Docker in Action and Architecture

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Intros

- I'm Jintao Zhang
- Linuxer/Vimer
- And more ...

Docker Overview

- Why Containers
- What is Docker
- The history of Docker
- First container

Docker in Action

- Images (pull/create/build/push)
- Layer
- Containers (run/inspect etc.)

Dockerfile in Action

- Dockerfile overview
- How to use Dockerfile
- Multi-stage build

Docker Architecture

Docker Internal

Docker Overview

Why Containers

- Many different stacks:
  - languages
  - framworks
  - libs
- Many different targets:
  - environments
  - dev, QA, staging, prod
  - Physical machine， cloud， hybrid

What is Docker

- Docker provides a way to run applications securely isolated in a container, packaged with all its dependencies and libraries.

The history of Docker

- 2008, LXC
- March 20, 2013, PyCon, dotCloud released the first version of Docker
- The same year, dotCloud changes name to Docker
- March, 2014, New default driver: libcontainer (Docker 0.9)
- June, 2014, Docker 1.0
- Mesos, Kubernetes etc
- Standardization around the OCI
- Docker CE 17.03 (after 1.13.1 at Feb, 2017))

First container

Hello World

In your shell, just run the command:

```
➜  ~ docker run hello-world

Hello from Docker!
This message shows that your installation appears to be working correctly.
...
```

Maybe you will see a few extra lines if your Docker install is brand new.

That was our first container

- We use the `hello-world` image.
- The container just say `Hello from Docker!`

A more useful container

Let's run a container

```
➜  ~ docker run --rm -i -t debian:9
root@51ca967672e8:/#
```

- This is a new container.
- It runs a bare `Debian` system version 9.
- `--rm` tells Docker that remove the container when it exits automatically.
- `-i` tells Docker keep stdin open and connect us to the container's stdin.
- `-t` tells Docker than we want a pseudo-TTY.

Do something in our container

Try to echo `Hello` and play fun with `toilet` command.

```
root@66fbe4fe71e1:/# echo Hello
Hello
root@66fbe4fe71e1:/# toilet
bash: toilet: command not found
```

Of course, we need to install it.

Package managemant in container

We need `toilet`, so let's install it:

```
root@66fbe4fe71e1:/# apt update && apt install -y toilet
Get:1 http://security.debian.org/debian-security stretch/updates InRelease [
...
```

One minute later, `toilet` is instaled.

Try to run toilet

The `toilet` takes a string as parameter. `-f` option to special font.

```
root@66fbe4fe71e1:/# toilet Docker -f mono9

▄▄▄▄                 █
█   ▀▄  ▄▄▄    ▄▄▄   █   ▄   ▄▄▄    ▄ ▄▄
█    █ █▀ ▀█  █▀  ▀  █ ▄▀   █▀  █   █▀  ▀
█    █ █   █  █      █▀█    █▀▀▀▀   █
█▄▄▄▀  ▀█▄█▀  ▀█▄▄▀  █  ▀▄  ▀█▄▄▀   █
```

It's OK.

Compare the container and host

- Enter `exit` or `^D` to exit our container.
- We can't find `toilet` command (if we never installed it on host).
- They have different, independent packages.

Where's our container

- It still exists on disk, but all compute resource have been freed up.
- The container is now in a `stopped` state.
- We can get back to the container.

Docker in Action

What is an Image?

- Image is files.
- These files form the root filesystem of our container.

