

Virtualization Techniques

Introduction to Virtualization Techniques

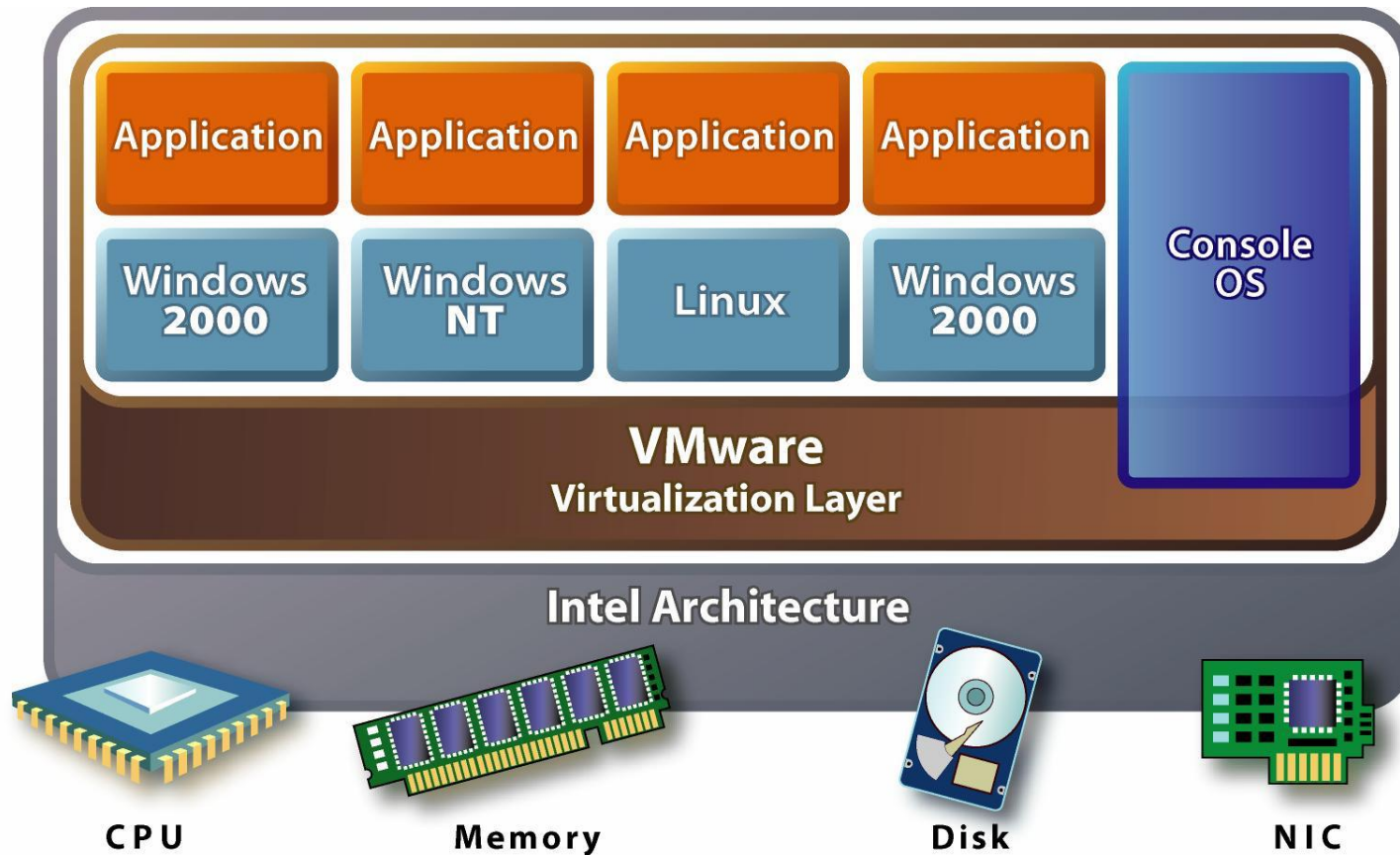
Agenda

- Overview
 - Virtualization Introduction
- Virtualization Techniques
 - System Virtualization
 - Storage Virtualization
 - Network Virtualization
 - GPU Virtualization
 - Software Virtualization
 - Hardware Support Virtualization

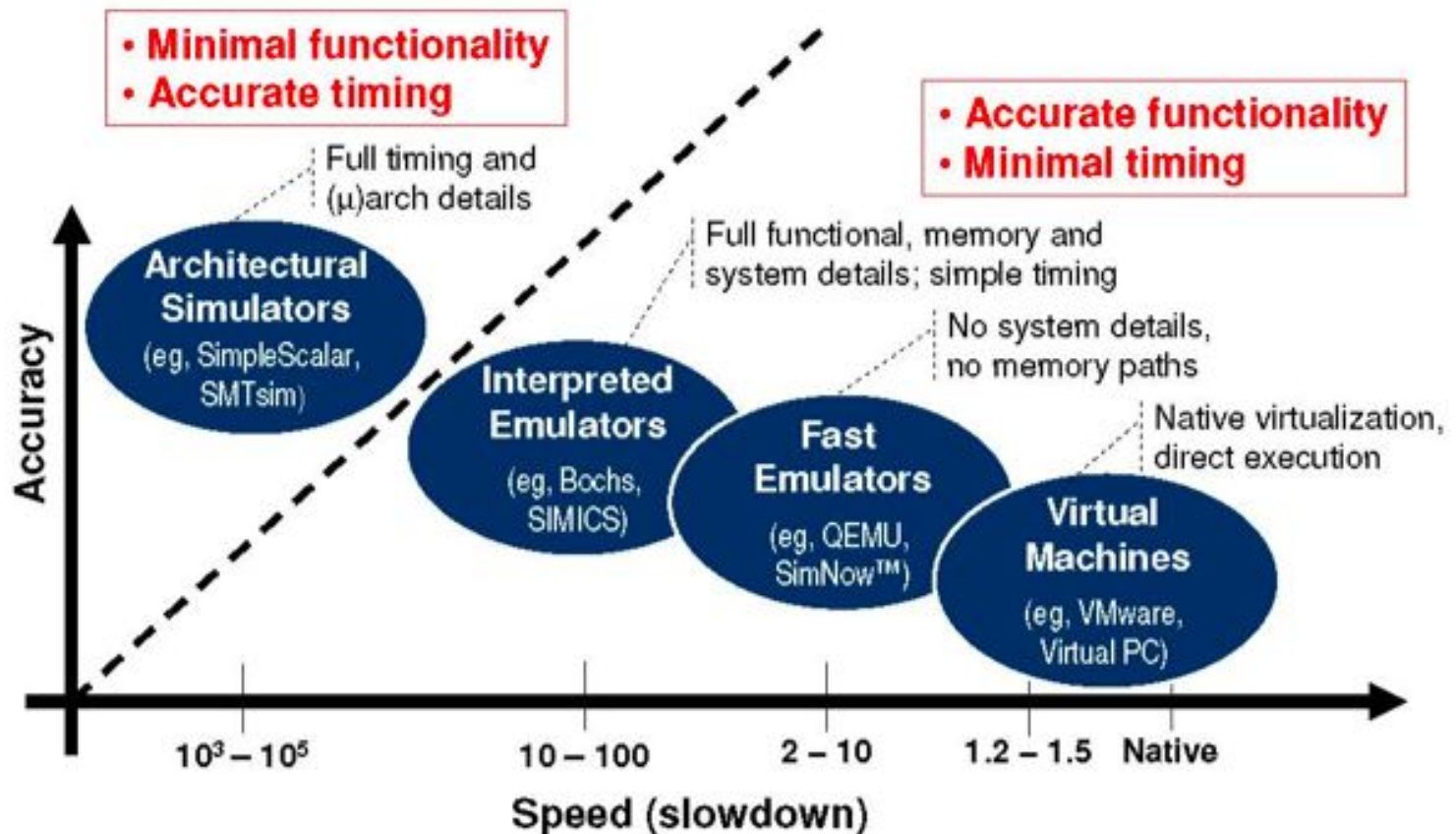
Definition of Virtualization

In computing, virtualization means to create a virtual version of a device or resource, such as a server, storage device, network or even an operating system where **the framework divides the resource into one or more execution environments.**

