UNIT V CLOUD COMPUTING

Definition of Cloud Computing – Characteristics of Cloud – Cloud Deployment Models – Cloud Service Models – Driving Factors and Challenges of Cloud – Virtualization – Load Balancing – Scalability and Elasticity – Replication – Monitoring – Cloud Services and Platforms: Compute Services – Storage Services – Application Services

Definition of Cloud Computing

Cloud computing is on-demand access, via the internet, to computing resources applications, servers (physical servers and virtual servers), data storage, development tools, networking capabilities, and more—hosted at a remote data center managed by a cloud services provider (or CSP). The CSP makes these resources available for a monthly subscription fee or bills them according to usage.

Cloud computing is a virtualization-based technology that allows us to create, configure, and customize applications via an internet connection. The cloud technology includes a development platform, hard disk, software application, and database.

The term cloud refers to a network or the internet. It is a technology that uses remote servers on the internet to store, manage, and access data online rather than local drives. The data can be anything such as files, images, documents, audio, video, and more.

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 centres to many users. Users can also access data from a remote server.

Cloud computing decreases the hardware and software demand from the user's side. The only thing that user must be able to run is the cloud computing systems interface software, which can be as simple as Web browser, and the Cloud network takes care of the rest. We all have experienced cloud computing at some instant of time, some of the popular cloud services we have used or we are still using are mail services like gmail, hotmail or yahoo etc.

Examples of Cloud Computing Services: AWS, Azure,

Characteristics of Cloud

The characteristics of cloud computing are given below:

1) Agility

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

2) High availability and reliability

The availability of servers is high and more reliable because the chances of infrastructure failure are minimum.

3) High Scalability

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

4) Multi-Sharing

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

5) Device and Location Independence

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

6) Maintenance

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

7) Low Cost

By using cloud computing, the cost will be reduced because to take the services of cloud computing, IT company need not to set its own infrastructure and pay-as-per usage ofresources.

8) Services in the pay-per-use mode

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

Cloud Deployment Models

The cloud deployment model identifies the specific type of cloud environment based on ownership, scale, access, and the cloud's nature and purpose. There are various deployment models are based on the location and who manages the infrastructure.

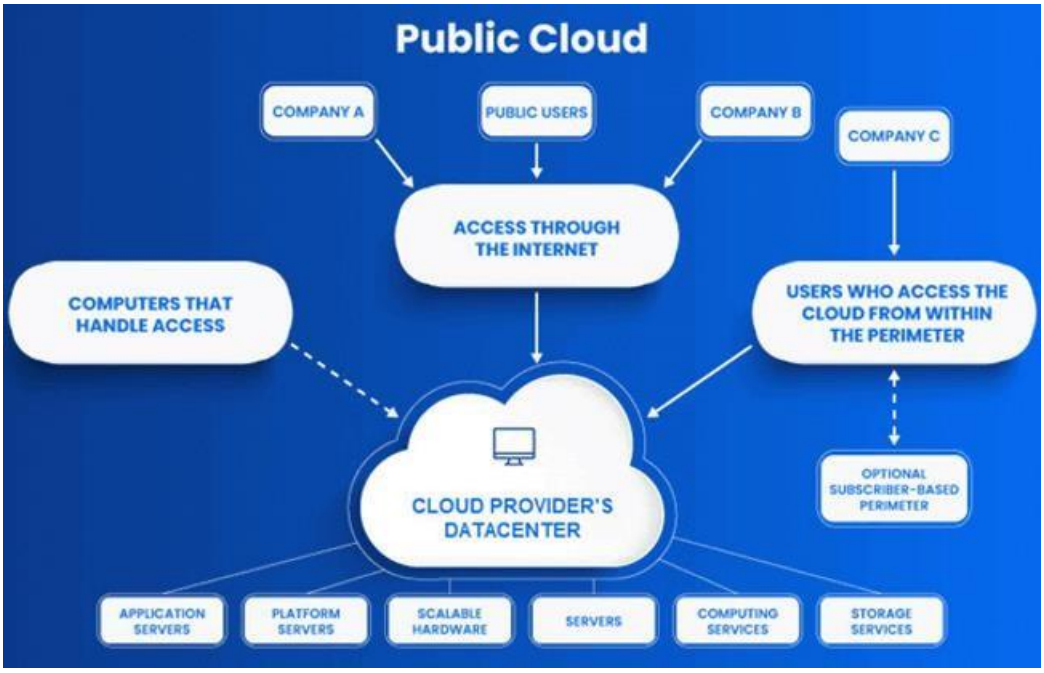
Type of Cloud Deployment Model

Here are some important types of Cloud Deployment models:

- **Private Cloud:** Resource managed and used by the organization.
- **Public Cloud:** Resource available for the general public under the Pay as you go model.
- **Community Cloud:** Resource shared by several organizations, usually in the same industry.
- **Hybrid Cloud:** This cloud deployment model is partly managed by the service provided and partly by the organization.

Public Cloud

The public cloud is available to the general public, and resources are shared between all users. They are available to anyone, from anywhere, using the Internet. The public cloud deployment model is one of the most popular types of cloud.



This computing model is hosted at the vendor's data center. The public cloud modelmakes the resources, such as storage and applications, available to the public over the WWW. It serves all the requests; therefore, resources are almost infinite.

Characteristics of Public Cloud

Here are the essential characteristics of the Public Cloud:

- Uniformly designed Infrastructure
- Works on the Pay-as-you-go basis
- Economies of scale
- SLA guarantees that all users have a fair share with no priority
- It is a multitenancy architecture, so data is highly likely to be leaked

Advantages of Public Cloud Deployments

Here are the pros/benefits of the Public Cloud Deployment Model:

- Highly available anytime and anywhere, with robust permission and authenticationmechanism.
- There is no need to maintain the cloud.

- Does not have any limit on the number of users.
- The cloud service providers fully subsidize the entire Infrastructure. Therefore, you don't need to set up any hardware.
- Does not cost you any maintenance charges as the service provider does it.
- It works on the Pay as You Go model, so you don't have to pay for items you don'tuse.
- There is no significant upfront fee, making it excellent for enterprises that requireimmediate access to resources.

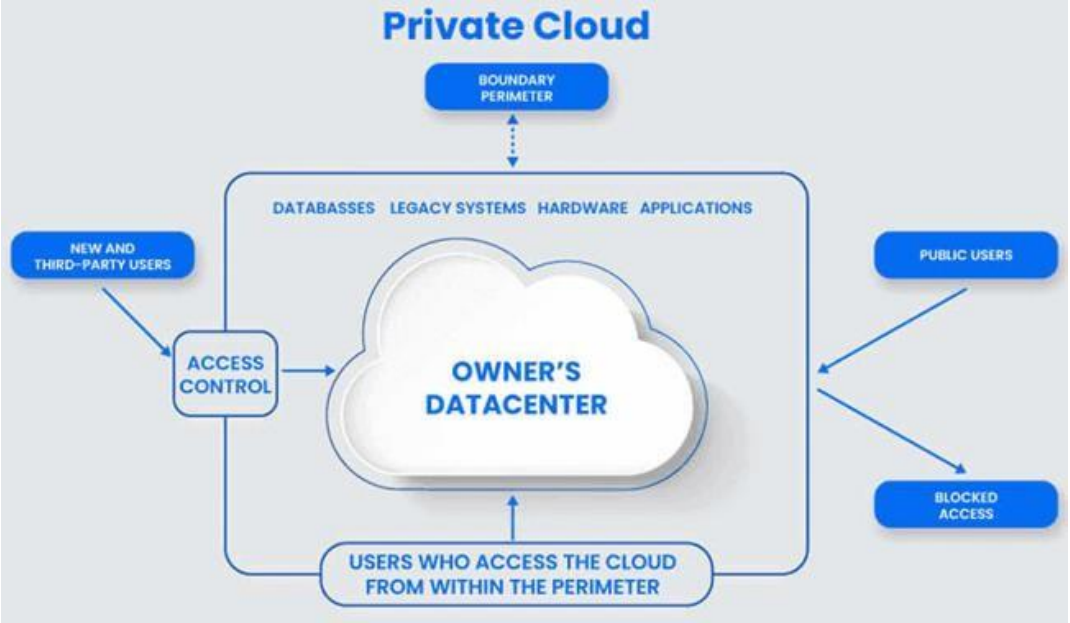
Disadvantages of Public Cloud Deployments

Here are the cons/drawbacks of the Public Cloud Deployment Model:

- It has lots of issues related to security.
- Privacy and organizational autonomy are not possible.
- You don't control the systems hosting your business applications.

Private Cloud Model

The private cloud deployment model is a dedicated environment for one user or customer.You don't share the hardware with any other users, as all the hardware is yours. It is a one-to-one environment for single use, so there is no need to share your hardware with anyone else. The main difference between private and public cloud deployment models is how you handlethe hardware. It is also referred to as "internal cloud," which refers to the ability to access systems and services within an organization or border.



Characteristics of Private Cloud

Here are the essential characteristics of the Private Cloud:

- It has a non-uniformly designed infrastructure.
- Very low risk of data leaks.
- Provides End-to-End Control.
- Weak SLA, but you can apply custom policies.
- Internal Infrastructure to manage resources easily.

Advantages of Private Cloud Deployments

Here are the pros/benefits of the Private Cloud Deployment Model:

- You have complete command over service integration, IT operations, policies, and userbehavior.
- Companies can customize their solution according to market demands.
- It offers exceptional reliability in performance.
- A private cloud enables the company to tailor its solution to meet specific needs.
- It provides higher control over system configuration according to the company'srequirements.
- Private cloud works with legacy systems that cannot access the public cloud.
- This Cloud Computing Model is small, and therefore it is easy to manage.

- It is suitable for storing corporate information that only permitted staff can access.
- You can incorporate as many security services as possible to secure your cloud.

