PA200 - Cloud Computing

Lecture 3: Virtualization technologies

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Warm-up

Let's rehearse on the previous lectures...

What's the cloud?

1. Usage model of computer resources
2. Networked computers
3. Distributed computing technology
4. A collection of heterogeneous computers

Cloud traits?

1. High availability
2. On-demand self-service
3. High performance
4. Broad network access
5. Resource pooling
6. Rapid elasticity
7. Measured service
8. Improved information security

Cloud service models?

1. Software as a Service
2. Application as a Service
3. Platform as a Service
4. Infrastructure as a Service
5. Data as a Service

Cloud deployment models?

1. Public Cloud
2. Private Cloud
3. Hybrid Cloud
4. Personal Cloud
5. Community Cloud
6. Enterprise Cloud

In this lecture

- History of virtualization
- Virtualization technologies
- Hypervisors
- Cloud software

History of virtualization

- Early 1960: batch processing
- 1970: first commercial time-sharing system - IBM S/370
- 2005: Intel VT-x, AMD-V - new instruction set
- 2005-: VMware, VirtualBox, KVM...

Early sixties: S/360

IBM S/360: non-interactive, single-user, batched jobs

- Expensive idling on I/O

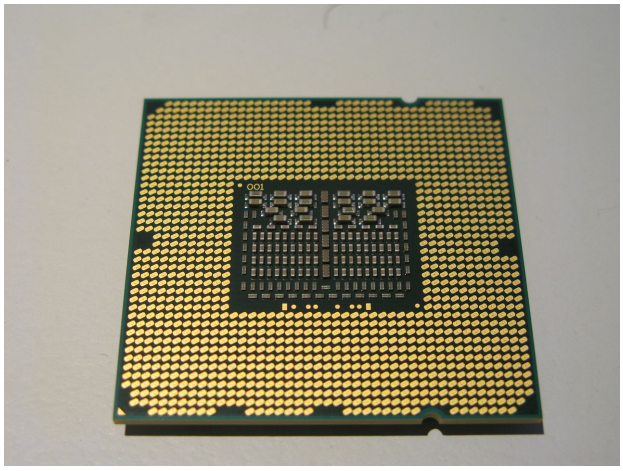
Mid-sixties: S/370

IBM S/370 introduced virtual memory, privilege separation

- Eventually lost out to batch jobs
- Security concerns due to multi-tenancy

Dark ages of virtualization

- No significant virtualizaton development for 40 years
- Up to the rise of the Web
- VM support in PC CPUs since 2005 (Intel VT-x, AMD-V)

