# How to run a software on a computer?

Lecture 5 from Intro to CS

- Running a software
  - Compiling, program file
- Multiple program on a computer
  - Protection-security
  - Isolation
  - Virtualization
- Operating system as a resource manager
- Virtual machine
  - Hypervisor
  - Virtualbox, vmware,
- Hardware Emulators
  - QEMU
- Containerization
  - OS-level containers
    - Dockers
      - Containerized applications
  - Application containers

# Compiling a program file

**source file**

program1.c

program2.py

Main.cpp

Main.java

**Binary(program) file (machine code)**

- gcc main.c -o pogramfile
  - Generates a binary file
- g++ main.cpp -o programfile
  - Generates a binary file
- javac Main.java
  - Generates a bytecode “.class” file
  - java Main.class runs the file on JVM
- Python main.py
  - compiles/interpretes and runs the code
  - Binary generated in the process

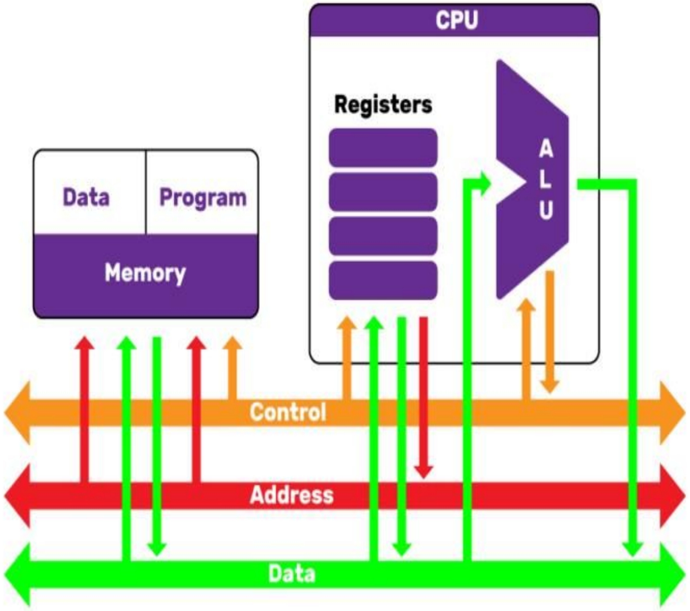
# Process

Program: a binary file in hard disk

When we run a program,

- We need to load its data, instructions into memory
- And run on CPU

Process: The program that is loaded into memory



https://www.icdrex.com/the-brain-behind-the-machine-transistors-in-cpu-architecture/

# Running one program vs running multiple program

Multi-tasking

- Computers can run many program at the same time
- Many programs use the same memory, CPU, I/O devices

**Problems?**

# Running one program vs running multiple program

Multi-tasking

- Computers can run many program at the same time
- Many programs use the same memory, CPU, I/O devices

Problems

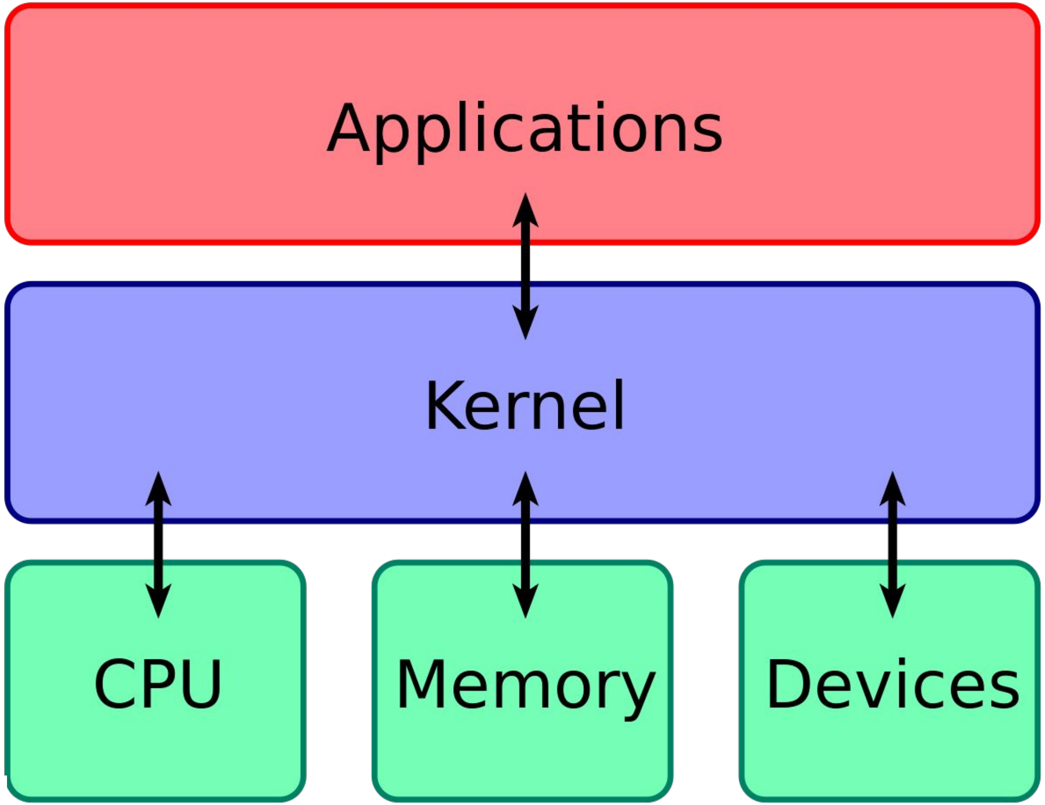
- One program can affect another
- One program can steal another’s data
- There may be more than one user

