Amirkabir University of Technology
(Tehran Polytechnic)

Cloud Computing

Hardware virtualization-Part1

Seyyed Ahmad Javadi

sajavadi@aut.ac.ir

Spring 2022

Introduction

Hardware-level Virtualization

یک محیط انتزاعی اجرایی از نظر سخت افزار کامپیوتر که بروی آن guest OS می‌تونه اجرا بشه

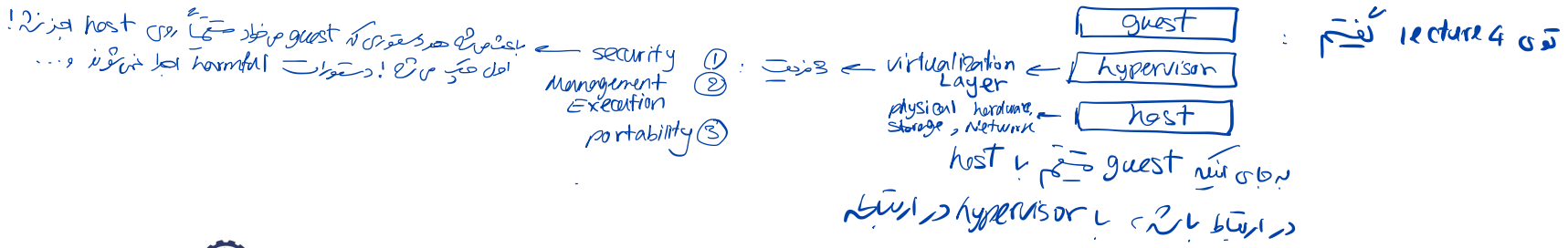
- **An abstract execution environment in terms of computer hardware** on top of which a ***guest operating system*** can be run.

Concept	Represented by
Guest	Operating system
Host	Physical computer hardware
Virtual machine	Its emulation
Virtual machine manager	Hypervisor

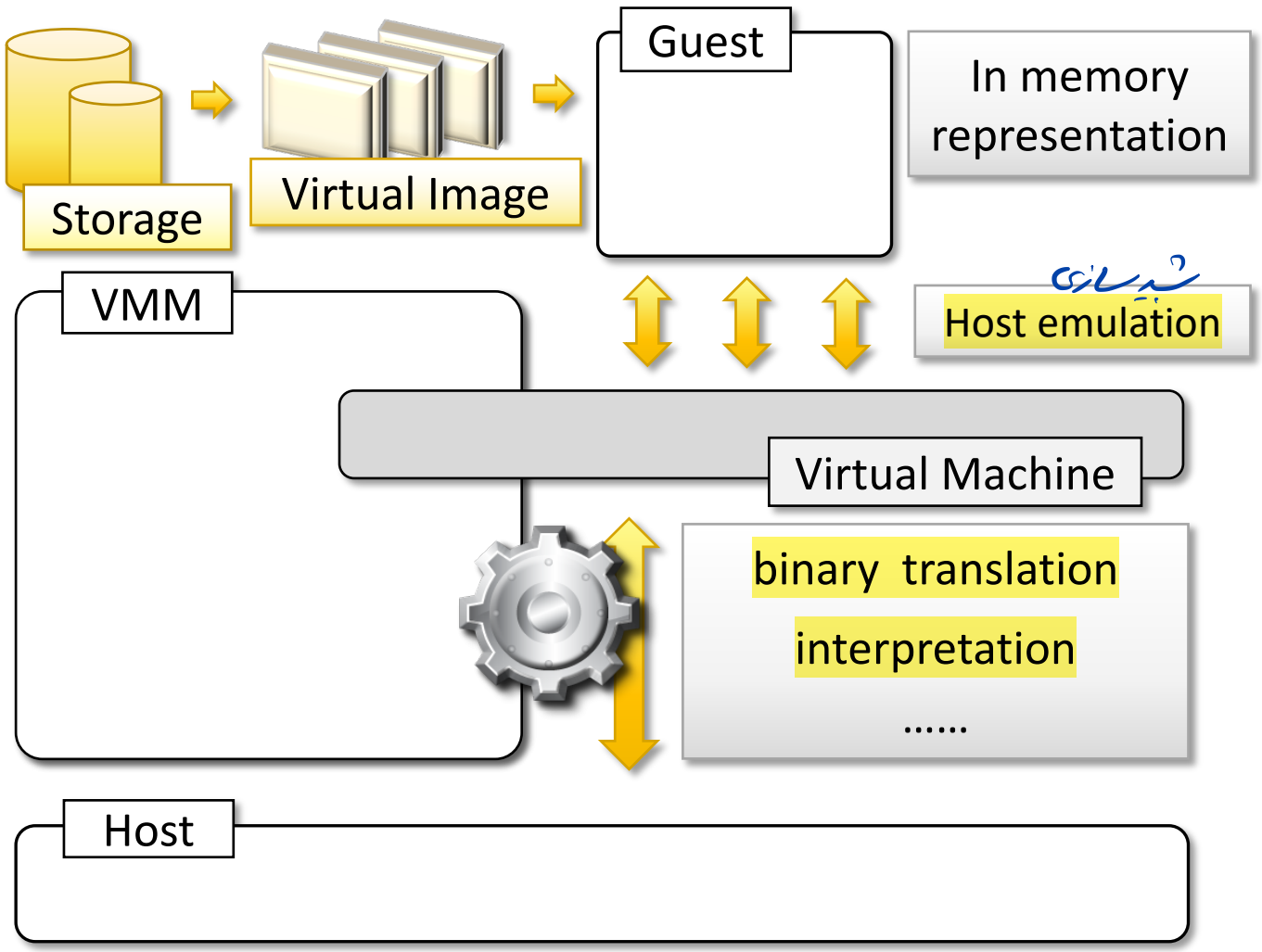
What is Hypervisor?