Image contents

This is a `debian:9`'s image.

```
(Tao) ➜  debian tree
.
├── 0783bfd2d1fc35d2dd7c457d9c7195ef2512acabe6ffa78fd035cece65292b0e
│   ├── json
│   ├── layer.tar
│   └── VERSION
├── 3bbb526d26083e7a65a7a112ed72e1ec58e81384412f2d3fcdbbd87d49fd588d.json
├── manifest.json
└── repositories

1 directory, 6 files
```

The read-write layer

```
+----------------------------------+
| read-write layer for container   |
|                                  |
|                                  |
+----------------------------------+
+----------------------------------+
|read only layer for image         |
|+-------------------------------+ |
|| 6bbb34566773         0 B      | |
||                               | |
|+-------------------------------+ |
|                                  |
|+-------------------------------+ |
|| 3bbb526d2608         101 M    | |
||                               | |
|+-------------------------------+ |
+----------------------------------+
```

- Base on `debian:9` docker image.
- Image is read only filesystem.
- Images can share layers to optimize disk usage and more.
- `docker run` start a container from a given image.

Set of commands

Pull

```
(Tao) ➜  ~ docker pull debian:9
9: Pulling from library/debian
Digest: sha256:07fe888a6090482fc6e930c1282d1edf67998a39a09a0b339242fbfa2b602fff
Status: Image is up to date for debian:9
```

Run

```
(Tao) ➜  ~ docker run --rm -it --name debian debian:9
root@17bae8832e6f:/#
```

Build

```
(Tao) ➜  ~ docker commit debian local/debian:9
sha256:86fb2e51de2c8501c51d10f4839154464cba66afe69490da0723a0e0fecb2a35
```

Images namespaces

- Official images

  e.g. `debian`, `centos`

- User images

  e.g. `taobeier/vim`, `taobeier/docker`

- Self-hosted images

  e.g. `registry.corp.youdao.com/infraop/openjdk`

Dockerfile in Action

Building images interactively

- Create a container with `docker run` .
- Do somethings, and run `docker commit` to commit our changes.
- Using `docker tag` to set images namespaces and name.

Docker tracks filesystem changes

As explained before:

- An image is read-only.
- Every changes happen in a copy of the image.
- We can use `docker diff` to show difference between the image and its copy.
- For performance, Docker uses copy-on-write systems.

When we want to make other changes

- Create a new container base on the exist image.
- Do somethings and commit our changes.
- We don't know everything about it.

How can we improve this?

- Automated process.
- A `Dockerfile` is a text document that contains all the commands a user could call on the command line to assemble an image.

Dockerfile in Action

Dockerfile overview

- A `Dockerfile` is a text document.
- It contains somethings about how an image is constructed.
- We can use `docker build` command build an image from `Dockerfile`.

How to use it

A `Dockerfile` need to be a **empty directory**.

- Create a new directory.

```
(Tao) ➜  ~ mkdir new-image
```

- Create a `Dockerfile` inside this directory.

```
(Tao) ➜  ~ cd new-image
(Tao) ➜  new-image vim Dockerfile
```

The simplest usage

```
FROM debian:9

RUN apt update
RUN apt install -y toilet
```

- A `Dockerfile` **must start with a `FROM` instruction**.
- The `FROM` instruction specifies the *Base Image* from which you are building.
- The `RUN` instruction will execute any commands in a new layer on top of the current image and commit the results.

Build it

```
(Tao) ➜  new-image docker build -t local/toilet .
```

- `-t` indicates the tag to apply to the image.
- `.` indicates the build location of the build context.

What happens

```
(Tao) ➜  new-image docker build -t local/toilet .
Sending build context to Docker daemon  2.048kB
Step 1/3 : FROM debian:9
 ---> f2aae6ff5d89
Step 2/3 : RUN apt update
 ---> Running in 677466dc02b1
...
Removing intermediate container 677466dc02b1
 ---> 49f7109e9c21
Step 3/3 : RUN apt install -y toilet
 ---> Running in 3d9dc635fd20
Setting up toilet (0.3-1.1) ...
...
Removing intermediate container 3d9dc635fd20
 ---> d8d2a8171e93
Successfully built d8d2a8171e93
Successfully tagged local/toilet:latest
```

