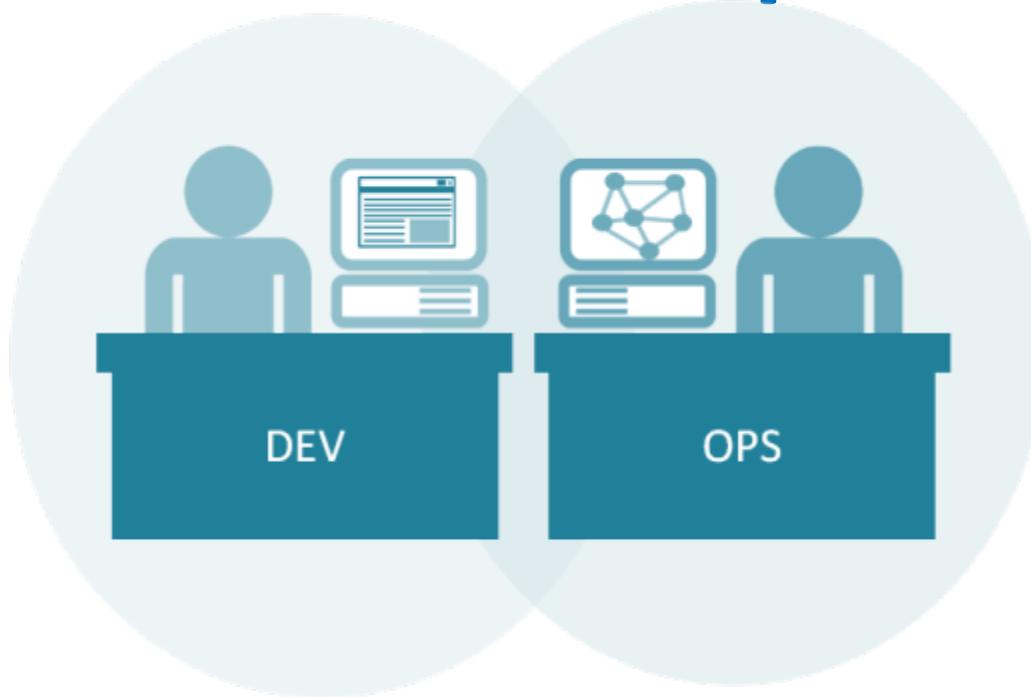


# Docker

# Container Implementation

# Boot Camp



# Welcome!

---

Logistics (breaks,  
facilities, lunch, etc.)

Rules of Engagement

Introductions

Let's Get Started!

# Instructor Information

---



**Who is your instructor?**  
*A little about me...*

---

# Introductions

What is your  
Name and  
Job Role?

Your  
company or  
team?

Expectations  
for the class?

Something  
interesting  
about  
yourself?

# What to expect from this class

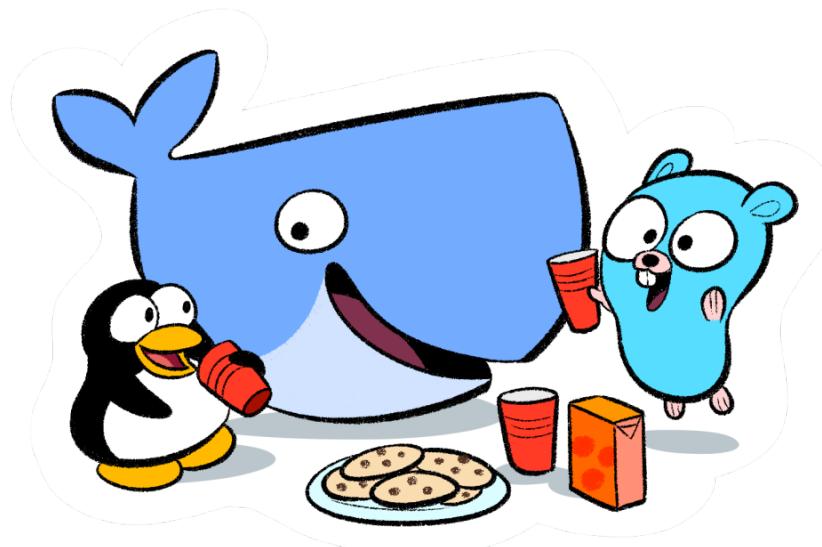
---

- Flexibility
- Conversations
- Literacy and awareness on many of the principles, tools, and practices surrounding Docker as part of a DevOps architecture.
- An effort to focus on your own situations and challenges so you can act on what you learn.

Part 1: DevOps Docker

# Introduction to Docker

---



# What is Docker?

## The Docker Project

### Open Source Project

- 2B+ Docker Image Downloads
- 2000+ contributors
- 40K+ GitHub stars
- 200K+ Dockerized apps
- 240 Meetups in 70 countries
- 95K Meetup members

## Docker Inc

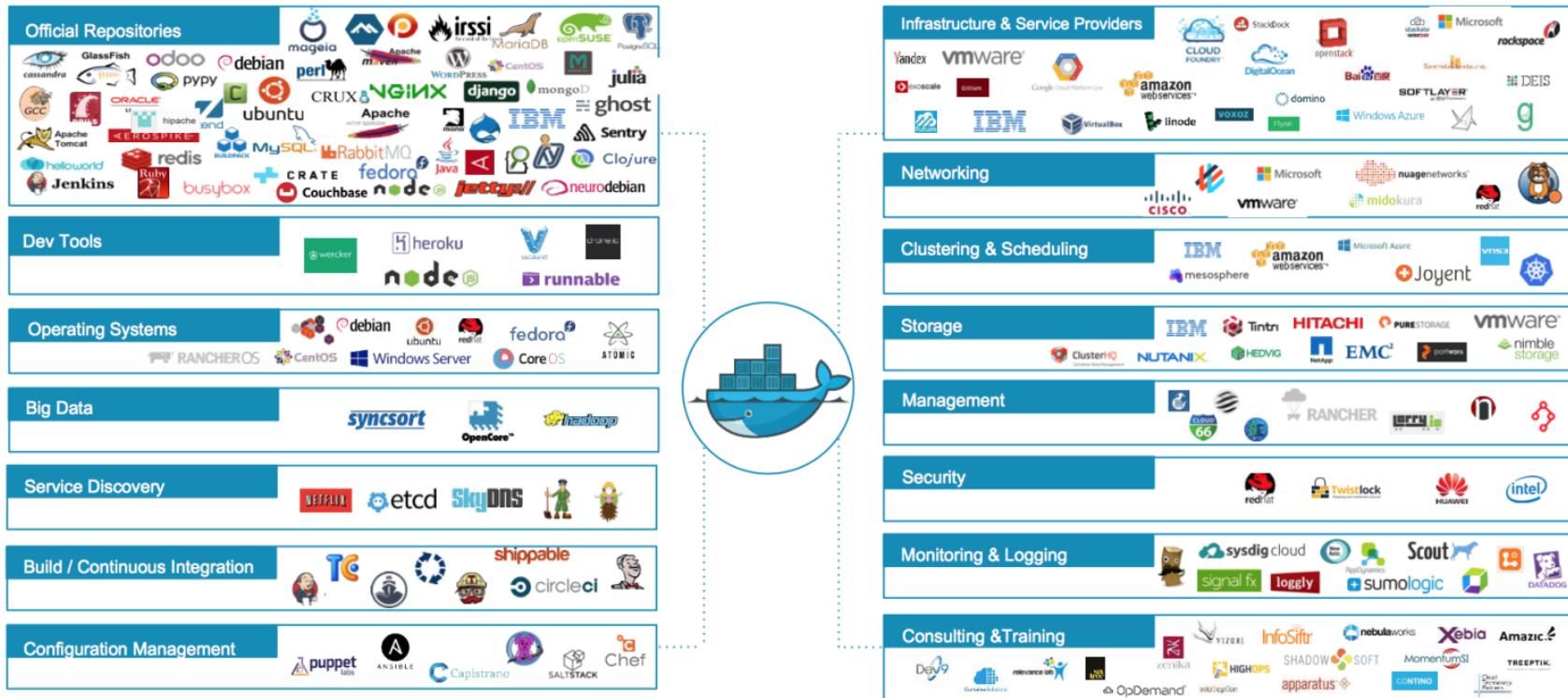
### Containers as a Service provider

- Integrated platform for dev and IT
- Commercial technical support

### Docker project sponsor

- Primary sponsor of Docker project
- Supports project maintainers

# Docker ecosystem



# Docker Basics



## Docker Image

- The basis of a Docker container



## Docker Container

- The standard unit in which the application service resides



## Docker Engine

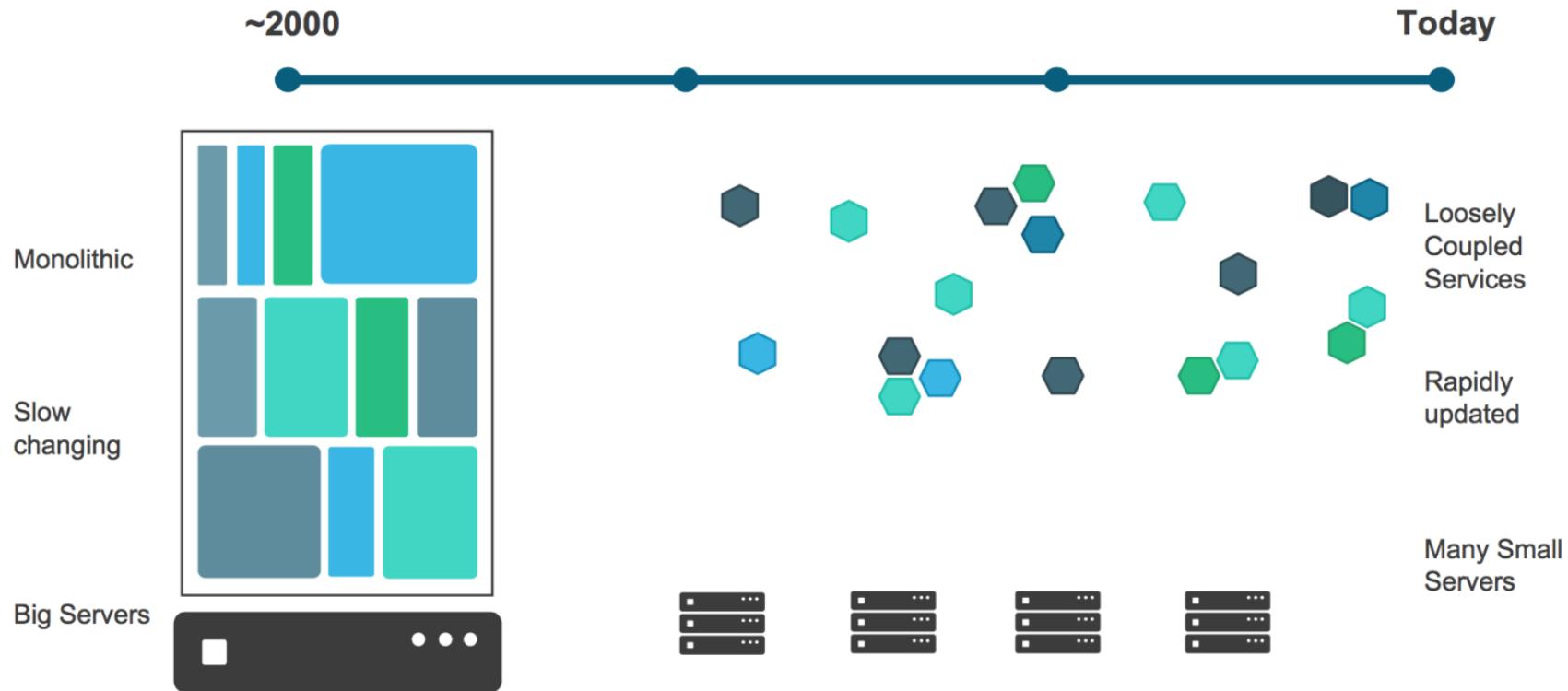
- Creates, ships and runs Docker containers deployable on physical or virtual host locally, in a datacenter or cloud service provider



## Docker Registry

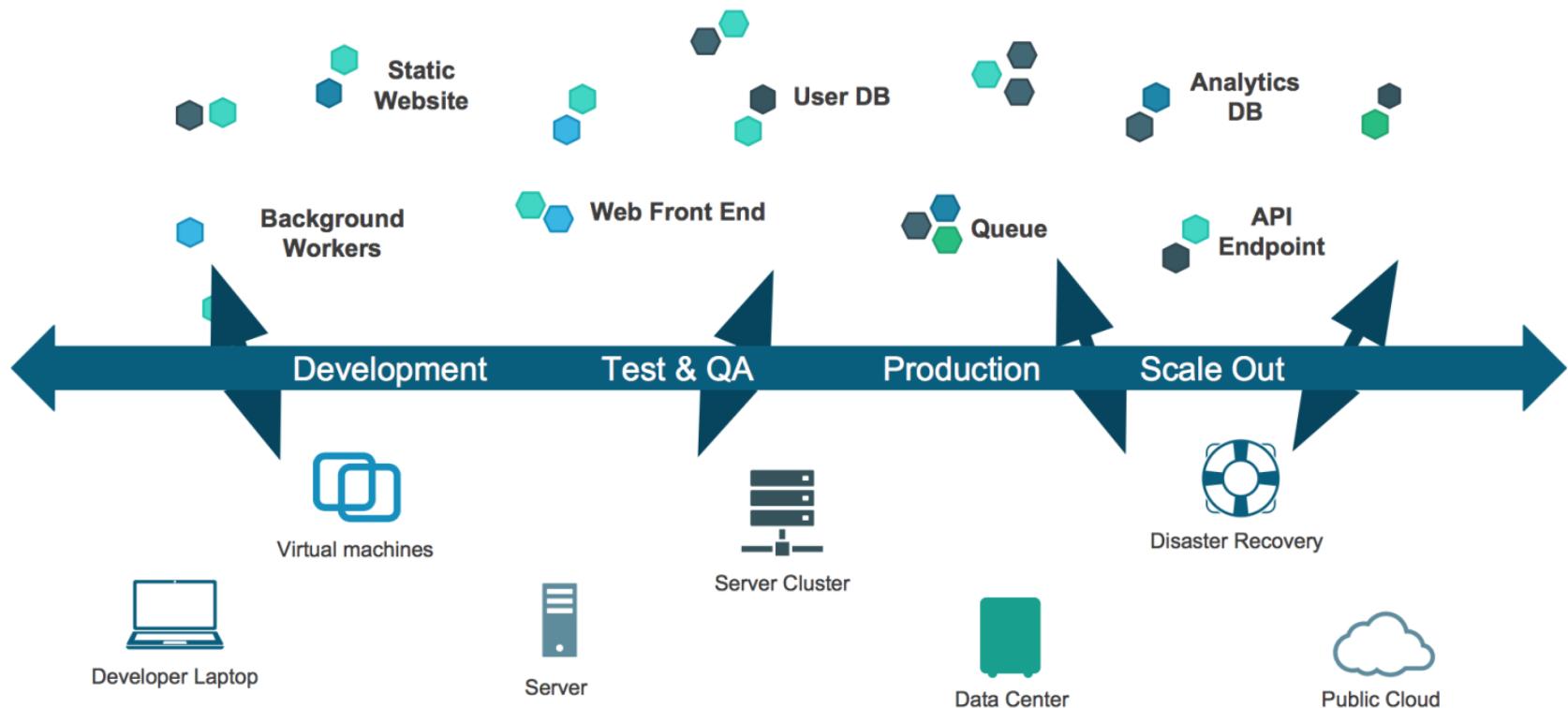
- On-premises registry for image storing and collaboration

# Application Evolution



# Challenge: The Dependency Matrix

## “It works on MY machine.”



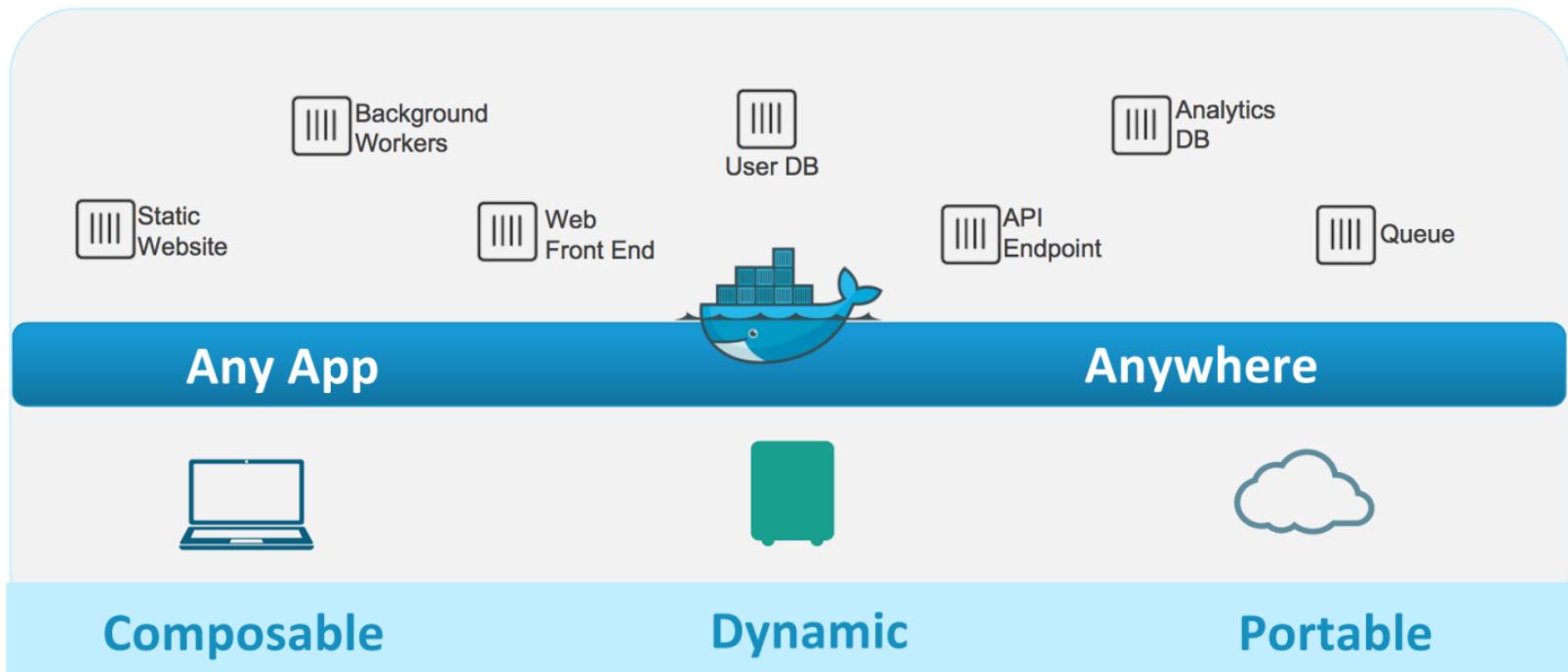
# Containers as a Solution



Container

- Packages up software binaries and dependencies
- Isolates software from each other
- Container is a standard format
- Easily portable across environment
- Allows ecosystem to develop around its standard

# Containers as a Solution



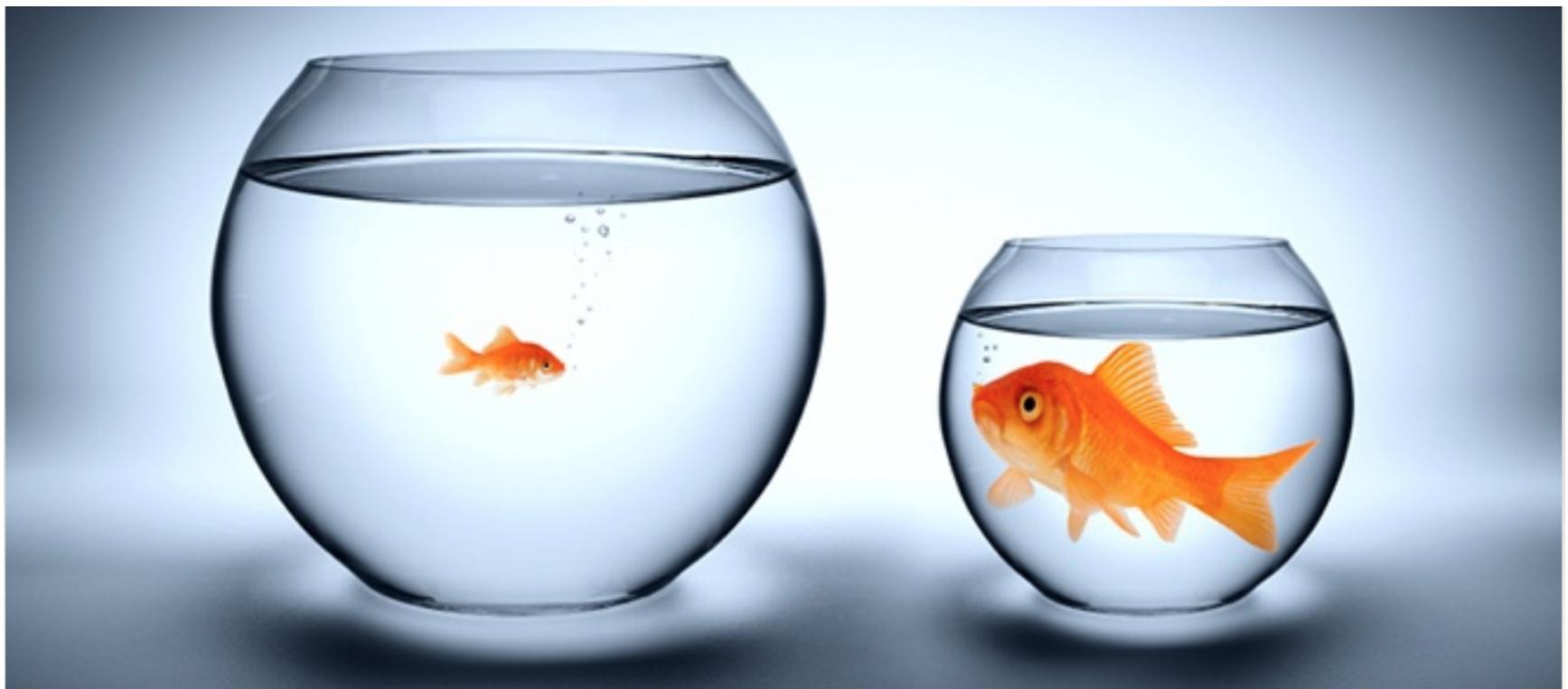
# Developer Benefits

- Build once... (finally) run anywhere
  - A clean, safe, hygienic and portable runtime environment for your app.
  - No worries about missing dependencies, packages and other pain points during subsequent deployments.
  - Run each app in its own isolated container, so you can run various versions of libraries and other dependencies for each app without worrying
  - Automate testing, integration, packaging... anything you can script
  - Reduce/eliminate concerns about compatibility on different platforms, either your own or your customers.
  - Cheap, zero-penalty containers to deploy services? A VM without the overhead of a VM? Instant replay and reset of image snapshots? That's the power of Docker

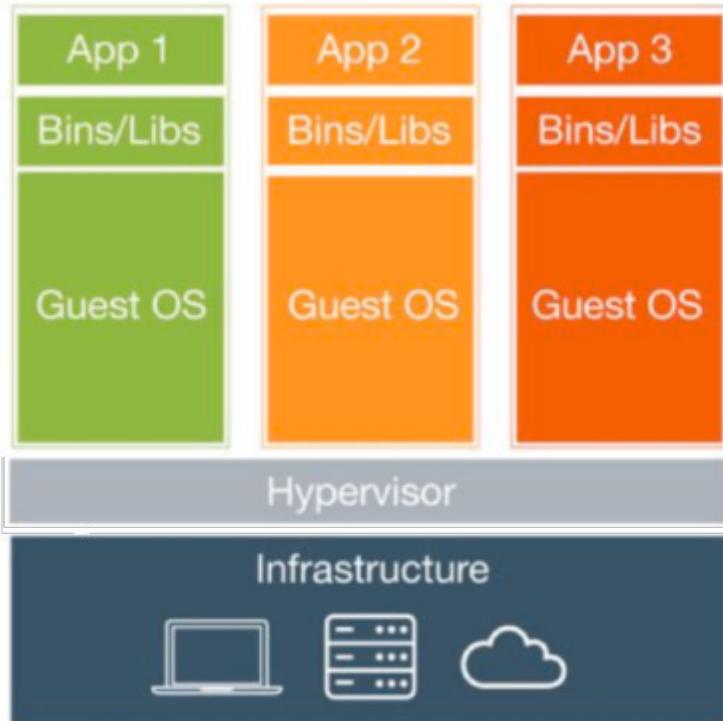
# Operational Benefits

- Configure once...run anything
  - Make the entire lifecycle more efficient, consistent, and repeatable
  - Increase the quality of code produced by developers.
  - Eliminate inconsistencies between development, test, production, and customer environments
  - Support segregation of duties
  - Significantly improves the speed and reliability of continuous deployment and continuous integration systems
  - Because the containers are so lightweight, address significant performance, costs, deployment, and portability issues normally associated with VM

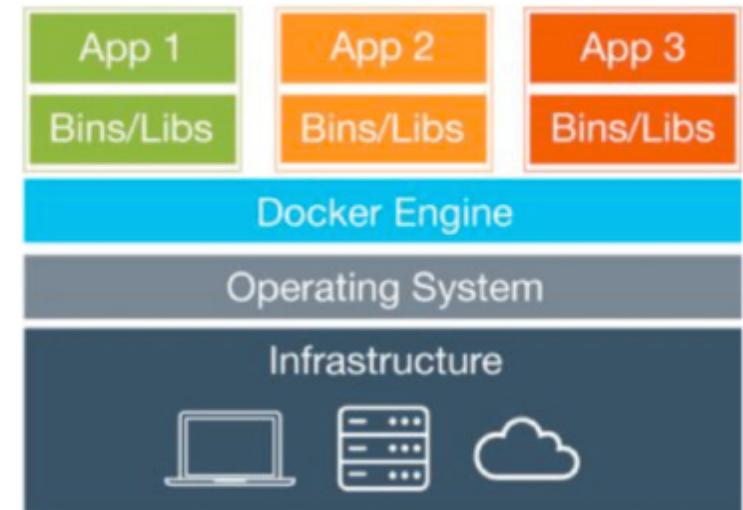
# VMs vs. Containers



# VMs vs. Containers



Virtual Machines



Containers

# VMs vs. Containers

Virtual Machines (VMs)	Containers
Represents hardware-level virtualization	Represents operating system virtualization
Heavyweight	Lightweight
Slow provisioning	Real-time provisioning and scalability
Limited performance	Native performance
Fully isolated and therefore more secure (maybe)	Process-level isolation and therefore less secure (maybe)

