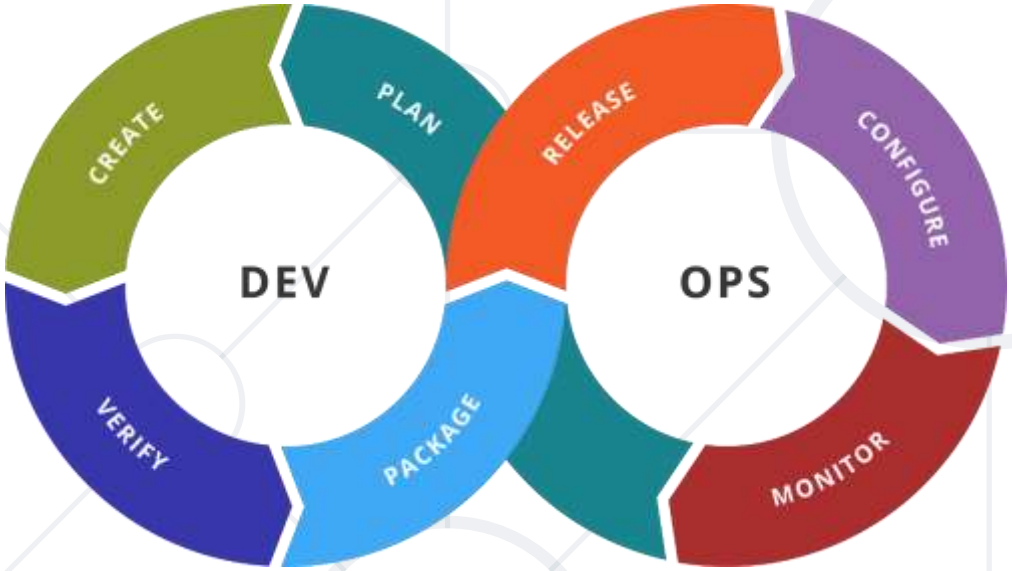
Introduction to Docker

Install Docker. Work with Images & Containers



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https://softuni.bg

You Have Questions?

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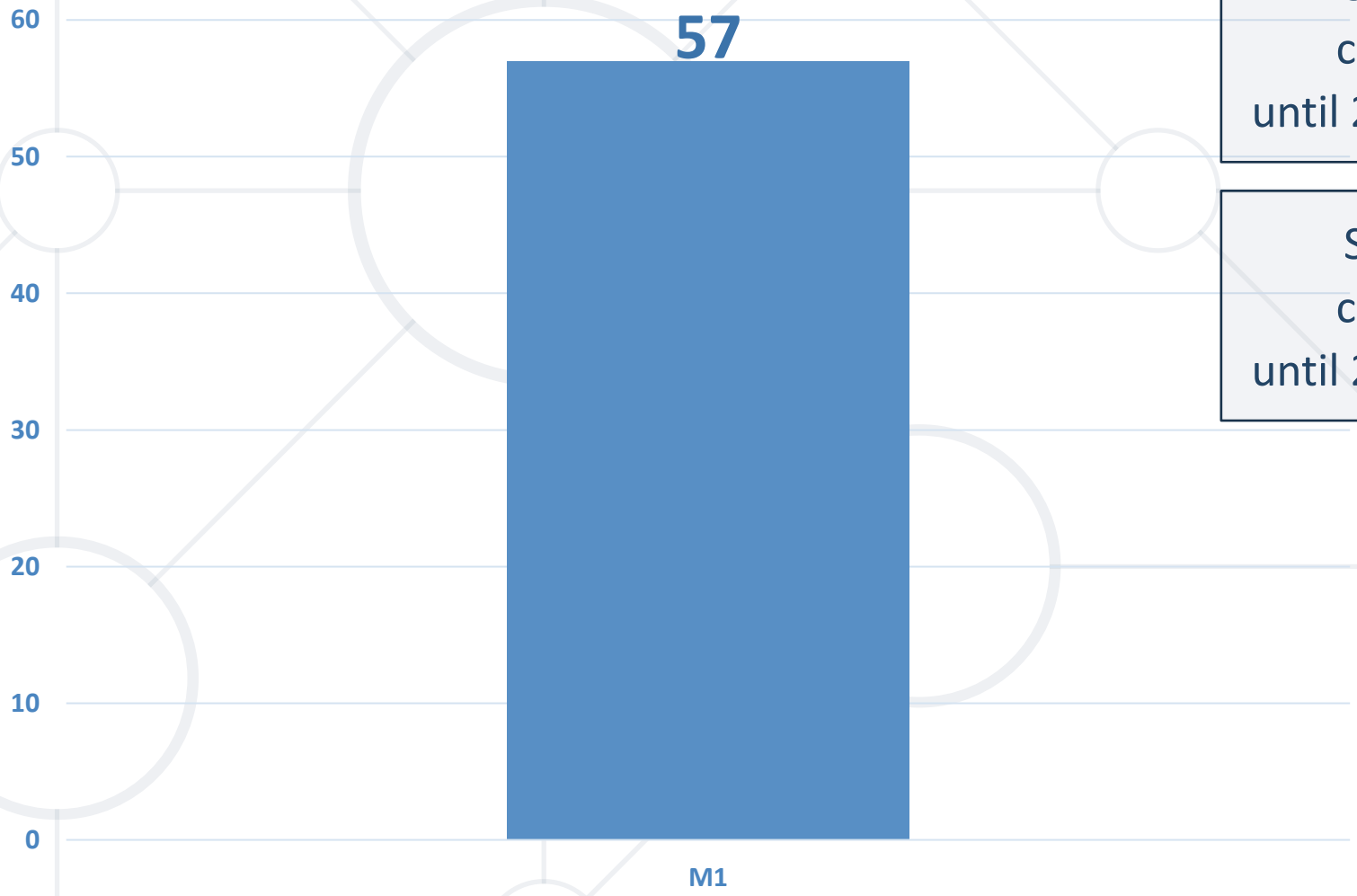
sli.do

#DevOps-23

facebook.com

/groups/DevOpsContainerizationCICDMonitoringJanuary2023

Homework Progress



Solutions for M1
can be submitted
until 23:59 on 06.02.2023

Solutions for M2
can be submitted
until 23:59 on 13.02.2023

Previous Module (M1)

