Unit-II M-16

# Virtualization

## 2.1 Introduction :-

Virtualization in cloud Computing is the technology that enables cloud providers to create & Manage Multiple virtual Resources such as Virtual Machines, Storage & Networks on a single physical infrastructure

"Virtualization is the process of creating a virtual Representation of Hardware such as server, Storage Network or other physical M/c.

"Virtualization is the process or technology that enable to create virtual environment from single physical Machine"

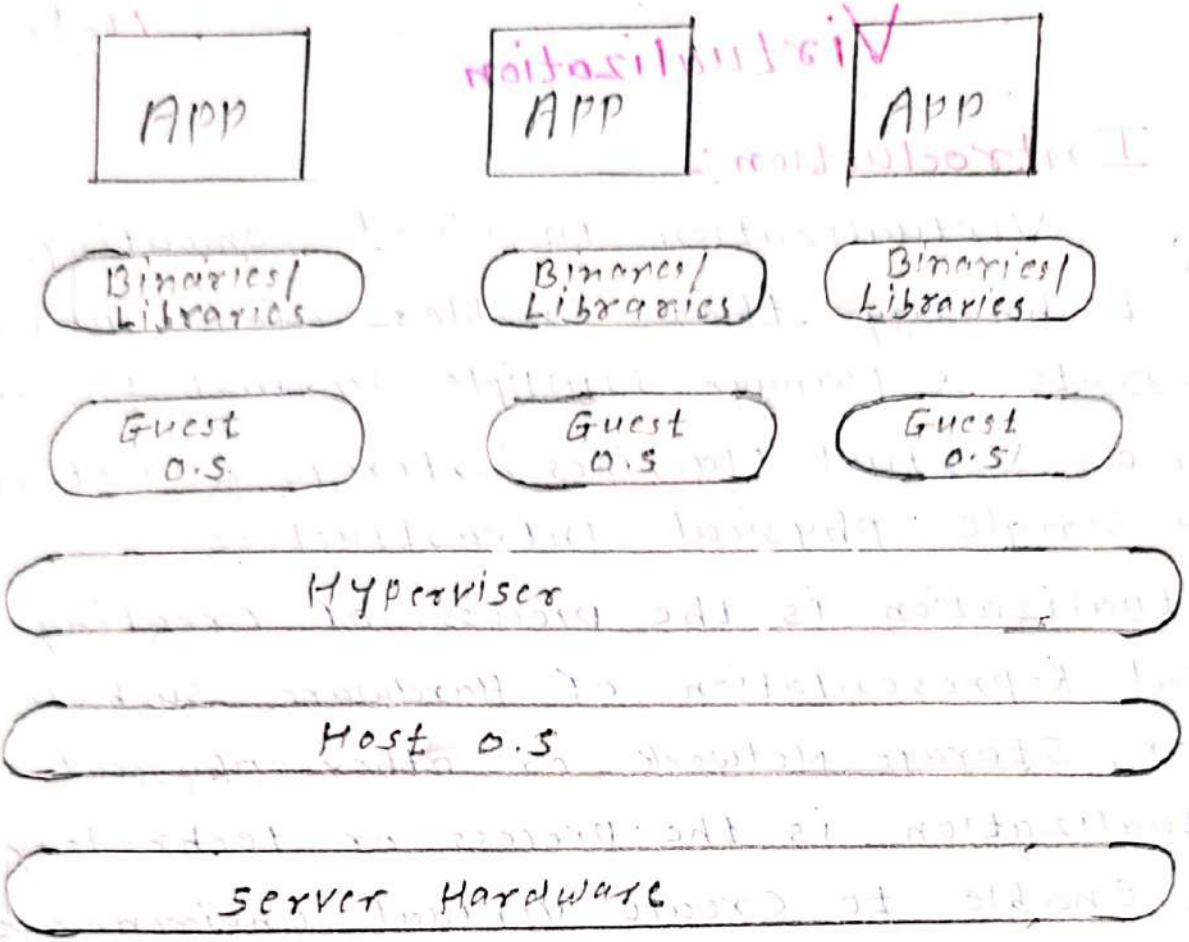
- It Supports Multiple Copies of Virtual Machines (VMs) to execute on one physical Machine each with their own operating System & programs

- This optimizes hardware efficiency & flexibility and enables Resources to be shared between multiple Customers or organizations

Virtualization technologies Not only provides a virtual environment for executing applications, but also for Storage, Memory & Networking

Virtualization is the key to provide Infrastructure As as Service (Iaas) solutions for cloud Computing Where by the User has access to Remote -

Computing Resources.




Virtualization

Virtualization Uses special software known as hypervisor to create many virtual computers (Cloud instances) on one physical computer The virtual Machine behave like Actual Computers Use the same physical Machine.

- After installing virtualization software on your computer you can setup one or more virtual Machines.

The virtual Machine are similar to other Applications on the computer

The Actual computer is "host" and the virtual computers are the "guests".

We can have several guests on a single host

& May the same or different from host.
- A hypervisors is the software that gets virtualization to work
- It serves as an intermediary between the physical computers & the virtual Machines
The hypervisor controls the virtual machines use of the physical Resources of the host computer (such as CPU & Memory)
There exist two categories of hypervisor

Type-I Hypervisor (Bare Metal Hypervisor)

The Hypervisor is installed directly onto the Computer hardware, without An operating System sitting in between
it is highly efficient as it has a direct Access to the Resources of the computer.

