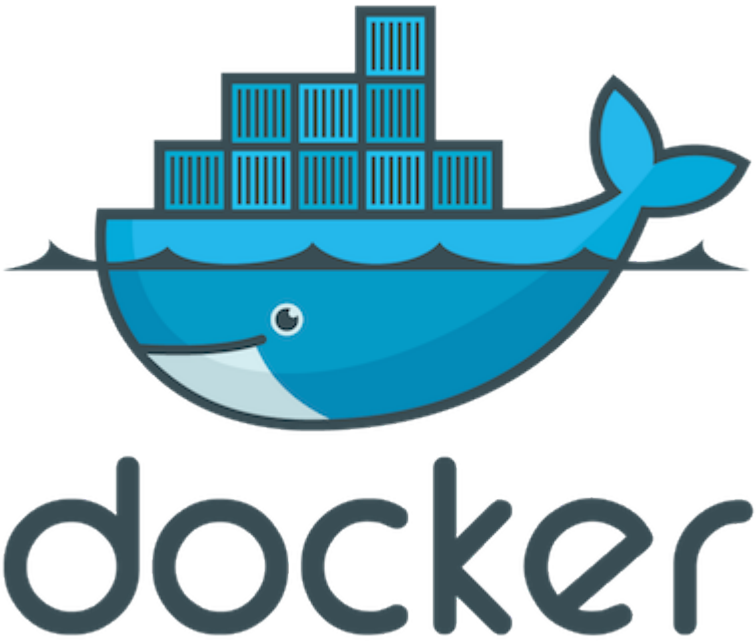
Introduction to Docker

Version: 2cb8348

See those slides at http://52.10.123.64/



An Open Platform to Build, Ship, and Run Distributed Applications

Other sessions on this topic, at SCALE...

Today:

- Containerization in Production: The Good, The Bad, The Ugly
- Building a Minimal Host for Docker Containers

Tomorrow:

- Using Docker, CoreOS, and git hooks to deploy applications
- NGINX 101 - now with more Docker
- Docker and Microservices

Sunday:

- Docker for Multi-Cloud Apps

Non exhaustive list!

Course Overview

You will:

- Learn what Docker is and what it is for.
- Learn the terminology, and define images, containers, etc.
- Learn how to install Docker.
- Use Docker to run containers.
- Use Docker to build containers.
- Learn how to orchestrate Docker containers.
- Interact with the Docker Hub website.
- Acquire tips and good practice.
- Know what's next: the future of Docker, and how to get help.

Course Agenda

Part 1

- About Docker
- Using the training virtual machines
- Installing Docker
- Our first containers
- Running containers in the background
- Images and containers
- Building images manually
- Building images automatically
- Basic networking
- Local development workflow

Course Agenda

Part 2

- Working with volumes
- Connecting containers
- Advanced Dockerfiles
- Orchestration
- Ambassadors
- The Docker Hub
- Automated builds
- Security
- The Docker API

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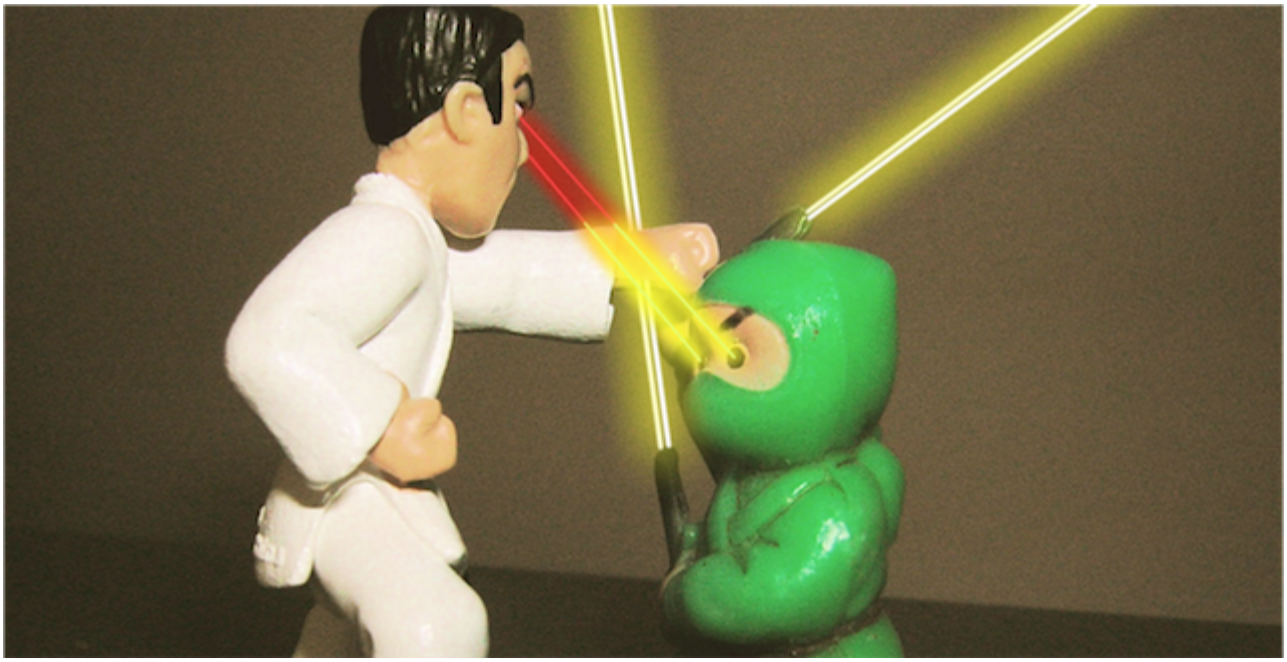
About Docker



Overview: About Docker

Objectives

In this lesson, we will learn about:

- Docker Inc. (the company)
- Docker (the Open Source project)
- Containers (how and why they are useful)

We won't actually run Docker or containers in this chapter (yet!), but don't worry, we will get to that fast enough!

About Docker Inc.

Focused on Docker and growing the Docker ecosystem:

- Founded in 2009.
- Formerly dotCloud Inc.
- Released Docker in 2013.

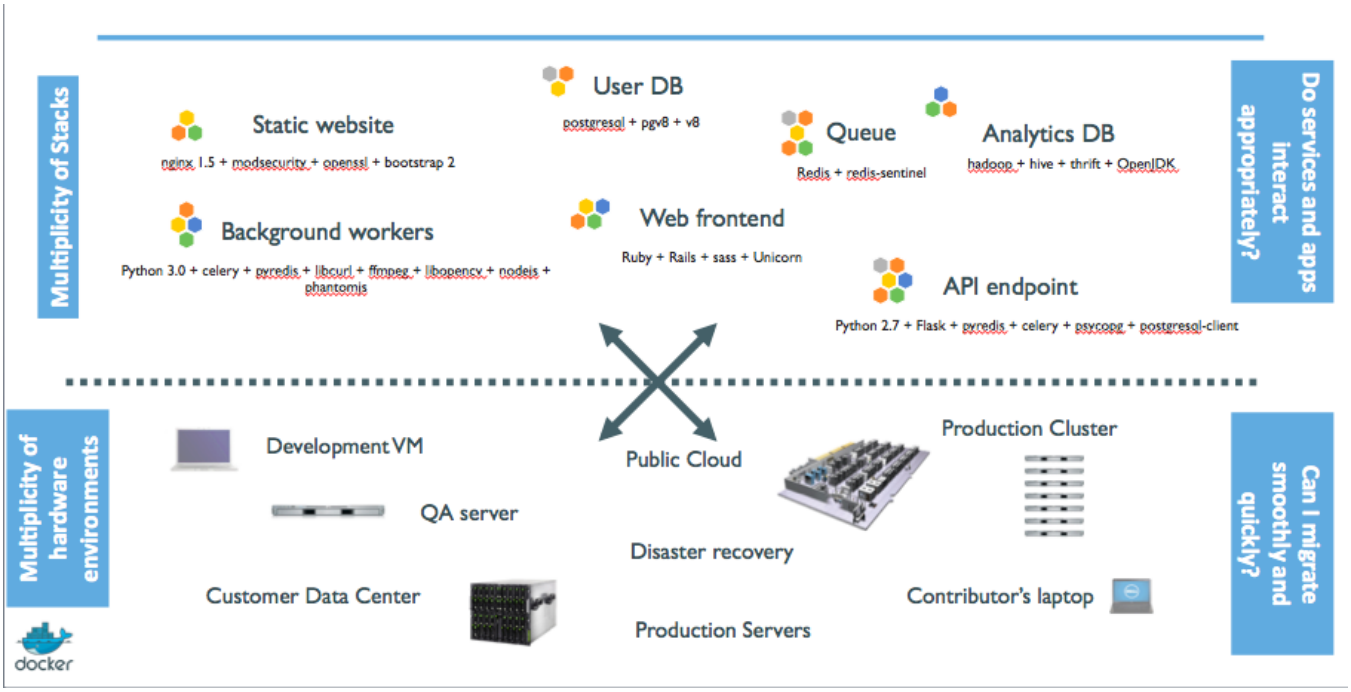
What does Docker Inc. do?

- Docker Engine - open source container management.
- Docker Hub - online home and hub for managing your Docker containers.
- Docker Enterprise Support - commercial support for Docker.
- Docker Services & Training - professional services and training to help you get the best out of Docker.

Why Docker?

- The software industry has changed.
- Applications used to be monolithic, with long lifecycles, scaled up.
- Today, applications are decoupled, built iteratively, scaled out.
- As a result, deployment is though!

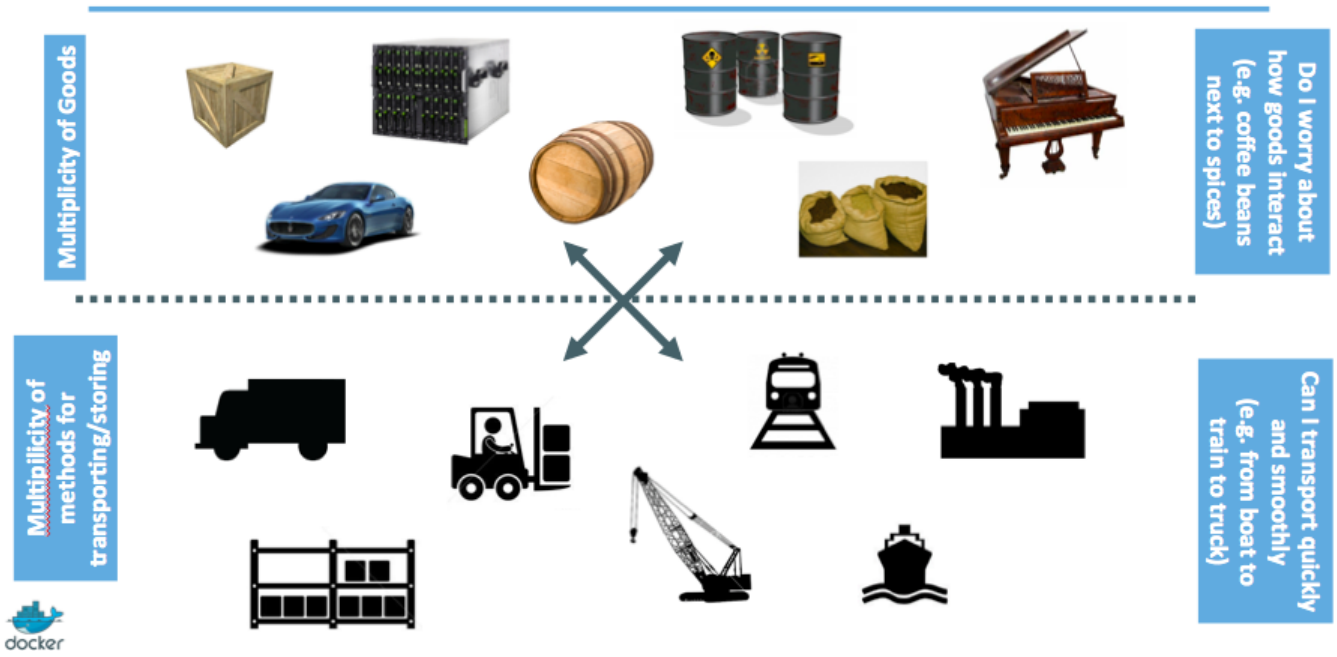
The problem in 2015



The Matrix from Hell

	Development VM	QA Server	Single Prod Server	Onsite Cluster	Public Cloud	Contributor's laptop	Customer Servers
Static website	?	?	?	?	?	?	?
Web frontend	?	?	?	?	?	?	?
Background workers	?	?	?	?	?	?	?
User DB	?	?	?	?	?	?	?
Analytics DB	?	?	?	?	?	?	?
Queue	?	?	?	?	?	?	?

An inspiration and some ancient history!



Intermodal shipping containers

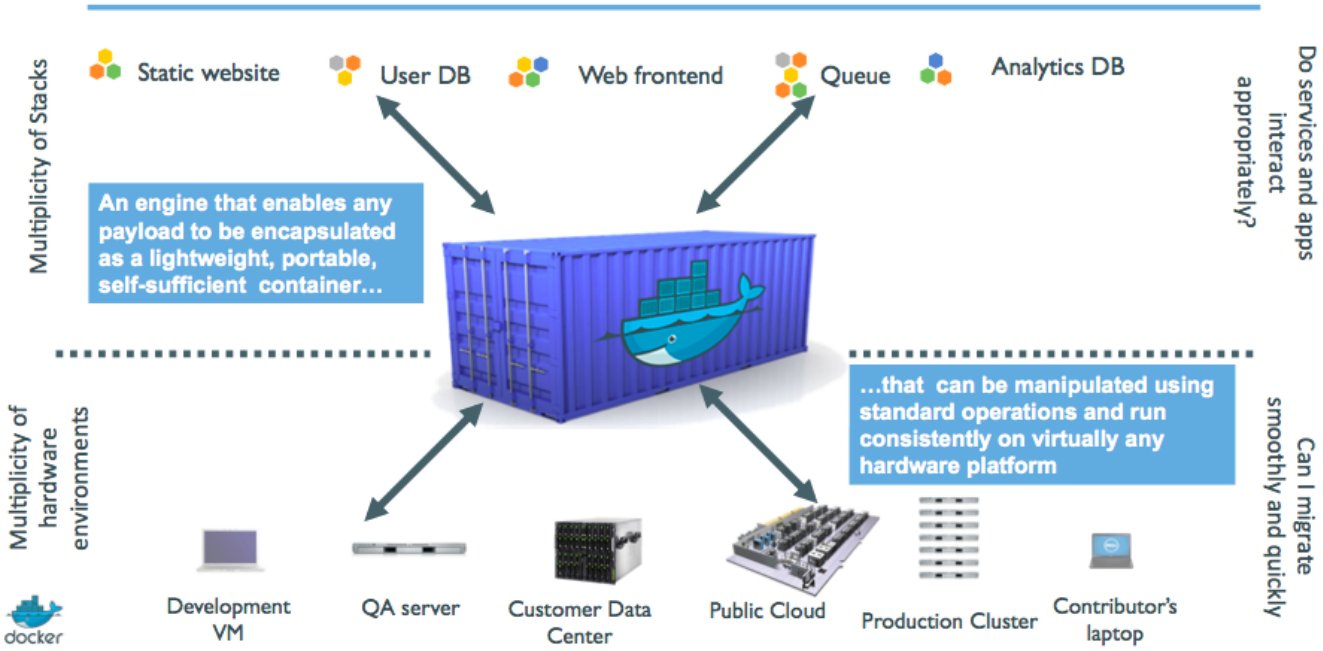
This spawned a Shipping Container Ecosystem!

- 90% of all cargo now shipped in a standard container
- Order of magnitude reduction in cost and time to load and unload ships
- Massive reduction in losses due to theft or damage
- Huge reduction in freight cost as percent of final goods (from >25% to <3%)

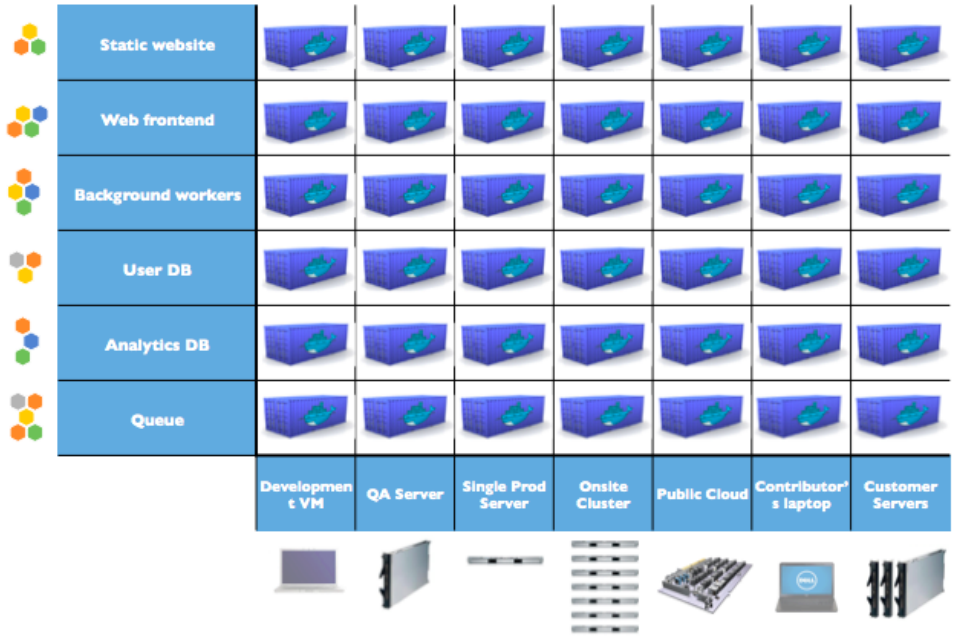
→ massive globalization

- 5000 ships deliver 200M containers per year

A shipping container system for applications



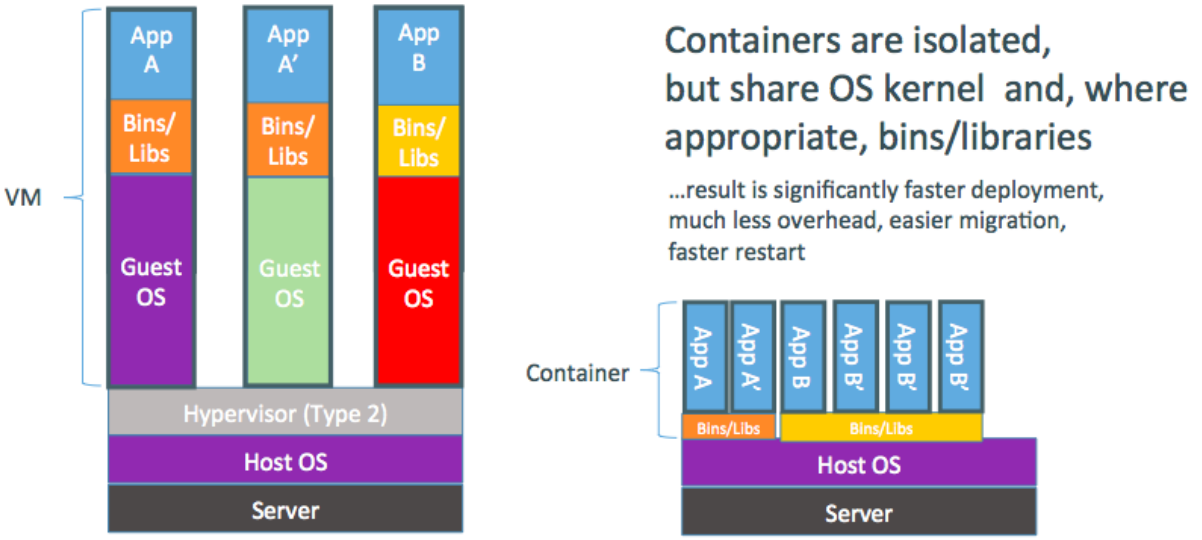
Eliminate the matrix from Hell



Docker high-level roadmap

- Step 1: containers as lightweight VMs
- Step 2: commoditization of containers
- Step 3: shipping containers efficiently
- Step 4: containers in a modern software factory

Step 1: containers as lightweight VMs



- This drew attention from hosting and PAAS industry.
- Highly technical audience with strong ops culture.

Step 2: commoditization of containers

Container technology has been around for a while.
(c.f. LXC, Solaris Zones, BSD Jails, LPAR...)

So what's new?

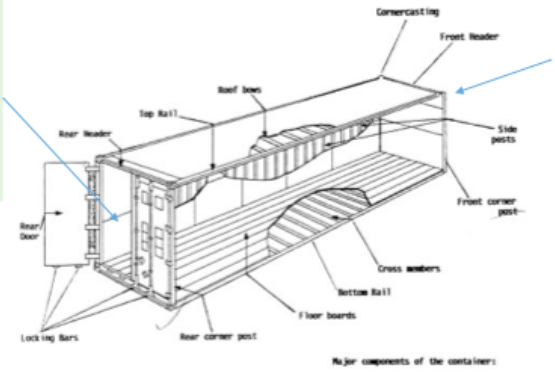
- Standardize the container format, because containers were not portable.
- Analogy:
  - shipping containers are not just steel boxes
  - they are steel boxes that are a standard size, with the same hooks and holes
- Make containers easy to use for developers.
- Emphasis on re-usable components, APIs, ecosystem of standard tools.
- Improvement over ad-hoc, in-house, specific tools.

Running containers everywhere

- Maturity of underlying technology (cgroups, namespaces, copy-on-write systems).
- Ability to run on any Linux server today: physical, virtual, VM, cloud, OpenStack...
- Ability to move between any of the above in a matter of seconds-no modification or delay.
- Ability to share containerized components.
- Self contained environment - no dependency hell.
- Tools for how containers work together: linking, discovery, orchestration...

Technical & cultural revolution: separation of concerns

- Dan the Developer
  - Worries about what's "inside" the container
    - His code
    - His Libraries
    - His Package Manager
    - His Apps
    - His Data
  - All Linux servers look the same

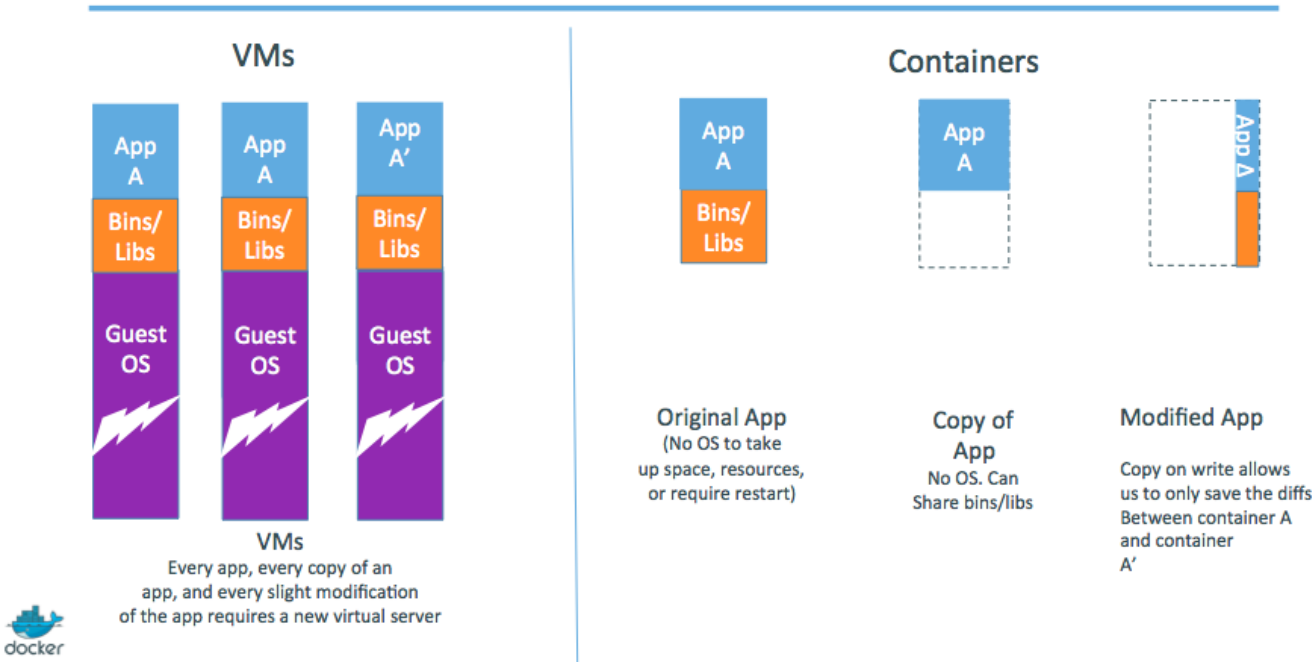


- Oscar the Ops Guy
  - Worries about what's "outside" the container
    - Logging
    - Remote access
    - Monitoring
    - Network config
  - All containers start, stop, copy, attach, migrate, etc. the same way

Step 3: shipping containers efficiently

Ship container images, made of reusable shared layers.

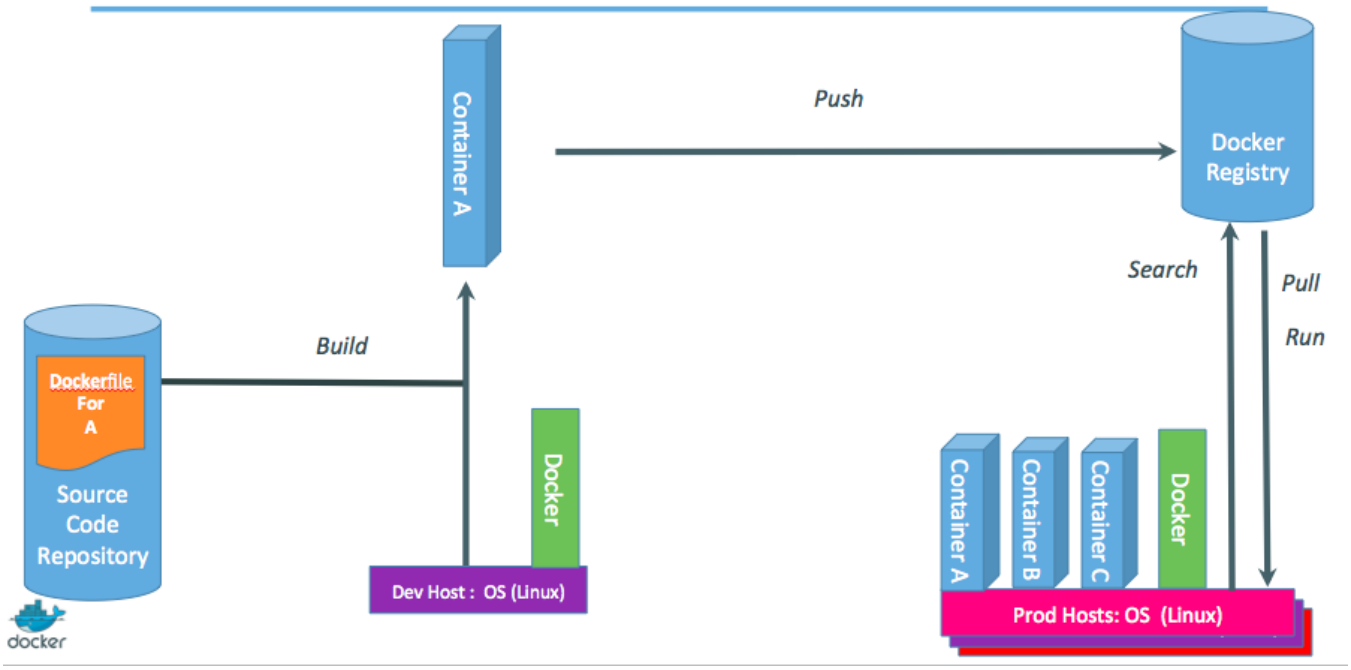
Optimizes disk usage, memory usage, network usage.



Step 4: containers in a modern software factory

The container becomes the new build artefact.

The same container can go from dev, to test, to QA, to prod.



Docker architecture

Docker is a client-server application.

- **The Docker daemon**
  Receives and processes incoming Docker API requests.

