



Intro to Docker

Presented by **Travis Holton**

Administrivia

- Bathrooms
- Fire exits

This course

- Makes use of official Docker docs
- Based on latest Docker
- A mix of command line and theory
- Assumes no prior Docker knowledge
- Assumes familiarity with the linux shell
- Assumes we are using ubuntu 14.04 (trusty)

Aims

- Understand how to use Docker on the command line
- Understand how Docker works
- Learn how to integrate Docker with applications
- Learn ops and developers can use Docker to deploy applications
- Get people thinking about where they could use Docker

Setup

Fetch course resources

```
$ cd ~/docker-introduction  
$ ls
```

- Slides for Reveal.js presentation
- docker-introduction.pdf
- Ansible setup playbook
- Sample code for some exercises

Ansible

- Some of the features we will be exploring require setup. We'll use ansible for that.
- Python based tool set
- Automate devops tasks
 - server/cluster management
 - installing packages
 - deploying code
 - managing config

Setup Ansible

```
$ cd ~/catalystcloud-ansible
$ ./install-ansible.sh
.
. <stuff happens>
.
$ source $CC_ANSIBLE_DIR/ansible-venv/bin/activate
```

- Installs python virtualenv with latest ansible libraries
- We'll be using this virtualenv for tasks throughout the course.

Setup Docker

- Follow instructions on website for installing
 - Docker Community Edition
 - `docker-compose`
- If you are using Ubuntu, use the ansible playbook included in course repo
- This playbook installs:
 - latest Docker *Community Edition*
 - `docker - compose`
 - Note: you might need to logout and login again

```
$ cd docker-introduction  
$ ansible-playbook -K ansible/docker-install.yml
```

Note: on some Ubuntu versions (eg. ≥ 16.04) you'll need to add:

```
-e ansible_python_interpreter=/usr/bin/python
```

Fetch and run slides

```
$ docker run --name docker-intro -d --rm \
  -p 8000:8000 heytrav/docker-introduction-slides
```

Follow along with course slides: <http://localhost:8000>

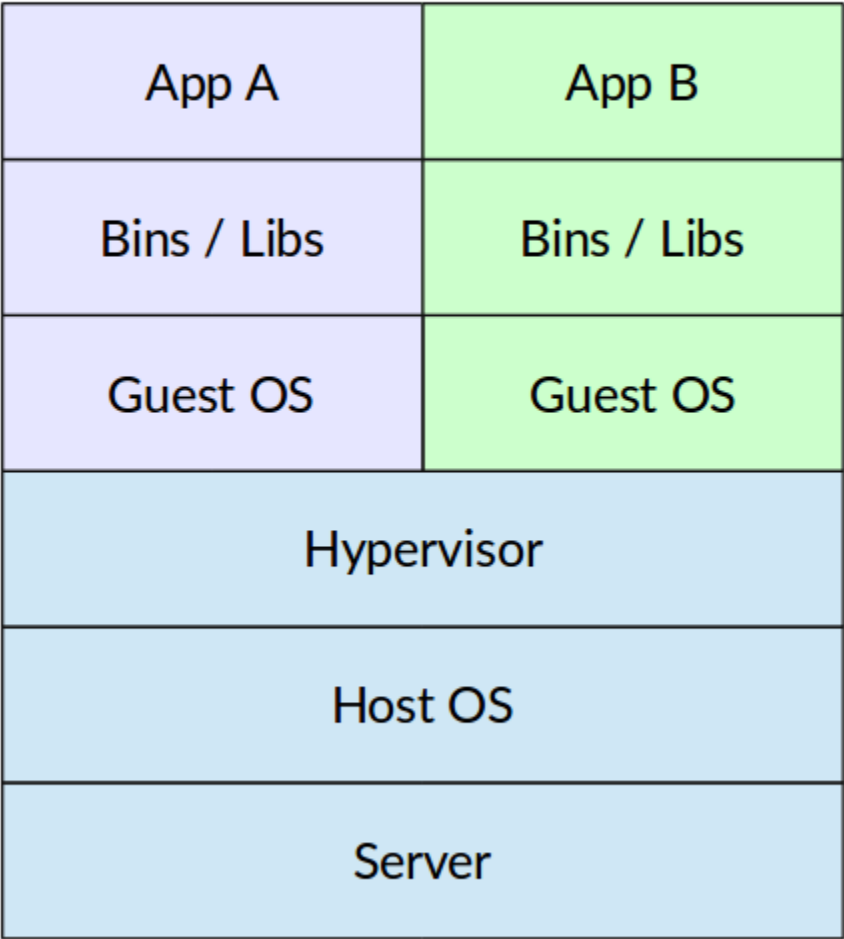
Introduction to containers

What is containerization?

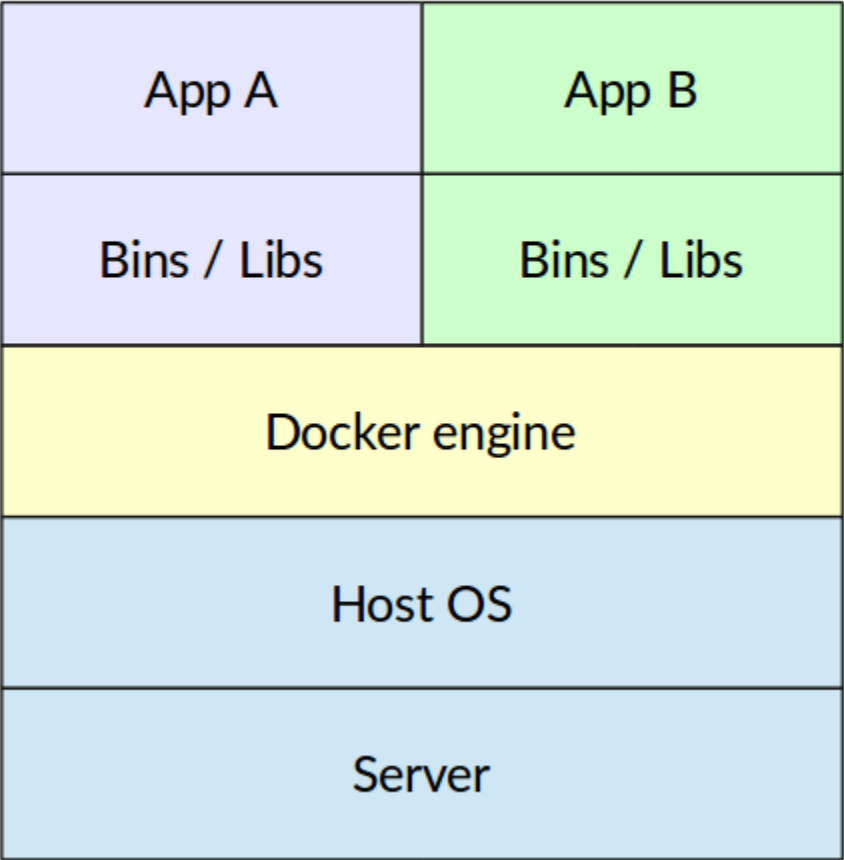
- A type of virtualization
- Difference from traditional VMs
 - Don't replicate entire OS, just bits needed for application
 - Run natively on host
- Key benefits:
 - More lightweight than VMs
 - Efficiency gains in storage, CPU
 - Portability

Lightweight

Virtualization



Docker

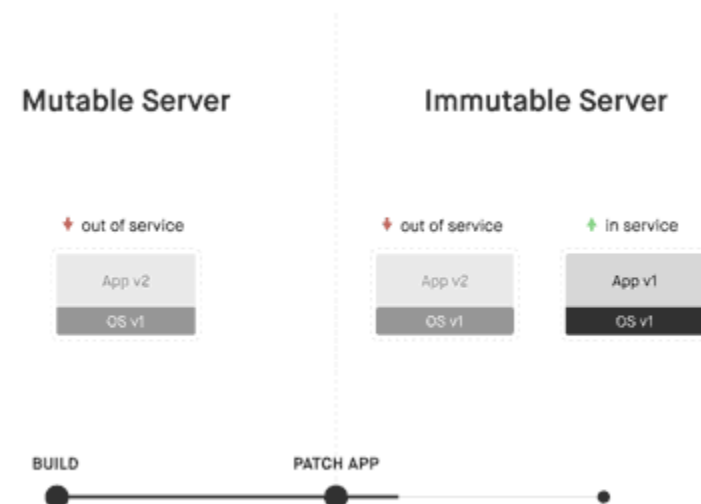


Benefits of Containers: Resources

- Containers share a kernel
- Use less CPU than VMs
- Less storage. Container image only contains:
 - executable
 - application dependencies

Benefits of Containers: Decoupling

- Application stack not coupled to host machine
- Scale and upgrade services independently
- Treat services like cattle instead of pets



Benefits of Containers: Workflows

- Easy to distribute
- Developers can wrap application with libs and dependencies as a single package
- Easy to move code from development environments to production in easy and replicable fashion

Introduction to Docker

The Docker Platform

What is Docker?

High level

An open-source platform for creating, running, and distributing software *containers* that bundle software applications with all of their dependencies.

Low level

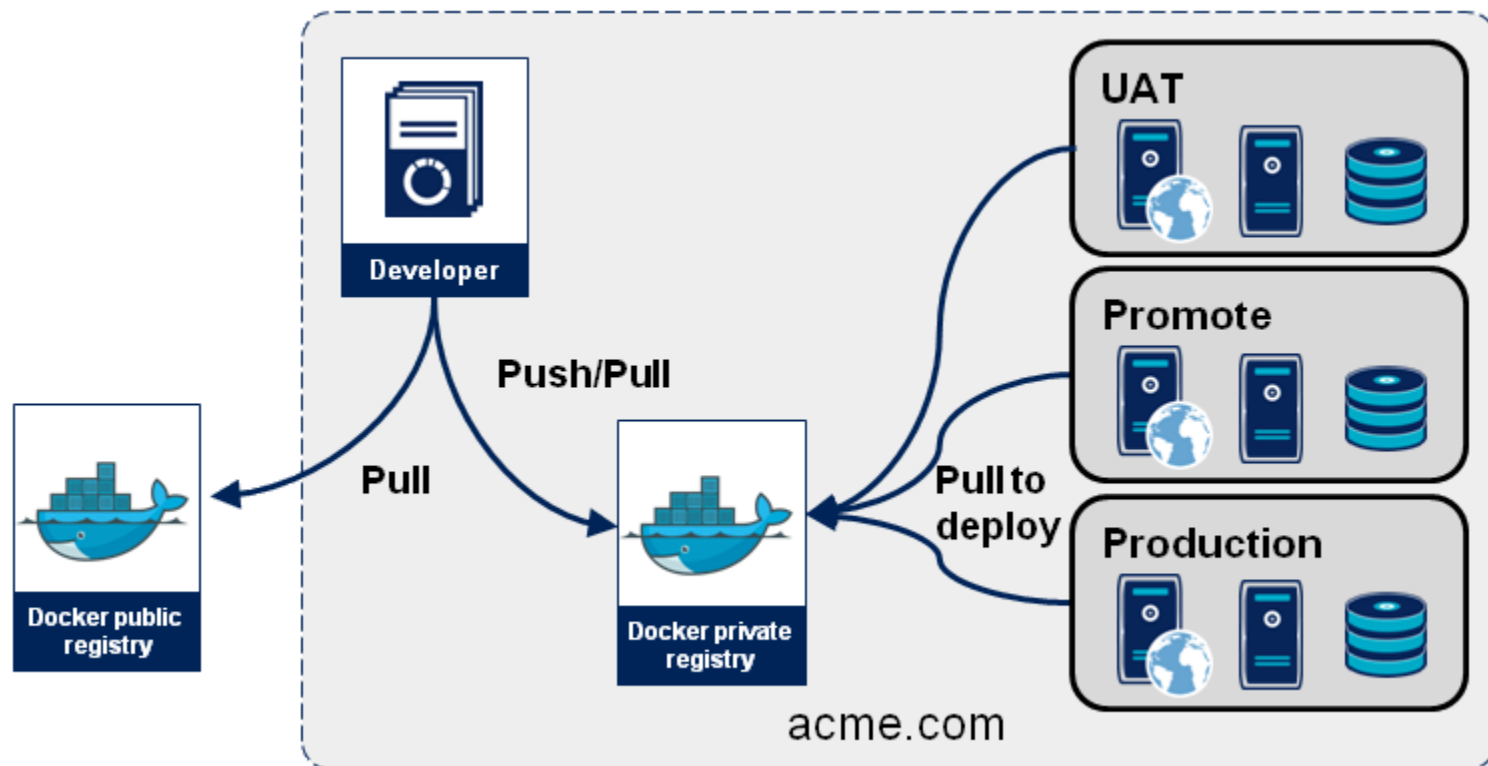
A command-line tool for programmatically defining the contents of a Linux container in code, which can then be versioned, reproduced, shared, and modified easily just as if it were the source code to a program

