1. INTRODUCTION

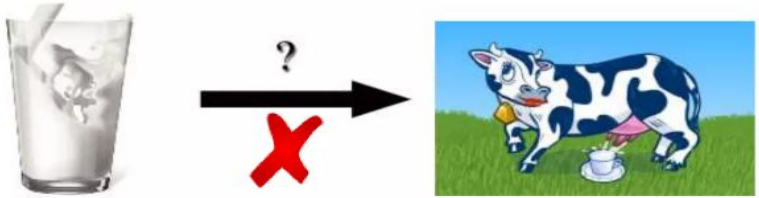
Cloud Computing: Overview, Layers &Types of Clouds, Cloud Infrastructure Management, Challenges & Applications.

Virtualization: Virtualization of Computing, Storage and Resources.

Do you Use the Cloud?

Analogy:

"If you only need milk, would you buy a cow? "



In Business View:

When its's smart to rent than why to buy …

In Techie's View:

Its better if we can access software or information that can be delivered on-demand, over the internet, without the need to store it locally…

Thus comes "Cloud Computing" in picture-inspired by the cloud symbol that's often used to represent the internet in flowcharts and diagrams.

Overview

Cloud computing is a general term for anything ***that involves delivering hosted services over the internet.***

Most **common characteristics** which a cloud should have:

- pay-per-use (no ongoing commitment, utility prices);
- elastic capacity and the illusion of infinite resources;
- self-service interface; and
- resources that is abstracted or virtualized.

Cloud Computing - Definitions

According to Webopedia

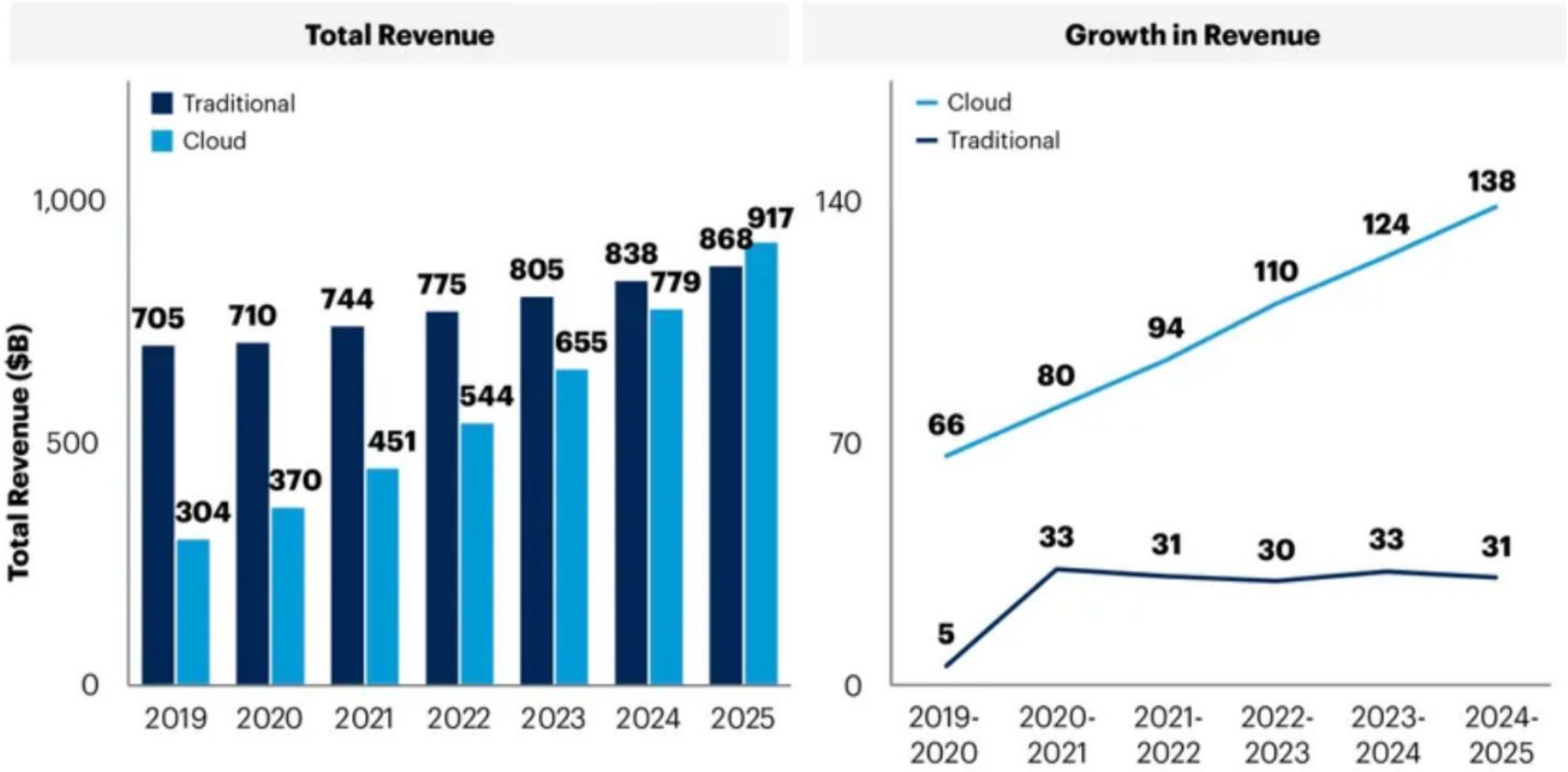
Cloud Computing is typically defined as a **type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications.**

According to IBM

Cloud Computing, often referred to as simply "the cloud", is the **delivery of on-demand computing resources** – everything from applications to data centers over the internet on a pay-for-use basis.

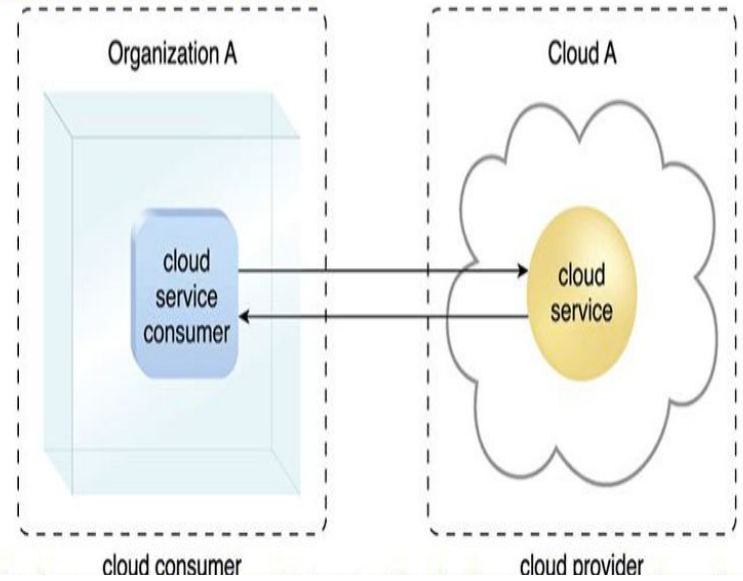
"Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service- level agreements (SLA) established through negotiation between the service provider and consumers."

Figure 1: Sizing Cloud Shift, Worldwide, 2019 – 2025



Basic Terms

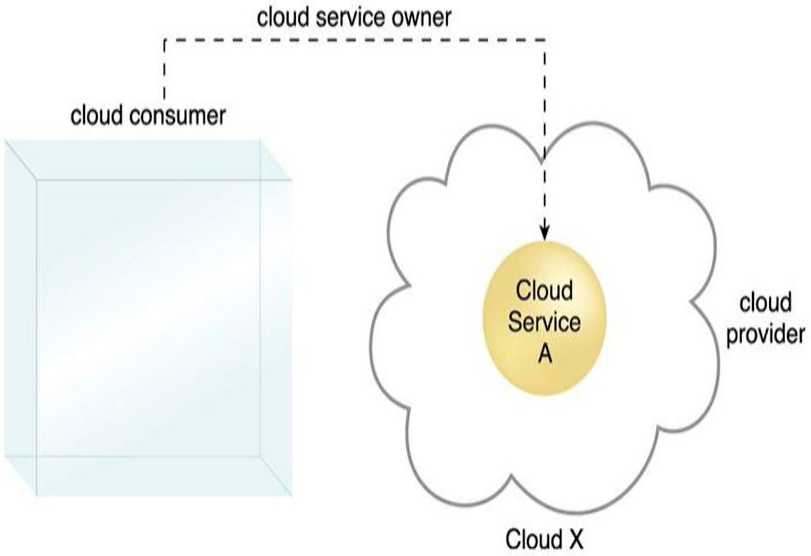
- The organization that provides cloud based IT resources is the **cloud provider.** His tasks includes administrative duties to ensure the on-going operation of the overall cloud infrastructure. Cloud providers normally own the IT resources that are made available for lease by cloud consumers; however some cloud providers also “resell” IT resources leased from other cloud providers.
- A **cloud consumer** is an organization (or a human) that has a formal contract or arrangement with a cloud provider to use IT resources made available by the cloud provider.

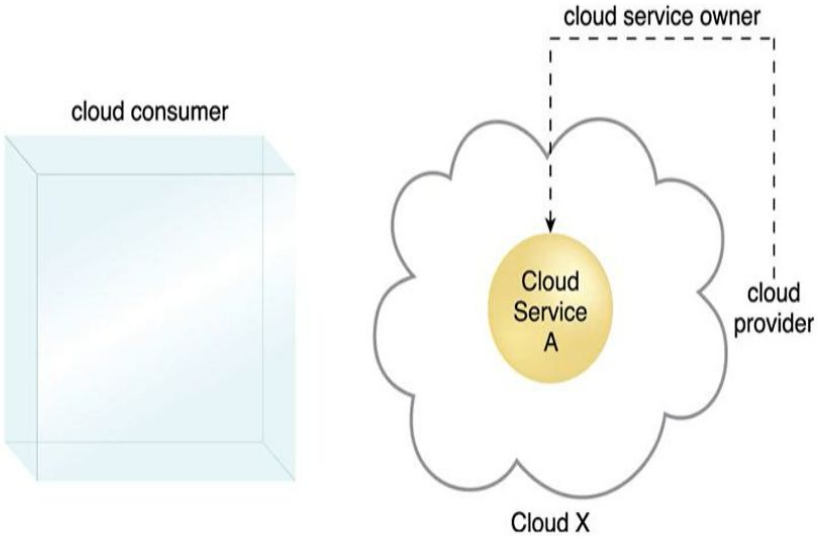


- The person or organization that legally owns a cloud service is called a **cloud service owner.**

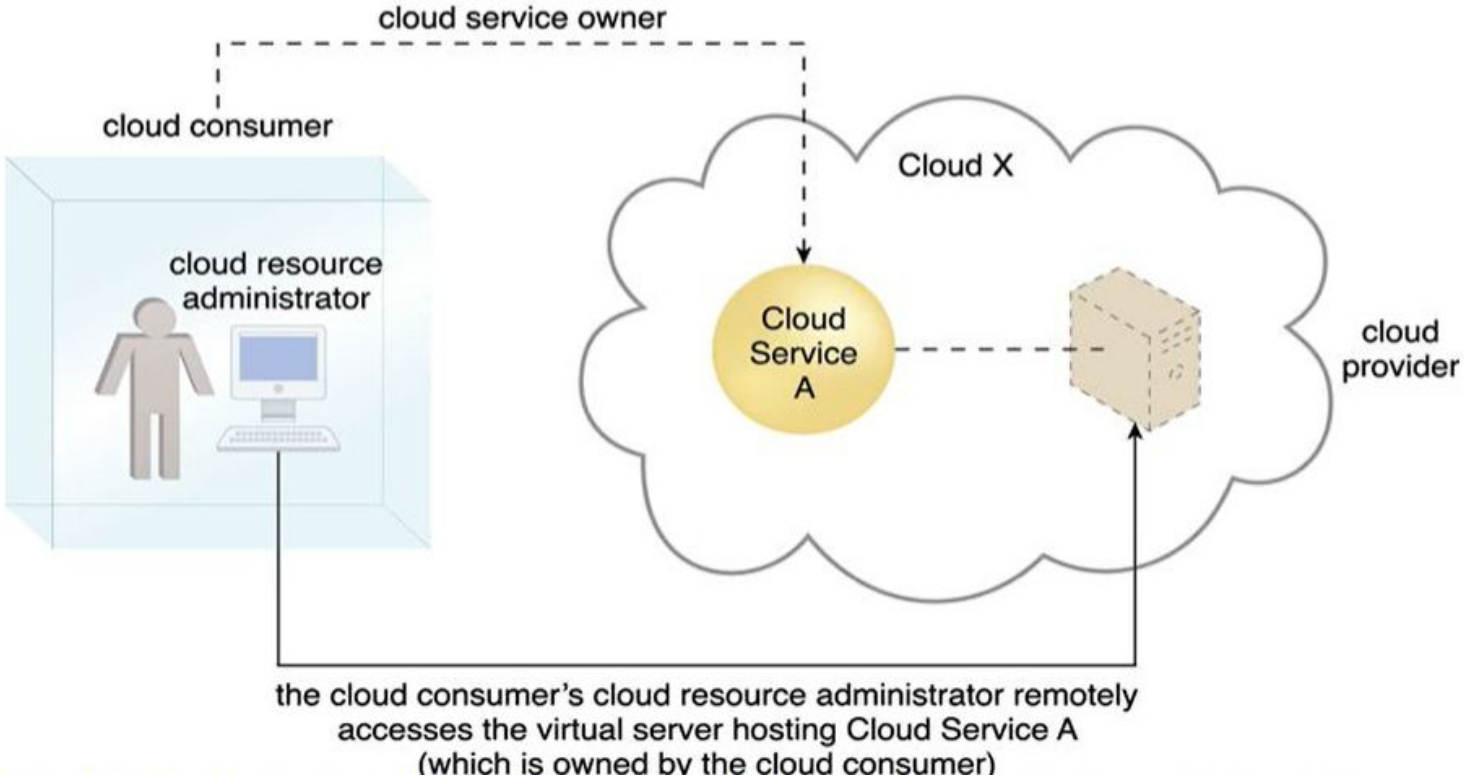
  - A cloud consumer can be a cloud service owner when it deploys its own service in cloud

  - A cloud service provider becomes a cloud service owner if it deploys its own cloud service, typically for other cloud consumers to use.

