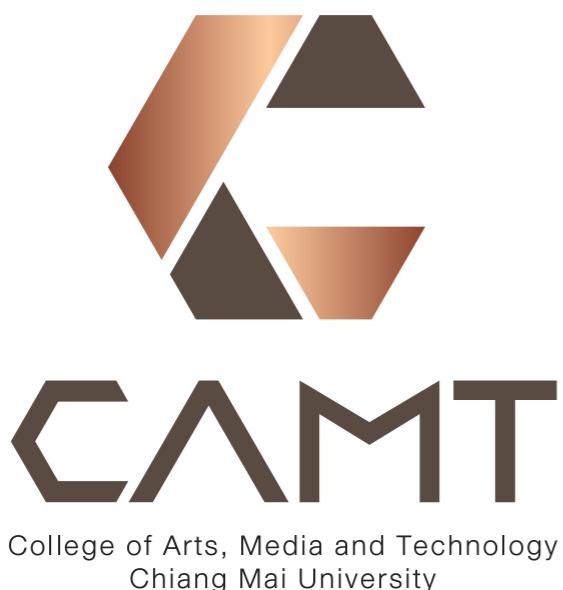


SE 234 Basic Development and Operations

#6 Virtualization



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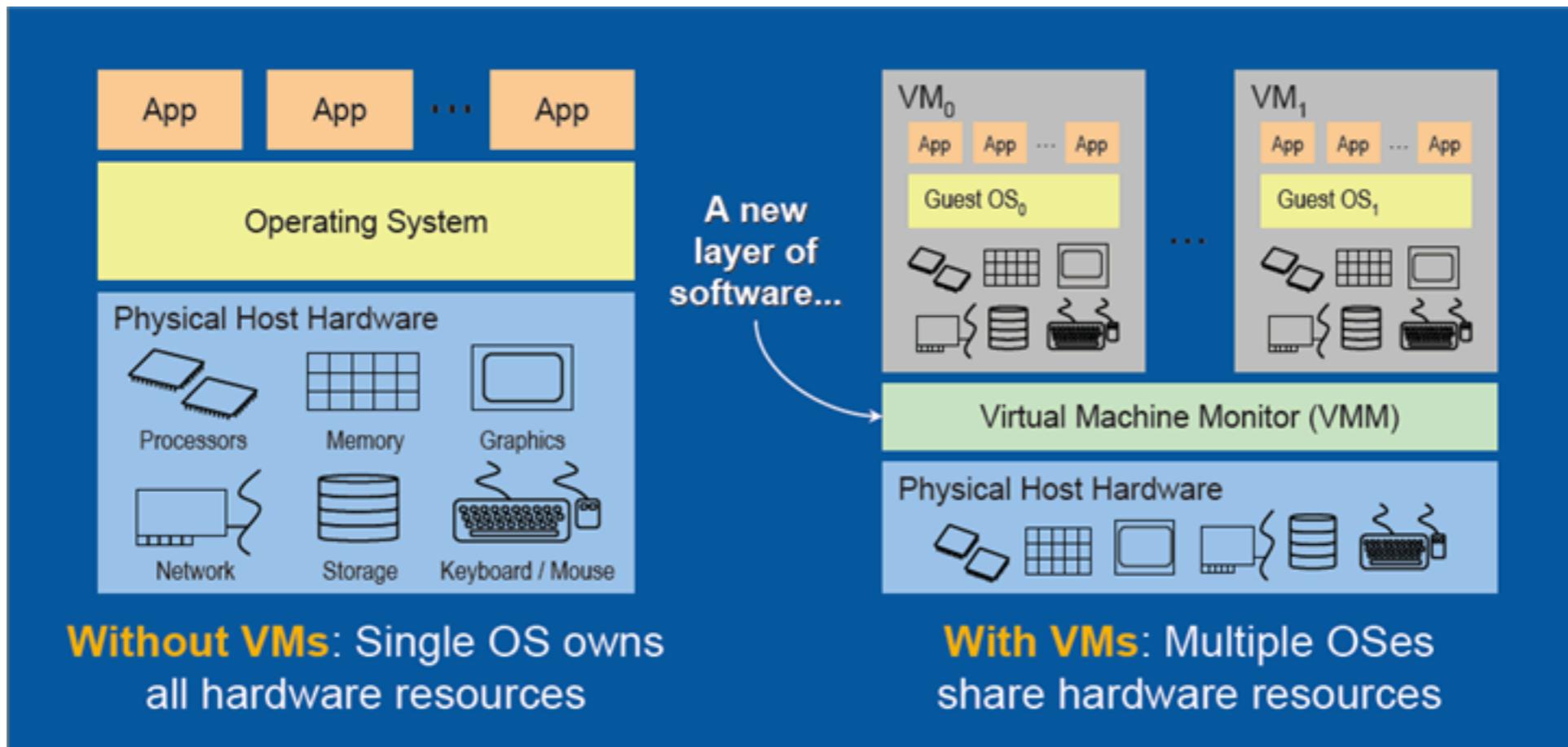
What is it all about?

- Combination of software and hardware engineering that creates Virtual Machines (VMs)
 - To run multiple virtual computers, i.e., multiple OSes, on one real hardware platform.
 - Without VMs: A single OS owns all hardware resources.
 - With VMs: Multiple OSes, each running its own virtual machine, share hardware resources
- In other words, virtualization enables multiple OSes to run on the same physical platform

Objectives

- To run a desired program, without interfering with any of the other services provided by the server or host platform to other users.

What is it all about?



