Lab 3: Managing Your Docker Images

Overview

In this lab, we will look into Docker layers and analyze how caching can help to speed up an image build. We will also deep dive into Docker images and set up Docker registries to increase the reusability of the images.

The next exercise will give you hands-on experience on how to work with Docker image layers.

Exercise 3.01: Working with Docker Image Layers

In this exercise, you will work with some basic `Dockerfiles` to see how Docker uses layers to build images. You will start by creating a `Dockerfile` and building a new image. You will then rebuild the image to see the advantage of using caching and how the build time is reduced due to its use:

1. Create a new file called `Dockerfile` with your favorite text editor and add in the following details:

```
FROM alpine
RUN apk update
RUN apk add wget
```

2. Save the `Dockerfile` and then, from the command line, make sure you are in the same directory as the `Dockerfile` you have created. Use the `docker build` command to create the new image using the `-t` option to name it `basic-app`:

```
docker build -t basic-app .
```

3. Use the `docker history` command along with the image name of `basic-app` to see the different layers of the image:

```
docker history basic-app
```

   The history gives you creation details, including the size of each layer:

```
IMAGE          CREATED             CREATED BY
                       SIZE
a6d7e99283d9   About a minute ago  /bin/sh -c apk add wget
                       476kB
bcecd2429ac0   About a minute ago  /bin/sh -c apk update
                       1.4MB
961769676411   5 weeks ago         /bin/sh -c #(nop)
CMD ["/bin/sh"]        0B
<missing>      5 weeks ago         /bin/sh -c #(nop)
ADD file:fe6407fb…     5.6MB
```

   Note

   The `docker history` command shows the layer of the original image used as part of the `Dockerfile` `FROM` command as `<missing>`. It is showing as `missing` in our output as it was created on a different system and then pulled onto your system.

4. Run the build again without making any changes:

```
docker build -t basic-app .
```

This will show you the build is done using the layers stored in the Docker image cache, thereby speeding up our build. Although this is only a small image, a much larger image would show a significant increase:

```
Sending build context to Docker daemon  4.096kB
Step 1/3 : FROM alpine
  ---> 961769676411
Step 2/3 : RUN apk update
  ---> Using cache
  ---> bcecd2429ac0
Step 3/3 : RUN apk add wget
  ---> Using cache
  ---> a6d7e99283d9
Successfully built a6d7e99283d9
Successfully tagged basic-app:latest
```

5. Say you forgot to install the `curl` package as part of your image creation. Add the following line to the `Dockerfile` from *Step 1*:

```
FROM alpine
RUN apk update
RUN apk add wget curl
```

6. Build the image again, and you'll now see the image created with a mix of cached layers and new layers that need to be created:

```
docker build -t basic-app .
```

7. Run the `docker images` command again:

```
docker images
```

You will now notice the image named and tagged as `<none>` to show we have now created a dangling image:

```
REPOSITORY   TAG      IMAGE ID        CREATED           SIZE
basic-app    latest   c7918f4f95b9    25 seconds ago    8.8MB
<none>       <none>   0e86ae52098d    2 minutes ago     7.48MB
Alpine       latest   961769676411    5 weeks ago       5.58MB
```

Note

Dangling images, represented by `<none>` in our image list, are caused when a layer has no relationship to any image on our system. These dangling images no longer serve a purpose and will consume disk space on your system. Our example dangling image is only 7.48 MB, which is small, but this could add up over time.

8. Run the `docker image inspect` command using the image ID to see the location of where the dangling images are located on our system:

```
docker image inspect UPDATE_ME
```

The following output has been reduced from the actual output to only show the directories of the image:

```
...
  "Data": {
    "LowerDir": "/var/lib/docker/overlay2/
      41230f31bb6e89b6c3d619cafc309ff3d4ca169f9576fb003cd60fd4ff
      4c2f1f/diff:/var/lib/docker/overlay2/
      b8b90262d0a039db8d63c003d96347efcfcf57117081730b17585e163f
      04518a/diff",
    "MergedDir": "/var/lib/docker/overlay2/
      c7ea9cb56c5bf515a1b329ca9fcb2614f4b7f1caff30624e9f6a219049
      32f585/
      merged",
    "UpperDir": "/var/lib/docker/overlay2/
      c7ea9cb56c5bf515a1b329ca9fcb2614f4b7f1caff30624e9f6a21904
      932f585/diff",
    "WorkDir": "/var/lib/docker/overlay2/
      c7ea9cb56c5bf515a1b329ca9fcb2614f4b7f1caff30624e9f6a21904
      932f585/work"
  },
...
```

All of our images are located in the same location as the dangling image. As they are sharing the same directory, any dangling images would waste space on our system.

