MODULE I

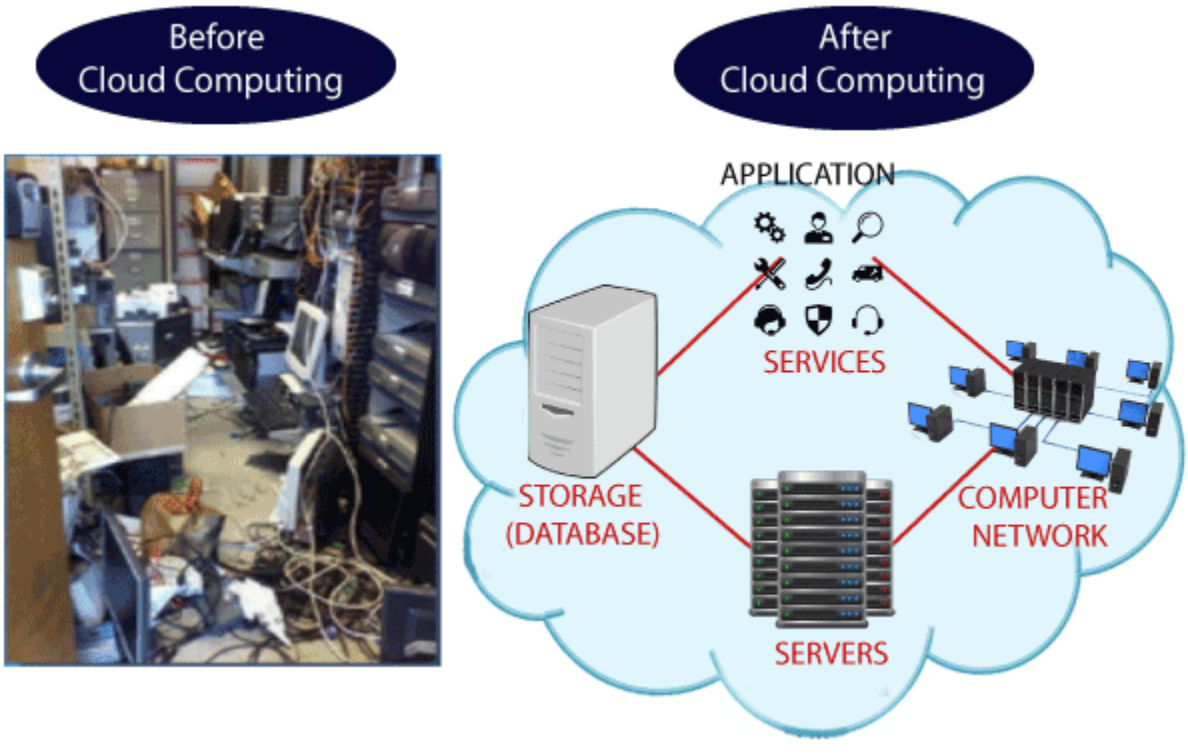
What is Cloud Computing

The term cloud refers to a network or the 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.
There are the following operations that we can do using cloud computing:

- Developing new applications and services
- Storage, back up, and recovery of data
- Hosting blogs and websites
- Delivery of software on demand
- Analysis of data
- Streaming videos and audios

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.



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**.

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**.

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 and Disadvantages of Cloud Computing

Advantages of Cloud Computing

As we all know that Cloud computing is trending technology. Almost every company switched their services on the cloud to rise the company growth.

1) **Back-up and restore data**

Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

2) Improved collaboration

Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

3) Excellent accessibility

Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection.

4) Low maintenance cost

Cloud computing reduces both hardware and software maintenance costs for organizations.

5) Mobility

Cloud computing allows us to easily access all cloud data via mobile.

6) Services in the pay-per-use model

Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.

7) Unlimited storage capacity

Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.

8) Data security

Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

Disadvantages of Cloud Computing

A list of the disadvantage of cloud computing is given below -

1) Internet Connectivity

In cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data.

2) Vendor lock-in

Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

3) Limited Control

As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

4) Security

Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

History of Cloud Computing

Before emerging the cloud computing, there was Client/Server computing which is basically a centralized storage in which all the software applications, all the data and all the controls are resided on the server side.
If a single user wants to access specific data or run a program, he/she need to connect to the server and then gain appropriate access, and then he/she can do his/her business.
Then after, distributed computing came into picture, where all the computers are networked together and share their resources when needed.

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

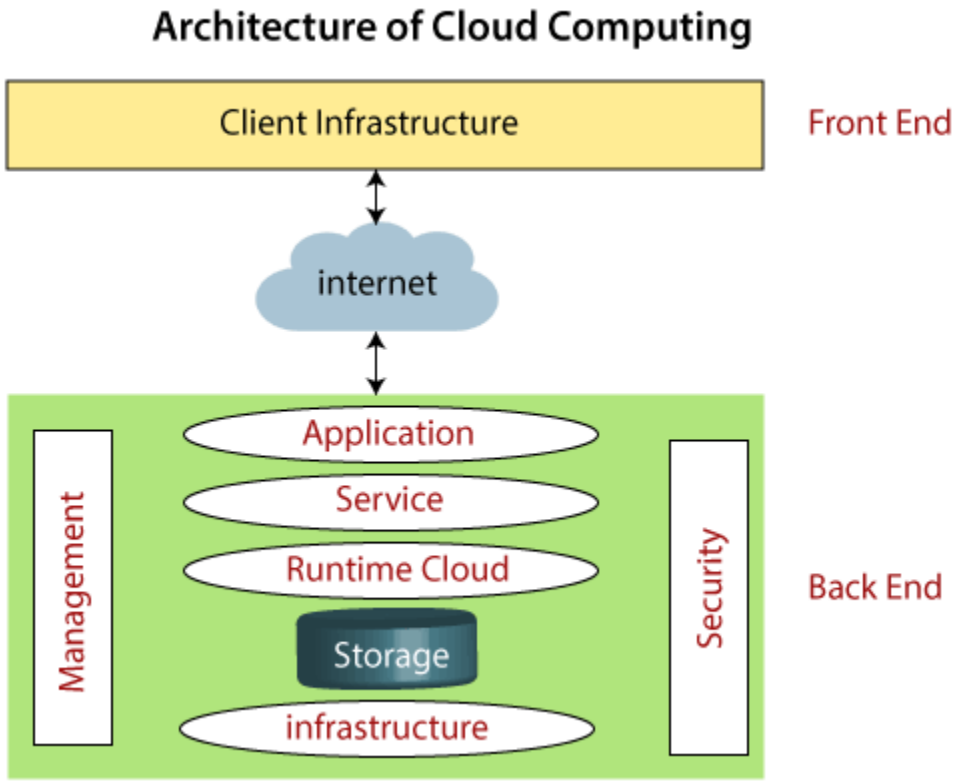
In 1999, **Salesforce.com** *started delivering of applications to users using a simple website*. The applications were delivered to enterprises over the Internet.
In 2002, **Amazon** *started Amazon Web Services*, providing services like storage, computation and even human intelligence. However, only starting with the launch of the Elastic Compute Cloud in 2006 a truly commercial service open to everybody existed.
In 2009, **Google Apps** *also started to provide cloud computing enterprise applications.*
Of course, all the big players are present in the cloud computing evolution, some were earlier, some were later.
In 2009, **Microsoft** *launched Windows Azure*, and companies like Oracle and HP have all joined the game. This proves that today, cloud computing has become mainstream.

Cloud Computing Architecture

As we know, 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 -

- Front End
- Back End

The below 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 browsers (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.

> *Note: Both front end and back end are connected to others through a network, generally using the internet connection.*

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

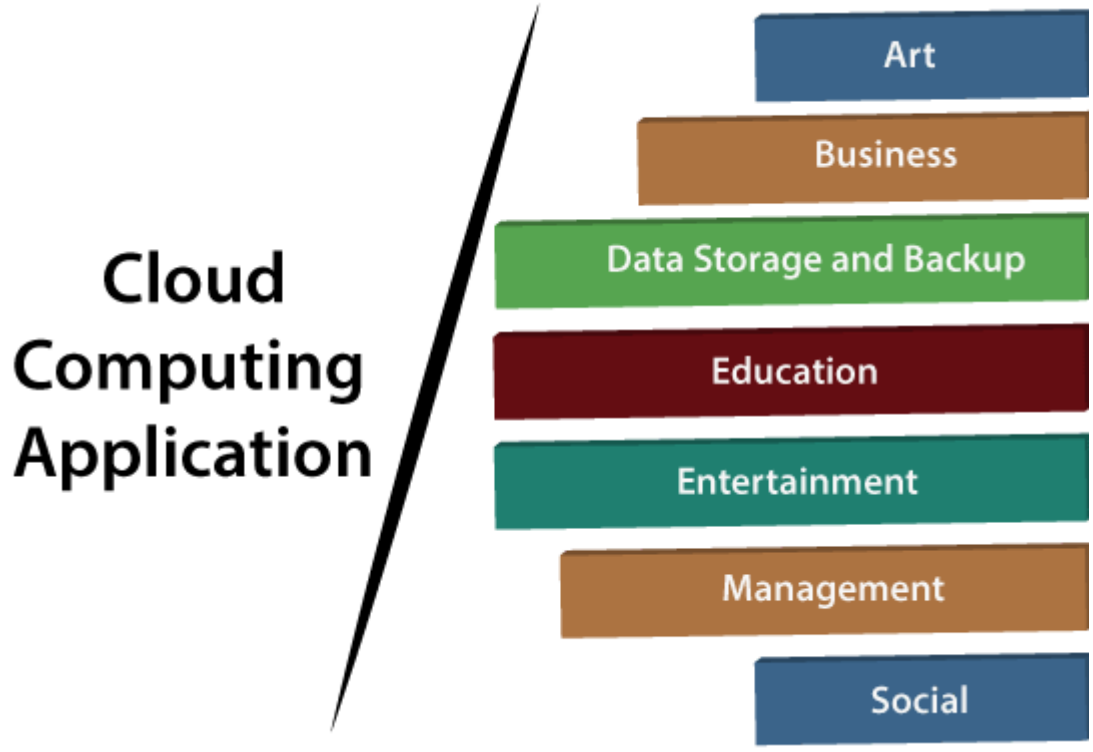
Security is an in-built back end component of cloud computing. It implements a security mechanism in the back end.

9. Internet

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

Cloud Computing Applications

Cloud service providers provide various applications in the field of art, business, data storage and backup services, education, entertainment, management, social networking, etc.
The most widely used cloud computing applications are given below -



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.

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.

ii. Salesforce

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

iii. Chatter

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

iv. 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.

v. 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

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.

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

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

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 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.

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.
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.

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
ii. Twitter
Twitter is a **social networking** site. It allows users to follow high profile celebrities, friends, relatives, and receive news.
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.

What are the Security Risks of Cloud Computing

Cloud computing provides various advantages, such as improved collaboration, excellent accessibility, Mobility, Storage capacity, etc. But there are also security risks in cloud computing.
Some most common Security Risks of Cloud Computing are given below-

Data Loss

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

Hacked Interfaces and Insecure APIs

As we all know, cloud computing is completely depends on Internet, so it is compulsory to protect interfaces and APIs that are used by external users. APIs are the easiest way to

communicate with most of the cloud services. In cloud computing, few services are available in the public domain. These services can be accessed by third parties, so there may be a chance that these services easily harmed and hacked by hackers.

Data Breach

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

Vendor lock-in

Vendor lock-in is the of the biggest security risks in cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving one cloud to another.

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 to the cloud.

Denial of Service (DoS) attacks

Denial of service (DoS) attacks occur when the system receives too much traffic to buffer the server. Mostly, DoS attackers target web servers of large organizations such as banking sectors, media companies, and government organizations. To recover the lost data, DoS attackers charge a great deal of time and money to handle the data.

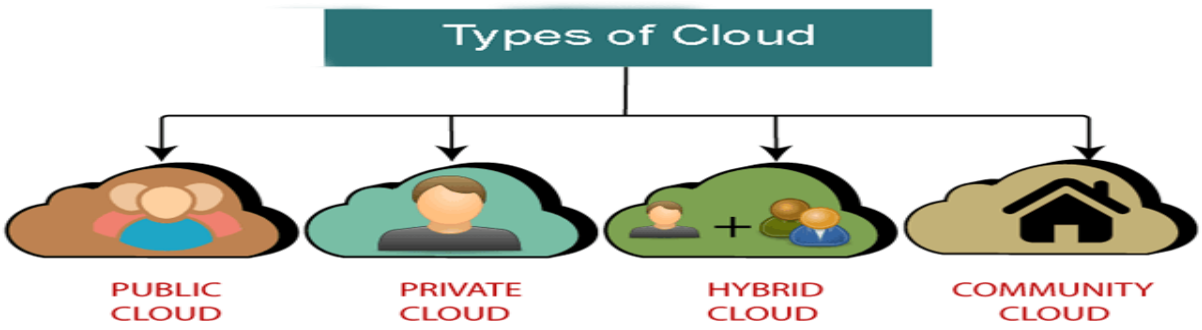
Account hijacking

Account hijacking is a serious security risk in cloud computing. It is the process in which individual user's or organization's 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.

CLOUD DEPLOYMENT MODELS

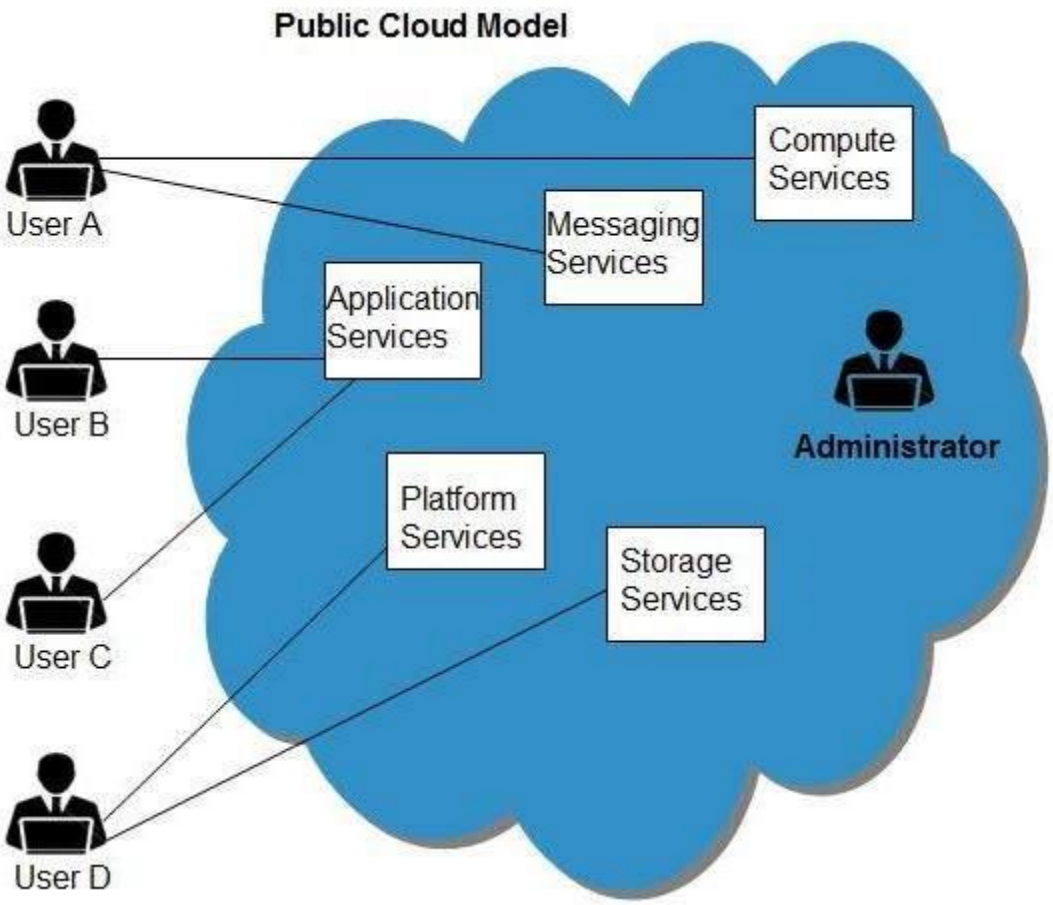
Deployment Model	Characteristics
Private cloud	Owned by a specific entity and normally used only by that entity or one or its customers. The underlying technology may reside on- or off-site. A private eoffers increased security at a greater cost.

Public cloud	Available for use by the general public. May be owned bya large organization or company offering cloud service. Because of its openness, the cloud may be less secure. Apublic cloud is usually the least expensive solution.
Community cloud	The cloud is shared by two or more organizations, typicallywith shared concerns (such as schools within a university).
Hybrid cloud	A cloud that consists of two or more private, public, orcommunity clouds.



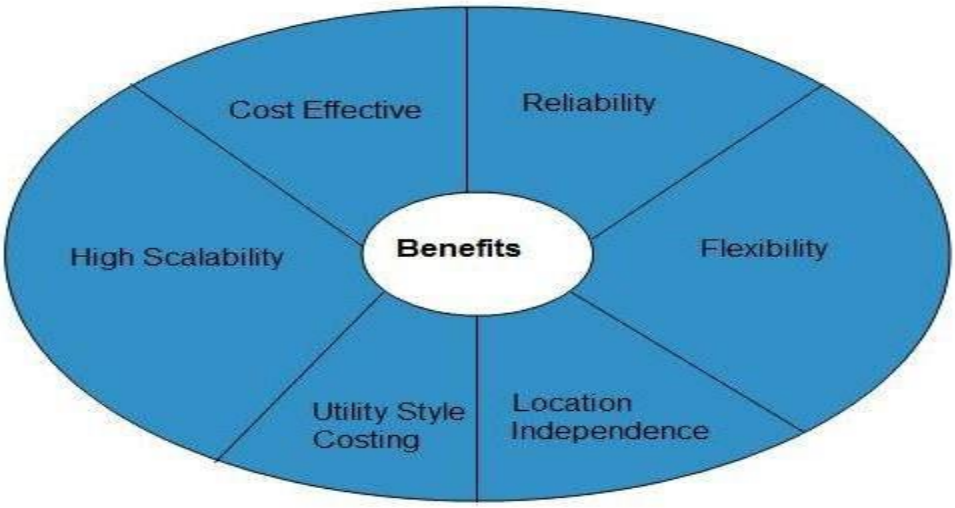
PUBLIC CLOUD

Public Cloud allows systems and services to be easily accessible to general public. The IT giants such as **Google, Amazon** and **Microsoft** offer cloud services via Internet. The Public Cloud Model is shown in the diagram below.



ADVANTAGES

There are many benefits of deploying cloud as public cloud model. The following diagram shows some of those benefits:



Cost Effective

Since **public cloud** shares same resources with large number of customers it turns out inexpensive.

Reliability

The **public cloud** employs large number of resources from different locations. If any of the resources fails, public cloud can employ another one.

Flexibility

The public cloud can smoothly integrate with private cloud, which gives customers a flexible approach.

Location Independence

Public cloud services are delivered through Internet, ensuring location independence.

Utility Style Costing

Public cloud is also based on **pay-per-use** model and resources are accessible whenever customer needs them.

High Scalability

Cloud resources are made available on demand from a pool of resources, i.e., they can be scaled up or down according the requirement.

Disadvantages

Here are some disadvantages of public cloud model:

Low Security

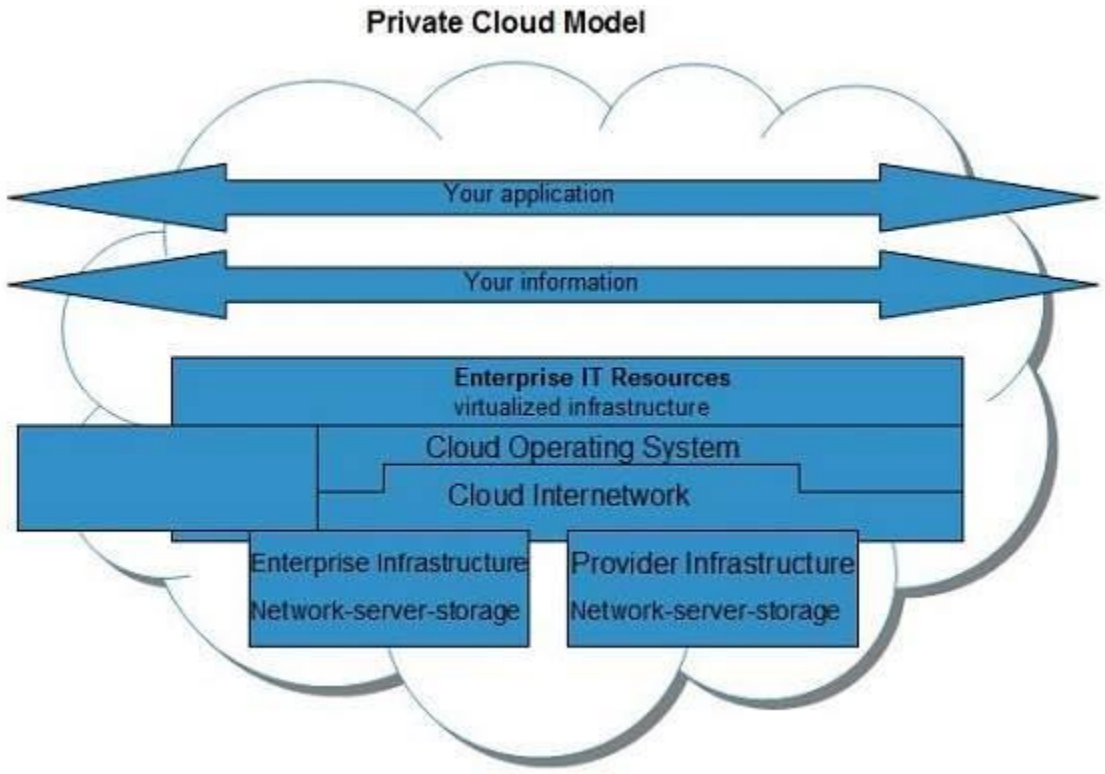
In **public cloud model,** data is hosted off-site and resources are shared publicly, therefore does not ensure higher level of security.

Less Customizable

It is comparatively less customizable than private cloud.

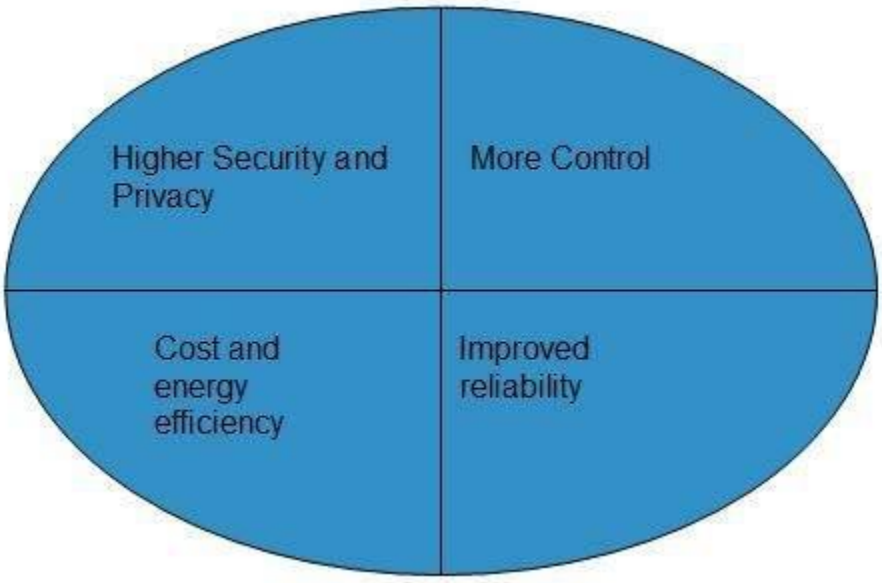
PRIVATE CLOUD

Private Cloud allows systems and services to be accessible within an organization. The Private Cloud is operated only within a single organization. However, it may be managed internally by the organization itself or by third-party. The private cloud model is shown in the diagram below.



Benefits

There are many benefits of deploying cloud as private cloud model. The following diagram shows some of those benefits:



High Security and Privacy

Private cloud operations are not available to general public and resources are shared from distinct pool of resources. Therefore, it ensures high **security** and **privacy.**

More Control

The **private cloud** has more control on its resources and hardware than public cloud because it is accessed only within an organization.

Cost and Energy Efficiency

The **private cloud** resources are not as cost effective as resources in public clouds but they offer more efficiency than public cloud resources.

Disadvantages

Here are the disadvantages of using private cloud model:

Restricted Area of Operation

The private cloud is only accessible locally and is very difficult to deploy globally.

High Priced

Purchasing new hardware in order to fulfill the demand is a costly transaction.