Disadvantages of Private Cloud Deployments

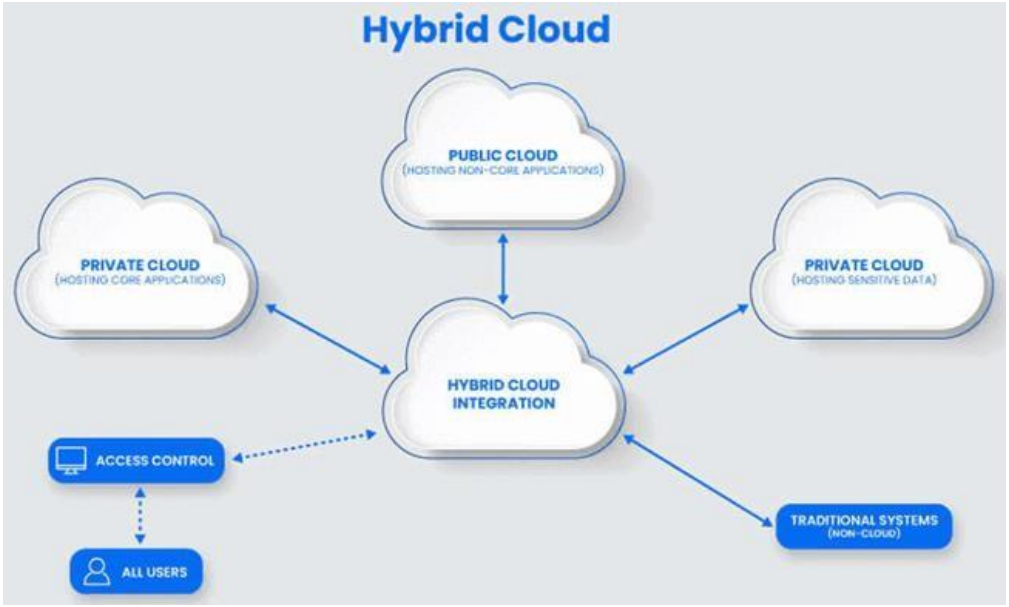
Here are the cons/drawbacks of the Private Cloud Deployment Model:

- It is a fully on-premises-hosted cloud that requires significant capital to purchase andmaintain the necessary hardware.
- Companies that want extra computing power must take extra time and money to scaleup their Infrastructure.
- Scalability depends on the choice of hardware.

Hybrid Cloud Model

A hybrid cloud deployment model combines public and private clouds. Creating a hybrid cloud computing model means that a company uses the public cloud but owns on- premises systems and provides a connection between the two. They work as one system, whichis a beneficial model for a smooth transition into the public cloud over an extended period.

Some companies cannot operate solely in the public cloud because of security concernsor data protection requirements. So, they may select the hybrid cloud to combine the requirements with the benefits of a public cloud. It enables on-premises applications with sensitive data to run alongside public cloud applications.



Characteristics of Hybrid Cloud

Here are the Characteristics of the Hybrid Cloud:

- Provides betters security and privacy
- Offers improved scalability
- Cost-effective Cloud Deployment Model
- Simplifies data and application portability

Advantages of Hybrid Cloud Deployments

Here are the pros/benefits of the Hybrid Cloud Deployment Model:

- It gives the power of both public and private clouds.
- It offers better security than the Public Cloud.
- Public clouds provide scalability. Therefore, you can only pay for the extra capacity ifrequired.
- It enables businesses to be more flexible and to design personalized solutions that meettheir particular needs.
- Data is separated correctly, so the chances of data theft by attackers are considerablyreduced.
- It provides robust setup flexibility so that customers can customize their solutions to fittheir requirements.

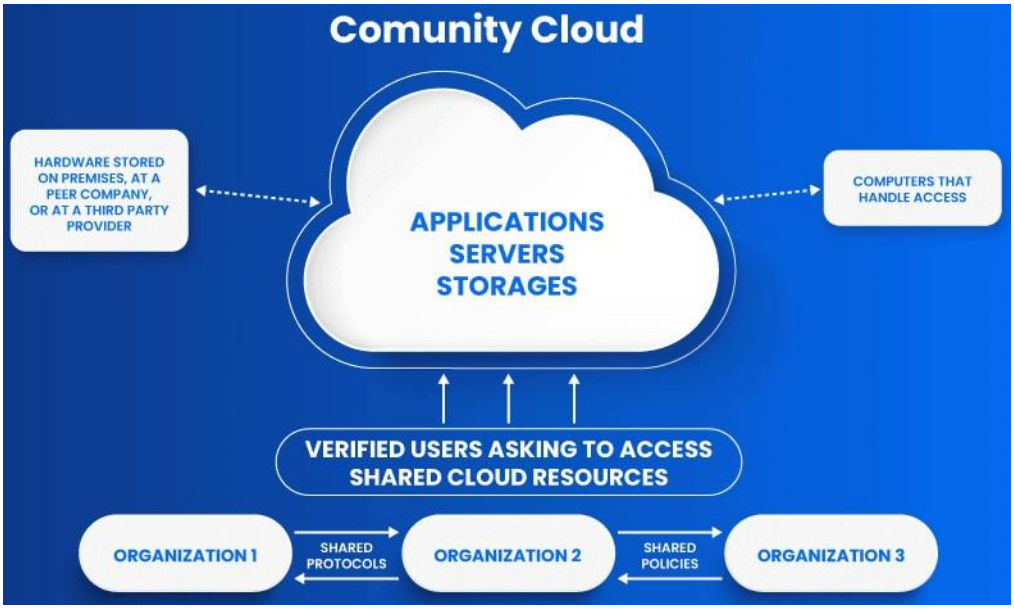
Disadvantages of Hybrid Cloud Deployments

Here are the cons/drawbacks of the Hybrid Cloud Deployment Model:

- It is applicable only when a company has varied use or demand for managing theworkloads.
- Managing a hybrid cloud is complex, so if you use a hybrid cloud, you may spend toomuch.
- Its security features are not good as the Private Cloud.

Community Cloud Model

Community clouds are cloud-based infrastructure models that enable multiple organizations to share resources and services based on standard regulatory requirements. It provides a shared platform and resources for organizations to work on their business requirements. This Cloud Computing model is operated and managed by community members, third-party vendors, or both. The organizations that share standard business requirements makeup the members of the community cloud.



Advantages of Community Cloud Deployments

Here are the pros/benefits of the Community Cloud Deployment Model:

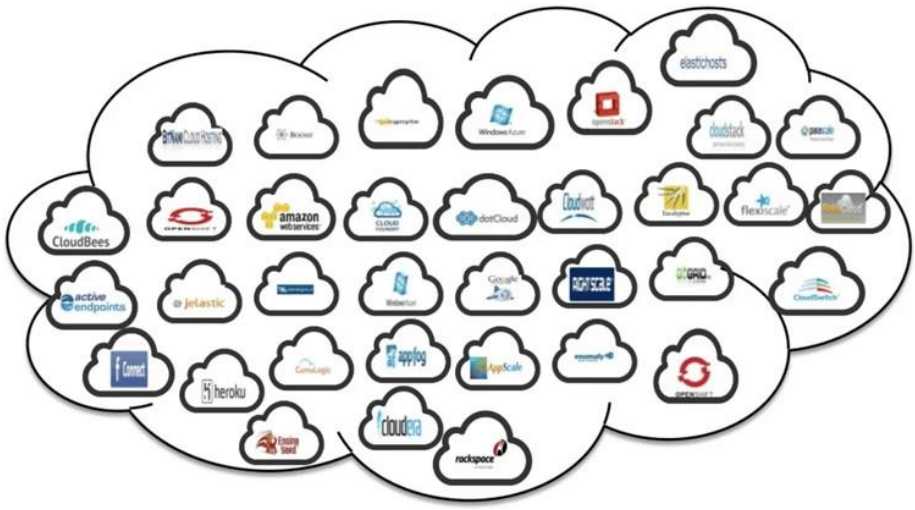
- You can establish a low-cost private cloud.
- It helps you to do collaborative work on the cloud.
- It is cost-effective, as multiple organizations or communities share the cloud.
- You can share resources, Infrastructure, etc., with multiple organizations.
- It is a suitable model for both collaboration and data sharing.
- Gives better security than the public cloud.
- It offers a collaborative space that allows clients to enhance their efficiency.

Disadvantages of Community Cloud Deployments

Here are the cons/drawbacks of the Community Cloud Deployment Model:

- Because of its restricted bandwidth and storage capacity, community resources oftenpose challenges.
- It is not a very popular and widely adopted cloud computing model.
- Security and segmentation are challenging to maintain.

Multi-cloud Model



Multi-cloud computing refers to using public cloud services from many cloud service providers. A company must run workloads on IaaS or PaaS in a multi-cloud configuration frommultiple vendors, such as Azure, AWS, or Google Cloud Platform.

There are many reasons an organization selects a multi-cloud strategy. Some use it to avoid vendor lock-in problems, while others combat shadow IT through multi-cloud deployments. So, employees can still benefit from a specific public cloud service if it does notmeet strict IT policies.

Benefits of Multi-Cloud Deployment Model

Here are the pros/benefits of the Multi-Cloud Deployment Model:

- A multi-cloud deployment model helps organizations choose the specific services thatwork best for them.
- It provides a reliable architecture.
- With multi-cloud models, companies can choose the best Cloud service provider basedon contract options, flexibility with payments, and customizability of capacity.
- It allows you to select cloud regions and zones close to your clients.

Disadvantages of Multi-Cloud Deployments

Here are the cons/drawbacks of the Multi-Cloud Deployment Model:

- Multi-cloud adoption increases the complexity of your business.
- Finding developers, engineers, and cloud security experts who know multiple clouds isdifficult.
- **Comparison of Top Cloud Deployment Models**

Parameters	**Public**	**Private**	**Community**	**Hybrid**
Setup and use	Easy	Need help from a professional IT team.	Require a professional IT team.	Require a profession al IT team.
Scalability and Elasticity	Very High	Low	Moderate	High
Data Control	Little to none	Very High	Relatively High	High
Security and privacy	Very low	Very high	High	Very high
Reliability	Low	High	Higher	High

Demand for in-house software	No	Very high in-house software requirement	No	In-house software is not a must.

