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*

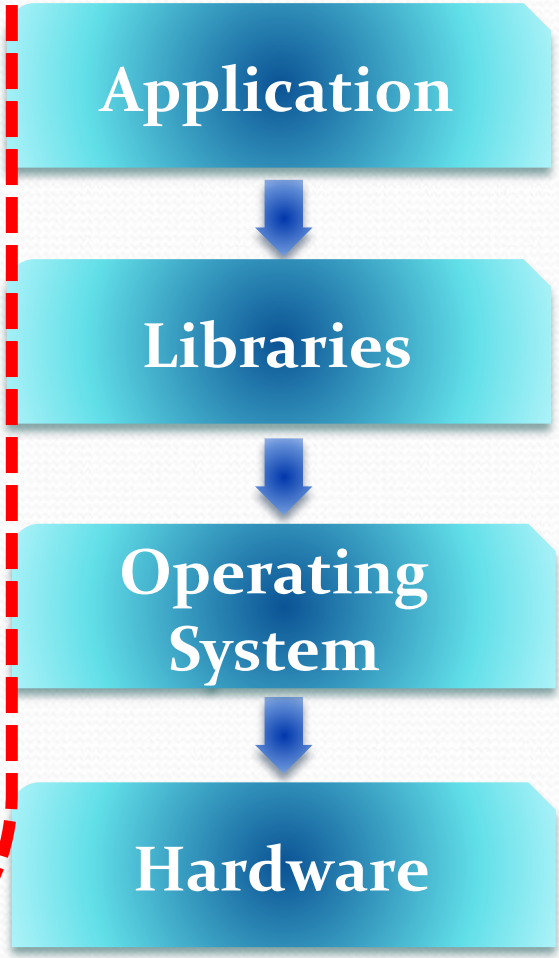
Virtualization

- 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.

