2	**Mozy** **Mozy** offers online backup service for files to prevent data loss.
3	**Joukuu** **Joukuu** is a web-based interface. It allows to display a single list of contents for files stored in **Google Docs, Box.net and Dropbox.**

Management Applications

There are apps available for management task such as **time tracking, organizing notes.** Applications performing such tasks are discussed below:

SN	Application Description
1	**Toggl** It helps in tracking time period assigned to a particular project.
2	**Evernote**

	It organizes the sticky notes and even can read the text from images which helps the user to locate the notes easily.
3	**Outright** It is an accounting app. It helps to track income, expenses, profits and losses in real time.

Social Applications:

There are several social networking services providing websites such as Facebook, Twitter, etc.

SN	Application Description
1	**Facebook** It **offers** social networking service. One can share photos, videos, files, status and much more.
2	**Twitter** It **helps** to interact with the public directly. One can follow any celebrity, organization and any person, who is on twitter and can have latest updates regarding the same.

Entertainment Applications

SN	Application Description
1	**Audio box.fm** It offers streaming service. The music files are stored online and can be played from cloud using the own media player of the service.

Art Applications

SN	Application Description
1	**Moo** It offers art services such as designing and printing **business cards, postcards** and **mini cards.**

Examples of Cloud Computing:

Examples of Cloud Computing which are mention below :

1. Dropbox, Facebook, Gmail

Cloud can be used for storage of files. The advantage is an easy backup. They automatically synchronize the files from the desktop.

Dropbox allowing users to access files and storage up to 1 terabyte of free storage. Social Networking platform requires a powerful hosting to manage and store data in real-time.

Cloud-based communication provides click-to-call capabilities from social networking sites, access to the Instant messaging system.

2. Banking, Financial Services

Consumers store financial information to cloud computing serviced providers. They store tax records as online backup services.

3. Health Care

Using cloud computing, Medical professionals host information, analytics and do diagnostics remotely. As healthcare also comes in the list of examples of cloud computing it allows other doctors around the world to immediately access this medical information for faster prescriptions and updates. Application of cloud computing in health care includes telemedicine, public and personal health care, E-health services and bioinformatics.

4. Education

This is useful in institutions of higher learning provide benefits to universities and colleges so henceforth Education comes in the examples of cloud computing. Google and Microsoft provide various services free of charge to staff and students in different learning institutions. Several Educational institutions in united states use them to improve efficiency, cut on costs. Example- Google App Education (GAE). They allow the user to use their personal workspace, teaching becomes more interactive.

Popular Course in this category

5. Government

They deliver e-Governance services to citizens using cloud-based IT services. They have the technology to handle large transactions, citizens can see fewer congestion bottlenecks.

6. Big data Analytics

Big data analytics is another example of Cloud computing, As cloud computing enables data scientist in analyzing their data patterns, insights, correlations, predictions and help in good decision making. There are many open sources of big tools like Hadoop, Cassandra.

7. Communication

Cloud allows network-based access to communication tools like emails and calendars. Wats app is also a cloud-based infrastructure as it comes in communication it is also one of the examples of cloud computing. All the messages and information are stored in service providers hardware.

8. Business Process

Business email is cloud-based. ERP, document management and CRM are based on a cloud service provider. SAAS has become an important method for the enterprise. Examples include Salesforce, HubSpot. They make many business processes more reliable because data can be copied at multiple redundant sites on the cloud providers.

Characteristics of Cloud Computing:

The characteristics of cloud computing are given below:

1) Agility:

The cloud **works in a distributed computing environment**. It shares resources among users and works very fast.

2) High availability and reliability

The availability of servers is high and more reliable because the **chances of infrastructure failure are minimum**.

3) High Scalability

Cloud offers **"on-demand" provisioning of resources on a large scale**, without having engineers for peak loads.

4) Multi-Sharing

With the help of cloud computing, **multiple users and applications can work more efficiently** with cost reductions by sharing common infrastructure.

5) Device and Location Independence

Cloud computing enables the users to access systems using a web browser regardless of their location or what device they use e.g. PC, mobile phone, etc. **As infrastructure is off-site** (typically provided by a third-party) **and accessed via the Internet, users can connect from anywhere**.

6) Maintenance

Maintenance of cloud computing applications is easier, since they **do not need to be installed on each user's computer and can be accessed from different places**. So, it reduces the cost also.

7) Low Cost

By using cloud computing, the cost will be reduced because to take the services of cloud computing, **IT company need not to set its own infrastructure** and pay-as-per usage of resources.

8) Services in the pay-per-use mode

Application Programming Interfaces **(APIs) are provided to the users so that they can access services on the cloud** by using these APIs **and pay the charges as per the usage of services**.

Advantages of cloud computing:

- **Cost:** It reduces the huge capital costs of buying hardware and software.
- **Speed:** Resources can be accessed in minutes, typically within a few clicks.
- **Scalability:** We can increase or decrease the requirement of resources according to the business requirements.
- **Productivity:** While using cloud computing, we put less operational effort. We do not need to apply patching, as well as no need to maintain hardware and software. So, in this way, the IT team can be more productive and focus on achieving business goals.
- **Reliability:** Backup and recovery of data are less expensive and very fast for business continuity.
- **Security:** Many cloud vendors offer a broad set of policies, technologies, and controls that strengthen our data security.

Disadvantages:

- Performance on shared infrastructure can be inconsistent. Servers maintained by cloud computing can fall to natural disasters and internal bugs.
- Privacy and security in the cloud are much more concerns.
- reliability, As well as privacy. Vendor lock and failure is also another concern in cloud computing.
- Data Transfer costs: Outbound data transfer over the monthly basis is charged as per GB Basis.
- Downtime: If the internet connection is down, Unable to access any of the applications, server or data from the cloud.

Cloud Service Models:

There are the following three types of cloud service models -

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

Infrastructure as a Service (IaaS)

IaaS is also known as **Hardware as a Service (HaaS)**. It is a computing infrastructure managed over the internet. The main advantage of using IaaS is that it helps users to avoid the cost and complexity of purchasing and managing the physical servers.

Characteristics of IaaS

There are the following characteristics of IaaS -

- Resources are available as a service
- Services are highly scalable
- Dynamic and flexible
- GUI and API-based access
- Automated administrative tasks

Example: Digital Ocean, Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Meta cloud.

Platform as a Service (PaaS):

PaaS cloud computing platform is created for the programmer to develop, test, run, and manage the applications.

Characteristics of PaaS

There are the following characteristics of PaaS -

- Accessible to various users via the same development application.
- Integrates with web services and databases.
- Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.

- Support multiple languages and frameworks.
- Provides an ability to "**Auto-scale**".

Example: AWS Elastic Beanstalk, Windows Azure, Heroku, Force.com, Google App Engine, Apache Stratos, Magento Commerce Cloud, and OpenShift.

Software as a Service (SaaS):

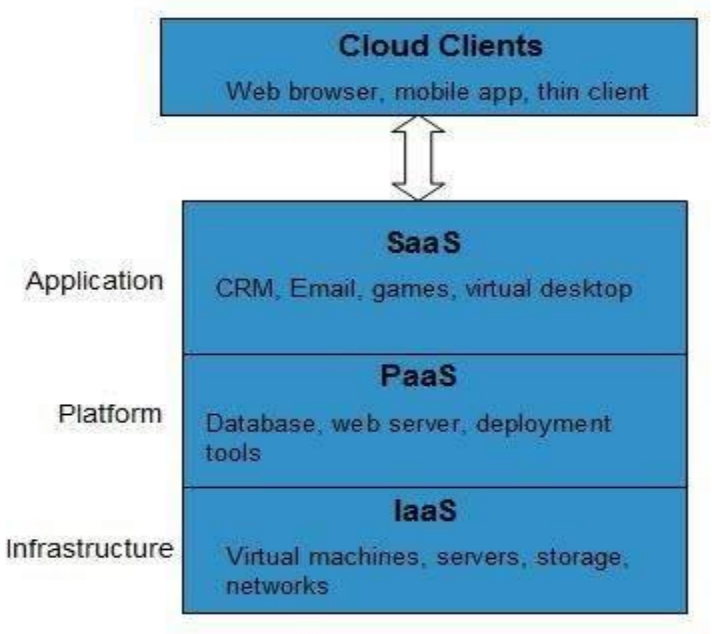
SaaS is also known as "**on-demand software**". It is a software in which the applications are hosted by a cloud service provider. Users can access these applications with the help of internet connection and web browser.

