



DOCKER

Alessandro Bocci

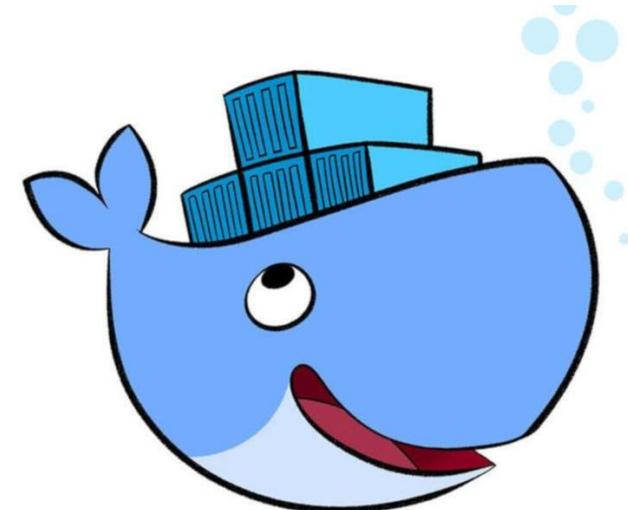
`name.surname@unipi.it`

Advanced Software Engineering (Lab)

17/10/2025

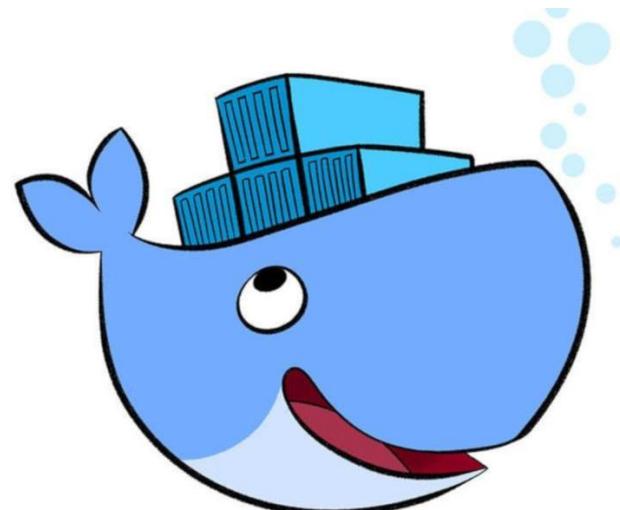
What will you do?

- Write **Dockerfile**(s) to create images to deploy your services.
- Learn the basic commands to manage containers.

