Lab Outline

Online

This document
You can find the most up-to-date version of this document online here (https://github.com/mjbright/jupyter_notebooks/blob/master/2016-Feb_Docker_Build_Lab/2016-Feb_Docker_Build_Lab.md) or as
- a PDF file (https://raw.githubusercontent.com/mjbright/jupyter_notebooks/master/2016-Feb_Docker_Build_Lab/2016-Feb_Docker_Build_Lab.pdf) (http://bit.ly/1QF0XaH (http://bit.ly/1QF0XaH)) or as
- a Jupyter (http://www.jupyter.org) notebook at 2016-Feb_Docker_Build_Lab (https://github.com/mjbright/jupyter_notebooks/blob/master/2016-Feb_Docker_Build_Lab/).

This notebook is runnable in a Jupyter installation with the bash_kernel installed.

Although that is not the subject of this lab, if you want to create your own environment in which to run this lab with Docker components already installed (and even Jupyter/bash_kernel), refer to the README.md here (https://github.com/mjbright/jupyter_notebooks/blob/master/2016-Feb_Docker_Build_Lab/)

mjbright (https://www.linkedin.com/in/mjbright),
mjbright (https://github.com/mjbright),
@mjbright (http://twitter.com/mjbright),

Lab-Description

TOP

We first need to recuperate the source code examples:

Lab Start

Start this lab by first performing the below step:

In [1]:

```
## Lab Start:

rm -rf ~/src

cd
git clone https://github.com/mjbright/docker-examples src

./src/START_LAB.sh
```

```
Cloning into 'src'...
remote: Counting objects: 156, done.
remote: Compressing objects: 100% (116/116), done.
remote: Total 156 (delta 64), reused 120 (delta 31), pack-reused 0
Receiving objects: 100% (156/156), 15.60 KiB | 0 bytes/s, done.
Resolving deltas: 100% (64/64), done.
Checking connectivity... done.
```

Then procede with the following sections:

Overall description of the lab steps

NOTE: All lab steps can be considered optional, attendees may perform them in order, or jump to the section of interest to them (to get to the more complicated steps)

Introduction

A refresh on Docker concepts

You may want to skip this section if you have already run the introductory lab.

Look at what docker version you are running. Note that the 'docker version' command reports the local client version as well as the server (docker engine) version.

In [2]:

```
docker version
```

```
Client:
 Version:      1.10.0
 API version:  1.22
 Go version:   go1.5.3
 Git commit:   590d5108
 Built:        Thu Feb  4 19:55:25 2016
 OS/Arch:      linux/amd64

Server:
 Version:      1.10.0
 API version:  1.22
 Go version:   go1.5.3
 Git commit:   590d5108
 Built:        Thu Feb  4 19:55:25 2016
 OS/Arch:      linux/amd64
```

Images are image layers

Remember that when we talk of a container image it is really a collection of image layers.

The docker info command provides information about the docker engine, see below.

In [4]:

```
docker info
```

```
Containers: 1
 Running: 0
 Paused: 0
 Stopped: 1
Images: 7
Server Version: 1.10.0
Storage Driver: aufs
 Root Dir: /var/lib/docker/aufs
 Backing Filesystem: extfs
 Dirs: 30
 Dirperm1 Supported: false
Execution Driver: native-0.2
Logging Driver: json-file
Plugins:
 Volume: local
 Network: null host bridge
Kernel Version: 3.13.0-77-generic
Operating System: Ubuntu 14.04.3 LTS
OSType: linux
Architecture: x86_64
CPUs: 1
Total Memory: 1.955 GiB
Name: vagrant-ubuntu-trusty-64
ID: 3BDW:ZNNN:SJXZ:MAT3:WBKG:4RQT:PEZJ:7PDN:VG72:XGAL:CU6U:XWX4
WARNING: No swap limit support
```

But if we look at the number of containers and images, the number of images it is not the same as provided above. Why do you think that is?

First let's list the number of running and number of stopped containers

NOTE: the value on your system will be different

In [5]:

```
# Show the running containers:
docker ps

# Count the number of running containers:
echo
echo "Total number of running containers:"
docker ps | tail -n +2 | wc -l
```

```
CONTAINER ID        IMAGE               COMMAND             CREATED
STATUS              PORTS               NAMES

Total number of running containers:
0
```

In [6]:

```
# Show all the containers (running or stopped):
docker ps -a

# Count all the containers (running or stopped):
echo
echo "Total number of containers (running or stopped):"
docker ps -a | tail -n +2 | wc -l # Number of stopped and running containers ('tail -
```

```
CONTAINER ID        IMAGE               COMMAND             CREATED
STATUS                     PORTS               NAMES
b19891aa2715        lab/c_prog          "/helloWorld"       24 seconds
ago      Exited (14) 23 seconds ago                       nauseous_mest
orf

Total number of containers (running or stopped):
1
```

We can see that the number of containers reported by docker info correctly reports the number of total containers, running or not

But listing images gives a different value from the 'docker info' value

In [7]:

```
# Show the images:
docker images

# Count the images:
echo
echo "Total number of images:"
docker images | tail -n +2 | wc -l
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/c_prog          latest              659400ddd8d4        31 seconds
ago      877.2 kB
swarm               latest              17cf22083736        3 days ago
18.11 MB
node                latest              baa18fdeb577        12 days ago
643.1 MB
swarm               1.1.0-rc2           81883ac55ffe        2 weeks ago
18.06 MB
alpine              latest              14f89d0e6257        2 weeks ago
4.794 MB

Total number of images:
5
```

That is because there are many intermediate image layers which are not normally listed. But we can list those layers using the '-a' option and now we see a number close to the value from 'docker info'.

(We will see later how the 'docker history' command allows us to see how the layers were created).

In [8]:

```
# Show all the image layers:
docker images -a

# Count all the image layers:
echo
echo "Total number of image layers:"

docker images -a | tail -n +2 | wc -l  # The number of image layers+1 (inc. header li
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
<none>              <none>              8e9605157ccf        42 seconds
ago         0 B
<none>              <none>              bde06bb6dcf5        42 seconds
ago         877.2 kB
lab/c_prog          latest              659400ddd8d4        42 seconds
ago         877.2 kB
swarm               latest              17cf22083736        3 days ago
18.11 MB
node                latest              baa18fdeb577        12 days ago
643.1 MB
swarm               1.1.0-rc2           81883ac55ffe        2 weeks ago
18.06 MB
alpine              latest              14f89d0e6257        2 weeks ago
4.794 MB

Total number of image layers:
7
```

Images can include 1 static binary file or more and can even include a whole distribution. Launching a container launches a single process within that container - which may in turn span other child processes.

Let us look at an extremely small image to have an idea just how small an executable image can be. Docker provide an official 'hello-world' image which simply echoes some output to the console.

Let's run that image to see and then investigate the image. First let's search for the image; we see that the first image is 'hello-world' which is an official build

In [9]:

```
docker search hello-world
```

```
NAME                                     DESCRIPTION
STARS     OFFICIAL   AUTOMATED
hello-world                              Hello World! (an example of mi
nimal Docker...   48        [OK]
tutum/hello-world                        Image to test docker deploymen
ts. Has Apac...   19                   [OK]
marcells/aspnet-hello-world              ASP.NET vNext - Hello World
2                    [OK]
bonomat/nodejs-hello-world               a simple nodejs hello world co
ntainer           1                    [OK]
carinamarina/hello-world-app             This is a sample Python web ap
plication, r...   1                    [OK]
vegasbrianc/docker-hello-world
1                    [OK]
carinamarina/hello-world-web             A Python web app, running on p
ort 5000, wh...   1                    [OK]
wowgroup/hello-world                     Minimal web app for testing pu
rposes            0                    [OK]
dockercloud/hello-world                  Sample hello world application
0                    [OK]
crccheck/hello-world                     Hello World web server in unde
r 2.5 MB          0                    [OK]
bencampbell/hello-world                  First automated build.
0                    [OK]
nirmata/hello-world
0                    [OK]
n8io/hello-world                         A simple hello world node.js a
pp to test d...   0                    [OK]
mikelh/hello-world                       simplified hello world as dumm
y start for ...   0                    [OK]
poojathote/hello-world                   this is 3rd POC
0                    [OK]
vamosporpartes/hello-world               Primeiro projeto para testar o
link entre ...   0                    [OK]
asakaguchi/docker-nodejs-hello-world     Hello World for Docker
0                    [OK]
cpro/http-hello-world                    Hello world
0                    [OK]
ileontyev81/docker-hello-world           hello world test build
0                    [OK]
chaliceg/docker-hello-world              Hello world
0                    [OK]
alexwelch/hello-world
0                    [OK]
vasia/docker-hello-world                 rhrthrth
0                    [OK]
asakaguchi/magellan-nodejs-hello-world   Hello World for MAGELLAN
0                    [OK]
wodge/docker-hello-world                 Hello World test for auto upda
te to Docker...   0                    [OK]
chalitac/hello-world                     Just Hello World
0                    [OK]
```