Characteristics of SaaS

There are the following characteristics of SaaS -

- Managed from a central location
- Hosted on a remote server
- Accessible over the internet
- Users are not responsible for hardware and software updates. Updates are applied automatically.
- The services are purchased on the pay-as-per-use basis

Example: BigCommerce, Google Apps, Salesforce, Dropbox, ZenDesk, Cisco WebEx, ZenDesk, Slack, and GoToMeeting.

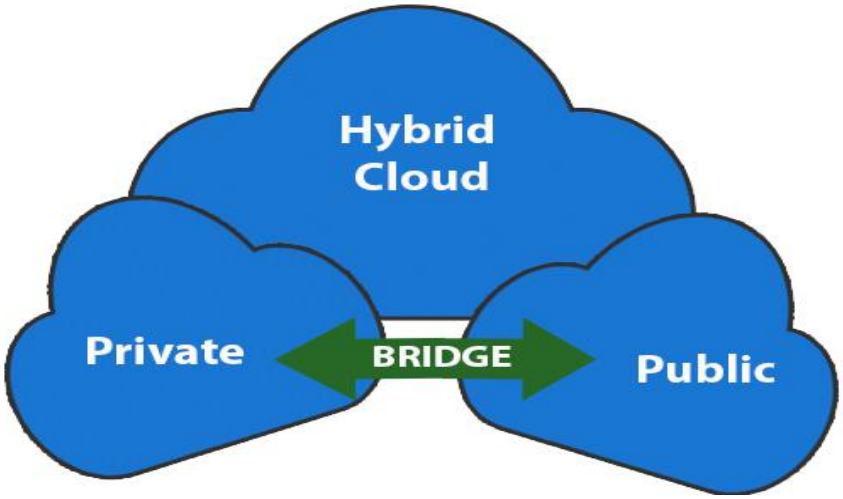


Difference between IaaS, PaaS, and SaaS

The below table shows the difference between IaaS, PaaS, and SaaS -

IaaS	Paas	SaaS
It provides a virtual data center to store information and create platforms for app development, testing, and deployment.	It provides virtual platforms and tools to create, test, and deploy apps.	It provides web software and apps to complete business tasks.
It provides access to resources such as virtual machines, virtual storage, etc.	It provides runtime environments and deployment tools for applications.	It provides software as a service to the end-users.
It is used by network architects.	It is used by developers.	It is used by end users.
IaaS provides only Infrastructure.	PaaS provides Infrastructure+Platform.	SaaS provides Infrastructure+Platform +Software.

Types of Cloud Computing:



- **Public Cloud:** The cloud resources that are owned and operated by a third-party cloud service provider are termed as public clouds. It delivers computing resources such as servers, software, and storage over the internet
- **Private Cloud:** The cloud computing resources that are exclusively used inside a single business or organization are termed as a private cloud. A private cloud may physically be located on the company's on-site data center or hosted by a third-party service provider.
- **Hybrid Cloud:** It is the combination of public and private clouds, which is bounded together by technology that allows data applications to be shared between them. Hybrid cloud provides flexibility and more deployment options to the business.

Cloud Concepts and Technologies:

Cloud Computing Technologies

A list of cloud computing technologies is given below -

i. Virtualization
ii. Service-Oriented Architecture (SOA)
iii. Grid Computing
iv. Utility Computing

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 -

i. Hardware virtualization
ii. Server virtualization
iii. Storage virtualization
iv. Operating system virtualization
v. Data Virtualization

Service-Oriented Architecture (SOA)

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

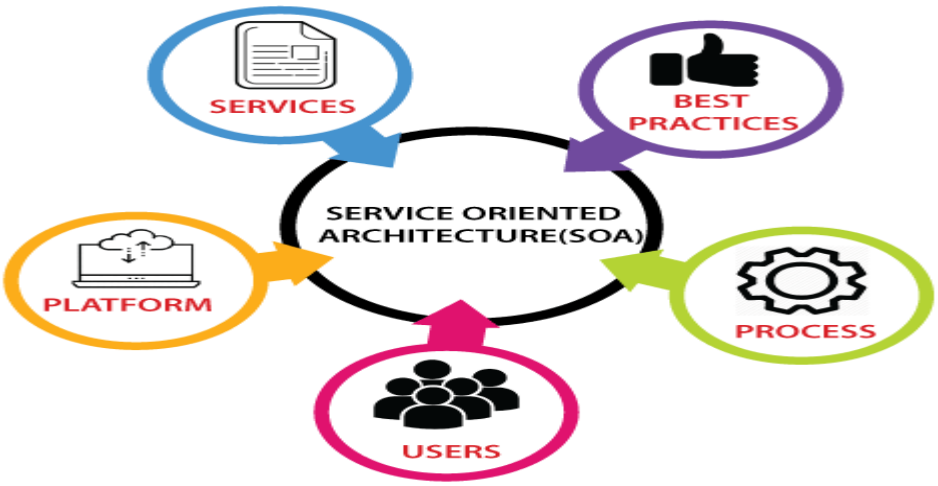
Service Provider and Service consumer are the two major roles within SOA.

Applications of Service-Oriented Architecture

There are the following applications of Service-Oriented Architecture -

- It is used in the healthcare industry.
- It is used to create many mobile applications and games.
- In the air force, SOA infrastructure is used to deploy situational awareness systems.

The service-oriented architecture is shown below:



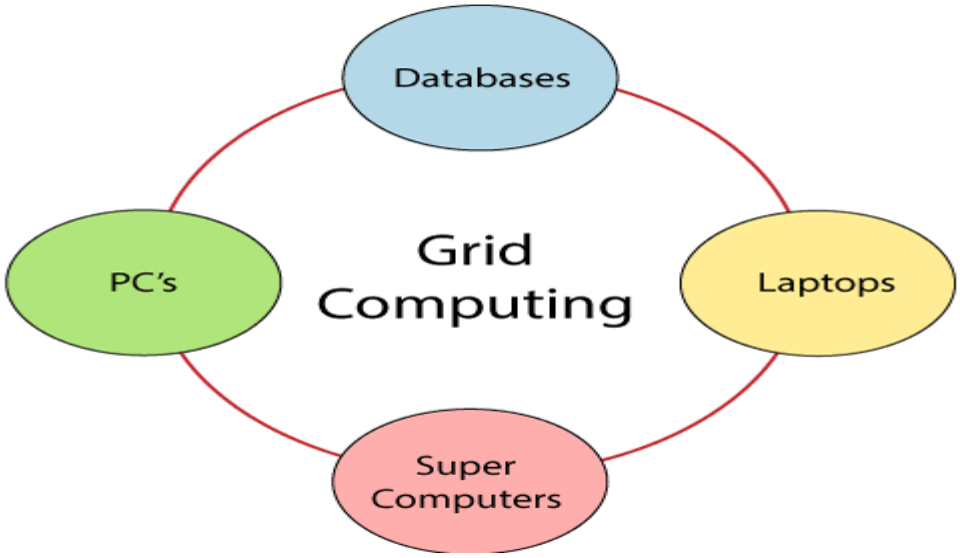
Grid Computing

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 -

1. **Control Node:** It is a group of server which administrates the whole network.
2. **Provider:** It is a computer which contributes its resources in the network resource pool.
3. **User:** It is a computer which uses the resources on the network.