- **The Docker client**
  Command line tool - the `docker` binary.
  Talks to the Docker daemon via the Docker API.

- **Docker Hub Registry**
  Public image registry.
  The Docker daemon talks to it via the registry API.

Your training Virtual Machine

Lesson 2: Your training Virtual Machine

If you are following this course as part of an official Docker training or workshop, you have been given credentials to connect to your own private Docker VM.

If you are following this course on your own, without access to an official training Virtual Machine, just skip this lesson, and check "Installing Docker" instead.

Your training Virtual Machine

If you are following this course as part of an official Docker training or workshop, you have been given credentials to connect to your own private Docker VM.

This VM has been created specifically for you, just before the training.

It comes pre-installed with the latest and shiniest version of Docker, as well as some useful tools.

It will stay up and running for the whole training, but it will be destroyed shortly after the training.

Connecting to your Virtual Machine

You need an SSH client.

- On OS X, Linux, and other UNIX systems, just use `ssh`:

```
$ ssh <login>@<ip-address>
```

- On Windows, if you don't have an SSH client, you can download Putty from www.putty.org.

Checking your Virtual Machine

Once logged in, make sure that you can run a basic Docker command:

```
$ docker version
Client version: 1.4.1
Client API version: 1.16
Go version (client): go1.3.3
Git commit (client): 5bc2ff8
OS/Arch (client): linux/amd64
Server version: 1.4.1
Server API version: 1.16
Go version (server): go1.3.3
Git commit (server): 5bc2ff8
```

- If this doesn't work, raise your hand so that an instructor can assist you!

Install Docker

Lesson 3: Installing Docker

Objectives

At the end of this lesson, you will be able to:

- Install Docker.
- Run Docker without `sudo`.

Note: if you were provided with a training VM for a hands-on tutorial, you can skip this chapter, since that VM already has Docker installed, and Docker has already been setup to run without `sudo`.

Installing Docker

Docker is easy to install.

It runs on:

- A variety of Linux distributions.
- OS X via a virtual machine.
- Microsoft Windows via a virtual machine.

Installing Docker on Linux

It can be installed via:

- Distribution-supplied packages on virtually all distros.
  (Includes at least: Arch Linux, CentOS, Debian, Fedora, Gentoo, openSUSE, RHEL, Ubuntu.)
- Packages supplied by Docker.
- Installation script from Docker.
- Binary download from Docker (it's a single file).

Installing Docker on your Linux distribution

On Fedora:

```
$ sudo yum install docker-io
```

On CentOS 7:

```
$ sudo yum install docker
```

On Debian and derivatives:

```
$ sudo apt-get install docker.io
```


Installation script from Docker

You can use the `curl` command to install on several platforms:

```
$ curl -s https://get.docker.com/ | sudo sh
```

This currently works on:

- Ubuntu
- Debian
- Fedora
- Gentoo

Installing on OS X and Microsoft Windows

Docker doesn't run natively on OS X or Microsoft Windows.

To install Docker on these platforms we run a small virtual machine using a tool called Boot2Docker.

Check that Docker is working

Using the `docker` client:

```
$ docker version
Client version: 1.5.0
Client API version: 1.17
Go version (client): go1.4.1
Git commit (client): a8a31ef
OS/Arch (client): linux/amd64
Server version: 1.5.0
Server API version: 1.17
Go version (server): go1.4.1
Git commit (server): a8a31ef
```


Su-su-sudo

The `docker` group

Warning!

The `docker` user is `root` equivalent.

It provides `root`-level access to the host.

You should restrict access to it like you would protect `root`.

Add the Docker group

```
$ sudo groupadd docker
```

Add ourselves to the group

```
$ sudo gpasswd -a $USER docker
```

Restart the Docker daemon

```
$ sudo service docker restart
```

Log out

```
$ exit
```


Check that Docker works without sudo

```
$ docker version
Client version: 1.5.0
Client API version: 1.17
Go version (client): go1.4.1
Git commit (client): a8a31ef
OS/Arch (client): linux/amd64
Server version: 1.5.0
Server API version: 1.17
Go version (server): go1.4.1
Git commit (server): a8a31ef
```


Section summary

We've learned how to:

- Install Docker.
- Run Docker without `sudo`.

Our First Containers

Overview: Our First Containers

Objectives

At the end of this lesson, you will have:

- Seen Docker in action.
- Started your first containers.

Hello World

In your Docker environment, just run the following command:

```
$ docker run busybox echo hello world
hello world
```


That was our first container!

- We used one of the smallest, simplest images available: `busybox`.
- `busybox` is typically used in embedded systems (phones, routers...)
- We ran a single process and echo'ed `hello world`.

A more useful container

Let's run a more exciting container:

```
$ docker run -it ubuntu bash
root@04c0bb0a6c07:/#
```

- This is a brand new container.
- It runs a bare-bones, no-frills `ubuntu` system.

Do something in our container

Try to run `curl` in our container.

```
root@04c0bb0a6c07:/# curl ifconfig.me/ip
bash: curl: command not found
```

Told you it was bare-bones!

Let's check how many packages are installed here.

```
root@04c0bb0a6c07:/# dpkg -l | wc -l
189
```

- `dpkg -l` lists the packages installed in our container
- `wc -l` counts them
- If you have a Debian or Ubuntu machine, you can run the same command and compare the results.

Install a package in our container

We want `curl`, so let's install it:

```
root@04c0bb0a6c07:/# apt-get update
...
Fetched 1514 kB in 14s (103 kB/s)
Reading package lists... Done
root@04c0bb0a6c07:/# apt-get install curl
Reading package lists... Done
...
Do you want to continue? [Y/n]
```

Answer Y or just press `Enter`.

One minute later, `curl` is installed!

```
# curl ifconfig.me/ip
64.134.229.24
```


Exiting our container

Just exit the shell, like you would usually do.

(E.g. with `^D` or `exit`)

```
root@04c0bb0a6c07:/# exit
```

- Our container is now in a *stopped* state.
- It still exists on disk, but all compute resources have been freed up.

Starting another container

What if we start a new container, and try to run `curl` again?

```
$ docker run -it ubuntu bash
root@b13c164401fb:/# curl
bash: curl: command not found
```

- We started a *brand new container*.
- The basic Ubuntu image was used, and `curl` is not here.
- We will see in the next chapters how to bake a custom image with `curl`.

Background Containers

Background Containers

Our first containers were *interactive*.

We will now see how to:

- Run a non-interactive container.
- Run a container in the background.
- List running containers.
- Check the logs of a container.
- Stop a container.
- List stopped containers.

A non-interactive container

We will run a small custom container.

This container just displays the time every second.

```
$ docker run jpetazzo/clock
Fri Feb 20 00:28:53 UTC 2015
Fri Feb 20 00:28:54 UTC 2015
Fri Feb 20 00:28:55 UTC 2015
...
```

- This container will run forever.
- To stop it, press ^C.
- Docker has automatically downloaded the image `jpetazzo/clock`.
- This image is a user image, created by `jpetazzo`.
- We will tell more about user images (and other types of images) later.

Run a container in the background

Containers can be started in the background, with the `-d` flag (daemon mode):

```
$ docker run -d jpetazzo/clock
47d677dcfba4277c6cc68fcaa51f932b544cab1a187c853b7d0caf4e8debe5ad
```

- We don't see the output of the container.
- But don't worry: Docker collects that output and logs it!
- Docker gives us the ID of the container.

List running containers

How can we check that our container is still running?

With `docker ps`, just like the UNIX `ps` command, lists running processes.

```
$ docker ps
CONTAINER ID  IMAGE                 COMMAND  CREATED        STATUS        ...
47d677dcfba4  jpetazzo/clock:latest  ...      2 minutes ago  Up 2 minutes  ...
```

Docker tells us:

- The (truncated) ID of our container.
- The image used to start the container.
- That our container has been running (Up) for a couple of minutes.
- Other information (COMMAND, PORTS, NAMES) that we will explain later.

Two useful flags for `docker ps`

To see only the last container that was started:

```
$ docker ps -l
CONTAINER ID  IMAGE                 COMMAND  CREATED        STATUS        ...
47d677dcfba4  jpetazzo/clock:latest  ...      2 minutes ago  Up 2 minutes  ...
```

To see only the ID of containers:

```
$ docker ps -q
47d677dcfba4
66b1ce719198
ee0255a5572e
```

Combine those flags to see only the ID of the last container started!

```
$ docker ps -q
47d677dcfba4
```


View the logs of a container

We told you that Docker was logging the container output.

Let's see that now.

```
$ docker logs 47d6
Fri Feb 20 00:39:52 UTC 2015
Fri Feb 20 00:39:53 UTC 2015
...
```

- We specified a *prefix* of the full container ID.
- You can, of course, specify the full ID.
- The `logs` command will output the *entire* logs of the container.
  (Sometimes, that will be too much. Let's see how to address that.)

View only the tail of the logs

To avoid being spammed with eleventy pages of output, we can use the `--tail` option:

```
$ docker logs --tail 3 47d6
Fri Feb 20 00:55:35 UTC 2015
Fri Feb 20 00:55:36 UTC 2015
Fri Feb 20 00:55:37 UTC 2015
```

- The parameter is the number of lines that we want to see.

Follow the logs in real time

Just like with the standard UNIX command `tail -f`, we can follow the logs of our container:

```
$ docker logs --tail 1 --follow 47d6
Fri Feb 20 00:57:12 UTC 2015
Fri Feb 20 00:57:13 UTC 2015
^C
```

- This will display the last line in the log file.
- Then, it will continue to display the logs in real time.
- Use ^C to exit.

Stop our container

There are two ways we can terminate our detached container.

- Killing it using the `docker kill` command.
- Stopping it using the `docker stop` command.

The first one stops the container immediately, by using the KILL signal.

The second one is more graceful. It sends a TERM signal, and after 10 seconds, if the container has not stopped, it sends KILL.

Reminder: the KILL signal cannot be intercepted, and will forcibly terminate the container.

Killing it

Let's kill our container:

```
$ docker kill 47d6
47d6
```

Docker will echo the ID of the container we've just stopped.

Let's check that our container doesn't show up anymore:

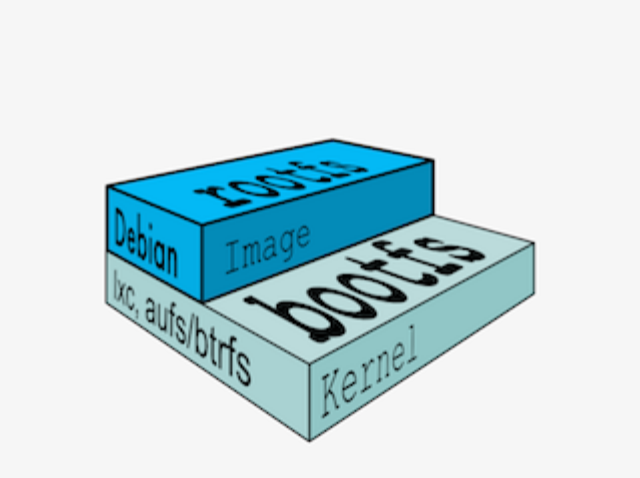
```
$ docker ps
```


List stopped containers

We can also see stopped containers, with the `-a` (`--all`) option.

```
$ docker ps -a
CONTAINER ID  IMAGE                  ...  CREATED      STATUS
47d677dcfba4  jpetazzo/clock:latest  ...  23 min. ago  Exited (0) 4 min. ago
5c1dfd4d81f1  jpetazzo/clock:latest  ...  40 min. ago  Exited (0) 40 min. ago
b13c164401fb  ubuntu:latest          ...  55 min. ago  Exited (130) 53 min. ago
```


Understanding Docker Images



Lesson 6: Understanding Docker Images

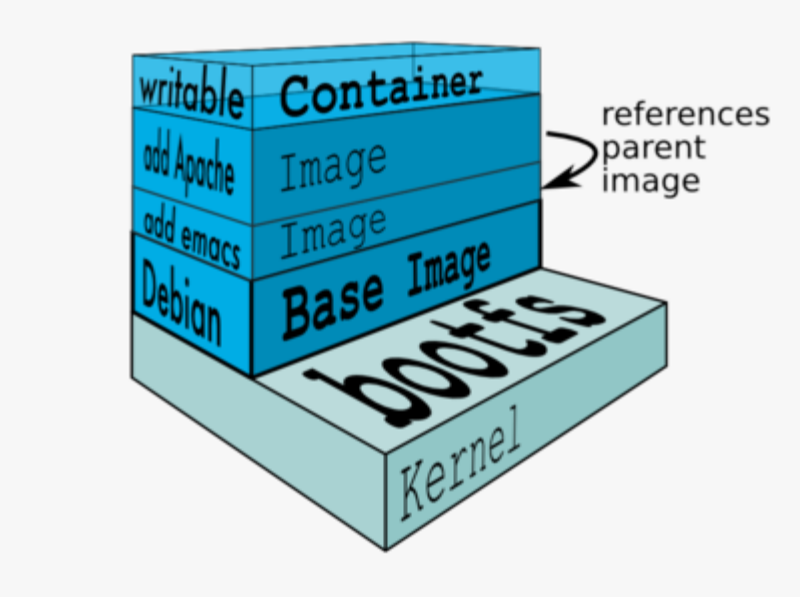
Objectives

In this lesson, we will explain:

- What is an image.
- What is a layer.
- The various image namespaces.
- How to search and download images.

What is an image?

- An image is a collection of files + some meta data.
  (Technically: those files form the root filesystem of a container.)
- Images are made of *layers*, conceptually stacked on top of each other.
- Each layer can add, change, and remove files.
- Images can share layers to optimize disk usage, transfer times, and memory use.



Differences between containers and images

- An image is a read-only filesystem.
- A container is an encapsulated set of processes running in a read-write copy of that filesystem.
- To optimize container boot time, *copy-on-write* is used instead of regular copy.
- `docker run` starts a container from a given image.

Let's give a couple of metaphors to illustrate those concepts.

Image as stencils

Images are like templates or stencils that you can create containers from.

Object-oriented programming

- Images are conceptually similar to *classes*.
- Layers are conceptually similar to *inheritance*.
- Containers are conceptually similar to *instances*.

Wait a minute...

If an image is read-only, how do we change it?

- We don't.
- We create a new container from that image.
- Then we make changes to that container.
- When we are satisfied with those changes, we transform them into a new layer.
- A new image is created by stacking the new layer on top of the old image.

In practice

There are multiple ways to create new images.

- `docker commit`: creates a new layer (and a new image) from a container.
- `docker build`: performs a repeatable build sequence.
- `docker import`: loads a tarball into Docker, as a standalone base layer.

We will explain `commit` and `build` in later chapters.

`import` can be used for various hacks, but its main purpose is to bootstrap the creation of base images.

Images namespaces

There are three namespaces:

- Root-like

```
ubuntu
```

- User (and organizations)

```
jpetazzo/clock
```

- Self-Hosted

```
registry.example.com:5000/my-private-image
```

Let's explain each of them.

Root namespace

The root namespace is for official images. They are put there by Docker Inc., but they are generally authored and maintained by third parties.

Those images include:

- Small, "swiss-army-knife" images like busybox.
- Distro images to be used as bases for your builds, like ubuntu, fedora...
- Ready-to-use components and services, like redis, postgresql...

User namespace

The user namespace holds images for Docker Hub users and organizations.

For example:

```
jpetazzo/clock
```

The Docker Hub user is:

```
jpetazzo
```

The image name is:

```
clock
```


Self-Hosted namespace

This namespace holds images which are not hosted on Docker Hub, but on third party registries.

They contain the hostname (or IP address), and optionally the port, of the registry server.

For example:

```
localhost:5000/wordpress
```

The remote host and port is:

```
localhost:5000
```

The image name is:

```
wordpress
```


Historical detail

Self-hosted registries used to be called *private* registries, but this was misleading!

- A self-hosted registry can be public or private.
- A registry in the User namespace on Docker Hub can be public or private.

How do you store and manage images?

Images can be stored:

- On your Docker host.
- In a Docker registry.

You can use the Docker client to download (pull) or upload (push) images.

To be more accurate: you can use the Docker client to tell a Docker server to push and pull images to and from a registry.

Showing current images

Let's look at what images are on our host now.

```
$ docker images
REPOSITORY          TAG     IMAGE ID     CREATED     VIRTUAL SIZE
ubuntu              13.10   9f676bd305a4 7 weeks ago 178 MB
ubuntu              saucy   9f676bd305a4 7 weeks ago 178 MB
ubuntu              raring  eb601b8965b8 7 weeks ago 166.5 MB
ubuntu              13.04   eb601b8965b8 7 weeks ago 166.5 MB
ubuntu              12.10   5ac751e8d623 7 weeks ago 161 MB
ubuntu              quantal 5ac751e8d623 7 weeks ago 161 MB
ubuntu              10.04   9cc9ea5ea540 7 weeks ago 180.8 MB
ubuntu              lucid   9cc9ea5ea540 7 weeks ago 180.8 MB
ubuntu              12.04   9cd978db300e 7 weeks ago 204.4 MB
ubuntu              latest  9cd978db300e 7 weeks ago 204.4 MB
ubuntu              precise 9cd978db300e 7 weeks ago 204.4 MB
```


Searching for images

Searches your registry for images:

```
$ docker search zookeeper
NAME                            DESCRIPTION                     STARS  ...
jplock/zookeeper                Builds a docker image for ...   27
thefactory/zookeeper-exhibitor  Exhibitor-managed ZooKeepe...   2
misakai/zookeeper               ZooKeeper is a service for...   1
digitalwonderland/zookeeper     Latest Zookeeper - cluster...   1
garland/zookeeper                                               1
raycoding/piggybank-zookeeper   Zookeeper 3.4.6 running on...   1
gregory90/zookeeper                                             0
```

- ''Stars'' indicate the popularity of the image.
- ''Official'' images are those in the root namespace.
- ''Automated'' images are built automatically by the Docker Hub. (This means that their build recipe is always available.)

Downloading images

There are two ways to download images.

- Explicitly, with `docker pull`.
- Implicitly, when executing `docker run` and the image is not found locally.

Pulling an image

```
$ docker pull debian:jessie
Pulling repository debian
b164861940b8: Download complete
b164861940b8: Pulling image (jessie) from debian
d1881793a057: Download complete
```

- As seen previously, images are made up of layers.
- Docker has downloaded all the necessary layers.
- In this example, `:jessie` indicates which exact version of Debian we would like. It is a *version tag*.

Image and tags

- Images can have tags.
- Tags define image variants.
- `docker pull ubuntu` will refer to `ubuntu:latest`.
- The `:latest` tag can be updated frequently.
- When using images it is always best to be specific.

Section summary

We've learned how to:

- Understand images and layers.
- Understand Docker image namespacing.
- Search and download images.

Building Images Interactively

Lesson 7: Building Images Interactively

In this lesson, we will create our first container image.

We will install software manually in a container, and turn it into a new image.

We will introduce commands `docker commit`, `docker tag`, and `docker diff`.

Building Images Interactively

As we have seen, the images on the Docker Hub are sometimes very basic.

How do we want to construct our own images?

As an example, we will build an image that has `wget`.

First, we will do it manually with `docker commit`.

Then, in an upcoming chapter, we will use a `Dockerfile` and `docker build`.

Building from a base

Our base will be the `ubuntu` image.

If you prefer `debian`, `centos`, or `fedora`, feel free to use them instead.

(You will have to adapt `apt` to `yum`, of course.)

Create a new container and make some changes

Start an Ubuntu container:

```
$ docker run -it ubuntu bash
root@<yourContainerId>:#/
```

Run the command `apt-get update` to refresh the list of packages available to install.

Then run the command `apt-get install -y wget` to install the program we are interested in.

```
root@<yourContainerId>:#/ apt-get update && apt-get install -y wget
.... OUTPUT OF APT-GET COMMANDS ....
```


Inspect the changes

Type `exit` at the container prompt to leave the interactive session.

Now let's run `docker diff` to see the difference between the base image and our container.

```
$ docker diff <yourContainerId>
C /root
A /root/.bash_history
C /tmp
C /usr
C /usr/bin
A /usr/bin/wget
...
```


Docker tracks filesystem changes

As explained before:

- An image is read-only.
- When we make changes, they happen in a copy of the image.
- Docker can show the difference between the image, and its copy.
- For performance, Docker uses copy-on-write systems.
  (i.e. starting a container based on a big image doesn't incur a huge copy.)

Commit and run your image

The `docker commit` command will create a new layer with those changes, and a new image using this new layer.

```
$ docker commit <yourContainerId>
<newImageId>
```

The output of the `docker commit` command will be the ID for your newly created image.

We can run this image:

```
$ docker run -it <newImageId> bash
root@fcfb62f0bfde:/# wget
wget: missing URL
...
```


Tagging images

Referring to an image by its ID is not convenient. Let's tag it instead.

We can use the `tag` command:

```
$ docker tag <newImageId> mydistro
```

But we can also specify the tag as an extra argument to `commit`:

```
$ docker commit <containerId> mydistro
```

And then run it using its tag:

```
$ docker run -it mydistro bash
```


What's next?

Manual process = bad.

Automated process = good.

In the next chapter, we will learn how to automate the build process by writing a `Dockerfile`.

Building Docker images

Lesson 8: Building Docker Images

Objectives

At the end of this lesson, you will be able to:

- Write a `Dockerfile`.
- Build an image from a `Dockerfile`.

`Dockerfile` overview

- A `Dockerfile` is a build recipe for a Docker image.
- It contains a series of instructions telling Docker how an image is constructed.
- The `docker build` command builds an image from a `Dockerfile`.

Writing our first `Dockerfile`

Our Dockerfile must be in a **new, empty directory**.

1. Create a directory to hold our `Dockerfile`.

```
$ mkdir myimage
```

2. Create a `Dockerfile` inside this directory.

```
$ cd myimage
$ vim Dockerfile
```

Of course, you can use any other editor of your choice.

Type this into our Dockerfile...

```
FROM ubuntu
RUN apt-get update
RUN apt-get install -y wget
```

- FROM indicates the base image for our build.
- Each RUN line will be executed by Docker during the build.
- Our RUN commands **must be non-interactive.**
  (No input can be provided to Docker during the build.)

Build it!

Save our file, then execute:

```
$ docker build -t myimage .
```

- `-t` indicates the tag to apply to the image.
- `.` indicates the location of the *build context*.
  (We will talk more about the build context later; but to keep things simple: this is the directory where our Dockerfile is located.)

What happens when we build the image?

The output of `docker build` looks like this:

```
$ docker build -t myimage .
Sending build context to Docker daemon 2.048 kB
Sending build context to Docker daemon
Step 0 : FROM ubuntu
 ---> e54ca5efa2e9
Step 1 : RUN apt-get update
 ---> Running in 840cb3533193
 ---> 7257c37726a1
Removing intermediate container 840cb3533193
Step 2 : RUN apt-get install -y wget
 ---> Running in 2b44df762a2f
 ---> f9e8f1642759
Removing intermediate container 2b44df762a2f
Successfully built f9e8f1642759
```

- The output of the RUN commands has been omitted.
- Let's explain what this output means.

Sending the build context to Docker

```
Sending build context to Docker daemon 2.048 kB
```

- The build context is the `.` directory given to `docker build`.
- It is sent (as an archive) by the Docker client to the Docker daemon.
- This allows to use a remote machine to build using local files.
- Be careful (or patient) if that directory is big and your link is slow.

Executing each step

```
Step 1 : RUN apt-get update
 ---> Running in 840cb3533193
(...output of the RUN command...)
 ---> 7257c37726a1
Removing intermediate container 840cb3533193
```

- A container (`840cb3533193`) is created from the base image.
- The `RUN` command is executed in this container.
- The container is committed into an image (`7257c37726a1`).
- The build container (`840cb3533193`) is removed.
- The output of this step will be the base image for the next one.

Running the image

The resulting image is not different from the one produced manually.

```
$ docker run -ti myimage bash
root@91f3c974c9a1:/# wget
wget: missing URL
```

- Sweet is the taste of success!

Using image and viewing history

The `history` command lists all the layers composing an image.

For each layer, it shows its creation time, size, and creation command.

When an image was built with a Dockerfile, each layer corresponds to a line of the Dockerfile.

```
$ docker history myimage
IMAGE         CREATED            CREATED BY                      SIZE
f9e8f1642759  About an hour ago  /bin/sh -c apt-get install -y  6.062 MB
7257c37726a1  About an hour ago  /bin/sh -c apt-get update      8.549 MB
e54ca5efa2e9  8 months ago       /bin/sh -c apt-get update &&   8 B
6c37f792ddac  8 months ago       /bin/sh -c apt-get update &&   83.43 MB
83ff768040a0  8 months ago       /bin/sh -c sed -i  s/^#\s*\(d  1.903 kB
2f4b4d6a4a06  8 months ago       /bin/sh -c echo  #!/bin/sh  >  194.5 kB
d7ac5e4f1812  8 months ago       /bin/sh -c #(nop) ADD file:ad  192.5 MB
511136ea3c5a  20 months ago                                      0 B
```


CMD and ENTRYPOINT

Lesson 9: CMD and ENTRYPOINT

Objectives

In this lesson, we will learn about two important Dockerfile commands:

`CMD` and `ENTRYPOINT`.

Those commands allow us to set the default command to run in a container.

Defining a default command

When people run our container, we want to automatically execute `wget` to retrieve our public IP address, using ifconfig.me.

For that, we will execute:

```
wget -O- -q http://ifconfig.me/ip
```

- `-O-` tells wget to output to standard output instead of a file.
- `-q` tells wget to skip verbose output and give us only the data.
- `http://ifconfig.me/ip` is the URL we want to retrieve.

Adding CMD to our Dockerfile

Our new Dockerfile will look like this:

```
FROM ubuntu
RUN apt-get update
RUN apt-get install -y wget
CMD wget -O- -q http://ifconfig.me/ip
```

- CMD defines a default command to run when none is given.
- It can appear at any point in the file.
- Each CMD will replace and override the previous one.
- As a result, while you can have multiple CMD lines, it is useless.

Build and test our image

Let's build it:

```
$ docker build -t ifconfigme .
...
Successfully built 042dff3b4a8d
```

And run it:

```
$ docker run ifconfigme
64.134.229.24
```


Overriding CMD

If we want to get a shell into our container (instead of running `wget`), we just have to specify a different program to run:

```
$ docker run -it ifconfigme bash
root@7ac86a641116:/#
```

- We specified `bash`.
- It replaced the value of `CMD`.

Using ENTRYPOINT

We want to be able to specify a different URL on the command line, while retaining `wget` and some default parameters.

In other words, we would like to be able to do this:

```
$ docker run ifconfigme http://ifconfig.me/ua
Wget/1.12 (linux-gnu)
```

We will use the `ENTRYPOINT` verb in Dockerfile.

Adding ENTRYPOINT to our Dockerfile

Our new Dockerfile will look like this:

```
FROM ubuntu
RUN apt-get update
RUN apt-get install -y wget
ENTRYPOINT ["wget", "-O-", "-q"]
```

- ENTRYPOINT defines a base command (and its parameters) for the container.
- The command line arguments are appended to those parameters.
- Like CMD, ENTRYPOINT can appear anywhere, and replaces the previous value.

Build and test our image

Let's build it:

```
$ docker build -t ifconfigme .
...
Successfully built 36f588918d73
```

And run it:

```
$ docker run ifconfigme http://ifconfig.me/ua
Wget/1.12 (linux-gnu)
```

Great success!

Using CMD and ENTRYPOINT together

What if we want to define a default URL for our container?

Then we will use ENTRYPOINT and CMD together.

- ENTRYPOINT will define the base command for our container.
- CMD will define the default parameter(s) for this command.

CMD and ENTRYPOINT together

Our new Dockerfile will look like this:

```
FROM ubuntu
RUN apt-get update
RUN apt-get install -y wget
ENTRYPOINT ["wget", "-O-", "-q"]
CMD http://ifconfig.me/ip
```

- ENTRYPOINT defines a base command (and its parameters) for the container.
- If we don't specify extra command-line arguments when starting the container, the value of CMD is appended.
- Otherwise, our extra command-line arguments are used instead of CMD.

