Frequently Answered Queries from StackOverflow

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How Do We Learn?

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- RTFM
- Practice
- Drills
- Teaching

Typical StackOverflow User Background

- Mostly developers
- Often more comfortable with an IDE than a CLI
- DevOps is shifting those Devs into more Ops tasks
- Pro: devs no longer depend on ops to manage their app runtime environment

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- Pro: devs no longer depend on ops to manage their app runtime environment
- Con: devs no longer depend on ops to manage their app runtime environment
- Devs are now learning OS/Linux/distributions, scripting, package managers, networking, and storage.

General Docker Questions

Q: How do containers differ from VM's

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- How do we change the mindset of people using containers as a lightweight VM?
  - Who likes uptime?
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  - Uptime quickly becomes a ticking time bomb.

Q: How do containers differ from VM's

- Containers have a shared kernel, application isolation vs hardware isolation
- How do we change the mindset of people using containers as a lightweight VM?
  - Who likes uptime?
  - Who wants to maintain a server that hasn't been rebooted for 3 years, and the original admin has left?
  - Uptime quickly becomes a ticking time bomb.
- What we want is availability, not uptime. We want a LB pointing to replicas spread across multiple AZ's so we can have **low uptime** and **high availability**.

Q: How do containers differ from VM's

Practical differences:

- Don't ssh into containers (exec, and only in dev)
- Don't upgrade containers in place (replace them)
- Don't install multiple apps inside a single container (compose files)
- Don't give containers static IP's (LB/reverse proxies)
- Don't backup containers (backup volumes)
- Don't export containers to make new images (use a Dockerfile)

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*terms and conditions apply

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The base of the OS is the kernel, docker containers run on the same kernel.

```
$ uname -v
#1 SMP Debian 4.9.82-1+deb9u3 (2018-03-02)

$ docker run --rm ubuntu uname -v
#1 SMP Debian 4.9.82-1+deb9u3 (2018-03-02)

$ docker run --rm centos uname -v
#1 SMP Debian 4.9.82-1+deb9u3 (2018-03-02)

$ docker run --rm alpine uname -v
#1 SMP Debian 4.9.82-1+deb9u3 (2018-03-02)
```

Q: Can I use docker to run different OS's?

Terms and Conditions:

- Base images are an OS to some people.
- Docker runs on different platforms.
- Swarm can include nodes from different platforms.
- Desktops typically include embedded VMs.
- Default `runc` can be swapped for a VM runtime.

Q: How do I pick a base image?

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A: It depends.

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A: It depends.

- Stick with tools you know
- Leverage existing open source resources
- Minimize your overhead and attack surface
- Statically compile binaries

Dockerfile

Q: Why doesn't RUN work?

Why am I getting `./build.sh` is not found?

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RUN cd /app/src
RUN ./build.sh
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- The only part saved from a RUN is the filesystem (as a new layer).
- Environment variables, launched daemons, and the shell state are all discarded with the temporary container when pid 1 exits.

Q: Why doesn't RUN work?

Why am I getting `./build.sh` is not found?

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RUN cd /app/src
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```

- The only part saved from a RUN is the filesystem (as a new layer).
- Environment variables, launched daemons, and the shell state are all discarded with the temporary container when pid 1 exits.
- Solution: merge multiple lines with `&&`:

```
RUN cd /app/src && ./build.sh
```

Q: Do I use ENTRYPOINT or CMD?

- Either alone have the same effect.
- CMD is overridden by

```
docker run my_image ${cmd}
```

- ENTRYPOINT is overridden by

```
docker run --entrypoint ${entrypoint} my_image
```

- Used together, docker runs `${entrypoint} ${cmd}`

Q: What's the difference between the string and json syntax?

- RUN, CMD, and ENTRYPOINT can each use either syntax
- The string syntax includes a shell, `/bin/sh -c "${cmd}"` by default.
- The json syntax executes the command directly, without a shell.

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Shell Pros:

- Expands variables
- Command chaining (`&&`)
- I/O redirection

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Shell Pros:

- Expands variables
- Command chaining (`&&`)
- I/O redirection

Shell Cons:

- Intercepts signals
- Extra processing to merge entrypoint with cmd

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String/Shell Syntax:

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RUN echo hello world
ENTRYPOINT /entrypoint.sh
CMD run a b c
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String/Shell Syntax:

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RUN echo hello world
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```

Json/Exec Syntax:

```
RUN ["echo", "hello", "world"]
ENTRYPOINT ["/entrypoint.sh"]
CMD ["run", "a", "b", "c"]
```

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What if cmd is a string and you have an entrypoint?

