# Unit 2: Cloud system and Virtulization

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- 2.4.2 Types of Virtualization
- 2.4.3 Virtualization of CPU, Memory, I/O Devices

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# 2.1 Types of clouds- Private Public, hybrid and community cloud

- Cloud computing is essentially an assortment of IT infrastructure services various providers offer.
- Reduced costs and improved resilience make it a viable solution for many IT needs.
- Not all cloud solutions are the same.
- There are some key differences in deployment that businesses need to understand to choose the right cloud solution for their unique needs, as the deployment model can impact the cost as well as the capabilities of a cloud architecture.

# Types of Cloud

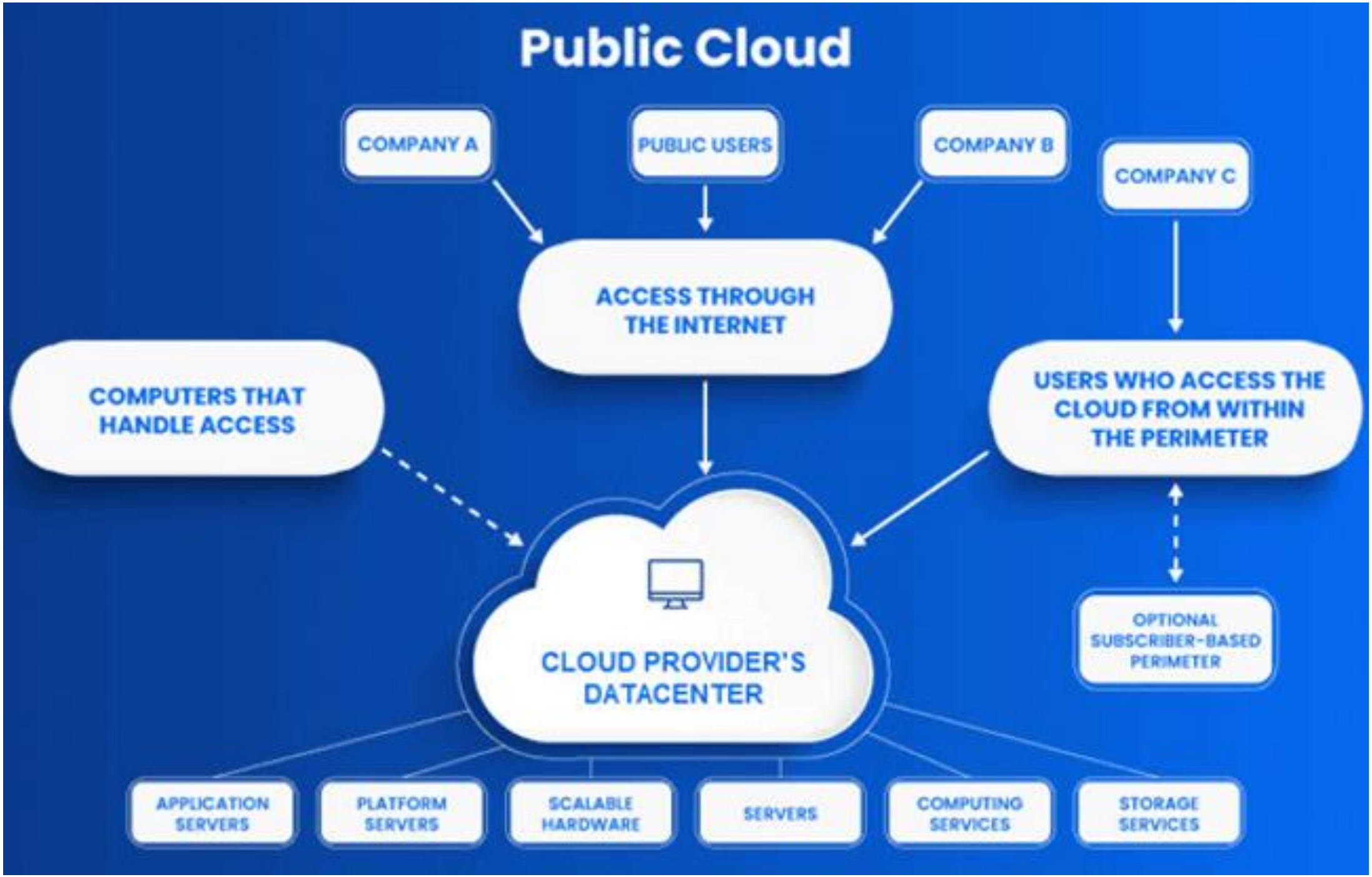
1.Public Cloud
2.Private Cloud
3.Hybrid Cloud
4.Community Cloud

# Public Cloud

- The public cloud is a model where a third-party provider owns computing resources and makes these resources available to users.
- While the subscription model is common, there are free public cloud services.
- They offer additional tools to help users get more out of their cloud architecture, including cloud-based apps, data storage, and more.
- Some public cloud service providers also offer a development environment where users can deploy their own apps.
- A common use of public cloud services is to deploy virtual machines.

