UNIT-II

virtual machines and virtualization of clusters and data centers:

- ⇒ Implementation levels of virtualization
- ⇒ virtualization structures/ Tools and mechanism
- ⇒ virtualization of CPU.
- ⇒ memory and I/o Devices
- ⇒ virtual clusters and Resource management
- ⇒ virtualization for data-center Automation.

Implementation levels of virtualization :-

virtualization:

virtualization is a process that allows a computer to share its hardware resources with multiple digitally separated environments.

⇒ virtualization is not that easy to implement.

⇒ A computer runs an os that is configured to that particular hardware.

⇒ Running different os on the same hardware is not exactly feasible.

⇒ there are five levels of virtualizations available that are most commonly used in industry.

Instruction set Architecture Level (ISA) :

⇒ In ISA, virtualization works through an ISA emulation.

⇒ this is helpful to run heaps of legacy code which was originally written for different Hardware configurations.

⇒ this code run on the virtual machine through as ISA

Hardware Abstraction Level (HAL) :

⇒ this level helps perform virtualization at the hardware level.

⇒ It uses bare hypervisor for its functioning

⇒ This level helps form the virtual machine and manages the hardware through virtualization.

⇒ It enables virtualization of each hardware component such as I/O devices, processors, memory, etc.

Operating System Level:-

⇒ At the operating system level, the virtualization model creates an abstract layer between the applications and the OS.

⇒ It is like an isolated container that utilizes hardware and software.

⇒ Here, every user gets their own virtual environment.

Library Level:

⇒ OS system calls are lengthy and cumbersome (ಕಿರಿಕಿರಿ).

⇒ Applications opt (ಆರಿಸು) for APIs from user level libraries.

Application Level:-

⇒ Application-level virtualization comes handy (ಸೂಕ್ತ) when you wish to virtualize only an application.

⇒ It does not virtualize an entire environment

⇒ on an OS, Applications work as one process is known as process-level virtualization.

Application Level

JVM / .NET CLR

Library Level

WINE / VCUDA

Operating System Level

Virtual Environment

Hardware Abstraction level

VMware / virtual PC

Instruction set Architecture level

BIRD / Dynamo

Virtualization structures / Tools and mechanisms :

Architectures of a machine before and after virtualization:-

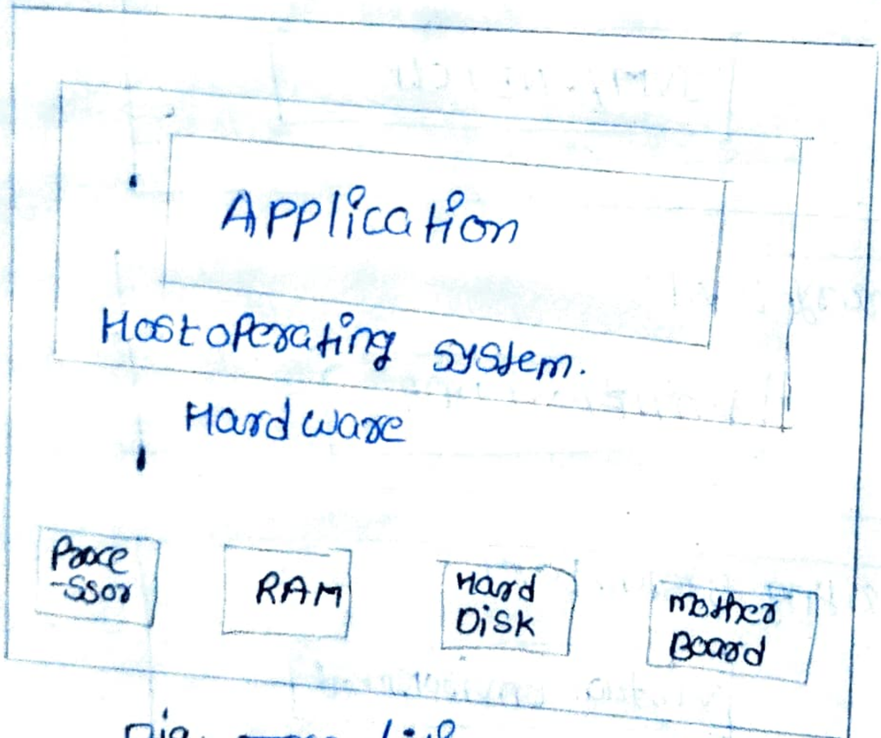


Fig: Traditional computer.

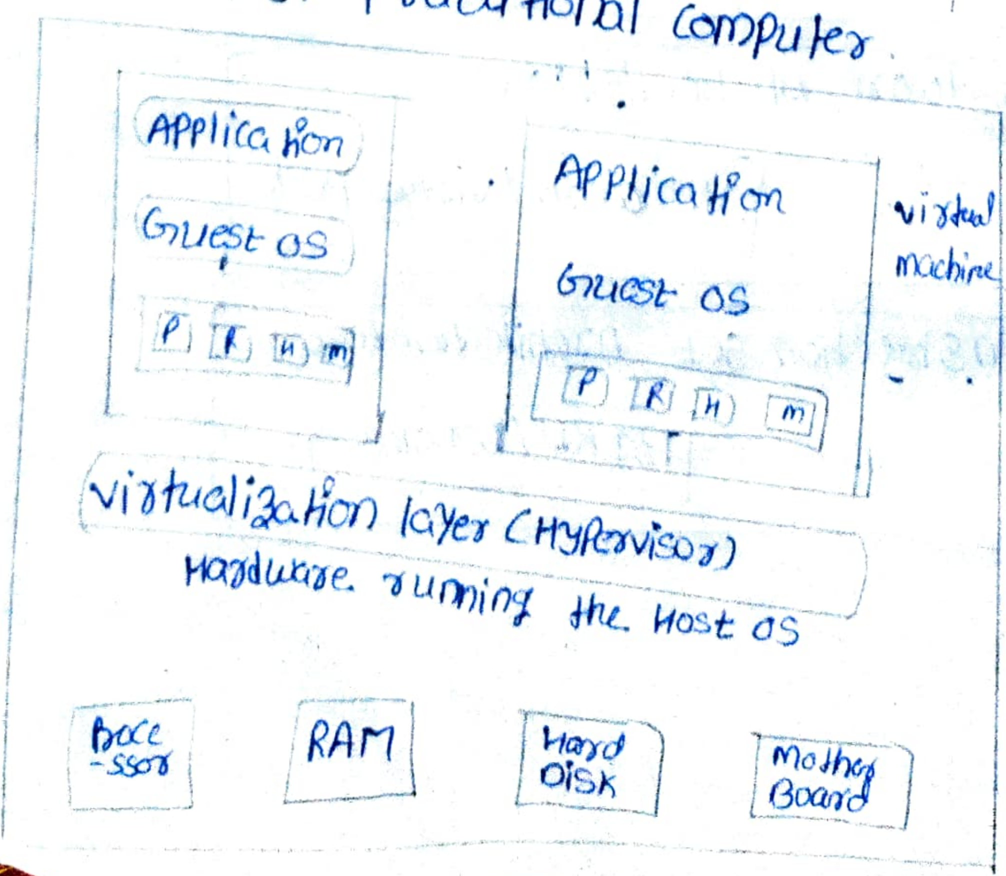


Fig: After virtualization.