9. Run the `docker images` command again using the `-a` option:

```
docker images -a
```

It will also show the intermediate layers used when our image is being built:

```
REPOSITORY   TAG      IMAGE ID      CREATED          SIZE
basic-app    latest   c7918f4f95b9  25 seconds ago   8.8MB
<none>       <none>   0e86ae52098d  2 minutes ago    7.48MB
<none>       <none>   112a4b041305  11 minutes ago   7MB
Alpine       latest   961769676411  5 weeks ago      5.58MB
```

10. Run the `docker image prune` command to remove all the dangling images. You could remove all the dangling images one at a time using the `docker rmi` command using the image ID, but the `docker image prune` command is an easier way to do that:

```
docker image prune
```

You should get output like the following:

```
WARNING! This will remove all dangling images.
Are you sure you want to continue? [y/N] y
Deleted Images:
deleted: sha256:0dae3460f751d16f41954e0672b0c41295d46ee99d71
         d63e7c0c8521bd9e6493
deleted: sha256:d74fa92b37b74820ccccea601de61d45ccb3770255b9
```

```
         c7dd22edf16caabafc1c
Total reclaimed space: 476.4kB
```

11. Run the `docker images` command again:

    ```
    docker images
    ```

    You will see we no longer have the dangling image in our list of images:

    ```
    REPOSITORY   TAG      IMAGE ID        CREATED           SIZE
    basic-app    latest   c7918f4f95b9    25 seconds ago    8.8MB
    Alpine       latest   961769676411    5 weeks ago       5.58MB
    ```

For our next exercise, we will look further at our layers and caching to see how they can be used to speed up the image build process.

Exercise 3.02: Increasing Build Speed and Reducing Layers

You have been working with smaller builds so far. However, as your applications increase in size and functionality, you'll start to consider both the size and number of layers of the Docker images you're creating and the speed at which you're creating them. The goal of this exercise is to speed up the build times and reduce the size of your images, as well as use the `--cache-from` option when building your Docker images:

1. Create a new `Dockerfile` to demonstrate the change you are going to make, but first, clear up all the images on your system. Run the `docker rmi` command with the `-f` option to force any removals needed, and the command in brackets will provide a list of all image IDs on your system. Use the `-a` option to show all running and stopped containers and the `-q` option to only show the container image hash value and nothing else:

    ```
    docker rmi -f $(docker images -a -q)
    ```

    The command should return output like the following:

    ```
    Untagged: hello-world:latest
    ...
    deleted: sha256:d74fa92b37b74820ccccea601de61d45ccb3770255
             b9c7dd22edf16caabafc1c
    ```

    It can be observed that the `hello-world: latest` image is untagged and the image with ID `sha256:d74fa92b37b74820ccccea601 de61d45ccb3770255b9c7dd22edf16caabafc1c` is removed.

2. Add the following code to your `Dockerfile` (which you created in *Exercise 3.01*). It will simulate a simple web server, as well as print the output of our `Dockerfile` during the build process:

    ```
    FROM alpine

    RUN apk update
    RUN apk add wget curl

    RUN wget -O test.txt https://github.com/fenago/docker-
    course/blob/master/lab03/Exercise3.02/100MB.bin
    ```

```
CMD mkdir /var/www/
CMD mkdir /var/www/html/

WORKDIR /var/www/html/

COPY Dockerfile.tar.gz /tmp/
RUN tar -zxvf /tmp/Dockerfile.tar.gz -C /var/www/html/
RUN rm /tmp/Dockerfile.tar.gz

RUN cat Dockerfile
```

You'll notice *line 6* of the `Dockerfile` is doing a fairly menial task (downloading a 100 MB file, named `100MB.bin`), which would not normally be performed in a `Dockerfile`. We have added it in to represent a build task or something similar that may be added during your build process, for example, downloading content or building software from a file.

