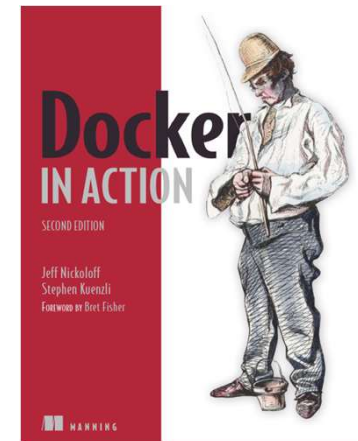
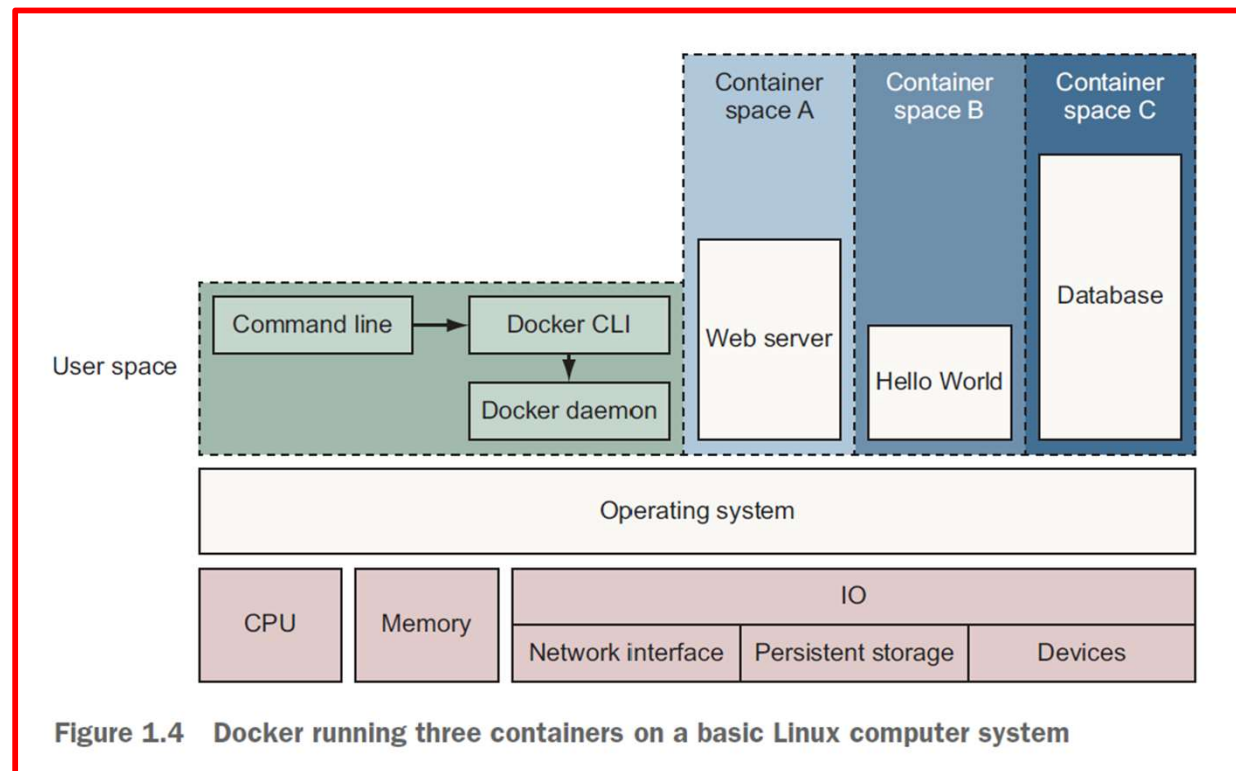


