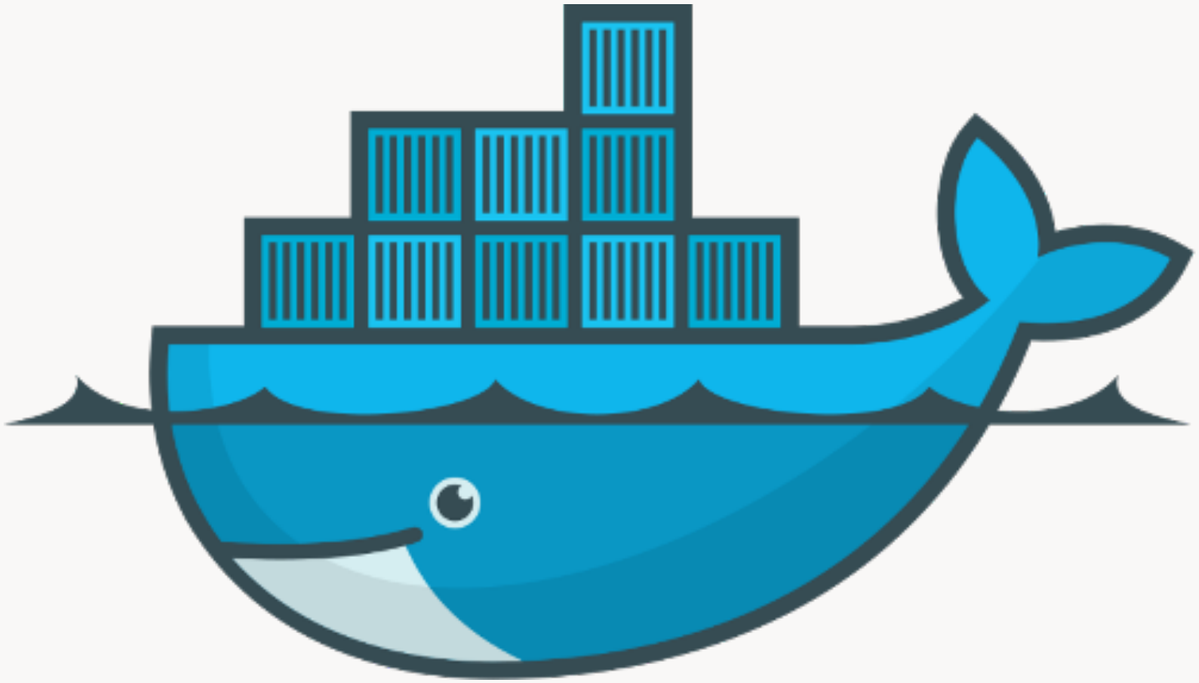
Intro to Docker



Intro

Lance Stephens

Been in the game for over a decade. Was a DevOps engineer at Greenhouse Software until May 2023 (3.5 years).

Now #opentowork!

Extracurriculars include community organizing with Pythonistas (founder) and Coffee & Code, volunteering with ReMerge, going to concerts, and travel.

Topics

Covered

— Brief explanation and history
— Setup environment
— Dockerfile
— Docker Compose
— Upload to Docker Hub registry
— Continuous Integration

Topics

Out of Scope

— Alternatives (Podman, Kaniko, OrbStack)
— Architectures (x86, ARM)
— Buildkit
— Kubernetes (k8s)
— Cloud providers (e.g., AWS, Azure, GCP)