Limited Scalability

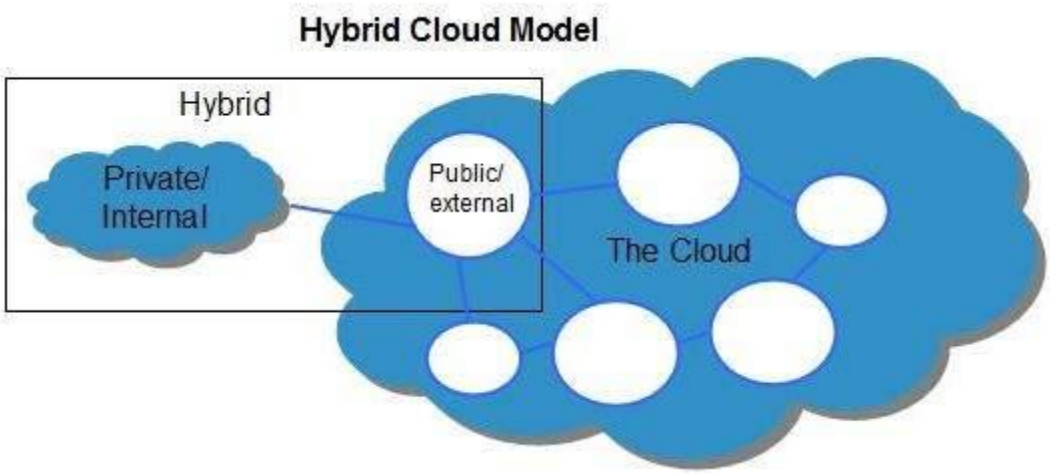
The private cloud can be scaled only within capacity of internal hosted resources.

Additional Skills

In order to maintain cloud deployment, organization requires skilled expertise.

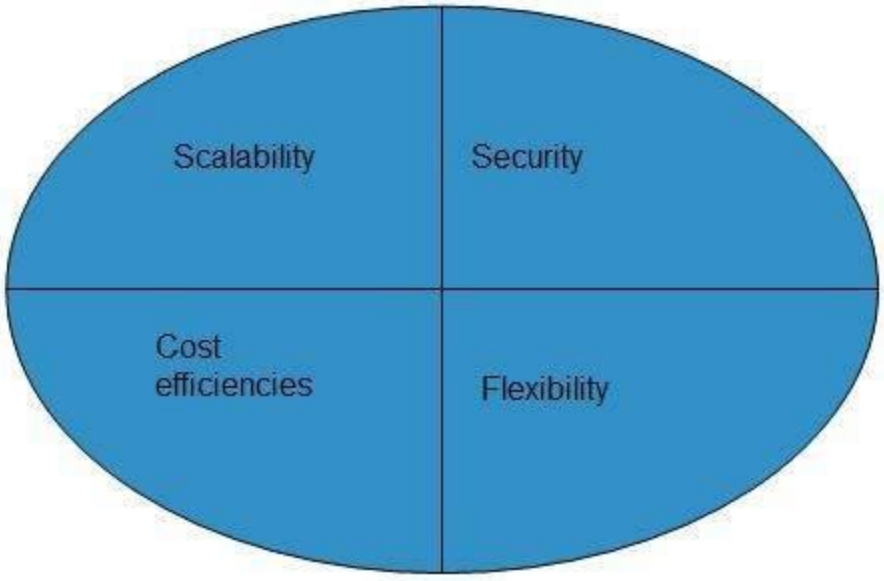
HYBRID CLOUD

Hybrid Cloud is a mixture of **public** and **private** cloud. Non-critical activities are performed using public cloud while the critical activities are performed using private cloud. The Hybrid Cloud Model is shown in the diagram below.



ADVANTAGES

There are many benefits of deploying cloud as hybrid cloud model. The following diagram shows some of those benefits:



Scalability

It offers features of both, the public cloud scalability and the private cloud scalability.

Flexibility

It offers secure resources and scalable public resources.

Cost Efficiency

Public clouds are more cost effective than private ones. Therefore, hybrid clouds can be cost saving.

Security

The private cloud in hybrid cloud ensures higher degree of security.

Disadvantages

Networking Issues

Networking becomes complex due to presence of private and public cloud.

Security Compliance

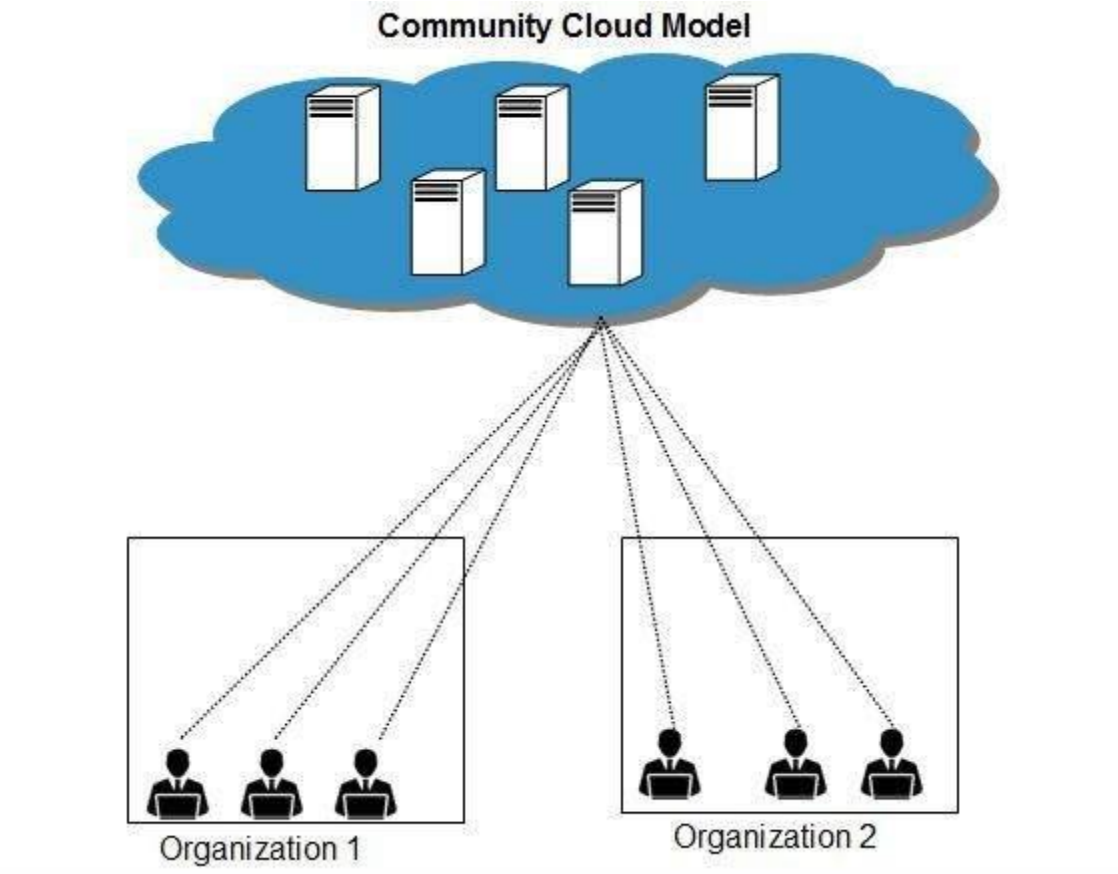
It is necessary to ensure that cloud services are compliant with security policies of the organization.

Infrastructure Dependency

The **hybrid cloud model** is dependent on internal IT infrastructure, therefore it is necessary to ensure redundancy across data centers.

COMMUNITY CLOUD

Community Cloud allows system and services to be accessible by group of organizations. It shares the infrastructure between several organizations from a specific community. It may be managed internally by organizations or by the third-party. The Community Cloud Model is shown in the diagram below.



ADVANTAGES

There are many benefits of deploying cloud as **community cloud model.**

Cost Effective

Community cloud offers same advantages as that of private cloud at low cost.

Sharing Among Organizations

Community cloud provides an infrastructure to share cloud resources and capabilities among several organizations.

Security

The community cloud is comparatively more secure than the public cloud but less secured than the private cloud.

Issues

- Since all data is located at one place, one must be careful in storing data in community cloud because it might be accessible to others.
- It is also challenging to allocate responsibilities of governance, security and cost among organizations.

CLOUD COMPUTING TECHNOLOGIES

A list of cloud computing technologies are given below -

- **Virtualization**
- **Service-Oriented Architecture (SOA)**
- **Grid Computing**
- **Utility Computing**

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

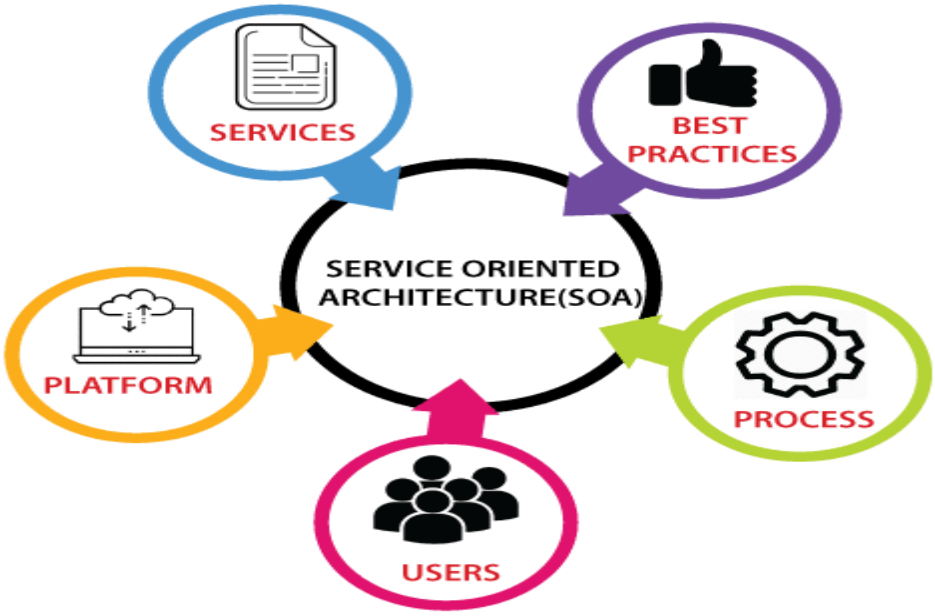
cloud computing. The advantages of using SOA is that it is easy to maintain, platform independent, and highly scalable.
Service Provider and Service consumer are the two major roles within SOA.

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:

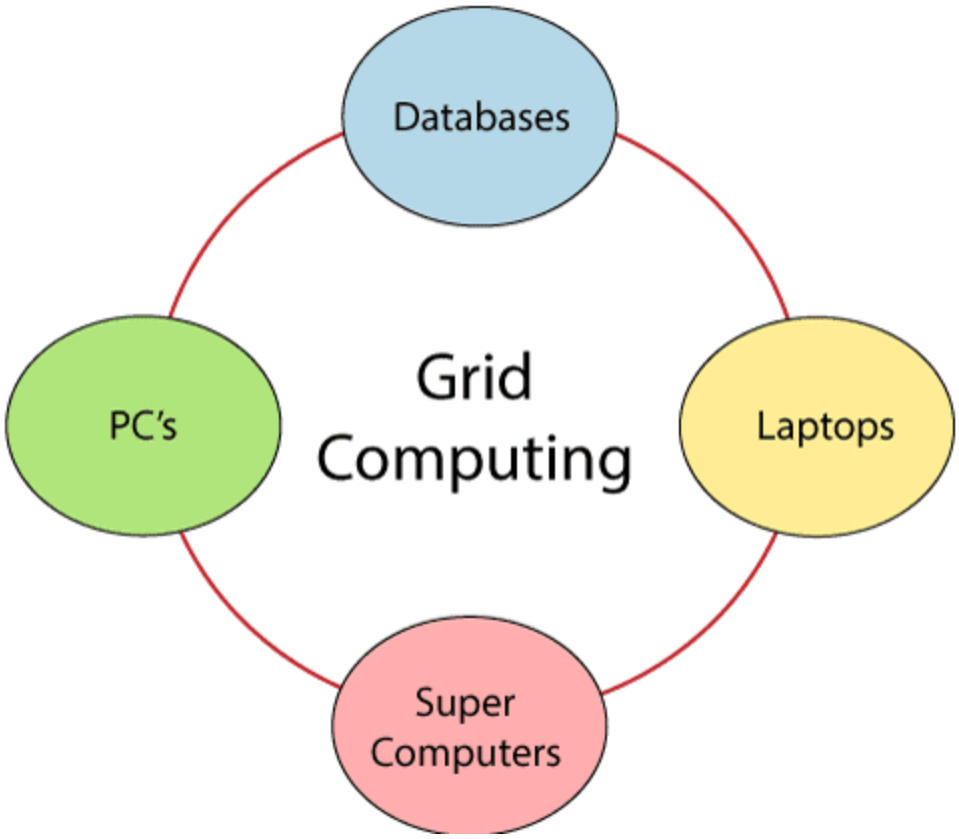


Grid Computing

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 -

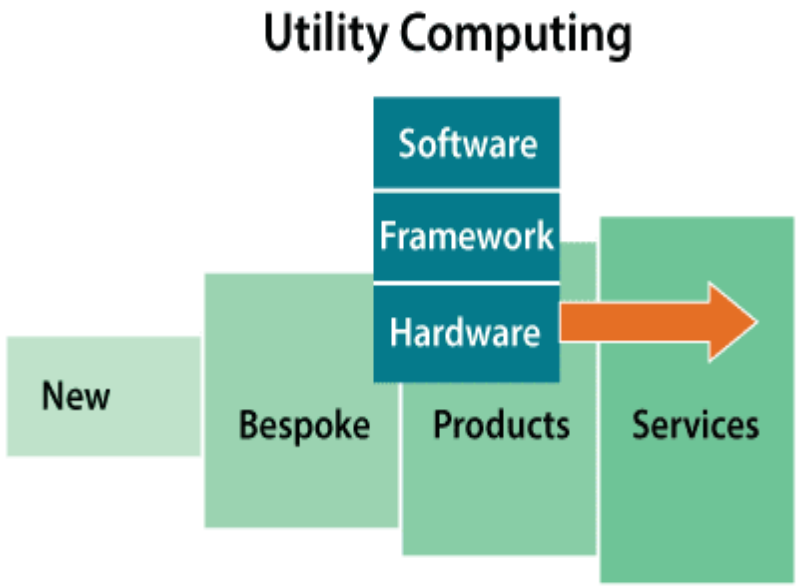
1. **Control Node:** It is a group of server which administrates the whole network.
2. **Provider:** It is a computer which contributes its resources in the network resource pool.
3. **User:** It is a computer which uses the resources on the network.

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.



Distributed Computing

If you are connecting a collection of independent computers via a network, that are concentrate on a particular task then it is distributed system. Independent computers mean they don't share memory or program execution space, Computing can be performed among network computers then it is a distributedcomputing. Computing in grid also achieves similar properties so distributedcomputing is also one of the concept for evaluating grid computing

Grid is a loosely-coupled-means systems in grid are jts own processor andmemory. They didn't share the program execution space (in tightly coupledsystems data can be shared using common memory space). The following diagram shows a simple distributed system.

Web 2.0 and the Cloud

For years, when companies wanted to place content on the web, they hired webdevelopers, who created the underlying HTML documents. Through this process,the number of documents on

the web exploded to billions worldwide. **Web 2.0**isa term used to describe the set of tools and websites that allow users to publish content to the web without the direct use of HTML. Behind the scenes, the toolsand web sites build the HTML documents for the user and then upload the documentsto a web server.

TABLE BELOW describes the common Web 2.0 applications.

Application/Site	Purpose
Blog	A web log that users can write and use to publish content directly to the web.
Wiki	A software program that allows users to collaborate on shared web-based documents.
Twitter	A microblogging service that allows users to send messages ofup to 140 characters to those who follow the users' tweets
Facebook	A social networking site to which users can post text,photos, and video-based content
YouTube	A site to which users can upload video content for sharingwith others.

CLOUD SERVICE MODELS

Cloud Service Model	Characteristics
Software as a service (SaaS)	A complete software application with a user interface.
Platform as a service (Paas)	A platform within which developers can deploy their applications. A PaaS solution includes hardware (servers and disks), operating systems, development tools, and administrative tools.
Infrastructure as a service (IaaS)	Provides machines, storage, and network resources that developers can manage by

	installing their own operating system, applications, and support resources.

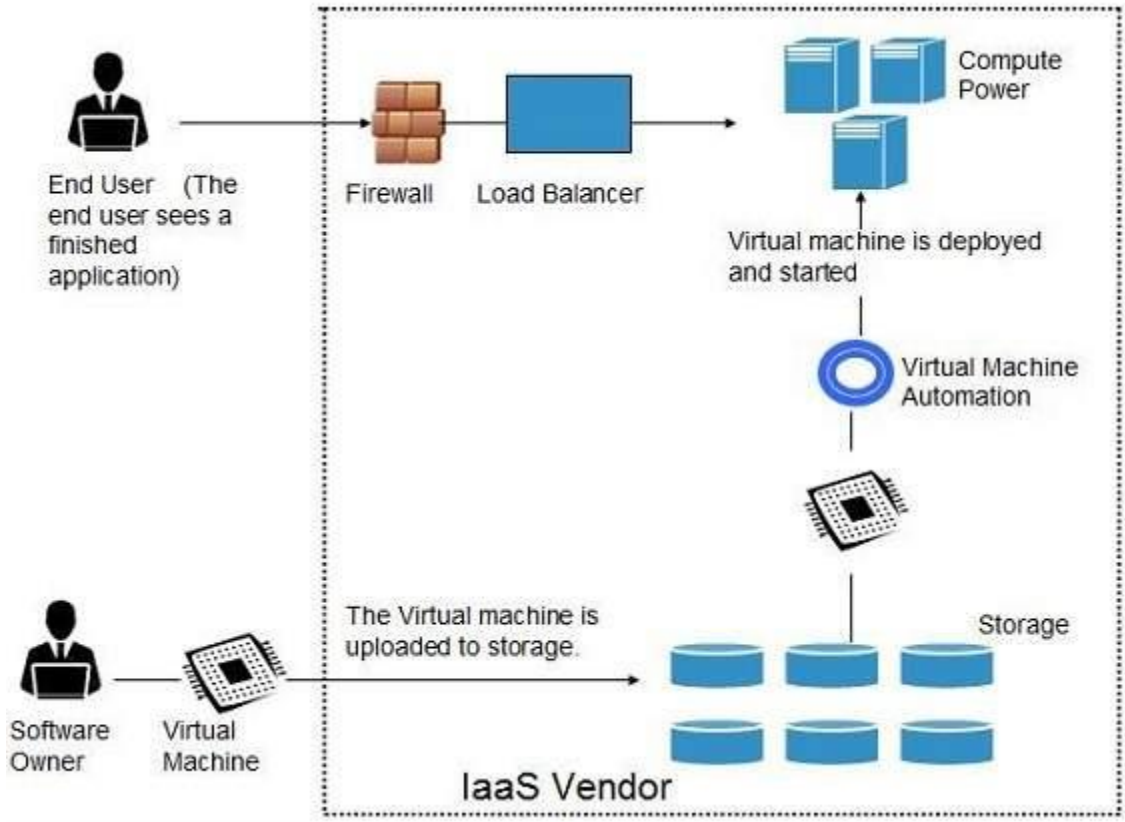
Cloud Computing Infrastructure as a Service (IaaS)

Iaas is also known as **Hardware as a Service (HaaS)**. It is one of the layers of the cloud computing platform. 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.

Infrastructure-as-a-Service provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc. Apart from these resources, the IaaS also offers:

- Virtual machine disk storage
- Virtual local area network (VLANs)
- Load balancers
- IP addresses
- Software bundles

All of the above resources are made available to end user via **server virtualization.** Moreover, these resources are accessed by the customers as if they own them.



Advantages

Flexible and efficient renting of computer hardware

IaaS resources such as virtual machines, storage devices, bandwidth, IP addresses, monitoring services, firewalls, etc. are made available to the customers on rent.

Portability, interoperability with legacy applications

It is possible to maintain legacy between applications and workloads between IaaS clouds.

Shared infrastructure
IaaS allows multiple users to share the same physical infrastructure.
Web access to the resources
Iaas allows IT users to access resources over the internet.
Pay-as-per-use model
IaaS providers provide services based on the pay-as-per-use basis. The users are required to pay for what they have used.
Focus on the core business
IaaS providers focus on the organization's core business rather than on IT infrastructure.
On-demand scalability
On-demand scalability is one of the biggest advantages of IaaS. Using IaaS, users do not worry about to upgrade software and troubleshoot the issues related to hardware components.

Disadvantages

Security

Security is one of the biggest issues in IaaS. Most of the IaaS providers are not able to provide 100% security.

Maintenance & Upgrade

Although IaaS service providers maintain the software, but they do not upgrade the software for some organizations.

Interoperability issues

It is difficult to migrate VM from one IaaS provider to the other, so the customers might face problem related to vendor lock-in.

Compatibility with legacy security vulnerabilities

Because IaaS offers the customer to run legacy software in provider's infrastructure,

Virtual Machine sprawl

The VM can become out-of-date with respect to security updates because IaaS allows the customer to operate the virtual machines in running, suspended and off state. However, the provider can automatically update such VMs, but this mechanism is hard and complex.

Data erase practices

The customer uses virtual machines that in turn use the common disk resources provided by the cloud provider. When the customer releases the resource, the cloud provider must ensure that next customer to rent the resource does not observe data from previous customer.

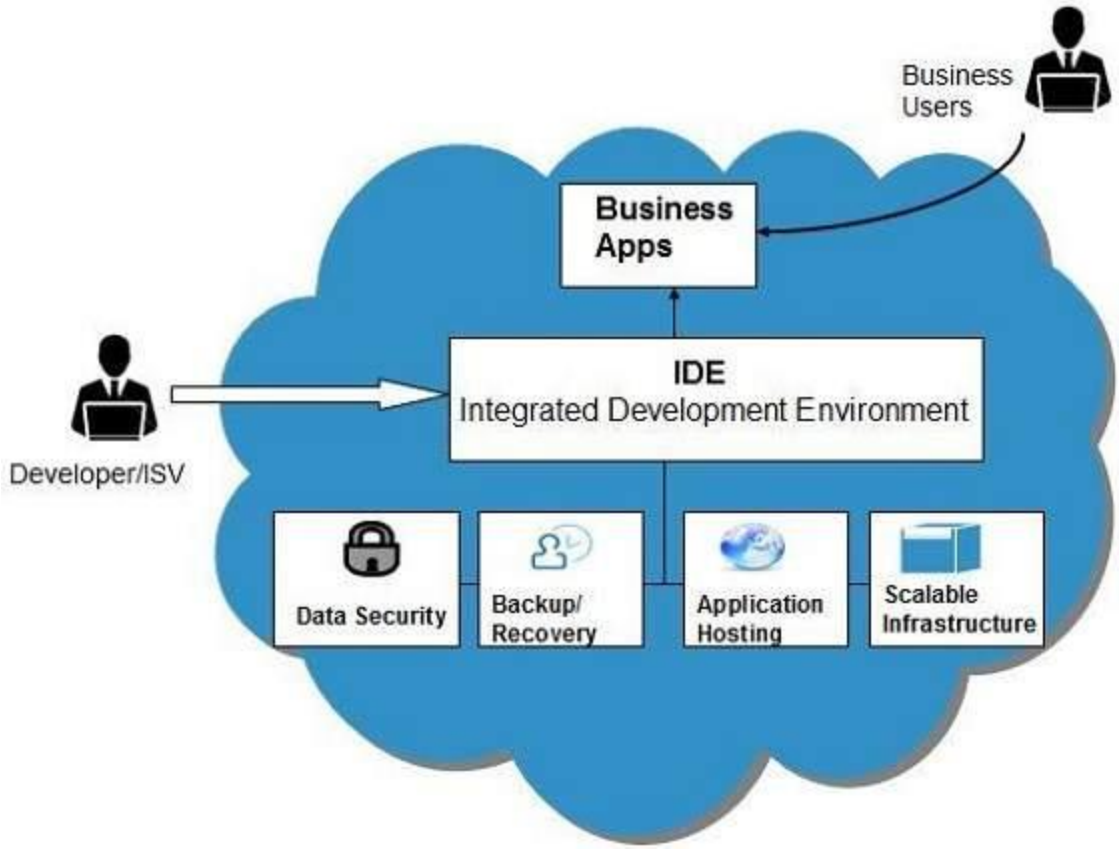
Platform as a Service | PaaS

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 the 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.

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

PaaS providers provide the Programming languages, Application frameworks, Databases, and Other tools:



1. Programming languages

PaaS providers provide various programming languages for the developers to develop the applications. Some popular programming languages provided by PaaS providers are Java, PHP, Ruby, Perl, and Go.

2. Application frameworks

PaaS providers provide application frameworks to easily understand the application development. Some popular application frameworks provided by PaaS providers are Node.js, Drupal, Joomla, WordPress, Spring, Play, Rack, and Zend.

3. Databases

PaaS providers provide various databases such as ClearDB, PostgreSQL, MongoDB, and Redis to communicate with the applications.

4. Other tools

PaaS providers provide various other tools that are required to develop, test, and deploy the 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 the ideas to 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 cloud 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.