# MEETING DOCKER



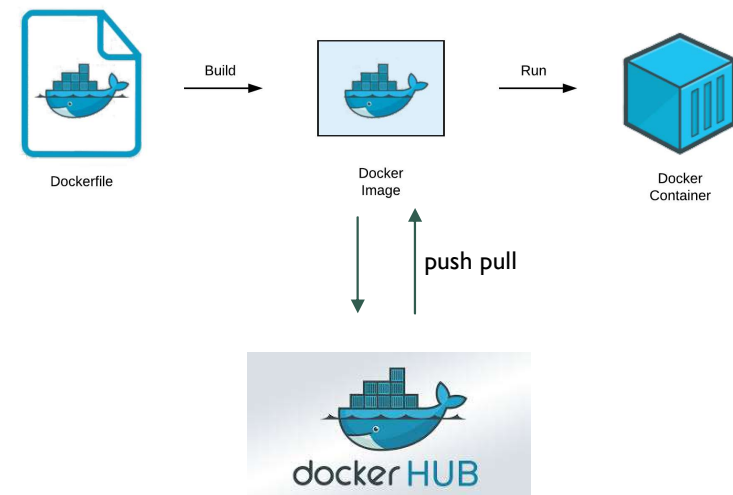
# DOCKER ARCHITECTURE

- **Docker Host** = The computer (physical or virtual) where containers run.
- **Docker Daemon** = The background process that manages Docker containers, images, and networks. It executes the commands sent to it.
- **Docker CLI** = The Command Line Interface that allows the user to send commands to the Docker Daemon.