Docker popularity

- Linux containers are not new
 - FreeBSD Jails
 - LXC containers
 - Solaris Zones
- Docker is doing for containers what Vagrant did for virtual machines
 - Easy to create
 - Easy to distribute

Docker workflow

- Developer packages application and supporting components into image
- Developer/CI pushes image to private or public registry
- The image becomes the unit for distributing and testing your application.

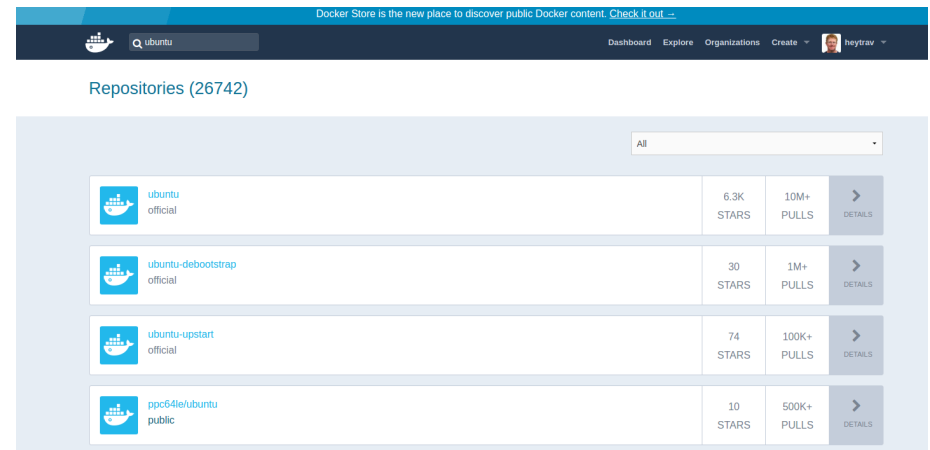


Docker Portability





- Most modern operating systems
 - Linux (RHEL, CentOS, Ubuntu LTS, etc.)
 - OSX
 - Windows
- Lightweight Docker optimized Linux distributions (CoreOS, Project Atomic, RancherOS, etc.)
- Private clouds (OpenStack, Vmware)
- Public clouds (AWS, Azure, Rackspace, Google)

Docker Registries

- Public repositories for docker images
 - Docker Hub
 - Quay.io
 - GitLab ships with docker registry
- Create your own private registry **docker/distribution**



The screenshot shows the Docker Hub search results for 'ubuntu'. The header includes a navigation bar with 'Dashboard', 'Explore', 'Organizations', 'Create', and a user profile 'heytrav'. Below the header, the search results are displayed in a table format. The table has columns for repository name, stars, pulls, and a details link. The results are filtered by 'All'.

Repositories (26742)			
All			
 ubuntu official	6.3K STARS	10M+ PULLS	> DETAILS
 ubuntu-debootstrap official	30 STARS	1M+ PULLS	> DETAILS
 ubuntu-upstart official	74 STARS	100K+ PULLS	> DETAILS
 ppc64le/ubuntu public	10 STARS	500K+ PULLS	> DETAILS

First Steps with Docker

Docker version

```
$ docker --version  
Docker version 17.03.1-ce, build c6d412e
```

Current version scheme similar to Ubuntu versioning:
YY.MM.#

Get command documentation

- Just typing **docker** returns list of commands
- Calling any command with **-h** or **--help** displays some docs
- Comprehensive online docs on **Docker website**

Basic client usage

`docker` **command** *[options]* *[args]*

```
$ docker<ENTER>
```

```
Usage:  docker COMMAND
```

```
A self-sufficient runtime for containers
```

```
Options:
```

<code>--config</code> string	Location of client config files (default 'C:\ProgramData\DockerDesktop\config.json')
<code>-D, --debug</code>	Enable debug mode
<code>--help</code>	Print usage

```
.
```

```
.
```

Exercise: View documentation for docker run

```
$ docker run --help
```

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

Run a command **in** a **new** container

Options:

<code>--add-host list</code>	Add a custom host- to -IP mapping (for
<code>-a, --attach list</code>	Attach to STDIN, STDOUT or STDERR
<code>--blkio-weight uint16</code>	Block IO (relative weight), between
<code>--blkio-weight-device list</code>	Block IO weight (relative device w
<code>.</code>	
<code>.</code>	

Docker run

Run a command in a container from an image

`docker run [options] image [command]`

- `docker run` requires an *image* argument

Option	Argument	Description
-i		Keep STDIN open
-t		Allocate a tty
--rm		Automatically remove container on exit
-v	list	Mount a volume
-p	list	List of port mappings
-e, --env	list	Set environment variables
-d, --detach		Run container in background and print container ID
--link	list	Add link to another container
--name	string	Name for the container

These are just examples that we'll use in the course. See complete list with `docker run --help`

Run a simple container

```
$ docker run hello-world
```

```
> docker run hello-world  
Unable to find image 'hello-world:latest' locally
```



The hello-world image was created by docker for instructional purposes. It just outputs a *hello world*-like message and exits.

Start a shell

`docker run image [command]`

```
$ docker run alpine /bin/sh
```

- Docker starts container using alpine image
- [command] argument is executed inside container
- Exits immediately
- A docker container only runs as long as it has a process (eg. a shell terminal or program) to run

```
→ ~ docker run alpine /bin/sh  
→ ~
```



00:09



Exercise: Start an *interactive* shell

docker run [options] alpine /bin/sh

```
$ docker run -it alpine /bin/sh
```

```
→ ~ docker run -it alpine /bin/sh
/ # ls
bin    dev    etc    home   lib    media  mnt    proc   root   run    sbin   srv    sys
/ # exit
→ ~
```

II 00:17

- Docker starts alpine image
 - -i interactively
 - -t allocate a pseudo-TTY
- Runs shell command
- Execute commands inside container
- Exiting the shell stops the process and the container

List running containers

docker ps

```
$ docker ps
```

```
CONTAINER ID   IMAGE                                     ... NAMES
b3169acf49f8   alpine                                 ... adoring_edison
02aa3e50580c   heytrav/docker-introduction-slides    ... docker-intro
```

Note: by default docker will assign a random name to each container (i.e. *adoring_edison*).

Option	Argument	Description
-a, --all		Show all containers (default shows just running)
-f, --filter	filter	Filter output based on conditions provided
--format	string	Pretty-print containers using a Go template
--help		Print usage
--no-trunc		Don't truncate output

Exercise: Assign the name *myalpine* when running previous example container

Hint: `docker run -it <option> alpine`

```
$ docker run -it --name myalpine alpine /bin/sh
```

```
> docker ps
```

CONTAINER ID	IMAGE	...	NAMES
db1faf244e7a	alpine	...	myalpine
02aa3e50580c	heytrav/docker-introduction-slides	...	docker-intro

- Exit the shell
- Repeat using same name. What happens?

```
> docker run -it --name myalpine alpin
```

Removing containers

```
docker rm name|containerID
```

Exercise: remove old myalpine container

```
$ docker rm myalpine
```

```
~  
> docker rm myalpine  
myalpine
```

```
~  
> █
```



00:04



If you pass the **--rm** flag to `docker run`, containers will be cleaned up when stopped.

Exercise: Run website in a container

- Run the image: **dockersamples/static-site**
- Name it *static-site*
- Pass your name to the AUTHOR environment variable
- Map port 8081 to 80 internally (hint **8081:80**)
- Container terminates when stopped
- Go to **localhost:8081**
- CTRL-C to exit

```
$ docker run --name static-site -e AUTHOR="YOUR NAME" \
  --rm -p 8081:80 dockersamples/static-site
```

```
> docker run --name static-site --rm \
  -e AUTHOR="Trav" -p 8081:80 dockersamples/static-site
Unable to find image 'dockersamples/static-site:latest' locally
latest: Pulling from dockersamples/static-site
fdd5d7827f33: Pull complete
a3ed95caeb02: Pull complete
716f7a5f3082: Extracting [=====>] 6.029MB/2
7b10f03a0309: Download complete
```

Exercise: Running a detached container

- Run static-site container like you did before, but add option to run in the background (i.e. *detached* state).

```
$ docker run --rm --name static-site -e AUTHOR="YOUR NAME" \  
-d -p 8081:80 dockersamples/static-site
```

```
> docker run --rm --name static-site -e AUTHOR="YOUR NAME" \  
-d -p 8081:80 dockersamples/static-site  
06ba2a841d43ad02a81e33f62561c87c5fb840aebcb0243e6b1a2c6d59a1e16d
```

```
> docker port static-site  
docker80/tcp -> 0.0.0.0:8081
```



00:12



View container logs

`docker logs [options] CONTAINER`

Option	Argument	Description
<code>--details</code>		Show extra details provided to logs
<code>-f, --follow</code>		Follow log output
<code>--help</code>		Print usage
<code>--since</code>	string	Show logs since timestamp (e.g. 2013-01-02T13:23:37) or relative (e.g. 42m for 42 minutes)
<code>--tail</code>	string	Number of lines to show from the end of the logs (default "all")
<code>-t, --timestamps</code>		Show timestamps

See [online documentation](#)

Exercise: view container logs for static-site container

```
> docker logs -f static-site
172.17.0.1 - - [28/May/2017:11:01:17 +0000] "GET / HTTP/1.1" 200 8747 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_12_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/58.0.3029.110 Safari/537.36" "-"
172.17.0.1 - - [28/May/2017:11:01:17 +0000] "GET /favicon.ico HTTP/1.1" 404 571 "http://localhost:8081/" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_12_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/58.0.3029.110 Safari/537.36"
2017/05/28 11:01:17 [error] 8#8: *1 open() "/usr/share/nginx/html/favicon.ico" failed (2: No such file or directory)
172.17.0.1, server: localhost, request: "GET /favicon.ico HTTP/1.1", host: "localhost:3277"
172.17.0.1 - - [28/May/2017:11:01:19 +0000] "GET / HTTP/1.1" 304 0 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_12_5) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/58.0.3029.110 Safari/537.36" "-"
```

