Docker

Information security club course II

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v0.1

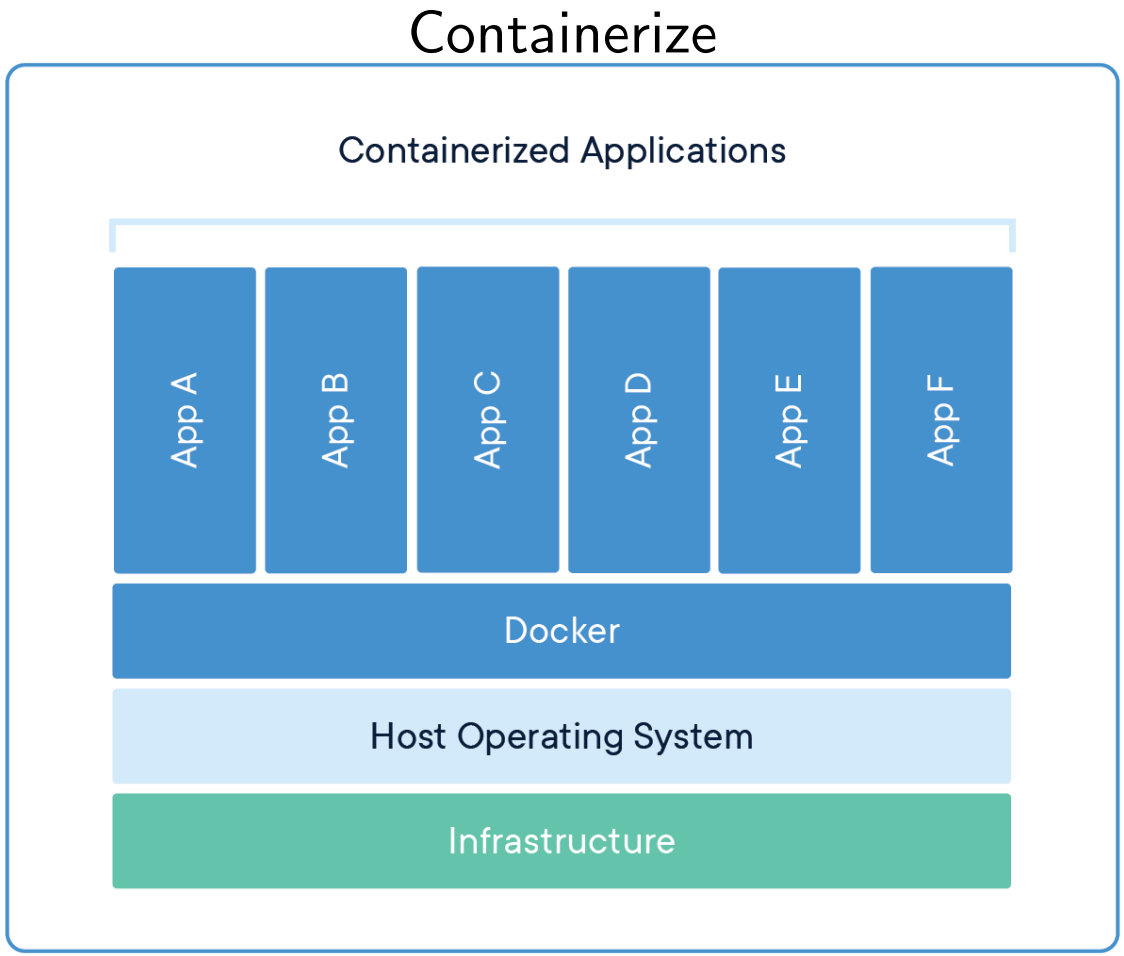
Outline

Before the speech

- The 'Learning Corner TA' of operating system class
  - 18:00 $\rightarrow$ 21:00 (Thur.)
  - EC1013
  - From 25nd March 2021
- The other time for OS problems
  - 18:00 $\rightarrow$ 21:00 (Fri.)
  - EC3034
  - Send an email before you come.
- zxc25077667@protonmail.com
- We learn more only if you ask.

