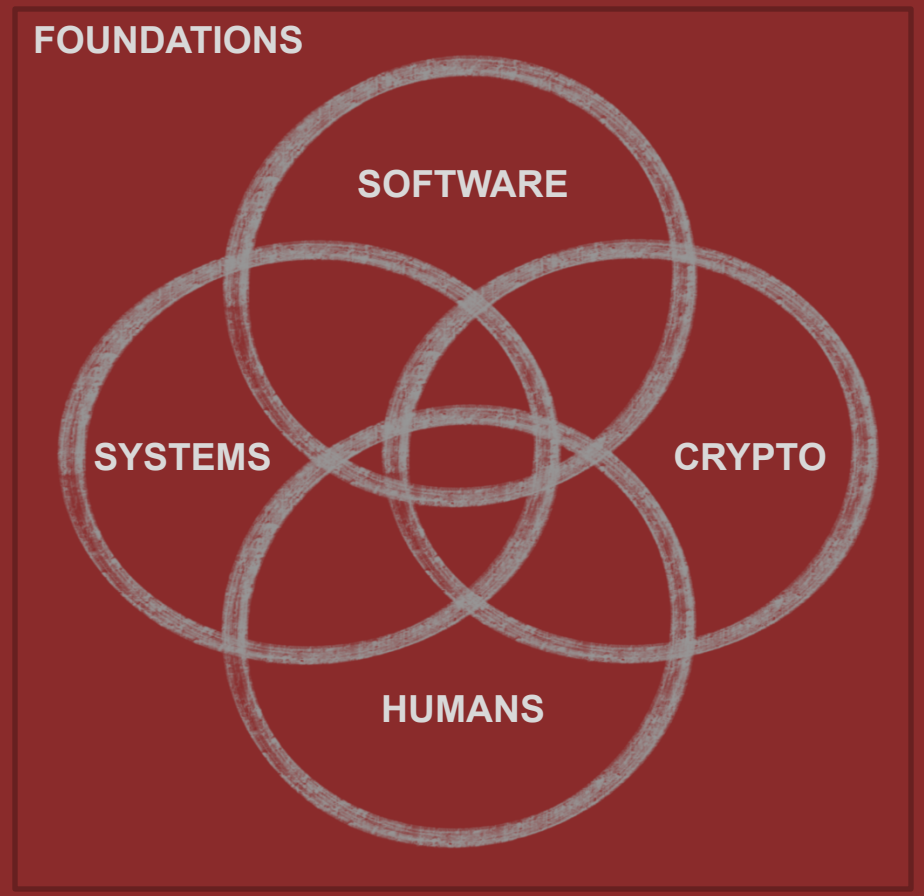
Διάλεξη #1 - Docker Basics

Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών

Εισαγωγή στην Ασφάλεια

Θανάσης Αυγερινός



Thank you to https://home.infn.it/it/ for their Docker slides!

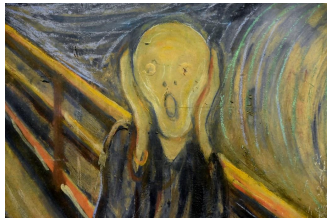
Την Προηγούμενη Φορά

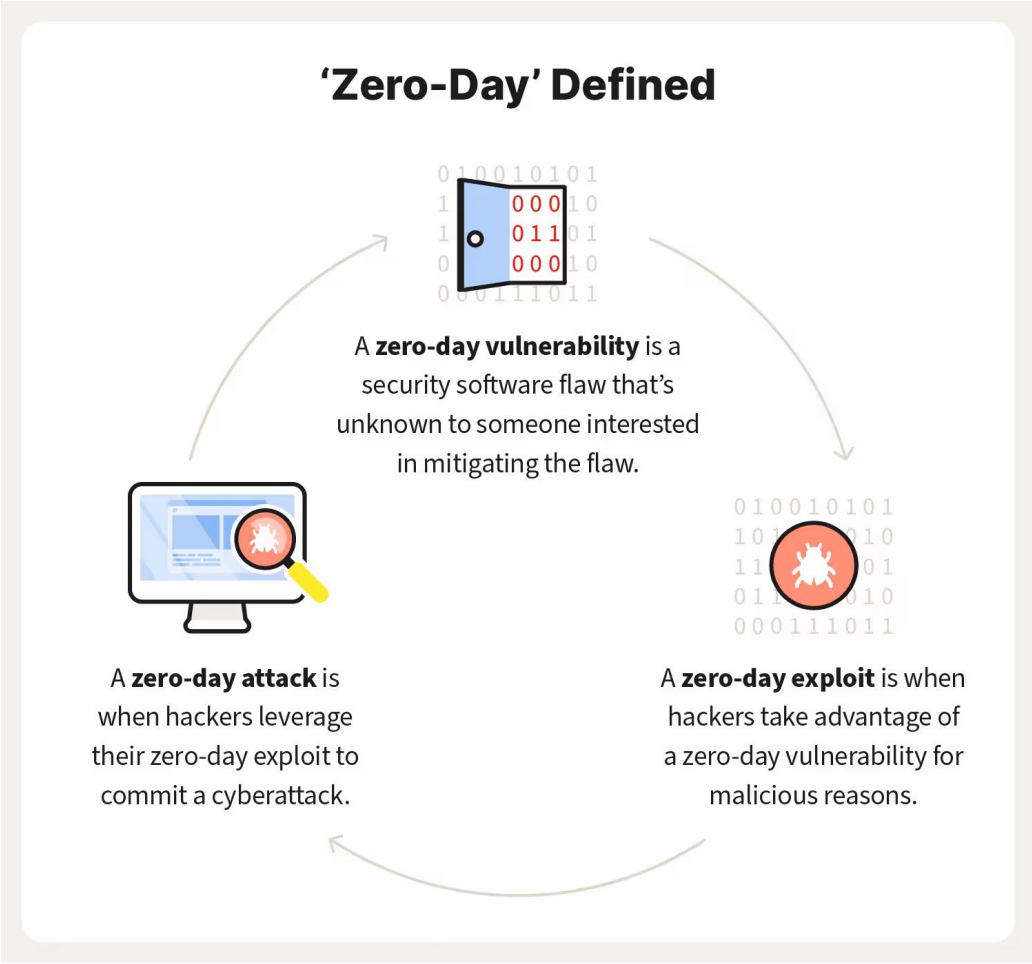
1. Διαδικαστικά
2. Σκοπός του μαθήματος
3. Ασφάλεια και Συστήματα
4. Σχέδιο για το μάθημα φέτος
5. Το πρώτο μας exploit

