docker

up leveled

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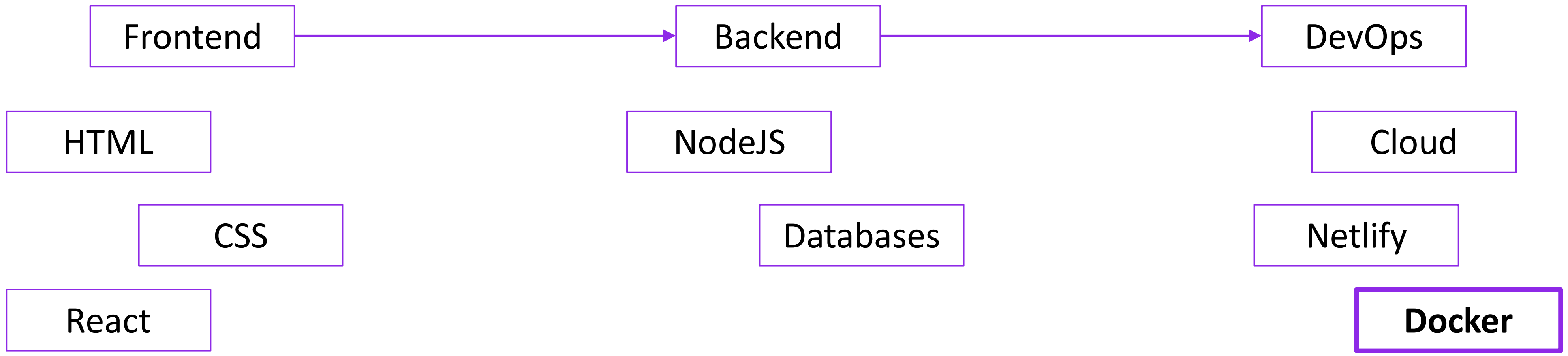
Docker in the Software Universe



What is Docker?

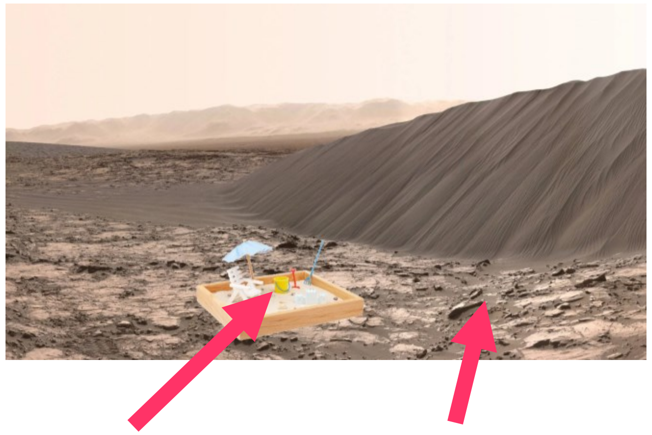
- Docker makes **deployment** of software packages really **easy**.

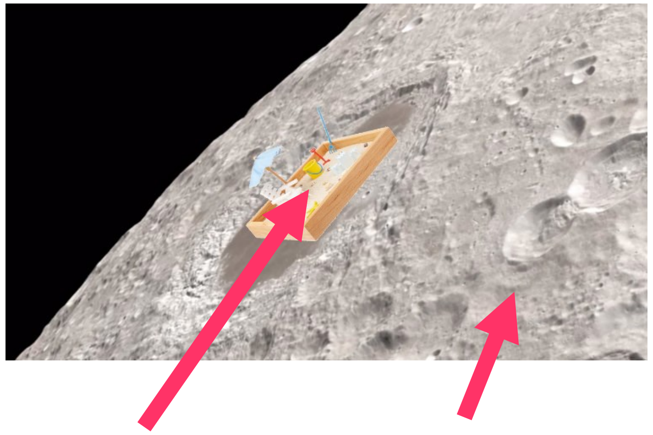
- **Docker** can be seen as a **sandbox** in which you can execute software packages.

What is a Sandbox?

- Inside the Sandbox you do not care about the environment
- When inside the Sandbox, you can only change things inside the sandbox, not outside.

MacOS
Docker





Test Docker installation

Installation Guide: https://github.com/upleveled/system-setup/blob/master/windows.md

```
$ docker run hello-world
…
Hello from Docker!
This message shows that your installation appears to be working correctly.
…
```

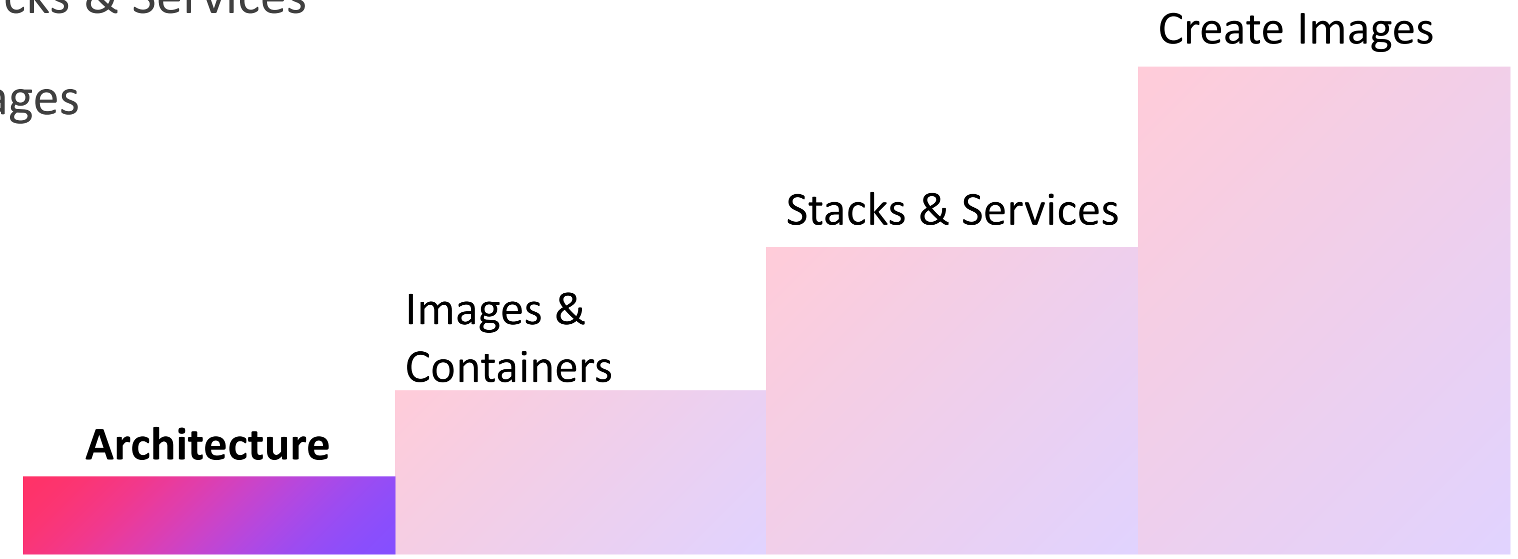
Outline

Docker Architecture

Docker Images & Containers

Docker Stacks & Services

Create Images



Terminology

We can execute Software Packages inside the Sandbox.

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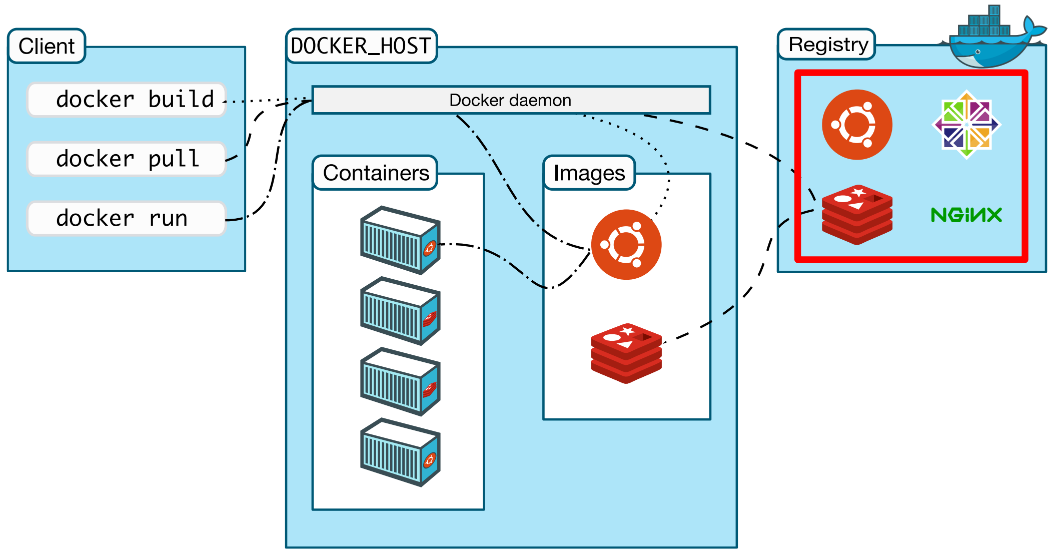
We can execute Software Packages inside the Sandbox.

