Virtualization - Introduction

- What is a Virtualization?
- Types of Virtualization
- Role of the Hypervisor
- Why Virtualization?

What is Virtualization?

"A virtual machine is taken to be an *efficient*, *isolated duplicate* of the real machine."

G.J. Popek, R.P. Goldberg, "Formal Requirements for Virtualizable Third Generation Architectures", CACM, July 1974

Duplicate: VM should behave identically to the real machine.

Isolated: Several VMs can share real machine without interfering with each other.

Efficient: VM should execute at speed comparable to that of the real machine.

What is Virtualization?

Duplicate: VM should behave identically to the real machine.
- Software **cannot distinguish** between real and virtual hardware.
- Exceptions: Fewer resources, some timing differences.

Isolated: Several VMs can share real machine without interfering with each other.

Efficient: VM should execute at speed comparable to that of real machine.
- Requires that most instructions are **executed directly** by real hardware.

Simulation, Emulation, Virtualization

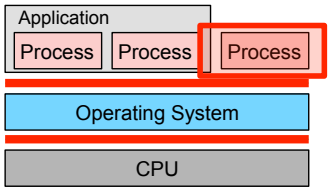
Simulation: Abstract model of a system is functionally simulated.

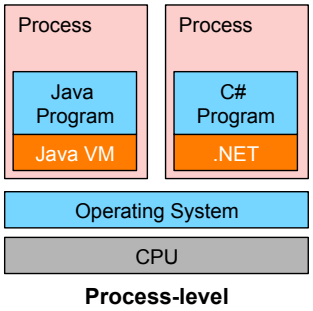
Emulation: Hardware or software (or both) emulates the behavior of the guest in a host so that emulated behavior is close to behavior of real system.

"Simulators as high-level emulators."

Virtualization: Virtualization involves simulating parts of a computer's hardware - enough for a guest operating system to run unmodified - but most operations still occur on the real hardware for efficiency reasons.

