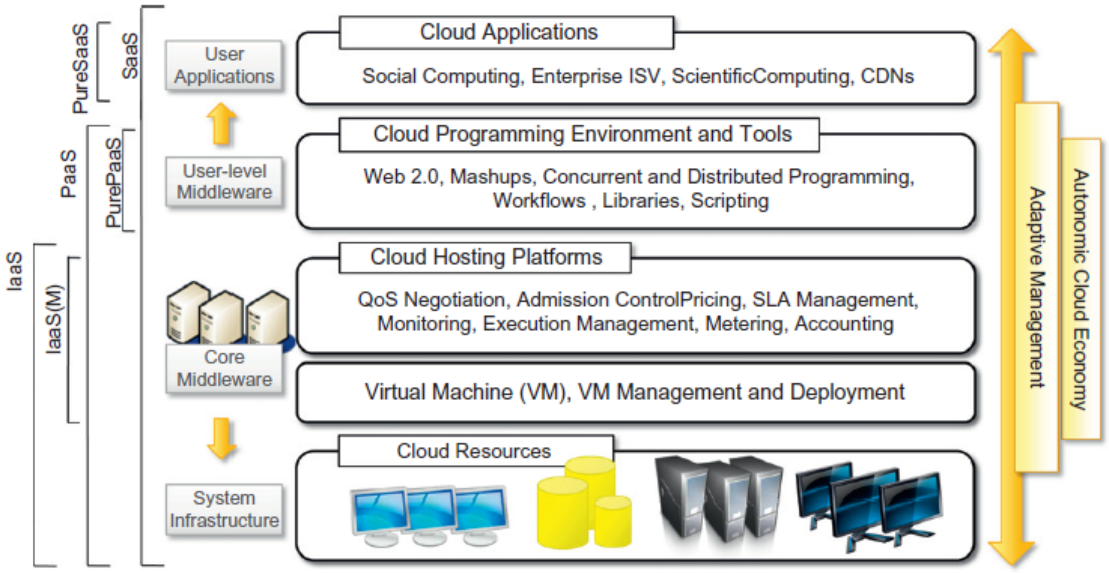
Cloud architecture -Layers

Knowledge & understanding:

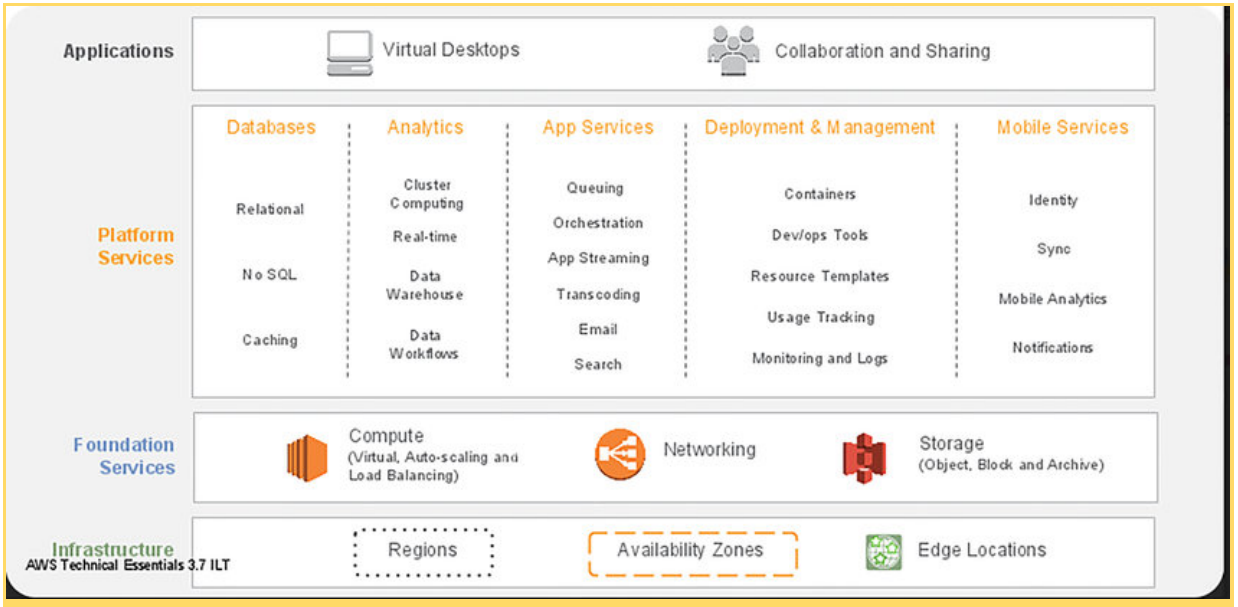
A cloud architecture is how individual technologies are integrated to create cloud computing environments.