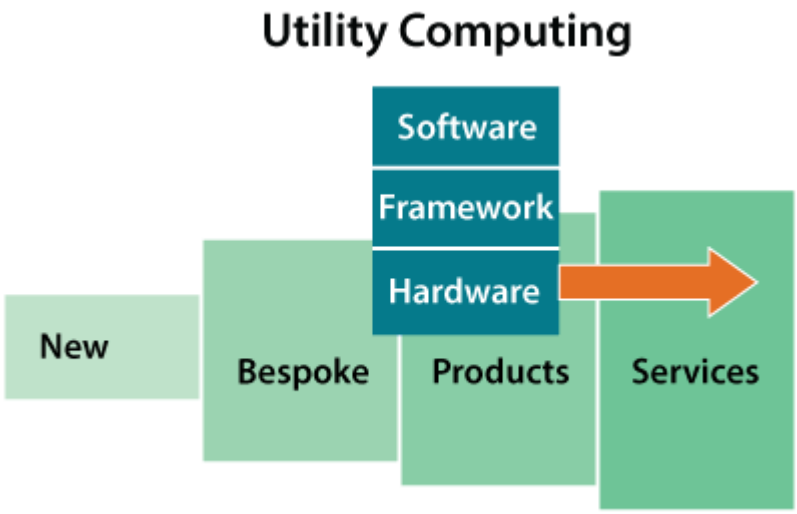
Mainly, grid computing is used in the **ATMs, back-end infrastructures,** and **marketing research**.



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 reduced the IT cost, provides greater flexibility, and easier to manage.

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



Cloud Computing Virtualization:

Virtualization is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources".

(OR)

Virtualization is a technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations. It does by assigning a logical name to a physical storage and providing a pointer to that physical resource when demanded.

What is the concept behind the Virtualization?

Creation of a virtual machine over existing operating system and hardware is known as Hardware Virtualization. A Virtual machine provides an environment that is logically separated from the underlying hardware.

The machine on which the virtual machine is going to create is known as **Host Machine** and that virtual machine is referred as a **Guest Machine**

Types of Virtualization:

1. Hardware Virtualization.
2. Operating system Virtualization.
3. Server Virtualization.
4. Storage Virtualization.

1) Hardware Virtualization:

When the virtual machine software or virtual machine manager *(VMM) is directly installed on the hardware system* is known as hardware virtualization.
The main job of hypervisor is to control and monitoring the processor, memory and other hardware resources.
After virtualization of hardware system we can install different operating system on it and run different applications on those OS.

Usage:

Hardware virtualization is mainly done for the server platforms, because controlling virtual machines is much easier than controlling a physical server.

2) Operating System Virtualization:

When the virtual machine software or virtual machine manager *(VMM) is installed on the Host operating system* instead of directly on the hardware system is known as operating system virtualization.

Usage:

Operating System Virtualization is mainly used for testing the applications on different platforms of OS.

3) Server Virtualization:

When the virtual machine software or virtual machine manager *(VMM) is directly installed on the Server system* is known as server virtualization.

Usage:

Server virtualization is done because a single physical server can be divided into multiple servers on the demand basis and for balancing the load.

4) Storage Virtualization:

Storage virtualization is the *process of grouping the physical storage from multiple network storage devices so that it looks like a single storage device*.
Storage virtualization is also implemented by using software applications.

Usage:

Storage virtualization is mainly done for back-up and recovery purposes.

Cloud Computing Load Balancing:

Cloud Load balancing is basically the process of distributing or dividing the workloads and different computing resources across one or more available servers. This kind of distribution ensures that maximum throughput in a minimum response time.

` The workload is divided among two or more servers, hard drives, network interfaces or other different computing resources, which helps to enable better resource utilization and improves system response time. Thus, for a website with high traffic rate, effective use of the cloud load balancing can

ensure better business continuity. The common objectives of using load balancers are:

Cloud providers like **Amazon Web Services (AWS), Microsoft Azure** and **Google offer** cloud load balancing to facilitate easy distribution of workloads. For exp: **Amazon Web Services (AWS) offers Elastic Load balancing (ELB) technology** to distribute traffic among Elastic Compute Cloud (EC2) instances. Most of the **Amazon Web Services (AWS)** powered applications have Elastic Load Balancers (ELBs) installed as the key architectural component. Similarly, **Azure's Traffic Manager** allocates its cloud servers' traffic across multiple data centers'

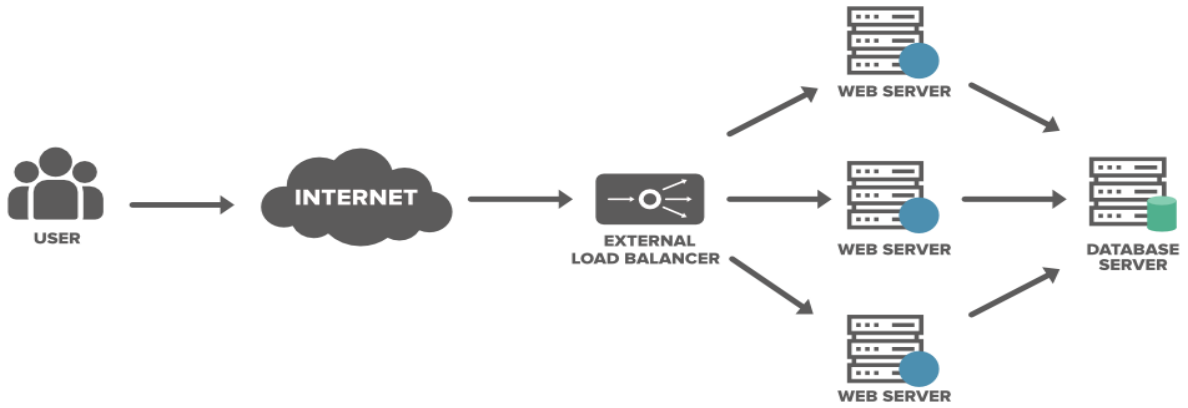
Load balancing solutions can be categorized into two types :

1. **Software-based load balancers:** Software-based load balancers run on standard hardware (desktop, PCs) and standard operating systems.

2. **Hardware-based load balancer:** Hardware-based load balancers are dedicated boxes which include Application Specific Integrated Circuits (ASICs) adapted for a particular use. ASICs allows high speed promoting of network traffic and are frequently used for transport-level load balancing because hardware-based load balancing is faster in comparison to software solution.

Load Balancing can be classified into two types based on the behavior of the algorithm:

- **Static Load Balancing:** Static load balancing is the method of dividing the incoming load on a server using algorithms that have prior information about the existing servers in the distributed network. These load balancing schemes have a pre-defined load schedule that determines a fixed amount of load that can be shed on other systems.
- **Dynamic Load Balancing:** It is a more versatile scheme of load balancing which can dynamically identify the amount of load that needs to be shed during runtime and which system should bear the load.



Difference between Static and Dynamic Load Balancing:

Sr. No.	Static Load Balancing	Dynamic Load Balancing
1.	Designed for the system with low fluctuation in incoming load.	Designed for the system with high fluctuation in incoming load.
2.	Traffic is equally divided among the servers.	Traffic is dynamically divided among the servers.
3.	It requires deeper information about available system resources.	It does not necessarily need deeper information about system resources beforehand.
4.	It does not require real-time communication with the servers.	It requires real-time communication actively with the servers.
5.	The allocated load cannot be retransferred to other servers during runtime.	The allocated load can be retransferred among servers to reduce the under utilization of resources.
6.	Example: Round Robin algorithm for load balancing.	Example: Least Connection algorithm for load balancing.

Types of Load Balancing:

Load balancing can also be based on cloud-based balancers.

