Cloud Computing and Big Data

Containers and the evolution of cloud native

Oxford University
Software Engineering Programme
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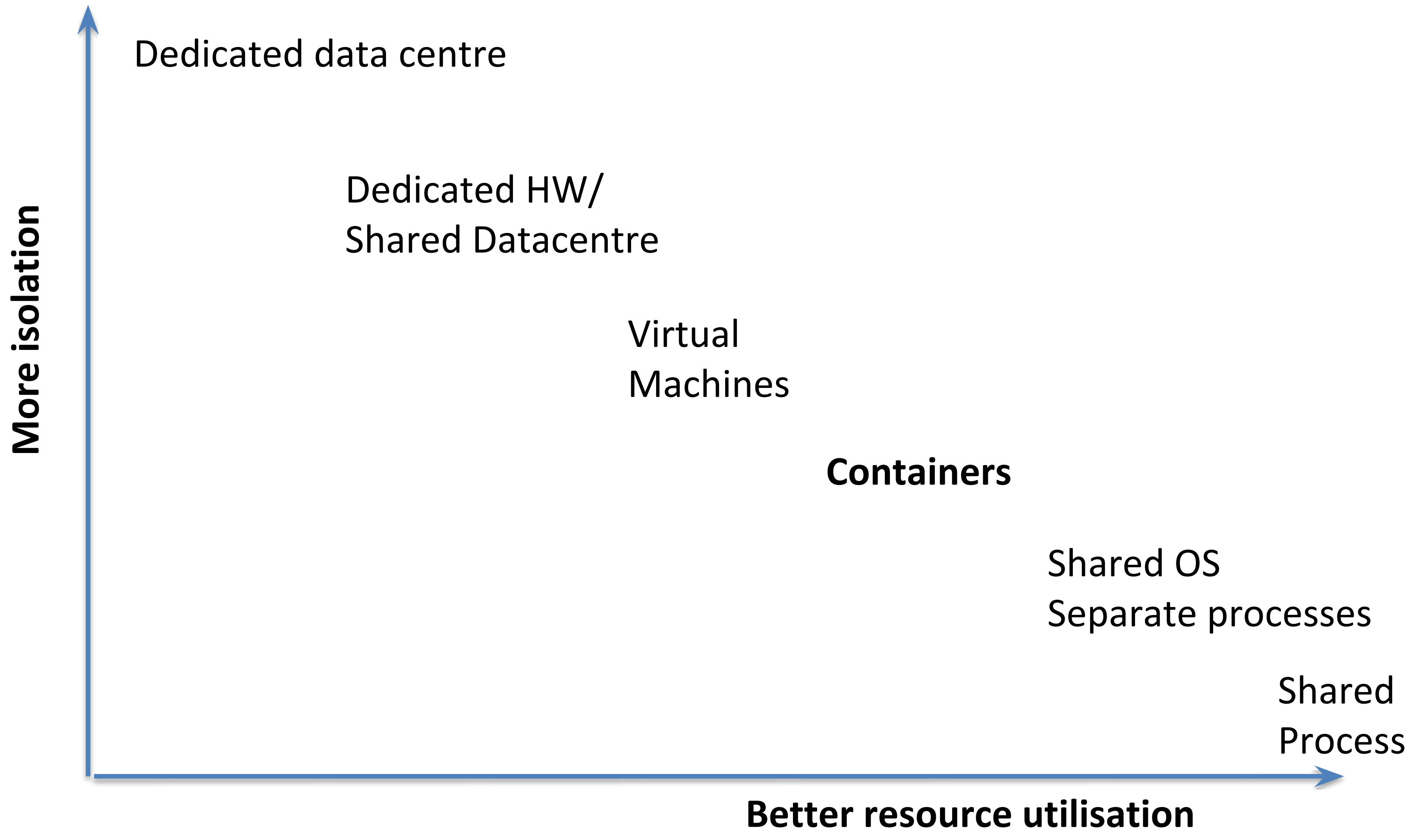
Contents

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

Sharing of resources vs Isolation


Dedicated data centre
Dedicated HW/ Shared Datacentre
Virtual Machines
Containers
Shared OS Separate processes
Shared Process
More isolation
Better resource utilisation

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

Linux Containers (LXC)

- Virtualization inside the Linux Operating System
  - Not the only Linux option, but the most popular
- Allows virtualization including CPU, memory, disk
- Simple and effective

cgroups

- Control of resources by process:
  - blkio — this subsystem sets limits block devices such as physical drives
  - cpu - access to the CPU.
  - cpuacct — this reports on CPU usage
  - cpuset — this controls usage by CPUs in a multicore
  - devices — this denies or grants access to devices
  - freezer — suspends and resumes tasks
  - memory — controls and reports on memory usage
  - net_cls — tags network packets with ids for control
  - net_prio — priority of network traffic per interface.
  - ns — the namespace subsystem.

libcontainer and the Open Container Foundation

- A standardised interface into the container layer
  - Part of runC the open runtime from Docker
  - A key basis of the Open Container Foundation

Cloud Native Computing Foundation

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

at&t
box
cisco
CLOUD FOUNDRY
CoreOS
CYCLECOMPUTING
docker
ebay
Goldman Sachs
Google
HUAWEI
IBM
intel
Joyent
KISMATIC
MESOSPHERE
Odin
redhat
SUPERNAP
A Switch Company
Twistlock
UNIVA
vmware
weaveworks