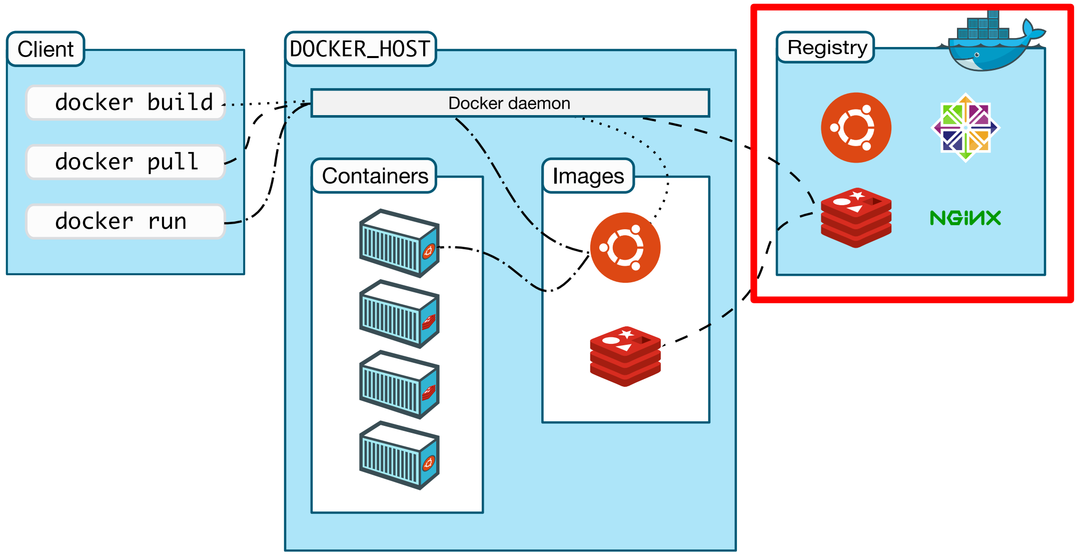
- Software Package (not executed) ➔ **Docker Image**



Terminology

We can execute Software Packages inside the Sandbox.

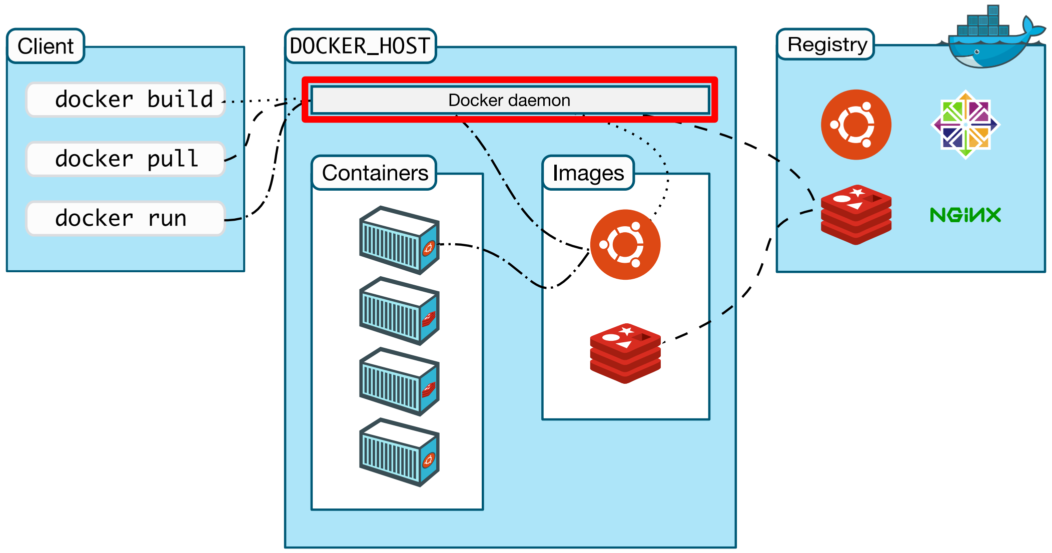
- Software Package (not executed) ➔ **Docker Image**
- Store for Docker Images ➔ **Docker Registry**



Terminology

We can execute Software Packages inside the Sandbox.

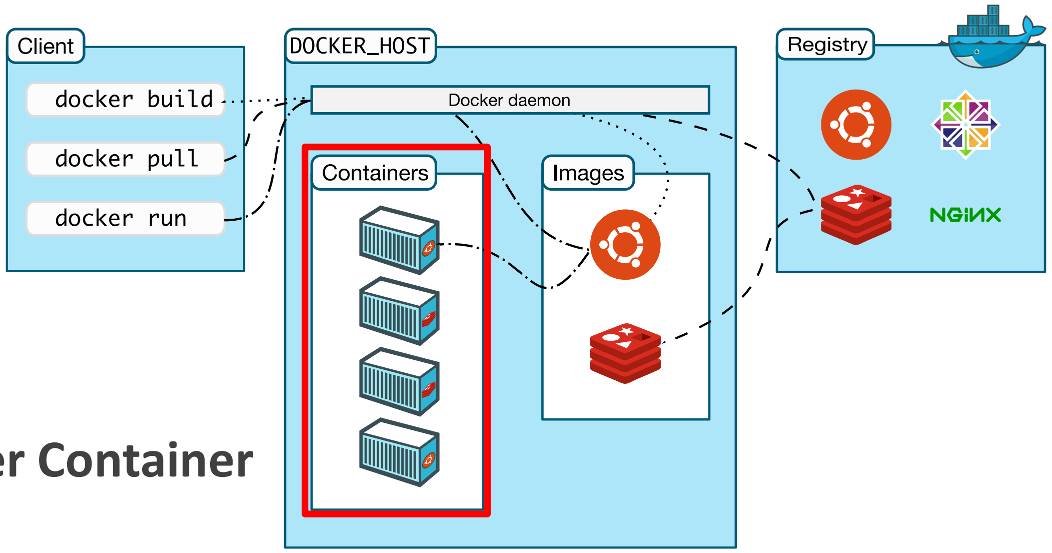
- Software Package (not executed) ➔ **Docker Image**
- Store for Docker Images ➔ **Docker Registry**
- Sandbox ➔ **Docker Daemon**



Terminology

We can execute Software Packages inside the Sandbox.

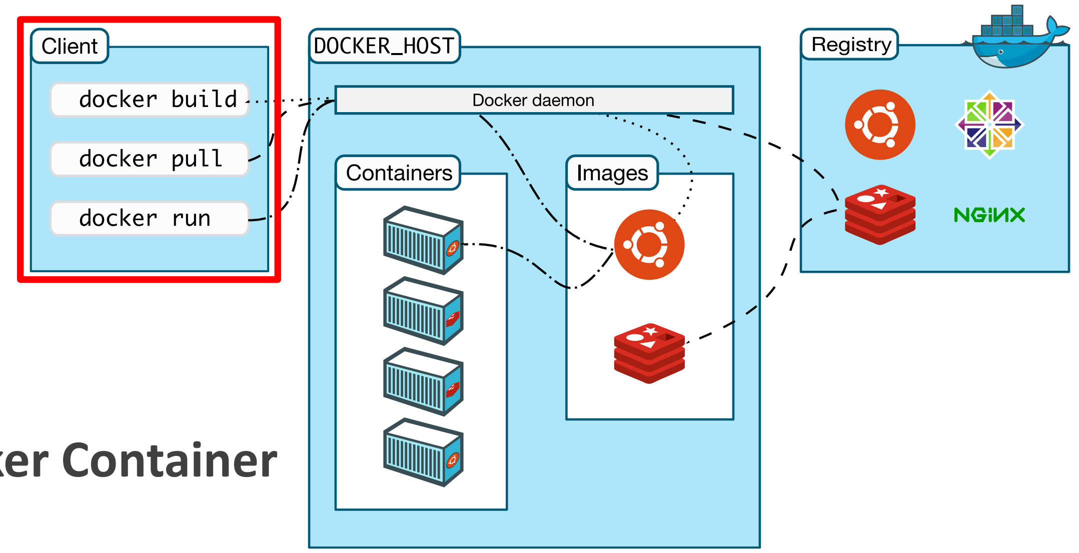
- Software Package (not executed) ➔ **Docker Image**
- Store for Docker Images ➔ **Docker Registry**
- Sandbox ➔ **Docker Daemon**
- **Executed Docker Image** in the **Docker Daemon** ➔ **Docker Container**
  - A Container is an instance of a Docker Image



Terminology

We can execute Software Packages inside the Sandbox.

