Containers, Cloud Native Computing, DevOps

Oxford University
Software Engineering
Programme
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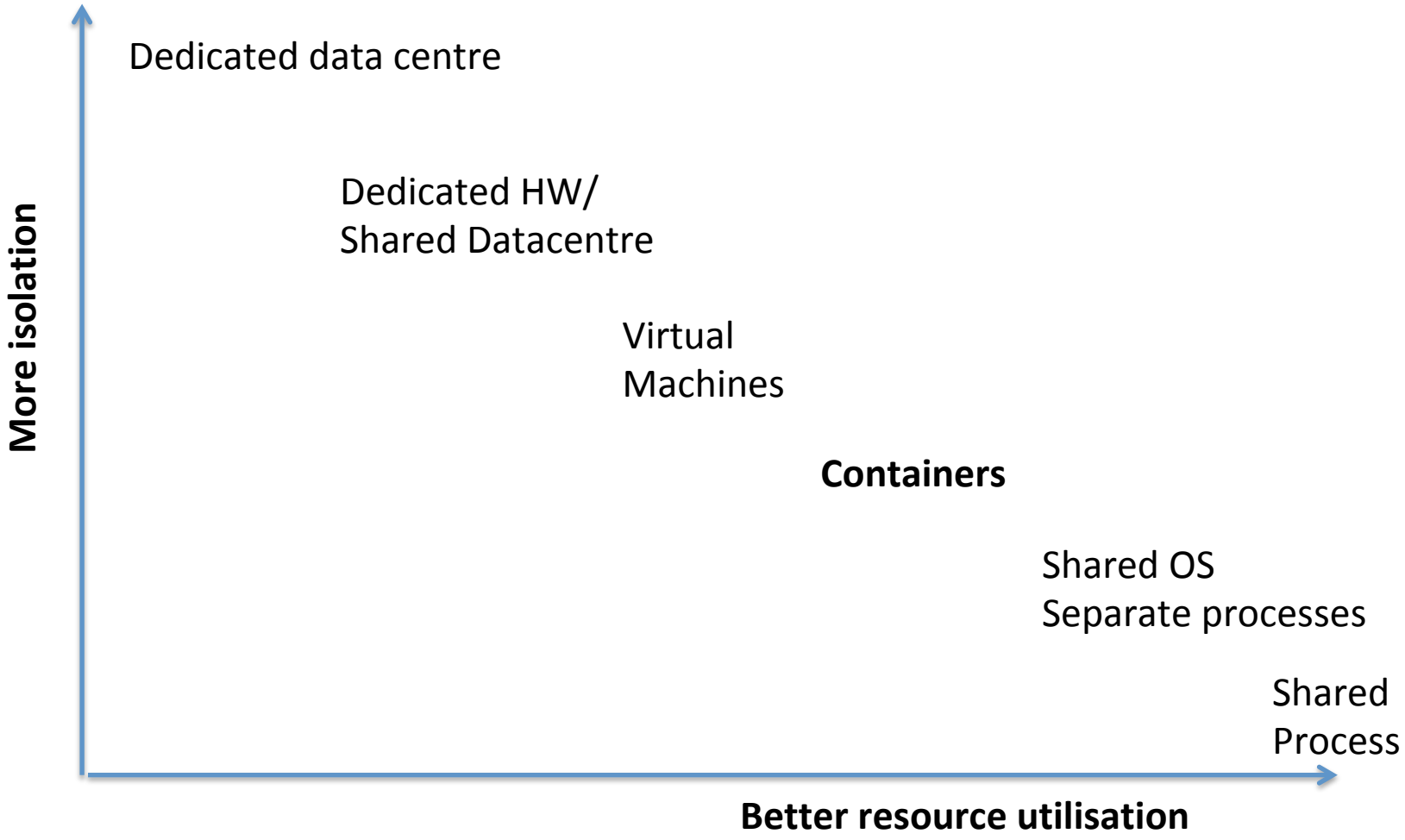
Contents

- Containers
- History and Approach
- Docker
- Docker ecosystem
- PaaS in a container model
- Futures

Sharing of resources vs Isolation



Lightweight Virtualization history

- zSystems Virtual Servers from late 1990s
  - (the mainframe really did do everything first)
- Solaris Containers
- AIX Workload Partitions
- FreeBSD Jail
- …

What is a Container?

- A lightweight virtual server
  - Running within an Operating System
  - Providing various levels of isolation and control
  - E.g. Disk isolation and control
  - Network isolation
  - CPU and memory controls

Containers at Google

- Every GMail session is a container
  - Try doing an export and then searching your email ☺
- "Everything runs in a container"
- **2 billion** containers launched a week
- Borg
  - **Any** Google developer can instantiate their code in **10,000 instances** any time they want
  - Takes about 5 minutes to start that many
  - Never exactly 10,000 because of failures

Cloud Native Computing Foundation

- A new definition of “Cloud Native”
  - Container Packaged
  - Dynamically Managed
  - Micro-Service oriented