A cloud infrastructure is the collection of hardware and software that enables the five essential characteristics of cloud computing.

If cloud infrastructure is the tools you need to build a cloud, then cloud architecture is the blueprint for how you'll build it.



K & U: Example: Layered architecture of AWS



Cloud Resources:

1. They are controlled & used to offer "computing horsepower" required for providing services.
2. Often, this layer is implemented using a data center in which hundreds and thousands of nodes are stacked together.

3. Cloud infrastructure can be heterogeneous in nature because a variety of resources,such as clusters and even networked PCs,can be used to build it.
4. Moreover,database systems and other storage services can also be part of the infrastructure.

Core Middleware (Cloud Hosting platform + Virtualization Layer):

1. The physical infrastructure is managed by the core middleware, the objectives of which are to provide an appropriate runtime environment for applications and to best utilise resources.
2. Infrastructure management is the key function of core middleware, which supports capabilities such as negotiation of the quality of service,admission control,execution management and monitoring,accounting,and billing.
3. The combination of cloud hosting platforms and resources generally classified as Infrastructure-as-a-Service(IaaS) solution.
4. At the bottom of the stack,virtualization technologies are used to guarantee runtime environment customization, application isolation,sandboxing,and quality of service.
5. Hardware Virtualization is most commonly used at this level.Hypervisors manage the pool of resources and expose the distributed infrastructure collection of virtual machines.
6. By using virtual machine technology it is possible to finely partition the hardware resources such as CPU and memory and to virtualize specific devices,thus meeting the requirements of users and applications.
7. Storage and network virtualization strategies,which allow the infrastructure to be completely virtualized and controlled.According to the specific service offered to end users,other virtualization techniques can be used.
8. For example,programming-level virtualization helps in creating a portable runtime environment where applications can be run and controlled.

Cloud programming environments and tools:

1. This layer offers users a development platform for applications.
2. The range of tools include Web-based interfaces,command-line tools,and frameworks for concurrent and distributed programming.
3. In this scenario,users develop their applications specifically for the cloud by using the API exposed at the user-level middleware.

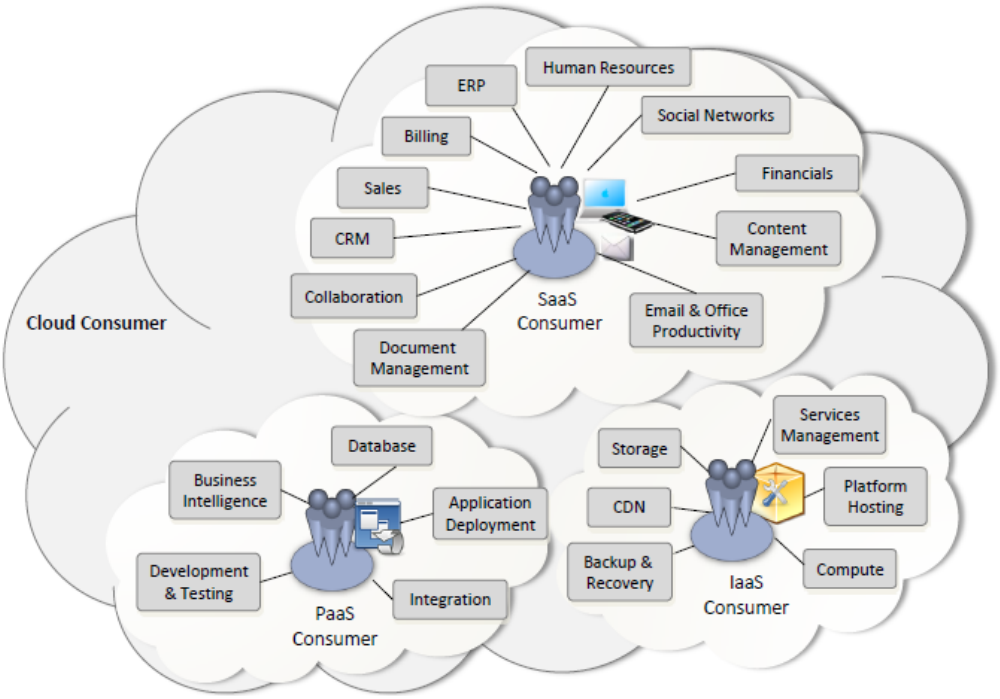
Cloud Applications:

1. The top layer of the reference model contains services delivered at the application level.
2. These are mostly referred to as Software-as-a-Service(SaaS). In most cases these are Web-based applications that rely on the cloud to provide service to end users.
3. Other applications belonging to this layer are those that strongly leverage the Internet for their core functionalities that rely on the cloud to sustain a larger number of users;this the case of gaming portals and,in general,social networking websites.