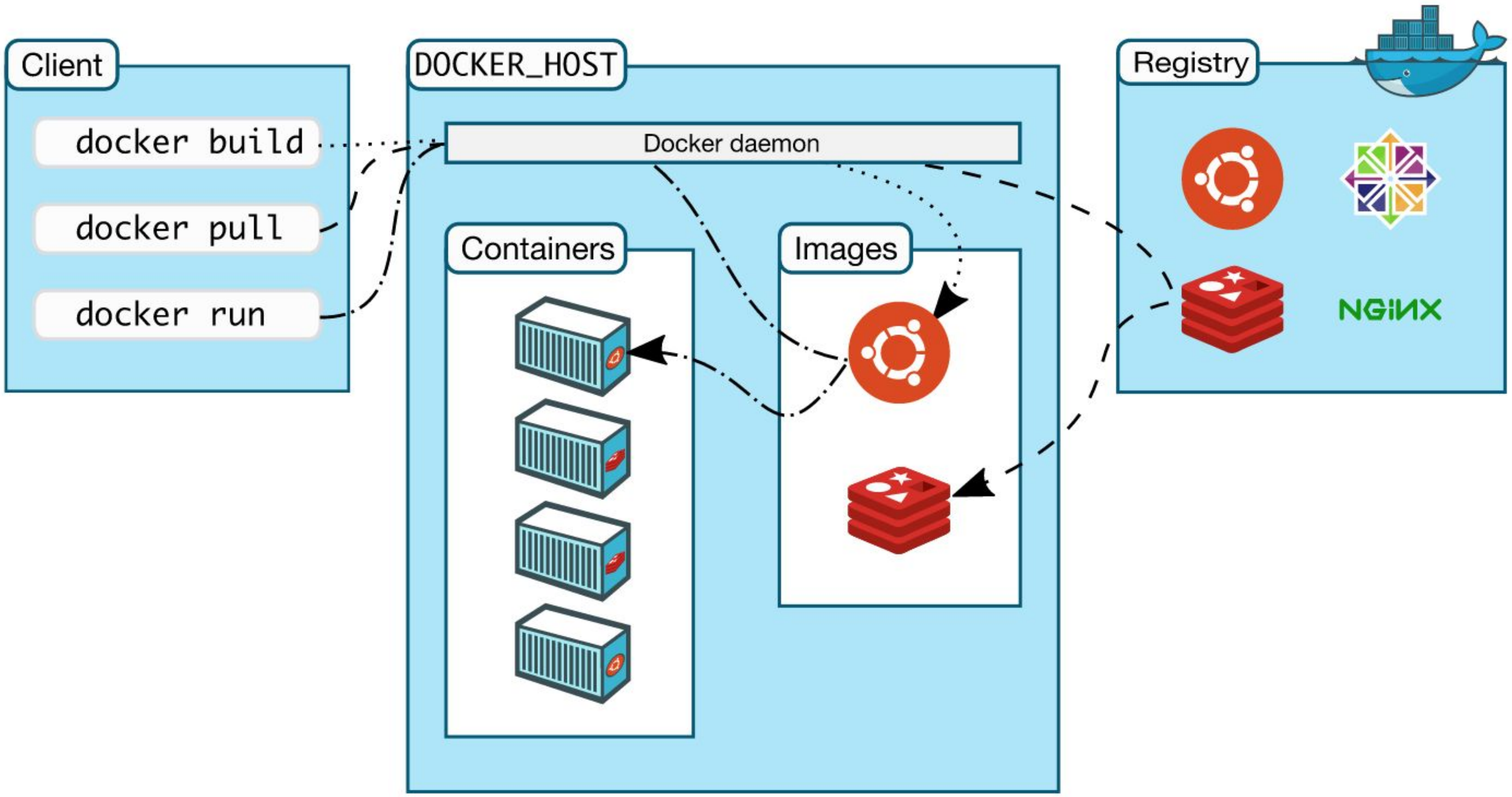
Docker on top of LXC

- 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)

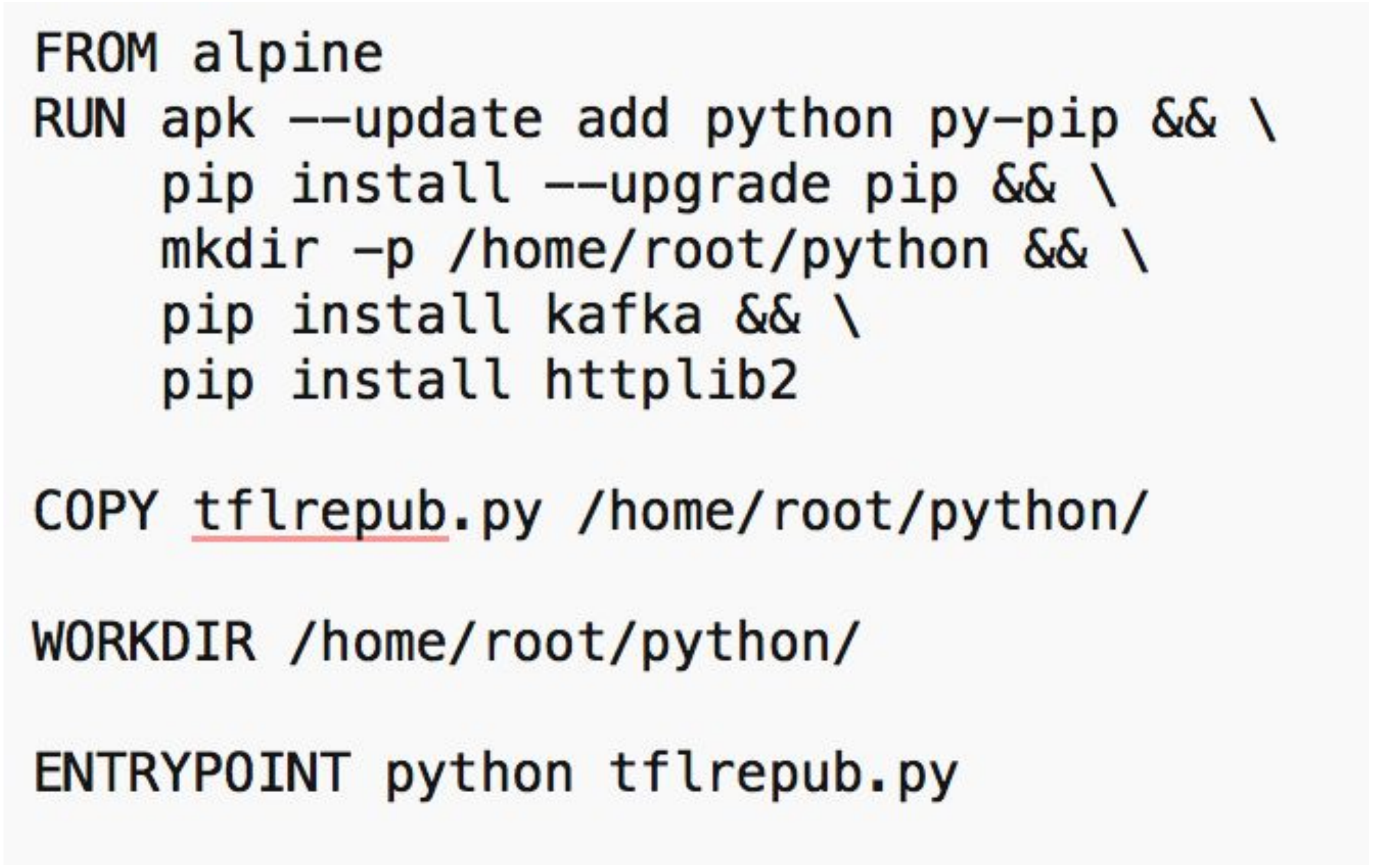
Why Docker?

