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A Review on Virtualization: A Cloud Technology

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Abstract:- Cloud computing is used to utilize the shared resources to a maximum possible extent. These resources are shared by more than one user at a time as per their need. This improves computing power for using various applications at various places with additional advantage of cost saving on storage space and electricity consumption. Virtualization is one of the important technologies of cloud computing, which directs to act virtually instead of actually doing something. Through virtualization software, sharing of the system resources is done across multiple environments. This paper mainly focuses on introduction to virtualization, advantages & disadvantages of virtualization and types of virtualization like: server, desktop, application, programming language, storage, network virtualization etc. Server virtualization involves partitioning a main server into different virtual servers. Desktop virtualization jointly with application virtualization is used to provide a desktop environment management system. Applications in the application virtualization are executed on different operating system as if it is executing on original operating system. Storage virtualization makes available data from multiple network storage devices into one single storage unit. Network virtualization is the process of combining hardware and software network resources into a single virtual network through software. In addition to this, the paper provides future research direction in virtualization.

Keywords- *Virtualization, Cloud Computing, Virtualization Types, Virtual Machine, Virtual Server, Hypervisor.*

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I. INTRODUCTION

Cloud Computing: The word "cloud" from "cloud computing" is a collection of hardware, storage, networks, interfaces and services that enable the delivery of computing as a service [1]. Cloud computing provides various services and resources from remote data centers to organizations or individuals. It is a technology used to reduce complexities of computing needs and getting results quickly and cost effectively. The cloud services may include: the delivery of software or infrastructure, may relate to: storage over internet, social networking (Facebook, LinkedIn) and collaboration tools (like video conferencing, document management, and webinars) etc. The services provided are either public (external) or private or hybrid (combination of public and private). It can be delivered wherever and whenever one may need. Applications of cloud computing are available in development of software product, architecture of software and in managing service foundations.

Cloud Characteristics: **Elasticity:** Users may demand additional resources whenever required or may release the same when they are not needed. It is the ability to scale up and down. **Multi-tenancy: U**sers of different organizations can share the same underlying resources. **Self-service provisioning and automatic de-provisioning**, **application programming interfaces:** These interfaces provide the instructions on how two applications or data sources can communicate with each other. **Billing and metering of services:** Usage in a pay-as-you-go model.

Virtualization: Cloud Computing virtualizes systems by pooling and sharing resources. Systems and storage can be provisioned wherever and whenever needed [2]. It is the process of creating new computer resources using the existing computer resources efficiently. In other words it is the process used to separate resources and services from the underlying physical system. Virtualization technologies are available in many kinds: operating system (OS) level, the programming language (PL) level, application level, storage, memory and networking. Virtualization has three main characteristics which make it suitable for cloud computing:

Partitioning: A single physical system can support various applications and operating systems by partitioning the available resources.

Isolation: Each virtual machine (VM) can work in isolation without affecting host physical system and other virtualized machines. Data is not shared between one virtual machine to another.

Encapsulation: A virtual machine can be identified easily based on the service it provides as it is stored or represented as a single file. Encapsulation can protect each application so that it doesn't interfere with another application.

In a virtualized environment [3] host, virtualization layer and guest are the main components as shown in fig. 1.1.

The component host represents the original physical system where the guest systems are managed. The component virtualization layer recreates the environment where the guest will operate. The component guest interacts with the virtualization layer directly rather than host system. The virtual environment is created to implement various kinds of virtualization by means of a software program. Different applications can be executed securely on guest systems against the virtual machine in the controlled execution environment. All the operations of these applications are then translated and applied on the host through the virtual machine manager (VMM). VMM prevents harmful operations from being performed on the guest. Various resources and sensitive information available on host system are hidden from the guest machine.

