

# Virtualization

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# Agenda

- Virtual machines
- Containers
- Bare metal vs Virtual machines vs Containers



# Virtualization



# What is a Virtualization? (1/5)

- A system software that provides multi-tenancy for sharing of hardware resources. It also provides isolation.

## Civil engineering example

- Dormitory complex with shared resources.  
Viz., lifts, generator, security staff, water pumps, television, restrooms, hall, bedroom.
- Hostel complex having multiple rooms with shared resources.  
Viz., all the above but not study/bedroom.
- Apartment complex having multiple flats with shared resources.  
Viz., all the above but not hall, restroom, study/bedroom, television.



# Types of Virtualization (1/4)

## Computing hardware resources

- CPU, RAM, Disk, NIC.
- Accelerators (GPU)

## Terminology

- Hypervisor: A software that emulates hardware/run-time environment.
- Guest: OS running in virtual hardware (aka VM).
- Host: OS running on physical hardware.



## Types of Virtualization (2/4)

### Types

- Full Virtualization:
  - Emulates entire computer system on bare metal without any host OS.
  - Runs unmodified guest OS (kernel and userspace).Eg. XenServer, VMWare ESX, Hyper-V, Oracle VM Server, etc
- Hosted Virtualization:
  - Emulates entire computer system on existing host OS.
  - Runs unmodified guest OS (kernel and userspace).Eg. VirtualBox, VMWare Workstation/Fusion, Microsoft Virtual PC, etc



Note: We will not talk about Full virtualization

## Types of Virtualization (3/4)

- Para Virtualization:
  - Emulates entire computer system in existing host OS.
  - Runs modified guest OS kernel, and unmodified guest OS userspace.Eg. Qemu-KVM
- Process Virtualization :
  - Emulates one programming language run-time environment.
  - Runs an application written in single programming language.Eg. Java/Python VM



Note: We will not talk about Para & Process virtualization



## Types of Virtualization (4/4)

- Operating System Virtualization :
  - Does not emulate any hardware. Directly uses host hardware.
  - Runs an user-space (application and libraries) of OS.

Eg. Containers/Dockers



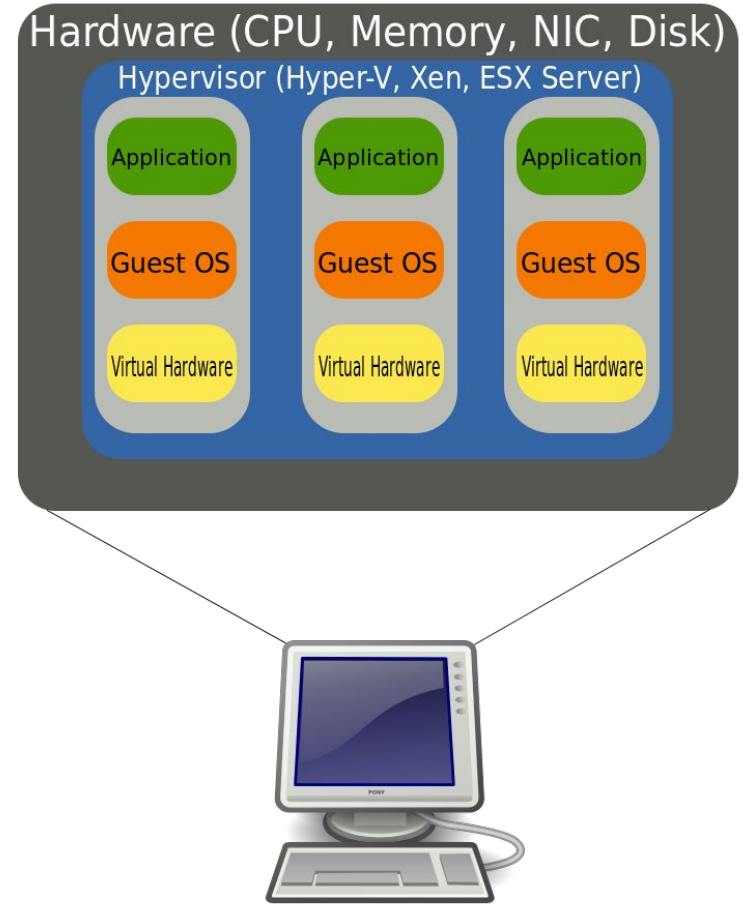


# Virtual Machines



# What is a Virtual Machine?

- Virtual Machine (VM) is an emulation of entire computer system, as result of full virtualization.
- Each VM runs its own operating system instance.
- Civil Engineering example :
  - Apartment complex having multiple flats.
  - Each flat has living, study, bed, kitchen, rest rooms as exclusive resources and generator, lift, security guard, water pump, etc. as shared resources.