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/entrypoint.sh /bin/sh -c "args to entrypoint"
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```
/entrypoint.sh /bin/sh -c "args to entrypoint"
```

To fix this in the entrypoint:

```
#!/bin/sh
if [ $# -gt 1 -a "$1" = "/bin/sh" -a "$2" = "-c" ]; then
  shift 2
  eval "set -- $1"
fi
exec "$@"
```

Q: Why can't I extend this image?

```
FROM busybox as parent
CMD echo hello cmd
FROM parent
COPY entrypoint.sh /
ENTRYPOINT [ "/entrypoint.sh" ]
```

```
$ cat entrypoint.sh
#!/bin/sh
echo hello entrypoint
exec "$@"
```

What does this output?

Q: Why can't I extend this image?

```
$ docker run -it --rm test-entrypoint
hello entrypoint
$
```

- Typically a child image will extend it's parent image, and any metadata will be inherited.

Q: Why can't I extend this image?

```
$ docker run -it --rm test-entrypoint
hello entrypoint
$
```

- Typically a child image will extend it's parent image, and any metadata will be inherited.
- One exception: when setting an `ENTRYPOINT` the value of `CMD` from parent images is nulled out.

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Cache requires:

- Same command to be run
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- Same previous layer
- Image was built locally

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- Changing a timestamp
- The previous layer being rebuilt

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- Changing a timestamp
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To trust images pulled from a registry, use:

```
docker build --cache-from my_image ...
```

Q: Should I use COPY or ADD?

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ADD provides additional features which comes with additional overhead:

- Pulls URL's
- Extracts tar files including compressed files

Q: Should I use COPY or ADD?

Both ADD and COPY:

- Cannot access local files outside of the build context
- Create a directory in the container if needed
- Copy the contents of the directory rather than the directory itself
- Default to creating files with uid/gid 0
  - Use `--chown` and `--chmod` to correct permissions

Q: Can I define runtime options in a Dockerfile?

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The Dockerfile cannot:

- Specify the image name
- Publish ports
- Mount volumes
- Add capabilities

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The Dockerfile cannot:

- Specify the image name
- Publish ports
- Mount volumes
- Add capabilities

Consider the security vulnerabilities if you could.

Q: Why is my image so large?

How big are the layers resulting from this Dockerfile:

```
FROM busybox

RUN mkdir /data
RUN dd if=/dev/zero bs=1024 count=1024 of=/data/one
RUN chmod -R 0777 /data
RUN dd if=/dev/zero bs=1024 count=1024 of=/data/two
RUN chmod -R 0777 /data
RUN rm /data/one

CMD ls -alh /data
```

Q: Why is my image so large?

- Running the image you see the 1MB file:

```
-rwxrwxrwx    1 root     root          1.0M May 12 00:14 two
```

- Each `dd` command adds a 1MB layer.

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- Running the image you see the 1MB file:

```
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```
-rwxrwxrwx    1 root     root          1.0M May 12 00:14 two
```

- Each `dd` command adds a 1MB layer.
- Each `chmod` command will change permissions and copy the entire 1MB file to the next layer.
- What does the `rm` command do to the image size?

Q: Why is my image so large?

The `rm` command only changes directory metadata in the next layer:

```
Step 6/7 : RUN chmod -R 0777 /data
 ---> Running in 038bd2bc5aea
  ---> 77793bf30d5f
Step 7/8 : RUN rm /data/one
 ---> Running in 504c6e9b6637
  ---> 9fe0e2f18893
...

$ docker image ls -a | grep 77793bf30d5f
REPOSITORY     TAG           IMAGE ID         CREATED             SIZE
<none>         <none>        77793bf30d5f     10 minutes ago      6.37MB
$ docker image ls -a | grep 9fe0e2f18893
REPOSITORY     TAG           IMAGE ID         CREATED             SIZE
<none>         <none>        9fe0e2f18893     10 minutes ago      6.37MB
```

Q: Why is my image so large?

- Resulting 1MB file has become 4MB on disk and over the network
- Compare the two resulting images to see the added disk space:

```
REPOSITORY    TAG       IMAGE ID       CREATED          SIZE
busybox       latest    54511612f1c4   8 months ago     1.13MB
test-layers   latest    757ce49dd12f   10 minutes ago   6.37MB
```

- Subtracting the two you get the expected ~5MB

Q: Why is my image so large?

- 5MB? Not 4MB? Where did the extra 1MB come from?

