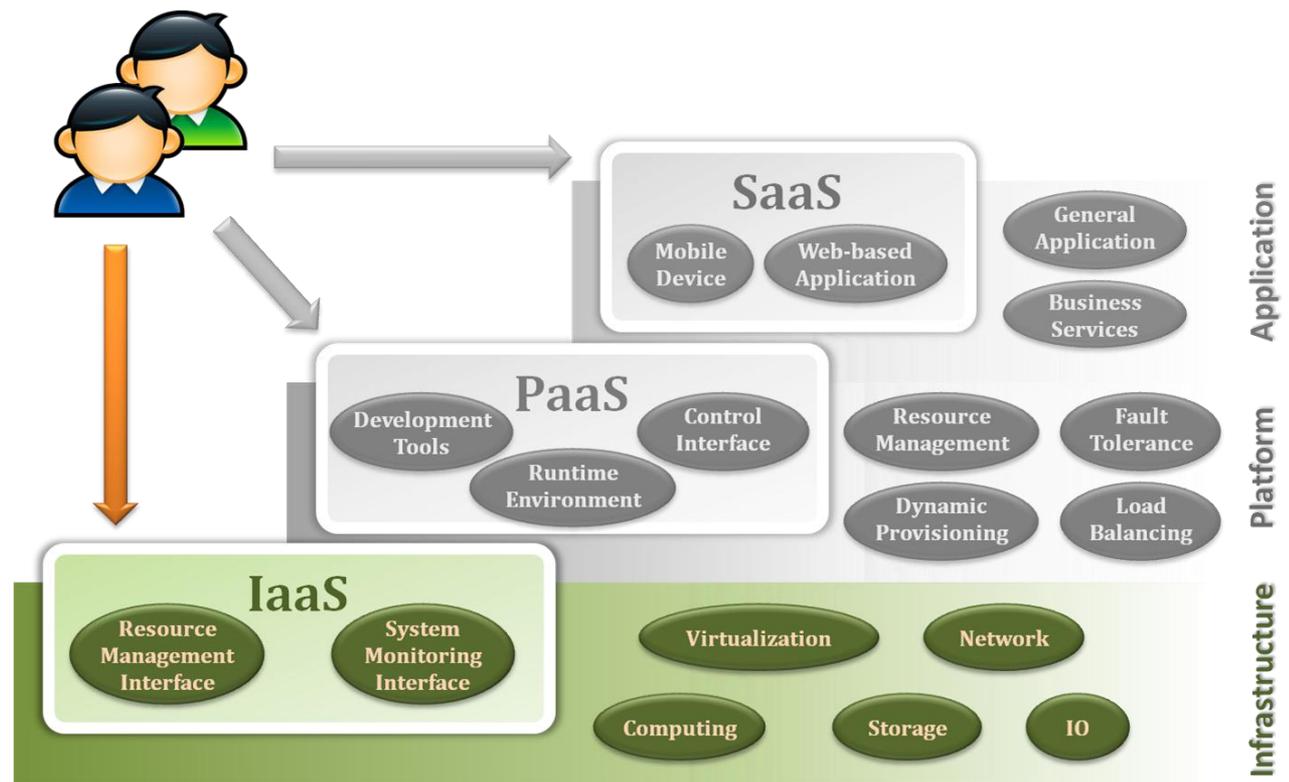


Agenda

- Overview
 - Why do we need IaaS ?
 - How IaaS meets cloud properties ?
- Enabling Techniques
 - Virtualization Overview
 - Terminology & Taxonomy



Why do we need IaaS ?

OVERVIEW

Overview

- What is the problems in conventional case ?
 - Companies IT investment for peak capacity
 - Lack of agility for IT infrastructure
 - IT maintain cost for every company
 - Usually suffered from hardware failure risk
 - ...etc
- These IT complexities force company back !!

Overview

- How to solve these problem ?
 - Let's consider some kind of out-sourcing solution
 - Somebody will handle on demand capacity for me
 - Somebody will handle high available resource for me
 - Somebody will handle hardware management for me
 - Somebody will handle system performance for me
 - Somebody will ...
 - Frankly, that would be a great solution IF there were “somebody”.
 - But who can be this “somebody”, and provide all these services ?

Overview

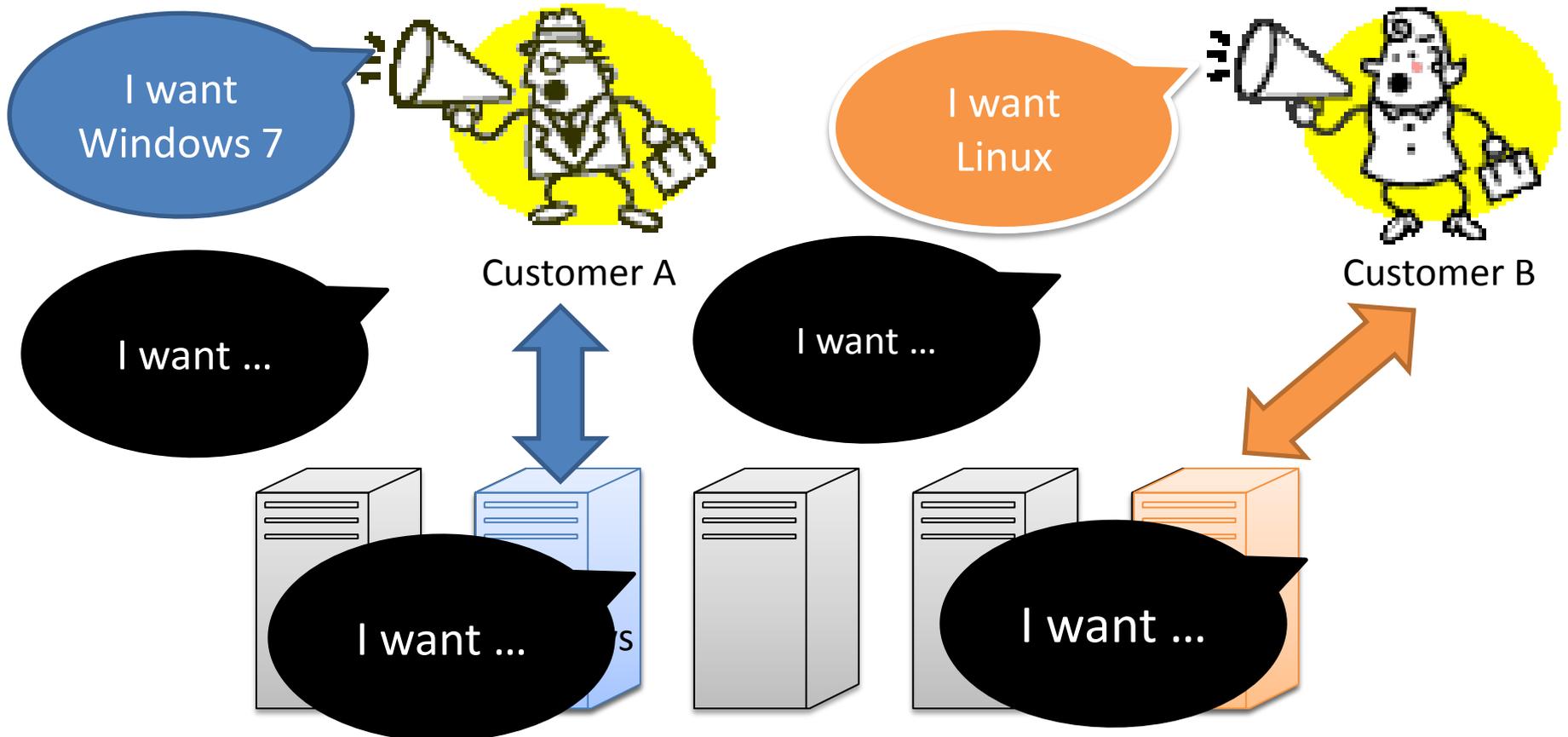
- **Infrastructure as a Service** will be the salvation.
 - IaaS cloud provider takes care of all the IT infrastructure complexities.
 - IaaS cloud provider provides all the infrastructure functionalities.
 - IaaS cloud provider guarantees qualified infrastructure services.
 - IaaS cloud provider charges clients according to their resource usage.
- But, what make all of these happen so magically ?

