Docker Deep Dive, Part One

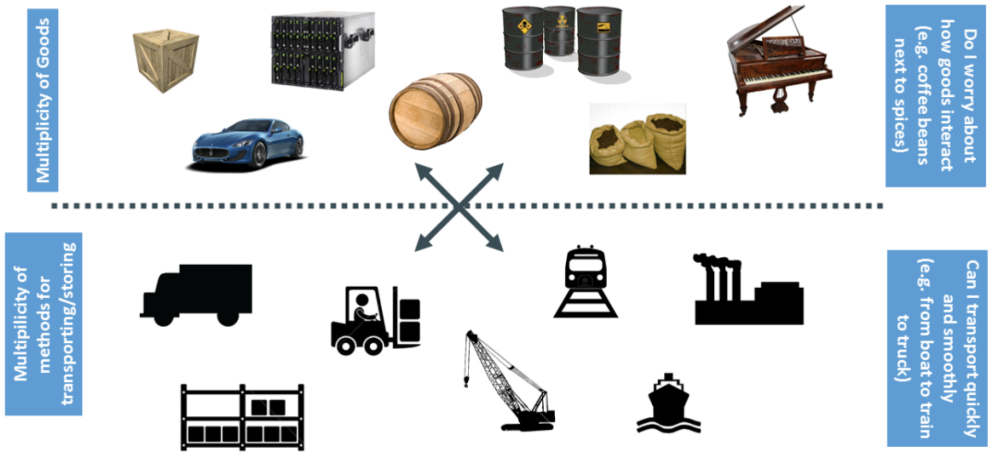
Understanding Images

Michael Irwin - December 14, 2016

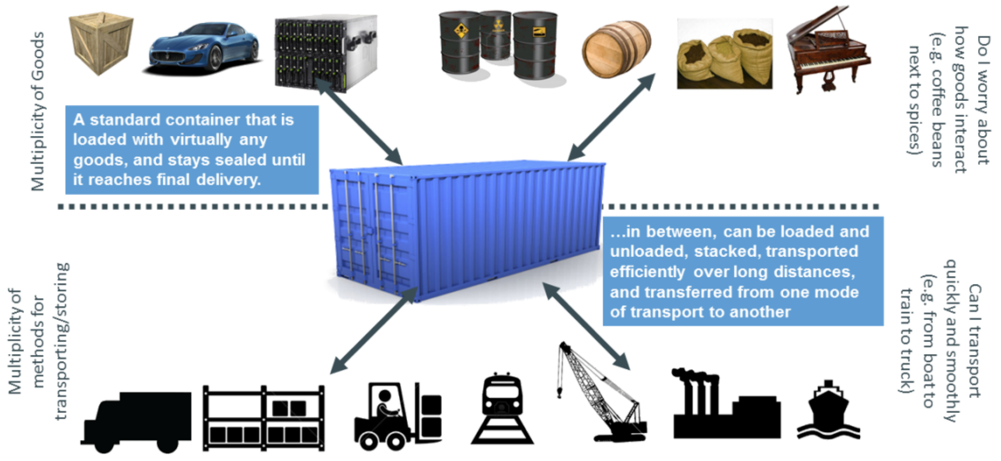
What problem is Docker addressing?

- Creating apps that can run anywhere is difficult
  - Environment differences
  - Dependency differences
  - Conflicts with other apps
- Onboarding new developers is costly
  - Takes a lot of time installing environment
  - Dev environments are often not documented (or up-to-date)
  - Isolation between app environments is tricky

Not the first time this problem's existed...


Multiplicity of Goods
Do I worry about how goods interact (e.g. coffee beans next to spices)
Multiplicity of methods for transporting/storing
Can I transport quickly and smoothly (e.g. from boat to train to truck)