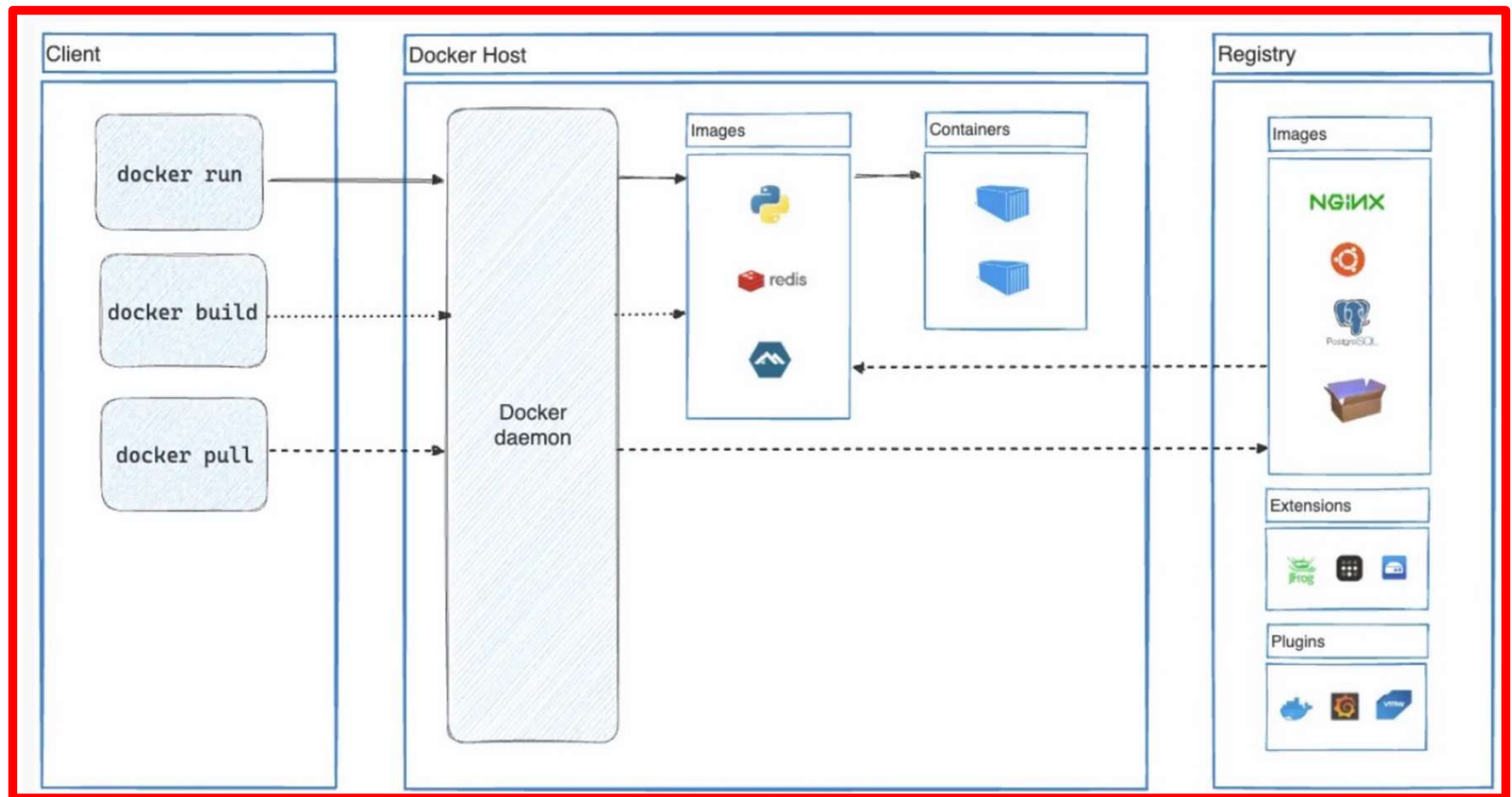
# DOCKER WORKFLOW

- Docker activities can be classified as
- **build, run, push** and **pull**
- A container is a running image
- `container : image = process : program`
- Registry = place where images are stored, can be public or private
- Docker hub = registry maintained by Docker Inc.

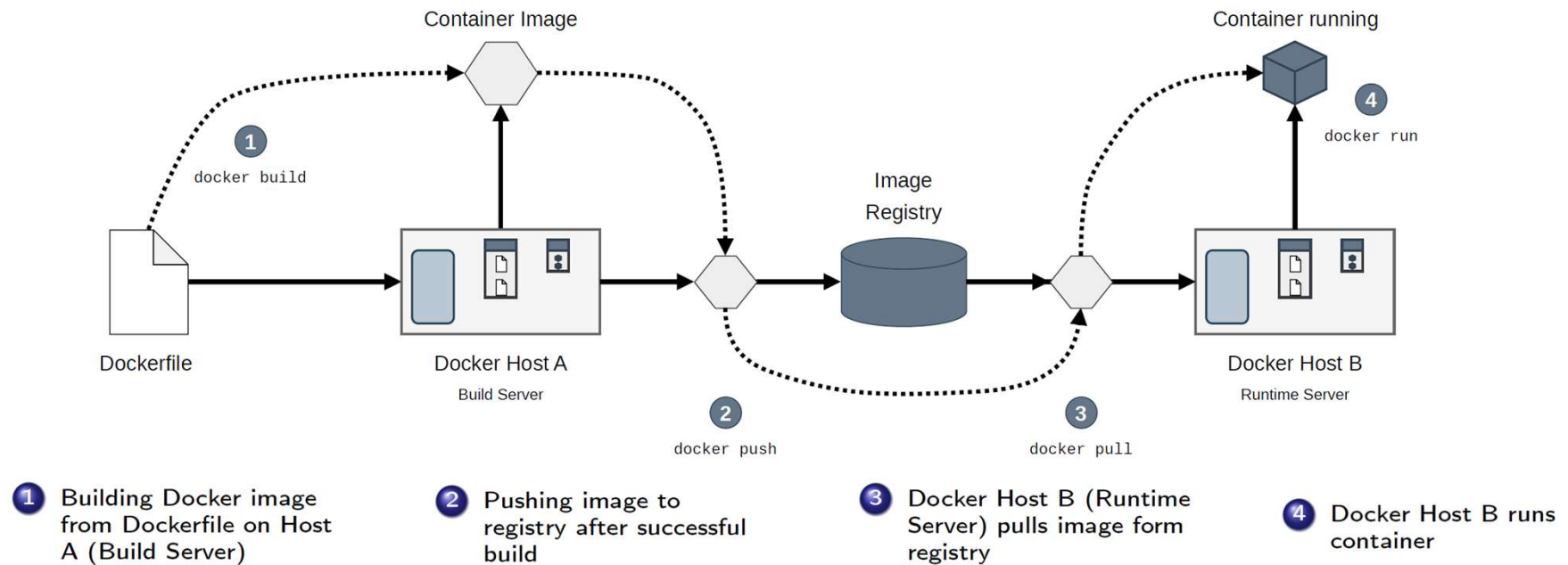


# DOCKER ARCHITECTURE

- **Plugins:** add functionalities of the (core) daemon, e.g. buildx
- **Extensions:** functionalities seen by users



