Docker

Information security club course II

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v0.1

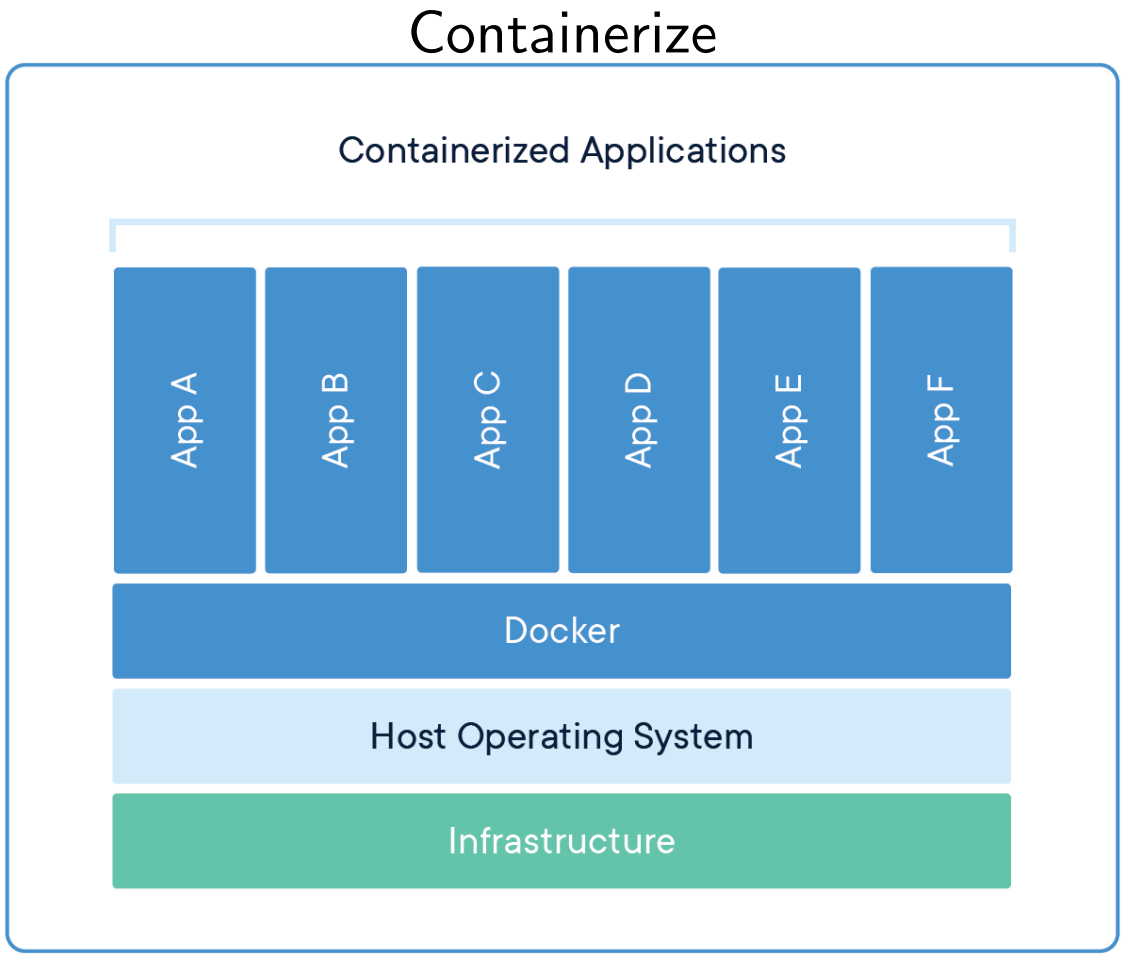
Outline

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