Let's now run that image

In [10]:

```
docker run hello-world

# Note how we see the pulling of the image if not already available locally:
```

```
Unable to find image 'hello-world:latest' locally
latest: Pulling from library/hello-world

03f4658f8b78: Pulling fs layer
Digest: sha256:8be990ef2aeb16dbcb9271ddfe2610fa6658d13f6dfb8bc72074cc1c
a36966a7
Status: Downloaded newer image for hello-world:latest

Hello from Docker.
This message shows that your installation appears to be working correct
ly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hu
b.
 3. The Docker daemon created a new container from that image which run
s the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which
sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker Hub accou
nt:
 https://hub.docker.com (https://hub.docker.com)

For more examples and ideas, visit:
 https://docs.docker.com/userguide/ (https://docs.docker.com/userguid
e/)
```

If it took a while to run, this was due to the time needed to download the image before running it - see above.

Try the command a second time to see how it runs instantaneously as there is no need to download the image which already exists locally on the 'docker engine'.

In [11]:

```
docker run hello-world

# The second time there is no need to repull the image:
```

```
Hello from Docker.
This message shows that your installation appears to be working correct
ly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hu
b.
 3. The Docker daemon created a new container from that image which run
s the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which
sent it
    to your terminal.

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nt:
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For more examples and ideas, visit:
 https://docs.docker.com/userguide/ (https://docs.docker.com/userguid
e/)
```

Let us inspect the image. We see that the file is only 960 bytes large, it must be machine code to print out the text. So we see that an image can be really very small

In [12]:

```
docker images hello-world
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
hello-world         latest              690ed74de00f        3 months ag
o         960 B
```

We can also inspect the image with the history command to see how it was constructed.

Note that history shows the image layers in reverse order, latest first.

From the below command we can see that the image was created from only 2 image layers.

The image was built simply by copying in a binary executable and then specifying the default command to invoke when the image is run.

In [13]:

```
docker history hello-world
```

```
IMAGE                   CREATED                 CREATED BY
SIZE                    COMMENT
690ed74de00f            3 months ago            /bin/sh -c #(nop) CMD ["/hell
o"]                    0 B
<missing>               3 months ago            /bin/sh -c #(nop) COPY file:1ad
52e3eaf4327c8f    960 B
```

In [14]:

```
echo
echo "Total size (in bytes) of text in 'hello-world' image:"
docker run hello-world | wc -c
```

```
Total size (in bytes) of text in 'hello-world' image:
801
```

So we see that 801 bytes of that executable is the actual text printed ! So the real program size is roughly 160 bytes (of assembler no doubt)

Basic Docker Builds

TOP

Dockerfile

Images are built from Dockerfiles which contain a series of commands used to build up a docker image. Note that each command in the Dockerfile results in a new image layer being created, no matter how trivial the command - even ENV "commands" create a new image layer.

In the following lab we will see how images can be built systematically from a Dockerfile using the 'docker build' command.

DockerHub

When we pull an image we pull it from a Docker Registry. The DockerHub (https://hub.docker.com/) is a free to use Docker registry allowing to store your own image files (which are publicly available unless you pay for your account) and to pull other image files of other users or officially provided images.

You can create images either by

- building them from a Dockerfile (thus in a **repeatable** manner)
- building them manually by modifying a running container and *'commit'*ing it's state

The DockerHub contains images which may be

- **Automated builds** (built from a git repository)
  - Such builds are usually built from an open-source git repo and so are called **Trusted builds** because the source code is available. *Note:* The github repo may contain binary files though
- **Official builds** are builds which are builds provided by partners or by Docker themselves

Other images may exist in the hub but their origin is unknown and so represent a security risk.

It is possible to search the DockerHub, or another Docker Registry, using the 'docker search' command with appropriate options. Other companies offer their own Docker Registry which may be freely accessible e.g. RedHat, internal to a company e.g. HPE IT, or available as part of a paid for service e.g. IBM or Amazon Web Services ECS.

In [20]:

```
cd ~/src/basic
```

In the ~/test folder create a Dockerfile with the contents shown below (the o/p of the cat command).

For this you may use vi if you are familiar, otherwise the 'nano' text editor is recommended.

Use ctrl-W to write out the file and ctrl-X to quit the editor.

In [25]:

```
cat Dockerfile
```

```
#
# Dockerfile to demonstrate the simplest build
#

FROM python

MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

# NOTE: all RUN commands are executed at build time, look at the output
of the "docker build"
#       below and you will see the output of the following line when we
build the first time
#       (i.e. when caching is not used):

RUN echo DATE: This build is being done at $(date)
#RUN python --version

CMD bash
```

In [26]:

```
ls -altr Dockerfile
```

```
-rw-rw-r-- 1 vagrant vagrant 439 Feb  8 15:31 Dockerfile
```

We can now build a new image using this dockerfile using the below command where

- we specify the current directory as the context for the build (any ADD/COPY or Dockerfile files will be sourced from here) with the **'.'** option
- we specify the specific tag to use for the generated image as "*lab/basic*" with

  -t lab/basic

In [27]:

```
docker build -t lab/basic .
```

```
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM python
 ---> 93049cc049a6
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Running in 1e836ce0bd8b
 ---> 265f1e4a525d
Removing intermediate container 1e836ce0bd8b
Step 3 : RUN echo DATE: This build is being done at $(date)
 ---> Running in e195f1a8d6fc
DATE: This build is being done at Mon Feb 8 15:31:23 UTC 2016
 ---> 58100f46a8de
Removing intermediate container e195f1a8d6fc
Step 4 : CMD bash
 ---> Running in 6a24b4f9634c
 ---> c028a15ddd50
Removing intermediate container 6a24b4f9634c
Successfully built c028a15ddd50
```

Note that during the build, the RUN commands are actually run.

They are used to build up this new image.

In this case we echo the 'Python' version string during the build process.

You can see the available options to the build command by issuing 'docker build --help'

In [28]:

```
docker build --help
```

```
Usage:  docker build [OPTIONS] PATH | URL | -

Build an image from a Dockerfile

  --build-arg=[]                  Set build-time variables
  --cpu-shares                    CPU shares (relative weight)
  --cgroup-parent                 Optional parent cgroup for the contai
ner
  --cpu-period                    Limit the CPU CFS (Completely Fair Sc
heduler) period
  --cpu-quota                     Limit the CPU CFS (Completely Fair Sc
heduler) quota
  --cpuset-cpus                   CPUs in which to allow execution (0-
3, 0,1)
  --cpuset-mems                   MEMs in which to allow execution (0-
3, 0,1)
  --disable-content-trust=true    Skip image verification
  -f, --file                      Name of the Dockerfile (Default is 'P
ATH/Dockerfile')
  --force-rm                      Always remove intermediate containers
  --help                          Print usage
  --isolation                     Container isolation level
  -m, --memory                    Memory limit
  --memory-swap                   Swap limit equal to memory plus swap:
'-1' to enable unlimited swap
  --no-cache                      Do not use cache when building the im
age
  --pull                          Always attempt to pull a newer versio
n of the image
  -q, --quiet                     Suppress the build output and print i
mage ID on success
  --rm=true                       Remove intermediate containers after
a successful build
  --shm-size                      Size of /dev/shm, default value is 64
MB
  -t, --tag=[]                    Name and optionally a tag in the 'nam
e:tag' format
  --ulimit=[]                     Ulimit options
```

We can see all the images available using the 'docker images' command

but if there are many, how do we see just our newly-created image?