Protection

- How to protect system resources (hardware)?
- How to prevent one program affecting another?
- ..

# Operating system

Kernel: the core of os that controls system resources



https://en.wikipedia.org/wiki/Kernel_(operating_system)

# Protection

Requires

- Isolation of processes
  - Isolate memories they use
  - Protect one process from another

https://www.patlabelsonline.co.uk/health-and-safety-labels-c203/danger-isolate-before-opening-warning-labels-p1117

# Protection

Requires

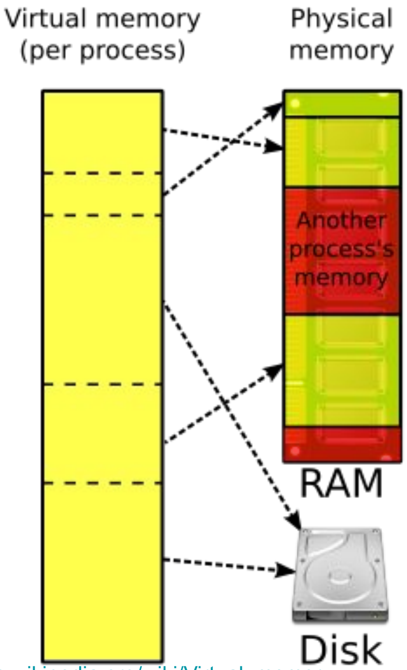
- Isolation of processes
  - Isolate memories they use
  - Protect one process from another

Adobe Stock | #804995897

- Virtualization of system resources
  - Process do not know the exact memory layout, or other hardware.
  - Goes through OS to access hardware

