Computing Paradigms

Definition of Cloud Computing:-

Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources.

Computing Paradigms Lists:-

we look into the various computing paradigms: namely

High-Performance Computing

Parallel Computing

Distributed Computing

Cluster Computing

Grid Computing

Cloud Computing

Biocomputing

Mobile Computing

Quantum Computing

Optical Computing

Nanocomputing

Network Computing

1. High-Performance Computing

In high-performance computing systems, a pool of processors (processor machines or central processing units [CPUs]) connected (networked) with other resources like memory, storage, and input and output devices, and the deployed software is enabled to run in the entire system of connected components.

The processor machines can be of homogeneous or heterogeneous type.

2. Parallel computing

In parallel computing, all processors are either tightly coupled with centralized shared memory or loosely coupled with distributed memory.

3. Distributed computing: This is a field of computer science/engineering that studies distributed systems. A distributed system consists of multiple autonomous computers, each having its own private memory, communicating through a computer network.

Advantages of Distributed computing systems are advantageous over centralized systems, because there is a support for the following characteristic features:

Scalability: It is the ability of the system to be easily expanded by adding more machines as needed, and vice versa, without affecting the existing setup.

Redundancy or replication: Here, several machines can provide the same services, so that even if one is unavailable (or failed), work does not stop because other similar computing supports will be available.

4. Cluster computing

Cluster computing systems became popular when the price/performance ratio of personal computers and workstations improved.At a certain point,

it became financially and technically attractive to build a supercomputer

using off-the-shelf technology by simply hooking up a collection of

relatively simple computers in a high-speed network. In virtually all cases,

cluster computing is used for parallel programming in which a single

(compute intensive) program is run in parallel on multiple machines.

5. Grid Computing

A characteristic feature of cluster computing is its homogeneity. In most

cases, the computers in a cluster are largely the same, they all have the

same operating system, and are all connected through the same network.

In contrast, grid computing systems have a high degree of heterogeneity:

no assumptions are made concerning hardware, operating systems,

networks, administrative domains, security policies, etc. A key issue in a

grid computing system is that resources from different organizations are

brought together to allow the collaboration of a group of people or

institutions. Such a collaboration is realized in the form of a virtual

organization.

Grid computing is more popular due to the following reasons:

1.Its ability to make use of unused computing power, and thus, it is a cost effective solution (reducing investments, only recurring costs)

2.As a way to solve problems in line with any HPC-based application

Enables heterogeneous resources of computers to work cooperatively and collaboratively to solve a scientific problem.

6. Cloud Computing

Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources.

7. Biocomputing

Biocomputing systems use the concepts of biologically derived or simulated molecules (or models) that perform computational processes in order to solve a problem.

8. Mobile Computing

In mobile computing, the processing (or computing) elements are small (i.e., handheld devices) and the communication between various resources is tak- ing place using wireless media. Mobile communication for voice applications (e.g., cellular phone).

9. Quantum Computing

Manufacturers of computing systems say that there is a limit for cramming more and more transistors into smaller and smaller spaces of integrated circuits (ICs).

10. Optical computing

Optical computing system uses the photons in visible light or infrared beams, rather than electric current, to perform digital computations.

11. Nanocomputing

Nanocomputing refers to computing systems that are constructed from nanoscale components.

12.Network Computing

Network computing is a way of designing systems to take advantage of the latest technology and maximize its positive impact on business solutions and their ability to serve their customers using a strong underlying network of computing resources.

Age of Internet Computing (Historical View):-

Computer technology has gone through five generations of development, with each generation lasting from 10 to 20 years. Successive generations are overlapped in about 10 years. For instance, from 1950 to 1970, a handful of mainframes, including the IBM 360 and CDC 6400, were built to satisfy the demands of large businesses and government organizations.

From 1960 to 1980, lower-cost mini-computers such as the DEC PDP 11 and VAX Series became popular among small businesses and on college campuses.

From 1970 to 1990, we saw widespread use of personal computers built with VLSI microprocessors. From 1980 to 2000, massive numbers of portable computers and pervasive devices appeared in both wired and wireless applications. Since 1990, the use of both HPC and HTC systems hidden in.

Mainframes and Cloud Computing: Similarities and Differences

What are the similarities?

Client-server model: If you look closely at both mainframes and cloud computing, you'll see that both are implementations of the client-server model where applications are stored and run on remote servers.

With the mainframe, applications are stored and run on large server computers stored in specialised, air-conditioned rooms designed specifically for housing the mainframe. Users then connect to the mainframe with the use of client terminals or, in more recent times, terminal emulation software. With cloud computing applications may be stored on various servers, but they are still accessed through a thin client).

Thin clients: Because all of the data is accessed from a remote location (ie. it is not stored on the user's own computer), users are able to get faster and more painless access to data from wherever they are located. Admittedly, these similarities are based on the differences in the computing environment in which they emerged.

What are the differences?

Server location: When it comes to a mainframe, the server is always a single, monolithic host that resides in a centralized location -- as mentioned earlier, this is usually a specially-built and air conditioned room to house the mainframe. Cloud computing, on the other hand, may be scattered across many individual servers.

Scalability: One of the main advantages of cloud computing over mainframe models is the ability to dynamically scale resources and power. Because the cloud can be accessed from anywhere, businesses can increase access to the server as they grow simply by adding further clients. They can even extend this access to mobile devices.

Security: One of the biggest advantages of mainframe computers is the security. Because cloud computing relies on an internet connection in order for users to access the server, it runs the risk of being compromised by intruders. Additionally, by utilising a cloud service provider, you're effectively putting your trust in that service provider that your data will be safe, as it will be kept on servers that are owned by them.