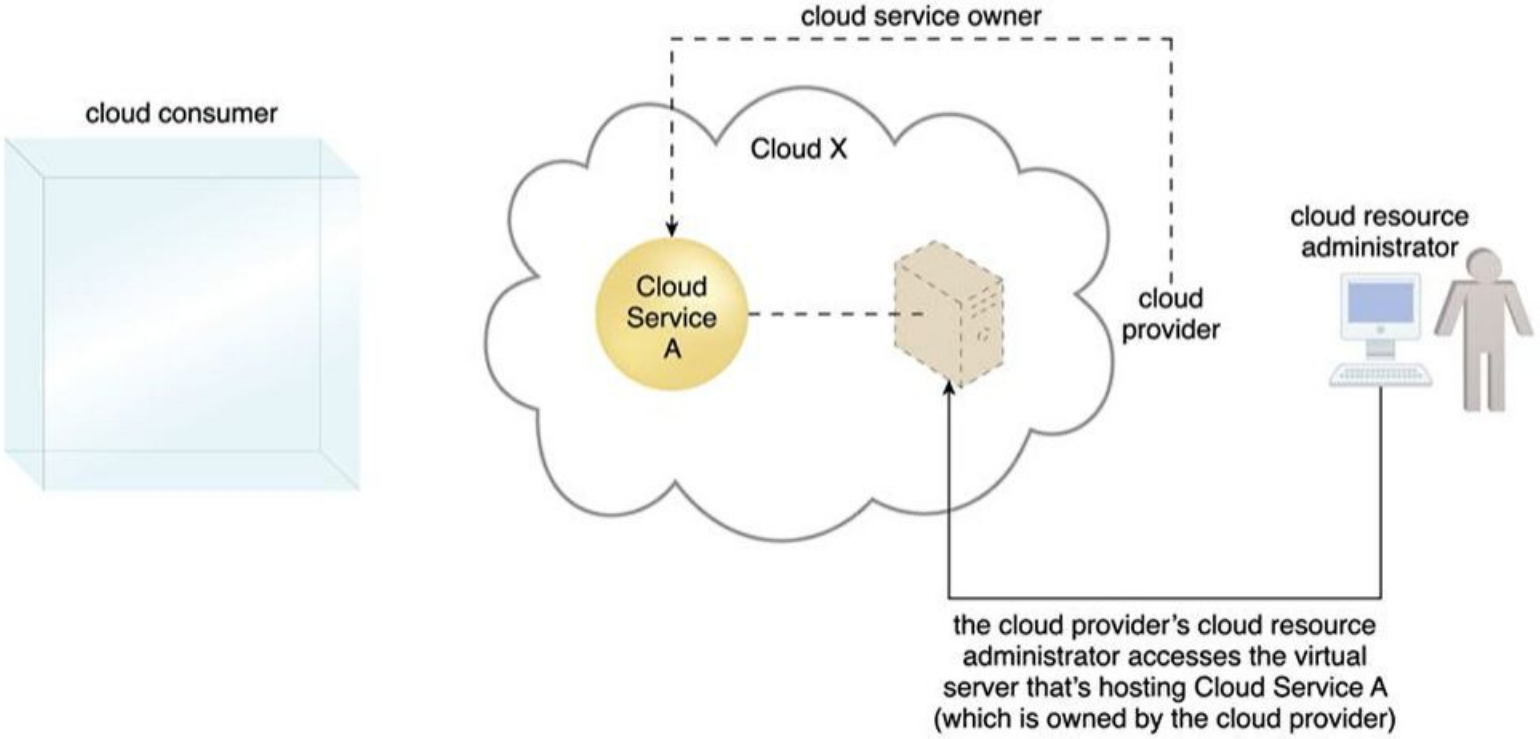




- A **cloud resource administrator** is the person or organization responsible for administering a cloud based IT resource (including cloud services)



- The **cloud resource administrator** can be (or belong to) the **cloud consumer or cloud provider** of the cloud within which the cloud service resides.



Advantage of Cloud Computing

Rather than owning their own computing infrastructure or data centres, companies can rent access to anything from applications to storage from a cloud service provider.

One benefit of using cloud-computing services is that firms can avoid the upfront cost and complexity of owning and maintaining their own IT infrastructure, and instead simply pay for what they use, when they use it.

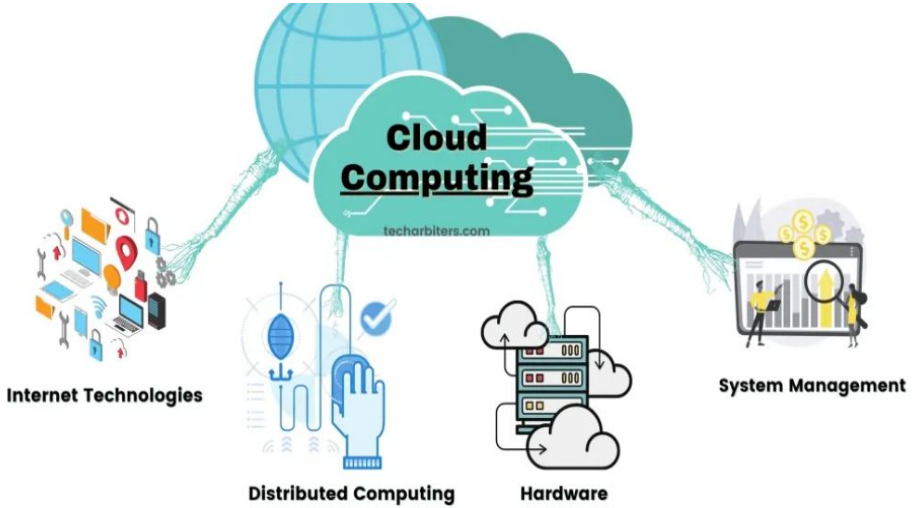
In turn, providers of cloud-computing services can benefit from significant economies of scale by delivering the same services to a wide range of customers.

For example, Netflix relies on cloud-computing services to run its video-streaming service and its other business systems, too.

- Cloud computing is becoming the default option for many apps: **software vendors are increasingly offering their applications as services over the internet rather than standalone products** as they try to switch to a subscription model.

- However, there are potential downsides to cloud computing, in that it can also introduce new costs and new risks for companies using it.

Roots of Cloud Computing



- Read this document for details : Unit 1 Doc

- The roots of clouds computing can be tracked by observing the advancement of several technologies, especially in hardware (virtualization, multi-core chips), Internet technologies (Web services, service-oriented architectures, Web 2.0),distributed computing (clusters, grids), and systems management (autonomic computing, data center automation).
- These roots help computers to extend their capacities and make them more powerful.

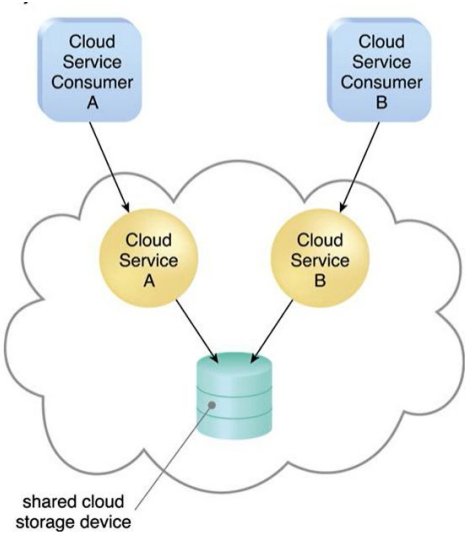
Features/ Characteristics of Cloud Computing

There are many characteristics of Cloud Computing here are few of them :

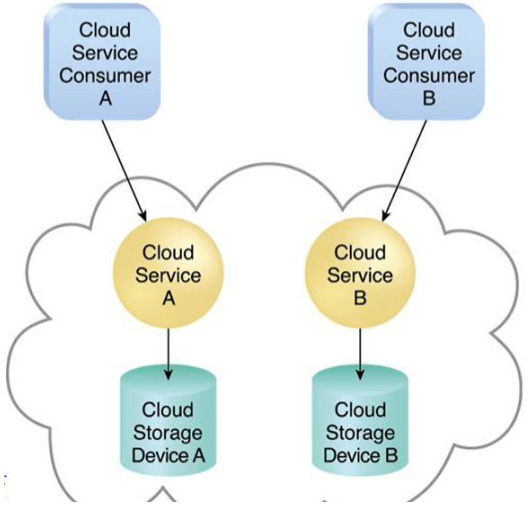
- **On-demand self-services:** The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
- **Ubiqitous/Broad-Network access:** The Computing services are generally provided over standard networks and range of devices, security technologies, interfaces.
- **Elasticity:** It is automated ability of a cloud to transparently scale IT resources, as required in response to runtime conditions. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.
- **Resource pooling:** The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.

Multi-tenancy: Cloud computing providers can support multiple tenants (users or organizations) on a single set of shared resources.

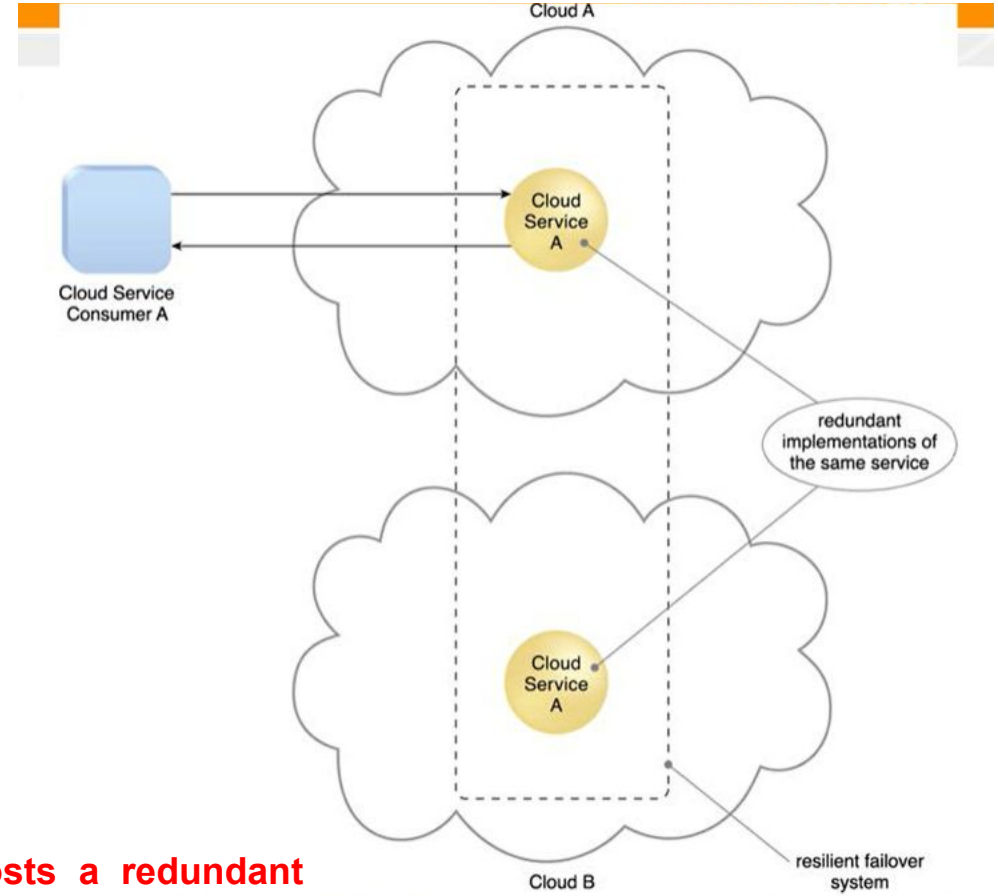
- Multitenancy allows several cloud consumers to use the same IT resource or its instance while each remains unaware that it may be used by others.



- In single tenant environment, each cloud consumer has a separate IT resource instance



- **Resilient computing:** Cloud computing services are typically designed with redundancy and fault tolerance in mind, which ensures high availability and reliability. Resiliency refers to redundant IT resources within the same cloud (but in different physical locations) or across multiple clouds.



A resilient system in which Cloud B hosts a redundant implementation of Cloud Service A to provide failover in case Cloud service A on cloud becomes unavailable.

- **Measured Usage:** The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.
- **Virtualization:** Cloud computing providers use virtualization technology to abstract underlying hardware resources and present them as logical resources to users.
- **Flexible pricing models:** Cloud providers offer a variety of pricing models, including pay-per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.
- **Security:** Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
- **Automation:** Cloud computing services are often highly automated, allowing users to deploy and manage resources with minimal manual intervention.
- **Sustainability:** Cloud providers are increasingly focused on sustainable practices, such as energy-efficient data centers and the use of renewable energy sources, to reduce their environmental impact.

Benefits of using Cloud Computing Technologies

- **High scalability:** It requests the supply of resources on a large scale without any human intervention.
- **High availability and reliability:** The servers are available at the right time without any delay or disappointment
- **Agility:** It divides the resources effectively among the users and executes very quickly.
- **Multi-sharing:** By distributed computing, different clients from multiple areas share the same resources by fundamental infrastructure.
- **Maintenance:** It is user-friendly as they are easy to access from their place and doesn't require any installation set up.
- **Low cost:** It is very cost-effective and pays to its usage.

- **Services as pay to use mode:** Application Programming Interface is given to customers to use resources and services and pay on the service basis.
- **On-Demand Self Service:** Cloud computing offers the required services and application to the client. With the login key, they can start to use without any human interaction and cloud service providers. It includes storage and virtual machines.

Layers of Cloud/ Cloud Architecture

- Cloud architecture **defines the working mechanism of cloud computing**. It helps us in understanding how cloud services are made available to the end users.
- In a generalized way, we can classify the cloud architecture into two ends i.e. **front-end and the back-end**.
- ***The front-end* is one with which *the end-users interact. The back end* is one with which *the cloud provider has to deal.*** Both of ***these ends are connected to each other with the help of the internet*** .
- The Internet is the most crucial element of cloud computing as every user needs the internet if it has to access the cloud.

- The **architecture of a cloud is developed at 3 layers** : ***infrastructure, platform and application.*** T

  These 3 development layers are implemented with virtualization and standardization of hardware and software resources provisioned in the cloud.

Thus Cloud computing services are divided into three classes

(1) Infrastructure as a Service,

(2) Platform as a Service, and

(3) Software as a Service

- The infrastructure layer is deployed first to support IaaS services.
- This infrastructure layer serves as the foundation for building the platform layer of the cloud for supporting PaaS services.
- In turn, the platform layer is a foundation for implementing the application layer for SaaS applications.