# Virtualization of system resources

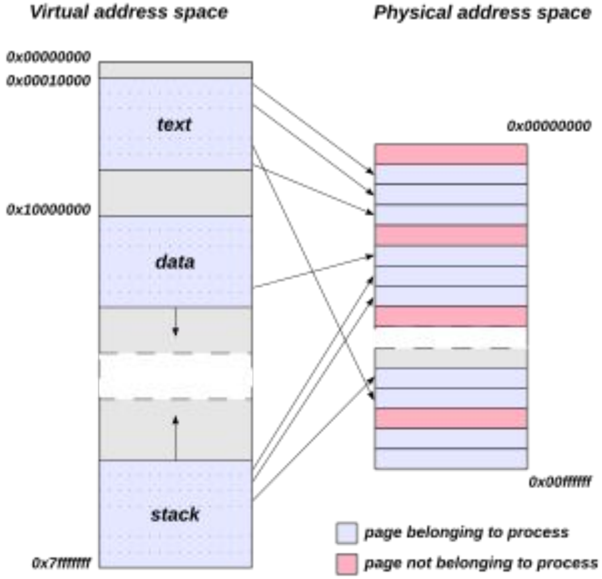
Memory management with Virtual memory



https://en.wikipedia.org/wiki/Virtual_memory

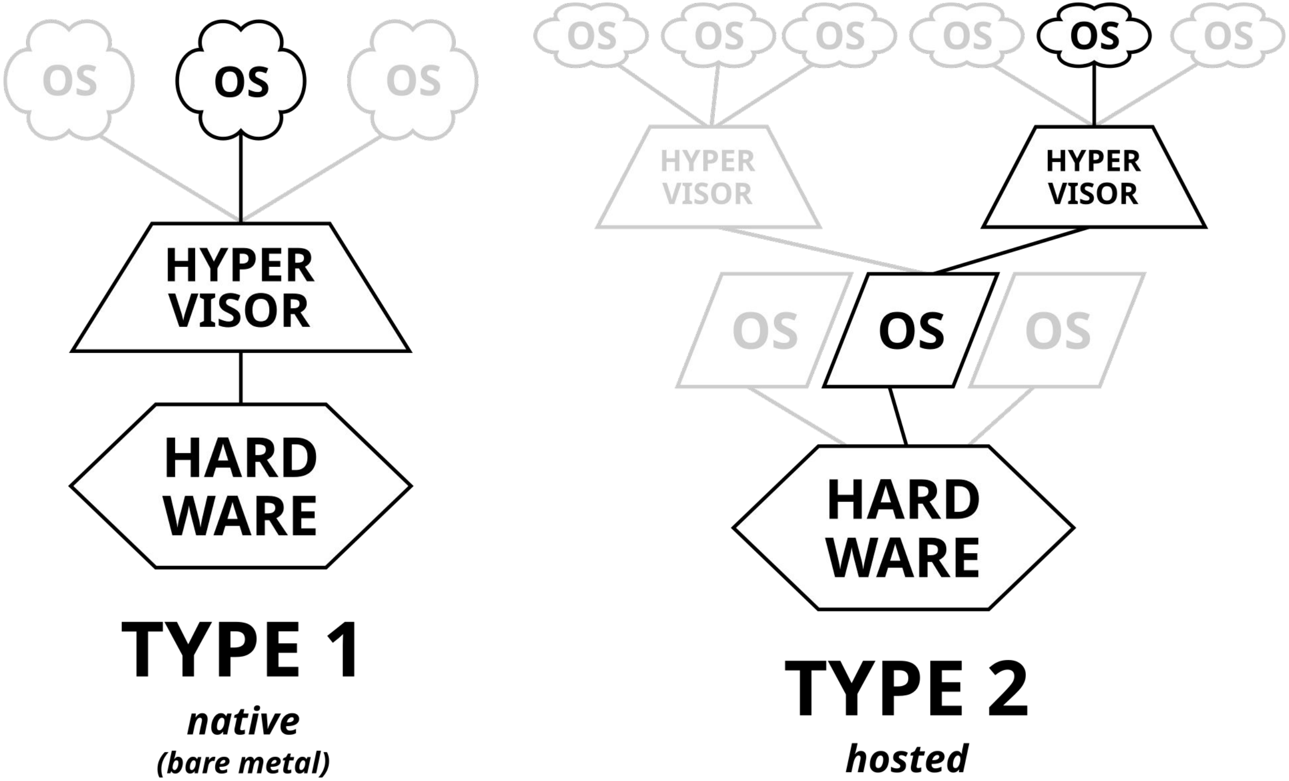
Virtual address space

(set of address available to a process)



https://en.wikipedia.org/wiki/Virtual_address_space

# Virtualization of full computer architecture



https://en.wikipedia.org/wiki/Hypervisor

# Hypervisors

a virtual machine monitor (VMM), manages virtual machines (VMs) as they run alongside each other.