# Public Cloud

- Virtual machines allow you to build a customizable infrastructure with the OS of your choice.
- It also facilitates remote work by making your work environment accessible from anywhere.
- It’s an on-demand model where a third-party cloud service provider can deliver customized solutions based on the needs of each user.
- At the same time, the providers can pool resources to accommodate the needs of a large group of users.


Public Cloud
COMPANY A
PUBLIC USERS
COMPANY B
COMPANY C
ACCESS THROUGH THE INTERNET
COMPUTERS THAT HANDLE ACCESS
USERS WHO ACCESS THE CLOUD FROM WITHIN THE PERIMETER
CLOUD PROVIDER'S DATACENTER
OPTIONAL SUBSCRIBER-BASED PERIMETER
APPLICATION SERVERS
PLATFORM SERVERS
SCALABLE HARDWARE
SERVERS
COMPUTING SERVICES
STORAGE SERVICES

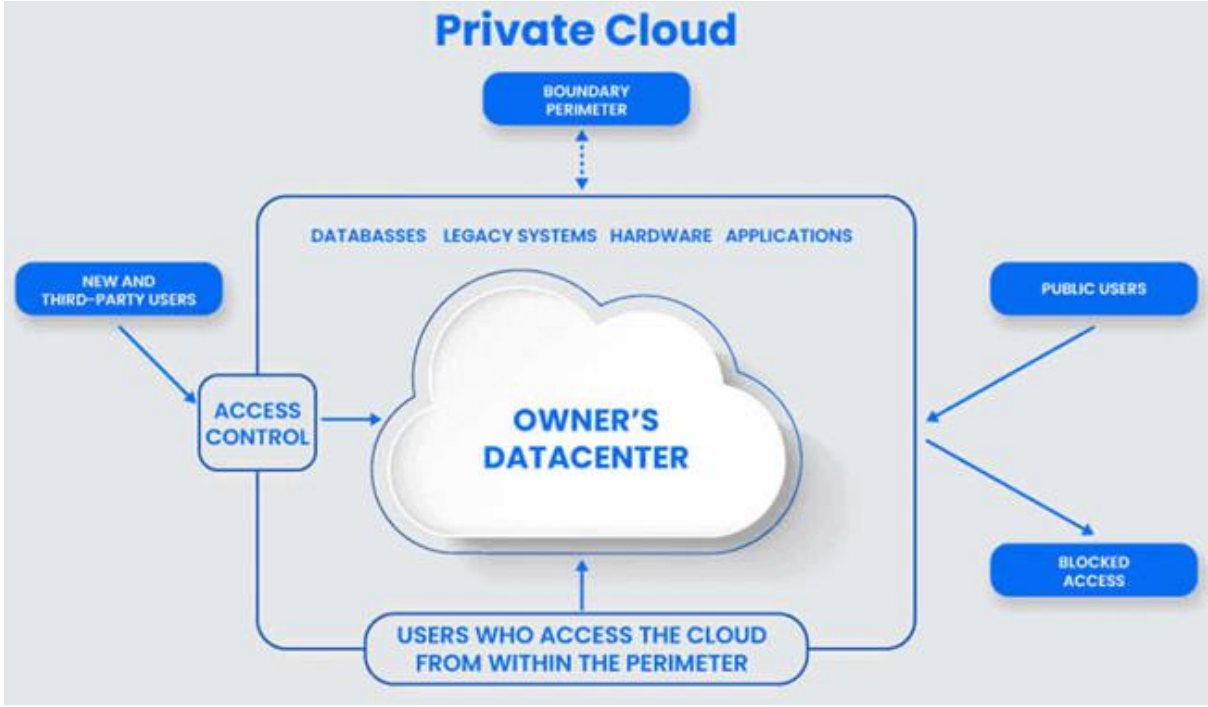
| Pros | Cons |
| --- | --- |
| It’s a scalable model where users can add or remove resources as needed. | Relying on a third-party cloud provider gives you minimal visibility over the back-end process. |
| Pooled resources help keep the cost down, and most providers have flexible pricing models. | Not ideal for resource-intensive applications that require dedicated servers to run properly. |
| Offer built-in backup solutions to facilitate recovery. | |
| Public cloud environments are a viable solution for businesses with limited IT teams and internal resources. | |
| Major companies like Amazon or Microsoft offer reliable public cloud services and innovative business solutions. | |

# Private Cloud

- Private cloud models leverage the advantages of on-premises hosting while giving you access to the flexibility of a cloud-based architecture.
- It’s a flexible model where you can decide how much of your architecture you want to outsource.
- This cloud computing model is used exclusively by a particular organization and never shared with other organizations.
- Some cloud service providers also offer services to manage private clouds, including handling app deployments, security, updates, and other aspects of managing your IT infrastructure.