Virtualization

- Assume that you are going to be an IaaS cloud provider.
 - Then, what are the problems you are facing ?
 - Clients will request different operating system.
 - Clients will request different storage size.
 - Clients will request different network bandwidth.
 - Clients will change their requests anytime.
 - Clients will ...
 - Is there any good strategy ?
 - Allocate a new physical machine for each incomer.
 - Prepare a pool of pre-installed machines for different requests.
 - or ...

Virtualization

- What if we allocate a new physical machine for each incomer ?

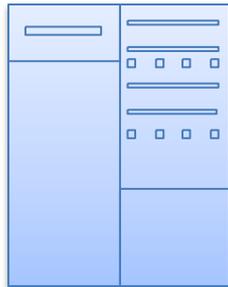


Virtualization

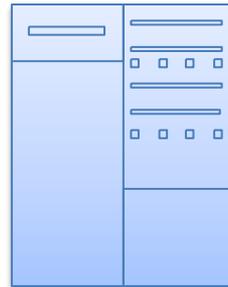
- How about preparing a pool of pre-installed physical machines for all kinds of request ?



Somebody
might want...



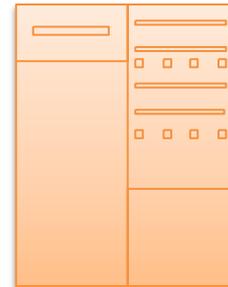
Windows + Office



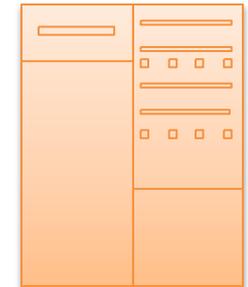
Windows Server



Somebody
might want...



Linux + OpenOffice



Linux Server

Virtualization

- Obviously, neither of previous strategies will work.
- We need more powerful techniques to deal with that.
- Virtualization techniques will help.
 - For computation resources
 - Virtual Machine technique
 - For storage resources
 - Virtual Storage technique
 - For communication resources
 - Virtual Network technique

Why do we need IaaS ?

How IaaS meets cloud properties ?

OVERVIEW

Properties and Characteristics

- As a cloud provider, all of the fundamental properties and characteristics stated in previous lectures should be concerned and implemented.



Scalability & Elasticity

- What do scalability and elasticity mean in IaaS ?
 - Clients should be able to dynamically increase or decrease the amount of infrastructure resources in need.
 - Large amount of resources provisioning and deployment should be done in short time, such as several hours or days.
 - System behavior should remain identical in small scale or large one.

Scalability & Elasticity

- How to approach scalability and elasticity in IaaS ?
 - For computation resources :
 - Dynamically create or terminate virtual machines for clients on demand.
 - Integrate hypervisors among all physical machines to collaboratively control and manage all virtual machines.
 - For storage resources :
 - Dynamically allocate or de-allocate virtual storage space for clients.
 - Integrate all physical storage resources in the entire IaaS system
 - Offer initial storage resources by thin provisioning technique.
 - For communication resources :
 - Dynamically connect or disconnect the linking state of virtual networks for clients on demand.
 - Dynamically divide the network request flow to different physical routers to maintain access bandwidth.



Availability
Reliability

- Fault tolerance
- System resilience
- System security

Availability & Reliability

- What do availability and reliability mean in IaaS ?
 - Clients should be able to access computation resources without considering the possibility of hardware failure.
 - Data stored in IaaS cloud should be able to be retrieved when needed without considering any natural disaster damage.
 - Communication capability and capacity should be maintained without considering any physical equipment shortage.

Availability & Reliability

- How to approach availability and reliability in IaaS ?
 - For computation resources :
 - Monitor each physical and virtual machine for any possible failure.
 - Regularly backup virtual machine system state for disaster recovery.
 - Migrate virtual machine among physical machines for potential failure prevention.
 - For storage resources :
 - Maintain data pieces replication among different physical storage devices.
 - Regularly backup virtual storage data to geographical remote location for disaster prevention.
 - For communication resources :
 - Built redundant connection system to improve robustness.

Manageability & Interoperability

- What do manageability and interoperability mean in IaaS ?
 - Clients should be able to fully control the virtualized infrastructure resources which allocated to them.
 - Virtualized resources can be allocated by means of system control automation process with pre-configured policy.
 - States of all virtualized resource should be fully under monitoring.
 - Usage of infrastructure resources will be recorded and then billing system will convert these information to user payment.

Manageability & Interoperability

- How to approach manageability and interoperability in IaaS ?
 - For computation resources :
 - Provide basic virtual machine operations, such as creation, termination, suspension, resumption and system snapshot.
 - Monitor and record CPU and memory loading for each virtual machine.
 - For storage resources :
 - Monitor and record storage space usage and read/write data access from user for each virtual storage resource.
 - Automatic allocate/de-allocate physical storage according to space utilization.
 - For communication resources :
 - Monitor and record the network bandwidth consumption for each virtual link.
 - Automatically reroute the data path when computation and storage are duplicated.

Performance & Optimization

- What do performance and optimization mean in IaaS ?
 - Physical resources should be highly utilized among different clients.
 - Physical resources should form a large resource pool which provide high computing power through parallel processing.
 - Virtual infrastructure resources will be dynamically configured to an optimized deployment among physical resources.

Performance & Optimization

- How to approach performance and optimization in IaaS ?
 - For computation resources :
 - Deploy virtual machine with load balancing consideration.
 - Live migrate virtual machines among physical ones to balance the system loading.
 - For storage resources :
 - Deploy virtual storage with hot spot access consideration.
 - Live migrate virtual storage among physical ones with different performance level.
 - For communication resources :
 - Consider network bandwidth loading when deploying virtual machines and storage.
 - Dynamically migrate virtual machines or storage to balance network flow.

