Docker
and
docker compose

Vocab

- Development Environment (dev)
  - The environment where you write your code
  - Ex. Your laptop
  - Add features; Find and eliminate bugs
- Production environment (prod)
  - The environment where your app will eventually live
  - The live server with real end users
  - Do everything we can to avoid bugs in production

Deployment Headaches

- It works on my laptop!
- Run your code in production and it's broken
- Many causes
  - Different version of compiler/interpreter
  - Dependancies not linked
  - Hard-coded paths
  - Different environment variables
  - etc.

Virtual Machines

- Simulate an entire machine
- Run the virtual machine (VM) in your development environment for testing
- Run an exact copy of the VM on the production server
- No more surprise deployment issues

- Simulating an entire machine can be inefficient
  - If you've ran a VM on your laptop you know how slow this can get

Security

- *Can't* break out of the VM [Without sophisticated attacks]
- If an attacker compromises the server, they can only access what you put in the container
  - Can't "rm -rf /" your entire machine
  - Patch the exploited vulnerability and rebuild the image
- The attacker can still cause significant damage and steal private data
  - They just can't destroy your server box

Security

- Sometimes an app has to allow code injection attacks to function
    - AutoLab
    - AWS
    - Digital Ocean
- Run user code in their own VM/Container

Containers

- Effectively, lightweight VMs

Docker

- Docker is software that's used to create containers

- **Install** Docker in your development environment to test containers
- Install Docker in your production environment and run the same containers

Dockerfile

- To start working with Docker, write a Dockerfile

- This file contains all the instructions needed to build a Docker image
  - Some similarities to a Makefile

Dockerfile

- Let's explore this sample Dockerfile
- This Dockerfile creates an image for a node.js app

```
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- The first line of your Dockerfile will specify the base image
- This image is downloaded and the rest of your Dockerfile adds to this image
- In this example: We start with Ubuntu 18.04
  - Our Dockerfile can run Linux commands in Ubunutu

```
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COPY . .

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EXPOSE 8000

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CMD node app-www.js
```

Dockerfile

- Use the RUN keyword to run commands in the base image
- Use this for any setup of your OS before setting up your app
- In this example: Updating apt-get which is used to install software

```
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
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RUN npm install

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# Run the app
CMD node app-www.js
```

Dockerfile

- Use ENV to set environment variables
    - Setting the home directory here
    - Can use ENV to setup any other variables you need
- Use WORKDIR to change your current working directory
    - Same as "cd"

```
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- Since we're starting with a fresh image of Ubuntu:
    - Only the default software is installed
- RUN commands to install all required software for your app
    - Typically the development tools for your language of choice

```
FROM ubuntu:18.04

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# Set the home directory to /root
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RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- COPY all your app file into the image
- "." denotes the current directory
- Run docker from your apps root directory
  - The the first "." will refer to your apps directory
- We changed the home and working directory to /root
  - The second "." refers to /root in the image

```
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
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# cd into the home directory
WORKDIR /root

# Install Node
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RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- Now that your apps files are in the image, run all app specific commands
- Order is important
  - Don't depend on your app files before copying them into the image
- Use RUN to install dependancies and perform any other required setup

```
FROM ubuntu:18.04

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# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- Use EXPOSE to allow specific ports to be accessed from outside the container
- By default, all ports are blocked
  - Container is meant to run in isolation
- To run a web app in a container, expose the port you need

```
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- Finally, use CMD to run your app
- Important: Do not use RUN to run your app!
- RUN will execute the command when the image is being **built**
- CMD will execute when the container is **ran**
- We do not want the app to run when the image is being built

```dockerfile
FROM ubuntu:18.04

RUN apt-get update

# Set the home directory to /root
ENV HOME /root

# cd into the home directory
WORKDIR /root

# Install Node
RUN apt-get update --fix-missing
RUN apt-get install -y nodejs
RUN apt-get install -y npm

# Copy all app files into the image
COPY . .

# Download dependancies
RUN npm install

# Allow port 8000 to be accessed
# from outside the container
EXPOSE 8000

# Run the app
CMD node app-www.js
```

Dockerfile

- There are many base images to choose from
- Start with an image with your language installed to simplify your docker file
  - Search "docker <language>" to find images/tutorials for your favorite language
- This image starts with node installed so we can remove the node installation lines

```
FROM node:13

ENV HOME /root
WORKDIR /root

COPY . .

# Download dependancies
RUN npm install

EXPOSE 8000

CMD node app-www.js
```

Dockerfile

- Example for Python

```
FROM python:3.8

ENV HOME /root
WORKDIR /root

COPY . .

# Download dependancies
RUN pip3 install -r requirements.txt

EXPOSE 8000

CMD python3 -u app.py
```

Dockerfile

- For Python
  - Make sure you add this -u flag
  - This will force stdout and stderr to be unbuffered
  - Without it, when running in Docker, you might not see your print statements

```
FROM python:3.8

ENV HOME /root
WORKDIR /root

COPY . .

# Download dependancies
RUN pip3 install -r requirements.txt

EXPOSE 8000

CMD python3 -u app.py
```