Type-2 Hypervisor:-

It is Run over an installed O.S (such as windows or Mac O.S)
It is employed when you Need to execute More than one o.s on one one Machine
it is expected that in a hypervisiour-managed environment code of guest os runs in User to to prevent it from the direct-Access of o.s Status It is No Longer possible to completely isolate the guest os when Non-priviledged instruction are implemented.

# Virtualization Reference Model:-

The Virtualization Reference Model (VRM) is a conceptual framework that describes how virtualization components interact in a cloud computing environment. It illustrates the layer & components involved in providing virtualized resources like compute, storage, network to user abstracted from the physical hardware

## Layers of Virtualization Reference Model:-

### 1. Physical or Hardware Layer:-

Description:- Represents the physical infrastructure

Components:- · Servers (CPU, Memory)
· Storage devices:- HDDs, SSDs, SAN
· Network devices:- Switches, Routers

Function:- Provides the Raw Resources that are Virtualized.

### 2. Virtualization or Hypervisor Layer:-

Also called as Virtual Machine Monitor (VMM)

Description:- Software that creates & manages virtual Machine (VMs)

Types:- Type-1 (Bare-Metal):- Runs directly on hardware e.g. VMware, Esxi, MS hyper-V, Xen)

Type-2 (Hosted):- Runs on a host O.S
e.g. oracle, Virtual Box, VMware Workstation

Functions:-
· Abstracts & Allocates Hardware to VMs
· Provides isolation between VMs
· Manages VM lifecycle (create, start,

suspend, destroy)

3. Virtual Machine Layer:

Description: Individual guest environments created by the hypervisor

Components:

Guest Operating system (Linux, windows etc)

Applications.

Functions: operates like a Real M/c, Users can install & Run s/w just like on physical H/w.

4. Management layer:-

Description: Interfaces & tools for Managing virtualization infrastructure

Components: VM Managers (VCenter, openstack, Nova, oVirt)

Monitoring & Analytics systems.

Functions: VM provisioning & deprovisioning

: Resource allocation & Scheduling

: performance Monitoring

: Fault Mgt. & Recovery

5. User Layer or Interface Layer:

Description: front-end interface for end-users or system administrators.

Components: Web-based dashboards

: API/CLI tools

Functions: Allows Users to Request, configure & access Virtual Resources.

provide Reports & Logs

Enable self-service in public & private clouds.

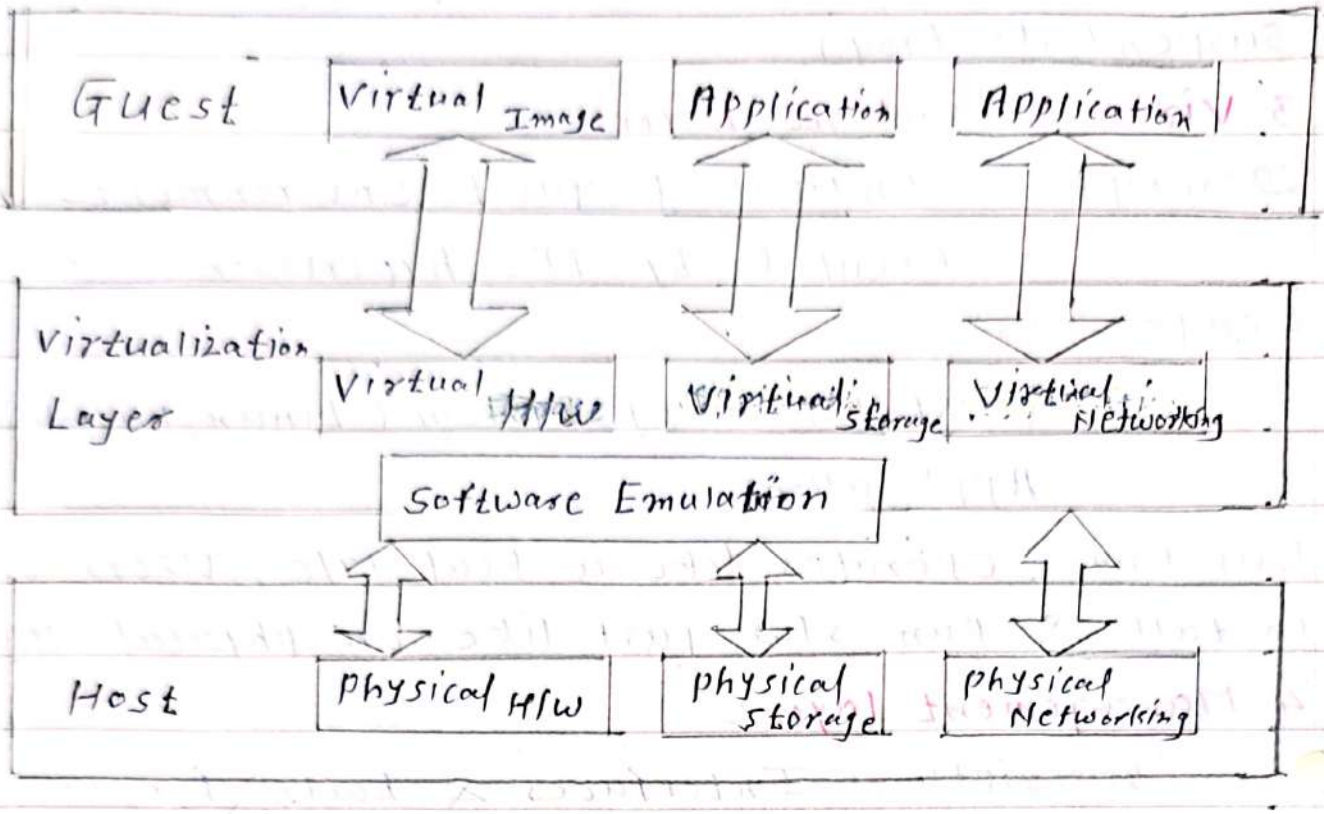



fig. Reference Model of virtualization

## Characteristics of Virtualized Environment:-

Some of the important characteristics of virtualization include the following.

