Introduction to Kubernetes

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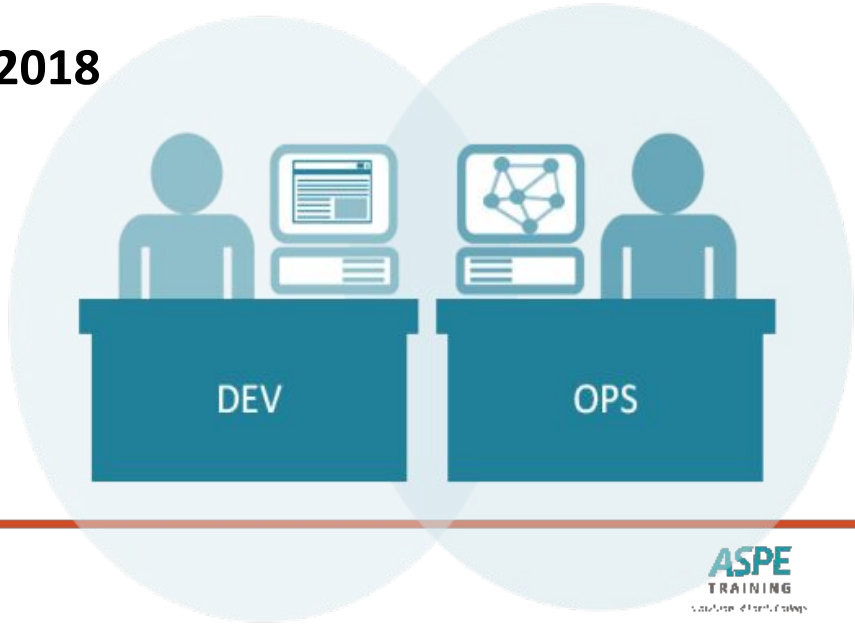


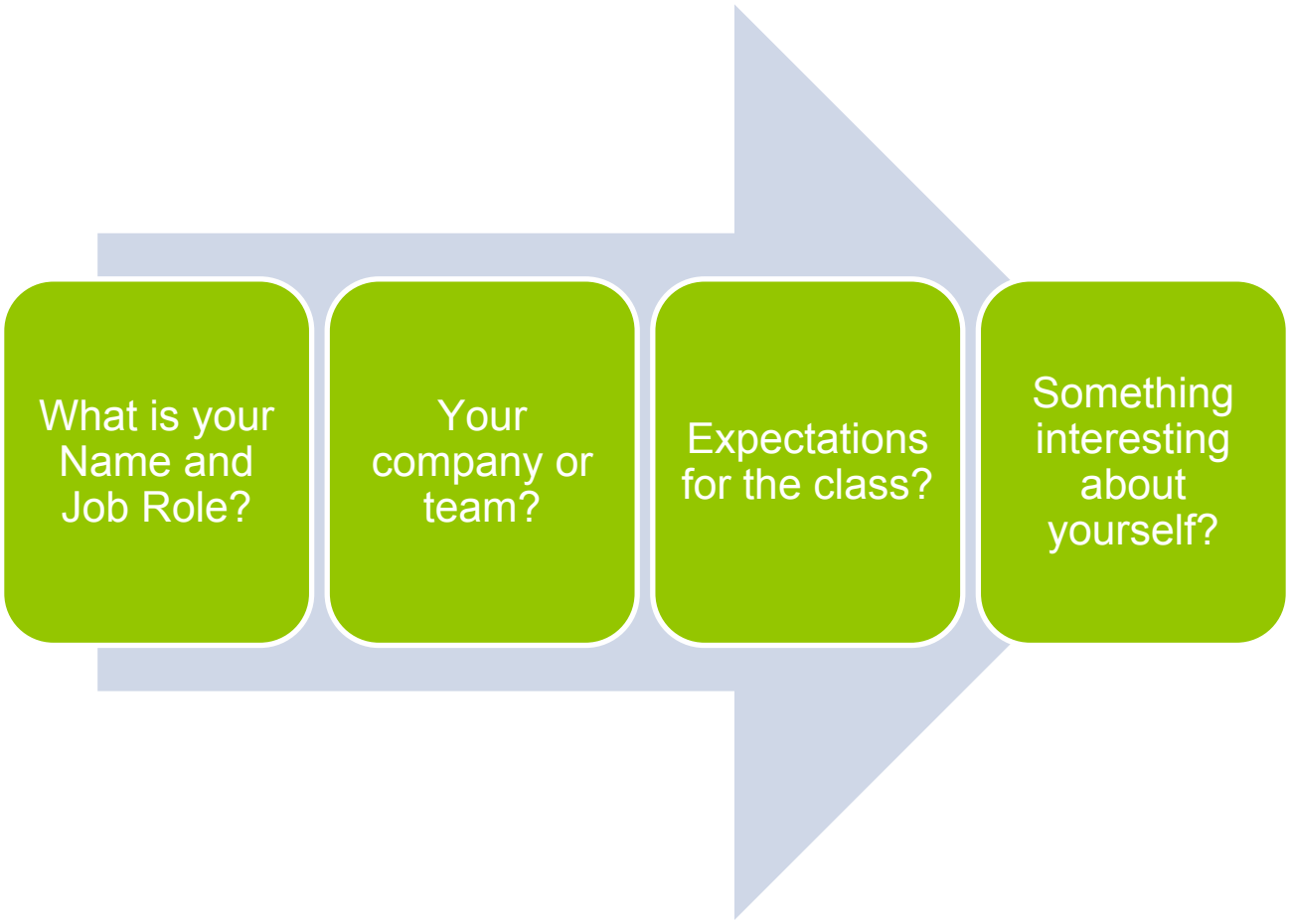
Welcome!

- Logistics (breaks, facilities, lunch, etc.)
- Rules of Engagement
- Introductions
- Let’s Get Started!

Who is your instructor?

A little about me…

Introductions



What to expect from this class

- Flexibility
- Conversations
- Literacy and awareness on many of the principles, tools, and practices **surrounding Microservices culture, architecture and implementation.**
- An effort to focus on your own situations and challenges so you can act on what you learn.

Introduction to Kubernetes

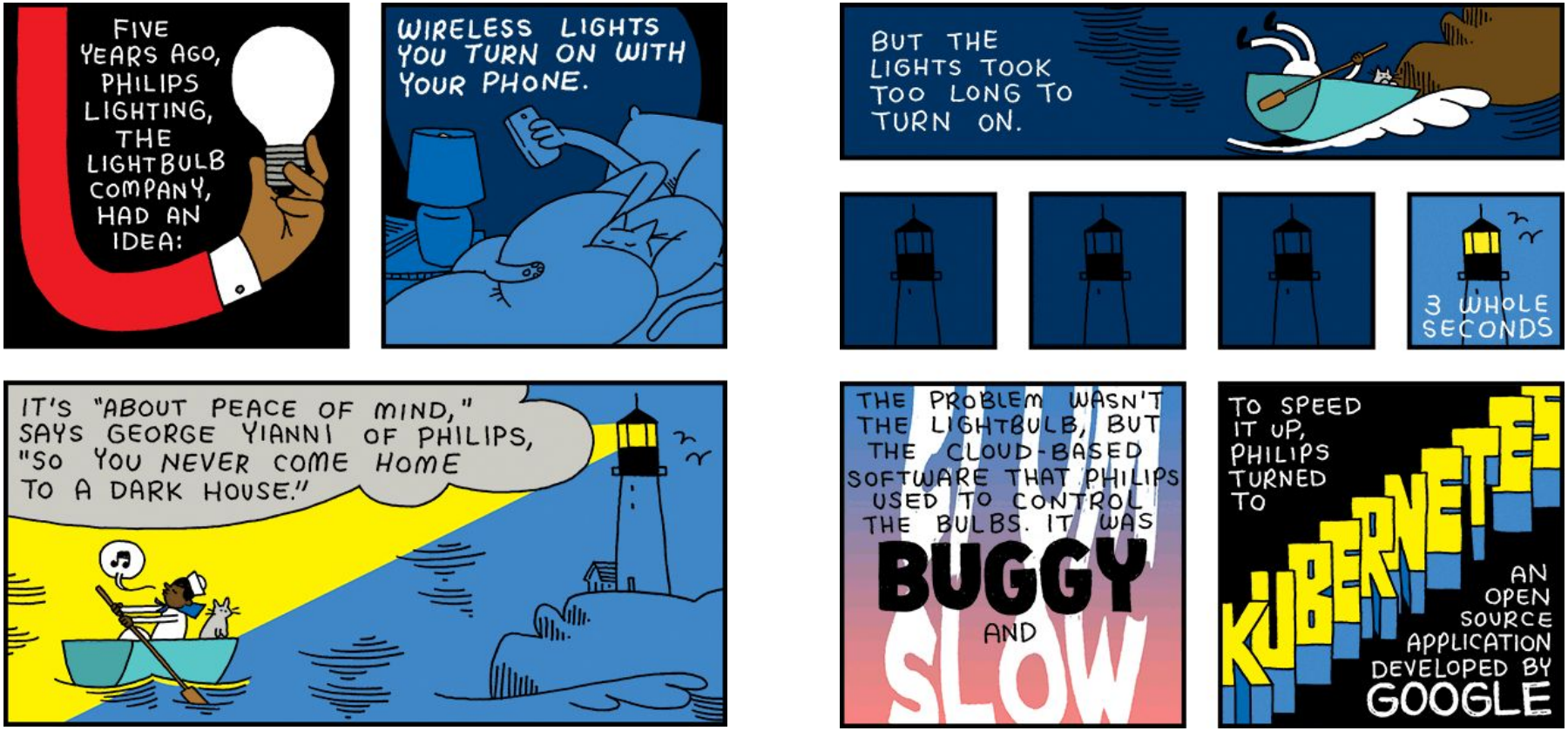
Part 1:

Journey is a “Team of Teams”

“First I needed to shift my focus from moving pieces on the board to shaping the ecosystem.”

– General S. McChrystal, *Team of Teams: New Rules of Engagement for a Complex World*

Kubernetes Intro (Phillips Case)



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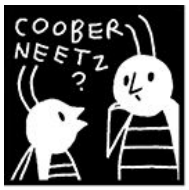

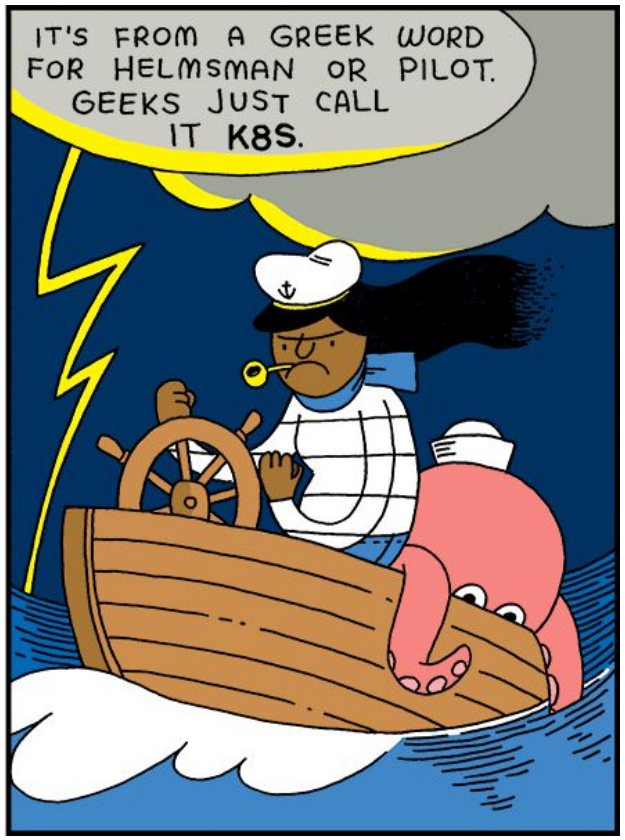

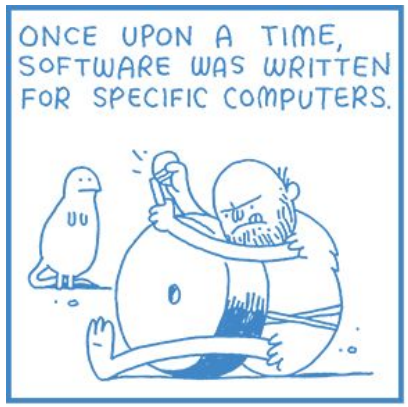

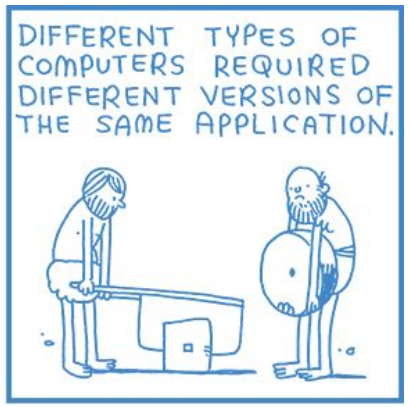

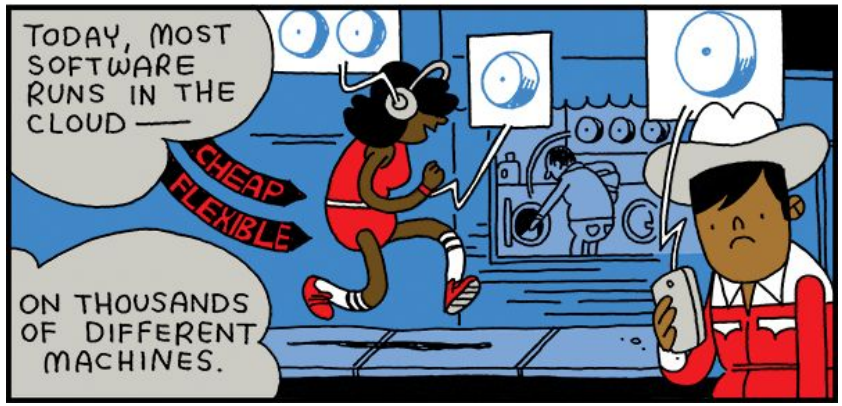

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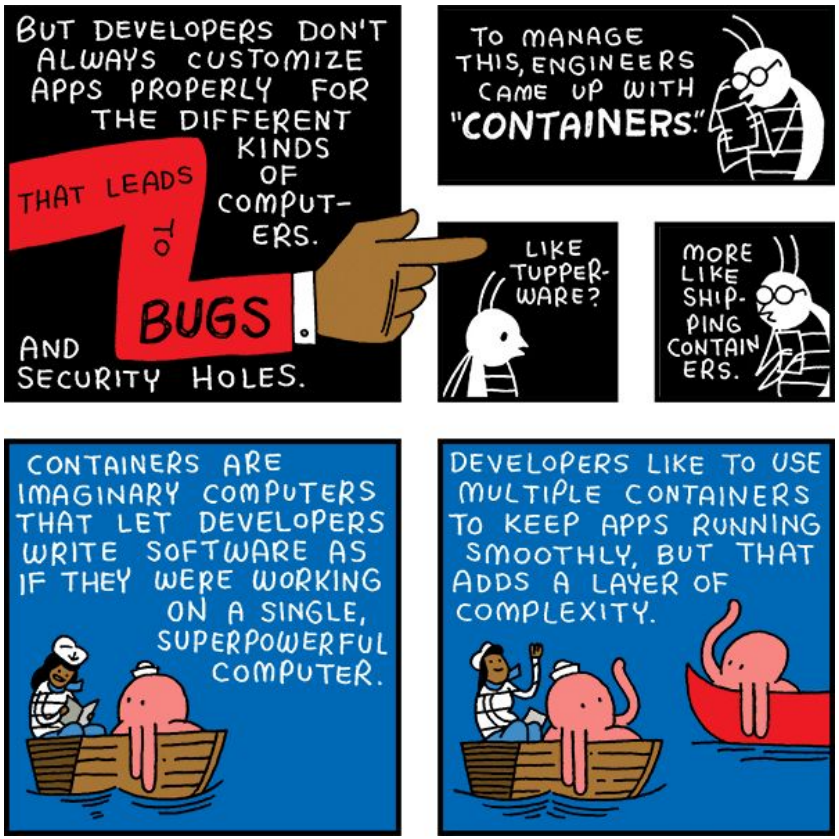

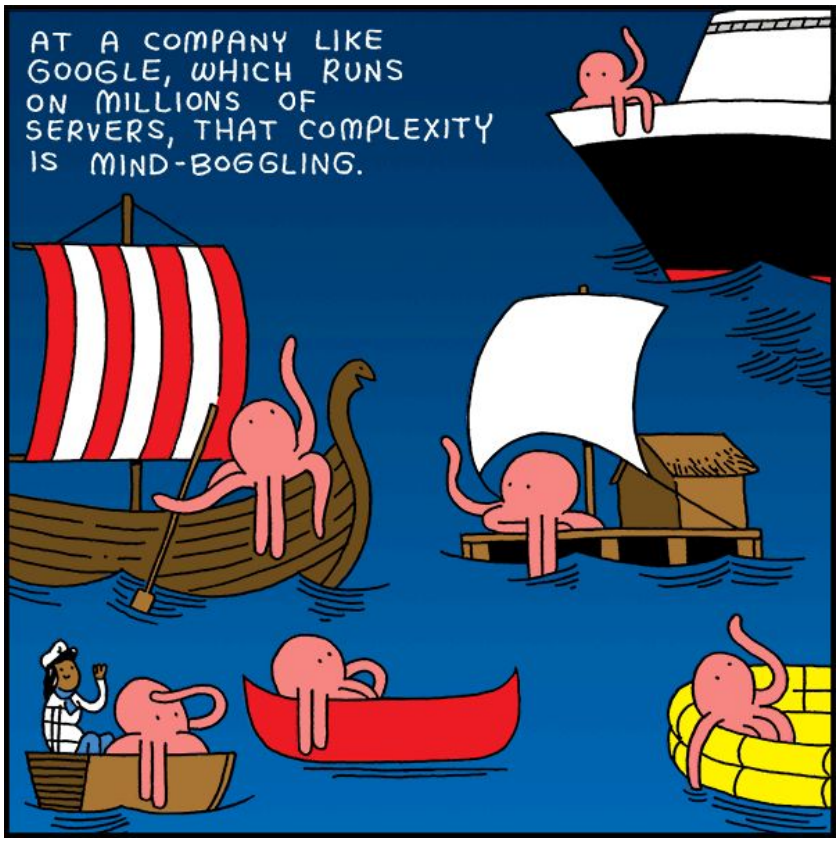

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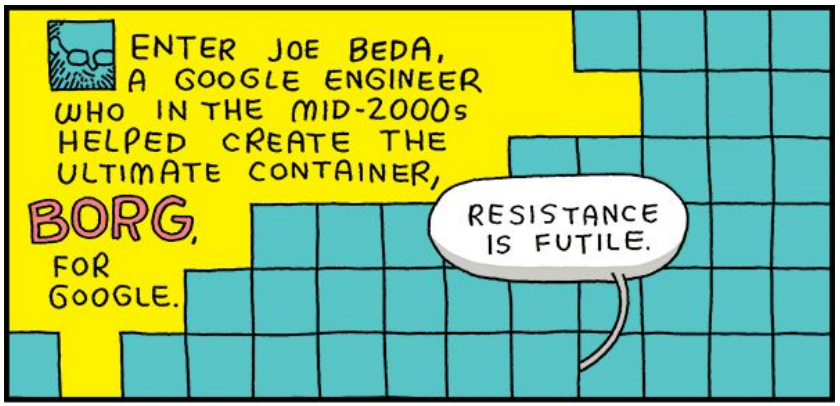