Hypervisor is a program enabling the abstraction of the underlying physical hardware.

Hypervisor is also called Virtual Machine Manager (**VMM**)

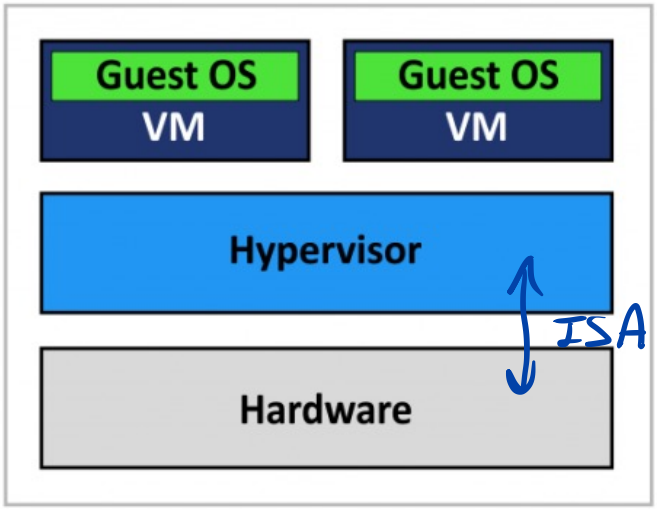


Hardware-level Virtualization



Types of Hypervisor

- ***Type I hypervisors*** (native VM)
  - Run *directly* on top of the hardware.
  - *Take the place* of the operating systems
  - Interact directly with the ISA interface

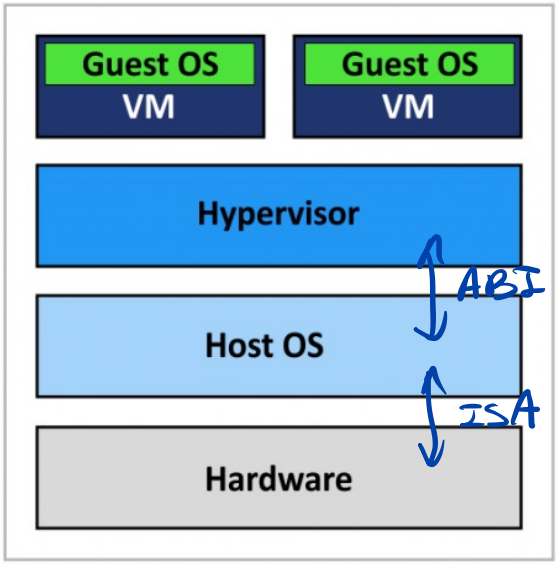


Type 1 Hypervisor
(Bare-Metal Architecture)

Source: http://: https://www.nakivo.com/blog/hyper-v-virtualbox-one-choose-infrastructure/

Types of Hypervisor (cont.)