Reliability: Another advantage of mainframe computing is higher reliability. If an internet connection goes down, or if the host servers go down, the client will be unable to access its data. At least if there is a problem with a local mainframe, there will be on-site IT staff available that can be working on the problem as a priority.

The Need for Cloud

The main reasons for the need and use of cloud computing are convenience and reliability. In the past, if we wanted to bring a file, we would have to save it to a Universal Serial Bus (USB) flash drive, external hard drive, or compact disc (CD) and bring that device to a different place. Instead, saving a file to the cloud (e.g., use of cloud application Dropbox) ensures that we will be able to access it with any computer that has an Internet connection.

The cloud also makes it much easier to share a file with friends, making it possible to collaborate over the web.

ROOTS OF CLOUD COMPUTING

The roots of clouds computing by observing the advancement of several technologies, especially in hardware (virtualization, multi-core chips), Internet technologies (Web services, service-oriented architectures, Web 2.0), distributed computing (clusters, grids), and systems management (autonomic computing, data center automation).

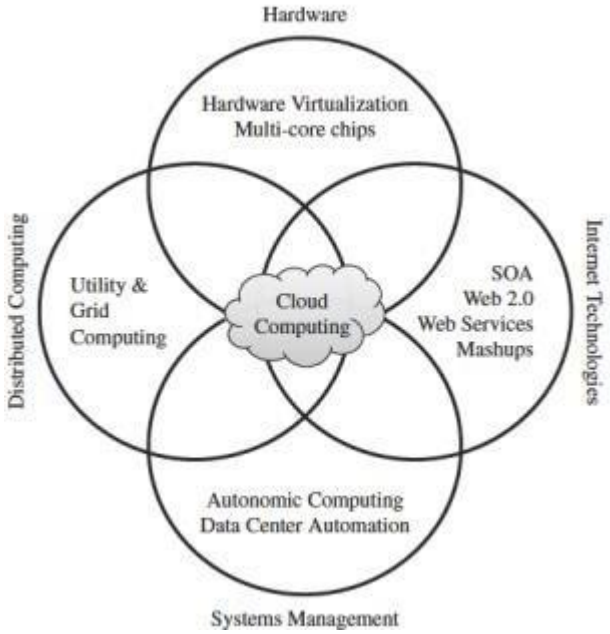


Figure : Convergence of various advances leading to the advent of cloud computing

Service-Oriented Architecture SOA Service-Oriented Architecture helps to use applications as a service for other applications regardless the type of vendor, product or technology. Therefore, it is possible to exchange the data between applications of different vendors without additional programming or making changes to services.

Key Properties of Cloud Computing:-

Cloud Computing Is User Centric : Once as a user are connected to the cloud, whatever is stored there—documents, messages, images, applications, whatever—becomes authorized to the user access them.

Cloud Computing Is Task-Centric: Instead of focusing on the application and what it can do, the focus is on what one need done and how the application can do it for us. Traditional applications—word processing, spreadsheets, email, and so on—are becoming less important than the documents they create.

Cloud Computing Is Powerful: Connecting hundreds or thousands of computers together in a cloud creates a wealth of computing power impossible with a single desktop PC.

Cloud Computing Is Accessible: Because data is stored in the cloud, users can instantly retrieve more information from multiple repositories. We are not limited to a single source of data, as we do with a desktop PC.

Cloud Computing Is Intelligent: With all the various data stored on the computers in a cloud, data mining and analysis are necessary to access that information in an intelligent manner.

Cloud Computing Is Programmable: Many of the tasks necessary with cloud computing must be automated.

Cloud Computing Benefits:-

Cloud computing benefits can be categorized into:

Cost Reduction: The consumer does not need to take the stress of updating the software and hardware as they can get the latest and updated resources and services relatively in less time.

Power Management: It is easier to manage virtual server as compared to physical server.

Scalability: It is the one of the main positive aspects of cloud computing. If there is peak load or high traffic for a site, cloud can handle easily without need of any additional hardware infrastructure or equipments.

Data Storage: There are various data centers spread throughout the world and it makes easy for the businesses to choose the datacenter as per their convenience to get fast and easy access of services with unlimited data storage.

Efficiency and reliability: To find efficiencies many organizations are moving towards cloud and backup is another significant advantage to the cloud and it maintains backup for all remote sites and branch offices.

Limitations of Cloud Computing

Data segregation: As data of many users are stored in same data center and same server or same hard disks it will raise the question from the users about the problem of mismatch. How

cloud securely isolate users and differentiate the memory and storage of each users as this failure could lead to leakage of information from one customer to another

The Offline cloud : As cloud computing is fully dependent upon internet connection. If the customer has a problem with internet connection then he/she is unable to access the application or data from internet.

Privacy: Privacy is one of the major issues in cloud. Users are always concerned about their data so to overcome this issue provider should assure the users in following points. First, Employees are aware of their responsibilities related to the confidentiality, integrity, availability of data and information systems. Second, The confidential and/or personal client data including system access credentials are protected (e.g. encrypted) from unauthorized interception.

Security: Cloud computing providers support encryption and identity management but still people do not want to place secrets in to the cloud.

Cloud Computing Architecture

Cloud Components:-

Clients

Clients are, in a cloud computing architecture, the exact same things that they are in a plain, old, everyday local area network (LAN). They are, typically, the computers that just sit on your desk. But they might also be laptops, tablet computers, mobile phones, or PDAs—all big drivers for cloud computing because of their mobility. Anyway, clients are the devices that the end users interact with to manage their information on the cloud. Clients generally fall into three categories:

Mobile: Mobile devices include PDAs or smartphones, like a Blackberry, Windows Mobile Smartphone, or an iPhone.