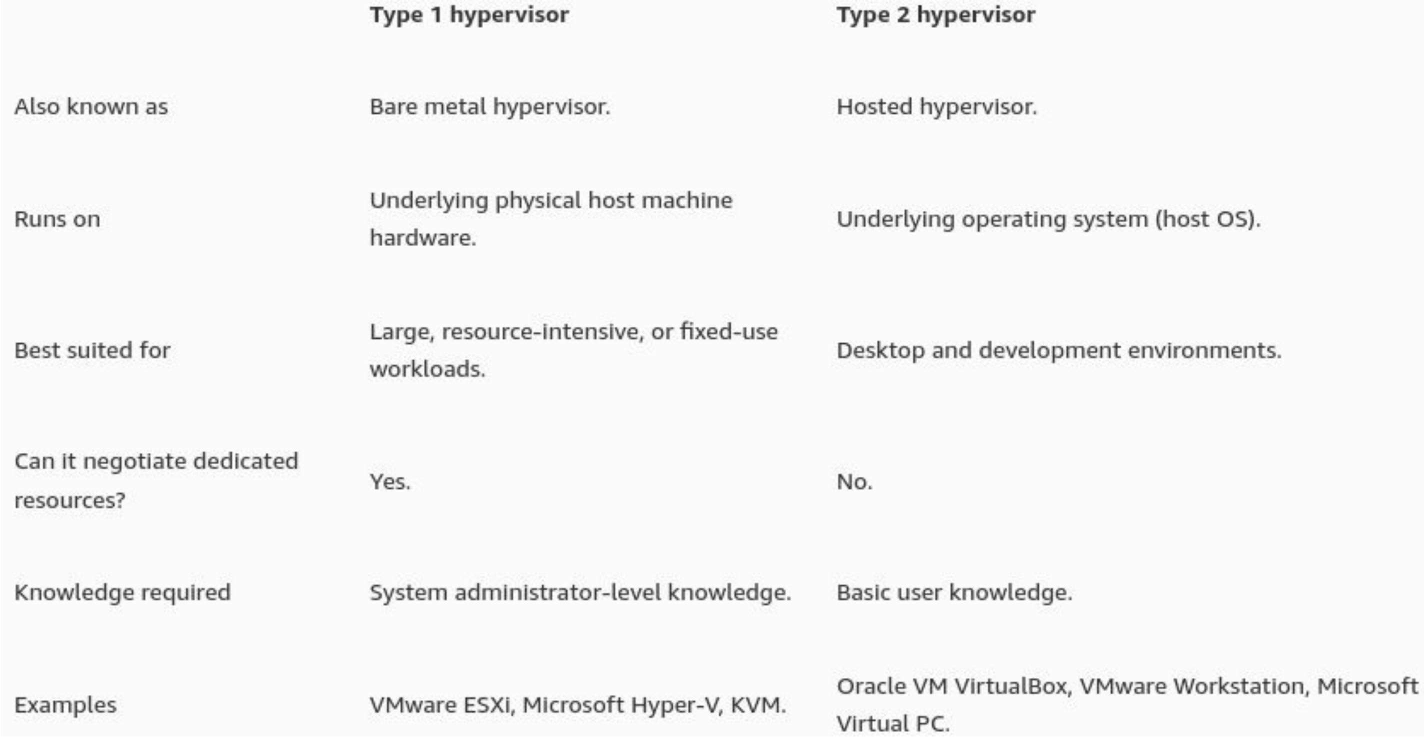
Type-1 hypervisor (bare metal hypervisor)

- Interacts directly with the underlying machine
- Installed on the host’s physical machine
  - Not through OS
- It can allocate/share resources to VMs

Type-2 hypervisor

- interacts with the underlying hardware through the host machine OS
- Runs as an application

https://en.wikipedia.org/wiki/Hypervisor



| | Type 1 hypervisor | Type 2 hypervisor |
|---|---|---|
| Also known as | Bare metal hypervisor. | Hosted hypervisor. |
| Runs on | Underlying physical host machine hardware. | Underlying operating system (host OS). |
| Best suited for | Large, resource-intensive, or fixed-use workloads. | Desktop and development environments. |
| Can it negotiate dedicated resources? | Yes. | No. |
| Knowledge required | System administrator-level knowledge. | Basic user knowledge. |
| Examples | VMware ESXi, Microsoft Hyper-V, KVM. | Oracle VM VirtualBox, VMware Workstation, Microsoft Virtual PC. |

https://aws.amazon.com/compare/the-difference-between-type-1-and-type-2-hypervisors/

# Distinction is not clear everytime

KVM and bhyve are kernel modules that effectively convert the host operating system to a type-1 hypervisor

Comparison of platform virtualization software - Wikipedia

# Virtualization on system level

Virtualization allows you to:

- Run software that requires an older versions and different operating systems.
- Experiment with other operating systems.
- Test software on multiple operating systems using multiple virtual machines.

you can run them all on a single desktop or laptop computer.

https://learn.microsoft.com/en-us/virtualization/hyper-v-on-windows/about/#reasons-to-use-virtualization

# QEMU(Quick Emulator)

QEMU is a generic and open source machine emulator and virtualizer.