Virtual Machine: It is the emulation of a particular computer system. These machines are operated on the basis of architecture and functions of a real machine, and are implemented as hardware, software or a combination of both.
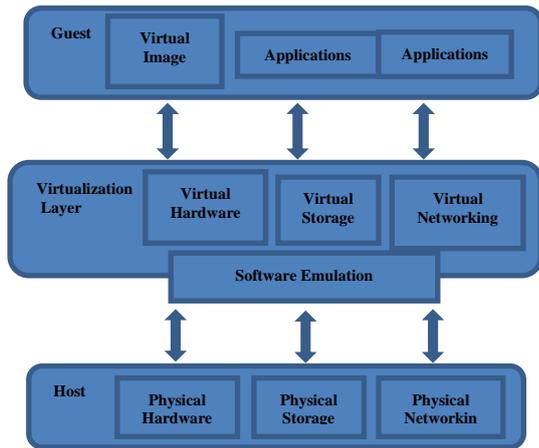
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Fig. 1.1 Reference Model for Virtualization

Hypervisor: The hypervisor is a program or a combination of software, hardware or firmware that creates and executes various Virtual machines. The computer running hypervisor is called the host machine. There are two types of hypervisors [4]: Type I: Native VM hypervisors and Type II: Hosted VM Hypervisors.

In type I, hardware and guest operating system can be controlled and managed resp. by executing hypervisors directly on the host machine. These are also called as bare metal hypervisors. On the host machine operating system of a guest runs as a process. In the 1960s, IBM developed the first hypervisors, which are called as native hypervisors.

In type II, it requires the support of an operating system to provide virtualization services. In this type hypervisors are run on a conventional operating system in the same way as other computer programs run. Type-2 hypervisors abstract guest operating systems from the host operating system. VMware workstation and virtual box are examples of type-2 hypervisors.

II. CLASSIFICATION OF VIRTUALIZATION TECHNIQUES

There are different areas of computing where virtualization techniques can be classified. Some of the commonly used techniques are shown in fig 1.2. Among these virtualization Process level and hardware virtualization are the most developed virtualization techniques. Process level techniques are implemented on top of the host operating system with full hardware control. System-level techniques are implemented directly on hardware and do not require any support from an existing operating system.

III. VIRTUALIZATION TYPES

Virtualization in cloud computing can be referred as the process of creating a virtual instead of actual version of something which includes operating system, hardware devices, storage devices, network and many more resources. Following section gives detailed information about this.

A. *Application Virtualization*

In this technology applications are executed in the runtime environment where no support is available for its features to run. These applications are executed without its installations

but as though it is running actually in that environment. This is done through a virtualization layer [4]. It replaces some part of execution environment of the operating system. This layer diverts all disk operations of the application to a virtual location (a file). The application doesn't know whether it is accessing virtual resources or actual resources. As the application is working with a file instead of files it becomes easy to run the application on a different computer. For ex. Windows 7 operating system allows Windows XP applications to run on Windows 7 without doing any modifications in the applications. Linux operating system also supports these types of virtualization. Different technologies that falls under application virtualization are application streaming, remote desktop services and desktop virtualization. Following are some of the advantages of the application virtualization: it runs applications in the environment which doesn't suit otherwise as explained earlier; number of resources used is less as compared to VM, reduces administration costs and allows applications to run on guest machines without installing them on it.
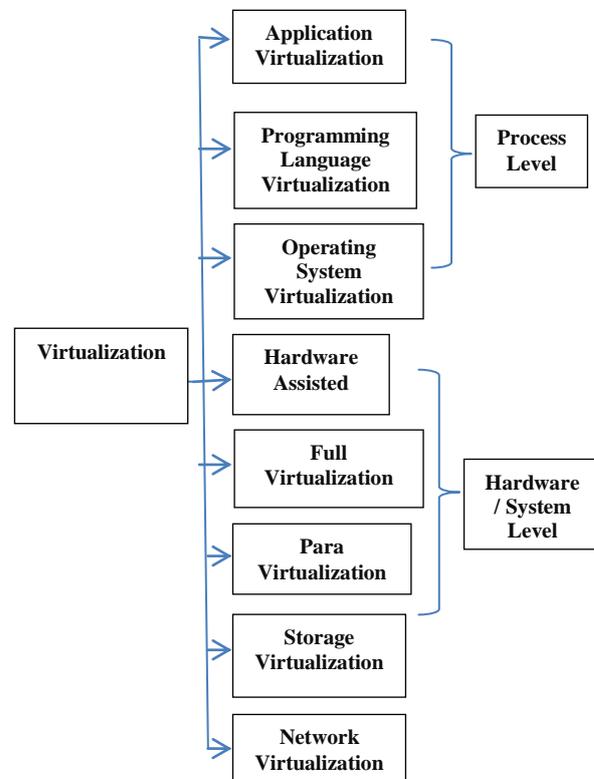

