Our Docker app got hacked…

Now what?

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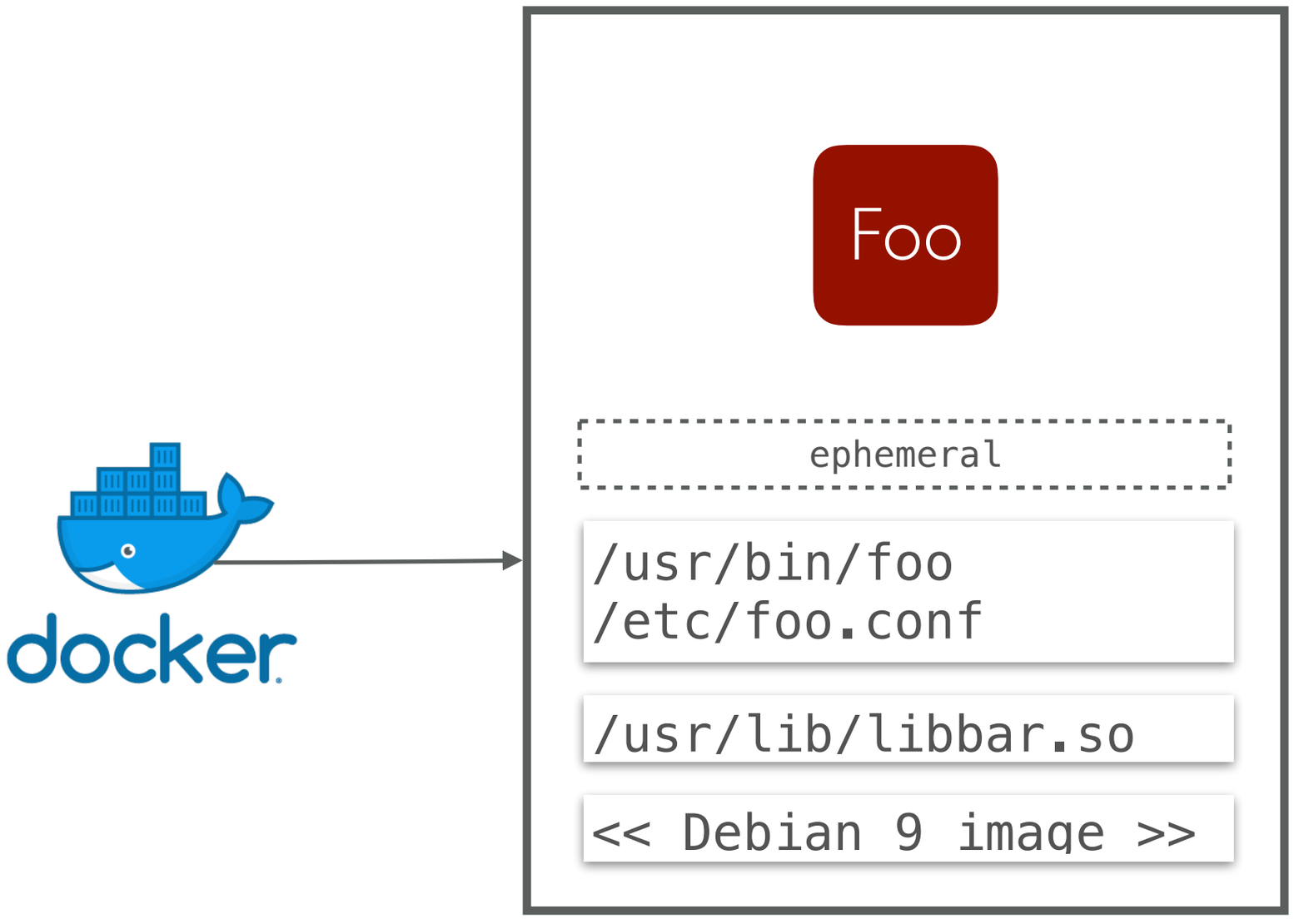
https://didactic-security.com/preso.pdf

Goals

Know how to forensically capture a Docker container ...