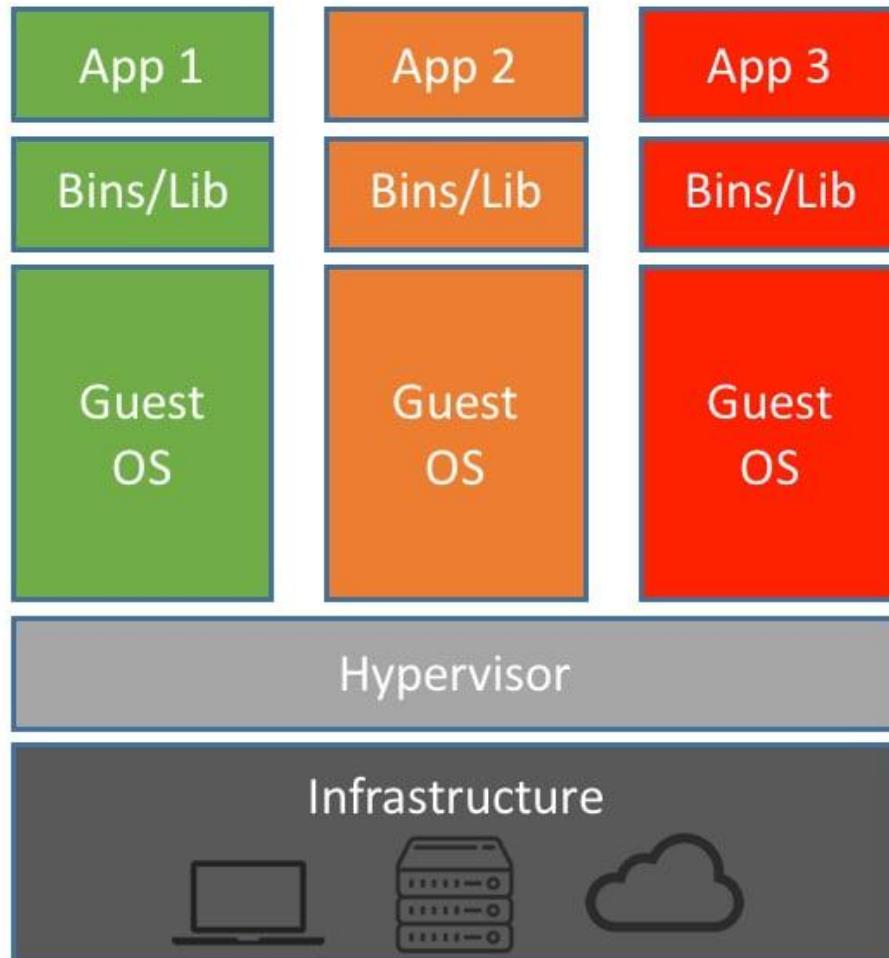


Software Prerequisites

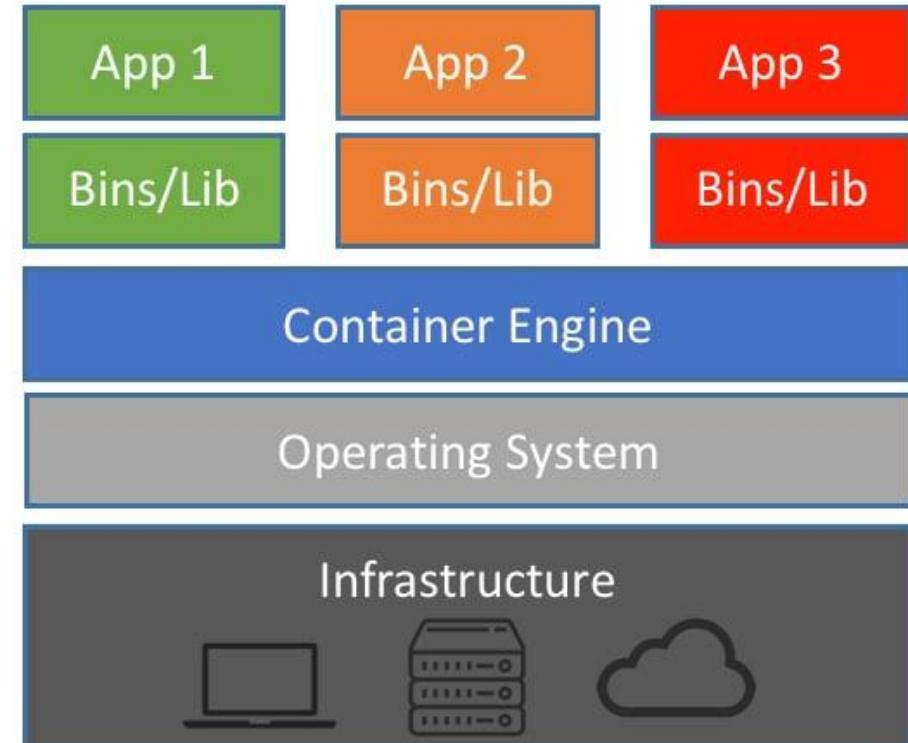
- Docker Engine
- Docker image `python:3.12-slim`



Virtual Machines vs Containers

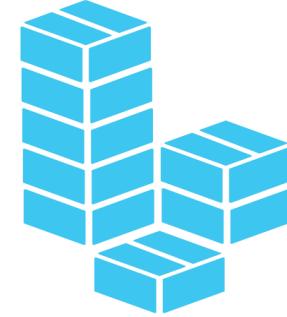


Machine Virtualization



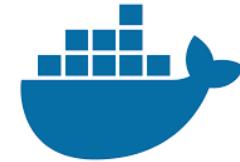
Containers

Why use containers?

