Fundamentals of Cloud Computing

Unit-1: Introduction to Cloud Computing

1.1 Fundamentals of Cloud Computing

1.1.1 Concepts of cloud and cloud computing

1.1.2 Types of cloud based on deployment (Public, Private and Hybrid)

1.2 Cloud service models:

1.2.1 IaaS (Infrastructure as a Service), PaaS (Platform as a Service)

1.2.2 SaaS (Software as a Service)

1.2.3 Network as a Service, Database as a Service

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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.

There has been a ton of discussion about what the cloud is. Many individuals consider the cloud as an assortment of innovations. The facts confirm that there is a bunch of normal innovations that normally make up a cloud environment, yet these advancements are not the quintessence of the cloud. The cloud is basically a class of services. This is somewhat why the explanation that the cloud has been so difficult to characterize. Initially, the cloud was considered a lot of Combined Services, advancements, and exercises. What occurred inside the cloud was not known to the clients of the services. This is somewhat the way that the cloud got its name. In any case, that definition has since changed. Suppliers have understood that albeit a few clients won't think often about what is happening in the background, many really care. This client interest provoked suppliers to be really impending about what they are doing. Much of the time, clients are even permitted to configure their own system monitoring solutions.

Key Cloud Characteristics

A lot of companies and services providers have been trying to cash in on the popularity of the cloud. Many providers claim to offer cloud services, even though they really do not. Just because an application is Web-based does not mean that it is a cloud application. The application and the service around the application must exhibit certain characteristics before they can be considered a true cloud implementation. The NIST definition of cloud computing outlines five key cloud characteristics: ondemand self-service, broad network access, resource pooling, rapid elasticity, and measured service. All five of these characteristics must be present in order for the offering to be considered a true cloud offering.

OnDemand Self-Service

OnDemand self-service means that a consumer can request and receive access to a service offering, without an administrator or some sort of support staff having to fulfil the request manually. The request processes and fulfilment processes are all automated. This offers advantages for both the provider and the consumer of the service.

Implementing user self-service allows customers to quickly procure and access the services they want. This is a very attractive feature of the cloud. It makes getting the resources you need very quick and easy. With traditional environments, requests often took days or weeks to be fulfilled, causing delays in projects and initiatives. You don't have to worry about that in cloud environments.

User self-service also reduces the administrative burden on the provider. Administrators are freed from the day-to-day activities around creating users and managing user requests. This allows an organization's IT staff to focus on other, hopefully more strategic, activities. Self-service implementations can be difficult to build, but for cloud providers they are definitely worth the time and money. User self-service is generally implemented via a user portal. There are several out-of-the-box user portals that can be used to provide the required functionality, but in some instances a custom portal will be needed. On the front end, users will be presented with a template interface that allows them to enter the appropriate information. On the back end, the portal will interface with management application programming interfaces (APIs) published by the applications and services. It can present quite a challenge if the backend systems do not have APIs or other methods that allow for easy automation. When implementing user self-service, you need to be aware of potential compliance and regulatory issues. Often, compliance programs like Sarbanes Oxley (SOX) require controls be in place to prevent a single user from being able to use certain services or perform certain actions without approval. As a result, some processes cannot be completely automated. It's important that you understand which process can or cannot be automated in implementing self-service in your environment.

Broad Network Access

Cloud services should be easily accessed. Users should only be required to have a basic network connection to connect to services or applications. In most cases, the connection used will be some type of Internet connection. Although Internet connections are growing in bandwidth, they are still relatively slow compared to local area network (LAN) connections. Therefore, the provider must not require users to have a large amount of bandwidth to use the service.

Limited bandwidth connections lead to the second part of this requirement: Cloud services should require either no client or a lightweight, thin client. First, downloading a fat client can take a very long time, especially on a low bandwidth connection. Second, if the client application requires a lot of communication between the client system and the services, users may experience issues with latency on low-bandwidth connections. This brings us to the third part of this requirement: Cloud services should be able to be accessed by a wide variety of client devices. Laptops and desktops aren't the only devices used to connect to networks and the Internet. Users also connect via tablets, smartphones, and a host of other options. Cloud services need to support all of these devices. If the service requires a client application, the provider may have to build platform-specific applications (i.e., Windows, Mac, iOS, and Android). Having to develop and maintain a number of different client applications is costly,

so it is extremely advantageous if the solution can be architected in such a way that doesn't require a client at all.

Resource Pooling

Resource pooling helps save costs and allows flexibility on the provider side. Resource pooling is based on the fact that clients will not have a constant need for all the resources available to them. When resources are not being used by one customer, instead of sitting idle those resources can be used by another customer. This gives providers the ability to service many more customers than they could if each customer required dedicated resources. Resource pooling is often achieved using virtualization. Virtualization allows providers to increase the density of their systems. They can host multiple virtual sessions on a single system. In a virtualized environment, the resources on one physical system are placed into a pool that can be used by multiple virtual systems.

Rapid Elasticity

Rapid elasticity describes the ability of a cloud environment to easily grow to satisfy user demand. Cloud deployments should already have the needed infrastructure in place to expand the service capacity. If the system is designed properly, this might only entail adding more computer resources, hard disks, and the like. They key is that even though the resources are available, they are not used until needed. This allows the provider to save on consumption costs (i.e., power and cooling). Rapid elasticity is usually accomplished through the use of automation and orchestration. When resource usage hits a certain point, a trigger is set off. This trigger automatically begins the process of capacity expansion. Once the usage has subsided, the capacity shrinks as needed to ensure that resources are not wasted.

The rapid elasticity feature of cloud implementations is what enables them to be able to handle the "burst" capacity needed by many of their users. Burst capacity is an increased capacity that is needed for only a short period of time. For example, an organization may need increased order-processing capacity at the end of the fiscal quarter. In a traditional environment, an organization would need to have internal capacity to support this load. Most likely this would mean that there are resources that are always available but are only used a fraction of the time. In a cloud environment, an organization may take advantage of public cloud resources for that short period of time. There is no need to have that capacity always available internally.

Measured Service

Cloud services must have the ability to measure usage. Usage can be quantified using various metrics, such as time used, bandwidth used, and data used. The measured service characteristic is what enables the "pay as you go" feature of cloud computing. Once an appropriate metric has been identified, a rate is determined. This rate is used to determine how much a customer should be charged. This way, the client is billed based on consumption levels. If the service is not used on a particular day, the customer is not charged for that time. If you are paying for cloud services, you need to make sure you understand exactly which services are being measured and charged for. In a measured service, it's very important that you understand the associated costs. If you don't have a good understanding of the charges, you may be in for an unwelcome surprise.

What is Cloud Computing?

To the basic, cloud computing is referred as data storage, type of software outsourcing and processing. Software outsourcing consists of networking, servers, analytics, storage, databases, software and intelligence through the Internet. This delivers enhanced innovation, adaptable resources, and economic scalability. Through the internet connection, users can log in and gain accessibility for files and applications. Programs and data are hosted by external parties and accommodate it on the global network of protected data locations rather than storing in the user's external components such as pen drive, hard disk, and others. This endorses for power management, simplifies data sharing and shows the path for easy mobile access irrespective of asking user details. So, this is an efficient method of providing computing resources.

Cloud computing is the next stage in evolution of the Internet. The cloud in cloud computing provides the means through which everything — from computing power to computing infrastructure, applications, business processes to personal collaboration — can be delivered to you as a service wherever and whenever you need. Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centres and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider. The cloud itself is a set of hardware, networks, storage, services, and interfaces that enable the delivery of computing as a service. Cloud services include the delivery of software, infrastructure, and storage over the Internet (either as separate components or a complete platform) based on user demand.

The world of the cloud has lots of participants:

✓ The end user doesn't really have to know anything about the underlying technology. In small businesses, for example, the cloud provider becomes the de facto data center. In larger organizations, the IT organization oversees the inner workings of both internal resources and external cloud resources.

✓ Business management needs to take responsibility for overall governance of data or services living in a cloud. Cloud service providers must provide a predictable and guaranteed service level and security to all their constituents.

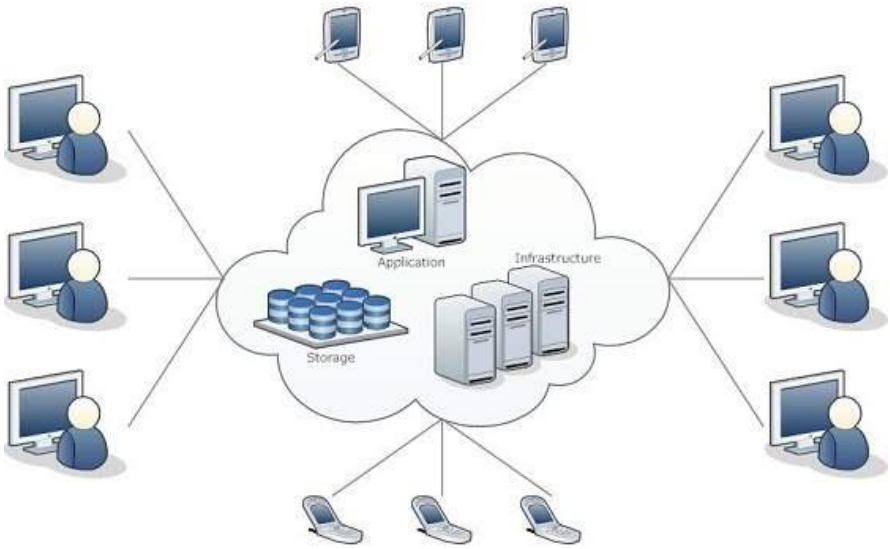
✓ The cloud service provider is responsible for IT assets and maintenance.

✓ Cloud computing is a general term for anything that involves delivering hosted services over the internet.

✓ Cloud computing is the delivery of different services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, and software.

✓ 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.

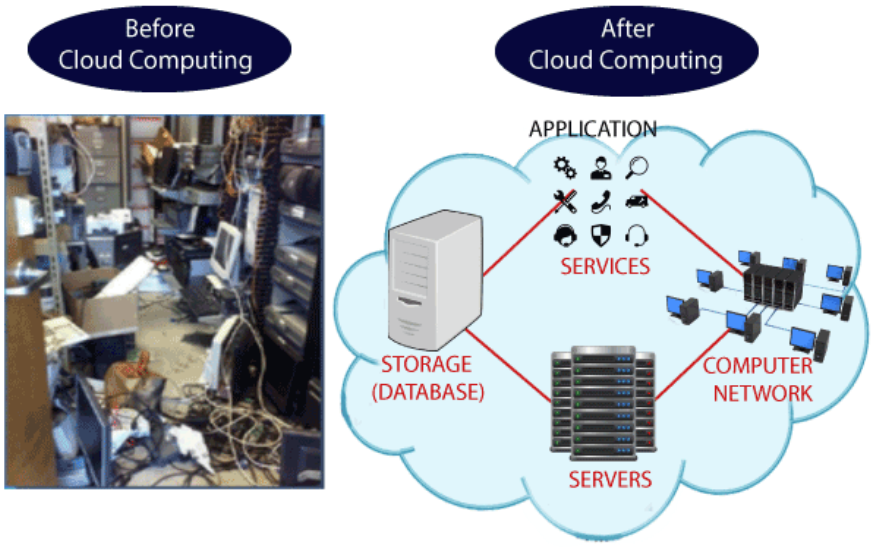


Why Cloud Computing?

