Technische Hochschule Rosenheim
Technical University of Applied Sciences

Microservices

Container - Basics

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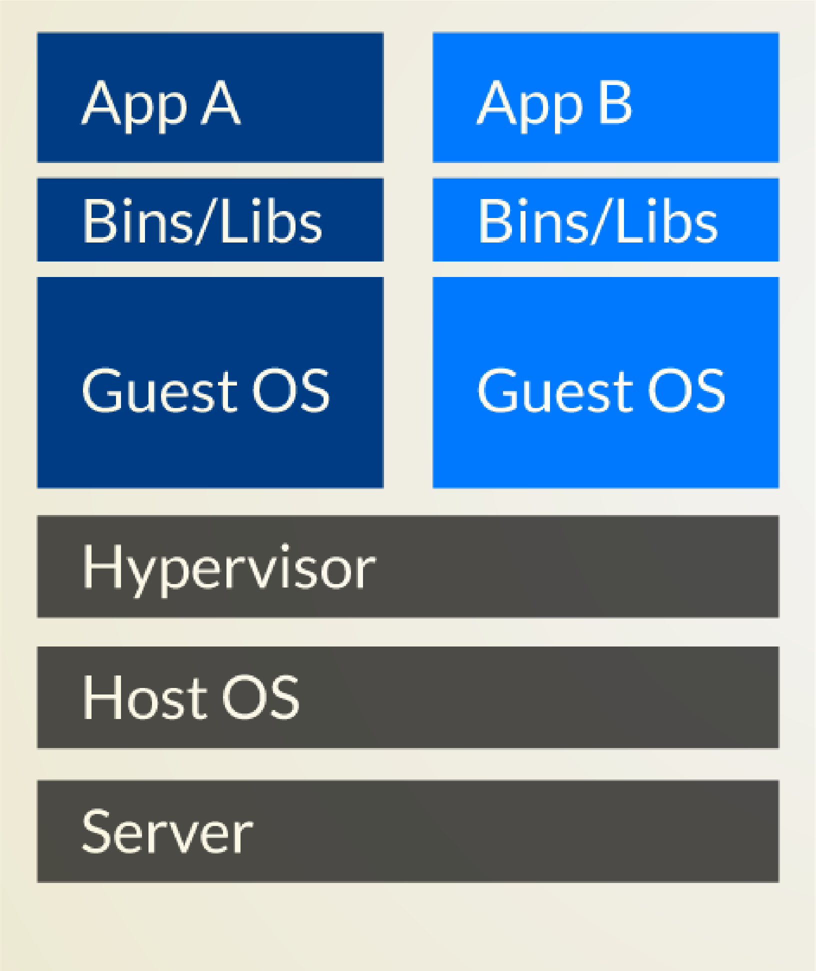
Container vs. virtualization



