Cloud Computing

Introduction

Cloud computing is a technology and service model that allows individuals and organizations to access and use computing resources (such as servers, storage, databases, networking, software, and more) over the internet. Instead of owning and managing physical servers and data centers, cloud computing users can leverage these resources on-demand from cloud service providers.

Characteristics

Key characteristics and components of cloud computing are

1. On-Demand Self Service
   Users can independently provision and manage computing resources as needed without requiring human intervention from the service provides. It's like being able to order or set up computer resources whenever you want without asking for help.

2. Broad Network Access
   Cloud services are accessible over the internet from various devices and locations. It's like being able to access files and applications from any device with an internet connections.

3. Resource Pooling
   Cloud providers use a shared pool of computing resources that are dynamically allocated and reassigned to serve multiple customers. It's like sharing a big pool of resources with others, and the pool adapts to meet everyone's needs.

Rapid Elasticity
Users can quickly scale their resources up or down to handle changes in workload. It's like being able to add or remove computer power instantly, like a rubber band that stretches or shrinks as needed.

Measured Services
Cloud resources are metered, and users are billed based on their actual usage. It's like paying for the exact amount of water or electricity you consumed so you don't waste money on unused resources.

Common characteristics
1) Massive Scale : Cloud services can easily scale up or down to meet changing demands. You can add or remove resources which is like adjusting the size of a storage unit based on how many things you have.

2) Low Cost Software : Users are charged on their actual usage. (Pay-as-you-go).

3) Advanced Security : Cloud providers invest in security measures to protect data. They also comply with industry standards such as data encryption and privacy laws, to keep your information safe.

4) Service Orientation : User can access and manage cloud resources without needing help from service providers

5) Homogeneity
6) Resilient Computing
7) Virtualization
8) Geographic Distribution

(*) Advantages

1. Lower Computer Costs
Cloud computing reduces the need for organizations to invest in and maintain their own physical hardware, leading to cost savings on equipment and infrastructure.

2. Improved Performance
Cloud providers offer high-performance computing resources that can be easily scaled to meet the demands of resource-intensive tasks and applications.

3. Reduced Software Costs
Cloud services can include software subscriptions, eliminating the need to purchase and license software separately.

4. Instant Software Updates
Cloud-based software is typically updated automatically by the provider, ensuring that users have access to the latest features, security patches, and improvements without manual updates.

5. Improved Document Format Compatibility
Cloud based software provide better compatibility with various document formats making it easier to collaborate and share documents across different platforms and devices.

6. Unlimited Storage Capacity
Cloud storage provides virtually unlimited storage capacity, allowing organizations to store and access large amounts of data without concerns of physical storage limitations

7. Increased Data Reliability
Cloud providers typically implement redundant storage and backup mechanisms, enhancing data reliability and reducing the risk of data loss.

8. Universal Document Access
Cloud-based document provides access to user and edit document from anywhere with an internet connection, promoting universal access and collaboration.

9. Latest Version Availability
Cloud software automatically update to latest versions ensuring that user always have access to the most up-to-date features and security enhancements.

10. Security
Cloud providers invest in security measures, including encryption, access controls, and monitoring, to protect data.

Disadvantages

1. Requires a Constant Internet Connections
Cloud services requires constant internet connection without this access to cloud resources and data can be disrupted

2. Does not work well with low-speed Connections
Cloud applications and services may perform poorly or slow or unreliable internet connections leading to lag and frustration.

3. Features Might Be Limited
Some cloud-based software may reduce functionality compared to their desktop counterparts, which can be limiting for users with specific needs.

4. Can Be Slow
The speed can vary based on internet speed, server load, and other factors. This can affect user experience.

5. Stored Data Might Not Be Secured
While cloud providers invest in security, data breaches and unauthorized access can still occur, potentially compromising sensitive information.

6. Stored Data can be Lost
Data stored in cloud can be lost due to technical failure, human errors or even closure of cloud service provider.

7. High-Performance Computing (HPC) Systems
Some complex tasks which require HPC may not be well-suited for standard cloud environments due to resource limitations and cost considerations.