# VMs vs. Containers

Simulates a physical machine

Provides a local file system

Can be accessed over a network

Full and independent guest operating system

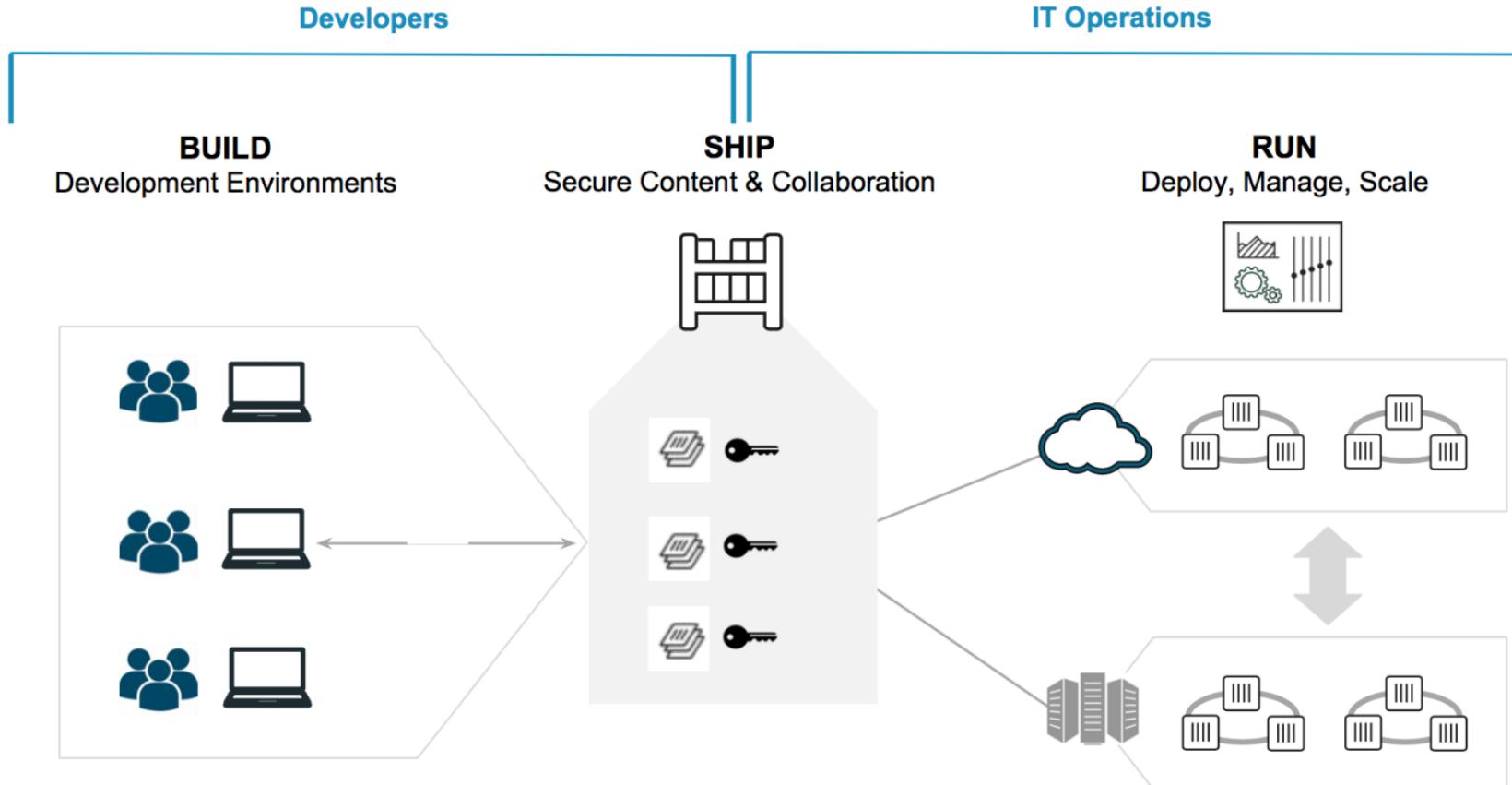
Virtualized device drivers

Strong resource and memory management

Huge memory foot-print

Needs a hypervisor

# Dev/Ops Container Workflow



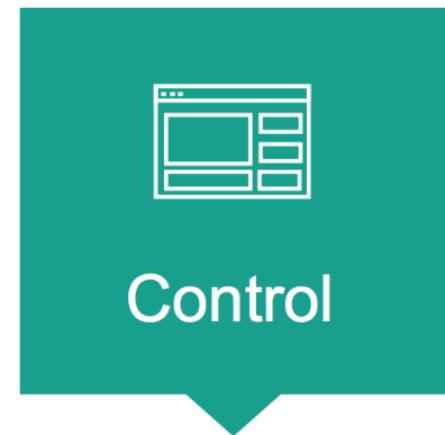
# Container Benefits



Innovation  
at speed



Frictionless  
movement



Manage and  
secure at scale

# Docker CE vs. Docker EE

	COMMUNITY EDITION	ENTERPRISE EDITION BASIC	ENTERPRISE EDITION STANDARD	ENTERPRISE EDITION ADVANCED
Container engine and built in orchestration, networking, security	✓	✓	✓	✓
<b>Docker Certified</b> - Infrastructure, Plugins and ISV (independent software vendors) Containers		✓	✓	✓
<b>Image Management</b> (private registry, caching)	Cloud hosted repos		✓	✓
<b>Docker Datacenter</b> - Integrated container app management			✓	✓
<b>Docker Datacenter</b> - Multi-tenancy with RBAC, LDAP/AD support			✓	✓
Integrated secrets mgmt, image signing policy			✓	✓
Image security scanning	Preview			✓
Support	Community	Biz Day or 24x7	Biz Day or 24x7	Biz Day or 24x7
Pricing	Free	\$750/node/year	\$1,500/node/year	\$2,000/node/year

# Installing Docker

- Docker container engine is built from and on top of the Linux kernel, so it needs Linux to run natively\*
    - Docker is increasingly being packaged with newer Linux distributions
    - Docker is also available on MacOS and Windows through the use of lightweight Linux VMs - HyperV-based on Windows, HyperKit-based on MacOS
- \* Native Windows containers can also be used with Docker for Windows if you have very specific versions of Windows.

# Prerequisite: Connect to Classroom VM



## CLASSROOM WORK

- \$ ssh student@FQDN
  - student password = DockerStudentPW0

FQDN = The fully qualified domain name of the machine assigned to you by your instructor. This will commonly be in the form docker#.domain.com (where # is your student number as assigned to you by your instructor).

# Prerequisite: Add & Update Repos



## CLASSROOM WORK

Done already in AWS instances

```
$ sudo apt-get update  
  
$ sudo apt-get -y install apt-transport-https ca-certificates curl  
  
$ curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -  
  
$ sudo add-apt-repository \  
  "deb [arch=amd64] https://download.docker.com/linux/ubuntu \  
  $(lsb_release -cs) \  
  stable"  
  
$ sudo apt-get update
```

Also at

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

# Install Docker-CE



## CLASSROOM WORK

```
$ sudo apt-get -y install docker-ce  
$ sudo docker run hello-world
```

Done already in AWS instances

Also at

<https://docs.docker.com/engine/installation/linux/docker-ce/ubuntu/#install-using-the-repository>

# Installing Docker Script

- It's good to install Docker the “hard” way at least once so you understand what is involved.
  - There is a Docker-maintained community script that will install the latest release on your Linux machine (most popular flavors) available at <https://get.docker.com/>
  - Run ‘curl -sSL https://get.docker.com/ | sh’ in your terminal
  - The script will also install a Union File System driver and verify Docker engine functionality

# Docker Basics

\$ sudo docker version

```
student@docker-proto:~$ sudo docker version
Client:
  Version:      17.03.1-ce
  API version:  1.27
  Go version:   go1.7.5
  Git commit:   c6d412e
  Built:        Mon Mar 27 17:14:09 2017
  OS/Arch:      linux/amd64

Server:
  Version:      17.03.1-ce
  API version:  1.27 (minimum version 1.12)
  Go version:   go1.7.5
  Git commit:   c6d412e
  Built:        Mon Mar 27 17:14:09 2017
  OS/Arch:      linux/amd64
  Experimental: false
student@docker-proto:~$
```

# Docker Basics

\$ sudo docker info

```
student@cludwig:~$ sudo docker info
Containers: 1
Running: 0
Paused: 0
Stopped: 1
Images: 1
Server Version: 17.03.1-ce
Storage Driver: aufs
  Root Dir: /var/lib/docker/aufs
  Backing Filesystem: extfs
  Dirs: 3
  Dirperm1 Supported: true
Logging Driver: json-file
Cgroup Driver: cgroupfs
Plugins:
  Volume: local
  Network: bridge host macvlan null overlay
Swarm: inactive
Runtimes: runc
Default Runtime: runc
Init Binary: docker-init
containerd version: 4ab9917febca54791c5f071a9d1f404867857fcc
runc version: 54296cf40ad8143b62dbcaa1d90e520a2136ddfe
init version: 949e6fa
Security Options:
  apparmor
  seccomp
    Profile: default
Kernel Version: 4.4.0-78-generic
```

# Docker Basics

- Standard command format:
  - docker [NOUN] verb
- \$ sudo docker --help #displays help and management subcommands (nouns)
- \$ sudo docker NOUN --help
- There are reasonable defaults and short forms of option flags for many things. i.e.:
  - “docker pull” assumes “image”
  - “docker stop” assumes “container”
  - can use “img” instead of “image”
  - can use “con” instead of “container”, etc.

# Docker Basics

Determine the status of the Docker service

- \$ sudo service docker status

```
[ubuntu@ubuntu-xenial:~/docker$ sudo service docker status
● docker.service - Docker Application Container Engine
   Loaded: loaded (/lib/systemd/system/docker.service; enabled; vendor preset: enabled)
     Active: active (running) since Tue 2016-11-29 14:12:54 UTC; 2h 47min ago
       Docs: https://docs.docker.com
 Main PID: 1204 (dockerd)
    Tasks: 22
   Memory: 82.9M
      CPU: 1min 31.242s
     CGroup: /system.slice/docker.service
             └─1204 /usr/bin/dockerd -H fd://
                  ├─1212 docker-containerd -l unix:///var/run/docker/libcontainerd/docker-containerd.sock --shim docker-containerd-shim --metrics-interval=0 --start-ti
Nov 29 16:29:33 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:29:33.147992827Z" level=info msg="Layer sha256:6fc2e4ad81348c14fd2d7e3880b5db2bbc2f699a5cdcf18b
Nov 29 16:29:36 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:29:36.424426912Z" level=info msg="Layer sha256:a21398f45083710727f6f382cf232d5d50d4dc9589d6ff5
Nov 29 16:30:09 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:30:09.788820380Z" level=info msg="Layer sha256:9359188bd45e8c8b98fc0f0297ba87b4f5ed64e9dc8fbfa7
Nov 29 16:30:09 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:30:09.913582571Z" level=info msg="Layer sha256:9359188bd45e8c8b98fc0f0297ba87b4f5ed64e9dc8fbfa7
Nov 29 16:30:28 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:30:28.557526233Z" level=info msg="Layer sha256:be3b076c597ddebb0e264d732927a160c2e91c78516c84a1
Nov 29 16:30:50 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:30:50.018714100Z" level=info msg="Layer sha256:47e85df6c4115d2974ab00ef823c215917dae0a9011f4262
Nov 29 16:30:56 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:30:56.620202459Z" level=info msg="Layer sha256:ce06475a45c5830b905647755ce0324b8c313502bf66ea0c
Nov 29 16:31:14 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:31:14.829527550Z" level=info msg="Layer sha256:2b9628b0eba7b5a870fd354986be4d15e605d51c8f97f2a
Nov 29 16:31:15 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:31:15.102270791Z" level=info msg="Layer sha256:c8f15147c2663dc3d68f177ffffc0934bb2c04e25eddc6007
Nov 29 16:32:33 ubuntu-xenial dockerd[1204]: time="2016-11-29T16:32:33.801824138Z" level=info msg="Layer sha256:72deb7ae364e53981d0d1befdf7d9c5b15208f93cd8e169b
lines 1-22/22 (END)
```

# Docker Hello World(s)

```
[vagrant@vagrant-ubuntu-trusty-64:~$ docker run -it hello-world
Unable to find image 'hello-world:latest' locally
latest: Pulling from library/hello-world

c04b14da8d14: Pull complete
Digest: sha256:0256e8a36e2070f7bf2d0b0763dbabdd67798512411de4cdcf9431a1feb60fd9
Status: Downloaded newer image for hello-world:latest

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

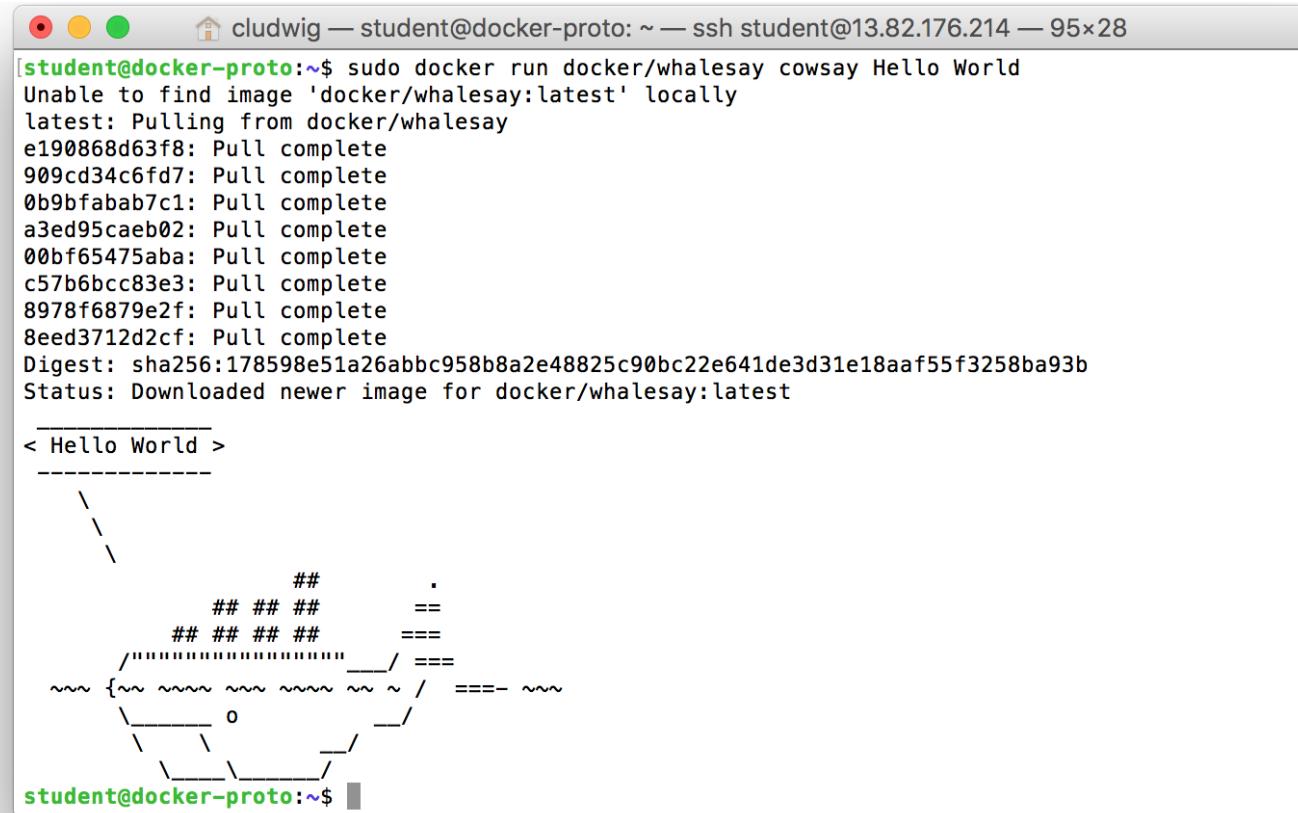
Share images, automate workflows, and more with a free Docker Hub account:
https://hub.docker.com

For more examples and ideas, visit:
https://docs.docker.com/engine/userguide/]

vagrant@vagrant-ubuntu-trusty-64:~$ ]
```

# Docker Hello World(s)

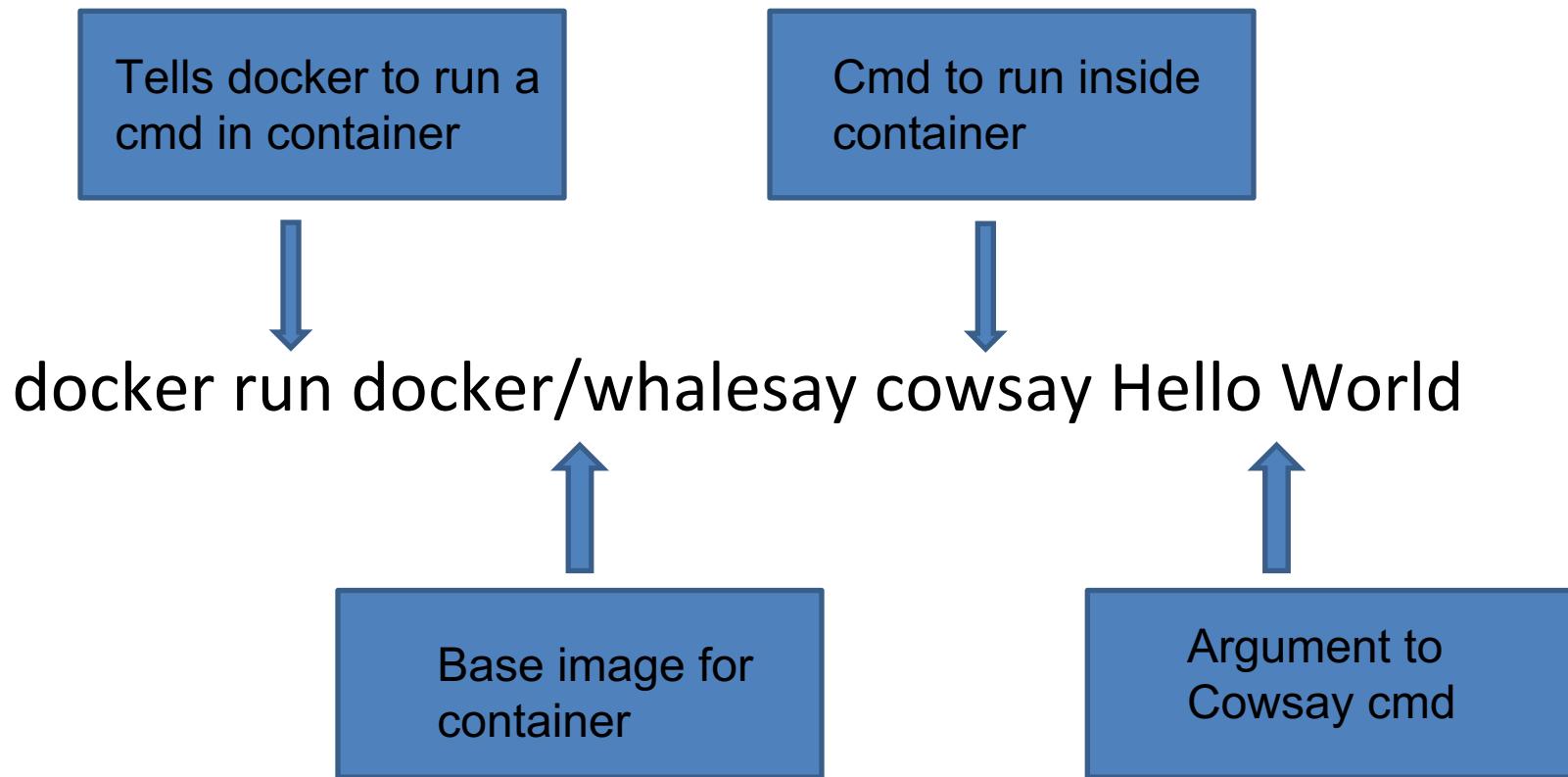
```
$ sudo docker run docker/whalesay cowsay Hello World
```