3. Download your base image using the `docker pull` command so that you can start with the same image for each test we do:

```
docker pull alpine
```

4. Create a TAR file to be added to our image as we have instructed in *line 13* of our `Dockerfile`:

```
tar zcvf Dockerfile.tar.gz Dockerfile
```

5. Build a new image using the same name as `basic-app.` You will use the `time` command at the start of the code to allow us to gauge the time it takes to build our image:

```
time docker build -t basic-app .
```

The output will return the time taken to build the image:

```
...
real 4m36.810s
user 0m0.354s
sys 0m0.286s
```

6. Run the `docker history` command over the new `basic-app` image:

```
docker history basic-app
```

We have a few extra commands in our `Dockerfile` compared to the previous exercise. So, there should be no surprise that we will see 12 layers in our new image:

```
IMAGE         CREATED      CREATED BY                              SIZE
5b2e3b253899 2 minutes ago /bin/sh -c cat Dockerfile               0B
c4895671a177 2 minutes ago /bin/sh -c rm /tmp/Dockerfile.tar.gz 0B
aaf18a11ba25 2 minutes ago /bin/sh -c tar -zxvf /tmp/Dockfil…   283B
507161de132c 2 minutes ago /bin/sh -c #(nop) COPY file:e39f2a0… 283B
856689ad2bb6 2 minutes ago /bin/sh -c #(nop) WORKDIR /var/…     0B
206675d145d4 2 minutes ago /bin/sh -c #(nop)  CMD ["/bin/sh"…   0B
c947946a36b2 2 minutes ago /bin/sh -c #(nop)  CMD ["/bin/sh"…   0B
```

```
32b0abdaa0a9 2 minutes ago /bin/sh -c curl https://github.com…  105MB
e261358addb2 2 minutes ago /bin/sh -c apk add wget curl         1.8MB
b6f77a768f90 2 minutes ago /bin/sh -c apk update                1.4MB
961769676411 6 weeks ago   /bin/sh -c #(nop)  CMD ["/bin/sh"]   0B
<missing>    6 weeks ago   /bin/sh -c #(nop) ADD file:fe3dc…    5.6MB
```

We can see that the `RUN`, `COPY`, and `ADD` commands in our `Dockerfile` are creating layers of a particular size relevant to the commands being run or files being added, and all the other commands in the `Dockerfile` are of size 0 B.

7. Reduce the number of layers in the image by combining the `RUN` commands in *lines 3 and 4* and combining the `CMD` commands in *lines 8 and 9* of the `Dockerfile` created in *step 1* of this exercise. With these changes, our `Dockerfile` should now look like the following:

```
FROM alpine

RUN apk update && apk add wget curl

RUN wget -O test.txt https://github.com/fenago/docker-
course/blob/master/lab03/Exercise3.02/100MB.bin

CMD mkdir -p /var/www/html/

WORKDIR /var/www/html/

COPY Dockerfile.tar.gz /tmp/
RUN tar -zxvf /tmp/Dockerfile.tar.gz -C /var/www/html/
RUN rm /tmp/Dockerfile.tar.gz

RUN cat Dockerfile
```

Running `docker build` again will reduce the number of layers for our new image from 12 to 9 layers, as even though there is the same number of commands being run, they are chained together in *lines 3* and *7*.

8. *Lines 11*, *12*, and *13* of our `Dockerfile` are using the `COPY` and `RUN` commands to `copy` and `unzip` our archived file, and then remove the original unzipped file. Replace these lines with the `ADD` command without needing to run the lines that unzip and remove the `.tar` file:

```
FROM alpine

RUN apk update && apk add wget curl

RUN wget -O test.txt https://github.com/fenago/docker-
course/blob/master/lab03/Exercise3.02/100MB.bin

CMD mkdir -p /var/www/html/

WORKDIR /var/www/html/

ADD Dockerfile.tar.gz /var/www/html/
RUN cat Dockerfile
```

9. Build the image again to reduce the number of layers in your new image from 9 to 8. If you have been watching the builds run, you will probably notice a lot of the time the build run as part of *lines 3* and *5* of our `Dockerfile`, where we run `apk update`, then install `wget` and `curl`, and then grab content from a website. Doing this once or twice will not be an issue, but if we create our base image, which the `Dockerfile` can then run on, you will be able to remove these lines completely from your `Dockerfile`.

