CLOUD COMPUTING
<u>UNIT-III</u>
Infrastructure As A Service(IAAS) & Platform   and Software As A Service(PAAS/SAAS)

The cloud is an emerging and one of the most popular computing technologies today. It has capability to serve millions of users at a time over the network.

o Every technology has some concepts which forms a base over which technology works/functions.

o Not only this, every technology is also associated with some components and processes/principles over which technology is built.

o The Cloud Computing technology is also not an exception, it also includes some components over which cloud technology is built and has some other components that works over it.

o To understand any technology in deep, first there is a need to understand its basic principles/components thoroughly.

The most important components of the cloud are

❖ Cloud Architecture
❖ Cloud Anatomy
❖ Networking in cloud.
❖ Applications on cloud
❖ Cloud Management
❖ Cloud Infrastructure Management
❖ Cloud Application Management
❖ Migrating Applications to cloud
❖ Phases of Application Migration

These components need to be understood thoroughly before analyzing/studying cloud Technology in deep.

1. Cloud Architecture:

Every Technology contains an architecture over which technology works.

The architecture provides hierarchical structural over view of the technology and describe each component and its working.

Cloud computing technology is also contain an architecture that describes about the components of its architecture and their importance and how they are used to make the technology to work on it

Based on the user access to the cloud, the cloud architecture is divided into 4-layers

- Layer-1 (User/client layer)

- Layer-2 (Network layer)

-Layer-3 (Cloud Management layer)

-Layer-4 (Hardware Resource layer)

(i) User/Client Layer(Layer-1):

- This is the lowest level layer in the architecture

- It includes end user/clients of the cloud who initiate the connection to the cloud for cloud services.

- The device initiating the connection can be a desktop/pc/ tablet /Smartphone thin client computer/thin client platform based device or it can be any electronic device that have capability to connect to the Internet and can access the web application

- The thin client computer is a generalized computer that have low processing computing power and depends on other computer for its full functionality.

- The thin client base Computers are becoming popular these days. They are widely used today to connect to the cloud for getting cloud services.

- This layer does not come wider Service Level Agreement (SLA). The SLA is the terms and conditions document accepted by the both cloud service provider and cloud service user/client. The SLA contain list of the services opted by the client their cost, service uptime, down time, the strength of computational power, availability of the cloud services, etc. all these details are written and accepted by the both user and service provider.

- Once, SLA is signed by both parties, the cloud service provider offers the services to the user as per the terms and conditions written in SLA Document.

- Any violation of provisioning of any service or resource will be prosecuted legally and heavy penalty will be charged on the service provider.

- The cloud services are offered to the user over the network, the user can access these services as like the web services. There is a lot of difference between web applications and cloud applications.

(ii) Network Layer (Layer-2):

- This is the most important layer of the architecture.

- The cloud Technology mainly depends on network layer because it offers all its services to the client over the network

- The network layer allows the users to connect their network devices like PCs/laptops/Tablets etc. to the network for gaining access to the cloud for getting Cloud services

- The network that is used to connect it Public Cloud will be the Internet. The Public Cloud collects various computing resources from different places and interconnects them over the Internet, makes them work as one unit to solve the Computational problem.

- When a user is accessing public cloud, he is not having any information about the location of the resource being offering the service to him, but he

will be having higher level abstract information like the name of the data center/ country /state from where he is getting the Service.

- The public cloud can be accessed by a user from any place in the world, at any time by any device.

- In case of Private cloud, the network over which services offered by the cloud is a LAN or WAN because private cloud is owned, managed and operated by one organization. Its Services are offered to the employees of organization owning the cloud.

- The private cloud is located with in the organization premises and it is local to the organization network. The private cloud services are not accessed from outside, they are available with in the organizational network.

- The network layer does not comes under SLA because of the factors effecting the Quality Of Service(QOS).

- To get good Quality of services either from Public Cloud or private cloud, the users need to have minimum network bandwidth usually, it is specified by the cloud Service provider

- The user must use the network with good bandwidth to get good quality of service, But it is completely left to the choice of the user. Hence it is not under the purview of SLA.

(iii) Cloud Management Layer(Layer-3):

- The cloud Management layer includes the softwares that is required to manage the cloud resources.

- The software can be cloud operating system or it is a software that acts as an interface between cloud user and data center.

