docker

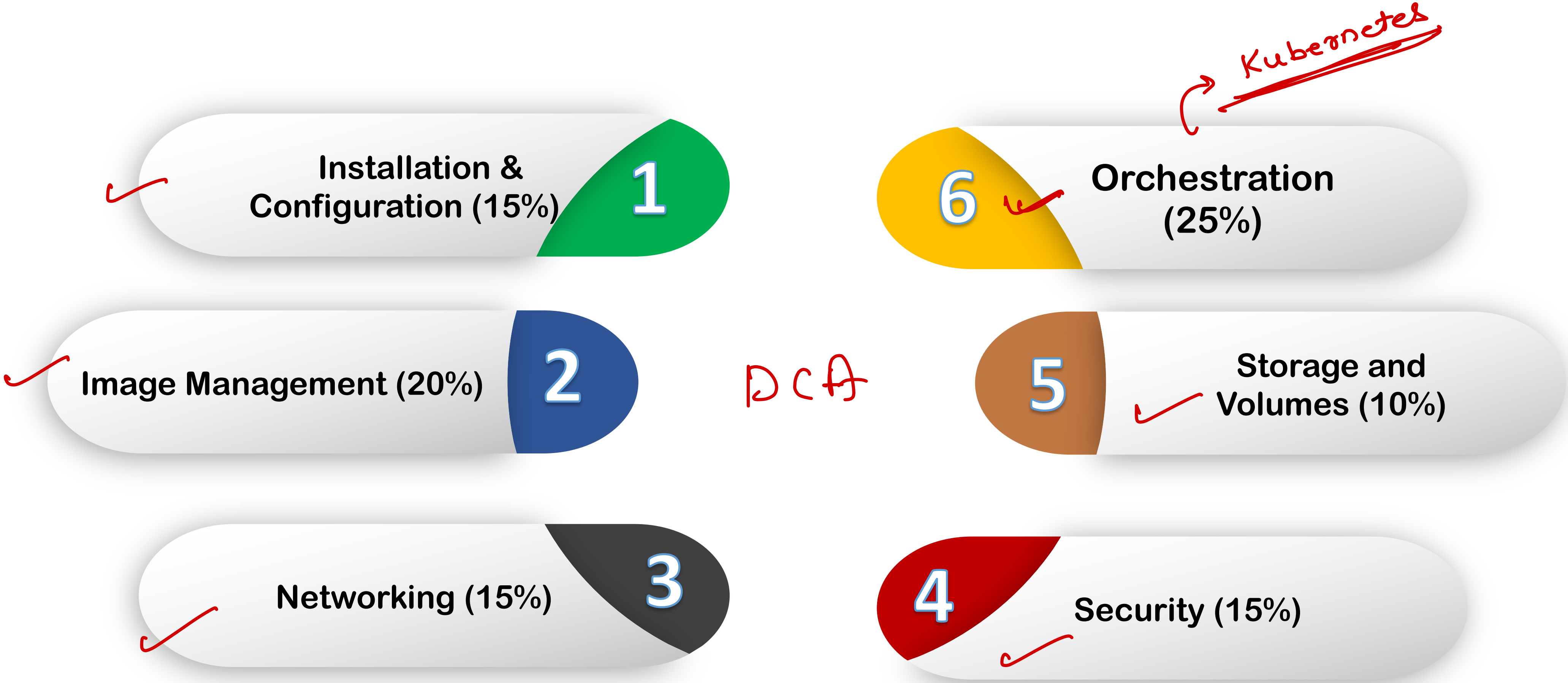
About your instructor

- 12+ years of experience
- Associate Technical Director at Sunbeam
- Freelance Developer
- Worked in various domains using different technologies
- Developed 180+ mobile applications on iOS and Android platforms
- Developed various websites using PHP, MEAN and MERN stacks
- Certification completed
  - Certified Kubernetes Application Developer (CKAD) ✓ ① + CKA ② 60%
  - Certified Jenkins Engineer (CJE)
  - Docker Certified Associate (DCA)

CERTIFIED kubernetes APPLICATION DEVELOPER

Certified Jenkins Engineer 2020

docker CERTIFIED ASSOCIATE



✓ Installation & Configuration (15%) 1

✓ Image Management (20%) 2

✓ Networking (15%) 3

DCA

6 ✓ Orchestration (25%) → Kubernetes

5 ✓ Storage and Volumes (10%)

4 ✓ Security (15%)

Installation and Configuration (15% of exam)

- Demonstrate the ability to upgrade the Docker engine
- Complete setup of repo, select a storage driver, and complete installation of Docker engine on multiple platforms
- Configure logging drivers (splunk, journald, etc)
- Setup swarm, configure managers, add nodes, and setup backup schedule
- Create and manager user and teams
- Interpret errors to troubleshoot installation issues without assistance
- Outline the sizing requirements prior to installation
- Understand namespaces, cgroups, and configuration of certificates
- Use certificate-based client-server authentication to ensure a Docker daemon has the rights to access images on a registry
- Consistently repeat steps to deploy Docker engine, UCP, and DTR on AWS and on premises in an HA config 1, 2, 3
- Complete configuration of backups for UCP and DTR
- Configure the Docker daemon to start on boot

Image Creation, Management, and Registry (20% of exam)

- Describe Dockerfile options(add, copy, volumes, expose, entrypoint, etc)
- Show the main parts of a Dockerfile
- Give examples on how to create an efficient image via a Dockerfile
- Use CLI commands such as list, delete, prune, rmi, etc to manage images
- Inspect images and report specific attributes using filter and format
- Demonstrate tagging an image
- Utilize a registry to store an image
- Display layers of a Docker image
- Apply a file to create a Docker image
- Modify an image to a single layer
- Describe how image layers work
- Deploy a registry (not architect)
- Configure a registry
- Log into a registry
- Utilize search in a registry
- Tag an image
- Push an image to a registry
- Sign an image in a registry
- Pull an image from a registry
- Describe how image deletion works
- Delete an image from a registry

Networking (15% of exam)

- Create a Docker bridge network for a developer to use for their containers
- Troubleshoot container and engine logs to understand a connectivity issue between containers
- Publish a port so that an application is accessible externally
- Identify which IP and port a container is externally accessible on
- Describe the different types and use cases for the built-in network drivers
- Understand the Container Network Model and how it interfaces with the Docker engine and network and IPAM drivers
- Configure Docker to use external DNS
- Use Docker to load balance HTTP/HTTPs traffic to an application (Configure L7 load balancing with Docker EE)
- Understand and describe the types of traffic that flow between the Docker engine, registry, and UCP controllers
- Deploy a service on a Docker overlay network
- Describe the difference between “host” and “ingress” port publishing mode (Host, Ingress)

Security (15% of exam)

- Describe the process of signing an image
- Demonstrate that an image passes a security scan
- Enable Docker Content Trust
- Configure RBAC in UCP
- Integrate UCP with LDAP/AD
- Demonstrate creation of UCP client bundles
- Describe default engine security
- Describe swarm default security
- Describe MTLS

Storage and Volumes (10% of exam)

- State which graph driver should be used on which OS
- Demonstrate how to configure devicemapper
- Compare object storage to block storage, and explain which one is preferable when available
- Summarize how an application is composed of layers and where those layers reside on the filesystem
- Describe how volumes are used with Docker for persistent storage
- Identify the steps you would take to clean up unused images on a filesystem, also on DTR
- Demonstrate how storage can be used across cluster nodes
- Identity roles
- Describe the difference between UCP workers and managers
- Describe process to use external certificates with UCP and DTR (UCP from cli, from GUI, print the public certificates), DTR)

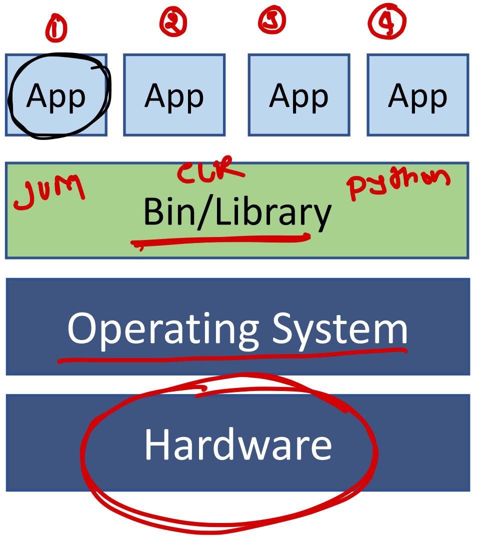
Orchestration (25% of exam) : docker swarm + kubernetes

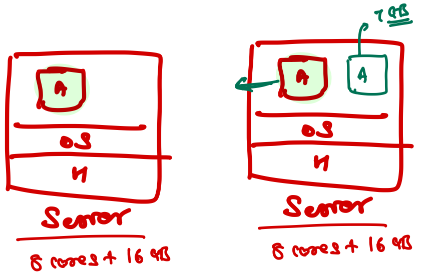
- Complete the setup of a swarm mode cluster, with managers and worker nodes
- State the differences between running a container vs running a service
- Demonstrate steps to lock a swarm cluster
- Extend the instructions to run individual containers into running services under swarm
- Interpret the output of “docker inspect” commands
- Convert an application deployment into a stack file using a YAML compose file with “docker stack deploy”
- Manipulate a running stack of services
- Increase number of replicas
- Illustrate running a replicated vs global service
- Mount volumes
- Add networks, publish ports
- Identify the steps needed to troubleshoot a service not deploying
- Apply node labels to demonstrate placement of tasks
- Sketch how a Dockerized application communicates with legacy systems
- Paraphrase the importance of quorum in a swarm cluster
- Demonstrate the usage of templates with “docker service create”

Fundamentals

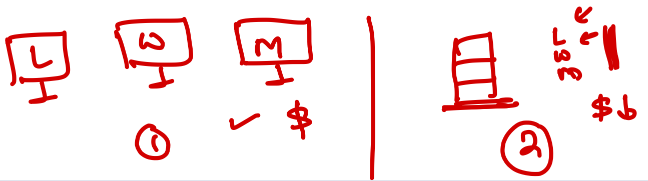
Traditional Deployment (Pre-Virtualization)

- Early on, organizations ran applications on physical servers
- There was no way to define resource boundaries for applications in a physical server, and this caused resource allocation issues
- For example, if multiple applications run on a physical server, there can be instances where one application would take up most of the resources, and as a result, the other applications would underperform
- A solution for this would be to run each application on a different physical server
- But this did not scale as resources were underutilized, and it was expensive for organizations to maintain many physical servers

