



# **Virtualization In Cloud Computing**

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# Virtualization

- ❑ It is a technology to run multiple same or different OSs on a single physical system which are completely isolated from each other to.
  - Share underlying hardware resources\*
  - Ex: Run both Windows and Linux on the same machine
- ❑ It is defined as the abstraction over computing resources, such as
  - storage, processing power, memory, and network, I/O, etc..
- ❑ It is the process by which one computer behaves as many computers.
- ❑ Virtualization used to improve **IT throughput** and **costs** by using physical resources as a pool from which virtual resources can be allocated.
- VMWare white paper, *Virtualization Overview*



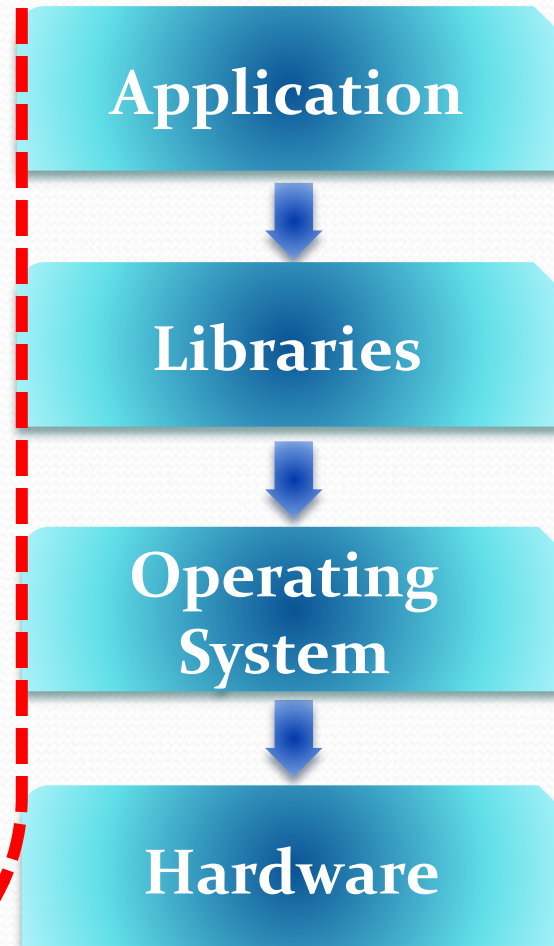
# Virtualization

- Creation of a virtual version of hardware using software.
- Runs several applications at the same time on a single physical server by hosting each of them inside their own virtual machine.
- By running multiple virtual machines simultaneously, a physical server can be utilized efficiently.