- The software provides the facility to the service provider to manage the cloud resources in terms of its scheduling, optimization, resources consolidation, storage consolidation, allocating or deallocating the resources.

- The complete management of the resources is done by the Software.

- This layer is most important layer in the cloud architecture because it comes under the perview of SLA.

- Any operations done in this layer will affect the SLA, if the cloud vendor is not able to provide any Service of resource to the user as per the SLA, it is treated as SLA violation. if there is a SLA violation, the cloud Service provider will be charged with penalty. This penalty amount of service provider must be payed to the user.

➢ The popular cloud service providers are

  o For Public cloud- Amazon Web Services (AWS)

    -Microsoft Azure Services

  o For Private cloud - Eucalyptus services

    -Open Stack Service

- The private cloud Service providers create, deploy, and manage the cloud at the location specified by the organization based on their requirement.

(iv)Cloud Hardware Resources Layer(Layer-4):

- This layer Includes all the physical resources of the cloud.

- In case of public cloud it can be a data center which is used as a back end. The data center is a huge collection of hardware resources collected from different places and connected over the network to work as one unit.

- In case of private cloud, large no. of highly configured systems acts as data center which is usually located in the organization premises.

- The data centers must give access to the user whenever they try to connect to the cloud. Hence, it must be available always.

- This layer comes under perview of SLA and the operations taking in this layer will mostly effects the Service Level Agreement (SLA).

5

- If there is any discrepancy in provisioning the required service/application, the cloud service provider is heavily charged penalty and must pay it to the user. Hence, most of the service providers use the high bandwidth network and efficient algorithms to transfer the data at high speed between the cloud and user.

- Usually, the cloud service provider also specify the minimum bandwidth the user should maintain for getting good quality of services from cloud.

- ❖ All these layers are systemically arranged one below the other having good separation among them as shown below.
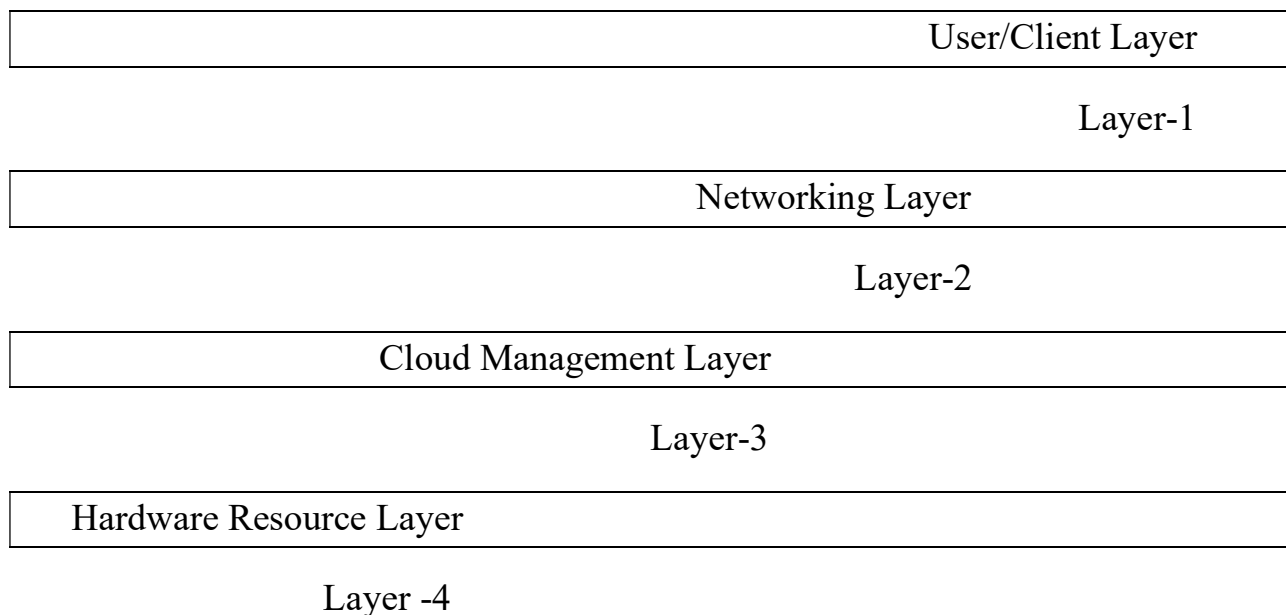
User/Client Layer

Layer-1

Networking Layer

Layer-2

Cloud Management Layer

Layer-3

Hardware Resource Layer

Layer -4

Fig: cloud Architecture

2. Cloud Anatomy:

The anatomy of cloud provides a core structural view of a cloud. Anatomy is part of cloud architecture but, it is different from it.