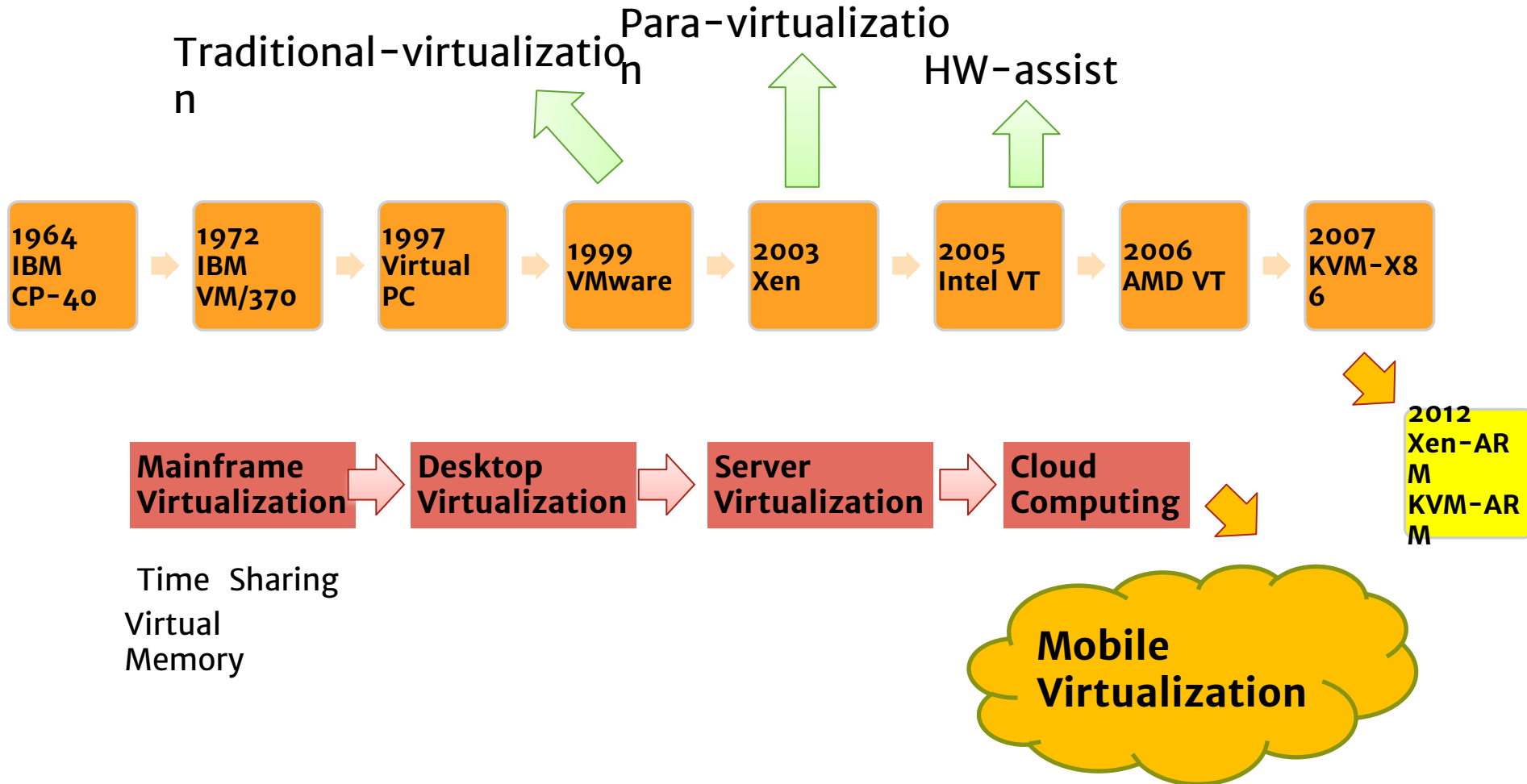
Multiple VMs in One Machine



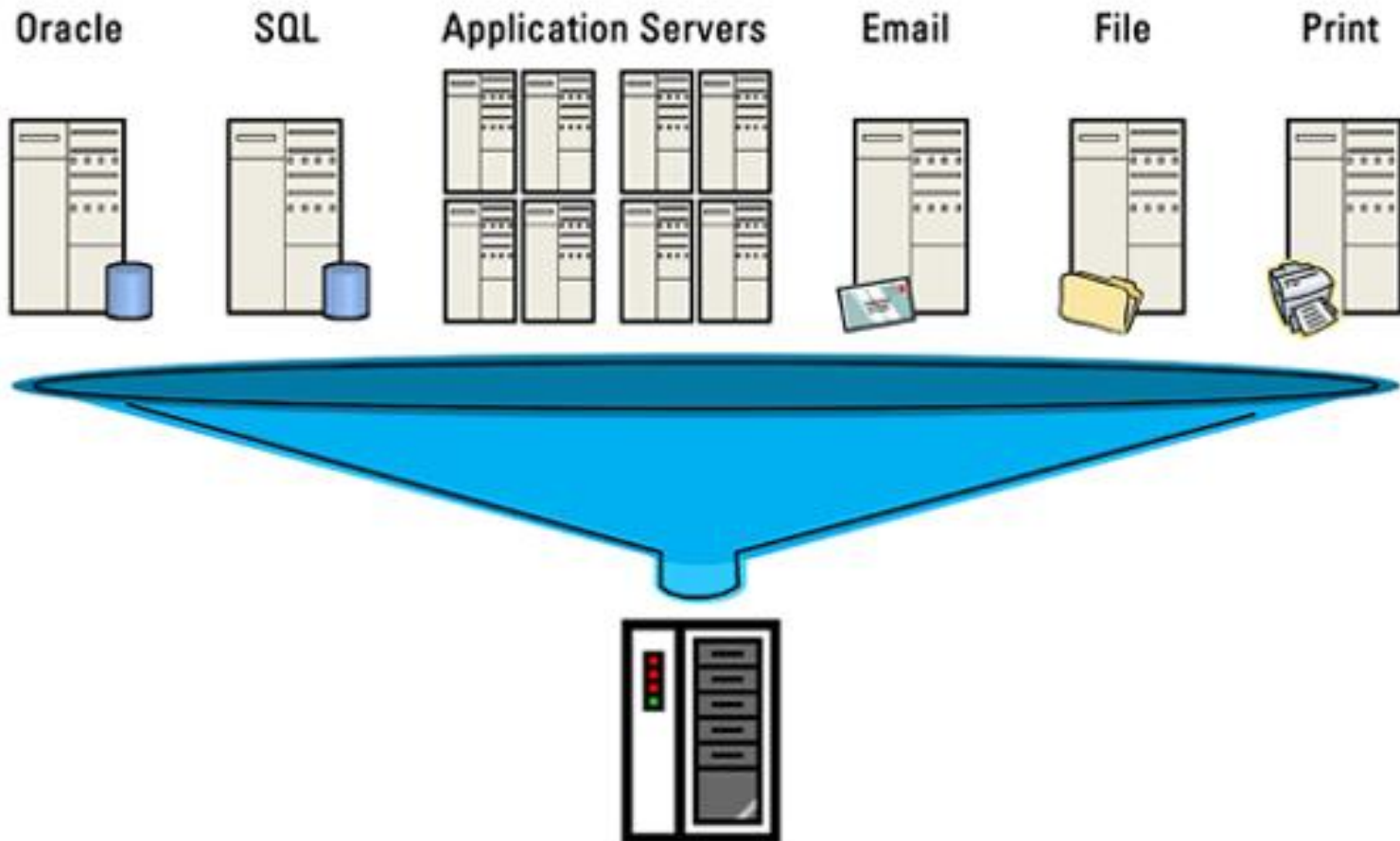
Performance of Virtualizations



History of Virtualization



Example: Server Virtualization



Benefits of Server Virtualization

- Virtualization can reduce data center energy expenses by 10%–40%
- Virtualization also improves scalability, reduces downtime, and enables faster deployments.
- Reduce the data center footprint