Ref: <https://software.intel.com/content/www/us/en/develop/articles/the-advantages-of-using-virtualization-technology-in-the-enterprise.html>

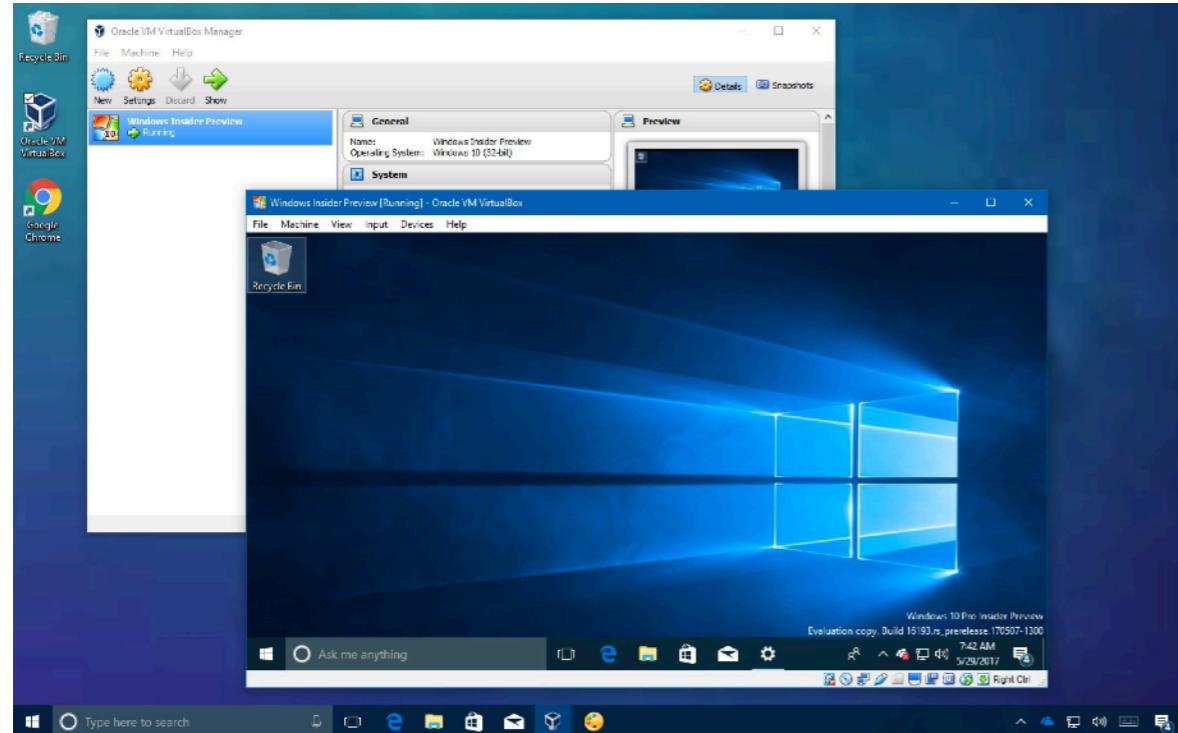
Recently, it can be done in many ways

- Xen
- VMWare
- VirtualBox
- MacOS Parallels
- Amazon AMI
- Many other could services