It supports various virtualization modes and can emulate a wide range of hardware.

About QEMU — QEMU documentation

QEMU

To run on Mac

- https://mac.getutm.app/

# Installing Linux via Virtual Machine softwares

Download virtual box

- Downloads – Oracle VirtualBox

You can also download VMware etc. or Virt-Manager,

How to run an Ubuntu Desktop virtual machine using VirtualBox 7

How To Install Debian 12 On VirtualBox

On mac

- Mac OS, OSX  is a UNIX based OS
  - Similar to linux

To install Linux

- https://mac.getutm.app/
- Ubuntu 22.04 | UTM Documentation

# Windows Subsystem for Linux(WSL1-WSL2)

WSL1

You can run Linux/GNU environments

- Command-line tools,
- Utilities,
- Applications

Uses compatibility layer

WSL2 uses hyper-V architecture to enable virtualization

- WSL1
- +Full linux kernel
-

Install WSL | Microsoft Learn

FAQ's about Windows Subsystem for Linux | Microsoft Learn

https://learn.microsoft.com/en-us/windows/wsl/compare-versions

# Another example: android emulators

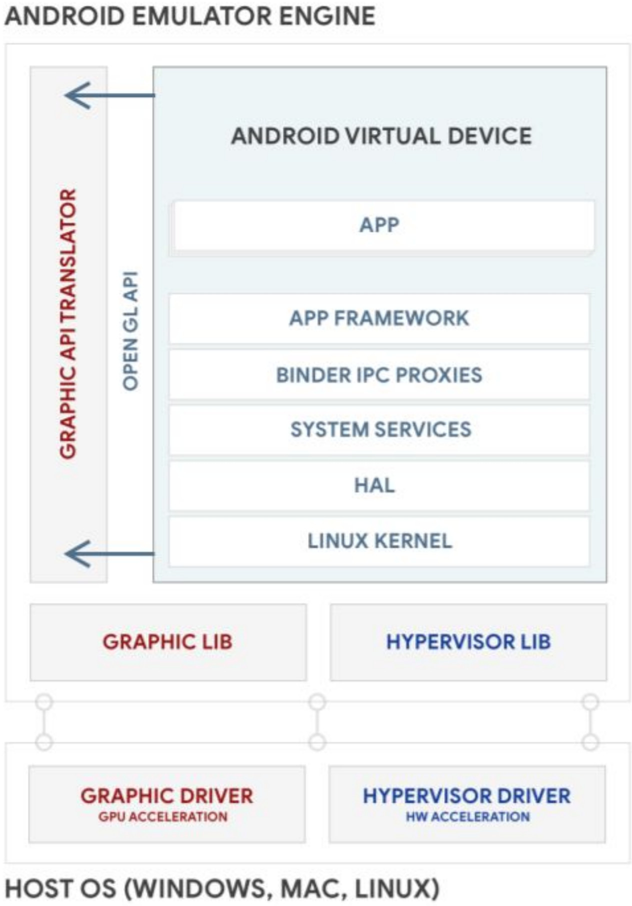
Uses the virtual machine

- Android Virtual Device
  - Contains full android software stack

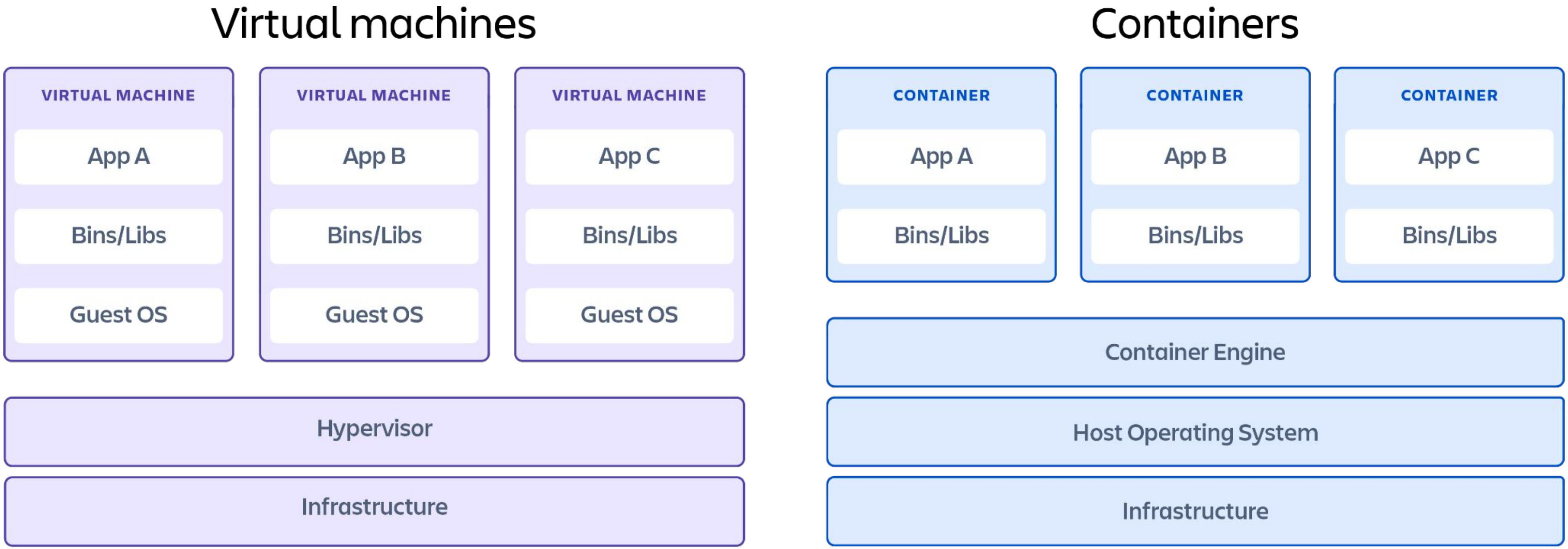
[Use Android Emulator virtual devices]()

[Cuttlefish virtual Android devices]()