How to select the suitable Cloud Deployment Models

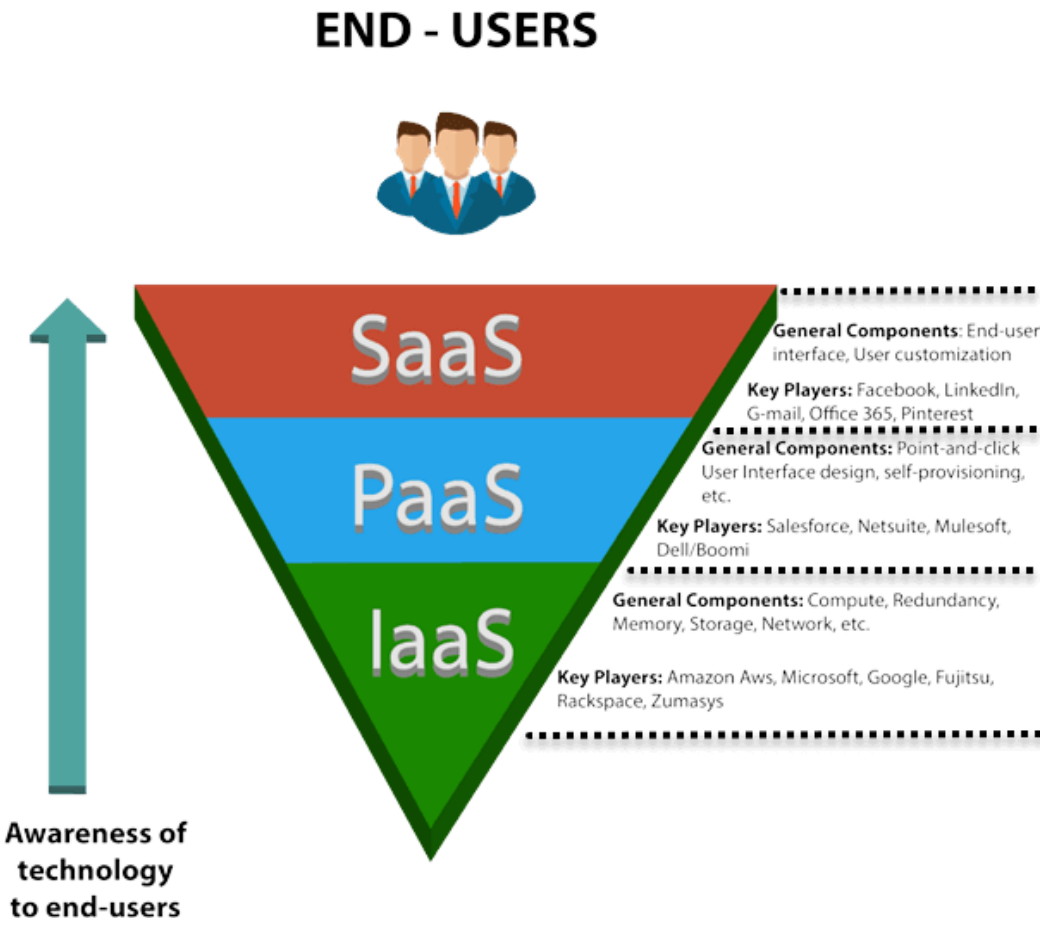
Companies are extensively using these cloud computing models all around the world. Each of them solves a specific set of problems. So, finding the right Cloud Deployment Modelfor you or your company is important.

Here are points you should remember for selecting the right Cloud Deployment Model:

- **Scalability:** You need to check if your user activity is growing quickly or unpredictablywith spikes in demand.
- **Privacy and security:** Select a service provider that protects your privacy and the security of your sensitive data.
- **Cost:** You must decide how many resources you need for your cloud solution. Then calculate the approximate monthly cost for those resources with different cloud providers**.**
- **Ease of use:** You must select a model with no steep learning curve.
- **Legal Compliance:** You need to check whether any relevant low stop you from selecting any specific cloud deployment model.

Cloud Service Models

SaaS, PaaS, and IaaS are the three main cloud computing service model categories. You can access all three via an Internet browser or online apps available on different devices. The cloud service model enables the team to collaborate online instead of offline creation andthen share online.



Software as a Service (SaaS)

Software as a Service (SaaS) is a web-based deployment model that makes the softwareaccessible through a web browser. SaaS software users don't need to care where the softwareis hosted, which operating system it uses, or even which programming language it is written in. The SaaS software is accessible from any device with an internet connection.

This cloud service model ensures that consumers always use the most current version of the software. The SaaS provider handles maintenance and support. In the SaaS model, users don't control the infrastructure, such as storage, processing power, etc.

Characteristics of SaaS

There are the following characteristics of SaaS:

- It is managed from a central location.
- Hosted directly on a remote server.
- It is accessible over the Internet.
- SaaS users are not responsible for hardware and software updates.
- The services are purchased on a pay-as-per-use basis.

Advantages SaaS

Here are the important advantages/pros of SaaS:

- The biggest benefit of using SaaS is that it is easy to set up, so you can start using itinstantly.
- Compared with on-premises software, it is more cost-effective.
- You don’t need to manage or upgrade the software, as it is typically included in a SaaSsubscription or purchase.
- It won’t use your local resources, such as the hard disk typically required to installdesktop software.
- It is a cloud computing service category that provides a wide range of hosted capabilities and services.
- Developers can easily build and deploy web-based software applications.
- You can easily access it through a browser.

Disadvantages SaaS

Here are the important cons/drawbacks of SaaS:

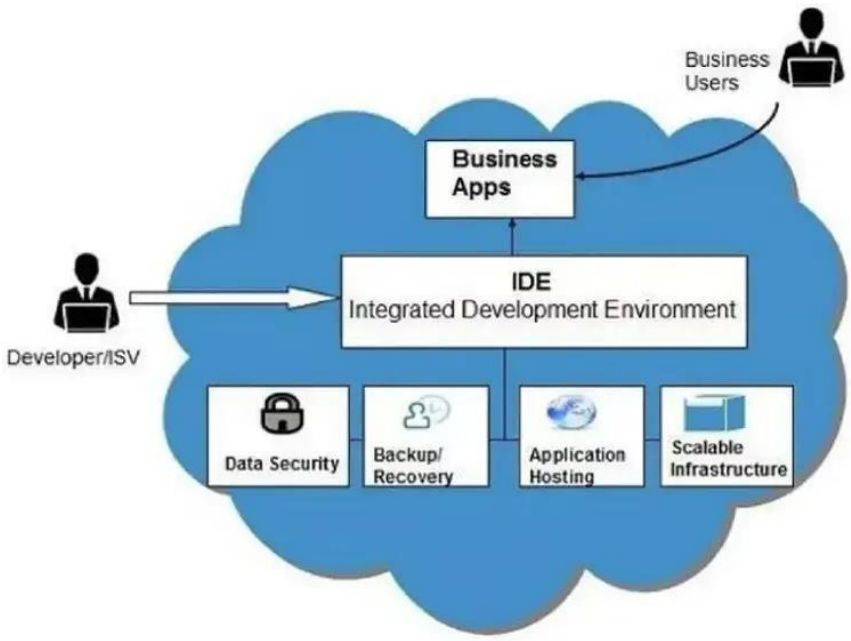
- Integrations are up to the provider, so it's impossible to "patch" an integration on yourend.
- SaaS tools may become incompatible with other tools and hardware already used inyour business.
- You depend on the SaaS company's security measures, so your data may be compromised if any leaks occur.

Consider Before SaaS Implementation

Need to consider before SaaS implementation:

- It would help if you opted for configuration over customization within a SaaS-baseddelivery model.
- You must carefully understand the usage rates and set clear objectives to achieve theSaaS adoption.
- You can complement your SaaS solution with integrations and security options to makeit more user-oriented.

Platform as a Service (PaaS)



Platform-as-a-Service (PaaS) provides a cloud computing framework for software application creation and deployment. It is a platform for the deployment and management of software apps. This flexible cloud computing model scales up automatically on demand. It alsomanages the servers, storage, and networking, while the developers manage only the application part. It offers a runtime environment for application development and deploymenttools.

This Model provides all the facilities required to support the complex life cycle of building and delivering web applications and services entirely for the Internet. This cloud computing model enables developers to rapidly develop, run, and manage their apps without building and maintaining the infrastructure or platform.

Characteristics of PaaS

There are the following characteristics of PaaS:

- Builds on virtualization technology, so computing resources can easily be scaled up(Auto-scale) or down according to the organization's needs.
- Support multiple programming languages and frameworks.
- Integrates with web services and databases.

Advantages PaaS

Here are the important benefits/pros of PaaS:

- Simple, cost-effective development and deployment of apps
- Developers can customize SaaS apps without the headache of maintaining the software
- Provide automation of Business Policy
- Easy migration to the Hybrid Model
- It allows developers to build applications without the overhead of the underlying operating system or cloud infrastructure
- Offers freedom to developers to focus on the application's design while the platform takes care of the language and the database
- It helps developers to collaborate with other developers on a single app

Disadvantages of SaaS

Here are the important cons/drawbacks of PaaS:

- You have control over the app's code and not its infrastructure.
- The PaaS organization stores your data, so it sometimes poses a security risk to yourapp's users.
- Vendors provide varying service levels, so selecting the right services is essential.
- The risk of lock-in with a vendor may affect the ecosystem you need for yourdevelopment environment.

Consider Before PaaS Implementation

Here are essential things you need to consider before PaaS implementation:

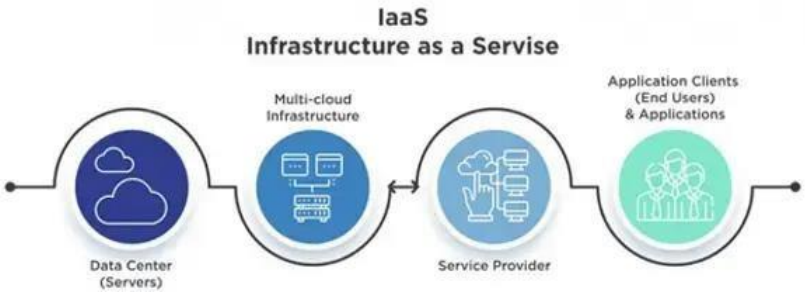
- Analyze your business needs, decide the automation levels, and also decides whetheryou want a self-service or fully automated PaaS model.
- You need to determine whether to deploy on a private or public cloud.
- Plan through the customization and efficiency levels.

Infrastructure as a Service (IaaS)

Infrastructure-as-a-Service (IaaS) is a cloud computing service offering on-demandcomputing, storage, and networking resources. It usually works on a pay-as-you-go basis.

Organizations can purchase resources on-demand and as needed instead of buying thehardware outright.

The IaaS cloud vendor hosts the infrastructure components, including the on-premisesdata center, servers, storage, networking hardware, and the hypervisor (virtualization layer).



This Model contains the basic building blocks for your web application. It provides complete control over the hardware that runs your application (storage, servers, VMs, networks& operating systems). IaaS model gives you the best flexibility and management control overyour IT resources.