Container

Big idea

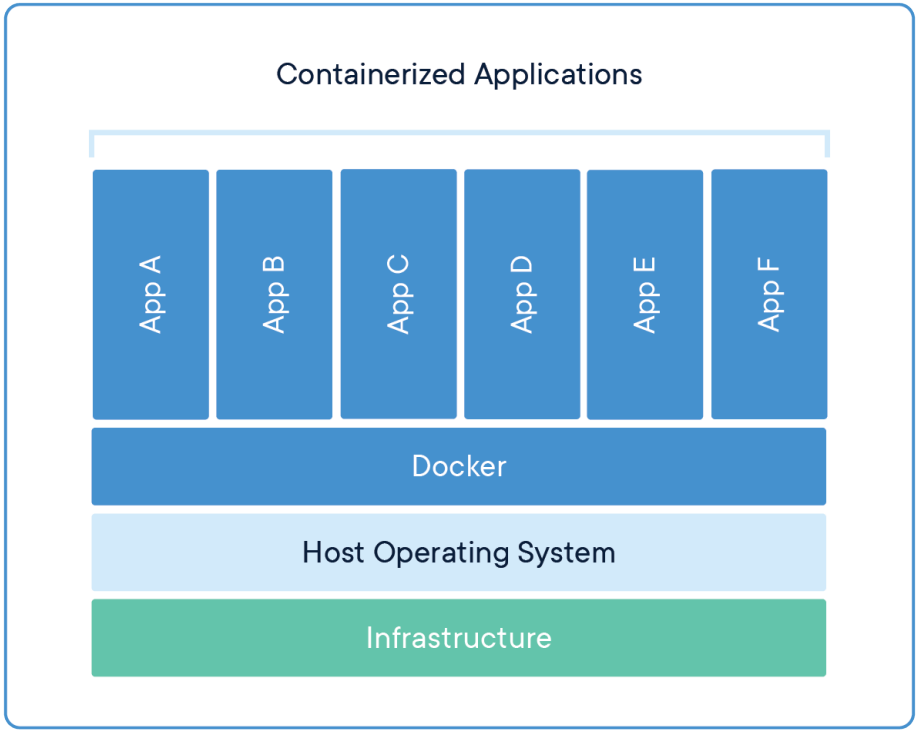

Containerize
Containerized Applications
App A
App B
App C
App D
App E
App F
Docker
Host Operating System
Infrastructure

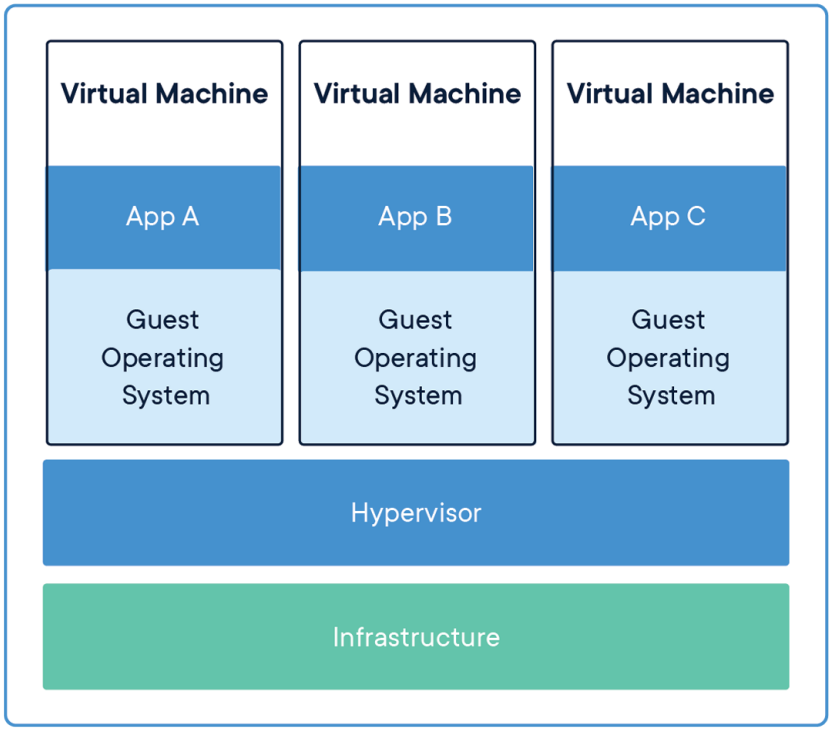
[1]

Big idea

[2]