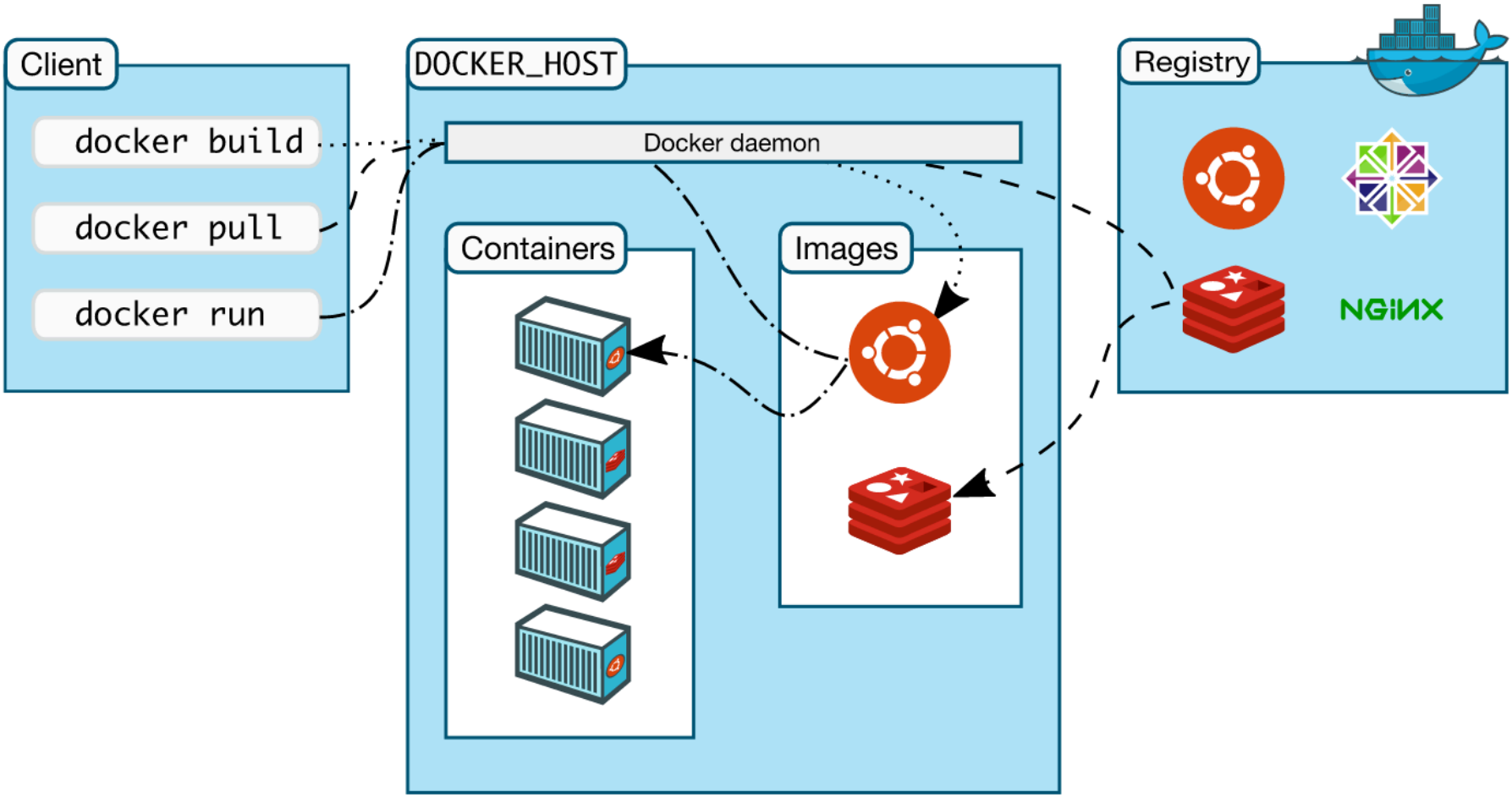
Docker on top of Containers

- Docker adds several things to LXC and containerization:
  - Copy on write filesystem
    - Layered images and the ability to extend machines easily
  - Simple textual config file
  - Portable deployment across machines
    - Creating an ecosystem of images
  - Application centric
    - Each VM is a process (roughly speaking)
  - Plus others (auto-build, etc)

Why Docker?

- The *ecosystem* has created a *network effect*
- Metcalfe's Law states
  - the value of a telecommunications network is proportional to the square of the number of connected users of the system
- There is surely a corollary for ecosystems

How does Docker work?