00:13

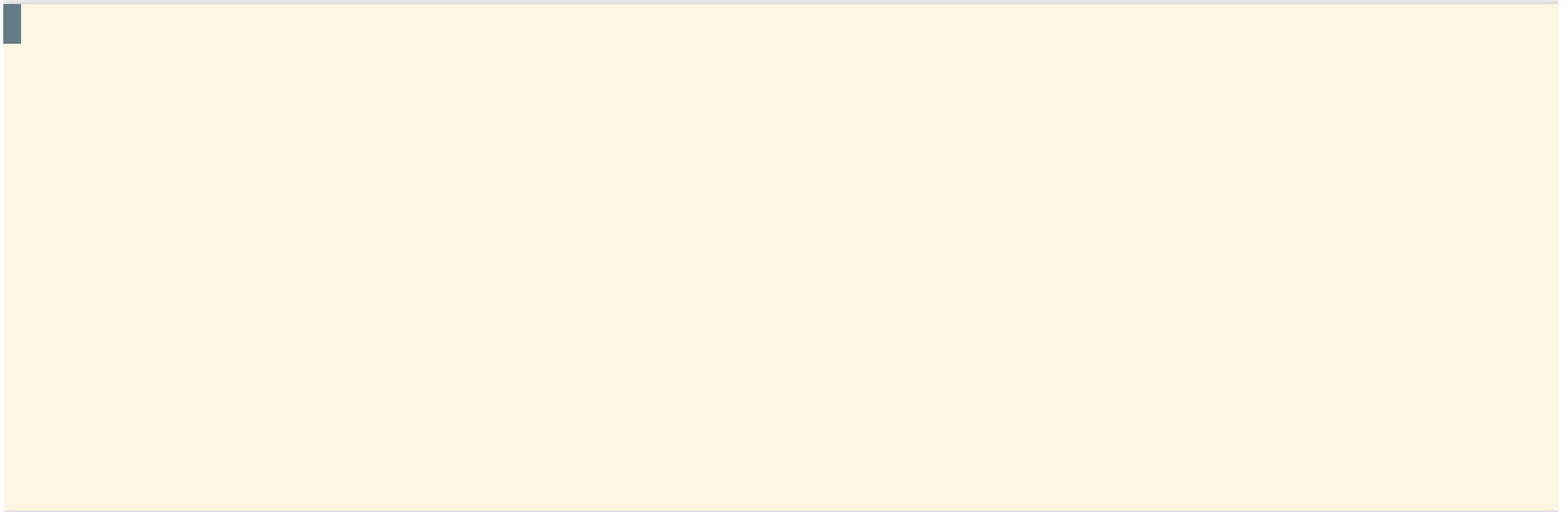
Note: Go to **localhost:8081** and refresh a few times

docker exec

docker **exec** [options] **CONTAINERID** [command]

- A way to interact with a running container
- Open a shell inside a running container.
- A bit like ssh'ing into a machine
- Can be useful for debugging
- See [online documentation](#)

Exercise: Check process list in static-site container



Stop a running container

```
docker stop name|containerID
```

Exercise: Stop the static-site container

- You actually have a couple options:
 - use the name you gave to the container
 - use the containerID from `docker ps` output (will depend on your environment)

```
$ docker stop static-site
```

```
$ docker stop 25eff330a4e4
```

List local images

```
$ docker image ls
```

```
→ ~ docker image ls
```

REPOSITORY	TAG	IMAGE ID	CREATED
heytrav/docker-introduction-slides	latest	1cedfbdf2482	4 days ago
alpine	latest	4a415e366388	2 months ago
hello-world	latest	48b5124b2768	3 months ago

```
→ ~ █
```



00:04



How Docker works

Components of Docker

Docker Image

contains basic read-only image that forms the basis of container



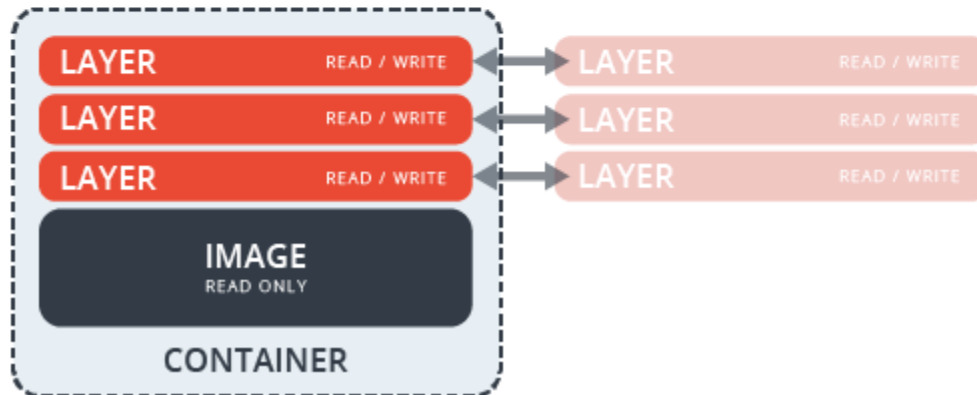
Docker Registry

a repository of images which can be hosted publicly (like Docker Hub) or privately and behind a firewall



Docker Container

is comprised of a base image with layers that can be swapped out so it's not necessary to replace the entire VM when updating an application



Underlying technology

Go

Implementation language developed by Google

Namespaces

Provide isolated workspace, or *container*

cgroups

limit application to specific set of resources

UnionFS

building blocks for containers

Container format

Combined namespaces, cgroups and UnionFS

Images and Containers

Docker images

- Images are the basis of containers
- An image is a *readonly* file system similar to tar archive
- *Distributable* artefact of Docker
- Image must have a name in lower case letters
- Tag is optional. Implicitly *:latest* if not specified
 - postgres:*9.4*
 - ubuntu == ubuntu:*latest* == ubuntu:*16.04*
- Url and username if pushing to registry
 - *docker.io/username/my-image*
 - *my.reg.com/my-image:1.2.3*

Types of images

Official Base Image

Images that have no parent (alpine, ubuntu, debian)

Base Image

Can be any image (official or otherwise) that is used to build a new image

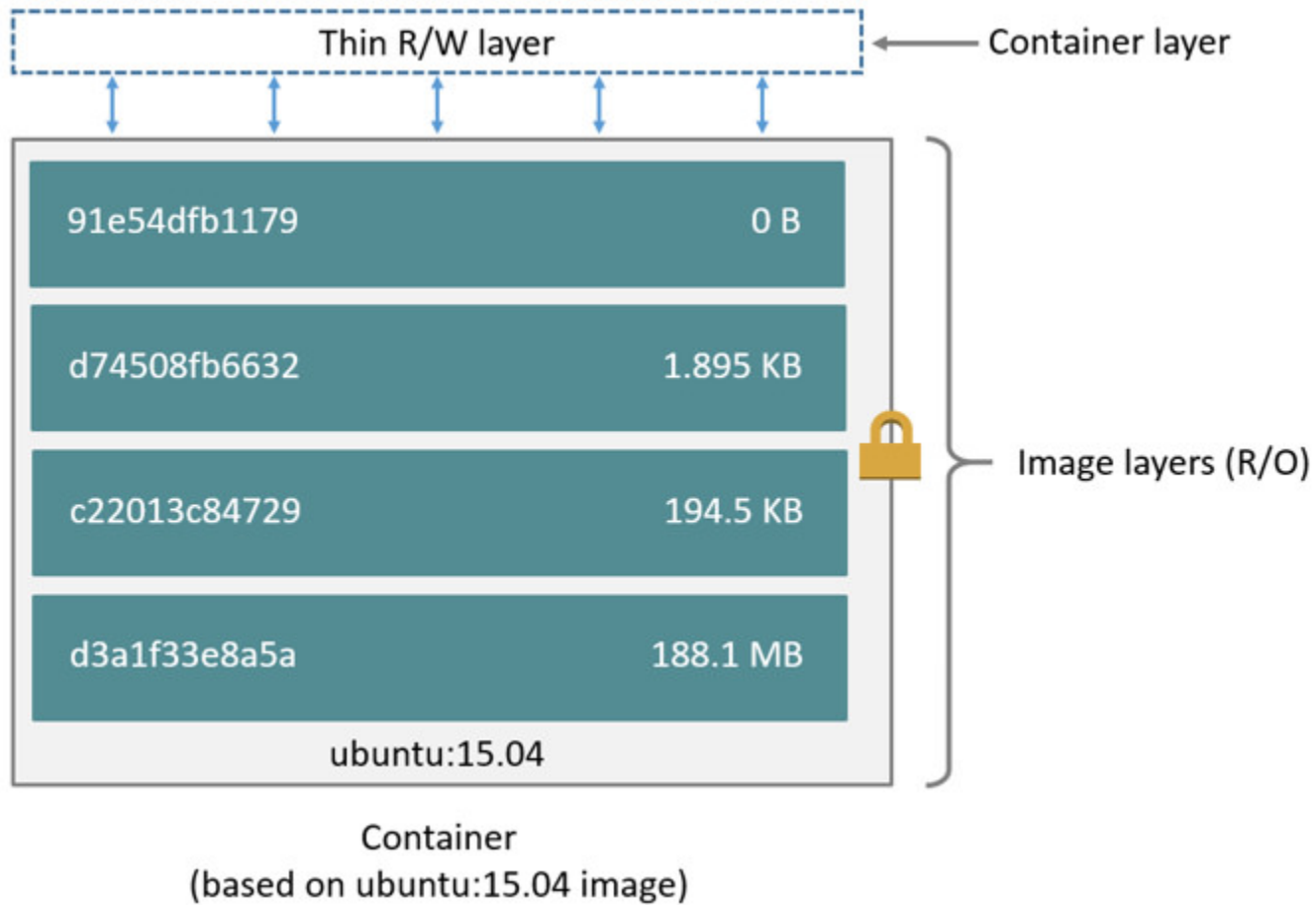
Child Images

Build on base images and add functionality (this is the type you'll build)

Layering of images

- Images are *layered*
- Images always consist of an *official base image*
 - ubuntu:14.04
 - alpine:latest
- Any child image built by adding layers on top of base
- Each successive layer is set of differences to preceding layer

Image layers



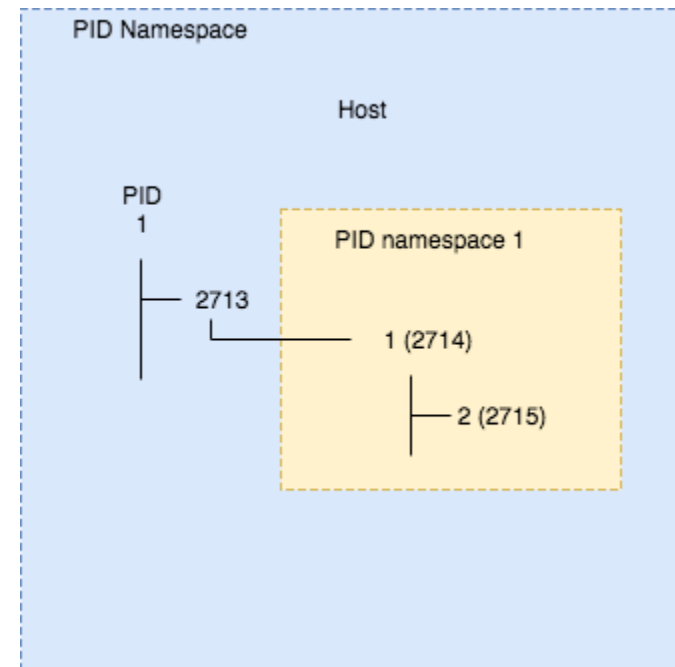
Sharing image layers

- Images will share any common layers
- Applies to
 - Images pulled from Docker
 - Images you build yourself