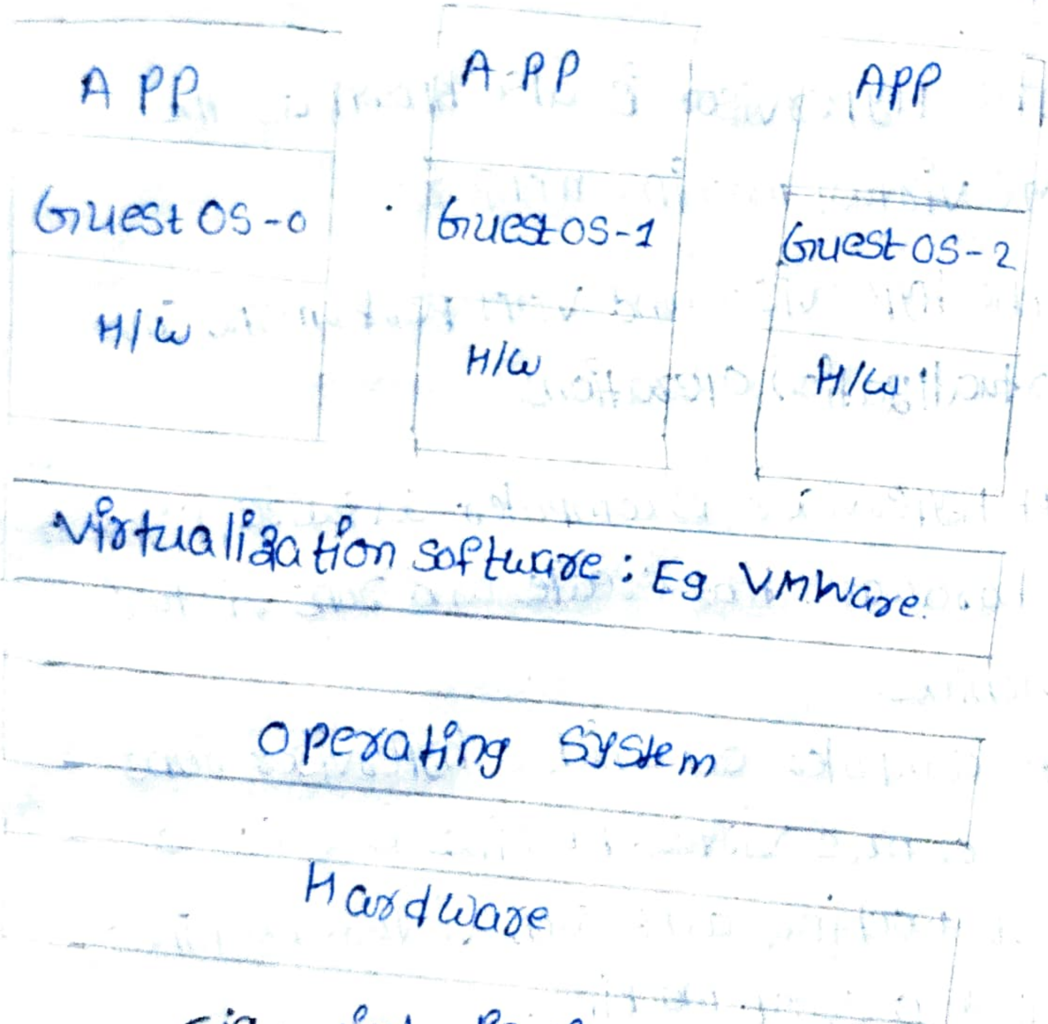


Fig: Virtualization Architecture.

⇒ Before virtualization, The operating system manages the hardware.

⇒ After virtualization, a virtualization layer is inserted between the hardware and the operating system.

⇒ The virtualization layer is responsible for converting portions of the ~~p~~ real hardware into virtual Hardware.

Hypervisor:-

⇒ The Hypervisor is also known as the VMM (virtual machine monitor).

⇒ The Hypervisor and VMM perform the same virtualization operations.

⇒ A Hypervisor is computer software, firmware, or hardware that creates and runs virtual machines.

⇒ A computer on which a hypervisor runs one or more virtual machines is called a host machine, and each virtual machine is called a guest machine.

⇒ The Hypervisor are two Types

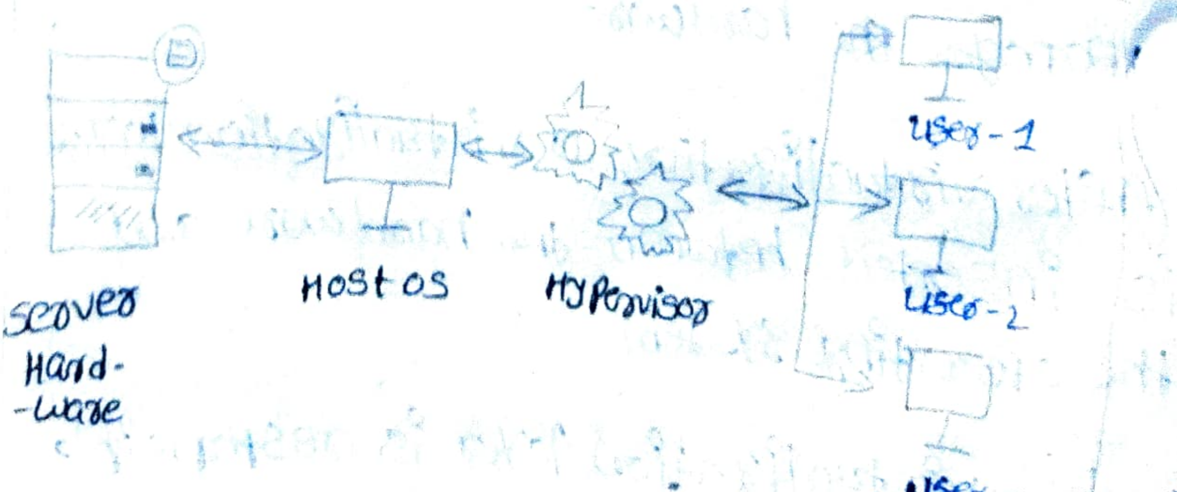


Fig: Native Hypervisor.

