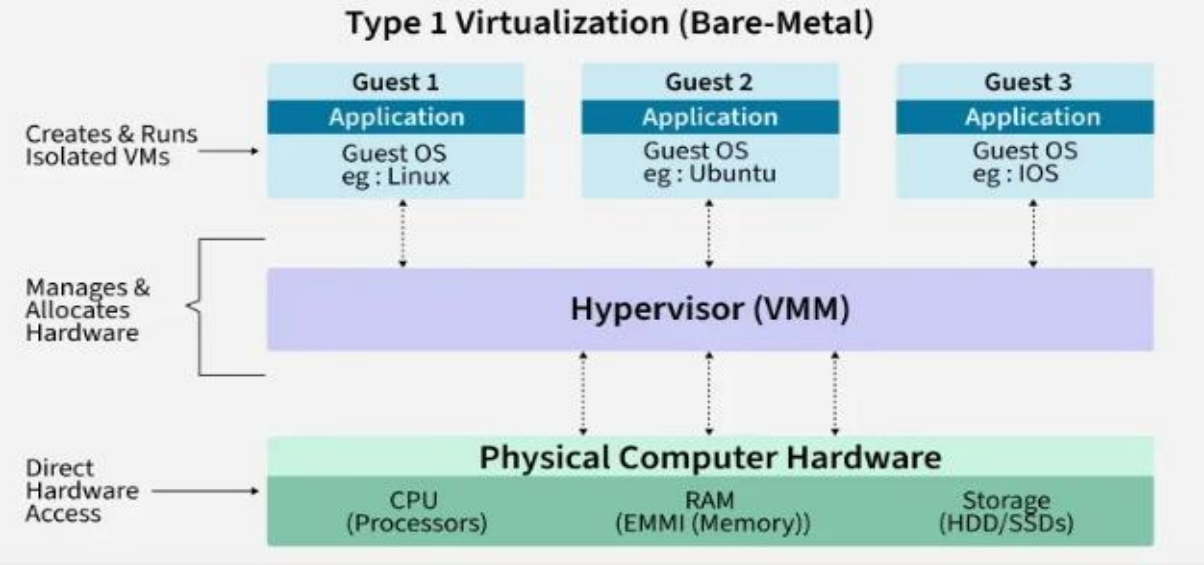
4.3. BASIC VIRTUALIZATION IN CLOUD COMPUTING

Virtualization is the fundamental technology that powers Cloud Computing. It allows you to create multiple simulated environments (Virtual Machines or VMs) from a single physical hardware system.

Before virtualization, a physical server could only run one Operating System (OS) and often one task. This wasted massive amounts of resources if your app only used 10% of the CPU, the other 90% was idle. Virtualization solves this by allowing one physical server to host dozens of virtual servers, each running its own OS and apps isolated from the others.



The Core Architecture

At the heart of virtualization is a piece of software called the **Hypervisor**.

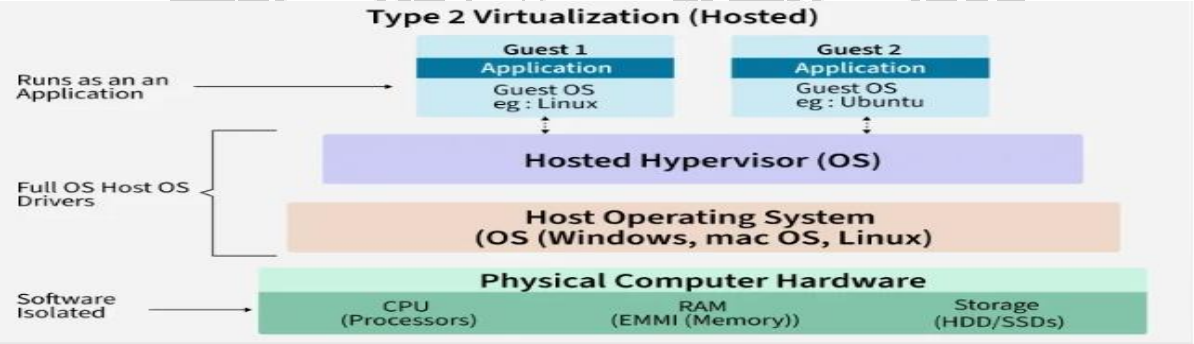
1. **Physical Hardware (Host):** The actual server (CPU, RAM, Disk).
2. **Hypervisor:** A lightweight software layer that sits between the hardware and the virtual machines. It allocates resources (e.g., "Give VM1 2GB of RAM") and manages the VMs.
3. **Virtual Machine (Guest):** A software-based computer that runs like a physical one. It has its own OS, libraries, and applications.

