Section 7 - Storage in Docker

Layered Architecture

Filesystem

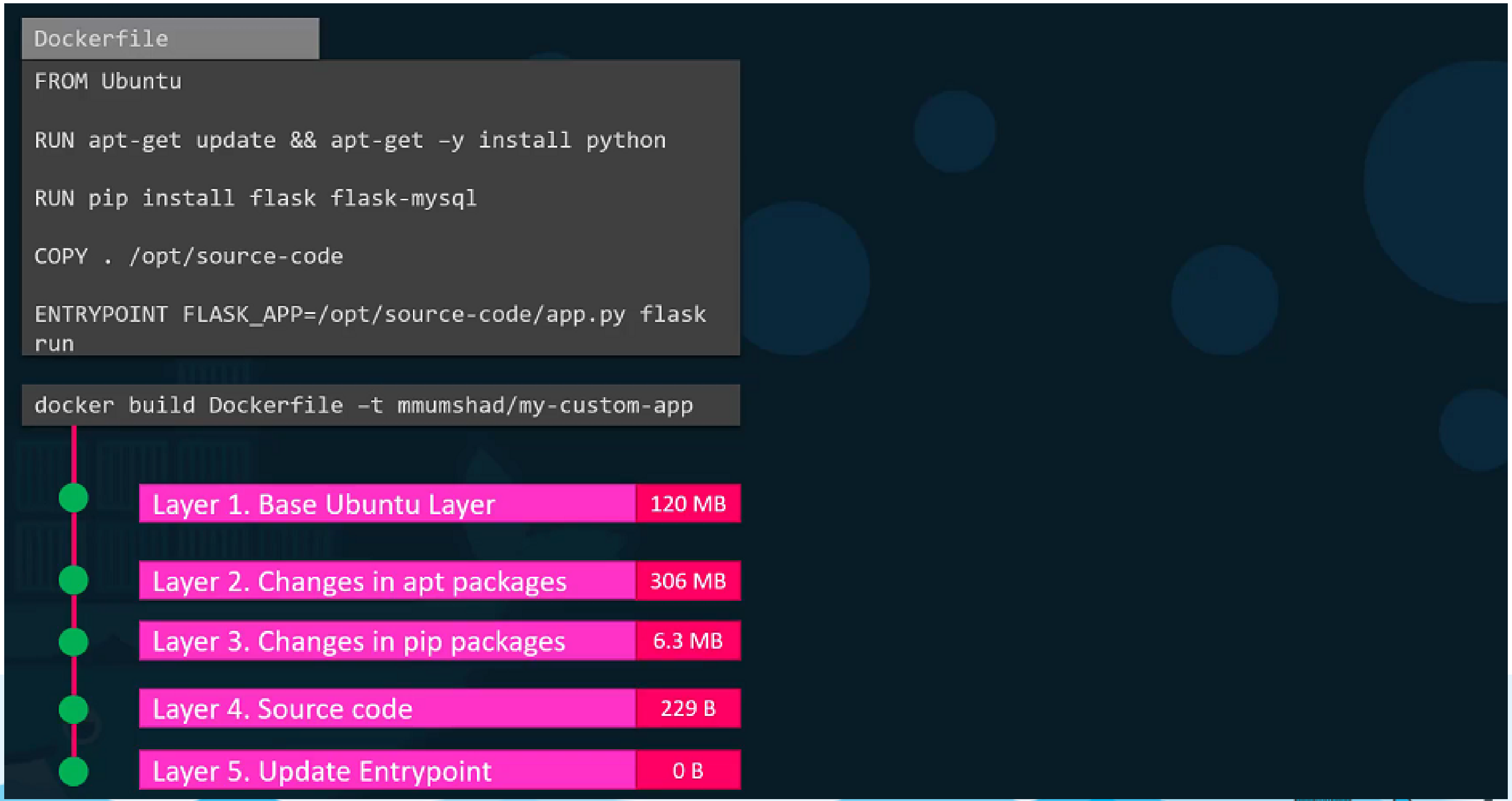
- When we install Docker on a system, it creates this directory structures at `/var/lib/docker`.

```
$ ls -1 /var/lib/docker/
...
containers
image
...
volumes
...
```

- This is where Docker stores all its data by default.
- We have multiple directories under it called containers, image, volumes and many others.