Thin Clients are computers that do not have internal hard drives, but rather let the server do all the work, but then display the information.

Thick Clients This type of client is a regular computer, using a web browser like Firefox or Internet Explorer to connect to the cloud.

Data Center

The data center is the collection of servers where the application to which you subscribe is housed. It could be a large room in the basement of your building or a room full of servers on the other side of the world that you access via the Internet. A growing trend in the IT world is virtualizing servers. That is, software can be installed allowing multiple instances of virtual servers to be used. In this way, you can have half a dozen virtual servers running on one physical server.

Distributed Servers

Distributed cloud is the application of cloud computing technologies to interconnect data and applications served from multiple geographic locations.

Cloud Computing Models:-

Cloud computing is a model that enables the end users to access the shared pool of resources such as compute, network, storage, database, and application as an on- demand service without the need to buy or own it. The services are provided and managed by the service provider, reducing the management effort from the end user side.. The National Institute of Standards and Technology (NIST) defines three basic service models, namely, IaaS, PaaS, and SaaS, as shown in Figure. The NIST definition of the three basic service models is given as follows:

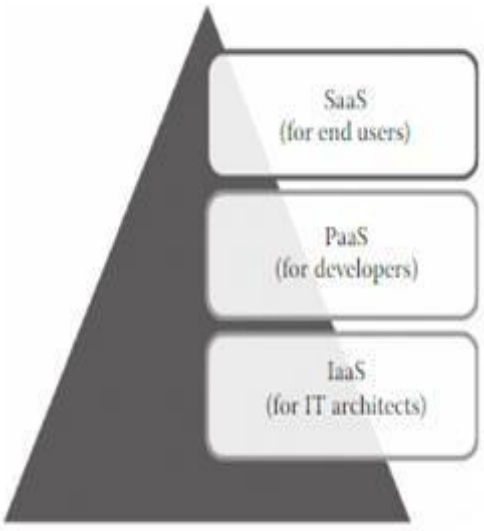


Figure: Basic cloud service models

Infrastructure as a Service (IaaS):

The ability given to the infrastructure architects to deploy or run any software on the computing resources provided by the service provider. Here, the underlying infrastructures such as compute, network, and storage are managed by the service provider. Thus, the infrastructure architects are exempted from maintaining the data center or underlying infrastructure. The end users are responsible for managing applications that are running on top of the service provider cloud infrastructure. Generally, the IaaS services are provided from the service provider cloud data center.

The end users can access the services from their devices through web command line interface (CLI) or application programming interfaces (APIs)provided by the service providers. Some of the popular IaaS providers include Amazon Web Services (AWS), Google Compute Engine, OpenStack, and Eucalyptus.

Benefits of IaaS:-

allows the cloud provider to freely locate the infrastructure over the Internet in a cost- effective manner. Some of the key benefits of IaaS are listed below:

Full Control of the computing resources through Administrative Access to VMs.

Flexible and Efficient renting of Computer Hardware.

Portability, Interoperability with Legacy Applications.

Platform as a Service (PaaS):

The ability given to developers to develop and deploy an application on the development platform provided by the service provider. The developers are responsible for managing the deployed application and configuring the development environment. Generally, PaaS services are provided by the service provider on an on-premise or dedicated or hosted cloud infrastructure.

The developers can access the development platform over the Internet through web CLI, web user interface (UI), and integrated development environments (IDEs).

Benefits of the PaaS model include:

Lower total cost of ownership: Consumer need not purchase expensive hardware, servers, power and data storage.

Scalable solutions: It is very easy to scale up or down utomatically based on application resource demands.

More current system software:It is the responsibility of the cloud provider to maintain software versions and patch installations.

Software as a Service (SaaS):

The ability given to the end users to access an application over the Internet that is hosted and managed by the service provider. Thus, the end users are exempted from managing or controlling an application, the development platform, and the underlying infrastructure. Generally, SaaS services are hosted in service provider–managed or service provider–hosted cloud infrastructure.

Benefits of the SaaS model include:

easier administration

automatic updates and patch management

compatibility: All users will have the same version of software.

easier collaboration, for the same reason

global accessibility.

Cloud Computing Architecture

Cloud Deployment Models

Deployment models can be defined as the different ways in which the cloud can be deployed. These models are fully user centric, that is, these depend on users' requirement and convenience. A user selects a model based on his or her requirement and needs. The NIST defines four different types of cloud deployment models in the cloud:

Private cloud

Public cloud

Community cloud

Hybrid cloud

The service delivery of cloud services through different deployment models is shown in Figure.

