Virtualization

Chapter 2

Topics

- Need for Virtualization
- Pros and cons of Virtualization
- Types of Virtualization
- System VM
- Process VM
- Virtual Machine monitor
- Virtual machine properties
- Interpretation and binary translation
- HLL VM
- Hypervisors - Xen, KVM, VM Ware, Virtual Box,Hyper-V.

VIRTUALIZATION

Virtualization is a kind of technology that is rapidly transforming the IT landscape and has changed the way people compute.

It reduces hardware utilization, saves energy and costs and makes it possible to run multiple applications and various operating systems on the same SERVER at the same time.

It increases the utilization, efficiency and flexibility of existing computer hardware

VIRTUALIZATION ..II
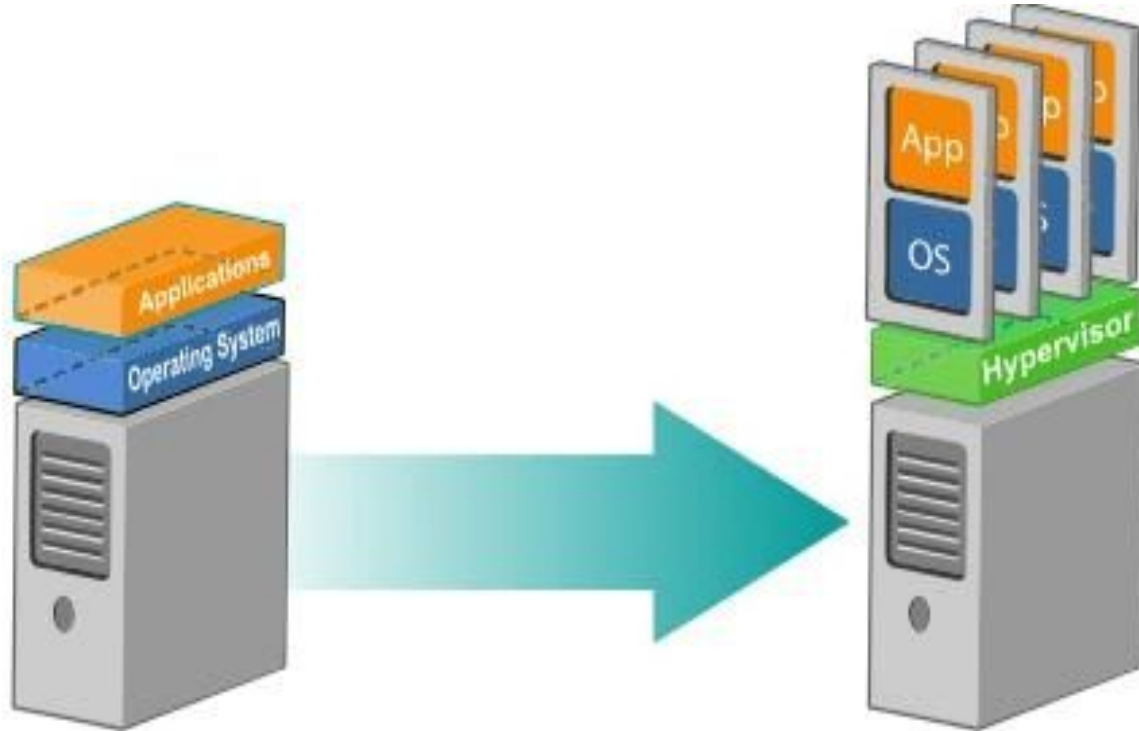
VIRTUALIZATION ..III

Virtualization is technology that allows you to create multiple simulated environments or dedicated resources from a single, physical hardware system.

Software called a hypervisor connects directly to that hardware and allows you to split 1 system into separate, distinct, and secure environments known as virtual machines (VMs).

These VMs rely on the hypervisor's ability to separate the machine's resources from the hardware and distribute them appropriately.

	Virtualization	Cloud
Definition	Technology	Methodology
Purpose	Create multiple simulated environments from 1 physical hardware system	Pool and automate virtual resources for on-demand use
Use	Deliver packaged resources to specific users for a specific purpose	Deliver variable resources to groups of users for a variety of purposes
Configuration	Image-based	Template-based
Lifespan	Years (long-term)	Hours to months (short-term)
Cost	High capital expenditures (CAPEX), low operating expenses (OPEX)	Private cloud: High CAPEX, low OPEX Public cloud: Low CAPEX, high OPEX
Scalability	Scale up	Scale out
Workload	Stateful	Stateless
Tenancy	Single tenant	Multiple tenants

Need for Virtualization

Virtualization provides various benefits including saving time and energy, decreasing costs and minimizing overall risk.