Compare with virtule machines

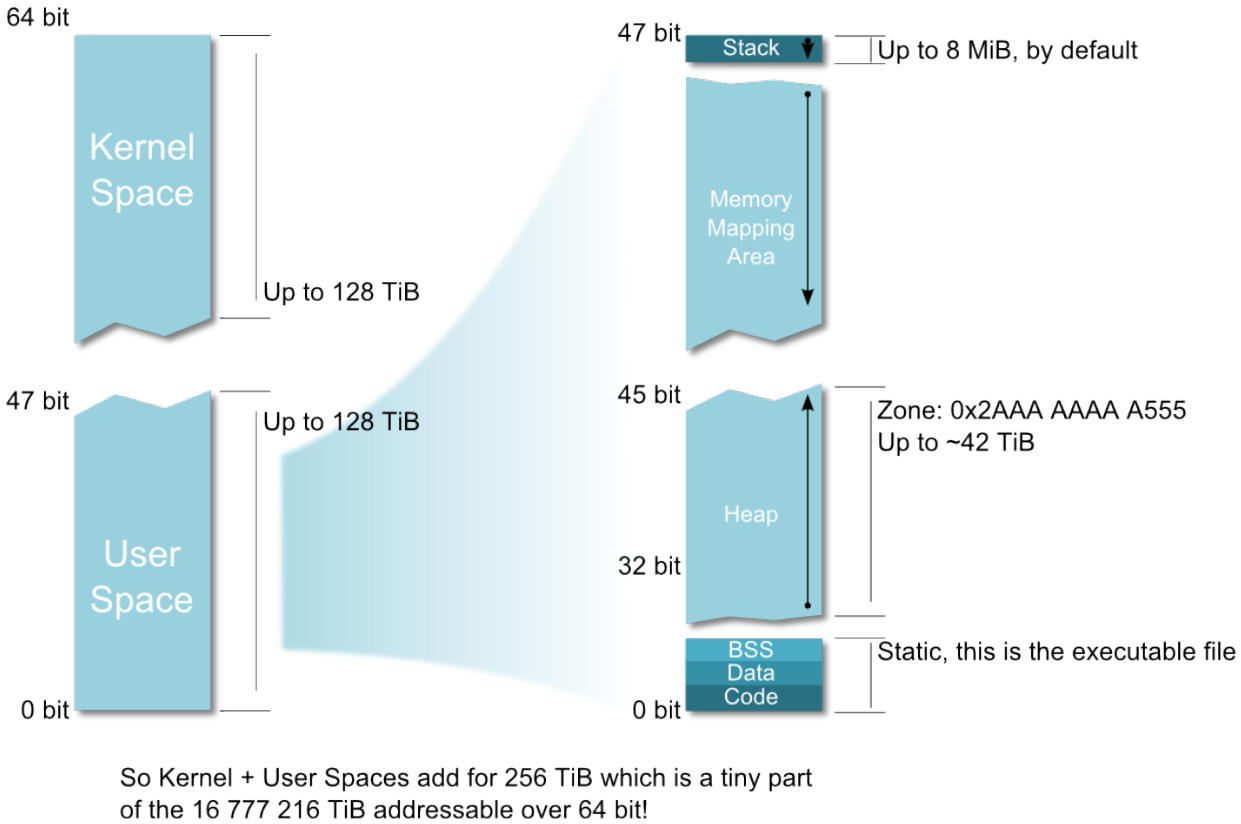




Wait, what is Hypervisor?

So, what is share kernel?