Accessibility & Portability

- What do accessibility and portability mean in IaaS ?
 - Clients should be able to control, manage and access infrastructure resources in an easy way, such as the web-browser, without additional local software or hardware installation.
 - Provided infrastructure resources should be able to be reallocated or duplicated easily.

Accessibility & Portability

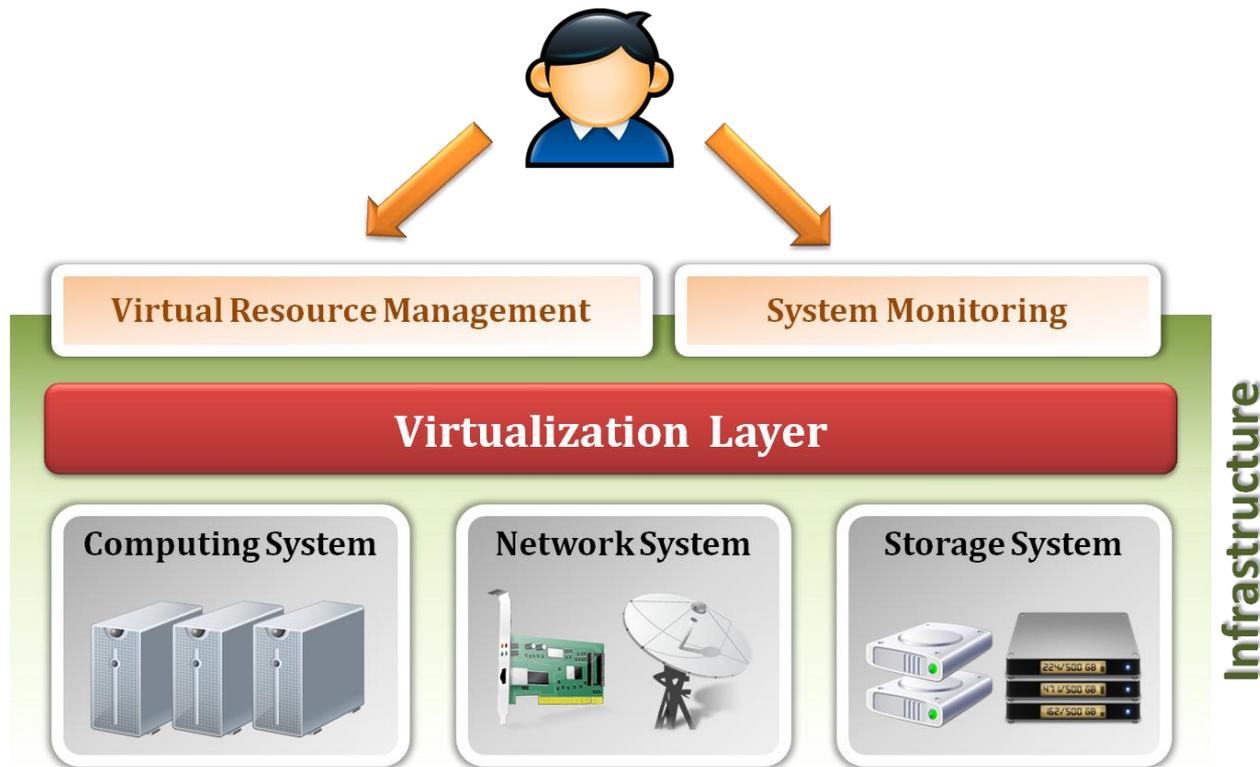
- How to approach accessibility and portability in IaaS ?
 - For computation resources :
 - Cloud provider integrate virtual machine management and access through web-based portal.
 - Comply the virtual machine standard for portability.
 - For storage resources :
 - Cloud provider integrate virtual storage management and access through web-based portal.
 - For communication resources :
 - Cloud provider integrate virtual network management and access through web-based portal.

Virtualization

ENABLING TECHNIQUES

IaaS Architecture

- **Infrastructure as a Service (IaaS)** delivers computer infrastructure for cloud user, typically a platform virtualization environment as a service.
- **Virtualization** is an enabling technique to provide an abstraction of logical resources away from underlying physical resources.

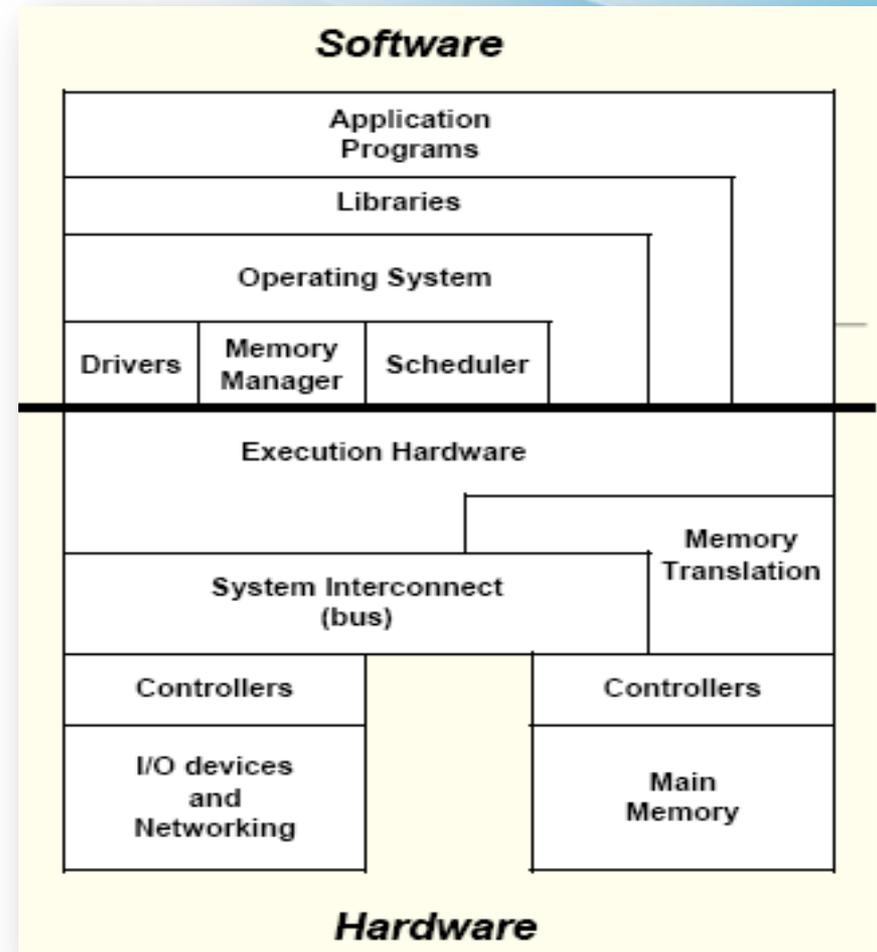


Virtualization Overview

- What is virtualization ?
 - Virtualization is the creation of a virtual (rather than physical) version of something, such as an operating system, a server, a storage device or network resources.
 - It hides the physical characteristics of a resource from users, instead showing another abstract resource.
- But, where does virtualization come from ?
 - Virtualization is NOT a new idea of computer science.
 - Virtualization concept comes from the component abstraction of system design, and it has been adapted in many system level.
 - Now, let's take a look of our original system architecture !!