And for many purposes

- Desktop
- Server
- Data center
- Cloud

Desktop virtualization



Ref: <https://pureinfotech.com/install-windows-10-virtual-machine-virtualbox/>

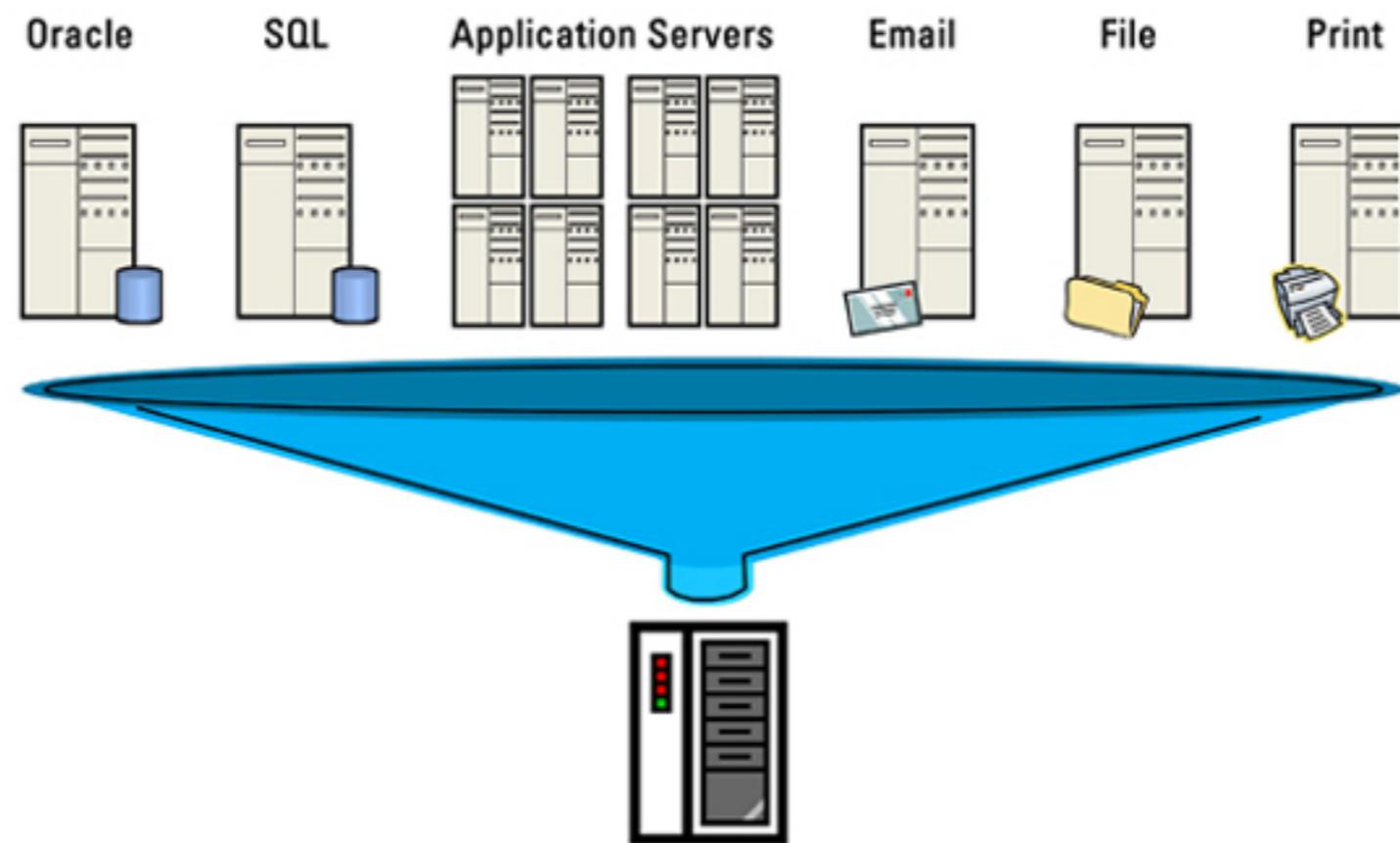


Ref: <https://www.macthai.com/2013/08/30/parallels-desktop-9-released/>

Who and what can benefit from desktop virtualization

- Developers are the most obvious
 - Develop on a VM can avoid messing up with the real hardware environment
 - Test on multiple environment can be done much easier
 - Make environment preparation much easier.

Server virtualization



Ref: <http://www.consultia.co/wp-content/uploads/2015/04/virtualization-power-consumption-savings.jpg>

Who and what can benefit from server virtualization

- Software vendors are the most obvious
 - Not everyone know how to run several full stack servers.
 - So, ship product virtualized can reduce mess, save costs, and improve disaster recovery.

Some historical backgrounds

- 1960s - 1970s
 - Due to high cost of computing machines, IBM create a VMM named VM/370 to allows multiuser to use its super powerful mainframe at th
- 1980s - 1990s
 - PC era make the earlier IBM approach obsoleted due to that everyone can own personal hardware. Thus, no need to be shared.
 - At that time, virtualization approach is more expensive than hardware.

Some historical backgrounds

- Late 1990s
 - Stanford's research project named Disco aims at better cost-effective and large-scale computing
 - Late spun off into VMWare
- 1998 - 2002
 - VMWare makes full-virtualization to run multiple unmodified OSes on the same physical machine.
 - Become very successful in both industries and academia

Some historical backgrounds

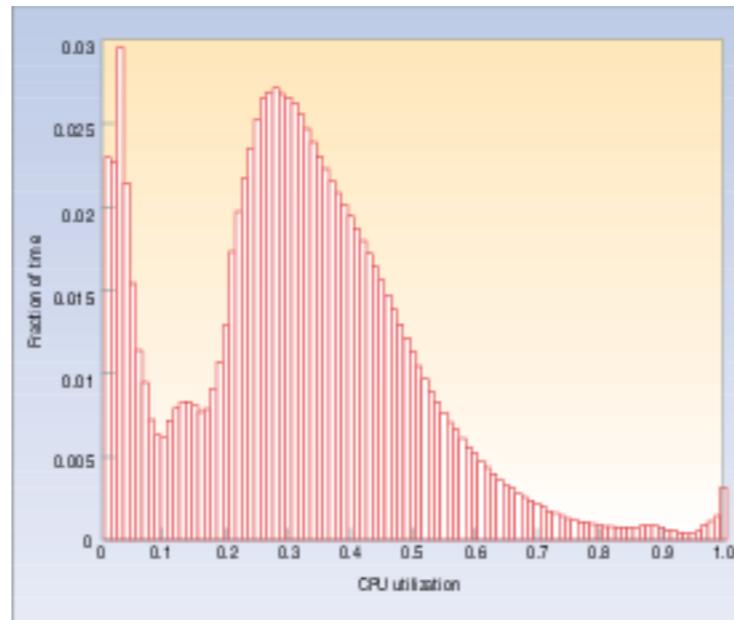
- 2003
 - University of Cambridge's created Xen as an open source projects.
 - Xen makes para-virtualization that modify OSes and make them run at the nearest performance as that of natives.
 - Citrix acquired the project in 2007.
- 2005
 - Hardware-assisted virtualization arrived
 - Intel VT-x and AMD-V
 - This make unmodified OSes run in virtualization with near-native performance.

Some historical backgrounds

- 2006 until now
 - Cloud computing — Infrastructure as a service (IaaS)
 - Virtual desktop infrastructure (VDI)
 - Mobile virtualization, i.e., ARM virtualization technology