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

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

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



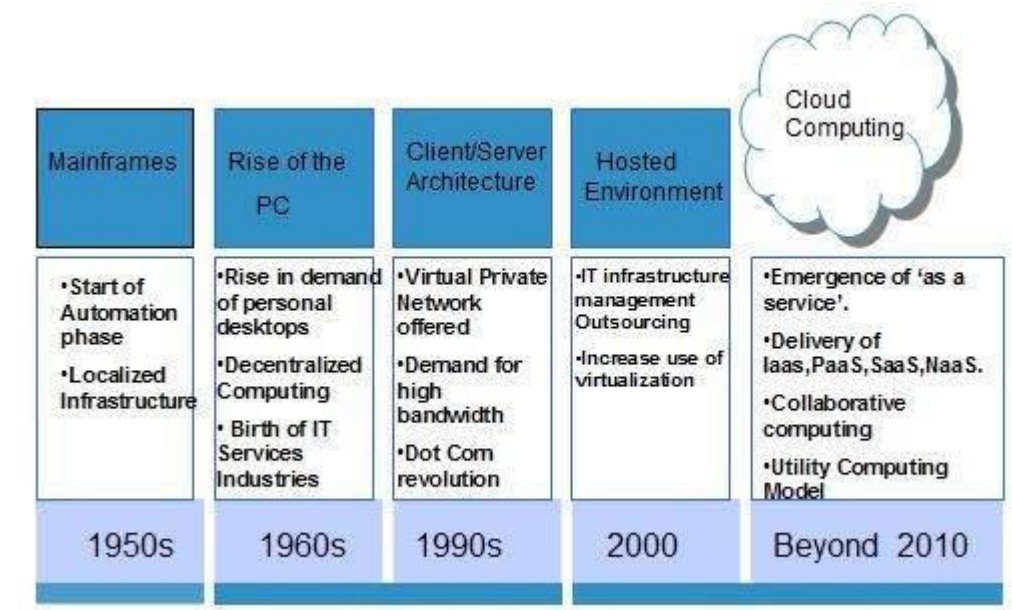
History of Cloud Computing

Many aspects of cloud computing can be traced as far back as the 1950s, when universities and companies rented out computation time on mainframe computers. At the time, renting was one of the only ways to access computing resources as computing technology was too large and expensive to be owned or managed by individuals. By the 1960s, computer scientists like John McCarthy of Stanford University and J.C.R Licklider of The U.S. Department of Defense Advanced Research Projects Agency (ARPA) began proposing ideas that anticipated some of the major features of cloud computing today, such as the conceptualization of computing as a public utility and the possibility of a network of computers that would allow people to access data and programs from anywhere in the world.

Cloud computing, however, didn't become a mainstream reality and a popular term until the first decade of the 21st century. This decade saw the launch of cloud services like Amazon's Elastic Compute (EC2) and Simple Storage Service (S3) in 2006, Heroku in 2007, Google Cloud Platform in 2008, Alibaba Cloud in 2009, Windows Azure (now Microsoft Azure) in 2010, IBM's SmartCloud in 2011. These services allowed existing businesses to optimize costs by migrating their in-house IT infrastructure to cloud-based resources and provided independent developers and small developer teams resources for creating and deploying apps. Cloud-based applications, known as Software as a Service (SaaS) — which we'll discuss in greater detail in the Cloud Delivery Models section — also became popular during this time period. Unlike on-premise software, or software that users need to physically install and maintain on their machines, SaaS increased the availability of applications by allowing users to access them from a variety of devices on demand.

Some of these cloud-based applications — such as Google's productivity apps (Gmail, Drive, and Docs) and Microsoft 365 (a cloud-based version of the Microsoft Office Suite) — were offered by the same companies that launched cloud infrastructure services, while other pre-existing software products, such as Adobe Creative Cloud, were launched as cloud-based applications using the services of cloud providers. New SaaS products and businesses also emerged based on the novel opportunities of these cloud providers, such as Netflix's streaming services in 2007, the music platform Spotify in 2008, the file-hosting service Dropbox in 2009, the video conferencing service Zoom in 2012, and the communication tool Slack in 2013. Today, cloud-based IT infrastructure and cloud-based applications have become a popular choice for both businesses and individual users and their market share is expected to grow.

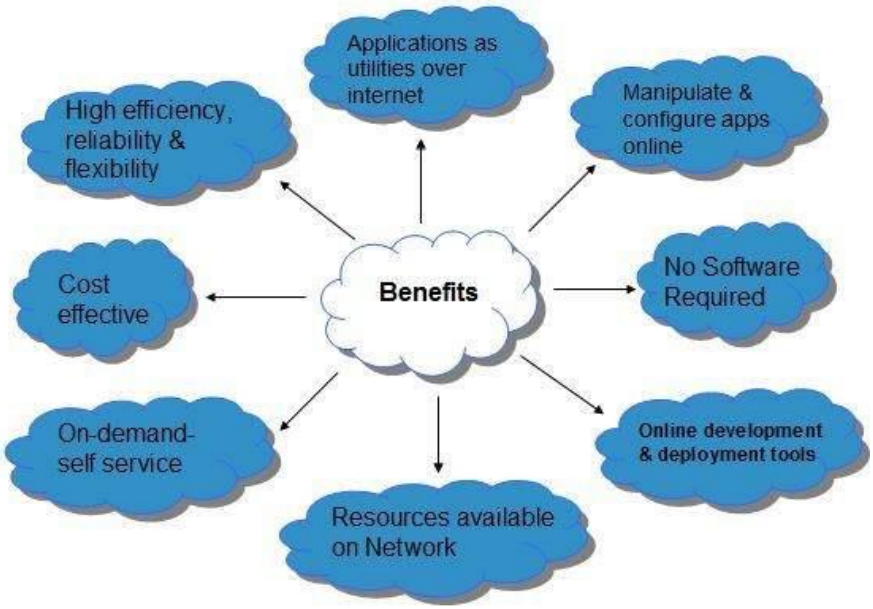
The concept of **Cloud Computing** came into existence in the year 1950 with implementation of mainframe computers, accessible via **thin/static clients.** Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services. The following diagram explains the 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. Some of them are discussed 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 tenants.

Management Interface Compromise

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

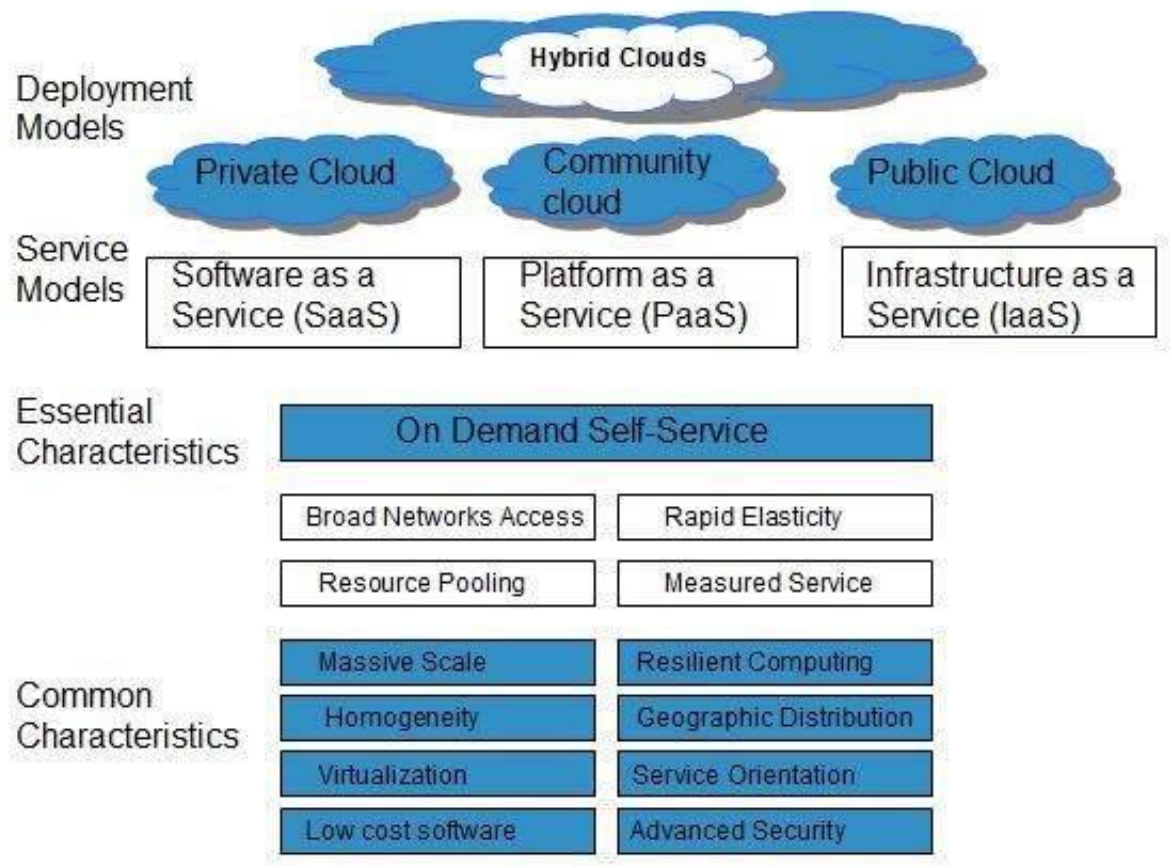
Insecure or Incomplete Data Deletion

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 tenants is destroyed.

Characteristics of Cloud Computing

The key characteristics of cloud computing. They are shown in the following diagram:



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. A client can provision computer resources without the need for interaction with cloud service provider personnel. We have already discussed about it in brief above in key characteristics of cloud.

Broad Network Access

Since cloud computing is completely web based, it can be accessed from anywhere and at any time. Access to resources in the cloud is available over the network using standard methods in a manner that provides platform-independent access to clients of all types. We have already discussed about it in brief above in key characteristics of cloud.

Resource Pooling

Cloud computing allows multiple tenants to share a pool of resources. One can share single physical instance of hardware, database and basic infrastructure. Physical and virtual systems are dynamically allocated or reallocated as needed. Intrinsic in this concept of pooling is the idea of abstraction that hides the location of resources such as virtual machines, processing, memory, storage, and network bandwidth and connectivity. We have already discussed about it in brief above in key characteristics of cloud.

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. Resources can be rapidly and elastically provisioned. The system can add resources by either scaling up systems (more powerful computers) or scaling out systems (more computers of the same kind), and scaling may be automatic or manual. From the standpoint of the client, cloud computing resources should look limitless and can be purchased at any time and in any quantity. We have already discussed about it in brief above in key characteristics of cloud.

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 use of cloud system resources is measured, audited, and reported to the customer based on a metered system. A client can be charged based on a known metric such as amount of storage used, number of transactions, network I/O (Input/Output) or bandwidth, amount of processing power used, and so forth. A client is charged based on the level of services provided. We have already discussed about it in brief above in key characteristics of cloud.

Agility

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

High availability and reliability

the scale of cloud computing networks and their ability to provide load balancing and failover makes them highly reliable, often much more reliable than what you can achieve in a single organization. The availability of servers is high and more reliable because the **chances of infrastructure failure are minimum**.

High Scalability

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

Multi-Sharing

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

Device and Location Independence

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

Maintenance

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

Low Cost

Because cloud networks operate at higher efficiencies and with greater utilization, significant cost reductions are often encountered. By using cloud computing, the cost will be reduced because to take the services of cloud computing, **IT company need not to set its own infrastructure** and pay-as-per usage of resources.

Simplified maintenance and upgrade: Because the system is centralized, you can easily apply patches and upgrades. This means your users always have access to the latest software versions.

