



# ECAP470: CLOUD COMPUTING

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# Learning Outcomes



**After this lecture, you will be able to,**

- ✓ know about the different types of virtualization
- ✓ learn the pros and cons of virtualization

# Virtualization and Cloud Computing

- **Virtualization-** Ability to run multiple operating systems on a single physical system and share the underlying hardware resources.
- Cloud Computing- Provisioning of services in a timely (near on instant), on-demand manner, to allow the scaling up and down of resources”.

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  - Fits well with the move to 64 bit (very large memories) multi-core (concurrency) processors.
  - Intel VT (Virtualization Technology) provides hardware to support the VMM layer.
- Virtualization is now a well-established technology.

# Cloud Computing Takes Virtualization to the Next Step

- Renting out spare capacity.
- Build data centers where hardware can be outsourced.
- You don't have to own the hardware.
- You “rent” it as needed from a cloud.



# Goal 1– Cost Control

- Cost
- Reduce Risk

## Goal 2- Business Agility

- **More than scalability - elasticity!**

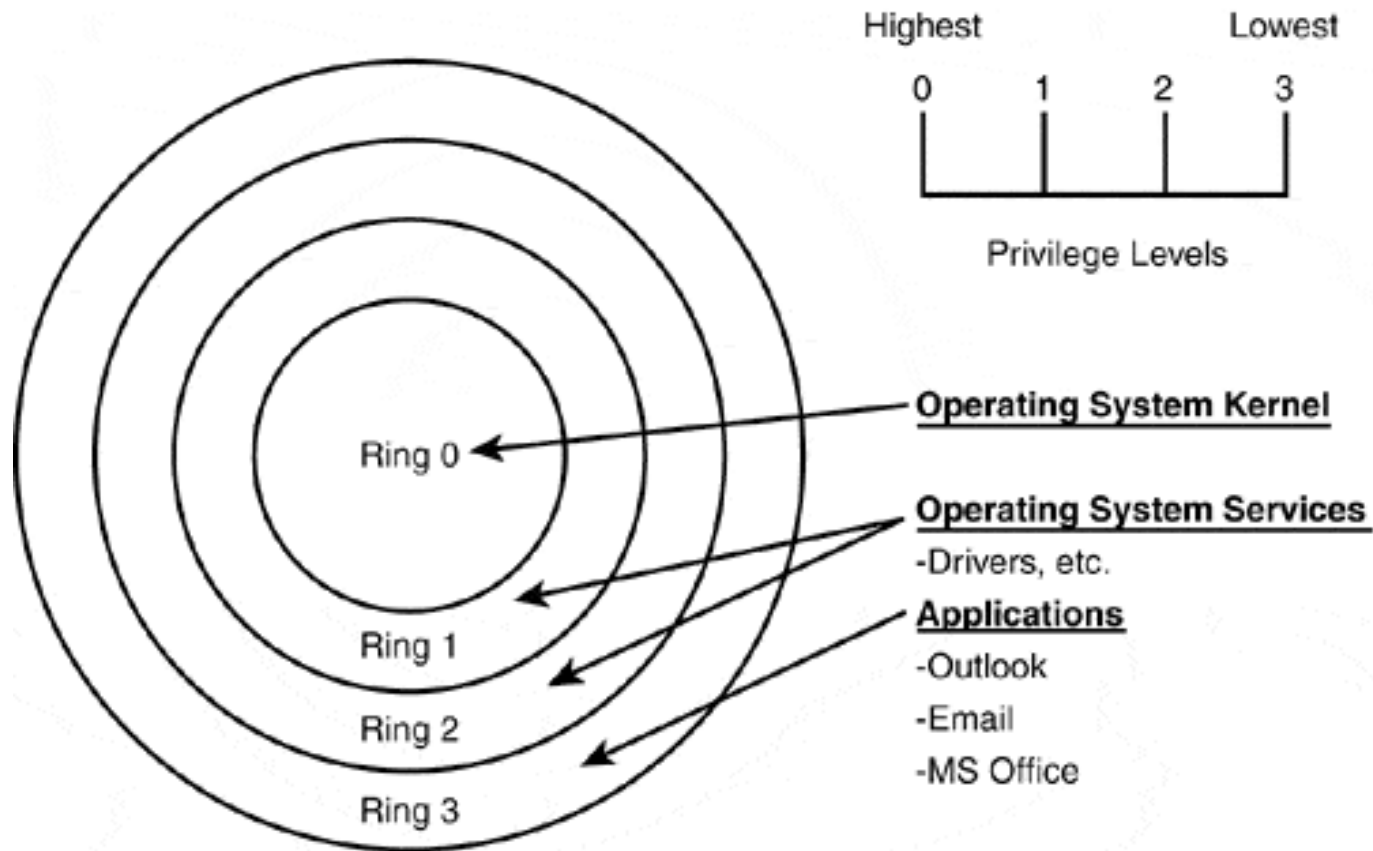
## Goal 3– Stick to Our Business

- Most companies don't want to do system administration.

# Types of Virtualization

- Virtualization covers a wide range of emulation techniques that are applied to different areas of computing.
- A classification of these techniques helps us better understand their characteristics and use.
- Protection rings in OSs.

# Types of Virtualization



Protection Rings in OSs

# Types of Virtualization

- Depending on the type of virtualization, the hypervisor and guest OS will run at different privilege levels. Normally, the hypervisor will run at the most privileged level, and the guest OS will run at the least privileged level than the hypervisor.