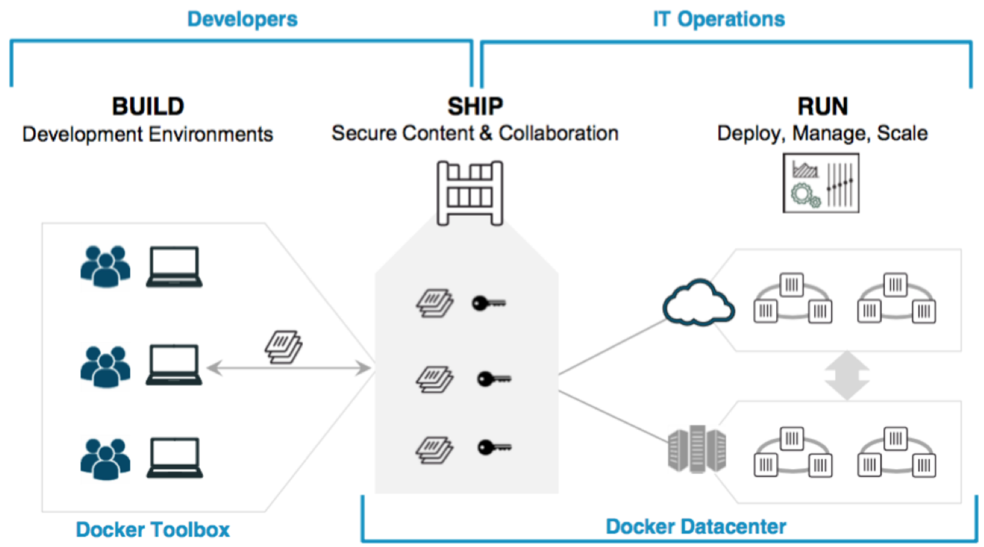
Just throw it in a container!


Multiplicity of Goods
A standard container that is loaded with virtually any goods, and stays sealed until it reaches final delivery.
Do I worry about how goods interact (e.g. coffee beans next to spices)
Multiplicity of methods for transporting/storing
...in between, can be loaded and unloaded, stacked, transported efficiently over long distances, and transferred from one mode of transport to another
Can I transport quickly and smoothly (e.g. from boat to train to truck)

"We create the tools behind the scenes to make things happen. We're passionate about making tools. We build tools of mass innovation."

- Solomon Hykes, Co-Founder and CTO of Docker

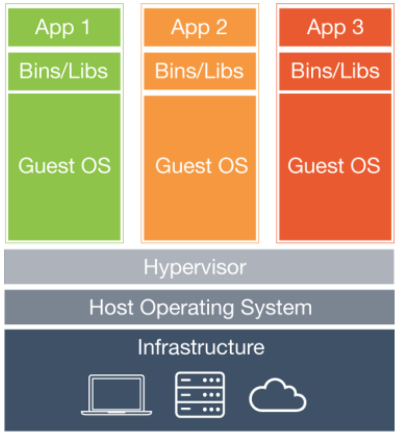
What are the tools? Build. Ship. Run.

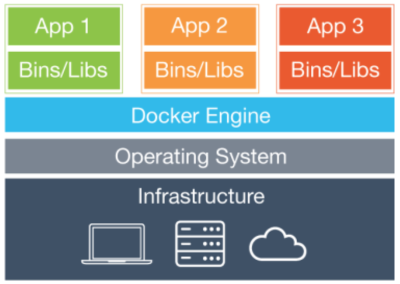


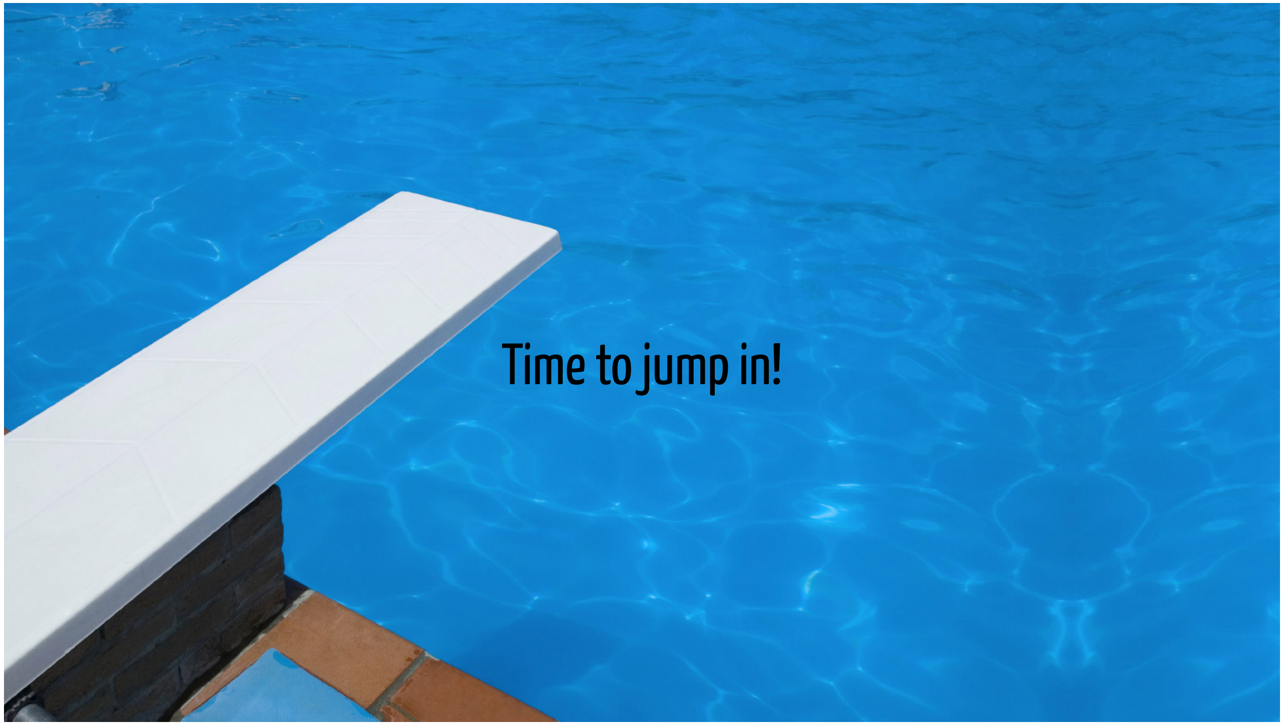
"Containers are not VMs. Docker is not a virtualization technology, it’s an application delivery technology."

