What is Cloud?

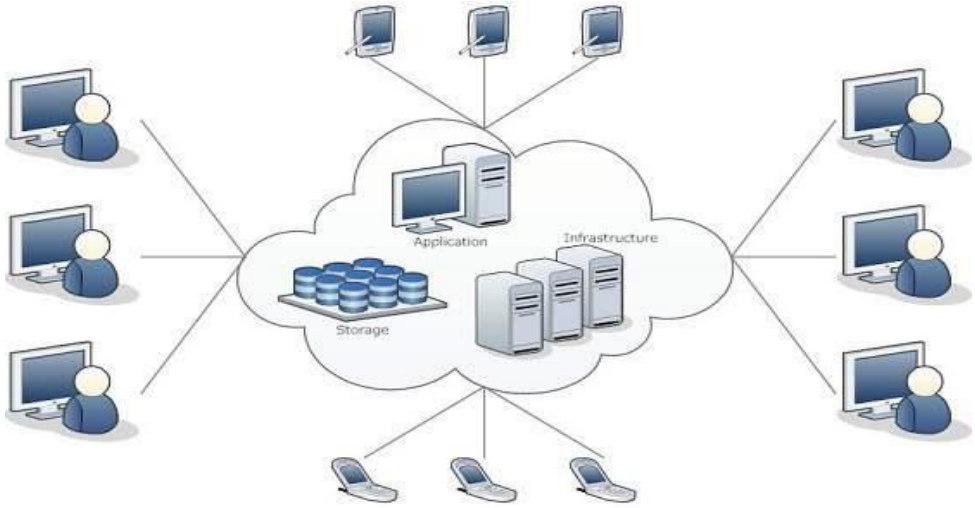
The term **Cloud** refers to a **Network** or **Internet.**

In other words, we can say that Cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.

Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.

What is Cloud Computing?

Cloud Computing refers to **manipulating, configuring,** and **accessing** the hardware and software resources remotely. It offers online data storage, infrastructure, and application.



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

Cloud Computing provides us resources of accessing the applications as utilities over the Internet. It allows us to create, configure, and customize the applications online.

Basic Concepts

There are certain services and models working behind the scene making the cloud computing feasible and accessible to end users.

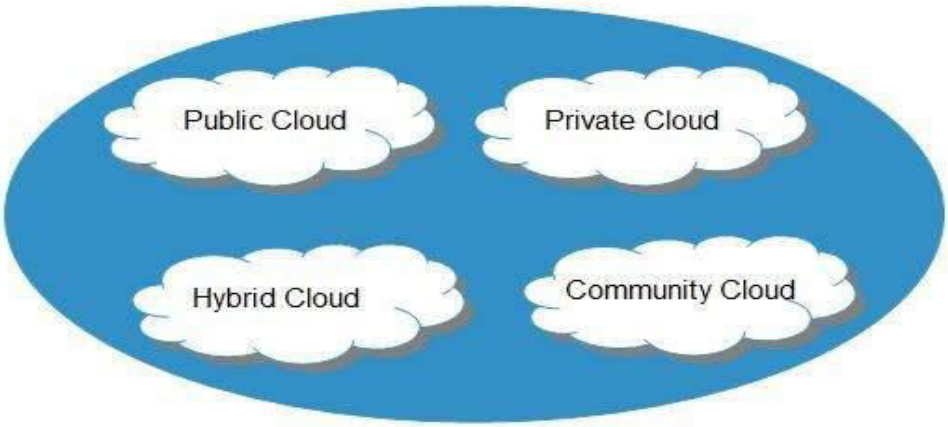
Following are the working models for cloud computing:

- Deployment Models
- Service Models

Deployment Models:

Deployment models define the type of access to the cloud, i.e., how the cloud is located?

Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.



Public Cloud:

The **public cloud** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness.

Private Cloud:

The **private cloud** allows systems and services to be accessible within an organization. It is more secured because of its private nature.

Community Cloud:

The **community cloud** allows systems and services to be accessible by a group of organizations.

Hybrid Cloud:

The **hybrid cloud** is a mixture of public and private cloud, in which the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.

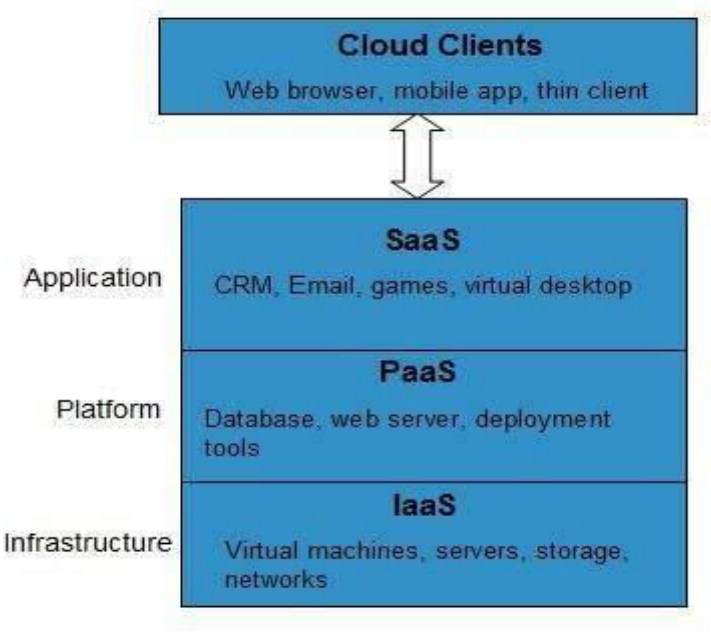
Service Models:

Cloud computing is based on service models. These are categorized into three basic service models:-

- Infrastructure-as–a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Software-as-a-Service (SaaS)

Anything-as-a-Service (XaaS) is yet another service model, which includes Network-as-a-Service, Business-as-a-Service, Identity-as-a-Service, Database-as-a-Service or Strategy-as-a-Service.

The **Infrastructure-as-a-Service (IaaS)** is the most basic level of service. Each of the service models inherit the security and management mechanism from the underlying model, as shown in the following diagram:



Infrastructure-as-a-Service (IaaS):

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

Platform-as-a-Service (PaaS):

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

Software-as-a-Service (SaaS):

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

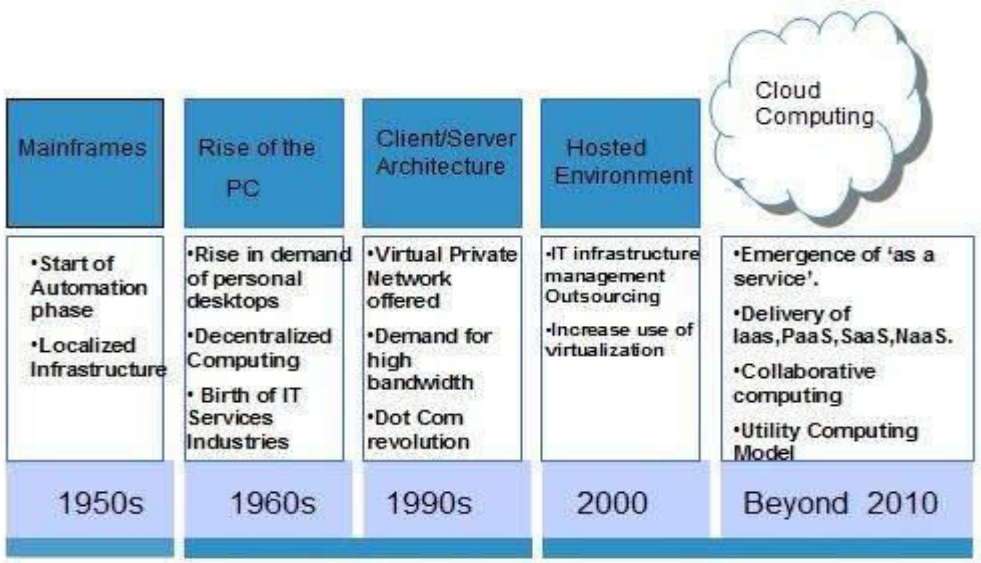
History of Cloud Computing

The concept of **Cloud Computing** came into existence in the year 1950 with implementation of mainframe computers, accessible via **thin/static clients.**

Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services.

[A **thin client** is a computer that runs from resources stored on a central server instead of a localized hard drive. **Thin clients** work by connecting remotely to a server-based computing environment where most applications, sensitive data, and memory, are stored.]

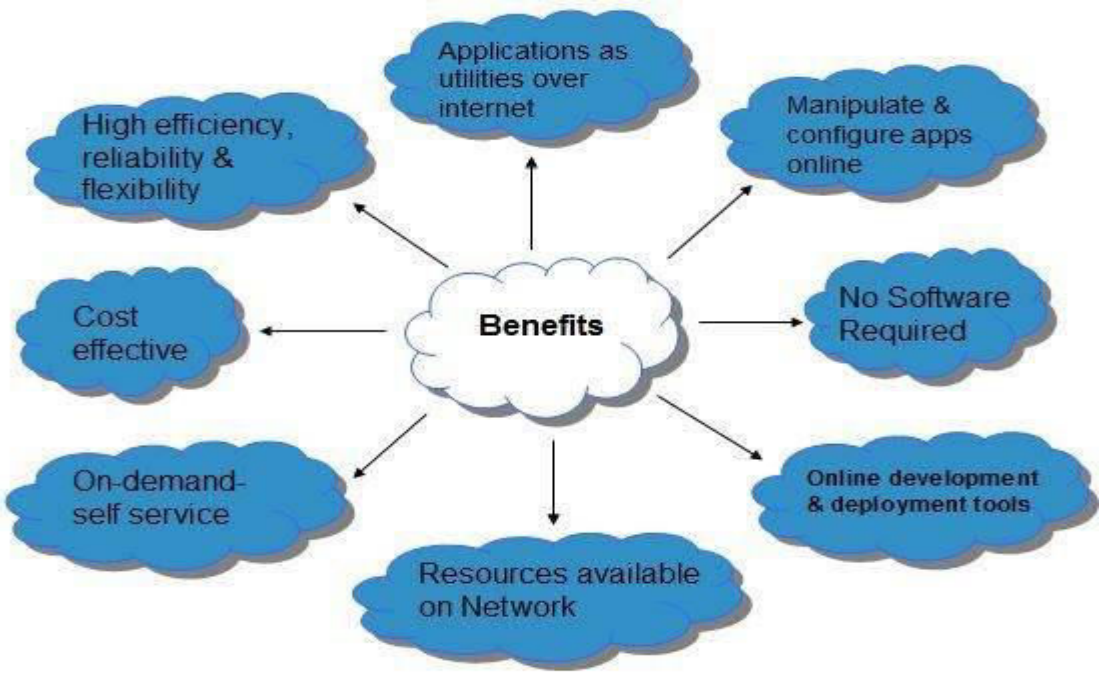
The following diagram explains the evolution of cloud computing:



Benefits

Cloud Computing has numerous advantages. Some of them are listed below -

- One can access applications as utilities, over the Internet.
- One can manipulate and configure the applications online at any time.
- It does not require to install a software to access or manipulate cloud application.
- Cloud Computing offers online development and deployment tools, programming runtime environment through **PaaS model.**
- Cloud resources are available over the network in a manner that provide platform independent access to any type of clients.
- Cloud Computing offers **on-demand self-service.** The resources can be used without interaction with cloud service provider.
- Cloud Computing is highly cost effective because it operates at high efficiency with optimum utilization. It just requires an Internet connection
- Cloud Computing offers load balancing that makes it more reliable.