App A | App B

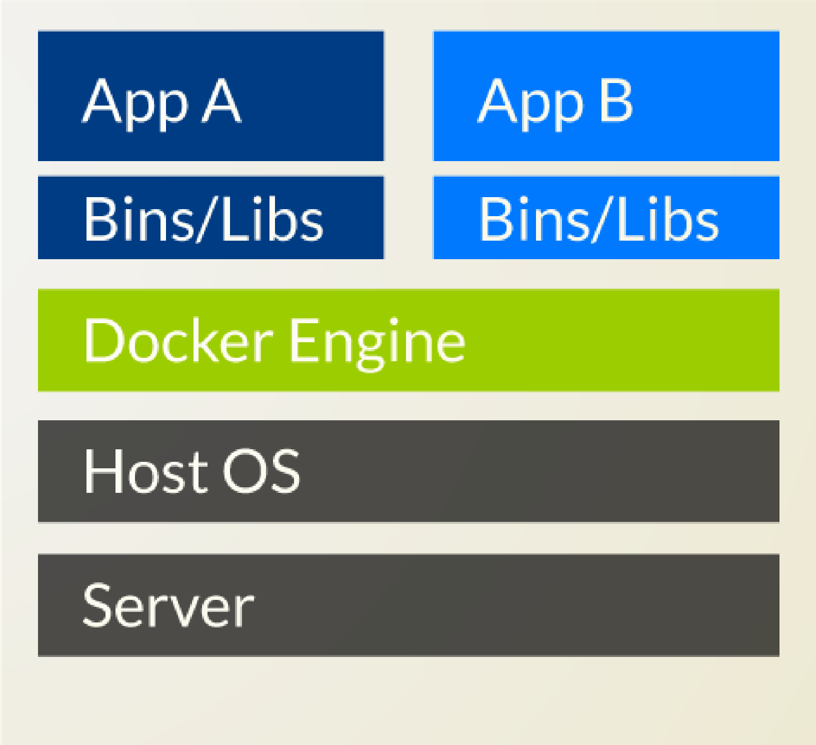
Bins/Libs | Bins/Libs

Guest OS | Guest OS

Hypervisor

Host OS

Server



App A | App B

Bins/Libs | Bins/Libs

Docker Engine

Host OS

Server

Virtualization - Pros

- Many excellent hypervisors available
- Feels like "ordinary" systems for administrators and developers
- No special knowledge needed

Virtualization - Cons

- Resource overhead for every virtual machine
- Takes longer to setup if no special tools are used (Puppet, Chef,... covered later)

Containers - Pros

- Lower resource overhead
- Very fast setup when prebuilt container images are available
- Isolation of every container
- Stable environment

Containers - Cons

- Training of developers and administrators required
- Getting complex if cluster is required (Kubernetes, DC/OS, Swarm)
- Backup

Container basics

Every container engine (e.g. Linux Containers (LXC) or Docker) is based on two Linux Kernel features:

- Process namespces
- Control groups (cgroups)

Namespaces

- Introduced in the Linux Kernel 2002
- Inspired by Plan 9 from Bell Labs
- Later on extended to support Process ID (PID) namespaces

Namespaces used in Docker:

- pid - PID isolation
- net - managing network interfaces
- ipc - managing access to inter-process communication (IPC) resources
- mnt - managing filesystem mount points
- uts - isolating kernel and version identifiers (Unix Timesharing System (UTS))

Control groups

- cgroups are used to restrict the resources a process or process group can allocate
- cgroups can be used to restrict classic resources e.g. RAM or CPU shares a proceses can allocate
- it is also possible to utilize cgroups to restrict access to certain devices

History of Docker

- 01/19/2013 - Initial commit
- 03/01/2013 - First announcement
- 10/29/2013 - Rebranding of dotCloud to Docker Inc.
- 07/01/2014 - Microsoft, Red Hat, IBM, Docker,... joined the Kubernetes project
- 10/15/2014 - Microsoft announces Docker support in Windows Server 2016
- 07/21/2015 - First Kubernetes version
- 06/08/2016 - Native Docker support with Hyper-V on Windows
- 06/20/2016 - Docker Swarm is built-in with Docker 1.12
- 07/19/2018 - Docker for Mac/Windows 18.06 stable ships with Kubernetes built-in

CONTAINERS, CONTAINERS
EVERYWHERE
makeameme.org

Why Docker?

- No more time consuming setup of servers:
    - Dependencies
    - Configurations
    - Documentation for administrators
- Every application/component can be packaged in a container (almost)
- Upgrades of containers are fast (if done right)
- Developers to not need to setup a heavy development environment but just start a few containers (docker-compose!)

- Administrators "only" have to pull the container images to deploy to production
- Containers can easily scale out (think of 5 containers of the service instead of just 1)
- Rollback of an entire application/a single component is possible by switching the container image (with proper tagging)

Why Docker in Microservices?

- Create a container per service
- Scale out a single service instead of the whole application by deploying more containers
- Continuous integration & continuous delivery
  - E.g. automatically build new container images
  - Deploy new containers to testing, staging (and optionally production) environments depending on which branch you are building
- Existing eco systems for service discovery and distributed configuration (see chapters 10 and 11)
- Clustering solutions available (Kubernetes, Docker Swarm, DC/OS Mesos,...)