- Mike Coleman, Sr. Technical Envangelist at Docker

VMs vs Containers





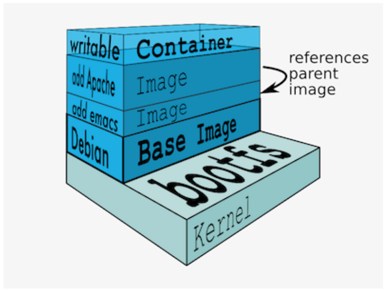

Time to jump in!

What's an image again?

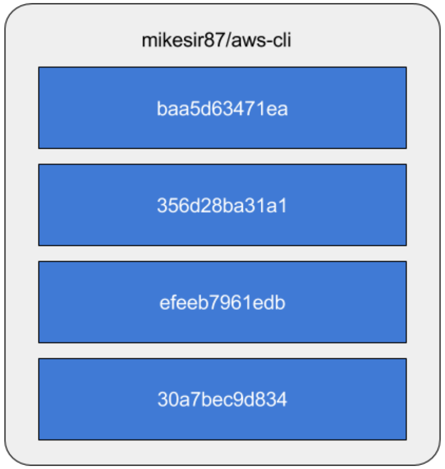
Anyone remember?

Images are...

- Collection of filesystem changes organized into "layers"
  - Contains ONLY file changes, not running state
  - Doesn't keep track of what processes you had running
- Each layer references its parent and contains its changes
- Each layer is read-only and, therefore, immutable

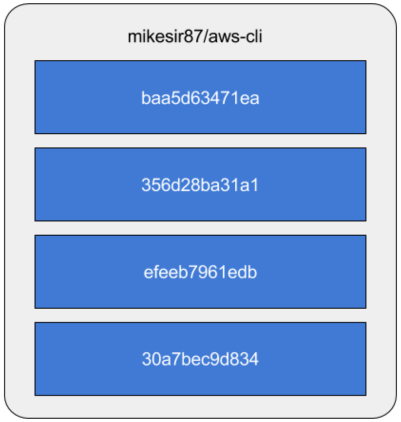


An actual image...



Dockerfile

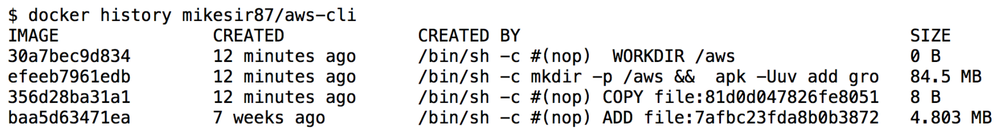
```
FROM alpine:latest

COPY cli-version /

RUN \
    mkdir -p /aws && \
    apk -Uuv add groff jq less python py-pip && \
    pip install awscli==$(cat /cli-version) && \
    apk --purge -v del py-pip && \
    rm /var/cache/apk/*

WORKDIR /aws
```