Running Your App

- When preparing your app to run in a container
    - **Do not use "localhost"** [in your code]
    - Use "0.0.0.0" as the host instead
    - This allows your app to be accessed from outside the container

Docker Compose

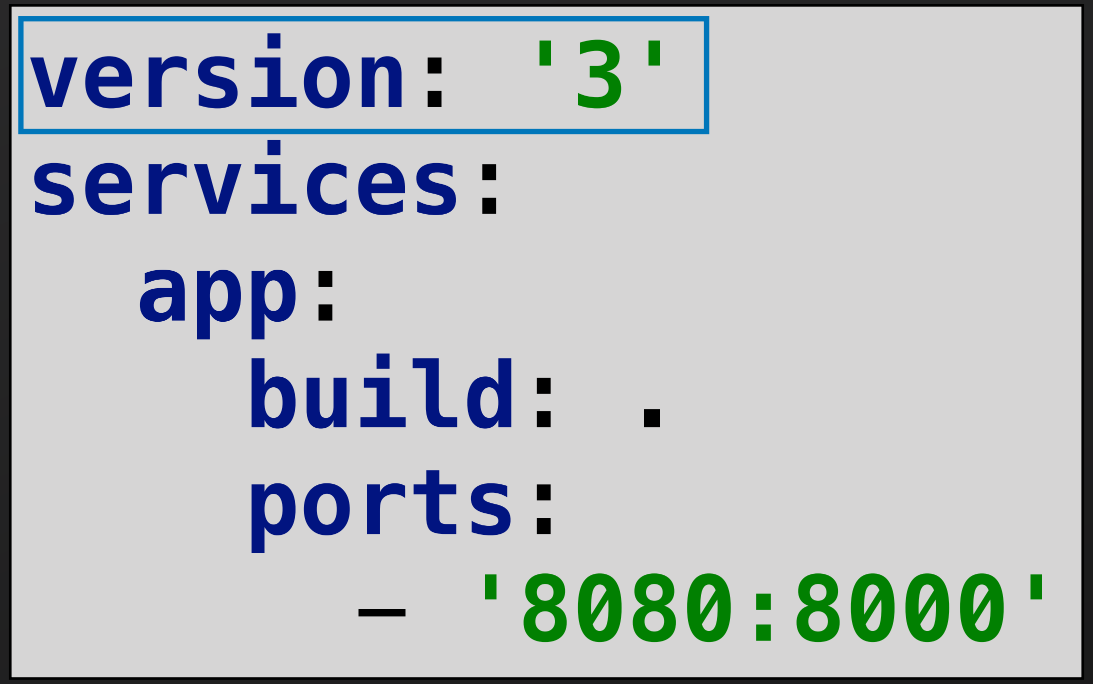
Docker Compose

- Manages building/running docker images/containers
- Build and run with one command
  - docker compose up --build --force-recreate
- No need to use docker build and docker run
- Will be used to manage multiple containers
  - Separate container for your database

- Let's walk through a docker-compose.yml file

Docker Compose

docker-compose.yml



```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- Specify the docker compose file format version
- Version 3[.8] is the current latest version
- This line is now optional

Docker Compose

docker-compose.yml

```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- List of all the services for docker compose to run
- A docker container is created for each service

Docker Compose

docker-compose.yml

```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- Name each service
- We have one service that we name "app"
- This name becomes the hostname when communicating between containers

Docker Compose

docker-compose.yml

```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- Use 'build' to specify the path to build from
  - Docker compose will look in this directory for a Dockerfile and use it to build the image
- Same as the trailing '.' when building an image

Docker Compose

docker-compose.yml

```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- Map a local port to a container port
- Same as using "-p 8080:8000" when running a single container

Docker Compose

docker-compose.yml

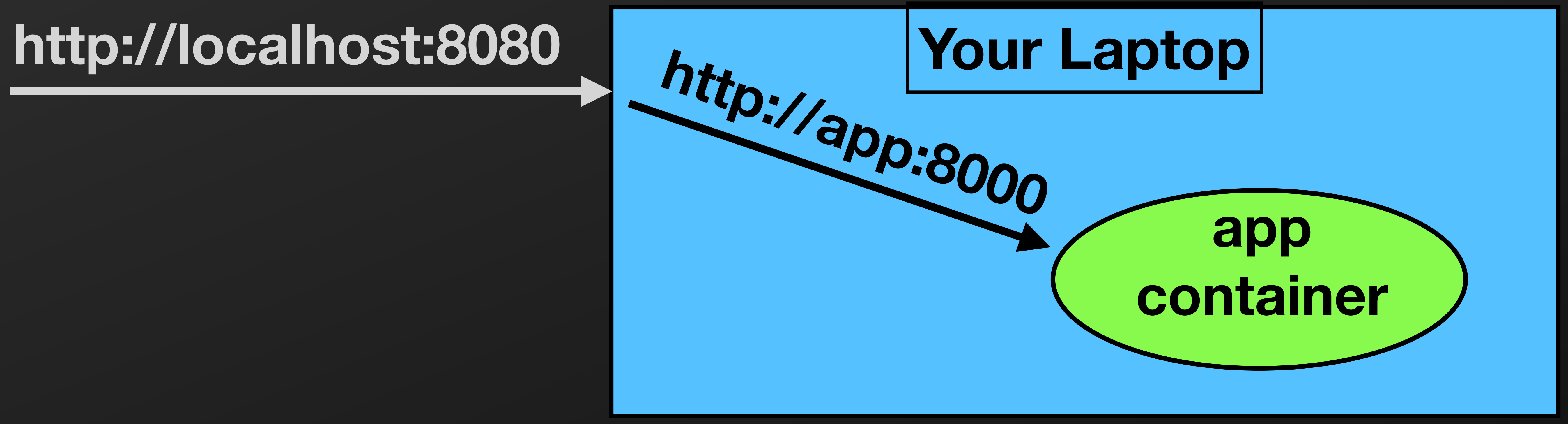
```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```