The Cloud Reference Model/ Cloud Service Model

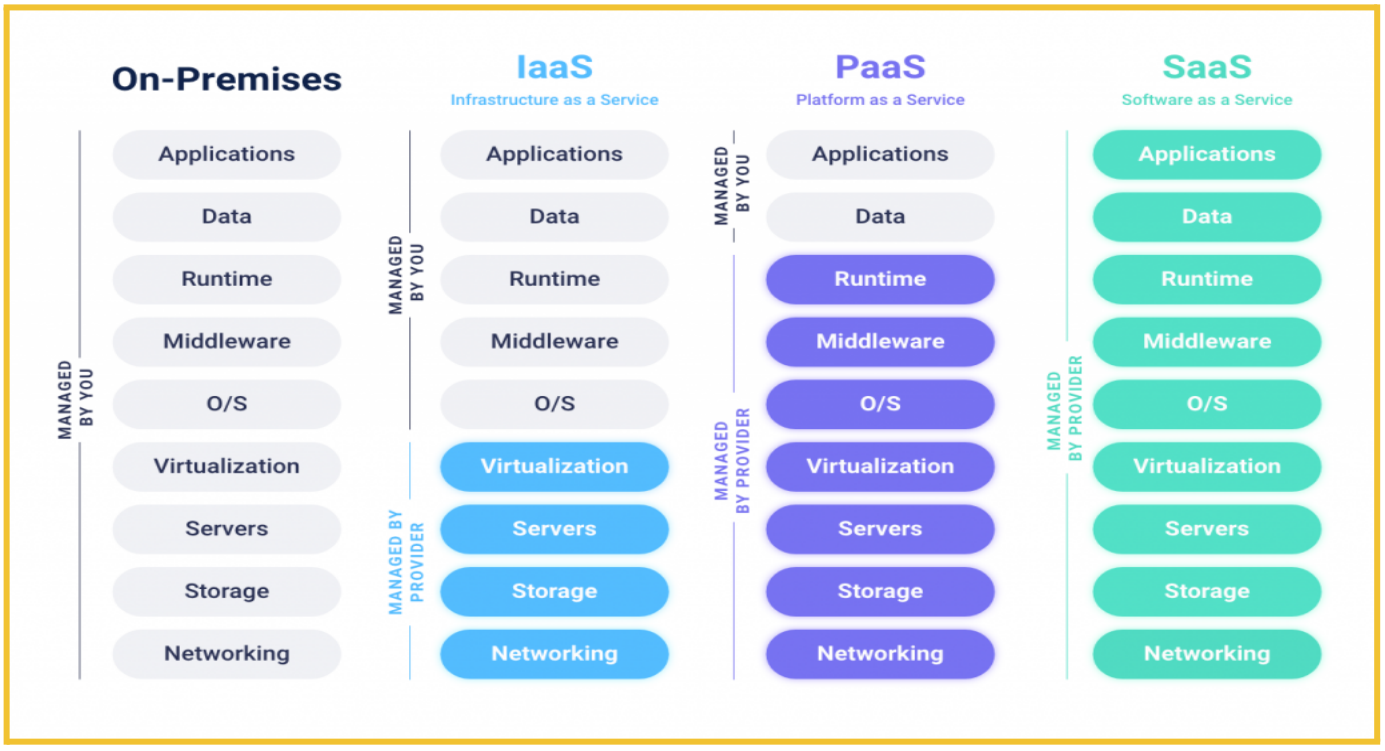
The cloud reference model is also known as the cloud service model on which the architecture is dependent. Cloud computing technology provides three main types of services that users can access on the cloud platform:

- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Software as a Service (SaaS)