Cloud Service Models

IaaS – Infrastructure as a Service

Cloud Service Provider provides infrastructure and resources

Manufacturing organization manages OS, data and software applications

PaaS – Platform as a Service

Cloud Service Provider provides infrastructure and development platform

Manufacturing organization can develop its own software applications

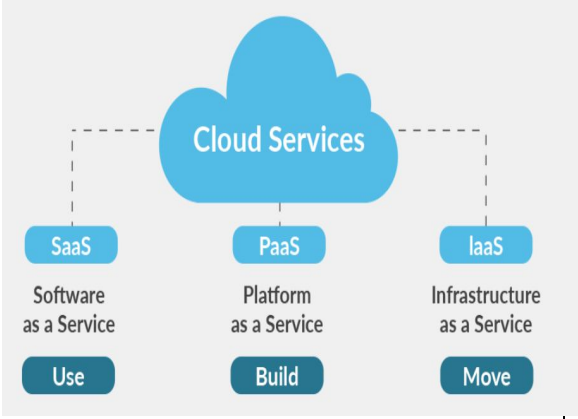
SaaS – Software as a Service

Cloud Service Provider has a full control over cloud and software

Manufacturing organization rents software applications

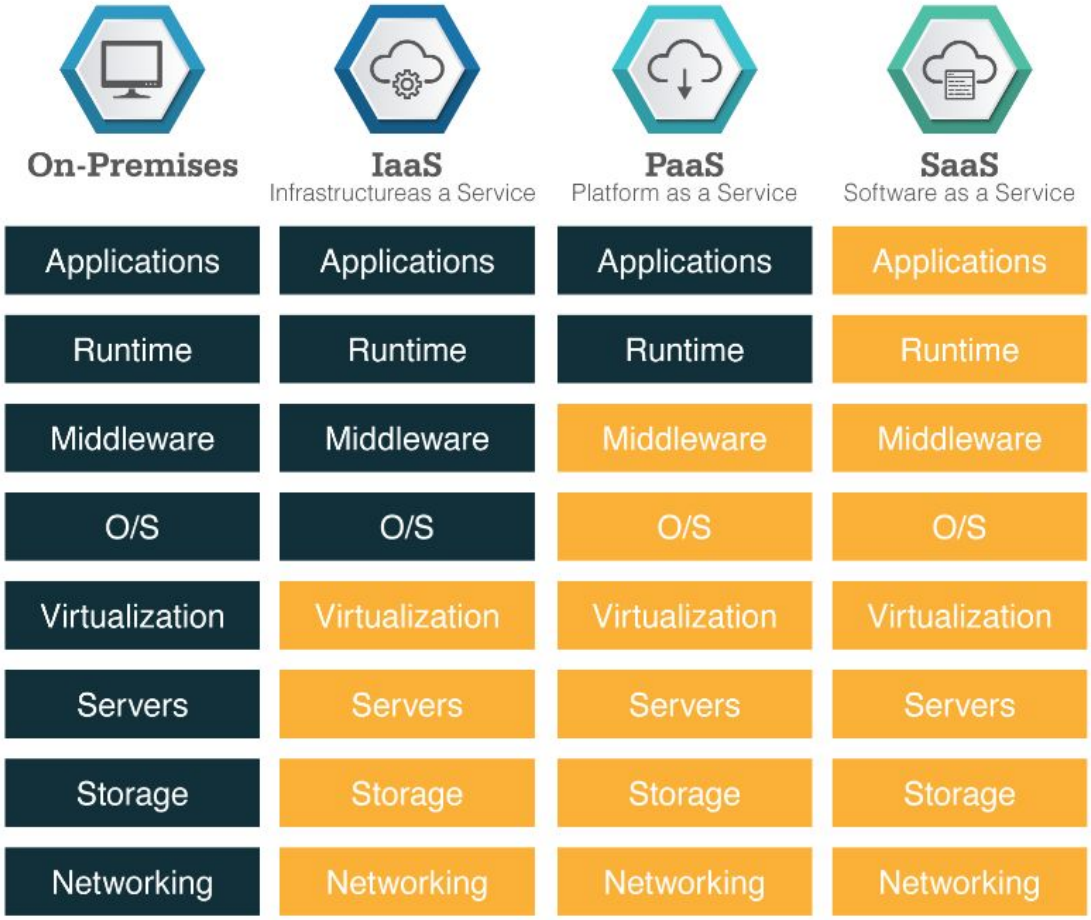
Cloud Computing Service Models

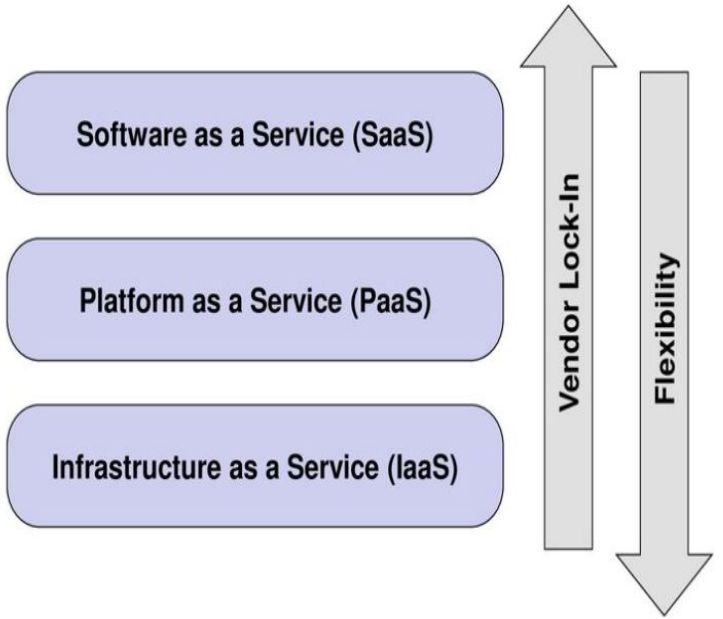
SaaS Software as a Service	Business User/Consumer	Email Business Process Industry Application CRM/EPR/HR	ORACLE, Sage CRM, salesforce, aprimo, Microsoft Dynamics CRM
PaaS Platform as a Service	Technical IT Community	Middleware Web 2.0 Application-Runtime Development Tools Database Java Runtime	Google app engine, Windows Azure, Engine Yard, OPENSHIFT, CLOUD Computing Wire
IaaS Infrastructure as a Service	Technical IT Community	Servers Networking Storage Data Center Fabric Load Balancer Firewalls	amazon web services, Microsoft, rackspace, hp, at&t, verizon, NTT Communications



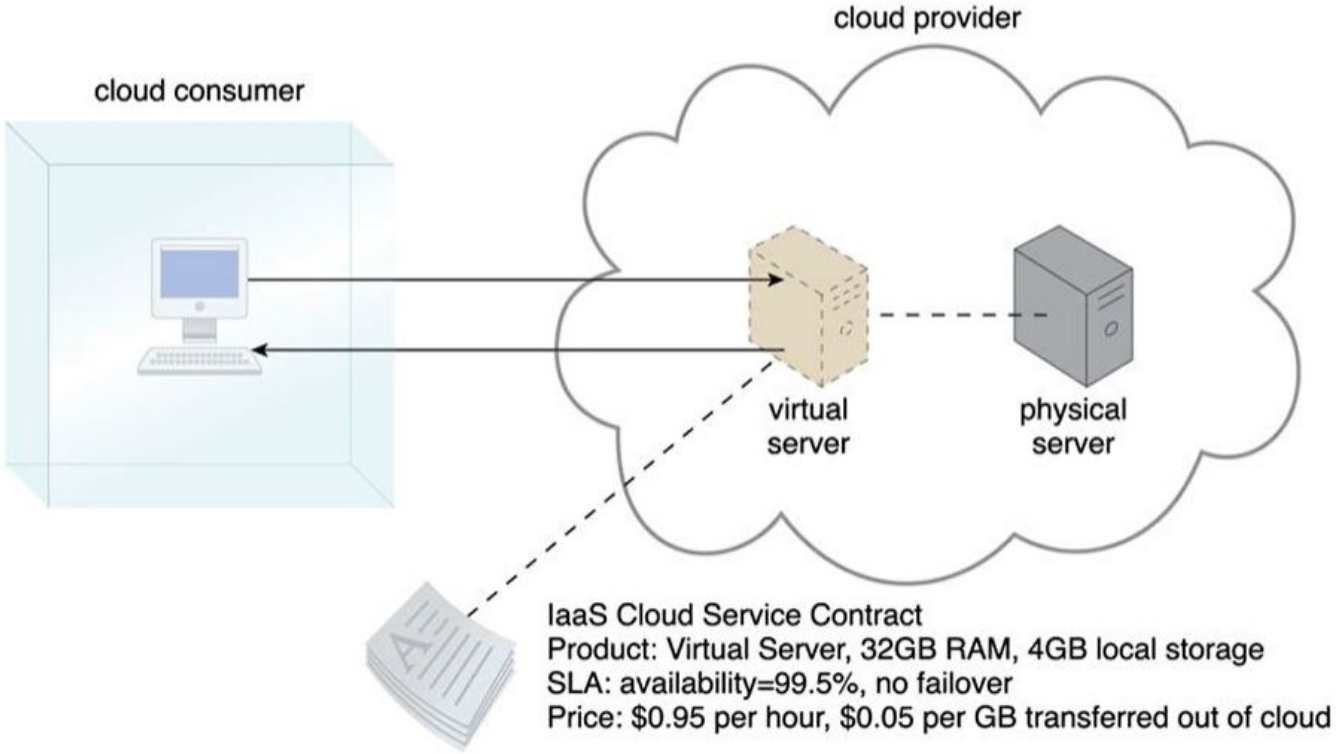
Software as a Service (SaaS)	Platform as a Service (PaaS)	Infrastructure as a Service (IaaS)
Refers to the delivery of applications as a service, probably the version of cloud computing that most people are used to on a day-to-day basis. The underlying hardware and operating system is irrelevant to the **end user**, who will access the service via a web browser or app; it is often bought on a per-seat or per-user basis.	This layer includes the tools and software that **developers** need to build applications on top, which could include middleware, database management, operating systems, and development tools.	Refers to the fundamental building blocks of computing that can be rented: physical or virtual servers, storage and networking This is attractive to **companies** that want to build applications from the very ground up and want to control nearly all the elements themselves, it does require firms to have the technical skills to be able to orchestrate services at that level.

Software as a Service (SaaS)	Platform as a Service (PaaS)	Infrastructure as a Service (IaaS)
SaaS Benefits •On-demand service •Automated provisioning/management of your cloud infrastructure •Subscription-based billing •Allows for full remote collaboration •Reduced software costs •Pay-as-you-go **SaaS Disadvantages** •Less control •Limited solutions	**PaaS Benefits** •Rapid product development through simplified process •Custom solutions •Highly scalable •Eliminates need to manage basic infrastructure •Future-proof •Multi-tenant architecture **PaaS Disadvantages** •Security issues •Increased dependency on vendor for speed and support	**IaaS Benefits** •Reduced vendor lock-in •Platform virtualizations •On-demand scaling •GUI and API-based access •Increased security •Multi-tenant architecture **IaaS Disadvantages** •Potential for vendor outages •The cost of training how to manage new infrastructure


On-Premises
IaaS
Infrastructureas a Service
PaaS
Platform as a Service
SaaS
Software as a Service
Applications
Runtime
Middleware
O/S
Virtualization
Servers
Storage
Networking
You Manage
Other Manages


Software as a Service (SaaS)
Platform as a Service (PaaS)
Infrastructure as a Service (IaaS)
Vendor Lock-In
Flexibility