You can see the available options to the images command by issuing 'docker images --help'

In [29]:

```
docker images --help
```

```
Usage:  docker images [OPTIONS] [REPOSITORY[:TAG]]

List images

  -a, --all          Show all images (default hides intermediate image
s)
  --digests          Show digests
  -f, --filter=[]    Filter output based on conditions provided
  --format           Pretty-print images using a Go template
  --help             Print usage
  --no-trunc         Don't truncate output
  -q, --quiet        Only show numeric IDs
```

So you can see your newly built 'lab/basic' with the following command:

In [30]:

```
docker images lab/basic
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/basic           latest              c028a15ddd50        18 seconds
ago         689.1 MB
```

Note that if you rerun the build command, the build should run faster, you will notice how build steps recognize that this step has already been performed and so will use the image layer already available in the local cache.

Now let us see what happens if we modify our Dockerfile, by inserting a line, such as defining an environment variable.

We will use the same Dockerfile, but this time we will insert an "ENV" line

In [31]:

```
cd ~/src/basic/
```

Now edit the Dockerfile to have the contents as shown below (the o/p of the cat command).

In [32]:

```
cat Dockerfile
```

```
#
# Dockerfile to demonstrate the simplest build
#

FROM python

MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

# NOTE: all RUN commands are executed at build time, look at the output
of the "docker build"
#       below and you will see the output of the following line when we
build the first time
#       (i.e. when caching is not used):

RUN echo DATE: This build is being done at $(date)
#RUN python --version

ENV myVar=anythingReally

CMD bash
```

This time when we build the image we will see that the addition of a line between the "RUN" line and the "CMD" line forces rebuild of subsequent image layers.

We see 'Using cache' for Step 2 and 3 only

In [33]:

```
docker build -t lab/basic .
```

```
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM python
 ---> 93049cc049a6
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Using cache
 ---> 265f1e4a525d
Step 3 : RUN echo DATE: This build is being done at $(date)
 ---> Using cache
 ---> 58100f46a8de
Step 4 : ENV myVar anythingReally
 ---> Running in 86c9262af943
 ---> f493d0962635
Removing intermediate container 86c9262af943
Step 5 : CMD bash
 ---> Running in 42344c05af2a
 ---> 6566cf6ed29d
Removing intermediate container 42344c05af2a
Successfully built 6566cf6ed29d
```

Similarly we can force to not use the cache with the --no-cache option.

This could be useful if we suspect the caching is not working properly due to some external change.

In [34]:

```
docker build --no-cache -t lab/basic .
```

```
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM python
 ---> 93049cc049a6
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Running in 352ab6578552
 ---> c5efd78c5c14
Removing intermediate container 352ab6578552
Step 3 : RUN echo DATE: This build is being done at $(date)
 ---> Running in 2be6e59360a4
DATE: This build is being done at Mon Feb 8 15:35:15 UTC 2016
 ---> 77f9a84551cc
Removing intermediate container 2be6e59360a4
Step 4 : ENV myVar anythingReally
 ---> Running in f56c83b6c061
 ---> e7e8c2a26251
Removing intermediate container f56c83b6c061
Step 5 : CMD bash
 ---> Running in afdea0bc90b9
 ---> e3d7946e9d93
Removing intermediate container afdea0bc90b9
Successfully built e3d7946e9d93
```

In [35]:

```
docker images lab/basic
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/basic           latest              e3d7946e9d93        12 seconds
ago         689.1 MB
```

Creating small images

TOP

Creating a small C Docker image

TOP

In this example we show how we can create a Docker image from a statically-linked binary.

The goal of this step is to show that we do not need an Operating System image for a Docker container.

All we need is a self-contained binary - i.e. statically linked binary.

Of course a dynamically linked binary could also be used, but in this case it's more complicated as you would have to manually add all it's dependent libraries. Let's let gcc to do that work for us!

This section comprises 2 things

- A Dockerfile to build our image from a static binary Note that it starts with "FROM scratch". Scratch is a special 'empty' image
- helloFromDocker.c

So first let's build our static binary

In [36]:

```
cd ~/src/createTinyC/

# For RHEL/Fedora/Centos only:
# First we must install *glibc-static*
#yum install -y glibc-static

gcc -static helloWorld.c -o helloWorld

ls -alh helloWorld
```

```
-rwxrwxr-x 1 vagrant vagrant 857K Feb  8 15:35 helloWorld
```

So we see that this created a binary file of approximately 857kby.

Now let's build our Docker image containing this binary.

You will need to recreate the Dockerfile as follows:

In [37]:

```
cat Dockerfile
```

```
FROM scratch
MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

ADD ./helloWorld /helloWorld
CMD ["/helloWorld"]
```

In [38]:

```
docker build -t lab/c_prog .
```

```
Sending build context to Docker daemon 882.2 kB
Step 1 : FROM scratch
 --->
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Using cache
 ---> 8e9605157ccf
Step 3 : ADD ./helloWorld /helloWorld
 ---> Using cache
 ---> bde06bb6dcf5
Step 4 : CMD /helloWorld
 ---> Using cache
 ---> 659400ddd8d4
Successfully built 659400ddd8d4
```

If we now look at the generated Docker image (below) we see an image of about 877kby.

So whilst this is larger than the 1kby hello-world image (no doubt written in assembler) it is still a very small Docker image which is only 20kbytes larger than the original binary file.

In [39]:

```
docker images lab/c_prog
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/c_prog          latest              659400ddd8d4        17 hours ag
o        877.2 kB
```

And now let's run that image

In [40]:

```
docker run lab/c_prog
```

```
Hello World!!
```

In [41]:

```
docker history lab/c_prog
```

```
IMAGE               CREATED             CREATED BY
SIZE                COMMENT
659400ddd8d4        17 hours ago        /bin/sh -c #(nop) CMD ["/helloW
orld"]           0 B
bde06bb6dcf5        17 hours ago        /bin/sh -c #(nop) ADD file:eb1f
2e0a74291359d0   877.2 kB
8e9605157ccf        17 hours ago        /bin/sh -c #(nop) MAINTAINER "D
ocker Build La   0 B
```

Creating a small Go Docker image

TOP

That's fine, but isn't Go taking over the world as a systems language? Docker, Kubernetes, LXD, Rocket, ... many new tools are being written in Go.

Let's see how we can do the same exercise but building a Go statically-linked binary.

The goal of this step is as the previous step (building an image from a single statically-linked binary) but using Go, but also to demonstrate how we can use a Docker image containing a Go compiler, rather than explicitly installing a compiler.

NOTE: We will do this **without** 'installing a Go compiler'

In [42]:

```
cd ~/src/createTinyGo
cat Dockerfile
```

```
FROM scratch
MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

ADD ./hello /hello
CMD ["/hello"]
```

NOW we invoke the golang container to build our go source code.

The following docker run

- mounts the current directory ($PWD) as /go within the container
- launches a container of the **golang** image which contains the go compiler
- invokes the command "go build -v hello" on the container to build the sources for the "hello.go" code.

The hello.go code is located under src/hello/hello.go.

This is a Go convention.

NOTE: The important thing to note here is that the compiler is within the image. We did not need to install a native Go compiler, we used an image which contains the compiler and by mounting the current directory the container can read the source code and write the executable outside the container. This is a nice pattern of providing a tool within a container.

In [43]:

```
# Compile our Go-code using the Go compiler provided by the 'golang' container:
docker run -it -v $PWD:/go golang go build hello

# Now we have our small static binary compiled
ls -l hello
```

```
Unable to find image 'golang:latest' locally
latest: Pulling from library/golang

03e1855d4f31: Already exists
a3ed95caeb02: Already exists
9269ba3950bb: Already exists
6ecee6444751: Already exists
a3ed95caeb02: Pulling fs layer
8ccc76a74787: Pulling fs layer
70fd525fbd3f: Pulling fs layer
Digest: sha256:2242a664699c7dd1aaf3c380107d20bff45cbbe39d92e848c4c83240
adc4169f
Status: Downloaded newer image for golang:latest
-rwxr-xr-x 1 root root 2367272 Feb  8 15:37 hello
```

Now we can build our image including this static binary.