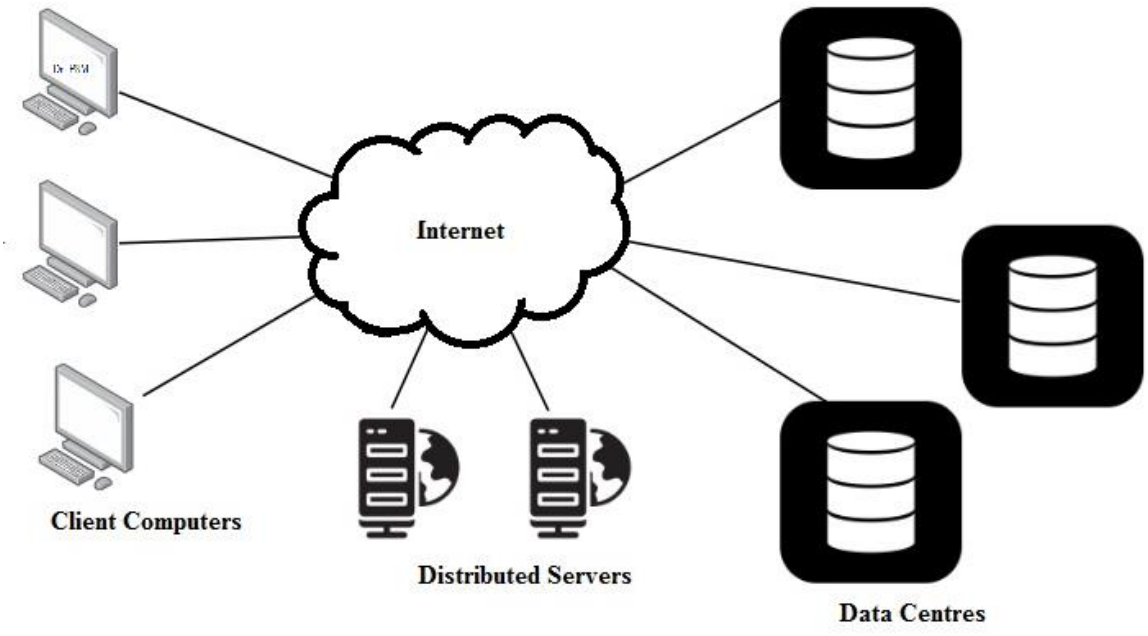
Low Barrier to Entry: In particular, upfront capital expenditures are dramatically reduced. In cloud computing, anyone can be a giant at any time.

Services in the pay-per-use mode

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

Components in Cloud Computing

Cloud computing components correspond to platforms such as front end, back end, and cloud-dependent delivery and the utilized network. So, a framework of cloud computing is broadly categorized as three specifically clients, distributed servers and datacentre.



Components

For the operation of this computing, the following three components have a big hand and the responsibilities of these components can be elucidated clearly as below:

Clients

Clients in cloud computing are in general to the operation of Local Area Networks (LAN's). They are just the desktops where they have their place on desks. These might be also in the form of laptops, mobiles, tablets to enhance mobility. Clients hold the responsibility of interaction which pushes for the management of data on cloud servers.

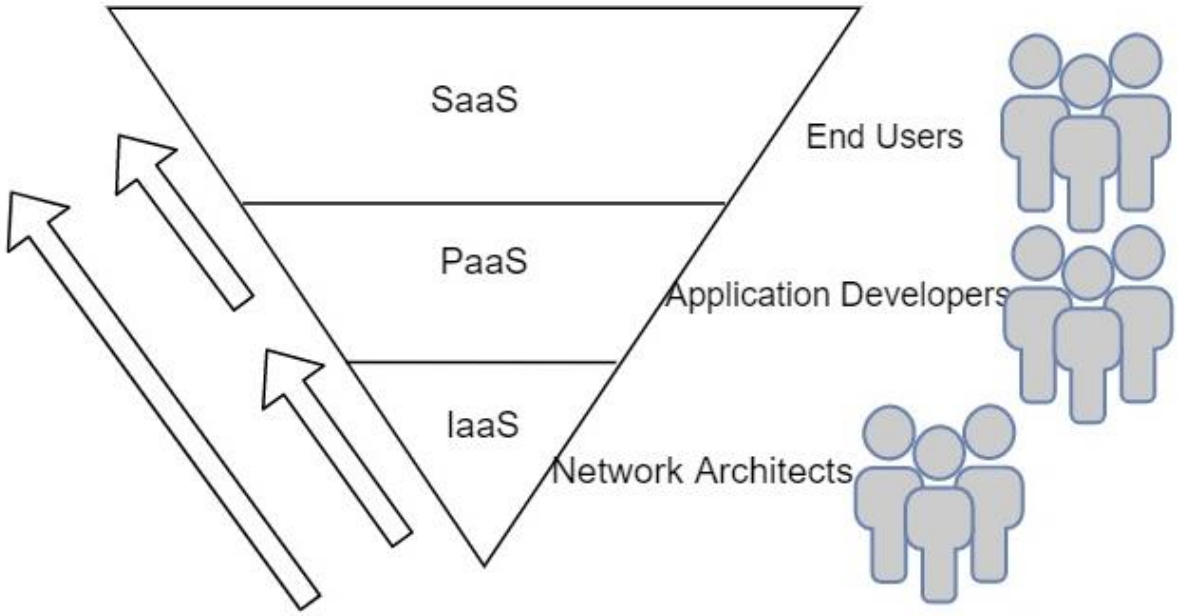
Datacentre

It is an array of servers that houses the subscribed application. Progressing the IT industry has brought the concept of virtualizing servers, where the software might be installed through the utilization of various instances of virtual servers. This approach streamlines the process of managing dozens of virtual servers on multiple physical servers.

Distributed Servers

These are considered as a server where that is housed in the other location. So, the physical servers might not be housed in a similar location. Even the distributed server and the physical server appear to be in different locations, they perform as they are so close to each other. While the other component is Cloud Applications, where it is defined as cloud computing in the form of software architecture. So, cloud applications serve as a service which operates both the hardware and software architecture.

Further, cloud computing has many other components and those come under mainly as four classifications and these components are the services of cloud computing and they can be described as follow:



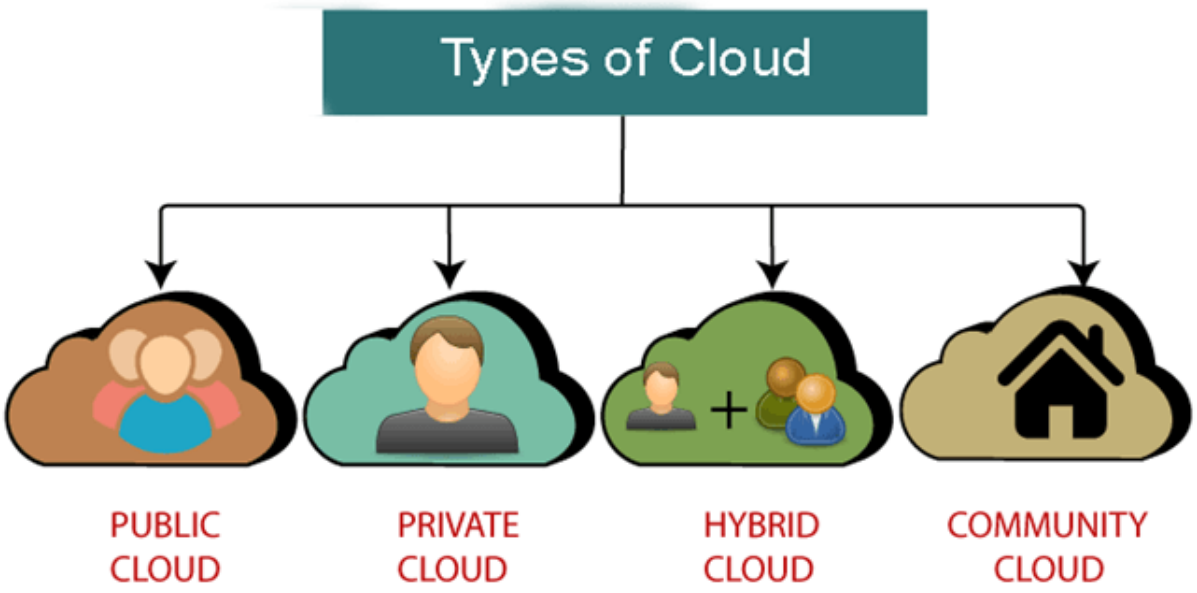
In chapter 1 below we will learn further about these in Cloud Service Models.

Cloud Network: A network is the bridge between the user and cloud services. The internet is the best choice for accessing the cloud.

Cloud Application programming interfaces (APIs): It is a ser of programming instruction and tool that provides abstraction over a specific provider cloud. It includes a custom or unique provider call that can be used to enhance the amount of control over a cloud implementation. APIs help programmers to have a common mechanism for connecting to a particular cloud service.

Types of Cloud

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



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

Public Cloud

Public clouds are environments that are entirely managed and serviced by an external service provider. When most people think about computer clouds, it is public clouds they are thinking about. In fact, most of the articles and material you find regarding clouds are in fact referring to public clouds. This is because the first cloud environments were public clouds. The idea of there being other types of cloud deployments took a little while to develop. Public clouds are still the most deployed cloud environments.

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

Public Cloud provides a shared platform that is accessible to the general public through an Internet connection.

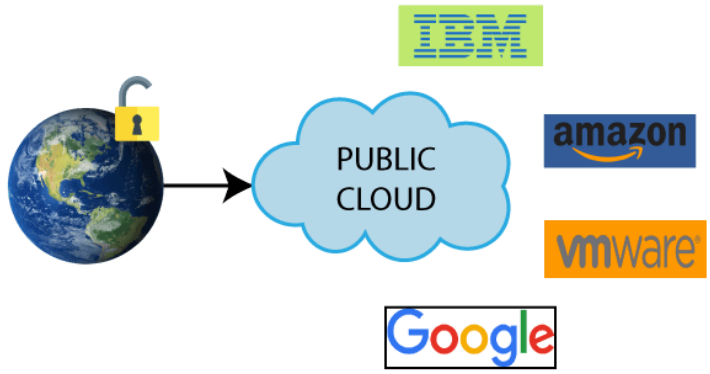
Public cloud operated on the pay-as-per-use model and administrated by the third party, i.e., Cloud service provider.

In the Public cloud, the same storage is being used by multiple users at the same time.

Public cloud is owned, managed, and operated by businesses, universities, government organizations, or a combination of them.

In public cloud, computing resources are managed and operated by the Cloud Service Provider (CSP).

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



Advantages of Public Cloud

There are the following advantages of Public Cloud –

1) Low Cost

Public cloud has a lower cost than private, or hybrid cloud, as it shares the same resources with a large number of consumers. Public cloud is owned at a lower cost than the private and hybrid cloud. Public clouds are particularly attractive because of the cost savings they offer. But you do have to be careful because the savings might not be as good as you think. You need to have a good understanding of not only the amount of savings but also the type of savings. Public clouds offer the most savings in terms of upfront costs. Using a cloud, organizations don't have to worry about spending money for initial hardware and software deployments. The service provider pays for these costs. The customer only has to pay for the services used. Most of these upfront costs would be capital costs because of the hardware that would need to be purchased. There are also support and maintenance savings that would be incurred—not just from hardware and software and support and maintenance but also from environment costs. Since the servers will not be in your data center, you will save on space, electricity, and cooling costs. In fact, if you outsource all your applications, you might not need your own data center at all. These are the cost savings that are really driving organizations to the cloud. The fact of the

matter is that few organizations will be able to outsource all their IT activities, however, at least in the near term.

2) Location Independent

Public cloud is location independent because its services are offered through the internet.

3) Save Time

In Public cloud, the cloud service provider is responsible for the manage and maintain data centers in which data is stored, so the cloud user can save their time to establish connectivity, deploying new products, release product updates, configure, and assemble servers.

4) Quickly and easily set up

Organizations can easily buy public cloud on the internet and deployed and configured it remotely through the cloud service provider within a few hours.

5) Business Agility

Public cloud provides an ability to elastically re-size computer resources based on the organization's requirements.