Risks related to Cloud Computing:

Although cloud Computing is a promising innovation with various benefits in the world of computing, it comes with risks as below:

Security and Privacy:

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

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

Lock In:

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

Isolation Failure:

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

Management Interface Compromise:

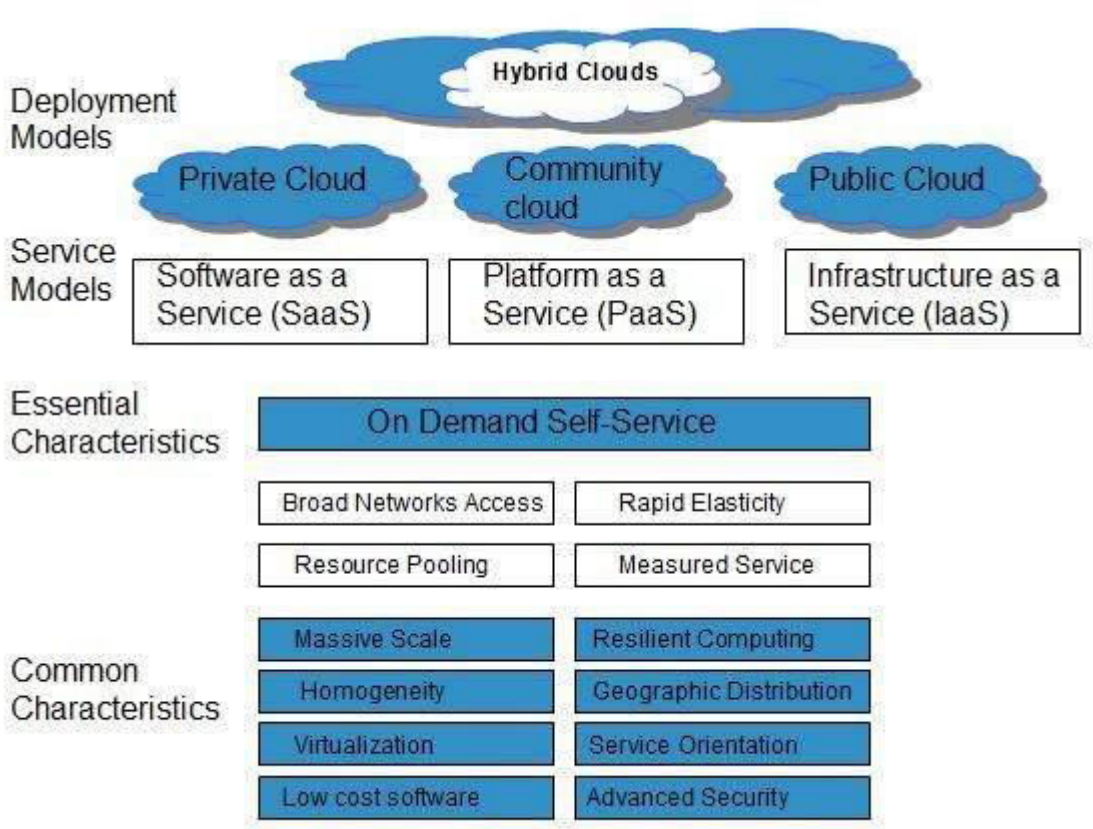
In case of public cloud provider, the customer management interfaces are accessible through the Internet.

Insecure or Incomplete Data Deletion:

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

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

Characteristics of Cloud Computing:



Following are the essential characteristics of Cloud Computing:

On Demand Self Service:

Cloud Computing allows the users to use web services and resources on demand. One can logon to a website at any time and use them.

The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.

Broad Network Access:

Since cloud computing is completely web based, it can be accessed from anywhere and at any time.

The Computing services are generally provided over standard networks and heterogeneous devices.

Resource Pooling:

Cloud computing allows multiple residents to share a pool of resources. One can share single physical instance of hardware, database and basic infrastructure.

The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.

Rapid Elasticity:

It is very easy to scale the resources vertically or horizontally at any time. Scaling of resources means the ability of resources to deal with increasing or decreasing demand.

The resources being used by customers at any given point of time are automatically monitored.

The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis.

Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over

Measured Service:

In this service cloud provider controls and monitors all the aspects of cloud service. Resource optimization, billing, and capacity planning etc. depend on it.

The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource

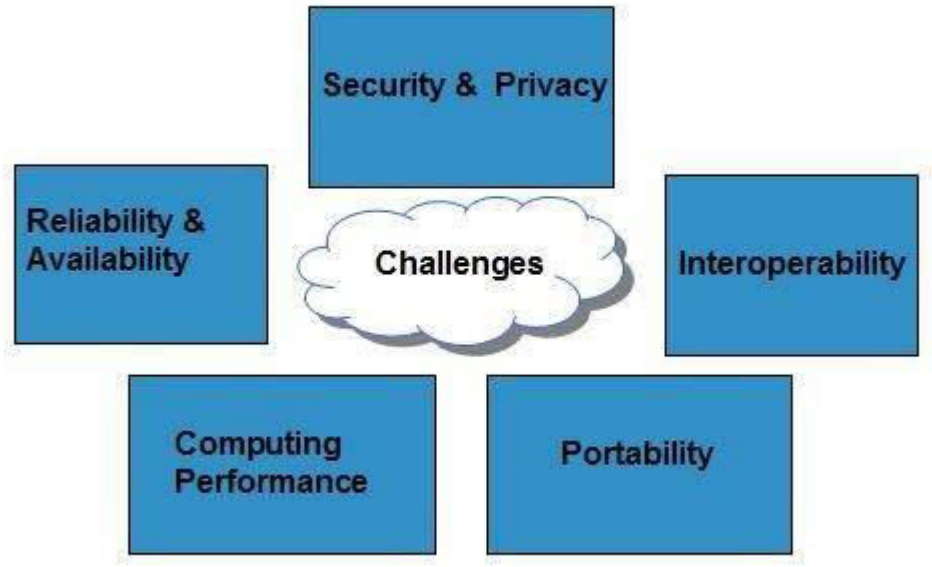
Cloud Vulnerability

> **Vulnerability** is a cyber-security term that refers to a flaw in a system that can leave it open to attack. A **vulnerability** may also refer to any type of weakness in a computer system itself, in a set of procedures, or in anything that leaves information security exposed to a threat.

Denial of Service (DoS) and Distributed Denial of Service (DDoS) attacks are **cloud** security **vulnerabilities** that make servers inaccessible for users by flooding the network's traffic. Data Loss.

Cloud Computing Challenges

Cloud computing, an emergent technology, has placed many challenges in different aspects of data and information handling. Some of these are shown in the following diagram:



Security and Privacy:

Security and Privacy of information is the biggest challenge to cloud computing. Security and privacy issues can be overcome by employing encryption, security hardware and security applications.

Portability:

This is another challenge to cloud computing that applications should easily be migrated from one cloud provider to another. There must not be vendor lock-in. However, it is not yet made possible because each of the cloud provider uses different standard languages for their platforms.

Interoperability:

It means the application on one platform should be able to incorporate services from the other platforms. It is made possible via web services, but developing such web services is very complex.

Computing Performance:

Data intensive applications on cloud requires high network bandwidth, which results in high cost. Low bandwidth does not meet the desired computing performance of cloud application.

Reliability and Availability:

It is necessary for cloud systems to be reliable and robust because most of the businesses are now becoming dependent on services provided by third-party.

Cloud Migration

Cloud migration is the process of moving data, applications or other business elements to a cloud computing environment. ... However, a cloud migration could also involve moving data and applications from one cloud platform or provider to another -- a model known as cloud-to-cloud migration.

There are various types of cloud migrations an enterprise can perform. One common model is the transfer of data and applications from a local, on-premises data center to the public cloud.

The most important part of any cloud migration is making sure the migration gets your company where it needs to be. The four types of cloud migration are called lift and shift, shift to Software-as-a-Service (SaaS), application refactoring, and replatforming.

Lift and Shift:

The lift and shift approach is for organizations looking to get out of the data center and stop managing hardware.

Lift and shift provides the same software that your company used in the data center, but now in the cloud. There isn't any learning curve for the cloud applications, since they work exactly the same as before. This is the fastest method for migrating applications to the cloud, and the one that causes the least disruption. It only requires the involvement of the infrastructure and security teams, leaving everyone else free to pursue their work uninterrupted.

It's also the option with the least upfront cost. Moving the application to the cloud allows it to handle peak performance, without your company having to pay for it.

Lift and shift comes with its drawbacks, however. This cloud migration can't take full advantage of the speed and versatility the cloud can provide.

Since the process doesn't change the application – it just moves the code to a new location – the shifted version of the application doesn't usually have better performance than the original.

It's also unlikely to lead to long-term savings. This model is best suited to companies with a regular peak schedule and slow, predictable changes in the market.

Food delivery companies with their regular peaks on Monday, Saturday, and Sunday are a good example of the former.

Tax companies are a good example of the latter, since tax rules change on a yearly basis and new rules are released a year in advance, giving the companies plenty of time to prepare.

Lift and shift cloud migration involves copying, bit by bit, the workloads, tasks, and applications housed within an organization's virtual machines, and storing the replicated version in a cloud-based location. Because the data is simply a replication, no code is modified and no costly, time-consuming redesign is required during migration.

The method is certainly less complex than other migration techniques, IT teams and their cloud provider will want to be sure data sets are properly matched with handling systems in the new environment. Additionally, they need to ensure that all applications have the resources needed to operate effectively and efficiently.

Shift to SaaS: Save Time and Trouble:

Companies that want to stop allocating time and resources to applications outside their core business should think about shifting to SaaS.

Shifting to SaaS means outsourcing one or more applications to a cloud services company that specializes in managing those applications. Companies do this on an application by application basis and only shift the applications they need to.Static applications can remain on-premises.

Shifting to SaaS frees employees up to focus on core competencies and the things that make a business unique and competitive.

It's extremely important when shifting an application to SaaS that you pick the right service.

The main drawback of shifting to SaaS, while you can personalize it, is that customizing it can lead to problems.

Shifting to SaaS should only be used for routine functions – not for anything that needs to be unique.

Email is a good example of a routine business function that can be shifted to SaaS. For example, we worked with a manufacturing company that built engine components. The company was sick of managing its own email. While it needed to have email for all its employees, the customers didn't care what the email service looked like – so long as it worked. We helped them find a hosting service that freed the company of needing to worry about their email so it could focus on manufacturing.

Application Refactoring: App Modernization:

App modernization is a preferred approach for organizations that have specific applications which could benefit from the cloud.

With refactoring, organizations can copy their inheritance applications whole and unbroken onto a cloud platform.

What makes it low risk is that inheritance applications can run in parallel while new applications are constructed, with the immediate benefits of quickness and speed to market. This approach focuses on the applications that benefit the most from a cloud platform.

Refactoring is about prioritization; it provides lots of opportunities to save over time by minimizing spending on things you won't need once you're in the cloud.

You can save money on the platform itself as well by switching to cloud native services that cost less than the ones you use on-premises.

Refactoring is not just about cutting costs. It also allows you to make changes to your enterprise very quickly, which means that you can keep up with your customers.

Refactoring lets you respond faster and prioritize updates. One big box store we worked with started out with its applications so hard coded that it took months to do simple things like changing the font or background color. Refactoring got them moving.

Refactoring usually requires outside help. We worked with a company that wanted to refactor its entire application suite into modern technology. The project would have taken four years for the company working on their own, but we were able to cut that time down to eighteen months. We provided the company making the migration with its unique model for retraining.

When introducing the new technology, we rotate through everyone who needs training. Slowly, over time, we dial back how many consultants they have helping until the local IT people are able to handle everything on their own. This means that the IT staff learns by doing, so there is no awkward learning curve. At every point in the process, there is someone trained to handle difficulties on-site.

Replatforming: Develop Applications in the Cloud:

Replatforming is for companies looking to hold benefits of the cloud, enterprise-wide.

These companies want their core capabilities to be scalable, flexible, robust, redundant, and available.

This is the hardest option to implement, requires the most planning for the future, and comes with the most upfront cost, but it's the only option that lets you utilize the full strength and flexibility of the cloud.

Replatforming is replacing the application at the code level to make it cloud native. This is a complete reimagination of the application and usually requires a complete rewrite.

When considering replatforming, think about how fast your company can change. Then think about how fast it needs to change to keep up with customers and the market.

By making applications truly cloud native, they can be updated and those updates pushed out at the speed of the cloud. This boosts the speed to change across the board for all aspects of the business.

Replatformed applications can also be designed to be more modular and thus easier to maintain.

Refactoring the application can save development time, since modules of code from your first refactored application can be used to extend the capabilities of new applications.

Unlike refactored applications, refactored platforms can work across multiple cloud providers. This makes it easier to port from one mobile platform to another, which positions replatforming as the ideal strategy for those looking to develop mobile applications.

We worked with a healthcare company building a net-new mobile application for patient management, which included sending push notifications on appointments and subscriptions. The company wanted to build this application as a cloud-native company. However, they already had internal patient managing applications for the nurses and doctors that complemented the new applications. The company used replatforming to get their inheritance patient management application to the cloud, so the application would be ready and waiting while it developed its net-new mobile application.

Determine your goals before you select your cloud migration model:

Each of the four primary methods we identified comes with its share of advantages, but also with its disadvantages. Finding the method that matches your organizations goals and needs is the first step to a successful migration.

Cloud Service Provider

A cloud provider is a company that delivers cloud computing based services and solutions to businesses and/or individuals. This service organization may provide rented and provider-managed virtual hardware, software, infrastructure and other related services.

Amazon Web Services:

AWS is Amazon's cloud web hosting platform which offers fast, flexible, reliable and cost-effective solutions. It offers a service in the form of building block which can be used to create and deploy any kind of application in the cloud. It is the most popular as it was the first to enter the cloud computing space.

Cloudways:

Cloudways provides managed cloud hosting to agencies, stores, etc.

The platform has partnered with top cloud providers including AWS, Google Cloud, DigitalOcean,etc.

Experience the freedom to build, deploy and manage applications including PHP, WordPress, etc without requiring any knowledge of cloud server management.

Cloudways users can focus on business growth without worrying about the technical complexities of server management, security, and maintenance.