Example: Mobile Virtualization



VMware MVP

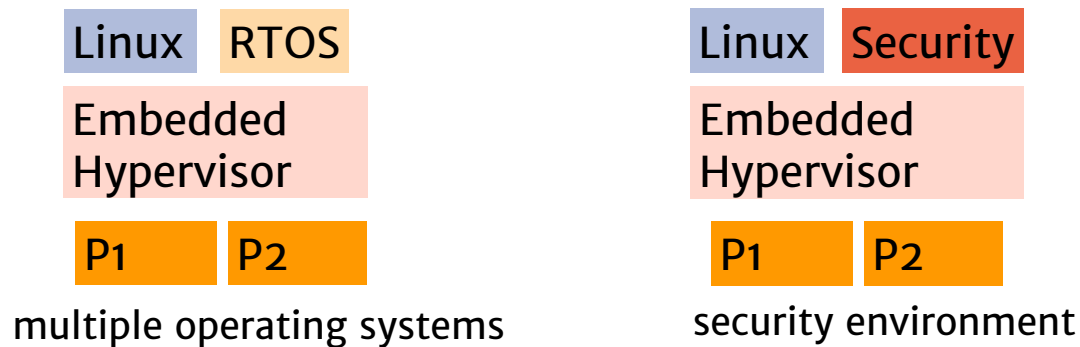
Gartner predict that by 2012, more than **50%** of new **smart phones** shipped will be **virtualized**

ARM **Cortex-A15** enables efficient handling of the complex software environments including full **hardware virtualization**



Benefits of Mobile Virtualization

- Portability
- Multiple OSES on a single chip
- Security
- Dynamic Update of System Software
- Legacy Code re-use
- IP Protection
- Mobile Manageability



Reference : http://en.wikipedia.org/wiki/Embedded_Hypervisor

Virtualization Techniques (1/2)

- System Virtualization
 - CPU Virtualization
 - Memory Virtualization
 - I/O Virtualization
- Storage Virtualization
 - LVM
 - RAID
- Network Virtualization
 - Software Defined Network
 - Open vSwitch
 - InfiniBand Virtualization

Virtualization Techniques (2/2)

- GPU Virtualization
- Software Virtualization
 - Virtual Desktop Infrastructure (VDI)
 - EyeOS
- Hardware Support Virtualization
 - Intel VT
 - ARM
 - SRIOV
 - MRIOV

VIRTUALIZATION TECHNIQUES

System Virtualization

Storage Virtualization

Network Virtualization

GPU Virtualization

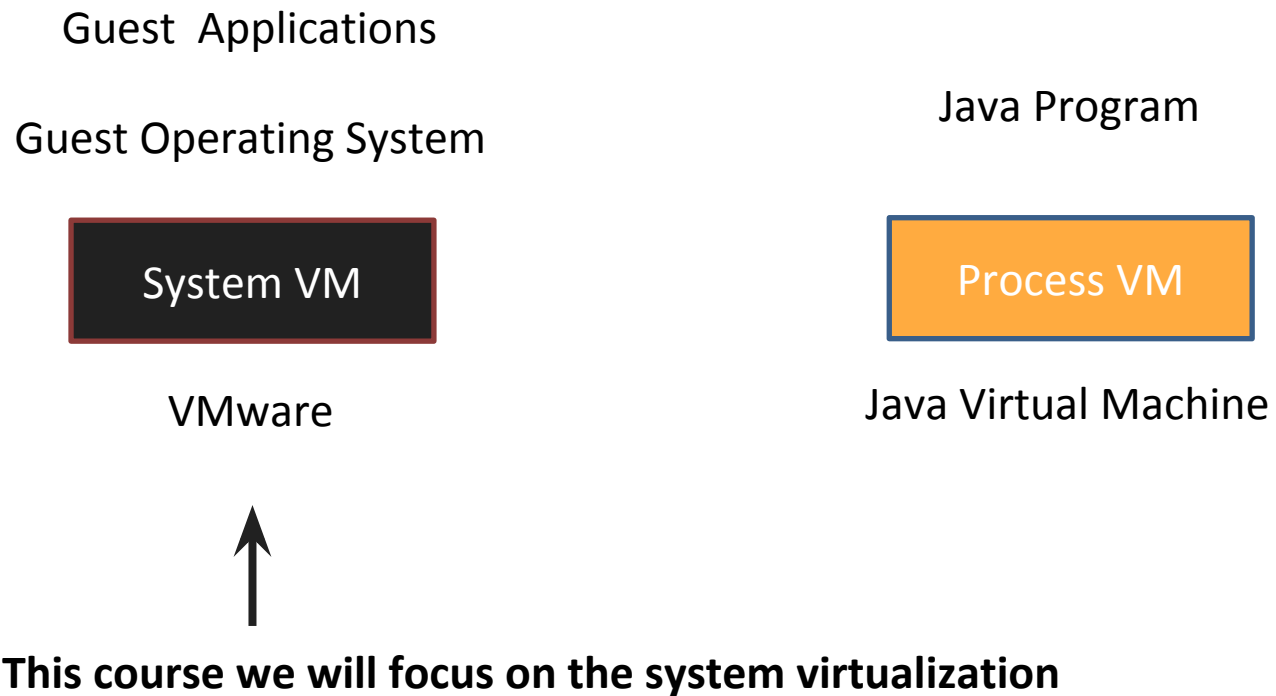
Software Virtualization

Hardware Support Virtualization

Virtual Machine (1/2)

- A virtual machine (VM) is a software implementation of a machine that executes programs like a physical machine. Virtual machines are separated into two major classifications:
 - **A system virtual machine**
 - Which provides a complete system platform which supports the execution of a complete operating system (OS)
 - **A process virtual machine**
 - Which is designed to run a single program, which means that it supports a single process.

Virtual Machine (2/2)



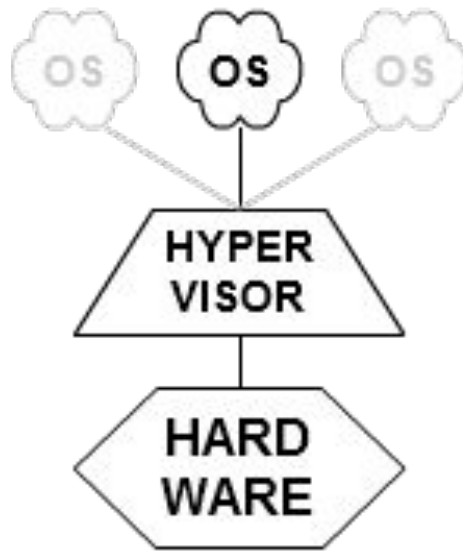
System Virtual Machine

- System virtual machine is controlled by a hypervisor or VMM (Virtual Machine Monitor)
- A hypervisor or VMM is a software to provide a hardware emulation interface including CPU, memory, I/O by multiplexing host resources

Two Types of Hypervisor (1/2)

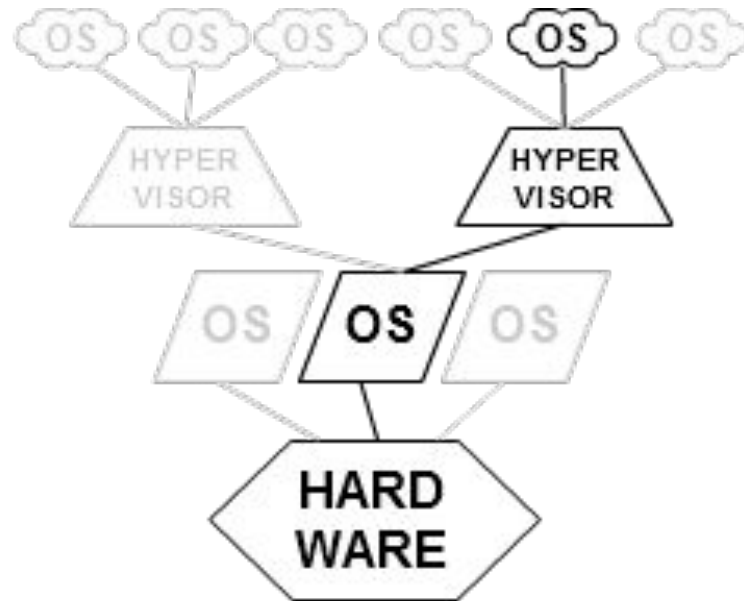
- In their 1974 article "Formal Requirements for Virtualizable Third Generation Architectures" Gerald J. Popek and Robert P. Goldberg classified two types of hypervisor:
 - Type 1 hypervisor : bare metal type
 - Type 2 hypervisor : hosted type