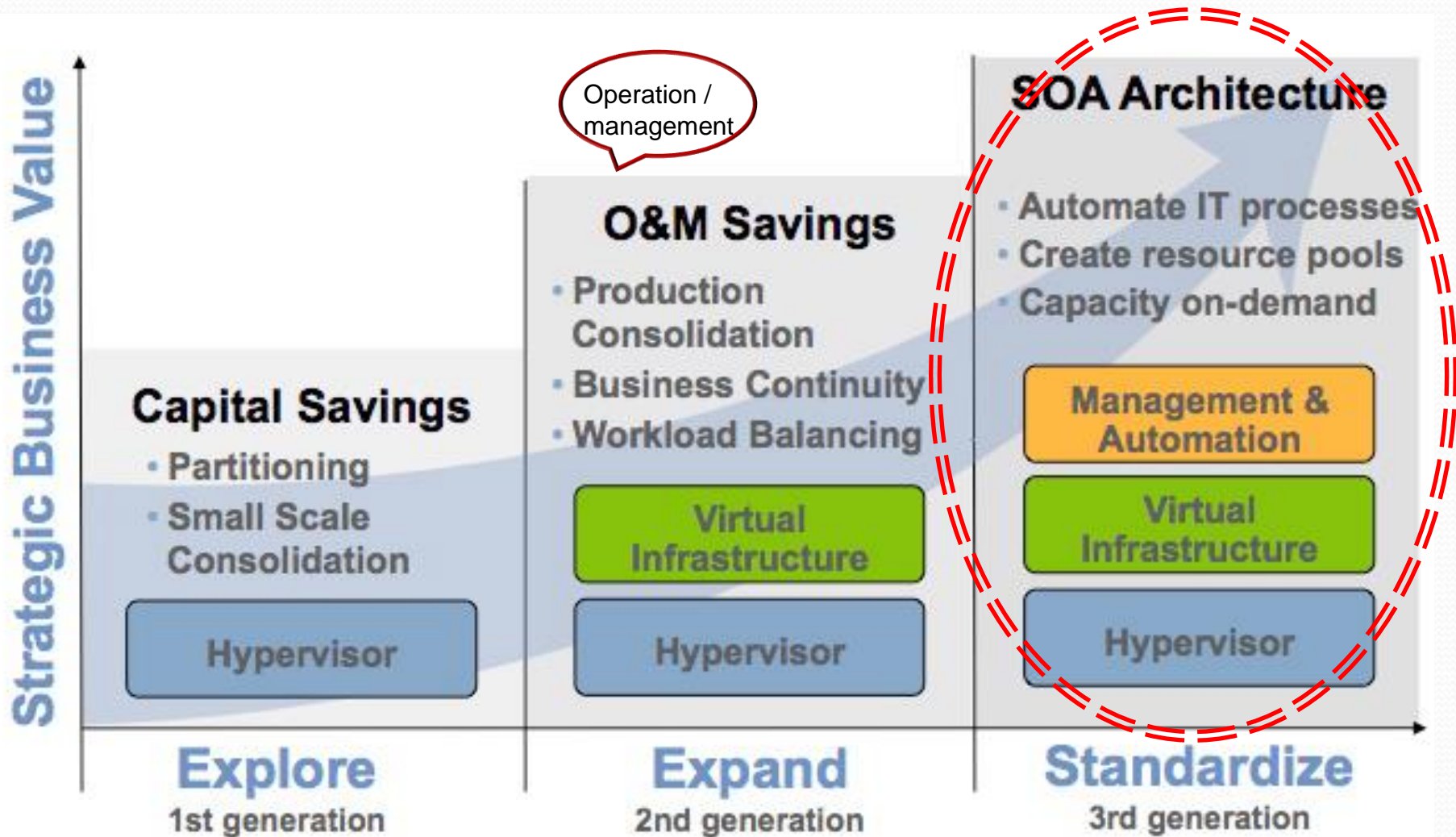
Primary approaches to virtualization

- **Platform virtualization**      Ex : Server
- **Resources virtualization**
  - Ex : Storage, Network

Machine Stack showing virtualization opportunities



# Virtualization Evolution





# *Advantages of Virtualization Over* **Cloud Computing**



- Zero downtime maintenance
- Freedom from vendor-imposed upgrade cycles
- Instant provisioning
- Pooling hardware resource
- Virtual hardware supports legacy operating systems efficiently
- Dynamic resource sharing
- Security and fault isolation
- Business continuity, backups, and automated restoration

# -----Impact of Virtualization

## Operations Require One Staff per 200-400 Virtual Machines

**Note:** Without virtualization one staff can handle up to 30 servers.

### Before

**From 20–40 hrs to build a server and re-load application...**

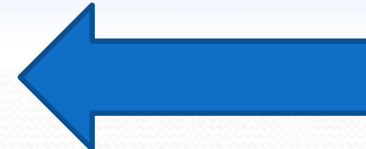
- Build and configure hardware
- Load operating system
- Load configuration tools (Backup, Resource Kit, Monitoring, etc...)
- Assign 2 IP addresses
- Build 3 network connections, copper or fiber
- Turn over to applications team to re-load and re-configure software
- Test applications
- Coordinate outage/data migration

### After

**...To 15–30 min to copy a virtual machine and restart**



**333 servers replaced per year = ~ 10,000 man/hrs saved**





# ***Impact of Virtualization***

## **Hard cost savings**

- > 70-80% reduction in data center space, power infrastructure
- > \$8M cumulative savings since 2003

## **Operational efficiency**

- > Server rebuild and application load went from 20-40 hrs => 15-30 min
- > 10,000 man hours saved per year

# Massively Virtualized Model - Cloud

- Cloud Computing offers **infrastructure as a service** which is based on:
  - Pay-as-you-use model
  - On-demand computing model
- To provide infrastructure as service (IaaS), the **provisioning** of the cloud infrastructure in data centers is a prerequisite
- However, the provisioning for systems and applications on a large number of physical machines is traditionally a **time consuming process**
- There are **two core services** enable the users to get the best out of the **IaaS model**:
  - Virtual machine provisioning
  - Migration services