DigitalOcean:

Digitalocean's droplet is a scalable computer service. It is more than just virtual machines.

This cloud platform offers add-on storage, security, and monitoring capabilities to run production applications easily.

Rackspace"

Rackspace is another useful cloud computer service tool. It offers services like hosting web applications, cloud files, cloud backup, database, and cloud server, etc.

Alibaba Cloud:

Alibaba is the largest Chinese cloud computing company. It is a new platform which created a global footprint with over 1500 Nodes worldwide of 19 regions and 56 availability zones across more than 200 countries.

[A content delivery network (**CDN**) is a system of distributed servers (network) that deliver pages and other web content to a user, based on the geographic **locations** of the user, the origin of the webpage and the content delivery server. ... CDNs also provide protection from large flows in traffic.]

Microsoft Azure:

Azure is a cloud computing platform which is launched by Microsoft in February 2010. This open source and flexible cloud platform which helps in development, data storage, service management & hosting solutions.

Google Cloud Platform:

Google Cloud is a set of solution and products which includes GCP & G suite. It helps you to solve all kind of business challenges with ease.

Oracle Cloud:

Oracle Cloud offers innovative and integrated cloud services. It helps you to build, deploy, and manage workloads in the cloud or on premises. Oracle Cloud also helps companies to transform their business and reduce complexity.

IBM Cloud:

IBM cloud is a full stack cloud platform which spans public, private and hybrid environments. It is built with a robust suite of advanced and AI tools.

Roles and Responsibilities:

There is a important growth of cloud adoption across small as well as large enterprises. This has resulted in a large spectrum of cloud offerings including cloud delivery models and a variety of cloud computing services that are being provided by cloud hosting companies.

Improved accessibility and security:

Cloud adoption not only helps improve business processes and enhances the efficiency of IT infrastructures but also brings down costs of running, upgrading, and maintaining on-site IT facilities.

Your business-critical data is armed with added security in the cloud environment. In reality, the data is not actually being placed up in the cloud but is distributed to a number of remote data center facilities that are owned and operated by third-party service providers. These establishments consist of climate-controlled rooms to house enterprise-grade servers for seamless protection and easy accessibility for maintaining business continuity in spite of any tragic event that may impact the main office of your enterprise.

The cloud data centers are designed to house a multitude of servers for storing data under strict security controls. The arrangement is aimed at enabling uninterrupted connectivity among vast networks comprising of millions of machines. Cloud computing is controled by end users as well as cloud hosting companies for the enhancement of their services.

Understanding the cloud's role in businesses:

In order to understand the precise reasons for increased cloud adoption in enterprise setups, we should have in-depth knowledge about of cloud's attributes that boost business processes.

Cloud services are designed to set your IT staff free from boring(ordinary) and time-consuming tasks of maintaining, repairing, and upgrading hardware equipment such as servers. On-site IT infrastructure in enterprises will be thinner after moving workloads to cloud data center. In the majority of cases, there will be no need to allocate separate space for housing servers and other IT equipment.

The direct benefit of cloud computing is associated with reduced capital expenditure as companies need not invest funds in purchasing costly hardware equipment. improvement of hardware costs is also backed by freedom from maintenance and repair costs of web servers. There is a definite reduction in upfront costs of ownership of cost-intensive software as well as hardware.

Performance with a promise of security:

In comparison with a physical server, a cloud hosting delivers better performance. This is because established web hosting service providers are in a better position to afford enterprise-grade cloud servers as against small or medium-sized enterprises.

Cloud hosting providers attach great importance to the security of customers' digital assets by spending a significant amount of financial and manpower resources. These providers harden the defences by the implementation of strict measures such as firewalls, anti-malware and anti-virus deployments. In addition to this, the host data centers are armed with barrier-like security for safeguarding physical as well as networking assets.

Greater affordability:

By provisioning top of the line hardware and software resources to customers at affordable prices, cloud hosting service providers help business enterprises reduce their capital as well as operating costs without impacting performance.

Cloud services go all out by investing huge sums of money to offer world-class resources to customers at economical prices. Their efficient staffs are well equipped to look after the routine tasks as well as technical problems irrespective of the time of the day for all weekdays.

Demand-oriented resource provisioning:

Users of cloud services are allowed to access the optimum amount of resources in response to resource requirements. This not only assures guaranteed resource availability but also helps businesses achieve resource optimization for reduction of operating costs.

Cloud-based infrastructure also enables users to access a variety of resources such as applications or platforms via any internet enabled device, from any location. These services are always available on round the clock basis for improved efficiency of enterprises. Employees can use a number of devices including smart-phones, tablets, and laptops to get their hands on a huge number of files and folders without the need to make a trip to the office. Cloud-based solutions are inherently flexible and accessible and businesses can easily keep their employees well-connected with each other for greater efficiency.

Freedom from maintenance:

On-site IT infrastructures are resource intensive and need to be regularly upgraded and maintained. In contrast, cloud service providers shoulder the entire responsibility of looking after the performance of servers, bandwidth, network, and software applications. This also includes periodic upgrades and security patching of operating systems and other business-critical applications.

This kind of infrastructure management requires large teams of software professionals to be available for 24 hours a day for 365 days in a year. Majority of companies that adopt cloud are

driven by the need to have consistently available, flexible, secure, and well managed IT infrastructure in the absence of any on-premise facility.

These are some of the valuable benefits of cloud computing that signify the role of cloud service providers. Therefore, the future of faultless data management is secure in the hands of established cloud service providers.

Cloud Service Consumer

A cloud consumer represents a person or organization that maintains a business relationship with, and uses the service from a cloud provider.

A cloud consumer browses the service catalog from a cloud provider, requests the appropriate service, sets up service contracts with the cloud provider, and uses the service.

The main expectation of cloud service consumer is to have a reliable service.

To satisfy consumer's expectation several Data centres are established all over the world and each Data centre contain thousands of servers.

The idle servers and resources in data center wastes huge amount of energy.

An appealing customer experience is essential for consumer business. If you can't manage expectations for consumer fast enough, they too may go elsewhere.

1. Flexibility:

Change is the only constant in the digital economy. A hybrid cloud model gives you the flexibility to adjust and grow.

This flexibility allows you to go after the big opportunities knowing that the location of your company's data won't be an obstacle.

The value is in more than just cost and speed, though these remain key principle for the public cloud.

The hybrid model also enables you to realize new insights across your entire ecosystem and quickly move priorities and resources to meet opportunities.

2. Freedom to choose:

Never forget you have options. You need to be able to easily change where an application runs based on your business needs. Which cloud helps you realize the most value: public, private?

What if that changes? If you're locked in with a public vendor, for example, moving data without disturbance can be very costly and time-consuming.

Look for solutions that give you the freedom to choose, with easy application portability regardless of your architectural environment across any cloud.

Solutions like IBM WebSphere Application Server Version 9 are built to put clients in control, not cloud providers.

3. Cognitive insights:

We're living in the cognitive era, inseparable from cloud innovation.

Cognitive is the way to outthink the competition and make sense of information. What can your data do? Bring new customer experiences, new applications and even new business models, for starters.

IBM Cloud offers a host of accessible cognitive capabilities which you can build into your applications.

You can rapidly infuse apps with cognitive capabilities to gain operational insights and dazzle your customers. Use these cognitive capabilities to breathe new life into your existing investments and extend their value while still putting the customer first.

Service level agreements in Cloud computing

A **Service Level Agreement (SLA)** is the bond for performance negotiated between the cloud services provider and the client.

Earlier, in cloud computing all Service Level Agreements were negotiated between a client and the service consumer. Nowadays, with the initiation of large utility-like cloud computing providers, most Service Level Agreements are standardized until a client becomes a large consumer of cloud services.

Service level agreements are also defined at **different levels** which are mentioned below:

- Customer-based SLA
- Service-based SLA
- Multilevel SLA

Few Service Level Agreements are enforceable as contracts, but mostly are agreements or contracts which are more along the lines of an Operating Level Agreement (OLA) and may not have the restriction of law.

It is fine to have an advocate review the documents before making a major agreement to the cloud service provider.

Service Level Agreements usually specify **some parameters** which are mentioned below:

1. Availability of the Service
2. Latency or the response time
3. Service components reliability
4. Each party accountability
5. Warranties

In any case, if a cloud service provider fails to meet the stated targets of minimums then the provider has to pay the penalty to the cloud service consumer as per the agreement. So, Service Level Agreements are like insurance policies in which the corporation has to pay as per the agreements if any casualty occurs.

Microsoft publishes the Service Level Agreements linked with the Windows Azure Platform components, which is demonstrative of industry practice for cloud service vendors.

Each individual component has its own Service Level Agreements.

Below are two **major Service Level Agreements (SLA)** described:

1. **Windows Azure SLA –**

   Window Azure has different SLA's for compute and storage. For compute, there is a guarantee that when a client deploys two or more role instances in separate fault and upgrade domains, client's internet facing roles will have external connectivity minimum 99.95% of the time. Moreover, all of the role instances of the client are monitored and there is guarantee of detection 99.9% of the time when a role instance's process is not runs and initiates properly.
2. **SQL Azure SLA –**

   SQL Azure clients will have connectivity between the database and internet gateway of SQL Azure. SQL Azure will handle a "Monthly Availability" of 99.9% within a month. Monthly Availability Proportion for a particular tenant database is the ratio of the time the database was available to customers to the total time in a month. Time is measured in some intervals of minutes in a 30-day monthly cycle. Availability is always remunerated for a complete month. A portion of time is marked as unavailable if the customer's attempts to connect to a database are denied by the SQL Azure gateway.

Service Level Agreements are based on the usage model. Frequently, cloud providers charge their pay-as-per-use resources at a premium and deploy standards Service Level Agreements only for that purpose.

Clients can also subscribe at different levels that guarantees access to a particular amount of purchased resources.

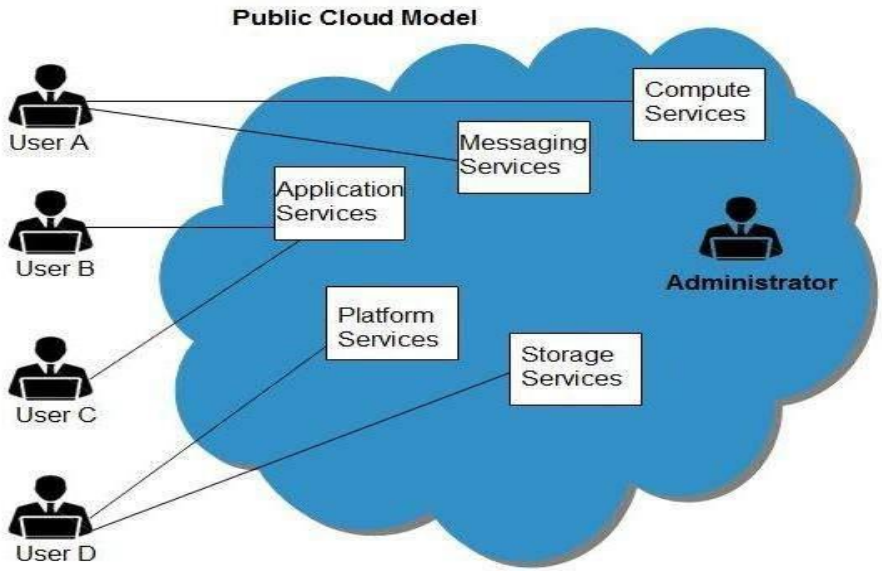
The Service Level Agreements (SLAs) attached to a subscription many times offer various terms and conditions. If client requires access to a particular level of resources, then the client need to subscribe to a service.

Types of Cloud

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.



Benefits:

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

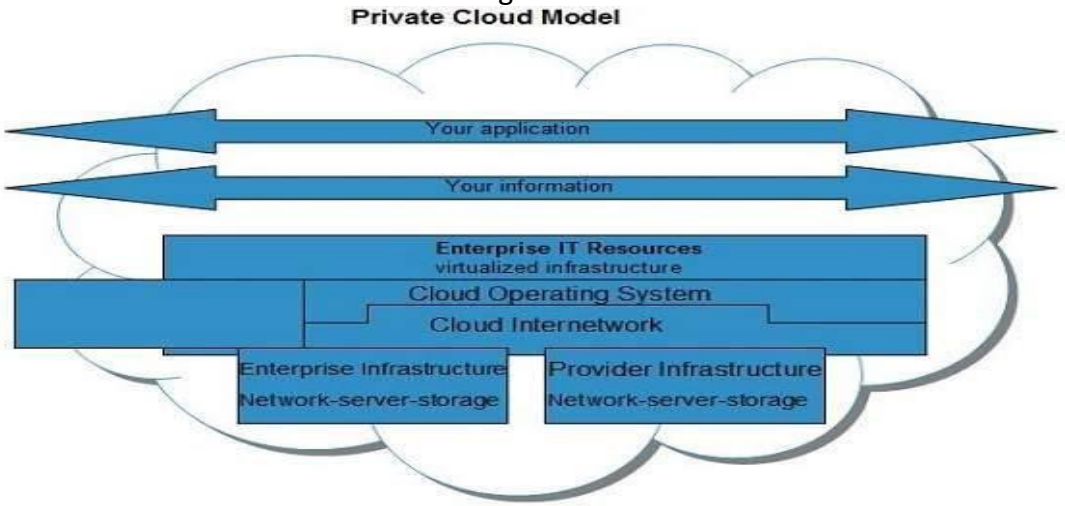
It is comparatively less customizable than private cloud.