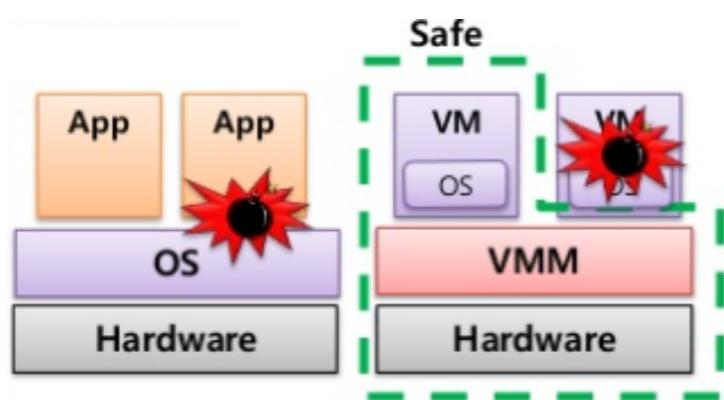
2006 until now — Cloud computing

- Average CPU utilization of 5,000 Google's servers in 2007



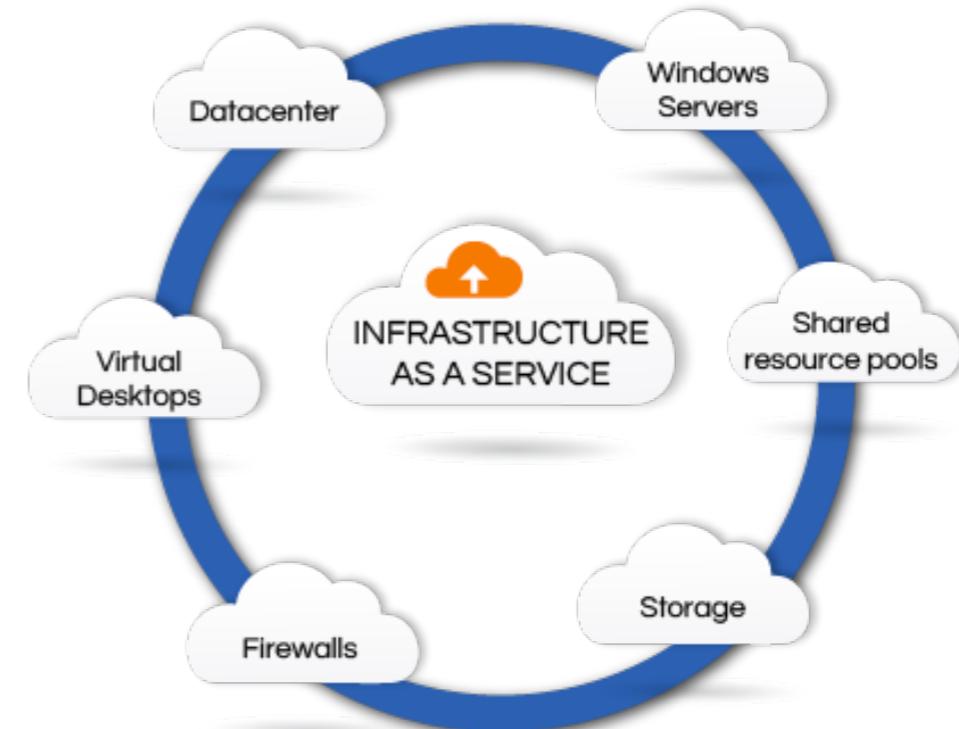
Example — Data centers

- With virtualization, cost can be saved through increased utilization and decreased IT overhead.
 - Flexible VM relocation
 - high availability
 - Strong isolation



2006 until now — Cloud computing

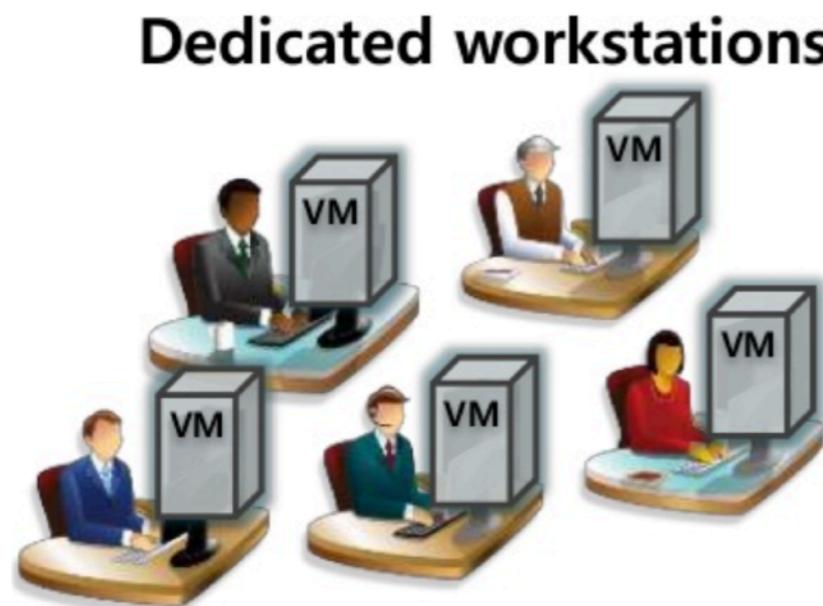
- Virtualized data centers
- IaaS provides highly reliable servers, storage, and security resources on-demand as a subscription based delivery model.



Ref: <http://lotussolutions.net/iaas/>

2006 until now — Virtual desktop infrastructure

- Desktop provisioning



- Energy wastage by idle desktops
- Resource underutilization
- High management cost
- High maintenance cost
- Low level of security

VM-based shared environments



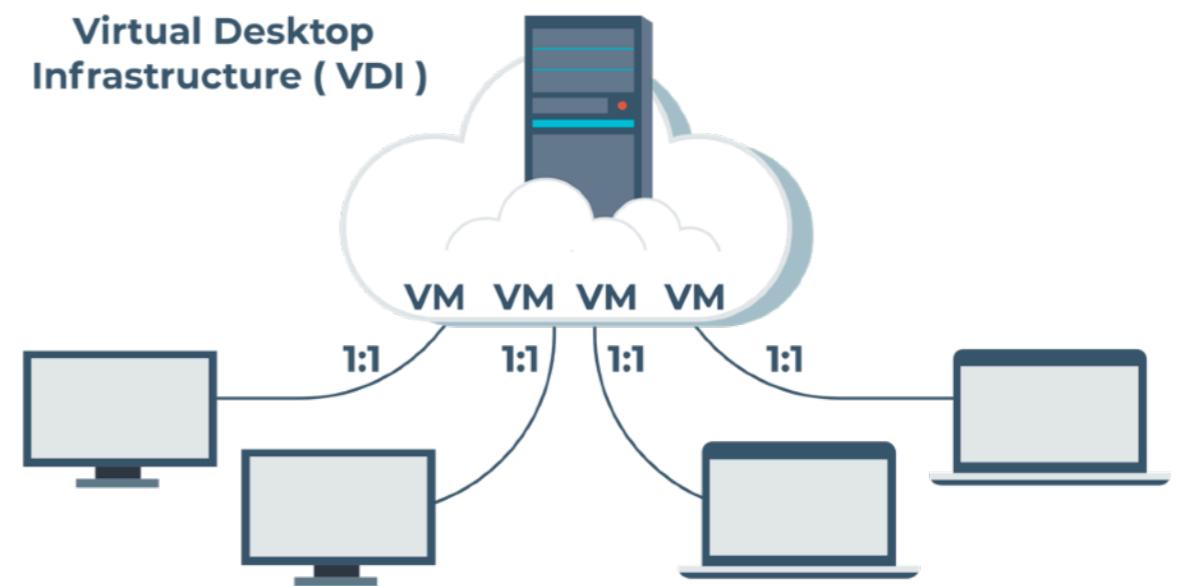
- + Energy savings by consolidation
- + High resource utilization
- + Low management cost
(flexible HW/SW provisioning)
- + Low maintenance cost
(dynamic HW/SW upgrade)
- + High level of security
(centralized data containment)