- Provides ability to manage resources effectively.

- Increases productivity, as it provides secure remote access.

- Provides for data loss prevention.

Need for Virtualization ..II

Partitioning: In virtualization, many applications and operating systems (OSes) are supported in a single physical system by partitioning (separating) the available resources.

Isolation: Each virtual machine is isolated from its host physical system and other virtualized machines. Because of this isolation, if one virtual-instance crashes, it doesn't affect the other virtual machines. In addition,data isn't shared between one virtual container and another.

Encapsulation: A virtual machine can be represented (and even stored)as a single file, so you can identify it easily based on the service it provides.In essence, the encapsulated process could be a business service. This encapsulated virtual machine can be presented to an application as a complete entity. Therefore, encapsulation can protect each application so that it doesn't interfere with another application.

Pros of Virtualization in Cloud Computing

Utilization of Hardware Efficiently –

With the help of Virtualization Hardware is Efficiently used by user as well as Cloud Service Provider which decreases hardware resource cost.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. Before Virtualization, Companies and organizations have to set up their own Server which require extra space for placing them, engineer's to check its performance and require extra hardware cost but with the help of Virtualization the all these limitations are removed by Cloud vendors who provide Physical Services without setting up any Physical Hardware system.

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.

Pros of Virtualization in Cloud Computing

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

BENEFITS OF VIRTUALIZATION

1. More flexible and efficient allocation of resources.

2. Enhance development productivity.

3. It lowers the cost of IT infrastructure.

4. Remote access and rapid scalability.

5. High availability and disaster recovery.

6. Pay peruse of the IT infrastructure on demand.

7. Enables running multiple operating systems.

Types of Virtualization

1. Application Virtualization.

2. Network Virtualization.

3. Desktop Virtualization.

4. Storage Virtualization.

5. Server Virtualization.

6. 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 infrastructure 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.

System Virtual Machine

System Virtual Machine

These types of virtual machines gives us complete system platform and gives the execution of the complete virtual operating system.

Just like virtual box, system virtual machine is providing an environment for an OS to be installed completely.

We can see in below image that our hardware of Real Machine is being distributed between two simulated operating systems by Virtual machine monitor.

And then some programs, processes are going on in that distributed hardware of simulated machines separately.

System Virtual Machine

| APP | APP | APP | APP | APP | APP | APP | APP |

| Operating System | Operating System |
| Simulated Machine | Simulated Machine |

Virtual Machine Monitor (VMM)

Hardware -- "Real Machine"
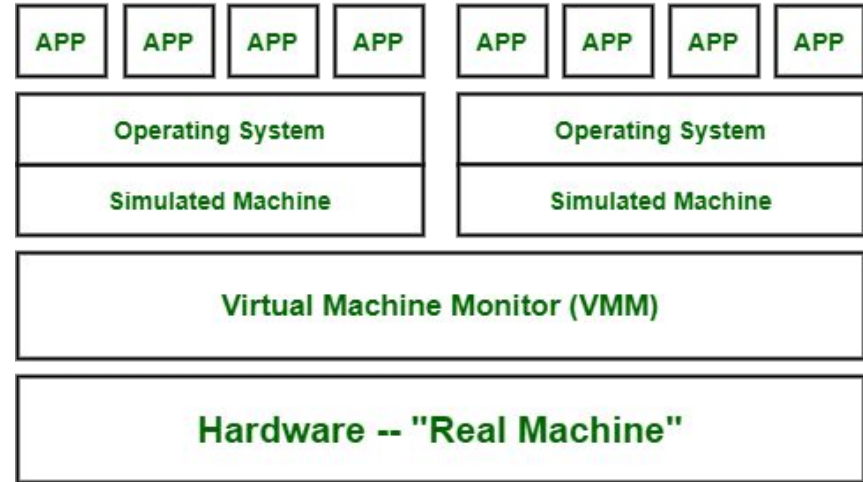
Process Virtual Machine

Process Virtual Machine

While process virtual machines, unlike system virtual machine, does not provide us with the facility to install the virtual operating system completely.