# Private Cloud

- Private cloud infrastructure can be a good match for businesses that must meet strict industry requirements regarding data handling and privacy.
- It also ensures that resource-intensive applications have the computing resources needed to run as expected.



| Pros | Cons |
| --- | --- |
| Managing your software and hardware resources yourself gives you complete freedom. | A private cloud architecture comes with a significant upfront cost if you purchase hosting hardware. |
| There are no limits over the number or type of apps that you can deploy in the private cloud. | Building a private cloud infrastructure can be complex due to the number of options available. |
| You can protect your entire cloud environment behind a firewall that you control. | |
| Owning your cloud architecture hardware can increase the valuation of your business and protect you from potential fluctuations in subscription prices. | |

# Hybrid Cloud

- A hybrid cloud deployment model uses public and private infrastructure elements.
- It’s a flexible model that allows you to leverage benefits from these two deployment models.
- A hybrid environment can help cut costs if your needs and requirements vary from one process to another.
- Sensitive data, legacy systems, and apps that require a configuration not supported by the public cloud service provider may remain in the private portion of the architecture.
- Moreover, workloads that require more bandwidth and SaaS solutions can run on a public cloud server.

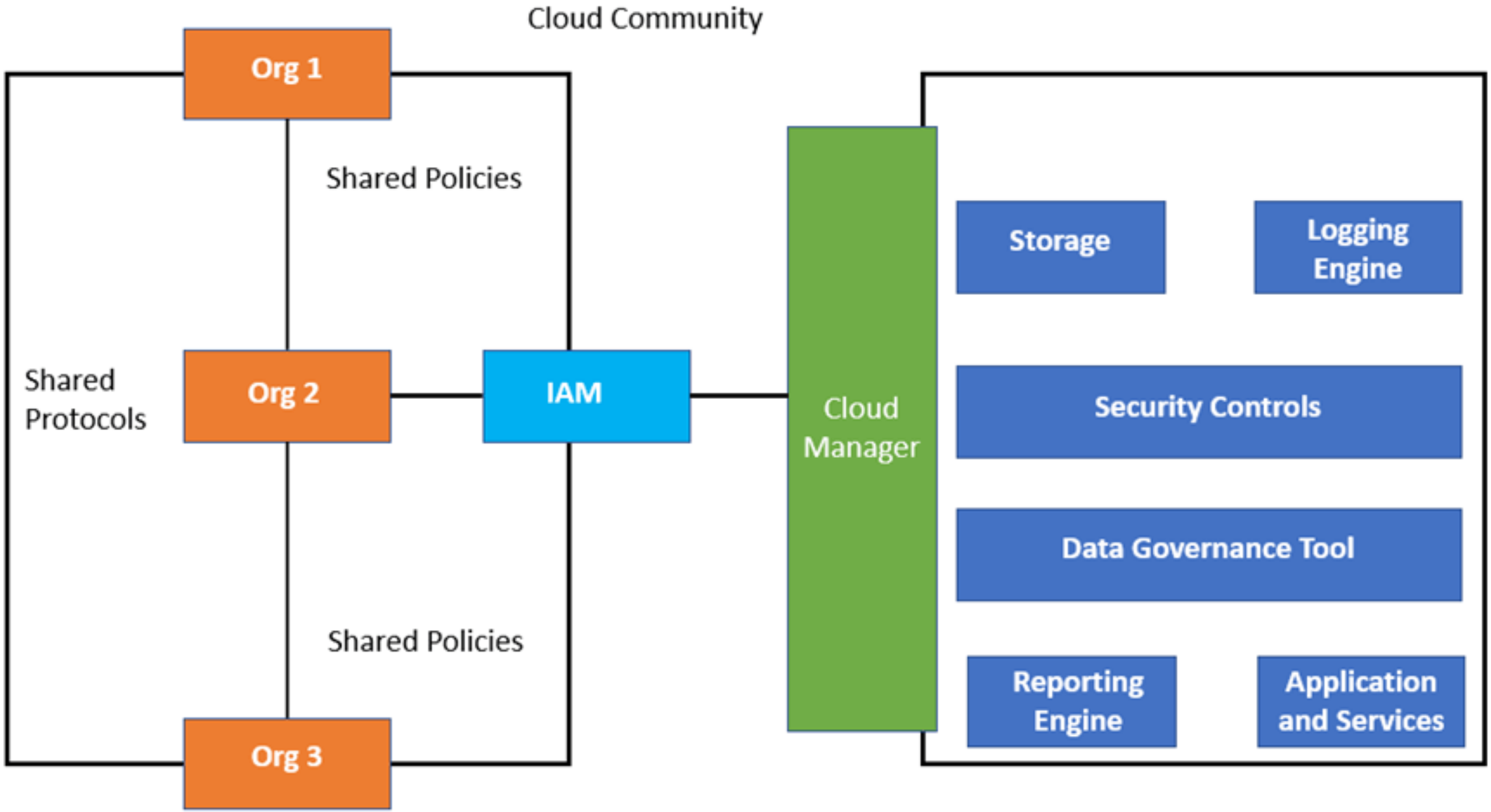
# Hybrid Cloud

- The public and private elements of the infrastructure can communicate with each other, and exchange data as needed.
- Nowadays, more and more businesses are using hybrid cloud infrastructure.
- Many of these businesses rely on third-party providers for applications that don’t require advanced security measures or a specific environment.