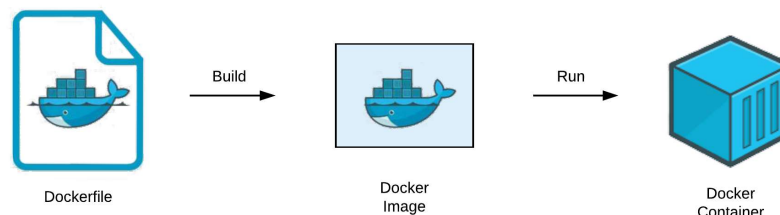
# DOCKER WORKFLOW



# DOCKER IMAGES

- Read-only template used to create a docker image
- Build means to create an image that includes all the dependencies of an app
- **\$docker build**: command that reads instructions from a **docker file**
- Docker file is a list of instructions, each that follows a simple syntax
- **INSTRUCTION** argument

```
FROM python:3.11-slim
WORKDIR /app
COPY app.py .
RUN pip install Flask
EXPOSE 5000
CMD ["python", "app.py"]
```



**FROM** specify parent image (mandatory)  
**WORKDIR** specify working directory  
**COPY** copy files from host and put them into image  
**RUN** to execute specified command  
**EXPOSE** to set specified network port exposed by container  
**CMD** `["", ""]`: to provide default command the container will run

<https://docs.docker.com/get-started/docker-concepts/buildingimages/writing-a-dockerfile/>

# DOCKER FILE

```
FROM python:3.11-slim
WORKDIR /app
COPY app.py .
RUN pip install Flask
EXPOSE 5000
CMD ["python", "app.py"]
```

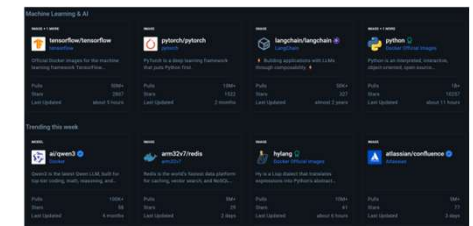
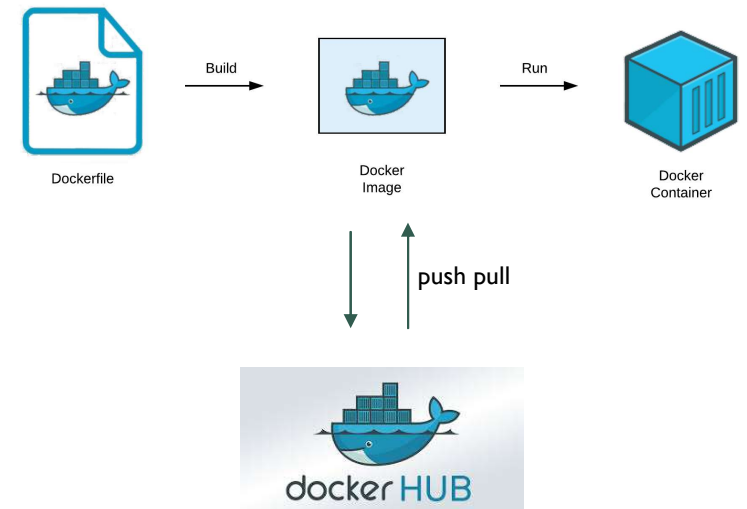
1. parent image (`python:3.11-slim`) pulled from Docker Hub
2. create and make current it the current directory in the container (`/app`)
3. copy the file `app.py` from the host into the current directory (`app.py`)
4. run the command `pip install Flask`
5. make port 5000 accessible (just information)
6. execute this command after the build

- 2.,3.,4. add a **layer** to the base image file identified by 1. (from) [see next slides]
5. Just information that are included in the image
6. Executed only after the build, it doesn't add any layer, modifies metadata

[REGISTRYHOST:PORT/][USERNAME/]NAME[:TAG]

# REGISTRY

- Images can also be pulled from a registry or pushed to a registry
- A *named repository* is a named bucket of images. The name is similar to a URL.
- For example, AWS has a public registry :: <https://gallery.ecr.aws>
- Docker hub: <https://hub.docker.com/>