Quick Overview

What We Covered

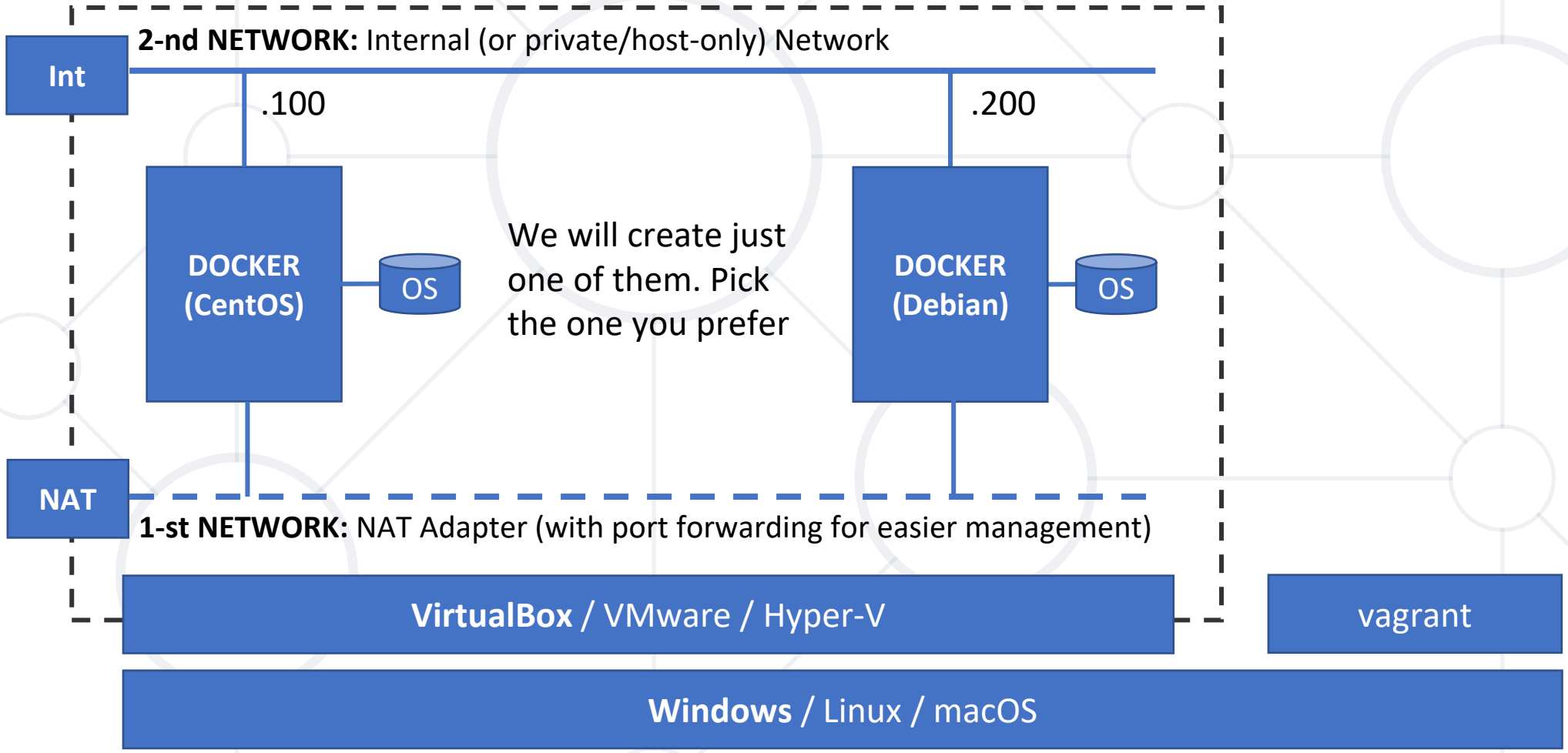
1. The Big Picture
   - Main Pain Points and Causes
   - Goals and Benefits
   - Adoption and Tools
2. Basic Toolkit
3. Basic Automation

This Module (M2)

Topics and Lab Infrastructure

Table of Contents

Lab Infrastructure



Containers and Docker

Past. Present. Future

Containerization

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> OS-level virtualization refers to an operating system paradigm in which the kernel allows the existence of **multiple isolated user space instances** known as **containers, zones, jails, …**

https://en.wikipedia.org/wiki/OS-level_virtualization

Road to Containers

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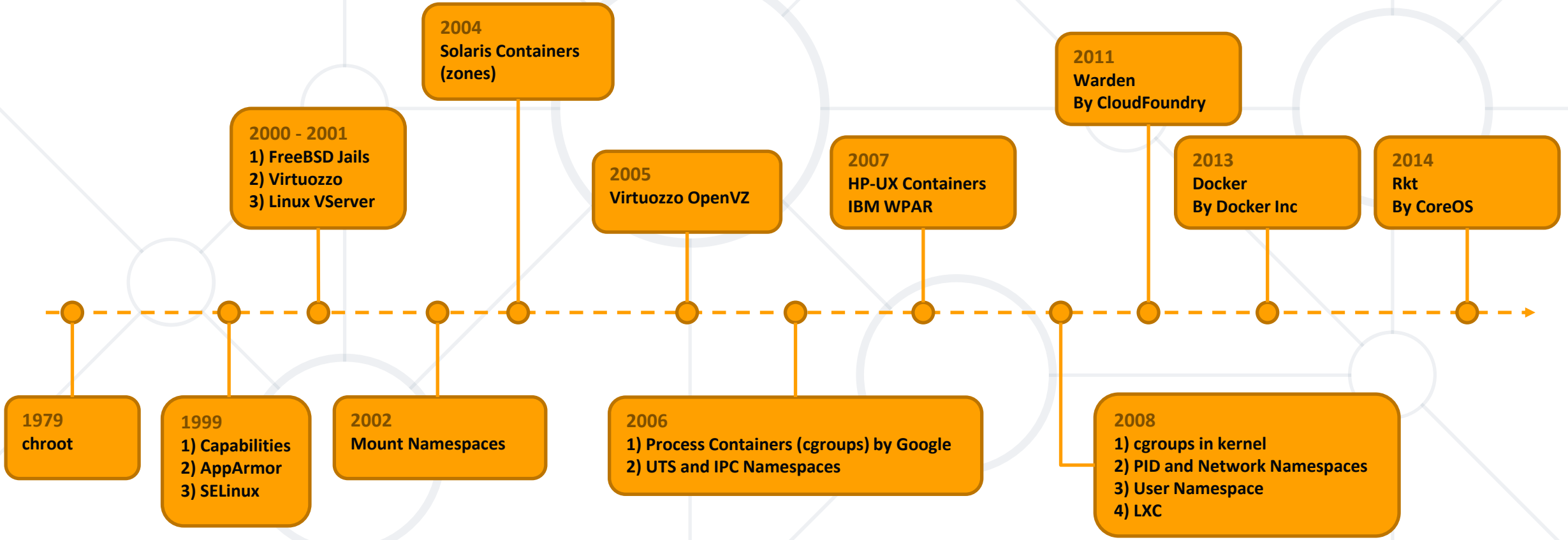
Companies and Solutions