Layered Architecture

- When docker builds images, it builds these in a layered architecture.
- Each line of instruction in the Dockerfile creates a new layer in the Docker image with just the changes from the previous layer.



```
FROM Ubuntu

RUN apt-get update && apt-get -y install python

RUN pip install flask flask-mysql

COPY . /opt/source-code

ENTRYPOINT FLASK_APP=/opt/source-code/app.py flask
run
```

```
docker build Dockerfile -t mmumshad/my-custom-app
```

Layer 1. Base Ubuntu Layer	120 MB
Layer 2. Changes in apt packages	306 MB
Layer 3. Changes in pip packages	6.3 MB
Layer 4. Source code	229 B
Layer 5. Update Entrypoint	0 B

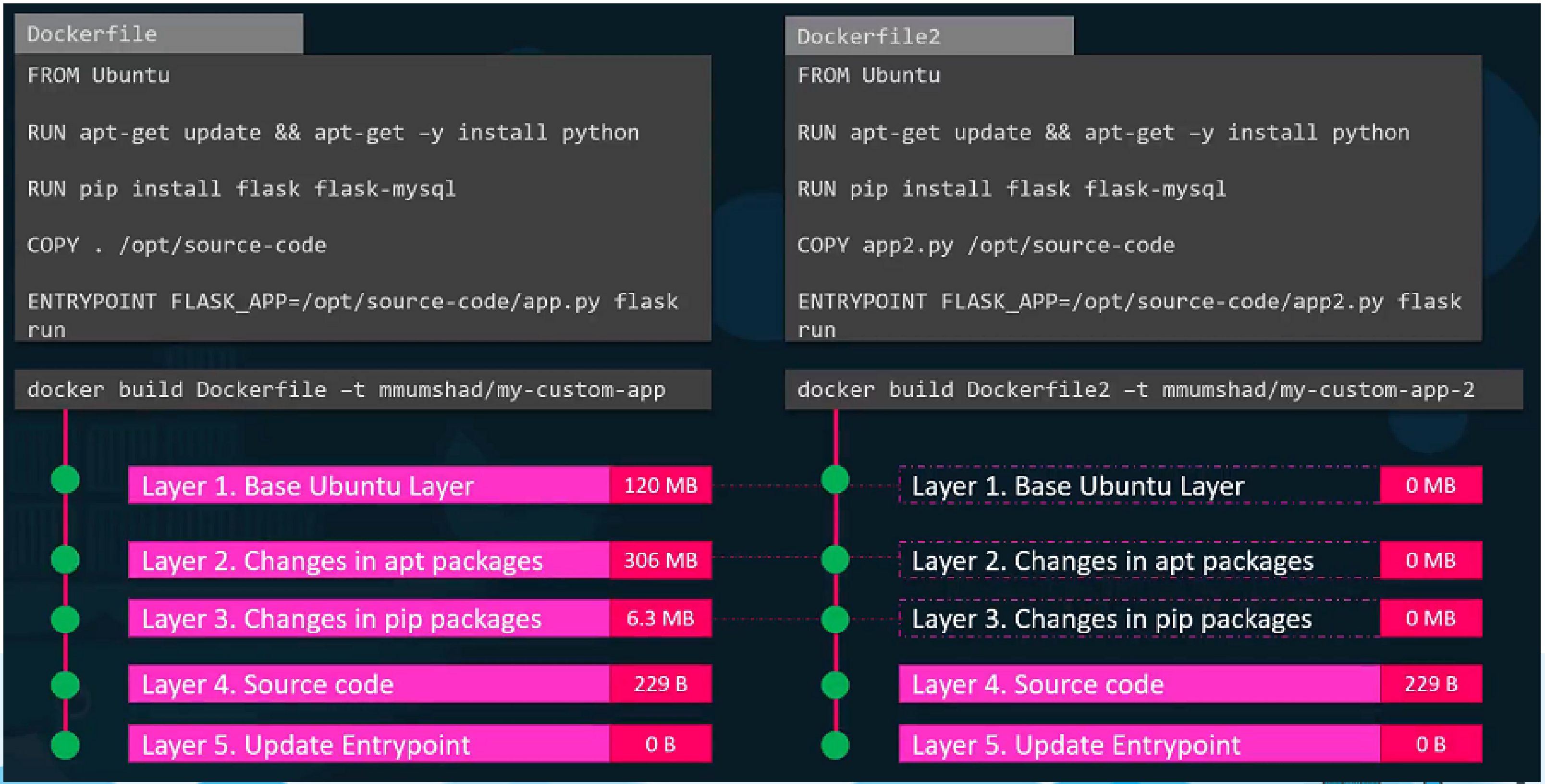
Layered Architecture

- As we can see in the previous image,
- layer-1 is the Ubuntu base layer,
- layer-2 install the packages,
- layer-3 install the python packages,
- layer-4 update the source code,
- layer-5 updates the entry point of the image.

> Since each layer only stores the changes from the previous layer. It is reflected in the **size** as well.

Layered Architecture - advantages