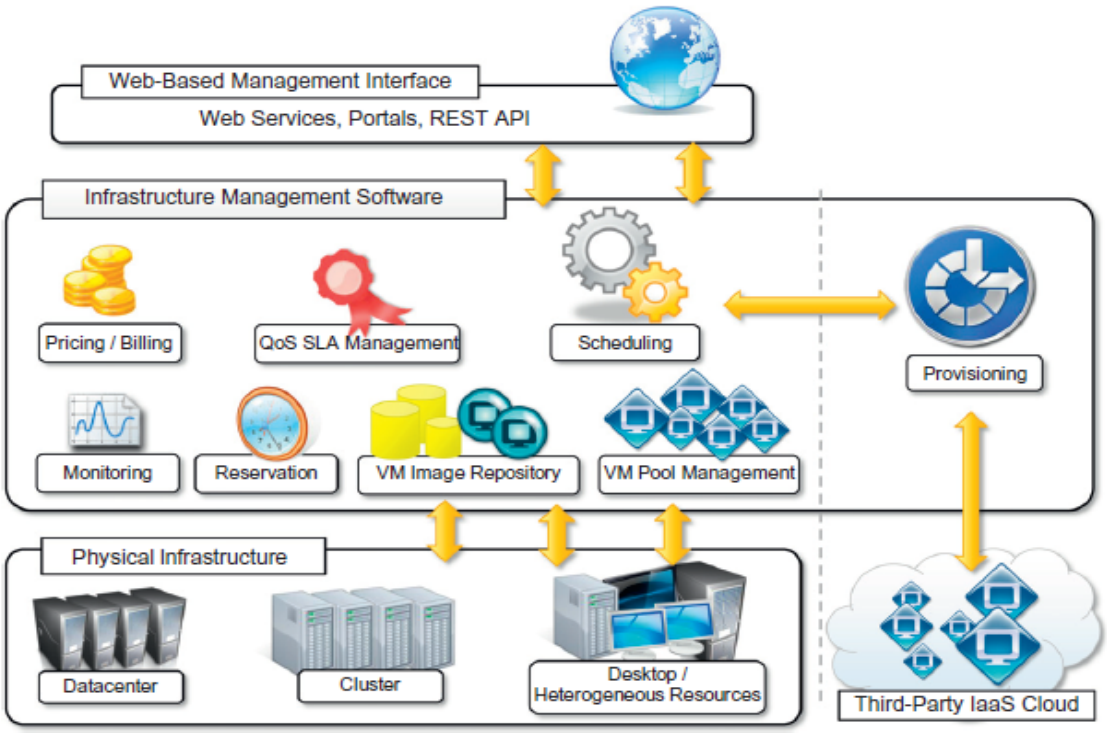
Use case of cloud service model

Knowledge and understanding



Infrastructure as a Service (IaaS)/Hardware as service(HaaS)

1. IaaS, as the term suggests, is a way of providing cloud computing infrastructure like virtual machines, servers, storage drives, operating systems and networks, which is also on same condition i.e. an on-demand service.
2. Customers are provided with virtualized hardware and storage on top of which they can build their infrastructure.
3. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications.
4. From the perspective of the Service provider,IaaS/HaaS allows better use of the IT infrastructure and provides a more secure environment to execute third party applications.
5. From the perspective of the customer it reduces the administration and maintenance cost as well as the capital costs allocated to purchase hardware.
6. There are three principal layers:the physical infrastructure, the software management infrastructure, and the user interface.
    - **User Interface**: It provides access to the services exposed by the software management infrastructure using web 2.0 technologies: web services, REST Api's etc.These technologies allow either applications or final users to access the services exposed by the underlying infrastructure.
    - **Infrastructure management software**: Management of the virtual machines is the most important function performed by this layer.A central role is played by the scheduler,which is incharge of allocating the execution of virtual machine instances. The scheduler interacts with the other components that perform a variety of tasks: pricing and billing, monitoring(checks system performance), VM Repository(a catalog of virtual machine image that user can select and create) , VM Pool manager (keeps track of VM live instances).
    - **Physical infrastructure**:The bottom layer is composed of the physical infrastructure,on top of which the management layer operates.



7. IaaS is used in several cases. It is useful for backing up, storing, and recovering data and helps manage fluctuating storage needs. Setting up test and development environments is also faster and cheaper with IaaS.
8. In addition, companies working with Big Data often use IaaS, which allows them to significantly increase their computing power.

Knowledge and understanding

Consider the case of a cable TV operator who is planning to expand its services to offer on-demand movies to users over an Internet Protocol (IP) network. The users should be able to stream movies to their laptops, desktops or IP-enabled TVs over a DSL or broadband. The problem is that the datacenter location is far from the customer base The operator does not have high-speed IP access to all its sers. The movies are very large and must be available on-demand. The operator decides to host the movies on the public cloud. It will allow the operator to manage massive data files and bandwidth demands without increasing physical resources or link speeds. The operator will pay only for storage space and bandwidth consumed to stream videos to the paying users. The cloud provider has user authentication and Role-Based Access Control (RBAC) to control administrators from the TV operator company who are authorised to change the movie database.