- Each command in the `Dockerfile` corresponds with a layer in the image

Seeing an image's layers (history)

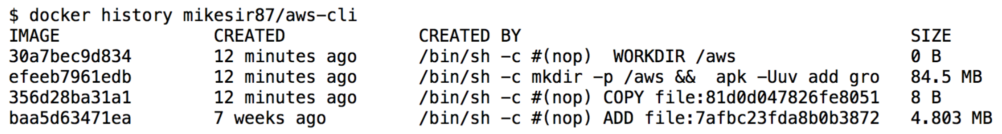
```
docker history mikesir87/aws-cli
```



```
$ docker history mikesir87/aws-cli
IMAGE               CREATED             CREATED BY                                      SIZE
30a7bec9d834        12 minutes ago      /bin/sh -c #(nop)  WORKDIR /aws                 0 B
efeeb7961edb        12 minutes ago      /bin/sh -c mkdir -p /aws &&  apk -Uuv add gro   84.5 MB
356d28ba31a1        12 minutes ago      /bin/sh -c #(nop) COPY file:81d0d047826fe8051   8 B
baa5d63471ea        7 weeks ago         /bin/sh -c #(nop) ADD file:7afbc23fda8b0b3872   4.803 MB
```

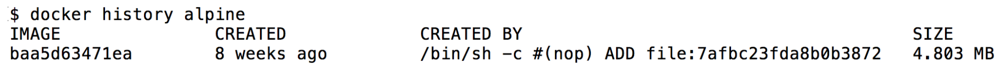
Seeing an image's layers (history)

```
docker history mikesir87/aws-cli
```



```
$ docker history mikesir87/aws-cli
IMAGE               CREATED             CREATED BY                                      SIZE
30a7bec9d834        12 minutes ago      /bin/sh -c #(nop)  WORKDIR /aws                 0 B
efeeb7961edb        12 minutes ago      /bin/sh -c mkdir -p /aws &&  apk -Uuv add gro   84.5 MB
356d28ba31a1        12 minutes ago      /bin/sh -c #(nop) COPY file:81d0d047826fe8051   8 B
baa5d63471ea        7 weeks ago         /bin/sh -c #(nop) ADD file:7afbc23fda8b0b3872   4.803 MB
```

```
docker history alpine
```



```
$ docker history alpine
IMAGE               CREATED             CREATED BY                                      SIZE
baa5d63471ea        8 weeks ago         /bin/sh -c #(nop) ADD file:7afbc23fda8b0b3872   4.803 MB
```

So… where does this image go?

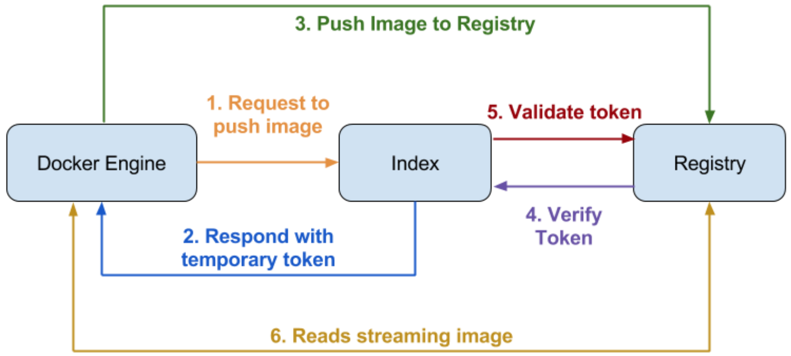
So... where does this image go?

A registry... duh!

What's a registry?

- Simply a place to store images!
- Has a standardized REST API around it
  - There's two versions... V1 and V2
  - As expected, V2 is current version (as of Docker ~1.6)
- Default registry is found at https://registry.docker.io/
- Many other registries exist, including ECR, GitLab, Sonatype Nexus, etc.
  - Can even run your own using the `registry` image (from Docker Hub)

Pushing an Image



Pulling an Image

```
docker pull mikesir87/aws-cli
```

Pulling an Image

```
docker pull mikesir87/aws-cli
```

What's going on?

