PSNA COLLEGE OF ENGINEERING AND TECHNOLOGY, DINDIGUL

DEPARTMENT OF COMPUTER APPLICATIONS (MCA)

MC5207 – CLOUD COMPUTING TECHNOLOGIES

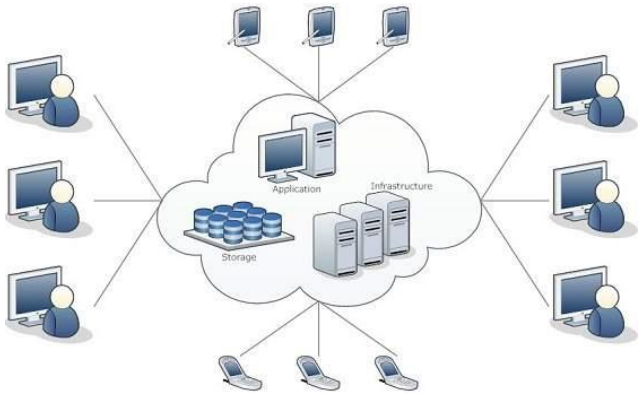
UNIT - 2 INTRODUCTION TO CLOUD COMPUTING

Cloud Computing Basics – Desired features of Cloud Computing – Elasticity in Cloud – On demand provisioning - Applications – Benefits – Cloud Components: Clients, Datacenters & Distributed Servers – Characterization of Distributed Systems – Distributed Architectural Models - Principles of Parallel and Distributed computing - Applications of Cloud computing – Benefits – Cloud services – Open source Cloud Software: Eucalyptus, Open Nebula, Open stack, Aneka, Cloudsim

CLOUD COMPUTING BASICS

Definition:

Cloud Computing is defined as storing and accessing of data and computing services over the internet. It doesn't store any data on your personal computer. It is the on-demand availability of computer services like servers, data storage, networking, databases, etc. The main purpose of cloud computing is to give access to data centers to many users. Users can also access data from a remote server.



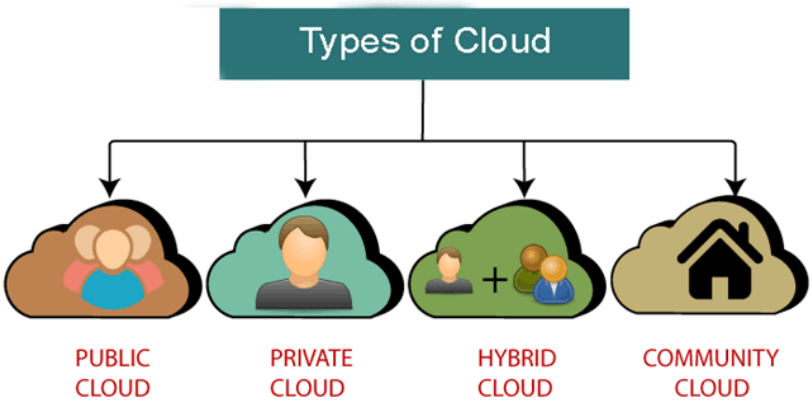
Working models of cloud computing

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

1. Deployment Models or Types of Cloud
2. Service Models or Cloud Computing Services

DEPLOYMENT MODELS OR TYPES OF CLOUD

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.

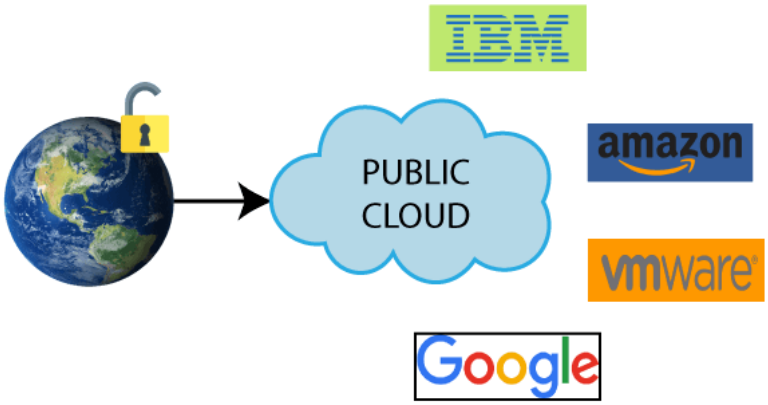


Public cloud

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

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

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



Advantages of Public Cloud

There are the following advantages of Public Cloud -

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

Disadvantages of Public Cloud

- Public Cloud is less secure because resources are shared publicly.