In [44]:

```
docker build -t lab/go-hello .
```

```
Sending build context to Docker daemon 2.377 MB
Step 1 : FROM scratch
 --->
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Using cache
 ---> 8e9605157ccf
Step 3 : ADD ./hello /hello
 ---> 0aac2ea7bdeb
Removing intermediate container e2ace3cfae0c
Step 4 : CMD /hello
 ---> Running in 345e7db6224d
 ---> 438d3567ae8a
Removing intermediate container 345e7db6224d
Successfully built 438d3567ae8a
```

In [45]:

```
docker images lab/*
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/go-hello        latest              438d3567ae8a        4 seconds a
go         2.367 MB
lab/basic           latest              e3d7946e9d93        2 minutes a
go         689.1 MB
lab/c_prog          latest              659400ddd8d4        17 hours ag
o          877.2 kB
```

Creating a toolset Docker image containing several executables

TOP

Now let's see how we can combine these static binaries into one image.

Let's build a new image derived from the Docker provided 'hello-world' image

The goal of this step is to show how we can combine several executables in an image, opening up the possibility of creating a container of tools.

We will do this without directly 'installing a Go compiler' but by using the official *'golang'* image which includes the Go compiler.

In [46]:

```
cd ~/src/toolset

cp ../createTinyC/helloWorld   helloWorld
cp ../createTinyGo/hello       helloWorldGo

ls -altr
```

```
total 3192
-rw-rw-r--  1 vagrant vagrant      68 Feb  7 21:27 helloWorld.c
-rw-rw-r--  1 vagrant vagrant     181 Feb  7 21:32 Dockerfile
-rwxrwxr-x  1 vagrant vagrant     333 Feb  7 21:32 createTinyDockerImag
e.sh
drwxrwxr-x 11 vagrant vagrant    4096 Feb  8 15:02 ..
-rwxrwxr-x  1 vagrant vagrant  877192 Feb  8 15:38 helloWorld
drwxrwxr-x  2 vagrant vagrant    4096 Feb  8 15:38 .
-rwxr-xr-x  1 vagrant vagrant 2367272 Feb  8 15:38 helloWorldGo
```

Create the Dockerfile with the following contents

In [47]:

```
cat Dockerfile
```

```
FROM hello-world
MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

ADD ./helloWorld /helloWorld
CMD ["/helloWorld"]

ADD ./helloWorldGo /helloWorldGo
CMD ["/helloWorldGo"]
```

Now build the toolset with these executables included:

In [48]:

```
docker build -t lab/toolset ./
```

```
Sending build context to Docker daemon  3.25 MB
Step 1 : FROM hello-world
 ---> 690ed74de00f
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Running in 2a30569f66fa
 ---> 2813581e3ac0
Removing intermediate container 2a30569f66fa
Step 3 : ADD ./helloWorld /helloWorld
 ---> e8d91e3e5713
Removing intermediate container 0a36f6762299
Step 4 : CMD /helloWorld
 ---> Running in 8eba1b0029d1
 ---> db82d13ae941
Removing intermediate container 8eba1b0029d1
Step 5 : ADD ./helloWorldGo /helloWorldGo
 ---> 1c25395172b0
Removing intermediate container aa5e10abd507
Step 6 : CMD /helloWorldGo
 ---> Running in 1ed9542b8551
 ---> 6b82de537bd1
Removing intermediate container 1ed9542b8551
Successfully built 6b82de537bd1
```

If we look at the history of this image we can see the different executables and CMDs which have been added including the original hello-world image.

In [49]:

```
docker history lab/toolset
```

```
IMAGE               CREATED             CREATED BY
SIZE                COMMENT
6b82de537bd1        5 seconds ago       /bin/sh -c #(nop) CMD ["/helloW
orldGo"]         0 B
1c25395172b0        5 seconds ago       /bin/sh -c #(nop) ADD file:e827
5a9025432fdf2e   2.367 MB
db82d13ae941        6 seconds ago       /bin/sh -c #(nop) CMD ["/helloW
orld"]           0 B
e8d91e3e5713        6 seconds ago       /bin/sh -c #(nop) ADD file:eb1f
2e0a74291359d0   877.2 kB
2813581e3ac0        6 seconds ago       /bin/sh -c #(nop) MAINTAINER "D
ocker Build La   0 B
690ed74de00f        3 months ago        /bin/sh -c #(nop) CMD ["/hell
o"]                0 B
<missing>           3 months ago        /bin/sh -c #(nop) COPY file:1ad
52e3eaf4327c8f   960 B
```

Now we are free to specify which command is to be run.

If we don't specify the command, the last (first in the above history list) will be run (so /helloWorldGo in this case)

In [50]:

```
docker run lab/toolset
```

```
Hello world from Go !!
```

Or we can explicitly choose the executable to be run, such as the /hello executable of the original "hello-world" image

In [51]:

```
docker run lab/toolset /hello
```

```
Hello from Docker.
This message shows that your installation appears to be working correct
ly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hu
b.
 3. The Docker daemon created a new container from that image which run
s the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which
sent it
    to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
 $ docker run -it ubuntu bash

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nt:
 https://hub.docker.com (https://hub.docker.com)

For more examples and ideas, visit:
 https://docs.docker.com/userguide/ (https://docs.docker.com/userguid
e/)
```

In [52]:

```
docker run lab/toolset /helloWorld
```

```
Hello World!!
```

In [53]:

```
docker run lab/toolset /helloWorldGo
```

```
Hello world from Go !!
```

We have seen how we can combine several executables in an image, and we can imagine creating a toolset container in this way (with some more useful executable tools!)

Pushing our image to Docker Hub

TOP

Note: If you have your own account on Docker Hub you may wish to use that for this exercise.

Otherwise we will all be using the same account **'dockerlabs'** so you will need to specify a tag which distinguishes your images from your neighbours.

The goal of this step is to demonstrate how we may push an image which we have built to the Docker Hub.

First we will retag our local image to be unique. If you are on podN, then tag with userN,

e.g. if you are pod3,

> docker tag lab/toolset dockerlabs/toolset:user3

Notice that we then have 2 toolset images with different tags.

They are otherwise identical (but they could be different) and have the same "IMAGE ID".

In [54]:

```
docker tag lab/toolset:latest dockerlabs/toolset:userN
docker images */toolset
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
dockerlabs/toolset   userN               6b82de537bd1        36 minutes
ago       3.245 MB
lab/toolset          latest              6b82de537bd1        36 minutes
ago       3.245 MB
```

First we must login to the Docker Hub.

Ask you instructor for the password to the dockerlabs account.

In [56]:

```
docker login -u dockerlabs -p $PASSWORD -e dockerlabs@mjbright.net
```

```
WARNING: login credentials saved in /home/vagrant/.docker/config.json
Login Succeeded
```

Now we may push our image to the public Docker Hub

In [57]:

```
docker push dockerlabs/toolset:userN
```

```
The push refers to a repository [docker.io/dockerlabs/toolset]

c04609a4ced5: Preparing
9cd6282bb409: Preparing
5f70bf18a086: Preparing
userN: digest: sha256:b77d291ac6e7b86640922f63048dd55f654cc1b2dc8019647
cfbaed20b643cc8 size: 4619
```

NOTE: The docker search command is not very useful.

and the below command doesn't show us the tags ... and so we don't know if the below image is tagged user1, user2, ...