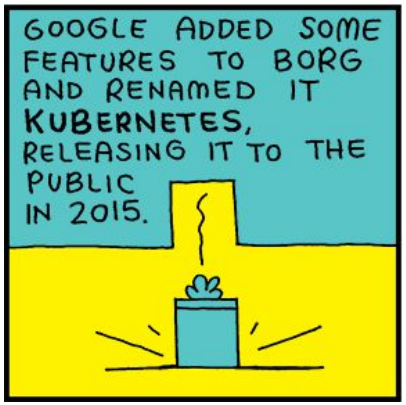

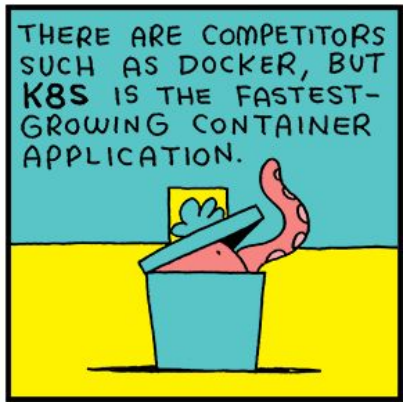

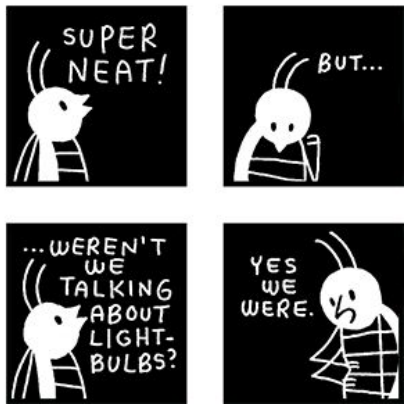

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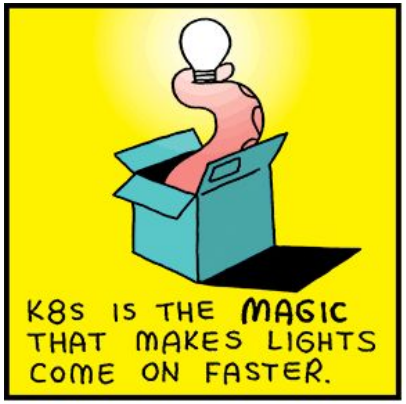
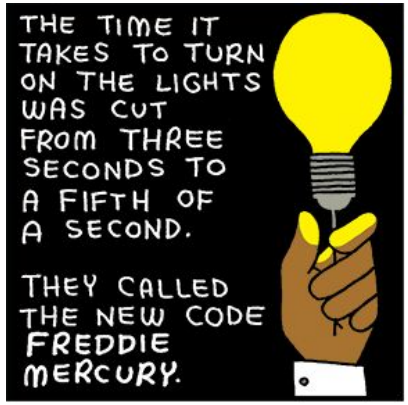




Kubernetes

The name Kubernetes is Greek

- Translates to “helmsman” or “pilot”
- Root of ”Governor” and “Cybernetic”

“K8s” is a shorthand abbreviation derived by replacing the 8 letters “ubernete” with 8.

Kubernetes

Project was originally started by Google, and shortly after joined by Redhat

- Based on 10+ years of experience of using containers
  - The most famous of which named “Borg”, Google’s cluster manager “Borg”
- Declarative
  - State desire (i.e. 5 pods)
  - System confirms to State (if currently 3 pods, system changes to 5. If unexpectedly goes to 4 pods, system restores to 5)

Cloud Native Computing Foundation (CNCF)

Mission of the Cloud Native Computing Foundation.

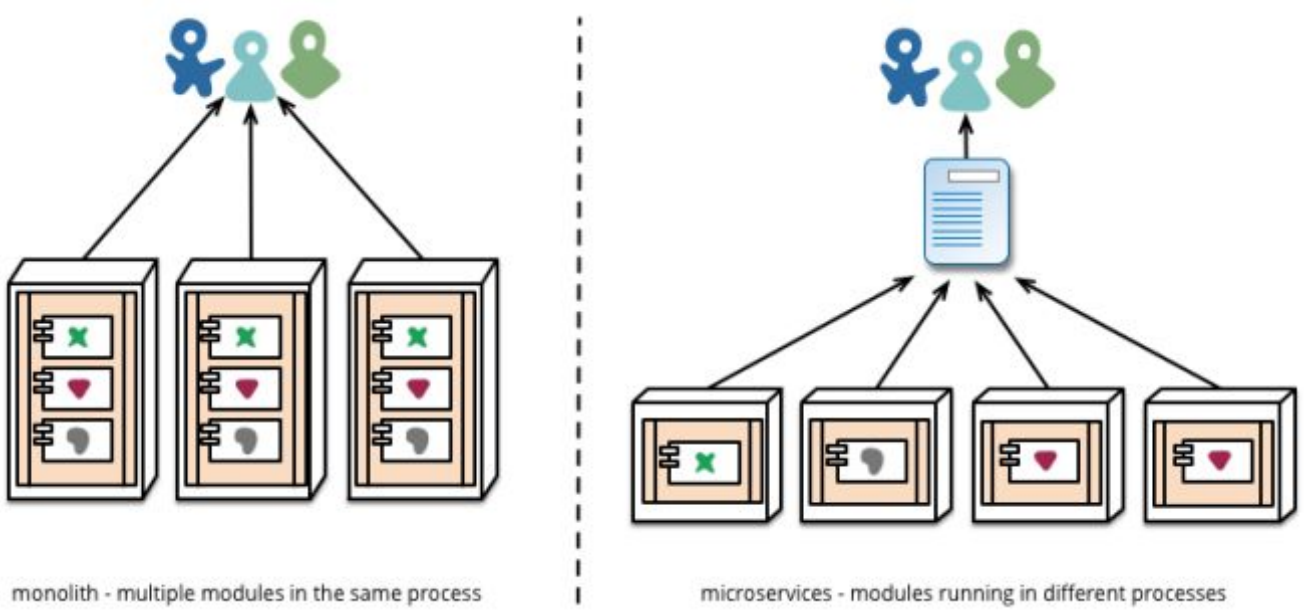
- "The Foundation's mission is to create and drive the adoption of a new computing paradigm that is optimized for modern distributed systems environments capable of scaling to tens of thousands of self healing multi-tenant nodes."

Formed in Nov 6, 2015 with Kubernetes as its first project

- The CNCF is building an ecosystem of complimentary projects including Prometheus, Fluentd, Linkerd, Rkt, and others

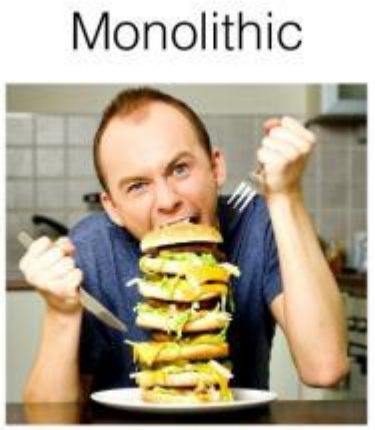
What is a Microservice?

- A service that can be <u>independently</u> deployed



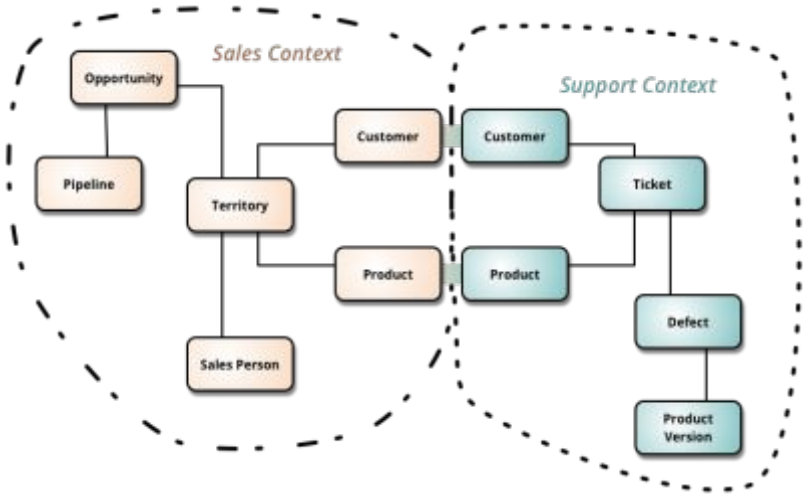
How big is a Microservice?

- A **single programmer** can design, implement, deploy and maintain a microservice – Fred George
- Software that **fits in your head** – Dan North



Where is the data for a Microservice?

- A single logical **database per service** – Chris Richardson
- A microservice implements a single **Bounded Context** – Martin Fowler, Sam Newman



How to maintain Microservices?

- Addressable through a **service discovery** system – Chris Richardson
- Microservices **built & deployed independently. Stateless**, with state as backing service s – 12Factor.net

How to architect Microservices?

Typically

- CRUD – Create, Read, Update and Delete api implementations
- Range between RPC, Message and Stream processing
- Evolve from a Monolith 1st iteration

Microservice: advantages

- **Simple** services that are focused on doing one thing well
- Each service can be built **using** the **best** tool for the job
- Systems built this way are inherently **loosely coupled**
- Teams can deliver and **deploy independently** from each other
- Enable **continuous delivery** but allowing frequent releases while the rest of the system continues to be stable

Microservices

Solve organizational problems

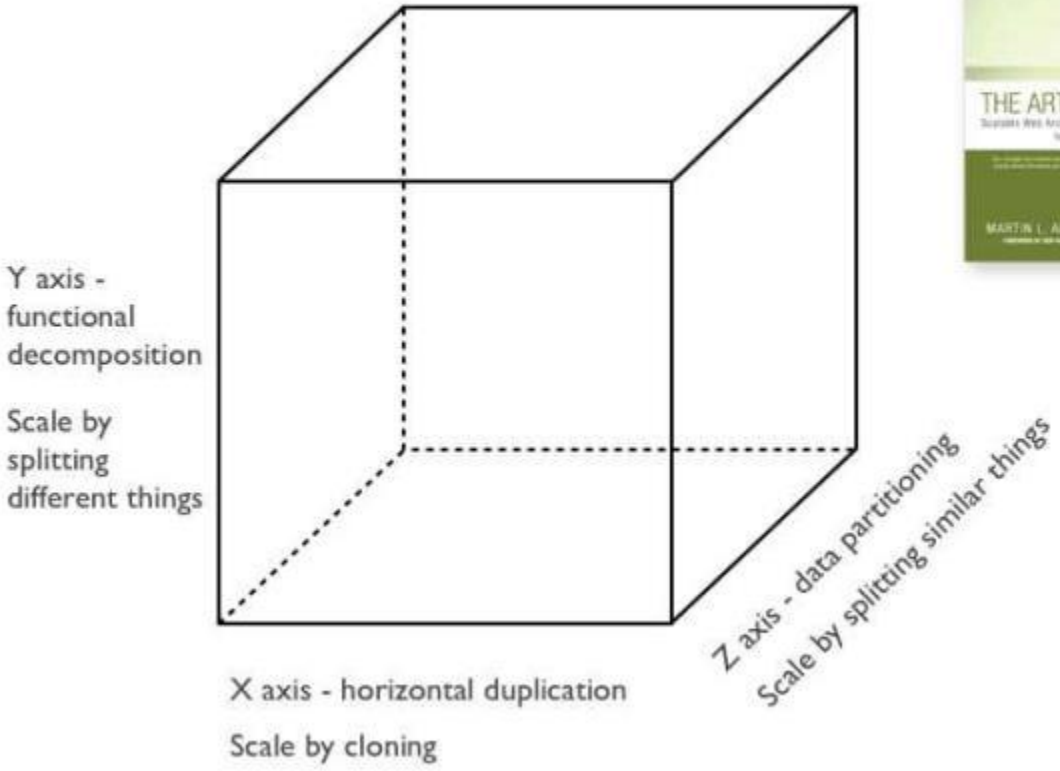
- Teams blocked by or waiting on other teams
- Communication overhead
- Slow velocity

Cause Technical Problems

- Requires Devops, devs deploying and operating their services
- Need well defined business domains
- More distributed systems
- Need an orchestration layer

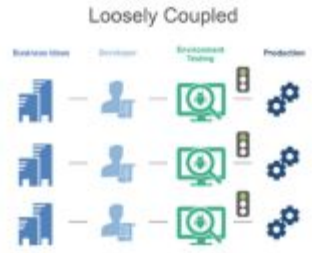
The Art of Scaling

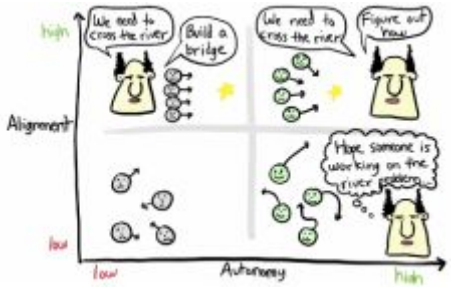
3 dimensions to scaling

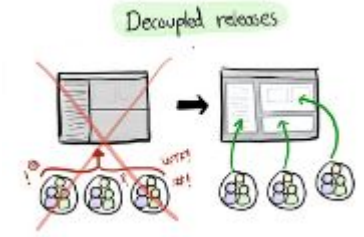


Small Team Size

- Build platform with small teams of 6-8 engineer teams
- **Self Sufficient**: Each team completely owns one or more services and has everybody they need to develop functionality
- **Automate Interfaces:** Teams connect to each other through API's. Teams don't hire an army of program managers to manage dependencies.
- **Decentralized:** Teams plan, develop and deploy autonomously





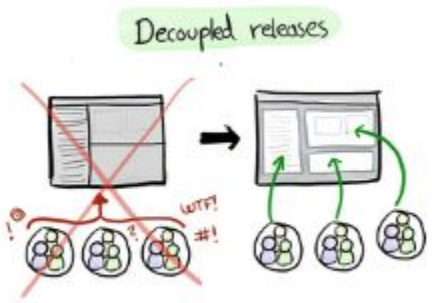


Starting and Scaling DevOps in the Enterprise by Gary Gruver
https://www.amazon.com/dp/B01M332BN2/ref=dp-kindle-redirect?_encoding=UTF8&btkr=1

Why Small Team Size? Scaling the Organization

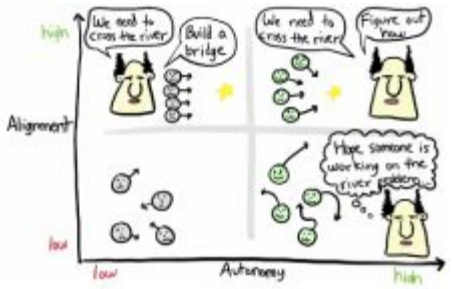
Autonomy

- Decentralizes power and creates autonomy which is critical to scaling the organization
- Each team can focus on the business metric they are responsible for and act autonomously to maximize the metric.



Amazon CTO Werner Vogels explained the advantages of this structure to Larry Dignan of *Baseline* in 2005. Dignan writes:

"Small teams are fast…and don't get bogged down in so-called administrivia….Each group assigned to a particular business is completely responsible for it….The team scopes the fix, designs it, builds it, implements it and monitors its ongoing use. This way, technology programmers and architects get direct feedback from the business people who use their code or applications—in regular meetings and informal conversations."

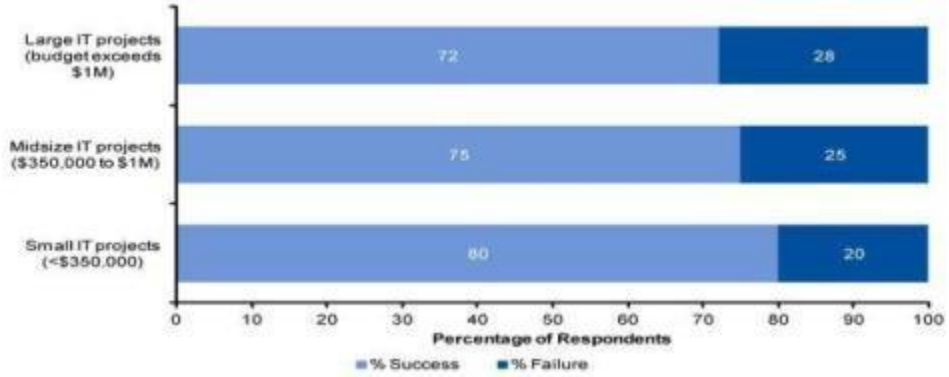


Science behind why two-pizza team works http://blog.idonethis.com/two-pizza-team/
ITRevolution, Conways Law by Gene Kim http://itrevolution.com/conways-law/

Why do Microservices?