Container basics

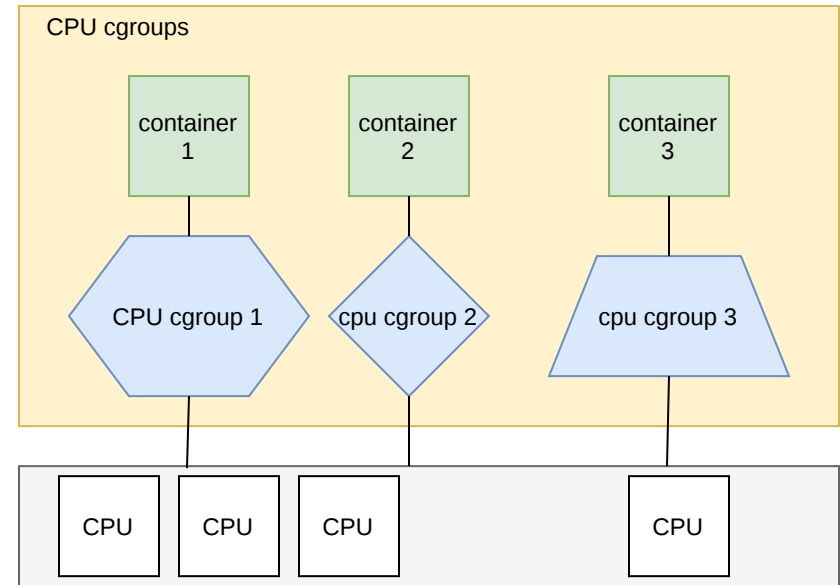
Namespaces

- Restrict visibility
- Processes inside a namespace should only see that namespace
- Namespaces:
 - pid
 - mnt
 - user
 - ipc



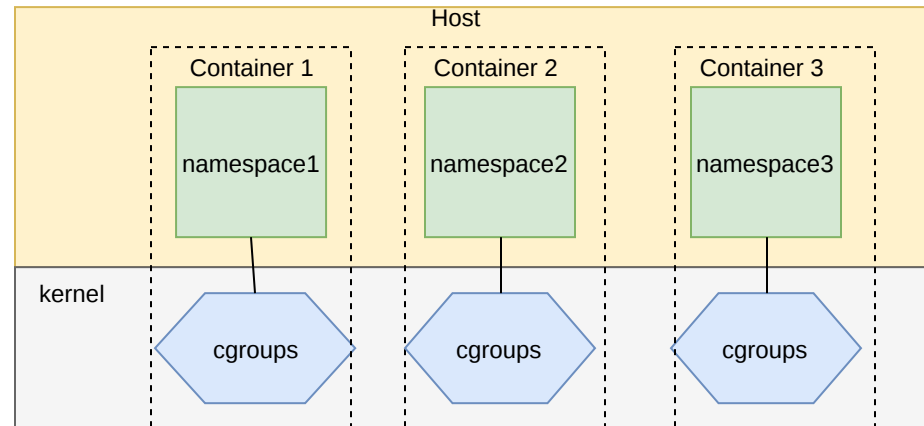
Cgroups

- Restrict usage
- Highly flexible; fine tuned
- Cgroups:
 - cpu
 - memory
 - devices
 - pids



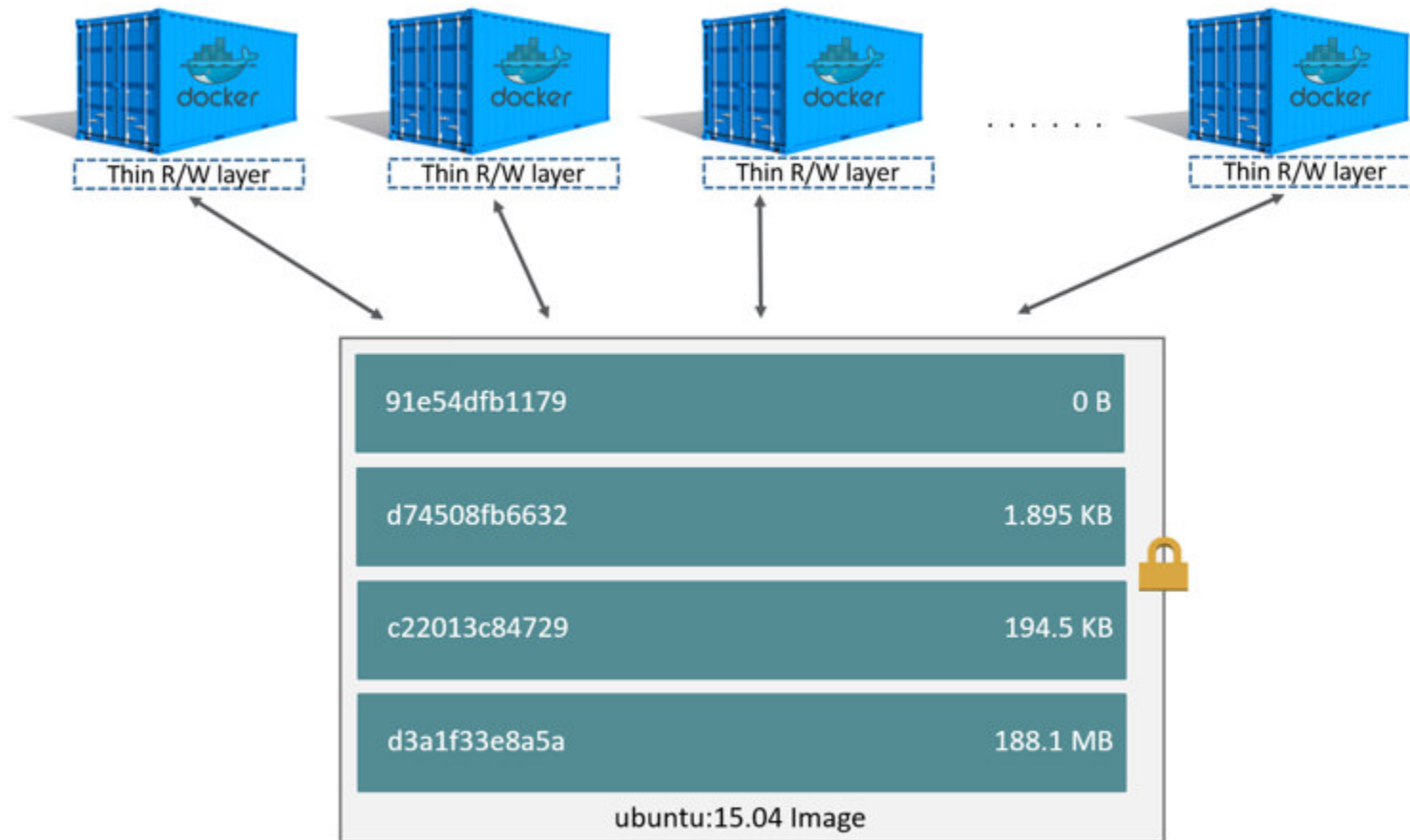
Combining the two

A running container represents a combination of layered file system, namespace and sets of cgroups



Container layering

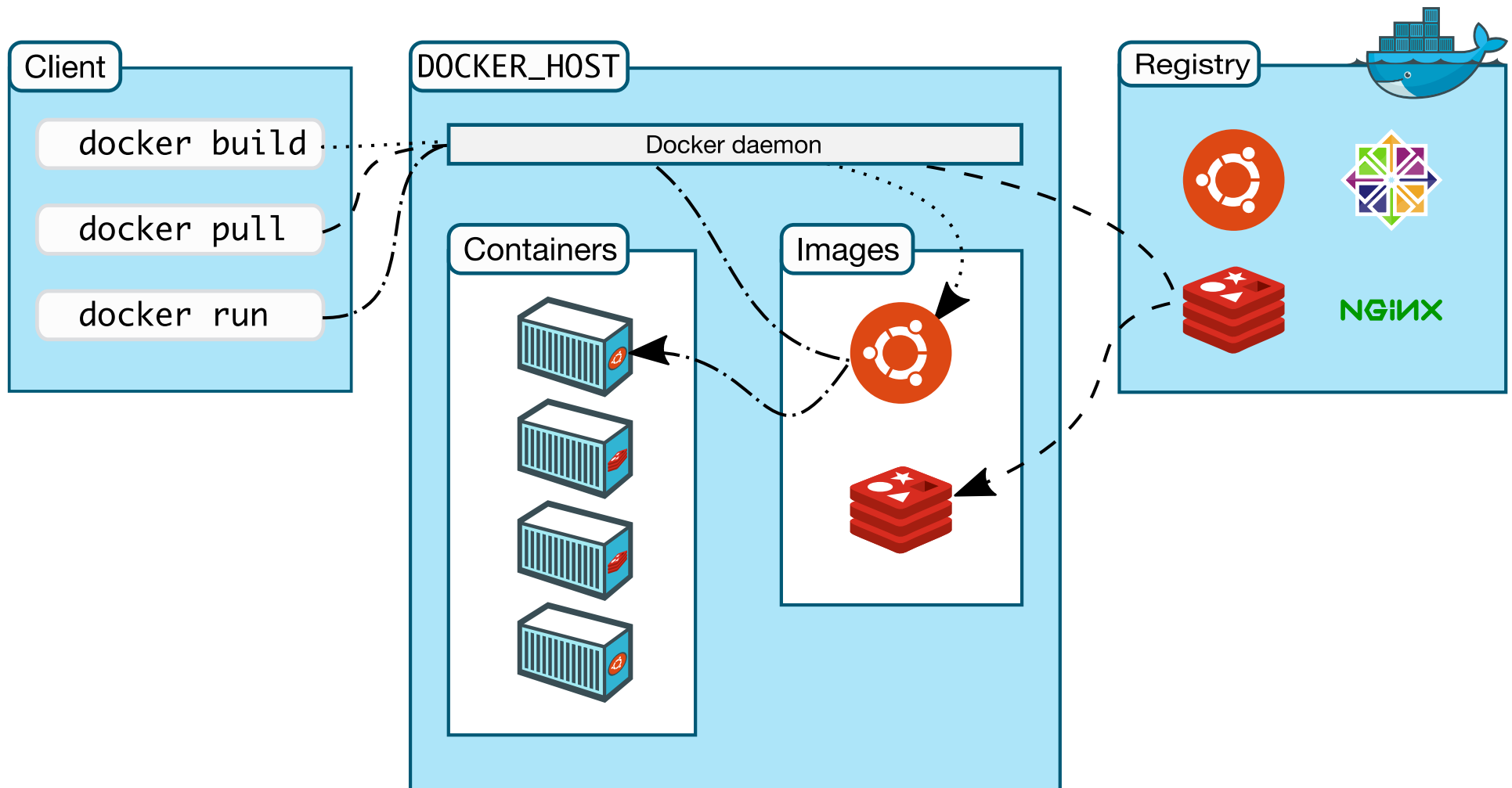
- Container creates its own read/write layer on top of image
- Multiple containers each have own read/write layer, but can share the actual image