```
FROM busybox
RUN mkdir /data
RUN dd if=/dev/zero bs=1024 count=1024 of=/data/one
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RUN rm /data/one
CMD ls -alh /data
```

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RUN chmod -R 0777 /data
RUN rm /data/one
CMD ls -alh /data
```

- A `chmod` or `chown` changes a timestamp on the file *even when there is no permission or ownership change made*.

Q: Why is my image so large?

How can we examine layers? Build with `docker build --rm=false .`

```
...
Step 2/7 : RUN mkdir /data
 ---> Running in 04c5fa1360b0
 ---> 9b4368667b8c
Step 3/7 : RUN dd if=/dev/zero bs=1024 count=1024 of=/data/one
 ---> Running in f1b72db3bfaa
1024+0 records in
1024+0 records out
1048576 bytes (1.0MB) copied, 0.006002 seconds, 166.6MB/s
 ---> ea2506fc6e11
```

Q: Why is my image so large?

Check each temp image with `docker diff ${cid}`

```
$ docker diff 04c5fa1360b0  # mkdir /data
A /data
$ docker diff f1b72db3bfaa  # dd if=/dev/zero bs=1024 count=1024 of=/data/one
C /data
A /data/one
$ docker diff 81c607555a7d  # chmod -R 0777 /data
C /data
C /data/one
$ docker diff 1bd249e1a47b  # dd if=/dev/zero bs=1024 count=1024 of=/data/two
C /data
A /data/two
$ docker diff 038bd2bc5aea  # chmod -R 0777 /data
C /data/one
C /data/two
$ docker diff 504c6e9b6637  # rm /data/one
C /data
D /data/one
```

Q: Why is my image so large?

Reducing image size by merging RUN lines:

```
FROM busybox

RUN mkdir /data \
 && dd if=/dev/zero bs=1024 count=1024 of=/data/one \
 && chmod -R 0777 /data \
 && dd if=/dev/zero bs=1024 count=1024 of=/data/two \
 && chmod -R 0777 /data \
 && rm /data/one

CMD ls -alh /data
```

The previous 5MB is now just 1MB:

```
REPOSITORY     TAG       IMAGE ID       CREATED              SIZE
busybox        latest    54511612f1c4   8 months ago         1.13MB
test-layers2   latest    951252cf34ed   25 seconds ago       2.18MB
```

Run

Q: What does "invalid reference format" mean?

- A reference is a pointer to an image.
- The docker command line is order dependent:

```
docker ${docker_args} run ${run_args} image ${cmd}
```

- Frequently happens when an invalid arg gets parsed as the image name or invalid characters from copy/pasting from a source that changes dashes and quotes.
- What does docker interpret as the image name here:

```
my project$ docker run -it –rm -v $(pwd):/data “my_image”
```

Q: Why do I get "executable not found"?

- Did you run the intended command?

```
docker run --rm my_image -it echo hello world
```

- Is docker trying to run a json string?
- Does the file exist... in the path and inside the container?
- If it is a shell script, check the first line

```
#!/bin/bash
```

- Check for windows linefeeds on linux shell scripts
- If it is a binary, there is likely a missing library

Q: What is this TTY error?

```
the input device is not a TTY
```

- The TTY is a terminal in linux
- `docker run -it`: Interactive terminal
- `docker run -i`: Input but no terminal, piping in a file
- `docker run -t`: Setup terminal but no input, color output in logs
- `docker run`: No input, no terminal, typically used for scripts/cron/ci-cd

Q: Why is tail broken?

This tail command never shows lines written to the logfile:

```
$ docker run -d --name test-tail --rm debian tail -f /etc/issue
$ docker exec test-tail /bin/sh -c \
   'ls -l /etc/issue; \
    echo hello container >>/etc/issue; \
    ls -l /etc/issue'
-rw-r--r-- 1 root root 26 Jul 13  2017 /etc/issue
-rw-r--r-- 1 root root 42 May 14 15:50 /etc/issue
$ docker logs test-tail
Debian GNU/Linux 9 \n \l

$
```

Q: Why is tail broken?

This error comes from the docker copy-on-write, note the inode numbers:

```
$ docker run -d --name test-tail --rm debian tail -f /etc/issue
$ docker exec test-tail /bin/sh -c \
  'ls -il /etc/issue; \
   echo hello container >>/etc/issue; \
   ls -il /etc/issue'
41813820 -rw-r--r-- 1 root root 26 Jul 13  2017 /etc/issue
41031155 -rw-r--r-- 1 root root 42 May 14 15:58 /etc/issue
$ docker logs test-tail
Debian GNU/Linux 9 \n \l

$
```

Q: Why is tail broken?