Enablement Technologies

Container Types and Solutions

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- **System Containers (BSD Jails, Solaris Zones, …)**
  - **LXC + LXD + LXCF** by **Canonical**
  - Container hypervisor (system containers)
  - https://linuxcontainers.org/

OS-centric
Multiple processes

- **Application Containers (containerd, CRI-O, …)**
  - **Docker** by **Docker Inc**
  - Tools and application container engine
  - https://www.docker.com/

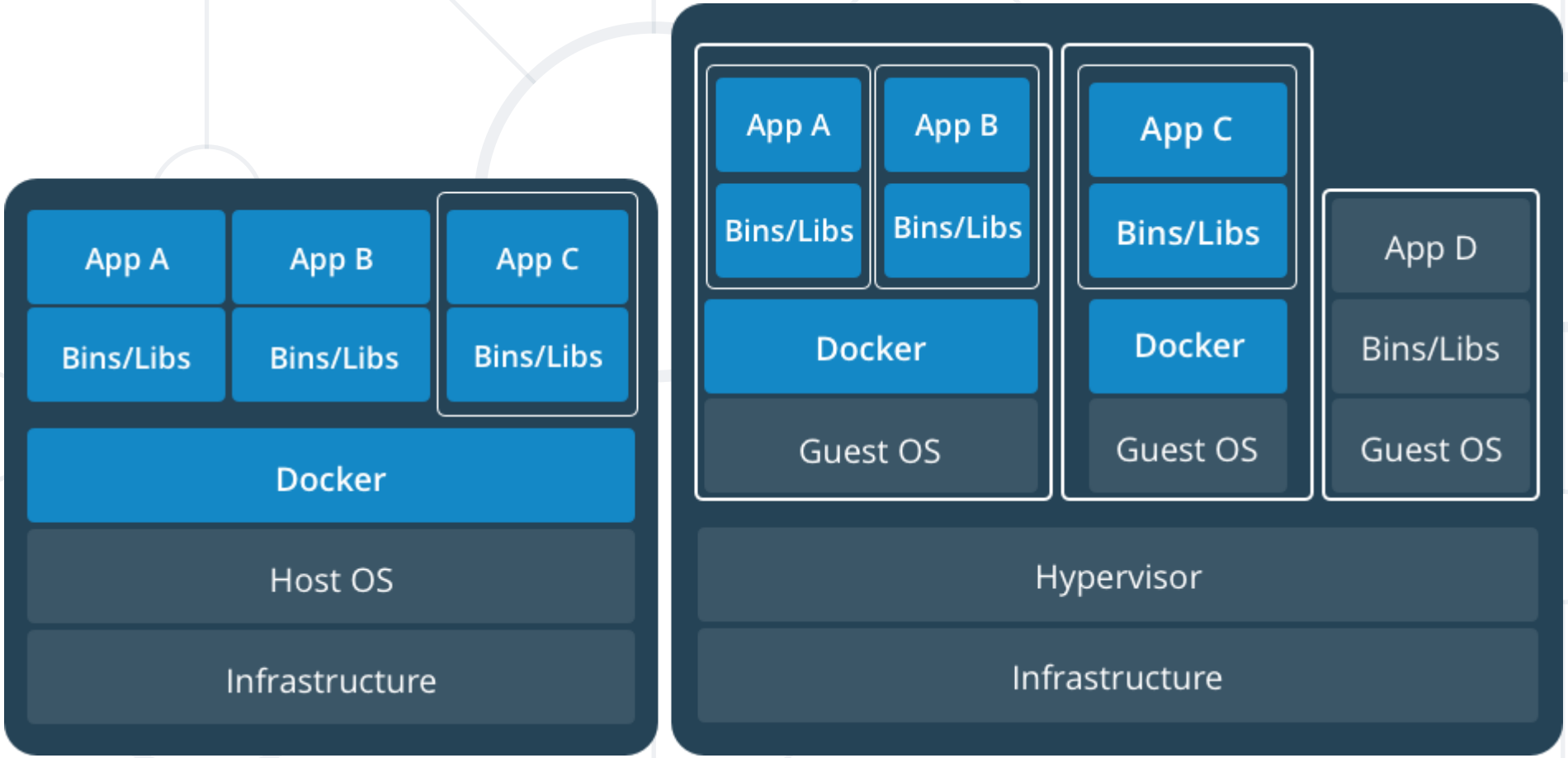
App-centric
Single process *

VMs vs Containers

- VMs virtualize the hardware
- Complete isolation
- Complete OS installation. Requires more resources
- Runs almost any OS

- Containers virtualize the OS
- Lightweight isolation
- Shared kernel. Requires fewer resources
- Runs on the same OS

Together: VMs and Containers



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

Docker

Whole New World

Containers Concepts (Docker View)

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- **Container host** is a physical or virtual computer system configured with **a container engine**
- **Container image** shows the state of a container, including registry or file system changes
- **Container OS image** is the first layer of potentially many image layers that make up a container
- **Container repository** stores container images and their dependencies

Definitions

- **Container**
  - A runnable instance of an image. Containers are processes with much more isolation
- **Image**
  - A read-only template of a container built from layers. Images provide a way for simpler software distribution
- **Repository**
  - A collection of different versions of an image identified by tags
- **Registry**
  - A collection of repositories