In [58]:

```
docker search dockerlabs/
```

```
NAME                     DESCRIPTION    STARS     OFFICIAL    AUTOMATED
dockerlabs/toolset                      0
```

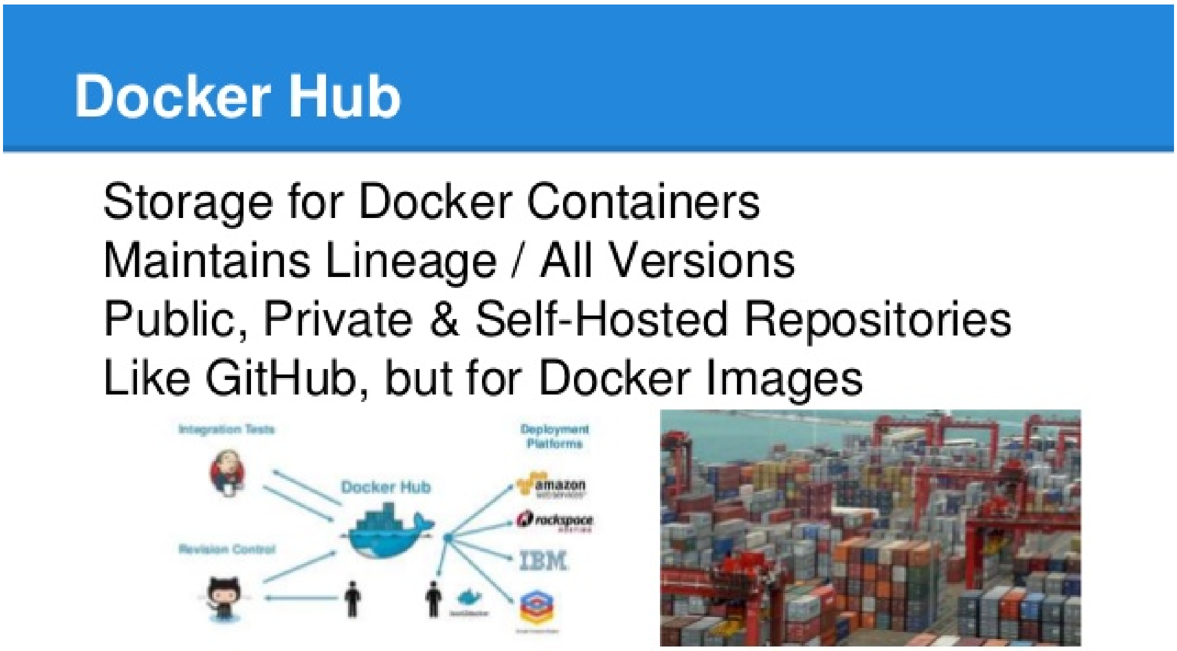
Logging on to DockerHub to see your tagged image there

So for this step, log onto DockerHub https://hub.docker.com/ (https://hub.docker.com/)

In [59]:

```
# Ignore this line: it is just to display the image below

curl -s 'http://image.slidesharecdn.com/dockerdemystifiedforsbjug-150918181554-lva1-a
```



Docker Hub

Storage for Docker Containers
Maintains Lineage / All Versions
Public, Private & Self-Hosted Repositories
Like GitHub, but for Docker Images

As dockerlabs (dockerlabs AT mjbright.net) with the appropriate password (ask your instructor)

Once logged you should see the dockerlabs/toolset listed, otherwise you can search for it.

Click on the dockerlabs/toolset (https://hub.docker.com/r/dockerlabs/toolset/) link, then on the Tags (https://hub.docker.com/r/dockerlabs/toolset/tags/) link and you should now see your tagged image there.

Remove any running *'dockerlabs/toolset'* containers on your system

We do this step to make sure we can easily delete your local dockerlabs/toolset:userN image.

These steps could be done by hand through use of 'docker ps' and 'docker ps -a' and picking containers ids corresponding to 'dockerlabs/toolset' containers to use with 'docker stop' and 'docker rm' commands.

The below expressions do this automatically for us.

In [60]:

```
IMAGE_NAME=dockerlabs/toolset

echo; echo "Currently running or stopped '$IMAGE_NAME' containers"
docker ps -a --filter=ancestor=$IMAGE_NAME

echo; echo "Stopping any running '$IMAGE_NAME' containers (so we can remove dockerlab
docker stop $(docker ps --filter=ancestor=$IMAGE_NAME) 2>/dev/null

echo; echo "Removing any stopped '$IMAGE_NAME' containers (so we can remove dockerlab
docker rm $(docker ps -a --filter=ancestor=$IMAGE_NAME) 2>/dev/null

echo; echo "There should be no more '$IMAGE_NAME' containers present:"
docker ps -a --filter=ancestor=$IMAGE_NAME
```

```
Currently running or stopped 'dockerlabs/toolset' containers
CONTAINER ID        IMAGE               COMMAND             CREATED
STATUS              PORTS               NAMES

Stopping any running 'dockerlabs/toolset' containers (so we can remove
dockerlabs/ image)

Removing any stopped 'dockerlabs/toolset' containers (so we can remove
dockerlabs/ image)

There should be no more 'dockerlabs/toolset' containers present:
CONTAINER ID        IMAGE               COMMAND             CREATED
STATUS              PORTS               NAMES
```

In [61]:

```
docker images dockerlabs/*
```

```
REPOSITORY           TAG                 IMAGE ID            CREATED
SIZE
dockerlabs/toolset   userN               6b82de537bd1        38 minutes
ago         3.245 MB
```

Note that the following rmi command 'Untags' the image.

This is because it is the same - has the same image id - as our original 'lab/toolset' image.

Removing the dockerlabs/toolset image does not remove the identical 'lab/toolset' image but removes the 'dockerlabs/toolset' tag.

In [62]:

```
docker rmi dockerlabs/toolset:userN
```

```
Untagged: dockerlabs/toolset:userN
```

In [63]:

```
docker images dockerlabs/*
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
```

As we have removed ('untagged') the dockerlabs/toolset image, the following run command will download it from the Docker Hub

In [64]:

```
docker run dockerlabs/toolset:userN
```

```
Unable to find image 'dockerlabs/toolset:userN' locally
userN: Pulling from dockerlabs/toolset

03f4658f8b78: Already exists
a3ed95caeb02: Already exists
157cafd668ce: Already exists
Digest: sha256:b77d291ac6e7b86640922f63048dd55f654cc1b2dc8019647cfbaed2
0b643cc8
Status: Downloaded newer image for dockerlabs/toolset:userN
Hello world from Go !!
```

In [65]:

```
docker images dockerlabs/*
```

```
REPOSITORY           TAG                  IMAGE ID             CREATED
SIZE
dockerlabs/toolset   userN                d34fbee9ad6f         39 minutes
ago      3.245 MB
```

In [66]:

```
docker run dockerlabs/toolset:userN /helloWorld
```

```
Hello World!!
```

In [67]:

```
docker run dockerlabs/toolset:userN /hello
```

```
Hello from Docker.
This message shows that your installation appears to be working correct
ly.

To generate this message, Docker took the following steps:
 1. The Docker client contacted the Docker daemon.
 2. The Docker daemon pulled the "hello-world" image from the Docker Hu
b.
 3. The Docker daemon created a new container from that image which run
s the
    executable that produces the output you are currently reading.
 4. The Docker daemon streamed that output to the Docker client, which
sent it
    to your terminal.

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nt:
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 https://docs.docker.com/userguide/ (https://docs.docker.com/userguid
e/)
```

Dockerfile best practices

TOP

The goal of this step is to demonstrate certain Dockerfile optimizations.

- group related commands together using '&&' to reduce image layers
- if temporary files are to be removed

In [68]:

```
cd ~/src/build-best-practices
cat Dockerfile
```

```
FROM ubuntu

MAINTAINER "Docker Labs" <dockerlabs@mjbright.net>

#
# Instead of perofmring the followinf commands individually which
# involves creating a separate image layer for each RUN command:
#   RUN apt-get update
#   RUN apt-get -y -q upgrade
#   RUN rm -rf /var/lib/apt/lists/*

# Here we combine the update, upgrade and cleanup steps into one comman
d
# - This produces less image layers (better for disk space and performa
nce)
# - This keeps image smaller by removing temporary files in the same la
yer
#     If we performed update/upgrade and then rm as a separate step the
re would
#     be an intermediate layer including those files, making the overal
l image larger.
#

RUN apt-get update && apt-get -y -q upgrade && rm -rf /var/lib/apt/list
s/*
```

TO be completed ... !!

Using the official 'Language Stack' images

TOP

Creating a Node.js application from the Node.js 'LanguageStack' Docker image

TOP

Docker provide a set of *'Language Stacks'* which are medium sized images representing the necessary dependencies for a particular language.

The goal of this step is to demonstrate the use of Docker-provided *Language Stacks*.