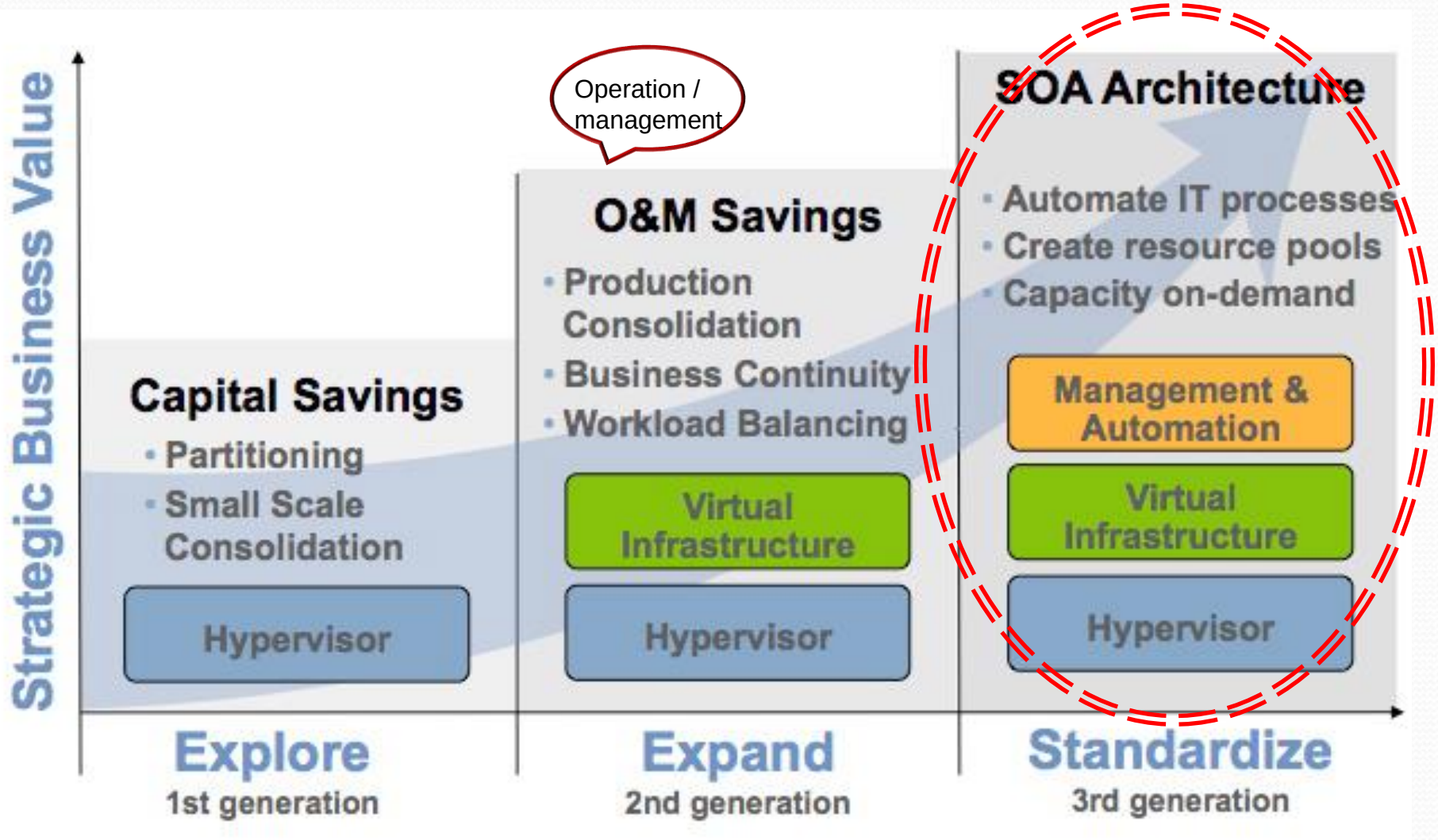
Primary approaches to virtualization

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

