Unit - II

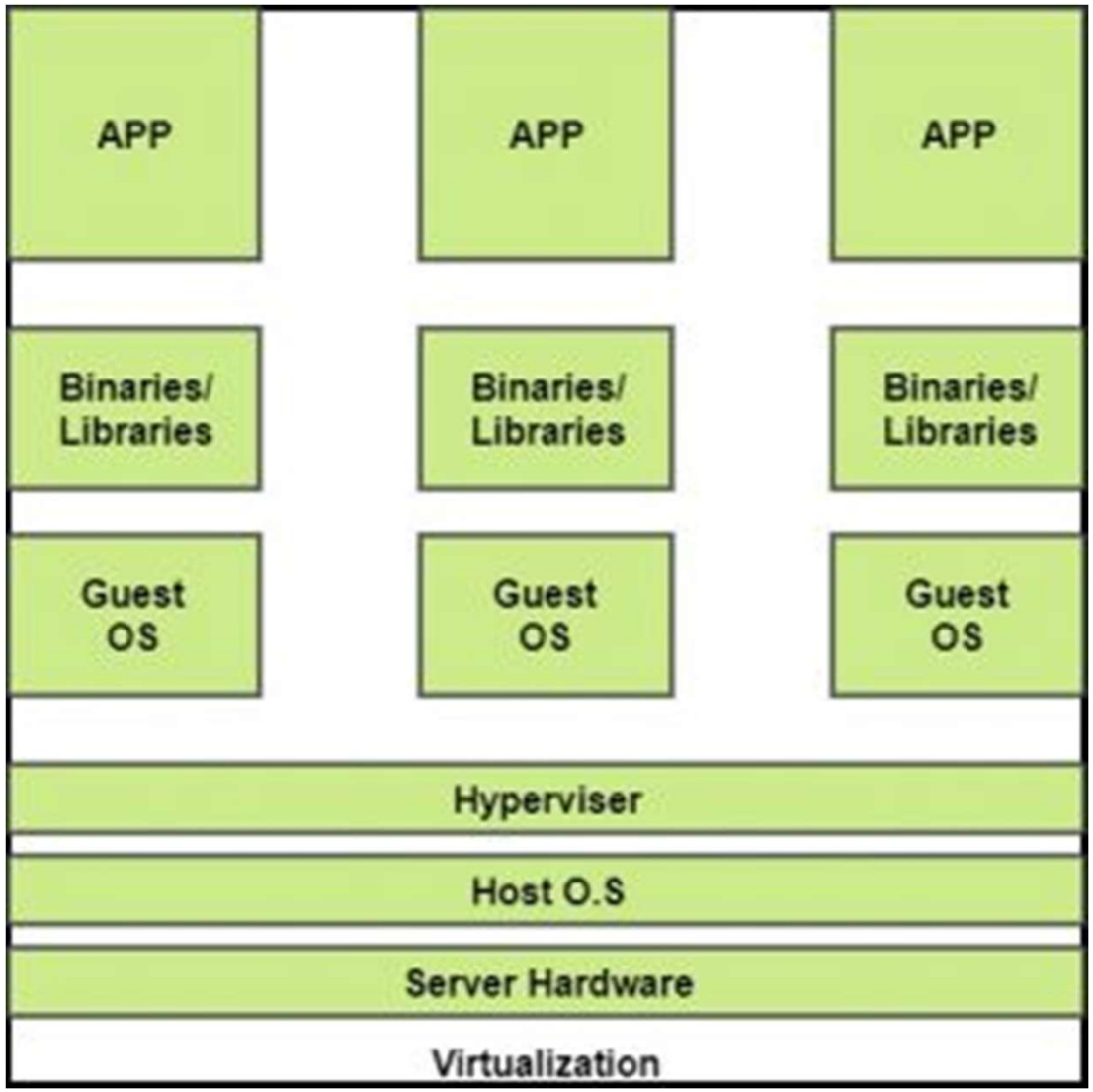
Virtualization

Introduction, Characteristics of Virtualized Environments, Taxonomy of Virtualization Techniques, Execution Virtualization, Types of hardware virtualization: Full virtualization - partial virtualization - para virtualization

Desktop virtualization: Software virtualization – Memory virtualization - Storage virtualization – Data Virtualization – Network virtualization, Virtualization and Cloud Computing, Pros and Cons of Virtualization, Technology Examples, Xen: Para virtualization, VMware: Full Virtualization, Microsoft Hyper-V.

