Virtualization in Cloud Computing.

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.

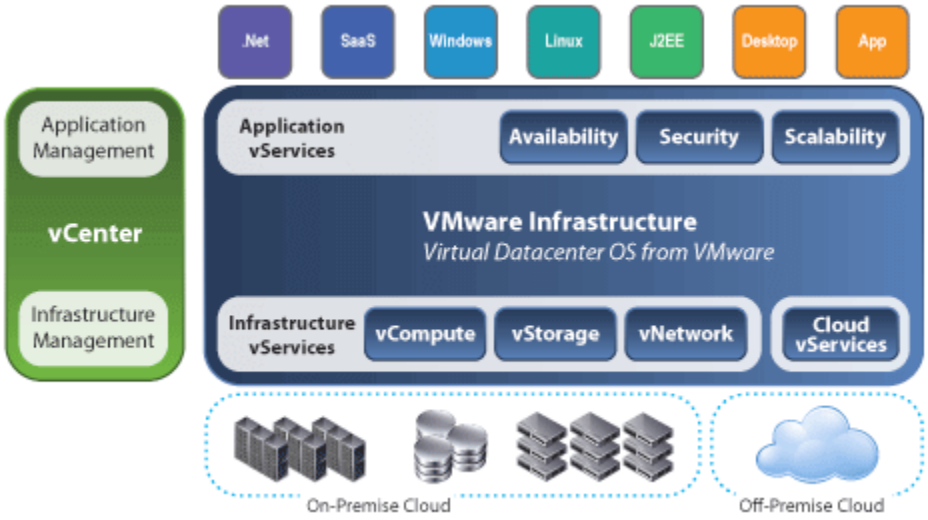
What is the concept behind the Virtualization?

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.

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**

How does virtualization work in cloud computing?

Virtualization plays a very important role in the cloud computing technology, normally in the cloud computing, users share the data present in the clouds like application etc, but actually with the help of virtualization users shares the Infrastructure.



The **main usage of Virtualization Technology** is to provide the applications with the standard versions to their cloud users, suppose if the next version of that application is released, then cloud provider has to provide the latest version to their cloud users and practically it is possible because it is more expensive.

To overcome this problem, we use basically virtualization technology, by using virtualization, all severs and the software application which are required by other cloud providers are maintained by the third party people, and the cloud providers has to pay the money on monthly or annual basis.

Mainly Virtualization means, running multiple operating systems on a single machine but sharing all the hardware resources. And it helps us to provide the pool of IT resources so that we can share these IT resources in order get benefits in the business.

Types of Virtualization:

1. Data Virtualization.
2. Hardware Virtualization.
3. Software Virtualization.
4. Server Virtualization.
5. Storage Virtualization.
6. OS Virtualization.

1) Data Virtualization

Data virtualization is the process of retrieve data from various resources without knowing its type and physical location where it is stored. It collects heterogeneous data from different resources and allows data users across the organization to access this data according to their work requirements. This heterogeneous data can be accessed using any application such as web portals, web services, E-commerce, Software as a Service (SaaS), and mobile application.

We can use Data Virtualization in the field of **data integration, business intelligence,** and **cloud computing**.

Advantages of Data Virtualization

There are the following advantages of data virtualization -

- It allows users to access the data without worrying about where it resides on the memory.
- It offers better customer satisfaction, retention, and revenue growth.
- It provides various security mechanism that allows users to safely store their personal and professional information.
- It reduces costs by removing data replication.
- It provides a user-friendly interface to develop customized views.
- It provides various simple and fast deployment resources.
- It increases business user efficiency by providing data in real-time.
- It is used to perform tasks such as data integration, business integration, Service-Oriented Architecture (SOA) data services, and enterprise search.

Disadvantages of Data Virtualization

- It creates availability issues, because availability is maintained by third-party providers.
- It required a high implementation cost.
- It creates the availability and scalability issues.
- Although it saves time during the implementation phase of virtualization but it consumes more time to generate the appropriate result.

Uses of Data Virtualization

There are the following uses of Data Virtualization -

1. Analyze performance

Data virtualization is used to analyze the performance of the organization compared to previous years.

2. Search and discover interrelated data

Data Virtualization (DV) provides a mechanism to easily search the data which is similar and internally related to each other.