Brief Explanation of Containers

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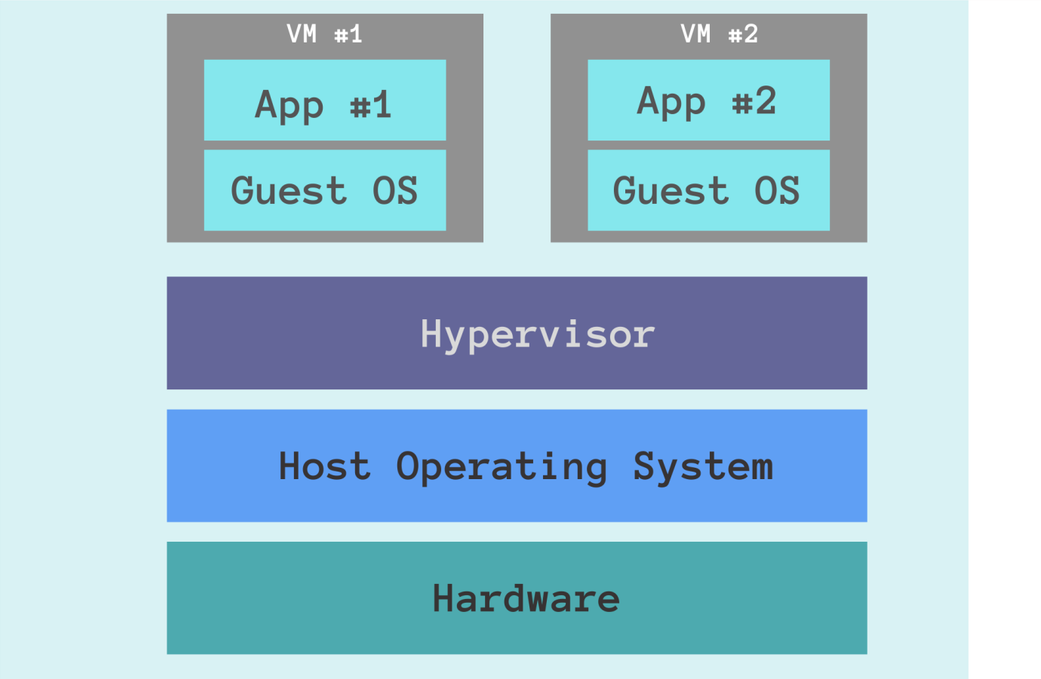
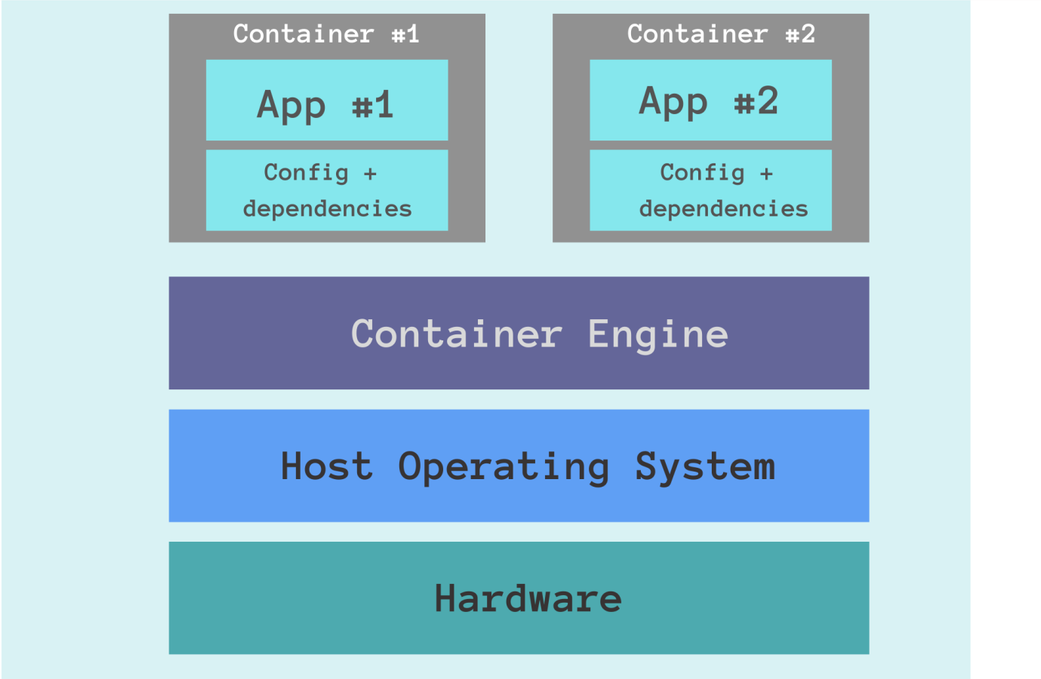
Virtual Machines

