

Course Overview

- Docker concepts overview
- Docker installation (on a Linux host)
- Searching for and fetching Docker images
- Running single Docker containers
- Docker container management
- Creating a new Docker image from scratch
- Publishing your Docker image to [hub docker](#)
- Autobuilds on Docker Hub
- Composing multi-container applications stacks using Docker compose (basic example)
- Demonstration of using Rancher as a Docker orchestration tool



What is not covered?

- Swarms / clusters / remote management
- Advanced permissions
- Secrets
- Remote storage
- Rancher in-depth
- Load balancing



Key Docker Concepts Overview

image

Dockerfile

port

build

container

docker-compose.yml

link

run

repository

rancher-compose.yml

volume

exec



A little Philosophy

Docker is great when you want to densely pack many isolated services onto each server. If you prefer to take the approach of e.g. deploying many microservers (e.g. AWS micro instances) you might be better off looking at using a configuration management tool like ansible. Although even then docker still has some advantages as it is nice to be able to just check out an image onto a micro instance and spin it up knowing everything will 'just work'.



Not virtual machines

If you go with docker really avoid the temptation of treating docker containers like virtual machines. Even though you can run multiple services in each container (e.g. using supervisord) you should really architect your docker images so that they are virtual application appliances, with each appliance doing one thing only (like the old unix mantra eh?). So have a discrete appliance for postgis, another for uwsgi, another for mapserver, another for geoserver etc. rather than mixing things into the same service.



Stateless

You should do everything you can to make your containers stateless. Or put differently, you should be able to confidently destroy and redeploy a container as a fresh instance with no loss of data or configuration. This means that your investment should be in building the images on which your containers are based and not the containers themselves. In practice this means that you should e.g. mount your postgres cluster from a host volume, store your user uploaded files in a host volume and store no generated data inside the container itself.



Configuration management

You should avoid the temptation to build your own container orchestration tools. Rather use a tool like docker-compose that uses a simple yaml file to define your micro services architecture and can be used to reliably spin up a working configuration.



Autobuilds

Learn how to publish your images into hub.docker.com and have them build on push to your repo and build when the upstream container your docker image is based on gets an update (e.g. a security fix). Also invest the time in learning to tag different versions in hub so that you can have a known good working configuration against specific image versions.



Layering

Build up your images in layers. Start with a standard base image e.g. 'ubuntu:trusty' then add python and save that as a new standard image, then add django and save that as a new base image etc. This way each virtual application you create is defined by only the thinnest amount of configuration and software deployment possible, and you can share the underlying logic of the lower layers between as many images as possible.



Images

search

```
docker image pull busybox
```

```
docker images
```

What's an Image?

An image is an inert, immutable, file that's essentially a snapshot of a container. Images are created with the [build](#) command, and they'll produce a container when started with [run](#). Images are stored in a Docker registry such as [registry.hub.docker.com](#). Because they can become quite large, images are designed to be composed of layers of other images, allowing a minimal amount of data to be sent when transferring images over the network.

Local images can be listed by running `docker images`:

REPOSITORY	TAG	IMAGE ID	CREATED	VIRTUAL SIZE
ubuntu	13.10	5e019ab7bf6d	2 months ago	180 MB
ubuntu	14.04	99ec81b80c55	2 months ago	266 MB
ubuntu	latest	99ec81b80c55	2 months ago	266 MB
ubuntu	trusty	99ec81b80c55	2 months ago	266 MB
<none>	<none>	4ab0d9120985	3 months ago	486.5 MB

Some things to note:

- 1 IMAGE ID is the first 12 characters of the true identifier for an image. You can create many tags of a given image, but their IDs will all be the same (as above).
- 2 VIRTUAL SIZE is *virtual* because it's adding up the sizes of all the distinct underlying layers. This means that the sum of all the values in that column is probably much larger than the disk space used by all of those images.
- 3 The value in the REPOSITORY column comes from the `-t` flag of the `docker build` command, or from `docker tag`-ing an existing image. You're free to tag images using a nomenclature that makes sense to you, but know that `docker` will use the tag as the registry location in a `docker push` or `docker pull`.
- 4 The full form of a tag is `[REGISTRYHOST/] [USERNAME/]NAME[:TAG]`. For `ubuntu` above, REGISTRYHOST is inferred to be `registry.hub.docker.com`. So if you plan on storing your image called `my-application` in a registry at `docker.example.com`, you should tag that image `docker.example.com/my-application`.
- 5 The TAG column is just the `[:TAG]` part of the *full* tag. This is unfortunate terminology.
- 6 The `latest` tag is not magical, it's simply the default tag when you don't specify a tag.
- 7 You can have untagged images only identifiable by their IMAGE IDs. These will get the `<none>` TAG and REPOSITORY. It's easy to forget about them.

More info on images is available from the [Docker docs](#) and [glossary](#).

Source: <https://stackoverflow.com/a/26960888>



Finding and fetching an image

image

```
docker search 2048
```

```
docker pull alexwhen/  
docker-2048
```



docker search

Default repository

hub.docker.com

You can run
your own!

docker pull

Default repository

hub.docker.com

Image downloaded to your
host

Running an Image

run

```
docker run busybox echo "Hello  
world"
```

Usage: docker run [OPTIONS] IMAGE [COMMAND] [ARG...]

Run a command in a new container

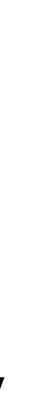
Options:

--cpuset-mems string	MEMs in which to allow execution (0-3, 0,1)
-d, --detach	Run container in background and print
container ID	
--dns list	Set custom DNS servers
--entrypoint string	Overwrite the default ENTRYPOINT of the
image	
-e, --env list	Set environment variables
--env-file list	Read in a file of environment variables
--help	Print usage
-h, --hostname string	Container host name
-i, --interactive	Keep STDIN open even if not attached
--link list	Add link to another container
--mount mount	Attach a filesystem mount to the container
--name string	Assign a name to the container
-p, --publish list	Publish a container's port(s) to the host
--restart string	Restart policy to apply when a container
exits (default "no")	
--rm	Automatically remove the container when it
exits	
-t, --tty	Allocate a pseudo-TTY
--volume list	Bind mount a volume
-w, --workdir string	Working directory inside the container



Image Naming

organisation Image name tag



kartoza/test:latest



Containers

container

```
docker run -ti -d busybox tail  
-f /dev/null
```

```
docker ps
```

```
docker ps -a
```

What's a container?

To use a programming metaphor, if an image is a class, then a container is an instance of a class—a runtime object. Containers are hopefully why you're using Docker; they're lightweight and portable encapsulations of an environment in which to run applications.

View local running containers with `docker ps`:

CONTAINER ID	IMAGE	COMMAND	CREATED	
STATUS	PORTS	NAMES		
f2ff1af05450	samalba/docker-registry:latest	/bin/sh -c 'exec doc	4 months ago	Up
12 weeks	0.0.0.0:5000->5000/tcp	docker-registry		

Here I'm running a dockerized version of the docker registry, so that I have a private place to store my images. Again, some things to note:

- 1 Like IMAGE ID, CONTAINER ID is the true identifier for the container. It has the same form, but it identifies a different kind of object.
- 2 `docker ps` only outputs *running* containers. You can view all containers (*running or stopped*) with `docker ps -a`.
- 3 NAMES can be used to identify a started container via the `--name` flag.