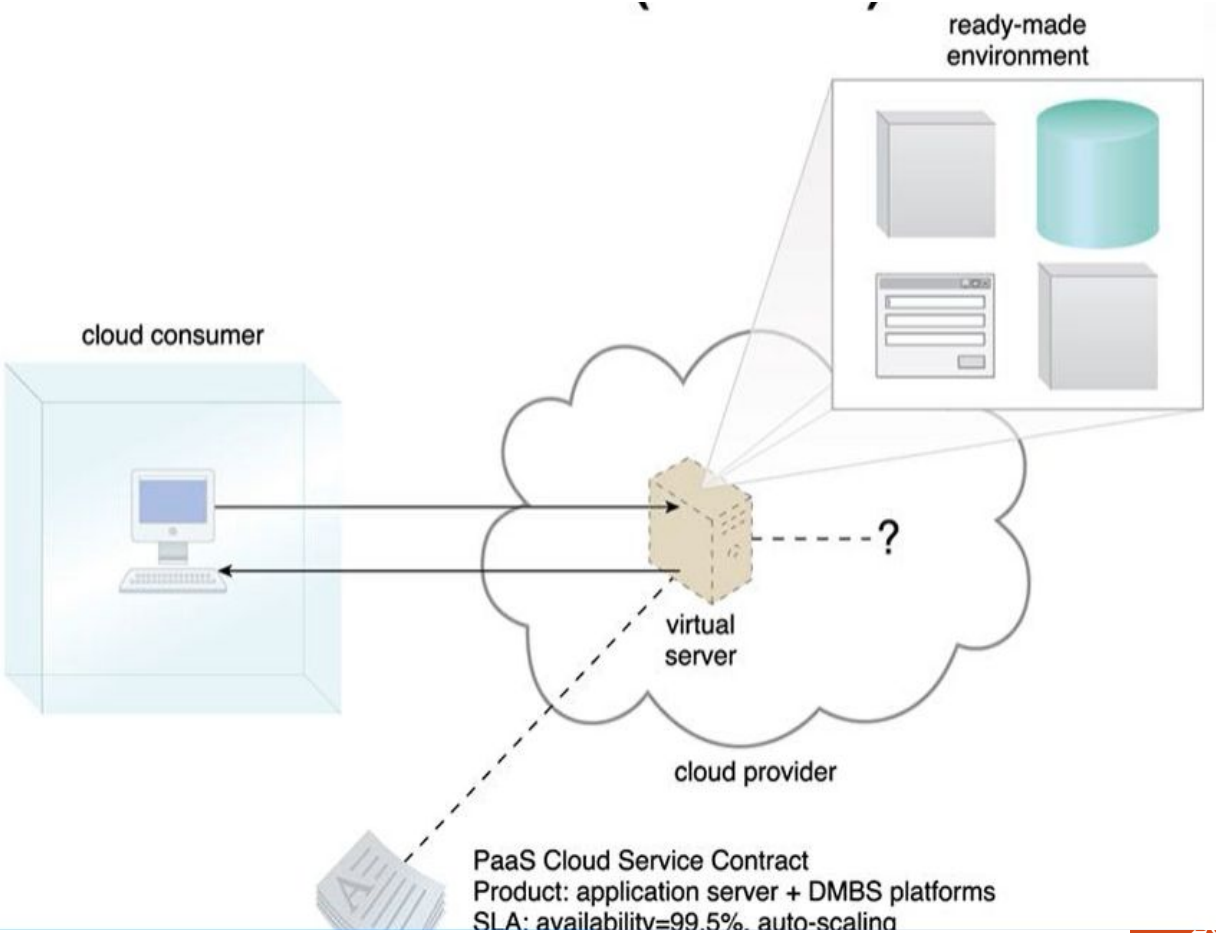
IaaS



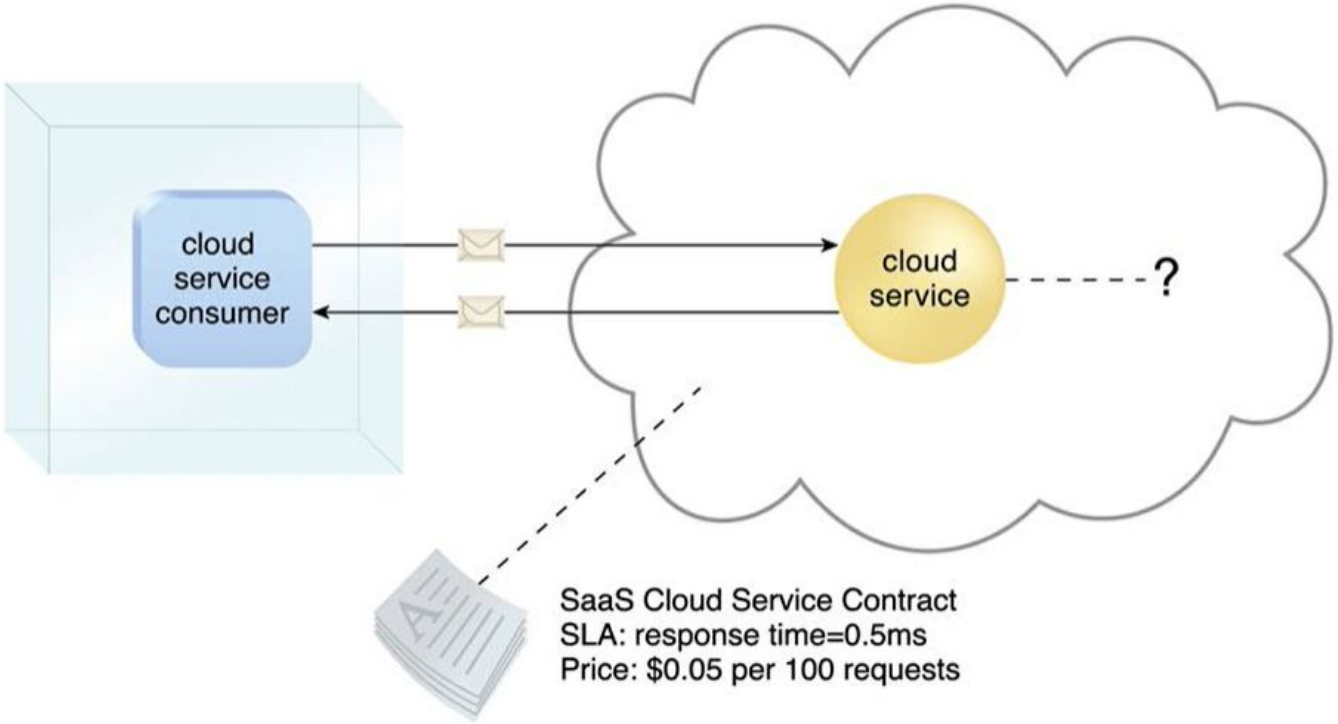
A cloud consumer is using a virtual server within an IaaS environment. Cloud consumers are provided with a range of contractual guarantees by the cloud provider, pertaining to characteristics such as capacity, performance, and availability

PaaS

A cloud consumer is accessing a ready-made PaaS environment. The question mark indicates that the cloud consumer is intentionally shielded from the implementation details of the platform.



SaaS



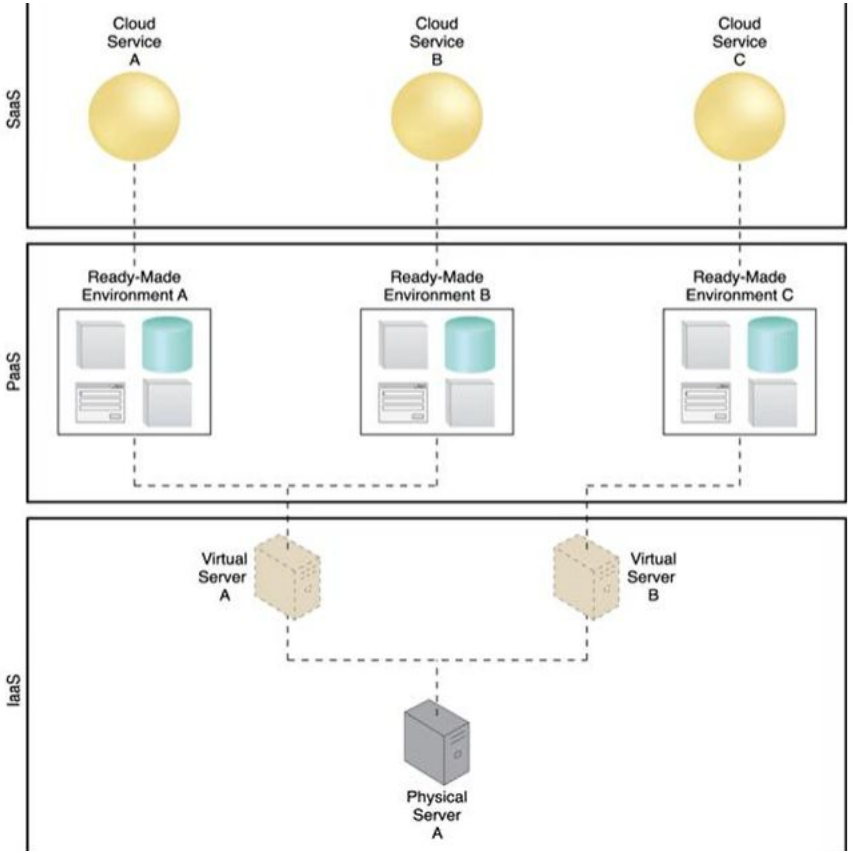
The cloud service consumer is given access the cloud service contract, but not to any underlying IT resources or implementation details.

Combining IaaS + PaaS + SaaS

IaaSa + PaaS + SaaS

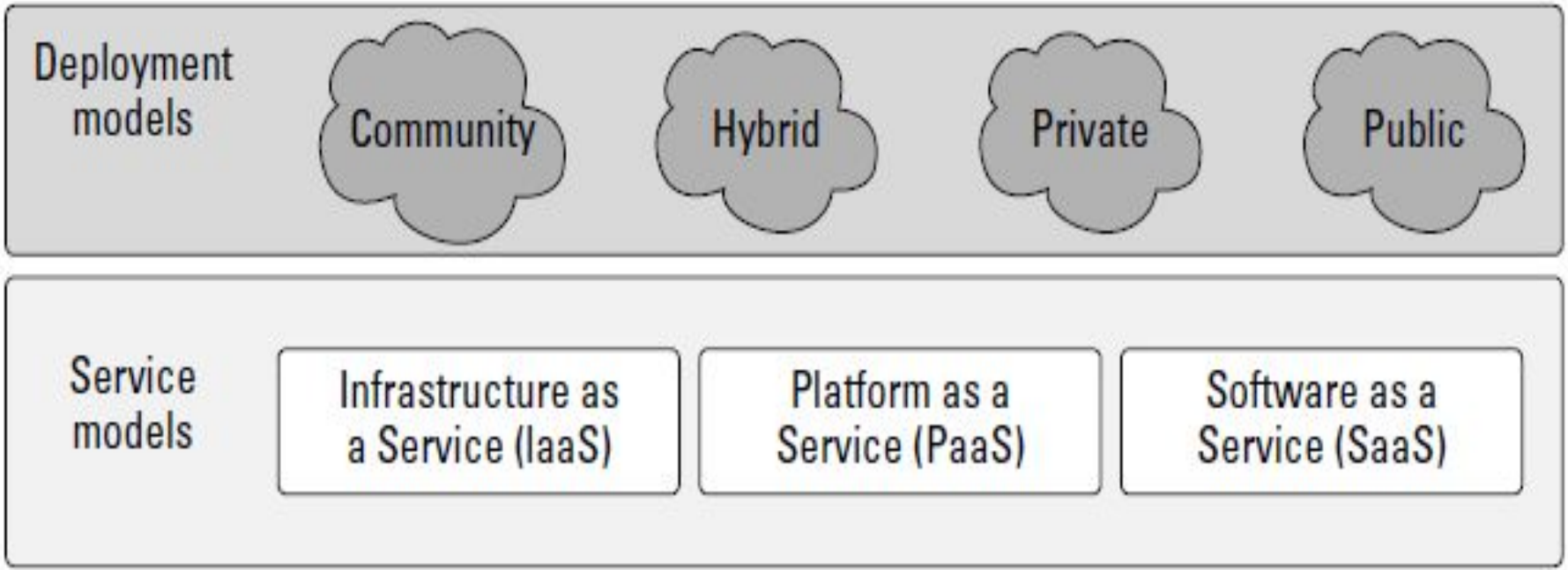
Ready-made environment provided by the PaaS environment can be used by the cloud consumer organization to develop and deploy its own SaaS cloud services that it can then make available as commercial products

A simple layered view of an architecture comprised of IaaS and PaaS environments hosting three SaaS cloud service implementations.



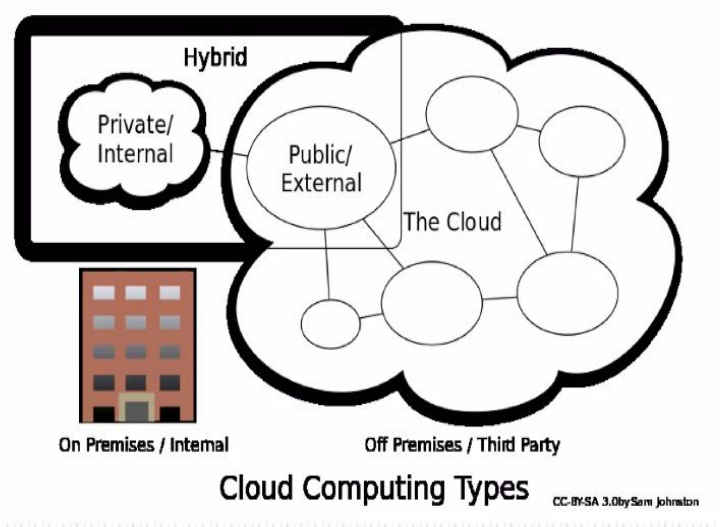
NIST Service Model

The NIST cloud computing definitions



Types of Cloud / Cloud Deployment Models

Cloud Types : ***Private , Public And Hybrid***



A **public** cloud sells services to anyone on the internet.

A **private** cloud is a proprietary network or a data center that supplies hosted services to a limited number of people, with certain access and permissions settings.

Public Cloud

"The cloud infrastructure is provisioned for open use by the general public.

It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them."

It exists on the premises of the cloud provider.

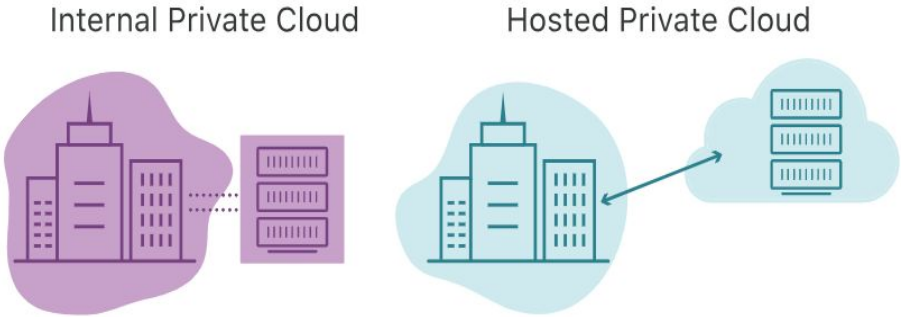
Public cloud services may be free or offered on a pay-peer-usage model.

Mostly similar public and private cloud architecture. But difference is in security, storage and other resources that are usually better in public cloud.

Figure 4.17 Organizations act as cloud consumers when accessing cloud services and IT resources made available by different

Private Cloud

The cloud infrastructure is operated solely for an organisation. Private Cloud may exist off premises and can be managed by a third party. Thus two private cloud scenarios exist:



Internal Private Cloud- applies to private clouds implemented at a customer's premises

Outsourced Private Cloud- applies to private clouds where the server is outsourced to a hosting company.

- **Examples of Private Cloud:**

  Eucalyptus, Ubuntu Enterprise Cloud, Amazon VPC, VMWare Cloud Insfrastructure suite,etc.

Hybrid Cloud

- "The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, and bound together by standardized or proprietary technology that enable data and application portability. (e.g, cloud bursting for load balancing between clouds)".
- It helps in extension of the capacity or the capability of cloud service by aggregation, integration with another cloud service.

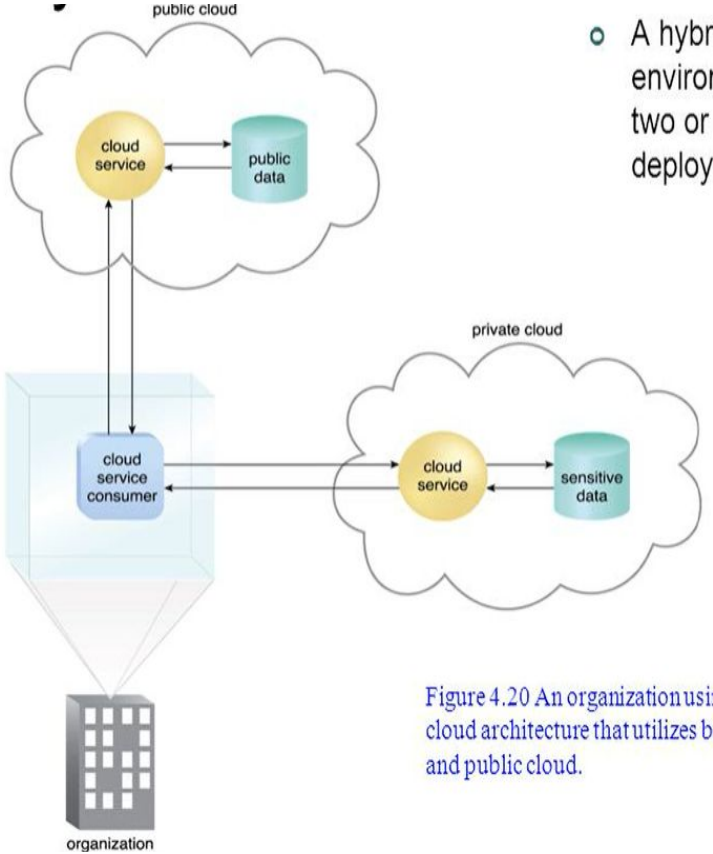
Example:-

If an organization have some client data on a private cloud application, but want to interconnect that application to a business intelligence application provided on a public cloud as a software service.