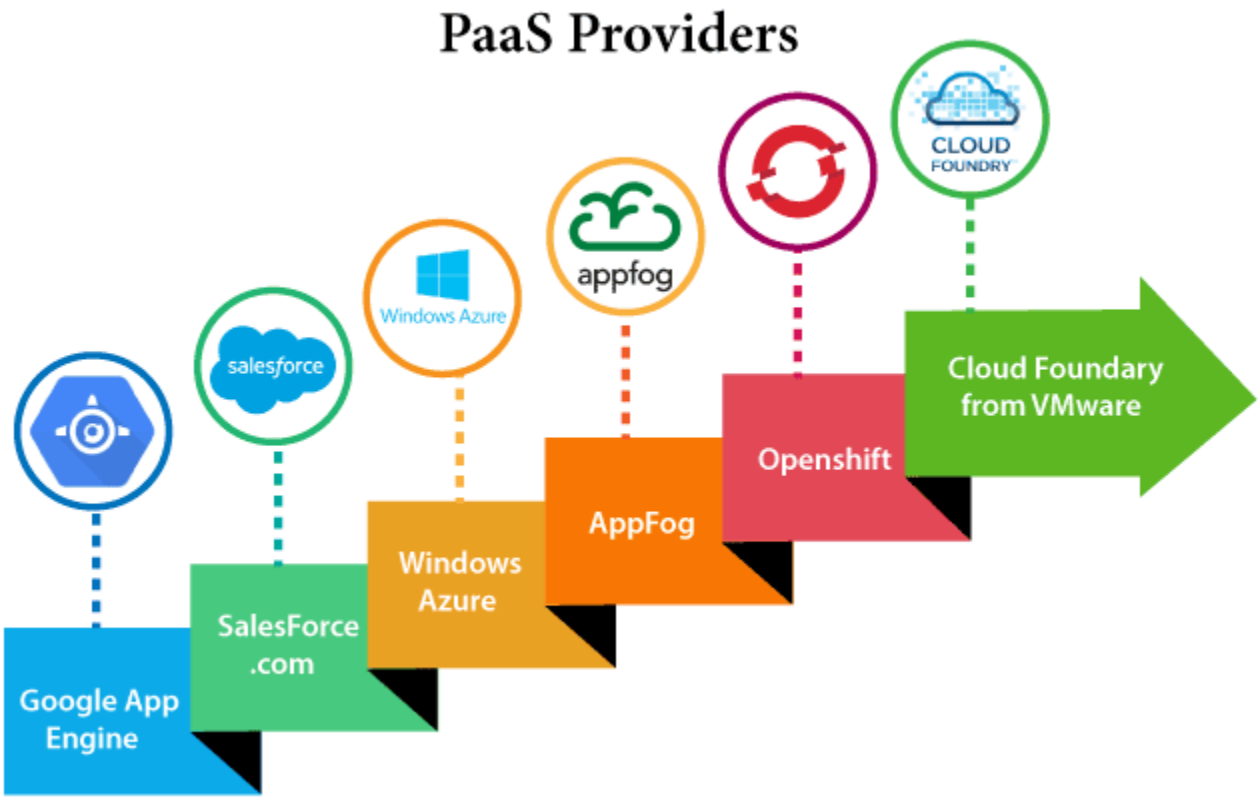
2) Data Privacy

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 which in the cloud with the local data.

Popular PaaS Providers



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.
There are the following services provided by SaaS providers -
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 providers) to create, manage, and track electronic documents.
Example: 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 offering their services using SaaS.

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.
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 the organizations. The initial set-up cost for SaaS is typically less than the enterprise software..
5. No special software or hardware versions 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 the internet connection, so 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..
3) Total Dependency on 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 the very large data files over the internet and then converting and importing them into another SaaS also.

Popular SaaS Providers

Identity as a Service (IDaaS)

Employees in a company require to login to system to perform various tasks. These systems may be based on local server or cloud based. Following are the problems that an employee might face:

- Remembering different username and password combinations for accessing multiple servers.
- If an employee leaves the company, it is required to ensure that each account of that user is disabled. This increases workload on IT staff.

To solve above problems, a new technique emerged which is known as **Identity-as–a-Service (IDaaS).**

IDaaS offers management of identity information as a digital entity. This identity can be used during electronic transactions.

Identity

Identity refers to set of attributes associated with something to make it recognizable. All objects may have same attributes, but their identities cannot be the same. A unique identity is assigned through unique identification attribute.

There are several **identity services** that are deployed to validate services such as validating web sites, transactions, transaction participants, client, etc.

Network as a Service (NaaS)

Network-as-a-Service allows us to access to network infrastructure directly and securely. NaaS makes it possible to deploy **custom routing protocols.**

NaaS uses **virtualized network infrastructure** to provide network services to the customer. It is the responsibility of NaaS provider to maintain and manage the network resources. Having a provider working for a customer decreases the workload of the customer. Moreover, NaaS offers **network as a utility.** NaaS is also based on **pay-per-use model.**

ON DEMAND COMPUTING

On-demand computing is an enterprise-level model of technology by which a customer can purchase cloud services as and when needed. On-demand computing is a business computing model in which computing resources are made available to the user on an "as needed" basis. Rather than all at once, on-demand computing allows cloud hosting companies to provide their clients with access to computing resources as they become necessary.

For example, if a customer needs to utilize additional servers for the duration of a project, they can do so and then drop back to the previous level after the project is completed. ODC make computing resources such as storage capacity, computational speed and software applications available to users as needed for specific temporary projects, known or unexpected workloads, routine work, or long-term technological and computing requirements.

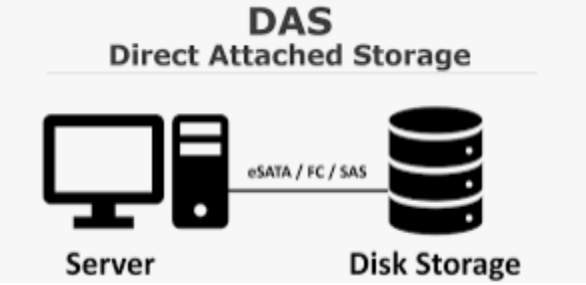
MODULE 2

THE ELEMENTS OF STORAGE

New mobile and digital technologies are among the many market factors that are responsible for an exponential rate of increase in the quantity and type of data that companies need to store. Some data needs to be readily available, and some needs to be stored for five to seven years or longer for compliance purposes..

Companies want to find new cost-effective and flexible storage solutions to help meet their evolving storage requirements. Following summarizes how large-scale storage is typically managed:

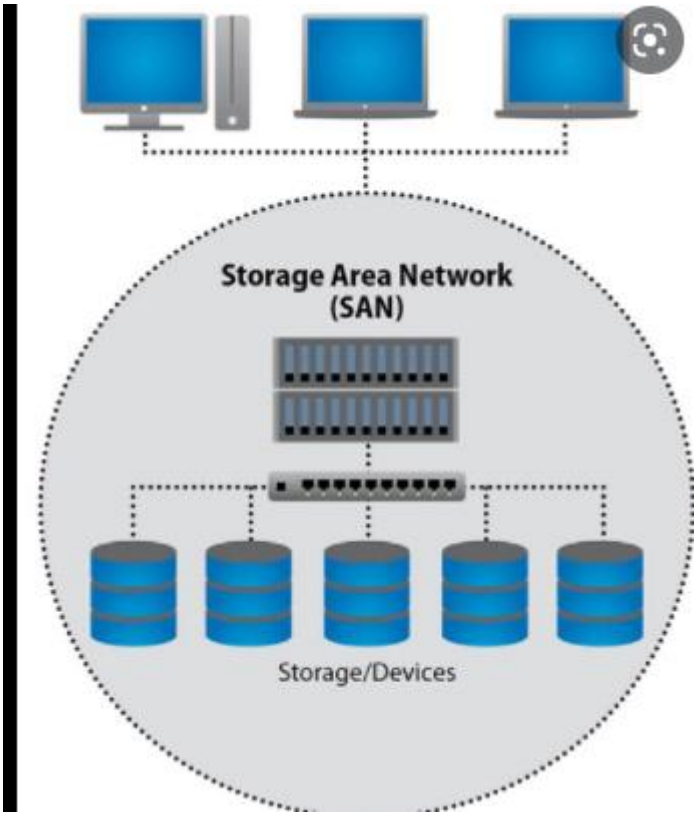
Direct attached storage (DAS): In this model, storage is generally connected to a server's local bus. DAS is not directly accessible to other servers. Direct-attached storage (DAS) is **digital storage directly attached to the computer accessing it**, as opposed to storage accessed over a computer network (i.e. network-attached storage). DAS consists of one or more storage units such as hard drives, solid-state drives, optical disc drives



Storage area network (SAN):

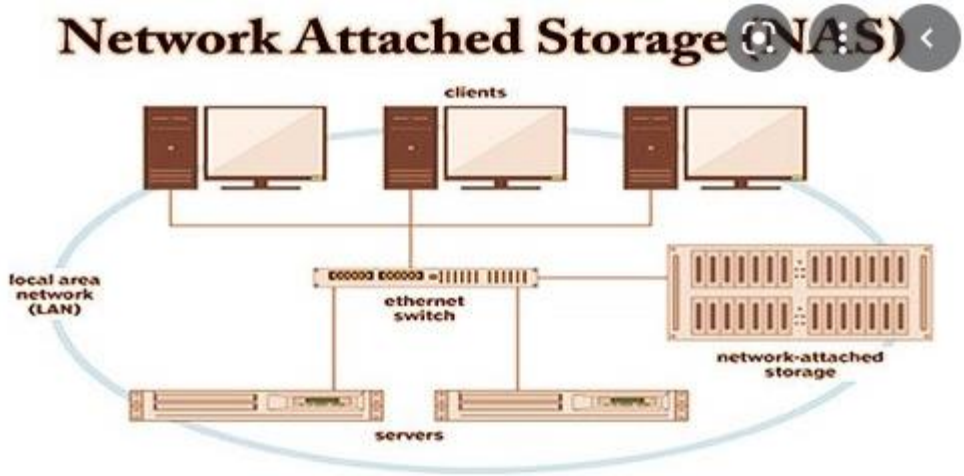
This is a high-speed network of interconnected storage devices that provides block storage to its users. A Storage Area Network (SAN) is a specialized, high-speed network that provides block-level network access to storage. SANs are typically composed of hosts, switches, storage elements, and storage devices that are interconnected using a variety of technologies, topologies, and protocols. SANs may also span multiple sites.

A SAN presents storage devices to a host such that the storage appears to be locally attached. This simplified presentation of storage to a host is accomplished through the use of different types of virtualization.



Network attached storage (NAS):

NAS is often implemented as a specialized kind of computer that provides file-based storage to other computers over a LAN. NAS is a kind of storage device that provides local area network (LAN) nodes with file-based shared storage through a standard Ethernet connection. A NAS server typically contains multiple hard drives, providing a large amount of centralized storage space for connected computers to save data. Instead of each computer sharing its own files, the shared data is stored on a single NAS server. This offers an easy way for multiple users to access the same data, which is important in situations where users are collaborating on projects or utilizing the same company standards.

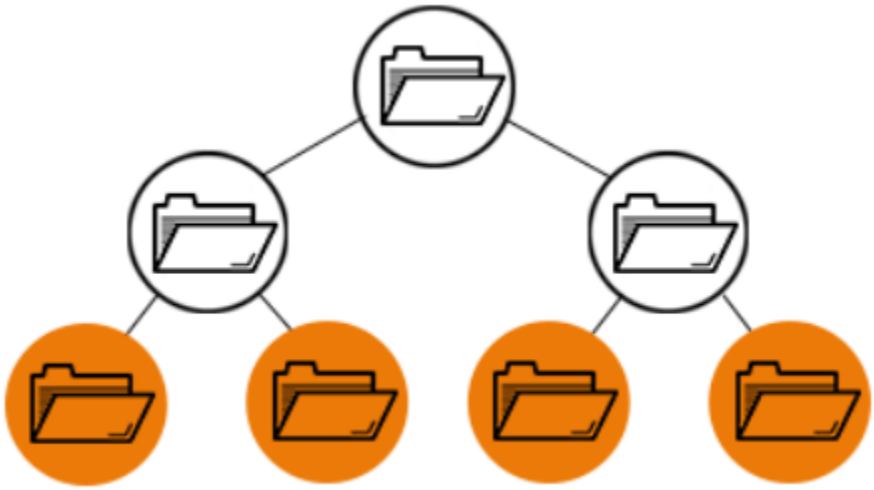


Cloud data storage and types

There are mainly three types of data storage, which are

object storage
file storage
block storage.

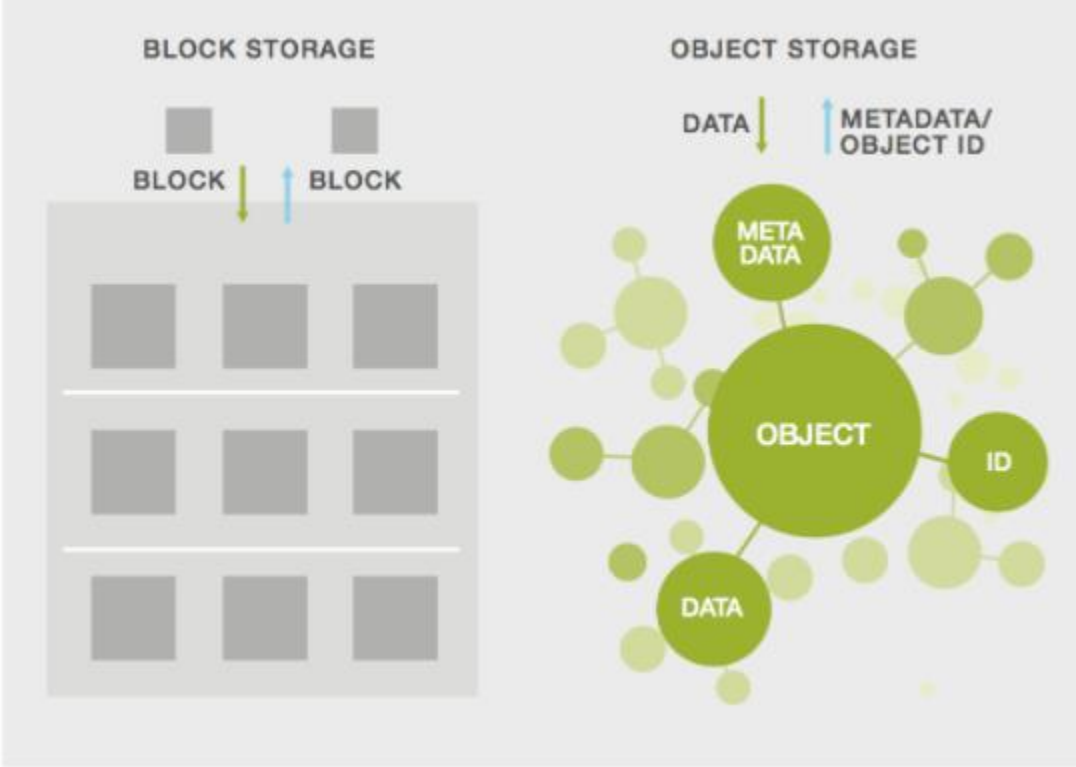
File Storage



File storage is one of the most common types of storage: most people are familiar with it from their day-to-day computer usage. Consider a simple case: you store photos from a recent trip on your personal laptop/desktop. First, you create a folder named ‘my trip’. Now you can add another folder under this folder with the name ‘my favorites’ and put your favorite photos in it. In this way, you are organizing your files into a hierarchical structure with folders and sub-folders and can access them using the folder/file path.

When a file is stored in this way, it has limited metadata attached to it such as creation date, modification date, and file size. This simple organizational schema can begin to cause problems as the amount of data grows. Performance can go down because of the increasing resource demands.
File storage is commonly seen and deployed on hard drives and Network Attached Storage (NAS) systems.

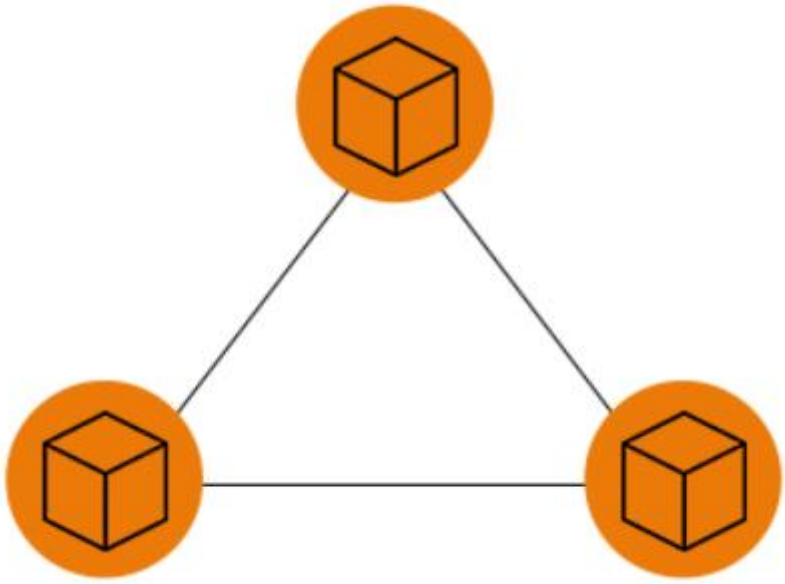
Object Storage



Object storage is a type of data storage in which each unit of data (called an "object") is stored as a discrete unit. These objects can be virtually any type of data: pdf, video, audio, text, website data or any other file type.
As opposed to file storage, these objects are stored in a single, flat structure without a folder hierarchy. In object storage, all the objects are stored in flat addresses space unlike the nested, hierarchical structure used by file storage. Moreover, all the default and custom metadata are stored with the object itself (not as part of a separate filesystem table or index), in a flat address space with a unique identifier, and in that way becomes easier to index and access.
Object storage is quite common in cloud-based storage scenarios and can be used to manage, process and distribute content with very high scalability and reliability. Compared to block storage, object storage is much newer. With object storage, data is bundled with customizable

metadata tags and a unique identifier to form objects. Objects are stored in a flat address space and there is no limit to the number of objects stored, making it much easier to scale out.

Block Storage



Object Storage and File Storage both treat files as a single “unit” of data. **Block Storage**, as the name suggests, treats data as a sequence of fixed-size “chunks” or “blocks” in which each file or object could be spread across multiple blocks. These blocks need not be stored contiguously. Whenever this data is requested by the user, the underlying storage system merges the data blocks back together and serves the user request.
This can be achieved without the need for a hierarchical structure because each block has a different and unique address and exists independently of all others. In some cases, block storage can retrieve data very quickly .Block storage also achieves high efficiency because blocks can be stored wherever it is most convenient. However, block storage is usually expensive and has limited capability to handle metadata .Block storage is commonly deployed in Storage Area Network (SAN) storage.

The table below compares the different features of different types of storage.

Cloud Storage Classes

Cloud storage can be broadly classified into two categories:

- Unmanaged Cloud Storage
- Managed Cloud Storage

Unmanaged Cloud Storage

Unmanaged cloud storage means the storage is preconfigured for the customer. The customer can neither format, nor install his own file system or change drive properties.

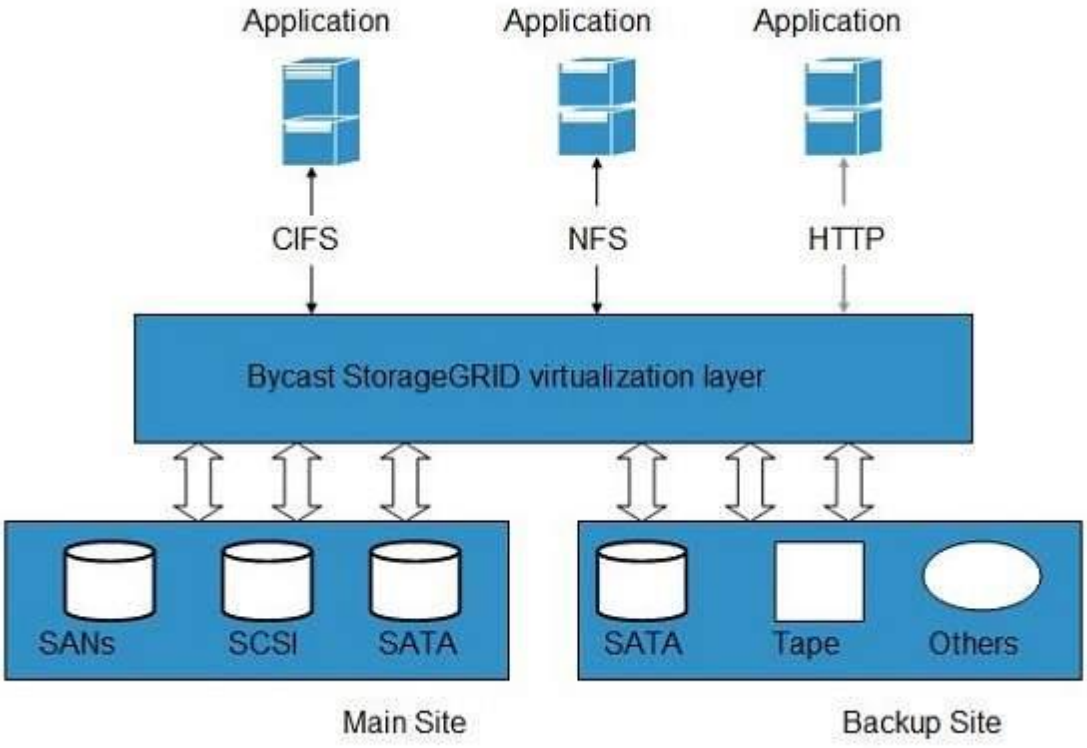
Managed Cloud Storage

Managed cloud storage offers online storage space on-demand. The managed cloud storage system appears to the user to be a raw disk that the user can partition and format.

Creating Cloud Storage System

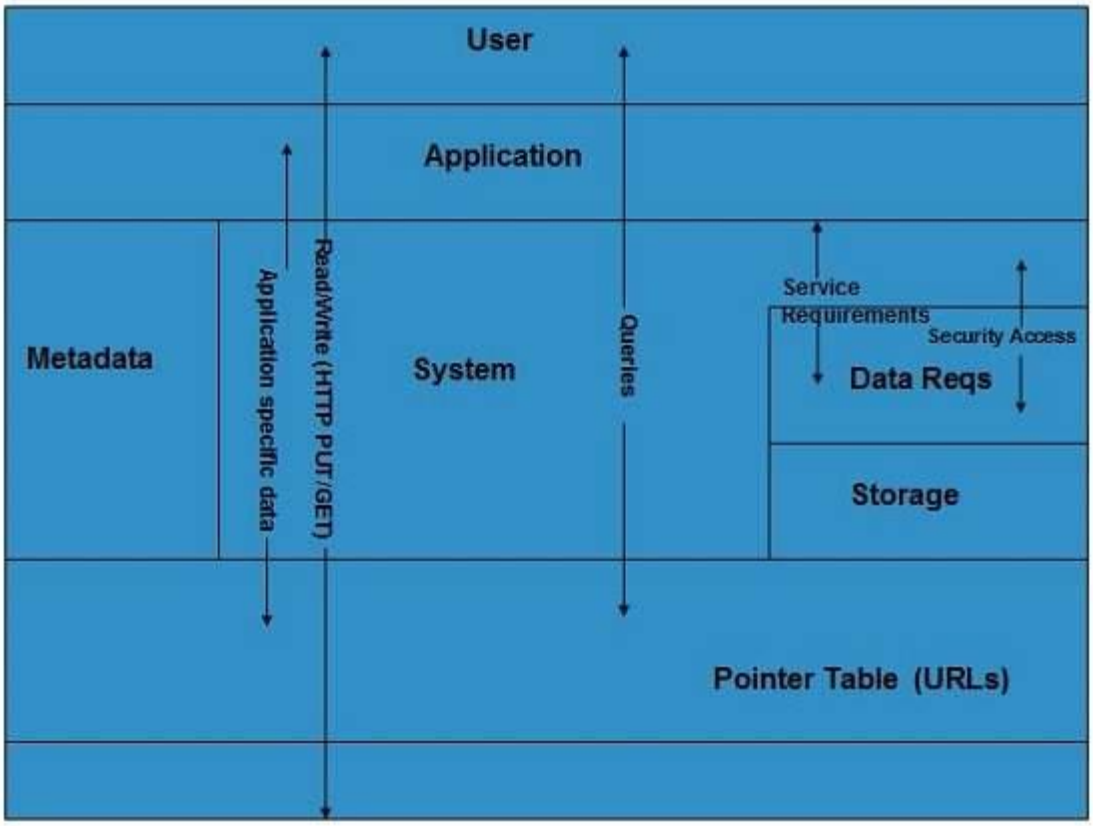
The cloud storage system stores multiple copies of data on multiple servers, at multiple locations. If one system fails, then it is required only to change the pointer to the location, where the object is stored.

To aggregate the storage assets into cloud storage systems, the cloud provider can use storage virtualization software known as **StorageGRID.** It creates a virtualization layer that fetches storage from different storage devices into a single management system. It can also manage data from **CIFS** and **NFS** file systems over the Internet. The following diagram shows how StorageGRID virtualizes the storage into storage clouds:



Virtual Storage Containers

The **virtual storage containers** offer high performance cloud storage systems. **Logical Unit Number (LUN)** of device, files and other objects are created in virtual storage containers. Following diagram shows a virtual storage container, defining a cloud storage domain:



- **Advantages and Disadvantages of Cloud-Based Data Storage**

  Cloud-based data storage provides the following advantages:

- **Scalability**: Most cloud-based data storage providers let you scale your storage capacity (up or down) to align with your storage needs.

- **Cost :**Purchasing physical storage can be expensive. Without the need for hardware cloud storage is exceptionally cheaper per GB than using external drives.
- **Pay for use**: With most cloud-based data storage facilities, users pay only for the storage (within a range) that they need.

- **Reliability**: Many cloud-based data storage facilities provide transparent data replication.

- **Ease of access**: Most cloud-based data storage facilities support web-based access to files from any place, at any time, using a variety of devices.

- **Ease of use**: Many cloud-based data storage solutions let users access the files through the use of a logical drive.

- **Recovery**
  In the event of a hard drive failure or other hardware malfunction, you can access your files on the cloud. It acts as a backup solution for your local storage on physical drives.
- **Security**
  Cloud storage providers add additional layers of security to their services.

