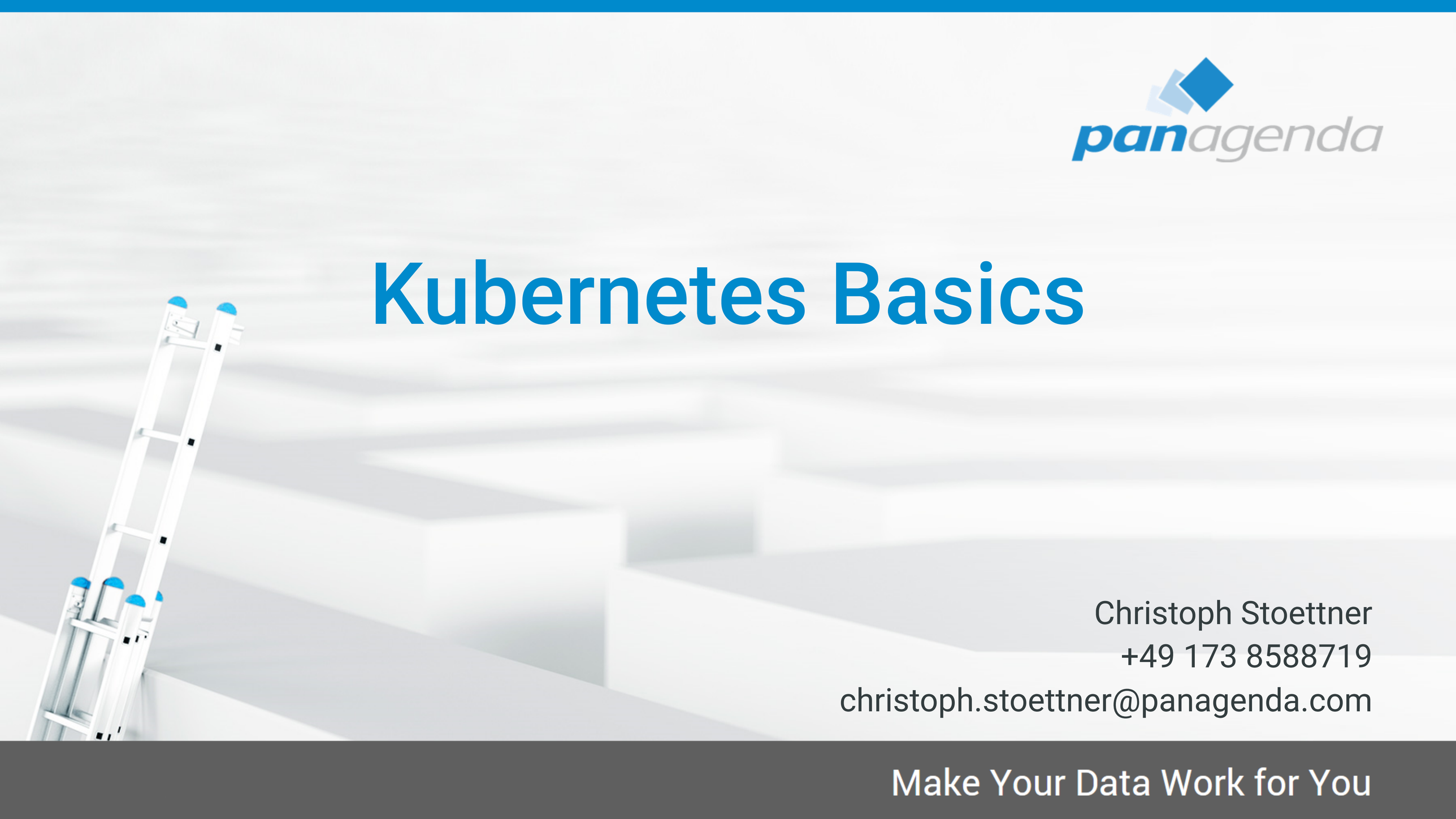

Kubernetes Basics

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IBM CHAMPION

- Senior Consultant at panagenda
  - Linux (Slackware) since 1995
  - IBM Domino since 1999
  - IBM Connections since 2009
- Experience in
  - Migrations, Deployments
  - Performance Analysis, Infrastructure
- Focusing in
  - Monitoring, Security
- More and more
  - DevOps stuff

Agenda

- History
- Kubernetes Infrastructure
- kubectl

History - Borg System

- **2003 / 2004**
- First unified container-management system
- Developed at Google
- Based on Linux control groups (cgroups)
- Container support in the Linux kernel became available
  - Google contributed much of this code to the kernel

Isolation between latency-sensitive user-facing services and CPU-hungry batch processes

History - Omega

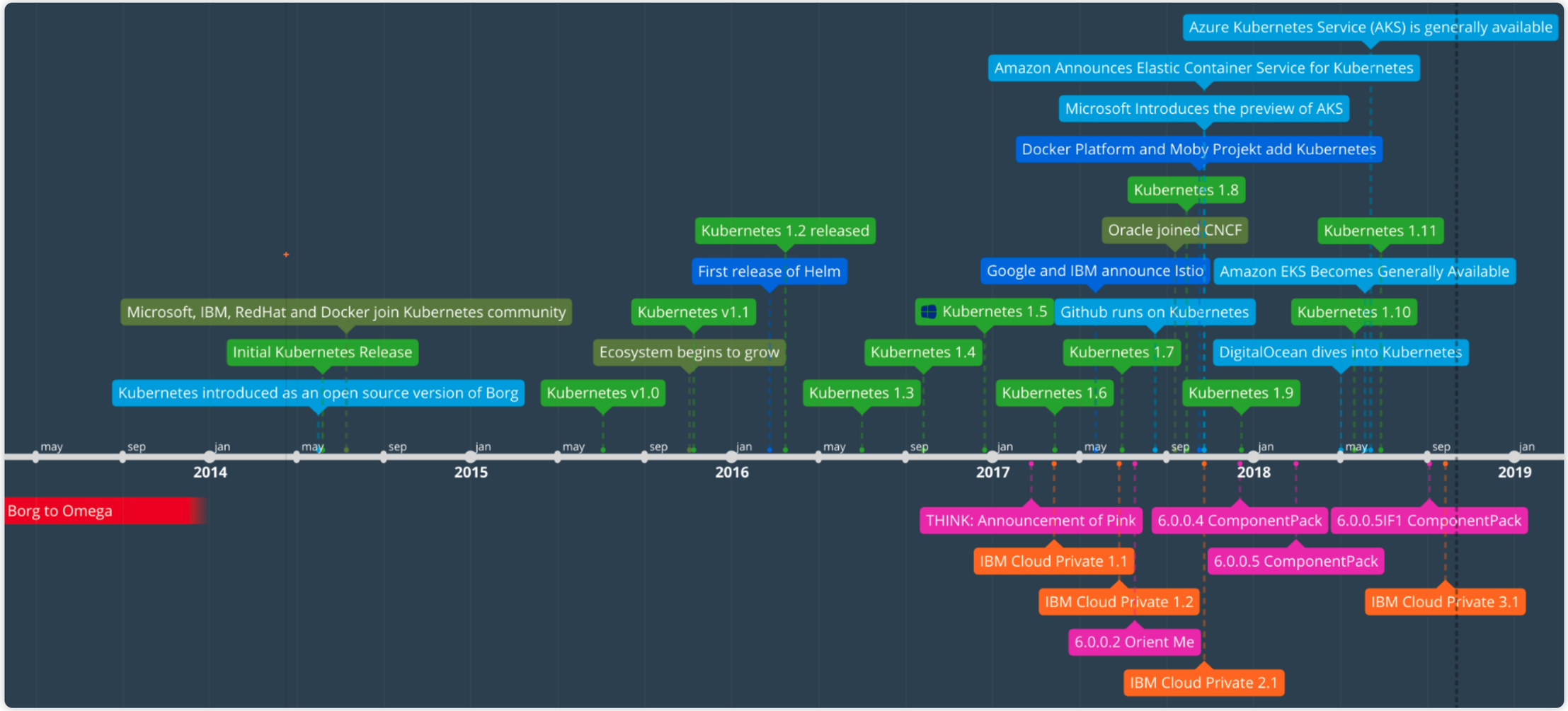
- **2013**
- Offspring of Borg
- Improve the software engineering of the Borg ecosystem
- Built from ground up
  - more consistent, principled architecture
- Seperate components which acted as peers
- Multiple schedulers
- No funneling through centralized master

History Kubernetes

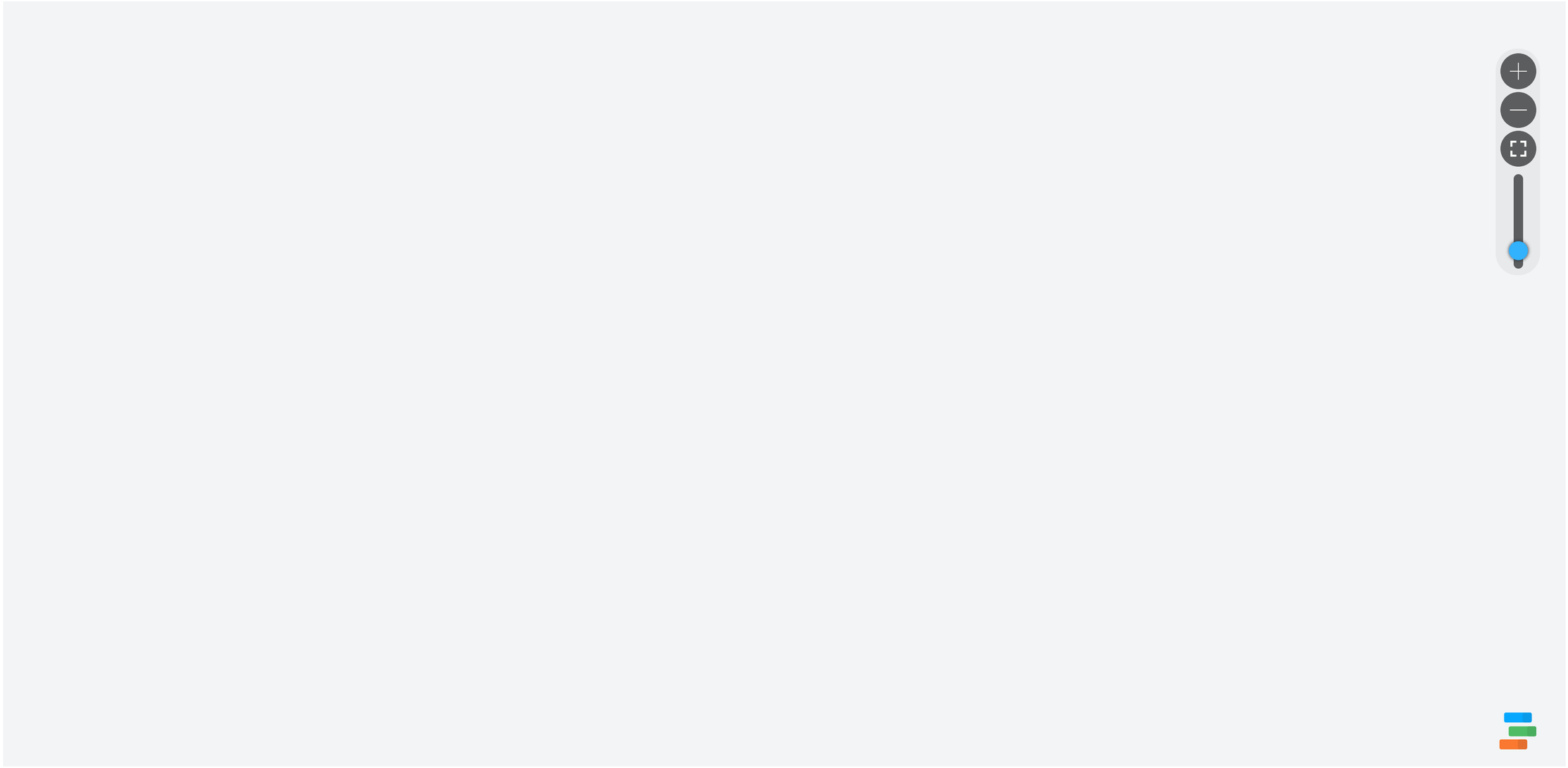
- **June 2014**
- Third container management system developed at Google
- Conceived and developed when external developers became interested in Linux containers
- Google released the code as Opensource to the Cloud Native Computing Foundation (CNCF)
- Around six weeks after the release:
  - Microsoft, IBM, Red Hat and Docker joined the Community

https://cloudplatform.googleblog.com/2014/07/welcome-microsoft-redhat-ibm-docker-and-more-to-the-kubernetes-community.html

Overview

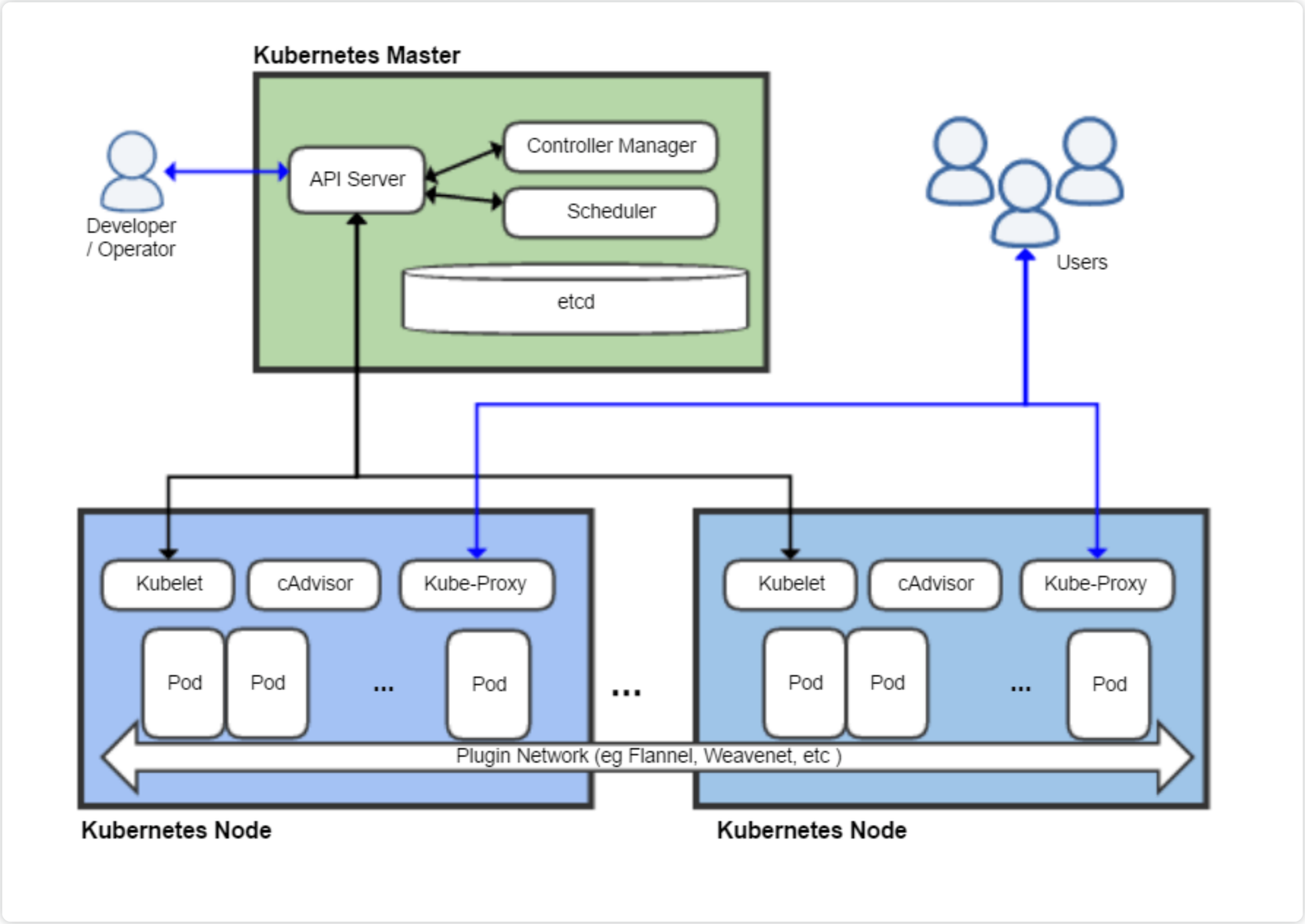

Azure Kubernetes Service (AKS) is generally available
Amazon Announces Elastic Container Service for Kubernetes
Microsoft Introduces the preview of AKS
Docker Platform and Moby Projekt add Kubernetes
Kubernetes 1.8
Kubernetes 1.2 released
Oracle joined CNCF
Kubernetes 1.11
First release of Helm
Google and IBM announce Istio
Amazon EKS Becomes Generally Available
Microsoft, IBM, RedHat and Docker join Kubernetes community
Kubernetes v1.1
Kubernetes 1.5
Github runs on Kubernetes
Kubernetes 1.10
Initial Kubernetes Release
Ecosystem begins to grow
Kubernetes 1.4
Kubernetes 1.7
DigitalOcean dives into Kubernetes
Kubernetes introduced as an open source version of Borg
Kubernetes v1.0
Kubernetes 1.3
Kubernetes 1.6
Kubernetes 1.9
may sep jan may sep jan may sep jan may sep jan may sep jan may sep jan may sep jan
2014 2015 2016 2017 2018 2019
Borg to Omega
THINK: Announcement of Pink
6.0.0.4 ComponentPack
6.0.0.5IF1 ComponentPack
IBM Cloud Private 1.1
6.0.0.5 ComponentPack
IBM Cloud Private 1.2
IBM Cloud Private 3.1
6.0.0.2 Orient Me
IBM Cloud Private 2.1

Dynamic Timeframe



Kubernetes

Kubernetes Architecture



Linux Kernel

- Namespaces
  - lightweight process virtualization
  - Isolation: enable a process to have different views of the system than other processes
  - Much like Zones in Solaris
  - No hypervisor layer!
- cgroups (control groups)
  - Resource Management providing a generic process-grouping framework

Cgroups is not dependent upon namespaces.

Container

- A container is a Linux userspace process
- LXC (Linux Containers)
  - Operating System Level virtualization
- Docker
  - Linux container engine
  - Initially written in Python, later in Go
  - Released by dotCloud 2013
  - Docker < 0.9 used LXC to create and manage containers

Pods

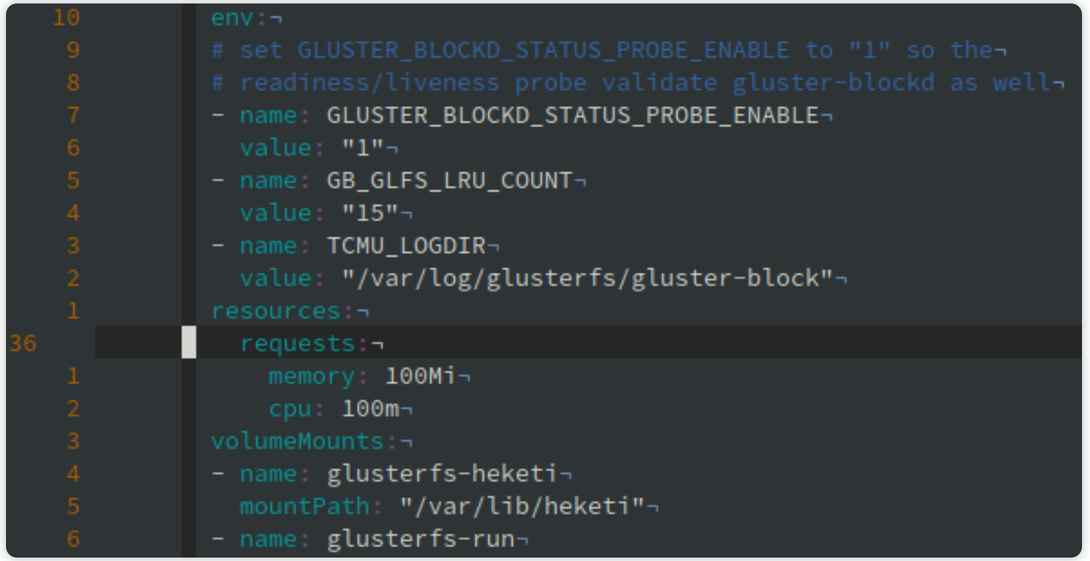
- Pods are the smallest unit in Kubernetes
- Have a relatively short life-span
- Born, and destroyed
- They are never healed

- system heals itself
  - by creating new Pods
  - by terminating those that are unhealthy
- system is long-living
- Pods are not

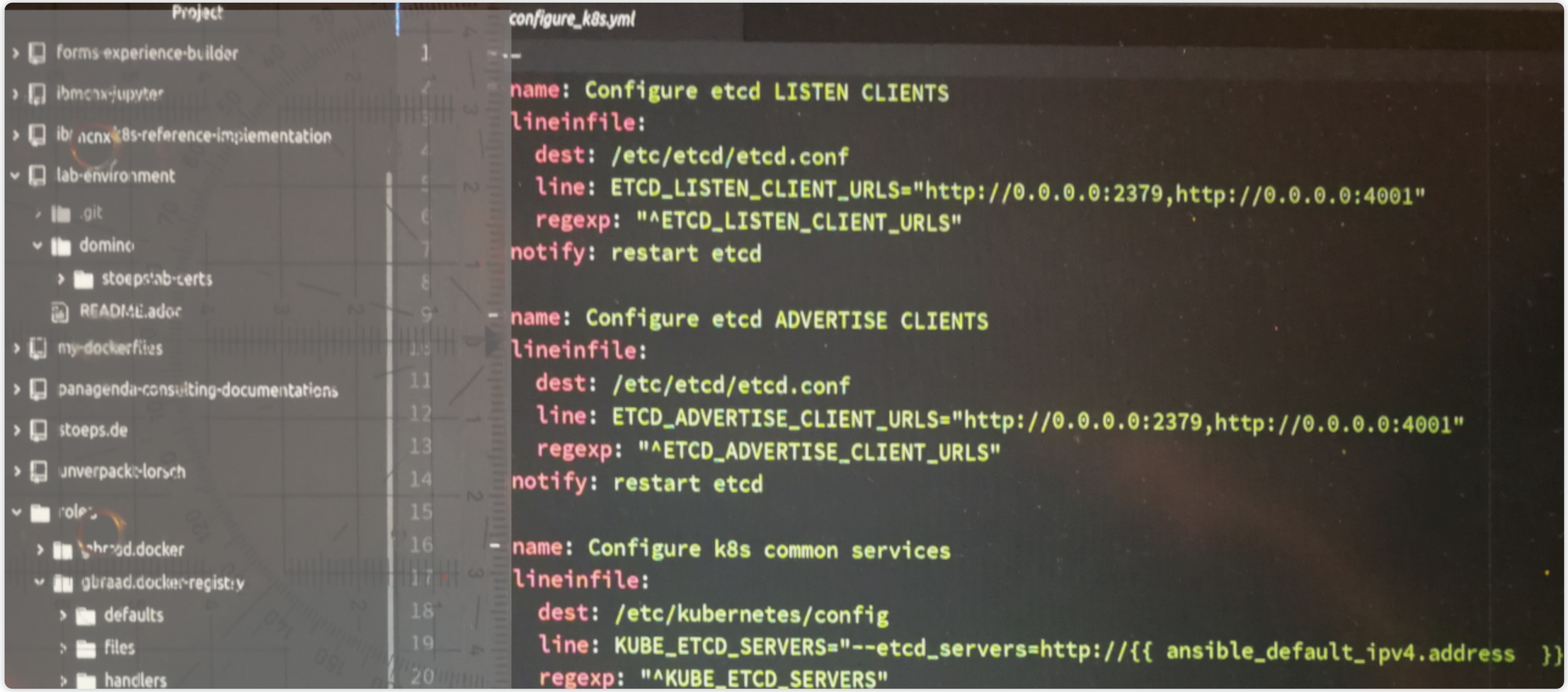
YAML with VIM

.vimrc

```
set cursorline          " highlight current line
hi CursorLine   cterm=NONE ctermbg=235 ctermfg=NONE guifg=gray guibg=black
set cursorcolumn        " vertical cursor line
hi CursorColumn ctermfg=NONE ctermbg=235 cterm=NONE guifg=gray guibg=black gui=bold
```



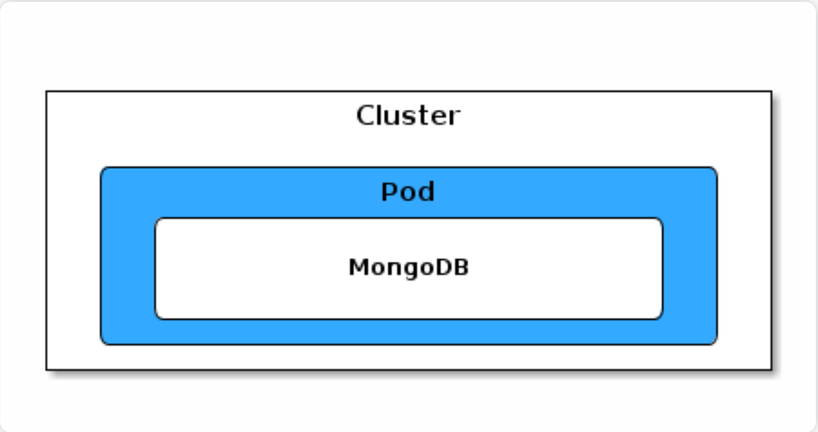
YAML → or use a ruler



Simple Pods

- Run a simple pod

```
kubectl run db --image mongo
```



Quick and dirty! Deprecated!

Simple Pod - what happend?

- Kubernetes automatically creates
  - ReplicaSet
  - Deployment

```
Every 2,0s: kubectl get all -o wide

NAME                     READY   STATUS    RESTARTS   AGE   IP          NODE       NOMINATED NODE
pod/db-5789985d94-pl9gt  1/1     Running   0          2m    10.42.3.7   rancher3   <none>

NAME                 TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)   AGE   SELECTOR
service/kubernetes   ClusterIP   10.43.0.1    <none>        443/TCP   3d    <none>

NAME                 DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE   CONTAINERS   IMAGES   SELECTOR
deployment.apps/db   1         1         1            1           2m    db           mongo    run=db

NAME                           DESIRED   CURRENT   READY   AGE   CONTAINERS   IMAGES   SELECTOR
replicaset.apps/db-5789985d94  1         1         1       2m    db           mongo    pod-template-hash=1345541850,run=db
```

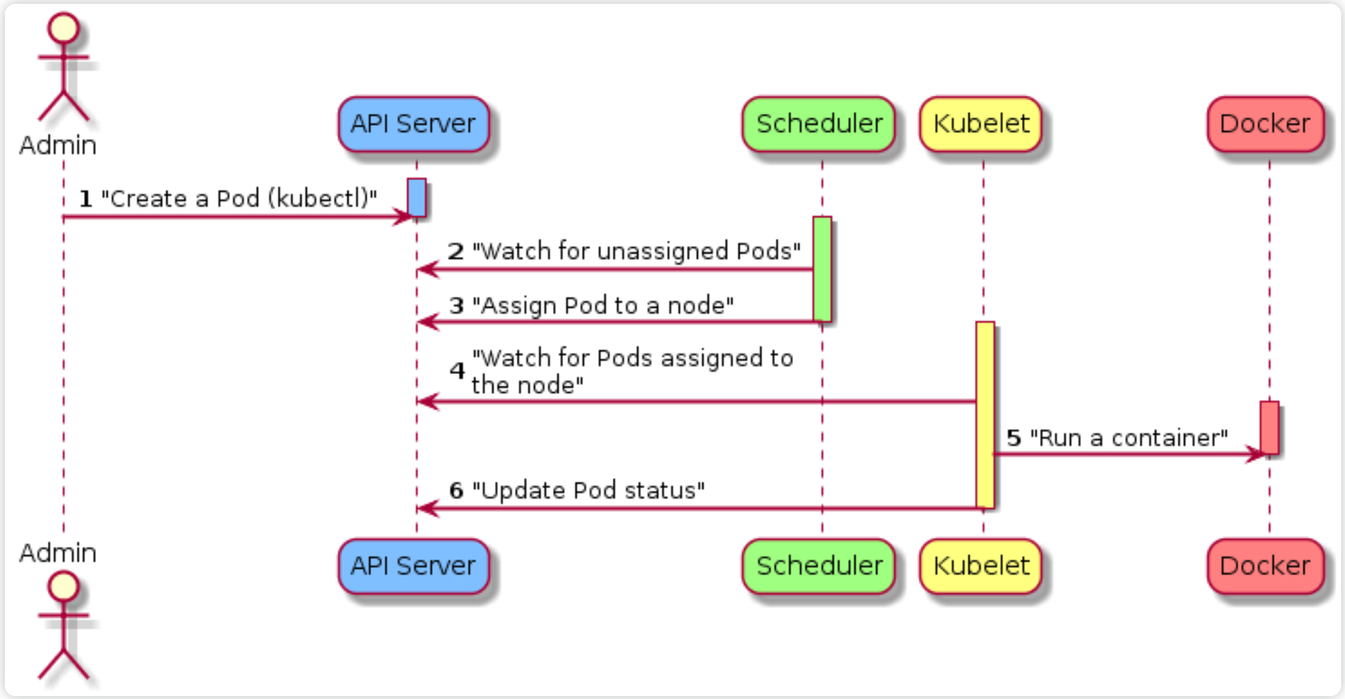
Create a pod with a yaml file

nginx.yaml

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    ports:
    - containerPort: 80
```

```
$ kubectl create -f nginx.yaml

$ kubectl get all -o wide

NAME         READY   STATUS    RESTARTS   AGE   IP            NODE
pod/nginx    1/1     Running   0          4m    10.42.1.13    rancher2
```

Overview creating pod



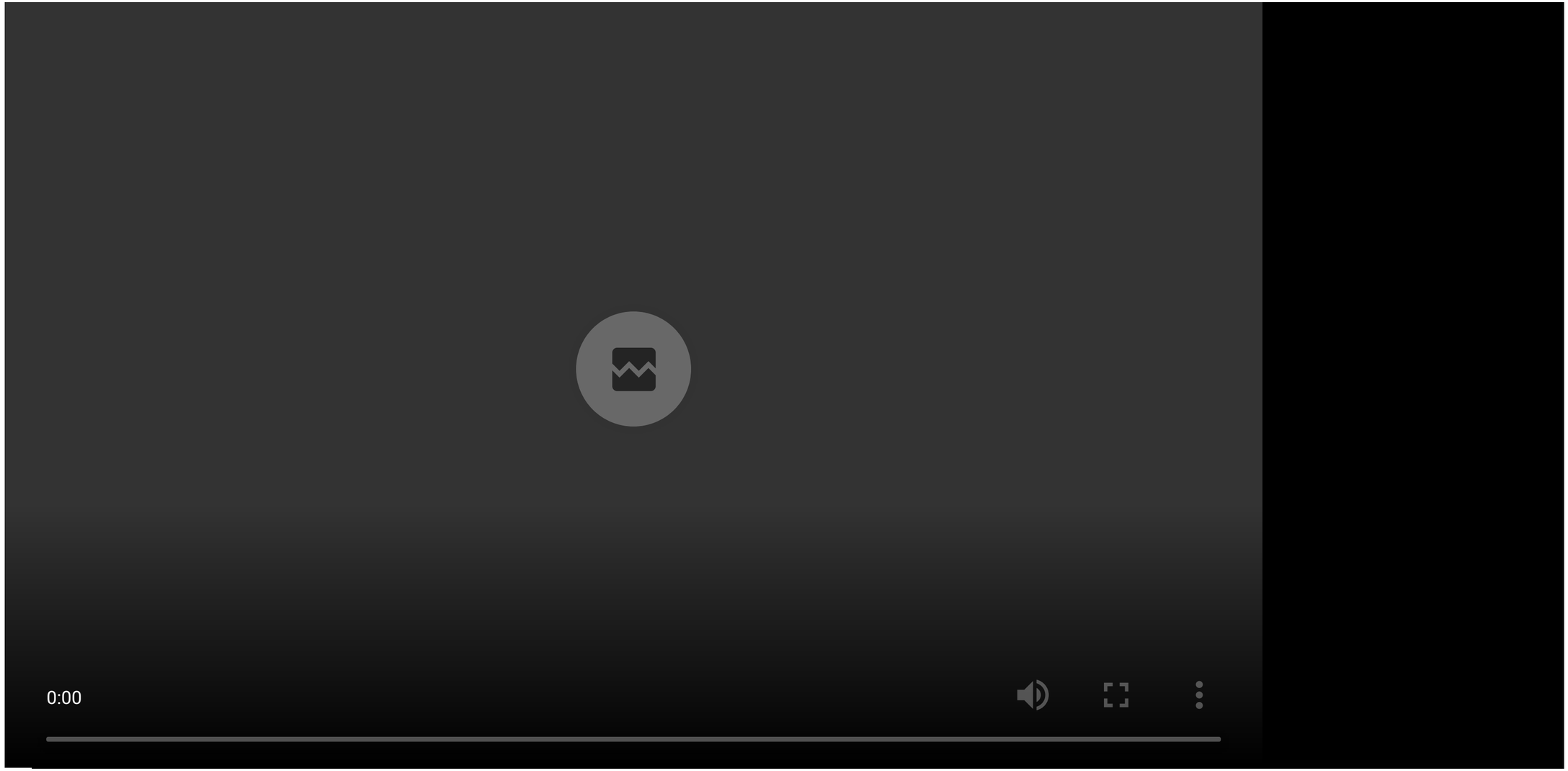

```
kubectl create pod -f pod.yml
```

Liveness Check

```
...
    - containerPort: 80
    env:
    - name: nginx
      value: localhost
    livenessProbe:
      httpGet:
        path: /                    (1)
        port: 80
      initialDelaySeconds: 5       (2)
      timeoutSeconds: 2            (3)
      periodSeconds: 5             (4)
      failureThreshold: 1          (5)
```

1. Check path - example with non existend path
2. Wait 5 seconds before performing the first probe
3. Timeout (no answer for 2 seconds → error)
4. Liveness check all 5 seconds
5. Kubernetes tries n times before giving up

Automatic restart



Check Events

```
Every 2,0s: kubectl get all -o wide                                                 stoeps-th

NAME                READY   STATUS             RESTARTS   AGE   IP           NODE       NOMINAT
pod/nginx           1/1     Running            0          7m    10.42.3.14   rancher3   <none>
pod/nginx-broken    0/1     CrashLoopBackOff   3          1m    10.42.2.10   rancher4   <none>
```

```
$ kubectl describe pod nginx-broken
```

```
Events:
  Type     Reason     Age                   From               Message
  ----     ------     ----                  ----               -------
  Normal   Scheduled  4m46s                 default-scheduler  Successfully assigned examples/nginx-broken to rancher4
  Normal   Pulling    4m42s                 kubelet, rancher4  pulling image "nginx:1.7.9"
  Normal   Pulled     4m18s                 kubelet, rancher4  Successfully pulled image "nginx:1.7.9"
  Normal   Created    3m48s (x4 over 4m18s) kubelet, rancher4  Created container
  Normal   Started    3m48s (x4 over 4m17s) kubelet, rancher4  Started container
  Warning  Unhealthy  3m39s (x4 over 4m9s)  kubelet, rancher4  Liveness probe failed: HTTP probe failed with statuscode: 404
  Normal   Killing    3m38s (x4 over 4m8s)  kubelet, rancher4  Killing container with id docker://nginx:Container failed liveness probe.. Container will be killed and recreated.
  Warning  BackOff    3m22s (x3 over 3m38s) kubelet, rancher4  Back-off restarting failed container
  Normal   Pulled     3m9s (x4 over 4m8s)   kubelet, rancher4  Container image "nginx:1.7.9" already present on machine
```

Pods vs Container

- Pod is smallest deployment in Kubernetes
- A pod contains minimum one container (Docker or RKT)
- Can contain multiple containers
  - Not very common
  - Most pods have one container
    - Easier to scale
- A pod runs on one node and shares resources

ReplicaSet

- ReplicaSet as a self-healing mechanism
- Pods associated with a ReplicaSet are guaranteed to run

ReplicaSet's primary function is to ensure that the specified number of replicas of a service are (almost) always running.

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: webserver
spec:
  replicas: 3
  selector:
    matchLabels:
      type: backend
      service: nginx
  template:
    metadata:
      labels:
        type: backend
        service: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.7.9
        env:
        - name: nginx
          value: localhost
        livenessProbe:
          httpGet:
            path: /
            port: 80
          initialDelaySeconds: 5
          timeoutSeconds: 2
          periodSeconds: 5
          failureThreshold: 1
```

ReplicaSet (2)

```
$ kubectl create -f nginx-rs.yaml --record --save-config  (1) (2)

$ kubectl get pods

NAME                   READY   STATUS    RESTARTS   AGE   IP            NODE       NOMINATED NODE
pod/webserver-79r7j    1/1     Running   0          15m   10.42.3.15    rancher3   <none>
pod/webserver-dg5bp    1/1     Running   0          15m   10.42.2.11    rancher4   <none>
pod/webserver-rmkgx    1/1     Running   0          15m   10.42.1.14    rancher2   <none>

NAME                         DESIRED CURRENT READY AGE CONTAINERS IMAGES       SELECTOR
replicaset.apps/webserver    3       3       3     15m nginx      nginx:1.7.9  service=nginx,type=backen
```

1. `--record` saves history
2. `--save-config` enables the use of `kubectl apply`, so we can change the ReplicaSet

ReplicaSet Scale

- Change `Replicas to 9`
- Apply file

```
...
spec:
  replicas: 9
```

```
$ kubectl apply -f nginx-rs-scaled.yaml

NAME                    READY   STATUS    RESTARTS   AGE   IP            NODE       NOMINATED NODE
pod/webserver-bw259     1/1     Running   0          5m    10.42.1.15    rancher2   <none>
pod/webserver-frcr7     1/1     Running   0          4m    10.42.1.16    rancher2   <none>
pod/webserver-g6zqd     1/1     Running   0          5m    10.42.2.12    rancher4   <none>
...
pod/webserver-p6k7f     1/1     Running   0          4m    10.42.2.13    rancher4   <none>
pod/webserver-wjwfd     1/1     Running   0          5m    10.42.3.16    rancher3   <none>

NAME                          DESIRED CURRENT READY AGE CONTAINERS IMAGES      SELECTOR
replicaset.apps/webserver 9       9       9     5m  nginx      nginx:1.7.9 service=nginx
```

Deployment

- Not supposed to create Pods directly or with ReplicaSet
- Use Deployments instead

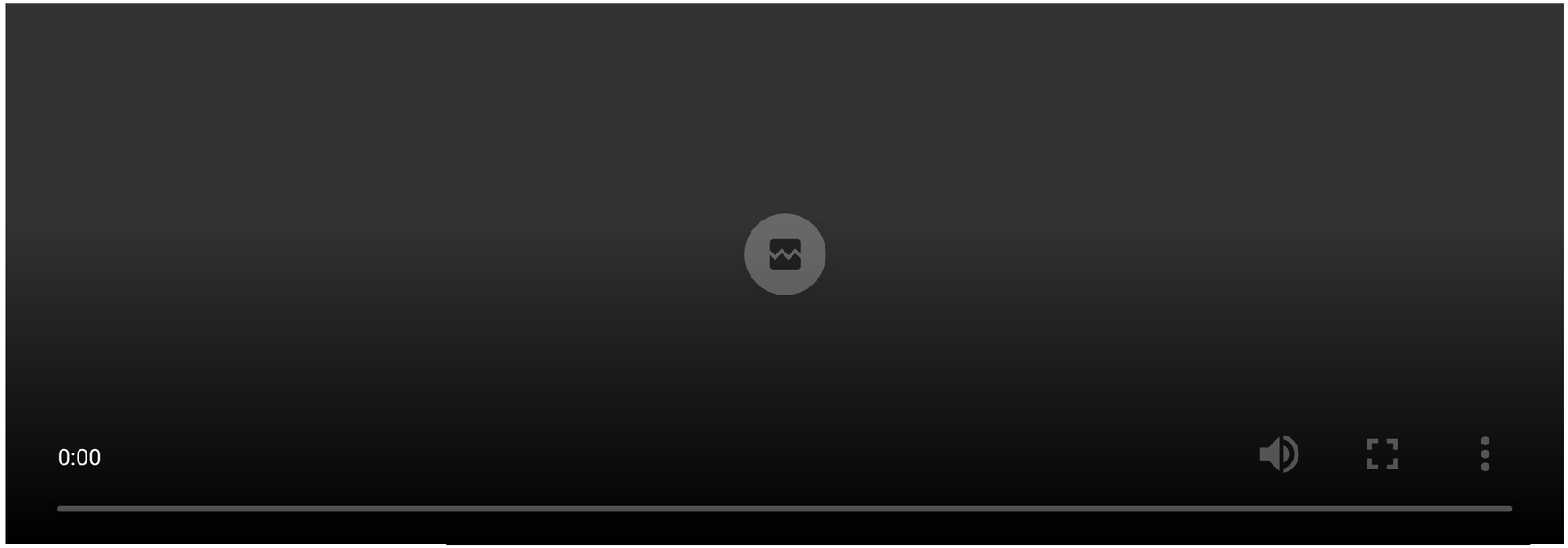
```
$ kubectl create -f nginx-deploy.yaml --record

$ kubectl get all

NAME                            READY   STATUS    RESTARTS   AGE
pod/nginx-54f7d7ffcd-wzjnf      1/1     Running   0          1m

NAME                     DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/nginx    1         1         1            1           1m

NAME                                DESIRED   CURRENT   READY   AGE
replicaset.apps/nginx-54f7d7ffcd    1         1         1       1m
```

nginx-deploy.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx
spec:
  selector:
    matchLabels:
      type: backend
      service: nginx
  template:
    metadata:
      labels:
        type: backend
        service: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.7.9
        ports:
        - containerPort: 80
          protocol: TCP
```

Scale, Rollout and Undo

```
$  kubectl create -f nginx-deploy.yaml --record
$  kubectl apply -f nginx-deploy-scaled.yaml
$  kubectl scale deployment nginx --replicas 9 --record
$  kubectl scale deployment nginx --replicas 5 --record
$  kubectl rollout history -f nginx-deploy.yaml
$  kubectl set image -f nginx-deploy-scaled.yaml nginx=nginx:1.8.1 --record
$  kubectl rollout history -f nginx-deploy.yaml
$  kubectl rollout undo -f nginx-deploy-scaled.yaml --to-revision=1
```



Kubernetes Networking model

- all containers can communicate with all containers without NAT
- all nodes can communitcate with all containers without NAT
- the IP that a container sees itself as the same IP that others see it
- this is provided through overlay network providers like
  - Flannel (Overlay network provider)
  - Calico (secure L3 networking and network policy provider)
  - Canal (unites Flannel and Calico)

Exposed ports are accessible from all containers/pods.

Istio

- service mesh
- microservices
  - secure
  - connect
  - monitor
- Automatic load balancing for HTTP, WebSocket and TCP traffic
- Fine grained traffic control
- Policy layer

Secure service-to-service communitcation in a cluster

Services

- Kubernetes Services provide addresses through which associated Pods can be accessed
- Services are resolved by `kube-proxy`

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
spec:
  type: NodePort  (1)
  ports:
  - port: 80
    nodePort: 30001  (2)
    protocol: TCP
  selector:
    service: nginx
```

(1) NodePort: available within the cluster and from outside on each node

(2) explicit port, without Kubernetes creates a random one

NodePort

- Port is exposed on each Node's IP at a static port
- A `ClusterIP` service is automatically created

No need that the pod is running on the node!

```
$ kubectl scale deployment nginx --replicas 1 --record
```

- Create the service:

```
kubectl create -f nginx-svc.yaml --record --save-config
```

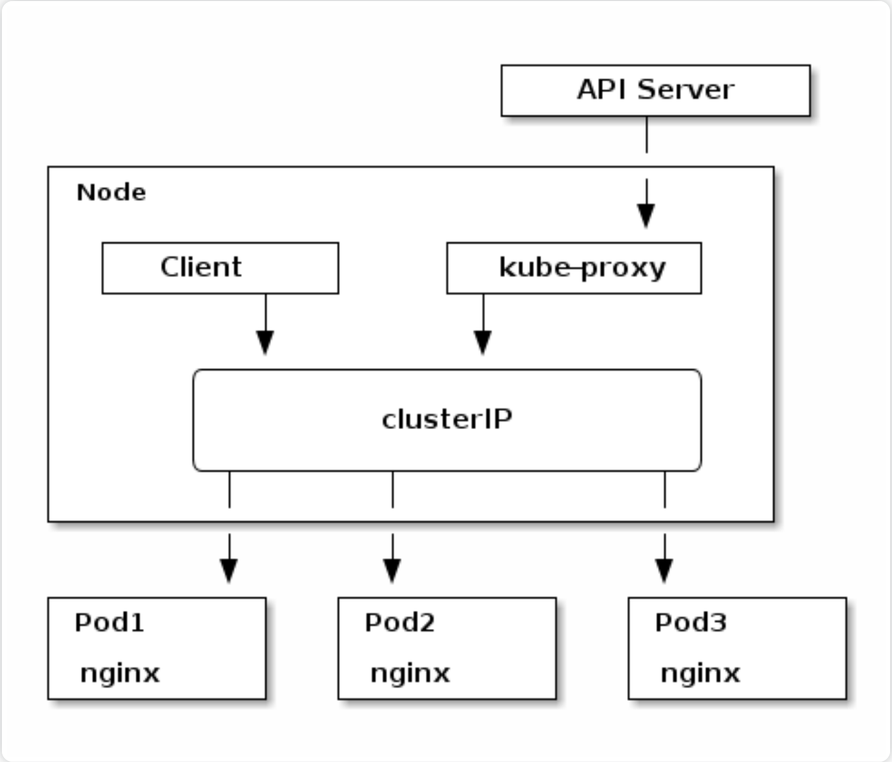
Check the Webserver

- Our nginx pod is only running on one of the the three worker nodes
  - Check if all workers deliver the webpage

```
for i in 2 3 4
do
    curl -s http://rancher$i.stoepslab.local | grep title
done
<title>Welcome to nginx!</title>
<title>Welcome to nginx!</title>
<title>Welcome to nginx!</title>
```

ClusterIP

- Exposes the service on a cluster-internal IP
- makes the service only reachable from within the cluster
- default `ServiceType`



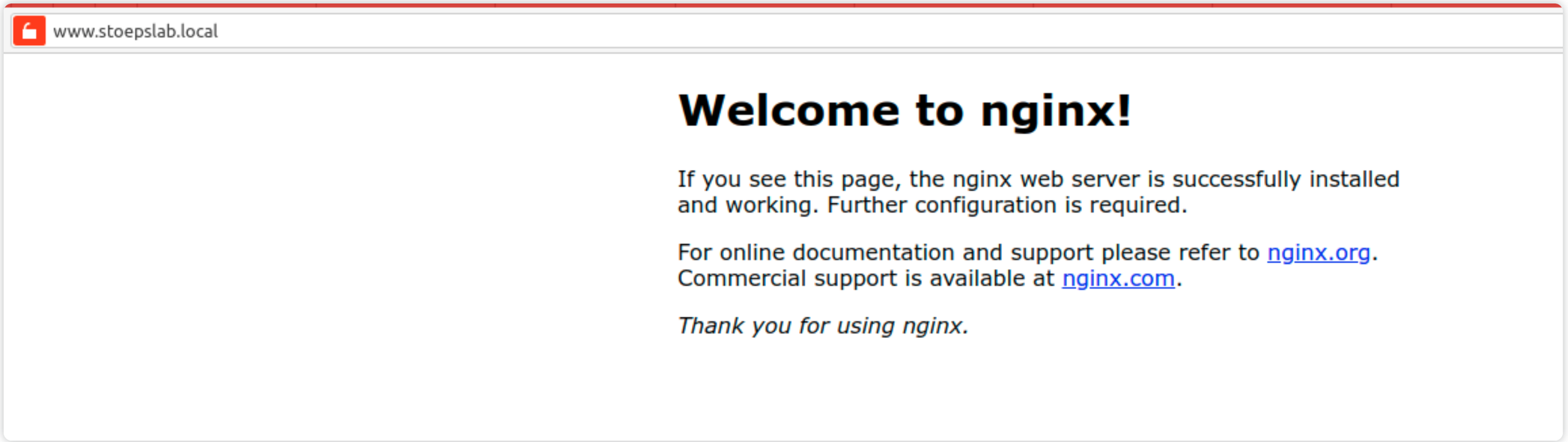
Ingress

- Route requests to services, based on
  - request host
  - path

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: my-ingress
spec:
  rules:
  - host: www.stoepslab.local
    http:
      paths:
      - backend:
          serviceName: nginx
          servicePort: 80
```

Working Ingress

- After adding the hostname to DNS or `/etc/hosts`



Storage / Volumes

- Docker knows a concept of volumes
- More complicated on Kubernetes
  - Different nodes need to have access to them
  - Network storage
- Kubernetes knows a lot of different storage types
- Examples:
  - local, iscsi, glusterfs, hostPath, nfs
  - configmap, secret
  - different cloud providers (aws, gce …)
- https://kubernetes.io/docs/concepts/storage/volumes/

Persistent Volume

- `Persistent Volume (PV)`
  - piece of storage in the cluster
  - provisioned by an administrator
- `PersistentVolumeClaim (PVC)`
  - request for storage by an user (size and access mode)
  - PVC consume PV resources
- PV have different properties
  - performance, backup, size

Cluster Admins need to be able to offer a variety of `PersistentVolumes`

StorageClass

- `StorageClass`: a way to describe the `classes` of storage
- different classes for
  - quality-of-service levels
  - backup policies
- Reclaim Policy
  - Delete or Retain
- Some storage classes auto provision `PersistentVolumes`
  - Heketi/Glusterfs, Rancher/Longhorn

⚠ NFS on one of your K8s nodes → single point of failure

ConfigMaps

- decouple configuration artifacts from image content
- keep containerized applications portable
- Configmaps can contain
- folder/files (mainly for config/properties)
  - `kubectl create configmap nginx-soccnx --from-file=html`

```
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    volumeMounts:
      - name: nginx-soccnx
        mountPath: /usr/share/nginx/html
  volumes:
    - name: nginx-soccnx
      configMap:
        name: nginx-soccnx
```

ConfigMaps (2)

- Value pairs

```
apiVersion: v1
   kind: ConfigMap
   metadata:
     name: special-config
     namespace: default
   data:
     SPECIAL_LEVEL: very
     SPECIAL_TYPE: charm
```

```
spec:
     containers:
       - name: nginx-soccnx
         image: alpine:latest
         command: [ "/bin/sh", "-c", "env" ]
         envFrom:
         - configMapRef:
             name: special-config
```

ConfigMaps results

- `index.html` in a configMap
- https://www.stoepslab.local

`kubectl logs nginx-soccnx`

```
...
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
PWD=/
SHLVL=1
SPECIAL_LEVEL=very
SPECIAL_TYPE=charm
```

Secrets

- object that contains a small amount of sensitive data
- reduces risk of accidental exposure
- Secrets are base64 encoded

```
$ kubectl create secret generic db-user-pass \
  --from-literal=username=dbadmin \
  --from-literal=password=MyGreatPassword
secret 'db-user-pass' created

$ kubectl create secret generic db-user-env \
  --from-env-file=password.txt
```

`password.txt`

```
username=dbadmin
password=myGreatPassword
```

Get secrets

```
➜ kubectl get secret db-user-env -o yaml
apiVersion: v1
data:
  password: TXlHcmVhdFBhc3N3b3Jk
  username: ZGJhZG1pbg==
kind: Secret
```

```
➜ kubectl get secret db-user-env -o jsonpath="{.data.password}" | base64 --decode
MyGreatPassword%
```

Mount secret into pod

```
volumes:
- name: db-creds
    secret:
      secretName: db-user-env
      defaultMode: 0444
      items:
      - key: username
        path: username
      - key: password
        path: password
```

Secrets compared with ConfigMaps

- Both allow to inject content into pods
  - files
  - literal values
  - files with environment variables
- Secrets
  - creates files in `tmpfs` → in memory files
- A step towards security, but should be combined with `authorization policies`
- 3rd party tool: Hashicorp Vault

⚠ Any user with permission to run pod can mount a secret.

Namespaces

- Namespaces are a way to devide cluster resources between multiple users
- Namespaces provide a scope for names
  - Names of resources need to be unique within a namespace
- It’s not necessary to use multiple namespaces just to seperate different resources
  - use `labels` to distinguish resources within the same namespace

When you delete a namespace, all objects in the namespace are deleted too!

Namespace and kube-dns

- You can reuse pod and service names in different namespaces
- `kube-dns` uses `podname.namespace` then

Example

```
$ kubectl exec -it <pod> -- sh

curl http://nginx.texting:8080
curl http://nginx.production:8080
```

- Namespaces are no extra security layer!
- Pods can connect to services and pods in other namespaces

kubectl config

- When you use `kubectl` you have to add `-n namespace`
  - or `--all-namespaces` (works only with `get`)
- During configuration phases it’s easier to switch the default namespace
- Very handy if you use different clusters too

```
$ kubectl create namespace soccnx

$ kubectl config set-context soccnx --namespace soccnx \
  --cluster rancher-cluster --user admin

$ kubectl config view

$ kubectl config use-context soccnx
```

Install additional products

Helm

- Kubernetes Package Manager
  - manage Kubernetes charts
  - Charts are packages of pre-configured Kubernetes resources
- Main tasks
  - Find and use popular software packaged as Helm charts
  - Share your own applications as Helm charts
  - Create **reproducible** builds of your Kubernetes applications
  - Manage releases of Helm packages
- 2 parts
  - client (helm)
  - server (tiller)

Examples

- Install a Docker registry
- Use ELK or EFK Stack for your logfiles
- GUI within IBM Cloud Private or Rancher

```
➜ helm search elastic

➜ helm install stable/kibana
```

Troubleshooting

Get log messages

- `kubectl logs <podname>`
- `kubectl logs <podname> -f`
- `kubetail`
- Multiple containers in your pod?

```
kubectl logs <podname> -c <containername>
```

- Log of a restarted pod

```
kubectl logs --previous ${POD_NAME} ${CONTAINER_NAME}
```

Troubleshooting Pod

- Get a shell in a running pod
- Depending on the image:
  - `/bin/sh`, `sh`
  - `/bin/bash`, `bash`
  - `/bin/ash`, `ash` (alpine)

```
# Single container pod
kubectl exec -it shell-demo -- /bin/bash

# Pod with multiple containers
kubectl exec -it my-pod --container main-app -- /bin/bash
```

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THANK YOU!