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Docker CLI - Basics

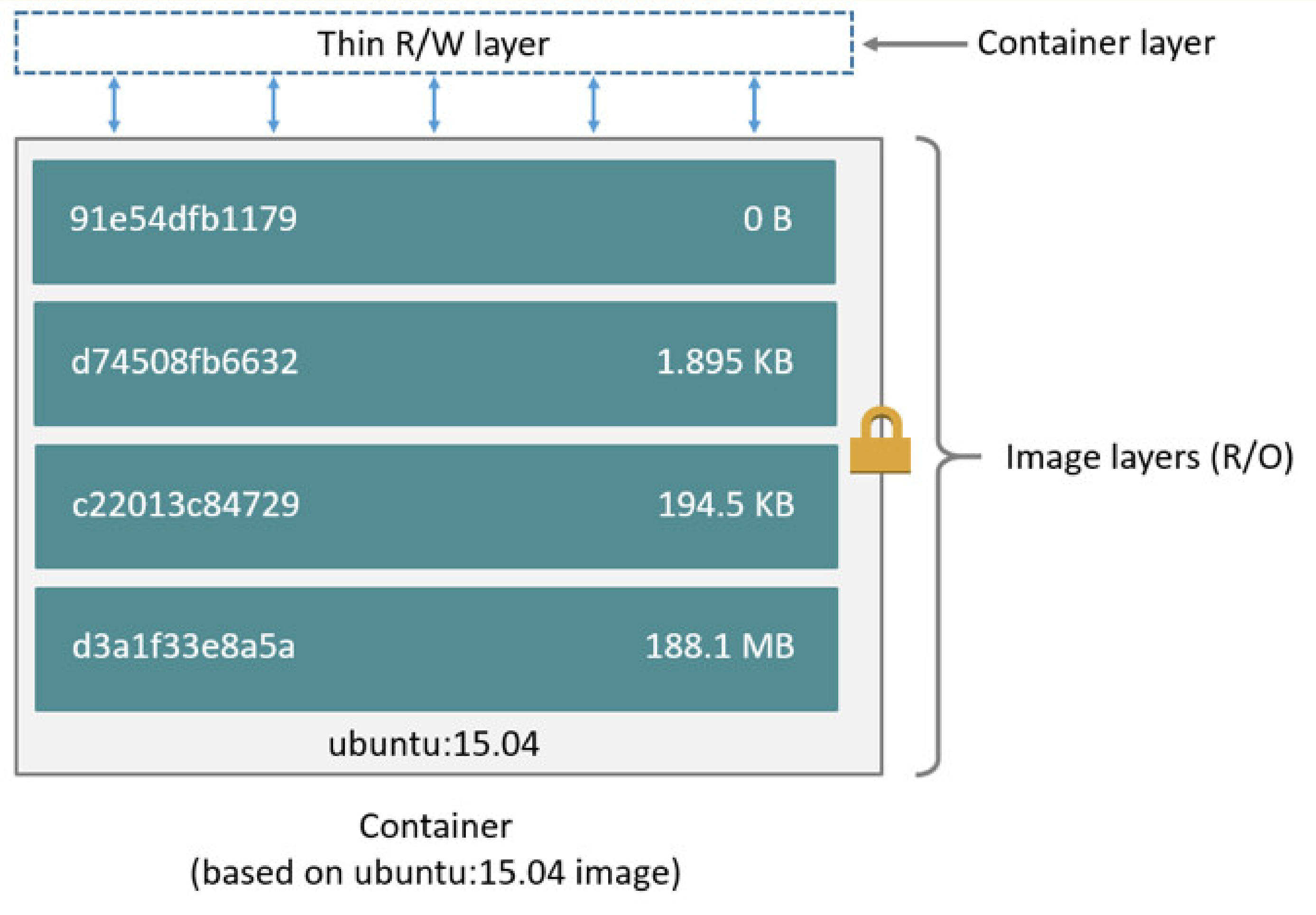
CMDlet	Explanation
`docker --help`	
`docker ps`	Show running containers
`docker ps -a`	Show all existing containers (including stopped)
`docker images`	Show all local images
`docker run –ti <image[:version]>`	Start a new interative container
`docker run –d <image[:version]>`	Start a new container i daemon mode (in the background)