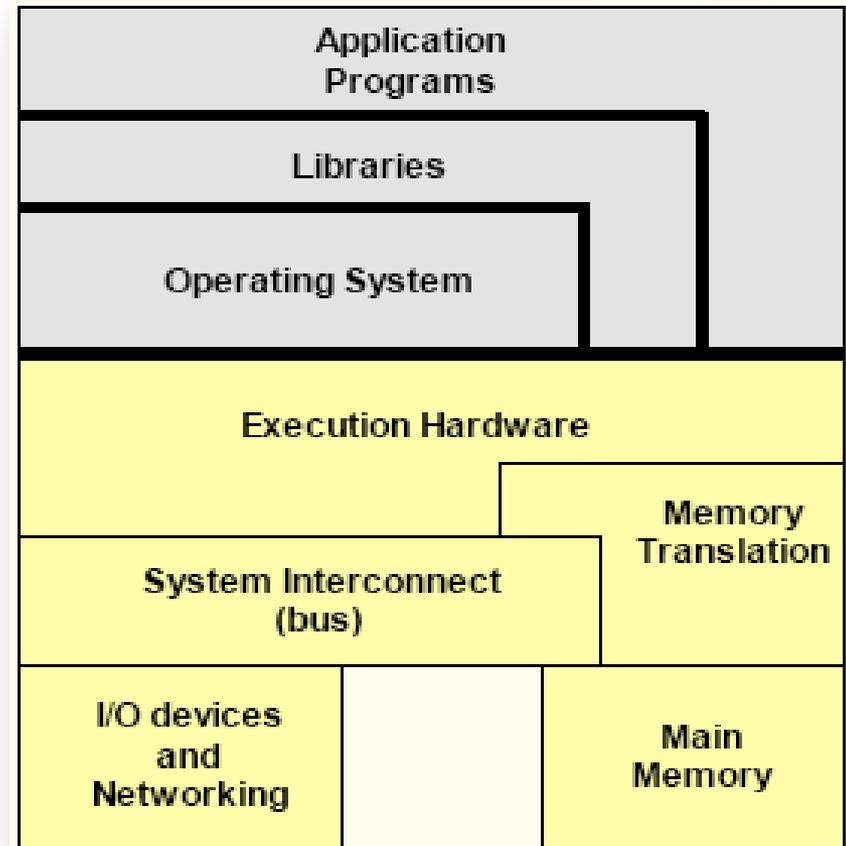
Virtualization Overview

- System abstraction :
 - Computer systems are built on levels of abstraction.
 - Higher level of abstraction hide details at lower levels.
 - Designer of each abstraction level make use of the functions supported from its lower level, and provide another abstraction to its higher one.
 - Example
 - files are an abstraction of a disk



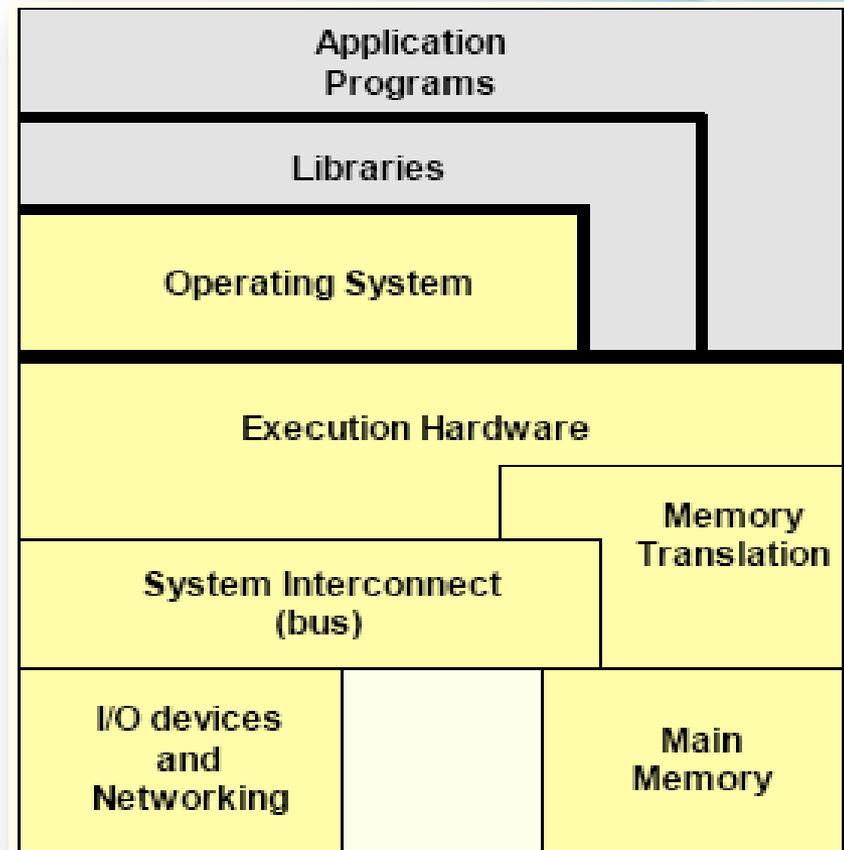
Virtualization Overview

- Machine level abstraction :
 - For OS developers, a machine is defined by ISA (Instruction Set Architecture).
 - This is the major division between hardware and software.
 - Examples :
 - X86
 - ARM
 - MIPS