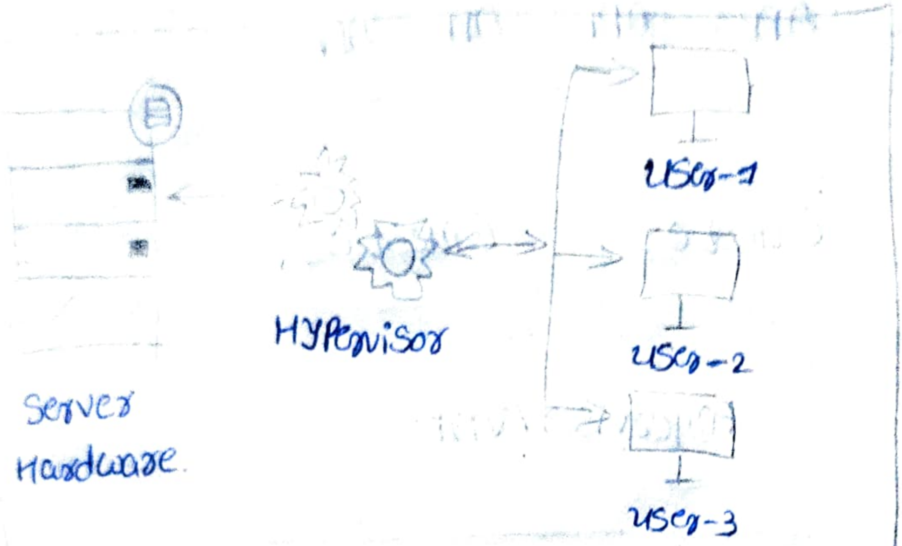


Fig: Hosted Hypervisor

TOP 5 Hypervisor Tools:-

* Microsoft Hyper-V
* Kernal virtual machine (KVM)
* VM ware.
* ORACLE virtual Box.
* Work Station Pro 12.

Hypervisor and Xen Architecture :-

⇒ The Hypervisor supports hardware-level virtualization like CPU, memory, disk and network interfaces.

⇒ The Hypervisor software sits directly between the physical hardware and its OS.

⇒ This virtualization layer is referred to as either the VMM or the hypervisor.

Full-virtualization

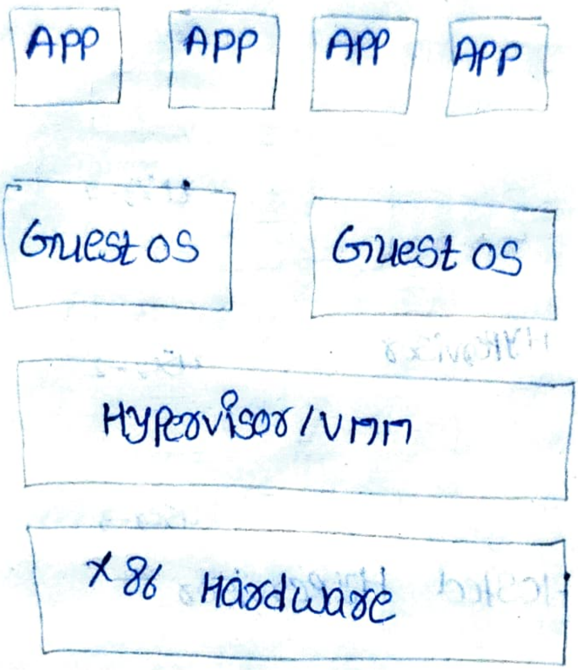


Fig: Hypervisor Architecture.

The xen Architecture:-

⇒ xen is an open source hypervisor program developed by cambridge university.

⇒ xen does not include any device drivers natively.

⇒ It just provides a mechanism by which a guest os can have direct access to the physical devices.

⇒ xen provides a virtual environment located between the hardware and the os.