CMDlet	Explanation
docker rm <container id/name>	Removes an existing container if it is stopped
docker rm –f <container id/name>	Removes an existing container even it is still running
docker exec –ti <container id/name>/bin/bash	Attaches a Bash instance to a running container
docker rmi <image id>	Removes a local container image
docker stop <container id/name>	Stops a running container
docker commit <container id/name> [repository[:tag]]	Create a new image from an existing container

Docker CLI - Build and registry

CMDlet	Explanation
`docker build [[registry/]user/image name]`	Create a new container based on a Dockerfile in the same directory
`docker build [[registry/]user/image name:tag]`	Create a new container based on a Dockerfile and add a tag to it
`docker push [[registry/]user/image name]`	Push a built image to a registry (default is Docker Hub)
`docker login [registry`	Login to a (private) Docker registry

Docker images



Concepts

- Every image consists of one or multiple layers
- Every layer is a kind of a snapshot and can be removed
- It is possible to inspect how a specific layer was created
- Each layer is nothing more than a `.tar.gz` archive which will be applied to a base image whenever a container is created
- When an image is rebuilt, the Docker daemon recognizes which layers aren't affected and is keeping them as they are to speed up the build process

Creating a new Docker image

- There are two ways to create a new Docker image:
  - Create a new container, do all required changes on your own e.g. via bash and commit the changes
  - Create a Dockerfile, describe all changes which have to be made to the base image and build it with the Docker CLI
- Most container are built with with Dockeriles because it is easier to make small changes and recreate an image. Building container manually is only acceptable for proof-of-concepts or development (exceptions are container images built with e.g. Ansbile more on that later)

Sample Dockerfile

```
# our base image
FROM alpine:3.5

# Install python and pip
RUN apk add --update py2-pip
# upgrade pip
RUN pip install --upgrade pip
# install Python modules needed by the Python app
COPY requirements.txt /usr/src/app/
RUN pip install --no-cache-dir -r /usr/src/app/requirements.txt
# copy files required for the app to run
COPY app.py /usr/src/app/
COPY templates/index.html /usr/src/app/templates/
# tell the port number the container should expose
EXPOSE 5000
```

Source

Dockerfile - Basics

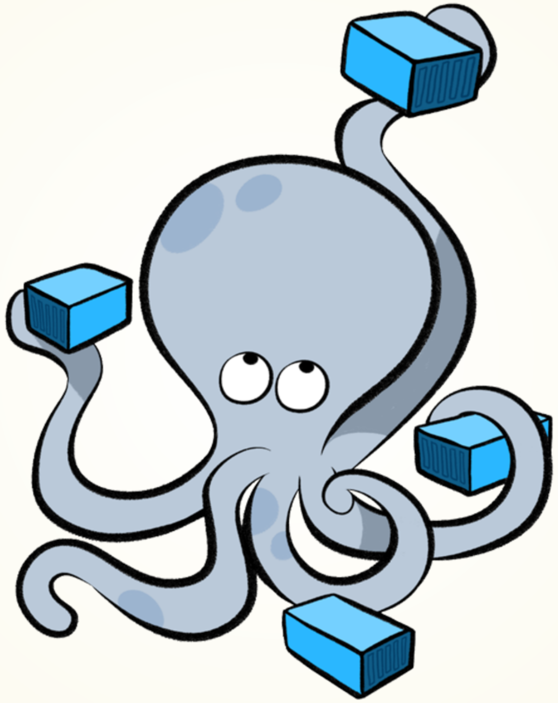
Command	Explanation
`FROM <image>[:tag]`	Declares base image which will be used
`RUN <command>`	Command to run while building the container (creates a new layer)
`CMD ["executable" [, "param1", "param2", ...]]`	Provide a default command when a new container is started
`EXPOSE <port number>`	Declare a port which will be exposed by the container (e.g. 80 for nginx or Apache web server)

Command	Explanation
`ENV <key> <value>`	Declare an environment variable for the container
`ARG <key> [<value>]`	Declare a build argument and optionally set a default value
`ADD <src> <dest>`	Copy files or directories from local or remote URLs into the container image
`COPY <src> <dest>`	Copy files or directories from local URLs into the container image
`ENTRYPOINT ["executable"[, "param1", "param2", ...]`	Declare the entrypoint of the container when it is started