Network Load Balancing

Cloud load balancing takes advantage of network layer information and leaves it to decide where network traffic should be sent. This is accomplished through Layer 4 load balancing, which handles TCP/UDP traffic. It is the fastest local balancing solution, but it cannot balance the traffic distribution across servers.

HTTP(S) load balancing

HTTP(s) load balancing is the oldest type of load balancing, and it relies on Layer 7. This means that load balancing operates in the layer of operations. It is the most flexible type of load balancing because it lets you make delivery decisions based on information retrieved from HTTP addresses.

Internal Load Balancing

It is very similar to network load balancing, but is leveraged to balance the infrastructure internally.

Load balancers can be further divided into hardware, software and virtual load balancers.

Hardware Load Balancer

It depends on the base and the physical hardware that distributes the network and application traffic. The device can handle a large traffic volume, but these come with a hefty price tag and have limited flexibility.

Software Load Balancer

It can be an open source or commercial form and must be installed before it can be used. These are more economical than hardware solutions.

Virtual Load Balancer

It differs from a software load balancer in that it deploys the software to the hardware load-balancing device on the virtual machine.

Different Types of Load Balancing Algorithms in Cloud Computing:

1. Static Algorithm

Static algorithms are built for systems with very little variation in load. The entire traffic is divided equally between the servers in the static algorithm. This algorithm requires in-depth knowledge of server resources for better

performance of the processor, which is determined at the beginning of the implementation.

2. Dynamic Algorithm

The dynamic algorithm first finds the lightest server in the entire network and gives it priority for load balancing. This requires real-time communication with the network which can help increase the system's traffic. Here, the current state of the system is used to control the load.

3. Round Robin Algorithm

As the name suggests, round robin load balancing algorithm uses round-robin method to assign jobs. First, it randomly selects the first node and assigns tasks to other nodes in a round-robin manner. This is one of the easiest methods of load balancing.

4. Weighted Round Robin Load Balancing Algorithm

Weighted Round Robin Load Balancing Algorithms have been developed to enhance the most challenging issues of Round Robin Algorithms. In this algorithm, there are a specified set of weights and functions, which are distributed according to the weight values.

5. Opportunistic Load Balancing Algorithm

The opportunistic load balancing algorithm allows each node to be busy. It never considers the current workload of each system. Regardless of the current workload on each node, OLB distributes all unfinished tasks to these nodes.

6. Minimum to Minimum Load Balancing Algorithm

Under minimum to minimum load balancing algorithms, first of all, those tasks take minimum time to complete. Among them, the minimum value is selected among all the functions. According to that minimum time, the work on the machine is scheduled.

Scalability and Elasticity:

Cloud Elasticity:

The Elasticity refers to the ability of a cloud to automatically expand or compress the infrastructural resources on a sudden-up and down in the requirement so that the workload can be managed efficiently. This elasticity helps to minimize infrastructural cost. This is not applicable for all kind of environment, it is helpful to address only those scenarios where the resources requirements fluctuate up and down suddenly for a specific time interval. It is not quite practical to use where persistent resource infrastructure is required to handle the heavy workload.
It is most commonly used in pay-per-use, public cloud services. Where IT managers are willing to pay only for the duration to which they consumed the resources.

Example :
Consider an online shopping site whose transaction workload increases during festive season like Christmas. So for this specific period of time, the resources need a spike up. In order to handle this kind of situation, we can go for Cloud-Elasticity service rather than Cloud Scalability. As soon as the season goes out, the deployed resources can then be requested for withdrawal.

Cloud Scalability:

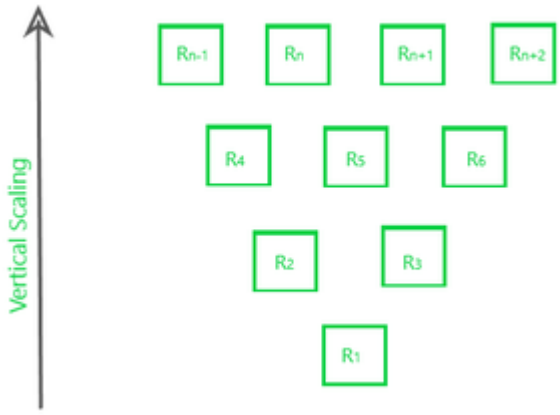
Cloud scalability is used to handle the growing workload where good performance is also needed to work efficiently with software or applications. Scalability is commonly used where the persistent deployment of resources is required to handle the workload statically.

Example:

Consider you are the owner of a company whose database size was small in earlier days but as time passed your business does grow and the size of your database also increases, so in this case you just need to request your cloud service vendor to scale up your database capacity to handle a heavy workload. It is totally different from what you have read above in Cloud Elasticity. Scalability is used to fulfill the static needs while elasticity is used to fulfill the dynamic need of the organization. Scalability is a similar kind of service provided by the cloud where the customers have to pay-per-use. So, in conclusion, we can say that Scalability is useful where the workload remains high and increases statically.

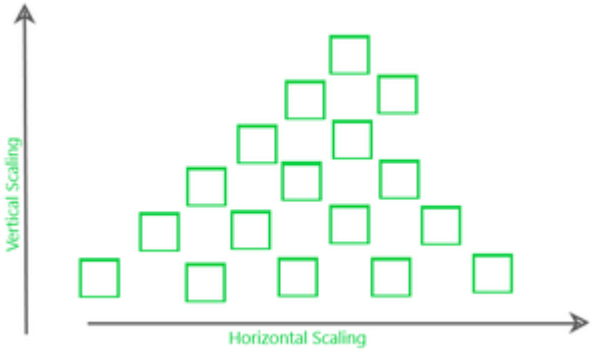
Types of Scalability:

1. Vertical Scalability (Scale-up) –
In this type of scalability, we increase the power of existing resources in the working environment in an upward direction.



2. Horizontal Scalability –
In this kind of scaling, the resources are added in a horizontal row.

3. Diagonal Scalability –
It is a mixture of both Horizontal and Vertical scalability where the resources are added both vertically and horizontally.



Difference between Scalability and Elasticity in Cloud Computing

S.No.	Cloud Elasticity	Cloud Scalability
1	It is used just to fulfil the sudden requirement in the workload for a short period.	It is used to fulfil the static boost in the workload.
2	It is preferred to satisfy the dynamic modifications, where the required resources can improve or reduce.	It is preferred to handle growth in the workload in an organisation.
3	Cloud elasticity is generally used by small enterprises whose workload expands only for a specific period.	Cloud scalability is utilised by big enterprises.
4	It is a short term event that is used to deal with an unplanned or sudden growth in demand.	It is a long term event that is used to deal with an expected growth in demand.

Deployment in Cloud Computing:

The cloud deployment model identifies the specific type of cloud environment based on ownership, scale, and access, as well as the cloud's nature and purpose. The location of the servers you're utilizing and who controls them are defined by a cloud deployment model. It specifies how your cloud infrastructure will look, what you can change, and whether you will be given services or will have to create everything yourself. Relationships between the infrastructure and your users are also defined by cloud deployment types.