- 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
```

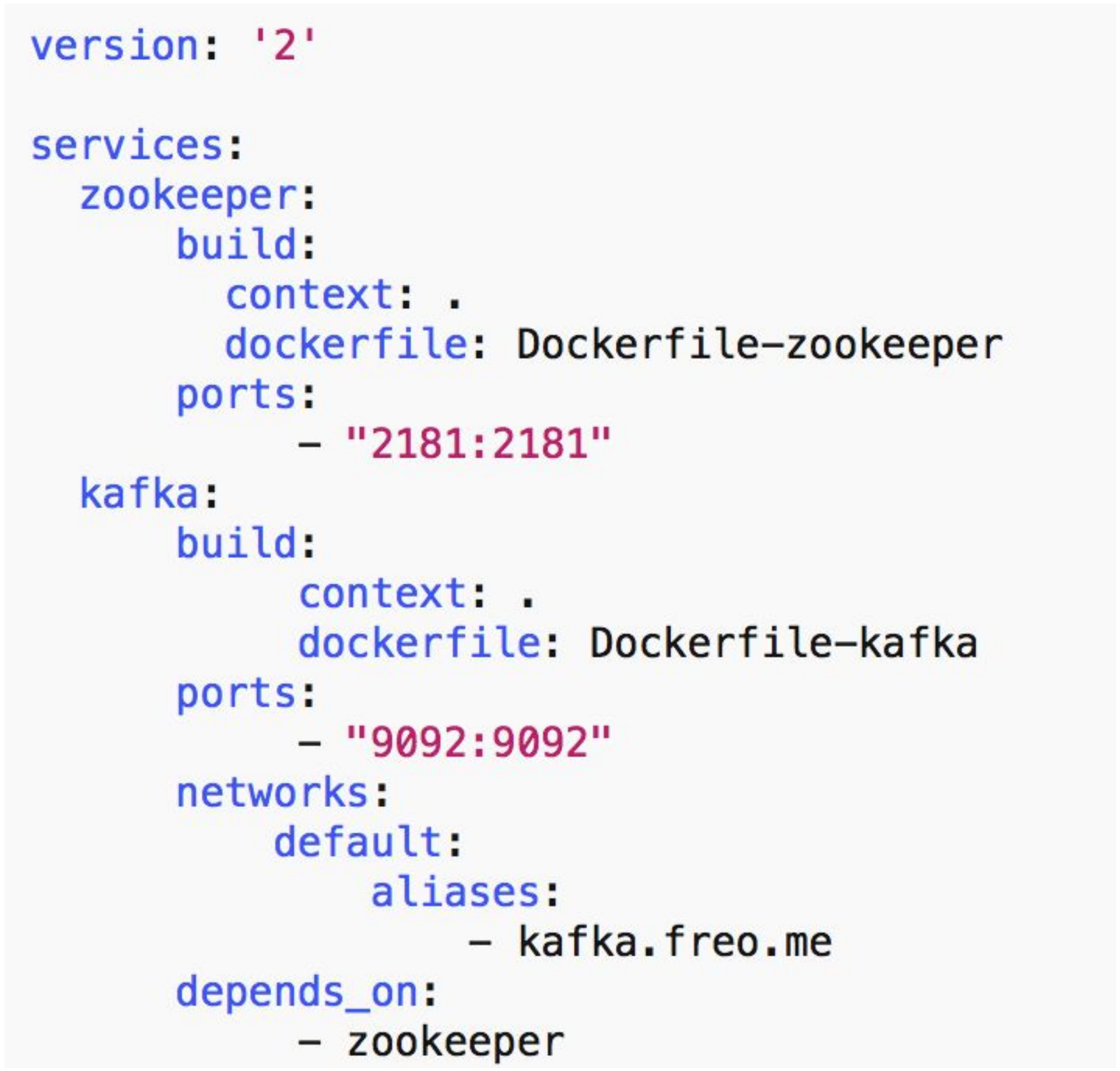
Some simple Docker commands

- 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

- A way of configuring multiple Docker containers
  - Solves security issues
    - Shouldn’t put secrets in Dockerfile or Docker image
  - Manages dependencies between containers

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

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

Large-scale cluster management at Google with Borg

Abhishek Verma[†] Luis Pedrosa[‡] Madhukar Korupolu
David Oppenheimer Eric Tune John Wilkes

Google Inc.

Abstract

Google's Borg system is a cluster manager that runs hundreds of thousands of jobs, from many thousands of different applications, across a number of clusters each with up to tens of thousands of machines.

It achieves high utilization by combining admission control, efficient task-packing, over-commitment, and machine sharing with process-level performance isolation. It supports high-availability applications with runtime features that minimize fault-recovery time, and scheduling policies