- More details: http://dwz.cn/7JzMttGN

The build cache system

If you run this build again, what happens?

```
(Tao) ➜  new-image docker build -t local/toilet .
Sending build context to Docker daemon  2.048kB
Step 1/3 : FROM debian:9
 ---> f2aae6ff5d89
Step 2/3 : RUN apt update
 ---> Using cache
 ---> 49f7109e9c21
Step 3/3 : RUN apt install -y toilet
 ---> Using cache
 ---> d8d2a8171e93
Successfully built d8d2a8171e93
Successfully tagged local/toilet:latest
```

History of image

```
(Tao) ➜  new-image docker history local/toilet:latest
IMAGE               CREATED             CREATED BY                                      SIZE
d8d2a8171e93        25 minutes ago      /bin/sh -c apt install -y toilet                4.36MB
49f7109e9c21        25 minutes ago      /bin/sh -c apt update                           16.2MB
f2aae6ff5d89        4 days ago          /bin/sh -c #(nop)  CMD ["bash"]                 0B
<missing>           4 days ago          /bin/sh -c #(nop) ADD file:58d5c21fcabcf1eec…   101MB
```

Two forms

- `RUN <command>` (*shell* form, the command is run in a shell, which by default is `/bin/sh -c` on Linux or `cmd /S /C` on Windows)
- `RUN ["executable", "param1", "param2"]` (exec form)

Parser directives

- escape

```
# escape=`

FROM microsoft/nanoserver
COPY testfile.txt c:\

RUN dir c:\
```

`CMD` and `ENTRYPOINT`

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)

There can only be one `CMD` instruction in a Dockerfile.

`ENTRYPOINT` has two forms:

- `ENTRYPOINT ["executable", "param1", "param2"]` (exec form, preferred)
- `ENTRYPOINT command param1 param2` (shell form)

The `ENTRYPOINT` same as `CMD`. Only the last one will take effect.

Multi-stage builds

Each stage is a separate image, and can copy files from previous stages. Each stage is numbered, starting at 0.

```
FROM debian AS builder
LABEL maintainer="Jintao Zhang <zhangjintao9020@gmail.com>"
...

RUN ./configure \
       --with-compiledby="Jintao Zhang <zhangjintao9020@gmail.com>" \
    && make \
    && make install

FROM debian

COPY --from=builder /usr/local/bin/ /usr/local/bin
...

ENTRYPOINT [ "executable" ]
CMD [ "--help" ]
```

Docker Architecture

Docker Engine

Docker Engine

- Client - docker(CLI)

