## UNIT-1
## Cloud computing

In the simplest terms, cloud computing means storing and accessing data and programs over the internet instead of your computer's hard drive.the "cloud" is just a metaphor for the internet. It goes back to the days of flowcharts and presentations that would represent the gigantic server-farm infrastructure of the internet as nothing but a puffy cloud, accepting connections and doling out information as it floats.

Cloud computing has two meanings. The most common refers to running workloads remotely over the internet in a commercial provider's data center, also known as the "public cloud" model. Popular public cloud offerings—such as Amazon Web Services (AWS), Salesforce's CRM system, and Microsoft Azure—all exemplify this familiar notion of cloud computing. Today, most businesses take a multicloud approach, which simply means they use more than one public cloud service.

The second meaning of cloud computing describes how it works: a virtualized pool of resources, from raw compute power to application functionality, available on demand. When customers procure cloud services, the provider fulfills those requests using advanced automation rather than manual provisioning. The key advantage is agility: the ability to apply abstracted compute, storage, and network resources to workloads as needed and tap into an abundance of prebuilt services.

## Characteristics of Cloud Computing

The characteristics of cloud computing are given below:

### 1) Agility

The cloud **works in a distributed computing environment**. It shares resources among users and works 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 engineers for 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 of resources.

**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**.

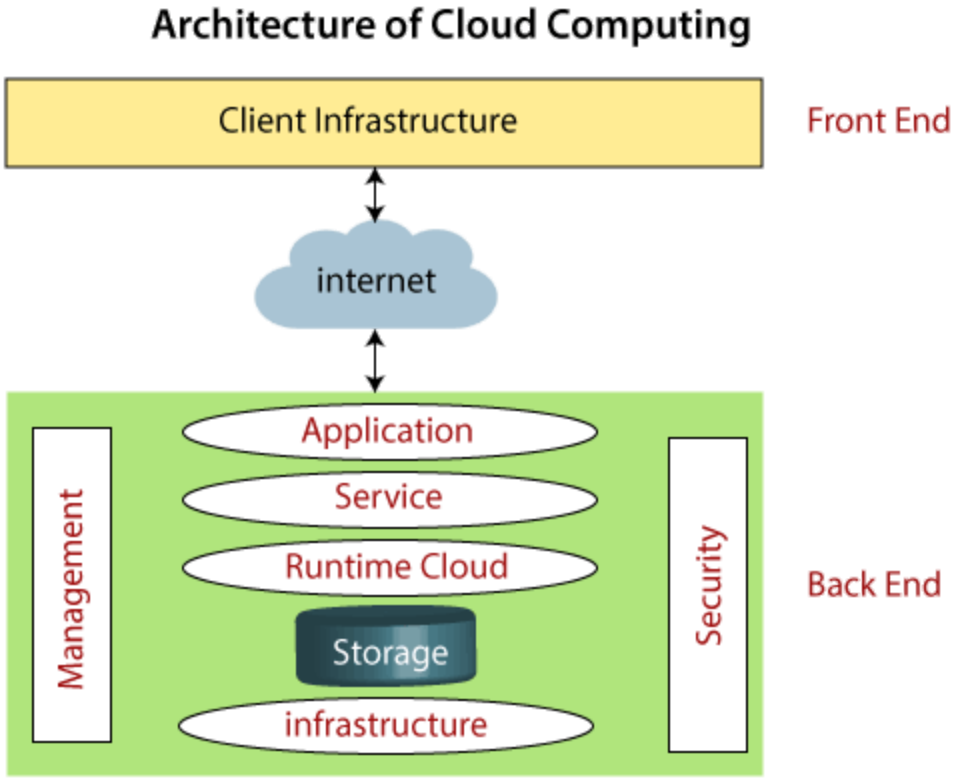
## Cloud Computing Architecture

**Cloud Computing Architecture** is a combination of components required for a Cloud Computing service. A Cloud computing architecture consists of several components like a front-end platform, a back-end platform or servers, a network or internet service, and a cloud based delivery service.

Let’s have a look into Cloud Computing and see what Cloud Computing is made of. Cloud computing comprises of two components

- front end and
- back end.

Front end consist client part of cloud computing system. It comprise of interfaces and applications that are required to access the Cloud Computing or Cloud Programming platform.




While back end refers to the cloud itself, it comprises of the resources that are required for cloud computing services. It consists of virtual machines, servers, data storage, security mechanism etc. It is under providers control.

Cloud computing distributes the file system that spreads over multiple hard disks and machines. Data is never stored in one place only and in case one unit fails the other will take over automatically. The user disk space is allocated on the distributed file system, while another important component is algorithm for resource allocation. Cloud computing is a strong distributed environment and it heavily depends upon strong algorithm.

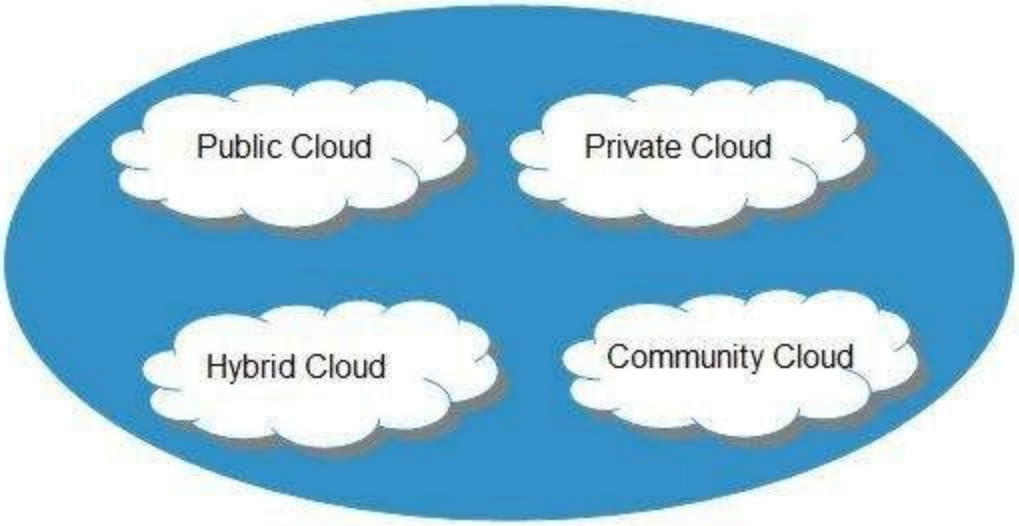
## Basic Concepts

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

- Deployment Models
- Service Models

**Deployment Models**

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




Advantages of Cloud Computing

1) Back-up and restore data

Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

2) Improved collaboration

Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

3) Excellent accessibility

Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.

4) Low maintenance cost

Cloud computing reduces both hardware and software maintenance costs for organizations.

5) Mobility

Cloud computing allows us to easily access all cloud data via mobile.

6) IServices in the pay-per-use model

Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.

7) Unlimited storage capacity

Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.