*Cuttlefish* is a configurable virtual Android device



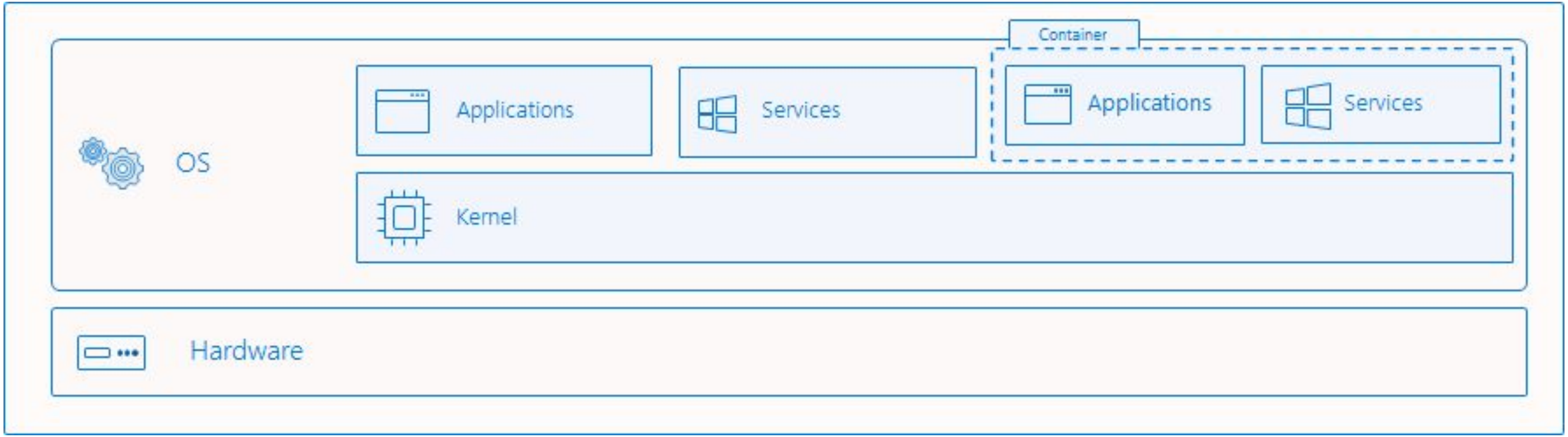
# Containerization



https://www.atlassian.com/microservices/cloud-computing/containers-vs-vms

# Example from Windows

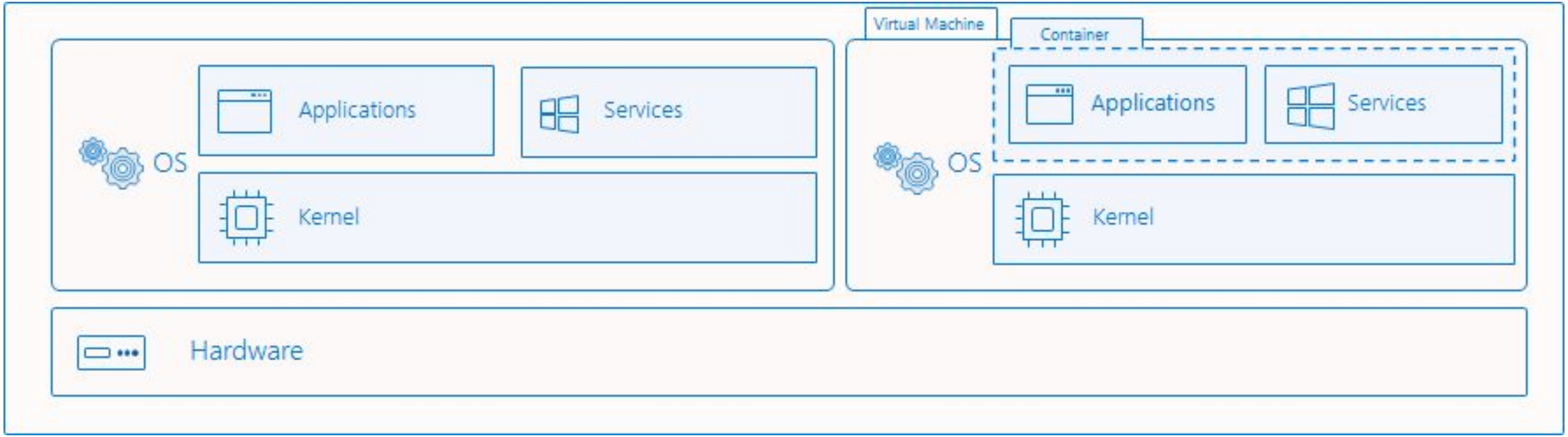
## Process isolation with Windows containers



https://learn.microsoft.com/en-us/virtualization/windowscontainers/manage-containers/hyperv-container

# Example from Windows

## Process isolation with virtual machine and containers



https://learn.microsoft.com/en-us/virtualization/windowscontainers/manage-containers/hyperv-container