The cloud architecture provides a hierarchical view of the cloud whereas anatomy provides core structural view of a cloud.

The architecture talks about the components over which cloud technology is dependent and the components which work over cloud technology whereas the anatomy does not discuss about any components, it is completely independent.

The architecture is the overall structure of the cloud whereas anatomy is the part of architecture.

The anatomy of the cloud is divided into 5-layers, each layer does a specific task. The layers of anatomy is shown below:

❖ Applications
❖ Platform
❖ Virtualized Infrastructure
❖ Virtualization
❖ Physical Resources(Servers/storage etc)

Application
Platform
virtualized Infrastructure
Virtualization
Servers/Storage/Datacenters

Fig: Cloud Anatomy.

(i)_Application layer:_

- This layer consisting of all applications that are implemented to run on cloud. Every application can't be deployed directly on to the cloud.

- To deploy an application on to cloud, the application must acquire properties of the cloud. If it not possess properties of cloud, the properties must be embedded into the application, then it can be deployed on to cloud.

- The applications implemented for cloud platform possess the properties of cloud. Hence, they can be deployed directly on to the cloud.

(ii)_Platform:_

- A platform is a support or base to run the application. The platform provides all the resources for the applications to run on cloud.

7

- The platform provides an environment where applications can run comfortably on cloud.

(iii) Infrastructure:

- It is the collection of all logical resources that provides a support for computational capabilities to the user.
- When an application is running on cloud, it uses all the resources from cloud infrastructure.
- All required resources are provided to the application by the cloud when it is running within no time. Once, the application is over, all resources allocated to it are released and used for other applications.

(iv) Virtualization:

- It is the process / technique of creating logical resources over the existing physical resources.

- The logical resources are separated from physical resources and both are made available to the application running on the cloud.

(v) Physical Resources:

- It is the collection of all the physical resources available at different places and connected over the network that provides computational capabilities to the user.

- All the resources connected to the cloud are available always to the user/application. The application uses these resources to perform its task.

4. Applications of cloud:-

*The power of computer can be realized by running the applications on the computer. If the computer has more computational power, the application runs fastly. If the computational has little computational power, the application runs slowly.

*The application running on the computer can be divided into 3 types:

1. Stand-alone application

2. Web-based application

3. Cloud based application

a) Stand-alone application:-

*These are the applications, developed to work on individual systems like PCs, Desktops, and Workstations etc.

*These application were there in the early days of the computers.They can serve only one user at a time.

*These applications run on the computer by using the computational resources and features available on that computer. They don't use data or computational power from other computers.

*These applications do not depend on the network for their functionality. These are popular in the early days of computer.

*But, as the time was going on, there was a need for the users to gain access to the services of the applications running on one computer from the other computer. This has led to the development of web-based applications.

b)Web-Based applications:-

*Web based applications are different from standalone applications in many aspects.

*These applications were developed based on the client-server architecture model.

*Server is usually a high-end configured system on which application is installed and running.

*Client is usually a lower-end configured system used to gain access to the applications running on server through a network.

*Thus, these applications depends on network to serve the users.

*These applications are capable of serving large number of users simultaneously.

*These applications are popular those days, even today also they are widely in use and become a part of our day-to-day life.

*These applications have some limitations:

-These are developed only for one specific platform.

-These are not multitenant i.e, they can't be shared among

multiple users.

-They are not elastic hence can't handle heavy loads.

-They can't handle continuously varying heavy loads since

they are not elastic.

*They don't provide quantitative measure of the resources consumed by the user for generating billing information. Hence, the applications are temporarily or permanently given full access to the applications.

*They don't use pay-as-you-go/use approach to generate

billing information.

