



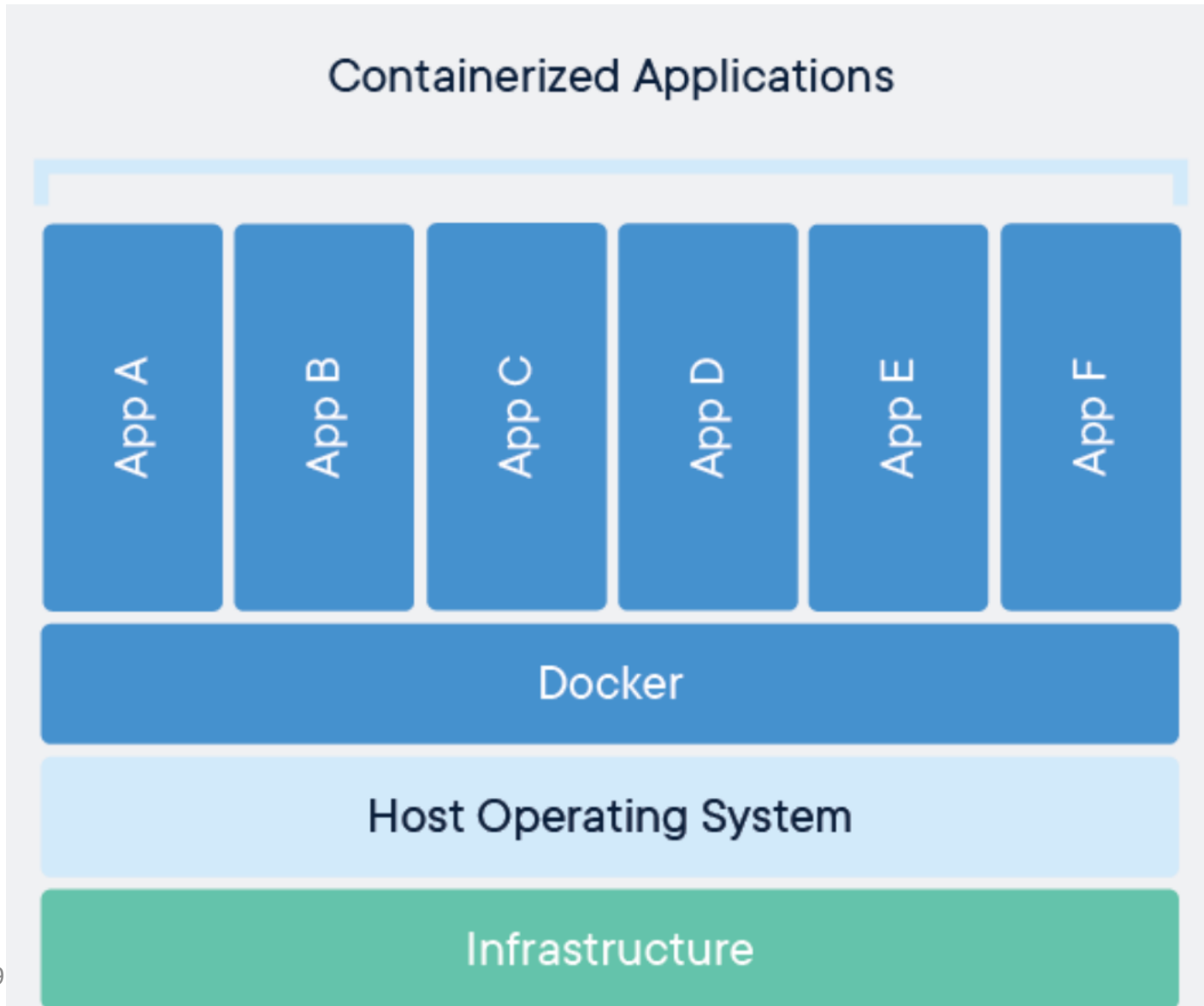
# Lecture 3, containers

# Basic of containers

- Lightweight virtualization
- Guests share OS kernel with host
- In Linux (LXC) basically separate namespaces
  - IPC – inter-process communication
  - Network
  - Mount – Filesystem
  - PID – Processes
  - User
  - UTS – hostname and domains
  - Cgroup –
- Nice tutorial (with commercial at the end)  
[https://www.youtube.com/watch?time\\_continue=2&v=n-JwAM6XF88](https://www.youtube.com/watch?time_continue=2&v=n-JwAM6XF88)