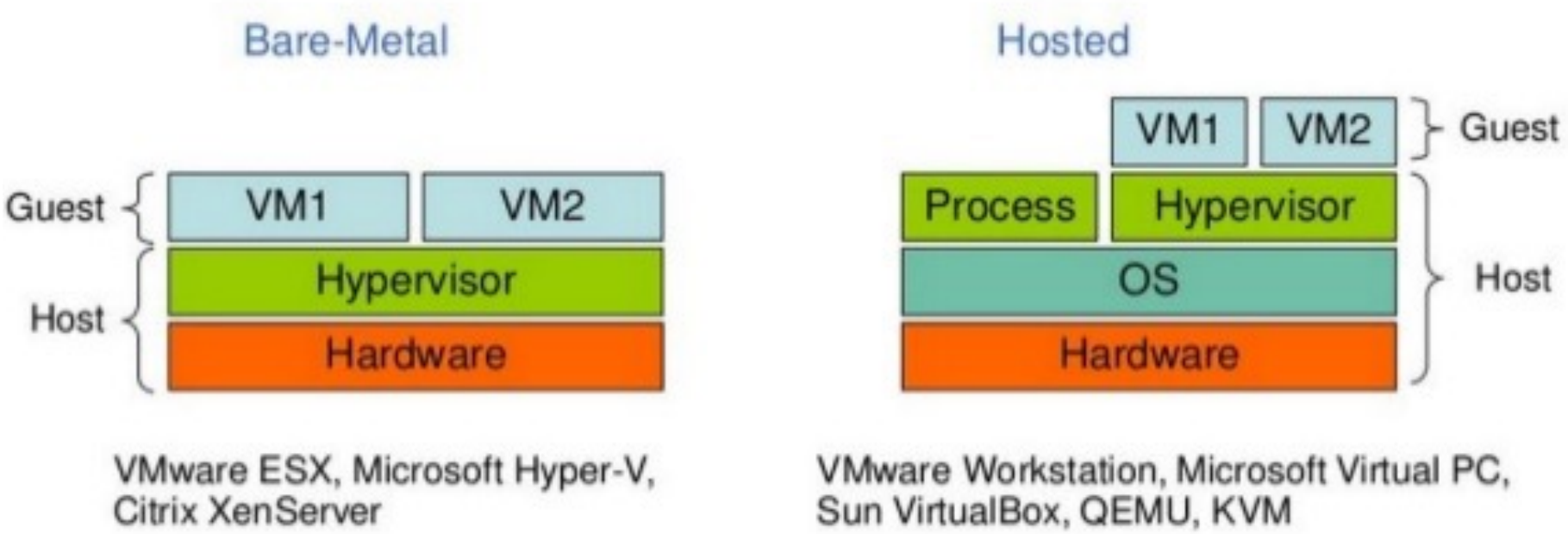
- ***Type II hypervisors*** (hosted VM)
  - Require the support of an operating system
  - Are programs **managed by the operating system**
  - Interact with operating system through the **ABI**.



Type 2 Hypervisor
(Hosted Architecture)

Source: http://: https://www.nakivo.com/blog/hyper-v-virtualbox-one-choose-infrastructure/

Type of Hypervisors (cont.)



Source: https://www.slideshare.net/PraveenHanchinal/virtualizationthe-cloud-enabler-by-inspiregroups/18-Types_of_hypervisors_VMM

Approaches of Executing Guest Instructions

Executing Guest Instructions

- **Emulation**
- **Direct native execution**

Emulation

"the process of implementing the interface and functionality of one system or subsystem on a system or subsystem having a different interface and functionality..."