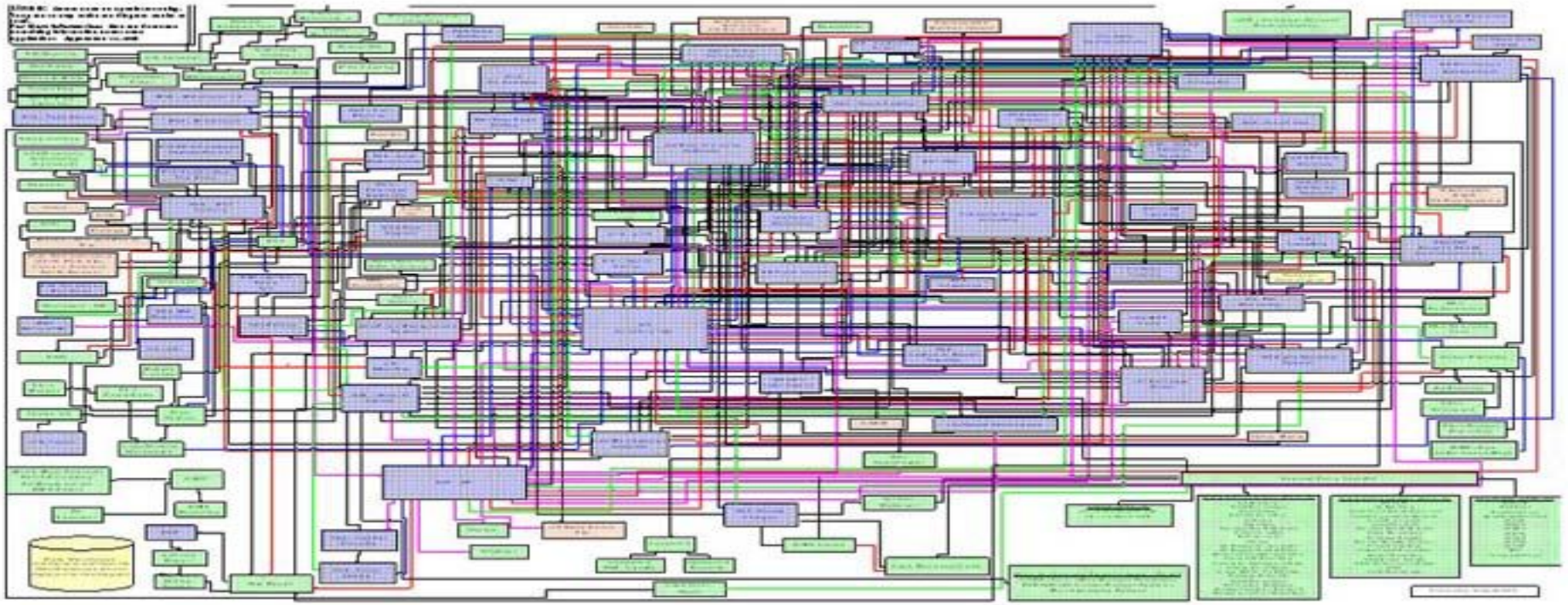
Reduce complexity, increase success

- According to a Gartner survey of 150 participants in 2011, the failure of projects exceeding $1 million was found to be almost 50% higher than for projects with budgets below $350,000.
- This result was reinforced by prior Gartner IT projects which found small IT projects to experience a one-third lower failure rate than large projects



https://thisiswhatgoodlookslike.com/2012/06/10/gartner-survey-shows-why-projects-fail/

The Hairball(*monolith*)

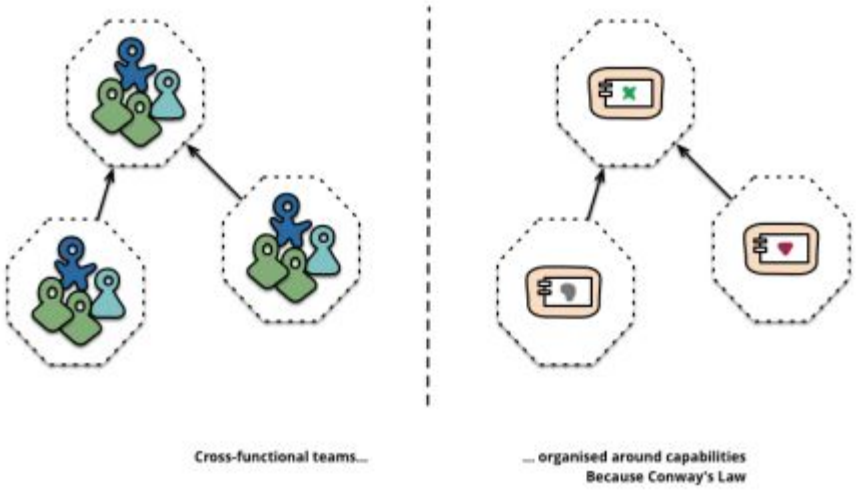


Because Conway's Law

"Organizations which design systems … are constrained to produce designs which are copies of the communication structures of these organizations."

–Melvin Conway

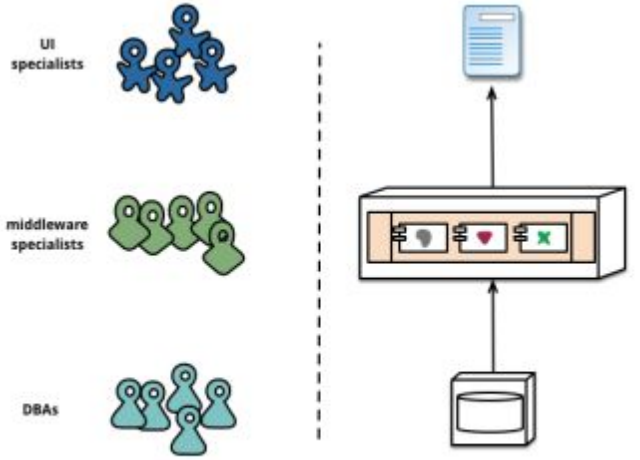
Do This



Cross-functional teams...

... organised around capabilities
Because Conway's Law

Not that



Siloed functional teams...

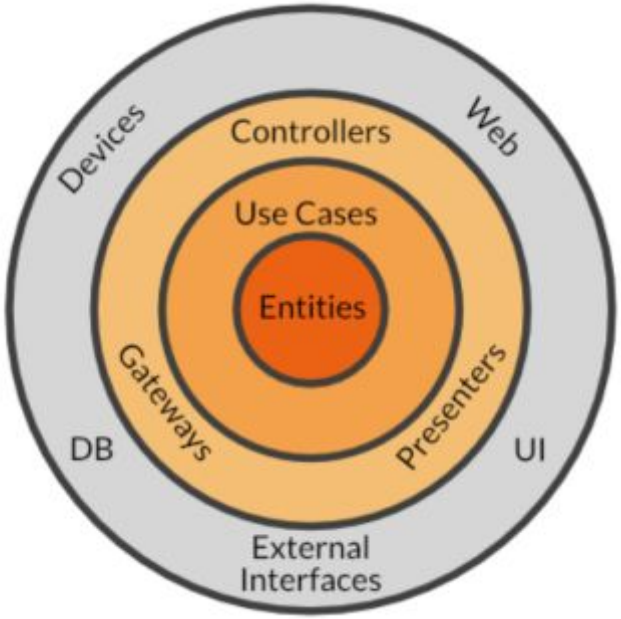
... lead to silod application architectures.
Because Conway's Law

Microservice building blocks

APIs provide the flexibility for businesses to grow by adopting new business models and enable accelerated development of new applications.

It is like picking different LEGO blocks to build a toy house.

Clean Architecture



The central rule of The Clean Architecture is the Dependency Rule, which says:

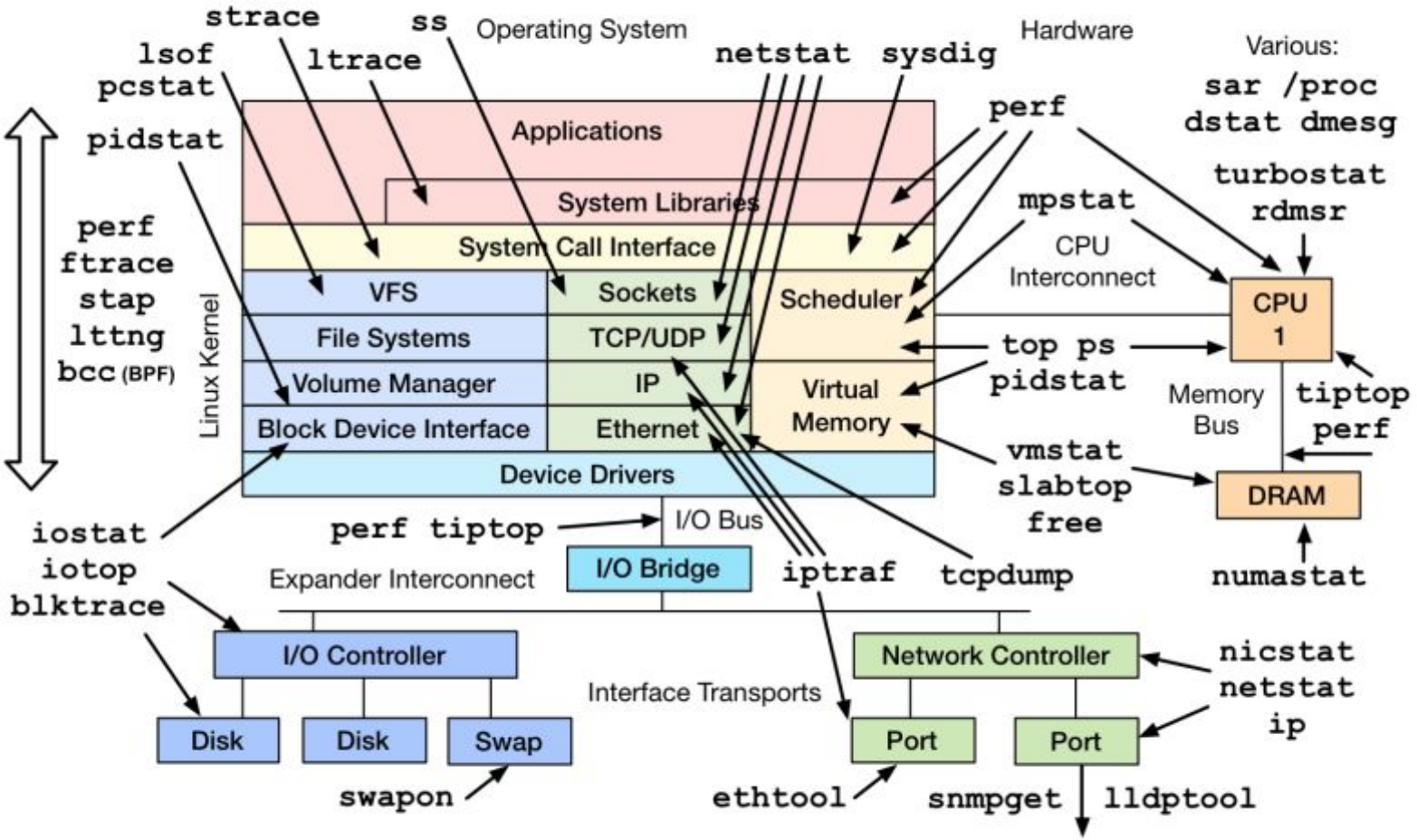
Source code dependencies can only point inwards

(Dependency Injection)

Observability Metrics

- **USE** method (Brendan Gregg)
- For every resource, check
  - **Utilization**: average time that the resource was busy servicing work
    - Example: One disk is running at 90%
  - **Saturation:** the degree to which the resource has extra work which it can't service, often queued
    - Example: The CPUs have an average run queue length of four
  - **Error count** (rate): the count of error events
    - Example: This network interface has had fifty late collisions
- Useful for resources such as queues, CPU's, memory, interconnects, etc

Linux Performance Observability Tools



http://www.brendangregg.com/linuxperf.html 2017

Observability Metrics

RED method (Tom Wilkie)

For every service, check that

- **Request count** (rate)
- **Error count** (rate)
- **Duration**

Are within SLO/A *(service level objectives)*

- Useful for API endpoints

Note:

Observability = Logging + Monitoring + Tracing + Visualization

All good instrumentation libraries monitoring and trending systems (Prometheus, Graphite, etc) have at least three main primitives

- Counter: records events that happen such as incoming requests, bad requests, errors, etc
- Gauge: records things that fluctuate over time such as the size of a threadpool
- Histogram: records observations of scalar quantities of events such as request durations

Optimize for Time to Value

"Today, when organizations measure and optimize their activities, time to value is becoming a dominant metric"

–Adrian Cockcroft, Devops thought leader reknown for architecture work at Netflix and VP of AWS

Kubernetes Setup

Kubernetes can be setup on multiple clouds

- Google(GCP) & Microsoft offer Kubernetes as a service, with reliable experiences
- AWS has two great open source methods, 'Kops' and Heptio's Cloud Formation Script
- Last year AWS added Kubernetes as a Service
- Kubernetes can readily be setup locally, with 'Minikube' or 'kubeadm'

Local Kubernetes

CLASSROOM WORK

Minikube is a option for developing locally, but some features are not available and require a cloud provider.

https://github.com/kubernetes/minikube

Exercise 2.1 Kubernetes Master Installation

CLASSROOM WORK 20 minutes (required)

** This is an important exercise, if this exercise is not completed, you won't be able to run any kubernetes related exercise

1. **Install docker and docker-compose**
2. **Install kubectl**
3. **Install kubeadm**
4. **Install pod networking; Flannel**
5. **Initialize kubelet to create master node**

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.1-install_kube_master.md

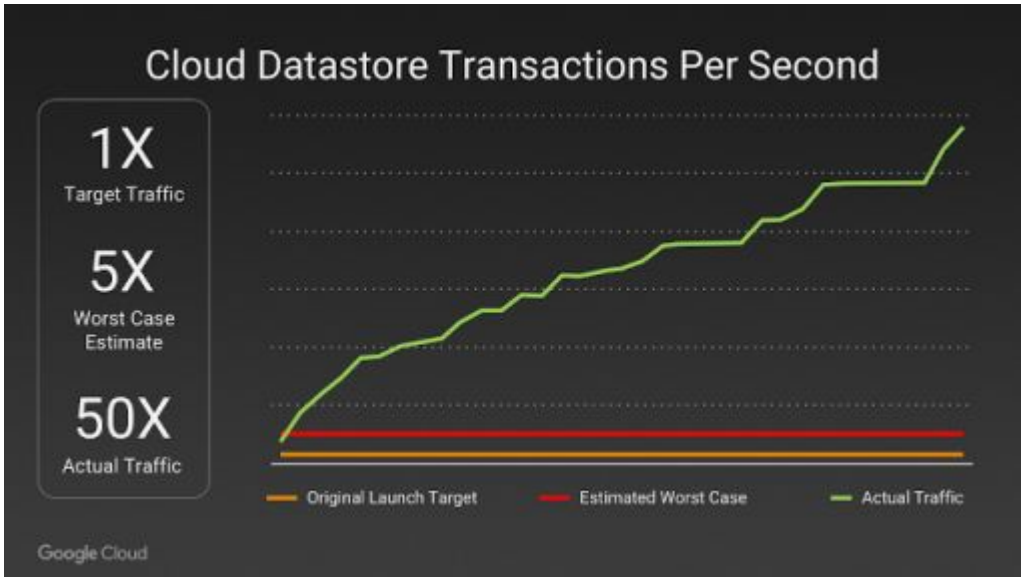
Pokemon Go

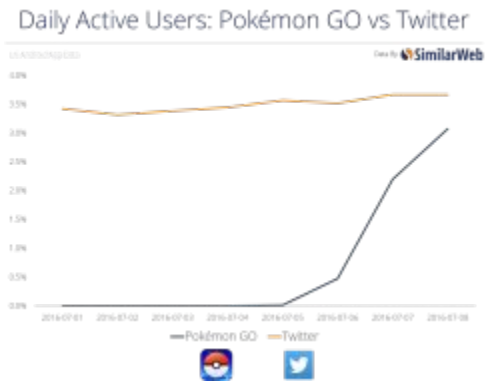
Pokemon Go: Situation

Pokemon Go launched a hit app! The application was a viral, overnight roaring success.

The challenge? It rapidly had 50x the worst case traffic estimate and grew rapidly

- Achieved the same active users in a month that took Twitter years to reach
- Was the most downloaded app in history within a few days





Pokemon Go: Action

Application for the logic ran on Google Container Engine powered by Kubernetes.

- Enabled automation to scale the application to millions of users
- Also enabled upgrading the version of the cluster and load balancer without downtime while millions of players were online

Pokemon Go: Action

Even Google doesn't have unlimited resources and engineers

- Google CRE (Cloud Reliability Engineer team) worked closely with Niantic to review and optimize the architecture.

Pokemon Go used Cloud Datastore, a cloud native NoSQL database.

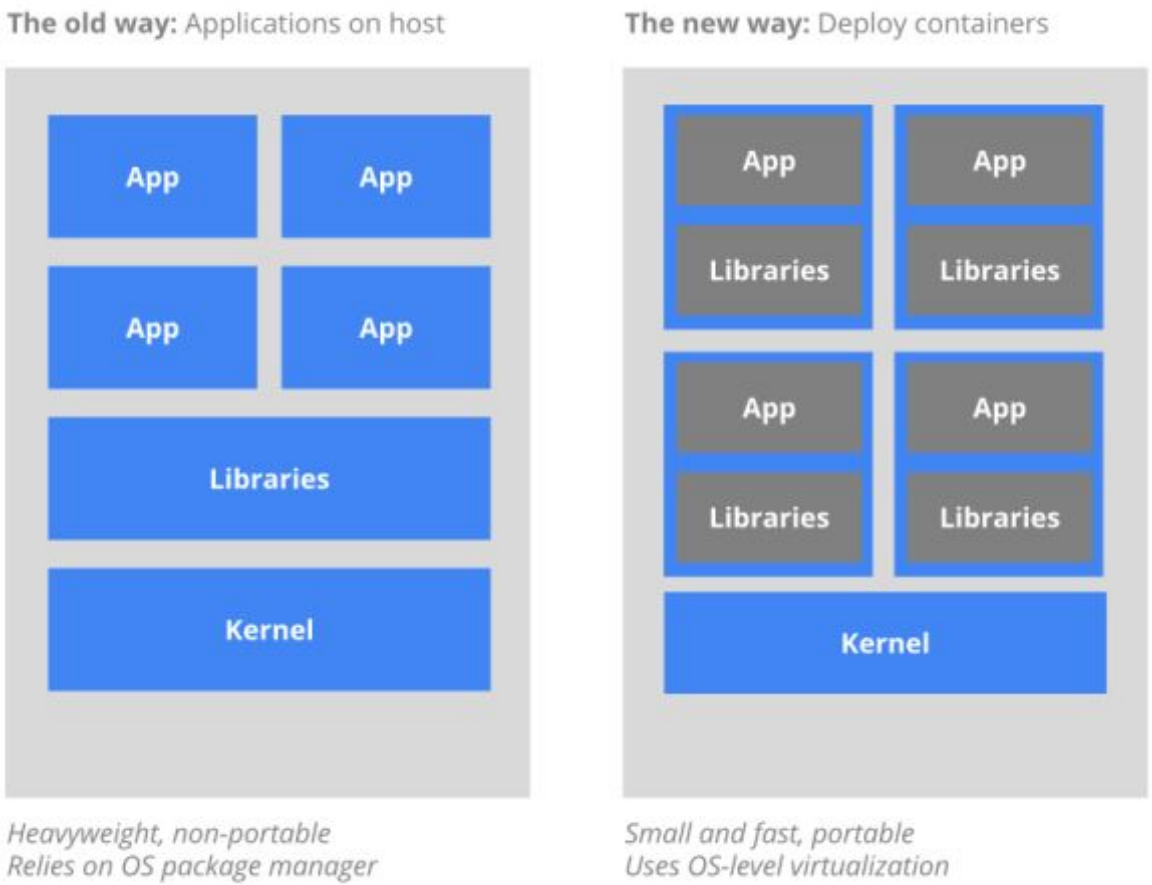
- This enabled the application to scale without the sharding requirements that would have been needed with MySQL or Postgres for example

Pokemon Go: Result

Was able to launch in Japan a mere two weeks after the US launch, where they received 3x the US users without incident.