If an organization use public cloud computing resources to meet temporary capacity needs that can be met by the private cloud.

- **Cloud Bursting :** when the demand for computing capacity increases then an application deployment model in a private cloud or data center will bursts to a public cloud. During spike in processing demand requirement private cloud infrastructure that supports average workloads will start using cloud resources from public or private clouds together.

- **Advantage:-** payment only for the extra compute resources when they are needed.



- A hybrid cloud is a cloud environment comprised of two or more different cloud deployment models.

Figure 4.20 An organization using a hybrid cloud architecture that utilizes both a private and public cloud.

Community Cloud

The cloud infrastructure is shared by several organization and supports a specific community that has shared concerns(mission, security requirement, policy and compliance considerations)

Internal Community Cloud – applies to community clouds implemented on the premises of the customers composing a community cloud

Outsourced Community Cloud- applies to community clouds where the server side is outsourced to a hosted company

Example:

government departments, univeristies, central banks, google apps for government, microsoft government community cloud, etc.

Community Clouds

- A community cloud is similar to a public cloud except that its access is limited to a specific community of cloud consumers.

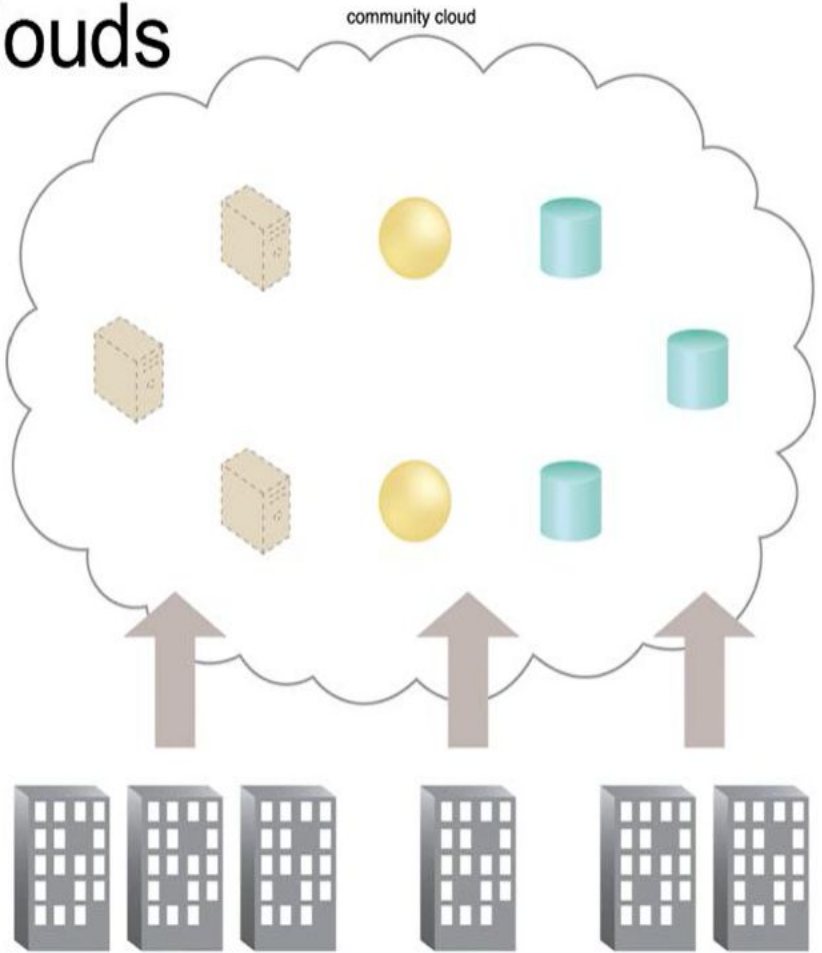


Figure 4.18 An example of a "community" of organizations accessing IT resources from a community cloud.

Public	Private	Community	Hybrid
Used by Small Enterprises	Used by Large Enterprises	Used By Small and Large Enterprises	Used by Large Enterprises
Supports Multiple Cust. (Multi-Tenant)	Supports Dedicated Cust. (Single Tenant)	Supports Multiple Cust. (Multi-Tenant)	Supports Multiple Cust. (Multi-Tenant)
Connectivity Over Internet.	Connectivity Over Internet, private network	Connectivity Over Internet, private network	Connectivity Over Internet, private network
Insecure. User for Non-Confidental Data	Very Secure. Used for Confidental Data	Secure towards outside the community	Medium Secure.
Cost-effective	Costly	Cost-effective	Cost-efffective
High Scalable	Low Scalable	High Scalable	High Scalable
Non-Guaranteed Solution	Guaranteed Solution	Guaranteed Solution	Partly Guaranteed Solution
Shared Servers	Dedicated Servers	Shared Servers between community members	Shared and Dedicated Servers
Provide Low Performance	Provide High Performance	Provide High Performance	Provide High Performance
Flexible	Inflexible. There can be unused resources	Flexible	Inflexible. There can be unused resources

Cloud Infrastructure and Management

- Cloud infrastructure involves the hardware and software components required for proper implementation of a cloud computing model.

- For many enterprises, the days of traditional in-house data centers are long gone, allows businesses to significantly benefit from increased scalability, reliability, cost savings and security.

- The cloud infrastructure management facilitate the configuration, monitoring and optimization of complex environments, allowing your IT teams to maximize the advantages and minimize the challenges of cloud computing.

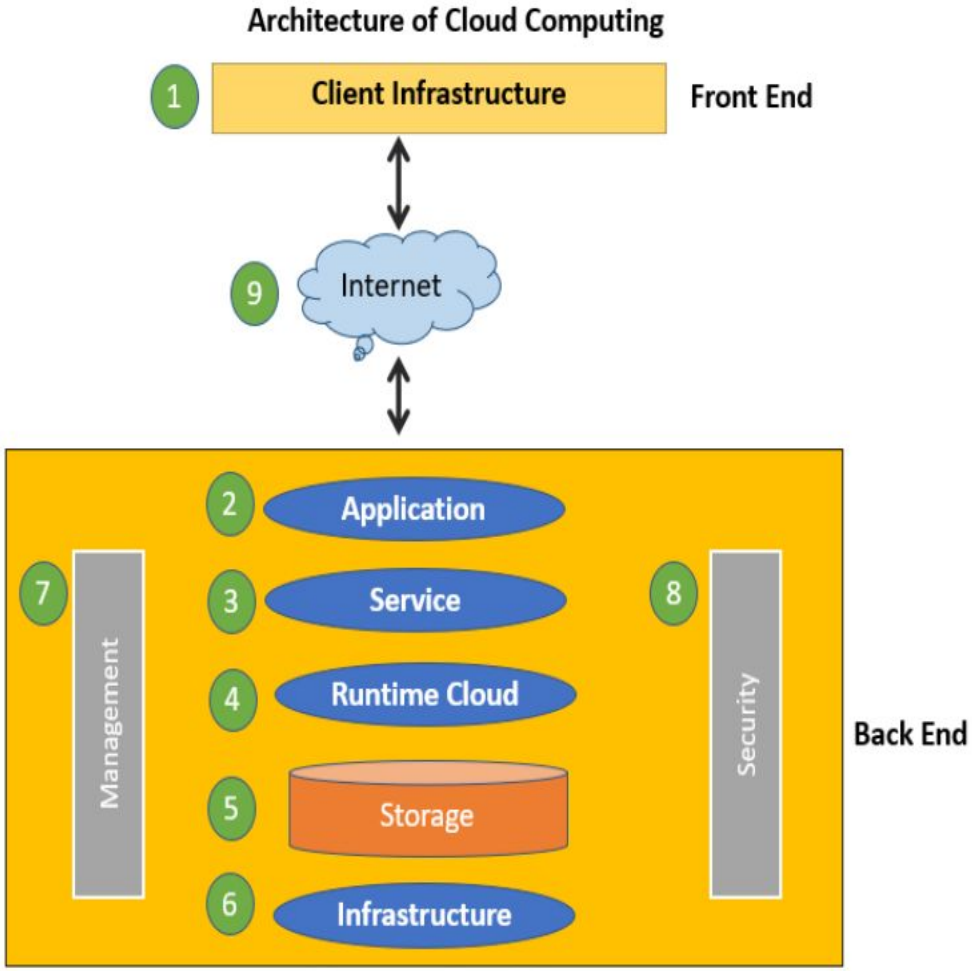
Contd..

Front End

- The client uses the front end, which contains a client-side interface and application. Both of these components are important to access the Cloud computing platform. The front end includes web servers (Chrome, Firefox, Opera, etc.), clients, and mobile devices.

Back End

- The backend part helps you manage all the resources needed to provide Cloud computing services. This Cloud architecture part includes a security mechanism, a large amount of data storage, servers, virtual machines, traffic control mechanisms, etc.



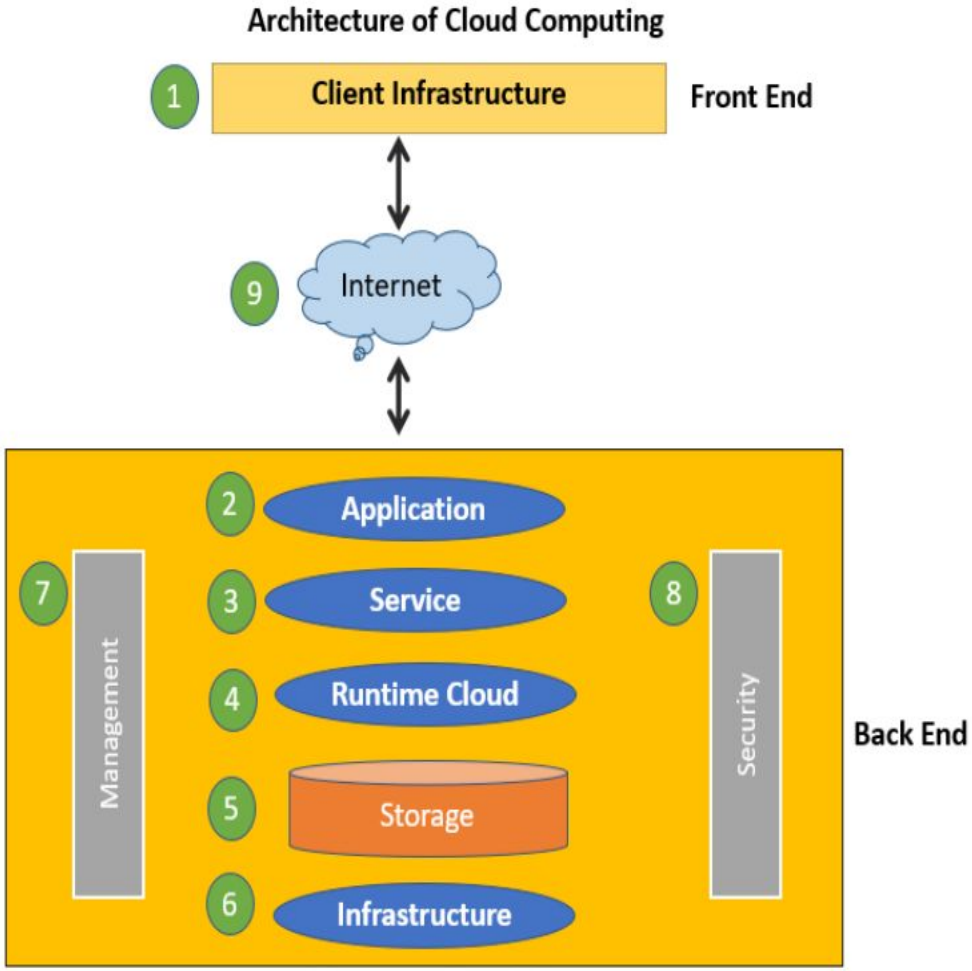
1. Client Infrastructure: Client Infrastructure is a front-end component that provides a GUI. It helps users to interact with the Cloud.

2. Application: The application can be any software or platform which a client wants to access.

3. Service: The service component manages which type of service you can access according to the client's requirements.
Three Cloud computing services are:

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

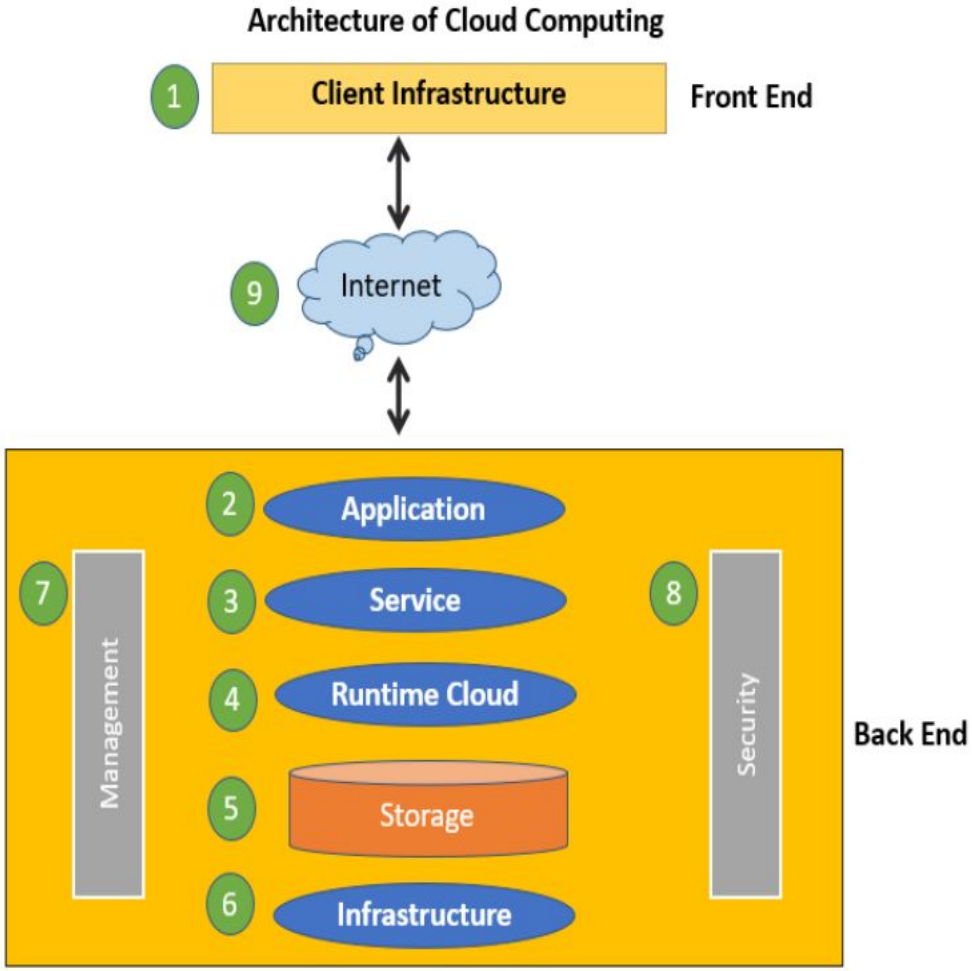
4. Runtime Cloud: Runtime cloud offers the execution and runtime environment to the virtual machines.