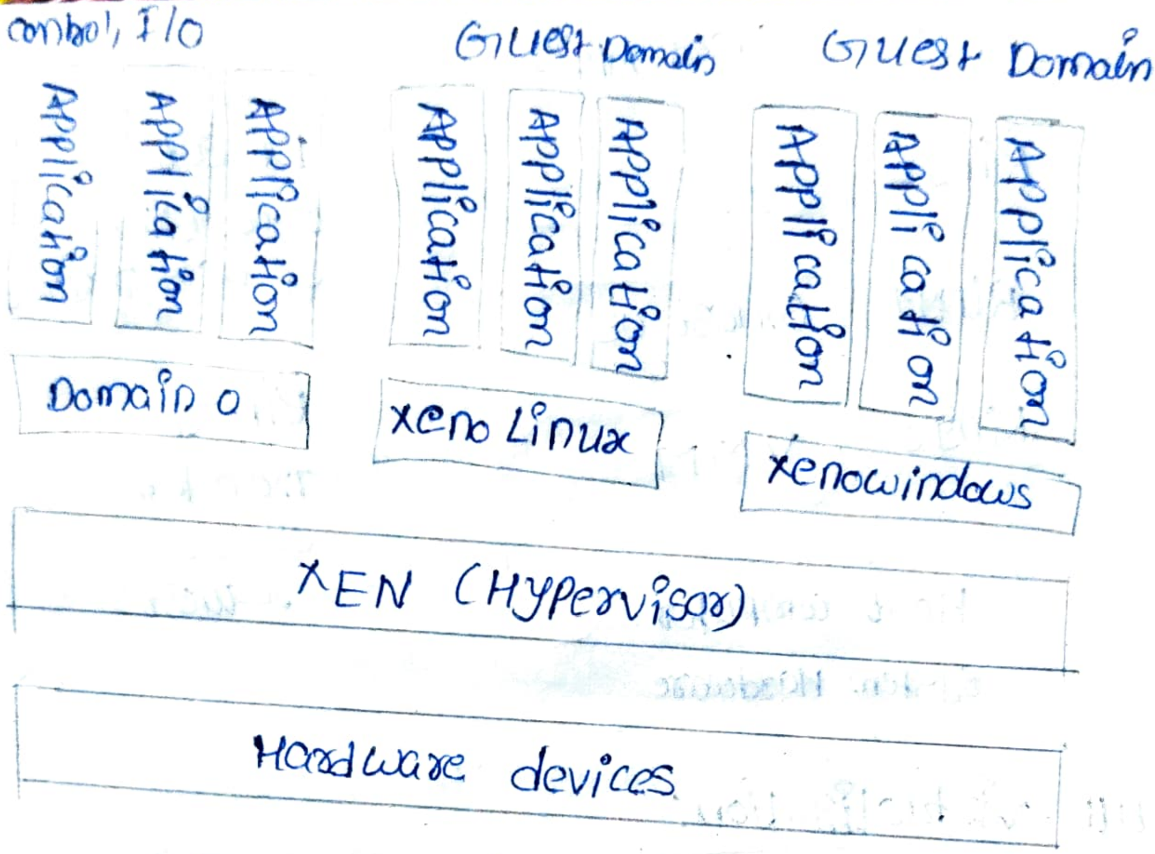


Fig: XEN Architecture

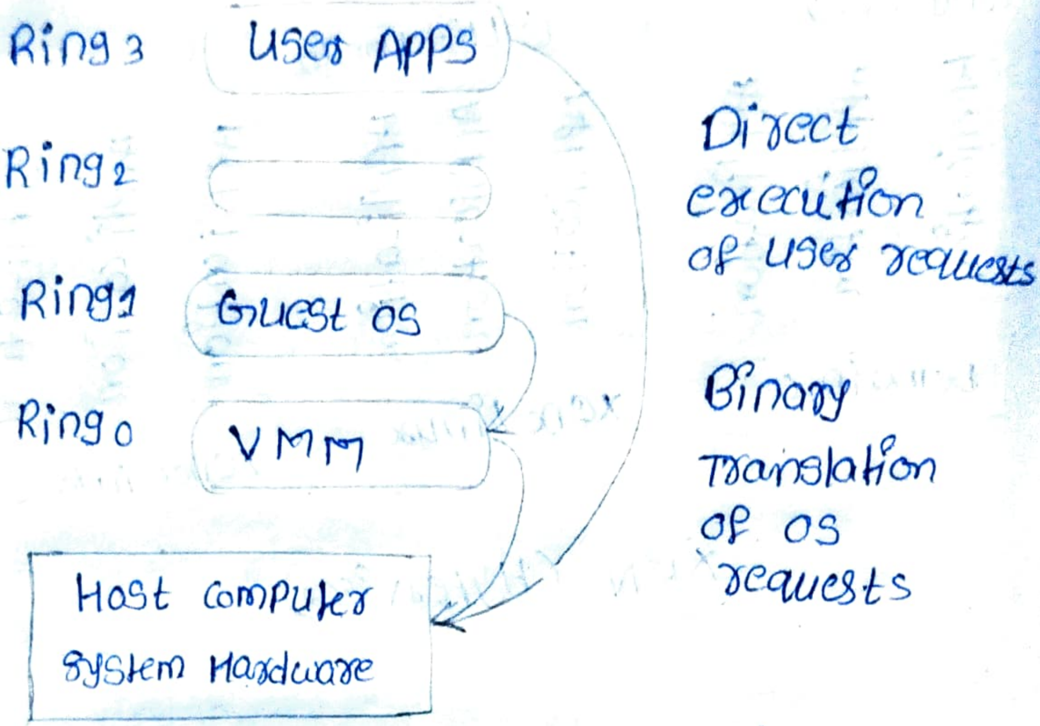
Binary Translation with Full Virtualization

⇒ Depending on implementation Technologies, hardware virtualization can be classified into two categories:

1. Full virtualization
2. Host-Based virtualization

⇒ Full virtualization does not need to modify the host OS.

⇒ In a host Based system, both a host OS and guest OS are used.



Full virtualization:-

⇒ Both the hypervisor and VMM approaches are consider full virtualization.

⇒ The performence of full virtualization may not be ideal, because it involves binary Translation.

⇒ Binary Translation which is rather time consuming

Binary Translation of Guest OS. Requests using a VMM :-

⇒ This approach was implemented by VMware and many other software companies.

⇒ VMware puts VMM at Ring 0 and The Guest OS at Ring 1

⇒ The VMM scans the instruction stream and identifies the privileged, control- and behavior sensitive instructions.

⇒ these instructions are identified and trapped into the VMM

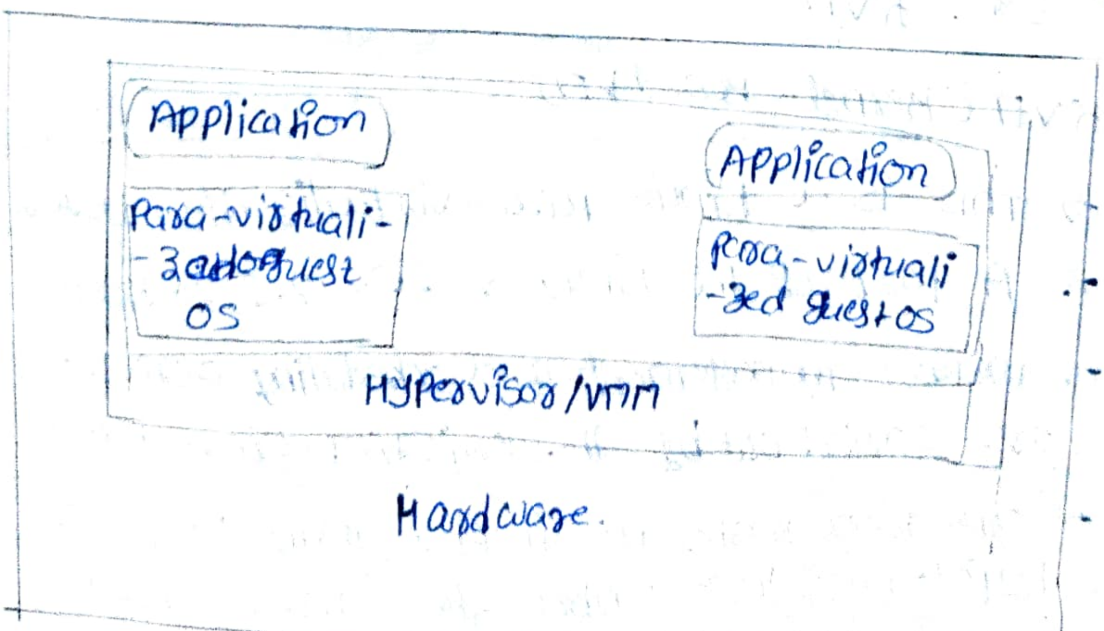
⇒ the method in this emulation is called binary translation.