Rather it creates virtual environment of that OS while using some app or program and this environment will be destroyed as soon as we exit from that app. Like in below image, there are some apps running on main OS as well some virtual machines are created to run other apps.

This shows that as those programs required different OS, process virtual machine provided them with that for the time being those programs are running. Example – Wine software in Linux helps to run Windows applications

Process Virtual Machine

APP	APP	APP

| | OS - 2 | OS - 3 |

APP	Virtual Machine

Operating System - 1

Hardware -- "Real Machine"
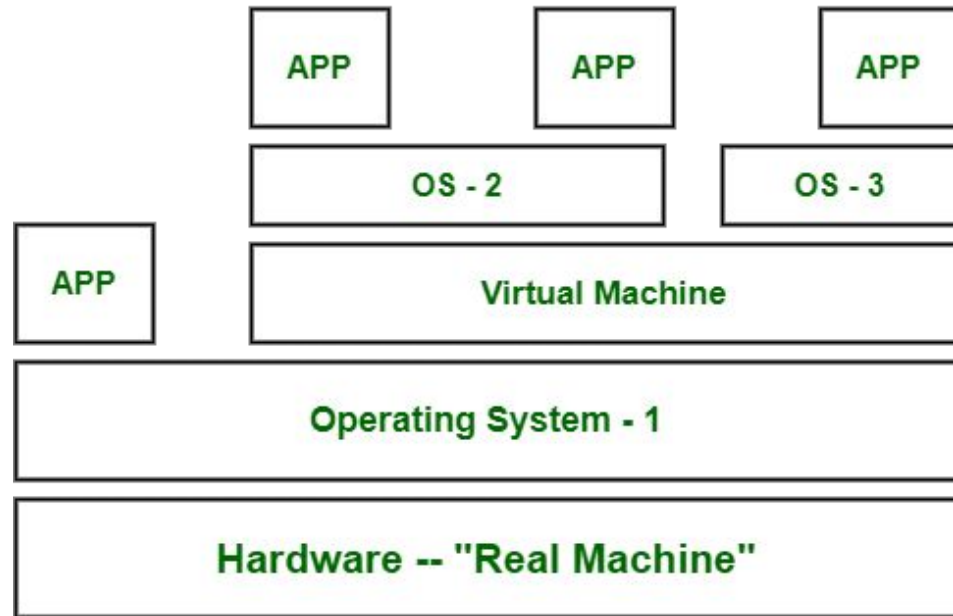
Virtual Machine Monitor (VMM)

- A virtual machine monitor (VMM), also known as a hypervisor, is a software, hardware, or firmware-based process that manages the creation and operation of virtualized environments from the host system.
- Virtual machine monitors provide IT operations managers visibility into the usage and performance of associated VMs.
- In supporting the management of a virtual environment, virtual machine monitoring supports efficient performance and maximal uptime of virtual machines; collects data about the performance of virtual machines necessary for troubleshooting and event resolution

VMM

- VMM is the primary software behind virtualization environments and implementations. When installed over a host machine, VMM facilitates the creation of VMs, each with separate operating systems (OS) and applications.
- VMM manages the backend operation of these VMs by allocating the necessary computing, memory, storage and other input/output (I/O) resources.
- VMM also provides a centralized interface for managing the entire operation, status and availability of VMs that are installed over a single host or spread across different and interconnected hosts.

Supported Apps

vmware	**Microsoft Hyper-v**	**CITRIX®**	**CITRIX®**
VMWware ESX/ESXi	Microsoft Hyper-V	Citrix Hypervisor	Citrix Virtual Apps
vmware	**docker**	**kubernetes**	**Red Hat**
VMware Horizon View	Docker	Kubernetes	Red Hat Virtualization
Red Hat	**ORACLE VM**		
Kernel-based VM	Oracle VM	Openshift	

Virtual Machine Properties

The Virtual Machine Properties shows details about a client computer that is deployed as a virtual machine (VM).

Virtualization Client Name – Name of the client computer that provides a management access point for the hypervisor where the virtual machine is deployed.

Virtual Machine Name – Name of the client computer for the virtual machine.

Vendor – Hypervisor for the virtual machine.

Uuid – Universally unique ID (UUID) for the virtual machine.

Hardware Version – The hardware version of the virtual machine on the host computer, which determines the virtual hardware functions supported for the VM.