8. General concerns
Vendor Lock-In: Moving away from a specific cloud provider can be difficult due to proprietary technologies and data formats, leading to vendor lock-in.

Types of Cloud

Three primary cloud types are

1. Public cloud

The cloud resources that are owned and operated by a third party cloud service provider are termed as public clouds. It delivers computing resources such as servers, software, and storage over the internet.

2. Private cloud

The cloud computing resources that are exclusively used inside a single business or organizations are termed as private cloud. A private cloud may physically be located on the company's on-site data centre or hosted by a third party service provider.

3. Hybrid cloud

It is a combination of public and private clouds, which is bounded together by technology that allows data applications to be shared between them. Hybrid cloud provides flexibility and more deployment options to the business.

Deployment Models

Cloud computing deployment models refer to the ways in which cloud computing services and resources are set up and made available to the users.

Public cloud

In a public cloud deployment, cloud services and resources are owned, operated, and maintained by third-party cloud service providers. These resources are made available to the general public or a wide range of customers over the internet.

Public clouds are accessible to anyone with an internet connection, and users typically pay for the resources they consume on a pay-as-you-go basis.

Example of public cloud providers include AWS, Microsoft Azure, and Google cloud Platform (GCP)

Private cloud

A private cloud deployment is a cloud infrastructure that is dedicated to a single organization or entity. It can be hosted on-premises within an organization's own data centre or by a third party provider.

Private cloud offer greater control, customization, and security over cloud resources and are suitable for organizations with strict data privacy, security, and compliance requirements.

Hybrid cloud

A hybrid cloud deployment combines elements of both public and private clouds. It allows data and applications to be shared and integrated b/w them.

Organizations use a hybrid cloud to take advantage of the scalability and cost-efficiency of public cloud resources while keeping sensitive and critical data & applications in a private environment.

Hybrid clouds enable seamless data and workload portability between the two cloud types.

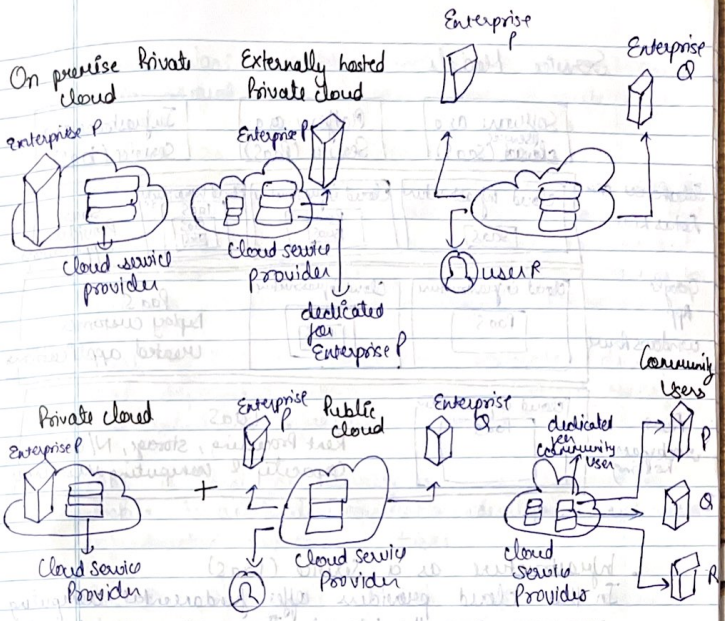
Community cloud
A community cloud is a cloud infrastructure that is shared by multiple organization or users who have similar interests, needs, or compliance requirements. It is tailored to serve a specific community or industry such as healthcare, finance or research.

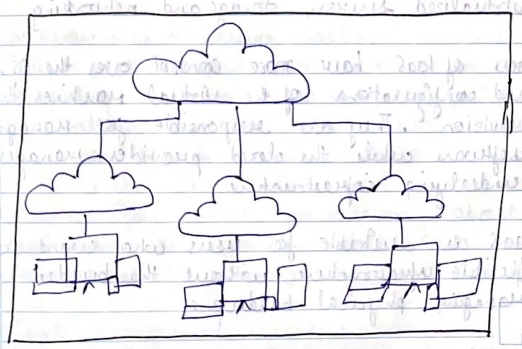
Community clouds offer shared infrastructure while addressing the unique requirements and regulations of their user community.