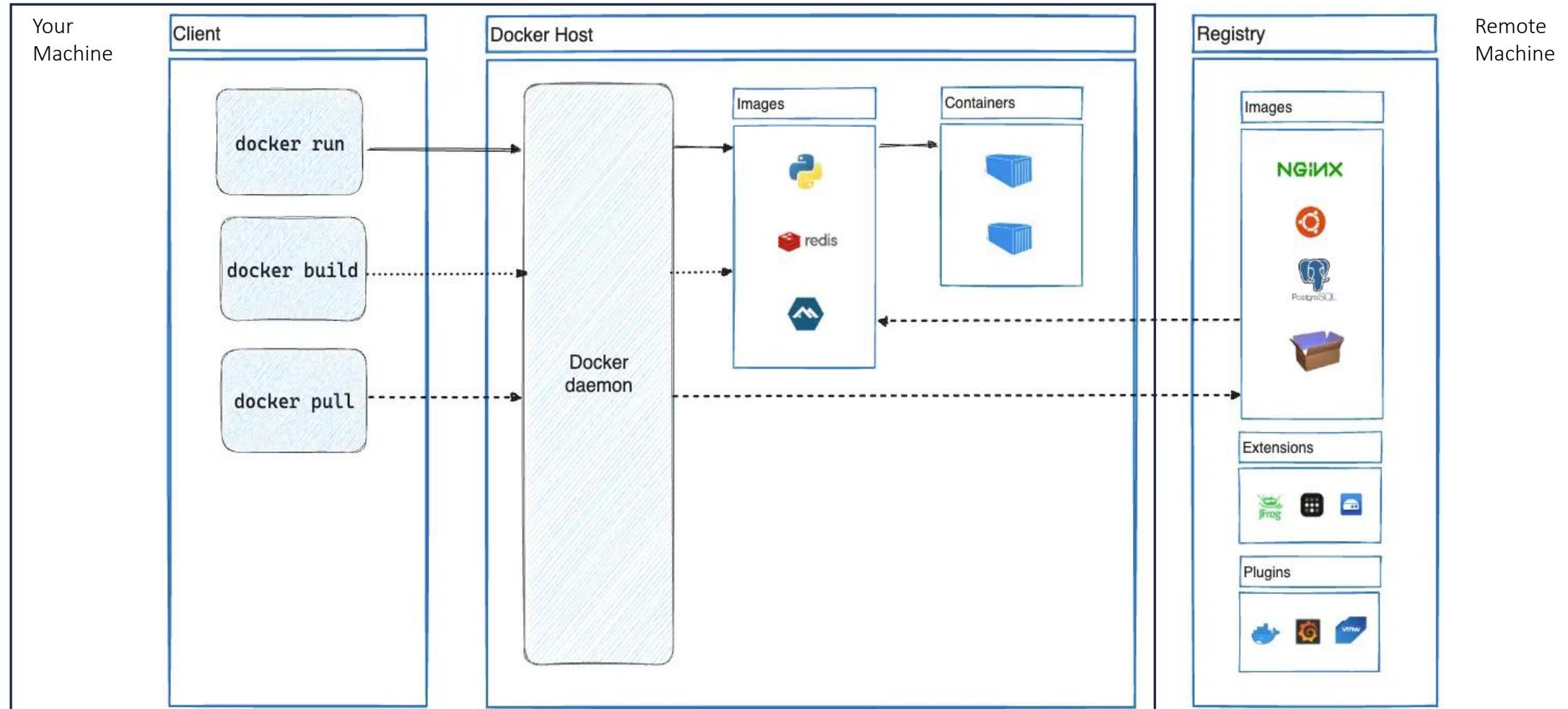


- Run anywhere: the same image works on your laptop, servers, and any cloud.
- Consistent & reproducible: packages app + dependencies → no “works on my machine.”
- Lightweight & fast: start in seconds, less overhead vs. full VMs.
- Isolated & safer: apps are sandboxed, avoiding conflicts and limiting blast radius.
- Scalable & rollouts: easy to replicate, update, and roll back with CI/CD.

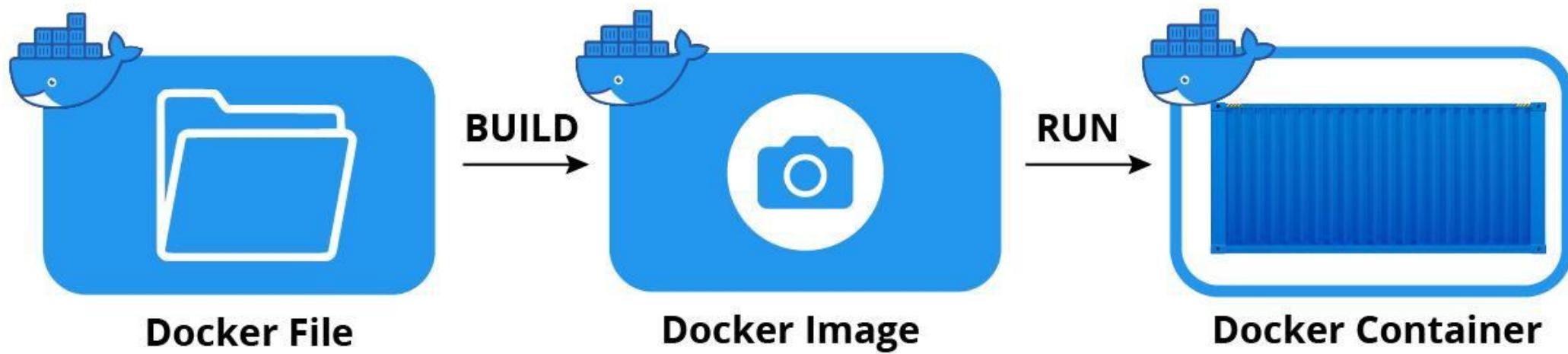
What is Docker?



Docker is an open platform for developing, shipping, and running containers.



Docker basic workflow



Dockerfile example

Commands executed in sequence
when building the image

Can you generate a simple, explanatory, Dockerfile for a webservice based on nodejs?

Certainly! Here's a simple Dockerfile for a Node.js web service:

Dockerfile

```
dockerfile
```

[Copia codice](#)

```
# Use the official Node.js image from Docker Hub
FROM node:18-alpine

# Set the working directory inside the container
WORKDIR /app

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# Install the dependencies
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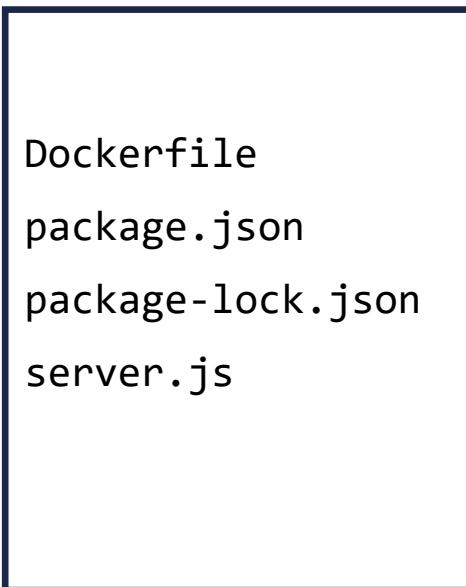
# Copy the rest of the application code to the working directory
COPY . .

# Expose the port that the web service will run on
EXPOSE 3000

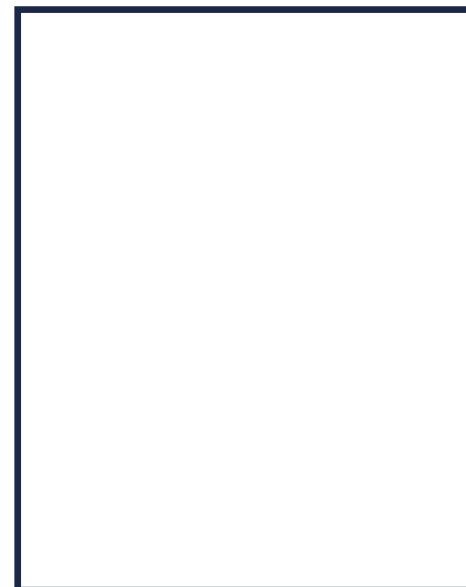
# Specify the command to run the web service
CMD ["npm", "start"]
```

Dockerfile example

Local machine



Image



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Dockerfile example

Local machine

```
Dockerfile  
package.json  
package-lock.json  
server.js
```

Image

node:18-alpine

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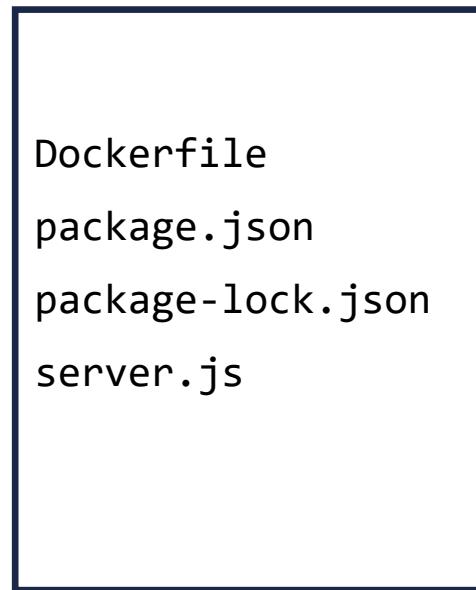
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Dockerfile example

Local machine



Image

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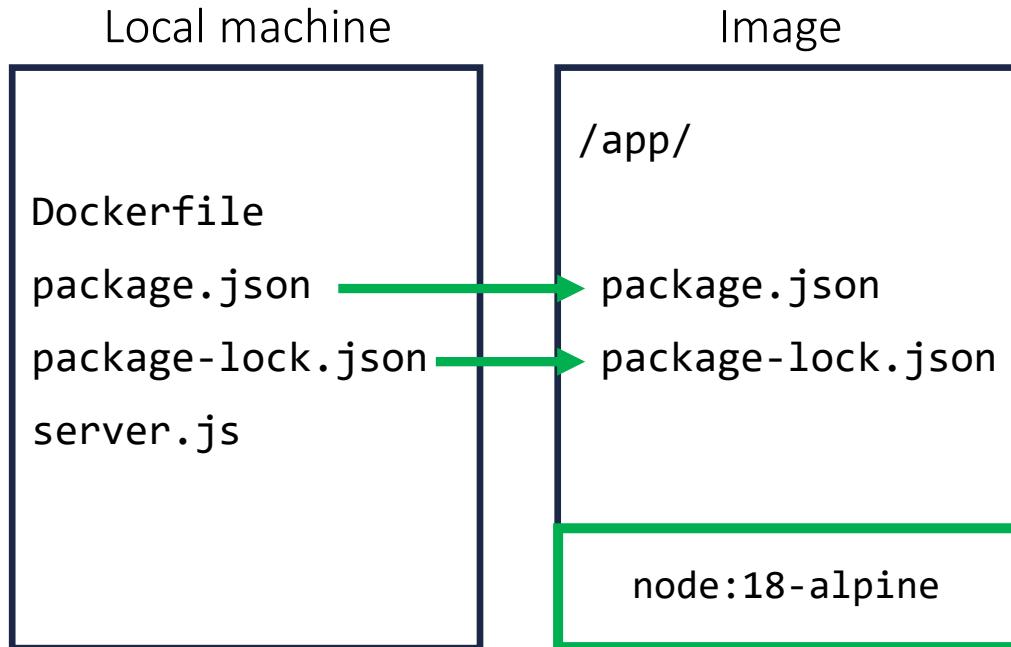
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Dockerfile example



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[Copia codice](#)

Dockerfile example

Local machine

```
Dockerfile  
package.json  
package-lock.json  
server.js
```

Image

```
/app/  
  
package.json  
package-lock.json  
  
~/app$ npm install  
  
node:18-alpine
```