| Pros | Cons |
| --- | --- |
| It can facilitate the transition from a public to a private cloud or the other way around. | Hybrid infrastructures can become complex and challenging to manage if you have too many elements. |
| It lowers your deployment time and allows you to leverage public resources to add new capabilities to your IT infrastructure. | Managing the private portion of your architecture can be expensive. |
| A scalable hybrid cloud gives you access to more public resources as needed. | |
| You don’t have to compromise your security or regulatory requirements. | |

# Community Cloud

- The community cloud model is relatively recent.
- This deployment model is similar to the public cloud but solves issues linked to implementing a one-size-fits-all model.
- The cloud provider creates an environment that meets your unique needs by adjusting the server configuration, implementing cybersecurity solutions, or following specific data storage requirements.
- As community cloud continues to grow in popularity, finding a solution that matches your needs will become easier.
- Businesses in industries like finance, insurance, healthcare, or the legal field can already choose from a wide range of community cloud solutions.


Cloud Community
Org 1
Shared Policies
Shared Protocols
Org 2
IAM
Cloud Manager
Storage
Logging Engine
Security Controls
Data Governance Tool
Reporting Engine
Application and Services
Shared Policies
Org 3

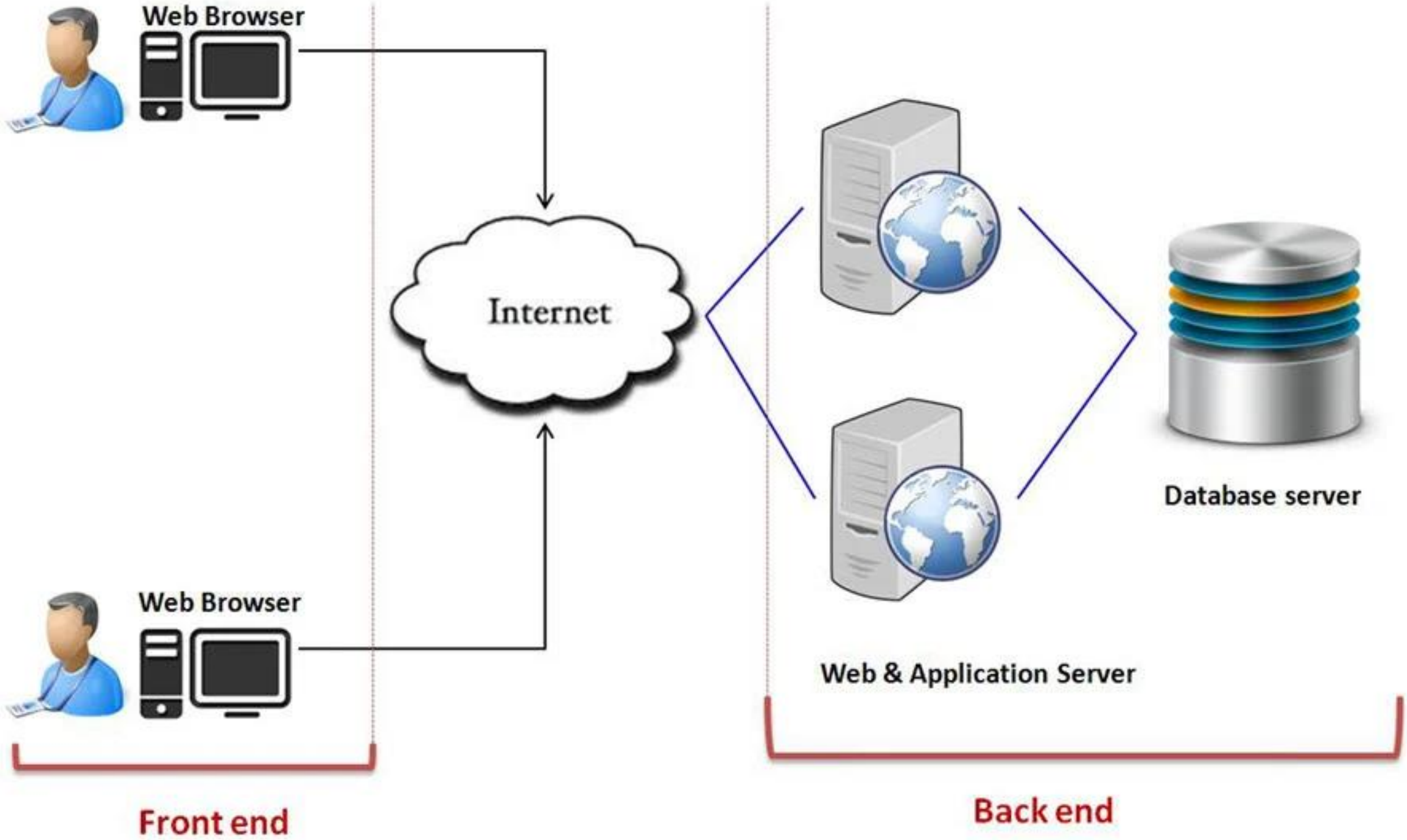
| Pros | Cons |
| --- | --- |
| This cloud platform gives you more visibility and control over your cloud environment. | Community cloud is relatively recent, and not all providers offer this model. |
| The community cloud is compatible with a hybrid architecture if you want to retain some elements of a private cloud model. | Its price is higher compared to a traditional public cloud solution. |
| You can reduce costs by outsourcing compliance to your cloud provider. | |
| Your cloud provider will cater to your industry's unique needs and requirements. | |