- from a live system
- from a cold disk image
  - … that used the `overlay2` storage backend
  - … that used the `devicemapper` storage backend

Anatomy



Live Capture

Container metadata

```
$ docker inspect foo
```

Container filesystem snapshot

```
$ docker commit foo image-of-foo

$ docker save image-of-foo | gzip > image-of-foo.tar.gz
```

Log of all terminal I/O

```
$ docker logs foo
```

Container process memory

```
$ docker top foo
UID   PID   PPID  C  STIME  TTY    TIME      CMD
root  4802  4784  0  17:53  pts/0  00:00:00  /usr/bin/my-app

$ gcore 4802
```

Cold Capture

Where are the goodies at?

```
/var/lib/docker
```

Image Listing

`image/<backend>/repositories.json`

```
{
  “Repositories”: {
    “alpine”: {
      “alpine:latest”: “sha256:196d12…”,
      “alpine@sha256:621c2f…”: “sha256:196d12…”
    },

    “testing”: {
      “testing:latest”: “sha256:2ba43e…”
    }
  }
}
```

Image Metadata

`image/<backend>/imagedb/content/sha256/<ID>`

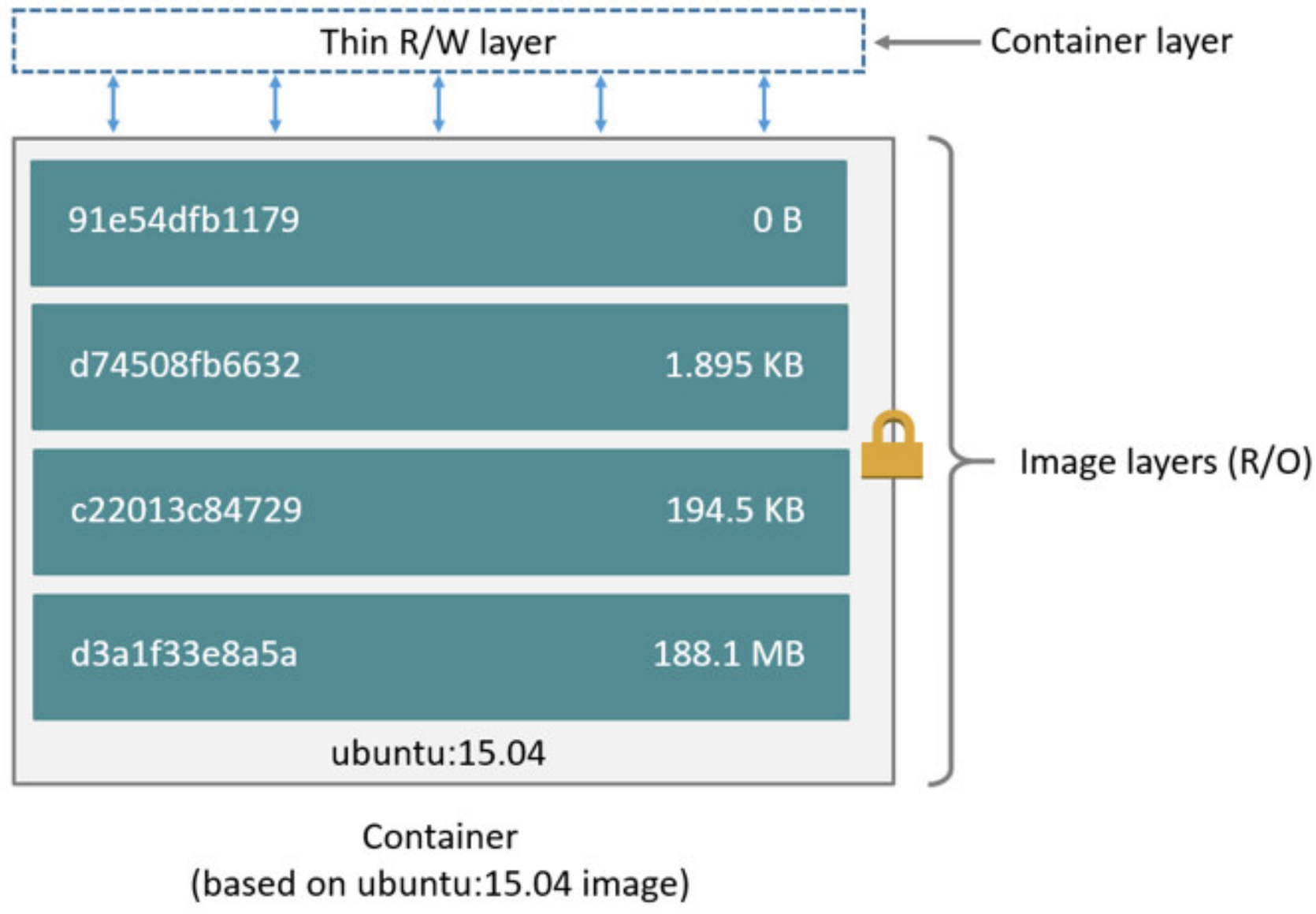
- A JSON file containing…
  - Image name
  - Container entrypoint script
  - Build history
  - Creation timestamp
  - … and more