that reduce the probability of correlated failures. Borg simplifies life for its users by offering a declarative job specification language, name service integration, real-time job monitoring, and tools to analyze and simulate system behavior.

We present a summary of the Borg system architecture and features, important design decisions, a quantitative analysis of some of its policy decisions, and a qualitative examination of lessons learned from a decade of operational experience with it.

1. Introduction

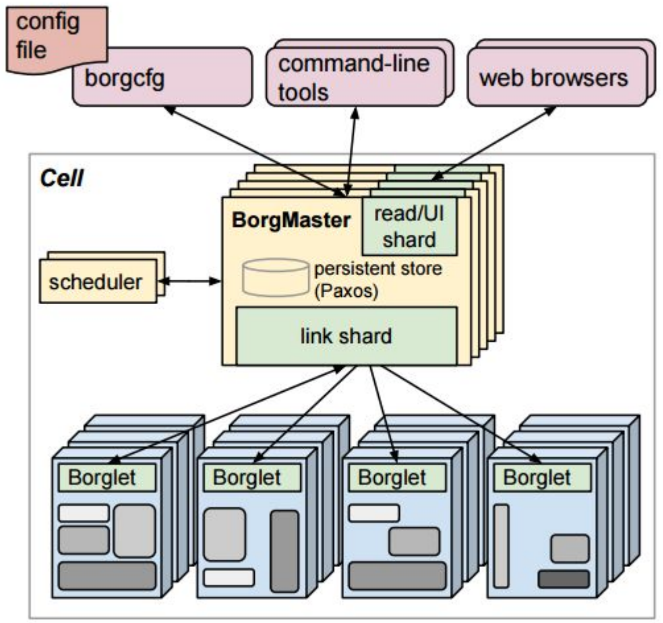


Figure 1: The high-level architecture of Borg. *Only a tiny fraction of the thousands of worker nodes are shown.*

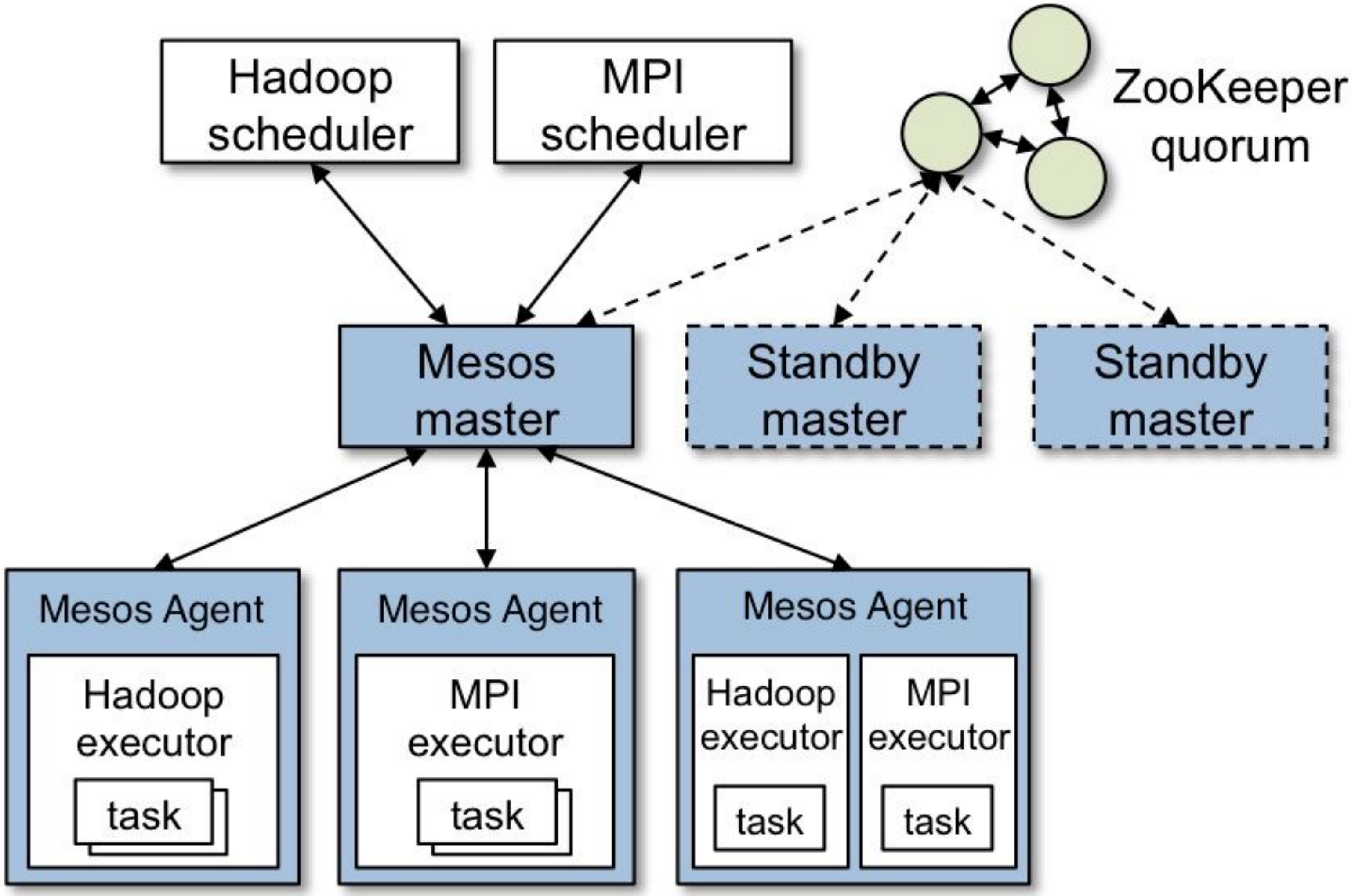
cluding with a set of qualitative observations we have made from operating Borg in production for more than a decade.

Datacenter Operating System

aka Container Orchestration

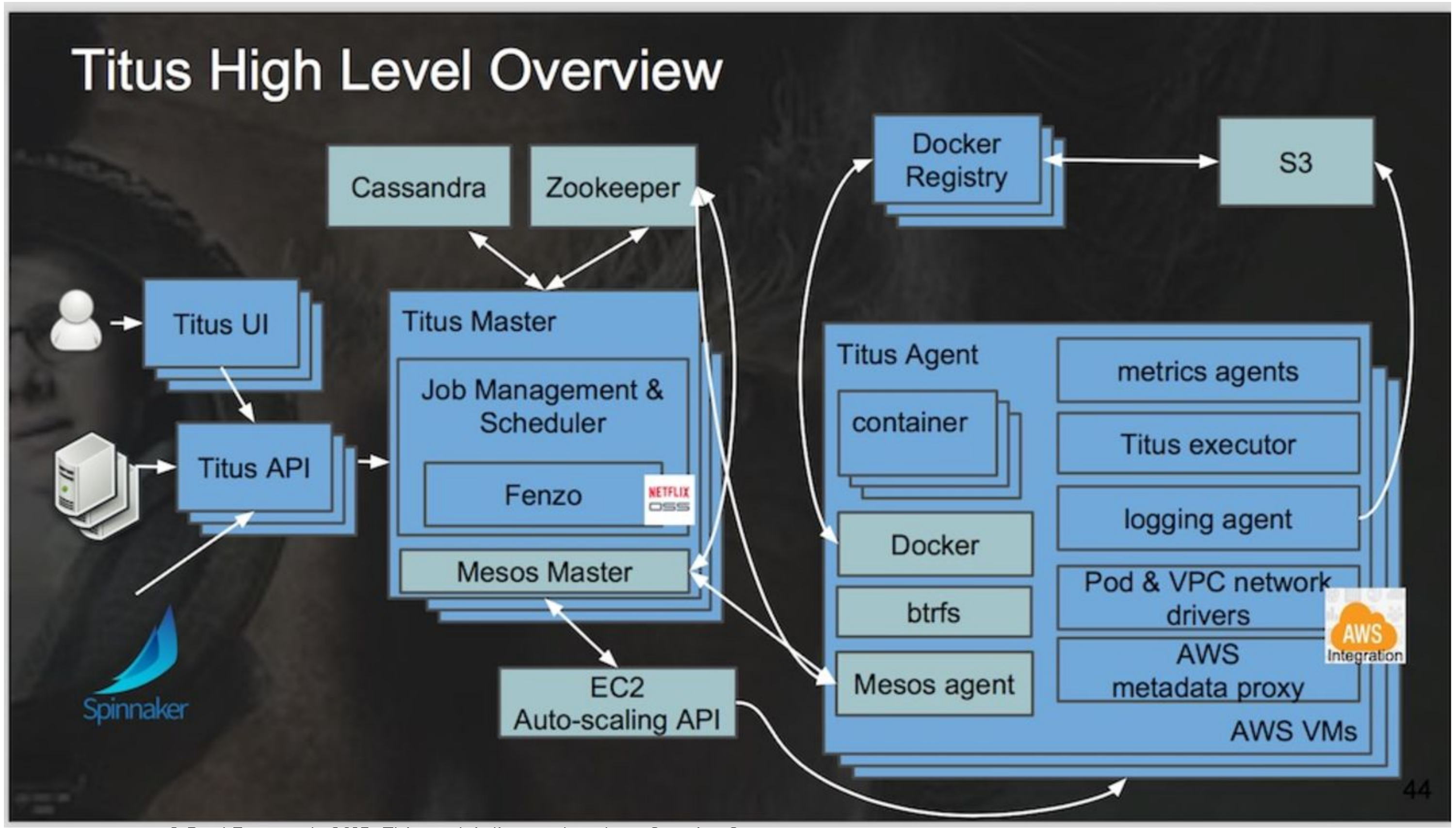
- Manages the placement of containers
  - Access to resources
  - Configuration and networking
  - Moves containers
  - Load balances across containers
- Effectively creating a single OS across a cloud