8) Data security

Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

Disadvantages of Cloud Computing

A list of the disadvantage of cloud computing is given below -

1) Internet Connectivity

As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

2) Vendor lock-in

Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

3) Limited Control

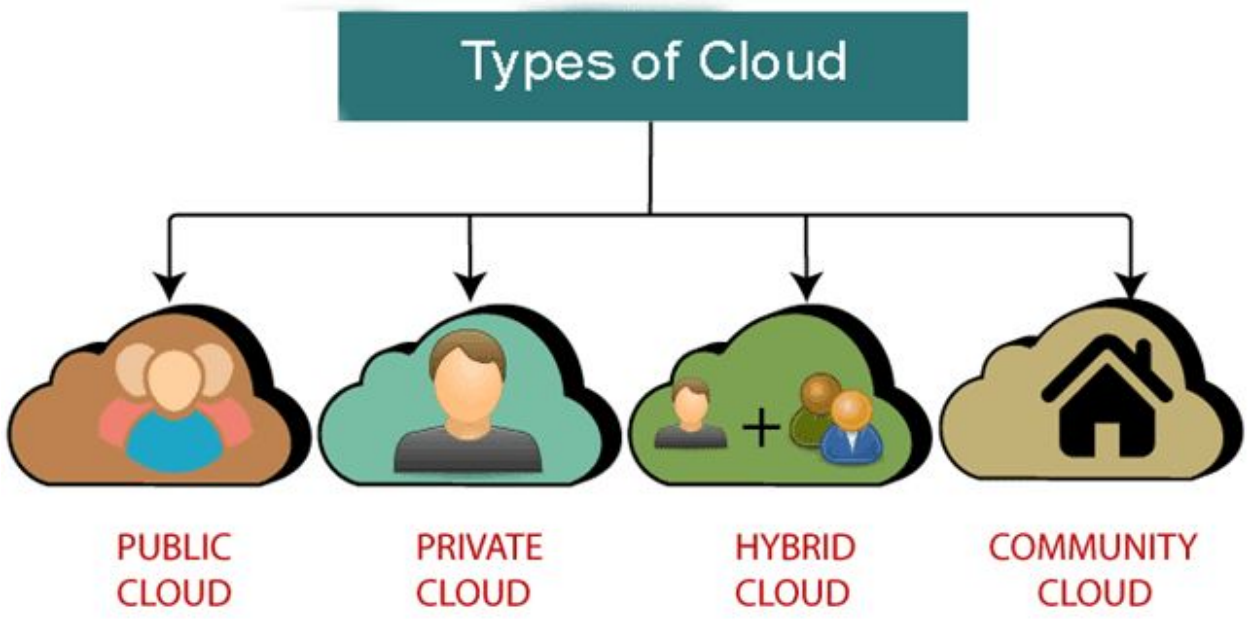
As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

4) Security

Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

**Types of Cloud**

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




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

## Public Cloud

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

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

### Advantages of Public Cloud

There are the following advantages of Public Cloud -

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

### Disadvantages of Public Cloud

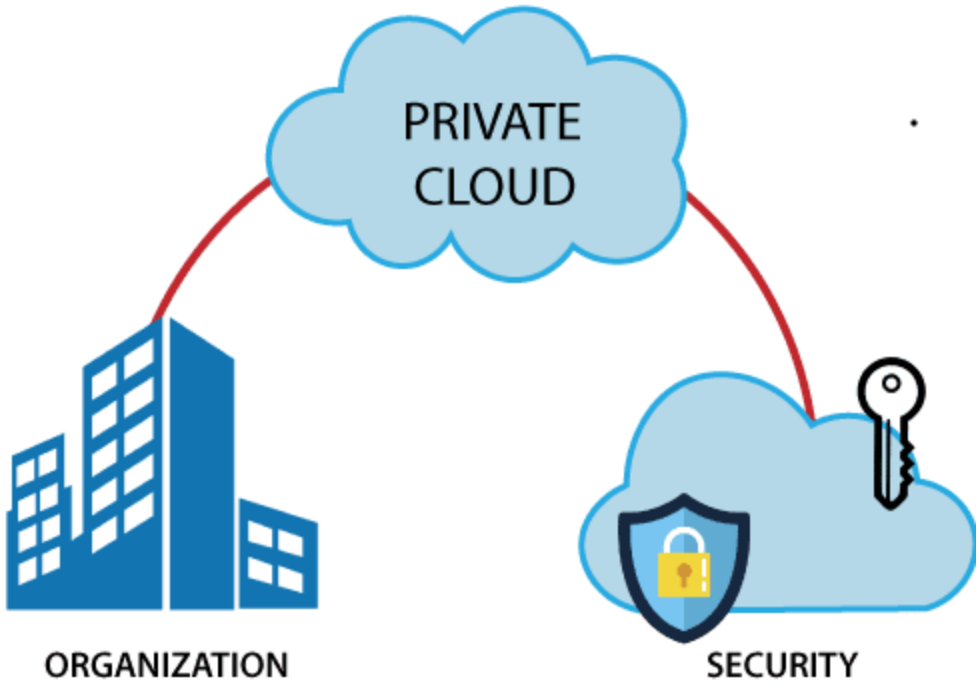
- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The Client has no control of data.

## Private Cloud

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

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

- On-premise private cloud
- Outsourced private cloud




**Advantages of Private Cloud**

There are the following advantages of the Private Cloud -

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

**Disadvantages of Private Cloud**

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

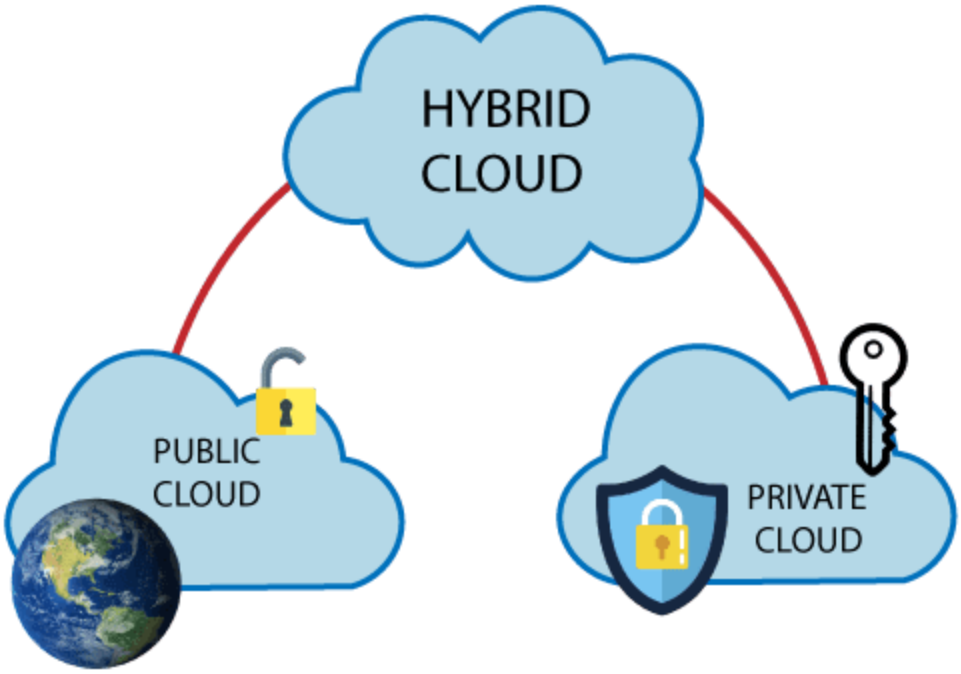
**Hybrid Cloud**

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

***Hybrid Cloud = Public Cloud + Private Cloud***

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

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




Advantages of Hybrid Cloud

There are the following advantages of Hybrid Cloud -

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

- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.