- Mapping a port allows your app [inside the container] to be accessed from your machine
- This line maps your local port 8080 [On your machine] to port 8000 inside your container

Docker Compose

docker-compose.yml

```yaml
version: '3'
services:
  app:
    build: .
    ports:
      - '8080:8000'
```



- When your machine receives a request for the mapped port
  - Docker forwards the request to the container on the specified port

Running Your App

- To run your app
  - docker compose up
- To run in detached mode
  - docker compose up -d
- To **rebuild** and restart the containers
  - docker compose up --build --force-recreate
  - *This is the best command to use!
- To restart the container without rebuilding
  - docker compose restart

Running Your App

- To **rebuild** and restart the containers
  - docker compose up --build --force-recreate

- Use this command during development
- Very important to rebuild your images after you change code
  - If you don't, you will not see your changes since you'll be running your old code

Docker Compose

docker-compose.yml

```yaml
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- Let's modify our docker compose configuration to run our database

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- "services" is a list of all the images/containers to create
- We'll add a second service for the DB

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- Name each service
- These names are used as the hostnames for each container
    - Used to communicate between containers

Docker Compose

docker-compose.yml

```yaml
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- This service named 'mongo' uses a pre-built image
  - Same as having a 1-line Dockerfile:
    - "FROM mongo:4.2.5"
- No Dockerfile is needed

Docker Compose

docker-compose.yml

```yaml
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- Use 'environment' to set any needed environment variables
- If using MySQL, set variables for your username/ password

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

```
FROM python:3.8.2

ENV HOME /root
WORKDIR /root

COPY . .
RUN pip install -r requirements.txt

EXPOSE 8000

ADD https://github.com/ufoscout/docker-compose-wait/releases/download/2.2.1/wait /wait
RUN chmod +x /wait

CMD /wait && python app.py
```

- We use an environment variable to tell our app to wait until the database is running before connecting to it

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- If the app runs before the database, it won't be able to establish a DB connection
- Solution: Wait for the DB to start before running the app

```
FROM python:3.8.2

ENV HOME /root
WORKDIR /root

COPY . .
RUN pip install -r requirements.txt

EXPOSE 8000

ADD https://github.com/ufoscout/docker-compose-wait/releases/download/2.2.1/wait /wait
RUN chmod +x /wait

CMD /wait && python app.py
```

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

```
FROM python:3.8.2

ENV HOME /root
WORKDIR /root

COPY . .
RUN pip install -r requirements.txt

EXPOSE 8000

ADD https://github.com/ufoscout/docker-compose-wait/releases/download/2.2.1/wait /wait
RUN chmod +x /wait

CMD /wait && python app.py
```

- This solution from github user "ufoscout" works well

Docker Compose

docker-compose.yml

```yaml
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

- This file is used to build both images and run both containers using docker-compose

Docker Compose

docker-compose.yml

```yaml
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

~~`mongo_client = MongoClient('localhost')`~~

```python
mongo_client = MongoClient('mongo')
```

- Recall that we chose names for each service
- When connecting to the database in your app
  - The service name is the hostname for the container

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mongo:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mongo:27017
    ports:
      - '8080:8000'
```

~~`mongo_client = MongoClient('localhost')`~~

```
mongo_client = MongoClient('mongo')
```

- Use the name of the service
- docker-compose will resolve this hostname to the appropriate container

Docker Compose

docker-compose.yml

```
version: '3.3'
services:
  mysupercooldatabase:
    image: mongo:4.2.5
  app:
    build: .
    environment:
      WAIT_HOSTS: mysupercooldatabase:27017
    ports:
      - '8080:8000'
```

~~`mongo_client = MongoClient('localhost')`~~

```
mongo_client = MongoClient('mysupercooldatabase')
```

- We can name our services whatever we want
- Make sure you are consistent!

Running Your App

- docker-compose up --build --force-recreate
  - Will now start both containers
  - Use the service name as the host name to communicate across containers