Container Metadata

`containers/<ID>/config.v2.json`

- Name
- Image ID
- Driver
- State.StartedAt & State.FinishedAt
- Path & Args
- Config.Env
- MountPoints
- LogPath
  - For JSON logger will be `<ID>-json.log` in same directory.
- … and more

What about disk content?



Source: https://docs.docker.com/storage/storagedriver

Example Container

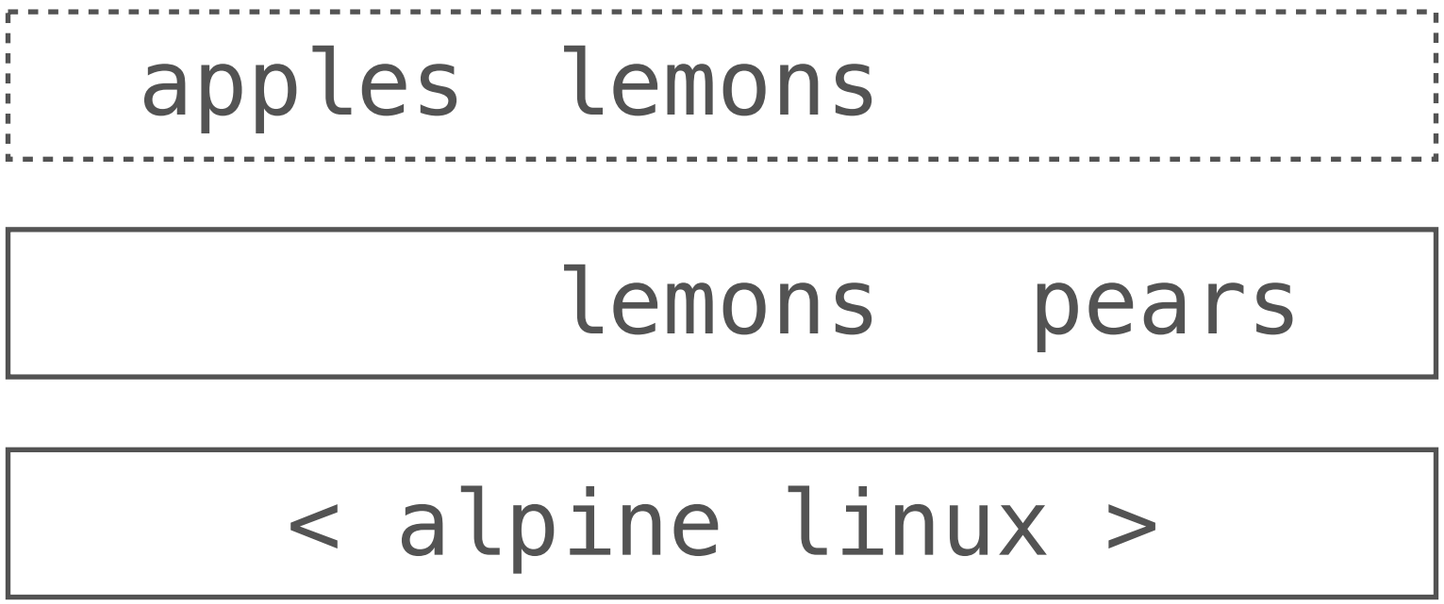
Dockerfile

```
FROM alpine

ADD lemons pears  /fruit/
ADD entrypoint.sh /

ENTRYPOINT ["/bin/sh", "/entrypoint.sh"]
```