3. Agile Business Intelligence

It is one of the most common uses of Data Virtualization. It is used in agile reporting, real-time dashboards that require timely aggregation, analyze and present the relevant data from multiple resources. Both individuals and managers use this to monitor performance, which helps to make daily operational decision processes such as sales, support, finance, logistics, legal, and compliance.

4. Data Management

Data virtualization provides a secure centralized layer to search, discover, and govern the unified data and its relationships.

Data Virtualization Tools

There are the following Data Virtualization tools -

1. Red Hat JBoss data virtualization

Red Hat virtualization is the best choice for developers and those who are using micro services and containers. It is written in **Java**.

2. TIBCO data virtualization

TIBCO helps administrators and users to create a data virtualization platform for accessing the multiple data sources and data sets. It provides a builtin **transformation** engine to combine non-relational and un-structured data sources.

3. Oracle data service integrator

It is a very popular and powerful data integrator tool which is mainly worked with Oracle products. It allows organizations to quickly develop and manage data services to access a single view of data.

4. SAS Federation Server

SAS Federation Server provides various technologies such as scalable, multi-user, and standards-based data access to access data from multiple data services. It mainly focuses on securing data.

5. Denodo

Denodo is one of the best data virtualization tools which allows organizations to minimize the network traffic load and improve response time for large data sets. It is suitable for both small as well as large organizations.

Industries that use Data Virtualization

- **Communication & Technology**

  In Communication & Technology industry, data virtualization is used to increase revenue per customer, create a real-time ODS for marketing, manage customers, improve customer insights, and optimize customer care, etc.

- **Finance**

  In the field of finance, DV is used to improve trade reconciliation, empowering data democracy, addressing data complexity, and managing fixed-risk income.

- **Government**

  In the government sector, DV is used for protecting the environment.

- **Healthcare**

  Data virtualization plays a very important role in the field of healthcare. In healthcare, DV helps to improve patient care, drive new product innovation, accelerating M&A synergies, and provide a more efficient claims analysis.

- **Manufacturing**

  In manufacturing industry, data virtualization is used to optimize a global supply chain, optimize factories, and improve IT assets utilization.

2) Hardware Virtualization

Previously, there was *"one to one relationship"* between physical servers and operating system. Low capacity of CPU, memory, and networking requirements were available. So, by using this model, the costs of doing business increased. The physical space, amount of power, and hardware required meant that costs were adding up.

The **hypervisor** *manages shared the physical resources of the hardware between the guest operating systems and host operating system*. The physical resources become abstracted versions in standard formats regardless of the hardware platform. The abstracted hardware is represented as actual hardware. Then the virtualized operating system looks into these resources as they are physical entities.

Virtualization means abstraction. Hardware virtualization is accomplished by abstracting the physical hardware layer by use of a hypervisor or VMM (Virtual Machine Monitor).

When the virtual machine software or virtual machine manager (VMM) or hypervisor software 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 of Hardware Virtualization

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

Advantages of Hardware Virtualization

The main benefits of hardware virtualization are more efficient resource utilization, lower overall costs as well as increased uptime and IT flexibility.

1) More Efficient Resource Utilization:

Physical resources can be shared among virtual machines. Although the unused resources can be allocated to a virtual machine and that can be used by other virtual machines if the need exists.

2) Lower Overall Costs Because Of Server Consolidation:

Now it is possible for multiple operating systems can co-exist on a single hardware platform, so that the number of servers, rack space, and power consumption drops significantly.

3) Increased Uptime Because Of Advanced Hardware Virtualization Features:

The modern hypervisors provide highly orchestrated operations that maximize the abstraction of the hardware and help to ensure the maximum uptime. These functions help to migrate a running virtual machine from one host to another dynamically, as well as maintain a running copy of virtual machine on another physical host in case the primary host fails.

4) Increased IT Flexibility:

Hardware virtualization helps for quick deployment of server resources in a managed and consistent ways. That results in IT being able to adapt quickly and provide the business with resources needed in good time.

3) Software Virtualization

Managing applications and distribution becomes a typical task for IT departments. Installation mechanism differs from application to application. Some programs require certain helper applications or frameworks and these applications may have conflict with existing applications.

Software virtualization is just like a virtualization but *able to abstract the software installation procedure and create virtual software installations*.

Virtualized software is an application that will be "installed" into its own self-contained unit.