Machine Stack showing virtualization opportunities



Virtualization Evolution



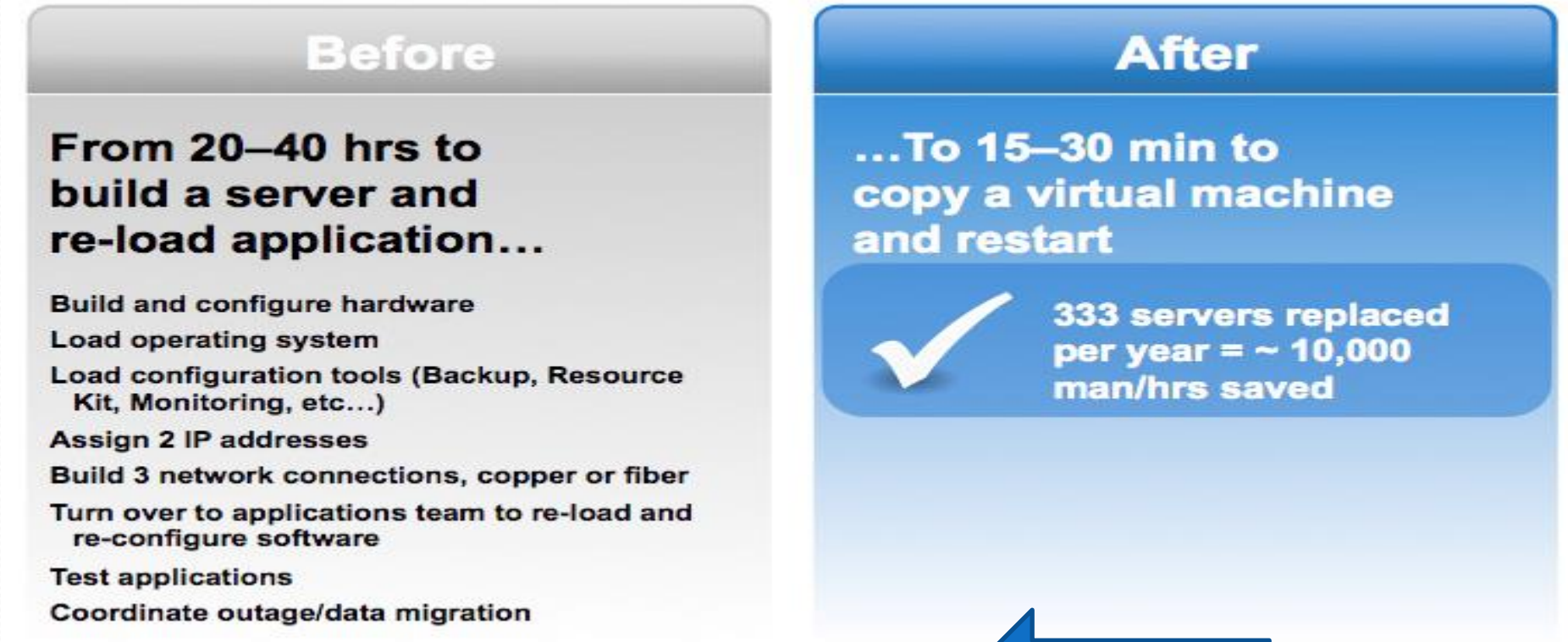
Advantages of Virtualization Over Cloud Computing