Build and test our image

Let's build it:

```
$ docker build -t ifconfigme .
...
Successfully built 6e0b6a048a07
```

And run it:

```
$ docker run ifconfigme
64.134.229.24
$ docker run ifconfigme http://ifconfig.me/ua
Wget/1.12 (linux-gnu)
```


Overriding ENTRYPOINT

What if we want to run a shell in our container?

We cannot just do `docker run ifconfigme bash` because that would try to fetch the URL `bash` (which is not a valid URL, obviously).

We use the `--entrypoint` parameter:

```
$ docker run -it --entrypoint bash ifconfigme
root@6027e44e2955:/#
```


Container Networking Basics

Lesson 10: Container Networking Basics

We will now run network services (accepting requests) in containers.

At the end of this lesson, you will be able to:

- Run a network service in a container.
- Manipulate container networking basics.
- Find a container's IP address.

We will also explain the network model used by Docker.

A simple, static web server

Run the Docker Hub image `jpetazzo/web`, which contains a basic web server:

```
$ docker run -d -P jpetazzo/web
66b1ce719198711292c8f34f84a7b68c3876cf9f67015e752b94e189d35a204e
```

- Docker will download the image from the Docker Hub.
- `-d` tells Docker to run the image in the background.
- `-P` tells Docker to make this service reachable from other computers.
  (`-P` is the short version of `--publish-all`.)

But, how do we connect to our web server now?

Finding our web server port

We will use `docker ps`:

```
$ docker ps
CONTAINER ID  IMAGE                ...     PORTS                     ...
66b1ce719198  jpetazzo/web:latest  ...     0.0.0.0:49153->8000/tcp   ...
```

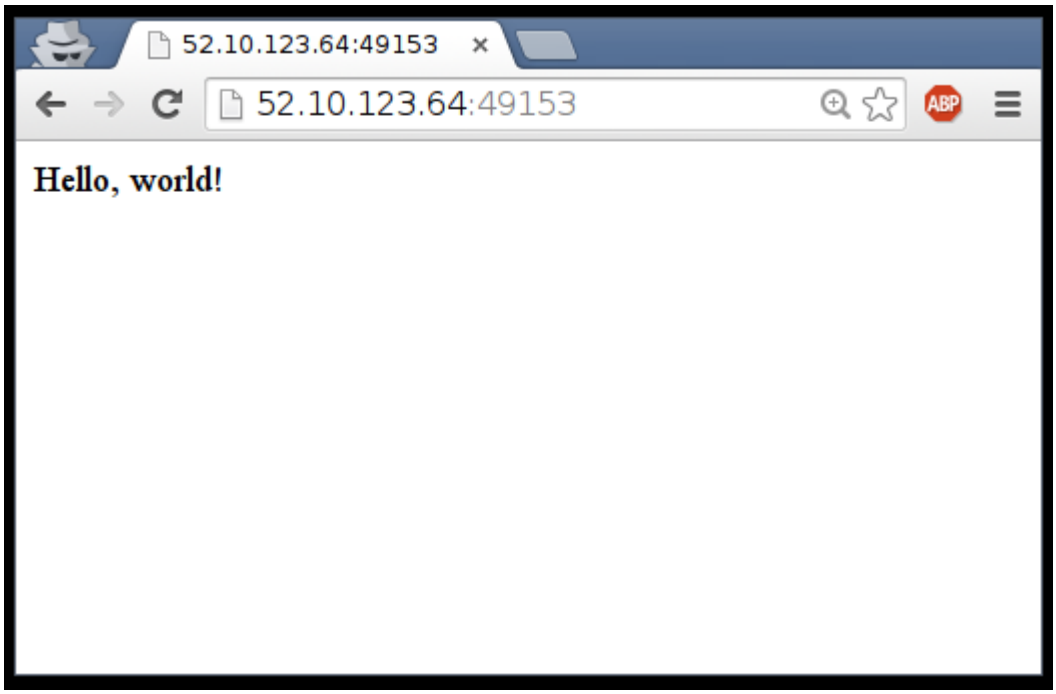
- The web server is running on port 8000 inside the container.
- That port is exposed on port 49153 on our Docker host.

We will explain the whys and hows of this port mapping.

But first, let's make sure that everything works properly.

Connecting to our web server (GUI)

Point your browser to the IP address of your Docker host, on the port shown by `docker ps`.



Connecting to our web server (CLI)

You can also use `curl` directly from the Docker host.

Make sure to use the right port number if it is different from the example below:

```
$ curl localhost:49153
Hello, world!
```


Docker network model

- We are out of IPv4 addresses.
- Containers cannot have public IPv4 addresses.
- They have private addresses.
- Services have to be exposed port by port.
- Ports have to be mapped to avoid conflicts.

Finding the web server port in a script

Parsing the output of `docker ps` would be painful.

There is a command to help us:

```
$ docker port <containerID> 8000
49153
```


Manual allocation of port numbers

If you want to set port numbers yourself, no problem:

```
$ docker run -t -p 80:8000 jpetazzo/web
```

- This time, we are running our container in the foreground.
  (That way, we can kill it easily with ^C.)
- We mapped port 80 on the host, to port 8000 in the container.

Plumbing containers into your infrastructure

There are (at least) three ways to integrate containers in your network.

- Start the container, letting Docker allocate a public port for it.
  Then retrieve that port number and feed it to your configuration.
- Pick a fixed port number in advance, when you generate your configuration.
  Then start your container by setting the port numbers manually.
- Use an overlay network, connecting your containers with e.g. VLANs, tunnels...

Finding the container's IP address

We can use the `docker inspect` command to find the IP address of the container.

```
$ docker inspect --format '{{ .NetworkSettings.IPAddress }}' <yourContainerID>
172.17.0.3
```

- `docker inspect` is an advanced command, that can retrieve a ton of information about our containers.
- Here, we provide it with a format string to extract exactly the private IP address of the container.

Pinging our container

We can test connectivity to the container using the IP address we've just discovered. Let's see this now by using the `ping` tool.

```
$ ping <ipAddress>
64 bytes from <ipAddress>: icmp_req=1 ttl=64 time=0.085 ms
64 bytes from <ipAddress>: icmp_req=2 ttl=64 time=0.085 ms
64 bytes from <ipAddress>: icmp_req=3 ttl=64 time=0.085 ms
```


Section summary

We've learned how to:

- Expose a network port.
- Manipulate container networking basics.
- Find a container's IP address.

NOTE: Later on we'll see how to network containers without exposing ports using the `link` primitive.

Local Development Work flow with Docker

Lesson 11: Local Development Workflow with Docker

Objectives

At the end of this lesson, you will be able to:

- Share code between container and host.
- Use a simple local development workflow.

Using a Docker container for local development

Docker containers are perfect for local development.

Let's grab an image with a web application and see how this works.

```
$ docker pull training/namer
```


Our namer image

Our `training/namer` image is based on the Ubuntu image.

It contains:

- Ruby.
- Sinatra.
- Required dependencies.

Adding our source code

Let's download our application's source code.

```
$ git clone https://github.com/docker-training/namer.git
$ cd namer
$ ls
company_name_generator.rb  config.ru  Dockerfile  Gemfile  README.md
```


Creating a container from our image

We've got an image, some source code and now we can add a container to run that code.

```
$ docker run -d \
      -v $(pwd):/opt/namer \
      -p 80:9292 \
      training/namer
```

- The `-d` flag indicates that the container should run in detached mode (in the background).
- The `-v` flag provides volume mounting inside containers.
- The `-p` flag maps port `9292` inside the container to port `80` on the host.
- `training/namer` is the name of the image we will run.

More on these later.

We've launched the application with the `training/namer` image and the `rackup` command. `rackup` has been set as the `CMD` in the `Dockerfile`.

Mounting volumes inside containers

The `-v` flag mounts a directory from your host into your Docker container. The flag structure is:

```
[host-path]:[container-path]:[rw|ro]
```

- If [host-path] or [container-path] doesn't exist it is created.
- You can control the write status of the volume with the `ro` and `rw` options.
- If you don't specify `rw` or `ro`, it will be `rw` by default.

Checking our new container

Now let us see if our new container is running.

```
$ docker ps
CONTAINER ID  IMAGE                 COMMAND CREATED       STATUS
PORTS               NAMES
045885b68bc5  training/namer:latest rackup  3 seconds ago Up 3 seconds
0.0.0.0:80->9292/tcp condescending_shockley
```


Viewing our application

Now let's browse to our web application on:

```
http://<yourHostIP>:80
```

We can see our company naming application.

Making a change to our application

Our customer really doesn't like the color of our text. Let's change it.

```
$ vi company_name_generator.rb
```

And change

```
color: royalblue;
```

To:

```
color: red;
```


Refreshing our application

Now let's refresh our browser:

```
http://<yourHostIP>:80
```

We can see the updated color of our company naming application.

Workflow explained

We can see a simple workflow:

1. Build an image containing our development environment.
   (Rails, Django...)
2. Start a container from that image.
   Use the `-v` flag to mount source code inside the container.
3. Edit source code outside the containers, using regular tools.
   (vim, emacs, textmate...)
4. Test application.
   (Some frameworks pick up changes automatically.
   Others require you to Ctrl-C + restart after each modification.)
5. Repeat last two steps until satisfied.
6. When done, commit+push source code changes.
   (You *are* using version control, right?)

Debugging inside the container

In 1.3, Docker introduced a feature called `docker exec`.

It allows users to run a new process in a container which is already running.

It is not meant to be used for production (except in emergencies, as a sort of pseudo-SSH), but it is handy for development.

You can get a shell prompt inside an existing container this way.

`docker exec` example

```
$ # You can run ruby commands in the area the app is running and more!
$ docker exec -it <yourContainerId> bash
root@5ca27cf74c2e:/opt/namer# irb
irb(main):001:0> [0, 1, 2, 3, 4].map {|x| x ** 2}.compact
=> [0, 1, 4, 9, 16]
irb(main):002:0> exit
```


Stopping the container

Now that we're done let's stop our container.

```
$ docker stop <yourContainerID>
```

And remove it.

```
$ docker rm <yourContainerID>
```


Section summary

We've learned how to:

- Share code between container and host.
- Set our working directory.
- Use a simple local development workflow.

Working with Volumes

Lesson 12: Working with Volumes

Objectives

At the end of this lesson, you will be able to:

- Create containers holding volumes.
- Share volumes across containers.
- Share a host directory with one or many containers.

Working with Volumes

Docker volumes can be used to achieve many things, including:

- Bypassing the copy-on-write system to obtain native disk I/O performance.
- Bypassing copy-on-write to leave some files out of `docker commit`.
- Sharing a directory between multiple containers.
- Sharing a directory between the host and a container.
- Sharing a *single file* between the host and a container.

Volumes are special directories in a container

Volumes can be declared in two different ways.

- Within a `Dockerfile`, with a `VOLUME` instruction.

```
VOLUME /var/lib/postgresql
```

- On the command-line, with the `-v` flag for `docker run`.

```
$ docker run -d -v /var/lib/postgresql \
  training/postgresql
```

In both cases, `/var/lib/postgresql` (inside the container) will be a volume.

Volumes bypass the copy-on-write system

Volumes act as passthroughs to the host filesystem.

- The I/O performance on a volume is exactly the same as I/O performance on the Docker host.
- When you `docker commit`, the content of volumes is not brought into the resulting image.
- If a RUN instruction in a `Dockerfile` changes the content of a volume, those changes are not recorded neither.

Volumes can be shared across containers

You can start a container with *exactly the same volumes* as another one.

The new container will have the same volumes, in the same directories.

They will contain exactly the same thing, and remain in sync.

Under the hood, they are actually the same directories on the host anyway.

This is done using the `--volumes-from` flag for `docker run`.

```
$ docker run -it --name alpha -v /var/log ubuntu bash
root@99020f87e695:/# date >/var/log/now
```

In another terminal, let's start another container with the same volume.

```
$ docker run --volumes-from alpha ubuntu cat /var/log/now
Fri May 30 05:06:27 UTC 2014
```


Volumes exist independently of containers

If a container is stopped, its volumes still exist and are available.

In the last exemple, it doesn't matter if container `alpha` is running or not.

Data containers

A *data container* is a container created for the sole purpose of referencing one (or many) volumes.

It is typically created with a no-op command:

```
$ docker run --name wwwdata -v /var/lib/www busybox true
$ docker run --name wwwlogs -v /var/log/www busybox true
```

- We created two data containers.
- They are using the `busybox` image, a tiny image.
- We used the command `true`, possibly the simplest command in the world!
- We named each container to reference them easily later.

Try it out!

Using data containers

Data containers are used by other containers thanks to `--volumes-from`.

Consider the following (fictitious) example, using the previously created volumes:

```
$ docker run -d --volumes-from wwwdata --volumes-from wwwlogs webserver
$ docker run -d --volumes-from wwwdata ftpserver
$ docker run -d --volumes-from wwwlogs pipestash
```

- The first container runs a webserver, serving content from `/var/lib/www` and logging to `/var/log/www`.
- The second container runs a FTP server, allowing to upload content to the same `/var/lib/www` path.
- The third container collects the logs, and sends them to logstash, a log storage and analysis system.

Managing volumes yourself (instead of letting Docker do it)

In some cases, you want a specific directory on the host to be mapped inside the container:

- You want to manage storage and snapshots yourself.
  (With LVM, or a SAN, or ZFS, or anything else!)
- You have a separate disk with better performance (SSD) or resiliency (EBS) than the system disk, and you want to put important data on that disk.
- You want to share your source directory between your host (where the source gets edited) and the container (where it is compiled or executed).

Wait, we already met the last use-case in our example development workflow! Nice.

Sharing a directory between the host and a container

```
$ cd
$ mkdir bindthis
$ ls bindthis
$ docker run -it -v $(pwd)/bindthis:/var/www/html/webapp ubuntu bash
root@<yourContainerID>:/# touch /var/www/html/webapp/index.html
root@<yourContainerID>:/# exit
$ ls bindthis
index.html
```

This will mount the `bindthis` directory into the container at `/var/www/html/webapp`.

Note that the paths must be absolute.

It defaults to mounting read-write but we can also mount read-only.

```
$ docker run -it -v $(pwd)/bindthis:/var/www/html/webapp:ro ubuntu bash
```

Those volumes can also be shared with `--volumes-from`.

Chaining container volumes together

Let's see how to put both pieces together.

1. Create an initial container.

```
$ docker run -it -v /var/appvolume \
  --name appdata ubuntu bash
root@<yourContainerID>#
```

2. Create some data in our data volume.

```
root@<yourContainerID># cd /var/appvolume
root@<yourContainerID># echo "Hello" > data
```

3. Exit the container.

```
root@<yourContainerID># exit
```


Use a data volume from our container.

1. Create a new container.

```
$ docker run -it --volumes-from appdata \
  --name appserver1 ubuntu bash
root@<yourContainerID>#
```

2. Let's view our data.

```
root@<yourContainerID># cat /var/appvolume/
data
Hello
```

3. Let's make a change to our data.

```
root@<yourContainerID># echo "Good bye" \
                        >> /var/appvolume/data
```

4. Exit the container.

```
root@<yourContainerID># exit
```


Chain containers with data volumes

1. Create a third container.

```
 docker run -it --volumes-from appserver1
--name appserver2 ubuntu bash
 root@179c063af97a#
```

2. Let's view our data.

```
 root@179c063af97a# cat /var/appvolume/data
 Hello
 Good bye
```

3. Exit the container.

```
 root@179c063af97a# exit
```

4. Tidy up your containers.

```
 $ docker rm -v appdata appserver1 appserver2
```


What happens when you remove containers with volumes?

- As long as a volume is referenced by at least one container, you will be able to access it.
- When you remove the last container referencing a volume, that volume will be orphaned.
- Orphaned volumes are not deleted (as of Docker 1.2).
- The data is not lost, but you will not be able to access it.
  (Unless you do some serious archeology in `/var/lib/docker`.)

Ultimately, you are the one responsible for logging, monitoring, and backup of your volumes.

Checking volumes defined by an image

Wondering if an image has volumes? Just use `docker inspect`:

```
$ # docker inspect training/datavol
[{
  "config": {
    . . .
    "Volumes": {
        "/var/webapp": {}
    },
    . . .
}]
```


Checking volumes used by a container

To look which paths are actually volumes, and to what they are bound, use `docker inspect` (again):

```
$ docker inspect <yourContainerID>
[{
  "ID": "<yourContainerID>",
. . .
  "Volumes": {
      "/var/webapp": "/var/lib/docker/vfs/dir/
f4280c5b6207ed531efd4cc673ff620cef2a7980f747dbbcca001db61de04468"
  },
  "VolumesRW": {
      "/var/webapp": true
  },
}]
```

- We can see that our volume is present on the file system of the Docker host.

Sharing a single file between the host and a container

The same `-v` flag can be used to share a single file.

```
$ echo 4815162342 > /tmp/numbers
$ docker run -it -v /tmp/numbers:/numbers ubuntu bash
root@<yourContainerId>:/# cat /numbers
4815162342
```

- All modifications done to `/numbers` in the container will also change `/tmp/numbers` on the host!

It can also be used to share a *socket*.

```
$ docker run -it -v /var/run/docker.sock:/docker.sock ubuntu bash
```

- This pattern is frequently used to give access to the Docker socket to a given container.

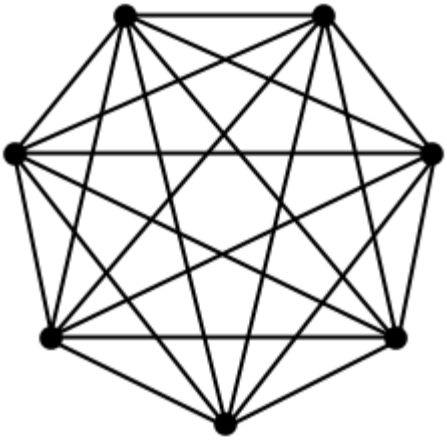
Warning: when using such mounts, the container gains root-like access to the host. It can potentially do bad things.

Section summary

We've learned how to:

- Create containers holding volumes.
- Share volumes across containers.
- Share a host directory with one or many containers.

Connecting Containers



Lesson 13: Connecting containers

Objectives

At the end of this lesson, you will be able to:

- Launch named containers.
- Create links between containers.
- Use names and links to communicate across containers.
- Use these features to decouple app dependencies and reduce complexity.

Connecting containers

- We will learn how to use names and links to expose one container's port(s) to another.
- Why? So each component of your app (e.g., DB vs. web app) can run independently with its own dependencies.

What we've got planned

- We're going to get two images: a Redis (key-value store) image and a Ruby on Rails application image.
- We're going to start containers from each image.
- We're going to link the container running our Rails application and the container running Redis using Docker's link primitive.

Our Redis database image

Let's start by pulling down our database image.

- There are multiple versions of the `redis` image.
- To save time and network resources, we will pull only the one we need (latest).

To do that, we will specify the exact version tag to be used.

```
$ docker pull redis:latest
```

Let's review the result.

```
$ docker images redis
REPOSITORY          TAG                 IMAGE ID            CREATED
VIRTUAL SIZE
redis               latest              b73cdc045d3c        2 weeks ago
98.42 MB
```


Launch a container from the `redis` image.

Let's launch a container from the `redis` image.

```
$ docker run -d --name mycache redis
<yourContainerID>
```

Let's check the container is running:

```
$ docker ps -l
CONTAINER ID        IMAGE               COMMAND             CREATED
STATUS              PORTS               NAMES
9efd72a4f320        redis:latest        redis-server        5 seconds ago       Up
4 seconds        6379/tcp            mycache
```

- Our container is launched and running an instance of Redis.
- Using the `--name` flag we've given it a name: `mycache`. Remember that! Container names are unique. We're going to use that name shortly.

Our Rails application image

Let's start by pulling down our Rails application image.

```
$ docker pull nathanleclaire/redisonrails
```

And reviewing it.

```
$ docker images nathanleclaire/redisonrails
```


The `nathanleclaire/redisonrails` Dockerfile

Let's look at the Dockerfile that builds this image.

```
FROM ruby
RUN apt-get update -qq && apt-get install -y build-essential libpq-dev
RUN mkdir /myapp
WORKDIR /myapp
ADD Gemfile /myapp/Gemfile
RUN bundle install -j8
EXPOSE 3000
ADD . /myapp
CMD ["bundle", "exec", "rails", "s"]
```


The `nathanleclaire/redisonrails` Dockerfile in detail

- Based on the `ruby` base image from Docker Hub (provided by Docker Inc.)
- Installs the required packages with `bundle install`.
- Adds the Rails application itself to the `/myapp` directory.
- Exposes port `3000`.
- Runs Ruby on Rails when a container is launched from the image.

Connecting to redis in the container

The following Ruby code will be used in `/myapp/config/initializers/redis.rb` to connect to the running Redis container.

```
$redis = Redis.new(:host => 'redis', :port => 6379)
```

As we'll see in more detail later, Links provide a DNS entry for the linked container as well as information about how to connect (IP address, ports, etc.) populated in environment variables.

Launch a container from the `nathanleclaire/redisonrails` image.

Let's launch a container from the `nathanleclaire/redisonrails` image, without links to start.

In the Rails console we can see that `$redis` exists, but we did not link to any actual Redis instance.

```
$ docker run -it nathanleclaire/redisonrails rails console
Loading development environment (Rails 4.0.2)
irb(main):001:0> $redis
=> #<Redis client v3.1.0 for redis://redis:6379/0>
irb(main):002:0> $redis.set('foo', 'bar')
SocketError: getaddrinfo: Name or service not known
    from /usr/local/lib/ruby/gems/2.1.0/gems/redis-3.1.0/lib/redis/connection/
ruby.rb:152:in `getaddrinfo'
    from /usr/local/lib/ruby/gems/2.1.0/gems/redis-3.1.0/lib/redis/connection/
ruby.rb:152:in `connect'
    from /usr/local/lib/ruby/gems/2.1.0/gems/redis-3.1.0/lib/redis/connection/
ruby.rb:211:in `connect'
    from /usr/local/lib/ruby/gems/2.1.0/gems/redis-3.1.0/lib/redis/client.rb:304:in
`establish_connection'
    .....
```

Without access to a Redis server at the proper location the initialized `$redis` object will not work.

Launch and link a container

Let's try again but this time we'll link our container to our existing Redis container.

```
$ docker run -it --link mycache:redis \
  nathanleclaire/redisonrails rails console
Loading development environment (Rails 4.0.2)
irb(main):001:0> $redis
=> #<Redis client v3.1.0 for redis://redis:6379/0>
irb(main):002:0> $redis.set('a', 'b')
=> "OK"
irb(main):003:0> $redis.get('a')
=> "b"
irb(main):004:0> $redis.set('someHash', {:foo => 'bar', :spam => 'eggs'})
=> "OK"
irb(main):005:0> $redis.get('someHash')
=> "{:foo=>\"bar\", :spam=>\"eggs\"}"
irb(main):006:0> $redis.set('users', ['Aaron', 'Jerome', 'Nathan'])
=> "OK"
irb(main):007:0> $redis.get('users')
=> "[\"Aaron\", \"Jerome\", \"Nathan\"]"
irb(main):008:0> exit
```

Woot! That's more like it.

- The `--link` flag connects one container to another.
- We specify the name of the container to link to, `mycache`, and an alias for the link, `redis`, in the format `name:alias`.
- We can use `$redis` in an `ActiveRecord` class to create data models that have the speed on in-memory lookups.

More about our link - Environment variables

The link provides a secure tunnel between containers. On our `mycache` container port 6379 (the default Redis port) has been exposed to the linked container.

Docker will automatically set environment variables in our container, and populate an `/etc/hosts` entry for DNS lookup, to indicate connection information.

Let's see that information:

```
$ docker run --link mycache:redis nathanleclaire/redisonrails env
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
HOSTNAME=0738e57b771e
REDIS_PORT=tcp://172.17.0.120:6379
REDIS_PORT_6379_TCP=tcp://172.17.0.120:6379
REDIS_PORT_6379_TCP_ADDR=172.17.0.120
REDIS_PORT_6379_TCP_PORT=6379
REDIS_PORT_6379_TCP_PROTO=tcp
REDIS_NAME=/dreamy_wilson/redis
REDIS_ENV_REDIS_VERSION=2.8.13
REDIS_ENV_REDIS_DOWNLOAD_URL=http://download.redis.io/releases/redis-2.8.13.tar.gz
REDIS_ENV_REDIS_DOWNLOAD_SHA1=a72925a35849eb2d38a1ea076a3db82072d4ee43
HOME=/
RUBY_MAJOR=2.1
RUBY_VERSION=2.1.2
```

- Each variables is prefixed with the link alias: `redis`.
- Includes connection information PLUS any environment variables set in the `mycache` container via ENV instructions.

DNS

Links also provides you with a DNS entry corresponding to the name of the container, which is what we've used in this sample application.

```
$ docker run -it --link mycache:redis nathanleclaire/redisonrails ping redis
PING redis (172.17.0.29): 56 data bytes
64 bytes from 172.17.0.29: icmp_seq=0 ttl=64 time=0.164 ms
64 bytes from 172.17.0.29: icmp_seq=1 ttl=64 time=0.122 ms
64 bytes from 172.17.0.29: icmp_seq=2 ttl=64 time=0.086 ms
^C--- redis ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max/stddev = 0.086/0.124/0.164/0.032 ms
```


Starting our Rails application

Now that we've poked around a bit let's start the application itself in a fresh container:

```
$ docker run -d -p 80:3000 --link mycache:redis nathanleclaire/redisonrails
```

Now let's check the container is running.

```
$ docker ps -l
```


Starting our Rails application

Our homepage controller contains the following code.

```
class WelcomeController < ApplicationController
  def index
      views = $redis.get('views').to_i()
      views += 1
      $redis.set('views', views)
      @page_views = views
  end
end
```


Viewing our Rails application

Finally, let's browse to our application and confirm it's working.

```
http://<yourHostIP>
```

Tidying up

Finally let's tidy up our database.

```
$ docker kill mycache
. . .
$ docker rm mycache
```

- We can use the container name to stop and remove them.
- We removed it so we can re-use its name later if we want.
  (Remember container names are unique!)

Section summary

We've learned how to:

- Launch named containers.
- Create links between containers.
- Use names and links to communicate across containers.
- Use these features to decouple app dependencies and reduce complexity.

Advanced Dockerfiles

Lesson 14: Advanced Dockerfiles

`Dockerfile` usage summary

- `Dockerfile` instructions are executed in order.
- Each instruction creates a new layer in the image.
- Instructions are cached. If no changes are detected then the instruction is skipped and the cached layer used.
- The `FROM` instruction MUST be the first non-comment instruction.
- Lines starting with # are treated as comments.
- You can only have one `CMD` and one `ENTRYPOINT` instruction in a `Dockerfile`.

The FROM instruction

- Specifies the source image to build this image.
- Must be the first instruction in the `Dockerfile`, except for comments.

The FROM instruction

Can specify a base image:

```
FROM ubuntu
```

An image tagged with a specific version:

```
FROM ubuntu:12.04
```

A user image:

```
FROM training/sinatra
```

Or self-hosted image:

```
FROM localhost:5000/funtoo
```


More about FROM

- The FROM instruction can be specified more than once to build multiple images.

```
FROM ubuntu:14.04
. . .
FROM fedora:20
. . .
```

  Each FROM instruction marks the beginning of the build of a new image.
  The `-t` command-line parameter will only apply to the last image.

- If the build fails, existing tags are left unchanged.

- An optional version tag can be added after the name of the image.
  E.g.: `ubuntu:14.04`.

The MAINTAINER instruction

The MAINTAINER instruction tells you who wrote the Dockerfile.

```
MAINTAINER Docker Education Team <education@docker.com>
```

It's optional but recommended.

The RUN instruction

The RUN instruction can be specified in two ways.

With shell wrapping, which runs the specified command inside a shell, with `/bin/sh -c`:

```
RUN apt-get update
```

Or using the `exec` method, which avoids shell string expansion, and allows execution in images that don't have `/bin/sh`:

```
RUN [ "apt-get", "update" ]
```


More about the RUN instruction

RUN will do the following:

- Execute a command.
- Record changes made to the filesystem.
- Work great to install libraries, packages, and various files.

RUN will NOT do the following:

- Record state of *processes*.
- Automatically start daemons.