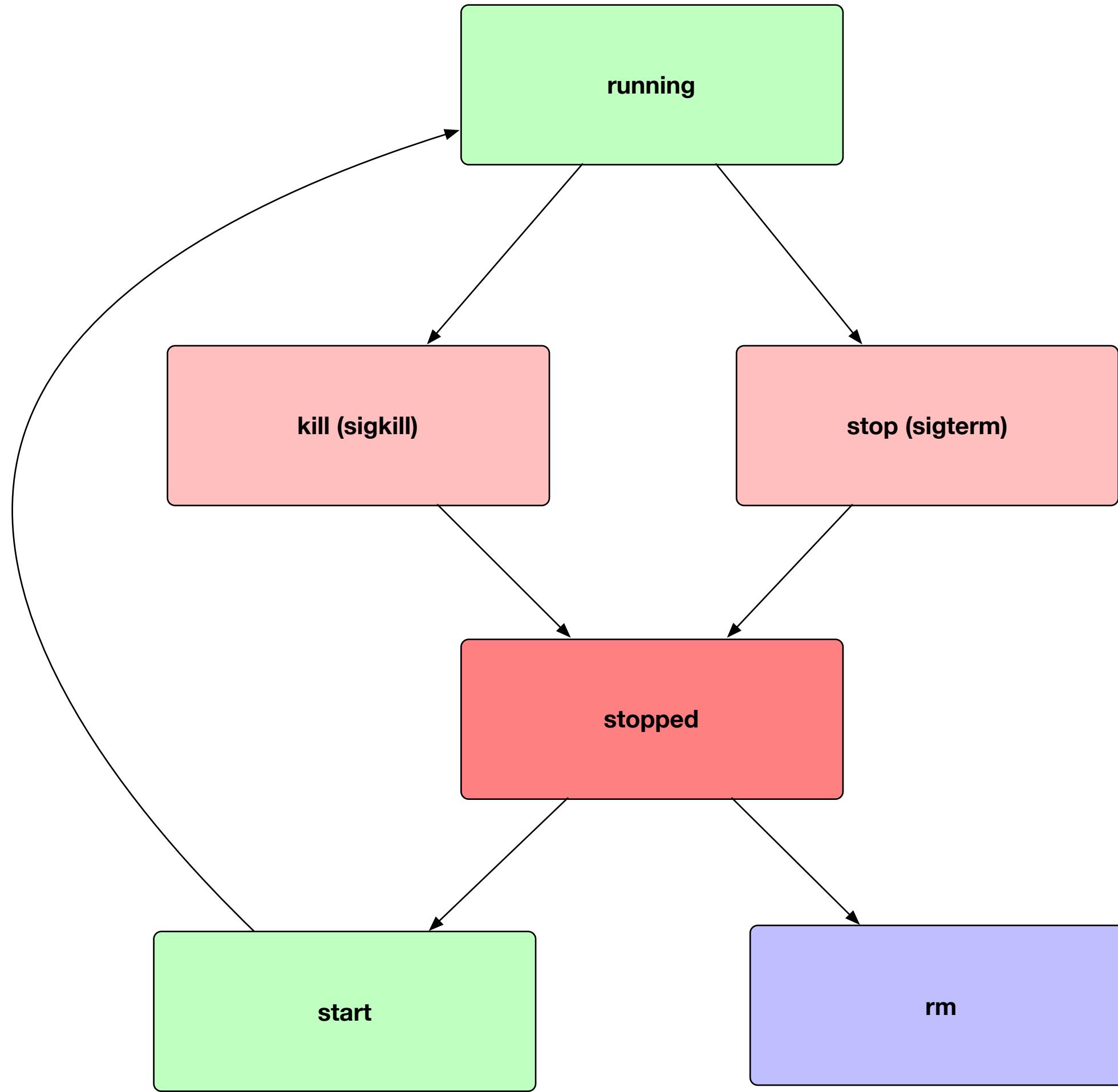
Source: <https://stackoverflow.com/a/26960888>



Container States

container

```
docker run --name test -ti -d  
busybox tail -f /dev/null  
  
docker ps  
  
docker stop test  
  
docker ps -a  
  
docker start test  
  
docker ps -a  
  
docker kill test  
docker rm test
```



Container Management

Usage: docker container COMMAND

Manage containers

Options:

Commands:

attach	Attach local standard input, output, and error streams to a running container
commit	Create a new image from a container's changes
cp	Copy files/folders between a container and the local filesystem
create	Create a new container
diff	Inspect changes to files or directories on a container's filesystem
exec	Run a command in a running container
export	Export a container's filesystem as a tar archive
inspect	Display detailed information on one or more containers
kill	Kill one or more running containers
logs	Fetch the logs of a container
ls	List containers
pause	Pause all processes within one or more containers
port	List port mappings or a specific mapping for the container
prune	Remove all stopped containers
rename	Rename a container
restart	Restart one or more containers
rm	Remove one or more containers
run	Run a command in a new container
start	Start one or more stopped containers
stats	Display a live stream of container(s) resource usage statistics
stop	Stop one or more running containers
top	Display the running processes of a container
unpause	Unpause all processes within one or more containers
update	Update configuration of one or more containers
wait	Block until one or more containers stop, then print their exit codes



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Converting a container to an Image

commit

```
docker run --name="test" -ti -d  
busybox tail -f /dev/null  
  
docker ps  
  
docker commit test kartoza/  
test:latest  
  
docker images | grep  
test
```

running

stopped

commit

image



Converting a container to an Image

Export

```
docker export test > test.tar  
cat test.tar | docker import - test/foo  
docker images | grep foo  
docker run -ti test/foo /bin/ash
```

```
/ # ls  
HelloWorld.txt  etc          root        usr  
bin            home         sys         var  
dev            proc         tmp
```



Publishing an image

Push

```
docker run --name="test" -ti -d  
busybox tail -f /dev/null  
  
docker ps  
  
docker commit test timlinux/  
test:latest  
  
docker images | grep  
test  
  
docker login  
  
docker push timlinux/  
test:latest
```

Image on your host

Docker push

docker pull

Default repository

hub.docker.com



build

```
docker build -t  
kartoza/python-server .  
  
docker run -p 8000:8000  
kartoza/python-server
```

The Dockerfile

https://docs.docker.com/v17.09/engine/userguide/eng-image/dockerfile_best-practices/#expose

```
# Let's use a nice small base image, only 1.8mb!  
FROM alpine:3.5  
# The guy who maintains this  
MAINTAINER Tim Sutton <tim@kartoza.com>  
# Install some alpine packages ...  
# See https://pkgs.alpinelinux.org/packages for a list of available alpine packages  
RUN apk add --update \  
    python \  
    python-dev \  
    py-pip \  
    build-base \  
    && pip install virtualenv \  
    && rm -rf /var/cache/apk/*  
WORKDIR /  
EXPOSE 8000  
ENTRYPOINT ["python"]  
CMD ["-m", "SimpleHTTPServer"]
```

Read about Copy On Write: <https://docs.docker.com/v17.09/engine/userguide/storagedriver/imagesandcontainers/#the-copy-on-write-cow-strategy>



The Dockerfile

https://docs.docker.com/v17.09/engine/userguide/eng-image/dockerfile_best-practices/#expose

FROM
(What base image to use)

ENTRYPOINT
(Application binary)

ENV

RUN
(Execute command in image)

CMD
(Application flags)

USER

WORKDIR

VOLUME

ADD / COPY



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Host / bindmount volumes

Note: -v will be replaced by —mount in the future (which are not covered in this training)

<https://docs.docker.com/storage/volumes/#start-a-service-with-volumes>

-v

```
docker build -t  
kartoza/python-server .
```

```
docker run -v /Users/  
timlinux/dev/docker/  
docker-training:/home -  
p 8000:8000 kartoza/  
python-server
```

