Lab No. 2: Containers

In the previous lab, you created a virtual machine and perform several installation tasks manually.

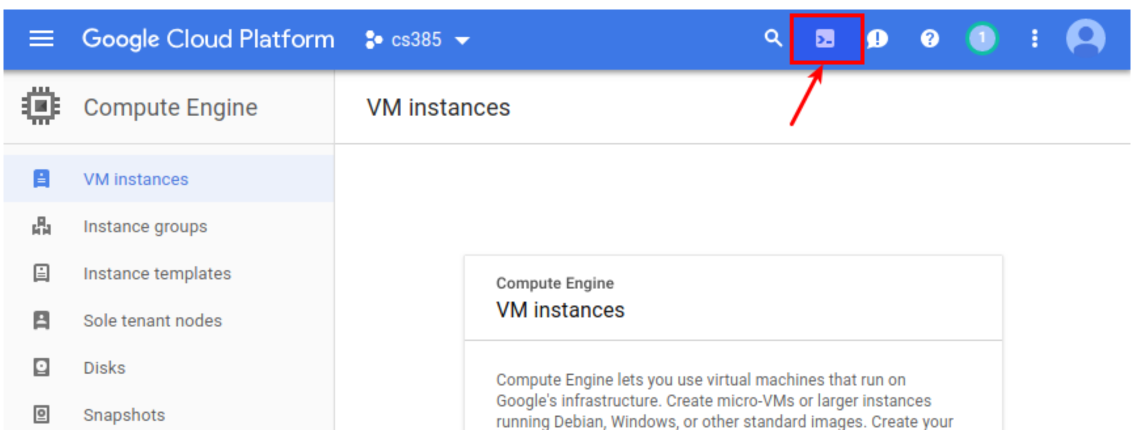
In this lab we are going to:

1. Learn about how to automate Virtual Machine creation
2. Learn how to run containers
3. Build and optmize containers
4. Deploy and manage containers using the basic docker tools

Part 1: Setup a Docker Host

Google cloud provides a service called “Cloud Shell” that has several tools preconfigured to allow command-line administration of cloud services. We are going to use this tool to create a Virtual machine.

1. Start the cloud shell by click on the icon in the Top Icons bar.



2. Create a new **Ubuntu 18.04 LTS micro instance** with an external IP instance by executing the following command:

```
> gcloud compute instances create docker-01 --zone=us-west1-c --machine-type=n1
WARNING: You have selected a disk size of under [200GB]. This may result in poo
Created [https://www.googleapis.com/compute/v1/projects/personal-211918/zones/u
NAME       ZONE        MACHINE_TYPE   PREEMPTIBLE  INTERNAL_IP  EXTERNAL_IP
docker-01  us-west1-c  n1-standard-1               10.138.0.3   35.230.13.202
```

3. SSH into the docker-01 host, install docker and the current user to the `docker` user group:

```
> sudo apt-get install -y apt-transport-https ca-certificates curl software-pro
> curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -
> sudo add-apt-repository "deb [arch=amd64] https://download.docker.com/linux/u
> sudo apt-get update
> sudo apt-get install -y docker-ce=18.06.1~ce~3-0~ubuntu
> sudo usermod -aG docker $USER
```

4. Log out and log back in in order to have a shell session with the updated group membership. Once you log back in test that docker daemon is running:

```
> docker run hello-world
```

Make sure that you read an understand the output of the last command.

Part 2: Run applications in Docker

In this part of the lab you are going to build and deploy applications in docker containers. You need to be logged into the Virtual Machine that was created on Part 1 (`docker-01`) to complete the steps of this lab,

1. We are going to run Kafka and Zookeeper in docker containers. Create a directory called `kafka` in your home(`~`) directory, and change into it. Create a `Dockerfile` with the following content:

```
FROM openjdk:8-jre

ENV KAFKA_VERSION 1.0.0
ENV KAFKA_SCALA_VERSION 2.11
ENV KAFKA_ARCH "kafka_$KAFKA_SCALA_VERSION-$KAFKA_VERSION.tgz"
ENV KAFKA_HOME /opt/kafka

WORKDIR /opt

RUN apt-get update
RUN apt-get install -y jq
RUN wget -O - $(wget -qO- https://www.apache.org/dyn/closer.cgi\?as_json\=1\&pa
RUN mv /opt/kafka_$KAFKA_SCALA_VERSION-$KAFKA_VERSION $KAFKA_HOME
RUN sed -i 's/zookeeper.connect=localhost:2181/zookeeper.connect=zookeeper:2181
RUN sed -i 's/broker.id=0/broker.id=-1/g' /opt/kafka/config/server.properties

CMD ["/opt/kafka/bin/kafka-server-start.sh", "/opt/kafka/config/server.properti
```