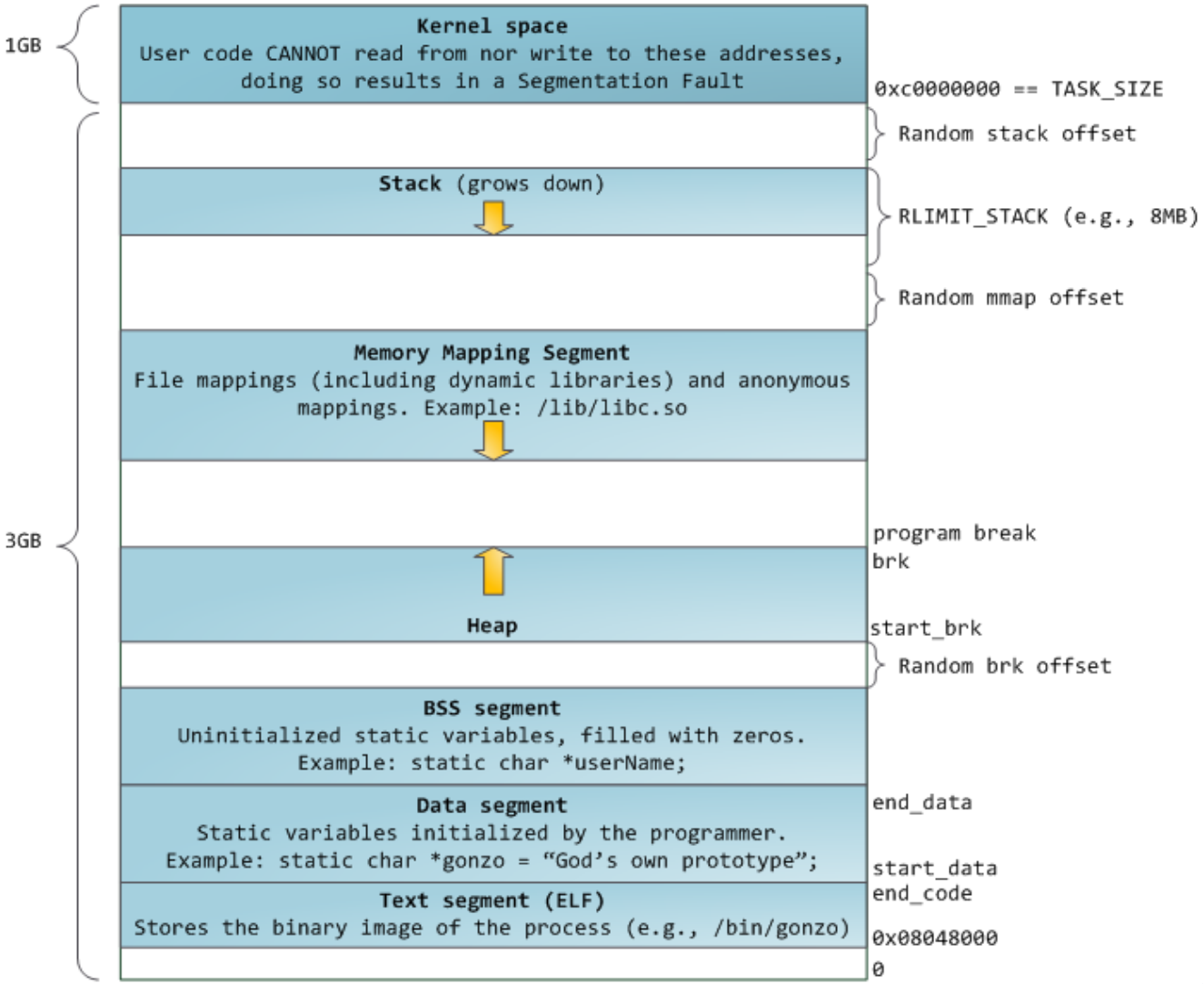
Let's recall the OS 101 course



[3]

So, what is share kernel?

The 32-bits memory layout



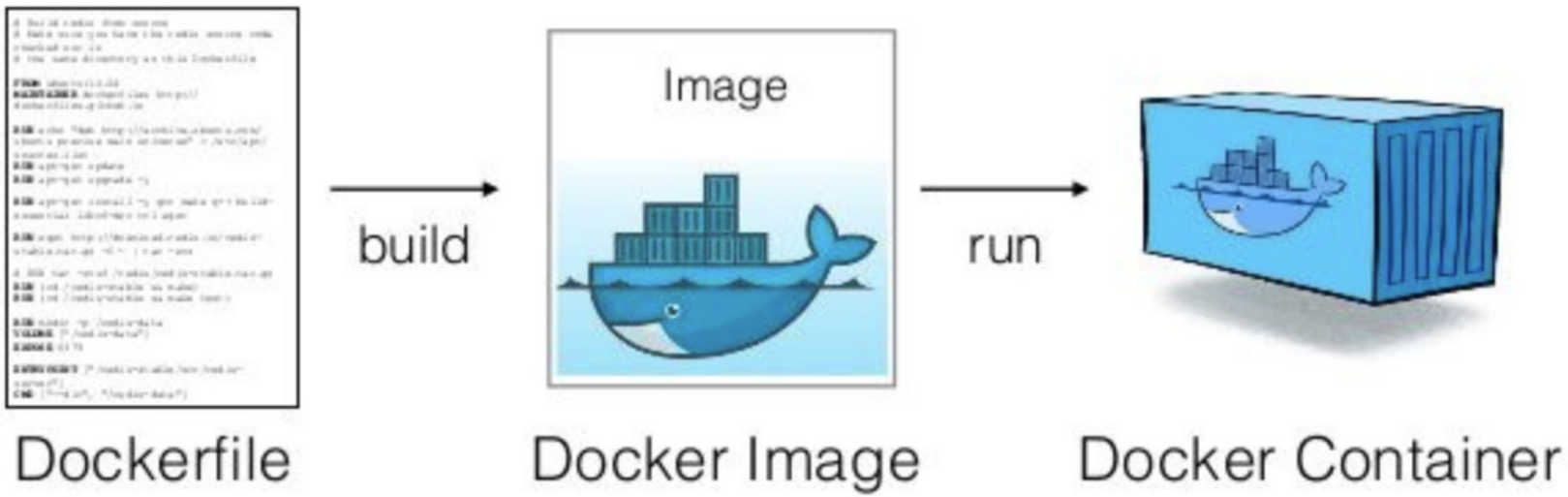
[4]

What is HYPERVISOR?

Virtual machine monitor

Monitor? Will introduce in the OS.