Characteristics of IaaS

There are the following characteristics of IaaS:

- Resources are available as a service
- Services are highly scalable
- Dynamic and flexible Cloud Service Model
- GUI and API-based access
- Automate the administrative tasks

Advantages of IaaS

Here are the important benefits/pros of PaaS:

- Easy to automate the deployment of storage, networking, and servers.
- Hardware purchases can be based on consumption.
- Clients keep complete control of their underlying infrastructure.
- The provider can deploy the resources to a customer's environment anytime.
- It can be scaled up or downsized according to your needs.

Disadvantages of IaaS

Here are the important Cons/drawbacks of IaaS:

- You should ensure that your apps and operating systems are working correctly andproviding the utmost security.
- You're in charge of the data, so if any of it is lost, it's up to you to recover it.

- IaaS firms only provide the servers and API, so you must configure everything else.

Consider Before IaaS Implementation

Here are some specific considerations you should remember before IaaS Implementation:

- You should clearly define your access needs and your network's bandwidth tofacilitate smooth implementation and functioning.
- Plan out detailed data storage and security strategy to streamline the business process.
- Ensure that your organization has a proper disaster recovery plan to keep your datasafe and accessible.

How can select the Best SaaS Service Provider

Here are some essential criteria for selecting the best cloud service provider:

- **Financial stability**: Look for a well-financed cloud provider that has steady profits from the infrastructure. If the company shuts down because of monetary issues, yoursolutions will also be in jeopardy.
- **Industries that prefer the solution**: Before finalizing cloud services, examine its existing clients and markets. Your cloud service provider should be popular amongcompanies in your niche or neighboring ones.
- **Datacenter locations**: To avoid safety risks, ensure that cloud providers enable yourdata's geographical distribution.
- **Encryption standards**: You should make sure the cloud provider supports majorencryption algorithms.
- **Check accreditation and auditing**: The widely used online auditing standard isSSAE. This procedure helps you to verify the safety of online data storage. ISO 27001 certificate verifies that a cloud provider complies with international safetystandards for data storage.
- **Backup**: The provider should support incremental backups so that you can storeoffsite and quickly restore.

Driving Factors and Challenges of Cloud

Data Security and Privacy

Data security is a major concern when switching to cloud computing. User ororganizational data stored in the cloud is critical and private. Even if the cloud service provider assures data integrity, it is your responsibility to carry out user authentication and authorization, identity management, data encryption, and access control. Security issues on thecloud include identity theft, data breaches, malware infections, and a lot more which eventuallydecrease the trust amongst the users of your applications. This can in turn lead to potential lossin revenue alongside reputation and stature. Also, dealing with cloud computing requires sending and receiving huge amounts of data at high speed, and therefore is susceptible to dataleaks.

Cost Management

Even as almost all cloud service providers have a "Pay As You Go" model, which reduces the overall cost of the resources being used, there are times when there are huge costs incurred to the enterprise using cloud computing. When there is under optimization of the resources, let's say that the servers are not being used to their full potential, add up to the hidden costs. If there is a degraded application performance or sudden spikes or overages in the usage, it adds up to the overall cost. Unused resources are one of the other main reasons why the costs go up. If you turn on the services or an instance of cloud and forget to turn it offduring the weekend or when there is no current use of it, it will increase the cost without evenusing the resources.

Multi-Cloud Environments

Due to an increase in the options available to the companies, enterprises not only use asingle cloud but depend on multiple cloud service providers. Most of these companies use hybrid cloud tactics and close to 84% are dependent on multiple clouds. This often ends up being hindered and difficult to manage for the infrastructure team. The process most of the time ends up being highly complex for the IT team due to the differences between multiple cloud providers.

Performance Challenges

Performance is an important factor while considering cloud-based solutions. If the performance of the cloud is not satisfactory, it can drive away users and decrease profits. Even a little latency while loading an app or a web page can result in a huge drop in the percentage of users. This latency can be a product of inefficient load balancing, which means that the server cannot efficiently split the incoming traffic so as to provide the best user experience. Challenges also arise in the case of fault tolerance, which means the operations continue asrequired even when one or more of the components fail.

Interoperability and Flexibility

When an organization uses a specific cloud service provider and wants to switch to another cloud-based solution, it often turns up to be a tedious procedure since applications written for one cloud with the application stack are required to be re-written for the other cloud. There is a lack of flexibility from switching from one cloud to another due to the complexities involved. Handling data movement, setting up the security from scratch and network also addup to the issues encountered when changing cloud solutions, thereby reducing flexibility.

High Dependence on Network

Since cloud computing deals with provisioning resources in real-time, it deals with enormous amounts of data transfer to and from the servers. This is only made possible due to the availability of the high-speed network. Although these data and resources are exchanged over the network, this can prove to be highly vulnerable in case of limited bandwidth or caseswhen there is a sudden outage. Even when the enterprises can cut their hardware costs, they need to ensure that the internet bandwidth is high as well there are zero network outages, or else it can result in a potential business loss. It is therefore a major challenge for smaller enterprises that have to maintain network bandwidth that comes with a high cost.

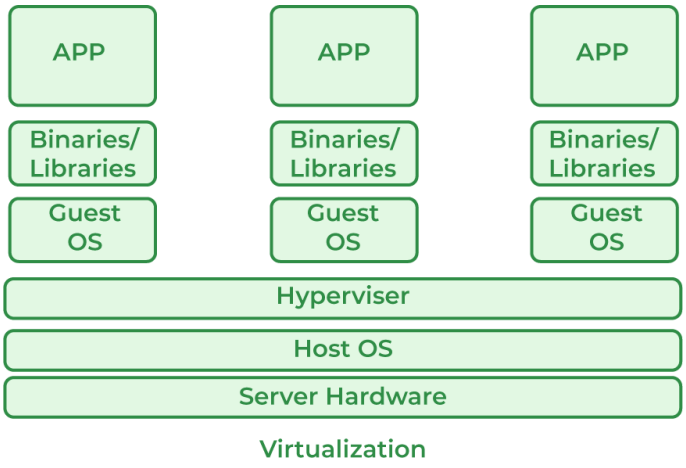
Lack of Knowledge and Expertise

Due to the complex nature and the high demand for research working with the cloud often ends up being a highly tedious task. It requires immense knowledge and wide expertise on the subject. Although there are a lot of professionals in the field they need to constantly update themselves. Cloud computing is a highly paid job due to the extensive gap between

demand and supply. There are a lot of vacancies but very few talented cloud engineers, developers, and professionals. Therefore, there is a need for upskilling so these professionals can actively understand, manage and develop cloud-based applications with minimum issues and maximum reliability.

Virtualization

Virtualization is a technique how to separate a service from the underlying physical delivery of that service. It is the process of creating a virtual version of something like computer hardware. It was initially developed during the mainframe era. It involves using specialized software to create a virtual or software-created version of a computing resource rather than the actual version of the same resource. With the help of Virtualization, multiple operating systems and applications can run on the same machine and its same hardware at thesame time, increasing the utilization and flexibility of hardware.



Virtualization

Host Machine: The machine on which the virtual machine is going to be built is known as Host Machine.

Guest Machine: The virtual machine is referred to as a Guest Machine.

Virtualization has a prominent impact on Cloud Computing. In the case of cloud computing, users store data in the cloud, but with the help of Virtualization, users have the extra benefit of sharing the infrastructure. Cloud Vendors take care of the required physical resources, but these cloud providers charge a huge amount for these services which impacts every user or organization. Virtualization helps Users or Organisations in maintaining those services which are required by a company through external (third-party) people, which helps in reducing costs to the company. This is the way through which Virtualization works in Cloud Computing.

Benefits of Virtualization

- More flexible and efficient allocation of resources.
- Enhance development productivity.
- It lowers the cost of IT infrastructure.
- Remote access and rapid scalability.
- High availability and disaster recovery.
- Pay peruse of the IT infrastructure on demand.
- Enables running multiple operating systems.

Drawback of Virtualization

- **High Initial Investment:** Clouds have a very high initial investment, but it is also truethat it will help in reducing the cost of companies.
- **Learning New Infrastructure:** As the companies shifted from Servers to Cloud, it requires highly skilled staff who have skills to work with the cloud easily, and for this,you have to hire new staff or provide training to current staff.
- **Risk of Data:** Hosting data on third-party resources can lead to putting the data at risk,it has the chance of getting attacked by any hacker or cracker very easily.

Characteristics of Virtualization

- **Increased Security:** The ability to control the execution of a guest program in a completely transparent manner opens new possibilities for delivering a secure, controlled execution environment. All the operations of the guest programs are generally performed against the virtual machine, which then translates and applies themto the host programs.
- **Managed Execution**: In particular, sharing, aggregation, emulation, and isolation are the most relevant features.
- **Sharing:** Virtualization allows the creation of a separate computing environment within the same host.
- **Aggregation:** It is possible to share physical resources among several guests, but virtualization also allows aggregation, which is the opposite process.

Types of Virtualization

1. Application Virtualization
2. Network Virtualization
3. Desktop Virtualization
4. Storage Virtualization
5. Server Virtualization
6. Data virtualization

1. Application Virtualization:

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

2. Network Virtualization:

The ability to run multiple virtual networks with each having a separate control and data plan. It co-exists together on top of one physical network. It can be managed by individual parties that are potentially confidential to each other. Network virtualization provides a facilityto create and provision virtual networks, logical switches, routers, firewalls, load balancers, Virtual Private Networks (VPN), and workload security within days or even weeks.

3. Desktop Virtualization:

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

4. Storage Virtualization:

Storage virtualization is an array of servers that are managed by a virtual storage system. The servers aren't aware of exactly where their data is stored and instead function more like worker bees in a hive. It makes managing storage from multiple sources be managed

and utilized as a single repository. storage virtualization software maintains smooth operations,consistent performance, and a continuous suite of advanced functions despite changes, breaksdown, and differences in the underlying equipment.

5. Server Virtualization:

This is a kind of virtualization in which the masking of server resources takes place. Here, the central server (physical server) is divided into multiple different virtual servers by changing the identity number, and processors. So, each system can operate its operating systems in an isolated manner. Where each sub-server knows the identity of the central server. It causes an increase in performance and reduces the operating cost by the deployment of main server resources into a sub-server resource. It's beneficial in virtual migration, reducing energyconsumption, reducing infrastructural costs, etc.