1. Fetches image manifest at tag (if no tag is specified, uses `latest`)
2. For each layer that's not downloaded, fetch it

Image Manifest

```
GET /v2/<image-name>/manifests/<tag>
```

```
{
   "schemaVersion": 1,
   "name": "aws-cli",
   "tag": "latest",
   "architecture": "amd64",
   "fsLayers": [
      { "blobSum": "sha256:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d4" },
      { "blobSum": "sha256:a5cc40516c60d5738c0dfe323677825d245a80edb6a751399a02ea6b88369a72" },
      { "blobSum": "sha256:9fa3e769ec114c6a0cd01a725fee47f0d482d35cc643e4d80492cf60ca471590" },
      { "blobSum": "sha256:3690ec4760f95690944da86dc4496148a63d85c9e3100669a318110092f6862f" }
   ],
   ...
}
```

Manifest - Layer History

```
   "history": [
      {
         "v1Compatibility": "{\"architecture\":\"amd64\",\"config\":{\"Hostname\":\"1d811a9194c4\",\"Domainname\":\"\",\"User\":\"\",\"Atta
\":false,\"AttachStdout\":false,\"AttachStderr\":false,\"Tty\":false,\"OpenStdin\":false,\"StdinOnce\":false,\"Env\":[\"PATH=/usr/local/sbi
local/bin:/usr/sbin:/usr/bin:/sbin:/bin\"],\"Cmd\":null,\"ArgsEscaped\":true,\"Image\":\"sha256:efeeb7961edb9a2479611f0340ccaa824cca38ed254
de858f8287678e\",\"Volumes\":null,\"WorkingDir\":\"/aws\",\"Entrypoint\":null,\"OnBuild\":[],\"Labels\":{}},\"container\":\"233c27f21cb4b34
05f2c4aa55dfa1ba85f844ee4865e90958358a0f5f\",\"container_config\":{\"Hostname\":\"1d811a9194c4\",\"Domainname\":\"\",\"User\":\"\",\"Attach
:false,\"AttachStdout\":false,\"AttachStderr\":false,\"Tty\":false,\"OpenStdin\":false,\"StdinOnce\":false,\"Env\":[\"PATH=/usr/local/sbin:
cal/bin:/usr/sbin:/usr/bin:/sbin:/bin\"],\"Cmd\":[\"/bin/sh\",\"-c\",\"#(nop) \",\"WORKDIR /aws\"],\"ArgsEscaped\":true,\"Image\":\"sha256:
61edb9a2479611f0340ccaa824cca38ed2542889a3cde858f8287678e\",\"Volumes\":null,\"WorkingDir\":\"/aws\",\"Entrypoint\":null,\"OnBuild\":[],\"L
:{}},\"created\":\"2016-12-13T04:49:16.461134488Z\",\"docker_version\":\"1.12.3\",\"id\":\"7571677e3d42720cfc39b2823a62eadb90bbe8bcc9cbb1f3
      },
      {
         "v1Compatibility": "{\"id\":\"527639ab97485271314381f8841f1b0724aa89eab5d9f37d14cb03d938eb159d\",\"parent\":\"2e
         f2ead2ef1cd54286222ec1829724a1d38aa696995eba261eb5e4b185f01a6f\",\"created\":\"2016-12-13T04:49:15.707543931Z\",
         \"container_config\":{\"Cmd\":[\"/bin/sh -c mkdir -p /aws \\u0026\\u0026 \\tapk -Uuv add groff jq less python
         py-pip \\u0026\\u0026 \\tpip install awscli==$(cat /cli-version) \\u0026\\u0026 \\tapk --purge -v del py-pip
         \\u0026\\u0026 \\trm /var/cache/apk/*\"]}}"
      },
      {
         "v1Compatibility": "{\"id\":\"2ef2ead2ef1cd54286222ec1829724a1d38aa696995eba261eb5e4b185f01a6f\",\"parent\":\"4b5
         9778f82f9d17a484a278bd23d2d0b3c7ddcf022ab5250cf4f59308b3bc3f5\",\"created\":\"2016-12-13T04:48:54.211871825Z\",
         \"container_config\":{\"Cmd\":[\"/bin/sh -c #(nop) COPY file:81d0d047826fe805139af418fd23c1dead99cafb8fee198218a
         67d03636d5cf7 in / \"]}}"
      },
      {
         "v1Compatibility": "{\"id\":\"4b59778f82f9d17a484a278bd23d2d0b3c7ddcf022ab5250cf4f59308b3bc3f5\",\"created\":\"
         2016-10-18T20:31:22.321427771Z\",\"container_config\":{\"Cmd\":[\"/bin/sh -c #(nop) ADD file:7afbc23fda8b0b38726
         23c16af8e3490b2cee951aed14b3794389c2f946cc8c7 in / \"]}}"
```