5. Storage: Storage is another important Cloud computing architecture component. It provides a large amount of storage capacity in the Cloud to store and manage data.

6. Infrastructure: It offers services on the host level, network level, and application level. Cloud infrastructure includes hardware and software components like servers, storage, network devices, virtualization software, and various other storage resources that are needed to support the cloud computing model.

7. Management: This component manages components like application, service, runtime cloud, storage, infrastructure, and other security matters in the backend. It also establishes coordination between them.



8. Security: Security in the backend refers to implementing different security mechanisms for secure Cloud systems, resources, files, and infrastructure to the end-user.

9. Internet: Internet connection acts as the bridge or medium between frontend and backend. It allows you to establish the interaction and communication between the frontend and backend.

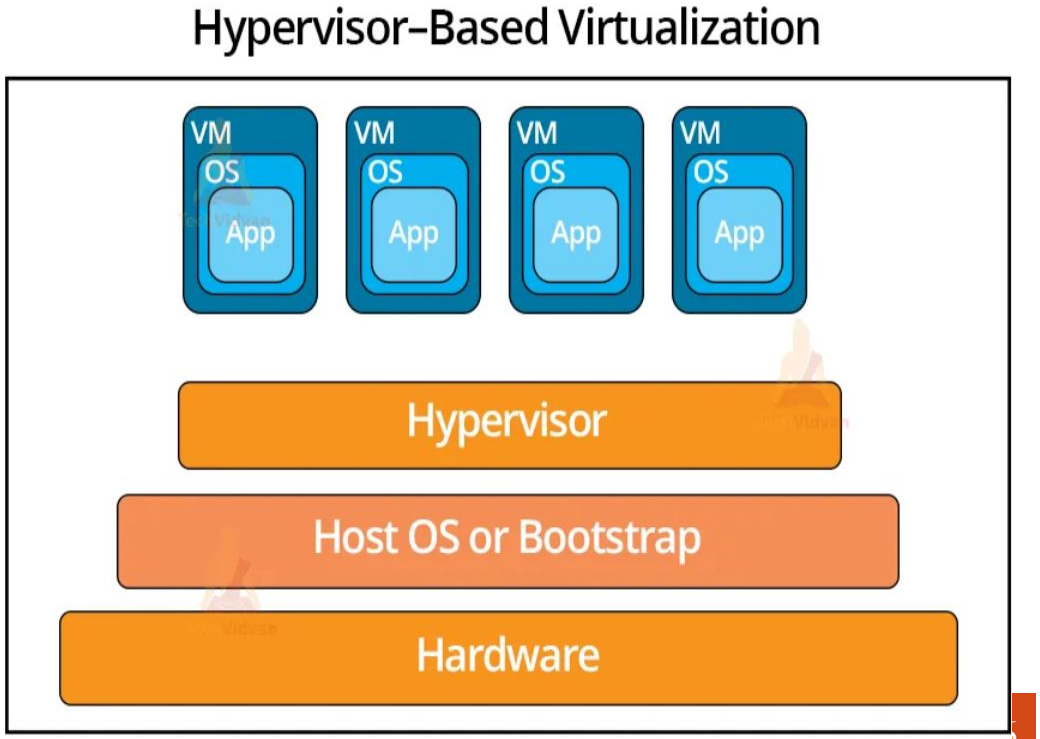
Features in Cloud Infrastructure Mgmt.

- Virtualization support
- Self Service, On demand resource provisioning
- Multiple Backend Hypervisors
- Storage Virtualization
- Interface to public cloud
- Dynamic Resource Allocation

Virtualization

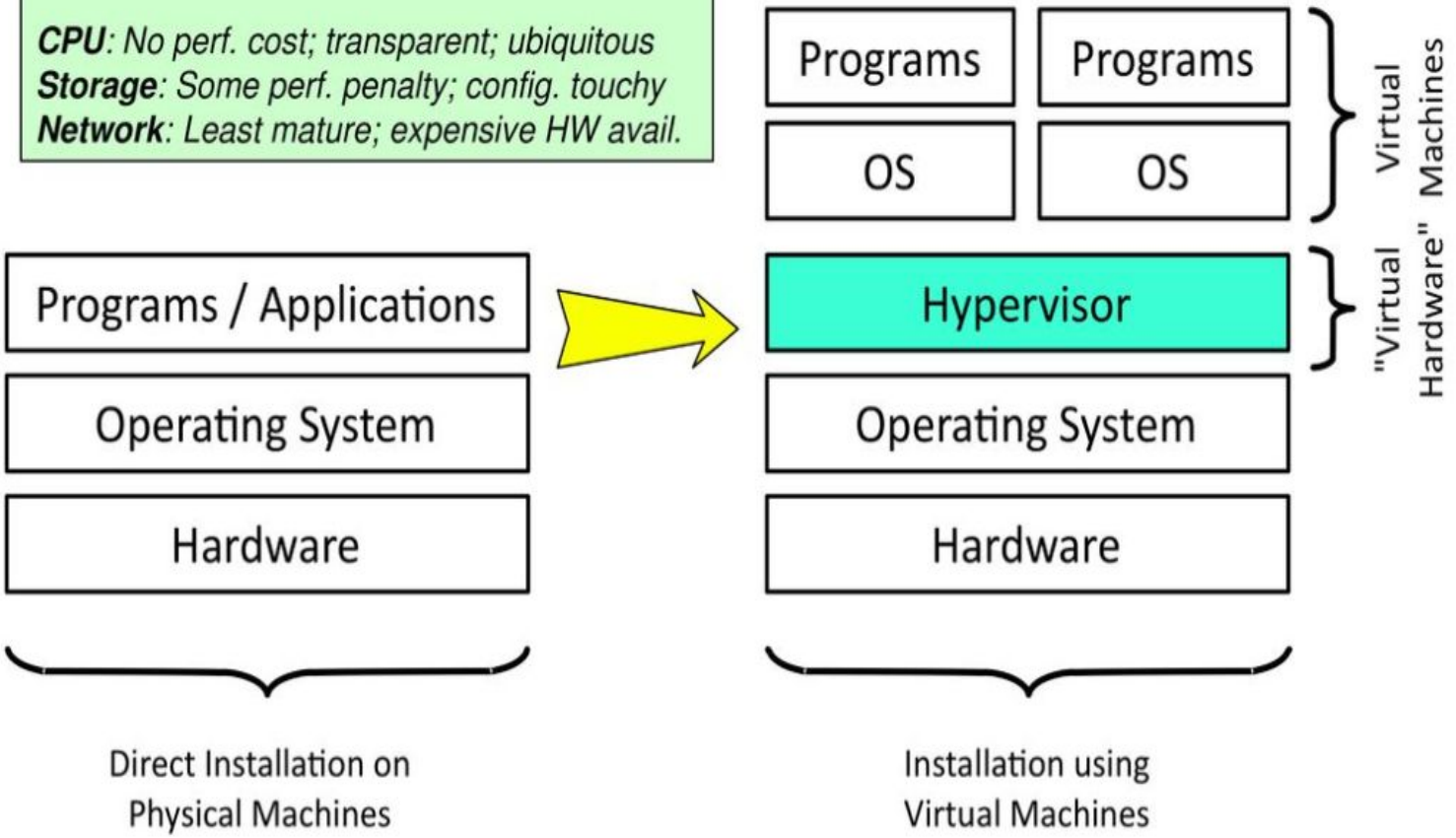
https://www.geeksforgeeks.org/virtualization-cloud-computing-types/?ref=lbp

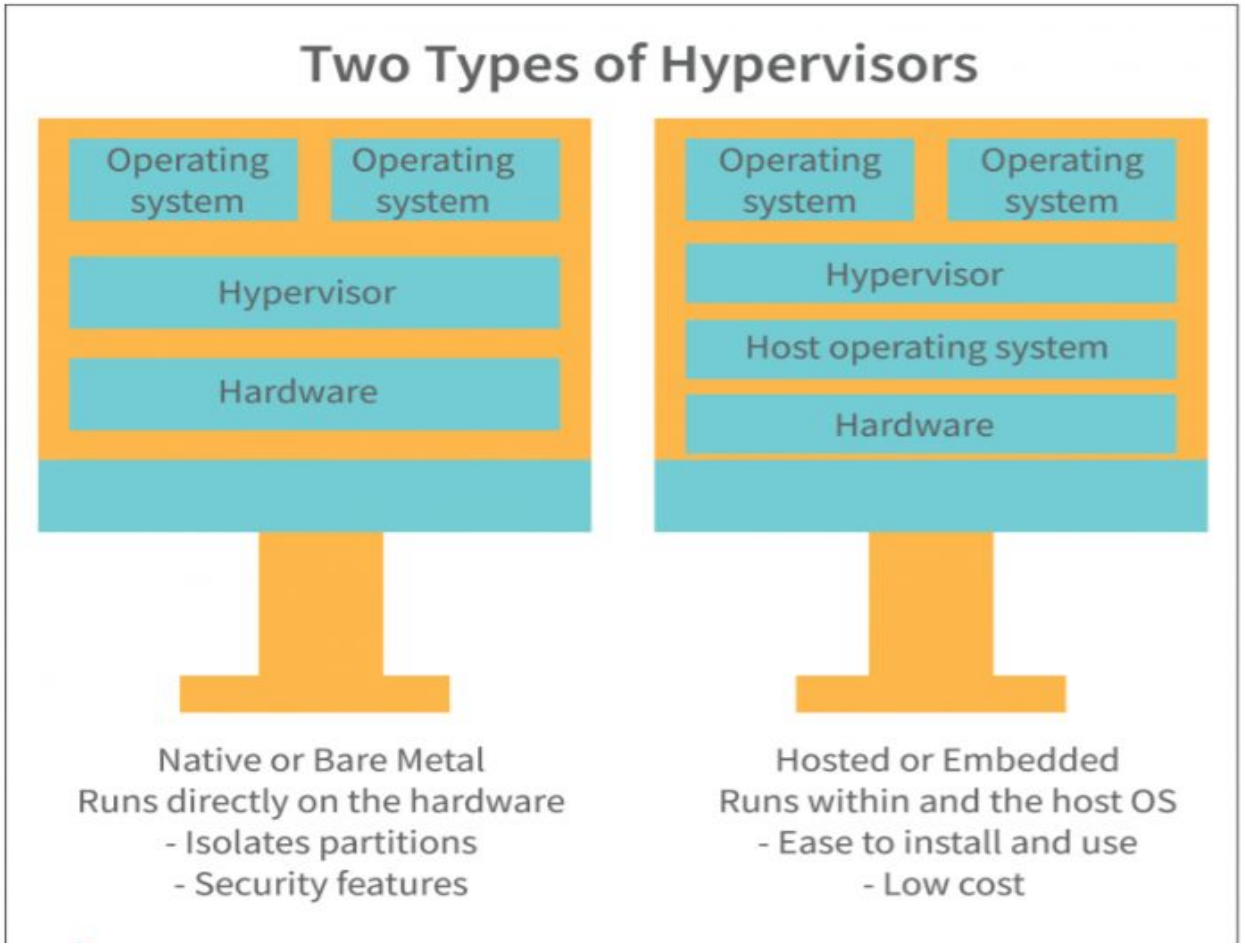
- Virtualization is technology that you can use to create virtual representations of servers, storage, networks, and other physical machines.
- Virtual software mimics the functions of physical hardware to run multiple virtual machines simultaneously on a single physical machine.

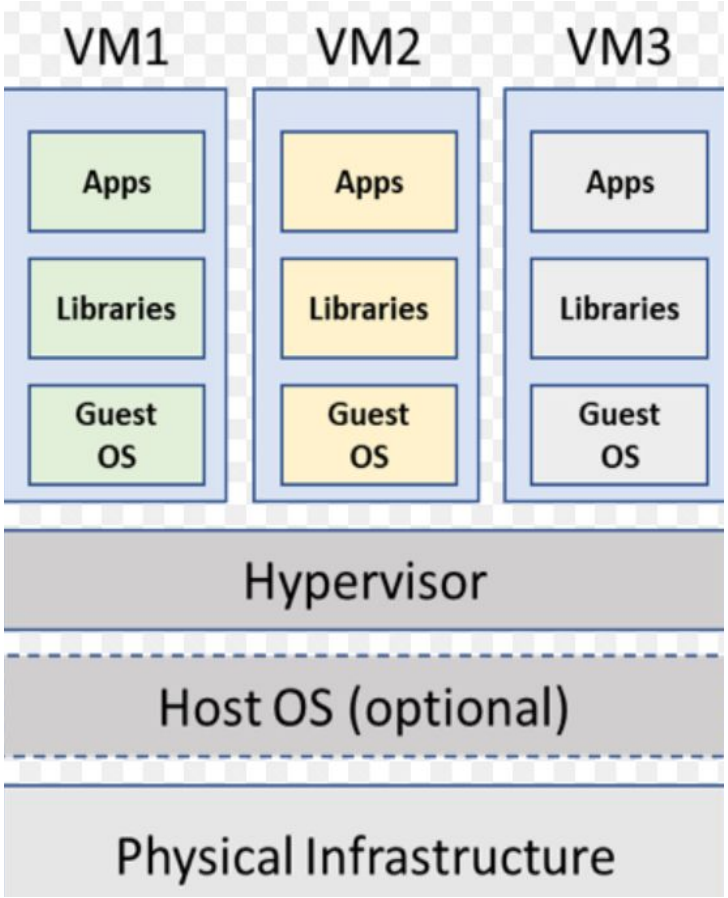


Different Maturity Levels

CPU: *No perf. cost; transparent; ubiquitous*
Storage: *Some perf. penalty; config. touchy*
Network: *Least mature; expensive HW avail.*




Two Types of Hypervisors
Operating system
Operating system
Hypervisor
Hardware
Native or Bare Metal
Runs directly on the hardware
- Isolates partitions
- Security features
Operating system
Operating system
Hypervisor
Host operating system
Hardware
Hosted or Embedded
Runs within and the host OS
- Ease to install and use
- Low cost



- It most commonly uses the hypervisor for managing every virtual systems. The hypervisor is a software that can virtualizes the hardware resources.