Directory listing for /

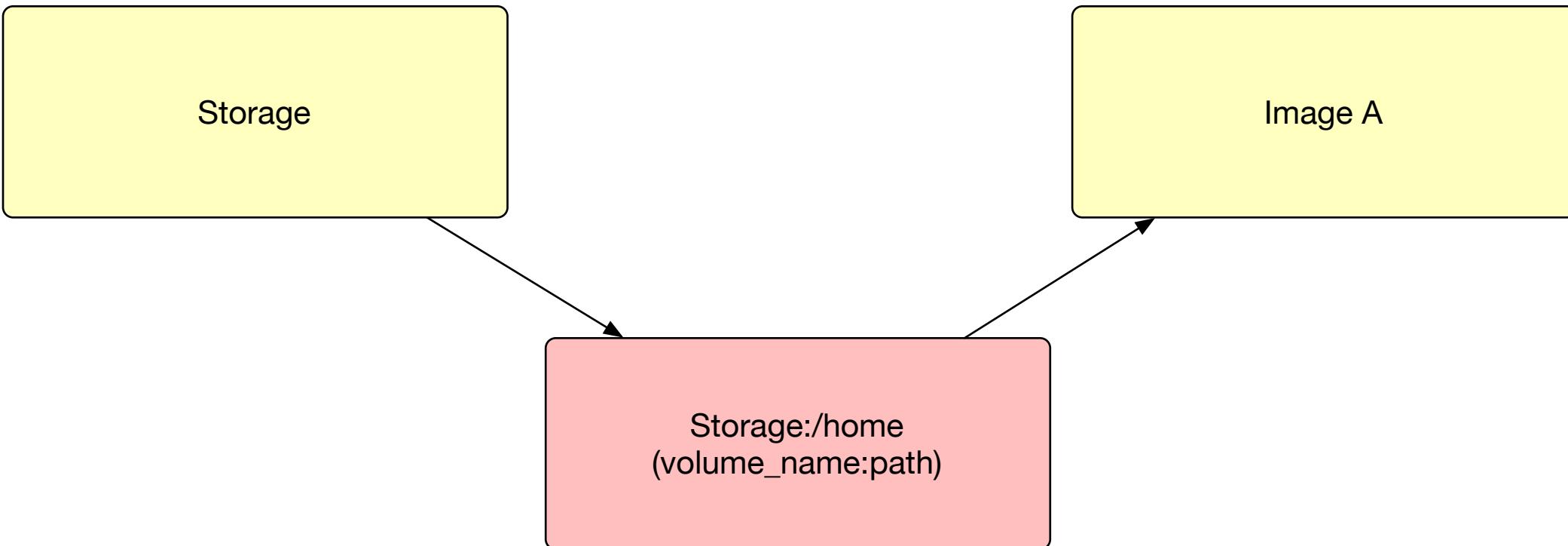
- [.dockerenv](#)
- [bin/](#)
- [dev/](#)
- [etc/](#)
- [home/](#)
- [lib/](#)
- [media/](#)
- [mnt/](#)
- [proc/](#)
- [root/](#)
- [run/](#)
- [sbin/](#)
- [srv/](#)
- [sys/](#)
- [tmp/](#)
- [usr/](#)
- [var/](#)

Directory listing for /home/

- [build_and_run_simple_server.sh](#)
- [build_and_run_simple_server_with_volume.sh](#)
- [Dockerfile](#)
- [KartozaDockerTrainingResources.pdf](#)



Storage Containers



Storage volumes

Note: -v will be replaced by –mount in the future (which are not covered in this training)

<https://docs.docker.com/storage/volumes/#start-a-service-with-volumes>

In this example we create a storage volume, mount it in an image, copy some data from the host to it, start a second container that shares the volume and then connect to it from a web browser.