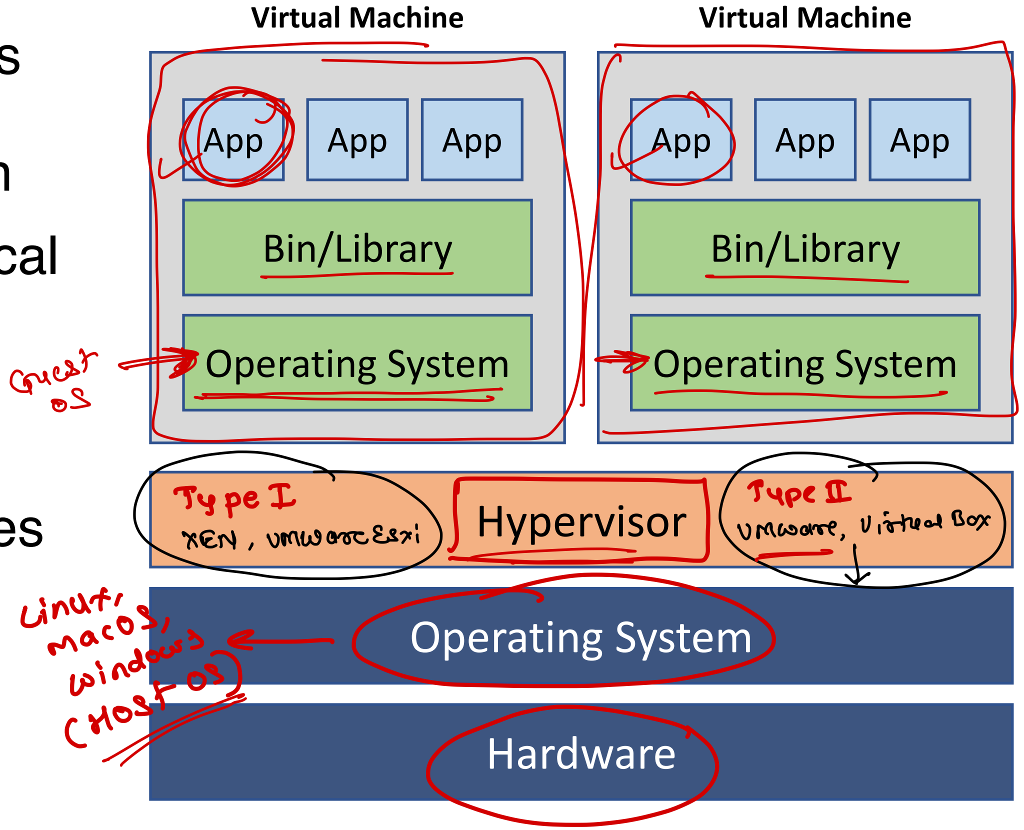




Virtualized Deployment



- It allows you to run multiple Virtual Machines (VMs) on a single physical server’s CPU
- Virtualization allows applications to be isolated between VMs and provides a level of security as the information of one application cannot be freely accessed by another application
- Virtualization allows better utilization of resources in a physical server and allows better scalability because
  - an application can be added or updated easily
  - reduces hardware costs
- With virtualization you can present a set of physical resources as a cluster of disposable virtual machines
- Each VM is a full machine running all the components, including its own operating system, on top of the virtualized hardware