# The dominant way to manage containers: Docker

So dominant that we go details of one technology



# Use case example

- Your application needs

- Certain version of nodejs
- Set of libraries (certain versions)
- Mongo database

- Your system has

- Wrong version of nodejs
- Mongo serving another application

- Solution

- Create a docker image (container)
- Install the image
- Run the image

<https://www.katacoda.com/courses/container-runtimes>  
(thanks to your fellow student from 2019)

```
Terminal +
Your Interactive Bash Terminal. A safe place to learn and execute commands.

$
$ docker pull redis:3.2.11-alpine
3.2.11-alpine: Pulling from library/redis
ff3a5c916c92: Pull complete
aae70a2e6027: Pull complete
87c655da471c: Pull complete
bc3141806bdc: Pull complete
53616fb426d9: Pull complete
9791c5883c6a: Pull complete
Digest: sha256:ebf1948b84dcaaa0f8a2849cce6f2548edb8862e2829e3e7d9e4cd5a324fb3b7
Status: Downloaded newer image for redis:3.2.11-alpine
$
```

# Let investigate a bit

```
$ docker image ls
```

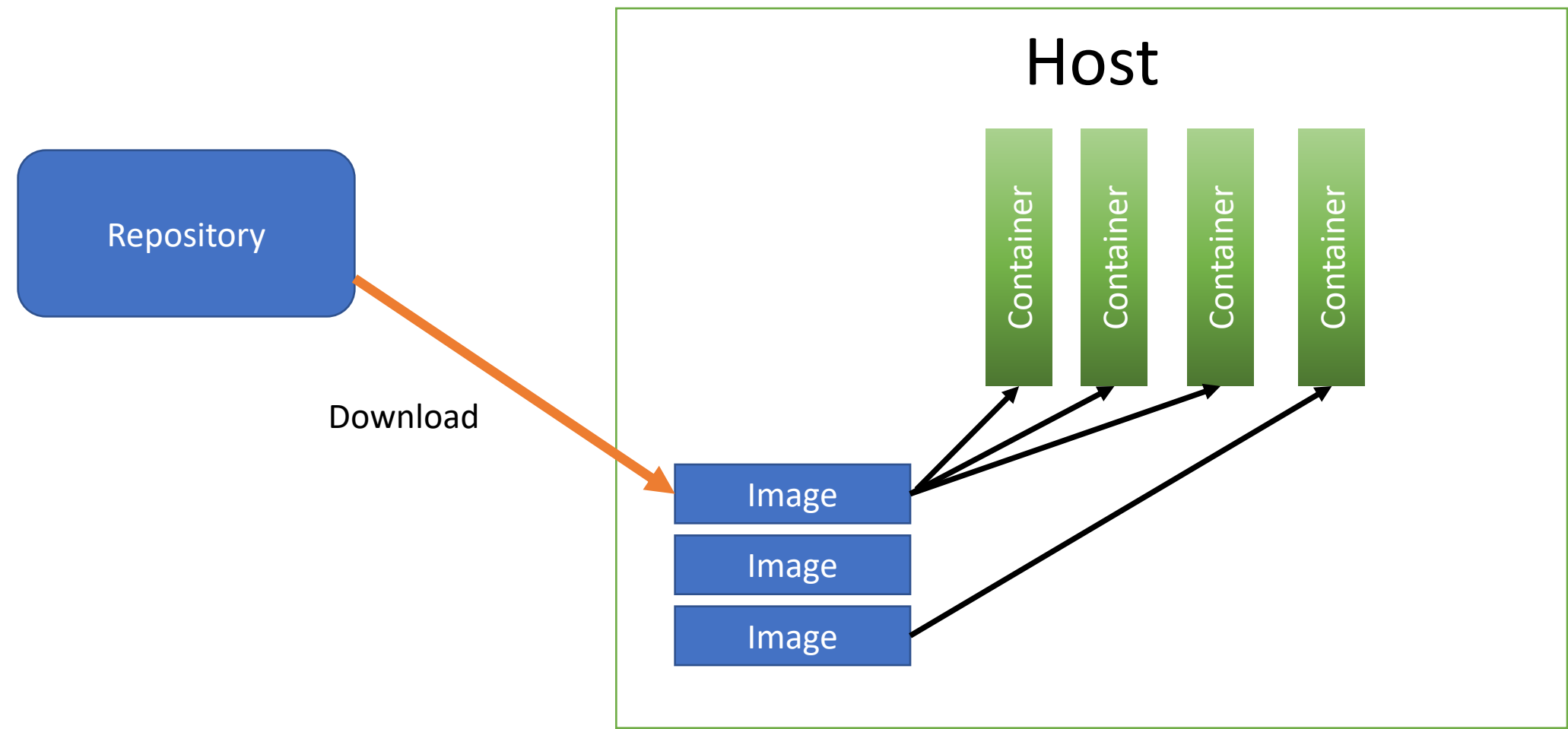
REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
redis	3.2.11-alpine	ca0b6709748d	15 months ago	20.7MB