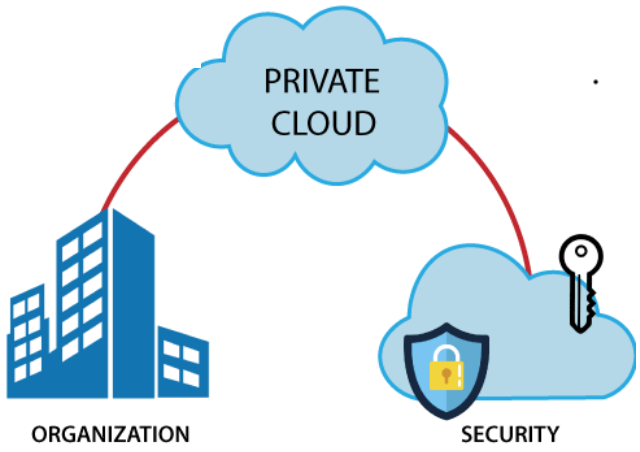
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

Private Cloud

Private cloud is also known as an **internal cloud** or **corporate cloud**. It is used by organizations to build and manage their own data centers internally or by the third party. It can be deployed using Opensource tools such as Openstack and Eucalyptus.

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

- On-premise private cloud
- Outsourced private cloud



Advantages of Private Cloud

There are the following advantages of the Private Cloud -

- Private cloud provides a high level of security and privacy to the users.

- Private cloud offers better performance with improved speed and space capacity.
- It allows the IT team to quickly allocate and deliver on-demand IT resources.
- The organization has full control over the cloud because it is managed by the organization itself. So, there is no need for the organization to depends on anybody.
- It is suitable for organizations that require a separate cloud for their personal use and data security is the first priority.

Disadvantages of Private Cloud

- Skilled people are required to manage and operate cloud services.
- Private cloud is accessible within the organization, so the area of operations is limited.
- Private cloud is not suitable for organizations that have a high user base, and organizations that do not have the prebuilt infrastructure, sufficient manpower to maintain and manage the cloud.

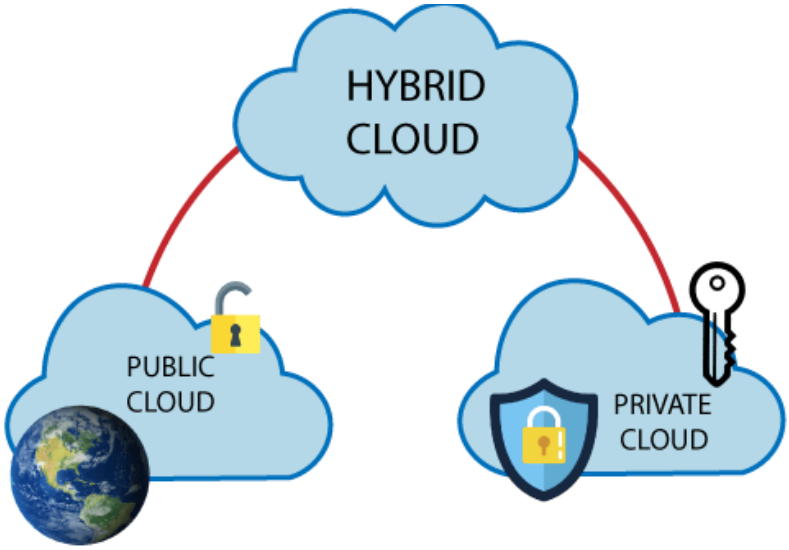
Hybrid Cloud

Hybrid Cloud is a combination of the public cloud and the private cloud. we can say:

Hybrid Cloud = Public Cloud + Private Cloud

Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users.

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



Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

- Hybrid cloud is suitable for organizations that require more security than the public cloud.
- Hybrid cloud helps you to deliver new products and services more quickly.
- Hybrid cloud provides an excellent way to reduce the risk.
- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

Disadvantages of Hybrid Cloud

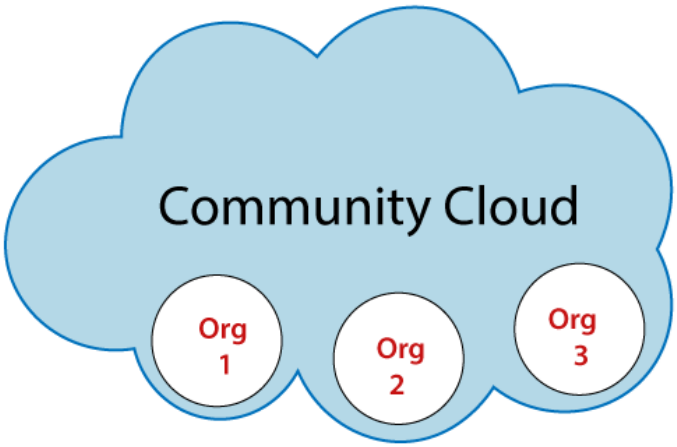
- In Hybrid Cloud, security feature is not as good as the private cloud.
- Managing a hybrid cloud is complex because it is difficult to manage more than one type of deployment model.

- In the hybrid cloud, the reliability of the services depends on cloud service providers.

Community Cloud

Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.

Example: Health Care community cloud



Advantages of Community Cloud

There are the following advantages of Community Cloud -

- Community cloud is cost-effective because the whole cloud is being shared by several organizations or communities.
- Community cloud is suitable for organizations that want to have a collaborative cloud with more security features than the public cloud.
- It provides better security than the public cloud.
- It provdes collaborative and distributive environment.