Behind the scenes

- User types docker commands
- Docker client contacts docker daemon
- Docker daemon checks if image exists
- Docker daemon downloads image from docker registry if it does not exist
- Docker daemon runs container using image

Docker architecture



Exercise: Create a basic image

```
$ docker run -t -i ubuntu:16.04 /bin/bash

root@69079aaaaab1:/$ apt-get update
root@69079aaaaab1:/$ exit

$ docker commit 69079aaaaab1 ubuntu:update
13132d42da3cc40e8d8b4601a7e2f4dbf198e9d72e37e19ee1986c280ffcb97c

$ docker image ls
$ docker diff 69079aaaaab1
$ docker history ubuntu:16.04
$ docker history ubuntu:update
```

- Created a new layer (cache files added by apt)
- Not an ideal way to create images
- Better to create images using a Dockerfile

Create images with a *Dockerfile*

- A text file. Usually named `Dockerfile`
- Sequential instructions for building a Docker image
- Each instruction creates a layer on the previous
- A very simple Dockerfile with 4 layers:

```
FROM ubuntu:16.04
COPY . /app
RUN make /app
CMD ["python", "/app/app.py"]
```

Structure of a Dockerfile

- Tell Docker which base image to use

```
FROM ubuntu
```

```
FROM postgres:9.4
```

```
FROM node:latest
```

- A number of commands telling docker how to build image

```
COPY . /app  
RUN make /app
```

- Optionally tell Docker what command to run when the container is started

```
CMD ["python", "/app/app.py"]
```

Common Dockerfile Instructions

...a non-exhaustive list

FROM

FROM **image:tag**

Define the base image for a new image

```
FROM ubuntu:17.04
```

```
FROM debian # :latest implicit
```

```
FROM my-custom-image:1.2.3
```

RUN

RUN **command** **arg1** **arg2** ...

Execute shell commands for building image

```
RUN apt-get update && apt-get install python3
```

```
RUN mkdir -p /usr/local/myapp && cd /usr/local/myapp
```

```
RUN make all
```

```
RUN curl https://domain.com/somebig.tar | tar -xv | /bin/sh
```

COPY

COPY **src** **dest**

Copy files from build directory into image

```
COPY package.json /usr/local/myapp
```

```
COPY . /usr/share/www
```

WORKDIR

WORKDIR **path**

- Create a directory in the image
- Container will run relative to this directory

```
WORKDIR /usr/local/myapp
```

ENTRYPOINT

- Docker images need not be executable by default
- ENTRYPOINT configures executable behaviour of container

```
$ cd ~/docker-introduction/sample-code/entrypoint_cmd_examples  
$ docker build -t not-executable -f Dockerfile.notexecutable .  
$ docker run not-executable # does nothing
```

- Two ways to execute a command:
 - shell form: ENTRYPOINT **command** **param1** **param2** ...
 - exec form: ENTRYPOINT ["command", "param1", "param2"]

```
$ docker build -t executable -f Dockerfile.executable .  
$ docker run executable
```

CMD

- Provide defaults to executable
- or provide executable
- *Shell* and *exec* forms just like ENTRYPOINT
- Arguments following the image for `docker run image` overrides CMD

```
$ docker build -t cmd-only -f Dockerfile.cmd_only .  
$ docker run cmd-only  
$ docker run cmd-only echo Good morning, Hal
```

Combining ENTRYPOINT & CMD

- Use exec form of ENTRYPOINT and CMD together to set base command and default arguments
- Hypothetical application

```
FROM ubuntu:latest  
.  
.  
ENTRYPOINT ["./base-script"]  
CMD ["test"]
```

```
$ docker run my-image
```

By default this image will just pass `test` as argument to `base-script` to run unit tests by default

```
$ docker run my-image server
```

Passing argument at the end tells it to override CMD and execute with `server` to run server feature

More Dockerfile instructions

EXPOSE

ports to expose when running

VOLUME

folders to expose when running

HEALTHCHECK CMD

Check container health by running command at regular intervals inside container

docker build

Build Docker images

docker **build** [options] image[:tag] path

Options	Arguments	Description
--compress		Compress the build context using gzip
-c, --cpu-shares	int	CPU shares (relative weight)
--cpuset-cpus	string	CPUs in which to allow execution (0-3, 0,1)
--cpuset-mems	string	MEMs in which to allow execution (0-3, 0,1)
--disable-content-trust		Skip image verification (default true)
-f, --file string		Name of the Dockerfile (Default is 'PATH/Dockerfile')
--pull		Always attempt to pull a newer version of the image
-t, --tag list		Name and optionally a tag in the 'name:tag' format

Exercise: build docker image using Dockerfile

- Call image **acme/my-base-image**
- Tag it **1.0**

```
$ docker build -t acme/my-base-image:1.0 .
```

`docker-introduction/sample-code/layering`

```
> docker build -t acme/my-base-image:1.0 .
```

```
Sending build context to Docker daemon 4.096kB
```

```
Step 1/2 : FROM ubuntu:16.04
```

```
16.04: Pulling from library/ubuntu
```

```
dca7be20e546: Downloading [=====>] 34.04MB/
```

```
40bca54f5968: Download complete
```

```
61464f23390e: Download complete
```

```
d99f0bcd5dc8: Download complete
```

```
120db6f90955: Download complete
```



Exercise: Build child image

- Create **acme/my-final-image**
- Tag **1.0**
- Use **Dockerfile.child** to build image

```
$ docker build -t acme/my-final-image:1.0 -f Dockerfile.child .
```

[docker-introduction/sample-code/layering](#)

```
> docker build -t acme/my-final-image:1.0 -f Dockerfile.child .
```

Sending build context to Docker daemon 4.096kB

Step 1/2 : FROM acme/my-base-image:1.0

---> 37ef47cb08fc

Step 2/2 : CMD /app/hello.sh

---> Running in a2688ba1f2db

---> d5d1947bca4f

Removing intermediate container a2688ba1f2db

Successfully built d5d1947bca4f

Successfully tagged acme/my-final-image:1.0

[docker-introduction/sample-code/layering](#) git/oct-10*

Exercise: Compare base and child image layers

- Use: docker **history** **image**
- The final image should contain all the same layers as the base image
- One additional layer: the last line of the Dockerfile

```
$ docker history acme/my-base-image:1.0
$ docker history acme/my-final-image:1.0
```

IMAGE	...		SIZE
5932655b26aa	...	#(nop) CMD ["/bin/sh" "-c" "/a...	0 B<--new layer
2f723f94263a	...	#(nop) COPY dir:dd75f285798cdc9...	106 B
8d4c9ae219d0	...	#(nop) CMD ["/bin/bash"]	0 B
<missing>	...	mkdir -p /run/systemd && echo '...	7 B
<missing>	...	sed -i 's/^#\s*\s*(deb.*universe\...	2.78 kB
<missing>	...	rm -rf /var/lib/apt/lists/*	0 B
<missing>	...	set -xe && echo '#!/bin/sh' >...	745 B
<missing>	...	#(nop) ADD file:9e2eabb7b05f940...	106 MB

Dockerising applications

Create web application in Docker

- Create a small web app based on Python Flask
- Write a Dockerfile
- Build an image
- Run the image
- Upload image to a Docker registry

Step 1. Set up the web app

- Under `~/docker-introduction/sample-code/flask-app`
 - app.py**
A simple flask application for displaying cat pictures
 - requirements.txt**
list of dependencies for flask
 - templates/index.html**
A jinja2 template
 - Dockerfile**
Instructions for building a Docker image

Our Dockerfile

```
FROM alpine:3.5

# Install python and pip
RUN apk add --update py2-pip

# install Python modules needed by the Python app
COPY requirements.txt /usr/src/app/
RUN pip install --no-cache-dir -r /usr/src/app/requirements.txt

# copy files required for the app to run
COPY app.py /usr/src/app/
COPY templates/index.html /usr/src/app/templates/

# tell the port number the container should expose
EXPOSE 5000

CMD ["python", "/usr/src/app/app.py"]
```


Build the Docker image

```
$ cd ~/docker-introduction/sample-code/flask-app
$ docker build -t YOURNAME/myfirstapp .
```

```
Status: Downloaded newer image for alpine:3.5
---> 4a415e366388
Step 2/8 : RUN apk add --update py2-pip
---> Running in a882d6e9cc6e
fetch http://dl-cdn.alpinelinux.org/alpine/v3.5/main/x86_64/APKINDEX.tar.gz
fetch http://dl-cdn.alpinelinux.org/alpine/v3.5/community/x86_64/APKINDEX.tar.gz
(1/12) Installing libbz2 (1.0.6-r5)
(2/12) Installing expat (2.2.0-r0)
(3/12) Installing libffi (3.2.1-r2)
(4/12) Installing gdbm (1.12-r0)
(5/12) Installing ncurses-terminfo-base (6.0-r7)
(6/12) Installing ncurses-terminfo (6.0-r7)
(7/12) Installing ncurses-libs (6.0-r7)
(8/12) Installing readline (6.3.008-r4)
(9/12) Installing sqlite-libs (3.15.2-r0)
(10/12) Installing python2 (2.7.13-r0)
(11/12) Installing py-setuptools (29.0.1-r0)
(12/12) Installing py2-pip (9.0.0-r1)
Executing busybox-1.25.1-r0.trigger
OK: 61 MiB in 23 packages
---> 04886f8f3d7c
```

Note: please replace YOURNAME with your Docker Hub username

Run the container

```
$ docker run -p 8888:5000 --name myfirstapp YOURNAME/myfirstapp
```

```
→ docker run -p 8888:5000 --name myfirstapp --rm YOURNAME/myfirstapp
* Running on http://0.0.0.0:5000/ (Press CTRL+C to quit)
172.17.0.1 - - [07/May/2017 11:17:17] "GET / HTTP/1.1" 200 -
172.17.0.1 - - [07/May/2017 11:17:23] "GET / HTTP/1.1" 200 -
172.17.0.1 - - [07/May/2017 11:17:30] "GET / HTTP/1.1" 200 -
```



00:36

...Now open **your test webapp**

Login to a registry

```
$ docker login <registry url>
```

example-voting-app/vote

```
> docker login
```

Login with your Docker ID to push and pull images from Docker Hub. If you don't have a Docker ID, you can create one.