Host – IP address for the host where the virtual machine is located.

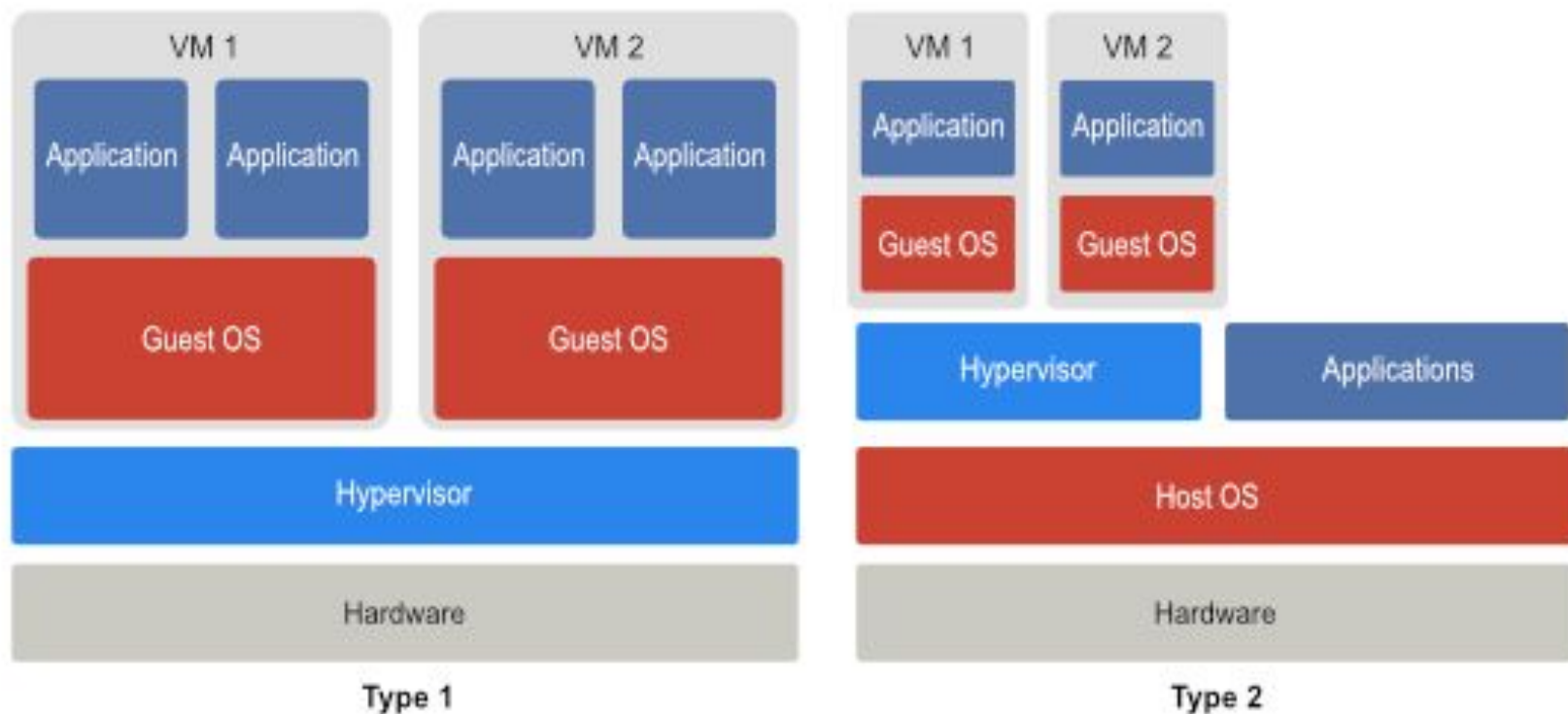Host Version – Version and build for the hypervisor software on the host.

Types of Hypervisor

- A hypervisor, also known as a virtual machine monitor or VMM, is software that creates and runs virtual machines (VMs). A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, such as memory and processing.
- There are two main hypervisor types, referred to as "Type 1" (or "bare metal") and "Type 2" (or "hosted").

Type 1 hypervisor

- A type 1 hypervisor acts like a lightweight operating system and runs directly on the host's hardware
- In this type of hypervisor , virtualization software is installed directly on the hardware where the operating system is normally installed
- Because bare-metal hypervisors are isolated from the attack-prone operating system, they are extremely secure.
- In addition, they generally perform better and more efficiently than hosted hypervisors. For these reasons, most enterprise companies choose bare-metal hypervisors for data center computing needs.