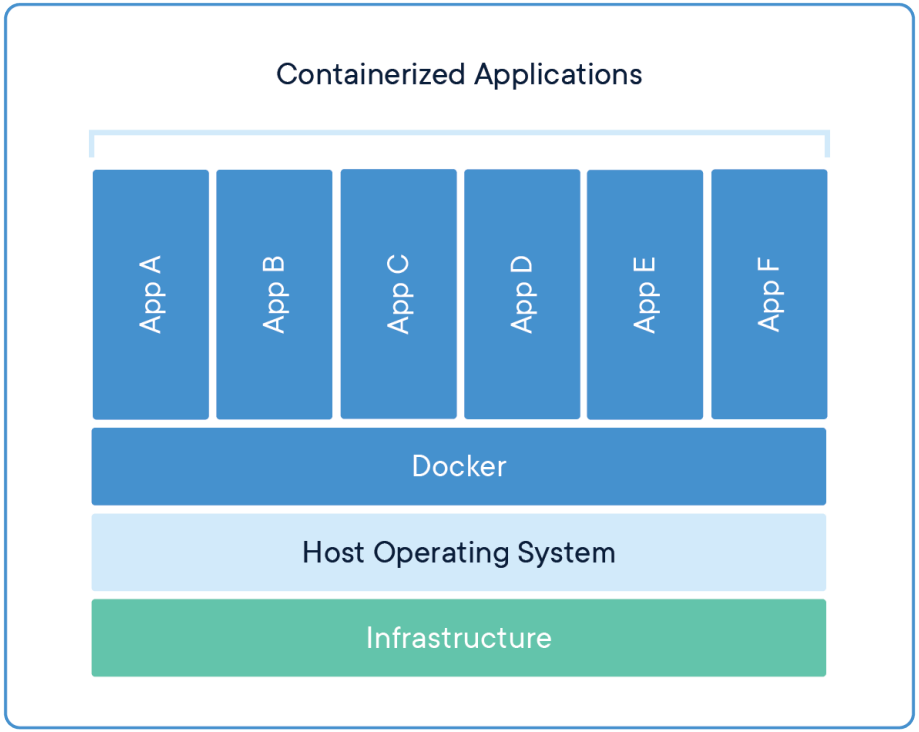

Containerize
Containerized Applications
App A
App B
App C
App D
App E
App F
Docker
Host Operating System
Infrastructure

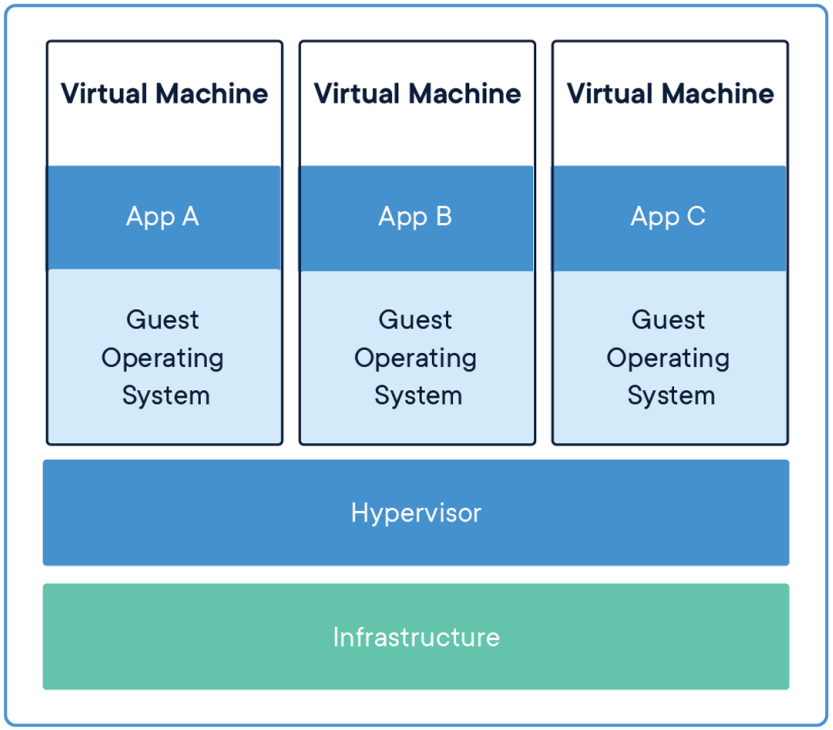
[1]

Big idea

[2]