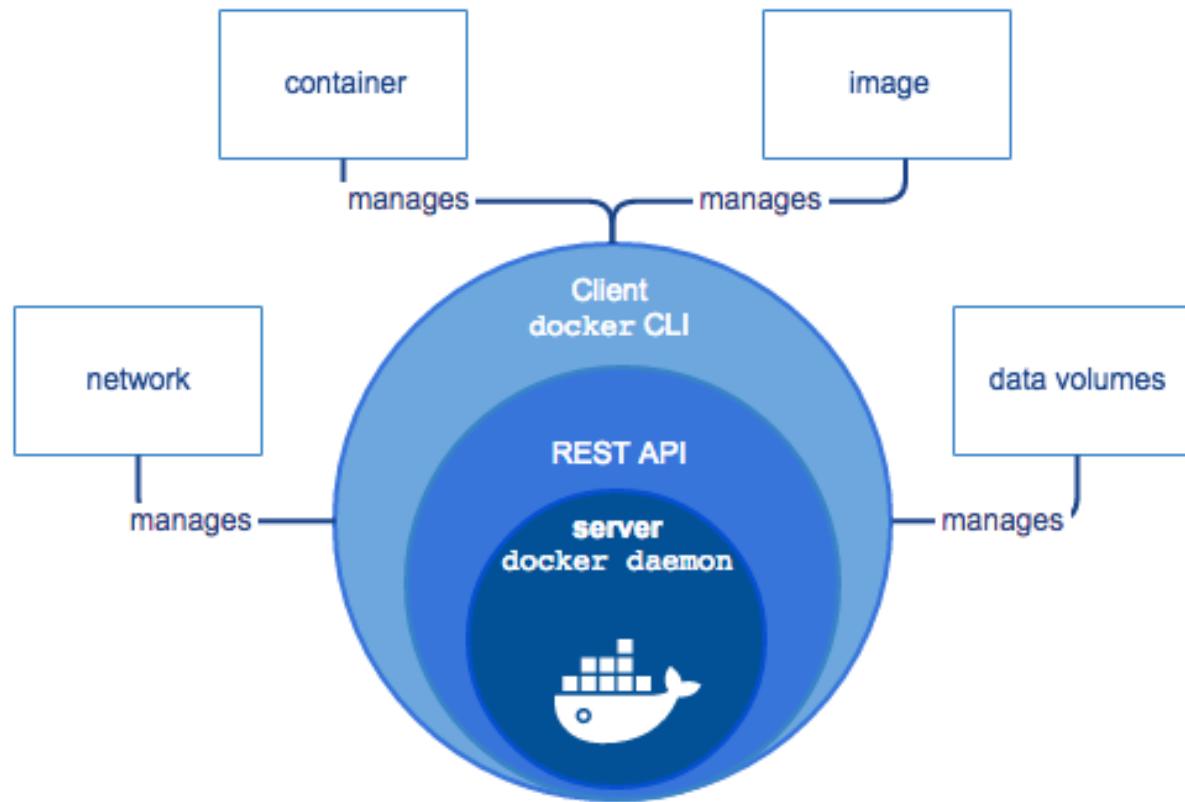
```
cludwig — student@docker-proto: ~ — ssh student@13.82.176.214 — 95x28
[student@docker-proto:~$ sudo docker run docker/whalesay cowsay Hello World
Unable to find image 'docker/whalesay:latest' locally
latest: Pulling from docker/whalesay
e190868d63f8: Pull complete
909cd34c6fd7: Pull complete
0b9bfabab7c1: Pull complete
a3ed95caeb02: Pull complete
00bf65475aba: Pull complete
c57b6bcc83e3: Pull complete
8978f6879e2f: Pull complete
8eed3712d2cf: Pull complete
Digest: sha256:178598e51a26abbc958b8a2e48825c90bc22e641de3d31e18aaf55f3258ba93b
Status: Downloaded newer image for docker/whalesay:latest

< Hello World >
-----
      \
      \
      \
          ##      .
          ## ## ##      ==
          ## ## ## ##      ===
          /"-----"\      ===
~~~ {~~ ~~~~ ~~~ ~~~~ ~ ~ /      === ~~~
      \_   o   _/      _/
      \_   \_ /      _/
student@docker-proto:~$
```

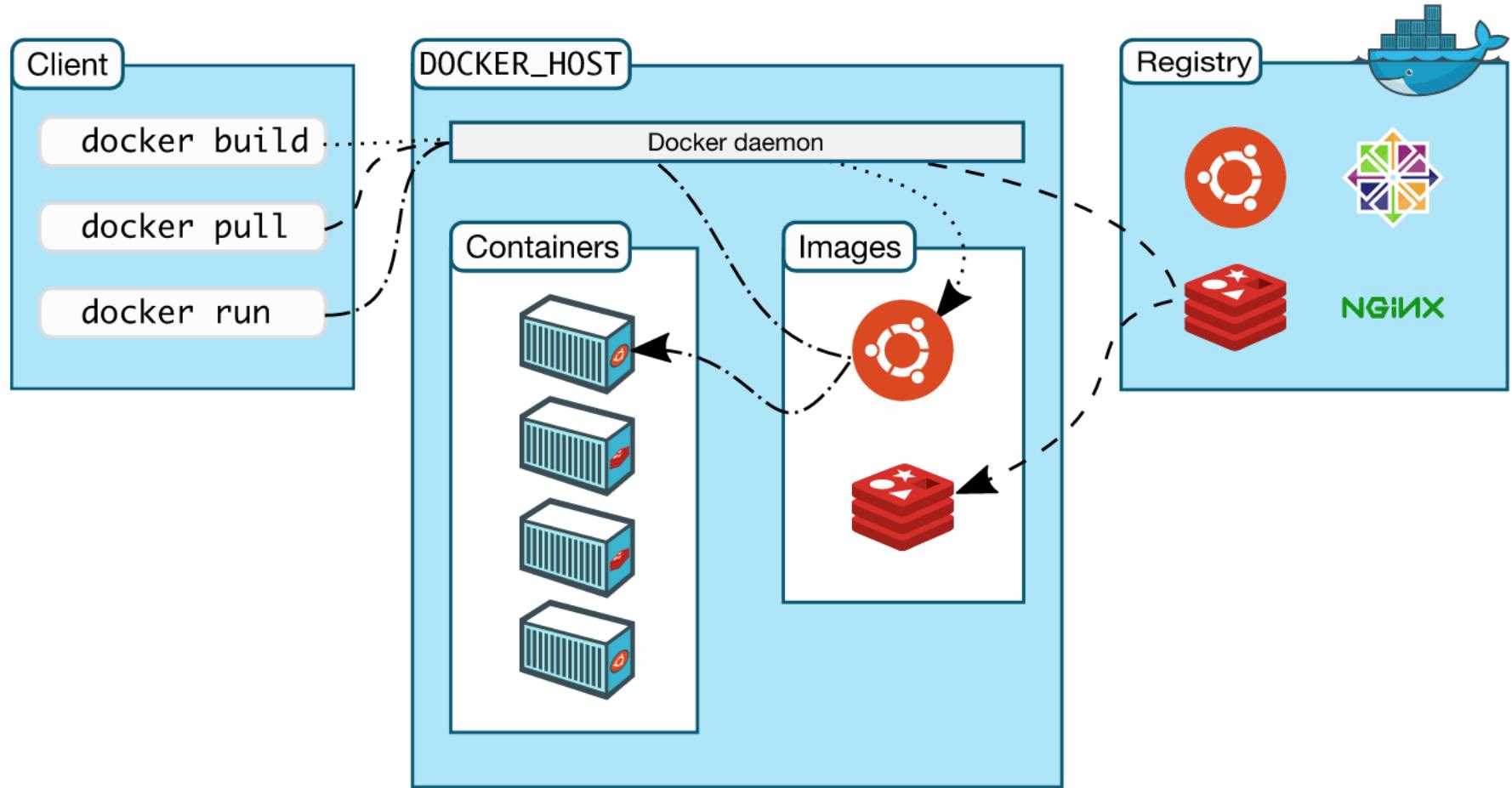
# Docker Hello World(s)



# What is ‘Docker Engine’?



# How is Docker Architected?



# No ‘sudo’ Configuration

---

Done already in AWS instances

---

- Run docker without sudo

– <https://docs.docker.com/engine/installation/linux/linux-postinstall/>

1. Create Docker group:

– `$ sudo groupadd docker`

2. Add your user to docker group:

– `$ sudo usermod -aG docker $USER`

3. Log out and log back in:

– `$ exit # then log back in`

# Docker Webapp & Hello World



---

CLASSROOM WORK

---

---

20 minutes

---

## Exercise 2.1 in Docker Labs

<https://github.com/docker/labs/blob/master/beginner/chapters/webapps.md>

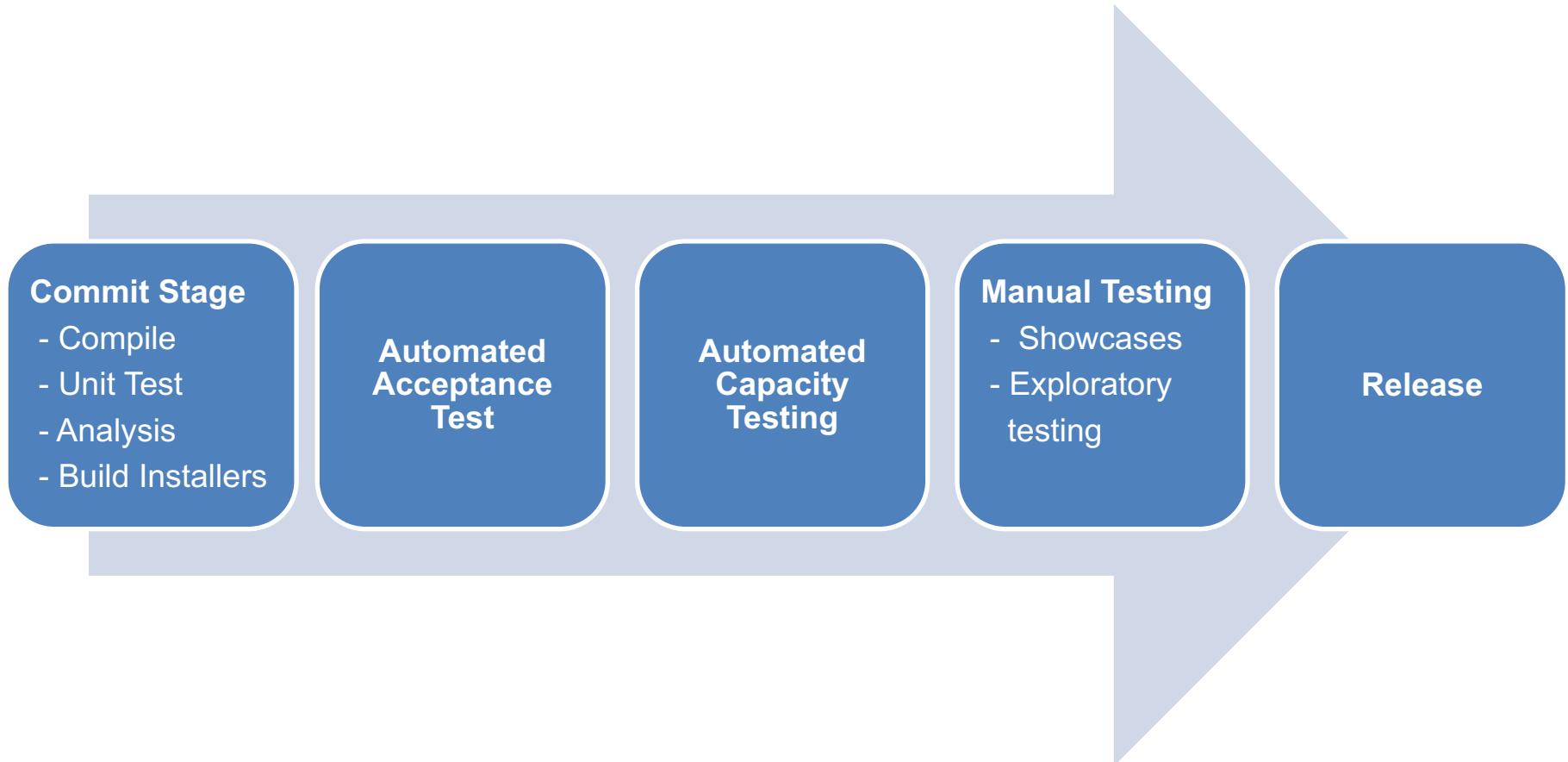
Do only exercise 2.1

# So far !!

- Basic difference between VMs and Containers
- Installing Docker
- Images:- Hello World, whalesay, static-website in action

# Where Containers are used?

- For automated testing & CICD



# Where Containers are used?

- DevOps (Mostly in all types of Automation)
- Automated testing (Unit, acceptance and stress testing)
- CICD (if not tested on production-like environment, CICD will be risky)
- Microservices
- Less risky deployment architectures
- Chef kitchen test
- Not only used for testing but is used in production (along with container orchestration) in B2C and B2B organizations

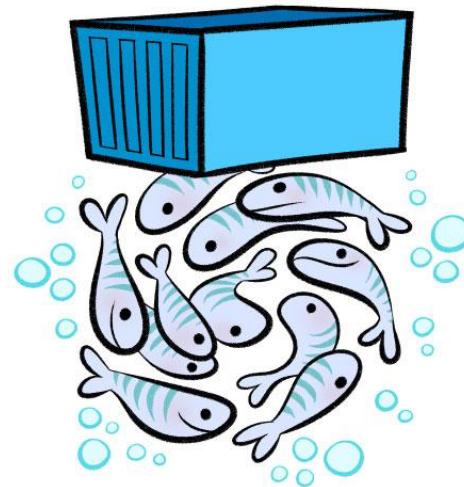
# Advantage of using Containers

- Developers testing their code in Prod environments
- Lesser hand-offs and drastically lesser waiting time (to get new environment setup)
  - Reduce technical debt
- Overall system resilience - Service failure does not kill the application & may be invisible to users
- Scalability
  - Seamless replication
- High Availability
- Less risky patterns for rolling updates available
- Prevent server sprawl and Jenga infrastructure

## Part 2: DevOps Docker

# Docker Images

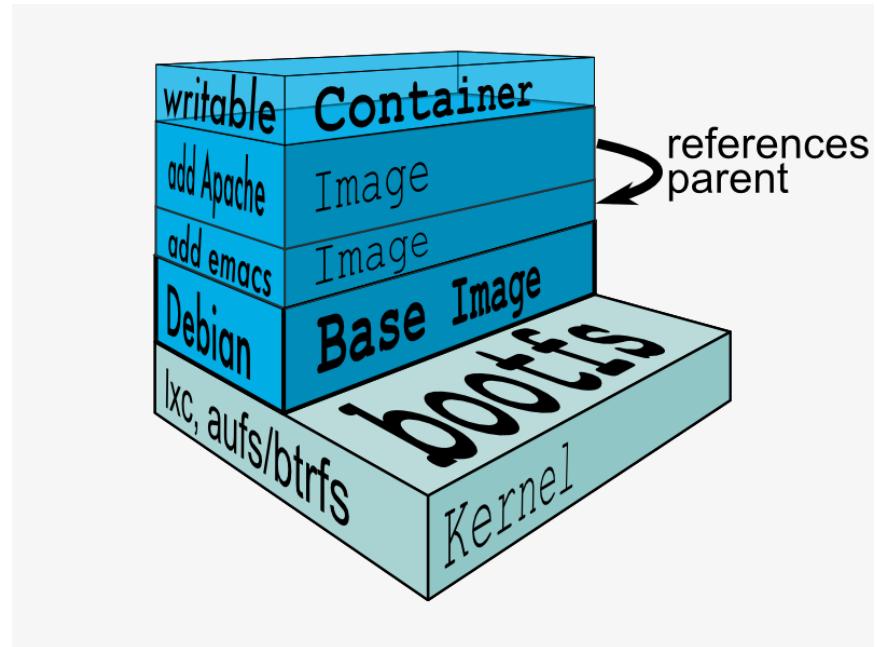
---



# Docker Union File System

AuFS (AnotherUnionFS) is a multi-layered filesystem that implements union mount

- allows several filesystems or directories to be simultaneously mounted and visible through a single mount point
- appears to be one filesystem to the end user



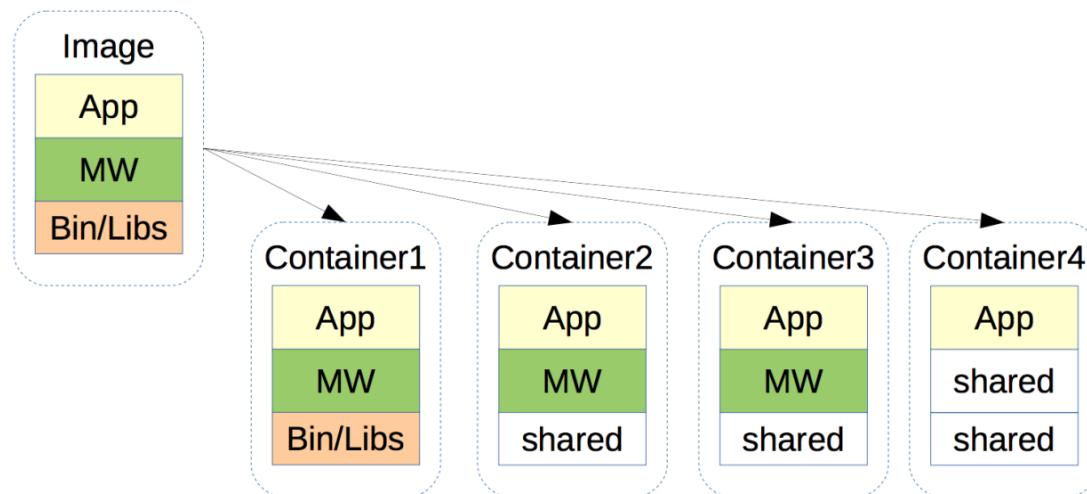
# Example Docker Layers



**Docker Layer** – Each Docker image is composed of a series of layers. Docker uses Union File Systems to combine these into a single image. The combination of these layers gives the illusion of a traditional file system. Only the top layer is writeable.

# Benefits of Union File Systems

- Files are shared across containers
- Storage and memory spaces are saved
- Faster deployment of containers



# Docker Hub

- Docker's first-party cloud-based registry
  - Hosts a broad repository of Docker images
  - Contains nearly any popular open source technology including MariaDB, Jenkins, Cloudera, etc
  - Contains 'Official images' from vendors such as Canonical, Oracle, Red Hat, etc
  - Provides one free private Docker repo, more for a paid subscription

# Docker Hub

A screenshot of a web browser window showing the Docker Hub search results for 'mariadb'. The search bar at the top contains 'mariadb'. Below the search bar, there are 1096 repositories listed. The first four repositories are displayed in detail:

Repository	Description	Stars	Pulls	Actions
mariadb/mariadb	official	935	5M+	<a href="#">DETAILS</a>
bitnami/mariadb	public   automated build	21	1M+	<a href="#">DETAILS</a>
million12/mariadb	public   automated build	9	10K+	<a href="#">DETAILS</a>
maxexcloo/mariadb	public   automated build	4	1.4K	<a href="#">DETAILS</a>

# \$ Few Basic Commands

# \$ docker search [searchterm]

```
student@docker-proto:~$ docker search mariadb
NAME                           DESCRIPTION                                              STARS   OFFICIAL   AUTOMATED
mariadb                         MariaDB is a community-developed fork of M...    1346    [OK]
bitnami/mariadb                 Bitnami MariaDB Docker Image                      34      [OK]
paintedfox/mariadb              A docker image for running MariaDB 5.5, a ...    29      [OK]
million12/mariadb               MariaDB 10 on CentOS-7 with UTF8 defaults       14      [OK]
toughiq/mariadb-cluster         Dockerized Automated MariaDB Galera Cluste...    11      [OK]
webhippie/mariadb               Docker images for mariadb                        9       [OK]
panubo/mariadb-galera          MariaDB Galera Cluster                         7       [OK]
gists/mariadb                   MariaDB on Alpine                           7       [OK]
kakilangit/mariadb              Docker for MariaDB with OQGraph & TokuDB E...    6       [OK]
maxexcloo/mariadb              Service container with MariaDB installed a...    4       [OK]
tianon/mariadb                  DEPRECATED; use mariadb:* -- I just met...    4       [OK]
takaomag/mariadb                docker image of archlinux (mariadb)           2       [OK]
desertbit/mariadb               This is an extended docker image of the of...    1       [OK]
drupaldocker/mariadb            MariaDB for Drupal                          1       [OK]
tcaxias/mariadb                 MariaDB container                         1       [OK]
jpc0/mariadb                    Mariadb, so I can have it on my raspberry       1       [OK]
lucidfrontier45/mariadb        Mariadb with some customizable properties       0       [OK]
vger/mariadb                    MariaDB image, based on Debian Jessie           0       [OK]
yannickvh/mariadb               Custom build of MariaDB based on the offic...    0       [OK]
dogstudio/mariadb               MariaDB Container for Dogs                     0       [OK]
objectstyle/mariadb              ObjectStyle MariaDB Docker Image             0       [OK]
nimmis/mariadb                  MariaDB multiple versions based on nimmis/...    0       [OK]
rkrahl/mariadb                  A docker image for MariaDB                      0       [OK]
mmckeen/mariadb                 MariaDB image based on openSUSE Tumbleweed       0       [OK]
danielsreichenbach/mariadb     Minimal MariaDB container to be used as co...    0       [OK]
student@docker-proto:~$
```

# Docker image commands

```
[ubuntu@ip-10-0-0-117:~/code/multistage$ docker image --help
```

```
Usage: docker image COMMAND
```

```
Manage images
```

```
Options:
```

```
--help Print usage
```

```
Commands:
```

build	Build an image from a Dockerfile
history	Show the history of an image
import	Import the contents from a tarball to create a filesystem image
inspect	Display detailed information on one or more images
load	Load an image from a tar archive or STDIN
ls	List images
prune	Remove unused images
pull	Pull an image or a repository from a registry
push	Push an image or a repository to a registry
rm	Remove one or more images
save	Save one or more images to a tar archive (streamed to STDOUT by default)
tag	Create a tag TARGET_IMAGE that refers to SOURCE_IMAGE

```
Run 'docker image COMMAND --help' for more information on a command.
```

# Docker Container commands

```
[ubuntu@ip-10-0-0-117:~/code/multistage$ docker container --help

Usage: docker container COMMAND

Manage containers

Options:
  --help    Print usage

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

Run 'docker container COMMAND --help' for more information on a command.
```

# \$ docker image pull [imageName]

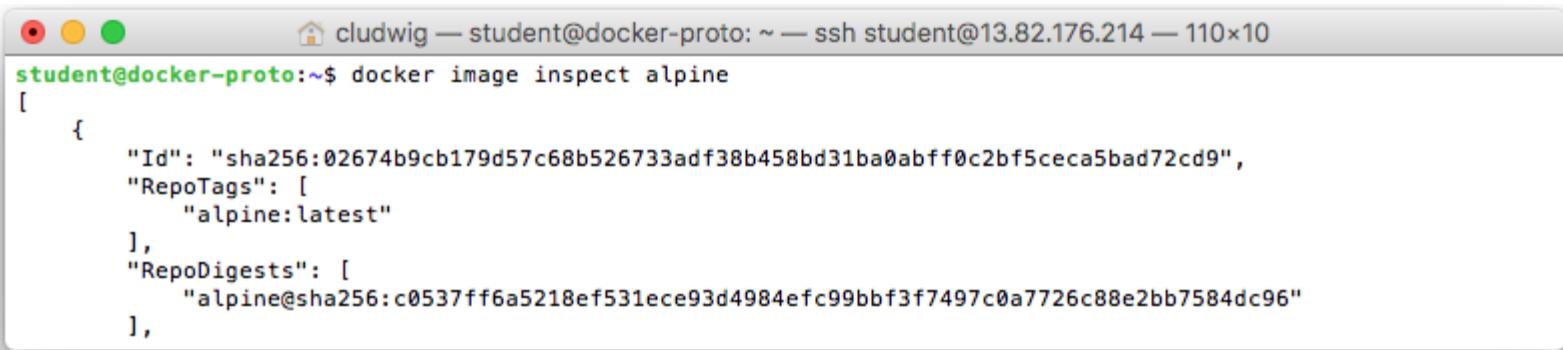
```
[student@docker-proto:~$ docker image pull alpine
Using default tag: latest
latest: Pulling from library/alpine
cfc728c1c558: Pull complete
Digest: sha256:c0537ff6a5218ef531ece93d4984efc99bbf3f7497c0a7726c88e2bb7584dc96
Status: Downloaded newer image for alpine:latest
```

**Best Practice:** Choose the smallest base images possible

Debian – 123 MB  
Alpine – 5 MB

```
[student@docker-proto:~$ docker image list
REPOSITORY          TAG      IMAGE ID   CREATED    SIZE
alpine              latest   02674b9cb179  11 days ago  3.99 MB
hello-world         latest   48b5124b2768  4 months ago  1.84 kB
dockersamples/static-site  latest   f589ccde7957  14 months ago  191 MB
docker/whalesay     latest   6b362a9f73eb  24 months ago  247 MB
student@docker-proto:~$
```

# \$ docker inspect [image|container]

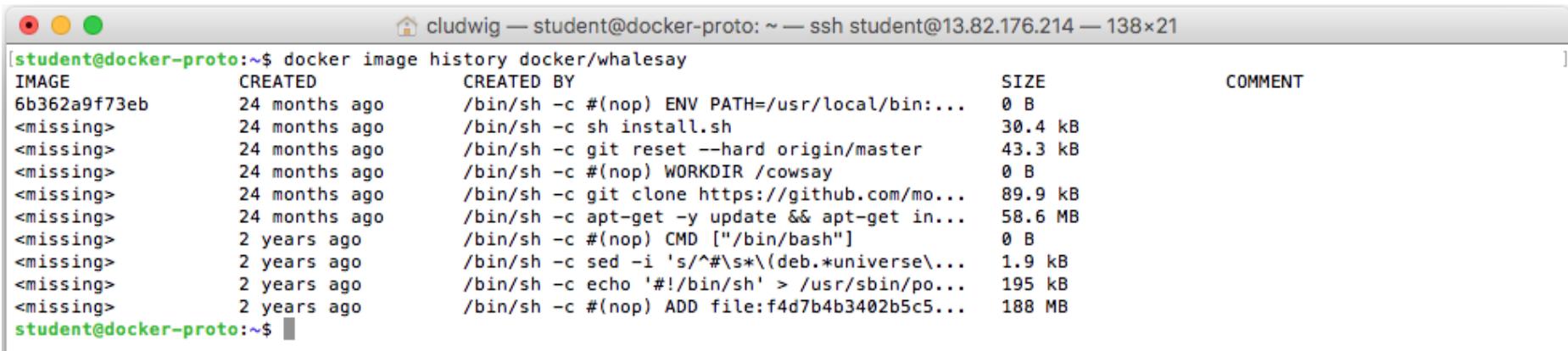


```
student@docker-proto:~$ docker image inspect alpine
[
  {
    "Id": "sha256:02674b9cb179d57c68b526733adf38b458bd31ba0abff0c2bf5ceca5bad72cd9",
    "RepoTags": [
      "alpine:latest"
    ],
    "RepoDigests": [
      "alpine@sha256:c0537ff6a5218ef531ece93d4984efc99bbf3f7497c0a7726c88e2bb7584dc96"
    ],
  }
]
```

- **ID** The unique identifier for the container
- **State** This stanza has various status flags and the process id for the container. Using the `ExitCode` from this `State` element a [graceful shutdown](#) or recovery process could be initiated. The following format will return just the `ExitCode` of the most recently run container:

```
docker inspect -f '{{.State.ExitCode}}' $(docker ps -lq)
```
- **Image** The image this container is running.
- **NetworkSettings** The network environment for the container and therefore for the application(s) within the image.
- **LogPath** The system path to this container's log file.
- **RestartCount** Keeps track of the number of times the container has been restarted. This value is the key value used when defining a container's [restart policy](#).
- **Name** The user defined name for the container.
- **Volumes** Defines the volume mapping between the host system and the container.
- **HostConfig** Key configurations for how the container will interact with the host system. These could take CPU and memory limits, networking values, or device driver paths.
- **Config** The runtime configuration options set when the `docker run` command was executed. Part of this configuration is another "Image" value. This image `{{.Config.Image}}` is the tagged image which may be different than the image listed in `{{.Image}}`

# \$ docker image history docker/whalesay



```
cludwig — student@docker-proto: ~ — ssh student@13.82.176.214 — 138x21
[student@docker-proto:~$ docker image history docker/whalesay
IMAGE          CREATED      CREATED BY
6b362a9f73eb  24 months ago  /bin/sh -c #(nop) ENV PATH=/usr/local/bin:...
<missing>      24 months ago  /bin/sh -c sh install.sh
<missing>      24 months ago  /bin/sh -c git reset --hard origin/master
<missing>      24 months ago  /bin/sh -c #(nop) WORKDIR /cowsay
<missing>      24 months ago  /bin/sh -c git clone https://github.com/mo...
<missing>      24 months ago  /bin/sh -c apt-get -y update && apt-get in...
<missing>      2 years ago   /bin/sh -c #(nop) CMD ["/bin/bash"]
<missing>      2 years ago   /bin/sh -c sed -i 's/^#\!*/deb.*universe\...
<missing>      2 years ago   /bin/sh -c echo '#!/bin/sh' > /usr/sbin/po...
<missing>      2 years ago   /bin/sh -c #(nop) ADD file:f4d7b4b3402b5c5...
student@docker-proto:~$ ]
```

Use history to view layers in an image

# Docker Interactive Mode

**Best Practice:** Run containers in interactive mode while developing docker images

```
[ubuntu@instance-41:~/flask-app$ sudo docker run -t -i ubuntu /bin/bash
Unable to find image 'ubuntu:latest' locally
latest: Pulling from library/ubuntu
6bbebd9b76a4: Pull complete
fc19d60a83f1: Pull complete
de413bb911fd: Pull complete
2879a7ad3144: Pull complete
668604fde02e: Pull complete
Digest: sha256:2d44ae143feeb36f4c898d32ed2ab2dffeb3a573d2d8928646dfc9cb7deb1315
Status: Downloaded newer image for ubuntu:latest
root@a4b1111d9d0e:/# ]
```

# Docker Interactive Mode

Create a terminal  
To use

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

Interactive mode

# Docker Interactive Mode

Attach to a running container and shell instance

```
docker attach some_container #by Name
```

Attach to a running container by starting a new shell instance

```
docker exec -it some_container /bin/bash #by Name
```

# Docker Interactive Mode

**Quick Tip:** Be aware that alpine and other distros may have a different entry point (sh vs bash)

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

# See all containers

- \$ docker container ls #show running

```
student@docker-proto:~$ docker container ls
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS
NAMES
e63ebe9ecaa2      dockersamples/static-site "/bin/sh -c 'cd /u..."  8 hours ago       Up 8 hours          0.0.0.0:327
69->80/tcp, 0.0.0.0:32768->443/tcp   dreamy_galileo
```

- \$ docker container ls -a #show all containers  
(including running, stopped, exited, etc.)