# Massively Virtualized Model - Cloud

## Virtualization Services:

### Historically

- ❑ When there is a need to install a new server for a certain workload to provide a particular service for a client
  - lots of effort needed by the IT administrator, and much time was spent to install and provision a new server because:
    - ❑ The administrator has to follow specific checklist and procedures to perform this task on hand

### Now

- ❑ By emerging of virtualization technology and the cloud computing IaaS model,
  - it is just **a matter of minutes** to achieve the same task

# Massively Virtualized Model - Cloud

## Migration services:

### Previously

- ❑ whenever there was a need for performing a **server's upgrade** or **performing maintenance** tasks, you would exert a lot of **time** and **effort**
  - Because it is an expensive operation to maintain or upgrade a **main server that has lots of applications and users**

### Now

- ❑ with the advance of the revolutionized virtualization technology and migration services associated with hypervisors' capabilities, these tasks (maintenance, upgrades, patches, etc.) are very easy and need no time to accomplish



# Massively Virtualized Model - Cloud

## Resource Provisioning

- The virtualization layer will partition the physical resource of the underlying physical server into multiple virtual machines with different workloads
- The main issue about this virtualization layer is that it **schedules, allocates** the physical resource, and makes each virtual machine think that it totally owns the whole underlying hardware's physical resource (processor, disks, RAMs, etc.)

# \*\*\*Virtualization Ranging from *Hardware* to *Applications* in Five Abstraction Levels

Application level

JVM / .NET CLR / Panot

Library (user-level API) level

WINE/ WABI/ LxRun / Visual MainWin / vCUDA

Operating system level

Jail / Virtual Environment / Ensim's VPS / FVM

Hardware abstraction layer (HAL) level

VMware / Virtual PC / Denali / Xen / L4 /  
Plex 86 / User mode Linux / Cooperative Linux

Instruction set architecture (ISA) level

Bochs / Crusoe / QEMU / BIRD / Dynamo



# **Virtualization at Instruction Set Architecture (ISA) Level:**

## **Emulating a given ISA by the ISA of the host machine.**

- e.g., MIPS binary code can run on an x-86-based host machine with the help of ISA emulation.
  - Typical systems: Bochs, Crusoe, Qemu, BIRD, Dynamo

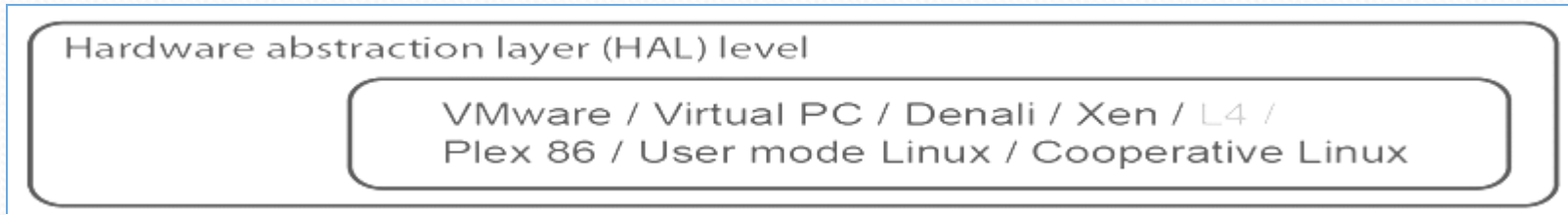
## **Advantage:**

- It can run a large amount of legacy binary codes written for **various processors** on any given new **hardware host machines**
- Best application flexibility

## **Shortcoming & limitation:**

- One source ISA instruction may require **tens** or **hundreds** of native target ISA instructions to perform its function, which is relatively **slow**.
- V-ISA requires adding a processor-specific software translation layer in the compiler.