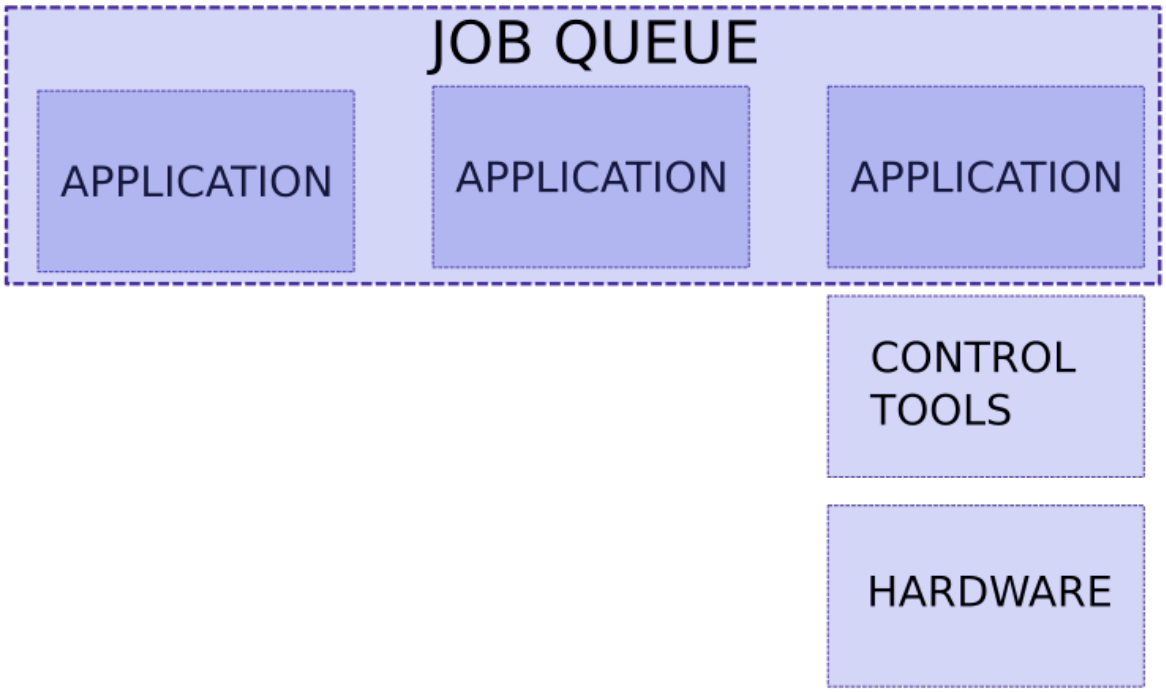


What exactly is virtualization?

- Multi-programming
- Multi-tasking
- Multi-threading
- Virtual machines
- Containers
- CPUs:
    - Multi-core
    - Hyper-threading