6) Scalability and reliability: Public cloud implementations offer a highly scalable architecture, as do most cloud implementations. What public cloud implementations offer that private clouds do not is the ability to scale your organization's capacity without having to build out your own infrastructure. Public cloud implementations can offer temporary burst capacity or permanent capacity, depending on which your organization needs. If your organization is using a SaaS service, you can add users to the application without adding the associated infrastructure. If you are using an IaaS or PaaS service, you will have increased capacity to build applications and services, but you will still need to ensure that the application you built can handle the increased load. Public cloud offers scalable (easy to add and remove) and reliable (24*7 available) services to the users at an affordable cost. Public cloud is highly scalable as per the requirement of computing resources.

7) Maintainability: Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.

8) Availability : Public cloud deployments can offer increased availability over what is achievable internally. Every organization has an availability quotient that they would like to achieve. Every organization also has an availability quotient that they are capable of achieving. Sometimes the two match; sometimes they don't. The problem is that availability comes at a cost, whether hardware cost, software cost, training cost, or staffing cost. Whichever it is, an organization may not be able to afford it, so they have to make do with what they have and therefore not be able to achieve the level of availability they would like. Most public cloud

providers already have the hardware, software, and staffing in place to make their offerings highly available. They may charge a little extra for the service to provide increased availability, but it will be nowhere near the cost of doing it internally. However, just because you go with a public cloud provider, you should not assume high availability or fault tolerance. You need to ask the provider what is offered with the service. If increased availability is an add-on, you need to know that when you calculate the cost. You should also ensure that the availability you desire is part of your service-level agreement (SLA). Your SLA can give you a level of assurance that your availability needs will be met. Be aware that although public clouds can increase your availability, you have to make sure you are cognizant of what will be available. It will depend on the service offering. In a SaaS offering, the application itself will be available. But if it's a PaaS or IaaS offering, although the platform or infrastructure may be available, the application might not be. Application issues will not be mitigated by using a public IaaS or PaaS offering.

9) Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.

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

Disadvantages of Public Cloud

- **Integration Limitations**: In public SaaS clouds, the systems are external to your organization; this means that the data is also external. Having your data housed externally can cause problems when you're doing reporting or trying to move to on-premises systems. If you need to run reports or do business intelligence (BI) analytics against the data, you could end up having to transmit the data through the Internet. This can raise performance concerns as well as security issues. Reports render much more quickly when they are generated in the same location as the data. Application integration can also be a problem in public SaaS offerings. In an ideal situation, different applications can use shared functionality. You don't want to repeat functionality in two different applications. So if the functionality exists in one application, you want another application to be able to call the functionality in another application. This can be a problem in public cloud applications. The application provider must expose APIs or web services that a customer can use in order to make this happen. If not, you may end up in a situation where functionality it repeated.
- **Reduced Flexibility**: - When you are using a public cloud provider, you are subject to that provider's upgrade schedule. In most cases, you will have little or no influence over when upgrades are performed. Even if it is possible for you to run a different instance than other customers, many providers are reluctant to deploy multiple versions

of an application or system online. Doing so would increase their administrative overhead. Users will have to be trained on the new system, which may have an impact on productivity.

- **Forced Downtime**: - When you use a public cloud provider, the provider controls when systems are taken offline for maintenance. Maintenance may be performed at a time that is inconvenient for you and your organization. Depending on how the system is partitioned, you may be able to postpone maintenance for a short period of time and agree on a time that is convenient for both your organization and the provider. However, it is highly unlikely that maintenance can be postponed for a long period of time.
- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

Private Cloud

Private clouds are completely managed and maintained by your organization. Generally, all the infrastructure for the environment will be housed in a data center that you control. So, you are responsible for purchase, maintenance, and support. Many people have an understanding of the cloud such that they do not believe that private clouds are actually clouds. They feel only public clouds are true clouds. But if you look at the characteristics of clouds, you can see that it doesn't matter where the cloud is hosted. The value proposition of the cloud changes when you talk about private clouds as opposed to public clouds; but the value proposition doesn't determine whether it's a cloud a not.

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.

Private cloud is also known as an internal cloud or corporate cloud.

Private cloud provides computing services to a private internal network (within the organization) and selected users instead of the general public.

Private cloud provides a high level of security and privacy to data through firewalls and internal hosting. It also ensures that operational and sensitive data are not accessible to third-party providers.

HP Data Centers, Microsoft, Elastra-private cloud, and Ubuntu are the example of a private cloud.

On-premises private cloud: On-premise private cloud solutions allow the business to host the cloud environment internally at their location. This option gives a business full control and flexibility over their internal data center, allowing them to have complete authority over the configurations of the servers and the hardware used. If the business already has system

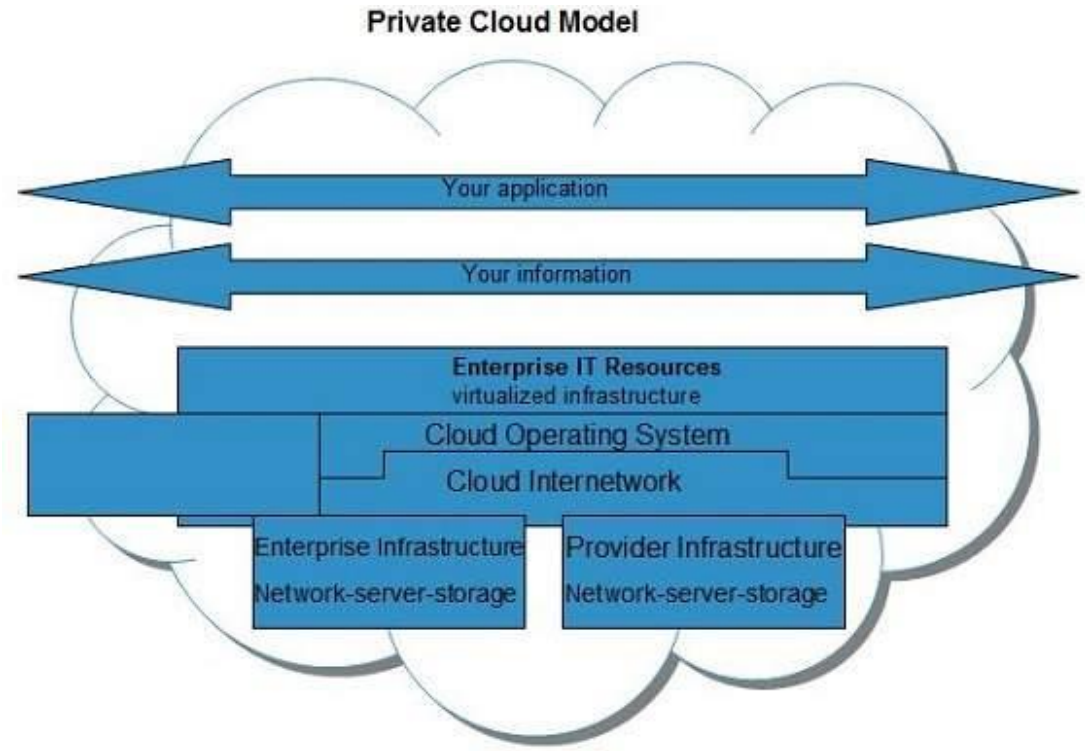
administrators or other appropriate experts, using a prescriptive deployment is usually the first stage.

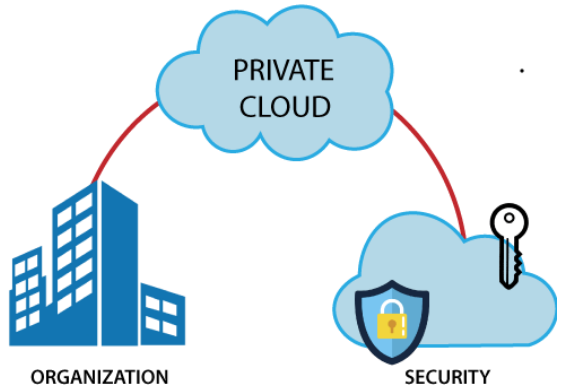
Many hardware manufacturers will release Reference Architectures that a skilled system admin and engineering team can follow. This typically requires pretty high level skills in networking, server hardware, the cloud software itself, like OpenStack, a storage software like Ceph, and monitoring. The cost of creation of a on-premise private cloud is significant.

With the decision to adopt an on-premise private cloud, a business is also taking full responsibility for cost and maintenance. This includes dealing with hardware failures and other possible disaster incidents. Businesses will also need to factor in additional costs for software licensing and staffing if system administrators aren't already part of the team.

Externally Hosted Private Cloud: Private clouds hosted by a third-party vendor, like InMotion Hosting, will allow you to deploy applications and store data on a flexible infrastructure without the business having to invest in hardware, software, servers, and sometimes staff. This is the key difference for hosted vs on-premise private cloud.
Additionally, because the third-party infrastructure is configured to serve a wide array of organizations, businesses benefit from a large scale. This includes the availability of more resources to provision and, if the hosting provider is modern, on-demand scalability options for businesses to use.

Private cloud solutions can also help businesses with any server regulatory requirements they need to follow per their industry. The third-party will manage server access and security, optionally provide support, and manage the data center.





To compare your cost benefit with a private cloud, you will want to compare the value you determine in the equation above with the same calculation:

CostDATACENTER = Σ(UnitCostDATACENTER x (Revenue – (CostDATACENTER/Utilization))

Benefits

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

Support and Troubleshooting: - Private cloud environments can be easier to troubleshoot than public cloud environments. In a private cloud environment, you will have direct access to all systems. You can access logs, run network traces, run debug traces, or do anything else you need to do to troubleshoot an issue. You don't have to rely on a service provider for help. If you are doing your own support and troubleshooting, you theoretically can provide much faster turnaround times, which will help maintain customer satisfaction. In the end, customer satisfaction is paramount to maintaining the success of your environment.

Maintenance: - With private clouds, you control the upgrade cycle. You aren't forced to upgrade when you don't want. You don't have to perform upgrades unless the newer version has some feature or functionality that you want to take advantage of. You can control when upgrades are performed. If your organization has regularly scheduled maintenance windows, you can perform your upgrades and other maintenance activities during that specified timeframe. This may help reduce the overall impact of a system outage. In some instances, you might need to run multiple versions of an application. This could be for compatibility, for example. If you do not control the systems, you might not be able to access multiple versions of the application. With an internal cloud, you are free to run multiple versions of an application when needed. This flexibility gives you an increased ability to service your customers' needs.

Monitoring: - Since you will have direct access to the systems in your private cloud environment, you will be able to do whatever monitoring you require. You can monitor everything from the application to the system hardware. One big advantage of this capability is that you can take preemptive measures to prevent an outage, so you are able to be more proactive in servicing your customers.

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.**

Security & privacy are one of the big advantages of cloud computing. Private cloud improved the security level as compared to the public cloud.

More Control

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

Private clouds have more control over their resources and hardware than public clouds because it is only accessed by selected users.

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

Disadvantages

Here are the disadvantages of using private cloud model:

Restricted Area of Operation

The private cloud is only accessible locally and is very difficult to deploy globally. As we know, private cloud is accessible within the organization, so the area of operations is limited.

Hardware and Software Compatibility

You have to make sure the software you implement is compatible with the hardware in your environment. In addition, you have to make sure the software you implement is compatible with the clients in your environment. There may be instances where you need specialized hardware—storage, for example—to implement a particular application.

Expertise Needed

With private clouds you still need expertise in all the applications and system you want to deploy. The need for internal expertise can lead to expensive training and education. You will be responsible for installing, maintaining, and supporting them, so you must ensure that you either have the in-house knowledge to do so or the ability to bring in outside contractors or consultants to help.

Building a cloud environment requires staff with knowledge of hardware, storage, networking, security, and virtualization. It can be very difficult to find employees who have all of this knowledge. In addition, your organization will need someone who has expertise in the particular cloud platform you want to implement.

Responsibilities

In a private cloud environment, the division of responsibilities is pretty straightforward. Your organization will be responsible for the end-to-end solution. You are responsible for the systems that provide the service, the client applications, and the maintenance of the client systems.