Disadvantages of Hybrid Cloud

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

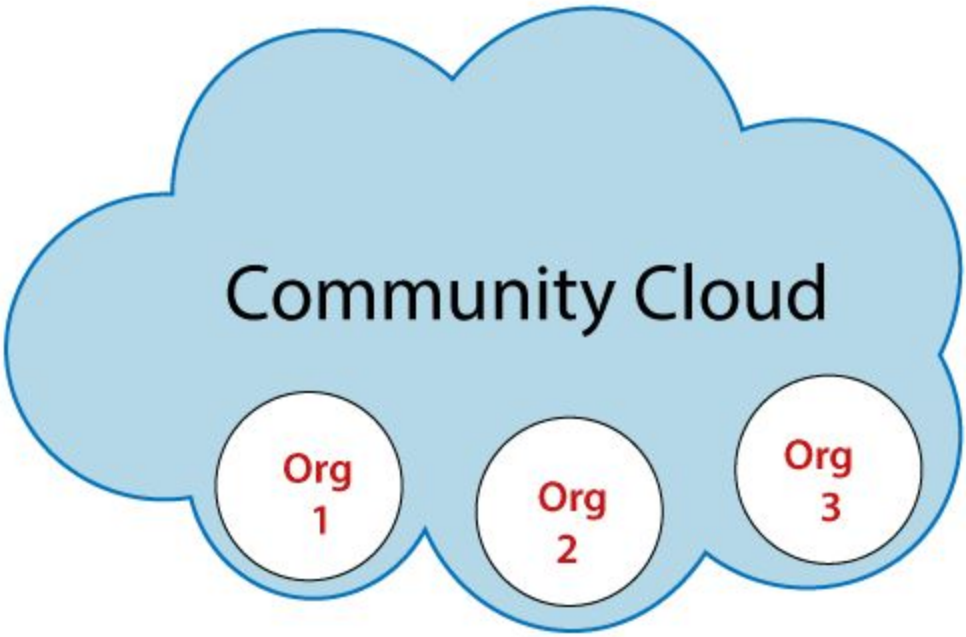
**To Read More Click Here**

---

Community Cloud

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

**Example:** Health Care community cloud




Advantages of Community Cloud

There are the following advantages of Community Cloud -

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

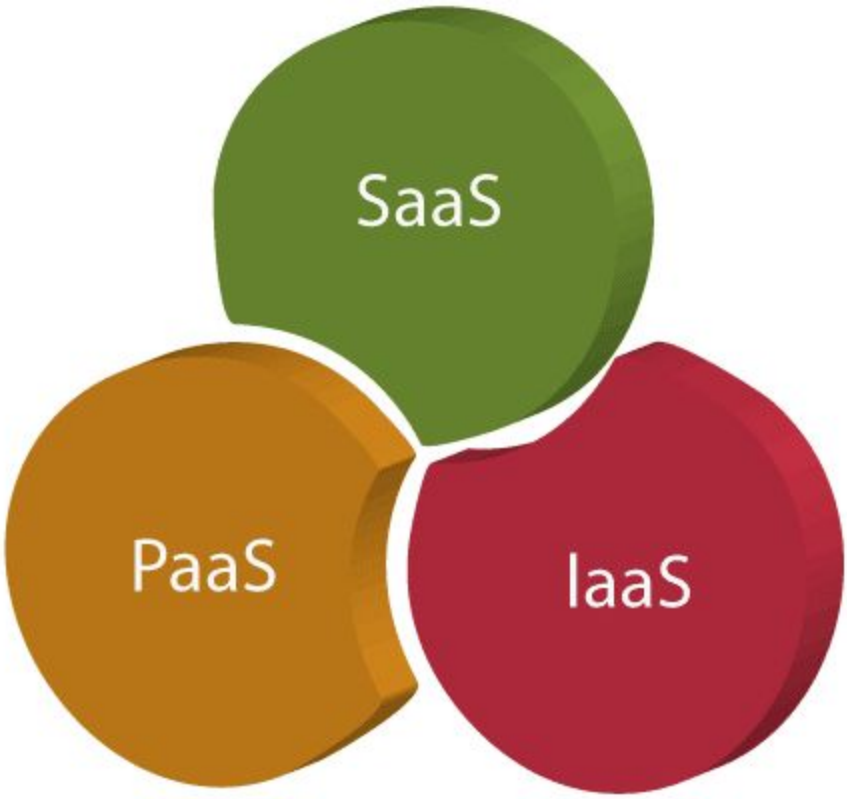
**Disadvantages of Community Cloud**

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

**Cloud Service Models**

There are the following three types of cloud service models -

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




---

## Infrastructure as a Service (IaaS)

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

## Characteristics of IaaS

There are the following characteristics of IaaS -

- Resources are available as a service
- Services are highly scalable
- Dynamic and flexible

- GUI and API-based access
- Automated administrative tasks

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

To know more about the IaaS, **click here**.

---

## Platform as a Service (PaaS)

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

### Characteristics of PaaS

There are the following characteristics of PaaS -

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

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

---

### Software as a Service (SaaS)

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

### Characteristics of SaaS

There are the following characteristics of SaaS -

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

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

## SCENARIOS WHERE CLOUD COMPUTING CAN BE USED

The Cloud usage scenarios are intended to illustrate the most typical cloud scenarios and are not meant to be an exhaustive list of realizations within a cloud environment.

**1.End User to Cloud**: In this scenario, an end user is accessing data or applications in the cloud. Common applications of this type include email hosting and social networking

sites. A user accesses the application and their data through any browser on any device. The user doesn't want to keep up with anything more than a password; their data is stored and managed in the cloud

**Concerned issues**

• Identity: The cloud service must authenticate the end user.

• An open client: Access to the cloud service should not require a particular platform or technology.

• SLAs: Although service level agreements for end users will usually be simpler, cloud vendors must be clear about what guarantees of service they provide.

**2. Enterprise to Cloud to End User**: In this scenario, an enterprise is using the cloud to deliver data and services to the end user. When the end user interacts with the enterprise, the enterprise accesses the cloud to retrieve data and / or manipulate it, sending the results to the end user. The end user can be someone within the enterprise or an external customer

**Concerned issues**

**• An open client:** Access to the cloud service should not require a particular platform or technology.

• **Federated identity:** In addition to basic identity needed by an end user, an enterprise user is likely to have an identity with the enterprise. The idea is that the enterprise user manages a single ID, with an infrastructure federating other identities that might be required by cloud services.

• **Metering and monitoring:** All cloud services must be metered and monitored for cost control, charge backs and provisioning.

• **Management and Governance:** Public cloud providers make it very easy to open an account and begin using cloud services; that ease of use creates the risk that individuals in an enterprise will use cloud services on their own initiative. Management of VMs and of cloud services such as storage, databases and message queues is needed to track what services are used. Governance is crucial to ensure that policies and government regulations are followed wherever cloud computing is used.

• **A Common Format for VMs**: A VM created for one cloud vendor's platform should be portable to another vendor's platform. Any solution to this requirement must account for differences in the ways cloud vendors attach storage to virtual machines.