Para-virtualization with compiler support:-

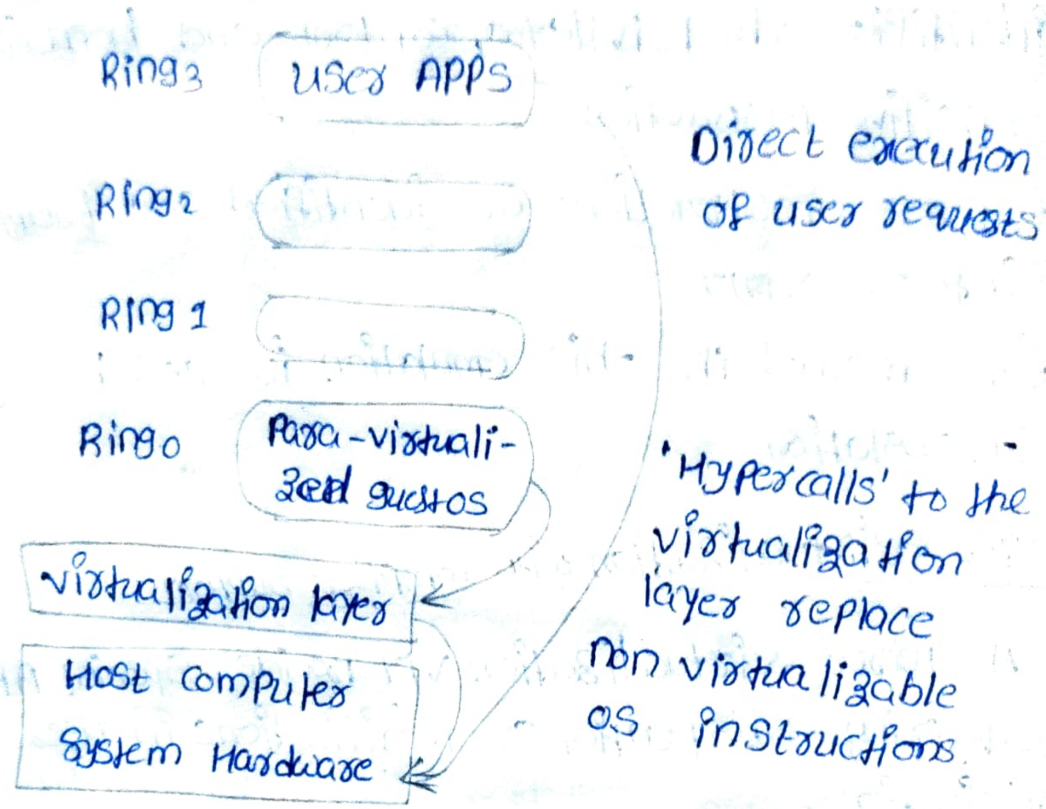
⇒ A para-virtualization VM provides special APIs requiring substantial OS modifications in user applications.

⇒ The virtualization layer can be inserted at different positions in a machine software stack.

⇒ Para-virtualization attempts to reduce the virtualization overhead.



Para-virtualization Architecture:-



⇒ Para-virtualization replaces nonvirtualizable instructions with hypercalls that communicate directly with the hypervisor.

⇒ Ex : KVM.

KVM (Kernel-Based VM)

⇒ This is a Linux para-virtualization system.

⇒ A part of the Linux version 2.6.20 kernel

⇒ memory management and scheduling activities are carried out by the existing Linux kernel

⇒ The KVM makes it simpler than the hypervisor that controls the entire machine.

⇒ which improves performance and supports unmodified guest OSes.

Virtualization of CPU, memory AND I/O Devices

Hardware support:-

⇒ modern OS and processors permit multiple processes to run simultaneously.

⇒ All processors have at least two modes, user mode and supervisor mode.

⇒ Instructions running in supervisor mode are called privileged instructions.

⇒ other instructions are unprivileged instructions

CPU virtualization:-

⇒ unprivileged instructions of VMs run directly on the host machine.

⇒ critical instructions should be handled carefully

⇒ three categories of critical instructions:

* privileged instructions.
* control-sensitive instructions
* Behavior-sensitive instructions

⇒ privileged instructions execute in a privileged mode.

⇒ control-sensitive instructions attempt to change the configuration of resources used.

⇒ Behavior - sensitive instructions have different behaviors depending on the configuration of resources.

⇒ RISC CPU architecture can be naturally virtualized.

⇒ A CPU architecture is virtualizable if it supports the ability to run the VM's privileged and unprivileged instructions

<u>Hardware Assisted CPU virtualization:-</u>

⇒ Intel and AMD add an additional mode called privilege mode level to x86 processors.

⇒ The privileged instructions are trapped hypervisor Automatically

⇒ this Technique remove difficulty ina binary Translation of full virtualization.

<u>Memory virtualization:</u>

⇒ virtual memory virtualization is similar to virtual memory supported by modern OS.

⇒ modern x86 CPU include a memory management unit (MMU) and a Translation lookaside buffer (TLB) to optimize virtual memory performance