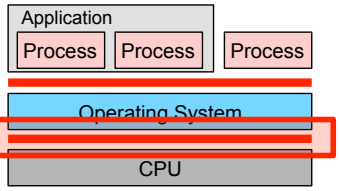
Types of Virtualization

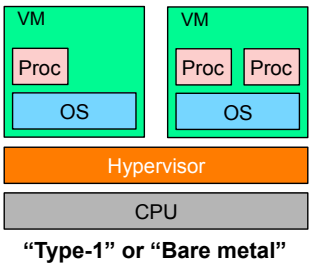




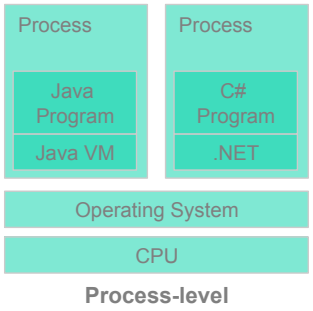
Process-level

Types of Virtualization

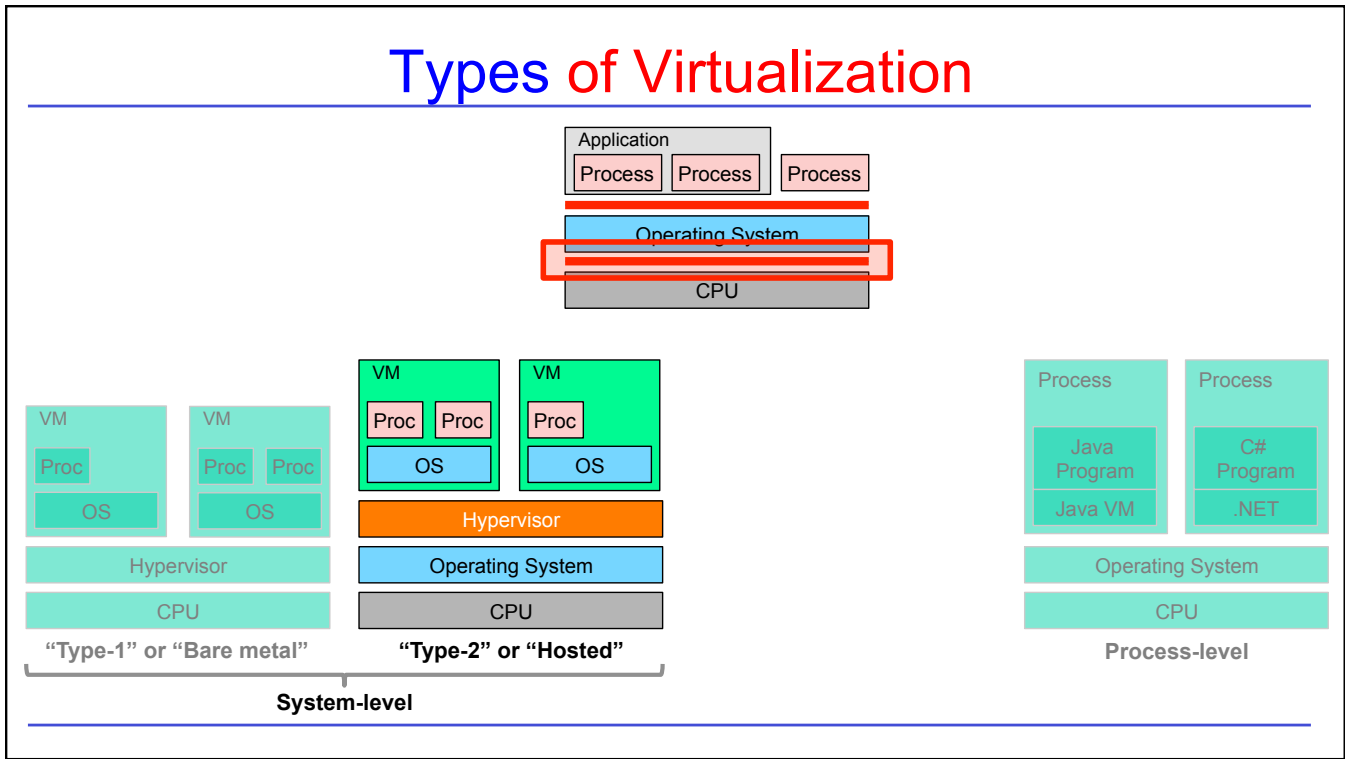




"Type-1" or "Bare metal"