Dependencies are installed in the image adding a new layer

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Dockerfile example

Local machine

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server.js
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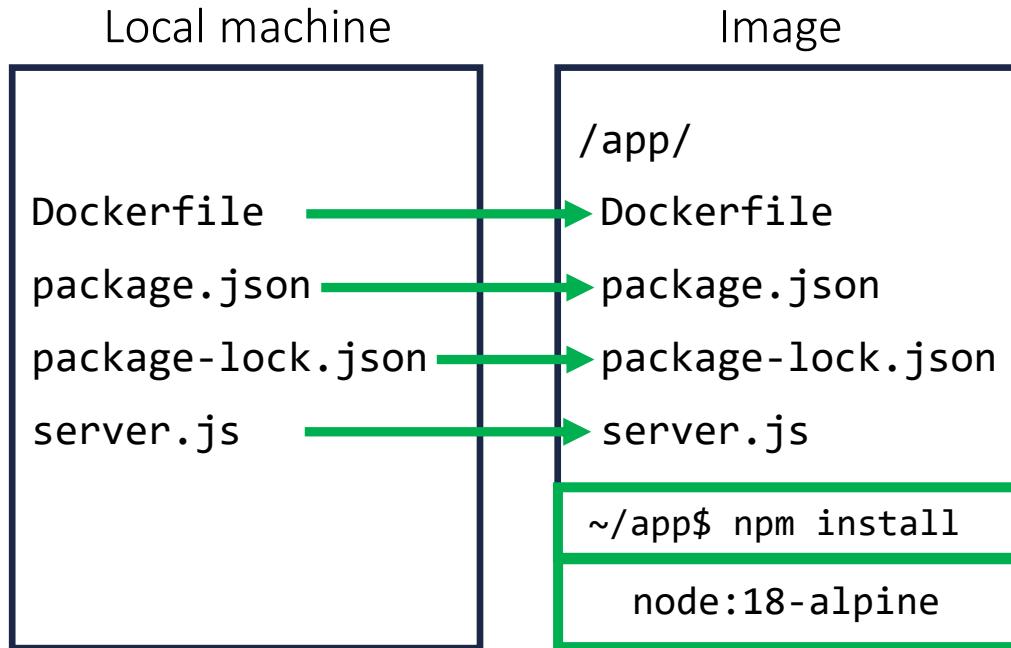
dockerfile

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```



Dockerfile example



Be carefull doing this, is not very safe!

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dockerfile Copia codice

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Dockerfile example

Local machine

```
Dockerfile  
package.json  
package-lock.json  
server.js
```

Image

```
/app/  
Dockerfile  
package.json  
package-lock.json  
server.js
```

```
~/app$ npm install  
node:18-alpine
```

3000

When a container based on this image will be started, a local machine port must be bound with the 3000 port of the container.

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Dockerfile example

Local machine

```
Dockerfile  
package.json  
package-lock.json  
server.js
```

Image

```
/app/  
Dockerfile  
package.json  
package-lock.json  
server.js
```

```
~/app$ npm install  
node:18-alpine
```

3000

E.g: -p 5000:3000

Contacting port 5000 on the local machine will forward the request to port 3000 on the container.

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Copia codice



Dockerfile example

Local machine

```
Dockerfile  
package.json  
package-lock.json  
server.js
```

Image

```
~/app$ npm start  
/app/  
Dockerfile  
package.json  
package-lock.json  
server.js  
~/app$ npm install  
node:18-alpine
```

3000

When a container based on this image will be run,
the command executed will be:

```
npm start
```

Can you generate a simple, explanatory, Dockerfile for a webservice
based on nodejs?



Certainly! Here's a simple Dockerfile for a Node.js web service:

Dockerfile

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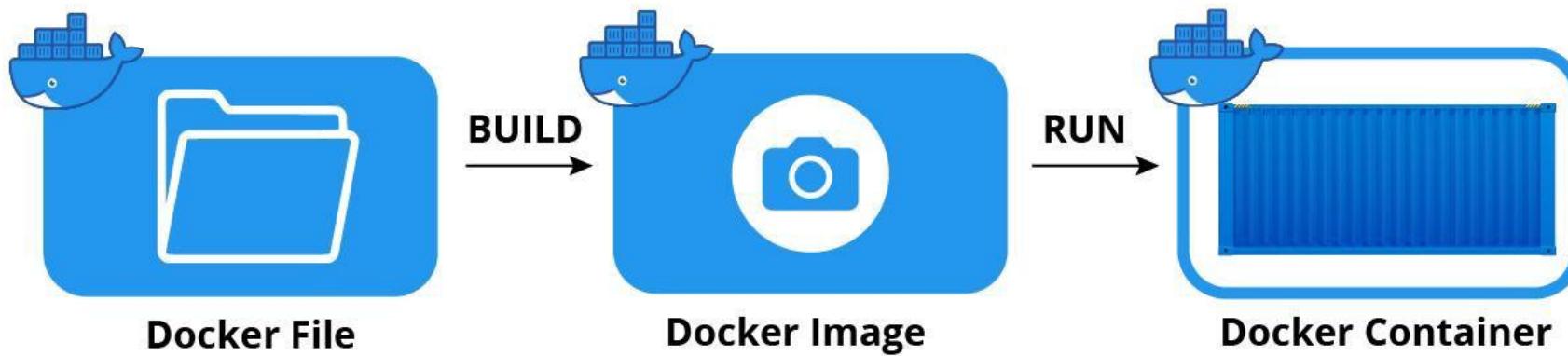