Compare with virtule machines

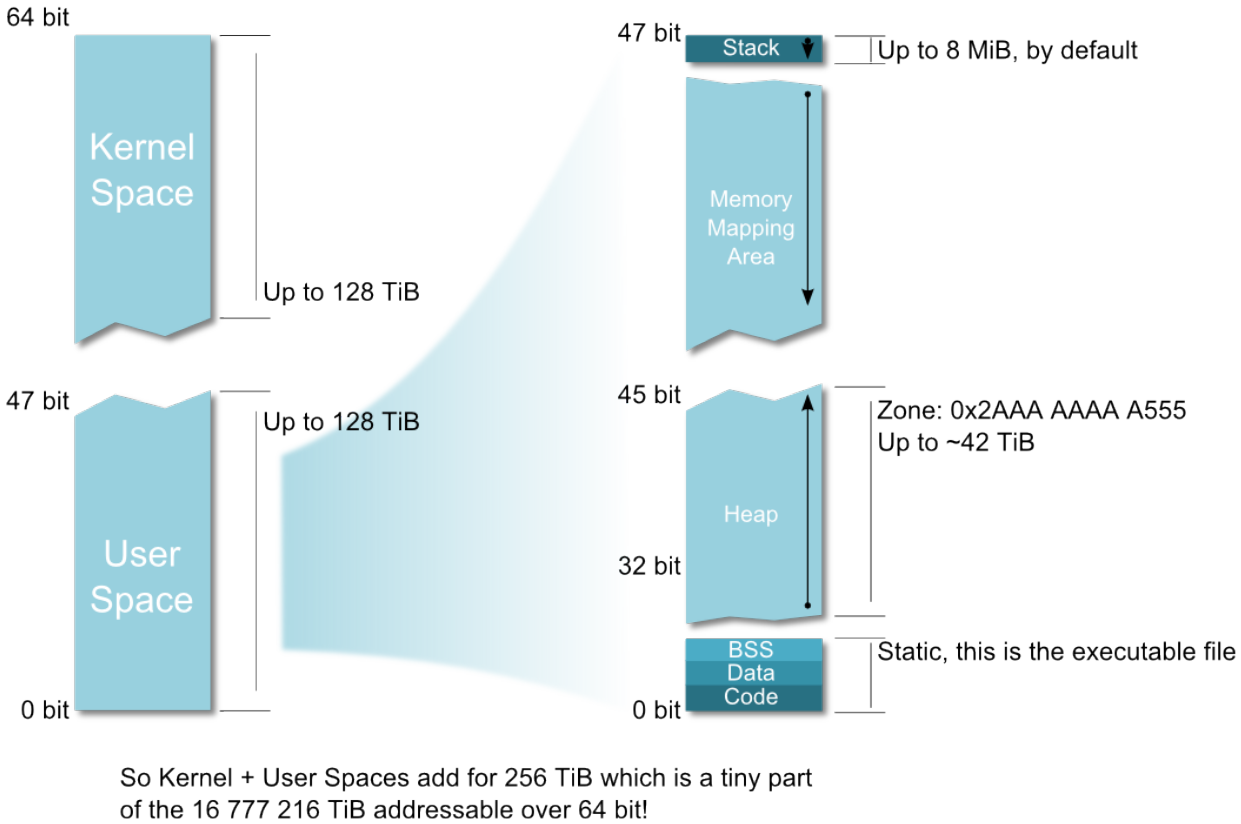




Wait, what is Hypervisor?

So, what is share kernel?