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 some 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.

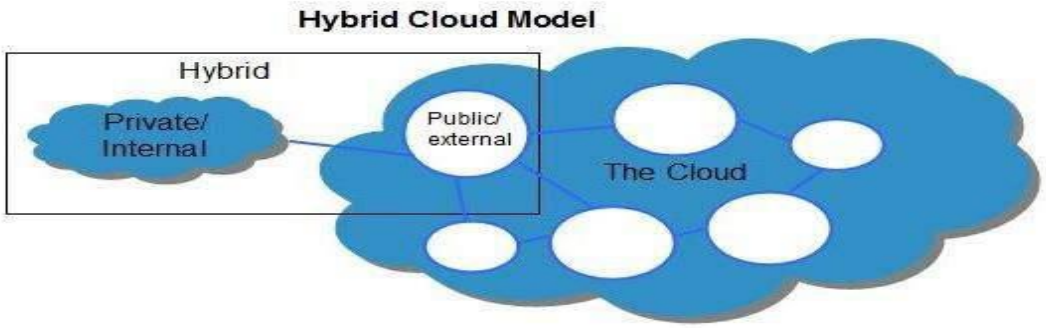
Additional Skills

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.



Benefits:

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.

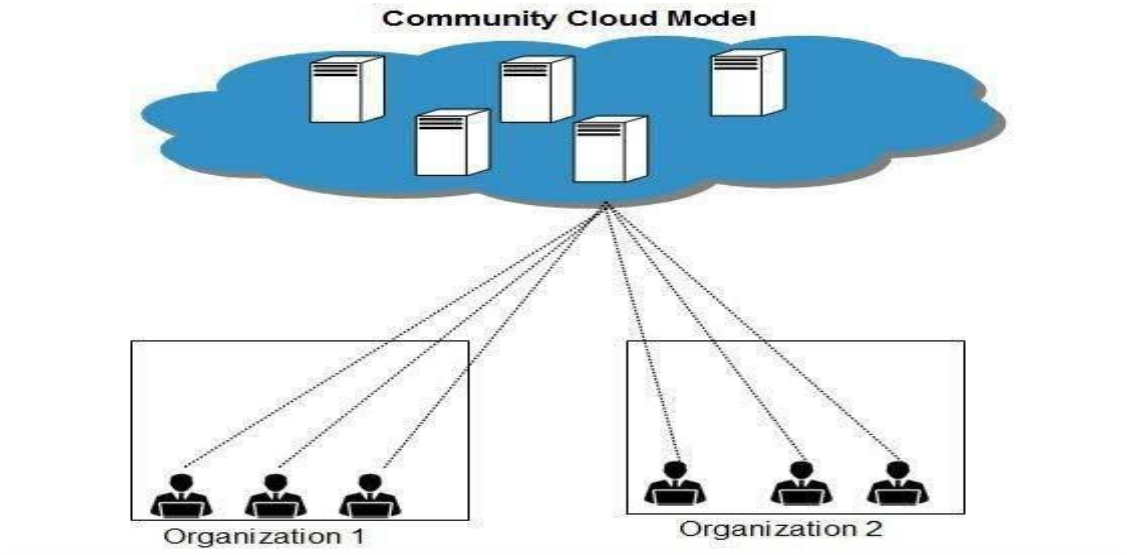
Infrastructure Dependency

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.



Benefits:

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 architecture

Cloud computing architecture refers to the components and subcomponents required for cloud computing. These components typically consist of a front end platform (fat client, thin client, mobile device), back end platforms (servers, storage), a cloud based delivery, and a network (Internet, Intranet, Intercloud).

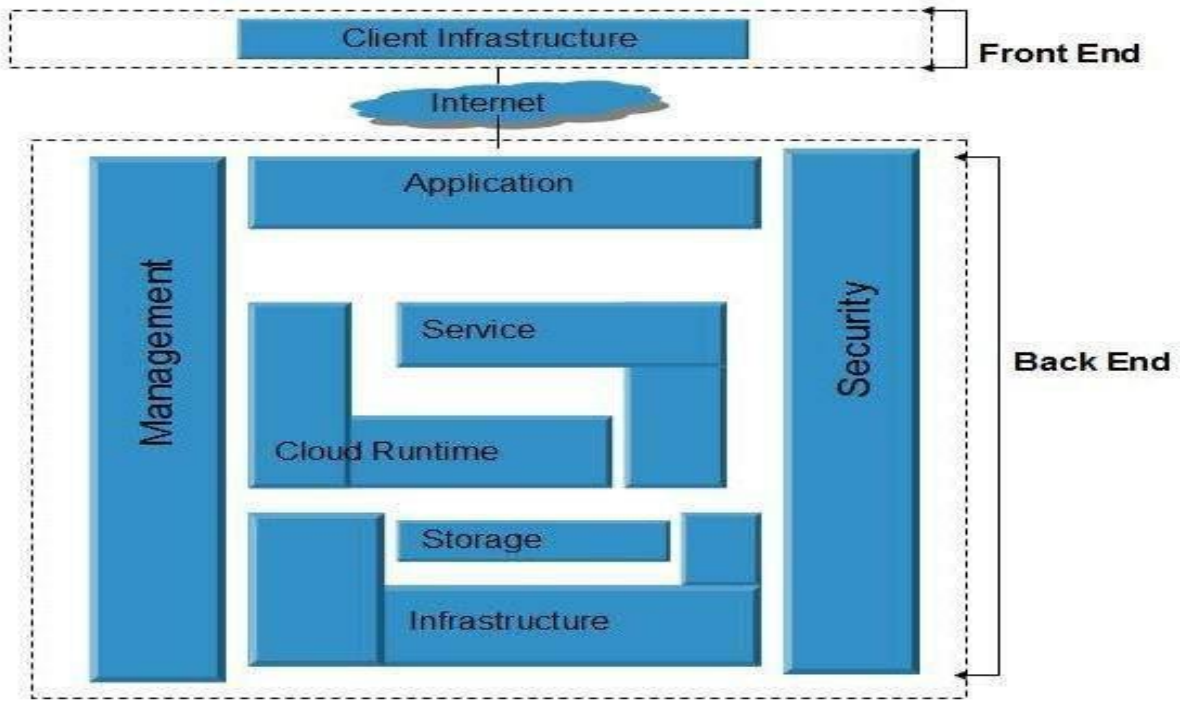
[A **fat client** (also called heavy, **rich** or **thick client**) is a computer (**clients**), in **client**–server architecture or networks, that typically provides **rich** functionality independent of the central server. It is Originally known as just a "client" or "thick client," the name is contrasted to thin client, which describes a computer heavily dependent on a server's applications.]

Cloud Computing architecture comprises of many cloud components, which are loosely coupled. We can broadly divide the cloud architecture into two parts:

- Front End
- Back End

Each of the ends is connected through a network, usually Internet.

The following diagram shows the graphical view of cloud computing architecture:



Front End:

The front end refers to the client part of cloud computing system. It consists of interfaces and applications that are required to access the cloud computing platforms, Example - Web Browser.

Back End:

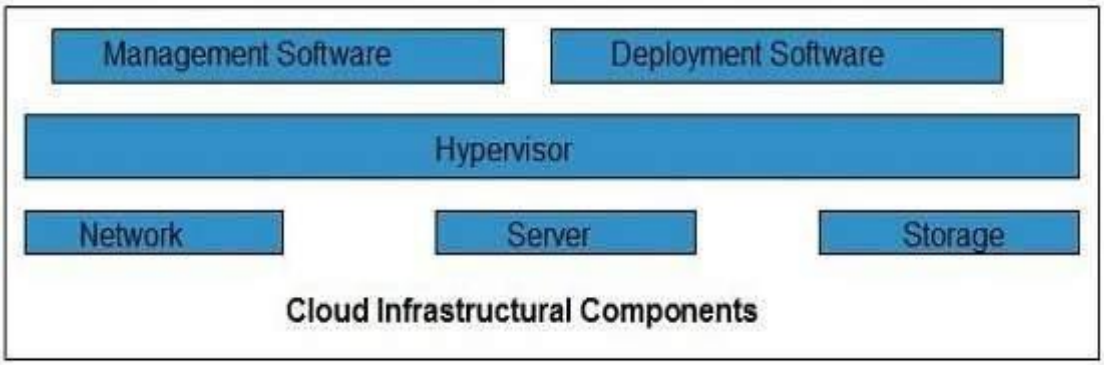
The back End refers to the cloud itself. It consists of all the resources required to provide cloud computing services. It comprises of huge data storage, virtual machines, security mechanism, services, deployment models, servers, etc.

Note:

- It is the responsibility of the back end to provide built-in security mechanism, traffic control and protocols.
- The server employs certain protocols known as middleware, which help the connected devices to communicate with each other.

Cloud Computing Infrastructure

Cloud infrastructure consists of servers, storage devices, network, cloud management software, deployment software, and platform virtualization.



Hypervisor:

Hypervisor is a firmware or low-level program that acts as a Virtual Machine Manager. It allows to share the single physical instance of cloud resources between several occupants.

Management Software:

It helps to maintain and configure the infrastructure.

Deployment Software:

It helps to deploy and integrate the application on the cloud.

Network:

It is the key component of cloud infrastructure. It allows to connect cloud services over the Internet. It is also possible to deliver network as a utility over the Internet, which means, the customer can customize the network route and protocol.

Server:

The **server** helps to compute the resource sharing and offers other services such as resource allocation and de-allocation, monitoring the resources, providing security etc.

Storage:

Cloud keeps multiple replicas of storage. If one of the storage resources fails, then it can be extracted from another one, which makes cloud computing more reliable.

Infrastructural Constraints

Fundamental constraints that cloud infrastructure should implement are shown in the following diagram:

Transparency:

Virtualization is the key to share resources in cloud environment. But it is not possible to satisfy the demand with single resource or server. Therefore, there must be transparency in resources, load balancing and application, so that we can scale them on demand.

Scalability:

Scaling up an application delivery solution is not that easy as scaling up an application because it involves configuration overhead or even re-architecting the network. So, application delivery solution is need to be scalable which will require the virtual infrastructure such that resource can be provisioned and de-provisioned easily.

Intelligent Monitoring:

To achieve transparency and scalability, application solution delivery will need to be capable of intelligent monitoring.

Security:

The mega data center in the cloud should be securely architected. Also the control node, an entry point in mega data center, also needs to be secure.

Virtualization

Virtualization in Cloud Computing is a process in which the user of cloud shares the data present in the cloud which can be application software etc. It provides a virtual environment in the cloud which can be software hardware or any other thing.

Virtualization is a technique how to separate a service from the underlying physical delivery of that service. It is the process of creating a virtual version of something like computer hardware.

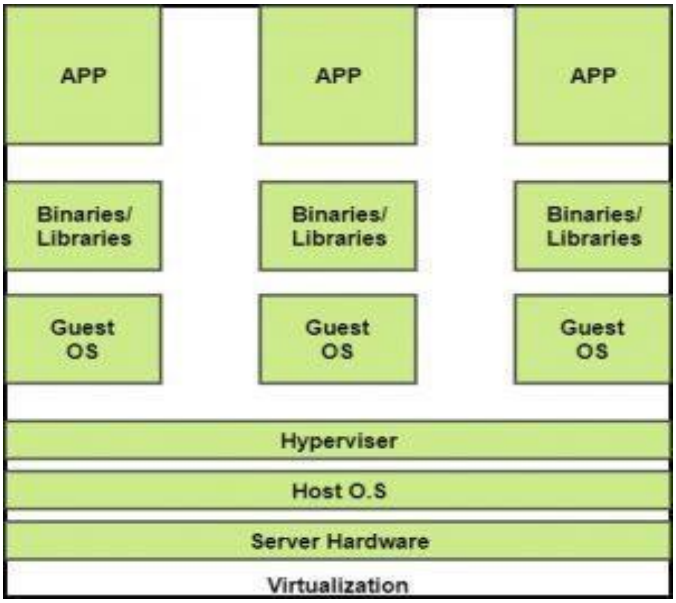
It involves using specialized software to create a virtual or software-created version of a computing resource rather than the actual version of the same resource.

With the help of Virtualization multiple operating systems and applications can run on same Machine and its same hardware at the same time increasing the utilization and flexibility of hardware.