1. Increased Security:- The ability to control the execution of a guest in a completely transparent Manners opens new posibilities for delivering a secure, controlled execution environment. The virtual Machine Represent an emulated environment in which the guest is executed. All the operations of the guest are generally performed against the virtual Machine which then translates & applies them to the host.

2. Managed Execution:- In particular, Sharing, Aggregation, emulation & isolation are the Most Relevant features

The following figure shows characteristics of virtualization

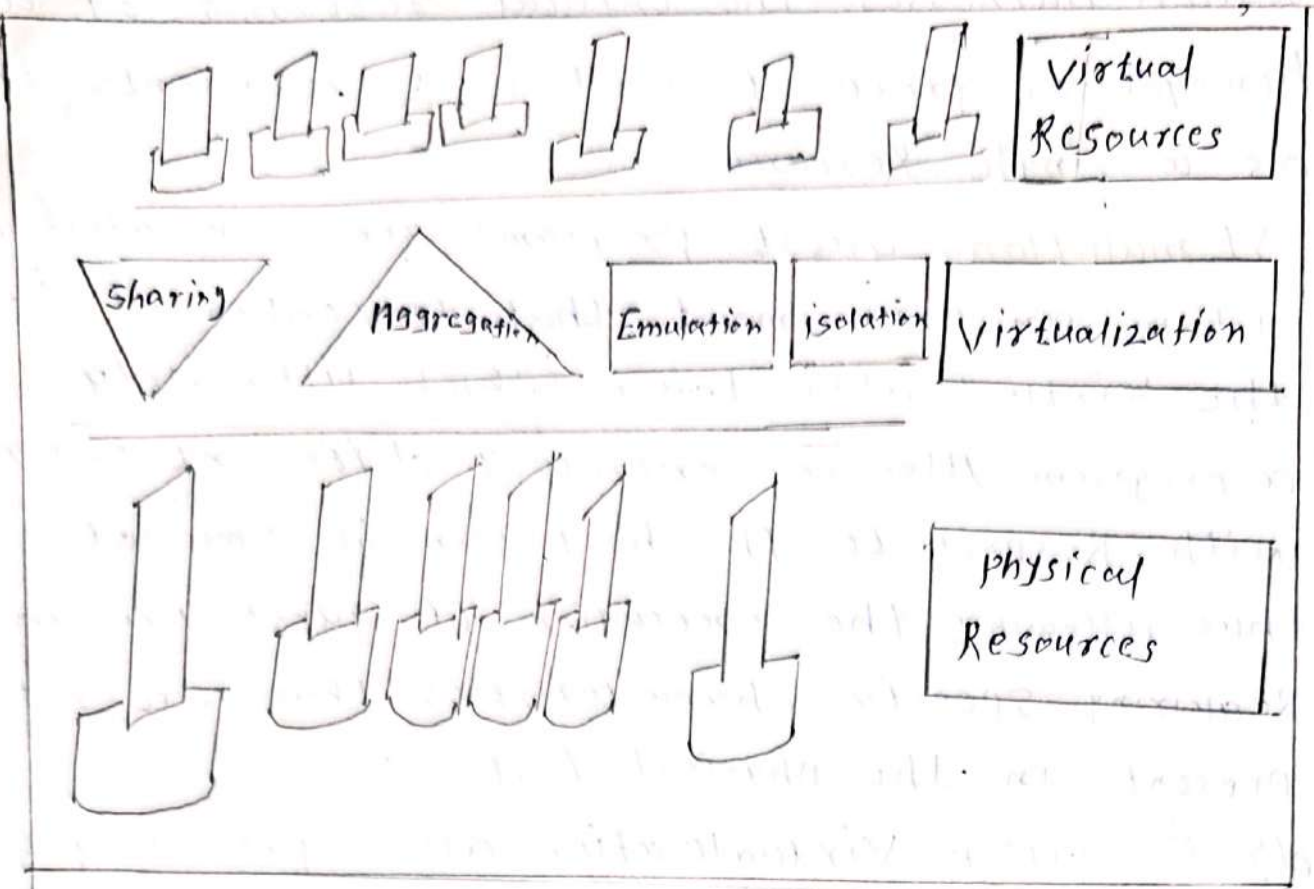



fig. characteristics of virtualization

a) Sharing:- Virtualization allows the creation of a seperate computing environments within the same host In this way it is possible to fully exploit the capabilities of a powerful guest, which would be otherwise underutilized.

b) Aggregation:- It is not only possible to share the physical Resource among several guest but virtualization also allows the aggregation which is the opposite process A group of seperate hosts can be tied together & Represented to guest as a single virtual guest.

This function is Naturally implemented in Middleware for distributed computing.