Security Considerations

With a private cloud implementation, your organization will have complete control over the systems, applications, and data. You can control who has access to what. Ensuring security is easier in a private cloud environment. There you have complete control over the systems, so you can implement any security means you like.

In a private cloud environment, you will be able perform your security and compliance audits. This will give you greater confidence, knowing that your systems are meeting your security and compliance needs.

Compliance

In a private cloud environment, you are responsible for making sure that you follow any applicable compliance regulations. If your organization has the skills and the technology to ensure adherence to compliance regulations, having the systems and the data internal can be a big advantage. If you don't have the skills and technology, you will have to obtain the skills, or you could face serious problems.

Having your systems and data housed at an external facility can aid your company with compliance. You can rely on the external provider to provide the skills and expertise needed. Payment card industry (PCI) compliance is a good example. PCI compliance requires special considerations to be taken for any system that processes credit card information. One thing you can do is outsource credit card processing to a third party. This can help ease some of the requirements on some of your internal systems. You have to be careful, however. You can't rely completely on the cloud provider. If there are security or compliance issues, your company can still be sued or at least suffer damage to your reputation. Many people won't make a distinction between your company and the provider. Others will blame you for choosing a bad provider.

Data

In a private cloud environment, you own the data and the systems that house the data. This gives you more control over who can access the data and what they can do with it. It also gives you greater assurance that your data is safe.

Auditing

In a private cloud environment, you have complete access to all the application and system logs. You can see who accessed what and what they did with it. The biggest advantage is that you can see all of this in real time, so you are able to take any corrective action necessary to ensure the integrity of your systems.

High Priced

Purchasing new hardware in order to fulfill the demand is a costly transaction. The cost is higher than a public cloud because set up and maintain hardware resources are costly. Implementing a private cloud requires substantial upfront costs. You have to implement an infrastructure that not only can support your current needs but your future needs as well. You need to estimate the needs of all the business units you will be supporting. You also have to implement an infrastructure that can support peak times. All the systems needed to support peak times don't always have to be running if you have a way of automatically starting them when necessary.

Limited Scalability

The private cloud can be scaled only within capacity of internal hosted resources. Private clouds are scaled only within the capacity of internal hosted resources.

Additional Skills

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

Skilled people

Skilled people are required to manage and operate cloud services.

Hybrid Cloud

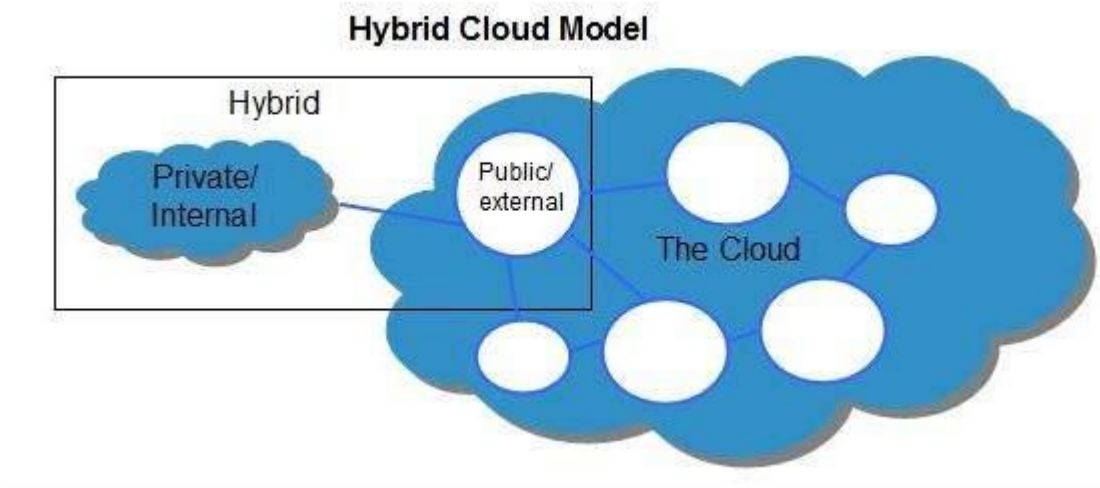
Hybrid cloud is a combination of public and private clouds. As the cloud computing era matures, hybrid clouds will most likely become the most common cloud implementation. There is a slight misconception about what a hybrid cloud actually is. Many people think a hybrid cloud is a cloud environment in which some components are public and some are private. This is not that case. Hybrid clouds can offer the best of both worlds as well as the worst of both worlds. Hybrid clouds offer the freedom to implement whatever is necessary to meet your organization's needs, but hybrid clouds can also be complex and expensive to implement.

Hybrid cloud = public cloud + private cloud

The main aim to combine these cloud (Public and Private) is to create a unified, automated, and well-managed computing environment.

In the Hybrid cloud, non-critical activities are performed by the public cloud and critical activities are performed by the private 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.



Mainly, a hybrid cloud is used in finance, healthcare, and Universities.

The best hybrid cloud provider companies are Amazon, Microsoft, Google, Cisco, and NetApp.

Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

1) Flexible and secure

It provides flexible resources because of the public cloud and secure resources because of the private cloud.

It offers secure resources and scalable public resources.

2) Cost effective

Hybrid cloud costs less than the private cloud. It helps organizations to save costs for both infrastructure and application supports. It offers the features of both the public as well as the private cloud. A hybrid cloud is capable of adapting to the demands that each company needs for space, memory, and system.

3) Security

Hybrid cloud is secure because critical activities are performed by the private cloud.

4) Risk Management

Hybrid cloud provides an excellent way for companies to manage the risk.

5) Scalability

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

Disadvantages of Hybrid Cloud

1) Networking issues

In the Hybrid Cloud, networking becomes complex because of the private and the public cloud. Networking becomes complex due to presence of private and public cloud.

2) Infrastructure Compatibility

Infrastructure compatibility is the major issue in a hybrid cloud. With dual-levels of infrastructure, a private cloud controls the company, and a public cloud does not, so there is a possibility that they are running in separate stacks. The hybrid cloud model is dependent on internal IT infrastructure, therefore it is necessary to ensure redundancy across data centers.

3) Reliability

The reliability of the services depends on cloud service providers.

4) Securities

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

5) Integration

You may have some applications in a private cloud and some applications in a private one, but these applications may need to access and use the same data. You have two choices here: You can duplicate copies of data, which would require you to set up some type of replication mechanism to keep the data in sync, or you can move data around as needed. Moving data around in a hybrid cloud environment can be tricky because you have to worry about bandwidth constraints.

Hybrid clouds can bring about particular security considerations. Not only do you have to worry about security issues in each individual environment, you have to worry about issues created by connecting the environments together.

6) Data

Moving data back and forth between cloud environments can be very risky. You have to ensure that all environments involved have satisfactorily secured data. Data in motion can be particularly difficult to secure. Both sides of the conversation must support the same security protocols, and they must be compatible with each other.

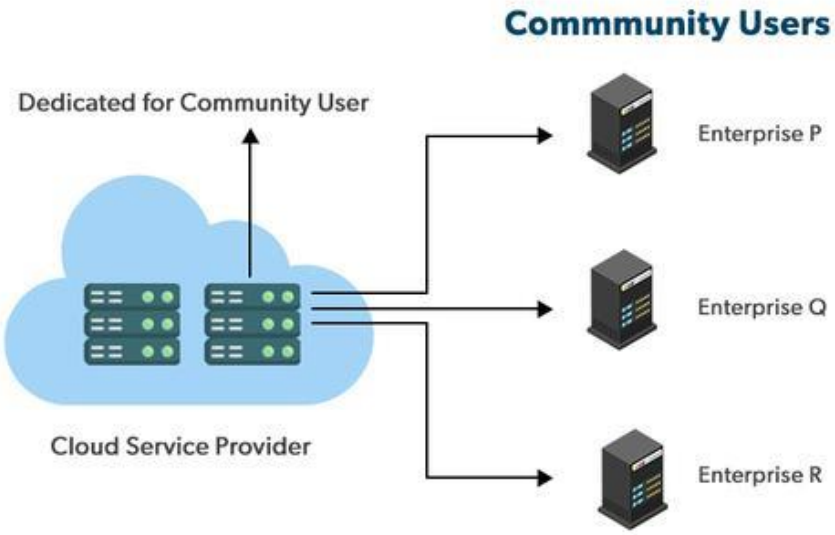
7)Auditing

Auditing in hybrid environments can be tricky. User access may rotate between internal and external. Following a process from start to finish may take you through both internal and external systems. It’s important that you have some way of doing event log correlation so that you can match up these internal and external events.

Community Cloud

Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them. Community clouds are distributed systems created by integrating the services of different clouds to address the specific needs of an industry, a community, or a business sector. However, sharing responsibilities among the organizations is difficult. In the community cloud, the infrastructure is shared between organizations that have shared concerns or tasks. An organization or a third party may manage the cloud. Community clouds aren't used as much as public or private clouds; in fact, they are the least known and least used cloud deployment model. In a community cloud, the cloud is shared by a group of organizations that have a common purpose or goal. The cloud environment is generally built to help them achieve that purpose or goal.

Example: Health Care community cloud



Sectors that use community clouds are:

Media industry: Media companies are looking for quick, simple, low-cost ways for increasing the efficiency of content generation. Most media productions involve an extended ecosystem of partners. In particular, the creation of digital content is the outcome of a collaborative process that includes the movement of large data, massive compute-intensive rendering tasks, and complex workflow executions.
Healthcare industry: In the healthcare industry community clouds are used to share information and knowledge on the global level with sensitive data in the private infrastructure.
Energy and core industry: In these sectors, the community cloud is used to cluster a set of solution which collectively addresses the management, deployment, and orchestration of services and operations.
Scientific research: In this organization with common interests in science share a large distributed infrastructure for scientific computing.

Advantages of Community Cloud

There are the following advantages of Community Cloud -

- ✓ Community cloud is cost-effective because the whole cloud is being shared by several organizations or communities.
- ✓ Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.
- ✓ It provides better security than the public cloud.
- ✓ It provides collaborative and distributive environment.
- ✓ Community cloud allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

Disadvantages of Community Cloud

- ✓ Security features are not as good as the private cloud.
- ✓ It is not suitable if there is no collaboration.
- ✓ The fixed amount of data storage and bandwidth is shared among all community members.
- ✓ Community cloud is not a good choice for every organization.
- ✓ Slow adoption to data
- ✓ Community Cloud is costly than the public cloud.
- ✓ Sharing responsibilities among organizations is difficult.
- ✓ 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.

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

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

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

Owner	Service provider	Enterprise	Enterprise	Community
Scalability	Very High	Limited	Very high	Limited
Reliability	Moderate	Very High	Medium to High	High
Security	Totally depends on Service Provider	High Class Security	Secure	Secure
Performance	Low to Medium	Good	Good	Good
Cost	Cheaper	High cost	Costly	Costly

Cloud Service Models

There are the following three types of cloud service models -

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

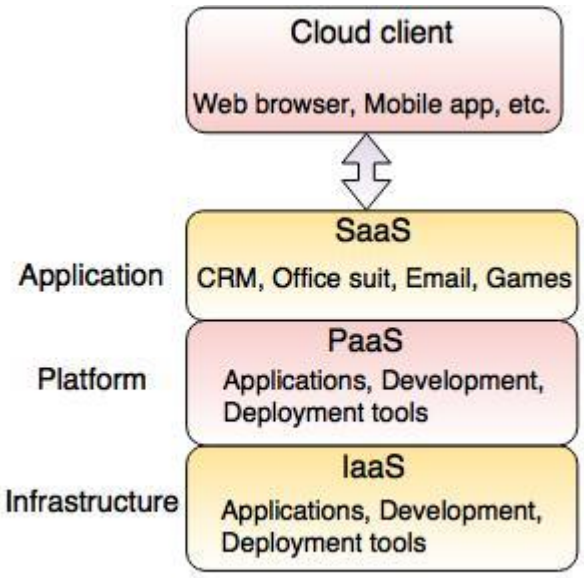


Fig. - Categories of Cloud Computing

Infrastructure-as-a-Service (IaaS)

Infrastructure as a service (IaaS) is a service model that delivers computer infrastructure on an outsourced basis to support various operations. Typically IaaS is a service where infrastructure is provided as outsourcing to enterprises such as networking equipment, devices, database, and web servers.