Virtualization in Cloud Computing and Types

- Virtualization is a technique of how to separate a service from the underlying physical delivery of that service.
- It is the process of creating a virtual version of something like computer hardware.
- It was initially developed during the mainframe era. It involves using specialized software to create a virtual or software-created version of a computing resource rather than the actual version of the same resource.
- With the help of Virtualization, multiple operating systems and applications can run on same machine and its same hardware at the same time, increasing the utilization and flexibility of hardware.


APP
APP
APP
Binaries/
Libraries
Binaries/
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Binaries/
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Guest
OS
Guest
OS
Guest
OS
Hyperviser
Host O.S
Server Hardware
Virtualization

BENEFITS OF VIRTUALIZATION

- More flexible and efficient allocation of resources.
- Enhance development productivity.
- It lowers the cost of IT infrastructure.
- Remote access and rapid scalability.
- High availability and disaster recovery.
- Pay peruse of the IT infrastructure on demand.
- Enables running multiple operating systems.

Types of Virtualization

- Application Virtualization.
- Network Virtualization.
- Desktop Virtualization.
- Storage Virtualization.
- Server Virtualization.
- Data virtualization.

Application Virtualization

- Application virtualization helps a user to have remote access of an application from a server.
- The server stores all personal information and other characteristics of the application but can still run on a local workstation through the internet.
- Example of this would be a user who needs to run two different versions of the same software.
- Technologies that use application virtualization are hosted applications and packaged applications.

Network Virtualization

- The ability to run multiple virtual networks with each has a separate control and data plan.
- It co-exists together on top of one physical network.
- It can be managed by individual parties that potentially confidential to each other.
  Network virtualization provides a facility to create and provision virtual networks—logical switches, routers, firewalls, load balancer, Virtual Private Network (VPN), and workload security within days or even in weeks.

Desktop Virtualization

- Desktop virtualization allows the users' OS to be remotely stored on a server in the data centre.
- It allows the user to access their desktop virtually, from any location by a different machine.
- Users who want specific operating systems other than Windows Server will need to have a virtual desktop.
- Main benefits of desktop virtualization are user mobility, portability, easy management of software installation, updates, and patches.

Storage Virtualization

- Storage virtualization is an array of servers that are managed by a virtual storage system.
- The servers aren’t aware of exactly where their data is stored, and instead function more like worker bees in a hive.
- It makes managing storage from multiple sources to be managed and utilized as a single repository.
- Storage virtualization software maintains smooth operations, consistent performance and a continuous suite of advanced functions despite changes, break down and differences in the underlying equipment.

Server Virtualization

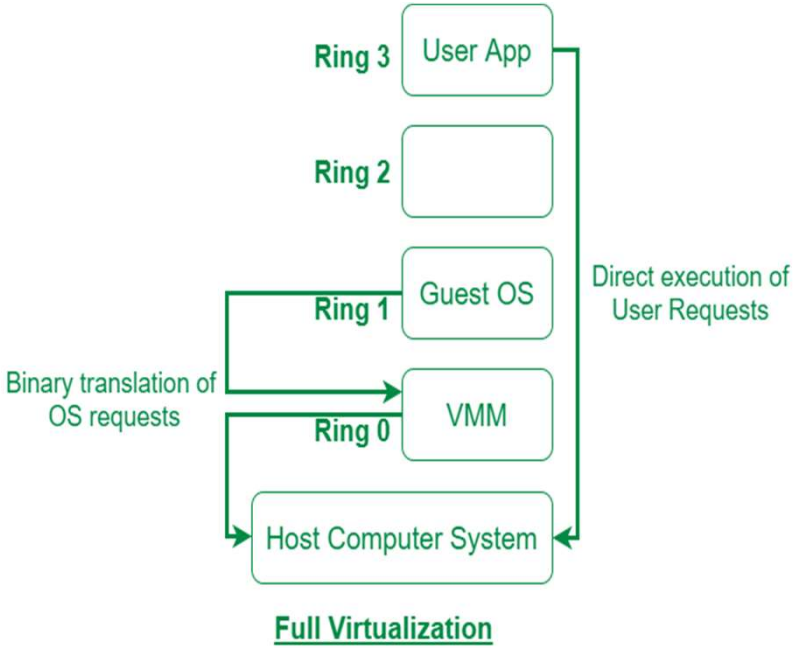
- This is a kind of virtualization in which masking of server resources takes place.
- Here, the central-server(physical server) is divided into multiple different virtual servers by changing the identity number, processors.
- So, each system can operate its own operating systems in isolate manner.
- Where each sub-server knows the identity of the central server.
- It causes an increase in the performance and reduces the operating cost by the deployment of main server resources into a sub-server resource.
- It’s beneficial in virtual migration, reduce energy consumption, reduce infrastructural cost, etc.