```
student@docker-proto:~$ docker container ls -a
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS
NAMES
e63ebe9ecaa2      dockersamples/static-site "/bin/sh -c 'cd /u..."  8 hours ago       Up 8 hours          0.0.
0:32769->80/tcp, 0.0.0.0:32768->443/tcp   dreamy_galileo
16528921a105      dockersamples/static-site "/bin/sh -c 'cd /u..."  14 hours ago      Exited (137) 8 hours ago
elegant_shockley
edb964673b1b       docker/whalesay      "cowsay Hello World"  15 hours ago      Exited (0) 15 hours ago
condescending_turing
31f3c64d31a1       hello-world        "/hello"           22 hours ago      Exited (0) 22 hours ago
admiring_goldberg
student@docker-proto:~$
```

# \$docker container stats

```
cludwig — student@docker-proto: ~ — ssh student@13.82.176.214 — 138x34
[student@docker-proto:~$ docker container ls
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS
NAMES
e63ebe9ecaa2      dockersamples/static-site   "/bin/sh -c 'cd /u..."   8 hours ago       Up  8 hours        0.0.0.0:32769->80/tcp, 0.
0.0.0:32768->443/tcp      dreamy_galileo
[student@docker-proto:~$ docker container stats e63
cludwig — student@docker-proto: ~ — ssh student@13.82.176.214 — 138x34
CONTAINER          CPU %           MEM USAGE / LIMIT     MEM %           NET I/O          BLOCK I/O         PIDS
e63                0.00%          1.562 MiB / 667.2 MiB  0.23%          4.29 kB / 12.4 kB  73.7 kB / 12.3 kB  3
```

- Provides the CPU, memory, network, and other monitoring KPI's of a docker container.
- Multiple containers can be profiled as well
- All containers can be profiled by leaving out the container id(s)

# Removing Docker Containers & Images

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

```
# Remove all stopped containers  
docker container prune [-f]
```

```
# Remove all unused images  
docker image prune [-f] [-a]
```

-f option skips confirmation.

-a option (for images) removes ALL unused images, not just those that were left behind when a container was removed (dangling).

**Best Practice:** Prevent image inflation and regularly clean up images

# Docker Working with Images and Containers



## CLASSROOM WORK 2.1

45 minutes

Practice Docker image and container commands

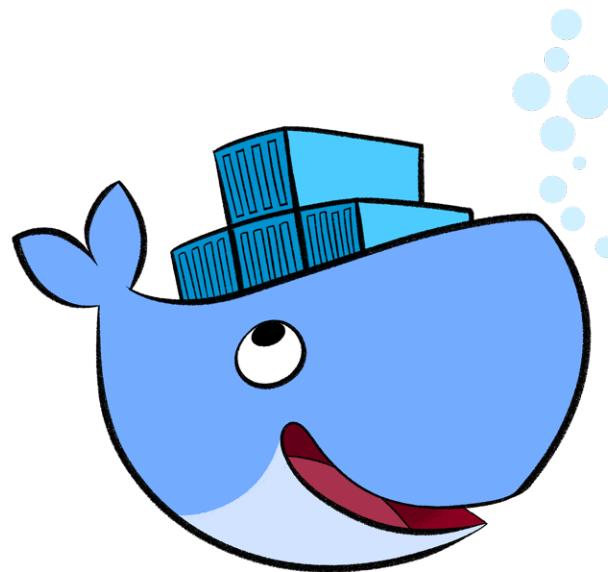
[https://github.com/shekhar2010us/microservices\\_monolithic\\_docker/blob/master/docker\\_image\\_container.md](https://github.com/shekhar2010us/microservices_monolithic_docker/blob/master/docker_image_container.md)

**\*\* Day 1:**  
Exercise 2.1  
4 – 5 pm ET

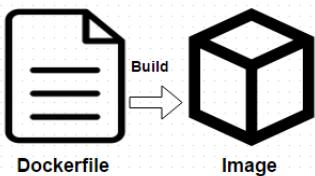
Part 3: DevOps Docker

# Docker Files

---



# Dockerfile



```
1 FROM ubuntu:14.04
2
3 # install cowsay, and move the "default.cow" out of the way so we can overwrite it with "docker.cow"
4 RUN apt-get update && apt-get install -y cowsay --no-install-recommends && rm -rf /var/lib/apt/lists/*
5   && mv /usr/share/cowsay/cows/default.cow /usr/share/cowsay/cows/orig-default.cow
6
7 # "cowsay" installs to /usr/games
8 ENV PATH $PATH:/usr/games
9
10 COPY docker.cow /usr/share/cowsay/cows/
11 RUN ln -sv /usr/share/cowsay/cows/docker.cow /usr/share/cowsay/cows/default.cow
12
13 CMD ["cowsay"]
14
```

- Docker images are built, layer by layer, from a base image
- Images are composed of layers, each with a simple command such as
  - Run a shell command
  - Add a file or directory
  - Create an environment variable
  - Modify permissions
  - Execute process or script

# Dockerfile

Dockerfile format

```
#Comment  
INSTRUCTION arguments
```

Command	Description
FROM	The base image to use in the build. This is mandatory and must be the first command in the file
MAINTAINER	An optional value for the maintainer of the script
RUN	Executes a command and save the result as a new layer This executes during build time
CMD	The command that runs when the container starts Doesn't execute during built time whereas RUN executes during build time
ENV	Sets an environment variable in the new container
COPY	Copies a file from source to destination in the file system of the container
ADD	Remote URL support and Copies a file from the host system onto the container
ENTRYPOINT	Primary command to run whenever the image is executed
EXPOSE	Opens a port for linked containers
ONBUILD	A command that is triggered when the image in the Dockerfile is used as a base for another image It behaves as if a RUN instruction is inserted immediately after the FROM instruction of the downstream Dockerfile
USER	Sets the default user within the container
VOLUME	Creates a shared volume that can be shared among containers or by the host machine
WORKDIR	Set the default working directory for the container for other instructions like RUN, CMD, COPY, ADD, ENTRYPOINT
LABEL	Add metadata to the image; LABEL key=value

# Dockerfile

## FROM command

The first instruction in a Dockerfile is a FROM command, to specify the Image from which you are building from.

FROM <image>

FROM <Image>:<tag>

**FROM ubuntu:14.04**

# Dockerfile

## **MAINTAINER** command

This lets you know who to consult (or blame ☺) for any dockerfile issues

**MAINTAINER** Santa Claus “santa@abc.org”

---

## **ENV** command

Used to provide environment variables for containers.

**ENV <key> <value>**

**ENV PATH \$PATH:/usr/foo**

# Dockerfile

## RUN command

Executes commands and commits the results in a new layer.

RUN <command>

RUN apt-get update

---

## CMD command

**Can only be one in a dockerfile.** The CMD instruction provides defaults to an executing container and can be overridden with arguments to docker run.

CMD ["cowsay"]

# Dockerfile

## ADD/COPY command

Places files onto a file system. ADD performs the same as copy, but also allows the <src> to be a URL. It will also unpack recognized compression formats.

COPY <src> <dest>

ADD <src> <dest>

---

## EXPOSE command

Informs Docker that the container listens on a network port at runtime. Ports of a container are still not accessible to the host unless –p flag is passed to the Docker run command when the container is invoked.

EXPOSE 80

# Dockerfile

Best Practices for writing Dockerfiles:

- Use `.dockerignore` to exclude any unnecessary files and improve Docker's performance
- Run a single process per container to simplify scale and reuse
- Minimize layers per container
- Sharing base images is a common among development teams
- When possible, base from tiny images such as Alpine Linux
- For production: specify version of the base image (do not use latest)
- For production: use image sha digest rather than image name

# Dockerfile

- Dockerfile build syntax

```
docker build .
```

```
docker build -t <namespace/image name:versiontag> /path
```

```
docker build -t myimage/kafka .
```

*\*\* Be aware that when you run 'docker build .', all files in the current folder get uploaded to docker engine. This may be undesirable, and use of .dockerignore will assist with this situation.*

- Then run the newly created image

```
Docker run –t myname/jenkins
```

# Docker Create your first image



## CLASSROOM WORK 3.1

45 minutes

[https://github.com/shekhar2010us/microservices\\_monolithic\\_docker/blob/master/docker\\_create\\_image.md](https://github.com/shekhar2010us/microservices_monolithic_docker/blob/master/docker_create_image.md)

\*\* Day 2:  
Exercise 3.1, 3.2, 3.3  
11 am – 1 pm ET

# Dockerfile Exercises



---

## CLASSROOM WORK 3.2

---

---

30 minutes

---

Exercise 2.2 & 2.3 in Docker Labs

<https://github.com/docker/labs/blob/master/beginner/chapters/webapps.md>

NB: You can skip the second part of step 2.3.4 (“Push Your Image”) unless you want to first create yourself an account at hub.docker.com.

# Dockerfile Optimization



---

## CLASSROOM WORK 3.3

---

---

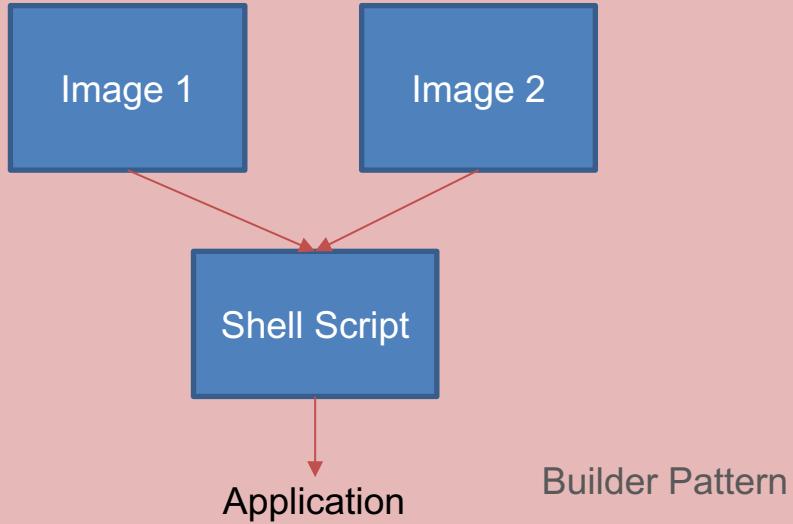
10 minutes

---

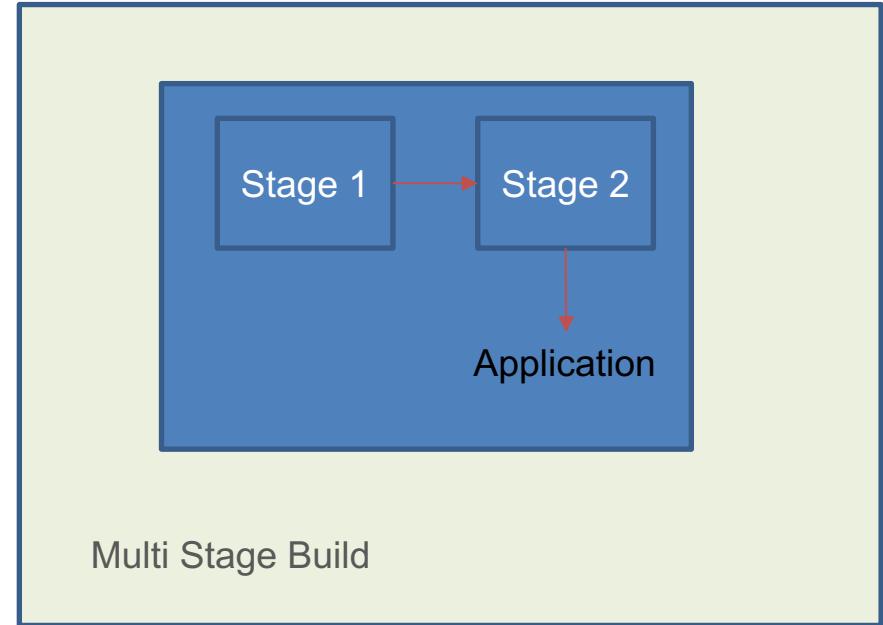
This exercise covers optimizing dockerfile to reduce the number of layers

[https://github.com/docker/dceu\\_tutorials/blob/master/11-infrastructure-as-code.md](https://github.com/docker/dceu_tutorials/blob/master/11-infrastructure-as-code.md)

# Multi-stage Build



Builder Pattern



Multi Stage Build

- **Builder Pattern:** Common practice to maintain two dockerfiles. One for development and other for production that contains application and only things needed to run the application

This is not ideal !!!!

- **Multi-Stage Build:** One stage to another

# Multi-stage Build

- New as of Docker 17.05
- Allows “ship artifacts, not build environments”
- Ideal for languages like Go, where binaries are built in a heavyweight environment, but can ship the binary in a lightweight container.

```
# first stage does the building
# for UX purposes, I'm naming this stage `build-stage`

FROM golang:1.8 as build-stage
WORKDIR /go/src/github.com/codeship/go-hello-world
COPY hello-world.go .
RUN go build -o hello-world .

# starting second stage
FROM alpine:latest

# copy the binary from the `build-stage`
COPY --from=build-stage /go/src/github.com/codeship/go-hello-world/hello-world /bin

CMD hello-world
```

```
$ docker images
```

REPOSITORY	TAG	IMAGE ID	CREATED	SIZE
single-stage	latest	58328409dbf7	2 minutes ago	704MB
multi-stage	latest	9af3c2a2bf40	23 minutes ago	5.54MB

# Docker Monitoring

<https://github.com/google/cadvisor> -

Monitor the system from inside the Docker container!



```
sudo 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=cadvisor1 google/cadvisor:latest
```

yourdockerhost:8080

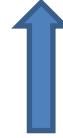
The screenshot shows the cAdvisor web interface. At the top, there's a browser header with the URL `13.82.176.214:8080/containers/`. Below the header, the word "Usage" is visible. The main area has a blue header "Overview". Under "Overview", there are five circular gauges: CPU (31), Memory (66), FS #1 (6), FS #2 (0), and FS #3 (6). Below the gauges is a table titled "Processes".

User	PID	PPID	Start Time	CPU %	MEM %	RSS	Virtual Size	Status	Running Time	Command	Container
root	11,956	11,939	13:05	7.60	3.80	25.69 MiB	307.25 MiB	Ssl	00:00:01	cadvisor	/docker/7d2e7e08c4d694428
root	5,160	1	May21	0.20	8.90	59.48 MiB	398.33 MiB	Ssl	00:03:18	dockerd	/system.slice/docker.service
root	1,571	1,151	May21	0.10	3.50	23.83 MiB	212.40 MiB	Sl	00:01:30	python3	/system.slice/walinuxagent
root	1	0	May21	0.00	0.80	5.87 MiB	37.18 MiB	Ss	00:00:23	systemd	/init.
root	2	0	May21	0.00	0.00	0.00 MiB	0.00 MiB	S	00:00:00	lshw	lshw

# Running a Private Docker Registry

- docker run -d -p 5000:5000 registry

```
[ubuntu@instance-41:~/app$ sudo docker pull registry
Using default tag: latest
latest: Pulling from library/registry
3690ec4760f9: Already exists
930045f1e8fb: Pull complete
feeaa90cbdbc: Pull complete
61f85310d350: Pull complete
b6082c239858: Pull complete
Digest: sha256:1152291c7f93a4ea2ddc95e46d142c31e743b6dd70e194af9e6ebe530f782c17
Status: Downloaded newer image for registry:latest
[ubuntu@instance-41:~/app$ sudo docker run -d -p5000:5000 registry
64730d7011f71d463d480982a765624b4f353e2f2c7003779281cf453c8b2178
```



Push/Pull enabled  
from private registry

# Docker Registry

- Tag an image
  - `docker tag ubuntu localhost:5000/myubuntu:0.1`
- Push the tagged image to registry
  - `docker push localhost:5000/myubuntu:0.1`
- Verify the pushed image
  - `docker rmi -f ubuntu`
  - `docker rmi -f localhost:5000/myubuntu:0.1`
  - `docker pull localhost:5000/myubuntu:0.1`
  - Run a container from the above image

# Docker Registry Search

- **Search Registry**

- <https://docs.docker.com/registry/spec/api/#listing-repositories>

```
curl -XGET http://localhost:5000/v2/_catalog
```

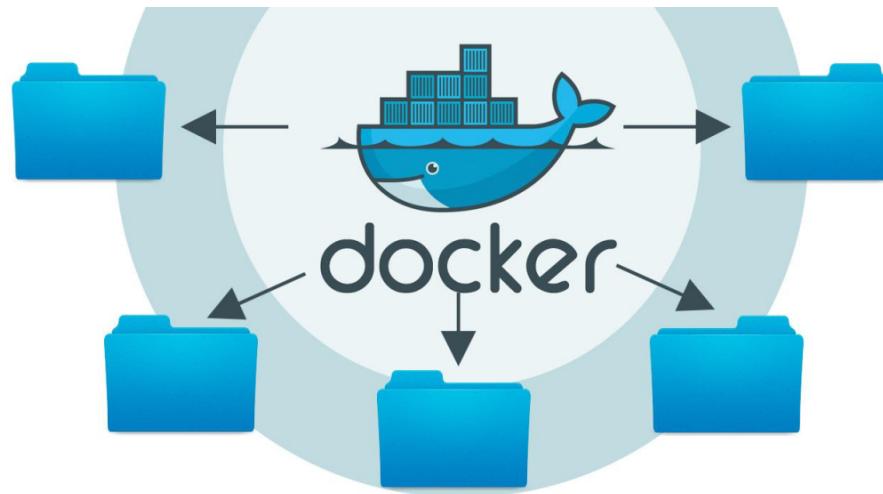
- **List Image Tags**

- <https://docs.docker.com/registry/spec/api/#listing-image-tags>

```
curl -XGET http://localhost:5000/v2/myubuntu/tags/list
```

## Part 4: DevOps Docker

# Docker Volumes



# Data volumes

A *data volume* is a specially-designated directory within one or more containers that bypasses the [Union File System](#). Data volumes provide several useful features for persistent or shared data:

- Volumes are initialized when a container is created. If the container's base image contains data at the specified mount point, that existing data is copied into the new volume upon volume initialization. (Note that this does not apply when [mounting a host directory](#).)
- Data volumes can be shared and reused among containers.
- Changes to a data volume are made directly.
- Changes to a data volume will not be included when you update an image.
- Data volumes persist even if the container itself is deleted.

Data volumes are designed to persist data, independent of the container's lifecycle. Docker therefore *never* automatically deletes volumes when you remove a container, nor will it "garbage collect" volumes that are no longer referenced by a container.

# Adding a data volume

- You can add a **data volume** to a container using the -v flag with the docker create and docker run command. You can use the -v multiple times to mount multiple data volumes. Now, mount a single volume in your web application container.
    - `docker run -it --name test1 -v data2:/data ubuntu`
  - In addition to creating a volume using the -v flag you can also **mount a directory** from your Docker engine's host into a container
    - `docker run -it --name test1 -v /home/ubuntu/src:/data ubuntu`
- This command mounts the host directory, /home/ubuntu/src, into the container at /data.

# Docker volume commands

Command	Description
docker volume create	Create a volume
docker volume ls	List volumes
docker volume inspect	Detailed information on volume
docker volume rm	Remove volume

# Working with Volumes (docker volumes)

```
ubuntu@ip-172-31-35-117:~$ docker volume ls
DRIVER          VOLUME NAME
local           0aaf0f814ce772146fbffbe8d67da39bc00e25d7f728a3a43b1f7080499342b
local           4e37dd17754c6f0ba9f43ebc8052be0c18db1c5b56b44f539b283406afc35e5c
local           b5f8b253293cc20b10133335eed74848fbf466b5d055fa5e3b16976766a4c618
ubuntu@ip-172-31-35-117:~$ docker volume create myvolume
myvolume
ubuntu@ip-172-31-35-117:~$ docker volume ls
DRIVER          VOLUME NAME
local           0aaf0f814ce772146fbffbe8d67da39bc00e25d7f728a3a43b1f7080499342b
local           4e37dd17754c6f0ba9f43ebc8052be0c18db1c5b56b44f539b283406afc35e5c
local           b5f8b253293cc20b10133335eed74848fbf466b5d055fa5e3b16976766a4c618
local           myvolume
```

```
ubuntu@ip-172-31-35-117:~$ docker volume inspect myvolume
[ {
    "Driver": "local",
    "Labels": {},
    "Mountpoint": "/var/lib/docker/volumes/myvolume/_data",
    "Name": "myvolume",
    "Options": {},
    "Scope": "local"
}]
```

# Working with Volumes (docker volumes)

```
ubuntu@ip-172-31-35-117:~$ docker run -it -v myvolume:/myvolume --name vlab nginx  
/bin/bash  
root@5476f2fa7f09:/# cd myvolume/  
root@5476f2fa7f09:/myvolume# ls  
root@5476f2fa7f09:/myvolume#  
root@5476f2fa7f09:/myvolume# echo "content from container" >> file.1  
root@5476f2fa7f09:/myvolume# ls  
file.1  
root@5476f2fa7f09:/myvolume# exit  
exit
```

```
ubuntu@ip-172-31-35-117:~$ sudo su -  
root@ip-172-31-35-117:~# ll /var/lib/docker/volumes/myvolume/_data  
total 12  
drwxr-xr-x 2 root root 4096 Aug  7 04:19 ./  
drwxr-xr-x 3 root root 4096 Aug  7 04:18 ../  
-rw-r--r-- 1 root root    23 Aug  7 04:19 file.1  
root@ip-172-31-35-117:~# cat /var/lib/docker/volumes/myvolume/_data/file.1  
content from container  
root@ip-172-31-35-117:~# exit  
logout
```

# Working with Volumes (absolute path)

```
ubuntu@ip-172-31-35-117:~$ mkdir data_dir
ubuntu@ip-172-31-35-117:~$ echo "file.1" >> data_dir/file.1
ubuntu@ip-172-31-35-117:~$ echo "file.2" >> data_dir/file.2
ubuntu@ip-172-31-35-117:~$ ll data_dir/
total 16
drwxrwxr-x 2 ubuntu ubuntu 4096 Aug  7 04:25 .
drwxr-xr-x 7 ubuntu ubuntu 4096 Aug  7 04:25 ..
-rw-rw-r-- 1 ubuntu ubuntu     7 Aug  7 04:25 file.1
-rw-rw-r-- 1 ubuntu ubuntu     7 Aug  7 04:25 file.2
ubuntu@ip-172-31-35-117:~$
ubuntu@ip-172-31-35-117:~$ docker run -it -v /home/ubuntu/data_dir:/mydata --name vlab2 nginx /bin/bash
root@4fd5e542d67c:/# ll mydata/
bash: ll: command not found
root@4fd5e542d67c:/# ls mydata/
file.1 file.2
root@4fd5e542d67c:/# cat mydata/file.1
file.1
root@4fd5e542d67c:/# exit
exit
```

# Working with Volumes (--volumes-from)

```
ubuntu@ip-172-31-35-117:~$ docker volume create --name backup  
backup  
ubuntu@ip-172-31-35-117:~$ docker volume create --name logs  
logs  
ubuntu@ip-172-31-35-117:~$ docker run -it --name master -v backup:/backup -v  
logs:/logs ubuntu bash  
root@cc963e4d24b9:/# echo "back up content" >> backup/back.file  
root@cc963e4d24b9:/# echo "log file content" >> logs/log.file  
root@cc963e4d24b9:/# exit  
exit  
ubuntu@ip-172-31-35-117:~$ docker run -it --name slave --volumes-from master ubuntu  
bash  
root@f027d96030ba:/# ll backup/  
total 12  
drwxr-xr-x 2 root root 4096 Aug 7 04:30 ./  
drwxr-xr-x 1 root root 4096 Aug 7 04:31 ../  
-rw-r--r-- 1 root root 16 Aug 7 04:30 back.file  
root@f027d96030ba:/# ll logs/  
total 12  
drwxr-xr-x 2 root root 4096 Aug 7 04:30 ./  
drwxr-xr-x 1 root root 4096 Aug 7 04:31 ../  
-rw-r--r-- 1 root root 17 Aug 7 04:30 log.file  
root@f027d96030ba:/# exit  
exit
```

# Dangling Volumes

- If container is deleted with a volume attached, the volume remains. Sometimes removing all such ‘dangling’ volumes is desired
  - \$ docker volume prune

# Dangling Volumes

- Before

```
[ubuntu@instance-41:~$ docker volume ls
DRIVER          VOLUME NAME
local           030f652ad7ea6766f3d17a421233896b78296cf89d9bc816c69e6084df1aa24d
local           1e16af70af2319707350ce672c0af925c010561a5f75f83393674b5f20df7074
local           94ed6b916617b932638619fcbdbfc77d843175a57c520d02d3162f5750916409
```

- After