Ανακοινώσεις / Διευκρινίσεις

Ερωτήσεις που δέχτηκα:

- Είναι όλα τα vulnerabilities που βρίσκουμε γνωστά;
  - Vulnerability σε τρέχον λογισμικό 0-day
  - Ο πιο επικίνδυνος τύπος αδυναμίας
- Τι κάναμε στο πρώτο μας exploit;
  - Αναλογία με το να ανοίξουμε PDF με έναν PDF reader;
- Μπορεί κάποιος να δημιουργήσει exploit χωρίς source;
- Λαπτοπ εν ώρα μαθήματος;





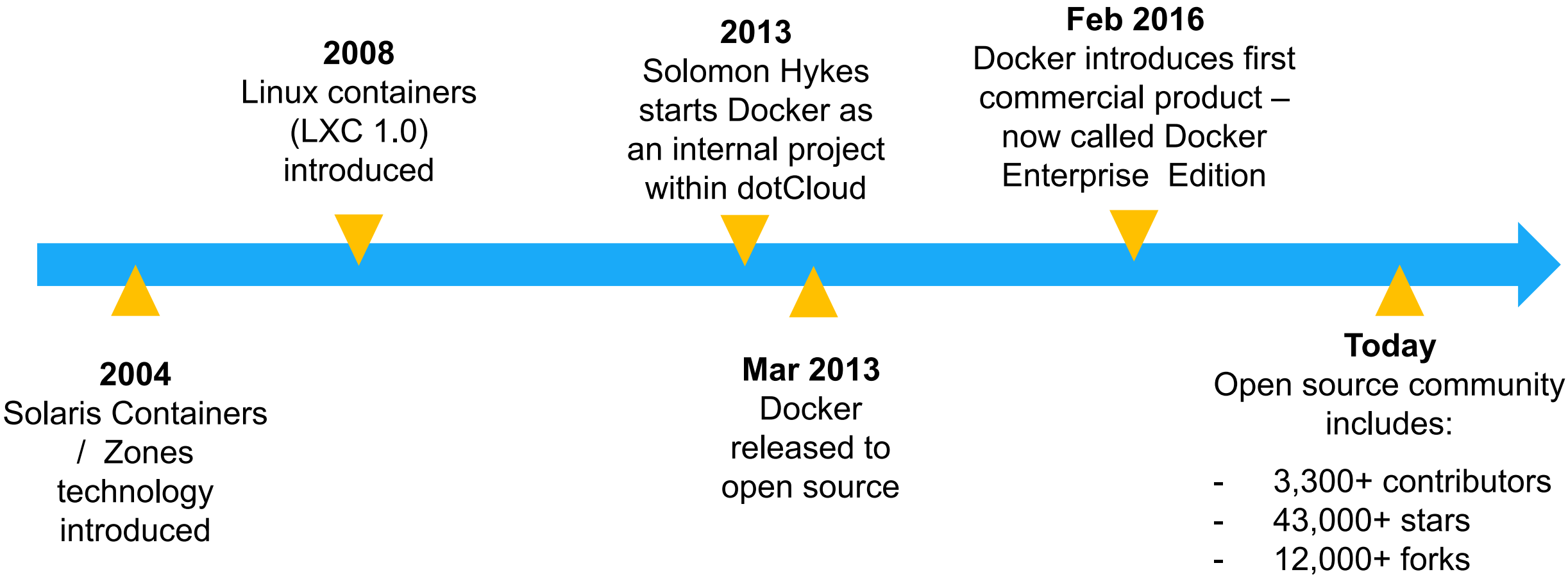
Σήμερα

- Docker (Linux / Bash κτλ αν προκύψει)

Docker Basics

Why: (1) embarrassing not to know, (2) understanding how modern software is built/packaged/secured today, and (3) to complete our hw :P