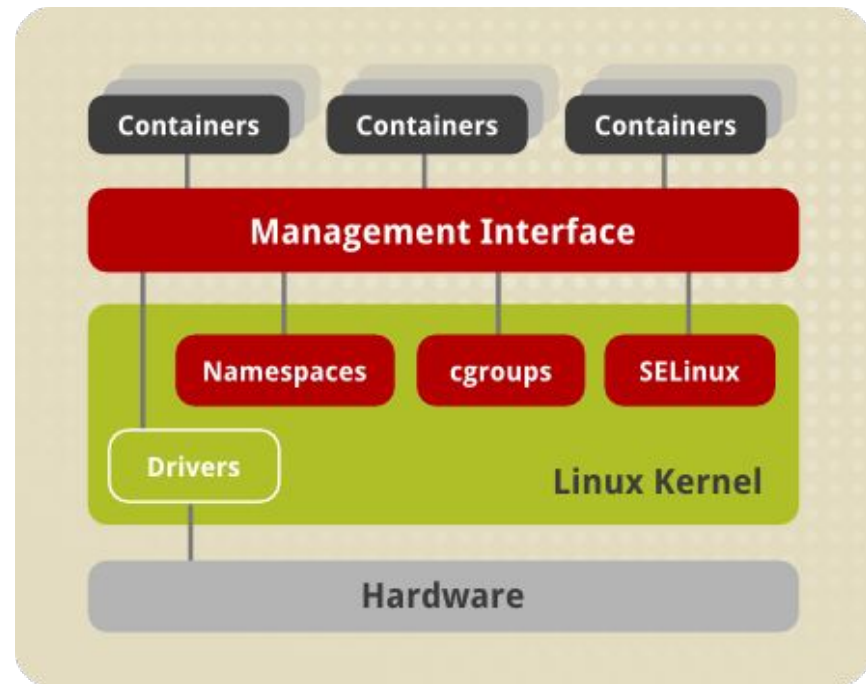


# Containers



## What is a Container? (1/2)

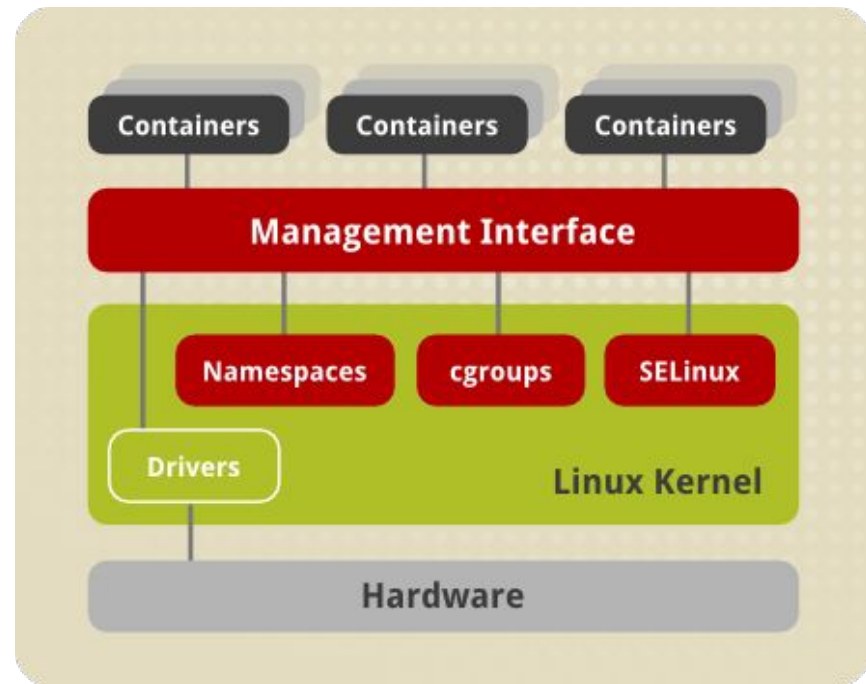
- Linux Containers (LXC ), Docker use operating-system-level virtualization method.
- For running multiple isolated Linux systems (containers) on a control host using a single Linux kernel.
- Directly runs on hardware. (No separate guest kernel)
- Civil Engineering example :
  - Hostel complex having multiple rooms with generator, lift, security guard, water pump, rest rooms, kitchen, etc as shared but study/bedroom as exclusive.