Username: heytrav

Password:



- If registry not specified, logs into hub.docker.com
- Can log in to multiple registries

Push image to registry

```
$ docker push YOURNAME/myfirstapp
```

```
→ ~ docker push heytrav/myfirstapp
The push refers to a repository [docker.io/heytrav/myfirstapp]
e3289250a9d4: Pushed
716e864bdc5d: Pushed
7e0c0ae20bfa: Pushed
b106808228c0: Pushed
f3fd8cb51e02: Pushing [=====>] 43.36 MB/48.6
23b9c7b43573: Pushing [=====>] 1.479 MB/3.98
```



00:36



Summary

- Wrote a small web application
- Used Dockerfile to create an image
- Pushed image to upstream registry

Dockerfile best practices

General guidelines

- Containers should be as ephemeral as possible
- Use a `.dockerignore` file
- Avoid installing unnecessary packages
- Minimise concerns
 - Avoid multiple processes/apps in one container

General guidelines

- Use current official repositories in FROM as base image
 - debian 124 MB
 - ubuntu 117 MB
 - alpine 3.99 MB
 - busybox 1.11 MB
- Minimise Layers
- Sort multiline arguments
- Split complex RUN statement on separate lines with backslashes
- Run apt-get update and apt-get install in same RUN
- Run clean up in same line whenever possible

Layer caching

```
$ cd ~/docker-introduction/sample-code/caching  
$ docker build -t caching-example -f Dockerfile.layering .
```

- Build image in sample-code/caching directory
- Run build a second time. What happens?
- Change line with Change me! and run again
- Each instruction creates a layer in an image
- Docker caches layers when building
- When a layer is changed Docker rebuilds from changed layer

Consequences of layer caching

```
# Example 1
FROM ubuntu:latest
RUN apt-get update
RUN apt-get install -y curl
#RUN apt-get install -y nginx
```

```
# Example 2
FROM ubuntu:latest
RUN apt-get update \
    && apt-get install -y curl #nginx
```

```
$ cd ~/docker-introduction/sample-code/caching
$ docker build -t bad-apt-example -f Dockerfile.bad .
$ docker build -t good-apt-example -f Dockerfile.good .
```

- Uncomment nginx line and run `docker build` again
- Only rebuilds from layer that was *changed*
- Example 1: `apt-get update` does not refresh index
 - apt repos might change
- Best to combine `apt-get update` and install packages to force apt to refresh index (Example 2)

Minimise Layers

Remove non-essential files when possible.

Image size: 471 MB

```
FROM ubuntu:latest

RUN apt-get update \
    && apt-get install -y \
        aufs-tools \
        automake \
        build-essential \
        curl \
        dpkg-sig \
        libcap-dev \
        libsqlite3-dev \
        mercurial \
        reprepro
```

Image size: 430 MB

```
FROM ubuntu:latest

RUN apt-get update \
    && apt-get install -y \
        aufs-tools \
        automake \
        build-essential \
        curl \
        dpkg-sig \
        libcap-dev \
        libsqlite3-dev \
        mercurial \
        reprepro \
    && rm -rf /var/lib/apt/lists/*
```

ADD is BADD

- Copies files to a directory

```
ADD . /usr/path/
```

- Downloads file from web

```
ADD http://domain.com/file.txt /usr/path/
```

- Unpack archives into directory

```
ADD file.tar /usr/path/
```

- However, does not unpack remote archives. This will just put `file.tar` in `/usr/path/`

```
ADD http://domain.com/file.tar /usr/path/
```

Problems with ADD

- Large intermediate layers

```
ADD http://domain.com/big.tar.gz /usr/path/ # large intermediate layer
RUN cd /usr/path && tar -xvf big.tar.gz \
    && rm big.tar.gz
```

- Increased overall image size
- Better solution:

```
RUN curl -SL http://domain.com/big.tar.gz \
    | tar -xJC /usr/path
```

- Smaller image size
- COPY only copies files

```
COPY . /usr/path/
```

- Recommend to only use COPY and never ADD

CMD & ENTRYPOINT

General best practices

- Avoid using *shell* form
 - `ENTRYPOINT "executable param1 param2 ..."`
- Docker directs POSIX commands at process with PID 1
- Using *shell* form, process is run internally using `/bin/sh -c` and do not have PID 1
- It can be difficult to stop container since process does not receive SIGTERM from `docker stop container`

```
$ cd ~/docker-introduction/sample-code/entrypoint_cmd_examples
$ docker build -t runtop-shell -f Dockerfile.top_shell .
$ docker run --rm --name topshell runtop-shell
```

What happens when you want to stop container *topshell*?

CMD & ENTRYPOINT

General best practices

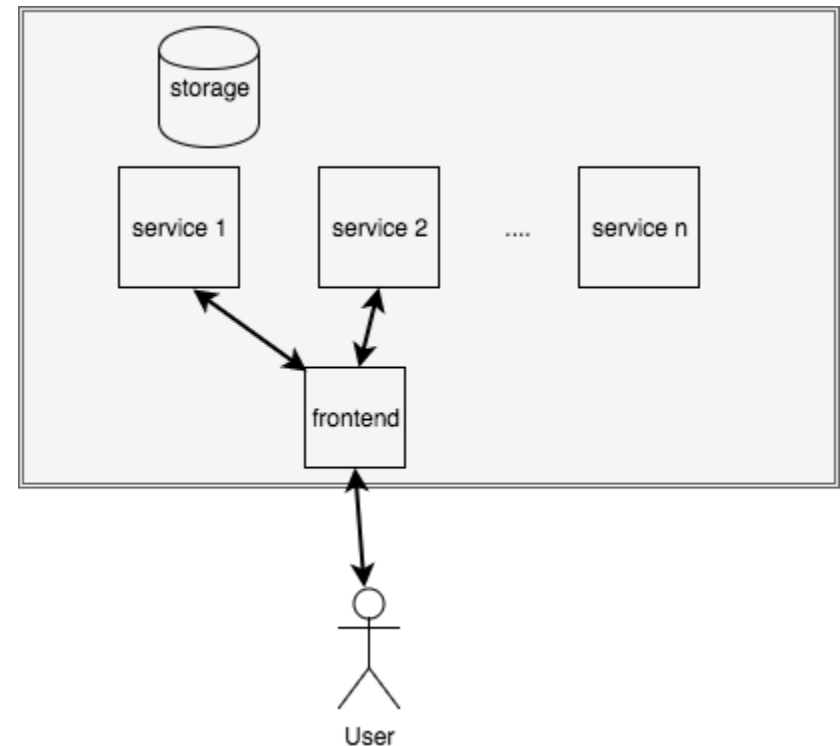
- Best practice to use **exec** form:
 - `CMD ["executable", "param1", "param2", ...]`
- Or in form that creates interactive shell like
 - `ENTRYPOINT ["python"]`
 - `CMD ["/bin/bash"]`

```
$ docker build -t runtop -f Dockerfile.top .  
$ docker run runtop
```


Docker and Development

Microservices vs. Monoliths

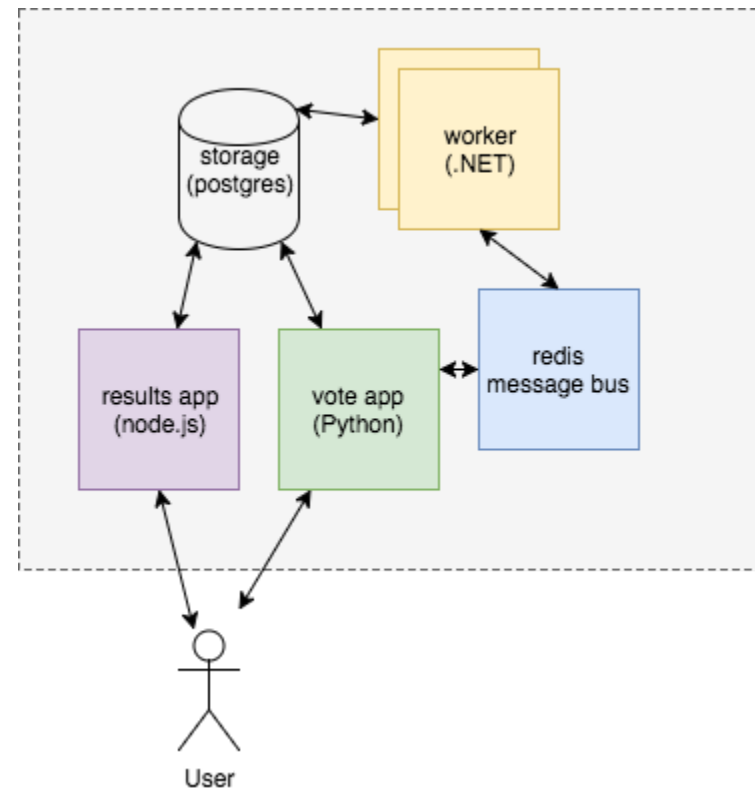
- Small decoupled applications vs. one big app
- Developed independently
- Deployed and updated independently
- Scaled independently
- Better modularity
- Docker containers fit with microservice architecture



Example voting application

Microservice application consisting of 5 components

- Python web application
- Redis queue
- .NET worker
- Postgres DB with a data volume
- Node.js app to show votes in real time



```
$ git clone https://github.com/dockersamples/example-voting-app.git
$ cd example-voting-app
```

Build vote app components

```
$ docker build -t vote vote
```

```
$ docker build -t result result
```

```
$ docker build -t worker worker
```

```
$ docker image ls
```

Run microservices

```
#!/bin/bash
# Helper services
docker run --rm -d -p 6379:6379 --name redis redis:alpine
docker run --rm -d --name db postgres:9.4

# Application
docker run --rm -d --name vote --link redis \
    --link db -v $PWD/vote:/app -p 5000:80 vote

docker run --rm -d --name worker --link redis --link db worker

docker run --rm -d --name result -v $PWD/result:/app \
    --link db -p 5001:80 -p 5858:5858 result nodemon --debug server.js
```

--link a:b

Link container *a* to container *b*

-v ./path:/var/lib/path

Mount a directory as a volume

-p 8080:80

Map port in container

Disadvantages of this approach

- Complicated with shell/script commands
 - Managing service interactions
 - Adding/managing services
- Can't scale services
- Stopping services is P.I.T.A.
- Better tools exist..