- Software Package (not executed) ➔ **Docker Image**
- Store for Docker Images ➔ **Docker Registry**
- Sandbox ➔ **Docker Daemon**
- **Executed Docker Image** in the **Docker Daemon** ➔ **Docker Container**
  - A Container is an instance of a Docker Image
- **Client** enter commands



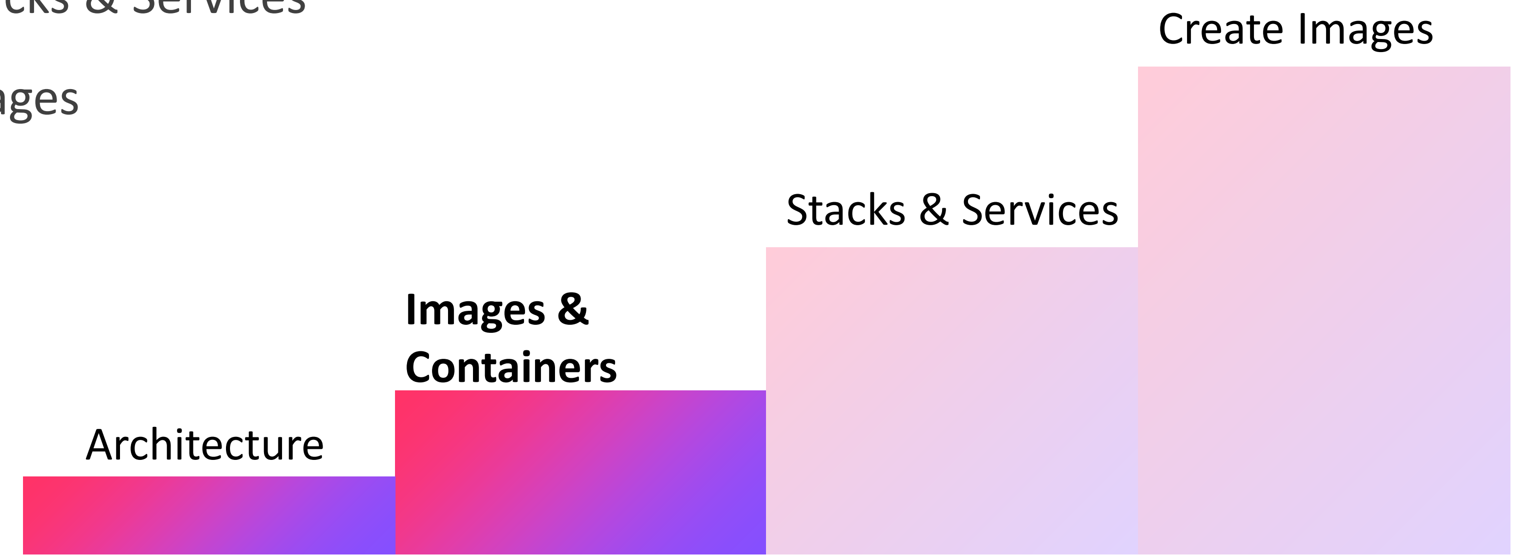
Outline

Docker Architecture

Docker Images & Containers

Docker Stacks & Services

Create Images



Docker Images & Containers

- Docker Images are stored in Docker Registries
- Largest Registry: https://hub.docker.com
- Contains tons of images
- Allows you to startup awesome stuff within minutes

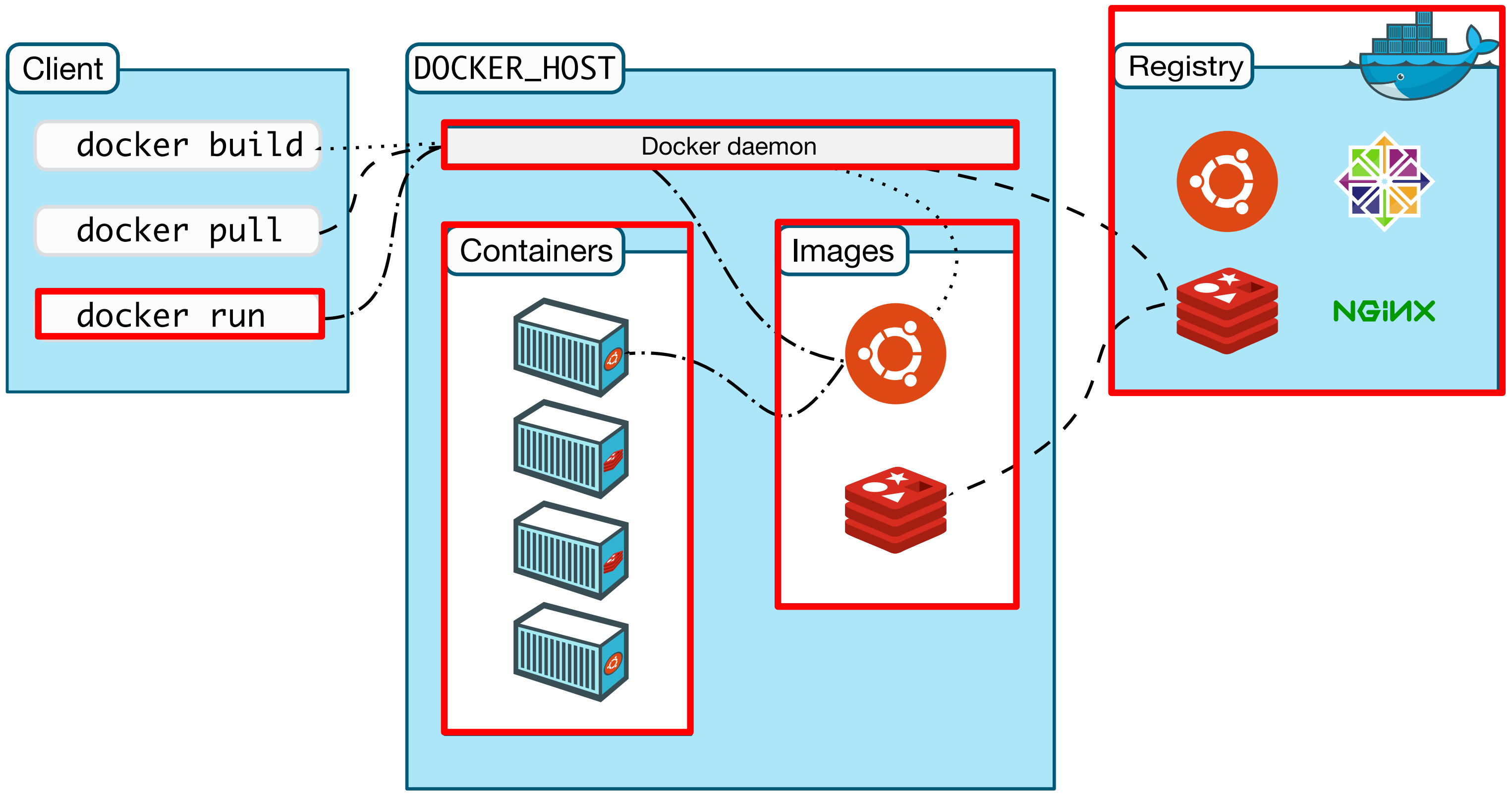
Docker Images & Containers

- Let‘s assume we would like to run our own Analytics Tool => Matomo
- Matomo Requirements
  - PHP installed on server
  - MySQL/MariaDB Database running somerwhere
  - Apache/Nginx/IIS webserver

  ➔ https://matomo.org/docs/installation

  - **Use Docker! ☺**
    - **$ docker run –p 8080:80 matomo**
    - In your browser: localhost:8080

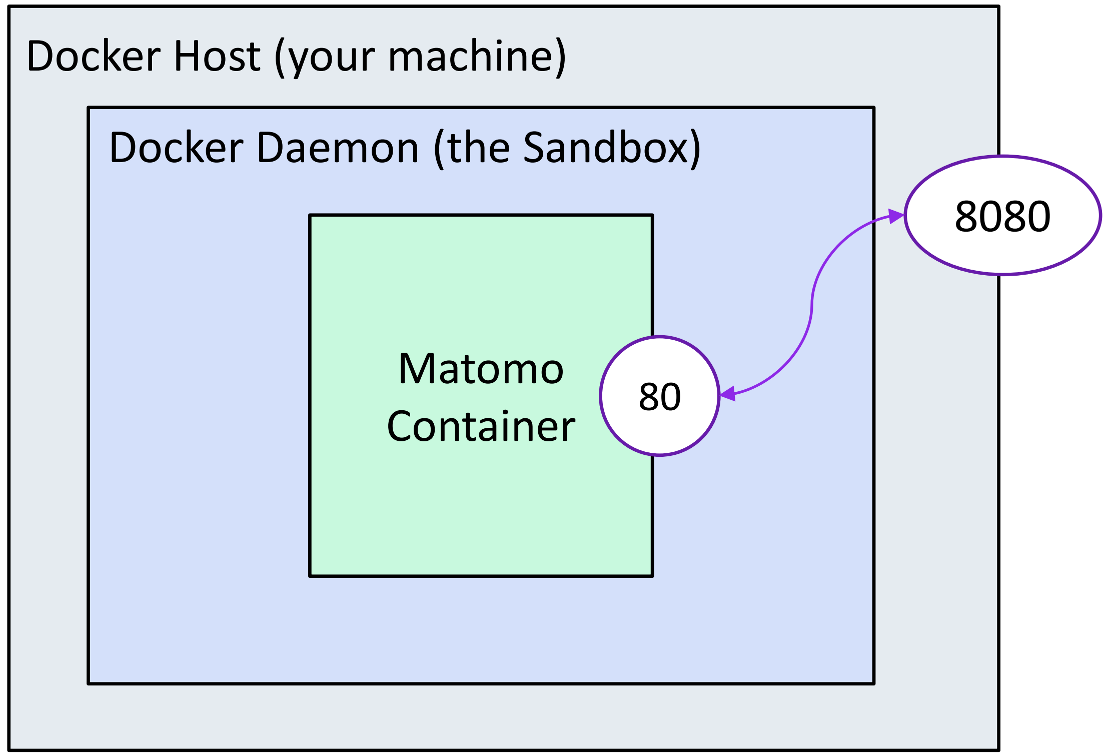
What just happened?



