

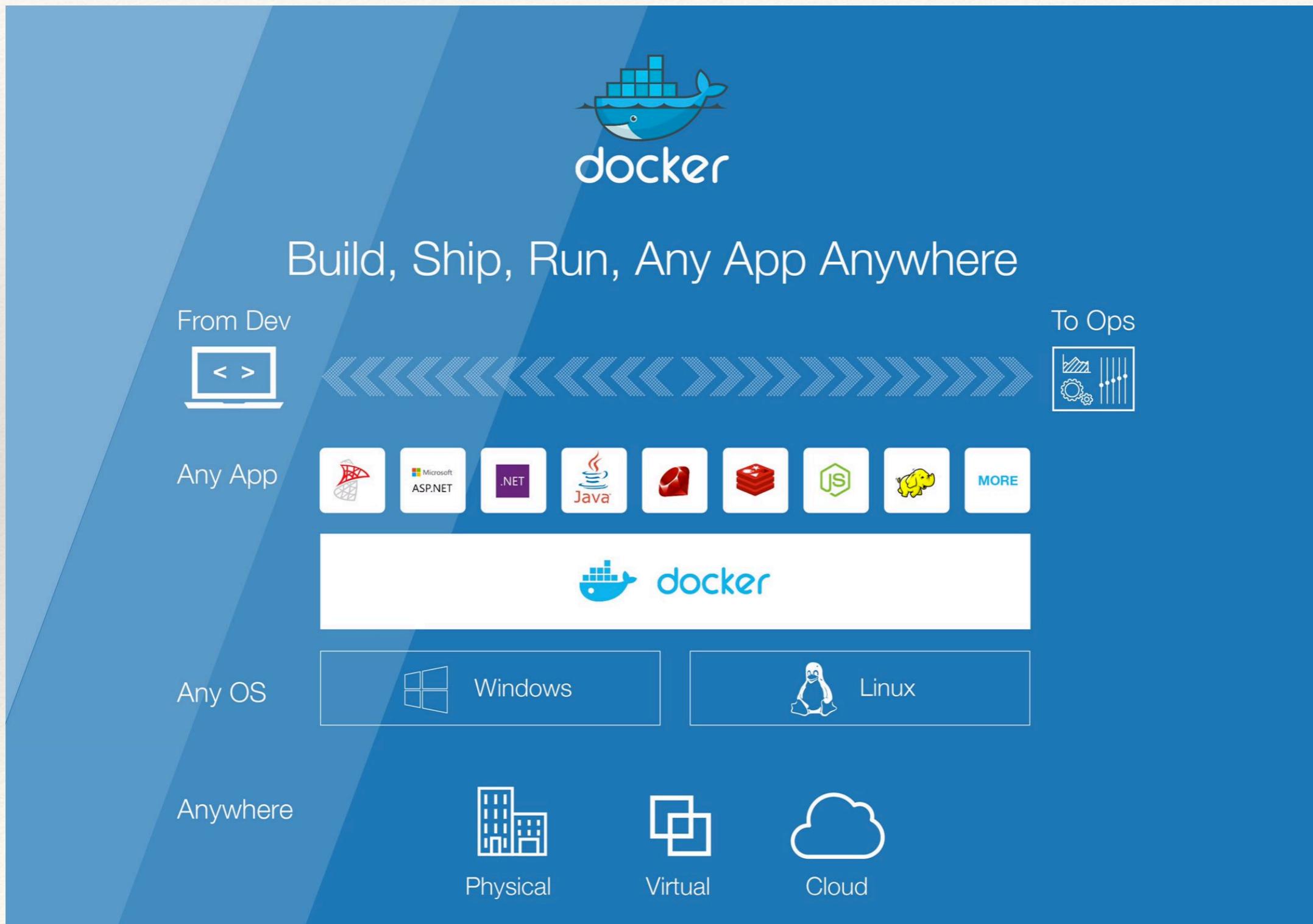
# Docker by Example



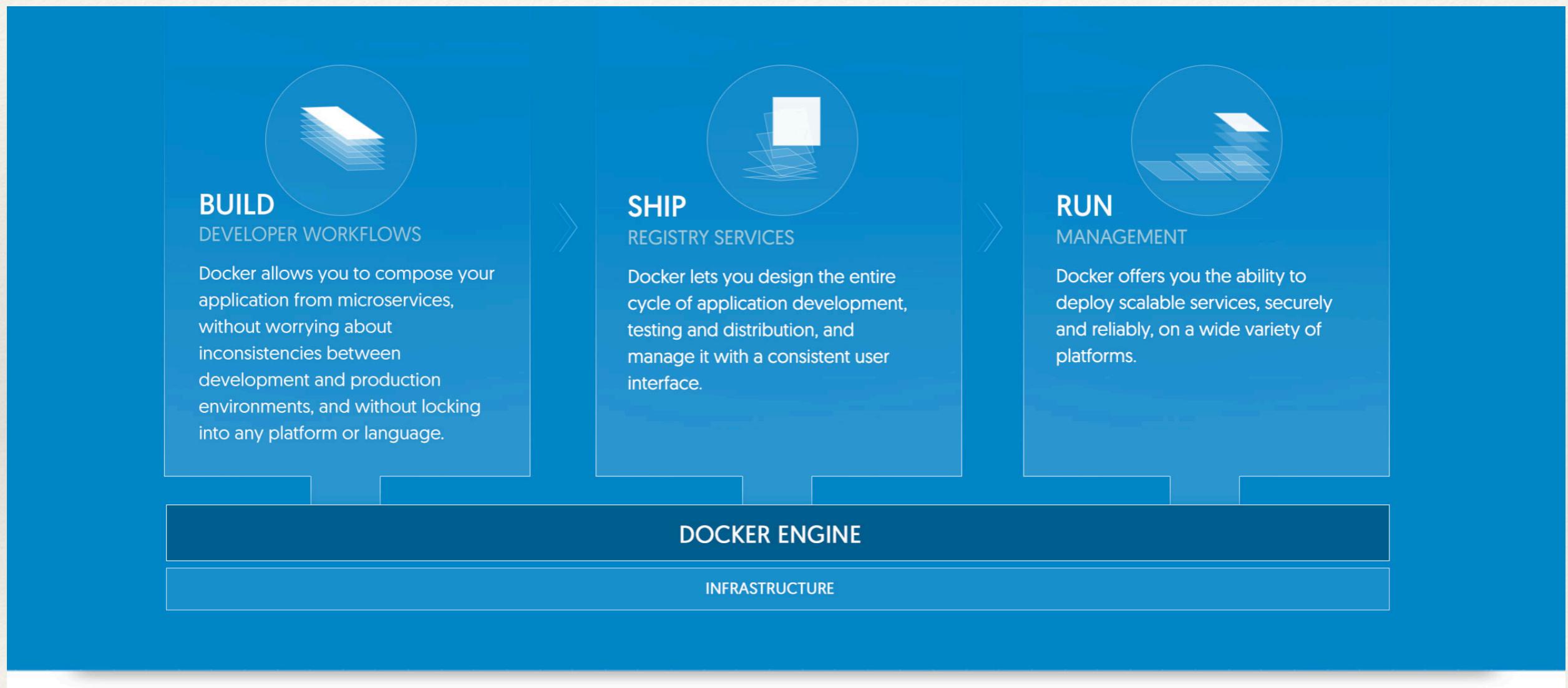
## Using a Visual Approach

Ganesh & Hari  
[ganesh@codeops.tech](mailto:ganesh@codeops.tech)  
[hari@codeops.tech](mailto:hari@codeops.tech)

# Why Docker?

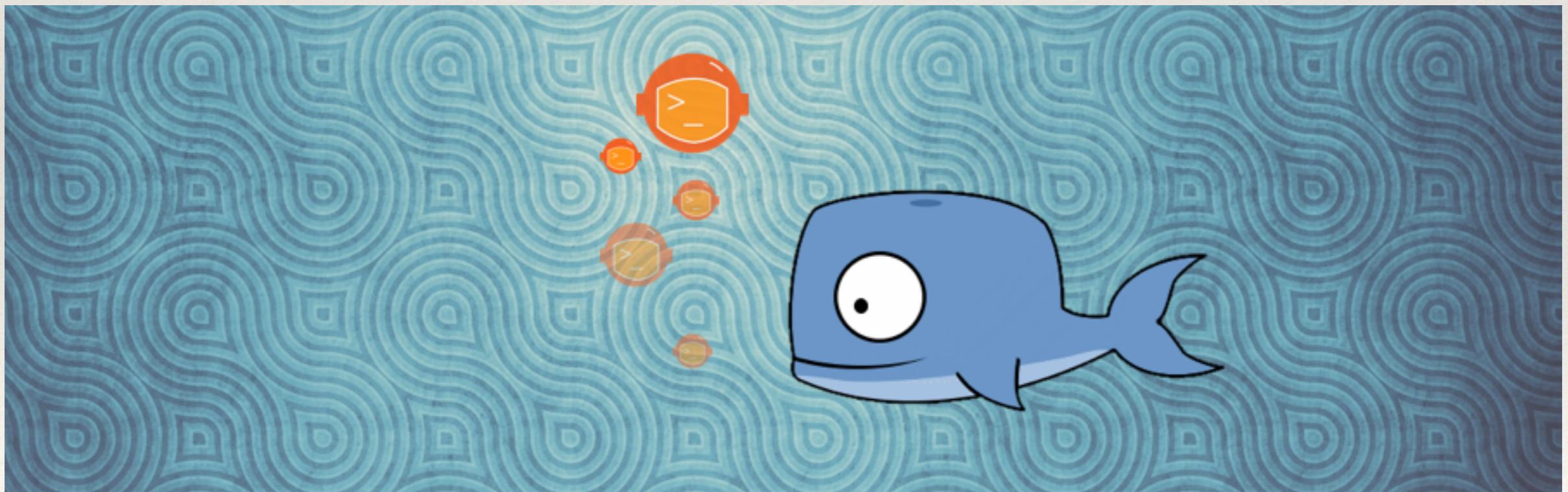


# Why Docker?



# What is Docker?

Docker is an open-source project that automates the deployment of applications inside software containers.



# What is Docker?

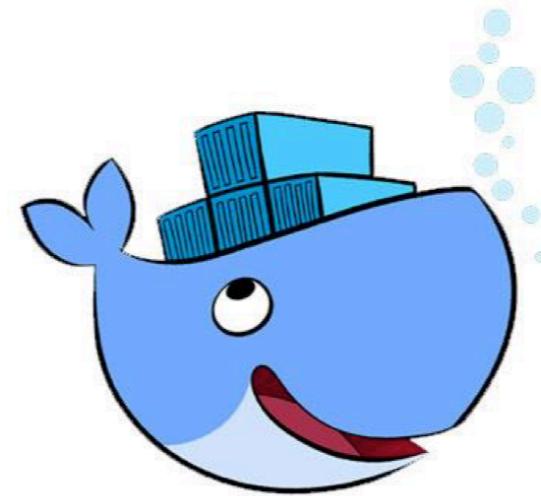
“an open platform for developers and sysadmins to build, ship, and run distributed applications”



# What is Docker?

Docker	
	docker
<b>Original author(s)</b>	Solomon Hykes
<b>Developer(s)</b>	Docker, Inc.
<b>Initial release</b>	13 March 2013; 3 years ago
<b>Stable release</b>	1.11.2 <sup>[1]</sup> / 31 May 2016; 36 days ago
<b>Written in</b>	Go <sup>[2]</sup>
<b>Operating system</b>	Linux <sup>[a]</sup>
<b>Platform</b>	x86-64 with modern Linux kernel
<b>Type</b>	Operating-system-level virtualization
<b>License</b>	Apache License 2.0
<b>Website</b>	<a href="http://www.docker.com">www.docker.com</a> ↗

# Pop quiz

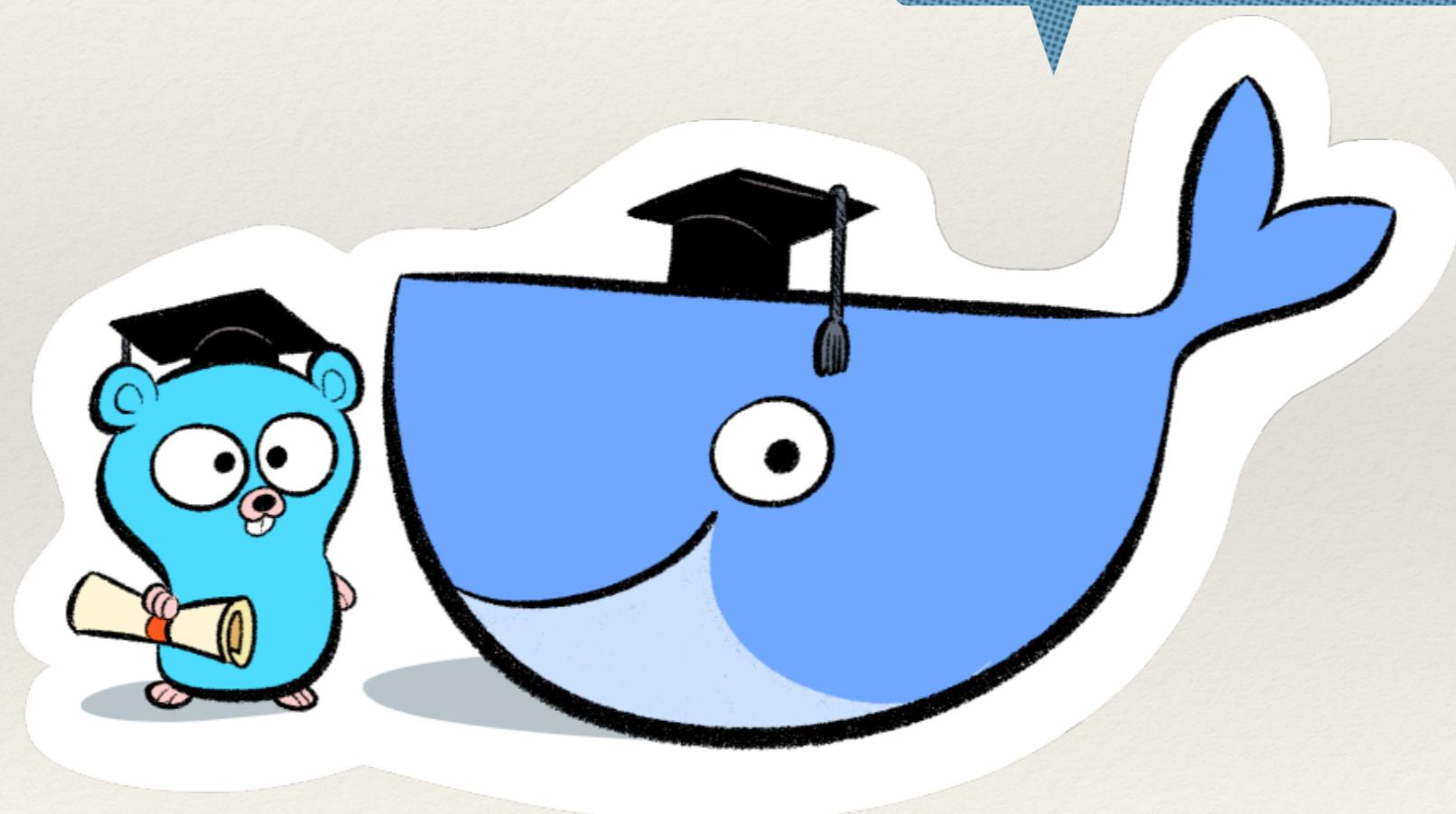


**Docker is written in:**

- A. Java language
- B. C language
- C. D language
- D. Go language

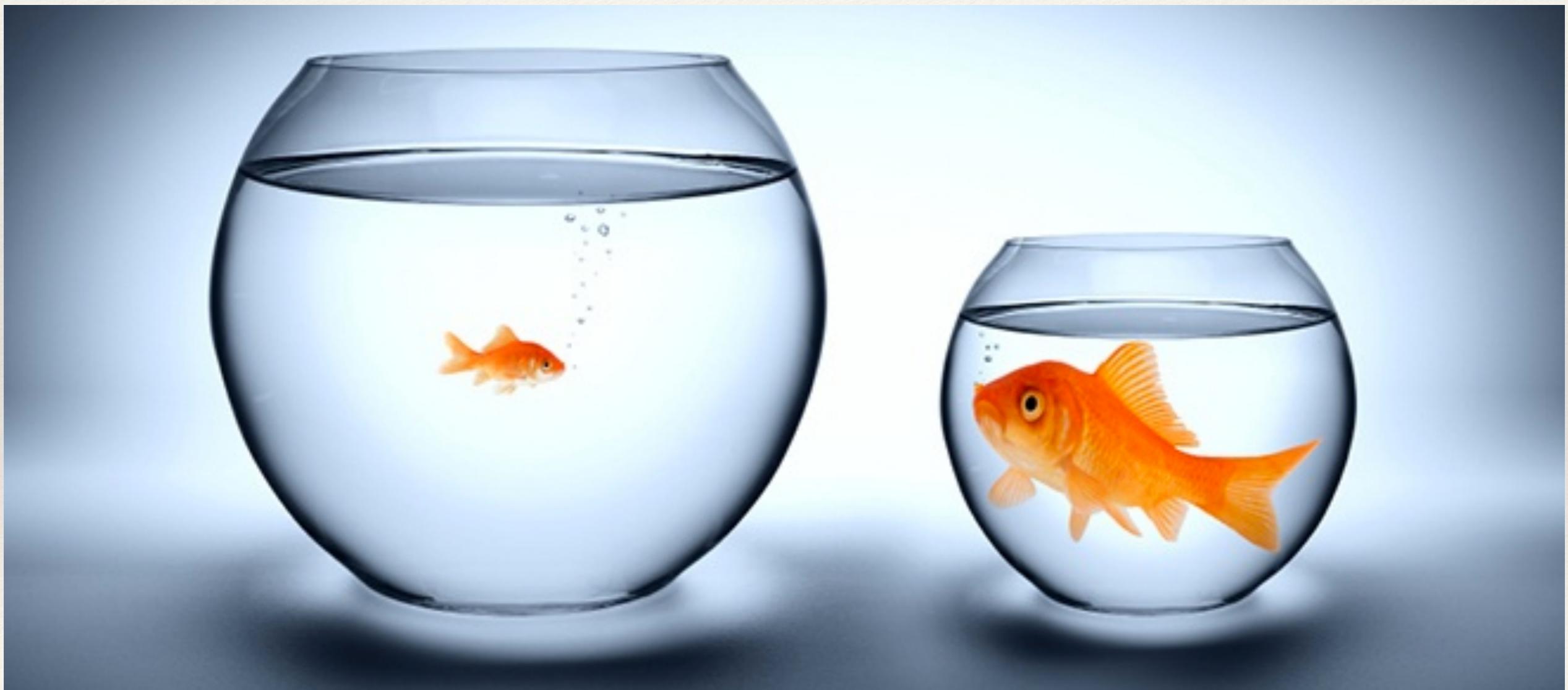
# Pop quiz: answer

Docker is written in  
Go language



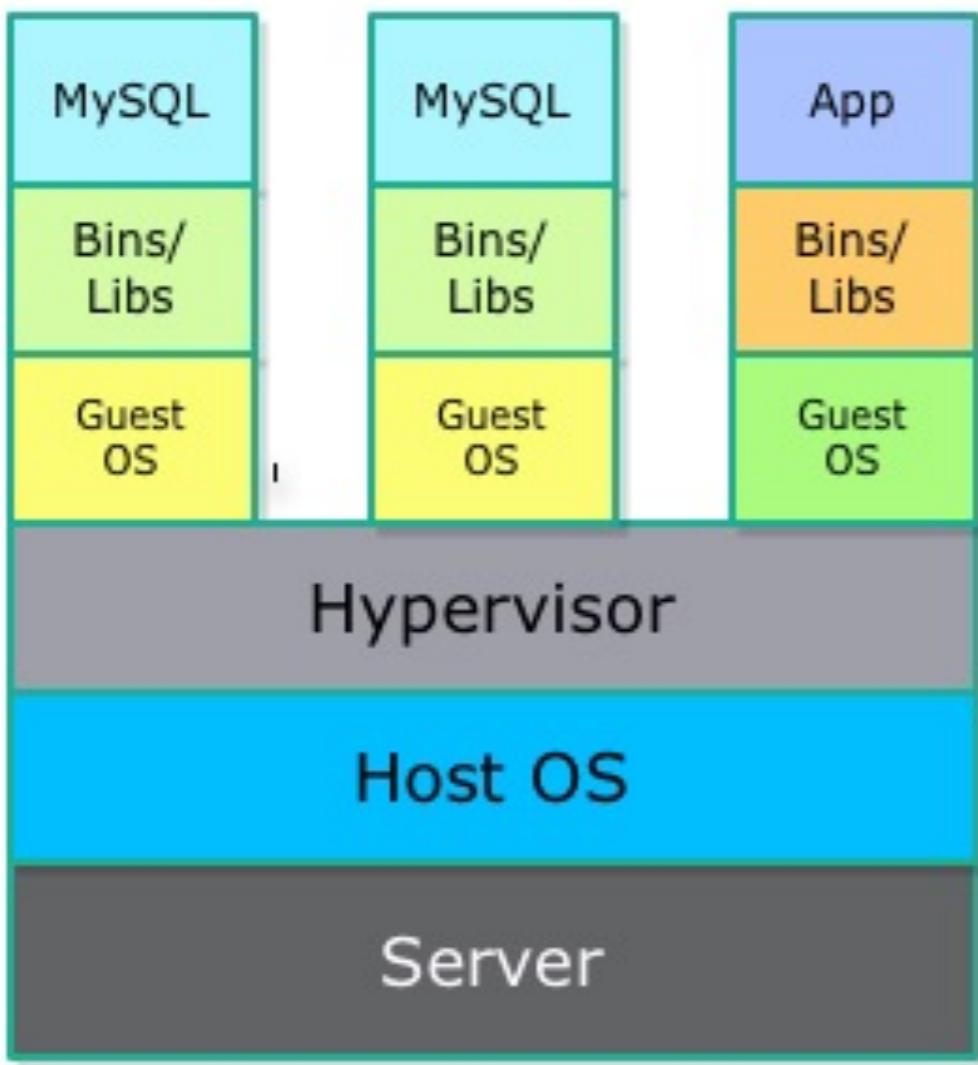
Good read: [Why Did We Decide to Write Docker in Go?](#)

# VMs vs. Docker

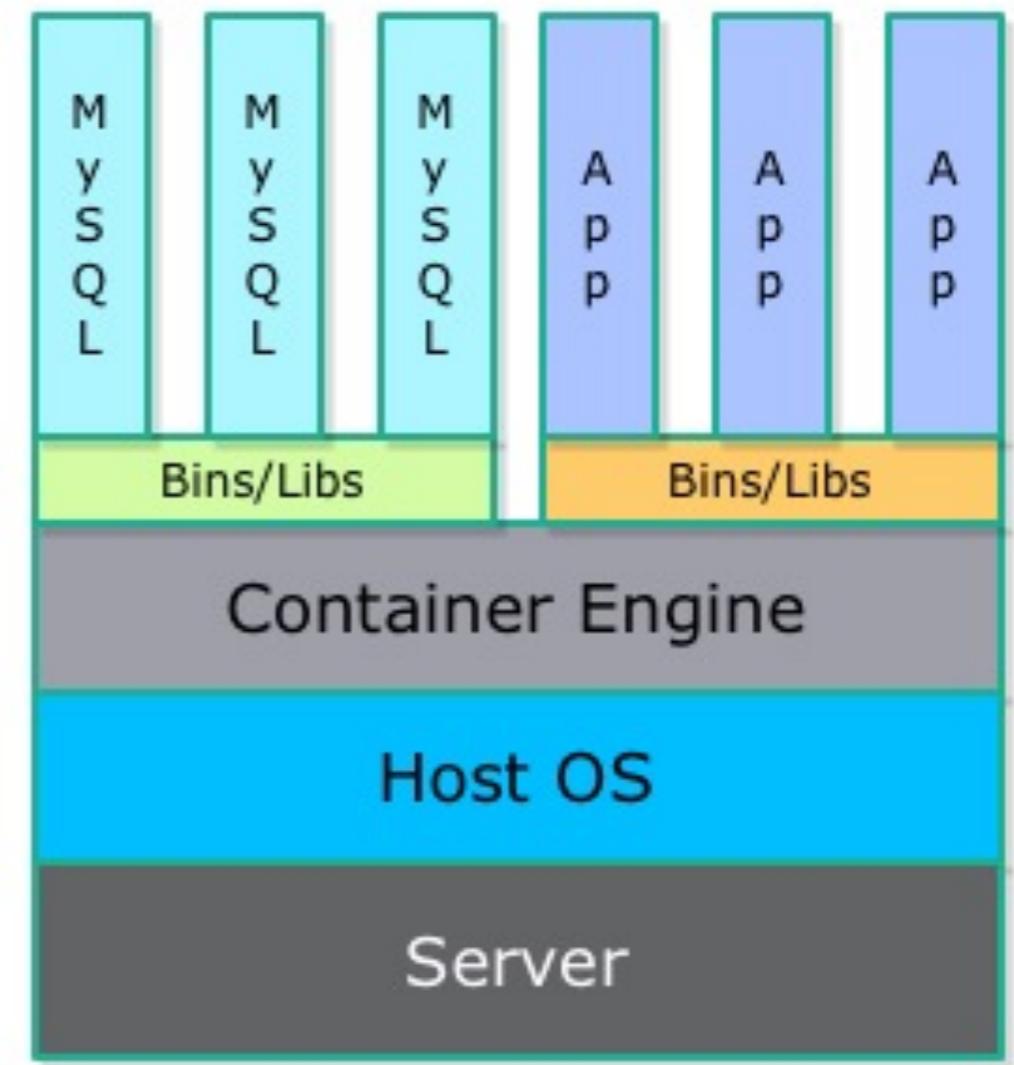


# VMs vs. Docker

Virtual Machines



Containers



# VMs vs. containers

Simulates a physical machine

Provides a local file system

Can be accessed over a network

Full and independent guest operating system

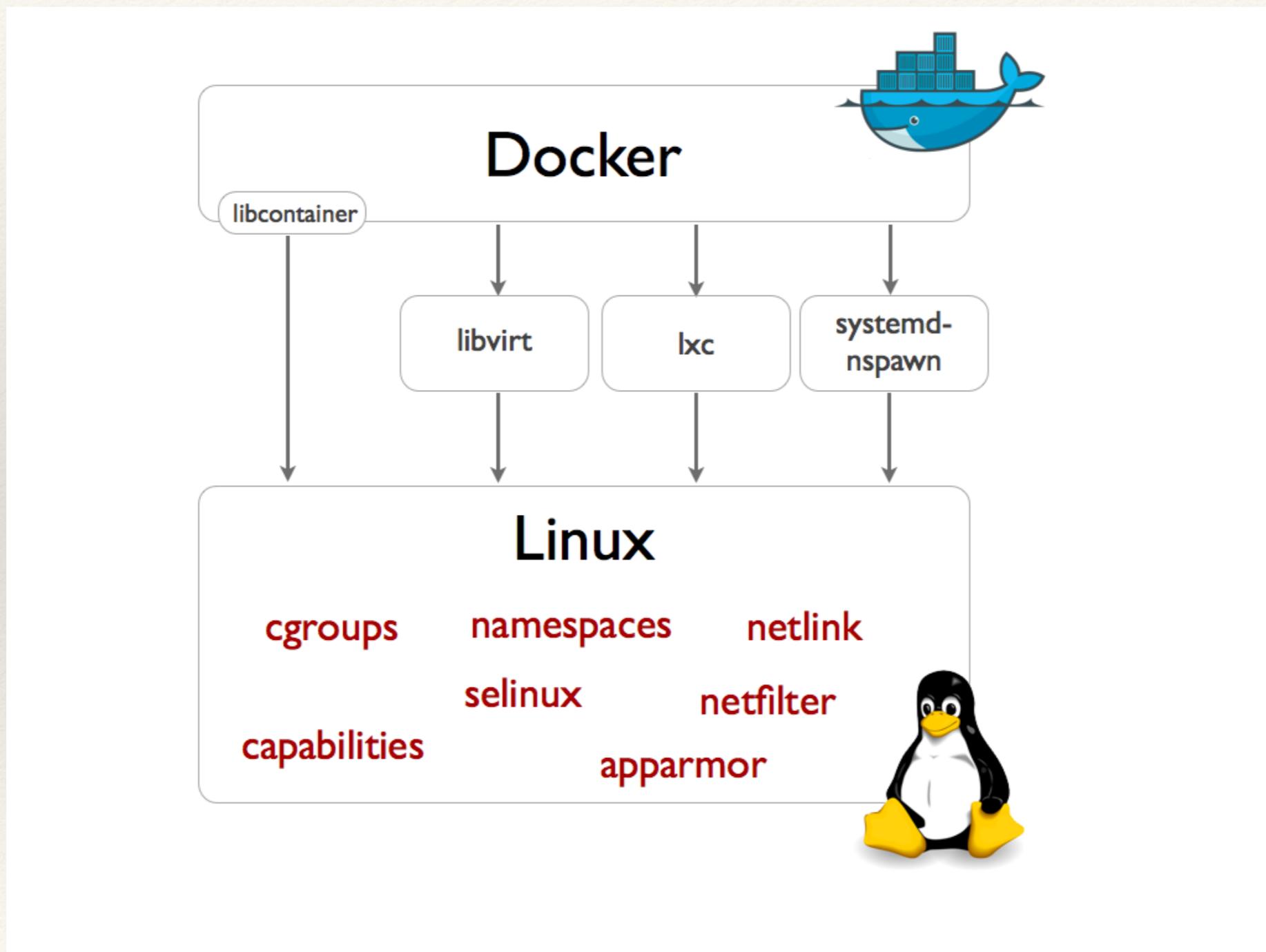
Virtualized device drivers

Strong resource and memory management

Huge memory foot-print

Needs a hypervisor

# Docker accesses virtualisation features of Linux



# Native Docker support on Windows

Docker and Microsoft delivers integrated tooling across the application lifecycle



Build



Source: <https://i2.wp.com/blog.docker.com/wp-content/uploads/windows.png?w=975&ssl=1>