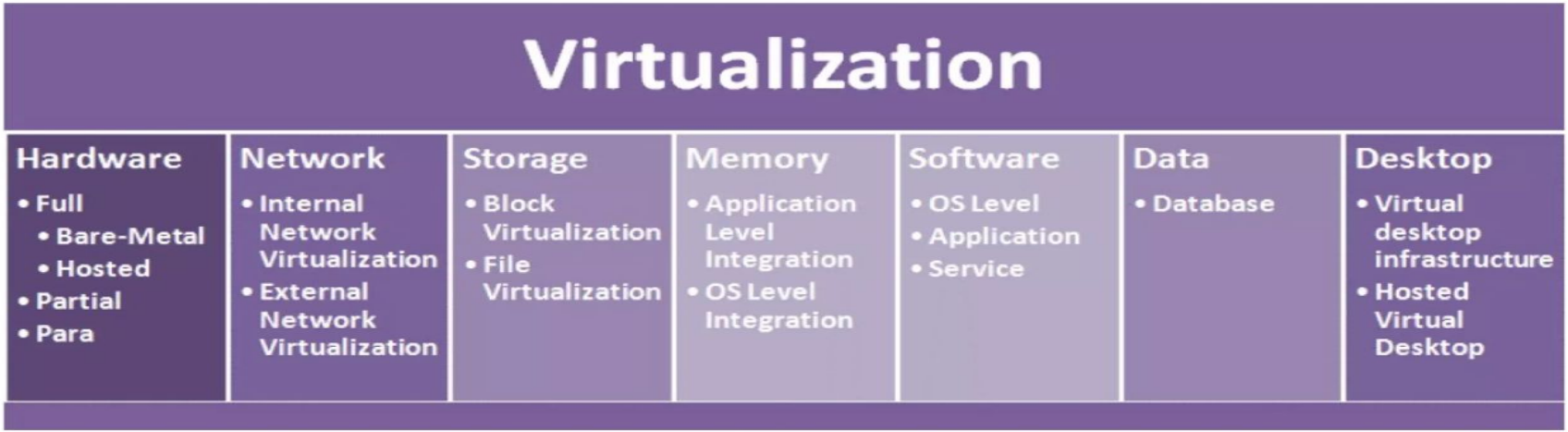
Benefits of Virtualization

- Virtualization is more flexible and efficient for allocating resources.
- It has enhanced the product development
- It cuts down the cost of IT Infrastructure
- Users can access applications remotely, and Virtualization offers rapid scalability.
- It provides high availability and disaster recovery.
- It fulfills the IT Infrastructure demand
- This permits running many operating systems.
- Virtualization helps in minimizing the servers
- It will build a mixed virtual environment
- It will help to improve the technology ability

Terms associated with Virtualization

1. **Hypervisor:-** The hypervisor is considered as an Operating System that is actually running on the hardware. The virtual counterpart segment is one of the sections of this operating system, and it is in the form of the running process. Hypervisors are viewed as Domain 0 or Dom0.
2. **Virtual Machine (VM):-** VM is a virtually based computer that is working under the hypervisor.
3. **Virtualization Software:-** Virtualization Software can play the role of a software application package or an operating system, or any particular version of that operating system. It is the software that will assist the user in deploying the Virtualization on any machine.
4. **Virtual Network:-** A virtual network is a logically divided network that is inside the Network. It can be expanded across many servers.

Major Types of



Virtualization makes it easy for companies to centrally maintain their IT processes. Since most of these processes are cloud-based, companies do not need to spend time and resources in maintaining physical servers.

Virtual machines allow developers to test a piece of code without disturbing the current configuration of their systems.

Cloud service providers offer virtual firewalls as a defense mechanism against threats to the data stored on a server. Hence, organizations do not have to spend extra on setting up dedicated data security measures.

Types of Virtualization

1) Hardware Virtualization:

- When the virtual machine software or virtual machine manager *(VMM) is directly installed on the hardware system* is known as hardware virtualization.
- The main job of hypervisor is to control and monitoring the processor, memory and other hardware resources.
- After virtualization of hardware system we can install different operating system on it and run different applications on those OS.

Usage:

- Hardware virtualization is mainly done for the server platforms, because controlling virtual machines is much easier than controlling a physical server.

Example: Microsoft Hyper V, Xen

Hardware virtualization is further subdivided into the following types:

- **Full Virtualization** — In it, the complete simulation of the actual hardware takes place to allow software to run an unmodified guest OS.
- **Para Virtualization —** In this type of virtualization, software unmodified runs in modified OS as a separate system.
- **Partial Virtualization** — In this type of hardware virtualization, the software may need modification to run.

2) Operating System Virtualization

- When the virtual machine software or virtual machine manager *(VMM) is installed on the Host operating system* instead of directly on the hardware system is known as operating system virtualization.
- With the help of OS virtualization nothing is pre-installed or permanently loaded on the local device and no-hard disk is needed. Everything runs from the network using a kind of virtual disk.
- This virtual disk is actually a disk image file stored on a remote server, SAN (Storage Area Network) or NAS (Non-volatile Attached Storage). The client will be connected by the network to this virtual disk and will boot with the Operating System installed on the virtual disk.

Usage:

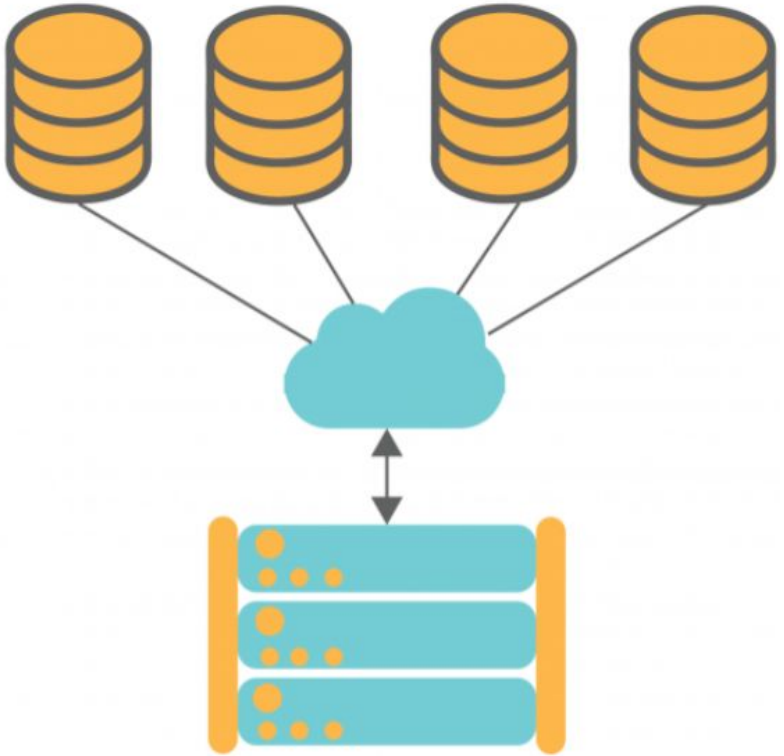
- Operating System Virtualization is mainly used for testing the applications on different platforms of OS.

3) Storage Virtualization

In this type of virtualization, multiple network storage resources are present as a single storage device for easier and more efficient management of these resources.

It provides various advantages as follows:

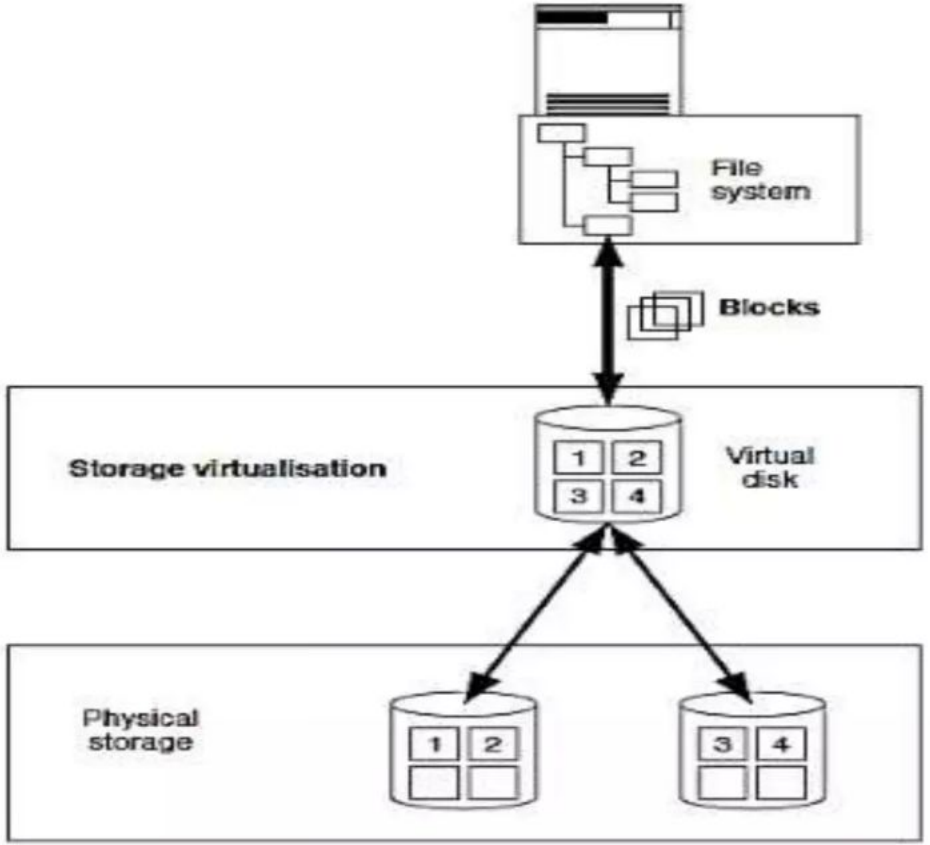
- Improved storage management in a heterogeneous IT environment
- Easy updates, better availability
- Reduced downtime
- Better storage utilization
- Automated management



In general, there are two types of storage virtualization:

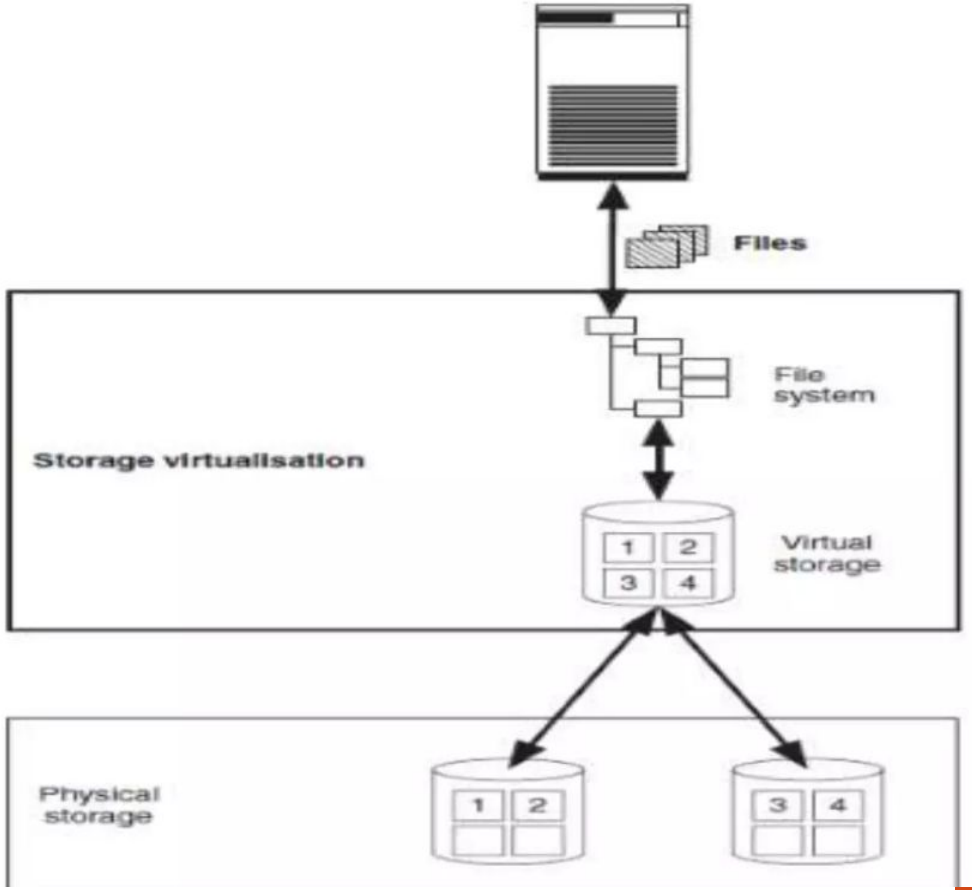
Block virtualization –

- Here storage capacity is made available to the OS or the application in form of virtual disks.
- The virtualization entity maps the virtual blocks to physical blocks.



File virtualization –

- The virtualization entity provides virtual storage to OS or application in form of directories and files.
- The application works with files instead of blocks and the conversion of files to blocks is performed by virtualization entity



4) Server Virtualization

- When the virtual machine software or virtual machine manager *(VMM) is directly installed on the Server system* is known as server virtualization.

Usage:

- Server virtualization is done because a single physical server can be divided into multiple servers on the demand basis and for balancing the load.