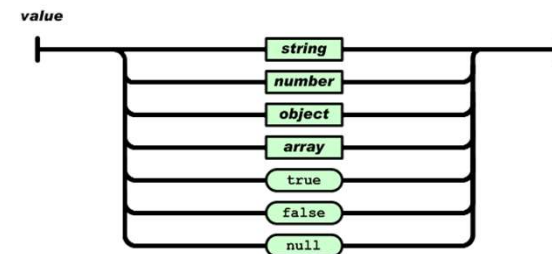
# APP.PY

- **Flask** = open-source micro-framework for web application and web-api
- **jsonify** = function to convert Python objects (usually dictionaries) into JSON-formatted responses
- **Annotation**: app.route is an 'annotation' that configure the server to route a HTTP get request on /, to the following method (get\_data in this example)

```
from flask import Flask, jsonify
app = Flask(__name__)

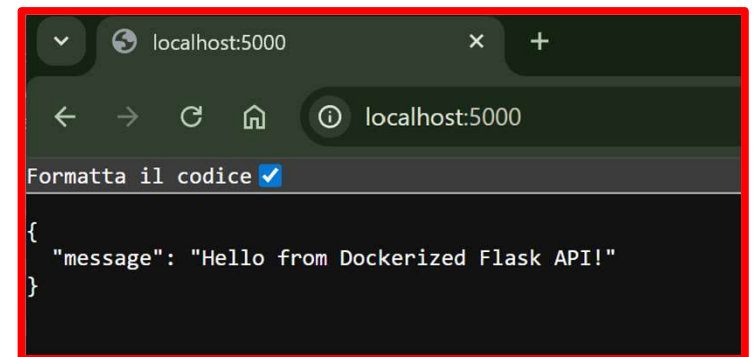
@app.route("/")
def home():
    return jsonify(message="Hello from Dockerized Flask API!")

if __name__ == "__main__":
    app.run(host="0.0.0.0", port=5000)
```



# BUILD THE IMAGE AND RUN IT

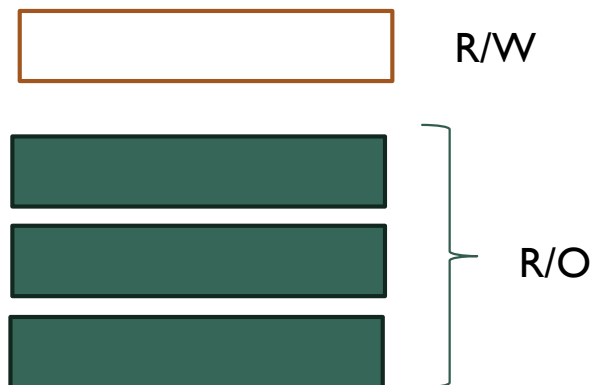
- `docker buildx build --load -t simple-flask-api .`
- `docker run -d -p 5000:5000 simple-flask-api:latest`
- `docker ps`

A screenshot of a web browser window with a dark theme. The address bar shows 'localhost:5000'. Below the address bar, there are navigation icons (back, forward, refresh, home) and an information icon. The main content area displays a JSON response: {"message": "Hello from Dockerized Flask API!"}. Above the JSON, there is a link that says 'Formatta il codice' with a checkmark icon. The entire browser window is outlined with a red border.

```
{  
  "message": "Hello from Dockerized Flask API!"  
}
```

# IMAGE FILE

- Each image consists of a stack of layers
- The first set of layers is read/only, which allows efficient sharing among other images
- The last layer is R/W and created at each run (containers are then **stateless**)



- Layers are created by commands in the docker file
- CMD doesn't create a layer; it specifies what command to run within the container
- One R/W layer created after RUN (doesn't persist)