- For better understanding the advantages of this layered architecture, Let's take a different Dockerfile, this is very similar to our first application. only source code and entry point is different to create this application.



Dockerfile

```
FROM Ubuntu

RUN apt-get update && apt-get -y install python

RUN pip install flask flask-mysql

COPY . /opt/source-code

ENTRYPOINT FLASK_APP=/opt/source-code/app.py flask
run
```

```
docker build Dockerfile -t mmumshad/my-custom-app
```

Layer 1. Base Ubuntu Layer	120 MB
Layer 2. Changes in apt packages	306 MB
Layer 3. Changes in pip packages	6.3 MB
Layer 4. Source code	229 B
Layer 5. Update Entrypoint	0 B

Dockerfile2

```
FROM Ubuntu

RUN apt-get update && apt-get -y install python

RUN pip install flask flask-mysql

COPY app2.py /opt/source-code

ENTRYPOINT FLASK_APP=/opt/source-code/app2.py flask
run
```

```
docker build Dockerfile2 -t mmumshad/my-custom-app-2
```

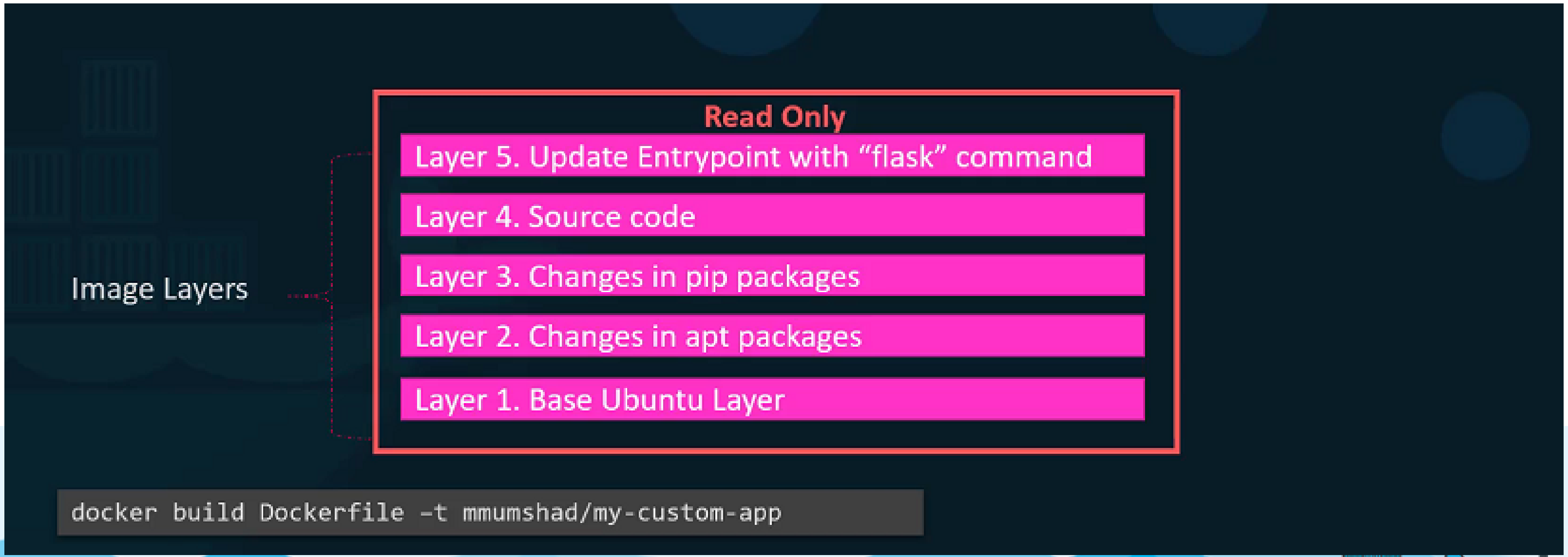
Layer 1. Base Ubuntu Layer	0 MB
Layer 2. Changes in apt packages	0 MB
Layer 3. Changes in pip packages	0 MB
Layer 4. Source code	229 B
Layer 5. Update Entrypoint	0 B