Ex:- Cluster Management software

which harnesses the physical resources of a homogenious group of machines & represents them as a single Resource.

c) Emulation:- Guest programs are executed within an environment that is controlled by the virtualization Layer, which ultimately is a program Also a completely different environment with Respect to the host can be emulated, thus allowing the execution of guest programs Requiring specific characteristics that are not present in the physical host.

d) Isolation:- Virtualization allows providing guests such as whether they are operating system, applications, or other entities with completely seperate environment, in which they are executed The guest program performs it's Activity by interacting with an abstraction layer which provides Access to the undersying Resources The virtual Machine can filter the activity of the guest & prevent harmful operations against the host.

5. portability:- The concept of portability applies in different ways according to the specific type of virtualization considered In the case of hardware virtualization solution, the guest is packaged into a virtual image that, in most cases, can be safely Moved & executed on top of different virtual Machines.

4) Sharing of the pool of Resources:-
The infrastructure provides offers a pool of resource that can be dynamically allocated to the resource consumers this capability creates a great flexibility to the cost-effective management of resources.

5) Service-oriented:- cloud computing adopts a service oriented operational model, putting a strong emphasis in service Management each provider offers his service trying to guagrantee a service Level Agreement (SLA) which is negotiated with the users of that service

6) Self organization:- The property of dynamic resource provisioning implies in the ability of providers & client to adjust their resource upon demand resource can be allocated or returned to the pool depending on the current needs this flexibility result in the elasticity property.

7) price Based Utilities:- cloud computing uses an economical model based in "pay what you use" the exact price of processing may be different for different services for example A SIW provider may Rent a VM in a by hour basis, while other may charge the service by the number of client served although services priced by use may reduce client costs, they introduce difficulties in the Mgt. of the whole operation.

## 2.2 Differentiate various types of Virtualization:

1) Desktop Virtualization: Desktop virtualization is a technology that allows multi-client environment to be controlled & managed from a central point.
Uses can access their desktop remotely from any device through a Network or the internet
In simple words, the desktop runs on a server & users view & control it from their own devices.
desktop virtualization encompasses both server side & client side virtualization options as well as both thin client & intelligent client options.

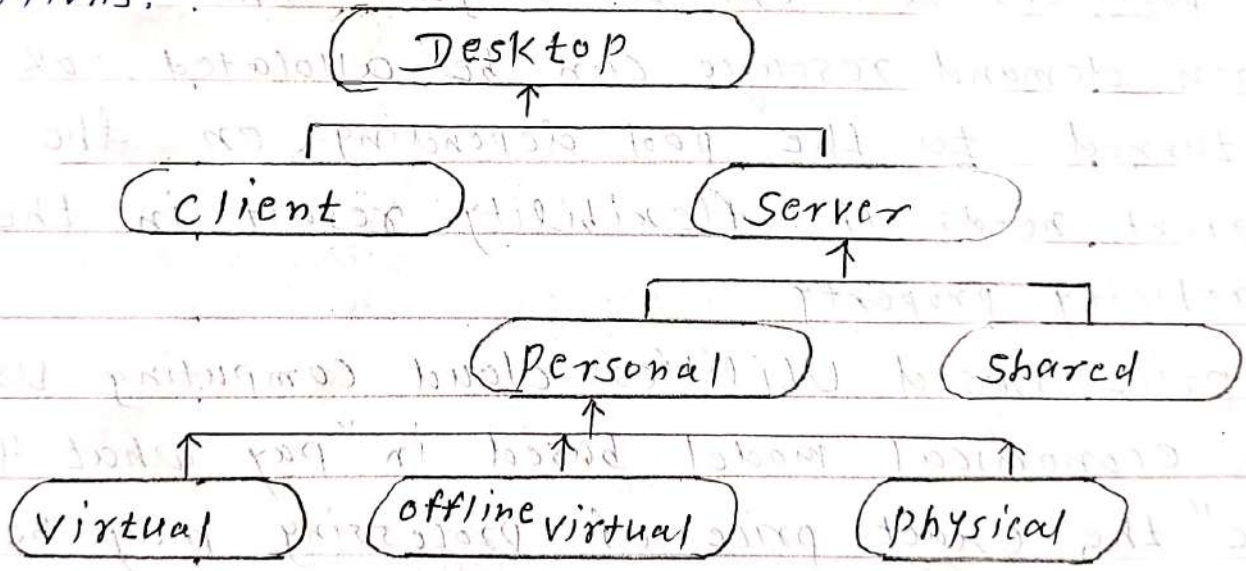



fig. Desktop virtualization classes.

Advantages: 1) Improved Security
2) Easy Back-up & Recovery.
3) Lower Maintaince cost
4) Better Resource Utilization

DisAdvantages: 1) High Initial Cost
2) Network Dependency

3) performance Issues.

2) Network Virtualization:- Network Virtualization is the process of creating Multiple virtual Networks from a single physical Network infrastructure it combine hardware & software resources to create logical (virtual) Network that operates independently

Network Virtualization allows the creations of Multiple virtual Network on same Sub-Strate each Virtual Network is a collection of Virtual Nodes & Virtual Links.