Process-level


Types of Virtualization
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OS
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Proc
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Hypervisor
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CPU
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Java Program
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.NET
Operating System
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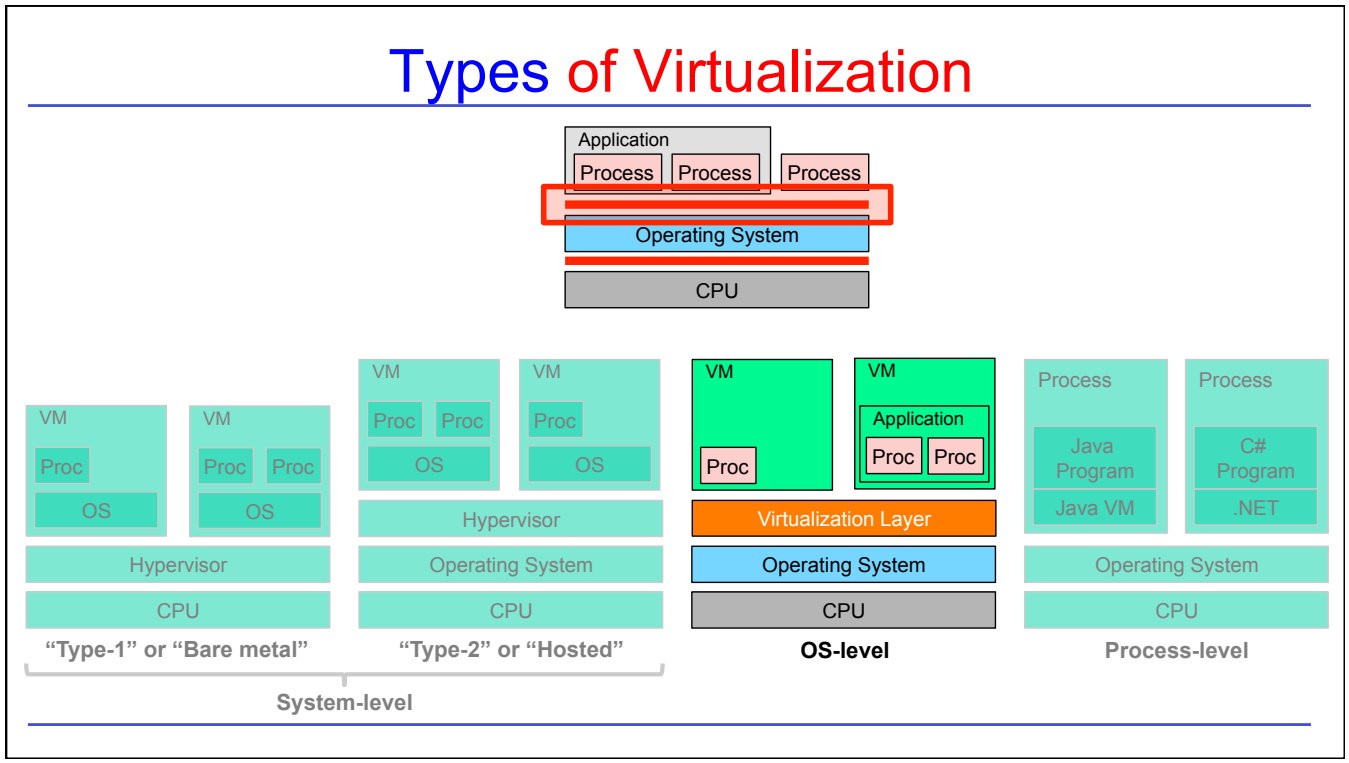
"Type-1" or "Bare metal"
"Type-2" or "Hosted"
System-level
Process-level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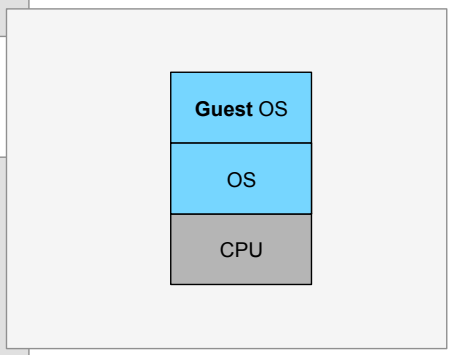
Role of the Hypervisor

Hypervisor: Program that runs on hardware or OS to implement the virtual machine(s).

Also called "Virtual Machine Monitor".

Controls resources:

- Partitions hardware
- Schedules guests
- Mediates access to shared resources
- Switches between "world" as seen by hypervisor and guests.



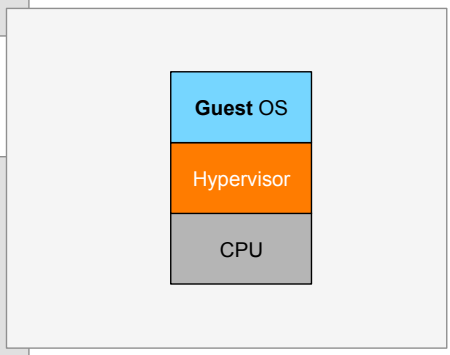
Role of the Hypervisor

Hypervisor: Program that runs on hardware or OS to implement the virtual machine(s).

Hypervisor "control resources".