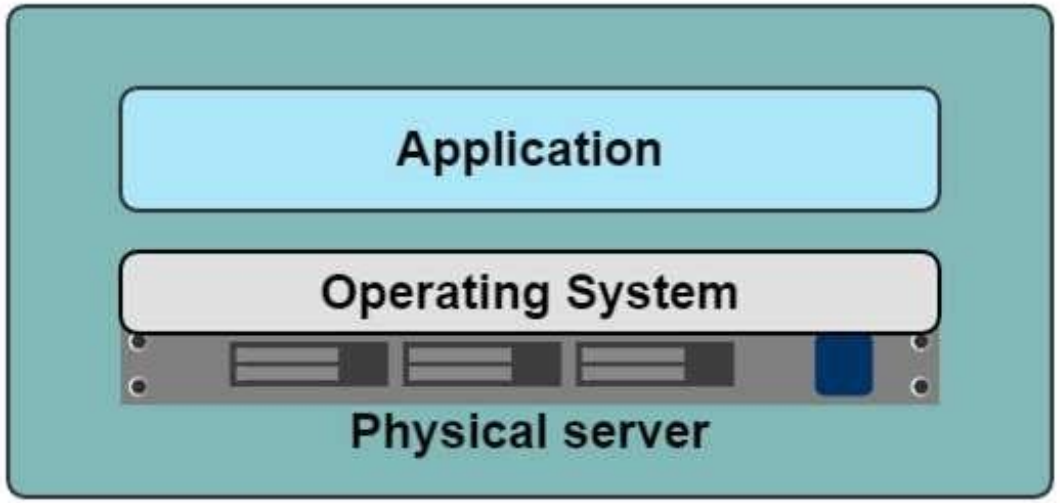
History of Docker



A History Lesson

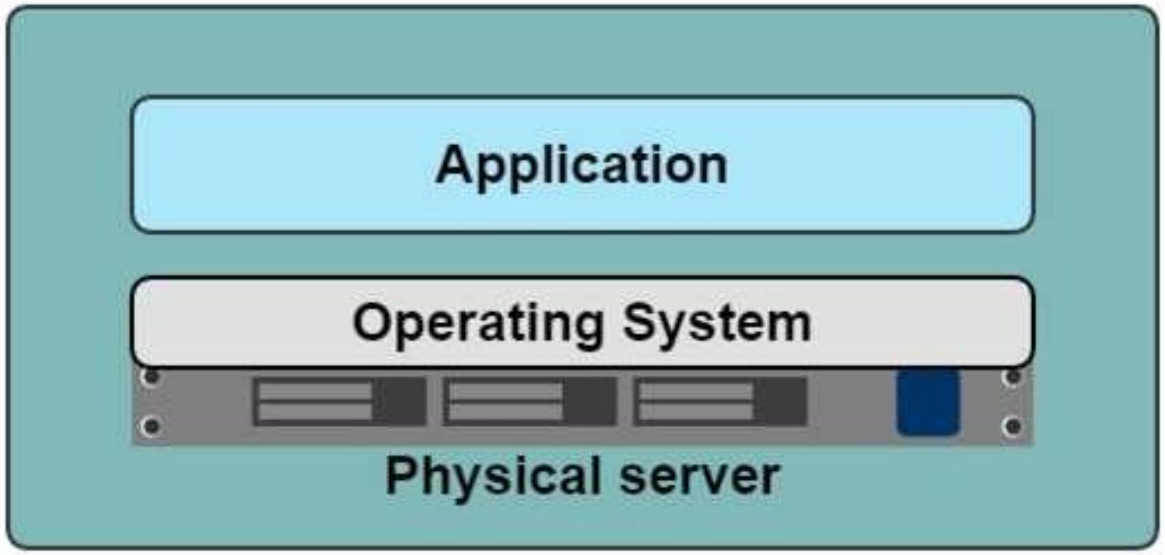
In the Dark Ages

One application on one physical server



Historical limitations of application deployment

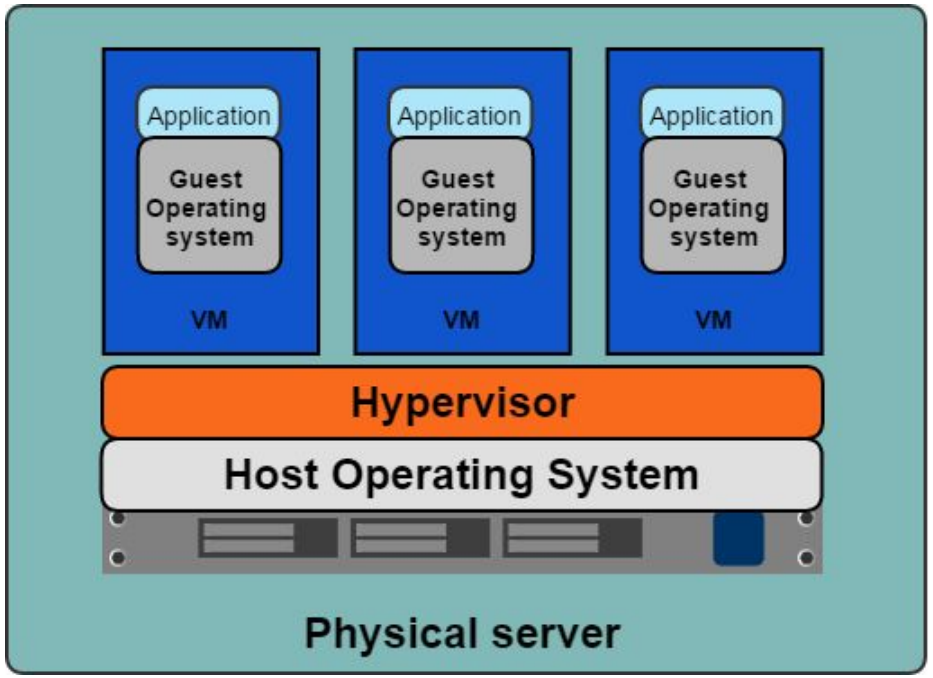
- Slow deployment times
- Huge costs
- Wasted resources
- Difficult to scale
- Difficult to migrate
- Vendor lock in



