What Is Virtualization in Cloud Computing?

Virtualization is the process of creating a virtual environment on an existing server to run your desired program, without interfering with any of the other services provided by the server or host platform to other users. The Virtual environment can be a single instance or a combination of many such as operating systems, Network or Application servers, computing environments, storage devices, and other such environments. The concept of virtualization will be easily understood after going through the different types of virtualization.

What Are The Benefits Of Virtualization?

Numerous benefits are provided by virtualization which includes, reduction in costs, efficient utilization of resources, better accessibility, and minimization of risk among others.

Virtualization Benefits for Companies

1. Removal of special hardware and utility requirements
2. Effective management of resources
3. Increased employee productivity as a result of better accessibility
4. Reduced risk of data loss, as data is backed up across multiple storage locations

Benefits for Data Centers

1. Maximization of server capabilities, thereby reducing maintenance and operation costs
2. Smaller footprint as a result of lower hardware, energy, and manpower requirements

How Does Virtualization Work?

Access to the virtual machine and the host machine or server is facilitated by software known as Hypervisor. Hypervisor acts as a link between the hardware and the virtual environment and distributes the hardware resources such as CPU usage, memory allotment between the different virtual environments.

What Are The Types of Virtualization?

Virtualization can take many forms depending on the type of application use and hardware utilization. The main types are listed below:

Hardware Virtualization

Hardware virtualization is also known as hardware-assisted virtualization or server virtualization runs on the concept that an individual independent segment of hardware or a physical server, may be made up of multiple smaller hardware segments or servers, essentially consolidating multiple physical servers into virtual servers that run on a single primary physical server. Each small server can host a virtual machine, but the entire cluster of servers is treated as a single device by any process requesting the hardware. The hardware resource allotment is done by the hypervisor. The main advantages include increased processing power as a result of maximized hardware utilization and application uptime.

Subtypes:

- Full Virtualization – Guest software does not require any modifications since the underlying hardware is fully simulated.
- Emulation Virtualization – The virtual machine simulates the hardware and becomes independent of it. The guest operating system does not require any modifications.
- Paravirtualization – the hardware is not simulated and the guest software runs their own isolated domains.

Software Virtualization

Software Virtualization involves the creation of an operation of multiple virtual environments on the host machine. It creates a computer system complete with hardware that lets the guest operating system to run. For example, it lets you run Android OS on a host machine natively using a Microsoft Windows OS, utilizing the same hardware as the host machine does.

Subtypes:

- Operating System Virtualization – hosting multiple OS on the native OS
- Application Virtualization – hosting individual applications in a virtual environment separate from the native OS
- Service Virtualization – hosting specific processes and services related to a particular application

Memory Virtualization

Physical memory across different servers is aggregated into a single virtualized memory pool. It provides the benefit of an enlarged contiguous working memory. You may already be familiar with this, as some OS such as Microsoft Windows OS allows a portion of your storage disk to serve as an extension of your RAM.

Subtypes:

- Application-level control – Applications access the memory pool directly
- Operating system-level control – Access to the memory pool is provided through an operating system

Storage Virtualization

Multiple physical storage devices are grouped together, which then appear as a single storage device. This provides various advantages such as homogenization of storage across storage devices of multiple capacity and speeds, reduced downtime, load balancing and better optimization of performance and speed. Partitioning your hard drive into multiple partitions is an example of this virtualization.

Subtypes:

- Block Virtualization – Multiple storage devices are consolidated into one
- File Virtualization – Storage system grants access to files that are stored over multiple hosts

Data Virtualization

It lets you easily manipulate data, as the data is presented as an abstract layer completely independent of data structure and database systems. Decreases data input and formatting errors.

Network Virtualization

It lets you easily manipulate data, as the data is presented as an abstract layer In network virtualization, multiple sub-networks can be created on the same physical network, which may or may not is authorized to communicate with each other. This enables restriction of file movement across networks and enhances security, and allows better monitoring and identification of data usage which lets the network administrators scale up the network appropriately. It also increases reliability as a disruption in one network doesn't affect other networks, and the diagnosis is easier.

Subtypes:

- Internal network: Enables a single system to function as a network
- External network: Consolidation of multiple networks into a single one, or segregation of a single network into multiple ones

Desktop Virtualization

This is perhaps the most common form of virtualization for any regular IT employee. The user's desktop is stored on a remote server, allowing the user to access his desktop from any device or location. Employees can work conveniently from the comfort of their homes. Since the data transfer takes place over secure protocols, any risk of data theft is minimized.

IMPLEMENTATION LEVELS OF VIRTUALIZATION IN CLOUD COMPUTING

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.

1.) Instruction Set Architecture Level (ISA)

ISA virtualization can work through ISA emulation. This is used to run many legacy codes that were written for a different configuration of hardware. These codes run on any virtual machine using the ISA. With this, a binary code that originally needed some additional layers to run is now capable of running on the x86 machines. It can also be tweaked to run on the x64 machine. With ISA, it is possible to make the virtual machine hardware agnostic.