$ docker run –p 8080:80 matomo

Docker Images & Registry

- $ docker run **–p 8080:80** matomo
- Maps localhost port 8080
  to container port 80



Some Docker Commands

- List all running containers: **$ docker ps**
- List all containers: **$ docker ps –a**
- Stop a container: **$ docker stop <containerId or name>**
- Start a container: **$ docker start <containerId or name>**
- Start a container and attach to output: **$ docker start –a <containerId or name>**
- See logs: **$ docker logs <containerId or name>**
- Follow logs: **$ docker logs -f <containerId or name>**
- List all local images: **$ docker image ls**

Docker Images & Containers

- Let‘s assume we would like to run our own Analytics Tool => Matomo
  - **$ docker run –p 8080:80 matomo**
  - In your browser: localhost:8080
- We are missing the MariaDB database and Matomo will not work without it!

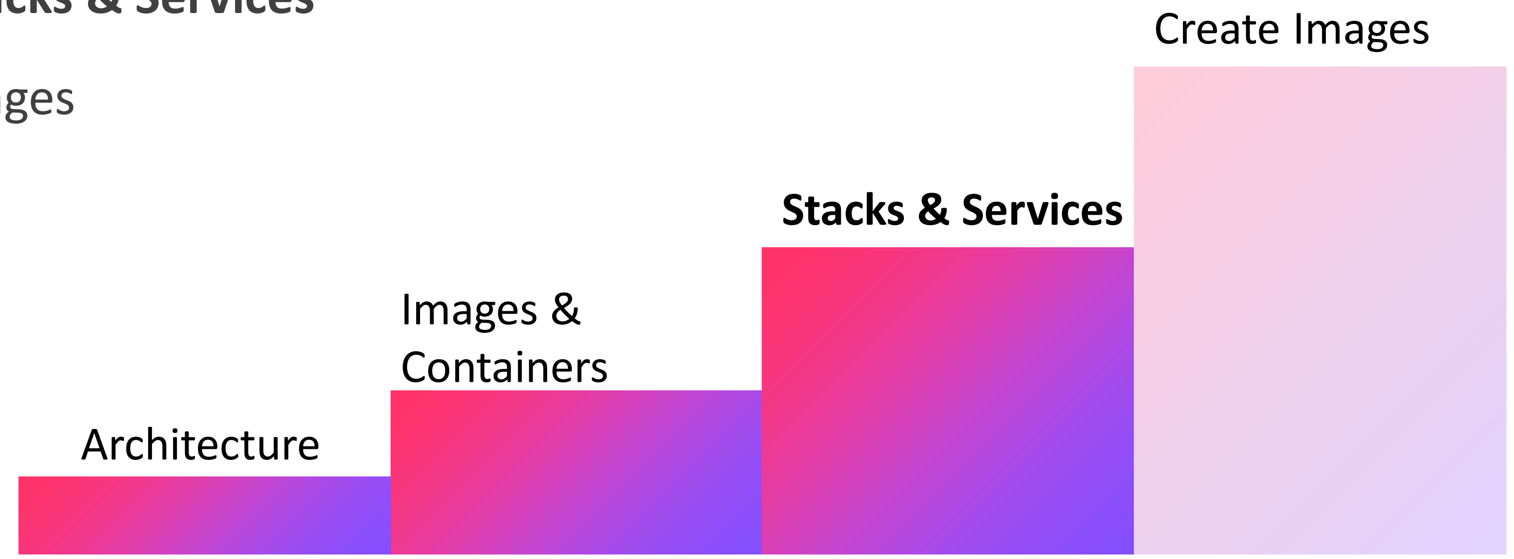
Outline

Docker Architecture

Docker Images & Containers

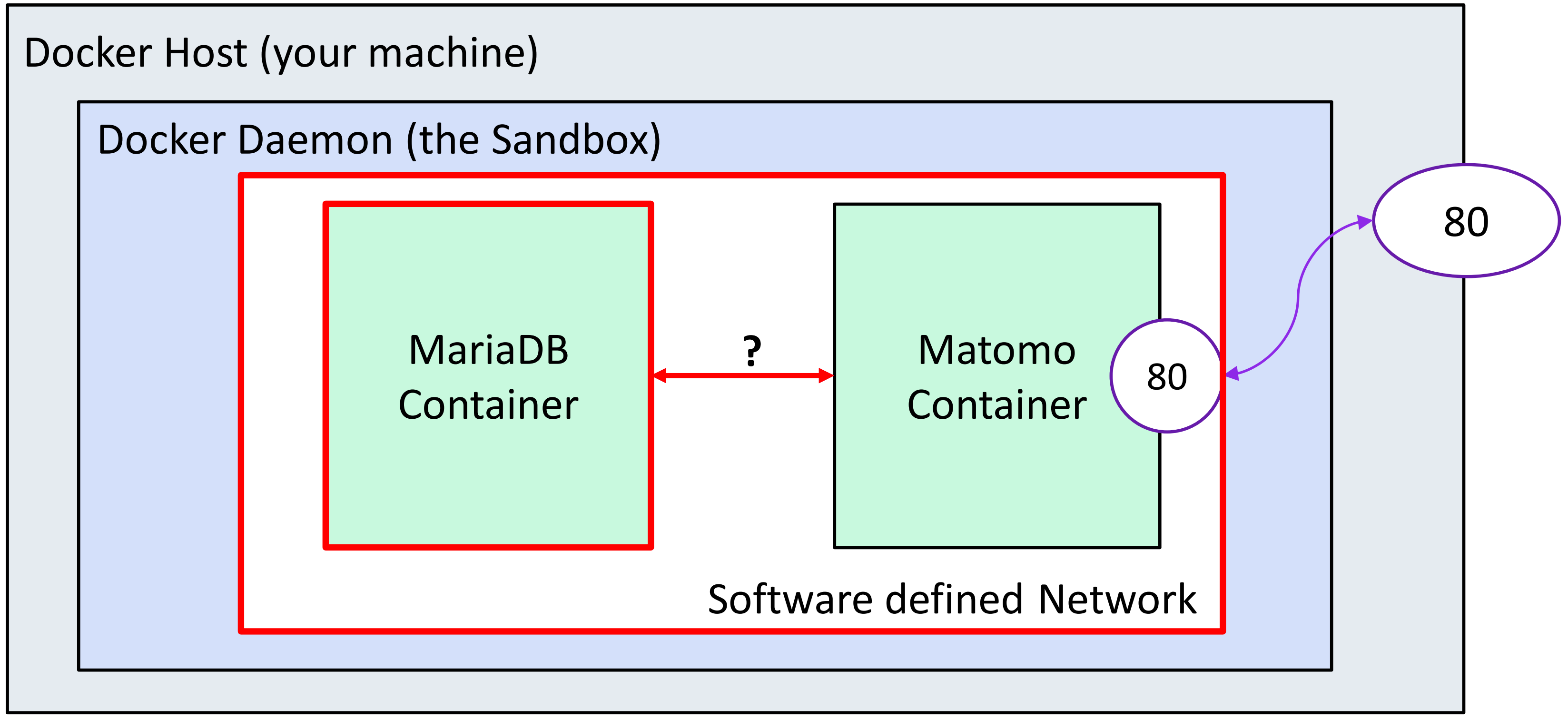
Docker Stacks & Services

Create Images



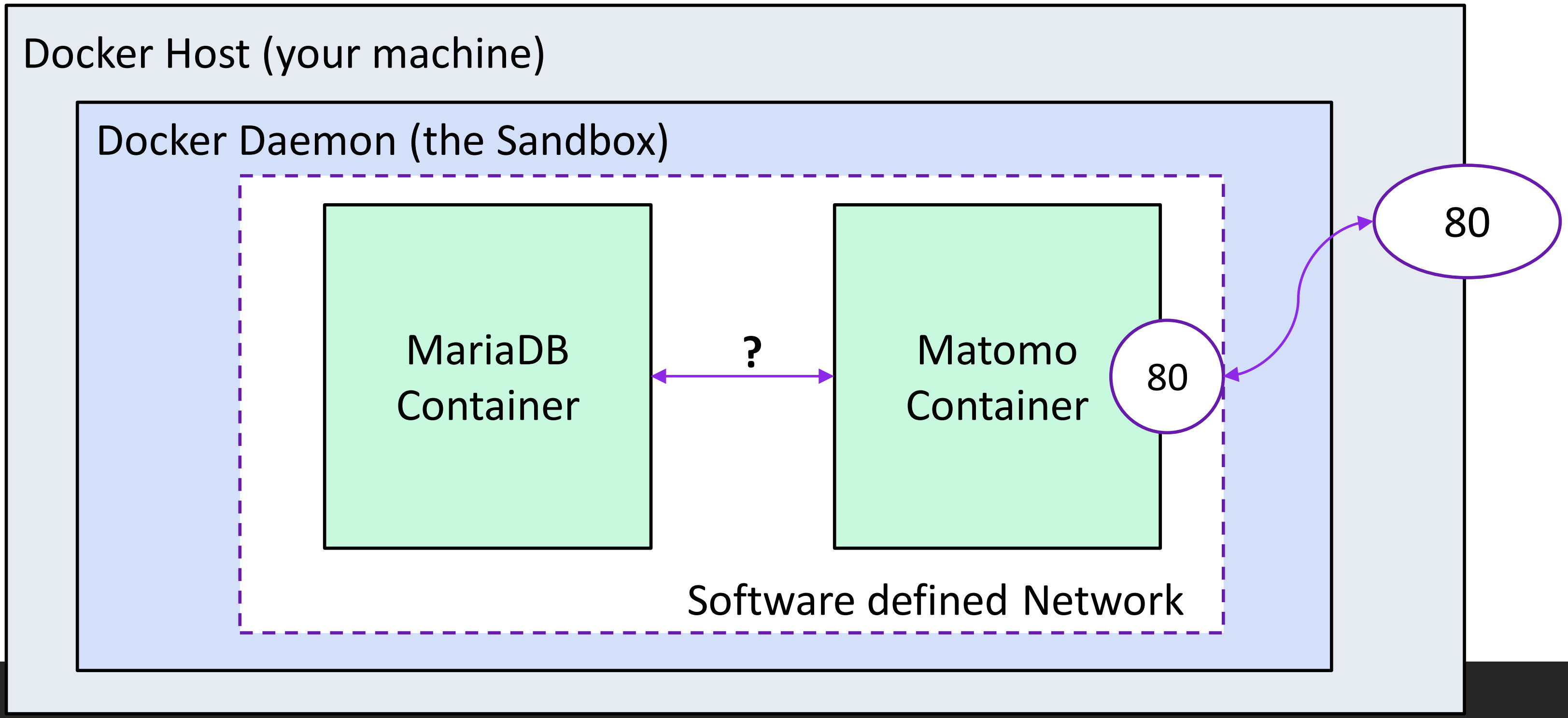
Docker Stacks

- For a full Matomo setup, we also need a MariaDB database



Docker Stacks

- This whole setup is called a „**Docker Stack**"
- Defined through .yml file ➔ stack.yml



Docker Stacks

- Create new project repository and a new file called: stack.yml

```
version: „3.8“
services:
		mymatomo:
				image: matomo
				ports:
						- 80:80
				networks:
						- mynetwork
networks:
		mynetwork:
```

- Indents (in Spaces not Tab) are important in this file format!

Docker Stacks

- Before we can do anything with this file call:
  - **$ docker swarm init**
  - Make sure that old matomo container is not running anymore