## What is a Container? (2/2)

It is implemented using following features in Linux

- Advanced Multi-layer Union File System (AUFS) (aka Overlays)
- Kernel namespaces
- Cgroups
- Capabilities
- Netfilter, Netlink
- Bind mount
- Role-Based Access Control (RBAC)
  - Eg. SELinux, AppArmor



# Physical Machine vs Virtual Machine vs Container



# Physical Machine vs Virtual Machine vs Container

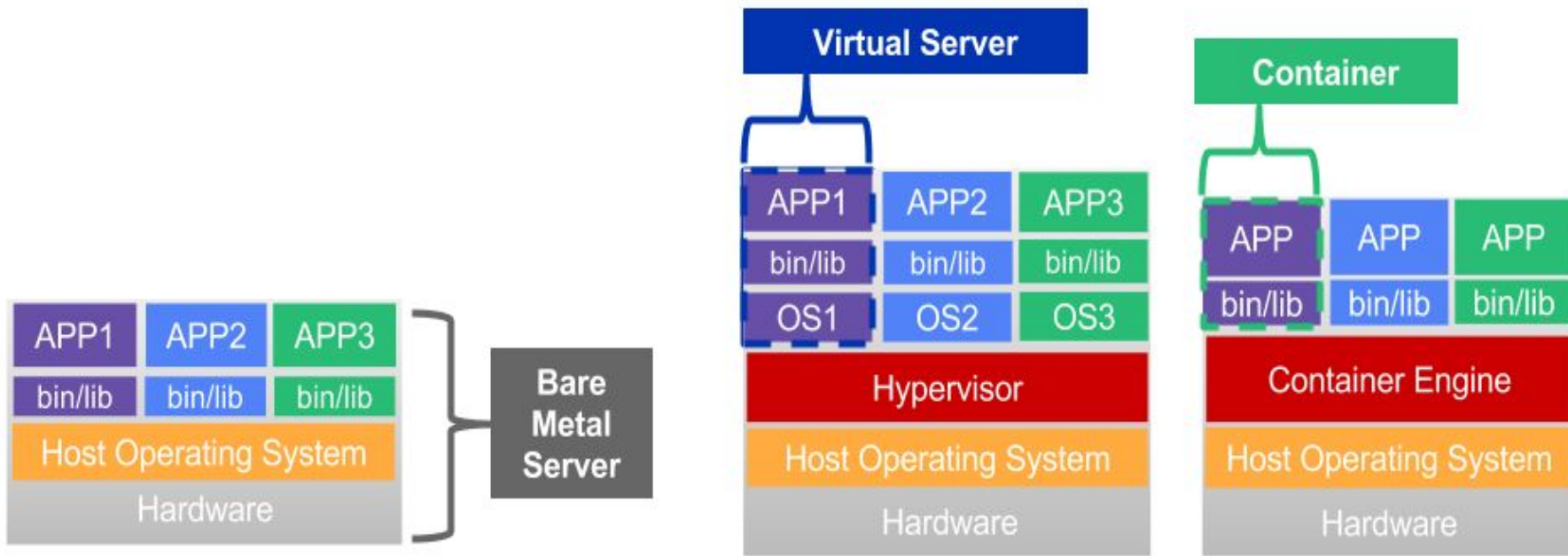