Working of Virtualization

Virtualizations uses special software known as hypervisor, to create many virtual computers (cloud instances) on one physical computer. The Virtual Machines behave like actual computers but use the same physical machine.

Virtual Machines (Cloud Instances)

- After installing virtualization software, you can create one or more virtual machines on your computer.
- Virtual machines (VMs) behave like regular applications on your system.
- The real physical computer is called the **Host**, while the virtual machines are called **Guests**.
- A single host can run multiple guest virtual machines.
- Each guest can have its own operating system, which may be the same or different from the host OS.
- Every virtual machine functions like a standalone computer, with its own settings, programs, and configuration.
- VMs access system resources such as **CPU, RAM, and storage**, but they work as if they are using their own hardware.



The Two Types of Hypervisors

Understanding the difference between Type 1 and Type 2 hypervisors is critical for system architects.

Type 1: Bare-Metal Hypervisor

- **How it works:** Installed directly on the physical hardware. There is no host Operating System.
- **Performance:** High. Direct access to hardware resources.
- **Use Case:** Enterprise Data Centers, Cloud Providers (AWS EC2, VMWare ESXi, Microsoft Hyper-V).

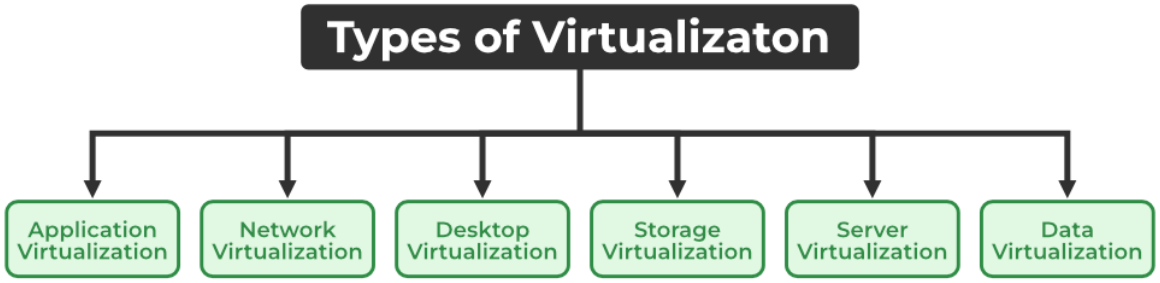
Type 2: Hosted Hypervisor

- **How it works:** Installed as an application *on top* of an existing OS (like Windows or macOS).
- **Performance:** Lower. Requests must pass through the Host OS first.

- **Use Case:** Personal use, testing labs (Oracle VirtualBox, VMWare Workstation).

Types of Virtualization

1. Application Virtualization
2. Network Virtualization
3. Desktop Virtualization
4. Storage Virtualization
5. Server Virtualization
6. Data virtualization