  - Containers vs Processes

Apache Mesos



Netflix Titus

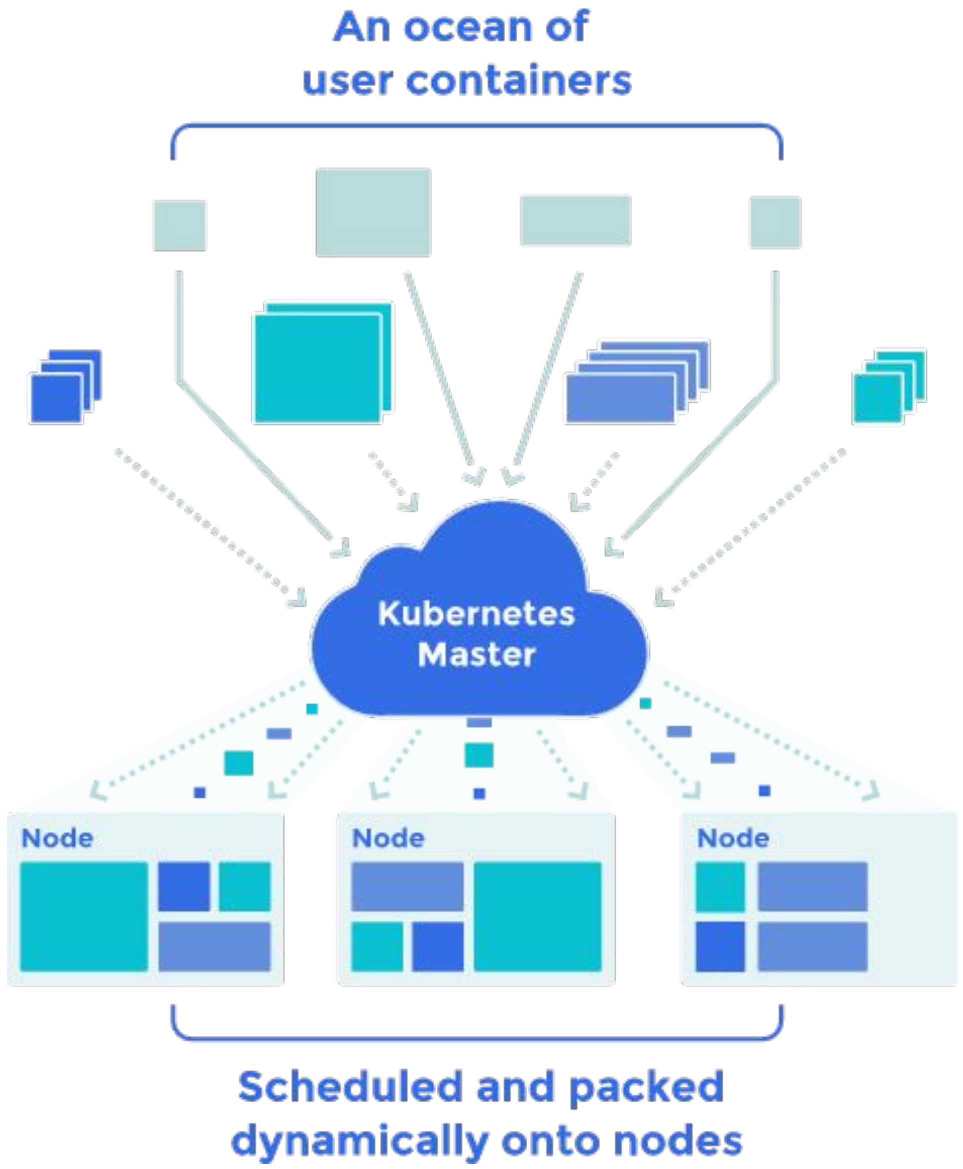
Running on 5000 AWS instances (m4.4xlarge and r3.8xlarge)
Three regions
10,000 containers running at any time
1,000,000 containers launched



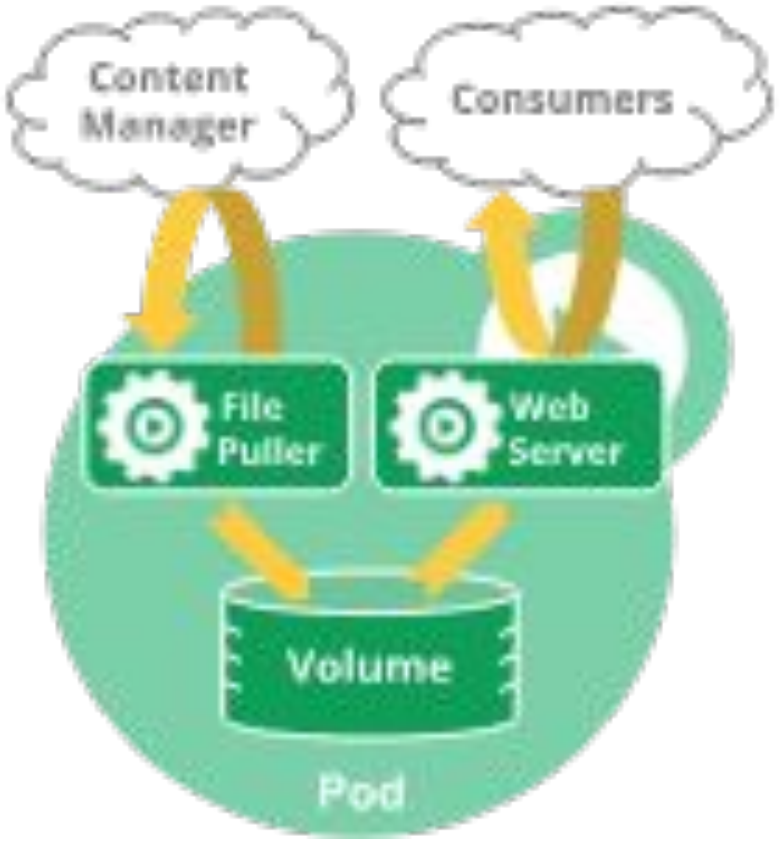
https://www.infoq.com/news/2017/07/netflix-titus

Kubernetes

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


An ocean of user containers
Kubernetes Master
Node
Node
Node
Scheduled and packed dynamically onto nodes

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

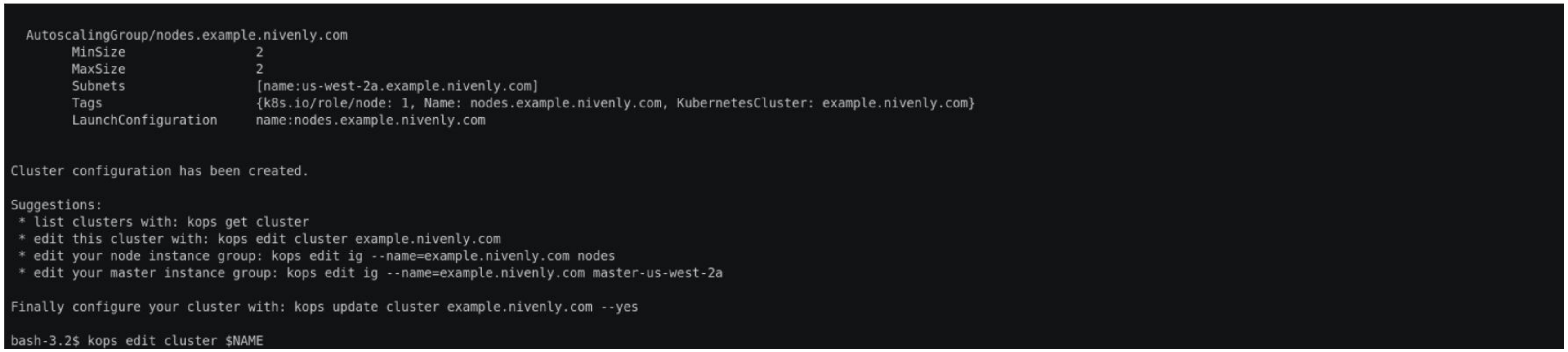
The easiest way to get a production grade Kubernetes cluster up and running.

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?



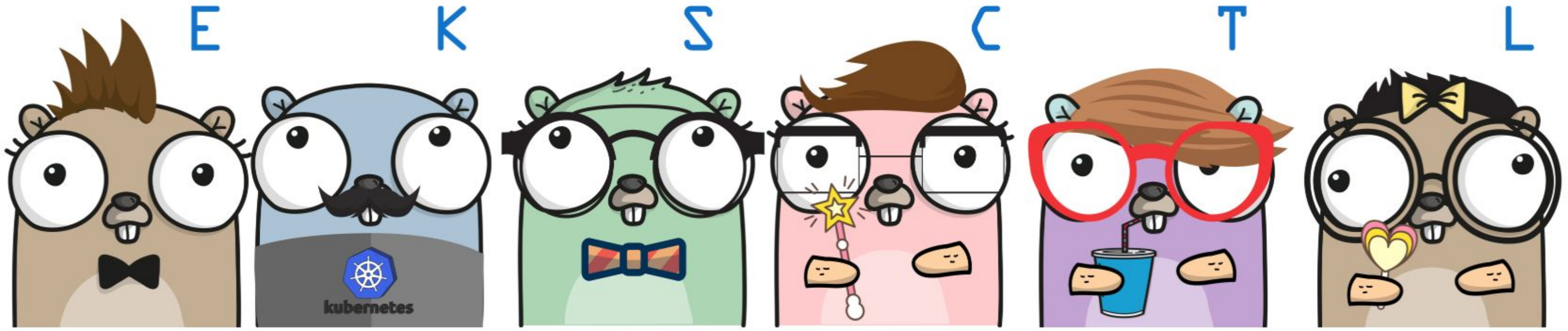
```
  AutoscalingGroup/nodes.example.nivenly.com
        MinSize                 2
        MaxSize                 2
        Subnets                 [name:us-west-2a.example.nivenly.com]
        Tags                    {k8s.io/role/node: 1, Name: nodes.example.nivenly.com, KubernetesCluster: example.nivenly.com}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