*All these issues are addressed by Cloud based applications.
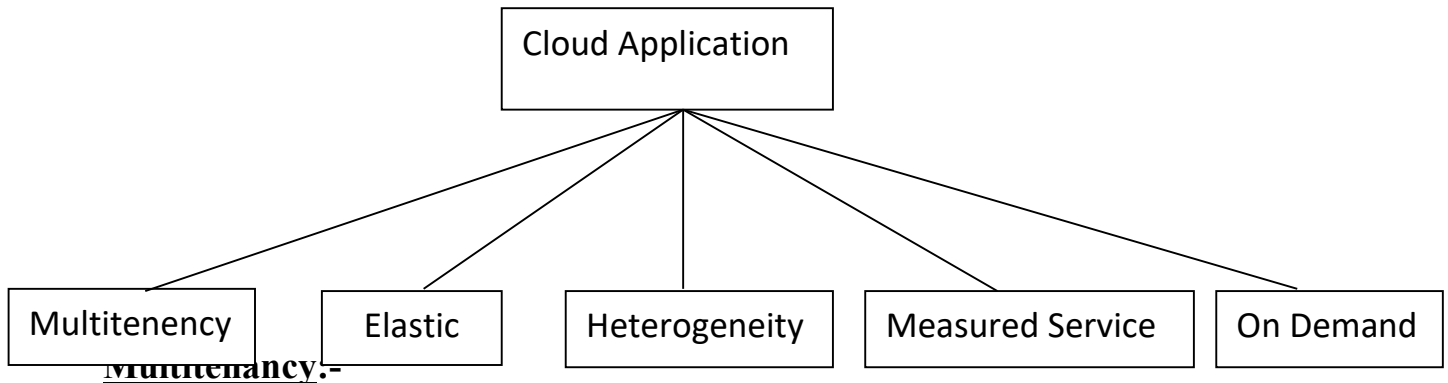
c) Cloud-Based applications:-

*Cloud based applications are different from the other applications in that they posses completely different properties.

*Cloud based applications can also be accessed like web-based applications from web browser.

*As per the definition of NIST, the cloud application should posses following properties which makes it different and unique from other applications.

-Multitenancy

-Elastic

-Heterogeneous platform

-Quantitative measurement

-On demand service

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                        ┌─────────────────────┐
                        │  Cloud Application  │
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| Multitenency | Elastic | Heterogeneity | Measured Service | On Demand |

Multitenancy:-

*This property is considered as one of the most important properties of the cloud which allows an application or resource to be shared among multiple users with full independence.

*The independence is a logical independence, it is obtained by creating an instance of application separately for each user. The modifications done to the data by one user will not affect the data of other user.

*The logical independence depends on physical independence. The degree at which logical independence is achieved is dependence on the physical isolation of the applications on the resources (database, servers etc) on which they are working.

*As long as the instances of applications are working on different parts of the resources, the logical independence among the users (multitenancy) can be provided, if the applications are physically close to each other, then multitenancy can't be achieved. Thus, the logical independence always depend on the physical isolation of the instances of the applications.

Elasticity:-

*This is another most important property of the cloud which allows the cloud to provide better services to its users.

*It is defined as the degree to which system is able to adopt to changes in the workload by allocating or releasing the resources to the applications such that at

any point of time, the number of available resources should match closely to the current demand of the application.

*The elasticity allows the cloud to serve its users in a better and efficient way. It can handle hundreds of users at a time.

*This property also helps cloud to support rapid fluctuations of load i.e, the increase or decrease in the number of users accessing the cloud.

*Heterogeneous platform:-

*The cloud supports heterogeneity i.e, the application developed for any platform can be easily deployed on to the cloud. Hence, most of the application developers prefers the cloud as their platform to develop their applications. Deploying applications on to the cloud can be easily done. Once the application is ported on to the cloud, it can be accessed by any user, from anywhere, by any type of device.

Quantitative measurement:-

*Cloud measures each service or the resource offered to the user to know how much extent it is used by the user. The billing information is generated based on usage of the resources. If resources are used heavily, the bill is also heavy, if the resources are used a little, the bill is also little.

*The cloud uses pay-as-you-use/go model for generating billing information to the user i.e, the user is charged only for the amount of consumed resources. This facility is not available in web-based applications.

*On demand service:-

*The cloud is capable of providing application services to the users on demand or whenever they want.

*The application service is available to the users round the clock without having any restrictions on the time, place and type of the device and duration of the service.

*All cloud application services can be offered over the internet to the users across the world. All services can be accessed over the internet through a web browsers.