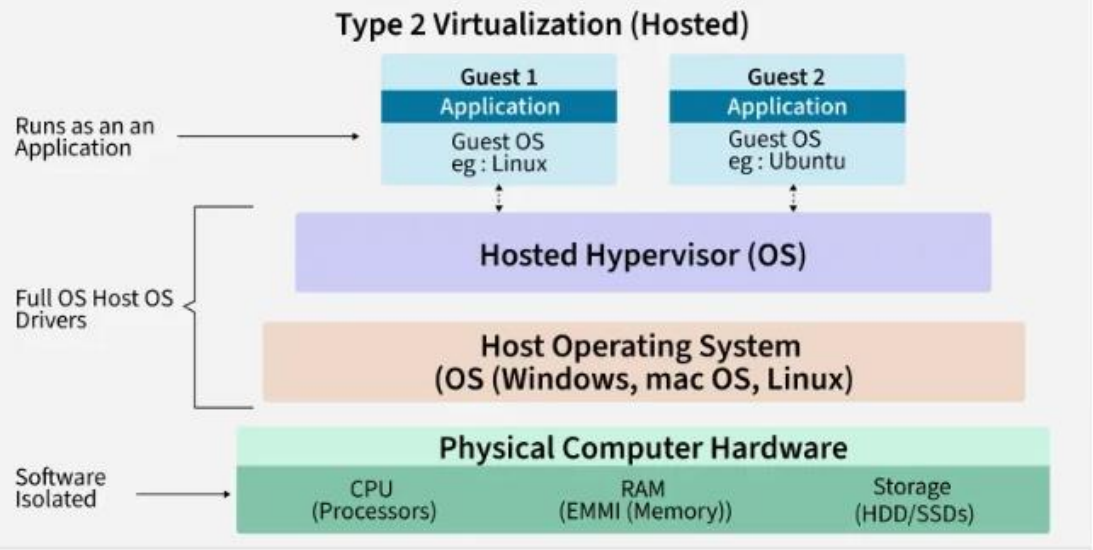
Types of Virtualization

1. Application Virtualization

- **Concept:** Encapsulating an application so it runs independently of the underlying OS. The user accesses the app remotely without installing it.
- **Example:** Using Microsoft App-V or Citrix to run Microsoft Excel on an iPad. The app runs on a server, but the user sees it on their tablet.

2. Network Virtualization

- Decoupling the network functions (routing, switching, firewalls) from the physical cables and switches. It creates a "Software-Defined Network" (SDN).
- **Example:** AWS VPC (Virtual Private Cloud). You create subnets and route tables in software, without touching a physical router.



3. Desktop Virtualization

- **Concept:** Hosting a user's desktop environment on a centralized server. The user connects via a "thin client" (a basic PC).
- **Example:** Amazon WorkSpaces. An employee logs in from a Chromebook, but sees a full high-power Windows 11 desktop running in the cloud

4. Storage Virtualization

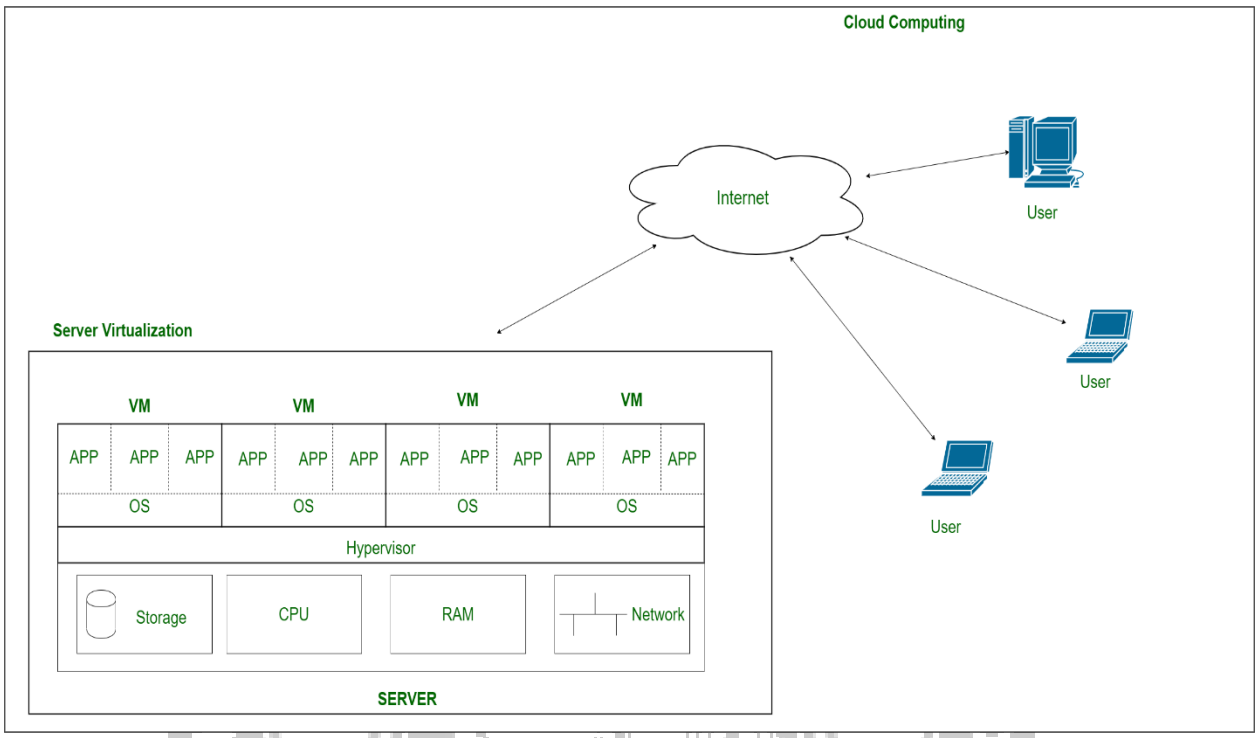
- **Concept:** Pooling physical storage from multiple network storage devices into what appears to be a single storage device managed from a central console.
- **Example:** SAN (Storage Area Network) or Amazon S3. You see a single "bucket" or drive, but the data is physically spread across hundreds of hard drives.