Virtual Machine

App

App

App

Bin/Library

Operating System

Virtual Machine

App

App

App

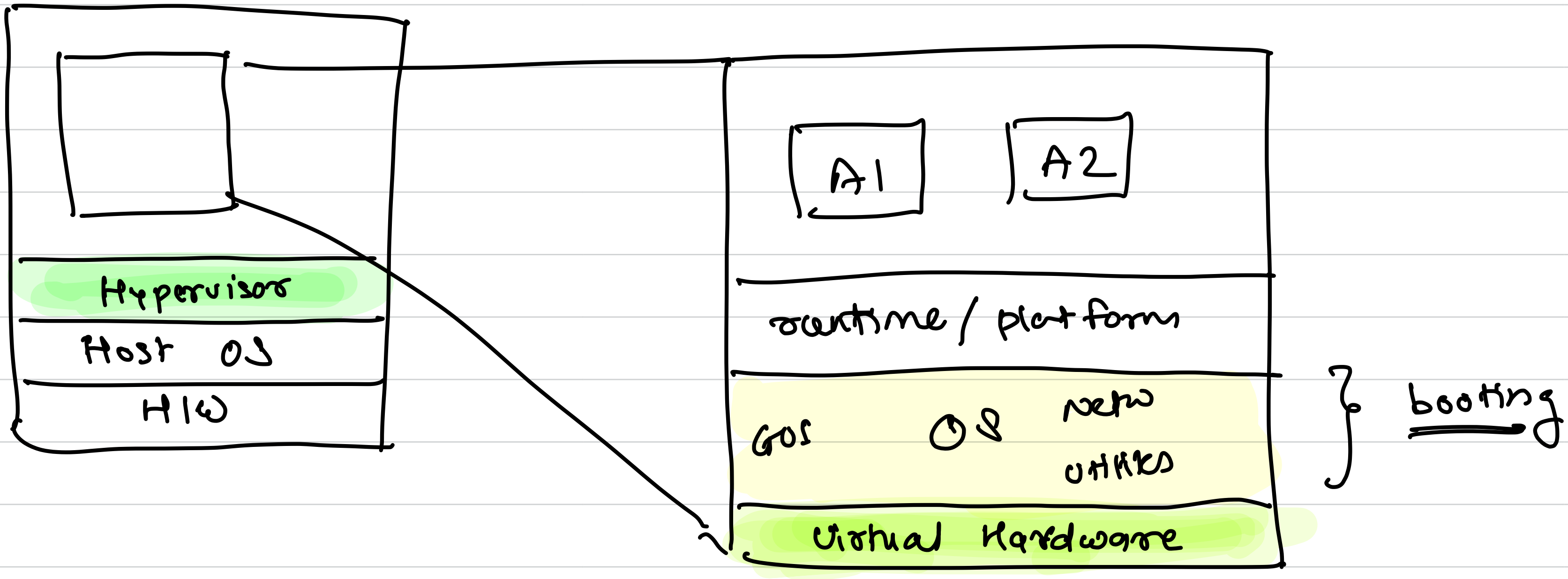
Bin/Library

Operating System

Hypervisor

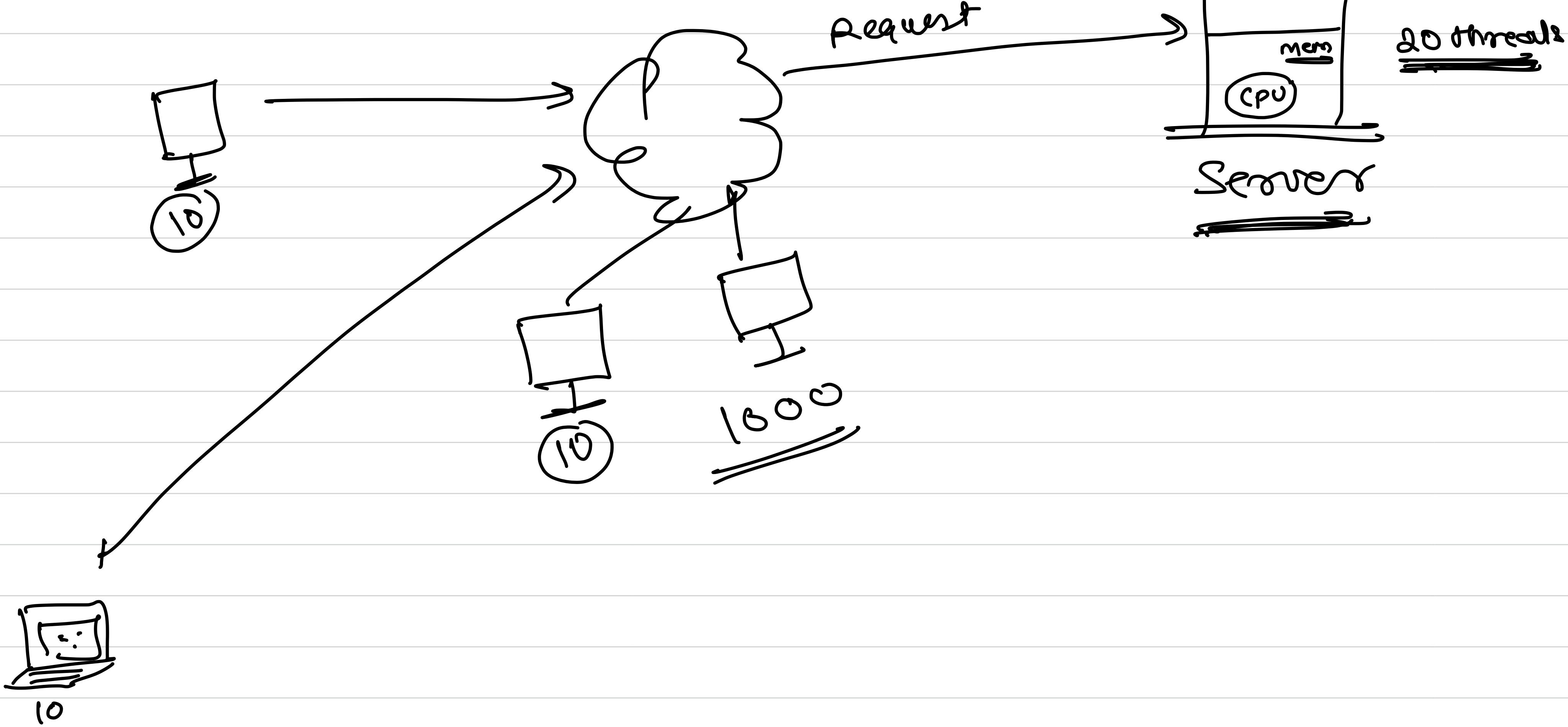
Operating System

Hardware

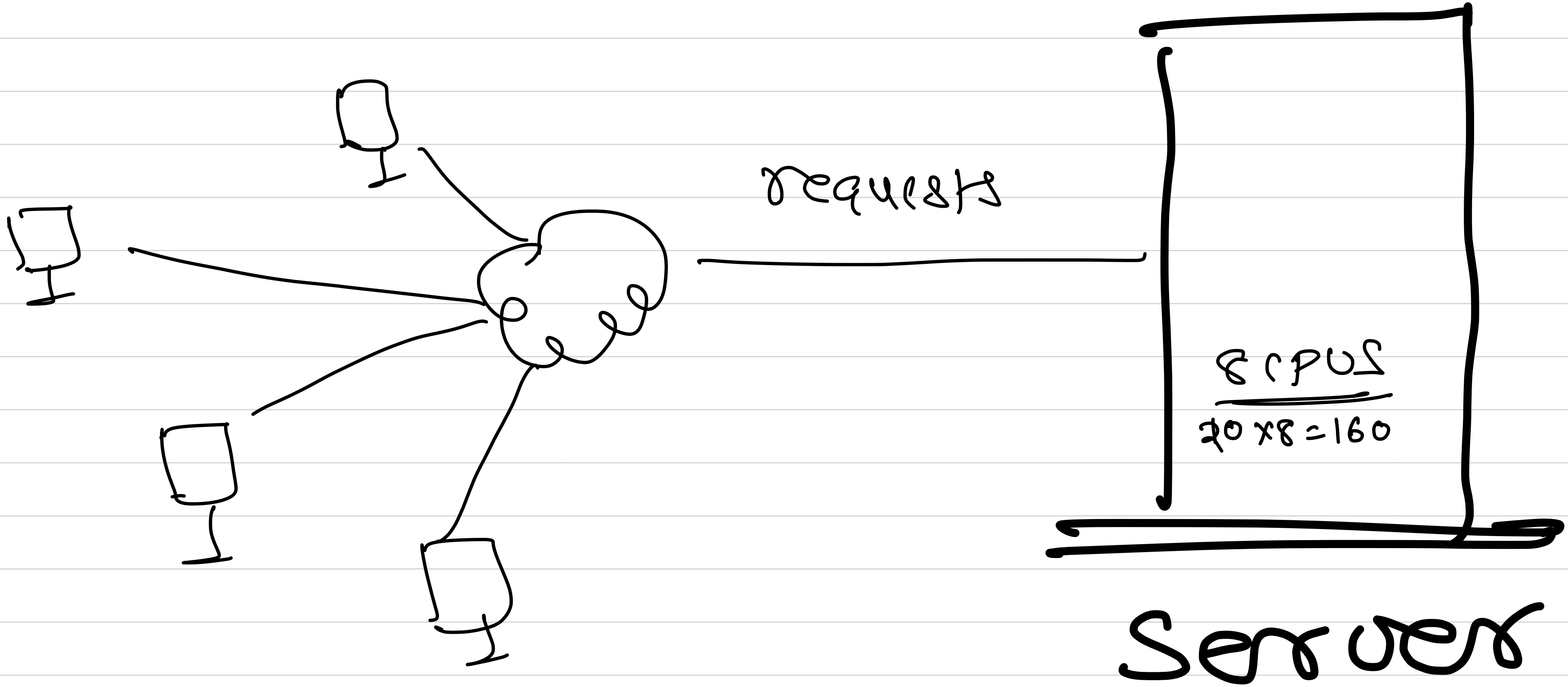


virtual machine

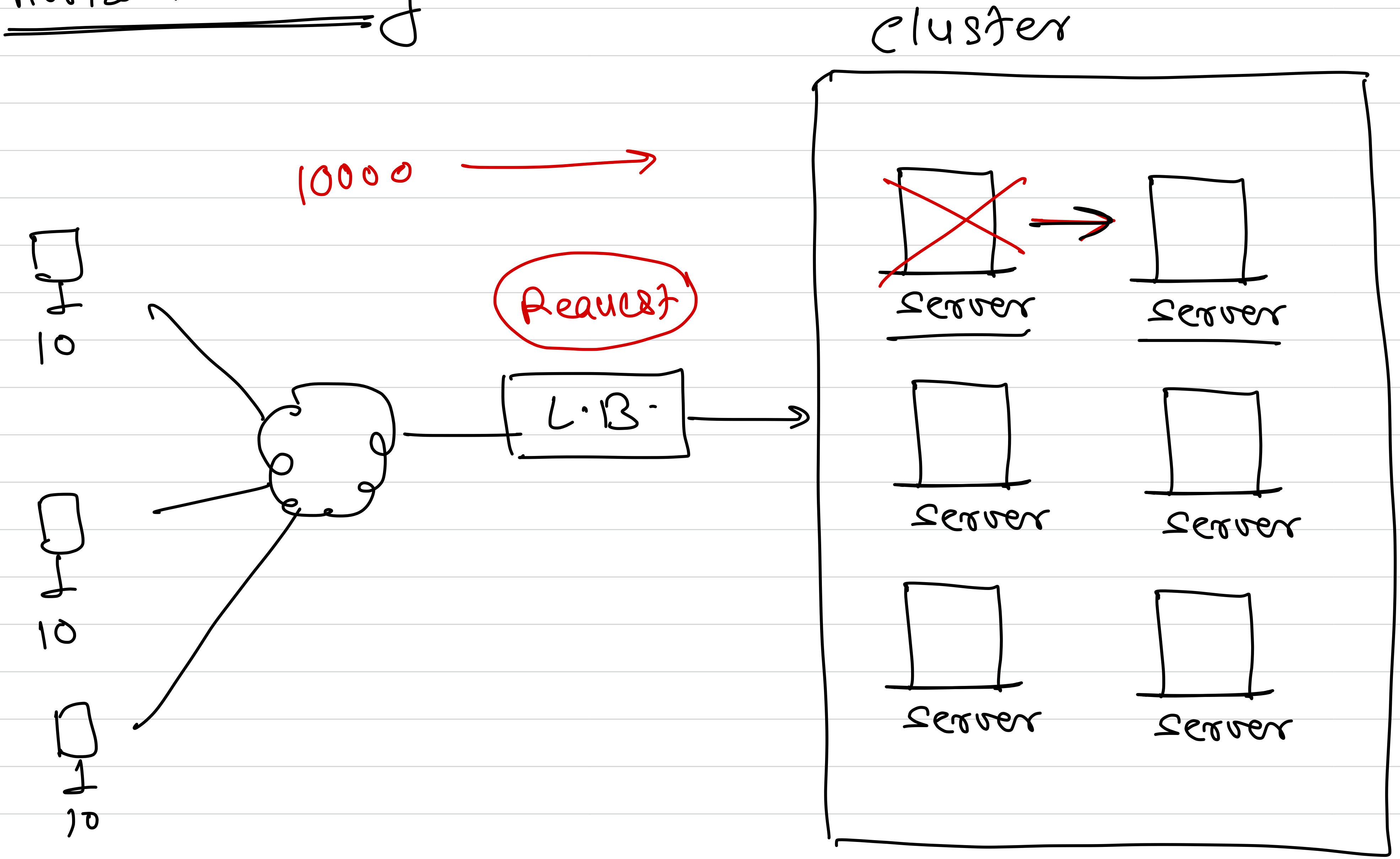
Scaling



Vertical scaling

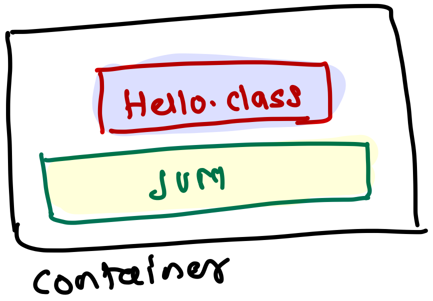


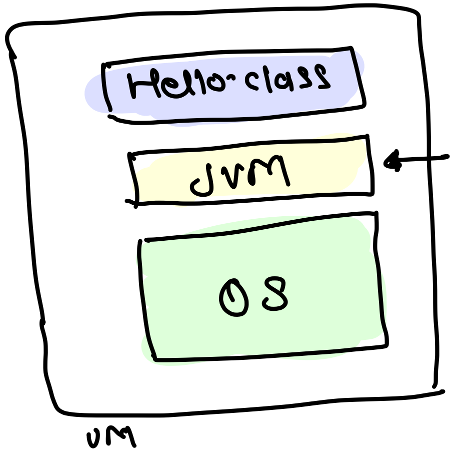
Horizontal scaling

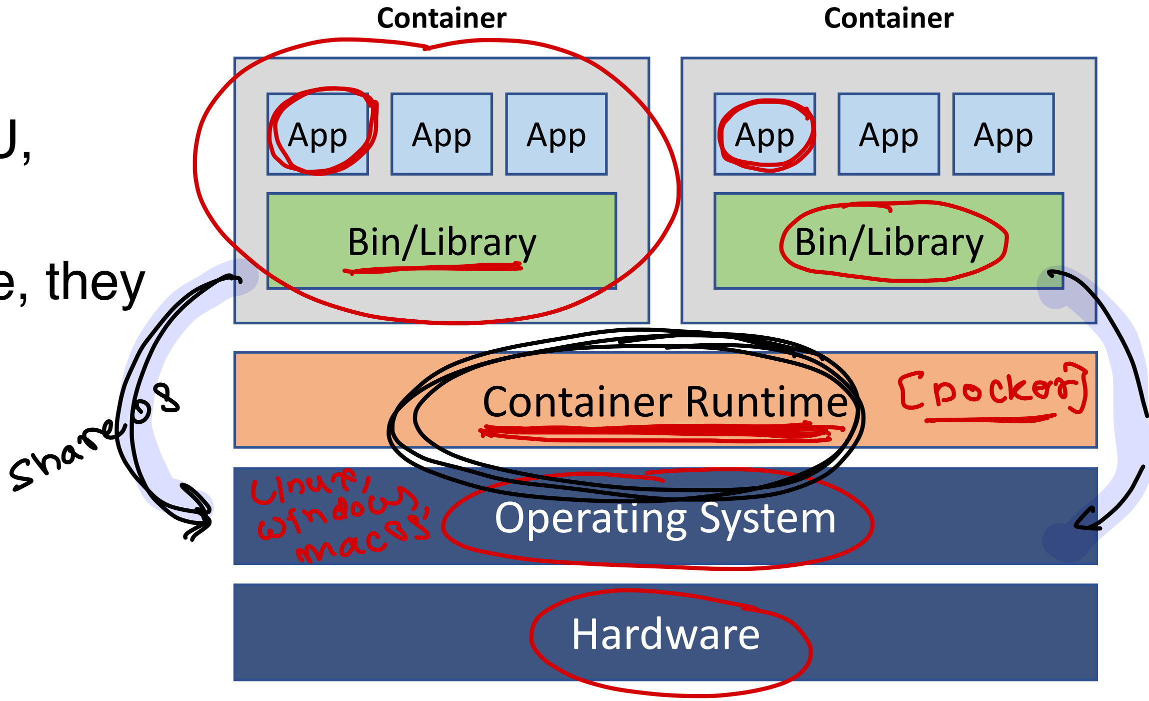


Container deployment

- Containers are similar to VMs, but they have relaxed isolation properties to share the Operating System (OS) among the applications
- Therefore, containers are considered lightweight
- Similar to a VM, a container has its own filesystem, CPU, memory, process space, and more
- As they are decoupled from the underlying infrastructure, they are portable across clouds and OS distributions







Container

- Allows developers to create and deploy applications faster and more securely
- A container is a standard unit which provides single point of service