2. Build the docker image (make sure you are in the `~/kafka` directory):

```
> docker build -t kafka-cs385 .
```

3. Run the `docker images` command. Notice how you have entries for the image that was just built and for the base image:

```
> docker images
REPOSITORY          TAG                 IMAGE ID            CREATED
kafka-cs385         latest              1f3ed9b84a19        7 seconds ago
openjdk             8u181-jre           66bf39162ea7        2 days ago
hello-world         latest              2cb0d9787c4d        8 weeks ago
```

4. Verfiy the image layers by using the `docker history` command. The output should return several lines, each one corresponds to a *layer*. You can see that the last layers added correspond to the build steps from the Dockerfile we just built. Compare the history of `kafka-cs385` with the history of `openjdk:8-jre` . How many layers on top of `openjdk:8-jre` were added by our kafka `Dockerfile` ? Can you find the correspondence between layers and commands in the kafka-cs385 `Dockerfile` ? How much bigger in MB is `kafka-cs385` when compared to `openjdk:8-jre` ?

```
> docker history kafka-cs385
```

5. Before proceeding any further, we need to test that our image runs. To do this, we first need to create a user-defined bridge network and then start a Zookeeper server. To run zookeeper we are going to use the official Apache Zookeeper Docker Image (https://hub.docker.com/_/zookeeper/). To run it, use this command:

```
> docker network create testnet
> docker run -d --name zookeeper --net testnet zookeeper:3.4.11
```

6. Verify that the Zookeeper container is running by using the `docker ps` command

```
> docker ps
```

7. Now that Zookeeper is running we can start Kafka:

```
> docker run -d --name kafka --net testnet kafka-cs385
```

8. Verify that both Kafka and Zookeeper are running by executing the `docker ps` command:

```
> docker ps
CONTAINER ID        IMAGE               COMMAND                  CREATED
6a76c10946f9        kafka-cs385         "/opt/kafka/bin/ka..."   7 seconds ago
c53269318237        zookeeper:3.4.11    "/docker-entrypoin..."   4 hours ago
```

9. To test Kafka, we are going to log into the container. To do this, we will use the `docker exec` command in *interactive* mode:

```
> docker exec -it kafka bash
root@6a76c10946f9:/opt#
```

10. Notice how your shell prompt changed, and it includes the container id as host name. You can now run commands that will be executed inside the container. We are going to do now several basic interactions with Kafka (refer to the Apache Kafka Quickstart (https://kafka.apache.org/quickstart) First create a topic:

```
root@6a76c10946f9:/opt# kafka/bin/kafka-topics.sh --create --zookeeper zookeepe
Created topic "mytopic".
```

11. Now we use the **Kafka console producer** to write some messages:

```
root@6a76c10946f9:/opt# kafka/bin/kafka-console-producer.sh --broker-list local
```

12. Enter several lines of text and press `Ctrl+C` to close the console producer. Now let's read those messages using the console consumer:

```
root@6a76c10946f9:/opt# kafka/bin/kafka-console-consumer.sh --bootstrap-server locall
```

13. Notice how the messages that you created earlier are retrieved by the console consumer. Once all the messages are written to the terminal, press `Ctrl+C` to terminate the console consumer.

14. Exit the container (by typing the `exit` command as you do with a normal bash session). We now want to terminate the container by using the docker stop command:

```
> docker stop kafka
```

15. If you run the `docker ps` command, the container is not shown as running anymore. Nevertheless, the container still exists and it can be restarted. Compare the output of `docker ps` with the same command but using the `-a` option which shows all the containers. If we want to remove a container completely, then we must use the `docker rm` command:

```
> docker rm kafka
```

Part 3: Dockerfile Optimization

The Dockerfile that we used works, but it generates an image that is rather big in size. We can reduce the size of the image by merging several instructions together.