Example of software virtualization is *VMware software, virtual box* etc. In the next pages, we are going to see how to install linux OS and windows OS on VMware application.

Advantages of Software Virtualization

1) Client Deployments Become Easier:

Copying a file to a workstation or linking a file in a network then we can easily install virtual software.

2) Easy to manage:

To manage updates becomes a simpler task. You need to update at one place and deploy the updated virtual application to the all clients.

3) Software Migration:

Without software virtualization, moving from one software platform to another platform takes much time for deploying and impact on end user systems. With the help of virtualized software environment the migration becomes easier.

4) Server Virtualization

Server Virtualization is the process of dividing a physical server into several virtual servers, called **virtual private servers**. Each virtual private server can run independently.

The concept of Server Virtualization widely used in the IT infrastructure to minimizes the costs by increasing the utilization of existing resources.

Types of Server Virtualization

1. Hypervisor

In the Server Virtualization, Hypervisor plays an important role. It is a layer between the operating system (OS) and hardware. There are two types of hypervisors.

- Type 1 hypervisor (also known as bare metal or native hypervisors)
- Type 2 hypervisor (also known as hosted or Embedded hypervisors)

The hypervisor is mainly used to perform various tasks such as allocate physical hardware resources (CPU, RAM, etc.) to several smaller independent virtual machines, called **"guest"** on the host machine.

Tabular differentiation between Type 1 and Type 2 hypervisors:

Characteristic	Type 1 Hypervisor (Bare Metal)	Type 2 Hypervisor (Hosted)
Deployment	Installed directly on physical hardware	Installed on top of a host OS
Resource Management	Has direct access to hardware resources	Shares resources with host OS
Performance	Offers better performance due to direct hardware access	Introduces some performance overhead
Security	Typically more secure with strong isolation	May have a larger attack surface
Use Cases	Ideal for data centers, cloud environments, and mission-critical workloads	Commonly used for development, testing, and desktop virtualization
Examples	VMware vSphere/ESXi, Microsoft Hyper-V (bare metal), Xen	Oracle VirtualBox, VMware Workstation, Parallels Desktop
Management	Managed remotely using dedicated tools	Often managed through GUIs on the host OS
Typical Applications	Enterprise servers, cloud infrastructure	Development, testing, desktop virtualization
Overhead	Minimal overhead, as it eliminates the need for a host OS	Adds overhead due to running on top of a host OS

2. Full Virtualization

Full Virtualization uses a **hypervisor** to directly communicate with the CPU and physical server. It provides the best isolation and security mechanism to the virtual machines.

The biggest disadvantage of using hypervisor in full virtualization is that a hypervisor has its own processing needs, so it can slow down the application and server performance.

VMWare ESX server is the best example of full virtualization.

3. Para Virtualization

Para Virtualization is quite similar to the Full Virtualization. The advantage of using this virtualization is that it is **easier to use**, **Enhanced performance**, and **does not require emulation overhead**. Xen primarily and UML use the Para Virtualization.

The difference between full and pare virtualization is that, in para virtualization hypervisor does not need too much processing power to manage the OS.

4. Operating System Virtualization

Operating system virtualization is also called as system-lever virtualization. It is a **server virtualization technology** that divides one operating system into multiple isolated user-space called **virtual environments**. The biggest advantage of using server visualization is that it reduces the use of physical space, so it will save money.

Linux OS Virtualization and **Windows OS Virtualization** are the types of Operating System virtualization.

FreeVPS, **OpenVZ**, and **Linux Vserver** are some examples of System-Level Virtualization.

Note: OS-Level Virtualization never uses a hypervisor.

5. Hardware Assisted Virtualization

Hardware Assisted Virtualization was presented by **AMD and Intel**. It is also known as **Hardware virtualization**, **AMD virtualization**, and **Intel virtualization**. It is designed to increase the performance of the processor. The advantage of using Hardware Assisted Virtualization is that it requires less hypervisor overhead.

6. Kernel-Level Virtualization

Kernel-level virtualization is one of the most important types of server virtualization. It is an **open-source virtualization** which uses the Linux kernel as a hypervisor. The advantage of using kernel virtualization is that it does not require any special administrative software and has very less overhead.

User Mode Linux (UML) and **Kernel-based virtual machine** are some examples of kernel virtualization.