App + binaries/ Lib

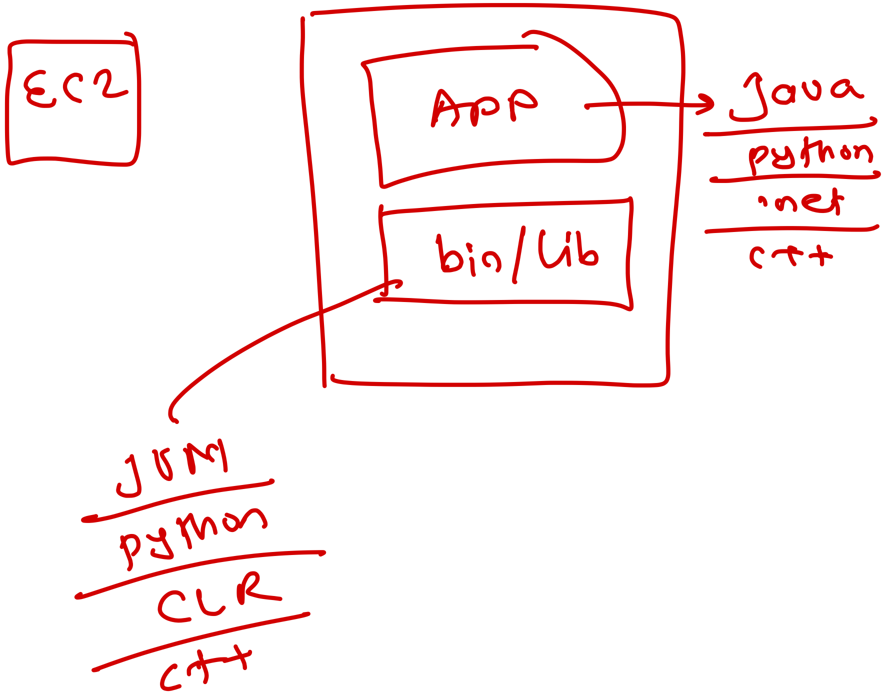
- Involves encapsulating or packaging up software code and all its dependencies so that it can run uniformly and consistently on any infrastructure
- It is a operating system virtualization

Containerization vs Virtualization

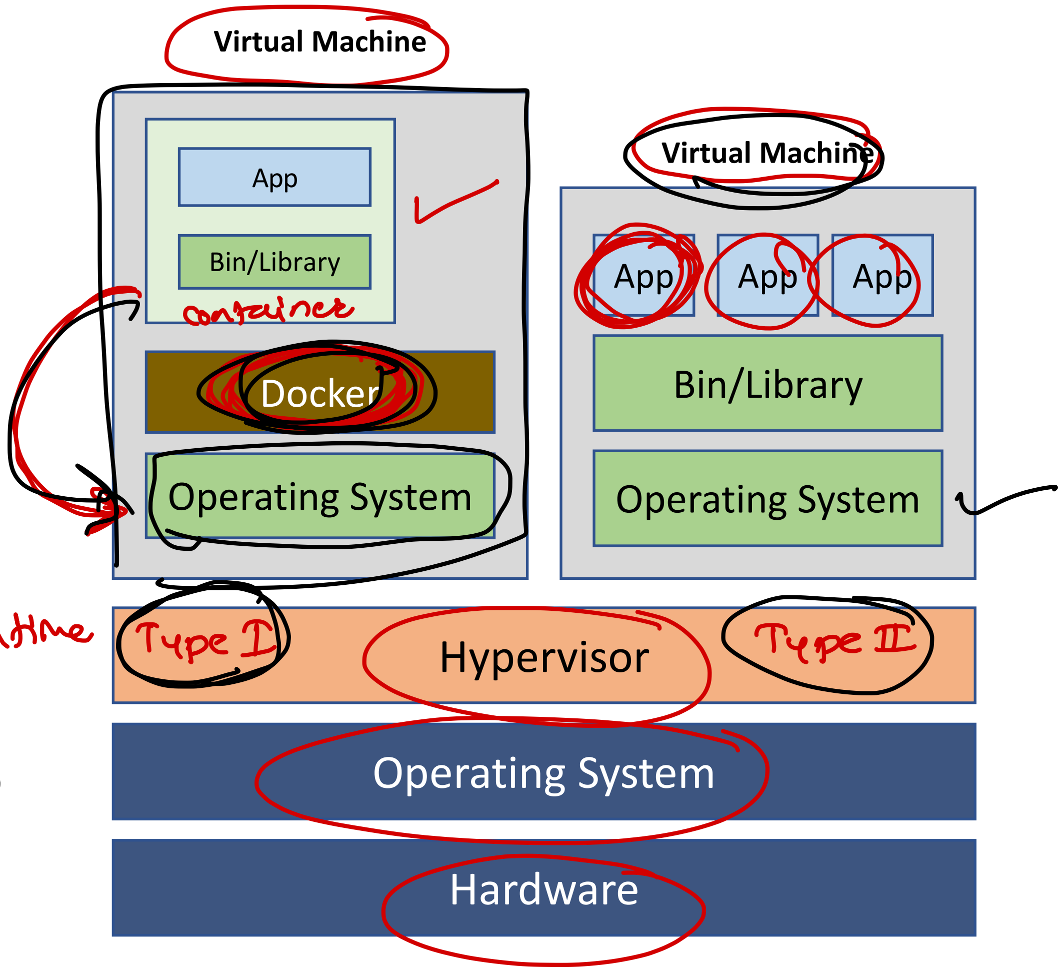
Virtual Machine	✓ Container
Hardware level virtualization	OS virtualization
Heavyweight (bigger in size) OS	Lightweight (smaller in size) no OS
Slow provisioning ← booting	Real-time and fast provisioning no booting
Limited Performance ← Software	Native performance → share OS + H/W
Fully isolated	Process-level isolation → containers will be treated as processes
More secure	Less secure
Each VM has separate OS	Each container ~~can~~ shares OS resources
Boots in minutes	Boots in seconds
Pre-configured VMs are difficult to find and manage	Pre-built containers are readily available
Can be easily moved to new OS	Containers are destroyed and recreated immutable
Creating VM takes longer time	Containers can be created in seconds

Containerization and Virtualization

- Containers can run inside virtual machines
- In which case, a physical machine can host VM that may house Docker containers
- This is preferred in the cloud environment



Container Runtime
- Docker
- containerd
- LXC
- LXD

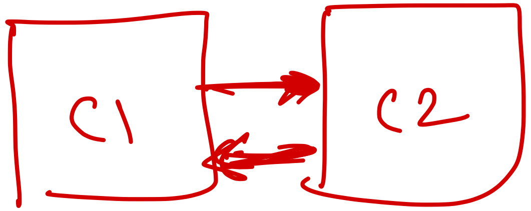


Docker

What is a docker ?

- Docker is containerization platform that enables developer to build, test and deploy the application easily and reliably inside containers
- Docker host runs multiple containers maintaining the isolation between the containers

container runtime ⇒ Docker



Why Docker?

- It is an easy way to create application deployable packages (images)
- Developer can create ready-to-run containerized applications
- It provides consistent computing environment
- It works equally well in on-prem as well as cloud environments
- It is light weight compared to VM

Little history about Docker

- Docker Inc, started by Solomon Hykes, is behind the docker tool
- Docker Inc started as PasS provider called as dotCloud
- In 2013, the dotCloud became Docker Inc
- Docker Inc was using LinuX Containers (LXC) before version 0.9
- After 0.9 (2014), Docker replaced LXC with its own library libcontainer which is developed in Go programming language
- Its not the only solution for containerization
  - “FreeBSD Jails”, launched in 2000
  - LXD is next generation system container manager build on top of LXC and REST APIs
  - Google has its own open source container technology lmctfy (Let Me Contain That For You)
  - Rkt is another option for running containers

Docker Editions

Feature	Docker CE	Docker EE
Container engine with orchestration, networking, security	✓	✓
Certified infrastructure, plugins and ISV containers		✓
Image Management		✓
Container App Management		✓
Secure Image Scanning		✓

Where are you running your containers

Docker Desktop

- Free
- Runs on Windows and macOS
- Installs Docker CE
- Community Support is available

Docker CE

- Server or VM for testing, training and development
- Free
- Runs on Windows and macOS
- Known as CE
- Community support is available

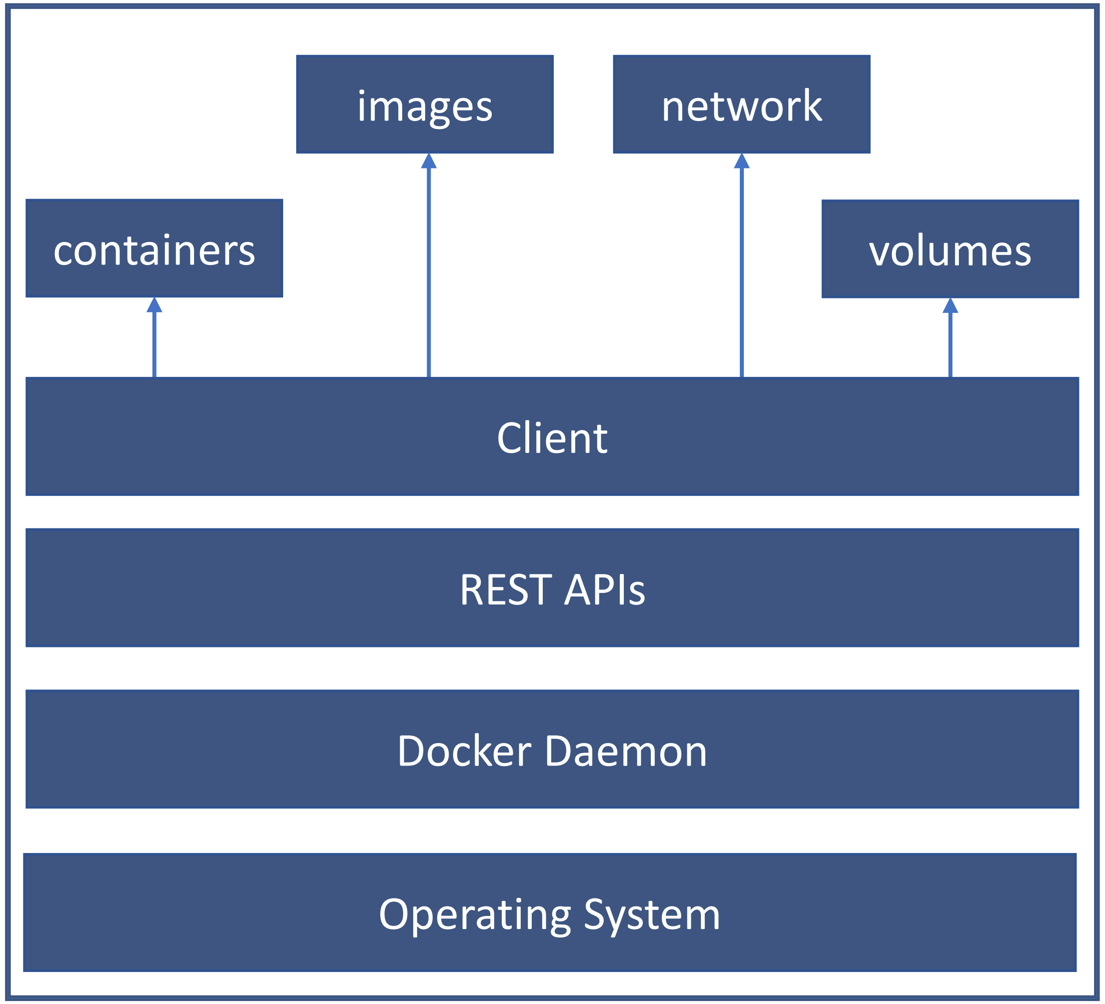
Linux

Docker EE

- Production applications in data center or cloud
- Paid license
- Runs on Windows and Linux
- Known as EE
- Full support is available
- Includes advanced features