- Now we can „deploy“ this stack
  - **$ docker stack deploy –c stack.yml MyStack**

- Browser: localhost:80

What just happened?

- Docker **created** a new stack called: „MyStack“
- Docker **created** a software defined **network** called: „MyStack_mynetwork “
- Docker **created** a **service** called: „MyStack_mymatomo“

Some Docker Commands

- List all running stacks: **$ docker stack ls**
- List all services for this stack: **$ docker stack services <stackname>**
- List all networks: **$ docker network ls**
- Remove a stack: **$ docker stack rm <stackname>**
- Deploy a stack: **$ docker stack deploy –c <.yml file> <stackname>**

Docker Stacks – Add database service

```
version: „3.8"
services:
		mymatomo:
				image: matomo
				ports:
						- 80:80
				networks:
						- mynetwork
		mydatabase:
				image: mariadb
				networks:
						- mynetwork
networks:
		mynetwork:
```

Docker Stacks

- Check if deployed stack is still running
  - **$ docker stack ls**
- Update deployed stack while it is running*:
  - **$ docker stack deploy –c stack.yml MyStack**
- Do you think this is going to work?
- Does the MariaDB container start?

* Unfortunately, does not work all the time! ;-)

Exercise 1

Find out, why MariaDB is not running.

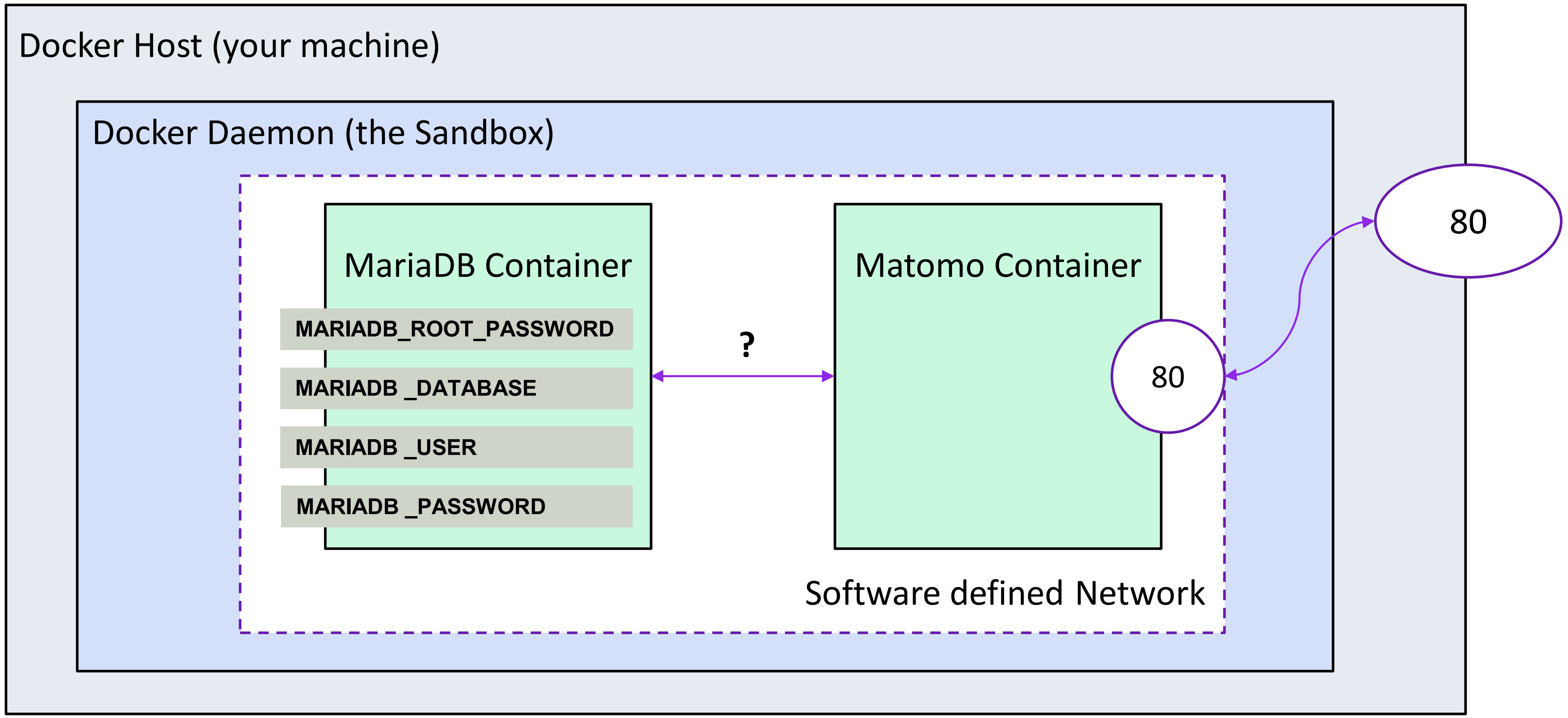
Hint: Use the commands we‘ve already learned

Docker Stacks

```
$ error: Database is uninitialized and password option is not specified
        You need to specify one of MARIADB_ROOT_PASSWORD,
MARIADB_ALLOW_EMPTY_ROOT_PASSWORD and
MARIADB_RANDOM_ROOT_PASSWORD
```

- MariaDB does not everything to startup the database server
- We need to tell this to the services
- ➔**Environment Variables!**

