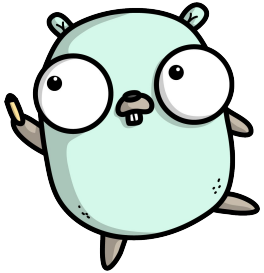
Getting Started with Kubernetes

Before We Begin



Requirements:

- **Minikube:**
  https://github.com/kubernetes/minikube
- **Virtualbox*:**
  https://www.virtualbox.org/wiki/Downloads
- **kubectl:**
  https://kubernetes.io/docs/tasks/tools/install-kubectl/
- **k8s-intro-tutorials repo:**
  https://github.com/mrbobbytables/k8s-intro-tutorials

$ whoami - Bob

Bob Killen

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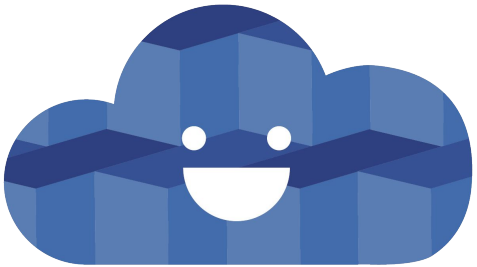
Senior Research Cloud Administrator

CNCF Ambassador

Github: @mrbobbytables

Twitter: @mrbobbytables



CLOUD NATIVE
COMPUTING FOUNDATION

AMBASSADOR

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Jeffrey Sica

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Senior Research Database Administrator

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Twitter: @jeefy

What is Kubernetes?

What Does “Kubernetes” Mean?

Greek for “pilot” or

“Helmsman of a ship”

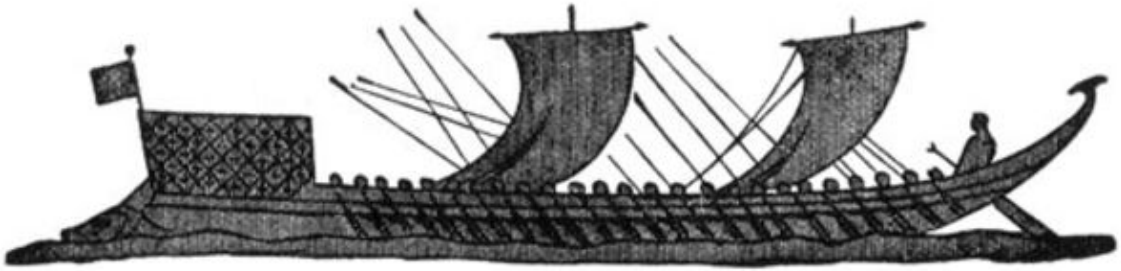
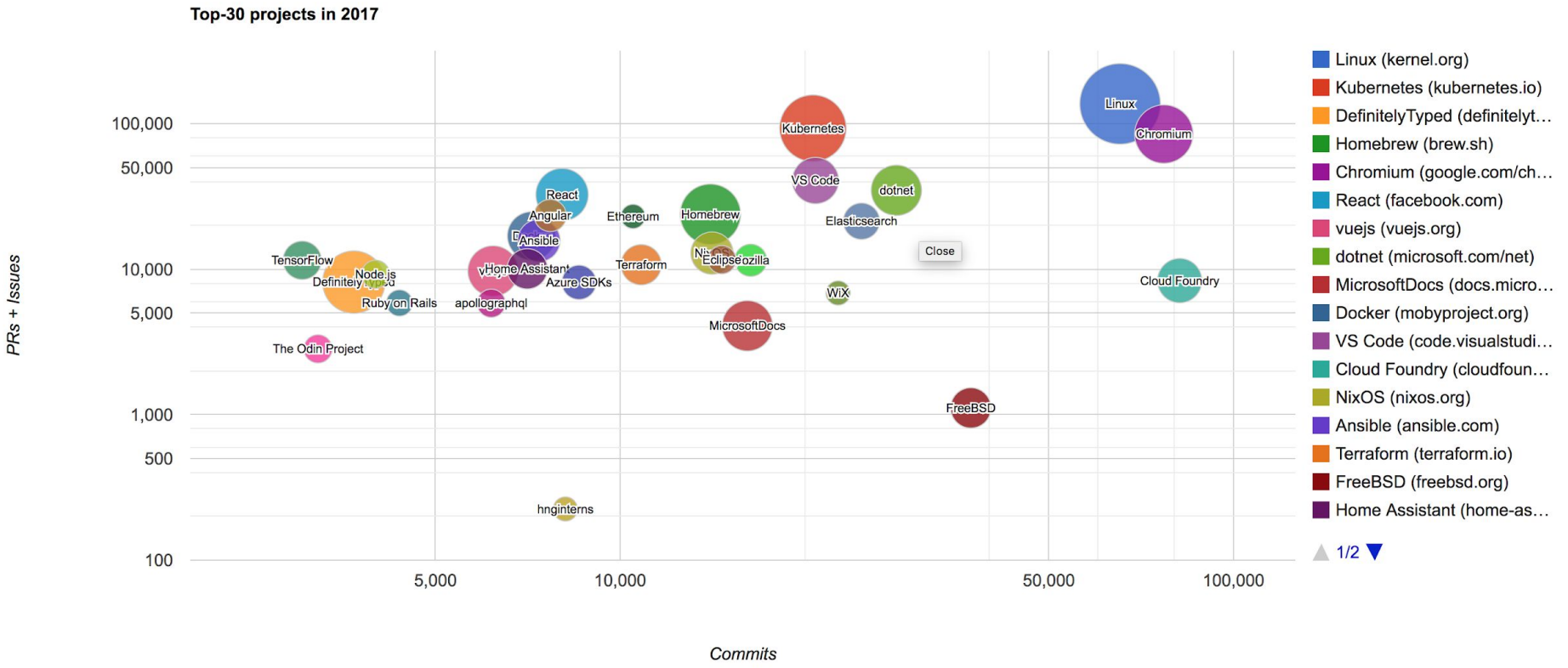