Disadvantages of cloud-based storage include the following:

- **Performance**: Because the cloud-based disk storage devices are accessed over the Internet, they will never be as fast as local drives.
- **Security**: Some users will never feel comfortable with their data in the cloud. Since that data is stored in remote servers located in different locations, users lack the ability to control them.
- **Data orphans**: Users may abandon data in cloud storage facilities, leaving confidential
- **Costs**
  There are additional costs for uploading and downloading files from the cloud.

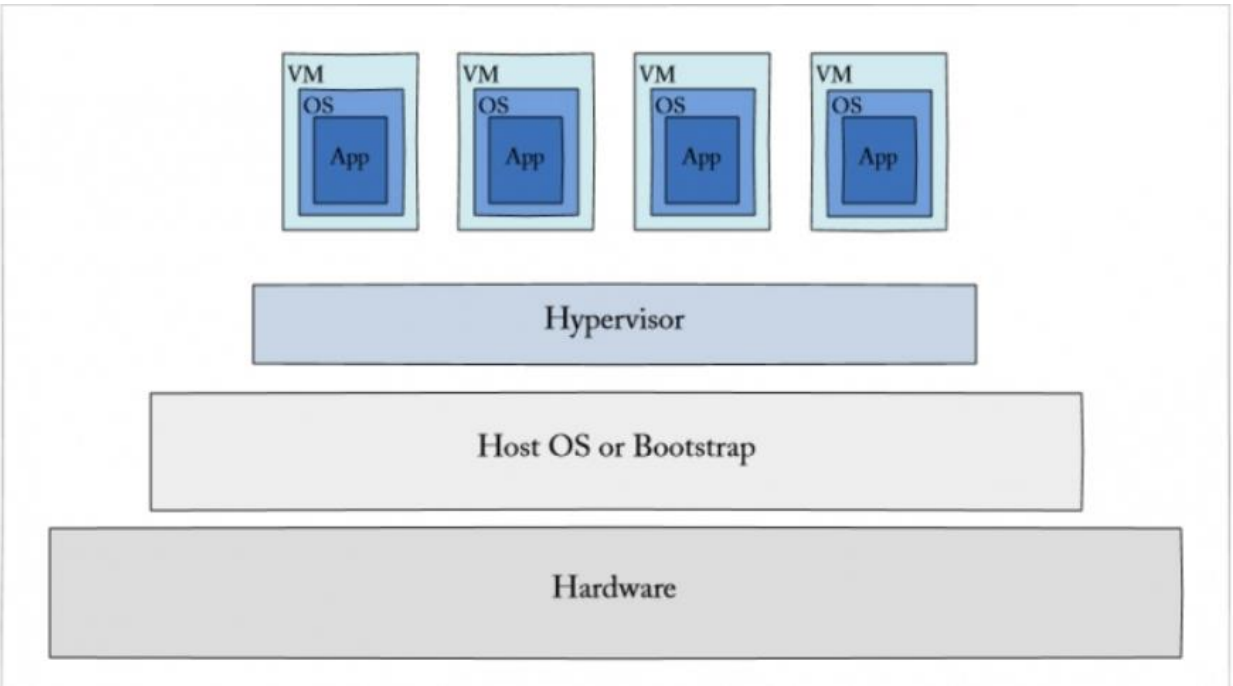
Support

In the event of any technical issues, you might have no other choice but to call your cloud service providers. Cloud storage lacks on the side of support. Especially if you are a user who uses free version of cloud storage. However many cloud service providers instruct their clients to refer online forums or FAQs for a technical advice

Virtualization in Cloud Computing

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".

In other words, 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.
5. Network virtualization.
6. Application 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.

5. Network virtualization in cloud computing is a method of combining the available resources in a network by splitting up the available bandwidth into different channels, each being separate and distinguished. They can be either assigned to a particular server or device or stay unassigned completely — all in real time.

6. Application virtualization

This way the application can run in an encapsulated form without being dependant upon the operating system underneath. In addition to providing a level of isolation, an application created for one OS can run on a completely different operating system.

How does virtualization work in cloud computing?

Virtualization plays a very important role in the cloud computing technology, normally in the cloud computing, users share the data present in the clouds like application etc, but actually with the help of virtualization users shares the Infrastructure.

The **main usage of Virtualization Technology** is to provide the applications with the standard versions to their cloud users, suppose if the next version of that application is released, then cloud provider has to provide the latest version to their cloud users and practically it is possible because it is more expensive.

To overcome this problem we use basically virtualization technology, By using virtualization, all severs and the software application which are required by other cloud providers are maintained by the third party people, and the cloud providers has to pay the money on monthly or annual basis.

Cloud Service Provider Companies

Cloud Service providers (CSP) offers various services such as **Software as a Service**, **Platform as a service**, **Infrastructure as a service**, **network services**, **business applications**, **mobile applications**, and **infrastructure** in the cloud. The cloud service providers host these services in a data center, and users can access these services through cloud provider companies using an Internet connection.

There are the following Cloud Service Providers Companies -

Amazon Web Services (AWS)

AWS (Amazon Web Services) is a **secure cloud service platform** provided by **Amazon**. It offers various services such as database storage, computing power,

content delivery, Relational Database, Simple Email, Simple Queue, and other functionality to increase the organization's growth.

Features of AWS

AWS provides various powerful features for building scalable, cost-effective, enterprise applications. Some important features of AWS is given below-

- AWS is **scalable** because it has an ability to scale the computing resources up or down according to the organization's demand.
- AWS is **cost-effective** as it works on a **pay-as-you-go** pricing model.
- It provides various flexible storage options.
- It offers various **security services** such as infrastructure security, data encryption, monitoring & logging, identity & access control, penetration testing.
- It can efficiently manage and secure Windows workloads.

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2. Microsoft Azure

Microsoft Azure is also known as **Windows Azure**. It supports various operating systems, databases, programming languages, frameworks that allow IT professionals to easily build, deploy, and manage applications through a worldwide network. It also allows users to create different groups for related utilities.

Features of Microsoft Azure

- Microsoft Azure provides **scalable**, **flexible**, and **cost-effective**
- It allows developers to quickly manage applications and websites.
- It manages each resource individually.
- Its IaaS infrastructure allows us to launch a general-purpose virtual machine in different platforms such as Windows and Linux.
- It offers a **Content Delivery System (CDS)** for delivering the Images, videos, audios, and applications.

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3. Google Cloud Platform

Google cloud platform is a product of **Google**. It consists of a set of physical devices, such as computers, hard disk drives, and virtual machines. It also helps organizations to simplify the migration process.

Features of Google Cloud

- Google cloud includes various **big data services** such as Google BigQuery, Google CloudDataproc, Google CloudDatalab, and Google Cloud Pub/Sub.
- It provides various services related to **networking**, including Google Virtual Private Cloud (VPC), Content Delivery Network, Google Cloud Load Balancing, Google Cloud Interconnect, and Google Cloud DNS.
- It offers various **scalable** and **high-performance**
- GCP provides various **serverless services** such as Messaging, Data Warehouse, Database, Compute, Storage, Data Processing, and Machine learning (ML)
- It provides a free cloud shell environment with Boost Mode.

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4. IBM Cloud Services

IBM Cloud is an open-source, faster, and more reliable platform. It is built with a suite of advanced data and AI tools. It offers various services such as Infrastructure as a service, Software as a service, and platform as a service. You can access its services like compute power, cloud data & Analytics, cloud use cases, and storage networking using internet connection.

Feature of IBM Cloud

- IBM cloud improves operational efficiency.
- Its speed and agility improve the customer's satisfaction.
- It offers Infrastructure as a Service (IaaS), Platform as a Service (PaaS), as well as Software as a Service (SaaS)
- It offers various cloud communications services to our IT environment.

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5. VMware Cloud

VMware cloud is a Software-Defined Data Center (SSDC) unified platform for the Hybrid Cloud. It allows cloud providers to build agile, flexible, efficient, and robust cloud services.

Features of VMware

- VMware cloud works on the **pay-as-per-use** model and **monthly subscription**
- It provides better customer satisfaction by protecting the user's data.

- It can easily create a new VMware **Software-Defined Data Center (SDDC)** cluster on AWS cloud by utilizing a RESTful API.
- It provides flexible storage options. We can manage our application storage on a per-application basis.
- It provides a dedicated high-performance network for managing the application traffic and also supports multicast networking.
- It eliminates the time and cost complexity.

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6. Oracle cloud

Oracle cloud platform is offered by the **Oracle Corporation**. It combines Platform as a Service, Infrastructure as a Service, Software as a Service, and Data as a Service with cloud infrastructure. It is used to perform tasks such as moving applications to the cloud, managing development environment in the cloud, and optimize connection performance.

Features of Oracle cloud

- Oracle cloud provides various tools for build, integrate, monitor, and secure the applications.
- Its infrastructure uses various languages including, Java, Ruby, PHP, Node.js.
- It integrates with Docker, VMware, and other DevOps tools.
- Oracle database not only provides unparalleled integration between IaaS, PaaS, and SaaS, but also integrates with the on-premises platform to improve operational efficiency.
- It maximizes the value of IT investments.
- It offers customizable Virtual Cloud Networks, firewalls, and IP addresses to securely support private networks.

7. Red Hat

Red Hat virtualization is an open standard and desktop virtualization platform produced by Red Hat. It is very popular for the Linux environment to provide various infrastructure solutions for virtualized servers as well as technical workstations. Most of the small and medium-sized organizations use Red Hat to run their organizations smoothly. It offers higher density, better performance, agility, and security to the resources. It also improves the organization's economy by providing cheaper and easier management capabilities.

Features of Rad Hat

- Red Hat provides secure, certified, and updated container images via the Red Hat Container catalog.
- Red Hat cloud includes **OpenShift,** which is an app development platform that allows developers to **access**, **modernize**, and **deploy apps**
- It supports up to 16 virtual machines, each having up to 256GB of RAM.
- It offers better reliability, availability, and serviceability.
- It provides flexible storage capabilities, including very large SAN-based storage, better management of memory allocations, high availability of LVMs, and support for particularly roll-back.
- In the Desktop environment, it includes features like New on-screen keyboard, GNOME software, which allows us to install applications, update application, as well as extended device support.

8. DigitalOcean

DigitalOcean is the unique cloud provider that offers computing services to the organization. It was founded in 2011 by Moisey Uretsky and Ben. It is one of the best cloud provider that allows us to manage and deploy web applications.

Features of DigitalOcean

- It uses the KVM hypervisor to allocate physical resources to the virtual servers.
- It provides high-quality performance.
- It offers a digital community platform that helps to answer queries and holding feedbacks.
- It allows developers to use cloud servers to quickly create new virtual machines for their projects.
- It offers one-click apps for droplets. These apps include MySQL, Docker, MongoDB, Wordpress, PhpMyAdmin, LAMP stack, Ghost, and Machine Learning.

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9. Rackspace

Rackspace offers cloud computing services such as hosting web applications, Cloud Backup, Cloud Block Storage, Databases, and Cloud Servers. The main aim

to designing Rackspace is to easily manage private and public cloud deployments. Its data centers operating in the USA, UK, Hong Kong, and Australia.

Features of Rackspace

- Rackspace provides various tools that help organizations to collaborate and communicate more efficiently.
- We can access files that are stored on the Rackspace cloud drive, anywhere, anytime using any device.
- It offers 6 globally data centers.
- It can manage both virtual servers and dedicated physical servers on the same network.
- It provides better performance at a lower cost.

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10. Alibaba Cloud

Alibaba Cloud is used to develop data management and highly scalable cloud computing services. It offers various services, including Elastic Computing, Storage, Networking, Security, Database Services, Application Services, Media Services, Cloud Communication, and Internet of Things.

Features of Alibaba Cloud

- Alibaba cloud offers a suite of global cloud computing services for both international customers and Alibaba Group's e-commerce ecosystem.
- Its services are available on a pay-as-per-use basis.
- It globally deals with its 14 data centers.
- It offers scalable and reliable data storage.

Service-oriented architecture (SOA) is an application development methodology with which developers create solutions by integrating one or more web services. Think of a web service as a function or subroutine a program can call to accomplish a specific task. As shown in **FIGURE,** when a program running on one computer calls a web service, a message, possibly containing parameter values, is sent across the network (or Internet) to the computer housing the web service. That computer, in turn, performs its processing and normally returns a result to the caller.

Some developers refer to web services as remote-procedure calls. Further,developers refer to a set of web services as an **application program interface (API**). Amazon and eBay, for example, provide APls that programmers can use to purchase products from across the web using the programs they create.

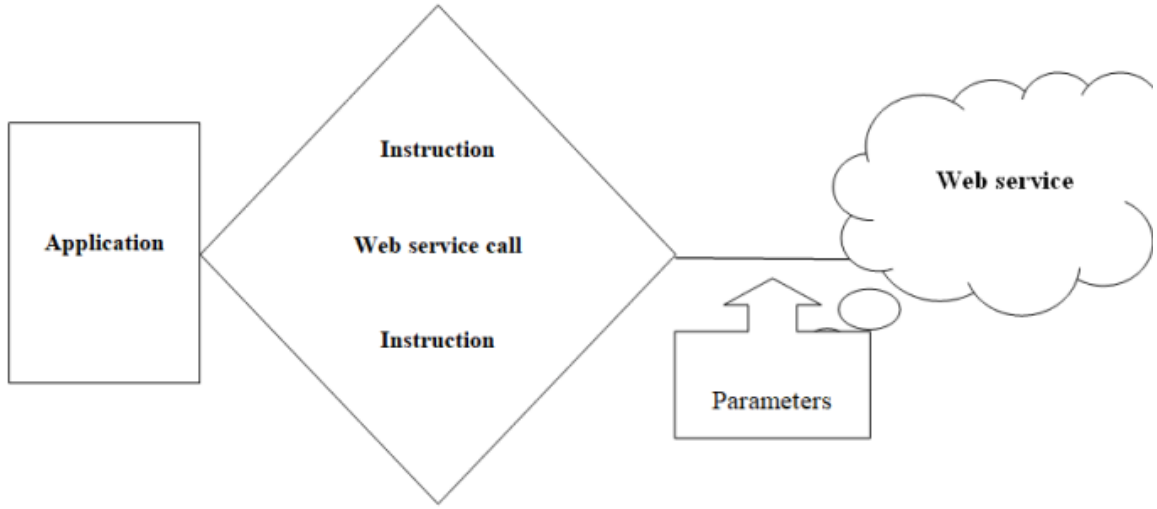


FIGURE . To call a web service, a program typically sends a message to the web servicethat resides on a remote computer and then waits for the web service to return a result.

Service-Oriented Architecture

Service-Oriented Architecture (SOA) is an architectural approach in which applications make use of services available in the network. In this architecture, services are provided to form applications, through a communication call over the internet.

1. SOA allows users to combine a large number of facilities from existing services to form applications.

2. SOA encompasses a set of design principles that structure system development and provide means for integrating components into a decentralized system.

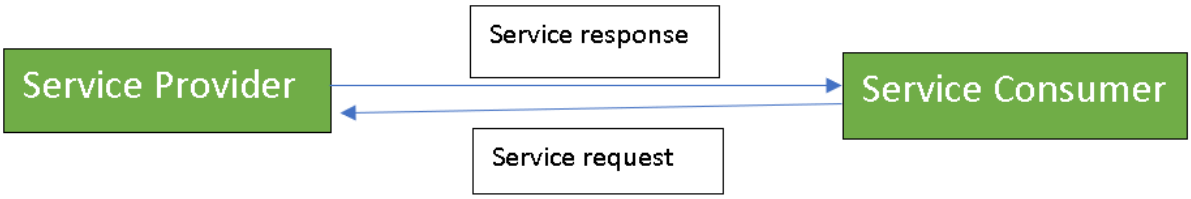
3. SOA based computing packages functionalities into a set of interoperable services, which can be integrated into different software systems belonging to separate business domains.

There are two major roles within Service-oriented Architecture:

1. **Service provider:** The service provider is the maintainer of the service and the organization that makes available one or more services for others to use.

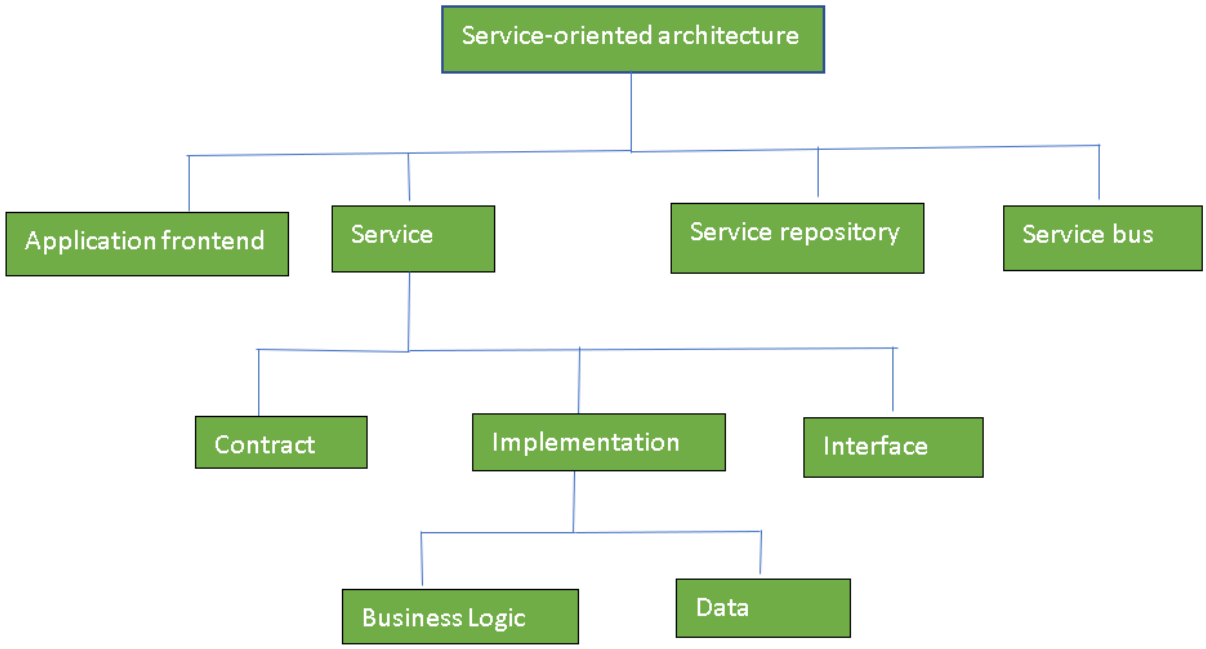
To advertise services, the provider can publish them in a registry, together with a service contract that specifies the nature of the service, how to use it, the requirements for the service, and the fees charged.

2. **Service consumer:** The service consumer can locate the service metadata in the registry and develop the required client components to bind and use the service.



Services might aggregate information and data retrieved from other services or create workflows of services to satisfy the request of a given service consumer. This practice is known as service orchestration. Another important interaction pattern is service choreography, which is the coordinated interaction of services without a single point of control.

Components of SOA:



Guiding Principles of SOA:

1. **Standardized service contract:** Specified through one or more service description documents.
2. **Loose coupling:** Services are designed as self-contained components, maintain relationships that minimize dependencies on other services.
3. **Abstraction:** A service is completely defined by service contracts and description documents. They hide their logic, which is encapsulated within their implementation.
4. **Reusability:** Designed as components, services can be reused more effectively, thus reducing development time and the associated costs.
5. **Autonomy:** Services have control over the logic they encapsulate and, from a service consumer point of view, there is no need to know about their implementation.
6. **Discoverability:** Services are defined by description documents that constitute supplemental metadata through which they can be effectively discovered. Service discovery provides an effective means for utilizing third-party resources.
7. **Composability:** Using services as building blocks, sophisticated and complex operations can be implemented. Service orchestration and choreography provide solid support for composing services and achieving business goals.

Advantages of SOA:

1. **Service reusability:** In SOA, applications are made from existing services. Thus, services can be reused to make many applications.
2. **Easy maintenance:** As services are independent of each other they can be updated and modified easily without affecting other services.
3. **Platform independent:** SOA allows making a complex application by combining services picked from different sources, independent of the platform.
4. **Availability:** SOA facilities are easily available to anyone on request.
5. **Reliability:** SOA applications are more reliable because it is easy to debug small services rather than huge codes
6. **Scalability:** Services can run on different servers within an environment, this increases scalability

Disadvantages of SOA:

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- **High investment:** A huge initial investment is required for SOA.
- **Complex service management:** When services interact they exchange messages to tasks. the number of messages may go in millions. It becomes a cumbersome task to handle a large number of messages.

Practical applications of SOA:

SOA is used in many ways around us whether it is mentioned or not.

1. SOA infrastructure is used by many armies and air force to deploy situational awareness systems.
2. SOA is used to improve the healthcare delivery.
3. Nowadays many apps are games and they use inbuilt functions to run. For example, an app might need GPS so it uses inbuilt GPS functions of the device. This is SOA in mobile solutions.

WEB SERVICES

A service is software and hardware. One or more services support or automate a business function.

There are two types of services:

atomic and composite.

An atomic service is a well-defined, self-contained function that does not depend on the context or state of other services.

A composite service is an assembly of atomic or other composite services. A service within a composite service may depend on the context or state of another service that is also within the same composite service

These requests are made through what is known as remote procedure calls. Remote Procedure Calls(RPC) are calls made to methods which are hosted by the relevant web service.

As an example, Amazon provides a web service that provides prices for products sold online via amazon.com. The front end or presentation layer can be in .Net or Java but either programming language would have the ability to communicate with the web service.

The main component of a web service design is the data which is transferred between the client and the server, and that is XML. XML (Extensible markup language) is a counterpart to HTML and easy to understand the intermediate language that is understood by many programming languages.

So when applications talk to each other, they actually talk in XML. This provides a common platform for application developed in various programming languages to talk to each other.

Web services use something known as SOAP (Simple Object Access Protocol) for sending the XML data between applications. The data is sent over normal HTTP. The data which is sent from the web service to the application is called **a SOAP message**. The SOAP message is nothing but an XML document. Since the document is written in XML, the client application calling the web service can be written in any programming language.

Web services provide a common platform that allows multiple applications built on various programming languages to have the ability to communicate with each other.

Type of Web Service

There are mainly two types of web services.

1. SOAP web services.
2. RESTful web services.

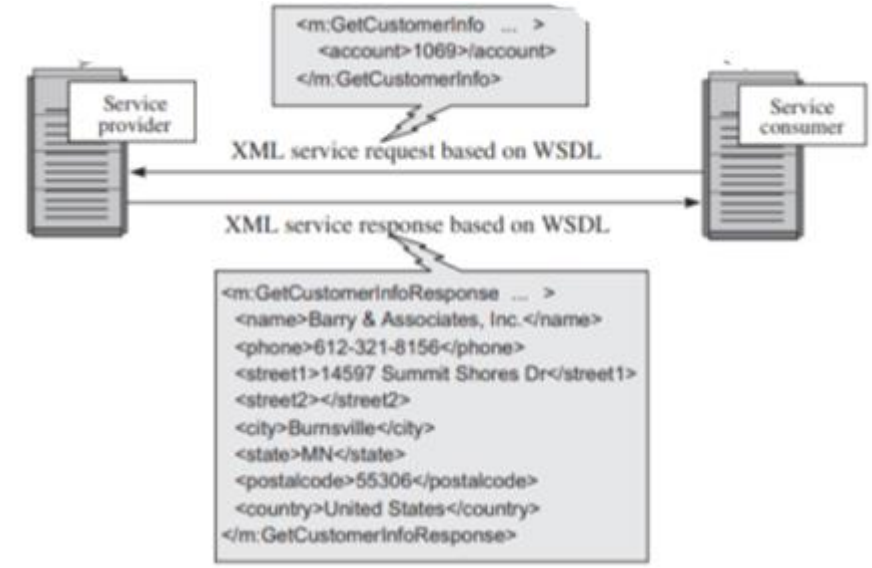
In order for a web service to be fully functional, there are certain components that need to be in place. Let's look at these components in more detail.

SOAP (Simple Object Access Protocol)

SOAP is known as a transport-independent messaging protocol. SOAP is based on transferring XML data as SOAP Messages. Each message has something which is known as an XML document. Only the structure of the XML document follows a specific pattern, but not the content. The best part of Web services and SOAP is that its all sent via HTTP, which is the standard web protocol.

a SOAP message consists of

3. Each SOAP document needs to have a root element known as the <Envelope> element. The root element is the first element in an XML document.
4. The "envelope" is in turn divided into 2 parts. The first is the header, and the next is the body.
5. The header contains the routing data which is basically the information which tells the XML document to which client it needs to be sent to.
6. The body will contain the actual message.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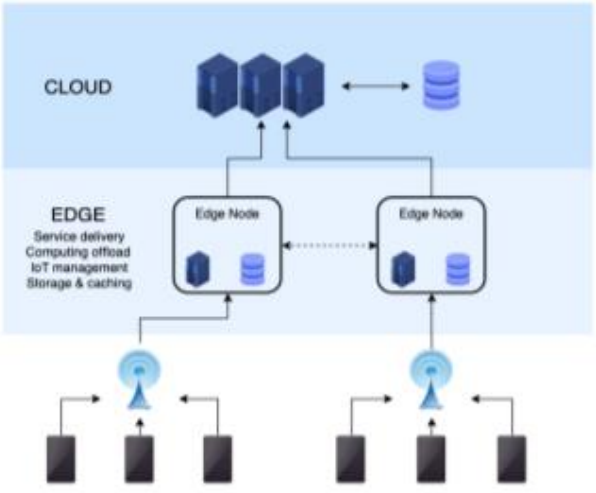
MODULE 3

EDGE COMPUTING

Edge computing is a distributed information technology (IT) architecture in which client data is processed at the periphery of the network, as close to the originating source as possible. Edge Computing brings the decentralization of networks. Edge Computing is a distributed computing system that allows to bring computation of data and storage too close to the source. It brings computing as much close as possible so as to minimize the bandwidth, improve response time, and use of latency.