Real Life example

https://kvs-vishnu23.medium.com/why-did-coca-cola-a-beverage-company-needed-aws-6c69f0699185

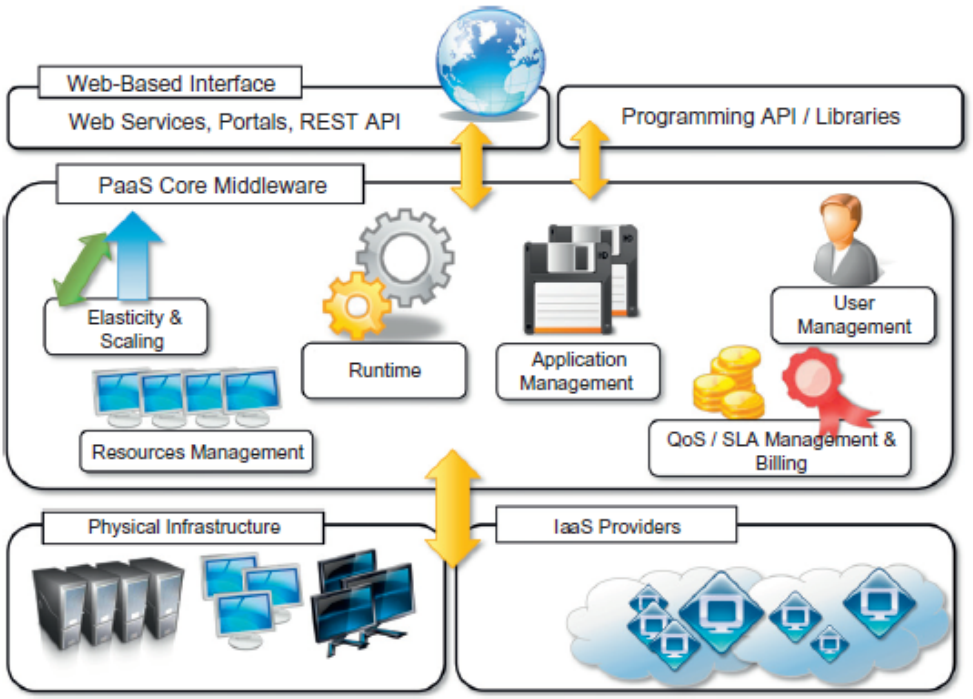
Benefits of IaaS

1. **Dynamic**: The users can dynamically select and configure devices like as CPUs, storage drives, etc.
2. **Easy Access**: Users can easily access various cloud computing infrastructure.
3. **Renting**: Flexible and efficient when hiring IT Infrastructure is quite flexible so user can use or pay as their requirement.

Disadvantages of IaaS

- Data security issues due to multitenant architecture
- IaaS depends on virtualization services. Also, restricts user-privacy & customization.

Platform as a Service (PaaS)



1. Platform-as-a-Service(PaaS) solutions provide a development and deployment platform for running applications in the cloud.
2. They constitute the middleware on top of which applications are built.
3. Application management is the core functionality of the middleware.
4. Developers design their systems in terms of applications and are not concerned with hardware (physical or virtual),operating systems,and other low-level services.
5. The core middleware is incharge of managing the resources and scaling applications on demand or automatically, according to the commitments made with users.
6. Web developers can use individual PaaS environments at every stage of the process to develop, test and host their websites.
7. Software developers can take advantage of a PaaS solution to build an application which they are planning to offer over the internet or software to be sold out of the box.
8. PaaS offerings can be divided into 3 categories:

Category	Description	Example
I	Software developers build, compile and test the app locally and then upload on the cloud.	Force.com, Google,Microsoft, Heroku, Amazon
II	PaaS implementations that completely follow the cloud computing style for application development and deployment.Hosted within the browser where applications are designed, developed, composed,and deployed.	Force.com, LongJump, Google app engine, Amazon
III	Solutions that target business experts, not coders or exprets. Vendors provide tools and templates that can be customised to build apps. No need to write original code.	Caspio, Wordpress and Zoho

9. Facebook is an example of PaaS. Developers can create specific applications for the Facebook platform using proprietary APIs and make that application available to any Facebook user. Some applications integrate a user's Twitter and Facebook account, others integrate a database with a Facebook profile. https://developers.facebook.com/docs/development/create-an-app/

Benefits of PaaS:

1. Lower cost – Companies face lower risk since they do not have to make upfront investment in hardware and software
2. Simplified deployment – The development team can concentrate on developing the cloud application without having to worry about the testing and deployment infrastructure
3. Security – Security is provided, including data security and backup and recovery.

Disadvantages of PaaS:

- Provider Languages only:
  Developing apps is restricted to the languages supported or provided the cloud provider.Eg Google supports Python, Java, Node.js, Go, Ruby, PHP, .NET

- Vendor lock in & migration issues:
  The cost of switching to a different vendor is so high that the customer is essentially stuck with the original vendor.
  A real-world example of vendor lock-in is the way Apple locked consumers into using iTunes in the early days of the service, because music purchased via iTunes could only be played within the iTunes application or on an iPod.