Image Source

What is Kubernetes?

- Originally sprung out of decades of container experience from inside Google (Borg, Omega, LMCTFY, etc.)
- Independent OSS project within the CNCF
- Production ready since July 2015.
- Automates deployment, scaling, and management of application containers

Kubernetes Stats



What Does Kubernetes do?

- The “**linux kernel of distributed systems**”
- Abstracts away the underlying hardware
- You **declare** a state, and Kubernetes’ main purpose is to make that happen
- Handles placement and scheduling of containers on nodes
- Provides basic monitoring, logging, and health checking
- Enables containers to discover each other (important!)

Decouples Infrastructure and Scaling

- **All services** within Kubernetes are natively Load Balanced.
- Can scale up and down dynamically.
- Used both to enable self-healing and seamless upgrading or rollback of applications.

Self Healing

Kubernetes will **ALWAYS** try and steer the cluster to its desired state.

- **Me:** “I want 3 healthy instances of redis to always be running.”
- **Kubernetes:** “Okay, I’ll ensure there are always 3 instances up and running.”
- **Kubernetes:** “Oh look, one has died. I’m going to attempt to spin up a new one.”

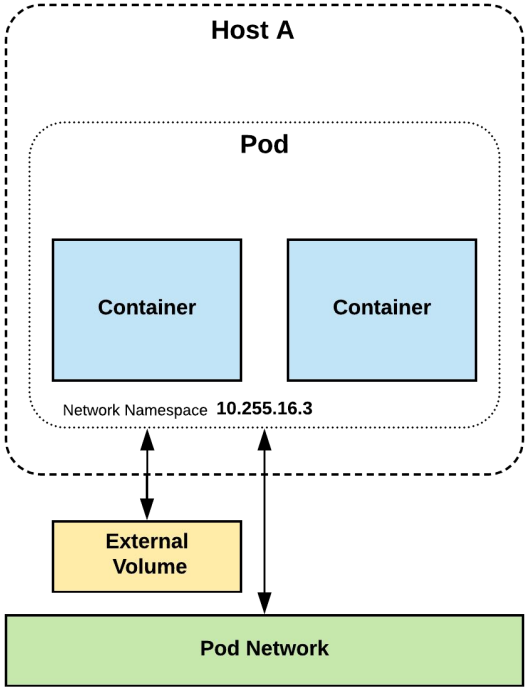
Most Importantly...