Dockerfile

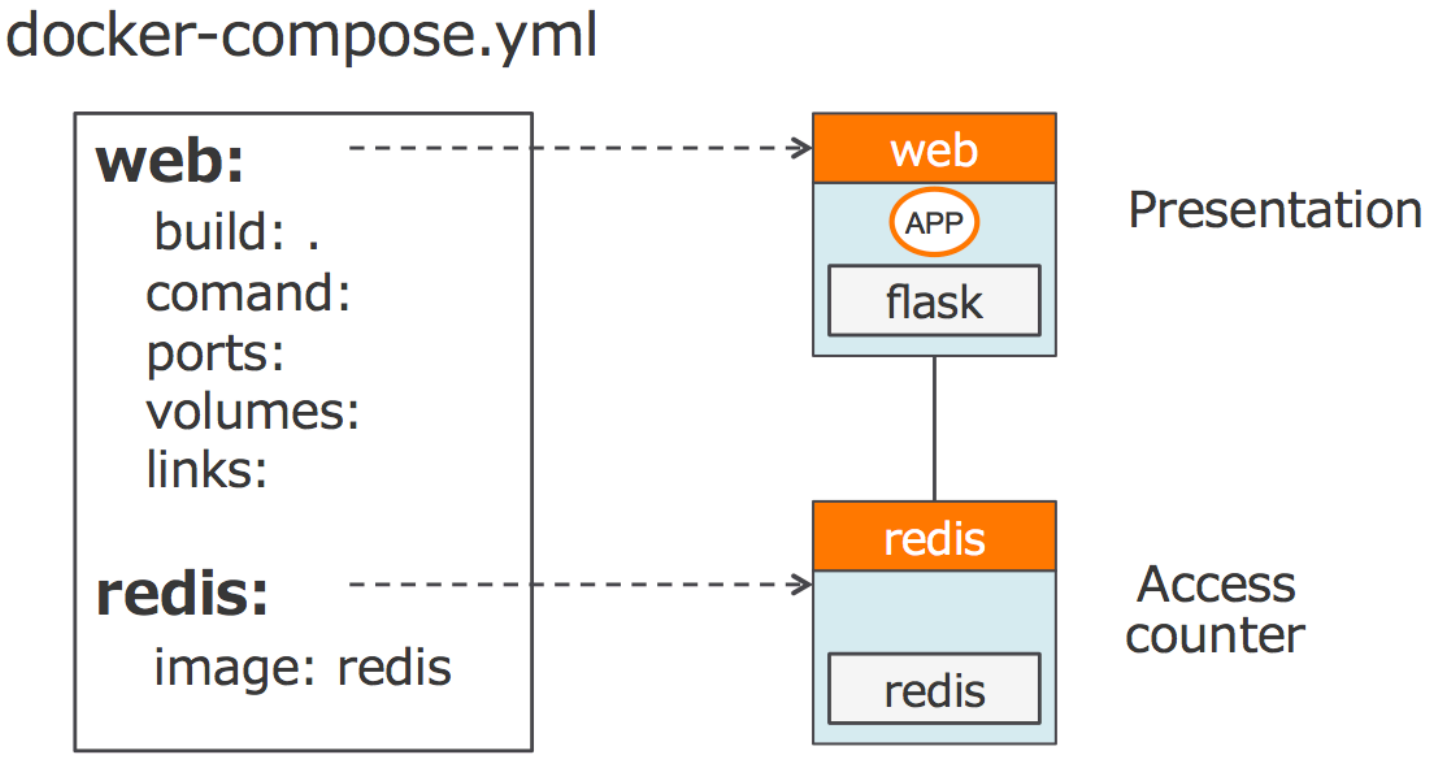
```
FROM alpine
RUN apk --update add python py-pip && \
    pip install --upgrade pip && \
    mkdir -p /home/root/python && \
    pip install kafka && \
    pip install httplib2

COPY tflrepub.py /home/root/python/

WORKDIR /home/root/python/

ENTRYPOINT python tflrepub.py
```

Some simple Docker commands

- apt-get install docker.io
- docker pull ubuntu
- docker run –t –i ubuntu /bin/bash
- docker ps
- docker commit funky_freo image
- docker push image

Docker Compose

- How to create a set of containers that work together



docker-compose.yml

```
version: '2'

services:
  zookeeper:
      build:
        context: .
        dockerfile: Dockerfile-zookeeper
      ports:
          - "2181:2181"
  kafka:
      build:
          context: .
          dockerfile: Dockerfile-kafka
      ports:
          - "9092:9092"
      networks:
          default:
              aliases:
                  - kafka.freo.me
      depends_on:
          - zookeeper
```

Docker Machine

- Manages docker servers
  - e.g. VirtualBox, Amazon, DigitalOcean
  - Let's you start/stop and configure Docker to talk to the remote server

Quick demo

Cloud Orchestration

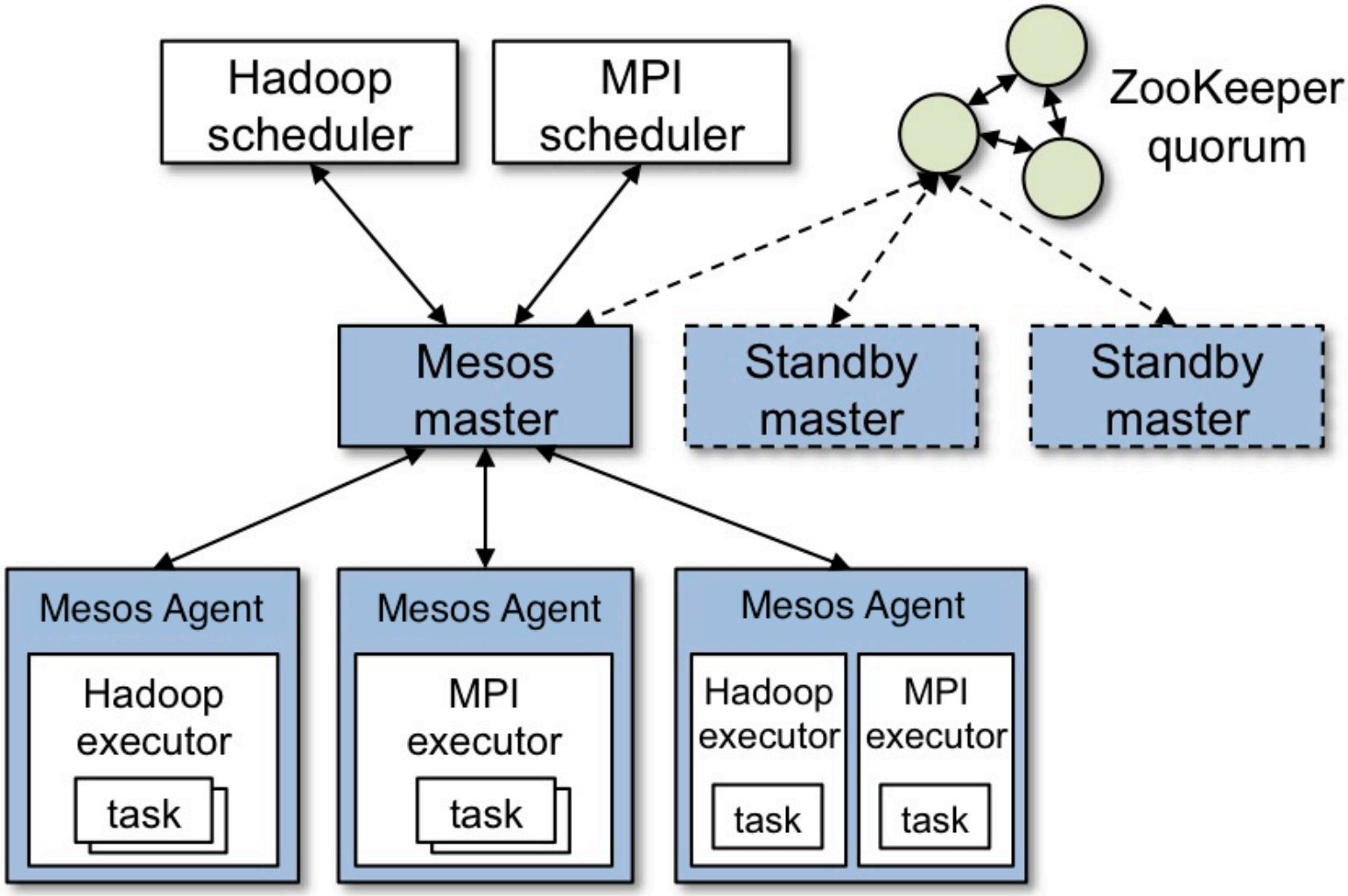
- What does an Operating System do?
  - Manages processes
  - Co-ordinates the processes access to resources
    - CPUs
    - Memory
    - Disk
    - Devices
  - Fairness and priority between processes