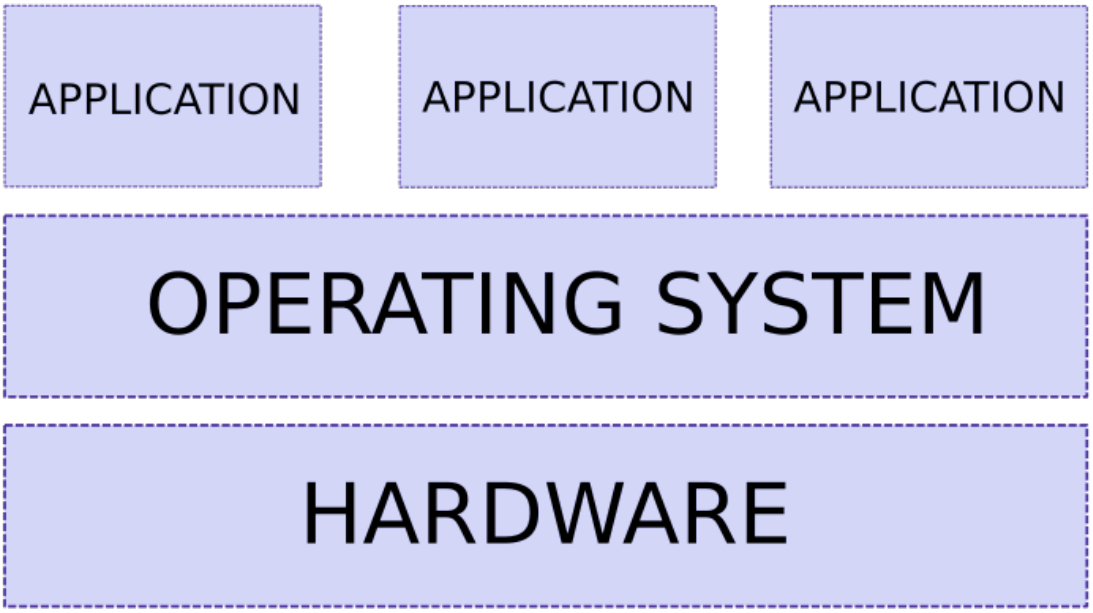
Concurrency: multi-programming

Sequential processes



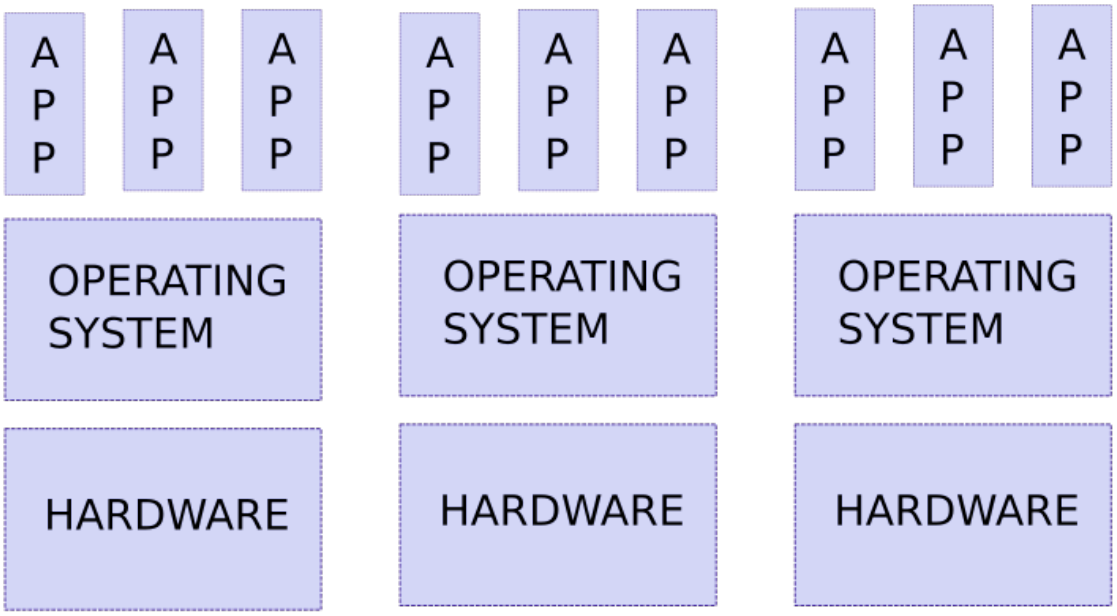
Concurrency: multi-tasking

Concurrent processes



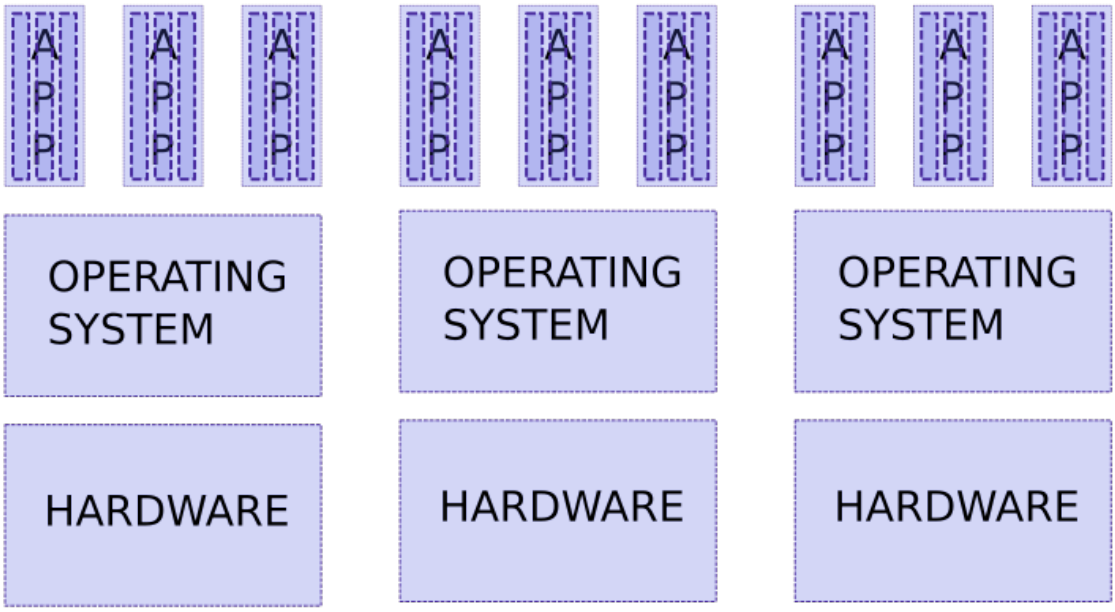
Concurrency: Multiple systems

Multiple systems, concurrent processes



Concurrency: Multiple threads