Data virtualization

- This is the kind of virtualization in which the data is collected from various sources and managed that at a single place without knowing more about the technical information like how data is collected, stored & formatted then arranged that data logically so that its virtual view can be accessed by its interested people and stakeholders, and users through the various cloud services remotely. Many big giant companies are providing their services like Oracle, IBM, At scale, Cdata, etc.
- It can be used to performing various kind of tasks such as:
  - **Data-integration**
  - **Business-integration**
  - **Service-oriented architecture data-services**
  - **Searching organizational data**

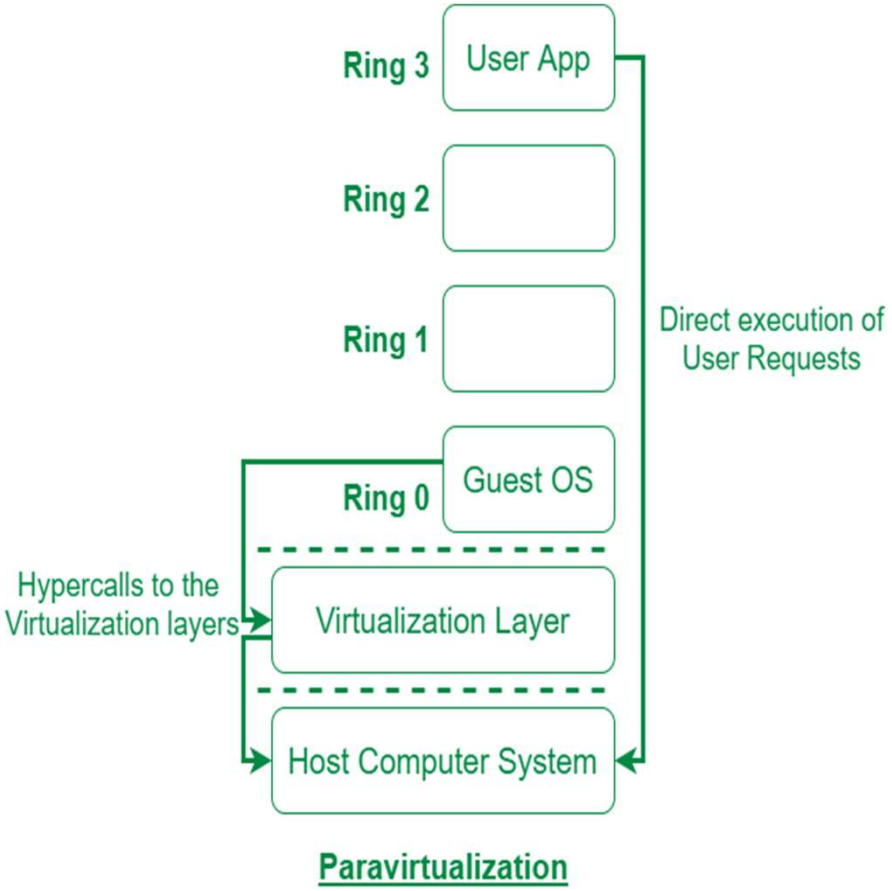
Difference between Full Virtualization and Paravirtualization

Full Virtualization :
Full Virtualization was introduced by IBM in the year 1966. It is the first software solution of server virtualization and uses binary translation and direct approach technique. In full virtualization, guest OS is completely isolated by the virtual machine from the virtualization layer and hardware. Microsoft and Parallels systems are examples of full virtualization.



Paravirtualization :

Paravirtualization is the category of CPU virtualization which uses hypercalls for operations to handle instructions at compile time. In paravirtualization, guest OS is not completely isolated but it is partially isolated by the virtual machine from the virtualization layer and hardware. VMware and Xen are some examples of paravirtualization.