Architecture of Network Virtualization

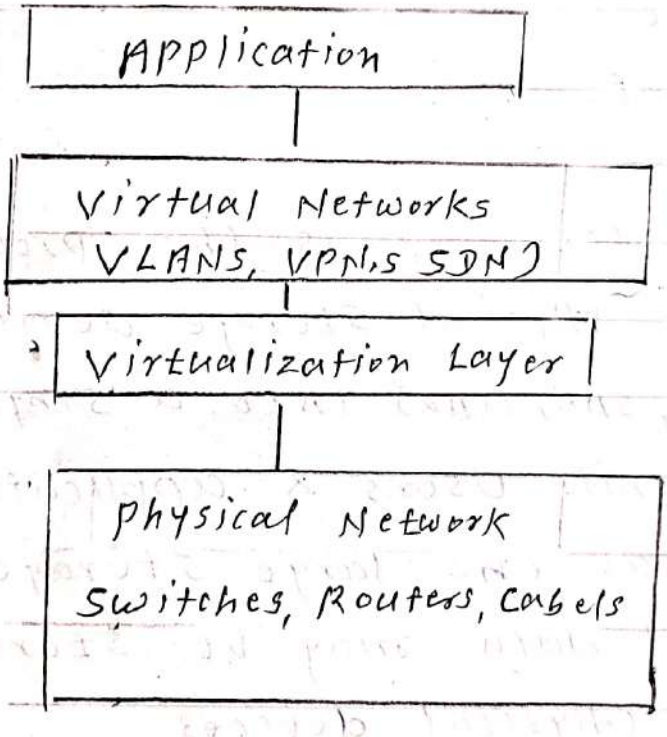



fig. Network Virtualization

The Virtualization layer Seperates the physical Network from the logical NIW & manages traffic between Virtual Networks.

Example: A College has - ① Student dept.
② Faculty dept. ③ Administration dept.

Instead of installing seperate physical NIW the college uses VLAN's

physical switch

VLAN 10 VLAN 20 VLAN-30

Students Faculty Admin

Each department works on it's own virtual NIW while sharing the same physical infrastructure

Advantages of Network virtualization

- Lower number of physical device
- Lower costs, less space, consumption, lower power/cooling requirements.

Multiple devices with seperate roles & Simpler configurations

- Easier to Manage
- Faster Deployment.

3. Storage Virtualization:- is the process of combining Multiple physical storage devices (Hard-disks, SSD's, SAN, NAS) into a single Logical Storage Unit. Users & applications See the storage as one large storage pool, while the actual data may be stored across multiple physical devices.

Storage virtualization is commonly used in file system, Storage area, Network (SANS), Switches & virtual tape systems, Storage virtualization is a concept in system Administraction Refering to the abstraction of logical

storage from physical storage

There are 3 basic Approaches to data storage

1 Direct Attached Storage (DAS)

2 Network Attached Storage (NAS)

3 Storage Area Network (SAN)

1. Direct Attached Storage: DAS refers to a storage system attached directly to a server without the ~~im~~involvement of a NIW system The main protocols used in DAS connections are ATA, SATA, SCSI, SAS & fiber channel.

2. Network Attached Storage: NAS is Another primary solution for data storage.

The main protocols used in file sharing protocols like AFP, NFS & CIFS/SMB file access is provided.

3. Storage Area Network: Storage devices can be connected directly to this NIW by a fabric which contains switches & hubs to connect Any storage to the server as if they were local

Example: ① Host-based volume Management

② LUN creation

③ Tape virtualization

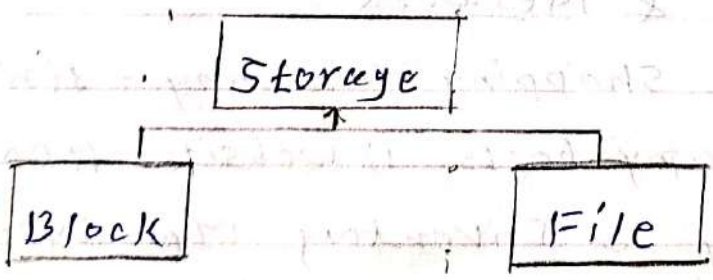



fig. Storage virtualization Classes

Benefits of Storage Virtualization

1. Much larger distance
2. Greater performance
3. Easier Testing
4. Increased scalability
5. Increased disk utilization
6. Adding or deleting Storage without affecting application availability.

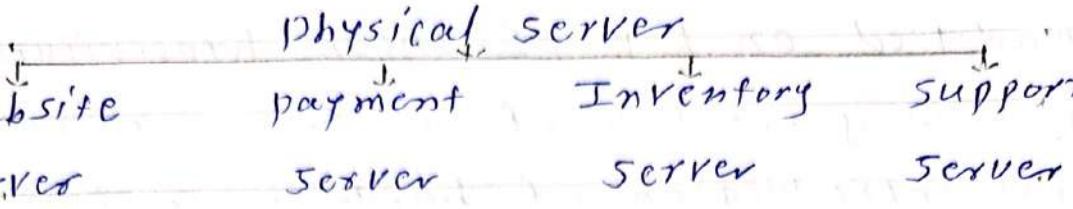
4) Application Server Virtualization

Application Server virtualization abstracts a collection of application server that provides the same services as a single virtual application Server by using load balancing Strategies & providing a high availability infrastructure for the service hosted in the application server

application Server virtualization is a virtualization technology that allows multiple application servers to run on a single physical server Each application Runs in it's isolated virtual environment while sharing the unde rlying hardware resources such as cpu, memory, storage & network

Example:- online shopping company - An e-Commerce company hosts 1) website Application 2) payment Gateway 3. Inventory Mgt System 4. Customer Support System

Instead of purchasing 4 physical servers the company uses 1 powerful server & creates 4 virtual application servers




Benefits :- Lower cost, Better Utilization, Easier Management

Advantages :- 1) Better Resource Utilization
2) Easy Deployment 3) Improved scalability
4) Energy saving 5) Faster Disaster Recovery

## 2.3 Technology Examples :-

### 2.3.1 VMWare : Full Virtualization Reference Model :-

VMWare Technology is based on the concept of full virtualization, where the underlying hardware is replicated & made available to the guest operating system which run unaware of such abstraction layer does not need to be modified. VMware implements full virtualization either in the desktop environment, by means of type-II hypervisors or in the server environment, by means of Type-I hypervisors in both of the cases Full Virtualization is made possible by means of direct execution & binary translation, thus allowing the virtualization of architecture such as X-86 Architectures.