Two Types of Hypervisor (2/2)



TYPE 1

native
(bare metal)



TYPE 2

hosted

Type 1 (or native, bare metal)
hypervisors

Type 2 (or hosted)
hypervisors

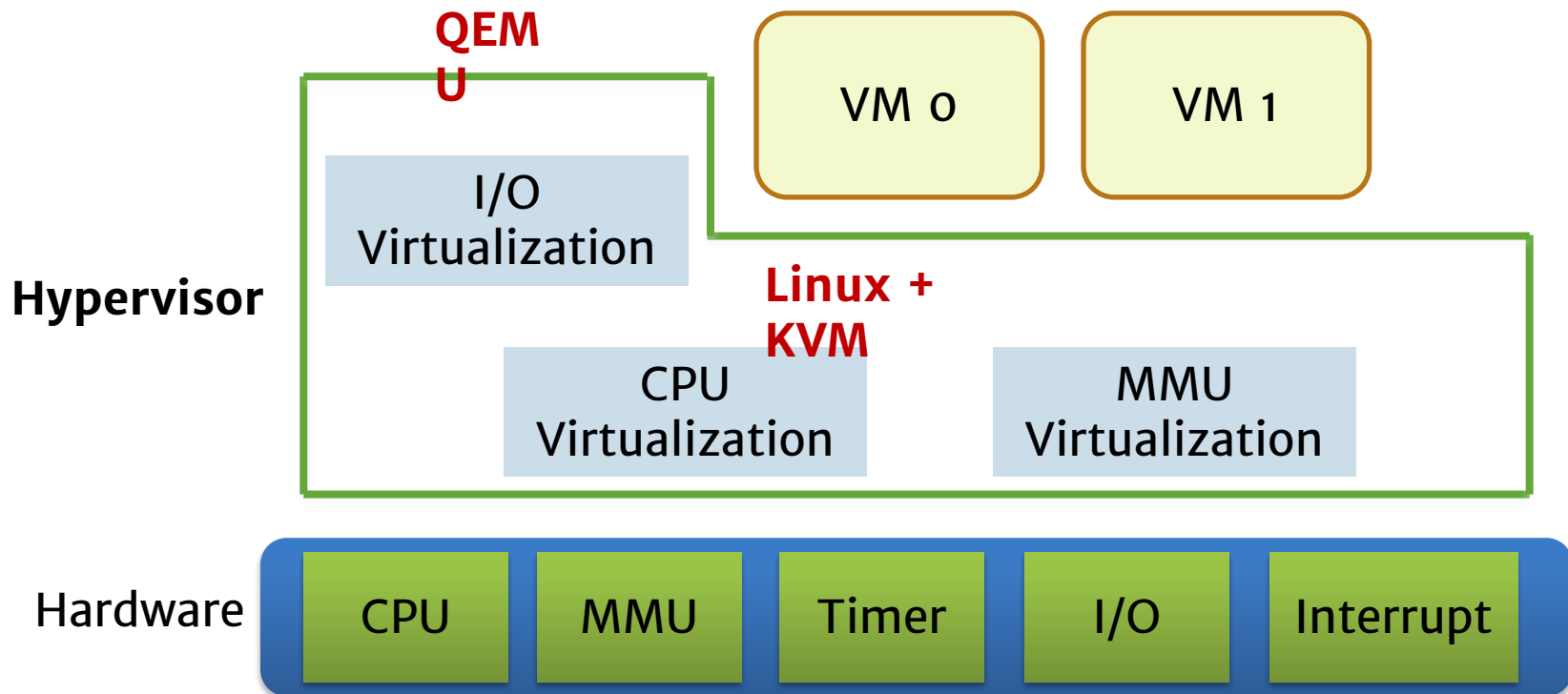
Purposes of Hypervisor

- CPU Virtualization
 - Handle all sensitive instructions by emulation
- Memory Virtualization
 - Allocate guest physical memory
 - Translate guest virtual address to host virtual address
- I/O Virtualization
 - Emulate I/O devices for guest
 - Ex: Keyboard, UART, Storage and Network

Implementations of Hypervisor

- Full Virtualization
 - A wholly emulated virtual machine makes guest operating system binary can be executed directly without modifying guest source code
 - For efficiency, it needs hardware-assisted virtualization
- Para-Virtualization
 - Hypercalls are defined and used in a guest operating system to make a virtual machine abstraction
 - According to literature, it's most efficient way
- Pre-Virtualization
 - By compiling technique, guest operating system binary or source could be compiled for virtualization

Hypervisor Case: KVM



1. CPU and memory virtualizations are handled in the Linux Kernel Space
2. I/O virtualization is handled in the Linux User Space by QEMU
3. It's a type 2 virtual machine
4. It's a full virtualization implementation