Ship



Run

Visual Studio Tools  
for DockerDocker for  
Windows

Library of Microsoft  
images on Docker Hub



Docker Datacenter for orchestration,  
management and security



Microsoft Operations Management Suite  
for hybrid cloud visibility and control



Windows Server

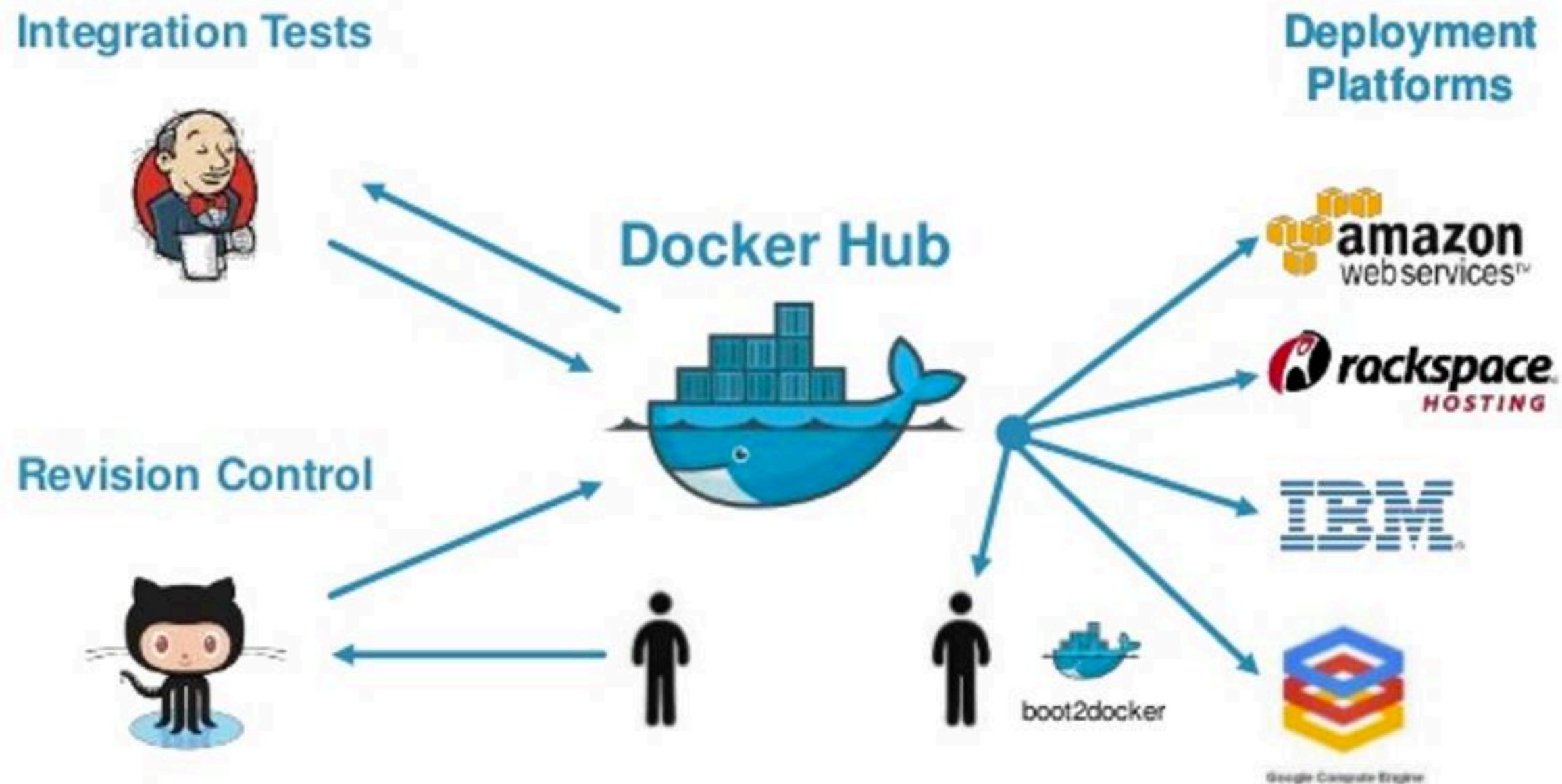
Docker containers available for Windows  
Server running on any infrastructure



Microsoft  
Hyper-V



# Docker for DevOps

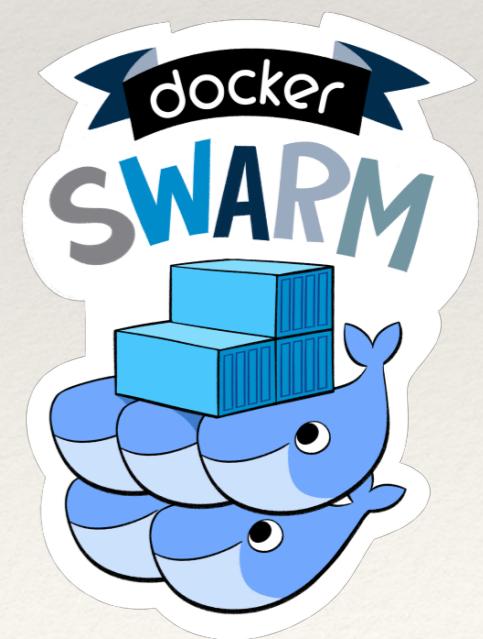
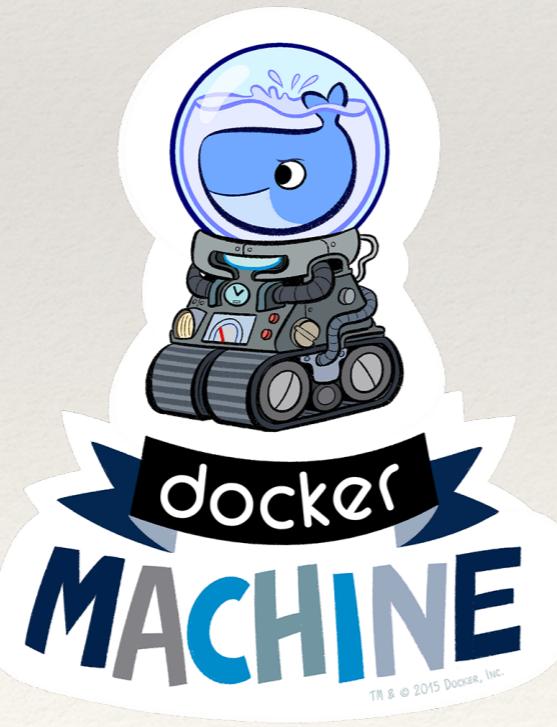
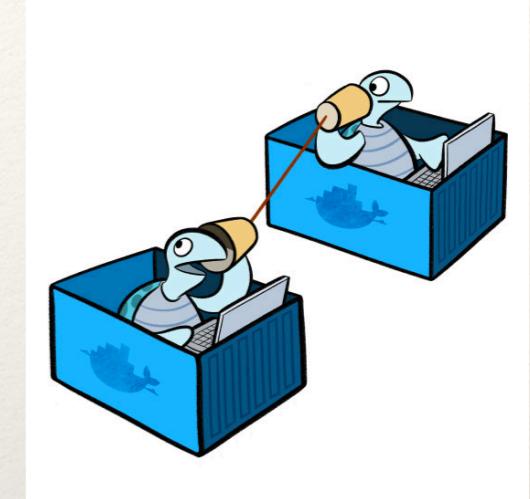
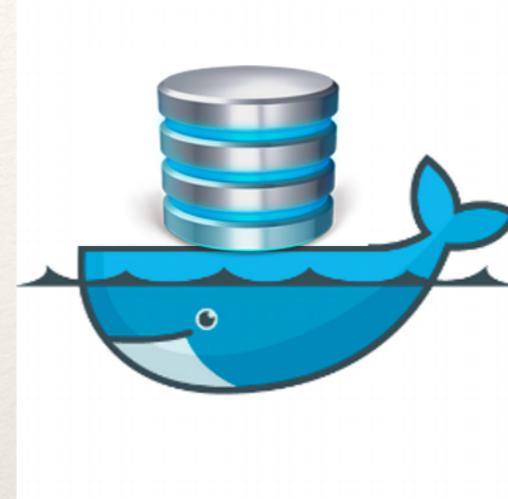
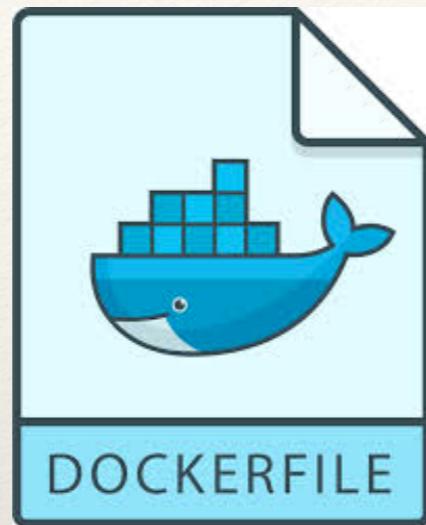
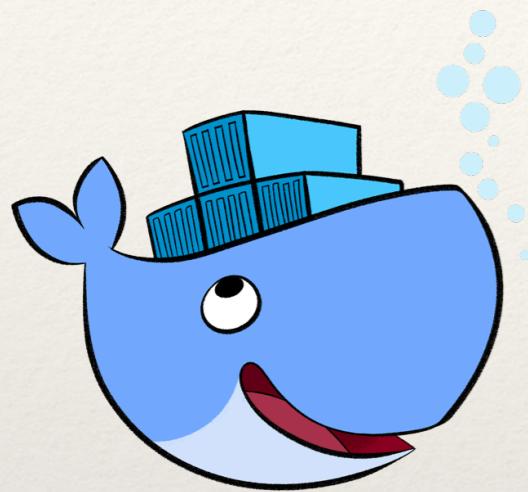


# Docker becoming popular over time



Google Trends: <https://www.google.co.uk/trends/explore?q=%2Fm%2F0wkcjgj&hl=en-US>

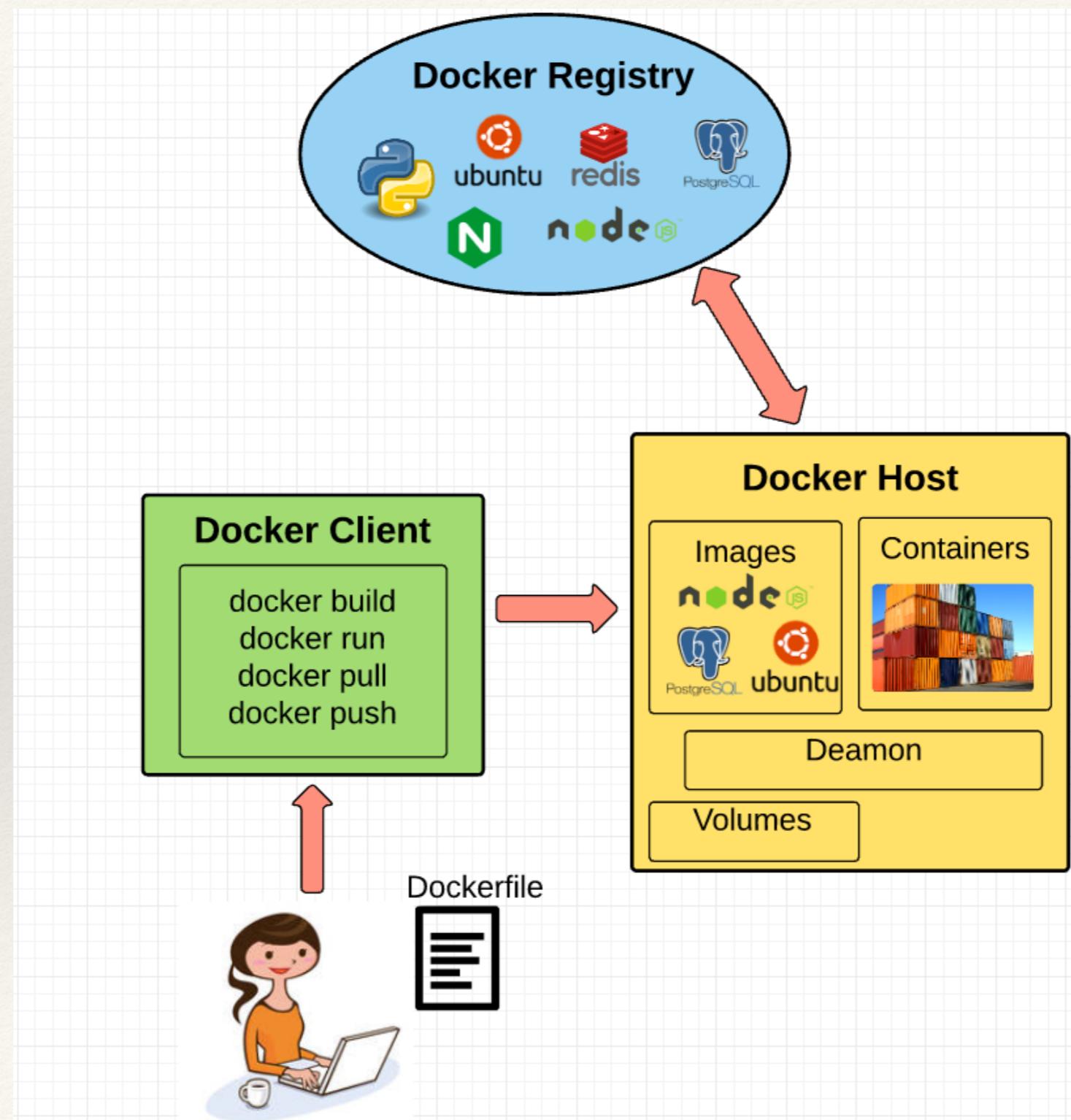
# What's covered in this session?



# Getting Started



# Essential Docker components



# Installing Docker

Install it from “<https://www.docker.com/products/overview>”

## INSTALL THE PLATFORM

Install Docker with easy to use installers for the major desktop and cloud platforms.



### MAC

A native Mac application with a user interface and auto-update capabilities, that is deeply integrated with OS X native virtualization.

[Learn More](#)

### WINDOWS

A native Windows application with a user interface and auto-update capabilities, that is deeply integrated with Windows native virtualization.

[Learn More](#)

### LINUX

Install Docker on nodes which have a Linux distribution already installed.

[Learn More](#)

### AWS

Quickly deploy, scale, and manage Docker on AWS. Docker for AWS takes optimal advantage of the underlying infrastructure, while providing a modern Docker platform that can be used to deploy portable apps.

[Learn More](#)

### AZURE

Quickly deploy, scale and manage Docker on Azure. Docker for Azure takes optimal advantage of the underlying infrastructure, while providing a modern Docker platform that can be used to deploy portable apps.

[Learn More](#)

### OTHERS

For platforms without a Docker installer, easily setup Docker using Docker Machine.

[Learn More](#)

# Official Docker images?

From “<https://hub.docker.com/explore/>”

 <b>nginx</b> official	3.5K STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>busybox</b> official	737 STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>ubuntu</b> official	4.3K STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>redis</b> official	2.4K STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>registry</b> official	950 STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>swarm</b> official	410 STARS	10M+ PULLS	<a href="#">DETAILS</a>
 <b>mongo</b> official	2.1K STARS	10M+ PULLS	<a href="#">DETAILS</a>

# Finding Docker version

```
mydocker — bash — 47x19
$ docker version
Client:
  Version:      1.12.0-rc4
  API version:  1.24
  Go version:   go1.6.2
  Git commit:   e4a0dbc
  Built:        Wed Jul 13 03:28:51 2016
  OS/Arch:      darwin/amd64
  Experimental: true

Server:
  Version:      1.12.0-rc4
  API version:  1.24
  Go version:   go1.6.2
  Git commit:   e4a0dbc
  Built:        Wed Jul 13 03:28:51 2016
  OS/Arch:      linux/amd64
  Experimental: true
$
```

# How to find my Docker version?

```
$ docker -v  
Docker version 1.12.0-rc4, build e4a0dbc, experimental
```

# Finding details of a Docker installation



The screenshot shows a terminal window titled "mydocker — -bash — 79x42". The window contains the output of the "docker info" command. The output provides detailed information about the Docker daemon's configuration and host system. Key details include:

- Containers: 36 (Running: 0, Paused: 0, Stopped: 36)
- Images: 44
- Server Version: 1.12.0-rc4
- Storage Driver: aufs (Root Dir: /var/lib/docker/aufs, Backing Filesystem: extfs, Dirs: 142, Dirperm1 Supported: true)
- Logging Driver: json-file
- Cgroup Driver: cgroupfs
- Plugins:
  - Volume: local
  - Network: host bridge null overlay
- Swarm: inactive
- Runtimes: runc
- Default Runtime: runc
- Security Options: seccomp
- Kernel Version: 4.4.15-moby
- Operating System: Alpine Linux v3.4
- OSType: linux
- Architecture: x86\_64
- CPUs: 2
- Total Memory: 1.954 GiB
- Name: moby
- ID: BJ3B:7ZHJ:BDQ2:X7BQ:3KBZ:XQI5:ID7C:VIFW:755U:0STC:ZX2B:JNX6
- Docker Root Dir: /var/lib/docker
- Debug Mode (client): false
- Debug Mode (server): true
  - File Descriptors: 18
  - Goroutines: 29
  - System Time: 2016-07-19T15:43:54.215107093Z
  - EventsListeners: 1
- No Proxy: \*.local, 169.254/16
- Registry: https://index.docker.io/v1/
- Experimental: true
- Insecure Registries:
  - 127.0.0.0/8

\$

# Can I install Docker from cmdline?

Yes! from [get.docker.com](https://get.docker.com/)

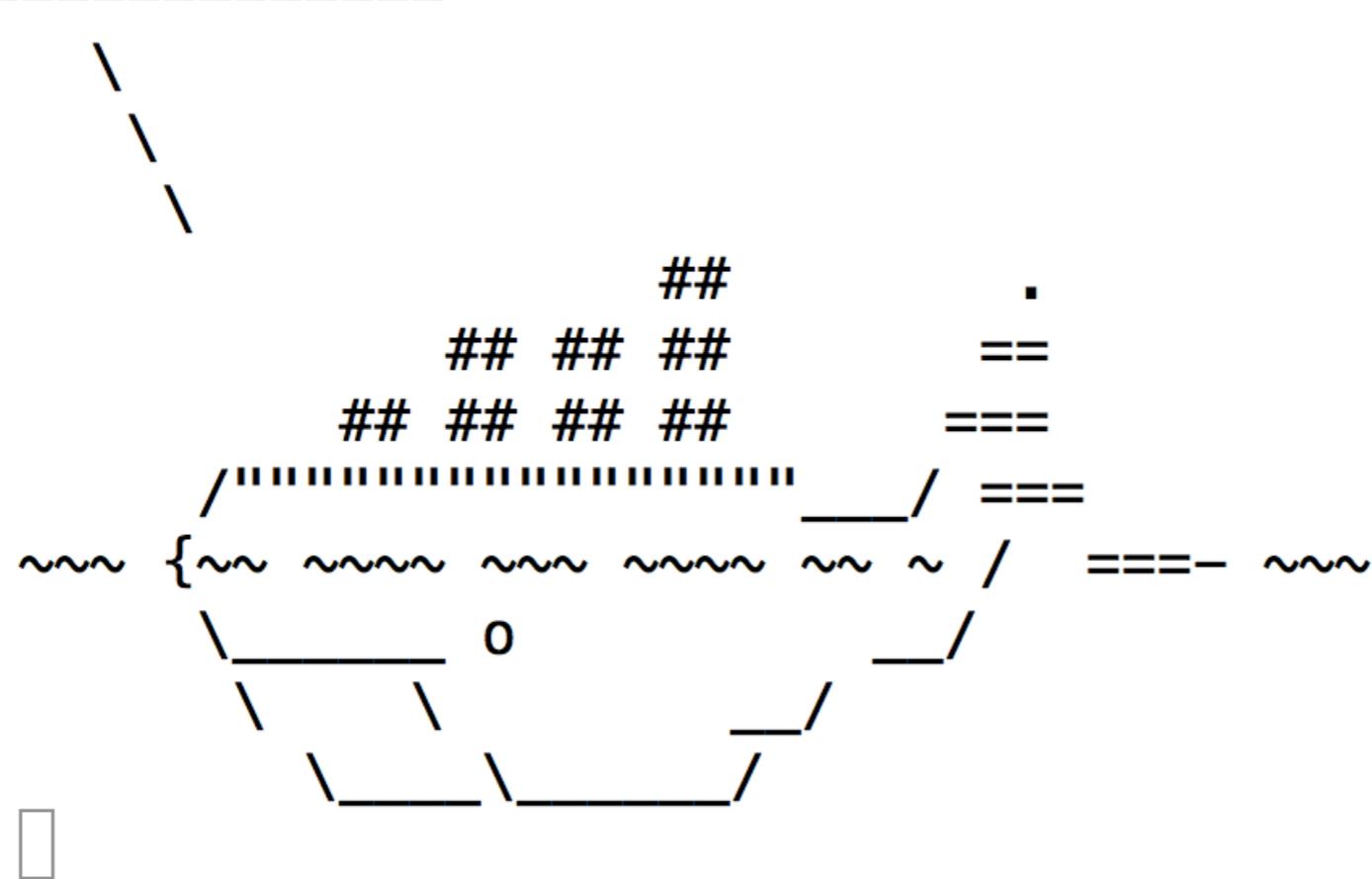
```
# This script is meant for quick & easy install via:  
# 'curl -sSL https://get.docker.com/ | sh'  
# or:  
# 'wget -qO- https://get.docker.com/ | sh'
```

# How to do “hello world” in Docker?

```
$ docker run docker/whalesay cowsay Hello world
```

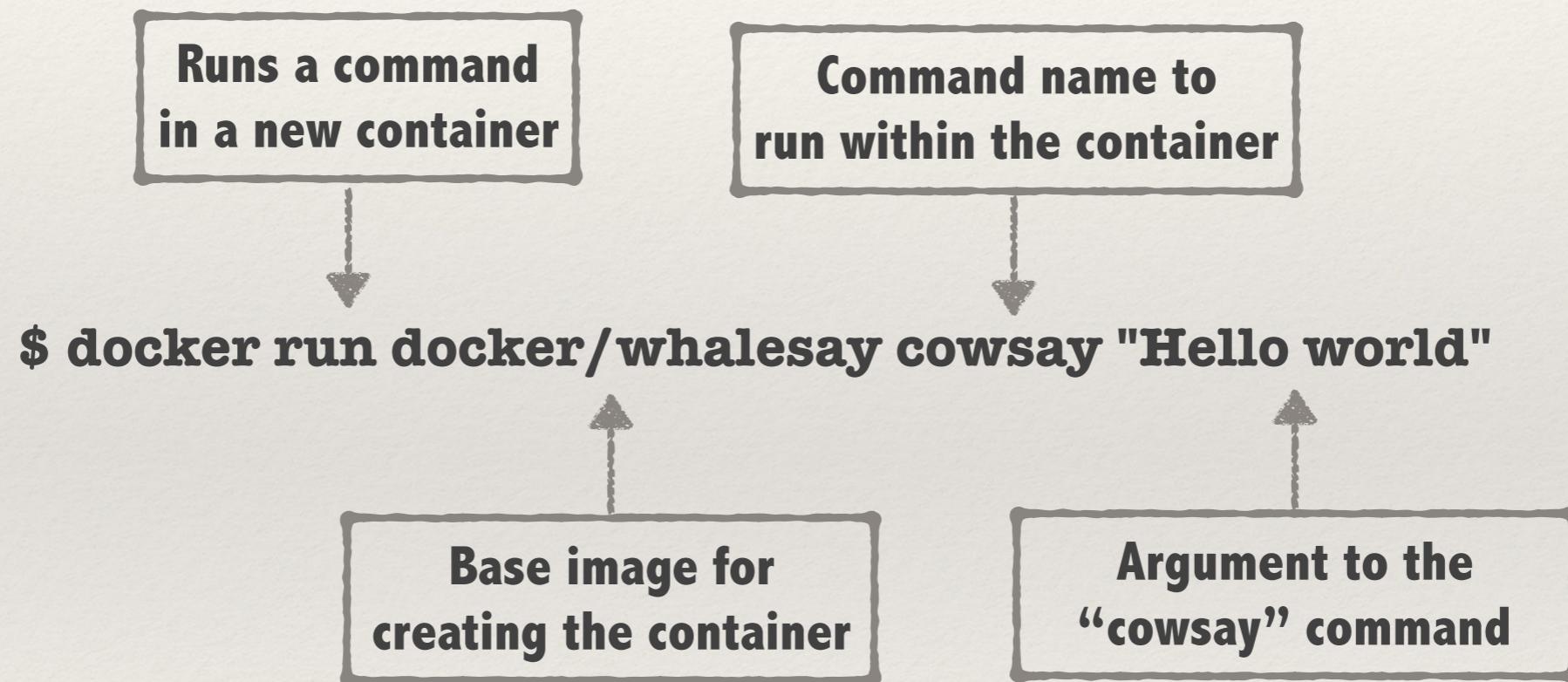
```
[\$ docker run docker/whalesay cowsay Hello world
```

```
< Hello world >
```



```
$ █
```

# How to do “hello world” in Docker?



# How to do “hello world” in Docker?

**\$ docker run -it hello-world**

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

Hello from Docker!

This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:

1. The Docker client contacted the Docker daemon.
2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
3. The Docker daemon created a new container from that image which runs the executable that produces the output you are currently reading.
4. The Docker daemon streamed that output to the Docker client, which sent it to your terminal.

To try something more ambitious, you can run an Ubuntu container with:

```
$ docker run -it ubuntu bash
```

Share images, automate workflows, and more with a free Docker Hub account:

<https://hub.docker.com>

For more examples and ideas, visit:

<https://docs.docker.com/engine/userguide/>

# How to get help on commands to use?

**Use “docker -h” command, as in:**

```
$ docker -h
Usage: docker [OPTIONS] COMMAND [arg...]
      docker [ --help | -v | --version ]
```

A self-sufficient runtime for containers.

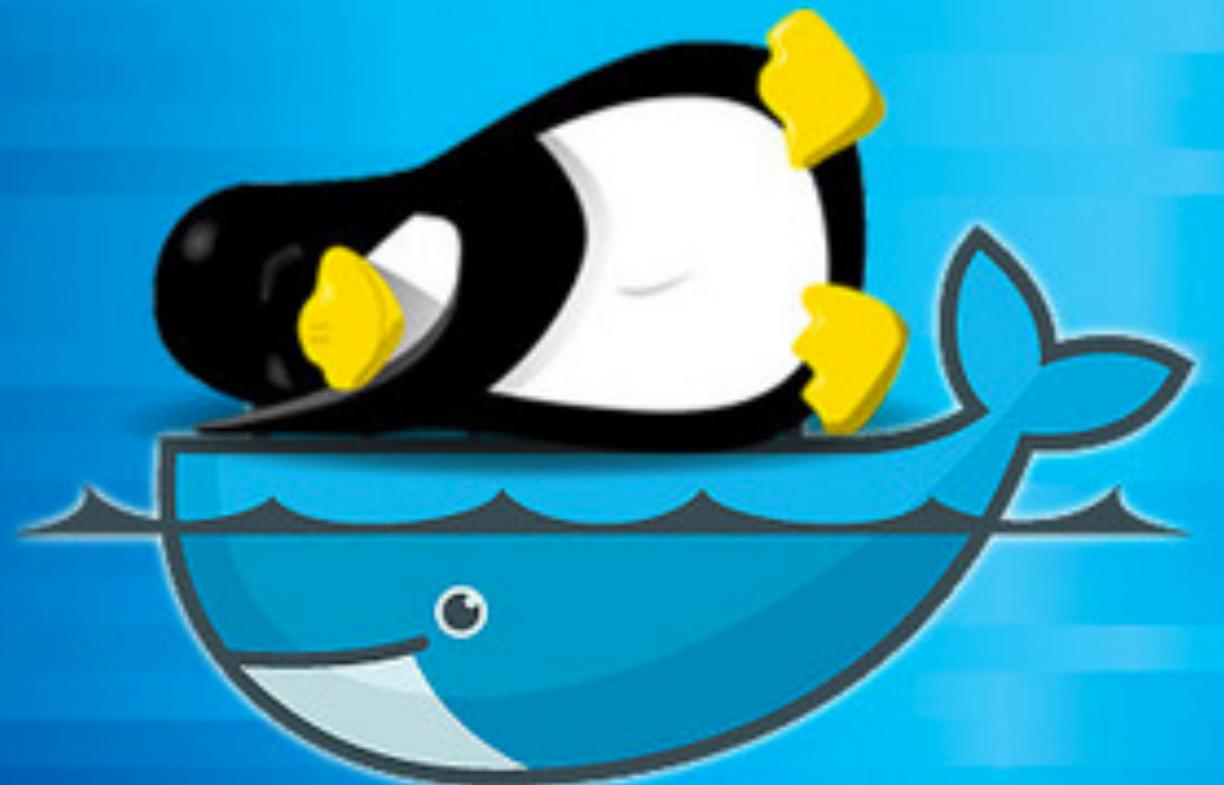
Options:

--config=~/.docker	Location of client config files
-D, --debug	Enable debug mode
-H, --host=[]	Daemon socket(s) to connect to
-h, --help	Print usage
-l, --log-level=info	Set the logging level

...

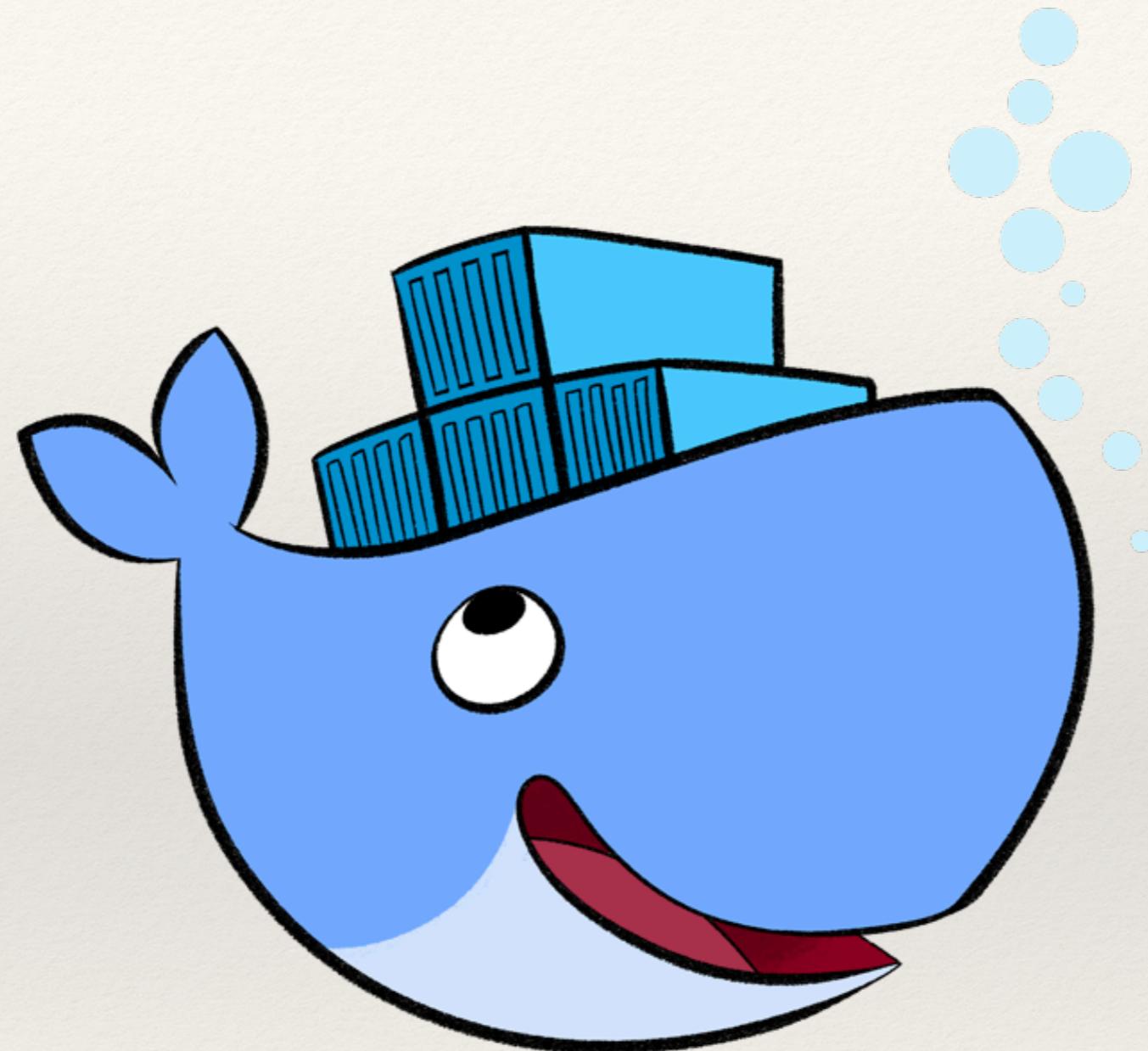
Commands:

attach	Attach to a running container
--------	-------------------------------



Docker commands look like Linux commands - so familiarity with Linux commands can really help to get up to speed quickly with Docker.