*All these are the few properties of the cloud applications. They make cloud as the unique platform to develop and run applications on cloud.

4. Networking in Cloud:

- The cloud computing Technology is a technology that collects all the computational resources available at different geographical places and connects them over the Internet and makes them to work as one unit for solving computational problem.

- The cloud also allows the resources to be shared among multiple clouds.

- When a application is submitted to the cloud, cloud allocates resources to the application so that application will smoothly runs on cloud and gives output. Thus, the interconnections of these resources are very important in deciding the performance of the cloud.

- The cloud has different deployment models, the networking connectivity of the resources and their accessibility in every deployment model is important. Because the network connectivity of the resources and their accessibility will decide the performance of the cloud.

a) Public Cloud Access and Networking:
- A public cloud is a collection of all the resources available at different places and connected over the internet and working together to solve a computational problem.
- The public cloud can be accessed over the Internet or Some Vendors also provide Virtual Private Network (VPN) connection over the internet to access public cloud.

- The public cloud which is accessed over the internet is always creates issues in terms of its Security that will intern effects the performance of the cloud.

- The possible approach for security is to use encrypted tunnels to transfer the information between user and the cloud. But, when encryption techniques are used to encrypt data, it introduce delays in the transfer of information from one place to another but the information is Secured when transmitted over the internet.

- To reduce the delays without compromising for security, best routing algorithms can be selected that reduces the no of hops between the ultimate Source and destination in end-to-end connectivity.

- When the no of hops are reduced between Source and destination, the distance is reduced and delays can be minimized.

- But, selecting best or shortest path involves, talk/discussions/or cooperation with no. of Internet service Providers (ISP) who connects their networks to form Internet. If this is achieved, the delays can be reduced.

(b) Private cloud Access & Networking:

- As the name represents, Private cloud is owned, managed and operated by only one organization. Usually is located in the premises of the Organization.

- The access to the private cloud is given over the LAN or WAN of the organization. Some network operators establishes VPN over organization network and provides access to the cloud.

- Since, the organizational network is protected from the outside access by the other users, there will not be any threat to the data transmitted between the user and the cloud over the organization network. Thus, the connectivity to the cloud is always internal to the organization.

- As long as organization network is protected from outsiders, the cloud performance is not going to be effected because of organizational network.

c) Intracloud Networking for Public cloud services:

- As the name represents, Public cloud is a collection computational resources available at different places and connected over the internet and working together to solve computational problem.

- The resources of public cloud usually spread over large geographical area and connected together on Internet.

- Thus, the connectivity of these resources plays a major role in providing the services to the user.

- The resources must be made available to the user when they request for it.

- The interconnectivity of resources in public cloud is very important. These connections are not visible to the user. The Security of information transmitted among these resources in the cloud is also important.

- Because all these resources are connected on public network called Internet. The user may send/receive valuable information to store or retrieve from cloud. If this information is hacked, it creates problems to user. Hence, security issues inside the cloud is to be taken care.
- The accessibility mechanisms used to inside the cloud is also important. The accessibility mechanisms must provide the access to the resources whenever user demands for it. Thus, the internal network Connectivity among the cloud resources will effect the performance of the cloud.

- The quality of Service (QoS) among the connected resources is another aspect. Good Quality of service can be obtained by using Secure network connections and efficient algorithm for access and data transfer.

(d) Intracloud Networking for Private Cloud Services: A private cloud is owned, managed and operated by one organization. It contains many computational resources in the form of highly configured systems.

- These systems act as a data center for private cloud.

- A organization may have one or more data centers.

- All data centers are connected using organizational network connectivity. How much amount of bandwidth is supported by organizational network to connect all the resources of cloud is an important issue. Because the network connectivity must support the applications running in this environment to give the best service to the user.

- Since the private cloud is a part of the organization network, it uses this intra cloud network to connect the users with applications running on cloud. Once the connection is established, the data flows between the user and the application over organization network. This network must have sufficient bandwidth to support for best service.

- If the cloud application was designed based on Service oriented architecture, the application equally distributes its traffic in all the directions of the network to provide good quality of service.

- Usually, Organization network is its own network and do not have access to the outsiders and uses best security policies to protect its own traffic on its network, equally distributes its network traffic in all possible paths, it does not affect the performance of cloud as long as its network maintenance is good, otherwise it impacts cloud performance.