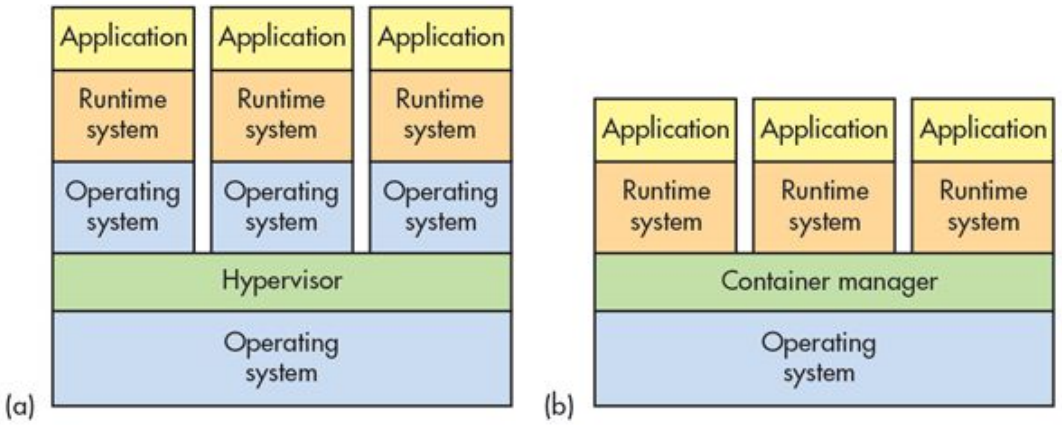
- Was the largest Kubernetes deployment ever, with multitude of bugs identified, fixed and merged into the open source repo
- The cluster ended up utilizing tens of thousands of cores
- Arguably the first successful overnight/viral planet-wide launch
- Was eventually downloaded more than 500 million times and 25 million players at peak
- Inspired users to walk over 5.4 billion miles over the course of a year due to gameplay

Containers


The old way: Applications on host
App
App
App
App
Libraries
Kernel
Heavyweight, non-portable
Relies on OS package manager
The new way: Deploy containers
App
App
Libraries
Libraries
App
App
Libraries
Libraries
Kernel
Small and fast, portable
Uses OS-level virtualization

Container Advantages

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

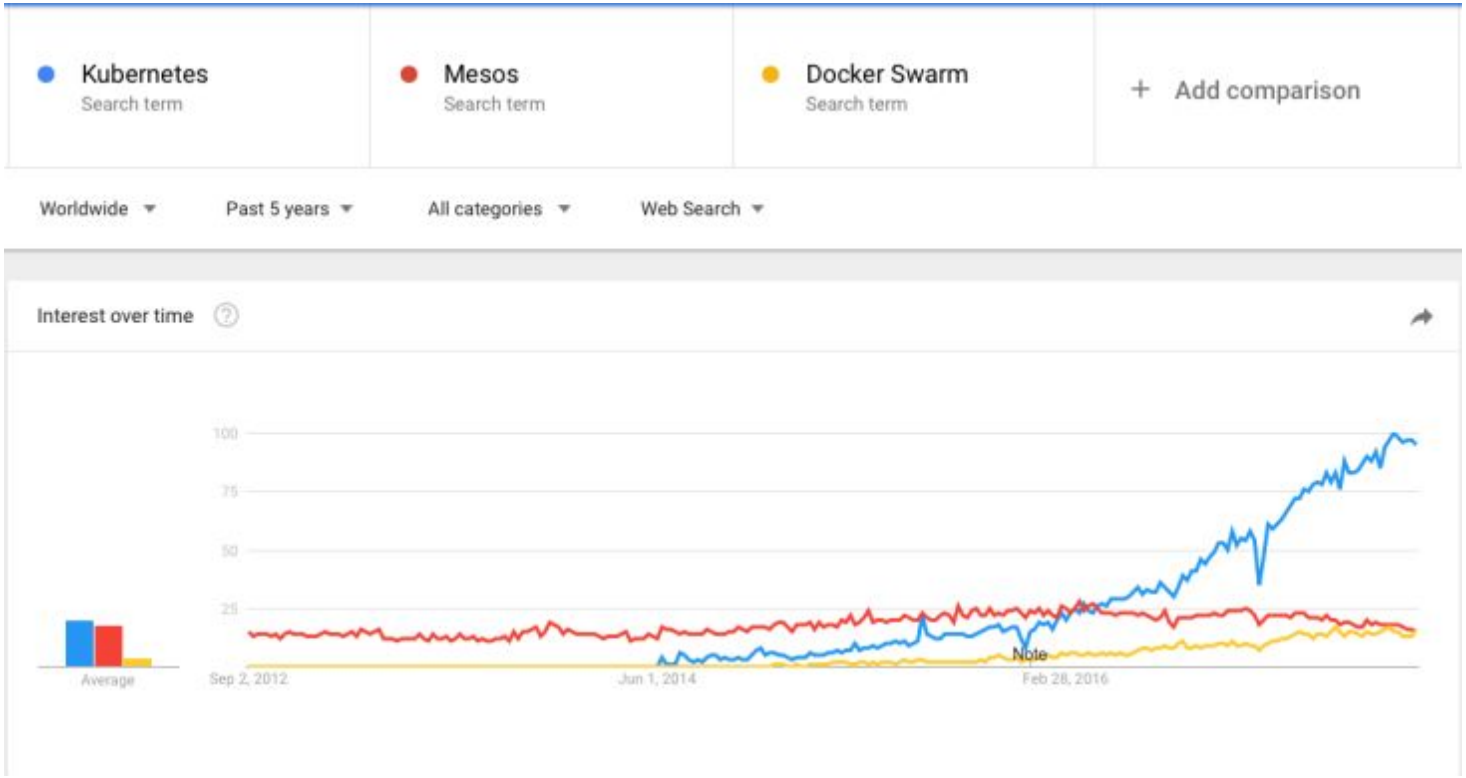


Challenges with multiple containers

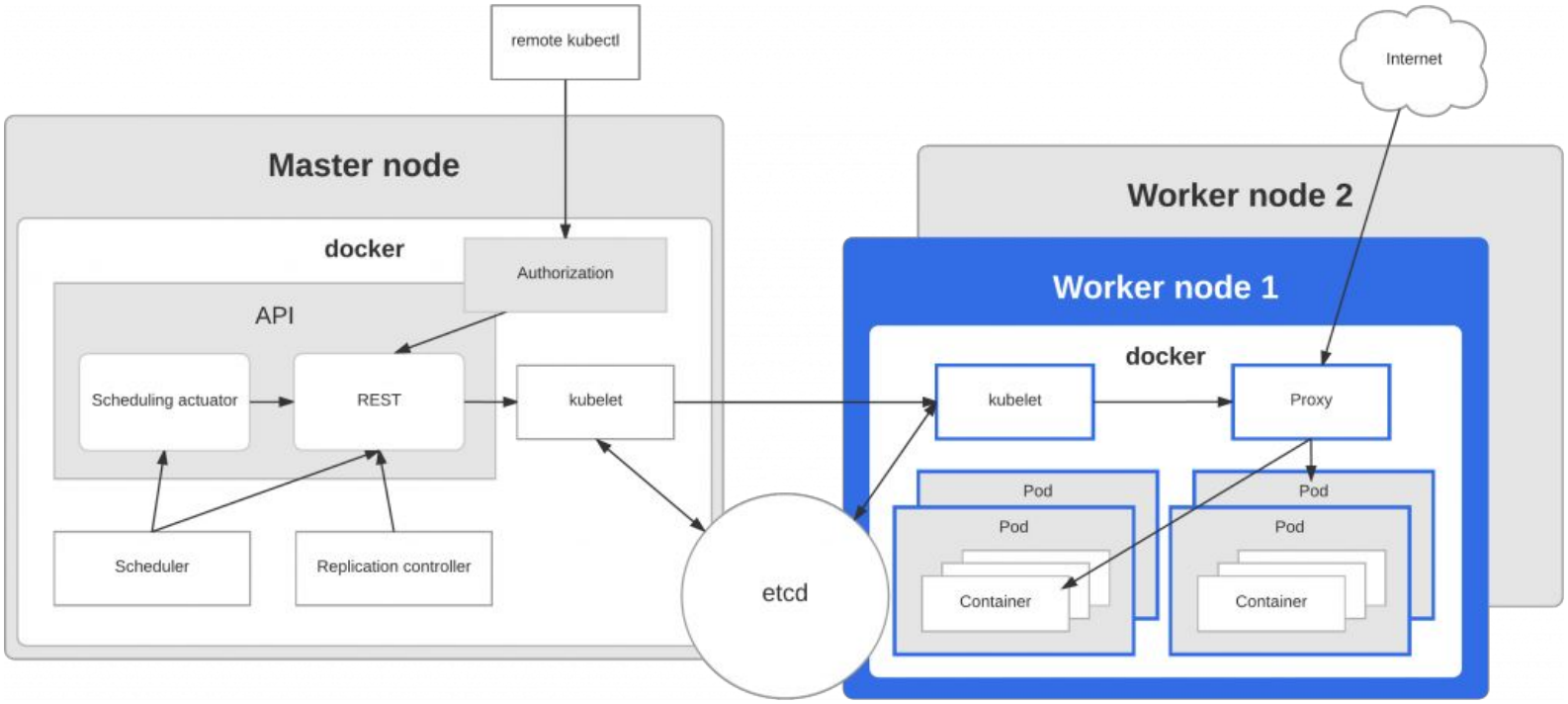
- How to scale?
- Once I scale, where are they?
- How do my containers find each other?
- How should I manage port conflicts?
- What if a host fails?
- How to update them? Health checks?
- How will I track their logs?

Container Orchestration Tools

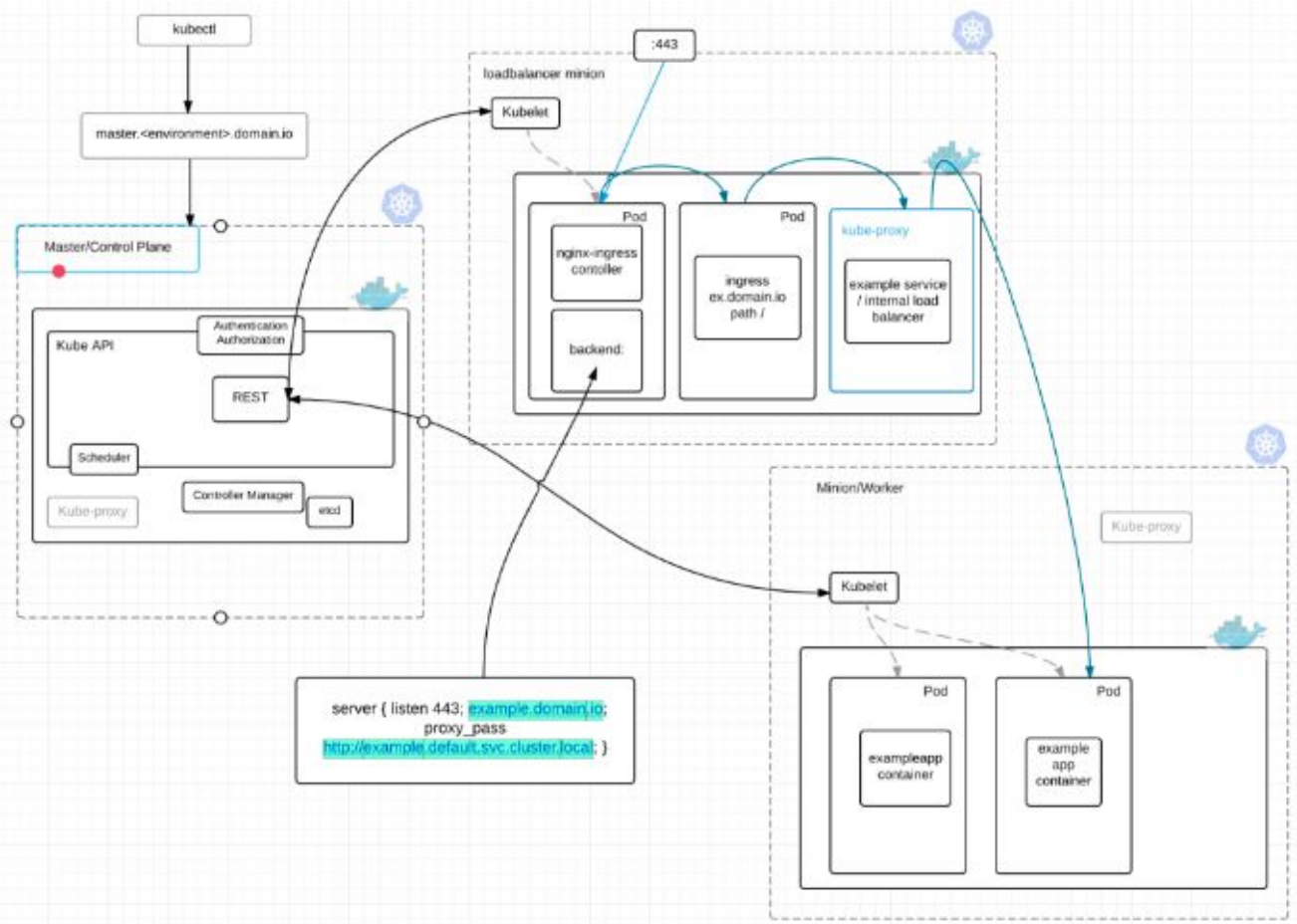
- The three most popular are: Kubernetes, Docker Swarm & Mesos
- Kubernetes has become the unofficial standard



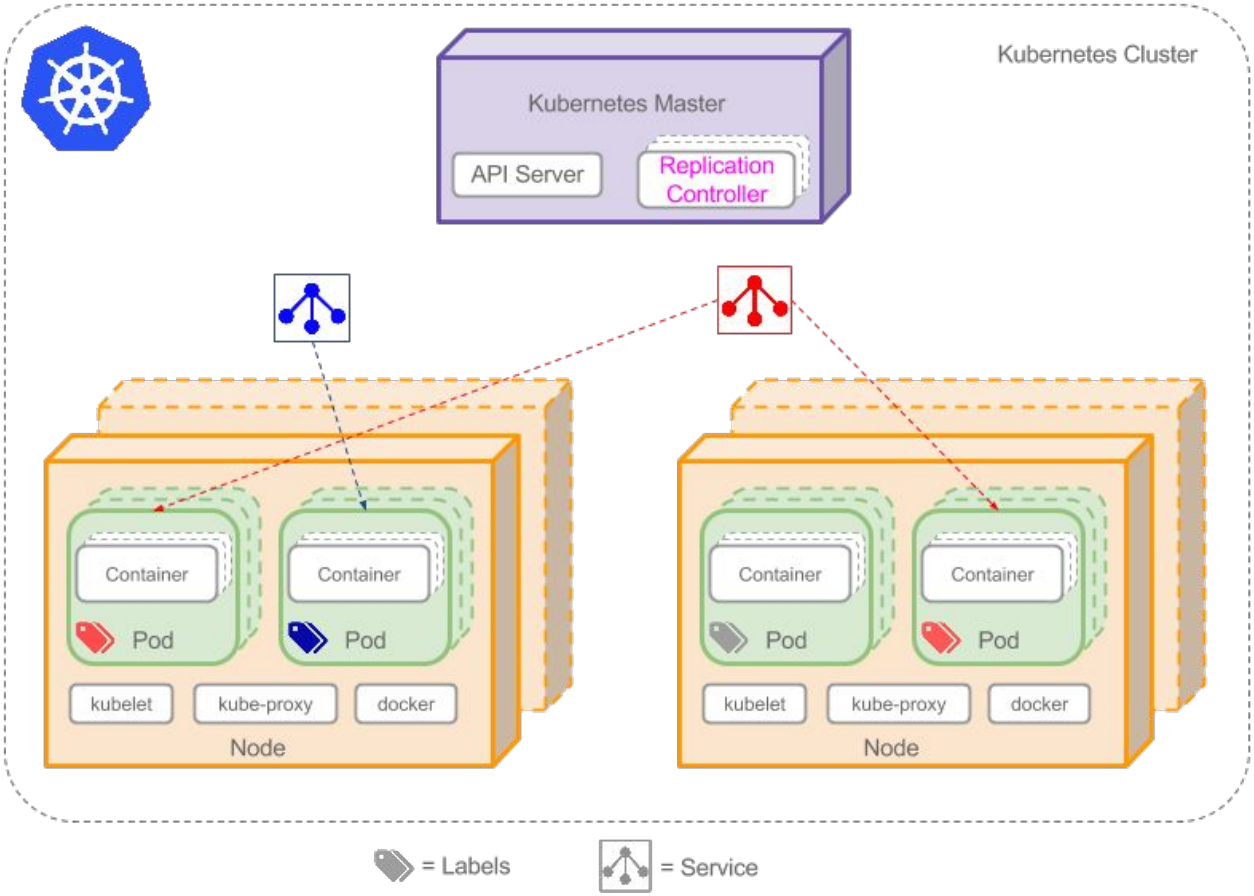
Kubernetes Architecture



K8s Architecture – Networking view



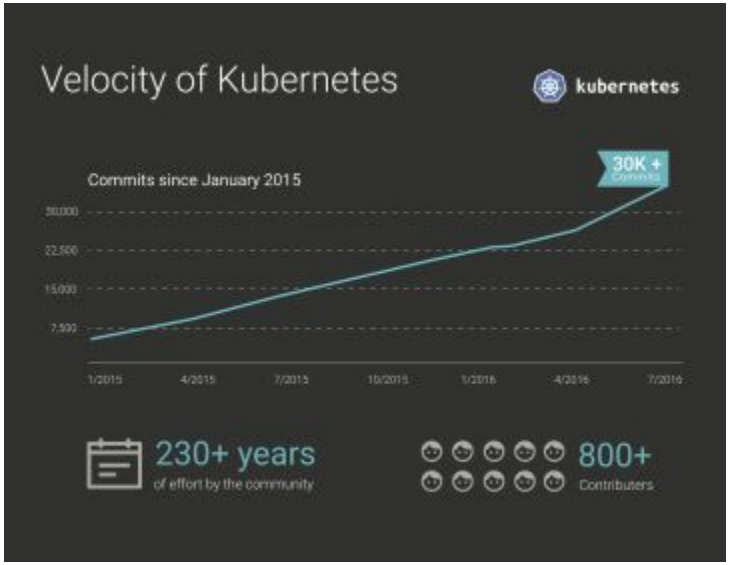
K8s Architecture – Simplified



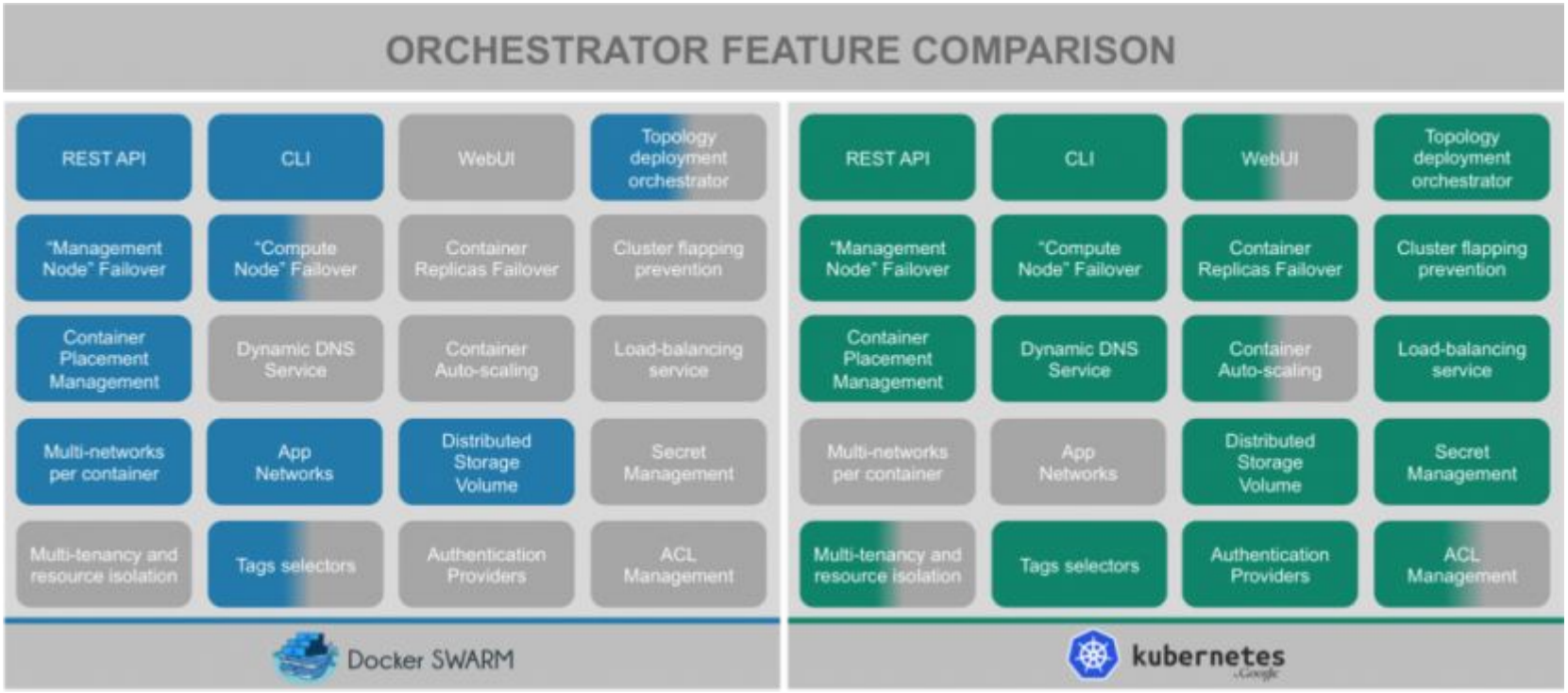
Kubernetes Stats

- Top 100 project by stars
- 22k LinkedIn professionals
- Largest container management ecosystem