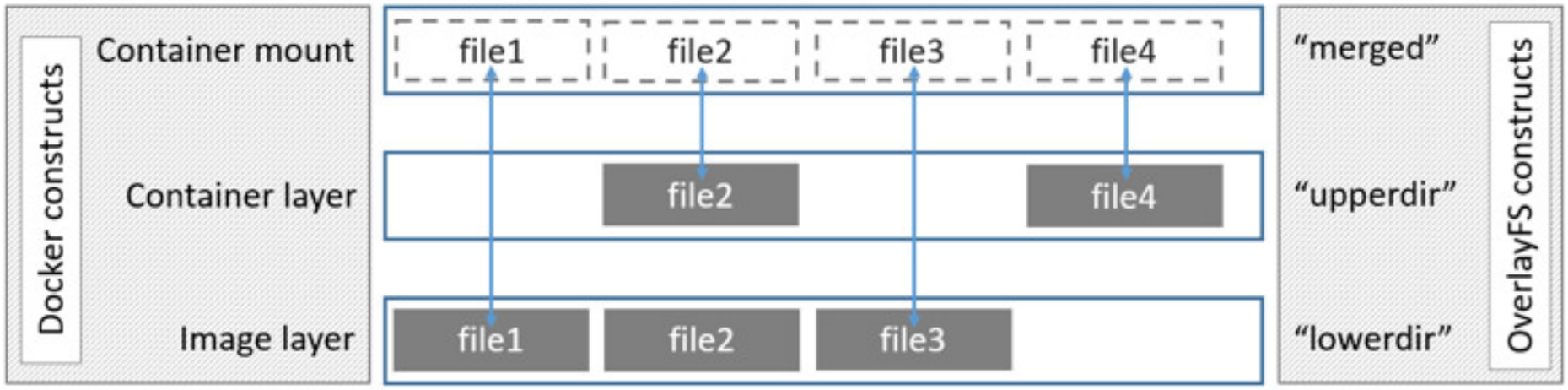
entrypoint.sh

```
echo 'Empires are the best!'      > /fruit/apples
echo 'Makes a good sugary drink.' > /fruit/lemons
echo 'This looks interesting...'  > /fruit/durian

sync                # force modifications to disk

rm /fruit/durian  # can't stand the smell
rm /fruit/pears   # over-ripen as soon as you turn your back
```