Dockerfile commands cheat sheet

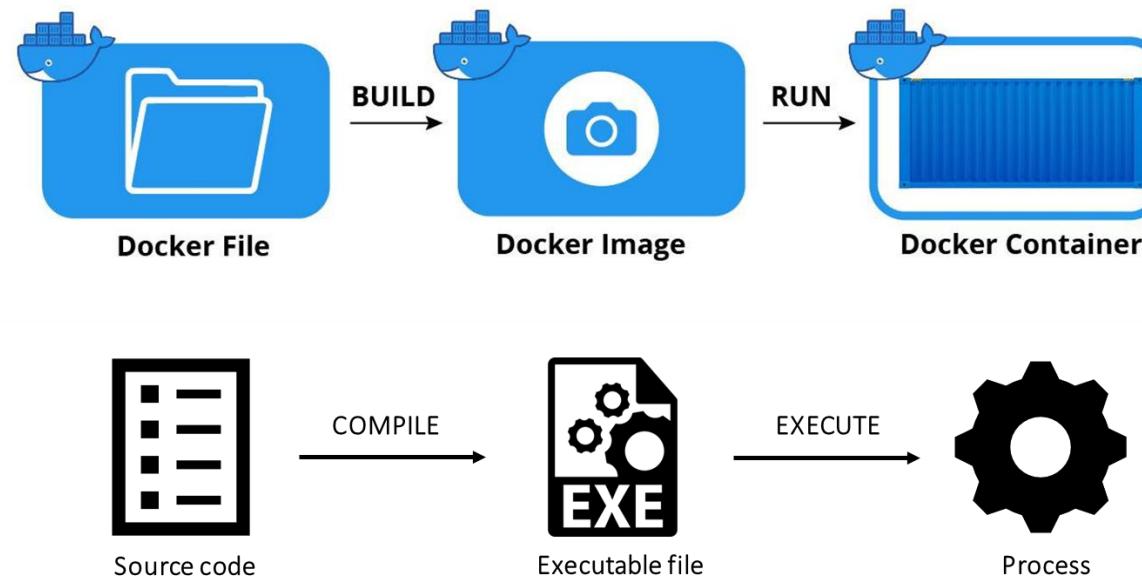
command	description
<code>FROM</code> <i>image</i>	base image for the build
<code>COPY</code> <i>path dst</i>	copy <i>path</i> from the context into the container at location <i>dst</i>
<code>ADD</code> <i>src dst</i>	same as <code>COPY</code> but accepts archives and urls as <i>src</i>
<code>RUN</code> <i>args...</i>	run an arbitrary command inside the container
<code>CMD</code> <i>args...</i>	set the default command
<code>USER</code> <i>name</i>	set the default username
<code>WORKDIR</code> <i>path</i>	set the default working directory
<code>ENV</code> <i>name value</i>	set an environment variable
<code>EXPOSE</code> <i>port(s)</i>	allow the container to listen on the network <i>port(s)</i>
<code>ENTRYPOINT</code> <i>exec args...</i>	configure a container that will run as an executable

The **Dockerfile** is a script file having (some of) those command that are executed in order.

Analogy



Analogy



- It is possible to have multiple containers from an image.
- If I change something in the Dockerfile (or in the code copied in the image) I have to build again the image and run the container again.

Docker cheat sheet

IMAGES

Docker images are a lightweight, standalone, executable package of software that includes everything needed to run an application: code, runtime, system tools, system libraries and settings.

Build an Image from a Dockerfile

```
docker build -t <image_name> .
```

Build an Image from a Dockerfile without the cache

```
docker build -t <image_name> . --no-cache
```

List local images

```
docker images
```

Delete an Image

```
docker rmi <image_name>
```

Remove all unused images

```
docker image prune
```

CONTAINERS

A container is a runtime instance of a docker image. A container will always run the same, regardless of the infrastructure.

Containers isolate software from its environment and ensure that it works uniformly despite differences for instance between development and staging.

Create and run a container from an image, with a custom name:

```
docker run --name <container_name> <image_name>
```

Run a container with and publish a container's port(s) to the host.

```
docker run -p <host_port>:<container_port> <image_name>
```

Run a container in the background

```
docker run -d <image_name>
```

Start or stop an existing container:

```
docker start|stop <container_name> (or <container_id>)
```

Remove a stopped container:

```
docker rm <container_name>
```

Open a shell inside a running container:

```
docker exec -it <container_name> sh
```

Fetch and follow the logs of a container:

```
docker logs -f <container_name>
```

To inspect a running container:

```
docker inspect <container_name> (or <container_id>)
```