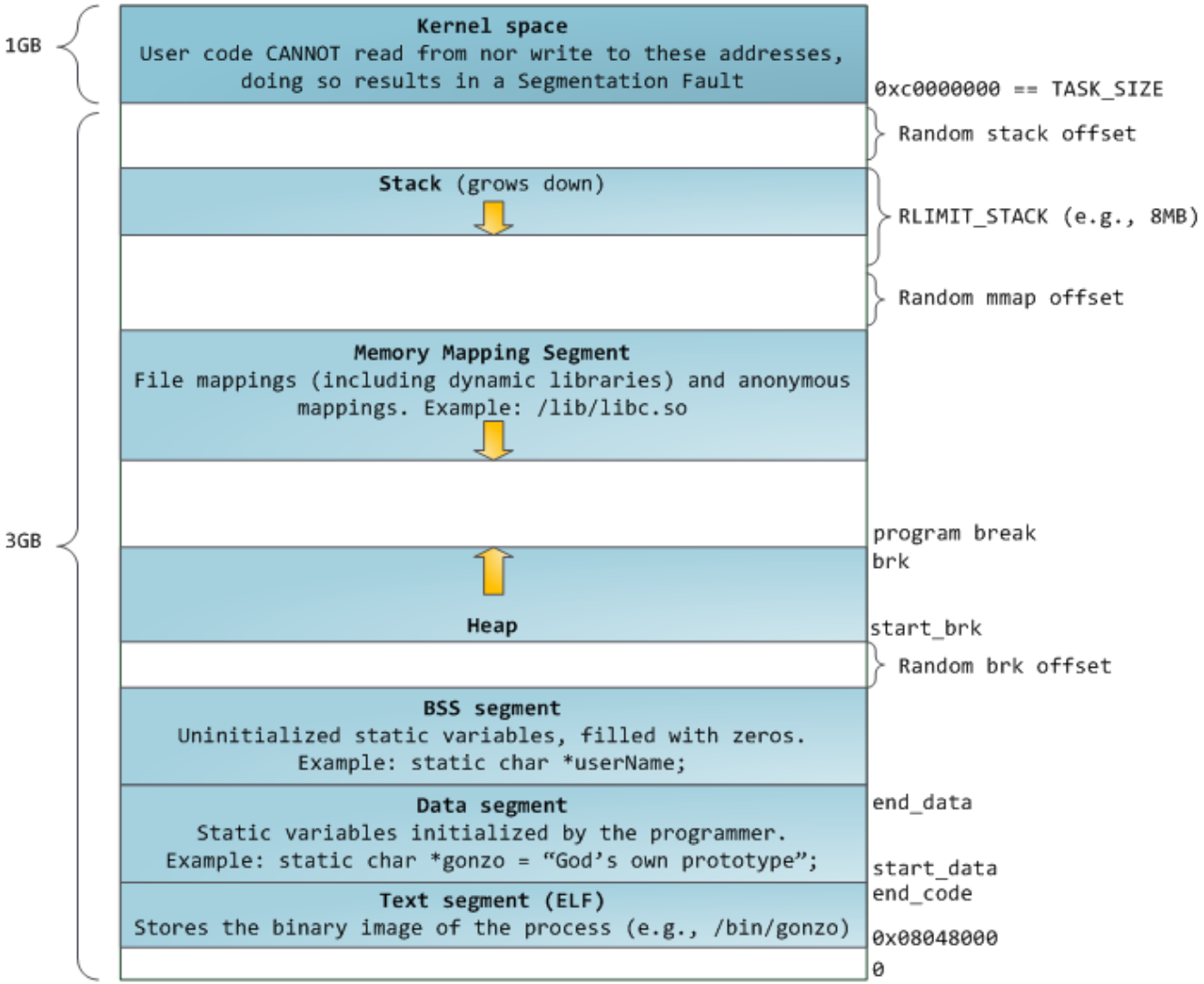
Let's recall the OS 101 course



[3]

So, what is share kernel?

The 32-bits memory layout



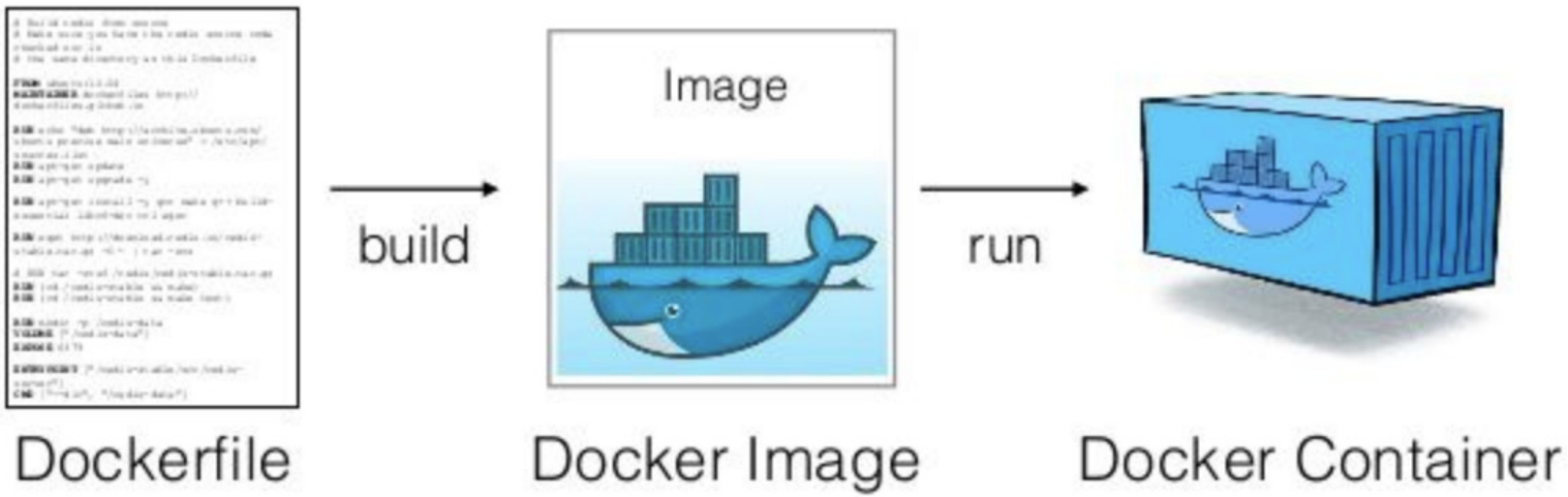
[4]

What is HYPERVISOR?