5. Server Virtualization

- **Concept:** Partitioning one physical server into multiple virtual servers.
- **Example:** Running a Web Server (Linux), a Database (Windows), and a Mail Server (Linux) all on one physical machine using VMware vSphere

Each VM here is an isolated server, that runs on their own operating system(like Windows and Linux) and run it's own applications. For example, a company might run A web server on one VM, A database server on another VM, A file server on a third VM all on the same physical machine. This reduces costs, makes

it easier to manage and back up servers, and allows quick recovery if one VM fails.



Data Virtualization

- **Concept:** An abstract layer that allows you to access data from multiple different sources (databases, files, cloud) as if it were in a single place, without moving the data.
- **Example:** Denodo or Oracle Data Service. A dashboard queries "Sales Data," and the virtualization layer pulls it from both an old SQL database and a new Cloud Data Lake instantly.

Virtualization vs. Cloud Computing

These terms are often confused, but they are not the same.

Feature	Virtualization	Cloud Computing
Definition	Technology that creates virtual versions of hardware.	Service that delivers shared computing resources via the internet.

Feature	Virtualization	Cloud Computing
Relationship	The Tool. Virtualization is the software technology.	The Service. Cloud Computing is the result or service built using virtualization.
Ownership	You usually own/manage the hardware (unless using Cloud).	You rent resources; the provider owns the hardware.
Focus	Maximizing hardware efficiency.	Maximizing user agility and scalability.

Virtualization is a technique, which allows to share single physical instance of an application or resource among multiple organizations or tenants (customers). It does so by**assigning a logical name** to a physical resource and providing a**pointer to that physical resource**on demand.

Virtualization Concept

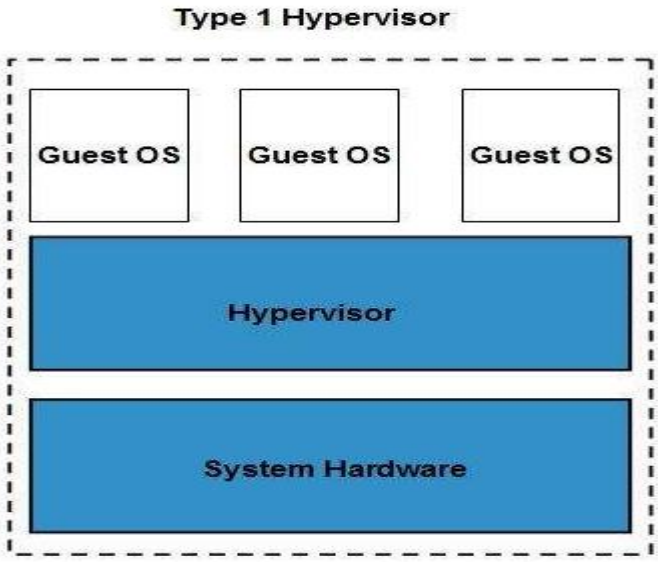
Creating a virtual machine over existing operating system and hardware is referred as Hardware Virtualization. Virtual Machines provide an environment that is logically separated from the underlying hardware.

The machine on which the virtual machine is created is known as**host machine**and**virtual machine** is referred as a**guest machine.** This virtual machine is managed by a software or firmware, which is known as**hypervisor.**

Hypervisor

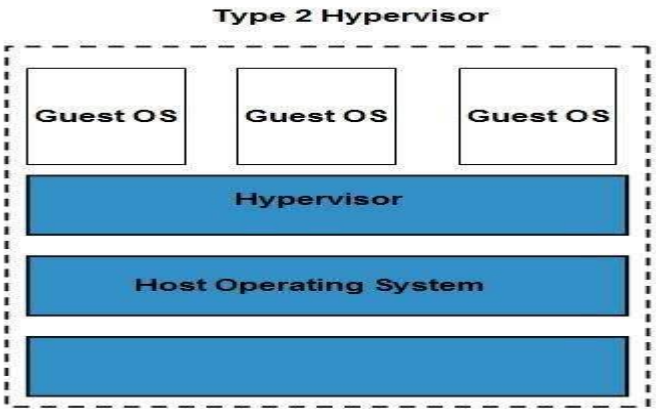
The **hypervisor**is a firmware or low-level program that acts as a Virtual Machine Manager. There are two types of hypervisor:

Type 1 hypervisorexecutes on bare system.LynxSecure, RTS Hypervisor, Oracle VM, Sun xVM Server, VirtualLogic VLXare examples of Type 1 hypervisor. The following diagram shows the Type 1 hypervisor.