1. Full Virtualization & Binary Translation.

VMware is well-known for the capability of virtualizing x-86 architectures, which Runs unmodified on-top of their hypervisors with the New generation of Hardware architectures & ~~inst~~ introduction of hardware assisted vir. tualization in 2006, full virtualization is made possible with hardware support But before that date, the use of dynamic binary translation was the only solution that allowed Running x-86 guest operating system unmodified in a virtualized environment.

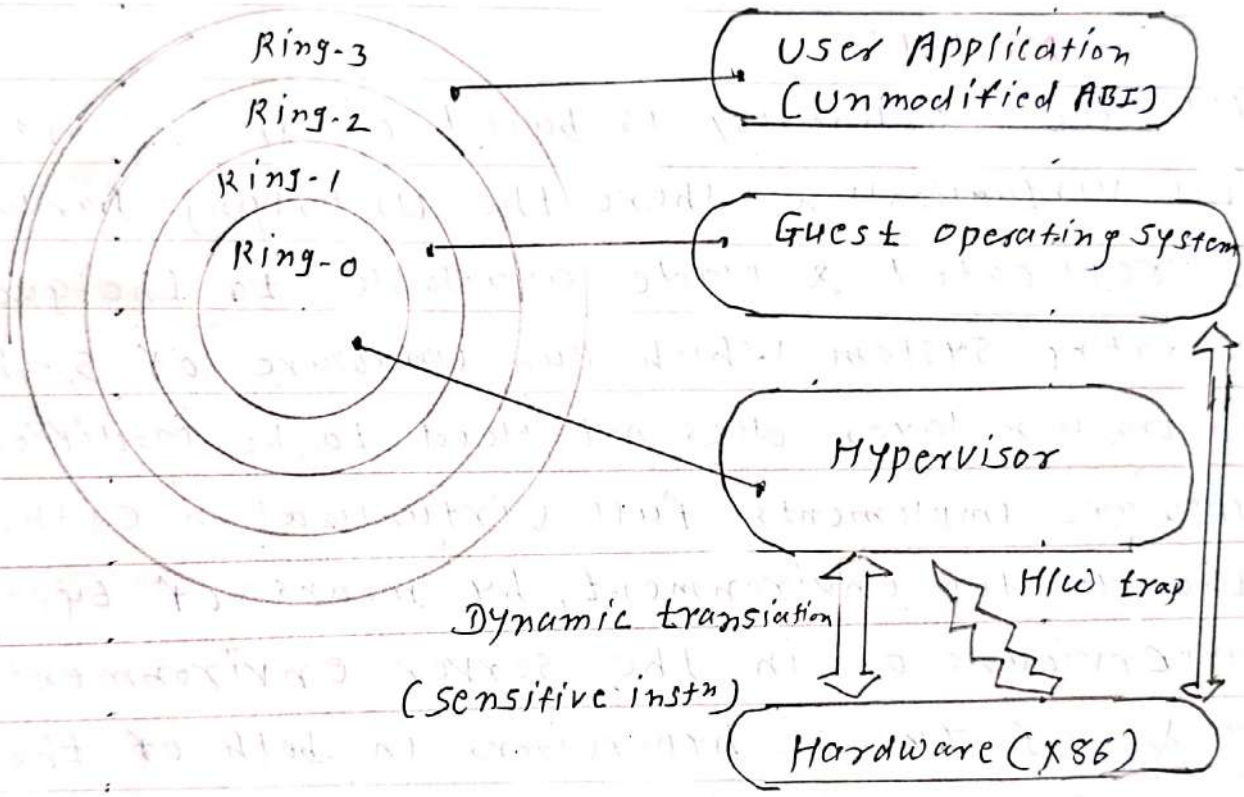



fig Full Virtualization Reference Model

Advantages:- 1) Complete Hardware Emulation 2) Isolation 3) portability 4) High availability 5) Snapshort support 6) Resource Sharing

Disadvantages:- 1) High Initial cost 2) Complexity 3) performance overhead.

## 2.3.2 XEN: Architecture & Guest operating System Management.

Xen is an open-source virtualization platform (hypervisor) that allows Multiple O.S to Run on a Single physical Machine Simultaneously Xen is the Most popular implementation of paravirtualization, although it also support Full virtualization through hardware assisted virtualization technologies such as Intel VT-x & AMD-V, Xen Hypervisor is a Type-1 (Bare Metal) hypervisor that runs directly on the hardware & Manages Multiple Virtual Machines (VMs) called Domains