Fig. 1.2 Virtualization Types

B. *Programming Language Virtualization*

PL virtualizations are created as a platform to develop internet enterprise applications in java. Java VM was used to execute java as well as other language programs like Python, Ruby, Pascal, Groovy etc. This technique can execute byte codes of programs produced by compilation process on VMs of any OS & platforms. This helps in development and deployment process otherwise it needs to provide different versions of the same code. This is quite expensive but can be done once for all applications. It has various advantages: easy to deploy applications, portability across different platforms & operating system and managed execution. At execution time, byte code can be interpreted against the underline hardware instruction set. The execution of programs does not require

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direct memory access. I/O operations are also filtered to provide security. This may lead to low quality performance and less importance to these types of applications.

C. Operating System Virtualization

In this virtualization, kernel of the operating system allows more than one user space instances in isolation. It creates various separate running environments for applications that are managed concurrently. It is generally used to allocate resources securely to the mutually mistrusting users. A user space instance contains information like: file system view, IP addresses, software configurations and access to devices. It also provides stronger namespace and has time sharing operating system. These are also used by system administrators for combining server hardware by moving services to separate hosts. This virtualization imposes no overhead as applications executed uses system calls directly without emulation. There is no need to modify any specific hardware or application to run it.

D. Hardware Virtualization

Hardware level virtualization provides computer hardware as an execution environment on which guest operating system can be executed. In this, the guest is represented as an operating system, the host is represented as a physical system, the virtual machine is represented by host emulation and the virtual machine manager by the hypervisor. The definition and types of hypervisor is already given in the introduction part.

A virtual machine created by hardware virtualization acts like a real computer with an operating system. The underlying hardware resources can separate various software's run on virtual machines. For example, if a host machine has an operating system as a Microsoft Windows then a guest machine may have the Ubuntu Linux as an operating system. It can also run Ubuntu-based software's on it. Hardware-assisted virtualization, para-virtualization and full-virtualization are the different types of hardware virtualization techniques. Hardware virtualization techniques are also called as server virtualization [5].

E. Server Virtualization

This technology works on the resources of the server system [6]. These resources include operating system and/or different devices connected to the system. These resources are distributed to various isolated virtual machines by using special software. This type of virtualization is mainly useful for following reasons: sharing, utilizing, improving scalability and management of resources connected to the server system.

F. Hardware-assisted Virtualization

This technique [4] is introduced by IBM System/370 in 1972 for use with VM/370, the first VM operating system. It provides hardware architectural support [3] to create a VMM which executes a guest operating system in isolation but this is not available on all x86/x86_64 processors. If hardware-assisted virtualization technique creates more VMs with unmodified guest operating systems then it may contribute some of the problems: high CPU overhead, less scalability and the efficiency of server consolidation. The main advantage of hardware assisted virtualization is to reduce the maintenance overhead of para-virtualization by eliminating the changes

needed in the guest OS. Better performance can also be acquired easily.

G. Full Virtualization

Full virtualization provides a complete simulation of every feature of the underlying hardware. This will include the privileged instructions (such as I/O instructions), interrupts, memory access, etc. All these elements are executed directly in a virtual machine as it runs on the raw hardware, provided VMM should be able to support a complete emulation of the underlying hardware. The main advantages of the full virtualization includes isolating users from each other, ease of emulation of different architectures, sharing a computer system among multiple users and emulating new hardware to achieve improved reliability and security.