Multi - cloud
Multi cloud refers to the practice of using multiple cloud providers to meet various business needs. Organizations might use different cloud providers for different applications or services.

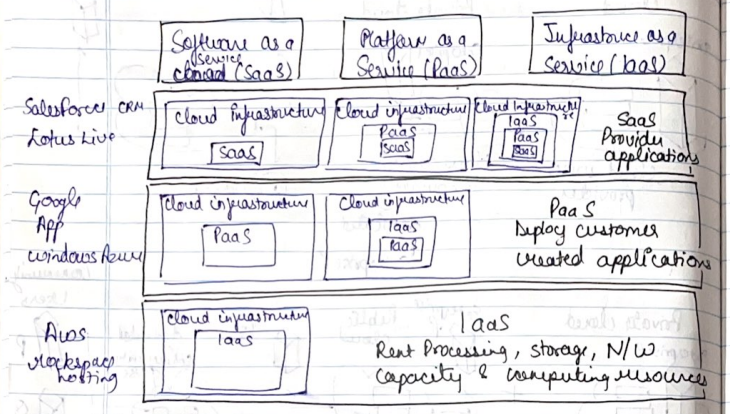
The goal of multi cloud is to avoide vendor lock-in, enhance redundancy and take advantage of the strengths of different cloud providers

Multi cloud can involve using cloud regions or data centers from different providers located in various geographic regions. This can help with compliance, data sovereignty, and low latency access.





Service Models



1. Infrastructure as a Service (IaaS)
In this cloud providers offer fundamental computing resources over the internet. These resources include virtualized servers, storage and networking.

IT administrators

Users of IaaS have more control over the OS, applications and configurations of the virtual machines they provision. They are responsible for managing the software while the cloud provider manages the underlying infrastructure.

IaaS is suitable for users who want scalable and flexible infrastructure without the burden of managing physical hardware.

Example IaaS providers include AWS EC2, Microsoft Azure virtual machines, and Google Compute Engine.

2. Platform as a Service (PaaS)
PaaS provides a higher level of abstraction than IaaS. In this model cloud providers offer a platform that includes not only the underlying infrastructure but also tools, development frameworks, and services for building, deploying, and managing applications.

Software developers

Users of PaaS can focus on application development and deployment without worrying about managing the underlying infrastructure or the OS.

PaaS is ideal for developers and organizations looking to accelerate application development and reduce infrastructure management tasks.

Example PaaS offerings include Google App Engine, Microsoft Azure App Service, and Heroku.

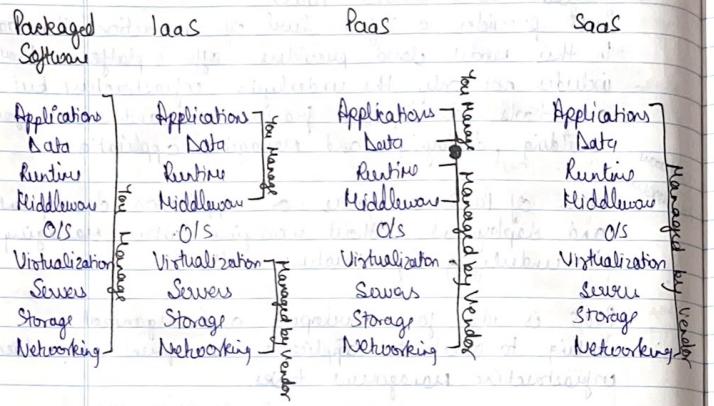
3. Software as a Service (SaaS)
SaaS is the highest level of abstraction in cloud computing. It involves delivering complete software applications over the internet, which users can access and use through a web browser.

End users

Users of SaaS do not need to worry about infrastructure maintenance, or software updates. Everything is managed by the cloud provider.