Docker Architecture

- Docker daemon (dockerd)
  - Continuous running process
  - Manages the containers
- REST APIs
  - Used to communicate with docker daemon
- Client (docker)
  - Provides command line interface
  - Used to perform all the tasks



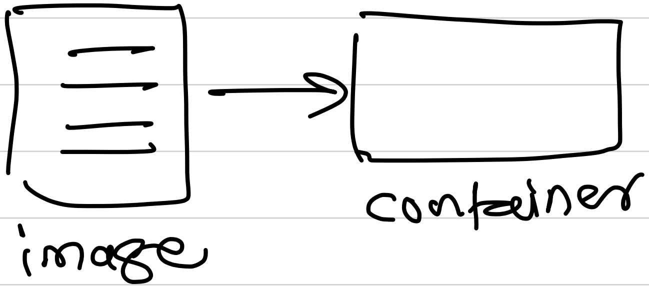
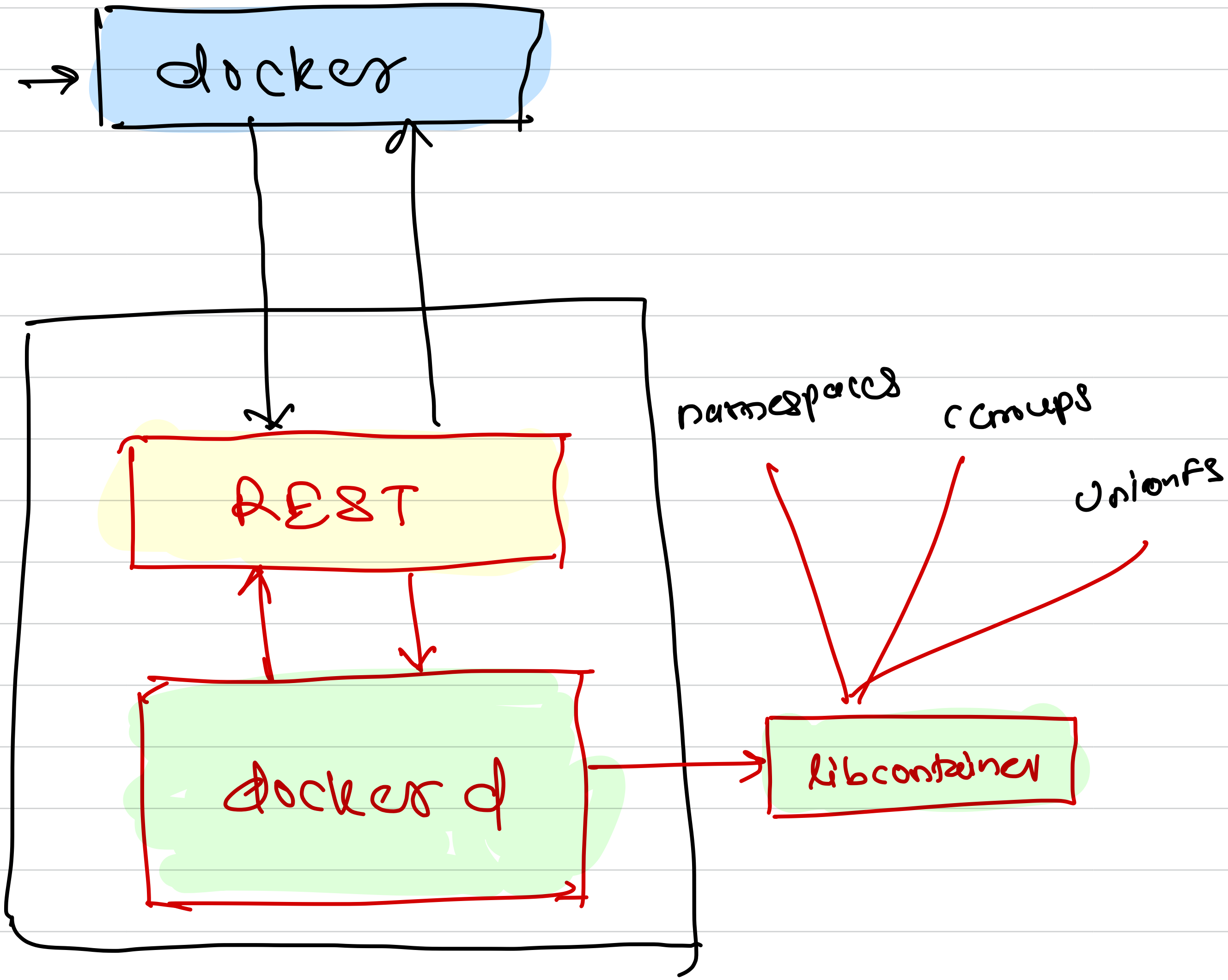
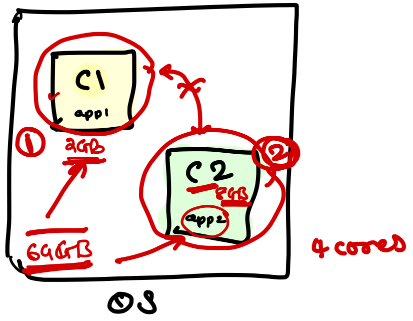


image
container


docker
REST
docker d
libcontainer
namespaces
cgroups
unionfs

libcontainer

- Docker has replaced LXC by libcontainer, which is used to manage the containers
- Libcontainer uses
  - Namespaces
    - Creates isolated workspace which limits what container can see
    - Provides a layer of isolation to the container
    - Each container runs in a separate namespace
    - Processes running in a namespace can interact with other processes or use resources which are the part of the same namespace
    - E.g. process ID, network, IPC, Filesystem
  - Control Groups (cgroups)
    - Used to share the available resources to the conainers
    - It optionally enforces limits and constraints on resource usage
    - It limits how much a container can use
    - E.g. CPU, Disk space, memory



libcontainer

- Union File System (UnionFS)
  - It uses layers
  - It is a lightweight and very fast FS
  - Docker uses different variants of UnionFS
    - Aufs (advanced multi-layered unification filesystem)
    - BtrFS (B-Tree FS)
    - VFS (Virtual FS)
    - Devicemapper

Docker Objects

- **Images**: read only template with instructions for creating docker containers
- **Container**: running instance of a docker image
- **Network**: network interface used to connect the containers to each other or external networks
- **Volumes**: used to persist the data generated by and used by the containers
- **Registry**: private or public collection of docker images
- **Service**: used to deploy application in a docker multi node cluster

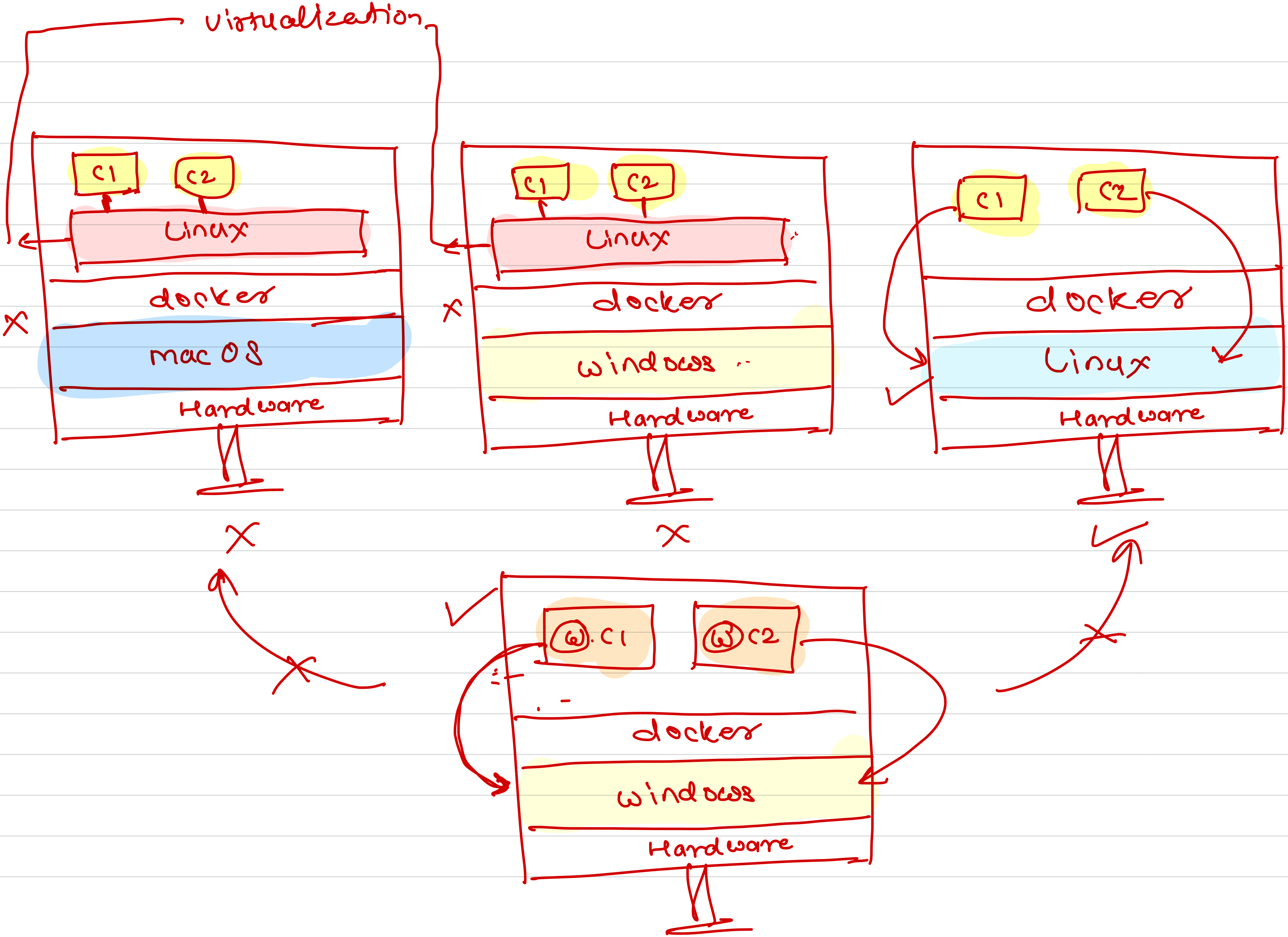
Installation

- macOS
- Windows
- Linux (Ubuntu)