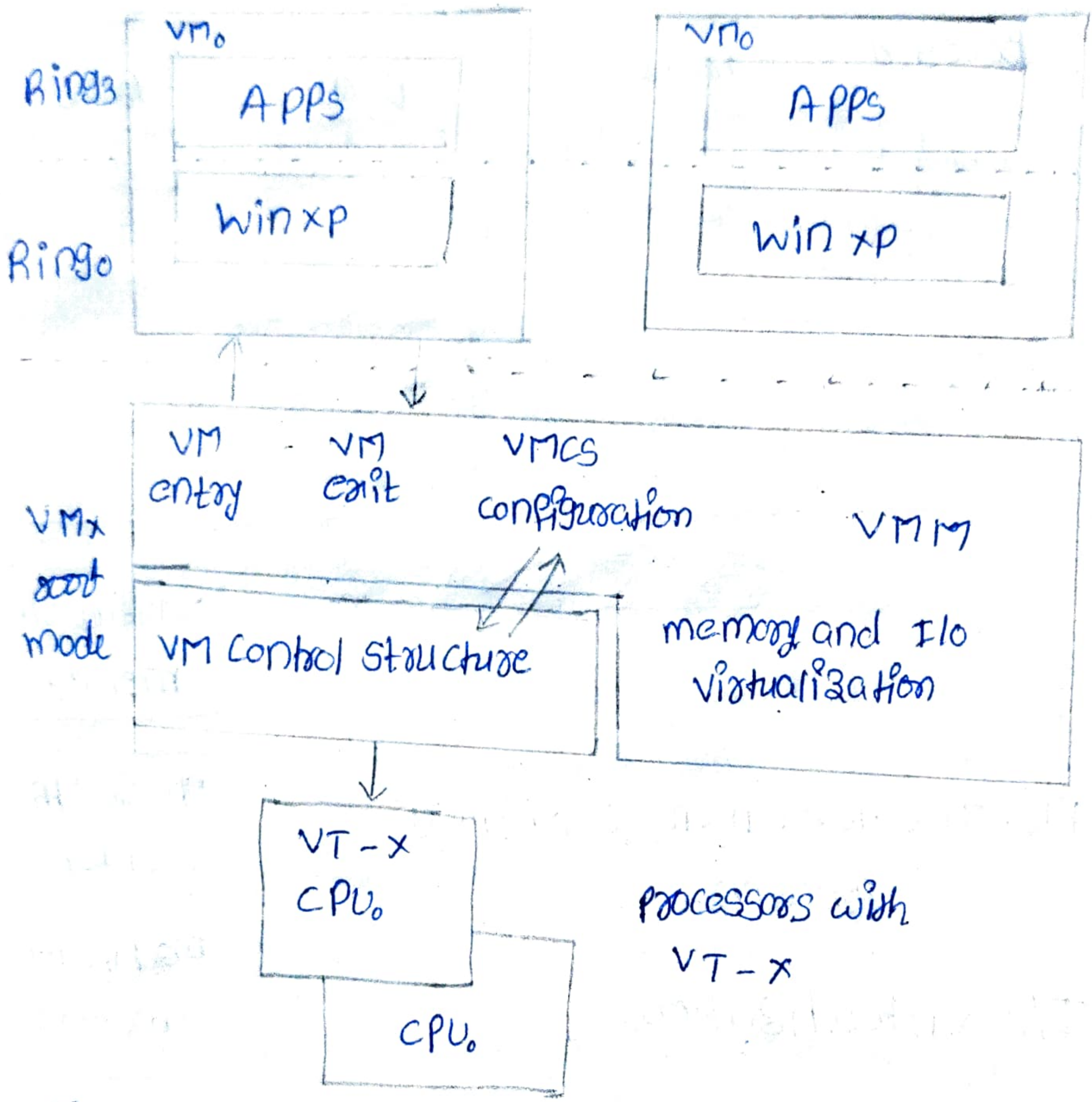


Fig: Intel Hardware-assisted CPU virtualization.

⇒ Two stage mapping process should be maintained by the guest OS and the VMM respectively: virtual memory to physical memory and physical memory to machine memory.

⇒ ~~To~~ processors use TLB hardware to map the virtual memory directly to the machine memory.