## **Virtualization at Hardware Abstraction Level:**



**Virtualization is performed on top of the hardware (full Virtualization).**

- It generates virtual hardware environments for VMs, and manages the underlying hardware through virtualization.
- **Typical systems:** VMware, Virtual PC, Denali

### **Advantage:**

- Has higher performance and good application isolation

### **Shortcoming & limitation:**

- Very expensive to implement (complexity)



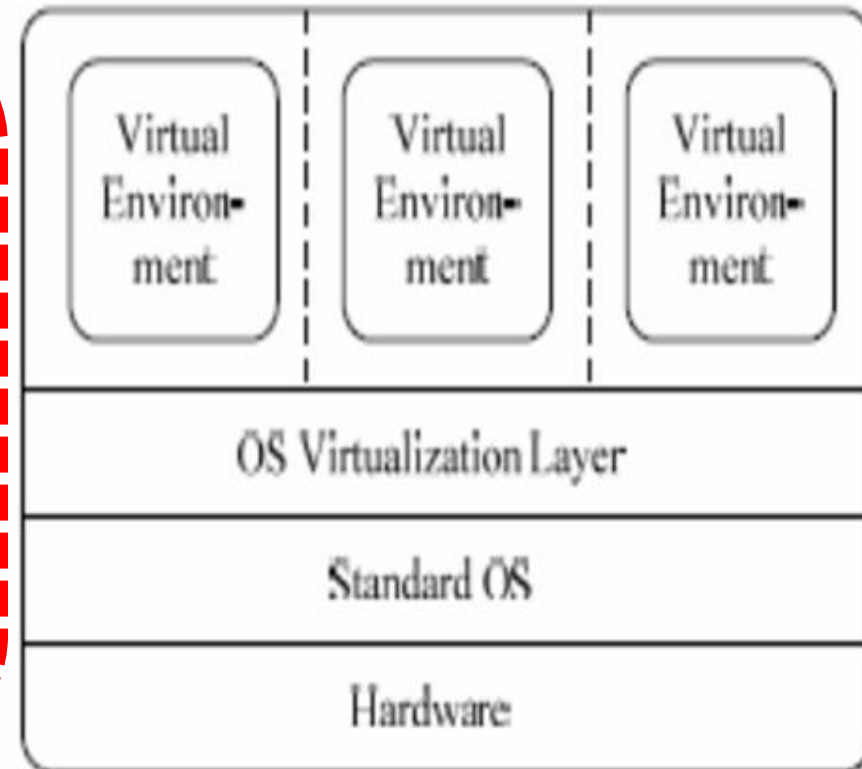
# Virtualization at OS Level:

Operating system level

Jail / Virtual Environment / Ensim's VPS / FVM

It is an abstraction layer between traditional OS and user applications

This virtualization creates **isolated containers** on a **single physical server** and the OS-instance to utilize the hardware and software in datacenters.



## Advantages of OS Extension for Virtualization

1. VMs at OS-level has minimum startup/shutdown costs
2. OS-level VM can easily synchronize with its environment

## Shortcoming & limitation:

1. All VMs at the OS-level must have ***the same kind of Host OS***
  - restrict ***application flexibility*** of different VMs on the same physical machine.
2. Poor application ***flexibility*** and ***isolation***.



# User-Application Level:



## It virtualizes an application

- This layer sits as an application program **on top of an operating system** and exports an abstraction of a VM that can run programs written and compiled to a particular abstract machine definition.
- Typical systems: **JVM** , **NET CLI** , **Panot**