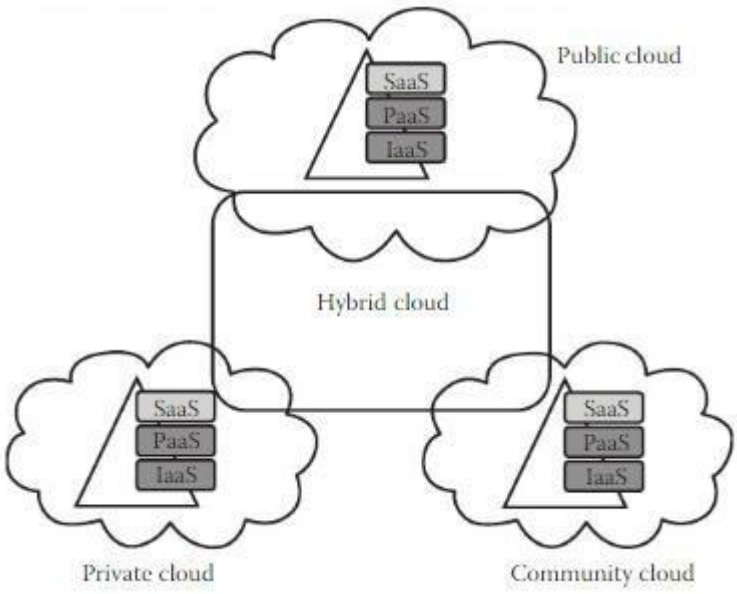


Figure 3.6 Deployment and delivery of different cloud service delivery models.

The private cloud is the most basic deployment model that can be deployed by a single organization for its personal use. It is not shared by other organizations, and it is not allowed for public use. The private cloud is to serve the people of an organization. It is usually on premise but can be outsourced also. The next one is the community cloud, which is an extension of the private cloud. Here, the cloud is the same as the private cloud but is shared by several organizations. The community cloud is established for a common cause.

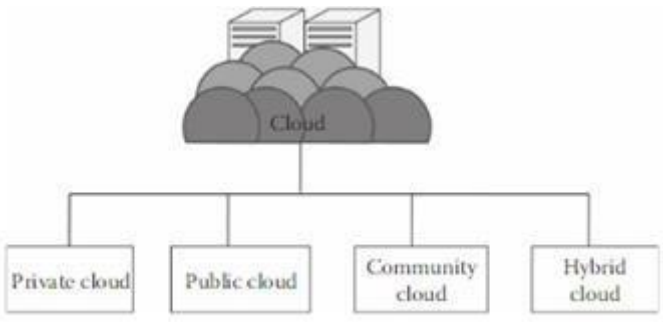


Figure: Cloud deployment models

The next is the public cloud, which is the opposite of the private cloud. This cloud allows access from any place in the world and is open to the public. This cloud is biggest in size among all other deployment models. The public cloud model is one of the most popular deployment models. The public cloud service provider charges the users on an hourly basis and serve the users according to the service-level agreements (SLAs), which are discussed in the succeeding sections. The next one is the hybrid cloud, which is a combination of other deployments. Usually, it consists of the private and public clouds combined. Several properties of the private cloud are used with the properties of the public cloud.

Private Cloud

In this section, the private cloud deployment model is discussed. According to the National Institute of Standards and Technology (NIST), private cloud can be defined as the cloud infrastructure that is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization

Characteristics

Certain characteristics of the private cloud are as follows:

Secure: The private cloud is secure. This is because usually the private cloud is deployed and managed by the organization itself, and hence there is least chance of data being leaked out of the cloud.

Central control: The organization mostly has full control over the cloud as usually the private cloud is managed by the organization itself.

Weak SLAs: Formal SLAs may or may not exist in a private cloud.

Suitability

Suitability refers to the instances where this cloud model can be used. It also signifies the most suitable conditions and environment where this cloud model can be used, such as the following:

The organizations or enterprises that require a separate cloud for their personal or official use.

The organizations or enterprises that have a sufficient amount of funds as managing and maintaining a cloud is a costly affair

The organizations or enterprises that consider data security to be important

The organizations that want autonomy and complete control over the cloud

The organizations that have a less number of users.

The organizations that have prebuilt infrastructure for deploying the cloud and are ready for timely maintenance of the cloud for efficient functioning.

Special care needs to be taken and resources should be available for troubleshooting.

The private cloud platform is not suitable for the following:

The organizations that have high user base

The organizations that have financial constraints

The organizations that do not have prebuilt infrastructure

Advantages

The cloud is small in size and is easy to maintain.

It provides a high level of security and privacy to the user.

It is controlled by the organization.

Disadvantages

For the private cloud, budget is a constraint.

The private clouds have loose SLAs.

Public Cloud

According to NIST, the public cloud is the cloud infrastructure that is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.

Characteristics

1.Highly scalable: The public cloud is highly scalable. The resources in the public cloud are large in number and the service providers make sure that all the requests are granted. Hence, the public cloud is considered to be scalable.

Affordable: The public cloud is offered to the public on a pay-as-you-go basis; hence, the user has to pay only for what he or she is using (usually on a per-hour basis).

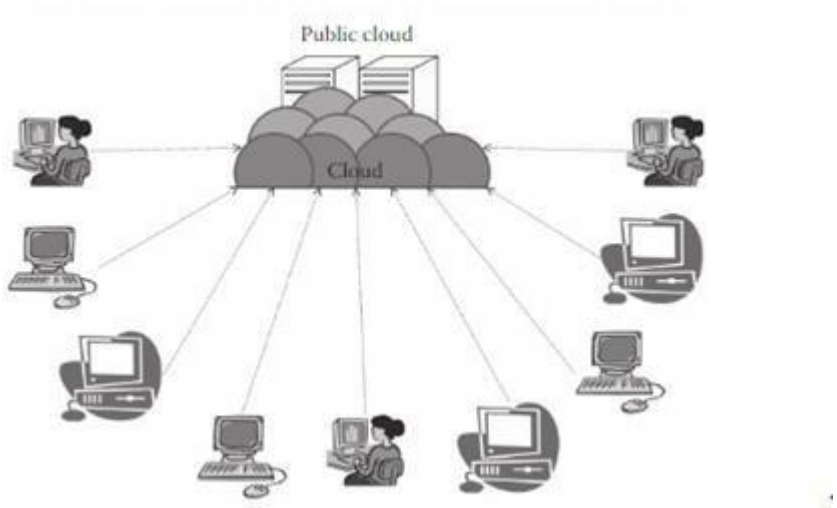


Figure : Public Cloud

Less secure: The public cloud is less secure out of all the four deployment models. This is because the public cloud is offered by a third party and they have full control over the cloud. Though the SLAs ensure privacy, still there is a high risk of data being leaked.