Github		
54k+ Commits	280+ Releases	1365+ Contributors
Top 100 Forked Github Project	Top 2 Starred Go Project	Top 0.01% Starred Github Project



Feature Comparison (March 2016)

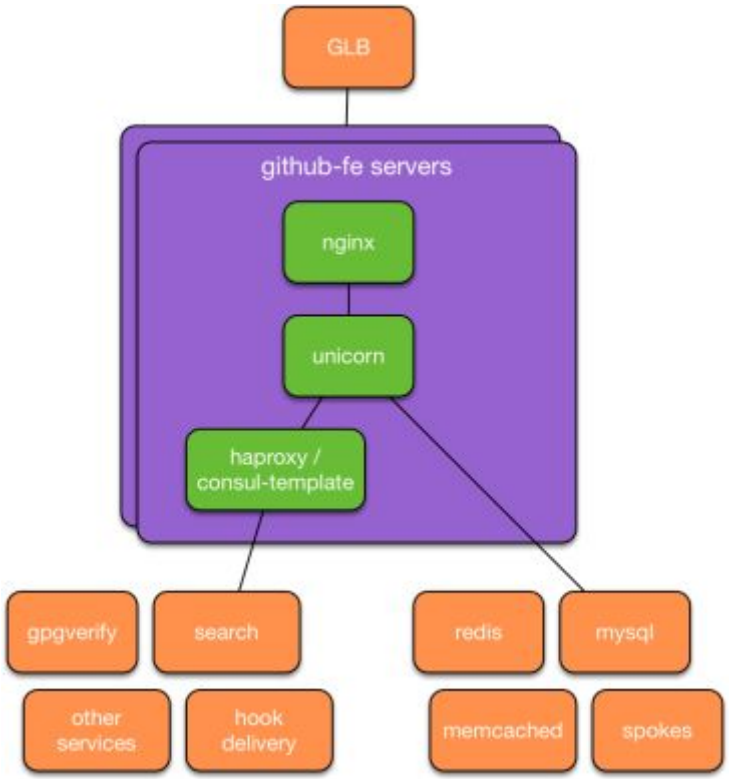


Github

Github: Situation

Written in Ruby with Puppet managed servers, the Github legacy architecture had challenges

- As traffic grew, latency started to increase
- As more GitHubbers came on board, overhead increased
- New services began to take days, weeks or months to deploy
- Increasingly the SRE team began to spend a large percentage of their time on maintenance, not features



Github: Situation

Over time, it because clear that this approach was not scaling. A joint team was formed to evaluate platforms against the following:

- Self Service platform for engineers to enable capacity
- Automate responding to changes in demand so changes can happen in seconds, not hours, days or more
- Insulate applications from differences between development, staging, production, enterprise and other environments

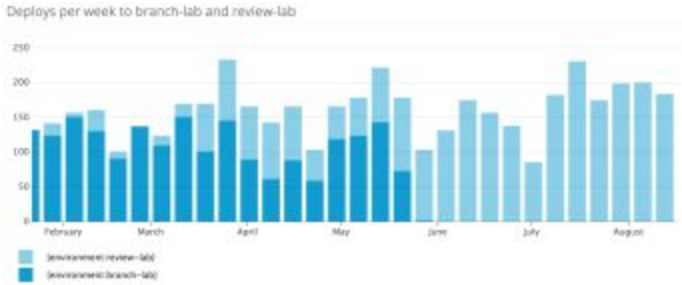
Several properties helped Kubernetes stand out from other platforms

- Vibrant open source community
- First run experience meant a small application was up within hours
- Wealth of information about the experience that motivated the design

Github: Action

Before:
Deploy environments were booked solid during business hours, challenging engineers ability to test their pull requests

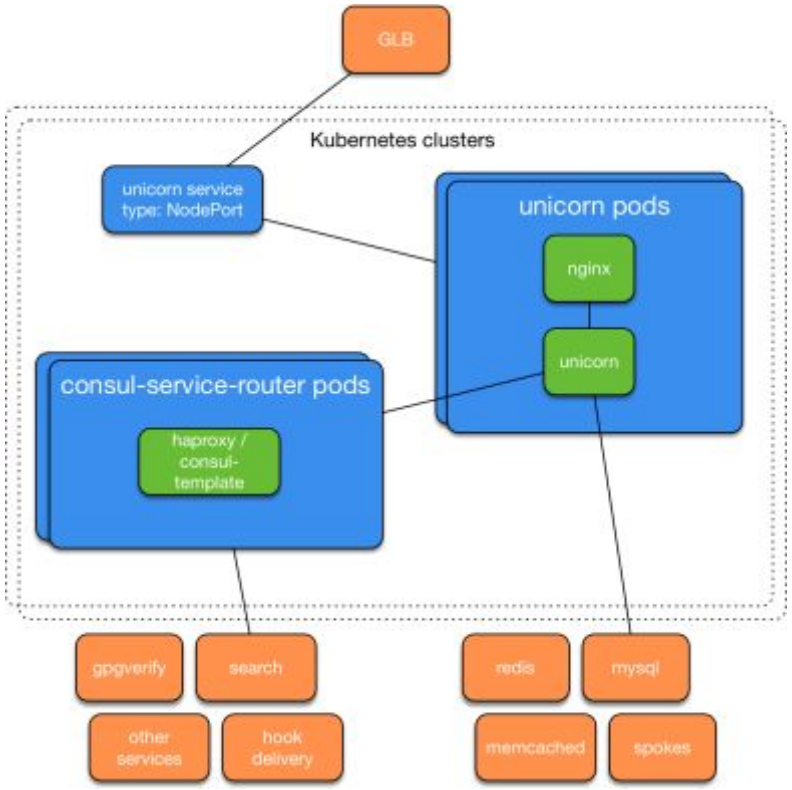
After:
Implemented capability for a chat-based interface for creating isolated deploys of Github for pull requests. This greatly enabled developer throughput as it empowered engineers to self service new environments with their Pull Requests.



Github: Result

Building on their success with the previous Kubernetes deployment, Github began to migrate their front end to Kubernetes

- Migrated from Legacy system to a K8s cluster in AWS to finally a K8s cluster in their data center on bare metal
- Traffic was migrated to the Kubernetes system without incident
- The original goals of self service, responsiveness and scalable environments was achieved
- Engineers have rolled out dozens of projects in a self service manner, and Github's SRE's are focusing more on delivering infrastructure products.
- Github plans to start investigating and moving stateful services to K8s in the future.



Why Kubernetes?

Kubernetes is an open-source system for automating deployment, scaling, and management of containerized applications.

- Co-locating helper processes, facilitating composite applications and preserving the one-application-per-container model
- Mounting storage systems
- Distributing secrets
- Checking application health
- Replicating application instances
- Using Horizontal Pod Autoscaling
- Naming and discovering
- Balancing loads
- Rolling updates
- Monitoring resources
- Accessing and ingesting logs
- Debugging applications
- Providing authentication and authorization
- This provides the simplicity of Platform as a Service (PaaS) with the flexibility of Infrastructure as a Service (IaaS), and facilitates portability across infrastructure providers.

Master Components

- kube-apiserver - Component on the master that exposes the Kubernetes API. It is the front-end for the Kubernetes control plane.
- etcd - Consistent and highly-available key value store used as Kubernetes' backing store for all cluster data
- kube-scheduler - Component on the master that watches newly created pods that have no node assigned, and selects a node for them to run on.
- kube-controller-manager
  - Node Controller: Responsible for noticing and responding when nodes go down.
  - Replication Controller: Responsible for maintaining the correct number of pods for every replication controller object in the system.
  - Endpoints Controller: Populates the Endpoints object (that is, joins Services & Pods).
  - Service Account & Token Controllers: Create default accounts and API access tokens for new namespaces.
- cloud-controller-manager - runs controllers that interact with the underlying cloud providers.

Node Components

- kubelet - An agent that runs on each node in the cluster. It makes sure that containers are running in a pod.
- kube-proxy - kube-proxy enables the Kubernetes service abstraction by maintaining network rules on the host and performing connection forwarding.
- Container Runtime - The container runtime is the software that is responsible for running containers. Kubernetes supports several runtimes: Docker, rkt, runc and any OCI runtime-spec implementation

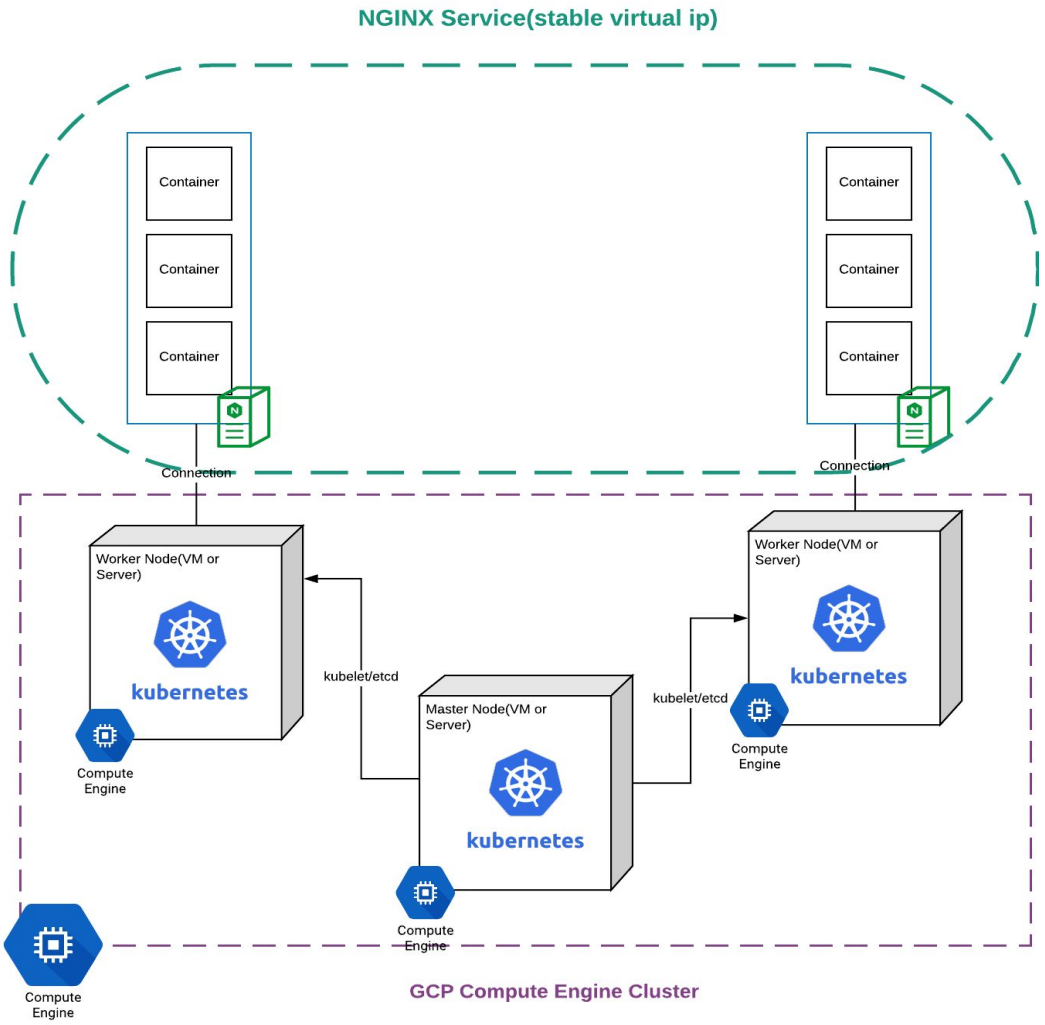
Addons

- DNS - While the other addons are not strictly required, all Kubernetes clusters should have cluster DNS, as many examples rely on it.
- Web UI (Dashboard) - Dashboard is a general purpose, web-based UI for Kubernetes clusters.
- Container Resource Monitoring - Container Resource Monitoring records generic time-series metrics about containers in a central database, and provides a UI for browsing that data.
- Cluster-level Logging - A Cluster-level logging mechanism is responsible for saving container logs to a central log store with search/browsing interface.

Kubernetes Terms

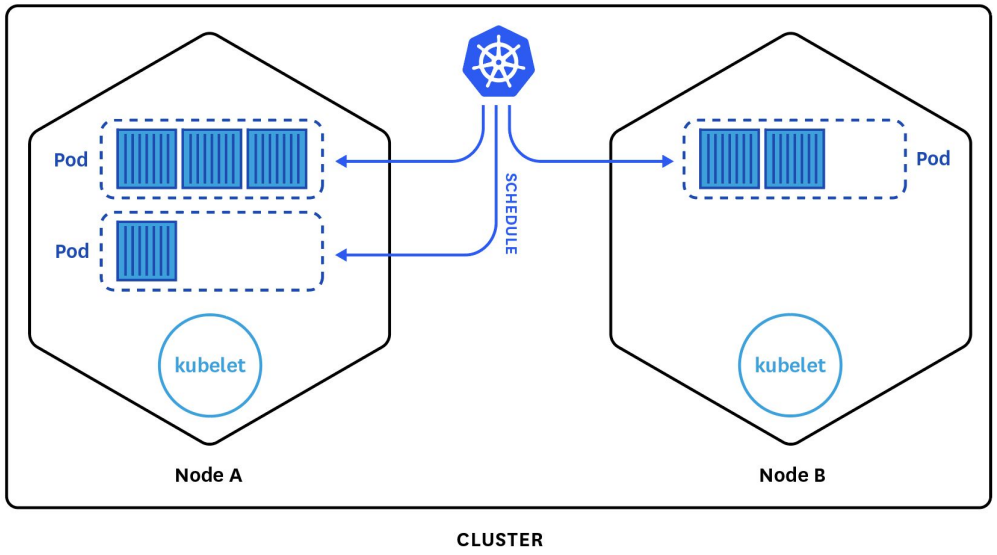
- Containers
- Nodes
- Clusters
- Deployment
- Pods
- ReplicaSets
- Services
- Labels
- Volumes

Kubernetes: Abstraction



Kubernetes: Nodes

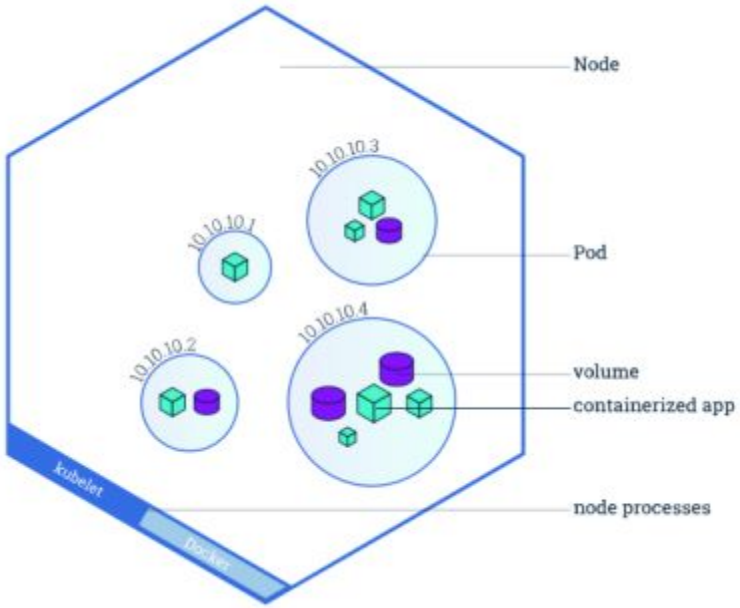
A node is a worker machine in Kubernetes. A node may be a VM or physical machine, depending on the cluster. Each node has the services necessary to run pods and is managed by the master components. The services on a node include Docker, kubelet and kube-proxy. See The Kubernetes Node section in the architecture design doc for more details.



Kubernetes: Nodes

Allows Pods to be scheduled. A basic worker physical or virtual machine of Kubernetes.