In other words, One of the main cost effective, hardware reducing, energy saving techniques used by cloud providers is virtualization.

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

The term virtualization is often synonymous with hardware virtualization, which plays a fundamental role in efficiently delivering Infrastructure-as-a-Service (IaaS) solutions for cloud computing. Moreover, virtualization technologies provide a virtual environment for not only executing applications but also for storage, memory, and networking.



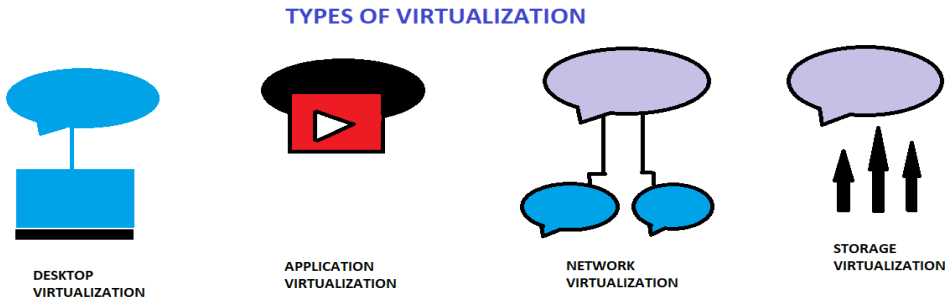
The machine on which the virtual machine is going to be build is known as Host Machine and that virtual machine is referred as a Guest Machine.

BENEFITS OF VIRTUALIZATION:

1. More flexible and efficient allocation of resources.
2. Enhance development productivity.
3. It lowers the cost of IT infrastructure.
4. Remote access and rapid scalibility.
5. High availability and disaster recovery.
6. Pay per use of the IT infrastructure on demand.
7. Enables running multiple operating system.

Types of Virtualization:

1. Application Virtualization.
2. Network Virtualization.
3. Desktop Virtualization.
4. Storage Virtualization.



1. Application Virtualization:

Application virtualization helps user to have a remote access of an application from a server. The server stores all personal information and other characteristics of the application, but can still run on a local workstation through internet. Example of this would be a user who needs to run two different versions of the same software. Technologies that use application virtualization are hosted applications and packaged applications.

2. Network Virtualization:

Network virtualization, provides a facility to create and provision virtual networks—logical switches, routers, firewalls, Virtual Private Network (VPN), and workload security within days or even in weeks.

3. Desktop Virtualization:

Desktop virtualization allows the users' OS to be remotely stored on a server in the data center. It allows the user to access their desktop virtually, from any location by different machine. Users who wants specific operating systems other than Windows Server will need to have a virtual desktop. Main benefits of desktop virtualization are user mobility, portability, easy management of software installation, updates and patches.

4. Storage Virtualization:

Storage virtualization is an array of servers that are managed by a virtual storage system. The servers aren't aware of exactly where their data is stored. It makes managing storage from multiple sources to be managed and utilized as a single repository. storage virtualization software maintains smooth operations, consistent performance and a continuous suite of advanced functions despite changes, break down and differences in the underlying equipment.

Hypervisor

Hypervisor is a form of virtualization software used in Cloud hosting to divide and allocate the resources on various pieces of hardware.

The program which provide partitioning, isolation or abstraction is called virtualization hypervisor.

Hypervisor is a hardware virtualization technique that allows multiple guest operating systems (OS) to run on a single host system at the same time.

A hypervisor is sometimes also called a virtual machine manager(VMM).

Types of Hypervisor:-

TYPE-1 Hypervisor:

Hypervisor runs directly on underlying host system. It is also known as "Native Hypervisor" or "Bare metal hypervisor". It dose not require any base server operating system. It has direct access to hardware resources.

TYPE-2 Hypervisor:

A Host operating system runs on undrlying host system. It is also known as 'Hosted Hypervisor".

Basically a software installed on an operating system. Hypervisor asks operating system to make hardware calls. Hosted hypervisors are often found on endpoints like PCs.

Choosing the right hypervisor:

Type 1 hypervisors offer much better performance than Type 2 because there's no middle layer, making them the logical choice for mission-critical applications and workloads.

But that's not to say that hosted hypervisors don't have their place – they're much simpler to set up, so they're a good.

One of the best ways to determine which hypervisor meets your needs is to compare their performance metrics. These include CPU overhead, amount of maximum host and guest memory, and support for virtual processors.

The following factors should be examined before choosing a suitable hypervisor:

1. Understand your needs: The company and its applications are the reason for the data centre (and your job). Besides your company's needs, you (and your co-workers in IT) also have your own needs.

Needs for a virtualization hypervisor are:

a. Flexibility
b. Scalability
c. Usability
d. Availability
e. Reliability
f. Efficiency
g. Reliable support

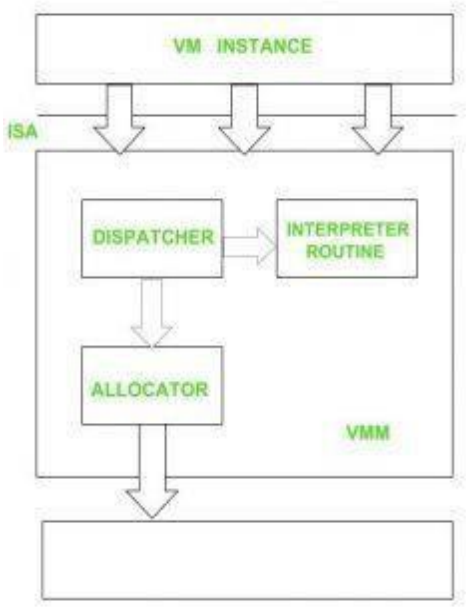
2. The cost of a hypervisor: For many buyers, the toughest part of choosing a hypervisor is striking the right balance between cost and functionality. While a number of entry-level solutions are free, or practically free, the prices at the opposite end of the market can be overwhelming. Licensing frameworks also vary, so it's important to be aware of exactly what you're getting for your money.

3. Virtual machine performance: Virtual systems should meet or exceed the performance of their physical counterparts, at least in relation to the applications within each server. Everything beyond meeting this benchmark is profit.

4. Ecosystem: It's tempting to overlook the role of a hypervisor's ecosystem – that is, the availability of documentation, support, training, third-party developers and consultancies, and so on – in determining whether or not a solution is cost-effective in the long term.

5. Test for yourself: You can gain basic experience from your existing desktop or laptop. You can run both Hypervisor to create a nice virtual learning and testing environment.

HYPERVISOR REFERENCE MODEL



There are 3 main modules coordinate in order to follow the fundamental hardware:

1. Dispatcher
2. Allocator
3. Interpreter

DISPATCHER:
The dispatcher behaves like the entry point of the monitor and reroutes the instructions of the virtual machine instance to one of the other two modules.

ALLOCATOR:
The allocator is responsible for deciding the system resources to be provided to the virtual machine instance. It means whenever virtual machine tries to execute an instruction that results in changing the machine resources associated with the virtual machine, the allocator is invoked by the dispatcher.

INTERPRETER:
The interpreter module consists of interpreter routines. These are executed, whenever virtual machine executes a privileged instruction.

CPU Virtualization

Virtualization of the hardware is known as CPU Virtualization. This is where any hardware platform that can be controlled by the user or a guest software over a virtual machine on a platform, virtually. This is not limited to guest software but also several operating systems.

A VM is a duplicate of an existing computer system in which a majority of the VM instructions are executed on the host processor in native mode. Thus, unprivileged instructions of VMs run directly on the host machine for higher efficiency. Other critical instructions should be handled carefully for correctness and stability.

The critical instructions are divided into three categories: privileged instructions, control-sensitive instructions, and behavior-sensitive instructions.

Privileged instructions execute in a privileged mode and will be attentive if executed outside this mode. Control-sensitive instructions attempt to change the configuration of resources used. Behavior-sensitive instructions have different behaviors depending on the configuration of resources, including the load and store operations over the virtual memory.

Memory Virtualization

Virtual memory virtualization is similar to the virtual memory support provided by modern operating systems.

In a traditional execution environment, the operating system maintains mappings of virtual memory to machine memory using page tables, which is a one-stage mapping from virtual memory to machine memory.

All modern x86 CPUs include a memory management unit (MMU) and a translation look aside buffer (TLB) to optimize virtual memory performance. However, in a virtual execution environment, virtual memory virtualization involves sharing the physical system memory in RAM and dynamically allocating it to the physical memory of the VMs.

That means a two-stage mapping process should be maintained by the guest OS and the VMM, respectively: virtual memory to physical memory and physical memory to machine memory.

Furthermore, MMU virtualization should be supported, which is transparent to the guest OS. The guest OS continues to control the mapping of virtual addresses to the physical memory addresses of VMs. But the guest OS cannot directly access the actual machine memory.

The VMM is responsible for mapping the guest physical memory to the actual machine memory.

Since each page table of the guest OS has a separate page table in the VMM corresponding to it, the VMM page table is called the shadow page table.

Nested page tables add another layer of indirection to virtual memory. The MMU already handles virtual-to-physical translations as defined by the OS. Then the physical memory addresses are translated to machine addresses using another set of page tables defined by the hypervisor.

Since modern operating systems maintain a set of page tables for every process, the shadow page tables will get flooded. Consequently, the performance overhead and cost of memory will be very high.

When the guest OS changes the virtual memory to a physical memory mapping, the VMM updates the shadow page tables to enable a direct lookup.

I/O Virtualization

I/O virtualization involves managing the routing of I/O requests between virtual devices and the shared physical hardware.

There are three ways to implement I/O virtualization: full device emulation, para-virtualization, and direct I/O.

Full device emulation is the first approach for I/O virtualization. Generally, this approach emulates well-known, real-world devices.

All the functions of a device or bus infrastructure, such as device enumeration, identification, interrupts, are replicated in software. This software is located in the VMM and acts as a virtual device.

The I/O access requests of the guest OS are trapped in the VMM which interacts with the I/O devices.

A single hardware device can be shared by multiple VMs that run concurrently. However, software emulation runs much slower than the hardware.

The para-virtualization method of I/O virtualization is typically used in Xen. [Xen Project is a type-1 hypervisor, providing services that allow multiple computer operating systems to execute on the same computer hardware concurrently.]

It is also known as the split driver model consisting of a front end driver and a backend driver. The frontend driver is running in Domain U and the backend driver is running in Domain 0. They interact with each other via a block of shared memory.

The frontend driver manages the I/O requests of the guest OS and the backend driver is responsible for managing the real I/O devices and multiplexing the I/O data of different VMs.
Although para-I/O-virtualization achieves better device performance than full device emulation, it comes with a higher CPU overhead.

Direct I/O virtualization lets the VM access devices directly. It can achieve close-to-native performance without high CPU costs. However, current direct I/O virtualization implementations focus on networking for mainframes.

There are a lot of challenges for commodity hardware devices. For example, when a physical device is reclaimed (required by workload migration) for later reassignment, it may have been set to an arbitrary state that can function incorrectly or even crash the whole system.

Since software-based I/O virtualization requires a very high overhead of device emulation, hardware-assisted I/O virtualization is critical.

VIRTUAL CLUSTERS AND RESOURCE MANAGEMENT

A physical cluster is a collection of servers (physical machines) interconnected by a physical network such as a LAN.

When a traditional VM is initialized, the administrator needs to manually write configuration information or specify the configuration sources. When more VMs join a network, an inefficient configuration always causes problems with overloading or underutilization.

Amazon's Elastic Compute Cloud (EC2) is a good example of a web service that provides elastic computing power in a cloud. EC2 permits customers to create VMs and to manage user accounts over the time of their use.

Most virtualization platforms, including XenServer and VMware ESX Server, support a bridging mode which allows all domains to appear on the network as individual hosts. By using this mode, VMs can communicate with one another freely through the virtual network interface card and configure the network automatically.

Physical versus Virtual Clusters:-

Virtual clusters are built with VMs installed at distributed servers from one or more physical clusters.

The VMs in a virtual cluster are interconnected logically by a virtual network across several physical networks.

Each virtual cluster is formed with physical machines or a VM hosted by multiple physical clusters. The virtual cluster boundaries are shown as distinct boundaries.

The provisioning of VMs to a virtual cluster is done dynamically to have the following interesting properties:

- The virtual cluster nodes can be either physical or virtual machines. Multiple VMs running with different OS can be deployed on the same physical node.
- A VM runs with a guest OS, which is often different from the host OS, that manages the resources in the physical machine, where the VM is implemented.
- The purpose of using VMs is to consolidate multiple functionalities on the same server. This will greatly enhance server utilization and application flexibility.