- Community cloud allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

Disadvantages of Community Cloud

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

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

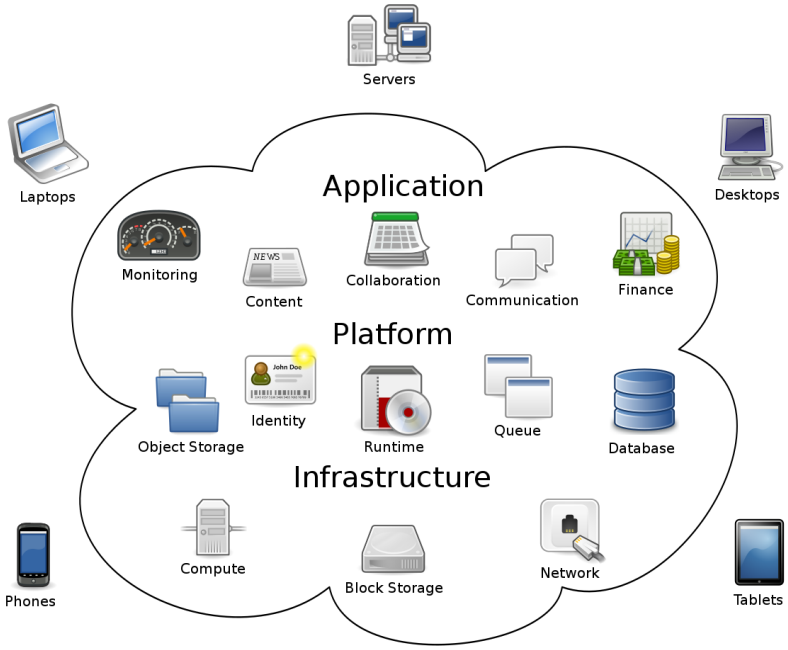
The below table shows the difference between public cloud, private cloud, hybrid cloud, and community cloud.

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

SERVICE MODELS OR CLOUD COMPUTING SERVICES

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

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



Infrastructure as a Service (IaaS)

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

Characteristics of IaaS

There are the following characteristics of IaaS -

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

Example: DigitalOcean, Linode, Amazon Web Services (AWS), Microsoft Azure, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.

Platform as a Service (PaaS)

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

Characteristics of PaaS

There are the following characteristics of PaaS -

- Accessible to various users via the same development application.
- Integrates with web services and databases.
- Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.
- Support multiple languages and frameworks.
- Provides an ability to "**Auto-scale**".

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

Software as a Service (SaaS)

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

Characteristics of SaaS

There are the following characteristics of SaaS -

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

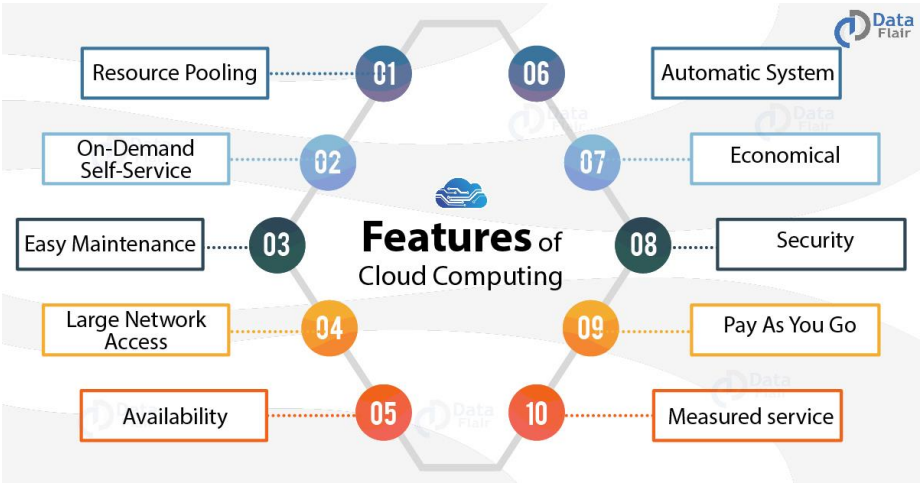
Example: BigCommerce, Google Apps, Salesforce, Dropbox, ZenDesk, Cisco WebEx, ZenDesk, Slack, and GoToMeeting.

Difference between IaaS, PaaS, and SaaS

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

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

DESIRED FEATURES OF CLOUD COMPUTING



1. 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.

2. Broad Network Access

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

3. 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.

4. 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.

5. 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.

6. Pay as you go

In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free.

7. Availability

The capabilities of the Cloud can be modified as per the use and can be extended a lot. It analyzes the storage usage and allows the user to buy extra **Cloud storage** if needed for a very small amount.

ELASTICITY IN CLOUD COMPUTING

The Elasticity refers to the ability of a cloud to automatically expand or compressed the infrastructural resources on a sudden-up and down in the requirement so that the workload can be managed efficiently. This elasticity helps to minimize infrastructural cost. This is not applicable for all kind of environment, it is helpful to address the only those scenarios where the resources requirements fluctuate up and down suddenly for a specific time interval. It is not quite practical to use where persistence resource infrastructure is required to handle the heavy workload.