Anticipated Layers



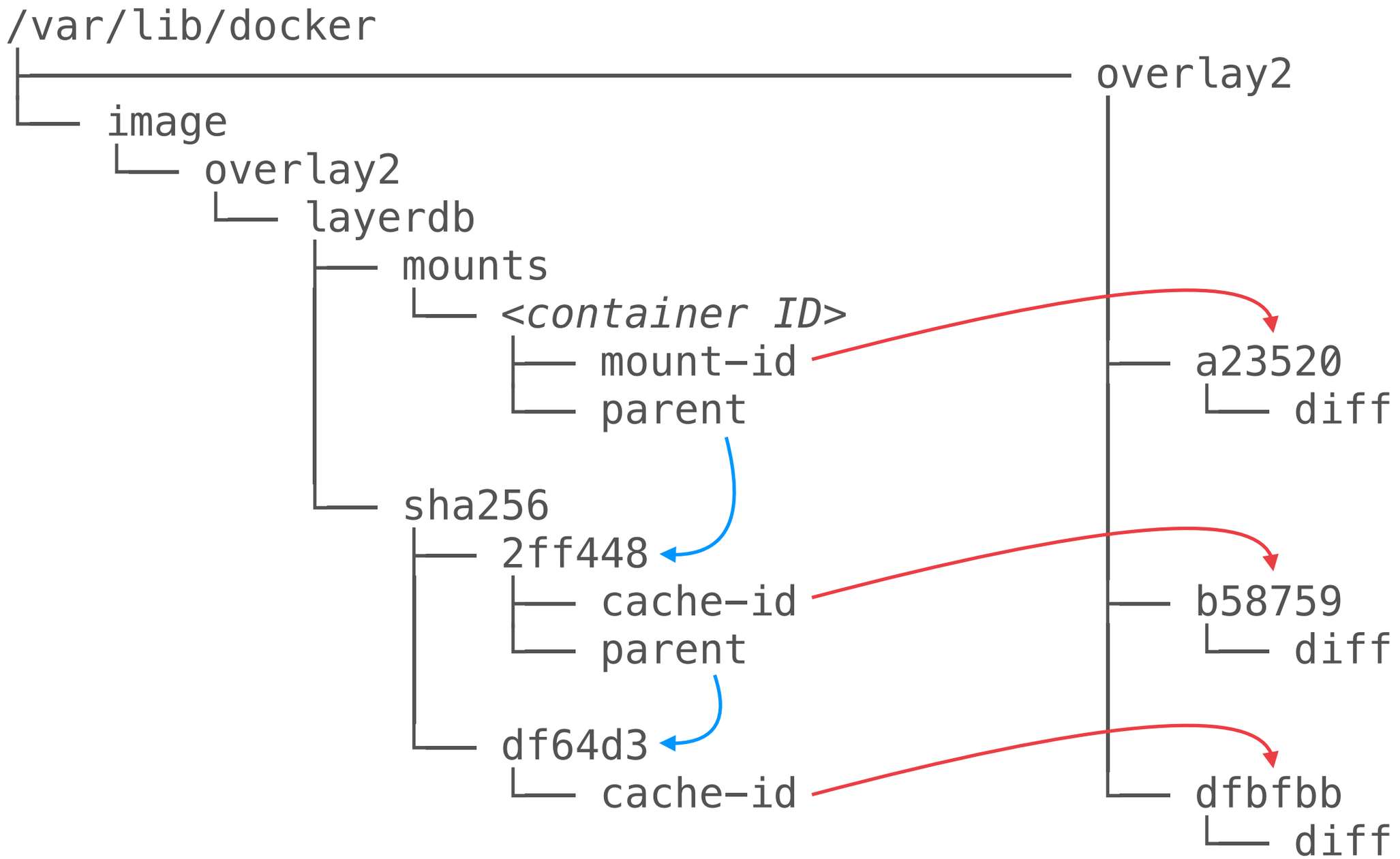
STORAGE BACKEND: OVERLAY2



Source: https://docs.docker.com/storage/storagedriver/overlayfs-driver

- Linux kernel module: OverlayFS
- Stacked directory tree differences
- Uses host filesystem
- Docker's preferred storage backend

Finding Container Storage



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Container R/W Layer

```
$ mkdir /tmp/view

$ mount -t overlay overlay
        -o ro,lowerdir="./overlay2/a23520/diff:
                        ./overlay2/b58759/diff:
                        ./overlay2/dfbfbb/diff"
        /tmp/view


$ ls -l /tmp/view/fruit
total 20
-rw-r--r-- 1 root root   22 Oct 12 13:45 apples
-rw-r----- 1 root root   27 Oct 12 13:45 lemons
```

Top Image Layer

```
$ mkdir /tmp/view

$ mount -t overlay overlay
        -o ro,lowerdir="./overlay2/b58759/diff:
                        ./overlay2/dfbfbb/diff"
        /tmp/view


$ ls -l /tmp/view/fruit
total 20
-rw-r----- 1 root root   17 Oct 11 20:54 lemons
-rw-r----- 1 root root   33 Oct 11 20:54 pears
```

Raw OverlayFS

```
$ ls -l overlay2/a23520/diff/fruit/
total 20
-rw-r--r-- 1 root root   22 Oct 12 13:45 apples
-rw-r----- 1 root root   27 Oct 12 13:45 lemons
c--------- 1 root root 0, 0 Oct 12 13:45 pears
```


Represents a deleted file

What about the durian?

```
$ ifind -f ext4 -n /var/lib/docker/overlay2/a23520/diff/fruit
        /dev/sda1
259987

$ fls /dev/sda1 259987
r/r 259988:   apples
r/r 259989:   lemons
r/l * 259990: durian
c/c 259974:   pears
```