# Docker Images



# How to get list of images?

\$ docker images	REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
	prasantk/average	latest	de756e5f8b96	10 days ago	34.22 MB
	<none>	<none>	3d02168f00fc	10 days ago	34.22 MB
	<none>	<none>	d3a03f4665ab	10 days ago	34.22 MB
	<none>	<none>	827527375287	10 days ago	34.22 MB
	<none>	<none>	264584ac458e	10 days ago	745.6 MB
	python	3.5	7fd24fb1b492	10 days ago	686 MB
	example/docker-node-hello	latest	92baf9b777b8	2 weeks ago	658.6 MB
	centos	latest	05188b417f30	2 weeks ago	196.8 MB
	hello-world	latest	c54a2cc56cbb	2 weeks ago	1.848 kB
	ubuntu	latest	0f192147631d	2 weeks ago	132.8 MB
	node	0.10	8beaba2e26be	3 weeks ago	642.4 MB
	alpine	latest	4e38e38c8ce0	3 weeks ago	4.799 MB
	fedora	latest	f9873d530588	4 weeks ago	204.4 MB
	nginx	latest	0d409d33b27e	6 weeks ago	182.8 MB
	docker/whalesay	latest	6b362a9f73eb	14 months ago	247 MB
	training/webapp	latest	6fae60ef3446	14 months ago	348.8 MB
	progrium/stress	latest	db646a8f4087	2 years ago	281.8 MB

# How to search for an image?

```
$ docker search debian
```

NAME	DESCRIPTION	STARS	OFFICIAL	AUTOMATED
debian	Debian is a Linux distribution that's comp...	1503	[OK]	
neurodebian	NeuroDebian provides neuroscience research...	25	[OK]	
armbuild/debian	ARMHF port of debian	8		[OK]
jesselang/debian-vagrant	Stock Debian Images made Vagrant-friendly ...	8		[OK]
eboraas/debian	Debian base images, for all currently-avai...	5		[OK]
mschuerig/debian-subsonic	Subsonic 5.1 on Debian/wheezy.	4		[OK]
reinblau/debian	Debian with usefully default packages for ...	2		[OK]
webhippie/debian	Docker images for debian	1		[OK]
datenbetrieb/debian	minor adaption of official upstream debian...	1		[OK]
opennsm/debian	Lightly modified Debian images for OpenNSM	1		[OK]
lucasbarros/debian	Basic image based on Debian	1		[OK]
lephare/debian	Base debian images	1		[OK]
eeacms/debian	Docker image for Debian to be used with EE...	1		[OK]
maxexcloo/debian	Docker base image built on Debian with Sup...	1		[OK]
servivum/debian	Debian Docker Base Image with Useful Tools	1		[OK]
konstruktoid/debian	Debian base image	0		[OK]
icedream/debian-jenkinsslave	Debian for Jenkins to be used as slaves.	0		[OK]
visono/debian	Docker base image of debian 7 with tools i...	0		[OK]
nimmis/debian	This is different version of Debian with a...	0		[OK]
vcatechnology/debian	A Debian image that is updated daily	0		[OK]
ustclug/debian	debian image for docker with rustic mirror	0		[OK]
fike/debian	Debian Images with language locale installed.	0		[OK]
pl31/debian	Debian base image.	0		[OK]
mariorez/debian	Debian Containers for PHP Projects	0		[OK]
gnumoksha/debian	[PT-BR] Imagem básica do Debian com ajust...	0		[OK]

```
$ □
```

# How to get an image?

Use “docker pull <image\_name>” command

```
$ docker pull debian
Using default tag: latest
latest: Pulling from library/debian
5c90d4a2d1a8: Already exists
Digest: sha256:8b1fc3a7a55c42e3445155b2f8f40c55de5f8bc8012992b26b570530c4bded9e
Status: Downloaded newer image for debian:latest
```

In my case debian image was already pulled. If it were not there, Docker would have pulled it afresh

# Choose smaller images

- ❖ Prefer choosing a smaller base image that provides equivalent functionality (for your requirement) instead of choosing a larger one
- ❖ Example: Choose Alpine vs. Fedora (5 MB vs. 205 MB)

alpine	latest	4e38e38c8ce0	4 weeks ago	4.799 MB
fedora	latest	f9873d530588	4 weeks ago	204.4 MB

# How to get details of an image?

Use “docker inspect <image\_name>” command

```
docker inspect debian
[
{
  "Id": "sha256:1b088884749bd93867ddb48ff404d4bbff09a17af8d95bc863efa5d133f87b78",
  "RepoTags": [
    "debian:latest"
  ],
  "RepoDigests": [
    "debian@sha256:8b1fc3a7a55c42e3445155b2f8f40c55de5f8bc8012992b26b570530c4bded9e"
  ],
  "Parent": "",
  "Comment": "",
  "Created": "2016-06-09T21:28:43.776404816Z",
  "Container": "2f3dc897cf758418389d50784c73b43b1fd7db09a80826329496f05eef7b377",
  "ContainerConfig": {
    "Hostname": "6250540837a8",
    "Domainname": "",
    "User": "",
    "AttachStdin": false,
    "AttachStdout": false,
    "AttachStderr": false,
    "Tty": false,
    "OpenStdin": false,
    // ...
  }
}
```

# How to see “layers” in an image?

Use “docker history <image\_name>” command

IMAGE	CREATED	CREATED BY	SIZE	COMMENT
a0b516dc1799	5 weeks ago	/bin/sh -c set -x && dpkg-divert --divert /u	8.657 MB	
<missing>	5 weeks ago	/bin/sh -c echo '/usr/local/lib64' > /etc/ld.	49.69 kB	
<missing>	5 weeks ago	/bin/sh -c buildDeps='flex' && set -x && ap	841.3 MB	
<missing>	5 weeks ago	/bin/sh -c #(nop) ENV GCC_VERSION=6.1.0	0 B	
<missing>	5 weeks ago	/bin/sh -c set -xe && for key in \$GPG_KEYS;	140.8 kB	
<missing>	5 weeks ago	/bin/sh -c #(nop) ENV GPG_KEYS=B215C1633BCA04	0 B	
<missing>	6 weeks ago	/bin/sh -c apt-get update && apt-get install	318.5 MB	
<missing>	6 weeks ago	/bin/sh -c apt-get update && apt-get install	131.2 MB	
<missing>	6 weeks ago	/bin/sh -c apt-get update && apt-get install	44.69 MB	
<missing>	6 weeks ago	/bin/sh -c #(nop) CMD ["/bin/bash"]	0 B	
<missing>	6 weeks ago	/bin/sh -c #(nop) ADD file:76679eeb94129df23c	125.1 MB	

Each of these lines are layers and the size column shows the exact size of each layer in the image

# Use tools to visualise layers

- ❖ You can use the online tool [imagelayers.io](https://imagelayers.io) to visualise the layers of an image

# How can I load and store images?

Use “docker save” and “docker load” commands

```
$ docker save nginx -o nginx.tar
$ ls -ltr nginx.tar
-rw----- 1 gsamarthyam staff 190775808 Jul 20 11:04 nginx.tar
$ docker load -i ./nginx.tar
Loaded image: nginx:latest
```

# How do I delete an image?

Use “`docker rmi <image-tag>`”

```
$ docker images alpine
REPOSITORY      TAG      IMAGE ID      CREATED      SIZE
alpine          latest   4e38e38c8ce0  4 weeks ago  4.799 MB
$ docker rmi alpine
Untagged: alpine:latest
Untagged: alpine@sha256:3dcdb92d7432d56604d4545cbd324b14e647b313626d99b889d0626de158f73a
$ docker images alpine
REPOSITORY      TAG      IMAGE ID      CREATED      SIZE
```

# How to delete all docker images?

Use “\$docker rmi \$(docker images -q)”

docker images -q  
lists all image ids

# Avoid “image sprawl”

- ❖ Remove unused images and release disk space

// output from the docker bench security tool

[INFO] 6.4 - Avoid image sprawl

[INFO] \* There are currently: 60 images

# How to find “dangling images”?

Use “`docker images -f "dangling=true"`”

\$ docker images -f "dangling=true"				
REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
<none>	<none>	777f9424d24d	7 minutes ago	125.2 MB
<none>	<none>	3d02168f00fc	12 days ago	34.22 MB
<none>	<none>	0f192147631d	3 weeks ago	132.8 MB

# Remove “dangling images”

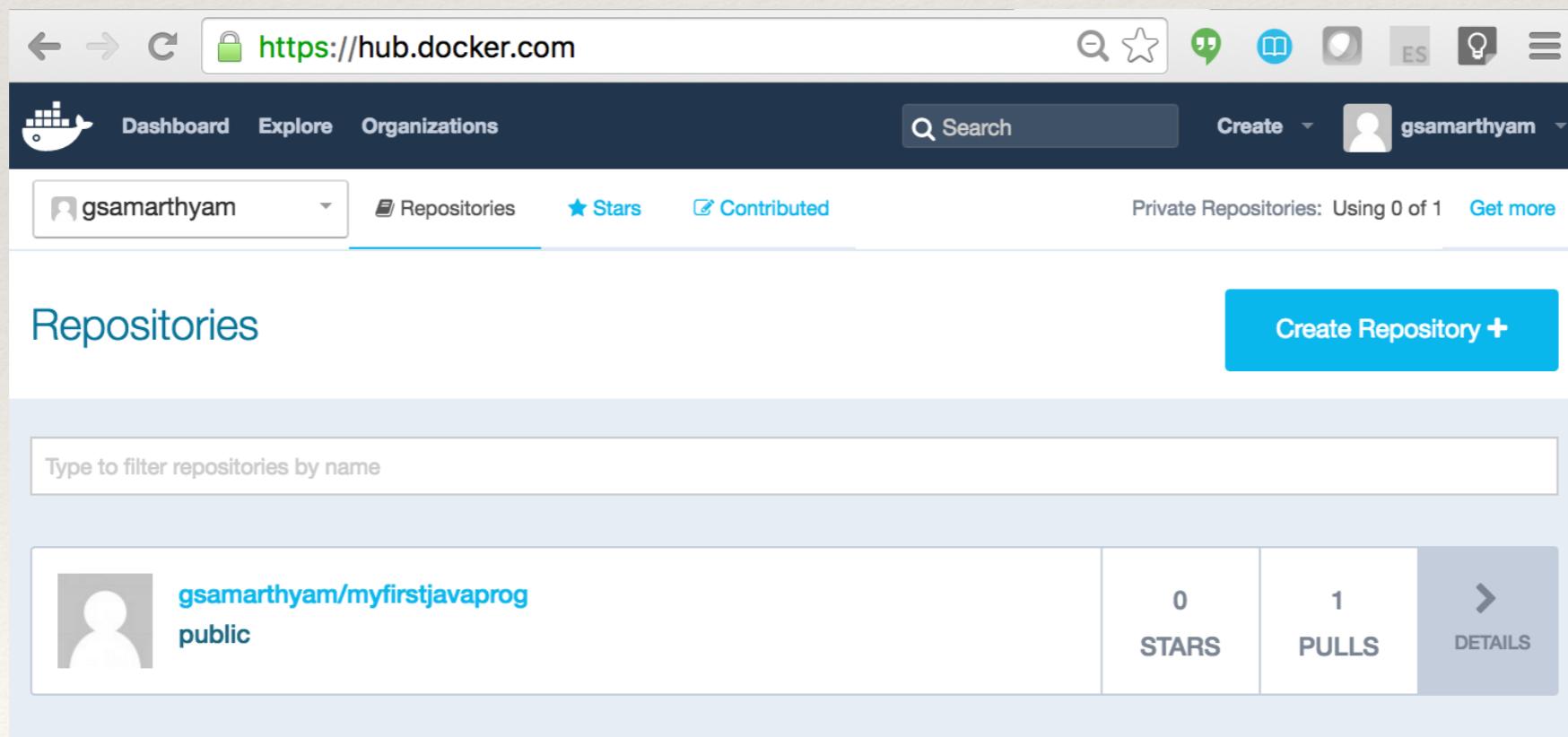
- ❖ Remove “dangling images” using the command “\$docker rmi \$(docker images -f "dangling=true" -q)”

# Using Registry & Repository



# How to push my image to Docker Hub?

```
$ docker tag myjavaapp gsamarthyam/myfirstjavaprogram:latest
$ docker push gsamarthyam/myfirstjavaprogram:latest
The push refers to a repository [docker.io/gsamarthyam/myfirstjavaprogram]
a97e2e0314bc: Pushed
3b9964bc9417: Pushed
de174b528b56: Pushed
// elided the output
latest: digest: sha256:1618981552efb12afa4e348b9c0e6d28f0ac4496979ad0c0a821b43547e13c13 size: 2414
$
```



# How to pull my image from Docker Hub?

```
$ docker pull gsamarthyam/myfirstjavaprog:latest
latest: Pulling from gsamarthyam/myfirstjavaprog
Digest: sha256:1618981552efb12afa4e348b9c0e6d28f0ac4496979ad0c0a821b43547e13c13
// output elided ...
$ docker images
REPOSITORY          TAG      IMAGE ID   CREATED    SIZE
myjavaapp           latest   0d7a3a12ba9d  About an hour ago  669.2 MB
gsamarthyam/myfirstjavaprog  latest   0d7a3a12ba9d  About an hour ago  669.2 MB
// output elided ...
$ docker run gsamarthyam/myfirstjavaprog
hello world
$
```

# How do I create and use my own registry?

Pull the “registry” image and run the container

```
$ docker pull registry
```

```
Using default tag: latest
```

```
latest: Pulling from library/registry
```

```
e110a4a17941: Already exists
```

```
2ee5ed28ffa7: Pull complete
```

```
d1562c23a8aa: Pull complete
```

```
06ba8e23299f: Pull complete
```

```
802d2a9c64e8: Pull complete
```

```
Digest: sha256:1b68f0d54837c356e353efb04472bc0c9a60ae1c8178c9ce076b01d2930bcc5d
```

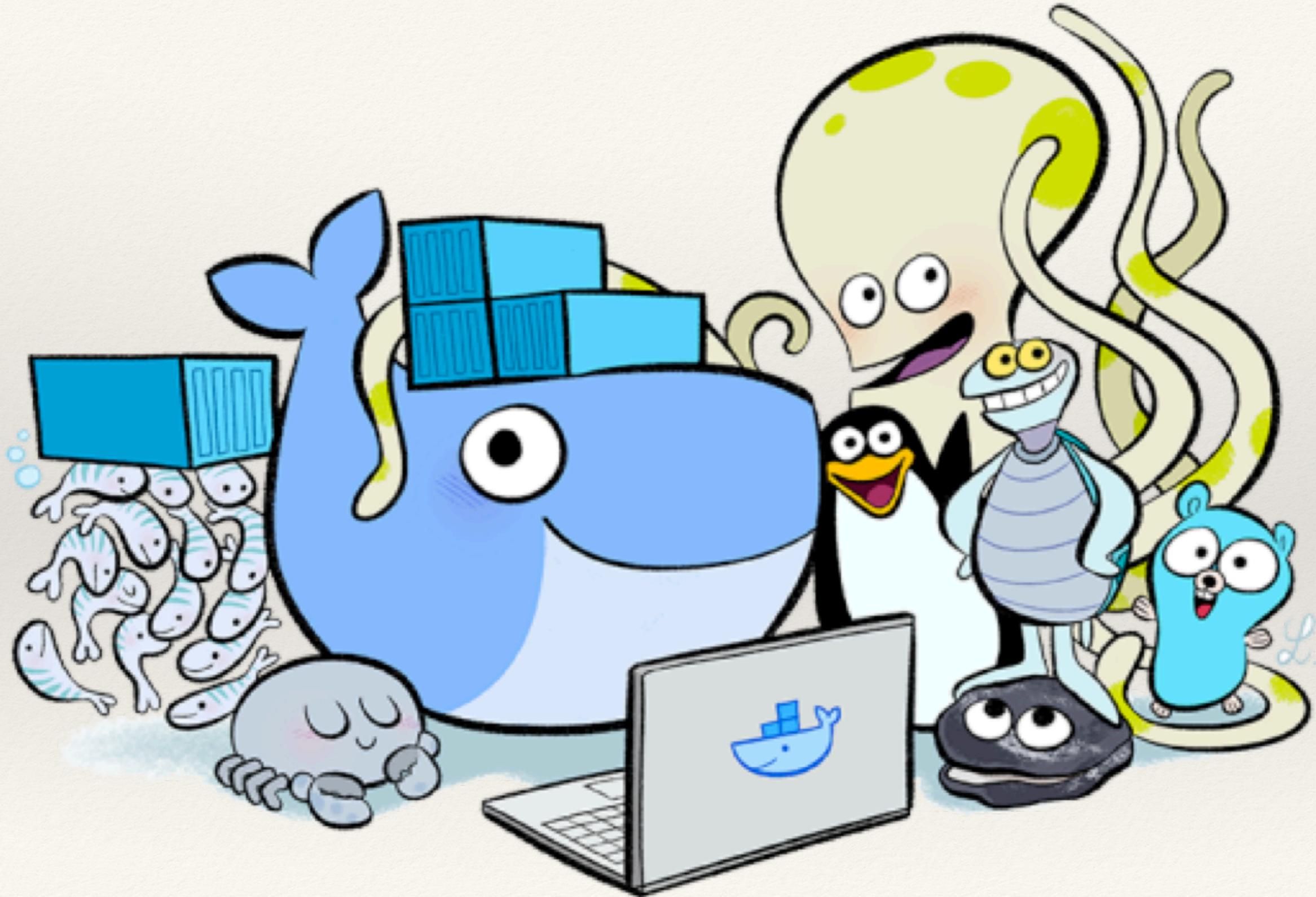
```
Status: Downloaded newer image for registry:latest
```

```
$ docker run -d -p5000:5000 registry
```

```
7768bed98a5e1916a820c84906e1f21cf84888a934c140ad22e19cee5e2541d
```

You can now push / pull  
images from this private  
registry

# Docker Containers



# How to get list of containers?

\$ docker ps -a	CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
	6322b8204a5d	ubuntu	"/bin/bash"	6 days ago	Exited (0) 6 days ago		desperate_aryabhata
	1e95fcfd15893	fedora	"/bin/bash"	6 days ago	Exited (0) 6 days ago		stoic_agnesi
	73c773524c8a	nginx	"nginx -g 'daemon off"	10 days ago	Exited (0) 9 days ago		serene_hoover
	70f0d1e4cd08	nginx	"-bridge:my-bridge-ne"	10 days ago	Created		happy_hawking
	c2e2f1fd2352	ubuntu	"/bin/bash -c export"	10 days ago	Exited (0) 10 days ago		sad_galileo
	77ded5de4b2f	prasantk/average	"node average.js 1 2 "	10 days ago	Exited (0) 10 days ago		mad_darwin
	c676058126b1	prasantk/average	"node average.js 1 2 "	10 days ago	Exited (0) 10 days ago		ecstatic_lalande
	6bddbe7885f5	prasantk/average	"node average.js"	10 days ago	Exited (0) 10 days ago		big_thompson
	0a3ad84c2221	3d02168f00fc	"node average.js"	10 days ago	Exited (0) 10 days ago		peaceful_minsky
	47e697c3fc12	3d02168f00fc	"node average.js"	10 days ago	Exited (0) 10 days ago		hungry_lamport
	78797aa37937	3d02168f00fc	"-e '1 2 3'"	10 days ago	Created		drunk_mayer
	8c13665a8ca8	3d02168f00fc	"1"	10 days ago	Created		loving_carson
	2afe5e6f1384	3d02168f00fc	"1 2 3"	10 days ago	Created		nostalgic_leavitt
	5d7403525309	3d02168f00fc	"1 2 3"	10 days ago	Created		happy_newton
	1045734ecd5c	3d02168f00fc	"node average.js"	10 days ago	Exited (0) 10 days ago		reverent_williams
	8989e7fc7d7a	nginx	"nginx -g 'daemon off"	10 days ago	Exited (0) 9 days ago		kickass_lichterman
	a08eb10ae2fa	nginx	"nginx -g 'daemon off"	10 days ago	Exited (0) 10 days ago		docker-nginx
	e447a0763ff1	nginx	"nginx -g 'daemon off"	10 days ago	Exited (0) 10 days ago		hopeful_dijkstra
	9a1eab880312	alpine	"/bin/sh"	10 days ago	Exited (0) 10 days ago		hungry_sinoussi
	1932e28ef5cc	alpine	"/bin/bash"	10 days ago	Created		modest_engelbart
	454adf9473f9	alpine	"echo hello"	10 days ago	Exited (0) 10 days ago		elated_curran
	ad834018d0a3	alpine	"echo hello"	10 days ago	Exited (0) 10 days ago		sleepy_davinci
	4a678e2c1c11	hello-world	"/hello"	10 days ago	Exited (0) 10 days ago		thirsty_keller
	369e76f97dd7	training/webapp	"python app.py"	13 days ago	Exited (0) 13 days ago	0.0.0.0:32771->5000/tcp	boring_roentgen
	826204fae788	hello-world	"/hello"	13 days ago	Exited (0) 13 days ago		happy_kalam
	4c8bacdd231a	docker/whalesay	"cowsay foobar"	13 days ago	Exited (0) 13 days ago		big_carson
	60809ce0320d	docker/whalesay	"cowsay boo"	13 days ago	Exited (0) 13 days ago		distracted_wilson
	1e5d8f24be78	ubuntu	"/bin/bash"	2 weeks ago	Exited (0) 2 weeks ago		fervent_agnesi
	8a23c6c978f3	ubuntu:latest	"/bin/bash"	2 weeks ago	Created		berserk_pare
	64c20bcac482	ubuntu	"echo hello"	2 weeks ago	Exited (0) 2 weeks ago		gloomy_darwin
	213605afcc24	ubuntu	"hello"	2 weeks ago	Created		goofy_jones
	6575e1b2ae09	ubuntu	"hello"	2 weeks ago	Created		condescending_shirley
	8345b4e82a5b	ubuntu	"hello"	2 weeks ago	Created		serene_jepsen
	ce31cb01a791	ubuntu	"echo hello"	2 weeks ago	Exited (0) 2 weeks ago		small_bhaskara
	cf3b1580e3d1	ubuntu	"hello"	2 weeks ago	Created		evil_heyrovsky
	f46a4880894e	ubuntu	"hello"	2 weeks ago	Created		sick_lamport

# How to run a container?

Use “`docker run OPTIONS <<image-tag>> CMD ARGS`”

```
$ docker run fedora /bin/echo 'Hello world'  
Hello world  
$
```

The diagram illustrates the components of a Docker run command. It shows the command `docker run fedora /bin/echo 'Hello world'` with callouts pointing to its parts:

- Image name:** Points to the word `fedora`.
- Command name:** Points to the word `/bin/echo`.
- Command argument:** Points to the string `'Hello world'`.

```
docker run fedora /bin/echo 'Hello world'
```

# How to run a container interactively?

```
$ docker run -t -i fedora /bin/bash
[root@00eef5289c91 /]# pwd
/
[root@00eef5289c91 /]# whoami
root
[root@00eef5289c91 /]# ls
bin  boot  dev  etc  home  lib  lib64  lost+found  media  mnt  opt  proc  root  run  sbin  srv
sys  tmp   usr  var
[root@00eef5289c91 /]# cc
bash: cc: command not found
[root@00eef5289c91 /]# gcc
bash: gcc: command not found
[root@00eef5289c91 /]# java
bash: java: command not found
[root@00eef5289c91 /]# tar
bash: tar: command not found
[root@00eef5289c91 /]# exit
exit
$
```

Create a terminal  
to interact with

`docker run -t -i fedora /bin/bash`

short for “—interactive”

# Cobb's totem - the top



COBB'S TOTEM - THE TOP

WHAT IT DOES:  
SPINS CONTINUOUSLY WHILE  
IN DREAM - STOPS SPINNING IN  
THE REAL WORLD.

# Running a container - Totem?



# Running a container - Totem?

```
$ hostname  
ganesh  
$ docker run -it alpine /bin/sh  
/ # hostname  
b4ebae46b156  
/ # ps -a  
  PID  USER      TIME  COMMAND  
    1  root      0:00  /bin/sh  
    6  root      0:00  ps -a  
/ # exit  
$ ps -a  
  PID TTY      TIME CMD  
15327 ttys001  0:00.02 login -pf gsamarthyam  
15328 ttys001  0:00.27 -bash
```

# How to run a container in the background?

short for “—detach” and it runs  
container in the background

```
$ docker run -d ubuntu /bin/sh -c "while true; do echo current date and time is: $(date); sleep 10; done"
9128bf57e03c3b32f0bf784a92332953996236d7e358a77c62c10bdec95fd5b9
$ docker ps
CONTAINER ID        IMAGE       COMMAND       CREATED          STATUS          PORTS
9128bf57e03c        ubuntu      "/bin/sh -c 'while tr'"   About a minute ago   Up About a
minute              lonely_einstein
$ docker logs 9128bf57e03c3b32f0bf784a92332953996236d7e358a77c62c10bdec95fd5b9
current date and time is: Fri Jul 22 15:42:49 IST 2016
current date and time is: Fri Jul 22 15:42:49 IST 2016
current date and time is: Fri Jul 22 15:42:49 IST 2016
current date and time is: Fri Jul 22 15:42:49 IST 2016
// output elided
```

# How to expose a port?

host port (machine on  
which this command is run)

mapped port -  
nginx

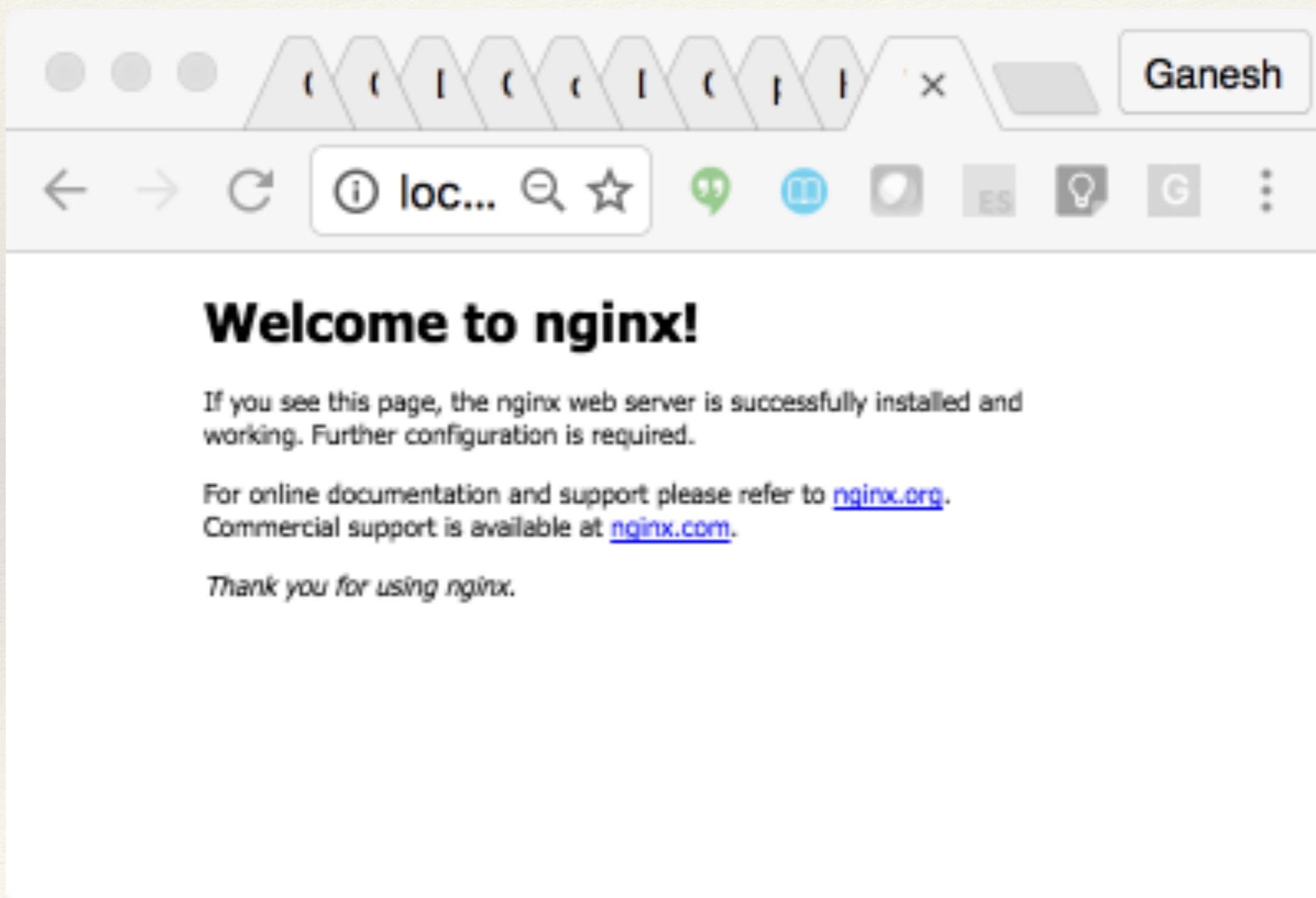
```
$ docker run -d -p 80:80 nginx  
9128bf57e03c3b32f0bf784a92332953996236d7e358a77c62c10bdec95fd5b9
```

```
$ docker inspect 9128bf57e03c3b32f0bf784a92332953996236d7e358a77c62c10bdec95fd5b9
```

```
"PortBindings": {  
    "80/tcp": [  
        {  
            "HostIp": "",  
            "HostPort": "80"  
        }  
    ],  
},
```

# Using Nginx

Type `http://localhost:80` in your browser window



## Welcome to nginx!

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to [nginx.org](http://nginx.org).  
Commercial support is available at [nginx.com](http://nginx.com).