Highly available: The public cloud is highly available because any body from any part of the world can access the public cloud with proper permission, and this is not possible in other models as geographical or other access restrictions might be there.

Stringent SLAs: SLA is very stringent in the case of the public cloud. As the service provider's business reputation and customer strength are totally dependent on the cloud services, they follow the SLA strictly and violations are avoided. These SLAs are very competitive.

2.Suitability

There are several occasions and environments where the public cloud is

suitable. Thus, the suitability of the public cloud is described. The public cloud can be used whenever the following applies:

The requirement for resources is large, that is, there is large user base.

The requirement for resources is varying.

There is no physical infrastructure available.

An organization has financial constraints.

The public cloud is not suitable, where the following applies:

Security is very important.

Organization expects autonomy.

Third-party reliability is not preferred.

3.Advantages.;

There is no need of establishing infrastructure for setting up a cloud.

There is no need for maintaining the cloud.

They are comparatively less costly than other cloud models.

Strict SLAs are followed.

There is no limit for the number of users.

The public cloud is highly scalable.

4.Disadvantages

Security is an issue

Privacy and organizational autonomy are not possible.

5. Issues

Network: The network plays a major role in the public cloud. Each and every user getting the services of the cloud gets it through the Internet. The services are accessed through the Internet by all the users, and hence, the service delivery wholly depends on the network. Unlike the private cloud where the organization takes responsibility for the network, here the service provider is not responsible for the network.

Multitenancy: The resources are shared, that is, multiple users share the resources, hence the term multitenant. Due to this property, there is a high risk of data being leaked or a possible unprivileged access.

Location: The location of the public cloud is an issue. As the public cloud is fragmented and is located in different regions, the access to these clouds involves a lot of data transfers through the Internet. There are several issues related to the location. For example, a user from India might be using the public cloud and he might have to access his personal resources from other countries. This is not good as the data are being stored in some other country.

Security and data privacy : Security and data privacy are the biggest challenges in the public cloud. As data are stored in different places around the globe, data security is a very big issue. A user storing the data outside his or her country has a risk of the data being viewed by other people as that does not come under the jurisdiction of the user's country. Though this might not always be true, but it may happen.

Laws and conflicts: The data are stored in different places of the world in different countries. Hence, data centers are bound to laws of the country in which they are located. This creates many conflicts and problems for the service providers and the users.

Community Cloud

Cloud Computing Architecture

Cloud Deployment Models

According to NIST, the community cloud is the cloud infrastructure that is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises. It is a further extension of the private cloud. Here, a private cloud is shared between several organizations.

The main advantage of the public cloud is that the organizations are able to share the resources among themselves based on specific concerns. Thus, here the organizations are able to extract the power of the cloud, which is much bigger than the private cloud, and at the same time, they are able to use it at a usually less cost. Figure bellow describes the community cloud.

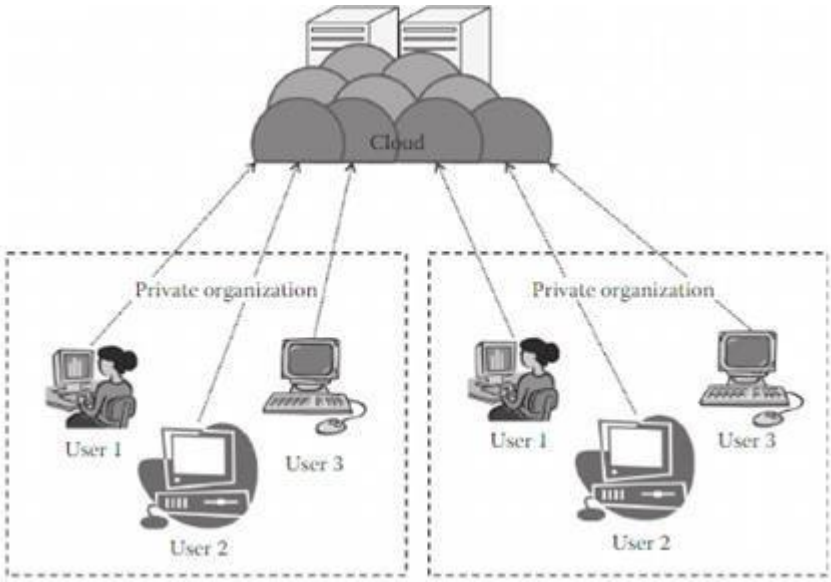


Figure : community cloud

Characteristics

Collaborative and distributive maintenance: The community cloud is wholly collaborative, and usually no single party has full control over the whole cloud (in some cases, it may be controlled by one party).

Partially secure: Partially secure refers to the property of the com-munity cloud where few organizations share the cloud, so there is a possibility that the data can be leaked from one organization to another, though it is safe from the outside world.

Cost effective: The community cloud is cost effective as the whole cloud is being shared by several organizations or a community.