Multiple systems, concurrent processes, concurrent threads

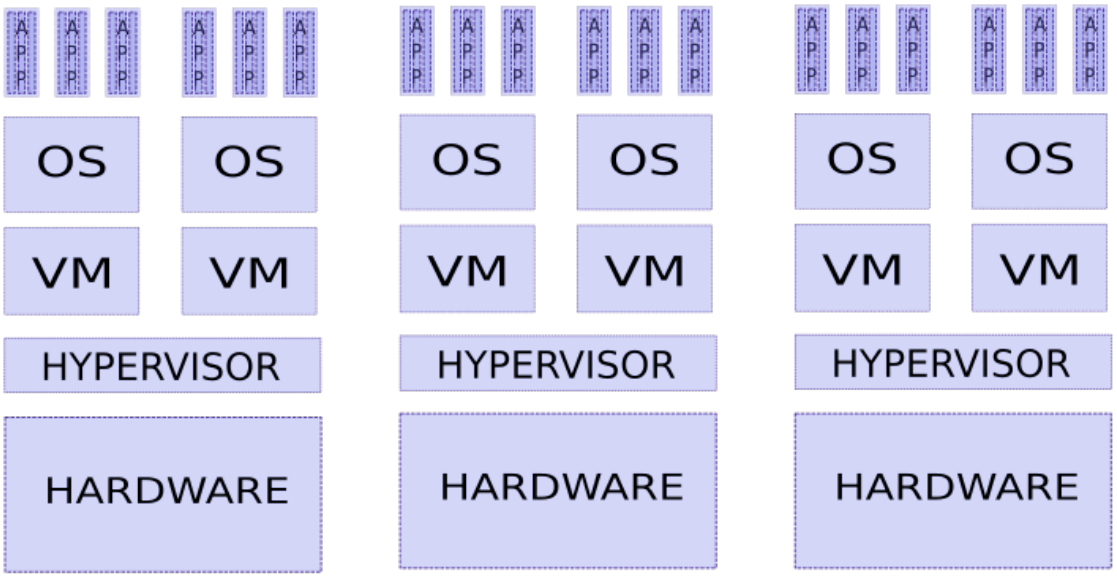


Full virtualization: VMs

- Virtual machine emulates a physical computer (can be different architecture)
- OS executes within a VM (can be different OS types)
- Tenant OSes are isolated from each other
- VMs are heavy and expensive