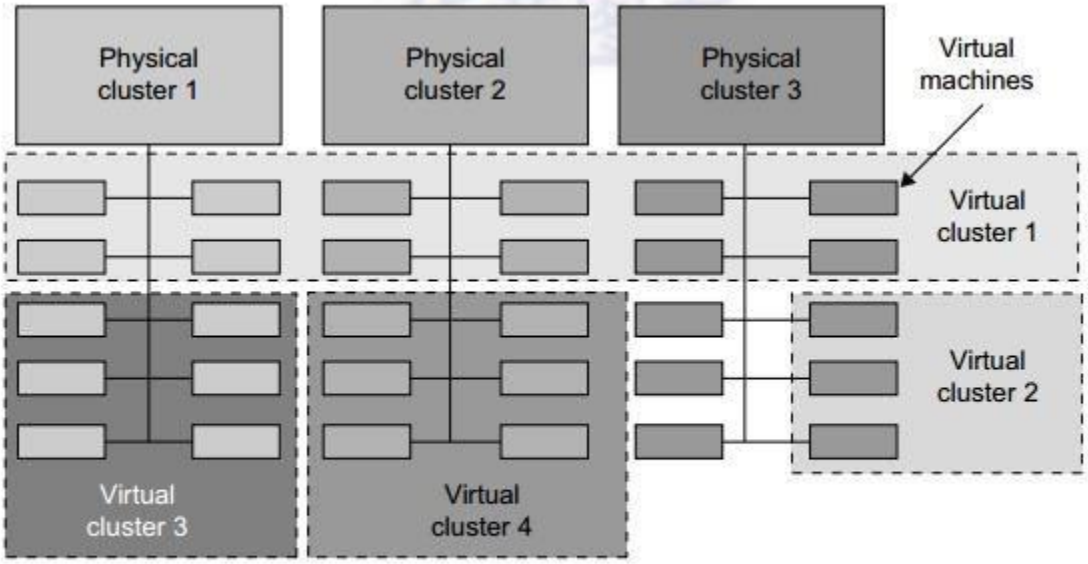


FIGURE 3.18

A cloud platform with four virtual clusters over three physical clusters shaded differently.

- VMs can be colonized (replicated) in multiple servers for the purpose of promoting distributed parallelism, fault tolerance, and disaster recovery.

- The size (number of nodes) of a virtual cluster can grow or shrink dynamically, similar to the way an overlay network varies in size in a peer-to-peer (P2P) network.

- The failure of any physical nodes may disable some VMs installed on the failing nodes. But the failure of VMs will not pull down the host system.

Fast Deployment and Effective Scheduling:

The system should have the capability of fast deployment. Here, deployment means two things: to construct and distribute software stacks (OS, libraries, applications) to a physical node inside clusters as fast as possible, and to quickly switch runtime environments from one user's virtual cluster to another user's virtual cluster.

If one user finishes using his system, the corresponding virtual cluster should shut down or suspend quickly to save the resources to run other VMs for other users.

The concept of "green computing" has attracted much attention recently. However, previous approaches have focused on saving the energy cost of components in a single workstation without a global vision. Consequently, they do not necessarily reduce the power consumption of the whole cluster.

The live migration of VMs allows workloads of one node to transfer to another node. However, it does not guarantee that VMs can randomly migrate among themselves. In fact, the probable overhead caused by live migrations of VMs cannot be ignored.

The overhead may have serious negative effects on cluster utilization and throughput issues. Therefore, the challenge is to determine how to design migration strategies to implement green computing without influencing the performance of clusters.

Another advantage of virtualization is load balancing of applications in a virtual cluster. Load balancing can be achieved using the load index and frequency of user logins. The automatic scale-up and scale-down mechanism of a virtual cluster can be implemented based on this model. Consequently, we can increase the resource utilization of nodes and shorten the response time of systems.

Mapping VMs onto the most appropriate physical node should promote performance. Dynamically adjusting loads among nodes by live migration of VMs is desired, when the loads on cluster nodes become quite unbalanced.

High-Performance Virtual Storage:

The template VM can be distributed to several physical hosts in the cluster to customize the VMs. In addition, existing software packages reduce the time for customization as well as switching virtual environments.

It is important to efficiently manage the disk spaces occupied by template software packages. Some storage architecture design can be applied to reduce duplicated blocks in a distributed file system of virtual clusters.

Basically, there are four steps to deploy a group of VMs onto a target cluster: preparing the disk image, configuring the VMs, choosing the destination nodes, and executing the VM deployment command on every host.

Many systems use templates to simplify the disk image preparation process. A template is a disk image that includes a preinstalled operating system with or without certain application software.

Users choose a proper template according to their requirements and make a duplicate of it as their own disk image. Templates could implement the COW (Copy on Write) format. A new COW backup file is very small and easy to create and transfer. Therefore, it definitely

reduces disk space consumption. In addition, VM deployment time is much shorter than that of copying the whole raw image file.
Every VM is configured with a name, disk image, network setting, and allocated CPU and memory. One needs to record each VM configuration into a file. However, this method is inefficient when managing a large group of VMs.

Live VM Migration Steps and Performance Effects:-

In a cluster built with mixed nodes of host and guest systems, the normal method of operation is to run everything on the physical machine. When a VM fails, its role could be replaced by another VM on a different node, as long as they both run with the same guest OS.

In other words, a physical node can fail over to a VM on another host. This is different from physical-to-physical failover in a traditional physical cluster. The advantage is enhanced failover flexibility.

The potential drawback is that a VM must stop playing its role if its residing host node fails. However, this problem can be mitigated with VM life migration. The migration copies the VM state file from the storage area to the host machine.

There are four ways to manage a virtual cluster:

First, you can use a guest-based manager, by which the cluster manager resides on a guest system. In this case, multiple VMs form a virtual cluster. For example, openMosix is an open source Linux cluster running different guest systems on top of the Xen hypervisor. Another example is Sun's cluster Oasis, an experimental Solaris cluster of VMs supported by a VMware VMM.

Second, you can build a cluster manager on the host systems. The host-based manager supervises the guest systems and can restart the guest system on another physical machine. A good example is the VMware HA system that can restart a guest system after failure. These two cluster management systems are either guest-only or host-only, but they do not mix.

A **third way** to manage a virtual cluster is to use an independent cluster manager on both the host and guest systems. This will make infrastructure management more complex, however.

Finally, you can use an integrated cluster on the guest and host systems. This means the manager must be designed to distinguish between virtualized resources and physical resources. Various cluster management schemes can be greatly enhanced when VM life migration is enabled with minimal overhead.

VMs can be live-migrated from one physical machine to another; in case of failure, one VM can be replaced by another VM. Virtual clusters can be applied in computational grids, cloud platforms, and high-performance computing (HPC) systems.

The major attraction of this scenario is that virtual clustering provides dynamic resources that can be quickly put together upon user demand or after a node failure. In particular, virtual clustering plays a key role in cloud computing.

When a VM runs a live service, it is necessary to make an exchange to ensure that the migration occurs in a manner that minimizes all three metrics.

Furthermore, we should ensure that the migration will not disrupt other active services residing in the same host through resource contention (e.g., CPU, network bandwidth).

A VM can be in one of the following four states:

An **inactive state** is defined by the virtualization platform, under which the VM is not enabled.

An **active state** refers to a VM that has been instantiated at the virtualization platform to perform a real task.

A **paused state** corresponds to a VM that has been instantiated but disabled to process a task or paused in a waiting state.

A VM enters the **suspended state** if its machine file and virtual resources are stored back to the disk.

Llive migration of a VM consists of the following six steps:

Steps 0 and 1: Start migration.

This step makes preparations for the migration, including determining the migrating VM and the destination host. Although users could manually make a VM migrate to an appointed host, in most circumstances, the migration is automatically started by strategies such as load balancing and server consolidation.

Steps 2: Transfer memory.

Since the whole execution state of the VM is stored in memory, sending the VM's memory to the destination node ensures continuity of the service provided by the VM. All of the memory data is transferred in the first round, and then the migration controller recopies the memory data which is changed in the last round. These steps keep iterating until the dirty portion of the memory is small enough to handle the final copy.

Step 3: Suspend the VM and copy the last portion of the data.

The migrating VM's execution is suspended when the last round's memory data is transferred. Other non memory data such as CPU and network states should be sent as well. During this step, the VM is stopped and its applications will no longer run. This "service unavailable" time is called the "downtime" of migration, which should be as short as possible so that it can be negligible to users.

Steps 4 and 5: Commit and activate the new host.

After all the needed data is copied, on the destination host, the VM reloads the states and recovers the execution of programs in it, and the service provided by this VM continues. Then the network connection is redirected to the new VM and the dependency to the source host is cleared. The whole migration process finishes by removing the original VM from the source host.

Migration of Memory, Files, and Network Resources:-

Since clusters have a high initial cost of ownership, including space, power conditioning, and cooling equipment, leasing or sharing access to a common cluster is an attractive solution when demands vary over time.

Shared clusters offer economies of scale and more effective utilization of resources by multiplexing. When one system migrates to another physical node, we should consider the following issues.

Memory Migration:

This is one of the most important aspects of VM migration. Moving the memory instance of a VM from one physical host to another can be approached in any number of ways. But traditionally, the concepts behind the techniques tend to share common implementation paradigms. The techniques employed for this purpose depend upon the characteristics of application/workloads supported by the guest OS.

Memory migration can be in a range of hundreds of megabytes to a few gigabytes in a typical system today, and it needs to be done in an efficient manner.

File System Migration:

To support VM migration, a system must provide each VM with a consistent, location-independent view of the file system that is available on all hosts. A simple way to achieve this is to provide each VM with its own virtual disk which the file system is mapped to and transport the contents of this virtual disk along with the other states of the VM. However, due to the current trend of high-capacity disks, migration of the contents of an entire disk over a network is not a viable solution.

Another way is to have a global file system across all machines where a VM could be located. This way removes the need to copy files from one machine to another because all files are network-accessible.

The relevant VM files are explicitly copied into the local file system for a resume operation and taken out of the local file system for a suspend operation. This approach relieves developers from the complexities of implementing several different file system calls for different distributed file systems.

Network Migration:

A migrating VM should maintain all open network connections without relying on forwarding mechanisms on the original host or on support from mobility or redirection mechanisms.

To enable remote systems to locate and communicate with a VM, each VM must be assigned a virtual IP address known to other entities. This address can be distinct from the IP address of the host machine where the VM is currently located.

Each VM can also have its own distinct virtual MAC address. The VMM maintains a mapping of the virtual IP and MAC addresses to their corresponding VMs.

In general, a migrating VM includes all the protocol states and carries its IP address with it.

Live migration means moving a VM from one physical node to another while keeping its OS environment and applications unbroken. This capability is being increasingly utilized in today's enter-prise environments to provide efficient online system maintenance, reconfiguration, load balancing, and proactive fault tolerance.

It provides desirable features to satisfy requirements for computing resources in modern computing systems, including server consolidation, performance isolation, and ease of management.

Live migration is a key feature of system virtualization technologies. Only memory and CPU status needs to be transferred from the source node to the target node.

Infrastructure as a Service (IaaS)

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

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

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

IaaS is offered in three models: public, private, and hybrid cloud:

The private cloud implies that the infrastructure resides at the customer-premise.

In the case of public cloud, it is located at the cloud computing platform vendor's data center.

The hybrid cloud is a combination of the two in which the customer selects the best of both public cloud or private cloud.

IaaS provider provides the following services -

Compute: Computing as a Service includes virtual central processing units and virtual main memory for the Vms that is provisioned to the end- users.
Storage: IaaS provider provides back-end storage for storing files.
Network: Network as a Service (NaaS) provides networking components such as routers, switches, and bridges for the Vms.
Load balancers: It provides load balancing capability at the infrastructure layer.

Advantages of IaaS cloud computing layer:

There are the following advantages of IaaS computing layer -

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 of IaaS cloud computing layer:

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.