The objective of Edge Computing is to improve the network technology by moving the computation of data close to the edge of the network and away from the data centers. when moving computation and data services in the hands of edge computing, it is possible to provide efficient service delivery, better data storage, and IoT management that could minimize the response time and transfer rate of data. With the 5G data network, it has enabled to converge 5G data network and edge technologies within reach. Thus, Edge Computing reduces the long-distance processing and slow communication of the data.



Challenges in Edge Computing

There are the following issues and challenges that take place in Edge Computing

Privacy and Security of Data:

It is the new change and enhancement in technology, and so there should be change and enhancement in the privacy and security feature also. According to advanced security schemes of cloud computing, "different encryption mechanisms should be introduced because few encryption methods are being used for encrypting the data, but before reaching to the cloud, data transit may take place between different distributed nodes that are connected via the internet".

Scalability: Edge Computing is based on a distributed network, and scalability becomes a challenge for such a distributed network-facing several issues. These issues are:

Heterogeneity of Devices: A focus should be present on the heterogeneity of those devices that have its own different energy and performance constraints.

Reliability: As edge computing relies on a distributed network, so if a single nodes fail or unable to reach, still the users must be able to avail the service without any disturbance. Also, the edge computing must be able to alert the user about the failure node and must provide actions to recover from the failure. For this, each device should maintain the network topology of the whole distributed system that will make the detection of errors and its recovery easy to process.

Speed: Edge computing should be able to provide speed services to the end-users as it brings analytical, computational resources near to the source (end users), and it leads to fast communication. Such a modern system will automatically out perform the cloud computing system, which is a traditional system. So, maintenance of good speed is also a challenging task for edge computing.

Efficiency: The efficiency of the edge computing becomes better because the availability of the analytical tools is too close to the end-users, and due to this, AI tools and analytical tools

which are sophisticated can possibly execute on the edge of the system. Such a platform improves and increases operational efficiency and thus provides several benefits to the system.

Why Edge Computing

Edge Computing is a new type of technology that will not only save time but also save the cost of servicing and other charges too. There are the following reasons that will answer the question:

• Through edge computing, it allows smart applications and devices for responding to data very quickly as soon as it is created and thus removing the lag time.

• Edge Computing also enables data stream acceleration that includes realtime processing of data without latency use. Data Stream acceleration is, 4 however, critical for self-driving cars type of technologies and provides equal and vital benefits for the businesses.

• Efficient processing of data at large scale by allowing processing close to the source, and it saves the use of internet bandwidth also. Thus, it reduces the cost and enables effective accessibility to the applications in remote locations.

• The ability of edge computing to provide services and processing data at the furthest distance makes a secured layer for the sensitive data without keeping it into a public cloud.

Applications of Edge Computing

Today, the world relies on the Internet from small to big things, and thus the prices of IoT devices such as sensors and computing cost is reducing too. In this way, more things will remain connected to the Internet. As a result, more connected devices become available, and edge computing will go on demand.

There are following sectors that will be potentially benefitted from Edge Computing:

1. **Transportation:**

   Edge computing plays a vital role and particularly in autonomous vehicles. It is because autonomous vehicles are full of different sensors types from the camera to the radar system of the car. Such autonomous devices can essentially utilize edge computing for processing data too close to the vehicle through these sensors, and consequently, a good amount of time will be saved.

2. **HealthCare:**

   People rely on fitness trackers, smartwatches, stamina measurement watches, etc., and find these health-monitoring wearable comfortable. However, the real-time analysis is essential for capturing the actual benefits of the collected data because many health wearables devices are directly connected to the cloud while others can be operated in an offline mode only. Such smart devices are useful for collecting and processing data in treating patients in any pandemic (such as COVID-19). Through edge computing, doctors will be able to more fastly collect and process the data and may provide better plus fast care to the patients.

3. **Manufacturing:**

   Edge computing in the field of manufacturing will reduce the data that goes to the cloud for applications like predictive maintenance, and it will move the operational technology to the edge computing platforms for running process similarly as processed in the cloud but with more speed and result.

4. **Remote monitoring of Oil and Gas:**

   At present, IoT devices are providing modern safety monitoring, sensory devices for controlling, viewing, and sensing the temperature, pressure, moisture, humidity, sound, and radiation of oil and gas. With edge computing, real-time safety monitoring can be possible for safeguarding critical machinery infrastructure and oil and gas systems from disasters. Thus, oil and gas services are the critical infrastructures that can be catastrophic in nature if not maintained with safety and precautions.

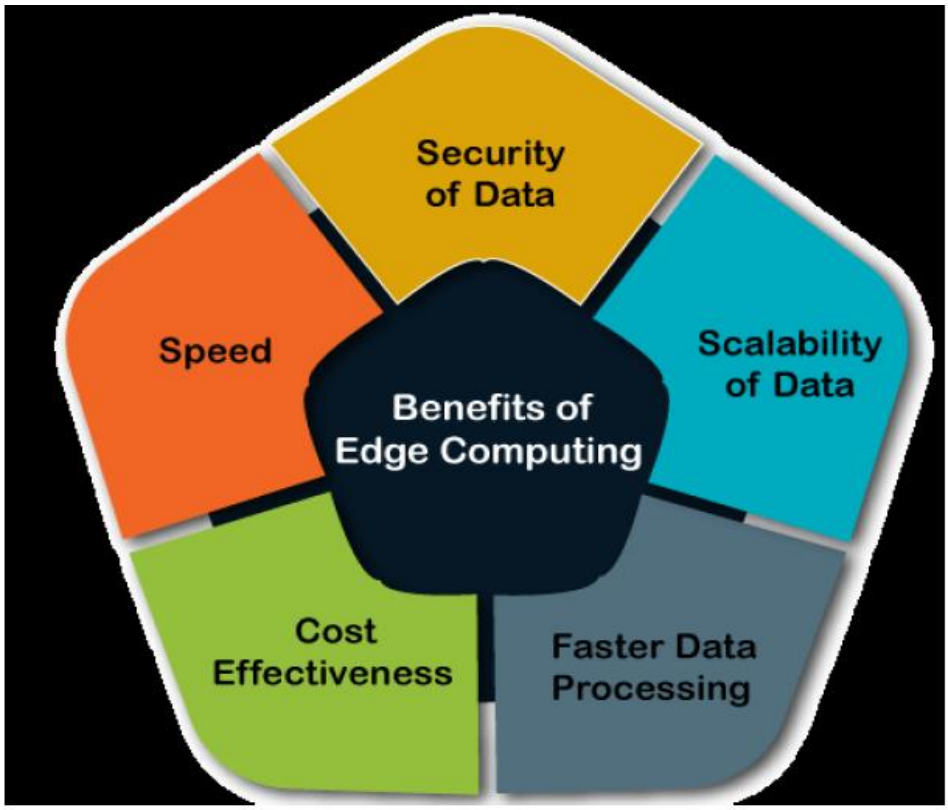
5. **Traffic Management:**

Traffic is the worst waste of time and needs to be optimized. The best way to optimize traffic is by maintaining and improving real-time data. For the traffic management process, the smart transportation systems such as self-driving cars, and other sensory systems make extensive use of edge computing devices.

6. **Edge Video Orchestration**:

   It uses edge computing resources for delivering heavy bandwidth videos by implementing a highly optimized method. It does not deliver the video through a centralized core network to all networks. Instead, it orchestrates, caches, and distributes the video files closely to the device. Through edge computing, it is fast to serve the freshly created video clips and live streams to the paying customers via rich media processing applications that run on mobile edge servers and hotspots in venues**.**

Benefits of Edge Computing



There are the following benefits of Edge Computing:

• **Speed:** Every company and industry demand high-speed technology aspects such as financial organizations because slow speed data processing can make a heavy financial loss to the company, healthcare industries because a fraction of second either can save the patient's life or can take the life, and other service-providing industries need fast speed computing otherwise it can irritate the customers which will make a bad impact of the industry on its customers. Edge Computing will definitely benefit these sectors because of its extremely fast computing speed. Through edge computing, the latency of the networks will be decreased, and also IoT devices will process data at edge data centers. Thus, data need not be traveled back to the central server (i.e., centralized server).

• **Security of Data:** In edge computing, data is located near to the source, which will distribute the work of data processing across several data centers as well as devices. It will safeguard your data from any type of cyber attack that can be vulnerable for confidential data such as safeguarding data from DDoS attacks. Thus, the data can be saved from the hackers to harm the data as the area of attack will increase because data is not placed at a single location only, i.e., data is decentralized. Also, when data is stored locally, it will become easy to monitor the data for its security .

• **Scalability of Data:** Scaling becomes easy and simple with edge computing where one can buy edge devices with high computation power for increasing their edge network. There is no such requirement to make their own private and centralized data centers for fulfilling their

data needs. Just combine the edge computing with colocation services in order to expand your edge network. Otherwise, companies need to purchase new equipment for expanding their IT infrastructure. Thus, it will save the companies for purchasing new devices. It is enough if the industries by few IoT devices to expand the network.

• **Faster Data Processing:** A massive amount of data is also generated that can create complexities for both servers and all the fragments of the IoT devices. However, if the server slows down or fails, the devices which are connected will also fail. Through, edge computing data can be accessed locally or near to the connected devices. Through, edge computing the cost of moving data, i.e., (traveling cost) to a centralized server, is also saved, and the time is taken for processing the data also becomes fast. All this brings more efficiency over the data. Also, when the entire network is not busy in exchanging data all the time, it saves a lot of network clustering and maintains data sharing between nodes only when required.

• **Cost-Effectiveness:** Edge Computing has gain popularity because it is the most cost-effective method as compared to the existing alternative technologies. It is because edge computing reduces the cost of data storage, network costs, data traveling costs, and data processing costs. Thus, there is no need to invest money in purchasing new IoT devices because we can easily connect the existing or older IoT devices via edge computing. With this, edge computing also enables the fragments to operate without any high-speed internet connectivity as for operating cloud functionalities, high-internet connectivity is essential.

Disadvantages of Edge Computing

There are the following disadvantages of edge computing:

1. Edge Computing requires more storage as data will be placed and processed at different and various locations.

2. As in edge computing, data is kept on distributed locations, and security becomes a challenging task in such an environment. It often becomes risky to identify thefts and cybersecurity issues. Also, if some new IoT devices are added, it can open gates for the attackers for harming the data.

3. It is known that edge computing saves many expenses in purchasing new devices, but edge computing is also expensive. It means the cost is too high.

4. It needs advanced infrastructure for processing data in an advanced way.

5. However, edge computing fails to pool resources in a resource pool. It means it is not capable of performing resource pooling.

6. It has a limit to a smaller number of peripherals only.

Edge Computing Vs. Cloud Computing

Although edge computing does not replace cloud computing technology, the emergence will certainly reduce and impact cloud computing. On the other hand, edge computing will enhance cloud computing technology by providing less complex solutions for handling messy data. Both these technologies have its own purpose and use, below we have discussed several points that distinguish between edge and cloud computing:

Edge Computing	Cloud Computing
It is good to be used for those organizations that have a limited budget to invest in financial resources. So, mid-level organizations can use edge computing.	It is generally recommended for processing and managing a high volume of data that is complex and massive enough. Thus, such organizations that deal with huge data storage use cloud computing.
It can use different programming languages on different platforms, each having different runtime.	Cloud Computing works for one target platform using one programming language only.
Security in edge computing needs tight and robust plans such as advanced authentication methods, network security, etc.	It does not need high and advanced security methods.
It processes time-sensitive data.	It process that data that is not driven by time, i.e., not time-driven.
It processes data at remote locations and uses the Decentralization approach.	It processes and deals with data at centralized locations by using a centralized approach.
Organizations can indulge in edge computing with the existing IoT devices, advance them, and use them. There is no need to purchase new devices.	For advancement, existing IoT devices need to be exchanged with the new ones that will cost more money and time.
Edge Computing is the upcoming future.	Cloud Computing is the currently existing technology

Grid computing

Grid computing is a processor architecture that combines computer resources from various domains to reach a main objective. In grid computing, the computers on the network can work on a task together, thus functioning as a supercomputer.

Typically, a grid works on various tasks within a network, but it is also capable of working on specialized applications. It is designed to solve problems that are too big for a supercomputer while maintaining the flexibility to process numerous smaller problems. Computing grids deliver a multiuser infrastructure that accommodates the discontinuous demands of large information processing.

A grid is connected by parallel nodes that form a computer cluster, which runs on an operating system, Linux or free software. The cluster can vary in size from a small work station to several networks. The technology is applied to a wide range of applications, such as mathematical, scientific or educational tasks through several computing resources. It is often used in structural analysis, Web services such as ATM banking, back-office infrastructures, and scientific or marketing research.

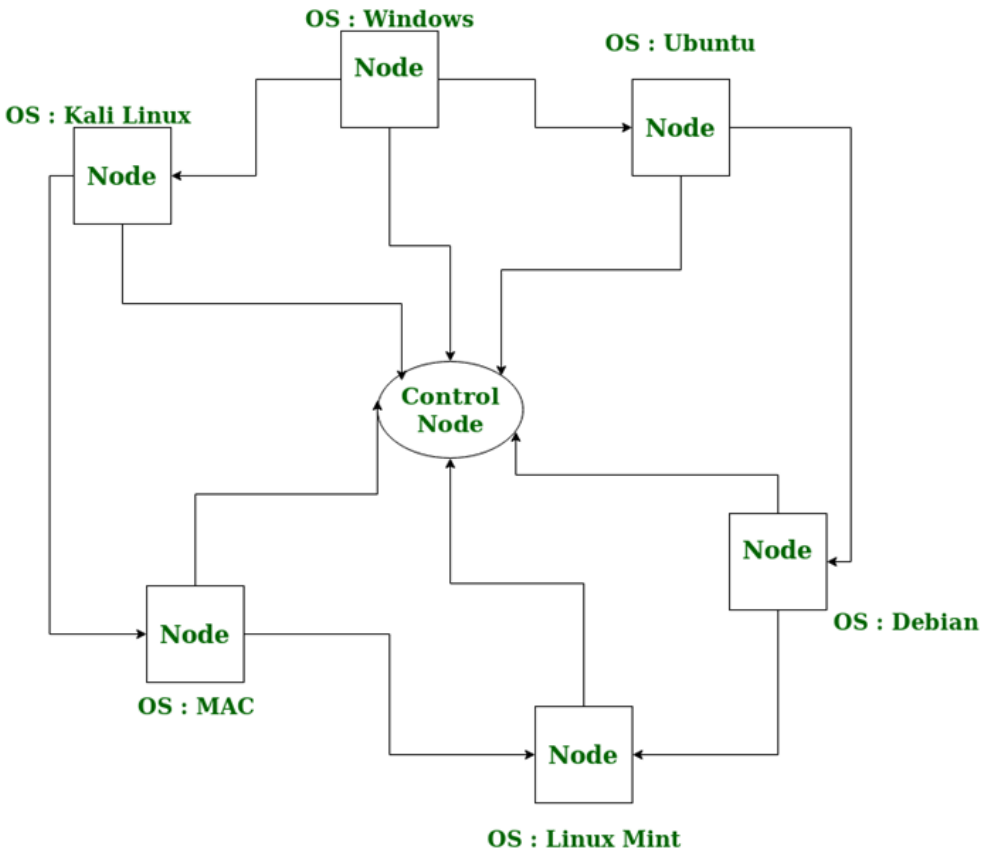
Grid Computing is a subset of distributed computing, where a virtual super computer comprises of machines on a network connected by some bus, mostly Ethernet or sometimes the Internet. It can also be seen as a form of Parallel Computing where instead of many CPU cores on a single machine, it contains multiple cores spread across various locations. The concept of grid computing isn't new, but it is not yet perfected as there are no standard rules and protocols established and accepted by people.

Working:
A Grid computing network mainly consists of these three types of machines

1. **Control Node:**
   A computer, usually a server or a group of servers which administrates the whole network and keeps the account of the resources in the network pool.
2. **Provider:**
   The computer which contributes it's resources in the network resource pool.
3. **User:**
   The computer that uses the resources on the network.

For controlling the network and it's resources a software/networking protocol is used generaly known as **Middleware**. This is responsible for administrating the network and the control nodes are merely it's executors.

Another job of the middleware is to authorize any process that is being executed on the network. In a grid computing system, a provider gives permission to the user to run anything on it's computer, hence it is a huge security threat for the network. Hence a middleware should ensure that there is no unwanted task being executed on the network.



Topology in Grid Computing

Advantages of Grid Computing:

1. It is not centralized, as there are no servers required, except the control node which is just used for controlling and not for processing.
2. Multiple heterogenous machines i.e. machines with different Operating Systems can use a single grid computing network.
3. Tasks can be performed parallel accross various physical locations and the users don't have to pay for it(with money).

The following areas will use the grid technologies.

Engineers and computer people wants the grid: Engineers wouldlike to visualize their applications in real time and, for many applications.Computational people wants to transfer the results of complex simulations.

Experimental scientists Experimentalscientists enhance their remote instrumentation to supercomputers or to advancedVisualization devices and, to use advanced user interfaces, such as java voicecommand for instrumental functions.

For Corporations: Almost all organizations in this world are global in extent. This organizations need to share the information and data from otherbranches which are located in some other areas

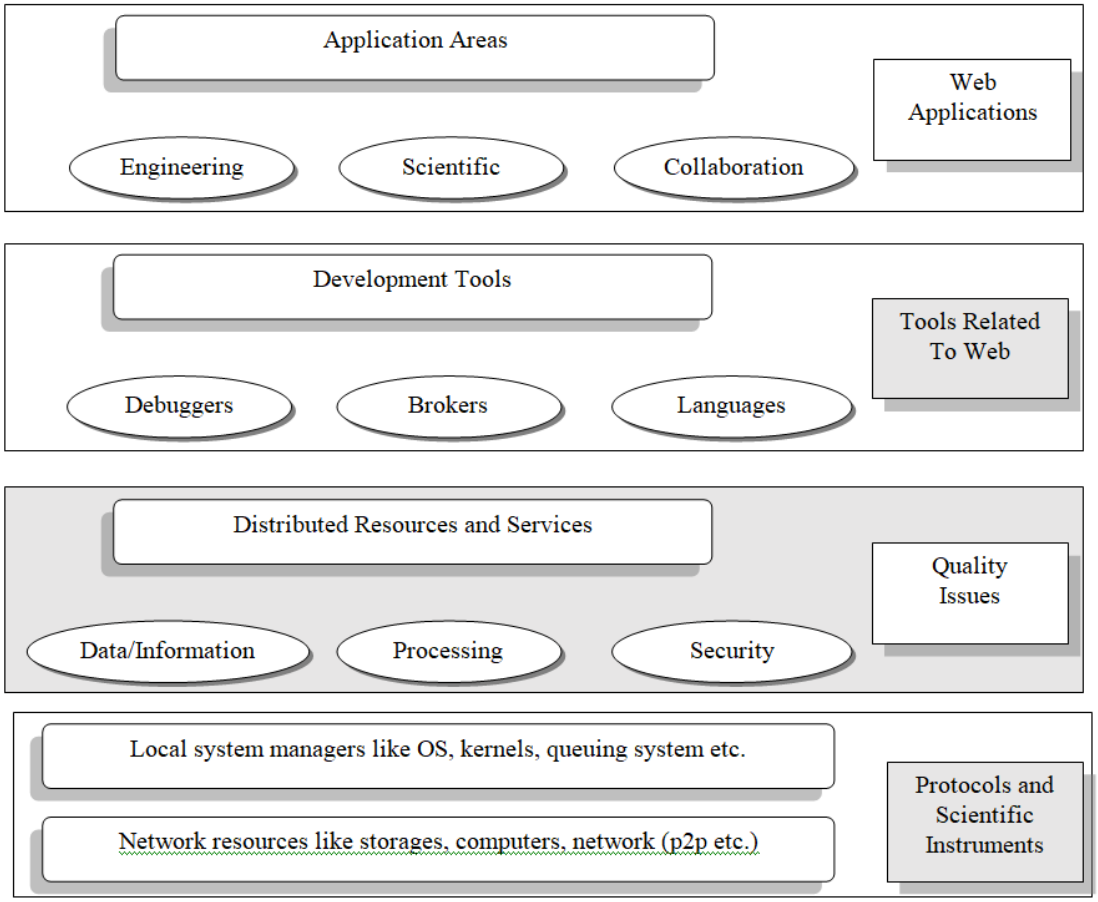
Training and Education need the grid: One of the first applications of the grid technologies will be in remote training and education. Some of theschools and institutions began the grid technologies to share the e-learning. On-line exam, virtual world games, and to share some other resources,

Real-time situations: the area of biomedical applications, the study ofthe cardiac electrical activity, especially under pathological conditions, requiresthe execution of several parametric simulations in order to analyze.

GRID LAYERED ARCHITECTURE

The grid architecture is a layered architecture. There are mainly four layers inarchitecture:

- Fabrication layer
- Grid core middleware
- Development layer
- Applications



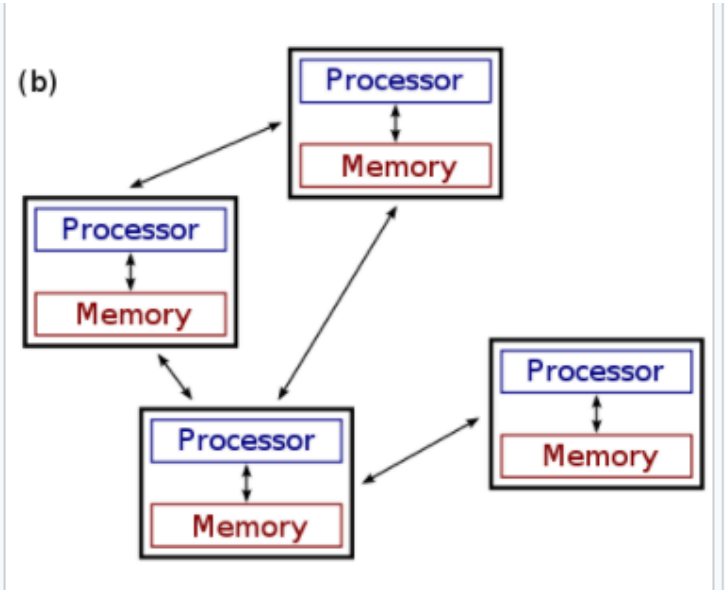
According to diagram grid contains

- Heterogeneous components
- The bottom layer has resource managers which are in local machinesand also network resources like data sources, secondary storageetc. It will take care about network protocols.
- The next layer was purely related to distributed services. Securitymechanisms are applied here like GSI Quality of Service (QoS) onealso considered here. Resources are shared the information efficientlyin distributed environment.
- Development environment provides tools and languages for developing grid applications.
- Application layer is the top layer in layered architecture. Users areinteracting and they applied problem solving skills from this layer.

Distributed computing is a field of computer science that studies distributed systems. A *distributed system* is a system whose components are located on different networked computers, which communicate and coordinate their actions by passing messages to one another from any system. The components interact with one another in order to achieve a common goal. Three significant characteristics of distributed systems are: concurrency of components, lack of a global clock, and independent failure of components. It deals with a central challenge that, when components of a system fails, it doesn't imply the entire system fails. Examples of distributed systems vary from SOA-based systems to massively multiplayer online games to peer-to-peer applications.

A computer program that runs within a distributed system is called a **distributed program** (and distributed programming is the process of writing such programs).

Distributed computing also refers to the use of distributed systems to solve computational problems. In *distributed computing*, a problem is divided into many tasks, each of which is solved by one or more computers, which communicate with each other via message passing.



Types of Distributed Systems

The nodes in the distributed systems can be arranged in the form of client/server systems or peer to peer systems. Details about these are as follows

1. Client/Server Systems
   In client server systems, the client requests a resource and the server provides that resource. A server may serve multiple clients at the same time while a client is in contact with only one server. Both the client and server usually communicate via a computer network and so they are a part of distributed systems.

2. Peer to Peer Systems
   The peer to peer systems contains nodes that are equal participants in data sharing. All the tasks are equally divided between all the nodes. The nodes interact with each other as required as share resources. This is done with the help of a network.

   Advantages of Distributed Systems
   Some advantages of Distributed Systems are as follows –
   • All the nodes in the distributed system are connected to each other. So nodes can easily share data with other nodes.
   • More nodes can easily be added to the distributed system i.e. it can be scaled as required.
   • Failure of one node does not lead to the failure of the entire distributed system. Other nodes can still communicate with each other.
   • Resources like printers can be shared with multiple nodes rather than being restricted to just one.

   Disadvantages of Distributed Systems
   Some disadvantages of Distributed Systems are as follows –
   • It is difficult to provide adequate security in distributed systems because the nodes as well as the connections need to be secured.
   • Some messages and data can be lost in the network while moving from one node to another.
   • The database connected to the distributed systems is quite complicated and difficult to handle as compared to a single user system.
   • Overloading may occur in the network if all the nodes of the distributed system try to send data at once.

