Distributed Systems (DSy)

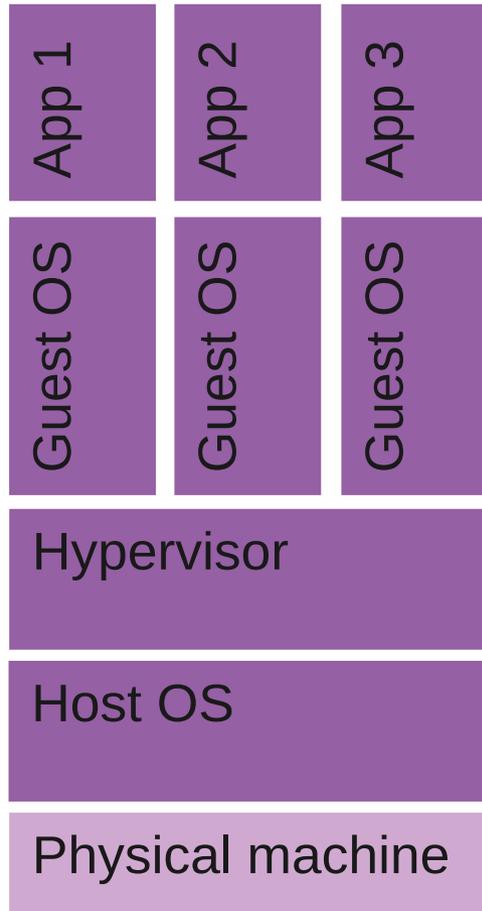**Containers and VMs**

Thomas Bocek

25.02.2026

Learning Goals

- Lecture 3 (Containers and VMs)

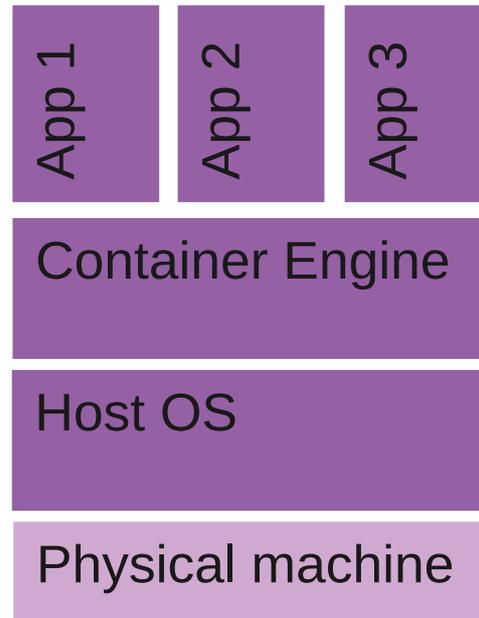 - What is the difference of VM / Container?

Virtualization

- Creation of a virtual machine that acts like a real computer with an operating system [source]

  - Host machine: machine where the virtualization software runs

  - Guest machine: virtual machine

- Hypervisor runs virtual machines

  - Type 1: bare-metal – e.g., Xen

    - History: "We built Amazon EC2 using a virtual machine monitor by the name of Xen" [source]

  - Type 2: hosted – e.g., VirtualBox

- Run unmodified OS with Intel VT-x and AMD-V, or paravirtualized if not present

  - E.g., VM should not access memory directly

- Needs to be the same architecture

  - Otherwise use emulation, e.g., QEMU

    - Ubuntu on a RISC-V processor

  - Many gaming console emulators: Mesen2 (NES/SNES/GB/GBA/PCE/SMS/GG/WS), Gopher64 (N64), Dolphin (GameCube/Wii), melonDS (DS), Azahar (3DS), SwanStation (PS1), PCSX2 (PS2), RPCS3 (PS3), PPSSPP (PSP), BlastEm (Genesis/Mega Drive), Ymir (Saturn), Flycast (Dreamcast), Xemu (OG Xbox), MAME (Arcade)

- Virtual desktop infrastructure (VDI)