It is also known as Hardware as a Service (HaaS). IaaS customers pay on a per-user basis, typically by the hour, week, or month. Some providers also charge customers based on the amount of virtual machine space they use.

It simply provides the underlying operating systems, security, networking, and servers for developing such applications, and services, and deploying development tools, databases, etc.

HaaS differs from IaaS in the way that users have the bare hardware on which they can deploy their own infrastructure using most appropriate software.

IaaS is a way to deliver a cloud computing infrastructure like server, storage, network and operating system.

The customers can access these resources over cloud computing platform i.e Internet as an on-demand service.

In IaaS, you buy complete resources rather than purchasing server, software, datacenter space or network equipment.

IaaS was earlier called as Hardware as a Service(HaaS). It is a Cloud computing platform based model.

Characteristics of IaaS

There are the following characteristics of IaaS -

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

Advantages of IaaS

Cost-Effective: Eliminates capital expense and reduces ongoing cost and IaaS customers pay on a per-user basis, typically by the hour, week, or month.

Website hosting: Running websites using IaaS can be less expensive than traditional web hosting. Iaas allows IT users to access resources over the internet.

Security: The IaaS Cloud Provider may provide better security than your existing software.

Maintenance: There is no need to manage the underlying data center or the introduction of new releases of the development or underlying software. This is all handled by the IaaS Cloud Provider.

Shared infrastructure

IaaS allows multiple users to share the same physical infrastructure.

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.

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.

In IaaS, user can dynamically choose a CPU, memory storage configuration according to need.

Users can easily access the vast computing power available on IaaS Cloud platform.

Disadvantages of IaaS

IaaS cloud computing platform model is dependent on availability of Internet and virtualization services.

Security

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

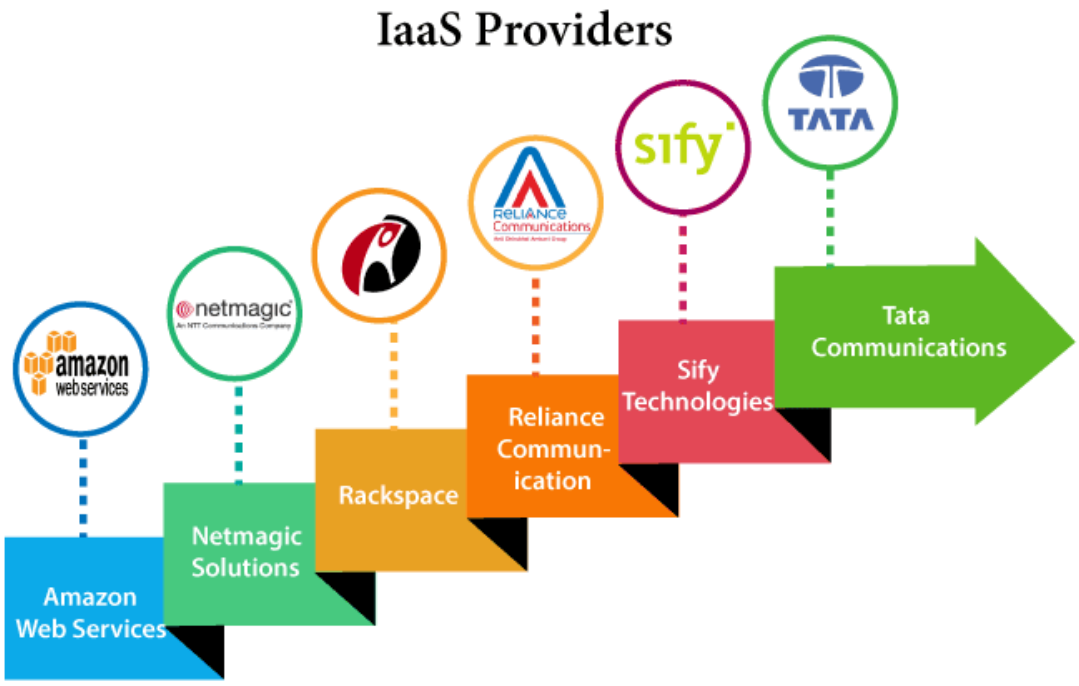
Maintenance & Upgrade

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.

Top Iaas Providers who are providing IaaS cloud computing platform



IaaS Vendor	Iaas Solution	Details
Amazon Web Services	Elastic, Elastic Compute Cloud (EC2) MapReduce, Route 53, Virtual Private Cloud, etc.	The cloud computing platform pioneer, Amazon offers auto scaling, cloud monitoring, and load balancing features as part of its portfolio.
Netmagic Solutions	Netmagic IaaS Cloud	Netmagic runs from data centers in Mumbai, Chennai, and Bangalore, and a virtual data center in the United States. Plans are underway to extend services to West Asia.
Rackspace	Cloud servers, cloud files, cloud sites, etc.	The cloud computing platform vendor focuses primarily on enterprise-level hosting services.
Reliance Communications	Reliance Internet Data Center	RIDC supports both traditional hosting and cloud services, with data centers in Mumbai, Bangalore, Hyderabad, and Chennai. The cloud services offered by RIDC include IaaS and SaaS.

Sify Technologies	Sify IaaS	Sify's cloud computing platform is powered by HP's converged infrastructure. The vendor offers all three types of cloud services: IaaS, PaaS, and SaaS.
Tata Communications	InstaCompute	InstaCompute is Tata Communications' IaaS offering. InstaCompute data centers are located in Hyderabad and Singapore, with operations in both countries.

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.
Platform-as-an-service (PaaS) is distributed computing model where an outsider supplier appropriates equipment and programming instruments to clients over Internet. As rule, these are required for application improvement. PaaS supplier has equipment and programming on its own framework. Therefore, it liberates designers from introducing inside equipment and programming to create or run another application. Press device is utilized in basic and helpful manner. Clients, as rule, pay on for each utilization premise. An association can step in for PAS that considers potential cost investment funds by utilizing nearby alternatives.
How PaaS functions? As referenced above, PaaS for programming advancement does not supplant whole IT foundation of whole organization. It is given by foundation facilitated by cloud specialist co-op, in which clients frequently get to entries through an internet browser.

Different PaaS Services :

- ✓ Advancement group support
- ✓ Application plan and improvement
- ✓ Application testing and arrangement
- ✓ Web administration mix
- ✓ Information security
- ✓ Database Integration

Example: AWS Elastic Beanstalk, Google App Engine, Force.com, Joyent, Azure, Heroku, Magento Commerce Cloud, OpenShift.

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

1. Programming languages

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

2. Application frameworks

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

3. Databases

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

4. Other tools

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

Characteristics of PaaS

Customization

With PaaS, you have complete control over the application, so you are free to customize the application as you see fit. You won't be able to make many changes to the development platform, however. In most cases, this platform will be strictly controlled by the provider. There will likely be different configuration options that you can set, but true customization will be limited.

Analytics

Since you, the customer, will be creating the applications, you will have the ability to view application usage and determine trends. You will be able to see which components are getting the most use and which ones are not being used. In a PaaS environment, you will also usually have visibility into the use of the platform. You will be able to determine when new systems need to be added to handle the load. Often, providers give you the ability to automatically spin up new systems when your current ones meet certain load thresholds.

Integration

In a PaaS environment, the data will be stored at the provider site, but the customer will have direct access to it. Conducting business intelligence and reporting should not be a problem from an access point of view, but you could run into issues when it comes to bandwidth usage, because you may be moving large amounts of data between your internal environment and the provider's environment. So there might be performance concerns there, as opposed to access or functionality concerns.

Advantages of PaaS

There are the following advantages of PaaS -

1) Simplified Development

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

2) Lower risk

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

3) Prebuilt business functionality

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

4) Instant community

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

5) Scalability

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

Disadvantages of PaaS cloud computing layer

1) Vendor lock-in

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

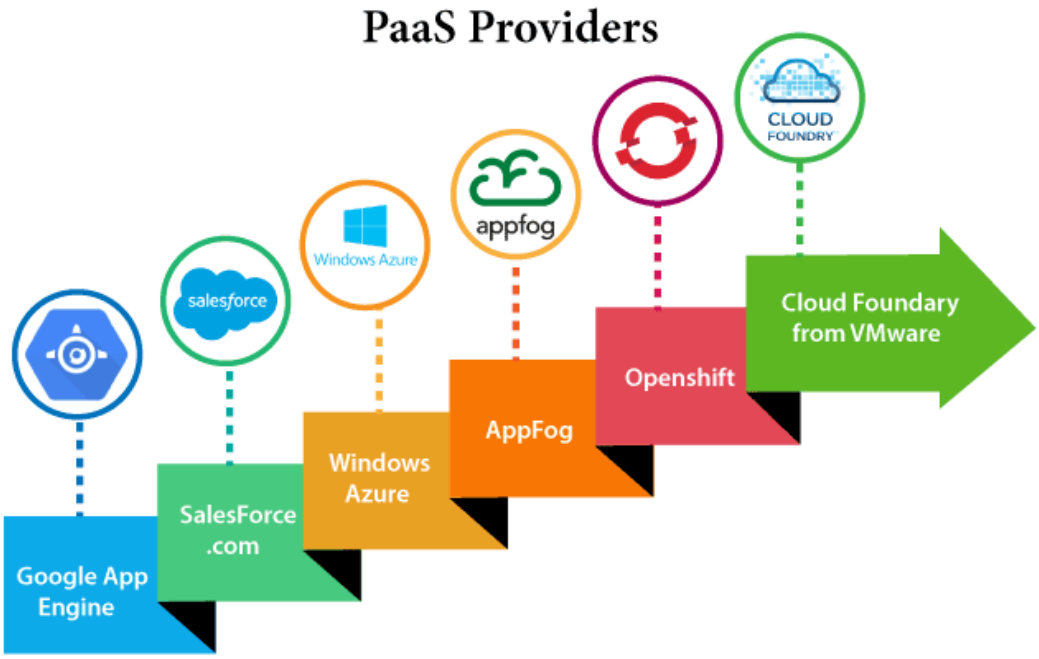
2) Data Privacy

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

3) Integration with the rest of the systems applications

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

Pass Service 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 the following services provided by SaaS providers -

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

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

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

Billing and invoicing system
Customer Relationship Management (CRM) applications
Help desk applications
Human Resource (HR) solutions

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.

Characteristics

Here are the characteristics of SaaS service model:

- SaaS makes the software available over the Internet.
- The software applications are maintained by the vendor.
- The license to the software may be subscription based or usage based. And it is billed on recurring basis.
- SaaS applications are cost-effective since they do not require any maintenance at end user side.
- They are available on demand.
- They can be scaled up or down on demand.
- They are automatically upgraded and updated.
- SaaS offers shared data model. Therefore, multiple users can share single instance of infrastructure. It is not required to hard code the functionality for individual users.
- All users run the same version of the software.
- Managed from a central location.

Advantages of SaaS cloud computing layer

1) SaaS is easy to buy

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

Unlike traditional software, which is sold as a licensed 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.

2. One to Many

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

3. Less hardware required for SaaS

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

4. Low maintenance required for SaaS

Software as a service removes the need for installation, set-up, and daily maintenance for the organizations. The initial set-up cost for SaaS is typically less than the enterprise software. 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.

5. No special software or hardware versions required

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

6. Multidevice support

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

7. API Integration

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

8. No client-side installation

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

Disadvantages of SaaS cloud computing layer

1) Security

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

2) Latency issue

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

3) Total Dependency on Internet

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

4) Switching between SaaS vendors is difficult

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

Popular SaaS Providers

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.