• **Common APIs for Cloud Storage and Middleware:** Common APIs are required for access to cloud storage services, cloud databases, and other cloud middleware services such as message queues. Writing custom code that works only for a particular vendor's cloud service locks the enterprise into that vendor's system and eliminates some of the financial benefits and flexibility that cloud computing provides. • SLAs and Benchmarks: In addition to the basic SLAs required by end users, enterprises who sign contracts based on SLAs will need a standard way of benchmarking performance. There must be an unambiguous way of defining what a cloud provider will deliver, and there must be an unambiguous way of measuring what was actually delivered. • Lifecycle Management: Enterprises must be able to manage the lifecycle of applications and documents. This requirement includes versioning of applications and the retention and destruction of data. There are substantial legal liabilities if certain data is no longer

available. In some cases an enterprise will want to make sure data is destroyed at some point.

**3. Enterprise to Cloud:** This scenario involves an enterprise using cloud services for its internal processes. This might be the most common scenario in the early stages of cloud computing because it gives the enterprise the most control. In this scenario, the enterprise uses cloud services to supplement the resources it needs, like:

• For backups or storage of seldom-used data

• Virtual machines in the cloud to bring additional processors online to handle peak loads

• Applications in the cloud (SaaS) for certain enterprise functions

• Cloud databases as part of an application's processing. This could be extremely useful for sharing that database with partners, government agencies, etc.

**Concerned issues** The basic requirements of the Enterprise to Cloud scenario are much the same as those for the Enterprise to Cloud to End User. Additional requirements for this are:

**Deployment:** It should be simple to build a VM image and deploy it to the cloud as necessary. When that VM image is built, it should be possible to move that image from one cloud provider to another, compensating for the different mechanisms vendors have for attaching storage to VMs.

• **Industry-specific standards and protocols:** Many cloud computing solutions between enterprises will use existing standards. The applicable standards will vary from one application to the other and from one industry to the other.

**4.Enterprise to Cloud to Enterprise**: This scenario involves two enterprises using the same cloud. The focus here is hosting resources in the cloud so that applications from the enterprises can interoperate. A supply chain is the most obvious example for this scenario.

**Concerned issues** The basic requirements of the Enterprise to Cloud to Enterprise scenario are much the same as those for the Enterprise to Cloud scenario. Other requirements for this scenario are:

• Transactions and concurrency: For applications and data shared by different enterprises, transactions and concurrency are vital. If two enterprises are using the same cloud-hosted application, VM, middleware or storage, it's important that any changes made by either enterprise are done reliably.

• Interoperability: Because more than one enterprise is involved, interoperability between the enterprises is essential.

**5. Private Cloud:** The Private Cloud scenario is different from the others in that the cloud is contained within the enterprise. This is useful for larger enterprises. For example, if the payroll department has a surge in workload on the 15th and 30th of each month, they need enough computing power to handle the maximum workload, even though their everyday workload for the rest of the month is much lower. With a private cloud, computing power is spread across the enterprise. The payroll department gets

extra cycles when they need it and other departments get extra cycles when they need it. This can deliver significant savings across the enterprise.

**Concerned issues** The basic requirements of the Private Cloud scenario are an open client, metering and monitoring, management and governance, deployment, interoperability, a common VM format, and SLAs. Keeping the cloud inside the enterprise removes many of the requirements for identity management, standards and common APIs.

**6. Hybrid Cloud:** This scenario involves multiple clouds working together, including both public and private clouds. A hybrid cloud can be delivered by a federated cloud provider that International Journal of Computing & Business Research ISSN (Online): 2229-6166 Proceedings of 'I-Society 2012' at GKU, Talwandi Sabo Bathinda (Punjab) combines its own resources with those of other providers. The provider of the hybrid cloud must manage cloud resources based on the consumer's terms.

**Concerned issues** All of the requirements of the previous scenarios apply here.

• SLAs: A machine readable, standard format for expressing an SLA. This allows the hybrid cloud provider to select resources according to the consumer's terms without human intervention.

**Comparison Among SAAS,PAAS & IAAS**

**1.SaaS: Software as a Service**

Software as a Service, also known as cloud application services, represents the most commonly utilized option for businesses in the cloud market. SaaS utilizes the internet

to deliver applications, which are managed by a third-party vendor, to its users. A majority of SaaS applications run directly through your web browser, which means they do not require any downloads or installations on the client side.

## SaaS Delivery

Due to its web delivery model, SaaS eliminates the need to have IT staff download and install applications on each individual computer. With SaaS, vendors manage all potential technical issues, such as data, middleware, servers, and storage, resulting in streamlined maintenance and support for the business.

## SaaS Advantages

SaaS provides numerous advantages to employees and companies by greatly reducing the time and money spent on tedious tasks such as installing, managing, and upgrading software. This frees up plenty of time for technical staff to spend on more pressing matters and issues within the organization.

## SaaS Characteristics

There are a few ways to help you determine when SaaS is being utilized:

- Managed from a central location
- Hosted on a remote server
- Accessible over the internet
- Users not responsible for hardware or software updates

## When to Use SaaS

SaaS may be the most beneficial option in several situations, including:

Startups or small companies that need to launch ecommerce quickly and don't have time for server issues or software

Short-term projects that require quick, easy, and affordable collaboration

Applications that aren't needed too often, such as tax software

Applications that need both web and mobile access

## SaaS Limitations & Concerns

Interoperability. Integration with existing apps and services can be a major concern if the SaaS app is not designed to follow open standards for integration. In this case, organizations may need to design their own integration systems or reduce dependencies with SaaS services, which may not always be possible.

Vendor lock-in. Vendors may make it easy to join a service and difficult to get out of it. For instance, the data may not be portable–technically or cost-effectively–across SaaS apps from other vendors without incurring significant cost or inhouse engineering rework. Not every vendor follows standard APIs, protocols, and tools, yet the features could be necessary for certain business tasks.

Lack of integration support. Many organizations require deep integrations with on-premise apps, data, and services. The SaaS vendor may offer limited support in this regard, forcing organizations to invest internal resources in designing and managing integrations. The complexity of

integrations can further limit how the SaaS app or other dependent services can be used.

Data security. Large volumes of data may have to be exchanged to the backend data centers of SaaS apps in order to perform the necessary software functionality. Transferring sensitive business information to public-cloud based SaaS service may result in compromised security and compliance in addition to significant cost for migrating large data workloads.

Customization. SaaS apps offer minimal customization capabilities. Since a one-size-fits-all solution does not exist, users may be limited to specific functionality, performance, and integrations as offered by the vendor. In contrast, on-premise solutions that come with several software development kits (SDKs) offer a high degree of customization options.

Lack of control. SaaS solutions involves handing control over to the third-party service provider. These controls are not limited to the software–in terms of the version, updates, or appearance–but also the data and governance. Customers may therefore need to redefine their data security and governance models to fit the features and functionality of the SaaS service.

Feature limitations. Since SaaS apps often come in a standardized form, the choice of features may be a compromising tradeoff against security, cost, performance, or other organizational policies. Furthermore, vendor lock-in, cost, or security concerns may mean it’s not viable to switch vendors or services to serve new feature requirements in the future.