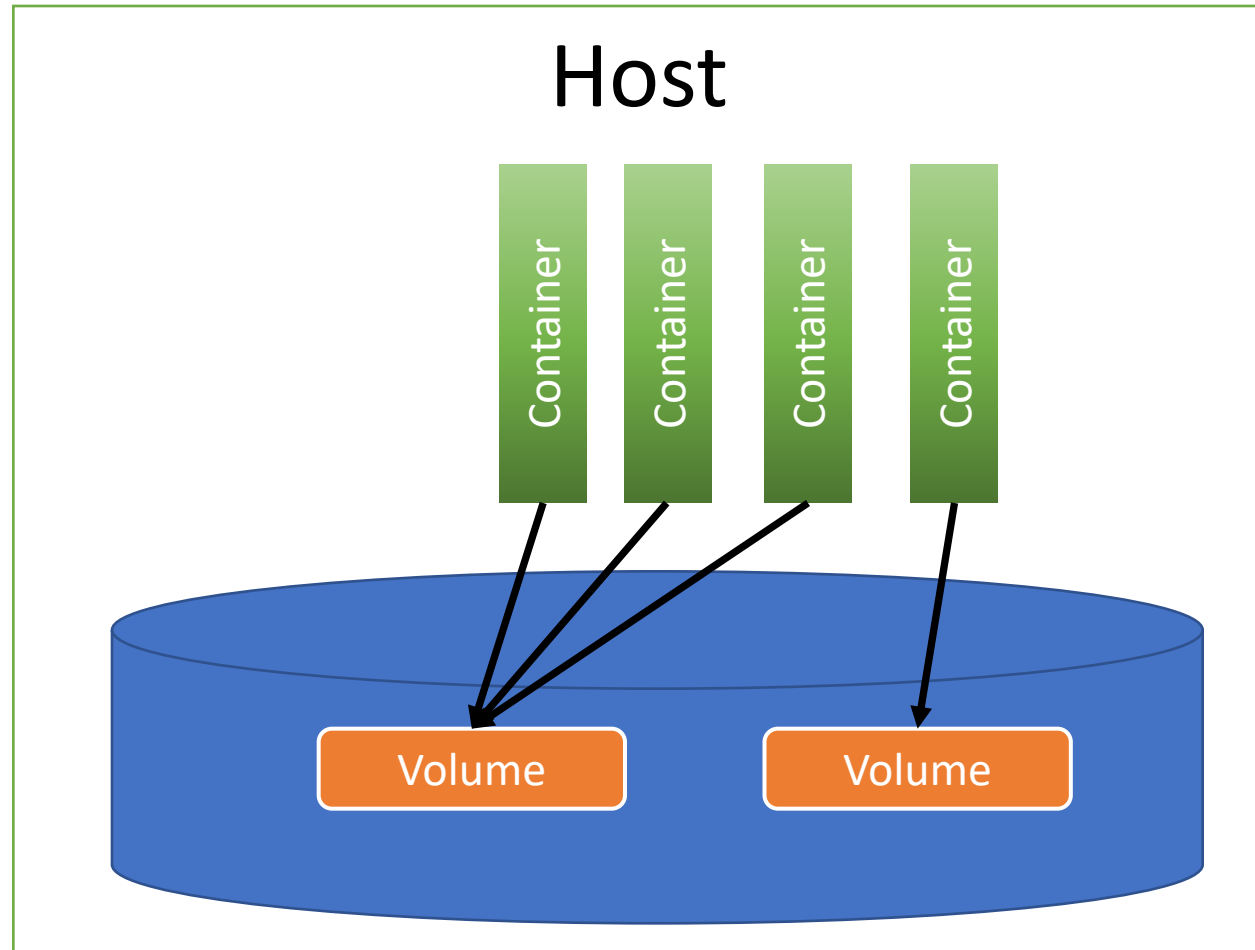
# What did we just see?