Use the **SAME** API
across bare metal and
EVERY cloud provider!!!

A Few Key Concepts...

Pods

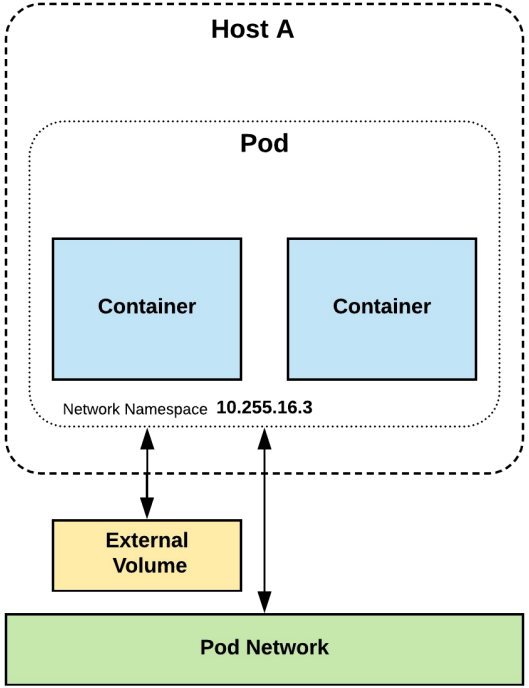
- A pod is the **atomic unit** of Kubernetes.
- Foundational building block of Kubernetes Workloads.
- Pods are one or more containers that share volumes, a network namespace, and are a part of a **single context**.



Pods

They are also Ephemeral!

(higher level objects manage replicas, fault-tolerance etc)