Datacenter Operating System

aka Container Orchestration

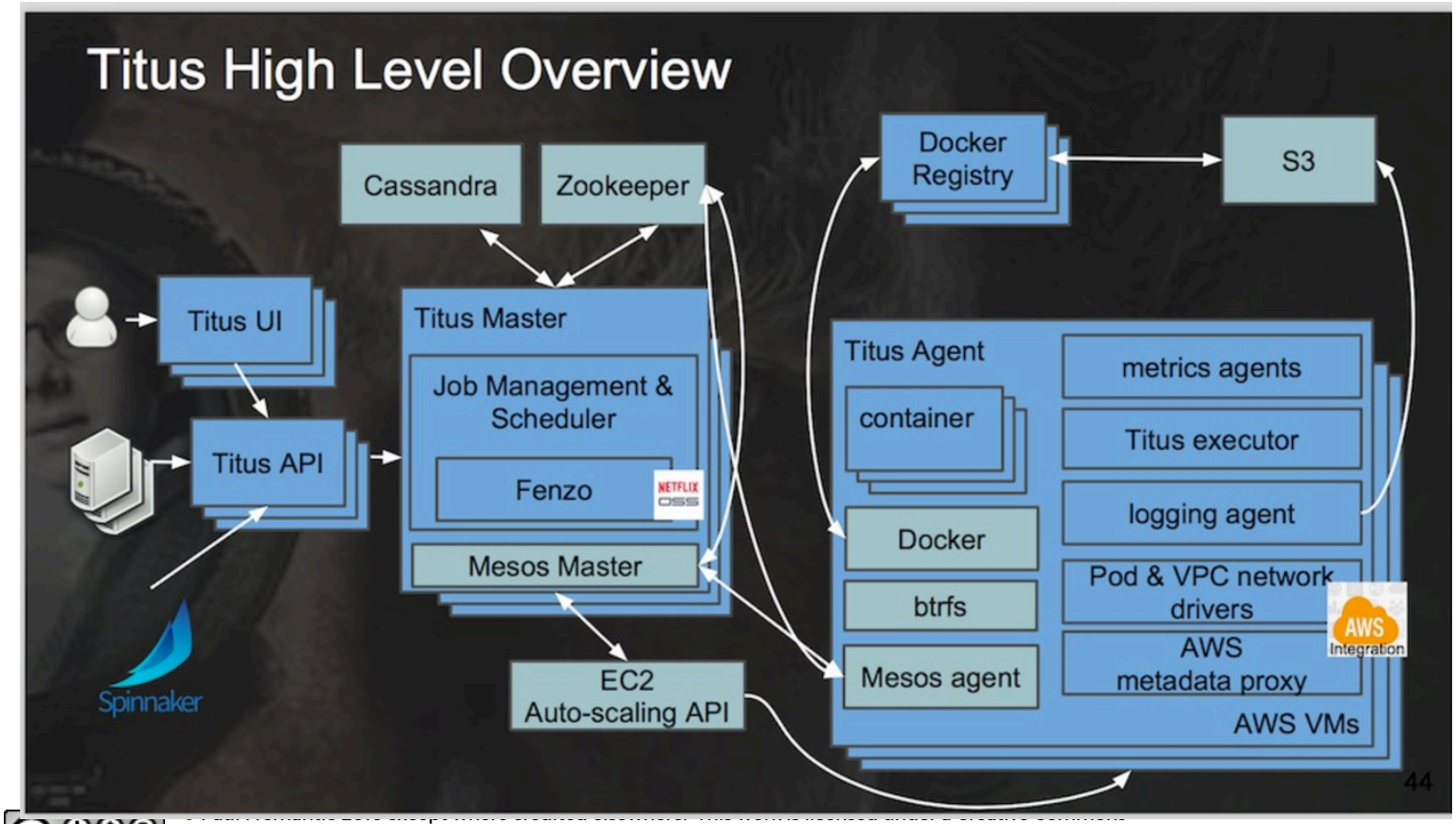
- Manages the placement of containers
  - Access to resources
  - Configuration and networking
  - Moves containers
  - Load balances across containers
- Effectively creating a single OS across a cloud
  - Containers vs Processes