Ref: <https://www2.slideshare.net/HwanjuKim/1introduction-to-virtualization>

2006 until now — Virtual desktop infrastructure

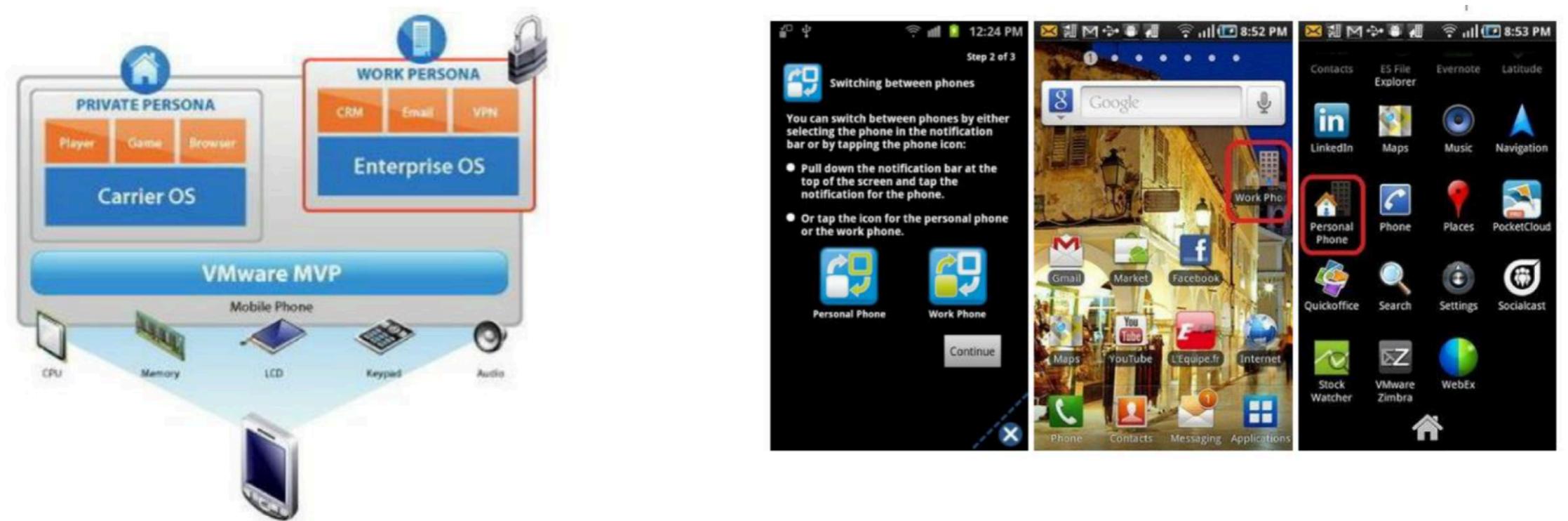
● VDI Benefits

- Resource sharing
- Flexibility in resource management
 - Centralized integrated management
- Security
- Authorization
- Cost saving



Ref: <https://www.diskinternals.com/vmfs-recovery/what-is-virtual-desktop-infrastructure/>

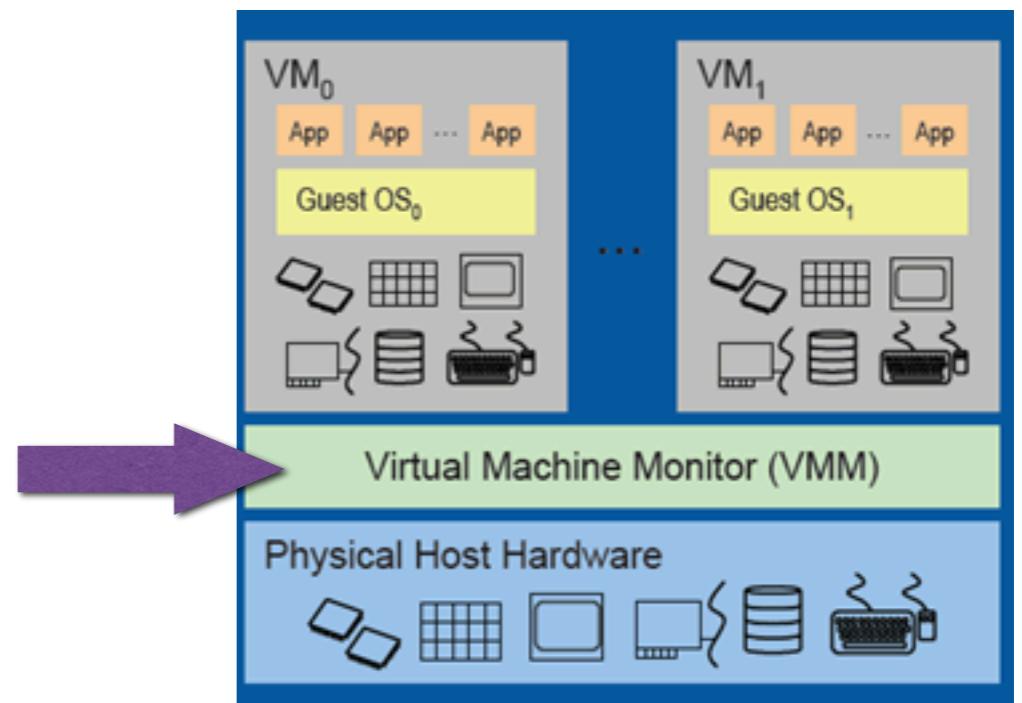
2006 until now — Mobile virtualization



Ref: <https://www.slideserve.com/prem/virtualization-and-cloud-computing>

Some terminologies

- Virtual machine monitor (VMM)
 - A layer added to virtualize multiple OSes.
 - Elsewhere, it is called Hypervisor.
 - Came from that OS is sometimes called supervisors.