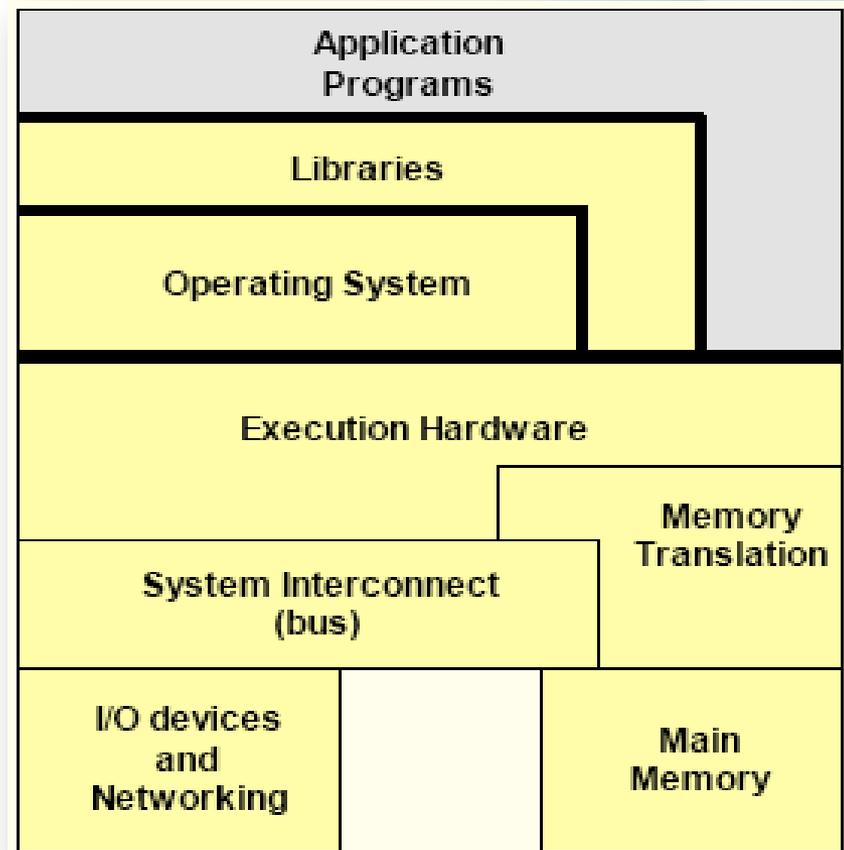
Virtualization Overview

- OS level abstraction :
 - For compiler or library developers, a machine is defined by ABI (Application Binary Interface).
 - This define the basic OS interface which may be used by libraries or user.
 - Examples :
 - User ISA
 - OS system call



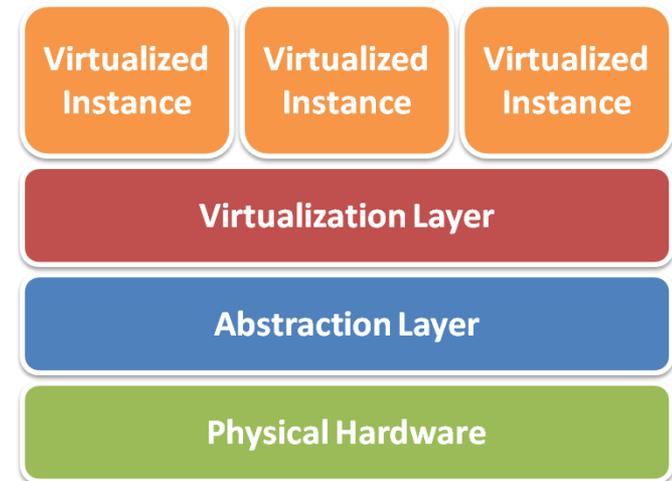
Virtualization Overview

- Library level abstraction :
 - For application developers, a machine is defined by API (Application Programming Interface).
 - This abstraction provides the well-rounded functionalities.
 - Examples :
 - User ISA
 - Standard C library
 - Graphical library



Virtualization Overview

- The concept of virtualization is **everywhere** !!
 - In IaaS, we focus the virtualization granularity at each physical hardware device.
- General virtualization implementation level :
 - Virtualized instance
 - Software virtualized hardware instance
 - Virtualization layer
 - Software virtualization implementation
 - Abstraction layer
 - Various types of hardware access interface
 - Physical hardware
 - Various types of infrastructure resources
- Different physical resources :
 - Server, Storage and Network

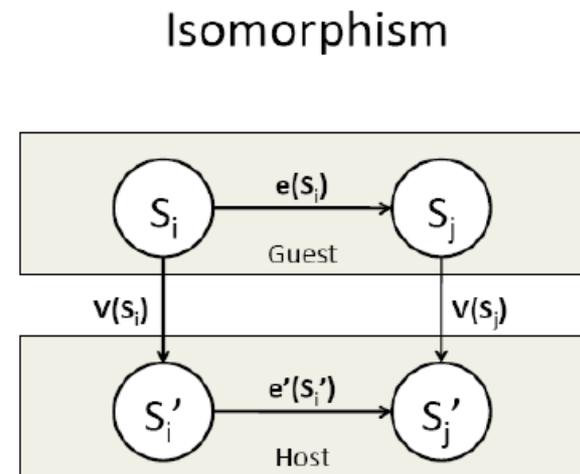


Terminology & Taxonomy

VIRTUALIZATION

Virtual Machine

- What is Virtual Machine (VM)?
 - **VM** is a software implementation of a machine (i.e. a computer) that executes programs like a real machine.
- Terminology :
 - **Host (Target)**
 - The primary environment where will be the target of virtualization.
 - **Guest (Source)**
 - The virtualized environment where will be the source of virtualization.



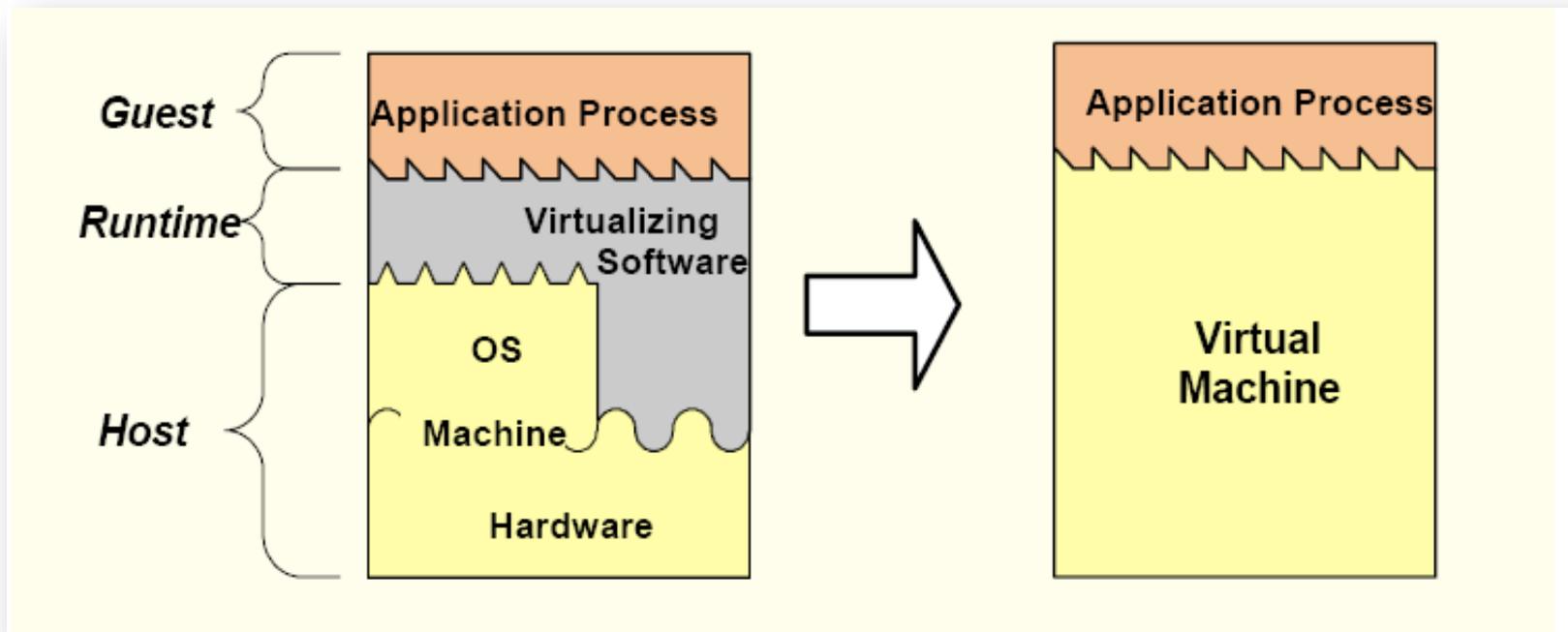
Formally, virtualization involves the construction of an **isomorphism** from **guest** state to **host** state.