Hypervisor Types

VM 1		VM 2	
Application	Application	Application	Application
Guest OS		Guest OS	

Hypervisor

Hardware

Type 1

VM 1	VM 2
Application	Application
Guest OS	Guest OS

Hypervisor	Applications

Host OS

Hardware

Type 2

TYPE 1 hypervisor examples:

1. VMware ESX and ESXi

- These hypervisors offer advanced features and scalability, but require licensing, so the costs are higher.
- There are some lower-cost bundles that VMware offers and they can make hypervisor technology more affordable for small infrastructures.
- VMware is the leader in the Type-1 hypervisors. Their vSphere/ESXi product is available in a free edition and 5 commercial editions.

TYPE 1 hypervisor examples:

2. Microsoft Hyper-V

- The Microsoft hypervisor, Hyper-V doesn't offer many of the advanced features that VMware's products provide. However, with XenServer and vSphere, Hyper-V is one of the top 3 Type-1 hypervisors.
- It was first released with Windows Server, but now Hyper-V has been greatly enhanced with Windows Server 2012 Hyper-V.
- Hyper-V is available in both a free edition (with no GUI and no virtualization rights) and 4 commercial editions – Foundations (OEM only), Essentials, Standard, and Datacenter.

TYPE 1 hypervisor examples:

3. Citrix XenServer

It began as an open source project. The core hypervisor technology is free, but like VMware's free ESXi, it has almost no advanced features.

Xen is a type-1 bare-metal hypervisor. Just as Red Hat Enterprise Virtualization uses KVM, Citrix uses Xen in the commercial XenServer.

Today, the Xen open source projects and community are at Xen.org. Today, XenServer is a commercial type-1 hypervisor solution from Citrix, offered in 4 editions.

Confusingly, Citrix has also branded their other proprietary solutions like XenApp and XenDesktop with the Xen name.

TYPE 1 hypervisor examples:

4. Oracle VM

- The Oracle hypervisor is based on the open source Xen.
- However, if you need hypervisor support and product updates, it will cost you.
- Oracle VM lacks many of the advanced features found in other bare-metal virtualization hypervisors.

Type 2 hypervisor

Type 2 hypervisor runs as a software layer on an operating system, like other computer programs

TYPE 2 hypervisor examples:

1. VMware Workstation/Fusion/Player

- VMware Player is a free virtualization hypervisor. It is intended to run only one virtual machine (VM) and does not allow creating VMs.
- VMware Workstation is a more robust hypervisor with some advanced features, such as record-and-replay and VM snapshot support.
- VMware Workstation has three major use cases:
    - for running multiple different operating systems or versions of one OS
    - on one desktop,
    - for developers that need sandbox environments and snapshots, or
    - for labs and demonstration purposes.

TYPE 2 hypervisor examples:

2. VMware Server

- VMware Server is a free, hosted virtualization hypervisor that's very similar to the VMware Workstation.
- VMware has halted development on Server since 2009

TYPE 2 hypervisor examples:

3. Microsoft Virtual PC

● This is the latest Microsoft's version of this hypervisor technology, Windows Virtual PC and runs only on Windows 7 and supports only Windows operating systems running on it.

TYPE 2 hypervisor examples:

4. Oracle VM VirtualBox

- VirtualBox hypervisor technology provides reasonable performance and features if you want to virtualize on a budget.
- Despite being a free, hosted product with a very small footprint, VirtualBox shares many features with VMware vSphere and Microsoft Hyper-V.

TYPE 2 hypervisor examples:

5. Red Hat Enterprise Virtualization

- Red Hat's Kernel-based Virtual Machine (KVM) has qualities of both a hosted and a bare-metal virtualization hypervisor.
- It can turn the Linux kernel itself into a hypervisor so the VMs have direct access to the physical hardware.

KVM

- This is a virtualization infrastructure for the Linux kernel. It supports native virtualization on processors with hardware virtualization extensions.
- The open-source KVM (or Kernel-Based Virtual Machine) is a Linux-based type-1 hypervisor that can be added to most Linux operating systems including Ubuntu, Debian, SUSE, and Red Hat Enterprise Linux, but also Solaris, and Windows.