Paravirtualization

The difference between Full Virtualization and Paravirtualization are as follows:

Full Virtualization	Paravirtualization
In Full virtualization, virtual machine permit the execution of the instructions with running of unmodified OS in an entire isolated way.	In paravirtualization, virtual machine does not implement full isolation of OS but rather provides a different API which is utilized when OS is subjected to alteration.
Full Virtualization is less secure.	While the Paravirtualization is more secure than the Full Virtualization.
Full Virtualization uses binary translation and direct approach as a technique for operations.	While Paravirtualization uses hypercalls at compile time for operations.
Full Virtualization is slow than paravirtualization in operation.	Paravirtualization is faster in operation as compared to full virtualization.
Full Virtualization is more portable and compatible.	Paravirtualization is less portable and compatible.
Examples of full virtualization are Microsoft and Parallels systems.	Examples of paravirtualization are VMware and Xen.

Partial Virtualization

- When entire operating systems cannot run in the virtual machine, but some or many applications can, it is known as Partial Virtualization. Basically, it partially simulates the physical hardware of a system.
- This type of virtualization is far easier to execute than full virtualization.

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).

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.

Pros of Virtualization

- **Utilization of Hardware Efficiently –**
  With the help of Virtualization Hardware is Efficiently used by user as well as Cloud Service Provider. In this the need of Physical Hardware System for the User is decreases and this results in less costly. In Service Provider point of View, they will vitalize the Hardware using Hardware Virtualization which decrease the Hardware requirement from Vendor side which are provided to User is decreased.
- **Availability increases with Virtualization –**
  One of the main benefit of Virtualization is that it provides advance features which allow virtual instances to be available all the times. It also has capability to move virtual instance from one virtual Server another Server which is very tedious and risky task in Server Based System. During migration of Data from one server to another it ensures its safety. Also, we can access information from any location and any time from any device.

- **Disaster Recovery is efficient and easy:** With the help of virtualization Data Recovery, Backup, Duplication becomes very easy. In traditional method , if somehow due to some disaster if Server system Damaged then the surety of Data Recovery is very less. But with the tools of Virtualization real time data backup recovery and mirroring become easy task and provide surety of zero percent data loss.
- **Virtualization saves Energy:** Virtualization will help to save Energy because while moving from physical Servers to Virtual Server's, the number of Server's decreases due to this monthly power and cooling cost decreases which will Save Money as well. As cooling cost reduces it means carbon production by devices also decreases which results in Fresh and pollution free environment.

- **Quick and Easy Set up:** In traditional methods Setting up physical system and servers are very time-consuming. Firstly Purchase them in bulk after that wait for shipment. When Shipment is done then wait for Setting up and after that again spend time in installing required software etc. Which will consume very time. But with the help of virtualization the entire process is done in very less time which results in productive setup.
- **Cloud Migration becomes easy:** Most of the companies those who already have spent a lot in the server have a doubt of Shifting to Cloud. But it is more cost-effective to shift to cloud services because all the data that is present in their server's can be easily migrated into the cloud server and save something from maintenance charge, power consumption, cooling cost, cost to Server Maintenance Engineer etc.