Some important point about IaaS cloud computing layer:

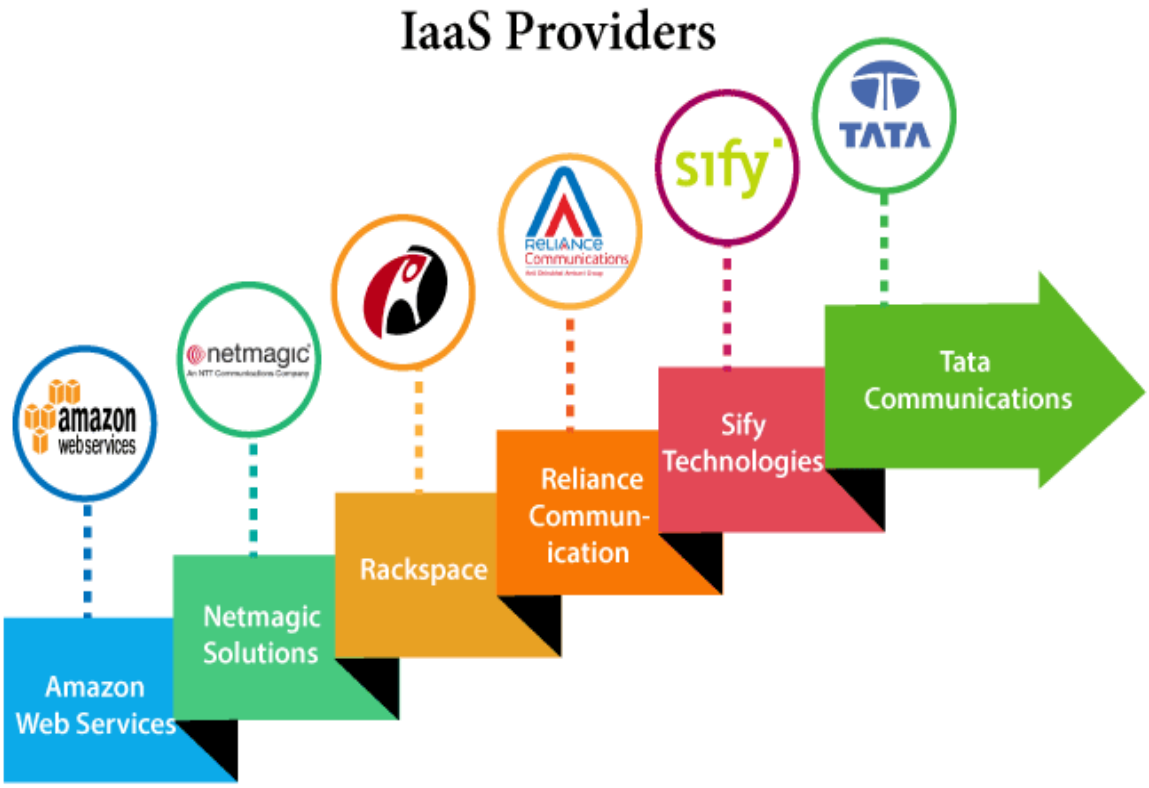
IaaS cloud computing platform cannot replace the traditional hosting method, but it provides more than that, and each resource which are used are predictable as per the usage.

IaaS cloud computing platform may not eliminate the need for an in-house IT department. It will be needed to monitor or control the IaaS setup. IT salary expenditure might not reduce significantly, but other IT expenses can be reduced.

Breakdowns at the IaaS cloud computing platform vendor's can bring your business to the halt stage. Assess the IaaS cloud computing platform vendor's stability and finances. Make sure that SLAs (i.e., Service Level Agreement) provide backups for data, hardware, network, and application failures. Image portability and third-party support is a plus point.

The IaaS cloud computing platform vendor can get access to your sensitive data. So, engage with credible companies or organizations. Study their security policies and precautions.

Top Iaas Providers who are providing IaaS cloud computing platform:



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, Azure.

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

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, Perl, etc.

Application frameworks:

PaaS providers provide application frameworks to easily understand the application development. Some popular application frameworks provided by PaaS providers are Node.js, Joomla, WordPress, Spring, etc.

Databases:

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

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 -

Simplified Development:

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

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.

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.

Instant community:

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

Scalability:

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

Disadvantages of PaaS cloud computing layer:

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.

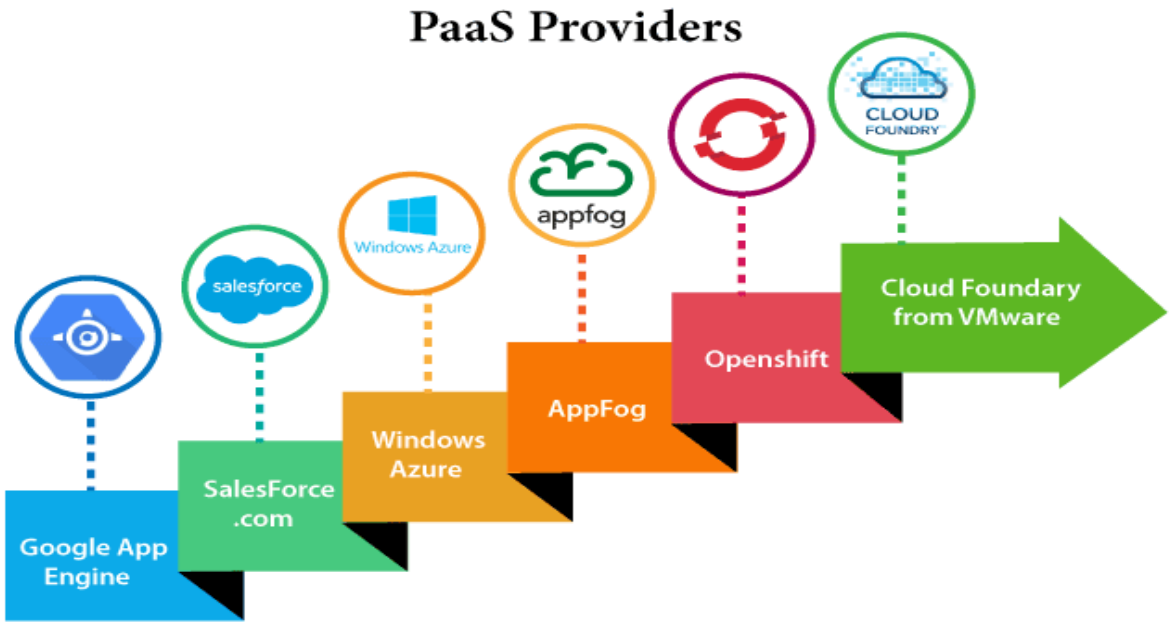
Data Privacy:

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.

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:



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

Providers	Services
Google App Engine (GAE)	App Identity, URL Fetch, Cloud storage client library, Logservice
Salesforce.com	Faster implementation, Rapid scalability, CRM Services, Sales cloud, Mobile connectivity, Chatter.
Windows Azure	Compute, security, IoT, Data Storage.
AppFog	Justcloud.com, SkyDrive, GoogleDocs
Openshift	RedHat, Microsoft Azure.
Cloud Foundry from VMware	Data, Messaging, and other services.

Software as a Service (SaaS)

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

There are 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.

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:

SaaS is easy to buy:

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

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

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.

Less hardware required for SaaS:

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

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. SaaS vendors are pricing their applications based on some usage parameters, such as a number of users using the application. So SaaS does easy to monitor and automatic updates.

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.

Multidevice support:

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

API Integration:

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

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:

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.

Latency issue:

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

Total Dependency on Internet:

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

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:

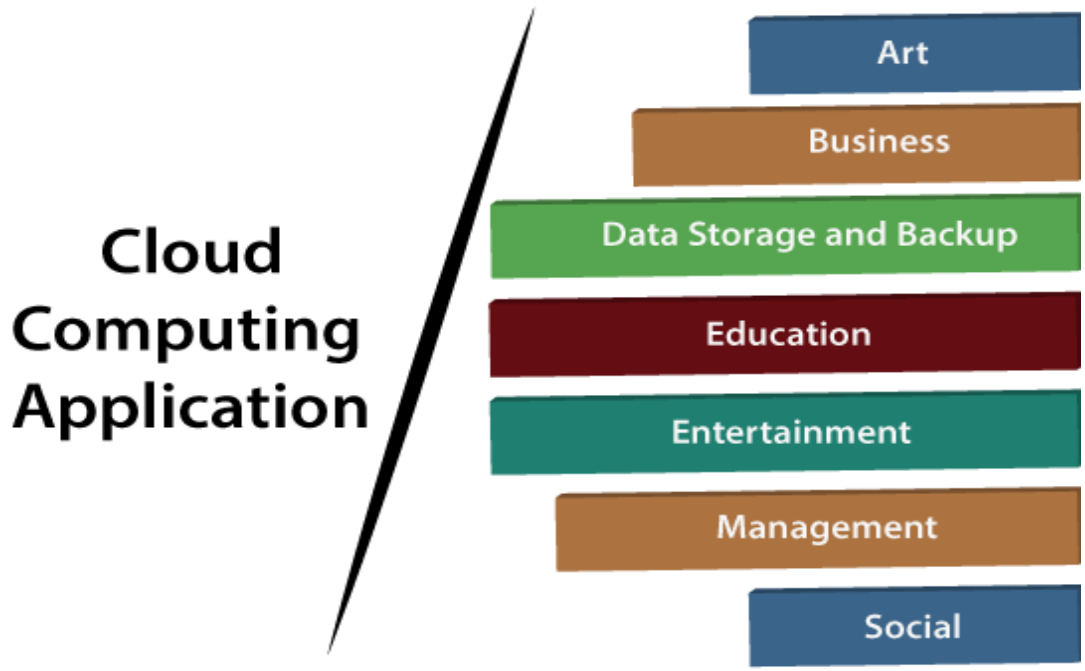
The below table shows some popular SaaS providers and services that are provided by them -

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

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 -



Art Applications:

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

i Moo

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

ii. Vistaprint

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

iii. Adobe Creative Cloud

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

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. Slack

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

vi. 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.

Data Storage and Backup Applications:

Cloud computing allows us to store information (data, files, images, audios, and videos) on the cloud and access this information using an internet connection. As the cloud provider is responsible for providing security, so they offer various backup recovery application for retrieving the lost data.

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

i. Box.com

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

ii. Mozy

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

iii. 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.

Education Applications:

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

There are the following education applications offered by the cloud -

i. Google Apps for Education

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

ii. Chromebooks for Education

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

iii. Tablets with Google Play for Education

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

iv. AWS in Education

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

Entertainment Applications:

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

i. Online games

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

ii. Video Conferencing Apps

Video conferencing apps provides a simple and instant connected experience. It allows us to communicate with our business partners, friends, and relatives using a

cloud-based video conferencing. The benefits of using video conferencing are that it reduces cost, increases efficiency, and removes interoperability.

Management Applications

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

Some important management applications are -

i. Toggl

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

ii. Evernote

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

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

iii. Outright

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

iv. GoToMeeting

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

Social Applications:

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

There are the following cloud based social applications -

i. Facebook

Facebook is a **social networking website** which allows active users to share files, photos, videos, status, more to their friends, relatives, and business partners using

the cloud storage system. On Facebook, we will always get notifications when our friends like and comment on the posts.

ii. Twitter

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

iii. LinkedIn

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

Service Oriented Architecture

SOA (**Service Oriented Architecture**) is built on computer engineering approaches that offer an architectural advancement towards enterprise system. **SOA** provides a translation and management layer within the **cloud architecture** that removes the barrier for **cloud** clients obtaining desired services.

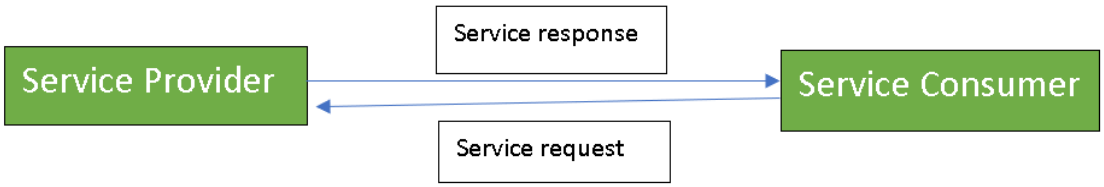
Service-Oriented Architecture (SOA) is an architectural approach in which applications make use of services available in the network. In this architecture, services are provided to form applications, through a communication call over the internet.

- SOA allows users to combine a large number of facilities from existing services to form applications.
- SOA encompasses a set of design principles that structure system development and provide means for integrating components into a coherent and decentralized system.
- 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.



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.

Advantages of SOA:

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

Disadvantages of SOA:

- **High overhead:** A validation of input parameters of services is done whenever services interact this decreases performance as it increases load and response time.
- **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.

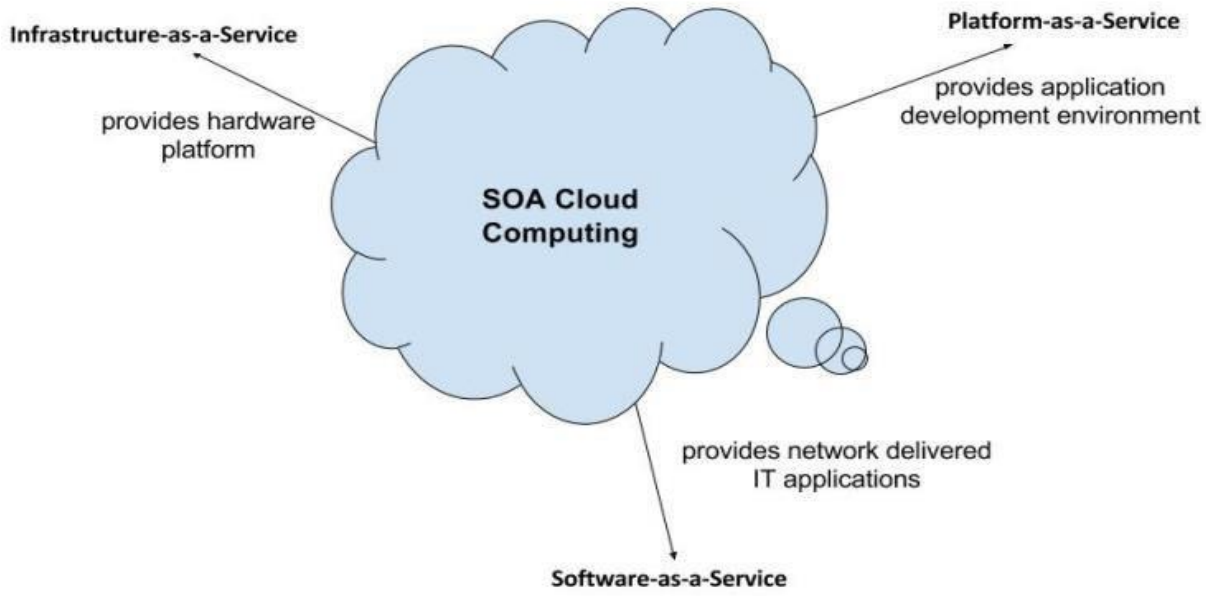
Concepts in Cloud Computing

Cloud computing is a model used for enabling convenient and usage-based network access to a configurable computing resources (eg. networks, servers etc) that can be provided and used rapidly.