# Examples

Linux Containers

Linux Containers - LXC - Introduction

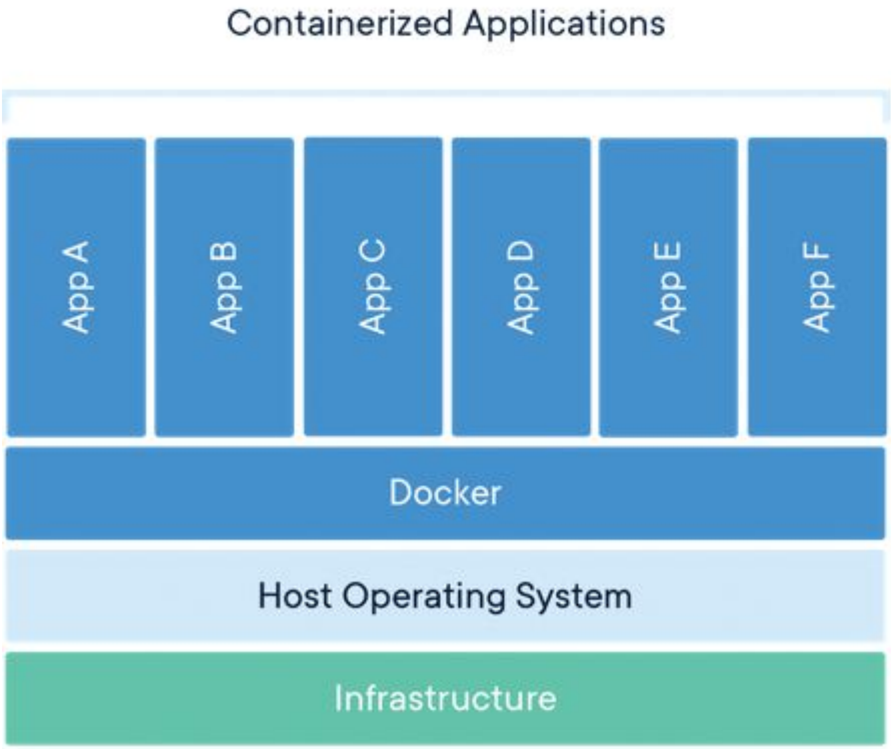
An Introduction to FreeBSD Jails

- Chapter 17. Jails and Containers | FreeBSD Documentation Portal

Podman

https://podman-desktop.io/

Docker



https://www.docker.com/resources/what-container/

# Installing  docker

https://docs.docker.com/engine/install/

- Install Docker Desktop on Linux

Install Docker Desktop on Windows

- Docker Desktop WSL 2 backend on Windows

Install Docker Desktop on Mac

# Installing Linux as a docker image

ubuntu - Official Image | Docker Hub

debian - Official Image | Docker Hub

https://hub.docker.com/search?type=image&operating_system=linux&image_filter=official&categories=Operating+Systems

# Kubernetes

Kubernetes, also known as K8s, is an open source system for managing containerized applications across multiple hosts.

It provides basic mechanisms  to

- deploy,
- scale,