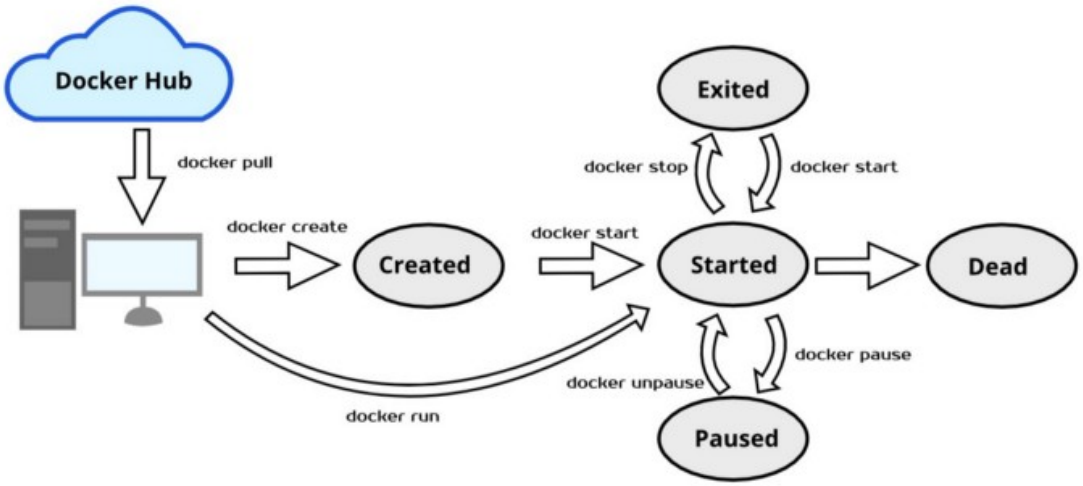
Image and Container



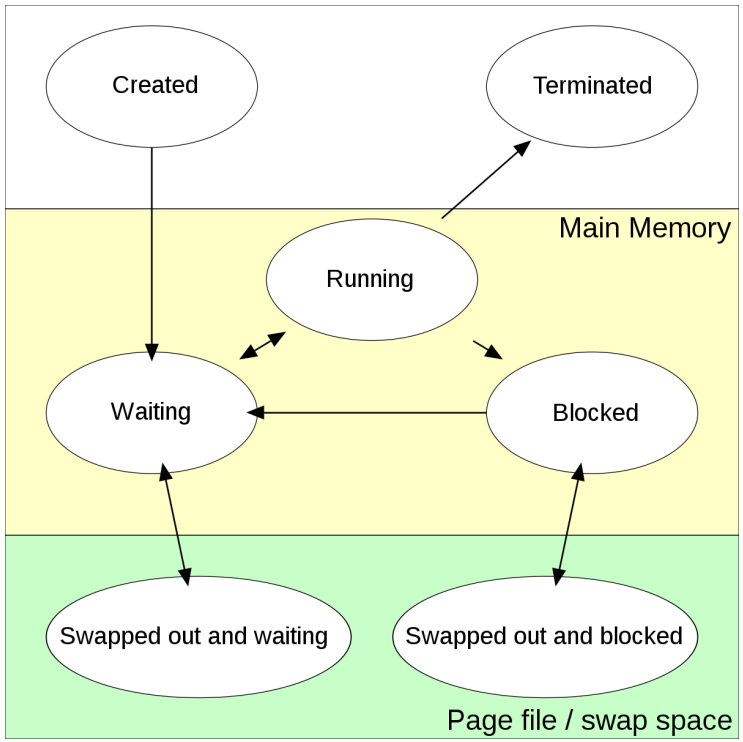
[5]

Like a program in execution is called a process.
An image in execution is called a container.

Lifecycle



(a) Container's Lifecycle



(b) Process's Lifecycle

[6, 7]

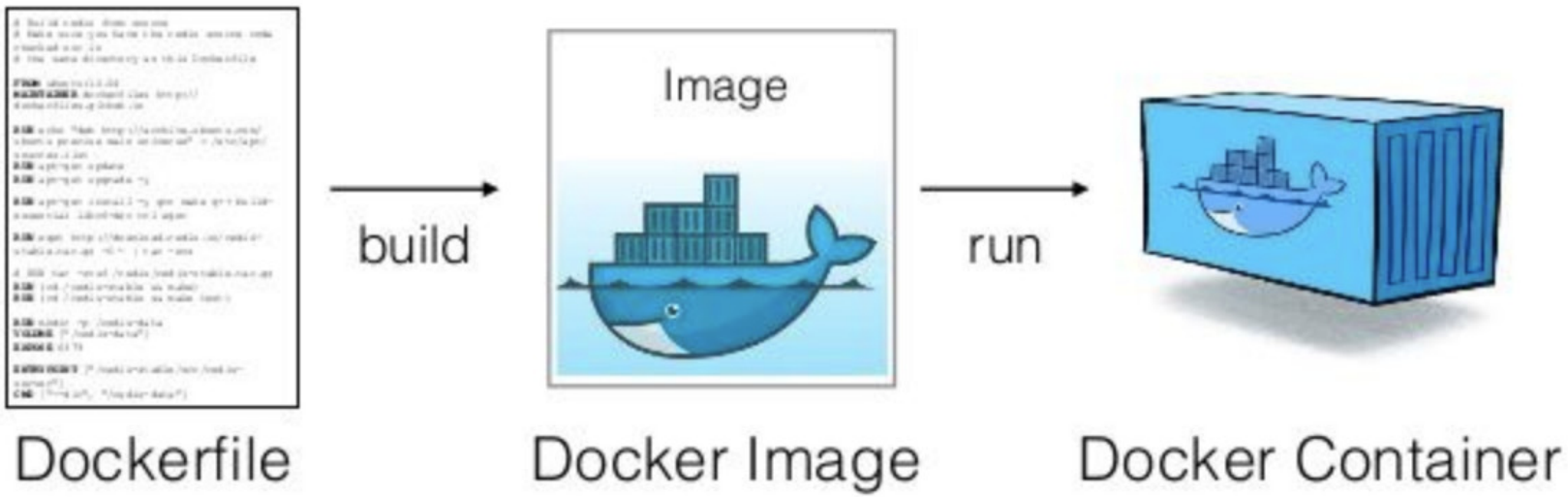
Dockerfile

What is Dockerfile?