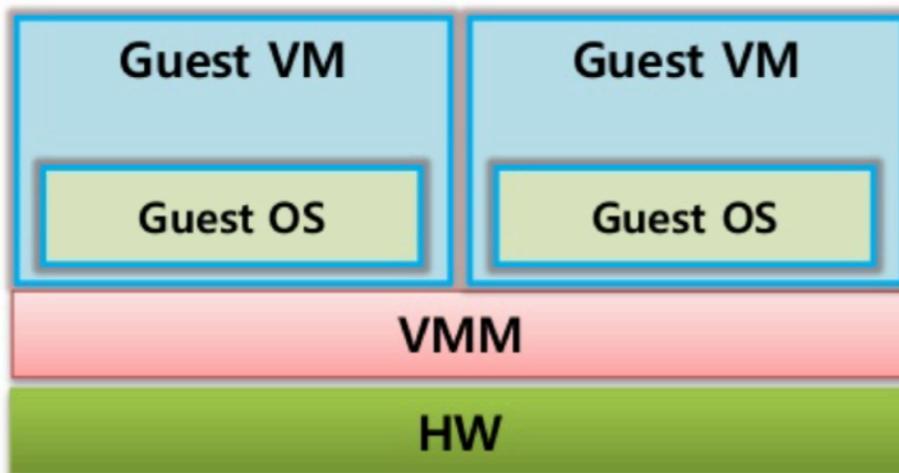
Some terminologies

- Types of VMM
 - Type-1 vs Type-2
 - Full-virtualization vs Para-virtualization

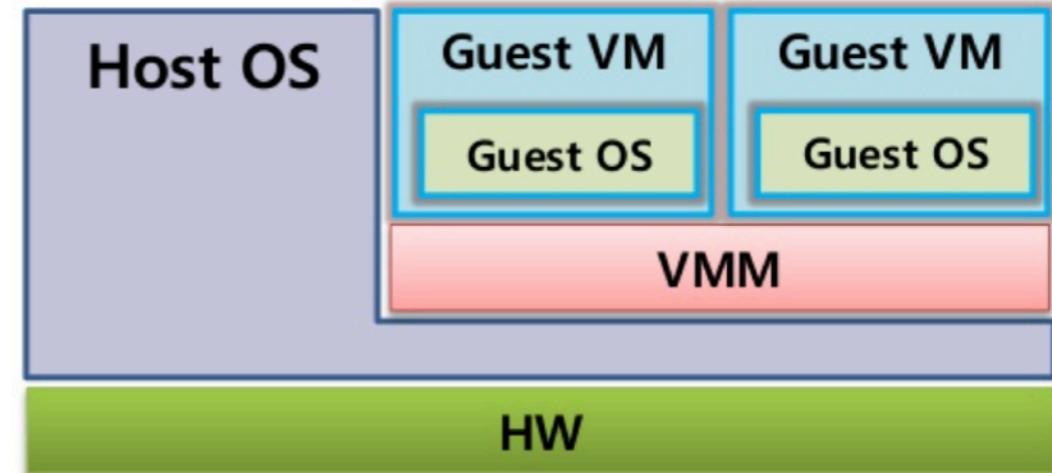
Some terminologies

- Type-1 vs Type-2
 - Depends on what is connected to hardwares

Type-1: VMM on HW



Type-2: Host OS on HW



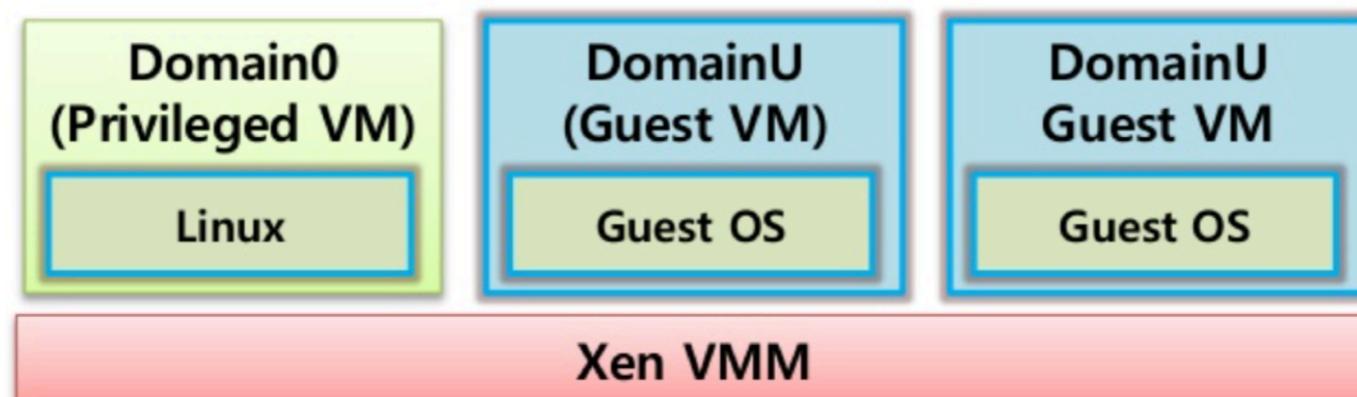
- Xen, VMware ESX server, Hyper-V
- Mostly for server, but not limited
- VMM by default
- OS-independent VMM

- KVM, VMware Workstation, VirtualBox
- Mostly for client devices, but not limited
- VMM on demand
- OS-dependent VMM