VIRTUALIZATION TECHNIQUES

System Virtualization

Storage Virtualization

Network Virtualization

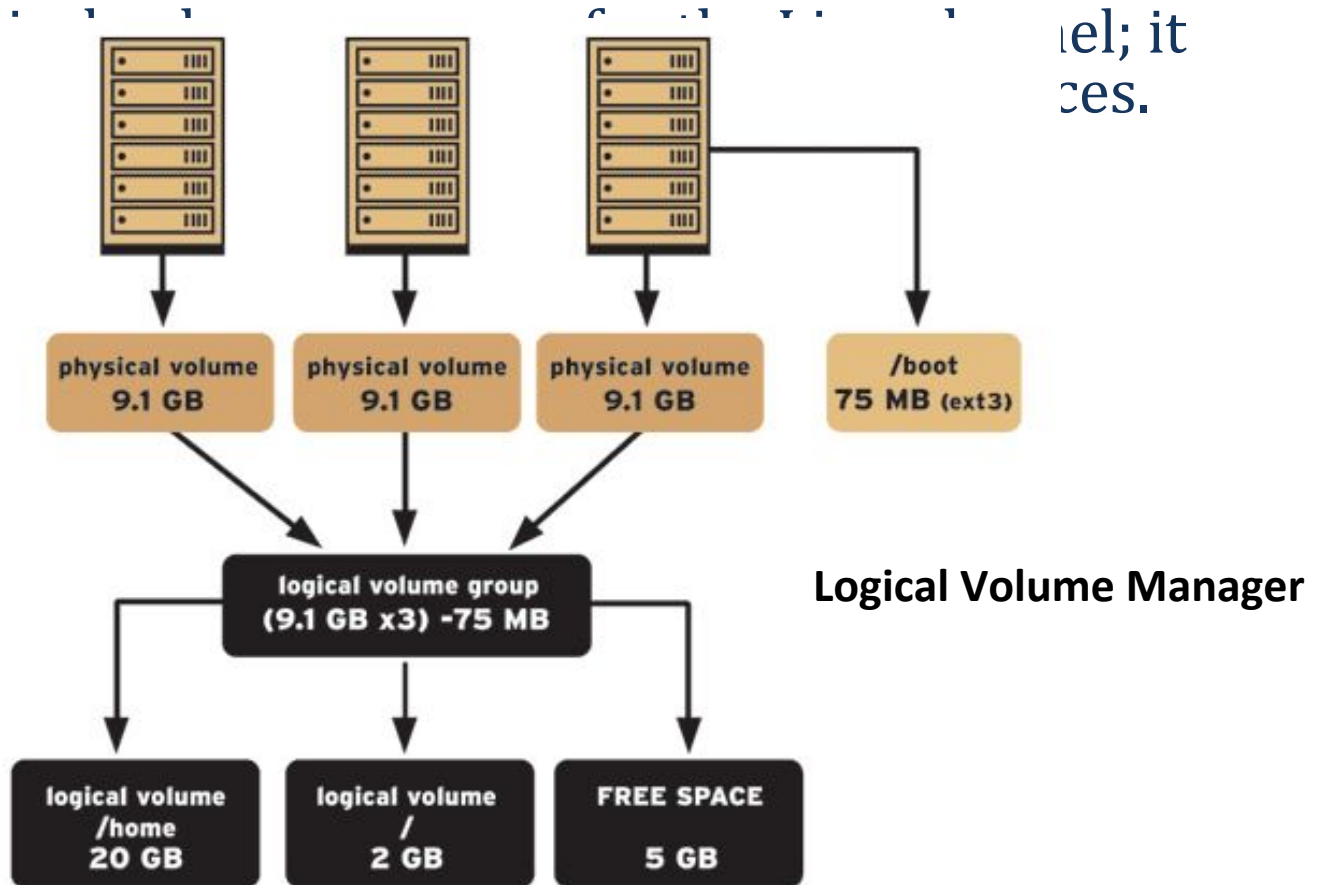
GPU Virtualization

Software Virtualization

Hardware Support Virtualization

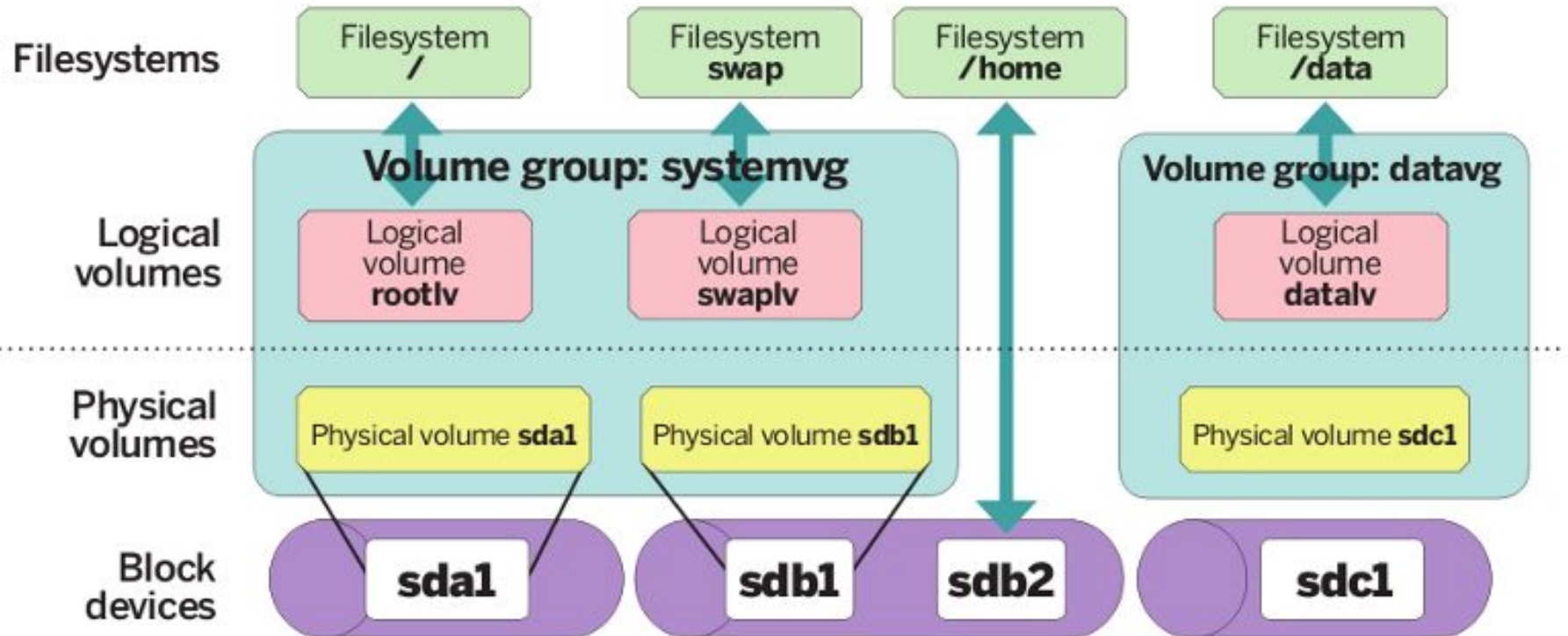
LVM(1/2)

- LVM is a logical volume manager; it manages disks.



LVM(2/2) : Example

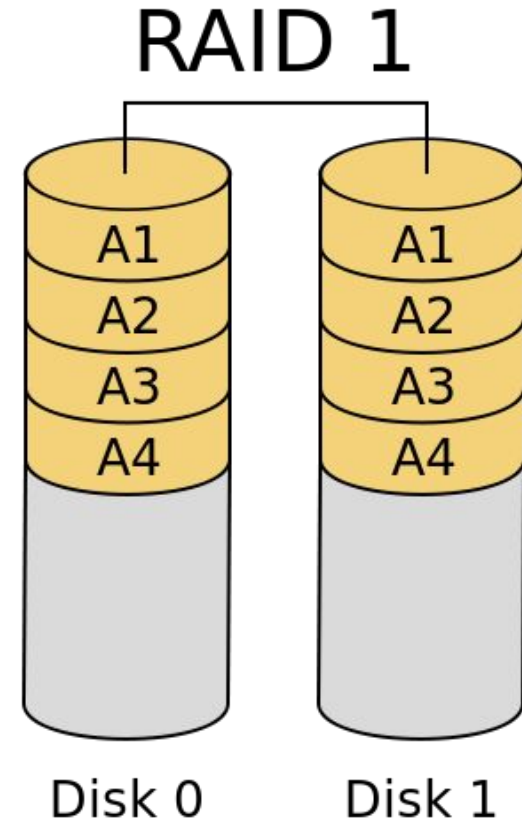
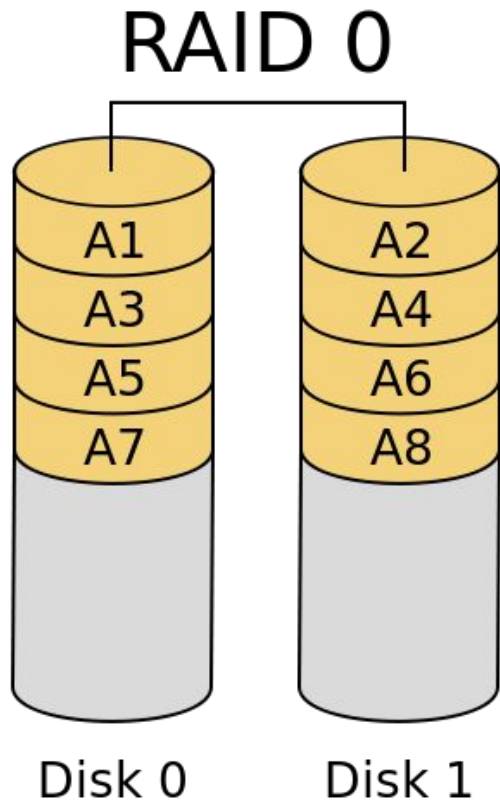
• Disk partition, physical volumes, volume group



RAID

- **RAID (redundant array of independent disks)** is a storage technology that combines multiple disk drive components into a logical unit.
- Data is distributed across the drives in one of several ways called "RAID levels", such as RAID0, RAID1, etc., depending on the level of redundancy and performance required.