- Must be managed by a master
- May host multiple pods
- Internal IP Address endpoint
- Can be tagged and filtered using labels
- Must be running two processes
  - Kubelet – Kubernetes client process. Communicates with master and schedules pods
  - Container runtime – Docker, Rocket, etc. Pulls and runs containers from registry



Kubernetes: Nodes

Node Status

A node status contains:

- Addresses
  - Hostname
  - ExternalIP
  - InternalIP
- Condition - describe condition of nodes.
- Capacity - describe the resources available on the node
- Info - general information about the node

$ kubectl get nodes

```
peter@Azure:~$ kubectl get nodes
NAME                    STATUS                     AGE       VERSION
k8s-agent-743d5653-0    Ready                      21h       v1.6.6
k8s-agent-743d5653-1    Ready                      21h       v1.6.6
k8s-agent-743d5653-2    Ready                      21h       v1.6.6
k8s-master-743d5653-0   Ready,SchedulingDisabled   21h       v1.6.6
```

Note: Afinity & Anti-affinity (Beta) allow further constraints on where a pod may run (coupled, de-coupled, only nodes with certain labels, etc)

Kubernetes: Clusters

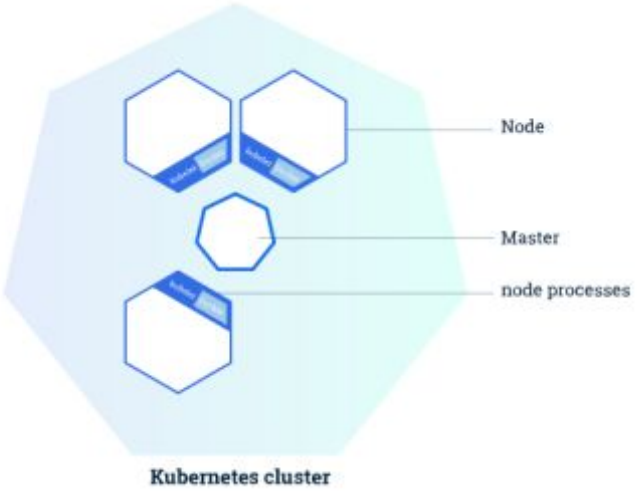
Allows you to deploy containerized applications to a cluster without tying them specifically to individual machines.

Masters

- Coordinates the cluster
  - **Schedules applications**
  - **Maintains application state**
  - **Scales applications**
  - **Rolls out updates**
- Can be duplicated when HA (High Availability is desired.
- Often run as a service by public cloud providers (Azure/Google Kubernetes as a Service)

Nodes

- House workers that run the applications
- Three node minimum for production clusters



Kubernetes: Pods

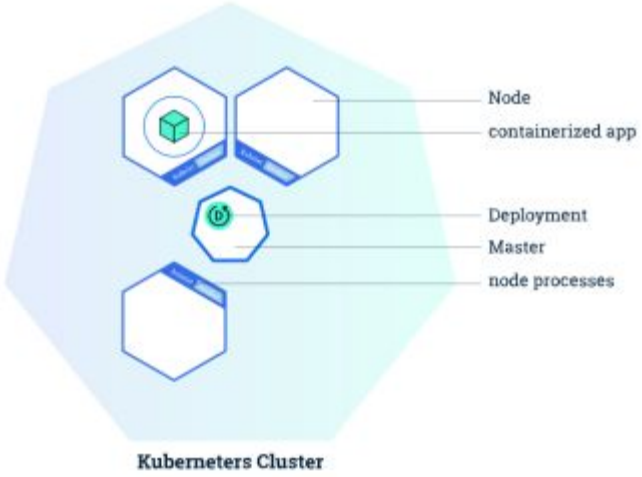
Allows you to create a group of one or more containers and some shared resources for those containers

- Pod Resource Types
  - Networking, as a unique cluster IP address
  - Container information:
    - container image version
    - specific ports
    - Etc
- Atomic unit of Kubernetes
- Tied to node which is it scheduled
- Always co-located and co-scheduled
- Containers in a pod share
  - IP address and port space
  - Filesystem
  - Storage (Volumnes)
  - Labels
  - Secrets

Kubernetes: Deployments

Allows you to deploy a (self-healing) instance of an application.

- **Self Healing: Continuously monitors and replaces instances if necessary**
- **Provides declarative updates for Pods and ReplicaSets**
  - **Updates actual state to desired state at a controlled rate**
  - **For example: Current state, 3 instances of Tomcat. Desired state, 5 instances of Tomcat. -> Create 2 more instances of Tomcat**
- **Relay on declarative manifest to determine intent (i.e. yaml/json file most commonly)**



$ kubectl create

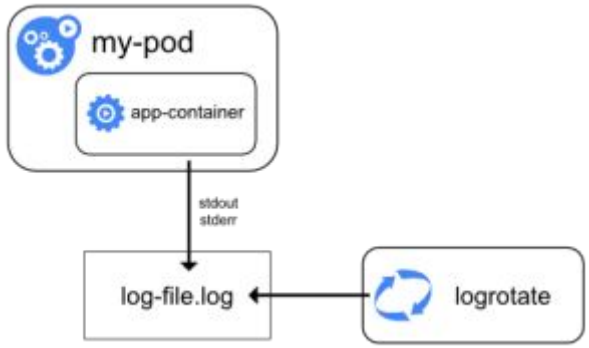
```
peter@Azure:~$ cat pod.yaml
# Copy of pod.yaml without file extension for test
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    name: nginx
spec:
  containers:
  - name: nginx
    image: nginx
    ports:
    - containerPort: 80
peter@Azure:~$ kubectl create -f pod.yaml
pod "nginx" created
peter@Azure:~$ kubectl get pods
NAME      READY     STATUS    RESTARTS   AGE
nginx     1/1       Running   0          17s
```

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.

$ kubectl get pods

```
peter@azure:~$ kubectl get pods
NAME                                READY     STATUS    RESTARTS   AGE
azure-vote-back-3048739398-dtklm    1/1       Running   0          9m
azure-vote-front-837696400-j9jh5    1/1       Running   0          9m
peter@azure:~$ kubectl logs azure-vote-back-3048739398-dtklm
1:C 06 Sep 12:24:58.141 # oooOoooOoooo Redis is starting oooOoooOoooo
1:C 06 Sep 12:24:58.141 # Redis version=4.0.1, bits=64, commit=00000000, modified=0, pid=1, just started
1:C 06 Sep 12:24:58.141 # Warning: no config file specified, using the default config. In order to specify a config file use redis-server /path/to/redis.conf
1:M 06 Sep 12:24:58.143 * Running mode=standalone, port=6379.
1:M 06 Sep 12:24:58.143 # WARNING: The TCP backlog setting of 511 cannot be enforced because /proc/sys/net/core/somaxconn is set to the lower value of 128.
1:M 06 Sep 12:24:58.143 # Server initialized
1:M 06 Sep 12:24:58.143 # WARNING you have Transparent Huge Pages (THP) support enabled in your kernel. This will create latency and memory usage issues with Redis. To fix this issue run the command 'echo never > /sys/kernel/mm/transparent
_hugepage/enabled' as root, and add it to your /etc/rc.local in order to retain the setting after a reboot. Redis must be restarted after THP is disabled.
1:M 06 Sep 12:24:58.143 * Ready to accept connections
```

Note: Logs from pods are readily available with a kubectl logs <podname> command.



Exercise 2.2 Kubernetes Connect

CLASSROOM WORK (15 minutes)

Kubernetes Simple Example

1. Start a deployment (pod will start automatically)
2. Expose deployment as service

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.2-k8s_simple_example.md

** Note – later we will discuss about pods, deployment, service in details. This exercise is just to start running containers, but a lot will be clear in later slides

Kubernetes: ReplicaSets

A **ReplicaSet** ensures that a specified number of pod replicas are running at any other time. If there are too many pods, the ReplicationController terminates the extra pods. If there are too few, the ReplicationController starts more pods. Unlike manually created pods, the pods maintained by a ReplicationController are automatically replaced if they fail, are deleted, or are terminated.

For example, your pods are re-created on a node after disruptive maintenance such as a kernel upgrade. For this reason, you should use a ReplicationController even if your application requires only a single pod. A ReplicationController is similar to a process supervisor, but instead of supervising individual processes on a single node, the ReplicationController supervises multiple pods across multiple nodes.

Kubernetes: Service

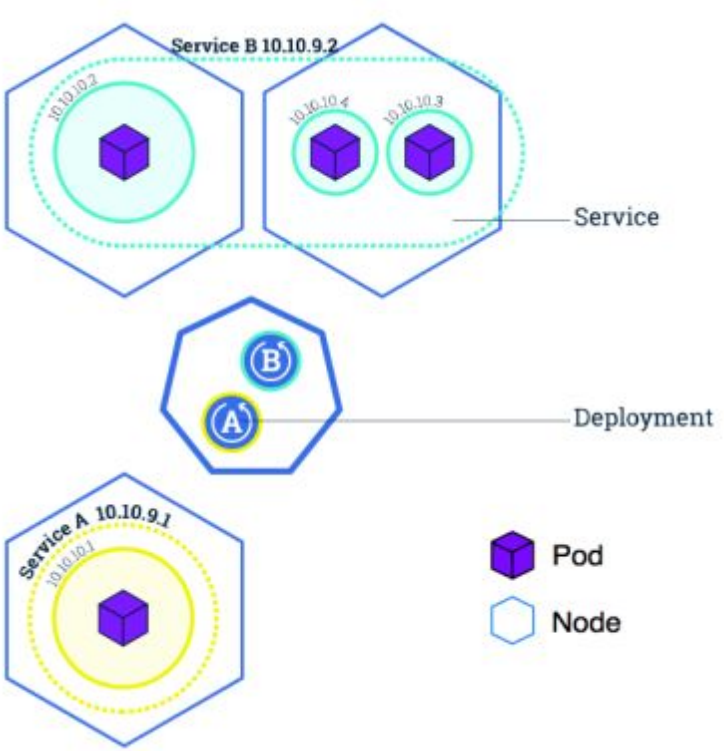
Kubernetes **Pods** are mortal. They are born and when they die, they are not resurrected. **ReplicaSets** in particular create and destroy **Pods** dynamically (e.g. when scaling up or down). While each **Pod** gets its own IP address, even those IP addresses cannot be relied upon to be stable over time. This leads to a problem: if some set of **Pods** (let's call them backends) provides functionality to other **Pods** (let's call them frontends) inside the Kubernetes cluster, how do those frontends find out and keep track of which backends are in that set?

A Kubernetes **Service** is an abstraction which defines a logical set of **Pods** and a policy by which to access them - sometimes called a micro-service. The set of **Pods** targeted by a **Service** is (usually) determined by a **Label Selector** (see below for why you might want a **Service** without a selector).

Kubernetes: Service

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

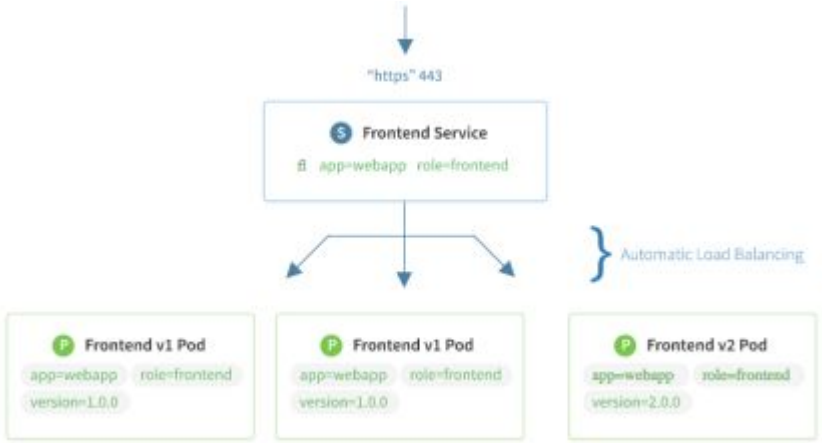
- Abstraction that allows pods to die and replicate in Kubernetes without affecting your application.
- Enable loose coupling between different Pods.
- Provides a **stable** virtual IP and port
- Services allow Pods to receive traffic.
  - Each Pod has a unique IP but those IP addresses are not exposed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



$ kubectl get services

```
peter@Azure:~$ kubectl get services --all-namespaces
NAMESPACE     NAME                   CLUSTER-IP     EXTERNAL-IP   PORT(S)          AGE
default       kubernetes             10.0.0.1       <none>        443/TCP          22h
kube-system   heapster               10.0.74.107    <none>        80/TCP           22h
kube-system   kube-dns               10.0.0.10      <none>        53/UDP,53/TCP    22h
kube-system   kubernetes-dashboard   10.0.69.57     <nodes>       80:31476/TCP     22h
kube-system   tiller-deploy          10.0.103.65    <none>        44134/TCP        22h
```

Note: A component called ‘kube-proxy’ runs on each node and implements a form of virtual IP for services of type other than ‘ExternalName’



Kubernetes Connect

CLASSROOM WORK

Kubernetes 101 **(Part 2 – Run only below section)**

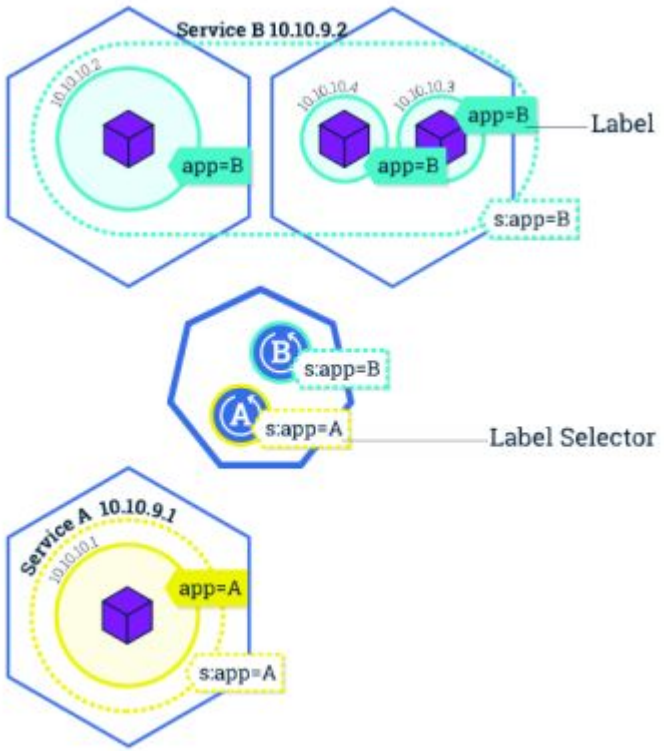
1. Deployments and Replica sets
2. Services
3. Back to Deployments

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.3-k8s_simple_example.md

Kubernetes: Label

Key/Value pairs that can be attached to objects to enable a variety of use cases.

- Designate objects for specific environments such as development, test and production
- Set versions to objects
- Set roles or other arbitrary information to classify objects
- Can be added or modified at any time



Kubernetes Command Line Tool: kubectl

Most common access point for launching workloads on Kubernetes clusters.

- **kubectl [command] [TYPE] [NAME] [flags]**
- Very popular commands
  - **kubectl get** - list resources about a target.
    - kubectl get services
    - kubectl get pods
  - **kubectl describe** - show basic information about a resource
    - Kubectl describe pods my-pod
  - **kubectl logs** - print the logs from a container in a pod. Extremely useful
    - Kubectl logs my-pod
- Also useful:
  - **kubectl exec** - execute a command on a container in a pod
  - **Kubectl top** – Show metrics for a node

$ kubectl get pod –l name=<label>

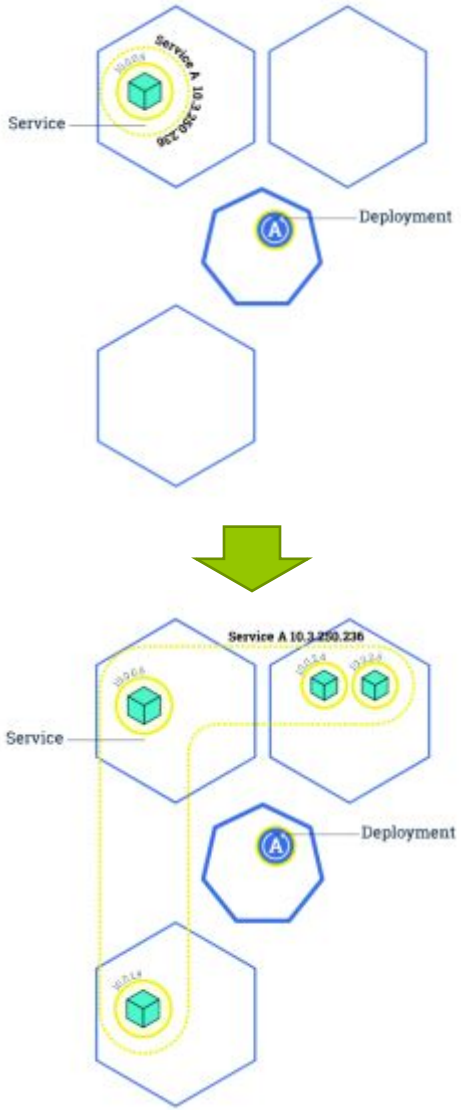
```
peter@Azure:~$ kubectl run nginx --image nginx --port 80
deployment "nginx" created
peter@Azure:~$ kubectl get pods
NAME                     READY     STATUS    RESTARTS   AGE
nginx-158599303-04h8d    1/1       Running   0          4s
peter@Azure:~$ kubectl label pods nginx-158599303-04h8d new-label=awesome
pod "nginx-158599303-04h8d" labeled
peter@Azure:~$ kubectl get pods -l new-label=else
No resources found.
peter@Azure:~$ kubectl get pods -l new-label=awesome
NAME                     READY     STATUS    RESTARTS   AGE
nginx-158599303-04h8d    1/1       Running   0          3m
peter@Azure:~$ kubectl get pods --show-labels
NAME                     READY     STATUS    RESTARTS   AGE       LABELS
nginx-158599303-04h8d    1/1       Running   0          3m        new-label=awesome,pod-template-hash=158599303,run=nginx
```

Note: Best mechanism to organize Kubernetes objects

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



$ kubectl scale deployments/<deployment> --replicas=<new num>

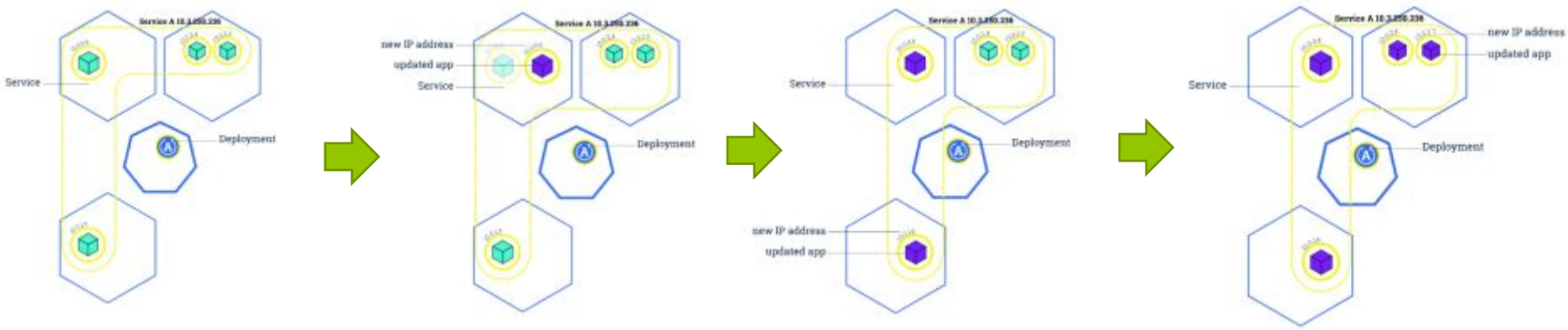
```
peter@Azure:~$ kubectl run nginx --image nginx --port 80
deployment "nginx" created
peter@Azure:~$
peter@Azure:~$ kubectl get deployments
NAME      DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx     1         1         1            1           39s
peter@Azure:~$ kubectl scale deployments/nginx --replicas=2
deployment "nginx" scaled
peter@Azure:~$ kubectl get deployments
NAME      DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx     2         2         2            1           1m
```

Note: Make sure to delete the deployments or replicasets when trying to clear out pods. Many a new user has repeated deleted pods and gotten frustrated when they respawn (as the deployments/replicasets are programed to do).