6. Data Virtualization:

This is the kind of virtualization in which the data is collected from various sources andmanaged at a single place without knowing more about the technical information like how datais collected, stored & formatted then arranged that data logically so that its virtual view can beaccessed by its interested people and stakeholders, and users through the various cloud servicesremotely. Many big giant companies are providing their services like Oracle, IBM, At scale, Cdata, etc.

Load Balancing

Load balancing is the method that allows you to have a proper balance of the amount of work being done on different pieces of device or hardware equipment. Typically, what happens is that the load of the devices is balanced between different servers or between the CPU and hard drives in a single cloud server.

Load balancing was introduced for various reasons. One of them is to improve the speed and performance of each single device, and the other is to protect individual devices from hitting their limits by reducing their performance.

Cloud load balancing is defined as dividing workload and computing properties in cloud computing. It enables enterprises to manage workload demands or application demandsby distributing resources among multiple computers, networks or servers. Cloud load balancing involves managing the movement of workload traffic and demands over the Internet.

Traffic on the Internet is growing rapidly, accounting for almost 100% of the current traffic annually. Therefore, the workload on the servers is increasing so rapidly, leading to overloading of the servers, mainly for the popular web servers. There are two primary solutions to overcome the problem of overloading on the server-

First is a single-server solution in which the server is upgraded to a higher-performanceserver. However, the new server may also be overloaded soon, demanding another upgrade. Moreover, the upgrading process is arduous and expensive.

The second is a multiple-server solution in which a scalable service system on a cluster of servers is built. That's why it is more cost-effective and more scalable to build a server cluster system for network services.

Cloud-based servers can achieve more precise scalability and availability by using farmserver load balancing. Load balancing is beneficial with almost any type of service, such as HTTP, SMTP, DNS, FTP, and POP/IMAP.

It also increases reliability through redundancy. A dedicated hardware device or program provides the balancing service.

Different Types of Load Balancing Algorithms in Cloud Computing:

1. Static Algorithm

Static algorithms are built for systems with very little variation in load. The entire traffic is divided equally between the servers in the static algorithm. This algorithm requires in-depth knowledge of server resources for better performance of the processor, which is determined at the beginning of the implementation.

However, the decision of load shifting does not depend on the current state of the system. One of the major drawbacks of static load balancing algorithm is that load balancing tasks work only after they have been created. It could not be implemented on other devices forload balancing.

2. Dynamic Algorithm

The dynamic algorithm first finds the lightest server in the entire network and gives it priority for load balancing. This requires real-time communication with the network which canhelp increase the system's traffic. Here, the current state of the system is used to control the load. The characteristic of dynamic algorithms is to make load transfer decisions in the current system state. In this system, processes can move from a highly used machine to an underutilized machine in real time.

3. Round Robin Algorithm

Round robin load balancing algorithm uses round-robin method to assign jobs. First, itrandomly selects the first node and assigns tasks to other nodes in a round-robin manner. Thisis one of the easiest methods of load balancing.

Processors assign each process circularly without defining any priority. It gives fast response in case of uniform workload distribution among the processes. All processes have different loading times. Therefore, some nodes may be heavily loaded, while others may remain under-utilised.

4. Weighted Round Robin Load Balancing Algorithm

Weighted Round Robin Load Balancing Algorithms have been developed to enhance the most challenging issues of Round Robin Algorithms. In this algorithm, there are a specifiedset of weights and functions, which are distributed according to the weight values.

Processors that have a higher capacity are given a higher value. Therefore, the highest loaded servers will get more tasks. When the full load level is reached, the servers will receive stable traffic.

5. Opportunistic Load Balancing Algorithm

The opportunistic load balancing algorithm allows each node to be busy. It never considers the current workload of each system. Regardless of the current workload on each node, OLB distributes all unfinished tasks to these nodes.

The processing task will be executed slowly as an OLB, and it does not count the implementation time of the node, which causes some bottlenecks even when some nodes are free.

6. Minimum to Minimum Load Balancing Algorithm

Under minimum to minimum load balancing algorithms, first of all, those tasks take minimum time to complete. Among them, the minimum value is selected among all the functions. According to that minimum time, the work on the machine is scheduled.

Other tasks are updated on the machine, and the task is removed from that list. This process will continue till the final assignment is given. This algorithm works best where many small tasks outweigh large tasks.

Load balancing solutions can be categorized into two types -

Software-based load balancers: Software-based load balancers run on standard hardware (desktop, PC) and standard operating systems.

Hardware-based load balancers: Hardware-based load balancers are dedicated boxes that contain application-specific integrated circuits (ASICs) optimized for a particular use. ASICs allow network traffic to be promoted at high speeds and are often used for transport-level loadbalancing because hardware-based load balancing is faster than a software solution.

Major Examples of Load Balancers

Direct Routing Request Despatch Technique: This method of request dispatch is similar tothat implemented in IBM's NetDispatcher. A real server and load balancer share a virtual IP address. The load balancer takes an interface built with a virtual IP address that accepts requestpackets and routes the packets directly to the selected server.

Dispatcher-Based Load Balancing Cluster: A dispatcher performs smart load balancing using server availability, workload, capacity and other user-defined parameters to regulate where TCP/IP requests are sent. The dispatcher module of a load balancer can split HTTP requests among different nodes in a cluster. The dispatcher divides the load among multiple servers in a cluster, so services from different nodes act like a virtual service on only one IP address; Consumers interconnect as if it were a single server, without knowledge of the back-end infrastructure.

Linux Virtual Load Balancer: This is an open-source enhanced load balancing solution usedto build highly scalable and highly available network services such as HTTP, POP3,

FTP, SMTP, media and caching, and Voice over Internet Protocol (VoIP) is done. It is a simple andpowerful product designed for load balancing and fail-over. The load balancer itself is the primary entry point to the server cluster system. It can execute Internet Protocol Virtual Server(IPVS), which implements transport-layer load balancing in the Linux kernel, also known as layer-4 switching.

Types of Load Balancing

Network Load Balancing

Cloud load balancing takes advantage of network layer information and leaves it to decide where network traffic should be sent. This is accomplished through Layer 4 load balancing, which handles TCP/UDP traffic. It is the fastest local balancing solution, but it cannot balance the traffic distribution across servers.

HTTP(S) load balancing

HTTP(s) load balancing is the oldest type of load balancing, and it relies on Layer 7. This means that load balancing operates in the layer of operations. It is the most flexible type of load balancing because it lets you make delivery decisions based on information retrieved from HTTP addresses.

Internal Load Balancing

It is very similar to network load balancing, but is leveraged to balance the infrastructure internally.

Load balancers can be further divided into hardware, software and virtual load balancers.

Hardware Load Balancer

It depends on the base and the physical hardware that distributes the network and application traffic. The device can handle a large traffic volume, but these come with a hefty price tag and have limited flexibility.

Software Load Balancer

It can be an open source or commercial form and must be installed before it can be used. These are more economical than hardware solutions.

Virtual Load Balancer

It differs from a software load balancer in that it deploys the software to the hardware load-balancing device on the virtual machine.

WHY CLOUD LOAD BALANCING IS IMPORTANT IN CLOUD COMPUTING?

Here are some of the importance of load balancing in cloud computing.

Offers better performance

The technology of load balancing is less expensive and also easy to implement. This allows companies to work on client applications much faster and deliver better results at a lower cost.

Helps Maintain Website Traffic

Cloud load balancing can provide scalability to control website traffic. By using effective load balancers, it is possible to manage high-end traffic, which is achieved using network equipment and servers. E-commerce companies that need to deal with multiple visitors every second use cloud load balancing to manage and distribute workloads.

Can Handle Sudden Bursts in Traffic

Load balancers can handle any sudden traffic bursts they receive at once. For example, in case of university results, the website may be closed due to too many requests. When one uses a load balancer, he does not need to worry about the traffic flow. Whatever the size of thetraffic, load balancers will divide the entire load of the website equally across different serversand provide maximum results in minimum response time.

Greater Flexibility

The main reason for using a load balancer is to protect the website from sudden crashes.When the workload is distributed among different network servers or units, if a single node fails, the load is transferred to another node. It offers flexibility, scalability and the ability to handle traffic better. Because of these characteristics, load balancers are beneficial in cloud environments. This is to avoid heavy workload on a single server.

Scalability and Elasticity

Cloud Elasticity

Elasticity refers to the ability of a cloud to automatically expand or compress the infrastructural resources on a sudden up and down in the requirement so that the workload canbe managed efficiently. This elasticity helps to minimize infrastructural costs. This is not applicable for all kinds of environments, it is helpful to address only those scenarios where theresource requirements fluctuate up and down suddenly for a specific time interval. It is not quite practical to use where persistent resource infrastructure is required to handle the heavy workload.

The Flexibility in cloud is a well-known highlight related with scale-out arrangements(level scaling), which takes into consideration assets to be powerfully added or eliminated when required. It is for the most part connected with public cloud assets which is generally highlighted in pay-per-use or pay-more only as costs arise administrations.

The Flexibility is the capacity to develop or contract framework assets (like process, capacity or organization) powerfully on a case by case basis to adjust to responsibility changesin the applications in an autonomic way.

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 a spike up.In order to handle this kind of situation, we can go for a Cloud-Elasticity service rather than Cloud Scalability. As soon as the season goes out, the deployed resources can then be requestedfor withdrawal.

Cloud Scalability

Cloud scalability is used to handle the growing workload where good performance is also needed to work efficiently with software or applications. Scalability is commonly used where the persistent deployment of resources is required to handle the workload statically.

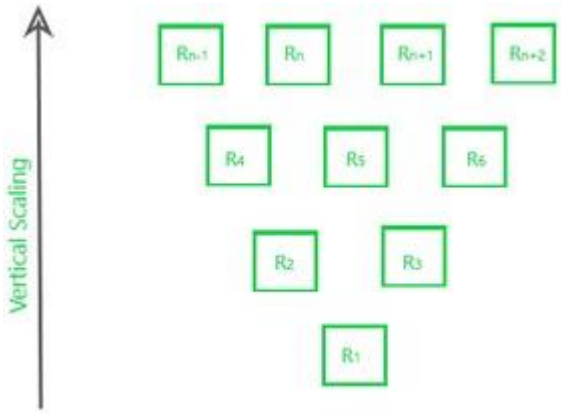
Example: Consider you are the owner of a company whose database size was small in earlierdays but as time passed your business does grow and the size of your database also increases,so in this case you just need to request your cloud service vendor to scale up your database capacity to handle a heavy workload.