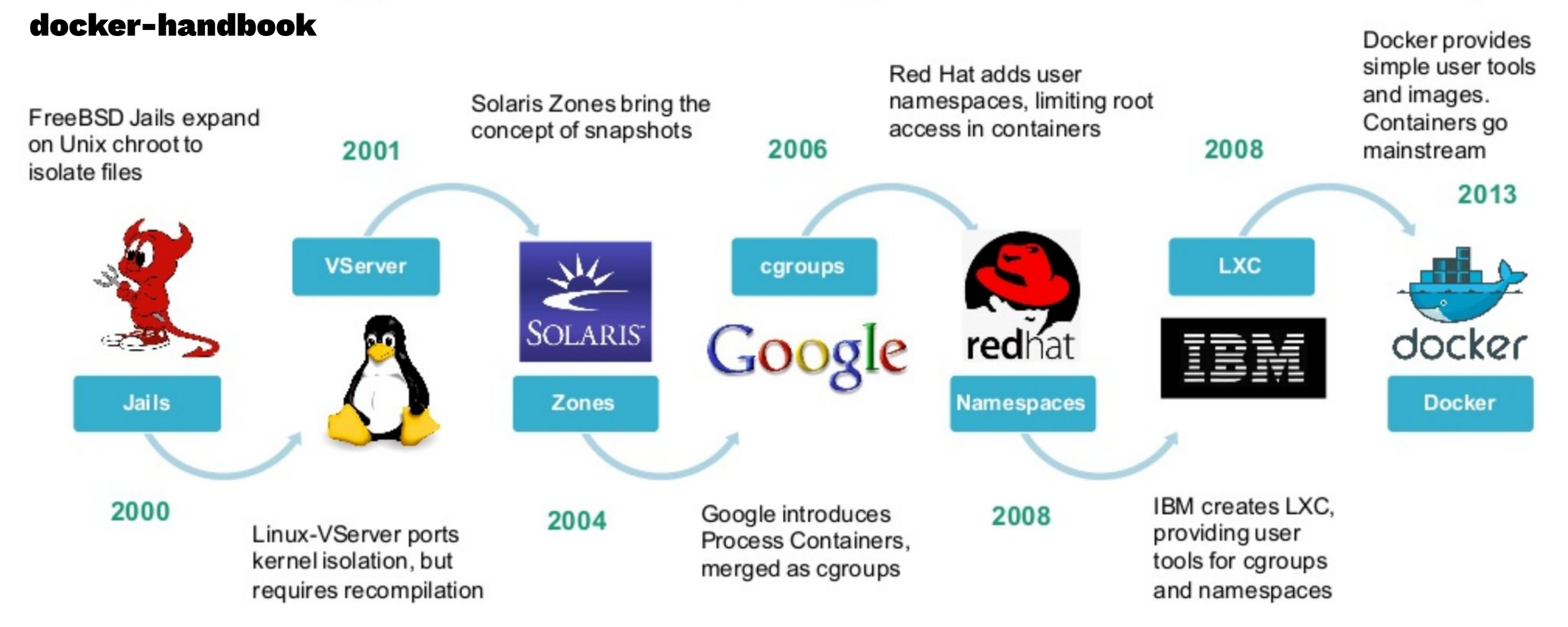


Containers



freecodecamp Docker vs Virtual Machine (VM) – Key Differences You Should Know

Brief History of Containers



docker-handbook Containerization History - Docker Handbook

Repo

https://github.com/pythoninthegrass/docker_101

Setup

Instructions for macOS below (Windows, Linux)

```
# install homebrew
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"

# install docker desktop
brew update
brew install --cask docker

# install docker-compose
brew install docker-compose

# hello world
docker run hello-world
```

Dockerfile vs. docker-compose.yml

Dockerfile

```
FROM awesome/webapp
COPY . /usr/src/app
CMD ["python", "app.py"]
```

docker-compose.yml

```yaml
services:
  frontend:
    image: awesome/webapp
    ports:
      - "443:8043"
    networks:
      - front-tier
      - back-tier
    configs:
      - httpd-config
    secrets:
      - server-certificate

  backend:
    image: awesome/database
    volumes:
      - db-data:/etc/data
    networks:
      - back-tier

volumes:
  db-data:
    driver: flocker
    driver_opts:
      size: "10GiB"

configs:
  httpd-config:
    external: true

secrets:
  server-certificate:
    external: true

networks:
  # The presence of these objects is sufficient to define them
  front-tier: {}
  back-tier: {}
```

`Dockerfile` vs. `docker-compose.yml`

`Dockerfile`

- Domain Specific Language (DSL)
- Builds an image
- Interpreted

`docker-compose.yml`

- Yet Another Markup Language (YAML)
- Definines services, networks, and volumes for a Docker application
  - Can build local image from `Dockerfile` or use remote image on a container registry
- Runtime based on element level and global directives