Example : RAID 0 and RAID 1



It provides improved performance and additional storage but no fault tolerance (block-level striping without parity or mirroring) .

mirroring without parity or striping

LVM and RAID for Virtualization

- LVM provides a virtual storage systems which is flexible to partition and allocate logical volumes to virtual machines
- RAID not only improves storage performance but has fault tolerance capability
- Learning how to configure LVM and RAID in the virtualization system

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Software Defined Network (1/2)

- **Software defined networking (SDN)** is an approach to building computer networks that separates and abstracts elements of these systems
- SDN decouples the system that makes decisions about where traffic is sent (the control plane) from the underlying system that forwards traffic to the selected destination (the data plane)

Software Defined Network (2/2)

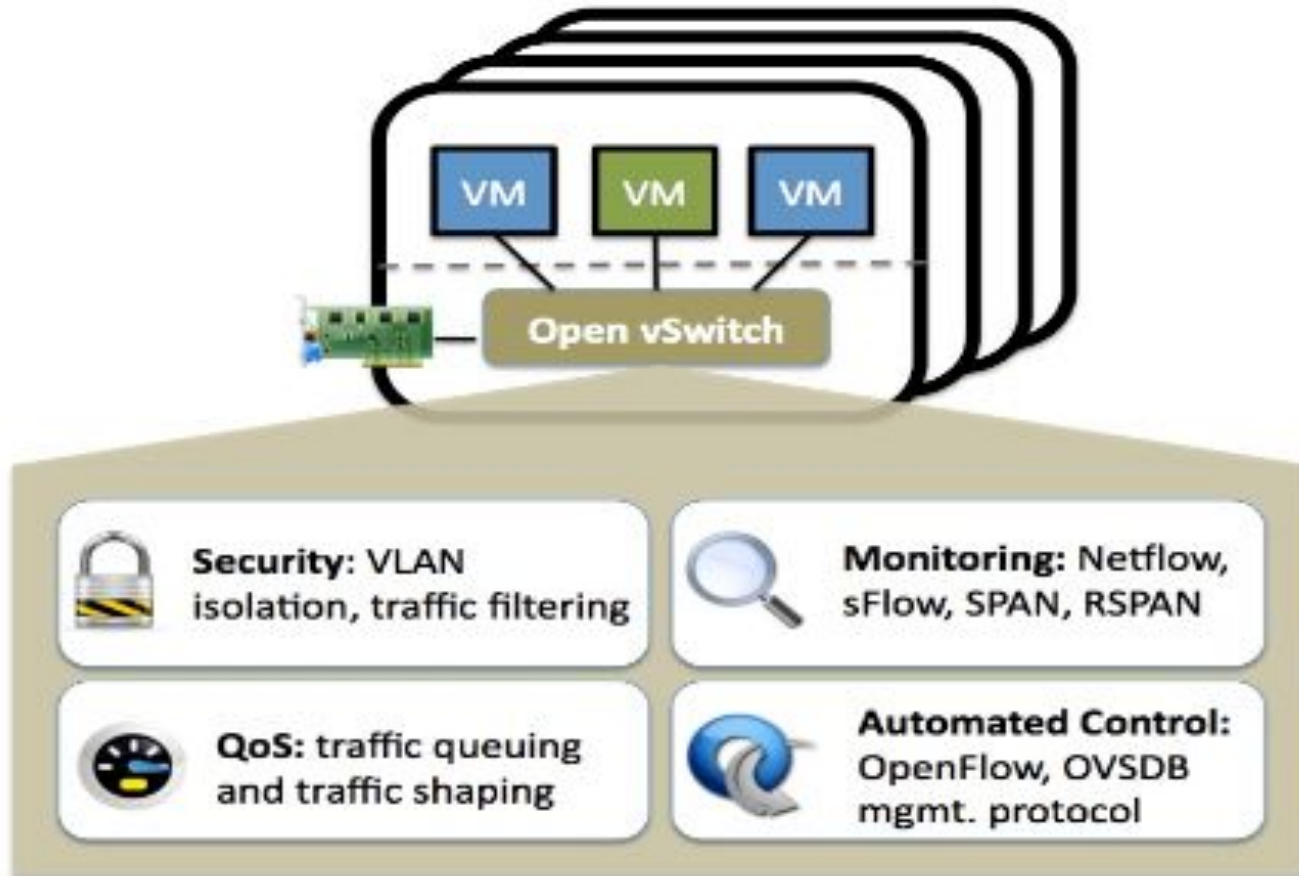
- The inventors and vendors of these systems claim that this technology simplifies networking and enables new applications, such as
 - network virtualization in which the control plane is separated from the data plane and implemented in a software application.

Open vSwitch (1/2)

- Open vSwitch is a flexible, multi-layer software network switch. **Typically used in virtualization environments as the network switching component in the hypervisor.**
- Open vSwitch maintains the logical state of a virtual machine's network connection across physical hosts when a virtual machine is migrated, and it can be managed and monitored by standard protocols such as: OpenFlow, NetFlow, sFlow, SPAN, RSPAN.

Open vSwitch (2./2)

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InfiniBand Virtualization

- **InfiniBand** is a switched fabric communications link used in high-performance computing and enterprise data centers.
- It has two key features : low latency and high bandwidth
- ***Virtualization Using InfiniBand Brings Big Benefits to Data Centers***

VIRTUALIZATION TECHNIQUES

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Network Virtualization

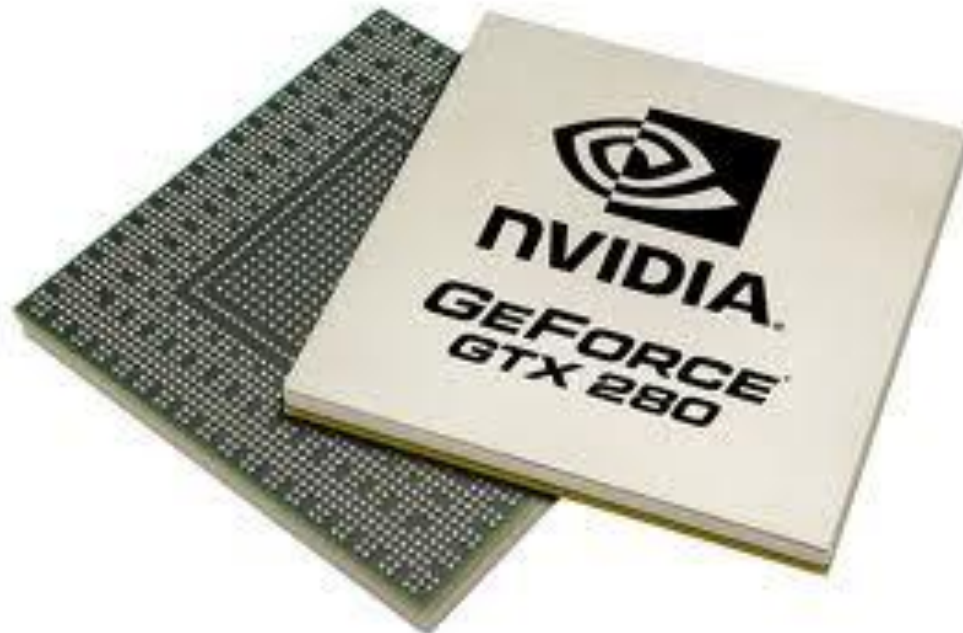
GPU Virtualization

Software Virtualization

Hardware Support Virtualization

What's GPU (Graphics processing unit)