*Thank you for using nginx.*

# How to expose a port?

host port (machine on which this command is run); since no explicit mapped port number is provided, a random port number is assigned

```
$ docker run -d -p 80 --name minenginx nginx  
9128bf57e03c3b32f0bf784a92332953996236d7e358a77c62c10bdec95fd5b9
```

```
$ docker inspect minenginx
```

```
"Ports": {  
    "443/tcp": null,  
    "80/tcp": [  
        {  
            "HostIp": "0.0.0.0",  
            "HostPort": "32770"  
        }  
    ]  
},
```

randomly assigned and mapped port number (by docker)

# How to expose all exposed ports?

-P publishes all exposed ports to random ports; in this case, ports 443 and 80 are respectively mapped to 32771 and 32772

```
$ docker run -d -P --name minenginx nginx  
6b873116f198f4235e3eee1b2085e0312eaa0067217da614c62e2ce55a8c8d4e  
$ docker port minenginx  
443/tcp -> 0.0.0.0:32771  
80/tcp -> 0.0.0.0:32772
```

# How to attach to a running container?

short for “—detach” and it runs  
container in the background

```
$ docker run -d ubuntu /bin/sh -c "while true; do echo current date and time is: $(date); sleep 10; done"  
acc349675098a0133366076f2082db6171ee4a0cd2e1e45ada9a485684ea4c01  
$ docker attach acc349675098a0133366076f2082db6171ee4a0cd2e1e45ada9a485684ea4c01  
current date and time is: Mon Aug 1 10:30:13 IST 2016  
current date and time is: Mon Aug 1 10:30:13 IST 2016
```

The “attach” command attaches  
to a running container

# How to detach from a running container (without exiting)?

From docker documentation

```
# To detach the tty without exiting the shell,  
# use the escape sequence Ctrl-p + Ctrl-q  
# note: This will continue to exist in a stopped state once exited (see "docker ps -a")
```

```
$ docker run -it alpine /bin/sh  
/ # echo "hello"
```

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS
NAMES					
99d946d9b4e0	alpine	"/bin/sh"	15 seconds ago	Up 14 seconds	
gloomy_mcclintock					

# How do I create an image from a running container?

Use “docker commit” command

```
$ docker run -d alpine echo "hello world"
9884347880f62f7c5d43702c3d701e3b87a49f9bdde5843380af1479f4dc0755
$ docker logs 9884347880f62f7c5d43702c3d701e3b87a49f9bdde5843380af1479f4dc0755
hello world
$ docker commit -m "my first image from container"
9884347880f62f7c5d43702c3d701e3b87a49f9bdde5843380af1479f4dc0755 myalpine:latest
sha256:b707ef35394c365bece70240213942e43da7f882107d30482ad6bec6b4bacfb7
$ docker images
REPOSITORY          TAG      IMAGE ID      CREATED
SIZE
myalpine            latest   b707ef35394c  18 hours ago
4.799 MB
$ docker run -it b707ef35394c365bece70240213942e43da7f882107d30482ad6bec6b4bacfb7
hello world
$
```

# Avoid “docker commit”

- ❖ Avoid creating docker images manually (e.g., using “docker commit”); rather automate the image build process (using Dockerfile and “docker build”)

# How to get list of containers?

Use “docker ps” command

\$ docker ps	CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
	3651758ff308	wordpress:latest	"/entrypoint.sh apach"	2 days ago	Up 2 days	0.0.0.0:8000->80/tcp	mywordpress_wordpress_1
	b9538054539	mysql:5.7	"docker-entrypoint.sh"	2 days ago	Up 2 days	3306/tcp	mywordpress_db_1

# How do I see all the containers?

Use “docker ps -a” command

\$ docker ps -a	CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
	2c378c6b84b1	fedora	"/bin/echo 'Hello wor"	4 minutes ago	Exited (0) 4 minutes ago		grave_thompson
	c4b2db95f268	hello-world	"/hello"	5 minutes ago	Exited (0) 5 minutes ago		amazing_jones
	2dcd9d0caf6f	777f9424d24d	"/bin/bash"	42 minutes ago	Exited (0) 42 minutes ago		prickly_khorana
	3651758ff308	wordpress:latest	"/entrypoint.sh apach"	2 days ago	Up 2 days	0.0.0.0:8000->80/tcp	mywordpress_wordpress_1
	b95388054539	mysql:5.7	"docker-entrypoint.sh"	2 days ago	Up 2 days	3306/tcp	mywordpress_db_1
	4b984664f9aa	golang:latest	"go run myapp.go"	2 days ago	Exited (1) 2 days ago		mydocker_app_1
	63cd7661a8ad	hello-world	"/hello"	2 days ago	Exited (0) 2 days ago		adoring_sammet
	c191fbeae884	ubuntu	"/bin/bash"	2 days ago	Exited (0) 2 days ago		clever_mcclintock
	08e173332d46	docker/whalesay	"cowsay Hello world"	2 days ago	Exited (0) 2 days ago		tender_joliot
	6322b8204a5d	0f192147631d	"/bin/bash"	9 days ago	Exited (0) 9 days ago		desperate_aryabhata
...							

# Explicitly remove exited containers

- ❖ Explicitly use --rm to remove the container from the file system - otherwise, even if the container exits, it is not cleaned up yet (and will hog memory).

# How do I remove a container?

Use “docker rm” command

```
$ docker stop mywordpress_db_1  
mywordpress_db_1  
$ docker rm mywordpress_db_1  
mywordpress_db_1
```

You have to first stop a container before trying to remove it

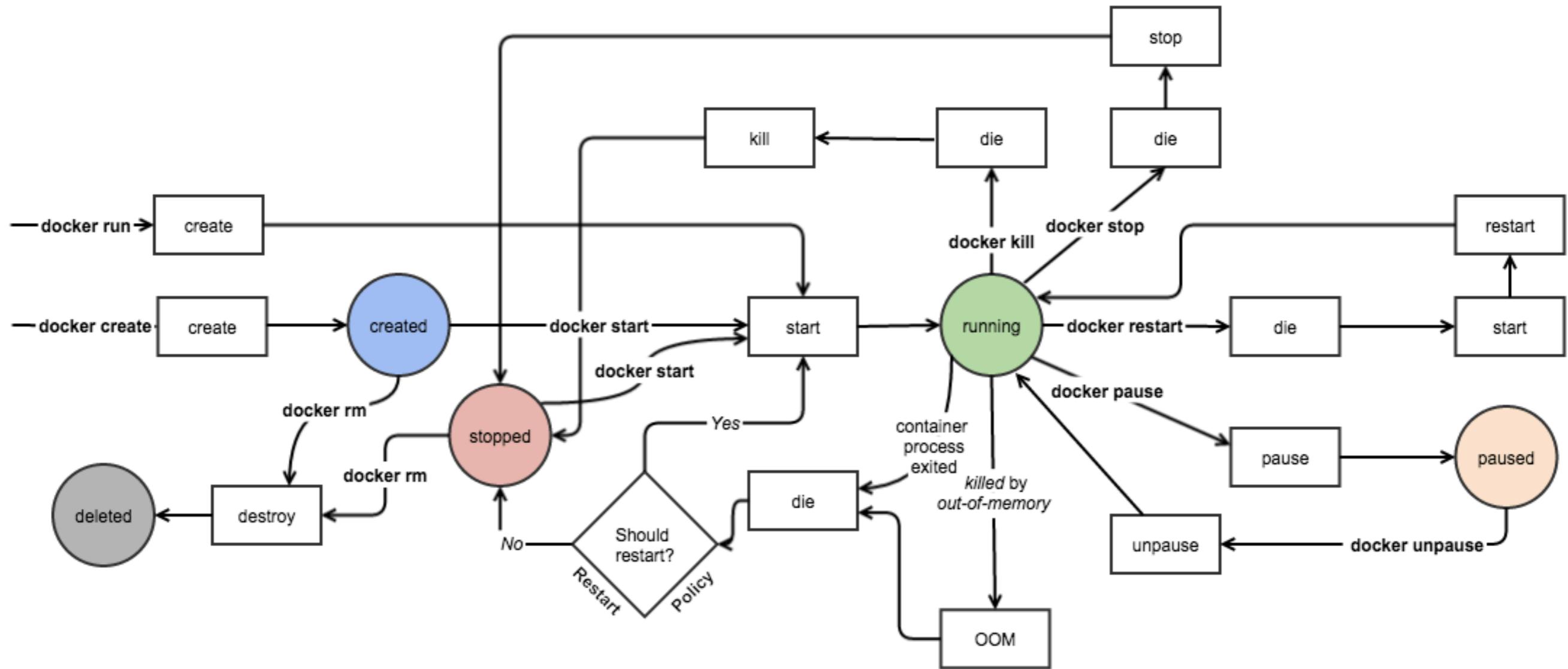
# How do I remove all the containers?

Use “`docker stop $(docker ps -a -q)`” and  
“`docker rm $(docker ps -a -q)`” commands

```
$ docker stop $(docker ps -a -q)
00eef5289c91
8553eebfab94
696a04db91db
// rest of the output elided
$ docker rm $(docker ps -a -q)
00eef5289c91
8553eebfab94
696a04db91db
// rest of the output elided
$ docker ps -a
CONTAINER ID        IMAGE NAMES          COMMAND      CREATED      STATUS
```

Note how the output  
shows no containers

# State transition



# Using nginx

Nginx exposes ports 80 and 443; -P maps them randomly in the ports range 49153 and 65535

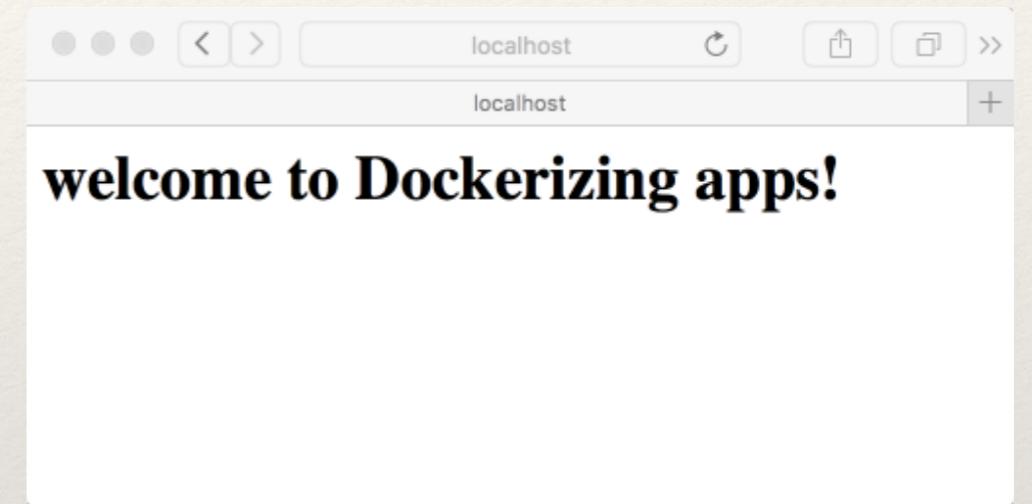
```
$ docker run --name mynginx -P -d nginx
561e15ac1848cf481f89bb161c23dd644f176b8f142fe617947e06f095e0953f
$ docker ps
CONTAINER ID        IMAGE       COMMAND       CREATED      NAMES
STATUS              PORTS
561e15ac1848        nginx      "nginx -g 'daemon off'"   18 hours ago   mynginx
Up About a minute   0.0.0.0:32771->80/tcp, 0.0.0.0:32770->443/tcp
$ curl localhost:32771
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
  body {
    width: 35em;
    margin: 0 auto;
    font-family: Tahoma, Verdana, Arial, sans-serif;
  }
</style>
</head>
// rest of the output elided ...
```

# Using nginx

```
$ cat Dockerfile
FROM nginx:latest
MAINTAINER Ganesh Samarthym

ADD ./index.html /usr/share/nginx/html/index.html
EXPOSE 80
$ cat index.html
<h1> welcome to Dockerizing apps! <h1>
$ docker build .
Sending build context to Docker daemon 3.072 kB
// output elided ...
Removing intermediate container b043a75a4e1c
Successfully built 1aae04309f8b
$ docker images
REPOSITORY          TAG      IMAGE ID      CREATED        SIZE
<none>              <none>   1aae04309f8b   6 seconds ago  182.8 MB
$ docker run -p 80:80 -d 1aae04309f8b
984c179231188445289e70d854250e4e981b77a899208360db4466e73930be42
$ curl localhost:80
<h1> welcome to Dockerizing apps! <h1>
$
```

Type “localhost:80” in  
the browser address bar



REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
<none>	<none>	1aae04309f8b	6 seconds ago	182.8 MB

# How do I run a C program?

```
$ docker pull gcc
Using default tag: latest
latest: Pulling from library/gcc
5c90d4a2d1a8: Already exists
ab30c63719b1: Already exists
c6072700a242: Already exists
abb742d515b4: Already exists
d32a4c04e369: Pull complete
276c31cf0a4c: Pull complete
a455d29f9189: Pull complete
dcfe5869552b: Pull complete
Digest: sha256:35256b5f4e4d5643c9631c92e3505154cd2ea666d2f83812b418cfdb1d5866e8
Status: Downloaded newer image for gcc:latest
$
```

# How do I run a C program?

```
$ docker pull ubuntu:latest
latest: Pulling from library/ubuntu
43db9dbdcb30: Pull complete
85a9cd1fcca2: Pull complete
c23af8496102: Pull complete
e88c36ca55d8: Pull complete
Digest: sha256:7ce82491d6e35d3aa7458a56e470a821baecee651fba76957111402591d20fc1
Status: Downloaded newer image for ubuntu:latest
```

```
$ docker run -i -t ubuntu /bin/bash
root@c191fbeae884:/# gcc
bash: gcc: command not found

root@c191fbeae884:/# apt-get update
// elided the output
root@c191fbeae884:/# apt-get install gcc
// elided the output
root@c191fbeae884:/# cat > hello.c
int main() { printf("hello world\n"); }
root@c191fbeae884:/# gcc -w hello.c
root@c191fbeae884:/# ./a.out
hello world
root@c191fbeae884:/#
```

# How do I run a C program?

```
$ cat Dockerfile
FROM gcc:latest
MAINTAINER Ganesh Samarthyam version: 0.1

COPY . /usr/src/mycapp

WORKDIR /usr/src/mycapp

RUN gcc -o first first.c
CMD ["./first"]

$ cat first.c
#include <stdio.h>

int main() { printf("hello world\n"); }

$ docker build . -t"mycapp:latest"
Sending build context to Docker daemon 3.072 kB
Step 1 : FROM gcc:latest
--> a0b516dc1799
// .. steps elided ...
Step 6 : CMD ./first
--> Using cache
--> f99e7f18fa42
Successfully built f99e7f18fa42
$ docker run -it mycapp
hello world
```

# How do I run a Java program?

```
$ cat Dockerfile
FROM java:latest
COPY . /usr/src/
WORKDIR /usr/src/
RUN javac hello.java
CMD ["java", "hello"]
$ cat hello.java
class hello {
    public static void main(String []args) {
        System.out.println("hello world");
    }
}
$ docker build . -t"myjavaapp:latest"
Sending build context to Docker daemon 3.072 kB
Step 1 : FROM java:latest
--> 264282a59a95
// intermediate steps elided
Successfully built 0d7a3a12ba9d
$ docker images
REPOSITORY          TAG      IMAGE ID      CREATED       SIZE
myjavaapp           latest   0d7a3a12ba9d   About an hour ago   669.2 MB
$ docker images
REPOSITORY          TAG      IMAGE ID      CREATED       SIZE
myjavaapp           latest   0d7a3a12ba9d   About an hour ago   669.2 MB
<none>              <none>   7cfb4bdf47a7   About an hour ago   669.2 MB
// rest of the output elided
$ docker run myjavaapp
hello world
```

# Beware of “container sprawl”

- ❖ Application broken to run in “too many containers” can be difficult to deal with!

“Breaking deployments into more functional discrete parts is smart, but that means we have MORE PARTS to manage. There's an inflection point between separation of concerns and sprawl.”

-- *Rob Hirschfeld*

(CEO of RackN and OpenStack Foundation board member)

# Pop quiz

**What happens when you execute this on the command-line?**

```
docker run debian /bin/sh
```

- A. A prompt from the shell of created container will be thrown to you
- B. A container is created and then exited immediately
- C. A container is created and executes in the detached mode; you can attach to it later using the container id
- D. Docker CLI issues the error: Error response from daemon: No command specified.

# Pop quiz: answer

When you execute this command,

```
docker run debian /bin/sh
```

A container is created and then exited immediately.

```
$ docker ps -a
CONTAINER ID        IMAGE       COMMAND
CREATED             STATUS      NAMES
4c12998fd392      debian     "/bin/bash"
6 seconds ago       Exited (0) 5 seconds ago
                                         sick_panini
```

# Pop quiz

**What happens when you execute this on the command-line?**

```
docker run -itd debian
```

- A. You get “Error response from daemon: No command specified.”
- B. The created container runs in the detached mode
- C. You get “unknown shorthand flag: -itd”
- D. A shell from the created container is returned to you

# Pop quiz: answer

When you execute

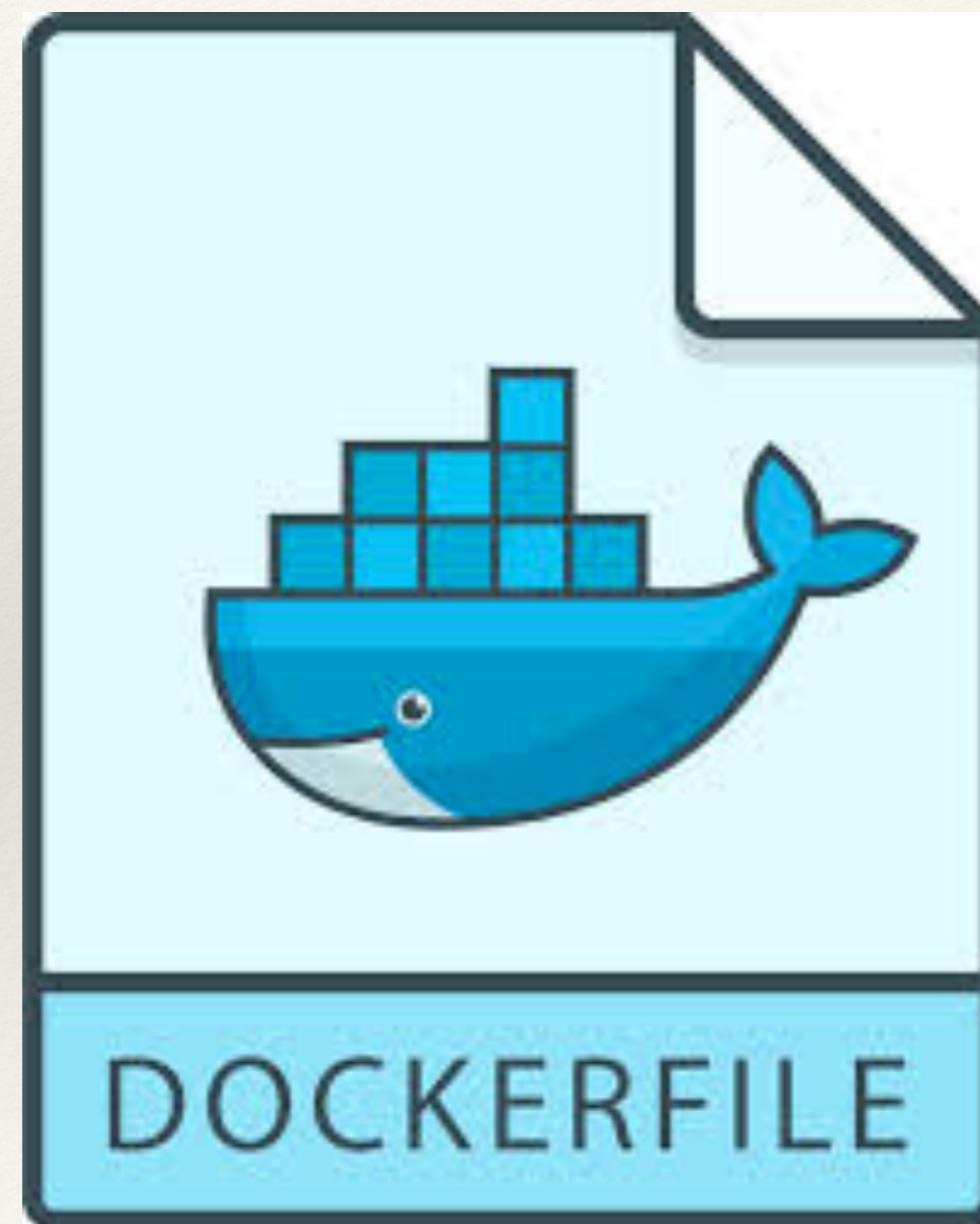
docker run -itd debian

the created container runs in the detached mode!

```
$ docker ps
```

CONTAINER ID	IMAGE	COMMAND	CREATED
STATUS	PORTS	NAMES	
a53779a74904	debian	/bin/bash"	2 minutes ago
Up 2 minutes		agitated_aryabhata	

# Building images using Dockerfile



# Different ways to create images

**docker commit**

Build an image from a container

**docker build**

Create an image from a Dockerfile by executing the build steps given in the file

**docker import**

Create a base image by importing from a tarball.  
[import is mainly used for creating base-images; first two options are widely used]

# Dockerfile - key instructions

<b>FROM</b>	The base image for building the new docker image; provide “FROM scratch” if it is a base image itself
<b>MAINTAINER</b>	The author of the Dockerfile and the email
<b>RUN</b>	Any OS command to build the image
<b>CMD</b>	Specify the command to be started when the container is run; can be overridden by the explicit argument when providing docker run command
<b>ADD</b>	Copies files or directories from the host to the container in the given path
<b>EXPOSE</b>	Exposes the specified port to the host machine

# How can I create an image from a Dockerfile?

Use docker build command  
“Dockerfile” - its like Makefile for Docker

```
$ cat myimage/Dockerfile
FROM ubuntu
RUN echo "my first image" > /tmp/first.txt
$ docker build myimage
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM ubuntu
--> ac526a356ca4
Step 2 : RUN echo "my first image" > /tmp/first.txt
--> Running in 18f62f47d2c8
--> 777f9424d24d
Removing intermediate container 18f62f47d2c8
Successfully built 777f9424d24d
$ docker images | grep 777f9424d24d
<none>           <none>          777f9424d24d      4 minutes ago    125.2 MB
$ docker run -it 777f9424d24d
root@2dcd9d0caf6f:/# ls
bin  boot  core  dev  etc  home  lib  lib64  media  mnt  opt  proc  root  run  sbin  srv
sys  tmp   usr   var
root@2dcd9d0caf6f:/# cat /tmp/first.txt
my first image
root@2dcd9d0caf6f:/# exit
exit
$
```

# How to name/tag an image when building?

Use “`docker build <<dirname>> -t"imagename:tag"` command

```
$ docker build myimage -t"myfirstimage:latest"
Sending build context to Docker daemon 2.048 kB
Step 1 : FROM ubuntu
--> ac526a356ca4
Step 2 : RUN echo "my first image" > /tmp/first.txt
--> Using cache
--> 777f9424d24d
Successfully built 777f9424d24d
$ docker images myfirstimage
REPOSITORY          TAG           IMAGE ID      CREATED        SIZE
myfirstimage        latest        777f9424d24d   58 minutes ago  125.2 MB
$
```

# Dockerfile for running a Java program

```
$ cat HiHello.java
import java.io.*;
import java.net.InetSocketAddress;
import com.sun.net.httpserver.*;

public class HiHello {
    public static void main(String[] args) throws Exception {
        HttpServer server = HttpServer.create(new InetSocketAddress(8080), 0);
        server.createContext("/hi", (HttpExchange t) ->
        {
            try {
                String response = "hello\n";
                t.sendResponseHeaders(200, response.length());
                try(OutputStream os = t.getResponseBody()) {
                    os.write(response.getBytes());
                }
            } catch (IOException ioe) {
                System.err.println("Error writing to outputstream: " + ioe);
                System.exit(-1);
            }
        });
        server.start();
    }
}

$ curl localhost:8080/hi
hello
```

# Dockerfile for running a Java program

```
$ cat Dockerfile
FROM java:latest
COPY HiHello.class /
EXPOSE 8080
ENTRYPOINT ["java"]
CMD ["HiHello"]
```

```
$ docker build .
Sending build context to Docker daemon 6.656 kB
Step 1 : FROM java:latest
--> 264282a59a95
// ... Successfully built 60a14f519720
$ docker run -d -p 8080:8080 60a14f519720
16f6d7eca560c96b995be9f0c6d68167930ab7501451a452818e04ce29ec177f
$ curl localhost:8080/hi
hello
```

# Pop quiz

**Which command do you use “to find layers and their sizes” in an image using Docker CLI?**

- A. Use “docker images -layers <<imageid>>” command
- B. Use “docker layers <<imageid>>” command
- C. Use “docker history <<imageid>>” command
- D. There is no way you can find layers and their sizes using Docker CLI  
- you need to use external tools

# Pop quiz: answer

**To find layers and their sizes in an image using Docker CLI, use“docker history <<imageid>> command.**

IMAGE	CREATED	CREATED BY	SIZE
COMMENT			
106e303be3a4	2 weeks ago	/bin/sh -c #(nop) ENTRYPOINT ["/usr/bin/cadvi	0 B
<missing>	2 weeks ago	/bin/sh -c #(nop) EXPOSE 8080/tcp	0 B
<missing>	2 weeks ago	/bin/sh -c #(nop) ADD file:1bde294f31142b3dee	25.87 MB
<missing>	2 weeks ago	/bin/sh -c apk --no-cache add ca-certificates	17.13 MB
<missing>	2 weeks ago	/bin/sh -c #(nop) ENV GLIBC_VERSION=2.23-r3	0 B
<missing>	2 weeks ago	/bin/sh -c #(nop) MAINTAINER dengnan@google.c	0 B
<missing>	3 months ago	/bin/sh -c #(nop) ADD file:852e9d0cb9d906535a	4.799 MB

# Pop quiz

**Which command do you use “recreate the Dockerfile that was used to build that image” from a given image id/tag using Docker CLI?**

- A. Use “docker images -dockerfile <<imageid>>” command
- B. Use “docker build -reverse <<imageid>>” command
- C. Use “docker history --no-trunc --out:<filename> <<imageid>>” command
- D. There is no way to recreate the Dockerfile that was used to build that image from a given image id/tag using Docker CLI

# Pop quiz: answer

There is **NO** way to recreate the Dockerfile that was used to build that image from a given image id/tag using Docker CLI.

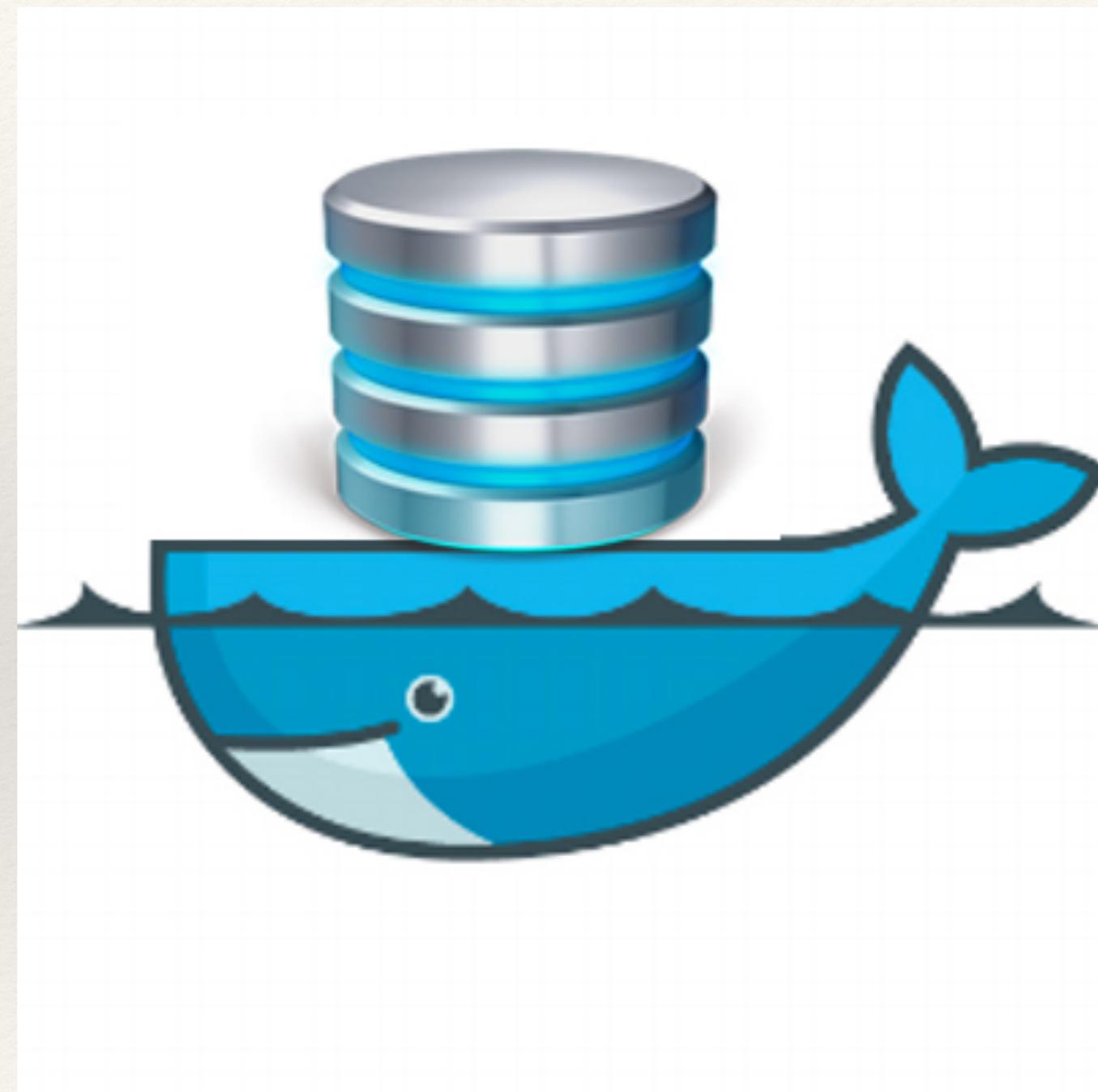
Think about Makefile: can you recreate the Makefile that was used to build that executable file? No.