Apache Mesos



Netflix Titus

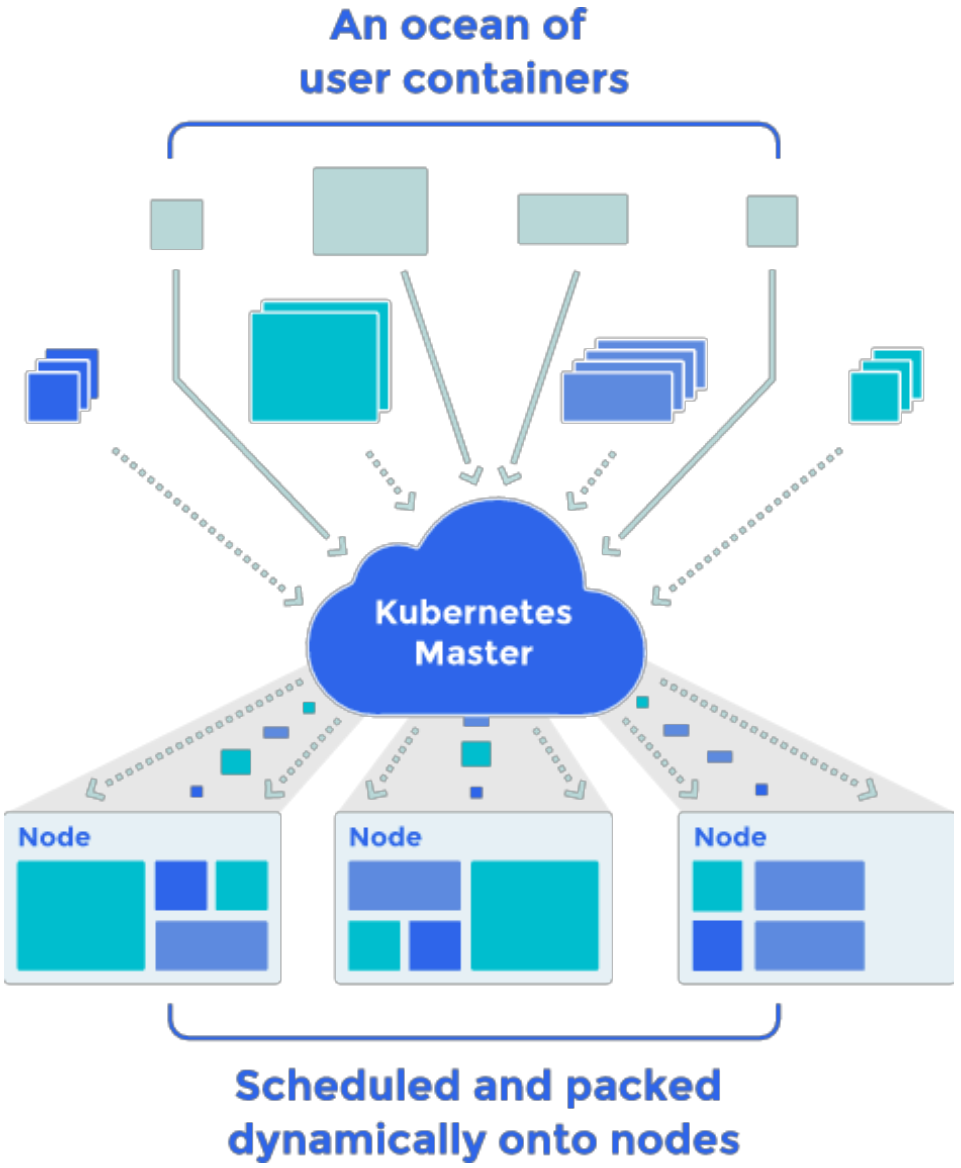
Running on 5000 AWS instances (m4.4xlarge and r3.8xlarge)
Three regions
10,000 containers running at any time
1,000,000 containers launched



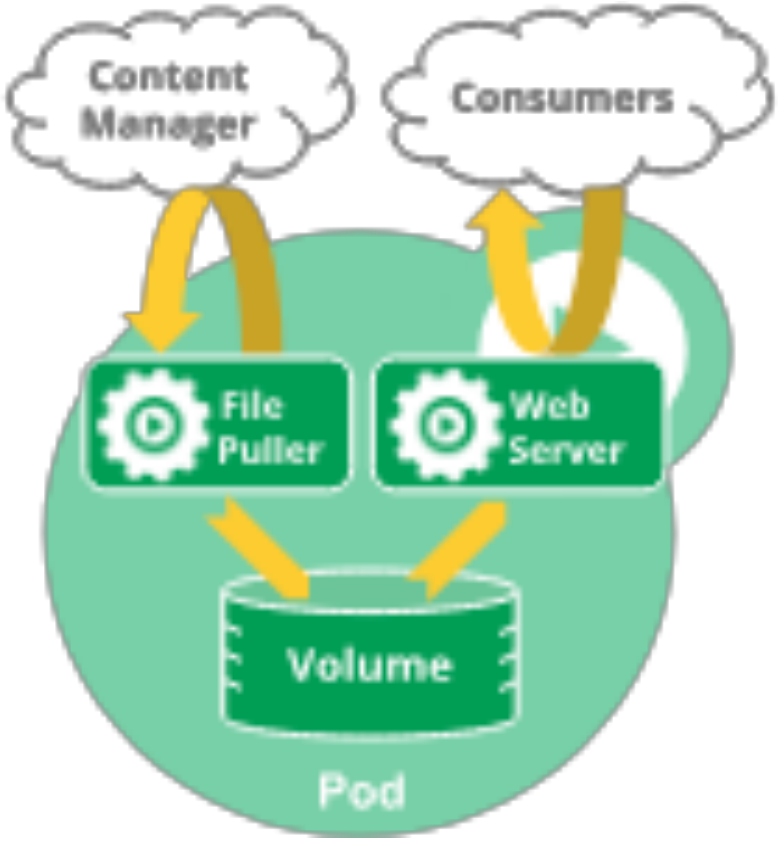
https://www.infoq.com/news/2017/07/netflix-titus