It is most commonly used in pay-per-use, public cloud services. Where IT managers are willing to pay only for the duration to which they consumed the resources.

Example :

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

ON DEMAND PROVISIONING

On-demand computing is a delivery model in which computing resources are made available to the user as needed. The resources may be maintained within the user's enterprise, or made available by a cloud service provider. When the services are provided by a third-party, the term cloud computing is often used as a synonym for on-demand computing.

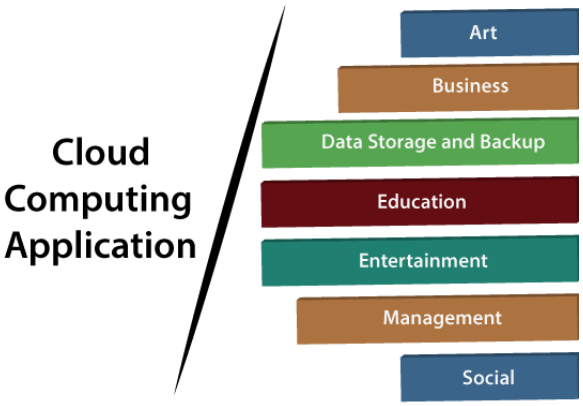
The on-demand model was developed to overcome the common challenge to an enterprise of being able to meet fluctuating demands efficiently. Because an enterprise's demand on computing resources can vary drastically from one time to another, maintaining sufficient resources to meet peak requirements can be costly. Conversely, if an enterprise tried to cut costs by only maintaining minimal computing resources, it is likely there will not be sufficient resources to meet peak requirements.

The on-demand model provides an enterprise with the ability to scale computing resources up or down with the click of a button, an API call or a business rule. The model is characterized by three attributes: scalability, pay-per-use and self-service. Whether the resource is an application program that helps team members collaborate or additional storage for archiving images, the computing resources are elastic, metered and easy to obtain.

Many on-demand computing services in the cloud are so user-friendly that non-technical end users can easily acquire computing resources without any help from the organization's information technology (IT) department.

CLOUD COMPUTING APPLICATIONS

Cloud service providers provide various applications in the field of art, business, data storage and backup services, education, entertainment, management, social networking, etc.



Art Applications

Cloud computing offers various art applications for quickly and easily design attractive cards, booklets, and images. Eg. MOO, Adobe Creative Cloud.

Business Applications

Business applications are based on cloud service providers. Today, every organization requires the cloud business application to grow their business. It also ensures that business applications are 24*7 available to users.(Eg. Salesforce, Paypal)

Data Storage and Backup Applications

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

Education Applications

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

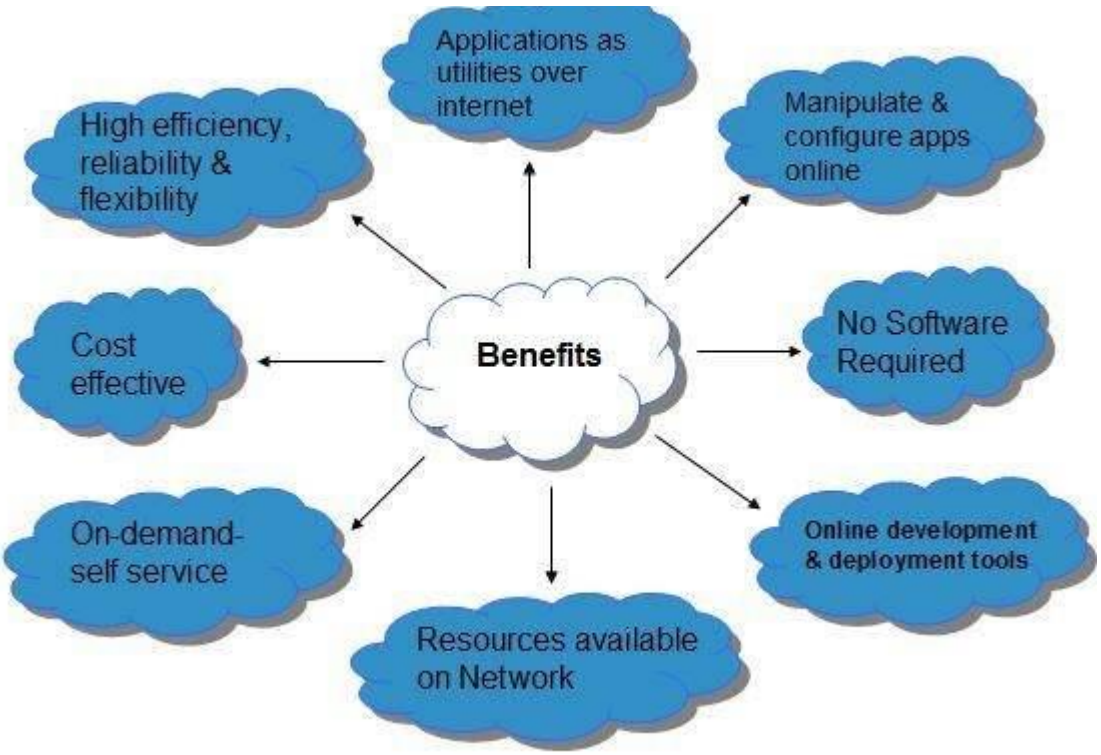
Entertainment Applications

Entertainment industries use a multi-cloud strategy to interact with the target audience. Cloud computing offers various entertainment applications such as online games and video conferencing.(Eg. Online games, Video conferencing apps)