Docker Services - Environment Variables

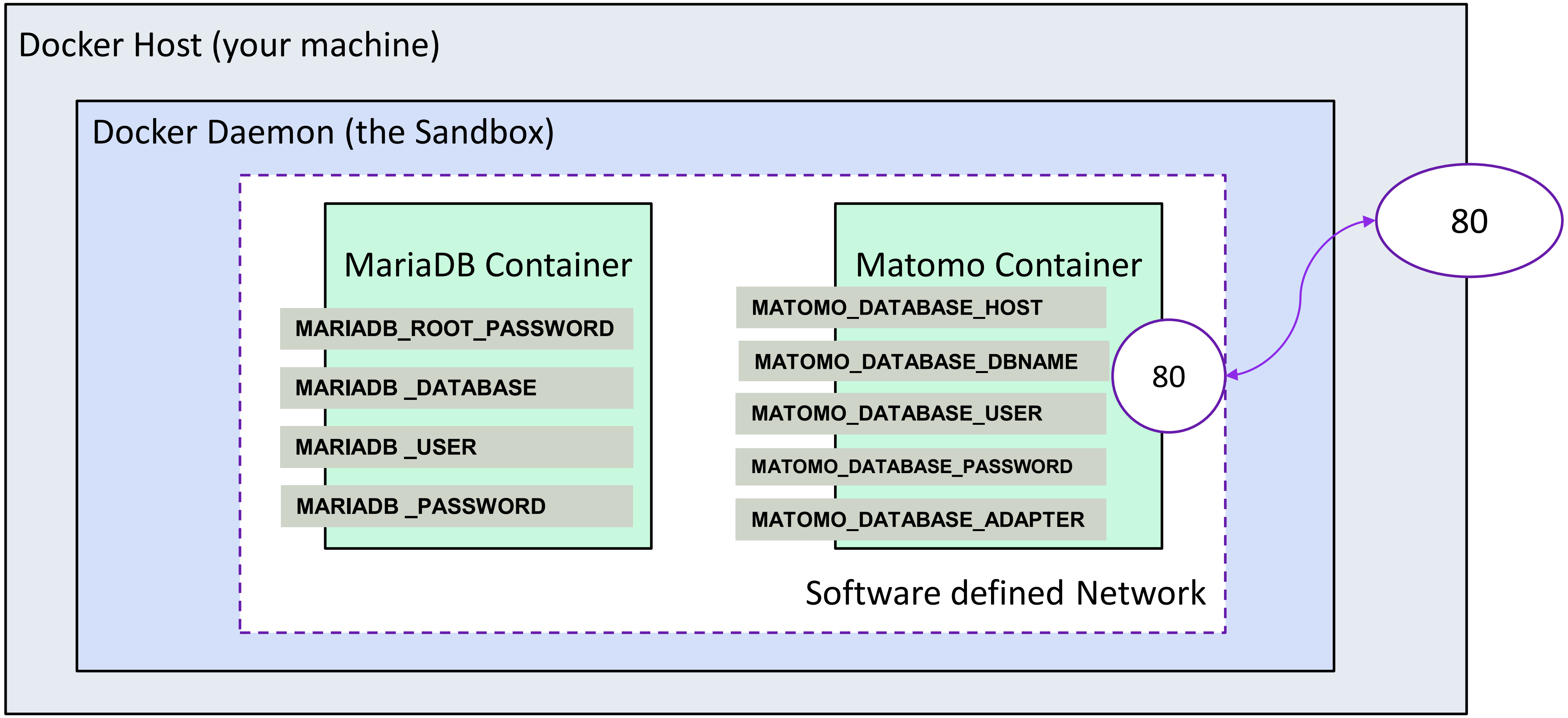


Docker Services - Environment Variables

- Add environment variables at **mydatabase section** into .yml file

```
….
mydatabase:
        image: mariadb
        environment:
                MARIADB_ROOT_PASSWORD: my-secret-root-pw
                MARIADB _DATABASE: matomo_db
                MARIADB _USER: matomo_user
                MARIADB _PASSWORD: my-secret-matomo-pw
networks:
                - mynetwork
```

Docker Services - Environment Variables



Docker Services - Environment Variables

- Add environment variables at **mymatomo section** into .yml file

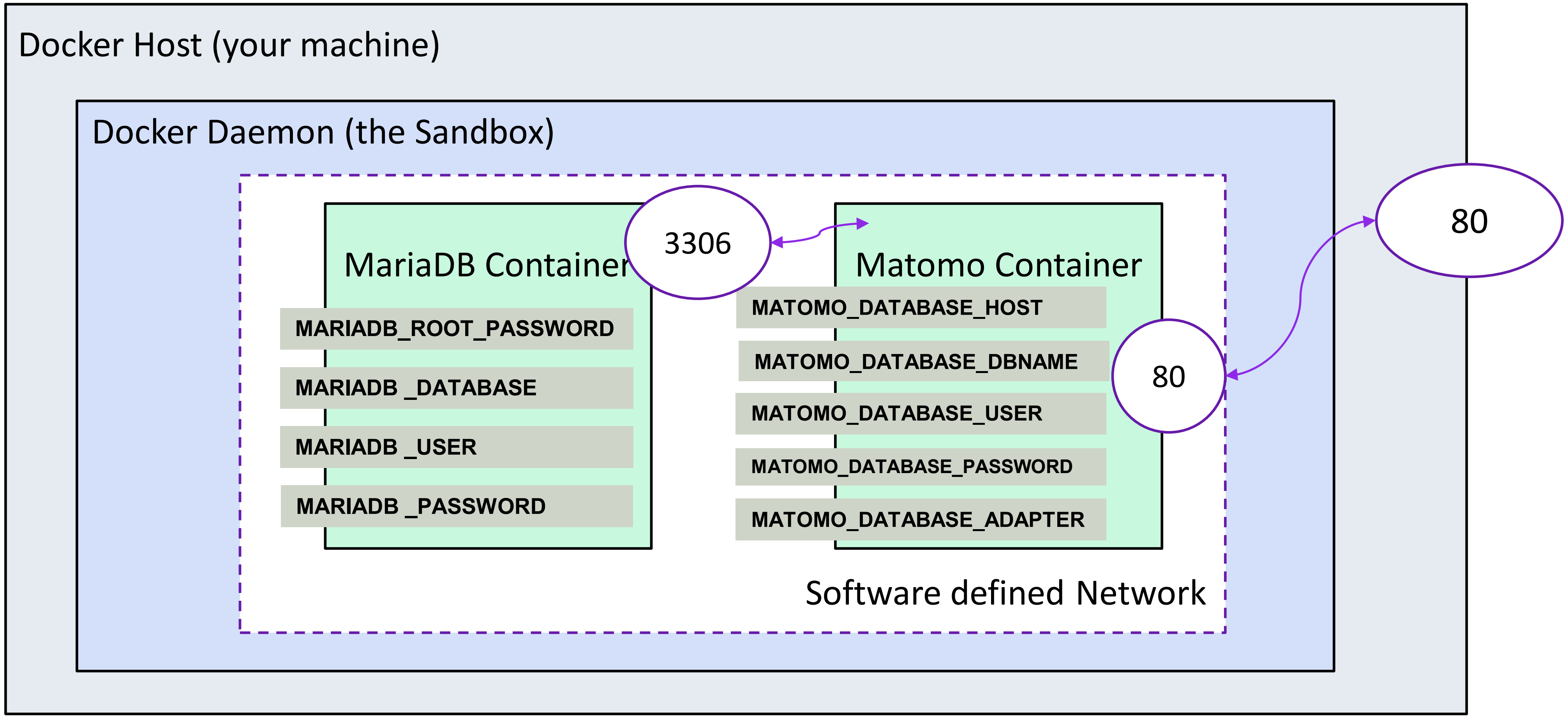
```
....
mymatomo:
        image: matomo
        ports:
                - 80:80
        environment:
                MATOMO_DATABASE_HOST: ???
                MATOMO_DATABASE_ADAPTER: mysql
                MATOMO_DATABASE_USERNAME: matomo_user
                MATOMO_DATABASE_PASSWORD: my-secret-matomo-pw
                MATOMO_DATABASE_DBNAME: matomo_db
        networks:
                - mynetwork
...
```

Docker Services - Environment Variables

- Add environment variables at **mymatomo section** into .yml file

```
....
mymatomo:
        image: matomo
        ports:
                - 80:80
        environment:
                MATOMO_DATABASE_HOST: mydatabase
                MATOMO_DATABASE_ADAPTER: mysql
                MATOMO_DATABASE_USERNAME: matomo_user
                MATOMO_DATABASE_PASSWORD: my-secret-matomo-pw
                MATOMO_DATABASE_DBNAME: matomo_db
        networks:
                - mynetwork
...
```

Docker Services - Environment Variables



Docker Services - Environment Variables

- Lets update our running Docker Stack:
  - **$ docker stack deploy –c stack.yml MyStack**

- Browser: localhost

- ➔ We‘ve (nearly) successfully setup a Matomo Analytics using Docker! ☺

15min break

Docker Services - Volumes

- What happens with our data if we remove the Stack and build a new one?
  - Configure your Matomo Analytics
  - **$ docker stack rm MyStack**
  - **$ docker stack deploy –c stack.yml MyStack**