10. Move into a new directory and create a new `Dockerfile` that will only pull the base image and run the `apk` commands, as listed here:

```
FROM alpine

RUN apk update && apk add wget curl

RUN wget -O test.txt https://github.com/fenago/docker-
course/blob/master/lab03/Exercise3.02/100MB.bin
```

11. Build the new base image from the preceding `Dockerfile` and name it `basic-base`:

```
docker build -t basic-base .
```

12. Remove *line 3* from the original `Dockerfile` as it will no longer be needed. Move into the project directory and update the image that is being used in the `FROM` command to `basic-base` and remove the `apk` commands in *line 3*. Our `Dockerfile` should now look like the following code:

```
FROM basic-base

CMD mkdir -p /var/www/html/

WORKDIR /var/www/html/

ADD Dockerfile.tar.gz /var/www/html/
RUN cat Dockerfile
```

13. Run the build again for our new `Dockerfile`. Using the `time` command again with our build, we now see the build complete in just over 1 second:

```
time docker build -t basic-app .
```

    If you've been watching the build, you'll notice that compared to our previous builds, it runs a lot quicker:

```
...
real 0m1.810s
user 0m0.117s
sys  0m0.070s
```

14. There is a different way we can use the `basic-base` image we used earlier. Use the `docker build` command with the `-cache-from` option to specify the cache layers that will be used when the image is built. Set out the `FROM` command to still use the `alpine` image and use the `-cache-from` option that follows to make sure the layers used to build `basic-base` are being used for our current image:

```
docker build --cache-from basic-base -t basic-app .
```

We still have some more tasks before we complete this exercise. In the following steps, we will look at committing changes to our image to see how it affects our layers. This is not something we would use often but there are times when we need to copy production data over to a development or test environment, and one way to do this is by using a Docker image with the `commit` command, which will make changes to the top writable layer of our running container.

15. Run `basic-app` in interactive shell mode to create some production data. To do this, run the following `docker run` command with the `-it` option to run in interactive mode and use the `sh` shell to access the running container:

```
docker run -it basic-app sh
/var/www/html #
```

16. Use the vi text editor to create a new text file called `prod_test_data.txt`:

```
vi prod_test_data.txt
```

17. Add the following line of text as some test data. The data in the text is not important; it is just a sample to show we can then copy these changes to another image:

18. This is a sample production piece of data. Exit out of the running container and then check the container ID using the `docker ps` command with the `-a` option:

```
docker ps -a
```

    You will get output like the following:

```
CONTAINER ID    IMAGE         COMMAND    CREATED
ede3d51bba9e    basic-app     "sh"       4 minutes ago
```

19. Run the `docker commit` command with the container ID to create a new image that will include all those changes. Make sure to add the name of the new image. In this example, use `basic-app-test`:

```
docker commit ede3d51bba9e basic-app-test
```

    You will get output like the following:

```
sha256:0717c29d29f877a7dafd6cb0555ff6131179b457
       e8b8c25d9d13c2a08aa1e3f4
```

20. Run the `docker history` command on the newly created image:

```
docker history basic-app-test
```

    This should now show us an extra layer where we added the sample production data, showing in our output as 72B in size:

```
IMAGE         CREATED       CREATED BY                          SIZE
0717c29d29f8 2 minutes ago sh                                   72B
302e01f9ba6a 2 minutes ago /bin/sh -c cat Dockerfile            0B
10b405ceda34 2 minutes ago /bin/sh -c #(nop) ADD file:e39f…     283B
397f533f4019 2 minutes ago /bin/sh -c #(nop) WORKDIR /var/…     0B
c8782986b276 2 minutes ago /bin/sh -c #(nop)  CMD ["/bin/sh"… 0B
```

```
6dee05f36f95 2 minutes ago /bin/sh -c apk update && apk ad    3.2MB
961769676411 6 weeks ago   /bin/sh -c #(nop)  CMD ["/bin/sh"] 0B
<missing>    6 weeks ago   /bin/sh -c #(nop) ADD file:fe3dc…  5.6MB
```

21. Now, run the newly created `basic-app-test` image and `cat`, the new file we added:

    ```
    docker run basic-app-test cat prod_test_data.txt
    ```

    This should show us the output we added, showing we can reuse existing images if needed:

    ```
    This is a sample production piece of data
    ```

This exercise demonstrated how the build cache and image layers work to improve the build time. We have started all our builds so far using an image we have pulled down from Docker Hub, but there are options to start with an image you have created yourself if you wish to control things even further. The next section will help you to create your base Docker images.

Creating Base Docker Images

Creating your base Docker image is actually straightforward. Just as we used the `docker commit` command previously to create an image from a running container, we can also create an image from a system or server we have originally been running our applications on. We need to remember that creating a base image still needs to remain small and lightweight. It is not simply a matter of moving existing applications running on existing servers over to Docker.