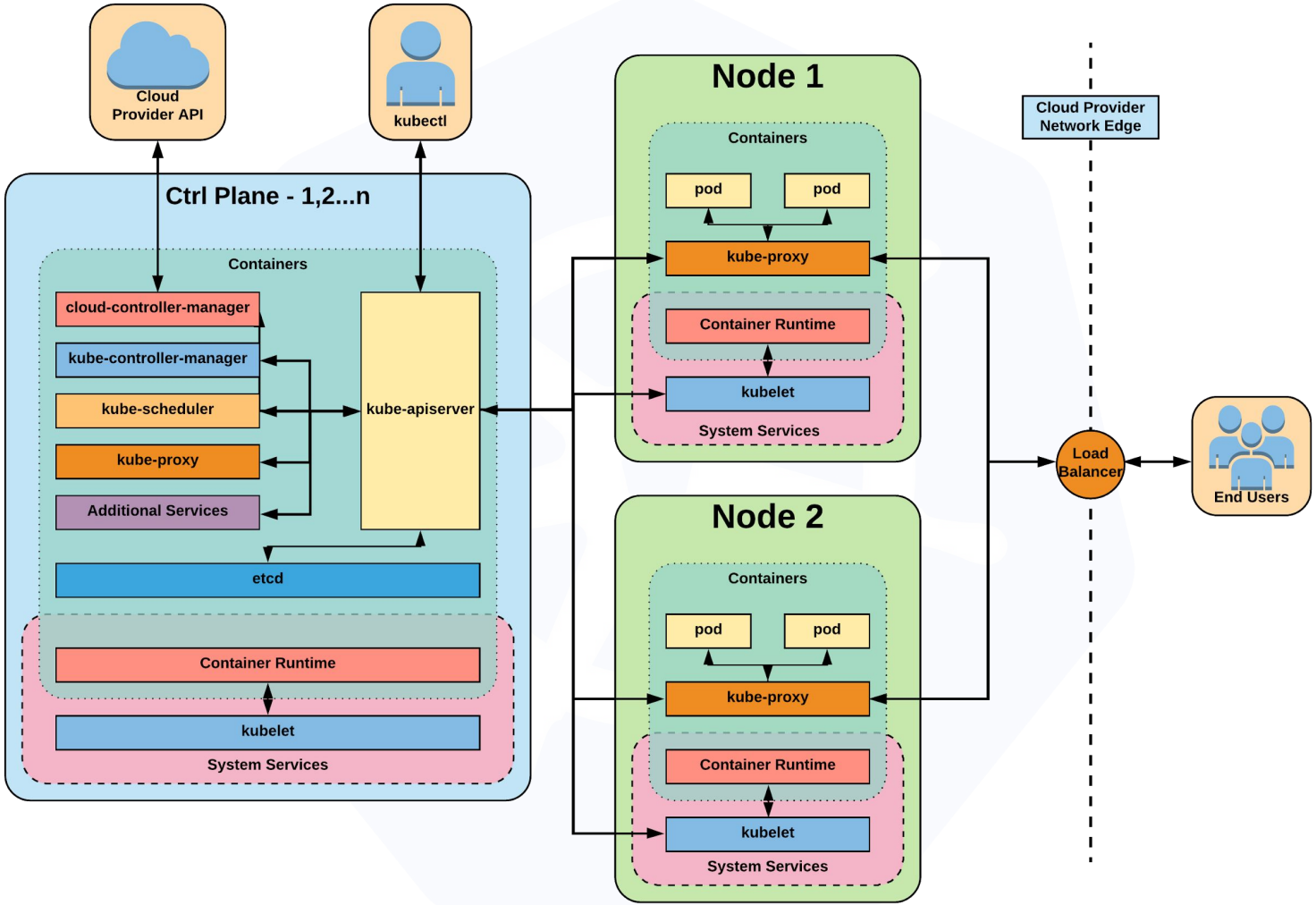


Services

- Services within Kubernetes are the **unified method of accessing** the exposed workloads of Pods.
- They are a **durable resource** (unlike Pods)
- Given a static cluster-unique IP, and in conjunction with kube-dns a static DNS name following the format of:

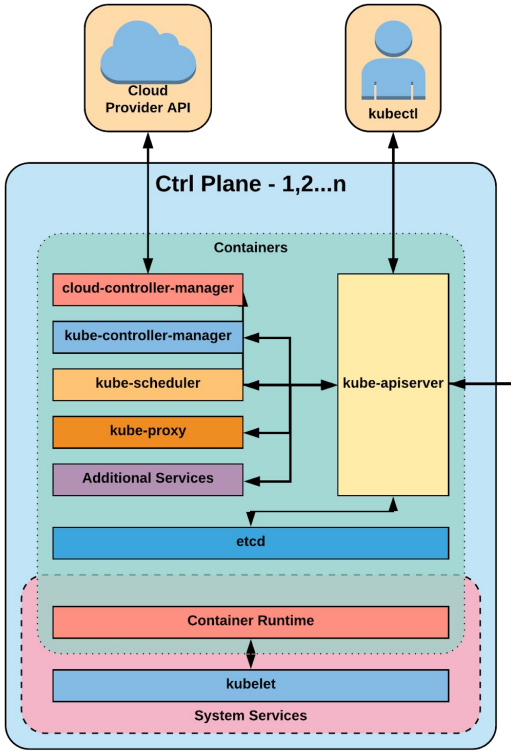
```
<service name>.<namespace>.svc.cluster.local
```

Architecture Overview


Cloud Provider API
kubectl
Ctrl Plane - 1,2...n
Containers
cloud-controller-manager
kube-controller-manager
kube-scheduler
kube-proxy
Additional Services
kube-apiserver
etcd
Container Runtime
kubelet
System Services
Node 1
Containers
pod
pod
kube-proxy
Container Runtime
kubelet
System Services
Node 2
Containers
pod
pod
kube-proxy
Container Runtime
kubelet
System Services
Cloud Provider Network Edge
Load Balancer
End Users