It is totally different from what you have read above in Cloud Elasticity. Scalability is used tofulfill the static needs while elasticity is used to fulfill the dynamic need of the organization. Scalability is a similar kind of service provided by the cloud where the customers have to pay-per-use. So, in conclusion, we can say that Scalability is useful where the workload remains high and increases statically.

Types of Scalability

1. Vertical Scalability (Scale-up)

In this type of scalability, increase the power of existing resources in the workingenvironment in an upward direction.

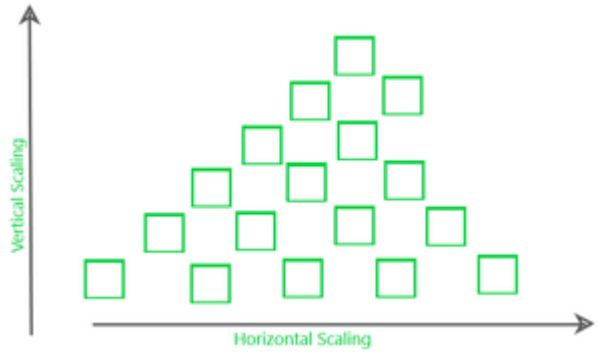


2. Horizontal Scalability

In this kind of scaling, the resources are added in a horizontal row.

3. Diagonal Scalability

It is a mixture of both Horizontal and Vertical scalability where the resources are addedboth vertically and horizontally.



Difference Between Cloud Elasticity and Scalability

	Cloud Elasticity	**Cloud Scalability**
1	Elasticity is used just to meet the sudden up and down in the workload for a small period of time.	Scalability is used to meet the static increase in the workload.
2	Elasticity is used to meet dynamic changes, where the resources need can increase or decrease.	Scalability is always used to address the increase in workload in an organization.
3	Elasticity is commonly used by small companies whose workload and demand increases only for a specific period of time.	Scalability is used by giant companies whose customer circle persistently grows in order to do the operations efficiently.
4	It is a short term planning and adopted just to deal with an unexpected increase in demand or seasonal demands.	Scalability is a long term planning and adopted just to deal with an expected increase in demand.

Replication

The simplest form of data replication in cloud computing environment is to store a copyof a file (copy), in expanded form, the copying and pasting in any modern operating systems.Replication is the reproduction of the original data in unchanged form. Changing data accessesare expensive in general through replication. In the frequently encountered master / slave replication, a distinction between the original data (primary data) and the dependent copies. In peer copies (version control) there must be merging of data sets (synchronization). Sometimesit is important to know which data sets must have the replicas. Depending on the type of replication it is located between the processing and creation of the primary data and their replication in a certain period of time. This period is usually referred to as latency.

Array-Based Data Replication

An array-based data replication strategy uses built-in software to automatically replicate data. With this type of data replication, the software is used in compatible storage arrays to copy data between each. Using this method has several advantages and disadvantages.

Advantages:

- More robust
- Requires less coordination when deployed
- The work gets offloaded from the servers to the storage device

Disadvantages:

- Requires homogenous storage environments: the source and target array have to besimilar
- It is costly to implement

Host-Based Data Replication

Host-based data replication uses the servers to copy data from one site to another site. Host-based replication software usually includes options like compression, encryption and, throttling, as well as failover. Using this method has several advantages and disadvantages.

Advantages:

- Flexible: It can leverage existing IP networks
- Can be customized to your business' needs: You can choose what data to replicate
- Can create a schedule for sending data: allows you to throttle bandwidth
- Can use any combination of storage devices on each end

Disadvantages:

- Difficult to manage with a large group of servers if there is no centralized managementconsole
- Consumes host resources during replication
- Both storage devices on each end need to be active, which means you will need topurchase dedicated hardware and OS
- Not all applications can support this type of data replication
- Can be affected by viruses or application failure
- Host-based replication offers the safest option if a business is looking for close to zeroimpact on operations after a disaster.

Network-Based Data Replication

Network-based data replication uses a device or appliance that sits on the network in the path of the data to manage replication. The data is then copied to a second device. These devices usually have proprietary replication technology but can be used with any host server and storage hardware.

Advantages

- Effective in large, heterogeneous storage and server environments
- Supports any host platform and works with any array
- Works separately from the servers and the storage devices
- Allows replication between multi-vendor products

Disadvantages:

- Higher initial set-up cost because it requires proprietary hardware, as well as ongoingoperational and management costs
- Requires implementation of a storage area network (SAN)

Monitoring

Cloud monitoring is a method of reviewing, observing, and managing the operational workflow in a cloud-based IT infrastructure. Manual or automated management techniques confirm the availability and performance of websites, servers, applications, and other cloud infrastructure. This continuous evaluation of resource levels, server response times, and speedpredicts possible vulnerability to future issues before they arise.

This technique tracks multiple analytics simultaneously, monitoring storage resourcesand processes that are provisioned to virtual machines, services, databases, and applications. This technique is often used to host infrastructure-as-a-service (IaaS) and software-as-a-service (SaaS) solutions. For these applications, you can configure monitoring to track performance metrics, processes, users, databases, and available storage. It provides data to help you focus on useful features or to fix bugs that disrupt functionality.

Monitoring is a skill, not a full-time job. In today's world of cloud-based architecturesthat are implemented through DevOps projects, developers, site reliability engineers (SREs), and operations staff must collectively define an effective cloud monitoring strategy. Such a strategy should focus on identifying when service-level objectives (SLOs) are not being met, likely negatively affecting the user experience. So, then what are the benefits of leveraging cloud monitoring tools? With cloud monitoring:

Benefits of cloud monitoring

- Scaling for increased activity is seamless and works in organizations of any size
- Dedicated tools (and hardware) are maintained by the host
- Tools are used across several types of devices, including desktop computers, tablets,and phones, so your organization can monitor apps from any location
- Installation is simple because infrastructure and configurations are already in place
- Your system doesn't suffer interruptions when local problems emerge, because

resources aren’t part of your organization’s servers and workstations

- Subscription-based solutions can keep your costs low

Cloud monitoring is primarily part of cloud security and management processes. It is normally implemented through automated monitoring software that provides central access and control over cloud infrastructure.

Cloud Services and PlatformsCloud Reference Model

• Infrastructure & Facilities Layer

Includes the physical infrastructure such as datacenter facilities, electrical and mechanical equipment, etc.

• Hardware Layer

Includes physical compute, network and storage hardware.

• Virtualization Layer

Partitions the physical hardware resources into multiple virtual resources that enablingpooling of resources.

• Platform & Middleware Layer

Builds upon the IaaS layers below and provides standardized stacks of services such asdatabase service, queuing service, application frameworks and run-time environments, messaging services, monitoring services, analytics services, etc.

• Service Management Layer

Provides APIs for requesting, managing and monitoring cloud resources.

• Applications Layer

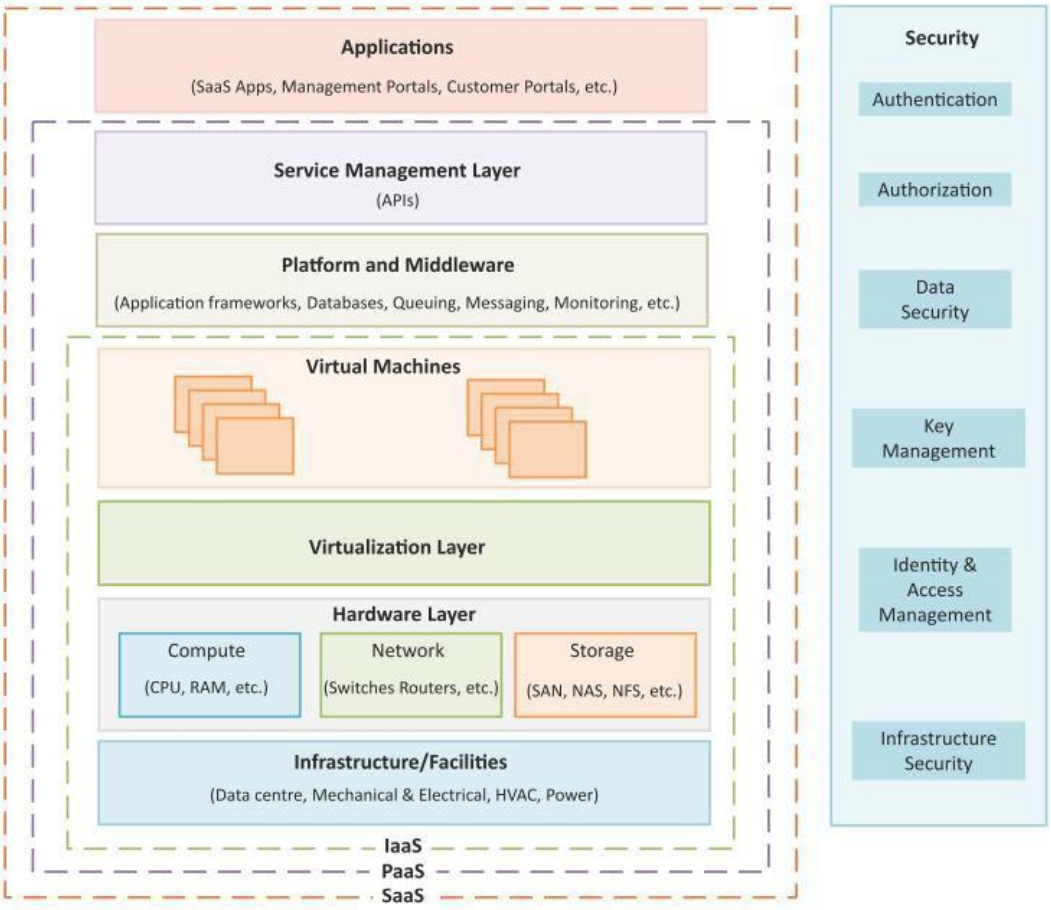
Includes SaaS applications such as Email, cloud storage application, productivity applications, management portals, customer self-service portals, etc.

• Infrastructure & Facilities Layer

Includes the physical infrastructure such as datacenter facilities, electrical and mechanical equipment, etc.

• **Hardware Layer**

Includes physical compute, network and storage hardware.



Compute Service

- Compute services provide dynamically scalable compute capacity in the cloud.
- Compute resources can be provisioned on-demand in the form of virtual machines. Virtual machines can be created from standard images provided by the cloud service provider or custom images created by the users.
- Compute services can be accessed from the web consoles of these services that provide graphical user interfaces for provisioning, managing and monitoring these services.
- Cloud service providers also provide APIs for various programming languages that allow developers to access and manage these services programmatically.