Manifest - Signatures

```
"signatures": [
   {
      "header": {
         "jwk": {
            "crv": "P-256",
            "kid": "Q6FY:RG6F:CXGE:V5V7:3RQN:CMGD:ZSAX:4WMR:TOC4:HOBK:NA3P:5YA2",
            "kty": "EC",
            "x": "KzcHjvNLfCahys-uVGX8WJ6uoIwc2AnO5oO94SAnGUA",
            "y": "e7UJDlQsBQF0EKFMtdVd6vOFmjVkQxgB7Z4A1hatUPU"
         },
         "alg": "ES256"
      },
      "signature": "aT8O9XaLF4_BdgyNxt9nzdeltYh1KPMfbIqdhPli0JCmEP_S5qDWpqT1gyiUy2Cu7kONPtM3fL9jku_ytADH9w",
      "protected": "eyJmb3JtYXRMZW5ndGgiOjMyNDksImZvcm1hdFRhaWwiOiJDbjAiLCJ0aW1lIjoiMjAxNi0xMi0xNFQwMzoyNTowNloifQ"
   }
]
```

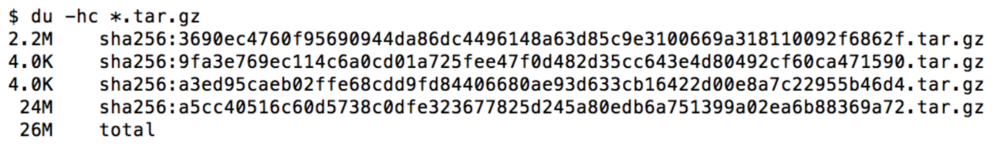
- With V2, signatures can be detached, rather than embedded within the manifest

Downloading Blobs

```
GET /v2/<image-name>/blobs/<digest>
```

Example: `/v2/aws-cli/blogs/sha256:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d4`

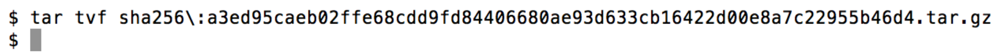
Response is simply a tar containing the contents of that layer. That's really it!



```
$ du -hc *.tar.gz
2.2M    sha256:3690ec4760f95690944da86dc4496148a63d85c9e3100669a318110092f6862f.tar.gz
4.0K    sha256:9fa3e769ec114c6a0cd01a725fee47f0d482d35cc643e4d80492cf60ca471590.tar.gz
4.0K    sha256:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d4.tar.gz
 24M    sha256:a5cc40516c60d5738c0dfe323677825d245a80edb6a751399a02ea6b88369a72.tar.gz
 26M    total
```

"Empty" layers

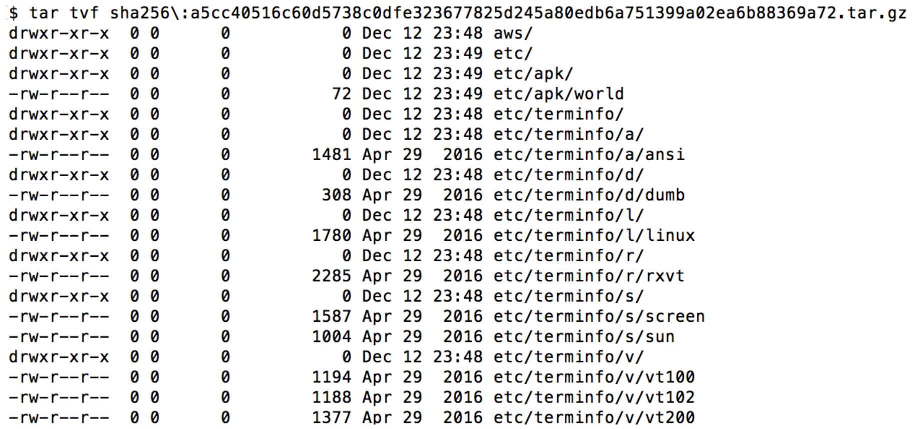
- `Dockerfile` commands that change no files (`CMD`, `EXPOSE`, `VOLUMES`, etc.) have an empty tar
- Will automatically be ignored when running the container
- Still downloads them to keep track of what's been downloaded



```
$ tar tvf sha256\:a3ed95caeb02ffe68cdd9fd84406680ae93d633cb16422d00e8a7c22955b46d4.tar.gz
$ 
```