Software as a Service (SaaS):

1. Software-as-a-Service(SaaS) is a software delivery model that provides access to applications through the Internet as a Web-based service.
2. It generally refers to a new and alternative way of accessing software, as opposed to more traditional methods of access.
3. SaaS utilizes the internet to deliver applications to its users. A majority of SaaS applications are run directly through the web browser, and do not require any downloads or installations on the client side.
4. Software-as-a-Service applications can serve different needs. CRM,ERP,and social networking applications are definitely the most popular ones.
5. Another important class of popular SaaS applications comprises social networking applications such as Facebook and professional networking sites such as LinkedIn.
6. Other than providing the basic features of networking, they allow incorporating and extending their capabilities by integrating third-party applications.
7. Office automation applications are also an important representative for SaaS applications: Google Documents and Zoho Office are examples of Web-based applications that aim to address all user needs for documents, spreadsheets, and presentation management.
8. They offer a Web-based interface for creating, managing, and modifying documents that can be easily shared among users and made accessible from anywhere.

Benefits/features of SaaS:

- Pay for what you use

Particularly beneficial when something is only required for a short period

- No hardware costs

Processing power is supplied by the cloud provider

- Accessible from any location

Users aren't restricted to one location and can access applications from any internet enabled device

Disadvantages of SaaS:

- Compliance restrictions- Need to go with the terms of the software to use it.
- Internet connection required

Some services may fall in both categories .Eg Wix.
While Wix provides everything you need to create a website, it is ultimately up to the user to decide how their website will look and function. As such, Wix could be considered both a PaaS and a SaaS.

Cloud Deployment Models

Cloud computing is the delivery of computing services like servers, storages and more over the Internet. The companies that offer these computing services are called cloud providers. They charge for cloud computing services based on usage.
Cloud can be classification is given according to the administrative domain of a cloud: It identifies the boundaries within which cloud computing services are Implemented,provides hints on the underlying infrastructure adopted to support such services,and qualifies them. It is then possible to differentiate four different types of cloud

- Public Cloud
- Private Cloud
- Community Cloud
- Hybrid or Heterogenous Cloud

Public Cloud

1. A public cloud is an infrastructure that is owned and managed by an organisation selling cloud services and is made available to the general public.
2. The physical and IT infrastructure and applications exist at the provider's location.
3. Public clouds are attractive to organisations that do not want to build or manage their own data centers, server rooms, IT infrastructure, or applications and providers, and do not want to spend capital on recurring operating expenses.

4. According to NIST, "A public cloud infrastructure is provisioned for open use by the general public, which may be owned, managed, and operated by a commercial business, academic or government organisation, or some combination of them and exists on the premises of the cloud provider."
5. A fundamental characteristic of public clouds is multi tenancy.A public cloud is meant to serve a multitude of users,not a single customer.
6. Every customer requires a virtual computing environment that is separated, and most likely isolated, from other users. This is a fundamental requirement to provide effective monitoring of user activities and guarantee the desired performance and the other QoS attributes negotiated with users. QoS management is very important aspect of public clouds.
7. Hence,a significant portion of the software infrastructure is devoted to monitoring the cloud resources, to bill them according to the contract made with the user, and to keep a complete history of cloud usage for each customer.
8. A public cloud can offer any kind of service: infrastructure, platform, or applications.For example, AmazonEC2 is a public cloud that provides infrastructure as a service; Google App Engine is a public cloud that provides an application development platform as a service; and SalesForce.com is a public cloud that provides software as a service.
9. From a structural point of view they are a distributed system, most likely composed of one or more data centers connected together, on top of which the specific services offered by the cloud are implemented.
10. Public Clouds can be composed of geographically dispersed data centers to share the load of users and better serve them according to their locations.
11. For example, Amazon Web Services has data centers installed in the United States, Europe, Singapore, and Australia; they allow their customers to choose between three different regions: us-west-1, us-east-1, or eu-west-1.
12. Such regions are priced differently and are further divided into availability zones, which map to specific data centers.

Features & Benefits:

- ULTIMATE SCALABILITY

Cloud resources are available on demand from the public clouds' vast pools of resource so that the applications that run on them can respond seamlessly to fluctuations in activity

- LOCATION INDEPENDENCE

The availability of public cloud services through an internet connection ensures that the services are available wherever the client is located. This provides invaluable opportunities to enterprise, such as remote access to IT infrastructure or online document collaboration from multiple locations

Disadvantages of Public Clouds

- Low visibility and control

Public cloud infrastructure is owned by the cloud service provider. You don't have much visibility and control over it.

- Lack of options.

Public cloud providers usually have a one-size-fits-all approach with standard options. If a company has a unique need, they may not be able to meet those requirements.