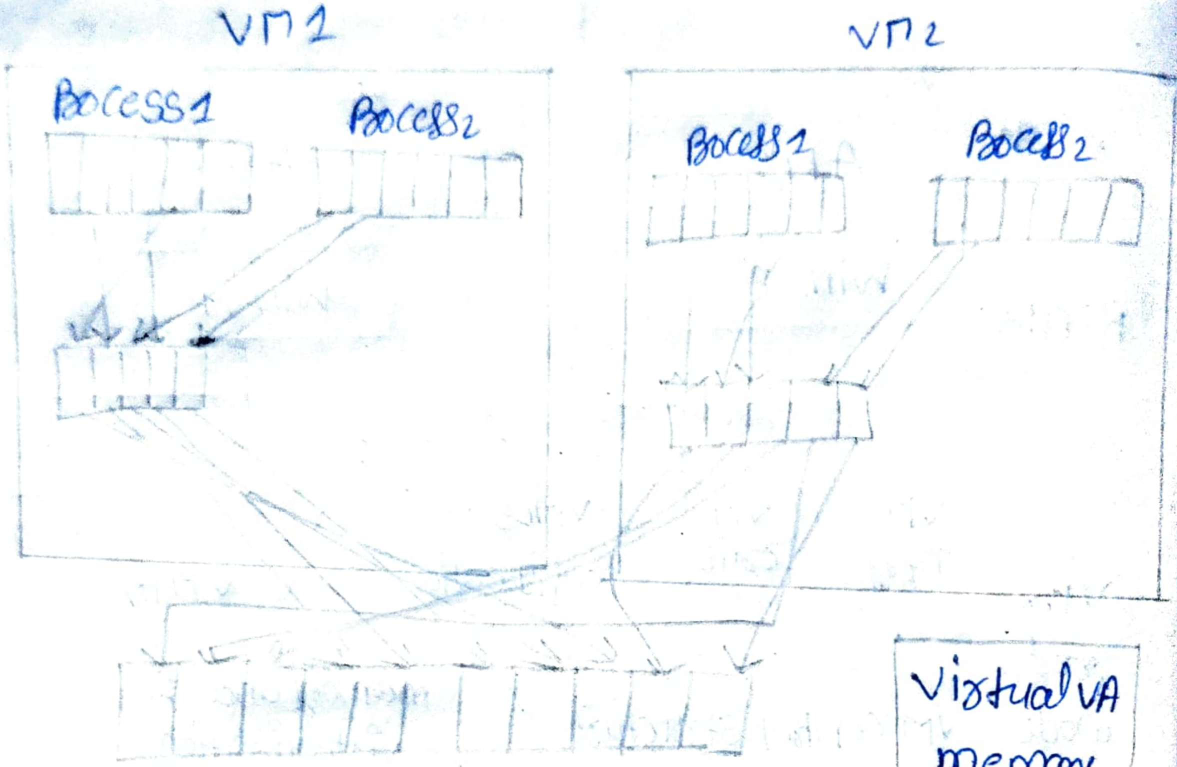


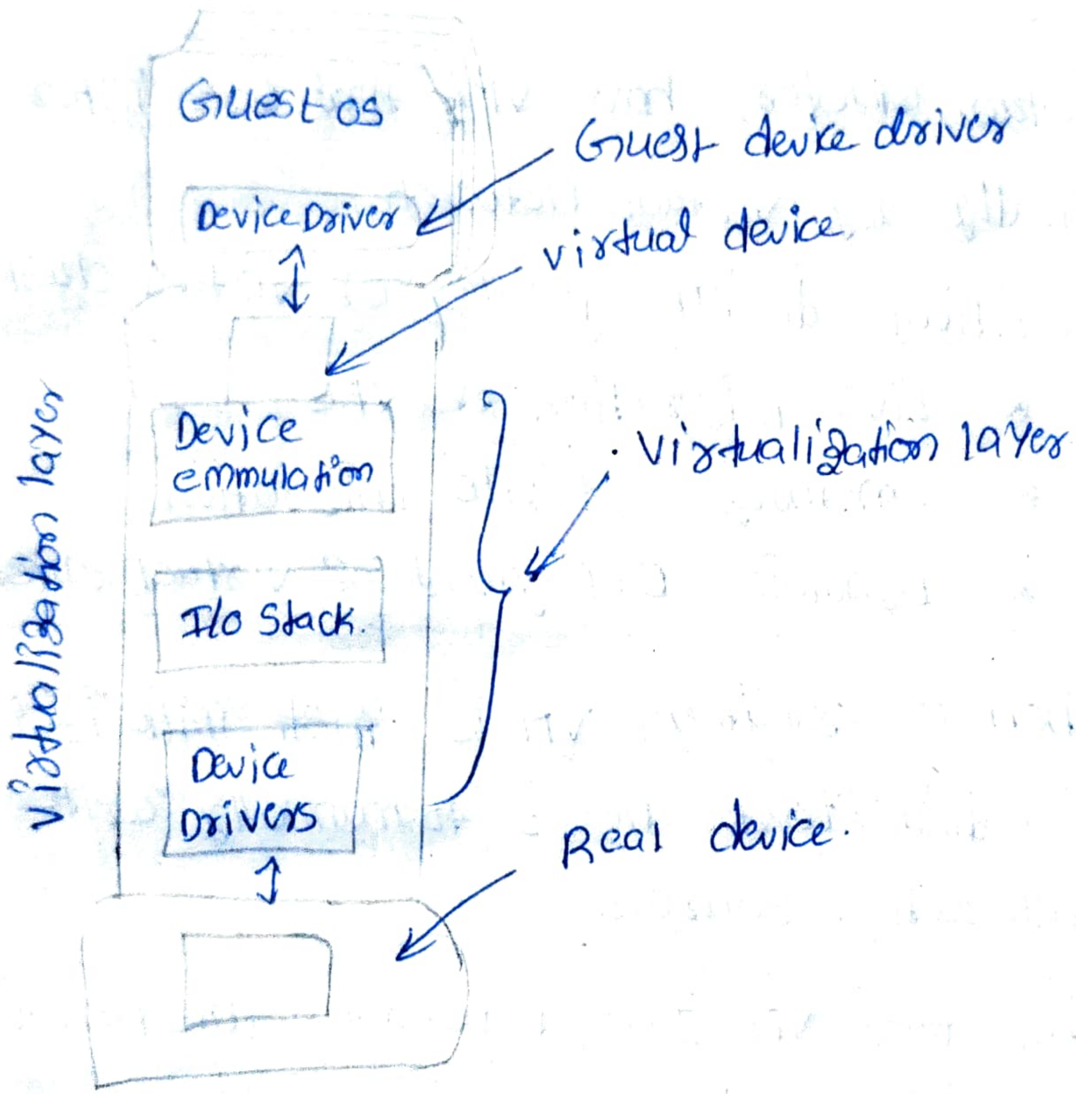
Fig: Two-level memory mapping Procedure.

I/O virtualization:-

⇒ Involves managing the routing of I/O requests between virtual devices and the shared physical hardware.

⇒ Three ways to implement I/O virtualization
- Full device emulation
- Para virtualization
- direct I/O.

⇒ Full device emulation: All the functions of a device or bus infrastructure are replicated in software.



⇒ Para virtualization: consisting of frontend and backend drivers.

⇒ The frontend drivers manage I/o request of the guest os.

⇒ Backend drivers manage the real I/o devices

⇒ Direct I/o virtualization: Virtual machine directly Access from devices.

Virtual clusters and Resource management:-

⇒ virtual clusters have VMs that are interconnected logically by virtual network.

⇒ critical design issues of virtual clusters

- * Live migration of VMs
- * memory and file migration
- * Dynamic Deployment of virtual clusters

⇒ when a Traditional VM is ~~first~~ initialized, The administrator needs to manually write configuration sources.

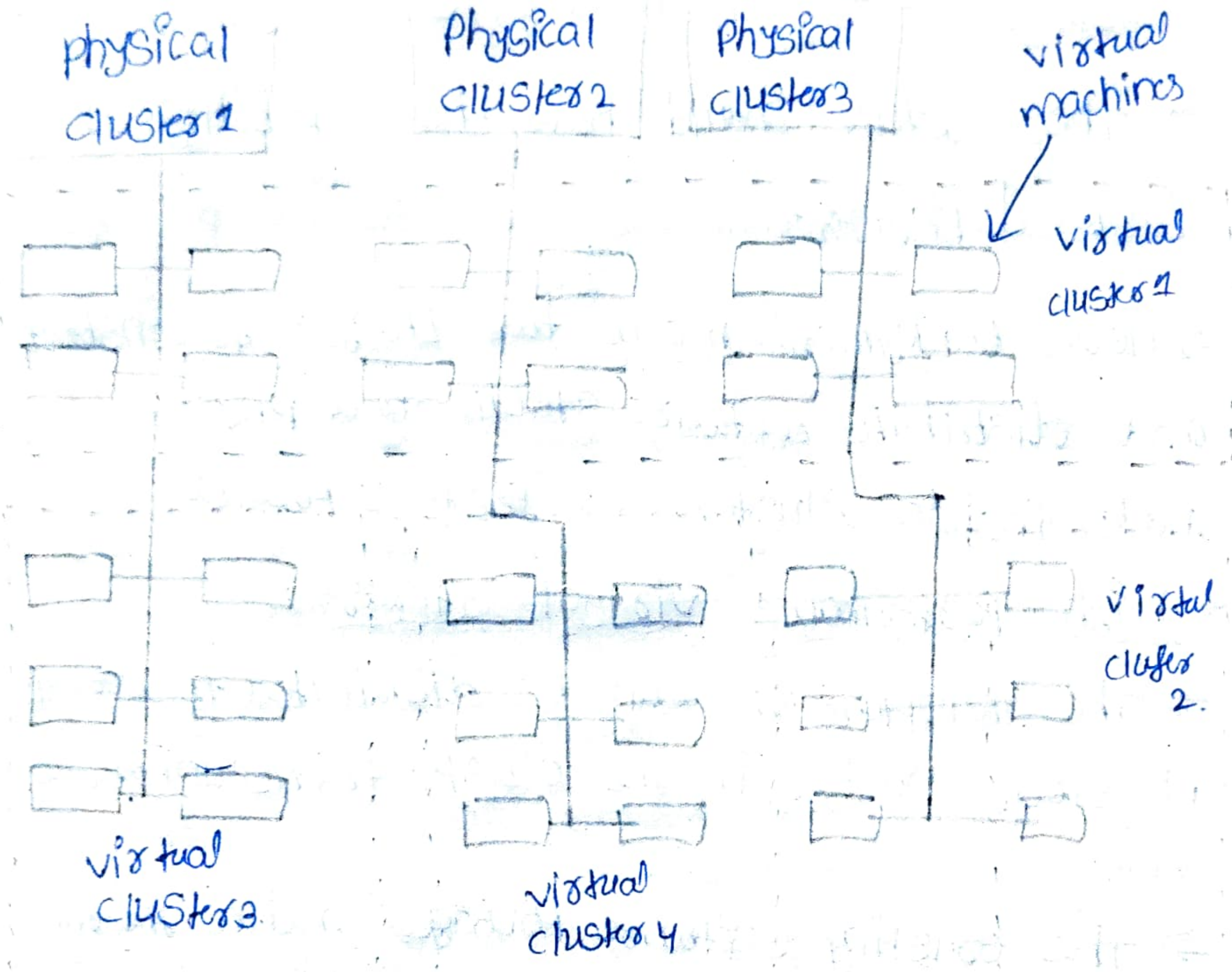
⇒ when more VM Join a network, This Problem may raise over loading.