- and manage containerized applications.

GitHub - kubernetes/kubernetes: Production-Grade Container Scheduling and Management

Kubernetes

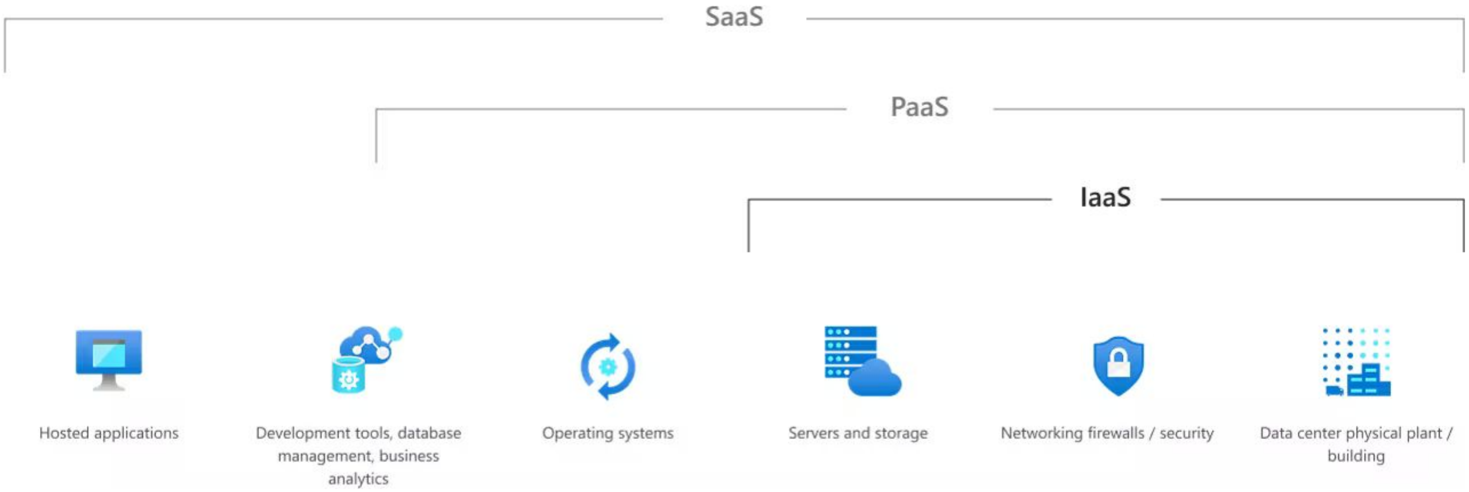
# Containerization on cloud computing

Infrastructure as a service (IaaS)

software as a service (SaaS),

platform as a service (PaaS)

serverless


SaaS
PaaS
IaaS
Hosted applications
Development tools, database management, business analytics
Operating systems
Servers and storage
Networking firewalls / security
Data center physical plant / building

What is IaaS? Infrastructure as a Service | Microsoft Azure

# When to use?

OS containers

- Linux containers (LXC)
- windows containers

➔ **When you need extra isolation for some apps!**

Virtual machine

➔ When you need to run different OS<br>
➔ Further isolation

Dockers etc.

➔ Deploying an app,<br>
➔ Bundled/portable apps

# HW:

Install Ubuntu/debian or any other Linux on VirtualBox

# Next

Linux OS

Terminal commands and more