For the basic emulation, an interpreter is needed, which interprets the source code and then converts it into a hardware format that can be read. This then allows processing. This is one of the five implementation levels of virtualization in cloud computing.

2.) Hardware Abstraction Level (HAL)

True to its name HAL lets the virtualization perform at the level of the hardware. This makes use of a hypervisor which is used for functioning. At this level, the virtual machine is formed, and this manages the hardware using the process of virtualization. It allows the virtualization of each of the hardware components, which could be the input-output device, the memory, the processor, etc.

Multiple users will not be able to use the same hardware and also use multiple virtualization instances at the very same time. This is mostly used in the cloud-based infrastructure.

3.) Operating System Level

At the level of the operating system, the virtualization model is capable of creating a layer that is abstract between the operating system and the application. This is an isolated container that is on the operating system and the physical server, which makes use of the software and hardware. Each of these then functions in the form of a server.

When there are several users, and no one wants to share the hardware, then this is where the virtualization level is used. Every user will get his virtual environment using a virtual hardware resource that is dedicated. In this way, there is no question of any conflict.

4.) Library Level

The operating system is cumbersome, and this is when the applications make use of the API that is from the libraries at a user level. These APIs are documented well, and this is why the library virtualization level is preferred in these scenarios. API hooks make it possible as it controls the link of communication from the application to the system.

5.) Application Level

The application-level virtualization is used when there is a desire to virtualize only one application and is the last of the implementation levels of virtualization in cloud computing. One does not need to virtualize the entire environment of the platform.

This is generally used when you run virtual machines that use high-level languages. The application will sit above the virtualization layer, which in turn sits on the application program.

It lets the high-level language programs compiled to be used in the application level of the virtual machine run seamlessly.

Benefits of virtualization

Virtualizing your environment can increase scalability while simultaneously reducing expenses, and the following details a just a few of the many benefits that virtualization can bring to your organization:

1. **Slash your IT expenses**

Utilizing a non-virtualized environment can be inefficient because when you are not consuming the application on the server, the compute is sitting idle and can't be used for other applications. When you virtualize an environment, that single physical server transforms into many virtual machines. These virtual machines can have different operating systems and run different applications while still all being hosted on the single physical server.

The consolidation of the applications onto virtualized environments is a more cost-effective approach because you'll be able to consume fewer physical customers, helping you spend significantly less money on servers and bring cost savings to your organization.

2**. Reduce downtime and enhance resiliency in disaster recovery situations**

When a disaster affects a physical server, someone is responsible for replacing or fixing it—this could take hours or even days. With a virtualized environment, it's easy to provision and deploy, allowing you to replicate or clone the virtual machine that's been affected. The recovery process would take mere minutes—as opposed to the hours it would take to provision and set up a new physical server—significantly enhancing the resiliency of the environment and improving business continuity.

3. **Increase efficiency and productivity**

With fewer servers, your IT teams will be able to spend less time maintaining the physical hardware and IT infrastructure. You'll be able to install, update, and maintain the environment across all the VMs in the virtual environment on the server instead of going through the laborious and tedious process of applying the updates server-by-server. Less time dedicated to maintaining the environment increases your team's efficiency and productivity.

4. **Control independence and DevOps**

Since the virtualized environment is segmented into virtual machines, your developers can quickly spin up a virtual machine without impacting a production environment. This is ideal for Dev/Test, as the developer can quickly clone the virtual machine and run a test on the environment.

For example, if a new software patch has been released, someone can clone the virtual machine and apply the latest software update, test the environment, and then pull it into their production application. This increases the speed and agility of an application.

5. **Move to be more green-friendly (organizational and environmental)**

When you are able to cut down on the number of physical servers you're using, it'll lead to a reduction in the amount of power being consumed. This has two green benefits:

- It reduces expenses for the business, and that money can be reinvested elsewhere.
- It reduces the carbon footprint of the data center.

Server virtualization

Server virtualization is a partition of physical servers into multiple virtual servers. Here, each virtual server is running its own operating system and applications. It can be said that server virtualization in cloud computing is the masking of server resources.

The server is familiar with the identity of individual physical servers. The single physical server is divided into multiple isolated virtual servers, with the help of software.

Types of Server Virtualization

There are 3 types of server virtualization in cloud computing:

i. **Hypervisor**

A Hypervisor is a layer between the **operating system** and hardware. The hypervisor is the reason behind the successful running of multiple operating systems.

It can also perform tasks such as handling queues, dispatching and returning the hardware request. Host operating system works on the top of the hypervisor, we use it to administer and manage the virtual machines.

ii**. Para-Virtualization**

In Para-virtualization model, simulation in trapping overhead in software virtualizations. It is based on the hypervisor and the guest operating system and modified entry compiled for installing it in a virtual machine.

After the modification, the overall performance is increased as the guest operating system communicates directly with the hypervisor.

iii**. Full Virtualization**

Full virtualizations can emulate the underlying **hardware**. It is quite similar to Para-virtualization. Here, machine operation used by the operating system which is further used to perform input-output or modify the system status.