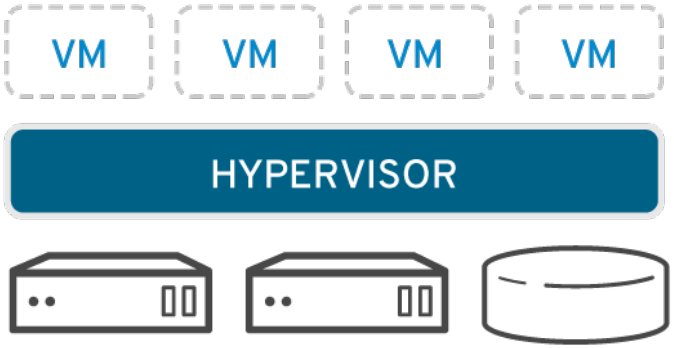
* زمانی که ISA guest با ISA host متفاوت، دستوراتش صحیحاً نمی‌تونه اجرا بشه روی host.

در نتیجه از طریق emulation خودش رو شبیه‌سازی می‌کنه تا بتونه دستورات guest رو اجرا کنه

Emulation (cont.)

Examining guest instruction

emulating on virtualized resources the exact actions that would have been performed on real resources



instruction 1

instruction 2

instruction 3

.....

instruction n

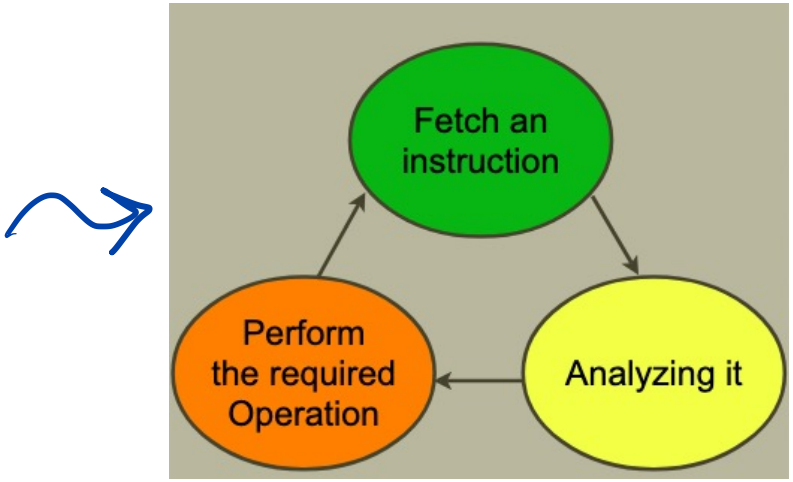
guest instructions

Only available mechanism when the **ISA of the guest** is ***different*** from the **ISA of the host**.