# Typical set-up



# Typical set-up

- Volumes** are for
- Persistent data
  - Data sharing



# Dockerfile

```
#This is a sample Image
FROM ubuntu
MAINTAINER demousr@gmail.com
RUN apt-get update
RUN apt-get install -y nginx
CMD ["echo", "Image created"]
```

# Docker commands (subset of)

<a href="#"><u>docker build</u></a>	Build an image from a Dockerfile
<a href="#"><u>docker container</u></a>	Manage containers (several subcommands)
<a href="#"><u>docker image</u></a>	Manage images (several subcommands)
<a href="#"><u>docker exec</u></a>	Run a command in a running container
<a href="#"><u>docker ps</u></a>	List containers
<a href="#"><u>docker run</u></a>	Run a command in a new container
<a href="#"><u>docker stop</u></a>	Stop one or more running containers
<a href="#"><u>docker commit</u></a>	Create a new image from a container's changes
<a href="#"><u>docker inspect</u></a>	Return low-level information on Docker objects
<a href="#"><u>docker swarm</u></a>	Manage Swarm
<a href="#"><u>docker volume</u></a>	Manage volumes

# Some Dockerfile commands

- FROM <image> [AS <name>]
- RUN <command>  
execute any commands in a new layer and commit the results.
- CMD  
default command to be executed when the container starts
- ENV <key> <value>
- ADD [--chown=<user>:<group>] <src>... <dest>
- COPY [--chown=<user>:<group>] <src>... <dest>

```
• $ docker image history 874176ca6a7c
```

IMAGE	CREATED	CREATED BY	SIZE	COMMENT
874176ca6a7c	6 months ago	/bin/sh -c #(nop) CMD ["/bin/sh" "-c" "nodeâ	0B	
e477afdf62b1	6 months ago	/bin/sh -c #(nop) EXPOSE 8893	0B	
bbb82ecea436	6 months ago	/bin/sh -c #(nop) ENV PORT=8893	0B	
f7e49216f8f8	6 months ago	/bin/sh -c #(nop) WORKDIR /home	0B	
75bf5968b264	6 months ago	/bin/sh -c #(nop) COPY dir:fed108fd8e77a8ed8â	553kB	
1fb4fbe8beb7	7 months ago	/bin/sh -c #(nop) USER root	0B	
8232a8b9c483	2 years ago	/bin/sh -c #(nop) CMD ["node"]	0B	
<missing>	2 years ago	/bin/sh -c apk add --no-cache --virtual .buiâ	3.56MB	
<missing>	2 years ago	/bin/sh -c #(nop) ENV YARN_VERSION=0.21.3	0B	
<missing>	2 years ago	/bin/sh -c adduser -D -u 1000 node && apâ	45.4MB	
<missing>	2 years ago	/bin/sh -c #(nop) ENV NODE_VERSION=6.10.0	0B	
<missing>	2 years ago	/bin/sh -c #(nop) ENV NPM_CONFIG_LOGLEVEL=iâ	0B	
<missing>	2 years ago	/bin/sh -c #(nop) ADD file:3df55c321c1c8d73fâ	4.81MB	

```
FROM node:6.10.0-alpine
# Never run processes as root!
USER root

# Copy application itself:
COPY . /home

WORKDIR /home

# Set port on ...:
ENV PORT=8893

# Expose port 8893:
EXPOSE 8893

CMD node pinger.js
```

A layer describes a difference to the previous layer.