- 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.



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

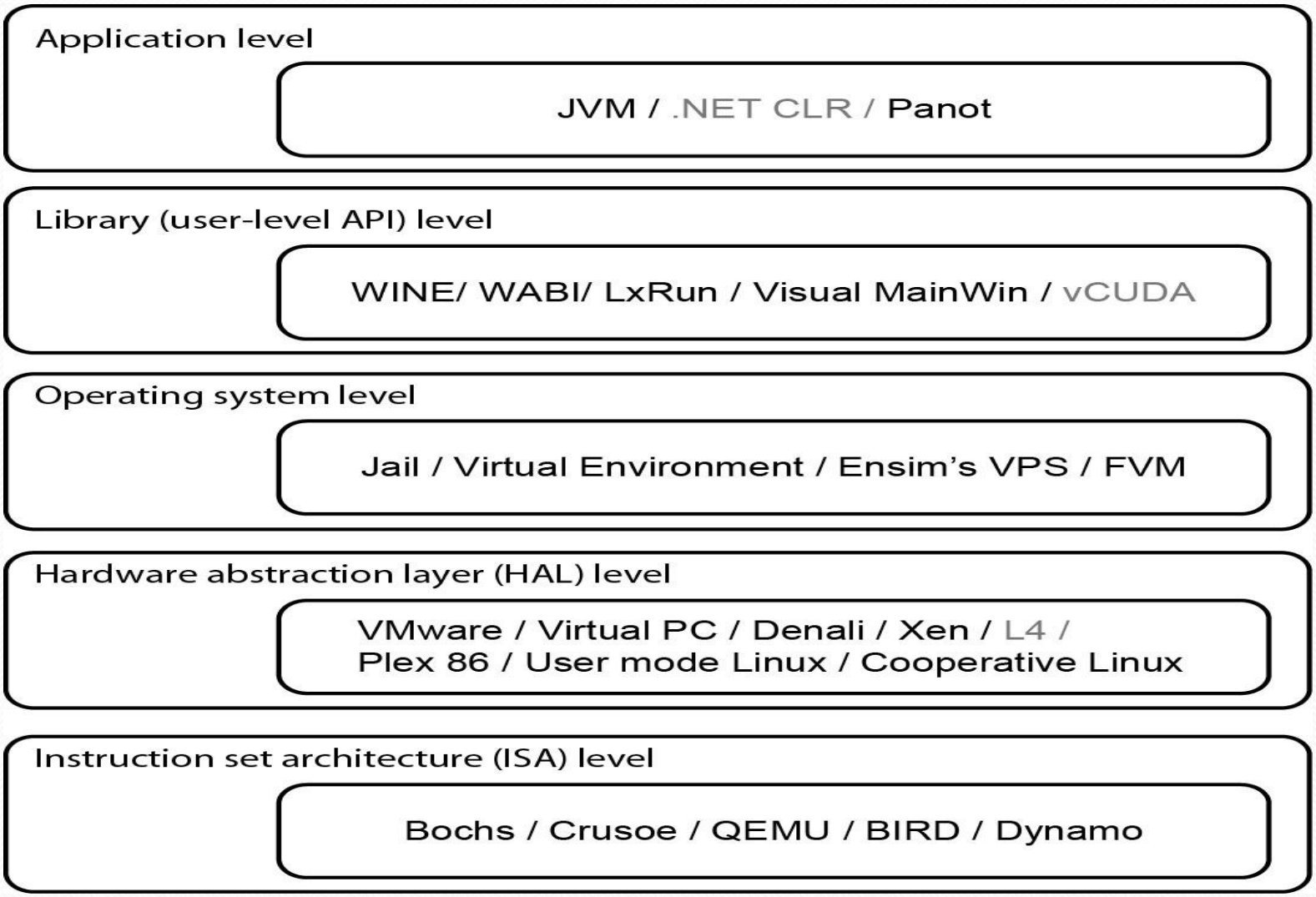
Massively Virtualized Model - Cloud

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