Virtual machine monitor

Monitor? Will introduce in the OS.

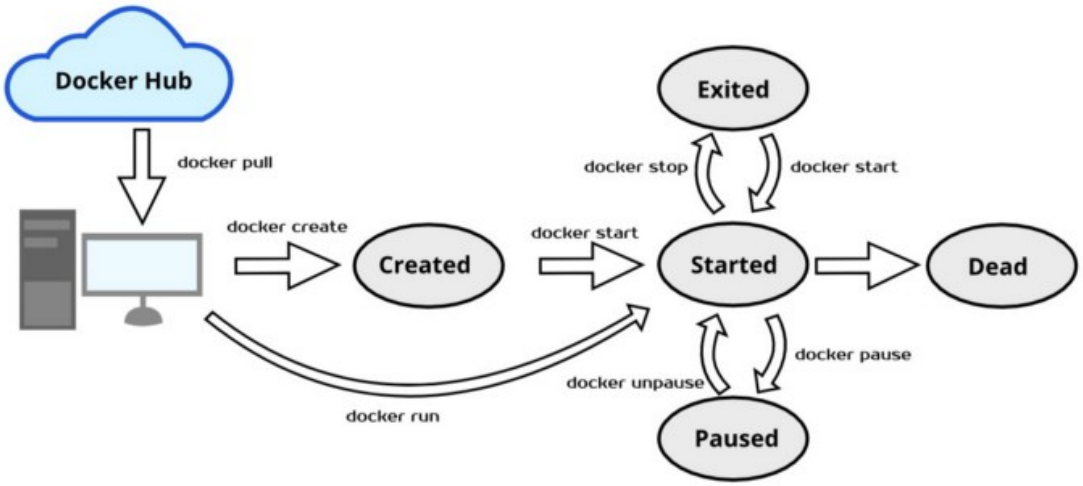
Image and Container



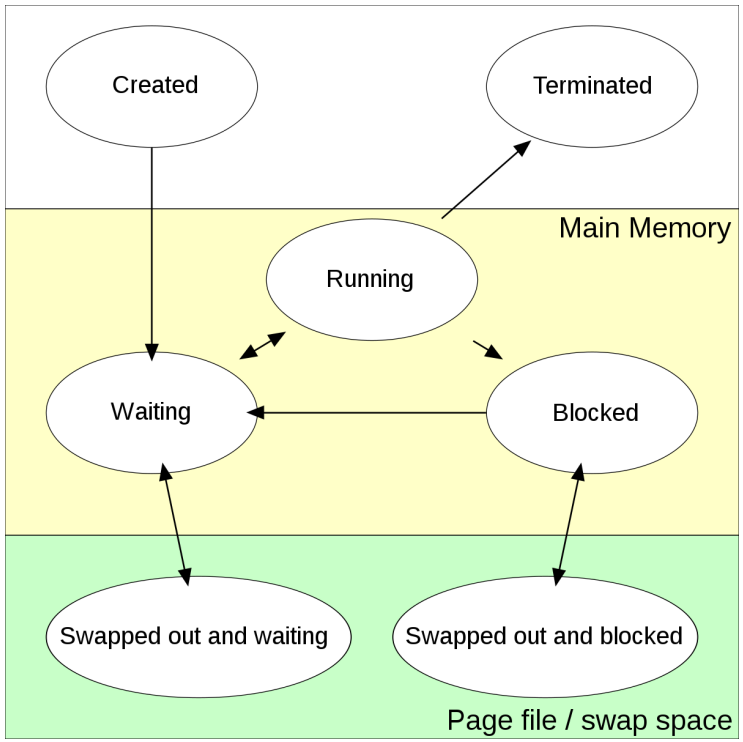
[5]

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]