## Advantage:

- It has the best **application isolation**
- **Support code portability**

## Shortcoming & limitation:

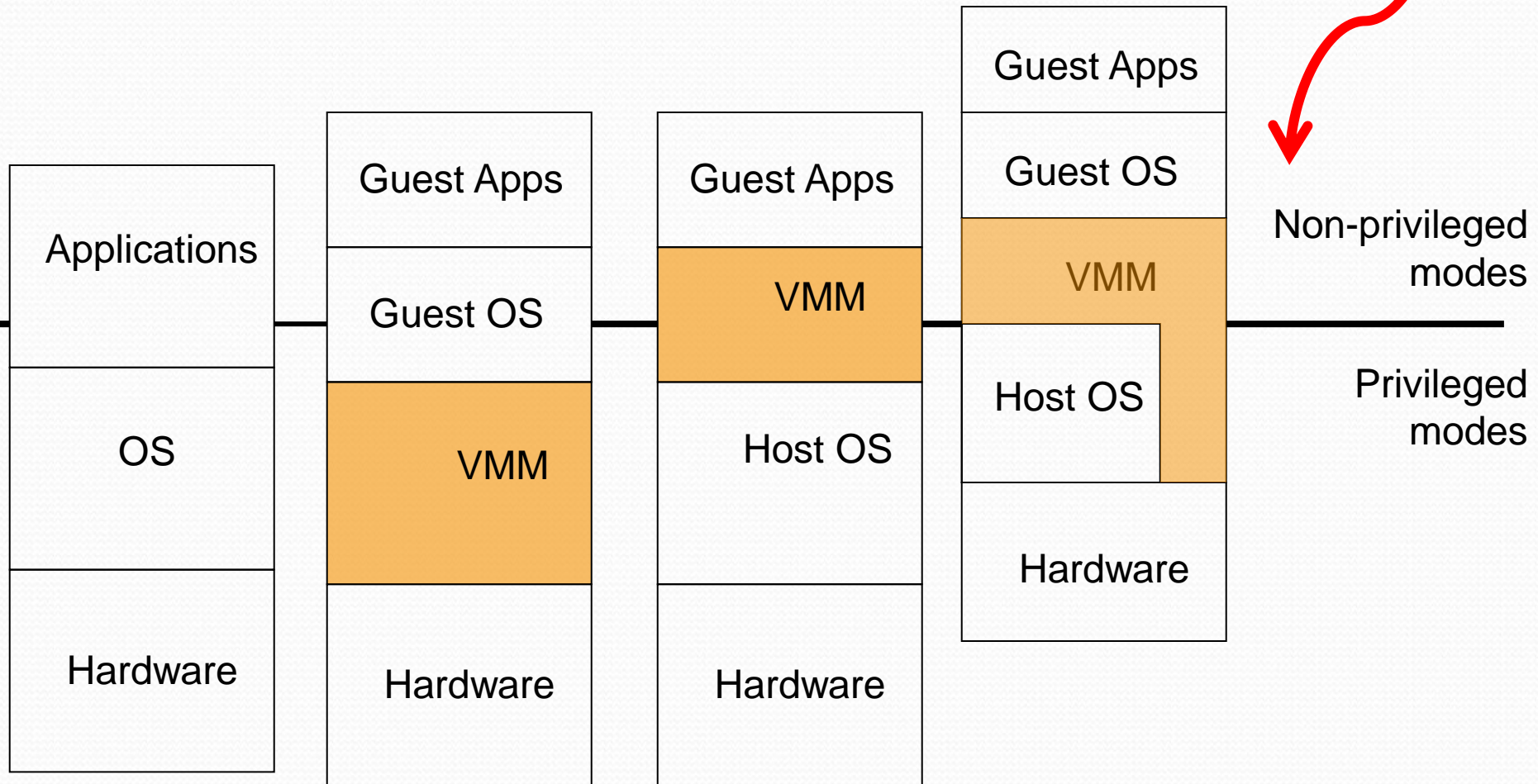
- low performance, low application flexibility and high implementation complexity.

# Generally; Virtualization

- ❑ Sharing the resources of a single hardware across multiple environments (*Full Virtualization*)
- ❑ **Host OS** provides an abstraction layer for running virtual **guest Oss** (*Para Virtualization*)
- ❑ It is the enabling technology and creates virtual machines that allows a single machine to act as if it were many machines (*OS-Level Virtualization*).
- ❑ Enable portability (migration) of virtual servers between physical servers
  - Increase utilization of physical servers