Dockerfile

Common Directives

- FROM
- ARG
- ENV
- RUN
- WORKDIR
- COPY
- EXPOSE
- ENTRYPOINT
- CMD

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
ENV PIP_DISABLE_PIP_VERSION_CHECK=on
ENV PIP_DEFAULT_TIMEOUT=100

# poetry env vars
ENV POETRY_HOME="/opt/poetry"
ENV POETRY_VERSION=1.4.2
ENV POETRY_VIRTUALENVS_IN_PROJECT=true
ENV POETRY_NO_INTERACTION=1

# path
ENV VENV="/opt/venv"
ENV PATH="$POETRY_HOME/bin:$VENV/bin:$PATH"

# working directory (creates dir if it doesn't exist)
RUN mkdir -p /app
WORKDIR /app

# copy all files from current dir to working dir
COPY . .

# install poetry and dependencies
RUN python -m venv $VENV && . "${VENV}/bin/activate"
RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

FROM

The FROM instruction initializes a new build stage and sets the Base Image for subsequent instructions.
As such, a valid Dockerfile must start with a FROM instruction.

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
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RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

ARG

The ARG instruction defines a variable that users can pass at build-time to the builder...
A `Dockerfile` may include one or more ARG instructions.

```
FROM python:3.11-slim-bullseye

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RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

ENV

The ENV instruction sets the environment variable <key> to the value <value>. This value will be in the environment for all subsequent instructions in the build stage and can be replaced inline in many as well.

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# path
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# copy all files from current dir to working dir
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RUN python -m venv $VENV && . "${VENV}/bin/activate"
RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

RUN

The RUN instruction will execute any commands in a new layer on top of the current image and commit the results.

The resulting committed image will be used for the next step in the `Dockerfile`.

```
FROM python:3.11-slim-bullseye

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RUN rm -rf /var/lib/apt/lists/*

# pip env vars
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ENV POETRY_VIRTUALENVS_IN_PROJECT=true
ENV POETRY_NO_INTERACTION=1

# path
ENV VENV="/opt/venv"
ENV PATH="$POETRY_HOME/bin:$VENV/bin:$PATH"

# working directory (creates dir if it doesn't exist)
RUN mkdir -p /app
WORKDIR /app

# copy all files from current dir to working dir
COPY . .

# install poetry and dependencies
RUN python -m venv $VENV && . "${VENV}/bin/activate"
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RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

WORKDIR

The `WORKDIR` instruction sets the working directory for any `RUN`, `CMD`, `ENTRYPOINT`, `COPY` and `ADD` instructions that follow it in the `Dockerfile`.

```
FROM python:3.11-slim-bullseye

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# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
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ENV POETRY_NO_INTERACTION=1

# path
ENV VENV="/opt/venv"
ENV PATH="$POETRY_HOME/bin:$VENV/bin:$PATH"

# working directory (creates dir if it doesn't exist)
RUN mkdir -p /app
WORKDIR /app

# copy all files from current dir to working dir
COPY . .

# install poetry and dependencies
RUN python -m venv $VENV && . "${VENV}/bin/activate"
RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

COPY

The COPY instruction copies new files or directories from <src> and adds them to the filesystem of the container at the path <dest>.