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, Quemu, BIRD, Dynamo

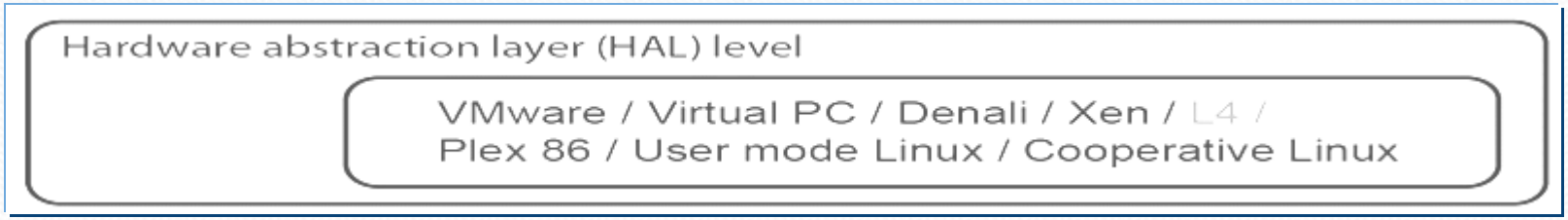
Advantage:

- 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 complier.

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

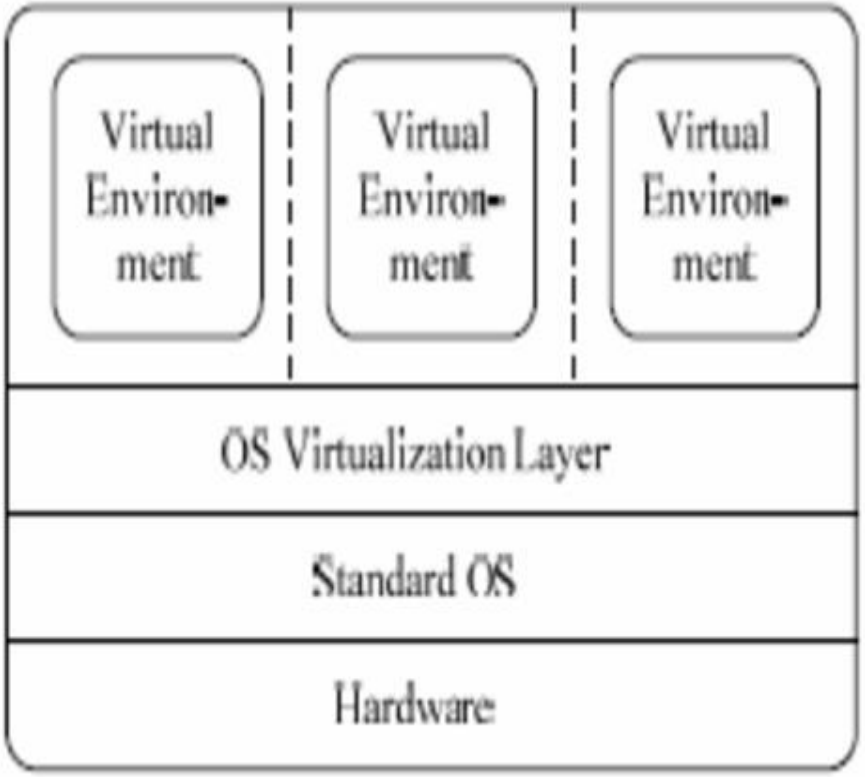
Shortcoming & limitation:

- Very expensive to implement (complexity)

Virtualization at OS Level:

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***

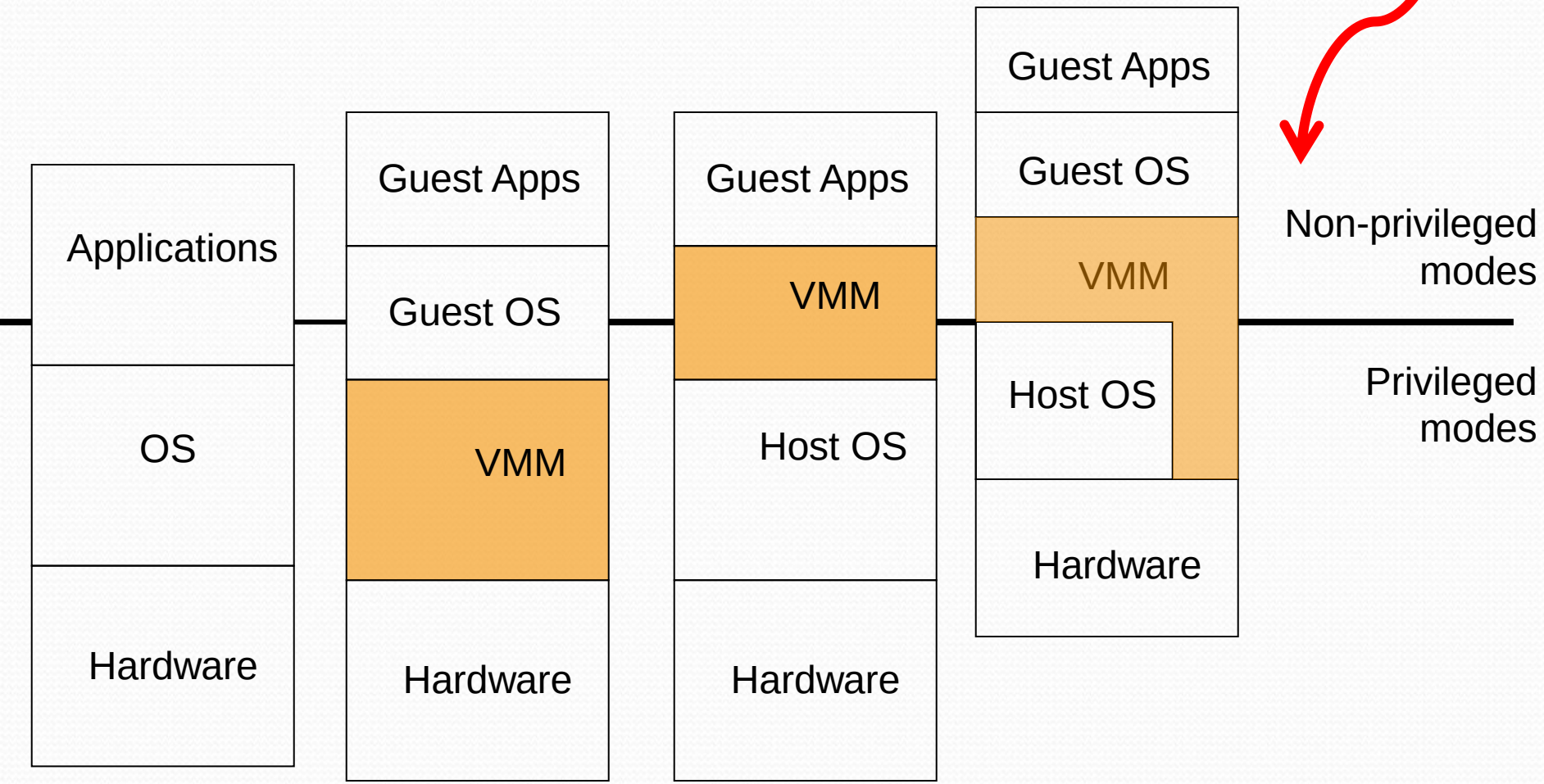
Shortcoming & limitation:

- 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

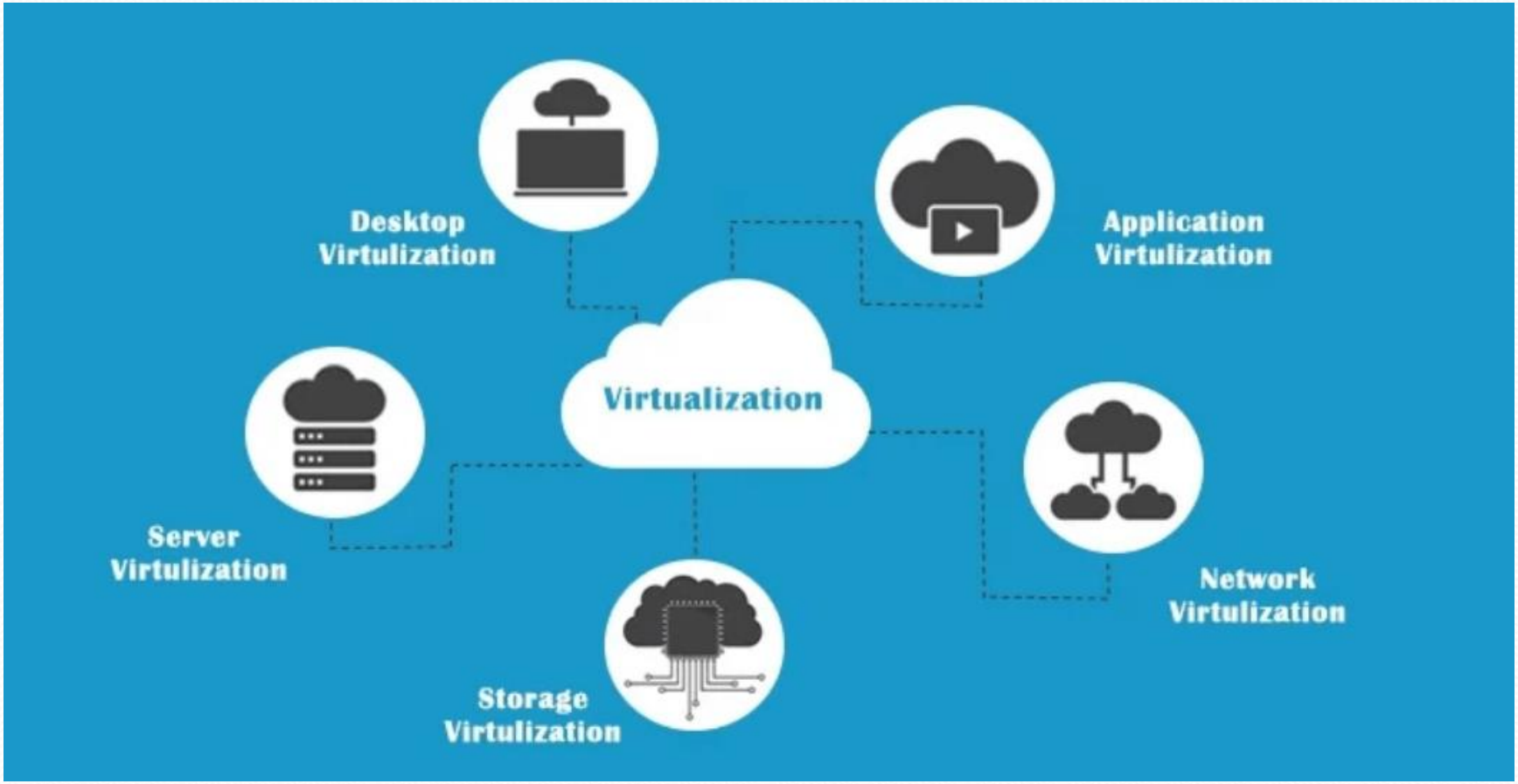
OS-Level Virtualization

- 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



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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

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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