Outlook on implications:

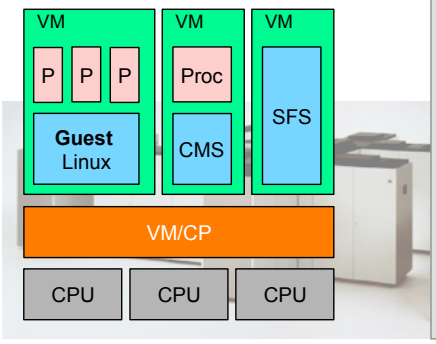
- Hypervisor must run in privileged mode.
- Guests must run in non-privileged mode.
- Privileged instructions of guests must be intercepted and run by hypervisor.



Why Virtualization?

Historically, used for easier sharing of expensive mainframes, e.g.

- IBM CP-40 research project in early 60's
- Became CP-67 in 1967 on System/360
- VM/CMS in 1972



VMs can run

- single-user guest OS (e.g. CMS)
- mainstream guest OS (e.g. MVS, AIX, Linux)
- "second level" guest VMs
- specialized OS subsystems (e.g. spooling, shared file server, etc.)

Great support for legacy systems.

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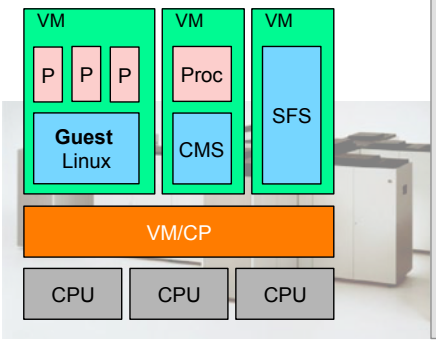


Other than for mainframes, largely disappeared in 80's.

- Time sharing supported by other operating systems.
- Hardware too cheap to worry about consolidation.

Why Virtualization?

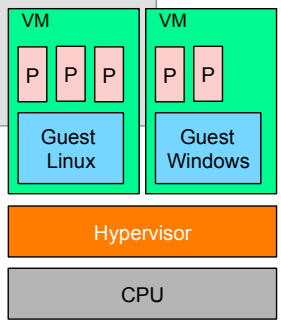
Improved Isolation helped virtualization become popular again in the early 2000's.

Isolation:
- improved Quality of Service
- improved security
- different concurrent OSs

Encapsulation:
- replication
- migration/consolidation
- checkpointing
- debugging

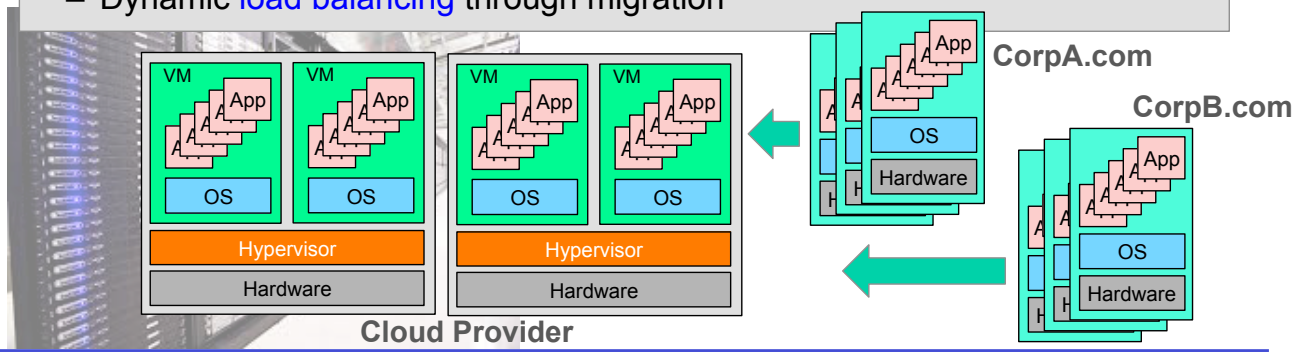
"This would be mostly unnecessary ... if OSes were doing their job!"

Guernot Heiser



Why Virtualization?

Cloud Computing is today's main driver.
- Increased utilization by sharing hardware (resource overallocation)
- Reduced maintenance through increased scale (pets vs. cattle)
- On-demand provisioning
- Dynamic load balancing through migration



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