Image Courtesy: Kumulus Technologies



# Protection Rings





# Rings of execution in processors

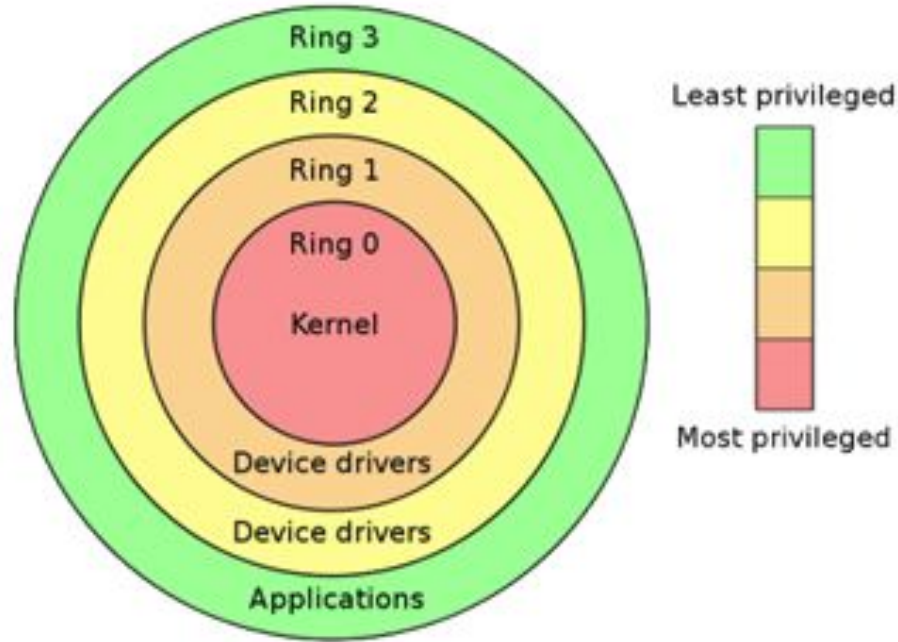


Image Courtesy: <https://itechthoughts.wordpress.com/tag/protection-rings/>

# Physical Machine vs Hosted vs Full virtualization

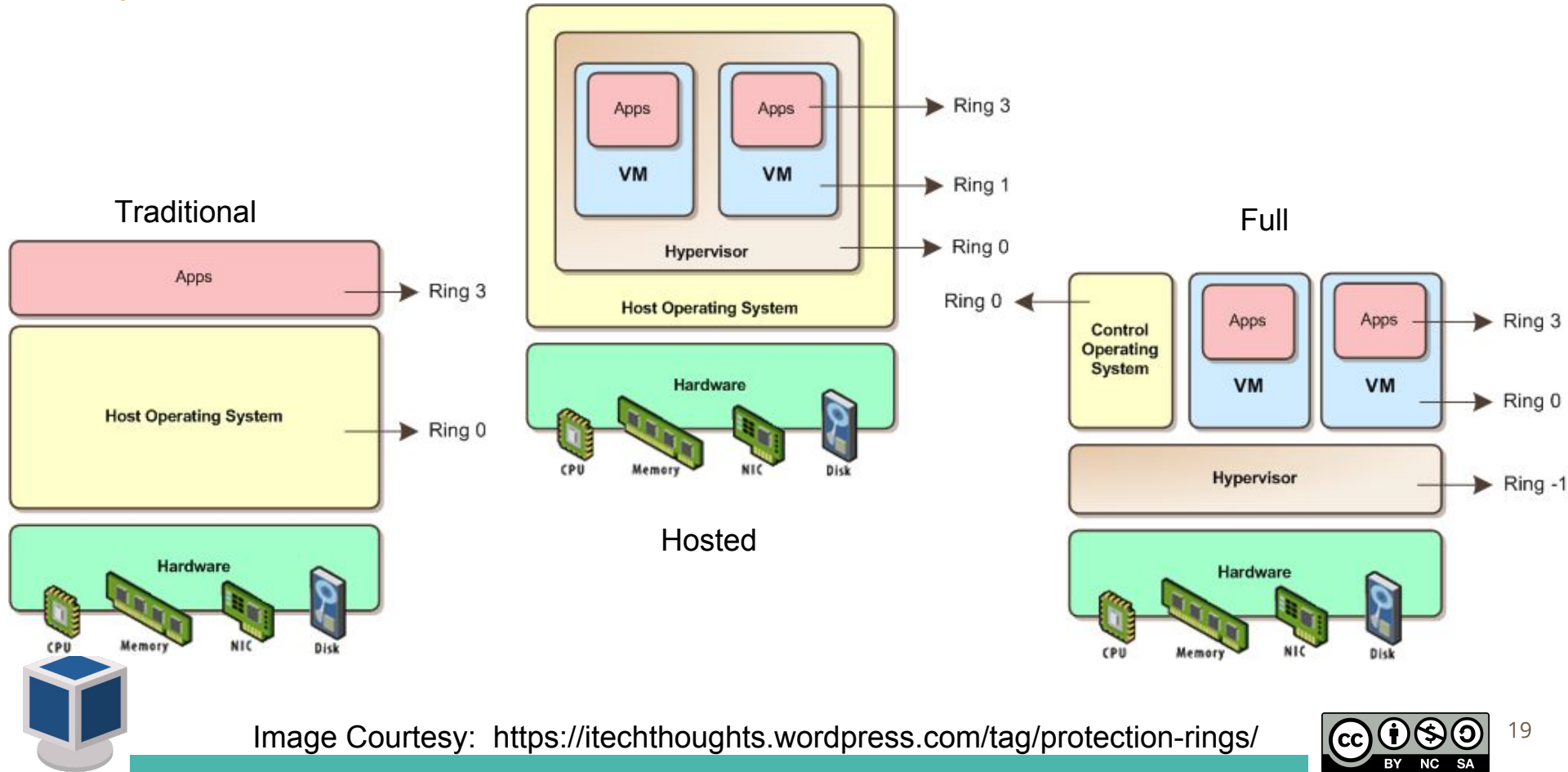
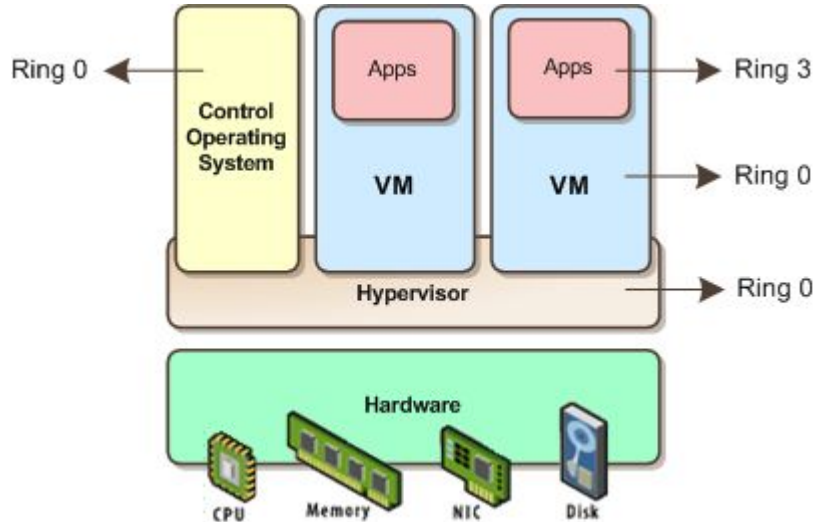
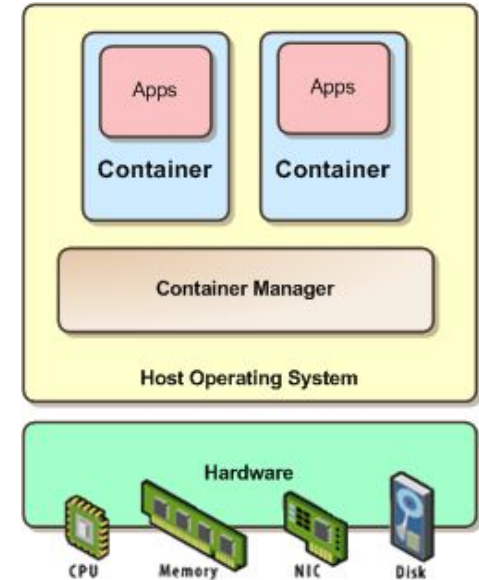