# LIFECYCLE OF A CONTAINER

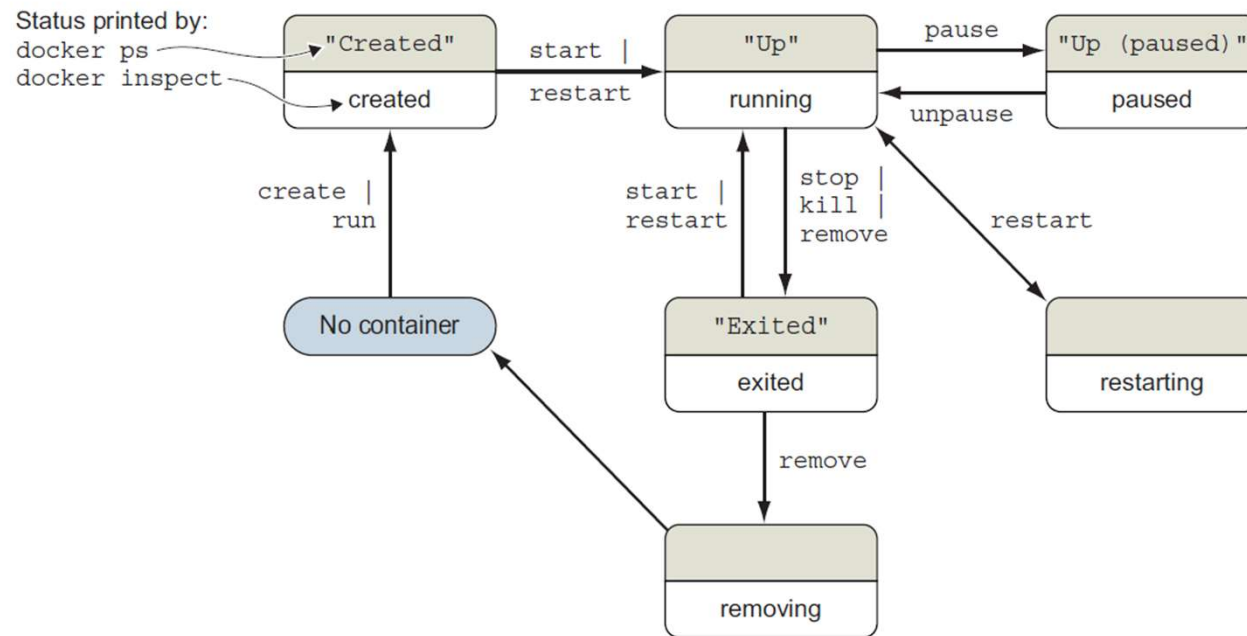


Figure 2.3 The state transition diagram for Docker containers

# IMAGE HANDLING

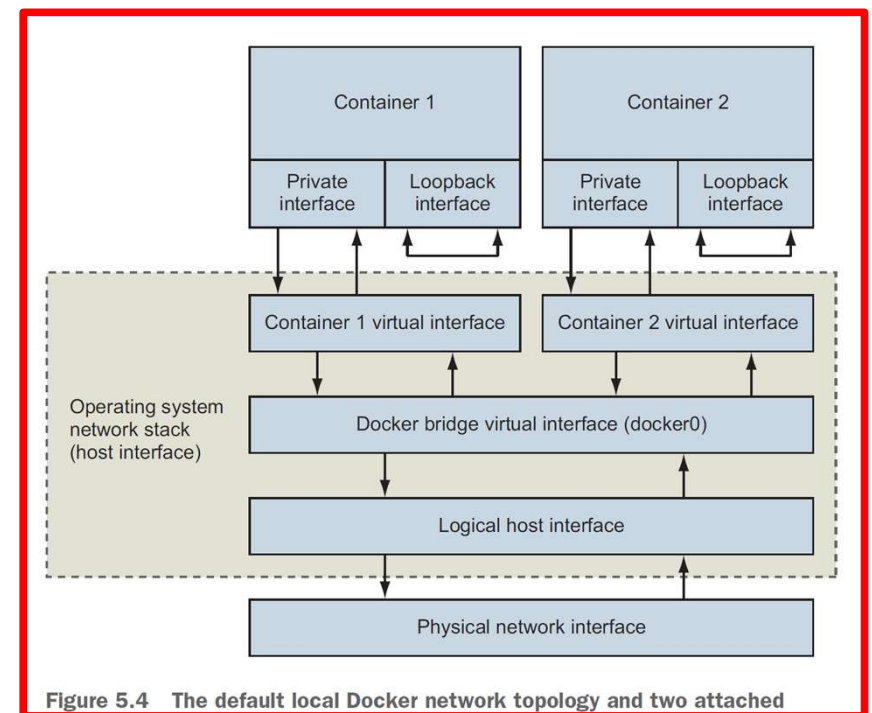
- List the image on the host (local repository)
- **\$ docker images**
- **\$ docker image ls**
- **\$ docker rmi *imageid***
- Remove an image (by id or name)