The **type1 hypervisor** does not have any host operating system because they are installed on a bare system.

Type 2 hypervisor is a software interface that emulates the devices with which a system normally interacts. Containers, KVM, Microsoft Hyper V, VMWare Fusion, Virtual Server 2005 R2, Windows Virtual PC and **VMW are workstation 6.0**are examples of Type 2 hypervisor. The following diagram shows the Type 2 hypervisor.



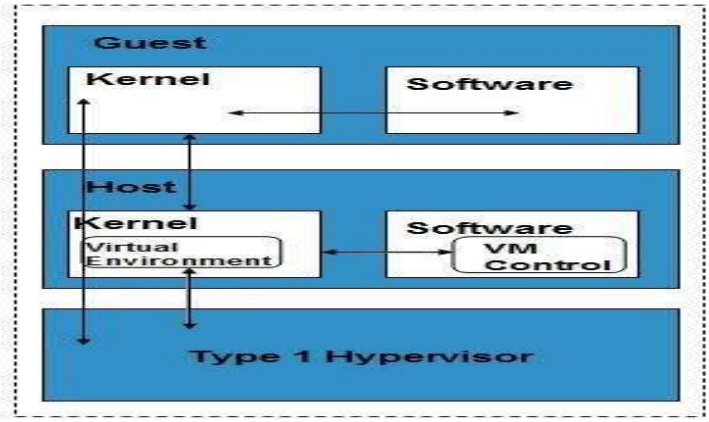
Types of Hardware Virtualization

Here are the three types of hardware virtualization:

- Full Virtualization
- Emulation Virtualization
- Paravirtualization

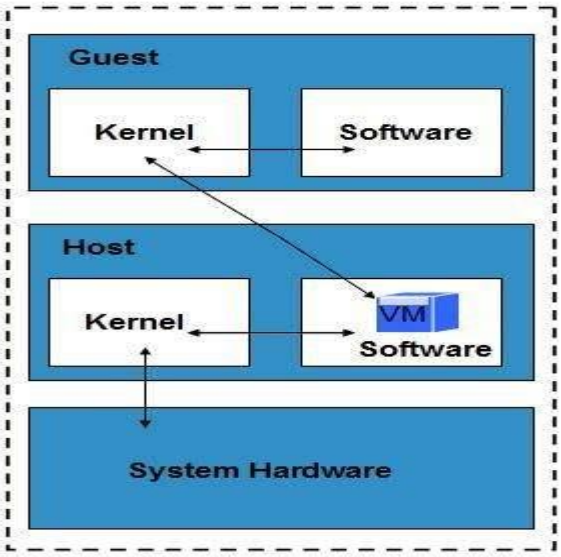
Full Virtualization

In**full virtualization,** the underlying hardware is completely simulated. Guest software does not require any modification to run.



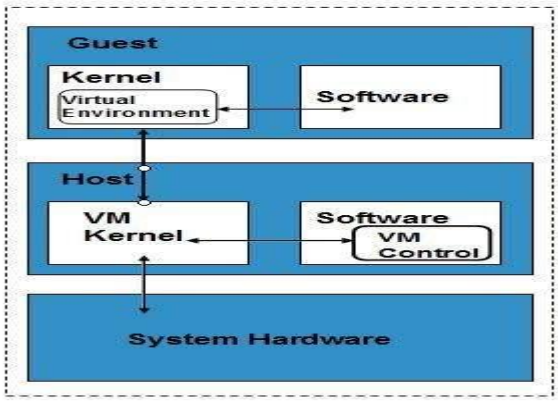
Emulation Virtualization

In**Emulation,** the virtual machine simulates the hardware and hence becomes independent of it. In this, the guest operating system does not require modification.



Paravirtualization

In**Paravirtualization,** the hardware is not simulated. The guest software run their own isolated domains.