# Types of Virtualization

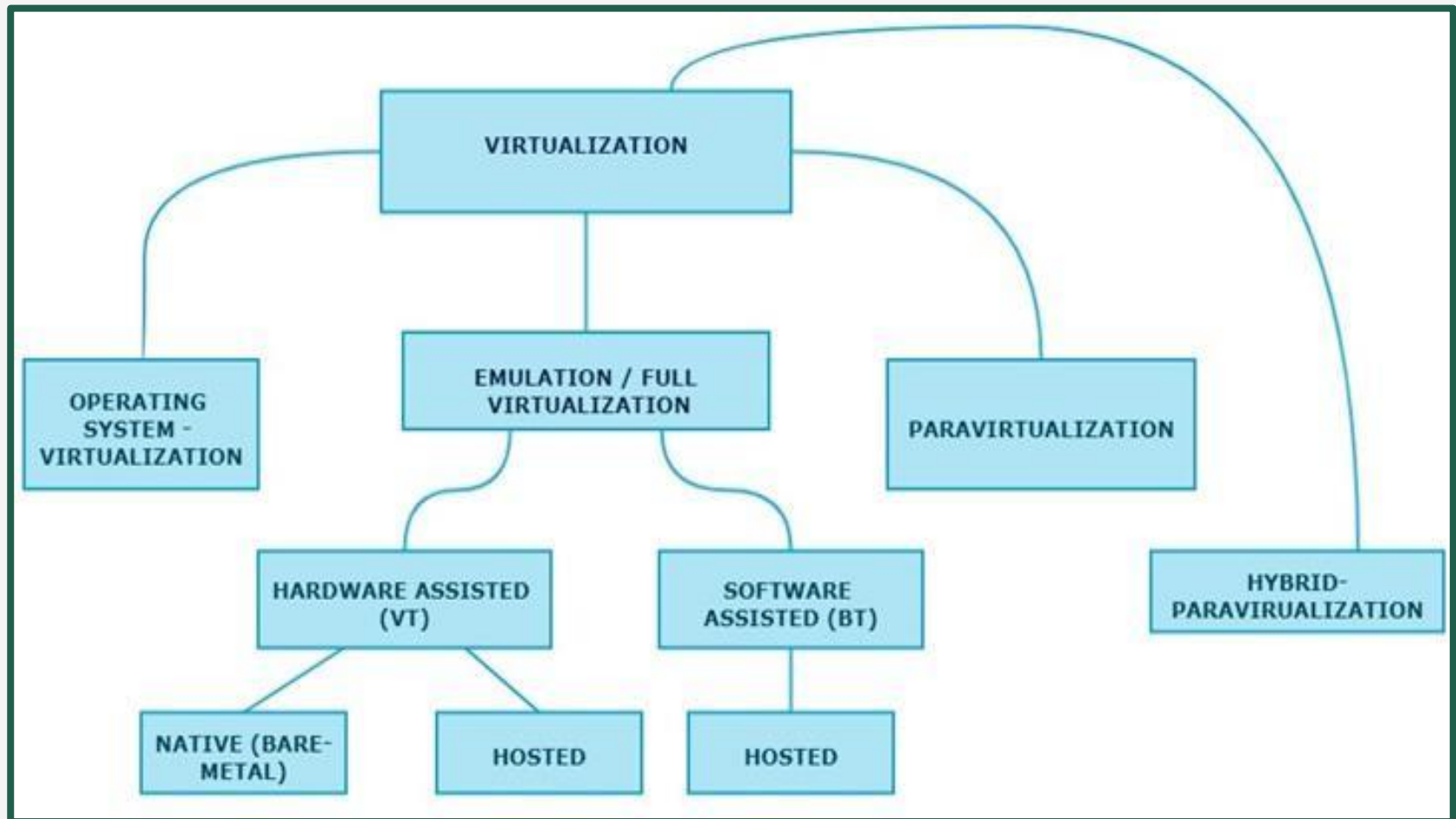
1. Full Virtualization or Emulation (Hardware-Assisted/ Binary Translation (Software-Assisted))
2. Para Virtualization or OS-assisted Virtualization
3. Processor Virtualization
4. Memory Virtualization
5. Storage Virtualization
6. Network Virtualization

# Types of Virtualization

- 7. Data Virtualization
- 8. Application Virtualization
- 9. Hybrid Virtualization
- 10. OS level Virtualization



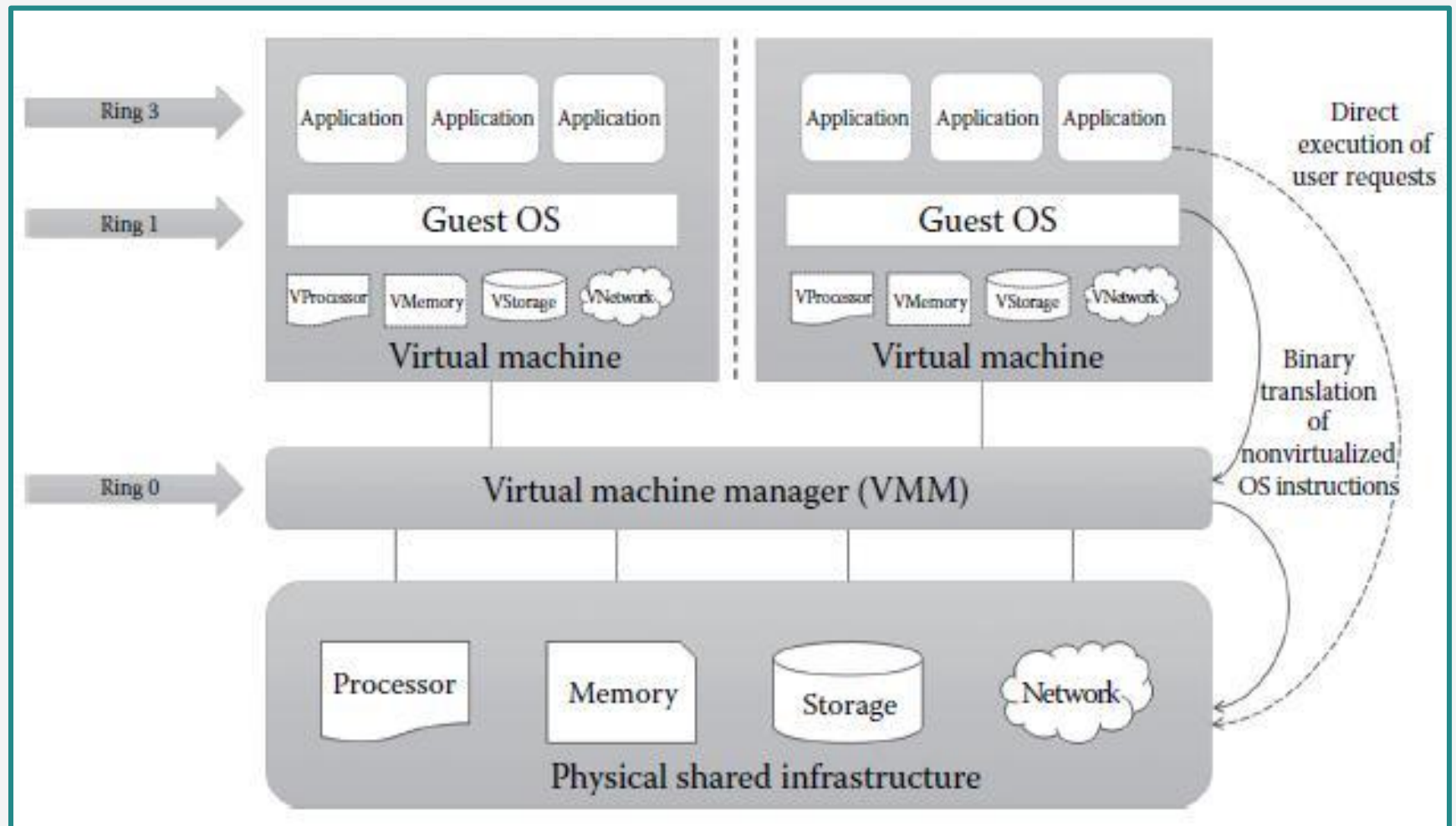
# Types of Virtualization



# Full Virtualization

- Guest OS is completely abstracted from the underlying infrastructure.
- Full virtualization uses a special kind of software called **a hypervisor**. A virtualization layer or virtual machine manager (VMM) or hypervisor **fully decouples the guest OS from the underlying infrastructure.**

# Full Virtualization



# Full Virtualization

- This approach uses binary translation and direct execution techniques.
- Binary translation
- Pros
- Cons

# Full Virtualization

- VM simulates hardware to allow an unmodified guest OS to be run in isolation.