Layered Architecture - advantages

- When image builds, docker is not going to build first three layers instead of it reuses the same three layers it built for the first application from the cache.
- Only creates the last two layers with the new sources and the new entry point.
- This way, Docker builds images faster and efficiently saves disk space.
- This is also applicable, if you were to update your application code. Docker simply reuses all the previous layers from the cache and quickly rebuild the application image by updating the latest source code

Layered Architecture - RO layers

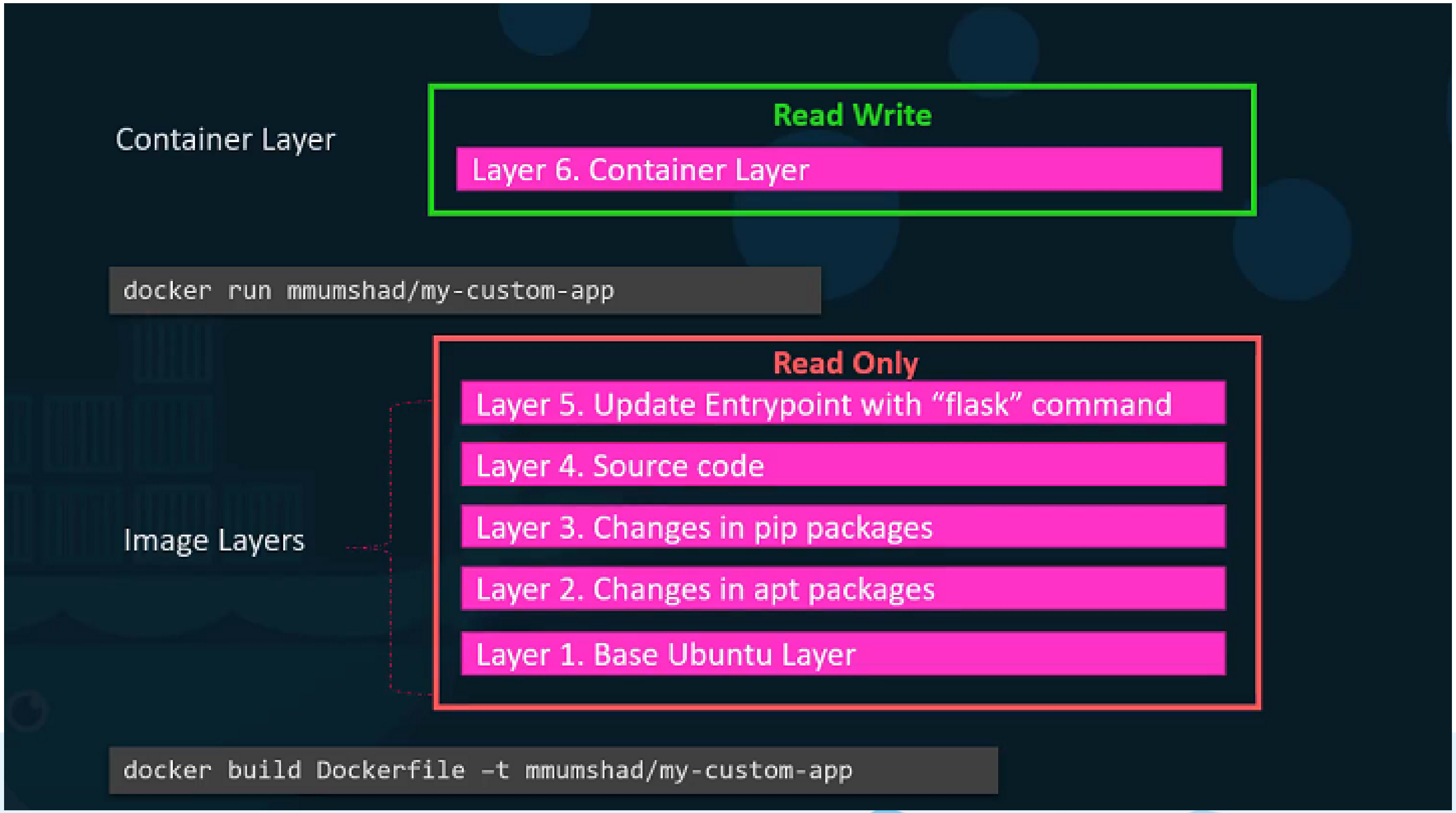
- Let's rearrange the layers bottom up so we can understand it better.
- All of these layers are created when we run the `docker build` command to form the final Docker image.
- Once the build is complete, we cannot modify the contents of these layers and so they are read-only
- we can only modify them by initiating a new build.