On the [Docker Hub (https://hub.docker.com/)](https://hub.docker.com/) we can find language stacks available for a variety of languages/environments, each with different release versions (Python 2.x and Python 3.x for example):

- [Node.js (Javascript) (https://hub.docker.com/_/node/)](https://hub.docker.com/_/node/)
- [Python (https://hub.docker.com/_/python/)](https://hub.docker.com/_/python/)
- [Ruby (https://hub.docker.com/_/ruby/)](https://hub.docker.com/_/ruby/)

You can browse the complete list of '*Official Images*' on the Docker Hub [here (https://hub.docker.com/explore/)](https://hub.docker.com/explore/)

Now let's look at an example of Node.js. To run a Node.js application this time we will need

In [69]:

```
docker pull node
```

```
Using default tag: latest
latest: Pulling from library/node

03e1855d4f31: Already exists
a3ed95caeb02: Already exists
9269ba3950bb: Already exists
6ecee6444751: Already exists
7a0c192d4d25: Already exists
a3ed95caeb02: Already exists
Digest: sha256:1bdda7cdd0a8f9c44ac6f51c77de9f42ed3f62efdf557dba6bcca675
084de1bd
Status: Image is up to date for node:latest
```

In [70]:

```
docker images node
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED             
SIZE
node                latest              baa18fdeb577        12 days ago         
643.1 MB
```

In [71]:

```
docker history node
```

```
IMAGE               CREATED             CREATED BY
SIZE                COMMENT
baa18fdeb577        12 days ago         /bin/sh -c #(nop) CMD ["node"]
0 B
<missing>           12 days ago         /bin/sh -c curl -SLO "https://n
odejs.org/dist   36.39 MB
<missing>           12 days ago         /bin/sh -c #(nop) ENV NODE_VERS
ION=5.5.0        0 B
<missing>           12 days ago         /bin/sh -c #(nop) ENV NPM_CONFI
G_LOGLEVEL=inf   0 B
<missing>           12 days ago         /bin/sh -c set -ex   && for key
in      9554F0   51.75 kB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    314.7 MB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    122.6 MB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    44.3 MB
<missing>           13 days ago         /bin/sh -c #(nop) CMD ["/bin/ba
sh"]             0 B
<missing>           13 days ago         /bin/sh -c #(nop) ADD file:e5a3
d20748c5d3dd5f   125.1 MB
```

In [72]:

```
cd ~/src/nodeJS/
ls -altr
```

```
total 24
drwxrwxr-x  2 vagrant vagrant 4096 Feb  7 21:27 src
-rw-rw-r--  1 vagrant vagrant  116 Feb  7 21:27 README.md
-rw-rw-r--  1 vagrant vagrant  315 Feb  7 21:32 Dockerfile
-rwxrwxr-x  1 vagrant vagrant   78 Feb  7 21:32 build_run.sh
drwxrwxr-x  3 vagrant vagrant 4096 Feb  7 21:32 .
drwxrwxr-x 11 vagrant vagrant 4096 Feb  8 15:02 ..
```

Once again edit the Dockerfile to have the contents shown below:

In [73]:

```
cat Dockerfile
```

```
FROM node

# make the src folder available in the docker image
ADD src/ /src


WORKDIR /src

# install the dependencies from the package.json file
RUN npm install

# make port 80 available outside of the image
EXPOSE 80

# start node with the index.js file of our hello-world application
CMD ["node", "index.js"]
```

Now let's build the image

In [74]:

```
docker build -t node-hello .
```

```
Sending build context to Docker daemon 6.656 kB
Step 1 : FROM node
 ---> baa18fdeb577
Step 2 : ADD src/ /src
 ---> 185d94954037
Removing intermediate container 9bb58bd74883
Step 3 : WORKDIR /src
 ---> Running in ff9be9297185
 ---> b9d929ce3d90
Removing intermediate container ff9be9297185
Step 4 : RUN npm install
 ---> Running in 40468215f688
npm info it worked if it ends with ok
npm info using npm@3.3.12
npm info using node@v5.5.0
npm info attempt registry request try #1 at 4:18:42 PM
npm http request GET https://registry.npmjs.org/express (https://r
istry.npmjs.org/express)
npm http 200 https://registry.npmjs.org/express (https://registry.
npmjs.org/express)
```

and run the image in the background, exposing port 80

In [75]:

```
docker run -p 80:80 --name web -d node-hello
```

```
c43f44797eddb266ffa9d9d69fa91e12927284f8ec0af209193865ca3a43b434
```

Now let's use curl to access this container (default port for curl is 80)

In [76]:

```
curl http://localhost
```

```
<html><body>Hello from Node.js container c43f44797edd</body></html>
```

Creating a Python application from the Python 'LanguageStack' Docker image

TOP

The goal of this step is to demonstrate the use of the Python *Language Stack*.

Now let's look at a Python example. To run a Node.js application this time we will need

Let's pull and examine the official 'Docker Language Stack' image of Python

Note how the earliest image layers (at the bottom of the list) have the same image ids as the earliest image layers of the Node;js image.

So we can see that they were both created from the same base.

In [77]:

```
docker pull python
```

```
Using default tag: latest
latest: Pulling from library/python

03e1855d4f31: Already exists
a3ed95caeb02: Already exists
9269ba3950bb: Already exists
6ecee6444751: Already exists
7a0c192d4d25: Already exists
a3ed95caeb02: Already exists
66777d6149f5: Already exists
Digest: sha256:4651b83dd903ce78b1c455794f63d4108d9469a6c7fe97cd07d08a77
b7e72435
Status: Image is up to date for python:latest
```

In [78]:

```
docker images python
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
python              latest              93049cc049a6        12 days ago
689.1 MB
```

In [79]:

```
docker history python
```

```
IMAGE               CREATED             CREATED BY
SIZE                COMMENT
93049cc049a6        12 days ago         /bin/sh -c #(nop) CMD ["python
3"]                0 B
<missing>           12 days ago         /bin/sh -c cd /usr/local/bin
&& ln -s easy_i    48 B
<missing>           12 days ago         /bin/sh -c set -ex  && gpg --ke
yserver ha.poo   81.53 MB
<missing>           12 days ago         /bin/sh -c #(nop) ENV PYTHON_PI
P_VERSION=7.1.   0 B
<missing>           12 days ago         /bin/sh -c #(nop) ENV PYTHON_VE
RSION=3.5.1      0 B
<missing>           12 days ago         /bin/sh -c #(nop) ENV GPG_KEY=9
7FC712E4C024BB   0 B
<missing>           12 days ago         /bin/sh -c #(nop) ENV LANG=C.UT
F-8              0 B
<missing>           12 days ago         /bin/sh -c apt-get purge -y pyt
hon.*            978.7 kB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    314.7 MB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    122.6 MB
<missing>           13 days ago         /bin/sh -c apt-get update && ap
t-get install    44.3 MB
<missing>           13 days ago         /bin/sh -c #(nop) CMD ["/bin/ba
sh"]             0 B
<missing>           13 days ago         /bin/sh -c #(nop) ADD file:e5a3
d20748c5d3dd5f   125.1 MB
```

The following command will run the 'python' docker image, invoking the command 'python --version' to show us which default python version is available.

In [80]:

```
docker run python python --version
```

```
Python 3.5.1
```

Now let's look at extending this to a small 2-tier application with Flask web server as front-end and Redis as a backend database (counter) to count access to a web page.