# Full Virtualization

- VM simulates hardware to allow an unmodified guest OS to be run in isolation.
- Two type of Full virtualizations in the enterprise market.
  - Software-assisted Full Virtualization
  - Hardware-assisted Full Virtualization

# Full Virtualization

- On both full virtualization types, guest OSs source information will not be modified.

# Software Assisted–Full Virtualization (BT–Binary Translation)

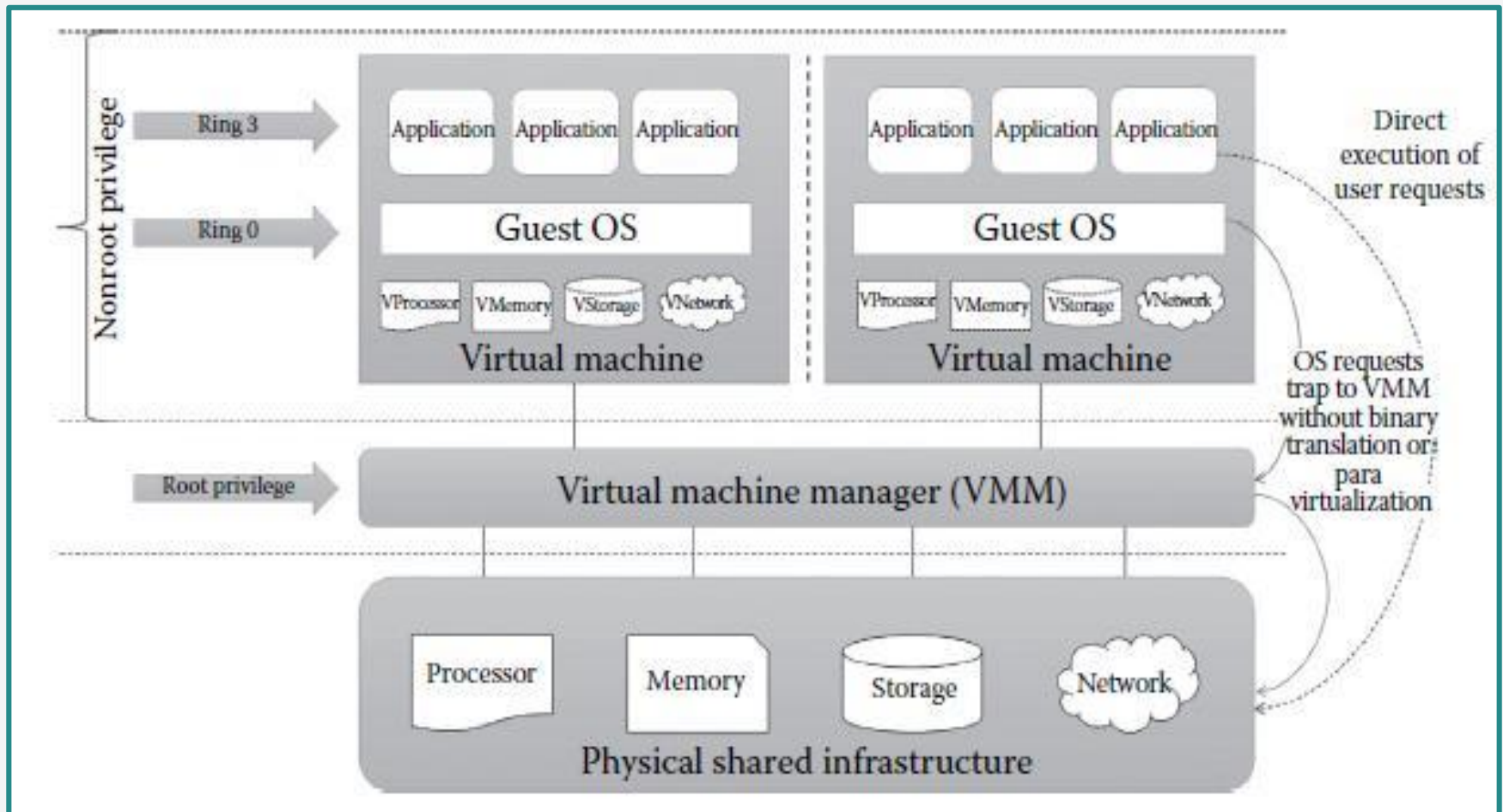
- Completely **relies on binary translation** to trap and virtualize the execution of sensitive, non-virtualizable instructions sets.
- **Emulates the hardware using the software instruction sets.**



# Hardware Assisted–Full Virtualization (VT)

- Hardware vendors like Intel and AMD, offer the support for virtualization, which **eliminates much overhead involved in the binary translation and guest OS modification.**