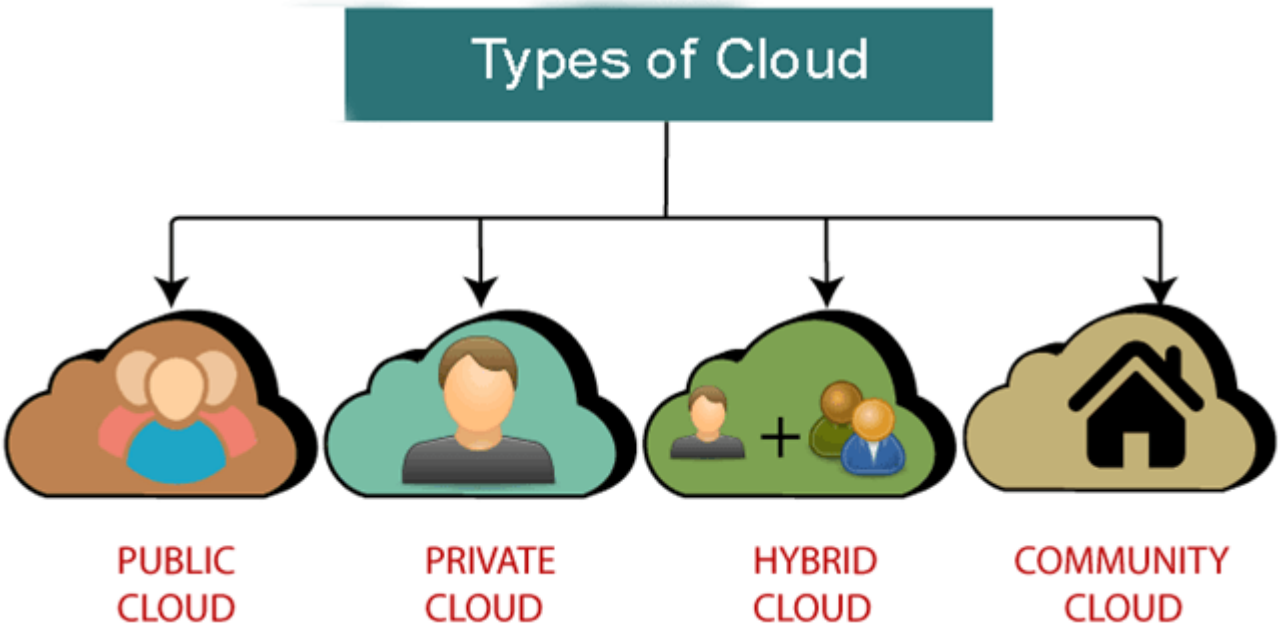
Different types of cloud computing deployment models are:

1. Public cloud
2. Private cloud
3. Hybrid cloud
4. Community cloud

Different Types of Cloud Computing Deployment Models:

Types of Cloud

There are the following 4 types of cloud that you can deploy according to the organization's needs-



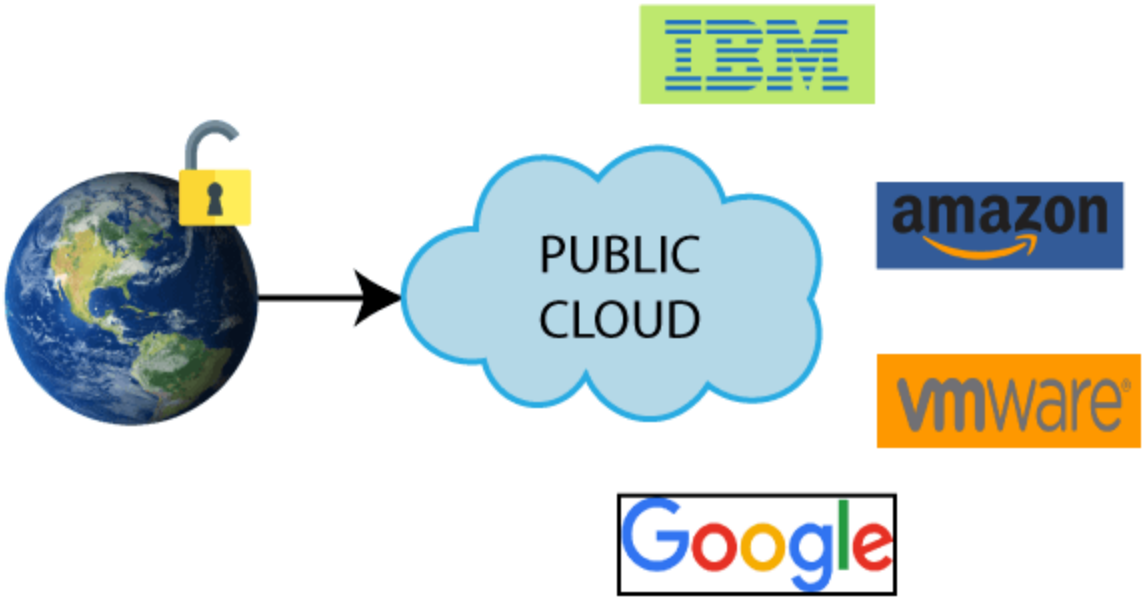
- Public Cloud
- Private Cloud
- Hybrid Cloud
- Community Cloud

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).

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



Advantages of Public Cloud

There are the following advantages of Public Cloud -

- Public cloud is owned at a lower cost than the private and hybrid cloud.
- Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.
- Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.
- Public cloud is location independent because its services are delivered through the internet.
- Public cloud is highly scalable as per the requirement of computing resources.
- It is accessible by the general public, so there is no limit to the number of users.

Disadvantages of Public Cloud

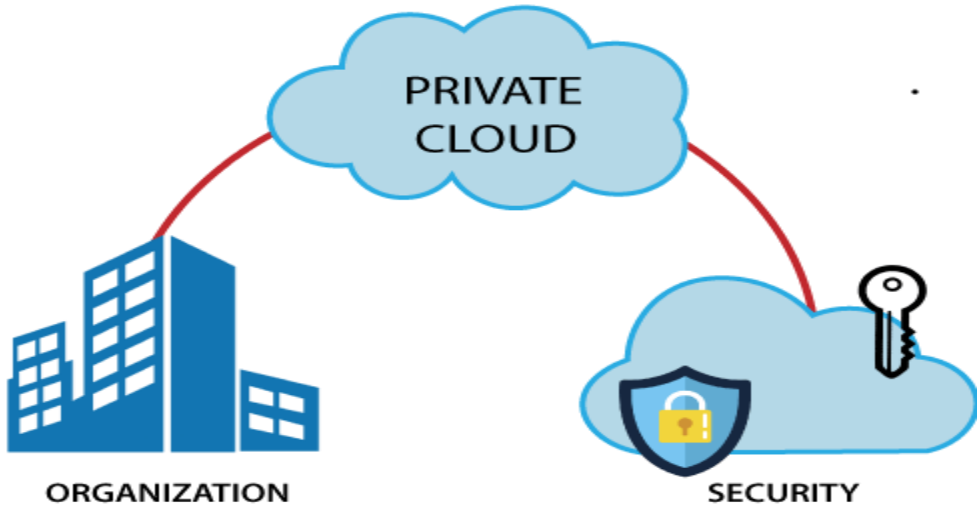
- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

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.

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

- On-premise private cloud
- Outsourced private cloud



Advantages of Private Cloud

There are the following advantages of the Private Cloud -

- Private cloud provides a high level of security and privacy to the users.
- Private cloud offers better performance with improved speed and space capacity.
- It allows the IT team to quickly allocate and deliver on-demand IT resources.
- 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.
- It is suitable for organizations that require a separate cloud for their personal use and data security is the first priority.

Disadvantages of Private Cloud

- Skilled people are required to manage and operate cloud services.
- Private cloud is accessible within the organization, so the area of operations is limited.
- 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.