5G and its timeline

5G is a collective name for technologies and methods that would go into the future networks to meet the extreme capacity and performance demands. The phrase ‘no latency, gigabit

experience' summarizes the user expectations that the industry is aspiring to meet. Both of the major standardization bodies, International Telecommunications Union (ITU) and European Telecommunications Standards Institute (ETSI) have initiated activities relating to 5G

What can users expect?

Some of the key performance parameters targeted to be achieved in 5G networks are: per device data rates up to 20 Gbps, less than 1ms latency contribution of the radio part, mobility at 500 km/hour and terminal localization within 1 meter. It will aim for service continuity in trains, sparse and dense areas, support for connecting 20 million user devices and more than a trillion Internet of Things (IoT)/Machine to Machine (M2M) devices with high reliability.

Technologies relevant for 5G

The design of 5G networks would revolve around virtualization and programmability of networks and services. It is envisioned that transition to 5G will be facilitated by today's emerging technologies such as Software Defined Networking (SDN), Network Functions Virtualization (NFV), Mobile Edge Computing (MEC) . SDN and NFV provide new tools that enhance flexibility in designing networks. These complementary technologies enable programmability of control and network functions and eventual migration of these key constituents of the network to the cloud.

2. Mobile edge computing

What is MEC?

Relevance of cloud computing to mobile networks is on an upward spiral. Social network services like Facebook and Twitter, the content from YouTube and Netflix, and navigation tools from Google Maps are all on clouds. Besides, users' increasing reliance on mobile devices to carry out compute and storage intensive operations, whether personal or business related, require offloading to the clouds for achieving better performance extending battery life. These objectives would be difficult and expensive to realize without bringing the cloud closer to the edge of the network and to the users. In response to this requirement the mobile operators are working on Mobile Edge Computing (MEC) in which the computing, storage and networking resources are integrated with the base station. Compute intensive and latency sensitive applications like augmented reality and image processing can be hosted at the edge of the network.

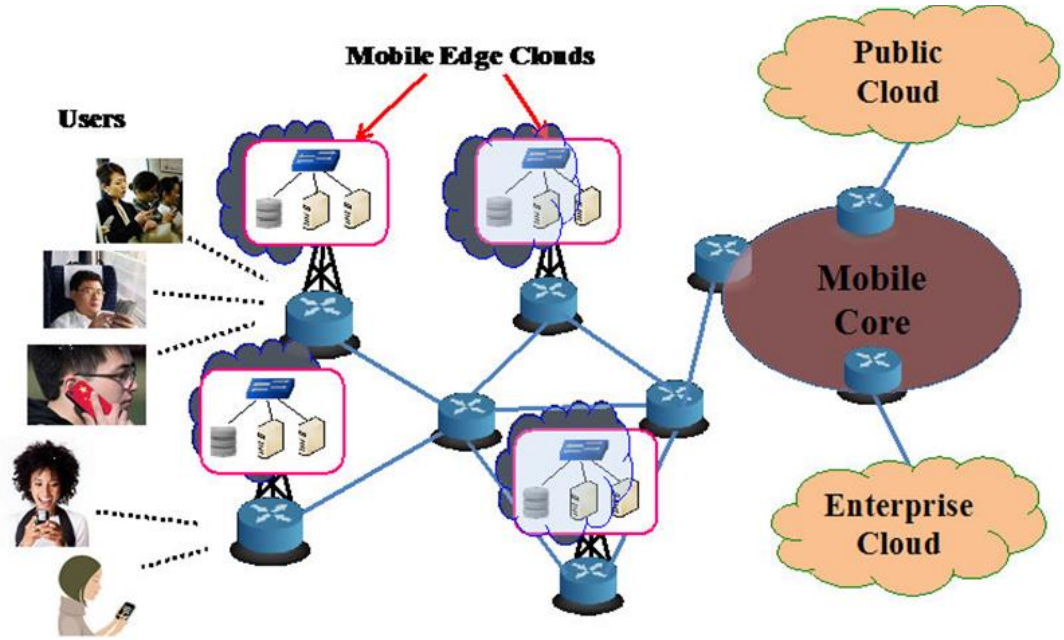


Fig. 1 Mobile Edge Clouds

MEC and application splitting

Mobile-edge computing provides a highly distributed computing environment that can be used to deploy applications and services as well as to store and process content in close proximity to mobile users. This would enable applications to be split into small tasks with some of the tasks performed at the local or regional clouds as long as the latency and accuracy are preserved.

The MEC Server platform

The key element of MEC is its Commercial-Off-The-Shelf (COTS) application server, which is integrated with the base station. The MEC server provides computing resources, storage capacity and connectivity as traditional cloud infrastructure would. Additionally, it provides access to user traffic and radio network information that can be used by application providers to tailor their applications and services for enhanced user experience.

Managing the edge clouds

From the point of view of application service providers, deploying and managing distributed applications across multiple clouds is a difficult proposition. It becomes very difficult for the providers to co-ordinate with individual clouds service providers each with their own interfaces and inter-cloud network providers to manage their application. They need a versatile application deployment and management platform to be able to optimize use of resources, ensure performance and contain cost. We are working on an open source management platform called MCAD (Multi-cloud Application Delivery) that would allow application and 5G service providers to specify multi-cloud virtual resource deployment

policies, create virtual resources, deploy services in the most appropriate cloud(s) and manage them while in operation.

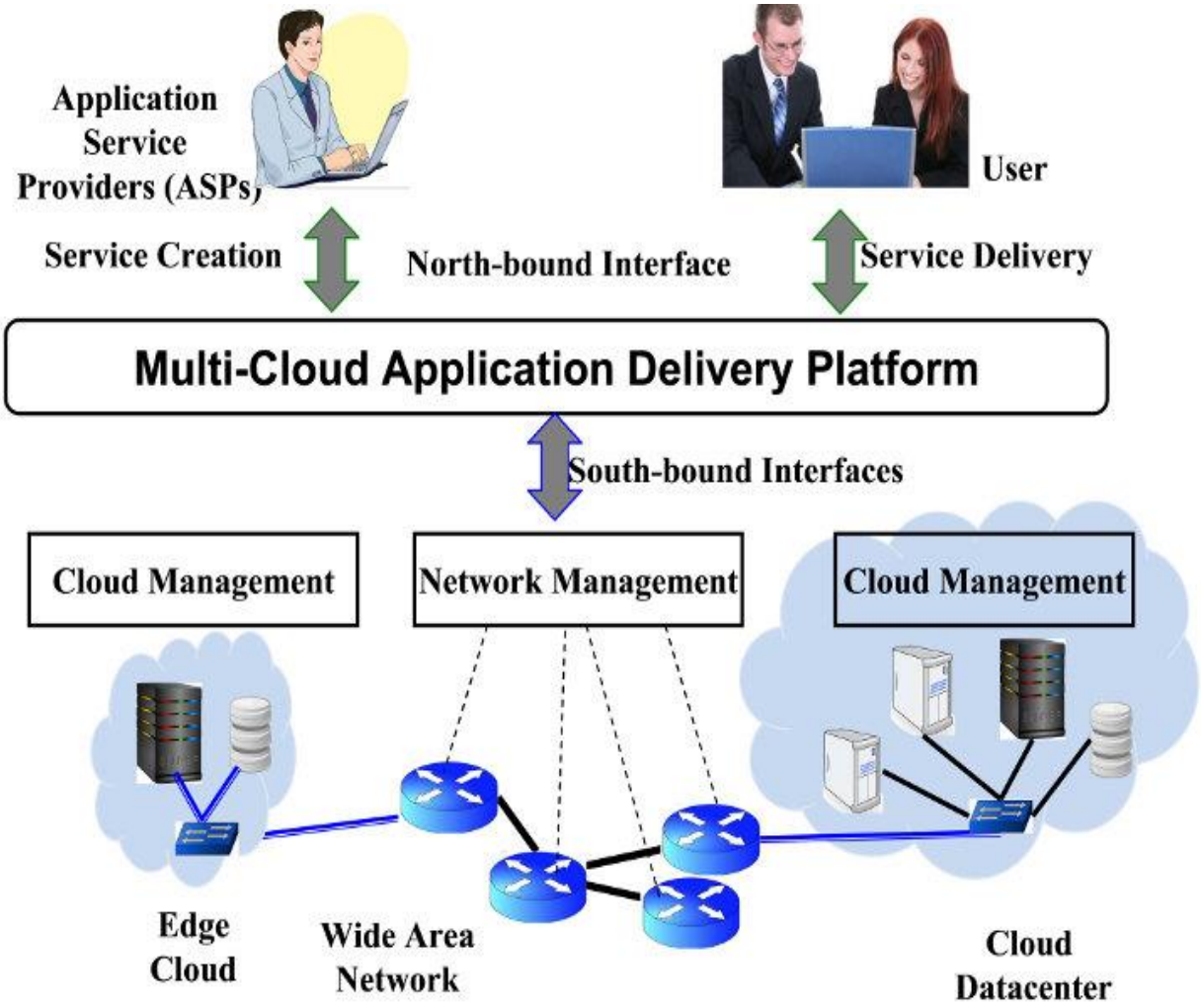


Fig. 3 The MCAD Based Multi-cloud Management Architecture

As shown in Fig. 3, MCAD design features a hybrid control system with a central global controller and per cloud/network local controllers. MCAD allows the cloud and networking resource owners to exercise complete control over their resources while tenants host their applications and program their policies on virtual resources anywhere on the participating clouds.

Introduction to Nerual Network Intelligence

The term ‘Neural’ is derived from the human (animal) nervous system’s basic functional unit ‘neuron’ or nerve cells that are present in the brain and other parts of the human (animal) body. A neural network is a group of algorithms that certify the underlying relationship in a set of data similar to the human brain. The neural network helps to change the input so that the network gives the best result without redesigning the output procedure.

In today's world, technology is growing very fast, and we are getting in touch with different new technologies day by day. Here, one of the booming technologies of computer science is Artificial Intelligence which is ready to create a new revolution in the world by making intelligent machines. It is currently working with a variety of subfields, ranging from general to specific, such as self-driving cars, playing chess, proving theorems, playing music, Painting, etc.

Artificial Intelligence is composed of two words **Artificial** and **Intelligence**, where Artificial defines *"man-made,"* and intelligence defines *"thinking power"*, hence AI means *"a man-made thinking power."*

"It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions."

Artificial Intelligence exists when a machine can have human based skills such as learning, reasoning, and solving problems.With Artificial Intelligence you do not need to preprogram a machine to do some work, despite that you can create a machine with programmed algorithms which can work with own intelligence, and that is the awesomeness of AI.

Why Artificial Intelligence?

With the help of AI, you can create such software or devices which can solve real-world problems very easily and with accuracy such as health issues, marketing, traffic issues, etc.

- With the help of AI, you can create your personal virtual Assistant, such as Cortana, Google Assistant, etc.
- With the help of AI, you can build such Robots which can work in an environment where survival of humans can be at risk.
- AI opens a path for other new technologies, new devices, and new Opportunities.

Goals of Artificial Intelligence

Following are the main goals of Artificial Intelligence:

1. Replicate human intelligence
2. Solve Knowledge-intensive tasks
3. An intelligent connection of perception and action
4. Building a machine which can perform tasks that requires human intelligence such as:

- Proving a theorem
- Playing chess
- Plan some surgical operation
- Driving a car in traffic

5. Creating some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

Advantages of Artificial Intelligence

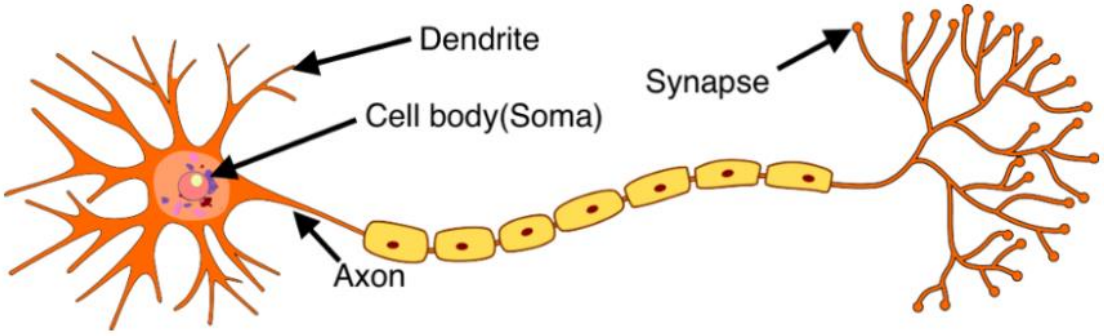
Following are some main advantages of Artificial Intelligence:

- **High Accuracy with less errors:** AI machines or systems are prone to less errors and high accuracy as it takes decisions as per pre-experience or information.
- **High-Speed:** AI systems can be of very high-speed and fast-decision making.
- **High reliability:** AI machines are highly reliable and can perform the same action multiple times with high accuracy.
- **Useful for risky areas:** AI machines can be helpful in situations such as defusing a bomb, exploring the ocean floor, where to employ a human can be risky.
- **Digital Assistant:** AI can be very useful to provide digital assistant to the users such as AI technology is currently used by various E-commerce websites to show the products as per customer requirement.
- **Useful as a public utility:** AI can be very useful for public utilities such as a self-driving car which can make our journey safer and hassle-free, facial recognition for security purpose.

Disadvantages of Artificial Intelligence

- **High Cost:** The hardware and software requirement of AI is very costly as it requires lots of maintenance to meet current world requirements.
- **No feelings and emotions:** AI machines can be an outstanding performer, but still it does not have the feeling so it cannot make any kind of emotional attachment with human, and may sometime be harmful for users if the proper care is not taken.
- **Increase dependency on machines:** With the increment of technology, people are getting more dependent on devices and hence they are losing their mental capabilities.
- **No Original Creativity:** As humans are so creative and can imagine some new ideas but still AI machines cannot beat this power of human intelligence and cannot be creative and imaginative.

Biological Neuron



Neurons are the basic functional units of the nervous system, and they generate electrical signals called **action potentials**, which allows them to quickly transmit information over long distances. Almost all the neurons have three basic functions essential for the normal functioning of all the cells in the body.

These are to:
1. Receive signals (or information) from outside.
2. Process the incoming signals and determine whether or not the information should be passed along.
3. Communicate signals to target cells which might be other neurons or muscles or glands.

Now let us understand the ***basic parts*** of a neuron to get a deeper insight into how they actually work…

A biological neuron is mainly composed of 3 main parts and an external part called synapse:-

1. **Dendrite**

Dendrites are responsible for getting incoming signals from outside

2. Soma

Soma is the cell body responsible for the processing of input signals and deciding whether a neuron should fire an output signal

3. Axon

Axon is responsible for getting processed signals from neuron to relevant cells

4. Synapse

Synapse is the connection between an axon and other neuron dendrites

Working of the parts

The task of receiving the incoming information is done by dendrites, and processing generally takes place in the cell body. Incoming signals can be either **excitatory** — which means they tend to make the neuron **fire** (generate an electrical impulse) — or **inhibitory** — which means that they tend to keep the neuron from firing.

Most neurons receive many input signals throughout their dendritic trees. A single neuron may have more than one set of dendrites and may receive many thousands of input signals. Whether or not a neuron is excited into firing an impulse depends on the sum of all of the excitatory and inhibitory signals it receives. The processing of this information happens in **soma** which is neuron cell body. If the neuron does end up firing, the nerve impulse, or **action potential**, is conducted down the axon.

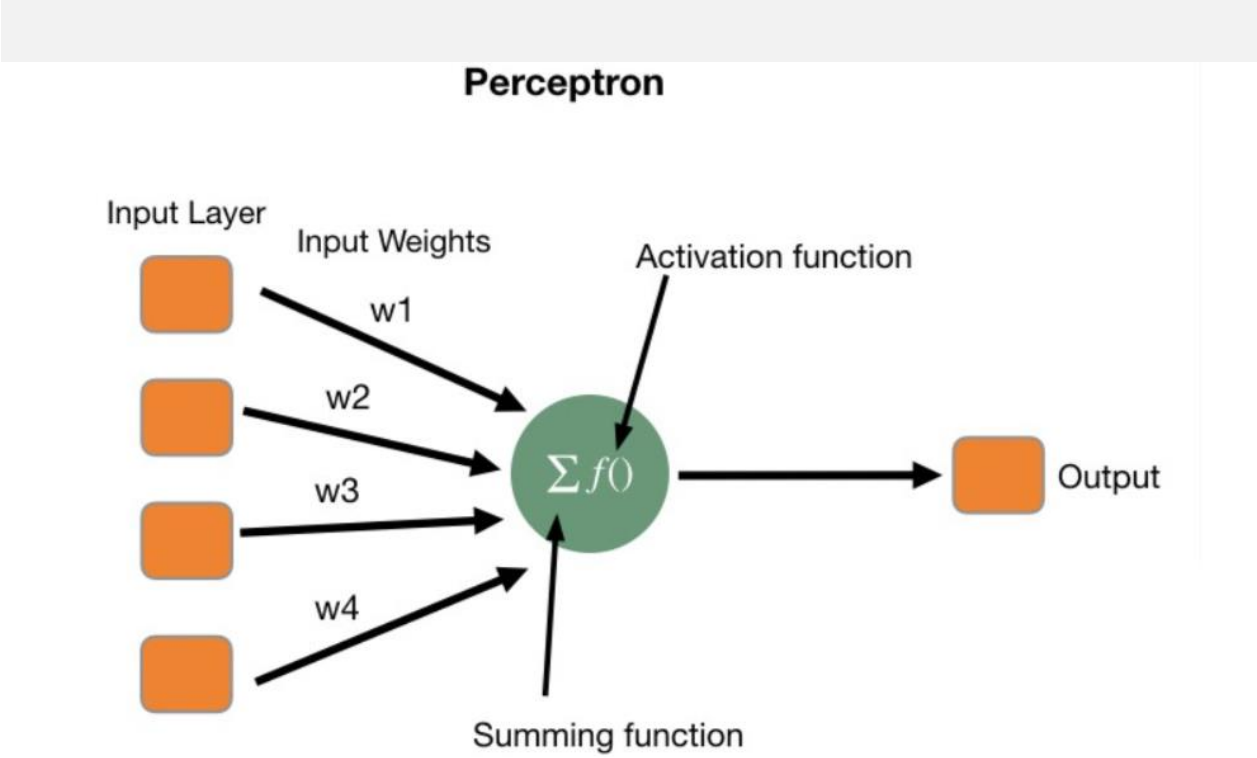
Towards its end, the axon splits up into many branches and develops bulbous swellings known as **axon terminals** (or **nerve terminals**). These axon terminals make connections on target cells.

Artificial Neurons

Artificial neuron also known as perceptron is the basic unit of the neural network. In simple terms, it is a mathematical function based on a model of biological neurons. It can also be seen as a simple logic gate with binary outputs. They are sometimes also called **perceptrons.**

Each artificial neuron has the following main functions:

1. Takes inputs from the input layer
2. Weighs them separately and sums them up
3. Pass this sum through a nonlinear function to produce output.



The perceptron(neuron) consists of 4 parts:

1. **Input values or One input layer**
   We pass input values to a neuron using this layer. It might be something as simple as a collection of array values. It is similar to a dendrite in biological neurons.

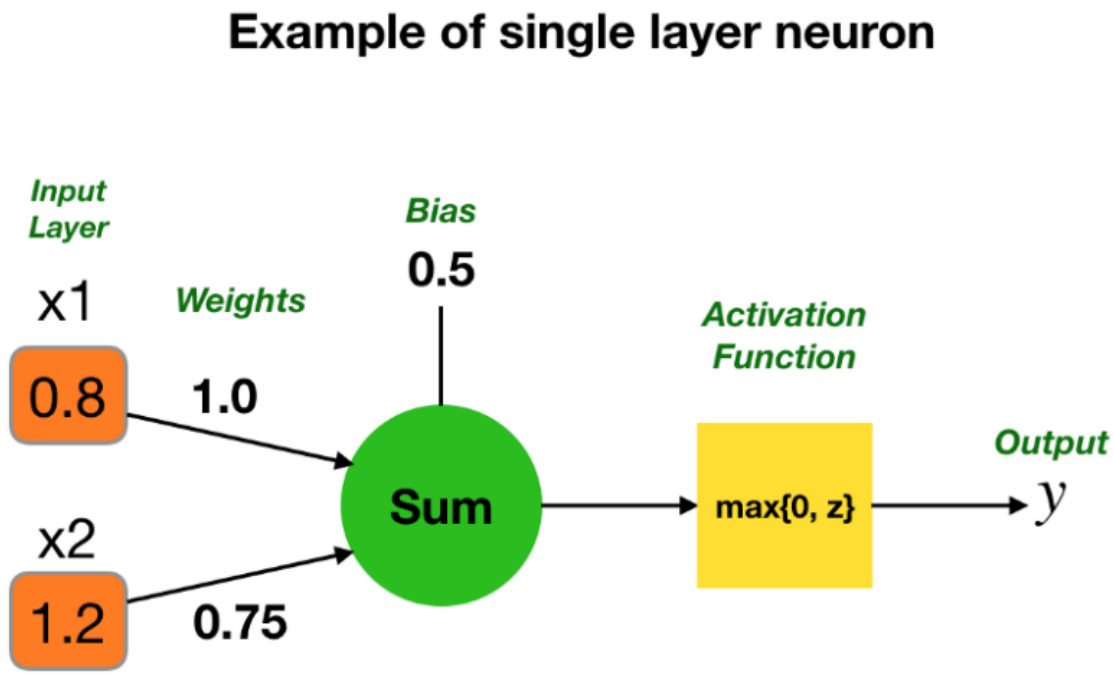
2. **Weights and Bias**
   Weights are a collection of array values which are multiplied to the respective input values. We then take a sum of all these multiplied values which is called a weighted sum. Next, we add a bias value to the weighted sum to get final value for prediction by our neuron.

3. **Activation Function**
   Activation Function decides whether or not a neuron is fired. It decides which of the two output values should be generated by the neuron.

4. **Output Layer**
   Output layer gives the final output of a neuron which can then be passed to other neurons in the network or taken as the final output value.

let's understand the working of an artificial neuron with an example.

Consider a neuron with two inputs (x1,x2) as shown below:



1. The values of the two inputs(x1,x2) are 0.8 and 1.2

2. We have a set of weights (1.0,0.75) corresponding to the two inputs

3. Then we have a bias with value 0.5 which needs to be added to the sum

The input to activation function is then calculated using the formula:-

$$C = w1 * x1 + w2 * x2 + b$$

$$= (1 * 0.8) + (0.75 * 1.2) + 0.5$$

$$= 0.8 + 0.9 + 0.5$$

$$= 2.2$$

Now the combination(C) can be fed to the activation function,

Let us first understand the logic of Rectified linear (ReLU) activation function which we are currently using in our example:

$$activation = \begin{cases} 0 & if \quad combination < 0 \\ combination & if \quad combination \geq 0 \end{cases}$$

In our case, the combination value we got was 2.2 which is greater than 0 so the output value of our activation function will be 2.2.

What is Artificial Neural Network?

The term "**Artificial Neural Network**" is derived from Biological neural networks that develop the structure of a human brain. Similar to the human brain that has neurons interconnected to one another, artificial neural networks also have neurons that are interconnected to one another in various layers of the networks. These neurons are known as nodes.

An **Artificial Neural Network** in the field of **Artificial intelligence** where it attempts to mimic the network of neurons makes up a human brain so that computers will have an option to understand things and make decisions in a human-like manner. The artificial neural network is designed by programming computers to behave simply like interconnected brain cells.

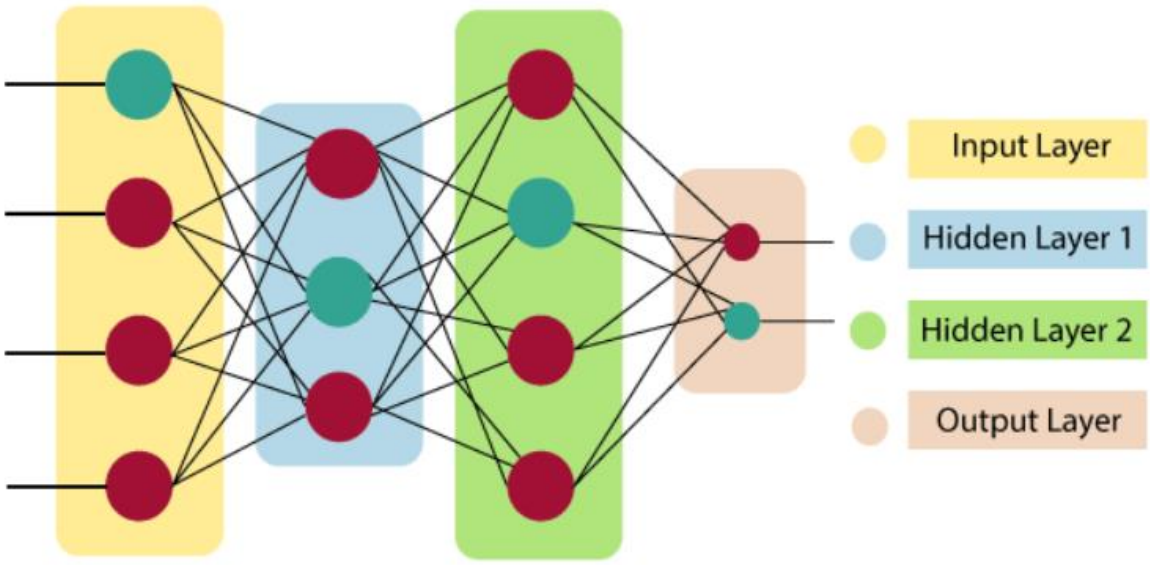
There are around 1000 billion neurons in the human brain. Each neuron has an association point somewhere in the range of 1,000 and 100,000. In the human brain, data is stored in such a manner as to be distributed, and we can extract more than one piece of this data when necessary from our memory parallelly. We can say that the human brain is made up of incredibly amazing parallel processors.