However, you can see the commands used to create the layers in the image. Pass “—no-trunc” option to “docker history” command.

*Example:* “`docker history --no-trunc google/cadvisor`”

Try it now!

# Docker Volumes



# Docker volume commands

Command	Description
<code>docker volume create</code>	Create a volume
<code>docker volume inspect</code>	Display detailed information on one or more volumes
<code>docker volume ls</code>	List the available volumes
<code>docker volume rm</code>	Remove one or more volumes

# Commands for Docker volumes

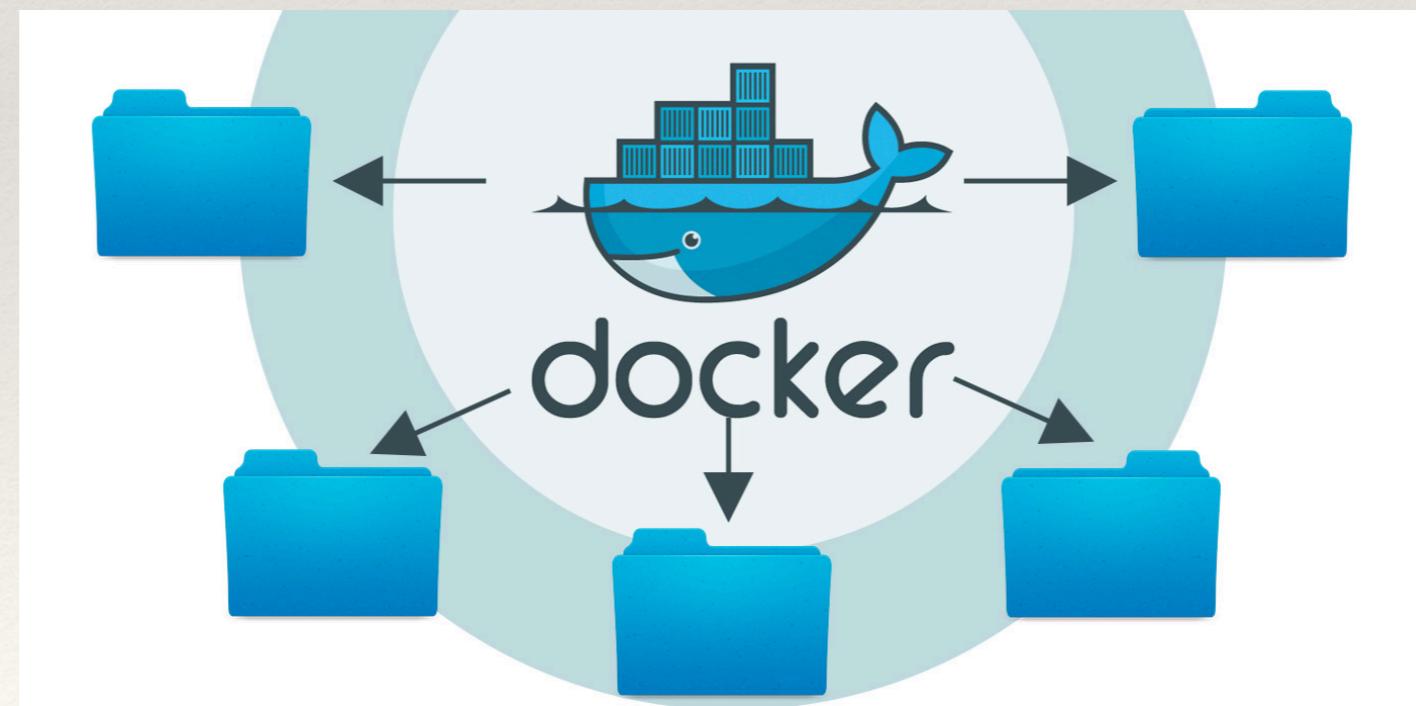
```
$ docker volume create --name myvolume  
myvolume  
$ docker volume ls  
local          myvolume  
$ docker volume inspect myvolume  
[  
  {  
    "Name": "myvolume",  
    "Driver": "local",  
    "Mountpoint": "/var/lib/docker/volumes/myvolume/_data",  
    "Labels": {},  
    "Scope": "local"  
  }  
]  
$ docker volume rm myvolume  
myvolume
```

# How to persist data?

Use -v option to “mount volumes”

```
$ docker run -v /volumetesting --name="persistdata" alpine /bin/sh -c "echo testing persistence with volumes > /volumetesting/textfile.txt"
```

```
$ docker run --volumes-from=persistdata alpine /bin/sh -c "cat /volumetesting/textfile.txt"  
testing persistence with volumes
```



# How to get info on volumes?

Use “docker volume ls and inspect” options

```
$ docker volume ls
DRIVER          VOLUME NAME
local           081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432
local           3357f5522da19b47c3996db5e129b52d4be420ccce25d60d4473602cd25f473b

$ docker volume inspect
081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432
[
  {
    "Name": "081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432",
    "Driver": "local",
    "Mountpoint": "/var/lib/docker/volumes/
081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432/_data",
    "Labels": null,
    "Scope": "local"
  }
]
```

# Removing volumes

Use “docker volume rm” option

```
$ docker volume rm 081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432  
081bf425dd953c6b13f8e36f24540d191792e51dbd9c327eadae131ded5da432
```

# Removing containers with volumes

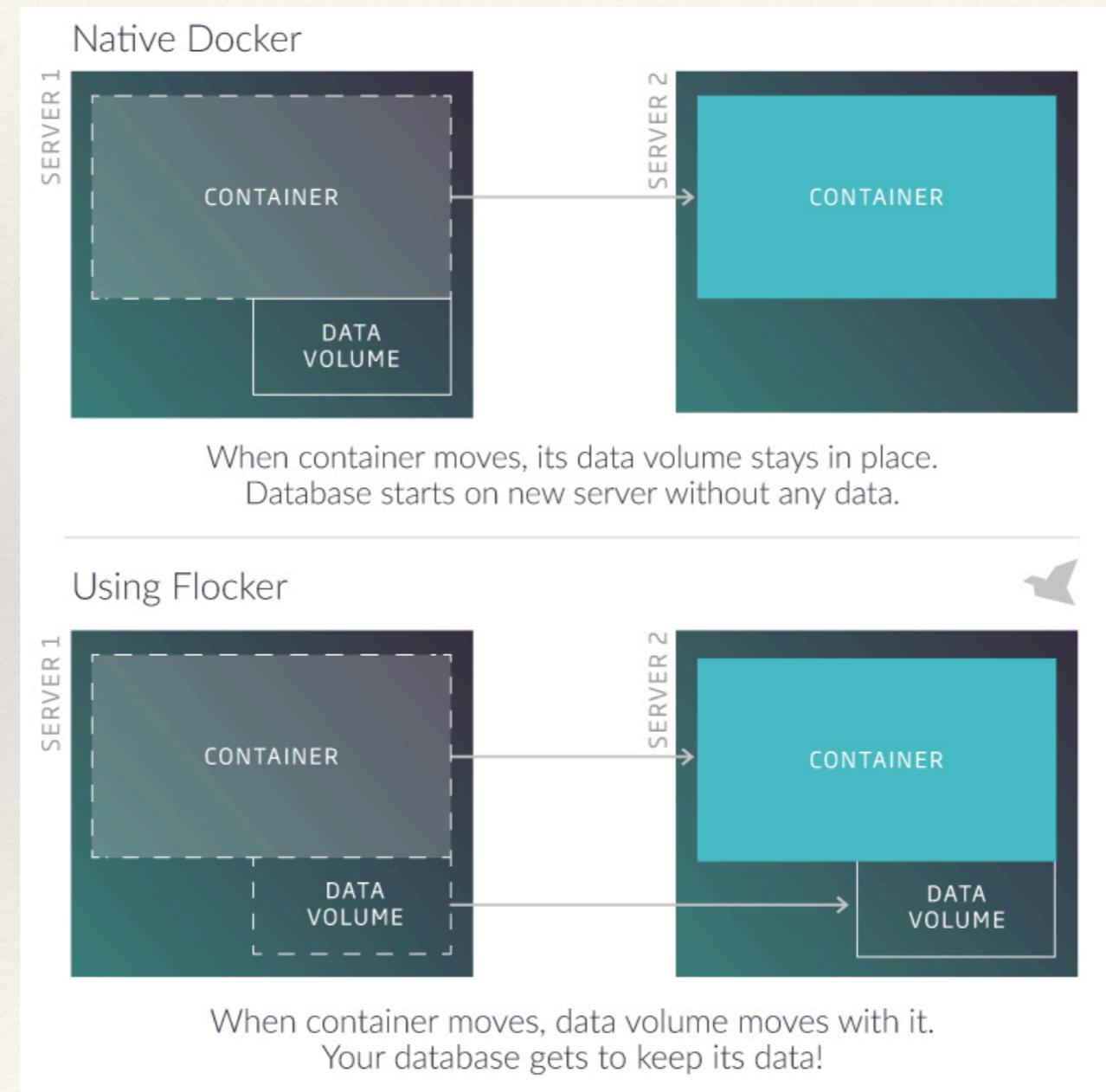
- ❖ When the container is removed, the volumes will not be removed. If the volumes also need to be removed, you have to use the -v option, as in: docker rm -v <<sha>>

# Clean up volumes

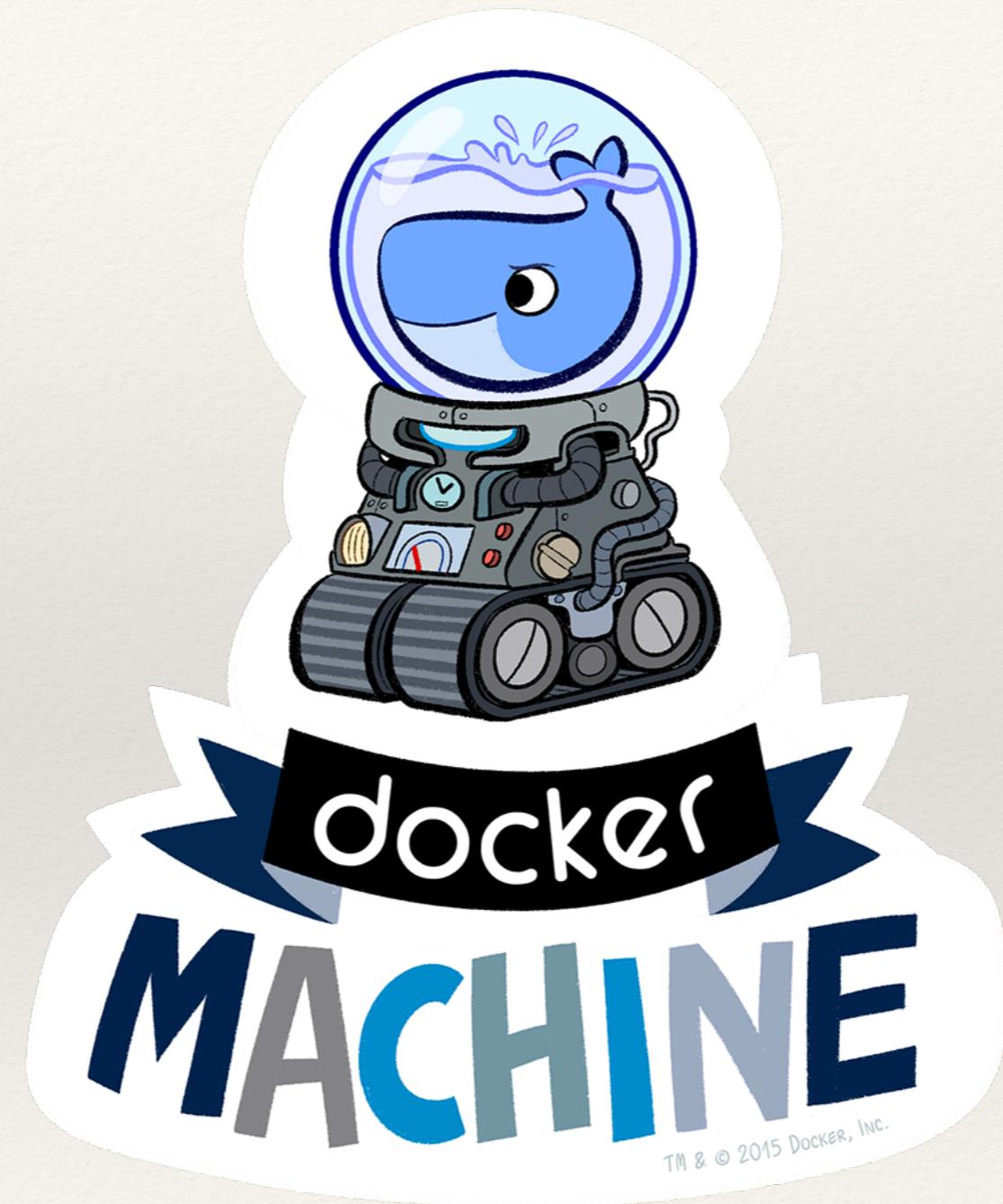
- ❖ You can “clean up” the volumes if you aren't using them. Use the command “`docker volume rm $(docker volume ls -q)`” to remove all the volumes.

# Use Flocker (data volume manager)

See: <https://clusterhq.com/flocker/>



# Docker Machine



# Docker Machine

Create and manage machines running Docker (cloud or on your computer)

```
$ docker-machine create --driver=virtualbox myhost
```

```
Running pre-create checks...
```

```
(myhost) Default Boot2Docker ISO is out-of-date, downloading the latest release...
```

```
(myhost) Latest release for github.com/boot2docker/boot2docker is v1.12.2
```

```
(myhost) Downloading /Users/gsamarthyam/.docker/machine/cache/boot2docker.iso from https://github.com/boot2docker/boot2docker/releases/download/v1.12.2/boot2docker.iso...
```

```
// ...
```

```
Setting Docker configuration on the remote daemon...
```

```
Checking connection to Docker...
```

```
Docker is up and running!
```

```
To see how to connect your Docker Client to the Docker Engine running on this virtual machine, run:
```

```
docker-machine env myhost
```

```
$ docker-machine env myhost
```

```
export DOCKER_TLS_VERIFY="1"
```

```
export DOCKER_HOST="tcp://192.168.99.100:2376"
```

```
export DOCKER_CERT_PATH="/Users/gsamarthyam/.docker/machine/machines/myhost"
```

```
export DOCKER_MACHINE_NAME="myhost"
```

```
# Run this command to configure your shell:
```

```
# eval $(docker-machine env myhost)
```

```
$ docker-machine ls
```

NAME	ACTIVE	DRIVER	STATE	URL	SWARM	DOCKER	ERRORS
myhost	-	virtualbox	Running	tcp://192.168.99.100:2376		v1.12.2	

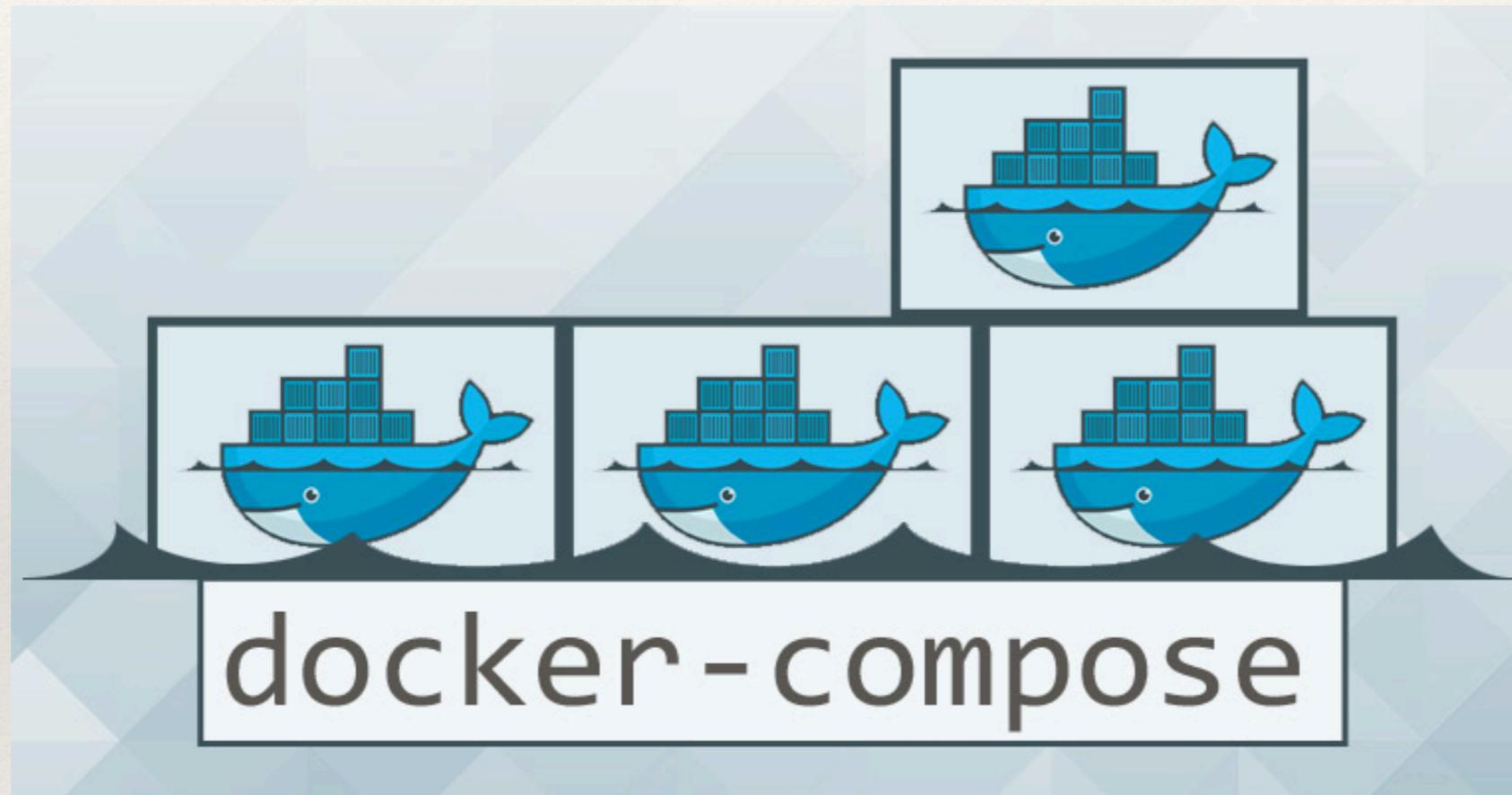
# Docker Compose



# docker-compose commands

Command	Description
<code>docker-compose up</code>	(Re)build services
<code>docker-compose kill</code>	Kill the containers
<code>docker-compose logs</code>	Show the logs of the containers
<code>docker-compose down</code>	Stop and remove images, containers, volumes and networks
<code>docker-compose rm</code>	Remove stopped containers

# Creating multiple Docker containers

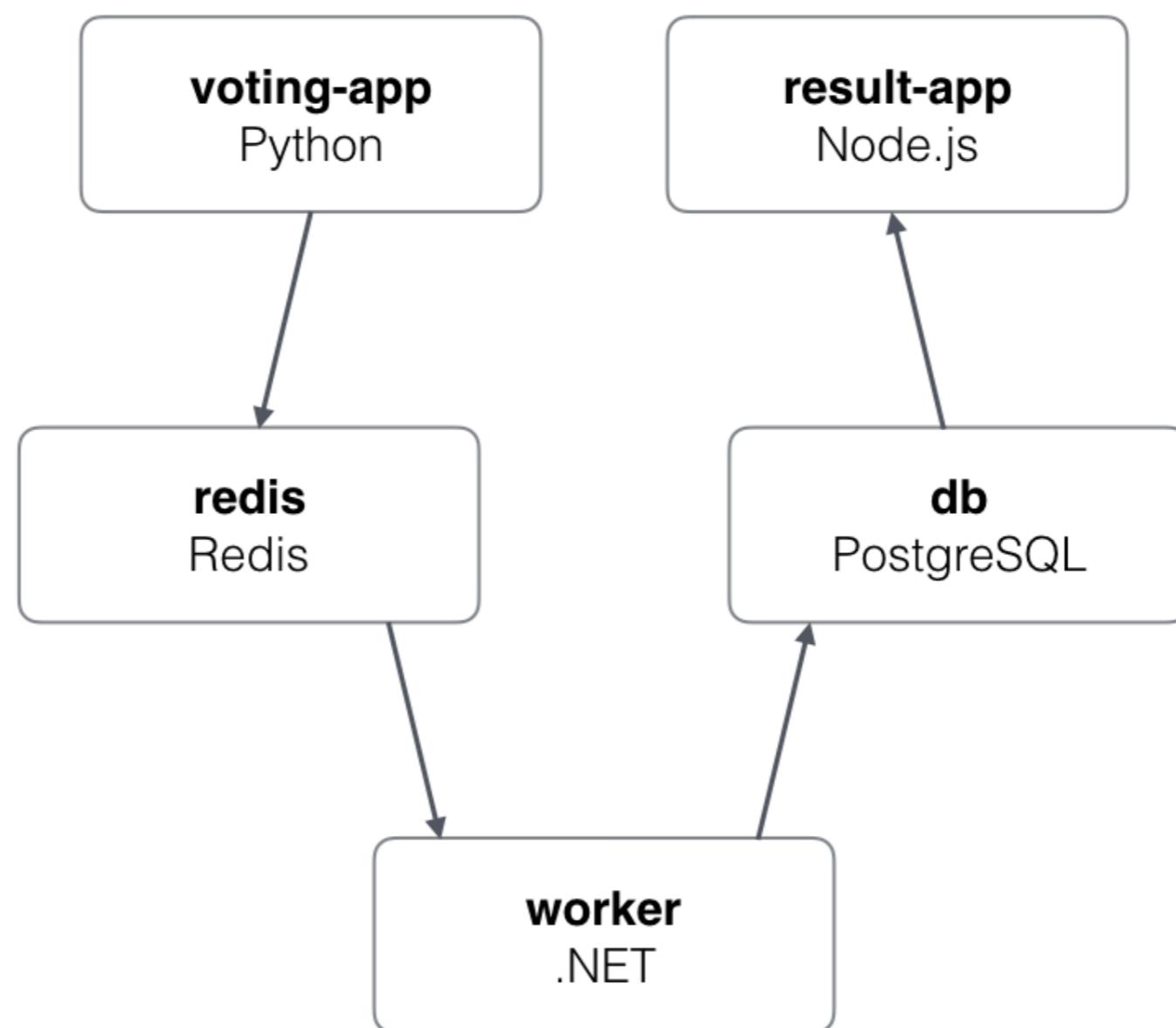


- Step 1.** Create a docker-compose.yml file (or docker-compose.yaml file)
- Step 2.** Execute “docker-compose up -d”
- Step 3.** Execute “docker-compose logs” from another shell (but from same dir)
- Step 4.** Execute “docker-compose down”

# docker-compose commands

Command	Description
<code>docker-compose up</code>	(Re)build services
<code>docker-compose kill</code>	Kill the containers
<code>docker-compose logs</code>	Show the logs of the containers
<code>docker-compose down</code>	Stop and remove images, containers, volumes and networks
<code>docker-compose rm</code>	Remove stopped containers

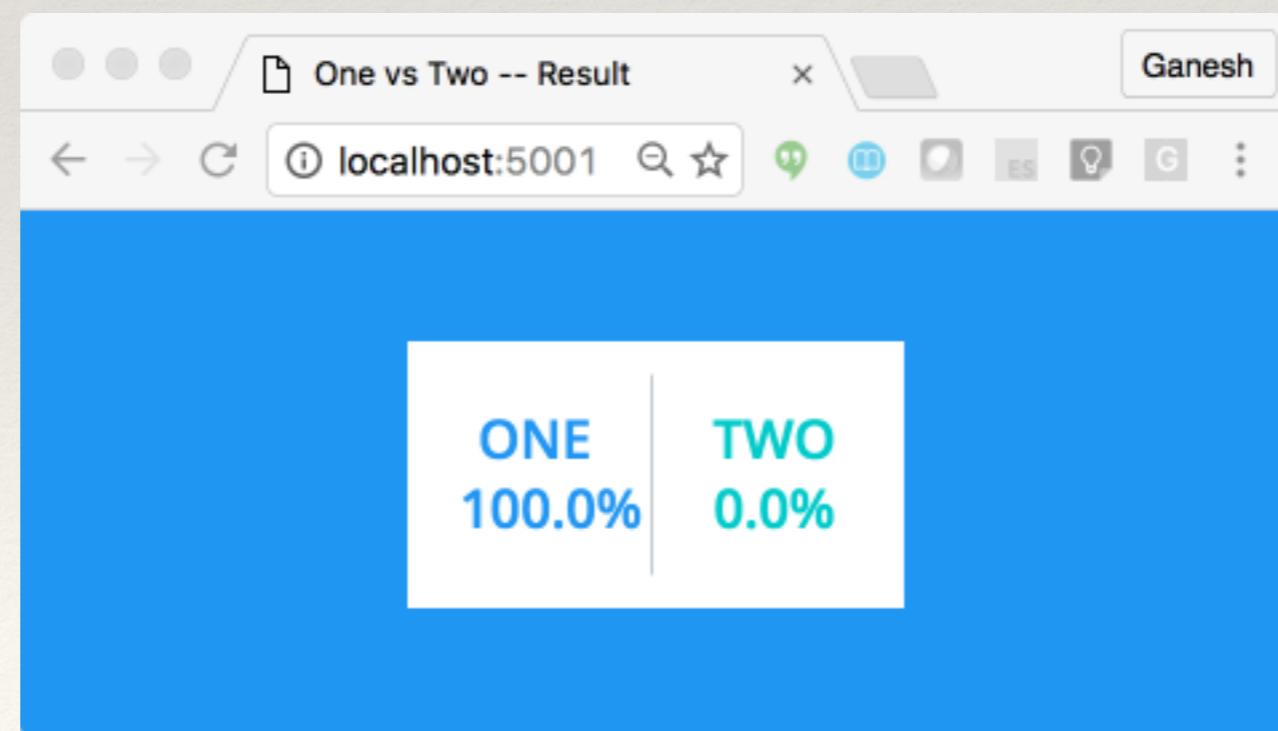
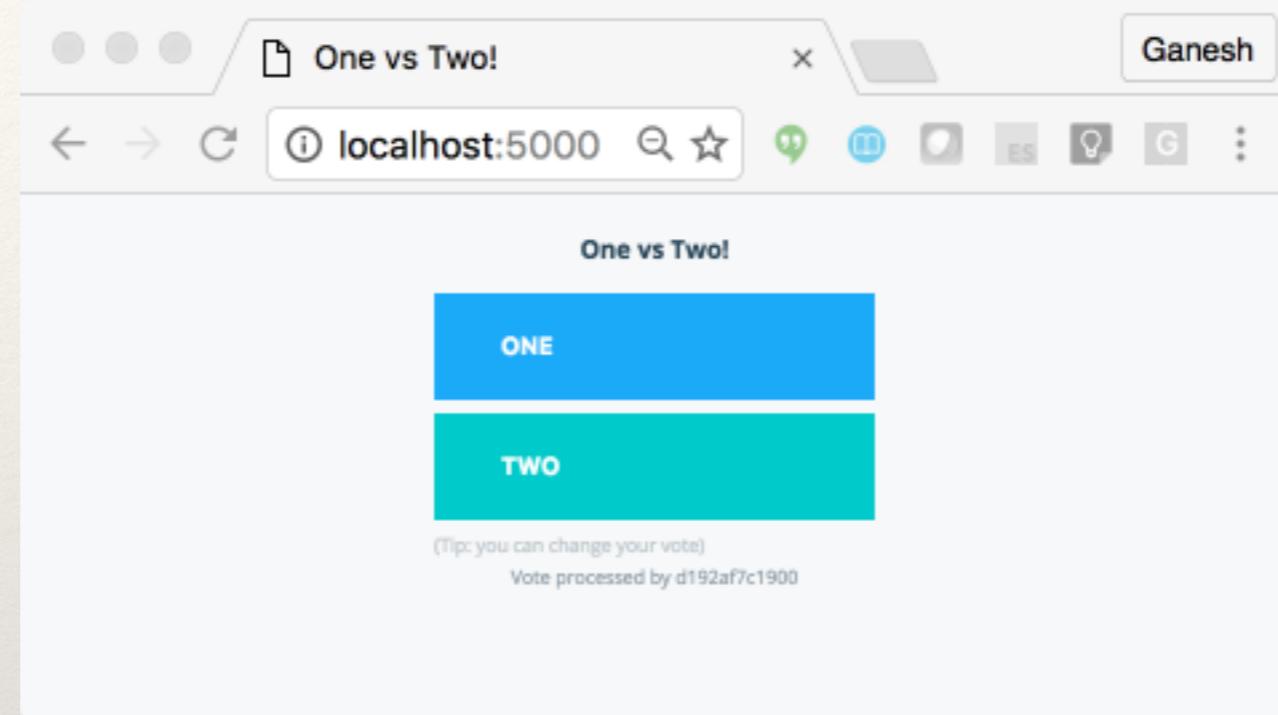
# Docker voting app