Suitability

This kind of cloud is suitable for organizations that

Want to establish a private cloud but have financial constraint

Do not want to complete maintenance responsibility of the cloud

Want to establish the cloud in order to collaborate with other clouds

Want to have a collaborative cloud with more security features than the public cloud

This cloud is not suitable for organizations that

Prefer autonomy and control over the cloud

Does not want to collaborate with other organizations

Advantages

It allows establishing a low-cost private cloud.

It allows collaborative work on the cloud

It allows sharing of responsibilities among the organization.

It has better security than the public cloud.

Disadvantages

Autonomy of an organization is lost

Security features are not as good as the private cloud

It is not suitable if there is no collaboration.

Hybrid Cloud

According to NIST, the hybrid cloud can be defined as the cloud infrastructure that is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.

The hybrid cloud usually is a combination of both public and private clouds. This is aimed at combining the advantages of private and public clouds. The usual method of using the hybrid cloud is to have a private cloud initially, and then for additional resources, the public cloud is used. There are several advantages of the hybrid cloud. The hybrid cloud can be regarded as a private cloud extended to the public cloud.

Figure in bellow shows the hybrid cloud.

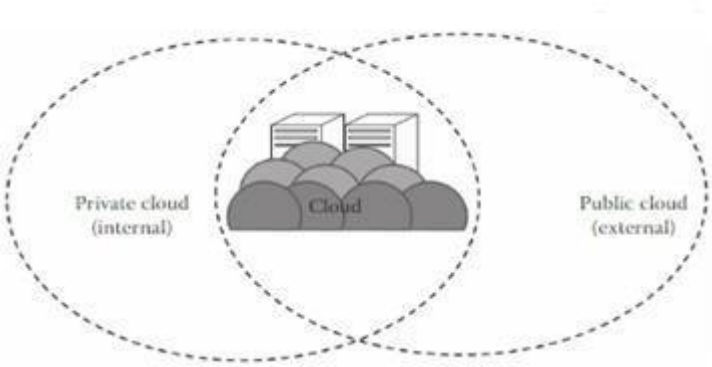


Figure 3.10 Hybird cloud

Characteristics

Scalable : The hybrid cloud is a combination of one or more deployment models. Usually, the private with public cloud gives hybrid cloud. The main reason of having a hybrid cloud is to use the property of a public cloud with a private cloud environment.

Partially secure: The hybrid cloud usually is a combination of public and private. The private cloud is considered to be secured, but as the hybrid cloud also uses the public cloud, there is high risk of security breach. Thus, it cannot be fully termed as secure but as partially secure.

Complex cloud management: Cloud management is complex and is a difficult task in the hybrid cloud because it involves more than one type of deployment models and also the numbers of users are high.

Suitability

The hybrid cloud environment is suitable for

Organizations that want the private cloud environment with the scalability of the public cloud

Organizations that require more security than the public cloud

The hybrid cloud is not suitable for

Organizations that consider security as a prime objective

Organizations that will not be able to handle hybrid cloud management

Issues

The cloud can be analyzed in the following aspects:

Network: The network is usually a private network, and whenever there is a necessity, the public cloud is used through the Internet. Unlike the public cloud, here there is a private network also.

Multitenancy: Multitenancy is an issue in the hybrid cloud as it involves the public cloud in addition to the private cloud. Thus, this property can be misused and the breaches will have adverse effects as some parts of the cloud go public.

Location: Like a private cloud, the location of these clouds can be on premise or off premise and they can be outsourced. They will have all the issues related to the private cloud; in addition to that, issues related to the public cloud will also come into picture whenever there is intermittent access to the public cloud.

Security and privacy: Whenever the user is provided services using the public cloud, security and privacy become more stringent. As it is the public cloud, the threat of data being lost is high.

Laws and conflicts: Several laws of other countries come under the purview as the public cloud is involved, and usually these public clouds are situated outside the country's boundaries.

Advantages

It gives the power of both the private and public clouds.

It is highly scalable.

It provides better security than the public cloud

Disadvantages

The security features are not as good as the public cloud.

Managing a hybrid cloud is complex.

STORAGE OF CLOUD COMPUTING

Storage Cloud Overview

A storage cloud provides storage as a service (SaaS) to storage consumers. It can be delivered in any of the previously described cloud delivery models (public, private, hybrid, and community). A storage cloud can be used to support a diverse range of storage needs, including mass data stores, file shares, backup, archive, and more. Implementations range from public user data stores to large private storage area networks (SAN) or network-attachedstorage (NAS), hosted in-house or at third-party managed facilities. The following examples are publicly available storage clouds:

IBM Cloud offers various storage options, including archive, backup, and object storage.

Skydrive from Microsoft allows the public to store and share nominated files on theMicrosoft public storage cloud service.

Email services, such as Hotmail, Gmail, and Yahoo, store user email and attachments intheir respective storage clouds.

Facebook and YouTube allow users to store and share photos and videos.

Storage cloud capability can also be offered in the form of storage as a service , where you pay based on the amount of storage space used. A storage cloud can be used in various ways, based on your organization's specific requirements.

Figure 4-1 shows how various electronic or portable devices can access storage through the Internet without necessarily knowing the explicit details of the type or location of storage that is used underneath. Although the devices can access SAN or NAS storage, SAN or NAS storage can itself use storage cloud for backup or other purposes

Figure 4.1 overview of storage cloud

Storage Usage Differences Within A Storage Cloud Infrastructure

Within a cloud infrastructure, a useful distinction can be made between how storage capacity is used. This distinction is similar to the difference that exists in traditional IT between system data (files, libraries, utilities, and so on), and application data and user files. This distinction becomes important for storage allocation in virtual server implementations.