Fix it by modifying the file before starting the tail command:

```
$ docker run -d --name test-tail --rm debian /bin/sh -c \
    ':>>/etc/issue && exec tail -f /etc/issue'
```

Q: Why is tail broken?

Now adding a line to the file shows in the logs:

```
$ docker exec test-tail /bin/sh -c \
  'ls -il /etc/issue; \
   echo hello container >>/etc/issue; \
   ls -il /etc/issue'
41031155 -rw-r--r-- 1 root root 26 Jul 13  2017 /etc/issue
41031155 -rw-r--r-- 1 root root 42 May 14 16:04 /etc/issue
$ docker logs test-tail
Debian GNU/Linux 9 \n \l

hello container
```

Networking

Q: EXPOSE vs Publishing a port?

- EXPOSE
  - Documentation from the image creator to the person running the image
  - Not needed to publish
  - Not needed for container-to-container communication
- Publish
  - Maps a port on the host to connect to a port in the container.
  - One-way, from host to container, it does not allow containers to access applications running on the host.

Q: Networking issues between containers?

- Make sure to listen on 0.0.0.0, not 127.0.0.1
- Use a user generated network
- Connect to the container port, not the host published port
- Use DNS: container id, container name, service name, or network alias
- Check the overlay networking ports on your firewalls

Follow-up Q: Do I need to expose the port?

- Nope, expose is documentation.

Follow-up Q: Do I need to publish the port?

- Nope, that only makes the container accessible from outside of docker.

Follow-up Q: Do I need links?

- Nope, links are deprecated, use user created networks.

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Follow-up Q: What's a network alias?

- You can give containers or services additional names on any network.

Q: Why can't my container reach an app on my host using 127.0.0.1?

- Container networking is namespaced.
- By default, each container gets it's own loopback interface (127.0.0.1).
- Solutions:
  - Bad: Use host networking
  - Ok: Connect to another interface on the host
  - Best: Move the host app into a container

Q: Issues accessing published port?

- Make sure the app is listening on that port, and on `0.0.0.0`:

```
docker run -it --rm --net container:${cid} \
  nicolaka/netshoot netstat -lnt
```

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docker run -it --rm --net container:${cid} \
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- Verify the publish command. `-p 8080:80` maps host port 8080 to container port 80.

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- Avoid IPv6 issues, connect to `127.0.0.1` instead of `localhost`. Do not try to connect to `0.0.0.0`.

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- Avoid IPv6 issues, connect to `127.0.0.1` instead of `localhost`. Do not try to connect to `0.0.0.0`.
- With overlay networking, open 7946/both, 4789/tcp, and protocol 50.

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- With overlay networking, open 7946/both, 4789/tcp, and protocol 50.
- Verify the docker host you are using with `echo $DOCKER_HOST`. If this is set, connect to that IP instead.

Volumes

Q: Build isn't updating a directory?

- Sometimes the image is updated, and a volume is mounted over that directory.
- Named volumes only get initialized on container create when the volume is empty. Host volumes never get initialized by docker.
- Volumes defined in the Dockerfile prevent future changes to that directory.

PSA: Remove VOLUME in Dockerfiles

- Users cannot extend the image with initialized data.
- Anonymous volumes are created that clutter the filesystem.
- Named and host volumes do not require the volume defined in the image.

PSA: Remove VOLUME in Dockerfiles

- Users cannot extend the image with initialized data.
- Anonymous volumes are created that clutter the filesystem.
- Named and host volumes do not require the volume defined in the image.
- Solution: define volumes in the compose file.

Q: How do I handle UID/GID and permission issues with host volumes?

- Option 1: `chmod 777`
- Option 2: Update image user to match host uid/gid
- Option 3: Use named volumes an manage data with containers
- Option 4: Correct permissions with entrypoint

Q: How do I handle UID/GID and permission issues?

Update image to match host uid/gid:

```
FROM debian:latest
ARG UID=1000
ARG GID=1000
RUN groupadd -g $GID cuser \
 && useradd -m -u $UID -g $GID -s /bin/bash cuser
USER cuser
```

```
$ docker build \
  --build-arg UID=$(id -u) --build-arg GID=$(id -g) .
```

Q: How do I handle UID/GID and permission issues?

Using named volumes:

```
# Populate named volume
$ tar -cC source . | docker run --rm -i -v vol:/target \
    busybox /bin/sh -c "tar -xC /target && chown -R 1000 /target"

# Use or initialize empty volume from image
$ docker run -d -v vol:/data my_image

# Backup/export named volume
$ docker run --rm -v vol:/source busybox tar -czC /source . \
  >backup.tgz
```

Q: How do I handle UID/GID and permission issues?