To list currently running containers:

```
docker ps
```

List all docker containers (running and stopped):

```
docker ps --all
```

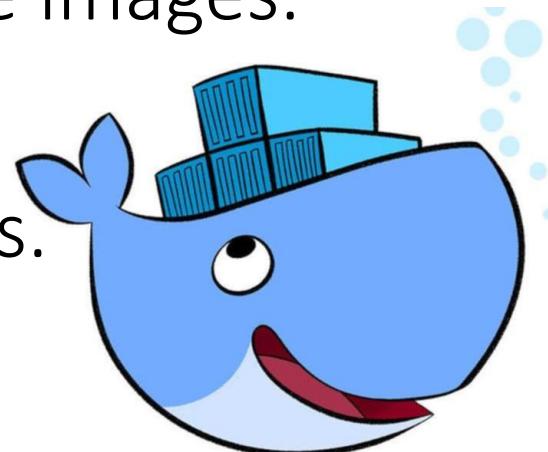
View resource usage stats

```
docker container stats
```



With Docker

- We do not need virtual environments for executing Python code.
- Be careful with your docker environment!
 - Check running containers -> they use CPU
 - Check not used images -> they use local storage
- When you are not using Docker, stop your containers (possibly remove them), and decide if you want to remove the images.
- Use the commands of the previous slide.
- The image `python:12-slim` will be used in most Labs.

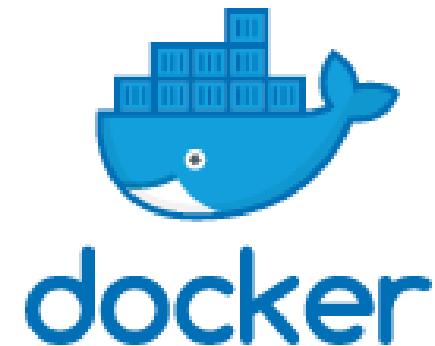


Today's Lab

Use the code developed in the first labs or download the zip from the Moodle containing a similar service .

1. Write the **Dockerfile** related to the developed app.
2. Build the image.
3. Run two containers based on the image and call their API.

(Details in the next slide)



Details



In the folder with the code:

1. Create and write the `Dockerfile` for building a docker image starting from `python:3.12-slim`, move the code in the image environment, install the requirements, expose a port and set the initial command to start Flask correctly.
(DockerFile docs @ <https://docs.docker.com/engine/reference/builder/>
Flask usage @ Lab 1 slides)
2. Build the docker image. Hint: tag it with a name.
(<https://docs.docker.com/engine/reference/commandline/build/>)
3. Use two different terminals to run two containers based on its image, changing the port binding (<https://docs.docker.com/engine/reference/run/>).
4. Try them! Using a browser (or an HTTP client) invoke the services sending GETs to it, e.g on my code:

`http://127.0.0.1:5001/add?a=2&b=1` should return a JSON with a field `s = 3`

Bonus

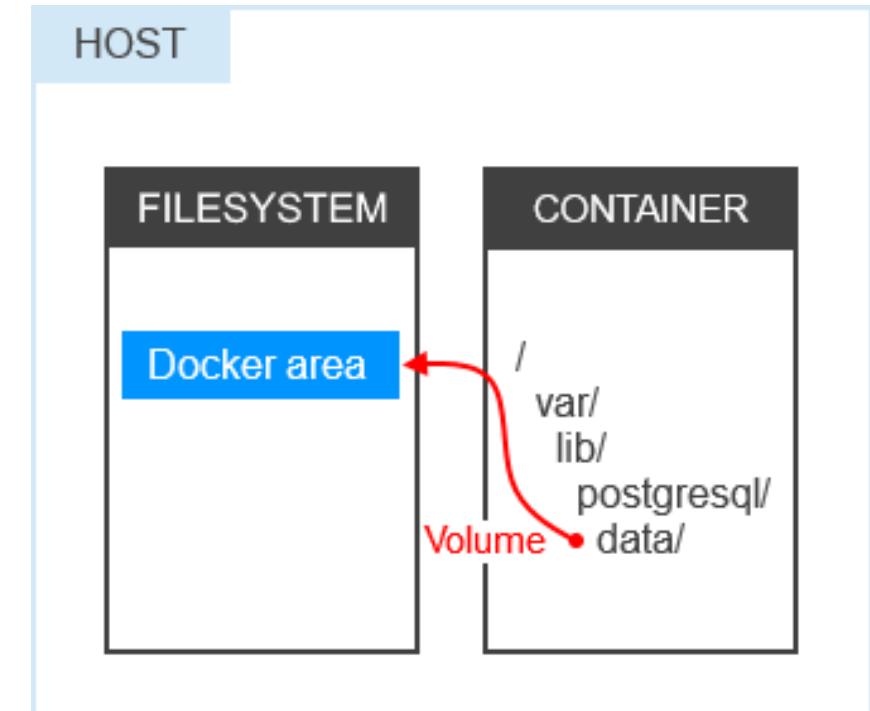
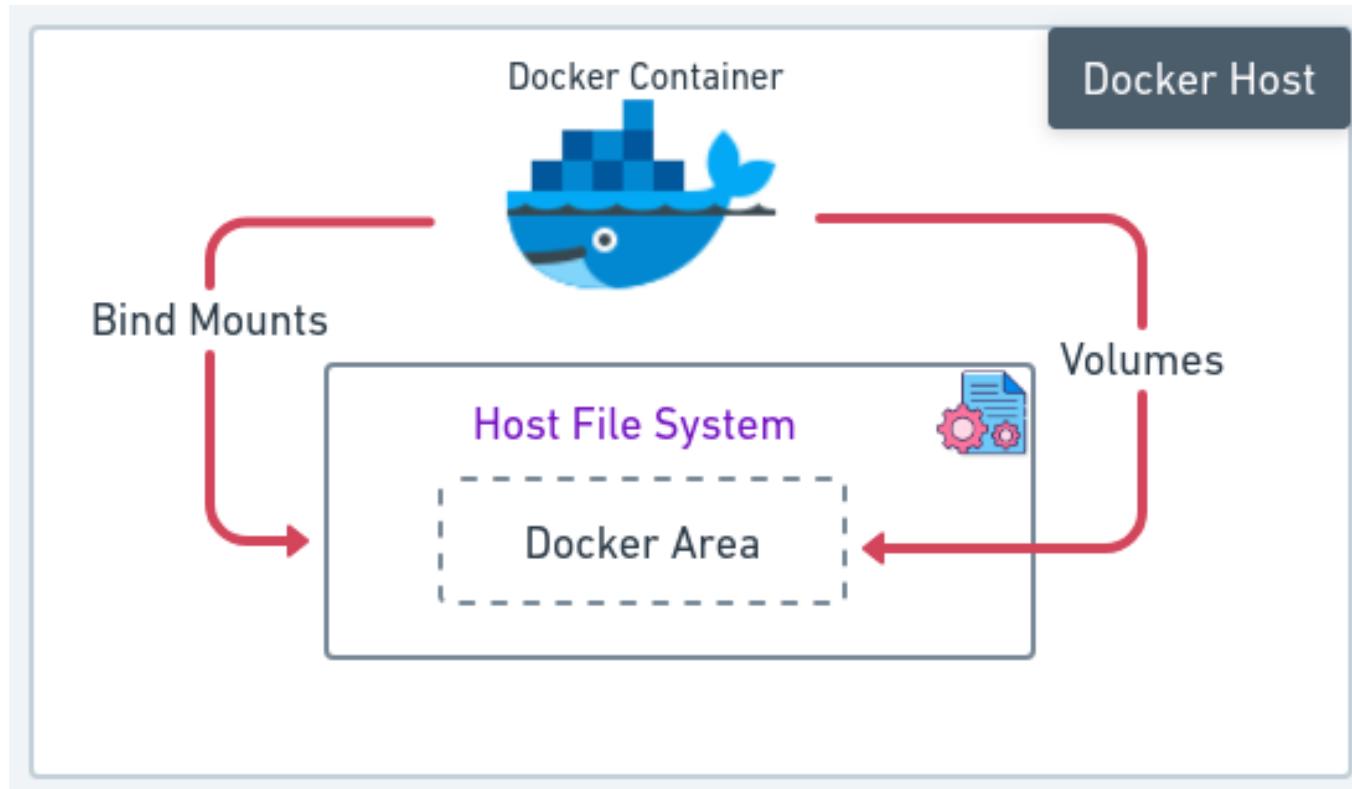
What happens if you:

1. Run a container of our app.
 2. Do an operation.
 3. Stop and remove the container.
 4. Start a new container.
 5. Call the /last endpoint
- ?



Docker Volumes

Mechanism to manage persisted data created and used by containers.



Docker Volumes - commands

```
alebocci@LaptopUnipiBoc:~$ docker volume --help
```

```
Usage: docker volume COMMAND
```

```
Manage volumes
```

```
Commands:
```

create	Create a volume
inspect	Display detailed information on one or more volumes
ls	List volumes
prune	Remove unused local volumes
rm	Remove one or more volumes

After creating the volume `myvolume` to mount it at `/app`:

```
docker run -p 5000:5000 --mount source=myvolume,target=/app pycalc  
or
```

```
docker run -p 5000:5000 -v myvolume:/app pycalc
```



Bonus stage

Use docker volumes to persist the /last endpoint file:

1. Run a container in detached mode (-d) and perform an operation.
2. Stop and remove the container.
3. Run a new container and call the /last endpoint.
4. It should answer with the operation of point 1.



Is Docker the only solution?

Obviously no!

- **Podman**: Daemonless containers you can run as non-root for stronger security.
- **containerd**: Lightweight, OCI-compliant runtime that scales cleanly.
- **CRI-O**: OCI runtime optimized for speed and security with tight Kubernetes integration.
- Many others...

OCI: Open Container Initiative



Lab take away

- Learn to write a **Dockerfile**
- Build docker images
- Run and interact with containers



A good guide to learn more:

<https://developers.redhat.com/blog/2018/02/22/container-terminology-practical-introduction>

Official Docker training website:

<https://training.play-with-docker.com/>

Project take away

- ❑ The service implemented in the project must be dockerized.
- ❑ You will need to write Dockerfiles for it.