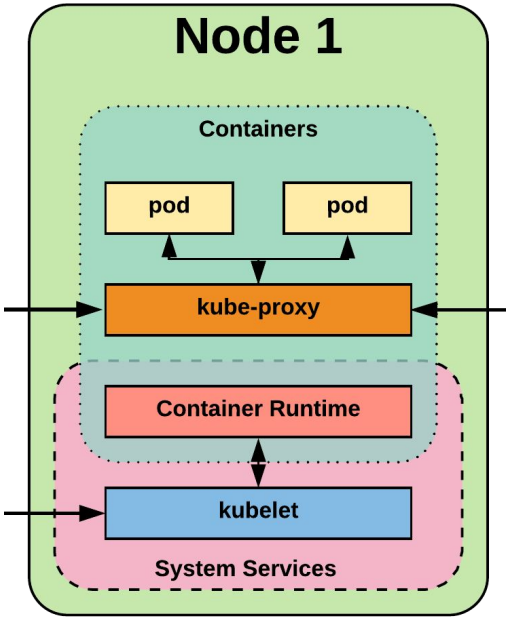
Control Plane Components

- kube-apiserver
- etcd
- kube-controller-manager
- kube-scheduler



Node Components

- kubelet
- kube-proxy
- Container Runtime Engine



Kubernetes Networking

- **Pod Network -** Cluster-wide network used for pod-to-pod communication managed by a CNI (Container Network Interface) plugin.

- **Service Network -** Cluster-wide range of **Virtual IPs** managed by kube-proxy for service discovery.

Fundamental Networking Rules

- All containers within a pod can communicate with each other unimpeded.
- All Pods can communicate with all other Pods without NAT.
- All nodes can communicate with all Pods (and vice-versa) without NAT.
- The IP that a Pod sees itself as is the same IP that others see it as.

The API and Object Model

Concepts and Resources

API Overview

The **REST API** is the true **keystone** of Kubernetes.

Everything within the Kubernetes platform is treated as an **API Object** and has a corresponding entry in the API itself.

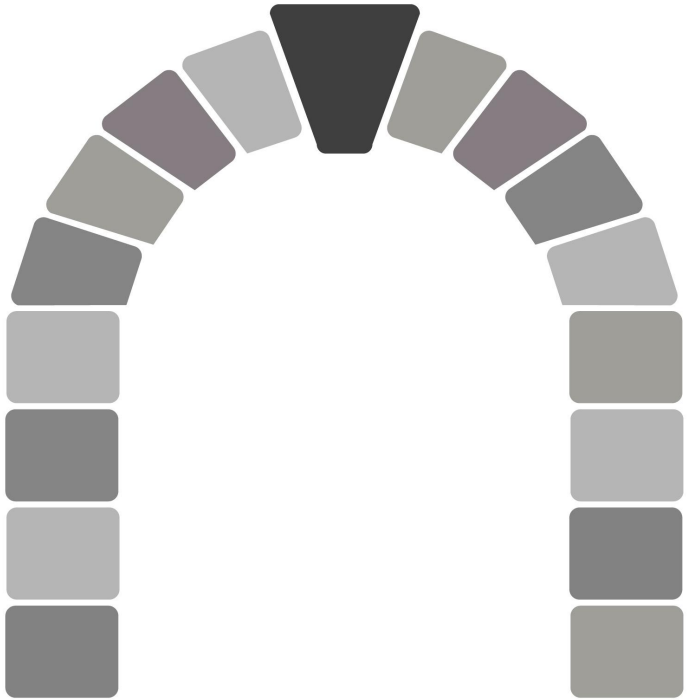


Image Source

Object Model

- Objects within Kubernetes are a “*record of intent*”
  - Persistent entity that represent the desired state of the object within the cluster.

- At a minimum all objects **MUST** have an `apiVersion`, `kind`, and poses the nested fields `metadata.name`, `metadata.namespace`, and `metadata.uid`.

Object Model Requirements

- `apiVersion:` Kubernetes API version of the Object
- `kind:` Type of Kubernetes Object
- `metadata.name:` Unique name of the Object
- `metadata.namespace:` Scoped environment name that the object belongs to (will default to current).
- `metadata.uid:` The (generated) uid for an object.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-example
  namespace: default
  uid: f8798d82-1185-11e8-94ce-080027b3c7a6
```

Using the API

(aka, using the CLI)

Core Objects

- Namespaces
- Pods
- Labels
- Selectors
- Services

Core Concepts

Kubernetes has several core building blocks that make up the foundation of their higher level components.

Namespaces

Pods **Services**

Labels **Selectors**

Namespaces

Namespaces are a logical cluster or environment, and are the primary method of partitioning a cluster or scoping access.

```
apiVersion: v1
kind: Namespace
metadata:
  name: prod
  labels:
    app: MyBigWebApp
```

```
$ kubectl get ns --show-labels
NAME          STATUS    AGE       LABELS
default       Active    11h       <none>
kube-public   Active    11h       <none>
kube-system   Active    11h       <none>
prod          Active    6s        app=MyBigWebApp
```

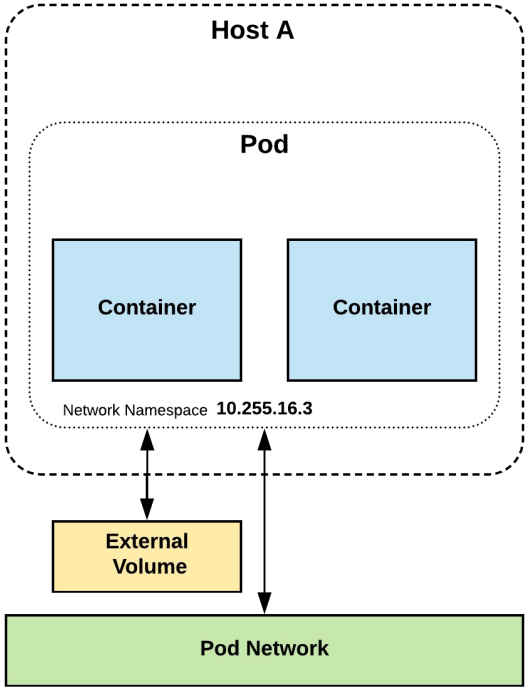
Default Namespaces

- **default**: The default namespace for any object without a namespace.
- **kube-system**: Acts as the the home for objects and resources created by Kubernetes itself.
- **kube-public**: A special namespace; readable by all users that is reserved for cluster bootstrapping and configuration.

```
$ kubectl get ns --show-labels
NAME          STATUS    AGE       LABELS
default       Active    11h       <none>
kube-public   Active    11h       <none>
kube-system   Active    11h       <none>
```

Pods

- A pod is the **atomic unit** of Kubernetes.
- It is the foundational building block of Kubernetes Workloads.
- Pods are one or more containers that share volumes, a network namespace, and are a part of a **single context**.



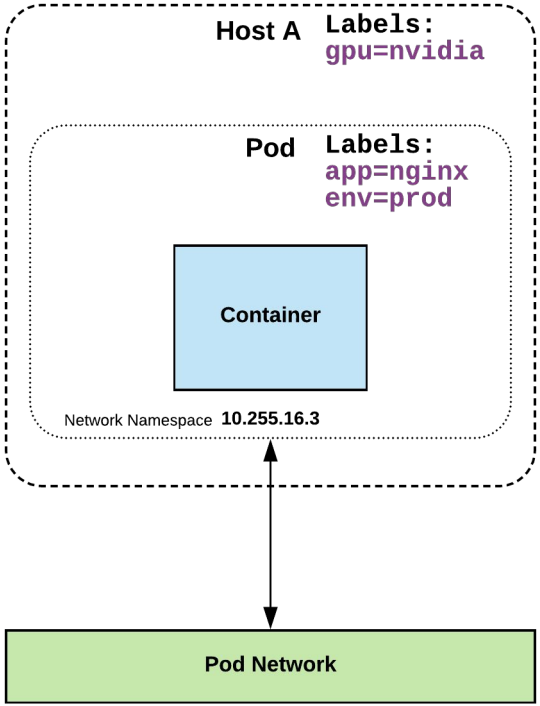
Pod Examples

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-example
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    ports:
    - containerPort: 80
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: multi-container-example
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    volumeMounts:
    - name: html
      mountPath: /usr/share/nginx/html
  - name: content
    image: alpine:latest
    command: ["/bin/sh", "-c"]
    args:
      - while true; do
          date >> /html/index.html;
          sleep 5;
        done
    volumeMounts:
    - name: html
      mountPath: /html
  volumes:
  - name: html
    emptyDir: {}
```