Definition:

A text document that contains all the commands a user could call on the command line to assemble an image.

Image and Container again



[5]

Like a program in execution is called a process.
An image in execution is called a container.

DockerHub

A public **images** hub. We push/pull **images** from it by default.
We push an image and pull an image rather than a container.

Make sense, right?

Dockerfile 101

1. FROM
2. RUN, CMD, ENTRYPOINT
3. EXPOSE
4. ENV
5. ADD, COPY
6. VOLUME
7. USER
8. WORKDIR
9. ONBUILD

`https://docs.docker.com/engine/reference/builder/`

Dockerfile's Lab

```
1  FROM ubuntu
2
3  ENV KFC=EGG_TART
4
5  RUN apt update && apt install -y x11vnc xvfb firefox
6
7  RUN useradd -m user1 --uid=1000 && \
8      echo "user1:Ch@ng3_m3" | chpasswd
9  USER user1:1000
10 WORKDIR /home/user1
11
12 RUN bash -c 'echo "firefox" >> /home/user1/.bashrc' && \
13     mkdir ~/.vnc && \
14     x11vnc -storepasswd nsysuisc ~/.vnc/passwd
15
16 EXPOSE 5900
17 CMD     ["x11vnc", "-forever", "-usepw", "-create"]
```

src/dockerfile101/Dockerfile

Docker-compose 101

```
version: "3.9"
services:

  redis:
    image: redis:alpine
    ports:
      - "6379"
    networks:
      - frontend
    deploy:
      replicas: 2
      update_config:
        parallelism: 2
        delay: 10s
      restart_policy:
        condition: on-failure
```

src/docker–compose101/example.yml

https://docs.docker.com/compose/compose-file/compose-file-v3/

Docker-compose's Lab

```
#!/bin/bash

git clone https://github.com/docker/example-voting-app.git
cd example-voting-app

# Initialize docker swarm
sudo docker swarm init

# Deploy
sudo docker stack deploy --compose-file docker-stack.yml
    vote
```

src/docker–compose101/auto_build.sh

Docker-compose's Lab requirements

```
#!/bin/bash

# Install docker compose
sudo curl -L "https://github.com/docker/compose/releases/
    download/1.28.5/docker-compose-$(uname -s)-$(uname -m)"
    -o /usr/local/bin/docker-compose
sudo chmod +x /usr/local/bin/docker-compose
sudo ln -s /usr/local/bin/docker-compose /usr/bin/docker-
    compose
```

src/docker–compose101/install_docker_compose.sh

Stop all containers:

sudo docker stop $(sudo docker ps -a -q)

sudo docker stack rm <name>

Docker commands

Basic

Commands Cheat Sheet

Container Lifecycle

docker create [IMAGE]	create a container without starting it
docker rename [CONTAINER_NAME] [NEW_CONTAINER_NAME]	rename a container
docker run [IMAGE]	create and start a container
docker run --rm [IMAGE]	remove a container after it stops
docker run -td [IMAGE]	start a container and keep it running
docker run -it [IMAGE]	create, start the container, and run a command in it
docker run -it-rm [IMAGE]	create, start the container, and run a command in it; after executing, the container is removed
docker rm [CONTAINER]	delete a container if it isn't running
docker update [CONTAINER]	update the configuration of a container

Image Lifecycle

docker build [URL]	create an image from a Dockerfile
docker build -t [URL]	build an image from a Dockerfile and tags it
docker pull [IMAGE]	pull an image from a registry
docker push [IMAGE]	push an image to a registry
docker import [URL/FILE]	create an image from a tarball
docker commit [CONTAINER] [NEW_IMAGE_NAME]	create an image from a container
docker rmi [IMAGE]	remove an image
docker load [TAR_FILE/STDIN_FILE]	load an image from a tar archieve as stdin
docker save [IMAGE] > [TAR_FILE]	save an image to a tar archive stream to stdout with all parent layers, tags, and versions

Networking

docker network ls	list networks
docker network rm [NETWORK]	remove one or more networks
docker network inspect [NETWORK]	show information on one or more networks
docker network connect [NETWORK] [CONTAINER]	connect a container to a network
docker network disconnect [NETWORK] [CONTINAER]	disconnect a container from a network

Start & Stop

docker start [CONTAINER]	start a container
docker stop [CONTAINER]	stop a running container
docker restart [CONTAINER]	stop a running container and start it up again
docker pause [CONTAINER]	pause processes in a running container
docker unpause [CONTAINER]	unpause processes in a container
docker wait [CONTAINER]	block a container until other containers stop
docker kill [CONTAINER]	kill a container by sending SIGKILL to a running container
docker attach [CONTAINER]	attach local standard input, output, and error streams to a running container