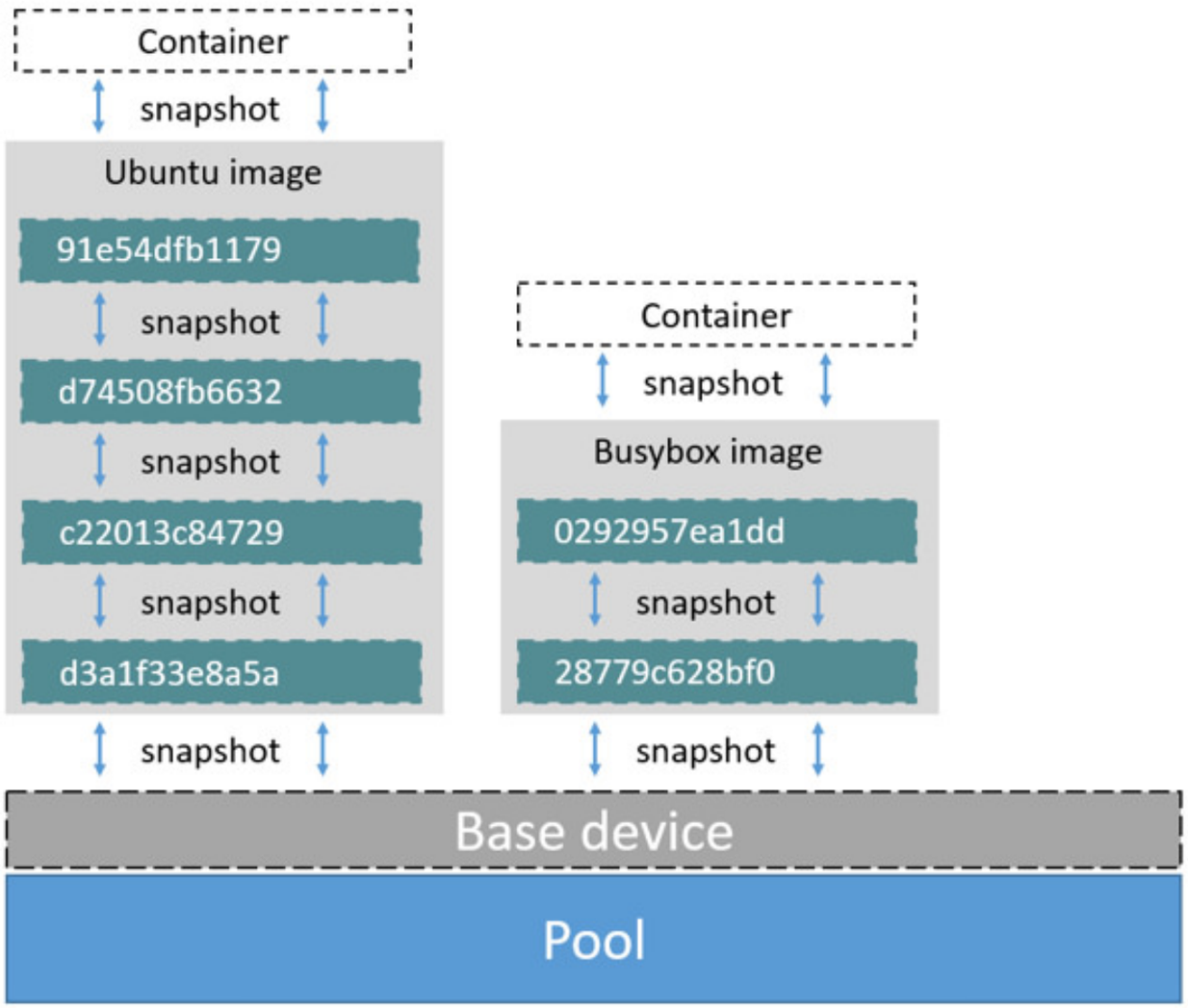
Easy Button!

Romain Gayon automated mounting `overlay2` container storage

https://github.com/google/docker-explorer

(Only works for `overlay`, `overlay2`, and `aufs` Docker storage backends.)