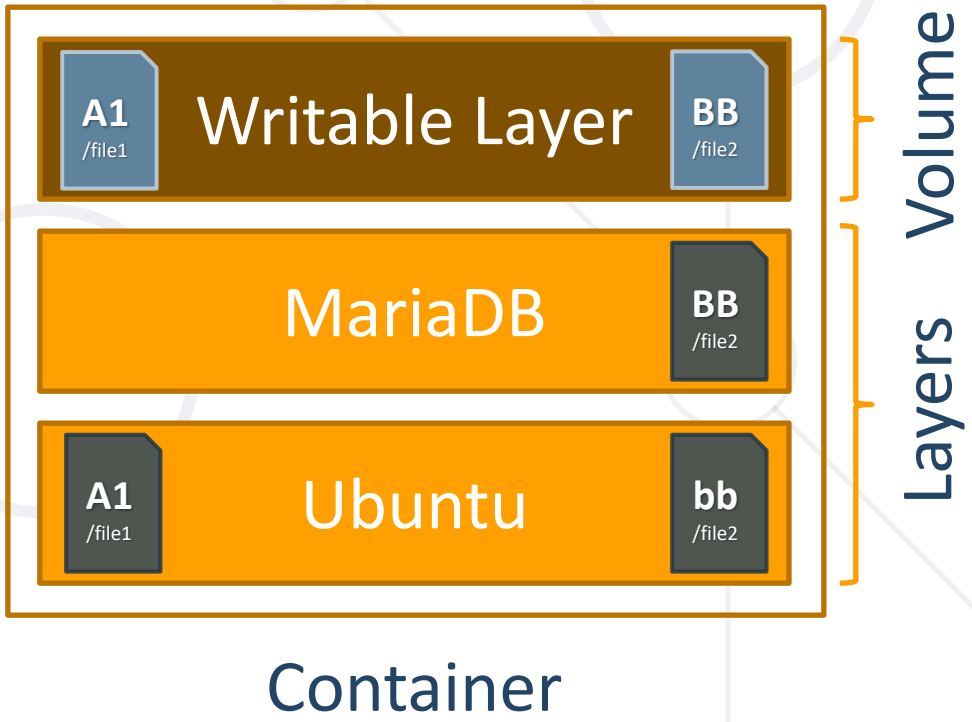
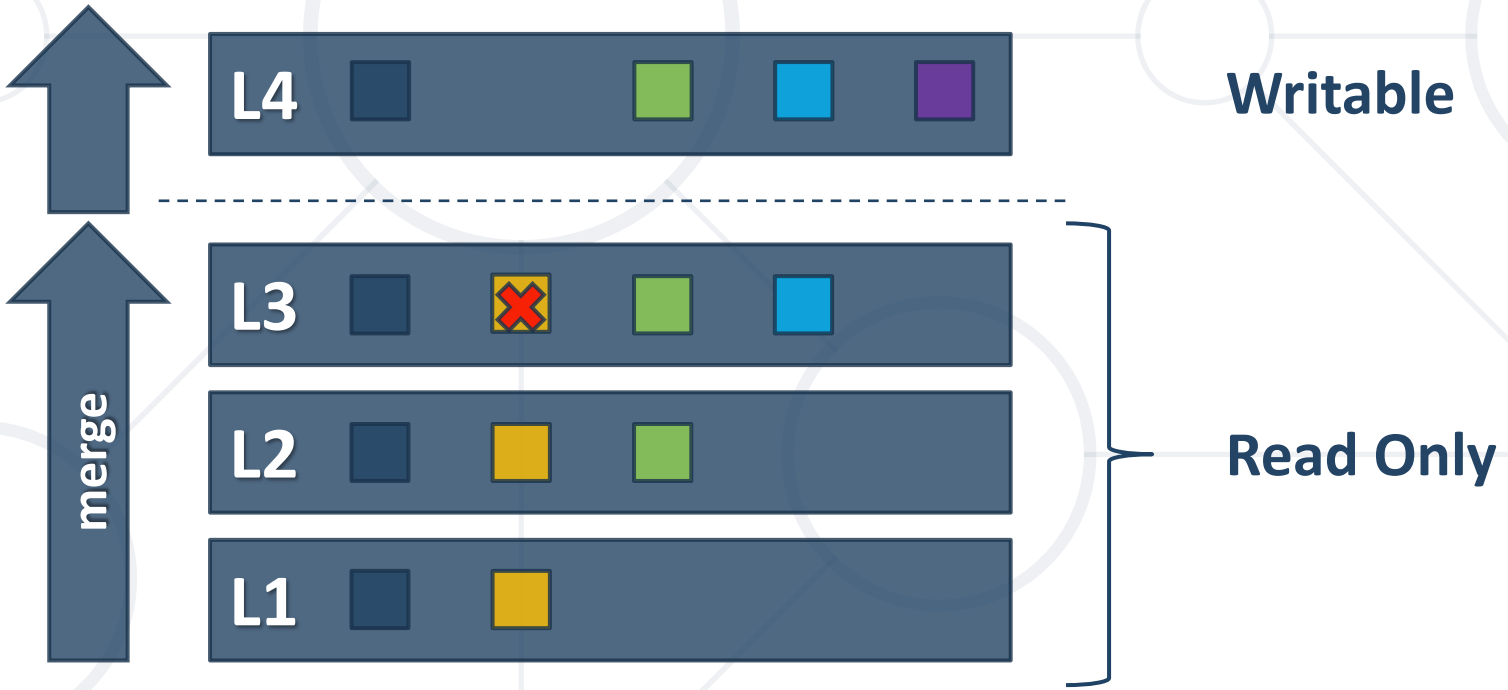
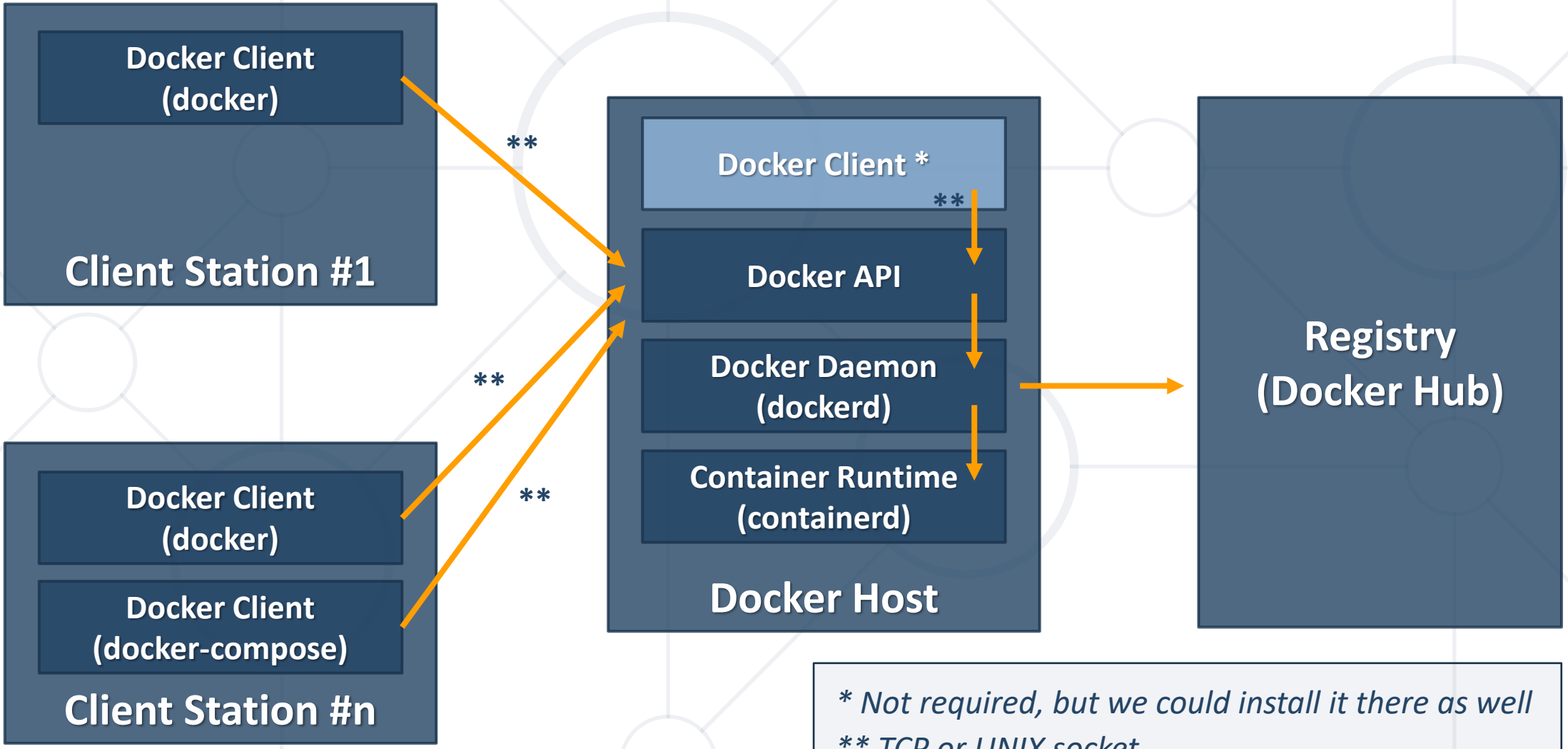