Layers of size 0 are "intermediate" layers

Non-zero layers are created with RUN, COPY and ADD.

```
kari@lepikko-nuc:~$ docker image ls
REPOSITORY          TAG          IMAGE ID          CREATED          SIZE
rabbitmq             3-management 38e57f281891     5 months ago    184MB
rabbitmq             3            ce51f7cc8a59     5 months ago    154MB
<none>              <none>      68ea2e469580     10 months ago   69.2MB
python              3.6         a2e9f0fba405     10 months ago   913MB
<none>              <none>      f49eea6b572d     11 months ago   69.2MB
apluslms/grading-base latest       669ef3db6a57     11 months ago   160MB
debian              buster-20190812-slim 83a10817c894     12 months ago   69.2MB
gitlab/gitlab-runner latest       53b7cdd9ce4a     18 months ago   408MB
gitlab/gitlab-ce    latest     8be4d926d44e     18 months ago   1.62GB
pinger              latest     874176ca6a7c     18 months ago   54.4MB
composetest_pingrelay latest     f1915b52acde     18 months ago   54.4MB
<none>              <none>      653b72c389fe     18 months ago   54.4MB
<none>              <none>      0ceea4e0dde7     18 months ago   53.8MB
<none>              <none>      2a1516bbcf7c     18 months ago   53.8MB
<none>              <none>      6f8e8a11dded     18 months ago   53.8MB
<none>              <none>      ce0842e65950     18 months ago   53.8MB
<none>              <none>      5c3f5be3e518     18 months ago   53.8MB
<none>              <none>      1037fb9e5f21     18 months ago   53.8MB
<none>              <none>      840f0aae6c3d     18 months ago   54.4MB
<none>              <none>      b0defb476587     18 months ago   54.4MB
<none>              <none>      3299381687af     18 months ago   54.4MB
<none>              <none>      0eafd852183d     18 months ago   54.4MB
<none>              <none>      08656cd757e0     18 months ago   54.4MB
<none>              <none>      2294d910c093     18 months ago   54.4MB
<none>              <none>      dd4036ed33e0     18 months ago   53.8MB
pingrelay           latest     52b9f6060548     18 months ago   53.8MB
<none>              <none>      68f5bdacbb58     18 months ago   53.8MB
<none>              <none>      b1b59d44b5fb     22 months ago   2.61GB
liquidiot-docker_ide latest     79214e5a582a     22 months ago   682MB
liquid-ide2         latest     c52aeb0af6ce     22 months ago   2.28GB
liquidiot-ide       latest     b20073f68dcd     22 months ago   1.67GB
liquidiot-base      latest     b88e10ba3196     22 months ago   205MB
hellotest           latest     27c7e8db4dd6     22 months ago   132MB
friendlyhello       latest     dfd0ebf0f838     22 months ago   132MB
ubuntu              14.04     f216cfb59484     22 months ago   188MB
ubuntu              latest     ea4c82dcd15a     22 months ago   85.8MB
python              2.7-slim  804b0a01ea83     22 months ago   120MB
mongo               3.2.21    0d365aaccf85     22 months ago   300MB
hello-world         latest     4ab4c602aa5e     24 months ago   1.84kB
piehei/base-qt593   latest     4318f4a85238     2 years ago     10.3GB
node                6.10.0-alpine 8232a8b9c483     3 years ago     53.8MB
```



```
kari@lepikko-nuc:~$ docker container ls
```

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
b74ff2393ba3	gitlab/gitlab-runner:latest	"/usr/bin/dumb-init ..."	10 months ago	Up 29 minutes	0.0.0.0:8000->80/tcp	xxx2
a1830c0f526f	gitlab/gitlab-runner:latest	"/usr/bin/dumb-init ..."	10 months ago	Up 29 minutes		gitlab-runner

```
FROM node:6.10.0-alpine
USER root
COPY ./home
WORKDIR /home
ENV PORT=8893
EXPOSE 8893
```

```
CMD node pinger.js
```