Social Applications

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

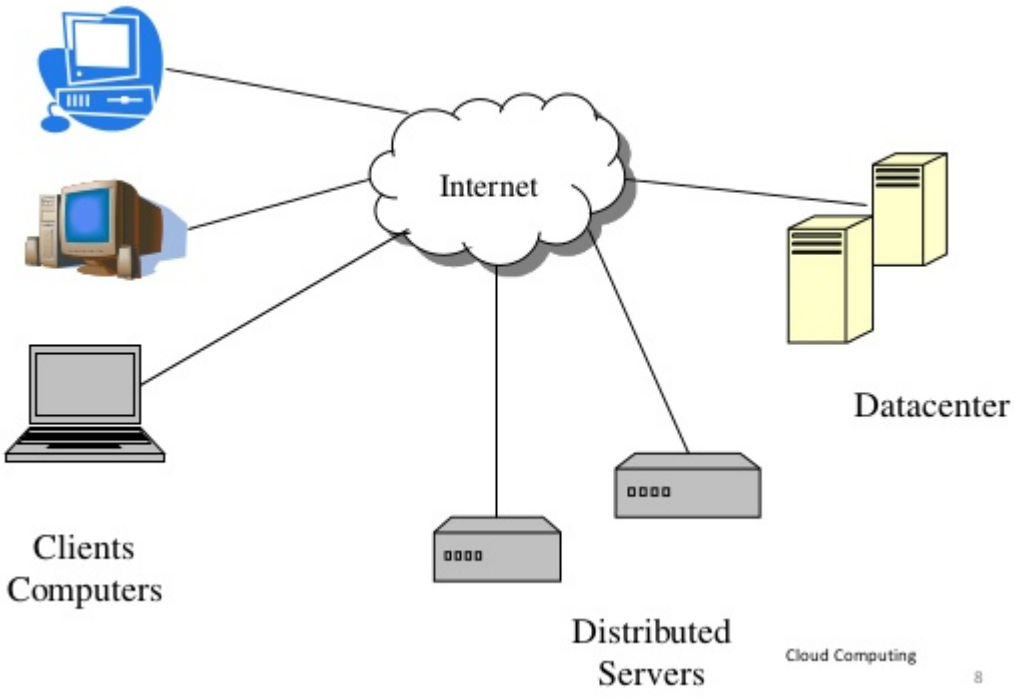
BENEFITS OF CLOUD COMPUTING



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.

CLOUD COMPONENTS: CLIENTS, DATACENTERS & DISTRIBUTED SERVERS



The basic components of cloud computing in a simple topology are divided into 3 (three) parts, namely clients, datacenter, and distributed servers. The three basic components have specific goals and roles in running cloud computing operations. The concept of the three components can be described as follows:

1. **Clients:**

   Clients on cloud computing architecture are said to be the exact same things that are plain, old, everyday local area networks (LANs). 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. Clients are interacting with to manage their information on the cloud.

2. **Data center:**

   Datacentre is collection of servers where the application to which you subscribe is housed. It could be a large room in the basement of your building 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.

3. **Distributed Servers:**

   Distributed Servers is a server placement in a different location. But the servers don't have to be housed in the same location. Often, servers are in geographically disparate locations. But to the cloud subscribers, these servers act as if they're right next to each other.

CHARACTERIZATION OF DISTRIBUTED SYSTEMS

Distributed computing is the use of distributed systems to solve single large problems by distributing tasks to single computers in the distributing systems. On the other hand, cloud computing is the use of network hosted servers to do several tasks like storage, process and management of data. Following are the characteristics of distributed systems also found in cloud.

Flexibility

One of the best thing about distributed computing is that it is highly flexible. Tasks can be completed using computers in different geographical areas.

Reliability

A single server can be rocked by glitches which can lead to complete systems malfunctions but with distributed computing, that is a thing of the past. With distributed computing, a single glitch cannot result to complete system failures.

Improved performance

Single computers can only perform to their best ability but with distributed computing, you get the best from across the whole system.

Both cloud computing use the same concept but individually they are two distinct things. Some of the examples of distributed computing are Facebook, World Wide Web and ATM. Examples of cloud computing are YouTube, Google Docs and Picasa.

PRINCIPLES OF PARALLEL AND DISTRIBUTED COMPUTING

Parallel and distributed computing builds on fundamental systems concepts, such as concurrency, mutual exclusion, consistency in state/memory manipulation, message-passing, and shared-memory models.

Creating a multiprocessor from a number of single CPUs requires physical links and a mechanism for communication among the processors so that they may operate in parallel.

Tightly coupled multiprocessors share memory and hence may communicate by storing information in memory accessible by all processors.