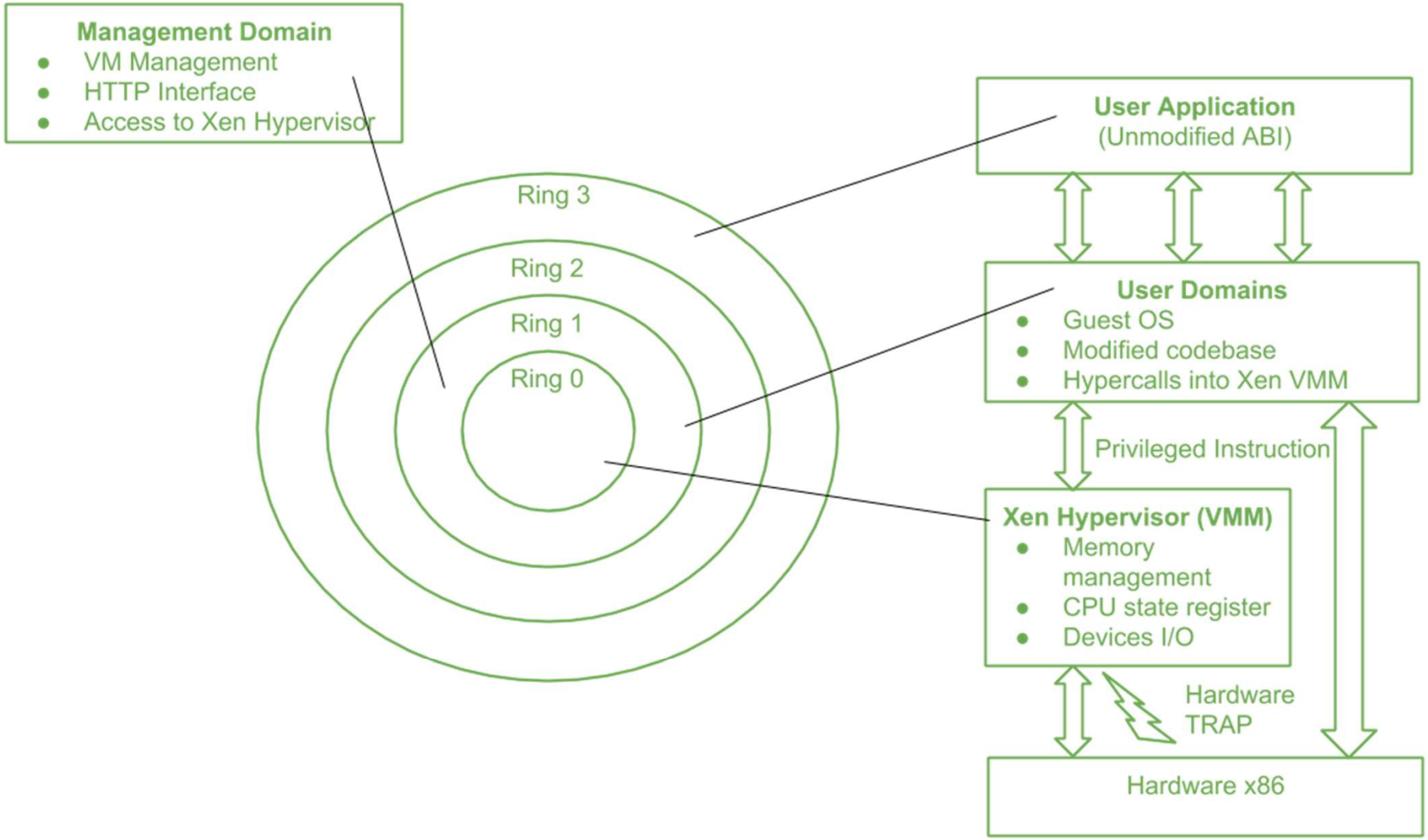
Cons of Virtualization

- **Data can be at Risk:** Working on virtual instances on shared resources means that our data is hosted on third party resource which put's our data in vulnerable condition. Any hacker can attack on our data or try to perform unauthorized access. Without Security solution our data is in threaten situation**.**
- **Learning New Infrastructure:** As Organization shifted from Servers to Cloud. They required skilled staff who can work with cloud easily. Either they hire new IT staff with relevant skill or provide training on that skill which increase the cost of company.

- **High Initial Investment:** It is true that Virtualization will reduce the cost of companies but also it is truth that Cloud have high initial investment. It provides numerous services which are not required and when unskilled organization will try to set up in cloud they purchase unnecessary services which are not even required to them.

Xen: Para virtualization

- **Xen** is an open source hypervisor based on paravirtualization. It is the most popular application of paravirtualization. Xen has been extended to compatible with full virtualization using hardware-assisted virtualization.
- It enables high performance to execute guest operating system.
- This is probably done by removing the performance loss while executing the instructions requiring significant handling and by modifying portion of the guest operating system executed by Xen, with reference to the execution of such instructions. Hence this especially support x86, which is the most used architecture on commodity machines and servers.