Read Only
Layer 5. Update Entrypoint with “flask” command
Layer 4. Source code
Layer 3. Changes in pip packages
Layer 2. Changes in apt packages
Layer 1. Base Ubuntu Layer
Image Layers

```
docker build Dockerfile -t mmumshad/my-custom-app
```

Layered Architecture - Rw layer

- Using the `docker run` command Docker creates a container based of these layers and creates a new RW layer on top of the image RO layers.



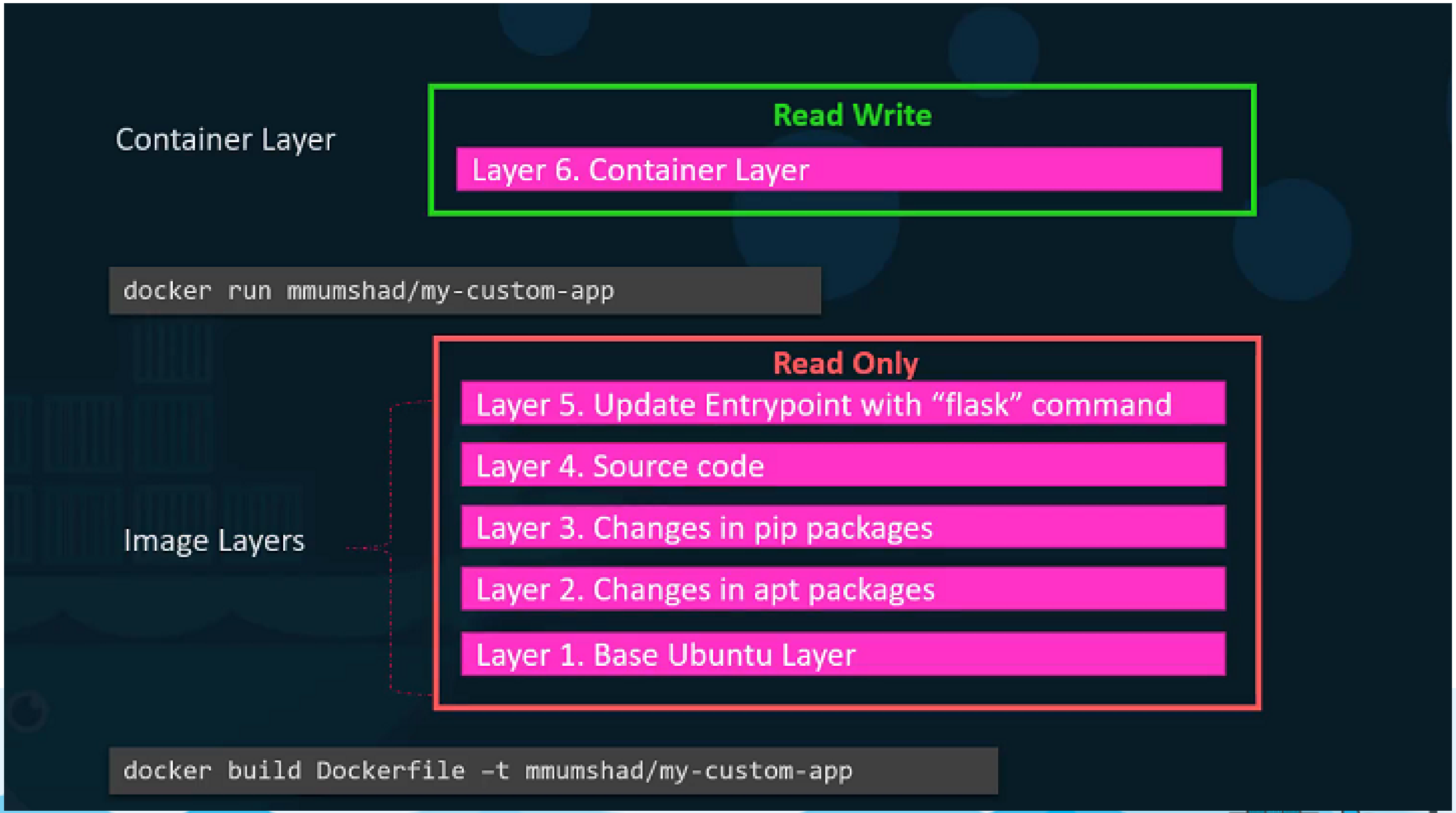
Container Layer
Read Write
Layer 6. Container Layer
Image Layers
Read Only
Layer 5. Update Entrypoint with "flask" command
Layer 4. Source code
Layer 3. Changes in pip packages
Layer 2. Changes in apt packages
Layer 1. Base Ubuntu Layer

```
docker run mmumshad/my-custom-app
```

```
docker build Dockerfile -t mmumshad/my-custom-app
```