# Native and Hosted VM Systems



# Confusion...

Full, Para, and  
OS-Level  
virtualization



## OS-Level Virtualization

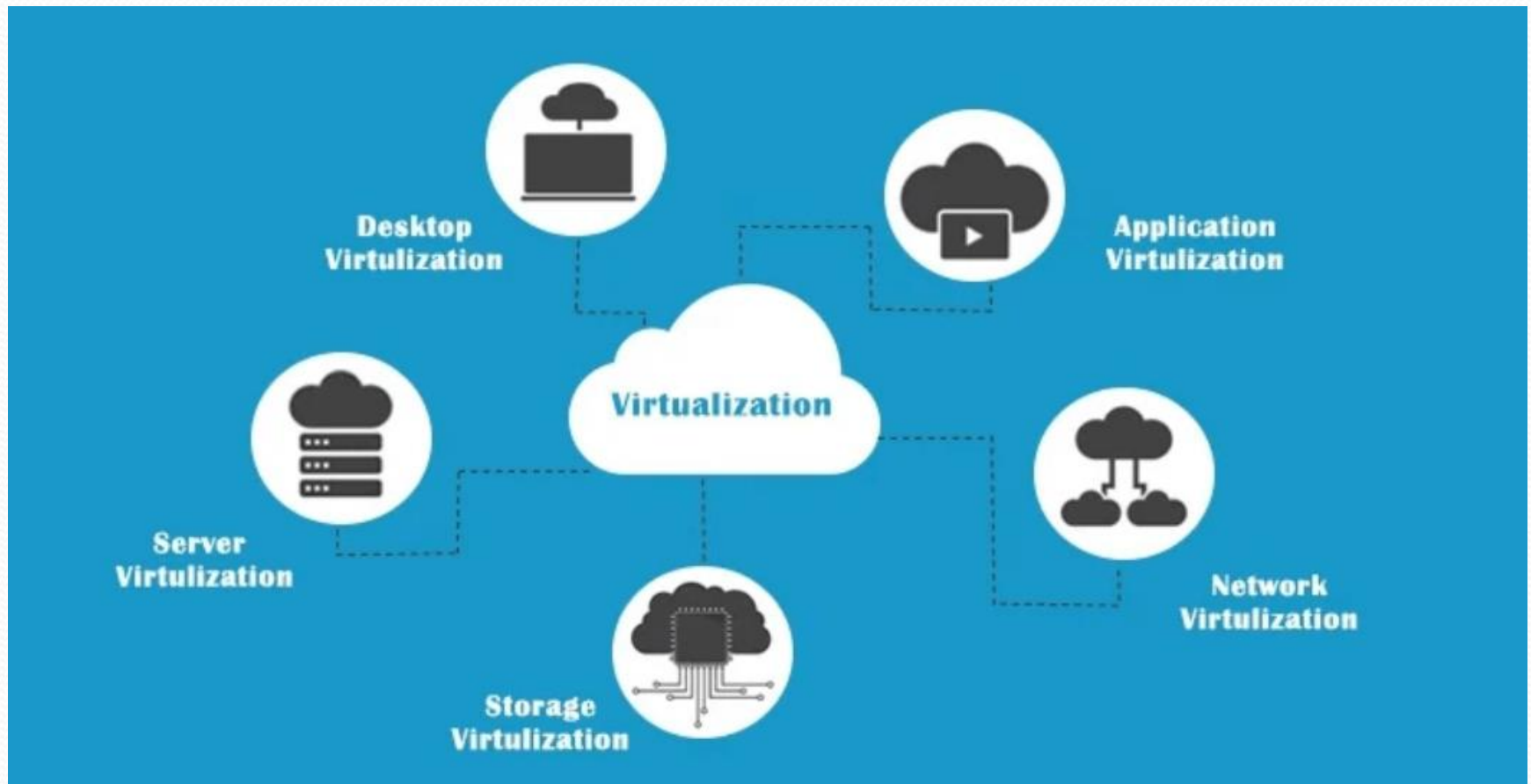
- A type of server virtualization technology which works at the OS layer. The *physical server and single instance of the operating system is virtualized into multiple isolated partitions, where each partition replicates a real server.*
- The OS kernel will run a single operating system and provide that operating system functionality to each of the partitions.

## Para Virtualization

- refers to the use of **software** to **allow system hardware to run multiple instances of different operating systems concurrently**, allowing you to run different applications requiring different operating systems on one computer system. The **operating systems do not interfere with each other or the various applications.**



# Different Virtualization Types in Cloud Computing



# Hardware Virtualization

- Hardware virtualization is also known as hardware-assisted virtualization or server virtualization
- consolidating multiple physical servers into virtual servers that run on a single primary physical server.
- the entire cluster of servers is treated as a single device by any process requesting the hardware.
- increased processing power as a result of maximized hardware utilization and application uptime.
- Subtypes: Full Virtualization, Para Virtualization



# Software Virtualization

- It involve the creation of an operation of multiple virtual environments on the host machine.
- It creates a computer system complete with hardware that lets the guest operating system to run.
- Subtypes: Operating System virtualization, Application Virtualization, Service Virtualization

# Memory Virtualization

- Physical memory across different servers is aggregated into a single virtualized memory pool.
- It provides the benefit of an enlarged contiguous working memory.