# Hardware Assisted-Full Virtualization (VT)



# Hardware Assisted–Full Virtualization (VT)

- Eliminates the binary translation
- Pros
- Cons

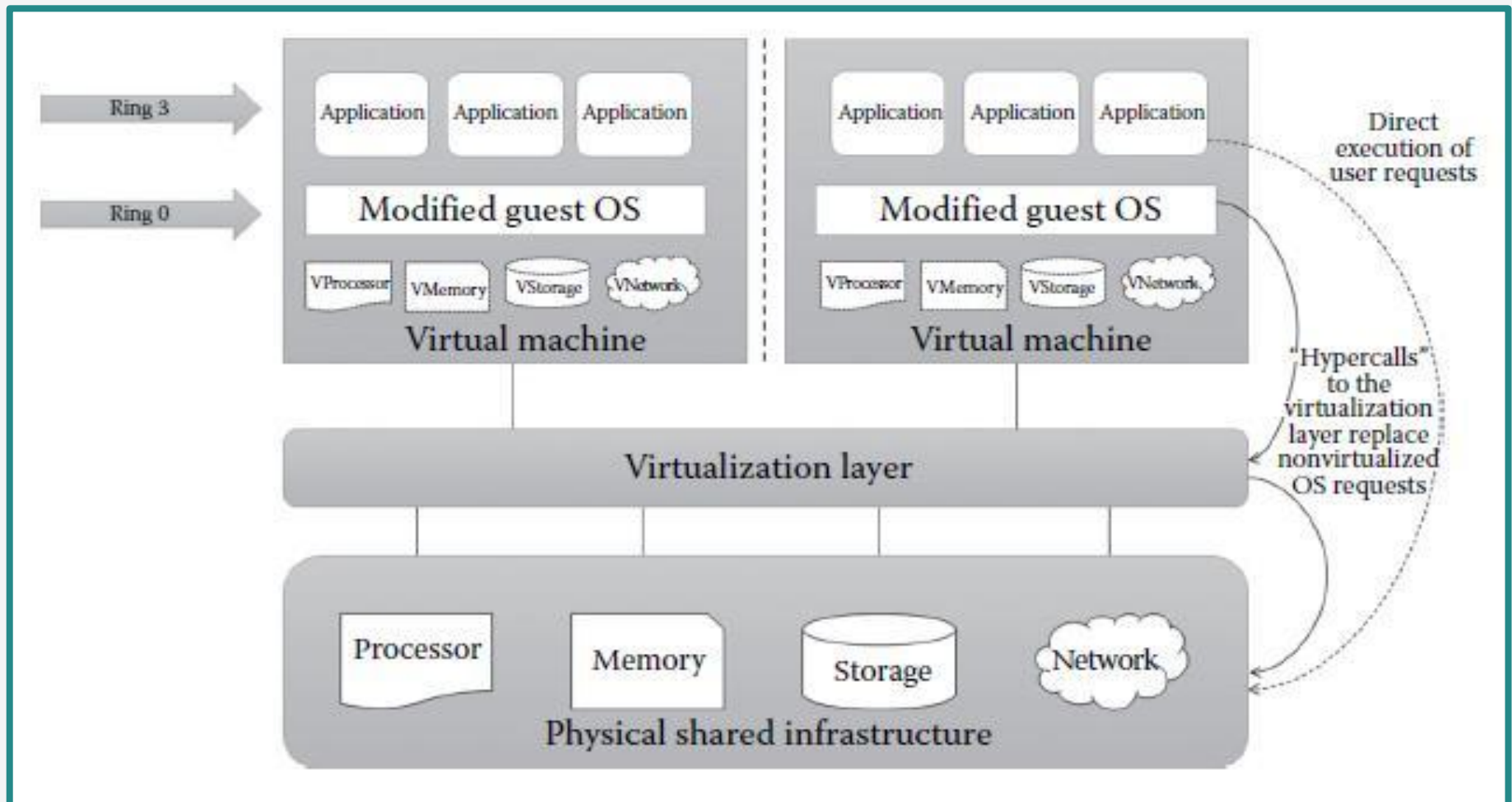
# Para Virtualization

- Works differently from the full virtualization.
- Also known as **partial virtualization** or **OS-assisted virtualization** and provides partial simulation of the underlying infrastructure.

# Para Virtualization

- Virtual guests are aware that it has been virtualized.
- Hypercalls
- Para Virtualization vs Full Virtualization

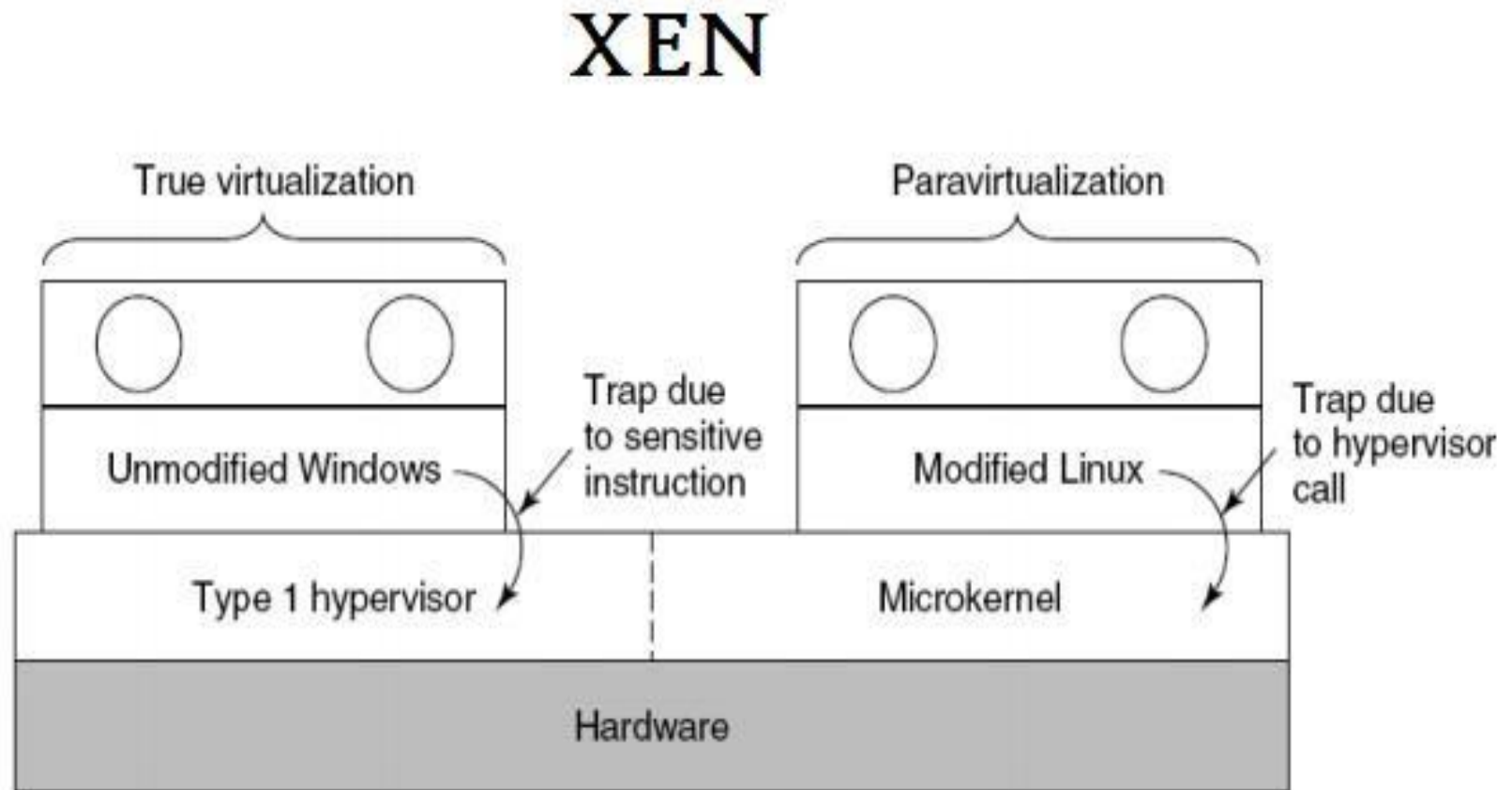
# Para Virtualization



# Para Virtualization

- Pros
- Cons
- List of products which supports paravirtualization.