SaaS is commonly used for productivity tools (eg email, office suites), customer relationship management (CRM) and a wide range of business applications.

Example of SaaS applications include Microsoft Office 365, Google Workspace, Salesforce, and Dropbox.



Services	Description
Application Focused: Services	Complete business services such as PayPal, OpenID, OAuth, Google Maps, Alexa
Application Focused: Application	Cloud based software that eliminates the need for local installation such as Google Apps, Microsoft Online
Application Focused: Development	Software development platforms used to build custom cloud based applications (PAAS & SAAS) such as Salesforce
Infrastructure Focused: Platform	Cloud based platforms, typically provided using virtualization, such as Amazon EC2, Sun Grid
Infrastructure Focused: Storage	Data storage as cloud based NAS such as CTERA, iDisk, cloudNAS
Infrastructure Focused: Hosting	Physical data centers such as those run by IBM, HP, Navisite, etc

HaaS — IaaS — STaaS
SECaaS — DBaaS
CaaS — XaaS — PaaS
SaaS — NaaS
MaaS — DaaS — DRaaS

Everything-as-a Service Model

(*) Virtualization

Virtualization is the process of creating/converting a physical IT resource into a virtual IT resource.

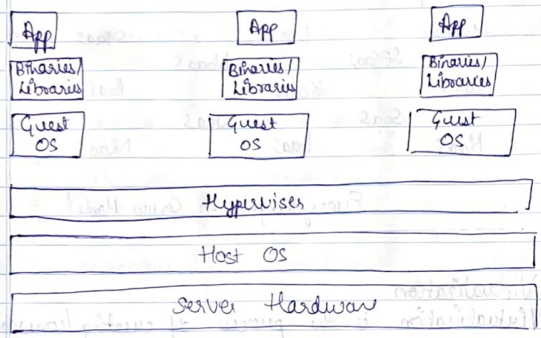
⇒ Servers, Storage, Network, Power } can be virtualized

It was initially developed in the mainframe era, it involves using specialized software to create a virtual version of computing resources rather than the actual version of the same resource.
With the help of virtualization multiple OS and applications can run on the same machine and its same hardware at same runtime, increasing the utilization and flexibility of hardware.

Virtualization allows sharing of a single physical

instance of a resource or an application among multiple customers and organizations at one time.

Virtualization provide a virtual environment for not only executing application but also for storage, memory, and networking.



Virtualization

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

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

⇒ Working of virtualization in cloud computing

Virtualization is like sharing a big playground in the cloud. When people use the cloud, they store their stuff here. But with virtualization it's like having lots of friends who can all use the same playground equipment at the same time. So, instead of each person buying their own playground, they all share one.

Companies that provide this shared playground like Amazon or Microsoft, have to buy and take care of the equipment. But sometimes they charge a lot of money for it. Virtualization is like having someone help you manage and organize this shared playground. This way, you don't have to spend as much money and still get to use the playground whenever you want. It's like having a helper who makes things cheaper and easier for everyone who wants to play in the cloud.

[A] Benefits of Virtualization

- More flexible and efficient allocation of resources
- Lowers the cost of IT infrastructure
- Remote access and rapid scalability
- High availability and recovery
- Enables running multiple OS
- Enhance development productivity

[B] Drawback of Virtualization

- High initial investment
- as companies shifted from server to client highly skilled staff is required
- Hosting data at third party resources leads to risk of data, it has chance of getting attacked by hacker

[C] Characteristics of Virtualization

Sharing: Virtualization enables the sharing physical resources among several virtual instances (guests). Sharing of resources help in cost reduction.

Isolation: Virtualization provides isolation b/w virtual instances. Host and other VM are completely isolated. Crash of a VM does not affect other VM. Data is not shared b/w VM. (Improves security and stability)

Encapsulation: Virtualization encapsulates everything a virtual instance needs, including its OS and application into a single container.

Hardware Independence: Virtual instances are independent of physical hardware. It runs multiple application and OS in a single physical machine by partitioning the available resources. It provides flexibility and mobility

Portability: Virtual machine can be migrated b/w different hosts.