Kvm architecture
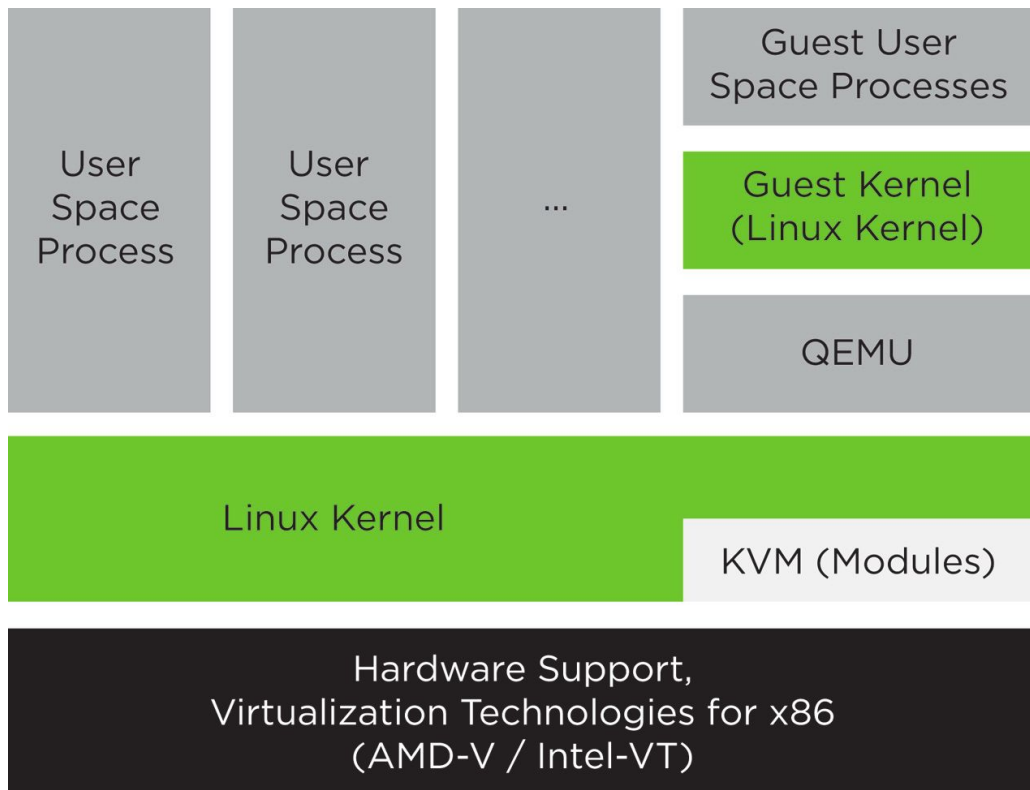
XEN

- Xen is a free and open-source type-1 hypervisor, providing services that allow multiple computer operating systems to execute on the same computer hardware concurrently.
- Xen provides a form of virtualization known as paravirtualization, in which guests run a modified operating system.
- The guests are modified to use a special hypercall ABI, instead of certain architectural features. Through paravirtualization, Xen can achieve high performance even on its host architecture (x86) which has a reputation for non-cooperation with traditional virtualization techniques.