Layered Architecture - Rw layer

- The writeable layer is used to store data created by the container such as log files written by the applications, any temporary files generated by the container.

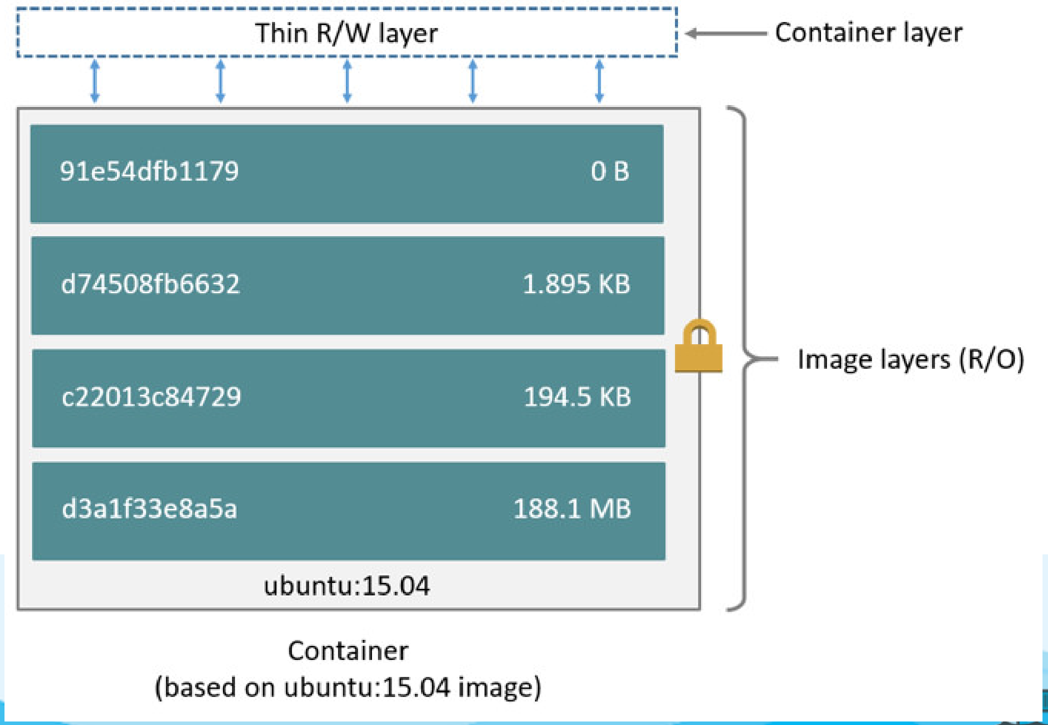

Container Layer
Read Write
Layer 6. Container Layer
Image Layers
Read Only
Layer 5. Update Entrypoint with “flask” command
Layer 4. Source code
Layer 3. Changes in pip packages
Layer 2. Changes in apt packages