We could use the system we are specifically working on, but if you are using a production server, the image could actually be pretty big. If you have a small virtual machine you would think is perfect for a base image, you could use the following steps to create a base image from it. Similar to the `docker commit` command, this can be used for any system you can access.

Exercise 3.03: Docker cp Command

The following exercise will use the `basic-app` image we are currently running and show how easy it is to create a base image. These same steps would be used for larger, more complex environments as well:

1. Execute the `docker run` command to run the container and log in at the same time:

   ```
   docker run -it basic-app sh
   ```

2. Run the `tar` command on the running container to create a backup of the system. To limit the information you have in the new image, exclude the `.proc`, `.tmp`, `.mnt`, `.dev`, and `.sys` directories, and create everything under the `basebackup.tar.gz` file:

   ```
   tar -czf *
   ```

3. To ensure that you have data in your `basebackup.tar.gz` file, run the `du` command to make sure it is of substantial size:

   ```
   du -sh basebackup.tar.gz
   ```

   The output returns the size of the `basebackup.tar.gz` file:

```
4.8M   basebackup.tar.gz
```

4. Run the `docker ps` command to find the container ID that is currently holding your new backup file, the `.tar` file:

   ```
   docker ps
   ```

   The command will return the container ID of the image:

   ```
   CONTAINER ID        IMAGE         COMMAND       CREATED
   6da7a8c1371a        basic-app     "sh"          About a minute ago
   ```

5. Copy the `.tar` file onto your development system with the `docker cp` command, using the container ID of our running container and the location and file you want to copy. The following command will do this with your container ID and move it into your `/tmp` directory:

   ```
   docker cp UPDATE_ME:/var/www/html/basebackup.tar.gz D:\\
   ```

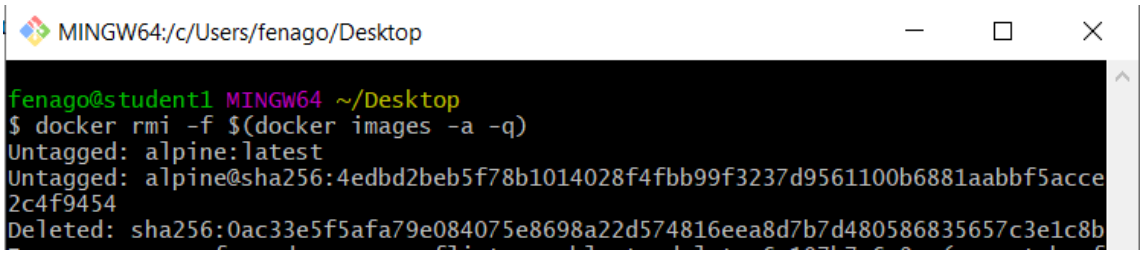
Exercise 3.05: Tagging Docker Images

In the following exercise, you will work with a different image, using the lightweight `busybox` image to demonstrate the process of tagging and start to implement tags in your project. BusyBox is used to combine tiny versions of many common UNIX utilities into a single small executable:

1. Run the `docker rmi` command to clear up the images you currently have on your system, so you don't get confused with a large number of images around:

   ```
   docker rmi -f $(docker images -a -q)
   ```

Note: Above command should be run in `git bash` only. It will not work in cmd/powershell



2. On the command line, run the `docker pull` command to download the latest `busybox` container:

   ```
   docker pull busybox
   ```

3. Run the `docker images` command:

   ```
   docker images
   ```

   This will give us the information we need to start putting some tag commands together:

   ```
   REPOSITORY    TAG       IMAGE ID        CREATED      SIZE
   Busybox       latest    19485c79a9bb    2 weeks ago  1.22MB
   ```

4. Name and tag the image using the `tag` command. You can either use the image ID or repository name to tag the images. Start by using the image ID, but note that on your system you'll have a different image ID. Name the repository `new_busybox` and include the tag `ver_1` :

```
docker tag UPDATE_ME new_busybox:ver_1
```

5. Use the repository name and image tag. Create a new repository using your name and tag with a new version of `ver_1.1` as follows:

```
docker tag new_busybox:ver_1 vince/busybox:ver_1.1
```

Note

We have used the author's name (`vince`) in this example.