5) Network Virtualization

Network virtualization refers to combining all the components of networks and administering them using only software. These network components include all the underlying hardware and software of a network

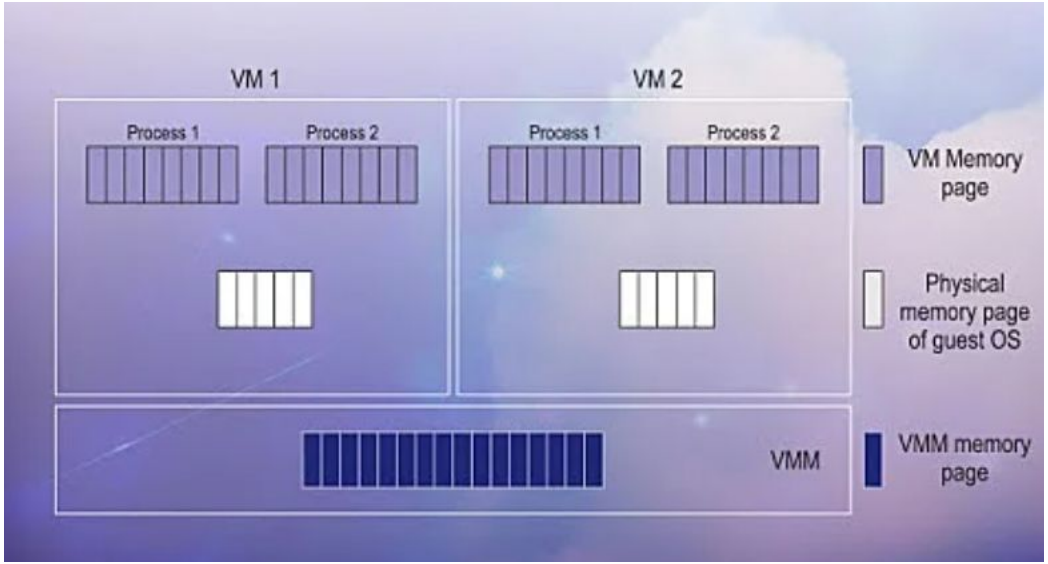
Virtualizing a network takes away its dependency on the software embedded in its underlying hardware, converting it into a virtual network. Now, it is the virtualizing software, similar to a hypervisor, that controls its functionality and availability, although the network is still using its hardware resources.

Virtualizing networks enforces greater flexibility among the pooled networks and allows for better networking at reduced costs.

Example: VLAN

6) Memory Virtualization

- Memory Virtualization can be understood as a concept where multiple physical memories across different servers are put together as one to form a singular virtual memory. This allows you an access to a bigger memory to work on.
- The main aim of this kind of virtualization is to provide for a better and a much more enhanced memory to function on.



There are two types of Memory Virtualizations-

- **Application-Level Control –** In this system, the applications that run on the connected devices connect directly to the combined memory with the help of the file system or an API system.
- **Operating System Level Control –** In this system, it is the operating system that first connects to the memory pool, making it available to the applications in the process.

7) Software Virtualization

- It provides the ability to the main computer to run and create one or more virtual environments. It is used to enable a complete computer system in order to allow a guest OS to run.

- For instance letting Linux to run as a guest that is natively running a Microsoft Windows OS (or vice versa) running Windows as a guest on Linux)

  Example: VMWare s/w, Virtual Box

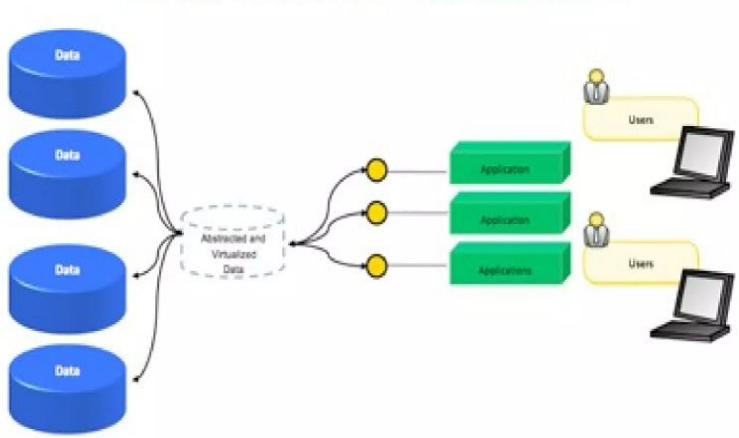
There are three types of Software Virtualizations-

- Operating System
- Application Virtualization
- Service Virtualization

8) Data Virtualization

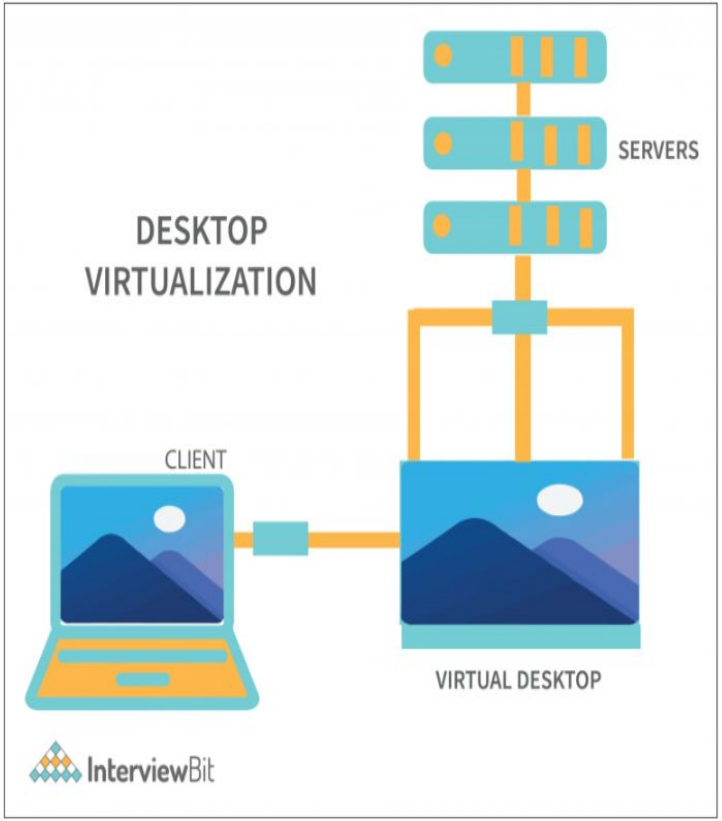
- Data virtualization is a solution to the data management problem of analyzing data from different sources collectively and at a much faster pace.
- It enables organizations to centrally manage and alter data from several sources, such as excel files, google analytics reports
- Data virtualization is primarily used as a part of data integration in areas such as BI (business intelligence), Cloud computing and of course, data management.

  Example: E-commerce site, Web portals



9) Desktop Virtualization

- It provides the work convenience and security. As one can access remotely, so can work from any location and on any PC.
- Desktop virtualization is especially useful for enterprises as it offers a consistent desktop experience to all employees.
- IT teams responsible for managing a company's devices can now manage and issue updates centrally.
- Virtual desktops also minimize the security risks associated with employees storing the company data locally. And, since most of the data is stored on servers, device failure will not result in any major loss.



Benefits of Cloud Computing Architecture

Following are the cloud computing architecture benefits:

- Makes the overall Cloud computing system simpler.
- Helps to enhance your data processing.
- Provides high security.
- It has better disaster recovery.
- Offers good user accessibility.
- Significantly reduces IT operating costs.

IaaS

- It allows customers to outsource their IT infrastructures such as servers, networking, processing, storage, virtual machines, and other resources.
- Customers access these resources on the Internet using a pay-as-per use model.
- IaaS provider provides the following services -
  - **Compute:** Computing as a Service includes virtual central processing units and virtual main memory that are provisioned to the end- users.
  - **Storage:** IaaS provider provides back-end storage for storing files.
  - **Network:** Network as a Service (NaaS) provides networking components such as routers, switches, and bridges.
  - **Load balancers:** It provides load balancing capability at the infrastructure layer

IaaS Providers

IaaS Vendor	Iaas Solution	Details
Amazon Web Services	Elastic Compute Cloud (EC2) MapReduce, Route 53, Virtual Private Cloud, etc.	The cloud computing platform pioneer, Amazon offers auto scaling, cloud monitoring, and load balancing features as part of its portfolio.
Netmagic Solutions	Netmagic IaaS Cloud	Netmagic runs from data centers in Mumbai, Chennai, and Bangalore, and a virtual data center in the United States. Plans are underway to extend services to West Asia.
Rackspace	Cloud servers, cloud files, cloud sites, etc.	The cloud computing platform vendor focuses primarily on enterprise-level hosting services.
Reliance Communications	Reliance Internet Data Center	RIDC supports both traditional hosting and cloud services, with data centers in Mumbai, Bangalore, Hyderabad, and Chennai. The cloud services offered by RIDC include IaaS and SaaS.
Sify Technologies	Sify IaaS	Sify's cloud computing platform is powered by HP's converged infrastructure. The vendor offers all three types of cloud services: IaaS, PaaS, and SaaS.
Tata Communications	InstaCompute	InstaCompute is Tata Communications' IaaS offering. InstaCompute data centers are located in Hyderabad and Singapore, with operations in both countries.

PaaS

- Platform as a Service (PaaS) provides a runtime environment. It allows programmers to easily create, test, run, and deploy web applications.
- You can purchase these applications from a cloud service provider on a pay-as-per use basis and access them using the Internet connection.
- In PaaS, back end scalability is managed by the cloud service provider, so end- users do not need to worry about managing the infrastructure.

Services provided by PaaS

- Programming languages
  - PaaS providers provide various programming languages for the developers to develop the applications. Some popular programming languages provided by PaaS providers are Java, PHP, Ruby, Perl, and Go.
- Application frameworks
  - PaaS providers provide application frameworks to easily understand the application development. Some popular application frameworks provided by PaaS providers are Node.js, Drupal, Joomla, WordPress, Spring, Play, Rack, and Zend.
- Databases
  - PaaS providers provide various databases such as ClearDB, PostgreSQL, MongoDB, and Redis to communicate with the applications.
- Other tools
  - PaaS providers provide various other tools that are required to develop, test, and deploy the applications.

PaaS Service Providers

Providers	Services
Google App Engine (GAE)	App Identity, URL Fetch, Cloud storage client library, Logservice
Salesforce.com	Faster implementation, Rapid scalability, CRM Services, Sales cloud, Mobile connectivity, Chatter.
Windows Azure	Compute, security, IoT, Data Storage.
AppFog	Justcloud.com, SkyDrive, GoogleDocs
Openshift	RedHat, Microsoft Azure.
Cloud Foundry from VMware	Data, Messaging, and other services.

SaaS

- It is a software distribution model in which services are hosted by a cloud service provider.

- These services are available to end-users over the internet so, the end-users do not need to install any software on their devices to access these services.

Services offered by SaaS

- **Business Services**
  - SaaS Provider provides various business services to start-up the business. The SaaS business services include ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), billing, and sales.
- **Document Management**
  - SaaS document management is a software application offered by a third party (SaaS providers) to create, manage, and track electronic documents.
- **Social Networks**
  - As we all know, social networking sites are used by the general public, so social networking service providers use SaaS for their convenience and handle the general public's information.
- **Mail Services**
  - To handle the unpredictable number of users and load on e-mail services, many e-mail providers offering their services using SaaS.

SaaS Providers

Provider	Services
Salseforce.com	On-demand CRM solutions
Microsoft Office 365	Online office suite
Google Apps	Gmail, Google Calendar, Docs, and sites
NetSuite	ERP, accounting, order management, CRM, Professionals Services Automation (PSA), and e-commerce applications.
GoToMeeting	Online meeting and video-conferencing software
Constant Contact	E-mail marketing, online survey, and event marketing
Oracle CRM	CRM applications
Workday, Inc	Human capital management, payroll, and financial management.

Challenges of Cloud Computing

1. **Security Issues :** Cloud computing security threats are a key and legitimate concern. The organizations are unable to see the precise location of data storage or its transmission. There are also concerns with insecure APIs, malicious insiders, and oversights or neglect in Cloud data management. It is necessary to verify that the provider has a strict policy on data recovery. Finally, a reliable cloud platform for the BI must be in place to exploit effective security measures.

2. **Lack Of Resources And Expertise:** Currently there is a increasing need for expertise as companies are putting more workload in the cloud, and cloud technologies are evolving rapidly. Additionally, it is impossible to keep up with the technologies because there is a shortage of knowledge and skills. The solution to this challenge is to give the IT staff as well as developers additional training.

3. **Compilance:** When an organization transfers data from internal storage to the cloud, it is critically necessary to comply with industry regulations and laws. Depending on the industrial conditions there are rules to be complied with. There's an intense need to store the data properly. Many of the vendors give accredited enforcement and ensure they comply properly.

4. **Performance:** The performance of Cloud computing solutions depends on the vendors who offer these services to clients, and if a Cloud vendor goes down, the business gets affected too. It is one of the major challenges associated with cloud computing.

5. **Data Lock-In:** The applications running on one platform should remain unhampered when being migrated to a new cloud service. Plus, the service provider should not lock-in customer data or services so that the transition is smooth, without altering coding or design. However, it is easier than done. The problem is different **cloud computing companies** use other standard languages for their platform, and the applications deployed on, say, Cloud A could be challenging to move to Cloud B.

6. **Cost Management:** The pay-as-you-go model is a sure way for the businesses to cut costs and save money. Cloud costs need to be kept in check and benefits minimized by improved financial monitoring and reporting, as well as automating governance policies, and ensuring the finest business practices in management. It would help, in a major way, to high challenges in cloud computing.

7. **Governance and Control Issues:** Good IT governance ensures that the right tools are used, and assets get implemented according to procedures and agreed-to policies. Lack of governance is a common problem, and companies use tools that do not align with their vision. IT teams don't get total control of compliance, risk management, and data quality checks, and there are many uncertainties faced when migrating to the Cloud from traditional infrastructures.

8. **Managing Multiple Clouds:** Adopting the multi-cloud approach is growing at a rapid pace these days. Companies are shifting or resorting to a combination of public and private clouds. Organizations have to deal with various clouds and face the challenges of cloud computing.

9. **Building Private Cloud:** Many organizations are thinking of having a private solution that comes with significant benefits. This will make sure that all the data is in-house. IT managers and departments have to build it by themselves.

10. **High Dependence on Network:** Lack of sufficient internet bandwidth is a common problem when transferring large volumes of information to and from Cloud data servers. It is one of the various challenges in cloud computing. Data is highly vulnerable, and there is a risk of sudden outages. Enterprises that want to lower hardware costs without sacrificing performance need to ensure there is high bandwidth, which will help prevent business losses from sudden outages.

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12. Reliability and Availability: High unavailability of Cloud services and a lack of reliability are two major concerns in these ecosystems. Organizations are forced to seek additional computing resources in order to keep up with changing business requirements. If a Cloud vendor gets hacked or affected, the data of organizations using their services gets compromised. It is another one of the many cloud security risks and challenges faced by the industry.

13. Password Security: Account managers use the same passwords to manage all their Cloud accounts. Password management is a critical problem, and it is often found that users resort to using reused and weak passwords

Cloud Computing is at a point where it will revolutionize the information technology industry and produce the finest performance. Many companies, including startups, as well as small and medium-sized enterprises, will reap these benefits. There is likely to be a new set of problems in every modern evolution that need to be tackled properly.