Layer 1. Base Ubuntu Layer

```
docker run mmumshad/my-custom-app
```

```
docker build Dockerfile –t mmumshad/my-custom-app
```

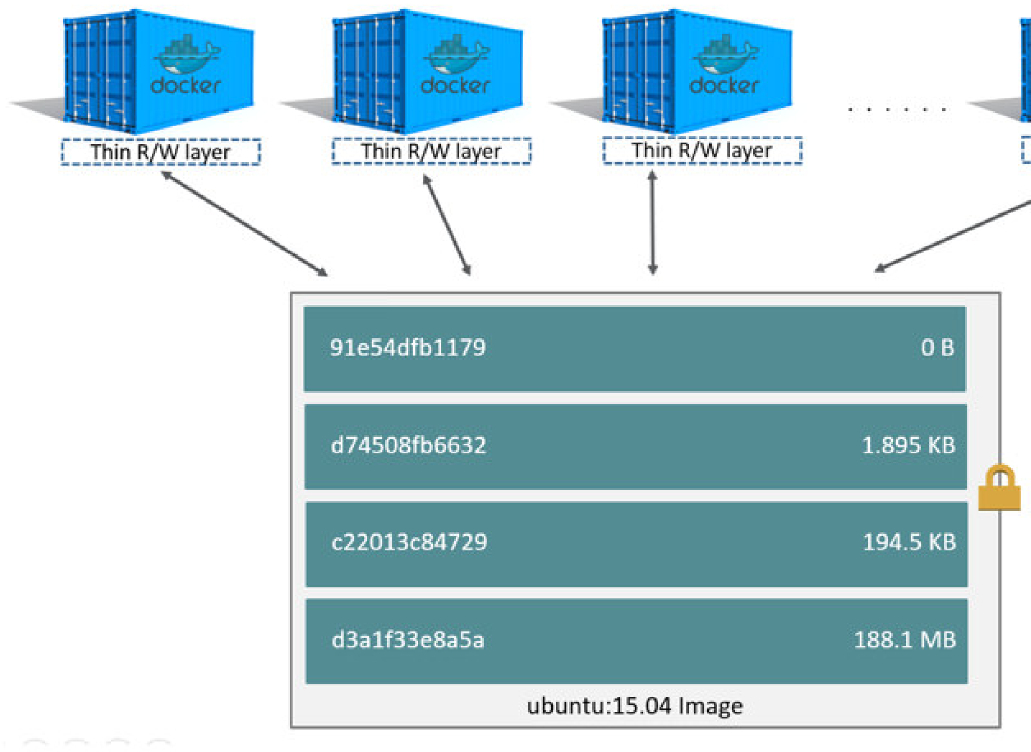
Image layers - Recap

- Images are made of RO layers created at build time.
- Each layer is related to a set of file system changes.
- When you run a Docker image to create a running container, Docker will create a new RW layer on top of the image.