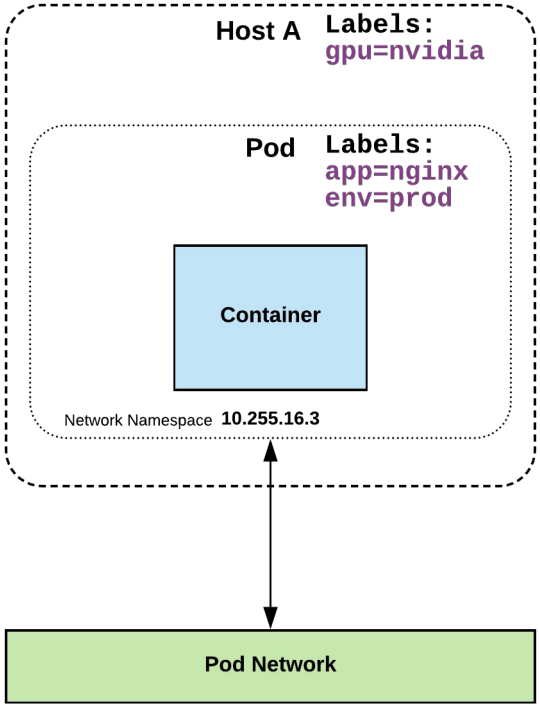
Labels

- Labels are key-value pairs that are used to identify, describe and group together related sets of objects or resources.



Label Example

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-label-example
  labels:
    app: nginx
    env: prod
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    ports:
    - containerPort: 80
```



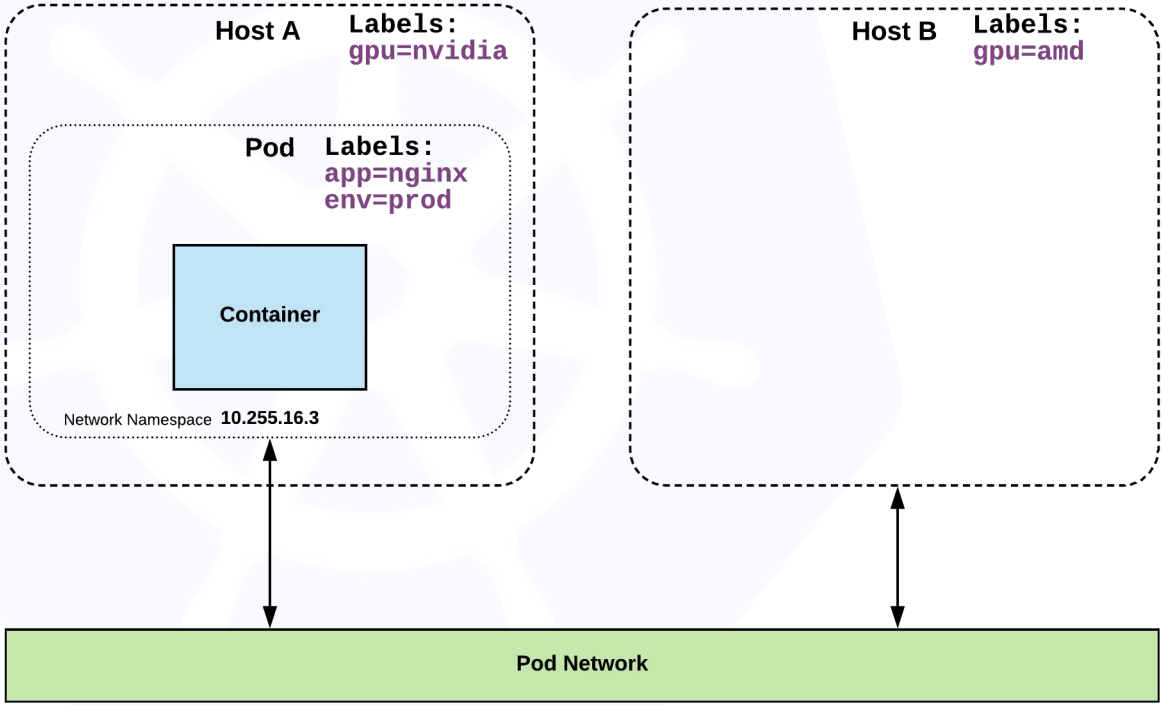
Selectors

Selectors use labels to filter or select objects, and are used throughout Kubernetes.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-label-example
  labels:
    app: nginx
    env: prod
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    ports:
    - containerPort: 80
  nodeSelector:
    gpu: nvidia
```