# Xen Supports both Full-Virtualization and Para-Virtualization





# Xen Supports both Full-Virtualization and Para-Virtualization

- Due to the architecture difference between windows and Linux based Xen hypervisor, Windows OS can't be para-virtualized.
- It does for Linux guest by modifying the kernel.
- VMware ESXi doesn't modify the kernel for both Linux and Windows guests.

# Summary of Different Approaches to Virtualization

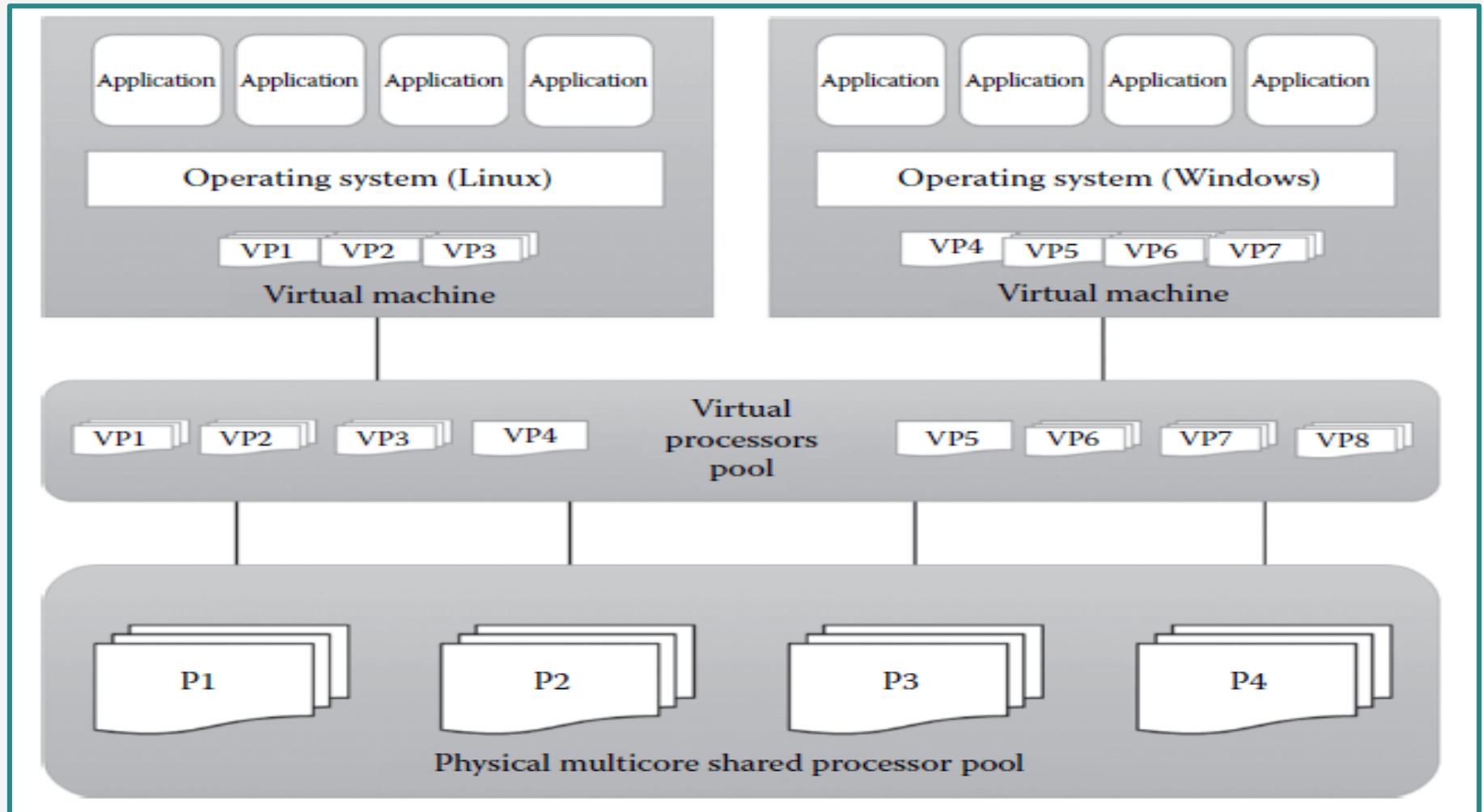
	Full Virtualization	Paravirtualization	Hardware-Assisted Virtualization
Technique	Binary translation and direct execution	Hypercalls	OS requests trap to VMM without binary translation or paravirtualization
Guest OS modification	No	Yes	No
Compatibility	Excellent compatibility	Poor compatibility	Excellent compatibility
Is guest OS hypervisor independent?	Yes	No	Yes
Performance	Good	Better in certain cases	Fair
Position of VMM and privilege level	Ring 0 Root privilege	Below ring 0	Below ring 0 Root privilege
Position of guest OS and privilege level	Ring 1 Nonroot privilege	Ring 0 Root privilege	Ring 0 Nonroot privilege
Popular vendor(s)	VMware ESX	Xen	Microsoft, Virtual Iron, and XenSorce

# Processor Virtualization

- Allows the VMs to share the virtual processors that are abstracted from the physical processors available at the underlying infrastructure.
- Processor virtualization can also be achieved from distributed servers.