Emulation Approaches

- Interpretation
  - Done in software,

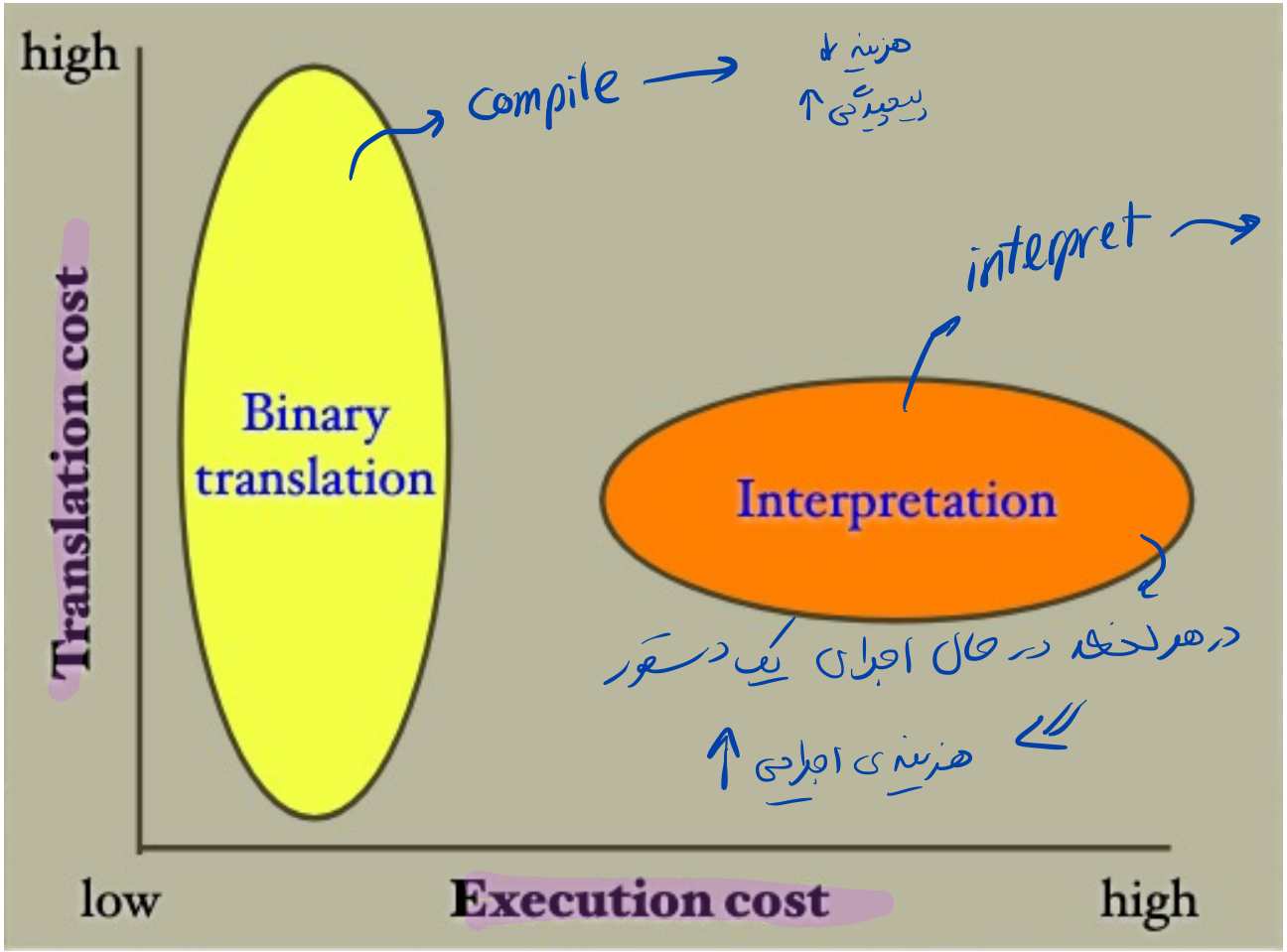
    one instruction at a time



http://cse.unl.edu/~witty/class/embedded/material/note/emulation.pdf

- Binary translation
  - Translating a block of source instructions to target instructions.
  - Saving the translated code for repeated use