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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.
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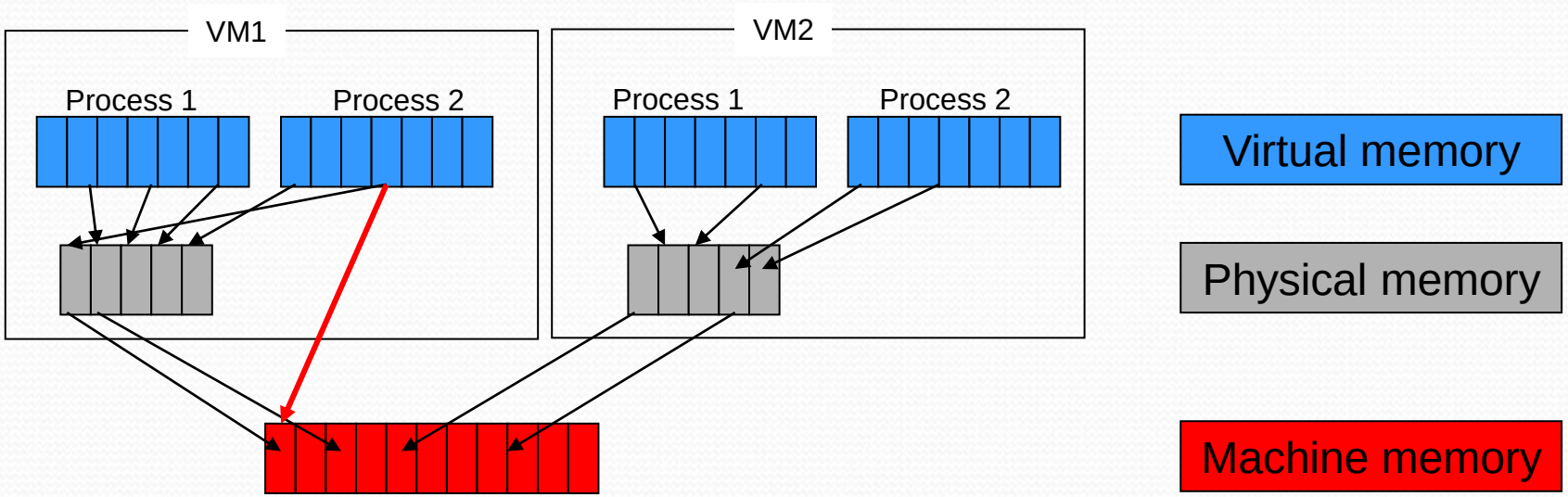
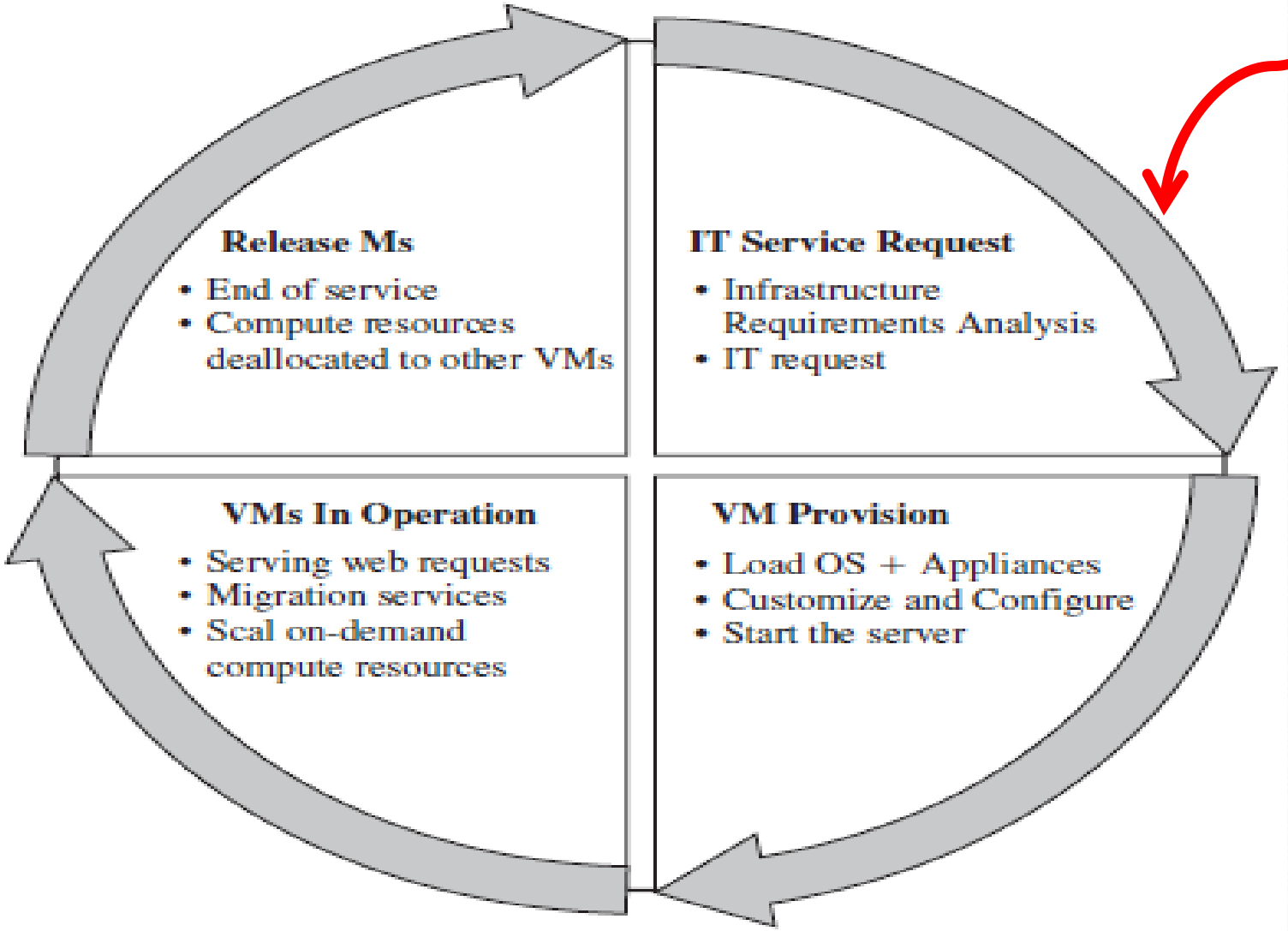
- The VMM is responsible for ***mapping guest physical memory to the actual machine memory, and it uses shadow page tables to accelerate the mappings.***



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