Information

docker ps	list running containers
docker ps -a	list running and stopped containers
docker logs [CONTAINER]	list the logs from a running container
docker inspect [OBJECT_NAME/ID]	list low-level information on an object
docker events [CONTAINER]	list real time events from a container
docker port [CONTAINER]	show port (or specific) mapping from a container
docker top [CONTAINER]	show running processes in a container
docker stats [CONTAINER]	show live resource usage statistics of containers
docker diff [CONTINAER]	show changes to files (or directories) on a filesystem
docker images ls	show all locally stored images
docker history [IMAGE]	show history of an image

[8]

Full cheat sheet

Next page reference: [9]

1. Containers

A lightweight virtual OS that run processes in full isolation.

1.1 Lifecycle

- docker create creates a container but does not start it.
- docker rename allows the container to be renamed.
- docker run creates and starts a container in one operation.
- docker rm deletes a container.
- docker update updates a container's resource limits.
- docker run --rm : remove the container after it stops.
- docker run -v $HOSTDIR:$DOCKERDIR: map the directory ($HOSTDIR) on the host to a
- docker container ($DOCKERDIR).
- docker rm –v: remove the volumes associated with the container.
- docker run --log-driver=syslog : run docker with a custom log driver.

1.2 Starting and Stopping

- docker start starts a container so it is running.
- docker stop stops a running container.
- docker restart stops and starts a container.
- docker pause pauses a running container, "freezing" it in place.
- docker unpause will unpause a running
- container.
- docker wait blocks until running container
- stops.

docker kill sends a SIGKILL to a running container.

docker attach will connect to a running container.

1.3 CPU Constraints

CPU can be limited either using a percentage over all CPUs, or by using specific cores.

- -c or cpu-shares: 1024 means 100% of the CPU, so if we want the container to take 50% of all CPU cores, we should specify 512 for instance, docker run -ti --c 512 ...cpuset-cpus
- : use only some CPU cores, for instance, docker run -ti --cpuset-cpus=0,4,6 ...

1.4 Memory Constraints

Memory can be limited using –m flag, for instance, docker run -it -m 300M ubuntu:14.04 /bin/bash

1.5 Capabilities

cap-add and cap-drop: Add or drop linux capabilities.

- Mount a FUSE based filesystem:
  - docker run --rm -it --cap-add SYS_ADMIN --device /dev/fuse sshfs
- Give access to a single device:
  - docker run -it --device=/dev/ttyUSB0 debian bash
- Give access to all devices:
  - docker run -it --privileged -v /dev/bus/usb:/dev/bus/usb debian bash

1.6 Info

- docker ps shows running containers.
- docker logs gets logs from container. (You can use a custom log driver, but logs is only available for json-fileand journald in 1.10).
- docker inspect looks at all the info on a container (including IP address).
- docker events gets events from container.
- docker port shows public facing port of container.
- docker top shows running processes in container.
- docker stats shows containers' resource usage statistics.
- docker diff shows changed files in the container's FS.
- docker ps –ashows running and stopped containers

1.7 Import / Export

- docker cp copies files or folders between a container and the local filesystem.
- docker export turns container filesystem into tarball archive stream to STDOUT.

1.8 Executing Commands

docker exec to execute a command in container.

2. Images

A template or blueprint for docker containers.

2.1 Lifecycle

- docker images shows all images.
- docker import creates an image from a tarball.
- docker build creates image from Dockerfile.
- docker commit creates image from a container, pausing it temporarily if it is running.
- docker rmi removes an image.
- docker load loads an image from a tar archive as STDIN, including images and tags (as of 0.7).
- docker save saves an image to a tar archive stream to STDOUT with all parent layers, tags & versions (as of 0.7).

2.2. Info

- docker history shows history of image.
- docker tag tags an image to a name (local or registry).

2.3. Cleaning up

- docker rmi remove specific images.
- docker-gc a toolto clean up images that are no longer used by any containers in a safe manner.

2.4. Load/Save image

- docker load < my_image.tar.gz load an image from file
- docker save my_image:my_tag | gzip > my_image.tar.gz save an existing image

2.5. Import/Export container

- cat my_container.tar.gz | docker import - my_image:my_tag import a container as an image from file
- docker export my_container | gzip > my_container.tar.gz export an existing container

3. Networks

A small def goes here

3.1. Lifecycle

- docker network create
- docker network rm

3.2. Info

- docker network ls
- docker network inspect

3.3. Connection

- docker network connect
- docker network disconnect

4. Registry & Repository

A repository is a hosted collection of tagged images that together create the file system for a container.
A registry is a host -- a server that stores repositories and provides an HTTP API for managing the uploading and downloading of repositories.
Docker.com hosts its own index to a central registry which contains a large number of repositories.