To run this application create a Dockerfile with the following contents in the 'python_flask' directory

In [81]:

```
cd ~/src/python_flask
cat Dockerfile
```

```
FROM python:2.7

MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>

WORKDIR /src

ADD requirements.txt /src/

RUN pip install -r requirements.txt

ADD . /src

CMD python flask_redis_app.py
```

In [82]:

```
docker build -t lab/python_flask .
```

```
Sending build context to Docker daemon 4.096 kB
Step 1 : FROM python:2.7
2.7: Pulling from library/python

03e1855d4f31: Already exists
a3ed95caeb02: Already exists
9269ba3950bb: Already exists
6ecee6444751: Already exists
7a0c192d4d25: Already exists
a3ed95caeb02: Already exists
7d4cc27b64c3: Pulling fs layer
Digest: sha256:84d75f33b4ae12997a0a2d51481ed18525ee7b49a5660c3301a00dfb
2db19a14
Status: Downloaded newer image for python:2.7
 ---> 31093b2dabe2
Step 2 : MAINTAINER "Docker Build Lab" <dockerlabs@mjbright.net>
 ---> Running in 404474a045cb
 ---> 7aa58734ef0a
Removing intermediate container 404474a045cb
Step 3 : WORKDIR /src
 ---> Running in 1709c7d0613f
 ---> 50364340ba7d
Removing intermediate container 1709c7d0613f
Step 4 : ADD requirements.txt /src/
 ---> 2a48226d80a9
Removing intermediate container 86e962852b66
Step 5 : RUN pip install -r requirements.txt
 ---> Running in b6136d317c71
Collecting flask (from -r requirements.txt (line 1))
  Downloading Flask-0.10.1.tar.gz (544kB)
Collecting redis (from -r requirements.txt (line 2))
  Downloading redis-2.10.5-py2.py3-none-any.whl (60kB)
Collecting Werkzeug>=0.7 (from flask->-r requirements.txt (line 1))
  Downloading Werkzeug-0.11.3-py2.py3-none-any.whl (305kB)
Collecting Jinja2>=2.4 (from flask->-r requirements.txt (line 1))
  Downloading Jinja2-2.8-py2.py3-none-any.whl (263kB)
Collecting itsdangerous>=0.21 (from flask->-r requirements.txt (line
1))
  Downloading itsdangerous-0.24.tar.gz (46kB)
Collecting MarkupSafe (from Jinja2>=2.4->flask->-r requirements.txt (li
ne 1))
  Downloading MarkupSafe-0.23.tar.gz
Building wheels for collected packages: flask, itsdangerous, MarkupSafe
  Running setup.py bdist_wheel for flask
  Stored in directory: /root/.cache/pip/wheels/d2/db/61/cb9b80526b8f3ba
89248ec0a29d6da1bb6013681c930fca987
  Running setup.py bdist_wheel for itsdangerous
  Stored in directory: /root/.cache/pip/wheels/97/c0/b8/b37c320ff57e15f
993ba0ac98013eee778920b4a7b3ebae3cf
  Running setup.py bdist_wheel for MarkupSafe
  Stored in directory: /root/.cache/pip/wheels/94/a7/79/f79a998b64c1281
cb99fa9bbd33cfc9b8b5775f438218d17a7
```

```
Successfully built flask itsdangerous MarkupSafe
Installing collected packages: Werkzeug, MarkupSafe, Jinja2, itsdangero
us, flask, redis
Successfully installed Jinja2-2.8 MarkupSafe-0.23 Werkzeug-0.11.3 flas
k-0.10.1 itsdangerous-0.24 redis-2.10.5
You are using pip version 7.1.2, however version 8.0.2 is available.
You should consider upgrading via the 'pip install --upgrade pip' comma
nd.
 ---> 7cf562861598
Removing intermediate container b6136d317c71
Step 6 : ADD . /src
 ---> a4044ed2f4ea
Removing intermediate container 4d4b3bce93c5
Step 7 : CMD python flask_redis_app.py
 ---> Running in 0d95fa7b3fa6
 ---> 64113b113a8a
Removing intermediate container 0d95fa7b3fa6
Successfully built 64113b113a8a
```

In [83]:

```
docker images lab/*
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED
SIZE
lab/python_flask    latest              64113b113a8a        17 seconds
ago        682.9 MB
lab/toolset         latest              6b82de537bd1        44 minutes
ago        3.245 MB
lab/go-hello        latest              438d3567ae8a        45 minutes
ago        2.367 MB
lab/basic           latest              e3d7946e9d93        48 minutes
ago        689.1 MB
lab/c_prog          latest              659400ddd8d4        18 hours ag
o          877.2 kB
```

Now let's run this container in the background

First we must launch our redis DB as a background container, it will be used to count the number of page accesses.

For this we launch a container instance of the 'redis' image, as a background process (-d) and we also give the instance the name 'redis' also. This will allow our 'flask' container to link to this image

In [85]:

```
docker run -d --name redis redis
```

```
b00a2d863d93bd50ea13bba2046bd6325097f05195b8d3799239a93bd5694817
```

Now we launch our 'flask' image which will be our web server.

We also launch that container in the background. Note that we link to the 'redis' container. This allows the 'flask' container to connect to the redis database to get and increment the counter value

In [86]:

```
docker run -d --link redis:db -p 5000:5000 lab/python_flask
```

```
f2b3fffe66eff7279d9e4d47cd15bb7e2ae6033552d5c335e6627cc8b017c44c
```

Now as we make successive curl (or web browser) requests to our 'flask' web server we see that page access counter gets incremented

In [87]:

```
curl http://localhost:5000
```

```
Hello World!
This page has been visited 1 times.
On host f2b3fffe66ef
```

In [88]:

```
curl http://localhost:5000
```

```
Hello World!
This page has been visited 2 times.
On host f2b3fffe66ef
```

In [89]:

```
curl http://localhost:5000
```

```
Hello World!
This page has been visited 3 times.
On host f2b3fffe66ef
```

In [90]:

```
curl http://localhost:5000
```

```
Hello World!
This page has been visited 4 times.
On host f2b3fffe66ef
```

Using Compose

TOP

Building complex systems with Compose

TOP

In [91]:

```
cd ~/src/compose
```

Create a docker-compose.yml specification file with the following contents.

This is a 2-tier architecture with

In [94]:

```
cat docker-compose.yml
```

```
version: 2
services:
  weba:
    build: ../nodeJS
    expose:
      - 80

  webb:
    build: ../nodeJS
    expose:
      - 80

  webc:
    build: ../nodeJS
    expose:
      - 80

  haproxy:
    image: haproxy
    volumes:
     - ./haproxy:/usr/local/etc/haproxy/
    links:
     - weba
     - webb
     - webc
    ports:
     - "80:80"
     - "70:70"
    expose:
     - "80"
     - "70"
```

Let's look at the docker-compose options

In [95]:

```
docker-compose
```

```
Define and run multi-container applications with Docker.

Usage:
  docker-compose [-f=<arg>...] [options] [COMMAND] [ARGS...]
  docker-compose -h|--help

Options:
  -f, --file FILE           Specify an alternate compose file (default:
docker-compose.yml)
  -p, --project-name NAME   Specify an alternate project name (default:
directory name)
  --verbose                 Show more output
  -v, --version             Print version and exit

Commands:
  build              Build or rebuild services
  config             Validate and view the compose file
  create             Create services
  down               Stop and remove containers, networks, images, and
volumes
  events             Receive real time events from containers
  help               Get help on a command
  kill               Kill containers
  logs               View output from containers
  pause              Pause services
  port               Print the public port for a port binding
  ps                 List containers
  pull               Pulls service images
  restart            Restart services
  rm                 Remove stopped containers
  run                Run a one-off command
  scale              Set number of containers for a service
  start              Start services
  stop               Stop services
  unpause            Unpause services
  up                 Create and start containers
  version            Show the Docker-Compose version information
```

Let's first do some cleanup of any existing containers invoked by compose

In [99]:

```
docker-compose stop
```

In [102]:

```
docker-compose rm -f
```

```
No stopped containers
```

Remove any other containers which might be listening on port 80 - here we stop and remove all containers to be sure

In [101]:

```
docker stop $(docker ps -q)
docker rm $(docker ps -aq)
```

```
f2b3fffe66ef
b00a2d863d93
c43f44797edd
f2b3fffe66ef
b00a2d863d93
c43f44797edd
```

Now we will startup our system.

```
docker-compose up
```

will startup the containers specified in docker-compose.yml (first building any images where 'build:' is specified)

Launching in the foreground will produce the following output:

```
    Creating compose_webc_1
    Building weba
    Step 1 : FROM node
     ---> baa18fdeb577
    Step 2 : ADD src/ /src
     ---> Using cache
     ---> 6d6e1fb506d4
    Step 3 : WORKDIR /src
     ---> Using cache
     ---> f293e728d28f
    Step 4 : RUN npm install
     ---> Using cache
     ---> 16107856389c
    Step 5 : EXPOSE 80
     ---> Using cache
     ---> eed510133b6b
    Step 6 : CMD node index.js
     ---> Using cache
     ---> 2e6df94ecab1
    Successfully built 2e6df94ecab1
    Creating compose_weba_1
    Creating compose_haproxy_1
    Attaching to compose_webb_1, compose_webc_1, compose_weba_1, compose_haprox
    y_1
    webb_1    | Running on http://localhost
    webc_1    | Running on http://localhost
    weba_1    | Running on http://localhost
    haproxy_1 | [WARNING] 038/165945 (1) : Server aj_backends/weba is UP, reaso
    n: Layer7 check passed, code: 200, info: "HTTP status check returned code <3
    C>200<3E>", check duration: 6ms. 3 active and 0 backup servers online. 0 ses
    sions requeued, 0 total in queue.
```

where we see that the necessary images were built and then started. We also see startup of the haproxy container and it's checks that it can contact the web servers.