Network as Service(NaaS)

NaaS is a cloud model that enables users to easily operate the network and achieve the outcomes they expect from it without owning, building, or maintaining their own infrastructure. NaaS can replace hardware-centric VPNs, load balancers, firewall appliances, and Multiprotocol Label Switching (MPLS) connections. Users can scale up and down as demand changes, rapidly deploy services, and eliminate hardware costs.

Network-as-a-Service will provide users with complete networking infrastructure along with security. It is mainly for the users who do not want to build their own application. With NaaS, it is possible for users to deploy with custom protocols. NaaS helps the user to reduce and deduct the cost of hardware-centric VPN, load balancers, VPNs, firewall applications, and Multiprotocol Label Switching connections. The users have the facility to scale up and scale down according to the requirements. Services can be deployed very easily and quickly. NaaS is similar to other cloud services, and the clients can run networking functions with the help of software. Users or companies can set up their own networks without the hardware. The main requirement is the internet. A new policy of routing traffic and security policies in NaaS has a significant impact on an organization’s networking architecture. The network service provider will take the responsibility to provide the networking infrastructure. It means the Third Party can deliver the network infrastructure. Sometimes NaaS also includes virtualization by using a protocol named OpenFlow.

Characteristics of Naas

NaaS authorizes the users to directly access the internet securely. Also, it permits the users to run custom-developed routing protocols.

Virtualized Network helps NaaS to provide network service to the users. This feature is beneficial for users from the issue of developing and managing infrastructure. So, the users can focus on development and their business.

It provides users with a virtual environment that helps them to reduce the physical cost and maintenance.

One of the main features is remote access, by which the users can access the data from any location by simply having a stable internet connection.

How NaaS is delivered?

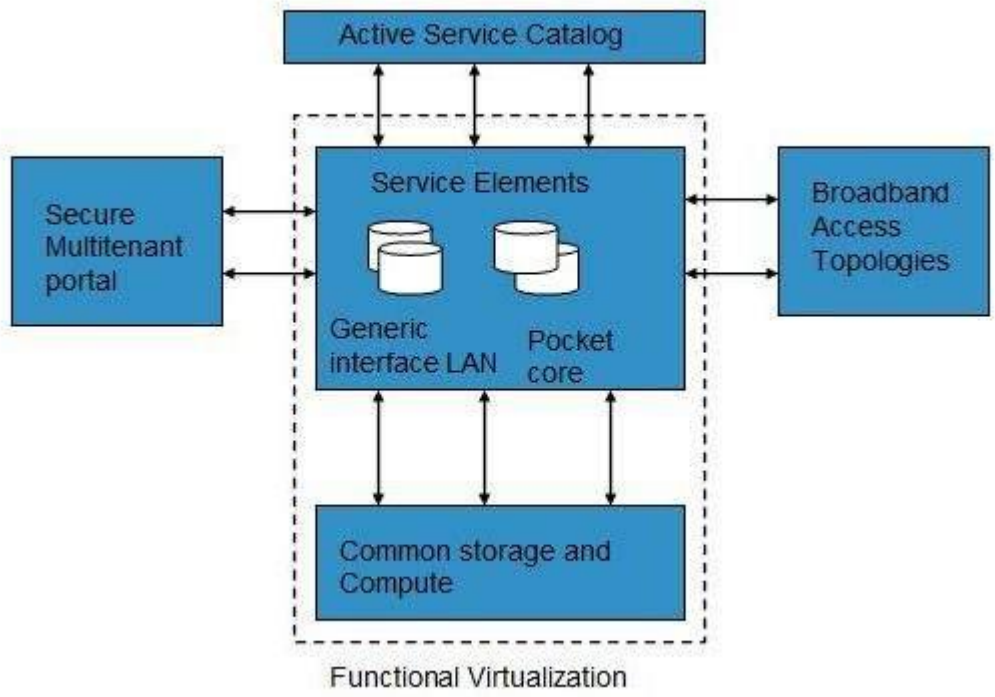
To use NaaS model, the customer is required to logon to the web portal, where he can get online API. Here, the customer can customize the route.

In turn, customer has to pay for the capacity used. It is also possible to turn off the capacity at any time.

Mobile NaaS

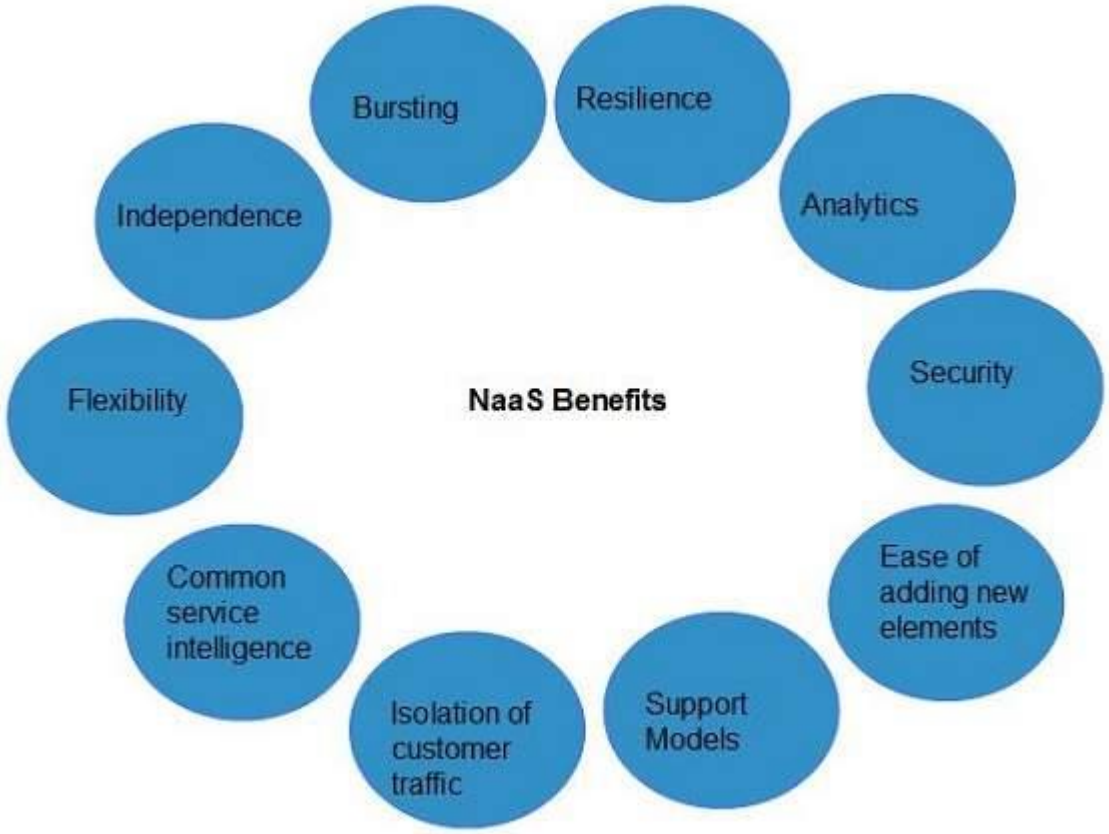
Mobile NaaS offers more efficient and flexible control over mobile devices. It uses virtualization to simplify the architecture thereby creating more efficient processes.

Following diagram shows the Mobile NaaS service elements:



NaaS Benefits

NaaS offers a number of benefits as discussed below:



Independence

Each customer is independent and can segregate the network.

Bursting

The customer pays for high-capacity network only on requirement.

Resilience

The reliability treatments are available, which can be applied for critical applications.

Analytics

The data protection solutions are available, which can be applied for highly sensitive applications.

Ease of Adding New Service Elements

It is very easy to integrate new service elements to the network.

Support Models

A number of support models are available to reduce operation cost.

Isolation of Customer Traffic

The customer traffic is logically isolated.

Database as a Service (DBaaS)

Database-as-a-Service (DBaaS) is a cloud computing service that allows companies to use a database without setting up physical hardware. Users also do not need to install software or hire staff members to maintain the underlying technologies. DBaaS simplifies database management with one-click operations, eliminates time-consuming tasks, and grants the agility for faster software development.

DBaaS(Database as a service) is a cloud computing managed service offering model that enables users to set up, operate, manage and scale with some form of access to a Database without the need for setting it up on physical hardware, installing software, or configuring it for performance, Database management by themselves. It has come up as a wonderful approach that extends the capabilities of the Private Cloud by Increasing Quality of Service, Faster Deployment, Providing Resource Elasticity, Rapid Provisioning. Moreover, DBaaS in Enterprise Manager is implemented by four options, which are: Virtual Machine based, Shared Cluster, Shared installation, Shared Database. Not only this, delivery model selection is the necessary step that best satisfies the intended use of Database services before you implement DBaaS.

Database-as-a-Service Features

In a traditional setup, the database server is a part of the on-premises computing infrastructure. The local staff is responsible for installing, managing, protecting, and scaling the database.

In contrast, DBaaS is a subscription service in which the provider manages the hardware and delivers the database as a private cloud service. The service provider handles the high-level database administrative (DBA) tasks, including:

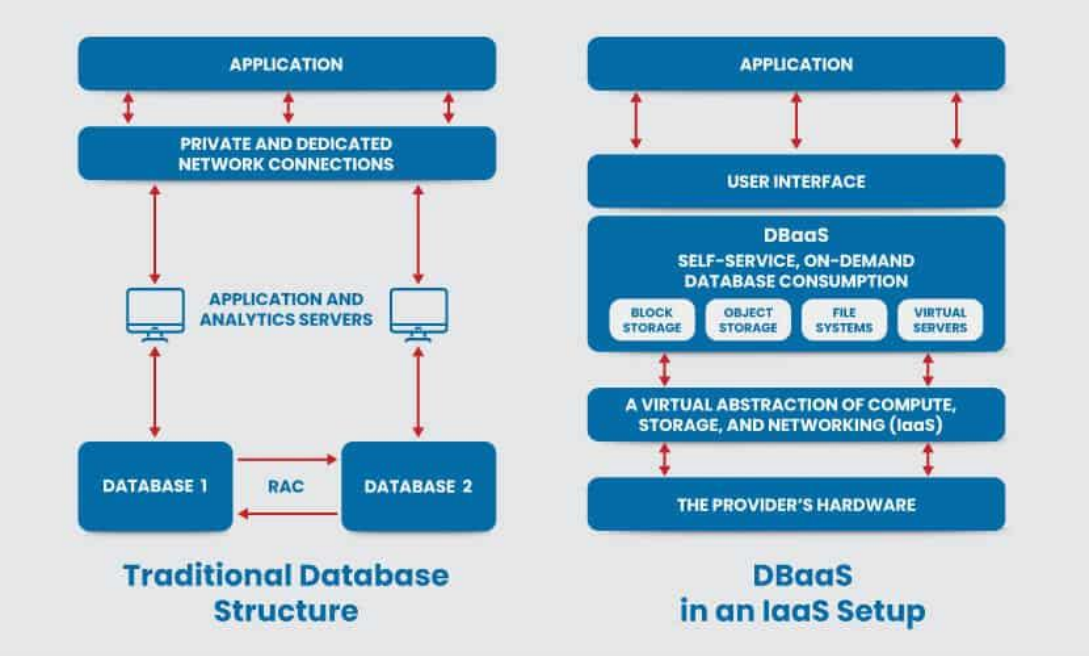
- Initial installation.
- Configuration management.
- Database maintenance.
- Performance management.
- Backups.
- Patches and upgrades.
- Disaster recovery.
- Cloud monitoring (both for the database and the underlying infrastructure).
- Maintaining high availability.

The DBaaS customer’s only responsibilities are using the database and controlling its content. However, if the company desires more control over the database, the DBaaS provider can enable more user involvement.