- docker login to login to a registry.
- docker logout to logout from a registry.
- docker search searches registry for image.
- docker pull pulls an image from registry to local machine.
- docker push pushes an image to the registry from local machine.

5. Volumes

Docker volumes are free-floating filesystems. They don't have to be connected to a particular container. You should use volumes mounted from data-only containers for portability.

5.1. Lifecycle

- docker volume create
- docker volume rm

5.2. Info

- docker volume ls
- docker volume inspect

6. Exposing ports

- docker run -p 127.0.0.1:$HOSTPORT:$CONTAINER-
- PORT --name CONTAINER -t docker_image mapping the container port to the host port using –p
- EXPOSE <CONTAINERPORT>expose port CONTAINERPORT at runtime (see dockerfile)
- docker port CONTAINER $CONTAINERPORT check the mapped port

7. Tips

7.1. Get IP address

```
> docker inspect some_docker_id | grep IPAddress | cut -d '"' -f 4
```

or install jq:

```
> docker inspect some_docker_id | jq -r '.[0].NetworkSettings.IPAddress'
```

or using a go template:

```
> docker inspect -f '{{ .NetworkSettings.IPAddress }}' <container_name>
```

7.2. Get port mapping

```
docker inspect -f '{{range $p, $conf := .NetworkSettings.Ports}} {{$p}} -> {{(index $conf 0).HostPort}} {{end}}' <containername>
```

7.3. Find containers by regular expression

```
for i in $(docker ps -a | grep "REGEXP_PATTERN" | cut -f1 -d" "); do echo $i; done
```

7.4. Get Environment Settings

```
docker run --rm ubuntu env
```

7.5. Kill running containers

```
docker kill $(docker ps -q)
```

7.6. Delete old containers

```
docker ps -a | grep 'weeks ago' | awk '{print $1}' | xargs docker rm
```

7.7. Delete stopped containers

```
docker rm -v $(docker ps -a -q -f status=exited)
```

7.8. Delete dangling images

```
docker rmi $(docker images -q -f dangling=true)
```

7.9. Delete all images

```
docker rmi $(docker images -q)
```

7.10. Delete dangling volumes

```
docker volume rm $(docker volume ls -q -f dangling=true)
```

Exercises

Tiny project

Single-responsibility principle

Why we should decompose this project into tiny-tiny parts?

Wikipedia:

The single-responsibility principle (SRP) is a computer-programming principle that states that every class in a computer program should have responsibility over a single part of that program's functionality, which it should encapsulate. All of that module, class or function's services should be narrowly aligned with that responsibility [10].

Our PWN Labs

`https://github.com/giantbranch/pwn_deploy_chroot`

Steps:

1. git clone `https://github.com/giantbranch/pwn_deploy_chroot.git`
2. Put teh PWN binary in to the bin/
3. python initialize.py
4. sudo docker-compose up –build -d

Wine with X11

Raspbian in Docker

We need a Qemu supervise it.

```
1  FROM navikey/raspbian-buster
2
3  COPY qemu-system-arm /usr/bin/qemu-system-arm
4
5  ENV TZ=Asia/Taipei
6
7  RUN ln -snf /usr/share/zoneinfo/$TZ /etc/localtime && \
8      echo $TZ > /etc/timezone && \
9      apt update -y && \
10     apt install libapparmor-dev build-essential python3 tmux
       zsh vim curl git -y
11
12 ADD ./work /work
13 WORKDIR /work
```

src/raspbian/Dockerfile

Toys

Docker-OSX: `https://github.com/sickcodes/Docker-OSX`
x11docker: `https://github.com/mviereck/x11docker`

Advanced issues

Some advanced issues

- Security
  - Privileged
  - Escape
- Scalability
  - SDN (Software defined network)
  - SDS (Software defined storage)
  - Dynamic infrastructure / Load balance
- CI/CD

References

References I


What is a Container? URL: https://www.docker.com/resources/what-container.


packhelp. URL: https://packhelp.com/plain-shipping-box/.


64-bit memory layout. URL: https://www.berthon.eu/wiki/foss:wikishelf:linux:memory.


32-bit memory layout. URL: https://unix.stackexchange.com/questions/31407/how-does-forking-affect-a-processs-memory-layout.


Build a Docker Image just like how you would configure a VM. URL: https://medium.com/platformer-blog/practical-guide-on-writing-a-dockerfile-for-your-application-89376f88b3b5.

References II

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Process state, wiki. URL: https://en.wikipedia.org/wiki/Process_state.

List Of Docker Commands: Cheat Sheet. URL: https://phoenixnap.com/kb/list-of-docker-commands-cheat-sheet.

Docker Commands - Complete Cheat Sheet. URL: https://linoxide.com/linux-how-to/docker-commands-cheat-sheet/.

References III

Single-responsibility principle. URL: https://en.wikipedia.org/wiki/Single-responsibility_principle.