6. Run the `docker images` command:

```
docker images
```

You should see a similar output to the one that follows. Of course, your image IDs will be different, but the repository names and tags should be similar:

```
REPOSITORY     TAG      ID             CREATED        SIZE
Busybox        latest   19485c79a9bb   2 weeks ago    1.22MB
new_busybox    ver_1    19485c79a9bb   2 weeks ago    1.22MB
vince/busybox  ver_1.1  19485c79a9bb   2 weeks ago    1.22MB
```

7. Create a basic image using a `Dockerfile` and the `-t` option of the `docker build` command to name and tag the image. You've done this a few times already in this lab, so from the command line, run the following command to create a basic `Dockerfile` , using the `new_busybox` image you named earlier. Also include the tag for the image name, as Docker will try to use the `latest` tag and, as this does not exist, it will fail:

```
echo "FROM new_busybox:ver_1" > Dockerfile
```

8. Run the `docker build` command to create the image while naming and tagging it at the same time:

```
docker build -t built_image:ver_1.1.1 .
```

9. Run the `docker images` command:

```
docker images
```

You should now have four images available on your system. All have the same container ID but will have different repository names and tagged versions:

```
REPOSITORY     TAG        ID             CREATED      SIZE
built_image    ver_1.1.1  19485c79a9bb   2 weeks ago  1.22MB
Busybox        latest     19485c79a9bb   2 weeks ago  1.22MB
new_busybox    ver_1      19485c79a9bb   2 weeks ago  1.22MB
vince/busybox  ver_1.1    19485c79a9bb   2 weeks ago  1.22MB
```

Tagging images with a proper version that is relevant to your organization or team does not take too much time, especially with a little practice. This section of the lab has shown you how to tag your images so they are no longer tagged with the default tag of the `latest`. You will see in the next section that using the `latest` tag and hoping it will work correctly could actually cause you some extra issues.

Exercise 3.06: Issues When Using latest

You may still be new to both using Docker and using tags, so you may not have experienced any issues using the `latest` tag as yet. This exercise will give you some clear ideas on how using the `latest` tag could cause problems with your development process and provide you with reasons as to why you should avoid it. You created a simple `Dockerfile` in the previous exercise using the `new_busybox:ver_1` image. In this exercise, you will extend this file further:

1. Open the `Dockerfile` and amend the file to now look like the following file. It is a simple script that will create the `version.sh` script with simple code to output the latest version of our service. The new file will be called `Dockerfile_ver1`.

   ```
   FROM new_busybox:ver_1

   RUN echo "#!/bin/sh\n" > /version.sh
   RUN echo "echo \"This is Version 1 of our service\""   >> /version.sh

   ENTRYPOINT ["sh", "/version.sh"]
   ```

2. Build the image and name it with your name and show the image is just a test:

   ```
   docker build -t vince/test .
   ```

3. Run the image using the `docker run` command:

   ```
   docker run vince/test
   ```

   You should now see the output of the `versions.sh` script:

   ```
   This is Version 1 of our service
   ```

4. Use the `docker tag` command to tag this image as `version1`:

   ```
   docker tag vince/test vince/test:version1
   ```

5. Open the `Dockerfile` and make the following change to *line 4*:

   ```
   FROM new_busybox:ver_1

   RUN echo "#!/bin/sh\n" > /version.sh
   RUN echo "echo \"This is Version 2 of our service\""   >> /version.sh

   ENTRYPOINT ["sh", "/version.sh"]
   ```

6. Build your amended `Dockerfile` and tag it with `version2`:

   ```
   docker build -t vince/test:version2 .
   ```

7. Run the amended image using the `docker run` command:

   ```
   docker run vince/test
   ```

   You should see your latest code changes as well:

   ```
   This is Version 1 of our service
   ```

   This isn't the version we were looking for, was it? Without using the correct tag, Docker will run what is the most recent version of the image that was tagged with the `latest`. This image was created in *step 3*.

8. Now, run both images with the `latest` and `version2` tags:

   ```
   docker run vince/test:latest
   This is Version 1 of our service
   ```

   We can now see the difference in the output:

   ```
   docker run vince/test:version2
   This is Version 2 of our service
   ```

   As you may have already thought, you need to specify the `version2` tag to run the amended version of the code. You may have seen this coming but remember this is going to make things more difficult to keep track of if you have multiple developers pushing images to a shared registry. If your team is using orchestration and using the `latest` version, you may end up with mixed versions of your services running across your production environment.