Image Layers



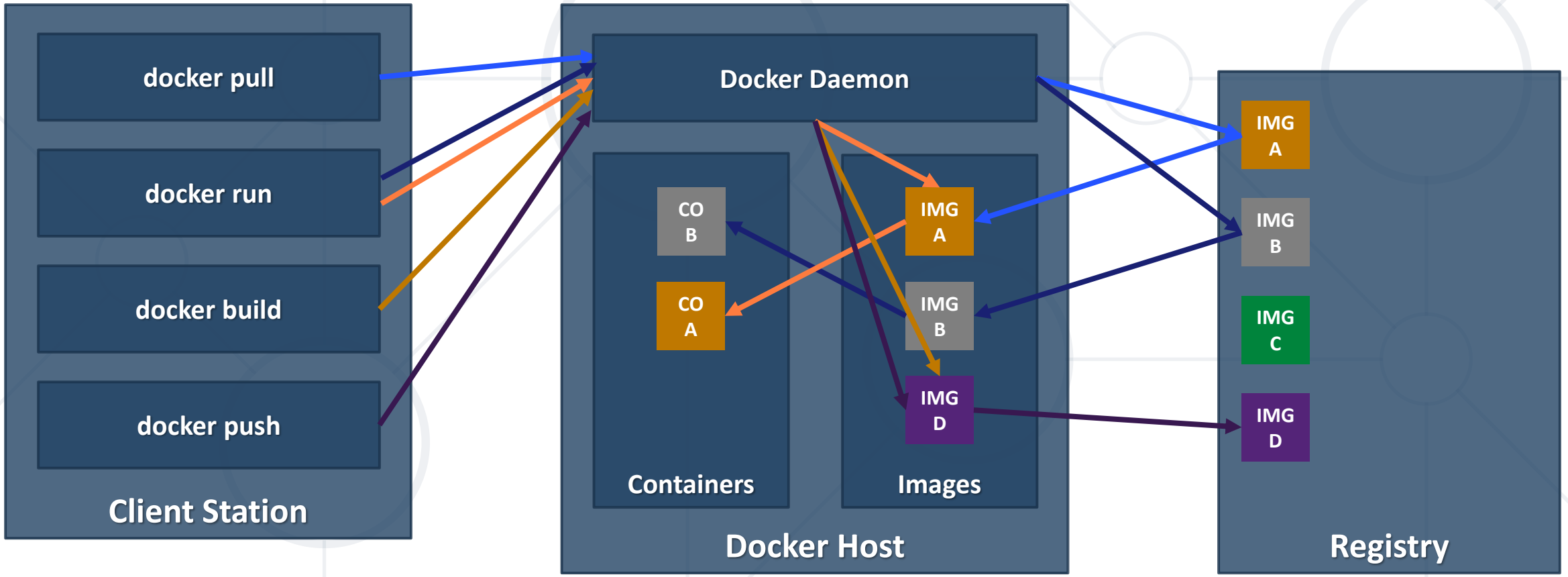
Docker Platform



** Not required, but we could install it there as well*

*** TCP or UNIX socket*

Workflow


docker pull
docker run
docker build
docker push
Client Station
Docker Daemon
CO B
CO A
Containers
IMG A
IMG B
IMG D
Images
Docker Host
IMG A
IMG B
IMG C
IMG D
Registry

Installation Options

- **Docker Desktop**
  - Linux
  - macOS
  - Windows

Specific requirements: OS version, Hypervisor, etc.

- **Docker Engine**
  - Various Linux distributions → Deployment via **package system** (two channels – **stable**, and **test**), **script**, or **archive**
  - Various hardware architectures

x86_64/amd64	arm64 (aarch64)	arm (armhf)	s390x

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

Registries

- Provided by Docker
  - Cloud
    - Docker Hub (https://hub.docker.com/explore/)
  - On-premise
    - Standalone
    - Containerized
- Provided by 3rd parties
  - Quay.io, Artifactory, Google Container Registry, etc.