```
ubuntu@instance-41:~$ docker volume prune
030f652ad7ea6766f3d17a421233896b78296cf89d9bc816c69e6084df1aa24d
1e16af70af2319707350ce672c0af925c010561a5f75f83393674b5f20df7074
94ed6b916617b932638619fcbdbfc77d843175a57c520d02d3162f5750916409
ubuntu@instance-41:~$ docker volume ls
DRIVER          VOLUME NAME
```

# Remote Volumes

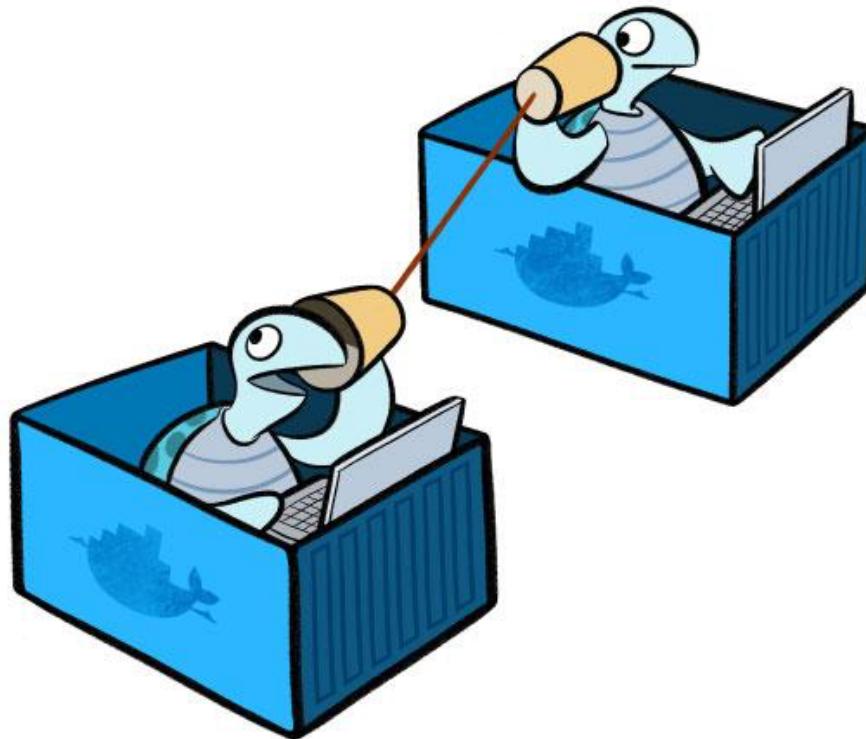
<https://container42.com/2014/03/29/docker-quicktip-4-remote-volumes/>

# Docker Volume Plugin - Flocker

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

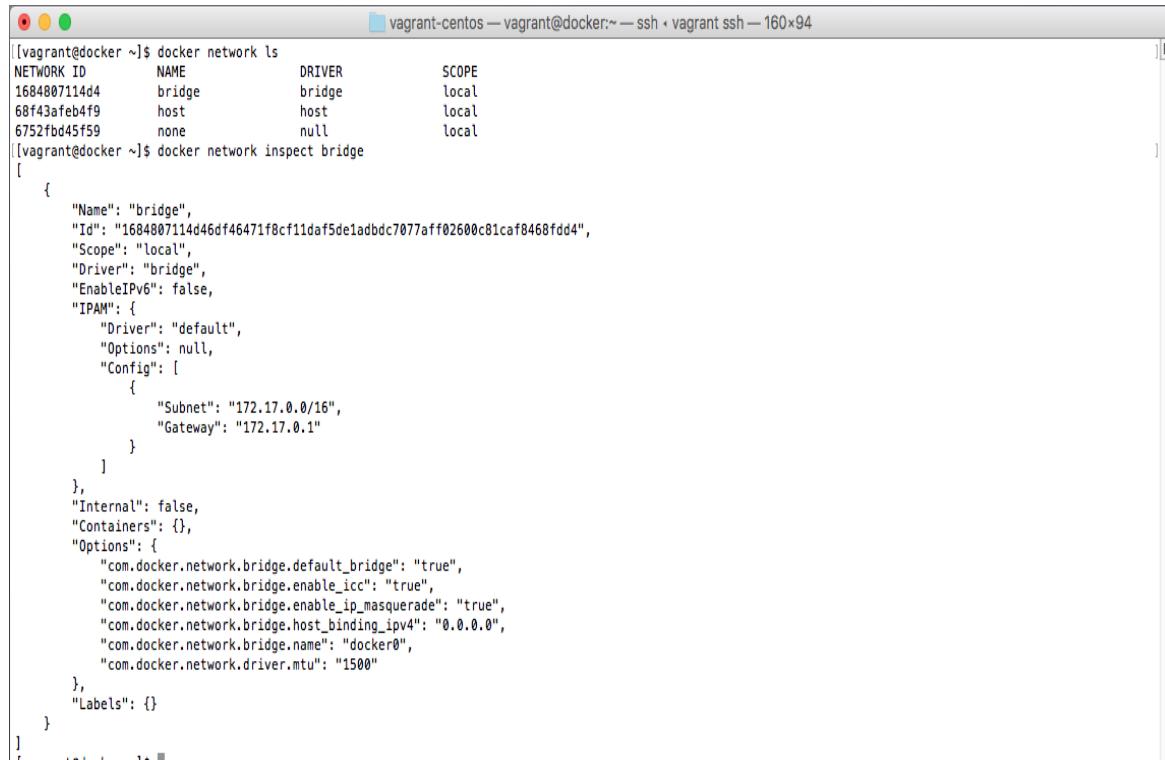


# Docker Networking



# Docker Network Defaults

- Three networks are created by default (bridge, host & none)
  - **docker network ls**
- We can easily inspect the bridge network
  - **docker network inspect bridge**
- We see that a 172.17.0.0/16 address space is allocated.  
Created Containers are given an IP in this space by default.



```
vagrant-centos — vagrant@docker:~ — ssh + vagrant ssh — 160x94
[vagrant@docker ~]$ docker network ls
NETWORK ID      NAME      DRIVER      SCOPE
1684807114d4    bridge    bridge      local
68f43afeb4f9    host      host       local
6752fb45f59    none      null       local
[vagrant@docker ~]$ docker network inspect bridge
[
  {
    "Name": "bridge",
    "Id": "1684807114d46df46471f8cf11daf5de1adbdcc077aff02600c81caf8468fdd4",
    "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": {},
    "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": {}
  }
]
```

# Docker Network Defaults

```
vagrant-centos — vagrant@docker:~ — ssh + vagrant ssh — 160x94
[vagrant@docker ~]$ docker run --name some-ghost -p 8080:2368 -d ghost
53e5d4de5054ca0b3cfaab91476f6901f373df3e4b215c2af855cc14be62a464
[vagrant@docker ~]$ docker network inspect bridge
[{"Name": "bridge",
 "Id": "1684807114d46df46471f8cf11daf5de1adbdc7077aff02600c81caf8468ffdd4",
 "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": {
   "53e5d4de5054ca0b3cfaab91476f6901f373df3e4b215c2af855cc14be62a464": {
     "Name": "some-ghost",
     "EndpointID": "e02d6b898b3d89ee192bbf228d467d49d8f811948a7bc79543524112148fa7f",
     "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": {}
}
[vagrant@docker ~]$ ping 172.17.0.2
PING 172.17.0.2 (172.17.0.2) 56(84) bytes of data.
64 bytes from 172.17.0.2: icmp_seq=1 ttl=64 time=0.049 ms
64 bytes from 172.17.0.2: icmp_seq=2 ttl=64 time=0.080 ms
64 bytes from 172.17.0.2: icmp_seq=3 ttl=64 time=0.183 ms
^C
--- 172.17.0.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 0.049/0.104/0.183/0.057 ms
```

- Created container is attached to bridge network by default
  - Can be attached to user created networks as well with `--network` flag
- Container is assigned 172.17.0.2 ip in the bridge network and appears in the docker inspect command
- The container can then be pinged at 172.17.0.2

# Docker network commands

Command	Description
docker network create	Create a network
docker network ls	List networks
docker network inspect	Detailed information on network
docker network rm	Remove network
docker network disconnect	Disconnect container from network
docker network connect	Connect container to network

# Working with Networks

Run redis container with default network

```
ubuntu@ip-172-31-35-117:~$ docker network ls
NETWORK ID      NAME      DRIVER      SCOPE
bcddd713372f    bridge    bridge      local
94a5aa84bbcd    host      host       local
e785de4a1213    none      null       local
ubuntu@ip-172-31-35-117:~$ docker run -d -p 1000:6379 --name red1 redis
82233b85cb84e2372e0e3fcdf03c5f46642c8faf0e201a7b0c43f7439c2ca02e
```

Run ubuntu container with default network

```
ubuntu@ip-172-31-35-117:~$ docker run -it --name ub1 ubuntu
root@65b7ce9e6028:/# apt-get update && apt-get install -y redis-tools
```

# Working with Networks

Check how to access redis container from ubuntu container → we can access

```
root@65b7ce9e6028:/# redis-cli -h 172.17.0.2 -p 6379
172.17.0.2:6379> set fool bar1
OK
172.17.0.2:6379> quit
root@65b7ce9e6028:/#
root@65b7ce9e6028:/# redis-cli -h 34.216.137.67 -p 1000
34.216.137.67:1000> get fool
"bar1"
34.216.137.67:1000> quit
root@65b7ce9e6028:/#
root@65b7ce9e6028:/# redis-cli -h 34.216.137.67 -p 6379
Could not connect to Redis at 34.216.137.67:6379: Connection refused
Could not connect to Redis at 34.216.137.67:6379: Connection refused
not connected> quit
root@65b7ce9e6028:/#
root@65b7ce9e6028:/# redis-cli -h 172.17.0.2 -p 1000
Could not connect to Redis at 172.17.0.2:1000: Connection refused
Could not connect to Redis at 172.17.0.2:1000: Connection refused
not connected>
not connected> quit
```

# Working with Networks

Create a new bridge network

```
ubuntu@ip-172-31-35-117:~$ docker network create bridgea
1f0afe0c3f5529403c5baa17e16e5534d0bf2f1966fd75c385902a7e97e5f61f
ubuntu@ip-172-31-35-117:~$ docker network ls
NETWORK ID      NAME      DRIVER      SCOPE
bcddd713372f    bridge    bridge      local
1f0afe0c3f55    bridgea   bridge      local
94a5aa84bcd    host      host       local
e785de4a1213    none     null       local
```

Run ubuntu container in the new network, install redis-tools

```
ubuntu@ip-172-31-35-117:~$ docker run -it --name ub2 --network bridgea ubuntu
root@34461322da59:/# apt-get update && apt-get install -y redis-tools
```

Redis (bridge network) is not accessible from ubuntu (bridgea) network

```
root@34461322da59:/# redis-cli -h 172.17.0.2 -p 6379
^Z
[2]+  Stopped                  redis-cli -h 172.17.0.2 -p 6379
root@34461322da59:/#
```

# Working with Networks

Connect ub2 container to bridge network

```
ubuntu@ip-172-31-35-117:~$ docker network connect bridge ub2
ubuntu@ip-172-31-35-117:~$ docker inspect ub2
```

```
"Networks": {
    "bridge": {
        "Gateway": "172.17.0.1",
        "IPAddress": "172.17.0.3",
    },
    "bridgea": {
        "Gateway": "172.18.0.1",
        "IPAddress": "172.18.0.2",
    }
}
```

Now Redis (bridge network) is accessible from ubuntu (bridgea + bridge) network

```
ubuntu@ip-172-31-35-117:~$ docker attach ub2
root@34461322da59:/# redis-cli -h 172.17.0.2 -p 6379
172.17.0.2:6379> keys *
1) "foo1"
172.17.0.2:6379> get foo1
"bar1"
172.17.0.2:6379> quit
```

# Docker Monitoring/Registry Exercise



---

CLASSROOM WORK

---

---

20 minutes

---

[https://github.com/shekhar2010us/microservices\\_monolithic\\_docker/blob/master/docker%20monitor%20registry.md](https://github.com/shekhar2010us/microservices_monolithic_docker/blob/master/docker%20monitor%20registry.md)

# Docker Volumes Exercise



---

CLASSROOM WORK

---

---

30 minutes

---

<https://goo.gl/gR6XTI>

([https://github.com/docker/dceu\\_tutorials/blob/master/07-volumes.md](https://github.com/docker/dceu_tutorials/blob/master/07-volumes.md))

# Docker --volumes-from Exercise



## CLASSROOM WORK

10 minutes

### volumes-from

- docker volume create --name backup
- docker volume create --name logs
- docker run -it --name master -v backup:/backup -v logs:/logs ubuntu bash
- create sample files in backup & logs folders in container
- You can stop the container, but do not remove it
- Create another container using master volumes
  - docker run -it --name slave1 --volumes-from master ubuntu bash
- check the 2 folders ; exit

# Docker Networks Exercise



## CLASSROOM WORK

20 minutes

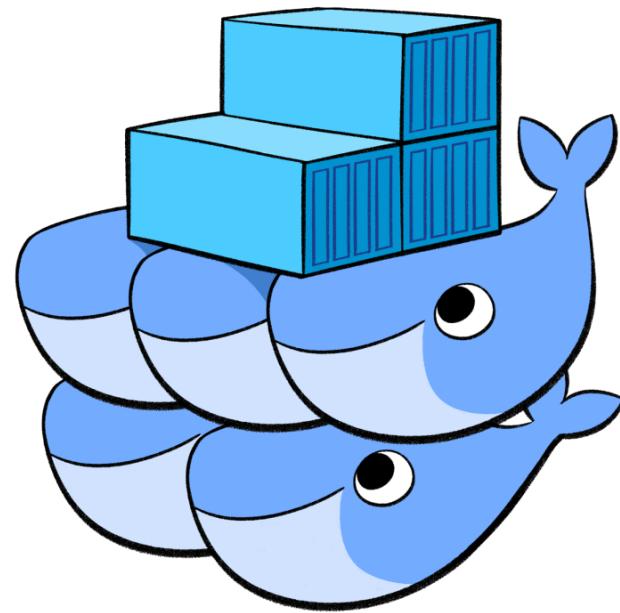
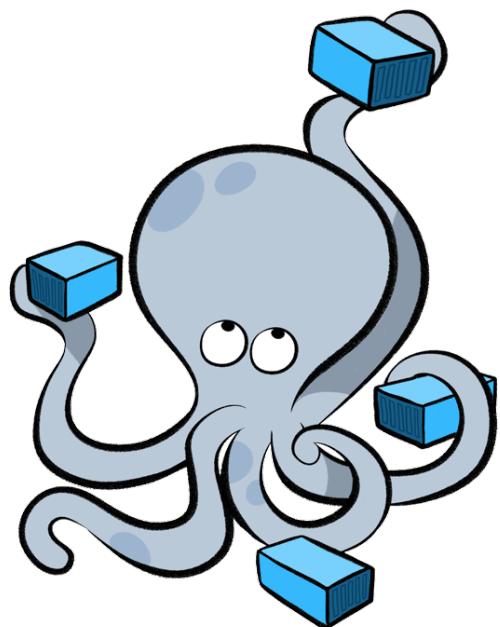
- Run a redis container with default network
- Run a ubuntu container with default network
- Install redis-tools in host and check if you can connect to redis container and add some data
- Install redis-tools in ubuntu container and check if you can connect to redis container. (optional: create an image with redis-tools and ubuntu)
- Create a bridge network (bridgea)
- Run a ubuntu container with bridgea network and the new image, check if you can connect to redis – probably not
- Connect this new ubuntu container with “bridge” network, and check again if you can connect to the redis container

**\*\* keep inspecting network and container after every step**

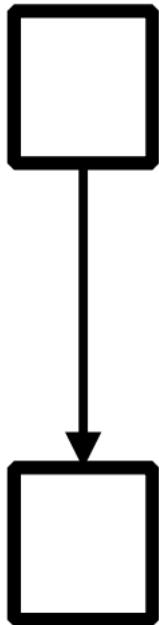
## Part 5: DevOps Docker

# Docker Compose/Swarm

---



# Launching multiple containers is clumsy



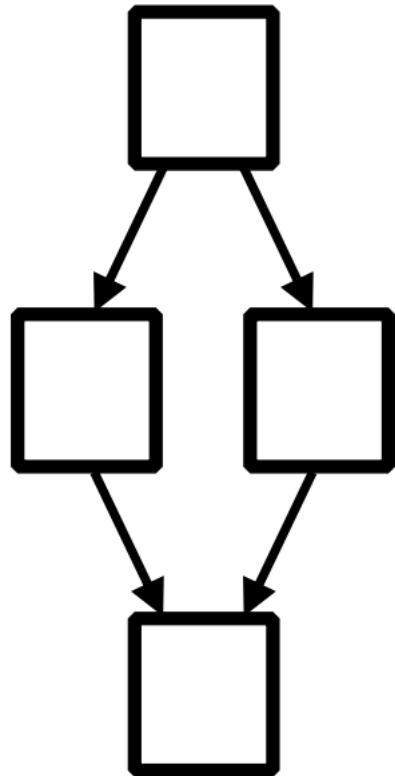
```
$ docker pull redis:latest
```

```
$ docker build -t web .
```

```
$ docker run -d --name=db redis:latest redis-server --  
appendonly yes
```

```
$ docker run -d --name=web --link db:db -p  
5000:5000 -v `pwd`:/code web python app.py
```

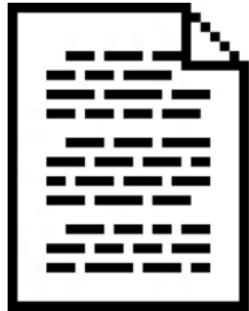
# Launching multiple containers is clumsy



```
$ docker pull ...  
$ docker pull ...  
$ docker build ...  
$ docker build ...
```

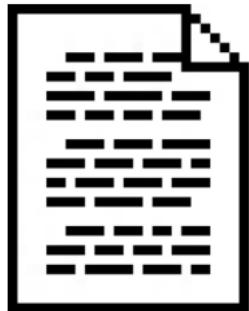
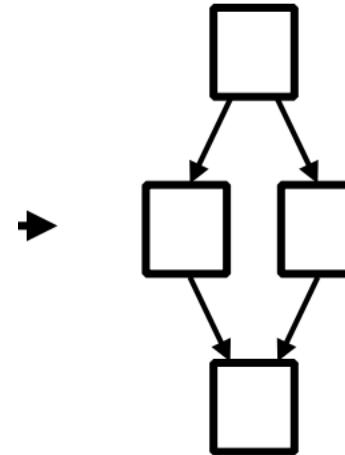
```
$ docker run ...  
$ docker run ...  
$ docker run ...  
$ docker run ...
```

# Docker Compose or Swarm launches app with a single command



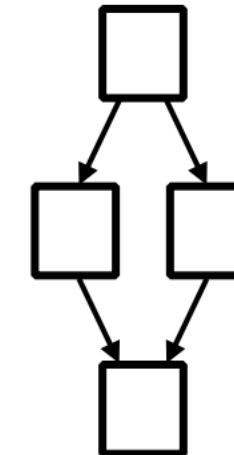
**Text file**

→ \$ docker-compose up



**Text file**

→ \$ docker stack deploy



# Docker Compose commands

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

# Docker Compose to deploy a cluster



## CLASSROOM WORK

First, install Compose:

<https://github.com/docker/compose/releases>

- sudo curl -L  
`https://github.com/docker/compose/releases/download/1.22.0/docker-compose-`uname -s`-`uname -m` -o /usr/local/bin/docker-compose`
- sudo chmod +x /usr/local/bin/docker-compose
- docker-compose version

Then, Compose “Getting Started” Lab:

<https://docs.docker.com/compose/gettingstarted/>

# Docker Swarm commands

Command	Description
docker swarm init	Create a swarm
docker stack deploy	Deploy the swarm
docker stack services	Show swarm services
docker stack rm	Remove stack

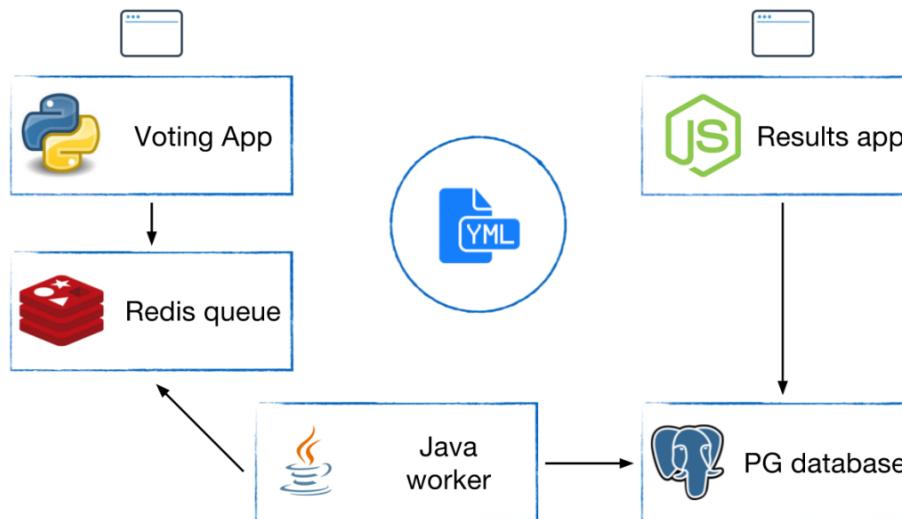
# Docker Swarm to deploy a cluster



## CLASSROOM WORK

Exercise 3.0 in Docker Labs

<https://github.com/docker/labs/blob/master/beginner/chapters/votingapp.md>



Part 7: DevOps Docker

# Docker Security

---



# Security For Docker Images

- Secure Registry/Mirror Access
- Getting trustworthy images
  - trusted sources
    - docker hub / docker store
      - official images
      - pull by digest
    - private registry
- Docker Content Security
  - Docker Notary
    - Digitally signed images
      - "only signed content in production"

# Docker Content Trust



## CLASSROOM WORK

In this exercise, we'll learn how to enable Docker Content Trust and sign images.

<https://github.com/docker/labs/blob/master/security/trust/README.md>

(Skip Step 5)

# Docker Bench Security

Docker Bench is an automated script that checks for dozens of best-practices around deploying Docker in production

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

Run with the following command  
(available at the github page above)

```
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
```

```
vagrant@vagrant-OptiPlex-5090:~$ vagrant 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 \v docker/docker-bench-security
Unable to find image "docker/docker-bench-security:latest" locally
Last login: Fri Dec 23 13:44:46 UTC 2016
[4233733] Pulling docker-bench-security
[4233733] Pull complete
[86295e3e006f] Pull complete
[86295e3e006f] Digest: sha256:7c9b03b3a4bc9362b2b5c8728aac2c45864df7c55e0983205f15569bb
Status: Downloaded newer image for docker/docker-bench-security:latest
[4233733] Docker Bench for Security v1.1.0
[4233733] Docker, Inc. (c) 2015-
[4233733] Checks for dozens of common best-practices around deploying Docker containers in production.
[4233733] Inspired by the CIS Docker 1.11 Benchmark:
[4233733] https://benchmarks.cisecurity.org/downloads/show-single/index.cfm?file=docker16.11B

Initializing Thu Dec 1 21:05:27 GMT 2016

[INFO] 1 - Host Configuration
[WARN] 1.1 - Create a separate partition for containers
[PASS] 1.2 - Use an updated Linux Kernel
[PASS] 1.4 - Remove all non-essential services from the host - Network
[PASS] 1.5 - Remove Docker daemon
[INFO] 1.6 - Using 1.12.3 which is current as of 2016-10-26
[INFO] 1.6 - * Checked with your operating system vendor for support and security maintenance for docker
[INFO] 1.6 - * Docker is also available via vagrant to control Docker daemon
[INFO] 1.7 - Failed to inspect: auditctl command not found.
[WARN] 1.8 - Failed to inspect: auditctl command not found.
[WARN] 1.9 - Failed to inspect: auditctl command not found.
[WARN] 1.9 - Failed to inspect: auditctl command not found.
[INFO] 1.11 - Audit Docker files and directories - docker.socket
[INFO] 1.12 - Audit Docker files and directories - /etc/default/docker
[INFO] 1.12 - * File not found
[INFO] 1.13 - Audit Docker files and directories - /etc/docker/daemon.json
[INFO] 1.13 - * File not found
[INFO] 1.14 - Audit Docker files and directories - /usr/bin/docker-containerd
[INFO] 1.14 - * File not found
[INFO] 1.35 - Audit Docker files and directories - /usr/bin/docker-runc
[INFO] 1.35 - * File not found

[INFO] 2 - Docker Daemon Configuration
[WARN] 2.1 - Restrict network traffic between containers
[PASS] 2.2 - Docker daemon listening on TCP port 2375
[PASS] 2.3 - Allow Docker to make changes to iptables
[PASS] 2.4 - Do not use insecure registries
[PASS] 2.5 - Use a secure certificate for Docker daemon
[INFO] 2.6 - Configure TLS authentication for Docker daemon
[INFO] 2.6 - * Docker daemon not listening on TCP
[INFO] 2.7 - Set default ulimit as appropriate
[INFO] 2.7 - * Docker daemon configuration file needs to be set
[WARN] 2.8 - Enable user namespace support
[PASS] 2.9 - Confirm default cgroup usage
[PASS] 2.10 - Verify that Docker daemon uses a large 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)