Concurrency: Virtual machines

Multiple systems, VMs, processes, threads

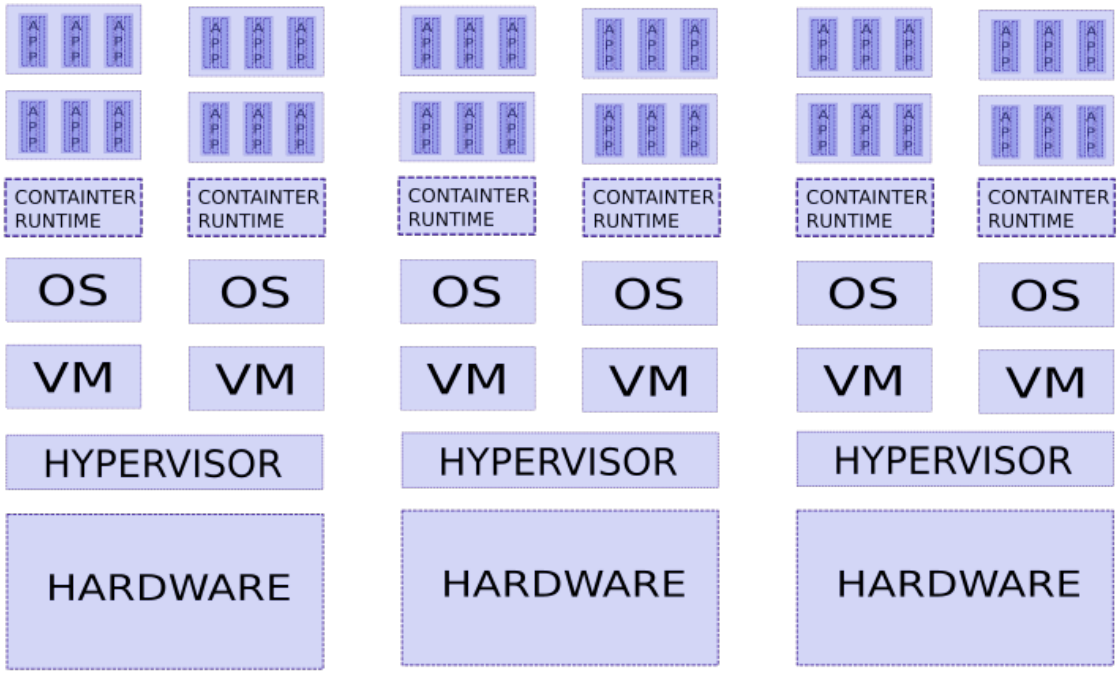


OS-level virtualization: containers

- Processes share the same kernel
- Processes have isolated memory, file system, network and PID spaces
- Many processes can be contained at once
- Containers are cheap and lightweight

Concurrency: Containers

Multiple systems, VMs, containers, processes, threads

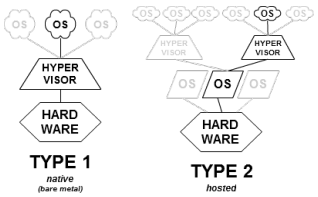


What makes up a cloud

- Isolated execution environment
  - Virtual machines and/or
  - Containers
- Guest life cycle management
  - Hypervisors
- Higher order infrastructure
  - Instance management
  - Access control
  - Networking
  - Storage

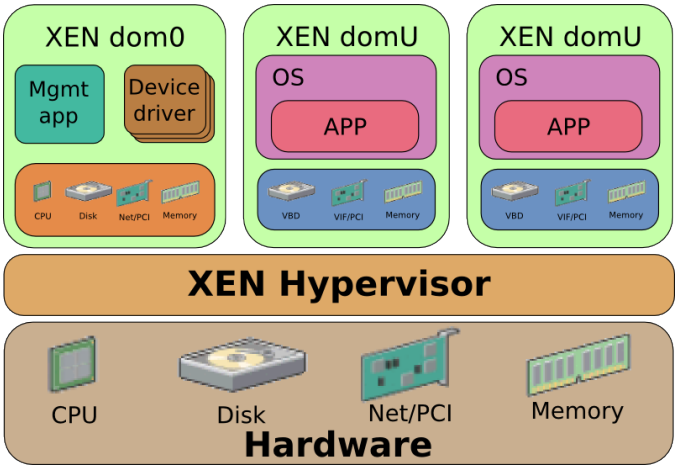
Hypervisors

- Type 1: Native
  - Runs directly on host's hardware
- Type 2: Hosted
  - The hypervisor and VMs are processes of host's operating system



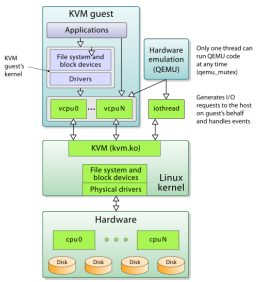
Example Type 1 hypervisors

Xen, Oracle VM Server, Microsoft Hyper-V, VMware ESX/ESXi



Example Type 2 hypervisors

VMware, Oracle VirtualBox, Parallels Desktop, Linux KVM (+QEMU), FreeBSD Bhyve



Native-hosted hypervisors

- Type 1/2:
  - Linux KVM
  - BSD bhyve

Full or para-virtualization

- Full virtualization
  - Unmodified OS on top of hypervisor
- Para-virtualization
  - Modified OS calls hypervisor API