Performance and downtime. Because the vendor controls and manages the SaaS service, your customers now depend on vendors to maintain the

service's security and performance. Planned and unplanned maintenance, cyber-attacks, or network issues may impact the performance of the SaaS app despite adequate service level agreement (SLA) protections in place.

**Examples of SaaS**

Popular examples of SaaS include:

- Google Workspace (formerly GSuite)
- Dropbox
- Salesforce
- Cisco WebEx
- SAP Concur
- GoToMeeting

**1.PaaS: Platform as a Service**

Cloud platform services, also known as Platform as a Service (PaaS), provide cloud components to certain software while being used mainly for applications. PaaS delivers a framework for developers that they can build upon and use to create customized applications. All servers, storage, and networking can be managed by the enterprise or a third-party provider while the developers can maintain management of the applications.

**PaaS Delivery**

The delivery model of PaaS is similar to SaaS, except instead of delivering the software over the internet, PaaS provides a platform for software creation. This platform is delivered via the web, giving developers the freedom to concentrate on building the software without having to worry about operating systems, software updates, storage, or infrastructure.

PaaS allows businesses to design and create applications that are built into the PaaS with special software components. These applications, sometimes called middleware, are scalable and highly available as they take on certain cloud characteristics.

## PaaS Advantages

No matter the size of your company, using PaaS offers numerous advantages, including:

- Simple, cost-effective development and deployment of apps
- Scalable
- Highly available
- Developers can customize apps without the headache of maintaining the software
- Significant reduction in the amount of coding needed
- Automation of business policy
- Easy migration to the hybrid model

## PaaS Characteristics

PaaS has many characteristics that define it as a cloud service, including:

Builds on virtualization technology, so resources can easily be scaled up or down as your business changes

Provides a variety of services to assist with the development, testing, and deployment of apps

Accessible to numerous users via the same development application

Integrates web services and databases

## When to Use PaaS

Utilizing PaaS is beneficial, sometimes even necessary, in several situations. For example, PaaS can streamline workflows when multiple developers are working on the same development project. If other vendors must be included, PaaS can provide great speed and flexibility to the entire process. PaaS is particularly beneficial if you need to create customized applications.

This cloud service also can greatly reduce costs and it can simplify some challenges that come up if you are rapidly developing or deploying an app.

## PaaS Limitations & Concerns

**Data security.** Organizations can run their own apps and services using PaaS solutions, but the data residing in third-party, vendor-controlled cloud servers poses security risks and concerns. Your security options may be limited as customers may not be able to deploy services with specific hosting policies.

**Integrations.** The complexity of connecting the data stored within an onsite data center or off-premise cloud is increased, which may affect

which apps and services can be adopted with the PaaS offering. Particularly when not every component of a legacy IT system is built for the cloud, integration with existing services and infrastructure may be a challenge.

**Vendor lock-in.** Business and technical requirements that drive decisions for a specific PaaS solution may not apply in the future. If the vendor has not provisioned convenient migration policies, switching to alternative PaaS options may not be possible without affecting the business.

Customization of legacy systems. PaaS may not be a plug-and-play solution for existing legacy apps and services. Instead, several customizations and configuration changes may be necessary for legacy systems to work with the PaaS service. The resulting customization can result in a complex IT system that may limit the value of the PaaS investment altogether.

**Runtime issues**. In addition to limitations associated with specific apps and services, PaaS solutions may not be optimized for the language and frameworks of your choice. Specific framework versions may not be available or perform optimally with the PaaS service. Customers may not be able to develop custom dependencies with the platform.

Operational limitation. Customized cloud operations with management automation workflows may not apply to PaaS solutions, as the platform tends to limit operational capabilities for end users. Although this is intended to reduce the operational burden on end users, the loss of operational control may affect how PaaS solutions are managed, provisioned, and operated.

**Examples of PaaS**

Popular examples of PaaS include:

- AWS Elastic Beanstalk
- Windows Azure
- Heroku
- Force.com
- Google App Engine
- OpenShift

## 3.IaaS: Infrastructure as a Service

Cloud infrastructure services, known as Infrastructure as a Service (IaaS), are made of highly scalable and automated compute resources. IaaS is fully self-service for accessing and monitoring computers, networking, storage, and other services. IaaS allows businesses to purchase resources on-demand and as-needed instead of having to buy hardware outright.

**IaaS Delivery**

IaaS delivers cloud computing infrastructure, including servers, network, operating systems, and storage, through virtualization technology. These cloud servers are typically provided to the organization through a dashboard or an API, giving IaaS clients complete control over the entire infrastructure. IaaS provides the same technologies and capabilities as a traditional data center without having to physically maintain or manage all of it. IaaS clients can still access their servers and storage directly, but it is all outsourced through a “virtual data center” in the cloud.

As opposed to SaaS or PaaS, IaaS clients are responsible for managing aspects such as applications, runtime, OSes, middleware, and data. However, providers of the IaaS manage the servers, hard drives, networking, virtualization, and storage. Some providers even offer more services beyond the virtualization layer, such as databases or message queuing.

**IaaS Advantages**

IaaS offers many advantages, including:

- The most flexible cloud computing model
- Easy to automate deployment of storage, networking, servers, and processing power
- Hardware purchases can be based on consumption
- Clients retain complete control of their infrastructure
- Resources can be purchased as-needed
- Highly scalable

**IaaS Characteristics**

Characteristics that define IaaS include:

- Resources are available as a service
- Cost varies depending on consumption
- Services are highly scalable
- Multiple users on a single piece of hardware
- Organization retain complete control of the infrastructure

Dynamic and flexible

**When to Use IaaS**

Just as with SaaS and PaaS, there are specific situations when IaaS is most advantageous.

Startups and small companies may prefer IaaS to avoid spending time and money on purchasing and creating hardware and software.

Larger companies may prefer to retain complete control over their applications and infrastructure, but they want to purchase only what they actually consume or need.

Companies experiencing rapid growth like the scalability of IaaS, and they can change out specific hardware and software easily as their needs evolve.

Anytime you are unsure of a new application's demands, IaaS offers plenty of flexibility and scalability.

**IaaS Limitations & Concerns**

Many limitations associated with SaaS and PaaS models – such as data security, cost overruns, vendor lock-in and customization issues – also apply to the IaaS model. Particular limitations to IaaS include:

Security. While the customer is in control of the apps, data, middleware, and the OS platform, security threats can still be sourced from the host or other virtual machines (VMs). Insider threat or system vulnerabilities may expose data communication between the host infrastructure and VMs to unauthorized entities.

Legacy systems operating in the cloud. While customers can run legacy apps in the cloud, the infrastructure may not be designed to deliver specific controls to secure the legacy apps. Minor enhancement to legacy apps may be required before migrating them to the cloud, possibly leading to new security issues unless adequately tested for security and performance in the IaaS systems.

Internal resources and training. Additional resources and training may be required for the workforce to learn how to effectively manage the infrastructure. Customers will be responsible for data security, backup, and business continuity. Due to inadequate control into the infrastructure however, monitoring and management of the resources may be difficult without adequate training and resources available inhouse.

Multi-tenant security. Since the hardware resources are dynamically allocated across users as made available, the vendor is required to ensure that other customers cannot access data deposited to storage assets by previous customers. Similarly, customers must rely on the vendor to ensure that VMs are adequately isolated within the multitenant cloud architecture.