# Processor Virtualization

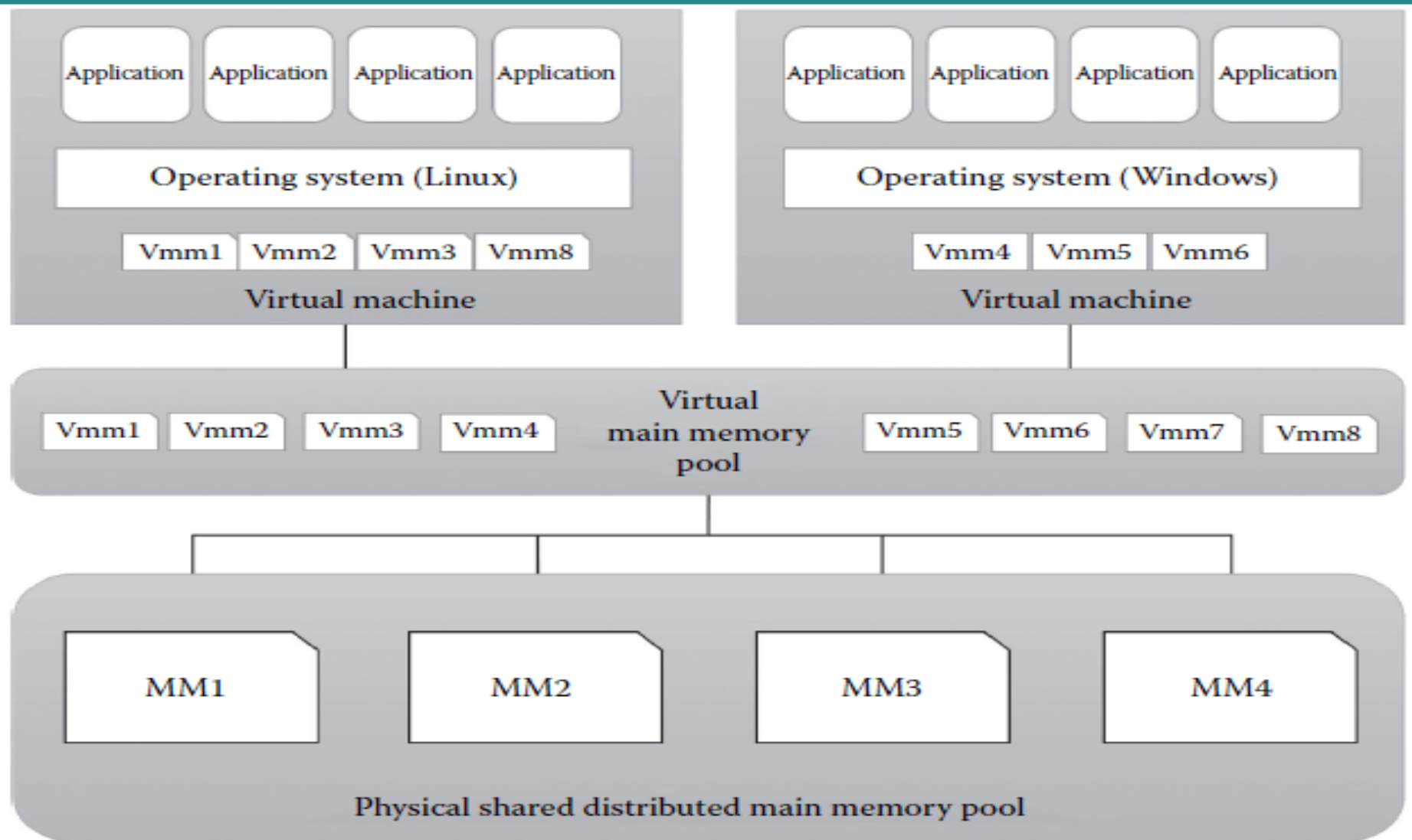
## Processor Virtualization from a Single Hardware



# Memory Virtualization

- Another important resource virtualization technique is memory virtualization.
- Process of providing a virtual main memory to the VMs is known as memory virtualization or main memory virtualization.

# Memory Virtualization

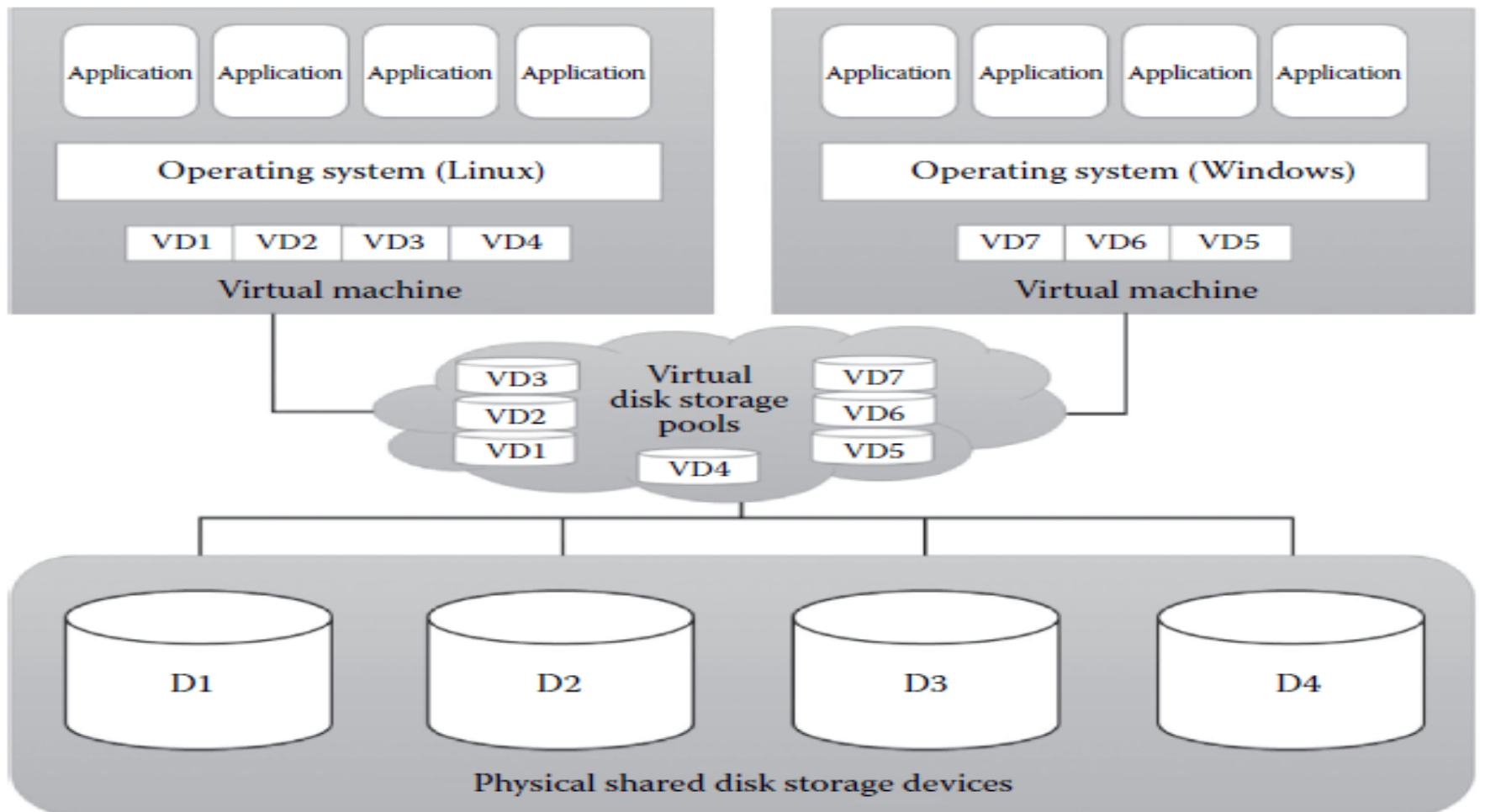


# Storage Virtualization

- A **form of resource virtualization** where multiple physical storage disks are abstracted as a pool of virtual storage disks to the VMs (Figure).
- Normally, the virtualized storage will be called a **logical storage**.