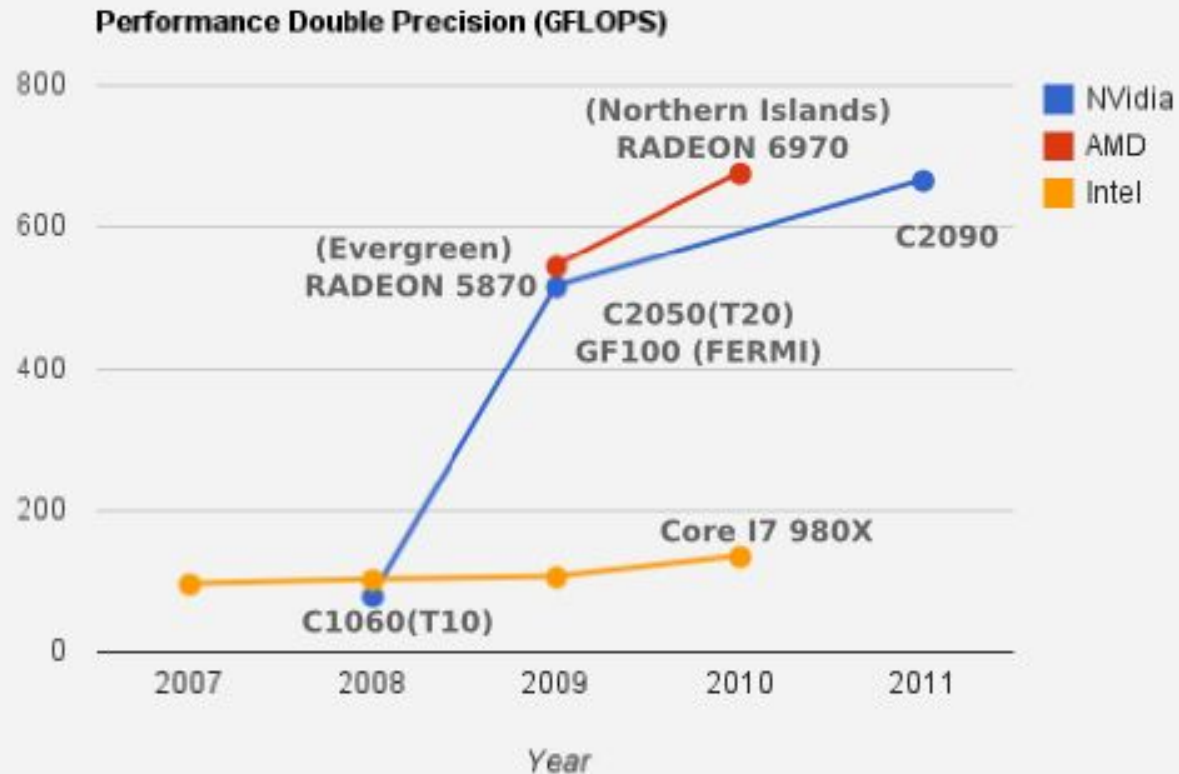
- A Graphics Processing Units (GPUs) are high-performance many-core processors capable of very high computation and data throughput.



Performance Comparison: GPU vs. CPU

- While such

CPUs

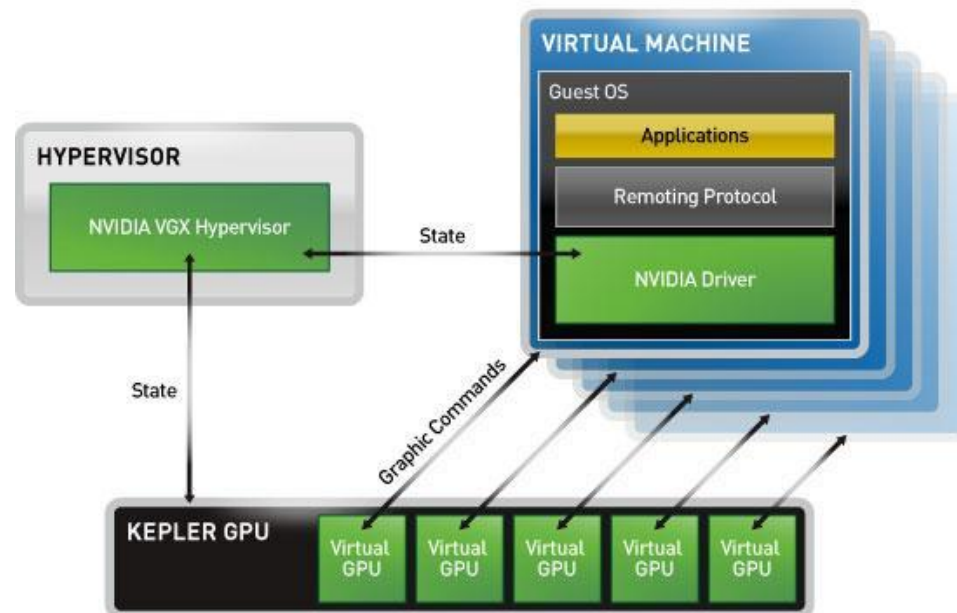


GPGPU

- High performance of modern Graphics Processing Units may be utilized not only for graphics related application but also for general computing.
- Today's GPUs are general-purpose parallel processors with support for accessible programming interfaces and industry-standard languages such as C.
- Developers who port their applications to GPUs often achieve speedups of orders of magnitude vs. optimized CPU implementations.

GPU Virtualization

- GPU virtualization allows multiple virtual machines to interact directly with a GPU and manages the GPU resources so multiple users can share common hardware, while improving user density.



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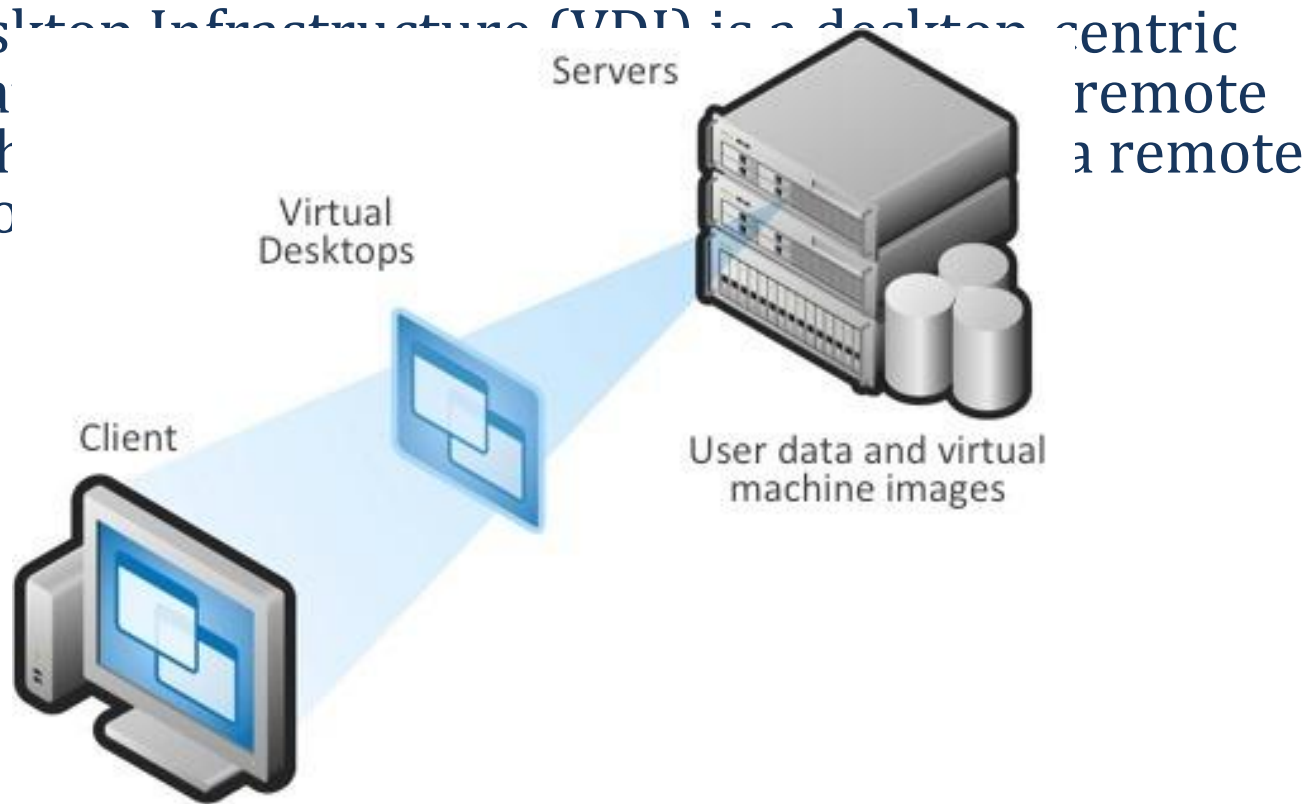
Hardware Support Virtualization