Another common name for DBaaS is the **managed database service**. This type of cloud service covers both relational and non-relational databases.

DBaaS removes the need to hire and train a team to manage the database. Instead, one staff member controls the database instances via an API and a management dashboard. The dashboard allows one-click operations that simplify complex processes such as provisioning and specification.

Once the console receives instructions from the user, the DBaaS platform provisions the database and returns a query-able endpoint. The user can use this code directly in the application.



Database-as-a-Service enables users to operate a database with a common set of abstractions (**primitives**) without knowing the implementations. For example, a developer could add a database instance using the same set of API calls regardless of the database type (MongoDB, Oracle, MySQL, etc.). The DBaaS model also provides simple mechanics for:

- Adding users.
- Creating schemas.
- Granting permissions.
- Activity tracking.

DBaaS Characteristics
Below are the six essential factors for choosing DBaaS providers:

Self-service: DBaaS allows the provision of Databases effortlessly to Database consumers from various backgrounds and IT experience.

On-demand - While generating overall IT savings, You pay for what you use.

Dynamic: Based on the resources available, it delivers a flexible Database platform that tailors itself to the environment's current needs.

Security - A team of experts at your disposal, continuously monitoring your Databases.

Automation: Automates Database administration and monitoring.

Leverage: Leverages existing servers and storage.

DBaaS Benefits

DBaaS offers significant operational and financial advantages over standard on-premises databases.

Developer Agility

Standard database deployment is a complex, multi-step process that requires various tasks. A typical deployment looks like this:

- A developer opens a request in the ticketing system.
- The ticket stays in the queue until it reaches the top of priorities.
- The IT team evaluates the ticket.
- If the request is valid, the team allocates the compute, storage, and networking resources for the new database.
- Resource configuration and installation start.
- The developer receives an entry point to the database and begins to use the new setup.

This process is far from agile, especially if the team is trying to transition to DevOps. Deploying databases this way is both prone to errors and time-consuming.

The DBaaS model requires zero IT intervention and automates the deployment process. The company establishes the standard of database provisioning, after which a developer can handle the deployment. IT admins focus on more crucial tasks, while developers can spin up and integrate a database in minutes.

This self-service model is ideal for companies trying to speed up the software development life cycle. The databases also become more consistent, which leads to better system reliability.

More IT Productivity

Standard database management requires the team to handle the tuning, monitoring, patching, upgrading, and resizing of the database. As companies grow, the number and types of databases that require management increase, and these tasks become even more time-consuming.

With DBaaS, the team saves valuable time as:

- The provider takes on most administrative duties.
- Complex procedures (like deployments, upgrades, and configuration changes) happen automatically.
- Developers can spin up and destroy multiple databases with a single operation.

The lack of repetitive duties and micro-managing allows the team to focus on more impactful tasks, such as building applications and innovating.

Application Security

Cloud database providers typically offer enterprise-level security. Good providers protect your databases with:

- Data encryption (both at rest and in transit).
- Integrated access management.
- Controls for regulatory compliance standards.
- End-to-end network security with micro-segmentation and virtual private networks.

The result of high-level security is less risk of data loss. Additionally, all major cloud providers offer a service-level agreement (SLA) that guarantees uptime.

Improve your data center security by adding strategic layers of protection that keep your data and systems safe.

Cost Savings

Database-as-a-Service is a cost-effective alternative to an in-house database setup. DBaaS allows a company to pay a predictable periodic fee based on the consumed resources. A business saves money by not having to invest in:

- Expensive, power-hungry hardware.
- Data centers.
- Software licensing.
- Additional on-hand capacity.
- Skilled staff to manage and maintain the infrastructure.

Database-as-a-Service also prevents unnecessary resource overhead. Like any cloud offering, users control how many resources they consume, which allows a business to ensure optimal consumption at all times.

Better Reliability and Performance

DBaaS solutions have high availability and run at peak performance. In the case of failure, the platform reroutes traffic to a replica and maintains uptime.

Database-as-a-Service has excellent scalability. Users can quickly and easily add storage and computing capacity to meet high processing demands. Scaling down during non-peak usage is also simple. This elasticity is ideal for dynamic database demands, such as end-of-quarter reporting or seasonal spikes in e-shopping.

A DBaaS system can also monitor the database for spikes in demands. If the user sets up policies for usage thresholds, the platform can automatically scale out as demand increases and scale back once demand reduces.

DBaaS Disadvantages

Despite notable benefits, DBaaS also has several disadvantages when compared to an on-premises database setup. These drawbacks are:

- **Lack of control:** In-house staff does not have access to the servers or storage behind the database. If the user's connection goes down or the provider experiences an outage, the customer cannot reach the stored content.
- **Security concerns:** Storing data on a cloud can lead to a breach if the provider is not careful. Also, the customer company does not influence the physical safety of servers.
- **Latency problems:** Accessing data over the internet can lead to performance issues, especially when loading large amounts of data.

Advantages of Cloud Computing:

On-demand self-service: A client can provision computer resources without the need for interaction with cloud service provider personnel.

Broad network access: Access to resources in the cloud is available over the network using standard methods in a manner that provides platform-independent access to clients of all types. This includes a mixture of heterogeneous operating systems, and thick and thin platforms such as laptops, mobile phones, and PDA.

Resource pooling: A cloud service provider creates resources that are pooled together in a system that supports multi-tenant usage. Physical and virtual systems are dynamically allocated or reallocated as needed. Intrinsic in this concept of pooling is the idea of abstraction that hides the location of resources such as virtual machines, processing, memory, storage, and network bandwidth and connectivity.

Rapid elasticity: Resources can be rapidly and elastically provisioned. The system can add resources by either scaling up systems (more powerful computers) or scaling out systems (more computers of the same kind), and scaling may be automatic or manual. From the standpoint of the client, cloud computing resources should look limitless and can be purchased at any time and in any quantity.

Measured service: The use of cloud system resources is measured, audited, and reported to the customer based on a metered system. A client can be charged based on a known metric such as amount of storage used, number of transactions, network I/O (Input/Output) or bandwidth, amount of processing power used, and so forth. A client is charged based on the level of services provided. While these five core features of cloud computing are on almost anybody's list, you also should consider these additional advantages:

Lower costs: Because cloud networks operate at higher efficiencies and with greater utilization, significant cost reductions are often encountered.

Ease of utilization: Depending upon the type of service being offered, you may find that you do not require hardware or software licenses to implement your service.

Quality of Service: The Quality of Service (QoS) is something that you can obtain under contract from your vendor.

Reliability: The scale of cloud computing networks and their ability to provide load balancing and failover makes them highly reliable, often much more reliable than what you can achieve in a single organization.

Outsourced IT management: A cloud computing deployment lets someone else manage your computing infrastructure while you manage your business. In most instances, you achieve considerable reductions in IT staffing costs.

Simplified maintenance and upgrade: Because the system is centralized, you can easily apply patches and upgrades. This means your users always have access to the latest software versions.

Low Barrier to Entry: In particular, upfront capital expenditures are dramatically reduced. In cloud computing, anyone can be a giant at any time.

Disadvantage of Cloud Computing

Every technology has both positive and negative aspects that are highly important to be discussed before implementing it. The aforementioned points highlight the benefits of using cloud technology and the following discussion will outline the potential cons or disadvantages of Cloud Computing.

Vulnerability to attacks

Storing data in the cloud may pose serious challenges of information theft since in the cloud every data of a company is online. A security breach is something that even the best organizations have suffered from and it's a potential risk in the cloud as well. Although advanced security measures are deployed on the cloud, still storing confidential data in the cloud can be a risky affair, and hence vulnerability to attacks shall be considered.

Network connectivity dependency

Cloud Computing is entirely dependent on the Internet. This direct tie-up with the Internet means that a company needs to have reliable and consistent Internet service as well as a fast connection and bandwidth to reap the benefits of Cloud Computing.

Downtime

Downtime is considered as one of the biggest potential downsides of using Cloud Computing. The cloud providers may sometimes face technical outages that can happen due to various reasons, such as loss of power, low Internet connectivity, data centers going out of service for maintenance, etc. This can lead to a temporary downtime in the cloud service. Downtime should also be considered while working with cloud computing. That's because your cloud provider may face power loss, low internet connectivity, service maintenance, etc.

Vendor lock-in

When in need to migrate from one cloud platform to another, a company might face some serious challenges because of the differences between vendor platforms. Hosting and running the applications of the current cloud platform on some other platform may cause support issues, configuration complexities, and additional expenses. The company data might also be left vulnerable to security attacks due to compromises that might have been made during migrations.

Limited control

Cloud customers may face limited control over their deployments. Cloud services run on remote servers that are completely owned and managed by service providers, which makes it hard for the companies to have the level of control that they would want over their back-end infrastructure.

May not get all the features
Some cloud providers offer only limited versions and with the most popular features. Before signing up, it is important to know what cloud services are provided.

Can’t do away with servers altogether
While there may be fewer servers to handle, it is not recommended to entirely let go of all your servers and staff because redundancy is key for backup and recovery.

No Redundancy
A cloud server is not redundant or backed up. Although it is an extra expense, make sure to invest in a redundancy plan as in most cases, it will be well worth it. Technology does sometimes seem to fail.

Bandwidth issues
For better performance, it is advisable not to pack large numbers of storage devices and servers into a small set of data centers. The additional charges could be, however, significantly costly.

Lacks Support
Cloud Computing companies do not provide proper support to their customers and expect them to depend on FAQs or online help.

Technical Issues
Cloud technology is known to experience outages and other technical issues. Despite high standards of maintenance, there are possibilities of technical issues. Cloud technology is always prone to an outage and other technical issues. Even, the best cloud service provider companies may face this type of trouble despite maintaining high standards of maintenance.

Performance Can Vary
When you are working in a cloud environment, your application is running on the server which simultaneously provides resources to other businesses. Any greedy behavior or DDOS attack on your tenant could affect the performance of your shared resource.
In a cloud environment, applications run on the server which also provides resources to other businesses. This means that any attack or harmful activity on a tenant could affect the performance of the shared resources.

Security Threat in the Cloud
Another drawback while working with cloud computing services is security risk. Before adopting cloud technology, you should be well aware of the fact that you will be sharing all your company’s sensitive information to a third-party cloud computing service provider. Hackers might access this information.

Internet Connectivity
Good Internet connectivity is a must in cloud computing. You can’t access cloud without an internet connection. Moreover, you don’t have any other way to gather data from the cloud.

Lower Bandwidth
Many cloud storage service providers limit bandwidth usage of their users. So, in case if your organization surpasses the given allowance, the additional charges could be significantly costly

Lacks of Support

Cloud Computing companies fail to provide proper support to the customers. Moreover, they want their user to depend on FAQs or online help, which can be a tedious job for non-technical persons.

Short Question

1) What is Cloud computing?
2) Explain hybrid cloud with example?
3) Explain IaaS with Example?
4) Explain PaaS with Example?
5) Explain SaaS with Example?
6) Explain NaaS with Example?
7) Explain DBaaS with Example?
8) List Companies providing the IaaS?
9) List Companies providing the PaaS?
10) List Companies providing the SaaS?
11) List Companies providing the NaaS?
12) List Companies providing the DBaaS?

Long Question

1) What is Cloud Computing? Explain with an example and also discuss the advantages and disadvantages?
2) Explain the components of the cloud with Example?
3) Explain Types of clouds with an example.
4) Comparison among Public, Private and Hybrid Cloud?
5) Explain IaaS service model with advantages and disadvantages?
6) Explain PaaS service model with advantages and disadvantages?
7) Explain SaaS service model with advantages and disadvantages?
8) Explain NaaS service model with advantages and disadvantages?
9) Explain DBaaS service model with advantages and disadvantages?
10) Comparison between IaaS, PaaS, SaaS, NaaS, and DBaaS?