Management Domain
VM Management
HTTP Interface
Access to Xen Hypervisor
Ring 3
Ring 2
Ring 1
Ring 0
User Application
(Unmodified ABI)
User Domains
Guest OS
Modified codebase
Hypercalls into Xen VMM
Privileged Instruction
Xen Hypervisor (VMM)
Memory management
CPU state register
Devices I/O
Hardware TRAP
Hardware x86

- Above figure describes the Xen Architecture and its mapping onto a classic x86 privilege model. A Xen based system is handled by Xen hypervisor, which is executed in the most privileged mode and maintains the access of guest operating system to the basic hardware. Guest operating system are run between domains, which represents virtual machine instances.
- In addition, particular control software, which has privileged access to the host and handles all other guest OS, runs in a special domain called Domain 0. This the only one loaded once the virtual machine manager has fully booted, and hosts an HTTP server that delivers requests for virtual machine creation, configuration, and termination. This component establishes the primary version of a shared virtual machine manager (VMM), which is a necessary part of Cloud computing system delivering Infrastructure-as-a-Service (IaaS) solution.

- Here, Ring 0 represents the level having most privilege and Ring 3 represents the level having least privilege. Almost all the frequently used Operating system, except for OS/2, uses only two levels i.e. Ring 0 for the Kernel code and Ring 3 for user application and non-privilege OS program. This provides a chance to the Xen to implement paravirtualization. This enables Xen to control unchanged the Application Binary Interface (ABI) thus allowing a simple shift to Xen-virtualized solutions, from an application perspective.
- Due to the structure of x86 instruction set, some instructions allow code execution in Ring 3 to switch to Ring 0 (Kernel mode). Such an operation is done at hardware level, and hence between a virtualized environment, it will lead to a TRAP or a silent fault, thus preventing the general operation of the guest OS as it is now running in Ring 1.

Pros:

- Xen server is developed over open-source Xen hypervisor and it uses a combination of hardware-based virtualization and paravirtualization. This tightly coupled collaboration between the operating system and virtualized platform enables the system to develop lighter and flexible hypervisor that delivers their functionalities in an optimized manner.
- Xen supports balancing of large workload efficiently that capture CPU, Memory, disk input-output and network input-output of data. It offers two modes to handle this workload: Performance enhancement, and For handling data density.
- It also comes equipped with a special storage feature that we call Citrix storage link. Which allows a system administrator to uses the features of arrays from Giant companies- Hp, Netapp, Dell Equal logic etc.
- It also supports multiple processor, Iive migration one machine to another, physical server to virtual machine or virtual server to virtual machine conversion tools, centralized multiserver management, real time performance monitoring over window and linux.