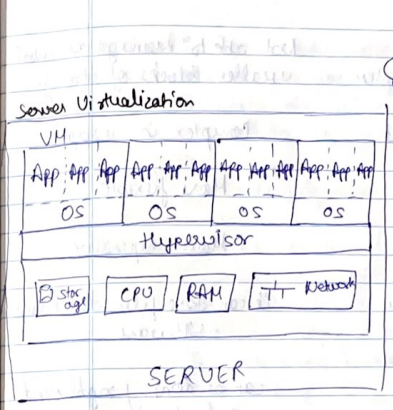
[D] Types of Virtualization

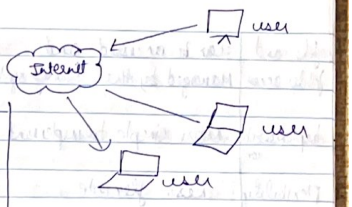
1) Server Virtualization

Hypervisor-based: This involves using a hypervisor to create and manage (VMs) on physical server. The hypervisor controls the allocation of physical resources to VMs. Eg Microsoft Hyper-V, KVM etc

Containers: Containers are light weight, isolated environments that share the host OS's kernel. They are more efficient than VMs as they don't require a separate OS instance for each container. Popular containerization platforms include Docker and Kubernetes

↳ Full: Hypervisor (needs)
↳ Para: Drivers (Less needs)
↳ OS level: no need of hypervisor (physical server OS)





2) Storage Virtualization

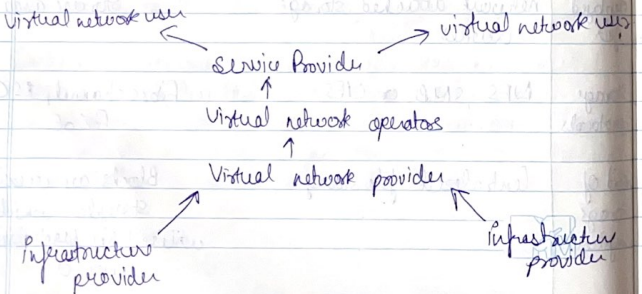
Storage virtualization is the process of grouping the physical storage from multiple network storage devices so that it looks like a single storage device.
It is implemented by using software applications
It is mainly done for backup and recovery purposes

Basis	File virtualization	Block Virtualization
deployed for	network attached storage devices	Storage area networks
Storage protocols	NFS, SMB or CIFS	Fibre channel, iSCSI and FCoE
Kind of storage system	Centralized file storage	Blocks are created to storefiles which are utilised by raw devices by the Server OS

file and folder access	can be accessed and managed by this storage system	Not able to manage or control smaller blocks of storage
Implementation	More simple to implement	Complex in usage
Flexibility	Less flexible	More flexible
Cost	Less expensive	More expensive
Uses	for mass storage of files and VM ware	It can store files, databases VM ware
Servers boot	cannot be done	can be done if right kind of devices are used.
file sharing	access permission given to user for file sharing	Separate OS is installed and attached to block

3) Network Virtualization

It is a process of logically grouping physical networks and making them operate as a single or multiple independent networks called virtual networks



Internal: This is like setting up different WiFi networks at home for your family and guests. They use the same physical router (eg WiFi box) but each network has its own name & password. It keeps your family's data separate from your guests just like different lanes on highway.

External: Think of shared office building with multiple companies. They all use the same internet connection, but they have separate networks, like have own secure lanes on internet highway. This way each company's data is kept private even though they share same internet line.

4) Desktop Virtualization

Virtual desktop infrastructure provide desktop environment (including OS & app) as virtual instances are hosted on remote servers. Users access their virtual desktops remotely, providing flexibility and centralized management. Eg VMware Horizon and Citrix Virtual Apps

A hosted virtual desktop (Desktop as a service) is like a computer in the cloud. It runs on powerful servers far away and can be accessed from anywhere with an internet connection. It gives you a virtual computer with your files and apps, so you don't need physical one. It's flexible, convenient and managed in the cloud.