circleci passing

`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`!



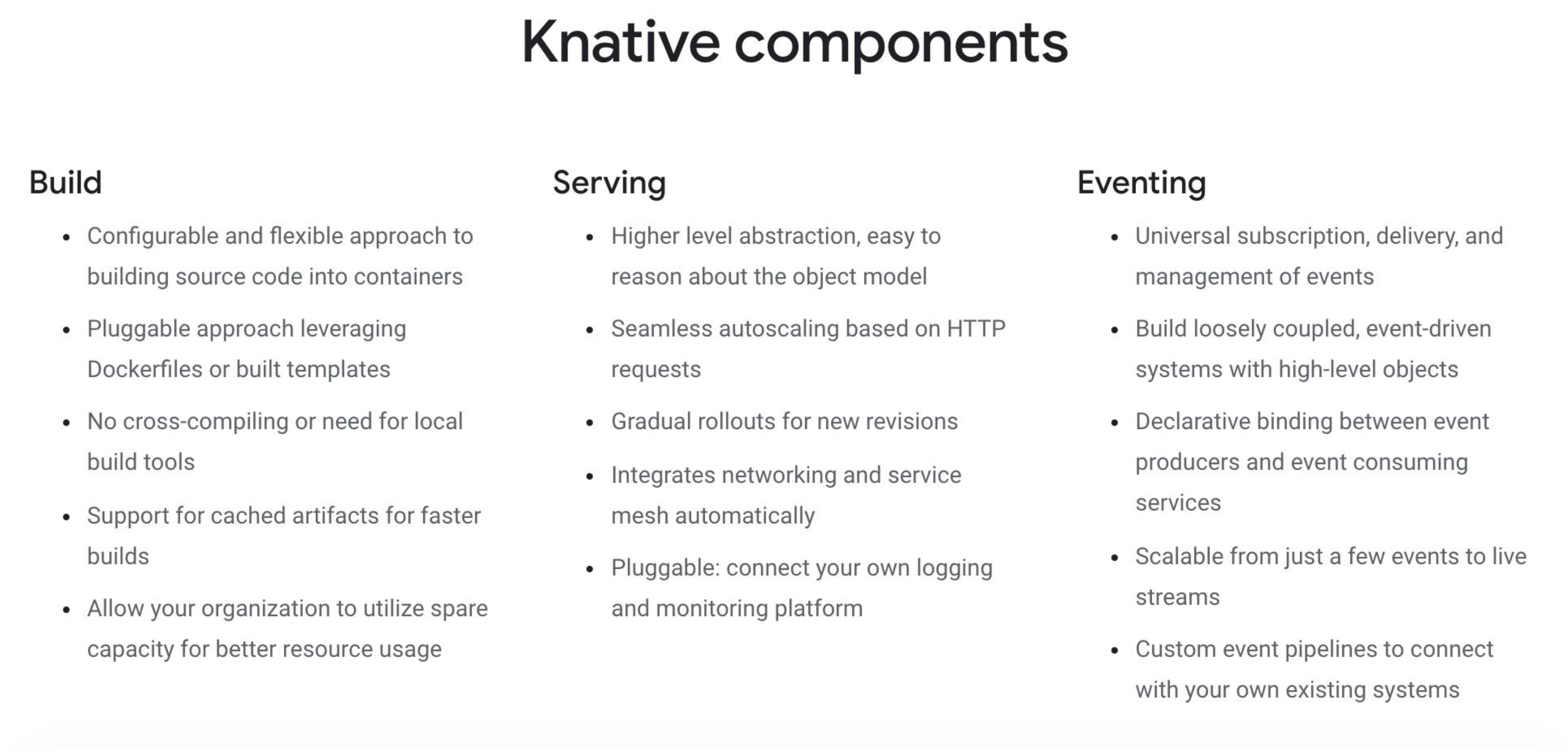
Usage

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:

knative



Knative components

Build

- Configurable and flexible approach to building source code into containers
- Pluggable approach leveraging Dockerfiles or built templates
- No cross-compiling or need for local build tools
- Support for cached artifacts for faster builds
- Allow your organization to utilize spare capacity for better resource usage