HelloWorld.txt

Hello World

Running ...

```
docker build -t kartozza/python-server .

docker volume create Storage

docker run --name="pyservel" -v Storage:/home -p 8000:8000 -dt kartozza/python-server
docker cp HelloWorld.txt pyservel:/home/

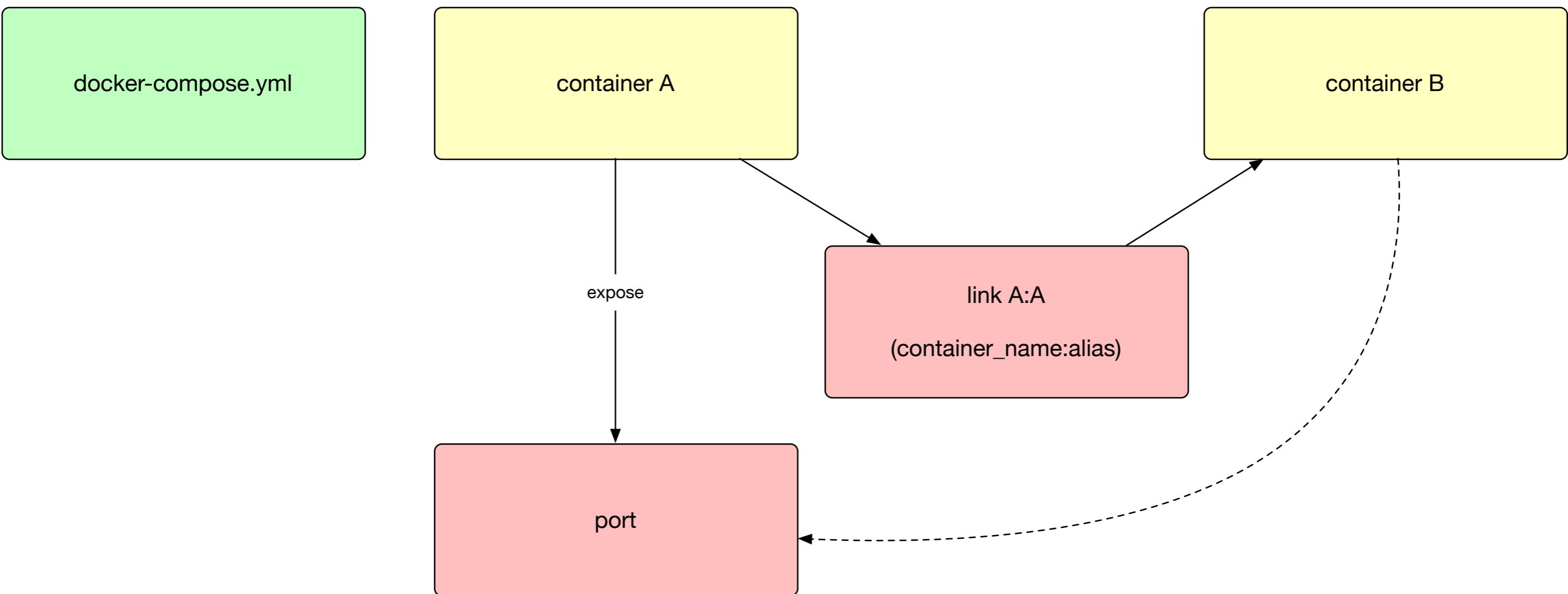
docker run --name="pyserve2" -v Storage:/home -p 8001:8000 -dt kartozza/python-server
```



Container Linking

Note: Container linking will be deprecated in future in favour of docker networks (which are not covered in this training)

See <https://docs.docker.com/network/network-tutorial-standalone/> for the ‘new’ way...



Container Linking

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In this example we will create a new Dockerfile and image, then run it, linking it to another running container (and storage volume)

wget-show.sh

```
#!/bin/ash
# Above is not a typo - alpine shell is ash not bash
wget -O hello.txt http://pyserve:8000/home/HelloWorld.txt
cat hello.txt
```

Dockerfile-wget

```
# Let's use a nice small base image, only 1.8mb!
FROM alpine:3.5
# The guy who maintains this
MAINTAINER Tim Sutton <tim@kartoza.com>
# Install some alpine packages ...
# See https://pkgs.alpinelinux.org/packages for a list of available alpine packages
RUN apk add --update wget && rm -rf /var/cache/apk/*
ADD wget-show.sh /wget-show.sh
RUN chmod +x /wget-show.sh
WORKDIR /
EXPOSE 8000
ENTRYPOINT ["/wget-show.sh"]
```