A History Lesson

Hypervisor-based Virtualization

- One physical server can contain multiple applications
- Each application runs in a virtual machine (VM)



Benefits of VMs

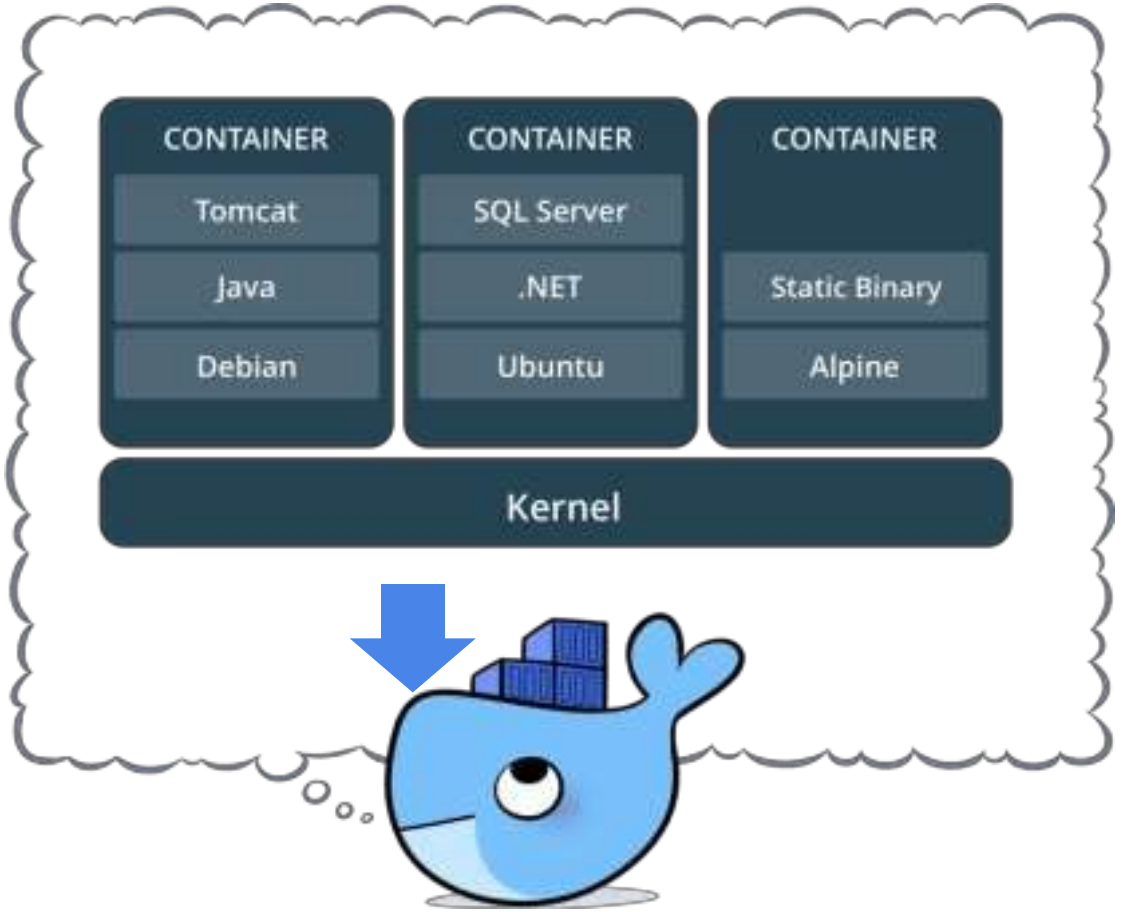
- Better resource pooling
  - One physical machine divided into multiple virtual machines
- Easier to scale
- VMs in the cloud
  - Rapid elasticity
  - Pay as you go model

Limitations of VMs

- Each VM stills requires
  - CPU allocation
  - Storage
  - RAM
  - An entire guest operating system

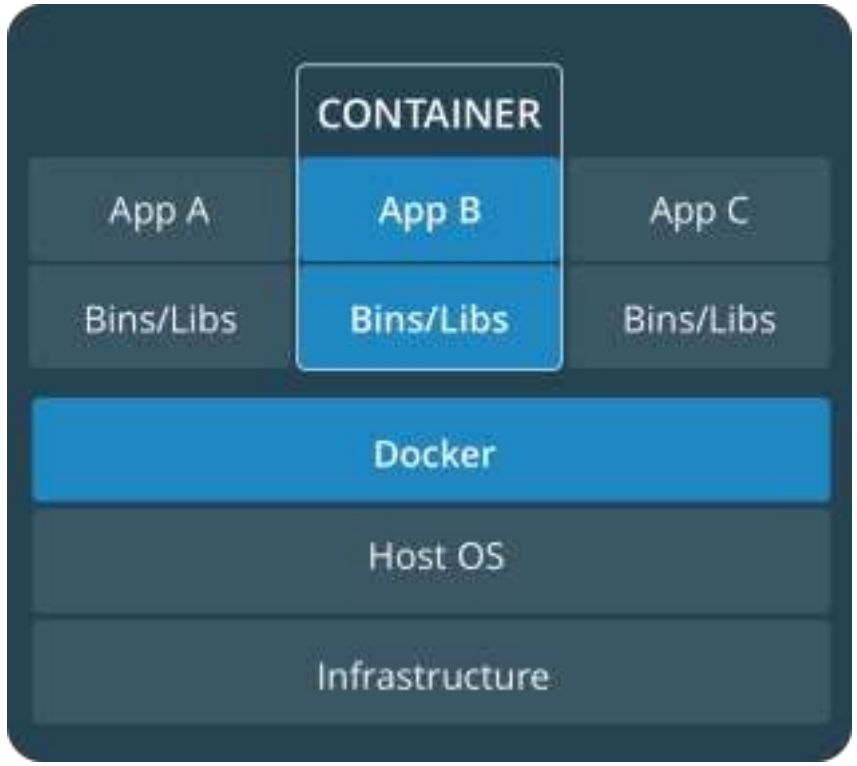
- The more VMs you run, the more resources you need
- Guest OS means wasted resources
- Application portability not guaranteed