Docker Images

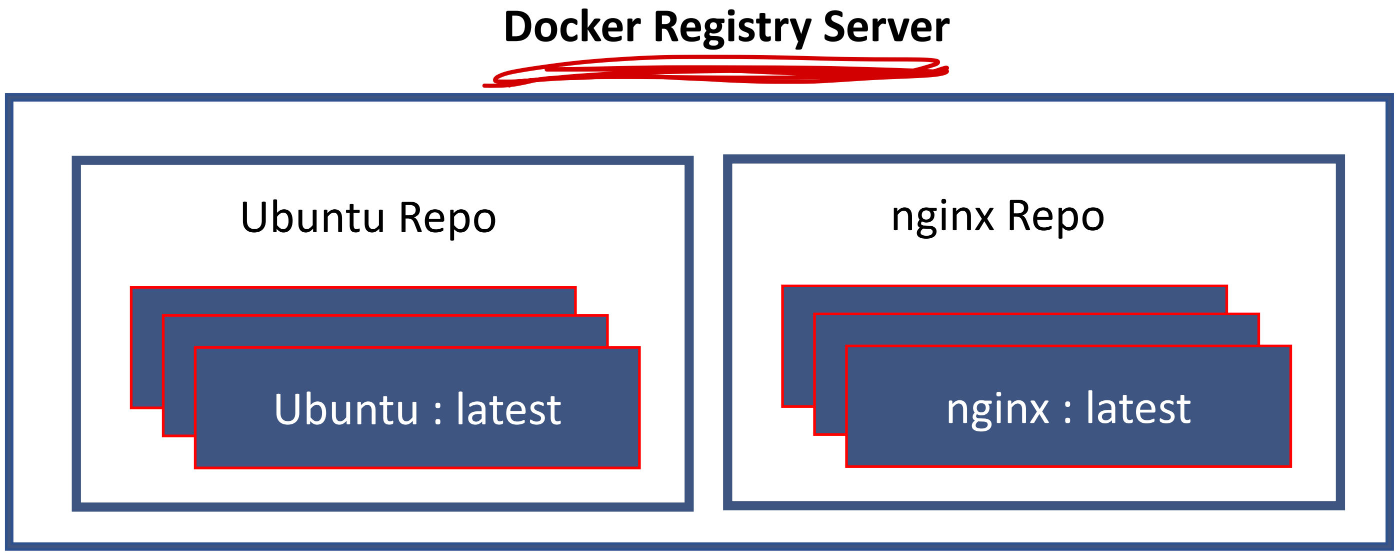
Docker Image

- An executable package that includes everything needed to run an application – the code, a runtime, libraries, environment variables and configuration files
- Read only template which has instructions for running docker containers
- In order to run a container, developer first need to package the application along with its dependencies in the form of a docker image
- It is highly portable and can be shared over network, stored and updated
- Docker provides public or private registry which contains collection of pre-built images
- If the image you are looking for is not available publicly, you can create your image using Dockerfile
- One image can be based on another image


virtualization
c1
c2
Linux
docker
mac OS
Hardware
c1
c2
Linux
docker
windows
Hardware
c1
c2
docker
Linux
Hardware
w.c1
w c2
docker
windows
Hardware

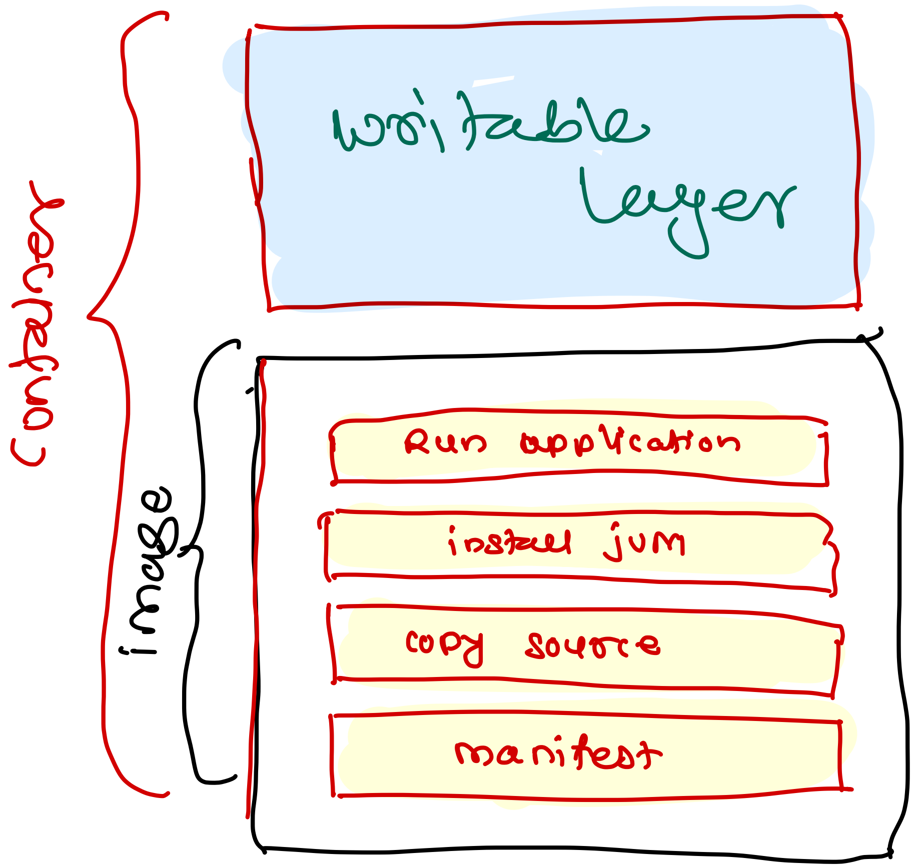
Docker Image

- Read-only instructions to run the containers
- It is made up of different layers
- Repositories hold images
- Docker registry stores repositories
- To create a custom image
  - Commit the running container
  - Use a Dockerfile



Layered File System

- Docker images are made up of multiple layers
- Docker uses UnionFS for implementing the layered docker images
- Any update on the image adds a new layer
- When an image is instantiated into a container, a top writable layer is created (which is deleted when container is removed)
- Docker uses storage drivers to manage the contents of image layer and writable layer
- Each storage driver handles the implementation differently, but all drivers use stackable image layers and copy-on-write (CoW) strategy)



Managing Docker Images

- Search images on docker hub
- Download/pull image
- Get information of an image
- List all pulled images
- Remove an image

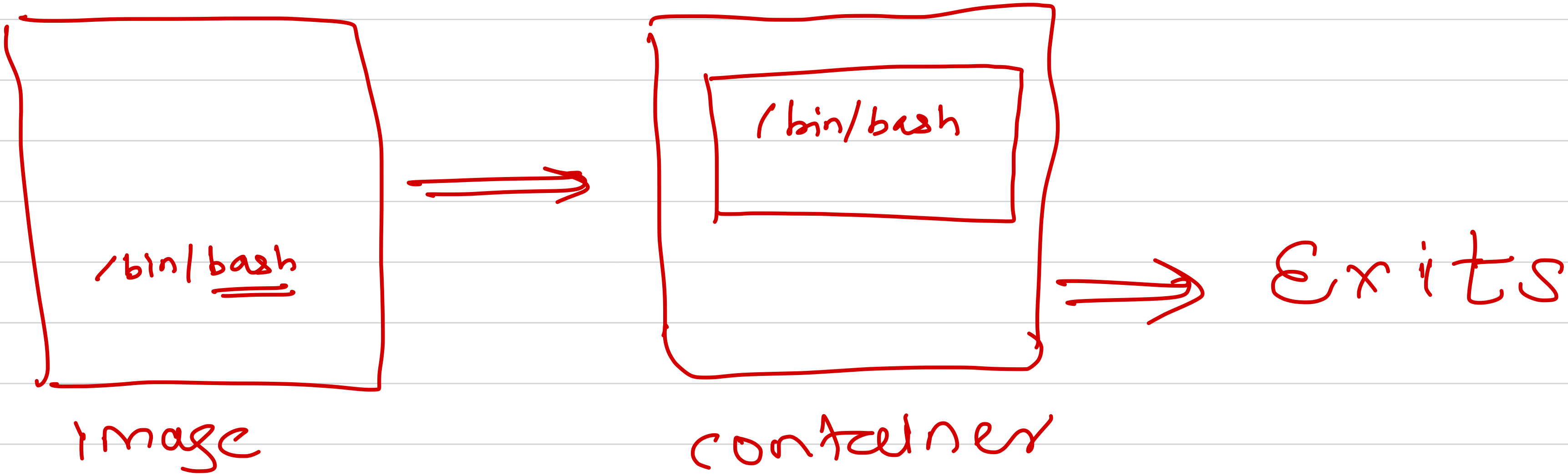
Docker Container

Container

- It is a running aspect of docker image
- Contains one or more running processes (instructions)
- It is a self-contained environment
- It wraps up an application into its own isolated box (application running inside a container has no knowledge of any other applications or processes that exist outside the container)
- A container can not modify the image from which it is created
- It consists of
  - Your application code
  - Dependencies (lib / binaries)
  - Networking
  - Volumes