The unmodified operating system can run on the top of the hypervisor. This is possible because of the operations, which are emulated in the software and the status codes are returned with what the real hardware would deliver.

How Server Virtualization Works?

Lucid is the basic principle of working of the server virtualization. Each virtual server performs like a unique physical device, which is capable to run its own operating system. Here software which is specially designed for this purpose is used.

An administrator which is present in the software can convert one physical server into multiple servers. So these multiple servers are enough to use all the machines processing power.

CPU works with multiple processors that provides the ability to run several complicated tasks with ease. Here, the virtual server specially dedicates only to a particular task to perform better. There are many servers which use only a small part of their overall capability.

Hypervisor

A hypervisor is a form of virtualization software used in Cloud hosting to divide and allocate the resources on various pieces of hardware. The program which provides partitioning, isolation or abstraction is called virtualization hypervisor. The hypervisor is a hardware virtualization technique that allows multiple guest operating systems (OS) to run on a single host system at the same time. A hypervisor is sometimes also called a virtual machine manager(VMM).

Types of Hypervisor

TYPE-1 Hypervisor:

The hypervisor runs directly on the underlying host system. It is also known as "Native Hypervisor" or "Bare metal hypervisor". It does not require any base server operating system. It has direct access to hardware resources. Examples of Type 1 hypervisors include VMware ESXi, Citrix XenServer and Microsoft Hyper-V hypervisor.

Pros & Cons of Type-1 Hypervisor:

Pros: Such kind of hypervisors are very efficient because they have direct access to the physical hardware resources(like Cpu, Memory, Network, Physical storage). This causes the empowerment the security because there is nothing any kind of the third party resource so that attacker couldn't compromise with anything.

Cons: One problem with Type-1 hypervisor is that they usually need a dedicated separate machine to perform its operation and to instruct different VMs and control the host hardware resources.

TYPE-2 Hypervisor:

A Host operating system runs on the underlying host system. It is also known as ‘Hosted Hypervisor”. Such kind of hypervisors doesn’t run directly over the underlying hardware rather they run as an application in a Host system(physical machine). Basically, software installed on an operating system. Hypervisor asks the operating system to make hardware calls. Example of Type 2 hypervisor includes VMware Player or Parallels Desktop. Hosted hypervisors are often found on endpoints like PCs. The type-2 hypervisor is are very useful for engineers, security analyst(for checking malware, or malicious source code and newly developed applications).

Pros & Cons of Type-2 Hypervisor:

Pros: Such kind of hypervisors allows quick and easy access to a guest Operating System alongside the host machine running. These hypervisors usually come with additional useful features for guest machine. Such tools enhance the coordination between the host machine and guest machine.

Cons: Here there is no direct access to the physical hardware resources so the efficiency of these hypervisors lags in performance as compared to the type-1 hypervisors, and potential security risks are also there an attacker can compromise the security weakness if there is access to the host operating system so he can also access the guest operating system.

HYPERVISOR REFERENCE MODEL :

There are 3 main modules coordinates in order to emulate the underlying hardware:

1. DISPATCHER:
   The dispatcher behaves like the entry point of the monitor and reroutes the instructions of the virtual machine instance to one of the other two modules.

2. ALLOCATOR:
   The allocator is responsible for deciding the system resources to be provided to the virtual machine instance.It means whenever virtual machine tries to execute an instruction that results in changing the machine resources associated with the virtual machine, the allocator is invoked by the dispatcher.

3. INTERPRETER:
   The interpreter module consists of interpreter routines.These are executed, whenever virtual machine executes a priviliged instruction.

Load balancing in Cloud Computing

Cloud load balancing is defined as the method of splitting workloads and computing properties in a cloud computing. It enables enterprise to manage workload demands or application demands by distributing resources among numerous computers, networks or servers. Cloud load balancing includes holding the circulation of workload traffic and demands that exist over the Internet.

As the traffic on the internet growing rapidly, which is about 100% annually of the present traffic. Hence, the workload on the server growing so fast which leads to the overloading of servers mainly for popular web server. There are two elementary solutions to overcome the problem of overloading on the servers-

- First is a single-server solution in which the server is upgraded to a higher performance server. However, the new server may also be overloaded soon, demanding another upgrade. Moreover, the upgrading process is arduous and expensive.
- Second is a multiple-server solution in which a scalable service system on a cluster of servers is built. That’s why it is more cost effective as well as more scalable to build a server cluster system for network services.

Load balancing solutions can be categorized into two types –

1. **Software-based load balancers:** Software-based load balancers run on standard hardware (desktop, PCs) and standard operating systems.
2. **Hardware-based load balancer:** Hardware-based load balancers are dedicated boxes which include Application Specific Integrated Circuits (ASICs) adapted for a particular use. ASICs allows high speed promoting of network traffic and are frequently used for transport-level load balancing because hardware-based load balancing is faster in comparison to software solution.