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



$ kubectl set image <deployment> <new-image>

```
peter@Azure:~$ kubectl run nginx --image nginx:1.12.1 --port 80
deployment "nginx" created
peter@Azure:~$ kubectl set image deployments/nginx nginx=nginx:latest
deployment "nginx" image updated
peter@Azure:~$ kubectl describe deployment nginx
Name:                   nginx
Namespace:              default
CreationTimestamp:      Fri, 15 Sep 2017 13:08:50 +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:  1 max unavailable, 1 max surge
Pod Template:
  Labels:       run=nginx
  Containers:
   nginx:
    Image:              nginx:latest
    Port:               80/TCP
    Environment:        <none>
    Mounts:             <none>
  Volumes:              <none>
Conditions:
  Type          Status  Reason
  ----          ------  ------
  Available     True    MinimumReplicasAvailable
OldReplicaSets: <none>
NewReplicaSet:  nginx-2688028062 (1/1 replicas created)
Events:
  FirstSeen     LastSeen        Count   From                    SubObjectPath   Type            Reason                  Message
  ---------     --------        -----   ----                    -------------   --------        ------                  -------
  32s           32s             1       deployment-controller                   Normal          ScalingReplicaSet       Scaled up replica set nginx-1295584306 to 1
  10s           10s             1       deployment-controller                   Normal          ScalingReplicaSet       Scaled up replica set nginx-2688028062 to 1
  10s           10s             1       deployment-controller                   Normal          ScalingReplicaSet       Scaled down replica set nginx-1295584306 to 0
```

Note: Rolling updates can also be undone (see next slide)

$ kubectl rollout undo <deployment>

```
peter@Azure:~$ kubectl rollout undo deployments/nginx
deployment "nginx" rolled back
peter@Azure:~$ kubectl describe deployments/nginx
Name:                   nginx
Namespace:              default
CreationTimestamp:      Fri, 15 Sep 2017 13:36:49 +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:  1 max unavailable, 1 max surge
Pod Template:
  Labels:       run=nginx
  Containers:
   nginx:
    Image:              nginx:1.12.1
    Port:               80/TCP
    Environment:        <none>
    Mounts:             <none>
  Volumes:              <none>
Conditions:
  Type          Status  Reason
  ----          ------  ------
  Available     True    MinimumReplicasAvailable
OldReplicaSets: <none>
NewReplicaSet:  nginx-1295584306 (1/1 replicas created)
Events:
  FirstSeen     LastSeen        Count   From                    SubObjectPath   Type            Reason              Message
  ---------     --------        -----   ----                    -------------   --------        ------              -------
  1m            1m              1       deployment-controller                   Normal          ScalingReplicaSet   Scaled up replica set nginx-2688028062 to 1
  1m            1m              1       deployment-controller                   Normal          ScalingReplicaSet   Scaled down replica set nginx-1295584306 to 0
  1m            10s             2       deployment-controller                   Normal          ScalingReplicaSet   Scaled up replica set nginx-1295584306 to 1
  10s           10s             1       deployment-controller                   Normal          DeploymentRollback  Rolled back deployment "nginx" to revision 1
  10s           10s             1       deployment-controller                   Normal          ScalingReplicaSet   Scaled down replica set nginx-2688028062 to 0
```

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

Exercise – 2.5 (RC, RS, Deploy)
20 minutes

- Exercise to create Replication Controllers, Replica Sets and Deployments and describe their functions
- Check the results and describe the objects

- sudo su –
- You already have the cloned the github project [https://github.com/techtown-training/microservices-bootcamp.git]
- Navigate to 'exercise/src_code/kubernetes_additional_exercise/ex2.5/' – for all config files required for this exercise
- Exercise instruction:-

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.5-rs_rc_deploy.md

Exercise – 2.6 (Pods, Deploy, Services) 15 minutes

- For all the concepts discussed until now
- Create pods, Services, Deployments
- Various ways to use the create command

We already have the git repo cloned in our machines.

Navigate to ‘exercise/src_code/kubernetes_additional_exercise/ex2.6/’ – for all config files required for this exercise

Exercise instruction:-

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.6-pod_deploy_service.md

Exercise – 2.7 (Kubernetes Labels)
15 minutes

- Create a series of pods with different labels
- Query the pods based on various labels
- Delete pods based on certain selectors

We already have the git repo cloned in our machines.

- Navigate to ‘exercise/src_code/kubernetes_additional_exercise/ex2.7/’ – for all config files required for this exercise
- Exercise instruction:-

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise2.7-label_usage.md

Ref:- https://www.linkedin.com/learning/learning-kubernetes/next-steps

Kubernetes at Box

Box: Situation

"In the summer of 2014, Box was feeling the pain of a decade's worth of hardware and software infrastructure that wasn't keeping up with the company's needs"

- 50 Million users, including several large enterprises such as General Electric
- Originally a PHP monolith of millions of lines of code
- Primarily hosted on bare metal within their own data centers
- Early adopter of Puppet representing one of its largest implementations
- Customer pressure to host workloads and data on every major cloud
- Was taking more than six months to deploy a new microservice

Box: Action

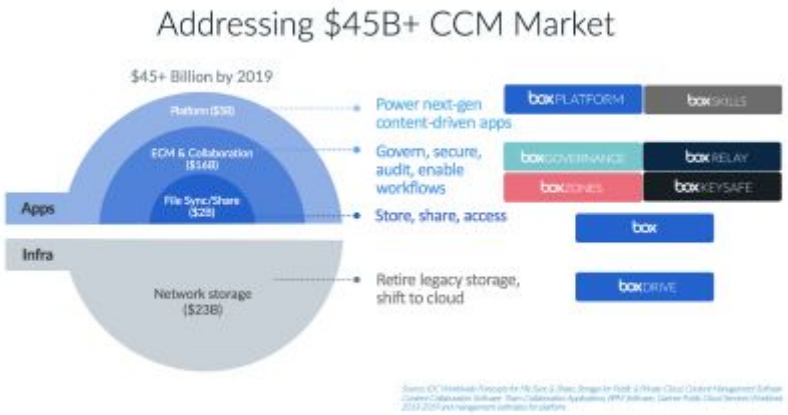
Box was an early adopter in Kubernetes. Working with the open source and contributing to the very early versions.

- Was initially attracted to the design documentation and influence from Google's experience with Borg, a bare metal container orchestration platform
- Also enjoyed the shared API primitives such as pods, services, and deployments that other PaaS layers such as OpenShift and Deis were building on top of.
- "There was clearly a pent-up demand for a better way of building software through microservices, and the increase in agility helped our developers be more productive and make better architectural choices."

Box: Result

Kubernetes at Box represented a shift towards cloud native development techniques

- "Kubernetes, and cloud native in general, represents a pretty big paradigm shift, and it's not very incremental"
- "We're essentially making this pitch that Kubernetes is going to solve everything because it does things the right way and everything is just suddenly better"
- Microservices have decreased to taking less than five days to deploy (from six months), and have the goal to getting that number under an hour



Kubernetes cheat sheet

Creating Objects

Kubernetes manifests can be defined in json or yaml. The file extension `.yaml`, `.yml`, and `.json` can be used.

```
$ kubectl create -f ./my-manifest.yaml           # create resource(s)
$ kubectl create -f ./my1.yaml -f ./my2.yaml     # create from multiple files
$ kubectl create -f ./dir                        # create resource(s) in all manifest files in dir
$ kubectl create -f https://git.io/vPieo         # create resource(s) from url
$ kubectl run nginx --image=nginx                # start a single instance of nginx
$ kubectl explain pods,svc                       # get the documentation for pod and svc manifests
```

Viewing, Finding Resources

```
# Get commands with basic output
$ kubectl get services                          # List all services in the namespace
$ kubectl get pods --all-namespaces             # List all pods in all namespaces
$ kubectl get pods -o wide                      # List all pods in the namespace, with more details
$ kubectl get deployment my-dep                 # List a particular deployment

# Describe commands with verbose output
$ kubectl describe nodes my-node
$ kubectl describe pods my-pod

$ kubectl get services --sort-by=.metadata.name # List Services Sorted by Name
```

Deleting Resources

```
$ kubectl delete -f ./pod.json                      # Delete a pod using the type and name specified in pod.json
$ kubectl delete pod,service baz foo                # Delete pods and services with same names "baz" and "foo"
$ kubectl delete pods,services -l name=myLabel      # Delete pods and services with label name=myLabel
$ kubectl -n my-ns delete po,svc --all              # Delete all pods and services in namespace my-ns
```

Kubernetes: Volumes

On-disk files in a container are the simplest place for an application to write data, but this approach has drawbacks. The files are lost when the container crashes or stops for any other reason. Furthermore, files within a container are inaccessible to other containers running in the same Pod. The Kubernetes Volume abstraction addresses both of these issues.

- A directory accessible to all containers in a pod
- Volumes out live containers that run within a pod
- May be passed between pods
- Data is preserved across container restarts

Kubernetes: Volumes

```
peter@Azure:~$ kubectl exec sharevol -c c1 -i -t -- bash
[root@sharevol /]# mount | grep xchange
/dev/sda1 on /tmp/xchange type ext4 (rw,relatime,discard,data=ordered)
[root@sharevol /]# echo 'some data' > /tmp/xchange/data
[root@sharevol /]# exit
exit
peter@Azure:~$ kubectl exec sharevol -c c2 -i -t -- bash
[root@sharevol /]# mount | grep /tmp/data
/dev/sda1 on /tmp/data type ext4 (rw,relatime,discard,data=ordered)
[root@sharevol /]# cat /tmp/data/data
some data
[root@sharevol /]#
```

Note: Volumes are based on a wide assortment of underlying storage provides. Every major public cloud (including Azure) has several options for volume storage

Kubernetes: Persistent Volumes

Persistent storage in a cluster

Managing storage is a distinct problem from managing compute. The PersistentVolume subsystem provides an API for users and administrators that abstracts details of how storage is provided from how it is consumed.

A PersistentVolume (PV) is a piece of storage in the cluster that has been provisioned by an administrator. It is a resource in the cluster just like a node is a cluster resource. PVs are volume plugins like Volumes, but have a lifecycle independent of any individual pod that uses the PV. This API object captures the details of the implementation of the storage, be that NFS, iSCSI, or a cloud-provider-specific storage system.

Kubernetes: Persistent Volumes

Persistent storage in a cluster

- Separate to **PersistentVolumeClaim**, which is a request for storage.
- May be created ahead of time in a static manner for use by a cluster
- May be created dynamically from available, unclaimed resources
- May be freed and passed from user to user so care should be taken to delete contents when done with use
- Critical for Stateful containers

Exercise 3.1 Wordpress on Kubernetes

CLASSROOM WORK 30 minutes

1. **Create persistent volume**
2. **Create secret for MySQL password**
3. **Launch Wordpress**

Source code:
https://github.com/techtown-training/kubernetes-intro/tree/master/exercise/src_code/kubernetes_additional_exercise/ex3.1

Step by step instruction
https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise3.1-create_pv.md

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise3.1-create_volumes.md

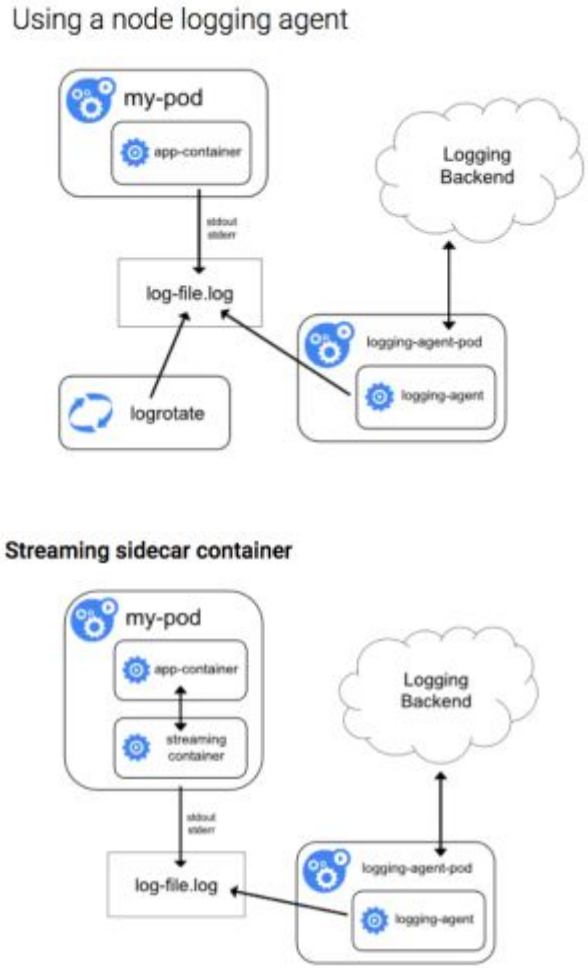
Introduction to Kubernetes

Part 2:

Kubernetes: Logging

Aggregate, access and print logs from containers

- Logs can be accessed from a currently run container or any number or previously run containers, accessed by container name
- Containerized apps write logs to stdout and stderr
- Cluster level logging can be performed using several different techniques including node level agents, container sidecars, or even having containers push directly to an application
- Node level logging is the most common approach, typically using Elasticsearch.



Kubernetes: Logging

```
peter@Azure:~$ kubectl create -f https://raw.githubusercontent.com/mhausenblas/kbe/master/specs/logging/pod.yaml
W1009 12:28:03.089702     121 factory_object_mapping.go:423] Failed to download OpenAPI (the server could not find the requested resource), falling b
ack to swagger
pod "logme" created
peter@Azure:~$ kubectl logs --tail=5 logme -c gen
Mon Oct 9 12:28:18 UTC 2017
Mon Oct 9 12:28:19 UTC 2017
Mon Oct 9 12:28:19 UTC 2017
Mon Oct 9 12:28:20 UTC 2017
Mon Oct 9 12:28:20 UTC 2017
peter@Azure:~$ kubectl logs -f --since=10s logme -c gen
```

```
peter@Azure:~$ kubectl create -f https://raw.githubusercontent.com/mhausenblas/kbe/master/specs/logging/oneshotpod.yaml
W1009 12:46:45.895922     139 factory_object_mapping.go:423] Failed to download OpenAPI (the server could not find the requested resource), falling b
ack to swagger
pod "oneshot" created
peter@Azure:~$ kubectl logs -p oneshot -c gen
9
8
7
6
5
4
3
2
1
```

Note: An external system can perform the log rotation by calling logrotate, which would result in kubectl logs returning an empty result

Kubernetes: Stateful Sets

Stateful Sets manage the deployment and scaling of a set of Pods, and provides guarantees about the ordering and uniqueness of these Pods.

Like a Deployment, a **Stateful Set** manages Pods that are based on an identical container spec. Unlike a Deployment, a StatefulSet maintains a sticky identity for each of their Pods. These pods are created from the same spec, but are not interchangeable: each has a persistent identifier that it maintains across any rescheduling.

A StatefulSet operates under the same pattern as any other Controller. You define your desired state in a StatefulSet object, and the StatefulSet controller makes any necessary updates to get there from the current state.

Kubernetes: Stateful Sets

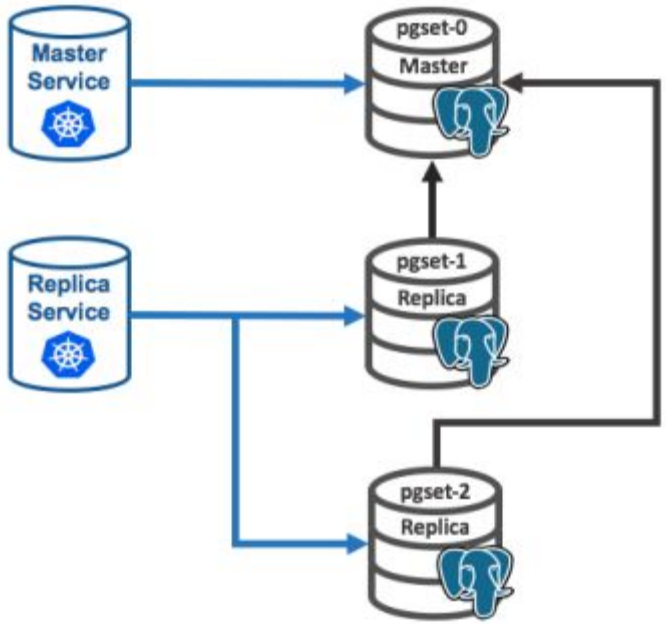
StatefulSets are valuable for applications that require one or more of the following:

- Stable, unique network identifiers.
- Stable, persistent storage.
- Ordered, graceful deployment and scaling.
- Ordered, graceful deletion and termination.
- Ordered, automated rolling updates.

Kubernetes: Stateful Sets

Functionality of deployments with guarantees about ordering and unique identities per Pod.

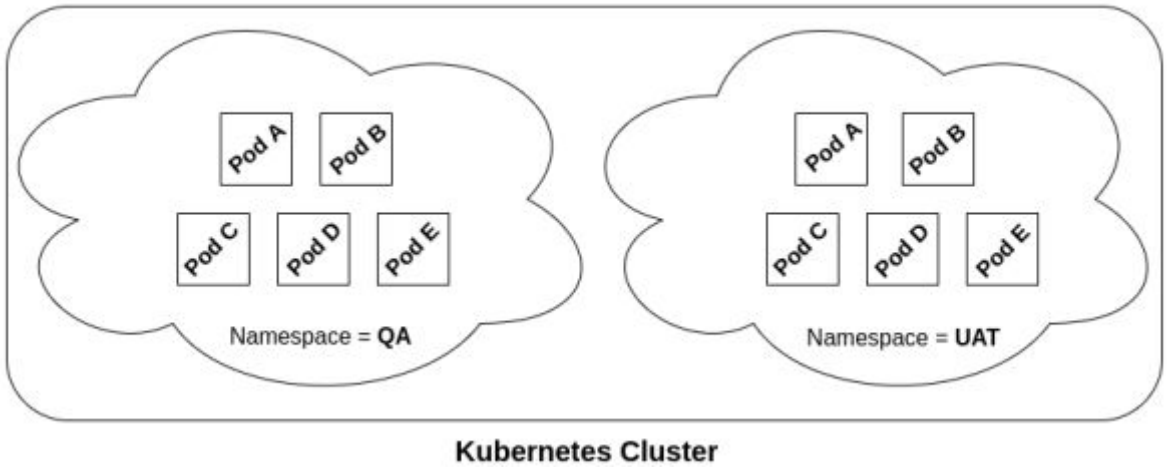
- Pods in a stateful set are not interchangeable
- Each Pod has a persistent identifier
- Define desired state object, controller performs updates to desired state
- Useful for applications that require persistent storage, unique network identifiers, ordered deployment, deletes or updates.