## Examples of IaaS

Popular examples of IaaS include:

- DigitalOcean
- Linode
- Rackspace
- Amazon Web Services (AWS)
- Cisco Metacloud
- Microsoft Azure
- Google Compute Engine (GCE)

**4.XaaS: Everything as a Service**

One term you're likely seeing more frequently in the world is XaaS, short for Everything as a Service. XaaS refers to the highly-individualized, responsive, data-driven products and offerings that are fully controlled by customers—and the data they provide via everyday IoT-powered sources like cell phones and thermostats.

By using that data generated over the cloud, businesses can innovate faster, deepen their customer relationships, and sustain the sale beyond the initial product purchase. XaaS is a critical enabler of the Autonomous Digital Enterprise.

**Benefits of XaaS:**

There are several benefits of XaaS: improving the expense model, speeding new apps and business processes, and shifting IT resources to higher-value projects.

**Improving the expense model.** With XaaS, businesses can cut costs by purchasing services from providers on a subscription basis. Before XaaS and cloud services, businesses had to buy individual products—software, hardware, servers, security, infrastructure—install them on site, and then link everything together to create networks. Now, with XaaS, businesses simply buy what they need, and pay as they go. Previous capital expenses now become operating expenses.

**Speeding new apps and business processes.** This model allows businesses to quickly adapt to changing market conditions with new apps or solutions. Using multitenant approaches, cloud services can provide much-needed flexibility. Resource pooling and rapid elasticity support mean that business leaders can simply add or subtract services as needed. A company can quickly access new technologies, scaling infrastructure automatically when users need innovative resources.

**Shifting IT resources to higher-value projects.** Increasingly, IT organizations are turning to an XaaS delivery model to streamline operations and free up resources for innovation. They are also using the benefits of XaaS to transform digitally and become more agile. In a recent survey by Deloitte, 71% of companies report that XaaS now

constitutes more than half of their company's enterprise IT. XaaS provides more users with access to cutting-edge technology, democratizing innovation.

**disadvantages of XaaS**

XaaS has some potential drawbacks: possible downtime, performance issues, and complexity.

**Possible downtime.** The internet sometimes breaks, and when it does, your XaaS provider might have problems as well. With XaaS, there can be issues of internet reliability, resilience, provisioning and managing the infrastructure resources . If XaaS servers go down, users won't be able to use them. XaaS providers can guarantee services through SLAs.

**Performance issues.** As XaaS becomes more popular, bandwidth, latency, data storage, and retrieval times can suffer . If too many customers use the same resources, the system can slow down. Apps running in virtualized environments can also face impacts. In these complex environments, there can be integration issues, including the ongoing management and security of multiple cloud services.

**Complexity impacts.** Pushing technology to XaaS can relieve IT staff of day-to-day operational headaches; however, if something does go wrong, it might be harder to troubleshoot. The internal IT staff still needs to stay current on the new technology. Costs for maintaining high-performing, robust networks can increase—although the overall cost savings of XaaS models are usually much greater. Nonetheless, some companies want to retain visibility into their XaaS service provider's environment and infrastructure. In addition, an XaaS provider that gets acquired, discontinues a service, or alters its roadmap can have a profound impact on XaaS users.

## Infrastructure as Services

## AmazonEC2

Amazon Elastic Compute Cloud (Amazon EC2) provides scalable computing capacity in the Amazon Web Services (AWS) Cloud. Using Amazon EC2 eliminates your need to invest in hardware up front, so you can develop and deploy applications faster. You can use Amazon EC2 to launch as many or as few virtual servers as you need, configure security and networking, and manage storage. Amazon EC2 enables you to scale up or down to handle changes in requirements or spikes in popularity, reducing your need to forecast traffic.

---

## Features of Amazon EC2

Amazon EC2 provides the following features:

- Virtual computing environments, known as *instances*
- Preconfigured templates for your instances, known as *Amazon Machine Images (AMIs)*, that package the bits you need for your server (including the operating system and additional software)

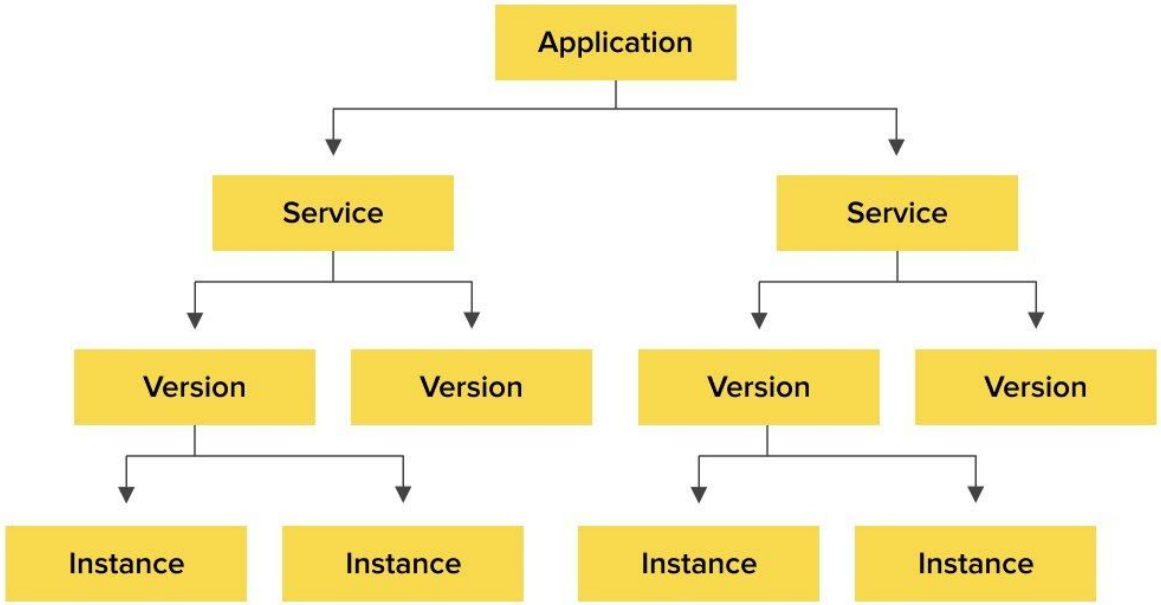
- Various configurations of CPU, memory, storage, and networking capacity for your instances, known as *instance types*
- Secure login information for your instances using *key pairs* (AWS stores the public key, and you store the private key in a secure place)
- Storage volumes for temporary data that's deleted when you stop, hibernate, or terminate your instance, known as *instance store volumes*
- Persistent storage volumes for your data using Amazon Elastic Block Store (Amazon EBS), known as *Amazon EBS volumes*
- Multiple physical locations for your resources, such as instances and Amazon EBS volumes, known as *Regions* and *Availability Zones*
- A firewall that enables you to specify the protocols, ports, and source IP ranges that can reach your instances using *security groups*
- Static IPv4 addresses for dynamic cloud computing, known as *Elastic IP addresses*
- Metadata, known as *tags*, that you can create and assign to your Amazon EC2 resources
- Virtual networks you can create that are logically isolated from the rest of the AWS Cloud, and that you can optionally connect to your own network, known as *virtual private clouds* (VPCs)

**Platform as Service**

**1.Google App Engine**

Building applications on the cloud is gaining traction as it accelerates your business opportunities while ensuring availability, security, accessibility, and scalability. However, to start with creating web applications, you would require a suitable cloud computing technology. This is where Google App Engine fits in by allowing you to build and host web applications on a fully-managed serverless platform.