# Storage Virtualization

## Process of Storage Virtualization



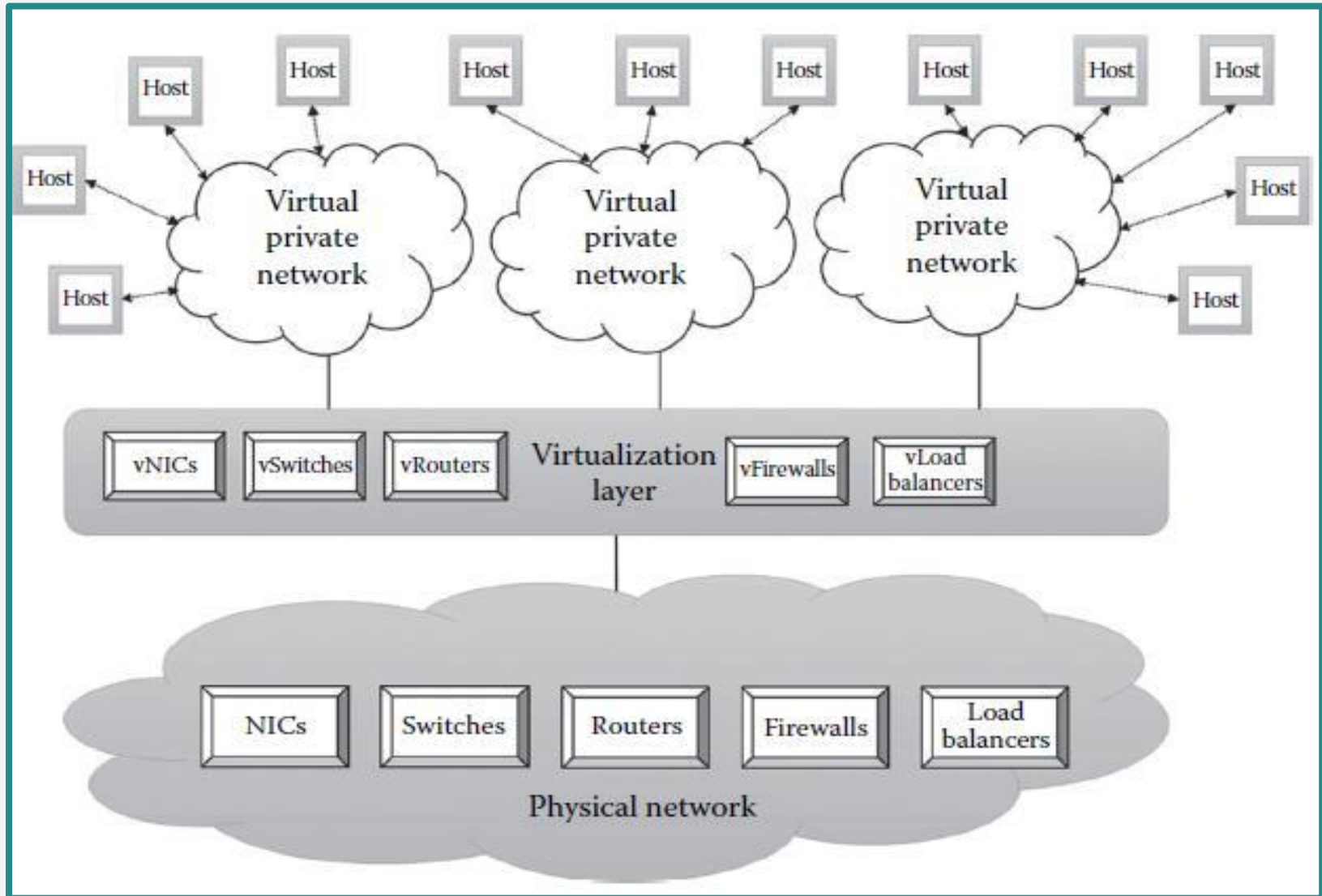


# Network Virtualization

- Type of resource virtualization in which the physical network can be abstracted to create a virtual network.
- Normally, the physical network components like router, switch, and Network Interface Card (NIC) will be controlled by the virtualization software to provide virtual network components.