# Summary

- These four cloud deployment models match different needs and requirements:
- There are four main types of cloud computing are: 1. Public cloud, 2. private cloud, 3. Hybrid cloud, and 4. community cloud
- Public cloud infrastructure is ideal if reducing costs is a priority. It remains the most scalable and flexible solution.
- Private model makes more sense for businesses with specific security or configuration requirements. This solution costs more, but it gives you more control over your IT infrastructure.
- You can leverage the benefits of the public and private cloud by investing in a hybrid model that lets you run some workloads on a public infrastructure while storing your data in a private environment.
- A community cloud platform can be a good fit if your industry has specific regulatory requirements.

# 2.2 Cloud Computing architecture

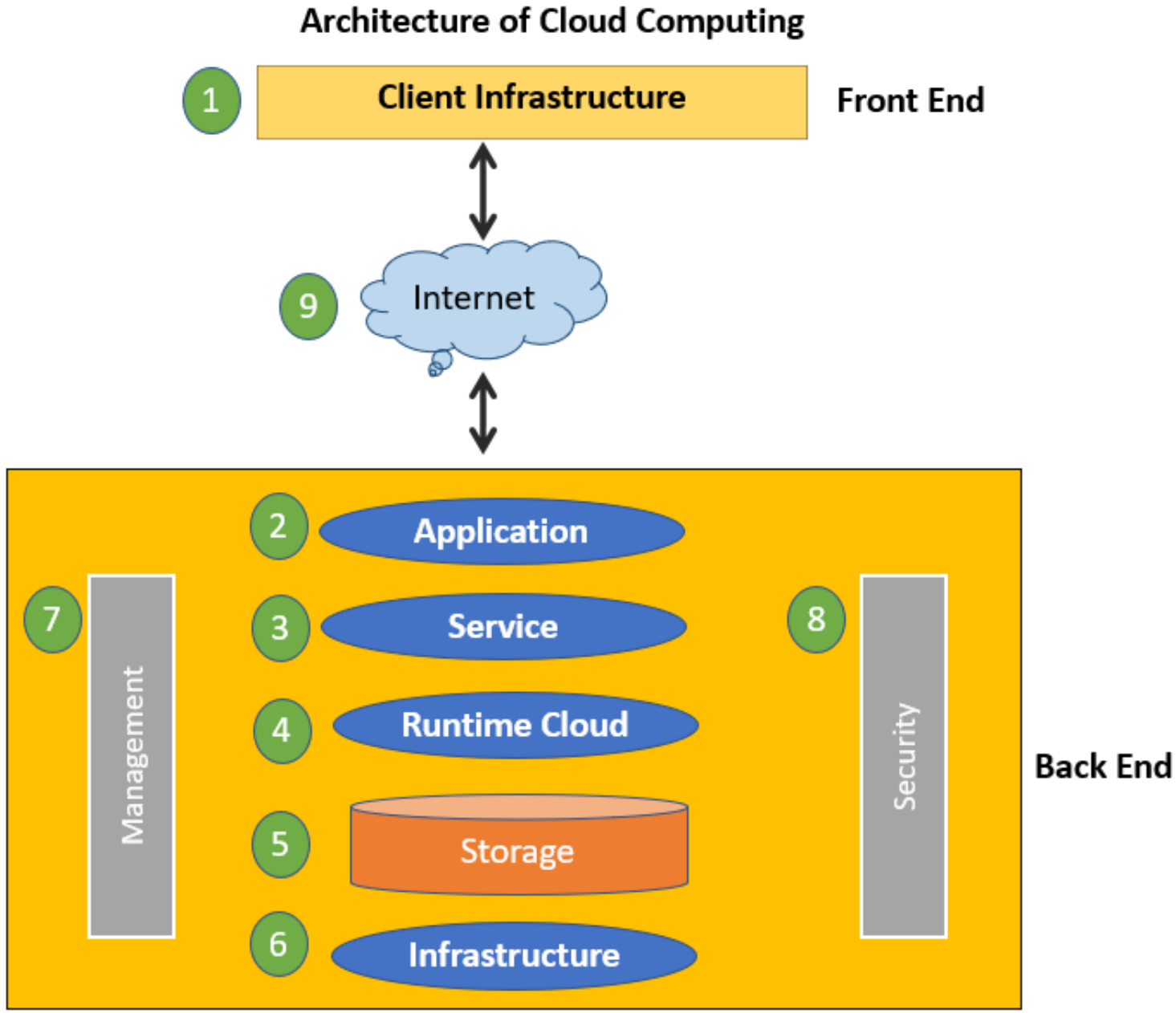
- Cloud Computing Architecture is a combination of components required for a Cloud Computing service.
- A Cloud computing architecture consists of several components like a frontend platform, a backend platform or servers, a network or Internet service, and a cloud-based delivery service.
- Let’s have a look into Cloud Computing and see what Cloud Computing is made of.
- Cloud computing comprises two components, the front end, and the back end.
- The front end consists of the client part of a cloud computing system.
- It comprises interfaces and applications that are required to access the Cloud computing or Cloud programming platform.