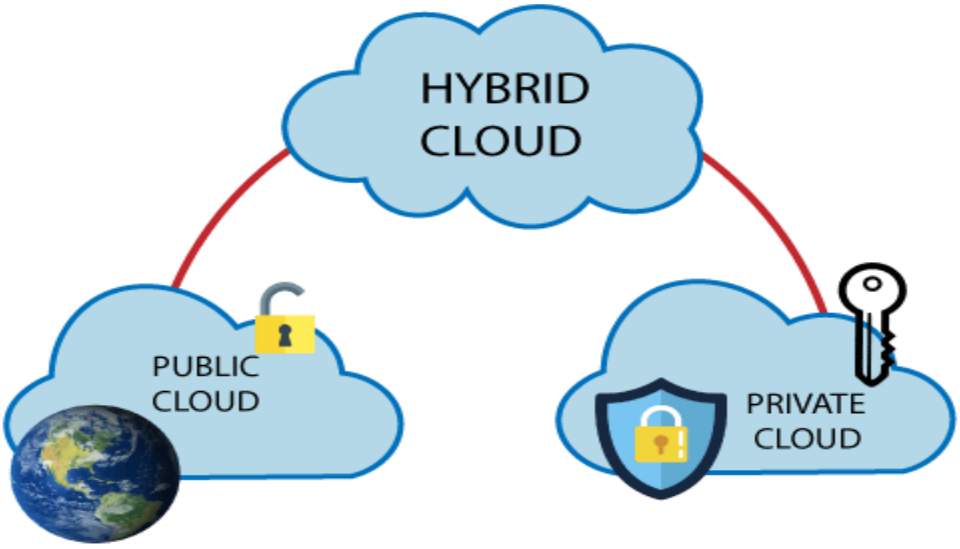
Hybrid Cloud

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.

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



Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

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

- Hybrid cloud helps you to deliver new products and services more quickly.
- Hybrid cloud provides an excellent way to reduce the risk.
- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

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.

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.

Example: Health Care community cloud

Advantages of Community Cloud

There are the following advantages of Community Cloud -

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

- Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.
- It provides better security than the public cloud.
- It provdes collaborative and distributive environment.

Disadvantages of Community Cloud

- Community cloud is not a good choice for every organization.
- Security features are not as good as the private cloud.
- It is not suitable if there is no collaboration.
- The fixed amount of data storage and bandwidth is shared among all community members.

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

The below table shows the difference between public cloud, private cloud, hybrid cloud, and community cloud.

Parameter	Public Cloud	Private Cloud	Hybrid Cloud	Community Cloud
Host	Service provider	Enterprise (Third party)	Enterprise (Third party)	Community (Third party)
Users	General public	Selected users	Selected users	Community members
Access	Internet	Internet, VPN	Internet, VPN	Internet, VPN
Owner	Service provider	Enterprise	Enterprise	Community

Replication:

Data replication is the process by which data residing on a physical/virtual server(s) or cloud instance (primary instance) is continuously replicated or copied to a secondary server(s) or cloud instance (standby instance). Organizations replicate data to support high availability, backup, and/or disaster recovery.

Data replication is the process of making multiple copies of data and storing them at different locations for backup purposes, fault tolerance and to improve their overall accessibility across a network. Similar to data mirroring, data replication can be applied to both individual computers and servers. The data replicates can be stored within the same system, on-site and off-site hosts, and cloud-based hosts.

Benefits of data replication:

Although data replication can be demanding in terms of cost, computational, and storage requirements, businesses widely use this database management technique to achieve one or more of the following goals:

1. Improve the availability of data
2. Increase the speed of data access
3. Enhance server performance
4. Accomplish disaster recovery

Types of data replication

Depending on data replication tools employed, there are multiple types of replication practiced by businesses today. Some of the popular replication modes are as follows

1. Full table replication
2. Transactional replication
3. Snapshot replication
4. Merge replication
5. Key-based incremental replication

Full table replication

Full table replication means that the entire data is replicated. This includes new, updated as well as existing data that is copied from source to the destination. This method of replication is generally associated with higher costs since the processing power and network bandwidth requirements are high.

However, full table replication can be beneficial when it comes to the recovery of hard-deleted data, as well as data that do not possess replication keys - discussed further down this article.

Transactional replication

In this method, the data replication software makes full initial copies of data from origin to destination following which the subscriber database receives updates whenever data is modified. This is more efficient mode of replication since fewer rows are copied each time data is changed. Transactional replication is usually found in server-to-server environments.

Snapshot replication

In Snapshot replication, data is replicated exactly as it appears at any given time. Unlike other methods, Snapshot replication does not pay attention to the changes made to data. This mode of replication is used when changes made to data tends to be infrequent; for example performing initial synchronizations between publishers and subscribers

Merge replication

This type of replication is commonly found in server-to-client environments and allows both the publisher and subscriber to make changes to data dynamically. In merge replication, data from two or more databases are

combined to form a single database thereby contributing to the complexity of using this technique

6. Key-based incremental replication

Key-based Incremental Replication is **a replication method in which Stitch identifies new and updated data using a column called a Replication Key**. For example: Stitch will use a column like updated at to identify records that have been updated since a specified time, and then only replicate those records.

Monitoring:

Cloud monitoring is **a method of reviewing, observing, and managing the operational workflow in a cloud-based IT infrastructure**. Manual or automated management techniques confirm the availability and performance of websites, servers, applications, and other cloud infrastructure.

Types of cloud monitoring:

The main types of cloud monitoring are:

Database monitoring

Because most cloud applications rely on databases, this technique reviews processes, queries, availability, and consumption of cloud database resources. This technique can also track queries and data integrity, monitoring connections to show real-time usage data.

Virtual network monitoring

This monitoring type creates software versions of network technology such as firewalls, routers, and load balancers. Because they're designed with software, these integrated tools can give you a wealth of data about their operation.

Cloud storage monitoring

This technique tracks multiple analytics simultaneously, monitoring storage resources and processes that are provisioned to virtual machines, services, databases, and applications. This technique is often used to host infrastructure-as-a-service (IaaS) and software-as-a-service (SaaS) solutions.

Virtual machine monitoring

This technique is a simulation of a computer within a computer; that is, virtualization infrastructure and virtual machines. It's usually scaled out in IaaS as a virtual server that hosts several virtual desktops.

Software Defined Networking(SDN)

Software Defined Networking (SDN) is **an architecture that gives networks more programmability and flexibility by separating the control plane from the data plane**. The role of software defined networks in cloud computing lets users respond quickly to changes. SDN management makes network configuration more efficient and improves network performance and monitoring.

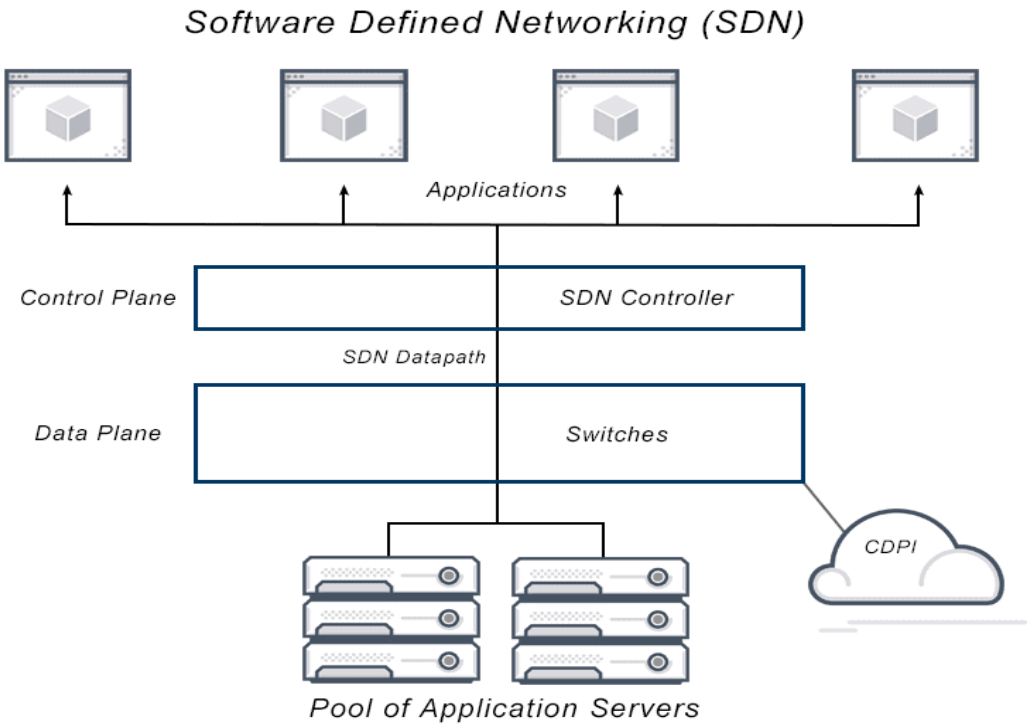


Fig: SDN Architecture

SDN architecture includes the following components:

• ***SDN Application*** — Communicates network resources and network devices to the SDN controller through the northbound interface (NBI).