Docker Services - Volumes

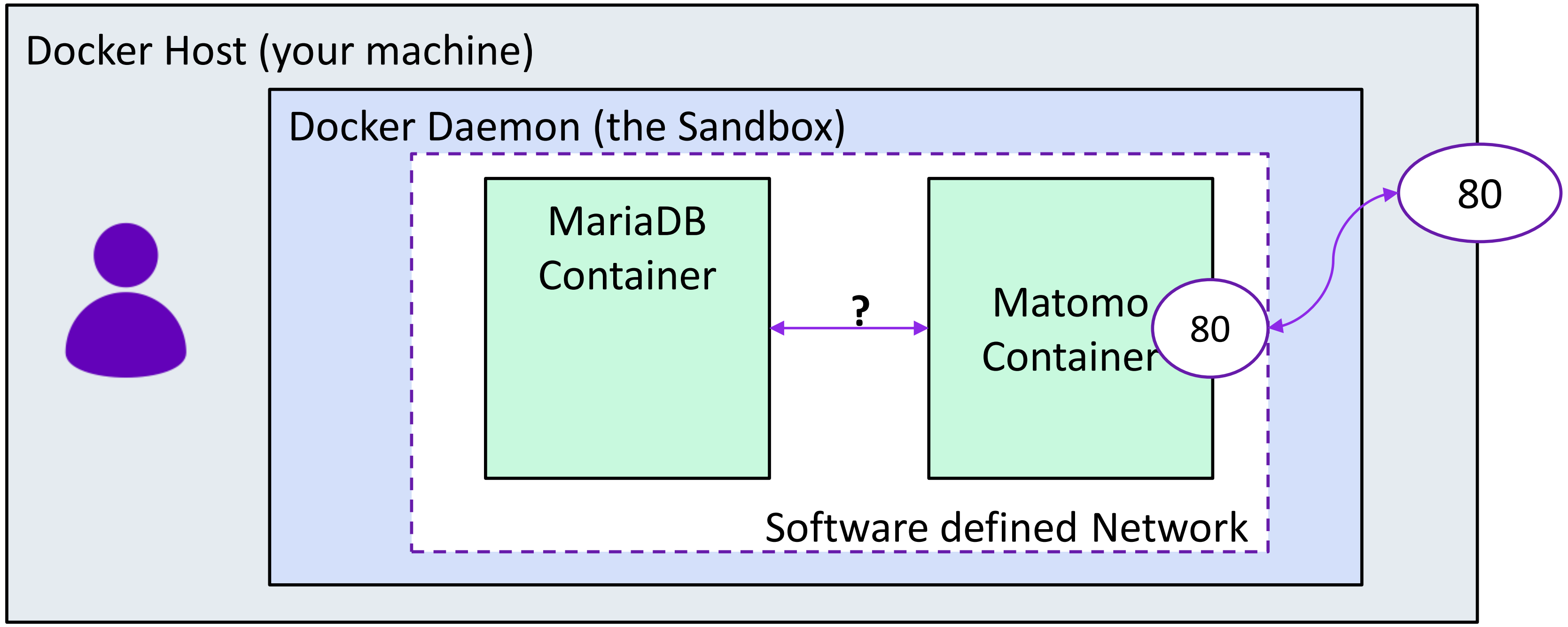
- All data is stored inside Containers
- **New Stack => New Containers => Previous Data is gone….**

- ➔ **Volumes** are used to store persistent data on the Docker Host

- Volumes **map directories** of the host into directories **inside** the container

Getting inside a Docker Container

- Get „inside“ a running container: **$ docker exec -it <containerid> <command>**



Docker Services - Volumes

- Map host directory to directory inside container

```
….
mydatabase:
        image: mariadb
        environment:
                MARIADB_ROOT_PASSWORD: my-secret-root-pw
                MARIADB_DATABASE: matomo_db
                MARIADB_USER: matomo_user
                MARIADB_PASSWORD: my-secret-wordpress-pw
        volumes:
                - ./data/mariadb:/var/lib/mysql
        …
```

Docker Services - Volumes

- Redeploy our stack
- **$ docker stack deploy –c stack.yml MyStack**

Exercise 2 - Volumes

- Create a volume for **/var/www/html** in the Matomo Service

Congratulations!!!

- You have setup a Matomo Analytics Environment using Docker!!!

What we‘ve learned so far

- How to run a Docker Container
- How to build a Docker Stack
- How to configure Docker Services
  - Ports
  - Environment Variables
  - Volumes
- How Docker Services communicate with each other in a Stack

- Everything was based on already existing matomo & mariadb images
- How do we create our own images?

Outline

Docker Architecture

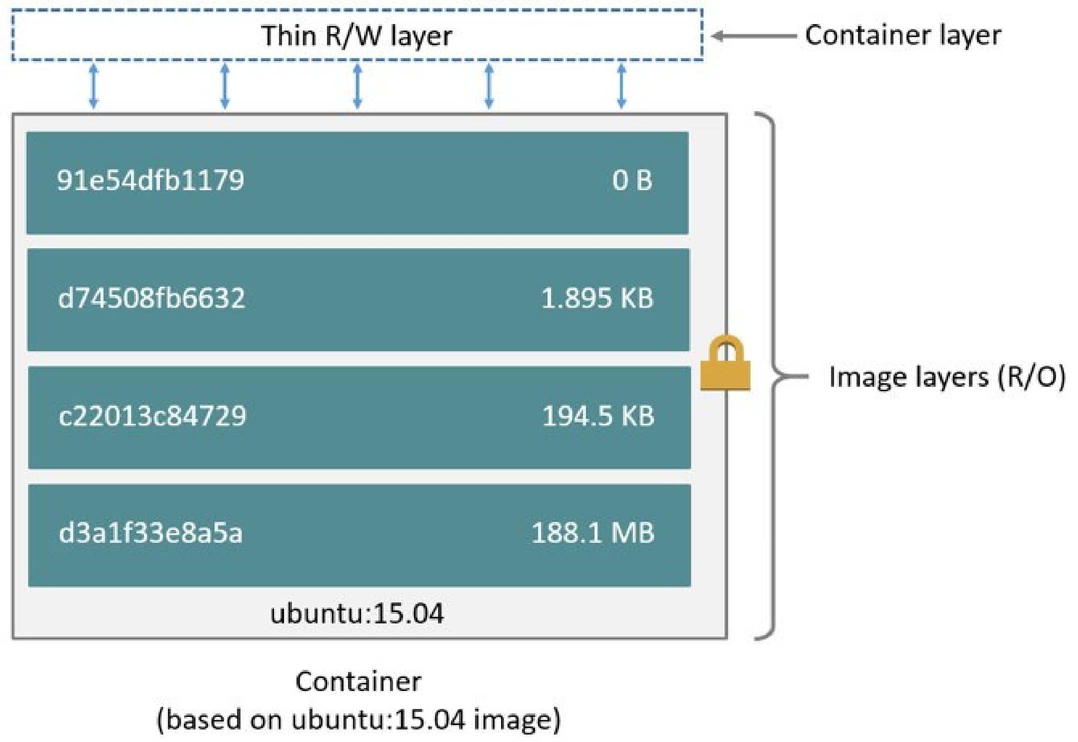
Docker Images & Containers

Docker Stacks & Services

Create Images

Docker Images and Containers

- Docker Images consist of **read-only layers** of files
- Containers have a **read/write layer** on top of the read-only layers



Graphics courtesy of Docker

Creating Docker Images

- Docker Images are created with a Dockerfile
- Each layer in an image corresponds to a command in the Dockerfile

1. Lets create a small Express App
2. Create a Docker Image of that App

Create Express App

- $ npm install express-generator –g
- $ express myexpressapp
- $ cd myexpressapp
- $ npm install
- $ npm start

- Browser: localhost:3000

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **FROM** tells Docker which image should be the **base image** for ours
- We need an **environment** where **node** is installed.
- Tag „alpine“: Alpine is a very small linux distribution
- Other tags are available: https://hub.docker.com/_/node

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **WORKDIR** tells Docker in which directory subsequent calls like COPY or RUN should happen

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **COPY** copies the package*.json files into our WORKDIR /app
- Why only package*.json and not the entire directory???

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **RUN** executes npm install
- npm install takes a lot of time in larger projects
- However, package.json changes not too often compared to source code in our app ➔ **RUN creates a new layer in our image**

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **COPY all files from directory . to the WORKDIR**

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **EXPOSE port 3000 in the container**

Create Dockerfile

```
FROM node:alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 3000
CMD ["npm", "start"]
```

- **CMD** execute **npm** with parameter **start** when starting the container

The .dockerignore file

- Docker Images should be as small as possible. Therefore we want to ignore those files, which are not essential to run our app.

```
.git
.gitignore
node_modules
npm-debug.log
Dockerfile*
docker-compose*
README.md
LICENSE
.vscode
```

Creating Docker Images

- $ docker build .

- **Note:** Each command in the Dockerfile created a layer!