Let's start the containers in the background

In [103]:

```
docker-compose up -d
```

```
Creating compose_webb_1
Creating compose_webc_1
Creating compose_weba_1
Creating compose_haproxy_1
```

Now we can see that appropriate images have been built and we can also use 'docker-compose ps' to see the running elements of our system

In [104]:

```
docker images compose*
```

```
REPOSITORY          TAG                 IMAGE ID            CREATED             
SIZE
compose_weba        latest              2e6df94ecab1        4 minutes a
go         645.8 MB
compose_webb        latest              2e6df94ecab1        4 minutes a
go         645.8 MB
compose_webc        latest              2e6df94ecab1        4 minutes a
go         645.8 MB
```

In [105]:

```
docker-compose ps
```

```
      Name                Command               State                Ports
-----------------------------------------------------------------------
--
compose_haproxy_   haproxy -f          Up                  0.0.0.0:70->7
0/t
1                  /usr/local/etc/                         cp, 0.0.0.0:8
0->
                   ...                                     80/tcp
compose_weba_1     node index.js       Up                  80/tcp
compose_webb_1     node index.js       Up                  80/tcp
compose_webc_1     node index.js       Up                  80/tcp
```

Now we can use curl connecting to localhost:80 (on which the haproxy container is listening) and we will see how haproxy is doing roundrobin scheduling to each of our web containers

In [106]:

```
curl localhost:80
```

```
<html><body>Hello from Node.js container 8727c713bfd4</body></html>
```

In [107]:

```
curl localhost:80
```

```
<html><body>Hello from Node.js container 594f34c12cb5</body></html>
```

In [108]:

```
curl localhost:80
```

```
<html><body>Hello from Node.js container 3ebf9e175082</body></html>
```

Note how the container id changes each time.

Now we can try scaling one of our services as shown below:

In [109]:

```
docker-compose scale weba=5
```

```
Creating and starting 2 ...
Creating and starting 3 ...
Creating and starting 4 ...
Creating and starting 5 ...
```

With 'docker-compose ps' we see that we now have scaled to 5 'weba' servers:

In [110]:

```
docker-compose ps
```

```
      Name                Command             State               Ports
-----------------------------------------------------------------------
--
compose_haproxy_   haproxy -f          Up                 0.0.0.0:70->7
0/t
1                  /usr/local/etc/                        cp, 0.0.0.0:8
0->
                   ...                                    80/tcp
compose_weba_1     node index.js       Up                 80/tcp
compose_weba_2     node index.js       Up                 80/tcp
compose_weba_3     node index.js       Up                 80/tcp
compose_weba_4     node index.js       Up                 80/tcp
compose_weba_5     node index.js       Up                 80/tcp
compose_webb_1     node index.js       Up                 80/tcp
compose_webc_1     node index.js       Up                 80/tcp
```

In [111]:

```
curl localhost:80
curl localhost:80
curl localhost:80
curl localhost:80
curl localhost:80
curl localhost:80
```

```
<html><body>Hello from Node.js container 8727c713bfd4</body></html><htm
l><body>Hello from Node.js container 594f34c12cb5</body></html><html><b
ody>Hello from Node.js container 3ebf9e175082</body></html><html><bod
y>Hello from Node.js container 8727c713bfd4</body></html><html><body>He
llo from Node.js container 594f34c12cb5</body></html><html><body>Hello
from Node.js container 3ebf9e175082</body></html>
```

Now let's stop our current system

In [113]:

```
docker-compose stop
docker-compose rm -f
docker-compose ps
```

```
No stopped containers
Name   Command   State   Ports
------------------------------
```

Building Docker

TOP

Building Docker with Docker

TOP

A major advantage of Docker is to simplify build environments.

Let's look at how we can build the Docker engine client/daemon binary without having to explicitly install a development environment.

The goal of this step is simply to show the ease with which we can build Docker, thanks to Docker itself.

We do not make particular use of the built image.

The process involves the following steps, several of which have already been performed so as to prevent excessive network utilisation during the lab. Nevertheless all steps are described here so that you can see just how easy it is to build Docker from scratch:

- Install make
- Clone the Docker source code
- Checkout the same code revision as our current Docker binary (client and daemon)
- Build the code - which pulls the docker-dev image containing the required version of the Go compiler
- Run the executable to demonstrate it is correct

Installing make

In your environment we have already installed the make package, but no compiler using yum:

```
yum install make
```

Cloning the Docker source code

We have already downloaded the Docker source code from github as follows:

```
mkdir -p /root/src/docker
cd /root/src/docker
git clone https://github.com/docker/docker .
```

To build Docker we simply have to build using the

```
make build
```

command.

Checkout the source code revision corresponding to our installed Docker Engine

If we build the latest sources this may not be compatible with our installed Docker version.

This is the case. We have 1.10.0-rc2 installed, which has API version 22, but the current github source is 1.10.0-dev which has changed to API version 23. So if we build this we find that we cannot use this client to communicate with the installed daemon.

So let's checkout the code for 1.10.0-rc2.

At the time of writing this is the latest release(candidate) of the Docker engine. We can obtain that version of the source code by referring to the releases page https://github.com/docker/docker/releases (https://github.com/docker/docker/releases) and selecting the SHA1 hash of build 1.10.0-rc2

```
git checkout c1cdc6e
```

Build the code - which pulls the docker-dev image containing the required version of the Go compiler

We can build the code as follows:

```
make build
```

We have run 'make build' already, so the docker-dev image has already been downloaded (again to prevent excessive network traffic). The docker-dev image includes the required go compiler and other build tools.

Run 'make build' again and you will see a standard build process and finally where it places the compiled binary

Run the executable to demonstrate it is correct

In preparation for the lab we built from the latest source (not the c1cdc6e version we checked out).

Run this build as follows to see that it is not compatible with the installed binary (/usr/bin/docker). We see that this binary has version 1.10.0-dev and API version 1.23 but that this cannot communicate with our installed binary which has API version 1.22.

In [ ]:

```
cd /root/src/docker; ls -altr bundles/1.10.0-dev/binary/docker-1.10.0-dev; ./bundles/
```

But if we run our new build - as follows - created from revision c1cdc6e of the source code (corresponding to Docker version 1.10.0-rc2) we see that it has the correct version, with the same API version and can interrogate the server.

In [ ]:

```
cd /root/src/docker; ls -altr bundles/1.10.0-rc2/binary/docker-1.10.0-rc2; ./bundles/
```

In [ ]:

References

TOP

- Dockerfile Reference (https://docs.docker.com/engine/reference/builder/)
- Compose file documentation (https://docs.docker.com/compose/compose-file/)
- Compose file reference (https://github.com/docker/compose/blob/1.6.0-rc1/docs/compose-file.md)
- Visualizing Docker Containers and Images (http://merrigrove.blogspot.in/2015/10/visualizing-docker-containers-and-images.html)
- Awesome Docker (https://github.com/veggiemonk/awesome-docker)
- Docker Cheat Sheet ()
- Building Good Docker Images (http://jonathan.bergknoff.com/journal/building-good-docker-images)
- How to scale a Docker Container with Docker Compose (https://www.brianchristner.io/how-to-scale-a-docker-container-with-docker-compose/)
- Docker Compose Demo (https://github.com/vegasbrianc/docker-compose-demo)

In [ ]: