Container orchestration with Kubernetes

Maddie Patrichi: ioana-madalina.patrichi@oracle.com

Tutorial Overview

1. Background
2. Kubernetes primitives
3. Architecture
4. Lifecycle of a pod
5. Single-node demo (Minikube)
6. Creating your own Kubernetes cluster (Terraform)
7. Multi-node demo (OKE)

Overview: What is Kubernetes?

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

Overview: What problems does it solve?

- Users expect applications/services to be available 24/7
- Developers expect to be able to deploy updates to their code multiple times per day
- Desire to use cloud resources efficiently via container orchestration
- Fault-tolerant, self-healing
- Scalability

Overview: History

- Born from a Google internal project in mid-2014 (Google “Borg”)
- 1.0 release in July 2015
- Google partnered with the Linux Foundation to form the Cloud Native Computing Foundation (CNCF) to offer Kubernetes as an open standard
- Abbreviated as “k8s”, Greek for “helmsman” or “pilot”
- Written in Golang

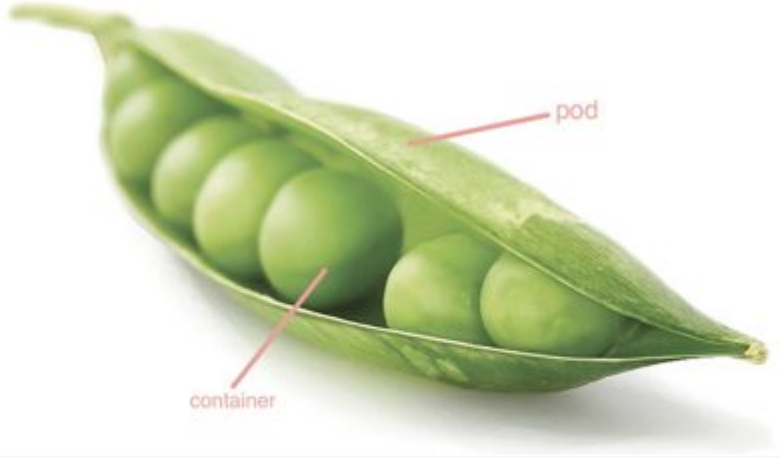
Overview: Advantages of using Kubernetes

… vs. other Container Orchestration applications

- Based on extensive experience from Google, over a long period of time
- Large open source community project, mature governing organisation (CNCF)
- Auto-scaling, cloud-agnostic-yet-integratable technologies

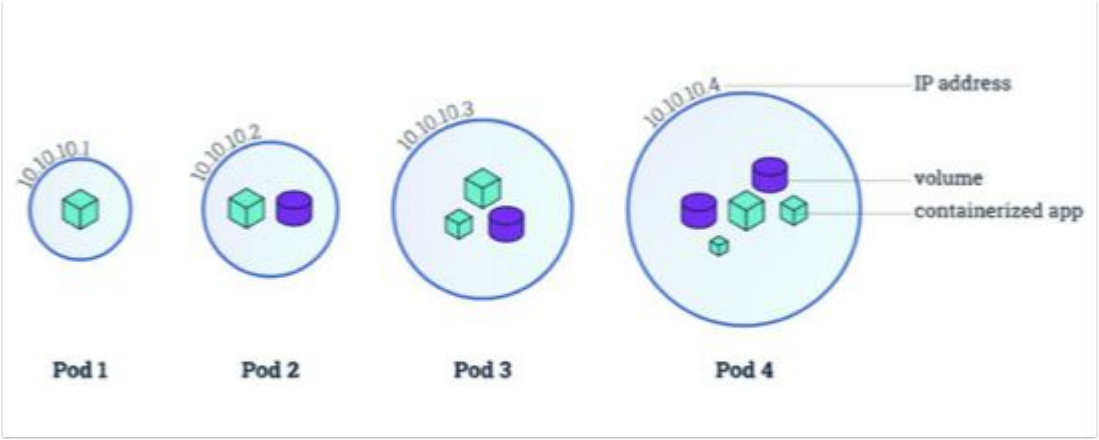
Kubernetes primitives: Pod

- Set of one or more containers that act as a unit and are scheduled onto a node together
- Share a local network and can share file-system volumes



Kubernetes primitives: Pod

- Set of one or more containers that act as a unit and are scheduled onto a node together
- Share a local network and can share file-system volumes



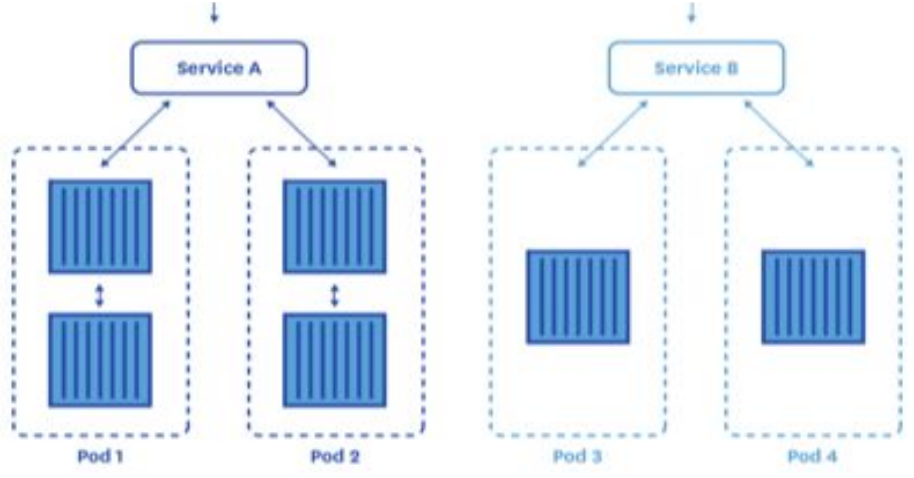
Kubernetes primitives: Deployment

- Responsible for creating and updating pods
- Kubernetes will manage state based on the definitions provided
- Can scale up/down to meet demand
- Can roll back to older version or roll forward

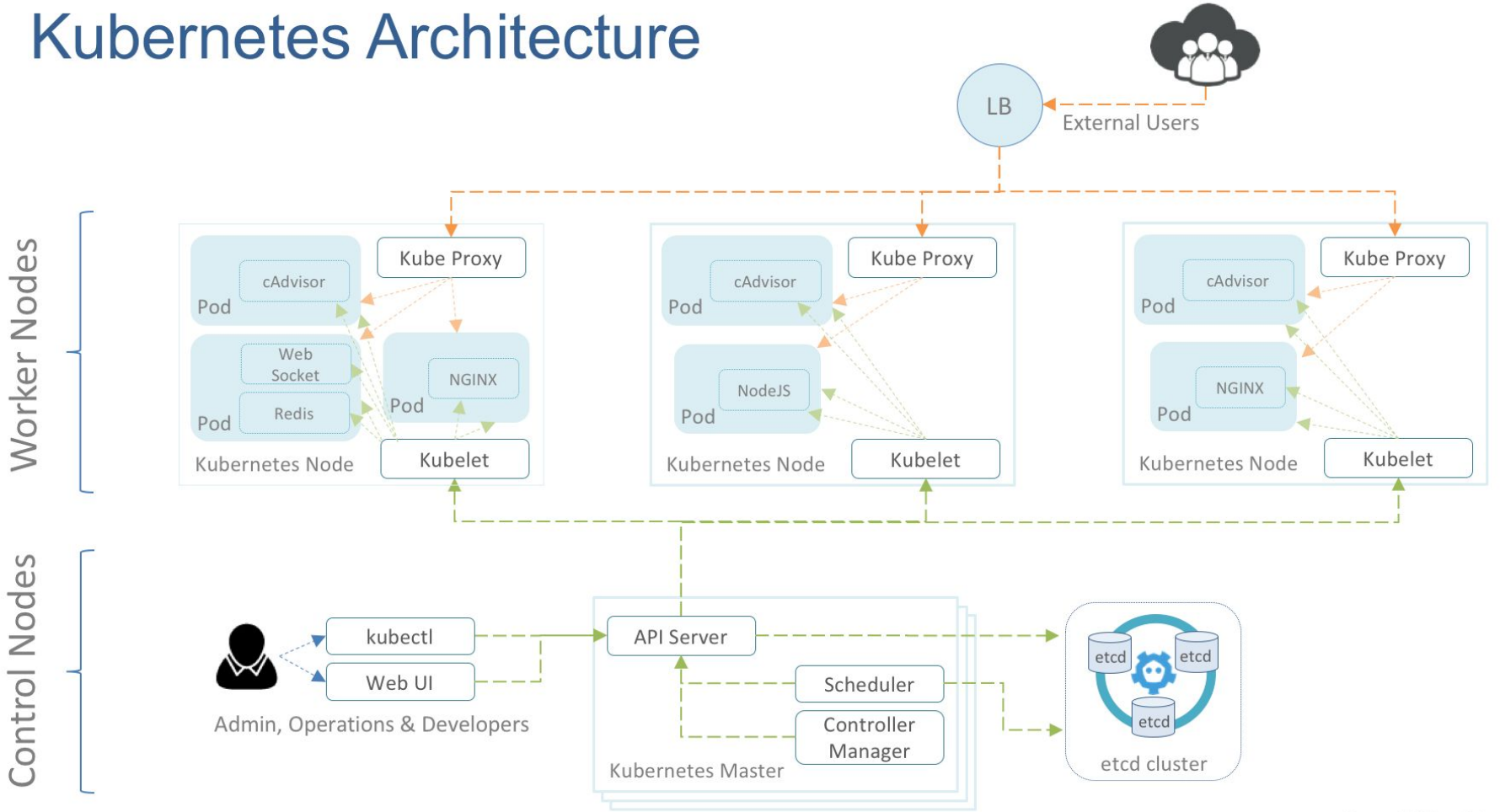
```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 4
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.7.9
        ports:
        - containerPort: 80
```

Kubernetes primitives: Service

- Defines a way to access pods in a consistent way
- Services find the Pod to route traffic based on the Labels/Selectors in the manifest
    - Inside the cluster, they perform load balancing
    - They can also interact with GKE, OKE, etc to create external load balancers

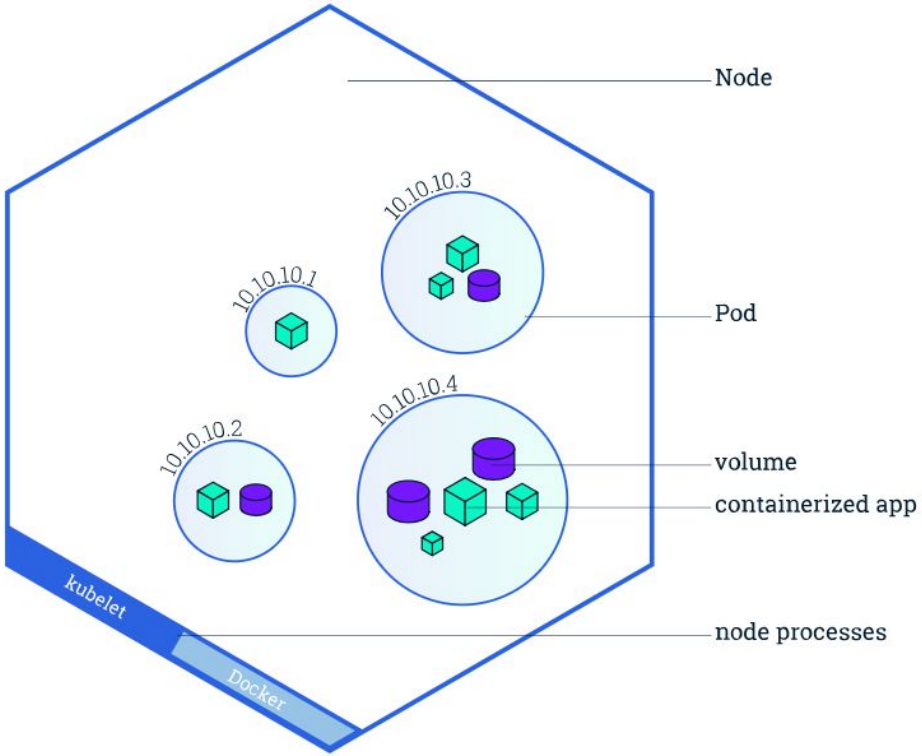


Kubernetes Architecture

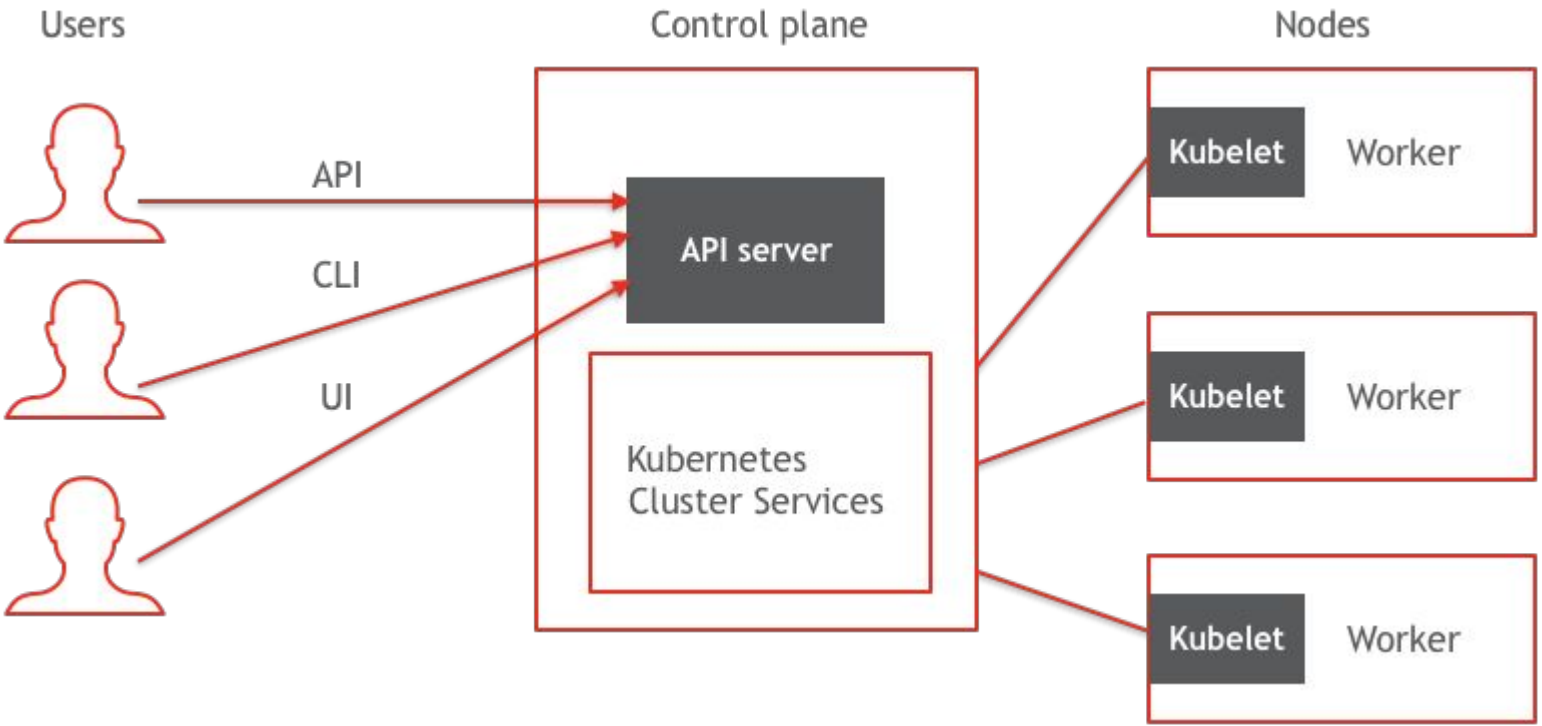


Source William Caban

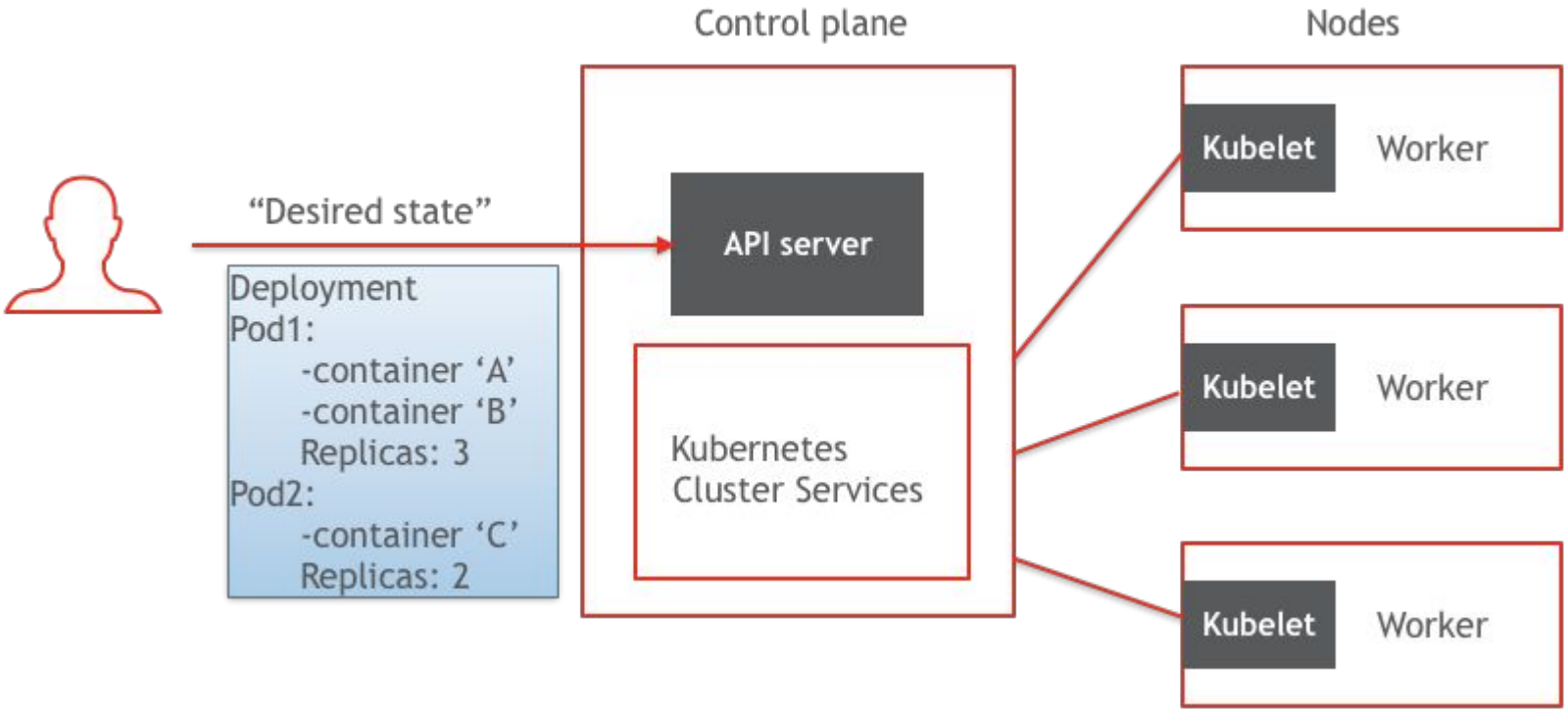
Kubernetes: Worker Nodes



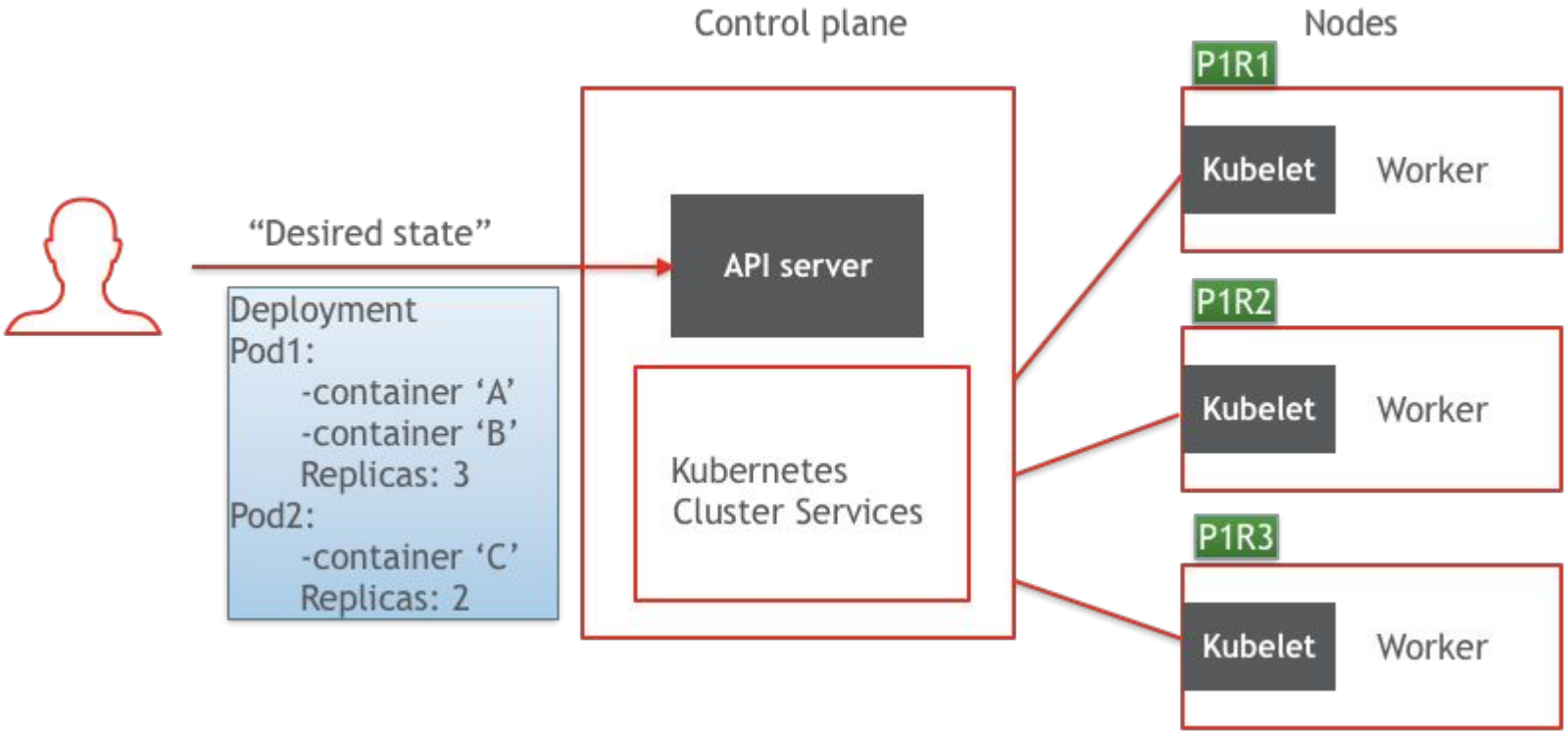
Lifecycle of a pod



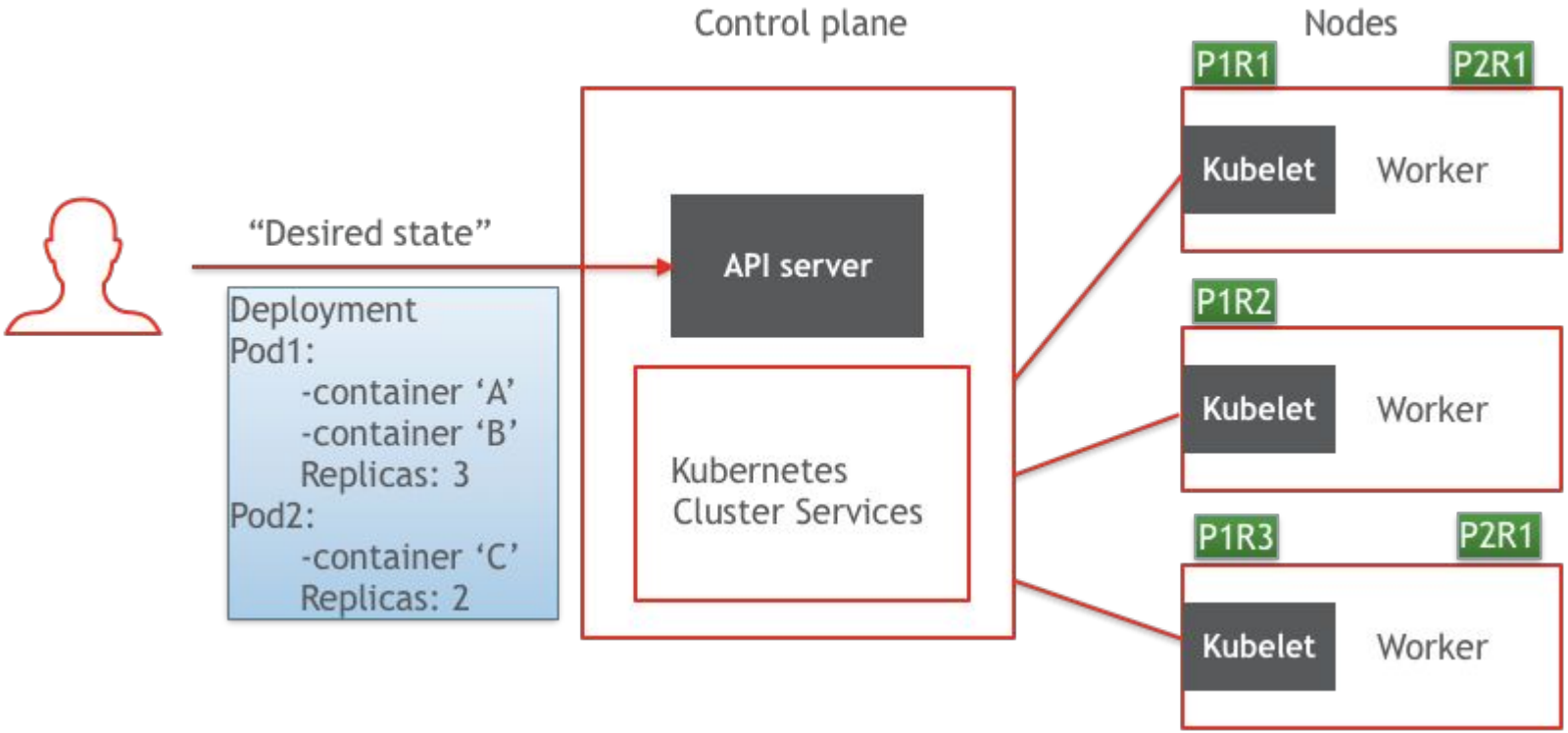
Lifecycle of a pod



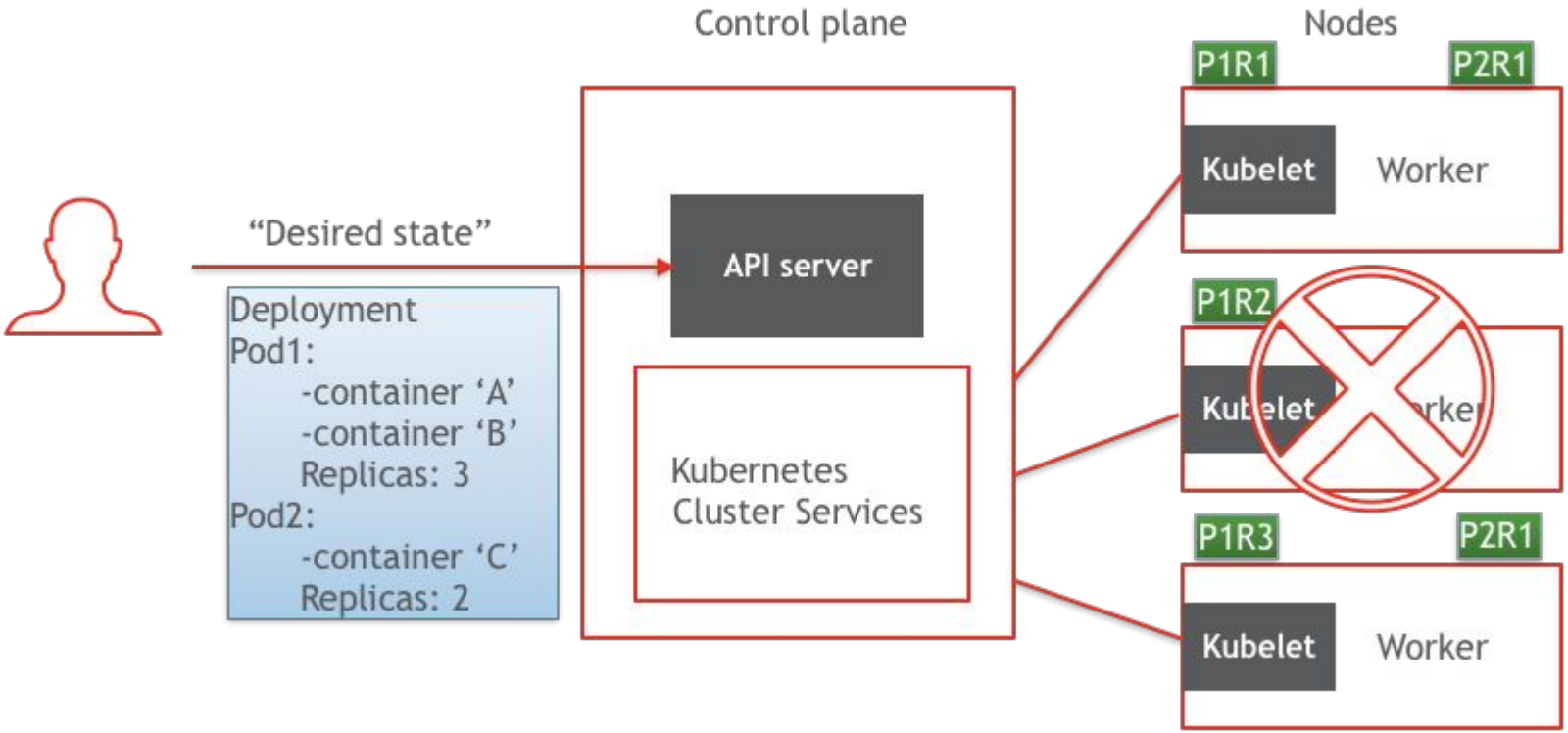
Lifecycle of a pod



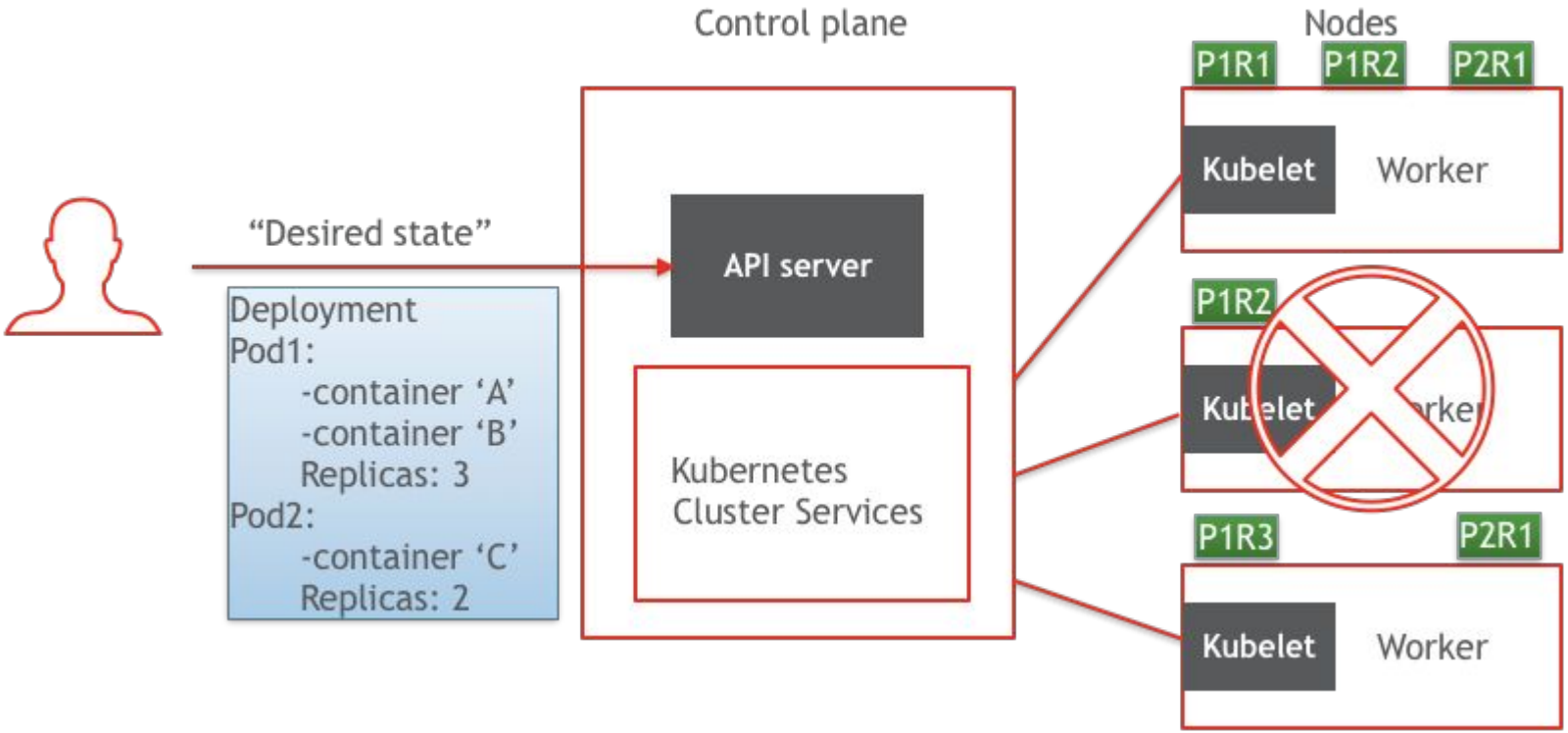
Lifecycle of a pod



Lifecycle of a pod



Lifecycle of a pod



Minikube

https://kubernetes.io/docs/tasks/tools/install-minikube/

https://github.com/kubernetes/minikube

- Tool which runs Kubernetes locally
- Great for testing out Kubernetes components
- Not so great in production

Minikube

https://kubernetes.io/docs/tasks/tools/install-minikube/

1. Start minikube

```
mpatrich-Mac:bristoldojo mpatrich$ minikube start
There is a newer version of minikube available (v0.30.0).  Download it here:
https://github.com/kubernetes/minikube/releases/tag/v0.30.0

To disable this notification, run the following:
minikube config set WantUpdateNotification false
Starting local Kubernetes v1.9.4 cluster...
Starting VM...
Getting VM IP address...
Moving files into cluster...
Setting up certs...
Connecting to cluster...
Setting up kubeconfig...
Starting cluster components...
Kubectl is now configured to use the cluster.
```

Minikube

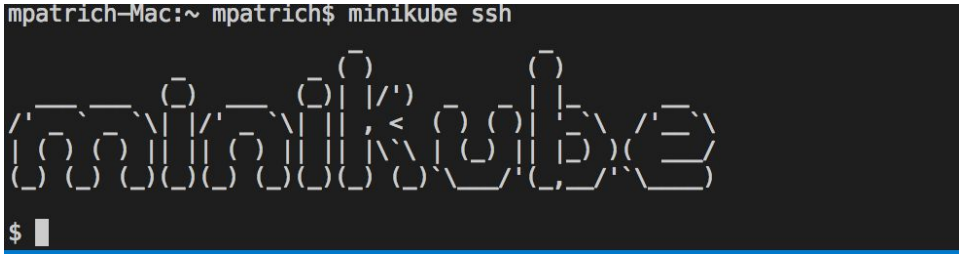
2. Check minikube status

```
mpatrich-Mac:~ mpatrich$ minikube status
minikube: Running
cluster: Running
kubectl: Correctly Configured: pointing to minikube-vm at 192.168.99.100
```

Minikube-vm which contains both K8S Master and Worker components

Note: Commands which you would typically run on your Kubernetes nodes will be prefixed by *minikube* if run from your local machine.

To ssh into the minikube vm:



Minikube: Kubectl

- CLI tool used to deploy and manage applications on Kubernetes
- Inspect cluster resources
- CRUD operations on components, etc.
- Interacts with the API server
- Configuration file: `~/.kube/config`

Minikube master node API server

```
apiVersion: v1
clusters:
- cluster:
    insecure-skip-tls-verify: true
    server: https://129.213.108.39:443
  name: bmcs-k8s-cluster
- cluster:
    certificate-authority: /Users/mpatrich/.minikube/ca.crt
    server: https://192.168.99.100:8443
  name: minikube
contexts:
- context:
    cluster: bmcs-k8s-cluster
    user: default-admin
  name: bmcs-k8s-context
- context:
    cluster: minikube
    user: minikube
  name: minikube
current-context: minikube
kind: Config
preferences: {}
users:
- name: default-admin
  user:
```

Minikube: Kubectl

- View physical nodes in K8S cluster:

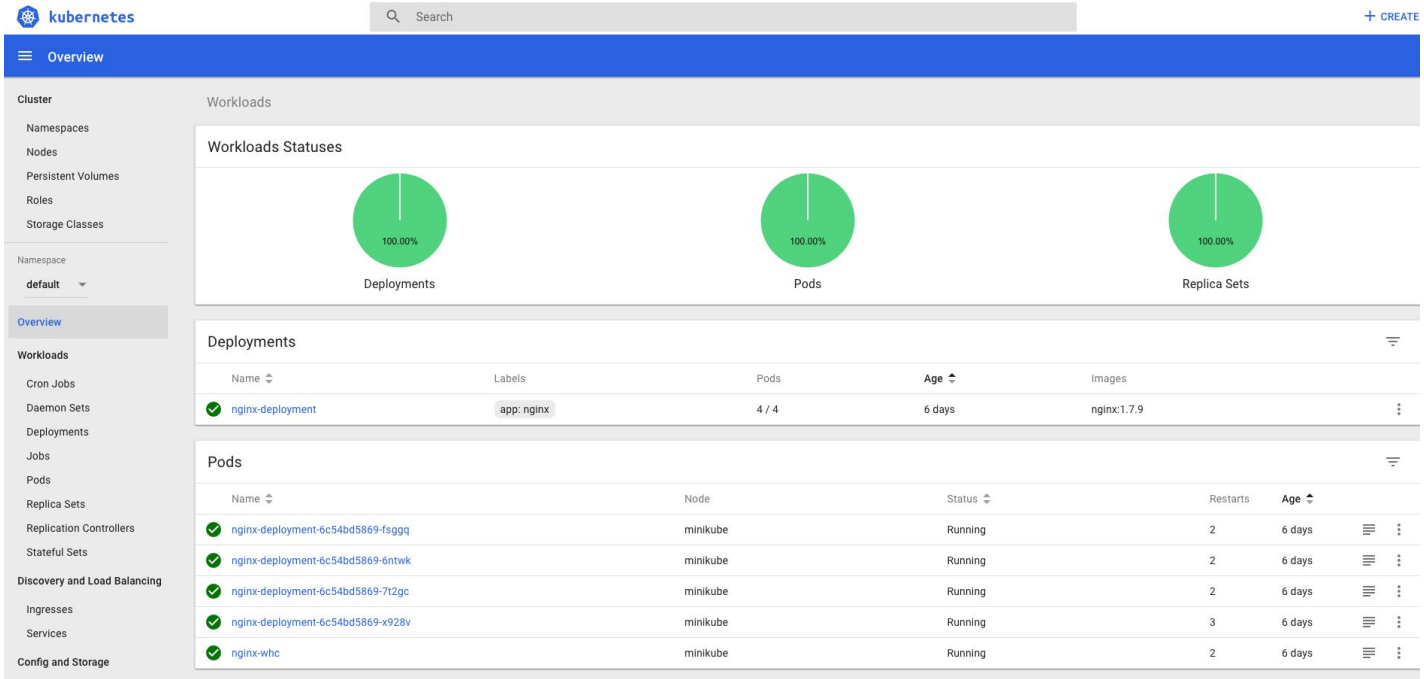
```
mpatrich—Mac:~ mpatrich$ kubectl get nodes
NAME       STATUS    ROLES     AGE       VERSION
minikube   Ready     <none>    159d      v1.9.4
```

- Get cluster info:

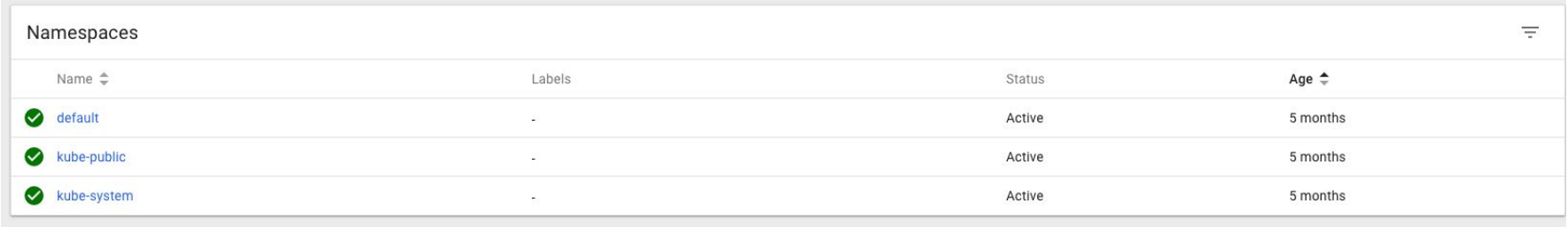
```
mpatrich—Mac:~ mpatrich$ kubectl cluster-info
Kubernetes master is running at https://192.168.99.100:8443

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.
```

Minikube: Dashboard

```
mpatrich—Mac:~ mpatrich$ minikube dashboard
Opening kubernetes dashboard in default browser...
```



Minikube: Dashboard - Namespaces



Minikube: Creating your first pod

- Create pod: kubectl create -f <pod_config_file.yaml>
- List pods: kubectl get pods
- Describe pod: kubectl describe <name_of_pod>

```
Name:         nginx-uob-installed-reqs
Namespace:    default
Node:         minikube/192.168.99.100
Start Time:   Thu, 01 Nov 2018 08:50:13 +0000
Labels:       name=nginx
Annotations:  <none>
Status:       Running
IP:           172.17.0.9
Containers:
```

- Exec into pod: kubectl exec -it <name_of_pod> -- /bin/bash

LIVE DEMO

Minikube: Accessing your first pod

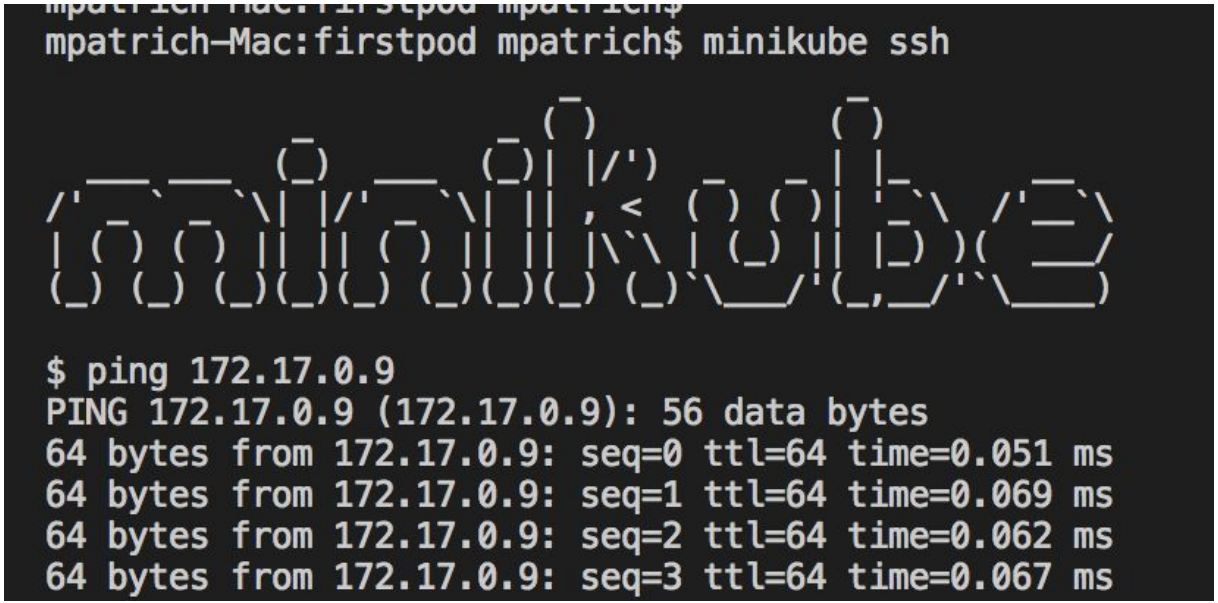
- Ping pod from our local machine:

```
mpatrich-Mac:firstpod mpatrich$ ping 172.17.0.9
PING 172.17.0.9 (172.17.0.9): 56 data bytes
Request timeout for icmp_seq 0
Request timeout for icmp_seq 1
Request timeout for icmp_seq 2
^C
--- 172.17.0.9 ping statistics ---
4 packets transmitted, 0 packets received, 100.0% packet loss
```

Will not work! Why?

Minikube: Accessing your first pod

- Ping pod from K8S node:



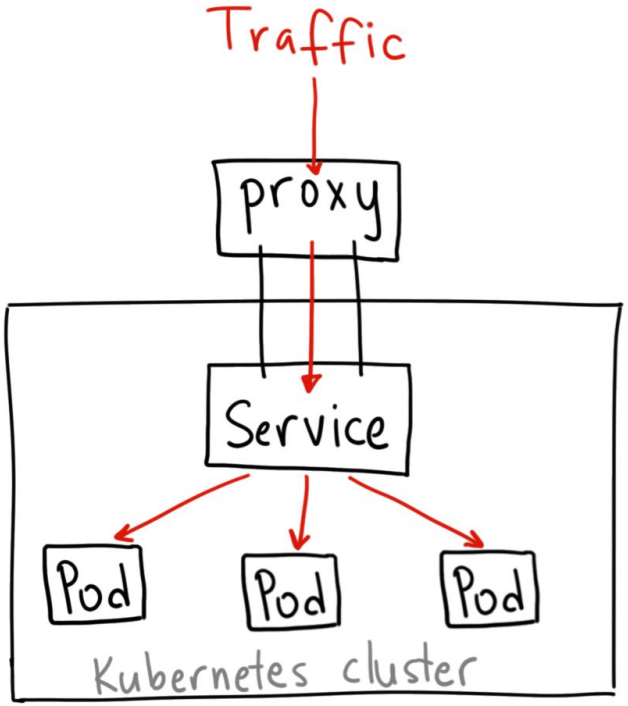
Minikube: Accessing your first pod

Solution:

1. hostPort
2. NodePort *Service*
3. LoadBalancer *Service* (Not available in Minikube)
4. ExternalName *Service* (Not available in Minikube) (Homework)

Pod Access: hostPort

- Makes use of the ClusterIP built-in Kubernetes service



Pod Access: hostPort

IP address of the K8S node where the container is running

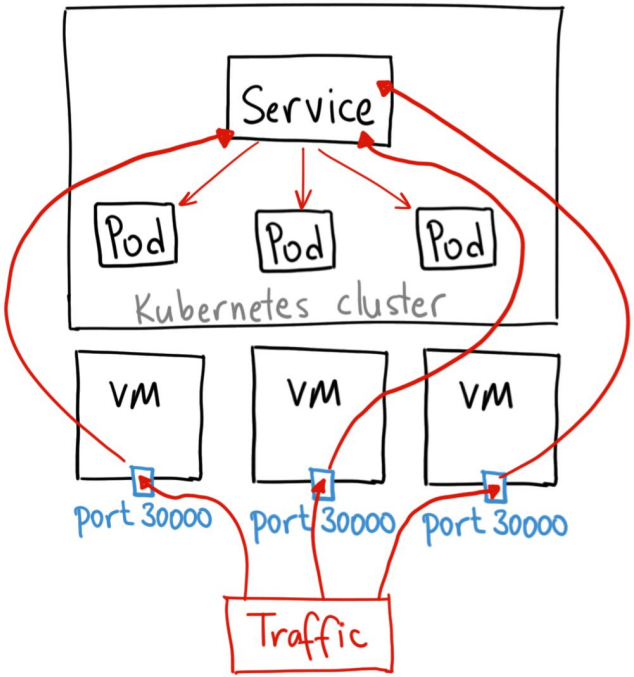
- Container port will be exposed to <hostIP>:<hostPort>

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-hostport
  labels:
    name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    ports:
    - containerPort: 80
      hostPort: 9001
```

- Drawback: hostIP can change when the container is restarted (if running in multi-node environment)

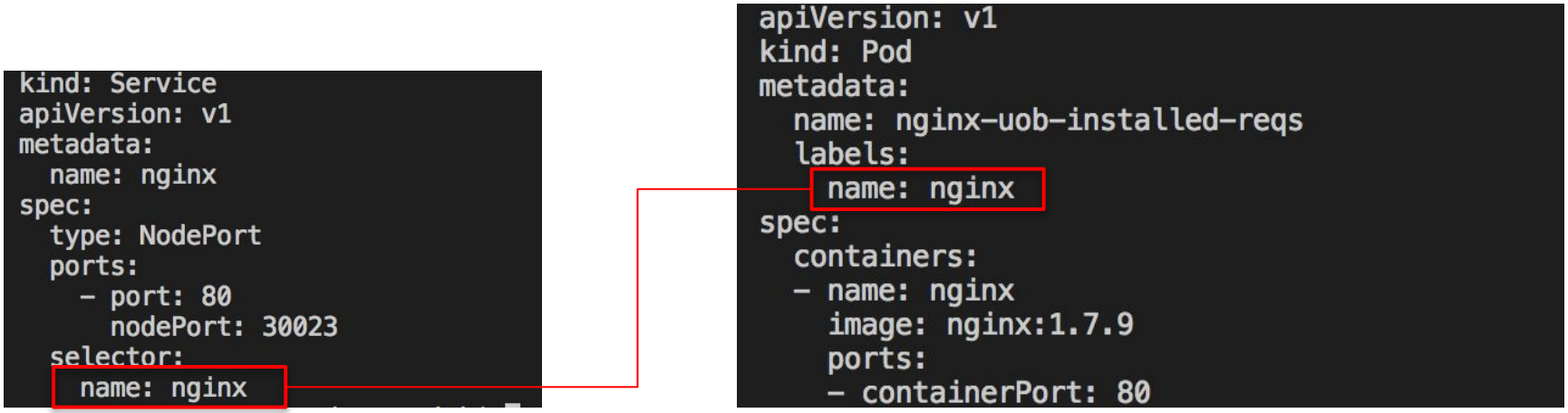
Pod Access: NodePort

- Is a type of K8S service that maps an internal port to an external one
- Port from range 30000-32767



Pod Access: NodePort

- Is a type of K8S service that maps an internal port to an external one
- Port from range 30000-32767



LIVE DEMO

- This is the most that Minikube can do with networking
- But what happens when a Kubernetes node goes down?

- Let’s create our own cluster….

Creating your own Kubernetes cluster: Terraform

- It’s kind of painful, needs some knowledge about interacting with the Cloud Provider and K8S architecture
- Terraform simplifies things for us

  https://www.terraform.io/

- Set up your own Kubernetes cluster on OCI with Terraform:

  https://github.com/oracle/terraform-kubernetes-installer

Creating your own Kubernetes cluster: OKE

- OKE (Oracle Cloud Infrastructure Container Engine for Kubernetes)
- Fully-managed, scalable, highly available service
- Used to deploy containerized application to the cloud

Creating your own Kubernetes cluster: OKE

- OKE (Oracle Cloud Infrastructure Container Engine for Kubernetes)
- Fully-managed, scalable, highly available service
- Used to deploy containerized application to the cloud

…. What it actually does

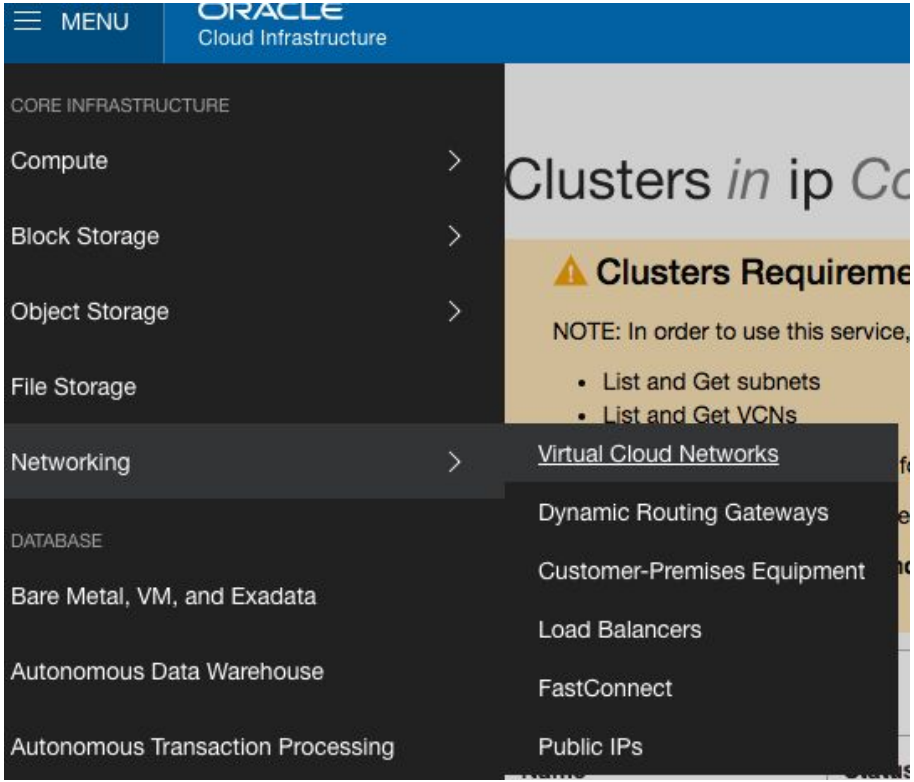
- Hosts the Control Plane on its own infrastructure
- Builds Node Pools for you to run your containers on

Creating your own Kubernetes cluster: OKE

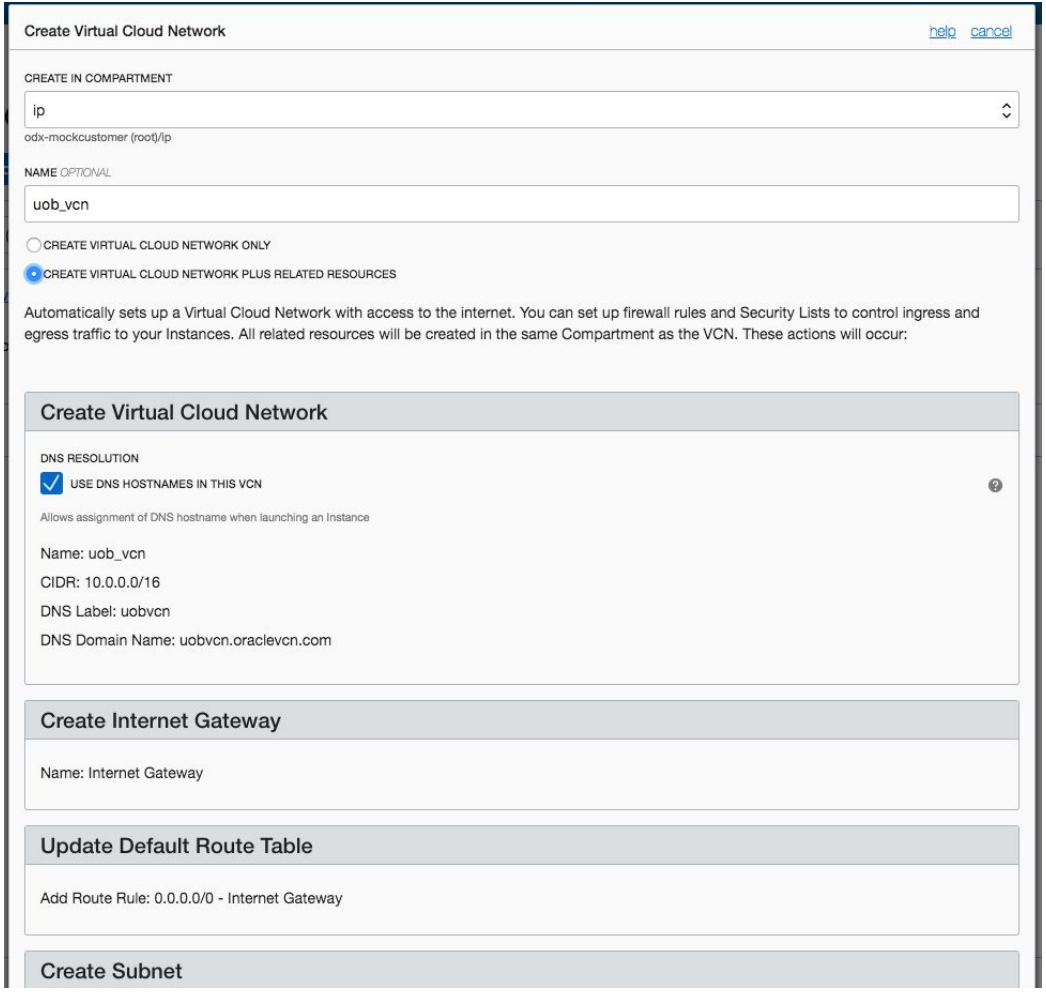
1. Create your own Virtual Cloud Network (VCN)
2. Add LoadBalancer subnets
3. Create Kubernetes cluster using OKE
4. Create NodePool (worker nodes) on the generated cluster

Chocolate time

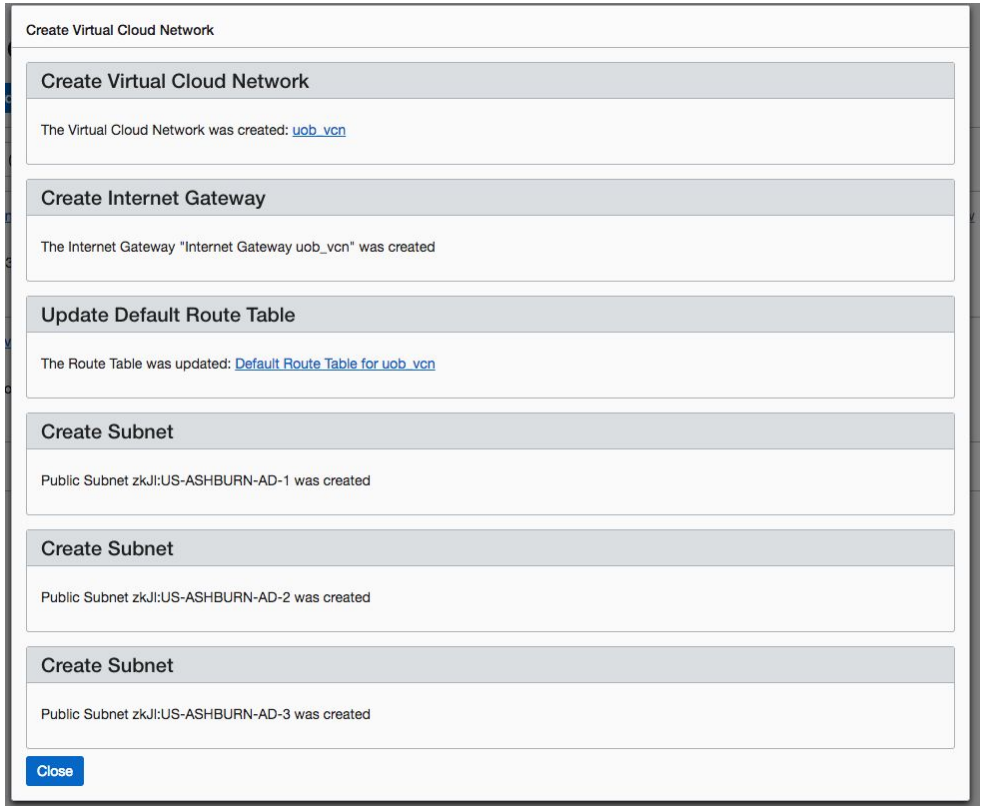
Create VCN


MENU
ORACLE
Cloud Infrastructure
CORE INFRASTRUCTURE
Compute
Block Storage
Object Storage
File Storage
Networking
DATABASE
Bare Metal, VM, and Exadata
Autonomous Data Warehouse
Autonomous Transaction Processing
Virtual Cloud Networks
Dynamic Routing Gateways
Customer-Premises Equipment
Load Balancers
FastConnect
Public IPs
Clusters in ip Co
Clusters Requireme
NOTE: In order to use this service,
List and Get subnets
List and Get VCNs

Create VCN

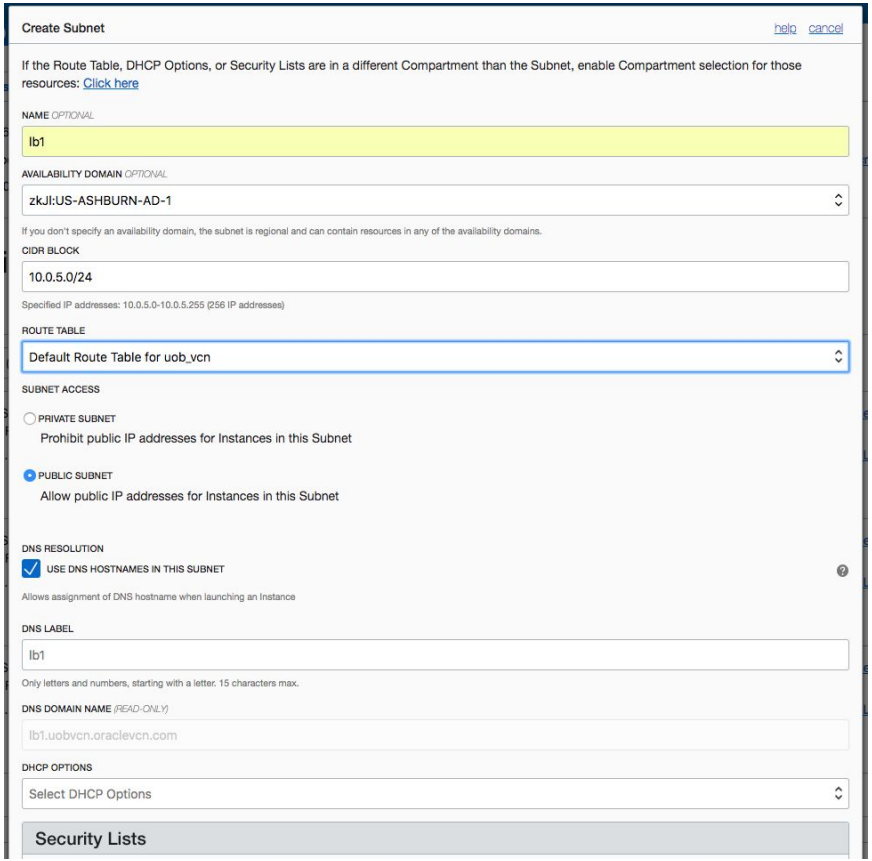

Create Virtual Cloud Network
help
cancel
CREATE IN COMPARTMENT
ip
odx-mockcustomer (root)/ip
NAME OPTIONAL
uob_vcn
CREATE VIRTUAL CLOUD NETWORK ONLY
CREATE VIRTUAL CLOUD NETWORK PLUS RELATED RESOURCES
Automatically sets up a Virtual Cloud Network with access to the internet. You can set up firewall rules and Security Lists to control ingress and egress traffic to your Instances. All related resources will be created in the same Compartment as the VCN. These actions will occur:
Create Virtual Cloud Network
DNS RESOLUTION
USE DNS HOSTNAMES IN THIS VCN
Allows assignment of DNS hostname when launching an Instance
Name: uob_vcn
CIDR: 10.0.0.0/16
DNS Label: uobvcn
DNS Domain Name: uobvcn.oraclevcn.com
Create Internet Gateway
Name: Internet Gateway
Update Default Route Table
Add Route Rule: 0.0.0.0/0 - Internet Gateway
Create Subnet

Create VCN

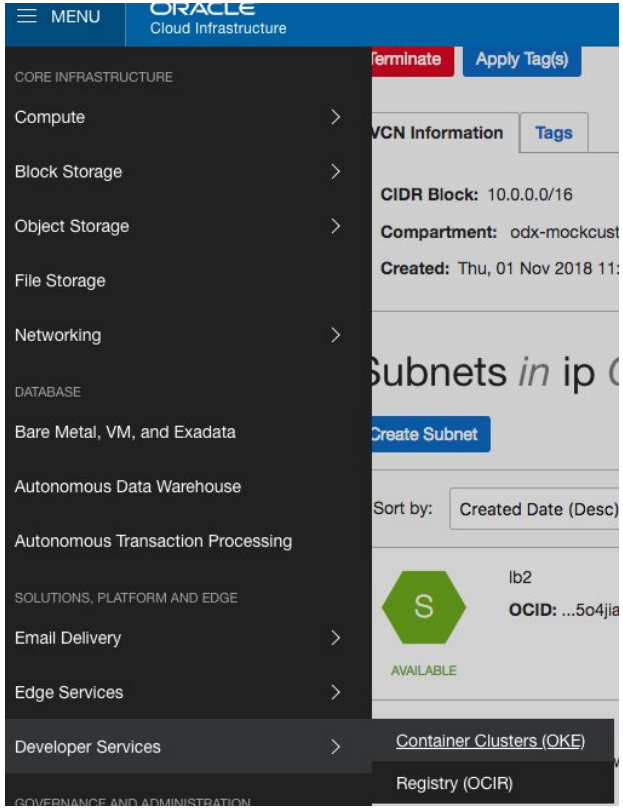

Create Virtual Cloud Network
Create Virtual Cloud Network
The Virtual Cloud Network was created: uob_vcn
Create Internet Gateway
The Internet Gateway "Internet Gateway uob_vcn" was created
Update Default Route Table
The Route Table was updated: Default Route Table for uob_vcn
Create Subnet
Public Subnet zkJI:US-ASHBURN-AD-1 was created
Create Subnet
Public Subnet zkJI:US-ASHBURN-AD-2 was created
Create Subnet
Public Subnet zkJI:US-ASHBURN-AD-3 was created
Close

Create Load Balancer subnets

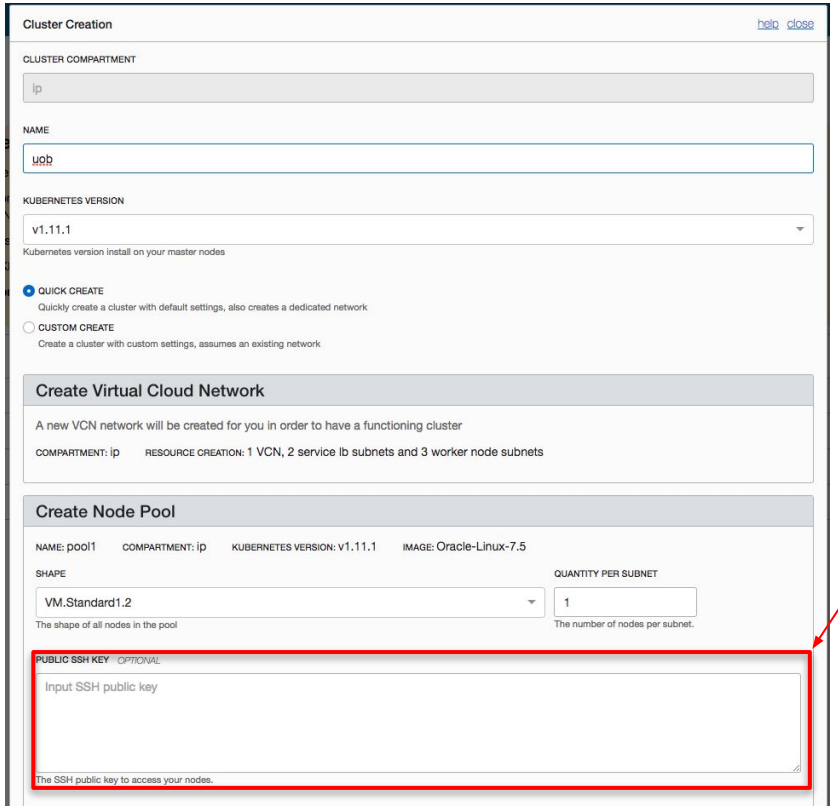
- Ideally created in different availability domains



Create OKE Custer

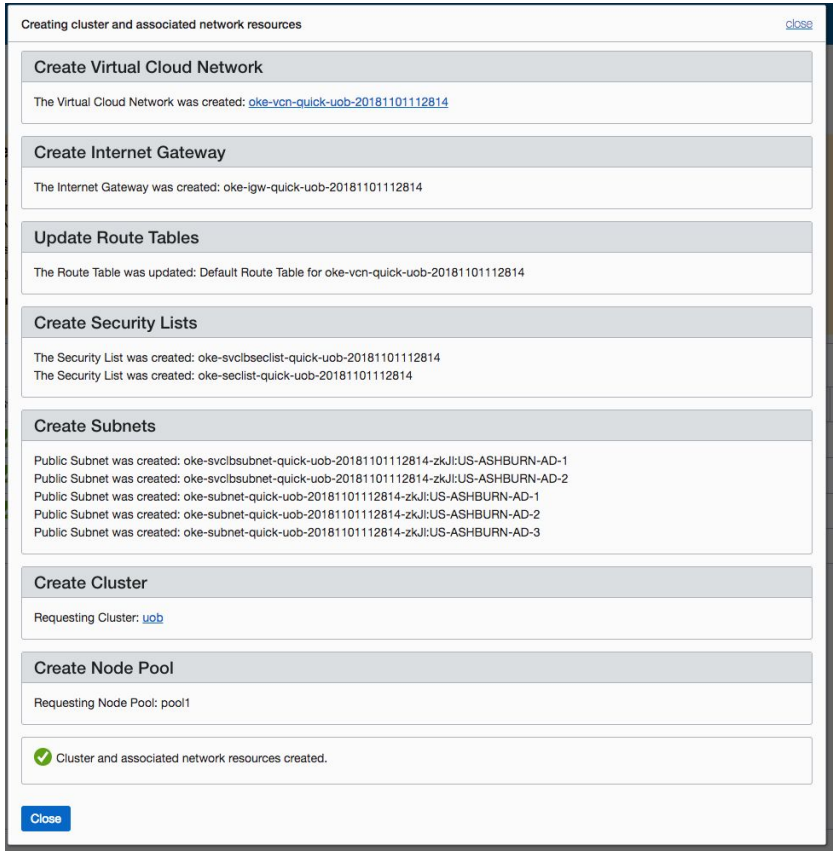


Create OKE Custer



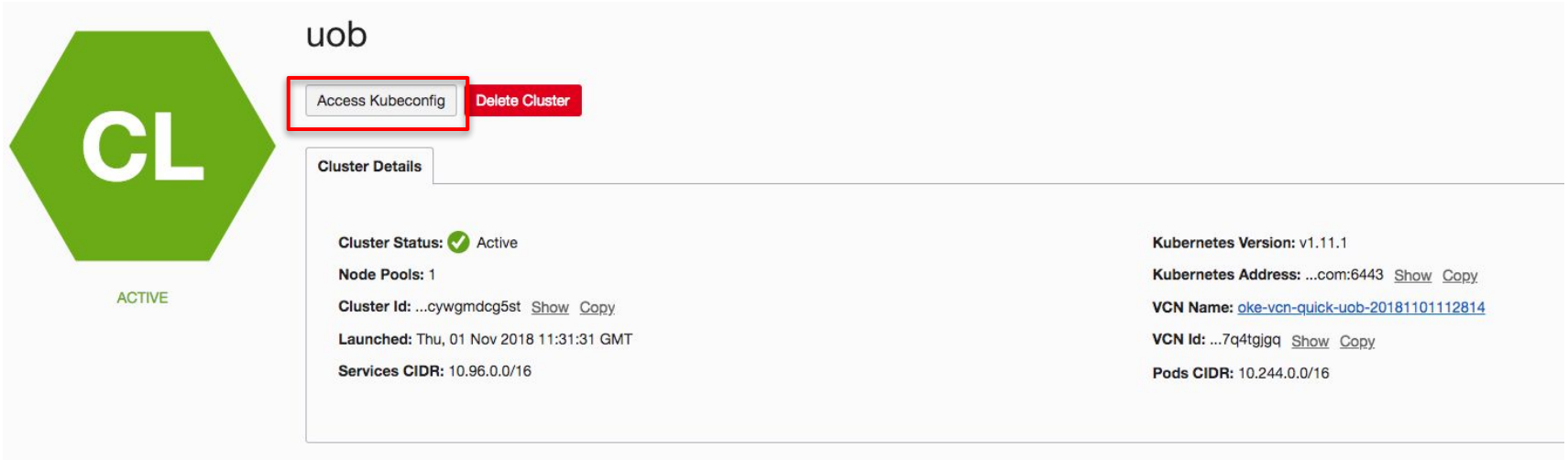
Don’t forget to add an ssh key if you want to access your nodes

Create OKE Custer

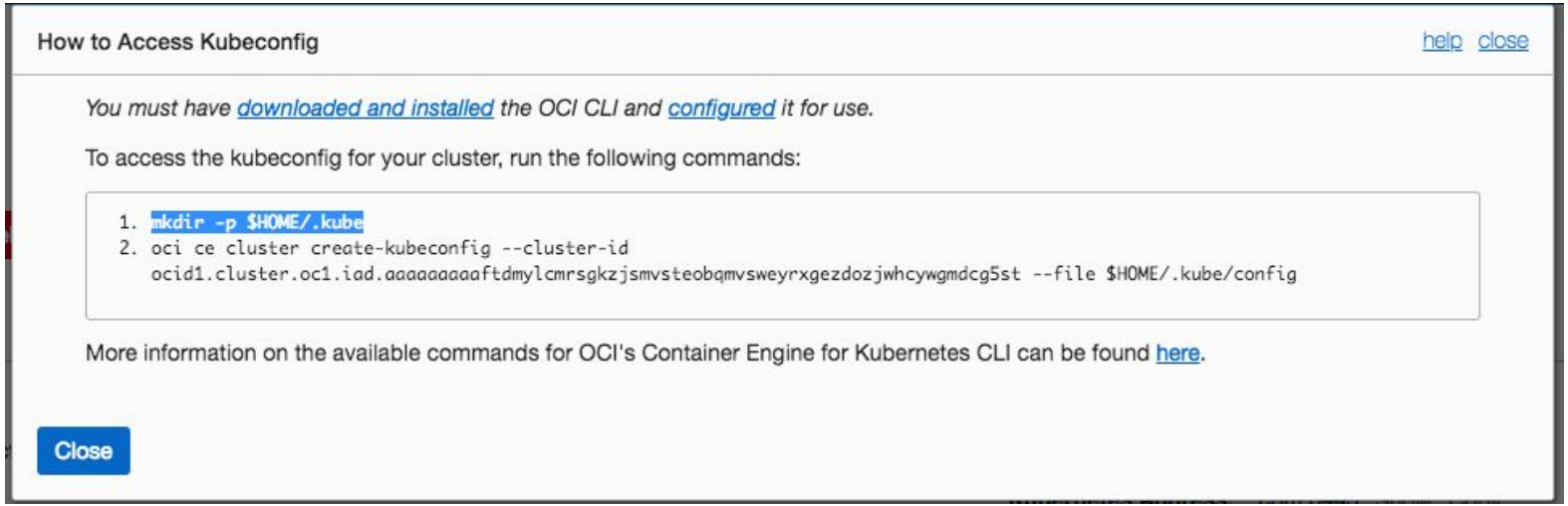


Create OKE Custer - Add NodePool

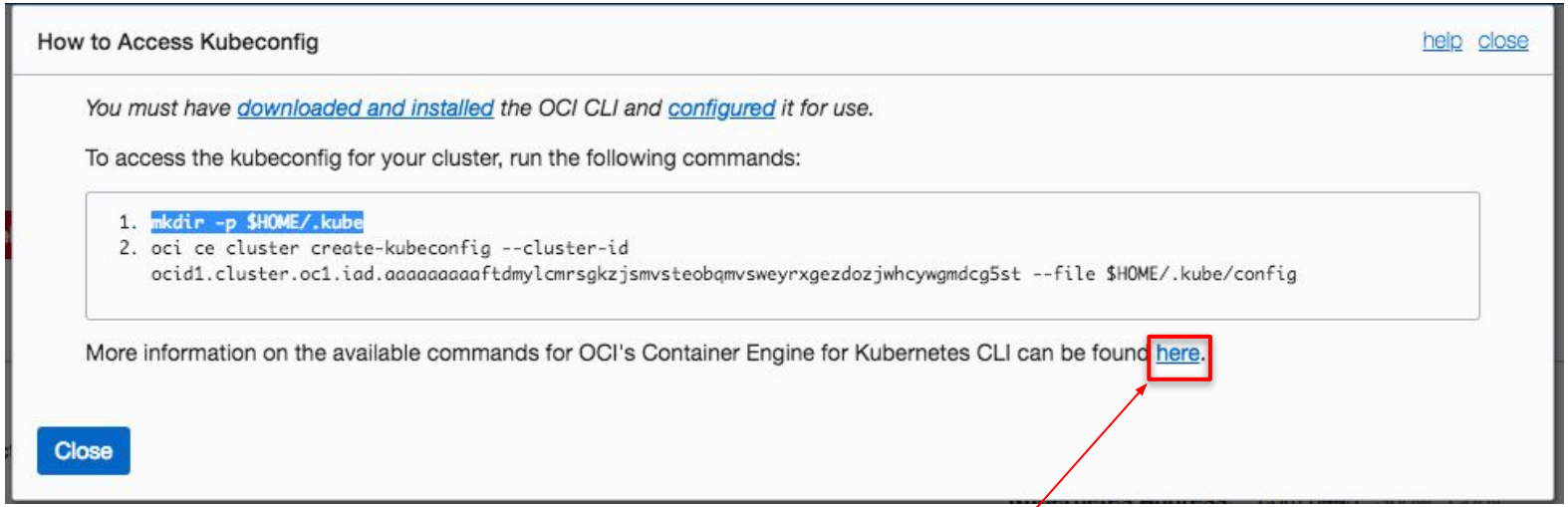
Create OKE Custer - Retrieve kubernetes config



Create OKE Custer - Retrieve kubernetes config



Create OKE Custer - Retrieve kubernetes config



Note: Will need to install and configure the oci CLI tool to communicate with OCI.

Create OKE Custer

Done!

Let’s use our cluster

Using your OKE Cluster: Kubectl

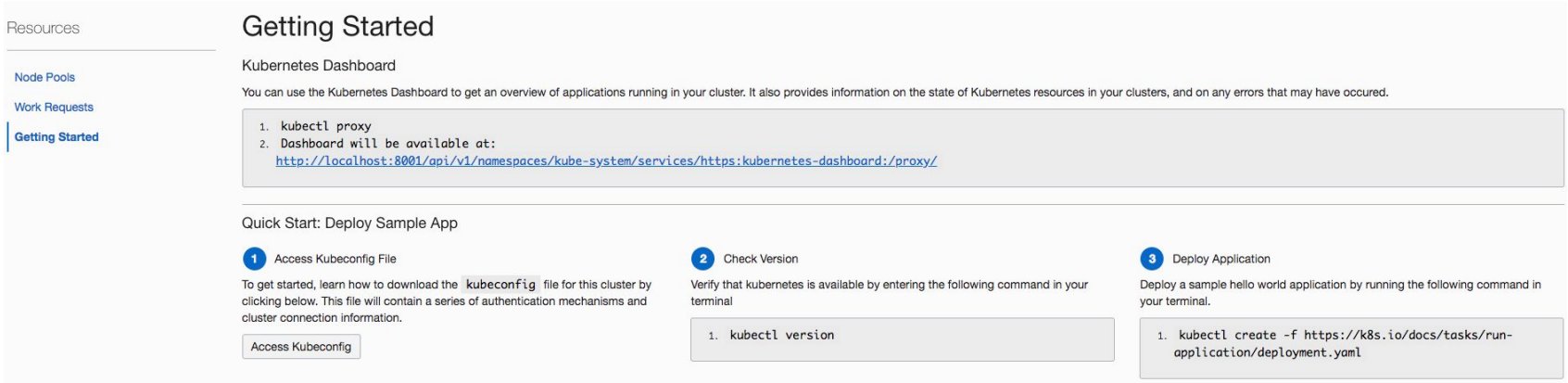
- Modify your ./kube/config with the one obtained from the Create OKE Cluster Step
- User kubectl commands to check on the status of the cluster

```
mpatrich-Mac:firstpod mpatrich$ kubectl get nodes
NAME             STATUS    ROLES     AGE       VERSION
129.213.53.71    Ready     node      8m        v1.11.1
129.213.88.24    Ready     node      8m        v1.11.1
132.145.154.41   Ready     node      8m        v1.11.1
```

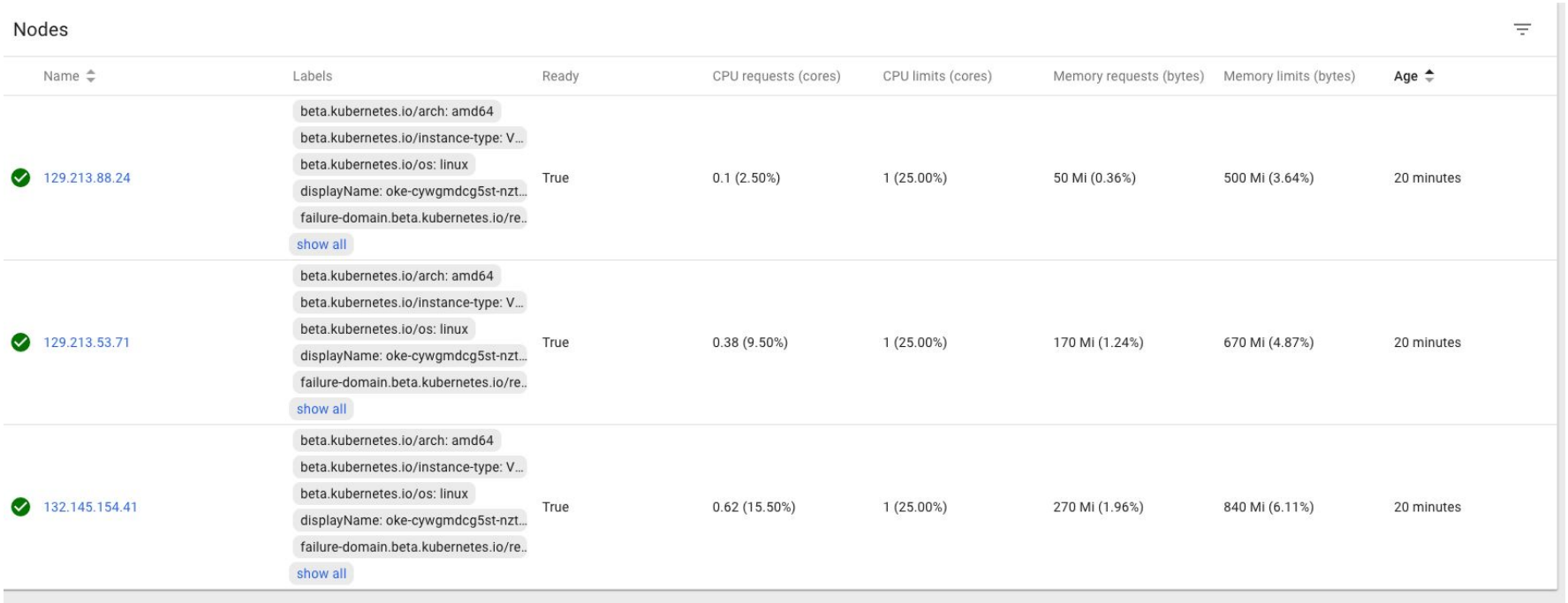
Not hosted in the same tenancy

```
Kubernetes master is running at https://cywgmdcg5st.us-ashburn-1.clusters.oci.oraclecloud.com:6443
KubeDNS is running at https://cywgmdcg5st.us-ashburn-1.clusters.oci.oraclecloud.com:6443/api/v1/namespaces/kube-system/services/kube-dns:dns/proxy

To further debug and diagnose cluster problems, use 'kubectl cluster-info dump'.
```

Using your OKE Cluster: Dashboard

- 

Using your OKE Cluster: Dashboard



Nodes

Name	Labels	Ready	CPU requests (cores)	CPU limits (cores)	Memory requests (bytes)	Memory limits (bytes)	Age
129.213.88.24	beta.kubernetes.io/arch: amd64 beta.kubernetes.io/instance-type: V... beta.kubernetes.io/os: linux displayName: oke-cywgmdcg5st-nzt... failure-domain.beta.kubernetes.io/re.. show all	True	0.1 (2.50%)	1 (25.00%)	50 Mi (0.36%)	500 Mi (3.64%)	20 minutes
129.213.53.71	beta.kubernetes.io/arch: amd64 beta.kubernetes.io/instance-type: V... beta.kubernetes.io/os: linux displayName: oke-cywgmdcg5st-nzt... failure-domain.beta.kubernetes.io/re.. show all	True	0.38 (9.50%)	1 (25.00%)	170 Mi (1.24%)	670 Mi (4.87%)	20 minutes
132.145.154.41	beta.kubernetes.io/arch: amd64 beta.kubernetes.io/instance-type: V... beta.kubernetes.io/os: linux displayName: oke-cywgmdcg5st-nzt... failure-domain.beta.kubernetes.io/re.. show all	True	0.62 (15.50%)	1 (25.00%)	270 Mi (1.96%)	840 Mi (6.11%)	20 minutes

Going back to our nginx app

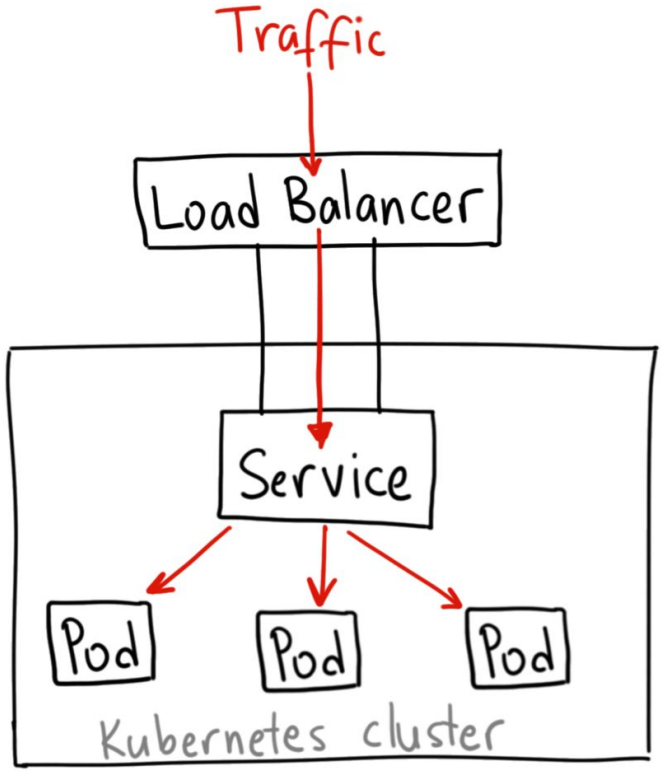
- Quickly recreate what we've done on the Minikube cluster
  - Create pod
  - Create nodeport
  - Check connection (use any IP address of the NodePool nodes):

```
mpatrich-Mac:firstpod mpatrich$ curl http://132.145.154.41:30023
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
```

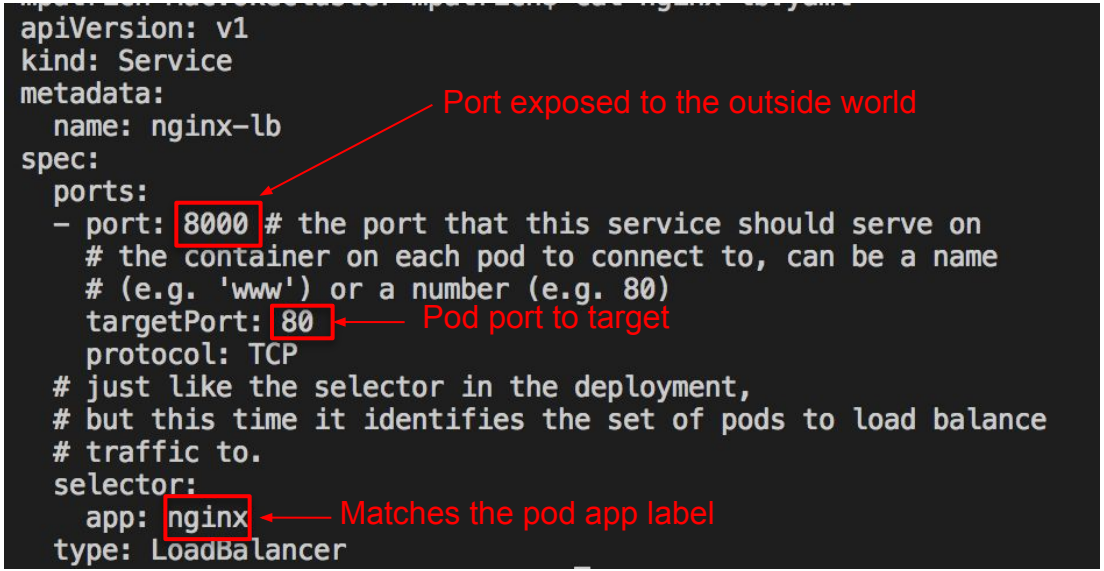
Nginx app: Add Load Balancer

- But what if one of our NodePool nodes goes down?

We need a reliable way of accessing our app with a *LoadBalancer Service*



Nginx app: Add LoadBalancer



Nginx app: Add LoadBalancer

```
mpatrich-Mac:okecluster mpatrich$ kubectl get service
NAME         TYPE           CLUSTER-IP      EXTERNAL-IP      PORT(S)          AGE
kubernetes   ClusterIP      10.96.0.1       <none>           443/TCP          1h
nginx        NodePort       10.96.101.85    <none>           80:30023/TCP     54m
nginx-lb     LoadBalancer   10.96.120.175   129.213.195.69   8000:32121/TCP   28m
```

Nginx app: Add LoadBalancer

Let’s test it!

```
mpatrich-Mac:okecluster mpatrich$ curl 129.213.195.69:8000
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
```

Nginx app: Adding more pods

- But what if the pod goes down?
- Ideally we would want to have multiple replicas of the same pod

Nginx app: Adding more pods

- But what if the pod goes down?
- Ideally we would want to have multiple replicas of the same pod

We need a way of managing the multiple replicas of our app
with a *Deployment*

Nginx app: Adding more pods

- But what if the pod goes down?
- Ideally we would want to have multiple replicas of the same pod

We need a way of managing the multiple replicas of our app
with a *Deployment*

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx-dep
spec:
  replicas: 4
  selector:
    matchLabels:
      app: nginx-dep
  template:
    metadata:
      labels:
        app: nginx-dep
    spec:
      containers:
      - name: nginx-dep
        image: nginx:1.7.9
        ports:
        - containerPort: 80
```

Homework

https://github.com/MadalinaPatrichi/uob-cloud-computing/blob/master/slides/week_4/part_2/Deploying_TodoApp_in_Kubernetes.pdf

Useful links

- Katacoda: https://www.katacoda.com/courses/kubernetes
- Minikube: https://kubernetes.io/docs/tutorials/hello-minikube/
- Oracle Cloud Infrastructure: https://cloud.oracle.com/en_US/tryit
- Terraform: https://www.terraform.io/
- Create your own Kubernetes cluster on OCI: https://github.com/oracle/terraform-kubernetes-installer