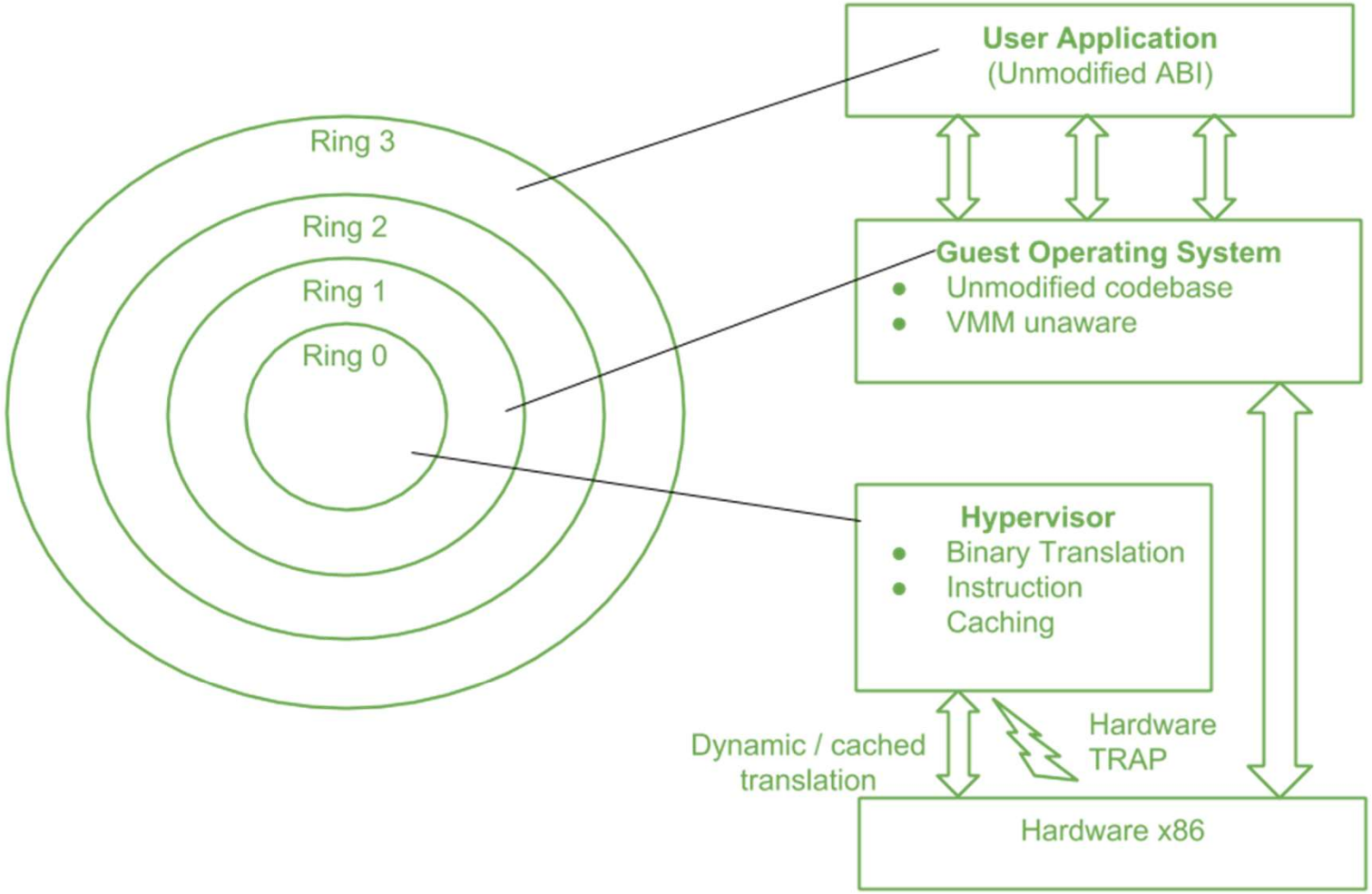
Cons:

- Xen is more reliable over linux rather than on window.
- Xen relies on 3rd-party component to manage the resources like drivers, storage, backup, recovery & fault tolerance.
- Xen deployment could be a burden some on your Linux kernel system as time passes.
- Xen sometimes may cause increase in load on your resources by high input-output rate and and may cause starvation of other Vm's.

VMware: Full Virtualization

- In full virtualization primary hardware is replicated and made available to the guest operating system, which executes unaware of such abstraction and no requirements to modify.
- Technology of VMware is based on the key concept of Full Virtualization.
- Either in desktop environment, with the help of type-II hypervisor, or in server environment, through type-I hypervisor, VMware implements full virtualization.
- In both the cases, full virtualization is possible through the direct execution for non-sensitive instructions and binary translation for sensitive instructions or hardware traps, thus enabling the virtualization of architecture like x86.

Full Virtualization and Binary Translation: VMware is widely used as it tends to virtualize x86 architectures, which executes unmodified on-top of their hypervisors. With the introduction of hardware-assisted virtualization, full virtualization is possible to achieve by support of hardware. But earlier, x86 guest operating systems unmodified in a virtualized environment could be executed only with the use of dynamic binary translation.


User Application
(Unmodified ABI)
Ring 3
Ring 2
Ring 1
Ring 0
Guest Operating System
Unmodified codebase
VMM unaware
Hypervisor
Binary Translation
Instruction Caching
Dynamic / cached translation
Hardware TRAP
Hardware x86

- The major benefit of this approach is that guests can run unmodified in a virtualized environment, which is an important feature for operating system whose source code does not existed.
- Binary translation is portable for full virtualization.
- As well as translation of instructions at runtime presents an additional overhead that is not existed in other methods like paravirtualization or hardware-assisted virtualization.
- Contradict, binary translation is only implemented to a subset of the instruction set, while the others are managed through direct execution on the primary hardware.
- This depletes somehow the impact on performance of binary translation.

Advantages of Binary Translation –

- This kind of virtualization delivers the best isolation and security for Virtual Machine.
- Truly isolated numerous guest OS can execute concurrently on the same hardware.
- It is only implementation that needs no hardware assist or operating system assist to virtualize sensitive instruction as well as privileged instruction.