Layered Architecture - Rw layer

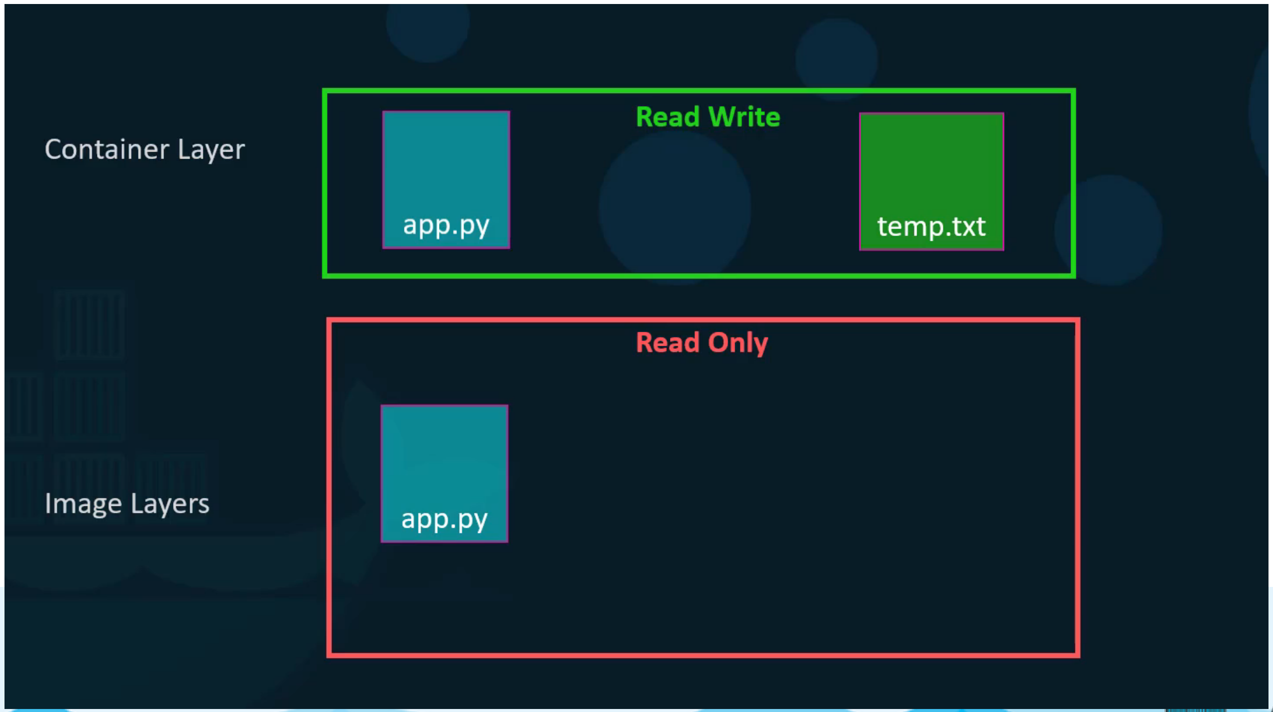
- The same image layers is shared by all containers created using this image.



> When the container is destroyed, this layer and all of the changes stored in it are also destroyed.

Layered Architecture - Editing files on RW layer

- If I will create a new file called temp.txt in the newly created container, this will be stored on the RW layer.
- If we edit an existing file of the image a new copy is stored on the RW layer.



Layered Architecture - Rw layer

- Let's take an example of our application code. Since we bake our code into the image, the code is part of the image and as such, its read-only. After running a container, what if I wish to modify the source code.
- Yes, I can still modify this file, but before I saved the modified file, Docker automatically creates a copy of the file in the read-write layer and I will then be modifying a different version of the file in the read-write layer. All future modifications will be done on this copy of the file in the read-write layer. This is called copy-on-right mechanism.

Storage drivers

- Docker uses storage drivers to manage the RO layers of a Docker image and the RW layer of a container
- Docker uses volume drivers to manage the persistent data of an application (Docker volumes)

Storage drivers

- Docker uses storage drivers to manage the contents of the *image layers* and the *writable container layer*.
- Each storage driver handles the implementation differently, but all drivers use stackable image layers and the copy-on-write (CoW) strategy.
- Docker supports different types of storage drivers such as: overlay2, aufs, devicemapper, btrfs etc..
- Recommended storage driver for Ubuntu, CentOS and RHEL is overlay2
- Recommended storage drivers

Kubernetes CSI - Container Storage Interface

- Kubernetes use CSI (Container Storage Interface)
- Kubernetes CSI ~ Docker Volume drivers