- Containers

  - Isolated user-space instances

  - OS support: isolations
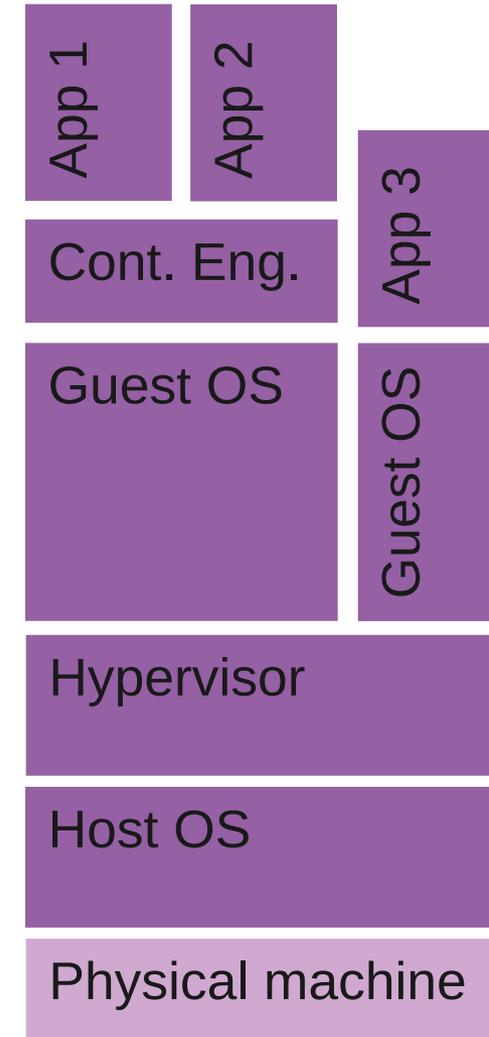
OST

Virtualization - Visualization

App 1	App 2	App 3
Guest OS	Guest OS	Guest OS
Hypervisor		
Host OS		
Physical machine		

- Virtual machines

App 1	App 2	App 3
Container Engine		
Host OS		
Physical machine		

- Container

App 1 App 2	App 3
Cont. Eng.	Guest OS
Guest OS	
Hypervisor	
Host OS	
Physical machine	

- Both

OST

Comparison

Container

+ Reduced size of snapshots 2MB vs 67MB

+ Quicker spinning up apps

+ / - Available memory is shared

+ / - Process-based isolation (share same kernel)

Use case: complex application setup, with container less complex configuration

Providers: ECS, Google Cloud Run, Digital Ocean App Platform, ...

Virtual Machine

+ App can access all OS resources

+ Live migrations

+ / - Pre allocates memory

+ / - Full isolation
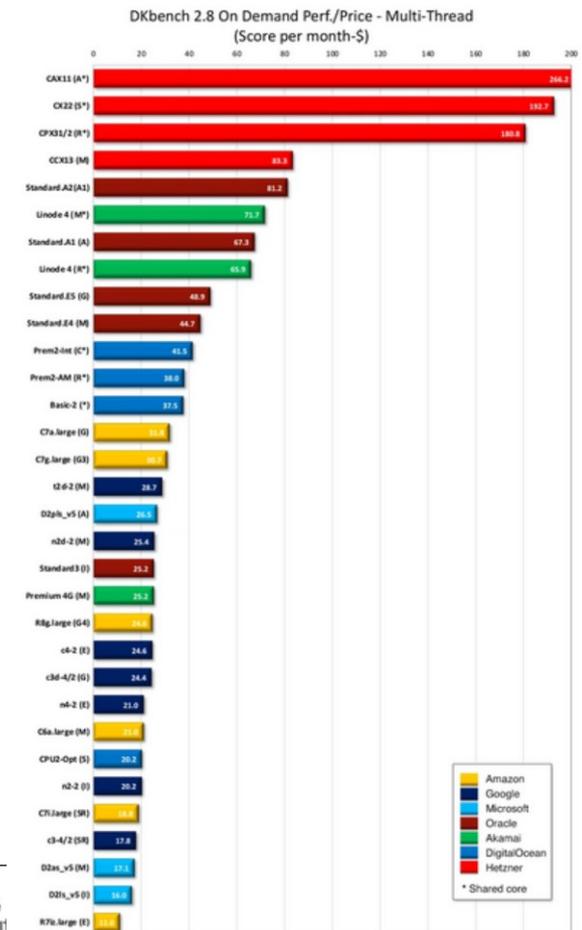
Use case: better hardware utilization / resource sharing

EC2, Virtual Machines, Compute Engine, Droplets

Market shares

OST

Prices / VM on e.g., AWS

Virtual Machines

- On-Demand

  - Machine, data transfer, IP address

- Spot instances (discount when not needed)

- Reserved Instances

- Comparison, comparison (price adjustment)

  - Optimize for cost → provider changes cost structure, you need to adapt again for optimizing

DKbench 2.8 On Demand Perf./Price - Multi-Thread (Score per month-$)

	aws	Microsoft Azure	Google Compute Engine
CPUs	1	1	1
RAM	2GB	2GB	3.75GB
Storage	30GB free	16GB	$.02/GB per month
Bandwidth	10GB free	5GB free	$.12/GB per month
Price	$7.00/month	$18.97/month	$15.60/month
	Visit site »	Visit site »	Visit site »

https://www.hostingadvice.com/how-to/aws-azure-google-cloud-alternatives/

OST

Firecracker vs. VirtualBox

- MicroVM: firecracker

  - Stripped-down Ubuntu rootfs (~10-20MB)

  - 5 emulated devices (virtio-net, virtio-block, virtio-vsock, serial, keyboard)

  - No BIOS/UEFI boot sequence

  - Uses KVM (Linux kernel module), type 2 hypervisor

  - Boot time: ~125ms

  - Memory overhead: <5 MiB, grows on demand

- Type 2 VM: VirtualBox

  - Alpine Linux (~67MB ISO)

  - Full device emulation (USB, audio, display, SATA, etc.)

  - Full BIOS/UEFI → bootloader → kernel boot chain

  - Uses own kernel module (vboxdrv), type 2 hypervisor

  - Boot time: ~10-30s (depending on config)

  - Pre-allocated memory (e.g., 512MB-1GB minimum)