Kubernetes

- Open Source cluster management of containers
- From Google, but separate from the Borg project



Pods



A Pod encapsulates an application container (or, in some cases, multiple containers), storage resources, a unique network IP, and options that govern how the container(s) should run.

A Pod represents a unit of deployment: a single instance of an application in Kubernetes, which might consist of either a single container or a small number of containers that are tightly coupled and that share resources.

Services

- An abstract exposure of pods
- Pods die and are recreated, replicated

"A Kubernetes Service is an abstraction which defines a logical set of Pods and a policy by which to access them"

Volumes

- A persistent virtual disk that belongs to a Pod
- Shares data between containers
- Lives longer than a container, but no longer than the pod

Namespaces

- A virtual cluster
- Names must be unique inside namespaces, can be the same across different namespaces

Kubernetes Operations (kops)

build passing | go report A | godoc reference

The easiest way to get a production grade Kubernetes cluster up and running.

What is kops?

We like to think of it as `kubectl` for clusters.

`kops` helps you create, destroy, upgrade and maintain production-grade, highly available, Kubernetes clusters from the command line. AWS (Amazon Web Services) is currently officially supported, with GCE and VMware vSphere in alpha and other platforms planned.

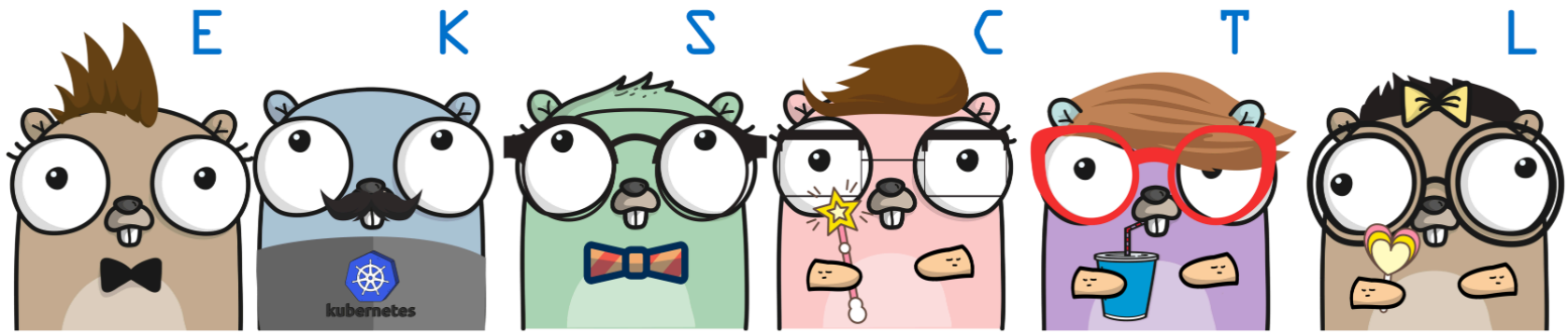
Can I see it in action?

```
  AutoscalingGroup/nodes.example.nivenly.com
        MinSize                 2
        MaxSize                 2
        Subnets                 [name:us-west-2a.example.nivenly.com]
        Tags                    {k8s.io/role/node: 1, Name: nodes.example.nivenly.com, KubernetesCluster: example.nivenly.com}
        LaunchConfiguration     name:nodes.example.nivenly.com


Cluster configuration has been created.

Suggestions:
 * list clusters with: kops get cluster
 * edit this cluster with: kops edit cluster example.nivenly.com
 * edit your node instance group: kops edit ig --name=example.nivenly.com nodes
 * edit your master instance group: kops edit ig --name=example.nivenly.com master-us-west-2a

Finally configure your cluster with: kops update cluster example.nivenly.com --yes

bash-3.2$ kops edit cluster $NAME
```

`eksctl` - a CLI for Amazon EKS

`eksctl` is a simple CLI tool for creating clusters on EKS - Amazon's new managed Kubernetes service for EC2. It is written in Go, and based on Amazon's official CloudFormation templates.

You can create a cluster in minutes with just one command – `eksctl create cluster`!