Ref: <https://www2.slideshare.net/HwanjuKim/1introduction-to-virtualization>

Some terminologies

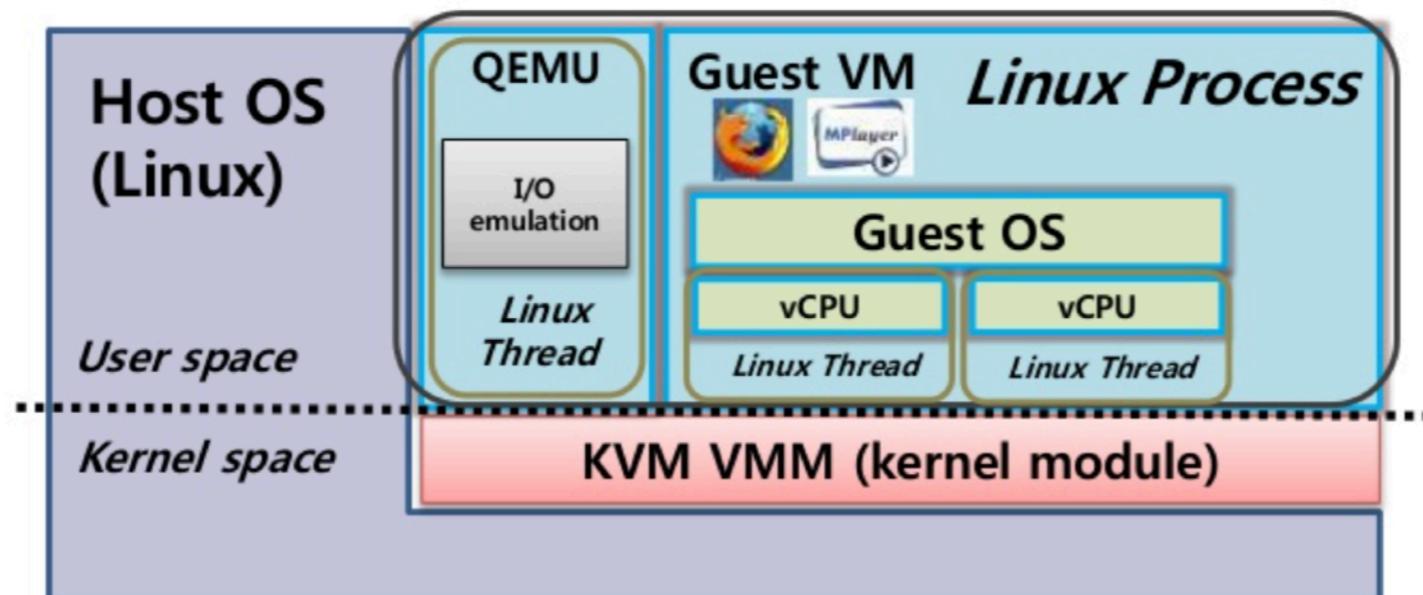
- Type-1 VMM a.k.a., Bare metal
 - E.g., Xen
 - Domain0 and DomainU
 - Privileged VM (Domain0) for guest VM (DomainU) management
 - Handling I/O operations request from DomainUs



Ref: <https://www2.slideshare.net/HwanjuKim/1introduction-to-virtualization>

Some terminologies

- Type-2 VMM a.k.a. hosted
 - Eg. Type-2 VMM for Linux as a host OS
 - Based on hardware-assisted virtualization



Ref: <https://www2.slideshare.net/HwanjuKim/1introduction-to-virtualization>

Some terminologies

- In other words
 - A type-1 VMM acts like a lightweight operating system and runs directly on the host's hardware.
 - A type-2 VMM runs as a software layer on an operating system, like other computer programs.
- Recently, the most commonly deployed type is the type 1
 - Isolated from the attack-prone operating system

Some terminologies

- Full- vs Para virtualization
 - Depends on whether OS source is modified
 - Full-virtualization — No OS modification
 - If software-based — Emulation
 - If hardware-based — Hardware-assisted virtualization
 - Para-virtualization — OS is modified
 - For performance
- Current state-of-the-art — Blended for the optimal performance

Some performance

- [https://browser.geekbench.com/v5/cpu/search?
dir=desc&page=1&q=ec2+c5&sort=score](https://browser.geekbench.com/v5/cpu/search?dir=desc&page=1&q=ec2+c5&sort=score)

System	Uploaded	Platform	Single-Core Score	Multi-Core Score
Amazon EC2 c5.metal Intel Xeon Platinum 8275CL 3900 MHz (48 cores)	May 9th, 2020	Linux	1124	35575

System	Uploaded	Platform	Single-Core Score	Multi-Core Score
Amazon EC2 c5.24xlarge Intel Xeon Platinum 8275CL 1336 MHz (48 cores)	May 4th, 2020	Linux	1093	33522

- Metal has direct access to the Xeon CPUs

Some performance

- Currently best single core performance in AWS EC2

System	Uploaded	Platform	Single-Core Score	Multi-Core Score
Amazon EC2 z1d.metal Intel Xeon Platinum 8151 4000 MHz (24 cores)	July 30th, 2020 DDriver	Linux	1158	21933

- Pricing

c5.24xlarge	96	375	192 GiB	EBS Only	\$4.08 per Hour
c5.metal	96	375	192 GiB	EBS Only	\$4.08 per Hour
z1d.12xlarge	48	235	384 GiB	2 x 900 NVMe SSD	\$4.704 per Hour
z1d.metal	48	271	384 GiB	2 x 900 NVMe SSD	\$4.704 per Hour

Some thoughts on pricing

- 32C/64T workstation
 - E.g. Lenovo P620 with Ryzen Threadripper pro 3975wx and 128 GiB memory



สรุป

ราคารถทั้งหมด	฿79,090.00
ตามการกำหนดค่า	฿195,390.00
การลดราคาสินค้า	-฿19,539.00
ราคารถของคุณ	฿175,851.00
จัดส่งภายใน 4 สัปดาห์	

ปรับแต่งต่อไป

ข้อมูลเพิ่มเติม ในรถเข็น >

Ref: <https://www.lenovo.com/th/th/workstations/thinkstation-p-series/ThinkStation-P620/p/30E0CTO1WWTHTH0/customize?>