```
COPY [--chown=<user>:<group>] [--chmod=<perms>] ["<src>",... "<dest>"]
```

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
ENV PIP_DISABLE_PIP_VERSION_CHECK=on
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# poetry env vars
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# path
ENV VENV="/opt/venv"
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# working directory (creates dir if it doesn't exist)
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RUN python -m venv $VENV && . "${VENV}/bin/activate"
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RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

EXPOSE

The EXPOSE instruction informs Docker that the container listens on the specified network ports at runtime... [T]he default is TCP if the protocol is not specified. The EXPOSE instruction does not actually publish the port. It [documents] which ports are intended to be published.

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
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RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

ENTRYPOINT

ENTRYPOINT has two forms:
The exec form, which is the preferred form:
ENTRYPOINT ["executable", "param1", "param2"]

The shell form:
ENTRYPOINT command param1 param2

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
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RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

CMD

The main purpose of a CMD is to provide defaults for an executing container.

There can only be one CMD instruction in a Dockerfile.

If you list more than one CMD then only the last CMD will take effect.

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
ENV PIP_DISABLE_PIP_VERSION_CHECK=on
ENV PIP_DEFAULT_TIMEOUT=100

# poetry env vars
ENV POETRY_HOME="/opt/poetry"
ENV POETRY_VERSION=1.4.2
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# path
ENV VENV="/opt/venv"
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RUN python -m venv $VENV && . "${VENV}/bin/activate"
RUN python -m pip install "poetry==${POETRY_VERSION}"
RUN poetry install --no-ansi --no-root --without dev

# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

CMD

The CMD instruction has three forms:
- CMD ["executable", "param1", "param2"]
  - exec form, this is the preferred form
- CMD ["param1", "param2"]
  - as default parameters to ENTRYPOINT
- CMD command param1 param2 (shell form)

Dockerfile

Common Directives

VOLUME

The VOLUME instruction creates a mount point with the specified name and marks it as holding externally mounted volumes from native host or other containers.

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
RUN rm -rf /var/lib/apt/lists/*

# pip env vars
ENV PIP_DISABLE_PIP_VERSION_CHECK=on
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# poetry env vars
ENV POETRY_HOME="/opt/poetry"
ENV POETRY_VERSION=1.4.2
ENV POETRY_VIRTUALENVS_IN_PROJECT=true
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# path
ENV VENV="/opt/venv"
ENV PATH="$POETRY_HOME/bin:$VENV/bin:$PATH"

# working directory (creates dir if it doesn't exist)
RUN mkdir -p /app
WORKDIR /app

# copy all files from current dir to working dir
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# install poetry and dependencies
RUN python -m venv $VENV && . "${VENV}/bin/activate"
RUN python -m pip install "poetry==${POETRY_VERSION}"
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# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

VOLUME

Wait.

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
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# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

VOLUME

Where **is** VOLUME??

```
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# listening port (not published)
EXPOSE 3000

ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

VOLUME

You **could** do this:

```
FROM ubuntu
RUN mkdir /myvol
RUN echo "hello world" > /myvol/greeting
VOLUME /myvol
```

```
FROM python:3.11-slim-bullseye

# avoid stuck build due to user prompt
ARG DEBIAN_FRONTEND=noninteractive

# install dependencies
RUN apt -qq update && apt -qq install curl gcc lsof python3-dev
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ENTRYPOINT ["python", "main.py"]
# CMD ["default", "arg"]
```

Dockerfile

Common Directives

VOLUME

But then...

The host directory is declared at container run-time: The host directory (the mountpoint) is, by its nature, host-dependent.

This is to preserve image portability, since a given host directory can't be guaranteed to be available on all hosts.

For this reason, you can't mount a host directory from within the `Dockerfile`. The `VOLUME` instruction does not support specifying a `host-dir` parameter.

You must specify the mountpoint when you create or run the container.

Dockerfile

Common Directives

Ergo, declaring a `VOLUME` in a `Dockerfile` is **useless***.

* Except as documentation (cf. `EXPOSE`)

Docker Commands

```
# show running containers
docker ps

# show images
docker images

# build docker image and tag
docker build -t helloworld .

# run image with interactive tty and remove container after
docker run -it --rm helloworld

# run image with volume mount and map port
docker run -it --rm -v $(pwd):/app -p 3000:3000 helloworld

# run image in background (detached) with shortened name 'hello'
docker run -it -d -name hello helloworld
```

Docker Commands

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# build docker image and tag
docker build -t helloworld .

# run image with interactive tty and remove container after
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Docker Commands

```
# show running containers
docker ps

# show images
docker images

# build docker image and tag
docker build -t helloworld .

# run image with interactive tty and remove container after
docker run -it --rm helloworld

# run image with volume mount and map port
docker run -it --rm -v $(pwd):/app -p 3000:3000 helloworld

# run image in background (detached) with shortened name 'hello'
docker run -it -d -name hello helloworld
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Demo Time

Dockerfile

Docker Compose (file)

Bird's Eye View

```yaml
version: "3.9"

services:
  helloworld:
    container_name: hello-world
    platform: linux/amd64         # linux/amd64 / linux/arm64/v8
    image: hello-world
    tty: false                    # false for `entrypoint` in Dockerfile
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    env_file:
      - ./.env
    environment:
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    volumes:
      - .:/app
    ports:
      - 3000:3000/tcp
    build:
      context: ./
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networks:
  default:
    driver: bridge                # bridge / host / none
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Docker Compose (file)

top-level keys

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Docker Compose (file)