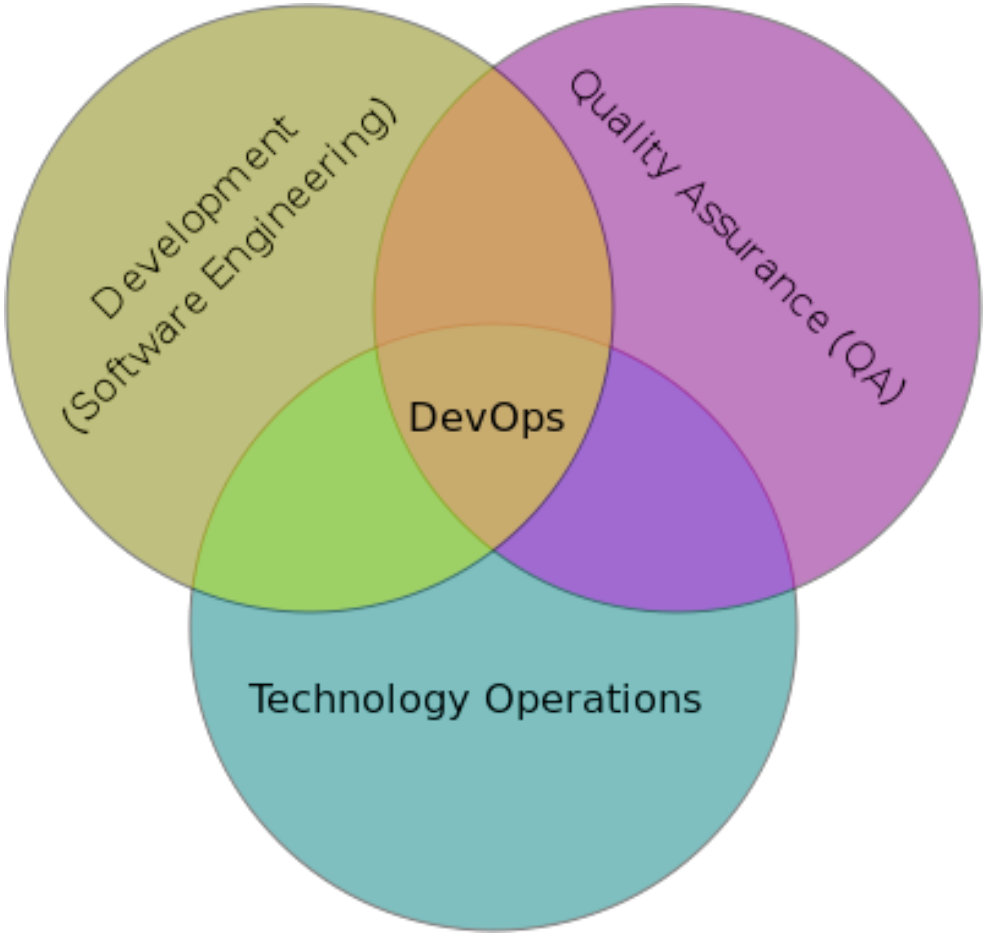
Usage

To download the latest release, run:

```
curl --silent --location "https://github.com/weaveworks/eksctl/releases/download/latest_release/eksctl_$(uname -s)_am
sudo mv /tmp/eksctl /usr/local/bin
```

Alternatively, macOS users can use Homebrew:

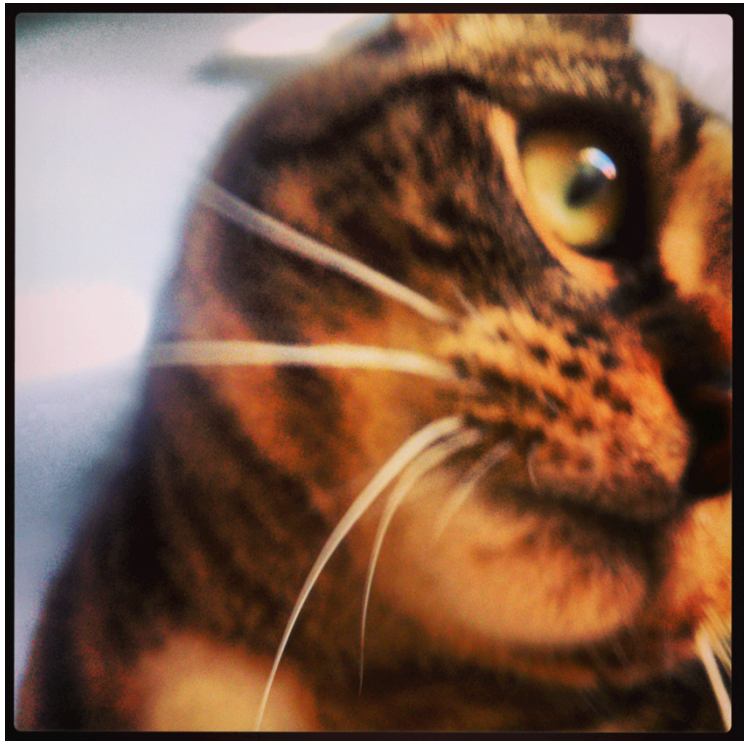
DevOps



DevOps

- DevOps is the codification of the interface between Development and Operations
  - Agile
  - Repeatable
  - Collaborative
  - Versioned
  - Automated

Kittens vs Cattle
(An unpleasant but effective analogy)