Registries can be **private** or **public**

Repositories can also be **private** or **public**

Practice: Installation & Hello World

Live Demonstration in Class

Working with Docker

Commands

Command Specifics

- Syntax varies amongst versions
  - Old (short) style – still available
  - New style – preferred
- Grouped by target
  - Management Commands
  - General Commands

search

- Purpose
  - Search the Docker Hub for images
- Old (short) syntax

```
docker search [OPTIONS] TERM
```

- New syntax

```
# same
```

- Example *(search for image that have ubuntu in their name)*

```
docker search ubuntu
```

pull / image pull

- Purpose
  - Pull an image or a repository from a registry
- Old (short) syntax

```
docker pull [OPTIONS] NAME[:TAG|@DIGEST]
```

- New syntax

```
docker image pull [OPTIONS] NAME[:TAG|@DIGEST]
```

- Example *(download the ubuntu:latest image locally)*

```
docker image pull ubuntu:latest
```

run / container run

- Purpose
  - Run a command in a new container
- Old (short) syntax

```
docker run [OPTIONS] IMAGE [COMMAND] [ARG]
```

- New syntax

```
docker container run [OPTIONS] IMAGE [COMMAND] [ARG]
```

- Example *(run bash in ubuntu based container interactively)*

```
docker container run -it ubuntu bash
```

images / image ls

- Purpose
  - List locally available images
- Old (short) syntax

```
docker images [OPTIONS] [REPOSITORY[:TAG]]
```

- New syntax

```
docker image ls [OPTIONS] [REPOSITORY[:TAG]]
```

- Example *(list all tags for the fedora image)*

```
docker image ls fedora
```

ps / container ls

- Purpose
  - List containers
- Old (short) syntax

```
docker ps [OPTIONS]
```

- New syntax

```
docker container ls [OPTIONS]
```

- Example *(return running and stopped container IDs)*

```
docker container ls -a -q
```

rm / container rm

- Purpose
  - Remove one or more containers
- Old (short) syntax

```
docker rm [OPTIONS] CONTAINER [CONTAINER]
```

- New syntax

```
docker container rm [OPTIONS] CONTAINER [CONTAINER]
```

- Example *(remove container by its name)*

```
docker container rm weezy_snake
```

rmi / image rm

- Purpose
  - Remove one or more images
- Old (short) syntax

```
docker rmi [OPTIONS] IMAGE [IMAGE]
```

- New syntax

```
docker image rm [OPTIONS] IMAGE [IMAGE]
```

- Example *(remove the ubuntu and fedora images)*

```
docker image rm ubuntu fedora
```

create / container create

- Purpose
  - Create a new container
- Old (short) syntax

```
docker create [OPTIONS] IMAGE [COMMAND] [ARG]
```

- New syntax

```
docker container create [OPTIONS] IMAGE [COMMAND] [ARG]
```

- Example *(create a container without starting it)*

```
docker container create -t -i fedora bash
```

rename / container rename

- Purpose
  - Rename a container
- Old (short) syntax

```
docker rename CONTAINER NEW_NAME
```

- New syntax

```
docker container rename CONTAINER NEW_NAME
```

- Example *(change container name from cont1 to newcont1)*

```
docker container rename cont1 newcont1
```

kill / container kill

- Purpose
  - Kill one or more running containers
- Old (short) syntax

```
docker kill [OPTIONS] CONTAINER [CONTAINER]
```

- New syntax

```
docker container kill [OPTIONS] CONTAINER [CONTAINER]
```

- Example *(stop a container by its ID)*

```
docker container kill 0cbf27183
```

start / container start

- Purpose
  - Start one or more stopped containers
- Old (short) syntax

```
docker start [OPTIONS] CONTAINER [CONTAINER]
```

- New syntax

```
docker container start [OPTIONS] CONTAINER [CONTAINER]
```

- Example *(start a container by its ID and attach to it)*

```
docker container start -a -i 0cbf27183
```

restart / container restart

- Purpose
  - Restart a one or more containers
- Old (short) syntax

```
docker restart [OPTIONS] CONTAINER [CONTAINER]
```

- New syntax

```
docker container restart [OPTIONS] CONTAINER [CONTAINER]
```

- Example *(restart a container by its ID)*

```
docker container restart 0cbf27183
```

stop / container stop

- Purpose
  - Stop one or more running containers
- Old (short) syntax

```
docker stop [OPTIONS] CONTAINER [CONTAINER]
```

- New syntax

```
docker container stop [OPTIONS] CONTAINER [CONTAINER]
```

- Example *(stop a container by its ID)*

```
docker container stop 0cbf27183
```

pause / container pause

- Purpose
  - Pause all processes within one or more containers
- Old (short) syntax

```
docker pause CONTAINER [CONTAINER]
```

- New syntax

```
docker container pause CONTAINER [CONTAINER]
```

- Example *(pause a container by its ID)*

```
docker container pause 0cbf27183
```

unpause / container unpause

- Purpose
  - Resume all processes within one or more containers
- Old (short) syntax

```
docker unpause CONTAINER [CONTAINER]
```

- New syntax

```
docker container unpause CONTAINER [CONTAINER]
```

- Example *(resume a container by its ID)*

```
docker container unpause 0cbf27183
```

attach / container attach

- Purpose
  - Attach to a running container
- Old (short) syntax

```
docker attach [OPTIONS] CONTAINER
```

- New syntax

```
docker container attach [OPTIONS] CONTAINER
```

- Example *(attach to the process in a container by its ID)*

```
docker container attach 0cbf27183
```

tag / image tag

- Purpose
  - Tag an image into a repository
- Old (short) syntax

```
docker tag SOURCE_IMAGE[:TAG] TARGET_IMAGE[:TAG]
```

- New syntax

```
docker image tag SOURCE_IMAGE[:TAG] TARGET_IMAGE[:TAG]
```

- Example *(create a new tag for an existing image)*

```
docker image tag test:1.0 repo-name/test:latest
```

push / image push

- Purpose
  - Push an image or repository to a registry
- Old (short) syntax

```
docker push [OPTIONS] NAME[:TAG]
```

- New syntax

```
docker image push [OPTIONS] NAME[:TAG]
```

- Example *(publish a local image to a remote registry)*

```
docker image push repo-name/test:latest
```

login

- Purpose
  - Log into a Docker registry
- Old (short) syntax

```
docker login [OPTIONS] [SERVER]
```

- New syntax

```
# same
```

- Example *(authenticate against a custom registry)*

```
docker login localrepo:5000
```

logout

- Purpose
  - Log out from a Docker registry
- Old (short) syntax

```
docker logout [OPTIONS] [SERVER]
```

- New syntax

```
# same
```

- Example *(log out from a custom registry)*

```
docker logout localrepo:5000
```

export / container export

- Purpose
  - Export a container's filesystem as a tar archive
- Old (short) syntax

```
docker export [OPTIONS] CONTAINER
```

- New syntax

```
docker container export [OPTIONS] CONTAINER
```

- Example *(export container's filesystem as a file)*

```
docker container export -o file.tar test
```

import / image import

- Purpose
  - Import the contents from a tar to create a filesystem image
- Old (short) syntax

```
docker import [OPTIONS] file|URL|- [REPOSITORY[:TAG]]
```

- New syntax

```
docker image import [OPTIONS] file|URL|- [REPOSITORY[:TAG]]
```