- Lets tag our image!
- Standard naming convention: dockerhubusername/imagename:version

Creating Docker Images

- $ docker build –t dockerhubusername/imagename:version .

- Push them into the Docker Hub Registry!

- $ docker login
- $ docker push dockerhubusername/imagename:version
- $ docker pull dockerhubusername/imagename:version

Congratulations!!!

- You have successfully created and pushed your first own Docker Image!!!

Conclusion – You‘ve learned about…

- Docker Architecture
- Docker Images & Containers
- Docker Stacks & Services
- creating Docker Images

Conclusion – Further reading

- Have a look at the Appendix in this presentation
- Container Orchestration
  - Docker Swarm - https://docs.docker.com/engine/swarm/
  - Kubernetes - https://kubernetes.io
- Docker documentation
  - https://docs.docker.com/

docker®

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Appendix - Docker Swarms

- As your awesome platform increases in popularity, so does the number of requests per second on your backend
- At a certain point your single server is going to be too weak to handle all the traffic
- You need a way to scale your platform

Docker Swarm - Scaling

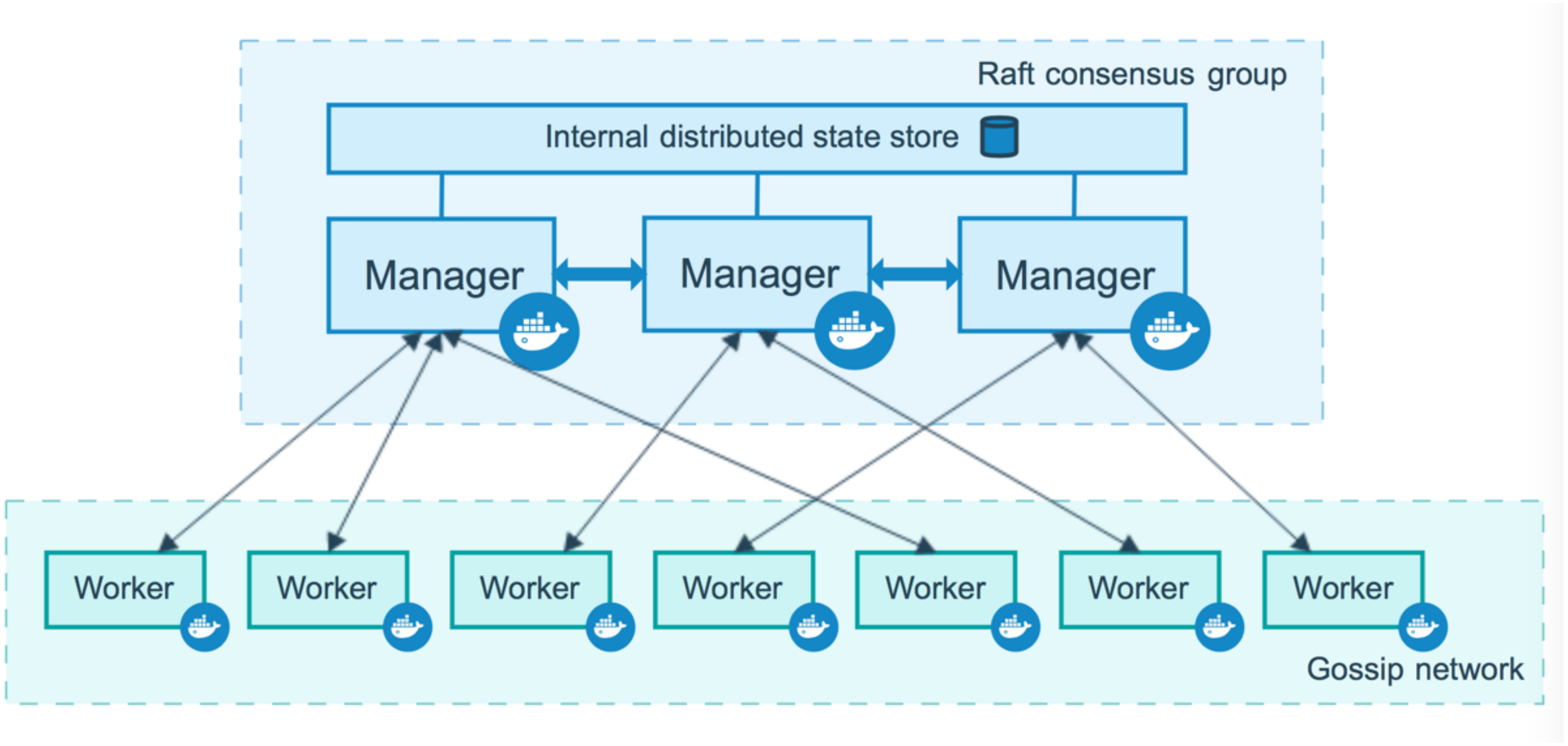
- Different ways to scale:
  - Vertical Scaling: ➔ Get a faster server
  - Horizontal Scaling: ➔ Distribute work over multiple servers

- Docker Swarm helps you to easily **scale** your platform **in a horizontal way!**

Docker Swarm - Nodes

- A Docker Swarm consists of multiple connected machines where Docker is installed
- These machines are called **Nodes**
- There are two types of **Nodes**
  - **Swarm Managers**
  - **Swarm Workers**

Docker Swarm



Graphics courtesy of Docker

Docker Swarm - Nodes

- Manager Nodes are responsible for scheduling services and managing the Swarms State
- You should aim for an **odd number of Managers**
- More than 7 Manager Nodes reduce the speed of the Swarm due to communication overhead between the Managers

- Worker Nodes are pure Container executers

Docker Swarm - Nodes

- Do you remember the command: **$ docker swarm init**?
- At this point we‘ve created a **Docker Swarm Manager Node**

```
Swarm initialized: current node (fe4uipd973z81lp2rcgjvqjrs) is now a manager.

To add a worker to this swarm, run the following command:

    docker swarm join --token SWMTKN-1-3rw0mlyjv4twd8fn98sxs4ihn0k1pn4jcffdjfjavbxexu1hr0-
6pmhy2h1ul6bmll9d725i9r7r 192.168.65.3:2377

To add a manager to this swarm, run 'docker swarm join-token manager' and follow the instructions.
```

Docker Swarm - Commands

- List all Nodes in a Docker Swarm
  - **$ docker node ls**
- Get the join token for a worker node
  - **$ docker swarm join-token –q worker**
- Get the join token for a manager node
  - **$ docker swarm join-token –q manager**
- Join an existing swarm
  - **$ docker swarm join --token <token> <Swarm Managers IP Address>:2377**

Docker Swarm - Commands

- Docker Stacks can be executed on Docker Swarms!
- Define the number of replicas of each of your Services in the Stack

```
…
        deploy:
            replicas: 5
 …
```

- **$ docker stack deploy –c stack.yml MyStack**

Docker Swarm - Reliability

- Docker Swarm manages load balancing between containers
- Try to stop one of your containers of MyStack
- **What happens?**
- Docker Swarm always tries to keep the number of replicas as defined in stack.yml

Appendix: Create your own registry

You can get the Docker Registry Server as Docker Image too! ☺

```
docker run -d -p 5000:5000 --name registry registry:2
```

Now you have a Docker Registry Server running at: localhost:5000

Appendix: Push image to your own registry

Tag an image to point to your registry:

```
docker image tag <imagename> localhost:5000/myimagename
```

Push the image:

```
docker push localhost:5000/myfirstimage
```

After that you can pull the image from your own registry:

```
docker pull localhost:5000/myfirstimage
```

Cheat Sheet – Docker Container

- List all running containers: **$ docker ps**
- List all containers: **$ docker ps –a**
- Stop a container: **$ docker stop <containerId or name>**
- Start a container: **$ docker start <containerId or name>**
- Start a container and attach to output: **$ docker start –a <conatinerId or name>**
- See logs: **$ docker logs <containerId or name>**
- Follow logs: **$ docker –f logs <containerId or name>**
- List all local images: **$ docker image ls**

Cheat Sheet – Docker Stack

- List all running stacks: **$ docker stack ls**
- List all services for this stack: **$ docker stack services <stackname>**
- List all networks: **$ docker network ls**
- Remove a stack: **$ docker stack rm <stackname>**
- Deploy a stack: **$ docker stack deploy –c <.yml file> <stackname>**

Cheat Sheet – Build / Push Image

- Build a Docker Image with a name
  - **$ docker build –t dockerhubusername/imagename:version .**

- Login to Docker Hub Registry
  - **$ docker login**

- Push an image to Docker Hub Registry
- **$ docker push dockerhubusername/imagename:version**

Cheat Sheet – Docker Swarm

- List all Nodes in a Docker Swarm
  - **$ docker node ls**
- Get the join token for a worker node
  - **$ docker swarm join-token –q worker**
- Get the join token for a manager node
  - **$ docker swarm join-token –q manager**
- Join an existing swarm
  - **$ docker swarm join --token <token> <Swarm Managers IP Address>:2377**