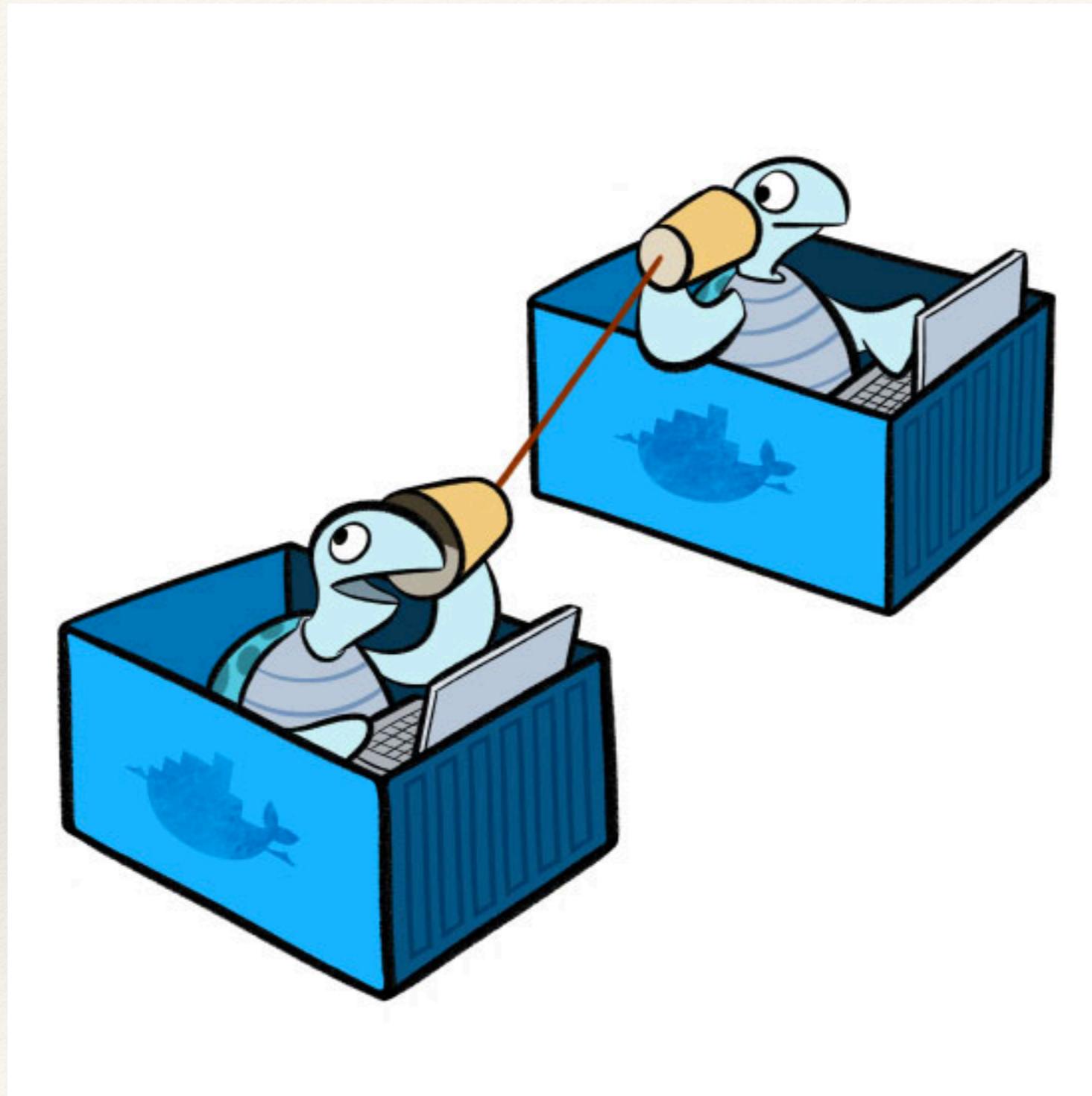
# Docker voting app

- Step 1.** Download .zip or clone: <https://github.com/docker/example-voting-app>
- Step 2.** Unzip the file and go to that directory from your shell
- Step 3.** Type “docker-compose up -d”
- Step 4.** From another shell, go to the same directory & type “docker-compose logs”
- Step 5.** In browser address bar, type “<http://localhost:5000>”
- Step 6.** In browser address bar, type “<http://localhost:5001>”
- Step 7.** From the shell, in that directory, type “docker-compose down”

# Docker voting app



# Docker Networking



# Getting the ip address of a container

```
$ docker inspect --format '{{ .NetworkSettings.IPAddress }}' fervent_sinoussi  
172.17.0.6
```

```
$ docker attach fervent_sinoussi  
root@856aed6a92f1:/# ip addr  
// ...  
92: eth0@if93: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group  
default  
    link/ether 02:42:ac:11:00:06 brd ff:ff:ff:ff:ff:ff  
    inet 172.17.0.6/16 scope global eth0  
        valid_lft forever preferred_lft forever  
    inet6 fe80::42:acff:fe11:6/64 scope link  
        valid_lft forever preferred_lft forever
```

```
root@856aed6a92f1:/# cat /etc/hosts  
// ...  
172.17.0.6 856aed6a92f1  
root@856aed6a92f1:/#
```

There are many ways to get the IP address of a container:

1. Use the docker inspect command
2. Use ip addr command from the container's shell
3. Use "cat /etc/hosts" and check the entry for the container

# How to get port mappings of a container?

```
$ docker run -d -p5000:5000 registry  
c51b984b4d64a05e924c7677f20e8c5c386e8bb53f5de0369337d31f73a7cf7e
```

```
$ docker port  
c51b984b4d64a05e924c7677f20e8c5c386e8bb53f5de0369337d31f73a7cf7e  
5000/tcp -> 0.0.0.0:5000
```

```
$ docker run -P -d nginx  
de6e17edec8223c9a5ac9fee4f9493929a22a78fe88c60b643b545078c60648  
$ docker port  
de6e17edec8223c9a5ac9fee4f9493929a22a78fe88c60b643b545078c60648  
443/tcp -> 0.0.0.0:32768  
80/tcp -> 0.0.0.0:32769
```

	CONTAINER ID	IMAGE	COMMAND	CREATED	NAMES
	STATUS	PORTS			
	de6e17edec8 ago	nginx Up 20 seconds	"nginx -g 'daemon off'" 0.0.0.0:32769->80/tcp, 0.0.0.0:32768->443/tcp	21 seconds	
	reverent_wright				

# Three kinds of networks

```
$ docker network ls
```

NETWORK ID	NAME
a3bb9a40c8e3	bridge
399711fd0635	host
790ae8b43d9b	none

Default, single-host driver

DRIVER	SCOPE
bridge	local
host	local
null	local

# Docker network commands

Command	Description
<code>docker network connect</code>	Connect a container to a network
<code>docker network create</code>	Create a network
<code>docker network disconnect</code>	Disconnect a container from a network
<code>docker network inspect</code>	Display detailed information on one or more networks
<code>docker network ls</code>	List networks
<code>docker network rm</code>	Remove one or more networks

# Bridge network

```
$ docker network inspect bridge
[
  {
    "Name": "bridge",
    "Id": "39457e56e7c0d172a239745e10ebf24f9e5046e9bc98f978f4e759f1f4e486c3",
    "Scope": "local",
    "Driver": "bridge",
    "EnableIPv6": false,
    "IPAM": {
      "Driver": "default",
      "Options": null,
      "Config": [
        {
          "Subnet": "172.17.0.0/16",
          "Gateway": "172.17.0.1"
        }
      ]
    },
    "Internal": false,
    "Containers": {
      "19857aa228f7ba76fc10d1e992e9fe49a0d361b5daab3a0a2703267aab862c58": {
        "Name": "furious_mcnulty",
        "EndpointID": "e2a7423a9108fa7bb18ea9893e299e1bceb73fa13c3123c5b0d515790be477d3",
        "MacAddress": "02:42:ac:11:00:03",
        "IPv4Address": "172.17.0.3/16",
        "IPv6Address": ""
      },
      "eaf4697b9989666e0c79cce6dc03697c8226aea37157d97bce1d08e250fb3c36": {
        "Name": "cadvisor",
        "EndpointID": "f907c7510aaef7196e6419733b64da689330948ca0f3c88bd4dd41258a4503e42",
        "MacAddress": "02:42:ac:11:00:02",
        "IPv4Address": "172.17.0.2/16",
        "IPv6Address": ""
      }
    },
    "Options": {
      "com.docker.network.bridge.default_bridge": "true",
      "com.docker.network.bridge.enable_icc": "true",
      "com.docker.network.bridge.enable_ip_masquerade": "true",
      "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
      "com.docker.network.bridge.name": "docker0",
      "com.docker.network.driver.mtu": "1500"
    },
    "Labels": {}
  }
]
```

By default, containers are added to the bridge network. You can see the containers in bridge network here

# Pop quiz

**You are creating a new container with this command:**

```
docker run -d --name myubuntu ubuntu /bin/sh -c "while true; do echo current date and  
time is: $(date); sleep 10; done"
```

**Which network is the “myubuntu” container attached to?**

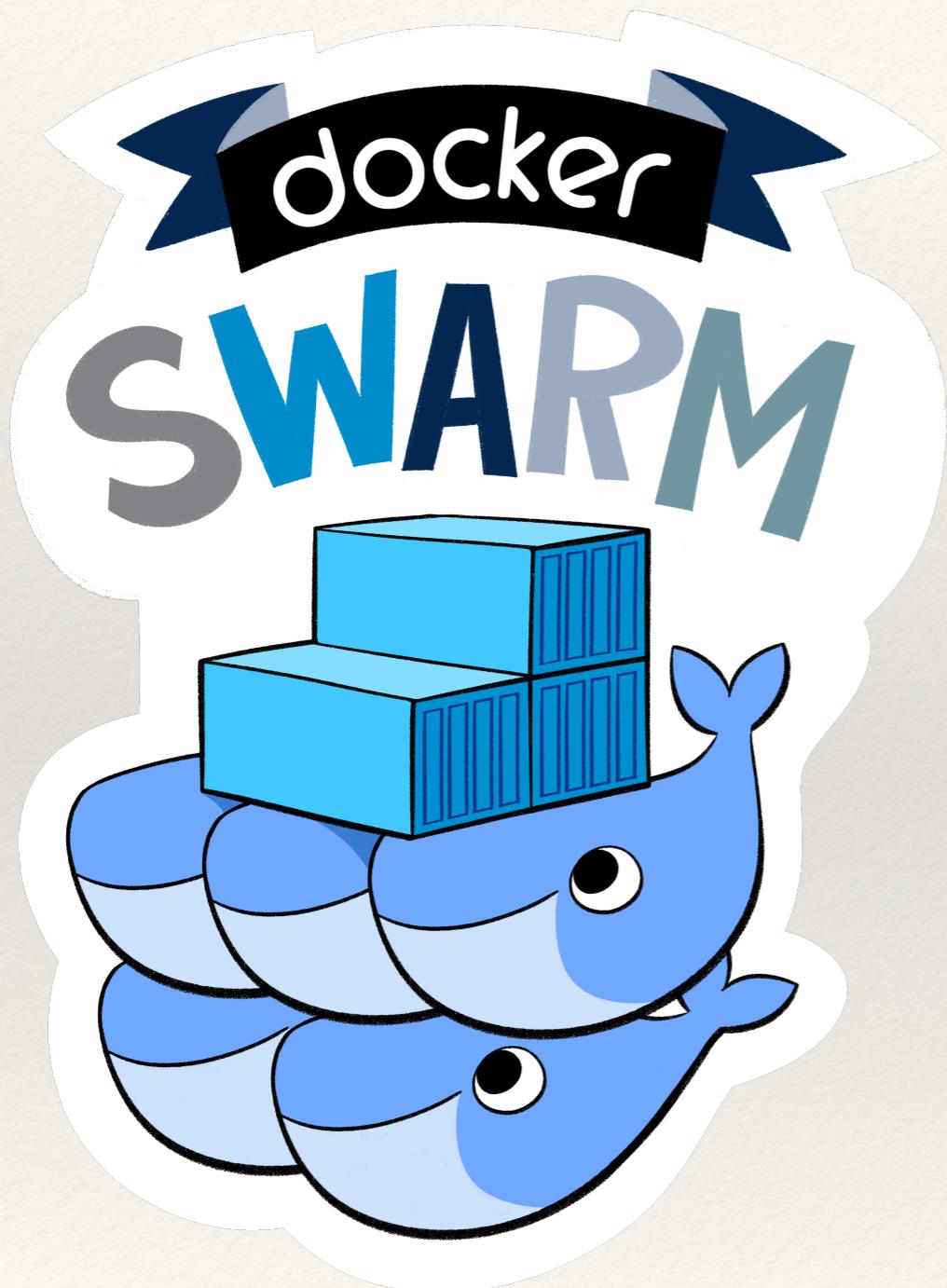
- A. Bridge
- B. Overlay
- C. Custom
- D. None

# Pop quiz: answer

**Bridge** network. By default, a newly created container is attached to the bridge network (unless a different network is specified, for example, using the “—network” option with the docker run command).

```
$ docker network inspect bridge
[
  {
    "Name": "bridge",
    // ...
    "Containers": {
      "04579b88a74c981ae854261dffc7ab17328c28bb6fafec0f9c1e9431e77b3b27": {
        "Name": "myubuntu",
        "EndpointID": "8a0e7a2559eac35eb60a90e85554679de276bd1ba39ff3a4083301d08e9ee384",
        "MacAddress": "02:42:ac:11:00:03",
        "IPv4Address": "172.17.0.3/16",
        "IPv6Address": ""
      },
      // ...
      // ...
    }
  ]
]
```

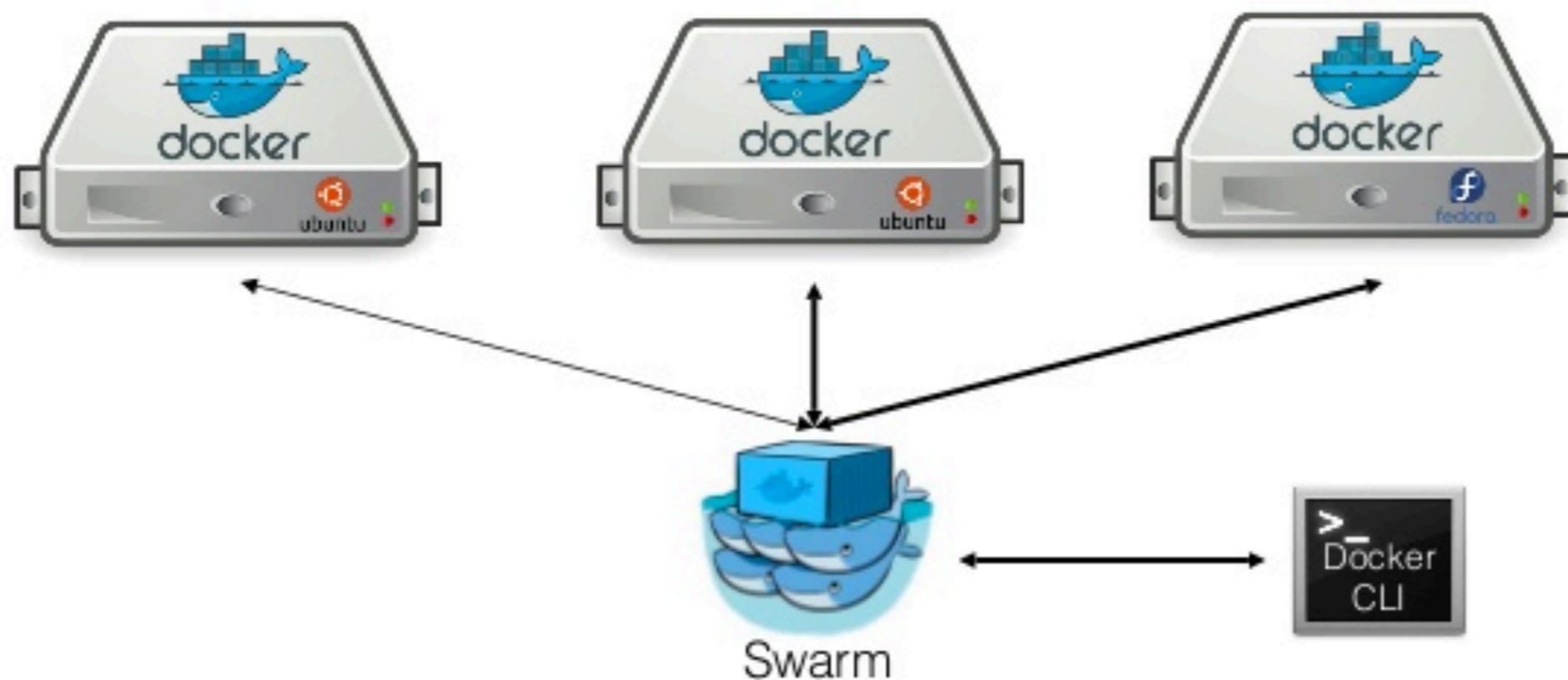
# Orchestration



Docker swarm provides “clustering capabilities”, i.e., be able to treat group of Docker engines into a single virtual Docker engine

# Docker Swarm

## With Docker Swarm



“swap, plug, and play”

# Docker Swarm

```
$ docker swarm init
```

```
Swarm initialized: current node (81snul7czu9pg42h3qnm2v5hr) is now a manager.
```

To add a worker to this swarm, run the following command:

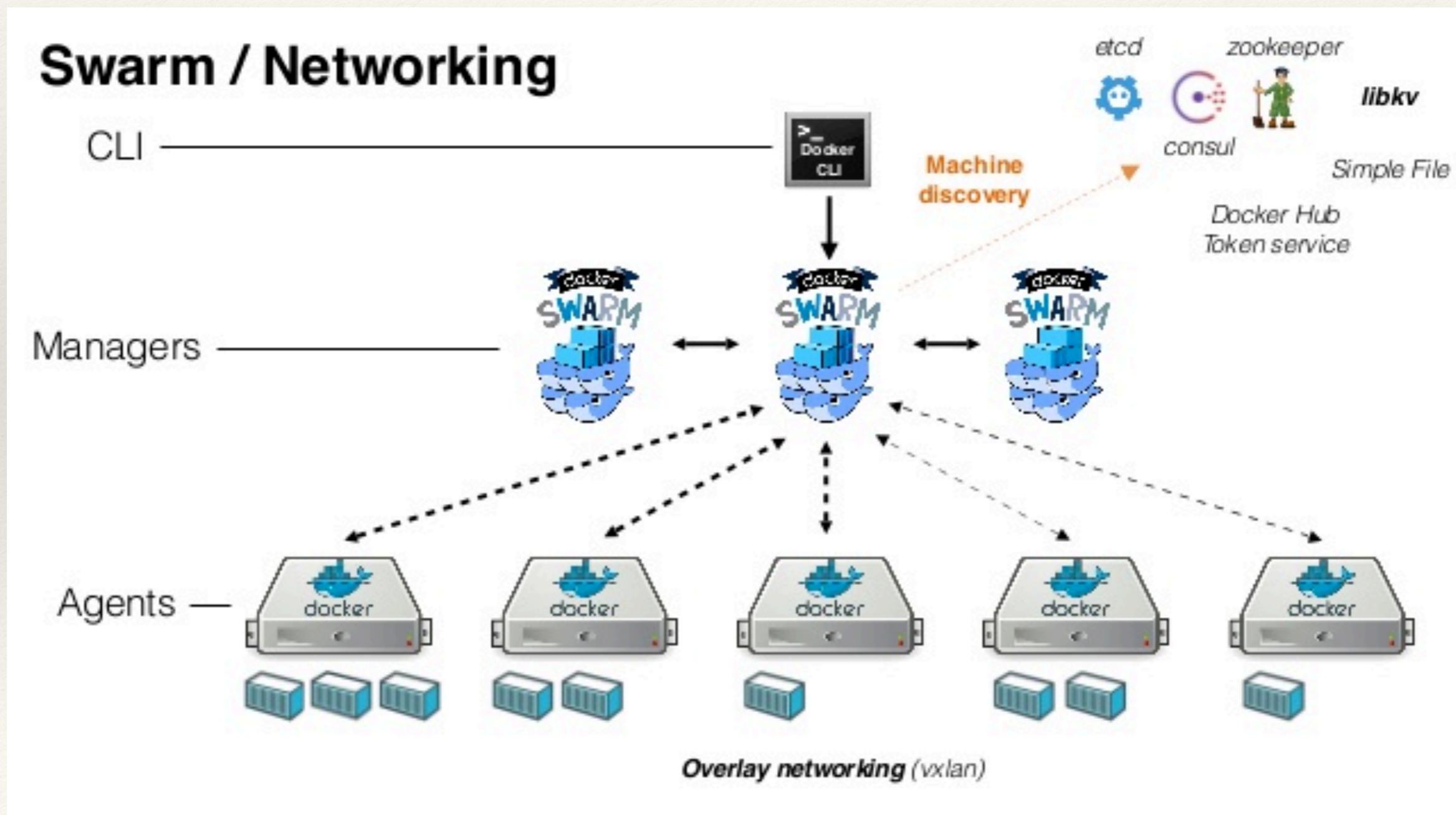
```
docker swarm join --token
```

```
SWMTKN-1-2tn8fic07uivk29ith095me3r6cro7bkrfnbtv6va3qvf6urew-6olc37m9ljymly3fcb6rig2nu  
192.168.65.2:2377
```

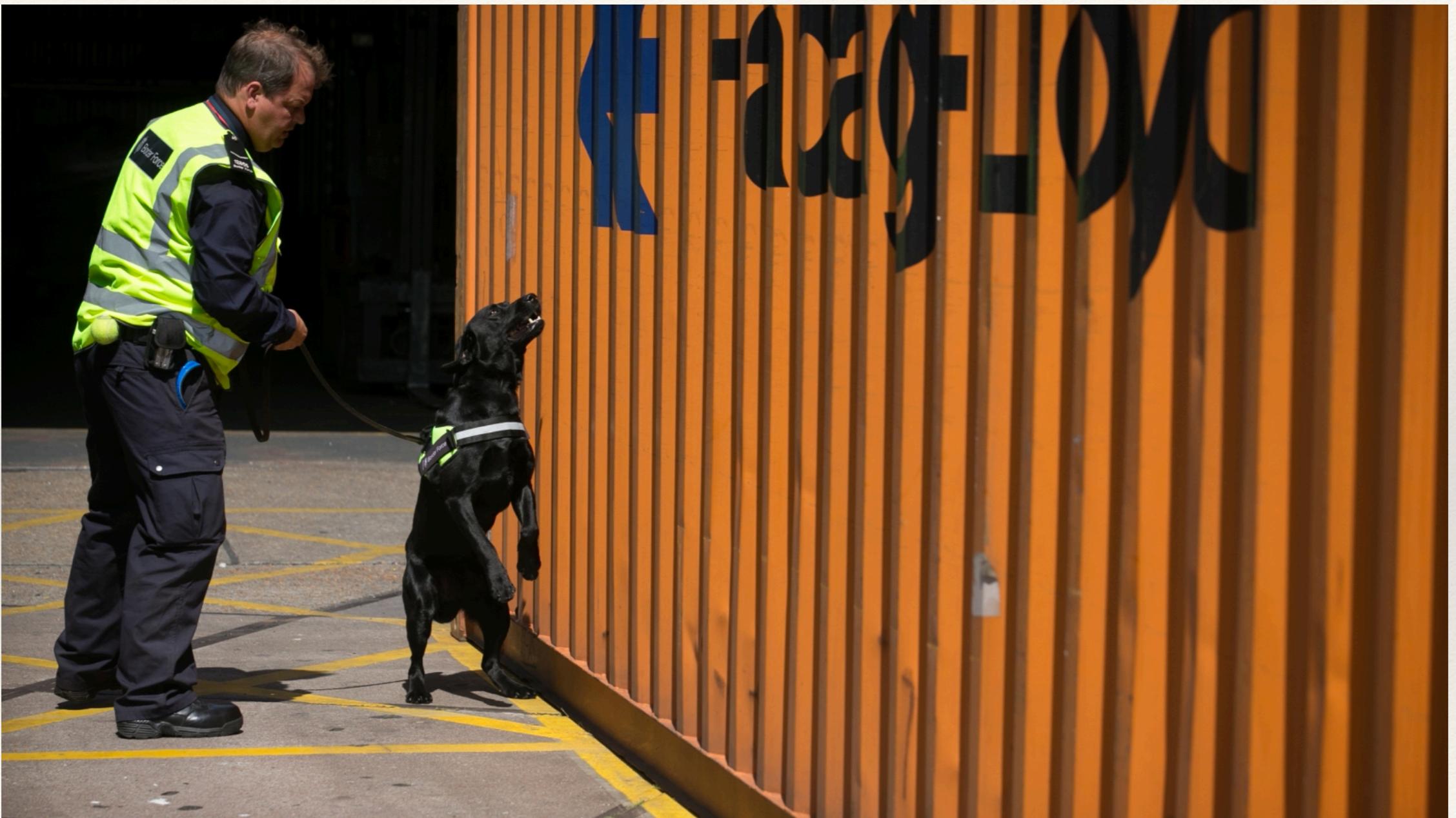
To add a manager to this swarm, run 'docker swarm join-token manager' and follow the instructions.

# Clustering for Docker

*"batteries included but swappable"*



# Docker Security



# Docker workbench for security

```
docker run -it --net host --pid host --cap-add audit_control \  
-v /var/lib:/var/lib \  
-v /var/run/docker.sock:/var/run/docker.sock \  
-v /usr/lib/systemd:/usr/lib/systemd \  
-v /etc:/etc --label docker_bench_security \  
docker/docker-bench-security
```

*OR*

```
git clone https://github.com/docker/docker-bench-security.git  
cd docker-bench-security  
docker-compose run --rm docker-bench-security
```

*OR*

```
git clone https://github.com/docker/docker-bench-security.git  
cd docker-bench-security  
sh docker-bench-security.sh
```

Source: <https://github.com/docker/docker-bench-security>

# Docker workbench for security

```
$ sh docker-bench-security.sh
# -----
# Docker Bench for Security v1.1.0
#
# Docker, Inc. (c) 2015-
#
# Checks for dozens of common best-practices around deploying Docker containers in production.
# Inspired by the CIS Docker 1.11 Benchmark:
# https://benchmarks.cisecurity.org/downloads/show-single/index.cfm?file=docker16.110
# -----


[WARN] Some tests might require root to run
[INFO] 1 - Host Configuration
[WARN] 1.1 - Create a separate partition for containers
[PASS] 1.2 - Use an updated Linux Kernel
[WARN] 1.4 - Remove all non-essential services from the host - Network
[WARN]     * Host listening on: 7 ports
[PASS] 1.5 - Keep Docker up to date
[INFO]     * Using 1.12.1 which is current as of 2016-08-16
[INFO]     * Check with your operating system vendor for support and security maintenance for docker
[INFO] 1.6 - Only allow trusted users to control Docker daemon
[WARN] 1.7 - Failed to inspect: auditctl command not found.
[INFO] 1.8 - Audit Docker files and directories - /var/lib/docker
[INFO]     * Directory not found
[INFO] 1.9 - Audit Docker files and directories - /etc/docker
[INFO]     * Directory not found

...
[INFO] 2 - Docker Daemon Configuration
[WARN] 2.1 - Restrict network traffic between containers
[PASS] 2.2 - Set the logging level
[PASS] 2.3 - Allow Docker to make changes to iptables
[PASS] 2.4 - Do not use insecure registries
[WARN] 2.5 - Do not use the aufs storage driver
[INFO] 2.6 - Configure TLS authentication for Docker daemon
[INFO]     * Docker daemon not listening on TCP
[INFO] 2.7 - Set default ulimit as appropriate
[INFO]     * Default ulimit doesn't appear to be set
[WARN] 2.8 - Enable user namespace support
[PASS] 2.9 - Confirm default cgroup usage
[PASS] 2.10 - Do not change base device size until needed
[WARN] 2.11 - Use authorization plugin
[WARN] 2.12 - Configure centralized and remote logging
[WARN] 2.13 - Disable operations on legacy registry (v1)

...
```

# Docker workbench for security

- ❖ Use the free Docker Workbench For Security (<https://github.com/docker/docker-bench-security>) to check for violations of security best practices

# Monitoring Docker



# Stats for all running containers

Use “docker stats” command

```
$ docker stats
```

CONTAINER	CPU %	MEM USAGE / LIMIT	MEM %	NET I/O	BLOCK I/O	PIDS
5394e9b78397	0.00%	1.805 MiB / 1.953 GiB	0.09%	648 B / 648 B	389.1 kB / 0 B	2
6b873116f198	0.00%	1.395 MiB / 1.953 GiB	0.07%	4.354 kB / 648 B	0 B / 0 B	2
742e01ef7fd4	0.00%	500 KiB / 1.953 GiB	0.02%	10.68 kB / 648 B	0 B / 0 B	1
c51b984b4d64	0.01%	18.54 MiB / 1.953 GiB	0.93%	12.49 kB / 648 B	16.6 MB / 0 B	7
ce042fe264b2	0.00%	60 KiB / 1.953 GiB	0.00%	14.94 kB / 648 B	0 B / 0 B	1
c8a954a62a19	0.00%	60 KiB / 1.953 GiB	0.00%	17.69 kB / 648 B	0 B / 0 B	1
725d93bb258c	0.00%	64 KiB / 1.953 GiB	0.00%	18.34 kB / 648 B	4.096 kB / 0 B	1
04579b88a74c	0.00%	340 KiB / 1.953 GiB	0.02%	19.08 kB / 648 B	94.21 kB / 0 B	2
99d946d9b4e0	0.00%	104 KiB / 1.953 GiB	0.01%	21.32 kB / 1.026 kB	24.58 kB / 0 B	1
9128bf57e03c	0.00%	288 KiB / 1.953 GiB	0.01%	5.692 kB / 648 B	0 B / 0 B	2

Displays resource utilisation (cpu, memory, etc) details; automatically updated when details change

# Stats for a specific Docker

Use “`docker stats <<CONTAINER_ID>>`” command

```
$ docker stats sleepy_wescoff
```

CONTAINER	CPU %	MEM USAGE / LIMIT	MEM %	NET I/O	BLOCK I/O	PIDS
sleepy_wescoff	0.00%	1.031 MiB / 4 MiB	25.78%	648 B / 648 B	0 B / 0 B	1

# Printing containers names in stat

TRY  
THIS!

```
$ docker stats $(docker ps --format='{{.Names}}')
```

# Monitoring Docker

Use the free cAdvisor tool  
(<https://github.com/google/cadvisor>)

```
docker run --volume=/:/rootfs:ro --volume=/var/run:/var/run:rw --volume=/sys:/sys:ro --volume=/var/lib/docker:/var/lib/docker:ro --publish=8080:8080 --detach=true --name=cadvisor google/cadvisor:latest
```

Now open localhost:8080 in your browser

# Monitoring Docker



# Monitoring Docker

- ❖ **datadog** (<https://www.datadoghq.com/>)
- ❖ **sysdig** (<http://www.sysdig.org/>)
- ❖ **prometheus** (<https://prometheus.io/>)

# Other topics



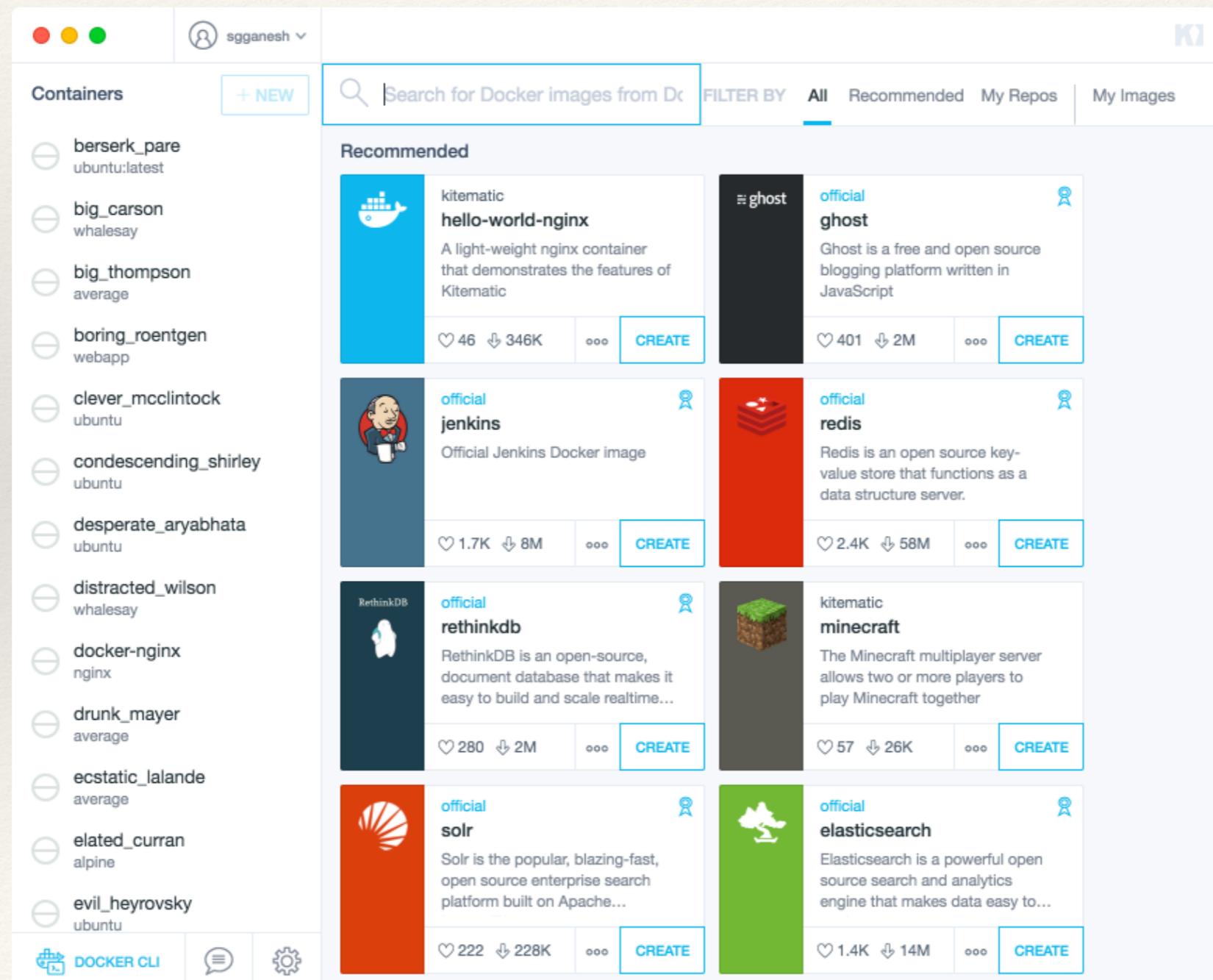
# How do debug on a running container?