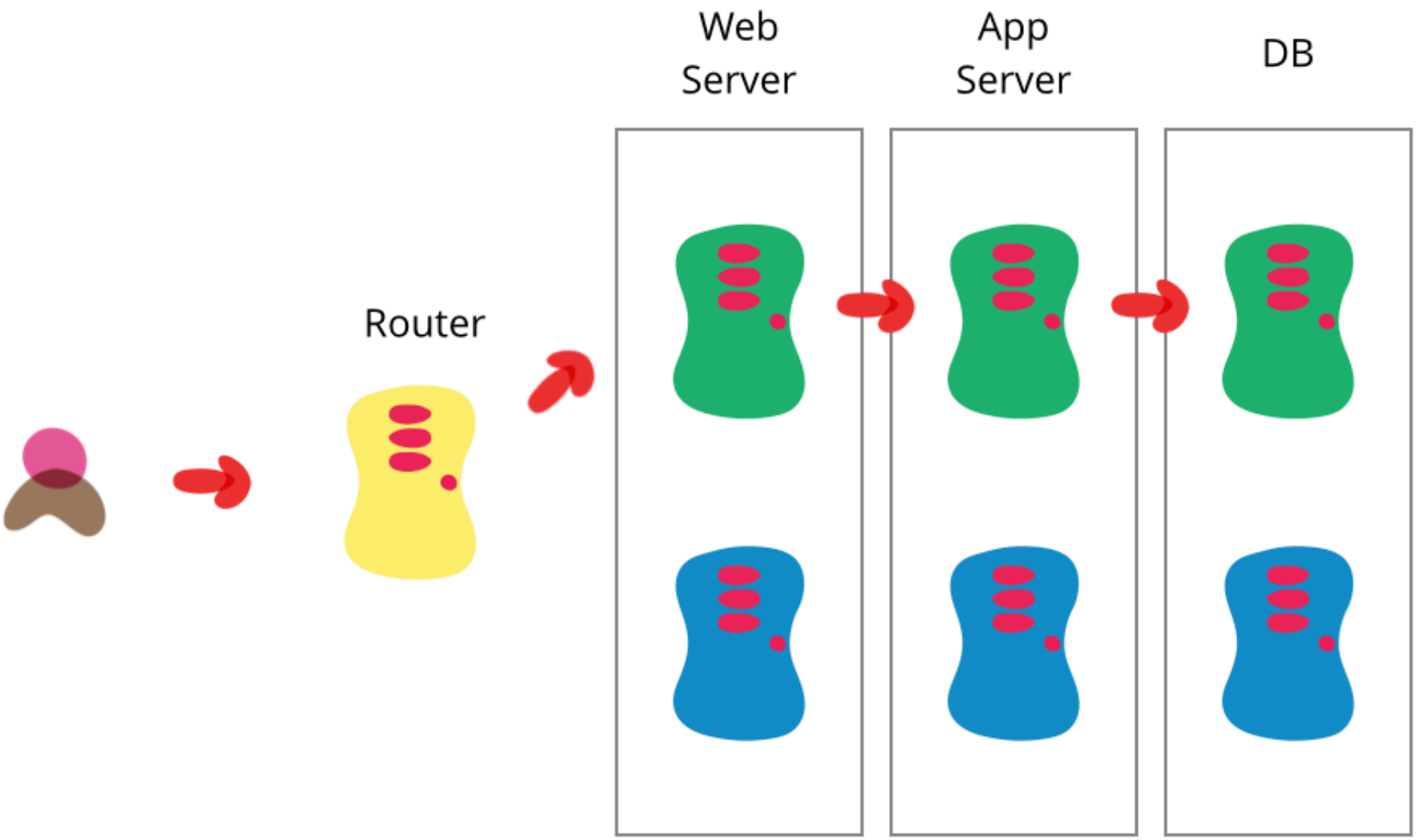


Immutable objects

- String in Java
- You can't change a String, only create a new one

- Applies to devops:
  - Never change a running server
  - Only create a new one that is better
  - Track the changes in a version control model

Blue Green Deployment



http://martinfowler.com/bliki/BlueGreenDeployment.html

DevOps tools

- Puppet, Chef
  - Automated configuration and deployment tools
  - Allow complex infrastructures to be re-configured automatically
- Vagrant
  - Create VMs instantly
- Plus many many more!

DevOps and Docker

- Docker is a key DevOps tool
- Speeds up the creation of repeatable deployments
- Consistency between development, test and production
- Versioned repository
- Works with Chef, Puppet, etc

What can be described and observed, can be automated and operated

https://www.weave.works/blog/gitops-git-push-all-the-things

GitOps

- Infrastructure as Code
- Terraform + Deployment + Containers + Build
- Everything is in Git
  - Any change to the infrastructure is a Pull Request

Summary

- Docker and the Container model
  - Lightweight virtualization and repeatability
  - Blue Green deployment
  - “Warehouse Scale” computing

The Twelve-Factor App

Introduction

In the modern era, software is commonly delivered as a service: called *web apps*, or *software-as-a-service*. The twelve-factor app is a methodology for building software-as-a-service apps that:

- Use **declarative** formats for setup automation, to minimize time and cost for new developers joining the project;
- Have a **clean contract** with the underlying operating system, offering **maximum portability** between execution environments;
- Are suitable for **deployment** on modern **cloud platforms**, obviating the need for servers and systems administration;
- **Minimize divergence** between development and production, enabling **continuous deployment** for maximum agility;
- And can **scale up** without significant changes to tooling, architecture, or development practices.

The twelve-factor methodology can be applied to apps written in any programming language, and which use any combination of backing services (database, queue, memory cache, etc).

http://12factor.net

12 Factor Apps

- Codebase
  - One codebase in revision control, many deploys
- Dependencies
  - Explicity define and declare
- Config
  - Store config in the environment
- Backing Services
  - Treat as attached resources
- Build, Release, Run
  - Strictly separate
- Processes
  - Execute the app as stateless processes
- Port Binding
  - Export services via port binding
- Concurrency
  - Scale out via processes
- Disposability
  - Fast startup and graceful shutdown
- Dev/Prod Parity
  - Keep dev/staging/prod as similar as possible
- Logs
  - Treat logs as event streams
- Admin Processes
  - Run admin/mgmt tasks as one-off processes

Summary

- Docker and the Container model
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  - Blue Green deployment
  - “Warehouse Scale” computing