5) Application Virtualization

It streams application components to end user devices on-demand, reducing the need for full application installations. It allows efficient app delivery & updates eg Citrix XenApp

6) Hardware Virtualization
CPUs: Hardware virtualization extensions in modern CPUs enables hypervisors to efficiently run multiple VMs on a single physical server.

Memory virtualization technologies enable efficient allocation and management of physical memory resources among VMs, ensuring optimal performance.

7) Data virtualization
It combines information from different sources, making it easy to access and use, just as if it all came from one place. It simplifies data management and helps with better decision making.

8) Memory virtualization
It abstracts and manages RAM to create a more flexible and efficient environment for running applications and managing system resources.
Application level integration: It divides an application memory into segments, providing isolation and efficient resource allocation while ensuring that each application believes it has full access to memory.

OS level integration: It is used in virtualized environment where OS or hypervisor manages memory allocation for multiple VM or containers, ensuring isolation and dynamic resource adjustments.

Hypervisor / Host OS / hardware

[E] Hypervisors.

It sits btw physical hardware and virtual instances and manages the allocation of physical resources to virtual instances.

Hypervisor is a hardware virtualization technique that allows multiple guest OS to run on a single host system at the same time. It is sometimes also called as virtual machine manager or management (VMM).

Types of Hypervisor

Type 1 Hypervisor
It runs directly on the physical hardware and it is also known as native hypervisor or bare metal hypervisor. It does not require any base server OS. It has direct access to hardware resources.
Eg VMware ESXi, Citrix XenServer, Microsoft Hyper-V

Hypervisor / hardware

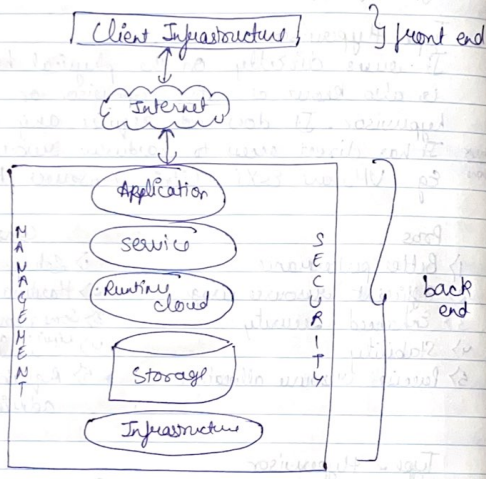
Pros	Cons
1) Better performance	1) Setup complexity
2) Efficient resource usage	2) Hardware compatibility requirements
3) Enhanced security	3) Some resource overhead
4) Stability	4) Limited access to specialized hardware
5) Precise resource allocation	5) Requires specialized administration skills.

Type 2 Hypervisor
It runs on top of an existing OS and is typically used for local development or testing environments. It is also known as hosted hypervisor. They run as an application in host system.

Pros	Cons
Easy to use and set up	Lower performance
Broad hardware compatibility	Resource limitations for VMs

Resource sharing with host OS	Less security due to host OS
No need for System reboots	Weaker isolation b/w VMs
Suitable for testing & development	Not typically used in production environment

Cloud Architecture



Front END
- → used by client
- → Contains all the client side interface of applications that are required to access the cloud platform

Back END
- → used by service provider
- → It manages all the resources that are required to provide cloud computing services
- → It includes huge amount of data storage, security mechanisms, ~~storage~~, ~~security~~, virtual machines, deployment models, servers etc.

Components

1) Client Infrastructure - front end components (provides GUI to interact with cloud)
2) Application - may be any s/w or platform that a client wants to access
3) Services - Manages that, which type of service you access acc. to client requirements
   IaaS, PaaS, SaaS
4) Runtime cloud - provides execution & runtime environment to the virtual machines
5) Storage - It provides a huge amount of storage capacity in the cloud to store & manage data.
6) Infrastructure - It include s/w & h/w components such as servers, storage, network devices, virtualization and other resources needed for cloud computing models.
7) Management - Manages components (applications, service, infrastructure)
8) Security - Inbuilt backend component → Provide backend security mechanisms
9) Internet - Medium through which frontend & backend interact.