1. Edit the docker file to merge all the **RUN** instructions into a single instruction. How much space do you save by doing this? Build this dockerfile and tag is as `kafka-cs385:consolidated_run` :

```
> docker build -t kafka-cs385:consolidated_run .
```

2. After you successfully build this new image, run it as we did before with the `kafka-cs385` image, and make sure that Kafka is working and you can create topics, produce messages and retrieve them.

3. We can also reduce the amount of used space by removing the cache of installation utilities. Add a command to the **RUN** instruction to remove the `apt` cache. Hint: The Dockerfile best practices (https://docs.docker.com/engine/userguide/eng-image/dockerfile_best-practices/#run) reference has very valuable information that can help you. Build this image and tag it as `kafka-cs385:nocache`

```
> docker build -t kafka-cs385:nocache .
```

4. As we did before, make sure that your image works and you can interact with topics.

5. We can further reduce the size of our Kafka image by using a smaller base image. The OpenJDK official docker repository (https://hub.docker.com/_/openjdk/) has many images that can be used. Typically, the *slim* versions are debian based images of much smaller size. Update the Dockerfile to use a *slim* base image. Note that you will need not only to update the base image, but you will probably need to install utilities that are no longer included in the base image and are needed to complete the installation of kafka. Build this image and tag is as `kafka-cs385:slim`

```
> docker build -t kafka-cs385:slim .
```

6. As before, make sure that your image works and you can interact with topics.

7. After performing the previous optimizations, you can compare the sizes of the resulting images (your image sizes might differ a little bit, but should be close to these values)

```
> docker images
REPOSITORY          TAG                 IMAGE ID            CREATED
kafka-cs385         slim                0c76aa21f306        5 minutes ago
kafka-cs385         nocache             eda22e7be277        12 minutes ago
kafka-cs385         consolidated_run    e9b0d0b69019        23 minutes ago
kafka-cs385         latest              0d5561696173        30 minutes ago
openjdk             8-jre               97c270c3cab0        2 weeks ago
openjdk             8-jre-slim          837969d6f968        2 weeks ago
```

8. You can go even further by instead of using an image based on debian, you can use an *alpine* base image to reduce the size of the image even more. You will need to do some experimentation to figure out which utilities need to be installed to be able to install kafka, and also to run it.

```
> docker images
REPOSITORY          TAG                 IMAGE ID            CREATED
kafka-cs385         alpine              44ea7ee63d23        16 hours ago
kafka-cs385         slim                0c76aa21f306        21 hours ago
kafka-cs385         nocache             eda22e7be277        21 hours ago
kafka-cs385         consolidated_run    e9b0d0b69019        22 hours ago
kafka-cs385         latest              0d5561696173        22 hours ago
zookeeper           3.4.11              09fe1e7c8f0f        11 days ago
openjdk             8-jre               97c270c3cab0        2 weeks ago
openjdk             8-jre-alpine        b36ec9de53a8        2 weeks ago
openjdk             8-jre-slim          837969d6f968        2 weeks ago
```

Part 4: Building a Python App

In this section we are going to learn how to interact with Kafka programatically using the pykafka (https://github.com/Parsely/pykafka) python library. We are going to create a simple app that exposes a REST API that receives messages and writes them to Kafka topics. We are then going to create another app that consumes those messages.

1. SSH into **docker-0**. Create a new directory called `kafkaclient` and change into it.

2. Create a file called `app.py` with the following content:

```
from flask import Flask, request, Response
from pykafka import KafkaClient


app = Flask(__name__)
client = KafkaClient(zookeeper_hosts="zookeeper")

# create topics

topics = ['deliveries', 'updates']

for item in topics:
    client.topics[item]


@app.route("/kafka", methods=['POST'])
def write_message():
    payload = request.get_json()
    req_topic = payload['topic'].encode('utf-8')
    req_message = payload['message'].encode('utf-8')
    if req_topic in client.topics:
        topic = client.topics[req_topic]
        with topic.get_sync_producer(max_queued_messages=0, linger_ms=0) as pro
            producer.produce(req_message)
        return Response(response='{"msg": "Success"}', status=200, mimetype="ap
    else:
        return Response(response='{"msg": "Invalid Topic"}', status=400, mimety
```