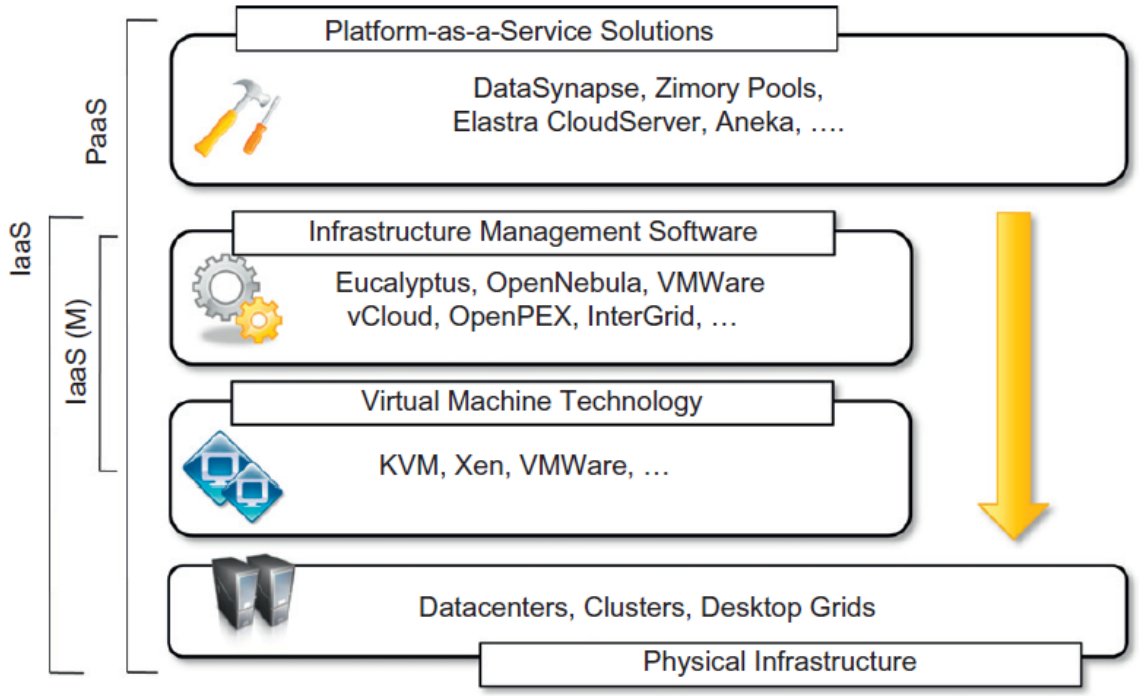
- Compliance Issues

It's no secret that businesses that deal with confidential data are under government regulation. This becomes more challenging when they put their IT infrastructure on the cloud. This is particularly a problem for financial institutions. Services offered may be subject to a wide array of legal and industry rules to ensure security and proper maintenance.

Private Cloud

1. The private cloud is defined as computing services offered either over the Internet or a private internal network and only to select users instead of the general public.
2. A private cloud is usually located on-premises, is dedicated to, and is used solely for a single organisation. It may be managed by the organisation itself or a third party.
3. It could be physically located within the corporate premises or off-premises. The users of a private cloud are the internal business units or divisions.
4. The owner or the corporation has the responsibility of managing various run-time aspects of the private cloud such as monitoring, security, load-balancing, backups, on-demand resource allocation, self-service, application hosting, customer elasticity, metering, and billing.
5. Private clouds have the advantage of keeping the core business operations in-house by relying on the existing IT infrastructure and reducing the burden of maintaining it once the cloud has been setup.

6. In this scenario, security concerns are less critical, since sensitive information does not flow out of the private infrastructure. Moreover, existing IT resources can be better utilized because the private cloud can provide services to a different range of users.
7. Different options can be adopted to implement private clouds. The physical layer is complemented with infrastructure management software or a PaaS solution, according to the service delivered to the users of the cloud.



8. At the bottom layer of the software stack,virtual machine technologies such as Xen, KVM, and VMware serve as the foundations of the cloud.Virtual machine management technologies such as VMware, vCloud, Eucalyptus, and OpenNebula can be used to control the virtual infrastructure and provide an IaaS solution.
9. Solutions that rely on the previous virtual machine managers and provide added value are OpenPEX and InterGrid. OpenPEX is Web-based system that allows the reservation of virtual machine instances and is designed to support different backends (at the moment only the support for Xen is implemented). InterGrid provides added value on top of OpenNebula and
10. AmazonEC2 by allowing the reservation of virtual machine instances and managing multi administrative domain clouds. PaaS solutions can provide an additional layer and deliver high level service for private clouds. Among the options available for private deployment of clouds we can consider Data Synapse, Zimory Pools, Elastra, and Aneka. DataSynapse is a global provider of application virtualization software.