Image Courtesy: <https://itechthoughts.wordpress.com/tag/protection-rings/>

# Para virtualization vs Container



Para



OS

# Storage



# Virtual Disks

- Virtual Disks are files with special structure to map virtual blocks to file-system or logical volume blocks.
- Types
  - Fixed (aka thick provisioned): space is allocated apriori.
  - Dynamic (aka thin provisioned): allocated on demand. Helps faster cloning.
- Formats
  - VDI
    - Used in VirtualBox
  - VMDK
    - Used in VMWare's ESX, Player
  - VHD
    - Used in Microsoft's HyperV
  - QCOW, QED
    - Used in QEMU-KVM



# Networking



# Virtual Networks (1/2)

- Virtual Network adapters are software defined network interface controllers
- Types
  - Bridge :
    - Guest joins the physical network.
    - Guest gets an IP address from physical network (static/dhcp).
    - Guest can be reached from other guests, the host and physical network (L1/L2).
  - Internal :
    - All/some guests will be in a separate internal private network.
    - Guests need to be assigned static IPs or a DHCP server need to be available in the internal network as a VM.
    - Guest cannot be reached from Host or physical network (L1/L2).
    - Guest can be reached from other guests in the same internal network.



## Virtual Networks (2/2)

- Types
  - NAT :
    - Each guest will be in a separate private network.
    - Guest gets a private IP address from DHCP server in hypervisor.
    - Guest cannot be reached from other guests, the host and physical network (L1/L2).
    - Hypervisor does source NATing from guest's IP to host's IP.
  - NAT network :
    - All/Some guests will be in a separate private network.
    - Guests get private IP address from DHCP server in hypervisor.
    - Guest cannot be reached from the host and physical network (L1/L2).
    - Guest can be reached from other guests in the same NAT network.
    - Hypervisor does source NATing from guests' IP to host's IP.





# Q & A