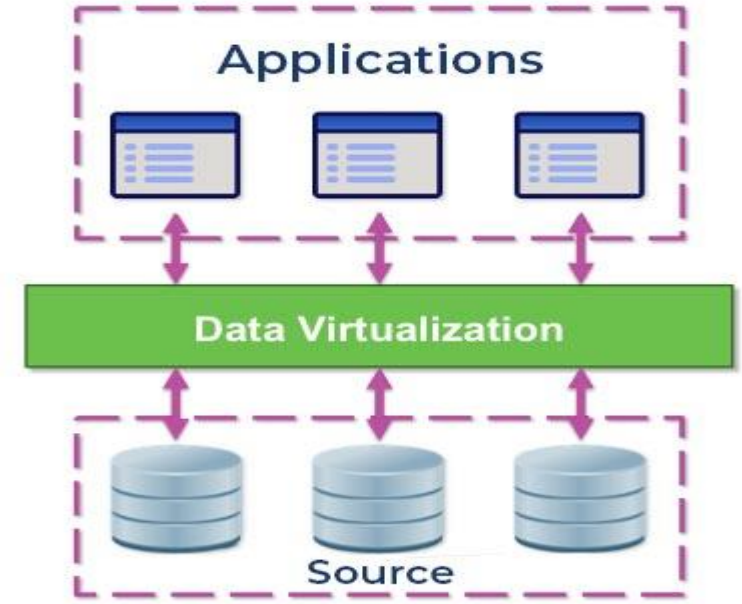


VMware vSphere is highly developed infrastructure that offers a management infrastructure framework for virtualization. It virtualizes the system, storage and networking hardware.

What is Data Virtualization?

Data virtualization is a data management technique in cloud computing that integrates data from different sources into a single virtual layer. It creates a single, logical, and virtual view of data. The virtual view of data can be access by applications such as web portals, dashboards, e-commerce, mobile apps, etc. Data virtualization allows users to retrieve and manipulate data without knowing how and where it is stored.

In big organizations data are collected from different sources and stored in different format. To manipulate and analyze the data, it is required that the data is retrieved in a suitable format. Data virtualization creates a virtual layer between data sources and applications that need it.



Data Virtualization tools process the data request from the application and returns the result in a suitable format. It gives users a feel that all data are at a single place.

How Data Virtualization Works?

The working of data virtualization in cloud computing can be understood through the following steps –

- **Data Abstraction** − data from different sources is pulled together into a single virtual layer.
- **Data Integration** − Data from different systems is combined into a single view.
- **Querying and transformation** − Users can access and query the data from the source systems and perform different tasks such as data analysis, manipulation, etc.

Advantages of Data Virtualization

There are different benefits and advantages of the data virtualization, some are discussed as follows –

- Data virtualization integrates all your data sources and creates a single view and allows real-time access.
- It provides applications with real-time access to multiple data sources in a single view regardless of data source and format.
- It provides best resource utilization by running multiple virtual instances on a single physical server.
- Data virtualization solutions increase flexibility for data integration and support cross-functional data analysis.
- It reduces costs by creating multiple virtual instances onto fewer physical servers.
- It provided user friendly interface to analyze and manipulate data.
- It reduces latency as it eliminates the complex data movement.
- It used metadata and advance data query optimization to retrieve data from sources. It reduces the data integration cost.

Disadvantages of Data Virtualization

With several advantages, the data virtualization come with some drawbacks or disadvantages also. We have discussed some of them ass follows-

- It creates flexibility and portability issue as organizations may become dependent on third party providers.
- It requires high implementation cost.
- It causes issues with availability and scalability as it depends on third-party providers.
- It may introduce new security risks.

Use Cases of Data Virtualization

There are different uses of the data virtualization in cloud computing. Some of the use cases are as follows −

- **Real-time data integration** − It combines data from different systems, CRM, ERP, and external data sources to provide real-time insights for decision-making. Real-time data integration is critical for industries like finance and telecommunications that depend on real-time data for operations and customer services.
- **Cross-functional reporting** − It allows different business units to access relevant data from various data sources for reporting and analysis.
- **Business Intelligence and Reporting** − It create virtual data sets for quick analysis and reporting across different business units.
- **Application development** − It facilitates developers access to different data sources that enhances the application development speed.

Industries using Data Virtualization

The data virtualization is used in many industries. The following is a list of industries where data virtualization ins used −

- Healthcare
- Finance
- Telecommunications
- Government
- Manufacturing
- Retail

Data Virtualization Tools

The following are some data virtualization tools used by different organizations

- IBM Cloud Pak for Data
- TIBCO Data Virtualization
- CData Software
- Informatica
- Red Hat JBoss Data Virtualization
- AtScale
- Stone Bond Technologies