The App Engine architecture in cloud computing looks like this:




*Source : Google Cloud*

**Services provided by App Engine includes**:

- Platform as a Service (PaaS) to build and deploy scalable applications
- Hosting facility in fully-managed data centers
- A fully-managed, flexible environment platform for managing application server and infrastructure
- Support in the form of popular development languages and developer tools

## Major Features of Google App Engine in Cloud Computing

## Some of the prominent Google App Engine features include:

### 1. Collection of Development Languages and Tools

The App Engine supports numerous programming languages for developers and offers the flexibility to import libraries and frameworks through docker containers. You can develop and test an app locally using the SDK containing tools for deploying apps. Every language has its SDK and runtime.

Some of the languages offered include — Python, PHP, .NET, Java, Ruby, C#, Go, Node.Js.

### 2. Fully Managed

Google allows you to add your web application code to the platform while managing the infrastructure for you. The engine ensures that your web apps are secure and running and saves them from malware and threats by enabling the firewall.

### 3. Pay-as-you-Go

The app engine works on a pay-as-you-go model, i.e., you only pay for what you use. The app engine automatically scales up resources when the application traffic picks up and vice-versa.

### 4. Effective Diagnostic Services

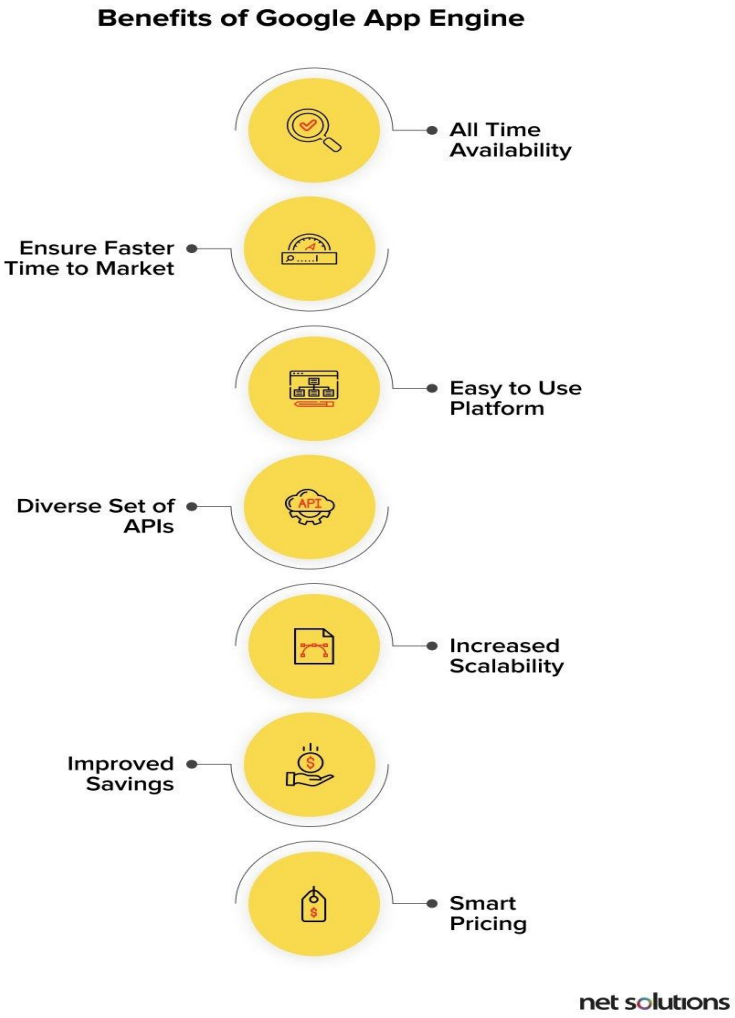
Cloud Monitoring and Cloud Logging that helps run app scans to identify bugs. The app reporting document helps developers fix bugs on an immediate basis.

### 5. Traffic Splitting

The app engine automatically routes the incoming traffic to different versions of the apps as a part of A/B testing. You can plan the consecutive increments based on what version of the app works best.

## Benefits of Google App Engine for Websites

Adopting the App Engine is a smart decision for your organization — it will allow you to innovate and stay valuable. Here the answer to why Google App Engine is a preferable choice for building applications:



### 1. All Time Availability

When you develop and deploy your web applications on the cloud, you enable remote access for your applications. Considering the impact of COVID-19 on businesses, Google App Engine is the right choice that lets the developers develop applications remotely, while the cloud service manages the infrastructure needs.

### 2. Ensure Faster Time to Market

For your web applications to succeed, ensuring faster time to market is imperative as the requirements are likely to change if the launch time is extended. Using Google App Engine is as easy as it can get for developers. The diverse tool repository and other functionalities ensure that the development and testing time gets reduced, which, in turn, ensures faster launch time for MVP and consecutive launches.

### 3. Easy to Use Platform

The developers only require to write code. With zero configuration and server management, you eliminate all the burden to manage and deploy the code. Google App Engine makes it easy to use the platform, which offers the flexibility to focus on other concurrent web applications and processes. The best part is that GAE automatically handles the traffic increase through patching, provisioning, and monitoring.

### 4. Diverse Set of APIs

Google App Engine has several built-in APIs and services that allow developers to build robust and feature-rich apps. These features include:

- Access to the application log
- Blobstore, serve large data objects
- Google App Engine Cloud Storage
- SSL Support
- Page Speed Services
- Google Cloud Endpoint, for mobile application
- URL Fetch API, User API, Memcache API, Channel API, XXMP API, File API

**5. Increased Scalability**

Scalability is synonymous with growth — an essential factor that assures success and competitive advantage. The good news is that the Google App Engine cloud development platform is automatically scalable. Whenever the traffic to the web application increases, GAE automatically scales up the resources, and vice-versa.

**6. Improved Savings**

With Google App Engine, you do not have to spend extra on server management of the app. The Google Cloud service is good at handling the backend process.

Also, Google App Engine pricing is flexible as the resources can scale up/down based on the app's usage. The resources automatically scale up/down based on how the app performs in the market, thus ensuring honest pricing in the end.

### 7. Smart Pricing

The major concern of organizations revolves around how much does Google App Engine cost? For your convenience, Google App Engine has a daily and a monthly billing cycle, i.e.,

- **Daily:** You will be charged daily for the resources you use
- **Monthly**: All the daily charges are calculated and added to the taxes (if applicable) and debited from your payment method

**2.Microsoft Azure**

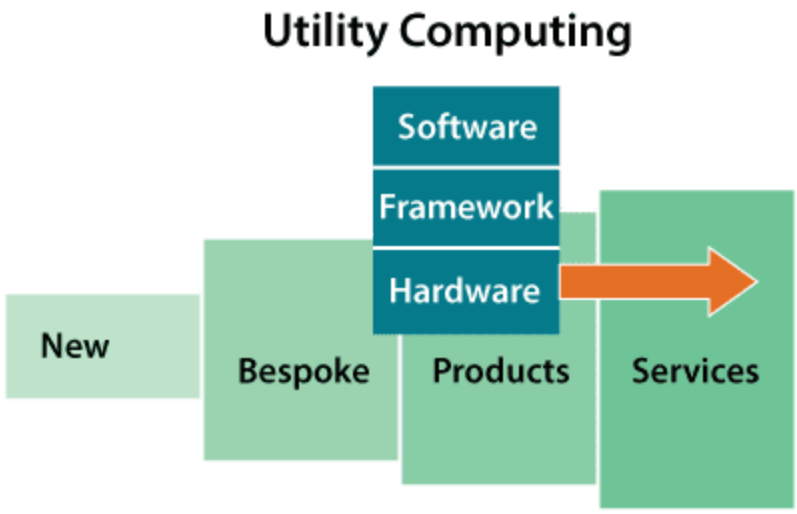
The Azure cloud platform is more than 200 products and cloud services designed to help you bring new solutions to life—to solve today's challenges and create the future. Build, run and manage applications across multiple clouds, on-premises and at the edge, with the tools and frameworks of your choice.