Loosely coupled multiprocessors, including computer networks, communicate by sending messages to each other across the physical links.

Concurrency refers to the execution of more than one procedure at the same time (perhaps with the access of shared data), either truly simultaneously (as on a multiprocessor) or in an unpredictably interleaved order. Modern programming languages such as Java include both encapsulation and features called “threads” that allow the programmer to define the synchronization that occurs among concurrent procedures or tasks.

Two important issues in concurrency control are known as deadlocks and race conditions. *Deadlock* occurs when a resource held indefinitely by one process is requested by two or more other processes simultaneously. As a result, none of the processes that call for the resource can continue; they are deadlocked, waiting for the resource to be freed. An operating system can handle this situation

with various prevention or detection and recovery techniques. A *race condition*, on the other hand, occurs when two or more concurrent processes assign a different value to a variable, and the result depends on which process assigns the variable first (or last).

Preventing deadlocks and race conditions is fundamentally important, since it ensures the integrity of the underlying application. A general prevention strategy is called process synchronization. Synchronization requires that one process wait for another to complete some operation before proceeding.

With the advent of networks, distributed computing became feasible. A distributed computation is one that is carried out by a group of linked computers working cooperatively. Such computing usually requires a distributed operating system to manage the distributed resources. Important concerns are workload sharing, which attempts to take advantage of access to multiple computers to complete jobs faster; task migration, which supports workload sharing by efficiently distributing jobs among machines; and automatic task replication, which occurs at different sites for greater reliability.

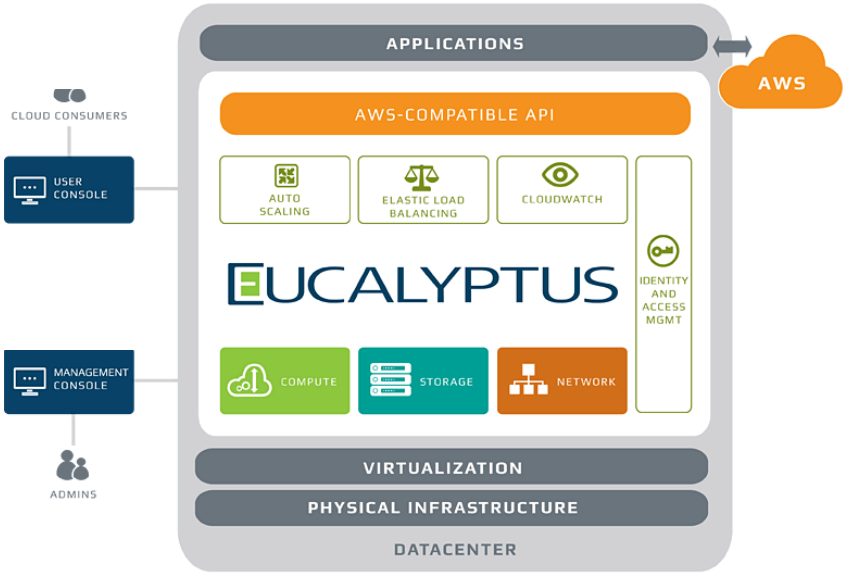
OPEN SOURCE CLOUD SOFTWARE

Eucalyptus

Eucalyptus is an open source software platform for implementing Infrastructure as a Service (IaaS) in a private or hybrid cloud computing environment.

The Eucalyptus cloud platform pools together existing virtualized infrastructure to create cloud resources for infrastructure as a service, network as a service and storage as a

service. The name Eucalyptus is an acronym for Elastic Utility Computing Architecture for Linking Your Programs To Useful Systems.



Eucalyptus was founded out of a research project in the Computer Science Department at the University of California, Santa Barbara, and became a for-profit business called Eucalyptus Systems in 2009. Eucalyptus Systems announced a formal agreement with Amazon Web Services (AWS) in March 2012, allowing administrators to move instances between a Eucalyptus private cloud and the Amazon Elastic Compute Cloud (EC2) to create a hybrid cloud. The partnership also allows Eucalyptus to work with Amazon's product teams to develop unique AWS-compatible features.

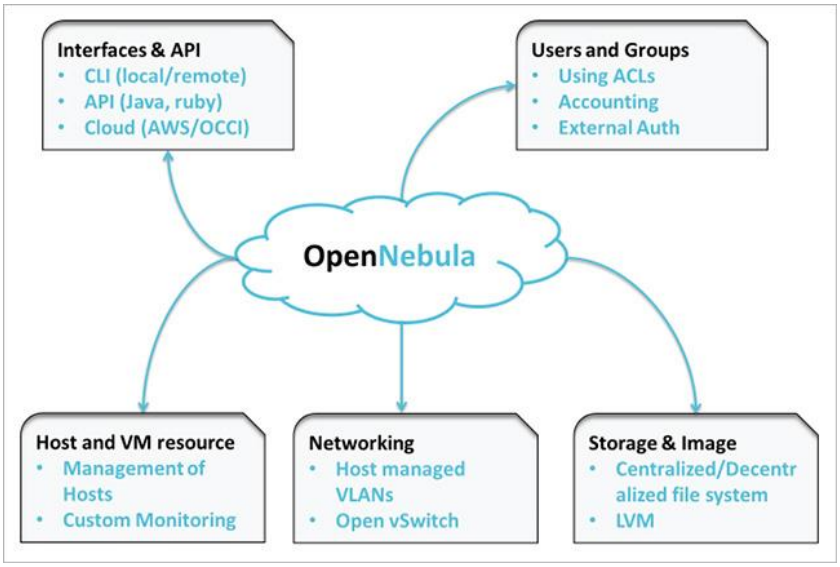
Eucalyptus features include:

- Supports both Linux and Windows virtual machines (VMs).
- Application program interface- (API) compatible with Amazon EC2 platform.