Storage cloud

Storage cloud is the storage capacity service that is provided for client data. A storage cloud exhibits the characteristics that are essential to any cloud service (self-service provisioning, Internet and intranet accessibility, pooled resources, elastic, and metered). It isa cloud environment on which the offered services can store and retrieve data on behalf of computing processes that are not part of the storage cloud service. A storage cloud can be used in combination with a compute cloud, a private compute facility, or as storage for a computing device. Storage in a storage cloud can be categorized as follows:

Hosted storage

This category is primary storage for block or file data that can be written and read on demand, and is provisioned as generally higher performance and availability storage.

Reference storage

This category is fixed content storage to which blocks or files are typically written to once, and read from many times. Examples of data typically on reference storage include multimedia, archival data, medical imaging, surveillance data, and log files.

Storage for cloud

Storage for cloud is a general name that is applied to the type of storage environment, implemented in cloud computing that is required to provision cloud computing services. For example, when a virtual server is created, some storage capacity is required. This storage is provisioned as part of the virtual machine creation process to support the operating system

and runtime environment for the instance. It is not delivered by a storage cloud. However, it can be provisioned from the same storage infrastructure as a storage cloud. The types of storage provisioned for a cloud service can be categorized as follows:

Ephemeral storage

This storage is required only while a virtual machine is running. It is freed from use and made available to the storage pool when the virtual machine is shut down. Examples of this category of storage include boot volumes, page files, and other temporary data.

Persistent storage

This storage is required across virtual machine restarts. It is retained even when a virtual machine is shut down. It includes “gold” (master template) images, systems customization, and user data. Figure 4.2 illustrates the categories of storage found in cloud computing

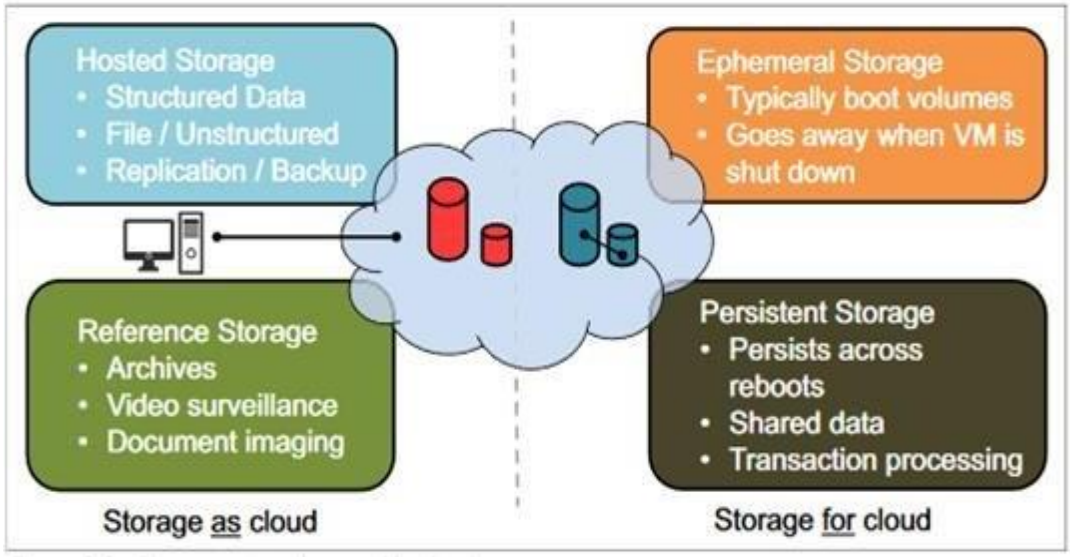


Figure 4.2 Storage Categories Used In Cloud

Storage Cloud Delivery Models

The cloud delivery model that is described in previous chapter can be extended to include storage cloud as outlined in the following descriptions.

Public storage cloud

Data is stored on the premises of the cloud storage service provider and is accessed through network services. All the management tasks that are associated with storage, such as upgrading and replacing, are carried out by the storage service provider. You just pay for the amount of storage space that is consumed. Typically, this storage capacity is somewhat inexpensive because of economies of scale, with different levels of performance and availability at different price points. For data stored in the public storage cloud, security and multitenancy are major areas of concern that need to be evaluated in accordance withbusiness requirements. Storage resources can be scaled up or down to meet the user requirements. In this model, the bulk of capital expenditures (CAPEX) to acquire storage capacity is shifted to operational expense because the storage cloud service provider purchases the resources and therefore incurs the CAPEX.

Private Storage Cloud

Data is stored on the client's own premises and accessed within the client's intranet. The management can be done either by the client or can be outsourced to a service provider. Like the public storage cloud, different levels of performance and availability can be provided at different price points. Unlike the public model, data is comparatively secure behind enterprise firewalls on dedicated hardware. Because the storage space is not shared byother organizations, security and multitenancy concerns are the same as in traditional IT. In this model, the client can also save significantly with storage consolidation and virtualization.

Hybrid Storage Cloud

As the name implies, hybrid storage data is provisioned in a mixed private and public environment. For example, business-critical data (payroll processing, human-resources (HR), finance) can be stored in a private cloud (to provide security and control over the data) and relatively less important data can be maintained in public cloud storage.

Community Storage Cloud

A community storage cloud limits access to a cloud infrastructure to organizations within a specific "community" that has common requirements and concerns (for example,

mission, security requirements, policy, and compliance considerations). The participating organizations realize the benefits of a storage cloud, such as shared infrastructure costs and a pay-as-you-go billing structure, with added levels of privacy, security, and policy compliancethat are usually associated with a private cloud. The community cloud infrastructure can be delivered on premises or at a third party's data center, and can be managed by the participating organizations or a third party.