Interpretation versus Binary Translation



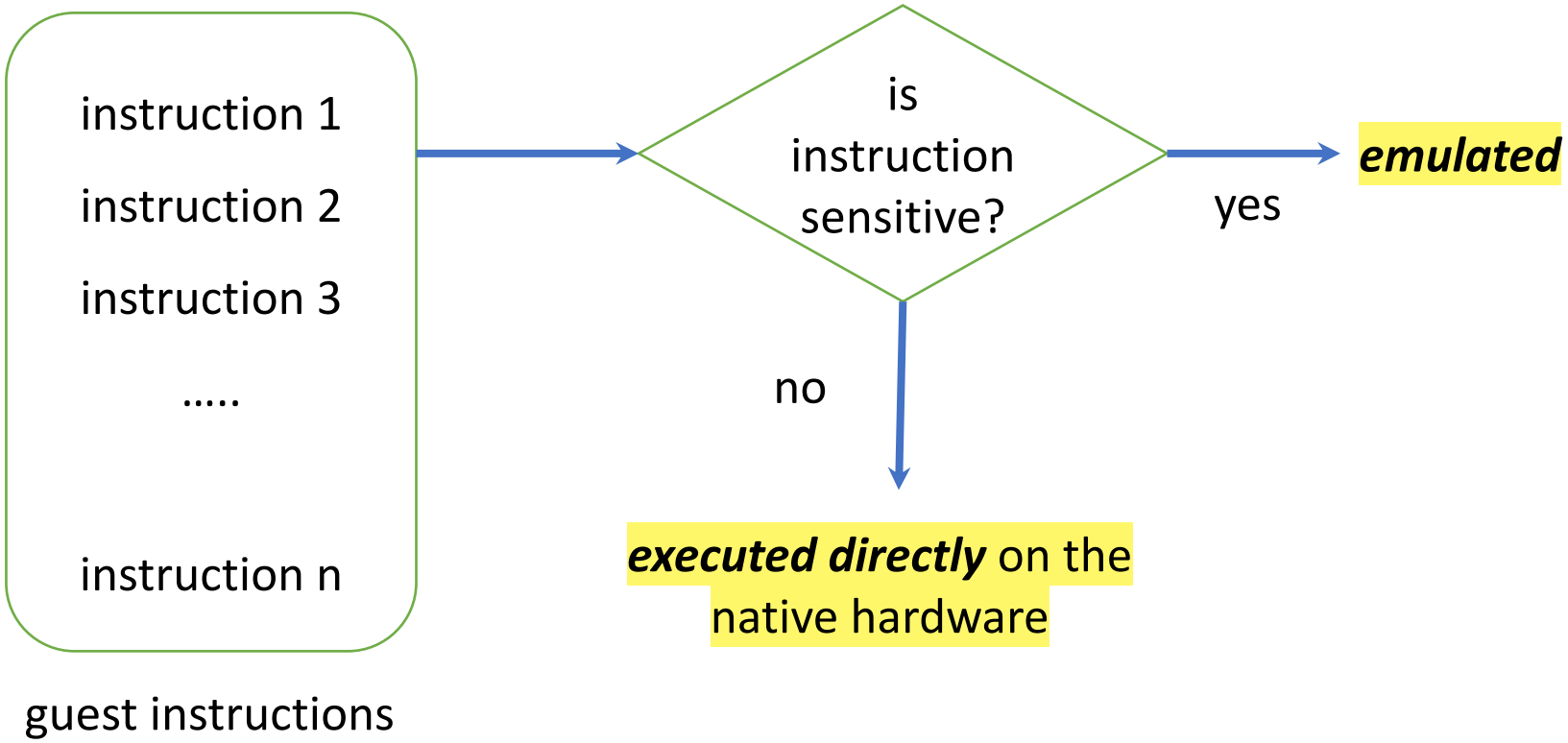
http://se.unl.edu/~witty/class/embedded/material/note/emulation.pdf

Interpretation versus Binary Translation (cont.)

	Implementation	Performance
Interpretation	simple and easy	low
Binary Translation	complex	***high initial*** translation cost, ***small execution*** cost

http://www.ittc.ku.edu/~kulkarni/teaching/EECS768/slides/chapter2.pdf

Direct Native Execution



Only if the ***ISA of the host is identical to the ISA of the guest***.

Hardware Virtualization Methods

Hardware Virtualization Methods

- **Full Virtualization**
  - Binary Translation
  - Hardware-assisted virtualization
- **Paravirtualization**

Full Virtualization

- Run a program **directly on top of a VM** and **without any modification**
  - The program thought it were run on the raw hardware.

- The principal advantage of full virtualization
  - Complete isolation → enhanced security
  - Ease of emulation of different architectures
  - Coexistence of different systems on the same platform.