Emulation vs. Virtualization

- Emulation technique
 - Simulate an independent environment where guest ISA and host ISA are different.
 - Example
 - Emulate x86 architecture on ARM platform.
- Virtualization technique
 - Simulate an independent environment where guest ISA and host ISA are the same.
 - Example
 - Virtualize x86 architecture to multiple instances.

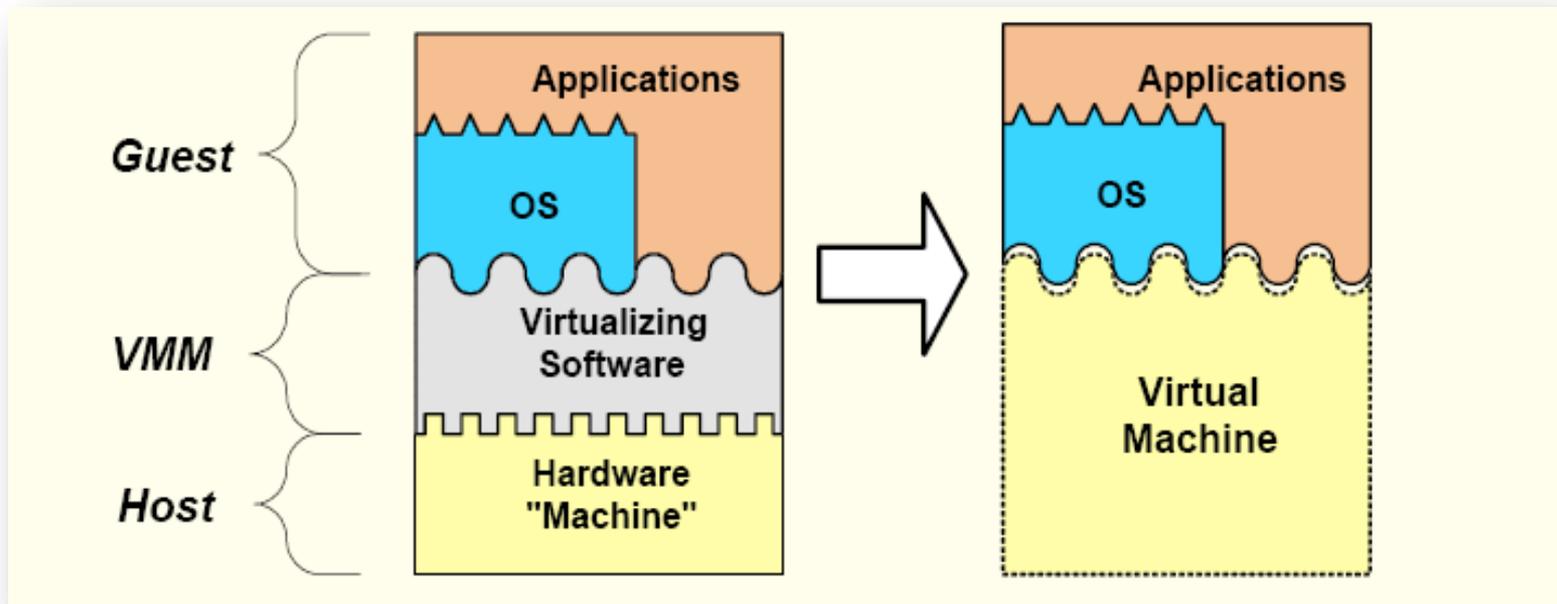
Process Virtual Machine

- Process virtual machine
 - Usually execute guest applications with an ISA different from host
 - Couple at ABI(Application Binary Interface) level via runtime system
 - Not persistent



System Virtual Machine

- System virtual machine
 - Provide the entire operating system on same or different host ISA
 - Constructed at ISA level
 - Persistent



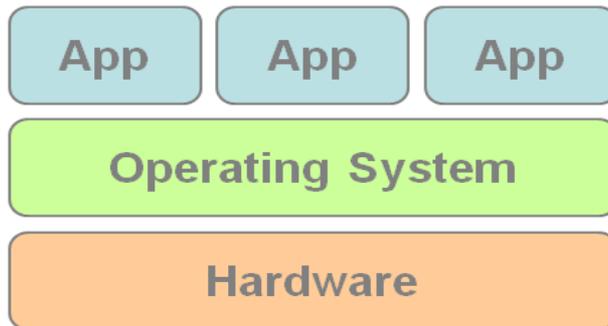
Taxonomy

| | System Virtual Machine | Process Virtual Machine |
|-----------------------|--|---|
| <i>Emulation</i> | <i>Transmeta Crusoe</i> (Emulate x86 on VLIW cpu) | <i>Multi-processing system</i> |
| <i>Virtualization</i> | XEN, KVM, VMWare (x86 virtualization software) | <i>JVM, Microsoft CLI</i> (High level language virtualization) |

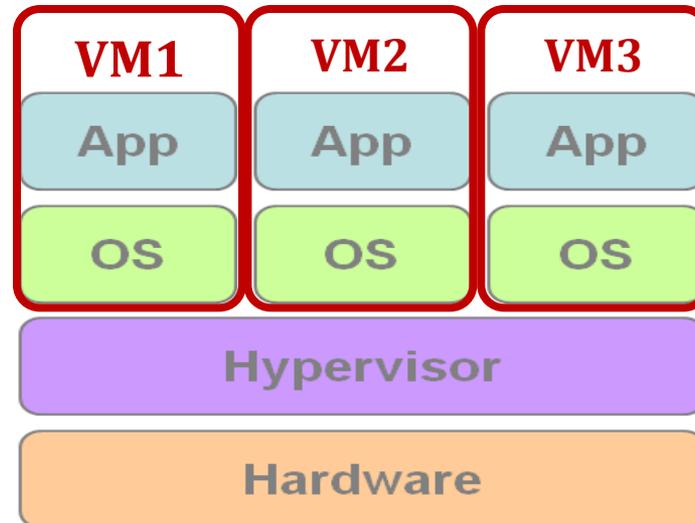
Techniques utilized in IaaS

Virtual Machine Monitor

- What's Virtual Machine Monitor (VMM) ?
 - **VMM** or **Hypervisor** is the software layer providing the virtualization.
- System architecture :