Xen architecture
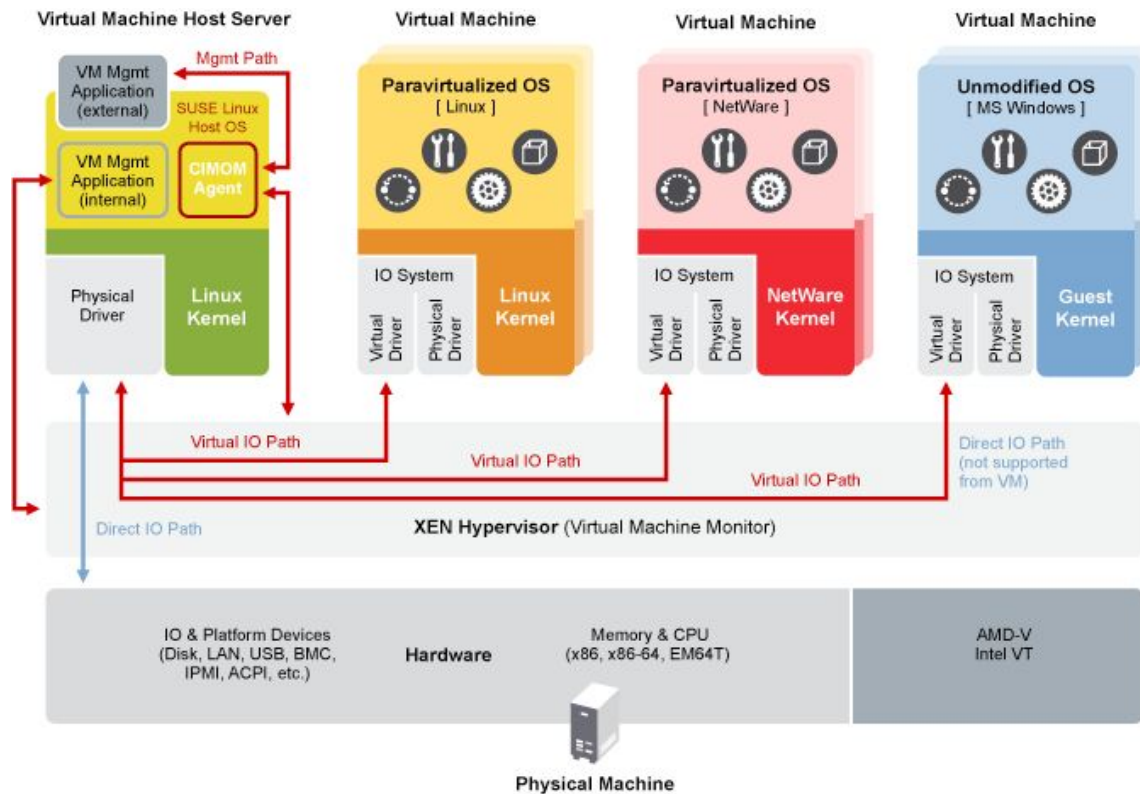
HIGH LEVEL LANGUAGE VM

Designing a special guest ISA/system interface is known to be HLL VM:

- With portability as the main goal

- Define an abstract interface that can be supported by all conventional OSes.

- Reflects important features of specific HLL or class of HLLs.

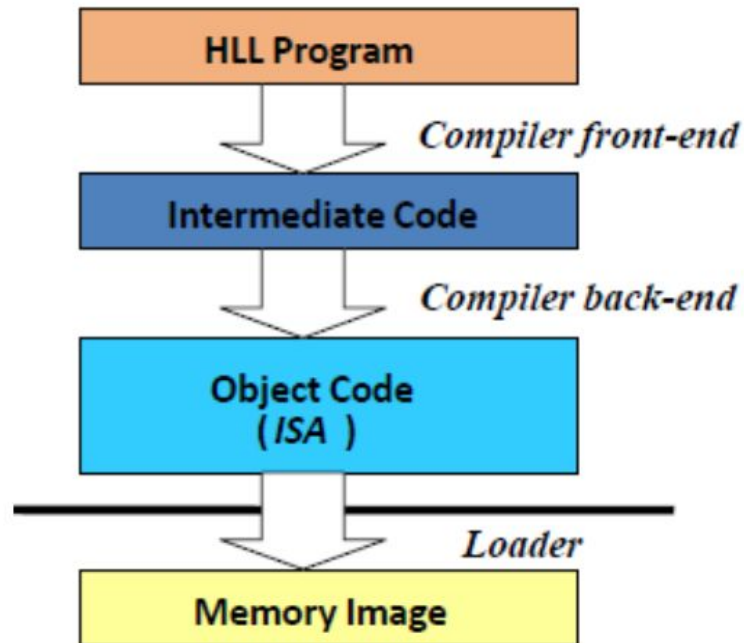- Simplifies compilation

HLL VM is similar to process VM but..