3. Create a file called `requirements.txt` with the following content:

```
Flask==0.12.2
pykafka==2.6.0
```

4. Create a `Dockerfile` with the following contents:

```
FROM python:2.7-alpine3.6

COPY * /opt/kafkaclient/

WORKDIR /opt/kafkaclient

RUN apk add --no-cache g++ \
    && pip install -r requirements.txt

ENV FLASK_APP app.py

CMD ["flask", "run", "--host=0.0.0.0", "--port=5000"]
```

5. Once all these files have been created, the directory tree of `kafkaclient` should look like this:

```
kafkaclient
    ├── app.py
    ├── Dockerfile
    └── requirements.txt
```

6. Build the image:

```
>  docker build -t kafkaclient .
```

7. Start Zookeeper and Kafka using the same instructions from the previous section (Use the most optimized Kafka image available)
8. Start a kafkaclient container that *exposes* the container's port 5000 in the host's port 80:

```
> docker run --rm -d -p 80:5000 --name kafkaclient --net testnet kafkaclient
```

9. The application has two hard-coded topics ("deliveries" and "updates"), and only writes messages to those topics. To write a message, we will use the `POST /kafka` REST API endpoint. On another terminal, in your workstation (i.e. without logging into `docker-0`) execute the following command (replace `DOCKER-01_EXTERNAL_IP_ADDRESS` with the corresponding value)

```
> curl -X POST -H 'Content-type: application/json' http://<DOCKER-01_EXTERNAL_I
```

10. Try writing different messages and writing to topics that are not `deliveries` or `updates`.

11. Back into a session where you are logged into `docker-01` , log into the `kafka` container and start a console consumer for the "deliveries" topic (we used the `kafka-console-consumer` back in the **Building a Dockerfile: Apache Kafka** section). Write some messages to the `deliveries` topic using the `POST /kafka` REST API and notice the effect on the console consumer.

Part 5: Deploy the Minibank app

In this section you are going to work on your own. The objective is to deploy the minibank application in docker. You need to follow these guidelines:

- The golang application and the mysql service need to run in two different containers. You will need to make (a very simple) modification to the minibank application that allows it to handle the fact that the mysql daemon is not running under the same host.
- The level of optimization of the resulting images will be taken into consideration when your work is evaluated.
- For the minibank applicaton, use an alpine linux base image. For the mysql image, use an ubuntu or debian image. If you prefer to use MariaDB instead of mysql, that is perfectly fine. **Update 09/20/2018**: You can use a publicly available image for mysql/mariadb.
- **Updated 09/20/2018**: ~~The images should not require mounting any directories to run.~~ Update 09/20/2018: You are allowed to use mounted directories on your mysql image.
- The minibank application should be able to handle the fact that the mysql service might not be running when it is started. You will need to modify the minibank sourcecode to return a 503 response in such case.
- **You will need to provide a Makefile that will have the following targets**
  - A target called `minibank` that will build the minibank docker image. To compile minibank, you need to use the procedure explained in https://github.com/docker-library/docs/tree/master/golang#compile-your-app-inside-the-docker-container (https://github.com/docker-library/docs/tree/master/golang#compile-your-app-inside-the-docker-container). (See note below about the system where this will be tested)
  - A target called `mysql` that will build the mysql image
  - A target called `run-images` that will start the minibank and the mysql containers.

What to turn in:

A link to a public Github repository that will contain:

1. The updated minibank source code
2. The Dockerfile for the minibank application
3. The Dockerfile for mysql
4. The makefile
5. (if needed) A README file with any instructions or additional information that you deem appropriate.

Your submission will be tested in an **Ubuntu 18.04 System** that **will not have the golang** binaries installed. If your make targets require to have a golang installation, they will not work. The only software that you are guaranteed to be installed on that system are docker, make, git and curl/wget. If there is another tool that is required to build/run your submission, make sure you ask or at least document it.

The minibank source code for this assignment is available at https://github.com/jcabmora/minibank/tree/week1/week1 (https://github.com/jcabmora/minibank/tree/week1/week1)

Additional Resources

https://docs.docker.com/v17.09/engine/docker-overview (https://docs.docker.com/v17.09/engine/docker-overview)

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