If you want to start something automatically when the container runs, you should use `CMD` and/or `ENTRYPOINT`.

The EXPOSE instruction

The EXPOSE instruction tells Docker what ports are to be published in this image.

```
EXPOSE 8080
```

- All ports are private by default.
- The `Dockerfile` doesn't control if a port is publicly available.
- When you `docker run -p <port> ...`, that port becomes public. (Even if it was not declared with EXPOSE.)
- When you `docker run -P ...` (without port number), all ports declared with EXPOSE become public.

A *public port* is reachable from other containers and from outside the host.

A *private port* is not reachable from outside.

The ADD instruction

The ADD instruction adds files and content from your host into the image.

```
ADD /src/webapp /opt/webapp
```

This will add the contents of the `/src/webapp/` directory to the `/opt/webapp` directory in the image.

Note: `/src/webapp/` is not relative to the host filesystem, but to the directory containing the `Dockerfile`.

Otherwise, a `Dockerfile` could succeed on host A, but fail on host B.

The ADD instruction can also be used to get remote files.

```
ADD http://www.example.com/webapp /opt/
```

This would download the `webapp` file and place it in the `/opt` directory.

More about the ADD instruction

- ADD is cached. If you recreate the image and no files have changed then a cache is used.
- If the local source is a zip file or a tarball it'll be unpacked to the destination.
- Sources that are URLs and zipped will not be unpacked.
- Any files created by the ADD instruction are owned by `root` with permissions of `0755`.

More on ADD here.

The VOLUME instruction

The VOLUME instruction will create a data volume mount point at the specified path.

```
VOLUME [ "/opt/webapp/data" ]
```

- Data volumes bypass the union file system.
  In other words, they are not captured by `docker commit`.
- Data volumes can be shared and reused between containers.
  We'll see how this works in a subsequent lesson.
- It is possible to share a volume with a stopped container.
- Data volumes persist until all containers referencing them are destroyed.

The WORKDIR instruction

The WORKDIR instruction sets the working directory for subsequent instructions.

It also affects CMD and ENTRYPOINT, since it sets the working directory used when starting the container.

```
WORKDIR /opt/webapp
```

You can specify WORKDIR again to change the working directory for further operations.

The ENV instruction

The ENV instruction specifies environment variables that should be set in any container launched from the image.

```
ENV WEBAPP_PORT 8080
```

This will result in an environment variable being created in any containers created from this image of

```
WEBAPP_PORT=8080
```

You can also specify environment variables when you use `docker run`.

```
$ docker run -e WEBAPP_PORT=8000 -e WEBAPP_HOST=www.example.com ...
```


The USER instruction

The USER instruction sets the user name or UID to use when running the image.

It can be used multiple times to change back to root or to another user.

The CMD instruction

The CMD instruction is a default command run when a container is launched from the image.

```
CMD [ "nginx", "-g", "daemon off;" ]
```

Means we don't need to specify `nginx -g "daemon off;"` when running the container.

Instead of:

```
$ docker run <dockerhubUsername>/web_image nginx -g "daemon off;"
```

We can just do:

```
$ docker run <dockerhubUsername>/web_image
```


More about the CMD instruction

Just like RUN, the CMD instruction comes in two forms. The first executes in a shell:

```
CMD nginx -g "daemon off;"
```

The second executes directly, without shell processing:

```
CMD [ "nginx", "-g", "daemon off;" ]
```


Overriding the CMD instruction

The CMD can be overridden when you run a container.

```
$ docker run -it <dockerhubUsername>/web_image bash
```

Will run `bash` instead of `nginx -g "daemon off;"`.

The ENTRYPOINT instruction

The ENTRYPOINT instruction is like the CMD instruction, but arguments given on the command line are *appended* to the entry point.

Note: you have to use the "exec" syntax (`[ "..." ]`).

```
ENTRYPOINT [ "/bin/ls" ]
```

If we were to run:

```
$ docker run training/ls -l
```

Instead of trying to run `-l`, the container will run `/bin/ls -l`.

Overriding the ENTRYPOINT instruction

The entry point can be overriden as well.

```
$ docker run -it training/ls
bin   dev  home  lib64  mnt  proc  run   srv  tmp  var
boot  etc  lib   media  opt  root  sbin  sys  usr
$ docker run -it --entrypoint bash training/ls
root@d902fb7b1fc7:/#
```


How CMD and ENTRYPOINT interact

The CMD and ENTRYPOINT instructions work best when used together.

```
ENTRYPOINT [ "nginx" ]
CMD [ "-g", "daemon off;" ]
```

The ENTRYPOINT specifies the command to be run and the CMD specifies its options. On the command line we can then potentially override the options when needed.

```
$ docker run -d <dockerhubUsername>/web_image -t
```

This will override the options CMD provided with new flags.

The ONBUILD instruction

The ONBUILD instruction is a trigger. It sets instructions that will be executed when another image is built from the image being build.

This is useful for building images which will be used as a base to build other images.

```
ONBUILD ADD . /app/src
```

- You can't chain ONBUILD instructions with ONBUILD.
- ONBUILD can't be used to trigger FROM and MAINTAINER instructions.

Building an efficient `Dockerfile`

- Each line in a `Dockerfile` creates a new layer.
- Build your `Dockerfile` to take advantage of Docker's caching system.
- Combine multiple similar commands into one by using && to continue commands and \ to wrap lines.
- ADD dependency lists (`package.json`, `requirements.txt`, etc.) by themselves to avoid reinstalling unchanged dependencies every time.

Example "bad" `Dockerfile`

The dependencies are reinstalled every time, because the build system does not know if `requirements.txt` has been updated.

```
FROM ubuntu:14.04
MAINTAINER Docker Education Team <education@docker.com>
RUN apt-get update
RUN DEBIAN_FRONTEND=noninteractive apt-get install -y -q \
    python-all python-pip
ADD ./webapp /opt/webapp/
WORKDIR /opt/webapp
RUN pip install -qr requirements.txt
EXPOSE 5000
CMD ["python", "app.py"]
```


Fixed `Dockerfile`

Adding the dependencies as a separate step means that Docker can cache more efficiently and only install them when `requirements.txt` changes.

```
FROM ubuntu:14.04
MAINTAINER Docker Education Team <education@docker.com>
RUN apt-get update
RUN DEBIAN_FRONTEND=noninteractive apt-get install -y -q \
    python-all python-pip
ADD ./webapp/requirements.txt /tmp/requirements.txt
RUN pip install -qr /tmp/requirements.txt
ADD ./webapp /opt/webapp/
WORKDIR /opt/webapp
EXPOSE 5000
CMD ["python", "app.py"]
```


Container Orchestration

Lesson 15: Orchestration

Objectives

In this lesson, you will:

- Understand what orchestration is and why it is needed.
- Use `fig`, our recommended tool, to bootstrap a development environment.
- Understand some of the options and when you would use each one.

What is Orchestration?

- Orchestration is a loosely defined term that people use to describe the set of practices around managing multiple Docker containers.
- It can be as simple as using tools to ease the "wiring together" of multiple Docker containers (one for application, one for DB, one for key-value store etc.), or it can be as complex as the coordinating and scheduling of many resources and containers across large clusters of computers.
- For instance, what we did in the last section was very handy for learning, but it is difficult / tedious to remember and type in long `docker run` commands all the time. So we want a better, more automatic way.

Getting started with Orchestration

We're going to get our hands dirty with an orchestration tool officially endorsed by Docker. It's called Fig.

Fig

With fig, we define a set of set of containers to boot up, and their runtime properties, in a YAML file. Then we run `fig up`, and watch as fig boots the containers, assigns the appropriate links, and multiplexes the logs' outputs together.

Installation

To install `fig`:

```
curl -L https://github.com/docker/fig/releases/download/0.5.2/linux \
    > /usr/local/bin/fig
chmod +x /usr/local/bin/fig
```

You can also use `pip` if you prefer:

```
sudo pip install -U fig
```


Gettin' Figgy With It

Clone the source code for the app we will be working on.

```
cd
git clone https://github.com/docker-training/simplefig
cd simplefig
```


Gettin' Figgy With It

Create this Dockerfile:

```
FROM python:2.7
ADD requirements.txt /code/requirements.txt
WORKDIR /code
RUN pip install -r requirements.txt
ADD . /code
```


Gettin' Figgy With It

Now create a `fig.yml` to store the runtime properties of the app.

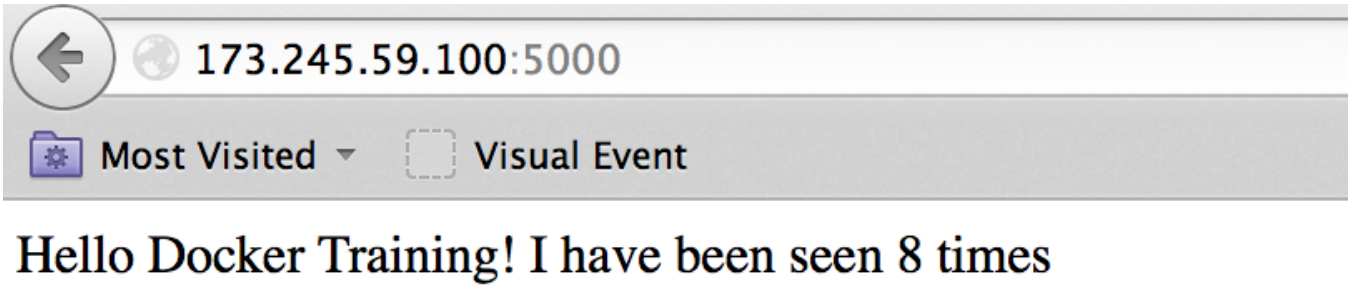
```
web:
  build: .
  command: python app.py
  ports:
   - "5000:5000"
  volumes:
   - .:/code
  links:
   - redis
redis:
  image: orchardup/redis
```


Gettin' Figgy With It

Run `fig up` in the directory, and watch fig build and run your app with the correct parameters, including linking the relevant containers together.

Gettin' Figgy With It

Verify that the app is running at `http://<yourHostIP>:5000`.



Some more useful fig commands

`fig` introduces a unit of abstraction called a "service" (mostly, a container that interacts with other containers in some way and has specific runtime properties).

To rebuild all the services in your `fig.yml`:

```
fig build
```

To run `fig up` in the background instead of the foreground:

```
fig up -d
```

To see currently running services:

```
fig ps
```

To remove the existing services:

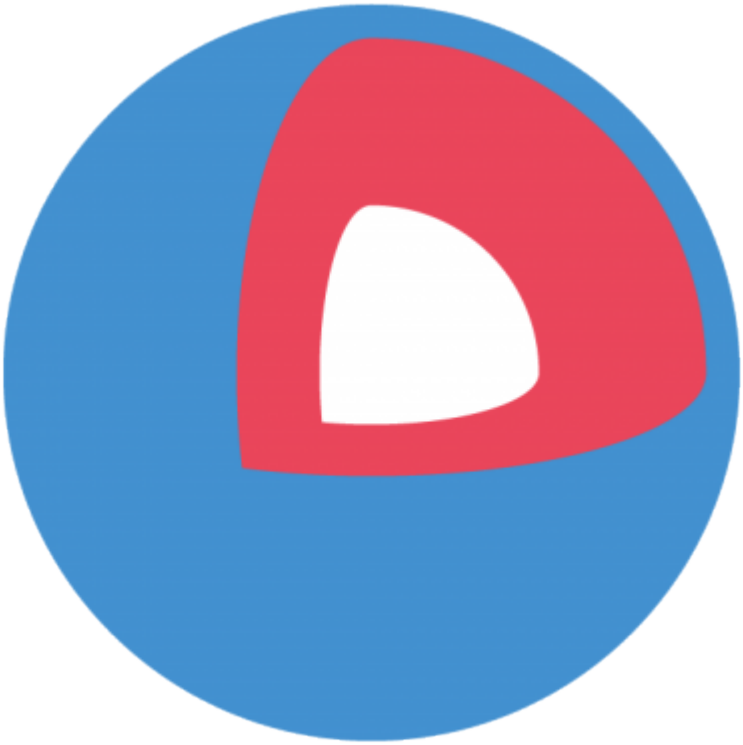
```
fig rm
```


Other Orchestration Options

Now to rattle off some of the other options very quickly. Many of these have a different focus than fig, so they may be useful in different ways.

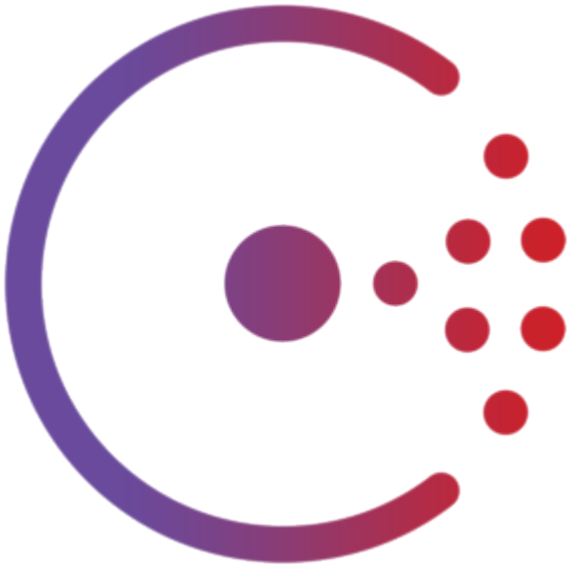
Fleet / etcd

Go - from CoreOS



Consul

Go - from HashiCorp



Kubernetes

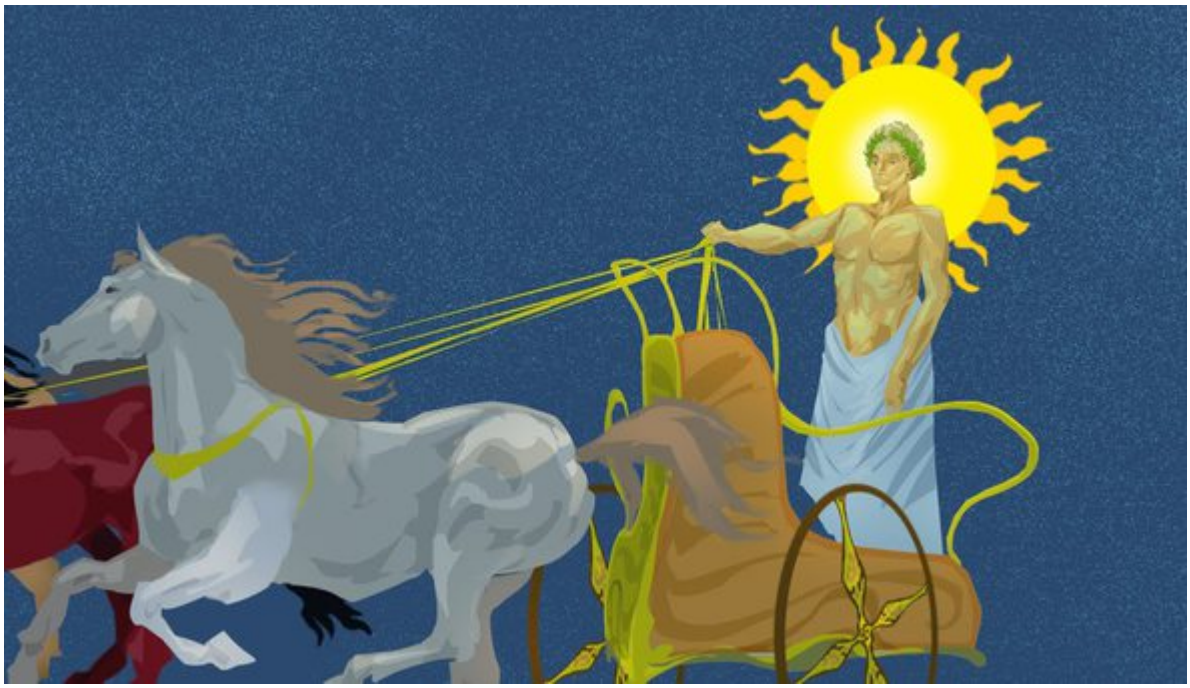
Go - from Google

Mesos

C++ - from Apache/Twitter

Helios

Java - from Spotify



Centurion

Ruby - from New Relic

Future

There are many choices - the dream is to eventually be able to swap these choices out seamlessly using `libswarm`, an ongoing project Docker has around orchestration, and use whatever fits your needs.

https://github.com/docker/libswarm

Section Summary

We've learned how to:

- Understand what orchestration is and why it is needed.
- Use `fig`, our recommended tool, to bootstrap a development environment.
- Understand some of the other options and when you would use each one.

Ambassadors

Lesson 16: Ambassadors

Objectives

At the end of this lesson, you will be able to:

- Understand the ambassador pattern and what it is used for (service portability).

Ambassadors

We've already seen a couple of ways we can manage our application architecture in Docker.

- With links.
- Using host-based volumes.
- Using data volumes shared between containers.

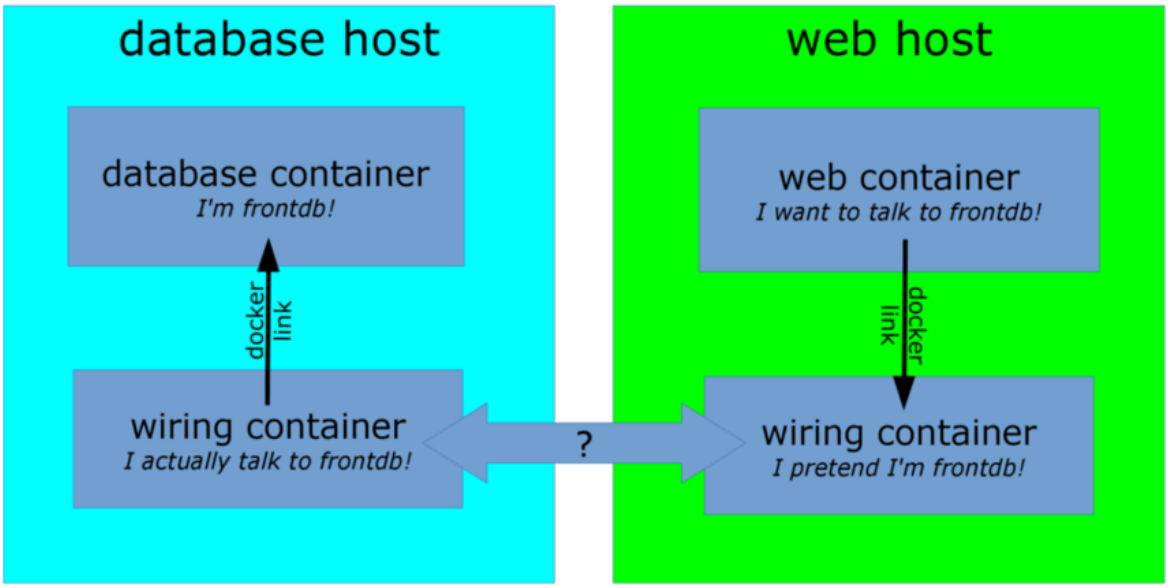
We're now going to see a pattern for service portability we call: ambassadors.

Introduction to Ambassadors

The ambassador pattern:

- Takes advantage of Docker's lightweight linkages and abstracts connections between services.
- Allows you to manage services without hard-coding connection information inside applications.

To do this, instead of directly connecting containers you insert ambassador containers.



Interacting with ambassadors

- The web application container uses a normal link to connect to the ambassador.
- The database container is linked with an ambassador as well.
- For both containers, there is no difference between normal operation and operation with ambassador containers.
- If the database container is moved, its new location will be tracked by the ambassador containers, and the web application container will still be able to connect, without reconfiguration.

Implementing the ambassador pattern

Different deployments will use different underlying technologies.

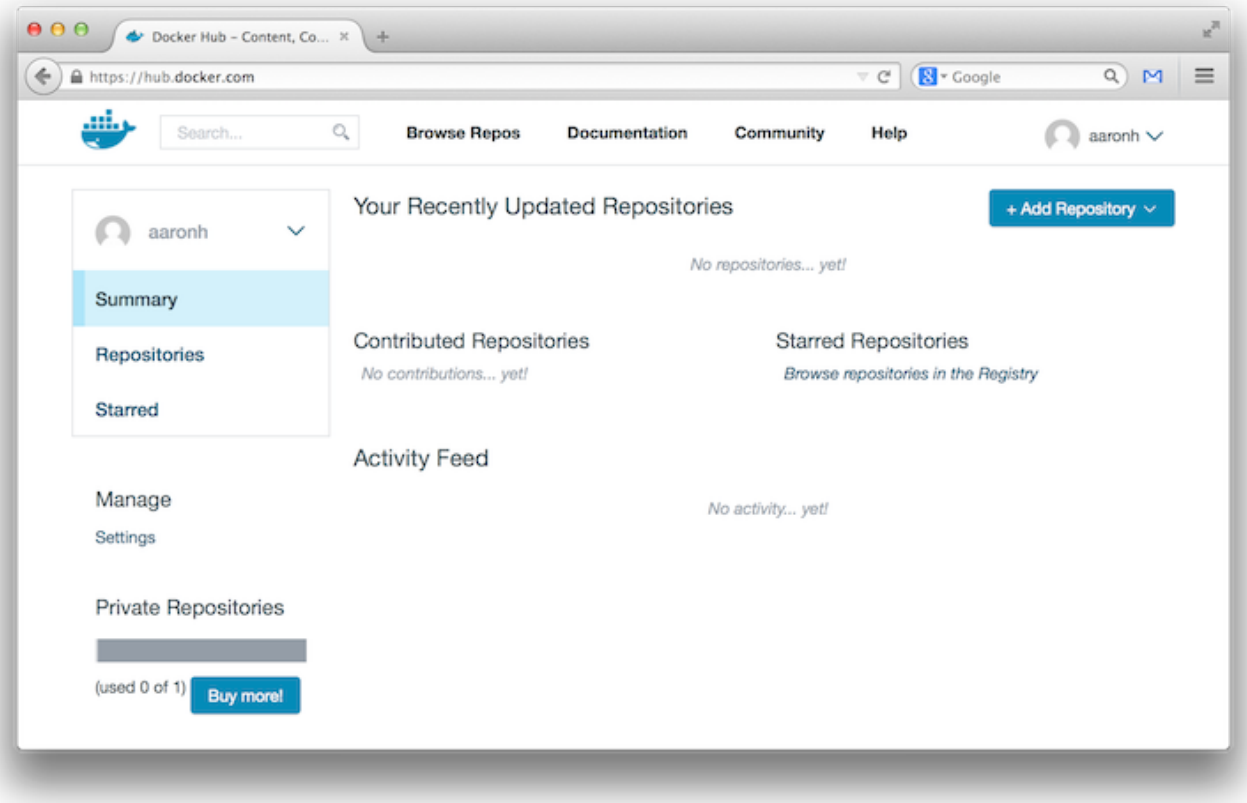
- On-premise deployments with a trusted network can track container locations in e.g. Zookeeper, and generate HAproxy configurations each time a location key changes.
- Public cloud deployments or deployments across unsafe networks can add TLS encryption.
- Ad-hoc deployments can use a master-less discovery protocol like avahi to register and discover services.

Section summary

We've learned how to:

- Understand the ambassador pattern and what it is used for (service portability).

Introducing Docker Hub



Lesson 17: Introducing Docker Hub

Objectives

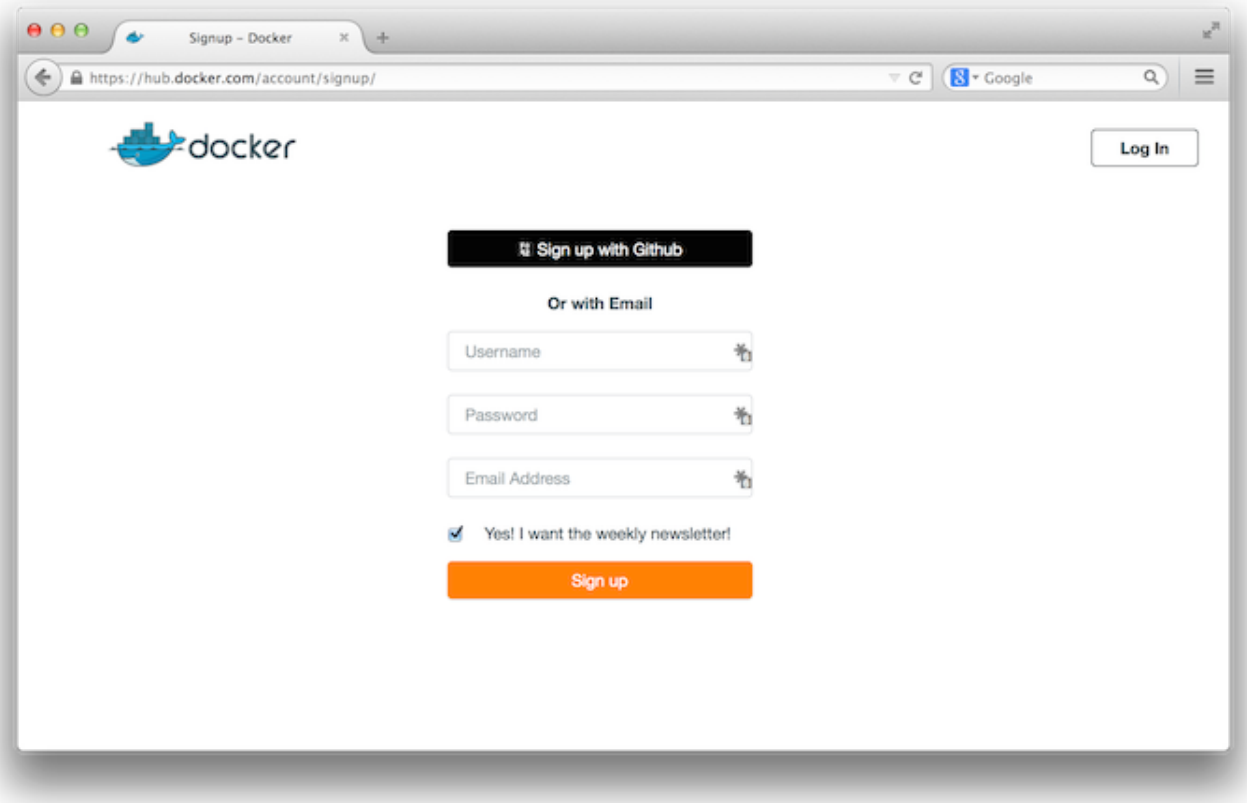
At the end of this lesson, you will be able to:

- Register for an account on Docker Hub.
- Login to your account from the command line.
- Learn about how Docker Hub works.
- Learn about how to integrate Docker Hub into your development workflow.

Sign up for a Docker Hub account

Note: if you already have an account on the Index/Hub, don't create another one.

- Having a Docker Hub account will allow us to store our images in the registry.
- To sign up, you'll go to hub.docker.com and fill out the form.
- Note: your Docker Hub username has to be all lowercase.



Activate your account through e-mail.

- Check your e-mail and click the confirmation link.

Login

Let's use our new account to login to the Docker Hub!

```
$ docker login
Username: my_docker_hub_login
Password:
Email: my@email.com
Login Succeeded
```

Our credentials will be stored in `~/.dockercfg`.

The `.dockercfg` configuration file

The `~/.dockercfg` configuration file holds our Docker registry authentication credentials.

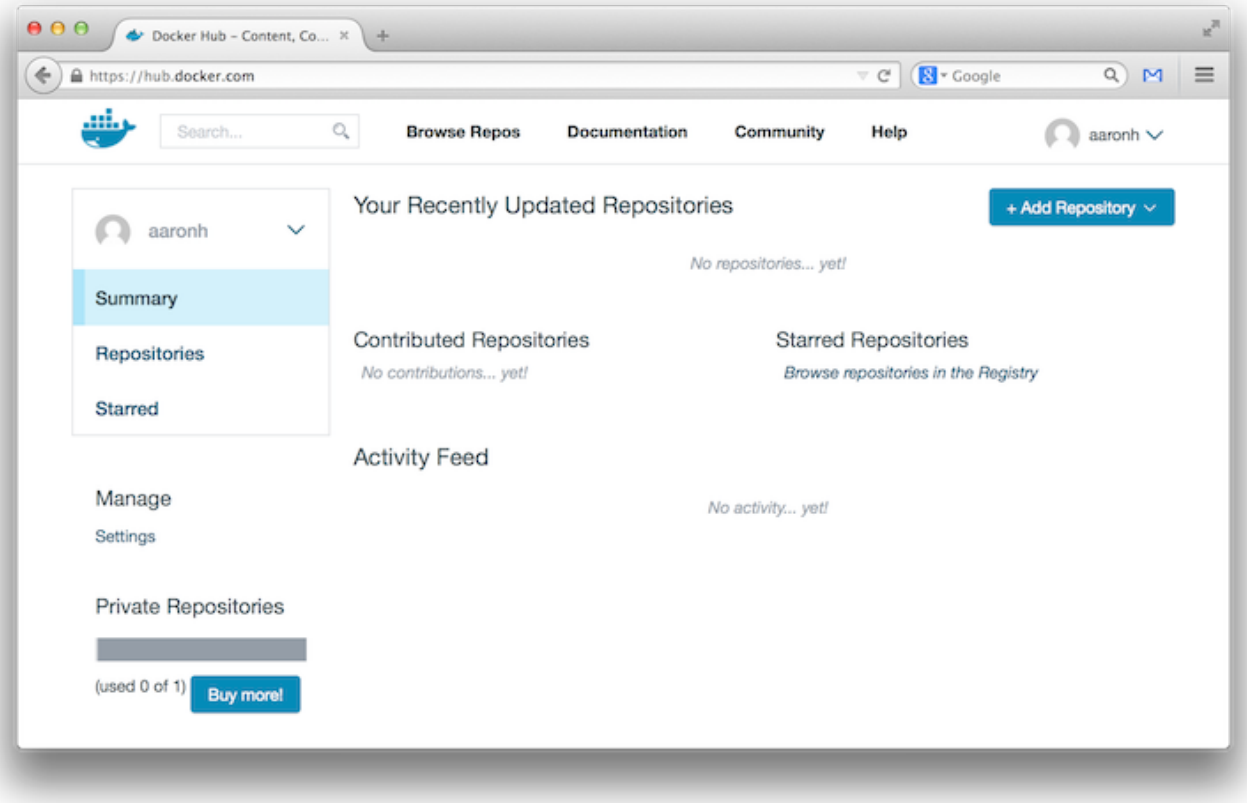
```
{
  "https://index.docker.io/v1/": {
    "auth":"amFtdHVyMDE6aTliMUw5ckE=",
    "email":"education@docker.com"
  }
}
```

The `auth` section is Base64 encoding of your user name and password.

It should be owned by your user with permissions of `0600`.

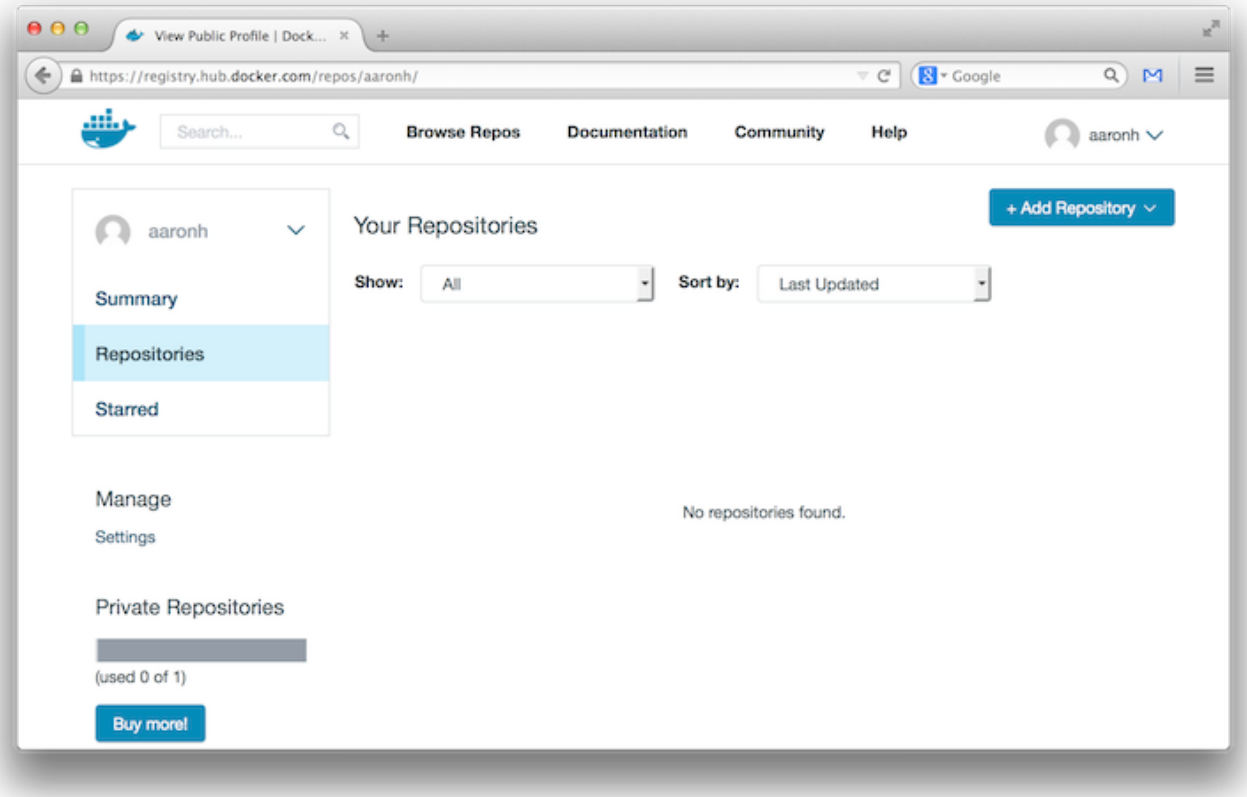
You should protect this file!

Navigating Docker Hub



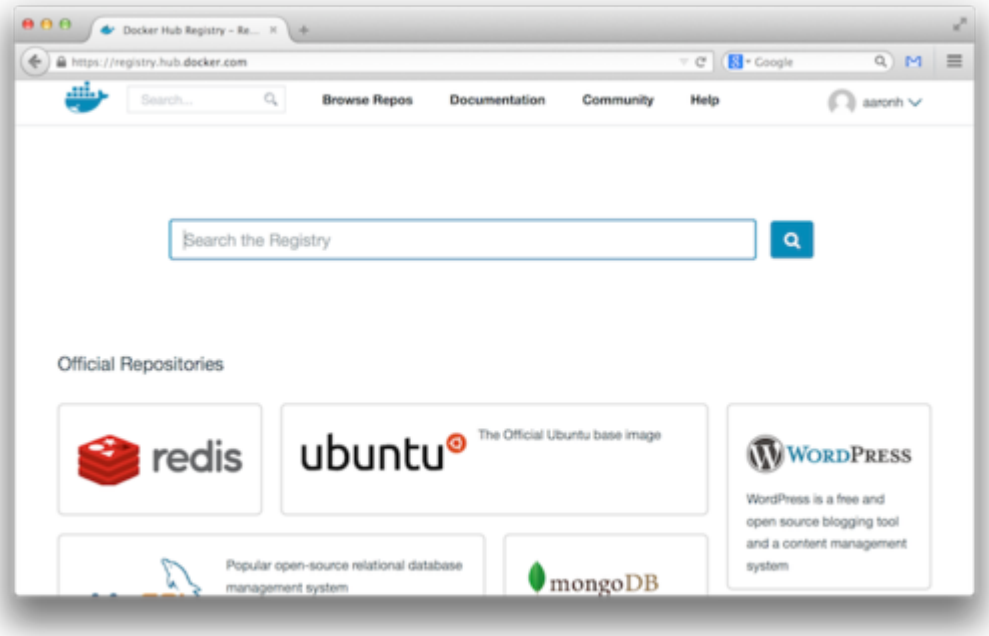
Repositories

- Store all public and private images in the registry
- Apply to your namespace
- Empty!



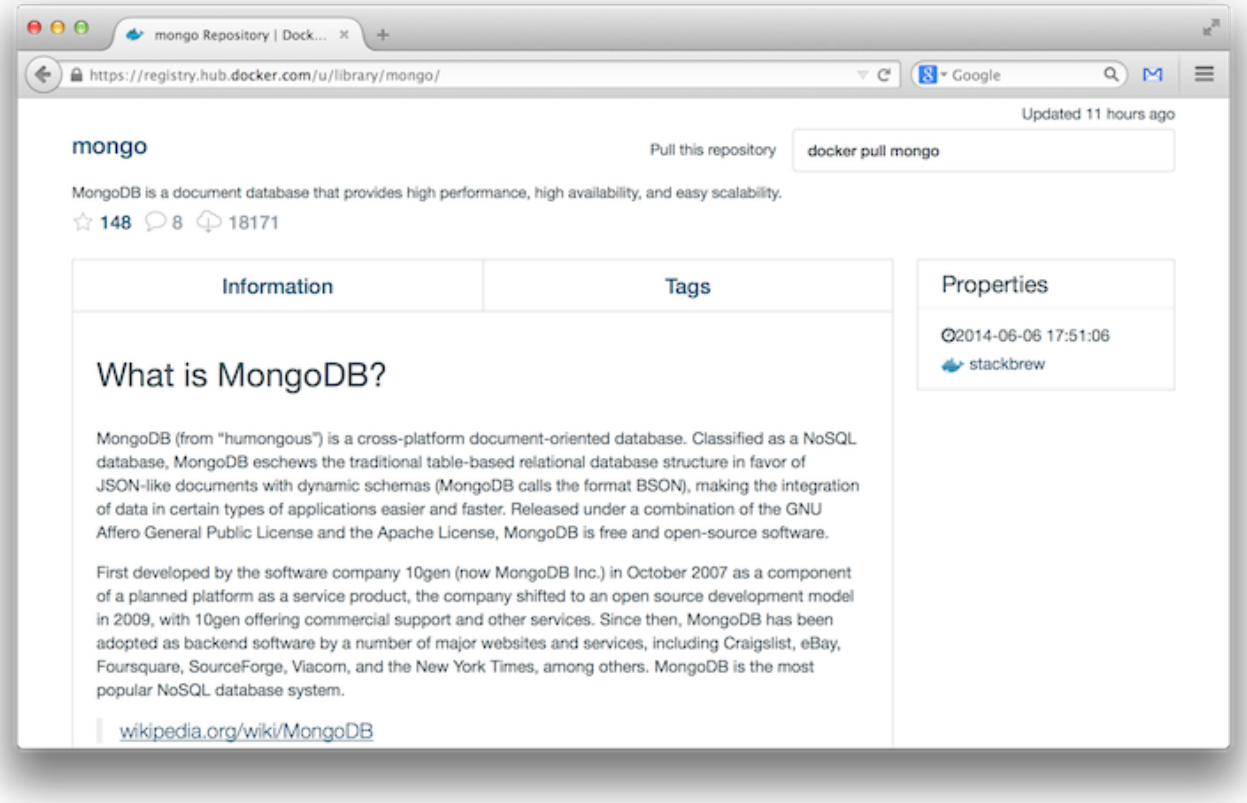
Public Repositories

- Docker Hub provides access to tens of thousands of pre-made images that you can build from.
- Some of these are `official builds` and live in the root namespace.
- Most are community contributed and maintained.



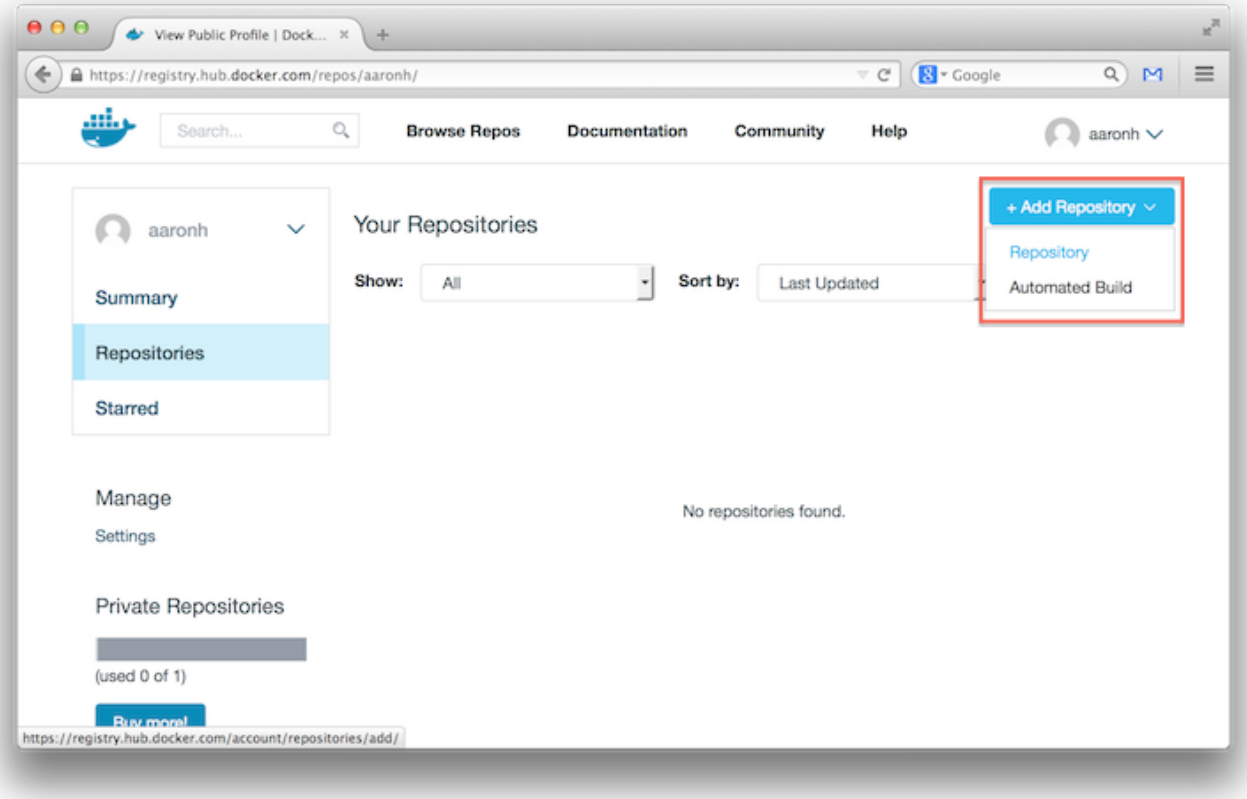
Official Repositories

- Are maintained by the product owners
- Blessed by Docker



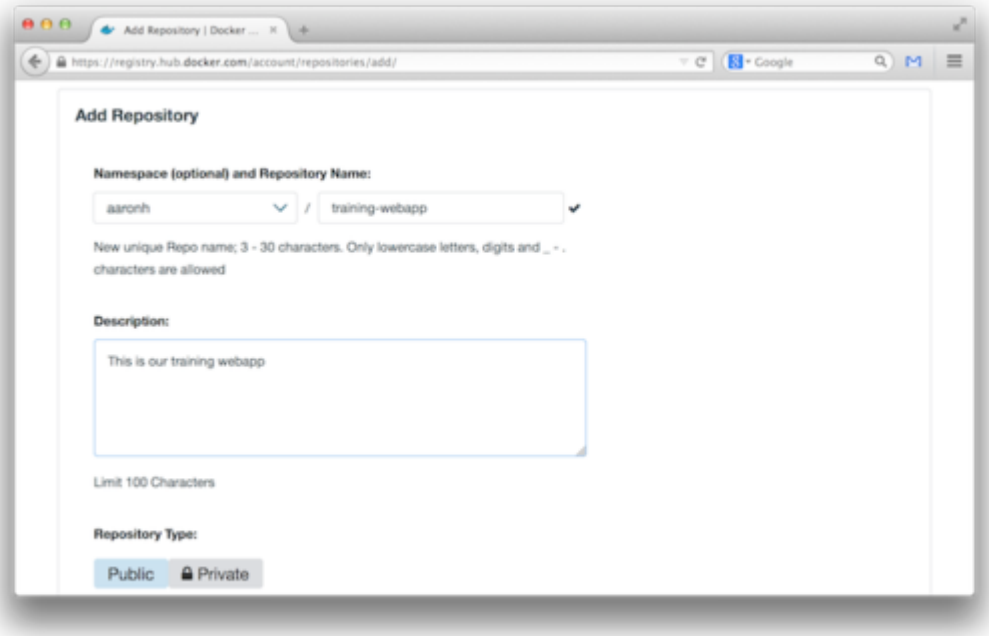
New Repository (1/3)

- Pull down `Add Repository` menu and select `Repository`



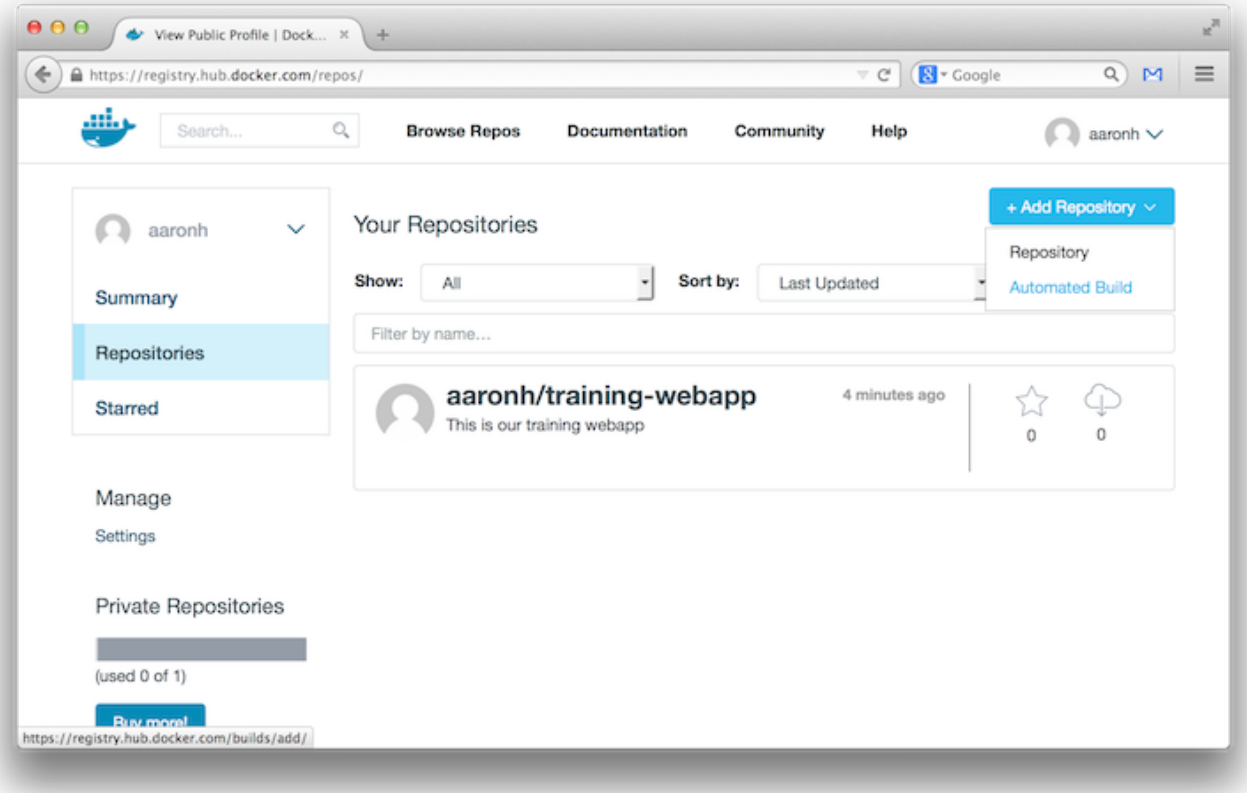
New Repository (2/3)

- Leave `namespace` at the default (your username)
- Give your repository a name
- Type a brief description so people know what it is
- Leave `Public` selected
- Submit the form with `Add Repository` button (not shown)



New Repository (3/3)

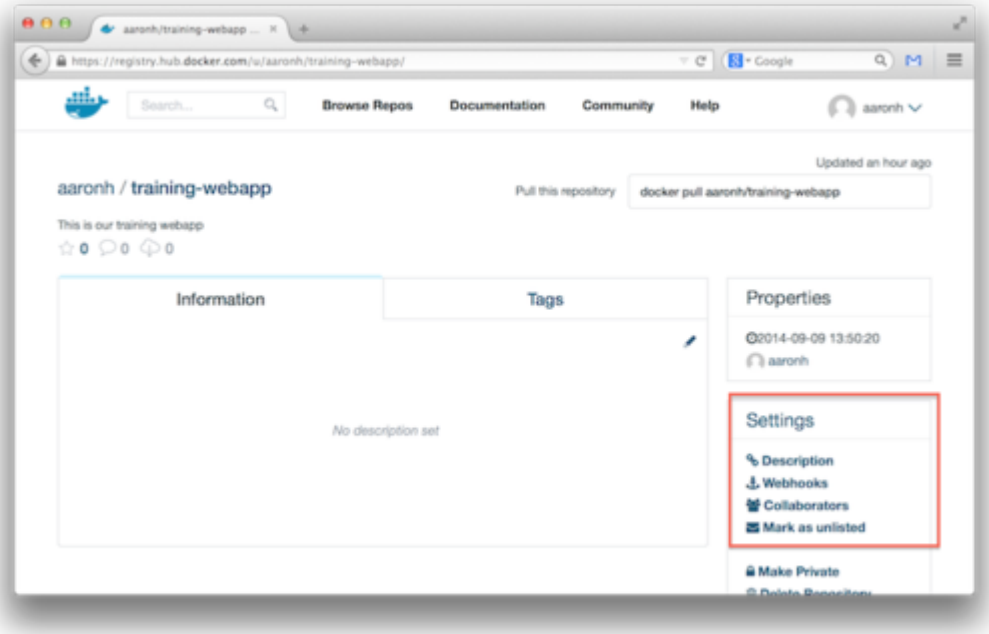
- Click `Repositories` and you will see your new repository.
- You can push images to this repository from the `docker` commandline.
- More on this later.



Repository Settings

You can change the following:

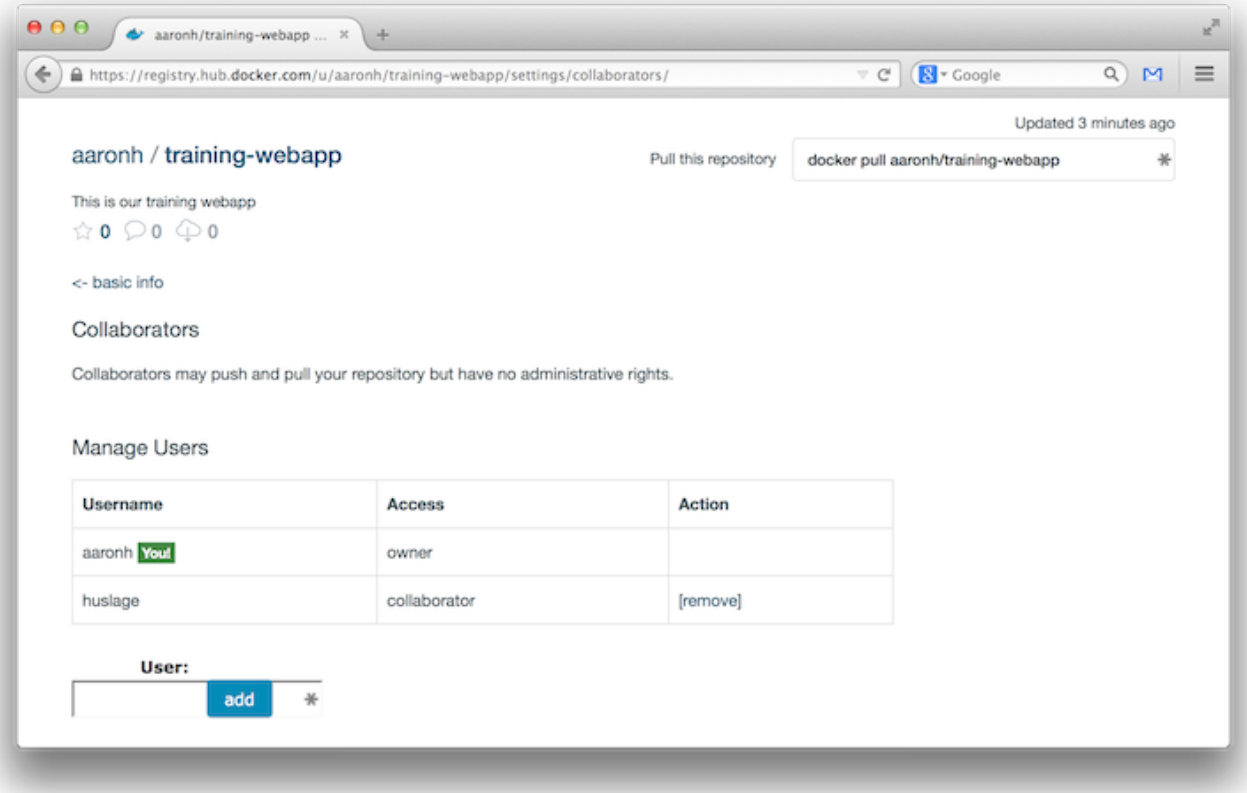
- Repository Description
- Webhooks
- Collaborators
- Mark as unlisted in the global search (NOT a private repository)



Collaborators

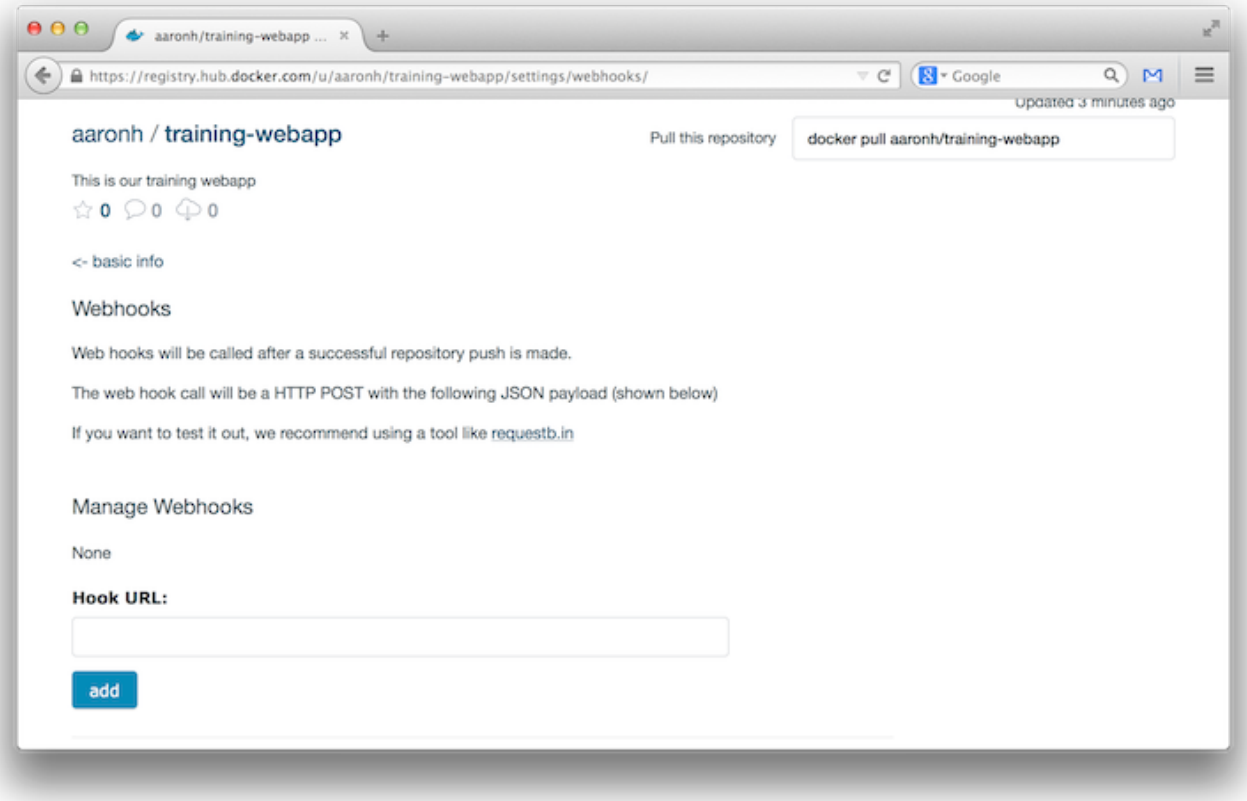
You can invite other Docker Hub to collaborate on your projects.

- Collaborators cannot change settings in the repository.
- Collaborators can push images to the repository.



Webhooks

- Notify external applications that an image has been uploaded to the repository.
- Powerful tool for integrating with your development workflow.
- Even more powerful when used with Automated Builds.



Automated Builds

- Automatically build an image when source code is changed.
- Integrated with Github and Bitbucket
- Work with public and private repositories
- Add the same as a regular repository, select `Automated Build` from the `Add Repository` menu
- We'll set one of these up later!
    - You will need a Github account to follow along later, so go ahead and create one now if you don't have one yet.

Section summary

We've learned how to:

- Register for an account on Docker Hub.
- Login to your account from the command line.
- Access some special Docker Hub features for better workflows.

Working with Images

Lesson 18: Working with Images

Objectives

At the end of this lesson, you will be able to:

- Pull and push images to the Docker Hub.
- Explore the Docker Hub.
- Understand and create *Automated Builds*.

Working with images

In the last section we created a new image for our web application.

This image would be useful to the whole team but how do we share it?

Using the Docker Hub!

Pulling images

Earlier in this training we saw how to pull images down from the Docker Hub.

```
$ docker pull ubuntu:14.04
```

This will connect to the Docker Hub and download the `ubuntu:14.04` image to allow us to build containers from it.

We can also do the reverse and push an image to the Docker Hub so that others can use it.

Before pushing a Docker image ...

We push images using the `docker push` command.

Images are uploaded via HTTP and authenticated.

You can only push images to the *user namespace*, and with your own username.

This means that you cannot push an image called `web`.

It has to be called `<dockerhubUsername>/web`.

Name your image properly

Here are different ways to ensure that your image has the right name.

Of course, in the examples below, replace `<dockerhubUsername>` with your actual login on the Docker Hub.

- If you have previously built the `web` image, you can re-tag it:

```
$ docker tag web <dockerhubUsername>/web
```

- Or, you can also rebuild it from scratch:

```
$ docker build -t <dockerhubUsername>/web \
  git://github.com/docker-training/
staticweb.git
```


Pushing a Docker image to the Docker Hub

Now that the image is named properly, we can push it:

```
$ docker push <dockerhubUsername>/web
```

You will be prompted for a user name and password.

(Unless you already did `docker login` earlier.)

```
Please login prior to push:
Username: <dockerhubUsername>
Password: *********
Email: ...
Login Succeeded
```

You will login using your Docker Hub name, account and email address you created earlier in the training.

More about pushing an image

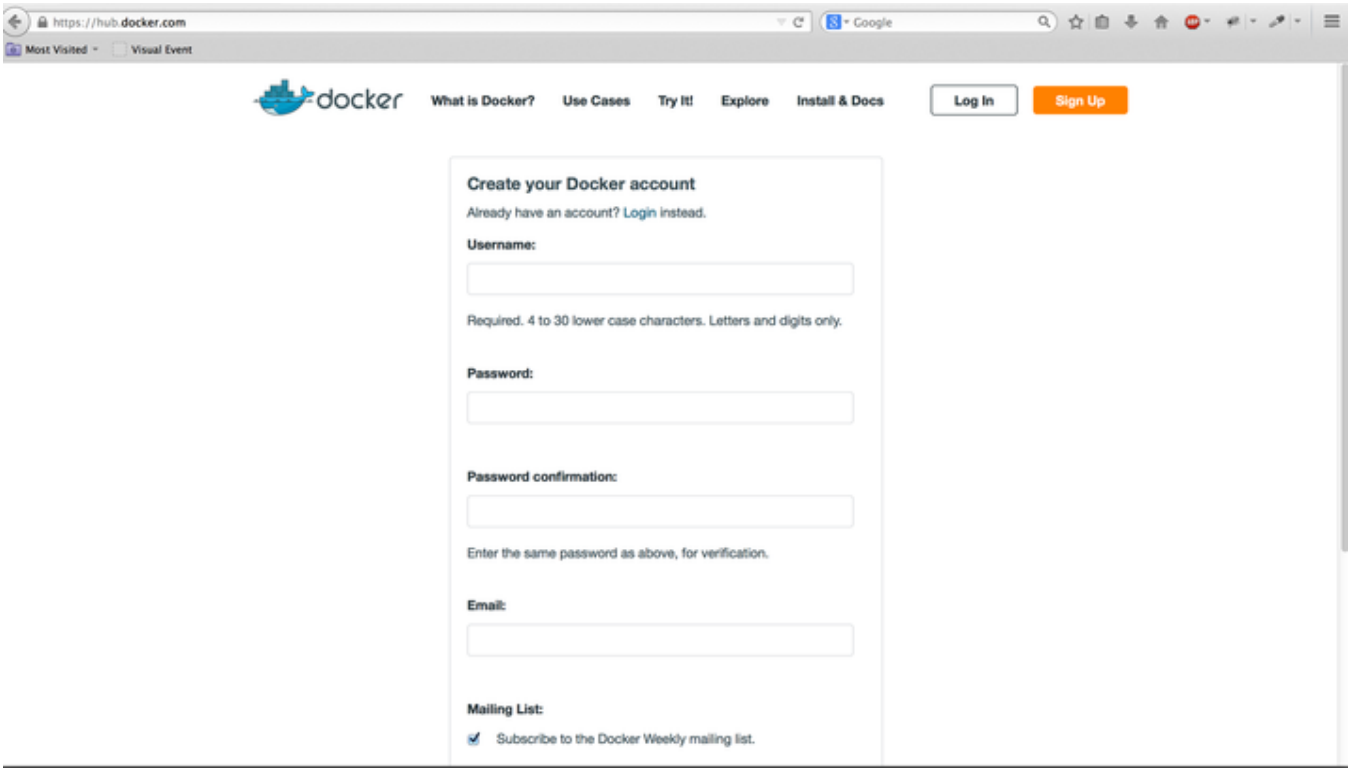
- If the image doesn't exist on the Docker Hub, a new repository will be created.
- You can push an updated image on top of an existing image. Only the layers which have changed will be updated.
- When you pull down the resulting image, only the updates will need to be downloaded.

Viewing our uploaded image

Let's sign onto the Docker Hub and review our uploaded image.

Browse to:

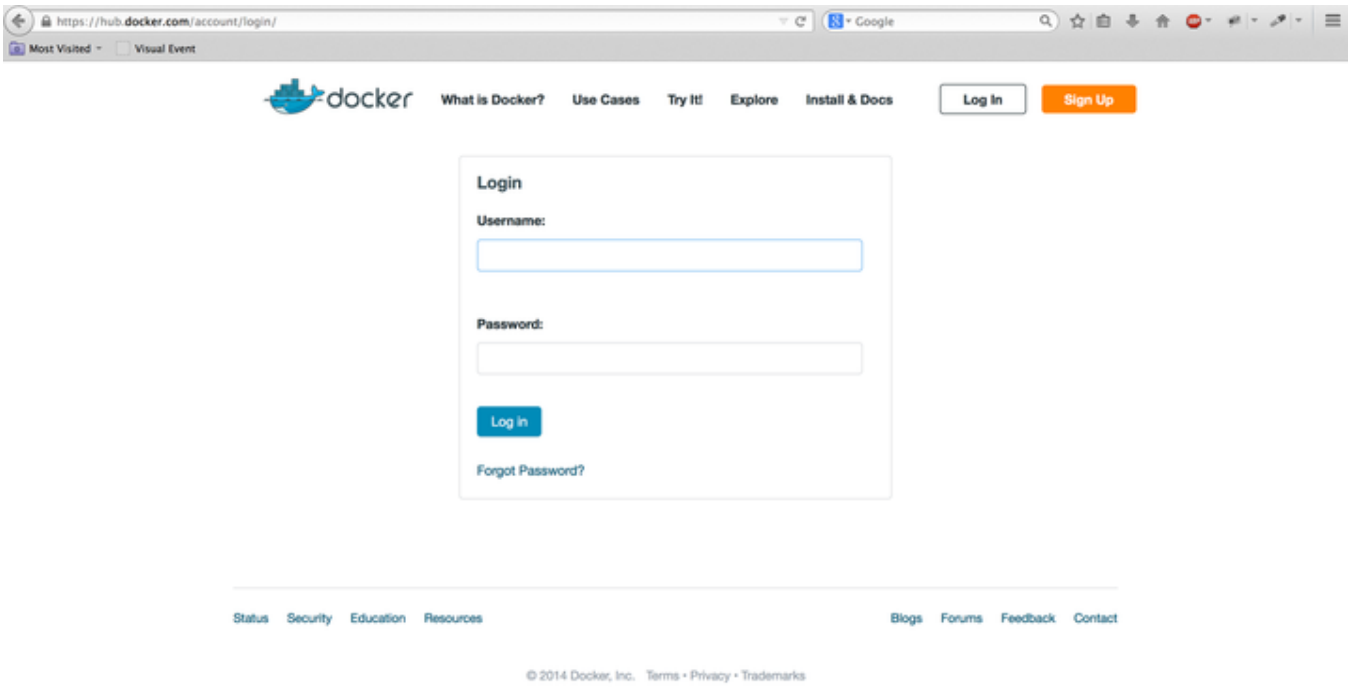
```
https://hub.docker.com/
```



Logging in to the Docker Hub

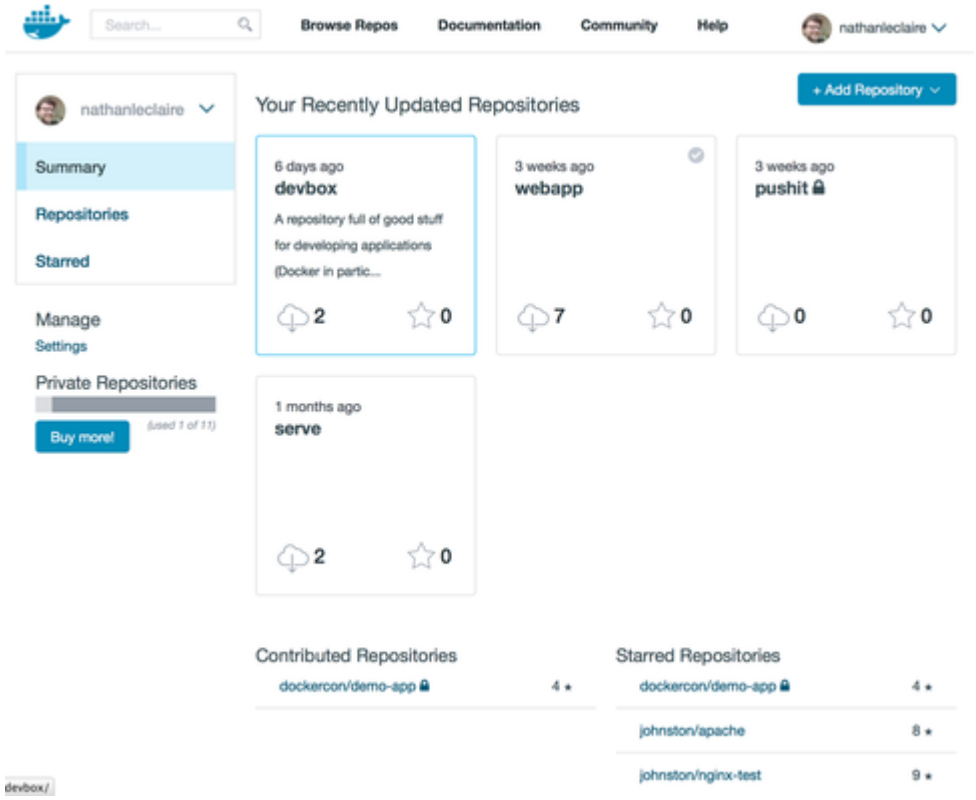
Now click the `Login` link and fill in the `Username` and `Password` fields.

And clicking the `Log In` button.



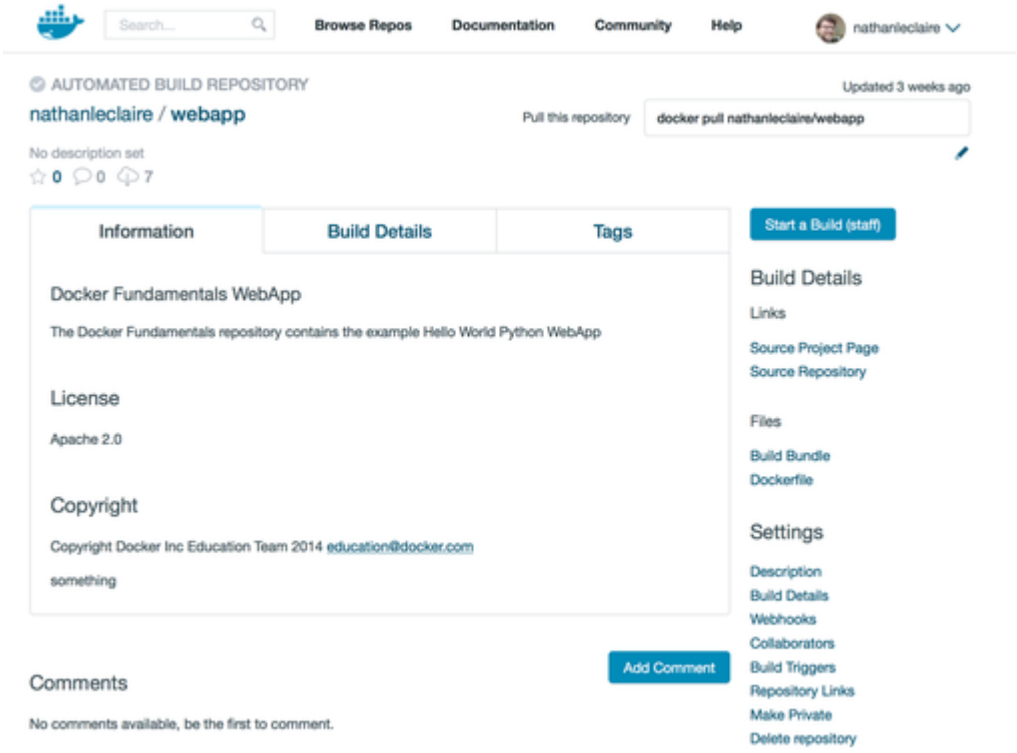
Your account screen

This is the master account screen. Here you can see your repositories and recent activity.



Review your webapp repository

Click on the link to your `<dockerhubUsername>/web` repository.



- You can see the basic information about your image.
- You can also browse to the `Tags` tab to see image tags, or navigate to a link in the "Settings" sidebar to configure the repo.

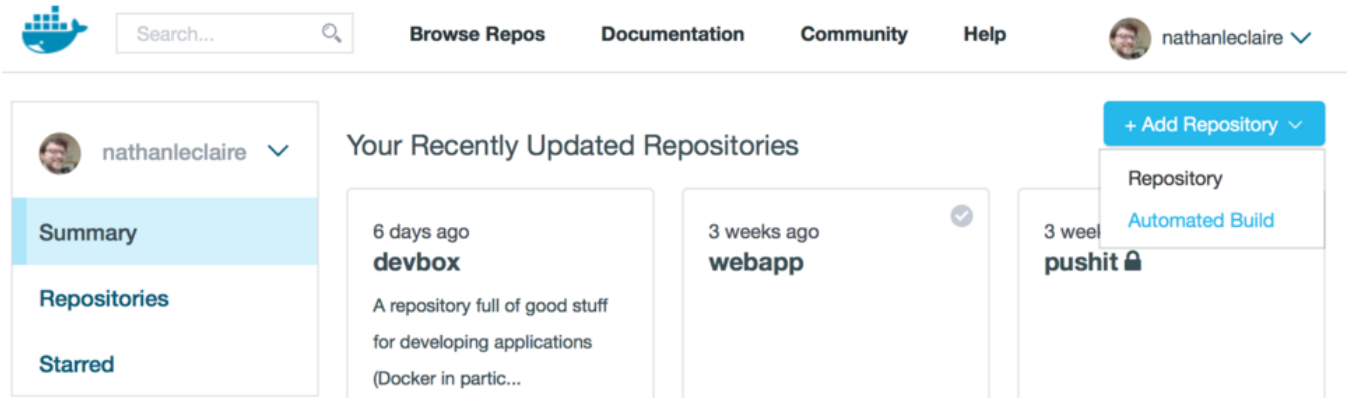
Automated Builds

In addition to pushing images to Docker Hub you can also create special images called *Automated Builds*. An *Automated Build* is created from a `Dockerfile` in a GitHub repository.

This provides a guarantee that the image came from a specific source and allows you to ensure that any downloaded image is built from a `Dockerfile` you can review.

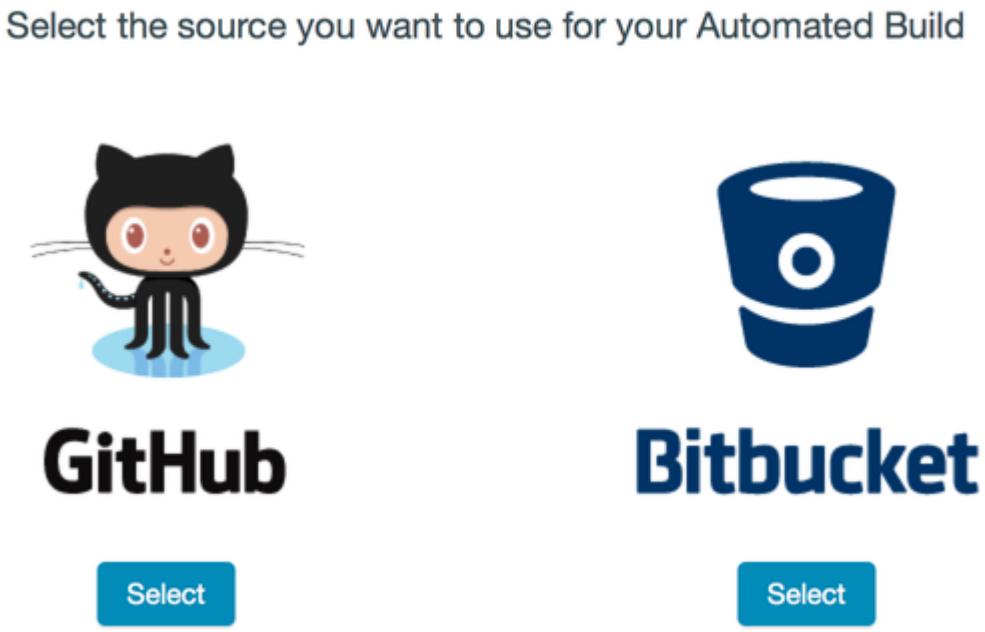
Creating an Automated build

To create an *Automated Build* click on the `Add Repository` button on your main account screen and select `Automated Build`.



Connecting your GitHub account

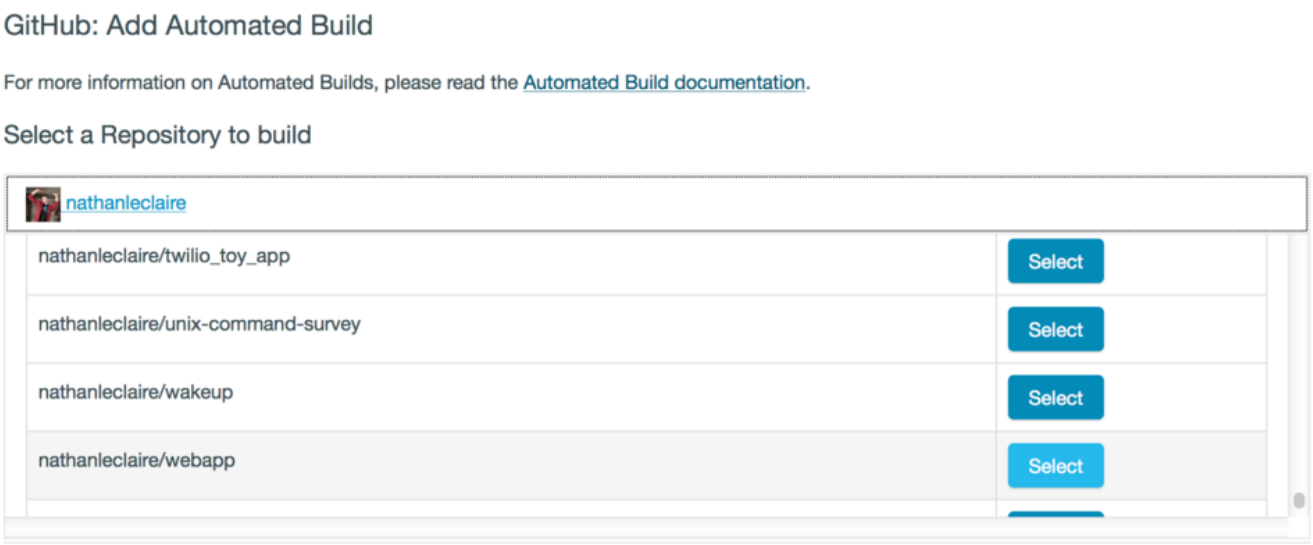
If this is your first *Automated Build* you will be prompted to connect your GitHub account to the Docker Hub.



Select specific GitHub repository

You can then select a specific GitHub repository.

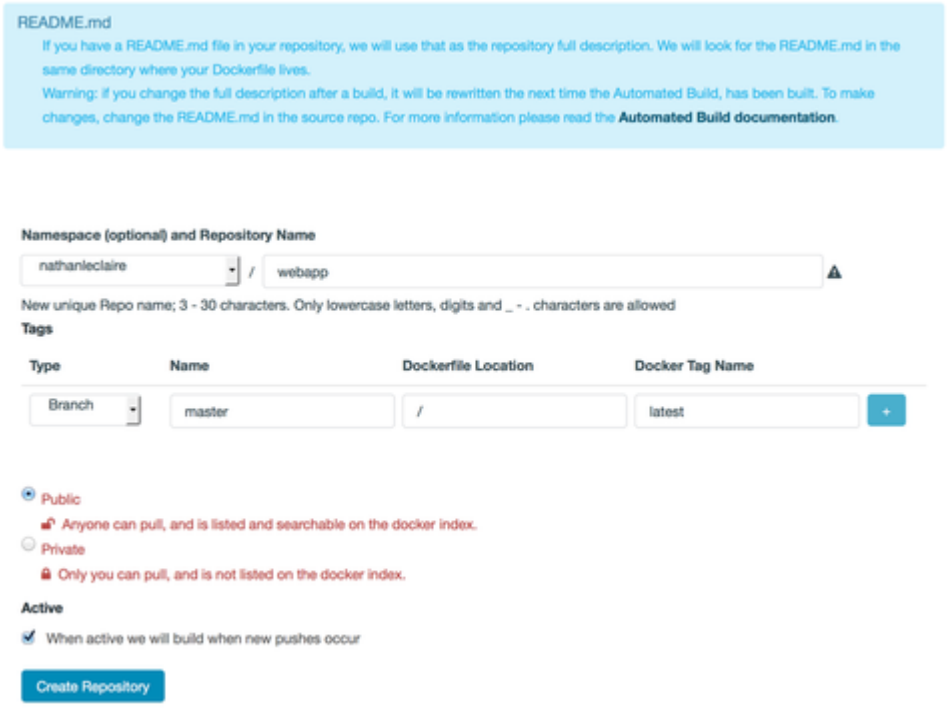
It must contain a `Dockerfile`.



If you don't have a repository with a Dockerfile, you can fork https://github.com/docker-training/staticweb, for instance.

Configuring Automated Build

You can then configure the specifics of your *Automated Build* and click the `Create Repository` button.



Automated Building

Once configured your *Automated Build* will automatically start building an image from the `Dockerfile` contained in your Git repository.

Every time you make a commit to that repository a new version of the image will be built.

Section summary

We've learned how to:

- Pull and push images to the Docker Hub.
- Explore the Docker Hub.
- Understand and create *Automated Builds*.

Using Docker for testing

Lesson 19: Using Docker for testing

Objectives

At the end of this lesson, you will be able to:

- Dockerize a Flask (Python) web application and its tests
- Integrate this Dockerized application with Jenkins for CI
- Use Web Hooks with Automated Builds to automate testing and deployment.

Docker for software testing

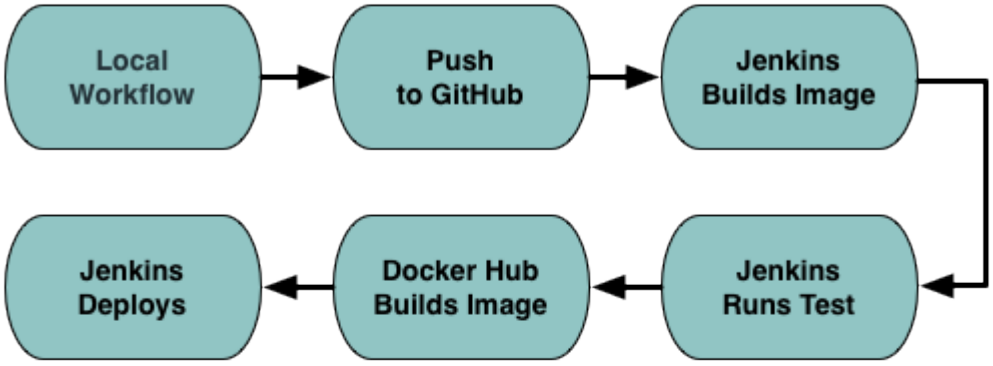
One of Docker's popular use cases is to better enable testing.

We're going to see how to integrate Docker into a Continuous Integration workflow.

To do this we're going to assume that every time we update an application that we want to rebuild its image and run the application's tests.

What we want

1. Every time our code changes we want our image rebuilt.
2. Every time our code changes we want the tests run against our new image.
3. If the tests are good, deploy the new code.



The plan

- Use a simple web application based on Python Flask.
- Look at the `Dockerfile` for that application.
- Look at the test suite for that application.
- Create a Automated Build for that application.
- Configure a Web Hook to trigger a Jenkins build.

Why?

This flow is designed to use all of the power of Docker Hub to distribute and maintain your repositories and images. It allows you to maintain the integrity and availability of images to all of your hosts. It also allows you to easily utilize any future Docker Hub features.

- We recommend using Docker Hub's repositiories as a known-good source of images for your deployments.
- The CI system (Jenkins in this case) should run tests inside of the same environments as development and production.
- Docker Hub should build all images that will be deployed to production environments.
- The CI system should be able to block Docker Hub from building an image if there is a test failure.
- The deployment system (also Jenkins in this case) should only deploy images that are built on Docker Hub.

Our web application

For simplicity, we are going to use a tiny Python Flask application, called `webapp`.

We're going to use this application as our example of using Docker for continous integration.

The webapp Dockerfile

Let's look at the `Dockerfile` for that application.

```
FROM ubuntu:14.04
MAINTAINER Docker Education Team <education@docker.com>
RUN apt-get update
RUN DEBIAN_FRONTEND=noninteractive apt-get install -y -q python-all python-pip
ADD ./webapp/requirements.txt /tmp/requirements.txt
RUN pip install -qr /tmp/requirements.txt
ADD ./webapp /opt/webapp/
WORKDIR /opt/webapp
EXPOSE 5000
CMD ["python", "app.py"]
```

You can see the `Dockerfile` and the application on GitHub:

https://github.com/docker-training/webapp

The webapp Dockerfile explained

Our `Dockerfile` is pretty simple:

- We use an Ubuntu 12.04 image as the base.
- We install basic prerequisites, like Python.
- We add the contents of the `webapp` directory that holds our application code.
- We specify the working directory of the image as `/opt/webapp`.
- We install the application's Python-based dependencies using `pip`.
- We expose port 5000 to serve our application on.
- Finally, our application is launched using `python app.py`.

Our Flask tests

Inside our application, in tests.py, we've also got a simple Python test for our Flask application.

```
from app import app

import os
import unittest

class AppTestCase(unittest.TestCase):

    def test_root_text(self):
        tester = app.test_client(self)
        response = tester.get('/')
        assert 'Hello world!' in response.data

if __name__ == '__main__':
    unittest.main()
```


Forking our GitHub repository

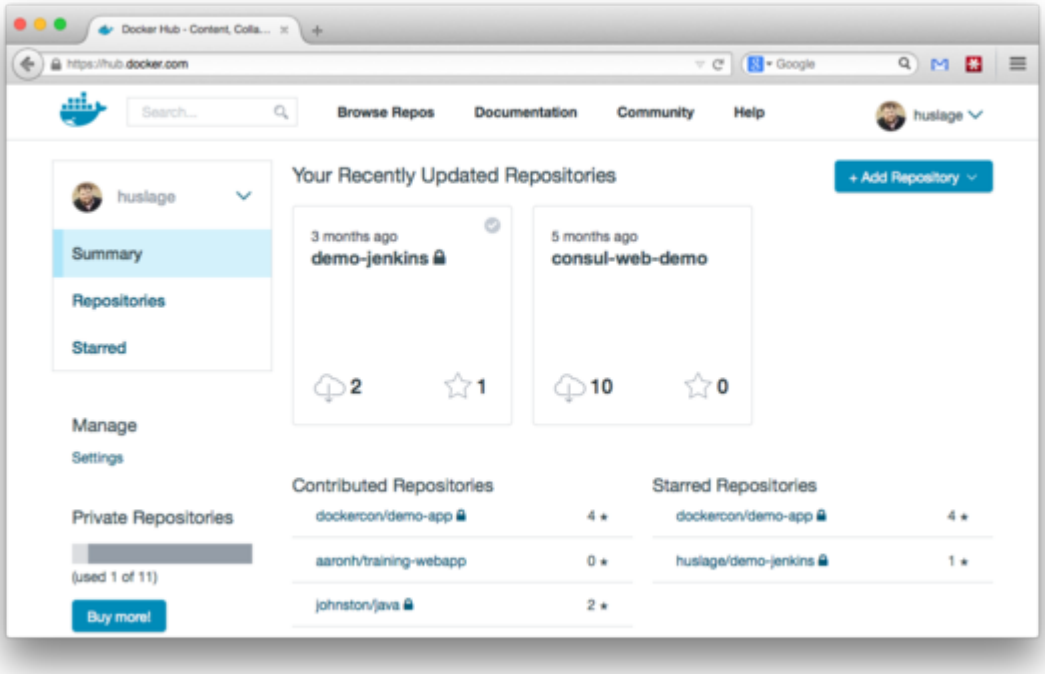
We need a place to put our code changes that will trigger this whole flow. Let's fork the docker-training/webapp repository.

Go to http://github.com/docker-training/webapp. Click `Fork` in the upper-right corner. This will create a new repository under your account to hold changes that you make.

Adding a new Automated Build

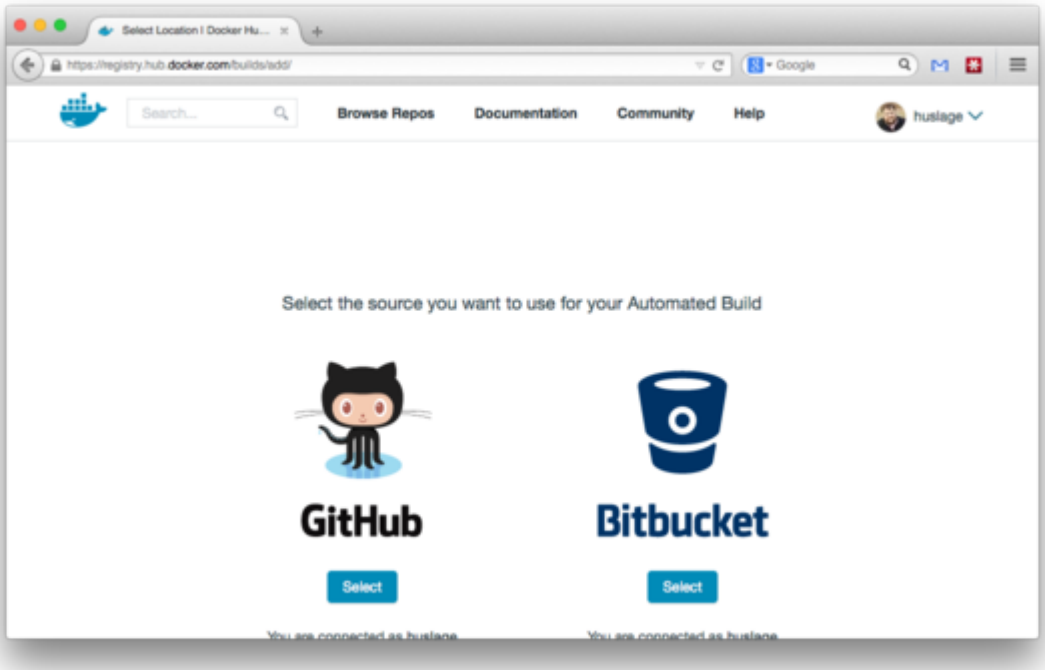
Go to your Docker Hub profile page and click:

`Add automated (source) build`



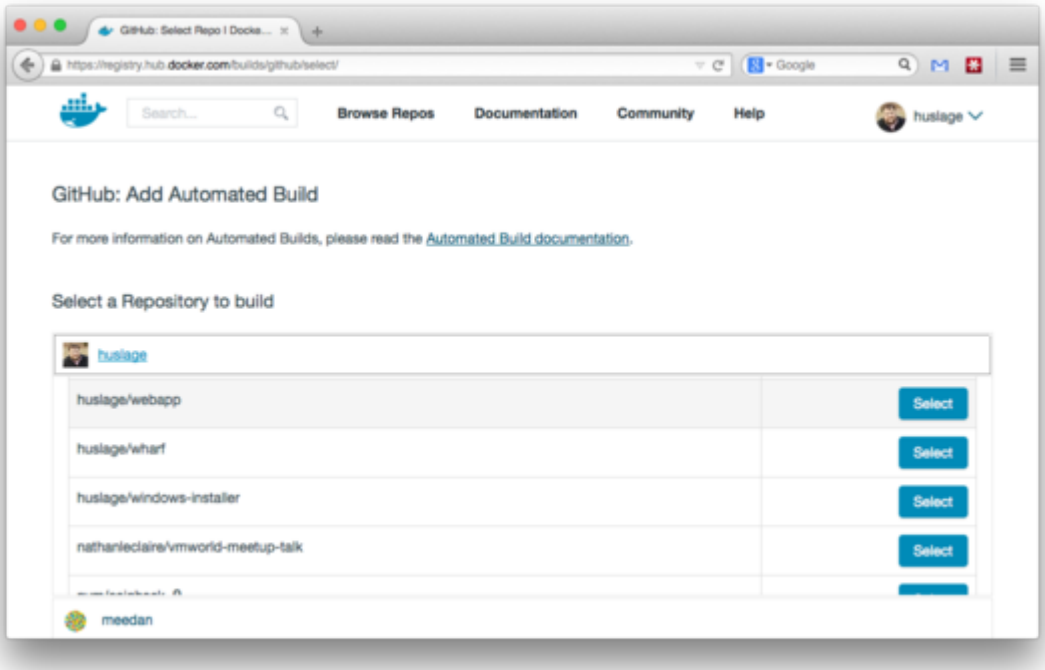
Selecting the Source Code Service

Click on `GitHub` for the service you want to use.



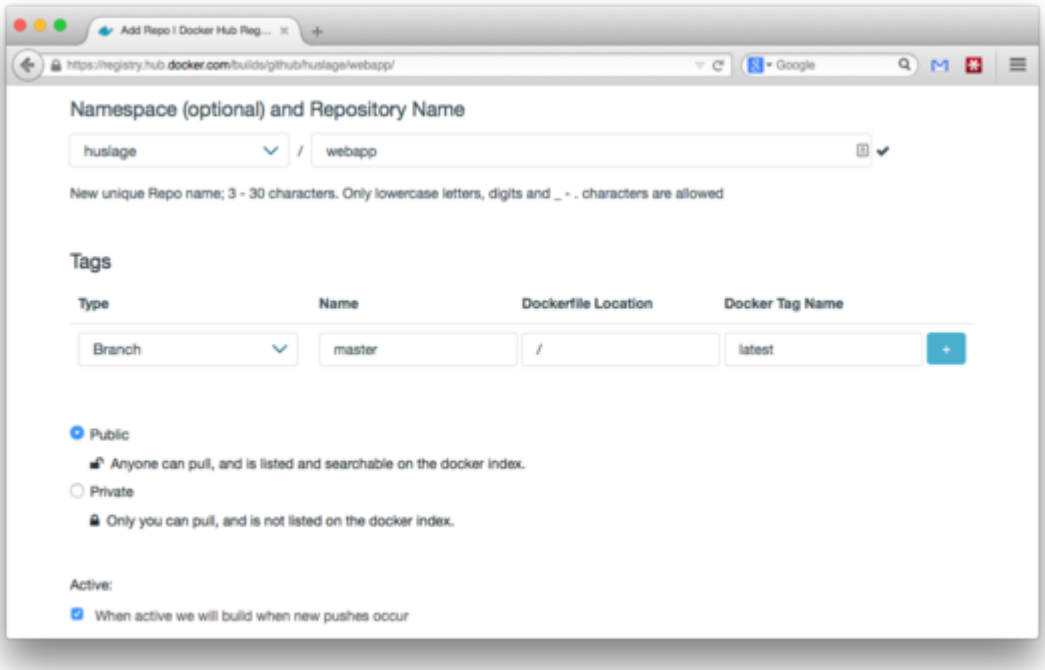
Selecting the repository

We then select the webapp repository from your GitHub Account.



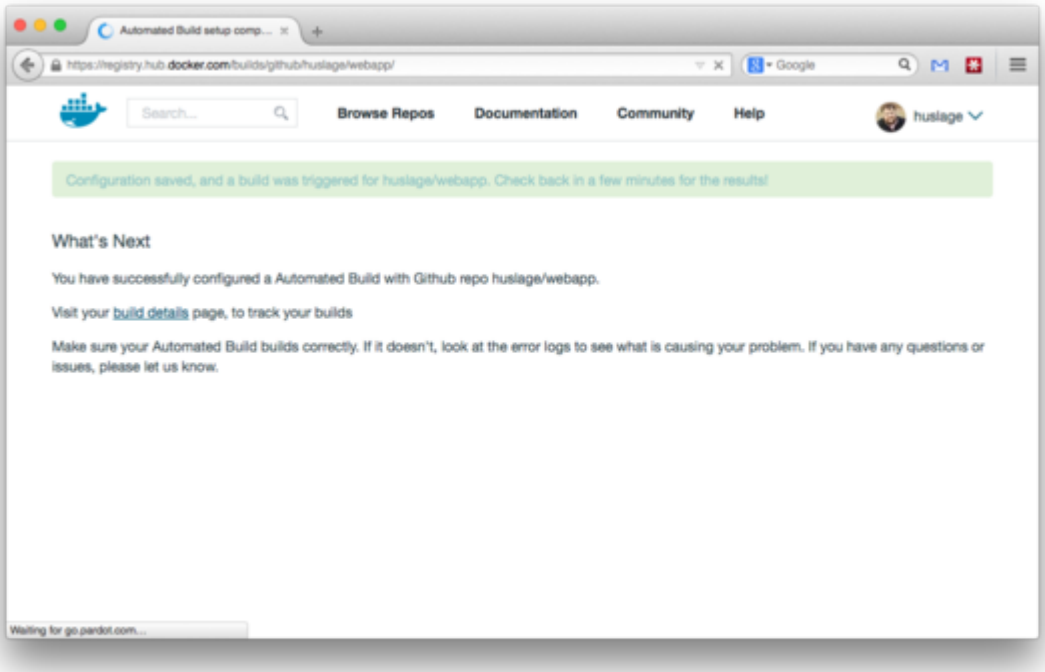
Configuring the build

We then configure our Automated Build and click the `Create Repository` link.



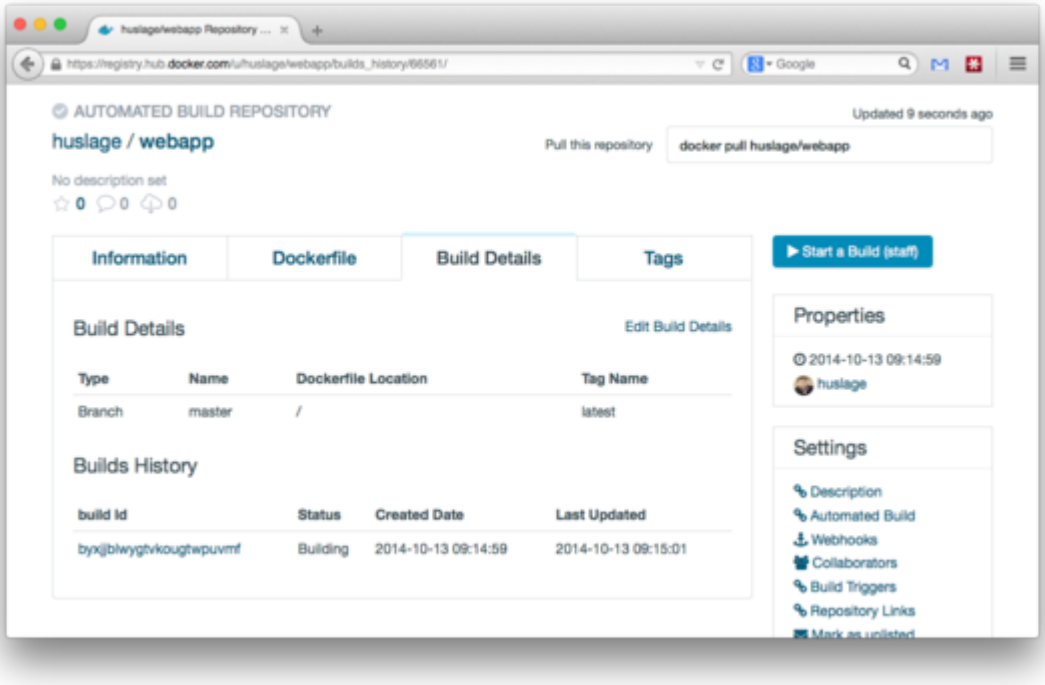
Success

This is what success looks like. Drink it in.



Build status page

If you click on `Automated Builds` on the left sidebar, you can view the status of your build. When you create a new build, we automatically run it the first time. How handy!



Run Jenkins

We can use an existing Docker image to run Jenkins, `nathanleclaire/jenkins`. Let's run a Jenkins instance now from this image.

```
$ docker run -d --name=jenkins -p 8080:8080 \
 -v /var/run/docker.sock:/var/run/docker.sock \
 -e DOCKERHUB_ID=<Your Docker Hub ID> \
 -e DOCKERHUB_EMAIL=<Your Docker Hub Email> \
 -e GITHUB_ID=<Your GitHub ID> \
 nathanleclaire/jenkins
```

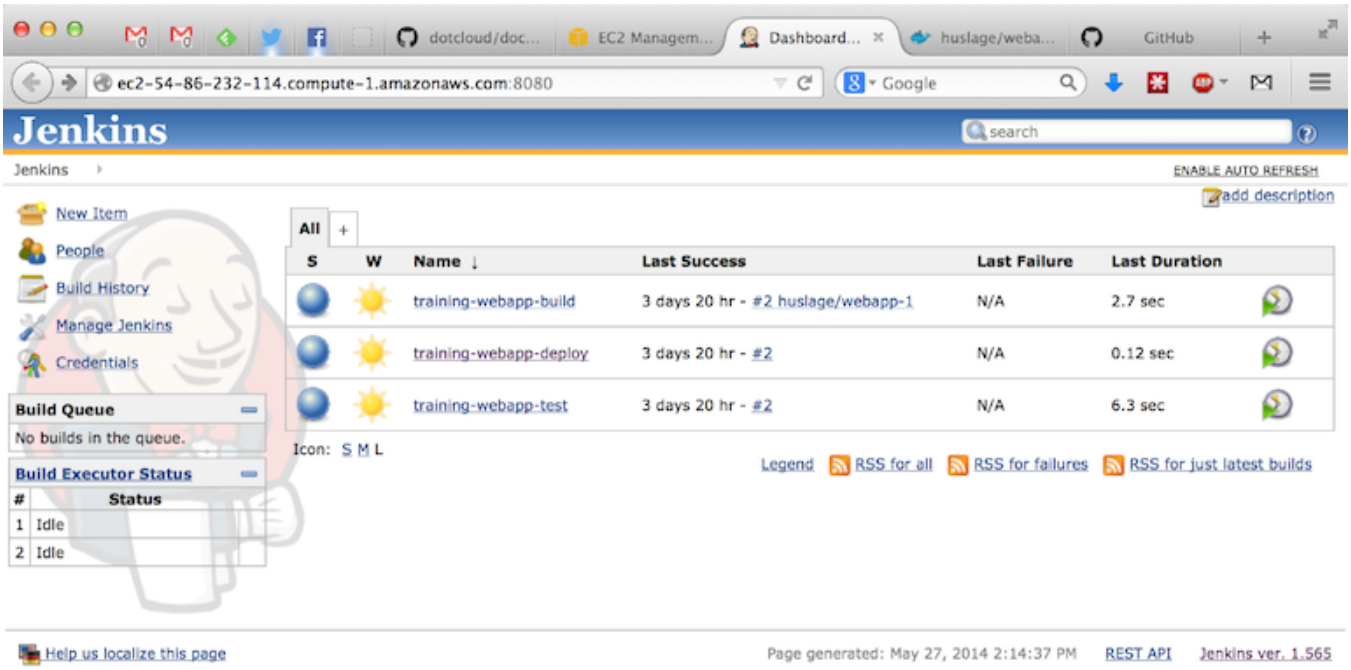
This will launch a container from our `nathanleclaire/jenkins` image and bind it to port `8080` on our local host. The `-e` options pass environment variables to the script that runs Jenkins. They configure the built-in jobs so that you don't have to.

P.S. If you're interested you can see the `Dockerfile` that built this image:

https://github.com/docker-training/jenkins/blob/master/Dockerfile

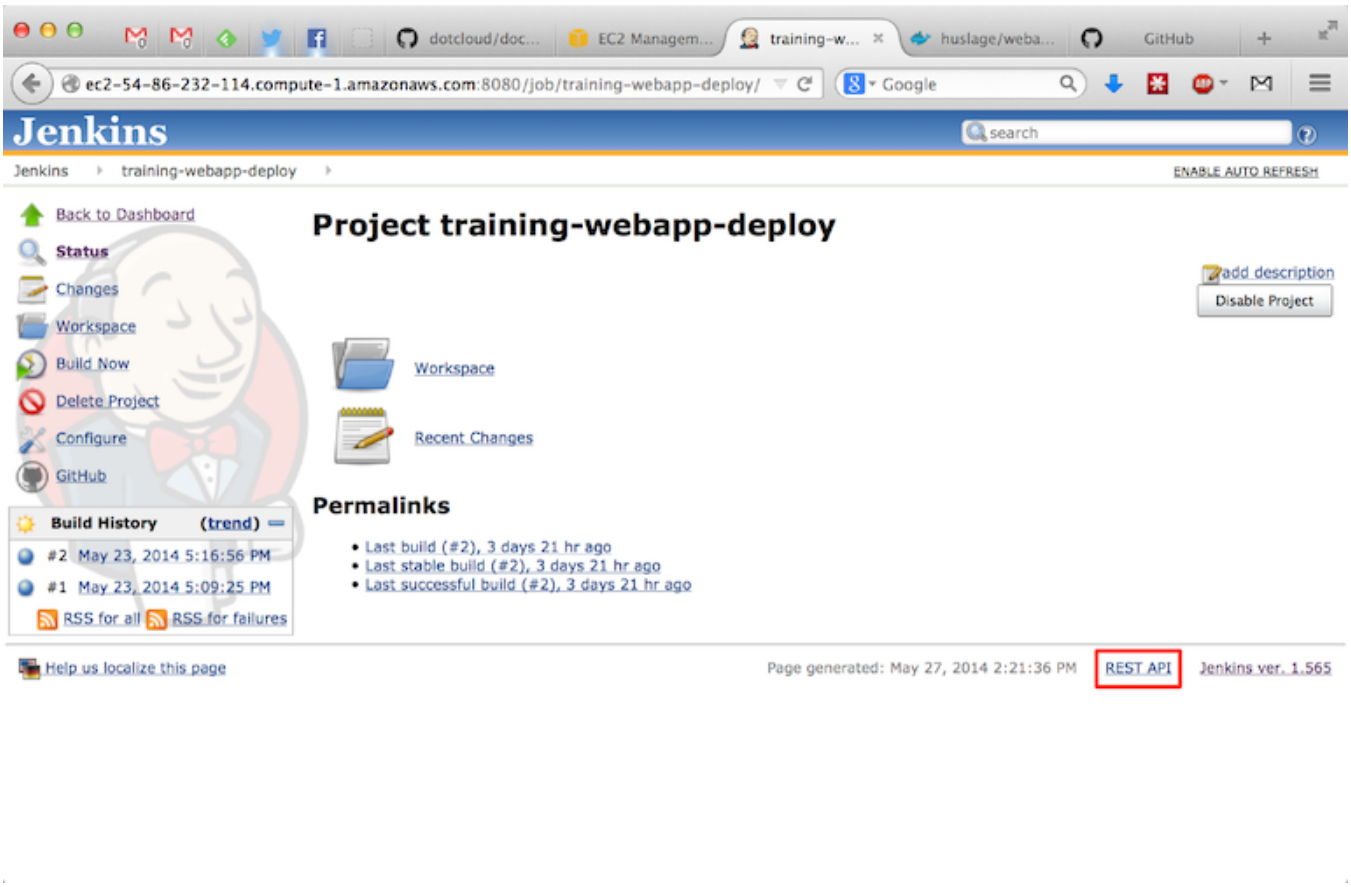
Configure Jenkins

Our Jenkins image is already pre-populated with jobs that will run our Webapp tests. Go to the URL of your Jenkins instance



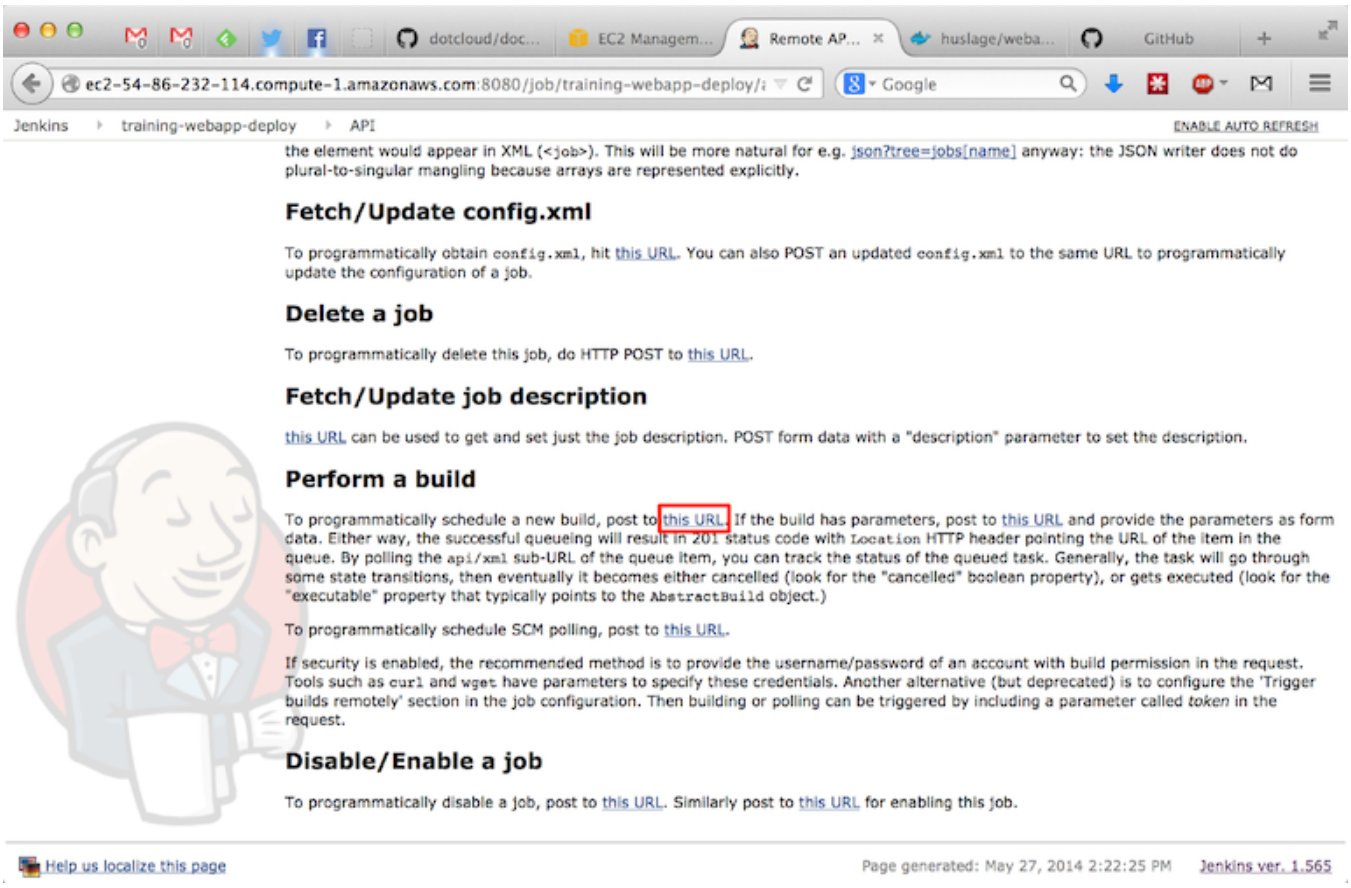
Configuring Deploy Job

We're almost done. Now we need to set up a trigger for the deployment step. From the Jenkins Dashboard click the `training-webapp-deploy` job. In the bottom-right of the page you will see a link for the REST API. Click that link.

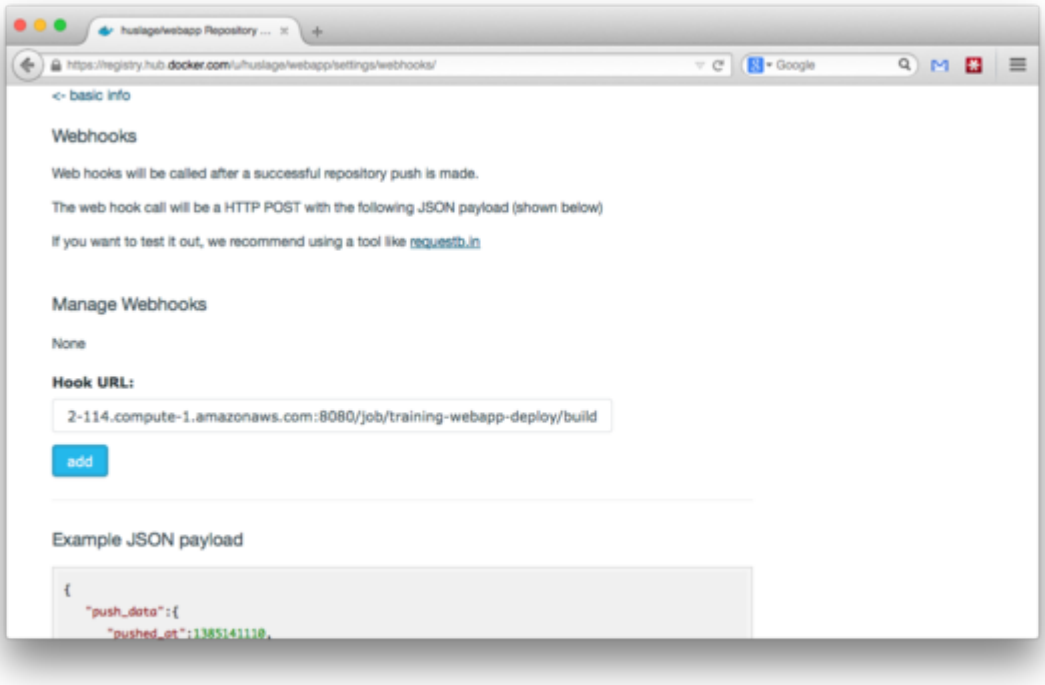


Get the build link URL

Scroll down a bit to the `Perform a build` section. Copy the link where it says `Post to this URL`.



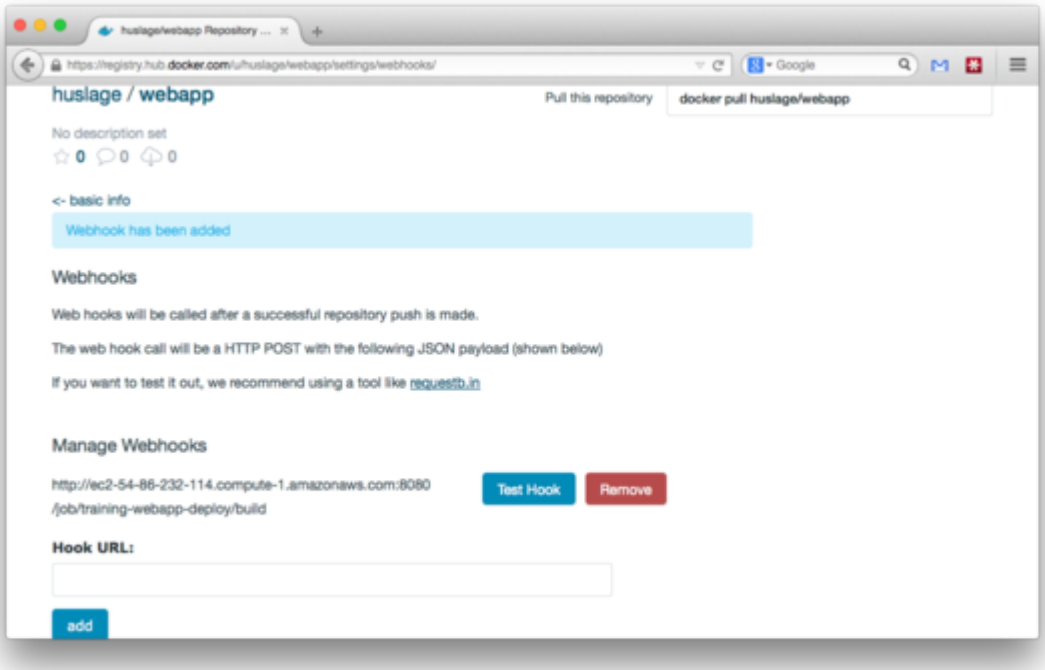
Go back to your webapp Docker Hub repository Settings and click Webhooks on the left sidebar. Paste the URL you just copied into the Hook URL box.



Click Add

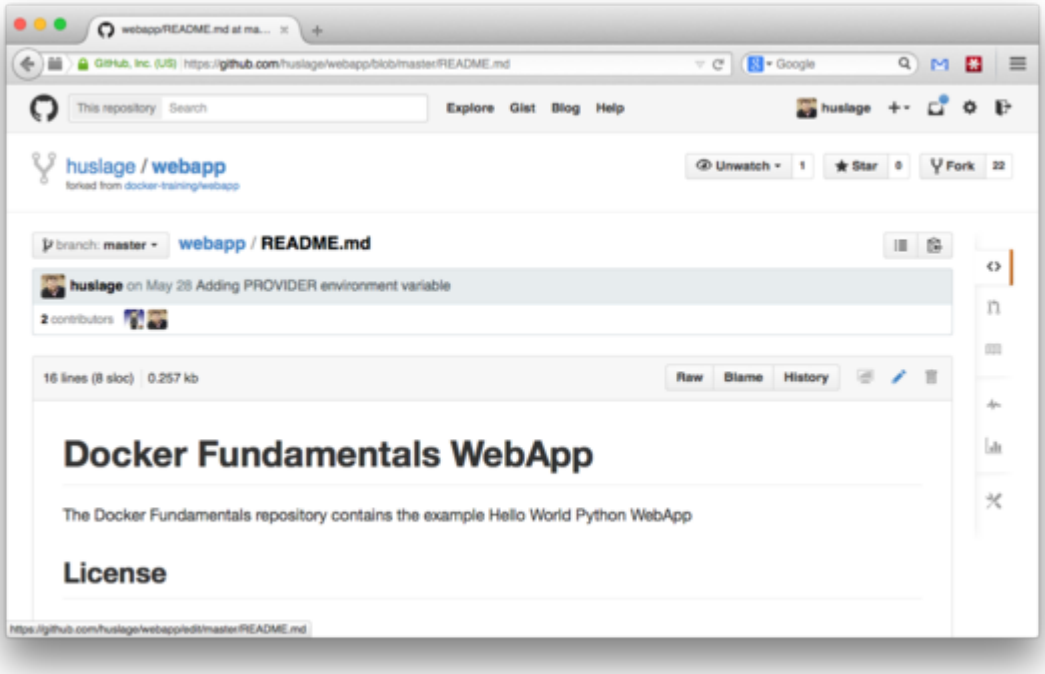
More Success!

We have successfully added a webhook.



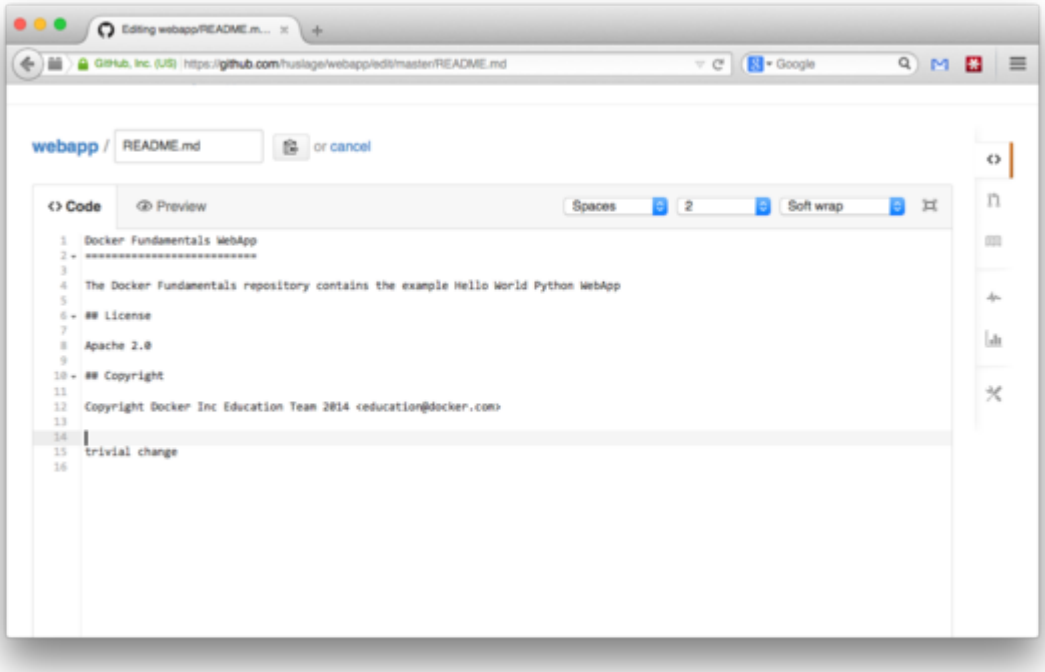
Make some changes

Now we need to make a change to the repository. From the repository home page, click on `README.md`. Then click `Edit` on the top of the next page.



Trivial changes are best

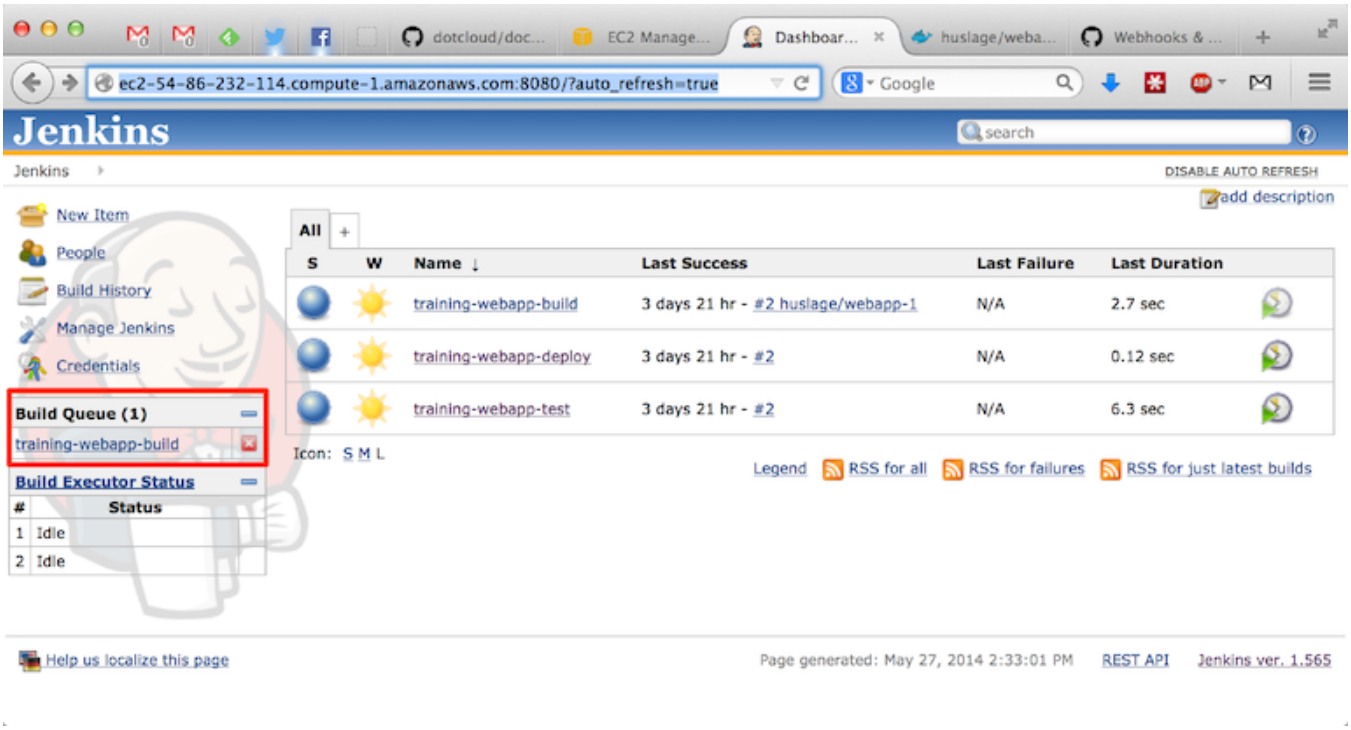
When the edit box comes up, add some text to the bottom of the file. Then scroll to the bottom of the page and click `Commit Changes`.



The Jenkins job will be triggered by this action!

Watch it go

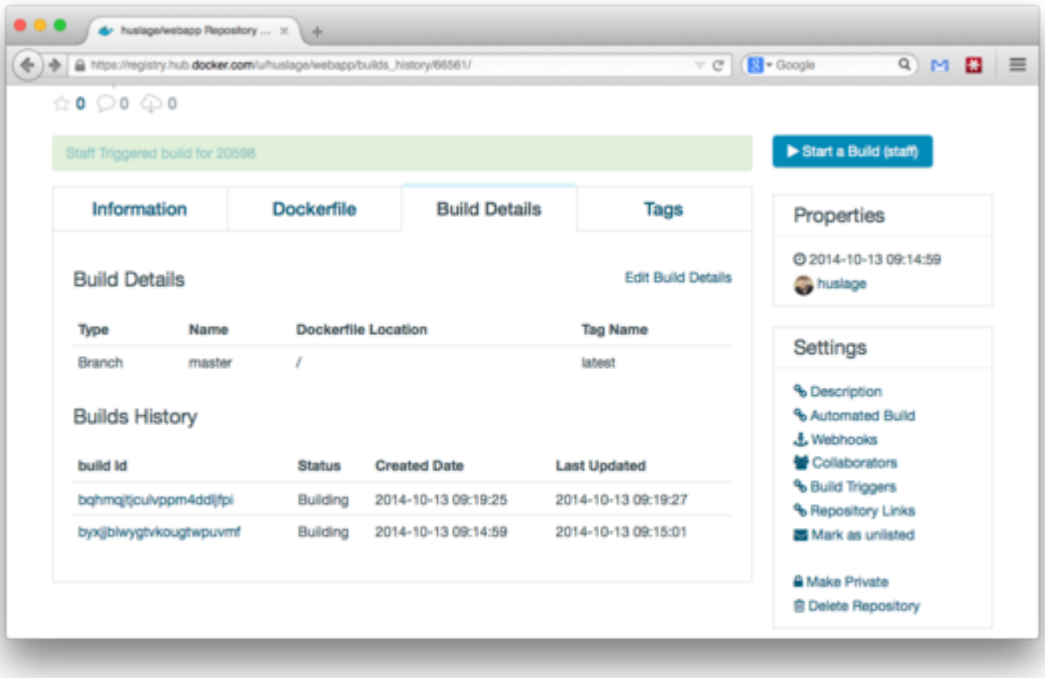
Go back to your Jenkins dashboard. You will see a job running or queued.



Automation in Action

When the `training-webapp-test` job finishes, you can look at the `Build Status` page on your Automated Build. It should build fine.

You can also try bOrking the source code to see that it fails ;)



Section summary

We've learned how to:

- Dockerize a Flask (Python) web application and its tests
- Integrate this Dockerized application with Jenkins for CI
- Use Web Hooks with Automated Builds to automate testing.

Security

Lesson 20: Security

Objectives

At the end of this lesson, you will know:

- The security implications of exposing Docker's API
- How to take basic steps to make containers more secure
- Where to find more information on Docker security

What can we do with Docker API access?

Someone who has access to the Docker API will have full root privileges on the Docker host.

If you give root privileges to someone, assume that they can do *anything they like* on the host, including:

- Accessing all data.
- Changing all data.
- Creating new user accounts and changing passwords.
- Installing stealth rootkits.
- Shutting down the machine.

Accessing the host filesystem

To do that, we will use `-v` to expose the host filesystem inside a container:

```
$ docker run -v /:/hostfs ubuntu cat /hostfs/etc/passwd
...This shows the content of /etc/passwd on the host...
```

If you want to explore freely the host filesystem:

```
$ docker run -it -v /:/hostfs -w /hostfs ubuntu bash
```


Modifying the host filesystem

Volumes are read-write by default, so let's create a dummy file on the host filesystem:

```
$ docker run -it -v /:/hostfs ubuntu touch /hostfs/hi-there
$ ls -l /
...You will see the hi-there file, created on the host...
```

Note: if you are using boot2docker or a remote Docker host, you won't see the `hi-there` file. It will be in the boot2docker VM, or on the remote Docker host instead.

Privileged containers

If you start a container with `--privileged`, it will be able to access all devices and perform all operations.

For instance, it will be able to access the whole kernel memory by reading (and even writing!) `/dev/kcore`.

A container could also be started with `--net host` and `--privileged` together, and be able to sniff all the traffic going in and out of the machine.

Other harmful operations

We won't explain how to do this (because we don't want you to break your Docker machines), but with access to the Docker API, you can:

- Add user accounts.
- Change password of existing accounts.
- Add SSH key authentication to existing accounts.
- Insert kernel modules.
- Run malicious processes and insert special kernel code to hide them.

What to do?

- Do not expose the Docker API to the general public.
- If you expose the Docker API, secure it with TLS certificates.
- TLS certificates will be presented in the next section.
- Make sure that your users are trained to not give away credentials.

Security of containers themselves

- ''Containers Do Not Contain!''
- Containers themselves do not have security features.
- Security is ensured by a number of other mechanisms.
- We will now review some of those mechanisms.

Do not run processes as root

- By default, Docker runs everything as root.
- This is a security risk.
- Docker might eventually drop root privileges automatically, but until then, you should specify USER in your Dockerfiles, or use `su` or `sudo`.

Don't colocate security-sensitive containers

- If a container contains security-sensitive information, put it on its own Docker host, without other containers.
- Other containers (private development environments, non-sensitive applications...) can be put together.

Run AppArmor or SELinux

- Both of these will provide you with an additional layer of protection if an attacker is able to gain elevated access.

Learn more about containers and security

- Presentation given at LinuxCon 2014 (Chicago)

http://www.slideshare.net/jpetazzo/docker-linux-containers-lxc-and-security

Section summary

We have learned:

- The security implications of exposing Docker's API
- How to take basic steps to make containers more secure
- Where to find more information on Docker security

Securing Docker with TLS

Lesson 21: Securing Docker with TLS

Objectives

At the end of this lesson, you will be able to:

- Understand how Docker uses TLS to secure and authorize remote clients
- Create a TLS Certificate Authority
- Create TLS Keys
- Sign TLS Keys
- Use these keys with Docker

Why should I care?

- Docker does not have any access controls on its network API unless you use TLS!

What is TLS

- TLS is Transport Layer Security.
- The protocol that secures websites with `https` URLs.
- Uses Public Key Cryptography to encrypt connections.
- Keys are signed with Certificates which are maintained by a trusted party.
- These Certificates indicate that a trusted party believes the server is who it says it is.
- Each transaction is therefor encrypted *and* authenticated.

How Docker Uses TLS

- Docker provides mechanisms to authenticate both the server the client to each other.
- Provides strong authentication, authorization and encryption for any API connection over the network.
- Client keys can be distributed to authorized clients

Environment Preparation

- You need to make sure that OpenSSL version 1.0.1 is installed on your machine.
- Make a directory for all of the files to reside.
- Make sure that the directory is protected and backed up!
- *Treat these files the same as a root password.*

Creating a Certificate Authority

First, initialize the CA serial file and generate CA private and public keys:

```
$ echo 01 > ca.srl
$ openssl genrsa -des3 -out ca-key.pem 2048
$ openssl req -new -x509 -days 365 -key ca-key.pem -out ca.pem
```

We will use the `ca.pem` file to sign all of the other keys later.

Create and Sign the Server Key

Now that we have a CA, we can create a server key and certificate signing request. Make sure that CN matches the hostname you run the Docker daemon on:

```
$ openssl genrsa -des3 -out server-key.pem 2048
$ openssl req -subj '/CN=**<Your Hostname Here>**' -new -key server-key.pem -out
server.csr
$ openssl rsa -in server-key.pem -out server-key.pem
```

Next we're going to sign the key with our CA:

```
$ openssl x509 -req -days 365 -in server.csr -CA ca.pem -CAkey ca-key.pem \
  -out server-cert.pem
```


Create and Sign the Client Key

```
$ openssl genrsa -des3 -out client-key.pem 2048
$ openssl req -subj '/CN=client' -new -key client-key.pem -out client.csr
$ openssl rsa -in client-key.pem -out client-key.pem
```

To make the key suitable for client authentication, create a extensions config file:

```
$ echo extendedKeyUsage = clientAuth > extfile.cnf
```

Now sign the key:

```
$ openssl x509 -req -days 365 -in client.csr -CA ca.pem -CAkey ca-key.pem \
  -out client-cert.pem -extfile extfile.cnf
```


Configuring the Docker Daemon for TLS

- By default, Docker does not listen on the network at all.
- To enable remote connections, use the -H flag.
- The assigned port for Docker over TLS is 2376.

```
$ sudo docker -d --tlsverify
--tlscacert=ca.pem --tlscert=server-cert.pem
--tlskey=server-key.pem -H=0.0.0.0:2376
```

Note: You will need to modify the startup scripts on your server for this to be permanent! The keys should be placed in a secure system directory, such as /etc/docker.

Configuring the Docker Client for TLS

If you want to secure your Docker client connections by default, you can move the key files to the `.docker` directory in your home directory. Set the `DOCKER_HOST` variable as well.

```
$ cp ca.pem ~/.docker/ca.pem
$ cp client-cert.pem ~/.docker/cert.pem
$ cp client-key.pem ~/.docker/key.pem
$ export DOCKER_HOST=tcp://:2376
```

Then you can run docker with the `--tlsverify` option.

```
$ docker --tlsverify ps
```


Section Summary

We learned how to:

- Create a TLS Certificate Authority
- Create TLS Keys
- Sign TLS Keys
- Use these keys with Docker

The Docker API

Lesson 22: The Docker API

Objectives

At the end of this lesson, you will be able to:

- Work with the Docker API.
- Create and manage containers with the Docker API.
- Manage images with the Docker API.

Introduction to the Docker API

So far we've used Docker's command line tools to interact with it. Docker also has a fully fledged RESTful API you can work with.

The API allows:

- To build images.
- Run containers.
- Manage containers.

Docker API details

The Docker API is:

- Broadly RESTful with some commands hijacking the HTTP connection for STDIN, STDERR, and STDOUT.
- The API binds locally to `unix:///var/run/docker.sock` but can also be bound to a network interface.
- Not authenticated by default.
- Securable with certificates.

In the examples below, we will assume that Docker has been setup so that the API listens on port 2375, because tools like `curl` can't talk to a local UNIX socket directly.

Testing the Docker API

Let's start by using the `info` endpoint to test the Docker API.

This endpoint returns basic information about our Docker host.

```
$ curl --silent -X GET http://localhost:2375/info \
  | python -mjson.tool
{
    "Containers": 68,
    "Debug": 0,
    "Driver": "aufs",
    "DriverStatus": [
        [
            "Root Dir",
            "/var/lib/docker/aufs"
        ],
        [
            "Dirs",
            "711"
        ]
    ],
    "ExecutionDriver": "native-0.2",
    "IPv4Forwarding": 1,
    "Images": 575,
    "IndexServerAddress": "https://index.docker.io/v1/",
    "InitPath": "/usr/bin/docker",
    "InitSha1": "",
    "KernelVersion": "3.14.0-1-amd64",
    "MemoryLimit": 1,
    "NEventsListener": 0,
    "NFd": 11,
    "NGoroutines": 11,
    "OperatingSystem": "<unknown>",
    "SwapLimit": 1
}
```


Doing `docker run` via the API

It is simple to do `docker run` with the CLI, but it is more complex with the API. It involves multiple calls.

We will focus on *detached* containers for now (i.e., running in the background). Interactive containers involve hijacking the HTTP connection. This is easily handled with Docker client libraries, but for now, we will use regular tools like `curl`.

Container lifecycle with the API

To run a container, you must:

- Create the container. It is then stopped, but ready to go.
- Start the container.
- Optionally, you can wait for the container to exit.
- You can also retrieve the container output (logs) with the API.

Each of those operations corresponds to a specific API call.

"Create" vs. "Start"

The `create` API call creates the container, and gives us the ID of the newly created container. The container does not run yet, though.

The `start` API call tells Docker to transition the container from "stopped" to "running".

Those are two different calls, so you can attach to the container before starting it, to make sure that you will not miss any output from the container, for instance.

Some parameters (e.g. which image to use, memory limits) must be specified with `create`; others (e.g. ports and volumes mappings) must be specified with `start`.

To see the list of all parameters, check the API reference documentation.

Creating a new container via the API

Let's use `curl` to create a simple container.

```
$ curl -X POST -H 'Content-Type: application/json' \
  http://localhost:2375/containers/create \
  -d '{
    "Cmd":["echo", "hello world"],
    "Image":"busybox"
  }'
  {"Id":"<yourContainerID>","Warnings":null}
```

- You can see the container ID returned by the API.
- The `Cmd` parameter has to be a list.
  (If you put `echo hello world` it will try to execute a binary called `echo hello world`.)
- You can add more parameters in the JSON structure.
- The only mandatory parameter is the `Image` to use.

Starting our new container via the API

In the previous step, the API gave you a container ID.

You will have to copy-paste that ID.

```
$ curl -X POST -H 'Content-Type: application/json' \
  http://localhost:2375/containers/<yourContainerID>/start \
  -d '{}'
```

No output will be shown (unless an error happens).

Inspecting our launched container

We can also inspect our freshly launched container.

```
$ curl --silent \
  http://localhost:2375/containers/<yourContainerID>/json |
  python -mjson.tool
{
  "Args": [
      "hello world"
   ],
  "Config": {
    "AttachStderr": false,
    "AttachStdin": false,
    "AttachStdout": false,
    "Cmd": [
        "echo",
    "hello world"
    ],
    . . .
}
```

- It returns the same hash the `docker inspect` command returns.

Waiting for our container to exit and check its status code

Our test container will run and exit almost instantly.

But for containers running for a longer period of time, we can call the `wait` endpoint.

The `wait` endpoint also gives the exit status of the container.

```
$ curl --silent -X POST \
  http://localhost:2375/containers/<yourContainerID>/wait
{"StatusCode":0}
```

- Note that you have to use a POST method here.
- The `StatusCode` of `0` means that the process exited normally, without error.

Viewing container output (logs)

Our container is supposed to echo `hello world`.

Let's verify that.

```
$ curl --silent \
  http://localhost:2375/containers/<yourContainerID>/logs?stdout=1

hello world
```

- There are other options, to select which streams to see (stdout and/or stderr), whether or not to show timestamps, and to follow the logs (like `tail -f` does).
- Check the API reference documentation to see all available options.

Stopping a container

We can also stop a container using the API.

```
$ curl --silent -X POST \
  http://localhost:2375/containers/<yourContainerID>/stop
```

- Note that you have to use a P0ST call here.
- If it succeeds it will return a HTTP 204 response code.

Working with images

We can also work with Docker images.

```
$ curl -X GET http://localhost:2375/images/json?all=0
[
  {
    "Created": 1396291095,
    "Id": "cccdc2d2ec497e814793e8bd952ae76d5d552c8bb7ed927db54aa65579508ffd",
    "ParentId": "9cd978db300e27386baa9dd791bf6dc818f13e52235b26e95703361ec3c94dc6",
    "RepoTags": [
        "training/datavol:latest"
    ],
    "Size": 0,
    "VirtualSize": 204371253
  },
  {
    "Created": 1396117401,
    "Id": "d4faa2107ddab5b22e815759d9a345f1381562ad44d1d95235347d6b006ec713",
    "ParentId": "439aa219e271671919a52a8d5f7a8e7c2b2950c639f09ce763ac3a06c0d15c22",
    . . .
  }
]
```

- Returns a hash of all images.

Searching the Docker Hub for an image

We can also search the Docker Hub for specific images.

```
$ curl -X GET http://localhost:2375/images/search?term=training
[
  {
    "description": "",
    "is_official": false,
    "is_trusted": true,
    "name": "training/namer",
    "star_count": 0
  },
  {
    "description": "",
    "is_official": false,
    "is_trusted": true,
    "name": "training/postgres",
    "star_count": 0
  }
]
```

This returns a list of images and their metadata.

Creating an image

We can then add one of these images to our Docker host.

```
$ curl -i -v -X POST \
  http://localhost:2375/images/create?fromImage=training/namer
  {"status":"Pulling repository training/namer"}
```

This will pull down the `training/namer` image and add it to our Docker host.

Section summary

We've learned how to:

- Work with the Docker API.
- Create and manage containers with the Docker API.
- Manage images with the Docker API.

Course Conclusion

Course Summary

During this class, we:

- Installed Docker.
- Launched our first container.
- Learned about images.
- Got an understanding about how to manage connectivity and data in Docker containers.
- Learned how to integrate Docker into your daily work flow

Questions & Next Steps

Still Learning:

- Docker homepage - http://www.docker.com/
- Docker Hub - https://hub.docker.com
- Docker blog - http://blog.docker.com/
- Docker documentation - http://docs.docker.com/
- Docker Getting Started Guide - http://www.docker.com/gettingstarted/
- Docker code on GitHub - https://github.com/docker/docker
- Docker mailing list - https://groups.google.com/forum/#!forum/docker-user
- Docker on IRC: irc.freenode.net and channels `#docker` and `#docker-dev`
- Docker on Twitter - http://twitter.com/docker
- Get Docker help on Stack Overflow - http://stackoverflow.com/search?q=docker

Thank You