These exercises have given you examples on how to use tags as well as showing you what the consequences could be if you decide to only use the `latest` tag. The following section will introduce tagging policies and how to implement automated processes.

Exercise 3.07: Automating Your Image Tagging

In this exercise, you are going to look at automating your image tagging to limit the amount of individual intervention needed in tagging your Docker images. This exercise uses the `basic-base` image again:

1. Create the `basic-base` image again by creating the following `Dockerfile`:

   ```
   FROM alpine

   RUN apk update && apk add wget curl
   ```

2. Build the new base image from the preceding `Dockerfile` and name it `basic-base`:

   ```
   docker build -t basic-base .
   ```

3. With the `basic-base` image created, set up the `Dockerfile` named `Dockerfile_ver1` to build a `basic-app` again. In this instance, return to the previous `Dockerfile` as listed here:

   ```
   FROM basic-base

   CMD mkdir -p /var/www/html/
   ```

```
WORKDIR /var/www/html/

ADD Dockerfile.tar.gz /var/www/html/
RUN cat Dockerfile
```

8. Alongside your `Dockerfile`, create a version file simply named `VERSION`. Set the new version as `1.0.0` for this build of `basic-app`:

```
echo "1.0.0" > VERSION
```

9. Make changes to the `Dockerfile` to remove the `GIT_COMMIT` details added previously and add the `VERSION` file as part of your build. Adding it into the image itself means users can always refer to the `VERSION` file if ever they need to verify the image version number:

```
FROM basic-base

CMD mkdir -p /var/www/html/

WORKDIR /var/www/html/

ADD VERSION /var/www/html/
ADD Dockerfile.tar.gz /var/www/html/
RUN cat Dockerfile
```

10. Create a build script to both build and tag your image. Call this `build.sh` and it will reside in the same directory as your `Dockerfile` and `VERSION` file.

11. Add the following details to `build.sh`. *Line 3* will be your Docker Hub username, and *line 4* is the name of the image or service you are building (in the following example, `basic-app`). The script then grabs the version number from your `VERSION` file and brings all your variables together to build your image with a nice name and tag relevant to your new semantic version:

```
set -ex

USER=<your_user_name>
SERVICENAME=basic-app

version=`cat VERSION`
echo "version: $version"

docker build -t $USER/$SERVICENAME:$version .
```

12. Make sure the build script is set to run as an executable script using the `chmod` command on the command line:

```
chmod +x build.sh
```

13. Run the build script from the command line. `set -xe` in *line 1* of the script will make sure all commands are output to the console and ensure that if any of the commands cause an error, the script will stop. Run the build script now, as follows:

```
./build.sh
```

Only the output of the build script is shown here as the rest of the build process happens as normal:

```
++ USERNAME=vincesestodocker
++ IMAGE=basic-app
+++ cat VERSION
++ version=1.0.0
++ echo 'version: 1.0.0'
version: 1.0.0
++ docker build -t vincesestodocker/basic-app:1.0.0 .
```

14. View the image using the `docker images` command:

```
docker images vincesestodocker/basic-app
```

It should reflect the name and tags created as part of the build script:

```
REPOSITORY                   TAG    IMAGE ID
  CREATED            SIZE
vincesestodocker/basic-app   1.0.0  94d0d337a28c
  29 minutes ago     8.8MB
```

This exercise goes a long way in automating our tagging process, and it allows the `build` script to be added to source control and run easily as part of a build pipeline. It is just a start though, and you will see in the activities at the end of the lab that we will extend this build script further. For now, we have completed this section on the tagging and naming of our images, and it fits in nicely with the next section, which covers storing and publishing your Docker images.

Exercise 3.08: Transporting Docker Images Manually

Sometimes, whether there are issues with firewalls or other security measures on your network, you may need to copy an image directly from one system to another. Fortunately, Docker has a way of achieving this and, in this exercise, you will move an image from one system to another without using a registry:

1. Run the `docker save` command with the `-o` option to save the image you created in the last part of this lab. The command needs the user to specify both the filename and the directory. In the following example, it is `/tmp/basic-app.tar`. Also specify the user, image name, and tag of the image:

```
docker save -o D:\\hello-world.tar hello-world
```

You should now see the packaged-up image in the `/tmp` directory. You are using `.tar` as the extension of your filename as the `save` command creates a TAR file of the image. You could actually use any name for the extension of the file.