Web Browser
Internet
Web Browser
Web & Application Server
Database server
Front end
Back end

- While the back end refers to the cloud itself, it comprises the resources required for cloud computing services.
- It consists of virtual machines, servers, data storage, security mechanisms, etc.
- It is under the provider’s control.
- Cloud computing distributes the file system that spreads over multiple hard disks and machines.
- Data is never stored in one place, and in case one unit fails, the other will take over automatically.
- The user disk space is allocated on the distributed file system, while another important component is an algorithm for resource allocation.
- Cloud computing is a strong distributed environment, and it heavily depends upon strong algorithms.

# Cloud Computing Architecture

- The Architecture of Cloud computing contains many different components. It includes Client infrastructure, applications, services, runtime clouds, storage spaces, management, and security. These are all the parts of a Cloud computing architecture.
- **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.


Architecture of Cloud Computing
1
Client Infrastructure
Front End
9
Internet
2
Application
7
Management
3
Service
8
Security
4
Runtime Cloud
5
Storage
6
Infrastructure
Back End

- **Important Components of Cloud Computing Architecture**
- Here are some important components of Cloud computing architecture:
- **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.

**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.

# Cloud computing infrastructure

- Cloud computing refers to providing on demand services to the customer anywhere and anytime irrespective of everything where the cloud infrastructure represents the one who activates the complete cloud computing system.
- Cloud infrastructure has more capabilities of providing the same services as the physical infrastructure to the customers.
- It is available for private cloud, public cloud, and hybrid cloud systems with low cost, greater flexibility and scalability.

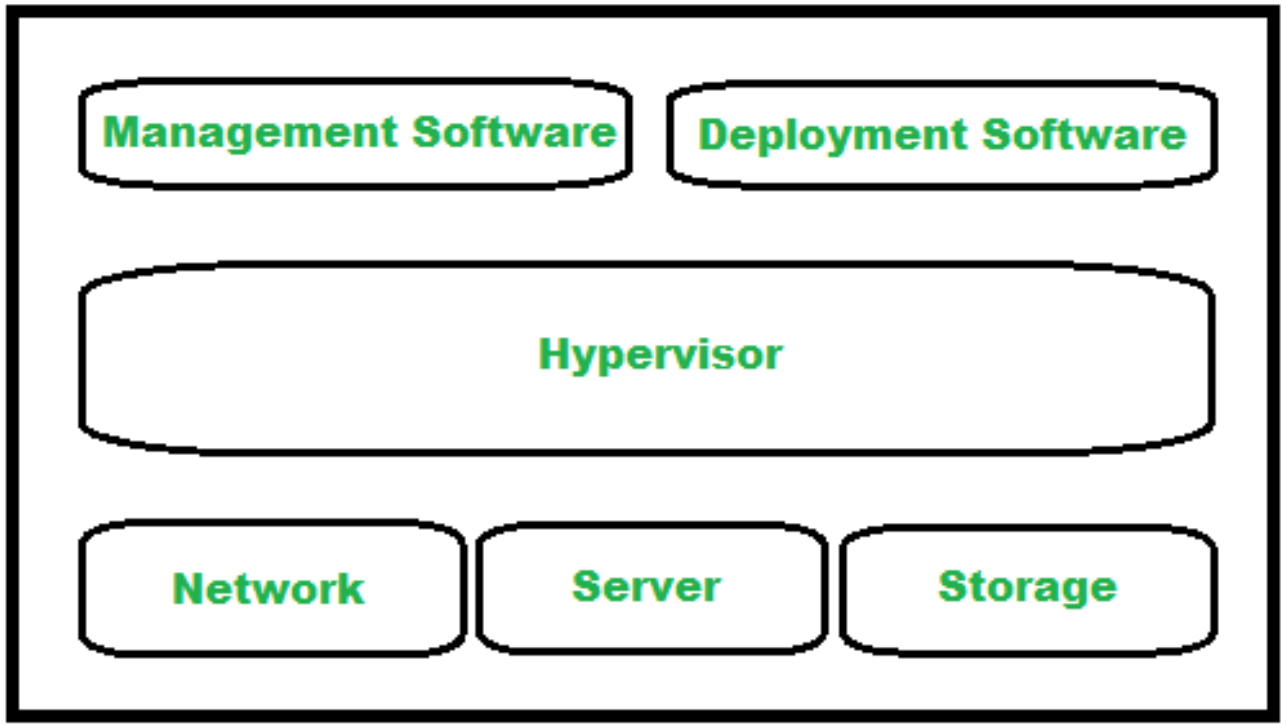
- **Cloud infrastructure components :**
- Different components of cloud infrastructure supports the computing requirements of a cloud computing model.
- Cloud infrastructure has number of key components but not limited to only server, software, network and storage devices.
- Still cloud infrastructure is categorized into three parts in general i.e.