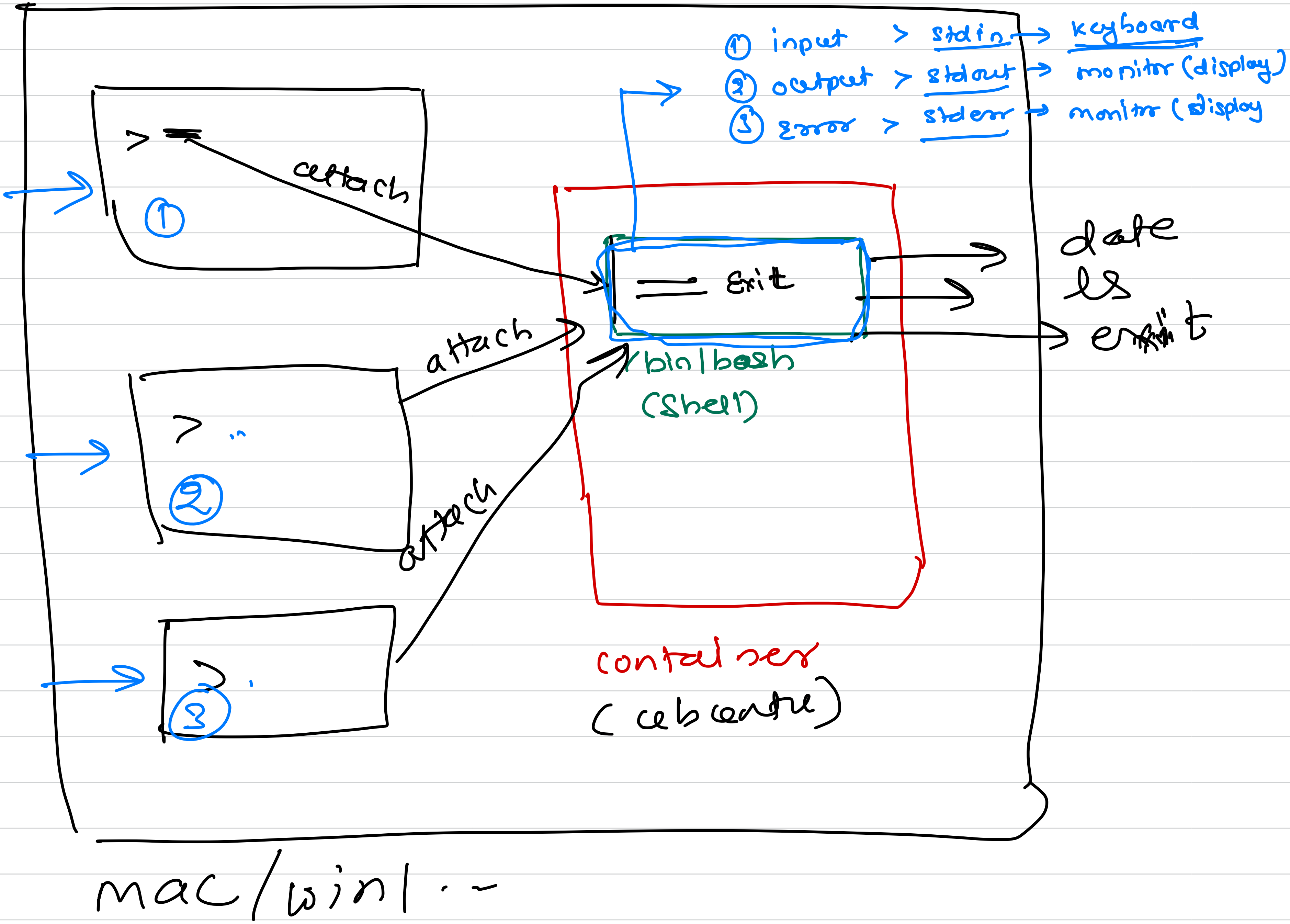
Managing Containers

- List the running containers on the host
- Create a container
- Start a created/stopped container
- Run a container
- Stop a container
- Restart a container

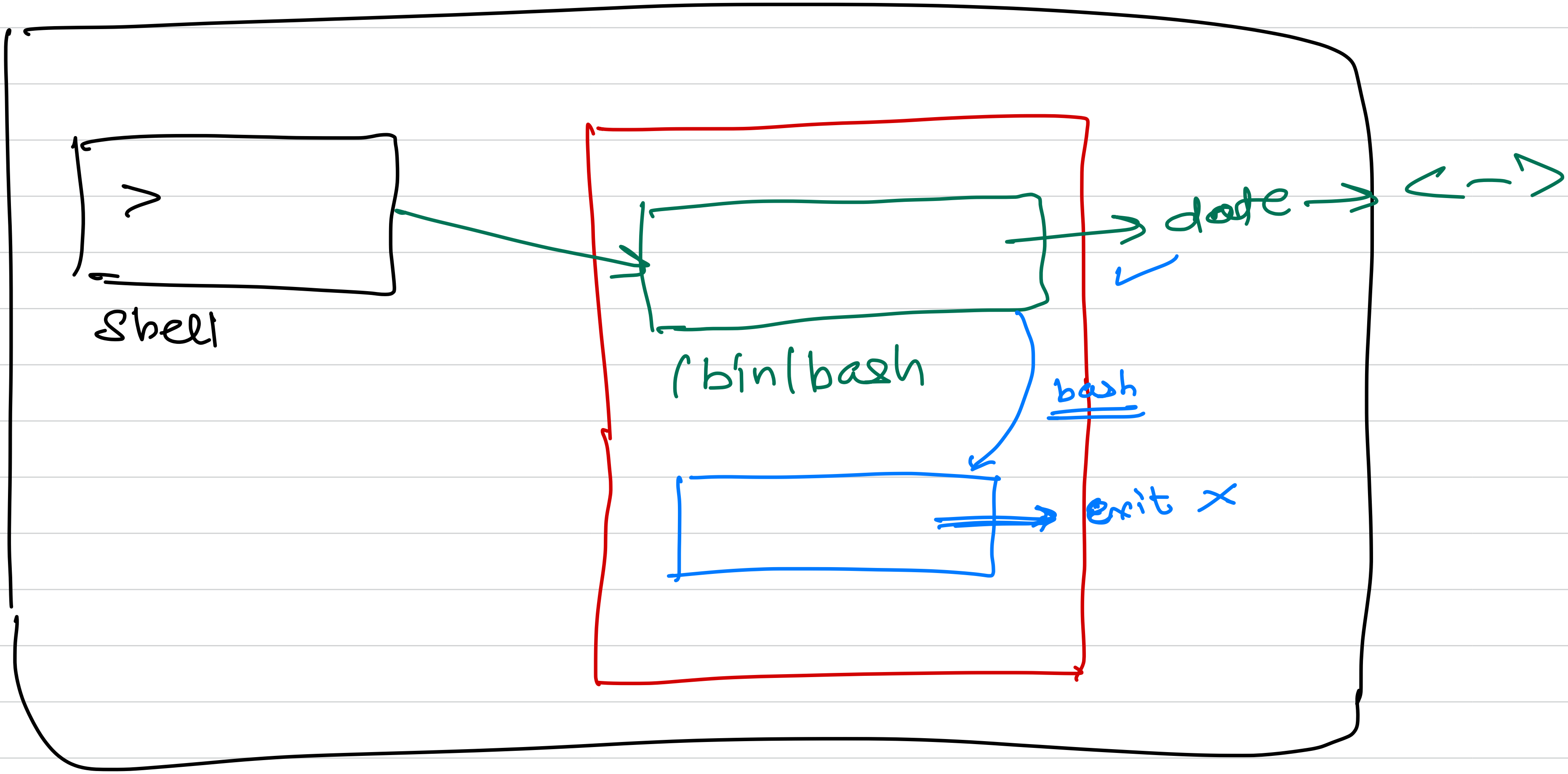


```
docker container run <parms> <image name> [command]
```

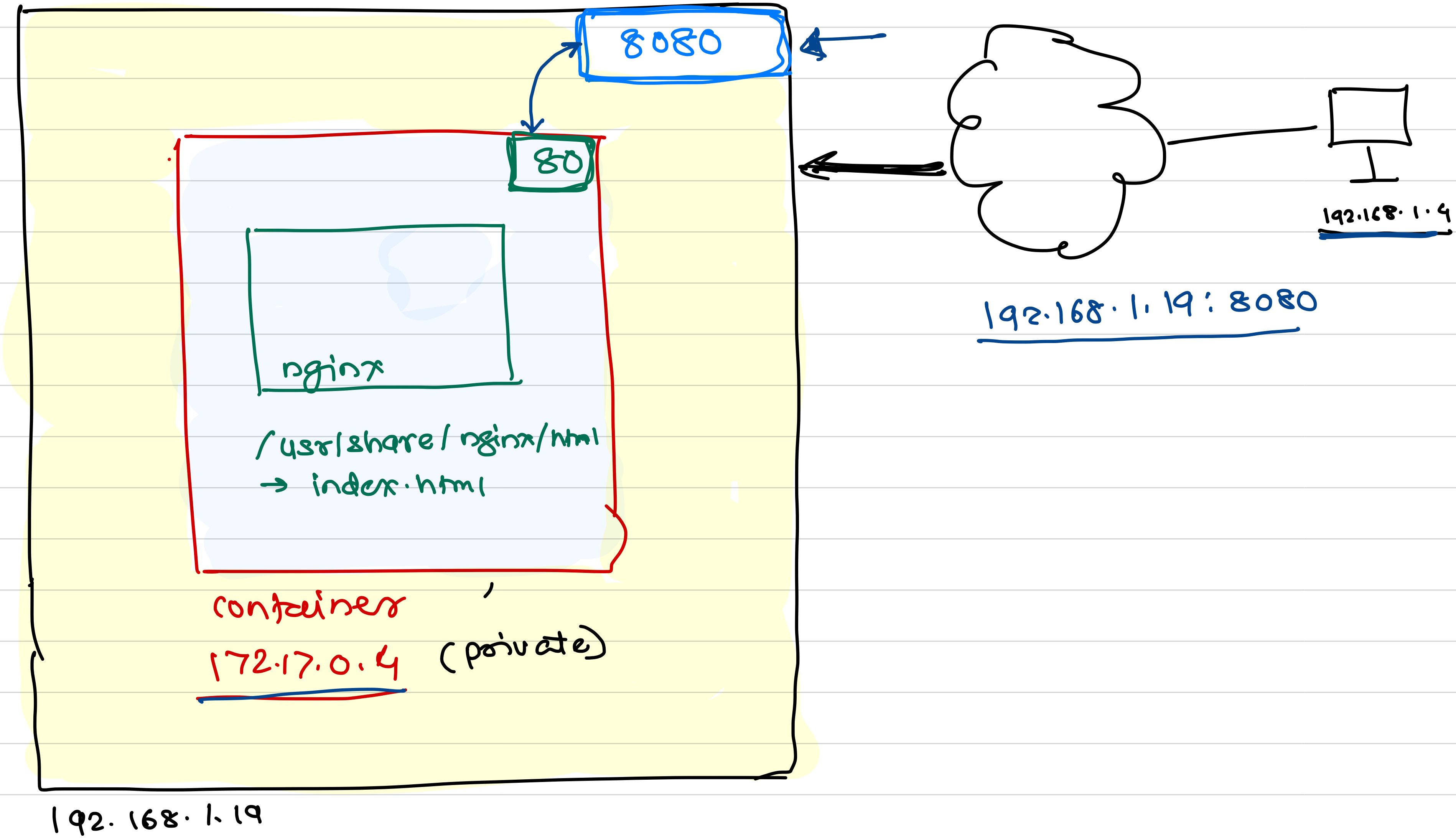
attach mode


① input > stdin → keyboard
② output > stdout → monitor (display)
③ error > stderr → monitor (display)
> =
attach
①
>
②
attach
attach
>
③
= exit
/bin/bash
(shell)
date
ls
exit
container
(ubuntu)
mac/win/..

detach mode



Port forwarding



Where are the containers stored?

- Containers are stored under /var/lib/docker
- This directory contains
  - image
  - containers
  - network
  - volumes
  - swarm

Hostname and name of container

- To check the host name
    - Go inside the container
    - Check the hostname by using a command hostname
- Docker uses the first 12 characters of container id as hostname
- Docker automatically generates a name at random for each container

Publishing port on container

- Publishing a port is required to give an external access to your application
- Port can be published only at the time of creating a container
- You can not update the port configuration on running container

Container information

- Docker top command
- Docker stats command
- Docker inspect command

Docker Network

Overview

- By default docker creates following networks on the host
  - Bridge
  - Host
  - None
- Task
  - Check the networks on the host machine
  - Get more information of any network

Bridge network

- Containers run on a separate network stacks, internal to docker host
- All of the containers share the external IP of the host machine using NAT
- Docker by default puts new container on bridge network
- Task
  - Get information about the bridge network
  - Run two containers on bridge network with same port published

Host network

- Containers behave just as any other process running in the docker host
- Host network adds the containers on the host's network stack
- There will be no isolation between the host machine and the container
- Does not perform any operation on incoming traffic (NAT)
- Task
  - Run a container on host network and verify the IP address
  - Run two containers on host network with same port published

Modify network settings on container

- Docker allows to modify the network settings without the need to restart the container
- Tasks
  - Start a container on none network
  - Disconnect the none network
  - Connect to bridge network

Custom network

- Docker network command can be used to create custom networks
- To create a custom network we have to use a driver
- If driver is not mentioned then docker uses bridge by default
- We can create as many networks as we need
- Tasks
  - Create a custom bridge network
  - Check the network interfaces on the docker host
  - Run a container using the newly created network

Remove the network

- Default networks can not be removed
- Active networks can not be removed
- Tasks
  - Create a custom network
  - Remove that custom network

- Prune command can be used to remove all unused networks

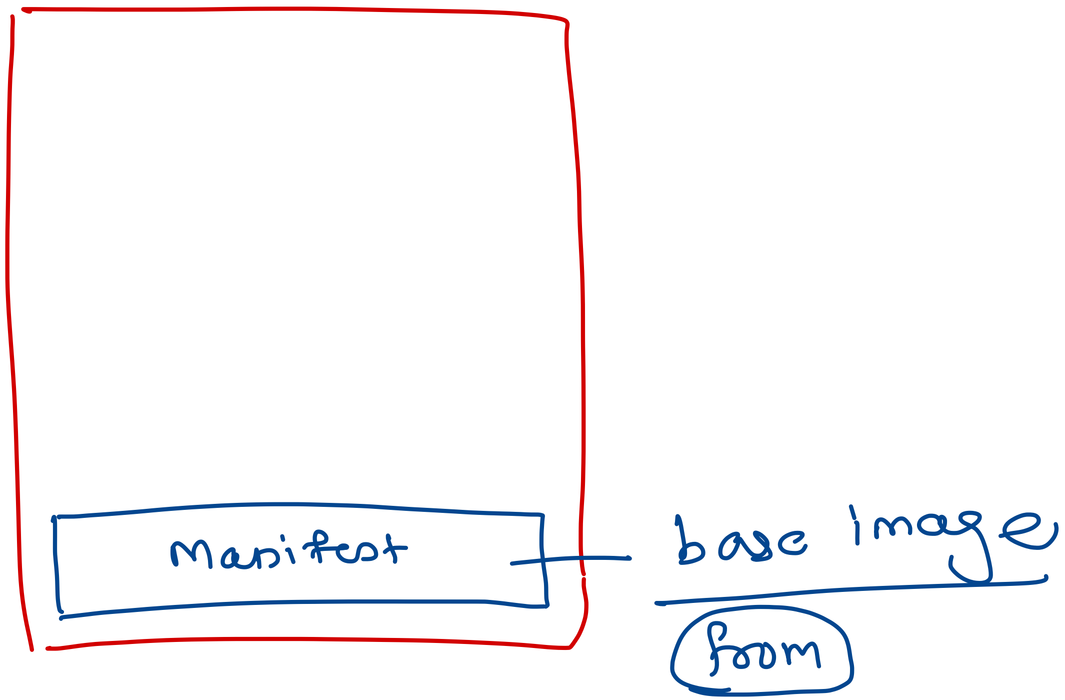
Docker Images (Advanced)

Dockerfile

- The Dockerfile contains a series of instructions paired with arguments
- Each instruction should be in upper-case and be followed by an argument
- Instructions are processed from top to bottom
- Each instruction adds a new layer to the image and then commits the image
- Upon running, changes made by an instruction make it to the container

Dockerfile instructions

- FROM ✓
- ENV ✓
- RUN ✓
- CMD ✓
- EXPOSE ✓
- WORKDIR ✓
- ADD ✓
- COPY ✓
- LABEL ✓
- MAINTAINER ✓
- ENTRYPOINT ✓

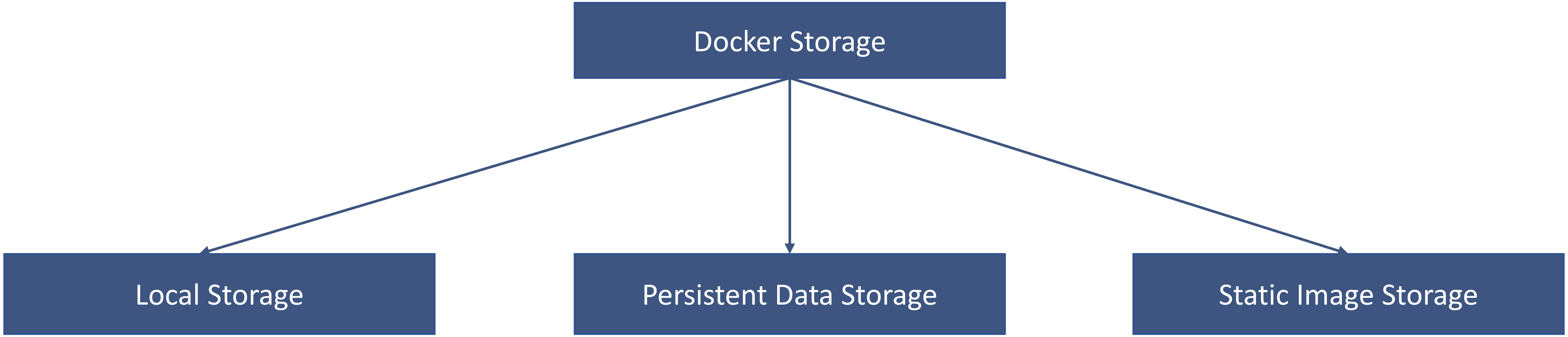


Sharing docker images

- Docker provides public docker hub to share the images
- Task
  - Create an image using Dockerfile
  - Push the image to dockerhub

Docker Volume

Overview



Docker Storage

Local Storage

Persistent Data Storage

Static Image Storage

Local Storage

- Storage provided for docker image run
- Uses storage drivers to read FS layers from a container

Persistent Data Storage

- Saving data beyond the container lifecycle
- Data is stored outside the container

Static Image Storage

- Storing images in the docker registry
- Image stored in the registry will not run unless container is spawned

Storage drivers

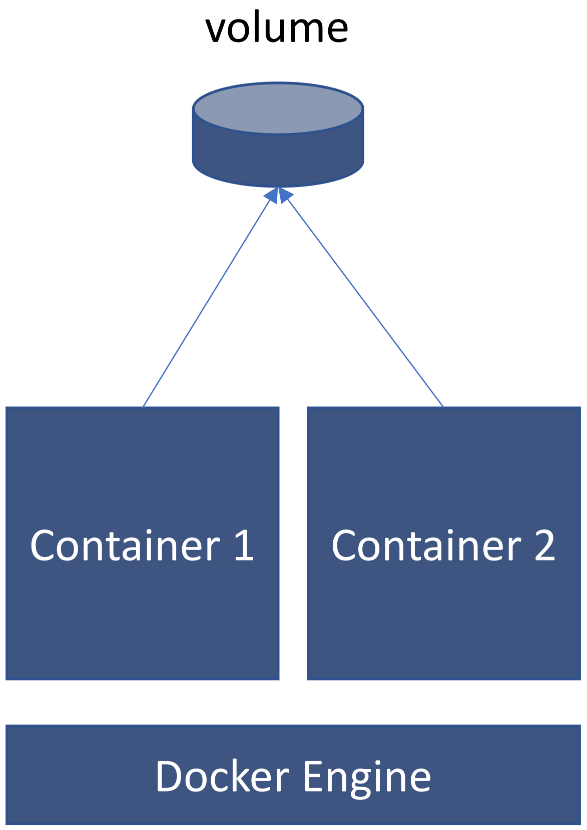
- Docker supports several different storage drivers
- E.g.
  - Overlay2
    - preferred storage driver, for all currently supported Linux distributions,
    - Requires no extra configuration
  - Aufs
    - Preferred storage driver for Docker 18.06 and older, when running on Ubuntu 14.04 on kernel 3.13 which has no support for overlay2
  - Devicemapper
    - is supported, but requires direct-lvm for production environments
  - Btrfs and zfs
    - Used if they are the backing filesystem (snapshots)
  - Vfs
    - Intended for testing purposes
- Tasks
  - Get the docker disk usage
  - Get the current storage driver configured

Local Storage

- Size taken by container
  - Size: data on the writable layer
  - Virtual Size: read-only image data + writable layer size
- Multiple containers share the image hence the image size will be shared
- Tasks
  - Create a container
  - Get the size information

Persistent Storage

- Downsides of using local storage for containers
  - Data does not persist when container is removed
  - Writable layer is tightly coupled to the host machine
- Volume provides persistent storage
- Allows to share the data among containers
- Can be managed using the docker CLI commands
- NOTE: Volume does not increase the size of container using it



Persistent Storage

- Volumes
  - Stored in the docker managed FS of the host
  - Supports the use of Volume Drivers
- BindMounts
  - Stored anywhere in the host
  - E.g. you can mount a local directory with the container to share the contents
- Tmpfs Mounts
  - Temporary and stored in the host’s memory
  - When the container stops, the tmpfs mount is removed
  - If the container is committed then tempfs is not saved
  - Available only with docker on linux