What is a container?

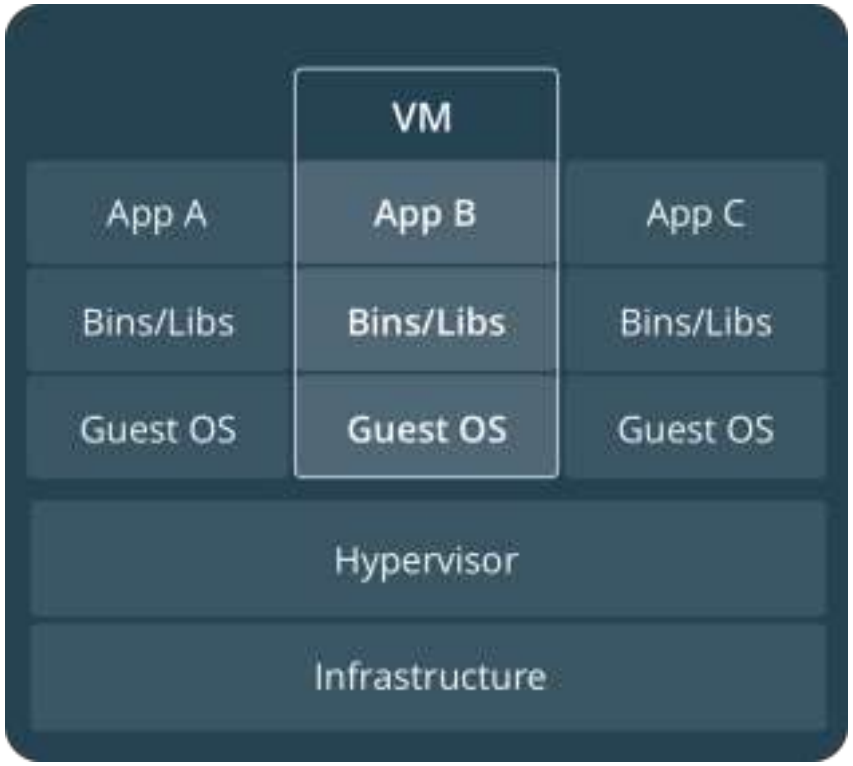


- Standardized packaging for software and dependencies
- Isolate apps from each other
- Share the same OS kernel
- Works with all major Linux and Windows Server OSes