- EC2 c5a.16xlarge instance

c5a.16xlarge	64	N/A	128 GiB	EBS Only	\$1.504 per Hour
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- $175851/45 = \sim 3900$ Hrs ~ Run at full CPUs 24/7 for half a year

Some thoughts on pricing

- 32C/64T workstation (Lenovo P620 with Ryzen Threadripper pro 3975wx)

System	Uploaded	Platform	Single-Core Score	Multi-Core Score
Lenovo ThinkStation P620 AMD Ryzen Threadripper PRO 3975WX s 3500 MHz (32 cores)	November 25th, 2020 ducphuc	Linux	1324	20648

- EC2 c5a.16xlarge instance

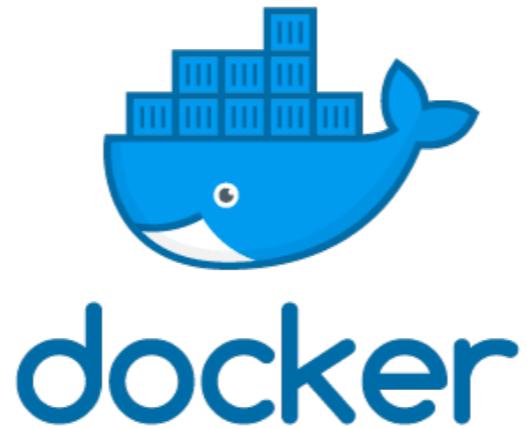
System	Uploaded	Platform	Single-Core Score	Multi-Core Score
Amazon EC2 c5a.16xlarge AMD EPYC 7R32 2401 MHz (32 cores)	December 31st, 2020	Linux	973	28227

Container vs VMM

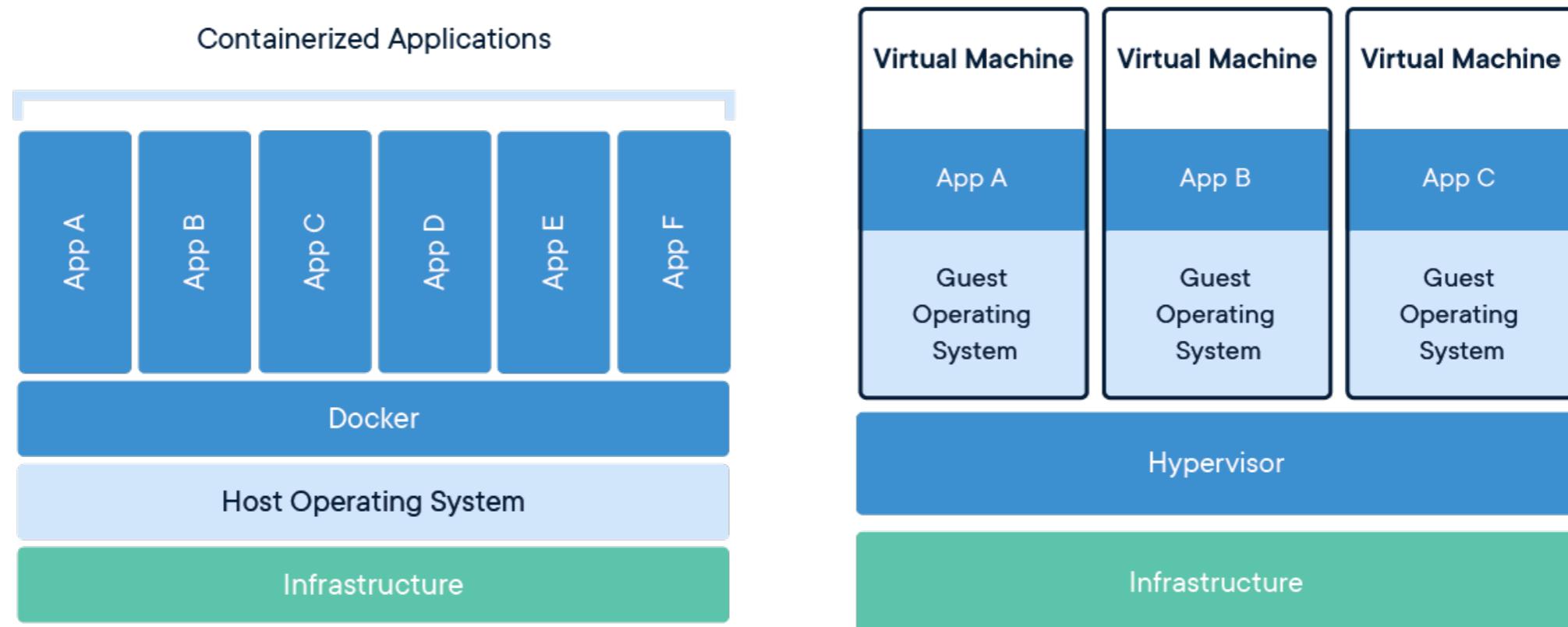
- Container
 - Containers are a lighter-weight, more agile way of handling virtualization.
 - Rather than making a huge **entire virtual machine**, a container packages together just everything needed to run a specific software.
 - Code + dependencies + OS.
 - This enables applications to run almost anywhere.

Container vs VMM

- Container
 - The common consensus is that the modern container era began in 2013 with the introduction of **Docker**.



Container vs VMM



Container vs VMM

- Hypervisor
 - Allow an OS to run independently from the underlying hardware through the use of virtual machines.
 - Share virtual computing, storage and memory resources.
 - Can run multiple operating systems on top of one server (type 1) or installed on top of one standard operating system and isolated from it (type 2)

Container vs VMM

- Container
 - Allow applications to run independently of an operating system.
 - Can run on any operating system—all they need is a container engine to run.
 - Are extremely portable since in a container, an application has everything it needs to run.

Container vs VMM

- Benefit of containers
 - Lightweight
 - Portable
 - Enable microservices

Container vs VMM

- When to use VMs
 - Workspace
 - Run multiple applications together
 - Ensure complete logical isolation
- When to use Containers
 - Microservice and DevOps
 - Web application
 - Speed is the top priority

Question Time