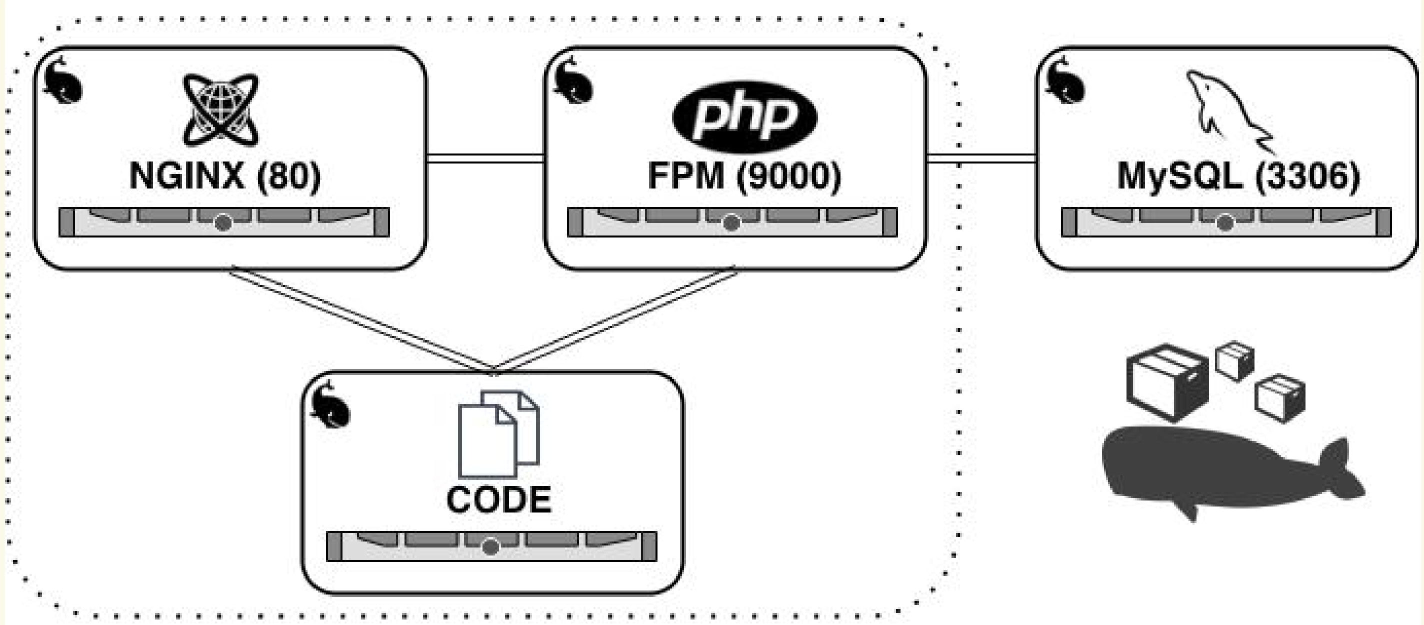
Command	Explanation
`VOLUME [ "/data" ]`	Declare a mount point to share data between the host and a container or between containers (persistence!)
`USER <user[:group]>`	Set the user context (and optionally the group) for all following `RUN`, `CMD` and the `ENTRYPOINT` in the Dockerfile
`WORKDIR /path/to/workdir`	Sets the working directory for every following `RUN`, `CMD`, `ENTRYPOINT`, `ADD` or `COPY` command, can be used multiple times in one Dockerfile, the directory will be created if it does not exist, the path can also be relative

See also Docker builder reference

docker-compose



Sample stack



Source

Concepts

- Tool to create multi-container applications
- Define all services the application consists of
- Separate services optionally in multiple networks
- Configure services (set environment variables, expose ports, mount volumes and so on)
- Start and stop a multi-container application by running a single command (`docker-compose up` or `docker-compose down`)
- An extended version is used to deploy multi-container applications to docker Swarm

- Other Docker cluster systems use similar formats (e.g. Pod definitoin in Kubernetes)
- Docs: https://docs.docker.com/compose/compose-file/compose-file-v2/
- Cheatsheet: https://devhints.io/docker-compose