Implementation Considerations for Storage Cloud

Storage cloud is still an emerging paradigm. Although it offers many advantages, you need to be aware of these challenges:

You need of a reliable and robust network infrastructure for remote data access. Becausethe storage is accessed over the Internet or intranet, a good network connection is essential. The reliability of network providers such as Internet service providers (ISPs) isan important factor because in some parts of the globe, the Internet is not up to current standards.

Security is an important factor. Beyond user name and password, consider encryption for sensitive data.

You need to maintain security and control of data that is stored off-site, especially at third-party locations. Data can be encrypted when transmitted from an on-premises data center to an off-premises cloud service provider.

Because standards are still evolving, avoiding vendor lock-in should be part of a selectionprocess. Focus on cloud service providers who adopt open standards and participate in open source communities.

Know the overall reliability of the cloud storage provider. Are SLAs required and will providers offer adequate assurance of service delivery? Will the provider remain viable inthe future?

Multitenancy (isolation) can be critical. Data needs to be protected from other clients whoshare cloud storage resources, security threats, viruses, and so on, because data is stored on a common shared storage infrastructure.

Difficulty in applying policies across many independent file systems in an enterprise cancause operational problems.

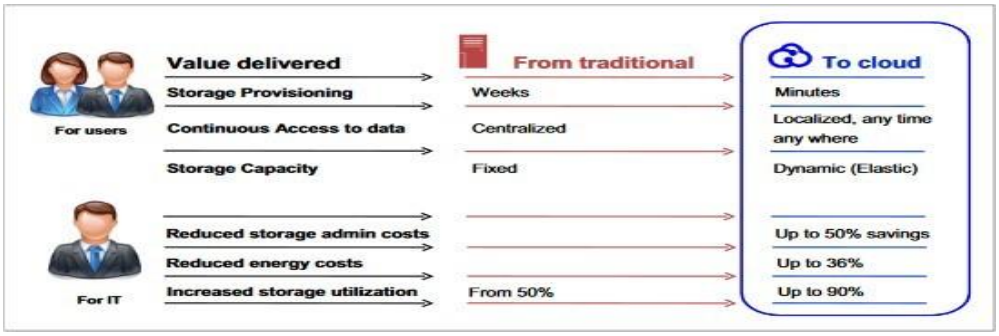
Determine whether the cloud storage provider can scale to your capacity requirements and maintain the required performance service levels.

Be able to manage complexity of separate hardware from multiple vendors. Standardization can simplify management for heterogeneous storage devices.

Benefits and Features Of Storage Cloud

The overall benefits of storage cloud vary significantly based on the underlyingstorage infrastructure. Storage cloud can help businesses achieve more effectivefunctionality at a lower cost while improving business agility and reducing project scheduling risk. Figure 4.3 identifies basic differences between the traditional IT model and a storage cloud model.

Figure 4.3 Benefits of moving to storage cloud from traditional IT infrastructure



Dynamic scaling and provisioning (elasticity)

One of the key advantages of storage cloud is dynamic scaling, also known as elasticity. Elasticity means that storage resources can be dynamically allocated (scaled up) or released (scaled down) based on business needs. Traditional IT storage infrastructure administration most often acquires capacity that is needed within the next year or two, which necessarily means this reserve capacity will be idle or underutilized for some period or time. A storage cloud can start small and grow incrementally with

business requirements, or even shrink to lower costs if appropriate to capacity demands. For this key reason, storage cloud can support a company’s growth while reducing net capital investment in storage.

Faster deployment of storage resources

New enterprise storage resources can be provisioned and deployed in minutes compared to less optimized traditional IT, which typically takes more time, sometimes days or even months.

Reduction in TCO and better ROI

Enterprise storage virtualization and consolidation lower infrastructure total cost of ownership (TCO) significantly, with centralized storage capacity and management driving improved usage and efficiency. It generally provides a significantly higher return on investment (ROI) through storage capacity cost avoidance. In addition, savings can be gained because of reduced floor space, energy required for cooling, labor costs, and also support and maintenance. This gain can be important where storage costs grow faster than revenues and directly affect profitability.

Reduce cost of managing storage

Virtualization helps in consolidating storage capacity and helps achieve much higher utilization, significantly reducing the capital expenditure on storage and its management. Dynamic, flexible chargeback model (pay-per-use)By implementing storage cloud, an organization pays only for the amount of storage that is actually used rather than paying for spare capacity that remains idle until needed. This model can provide an enterprise with enormous benefits financially. Savings can also be realized from hardware and software licensing for functions such as replication and point-in-time copy.

Integrated storage and service management

The storage cloud infrastructure usually includes integrated management software, which helps to manage the complete storage infrastructure from a single console, without having to buy proprietary management software from multiple vendors. This technique saves time and helps reduce spending on management software.

Self-service user portal

A self-service user portal that is based on a service catalog empowers clients to automatically provision based on predefined templates. You can manage IT infrastructure that is based on the user's needs.

Improved efficiency of data management

Consolidation and standardization of storage resources facilitates less infrastructure complexity, which is intrinsically simpler to manage. Consistent policies and processes with integrated management tools support geographically diverse infrastructure requirements that are driven by performance or availability considerations.

Faster time to market

Automation, self-service portals, rapid deployment, dynamic scaling, and centralized storage management enhance business agility by facilitating significant improvements, such

as decreased time-to-market for new products. Businesses can focus on building their core products and competencies instead of worrying about the management of their IT infrastructure.