- As the time goes on, the cloud based applications are increasing, many users are accessing these applications, and slowly it is increasing the traffic on the network.

- Hence, there is a reason to consider network connectivity and their access mechanisms to the resources with the increased traffic. As the traffic is increasing, the network requires more flexible architecture to support increased load on the network with global standards..

(e)New Facets in Private Networks: Most of the private networks are conventional/traditional networks designed to deliver Services with the applications running on the servers located within the premises of the organization.

- The most popular network based applications like E-Mail, File sharing and Enterprise Resource Planning (ERP) are deigned to work on Servers located within the organizational network to serve the users.

- Now a days, most cloud Service providers offering their software to the corporate organization as Software As A Service (SaaS). This software runs on the cloud owned by third party but, providing services to the organizations.

- When the organizations are getting cloud based services, the important issue is whether the organization Conventional network can support traffic from the cloud services or not, because these networks are not designed for this purpose.

- Since, many users in the organization access cloud based services simultaneously, it increases traffic on organization network, most organizations network are not architected to optimize performance for cloud applications.

- Hence, it brings lot of challenges in accessing and usage mechanisms of applications running on cloud data centers.

- Today, most of the widely used applications are slowly moving from on-premises based applications to cloud based applications and offering their services to the organizations as SaaS at inexpensive prices.

- Hence, there is a need to change the architecture of conventional networks owned by organizations to give the support for cloud based applications. otherwise, the organizations can't function if access is not given to cloud applications as and when needed.

(f) Path for Internet Traffic:

- With the increase of cloud based applications, the no.of users accessing these applications are increasing day by day, which in turn increasing the network traffic on the Internet.
- But the Internet is using limited set of gateways to control the traffic. This is not sufficient to control the increasing traffic on the Internet, it leads to availability, Performance and access issues to the cloud.
- To overcome the problem, there is a need to keep more no. of Internet Gateways on the internet especially, at the places where more traffic is found on the internet.This will address the problem of availability, performance and access to the cloud and reduces network latency.
- Today, the most popular application running on Internet i.e video conferencing, which consumes more internet bandwidth and most critical application of organizations ERP, Consumes less bandwidth on internet.

- Because of video Conferencing, the ERP application should not be interrupted or stopped. Therefore, a good and correct plan is required to divert the traffic equally in various directions on Internet. So that no application is getting effected because of non-availability of network facility.

- These challenges must be consider on Internet to manage the traffic with more no. of Gateways and with increased network bandwidth otherwise, cloud services performance is being affected.

4. Managing the cloud:-

- The cloud management is one of the most important job of the cloud. The cloud performance mainly depends on how a cloud is managed. If the cloud is managed properly, it provides a good quality of the services(QoS), otherwise, it effects the performance of the cloud.
- The cloud management consisting of 2 parts.

    -Managing the cloud infrastructure

    -Managing the cloud applications

a) Managing the cloud infrastructure:-

- Cloud infrastructure is considered as backbone of the cloud. It is responsible for providing good quality of services(QoS) to the cloud users. The cloud performance also mainly depends on the quality of cloud resources.
- In a cloud, cloud resources includes computers, servers, storage, networking devices, databases, applications, etc. all these resources are collected from different places and made as a part of cloud infrastructure.

- The main factors to be considered as per as cloud infrastructure management is concern are

    -Cloud OS

    - Cloud performance and SLA

    -Cloud maintenance cost

    -Power consumption

    -Service delivery methods and load fluctuations

    -Cloud governance

Cloud OS:

- A cloud contains all its resources from different places and all of them are connected over the internet.
- The cloud maintains all these resources, provides co-ordination among them through a cloud core software called **Cloud Operating System(OS)**.
- The cloud OS maintains all cloud resources by performing tasks such as resource scheduling, allocating and deallocating resources to the applications, load balancing, optimizing resources consumption, etc.
- The cloud OS also allows the users to share cloud resources as long as there is no risks involved.
- The cloud OS must be powerful to efficiently manage its resources, otherwise the cloud cannot provide give/provide best services to users.

Performance of the cloud and SLA:

- The performance of the cloud is one of the most important feature. It mainly depends on its resource management.
- If the performance of the cloud is not good, it will lead to several inefficiencies in terms of QoS and SLA.
- The Service Level Agreement (SLA) is a set of rules document governed by both the cloud service vendor and the user. This document is created at the time of purchasing the cloud services from the cloud vendor by the user.