### \$ docker history 874176ca6a7c

IMAGE	CREATED	CREATED BY	SIZE
874176ca6a7c	18 months ago	/bin/sh -c #(nop) CMD ["/bin/sh" "-c" "node...]	0B
e477afdf62b1	18 months ago	/bin/sh -c #(nop) EXPOSE 8893	0B
bbb82ecea436	18 months ago	/bin/sh -c #(nop) ENV PORT=8893	0B
f7e49216f8f8	18 months ago	/bin/sh -c #(nop) WORKDIR /home	0B
75bf5968b264	18 months ago	/bin/sh -c #(nop) COPY dir:fed108fd8e77a8ed8...	553kB
1fb4fbe8beb7	18 months ago	/bin/sh -c #(nop) USER root	0B
8232a8b9c483	3 years ago	/bin/sh -c #(nop) CMD ["node"]	0B
<missing>	3 years ago	/bin/sh -c apk add --no-cache --virtual .bui...	3.56MB
<missing>	3 years ago	/bin/sh -c #(nop) ENV YARN_VERSION=0.21.3	0B
<missing>	3 years ago	/bin/sh -c adduser -D -u 1000 node && ap...	45.4MB
<missing>	3 years ago	/bin/sh -c #(nop) ENV NODE_VERSION=6.10.0	0B
<missing>	3 years ago	/bin/sh -c #(nop) ENV NPM_CONFIG_LOGLEVEL=i...	0B
<missing>	3 years ago	/bin/sh -c #(nop) ADD file:3df55c321c1c8d73f...	4.81MB

I found a nice article (but old and partially out of date):  
<https://windsock.io/explaining-docker-image-ids/>

## Image

```
ID:      sha256:1742affe03b5
Name:    my_image:1.0
Layers:  [
  sha256:4dcab49015d4
  sha256:3c9c1b11a52b
  sha256:70c557e50ed6
  sha256:b72889fa879c
]
```

## Layers

.../aufs/diff



```
kari@lepicko-nuc:~$ docker history pingrelay
```

IMAGE	CREATED	CREATED BY	SIZE	COMMENT
52b9f6060548	2 years ago	/bin/sh -c #(nop) CMD ["/bin/sh" "-c" "node...	0B	
20e97c5340b3	2 years ago	/bin/sh -c #(nop) EXPOSE 8894	0B	
aed7842203d6	2 years ago	/bin/sh -c #(nop) ENV PORT=8894	0B	
b42a225080f7	2 years ago	/bin/sh -c #(nop) COPY dir:10a4bc704d33f8ef9...	2.86kB	
<b>d62176fb4127</b>	2 years ago	/bin/sh -c #(nop) USER node	0B	
8232a8b9c483	4 years ago	/bin/sh -c #(nop) CMD ["node"]	0B	
<missing>	4 years ago	/bin/sh -c apk add --no-cache --virtual .bui...	3.56MB	
<missing>	4 years ago	/bin/sh -c #(nop) ENV YARN_VERSION=0.21.3	0B	
<missing>	4 years ago	/bin/sh -c adduser -D -u 1000 node && ap...	45.4MB	
<missing>	4 years ago	/bin/sh -c #(nop) ENV NODE_VERSION=6.10.0	0B	
<missing>	4 years ago	/bin/sh -c #(nop) ENV NPM_CONFIG_LOGLEVEL=i...	0B	
<missing>	4 years ago	/bin/sh -c #(nop) ADD file:3df55c321c1c8d73f...	4.81MB	

```
kari@lepicko-nuc:~$ docker history d62176fb4127
```

IMAGE	CREATED	CREATED BY	SIZE	COMMENT
d62176fb4127	2 years ago	/bin/sh -c #(nop) USER node	0B	
8232a8b9c483	4 years ago	/bin/sh -c #(nop) CMD ["node"]	0B	
<missing>	4 years ago	/bin/sh -c apk add --no-cache --virtual .bui...	3.56MB	
<missing>	4 years ago	/bin/sh -c #(nop) ENV YARN_VERSION=0.21.3	0B	
<missing>	4 years ago	/bin/sh -c adduser -D -u 1000 node && ap...	45.4MB	
<missing>	4 years ago	/bin/sh -c #(nop) ENV NODE_VERSION=6.10.0	0B	
<missing>	4 years ago	/bin/sh -c #(nop) ENV NPM_CONFIG_LOGLEVEL=i...	0B	
<missing>	4 years ago	/bin/sh -c #(nop) ADD file:3df55c321c1c8d73f...	4.81MB	