Entrypoint to correct uid/gid:

```
FROM jenkins/jenkins:lts
USER root
RUN  apt-get update \
  && wget -O /usr/local/bin/gosu "https://github.com/..." \
  && chmod +x /usr/local/bin/gosu \
  && curl -sSL https://get.docker.com/ | sh \
  && usermod -aG docker jenkins
COPY entrypoint.sh /entrypoint.sh
ENTRYPOINT ["/entrypoint.sh"]
```

Q: How do I handle UID/GID and permission issues?

Entrypoint to correct uid/gid:

```
#!/bin/sh

# if image and volume gid do not match, modify container user
SOCK_DOCKER_GID=$(ls -ng /var/run/docker.sock | cut -f3 -d' ')
CUR_DOCKER_GID=$(getent group docker | cut -f3 -d: || true)
if [ "$SOCK_DOCKER_GID" != "$CUR_DOCKER_GID" ]; then
    groupmod -g ${SOCK_DOCKER_GID} docker
fi

# drop access to jenkins user and run jenkins entrypoint
exec gosu jenkins /bin/tini -- /usr/local/bin/jenkins.sh "$@"
```

Q: How to initialize a host volume from image?

- Option 1: Don't. Initialize outside of docker, before starting the container
- Option 2: Copy with an entrypoint from a saved location in the image.

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- Option 1: Don't. Initialize outside of docker, before starting the container
- Option 2: Copy with an entrypoint from a saved location in the image.
- Option 3: Define a named volume that's a bind mount.

```
$ docker volume create --driver local \
  --opt type=none \
  --opt device=/home/user/test \
  --opt o=bind \
  test_vol
```

Q: How to initialize a host volume from image?

Walk-through of example 3 - Dockerfile:

```
FROM busybox:latest
RUN adduser --home /home/user --uid 5001 \
    --disabled-password user
USER user
COPY --chown=user sample-data/ /home/user/data/
```

Q: How to initialize a host volume from image?

Walk-through of example 3 - Sample data:

```
$ ls -al sample-data/
total 24
drwxr-xr-x  3 bmitch bmitch 4096 Jan 22  2017 .
drwxr-xr-x 30 bmitch bmitch 4096 May 14 09:41 ..
drwxr-xr-x  2 bmitch bmitch 4096 Jan 22  2017 dir
-rw-r--r--  1 bmitch bmitch   14 Jan 22  2017 file2.txt
-rw-r--r--  1 bmitch bmitch   12 Jan 22  2017 file.txt
-rw-r--r--  1 bmitch bmitch  214 Jan 22  2017 tar-file.tgz
```

Q: How to initialize a host volume from image?

Walk-through of example 3 - create volume:

```
$ mkdir test-vol

$ ls -al test-vol
total 8
drwxr-sr-x  2 bmitch bmitch 4096 May 14 09:40 .
drwxr-xr-x 30 bmitch bmitch 4096 May 14 09:33 ..

$ docker volume create --driver local --opt type=none \
  --opt device=$(pwd)/test-vol --opt o=bind test-vol
test-vol
```

Q: How to initialize a host volume from image?

Walk-through of example 3 - Run the container:

```
$ docker run -it --rm -v test-vol:/home/user/data test-vol \
  /bin/sh -c "\
    echo hello world >/home/user/data/inside-container.txt \
    && ls -l /home/user/data"
total 20
drwxr-xr-x  2 user   user   4096 May 14 13:43 dir
-rw-r--r--  1 user   user     12 Jan 23  2017 file.txt
-rw-r--r--  1 user   user     14 Jan 23  2017 file2.txt
-rw-r--r--  1 user   user     12 May 14 13:43 inside-container.txt
-rw-r--r--  1 user   user    214 Jan 23  2017 tar-file.tgz
```

Q: How to initialize a host volume from image?

Walk-through of example 3 - Show the local directory from the host:

```
$ ls -al test-vol/
total 28
drwxr-sr-x  3   5001   5001 4096 May 14 09:43 .
drwxr-xr-x 30 bmitch bmitch 4096 May 14 09:41 ..
drwxr-xr-x  2   5001   5001 4096 May 14 09:43 dir
-rw-r--r--  1   5001   5001   14 Jan 22  2017 file2.txt
-rw-r--r--  1   5001   5001   12 Jan 22  2017 file.txt
-rw-r--r--  1   5001   5001   12 May 14 09:43 inside-container.txt
-rw-r--r--  1   5001   5001  214 Jan 22  2017 tar-file.tgz
```

Thank You

Slides: https://github.com/sudo-bmitch/dc2018

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