- If cloud performance is not good, it can't satisfy SLA. If SLA is not satisfied the cloud vendor is charged with heavy penalty, it should be paid to the cloud user.
- As per as SLA, the cloud should always provide certain basic services to the cloud user otherwise, the whole purpose of the cloud is last.

Cost of cloud Maintenance:

- The cloud resources must be maintained properly otherwise, it effects the QoS and SLA.
- If the cloud vendor invests more in maintaining cloud resources, it will automatically increases the cost of cloud services. If the cloud service is expensive, many users do not opt for cloud services, this will results in lower users pool. If the no. of users are less, the cloud vendor does not get profits.
- On the other hand, if the cloud vendor invests less in cloud maintenance, it will decrease the cost of cloud services, the services becomes cheap. If the services are cheap, more user will opt for cloud services, that increases users pool, if users pool is more, vendor can get profits but, the cloud can't offer good QoS. Hence, users will not be satisfied with cloud services. That leads to the collapse of the cloud within a short span of time.

Hence, there should be always a trade-off between the investment made by the cloud vendor in maintaining cloud resources and the QoS offered to the cloud users.

Power consumption:

- The power consumption of cloud resource is another important issue to be considered. It will also lead to increase the cost of cloud services.
- If more number of resources are employed to provide a service to the user, it consumes more power. In order to reduce more no.of resources, the techniques like "**server consolidation**" and "**storage workload**" can be used.
- The server consolidation is a process of reducing no.of servers or server locations that are required by an organization to deliver the service to it.

- The storage workload is a process of distributing the workload equally to all storage units such that no unit is left under utilized or over utilized.

Service delivery methods of Load Fluctuations:

- All the above factors discussed related to the physical resources management. Apart from this, there are different management methods are available to deliver services to the user.
- Different type of services use different service delivery management methods to efficiently deliver the services to the user.
- All service delivery methods are developed based on "Load Fluctuations". A Load fluctuation is a phenomenon in which the system workload will change continuously. The workload is nothing but the rapid increase or decrease in the no.of users accessing cloud services.
- The load fluctuations is the critical issue to be considered as per as cloud applications are concerned.
- Load fluctuations are of two types
  - **predictable Load Fluctuations**
  - **unpredictable Load Fluctuations**
- The predictable load fluctuations can be handled easily. The cloud can be configured to handle such load fluctuations.
- Unpredictable load fluctuations can't be handled easily. However, the methods have been developed to handle such situations by the cloud. The cloud is mainly intended to handle unpredictable load fluctuations.

Cloud governance:

- The cloud governance is a word widely used in corporate world. It is closely related to cloud maintenance but it is different from it.
- The cloud governance mainly focuses on policies, SLAs, cloud performance, QoS, etc.
- The cloud governance is the process of creating a value to the organization by creating a strategic objective which leads to the growth of the organization and helps in obtaining more grip on the organization.

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- Several aspects are focused by cloud governance as mentioned previously, out of which SLA is most important.
- The total cloud is governed by SLA. If SLA is not satisfied, the cloud vendor has to pay hear by penalty to the cloud user.

(b) Management of cloud applications:

- Most of the corporate organizations today looking at the cloud to move or create their corporate applications from their traditional environment to the cloud environment.
- Moving applications from corporate to cloud environment brings/poses lot of challenges to the cloud application developers, the applications becomes more composite and complex.
- The cloud resources also need to be enhanced both in terms of IaaS and SaaS.
- As per as IaaS is considered, the cloud computers, servers, storages, databases, platforms need to be enhanced.
- As per as SaaS is considered, the application softwares like e-mail, SMS, etc need to be incorporated in the cloud.
- All these issues are addressed by the cloud application management.
- The cloud application management techniques provides possible solutions to make applications to run on cloud platform without any difficulty.
- Cloud application management also helps in implementing the corporate policies like governance, auditing and the environment management required while deploying applications on to the cloud.
- The cloud application management also

  - helps in collecting information about various events, analyzes it and identifies critical information that needs action immediately such as increasing no.of resources or adding new services to the cloud, etc.

  - provides tools and processes to easily manage applications.