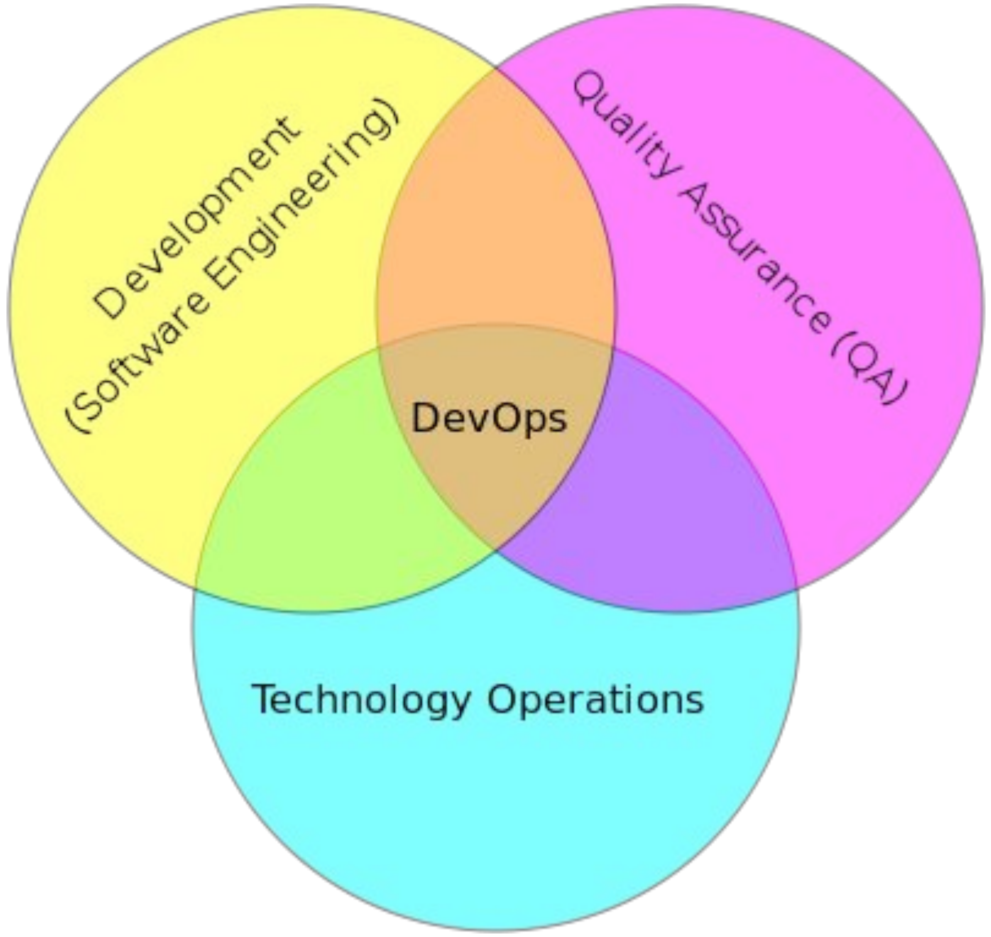
Serving

- Higher level abstraction, easy to reason about the object model
- Seamless autoscaling based on HTTP requests
- Gradual rollouts for new revisions
- Integrates networking and service mesh automatically
- Pluggable: connect your own logging and monitoring platform

Eventing

- Universal subscription, delivery, and management of events
- Build loosely coupled, event-driven systems with high-level objects
- Declarative binding between event producers and event consuming services
- Scalable from just a few events to live streams
- Custom event pipelines to connect with your own existing systems

DevOps


Development
(Software Engineering)
Quality Assurance (QA)
DevOps
Technology Operations

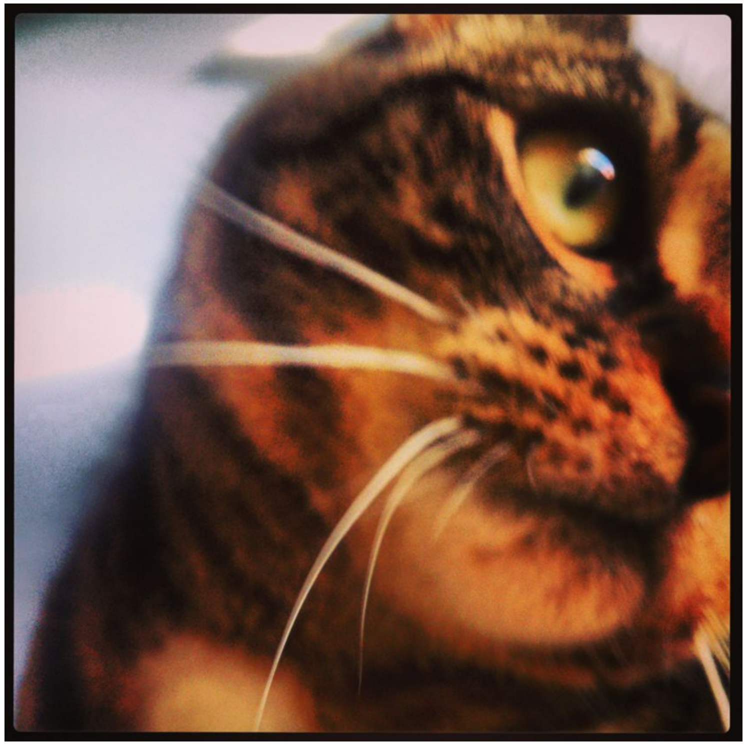
DevOps

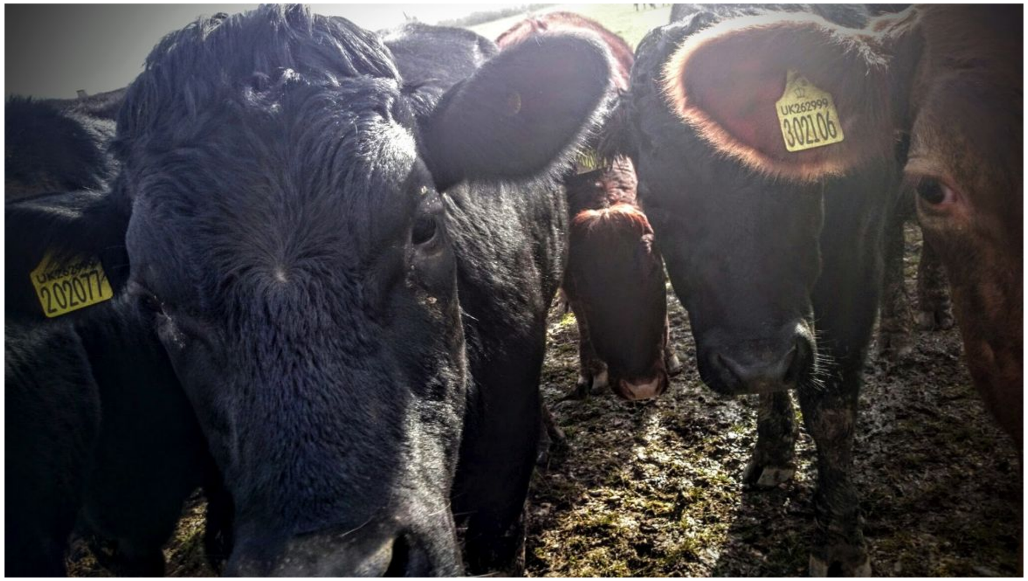
- DevOps is the codification of the interface between Development and Operations
  - Agile
  - Repeatable
  - Collaborative
  - Versioned
  - Automated