Bare metal machine hypervisor

- Traditional hypervisors
    - Manage VMs running on bare metal machines
- Baremetal machine hypervisors
    - Manager bare metal machines
    - In the same way as VMs

Full virtualization infrastructure

- Basic cloud features
    - Hypervisor abstraction layer
    - User authentication and accounting
    - Instance life cycle management (scheduling)
    - Automated OS deployment and configuration
    - Virtualized network (SDN)
    - Storage services
- More features
    - High-availability services
    - Instance monitoring and scaling
    - Instance backup/migration
    - Virtualized databases
    - User interfaces

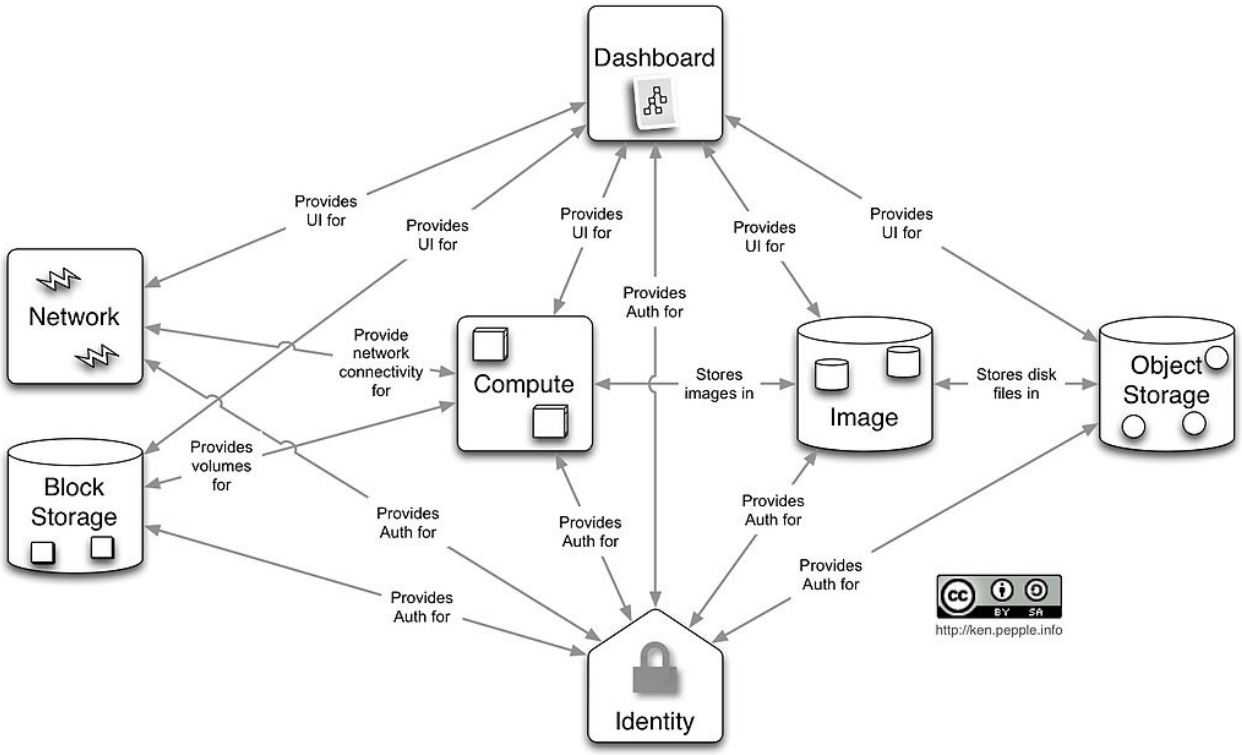
Example: oVirt

- Lightweight, all-in-one cloud (e.g. desktop)
- KVM as a hypervisor
- Reliable VMs (pets)
- Vertical scalability