**1.Computing**

**2.Networking**

**3.Storage**

The most important point is that cloud infrastructure should have some basic infrastructural constraints like transparency, scalability, security and intelligent monitoring etc.
The below figure **represents components of cloud infrastructure**



**1. Hypervisor :**

Hypervisor is a firmware or a low level program which is a key to enable virtualization. It is used to divide and allocate cloud resources between several customers. As it monitors and manages cloud services/resources that's why hypervisor is called as VMM (Virtual Machine Monitor) or (Virtual Machine Manager).

**2. Management Software :**

Management software helps in maintaining and configuring the infrastructure. Cloud management software monitors and optimizes resources, data, applications and services.

**3. Deployment Software :**

Deployment software helps in deploying and integrating the application on the cloud. So, typically it helps in building a virtual computing environment.

**4. Network :**

It is one of the key component of cloud infrastructure which is responsible for connecting cloud services over the internet. For the transmission of data and resources externally and internally network is must required.

**5. Server :**

Server which represents the computing portion of the cloud infrastructure is responsible for managing and delivering cloud services for various services and partners, maintaining security etc.

**6. Storage :**

Storage represents the storage facility which is provided to different organizations for storing and managing data. It provides a facility of extracting another resource if one of the resource fails as it keeps many copies of storage.

Along with this, virtualization is also considered as one of important component of cloud infrastructure. Because it abstracts the available data storage and computing power away from the actual hardware and the users interact with their cloud infrastructure through GUI (Graphical User Interface).

# Virtulization

- **Virtualization** is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources".
- In other words, Virtualization is a technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations.
- It does by assigning a logical name to a physical storage and providing a pointer to that physical resource when demanded.
- Creation of a virtual machine over existing operating system and hardware is known as Hardware Virtualization. A Virtual machine provides an environment that is logically separated from the underlying hardware.

# Virtulization

- The machine on which the virtual machine is going to create is known as **Host Machine** and that virtual machine is referred as a **Guest Machine**

# Types of Virtualization:

1.Hardware Virtualization.

2.Operating system Virtualization.

3.Server Virtualization.

4.Storage 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.

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

# 3) 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.

# 4) 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*.
- **Usage:**
- Storage virtualization is mainly done for back-up and recovery purposes.

# Virtualization of CPU, Memory, I/O Devices

- **CPU Virtualization:**
- CPU Virtualization is one of the cloud-computing technology that requires a single CPU to work as multiple machines working together. Virtualization got its existence since the 1960s that became popular with CPU virtualization. To work efficiently and utilize all the computing resources to work together, CPU virtualization was invented to manage things easily by running every OS in one single machine

- The virtualization mainly focusses on efficiency and performance-related operations by saving time. CPU Virtualization emphasizes on running programs and instructions through virtual machine giving the feeling as it is working on a physical workstation.
- All the operations are handled by an emulator that controls software to run according to it. The emulator performs the same way as a normal computer machine does. It replicates the same copy or data and generates the same output just like a physical machine does.

- The emulation function offers great portability and facilitates working on a single platform acting like working on multiple platforms.
- With CPU Virtualization, all the virtual machines act as physical machine and distribute their hosting resources just like having various virtual processors.
- Sharing of physical resources takes place to each virtual machine when all hosting services get the request. Finally, the virtual machines get a share of the single CPU allocated to it, being a single-processor acting as dual-processor.