# CONTAINER MANAGEMENT

- `$ docker ps`
- `$ docker stop containerid`
- `$ docker start containerid`
- `$ docker kill containerid`
- `$ docker rm containerid`

# DOCKER NETWORKING

- Communication with other containers in the same host or to non-Docker processes
- By default, Docker includes three networks, and each is provided by a different **driver**.
- The network named **bridge** is the default network provided by a bridge driver.
- The bridge driver provides inter container connectivity for all containers running on the same machine.



# DOCKER NETWORKING

- The **host** driver allows containers interact with the host's network stack like uncontained processes.
- **\$docker run the -p** flag (publish) makes a port available to outside
- The **none** network uses the null driver.
- Containers attached to the none network will not have any network connectivity outside themselves.

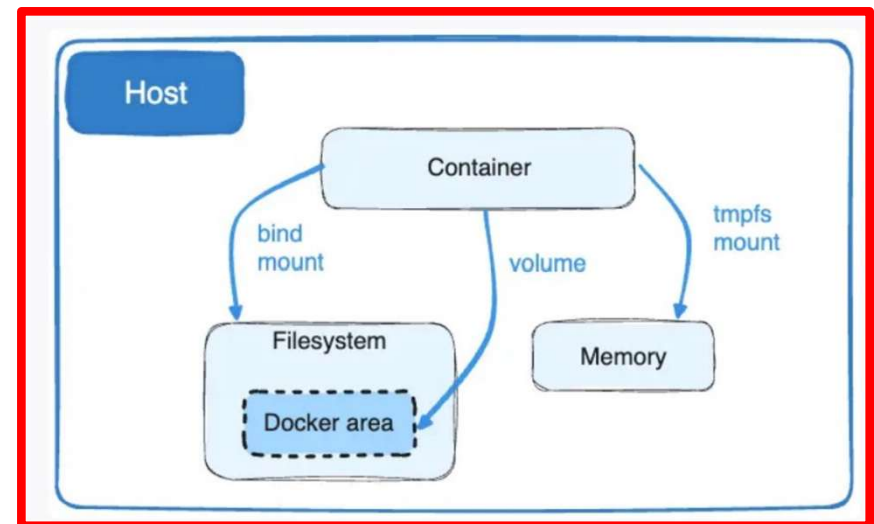
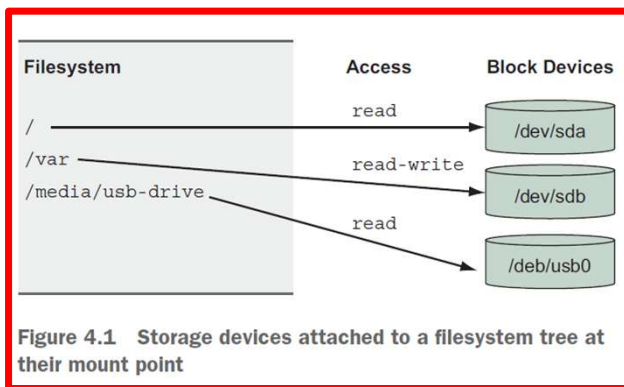
**\$ docker network ls**

NETWORK ID	NAME	DRIVER	SCOPE
8ada112f2067	bridge	bridge	local
0a8ff0aa78a0	host	host	local
6e7bc3bed9a6	none	null	local



# DOCKER STORAGE

- Recall in linux the file system is a tree and some point of the tree one can **mount** a device
- To persist data, a container can mount part of the host file system tree to the container tree (**bind-mount**)
- This however ties the container to a specific host configuration
- The preferred option is to use docker **volumes** generated and managed by docker
- Volumes provide container-independent data management
- The last option is to use **in-memory** fs (cache)