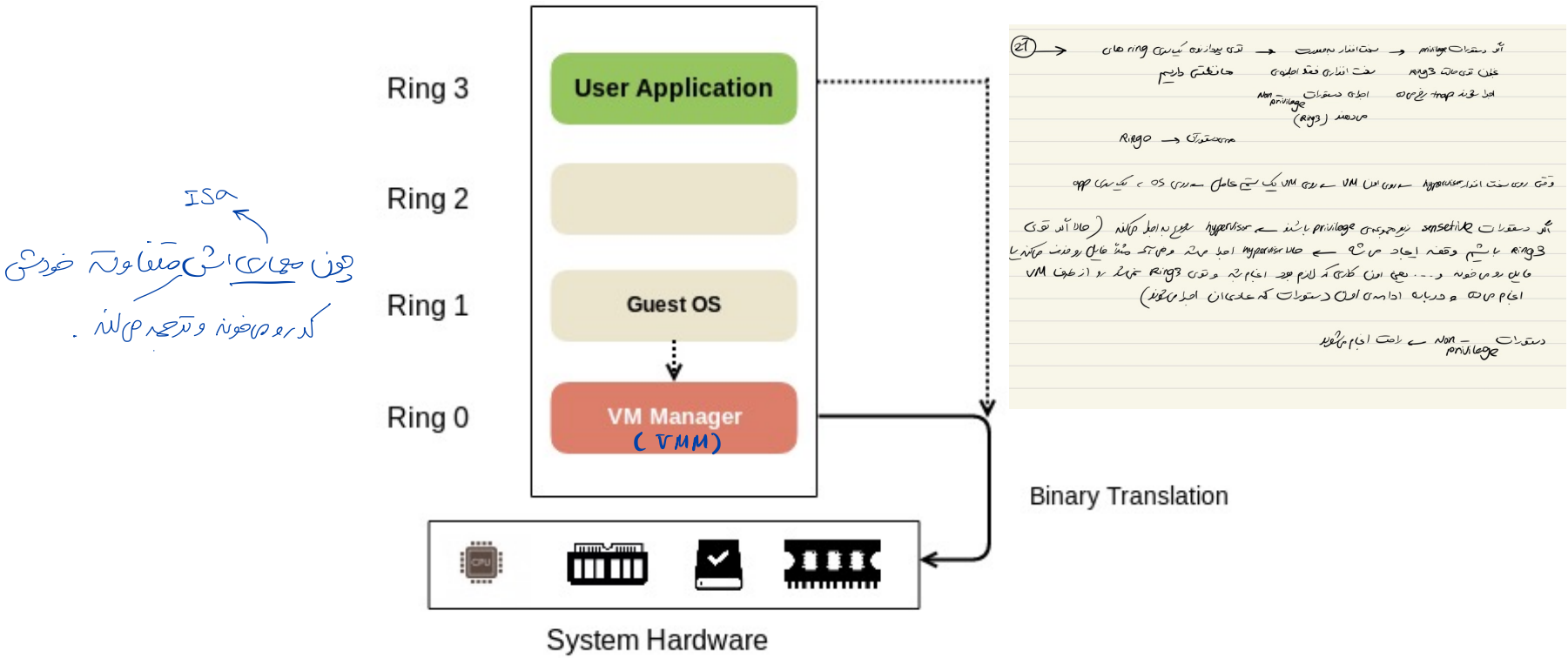
Full Virtualization (cont.)

- In some architectures, **some sensitive instructions are not privileged**
  - They cannot be virtualized in the classic way.
  - Like the non-hardware-assisted x86

- ***Two technologies:***
  - Binary translation (emulation)
  - Hardware-assisted virtualization (direct native execution)

Binary Translation

- Replaces the sensitive instructions that **do not generate traps** with a **trap into the VMM** to be **emulated in software**.



https://www.oreilly.com/library/view/enterprise-cloud-security/9781788299558/e301e0ae-2518-4081-82c3-b073b4ee8732.xhtml

Binary Translation (cont.)

- **Static Binary Translation**
  - On a full program

- **Dynamic Binary Translation**
  - Introduces an additional overhead.

Dynamic Binary Translation

- It is usually performed in small units called "***basic blocks***".
- A basic block is a set of instructions that ends with a branch instruction but does not have any branch instructions inside.
  - Be executed start to finish by a CPU
  - An ideal unit for translation
- The translations of the basic blocks are ***cached***
  - Overhead of translating only happens the first time a block is executed.

https://blogs.oracle.com/ravello/nested-virtualization-with-binary-translation

Static vs Binary Translation

	Input type	Granularity	Translation time
Static binary translation	Binary program	Full program	Before running program
Dynamic binary translation	Binary program	Basic block	At runtime