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Docker Compose (commands)

```
# clean build (remove --no-cache for speed,
docker-compose build --no-cache --parallel

# start container
docker-compose up --remove-orphans -d

# exec into container
docker attach hello

# stop container
docker-compose stop

# destroy container and network
docker-compose down
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Demo Time

Docker Compose

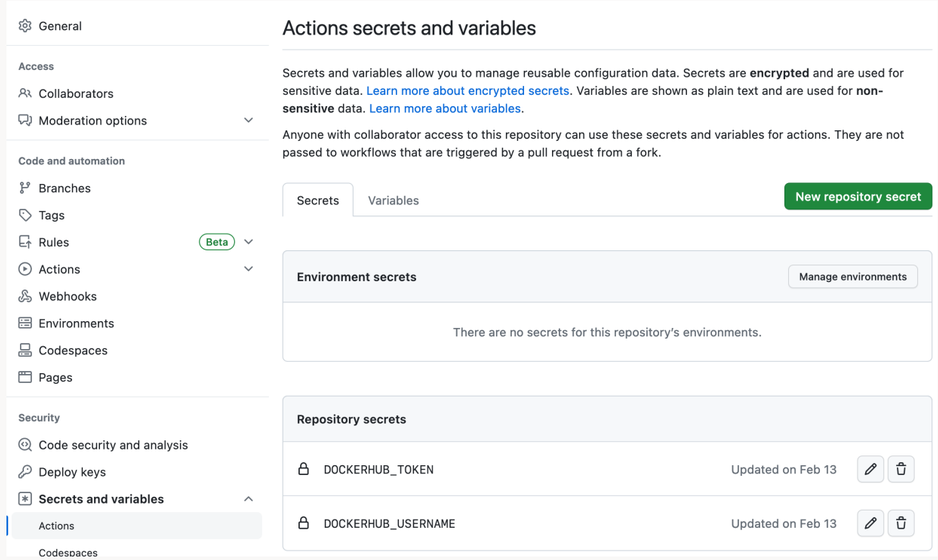
Push Docker Image to Docker Hub Manually

```
# login to docker hub
docker login

# tag image
docker tag hello:latest <dockerhub_username>/hello:latest

# push image
docker push <dockerhub_username>/hello:latest
```

Push Docker Image to Docker Hub Automatically with GitHub Actions (CI)

Setup Actions secrets and variables

* DOCKERHUB_USERNAME
* DOCKERHUB_TOKEN



Push Docker Image to Docker Hub Automatically with GitHub Actions (CI)

```yaml
name: ci

on:
  schedule:
    - cron: "0 10 * * *"
  push:
    branches:
      - "**"
    tags:
      - "v*.*.*"
  pull_request:
    branches:
      - "main"

env:
  docker_user: ${{ secrets.DOCKERHUB_USERNAME }}
  app_name: ${{ vars.APP_NAME }}

jobs:
  docker:
    strategy:
      fail-fast: true
    runs-on: ubuntu-latest
    steps:
      - name: Checkout
        uses: actions/checkout@v3
      - name: Docker meta
        id: meta
        uses: docker/metadata-action@v4
        with:
          images: |
            ${{ env.docker_user }}/${{ env.app_name }}
          tags: |
            type=schedule
            type=ref,event=branch
            type=ref,event=pr
            type=semver,pattern={{version}}
            type=semver,pattern={{major}}.{{minor}}
            type=semver,pattern={{major}}
            type=sha
      - name: Set up QEMU
        uses: docker/setup-qemu-action@v2
      - name: Set up Docker Buildx
        uses: docker/setup-buildx-action@v2
      - name: Login to Docker Hub
        if: github.event_name != 'pull_request'
        uses: docker/login-action@v2
        with:
          username: ${{ secrets.DOCKERHUB_USERNAME }}
          password: ${{ secrets.DOCKERHUB_TOKEN }}
      - name: Build and push
        uses: docker/build-push-action@v4
        with:
          context: .
          push: ${{ github.event_name != 'pull_request' }}
          tags: ${{ steps.meta.outputs.tags }}
          labels: ${{ steps.meta.outputs.labels }}
```

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Thank You!

— Hartwig Staffing
— OKC Coffee & Code
— Techlahoma
— Gabe Cook @gabe565
— For salvaging the legendary `telnet` ASCII video and leveling it up

Repo (One Last Time)

https://github.com/pythoninthegrass/docker_101

Also...

May the 4th Be With You

```
docker run --rm -it ghcr.io/gabe565/ascii-movie play
```