2. Use the `du` command to verify that the `basic-app.tar` file has data in it:

```
du -sh /tmp/basic-app.tar
8.9M    /tmp/basic-app.tar
```

3. You can now move the image as you need to, whether it be via `rsync`, `scp`, or `cp`. As it is a TAR file, you could also compress the file as a ZIP file if you need to save some space during the transfer. In this example, you will simply delete the image from your current system. Run the `docker rmi` command with the ID of the image you have just saved:

```
docker rmi -f 94d0d337a28c
```

4. Load the new image back as a Docker image using the `docker load` command with the `-i` option, pointing to where the packaged image is located. In this case, it is the `/tmp` directory:

   ```
   docker load -i D:\\hello-world.tar
   ```

   You should get output like the following:

   ```
   Loaded image: hello-world
   ```

5. Use the `docker image` command to bring up the image you have just loaded into your local environment:

   ```
   docker images hello-world
   ```

   You should get output like the following:

   ```
   REPOSITORY                    TAG       IMAGE ID
     CREATED             SIZE
   vincesestodocker/basic-app    1.0.0     2056b6e48b1a
     29 minutes ago      8.8MB
   ```

This was just a simple exercise, but it hopefully served to show you that if there is ever a situation where you are unable to connect to a registry, you are still able to transport your Docker images. The next exercises are more focused on the usual methods of storing, publishing, and distributing your Docker images.

The Docker Registry

Docker simplifies things for us as they have a registry image available on Docker Hub to download and use for your projects. For more information on the image we will be using, you can find it at the following location:

https://hub.docker.com/_/registry.

Exercise 3.10: Creating a Local Docker Registry

In this exercise, you will set up a Docker registry for your images and run them on your system. You are not going to set up a registry available to your team, or the outside world. You will set up a nice domain to use on your systems that reflect the work you are doing. This will help you decide whether to then have this registry available to your team or other users:

1. To set up your domain, add a domain for your local registry to your system hosts file. On a Windows system, you will need to access the hosts file at `C:\Windows\System32\drivers\etc\hosts`, while on a Linux or Max, it will be `/etc/hosts`. Open the `hosts` file and add the following line to the file:

   ```
   127.0.0.1       dev.docker.local
   ```

   This will allow you to use the `dev.docker.local` domain instead of using localhost for your local registry.

2. Pull the latest `registry` image down from Docker Hub:

```
docker pull registry
```

3. Use the following command to run the registry container. Provide the ports you can access the registry with; in this case, use port `5000`. You also need to use the `--restart=always` option, which will make sure the container restarts if Docker or your system needs to restart:

```
docker run -d -p 5000:5000 --restart=always --name registry registry
```

4. Run the `docker ps` command to show the `registry` container running on your system, which is ready to accept and store new images:

```
docker ps
```

The command will return the output like the following:

```
CONTAINER ID  IMAGE     COMMAND                  CREATED
41664c379bec  registry  "/entrypoint.sh /etc…"  58 seconds ago
```

5. Run the `docker tag` command to tag your existing images with the registry hostname and port `dev.docker.local:5000`.

```
docker tag busybox dev.docker.local:5000/busybox
```

This will ensure that your `busybox` image will be automatically pushed to the local registry:

```
docker push dev.docker.local:5000/busybox
```

6. Delete the original images from the system you are currently working on using the `docker image remove` command:

```
docker image remove dev.docker.local:5000/busybox
```

7. Now, pull down the image from your local registry by including the registry hostname and port `dev.docker.local:5000` as part of the `pull` command:

```
docker pull dev.docker.local:5000/busybox
```

This brings us to the end of this section where we have created our registry to store our Docker images on our local system. The registry itself is simple and is not really supported but does go a long way to help you understand how a registry will work and how it can work with your team. If you are looking for a more robust and supported image, Docker also provides Docker Trusted Registry, which is a commercial offering by Docker.

Summary

This lab demonstrated how Docker allows users to work with images to package their applications together with a working environment to be moved across different working environments. You've seen how Docker uses layers and caching to improve build speed and ensure you can also work with these layers to reserve resources or disk space.

We also spent some time creating a base image with only one layer of our image. We've explored tagging and tagging practices you can adopt in order to counter issues associated with deploying and publishing your images. We also took a look at different ways we can publish our images and share them with other users and developers. We are only just getting started and still have a long way to go.

In the next lab, we'll be working further with our `Dockerfiles` to learn how multistage `Dockerfiles` work. We'll also find more ways in which we can optimize our Docker images for better performance when they're released into a production environment.