Kubernetes: Namespace

Partitions the names of API objects

- Resources are segmented within namespaces
  - Sandbox per developer for example
- Pods will route dns to default (own) namespace
  - api.default.svc.cluster.local
  - Api.foo…
- The same app could run independently in different namespaces



Kubernetes: Namespace

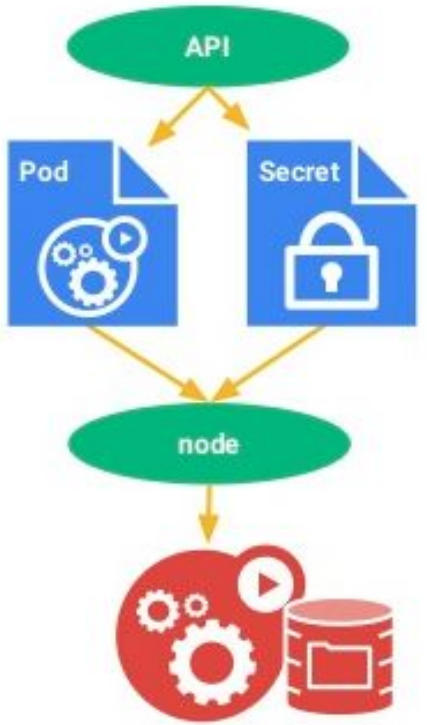
```
peter@Azure:~$ kubectl get ns
NAME          STATUS    AGE
default       Active    23d
kube-public   Active    23d
kube-system   Active    23d
peter@Azure:~$ kubectl create -f https://raw.githubusercontent.com/mhausenblas/kbe/master/specs/ns/ns.yaml
W1006 13:59:41.630630     134 factory_object_mapping.go:423] Failed to download OpenAPI (the server could not find the requested resource), falling back to swagger
namespace "test" created
peter@Azure:~$ kubectl get ns
NAME          STATUS    AGE
default       Active    23d
kube-public   Active    23d
kube-system   Active    23d
test          Active    19s
peter@Azure:~$ kubectl create --namespace=test -f https://raw.githubusercontent.com/mhausenblas/kbe/master/specs/ns/pod.yaml
W1006 14:00:18.027941     145 factory_object_mapping.go:423] Failed to download OpenAPI (the server could not find the requested resource), falling back to swagger
pod "podintest" created
peter@Azure:~$ kubectl get pods --namespace=test
NAME         READY     STATUS              RESTARTS   AGE
podintest    0/1       ContainerCreating   0          11s
```

Note: Namespaces create an excellent mechanism to subdivide resources and provide isolation. This enables using a cluster for multiple projects or multiple teams

Kubernetes: Secrets

An object that contains a small amount of sensitive data such as a password, token or key.

- According to 12-factor configuration comes from the environment
  - Config is everything that is likely to vary between deployments
- Can be used by pods and the underlying Kubelet when pulling images
- Secrets belong to a specific Kubernetes Namespace
- Secret size cannot exceed 1MB



Kubernetes: Secrets

```
peter@Azure:~/secret$ echo -n "A19fh68B001j" > ./apikey.txt
peter@Azure:~/secret$ ls
apikey.txt  config.json  vault
peter@Azure:~/secret$ kubectl create secret generic apikey --from-file=./apikey.txt
secret "apikey" created
peter@Azure:~/secret$ kubectl describe secrets/apikey
Name:         apikey
Namespace:    default
Labels:       <none>
Annotations:  <none>

Type:  Opaque

Data
====
apikey.txt:  12 bytes
peter@Azure:~/secret$ kubectl create -f https://raw.githubusercontent.com/mhausenblas/kbe/master/specs/secrets/pod.yaml
W1103 11:54:36.624294     136 factory_object_mapping.go:423] Failed to download OpenAPI (the server could not find the requested
 resource), falling back to swagger
pod "consumesec" created
peter@Azure:~/secret$ kubectl exec consumesec -c shell -i -t -- bash
[root@consumesec /]# mount | grep apikey
tmpfs on /tmp/apikey type tmpfs (ro,relatime)
[root@consumesec /]# cat /tmp/apikey/apikey.txt
```

Note: Can be mounted as data volumes or exposed as environment variables

Exercise 3.2 Kubernetes Secrets

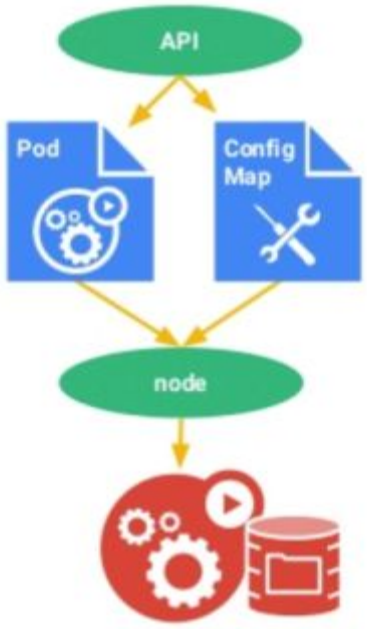
CLASSROOM WORK - Optional

1. **Create Secret config file and pods**
2. **Install and Launch Vault**

https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise3.2-secrets.md

Kubernetes: Configmap

A set of key-value pairs that serve as configuration data for pods. They solve the problem of how to pass config data such as environment variables to pods.



Config maps are commonly composed of:

- Command line arguments
- Environment variables
- Files in a volume

Config maps function similar to secrets, but values are stored as strings and are more readily readable.

$ kubectl create -f etcd-config.yml

```
apiVersion: extensions
kind: ConfigMap
metadata:
  name: etcd-env-config
data:
  discovery_url: http://etcd-discovery:2379
  etcdctl_peers: http://etcd:2379
```

Exercise 3.3 Kubernetes Configmap

CLASSROOM WORK

1. **Create Configmap**
2. **Consume Configmap in environment variables**
3. **Set command line using Configmap**

Source code:
https://github.com/techtown-training/kubernetes-intro/tree/master/exercise/src_code/kubernetes_additional_exercise/ex3.3

Step by step instruction:
https://github.com/techtown-training/kubernetes-intro/blob/master/exercise/exercise3.3-configmap.md

Kubernetes Tools : Prometheus

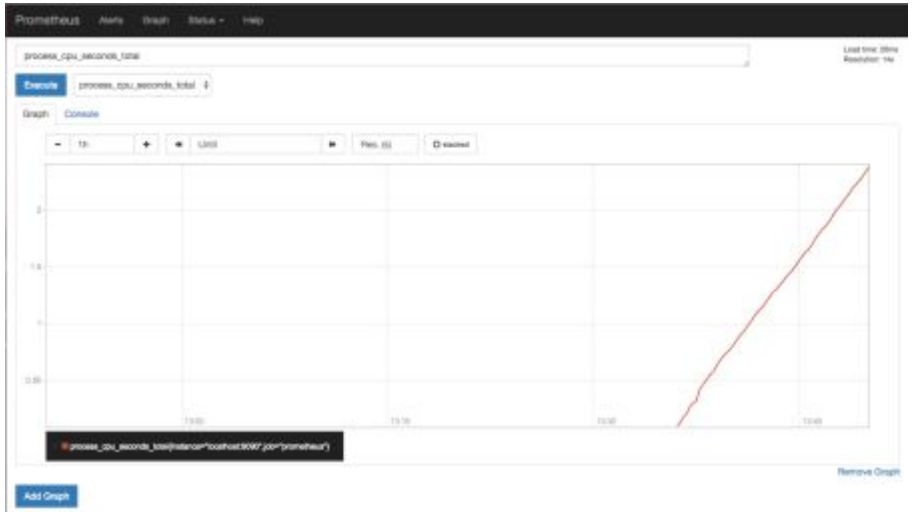
Prometheus is an open source time series monitoring and alerting toolkit (originally written by SoundCloud). It is sponsored by the Cloud Native Computing Foundation and was the second project to be adopted after Kubernetes.

- Dimensional Data
- Powerful Queries
- Visualization Tools
- Efficient Storage
- Alerting System

Kubernetes & Prometheus (Metrics)

CLASSROOM WORK

1. Stand up Prometheus
2. Gather and monitor metrics

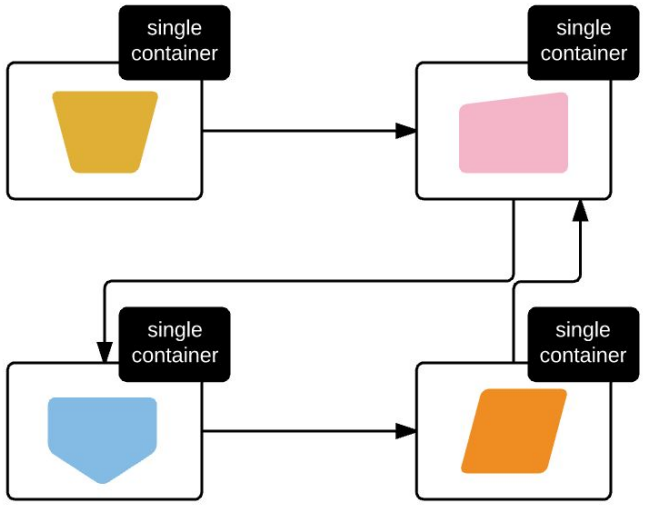


Extending Kubernetes

- Helm - package manager
- Third party extensions/plugins
- Operators

Secure Service to Service Communication

- How to authenticate the user and then pass the login context between Microservices (pods)?
- How will each Microservice authorize the user?



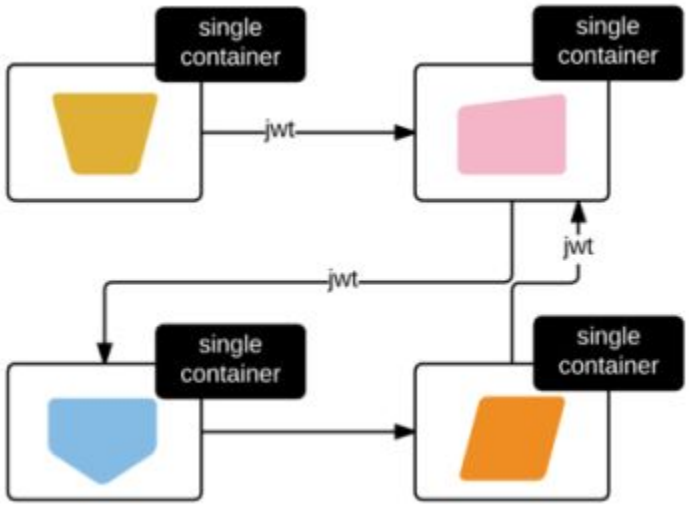
Secure Service to Service Communication: OpenID & JSON Web Token (JWT)

OpenID is a flavor of OAuth2
OAuth2 returns an access token called an ID Token or JSON Web Token
Pros

- Distributes identity and entitlements between services
- Transfers securely over an unsecured channel
- Asserts identity as long as sender is trusted

Cons

- Must provision the trusted certificates by service to each Microservice
- Must trust every certificate



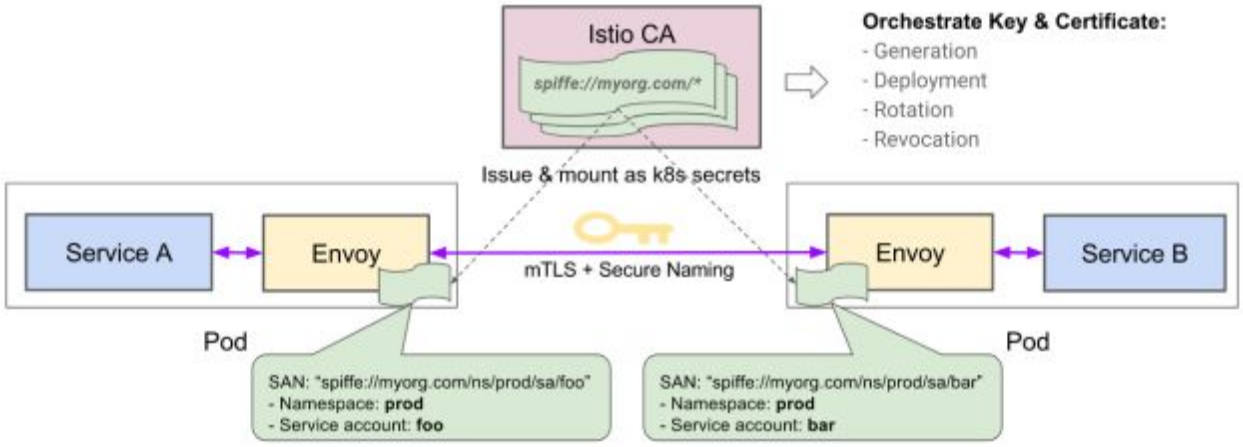
Secure Service to Service Communication: Private Certificate Authority

Pros

- Enables Services to only trust either root certificate authority or intermediary
- Reduced overhead in certificate provisioning

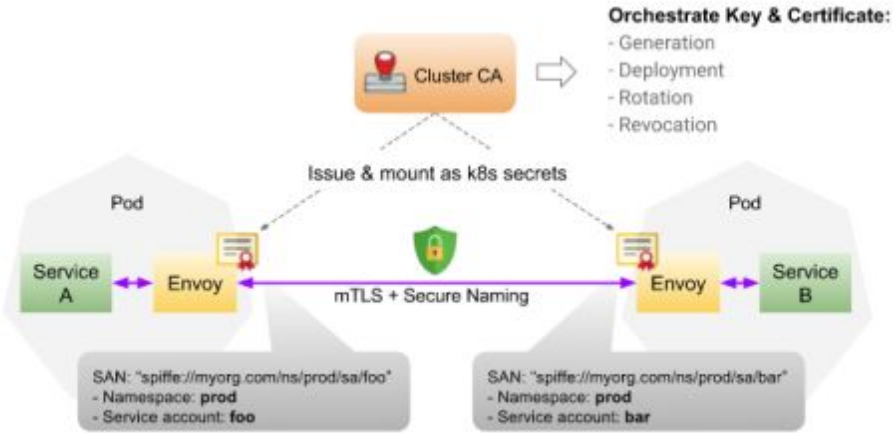
Cons

- Newer technique and technologies, must be appropriate for the given project



Secure Traffic

- Secure traffic between Microservices
  - HTTPS
    - Re-configure ELBs (on AWS)
    - Add certificate (letsencrypt.org)
- Secure traffic for users
  - HTTPS
  - Secure Identity with SPIFFEE & Istio



Security Actions

- Ensure attacker who gains access to web container can't get into the database
- Create separate DB users for each microservice
- Strong passwords
  - K8's secrets and/or Vault
  - Only accessed by containers who need them

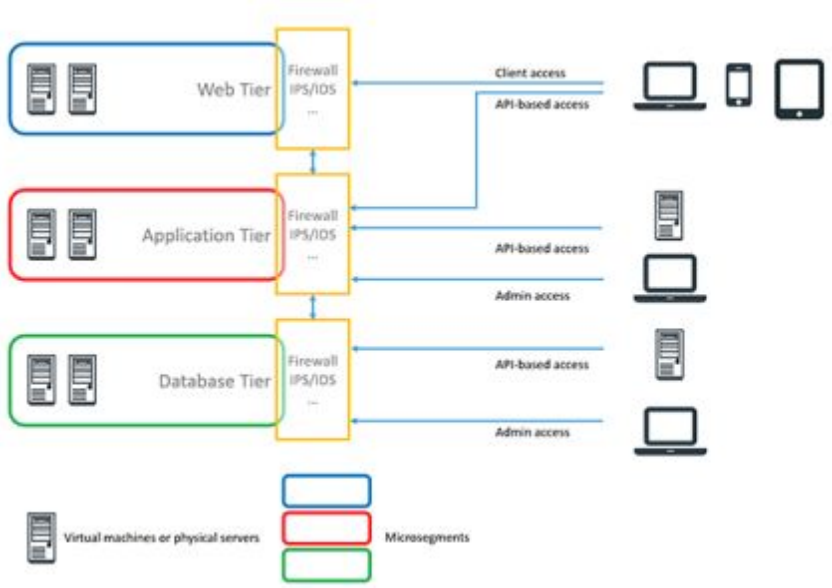
Kubernetes Secrets

CLASSROOM WORK

1. Create Secret config file and pods
2. Install and Launch Vault
3. (Optional) Challenge: Replicate Vault Secrets into Kubernetes

Security - Microsegmentation

- Segment the network
  - Only allow white-listed traffic between pods
- Common tools
  - Istio
  - Calico
  - Weave
  - OpenContrail



Security – Least Privilege

"Each subject in a system be granted the most restrictive set of privileges"

- Disable public IP access for any machine that doesn't need it
- VPN only for admin access

Security Actions

- Limit admin access
- ABAC mode by default
  - Commonly in srv/kubernetes
- Access control by token
  - Can allow/deny API operations
  - Can be used to only allow certain actions
- Webhook (optional)
  - Add url for k8s to verify authorization

Secure Images

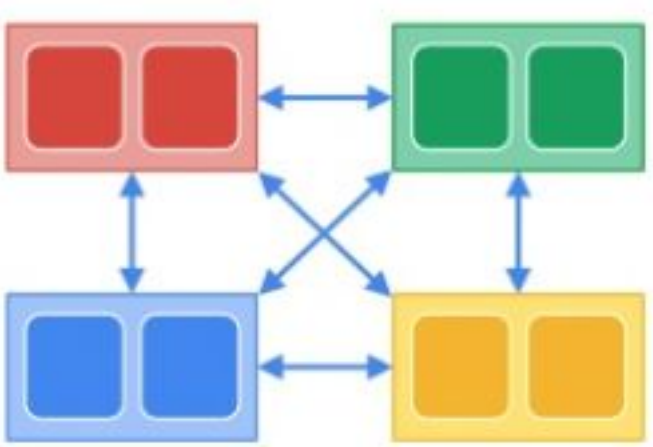
- Follow best practices for packaging and distributing applications
  - In general, try not to mix secrets and images
  - This can include containers with passwords baked in

Kubernetes Networking

Kubernetes assumes that pods can communicate with other pods, regardless of host

- Kubernetes requires
  - All containers to communicate with other containers without NAT
  - All nodes can communicate with all containers without NAT
  - IP that container sees itself as is the same as others see it

In practice, Kubernetes cannot be installed simply with Docker. It usually requires a networking layer such as Weave, Flannel, etc



Kubernetes Networking

Every pod has its own IP

- No mapping ports
- Clean, backwards compatible model where Pods can be treated like VMs

Kubernetes Ingress

Simplified Layer 7 access to Kubernetes services i.e. allows “internet” to reach services

- Works with load balancers, including nginx & cloud
- Single root URL mapping
- Publicly expose private networks
- Terminates TLS/SSL