Comparing Containers and VMs

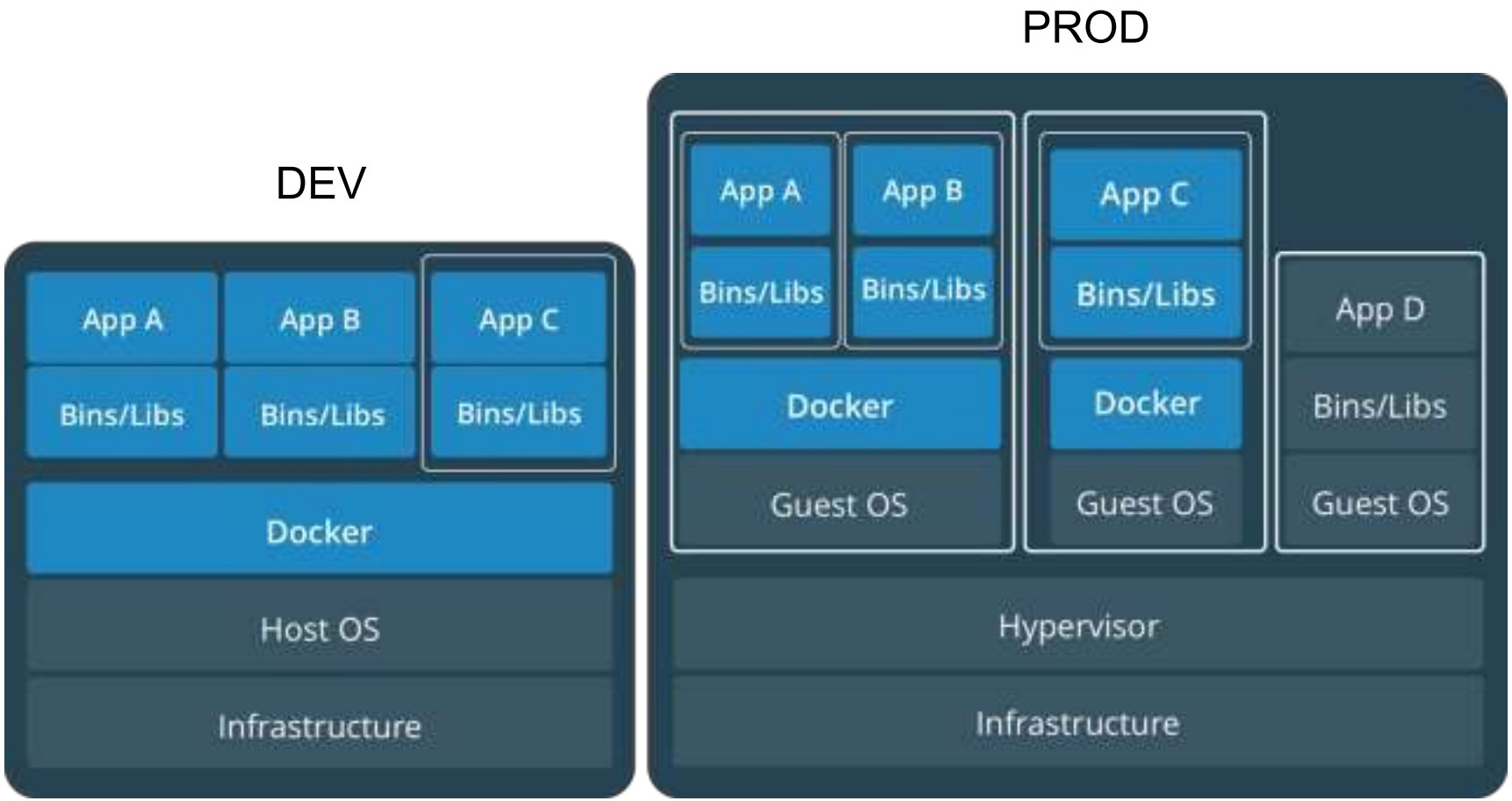


Containers are an app level construct



VMs are an infrastructure level construct to turn one machine into many servers

Containers and VMs together



Containers and VMs together provide a tremendous amount of flexibility for IT to optimally deploy and manage apps.

Key Benefits of Docker Containers

Speed

- No OS to boot = applications online in seconds

Portability

- Less dependencies between process layers = ability to move between infrastructure

Efficiency

- Less OS overhead
- Improved VM density

Docker Terminology

Image

The basis of a Docker container. The content at rest.

Container

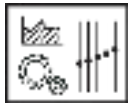
The image when it is ‘running.’ The standard unit for app service.

Engine

The software that executes commands for containers. Networking and volumes are part of Engine. Can be clustered together.

Registry

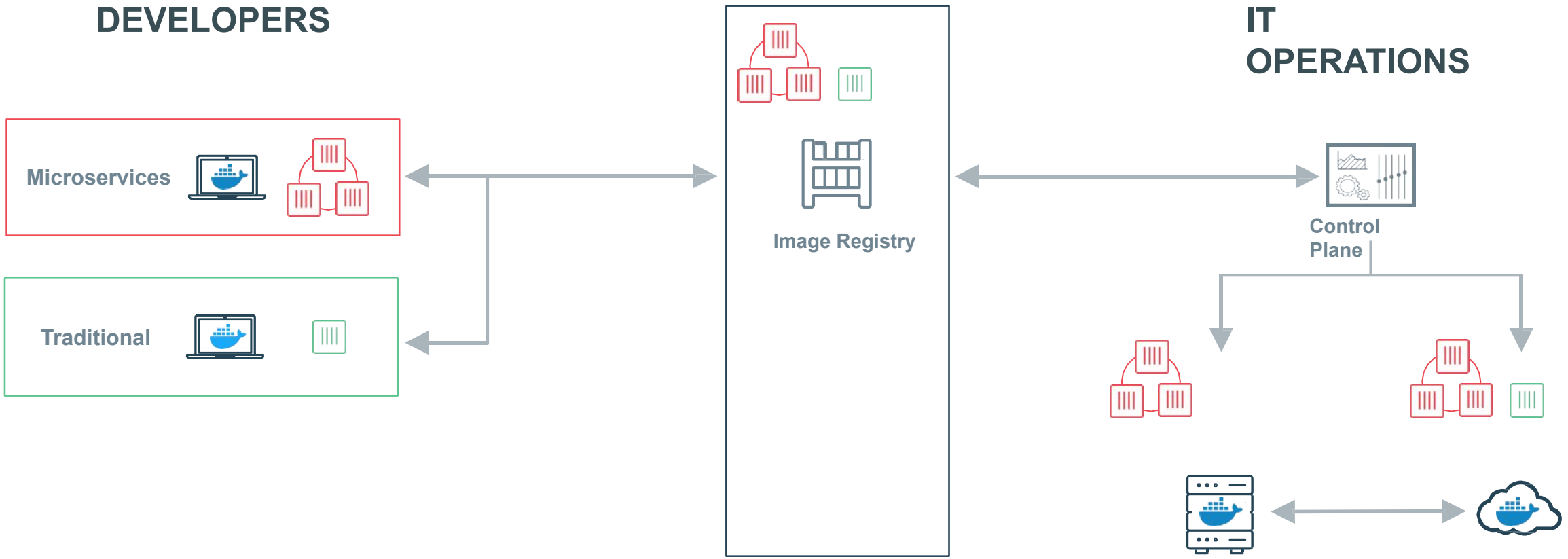
Stores, distributes and manages Docker images.