Compute Service - Amazon EC2

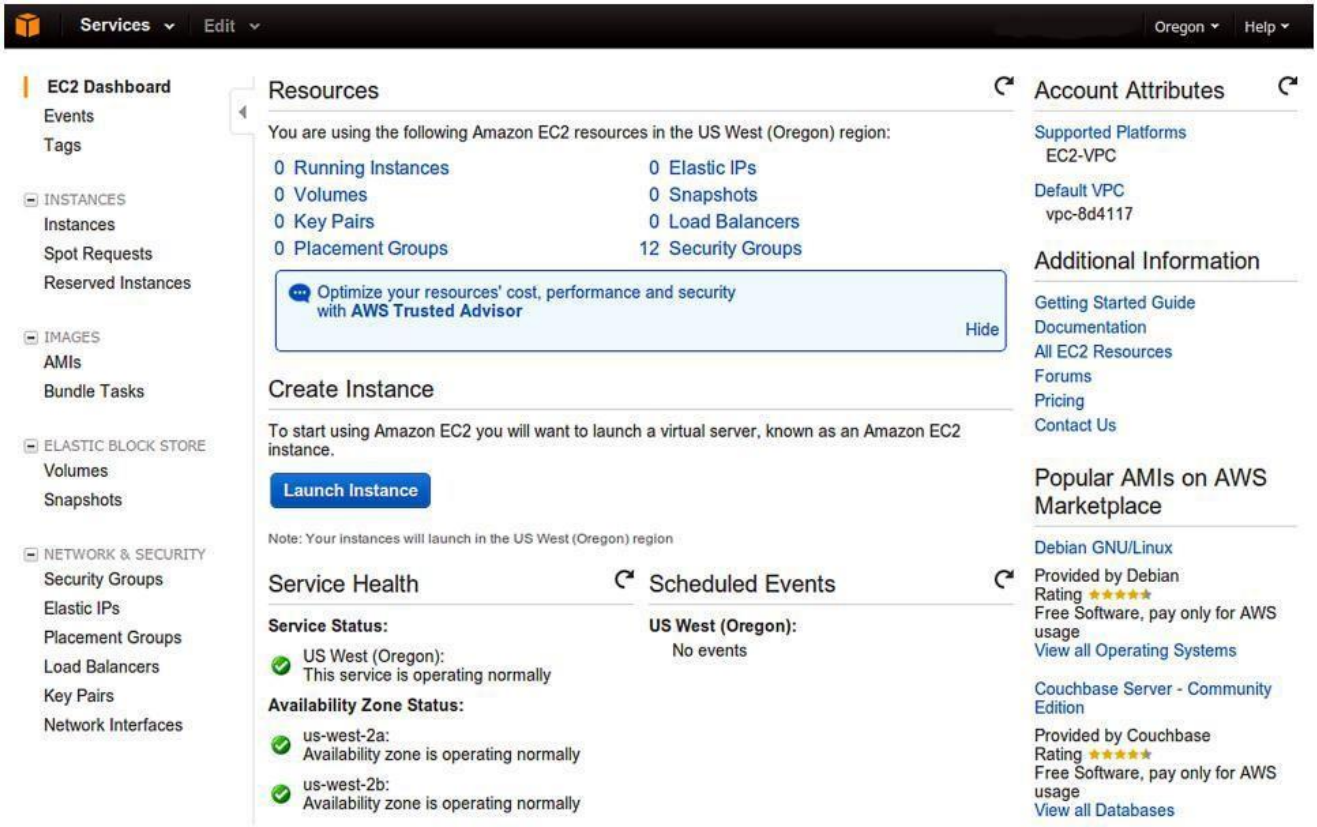
- Amazon Elastic Compute Cloud (EC2) is a compute service provided by Amazon.
- Launching EC2 Instances

  To launch a new instance click on the launch instance button. This will open awizard where you can select the Amazon machine image (AMI) with which you want to launch the instance. You can also create their own AMIs with custom applications, libraries and data. Instances can be launched with a variety of operating systems.
- Instance Sizes

  When you launch an instance you specify the instance type (micro, small, medium, large, extra-large, etc.), the number of instances to launch based on the selected AMI and availability zones for the instances.
- Key-pairs

  When launching a new instance, the user selects a key-pair from existing keypairs or creates a new keypair for the instance. Keypairs are used to securely connect to an instance after it launches.
- Security Groups

  The security groups to be associated with the instance can be selected from theinstance launch wizard. Security groups are used to open or block a specific network port for the launched instances.



Compute Services – Google Compute Engine

- Google Compute Engine is a compute service provided by Google.

- **Launching Instances**

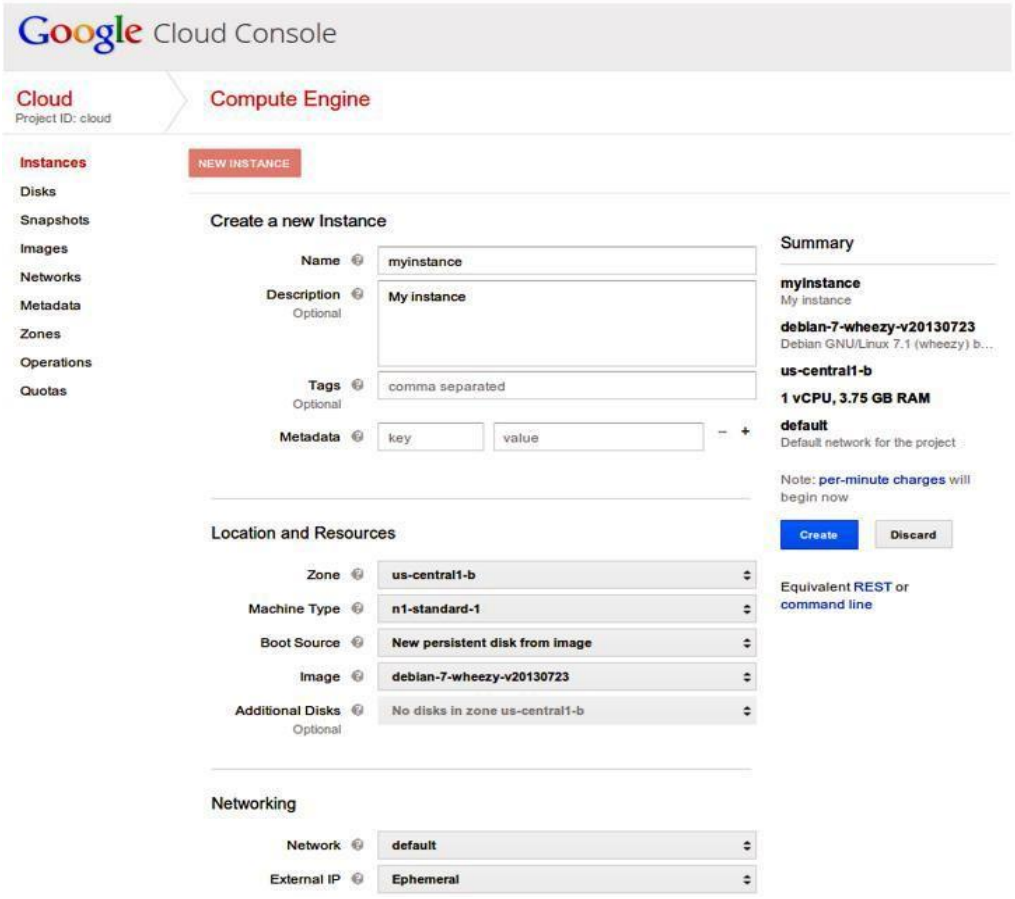
To create a new instance, the user selects an instance machine type, a zone in which the instance will be launched, a machine image for the instance and provides an instance name,instance tags and meta-data.

- **Disk Resources**

Every instance is launched with a disk resource. Depending on the instance type, the disk resource can be a scratch disk space or persistent disk space. The scratch disk space is deleted when the instance terminates. Whereas, persistent disks live beyond the life of an instance.

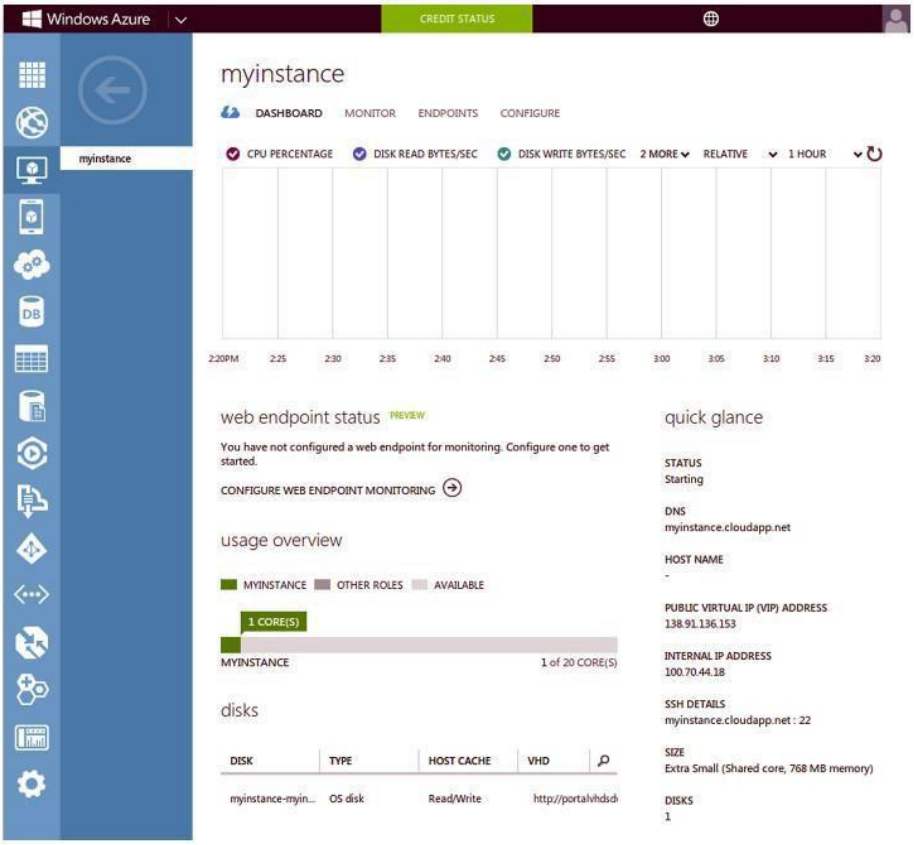
- **Network Options**

Network option allows you to control the traffic to and from the instances. By default,traffic between instances in the same network, over any port and any protocol and incoming SSH connections from anywhere are enabled.