Traditional Stack



Virtualized Stack

Virtualization Types

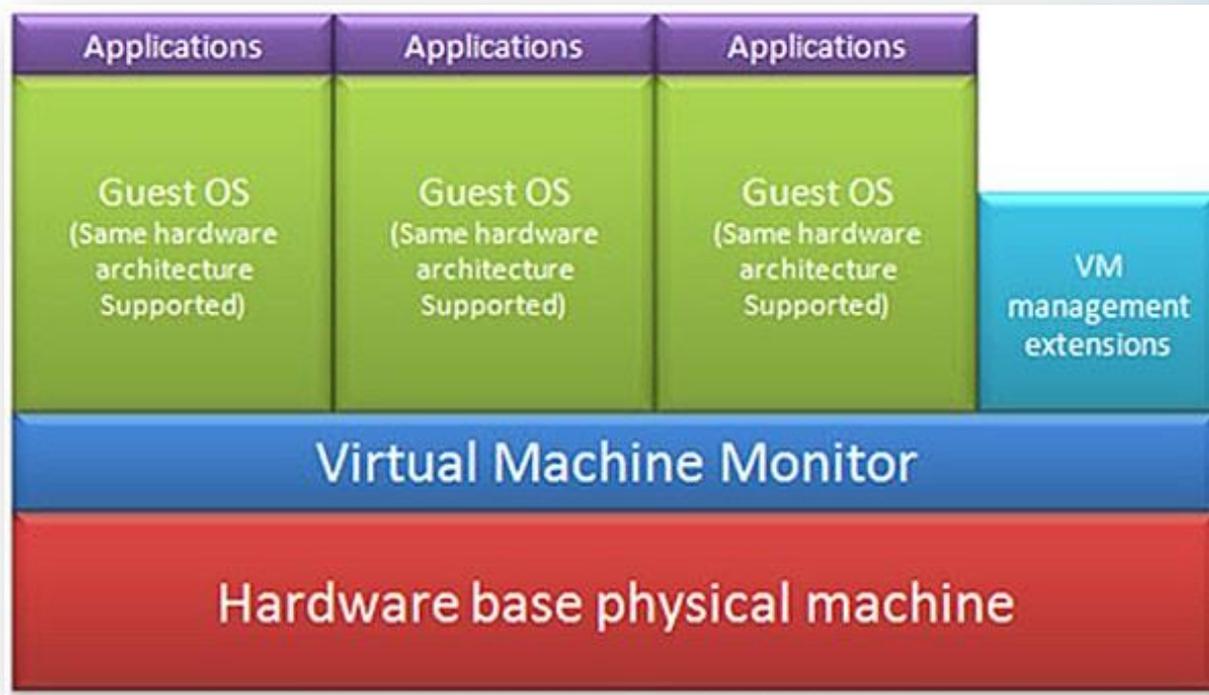
- Virtualization Types :
 - Type 1 – Bare metal
 - VMMs run directly on the host's hardware as a hardware control and guest operating system monitor.
 - Type 2 – Hosted
 - VMMs are software applications running within a conventional operating system.

Virtualization Approaches

- Virtualization Approaches :
 - Full-Virtualization
 - VMM simulates enough hardware to allow an unmodified guest OS.
 - Para-Virtualization
 - VMM does not necessarily simulate hardware, but instead offers a special API that can only be used by the modified guest OS.

Virtualization Approaches

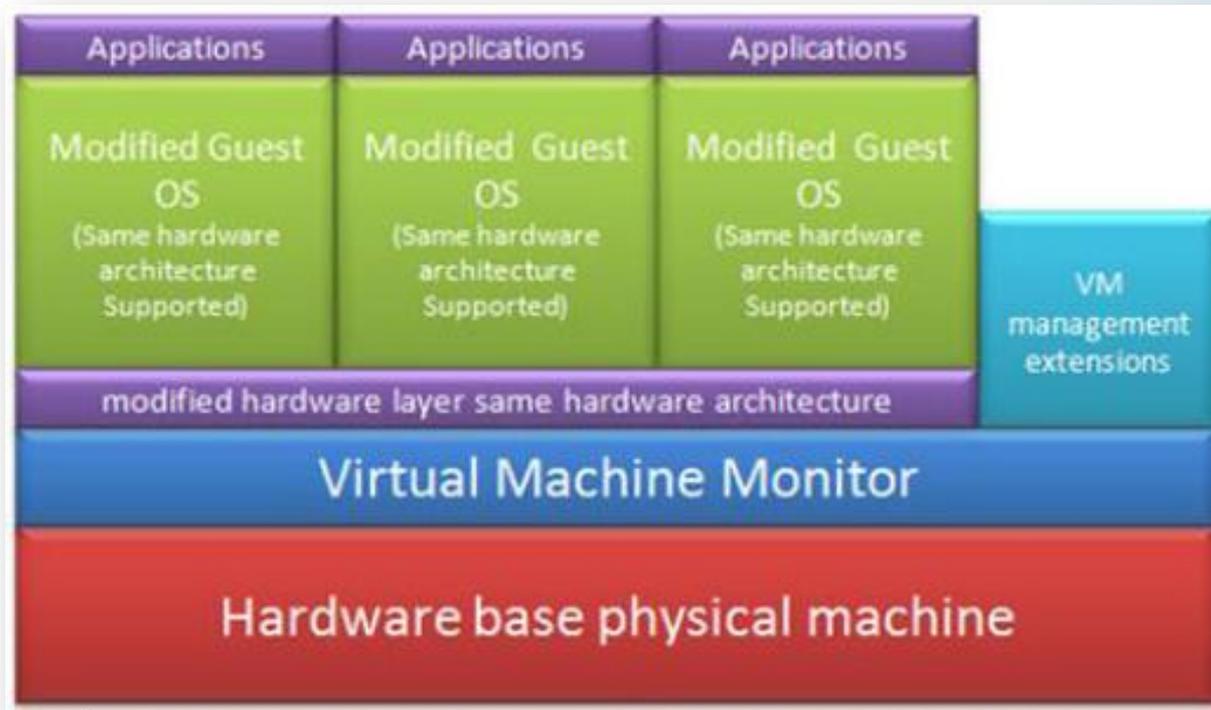
- Full-Virtualization



| | |
|-------------|------------------------------------|
| Pros | Need not to modify guest OS |
| Cons | Significant performance hit |

Virtualization Approaches

- Para-Virtualization

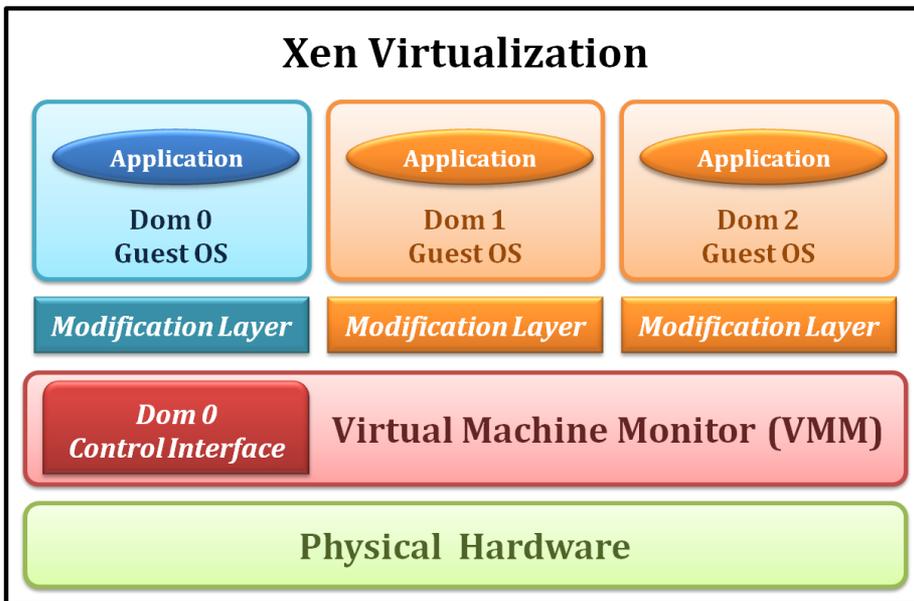


| | |
|-------------|--|
| Pros | Light weight and high performance |
| Cons | Require modification of guest OS |