We can understand the artificial neural network with an example, consider an example of a digital logic gate that takes an input and gives an output. "OR" gate, which takes two inputs. If one or both the inputs are "On," then we get "On" in output. If both the inputs are "Off," then we get "Off" in output. Here the output depends upon input. Our brain does not perform the same task. The outputs to inputs relationship keep changing because of the neurons in our brain, which are "learning."

The architecture of an artificial neural network:

To understand the concept of the architecture of an artificial neural network, we have to understand what a neural network consists of. In order to define a neural network that consists of a large number of artificial neurons, which are termed units arranged in a sequence of layers. Lets us look at various types of layers available in an artificial neural network.

Artificial Neural Network primarily consists of three layers:



Input Layer:

As the name suggests, it accepts inputs in several different formats provided by the programmer.

Hidden Layer:

The hidden layer presents in-between input and output layers. It performs all the calculations to find hidden features and patterns.

Output Layer:

The input goes through a series of transformations using the hidden layer, which finally results in output that is conveyed using this layer.

The artificial neural network takes input and computes the weighted sum of the inputs and includes a bias. This computation is represented in the form of a transfer function.

$$\sum_{i=1}^{n} Wi * Xi + b$$

It determines weighted total is passed as an input to an activation function to produce the output. Activation functions choose whether a node should fire or not. Only those who are fired make it to the output layer. There are distinctive activation functions available that can be applied upon the sort of task we are performing.

Advantages of Artificial Neural Network (ANN)

Parallel processing capability:

Artificial neural networks have a numerical value that can perform more than one task simultaneously.

Storing data on the entire network:

Data that is used in traditional programming is stored on the whole network, not on a database. The disappearance of a couple of pieces of data in one place doesn't prevent the network from working.

Capability to work with incomplete knowledge:

After ANN training, the information may produce output even with inadequate data. The loss of performance here relies upon the significance of missing data.

Having fault tolerance:

Extortion of one or more cells of ANN does not prohibit it from generating output, and this feature makes the network fault-tolerance.

Disadvantages of Artificial Neural Network:

Assurance of proper network structure:

There is no particular guideline for determining the structure of artificial neural networks. The appropriate network structure is accomplished through experience, trial, and error.

Unrecognized behavior of the network:

It is the most significant issue of ANN. When ANN produces a testing solution, it does not provide insight concerning why and how. It decreases trust in the network.

Hardware dependence:

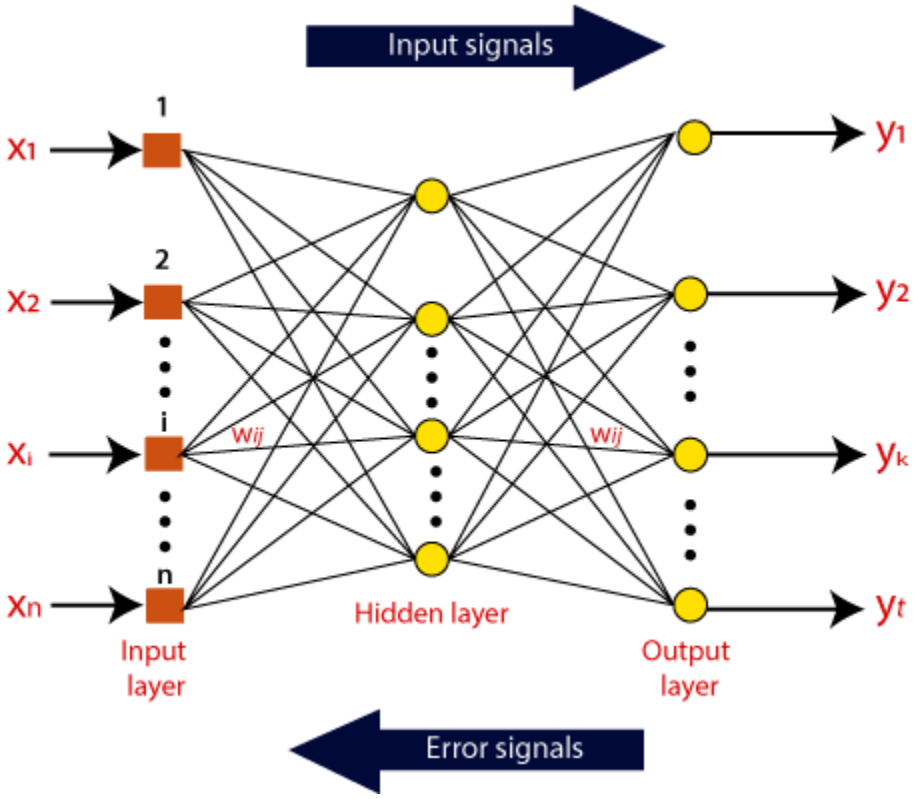
Artificial neural networks need processors with parallel processing power, as per their structure. Therefore, the realization of the equipment is dependent.

Difficulty of showing the issue to the network:

ANNs can work with numerical data. Problems must be converted into numerical values before being introduced to ANN. The presentation mechanism to be resolved here will directly impact the performance of the network. It relies on the user's abilities.

How do artificial neural networks work?

Artificial Neural Network can be best represented as a weighted directed graph, where the artificial neurons form the nodes. The association between the neurons outputs and neuron inputs can be viewed as the directed edges with weights. The Artificial Neural Network receives the input signal from the external source in the form of a pattern and image in the form of a vector. These inputs are then mathematically assigned by the notations x(n) for every n number of inputs.



Afterward, each of the input is multiplied by its corresponding weights (these weights are the details utilized by the artificial neural networks to solve a specific problem). In general terms, these weights normally represent the strength of the interconnection between neurons inside the artificial neural network. All the weighted inputs are summarized inside the computing unit.

If the weighted sum is equal to zero, then bias is added to make the output non-zero or something else to scale up to the system's response. Bias has the same input, and weight equals to 1. Here the total of weighted inputs can be in the range of 0 to positive infinity. Here, to keep the response in the limits of the desired value, a certain maximum value is benchmarked, and the total of weighted inputs is passed through the activation function.

The activation function refers to the set of transfer functions used to achieve the desired output. There is a different kind of the activation function, but primarily either linear or non-linear sets

of functions. Some of the commonly used sets of activation functions are the Binary, linear, and Tan hyperbolic sigmoidal activation functions. Let us take a look at each of them in details:

Binary:

In binary activation function, the output is either a one or a 0. Here, to accomplish this, there is a threshold value set up. If the net weighted input of neurons is more than 1, then the final output of the activation function is returned as one or else the output is returned as 0.

Sigmoidal Hyperbolic:

The Sigmoidal Hyperbola function is generally seen as an "**S**" shaped curve. Here the tan hyperbolic function is used to approximate output from the actual net input. The function is defined as:

F(x) = (1/1 + exp(-????x))

Types of Artificial Neural Network:

There are various types of Artificial Neural Networks (ANN) depending upon the human brain neuron and network functions, an artificial neural network similarly performs tasks. The majority of the artificial neural networks will have some similarities with a more complex biological partner and are very effective at their expected tasks. For example, segmentation or classification.

Feedback ANN:

In this type of ANN, the output returns into the network to accomplish the best-evolved results internally. As per the **University of Massachusetts**, Lowell Centre for Atmospheric Research. The feedback networks feed information back into itself and are well suited to solve optimization issues. The Internal system error corrections utilize feedback ANNs.

Feed-Forward ANN:

A feed-forward network is a basic neural network comprising of an input layer, an output layer, and at least one layer of a neuron. Through assessment of its output by reviewing its input, the intensity of the network can be noticed based on group behavior of the associated neurons, and the output is decided. The primary advantage of this network is that it figures out how to evaluate and recognize input patterns.

Application Scope of Neural Networks

The Neural Networks can be effectively used in the following areas:

⇒ Photos and fingerprints could be recognized by imposing a fine grid over thephoto. Each square of the grid becomes an input to the neural network.
⇒ Lake water level could be predicted based upon precipitation patterns andriver/dam flows.
⇒ Medical diagnosis is an ideal application for neural networks.
⇒ Scheduling of buses, airplanes and elevators could be optimized by predicting demand
⇒ Voice reorganization could be obtained by analyzing the audio oscilloscopepattern, much like a stock market graph.
⇒ Whether prediction may be possible. Inputs would include weather reports from surrounding areas. Output(s) would be the future weather in specificareas based on the input information. Effect such as Ocean currents and jetstreams could be included.
⇒ Air traffic control could be automated with the location, altitude, directionand speed of each radar blip taken as input to the network. The outputwould be the air traffic controller's instruction in response to each blip
⇒ Appraisal and valuation of property, buildings, automobiles, machinery, etc.,should be an easy task for a neural network.
⇒ Criminal sentencing could be predicted using a large sample of crime detailsas input and the resulting sentences as output.
⇒ Data mining, cleaning and validation could be achieved by determining which records suspiciously diverge from the pattern of their peers.
⇒ Employee hiring could be optimized if the neural network were able topredict which job applicant would show the best of job performance.
⇒ Expert consultants could package their intuitive expertise into a neuralnetwork to automate their services.
⇒ Fraud detection regarding credit cards, insurance or taxes could be automatedusing a neural network analysis of past incidents.
⇒ Handwriting and typewriting could be recognized by imposing a grid overthe writing, and then each square of the grid becomes an input to the neuralnetwork. This is called "Optical Character Recognition
⇒ Staff scheduling requirements for restaurants, retail stores, police stations,banks, etc could be predicted based on the customer flow, day week,paydays, holidays, weather, season, etc.
⇒ Traffic flows could be predicted so that signal timing could be optimized.The neural network could recognize "a weekday morning rush hour duringa school holiday'" or "a typical winter Sunday morning".

Brain vs. Computer- Comparison Between and Biological neuron andArtificial Neuron (Brain vs. Computer)

A comparison could be made between biological and artificial neurons on the basisof the following criteria:

1. Speed:

The cycle time of execution in the ANN is of fewnanoseconds whereas in the case of biological neuron it isof a few milliseconds hence, the artificial neuron modeled using a computer is the faster.

2. Processing:

Basically, biological neuron can perform massive paralleloperations simultaneously. The artificial neuron can also performseveral parallel operations simultaneouslyBut, ingeneral, the artificial neuron network prices faster thanthat of the brain.

3**. Size and Complexity:**

The total number of neurons in the brain is all about 10^{11} and the total number of interconnections is about $10^{15.}$ Hence it can be noted that the complexity of the brain is comparatively higher i.e. the computational Work takesplaces not only in the brain cell body, but also in axonsynapse, etc. On the other hand, the size and complexityof an ANN is based on the chosen application and thenetwork designer. The size and complexity of a biologicalneuron is more than that of an artificial neuron

4. Storage Capacity:

The biological neuron stores the information in itsinterconnections or in synapse strength but in an artificialneuron it is stored in its contiguous memory locations. In anartificial neuron, the continuous loading of new informationmay sometimes overload the memory locations. As a resultsome of the addresses containing older memory locationsmay be destroyed. But in case of the brain, new informationcan be added in the interconnections by adjusting thestrength without destroying the older information. Adisadvantage related to brain is that sometimes its memory may fail to recollect the stored information whereas inan artificial neuron, once the information is stored in itsmemory locations, it can be retrieved. Owing to these facts, the adaptability is more towards an artificial neuron

5.Tolerance:

The biological neuron possesses fault role rant capability whereas the artificial neuron has no fault tolerance thedistributed nature of

the biological neuron enables to store and retrieve information even when the interconnected in them get disconnected thus biological neuron are fault tolerant. But in case of artificial neurons, the informationgets corrupted if the network interconnections are disconnected, Biological neurons can accept redundancieswhich is not possible in artificial neuron.Even when some cells die, 'The human nervous system appears to be performing whit the same efficiency

6. Control mechanism:

In an artificial neuron modeled using a computer, there is a control unit present in Central Processing Unit, whichcan transfer and control precise scalar values from unit tounit, but there is no such control unit for monitoring in thebrain the strength of a neuron in the brain depends on theactive chemicals present and whether neuron connectionare strong or weak as a result of structure layer rather thanindividual synapses. However, the ANN possesses simplerinterconnection and is free from chemical actions similarto those taking place in brain (biological neuron).thus theControl mechanism neuron is very simple compared to thatof a biological neuron.

So, we have gone through a comparison between ANN and biological neural network.In short, we can say an ANN possesses the following characteristics:

1. It is a neutrally implemented mathematical model.
2. There exist a larger number of highly interconnected processing elementscalled neurons in an ANN.
3. The interconnection with their weighted linkages holds the informativeknowledge.
4. The input signals arrive at the processing elements through connection andconnecting weights.
5. The processing elements of the ANN have the ability to learn, recall and generalize from the given data by suitable assignment or adjustment ofweights.
6. The computational power can be demonstrated only by the collectivebehavior of neurons, and it should be noted that no single neuron carriesspecific information.

The above mentioned characteristics make the ANN as connection model; paralleldistributed processing models, self organizing systems, neuron computing system and neuron morphic systems.

Table 2.1: Von Neumann machine Vs Human Brain

Von Neumann machine	Human Brain
➢ One or a few high speed (ns) processors with considerable computing power	➢ It is "Large number" (101) of low speed processors ms) with limited computing power
➢ One or few shared high speed buses for communication	➢ It is “Large number” (10^{15}) of low speed connections
➢ Problem-solving knowledge is separated from the computing component	➢ Problem-solving knowledge resides in the connectivity of neurons
➢ Hard to be adaptive	➢ Adaptations by changing the connectivity

Typical Problem Areas

The number of application areas in which artificial neural networks are used isgrowing daily. Here we simply produce a few representative types of problems onwhich neural networks have been used

⇒ **Patterncompletion**: ANNS can be trained on sets of visual patternsrepresented by pixel values. If subsequently, a part of an individual pattern(or a noisy pattern) is presented to the network, we can allow the network'sactivation to propagate through the network till it converges to the originalmemorised) visual pattern. The network is acting like a content-addressablememory. Typically such networks have a recurrent (feedback as opposed toa feed forward) aspect to their activation passing. You will sometimes seethis described as a network's topology.

⇒ **Classification**: An early example of this type of network was trained todifferentiate between male and female faces. It is actually very difficult tocreate an algorithm to do so yet an ANN has been shown to have nearhuman capacity to do so.

⇒ **Optimization**: It is notoriously difficult to find algorithms for solving optimization problems. A famous optimization problem is the TravellingSalesman Problem in which a salesman must travel to each of a number ofcities, visiting each one once and only once in an optimal (i.e. least distance or least cost) route, There are several types of neural networks which havebeen shown to converge to 'good-enough' solutions to this problem i.e.solutions which may not be globally optimal but can be shown to be close to the global optimum for any given set of parameters.

⇒ **Featuredetection**: An early example of this is the phoneme producing feature map of Kohonen: the network is provided with a set of inputs andmust learn to pronounce the words; in doing so, it must identity a set ofeatures which are important in phoneme production,

⇒ **Datacompression**: There are many ANNs which have been shown to becapable of representing input data in a compressed format losing as little orthe information as possible; for example, in image compression we may showthat a great deal of the information given

by a pixel to pixel representation of the data is redundant and a more compact representation of the image canbe found by ANNs.

⇒ **Approximation**: Given examples of an input to output mapping, a neuralnetwork can be trained to approximate the mapping so that a future inputWill give approximately the correct answer i.e. the answer which the mappingshould give.

⇒ **Association**: We may associate a particular input with a particular Output sothat given the same (or similar) output again, the network will give the same(or a similar) output again.

⇒ **Prediction**: This task may be stated as: given a set of previous examplesfrom a time series, such as a set of closing prices for the FTSE, to predict thenext (future) sample.

⇒ **Control**: For example to control the movement of a robot arm (Or truck, orany non-linear process) to learn what inputs (actions) will have the correctoutputs (results).

Training of artificial Neural Network

Introduction

Artificial Neural Network (ANN) is having ability to learn from its environment and improve it's perform through learning.

Learning is a process by which the free parameters of a neural network are adaptedthrough a process of stimulation by the environment in which the network is embeddedthe type of learning is determined by the member in which the parameter change takeplace.

One way is to set the weights explicitly, using a priori knowledge. Another way is to**'train' the neural network** by feeding it teaching patterns and letting it change itsweights according to some learning rule.

This definition of the learning process implies thefollowing sequence of events.

1) The Neural Network is stimulated by the environment.
2) The Neural Network undergoes change in its free parameters as a result ofthis stimulation.
3) The Neural Network responds in a new way to the environment because of the change the name occurred in its internal structure.

There are a number of approaches for training neural networks. Most fall into one of following three categories.

Machine learning is a sub-field of artificial intelligence (AI) that provides **systems** the ability
to **automatically learn** and **improve** from **experience without** being **explicitly** progra mmed.

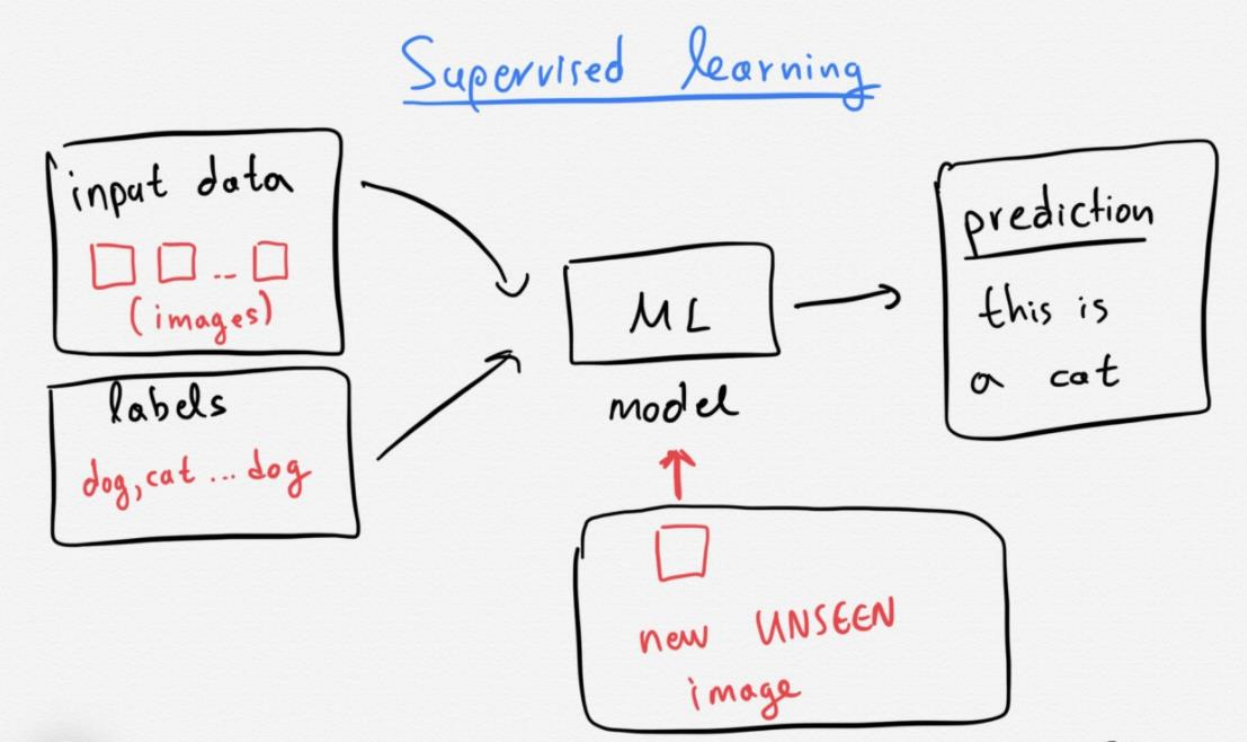
For the process of **learning** (model fitting) we need to have available some **observations** or **data** (also known as *samples* or *examples*) in order to explore **potential underlying patterns**, hidden in our data.
These **learned patterns** are **nothing** more that some **functions** or **decision boundaries**.

These patterns are learned by the systems (computer systems) automatically without human intervention or input.

2. The main machine learning categories

Machine learning algorithms are usually categorized as supervised or unsupervised.

2.1 Supervised machine learning algorithms/methods



For this family of models, the research needs to have at hand a dataset with some observations and the labels/classes of the observations. For example, the observations could be images of animals and the labels the name of the animal (e.g. cat, dog etc).

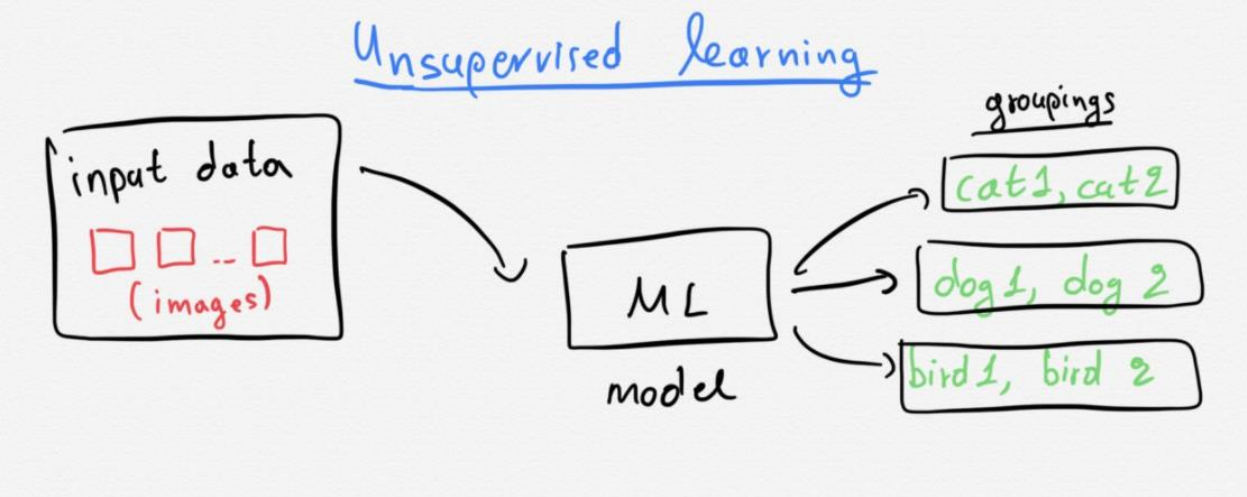
These models learn from the labeled dataset and then are used to predict future events. For the training procedure, the input is a known training data set with its corresponding labels, and the learning algorithm produces an inferred function to finally make predictions about some new unseen observations that one can give to the model. The model is able to provide targets for any new input after sufficient training. The learning algorithm can also compare its output with the correct intended output (ground truth label) and find errors in order to modify itself accordingly (e.g. via back-propagation).

Supervised models can be further grouped into **regression** and classification **cases**:

- **Classification**: A classification problem is when the output variable is a category e.g. “disease” / “no disease”.
- **Regression**: A regression problem is when the output variable is a real continuous value e.g. stock price prediction

Some examples of models that belong to this family are the following: SVC, LDA, SVR, regression, random forests etc.

Unsupervised machine learning algorithms/methods



For this family of models, the research needs to have at hand a dataset with some observations without the need of having also the labels/classes of the observations.

Unsupervised learning studies how systems can infer a function to describe a hidden structure from unlabeled data. The system doesn't predict the right output, but instead, it explores the data and can draw inferences from datasets to describe hidden structures from unlabeled data.

Unsupervised models can be further grouped into **clustering** and **association** cases.

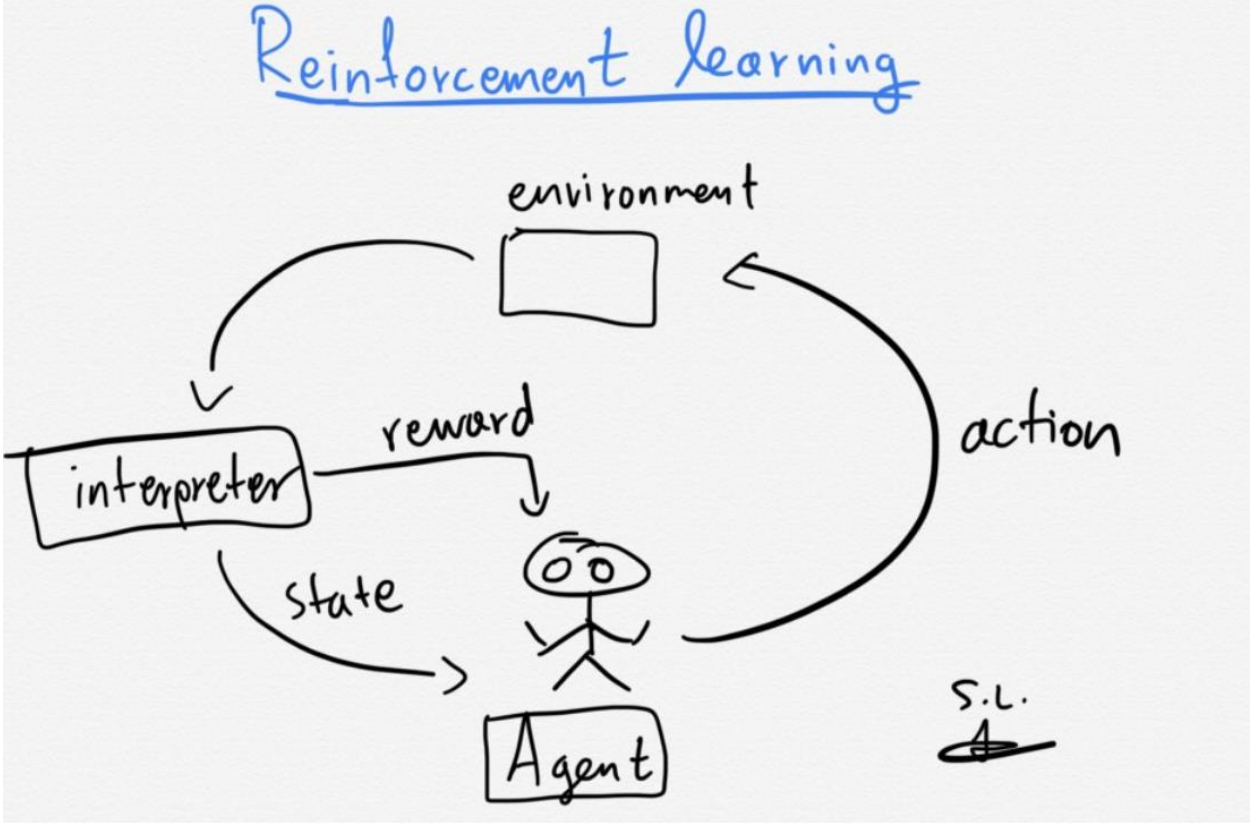
- **Clustering**: A clustering problem is where you want to unveil the **inherent groupings** in the data, such as grouping animals based on some characteristics/features e.g. number of legs.
- **Association**: An association rule learning is where you want to discover **association** rules such as people that buy X also tend to buy Y.