[INFO] 3 - Docker Daemon Configuration Files
[PASS] 3.1 - Verify that docker-service file ownership is set to root:root
[PASS] 3.2 - Verify that docker.service file permissions are set to 644
[INFO] 3.3 - Verify that docker.socket file ownership is set to root:root
[INFO] 3.3 - Verify that docker.socket file permissions are set to 644
[INFO] 3.4 - Verify that docker.socket file permissions are set to 644
[INFO] 3.4 - * File not found
[INFO] 3.5 - Verify that /etc/docker directory ownership is set to root:root
[PASS] 3.6 - Verify that /etc/docker directory permissions are set to 755
[INFO] 3.7 - Verify that registry/certificate file ownership is set to root:root
[INFO] 3.7 - * Directory not found
[INFO] 3.8 - Verify that registry/certificate file permissions are set to 444
[INFO] 3.8 - * Directory not found
[INFO] 3.9 - Verify that TLS CA certificate file ownership is set to root:root
[INFO] 3.9 - * Certificate file not found
[INFO] 3.10 - Verify that TLS CA certificate file permissions are set to 444
[INFO] 3.10 - * No TLS CA certificate found
[INFO] 3.11 - Verify that Docker server certificate file ownership is set to root:root
[INFO] 3.11 - * No TLS Server certificate found
[INFO] 3.12 - Verify that Docker server certificate file permissions are set to 444
[INFO] 3.12 - * No TLS Server certificate found
[INFO] 3.13 - Verify that Docker server key file ownership is set to root:root
[INFO] 3.13 - * No TLS Key found
[INFO] 3.14 - Verify that Docker server key file permissions are set to 400
[INFO] 3.14 - * No TLS Key found
[PASS] 3.15 - Verify that Docker socket file ownership is set to root:docker
[PASS] 3.15 - Verify that Docker socket file permissions are set to 660
[INFO] 3.17 - Verify that daemon.json file ownership is set to root:root
```



# Security

*10-15 Minutes*

---

# Docker Bench Results Discussion

<https://www.nearform.com/blog/securing-docker-containers-on-aws/>

<https://www.cisecurity.org/cis-benchmarks/>

# (Some) Docker Security Best Practices

- Docker containers can attach to volumes in read only mode with :ro option
  - Docker run -d -v /some/volume:ro jenkins
- Start Docker containers with the -u flag so that they run as an ordinary user instead of root.
- Mitigate by limiting CPU, RAM, Sockets that each container can consume
- Use secure computing (seccomp) to block system calls at kernel level. Use strace to determine kernel calls made, then create a profile file in json format and start the container using that profile file
  - docker run --rm -it --security-opt seccomp=custom\_profile.json custom\_app
- Log to stdout / stderr - so you can see with docker logs and docker can move to syslogs (for capture/rotate by ELK, etc.)
  - docker inspect --format='{{.LogPath}}' <containerid> => push to ELK for monitoring

# Docker Security Scanning (formerly Project Nautilus)

- Docker Security Scanning conducts binary level scanning of your images before they are deployed, provides a detailed bill of materials (BOM) that lists out all the layers and components, continuously monitors for new vulnerabilities, and provides notifications when new vulnerabilities are found.
- Available for **private Docker Hub repositories** (potentially free)
- Available as a paid service to Docker Cloud customers, maintainers of “Official” repositories on Docker Hub, and Docker EE Advanced

<https://github.com/docker/labs/blob/master/security/scanning/README.md>

# Clair by CoreOS

- Robust free and open source image security scanning tool
- <https://github.com/coreos/clair>
- Static analysis of images for known vulnerabilities
- Integrates into CI pipelines

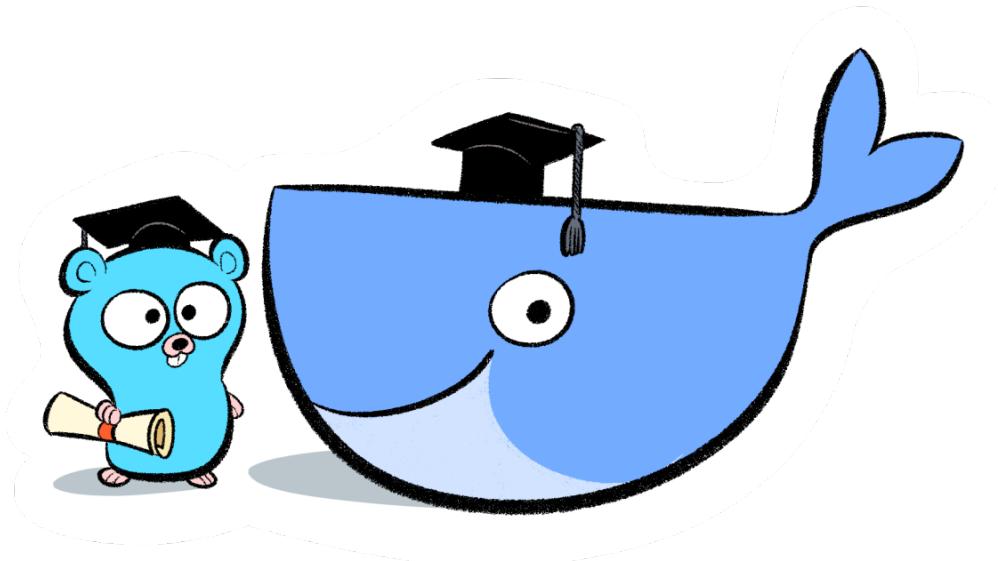
# Docker Security

- Stay up to date with the discussion at Docker's user group, forum, github issues, and IRC channel
  - <https://groups.google.com/forum/#!forum/docker-dev>
  - <https://forums.docker.com/>
  - <https://github.com/docker/docker/issues>
  - <https://docs.docker.comopensource/get-help/>
  - IRC #docker & #docker-dev

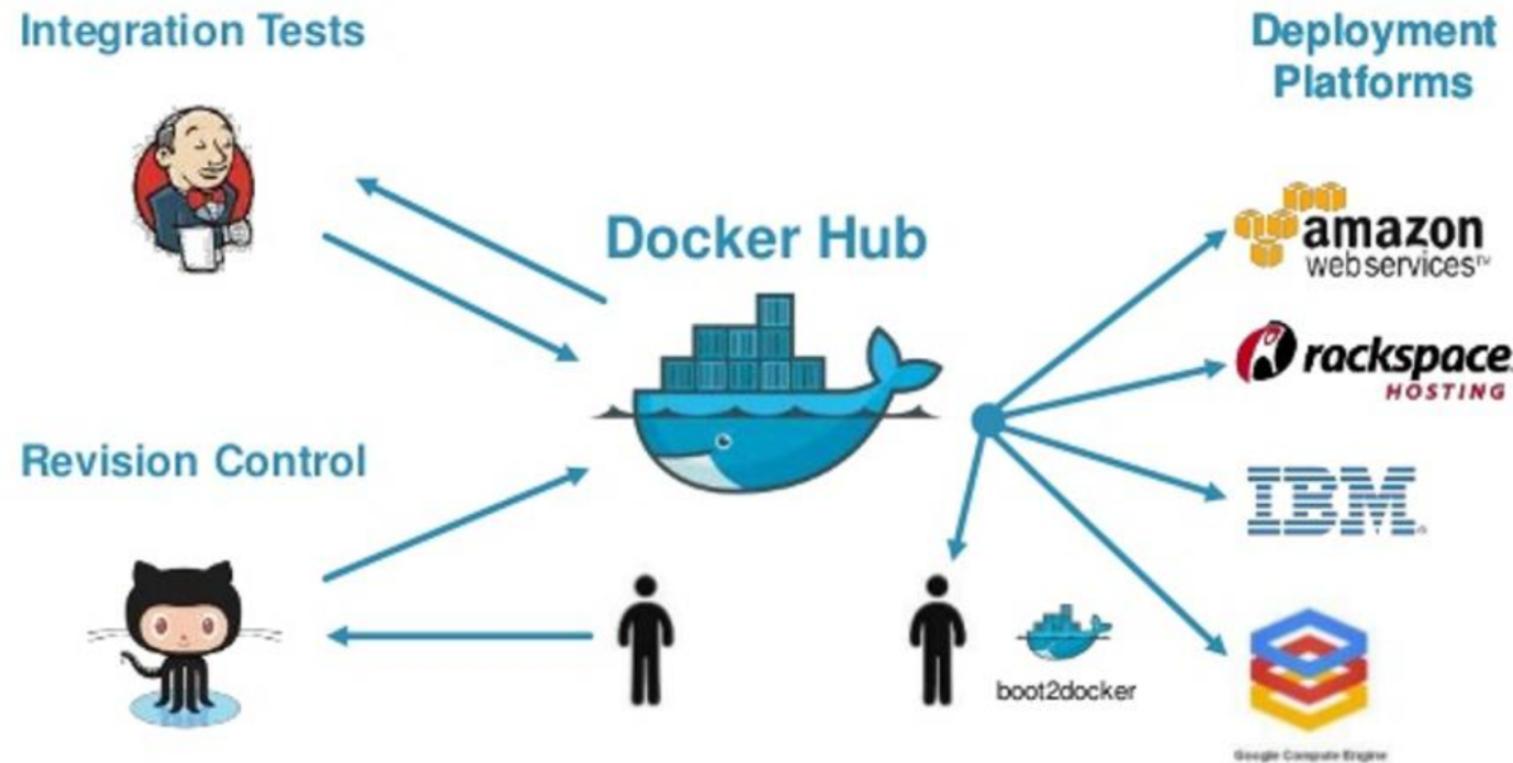
Part 6: DevOps Docker

# Docker Patterns

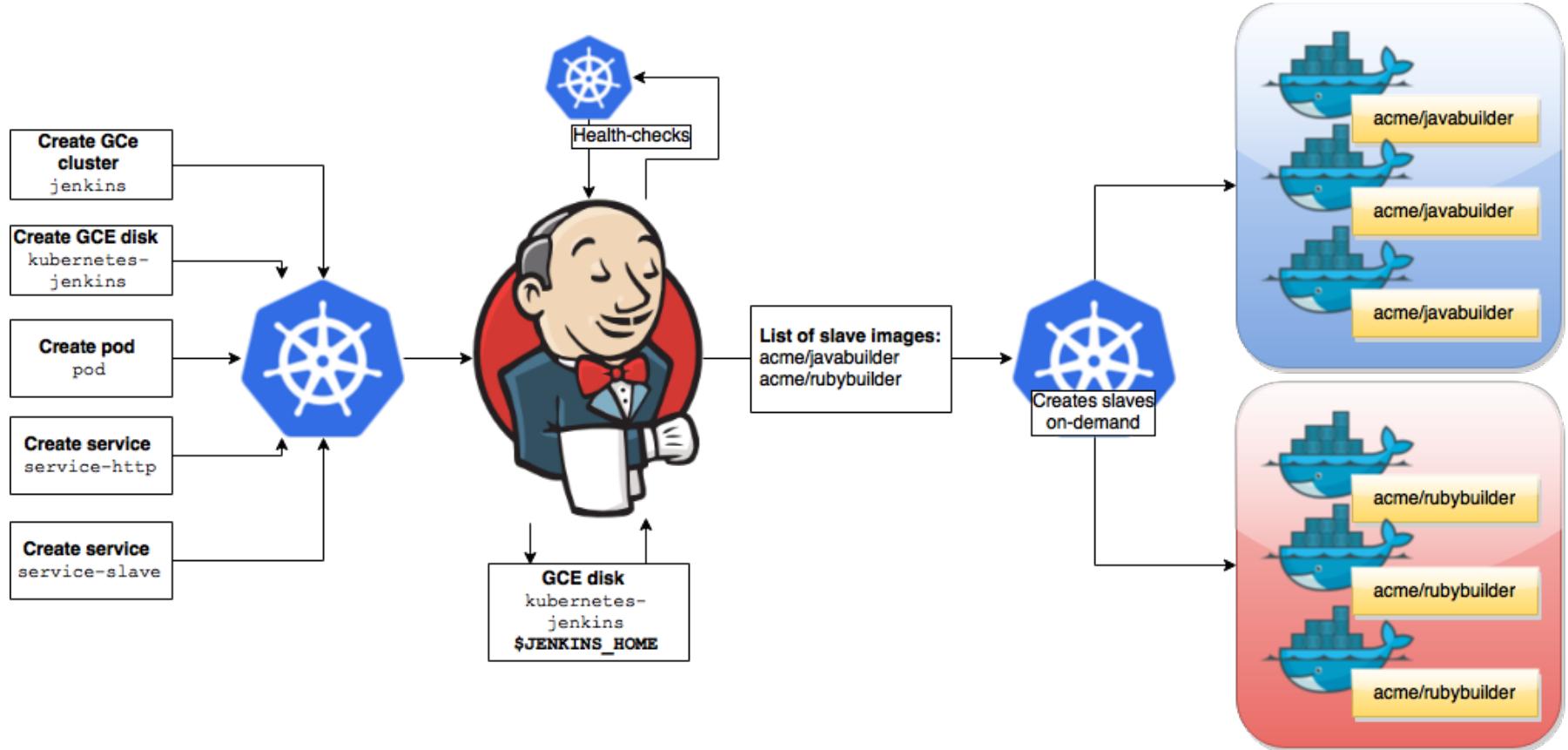
---



# Docker Patterns

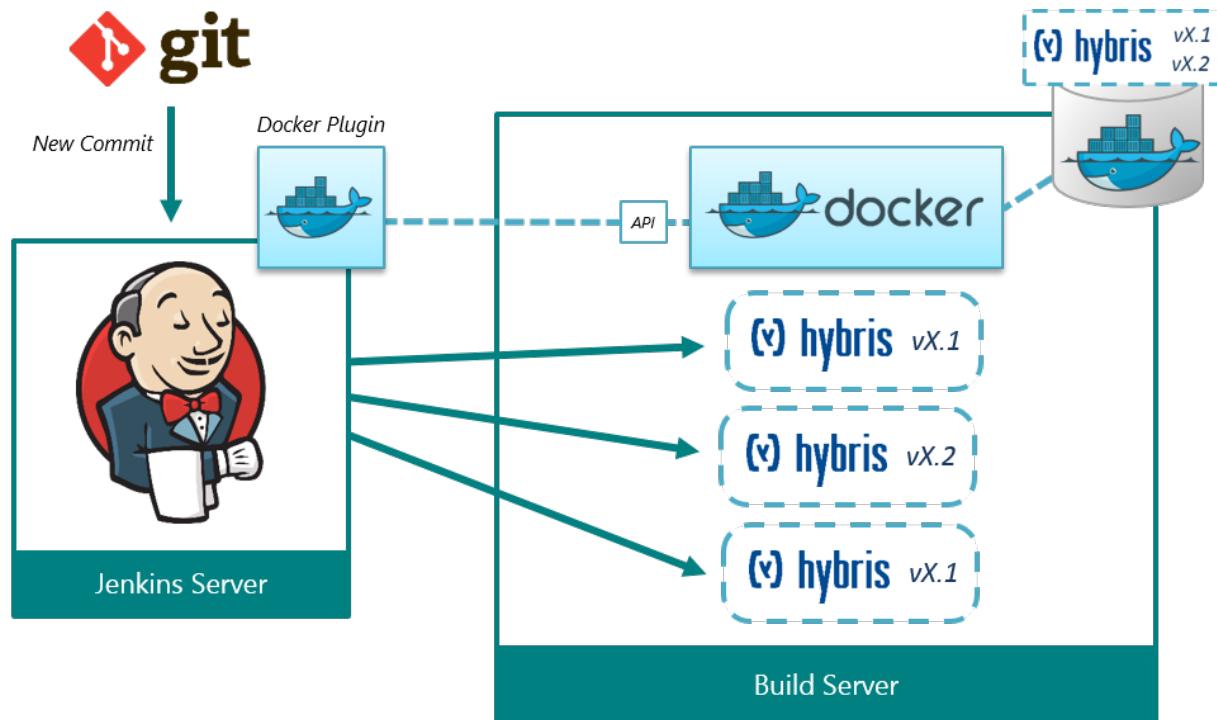


# Jenkins Continuous Integration-Cloudbees



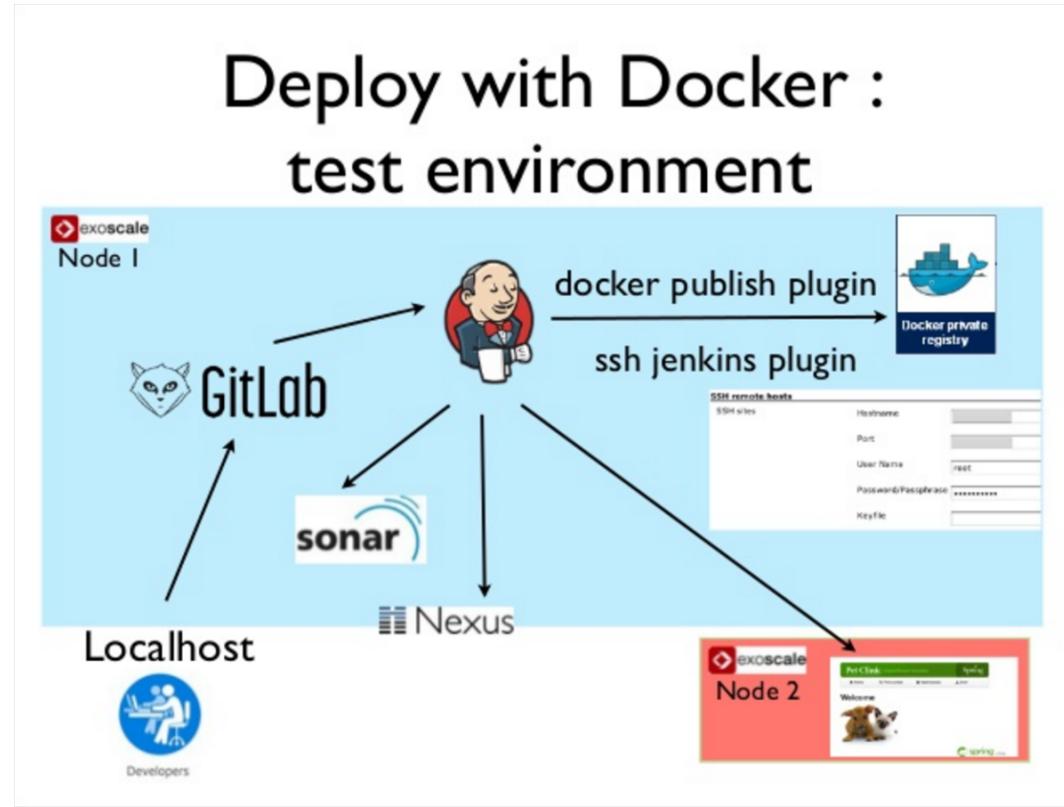
Link to Blog: Clustering Jenkins  
<http://bit.ly/2a092Xo>

# According to Michael Duke



Link to Blog: Docker as Jenkins Build Solution  
<http://bit.ly/2a57Za8>

# According to Julia Mateo



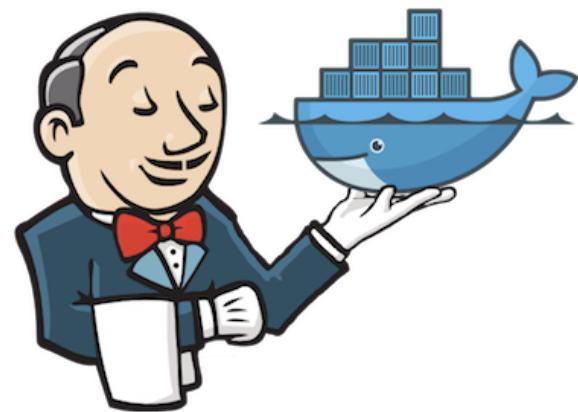
Link to Presentation: Continuous Delivery  
<http://bit.ly/2aHZj9o>

# Docker and Jenkins

Docker and Jenkins, a popular open source continuous integration tool, is a fairly common pattern, enough so that it is worth going into an example.

Spin up Jenkins in  
a Docker  
Container

Enable Jenkins to  
create other  
containers on the  
Docker Host computer



# How to run a ‘Host’ Docker command inside a ‘Client’ Docker container?

- Mount a Docker socket
  - Issuing a Docker run command with the Docker socket will enable you to manage host containers from within the client container
  - ‘`docker run -v /var/run/docker.sock:/var/run/docker.sock`’

# Docker and Jenkins, Part 1



## CLASSROOM WORK

### Part 1, Jenkins Exercise in Docker Tutorials

This assignment is to set up a dockerfile that uses an official Jenkins image from Docker Hub, build an image with that image as a starting point, run a Jenkins container using the new image, and successfully get a Docker Hello world container running on the host but orchestrated from Jenkins in the container.

This exercise will help you practice Docker volume syntax as well as configure a client container (our Jenkins container) such that it can make calls to its host Docker engine.

Estimated time to complete: 20-30 min

Solution:

<https://github.com/papaludwig/docker-tutorials/tree/master/jenkins>

# Sharing Persistent Volumes

```
[ubuntu@ubuntu-xenial:~/docker-workshop/jenkins$ docker create -v /var/jenkins_home --name jenkinstore library/jenkins
eef810fbad2247678db46187c0dec05d86a93397f27b40aff30640957977e15
[ubuntu@ubuntu-xenial:~/docker-workshop/jenkins$ docker volume ls
DRIVER          VOLUME NAME
local           e99cc1a13396614cd1d6eaf0b44be7544c6af0560a4ca93c8605e3bcfa0a7161

ubuntu@ubuntu-xenial:~/docker-workshop/jenkins$ docker volume inspect e99cc1a13396614cd1d6eaf0b44be7544c6af0560a4ca93c8605e3bcfa0a7161
[
  {
    "Name": "e99cc1a13396614cd1d6eaf0b44be7544c6af0560a4ca93c8605e3bcfa0a7161",
    "Driver": "local",
    "Mountpoint": "/var/lib/docker/volumes/e99cc1a13396614cd1d6eaf0b44be7544c6af0560a4ca93c8605e3bcfa0a7161/_data",
    "Labels": null,
    "Scope": "local"
  }
]

[ubuntu@ubuntu-xenial:~/docker-workshop/jenkins$ docker run --volumes-from jenkinstore --name jenkin1 -p 8080:8080 -p 50000:50000 library/jenkins
Running from: /usr/share/jenkins/jenkins.war
webroot: EnvVars.masterEnvVars.get("JENKINS_HOME")
Nov 23, 2016 4:58:27 PM Main deleteWinstoneTempContents