- Example *(import the file.tar as a new-test container image)*

```
docker image import file.tar new-test
```

save / image save

- Purpose
  - Save one or more images to a tar archive or STDOUT
- Old (short) syntax

```
docker save [OPTIONS] IMAGE [IMAGE]
```

- New syntax

```
docker image save [OPTIONS] IMAGE [IMAGE]
```

- Example *(export the busybox image as a file)*

```
docker image save -o busybox.tar busybox
```

load / image load

- Purpose
  - Load an image from a tar archive or STDIN
- Old (short) syntax

```
docker load [OPTIONS]
```

- New syntax

```
docker image load [OPTIONS]
```

- Example *(import an image from a tar archive file)*

```
docker image load -i busybox.tar
```

Practice: Working with Containers

Live Demonstration in Class

Image from Container

Introduction

- **Commit** a container's file changes to a new image
- Use **running** or **stopped** container
- If running, all processes are **paused**
- Mounted volumes' data is **not included**
- It is advisable to use **Dockerfile** instead

commit / container commit

- Purpose
  - Create a new image from a container's changes
- Old (short) syntax

```
docker commit [OPTIONS] CONTAINER [REPOSITORY[:TAG]]
```

- New syntax

```
docker container commit [OPTIONS] CONTAINER [REPOSITORY[:TAG]]
```

- Example *(commit a container by its ID and create an image)*

```
docker container commit 0cf23a31 new-cont
```

Image from File

General Structure and Common Fields

General Structure (Dockerfile)

- Script, composed of commands and arguments
- Always begins with FROM instruction

Comment

Command (Instruction)

```
# Set the base image
FROM nginx

# Set the maintainer
MAINTAINER John Smith

# Copy files
COPY index.html /usr/share/nginx/html/
```

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

FROM

- Purpose
  - Defines the base image to use to start the build process
- Syntax

```
FROM <image>[:<tag>] [AS <name>]
```

- Example

```
# it is a good practice to state a version (tag)
FROM ubuntu:18.04
# for the latest version, the tag could be skipped
FROM ubuntu
```

https://docs.docker.com/engine/reference/builder/#from

MAINTAINER

- Purpose
  - Sets the author field of the image. It is deprecated
- Syntax

```
MAINTAINER <name>
```

- Example

```
# deprecated
MAINTAINER John Smith
# newer variant is this:
LABEL maintainer="John Smith"
```

https://docs.docker.com/engine/reference/builder/#maintainer-deprecated

LABEL

- Purpose
  - Adds metadata to the image
- Syntax

```
LABEL <key>=<value> <key>=<value> <key>=<value> ...
```

- Example

```
# single key-value pair
LABEL maintainer="John Smith“
# multiple key-value pairs
LABEL maintainer="John Smith" version="1.0"
```

https://docs.docker.com/engine/reference/builder/#label

RUN

- Purpose
  - Used during build process to add software (forms another layer)
- Syntax

```
RUN <command>
```

- Example

```
# single command
RUN apt-get -y update
# more than one command
RUN apt-get -y update && apt-get -y upgrade
```

https://docs.docker.com/engine/reference/builder/#run

COPY

- Purpose
  - Copy files between the host and the container (adds a layer)
- Syntax

```
COPY [--chown=<user>:<group>] <src>... <dest>
```

- Example

```
# Copy single file
COPY readme.txt /root
# Copy multiple files
COPY *.html /var/www/html/my-web-app
```

https://docs.docker.com/engine/reference/builder/#copy

ADD

- Purpose
  - Copy files to the image (adds a layer)
- Syntax

```
ADD [--chown=<user>:<group>] <src>... <dest>
```

- Example

```
# Add single file from URL
ADD https://softuni.bg/favicon.ico /www/favicon.ico
# Add tar file content
ADD web-app.tar /var/www/html/my-web-app
```

https://docs.docker.com/engine/reference/builder/#add

EXPOSE

- Purpose
  - Informs Docker that the container listens on the specified ports
- Syntax

```
EXPOSE <port> [<port>/<protocol>...]
```

- Example

```
# single port
EXPOSE 80
# multiple ports
EXPOSE 80 8080
```

https://docs.docker.com/engine/reference/builder/#expose

ENTRYPOINT

- Purpose
  - Allows configuration of container that will run as an executable
- Syntax

```
# exec form, this is the preferred form
ENTRYPOINT ["executable", "param1", "param2"]

# shell form
ENTRYPOINT command param1 param2
```

https://docs.docker.com/engine/reference/builder/#entrypoint

CMD

- Purpose
  - Main purpose is to provide defaults for an executing container
- Syntax

```
# exec form, this is the preferred form
CMD ["executable","param1","param2"]

# as default parameters to ENTRYPOINT
CMD ["param1","param2"]

# shell form
CMD command param1 param2
```

https://docs.docker.com/engine/reference/builder/#cmd

CMD vs ENTRYPOINT

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- Both **define** what **command** gets **executed** when **running** a container
- **Dockerfile** should specify at **least one** of **them**
- **ENTRYPOINT** should be defined when using the **container** as an **executable**
- **CMD** should be used as a way of defining **default arguments** for an **ENTRYPOINT** command or for **executing** an **ad-hoc** command in a container
- **CMD** will be overridden when **running** the container with **alternative** arguments

CMD vs ENTRYPOINT

- Both have **exec** and shell **form**
- When used **together always** use their **exec** form

CMD \ ENTRYPOINT	N/A	exec_entry p1_entry	["exec_entry", "p1_entry"]
N/A	Error	/bin/sh -c exec_entry p1_entry	exec_entry p1_entry
["exec_cmd", "p1_cmd"]	exec_cmd p1_cmd	/bin/sh -c exec_entry p1_entry	**exec_entry p1_entry exec_cmd p1_cmd**
["p1_cmd", "p2_cmd"]	p1_cmd p2_cmd	/bin/sh -c exec_entry p1_entry	**exec_entry p1_entry p1_cmd p2_cmd**
exec_cmd p1_cmd	/bin/sh -c exec_cmd p1_cmd	/bin/sh -c exec_entry p1_entry	~~**exec_entry p1_entry /bin/sh -c exec_cmd p1_cmd**~~

Ignores any **CMD** or **docker run** command line arguments

https://docs.docker.com/engine/reference/builder/#understand-how-cmd-and-entrypoint-interact

build / image build

- Purpose
  - Build an image from a Dockerfile
- Old syntax

```
docker build [OPTIONS] PATH | URL | -
```

- New syntax

```
docker image build [OPTIONS] PATH | URL | -
```

- Example

```
docker image build -t new-image .
```

Recommendations

Just a Few

Recommendations

- Don't create large images
- Don't use only the "latest" tag
- Don't run more than one process in a single container
- Don't rely on IP addresses
- Put information about the author

https://developers.redhat.com/blog/2016/02/24/10-things-to-avoid-in-docker-containers/

http://www.projectatomic.io/docs/docker-image-author-guidance/

Heredoc Container

Why Not?!