Docker Compose

Docker as a dev environment

- Declarative YAML syntax
- Specifies
 - Services
 - image or build
 - volumes
 - environment variables
- Interactive development
- Can be used for staging/production environments

```
---
# docker-compose.yml
version: '3'
services:
  web:
    build: .
    ports:
      - "5000:5000"
    volumes:
      - ./code
      - logvolume01:/var/log
    links:
      - redis
  redis:
    image: redis
    volumes:
      logvolume01: {}
```

Docker Compose

Basic commands

`docker-compose` **COMMAND** [options] [args]

scale

Command	Description
up	Start compose
down	Stop & tear down containers/networks
restart <service name>	Restart a service

Use `docker-compose -h` to view inline documentation

Have a look at the [documentation](#)

Docker Compose Example

```
$ cd example-voting-app
$ docker-compose up -d
```

```
Creating db ...
Creating examplevotingapp_worker_1
Creating examplevotingapp_result_1 ...
Creating redis
Creating examplevotingapp_vote_1
Creating db
Creating redis ... done
```

example-voting-app 9s

> docker ps

CONTAINER ID	IMAGE	COMMAND	CREATED
f2b011912dcc	examplevotingapp_result	"nodemon --debug s..."	5 seconds ago
410d8739c4bc	examplevotingapp_vote	"python app.py"	5 seconds ago



00:18

Vote and view results

Interactive development

- Open up `vote/app.py`
- On lines 8 & 9, modify vote options
- View change in **voting** application

Change vote options

```
1 from flask import Flask, render_template, request, make_response, g
2 from redis import Redis
3 import os
4 import socket
5 import random
6 import json
7
8 option_a = os.getenv('OPTION_A', "Beer")
9 option_b = os.getenv('OPTION_B', "")
10 hostname = socket.gethostname()
11
12 app = Flask(__name__)
13
14 def get_redis():
15     if not hasattr(g, 'redis'):
16         g.redis = Redis(host="redis", db=0, socket_timeout=5)
17     return g.redis
18
19 @app.route("/", methods=['POST','GET'])
```

INSERT  master  vote/app.py + 

[Pymode] Activate virtualenv: /home/travis/workspace/catalystcloud-ansible/ansible-venv

Scaling services

```
$ docker-compose up -d --scale SERVICE=<number>
```

```
Creating examplevotingapp_worker_2 ... done
Creating examplevotingapp_worker_3 ... done
```

example-voting-app

```
> docker ps
```

CONTAINER ID	IMAGE	COMMAND	CREATED
420c73d2d874	examplevotingapp_worker	"/bin/sh -c 'dotne..."	5 secon
7584903592d4	examplevotingapp_worker	"/bin/sh -c 'dotne..."	5 secon
215ebf4f9d52	postgres:9.4	"docker-entrypoint..."	5 minut
8b60a02a898f	examplevotingapp_vote	"python app.py"	5 minut
bc4de04d5264	redis:alpine	"docker-entrypoint..."	5 minut
3e264f1af5a9	examplevotingapp_worker	"/bin/sh -c 'dotne..."	5 minut
00802d4f0393	examplevotingapp_result	"nodemon --debug s..."	5 minut
05e6a293c67b	heytrav/docker-introduction-slides	"/usr/local/bin/du..."	15 hour

example-voting-app

```
> docker-compose up -d --scale worker=1
```

```
examplevotingapp_vote_1 is up-to-date
```

```
redis is up-to-date
```

```
Stopping and removing examplevotingapp_worker_2 ...
```

```
db is up-to-date
```

Container Orchestration

First, some more buzzwords

- Immutable infrastructure
- Cattle vs pets
- Snowflake Servers **vs.** Phoenix Servers

Immutable Architecture/Infrastructure

- Phoenix servers
- The environment is defined in code
- If you need to change *anything* you create a new instance and destroy the old one
- Docker makes it much more likely you will work in this way



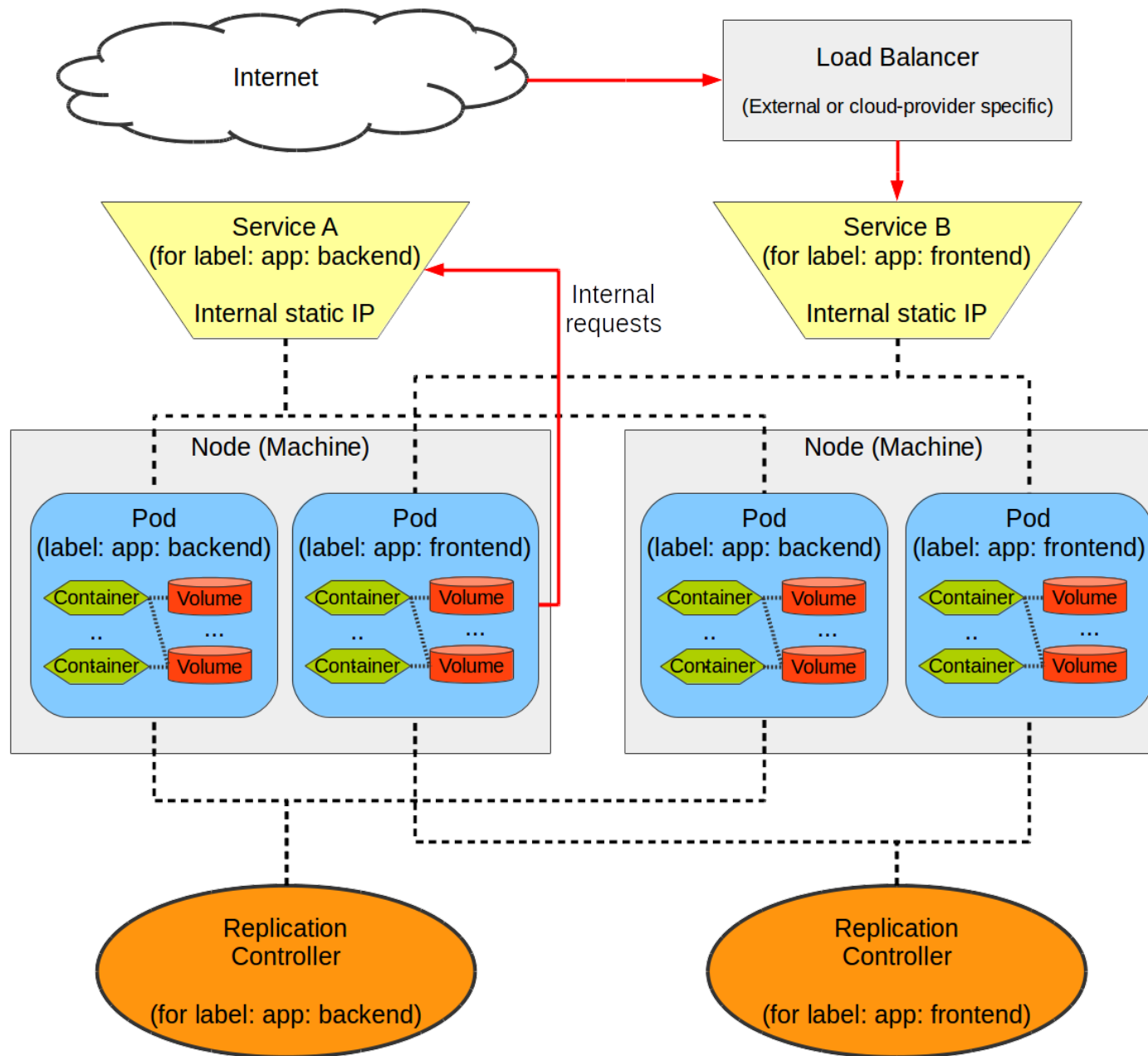
Container orchestration

- Frameworks for container orchestration
 - Docker Swarm
 - Kubernetes
- Manage deployment/restarting containers across clusters
- Networking between containers (microservices)
- Scaling microservices
- Fault tolerance

Kubernetes

- Container orchestrator
- Started by Google
- Inspired by Borg (Google's cluster management system)
- Open source project written in Go
- Cloud Native Computing Foundation
- Manage applications not machines

Kubernetes Overview



Kubernetes Components

- Pods - an ephemeral group of co-scheduled containers that together provide a service
- Flat Networking Space - each pod has an IP and can talk to other pods, within a pod containers communicate via localhost (need to manage ports)
- Labels - Key value pairs, used to label pods and other objects so the scheduler can operate on them
- Services - stable endpoints comprised of one or more pods (external services are supported)
- Replication Controllers - the orchestrator that controls and monitors the pods within a service (known as replicas)

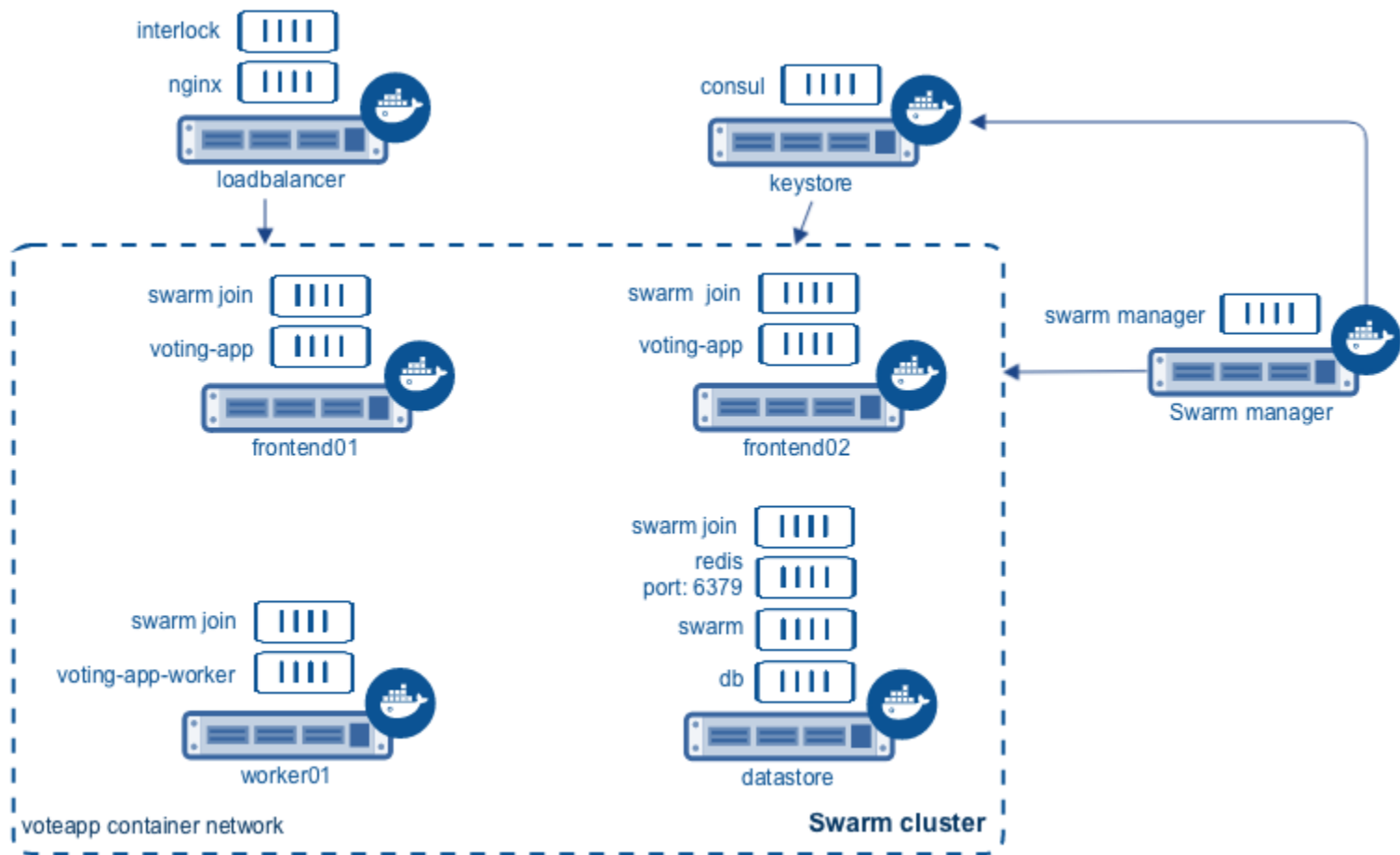
Docker Swarm

- Standard since Docker 1.12
- Manage containers across multiple machines
 - Scaling services
 - Healthchecks
 - Load balancing



Docker Swarm

- Two types of machines or *nodes*
 - 1 or more *manager* nodes
 - 0 or more *worker* nodes
- Managers control global state of cluster
 - Raft Consensus Algorithm
 - If one manager fails, any other should take over



Swarm Stack File

- Similar to file used for docker - compose
- A few differences
 - No build option
 - No shared volumes

```
# stack.yml
version: "3.3"
services:
  db:
    image: postgres:9.4
    .
    .
  redis:
    image: redis:latest
    deploy:
      replicas: 3

  vote:
    image: vote:latest
    depends_on:
      - redis
      - db
    deploy:
```


Initiate a Swarm

```
$ docker swarm init  
$ cd ~/example-voting-app
```

- `docker swarm init` puts your machine in *swarm mode*
- Only need to do once to create manager node

Deploy the stack

```
$ docker stack deploy --compose-file docker-stack.yml vote
```

master

>



00:01



Verify stack is running

```
$ watch docker stack ps vote
```

master

```
> docker stack ps v
```



00:05



Now, let's go **vote**! When you're done, have a look at the **results**.