- Compatible with Amazon Web Services (AWS) and Simple Storage Service (S3).
- Works with multiple hypervisors including VMware, Xen and KVM.
- Can be installed and deployed from source code or DEB and RPM packages.
- Internal processes communications are secured through SOAP and WS-Security.
- Multiple clusters can be virtualized as a single cloud.
- Administrative features such as user and group management and reports.

OpenNebula

OpenNebula is an open source platform for constructing virtualised private, public and hybrid clouds. It is a simple yet feature-rich, flexible solution to build and manage data centre virtualisation and enterprise clouds. So, with OpenNebula, virtual systems can be administered and monitored centrally on different Hyper-V and storage systems. When a component fails, OpenNebula takes care of the virtual instances on a different host system. The integration and automation of an existing heterogeneous landscape is highly flexible without further hardware investments.



Benefits of OpenNebula

The plurality of support to Hyper-V and platform-independent architecture makes OpenNebula the ideal solution for heterogeneous computing centre environments.

The main advantages of OpenNebula are:

- It is 100 per cent open source and offers all the features in one edition.
- It provides control via the command line or Web interface, which is ideal for a variety of user groups and needs.
- OpenNebula is available for all major Linux distributions, thus simplifying installation.
- The long-term use of OpenNebula in large scale production environments has proven its stability and flexibility.
- OpenNebula is interoperable and supports OCCI (Open Cloud Computing Interface) and AWS (Amazon Web Services).

Key features of OpenNebula

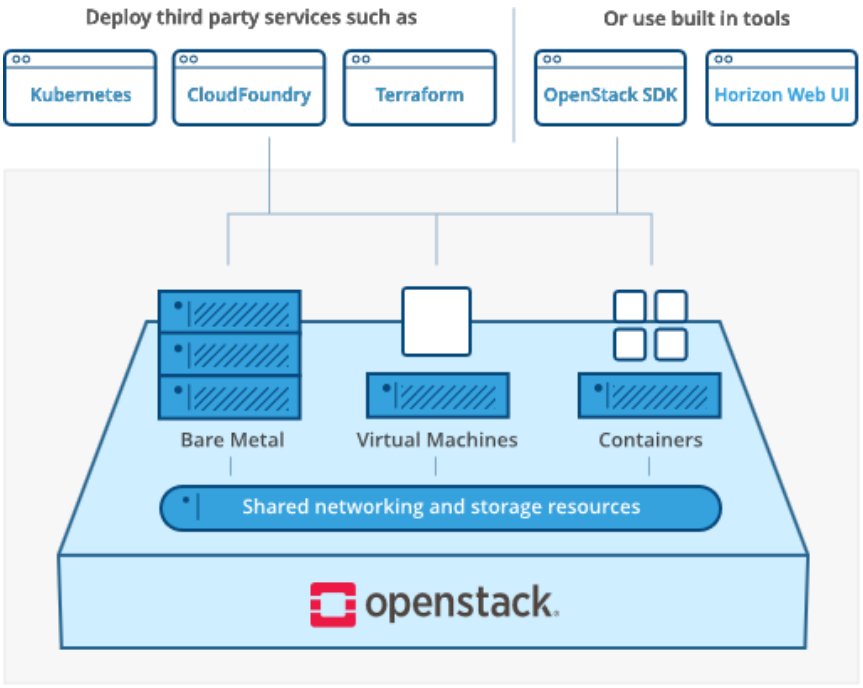
OpenNebula has features for scalability, integration, security and accounting. The developers also claim that it supports standardisation, interoperability and portability. It allows cloud users and administrators to choose from several cloud interfaces. Figure 1 shows the important features of OpenNebula.

Openstack

OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a

datacenter, all managed and provisioned through APIs with common authentication mechanisms.

A dashboard is also available, giving administrators control while empowering their users to provision resources through a web interface. Beyond standard infrastructure-as-a-service functionality, additional components provide orchestration, fault management and service management amongst other services to ensure high availability of user applications.