Some examples of models that belong to this family are the following: PCA, K-means, DBSCAN, mixture models etc.

2.3 Semi-supervised machine learning algorithms/methods

This family is between the supervised and unsupervised learning families. The semi-supervised models use both labeled and unlabeled data for training.

2.4 Reinforcement machine learning algorithms/methods



This family of models consists of algorithms that use the estimated errors as rewards or penalties. If the error is big, then the penalty is high and the reward low. If the error is small, then the penalty is low and the reward high.

Trial error search and **delayed reward** are the most relevant characteristics of reinforcement learning. This family of models allows the automatic determination of the ideal behavior within a specific context in order to maximize the desired performance.

Reward feedback is required for the model to learn which action is best and this is known as "**the reinforcement signal**"

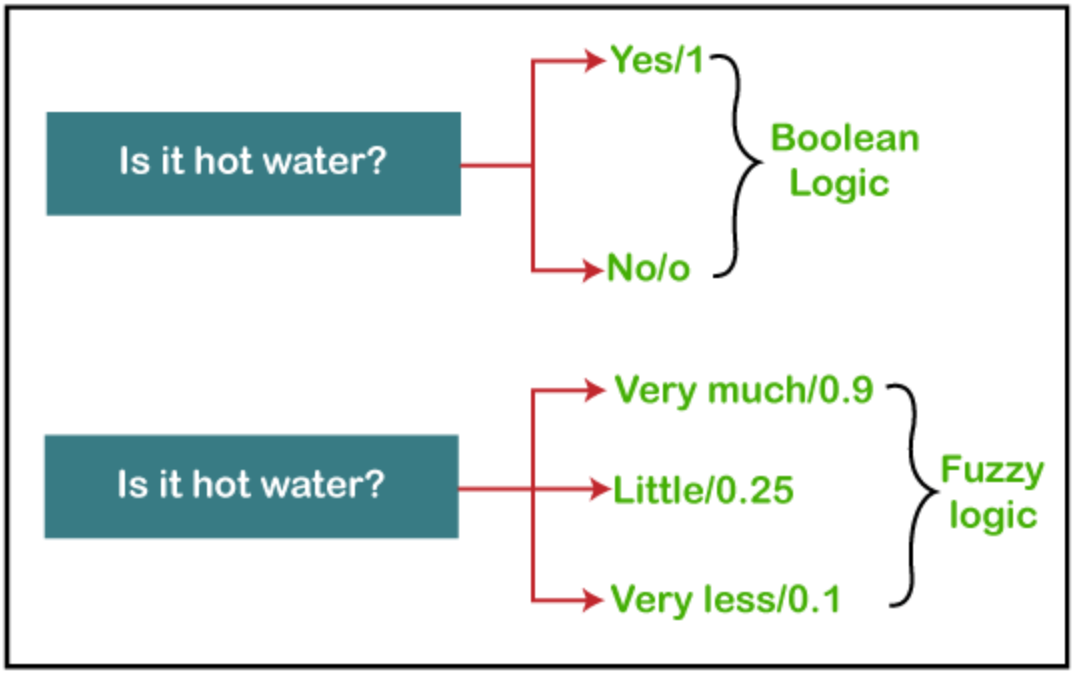
Difference b/w Supervised and Unsupervised Learning :

	SUPERVISED LEARNING	UNSUPERVISED LEARNING
Input Data	Uses Known and Labeled Data as input	Uses Unknown Data as input
Computational Complexity	Very Complex	Less Computational Complexity
Real Time	Uses off-line analysis	Uses Real Time Analysis of Data
Number of Classes	Number of Classes are known	Number of Classes are not known
Accuracy of Results	Accurate and Reliable Results	Moderate Accurate and Reliable Results

What is Fuzzy Logic?

The **'Fuzzy'** word means the things that are not clear or are vague. Sometimes, we cannot decide in real life that the given problem or statement is either true or false. At that time, this concept provides many values between the true and false and gives the flexibility to find the best solution to that problem.

Example of Fuzzy Logic as comparing to Boolean Logic



Fuzzy logic contains the multiple logical values and these values are the truth values of a variable or problem between 0 and 1. This concept was introduced by **Lofti Zadeh** in **1965** based on the **Fuzzy Set Theory**. This concept provides the possibilities which are not given by computers, but similar to the range of possibilities generated by humans.

In the Boolean system, only two possibilities (0 and 1) exist, where 1 denotes the absolute truth value and 0 denotes the absolute false value. But in the fuzzy system, there are multiple possibilities present between the 0 and 1, which are partially false and partially true.

The Fuzzy logic can be implemented in systems such as micro-controllers, workstation-based or large network-based systems for achieving the definite output. It can also be implemented in both hardware or software.

Characteristics of Fuzzy Logic

ADVERTISING

Following are the characteristics of fuzzy logic:

1. This concept is flexible and we can easily understand and implement it.
2. It is used for helping the minimization of the logics created by the human.
3. It is the best method for finding the solution of those problems which are suitable for approximate or uncertain reasoning.
4. It always offers two values, which denote the two possible solutions for a problem and statement.
5. It allows users to build or create the functions which are non-linear of arbitrary complexity.
6. In fuzzy logic, everything is a matter of degree.
7. In the Fuzzy logic, any system which is logical can be easily fuzzified.
8. It is based on natural language processing.
9. It is also used by the quantitative analysts for improving their algorithm's execution.

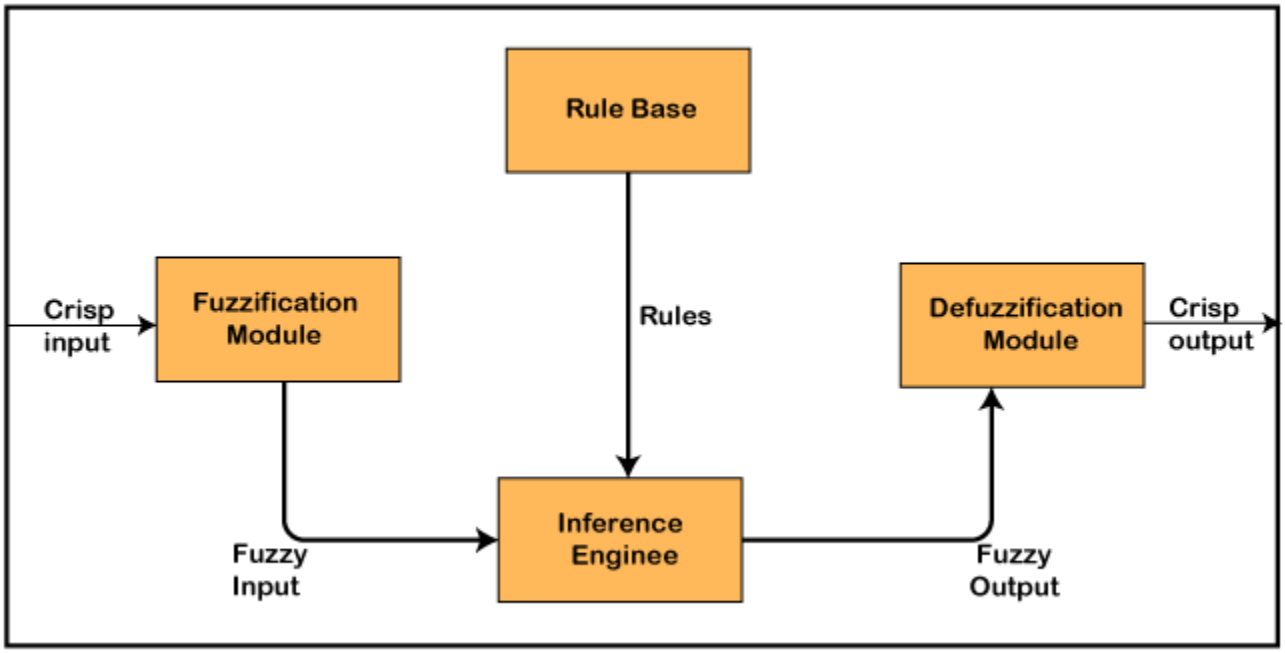
10. It also allows users to integrate with the programming.

Architecture of a Fuzzy Logic System

In the architecture of the **Fuzzy Logic** system, each component plays an important role. The architecture consists of the different four components which are given below.

1. Rule Base
2. Fuzzification
3. Inference Engine
4. Defuzzification

Following diagram shows the architecture or process of a Fuzzy Logic system:



1. Rule Base

Rule Base is a component used for storing the set of rules and the If-Then conditions given by the experts are used for controlling the decision-making systems. There are so many updates that come in the Fuzzy theory recently, which offers effective methods for designing and tuning of fuzzy controllers. These updates or developments decreases the number of fuzzy set of rules.

2. Fuzzification

Fuzzification is a module or component for transforming the system inputs, i.e., it converts the crisp number into fuzzy steps. The crisp numbers are those inputs which are measured by the sensors and then fuzzification passed them into the control systems for further processing. This component divides the input signals into following five states in any Fuzzy Logic system:

- Large Positive (LP)

- Medium Positive (MP)
- Small (S)
- Medium Negative (MN)
- Large negative (LN)

3. Inference Engine

This component is a main component in any Fuzzy Logic system (FLS), because all the information is processed in the Inference Engine. It allows users to find the matching degree between the current fuzzy input and the rules. After the matching degree, this system determines which rule is to be added according to the given input field. When all rules are fired, then they are combined for developing the control actions.

4. Defuzzification

Defuzzification is a module or component, which takes the fuzzy set inputs generated by the **Inference Engine**, and then transforms them into a crisp value. It is the last step in the process of a fuzzy logic system. The crisp value is a type of value which is acceptable by the user. Various techniques are present to do this, but the user has to select the best one for reducing the errors.

Membership Function

The membership function is a function which represents the graph of fuzzy sets, and allows users to quantify the linguistic term. It is a graph which is used for mapping each element of x to the value between 0 and 1.

This function is also known as indicator or characteristics function.

This function of Membership was introduced in the first papers of fuzzy set by **Zadeh**. For the Fuzzy set B, the membership function for X is defined as: $\mu B:X \rightarrow [0,1]$. In this function X, each element of set B is mapped to the value between 0 and 1. This is called a degree of membership or membership value.

Classical and Fuzzy Set Theory

To learn about classical and Fuzzy set theory, firstly you have to know about what is set.

Set

A set is a term, which is a collection of unordered or ordered elements. Following are the various examples of a set:

1. A set of all-natural numbers
2. A set of students in a class.
3. A set of all cities in a state.
4. A set of upper-case letters of the alphabet.

Types of Set:

There are following various categories of set:

1. Finite
2. Empty
3. Infinite

4. Proper
5. Universal
6. Subset
7. Singleton
8. Equivalent Set
9. Disjoint Set

Classical Set

It is a type of set which collects the distinct objects in a group. The sets with the crisp boundaries are classical sets. In any set, each single entity is called an element or member of that set.

Mathematical Representation of Sets

Any set can be easily denoted in the following two different ways:

1. Roaster Form: This is also called as a tabular form. In this form, the set is represented in the following way:

$$\text{Set\_name} = \{ \text{element1}, \text{element2}, \text{element3}, ..., \text{element N}\}$$

The elements in the set are enclosed within the brackets and separated by the commas.

Following are the two examples which describes the set in Roaster or Tabular form:

Example 1:

$$\text{Set of Natural Numbers: } N=\{1, 2, 3, 4, 5, 6, 7, ...,n).$$

Example 2:

$$\text{Set of Prime Numbers less than 50: } X=\{2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47\}.$$

2. Set Builder Form: Set Builder form defines a set with the common properties of an element in a set. In this form, the set is represented in the following way:

$$A = \{x:p(x)\}$$

The following example describes the set in the builder form:

$$\text{The set } \{2, 4, 6, 8, 10, 12, 14, 16, 18\} \text{ is written as:}$$

$$B = \{x:2 \leq x < 20 \text{ and } (x\%2) = 0\}$$

Operations on Classical Set

Following are the various operations which are performed on the classical sets:

1. Union Operation

2. Intersection Operation
3. Difference Operation
4. Complement Operation

1. Union:

This operation is denoted by (A U B). A U B is the set of those elements which exist in two different sets A and B. This operation combines all the elements from both the sets and make a new set. It is also called a Logical OR operation.

It can be described as:

$$A \cup B = \{ x \mid x \in A \text{ OR } x \in B \}.$$

Example:

$$\text{Set A} = \{10, 11, 12, 13\}, \text{Set B} = \{11, 12, 13, 14, 15\}, \text{then } A \cup B = \{10, 11, 12, 13, 14, 15\}$$

2. Intersection

This operation is denoted by (A ∩ B). A ∩ B is the set of those elements which are common in both set A and B. It is also called a Logical OR operation.

It can be described as:

$$A \cap B = \{ x \mid x \in A \text{ AND } x \in B \}.$$

Example:

$$\text{Set A} = \{10, 11, 12, 13\}, \text{Set B} = \{11, 12, 14\} \text{ then } A \cap B = \{11, 12\}$$

3. Difference Operation

This operation is denoted by (A - B). A-B is the set of only those elements which exist only in set A but not in set B.

It can be described as:

$$A - B = \{ x \mid x \in A \text{ AND } x \notin B \}.$$

4. Complement Operation: This operation is denoted by (A`). It is applied on a single set. A` is the set of elements which do not exist in set A.

It can be described as:

$$A' = \{x | x \notin A\}.$$

Properties of Classical Set

There are following various properties which play an essential role for finding the solution of a fuzzy logic problem.

1. Commutative Property:

This property provides the following two states which are obtained by two finite sets A and B:

$$A \cup B = B \cup A$$

$$A \cap B = B \cap A$$

2. Associative Property:

This property also provides the following two states but these are obtained by three different finite sets A, B, and C:

$$A \cup (B \cup C) = (A \cup B) \cup C$$

$$A \cap (B \cap C) = (A \cap B) \cap C$$

3. Idempotency Property:

This property also provides the following two states but for a single finite set A:

$$A \cup A = A$$

$$A \cap A = A$$

4. Absorption Property

This property also provides the following two states for any two finite sets A and B:

$$A \cup (A \cap B) = A$$

$$A \cap (A \cup B) = A$$

5. Distributive Property:

This property also provides the following two states for any three finite sets A, B, and C:

$$A\cup (B \cap C) = (A \cup B)\cap (A \cup C)$$

$$A\cap (B \cup C) = (A\cap B) \cup (A\cap C)$$

6. Identity Property:

This property provides the following four states for any finite set A and Universal set X:

$$A \cup \varphi = A$$

$$A \cap X = A$$

$$A \cap \varphi = \varphi$$

$$A \cup X = X$$

7. Transitive property

This property provides the following state for the finite sets A, B, and C:

If $A \subseteq B \subseteq C$, then $A \subseteq C$

8. Ivolution property

This property provides following state for any finite set A:

$$\overline{\overline{A}} = A$$

9. De Morgan's Law

This law gives the following rules for providing the contradiction and tautologies:

$$\overline{A \cap B} = \overline{A} \cup \overline{B}$$

$$\overline{A \cup B} = \overline{A} \cap \overline{B}$$

Fuzzy Set

The set theory of classical is the subset of Fuzzy set theory. Fuzzy logic is based on this theory, which is a generalisation of the classical theory of set (i.e., crisp set) introduced by Zadeh in 1965.

A fuzzy set is a collection of values which exist between 0 and 1. Fuzzy sets are denoted or represented by the tilde (~) character. The sets of Fuzzy theory were introduced in 1965 by Lofti A. Zadeh and Dieter Klaua. In the fuzzy set, the partial membership also exists. This theory released as an extension of classical set theory.

This theory is denoted mathematically asA fuzzy set (Ã) is a pair of U and M, where U is the Universe of discourse and M is the membership function which takes on values in the interval [0, 1]. The universe of discourse (U) is also denoted by Ω or X.

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) | x \in X\}$$

Operations on Fuzzy Set

Given Ã and B are the two fuzzy sets, and X be the universe of discourse with the following respective member functions:

$$\mu_{\tilde{A}}(x) \text{ and } \mu_{\tilde{B}}(x)$$

The operations of Fuzzy set are as follows:

1. Union Operation: The union operation of a fuzzy set is defined by:

$$\mu_{A \cup B}(x) = \max(\mu_A(x), \mu_B(x))$$

Example:

Let's suppose A is a set which contains following elements:

$$A = \{(X_1, 0.6), (X_2, 0.2), (X_3, 1), (X_4, 0.4)\}$$

And, B is a set which contains following elements:

$$B = \{(X_1, 0.1), (X_2, 0.8), (X_3, 0), (X_4, 0.9)\}$$

then,

$$A \cup B = \{(X_1, 0.6), (X_2, 0.8), (X_3, 1), (X_4, 0.9)\}$$

Because, according to this operation

For X_1

$$\mu_{A \cup B}(X_1) = \max(\mu_A(X_1), \mu_B(X_1))$$
$$\mu_{A \cup B}(X_1) = \max(0.6, 0.1)$$
$$\mu_{A \cup B}(X_1) = 0.6$$

For X_2

$$\mu_{A \cup B}(X_2) = \max(\mu_A(X_2), \mu_B(X_2))$$
$$\mu_{A \cup B}(X_2) = \max(0.2, 0.8)$$
$$\mu_{A \cup B}(X_2) = 0.8$$

For X_3

$$\mu_{A \cup B}(X_3) = \max(\mu_A(X_3), \mu_B(X_3))$$
$$\mu_{A \cup B}(X_3) = \max(1, 0)$$
$$\mu_{A \cup B}(X_3) = 1$$

For X_4

$$\mu_{A \cup B}(X_4) = \max(\mu_A(X_4), \mu_B(X_4))$$
$$\mu_{A \cup B}(X_4) = \max(0.4, 0.9)$$
$$\mu_{A \cup B}(X_4) = 0.9$$

2. Intersection Operation: The intersection operation of fuzzy set is defined by:

$$\mu_{A \cap B}(x) = \min(\mu_A(x), \mu_B(x))$$

Example:

Let's suppose A is a set which contains following elements:

$$A = \{(X_1, 0.3), (X_2, 0.7), (X_3, 0.5), (X_4, 0.1)\}$$

And, B is a set which contains following elements:

$$B = \{(X_1, 0.8), (X_2, 0.2), (X_3, 0.4), (X_4, 0.9)\}$$

then,

$$A \cap B = \{(X_1, 0.3), (X_2, 0.2), (X_3, 0.4), (X_4, 0.1)\}$$

Because, according to this operation

For X_1

$$\mu_{A \cap B}(X_1) = \min(\mu_A(X_1), \mu_B(X_1))$$
$$\mu_{A \cap B}(X_1) = \min(0.3, 0.8)$$
$$\mu_{A \cap B}(X_1) = 0.3$$

For X_2

$$\mu_{A \cap B}(X_2) = \min(\mu_A(X_2), \mu_B(X_2))$$
$$\mu_{A \cap B}(X_2) = \min(0.7, 0.2)$$
$$\mu_{A \cap B}(X_2) = 0.2$$

For X_3

$$\mu_{A \cap B}(X_3) = \min(\mu_A(X_3), \mu_B(X_3))$$
$$\mu_{A \cap B}(X_3) = \min(0.5, 0.4)$$
$$\mu_{A \cap B}(X_3) = 0.4$$

For X_4

$$\mu_{A \cap B}(X_4) = \min(\mu_A(X_4), \mu_B(X_4))$$
$$\mu_{A \cap B}(X_4) = \min(0.1, 0.9)$$
$$\mu_{A \cap B}(X_4) = 0.1$$

3. Complement Operation: The complement operation of fuzzy set is defined by:

$\mu_{\bar{A}}(x) = 1-\mu_A(x)$,

Example:

Let's suppose A is a set which contains following elements:

$$A = \{(X_1, 0.3), (X_2, 0.8), (X_3, 0.5), (X_4, 0.1)\}$$

then,

$$\bar{A} = \{(X_1, 0.7), (X_2, 0.2), (X_3, 0.5), (X_4, 0.9)\}$$

Because, according to this operation

For X_1

$\mu_{\bar{A}}(X_1) = 1-\mu_A(X_1)$

$\mu_{\bar{A}}(X_1) = 1 - 0.3$

$\mu_{\bar{A}}(X_1) = 0.7$

For X_2

$\mu_{\bar{A}}(X_2) = 1-\mu_A(X_2)$

$\mu_{\bar{A}}(X_2) = 1 - 0.8$

$\mu_{\bar{A}}(X_2) = 0.2$

For X_3

$\mu_{\bar{A}}(X_3) = 1-\mu_A(X_3)$

$\mu_{\bar{A}}(X_3) = 1 - 0.5$

$\mu_{\bar{A}}(X_3) = 0.5$

For X_4

$\mu_{\bar{A}}(X_4) = 1-\mu_A(X_4)$

$\mu_{\bar{A}}(X_4) = 1 - 0.1$

$\mu_{\bar{A}}(X_4) = 0.9$

Classical Set Theory	Fuzzy Set Theory

1. This theory is a class of those sets having sharp boundaries.	1. This theory is a class of those sets having un-sharp boundaries.
2. This set theory is defined by exact boundaries only 0 and 1.	2. This set theory is defined by ambiguous boundaries.
3. In this theory, there is no uncertainty about the boundary's location of a set.	3. In this theory, there always exists uncertainty about the boundary's location of a set.
4. This theory is widely used in the design of digital systems.	4. It is mainly used for fuzzy controllers.

Applications of Fuzzy Logic

Following are the different application areas where the Fuzzy Logic concept is widely used:

1. It is used in **Businesses** for decision-making support system.
2. It is used in **Automative systems** for controlling the traffic and speed, and for improving the efficiency of automatic transmissions. **Automative systems** also use the shift scheduling method for automatic transmissions.
3. This concept is also used in the **Defence** in various areas. Defence mainly uses the Fuzzy logic systems for underwater target recognition and the automatic target recognition of thermal infrared images.
4. It is also widely used in the **Pattern Recognition and Classification** in the form of Fuzzy logic-based recognition and handwriting recognition. It is also used in the searching of fuzzy images.
5. Fuzzy logic systems also used in **Securities**.
6. It is also used in **microwave oven** for setting the lunes power and cooking strategy.
7. This technique is also used in the area of **modern control systems** such as expert systems.
8. **Finance** is also another application where this concept is used for predicting the stock market, and for managing the funds.
9. It is also used for controlling the brakes.
10. It is also used in the **industries of chemicals** for controlling the ph, and chemical distillation process.
11. It is also used in the **industries of manufacturing** for the optimization of milk and cheese production.
12. It is also used in the vacuum cleaners, and the timings of washing machines.
13. It is also used in heaters, air conditioners, and humidifiers.

Advantages of Fuzzy Logic

Fuzzy Logic has various advantages or benefits. Some of them are as follows:

1. The methodology of this concept works similarly as the human reasoning.
2. Any user can easily understand the structure of Fuzzy Logic.
3. It does not need a large memory, because the algorithms can be easily described with fewer data.

4. It is widely used in all fields of life and easily provides effective solutions to the problems which have high complexity.
5. This concept is based on the set theory of mathematics, so that's why it is simple.
6. It allows users for controlling the control machines and consumer products.
7. The development time of fuzzy logic is short as compared to conventional methods.
8. Due to its flexibility, any user can easily add and delete rules in the FLS system.

Disadvantages of Fuzzy Logic

Fuzzy Logic has various disadvantages or limitations. Some of them are as follows:

1. The run time of fuzzy logic systems is slow and takes a long time to produce outputs.
2. Users can understand it easily if they are simple.
3. The possibilities produced by the fuzzy logic system are not always accurate.
4. Many researchers give various ways for solving a given statement using this technique which leads to ambiguity.
5. Fuzzy logics are not suitable for those problems that require high accuracy.
6. The systems of a Fuzzy logic need a lot of testing for verification and validation.