## Subtypes: •

- Application-level control – Applications access the memory pool directly
- Operating system-level control – Access to the memory pool is provided through an operating system



# Storage Virtualization

- Multiple physical storage devices are grouped together, which then appear as a single storage device.
- Homogenization of storage across storage devices of multiple capacity and speeds
- reduced downtime, load balancing
- better optimization of performance and speed.

## Subtypes: •

- Block Virtualization – Multiple storage devices are consolidated into one
- File Virtualization – Storage system grants access to files that are stored over multiple hosts

# Data Virtualization

- It lets you easily manipulate data.
- The data is presented as an abstract layer completely independent of data structure and database systems.
- Decreases data input and formatting errors.



# Network Virtualization

- The data is presented as an abstract layer In network virtualization.
- Multiple sub-networks can be created on the same physical network, which may or may not is authorized to communicate with each other.
- It enables restriction of file movement across networks and enhances security, and allows better monitoring and identification of data usage which lets the network administrators scale up the network appropriately.
- It also increases reliability as a disruption in one network doesn't affect other networks, and the diagnosis is easier.

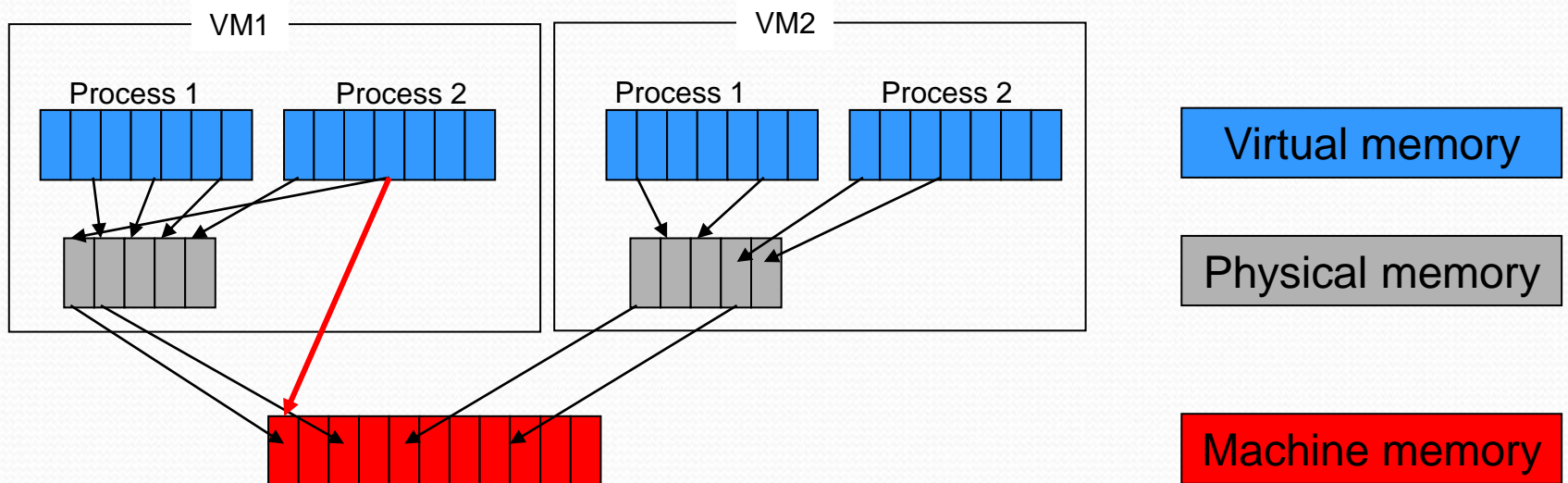
# Desktop Virtualization

- The user's desktop is stored on a remote server, allowing the user to access his desktop from any device or location.
- Employees can work conveniently from the comfort of their homes. Since the data transfer takes place over secure protocols, any risk of data theft is minimized.