ubuntu@ubuntu-xenial:~/docker-workshop/jenkins$ docker run --volumes-from jenkinstore --name jenkin2 -p 8080:8080 -p 50000:50000 library/jenkins
Running from: /usr/share/jenkins/jenkins.war
webroot: EnvVars.masterEnvVars.get("JENKINS_HOME")
Nov 23, 2016 5:03:06 PM Main deleteWinstoneTempContents
WARNING: Failed to delete the temporary Winstone file /tmp/winstone/jenkins.war
```

# Docker and Jenkins, Part 2



## CLASSROOM WORK

Part 2, Shared Volumes Exercise in Docker workshop

The second assignment is to successfully share a persistent storage volume between two different Jenkins containers. Simulate the scenario of restoring your Jenkins state after a failure of the first container using the storage volume.

This exercise of sharing volumes could be extended to some simple open source databases as well.

Estimated time to complete: 15-25 min

Solution:

<https://github.com/papaludwig/docker-tutorials/tree/master/sharedvolume>

# Docker and Jenkins, Part 3



## CLASSROOM WORK

Part 3, Set up a Continuous Integration example.

Get a three-stage continuous integration pipeline working within your Jenkins container. This may involve installing additional plugins to your Jenkins instance (automate within your dockerfile) and adjusting the permissions on the Docker run command.

Estimated time to complete: 20-30 min

Solution:

<https://github.com/papaludwig/docker-tutorials/tree/master/ciexample>

# Docker and Jenkins, Part 4



## CLASSROOM WORK

Part 4, Call Continuous Integration Container from Docker Compose

Take the working code from Part 3 and summarize it with a call to Docker Compose. Docker Compose is a much more convenient interface and scales better when multiple containers must be invoked.

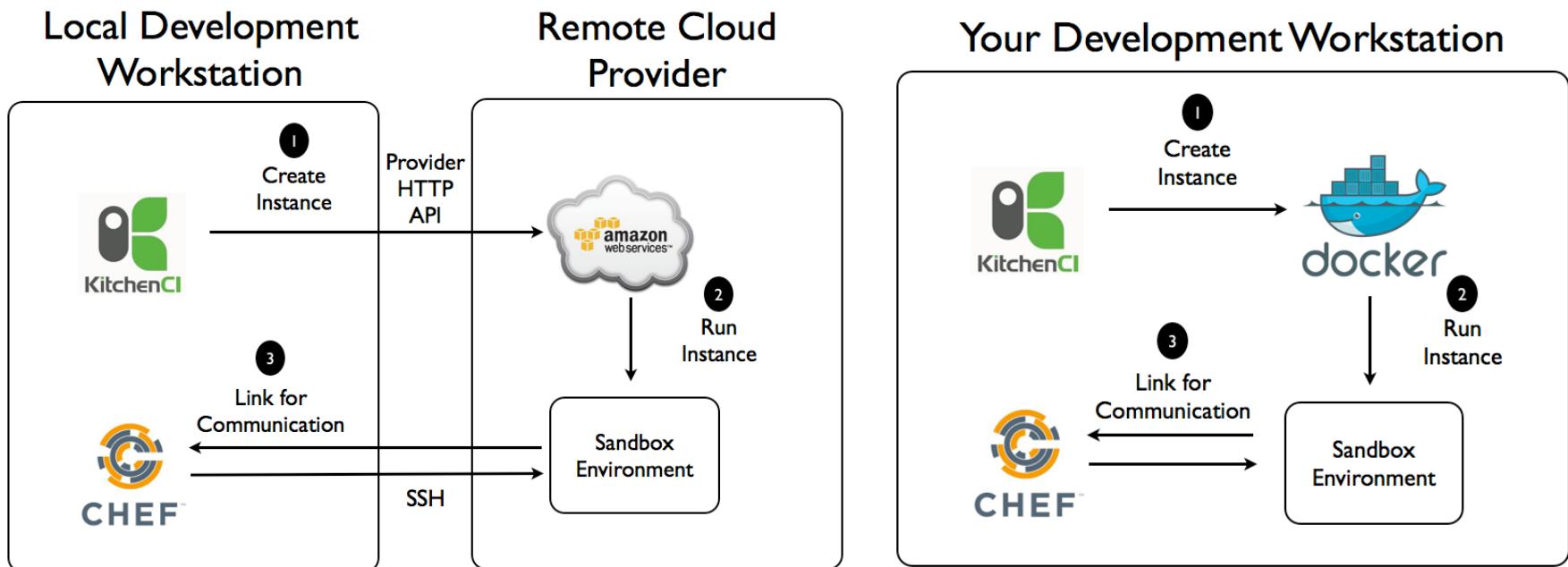
Bonus: Configure Jenkins container to skip setup workflow

Estimated time to complete: 15-25 min

Solution:

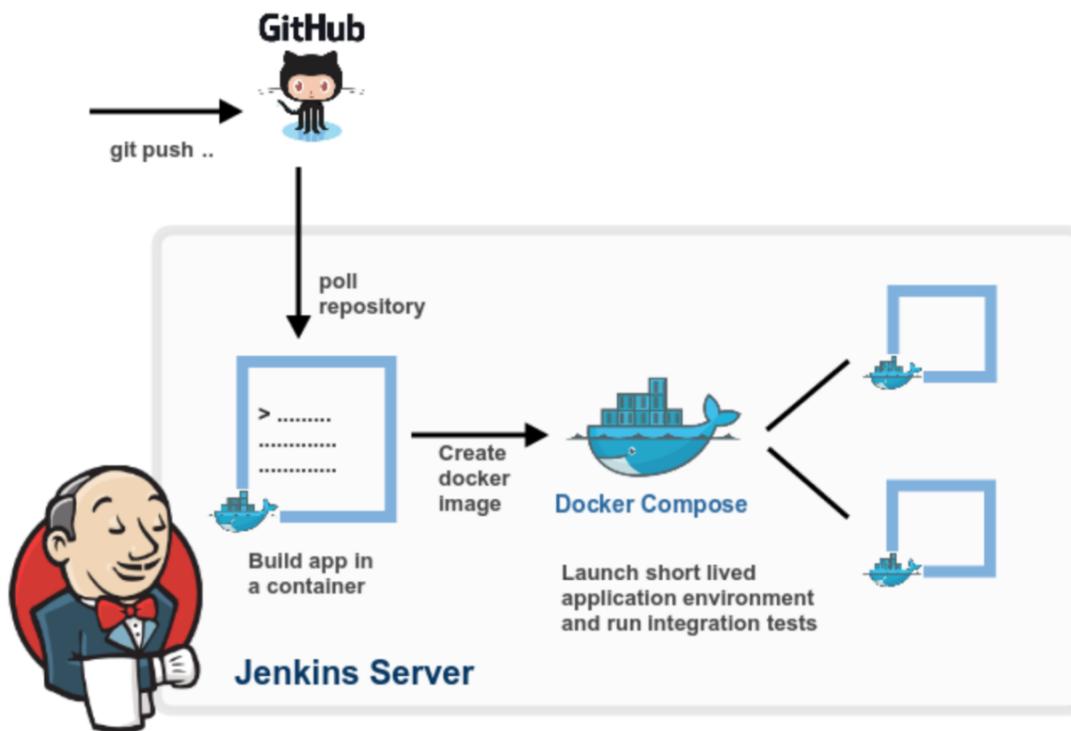
<https://github.com/papaludwig/docker-tutorials/tree/master/compose>

# According to Mischa Taylor



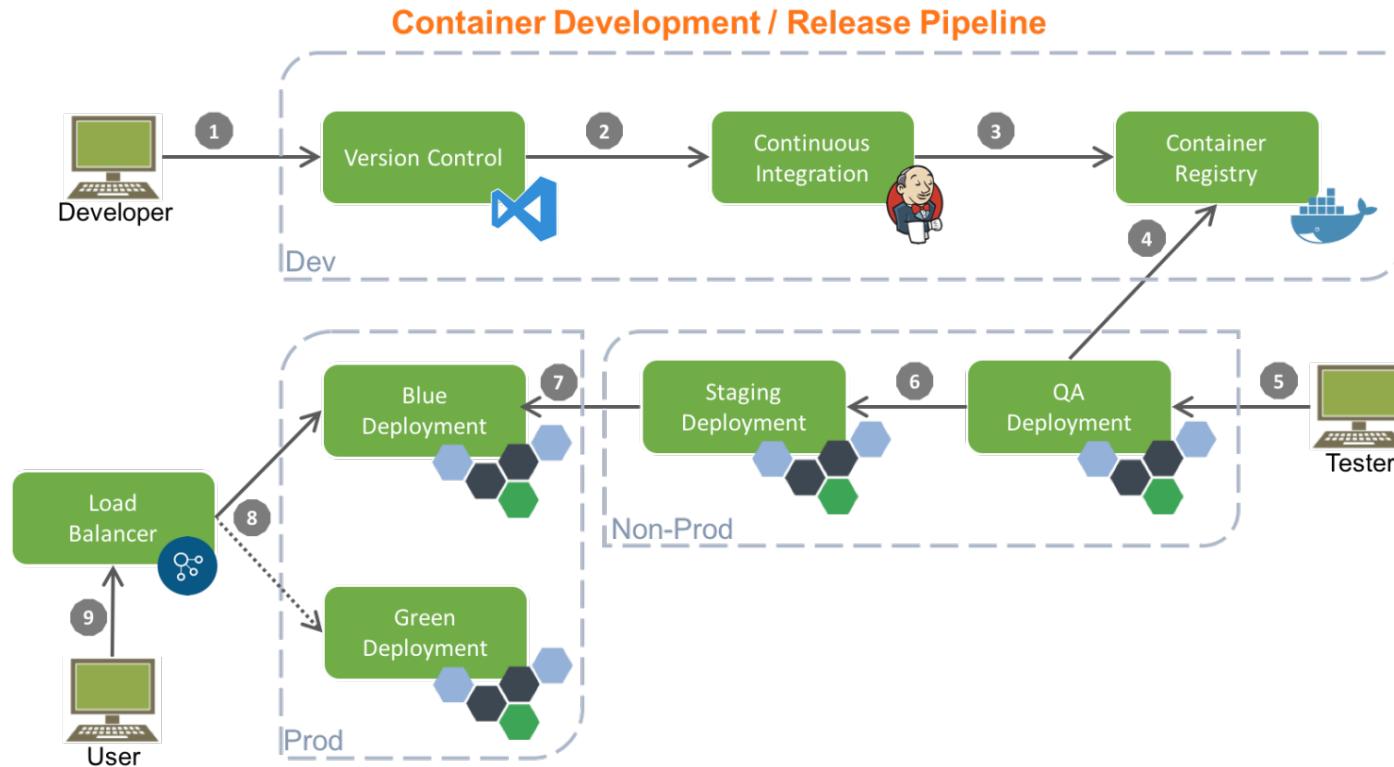
Link to Blog: Survey of Test Kitchen Providers  
<http://bit.ly/2a56kS2>

# According to Rancher



Link to Blog: Docker-based Build Pipelines  
<http://bit.ly/2aHtu0K>

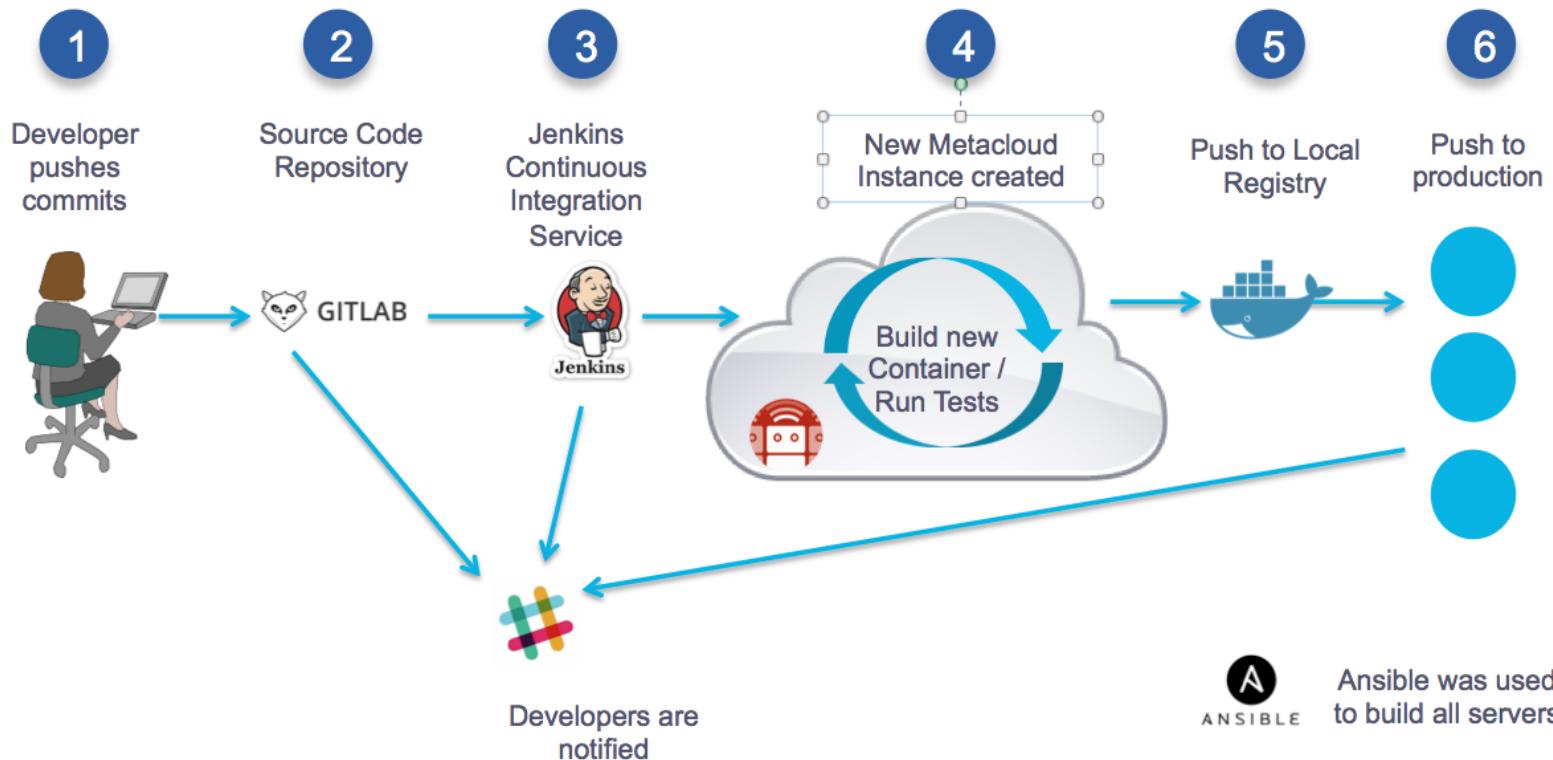
# According to Robert Greiner



Link to Blog: Continuous Integration with Docker

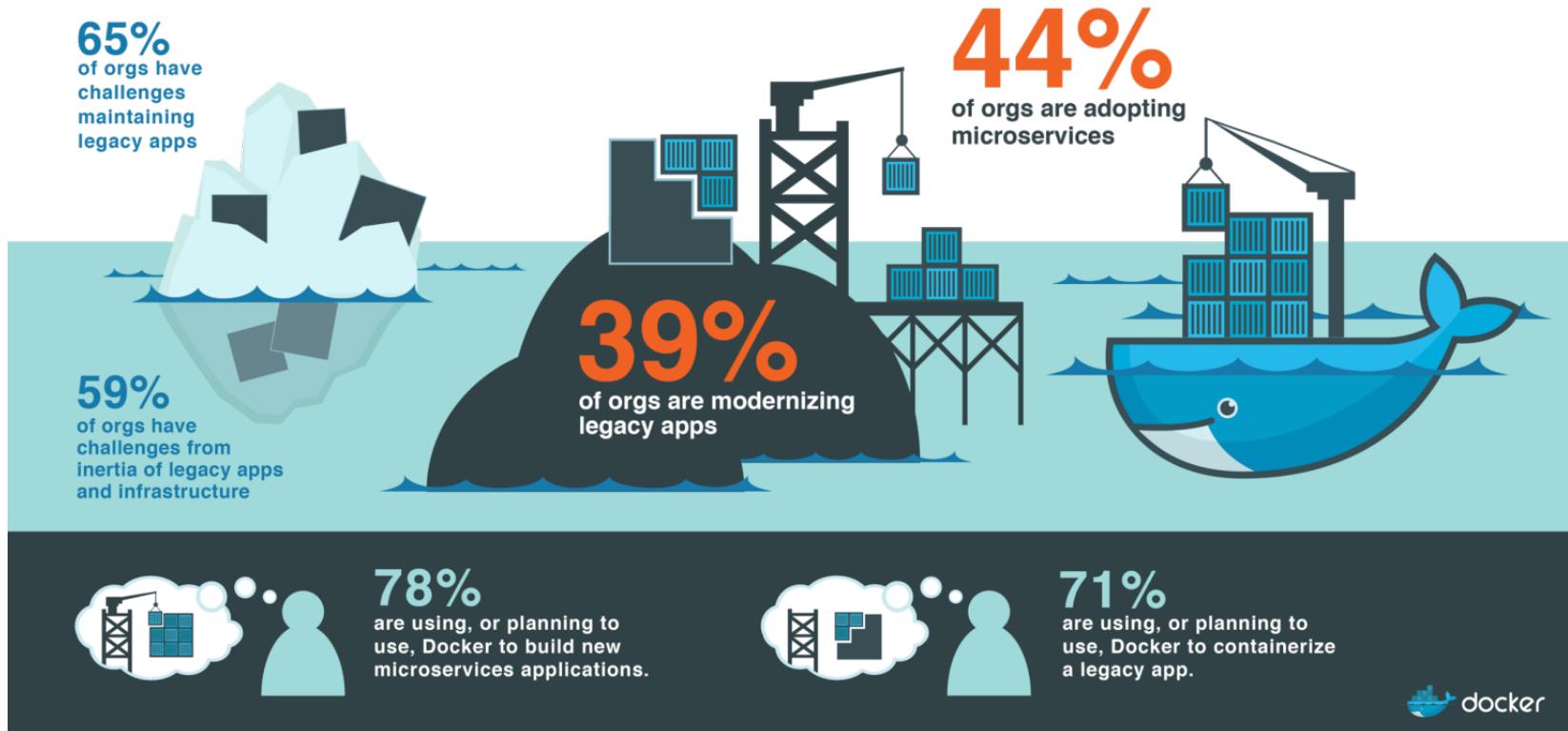
<http://bit.ly/2aeA1io>

# According to Vallard



Link to Blog: Continuous Delivery of a Simple Web Application  
<http://bit.ly/2asS8G3>

# Docker Adoption & Usage Data

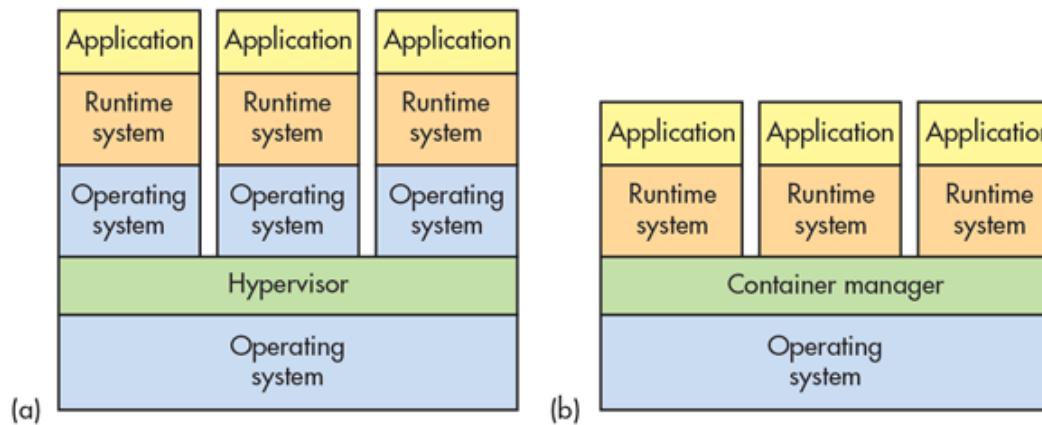


# Kubernetes

---

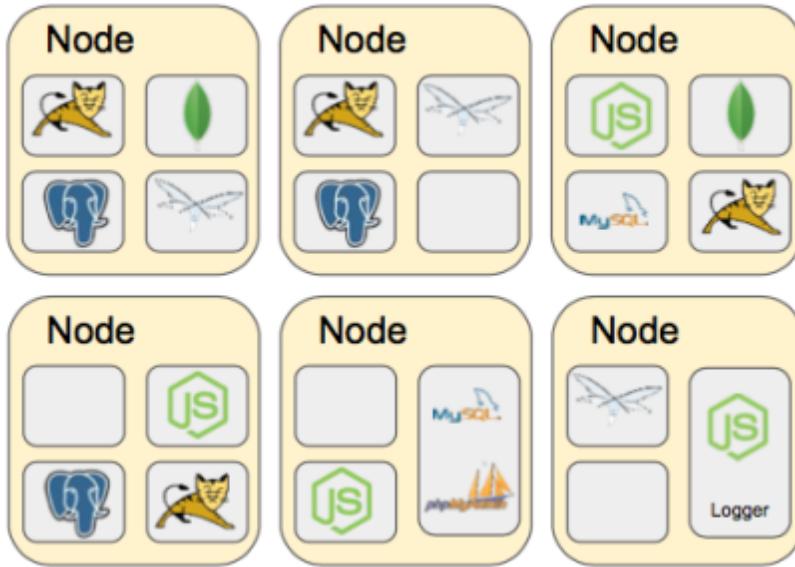
# Container Advantages

- Portable
- Isolated
- Lighter footprint & overhead (vs VMs)
- Simplify Devops practices
- Speed up Continuous Integration
- Empower Microservice architectures and adoption



# Challenges with multiple containers

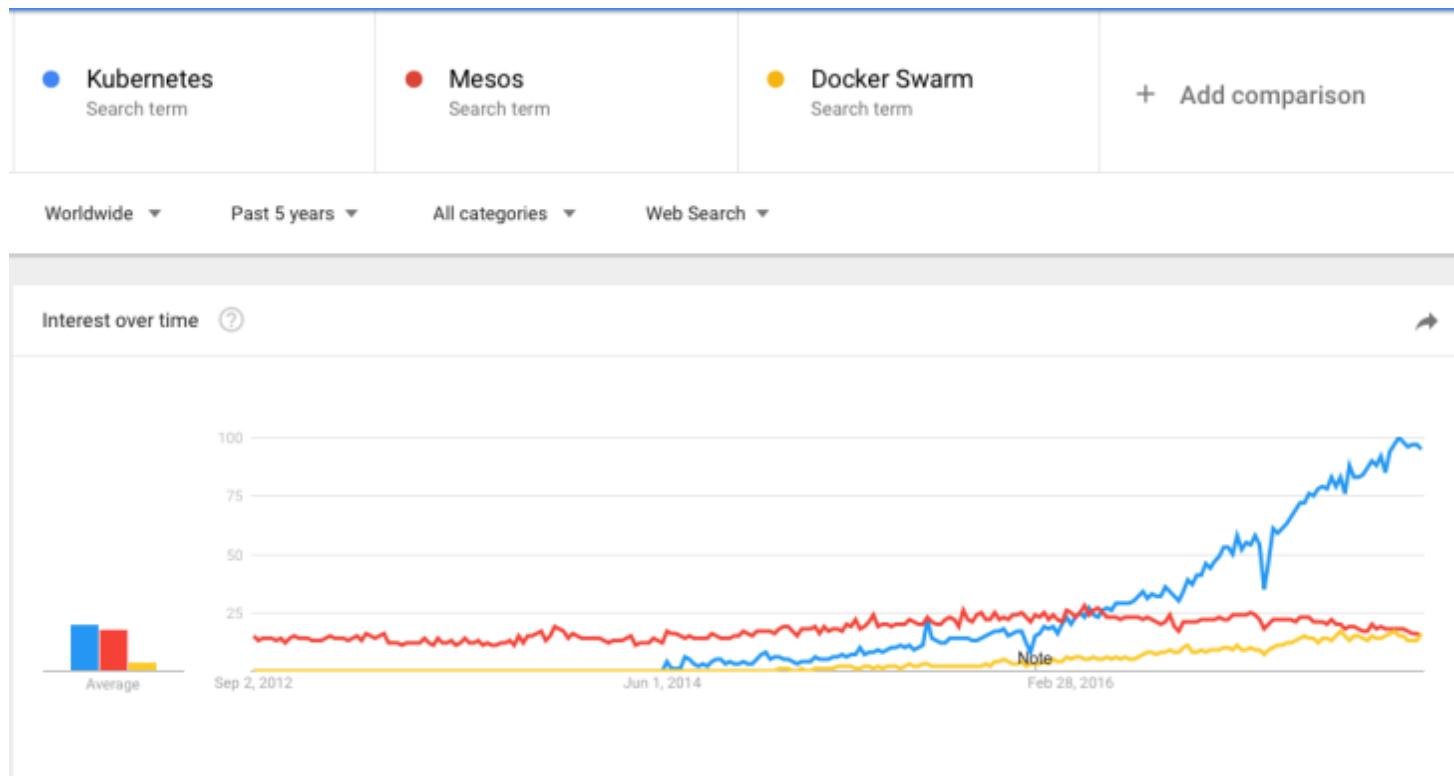
---



- How to scale?
- Once I scale, where are they?
- How do my containers find each other?
- How should I manage port conflicts?
- What if a host fails?
- How to update them? Health checks?
- How will I track their logs?

# Container Orchestration Tools

- The three most popular are: Kubernetes, Docker Swarm & Mesos
- Kubernetes has become the unofficial standard

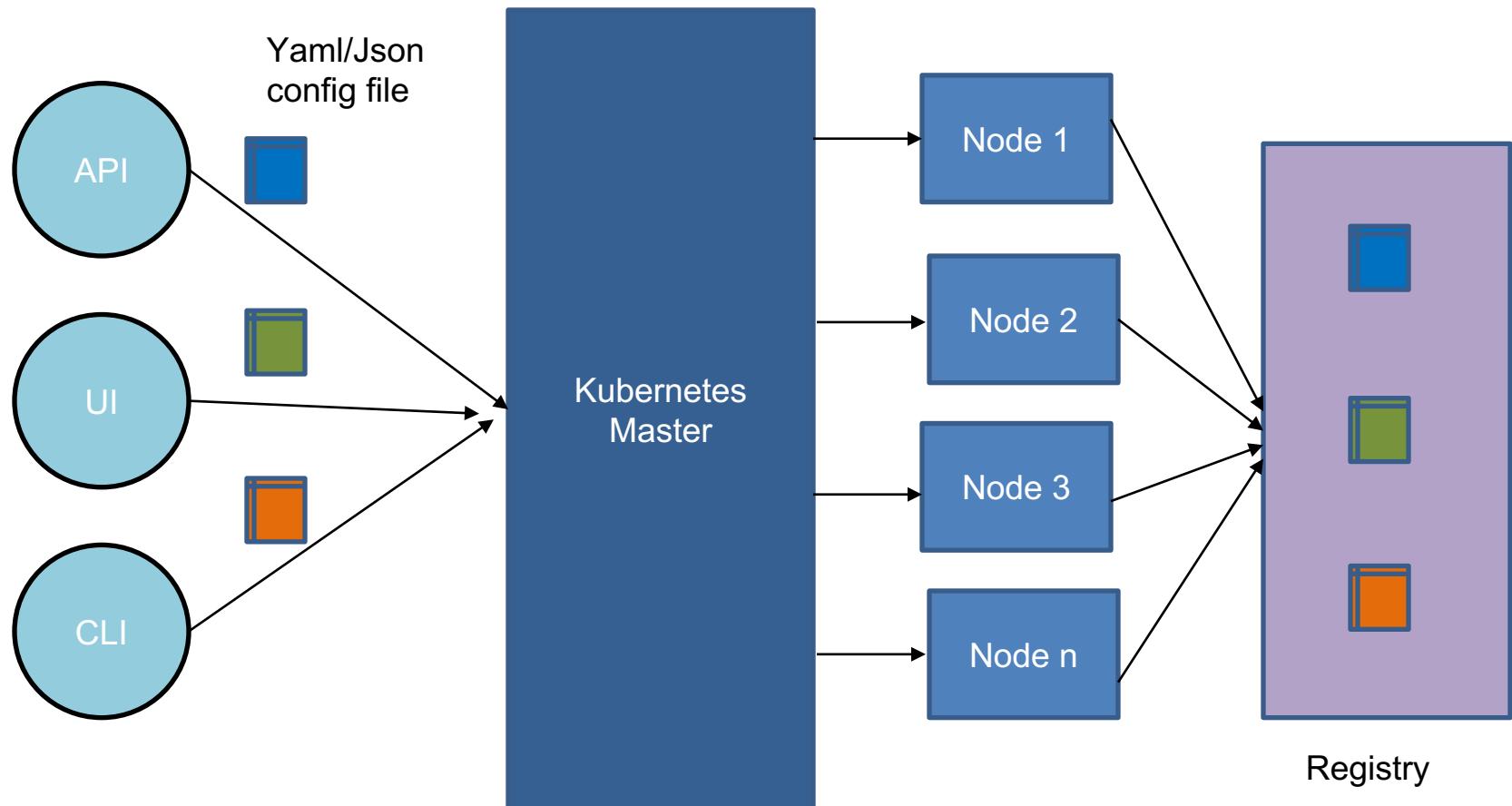


# What is Kubernetes?

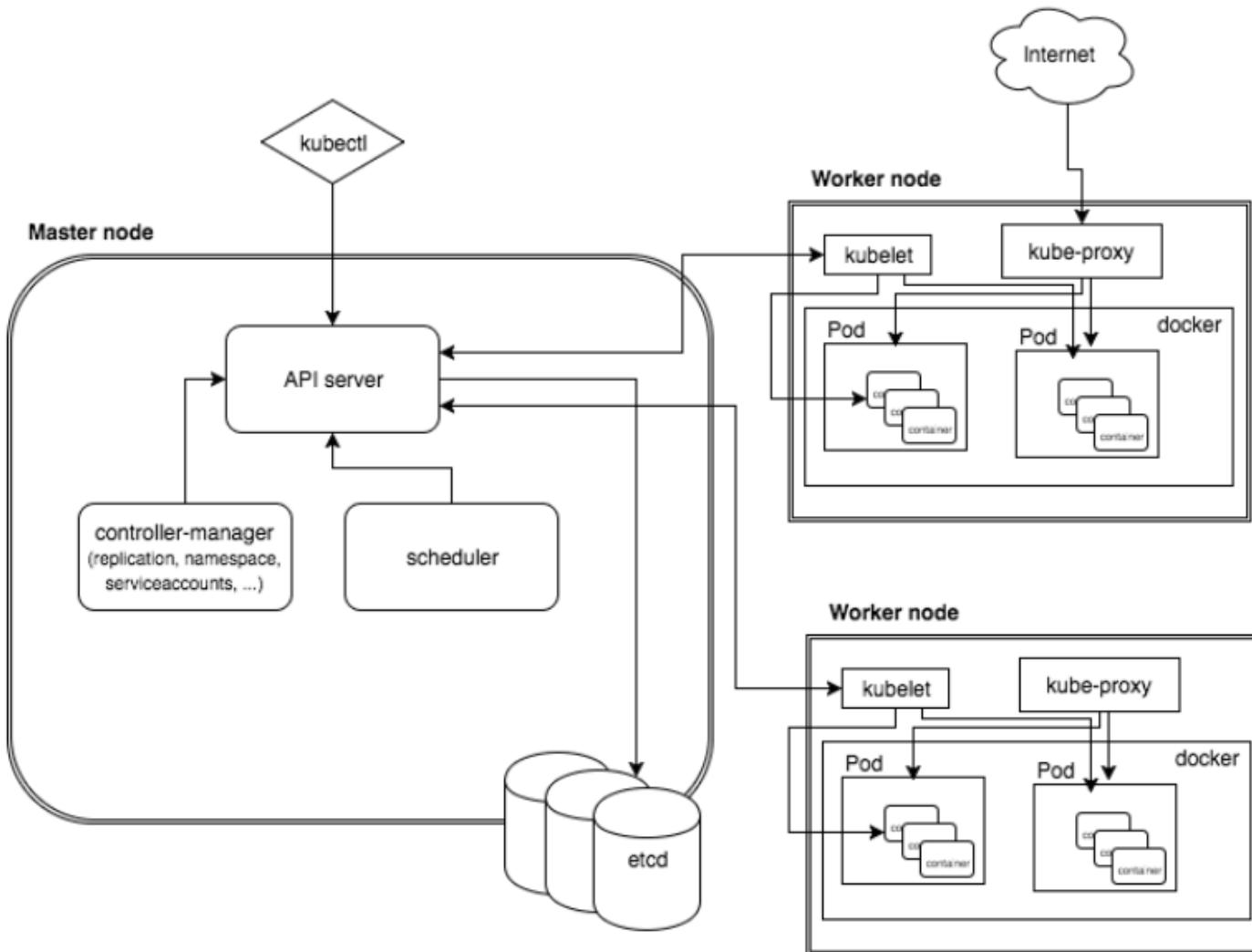
---

- Kubernetes is inspired from an internal Google project called Borg
- Open source project managed by the Linux Foundation
- Unified API for deploying web applications, batch jobs, and databases
- Decouples applications from machines through containers
- Declarative approach to deploying applications
- Automates application configuration through service discovery
- Maintains and tracks the global view of the cluster
- APIs for deployment workflows
  - Rolling updates, canary deploys, and blue-green deployments

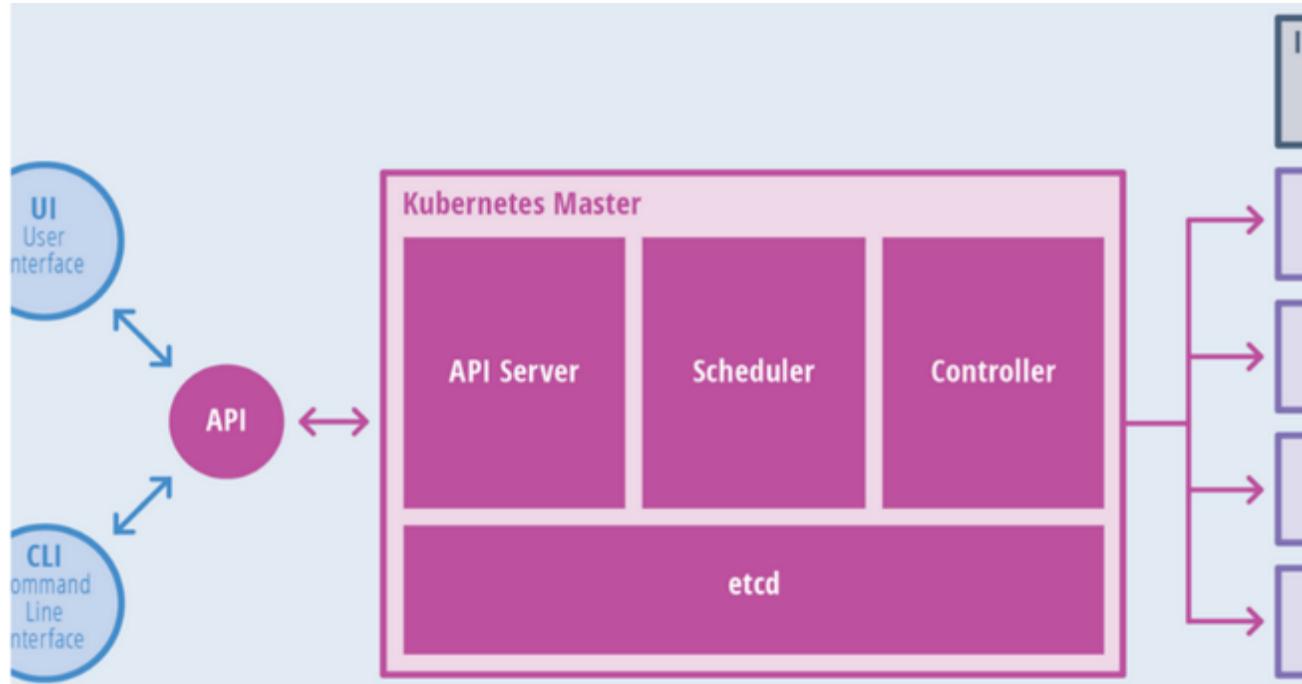
# Kubernetes Architecture



# K8s Architecture - detailed



# Kubernetes Master



Components of master:

- API Server
- Scheduler
- Controller
- etcd

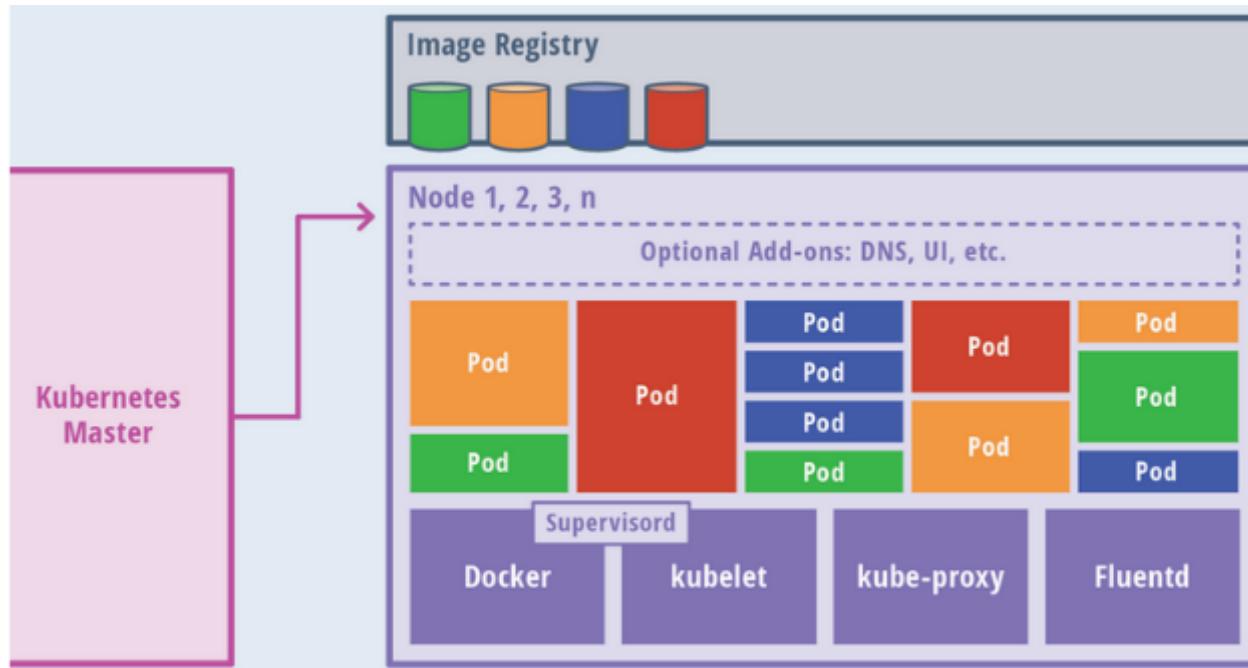
# Kubernetes Master

- The **API server** is the entry points for all the REST commands used to control the cluster. It processes REST requests, validates them, and executes the bound business logic. The result state has to be persisted in the “etcd” component.
- **Etcd** is an open source, distributed key-value database; it acts as a single source of truth (SSOT) for all components of the Kubernetes cluster. Masters query etcd to retrieve various parameters of the state of the nodes, pods and containers. Etcd is considered a metadata service in Kubernetes.

# Kubernetes Master

- **Controller Manager** is responsible for most of the collectors that regulate the state of the cluster. In general, a controller can be considered a daemon that runs in nonterminating loop and is responsible for collecting and sending information to the API server. It works toward getting the shared state of cluster and then making changes to bring the current status of the server to the desired state. The key controllers are **replication controller**, **endpoint controller**, **namespace controller**, and **service account controller**. The controller manager runs different kind of controllers to handle nodes, endpoints, etc.
- **Scheduler** is one of the key components of Kubernetes master. It is responsible for distributing the workload, tracking resource utilization on cluster nodes and selecting the nodes for the workloads to run. In other words, this is the mechanism responsible for allocating pods to available nodes.

# Kubernetes Nodes



Components of a node:

- kubelet
- Kube-proxy
- Docker
- Fluentd

# Kubernetes Node - Kubelet

- **Kubelet** Service on each node is responsible for relaying information to and from the control plane service. It interacts with etcd store to read configuration details and to write values **via api-server**. It communicates with the master component to receive commands and work. The kubelet process then assumes responsibility for maintaining the state of work and the node server. It manages network rules, port forwarding, etc.

# Kubernetes Node - KubeProxy

- Kubernetes **Proxy** Service is a proxy service which runs on each node and helps in making services available to the external host. It helps in forwarding the request to correct containers and is capable of performing primitive load balancing. It makes sure that the networking environment is predictable and accessible and at the same time it is isolated as well. It manages pods on node, volumes, secrets, creating new containers' health checkup, etc.

# Kubernetes Installed in AWS

Kubernetes installed in the machine (Just 1 master and is configured to use master to deploy pods)

**52.91.63.45**