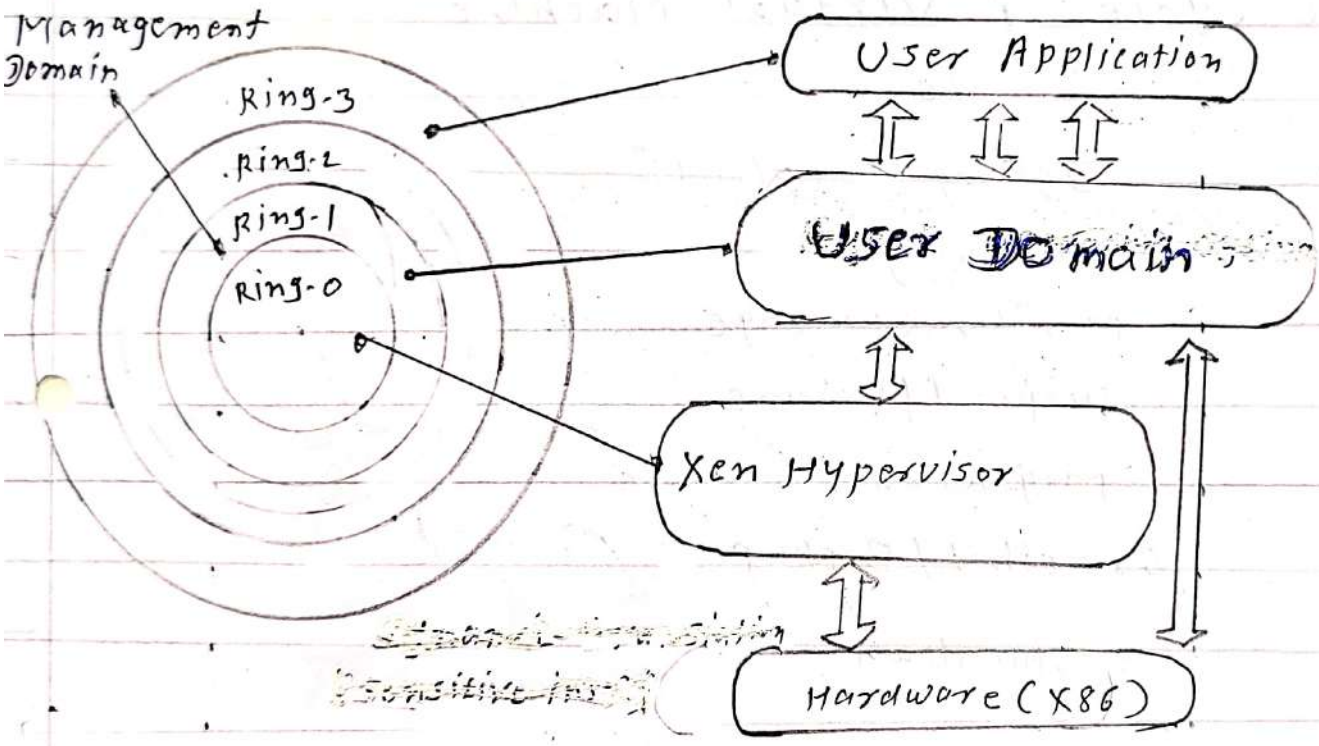



fig. Xen Architecture & Guest OS mgt.

Guest operating system Management Refers to the creation, execution, Monitoring & control of guest operating system Running on Xen.

Advantages of Xen

1) High performance 2) Strong security
3) open source 4) Live Migration
5) Scalability

## 2.4 Definition and Life cycle of Virtual Machine (VM)

Defination of Virtual Machine (VM): is a software-based computer that Runs an operating system & application on physical Machine Using virtualized resources such as CPU, Memory, storage & Network provided by a hypervisor

Life cycle of Virtual Machine

Create
↓
Deploy / Install
↓
Running
↓
Monitor & Manage
↓
Suspend / Resume
↓
Migration
↓
Snapshot / Backup
↓
Shutdown
↓
Termination

1. Creation (provisioning): VM is defined & Instantiated using a hypervisor or cloud platform Resources like CPU, RAM, & disk space are allocated.

Example:- A company creates a new Ubuntu VM with 4-vcpu, 8 GB RAM, 100 GB Storage.

2. Deploy / Install:- Deployment makes the VM available for production use

Activities:- 1) connecting the VM to the Network 2) Assigning IP Address 3) Registering Services

Example:- Deploying a VM as a web-server for an e-commerce website.

3. Running :- In this phase, the VM performs it's assigned tasks

Activities:- 1) Running application 2) processing User Request 3) Handling Workloads

purpose:- To deliver business service continuosly

Example:- A database VM Serving thousands of user queries daily

4) Monitor / Manage:- Continious Monitoring ensures optimal performance

Activities:- 1) Monitoring CPU Utilization -> Tracking MIM usage 3) checcking NIW traffic 4) Detecting failure

purpose:- To improve Reliability & performance

Example:- An administrator observe high CPU usage & Add more Resources.

5) Suspend / Resume:- Suspend is the process of Saving the current State of VM & stopping it's execution temporarily & Resume is process of Restoring a Suspended VM to it's previous Running State.

Example-1) A Linux VM running a Web appn is suspended before server maintainance. this application state is preserved

2) After Maintanance is completed the suspended Linux VM is Resumed & the web application continious Running Normally.

6) Migration: Means Moving a VM from one physical host to Another

purpose: 1) Load balancing 2) Hardware Maintaince 3) Disaster Recovery

Example: Moving a VM from an overloaded server to another server

7) Snapshot: A Snapshort captures the VM's current State includes Memory, disks & configuration information

used for Back-up & Recovery

Example: Taking a Snapshort before installing Software Updates

8) Shutdown: 1) The VM is gracefully powered off 2) Application & Services Stop Running 3) Resources are Released

Example: Stopping a test VM after project completion.

9) Termination: 1) The VM is permanently Removed. 2) Associated resources may also be deleted. 3) This is the final Stage of the VM lifecycle

Example: Deleting a temporary VM after testing is completed.