• ***SDN Controller*** — Translates the requirements from the SDN application layer to the SDN datapaths.

• ***SDN Datapath*** — Implements switches that move data packets on a network.

• ***SDN API*** — Application program interfaces (APIs) provide both open and proprietary communication between the SDN Controller and the routers of the network.

Benefits of Software Defined Networking:

Software defined network (SDN) basics include the following benefits:
• ***Control*** — Administrators have more control over traffic flow with the ability to change a network's switch rules based on need.
• ***Management*** — A centralized controller lets network administrators distribute policies through switches without having to configure individual devices.
• ***Visibility*** — By monitoring traffic, the centralized controller can identify suspicious traffic and reroute packets.
• ***Efficiency*** — Virtualization of services reduces reliance on costly hardware.

Network Function Virtualization in cloud computing (NFV):

Network Virtualization is a process of logically grouping physical networks and making them operate as single or multiple independent networks called Virtual Networks.

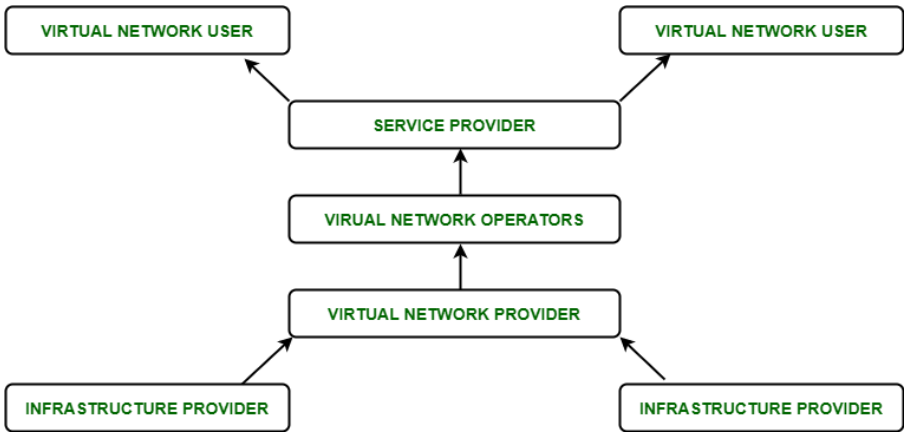


Fig: General Architecture of Network Virtualization

Tools for Network Virtualization:

1. **Physical switch OS** –
   It is where the OS must have the functionality of network virtualization.
2. **Hypervisor –**
   It is which uses third-party software or built-in networking and the functionalities of network virtualization.

The basic functionality of the OS is to give the application or the executing process with a simple set of instructions. System calls that are generated by

the OS and executed through the libc library are comparable to the service primitives given at the interface between the application and the network through the SAP (Service Access Point).

The hypervisor is used to create a virtual switch and configuring virtual networks on it. The third-party software is installed onto the hypervisor and it replaces the native networking functionality of the hypervisor. A hypervisor allows us to have various VMs all working optimally on a single piece of computer hardware.

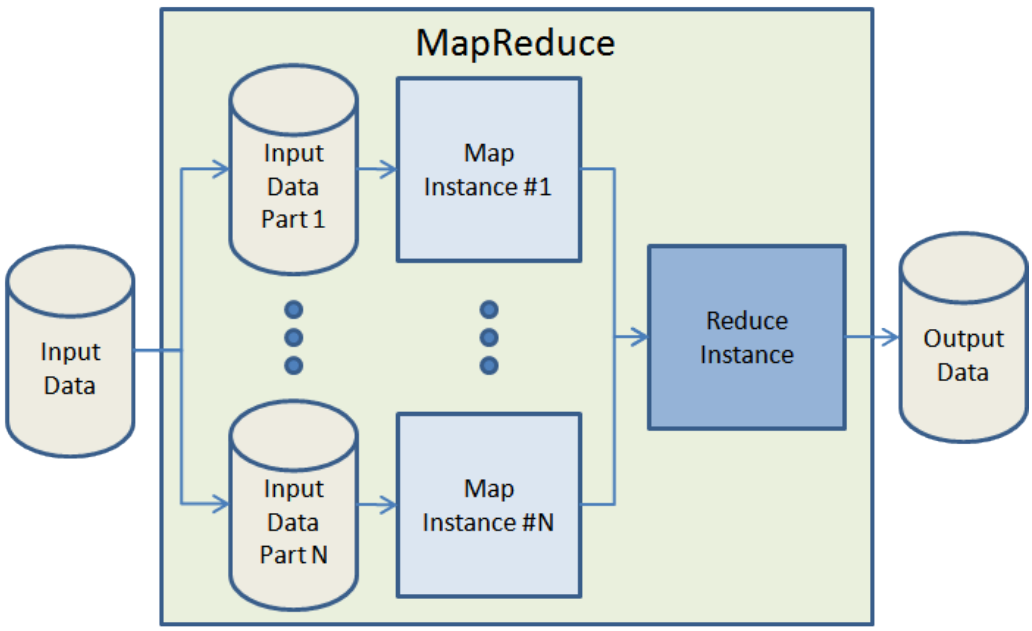
Functions of Network Virtualization:

- It enables the functional grouping of nodes in a virtual network.
- It enables the virtual network to share network resources.
- It allows communication between nodes in a virtual network without routing of frames.
- It restricts management traffic.
- It enforces routing for communication between virtual networks.

Map Reduce:

MapReduce is **a programming model or pattern within the Hadoop framework that is used to access big data stored in the Hadoop File System (HDFS)**. It is a core component, integral to the functioning of the Hadoop framework.

A MapReduce is a data processing tool which is used to process the data parallelly in a distributed form. It was developed in 2004, on the basis of paper titled as "MapReduce: Simplified Data Processing on Large Clusters," published by Google.



The Map Reduce is a paradigm which has two phases, the

i. ***Mapper phase,***
ii. ***Reducer phase***.

The Mapper, the input is given in the form of a key-value pair. The output of the Mapper is fed to the reducer as input.

The reducer runs only after the Mapper is over. The reducer too takes input in key-value format, and the output of reducer is the final output.