Advantages of Server Virtualization

There are the following advantages of Server Virtualization -

1. Independent Restart

In Server Virtualization, each server can be restarting independently and does not affect the working of other virtual servers.

2. Low Cost

Server Virtualization can divide a single server into multiple virtual private servers, so it reduces the cost of hardware components.

3. Disaster Recovery

Disaster Recovery is one of the best advantages of Server Virtualization. In Server Virtualization, data can easily and quickly move from one server to another and these data can be stored and retrieved from anywhere.

4. Faster deployment of resources

Server virtualization allows us to deploy our resources in a simpler and faster way.

5. Security

It allows uses to store their sensitive data inside the data centers.

Disadvantages of Server Virtualization

There are the following disadvantages of Server Virtualization -

1. The biggest disadvantage of server virtualization is that when the server goes offline, all the websites that are hosted by the server will also go down.
2. There is no way to measure the performance of virtualized environments.
3. It requires a huge amount of RAM consumption.
4. It is difficult to set up and maintain.
5. Some core applications and databases are not supported virtualization.
6. It requires extra hardware resources.

Uses of Server Virtualization

A list of uses of server virtualization is given below -

- Server Virtualization is used in the testing and development environment.
- It improves the availability of servers.
- It allows organizations to make efficient use of resources.
- It reduces redundancy without purchasing additional hardware components.

5) Storage Virtualization

As we know that, there has been a strong link between the physical host and the locally installed storage devices. However, that paradigm has been changing drastically, almost local storage is no longer needed. As the technology progressing, more advanced storage devices are coming to the market that provide more functionality, and obsolete the local storage.

Storage virtualization is a major component for storage servers, in the form of functional RAID levels and controllers. Operating systems and applications with device can access the disks directly by themselves for writing. The controllers configure the local storage in RAID groups and present the storage to the operating system depending upon the configuration. However, the storage is abstracted and the controller is determining how to write the data or retrieve the requested data for the operating system.

Storage virtualization is becoming more and more important in various other forms:

File servers: The operating system writes the data to a remote location with no need to understand how to write to the physical media.

WAN Accelerators: Instead of sending multiple copies of the same data over the WAN environment, WAN accelerators will cache the data locally and present the re-requested blocks at LAN speed, while not impacting the WAN performance.

SAN and NAS: Storage is presented over the Ethernet network of the operating system. NAS presents the storage as file operations (like NFS). SAN technologies present the storage as block level storage (like Fibre Channel). SAN technologies receive the operating instructions only when if the storage was a locally attached device.

Storage Tiering: Utilizing the storage pool concept as a stepping stone, storage tiering analyze the most commonly used data and places it on the highest performing storage pool. The lowest one used data is placed on the weakest performing storage pool.

This operation is done automatically without any interruption of service to the data consumer.

Advantages of Storage Virtualization

1. Data is stored in the more convenient locations away from the specific host. In the case of a host failure, the data is not compromised necessarily.
2. The storage devices can perform advanced functions like replication, reduplication, and disaster recovery functionality.
3. By doing abstraction of the storage level, IT operations become more flexible in how storage is provided, partitioned, and protected.

Disadvantages of Storage Virtualization

1) **Complexity:** Implementing storage virtualization can introduce complexity to the IT infrastructure. Managing virtualized storage resources and ensuring they are properly allocated and optimized can be challenging, especially in large-scale environments.
2) **Cost:** While storage virtualization can lead to cost savings through better resource utilization, the initial investment in virtualization hardware and software can be significant. Additionally, ongoing maintenance and management costs can add up over time.
3) **Performance Overheads:** Storage virtualization introduces an additional layer of abstraction between applications and physical storage devices. This layer can introduce performance overhead, especially if not properly configured or if the virtualization layer becomes a bottleneck.
4) **Compatibility and Vendor Lock-In:** Storage virtualization solutions may not always be compatible with all existing storage hardware or software. This can limit your choice of storage devices and potentially lead to vendor lock-in, where you are dependent on a specific vendor's virtualization technology.
5) **Data Migration Challenges:** Moving data between different storage arrays or platforms can be complex and time-consuming. Storage virtualization solutions may require data migration when new hardware is added or when you want to change storage vendors.
6) **Risk of Data Loss:** Any issues with the storage virtualization layer, such as software bugs or hardware failures, can potentially lead to data loss or corruption. It's crucial to have robust backup and disaster recovery plans in place.