H. Para-Virtualization

In this technology, a software interface to VMs can be provided which may not be identical but similar to the underlying hardware. The main advantage of para-virtualization is to provide the capability to host machine to perform critical operations and prevent performance losses if any, which would otherwise be experienced on guest machines. The process can be done through VMM by transferring the execution of these operations from guest machine to host machines and therefore guest operating system needs to be modified and should be ported through VM software interface. If the operating system's source code is available then only this process is possible otherwise not and because of this reason para-virtualization was explored in the open source. Operating systems that cannot be ported can still take advantage of para-virtualization by using ad hoc device drivers that remap the execution of critical instructions to the para-virtualization APIs exposed by the hypervisor. Examples of para-virtualization includes: IBM VM, Xen, etc.

I. Storage Virtualization

This technology provides reliable and advanced facilities (to protect data) in the storage systems. This also provides vary fast access for computing and data processing purpose through special software, hardware and hard disk drives. Users don't need to worry about the location of the data as it can be represented as a logical path. Storage virtualization has following types of virtualization: Block Virtualization and File Virtualization. In block virtualization, data can be accessed without concern to its actual storage location as logical storage is separated from its physical storage. In file virtualization, it removes the dependencies between actual data location and data access. The most common advantages of the storage virtualization are as follows: these are very simple to design and code, it supports various storage types and improves use of storage without any restriction.

J. Network Virtualization

This technology provides a virtual network through which it facilitates software & hardware network resources along with network facilities. This is classified as external (combination of part/full of networks into a virtual logical unit) or internal (a software containing network functionalities) virtualization. External network virtualization is also called as a virtual LAN. In internal network virtualization guests can communicate with the virtual network through the virtual network interfaces shared by the host. Network virtualization is useful in software testing applications to verify software simulation of a network

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environment by emulating connections between services, applications, dependencies and users without testing it physically.

IV. CLOUD COMPUTING AND VIRTUALIZATION

Role of virtualization is very crucial in cloud computing because it has so many advantages to deliver IT services on demand to various users, like execution in isolation, security, manageability etc. Virtualization also provides virtual computing environment along with execution of virtualization techniques. Primarily, cloud computing have adopted Infrastructure as a service (IaaS) and Platform as a service (PaaS) as hardware and PL virtualization techniques respectively. Hardware virtualization uses server consolidation and VM migration techniques more than the PL virtualization. VM migration allows changing a platform from an environment to another one in isolation and controllable manner. This is more useful when resources are underutilized. Server consolidation allows aggregation of VMs over a smaller number of resources with full utilization. Virtualization technology also offers dynamic and huge storage facilities as a service along with the execution of virtualization techniques. Finally, cloud computing offers an ability to recreate the entire computing stack from IaaS to application services on demand to a thin client over a capable Internet connection.

V. ADVANTAGES AND DISADVANTAGES OF VIRTUALIZATION

In spite of various on demand IT services and infrastructure provided by virtualization it has various advantages and disadvantages. Advantages of virtualization includes: managed execution and isolation, portability & self-containment, more efficient use of resources, data recovery is simple, safe platform to check software configurations before deployment, less energy consumption and better system security and reliability. Disadvantages of virtualization includes: performance degradation, dependent on processing power and memory of host system, inefficiency and degraded user experience, security holes and new threats.

VI. CONCLUSION AND FUTURE RESEARCH DIRECTION

This paper has discussed basic knowledge about cloud computing & virtualization, different virtualization types, hypervisors and advantages and disadvantages of virtualization. Combination of virtualization techniques and cloud computing provides services to customers which are pooled with different resources that are utilized anywhere any time. In future, new policies may be developed to reach to next higher level than the elasticity where security and legislation issues of cloud computing can be solved.

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