Migrating application to the cloud:

- It is the process of moving one or more enterprise applications and its IT environment from corporate traditional environment to the cloud environment.
- Moving applications to the cloud environment is not easy, it brings lot of challenges to the application developers.
- Moving applications to the cloud, provides lot of benefits to the organizations in terms of investment made on purchasing hardware and software and their maintenance. All this cost is saved.
- Moving applications to the cloud is done phase by phase. The phases of applications migration to the cloud are as follows:

  - Evaluation

  - Strategies of migration

  - Prototyping

  - Provisioning

  -Testing

(a)Phases of migration:

1. Evalution:

- To migrate an application from other environment to the cloud environment, the components available in cloud must be evaluated. To know that whether the components available in cloud can support the application or not. The evaluation of components includes cloud resources such as servers, computational power, storage, platform, applications, cloud architecture, software licenses, application architecture, etc. Other components includes risks, security issues, compliance, SLAs, operational processes, management strategies, etc.
- All these factors are analyzed to move applications to the cloud.

2. Migration Strategies:

- Based on the evaluation, a particular migration strategy is selected to move application on to cloud.
- Two types of migration strategies are available

    -Hotplug strategy

    -Fusion strategy

- In the hotplug strategy, the applications and its data and its dependencies are isolated and moved on to the cloud. Then, the entire application is made to run at all once.
- In the fusion strategy, the application is partially moved. In the sense, only application itself is moved but its dependencies such as data and software licences, specialized servers, interconnections with other applications are preserved/maintained in the old environment.

Prototyping:

- The migration strategy is normally preceded by prototyping. Prototyping is the process of validating and assuring that the application runs in the cloud environment.
- To prove this, a small part of the application is installed on the cloud and run with the test dataset.

Provisioning:

- It is the process of providing all the required resources in the cloud environment to make the application to run in the cloud.
- Normally, the short falls identified in the evaluation are provided which includes
    -servers to be provided in the environment.
    -required platform softwares are installed and configured.
    -required application software is installed and configured.
    -the environment is also configured to match with the application requirement.
    -databases and files are replicated/copied.
    -all internal and external integration points are configured.
    -operation and management software is setup.
    -web servers, services, batch jobs are configured.

Testing:

- After application is deployed, a port migration test are usually performed to assure that application is successfully migrated and working.
- The tests that are usually performed are

    -failure and recovery tests.

    -performance and load testing.

    -scale up and down test.

All these tests are performed against expected traffic load and resource utilization levels.

b. Cloud Migration approaches:

- It is the process of moving from traditional corporate environment to cloud environment.
- There are four approaches available. Any one of these approaches can be used to migrate to cloud.
    -Migrating existing applications.
    -Start from scratch.
    -New separate company.
    -Buy an existing cloud vendor.

Migrating Existing Applications:

- The applications running in the traditional corporate environment can be rebuild or rearchitected to suit for the needs of cloud environment. This can be done by the top level engineers to develop/introduce new functionalities. This also requires that new R&D decision to be taken. This is usually done in several release to have a full fledged applications.

Start from the scratch:

- The applications available in traditional corporate environment is rebuilt right from the scratch by taking the advantage of facilities and features available in the cloud environment.
- This requires the software architects to have grip on the facilities and features available in the cloud to develop efficient applications.
- Instead of modifying the applications as in first step, developing application from the scratch is easy efficient.
- All this can be done even with a small team of engineers who have full knowledge in the cloud environment.

Starting a new company:

- Instead of moving applications from the traditional corporate environment to the cloud environment, a new company can be started with latest cloud applications and platform.
- The required funding and software licensing can be obtained from the existing company.
- This will benefit the new company in many ways as follows
  -If any remarks are there on existing company it can't be carried on to new company.
  -With new company, new brand can be introduced into the market.
  -New company may have new management, new policies, different way of working hierarchy.
- The most important is, the new company must behave like a cloud vendor.

Buying an Existing Cloud Vendor:

- The existing company, if it is having large amount of capital, it can invest in purchasing an existing reputed cloud vendor company, it will save lot of time to the organization and gets two advantages.
  -The leading competitor will not be there in the cloud vendors to the organization.
  -It can touch the ground by running in the cloud space with no time.
- The most important here is, the cloud company innovation techniques, operational approaches, management strategies, hierarchy should not be

distributed but, it can be enhanced with new ideas and objectives on a phase by phase number.

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