- ISA defined for user-mode programs only

- ISA not designed for real hardware
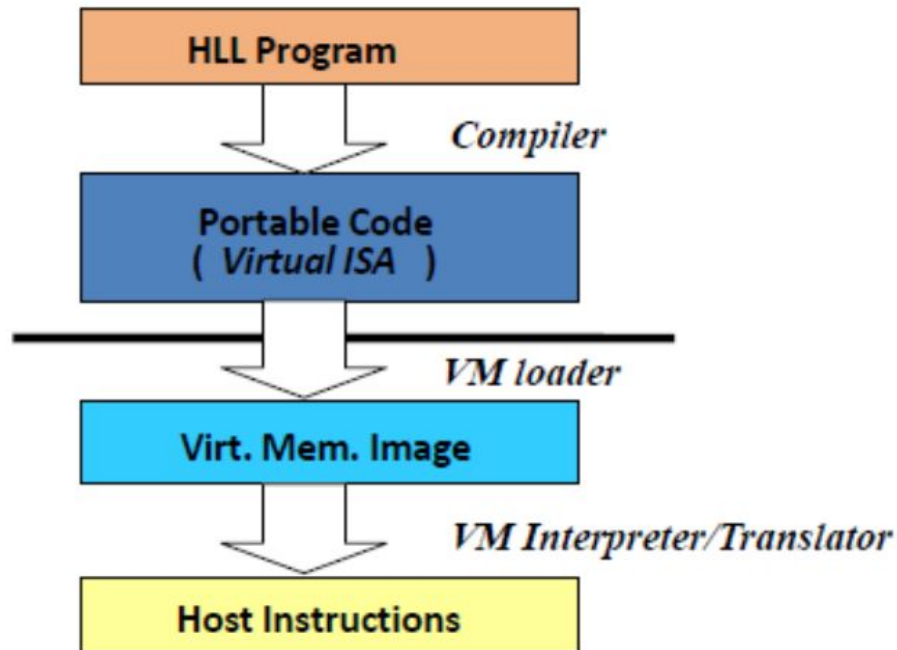
Only to be executed on virtual processor

Referred to as virtual-ISA or v-ISA

- System interface is a set of standardized APIs.

HLL VM

Traditional

HLL VM

BINARY TRANSLATION
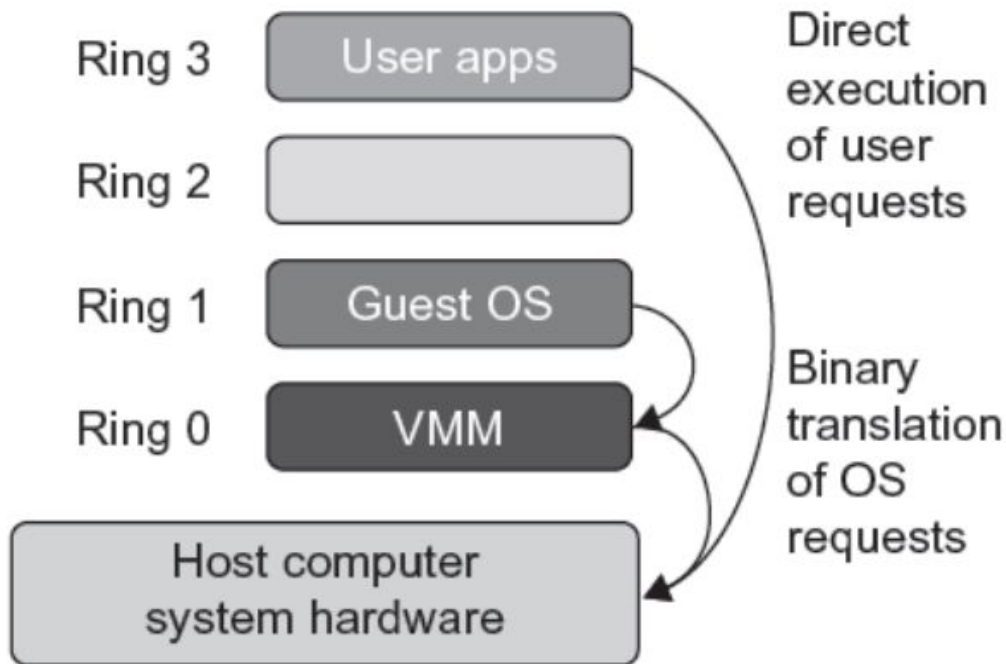
Depending on implementation technologies, hardware virtualization can be classified into two categories:full virtualization and host-based virtualization.

Full virtualization does not need to modify the host OS. It relies on binary translation to trap and to virtualize the execution of certain sensitive, nonvirtualizable instructions.

The guest OSes and their applications consist of noncritical and critical instructions.

In a host-based system, both a host OS and a guest OS are used. A virtualization software layer is built between the host OS and guest OS.

Binary translation

Ring 3 — User apps
Ring 2
Ring 1 — Guest OS
Ring 0 — VMM
Host computer system hardware

Direct execution of user requests

Binary translation of OS requests