Use “docker exec” command

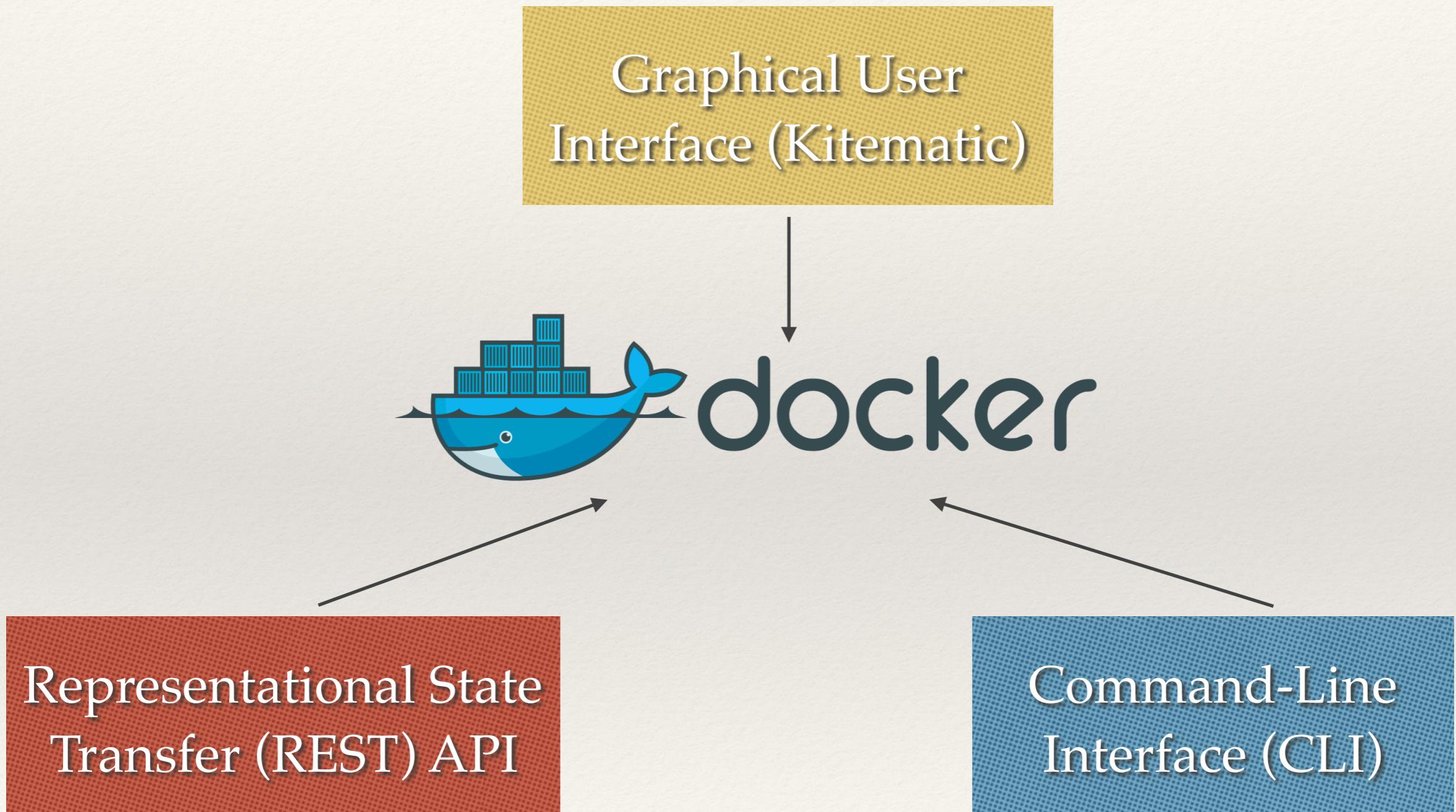
```
$ docker ps -a
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              NAMES
9128bf57e03c        ubuntu              "/bin/sh -c 'while tr"   24 minutes ago   Up      lonely_einstein
24 minutes
$ docker exec -ti lonely_einstein /bin/bash
root@9128bf57e03c:/#
```

# Can I use GUI instead of command-line?

Use “kitematic” (<https://github.com/docker/kitematic>)



# Different ways to access Docker



# Crazy stuff: Docker in Docker!!

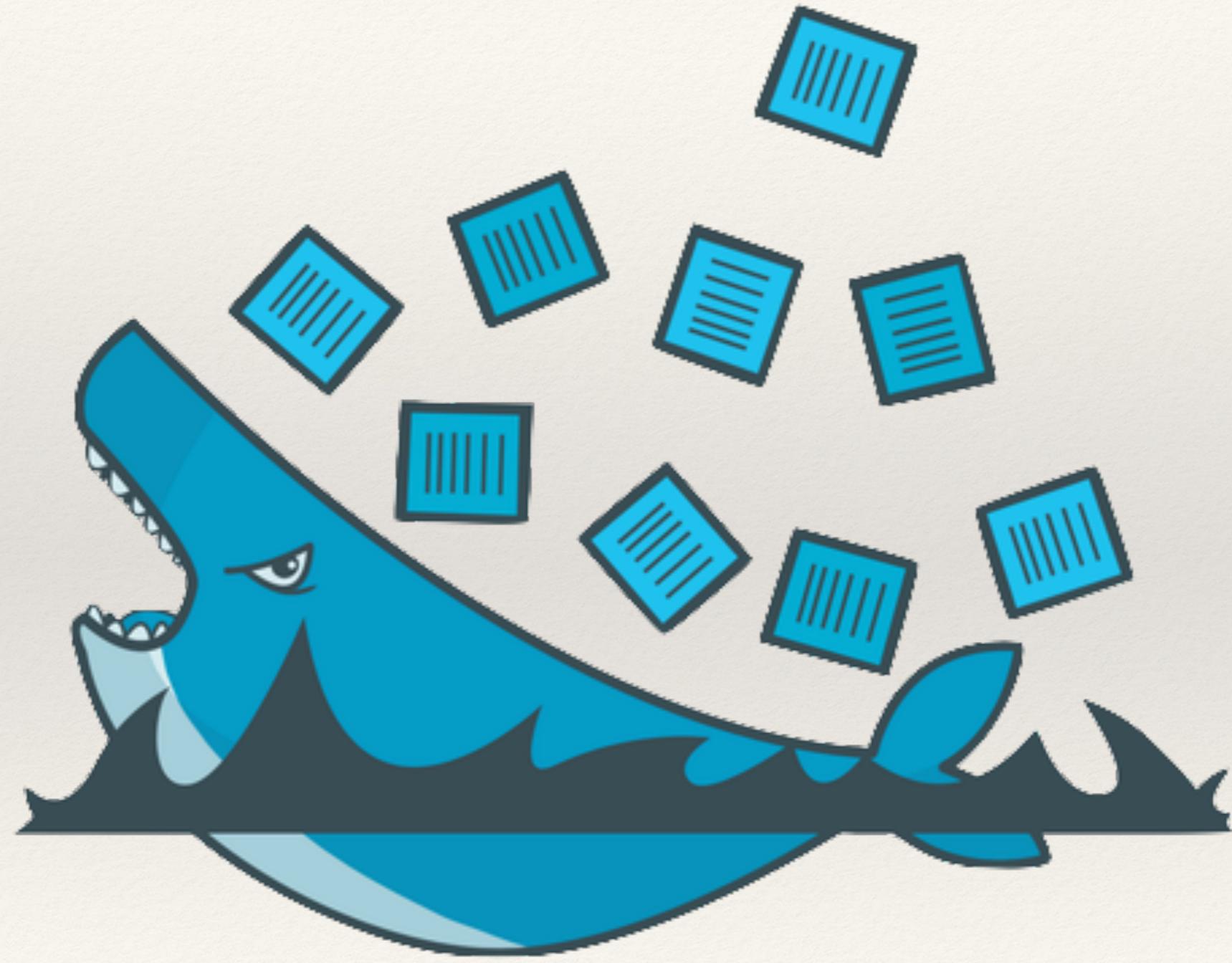
Use “`docker run --privileged -d docker:dind`”

“`docker:dind`” is the official “Docker in Docker base image”

See: <https://github.com/jpetazzo/dind>



# Myths and Misconceptions



# Docker \*completely\* replaces VMs



**Docker**   
@docker



Following

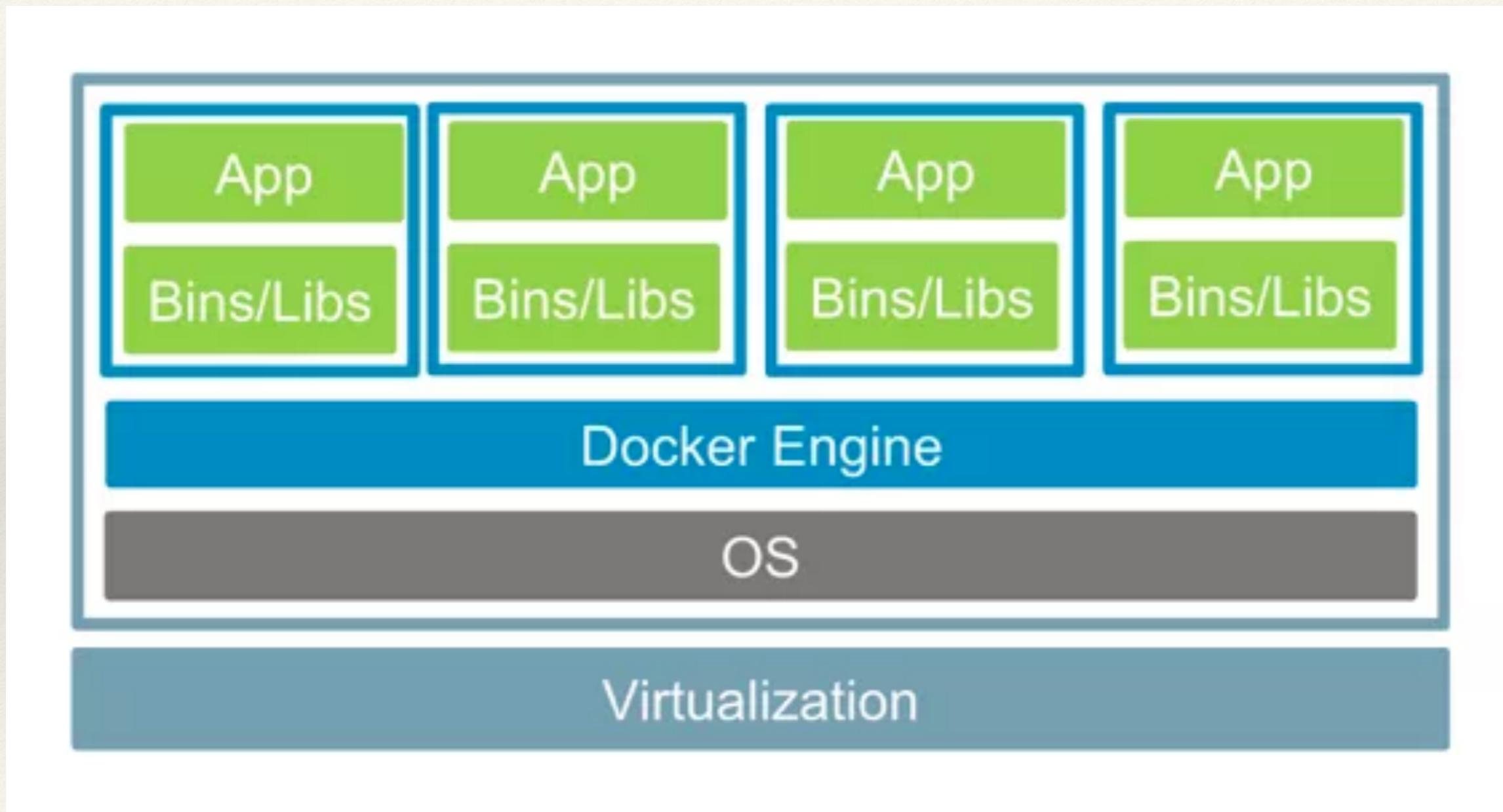
Are you currently using @docker containers & VMs together? #Twitterpoll #VMWorld

**58%** YES

**42%** NO

1,338 votes • Final results

# Containers AND VMs



# Docker is \*completely\* portable

Build once, run anywhere - but conditions apply!

There are limitations to portability with Docker (depending on what you mean by “portable”).

For example, you can run a Windows Docker container only on Windows and run a Linux Docker container only on Linux (and not vice versa).

“Management says we need  
Docker, so let’s use it”



# Quick reference



# Docker commands

attach	Attach to a running container
build	Build an image from a Dockerfile
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
deploy	Create and update a stack from a Distributed Application Bundle (DAB)
diff	Inspect changes on a container's filesystem
events	Get real time events from the server
exec	Run a command in a running container
export	Export a container's filesystem as a tar archive
history	Show the history of an image
images	List images
import	Import the contents from a tarball to create a filesystem image
info	Display system-wide information
inspect	Return low-level information on a container, image or task
kill	Kill one or more running container
load	Load an image from a tar archive or STDIN
login	Log in to a Docker registry.
logout	Log out from a Docker registry.
logs	Fetch the logs of a container
network	Manage Docker networks
node	Manage Docker Swarm nodes
pause	Pause all processes within one or more containers
plugin	Manage Docker plugins

# Docker commands

port	List port mappings or a specific mapping for the container
ps	List containers
pull	Pull an image or a repository from a registry
push	Push an image or a repository to a registry
rename	Rename a container
restart	Restart a container
rm	Remove one or more containers
rmi	Remove one or more images
run	Run a command in a new container
save	Save one or more images to a tar archive (streamed to STDOUT by default)
search	Search the Docker Hub for images
service	Manage Docker services
stack	Manage Docker stacks
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
swarm	Manage Docker Swarm
tag	Tag an image into a repository
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
version	Show the Docker version information
volume	Manage Docker volumes
wait	Block until a container stops, then print its exit code

## Glossary

**Layer** - a set of read-only files to provision the system

**Image** - a read-only layer that is the base of your container. Might have a parent image

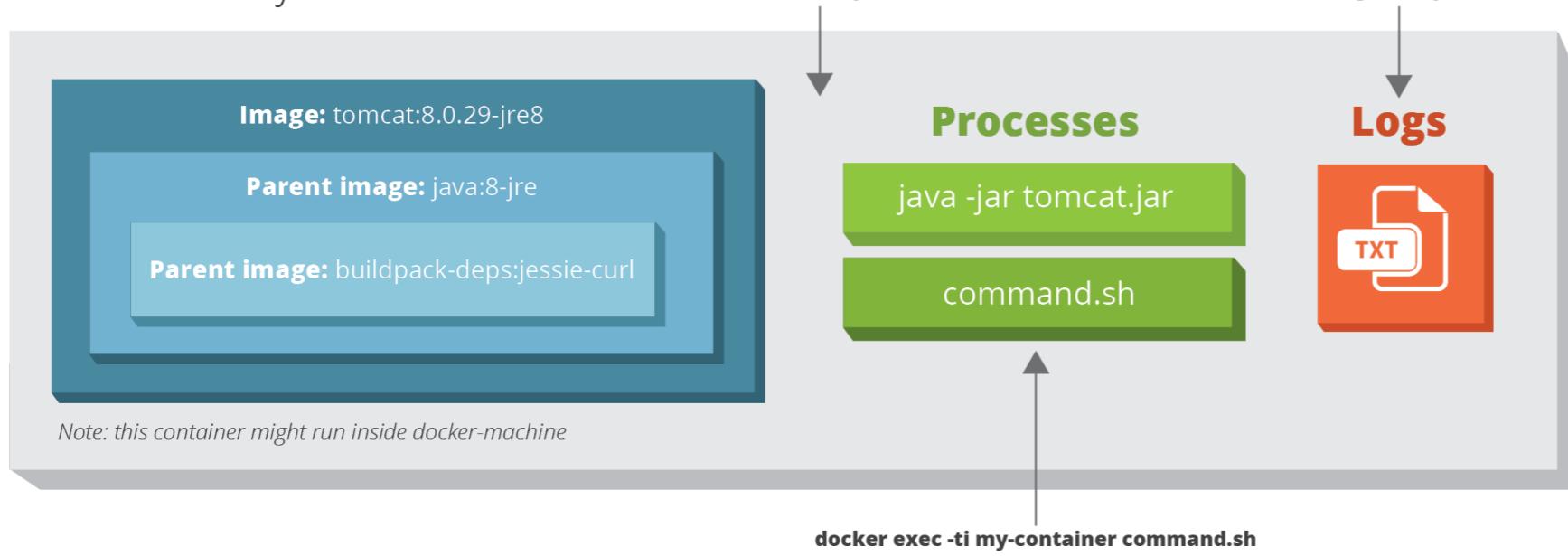
**Container** - a runnable instance of the image

**Registry / Hub** - central place where images live

**Docker machine** - a VM to run Docker containers (Linux does this natively)

**Docker compose** - a utility to run multiple containers as a system

## Container: my-container



## Useful one-liners

Download an image

```
docker pull image_name
```

Start and stop the container

```
docker [start|stop] container_name
```

Create and start container, run command

```
docker run -ti --name container_name
           image_name command
```

Create and start container, run command, destroy container

```
docker run --rm -ti image_name command
```

Example filesystem and port mappings

```
docker run -it --rm -p 8080:8080 -v
           /path/to/agent.jar:/agent.jar -e
           JAVA_OPTS="-javaagent:/agent.jar"
           tomcat:8.0.29-jre8
```

## Docker cleanup commands

Kill all running containers

```
docker kill $(docker ps -q)
```

Delete dangling images

```
docker rmi $(docker images -q -f
              dangling=true)
```

Remove all stopped containers

```
docker rm $(docker ps -a -q)
```

## Docker machine commands

Use docker-machine to run the containers

Start a machine

```
docker-machine start machine_name
```

Configure docker to use a specific machine

```
eval "$(docker-machine env machine_name)"
```

## Docker compose syntax

docker-compose.yml file example

```
version: "2"
services:
  web:
    container_name: "web"
    image: java:8 # image name
    # command to run
    command: java -jar /app/app.jar
    ports: # map ports to the host
      - "4567:4567"
    volumes: # map filesystem to the host
      - ./myapp.jar:/app/app.jar
  mongo: # container name
    image: mongo # image name
```

Create and start containers

```
docker-compose up
```

## Interacting with a container

Run a command in the container

```
docker exec -ti container_name command.sh
```

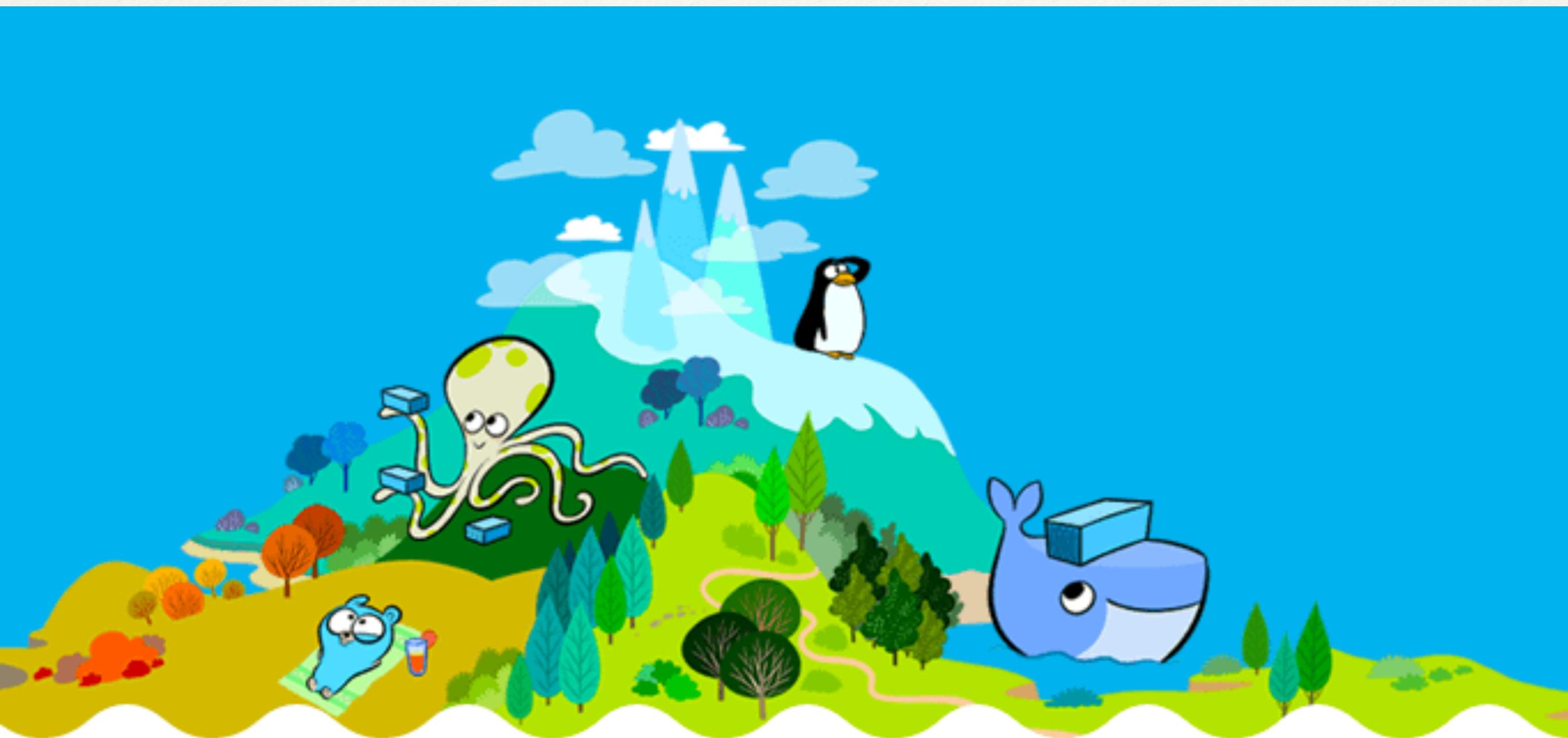
Follow the container logs

```
docker logs -ft container_name
```

Save a running container as an image

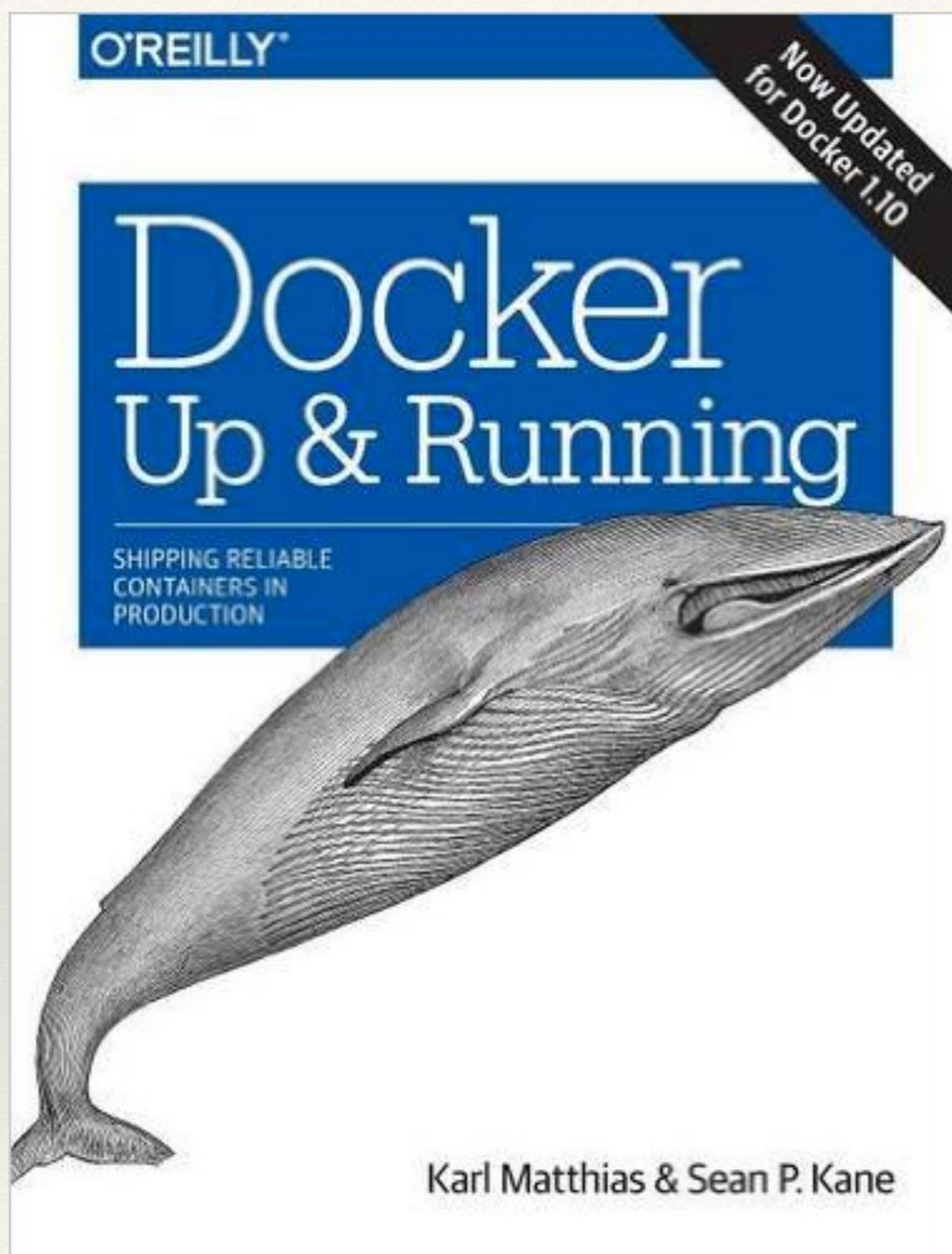
```
docker commit -m "commit message" -a "author"
               container_name username/image_name:tag
```

# Where to learn more?



# Relevant URLs

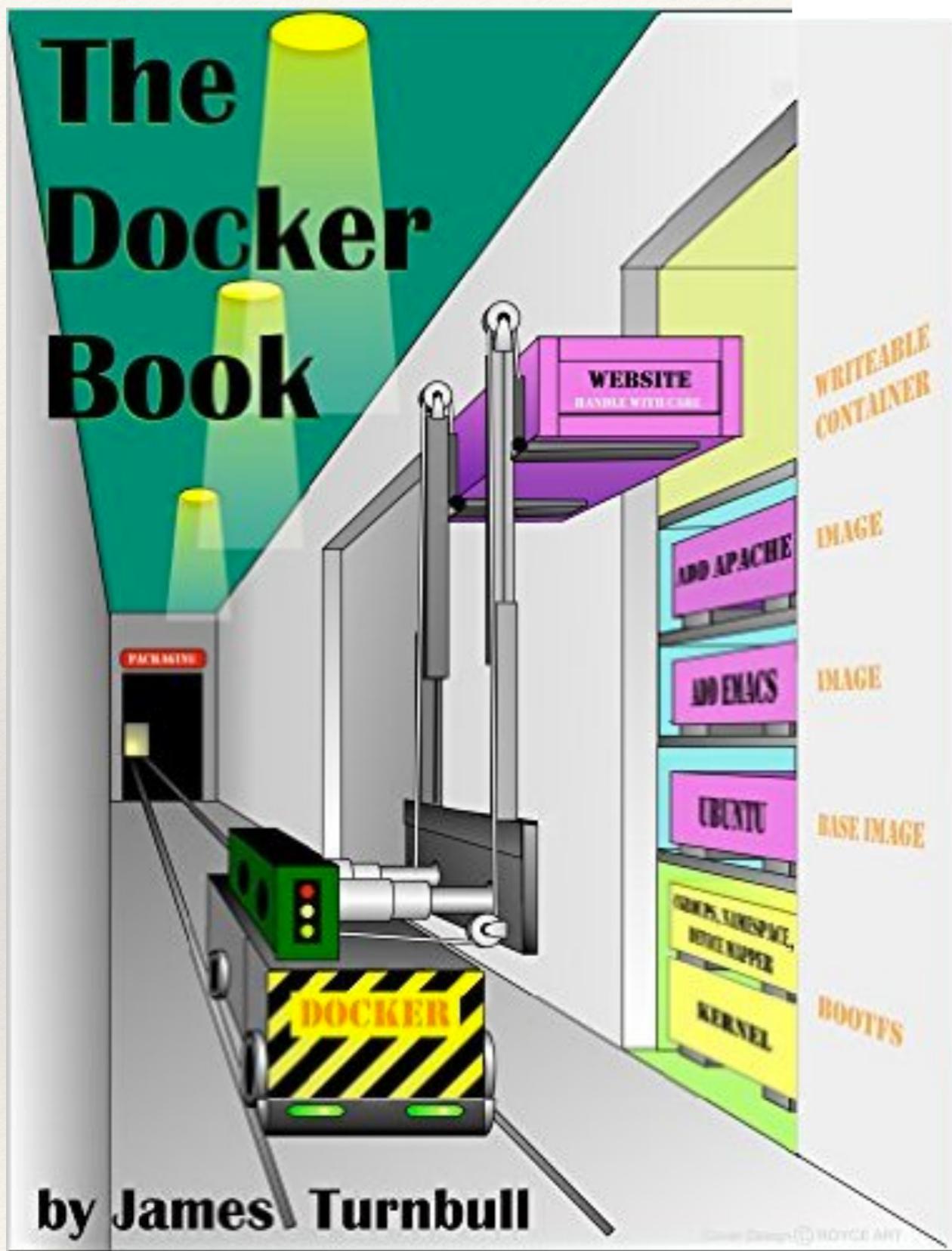
- ❖ Detailed list of resources: <https://github.com/hangyan/docker-resources>
- ❖ Self-learning courses: <https://training.docker.com/>
- ❖ Detailed documentation: <https://docs.docker.com/>
- ❖ Detailed tutorial (presentation): <http://docker.training>
- ❖ SE-Radio Episode 217: [James Turnbull on Docker](#)
- ❖ Docker related presentations in [parleys.com](#)
- ❖ [Blog on Docker resource utilisation](#)



## DOCKER: UP & RUNNING

- Covers how to develop, test, debug, ship, scale, and support with Docker from DevOps perspective
- We liked the useful tips; examples:
  - “Maximize robustness with fast startup and graceful shutdown.”
  - “Explicitly declare and isolate dependencies.”
  - “Strictly separate build and run stages.”