Usage of Map Reduce

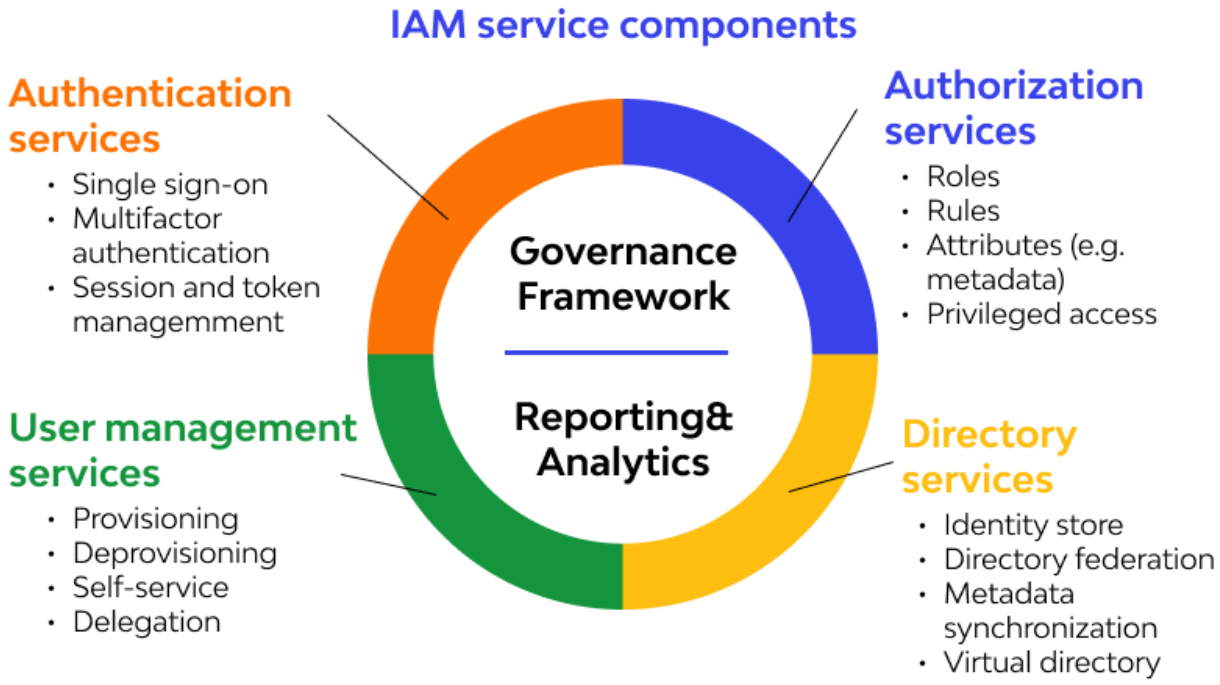
- It can be used in various application like document clustering, distributed sorting, and web link-graph reversal.
- It can be used for distributed pattern-based searching.
- We can also use MapReduce in machine learning.
- It was used by Google to regenerate Google's index of the World Wide Web.
- It can be used in multiple computing environments such as multi-cluster, multi-core, and mobile environment.

Identity and Access Management(IAM):

IAM is **a cloud service that controls the permissions and access for users and cloud resources**. IAM policies are sets of permission policies that can be attached to either users or cloud resources to authorize what they access and what they can do with it.

Identity and Access Management (IAM) is a combination of policies and technologies that allows organizations to identify users and provide the right form of access as and when required. There has been a burst in the market with new applications, and the requirement for an organization to use these applications has increased drastically.

The services and resources you want to access can be specified in IAM. IAM doesn't provide any replica or backup. IAM can be used for many purposes such as you want to secure the control of individual and group access from your AWS resources.



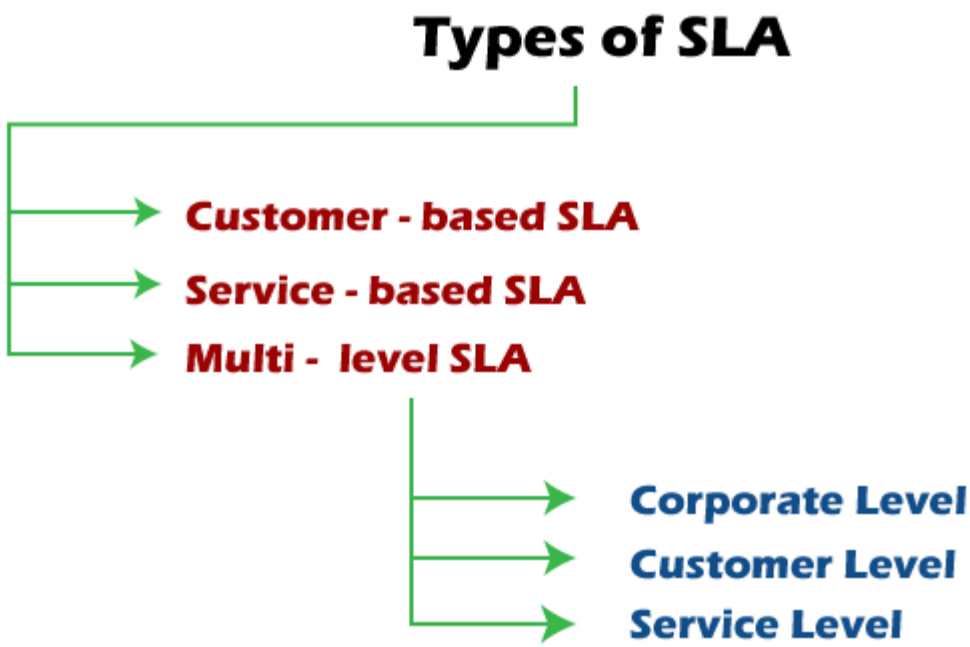
Service Level Agreements(SLA):

A service-level agreement (SLA) is a commitment between a service provider and a client. Particular aspects of the service, such as ***quality, availability, responsibilities*** are agreed upon between the service provider and the service user.

The most common component of an SLA is that the services should be provided to the customer as agreed upon in the contract. It is a critical component of any technology vendor contract. For example, Internet service providers will commonly include service level agreements within the terms of their contracts with customers to define the level of service being sold in plain language terms. Usually, SLAs are between companies and external suppliers, but they may also be between two departments within a company.

Types of SLA

The selection of the types of SLA in an organization depends on many significant aspects



1. Customer-based SLA

This type of agreement is used for individual customers and comprises all relevant services that a client may need while leveraging only one contract. It contains details regarding the type and quality of service that has been agreed upon.

For example, a telecommunication service includes voice calls, messaging, and internet services, but all exist under a single contract.

2. Service-based SLA

This SLA is a contract that includes one identical type of service for all of its customers. Because the service is limited to one unchanging standard, it is more straightforward and convenient for vendors.

For example, using a service-based agreement regarding an IT helpdesk would mean that the same service is valid for all end-users that sign the service-based SLA.

3. Multi-level SLA

This agreement is customized according to the needs of the end-user company. It allows the user to integrate several conditions into the same system to create a more convenient service. This type of SLA can be divided into the following subcategories:

- **Corporate level:** This SLA does not require frequent updates since its issues are typically unchanging. It includes a comprehensive discussion

of all the relevant aspects of the agreement and applies to all customers in the end-user organization.

- **Customer level:** This contract discusses all service issues that are associated with a specific group of customers. However, it does not take into consideration the type of user services. For example, when an organization requests that the security level in one of its departments is strengthened. In this situation, the entire company is secured by one security agency but requires that one of its customers is more secure for specific reasons.
- **Service level:** In this agreement, all aspects attributed to a particular service regarding a customer group are included.

Billing:

A Cloud Billing account defines who pays for a given set of Google Cloud resources. To use Google Cloud services, you must have a valid Cloud Billing account, and must link it to your Google Cloud projects. Your project's Google Cloud usage is charged to the linked Cloud Billing account.

You must have a valid Cloud Billing account even if you are in your free trial period or if you only use Google Cloud resources that are covered by the Google Cloud Free Tier.

Benefits:

- Licensing costs are reduced; hence increase in revenues
- Service costs are reduced
- Security and data protection
- Increased scalability
- Modernized business collaboration tools
- Portability and mobility: you can work over it from anywhere you are sitting and can be accessed easily.
- Flexible pricing
- On-demand scalability
- Improved business insight & reporting
- Complete integration & enhanced operational processes
  - Improves customer relationships

Important Questions

2 Marks:

1. What is Map reducing.
2. Define IAM.
3. How can you identify cc billing?
4. Differentiate Scalability and Elasticity.
5. What are the services are performed in Cloud Computing?
6. Define Replication.
7. What are the types in SLA.

5 /10 Marks

1. Define Cloud Computing. What are the characteristics in CC?
2. What are the different types of Cloud Computing? Explain each one detail.
3. What CC Virtualization. Explain CC Virtualization types.
4. Define Load Balancing. What are the different types load balancing? Explain each one detail.
5. What is Replication. What are the benefits of replication? Explain replication types.
6. Define SDN. Explain SDN Architecture with neat sketch.
7. Define SLA. Explain SLA types.