- It provides a chance to business users to implement services with usage-based billing that is changed according to their requirements without need of consulting with IT department.

- It provides an abstraction layer between computing resources and its technical implementation details and sequentially enables computational resources to be used while avoiding efforts in infrastructure management.

The below figure shows the SOA cloud computing along with the models:



Below are the models that are differentiated on the horizontal scaling basis in cloud computing:

- **Infrastructure-as-a-Service (IaaS)**: It provides a hardware platform as a service.
- **Platform-as-a-Service (PaaS)**: It provides end-users an application development environment delivered over the internet.
- **Software-as-a-Service (SaaS)**: It provides end-users a standardized, network-delivered IT applications.

The distinctions are made according to availability and the location of installation in the deployment models. Private clouds are internal company services whereas public clouds are the services that are available to the public on internet.

In the large companies where IT plays an important role, internal company cloud solutions are often built in their own data centers. Small and medium companies often use public cloud services.

Cloud Computing provides a very flexible and scalable platform through processing external services and also has the ability to connect with customers, suppliers etc.

Diversified Services

Diversified is a full-service information technology service provider delivering data. deploying a data centre on virtualization and cloud computing technologies.

Virtualization:

Data centre virtualization is the process of designing, developing and deploying a data centre on virtualization and cloud computing technologies. It primarily enables virtualizing physical servers in a data centre facility along with storage, networking and other infrastructure devices and equipment. Diversified's expertise in virtualization helps data centres achieve the following benefits:

- Reduce hardware vendor lock-in
- Improve disaster recovery
- Smooth migration to cloud
- Reduce data center footprint
- Faster server provisioning

Premise, Hybrid & Cloud Computing:

The overwhelming number of vendors, products and hybrid options make it challenging to develop your future IT roadmap. Diversified aides clients in navigating the pros and cons of hosting locally, in a private/public cloud, or a combination thereof to create a strategy that works.

Storage:

A proper strategy for storage is essential for quality and cost efficiency. Diversified assists clients in selecting the proper storage to fit their needs and budget.

- Design for migrating inheritance storage solutions from drives, tapes, and arrays.
- Deployment of complete storage solutions consisting of internal and external storage, backup and storage software, storage networking, hyperconverged, cloud, and policies.

Hyperconverged Infrastructure:

The drive to reduce complexity while increasing scalability is also becoming increasingly popular in the data centre. Diversified's hyperconverged infrastructure solutions provide a software-centric architecture that tightly integrates computing, storage and virtualization resources in a single system that runs on off the shelf servers.

Performance Issues in Cloud Computing Services

Application that fits the cloud:

Not all the applications are suitable for cloud. It is extremely important to identify the most suitable applications for migration and identify any potential problems. Create a checklist to ensure a complete and successful migration.

Dealing with the performance issues:

If you are managing application performance in the cloud, you need a topological map of service delivery across all tiers. Although cloud computing offers numerous benefits, performance issues can complicate or reduce the benefits.

Addressing the topological dependencies:

While moving to cloud, various businesses need to face the impact of moving from a primarily static to dynamic network architecture. Firewall, load balancing and security services are still required for the network architecture.

Monitoring consumption for every service:

While transitioning from a resource focused cost center to a business service focused profit center, it demands assessing the resource consumption. Unfortunately, the traditional chargeback and AMP (Advanced Malware Protection) tools lack the ability to enable the business aligned costing and chargeback paradigms. This means that you need to come up with a solution to monitor consumption for every service across multiple applications and tiers.

Have a clear picture of resource consumption:

In order to make it sure that SLA's in cloud are met, you need to prioritize the allocation of resources based on the measurement of the end user performance. It demands a clear picture of the resource consumption at the transaction level.

Lack of infrastructure configuration for service deployment:

The lack of knowledge and infrastructure configuration for the service deployment has limited the ability of researchers to study the impact of resource management inside the cloud infrastructures on the service performance through measurement-based evaluations. This makes it difficult for a service customer to use a measurement-based method to get insight about the performance behaviours of new Cloud services.

Depending upon the size and the type of business you are running, the cloud offers you various benefits. For a startup, cloud computing provides essential differentiators to keep the business up and running quickly with minimal up-front costs. Larger businesses often

face complex challenges to ensure the availability and performance of the high traffic websites.

You will face various risks along the way along that can be complex to manage. Transitioning to the cloud is a non-trivial decision that demands a proper evaluation of both the data and services. It is important to perform a thorough evaluation on the cloud service performance as this is what will be beneficial for both service providers as well as customers.

Overall, cloud performance issues are considerable and demands innovation to overcome the challenges.

Data Centre

Data centres are simply centralized locations where computing and networking equipment is concentrated for the purpose of collecting, storing, processing, distributing or allowing access to large amounts of data. They have existed in one form or another since the introduction of computers.

Data centre refers to on-premise hardware while the cloud refers to off-premise computing. The cloud stores your data in the public cloud, while a data centre stores your data on your own hardware.

They are also responsible for data backup and recovery, as well as networking. These centres also host websites, manage e-mails, and instant messaging services. They support cloud storage applications and e-commerce transactions. Even online gaming communities require data centres to manage their online activities.

Data centres connect communication networks so end-users can access information remotely. These vast numbers of clustered servers and related equipment can be found in a room or even in an entire compound.

Evolution of Data Centres:

Decades ago, early computers were massive machines that can occupy whole rooms. But as technology evolved, equipment shrunk and became cheaper than before. However, with this progress, data processing demands have also begun to increase exponentially.

Unlike before, where data centres are just one big supercomputer, modern aged data centres functions using multiple servers to optimize further and boost its processing power. Now data centres consist of thousands of potent and tiny servers that run non-stop around the clock.

Importance of Data Centres:

Almost every modern business and government offices need their very own data centre, or they may decide to lease data centr. Big corporations and government institutions may choose to build and manage them in-house if they have the resources. While others choose to rent servers at 'colos' or colocation facilities. Some business owners also have the choice to use public cloud-based services.

Corporations that handle education, finance, telecommunication, retailers, and social networking services process a lot of information every day. This business that produces and utilizes data requires data centres in running their operations. Without these centres, they will suffer the absence of speedy and secure access to data. This failure in delivering services will ultimately lead to the loss of clients and profits.

Now, we must remember that all of this information needs to be housed somewhere. The idea of running or storing our data and resources at home or work computers is getting replaced by faraway storing mentality. Many firms are also migrating their professional applications to data centre services to minimize the cost of running an in-house server.

That is why data centres are an essential resource for a business that wants to run their operation without worries. The importance of data centres in the modern world has increased ten times due to the rising demand of information trading.

How Do Data Centres Work?

The data that is stored on a data centre server is distributed into packets before transmission and is sent via routers that decide the most suitable path for that data to progress.

It then uses a series of wired and wireless networks to reach the user's Internet service provider and finally arrive at the end user's computer. Every time a Web address is enters into a browser, it automatically requests information from a server. If the end-user wants to upload information, then the process will be reversed.

Types of Data Centres:

With how data centres are essential in running big corporations and with even small-medium enterprises joining the trend, choosing one to fit a business model is essential. There are different types of data centres and service models.

Here are four main types of data centres:

Colocation Data Centers:

Colocation data centers or most commonly known as "colo" is a company that rents space within a data centre that they do not own and is housed outside the company's premises. The colocation data centre provides the infrastructure like the building itself, cooling,

bandwidth, and security, among others. While the company produces and maintains the components, which include the servers, storage system, and security firewalls.

Enterprise Data Centres:

Enterprise data centres are established, owned, and managed by companies. These data canters are operated under a single purpose and that this optimized service for their end-user clients. Enterprise data canters are often located inside corporate compounds.

Managed Services Data Canters:

These data canters are operated by a third-party entity or a managed services provider instead of the company. The company rents the equipment and infrastructure to cut costs.

Cloud Data Canters:

Cloud data canters are an off-premises form of a data centre. The most common cloud hosting services are Amazon Web Services (AWS), Microsoft (Azure), and IBM Cloud.

How Reliable Is a Data Centre Facility?

Business owners are in constant need of reliability when in terms of maintaining a smooth operation. Good thing that a Data centre is built to withstand a 24/7 service easily. However, the components require a significant amount of infrastructure support in both hardware and software areas.

These include power subsystems, stable and uninterruptible power supplies, proper ventilation, high-quality cooling systems, fire control, reliable backup generators, and connections to external networks.

The business world is moving at an incredibly fast pace that matches the overwhelming demand for information. With the ever-changing requirements of the modern business model, many companies place their confidence in data canters, as these facilities play a crucial role in reaching their IT specifications.

Data centre service providers are capable of handling higher volumes of traffic without making compromises on security and storage capacity of data. Generally, a typical data centre carries the responsibility of managing significant characteristics like data workloads, operating conditions, data protection and security fulfilment.

Data canters are more than just a safe and secure facility with space that is equipped with reliable power, and network. They are becoming a valuable addition to many businesses as they prove to be a dependable extension of their IT team. That is why data canters in modern business set up are increasingly becoming an essential factor for success.

Legal issues in cloud computing service provision

Cloud computing, being one of such recent advancements, have raised a number of legal issues including privacy and data security, contracting issues, issues relating to the location of the data, and business considerations. Issues relating to contractual relation between the cloud service provider and the customer.

Cloud computing is bringing amazing advantages and benefits companies. But it also brings some challenges. There are several legal issues that must be taken into consideration when moving into the cloud. Let's see which are the most challenging legal issues around cloud computing.

Security procedures:

The majority of companies which implemented cloud solutions and services do not have security procedures in place. Also, they lack measures to approve or evaluate cloud applications. When adopting the BYOD trend for example, organizations needed these security procedures more than ever. General data security trainings, multiple levels of security, rigorous procedures to use one's own device and to transfer or copy data are some of the options available to protect data in organizations. The bottom line is that security procedures must be established according to every company's objectives and work flow.

[Bring your own device (**BYOD**) refers to the **trend** of employees using personal devices to connect to their organizational networks and access work-related systems and potentially sensitive or confidential data. Personal devices could include smartphones, personal computers, tablets, or USB drives.]

Third party access issues:

Third-party involvement could be a risk. All third parties using a multi-tenant shared cloud are using the same administration interface, so make sure multi-factor authentication and enhanced security is present. Also, look for HIPAA (Health Insurance Portability and Accountability Act) compliant providers – a business associate agreement (BAA) with third-party vendor who access Protected Health Information (PHI) is necessary to ensure privacy and security requirements. A partnership with a HIPAA solutions provider that signs a BAA is an efficient method to make sure this goes smoothly and everything is secure. And don't forget to read carefully the terms and conditions before signing up for a cloud based services.

Intellectual Property Rights:

Intellectual Property Rights differ from one country to another, so it is not very clear what intellectual property laws will apply in the cloud computing environment. Make sure you are aware of the regulations and rights from the country you store your intellectual work. The provider you choose should know how to protect intellectual property it stores and how to avoid potential infringement pitfalls.

Confidential data theft attacks:

Data stored in the cloud might be compromised or breached. Therefore, most cloud computing providers also offer the customer different levels of security protection, which allows for more enhanced security. Encryption might seem to have failed in protecting data from theft attacks, but other methods have been discovered and implemented, including monitoring data access in the cloud to detect abnormal data access patterns. The customer has to understand the cloud provider's disclosure policy and how quickly the breach would be disclosed to them. Most of the U.S. states have security breach disclosure laws requiring the provider to inform the customers when their data has been compromised.

Many of these legal issues and the methods to inform about them or to solve them should be mentioned in the Service Level Agreement. It is essential to understand all the terms of the cloud's provider and to consider the needs and objectives of the enterprise before signing an agreement.