# Network Virtualization

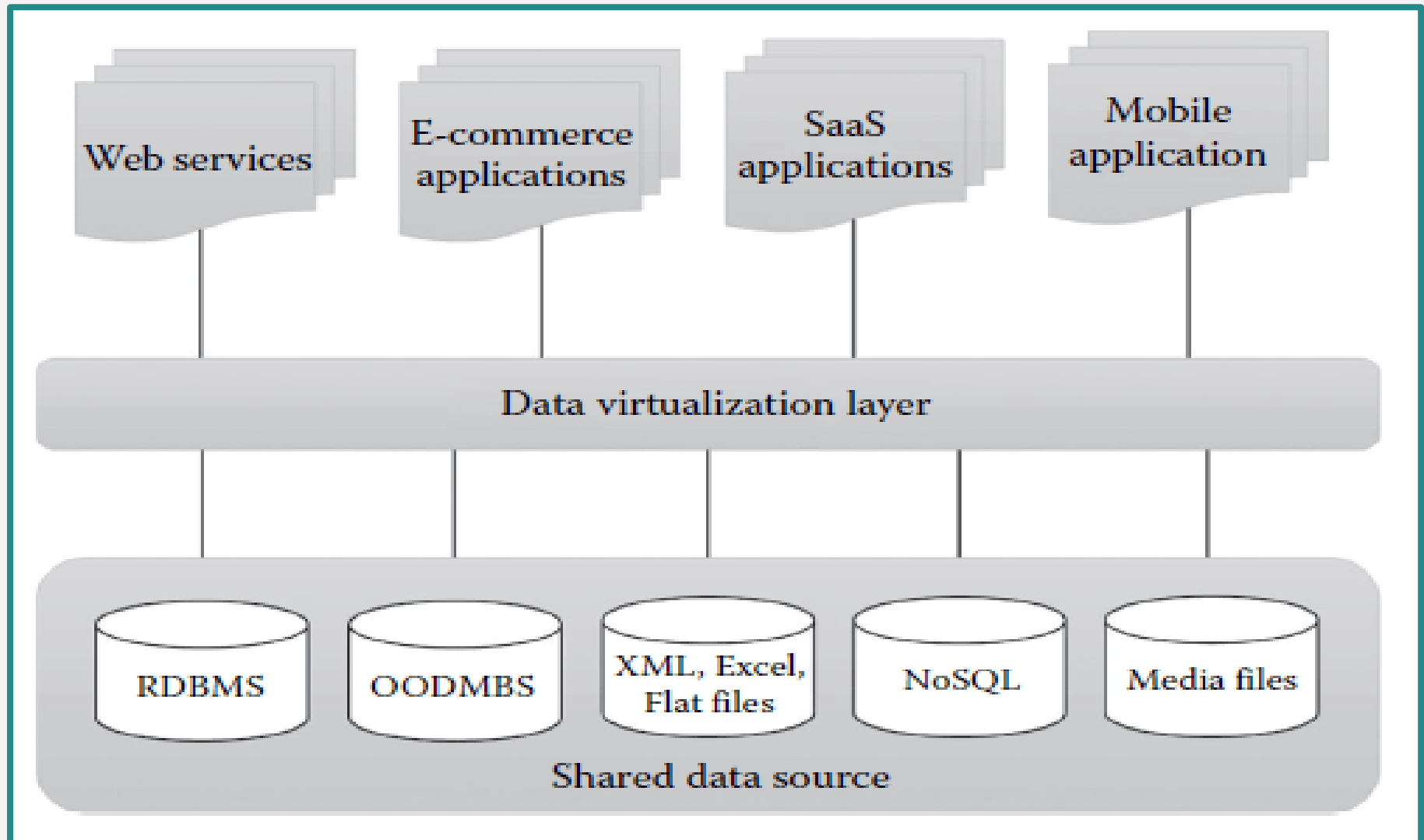
## Concept of Network Virtualization



# Data Virtualization

- Ability to retrieve the data without knowing its type and the physical location where it is stored.
- Aggregates the heterogeneous data from the different sources to a single logical/virtual volume of data.

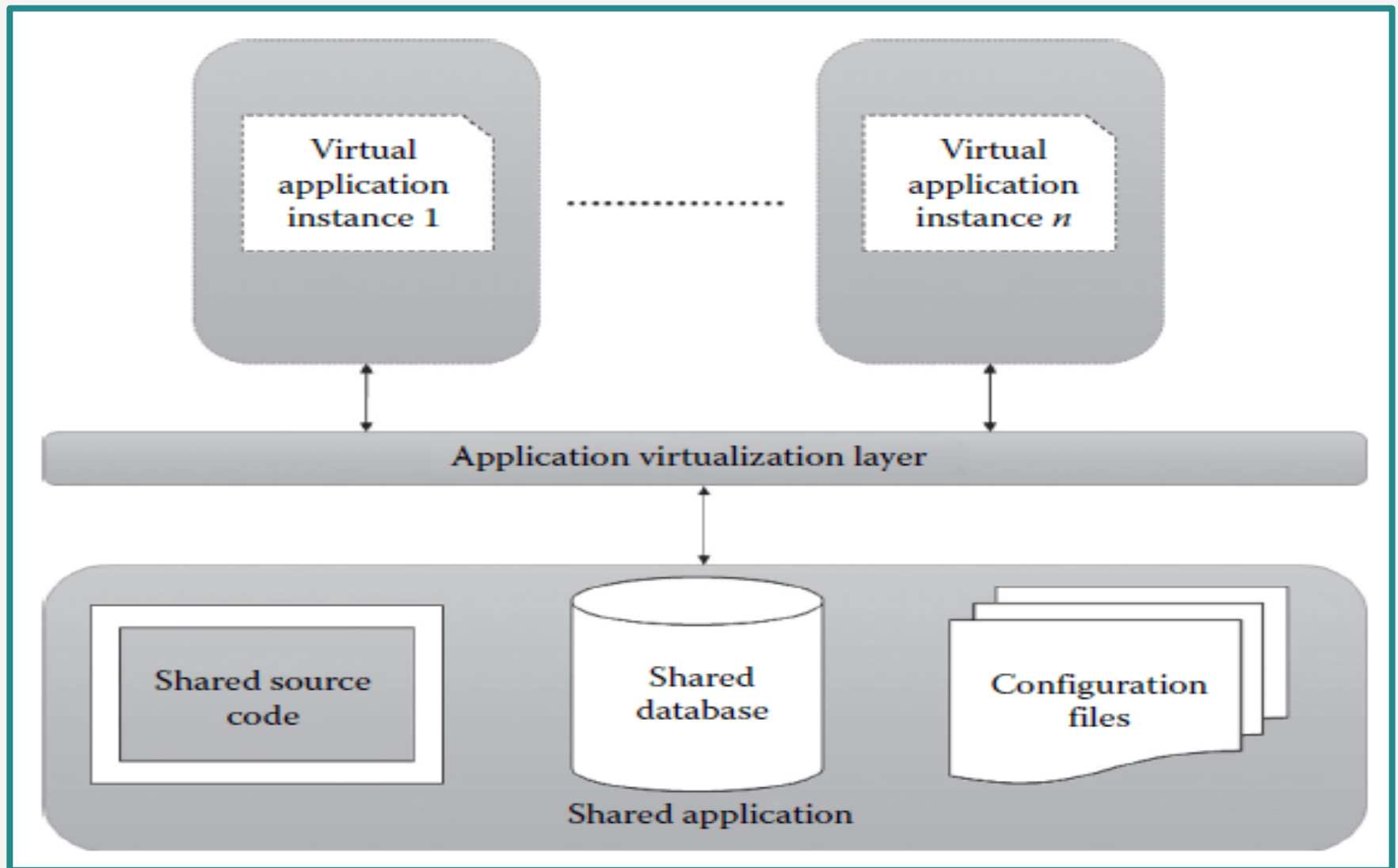
# Data Virtualization



# Application Virtualization

- Application virtualization is the enabling technology for SaaS of cloud computing.
- Offers the ability to the user to use the application without the need to install any software or tools in the machine.

# Application Virtualization



# Hybrid Virtualization: (Hardware Virtualized with PV Drivers)

- In Hardware-assisted full virtualization, Guest OSs are unmodified.
- Combination of both Full & Paravirtualization.
- Products supporting Hybrid Virtualization.

# OS Level Virtualization

- Widely used and also known as “containerization”.
- Host OS kernel allows multiple user spaces aka instance.
- Containers



# Pros of Virtualization

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- Increased Security.
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- Portability.
- More Efficient Use of Resources.

# Cons of Virtualization

## Virtualization also has downsides-

- Performance Degradation.
- Inefficiency and Degraded User Experience.
- Security Holes and New Threats.
- Software Licensing Considerations.
- Possible Learning Curve.

The image features a teal gradient background. In the center is a 3D oval button with a light blue-to-white gradient and a dark teal border. The text "That's all for now..." is centered on the button in a bold, black, sans-serif font.

**That's all for now...**