Running ...

```
#!/bin/bash

docker build -t kartoza/wget-show:latest -f Dockerfile-wget .
docker build -t kartoza/python-server .
docker volume create Storage
docker run --name="pyserve" -v Storage:/home -p 8000:8000 -dt kartoza/python-server
docker cp HelloWorld.txt pyserve:/home/
docker container ls
docker volume ls | grep Storage
docker run -ti --name="wget-show" --rm --link pyserve:pyserve kartoza/wget-show
```



Autobuilds on hub.docker.com

- * Build when your base image changes
- * Build when your code / configuration changes



docker-compose

Docker compose

https://docs.docker.com/v17.09/engine/userguide/eng-image/dockerfile_best-practices/#expose

```
pip install docker-compose
```

Commands:

build	Build or rebuild services
bundle	Generate a Docker bundle from the Compose file
config	Validate and view the Compose file
create	Create services
down	Stop and remove containers, networks, images, and volumes
events	Receive real time events from containers
exec	Execute a command in a running container
help	Get help on a command
images	List images
kill	Kill containers
logs	View output from containers
pause	Pause services
port	Print the public port for a port binding
ps	List containers
pull	Pull service images
push	Push service images
restart	Restart services
rm	Remove stopped containers
run	Run a one-off command
scale	Set number of containers for a service
start	Start services
stop	Stop services
top	Display the running processes
unpause	Unpause services
up	Create and start containers
version	Show the Docker-Compose version information

Docker compose example

```
pip install docker-compose  
  
docker-compose build  
  
docker-compose up -d  
pyserve  
  
docker-compose run  
wget-show
```

```
version: "3"  
  
services:  
    pyserve:  
        image: timlinux/docker-training:latest  
        volumes:  
            - data:/home  
        restart: unless-stopped  
        ports:  
            - "8000:8000"  
        user: root  
  
    wget-show:  
        build:  
            context: .  
            dockerfile: Dockerfile-wget  
        hostname: wget  
        links:  
            - pyserve:pyserve  
        volumes:  
            data:
```

See also <https://docs.docker.com/compose/gettingstarted/#step-2-create-a-dockerfile>



Rancher Demo



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Docker Helpers

<https://github.com/kartoza/docker-helpers>

Command quick reference

- **dcall** - Commit all named containers. Provide a prefix for the image name. The committed image will be in the form <namespace>/<container name>.
- **dcalldated** - Like the above command but adds a date stamp as the tag. The committed image will be in the form <namespace>/<container name>:01-September-2014.
- **deall** - Export all named containers. Exported containers will be named in the form docker-export-<container name>.tar.
- **dealldated** - Export all named containers. Exported containers will be named in the form docker-export:<namespace>:<container name>:<date>.tar.
- **dipall** - List the name and IP address of all named containers. Output will be in the form <container name> : IP Address.
- **dli** - List all images. Shorthand for docker images.
- **dnames** - List all the names of named containers.
- **dpasswords** - Print the names and passwords from all named containers. When you set up your container, print any passwords to stdout so they show up in the docker logs command. Be sure to print the word password in your stdout message as this is a simple grep operation.
- **dps** - List all running containers. Short hand for docker ps.
- **dpsa** - List all running containers. Short hand for docker ps -a.
- **drmc** - Remove all stopped containers.
- **drmi** - Remove all images that have no tags.
- **dstart** - Start all exited containers. Typically you want to do this after a host reboot.



The next section will be more advanced

Docker compose variables

.env

Add variables
parameters to a file
called .env and
reference them in your
docker-compose file
using

```
 ${VARIABLE}
```

```
 docker-compose up -d  
pyserve
```

VERSION=latest

docker-compose.yml

```
version: "3"

services:
  pyserve:
    image: timlinux/docker-training:${VERSION}
    volumes:
      - data:/home
    restart: unless-stopped
    ports:
      - "8000:8000"
    user: root

  wget-show:
    build:
      context: .
      dockerfile: Dockerfile-wget
    hostname: wget
    links:
      - pyserve:pyserve
    volumes:
      data:
```

See also <https://docs.docker.com/compose/environment-variables/> for other ways to use environment variables