Build image

In example-voting-app...

```
$ docker build -t vote:v2 vote
```

Note: please replace yourname with your docker hub username if you have one

example-voting-app

```
> docker build -t yourname/vote .
```

```
Sending build context to Docker daemon 12.29 kB
```

```
Step 1/7 : FROM python:2.7-alpine
```



Update a service

```
$ docker service update --image vote:v2 vote_vote
```

Now go to the **voting app** and see what changed

Remove Swarm Stack

```
$ docker stack rm vote
```

example-voting-app

```
> docker stack rm vote
```

```
Removing service vote_redis
```

```
Removing service vote_result
```

```
Removing service vote_db
```

```
Removing service vote_vote
```

```
Removing service vote_worker
```

```
Removing service vote_visualizer
```

```
Removing network vote_backend
```

```
Removing network vote_frontend
```

```
Removing network vote_default
```

example-voting-app

```
> █
```



00:04



Summary

- Deployed a set of services on our local host
- Docker created a couple networks (front-tier, back-tier)
- Some services running multiple instances
- Next, we'll look at doing this across multiple machines

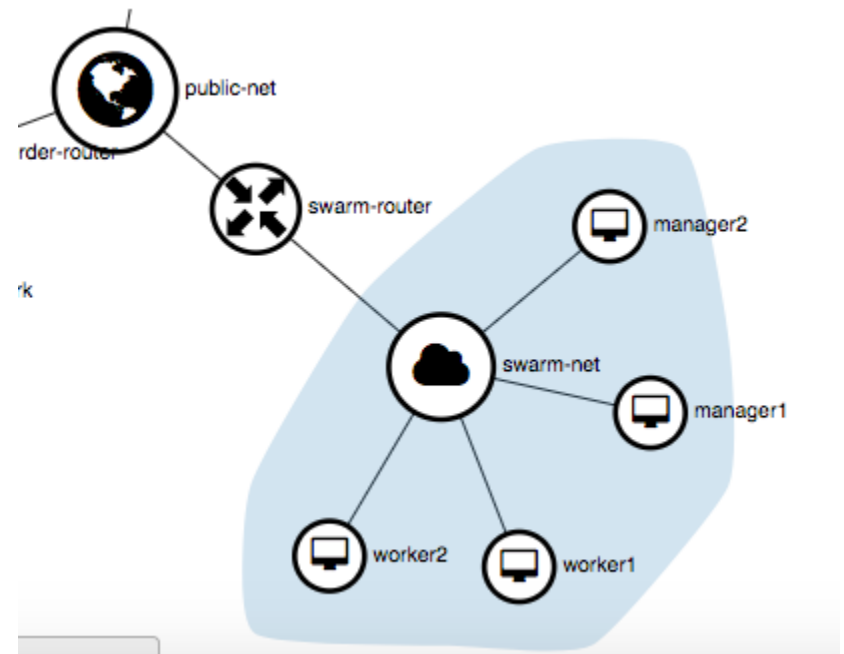
Running apps in the cloud

Goals

- Set up cluster of multiple machines
 - Catalyst Cloud (OpenStack)
- Install Docker on each machine
- Initialise a swarm
- Deploy our voting app
- Run through a few typical scenarios
 - Rolling update with *vote:v2*
 - Drain node for maintenance

Setting up cluster

- Need to:
 - provision machines
 - set up router(s)
 - set up security groups
- Preferable to use automation tools:
 - Chef
 - Puppet
 - Terraform
 - Ansible



Create a cluster

```
$ cd ~/catalystcloud-ansible/example-playbooks/docker-swarm-mode
$ ansible-playbook --ask-sudo-pass \
  --extra-vars "suffix=-$(hostname)" \
  create-swarm-hosts.yaml
```

Create Swarm

```
$ ssh manager<TAB><ENTER>  
$ docker swarm init
```

```
ubuntu@manager1-trainingpc:~$ docker swarm init
```



00:05



Copy the `docker swarm join ...` command that is
output

Join Worker Nodes

Paste the command from the manager node onto command line.

```
$ ssh worker1<TAB><ENTER>  
$ docker swarm join --token $TOKEN 192.168.99.100:2377
```

```
ubuntu@worker1-trainingpc:~$
```



00:00



Repeat this for worker2

Check nodes

```
$ docker node ls
```

```
ubuntu@manager1-trainingpc:~$
```



00:00



Deploying voting app

Upload docker-stack.yaml to manager node

```
$ cd ~/example-voting-app  
$ scp docker-stack.yaml manager1-TRAININGPC:~/
```

Deploy application

```
$ docker stack deploy -c docker-stack.yml vote
```

```
ubuntu@manager1-trainingpc:~$ docker stack deploy -c docker-stack.yml vote
Creating network vote_backend
Creating network vote_frontend
Creating network vote_default
Creating service vote_redis
Creating service vote_db
```

▶ 00:00



Recorded with [asciinema](#)

Monitor deploy progress

```
$ watch docker stack ps vote
```

```
$ watch docker service ls
```

Try out the voting app

<http://voting.app:5000>

To vote

<http://voting.app:5001>

To see results

<http://voting.app:8080>

To visualise running containers

Scale services

```
$ docker service scale vote_vote=3
```

Look at the changes in the **visualizer**

Update a service

```
$ docker service update --image heytrav/vote vote_vote
```

```
ubuntu@manager1-trainingpc:~$ docker service update --image heytrav/vote
```



00:13



Now go to the **voting app** and verify the change

Developer workflow

- Push code to repository
- Continuous Integration (CI) system runs tests
- If tests successful, automate image build & push to a docker registry
- Manually/automatically run docker service update
- Easy to setup with existing services and automation tools like Ansible
 - DockerHub (eg. [these slides](#))
 - GitHub
 - CircleCI
 - GitLab
 - Quay.io

Drain a node

```
$ docker node update --availability drain worker1
```

- Sometimes necessary to take host offline
 - Planned maintenance
 - Patching vulnerabilities
 - Resizing host
- Prevents node from receiving new tasks
- Manager stops tasks running on node and launches replicas on active nodes

Return node to service

```
$ docker node update --availability active worker1
```

- during a service update to scale up
- during a rolling update
- when you set another node to Drain availability
- when a task fails on another active node

Summary

- Created a cluster with a cloud provider using ansible
 - 1 manager node
 - 2 worker nodes
- Deployed microservice for voting app in Docker Swarm
- Scaled service from 2 to 3 services
- Rolling-Updated image

Tear down your cluster

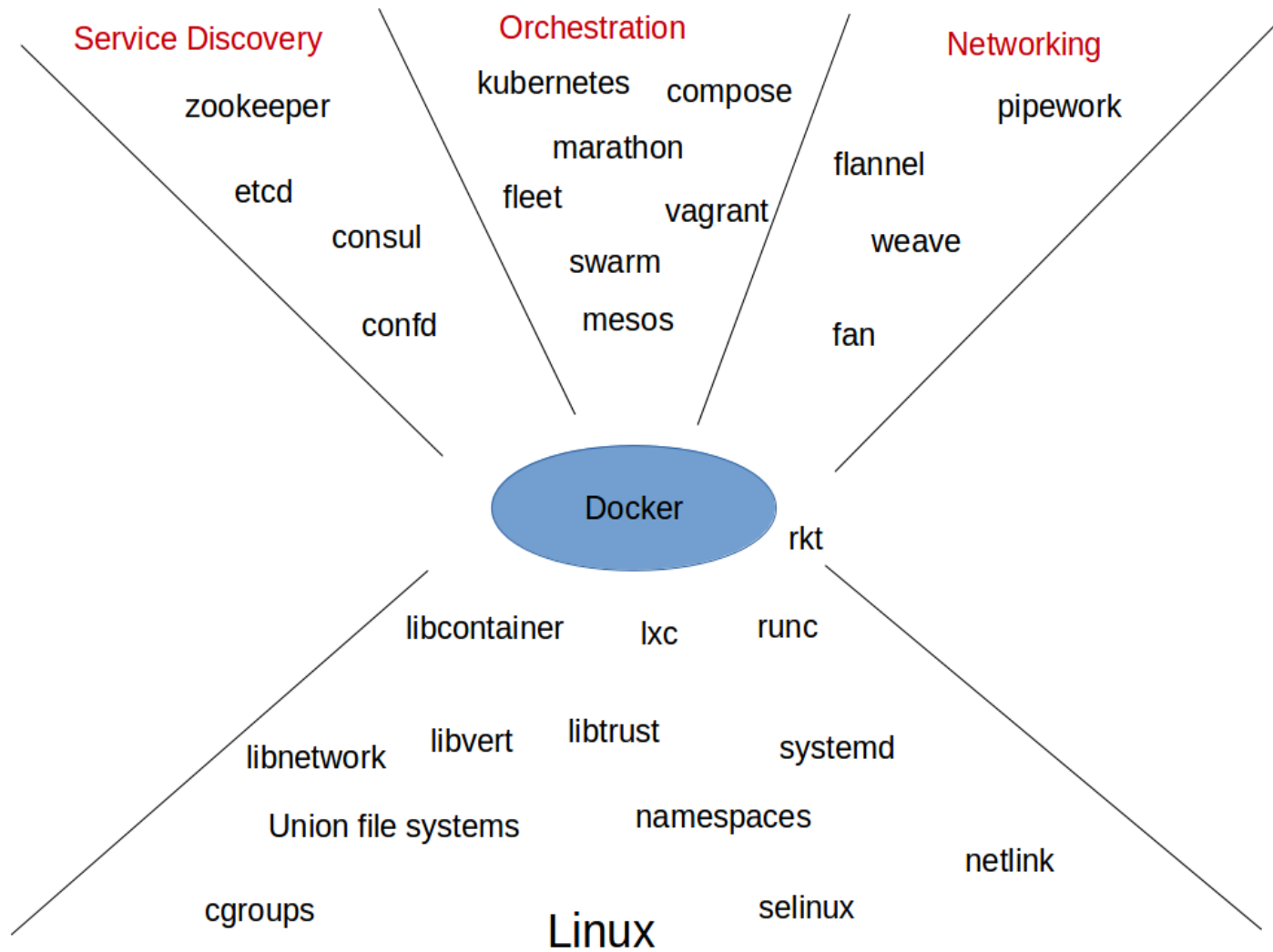
```
$ ansible-playbook -K --extra-vars "suffix=-$(hostname )" remove-swarm.
```

Wrap up

Docker ecosystem

- An explosion of tools
- Hard to keep up
- Lets have a quick look

Docker ecosystem



Competing technologies

- rkt (CoreOS)
- Serverless (FaaS)
 - Lambda (AWS)
 - Azure Functions (Microsoft)
 - Google cloud functions
 - iron.io

The end