# DOCKER VOLUME

- Commands to manage a container
- Create a volume: **\$ docker volume create *name***
  - will create a directory to store the contents of a volume somewhere in a part of the host filesystem under control of the Docker engine.
  - List volumes: **\$ docker volume ls**
- Inspect volume: **\$ docker volume inspect *name***
- Remove volume: **\$ docker volume rm *name***
- Mount a volume: **\$ docker run ... -v *source* : *destination***

# HANDS-ON

```
from flask import Flask, jsonify
from datetime import datetime

LOG_FILE = "/data/log.txt" # will later be a mounted volume

app = Flask(__name__)

@app.route("/")
def home():
    with open(LOG_FILE, "a") as f:
        f.write(f"GET request received at {datetime.now()}\n")
    return jsonify(message="Hello from Dockerized Flask API!")

if __name__ == "__main__":
    app.run(host="0.0.0.0", port=5000)
```

-v mount volume

-t image name

-d image runs detached (bg)

-p port mapping

**docker buildx build -t simple-flask . --load**

**docker run -d -p 5000:5000 -v \$(pwd)/data:/data simple-flask**

# MULTI-CONTAINER APPLICATIONS

- **Docker Compose**: tool to manage multiple containers on the same host
  - Coordinate a composition of containers on the same host, communicating via bridge (private network among containers)
  - The composition is defined into a text file (with **YAML** formatting)
- **Docker swarm** or **Kubernetes (K8)**: container management on multiple hosts

# DOCKER COMPOSE

- Tool for defining and running multi-container Docker applications
  - <https://docs.docker.com/compose/>
- Allows us to coordinate a composition of multiple containers running on a single host (i.e., single Docker engine)
- User expresses the containers to be instantiated at once and their relationships

# DOCKER SERVICE

- **Service:** abstract definition of computing resources within application
- **Build:** means used the Docker file in the current directory to build the image
- Call the container `my_python_app`
- **\$ docker compose up --build**

```
Compose now can delegate build to bake for better performances
Just set COMPOSE_BAKE=true
[*] Building 1.5s (11/11) FINISHED
=> [app internal] Load build definition from Dockerfile
=> => transferring Dockerfile: 19kB
=> [app internal] Load metadata for docker.io/library/python:3.11-slim
=> [app internal] Load dockerignore
=> => transferring context: 2B
=> [app 1/4] FROM docker.io/library/python:3.11-slim@sha256:6e993a415c679051e7050d2dde0ddcaad8c132d
=> => resolve docker.io/library/python:3.11-slim@sha256:6e993a415c679051e7050d2dde0ddcaad8c132d
=> [app internal] Load build context
=> => transferring context: 20B
=> CACHED [app 2/4] WORKDIR /app
=> CACHED [app 3/4] COPY app.py
=> CACHED [app 4/4] RUN pip install Flask
=> [app] exporting to oci image format
=> => exporting layers
=> => exporting manifest sha256:0e940aaf8e93e7ad8c97d0c93aa5f22a5088468d70071e59608300c90b27a9
=> => exporting config sha256:f3081b977b940c1c2d5394c0c3c5c0a0390a08c3c596975ea3b4607415d4
=> => sending tarball
=> [app] importing to docker
=> [app] resolving provenance for metadata file
[*] Running 2/2
✓app Built
✓Container my_python_app Created
Attaching to my_python_app
my_python_app | * Serving Flask app 'app'
my_python_app | * Debug mode: off
my_python_app | WARNING: This is a development server. Do not use it in a production deployment. Use
my_python_app | * Running on all addresses (0.0.0.0)
my_python_app | * Running on http://127.0.0.1:5000
my_python_app | * Running on http://172.18.0.2:5000
my_python_app | Press CTRL+C to quit
```

## docker-compose.yml

```
services:
  app:
    build: .
    container_name: my_python_app
    volumes:
      - app_data:/app/data          # use a volume managed by docker
    ports:
      - "5000:5000"                # makes the port visible outside
    networks:
      - app_net

volumes:
  app_data:                        # volume Docker declaration
networks:
  app_net:
```

# DOCKER COMPOSE

- To start Docker composition (background -d): **\$ docker compose up -d**
- By default, Docker Compose looks for compose.yaml in working directory
- To stop running containers: **\$ docker compose stop**
- To bring composition down, removing everything **\$ docker compose down**