Examples

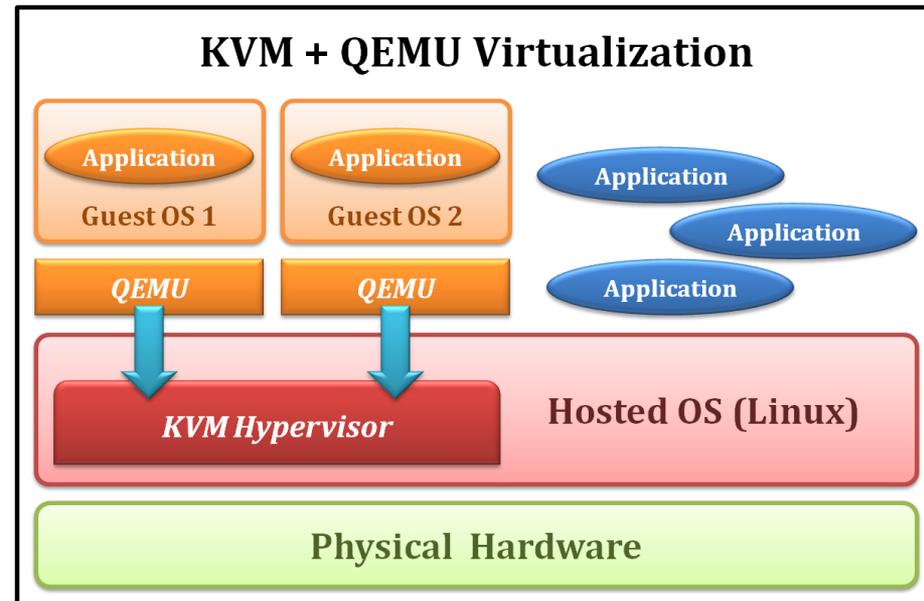
Xen

- Type 1 Virtualization
- Para-Virtualization



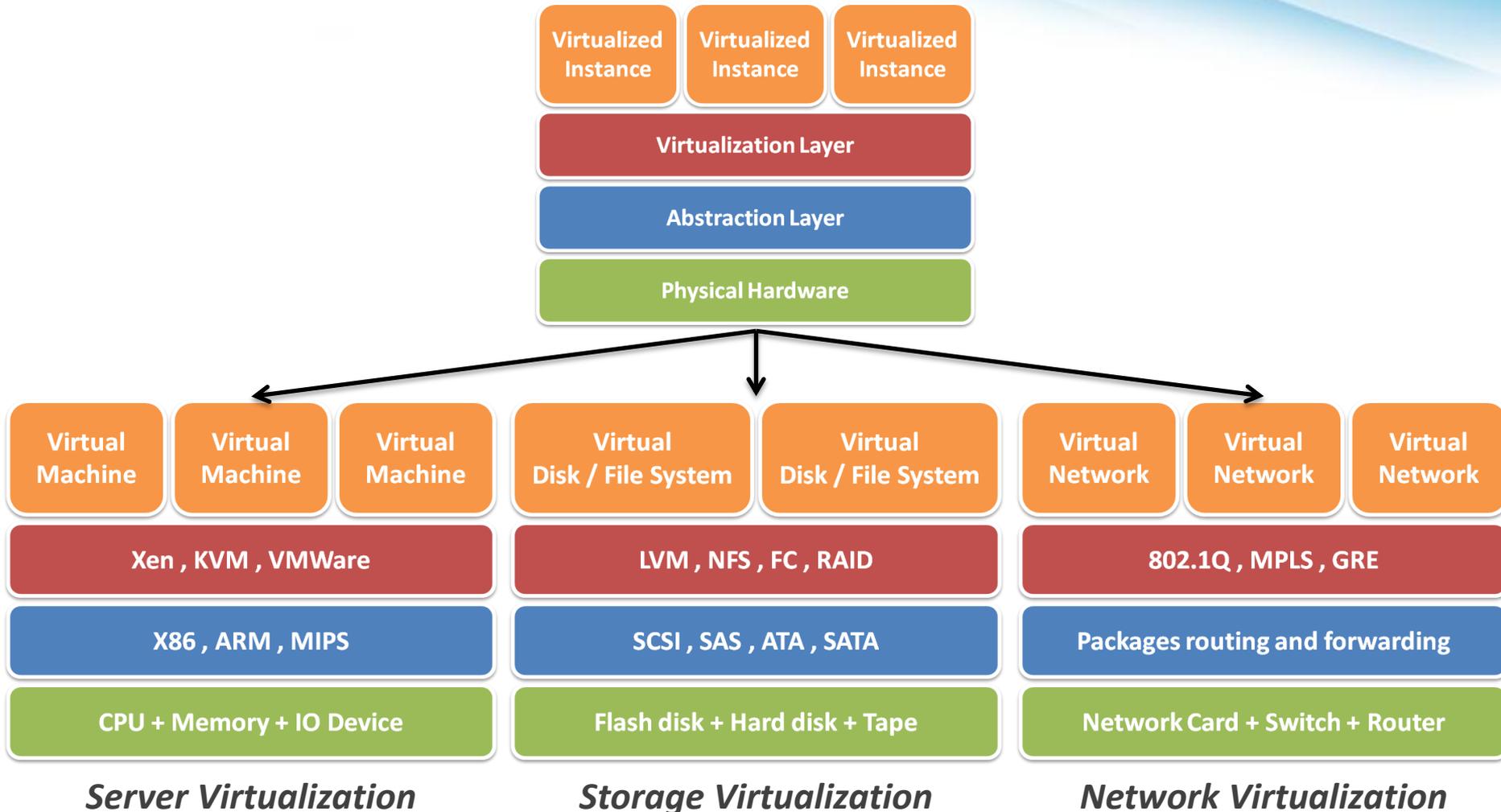
KVM

- Type 2 Virtualization
- Full-Virtualization



To be continued...

- Virtualization techniques



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- Kernel-based Virtual Machine (KVM). http://www.linux-kvm.org/page/Main_Page
- From Wikipedia, the free encyclopedia
- All resources of the materials and pictures were partially retrieved from the Internet.