Control Plane

Management plane for container and cluster orchestration.

Building a Software Supply Chain



Docker registry

A Docker registry is a storage and distribution system for named Docker images. The same image might have multiple different versions, identified by their tags.

A Docker registry is organized into Docker repositories , where a repository holds all the versions of a specific image.
The registry allows Docker users to pull images locally, as well as push new images to the registry (given adequate access permissions when applicable).

By default, the Docker engine interacts with DockerHub , Docker’s public registry instance.

However, it is possible to run on-premise the open-source Docker registry/distribution, as well as a commercially supported version called Docker Trusted Registry .

Run your first docker

Docker run

One of the first and most important commands Docker users learn is the `docker run` command. This comes as no surprise since its primary function is to build and run containers.

There are many different ways to run a container. By adding attributes to the basic syntax, you can configure a container to run in detached mode, set a container name, mount a volume, and perform many more tasks.

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

Docker run

> docker run hello-world

Unable to find image 'hello-world:latest' locally

latest: Pulling from library/hello-world

[...]

Status: Downloaded newer image for hello-world:latest

Hello from Docker!

This message shows that your installation appears to be working correctly.

[...]

Build your own docker

Dockerfile basics

A Dockerfile is a simple text file that contains a list of commands that the Docker client calls while creating an image.

It's a simple way to automate the image creation process.

The commands you write in a Dockerfile are *almost* identical to their equivalent Linux commands: this means you don't really have to learn new syntax to create your own dockerfiles.

Dockerfile directives(1/3)

FROM

The from directive is used to set base image for the subsequent instructions. A Dockerfile must have FROM directive with valid image name as the first instruction.

FROM ubuntu:20.04

RUN

Using RUN directing ,you can run any command to image during build time. For example you can install required packages during the build of image.

RUN apt-get update
RUN apt-get install -y apache2 automake build-essential curl

Dockerfile directives (2/3)

COPY

The COPY directive used for copying files and directories from host system to the image during build.

For example the first commands will copy all the files from hosts html/ directory /var/www/html image directory.

Second command will copy all files with extension .conf to /etc/apache2/sites-available/ directory.

COPY html/ /var/www/html/*
*COPY *.conf /etc/apache2/sites-available/*

WORKDIR

The WORKDIR directive used to sets the working directory for any RUN, CMD, ENTRYPOINT, COPY and ADD commands during build.

WORKDIR /opt

Dockerfile directives (3/3)

CMD
The CMD directive is used to run the service or software contained by your image, along with any arguments during the launching the container. CMD uses following basic syntax

CMD ["executable","param1","param2"]
CMD ["executable","param1","param2"]

For example, to start Apache service during launch of container, Use the following command.

CMD ["apachectl", "-D", "FOREGROUND"]

EXPOSE

The EXPOSE directive indicates the ports on which a container will listen for the connections. After that you can bind host system port with container and use them.

EXPOSE 80
EXPOSE 443

Sample Dockerfile #1

Given this Dockerfile:

FROM alpine
CMD ["echo", "Hello Tor Vergata!"]

Build and run it:

docker build -t hello .
docker run --rm hello

This will output:

Hello Tor Vergata!

Sample Dockerfile #2

```
FROM nginx:latest

RUN touch /testfile

COPY ./index.html /usr/share/nginx/html/index.html
```

Docker build / push

Use Docker build to build your image locally

docker build -t <registry>/<image name>:<tag> .

And Docker push to publish your image on registry

docker push <registry>/<image name>:<tag>

Data persistence

Data persistence

Docker containers provide you with a writable layer on top to make changes to your running container.

But these changes are bound to the container's lifecycle: If the container is deleted (not stopped), you lose your changes.

Let's take a hypothetical scenario where you are running a database in a container without any data persistence configured.

You create some tables and add some rows to them: but, if some reason, you need to delete this container, as soon as the container is deleted all your tables and their corresponding data get lost.

Docker provides us with a couple of solutions to persist your data even if the container is deleted.

The two possible ways to persist your data are:

- **Bind Mounts**
- **Volumes**

Bind mounts

Bind mounts have been around since the early days of Docker.

When you use a bind mount, **a file or directory on the host machine is mounted into a container.**

The file or directory is referenced by its absolute path on the host machine.

By contrast, when you use a volume, a new directory is created within Docker's storage directory on the host machine, and Docker manages that directory's contents.

The file or directory does not need to exist on the Docker host already.
It is created on demand if it does not yet exist.
Bind mounts are very performant, but they rely on the host machine's filesystem having a specific directory structure available.
If you are developing new Docker applications, consider using named volumes instead.

Not covered here: Docker Volumes & Networking (research it!)