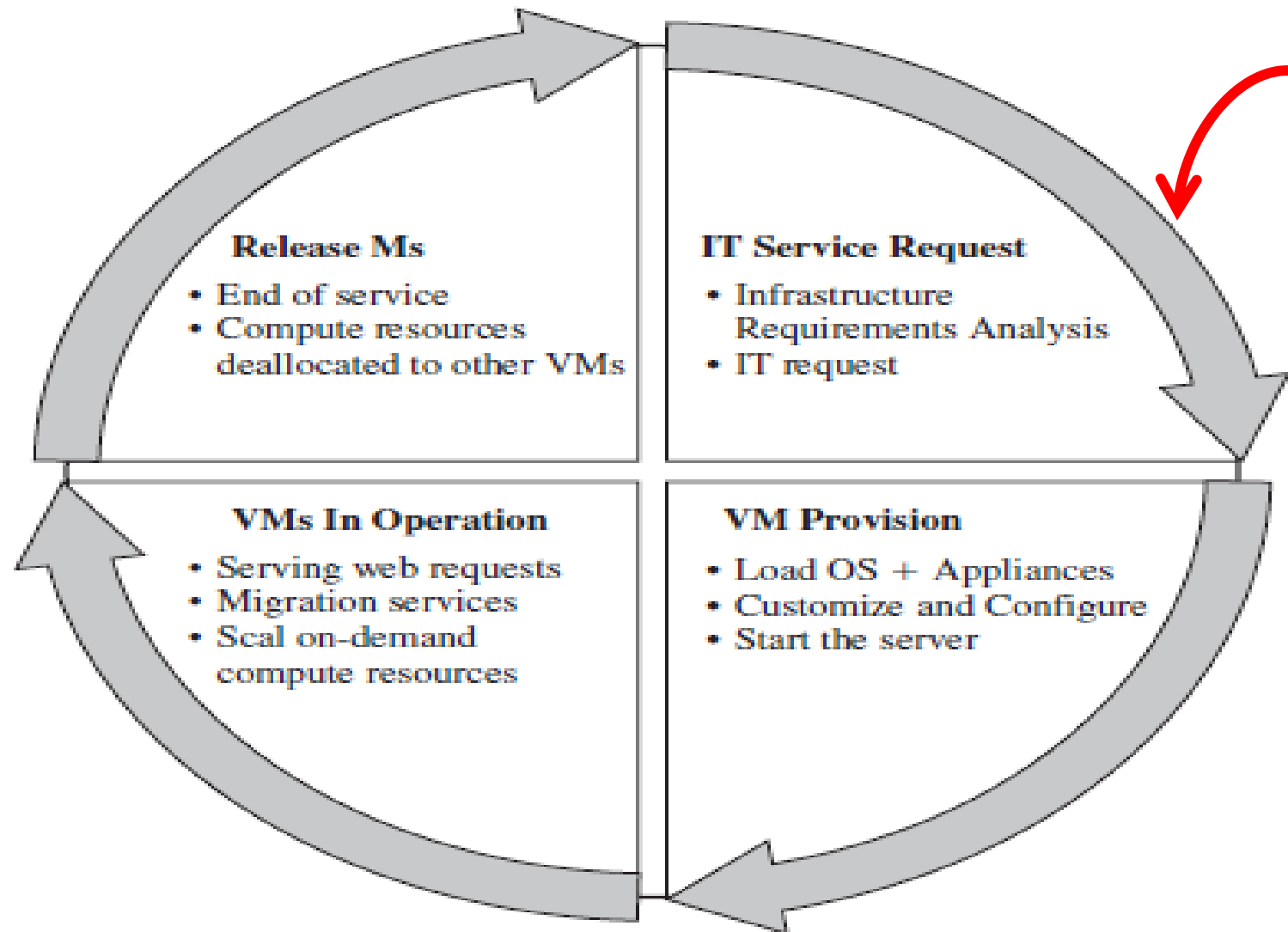


# Memory Virtualization

- To run multiple VMs on a single system, another level of **memory virtualization** is required.
- 
- The VMM is responsible for **mapping guest physical memory to the actual machine memory, and it uses shadow page tables to accelerate the mappings.**



# Virtual Machines Provisioning Life Cycle





# Provisioning in Public Cloud

- Resources are dynamically provisioned via publicly accessible Web applications/Web services (SOAP or RESTful interfaces) *from an off-site third-party provider*, who shares resources and bills on a fine-grained utility computing basis

## Public Cloud Providers:

- Amazon EC2
- GoGrid
- RackSpace
- AppNexus
- FlexiScal
- ...

# Provisioning in Private Cloud

- A private cloud aims at providing public cloud functionality, but on private resources, while maintaining control over an organization's data and resources to meet security and governance's requirements in an organization.
- Private cloud exhibits a highly virtualized cloud data center located inside your organization's firewall.
- Private Cloud Frameworks:
  - Eucalyptus
  - OpenNebula