Docker Engine

- Client - docker(CLI)
- REST API - Over UNIX sockets or a network interface

Docker Engine

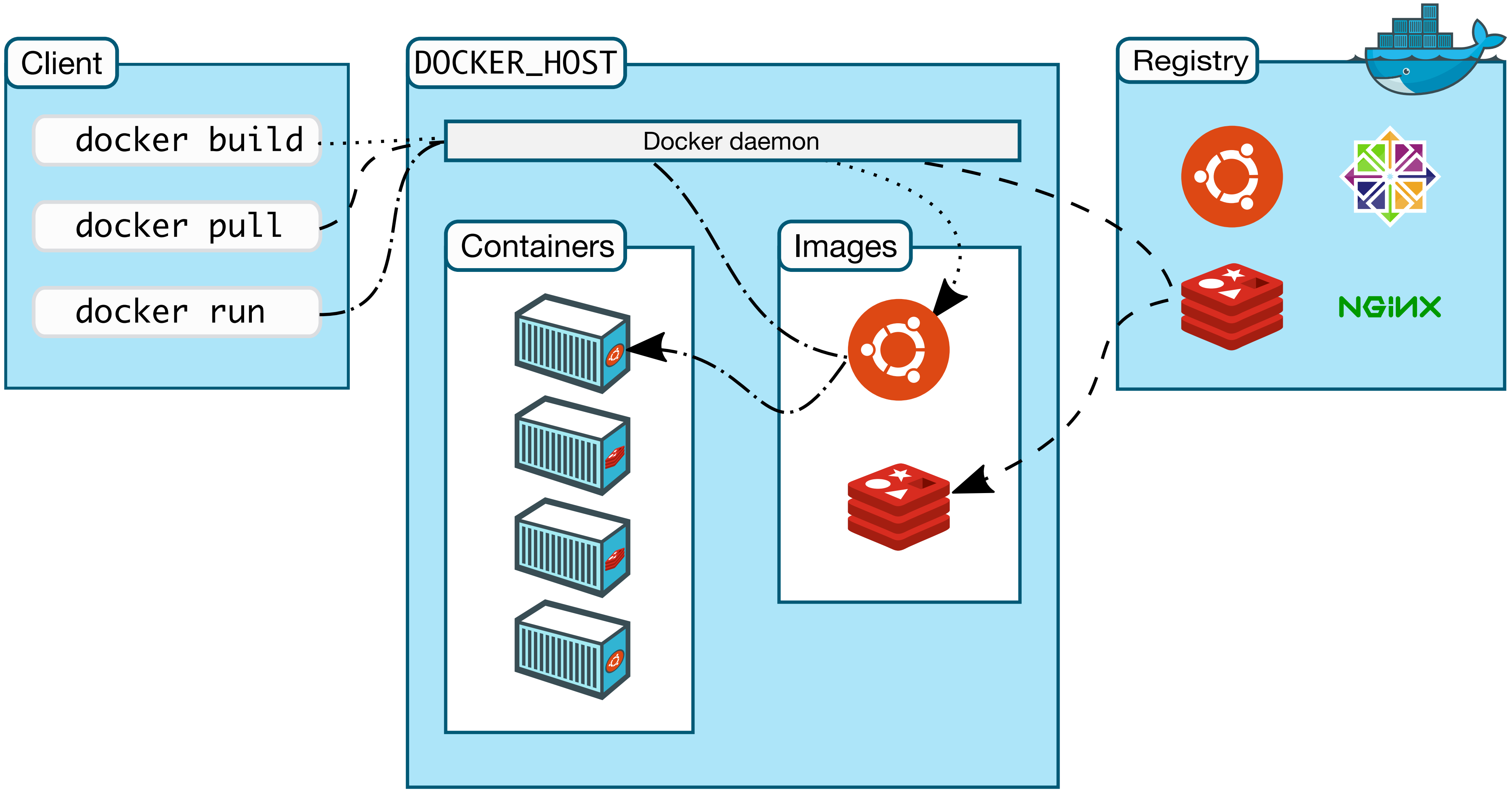
- Client - docker(CLI)
- REST API - Over UNIX sockets or a network interface
- Server - dockerd

docker version

```
(Tao) ➜  ~ docker version
Client:
 Version:      17.06.0-ce
 API version:  1.30
 Go version:   go1.8.3
 Git commit:   02c1d87
 Built:        Fri Jun 23 21:15:15 2017
 OS/Arch:      linux/amd64

Server:
 Version:      dev
 API version:  1.39 (minimum version 1.12)
 Go version:   go1.10.3
 Git commit:   e8cc5a0b3
 Built:        Tue Sep 11 02:09:53 2018
 OS/Arch:      linux/amd64
 Experimental: false
```

Docker Engine architecture



All tools

List all tools about docker.

```
(Tao) ➜  ~ ls /usr/bin |grep docker
docker  # docker cli
docker-containerd
docker-containerd-ctr  # containerd cli
docker-containerd-shim
dockerd
docker-init  # init injects
docker-proxy
docker-runc
```

Docker Engine internal

```
      +-------------------------+
      |      dockerd            |
      +-------------------------+
                 |
      +-------------------------+
      |      containerd         |
      +-------------------------+
          |                 |
+---------------+     +---------------+
|containerd-shim|     |containerd-shim|
+---------------+     +---------------+
        |                     |
+---------------+     +---------------+
|     runc      |     |     runc      |
+---------------+     +---------------+
```

Q&A