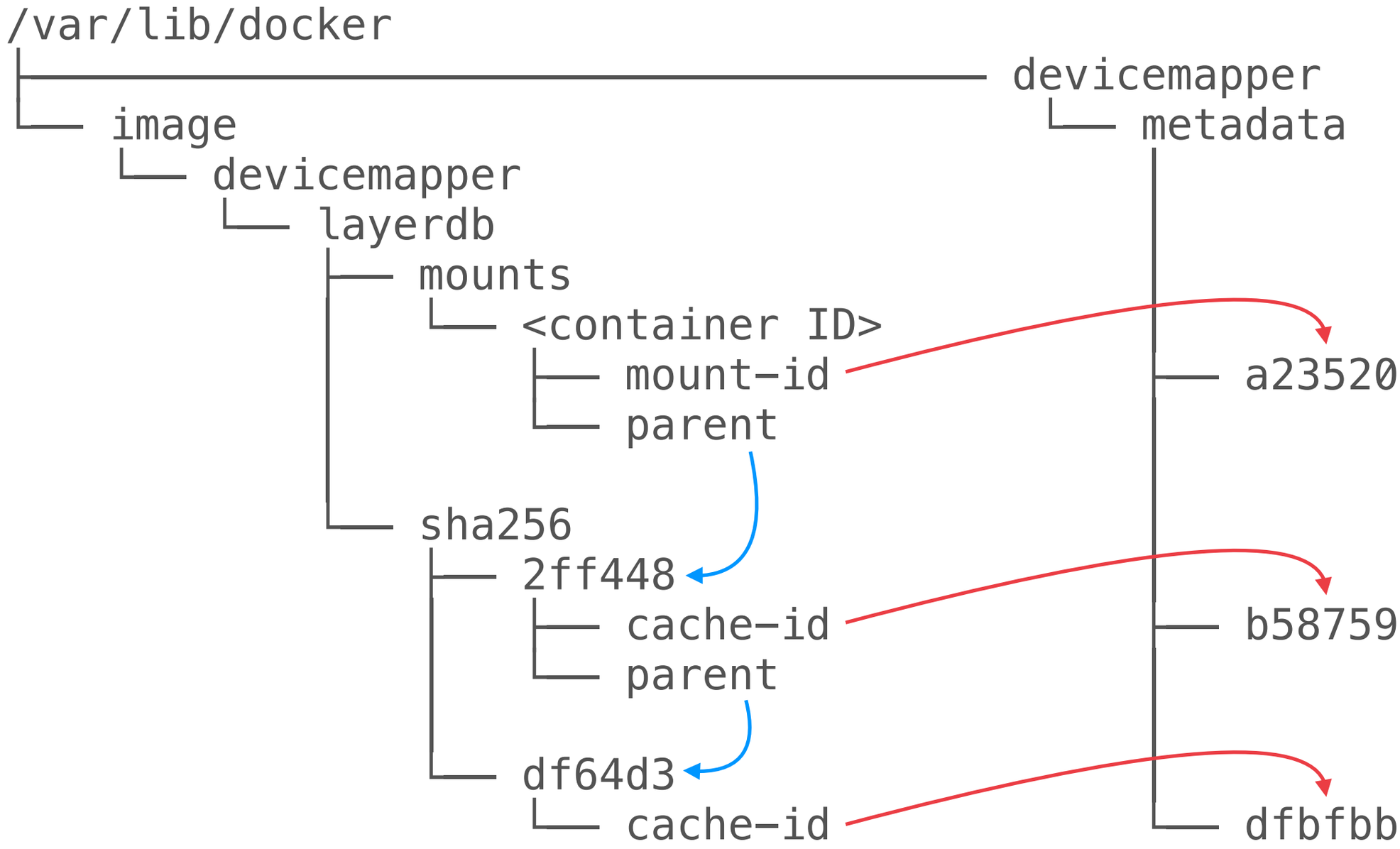
STORAGE BACKEND: DEVICEMAPPER



Source: https://docs.docker.com/storage/storagedriver/device-mapper-driver

- Uses an **LVM storage pool** for production deployments
- Leverages "thin" device mapper **snapshots**
- Unlike OverlayFS, the base units are **block devices**, not files
- You'll likely encounter this if the host is **RedHat** or CentOS

Finding Container Storage



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Thin Pool Devices

new device name

```
dmsetup create my-new-device –table
        "0 10240 thin /dev/mapper/pool-device 3"
```

starting sector

size in sectors

pool device

volume ID

Accessing a Layer*

```
$ jq . devicemapper/metadata/a23520
{
  "device_id":      13,
  "size":           10737418240,
  "transaction_id": 16,
  "initialized":    false,
  "deleted":        false
}

$ dmsetup create dk-my-container --table \
          "0 $((10737418240 / 512)) thin /dev/docker/thinpool 13”

$ file -s -L /dev/mapper/dk-my-container
/dev/mapper/dk-base: SGI XFS filesystem data
                     (blksz 4096, inosz 256, v2 dirs)
```

* You will need to load the LVM volumes first.

Mounting the Layer

```
$ mkdir /mnt/my-container

$ mount -o ro,nouuid /dev/mapper/dk-my-container /mnt/my-container

$ ls -l /mnt/my-container/rootfs/fruit/
total 8
-rw-r--r--. 1 root root 22 Oct 13 16:40 apples
-rw-r-----. 1 root root 27 Oct 13 16:40 lemons
```

Further Analysis

- Thin pool devices ⇒ Virtual disks
  - Use your regular imaging & analysis tools!
- Can compare with lower layers
- `thin_dump` reveals block-level differences

Summary

- Metadata in JSON files
- Follow the `layerdb` chain of `parent` pointers
- `overlay2`: Layers are directory differences
- `devicemapper`: Layers are virtual disk snapshots

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Questions?

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Bonus!

https://didactic-security.com/cheatsheet.pdf

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Thank You!