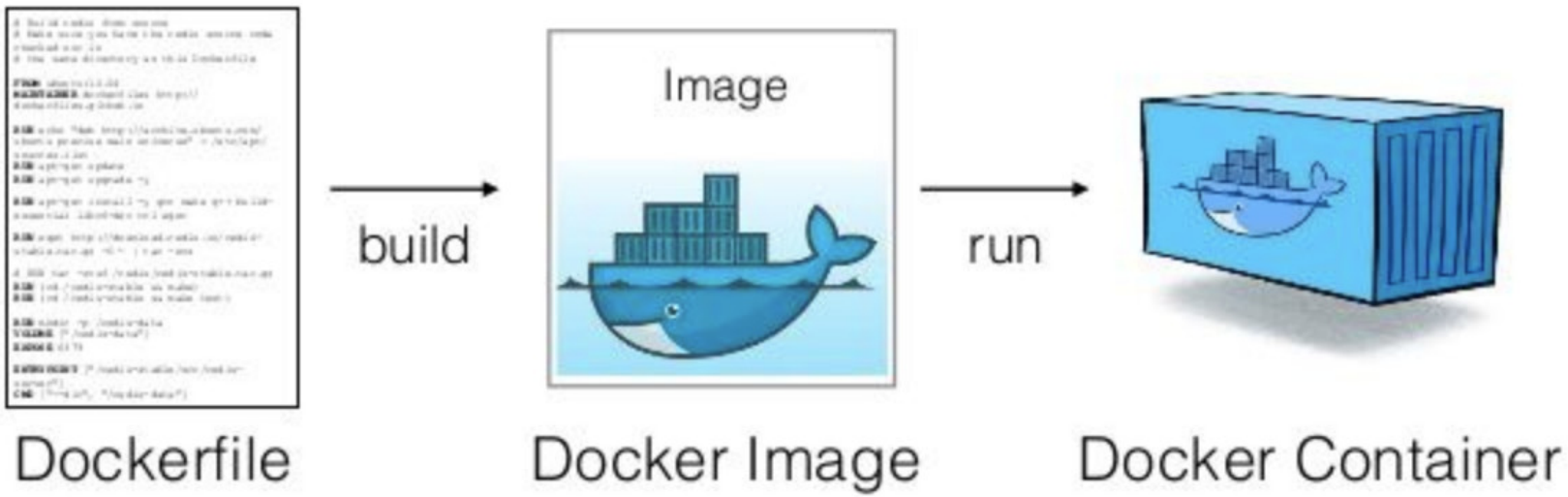
Dockerfile

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

1. Write a "hello world program" in a ubuntu docker container.
2. Execute the "hello world program".
3. Export the container to a gzip, which is named foo.tar.gz .
4. Stop the container which had print the "hello world program".
5. Import the foo.tar.gz as an image, which is named foo.
6. Run the "hello world program" from image foo.
7. Commit the previous step container as an image, which is named goo.
8. Show me this figure.

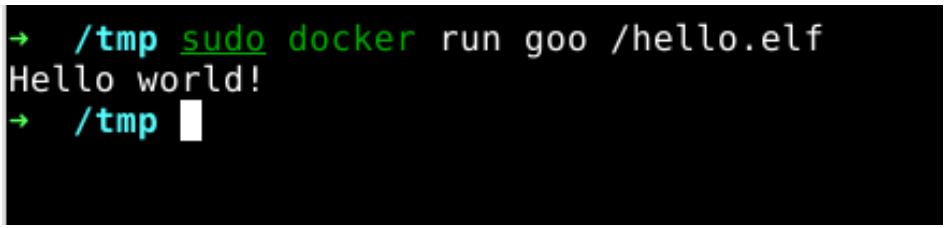


Figure: The output

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 the PWN binary in to the bin/
3. python initialize.py
4. sudo docker-compose up –build -d

Wine with X11

```
1 FROM debian
2
3 COPY . .
4
5 RUN dpkg --add-architecture i386
6 RUN apt-get update && \
7     apt install wine wine32 wine64 libwine libwine:i386
    fonts-wine -y
8
9 ENV DISPLAY :0
```

src/wine/Dockerfile

Build

sudo docker build -t wine0 .

Wine with X11

```
sudo docker run -it --rm --env="DISPLAY" \
    --volume="${XAUTHORITY:-${HOME}/.Xauthority}:/root/.
    Xauthority:ro" \
    --volume="/tmp/.X11-unix:/tmp/.X11-unix" \
    --volume="winehome:/home/wineuser" \
    -v "${pwd}":"/line" \
    --hostname="$(hostname)" wine0 \
    wine LineInst.exe
```

src/wine/run.sh

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.
* *Introduction To The Docker Life Cycle*. URL: https://medium.com/faun/introduction-to-docker-life-cycle-3bf3aeba883.
* *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 II

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