<http://amzn.com/1491917571>

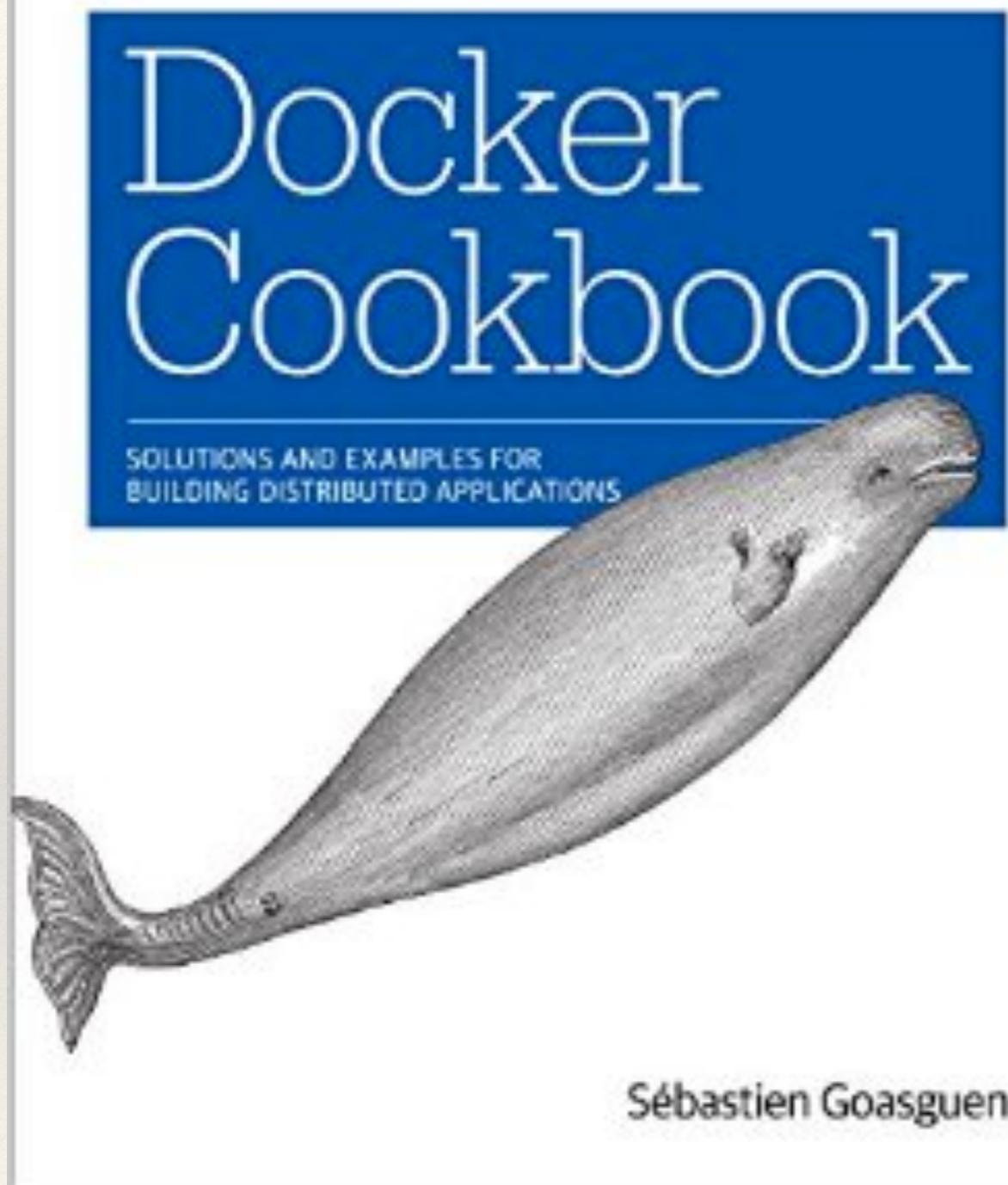


<http://www.amazon.in/dp/B00LRR0T14>

*The Docker Book, James Turnbull, Amazon Digital South Asia Services, July 2014*

# THE DOCKER BOOK

- Interesting sub-title:  
“Containerization is the new virtualization”.
- From James Turnbull (CTO at Kickstarter and Advisor at Docker)
- Useful to get comfortable with core concepts of Docker
- Useful for developers, operations staff (and DevOps), and SysAdmins
- Supporting website: <http://dockerbook.com/>

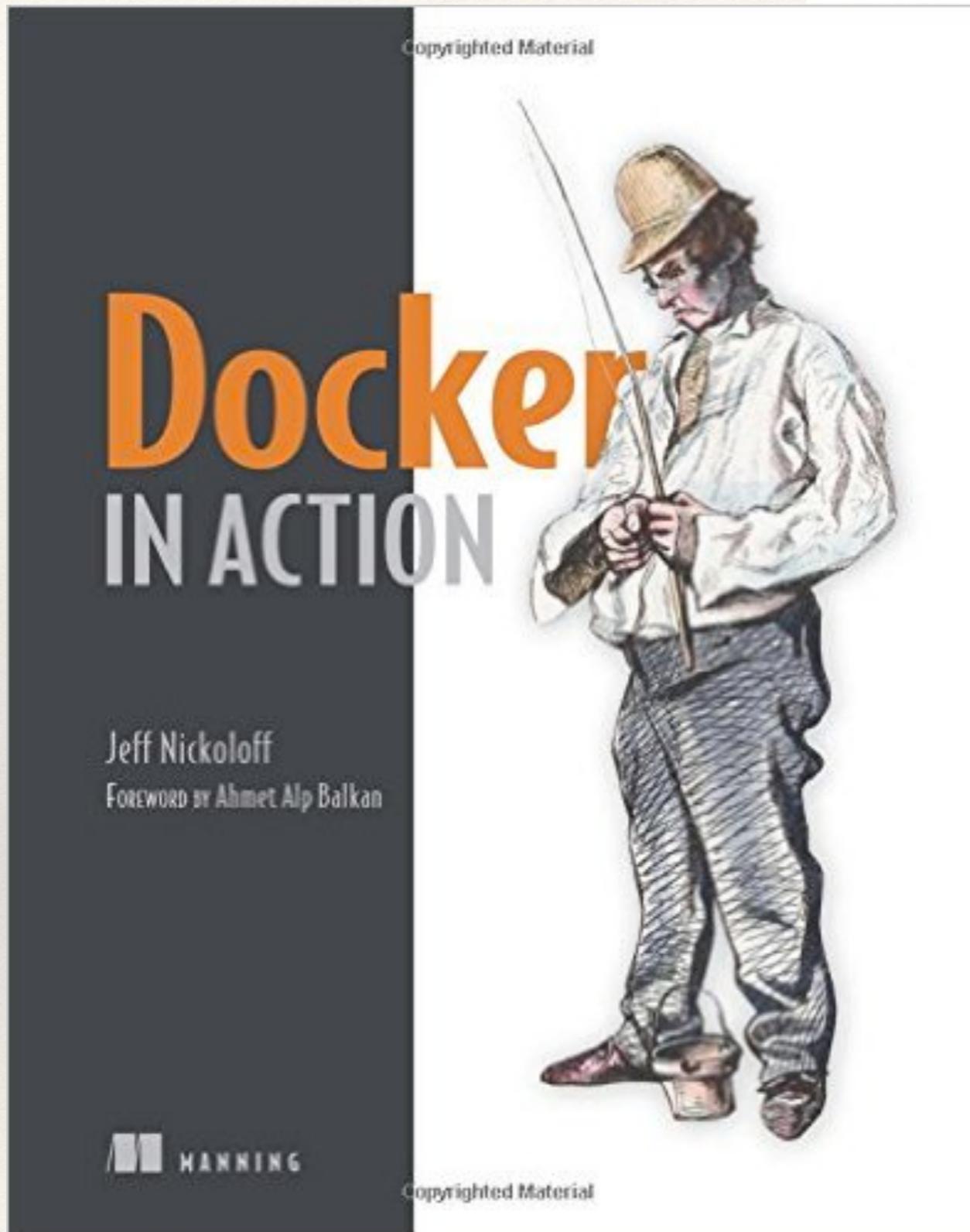


<http://amzn.com/149191971X>

"Docker Cookbook", Sébastien Goasguen, O'Reilly Media, 2015

## DOCKER COOKBOOK

- Contents written in recipe format (Problem, Solution, Discussion)
- Useful because we can look for solutions to the problems that we face when using Docker
- What we like: it covers topics that are not covered well in other books including Kubernetes, Docker ecosystem tools, monitoring Docker, and application use cases (CI, CD)

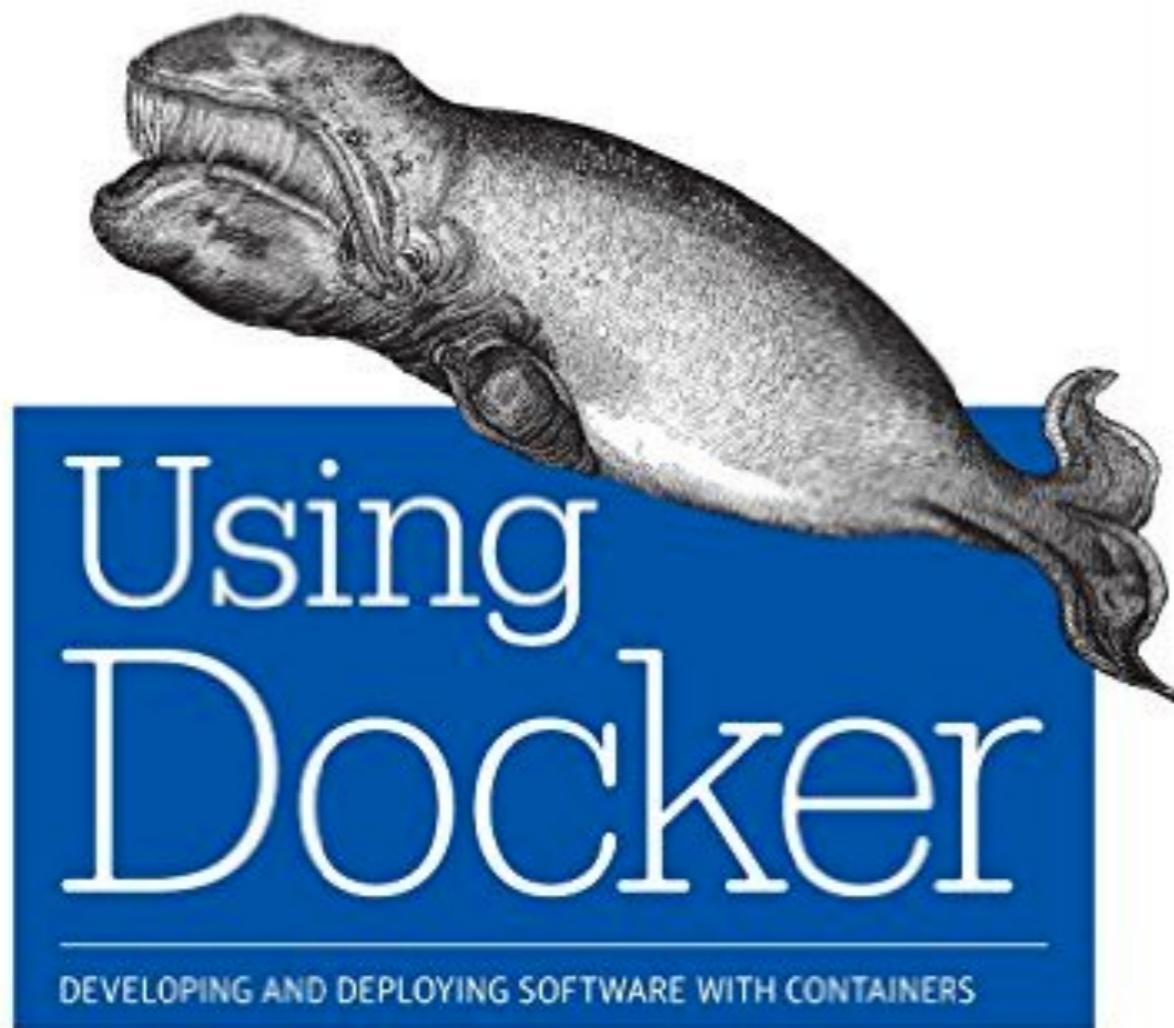


## DOCKER IN ACTION

- Wide coverage from basics to advanced topics like managing massive clusters
- Book organised into three parts:
  - Keeping a tidy computer
  - Packaging software for distribution
  - Multi-container and multi-host environments
- The third part is more interesting for us because it is not covered well in other books
  - Covers Docker Compose, Machine and Swarm

<http://amzn.com/1633430235>

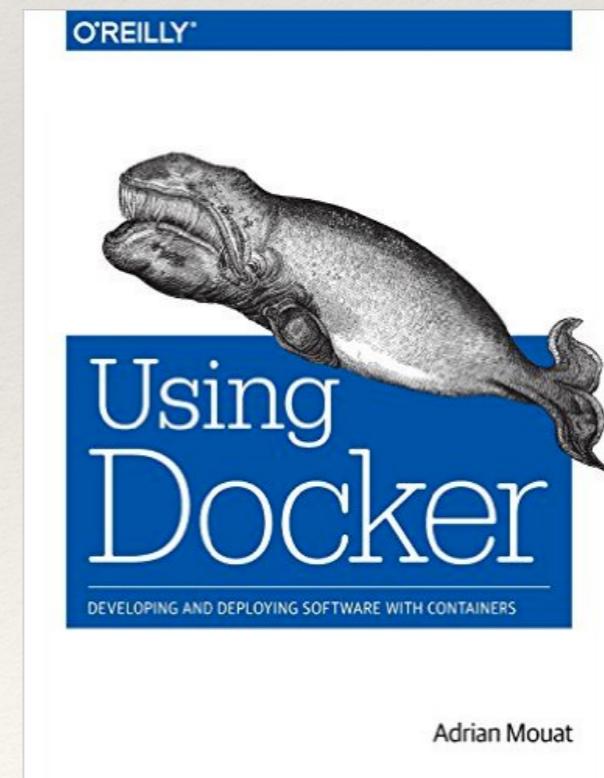
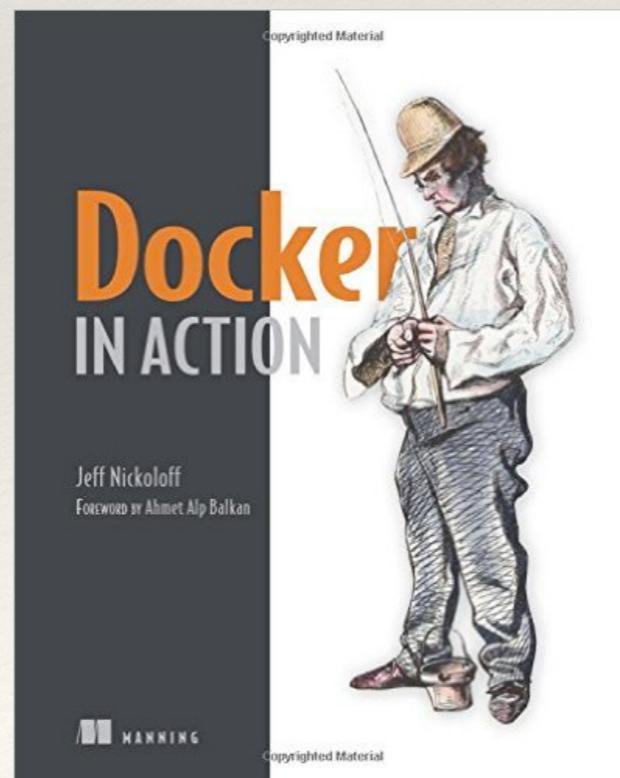
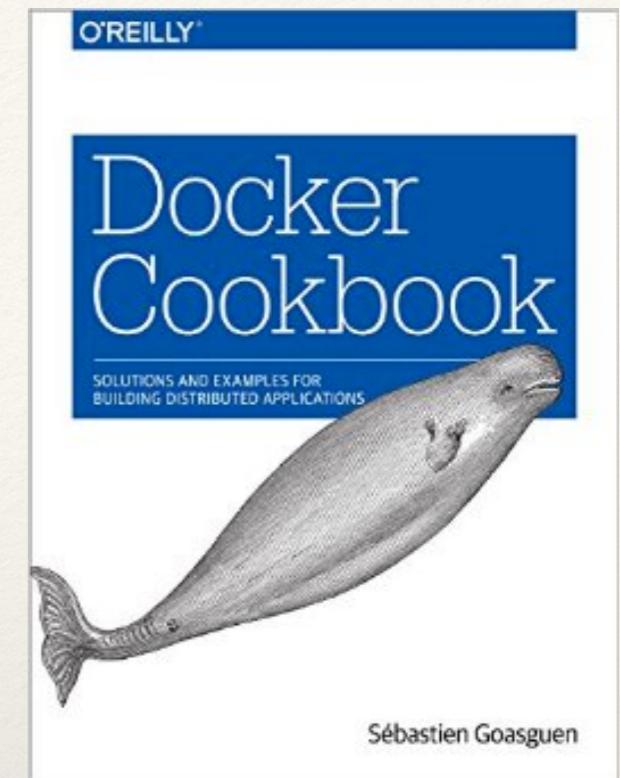
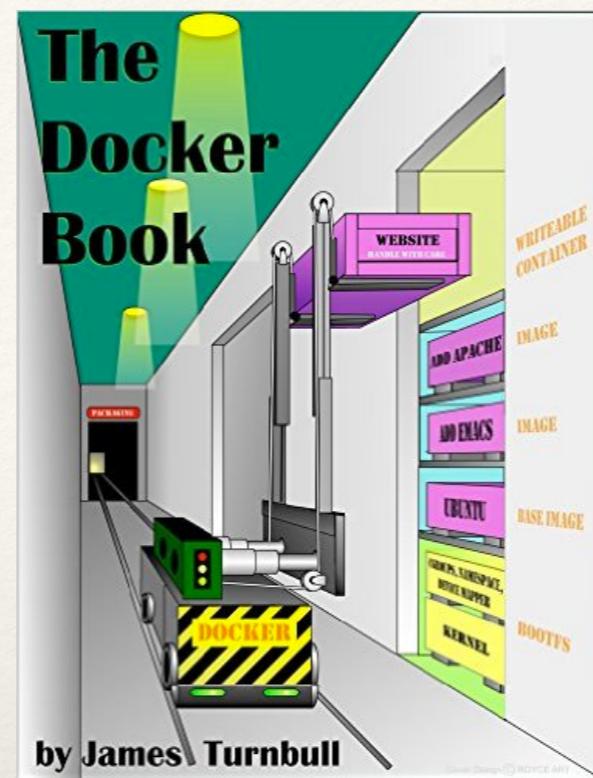
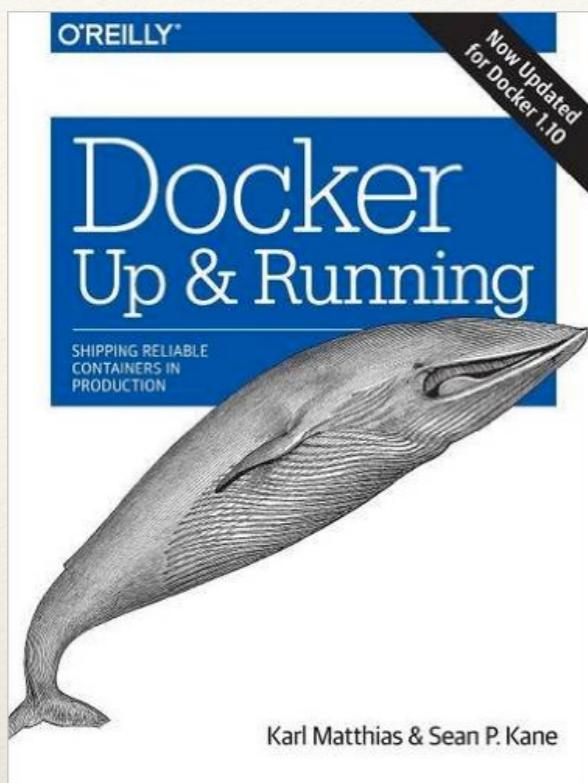
Docker in Action, Jeff Nickoloff, Manning Publications, 2016



## USING DOCKER

- Book organised into three parts:
  - Background and Basics
  - The Software Lifecycle with Docker
  - Tools and Techniques
- Useful example: Walks you through the steps to develop and deploy web applications with Docker
- Though the book touches upon basics, it covers more advanced topics

<http://amzn.com/1491915765>



# Upcoming bootcamps

AngularJS (22nd Oct)

Modern Software Architecture (5th Nov)

SOLID Principles (19th Nov)

# Meetups



<http://www.meetup.com/JavaScript-Meetup-Bangalore/>

<http://www.meetup.com/Container-Developers-Meetup-Bangalore/>

<http://www.meetup.com/Software-Craftsmanship-Bangalore-Meetup/>

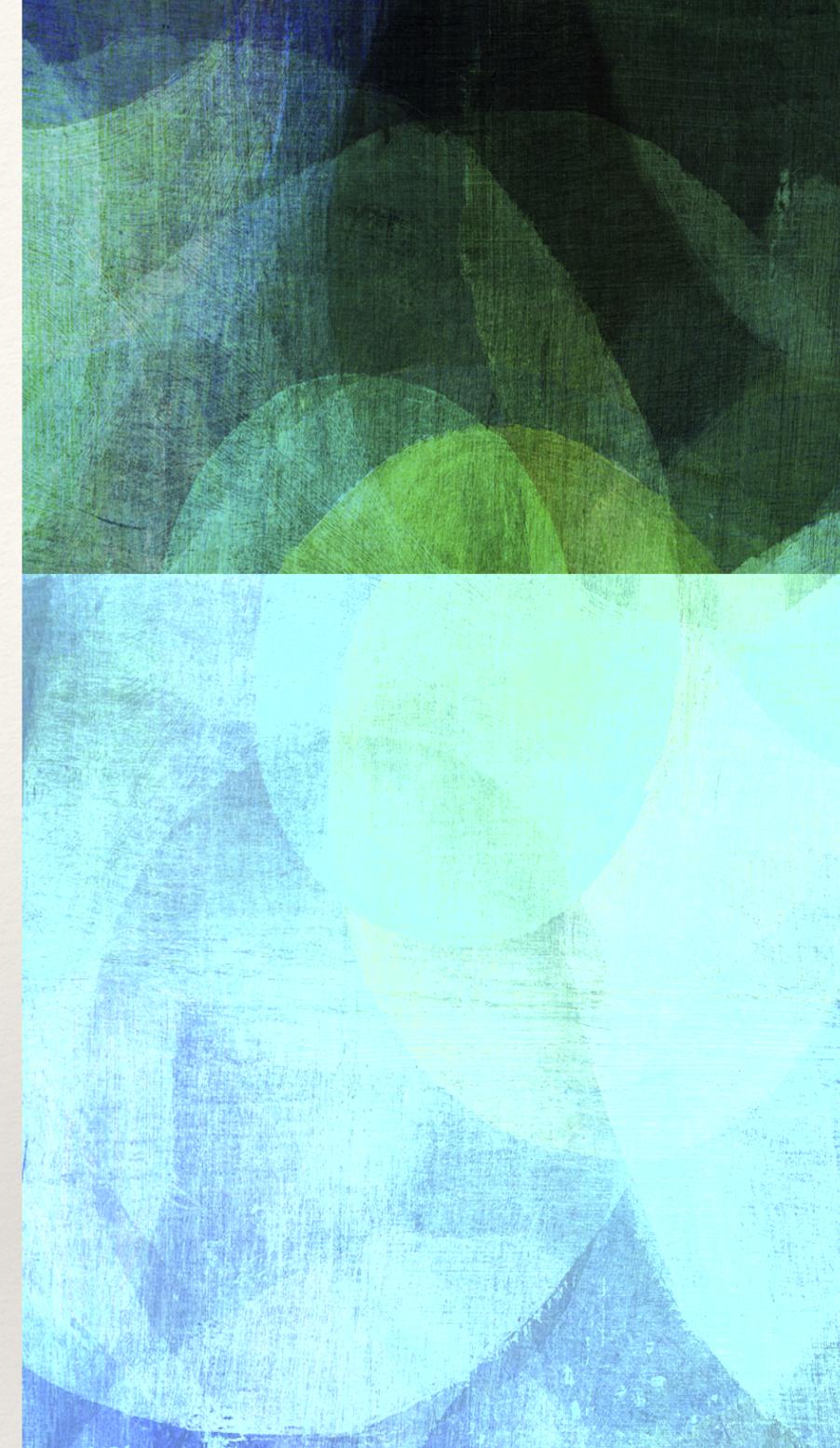
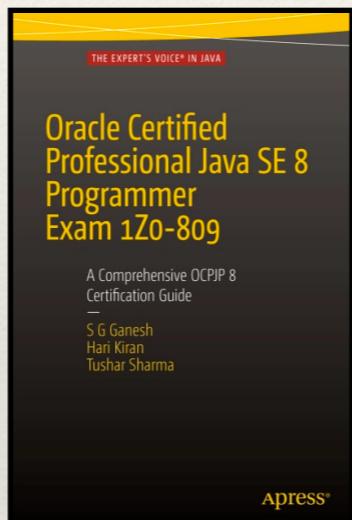
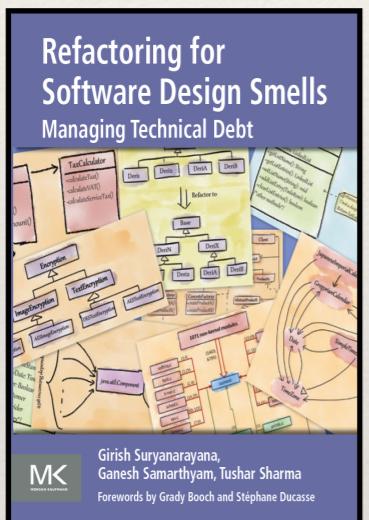
<http://www.meetup.com/Core-Java-Meetup-Bangalore/>

<http://www.meetup.com/Technical-Writers-Meetup-Bangalore/>

<http://www.meetup.com/CloudOps-Meetup-Bangalore/>

<http://www.meetup.com/Bangalore-SDN-IoT-NetworkVirtualization-Enthusiasts/>

<http://www.meetup.com/SoftwareArchitectsBangalore/>



[ganesh@codeops.tech](mailto:ganesh@codeops.tech)

[www.codeops.tech](http://www.codeops.tech)

+91 98801 64463

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# Image credits

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- ❖ [http://patg.net/assets/container\\_vs\\_vm.jpg](http://patg.net/assets/container_vs_vm.jpg)
- ❖ <http://static1.businessinsider.com/image/525e9c7669bedd9c3015dc60-1190-625/the-10-funniest-dilbert-comic-strips-about-idiot-bosses.jpg>
- ❖ <https://blog.docker.com/wp-content/uploads/2014/03/docker-execdriver-diagram.png>
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- ❖ <https://en.wikipedia.org/wiki/File:Docker-linux-interfaces.svg>
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- ❖ [http://core0.staticworld.net/images/article/2014/11/docker\\_linux-100530817-primary.idge.jpg](http://core0.staticworld.net/images/article/2014/11/docker_linux-100530817-primary.idge.jpg)
- ❖ <http://cdn.hrpayrollsheets.net/wp-content/uploads/2015/02/best-practices-hris.jpg>
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- ❖ <https://blog.docker.com/media/2015/04/sticker-02-15-2-1024x711.png>
- ❖ <http://blogs-images.forbes.com/janakirammsv/files/2016/06/docker1.jpg?width=960>
- ❖ [http://blogs-images.forbes.com/janakirammsv/files/2016/06/Docker\\_CI\\_CD.jpg?width=960](http://blogs-images.forbes.com/janakirammsv/files/2016/06/Docker_CI_CD.jpg?width=960)

# Image credits

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- ❖ <http://cormachogan.com/wp-content/uploads/2016/07/docker-volumes.jpg>
- ❖ <http://image.slidesharecdn.com/swarmonlinemeetup-150507153718-lva1-app6891/95/docker-swarm-020-5-638.jpg?cb=1431013147>
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# Image credits

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