⇒ most virtualization platforms, including xen server and VMware ESX server, support a brid-ging mode which allows all domains to appear on network individual hosts.

⇒ This mode, VMs can communicate with one another freely through the virtual network interface

1. Physical versus Virtual clusters:-

⇒ virtual clusters are built with VMs installed at distributed server from one or more physical clusters.



⇒ The virtual cluster nodes can be either physical or virtual machines. multiple VMs running with different OSes can be deployed on the same physical node.

⇒ ~~A~~ VM runs with a guest OS, that manages the resources in the physical machine.

⇒ The purpose of VM is to consolidate multiple functionalities on the same server.

⇒ VM can be colonized in multiple servers for the purpose of promoting distributed parallelism, fault tolerance, and disaster recovery.

* **Fast Deployment and effective scheduling:-**

⇒ the System should have the capability of fast deployment.

⇒ Here, Deployment means two things: to construct and distribute software stacks to a physical node inside clusters as fast as possible.

* **High - Performance virtual Storage:-**

⇒ The Template VM can be distributed to several physical hosts in the cluster to customize the VMs.

⇒ the existing software Packages reduce the time for customization as well as switching virtual environment.

⇒ It is important to manage efficiently disk space.

⇒ Basically, There are four steps to deploy a group of VMs onto a target cluster:

* Preparing the disk image
* Configuring the VMs
* choosing the destination nodes
* Executing the VM deployment command on every host.

2. Live VM migration steps and performance effects:-

⇒ A cluster built with mixed nodes of host and guest systems, the normal method of operation is to run everything on the physical machine.

⇒ When a VM fails, its role could be replaced by another VM on a different node, as long as they both run with the same guest OS.

VM running normally on Host A

Stage 0: Pre-migration
Active VM on Host A
Alternate physical Host may be preselected for migration Block devices mirrored and free resource maintained.

Stage 1: Reservation
Initialize a container on the target host.

Overhead due to copying

Stage 2: Iterative - Pre - copy
Enable shadow paging copy dirty pages in successive rounds

Downtime

Stage 3: Stop and copy
Suspend VM on host A
Generate ARP to redirect traffic to Host B.
Synchronize all remaining VM state to Host B.

Stage 4: Commitment
VM state on Host A is released

VM running normally on Host B

Stage 5: Activation
VM starts on Host B
connects to local devices
Resumes normal operation.

Steps 0 and 1 :-

* Start migration.
* This step makes preparations for the migration.
* The migration is automatically started by load balancing and server consolidation.

Step 2 :

* Transfer memory
* Sending the VM's memory to the destination node ensures continuity of the service provided by the VM.

Step 3:

* Suspend the vm and copy the last portion of the data.
* The migrating vm's execution is suspended when the last round's memory data is Transferred

Step 4 and 5:

* Commit and Activate the new host.
* All the needed data is copied, on the destination host.

3. migration of memory, files and Network Resources :

⇒ Since clusters have a high initial cost of ownership including space, Power conditioning and cooling equipment.

⇒ when one system migrates to another Physical node we should consider the following issues:

* Memory migration:-

⇒ This is one of the most important aspects of vm migration.

⇒ moving the memory instance of a vm from one Physical host to another can be approached in any number of ways.

* File system migration:

⇒ A system must provide each vm with a consistent, location - independent view of The file system that is available on all hosts.

* Network migration:

⇒ A migrating vm should maintain all open network connections without relying on forwarding mechanisms on the original host.

⇒ each vm must be assigned a virtual IP address known to other entities.

Virtualization for Data-Center Automation:

⇒ Data Centers have grown rapidly in recent years, and all major IT companies are pouring their resources into building new data centers.

⇒ Data - Center Automation means that huge volume of hardware, Software and database resources in Data centers can be allocated dynamically to millions of Internet users simultaneously.

⇒ this Automation process is triggered (ప్రేరేపిం-పబడింది) by the growth of virtualization products and cloud computing services.

1) Server consolidation in Data centers:-
ఏకీకరణ

→ In datacenters, a large number of heterogeneous workload can run on server at various Times.

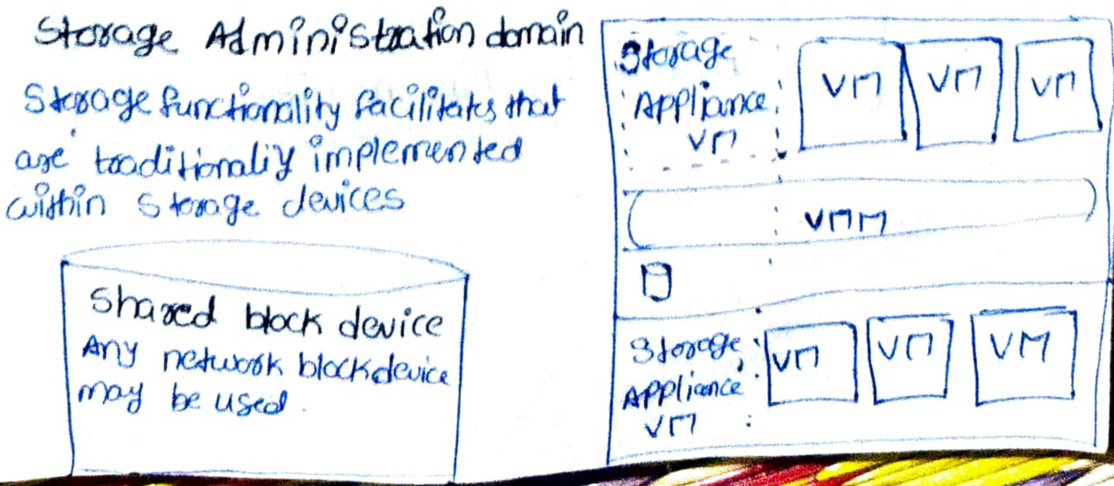
→ This hetrogeneous workloads can be divided into two categories
* chatty workloads
* Noninter-active workloads.

→ chatty workloads may burst at some point and return to a silent state to at some other point

→ Server consolidation is an approach to improve the low utility ratio of hardware resources by reducing the number of physical servers.

2) Virtual Storage management:-
→ The term "storage virtualization" was widely used before the renaissance (పునరుజ్జీవనం) of system virtualization.

→ In system virtualization, virtual storage includes the storage managed by VMMs and guest OSes.



3. Cloud OS for virtualized Data centers:

⇒ Data centers must be virtualized to serve as cloud providers.

⇒ This Cloud Providers can be used to Access data from anywere through network.

4. Trust management in virtualized Data centers:

⇒ A VMM changes the computer Architecture.

⇒ It provides a layer of software between the operating system and system hardware