```
kubectl get nodes --all-namespaces -o wide
```

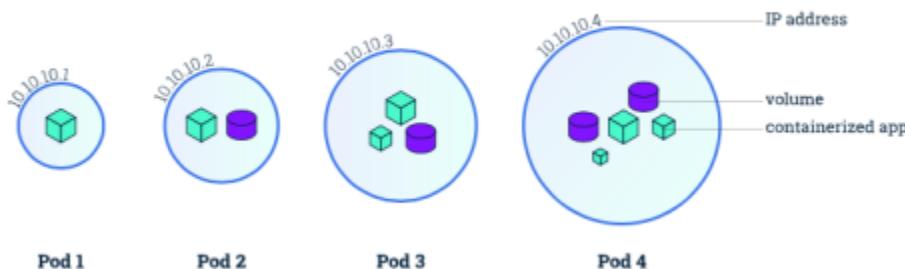
```
kubectl get services --all-namespaces -o wide
```

```
kubectl get pods --all-namespaces -o wide
```

```
kubectl get deployment --all-namespaces -o wide
```

# Kubernetes: Pods

- The smallest unit that can be scheduled to be deployed through K8s is called a *pod*.
- Homogeneous group of containers.
- This group of containers would share storage, Linux namespaces, cgroups, IP addresses. These are co-located, hence share resources and are always scheduled together.
- Pods are not intended to live long. They are created, destroyed and re-created on demand, based on the state of the server and the service itself.



- Containers in a pod share
  - IP address and port space
  - Filesystem
  - Storage (Volumes)
  - Labels
  - Secrets

## pod.yml

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-apparmor
  labels:
    app: nginx
spec:
  containers:
  - name: nginx
    image: nginx
    ports:
    - containerPort: 80
```

```
[root@ip-172-31-68-96:~/code# kubectl create -f pod.yml
pod/nginx-apparmor created
[root@ip-172-31-68-96:~/code# kubectl get pods
NAME           READY   STATUS    RESTARTS   AGE
nginx-apparmor  1/1     Running   0          4s
root@ip-172-31-68-96:~/code# ]
```

**Note:** This is just creation of the pod. In order to expose it, a service must be created. In order for it to be respawned, a deployment or replication control must be created.

# Kubernetes: Deployment

---

**Abstraction that use Replication controller (Controller manager of kubernetes master) to manage replica-sets of pods**

- If object {pod} is used, and it dies, it will not start again
- If object {deployment} is used to start pods, if the pod dies, deployment use replica-set to start the pods again to make sure desired number of pods are always alive
- Try deleting a pod (deployed using deployment) and check if it comes back?

## dep.yml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.7.9
        ports:
        - containerPort: 80
```

```
[root@ip-172-31-68-96:~/code# kubectl create -f dep.yml
deployment.apps/nginx-deployment created
[root@ip-172-31-68-96:~/code# kubectl get pods,deployments
NAME                                         READY   STATUS    RESTARTS   AGE
pod/nginx-apparmor                           1/1     Running   0          52s
pod/nginx-deployment-67594d6bf6-7jc78       1/1     Running   0          11s
pod/nginx-deployment-67594d6bf6-tf5df        1/1     Running   0          11s
pod/nginx-deployment-67594d6bf6-xzwww        1/1     Running   0          11s

NAME                                         DESIRED  CURRENT  UP-TO-DATE  AVAILABLE  AGE
deployment.extensions/nginx-deployment       3         3         3           3          11s
root@ip-172-31-68-96:~/code# ]
```

# Kubernetes: Services

---

**Abstraction regarding a set of pods which enables load balancing, traffic exposure, load balancing and service discovery.**

- Abstraction that allows pods to die and replicate in Kubernetes without affecting your application.
- Enable loose coupling between different Pods.
- Provides a stable virtual IP and port
- Services allow Pods to receive traffic.
  - Each Pod has a unique IP but those IP addresses are not exposed outside the Pod without a service.

# Kubernetes: Types of Services

---

- **Cluster IP**:- Expose the service on a cluster-internal IP. Using this makes the service only reachable from within the cluster.
- **NodePort** :- Expose the service on each Node's IP at a static port. You will be able to contact the NodePort Service, from outside the cluster by <NodeIP>:<NodePort>
- **LoadBalancer** :- Expose the service externally using load balancer

```
root@ip-172-31-68-96:~# kubectl get svc
NAME          TYPE      CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
kubernetes   ClusterIP  10.96.0.1    <none>        443/TCP   37m
root@ip-172-31-68-96:~#
root@ip-172-31-68-96:~# kubectl expose deployment nginx-deployment --type=LoadBalancer --name=nginx-service
service/nginx-service exposed
root@ip-172-31-68-96:~#
root@ip-172-31-68-96:~# kubectl get svc
NAME          TYPE      CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
kubernetes   ClusterIP  10.96.0.1    <none>        443/TCP   37m
nginx-service LoadBalancer  10.102.89.83  <pending>    80:31095/TCP  3s
root@ip-172-31-68-96:~#
```

```
[root@ip-172-31-0-112:~/code# cat userservice.yml
apiVersion: v1
kind: Service
metadata:
  name: userservice
spec:
  type: NodePort
  ports:
  - name: "user-service"
    port: 8080
    targetPort: 8080
    nodePort: 31001
  selector:
    app: userservice
```

# Using mount host path

[https://github.com/shekhar2010us/microservices\\_kubernetes\\_docker/blob/master/k8s\\_yaml/5apicomposerservice-deployment.yml](https://github.com/shekhar2010us/microservices_kubernetes_docker/blob/master/k8s_yaml/5apicomposerservice-deployment.yml)

# Kubernetes: Persistent Volumes

---

- PV: Storage in the cluster that has been provisioned by an administrator (static or dynamic) and is independent of any individual pod that uses the PV.

**Following volumes are supported by Kubernetes:**

GCEPersistentDisk ; AWSElasticBlockStore

AzureFile ; AzureDisk

FC (Fibre Channel) ; FlexVolume

Flocker ; NFS

iSCSI ; RBD (Ceph Block Device)

CephFS ; Cinder (OpenStack block storage)

Glusterfs ; VsphereVolume

Portworx Volumes ; ScaleIO Volumes

StorageOS

# Kubernetes: Persistent Volumes

---

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv0003
spec:
  capacity:
    storage: 5Gi
  volumeMode: Filesystem
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Recycle
  storageClassName: slow
  mountOptions:
    - hard
    - nfsvers=4.1
nfs:
  path: /tmp
  server: 172.17.0.2
```

# Kubernetes: Persistent Volume Claims

---

- PVC: Request for a storage by a user, it is similar to pod and it can request specific size and access modes (e.g., can be mounted once read/write or many times read-only).

[https://github.com/shekhar2010us/microservices\\_kubernetes\\_docker/blob/master/k8s\\_yml/userservice-pc.yml](https://github.com/shekhar2010us/microservices_kubernetes_docker/blob/master/k8s_yml/userservice-pc.yml)

[https://github.com/shekhar2010us/microservices\\_kubernetes\\_docker/blob/master/k8s\\_yml/3userservice-deployment.yml](https://github.com/shekhar2010us/microservices_kubernetes_docker/blob/master/k8s_yml/3userservice-deployment.yml)

# CronJob Example

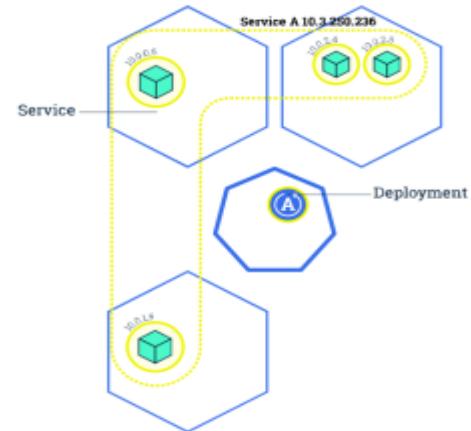
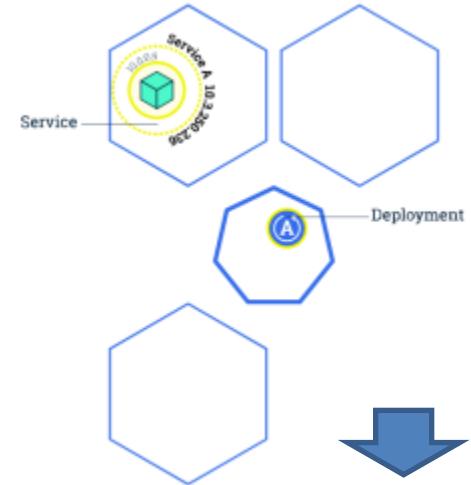
---

```
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: hello
spec:
  schedule: "*/1 * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
            - name: hello
              image: busybox
              args:
                - /bin/sh
                - -c
                - date; echo Hello from the Kubernetes cluster
  restartPolicy: OnFailure
```

# Kubernetes: Scaling

## Changing the number of resources to meet a desired state

- Accomplished by adjusting the number of replicas in a deployment
- Accommodates both scaling up and scaling down to a minimum of 0
- Traffic is automatically sent to newly created instances through the service load balancer
- Can be used to enable rolling updates without downtime

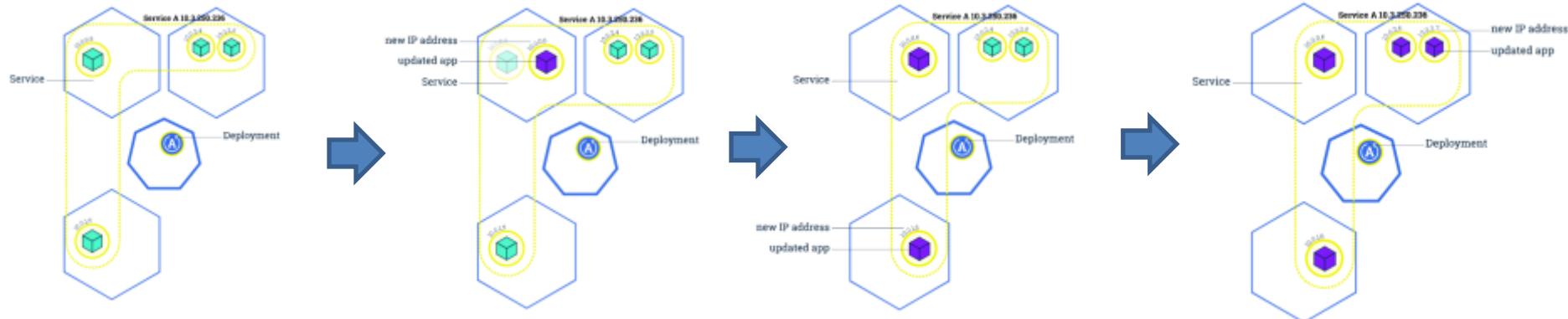


```
root@ip-172-31-0-112:~/code# kubectl run nginx --image nginx --port 80
deployment.apps/nginx created
root@ip-172-31-0-112:~/code#
root@ip-172-31-0-112:~/code# kubectl get deployments
NAME          DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx         1          1          1           1           8s
nginx-deployment 3          3          3           3           17m
redis         1          1          1           1           33m
root@ip-172-31-0-112:~/code#
root@ip-172-31-0-112:~/code# kubectl scale deployments/nginx --replicas=3
deployment.extensions/nginx scaled
[root@ip-172-31-0-112:~/code# kubectl get deployments
NAME          DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx         3          3          3           3           34s
nginx-deployment 3          3          3           3           18m
redis         1          1          1           1           33m
[root@ip-172-31-0-112:~/code# kubectl get pods
NAME                               READY   STATUS    RESTARTS   AGE
nginx-6f858d4d45-b4cv2            1/1     Running   0          42s
nginx-6f858d4d45-g42mg            1/1     Running   0          16s
nginx-6f858d4d45-169jv            1/1     Running   0          16s
nginx-apparmor                     1/1     Running   0          30m
nginx-deployment-67594d6bf6-7v5lk  1/1     Running   0          12m
nginx-deployment-67594d6bf6-fdqx2  1/1     Running   0          18m
nginx-deployment-67594d6bf6-sx62p  1/1     Running   0          18m
redis-7869f8966-sq8xm             1/1     Running   0          33m
```

# Kubernetes: Rolling Update

**Updates the pods in a serial manner will load balancing traffic to available instances**

- If deployment is exposed publicly, the service will load-balance traffic to only active and available pods
- Used to enable zero downtime updates
- Allows greater application update frequency
- Can also be leveraged to rollback to previous versions



```
[root@ip-172-31-0-112:~/code# kubectl run nginx --image nginx:1.12.1 --port 80
deployment.apps/nginx created
[root@ip-172-31-0-112:~/code# kubectl set image deployments/nginx nginx=nginx:latest
deployment.extensions/nginx image updated
[root@ip-172-31-0-112:~/code# kubectl describe deployment nginx
Name:                   nginx
Namespace:              default
CreationTimestamp:      Thu, 19 Jul 2018 04:00:55 +0000
Labels:                 run=nginx
Annotations:            deployment.kubernetes.io/revision=2
Selector:               run=nginx
Replicas:               1 desired | 1 updated | 1 total | 1 available | 0 unavailable
StrategyType:           RollingUpdate
MinReadySeconds:        0
RollingUpdateStrategy:  25% max unavailable, 25% max surge
Pod Template:
  Labels:  run=nginx
  Containers:
    nginx:
      Image:      nginx:latest
      Port:       80/TCP
      Host Port:  0/TCP
      Environment: <none>
      Mounts:     <none>
      Volumes:    <none>
  Conditions:
    Type        Status  Reason
    ----        ----   -----
    Available   True    MinimumReplicasAvailable
    Progressing True    NewReplicaSetAvailable
  OldReplicaSets: <none>
  NewReplicaSet:  nginx-6c486b77db (1/1 replicas created)
Events:
  Type      Reason          Age   From                  Message
  ----      ----          ----  ----                  -----
  Normal    ScalingReplicaSet 43s   deployment-controller  Scaled up replica set nginx-7f9bc86464 to 1
  Normal    ScalingReplicaSet 11s   deployment-controller  Scaled up replica set nginx-6c486b77db to 1
  Normal    ScalingReplicaSet 10s   deployment-controller  Scaled down replica set nginx-7f9bc86464 to 0
```

```

root@ip-172-31-0-112:~/code# kubectl rollout undo deployments/nginx
deployment.extensions/nginx
root@ip-172-31-0-112:~/code# kubectl describe deployments/nginx
Name:           nginx
Namespace:      default
CreationTimestamp: Thu, 19 Jul 2018 04:00:55 +0000
Labels:          run=nginx
Annotations:    deployment.kubernetes.io/revision=3
Selector:        run=nginx
Replicas:       1 desired | 1 updated | 1 total | 1 available | 0 unavailable
StrategyType:   RollingUpdate
MinReadySeconds: 0
RollingUpdateStrategy: 25% max unavailable, 25% max surge
Pod Template:
  Labels:  run=nginx
  Containers:
    nginx:
      Image:      nginx:1.12.1
      Port:       80/TCP
      Host Port:  0/TCP
      Environment: <none>
      Mounts:     <none>
      Volumes:    <none>
  Conditions:
    Type        Status  Reason
    ----        ----   -----
    Available   True    MinimumReplicasAvailable
    Progressing True    NewReplicaSetAvailable
    OldReplicaSets: <none>
    NewReplicaSet:  nginx-7f9bc86464 (1/1 replicas created)
  Events:
    Type        Reason            Age            From                  Message
    ----        -----            --            ----                  -----
    Normal     ScalingReplicaSet  1m             deployment-controller  Scaled up replica set nginx-6c486b77db to 1
    Normal     ScalingReplicaSet  1m             deployment-controller  Scaled down replica set nginx-7f9bc86464 to 0
    Normal     ScalingReplicaSet  18s (x2 over 2m) deployment-controller  Scaled up replica set nginx-7f9bc86464 to 1
    Normal     DeploymentRollback 18s            deployment-controller  Rolled back deployment "nginx" to revision 1
    Normal     ScalingReplicaSet  17s            deployment-controller  Scaled down replica set nginx-6c486b77db to 0

```

**Note:** Rollbacks can also be enacted with zero-downtime

kubectl rollout status deployment nginx

kubectl rollout history deployment nginx

kubectl rollout history deployment/nginx --revision=3

kubectl rollout undo deployment/nginx --to-revision <num>

# Java Example

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- Install Kubernetes on bare metal

[https://github.com/shekhar2010us/microservices\\_kubernetes\\_docker  
/blob/master/kubernetes\\_aspe.docx](https://github.com/shekhar2010us/microservices_kubernetes_docker/blob/master/kubernetes_aspe.docx)

- Java application – Monolithic with Docker

[https://github.com/shekhar2010us/microservices\\_monolithic\\_docker](https://github.com/shekhar2010us/microservices_monolithic_docker)

- Java application – Microservices with Kubernetes

[https://github.com/shekhar2010us/microservices\\_kubernetes\\_docker](https://github.com/shekhar2010us/microservices_kubernetes_docker)

# **eval( this.class );**

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# **THANK YOU !!!**