Compute Services – Windows Azure VMs

- Windows Azure Virtual Machines is the compute service from Microsoft.
- Launching Instances:
    - To create a new instance, you select the instance type and the machine image.
    - You can either provide a user name and password or upload a certificate file forsecurely connecting to the instance.
    - Any changes made to the VM are persistently stored and new VMs can becreated from the previously stored machine images.



Storage Services

- Cloud storage services allow storage and retrieval of any amount of data, at any timefrom anywhere on the web.
- Most cloud storage services organize data into buckets or containers.

- Scalability

Cloud storage services provide high capacity and scalability. Objects upto several tera-bytes in size can be uploaded and multiple buckets/containers can be created on cloudstorages.

- Replication

When an object is uploaded it is replicated at multiple facilities and/or on multipledevices within each facility.

- Access Policies

Cloud storage services provide several security features such as Access

Control Lists (ACLs), bucket/container level policies, etc. ACLs can be used to selectively grant access permissions on individual objects. Bucket/container level policies can also be defined to allow or deny permissions across some or all of the objects within a single bucket/container.

- Encryption

Cloud storage services provide Server Side Encryption (SSE) options to encrypt alldata stored in the cloud storage.

- Consistency

Strong data consistency is provided for all upload and delete operations. Therefore,any object that is uploaded can be immediately downloaded after the upload is complete.

Storage Services – Amazon S3

- Amazon Simple Storage Service(S3) is an online cloud-based data storage infrastructure for storing and retrieving any amount of data.
- S3 provides highly reliable, scalable, fast, fully redundant and affordable storageinfrastructure.
    - **Buckets**
- Data stored on S3 is organized in the form of buckets. You must create a bucketbefore you can store data on S3.
    - **Uploading Files to Buckets**
- S3 console provides simple wizards for creating a new bucket and uploading files.
- You can upload any kind of file to S3.
- While uploading a file, you can specify the redundancy and encryption options andaccess permissions.

Storage Services – Google Cloud Storage

- GCS is the Cloud storage service from Google
- Buckets

  Objects in GCS are organized into buckets.
- Access Control Lists

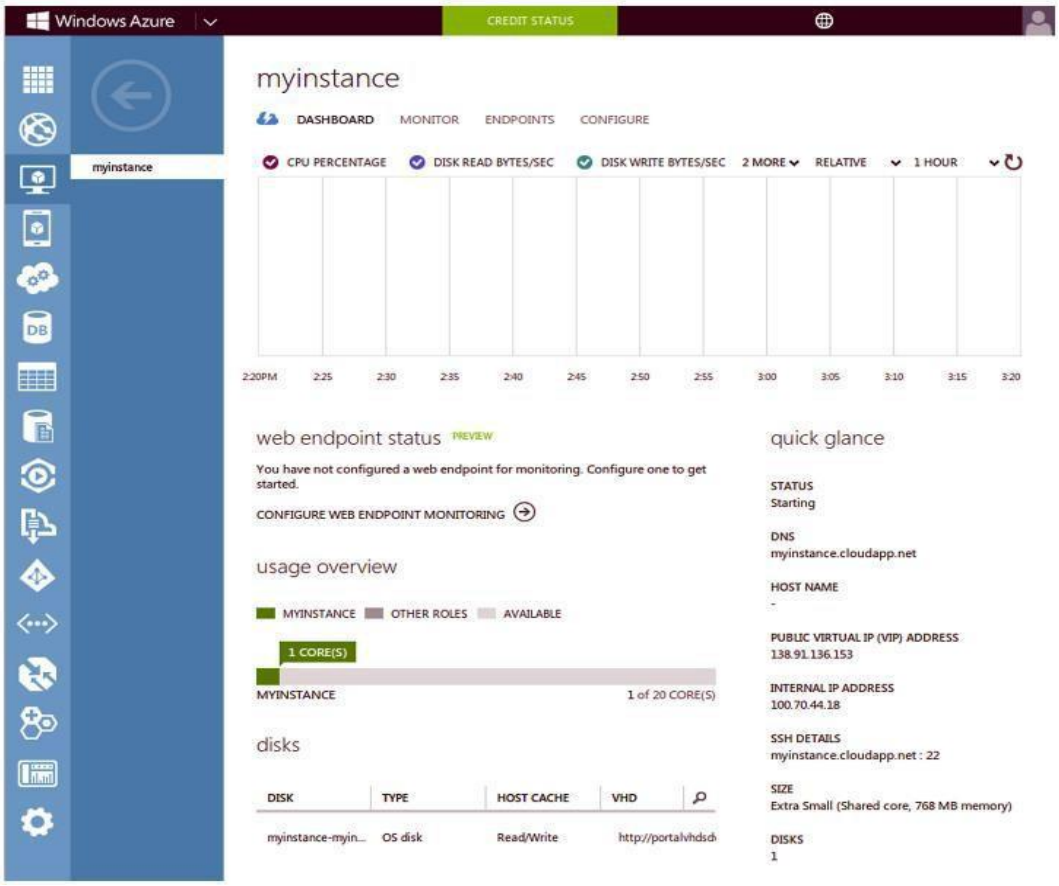
  ACLs are used to control access to objects and buckets. ACLs can be configuredto share objects and buckets with the entire world, a Google group, a Google-hosted domain, or specific Google account holders.

Storage Services – Windows Azure Storage

- Windows Azure Storage is the cloud storage service from Microsoft.
- Windows Azure Storage provides various storage services such as blob storage service,table service and queue service.
- Blob storage service
  - The blob storage service allows storing unstructured binary data or binary largeobjects (blobs).
  - Blobs are organized into containers.
  - Block blobs - can be subdivided into some number of blocks. If a failure occurswhile transferring a block blob, retransmission can

resume with the most recentblock rather than sending the entire blob again.

- Page blobs - are divided into number of pages and are designed for random access. Applications can read and write individual pages at random in a page blob.



Application Runtimes & Frameworks

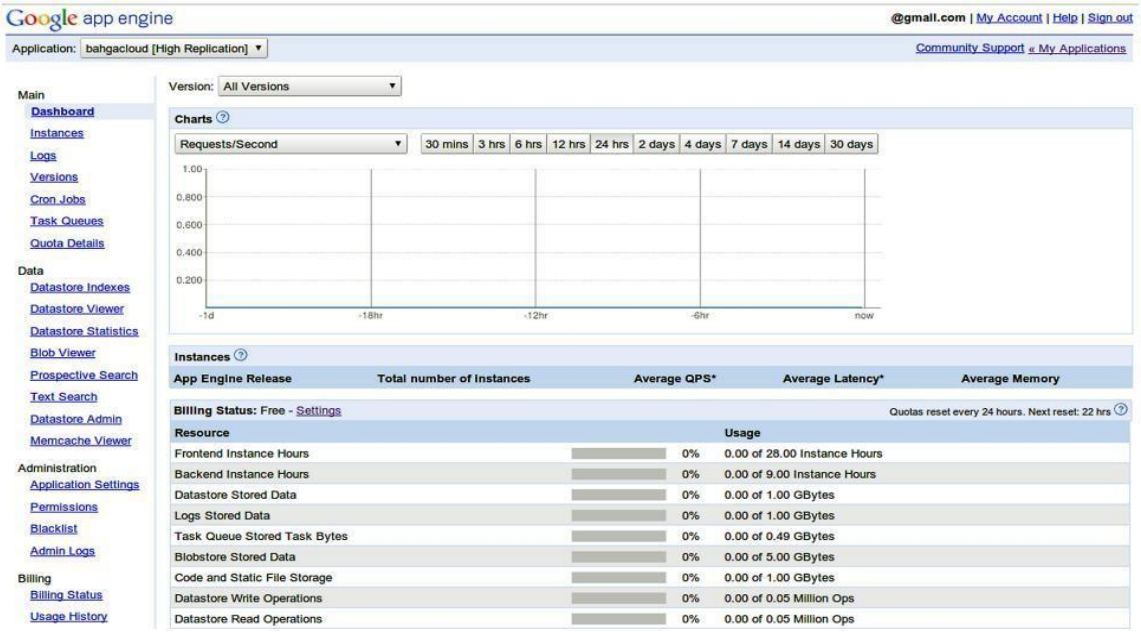
- Cloud-based application runtimes and frameworks allow developers to develop andhost applications in the cloud.
- Support for various programming languages

  Application runtimes provide support for programming languages (e.g., Java,Python, or Ruby).
- Resource Allocation

  Application runtimes automatically allocate resources for applications andhandle the application scaling, without the need to run and maintain servers.

Google App Engine

- Google App Engine is the platform-as-a-service (PaaS) from Google, which includesboth an application runtime and web frameworks.
- Runtimes
  - App Engine provides runtime environments for Java, Python, PHP and Goprogramming language.
- Sandbox
  - Applications run in a secure sandbox environment isolated from other applications.
  - The sandbox environment provides a limited access to the underlying operatingsystem.



- Web Frameworks
  - App Engine provides a simple Python web application framework called webapp2. App Engine also supports any framework written in pure Python that speaks WSGI,including Django, CherryPy, Pylons, web.py, and web2py.
- Datastore
  - App Engine provides a no-SQL data storage service
- Authentication
  - App Engine applications can be integrated with Google Accounts for

user authentication.

- URL Fetch service
  - URL Fetch service allows applications to access resources on the Internet, such asweb services or other data.
- Other services
  - Email service
  - Image Manipulation service
  - Memcache
  - Task Queues
  - Scheduled Tasks service

Windows Azure Web Sites

- Windows Azure Web Sites is a Platform-as-a-Service (PaaS) from Microsoft.
- Azure Web Sites allows you to host web applications in the Azure cloud.
- Shared & Standard Options.
  - In the shared option, Azure Web Sites run on a set of virtual machines that maycontain multiple web sites created by multiple users.
  - In the standard option, Azure Web Sites run on virtual machines (VMs) that belongto an individual user.
- Azure Web Sites supports applications created in ASP.NET, PHP, Node.js and Pythonprogramming languages.
- Multiple copies of an application can be run in different VMs, with Web Sitesautomatically load balancing requests across them.