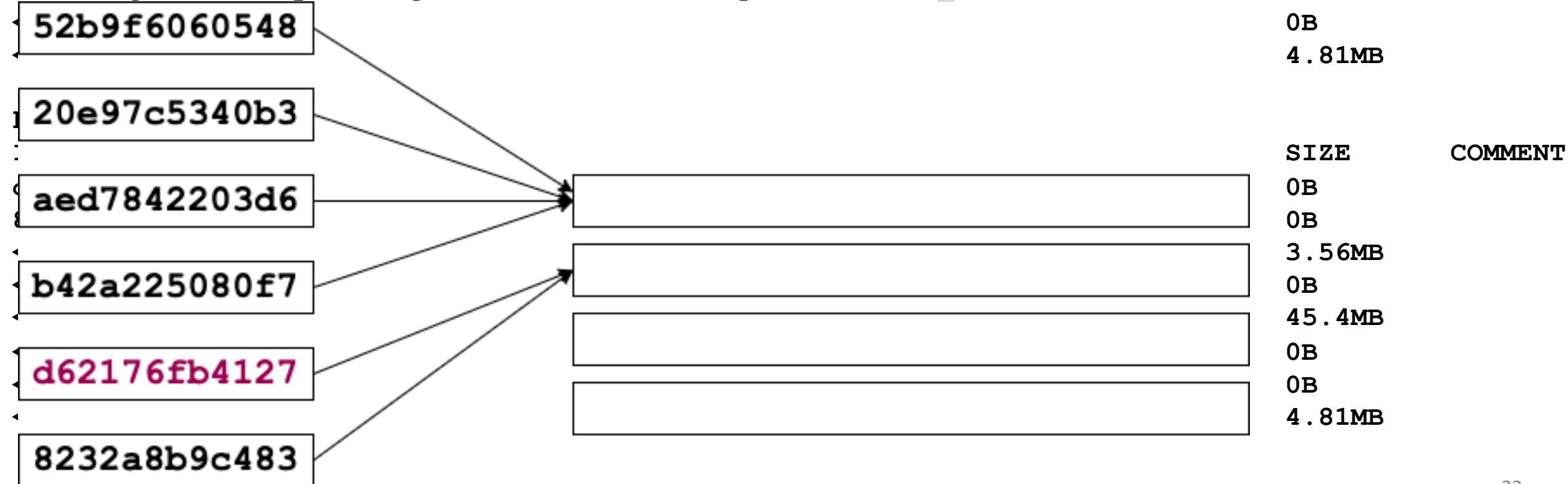
```
kari@lepikko-nuc:~$ docker inspect b42a225080f7 | more
```

```
...
```

```
"RootFS": {  
  "Type": "layers",  
  "Layers": [  
    "sha256:9f8566ee5135862dd980160c27bd7721448a6f7f385bbb81f7f001f1b78a5fbf",  
    "sha256:a29f1bf1f8df55abcb2230162480199bb2839e29e40b5d747cccce32a9696e86",  
    "sha256:d7a4e57a4ae0051473917c87c590af2b2b95ad9517740fbe05b27b43e5dbfa4b",  
    "sha256:45334db71e1d93df59509957eb38807c3a0841bdef75058b5bc0e55f9edfd968"  
  ]  
},
```

```
kari@lepickko-nuc:~$ docker history pingrelay
```

IMAGE	CREATED	CREATED BY		SIZE	COMMENT
52b9f6060548	2 years ago	/bin/sh -c #(nop)	CMD ["/bin/sh" "-c" "node...	0B	
20e97c5340b3	2 years ago	/bin/sh -c #(nop)	EXPOSE 8894	0B	
aed7842203d6	2 years ago	/bin/sh -c #(nop)	ENV PORT=8894	0B	
b42a225080f7	2 years ago	/bin/sh -c #(nop)	COPY dir:10a4bc704d33f8ef9...	2.86kB	
<b>d62176fb4127</b>	2 years ago	/bin/sh -c #(nop)	USER node	0B	
8232a8b9c483	4 years ago	/bin/sh -c #(nop)	CMD ["node"]	0B	
<missing>	4 years ago	/bin/sh -c apk add --no-cache --virtual .bui...		3.56MB	
<missing>	4 years ago	/bin/sh -c #(nop)	ENV YARN_VERSION=0.21.3	0B	
<missing>	4 years ago	/bin/sh -c adduser -D -u 1000 node && ap...		45.4MB	
<missing>	4 years ago	/bin/sh -c #(nop)	ENV NODE_VERSION=6.10.0	0B	