## Utility Computing

Utility computing is the most trending IT service model. It provides on-demand computing resources (computation, storage, and programming services via API) and infrastructure based on the **pay per use** method. It minimizes the associated costs and

maximizes the efficient use of resources. The advantage of utility computing is that it reduced the IT cost, provides greater flexibility, and easier to manage.

Large organizations such as **Google** and **Amazon** established their own utility services for computing storage and application.




**Components of Utility Computing**

The few components that included in the package of utility computing is computer hardware component, software applications, internet access, and cloud systems.

- The computer hardware such as monitors, input devices, servers, CPU and network cables.
- The browsing software and web servers provide internet access.
- The software applications that execute the huge amount of computer mandatory programs such as communication tools, mailbox, report generation, CRM and

other project and process-oriented applications and everything that lies in between the client, company and the end-users. The experts from the industries call this process as software as a service.

- Enabling the confidential access to a few processes of a supercomputer. Because few enterprises have substantial computational requirements. The status of the financial company keeps on changing rapidly concerning the updating cycle of the stock market. The normal computers take maximum processing time to retrieve or process the data whereas the supercomputer takes only minimum time to process and execute the information and complete the task as quickly as possible.
- The usage of the grid computing system runs on a unique software is known as middleware. It finds the ideal processing power of CPU and enables an application executing on another computer to retrieve the benefits of it. The bunk of a larger computational system is divided into smaller chunks which makes the user access easily.
- Cloud storage is the offsite data storage that provides reasons for companies to store and handle the data. If the company has to process higher dimensional data, but it doesn't have the space to hold such huge data. so it looks for any third party to save the data offsite. An off-site backup is a smart way to protect the data in terms of catastrophe. Or in case of fire accident to any organization, if the data is stored in some other location it will be helpful to retrieve and use the data.

**Properties of Utility Computing**

The important properties of utility computing are its scalability, demand pricing, standardized utility computing services, utility computing on virtualization and automation.

- Scalability is an important metric that should be ensured in utility computing to provide sufficient IT resources available at any time. If the demand gets extended, the response time and quality should not get impacted.
- Demand pricing is scheduled effectively to pay for both hardware and software components as per the usage.
- The catalog is produced with standardized services with different service level agreements to the customers. So the consumer has no influence on the behind technology on the computer platform.
- The web services and other resources are shared by the pool of machines which is used in automation and virtualization technologies. It segregates the network into many logical resources instead of the available physical resources. An application is allotted with no specific predefined servers or storage space of any severs with more memory or free server runtime from the resource pool. The deployment and installation of a new server can be done easily and repetitive tasks and jobs can be automated according to SLA.

Utility computing is a bundle of advantage and treats to any type of business because of their variety of services and the pay per use policy. So it is most welcomed in the

market and gathered huge attention which can be used and remove according to the demand.

## Elastic Computing (EC)

**Elasticity** refers the ability to fit the resources needed to cope with loads, so that when load increase you scale up by adding more resources and when demand diminishes you shrink back and remove unneeded resources. Elasticity is mostly important in Cloud environment where you pay-per-used resources only.
Elastic computing is a concept in cloud computing in which computing resources can be scaled up and down easily by the cloud service provider. Elastic computing is the ability of a cloud service provider to provision flexible computing power when and wherever required. The elasticity of these resources can be in terms of processing power, storage, bandwidth, etc.
Cloud computing is about provisioning on-demand computing resources with the simplicity of a mouse click. The amount of resources which can be sourced through cloud computing incorporates almost all the facets of computing from raw processing power to massive storage space.

Besides providing these services on demand basis, the resources are elastic in nature, i.e. they can be easily scaled depending upon the underlying resource requirements on run time without even disrupting the operations and this ability is known as elastic computing. On a small scale this is done manually, but for larger installations, the scaling is automatic. For example, a larger provider of online video could setup a system so that the number of webservers online scaled during peak viewing hours.

### Benefits/Pros of Elastic Cloud Computing

Elastic Cloud Computing has numerous advantages. Some of them are as follow:-

1. **Cost Efficiency: –** Cloud is available at much cheaper rates than traditional approaches and can significantly lower the overall IT expenses. By using cloud solution companies can save licensing fees as well as eliminate overhead charges such as the cost of data storage, software updates, management etc.
2. **Convenience and continuous availability: –** Cloud makes easier access of shared documents and files with view and modify choice. Public clouds also offer services that are available wherever the end user might be located. Moreover it guaranteed continuous availability of resources and In case of system failure; alternative instances are automatically spawned on other machines.
3. **Backup and Recovery**: – The process of backing up and recovering data is easy as information is residing on cloud simplified and not on a physical device. The various cloud providers offer reliable and flexible backup/recovery solutions.
4. **Cloud is environmentally friendly**:-The cloud is more efficient than the typical IT infrastructure and it takes fewer resources to compute, thus saving energy.

5. **Scalability and Performance**: – Scalability is a built-in feature for cloud deployments. Cloud instances are deployed automatically only when needed and as a result enhance performance with excellent speed of computations.
6. **Increased Storage Capacity**:-The cloud can accommodate and store much more data compared to a personal computer and in a way offers almost unlimited storage capacity.

**Disadvantages/Cons of Elastic Cloud Computing:-**

1. **Security and Privacy in the Cloud**: – Security is the biggest concern in cloud computing. Companies essentially hide their private data and information over cloud as remote based cloud infrastructure is used, it is then up to the cloud service provider to manage, protect and retain data confidential.
2. **Limited Control**: – Since the applications and services are running remotely companies, users and third party virtual environments have limited control over the function and execution of the hardware and software.
3. **Dependency and vendor lock-in: –** One of the major drawbacks of cloud computing is the implicit dependency on the provider. It is also called “vendor lock-in”. As it becomes difficult to migrate vast data from old provider to new. So, it is advisable to select vendor very carefully.
4. **Increased Vulnerability**: – Cloud based solutions are exposed on the public internet therefore are more vulnerable target for malicious users and hackers. As we know nothing is completely secure over Internet even the biggest organizations also suffer from serious attacks and security breaches.

Regardless the disadvantages elastic cloud computing even remains stronger and has great potential for the future. Elastic computing offering better, more fine-tuned and easy to use services and solutions. We can only hope that the advantages will grow more and the disadvantages will be diminished as cloud is the future.