Heredoc Container

- Purpose
  - Create a new image on the fly ☺
- Example

```
devops@sulab:~$ docker build -t htop - << EOF
FROM alpine
RUN apk --no-cache add htop
EOF
```

Practice: Creating Images

Live Demonstration in Class

Summary

- Containerization is a hot topic, but it isn't something new
- Docker is de-facto a standard
- Docker is offered in two versions – CE and EE
- There are several installation options
- Images can be published to private or public registries
- Two sets of commands are still available
- There are multiple ways to create an image

Resources

Docker Documentation

https://docs.docker.com/

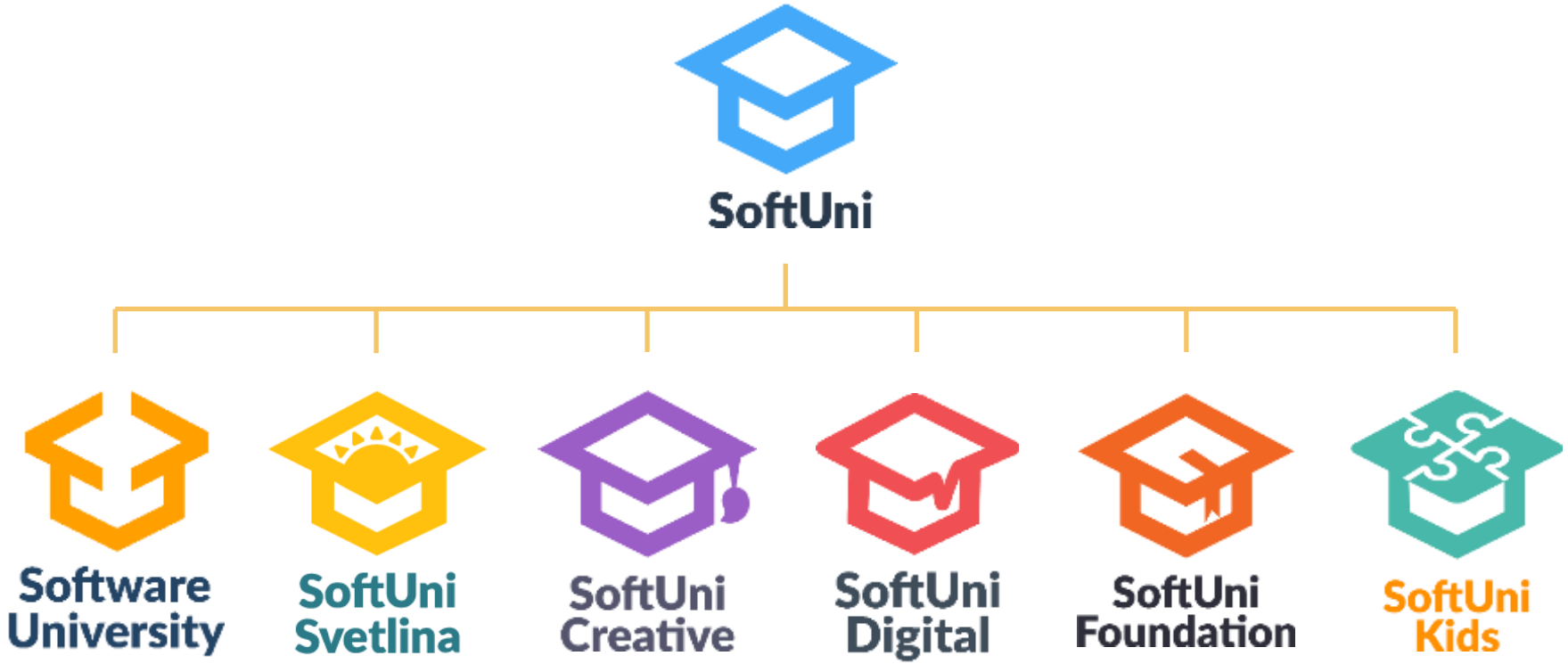
Docker Hub Documentation

https://docs.docker.com/docker-hub/

Docker Registry Documentation

https://docs.docker.com/registry/

Questions?



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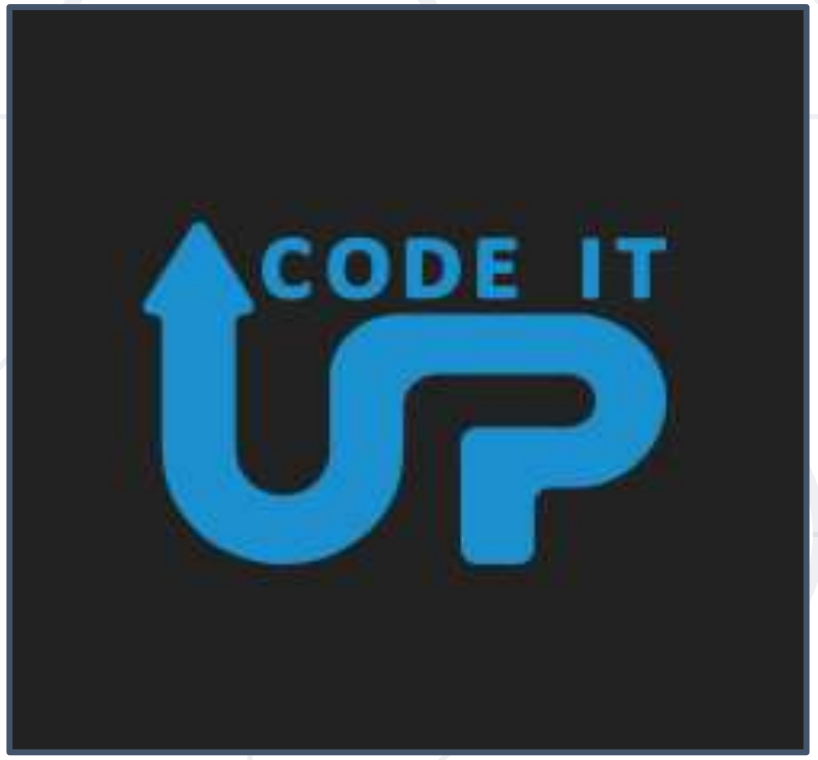

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