Software Virtualization

- IT administrators have a lot to deal with in today's corporate infrastructure. With the ever increasing prices of upgrading desktop computers, software virtualization is becoming very appealing.
- It has following features:
 - Ease of Management
 - Security
 - Green
 - Portable

Virtual Desktop Infrastructure (VDI)

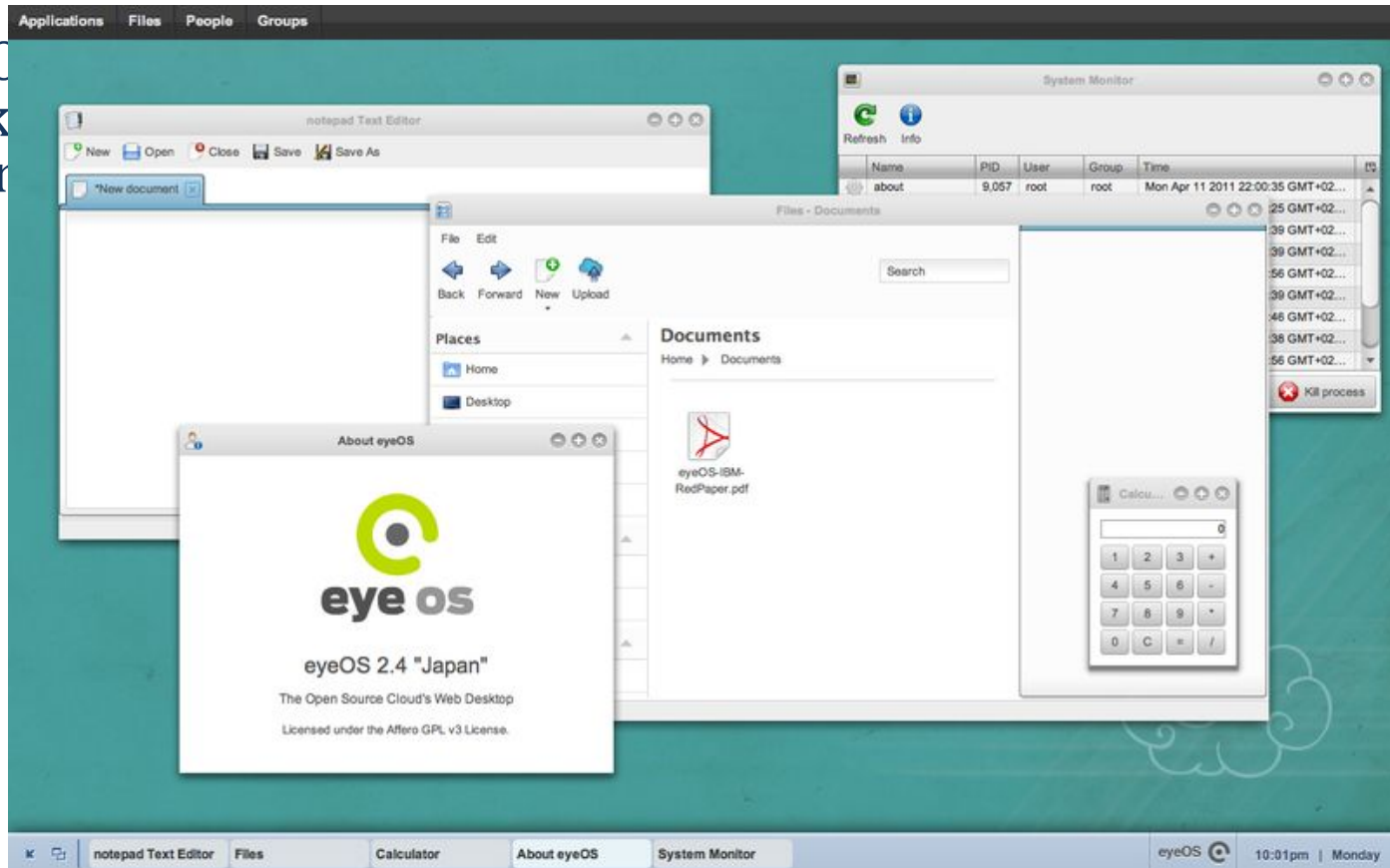
- Virtual desktop service that runs on servers, which display processes to the client.



EyeOS : Web Desktop Virtualization

- eyeOS seeks to provide a main

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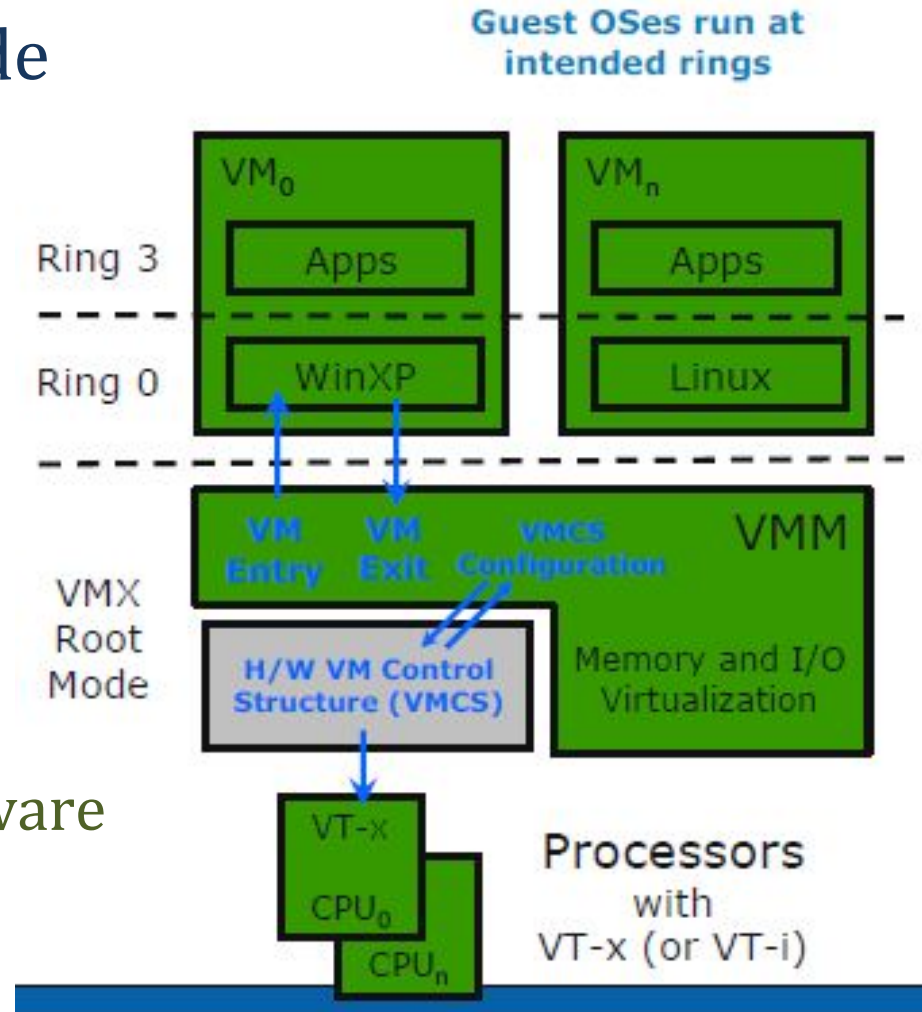
GPU Virtualization

Software Virtualization

Hardware Support Virtualization

Intel VT-x

- New CPU Operating Mode
 - VMX Root Operation
 - Non-Root Operation
- New Transitions
 - VM entry to Guest
 - VM exit to VMM
- VM Control Structure
 - Configured by VMM software



ARM Virtualization Extension