Docker cheatsheet

Cheatsheet for Docker CLI

Run a new Container

Start a new Container from an Image
```
docker run IMAGE
docker run nginx
```

...and assign it a name
```
docker run --name CONTAINER IMAGE
docker run --name web nginx
```

...and map a port
```
docker run -p HOSTPORT:CONTAINERPORT IMAGE
docker run -p 8080:80 nginx
```

...and map all ports
```
docker run -P IMAGE
docker run -P nginx
```

...and start container in background
```
docker run -d IMAGE
docker run -d nginx
```

...and assign it a hostname
```
docker run --hostname HOSTNAME IMAGE
docker run --hostname srv nginx
```

...and add a dns entry
```
docker run --add-host HOSTNAME:IP IMAGE
```

...and map a local directory into the container
```
docker run -v HOSTDIR:TARGETDIR IMAGE
docker run -v ~/:/usr/share/nginx/html nginx
```

...but change the entrypoint
```
docker run -it --entrypoint EXECUTABLE IMAGE
docker run -it --entrypoint bash nginx
```

Manage Containers

Show a list of running containers
```
docker ps
```

Show a list of all containers
```
docker ps -a
```

Delete a container
```
docker rm CONTAINER
docker rm web
```

Delete a running container
```
docker rm -f CONTAINER
docker rm -f web
```

Delete stopped containers
```
docker container prune
```

Stop a running container
```
docker stop CONTAINER
docker stop web
```

Start a stopped container
```
docker start CONTAINER
docker start web
```

Copy a file from a container to the host
```
docker cp CONTAINER:SOURCE TARGET
docker cp web:/index.html index.html
```

Copy a file from the host to a container
```
docker cp TARGET CONTAINER:SOURCE
docker cp index.html web:/index.html
```

Start a shell inside a running container
```
docker exec -it CONTAINER EXECUTABLE
docker exec -it web bash
```

Rename a container
```
docker rename OLD_NAME NEW_NAME
docker rename 096 web
```

Create an image out of container
```
docker commit CONTAINER
docker commit web
```

Manage Images

Download an image
```
docker pull IMAGE[:TAG]
docker pull nginx
```

Upload an image to a repository
```
docker push IMAGE
docker push myimage:1.0
```

Delete an image
```
docker rmi IMAGE
```

Show a list of all Images
```
docker images
```

Delete dangling images
```
docker image prune
```

Delete all unused images
```
docker image prune -a
```

Build an image from a Dockerfile
```
docker build DIRECTORY
docker build .
```

Tag an image
```
docker tag IMAGE NEWIMAGE
docker tag ubuntu ubuntu:18.04
```

Build and tag an image from a Dockerfile
```
docker build -t IMAGE DIRECTORY
docker build -t myimage .
```

Save an image to .tar file
```
docker save IMAGE > FILE
docker save nginx > nginx.tar
```

Load an image from a .tar file
```
docker load -i TARFILE
docker load -i nginx.tar
```

Info & Stats

Show the logs of a container
```
docker logs CONTAINER
docker logs web
```

Show stats of running containers
```
docker stats
```

Show processes of container
```
docker top CONTAINER
docker top web
```

Show installed docker version
```
docker version
```

Get detailed info about an object
```
docker inspect NAME
docker inspect nginx
```

Show all modified files in container
```
docker diff CONTAINER
docker diff web
```

Show mapped ports of a container
```
docker port CONTAINER
docker port web
```

Docker ecosystems

Docker compose

Docker Compose is a tool that was developed to help define and share multi-container applications.

With Compose, we can create a YAML file to define the services and with a single command, can spin everything up or tear it all down.

Each of the containers here run in isolation but can interact with each other when required.

Docker Compose files are very easy to write in a scripting language called YAML, which is an XML-based language that stands for Yet Another Markup Language.

```
version: "3.7"

services:
  app:
    image: node:12-alpine
    command: sh -c "yarn install && yarn run dev"
    ports:
      - 3000:3000
    working_dir: /app
    volumes:
      - ./:/app
    environment:
      MYSQL_HOST: mysql
      MYSQL_USER: root
      MYSQL_PASSWORD: secret
      MYSQL_DB: todos

  mysql:
    image: mysql:5.7
    volumes:
      - mysql-data:/var/lib/mysql
    environment:
      MYSQL_ROOT_PASSWORD: secret
      MYSQL_DATABASE: todos

volumes:
  mysql-data:
```

Docker orchestration

Docker swarm

Docker swarm is a container orchestration tool, meaning that it allows the user to manage multiple containers deployed across multiple host machines.

A Docker Swarm is a group of either physical or virtual machines that are running the Docker application and that have been configured to join together in a cluster.

Once a group of machines have been clustered together, you can still run the Docker commands that you're used to, but they will now be carried out by the machines in your cluster.

The activities of the cluster are controlled by a swarm manager, and machines that have joined the cluster are referred to as nodes.

Kubernetes

Kubernetes is an open source system to deploy, scale, and manage containerized applications.

It automates operational tasks of container management and includes built-in commands for deploying applications, rolling out changes to your applications, scaling your applications up and down to fit changing needs, monitoring your applications, and more.

Application developers, IT system administrators and DevOps engineers use Kubernetes to automatically deploy, scale, maintain, schedule and operate multiple application containers across clusters of nodes.

Containers run on top of a common shared operating system (OS) on host machines but are isolated from each other unless a user chooses to connect them.

Docker Swarm

1. No Auto Scaling
2. Good community
3. Easy to start a cluster
4. Limited to the Docker API's capabilities
5. Does not have as much experience with production deployments at scale

Kubernetes

1. Auto Scaling
2. Great active community
3. Difficult to start a cluster
4. Can overcome constraints of Docker and Docker API
5. Deployed at scale more often among organizations

Docker playground

https://www.docker.com/play-with-docker/

Questions on Docker / Containers?

Ευχαριστώ και καλή μέρα εύχομαι!

Keep hacking!