Disadvantages of Binary Translation –

- It is time consuming at run-time.
- It acquires a large performance overhead.
- It employs a code cache to stock the translated most used instructions to enhance the performance, but it increases memory utilization along with the hardware cost.
- The performance of full virtualization on the x86 architecture is 80 to 95 percent that of the host machine.

Microsoft Hyper-V

- Hyper-V is Microsoft's hardware virtualization product. It lets you create and run a software version of a computer, called a *virtual machine*. Each virtual machine acts like a complete computer, running an operating system and programs. When you need computing resources, virtual machines give you more flexibility, help save time and money, and are a more efficient way to use hardware than just running one operating system on physical hardware.
- Hyper-V runs each virtual machine in its own isolated space, which means you can run more than one virtual machine on the same hardware at the same time. You might want to do this to avoid problems such as a crash affecting the other workloads, or to give different people, groups or services access to different systems.

Hyper-V can help you:

- **Establish or expand a private cloud environment.** Provide more flexible, on-demand IT services by moving to or expanding your use of shared resources and adjust utilization as demand changes.
- **Use your hardware more effectively.** Consolidate servers and workloads onto fewer, more powerful physical computers to use less power and physical space.
- **Improve business continuity.** Minimize the impact of both scheduled and unscheduled downtime of your workloads.
- **Establish or expand a virtual desktop infrastructure (VDI).** Use a centralized desktop strategy with VDI can help you increase business agility and data security, as well as simplify regulatory compliance and manage desktop operating systems and applications. Deploy Hyper-V and Remote Desktop Virtualization Host (RD Virtualization Host) on the same server to make personal virtual desktops or virtual desktop pools available to your users.
- **Make development and test more efficient.** Reproduce different computing environments without having to buy or maintain all the hardware you'd need if you only used physical systems.

Hyper-V offers many features. This is an overview, grouped by what the features provide or help you do.

- **Computing environment** - A Hyper-V virtual machine includes the same basic parts as a physical computer, such as memory, processor, storage, and networking. All these parts have features and options that you can configure different ways to meet different needs. Storage and networking can each be considered categories of their own, because of the many ways you can configure them.
- **Disaster recovery and backup** - For disaster recovery, Hyper-V Replica creates copies of virtual machines, intended to be stored in another physical location, so you can restore the virtual machine from the copy. For backup, Hyper-V offers two types. One uses saved states and the other uses Volume Shadow Copy Service (VSS) so you can make application-consistent backups for programs that support VSS.
- **Optimization** - Each supported guest operating system has a customized set of services and drivers, called *integration services*, that make it easier to use the operating system in a Hyper-V virtual machine.
- **Portability** - Features such as live migration, storage migration, and import/export make it easier to move or distribute a virtual machine.
- **Remote connectivity** - Hyper-V includes Virtual Machine Connection, a remote connection tool for use with both Windows and Linux. Unlike Remote Desktop, this tool gives you console access, so you can see what's happening in the guest even when the operating system isn't booted yet.
- **Security** - Secure boot and shielded virtual machines help protect against malware and other unauthorized access to a virtual machine and its data.

Assignment 2

- Analyze the Characteristics of Virtualized Environments with suitable examples.
- Analyze Taxonomy of Virtualization Techniques with suitable diagram.
- Analyze Types of hardware virtualization: Full virtualization - partial virtualization - para virtualization with suitable case study.
- Analyze Desktop virtualization, Software virtualization, Memory virtualization, Storage virtualization, Data Virtualization with suitable case study.
- Analyze Pros and Cons of Virtualization, Technology with suitable Examples of Xen, Vmware and Microsoft Hyper-V.
- Case study of following TCS services: ignioTM, BaNCSTM, Quartz, ADDTM, OptumeraTM, OmnistoreTM, HOBSTM, iON, MasterCraftTM, & JileTM

Submission link: https://forms.gle/f8vGUapeDMowSL7n9

Presentation II (Choose any one topic)

- Case study on Virtualization
- Case study on hardware virtualization
- Case study on Desktop virtualization
- Case study on Storage virtualization
- Case study on Network virtualization

Submission link: https://forms.gle/f8vGUapeDMowSL7n9

Lab 2

To use GOOGLE APP ENGINE launcher to launch the web applications using eclipse.

Submission link: https://forms.gle/f8vGUapeDMowSL7n9