11. Aneka is a software development platform that can be used to deploy a cloud infrastructure on top of heterogeneous hardware: data centers,clusters, and desktop grids. It provides pluggable service-oriented architecture that's mainly devoted to supporting the execution of distributed applications with different programming models: bag of tasks, MapReduce,and others.

Features/Benefits of Private clouds:

- Customer Information Protection/Security:

Despite assurances by the public cloud leaders about security, few provide satisfactory disclosure or have long enough histories with their cloud offerings to provide warranties about the specific level of security put in place on their systems.In-house security is easier to maintain and rely on.

- Infrastructure ensuring SLAs:

Quality of service implies specific operations such as appropriate clustering and failover, data replication, system monitoring and maintenance,and disaster recovery, and other uptime services can be commensurate to the application needs. Although public cloud vendors provide some of these features, not all of them are available as needed.

- Compliance With Standards Procedures And Operations:

If organisations are subject to third-party compliance standards, specific procedures have to be put in place when deploying and executing applications. This could be not possible in the case of the virtual public infrastructure.

Disadvantages of Private clouds:

- Private clouds can provide in-house solutions for cloud computing, but if compared to public clouds they exhibit more limited capability to scale elastically on demand.
- A private cloud will cost you more to implement than a public cloud if you host your private cloud on-site. You must make capital investments in servers, network infrastructure, data centers and software licenses.
- If you manage your private cloud yourself on premises, you require the IT staff to deploy, configure, patch and manage your hardware and software.

Community Clouds

1. A community cloud can be defined as a cloud-based infrastructure that enables an industry, a business sector or organisations to share services and resources derived from common regulatory and operational requirements.
2. The users of a specific community cloud fall into a well-identified community, sharing the same concerns or needs; they can be government bodies, industries, or even simple users, but all of them focus on the same issues for their interaction with the cloud.
3. This is a different scenario than public clouds, which serve a multitude of users with different needs.
4. Community clouds are also different from private clouds, where the services are generally delivered within the institutions that owns the cloud.
5. A community cloud is most likely implemented over multiple administrative domains.
6. This means that different organizations such as government bodies private enterprises, research organizations, and even public virtual infrastructure providers contribute with their resources to build the cloud infrastructure.
7. Candidate sectors for community clouds are as follows:
   - **Public and Government sectors:** The community cloud model has become popular among government departments for managing sensitive communication and infrastructure needs. Federal agencies generally develop highly secure government clouds which ensure that the data remains protected.
   - **Educational institutions:** The community cloud model is the most suited model for educational institutions as it allows them to share information, research material, and educational content on the cloud. In group projects, the model can be used to facilitate question-and-answer sessions that help foster collaboration.
   - **Health care industry:** The community cloud model has use cases for the healthcare sector. This sector deals with highly sensitive information when collaborating with several pharmaceutical companies. Community cloud helps in information sharing without disclosing any private information. Many pharmaceutical companies are part of the healthcare sector and collaborate with hospitals to provide quick healthcare solutions.

Benefits/ Features of Community Cloud:

• Openness:

By removing the dependency on cloud vendors, community clouds are open systems in which fair competition between different solutions can happen.

• Community:
Being based on a collective that provides resources and services, the infrastructure turns out to be more scalable because the system can grow simply by expanding its user base.
• Convenience and control. Within a community cloud there is no conflict between convenience and control because the cloud is shared and owned by the community, which makes all the decisions through a collective democratic process.
• Environmental Sustainability. The community cloud is supposed to have a smaller carbon footprint because it harnesses underutilized resources. Moreover, these clouds tend to be more organic by growing and shrinking in a symbiotic relationship to support the demand of the community,which in turn sustains it.

Hybrid Cloud/ Heterogeneous Cloud

1. Hybrid Cloud is a mixture of public and private cloud. Non-critical activities are performed using public cloud while the critical activities are performed using private cloud.
2. A hybrid cloud approach is suited for you if you want to take advantage of the scale and security of a public cloud, such as Google Cloud, while keeping your data on-premises to comply with data residency laws or supporting computing needs closer to your customers.
3. The industry which is most benefited with the Hybrid cloud computing is the ones who provide financial services. This can be a perfect public private hybrid community cloud example.
4. Mostly the private cloud is for accessing trade services however public cloud is mostly used in trade analytics.
5. There is a difference between the two, private is involved in the trading process while the public is involved in statistics of trade occurred.
6. In this way, most of the organizations are able to reduce their space requirements which enhances the functioning in a better manner.

Benefits/Features and benefits

- SECURITY

The private cloud element of the hybrid cloud model not only provides the security where it is needed for sensitive operations, but can also satisfy regulatory requirements for data handling and storage where it is applicable

- FLEXIBILITY

The availability of both secure resource and scalable cost effective public resource can provide organisations with more opportunities to explore different operational avenues