# I/O virtualization:

- I/O virtualization involves managing the routing of I/O requests between virtual devices and the shared physical hardware. At the time of this writing, there are three ways to implement I/O virtualization:
- 1. Full device emulation
- 2. Para-virtualization
- 3. Direct I/O

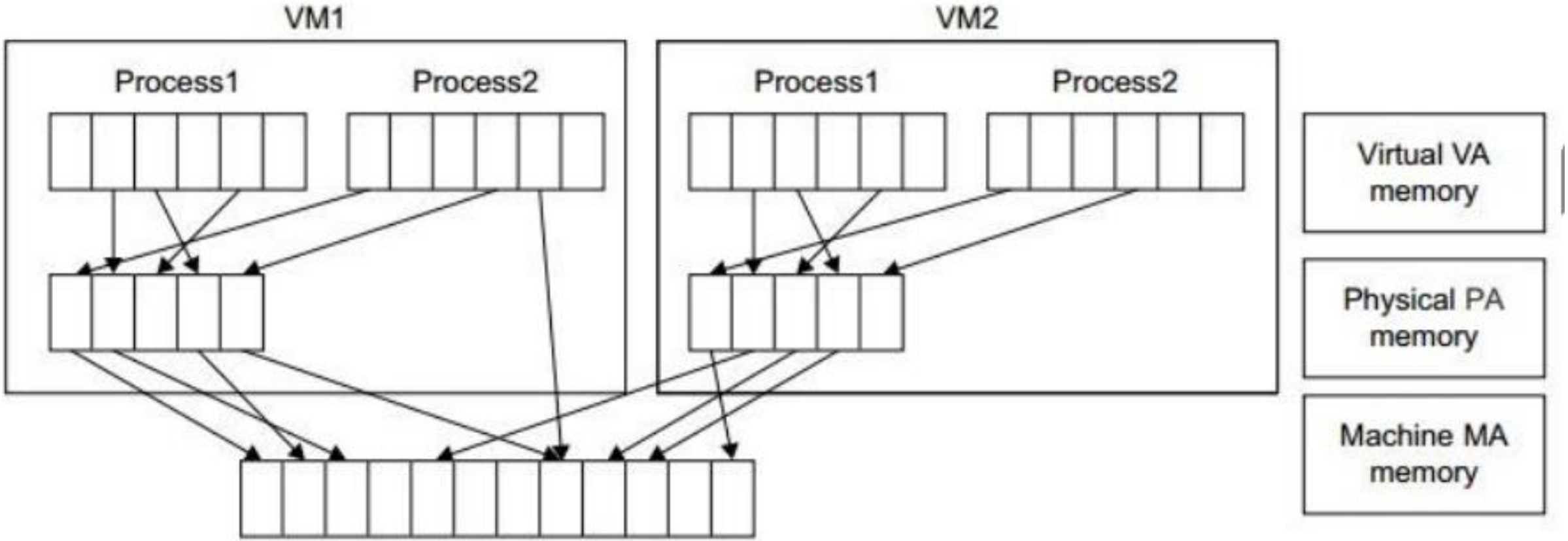
- 1. Full device emulation:
- Full device emulation is the first approach for I/O virtualization. Generally, this approach emulates well-known, real-world devices.
- All the functions of a device or bus infrastructure, such as device enumeration, identification, interrupts are replicated in software.
- This software is located in the VM and acts as a virtual device. The I/O access requests of the guest OS are trapped in the VM which interacts with the I/O devices
- A single hardware device can be shared by multiple VMs that run concurrently.
- The software emulation runs much slower than the hardware it emulates.

- 2. Para-virtualization:
- In para-virtualization, virtual machine does not implement full isolation of OS but rather provides a different API which is utilized when OS is subjected to alteration.
- Para-virtualization uses hypercalls at compile time for operations.

- 3. Direct I/O virtualization:
- Direct I/O virtualization lets the VM access devices directly. It can achieve close-to-native performance without high CPU costs.
- However, current direct I/O virtualization implementations focus on networking for mainframes.

- Memory Virtualization
- All modern CPUs include a memory management unit (MMU) and a translation lookaside buffer (TLB) to optimize virtual memory performance.
- A translation lookaside buffer is a memory cache that stores the recent translations of virtual memory to physical memory. It is used to reduce the time taken to access a user memory location.
- However, in a virtual execution environment, virtual memory virtualization involves sharing the physical system memory in RAM and dynamically allocating it to the physical memory of the VMs.
- That means a two-stage mapping process should be maintained by the guest OS and the VM, respectively: virtual memory to physical memory and physical memory to machine memory.

- Furthermore, MMU virtualization should be supported, which is transparent to the guest OS. The guest OS continues to control the mapping of virtual addresses to the physical memory addresses of VMs. But the guest OS cannot directly access the actual machine memory. The VM is responsible for mapping the guest physical memory to the actual machine memory


VM1
Process1
Process2
VM2
Process1
Process2
Virtual VA memory
Physical PA memory
Machine MA memory

# Assignment:

1. What are the types of clouds in cloud computing?
2. What is cloud computing architecture?
3. What are the main components of cloud computing infrastructure?
4. What is virtualization in cloud computing?
5. What are the types of virtualization?
6. What are the basics of virtualization?
7. What is CPU virtualization?
8. What is memory virtualization?
9. What is I/O device virtualization?
10. What are virtual clusters and their role in resource management?