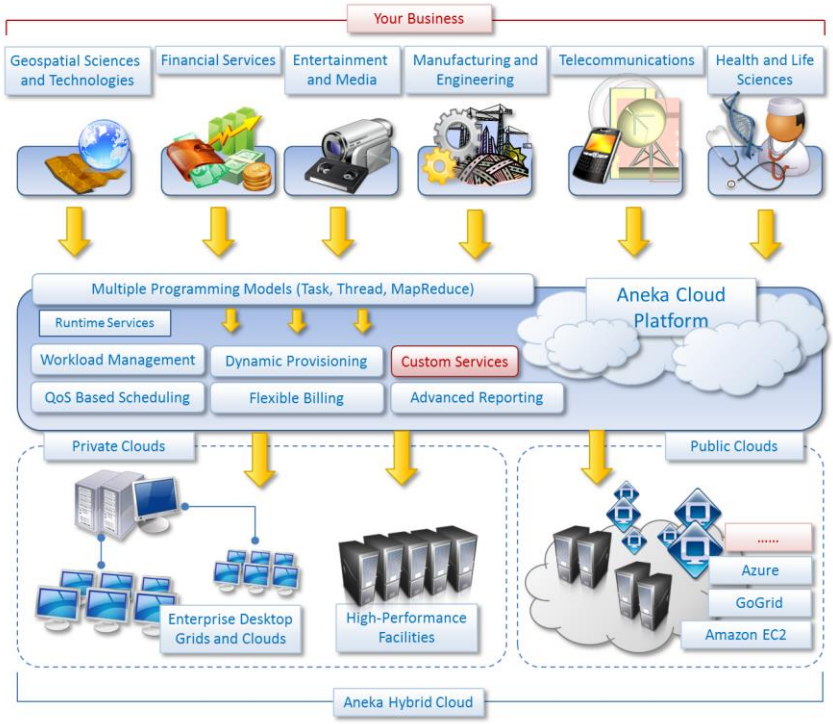


Aneka

Aneka provides a platform in cloud computing for building distributed applications that we want to deploy in the cloud.

Distributed applications mean those applications that multiple computers can access at the same time through networking. For example, if we put an application on the internet, then with the internet's help, more than one computing device can use the same

application at a time. So in this way, we can say that in cloud computing, ANEKA is a software-based on the .net framework and work under the RAD (rapid application development) environment. And this software was an example of Platform as a service (PAAS), and the company which governs ANEKA was manjrasoft private limited.



The Aneka based computing cloud is a collection of physical and virtualized resources connected through a network, which are either the Internet or a private intranet. Each of these resources hosts an instance of he Aneka Container representing the runtime environment where the distributed applications are executed. The container provides the basic management features of the single node and leverages all the other operations on the services that it is hosting. The services are broken up into fabric, foundation, and execution services. Fabric services directly interact with the node through the Platform Abstraction Layer (PAL) and perform hardware profiling and dynamic

resource provisioning. Foundation services identify the core system of the Aneka middleware, providing a set of basic features to enable Aneka containers to perform specialized and specific sets of tasks. Execution services directly deal with the scheduling and execution of applications in the Cloud.

Cloudsim

CloudSim provides a generalised and extensible simulation framework that enables seamless modelling and simulation of app performance. By using CloudSim, developers can focus on specific systems design issues that they want to investigate, without getting concerned about details related to cloud-based infrastructures and services.

CloudSim is a simulation tool that allows cloud developers to test the performance of their provisioning policies in a repeatable and controllable environment, free of cost. It helps tune the bottlenecks before real-world deployment. It is a simulator; hence, it doesn't run any actual software. It can be defined as 'running a model of an environment in a model of hardware', where technology-specific details are abstracted.

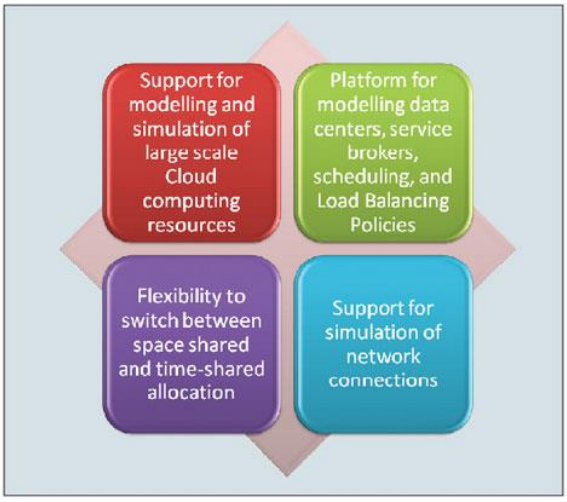


Figure 1: Features of CloudSim

CloudSim is a library for the simulation of cloud scenarios. It provides essential classes for describing data centres, computational resources, virtual machines, applications, users, and policies for the management of various parts of the system such as scheduling and provisioning. Using these components, it is easy to evaluate new strategies governing the use of clouds, while considering policies, scheduling algorithms, load balancing policies, etc. It can also be used to assess the competence of strategies from various perspectives such as cost, application execution time, etc. It also supports the evaluation of Green IT policies. It can be used as a building block for a simulated cloud environment and can add new policies for scheduling, load balancing and new scenarios. It is flexible enough to be used as a library that allows you to add a desired scenario by writing a Java program.

By using CloudSim, organisations, R&D centres and industry-based developers can test the performance of a newly developed application in a controlled and easy to set-up environment.