Cloud and DevOps

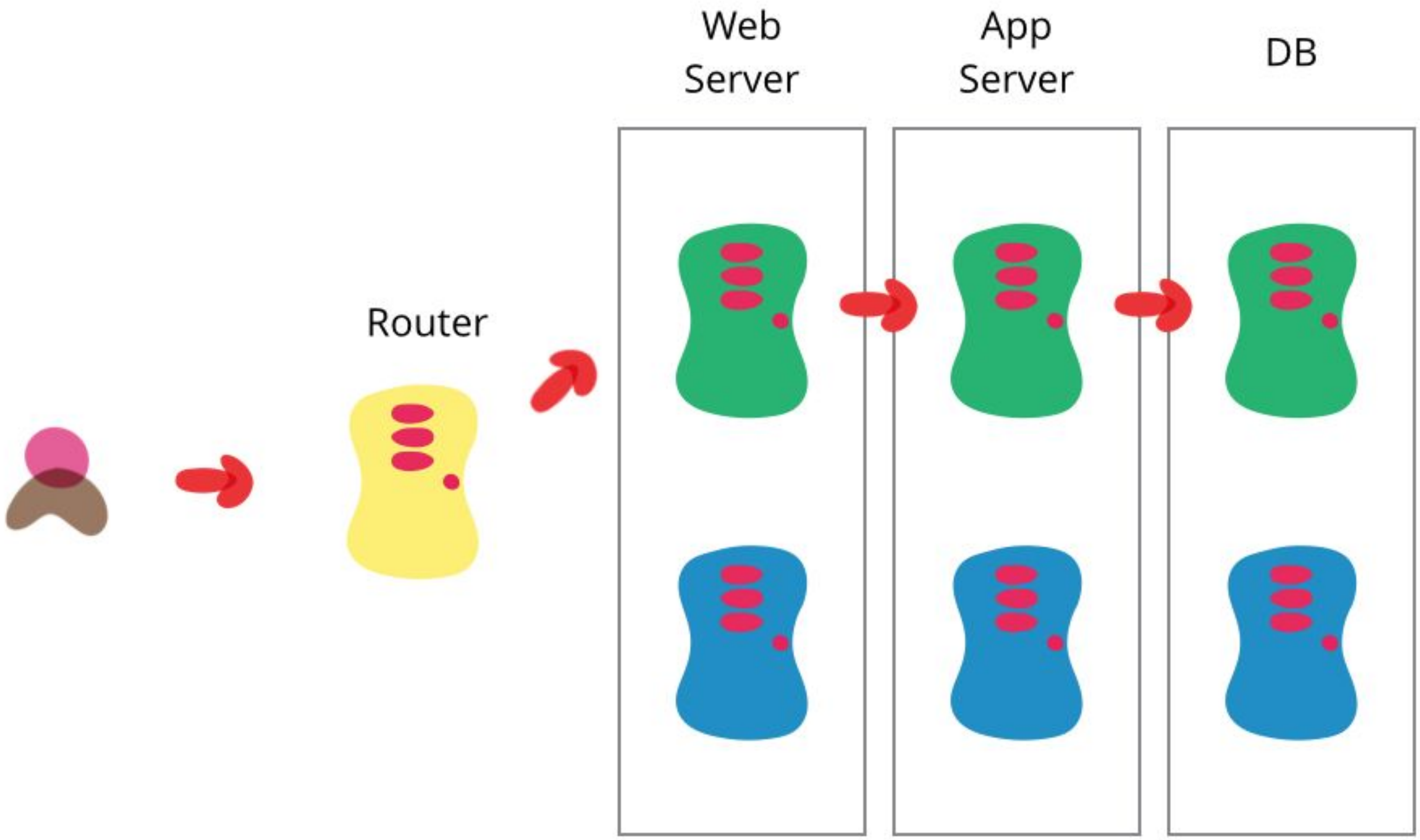
- It could be argued strongly that the rise of DevOps is tied to the rise of Cloud
  - Clear requirement for automated, repeatable configuration and deployment
  - Reducing the hardware provisioning time has highlighted the challenges

Kittens vs Cattle
(An unpleasant but effective analogy)



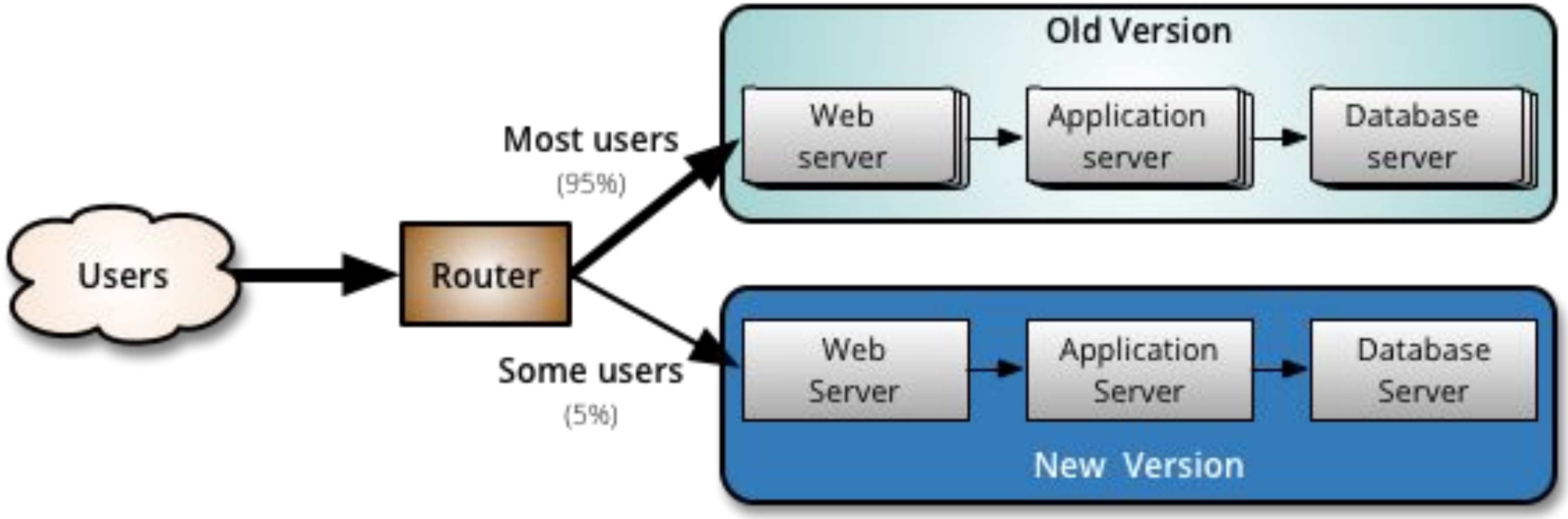


Blue Green Deployment



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

Canary Deployment



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