Example: OpenStack

- Heavyweight, large cloud
- Large collection of loosely-coupled projects
- Unreliable, replaceable VMs (cattle)
- Horizontal scalability

OpenStack components



Container orchestration

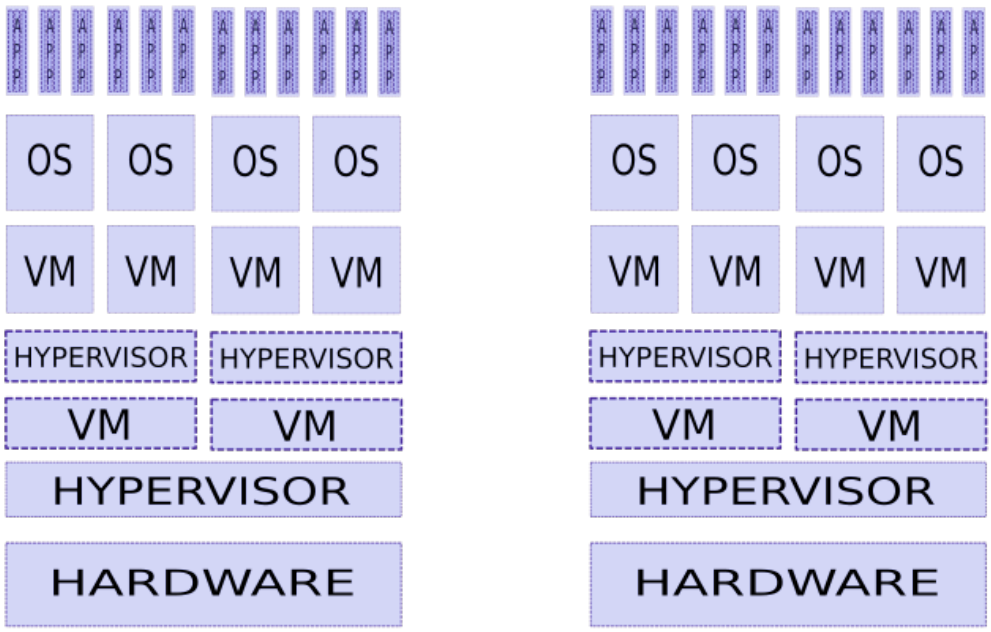
- Basic features
    - Container runtime abstraction layer
    - Container life cycle management (scheduling)
    - Resource management: memory, CPU, file system, storage volumes, network addresses etc.
    - Clustering
- More features
    - Load balancing and scaling
    - Container images management
    - User interfaces

Example: container orchestration

- Docker Swarm
- Kubernetes / OpenShift
- Amazon EC2 Container Service
- Nomad

Nested virtualization

Multiple systems, VMs, nested VMs, processes, threads



Recap: the age of virtualization?

1. IBM 700/7000, since 1952
2. CP-40 research project, early sixties
3. IBM S/370, 1970
4. Gameframes, since 2007
5. Intel VT-x, AMD-V, since 2005

Recap: virtualization technologies?

1. Multi-tasking
2. Multi-threading processes
3. Containers
4. Hyper-threading CPU
5. Multi-core CPU
6. Intel VT-x, AMD-V
7. Multi-programming

Recap: hypervisor types?

1. Hybryd
2. Bare-metal
3. Native
4. Hosted
5. Para-hypervisor

Recap: what makes up a cloud?

1. One hypervisor
2. One or more hypervisors
3. Baremetal computers
4. Baremetal switches and routers
5. Networking service

Recap: virtualization vs containers?

1. We can run OS in a container
2. We can run different OS'es in containers
3. We can run VM in a container
4. Containers are more secure than VM
5. Containers consume less resources than VM
6. We can run Windows app in Linux container

Q&A

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