# From: <https://windsock.io/explaining-docker-image-ids/>

- A Docker image provides a filesystem for a derived container based on the references it stores to layer diffs
- Layer diffs are referenced using a digest, which contains an SHA256 hash of an archive of the diff's contents
- A Docker image's ID is a digest, which contains an SHA256 hash of the image's JSON configuration object
- Docker creates intermediate images during a local image build, for the purposes of maintaining a build cache
- An image manifest is created and pushed to a Docker registry when an image is pushed
- An image manifest contains digests of the image's layers, which contain the SHA256 hashes of the compressed, archived diff contents



```
kari@lepikko-nuc:~/CloudApplications/test$ docker build .
```

```
Sending build context to Docker daemon 3.072kB
```

```
Step 1/3 : FROM debian:buster-20190812-slim
```

```
---> 83a10817c894
```

```
Step 2/3 : RUN date > /home/123456.txt
```

```
---> Using cache
```

```
---> 38b806d0d640
```

```
Step 3/3 : CMD cat /home/123456.txt
```

```
---> Using cache
```

```
---> 68ea2e469580
```

```
Successfully built 68ea2e469580
```

```
kari@lepikko-nuc:~/CloudApplications/test$ docker run 68ea2e469580
```

```
Wed Oct 23 16:34:26 UTC 2019
```



```
$ docker image rm 68ea2e469580
```

```
Error response from daemon: conflict: unable to delete 68ea2e469580 (must be forced) - image is being used by stopped container 832701d84725
```

```
$ docker image rm -f 68ea2e469580
```

```
Deleted:
```

```
sha256:68ea2e469580458998dfdc9c0a13db39541803e6f988245ee55f2b124fb  
1035f
```

```
Deleted:
```

```
sha256:38b806d0d64026fe73682cead45e9089772618392a86fe29cff70f0aebff9  
a2c
```



**\$ docker build .**

Sending build context to Docker daemon 5.12kB

Step 1/3 : FROM debian:buster-20190812-slim

---> 83a10817c894

Step 2/3 : RUN date > /home/123456.txt

---> Running in 646f50d34715

Removing intermediate container 646f50d34715

---> d97b91c429fc

Step 3/3 : CMD cat /home/123456.txt

---> Running in 2750a97284f8

Removing intermediate container 2750a97284f8

---> fc4c5d3376a9

Successfully built fc4c5d3376a9

**\$ docker run fc4c5d3376a9**

Sun Sep 6 08:53:24 UTC 2020

## \$ docker history fc4c5d3376a9

IMAGE	CREATED	CREATED BY	SIZE
fc4c5d3376a9	About a minute ago	/bin/sh -c #(nop) CMD ["/bin/sh" "-c" "cat ...	0B
d97b91c429fc	About a minute ago	/bin/sh -c date > /home/123456.txt	29B
83a10817c894	12 months ago	/bin/sh -c #(nop) CMD ["bash"]	0B
<missing>	12 months ago	/bin/sh -c #(nop) ADD file:330bfb91168adb4a9...	69.2MB

# Docker image ls

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
<none>	<none>	99d4b9dd0fea	32 seconds ago	1.19GB
<none>	<none>	f86de57f2f64	2 minutes ago	1.19GB
<none>	<none>	c6f93e248201	14 minutes ago	944MB
<none>	<none>	8d4c9c98fece	15 minutes ago	944MB
<none>	<none>	51257e92bd03	18 minutes ago	944MB
<none>	<none>	fc4c5d3376a9	33 minutes ago	69.2MB
node	latest	40ce906a3734	4 days ago	944MB
gcc	latest	cfe277915109	4 days ago	1.19GB
rabbitmq	3-management	38e57f281891	5 months ago	184MB
rabbitmq	3	ce51f7cc8a59	5 months ago	154MB

kari@lepikko-nuc:~/CloudApplications/DockerExercise\$ docker build -f Dockerfile.gcc -t gcc-hello .

Successfully built 99d4b9dd0fea

Successfully tagged gcc-hello:latest

kari@lepikko-nuc:~/CloudApplications/DockerExercise\$ docker image ls

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
gcc-hello	latest	99d4b9dd0fea	28 minutes ago	1.19GB
<none>	<none>	f86de57f2f64	30 minutes ago	1.19GB
<none>	<none>	c6f93e248201	42 minutes ago	944MB