Non-empty Layers

- As expected, layers with filesystem changes have lots of files in them!
- Deleted files are marked with a `.wh.` prefix
  - Example - if `file.txt` was removed, the layer would have an empty `.wh.file.txt` file



```
$ tar tvf sha256\:a5cc40516c60d5738c0dfe323677825d245a80edb6a751399a02ea6b88369a72.tar.gz
drwxr-xr-x  0 0      0           0 Dec 12 23:48 aws/
drwxr-xr-x  0 0      0           0 Dec 12 23:49 etc/
drwxr-xr-x  0 0      0           0 Dec 12 23:49 etc/apk/
-rw-r--r--  0 0      0          72 Dec 12 23:49 etc/apk/world
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/a/
-rw-r--r--  0 0      0        1481 Apr 29  2016 etc/terminfo/a/ansi
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/d/
-rw-r--r--  0 0      0         308 Apr 29  2016 etc/terminfo/d/dumb
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/l/
-rw-r--r--  0 0      0        1780 Apr 29  2016 etc/terminfo/l/linux
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/r/
-rw-r--r--  0 0      0        2285 Apr 29  2016 etc/terminfo/r/rxvt
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/s/
-rw-r--r--  0 0      0        1587 Apr 29  2016 etc/terminfo/s/screen
-rw-r--r--  0 0      0        1004 Apr 29  2016 etc/terminfo/s/sun
drwxr-xr-x  0 0      0           0 Dec 12 23:48 etc/terminfo/v/
-rw-r--r--  0 0      0        1194 Apr 29  2016 etc/terminfo/v/vt100
-rw-r--r--  0 0      0        1188 Apr 29  2016 etc/terminfo/v/vt102
-rw-r--r--  0 0      0        1377 Apr 29  2016 etc/terminfo/v/vt200
```

FORK IN THE ROAD!!

Let's apply some of this...

How can we make this build faster and better?

```
CMD "bash"
COPY ./src /app
RUN apt-get update && apt-get install -y nodejs && npm install
```

Hint: Think about what's most likely to change most often...

(In case you don't know anything about Node, there's a `package.json` file that lists all dependencies to install during `npm install`. We're assuming that's found at `/src/package.json`)

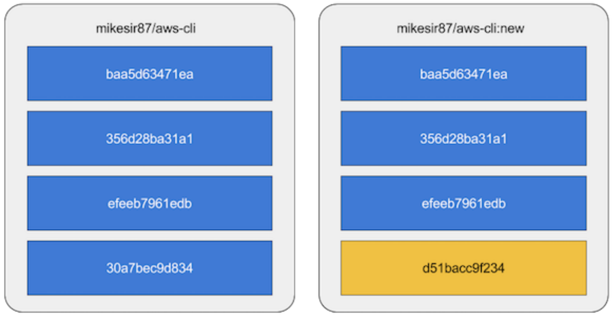
Tip #1: Take advantage of Docker build cache

```
RUN apt-get update && apt-get install -y nodejs
COPY ./src/package.json /app/package.json
RUN npm install
COPY ./src /app
CMD "sh"
```

- When Docker builds, it checks to see if a layer with that parent and command exists already
  - If so, it uses the cached version. If not, it'll build a new image layer
  - Once a new image is built, all subsequent steps have to be re-built due to the new parent
- **Pro tip:** Move commands/files that will change often to end of `Dockerfile` to increase cache hits
  - Decreases build times quite dramatically
  - Reduces the number of layers needed to be pushed/pulled

Tip #1 Graphically...

- Example below shows a change `Dockerfile` with only last instruction changed
- Note how all parent images are still the same
  - Means when it's time to pull the `new` tag, we only have to pull the last layer



What's wrong with this `Dockerfile`?

```
RUN apt-get update && \
    apt-get install -y vim curl
RUN rm -rf /var/lib/apt/lists/*
```

What's wrong with this `Dockerfile`?

```
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RUN rm -rf /var/lib/apt/lists/*
```

- First `RUN` command contains the apt cache
- Second `RUN` removes the cache (lots of `.wh.` files)
- Final image doesn't need the cache, so why pay to push and then pull it all?

Tip #2: Remove no longer needed files as you go

```
RUN apt-get update && \
    apt-get install -y vim curl && \
    rm -rf /var/lib/apt/lists/*
```

Layer now has only the things we installed... no package management cache now!

BREAK
TIME
makeameme.org