Virtual Machine Migration: is the process of moving a virtual machine from one physical host server to another without changing the VM's application, operating system, or data

Example: Suppose an online shopping website is running on a VM if the physical server becomes overloaded, the VM can be migrated to another server with more resources without affecting users.

VM- Migration Techniques:

1) Cold Migration (offline Migration):
VM is powered off before Migration
Entire VM state is moved to another host
causes downtime
process: 1) Shutdown VM 2) Copy VM files to destination host 3) Restart VM on new host.
Example: Moving a test server VM during Non-working hours.

2) Live Migration (Hot Migration):
VM continious Running during Migration
Minimal or No downtime
Most popular Migration technique.
process: 1) Memory pages are copied to destination host 2) VM execution is switched to destination host 3) Source VM is stopped.
Example: Migrating a banking Application VM. Without interrupting customer transactions.

3) Warm Migration 1) VM is suspended before Migration 2) Memory state is saved & transferred 3) Downtime is less than cold migration but more than live migration.

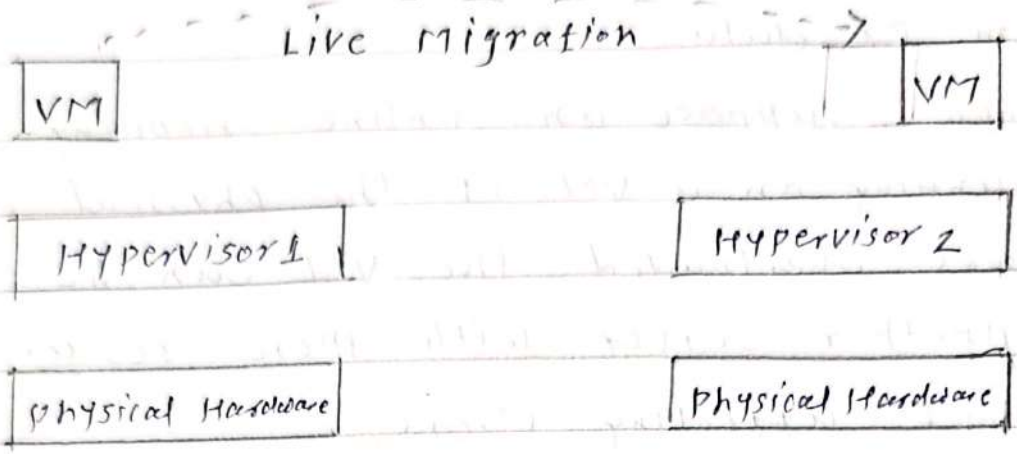



fig Live VM Migration.

VM Consolidation:- is the process of combining multiple virtual Machines onto a smaller number of physical servers to improve Resource utilization, Reduce power consumption, & Lower operational costs.

Instead of Running one application on one physical server, multiple VM's are hosted on a single physical server using a hypervisor, this helps organizations use hardware resources more efficiently

Example:- Before consolidation

- Server 1 (20% utilization) → VM1
- Server 2 (15% utilization) → VM2
- Server 3 (25% utilization) → VM3
- Server 4 (20% utilization) → VM4

After Consolidation:

Physical server

- VM1
- VM2
- VM3
- VM4

Total Utilization = 80%.

Example: A company has 10 physical server running at only 15 to 20% Utilization By consolidating workloads using utilization technologies such as VMware, Microsoft, Hyper-V or Citrix Xen, the company can reduce the number of active servers from 10 to 3, significantly saving energy & infrastructure costs.

Advantages of VM Consolidation:

1. Cost Reduction
2. Energy Efficiency
3. Better Resource Utilization
4. Simplified Management
5. Improved Scalibility

VM Management Concepts: VM Management refers to the process of creating, Monitoring, controlling, Maintaining & optimizing virtual machine throughout their lifecycle in a virtualized or cloud computing environment. VM Management ensures that virtual machines operates efficiently, securely & reliably while

Making the best use of available resources.

Objectives of VM Management:-

1) Efficient Allocation of Resources
2) High availability of services
3) Performance optimization
4) Back-up & disaster Recovery
5) security & compliance
6) Cost Reduction & Resource utilization.

Example: A cloud provider such as Amazon Web Services, Microsoft Azure, or google cloud manages thousands of VMs by automatically provisioning Resources, Monitoring performances, Migrating workloads, taking back-up & ensuring high availability for customers.

Advantages of VM Management:

1) improved Resource Utilization
2) Better security
3) High availability
4) Faster deployement
5) Efficient disaster Recovery
6) Simplified Administration

## Advantages of Virtualization:

1) Improved Resource Utilization
2) Cost Reduction
3) Faster Deployment
4) High availability
5) Disaster Recovery
6) Easy Back-up & Recovery
7) Scalability & flexibility
8) Simplified Management
9) Increased Security
10) Free-up Unused physical Resources
11) Hardware Maintenance
12) Conserve power
13) Multiple Virtual Servers on one physical Hardware
14) Easily Move VMs to other data Centers
15) Easier Automation
16) Managed Execution
17) Hardware Independence
18) Better Testing Development
19) Reduced downtime
20) Space Saving

## * Disadvantages of Virtualization:

1) High Initial Cost
2) performance overhead
3) Single point of failure

4) Security Risks
5) Resource contention
6) Complex Management
7) Network Complexity
8) Hypervisor Failure
9) Limited Access to Hardware
10) Vendor Lock-In
11) Migration Risks.

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