Selector Example

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-label-example
  labels:
    app: nginx
    env: prod
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    ports:
    - containerPort: 80
  nodeSelector:
    gpu: nvidia
```



Selector Types

Equality based selectors allow for simple filtering (=,==, or !=).

```
selector:
  matchLabels:
    gpu: nvidia
```

Set-based selectors are supported on a limited subset of objects. However, they provide a method of filtering on a set of values, and supports multiple operators including: `in`, `notin`, and `exist`.

```
selector:
  matchExpressions:
    - key: gpu
      operator: in
      values: [“nvidia”]
```

Service Types

There are 4 major service types:

- **ClusterIP** (default)
- **NodePort**
- **LoadBalancer**
- **ExternalName**

ClusterIP Service

- **ClusterIP** services exposes a service on a strictly cluster-internal virtual IP.

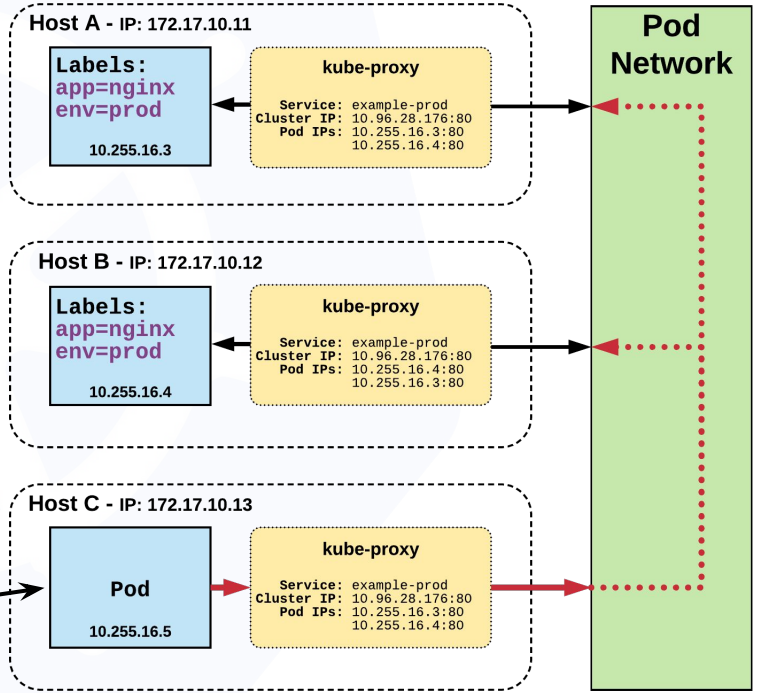
```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  selector:
    app: nginx
    env: prod
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

Cluster IP Service

```
Name:           example-prod
Selector:       app=nginx,env=prod
Type:           ClusterIP
IP:             10.96.28.176
Port:           <unset>  80/TCP
TargetPort:     80/TCP
Endpoints:      10.255.16.3:80,
                10.255.16.4:80
```

```
/ # nslookup example-prod.default.svc.cluster.local

Name:      example-prod.default.svc.cluster.local
Address 1: 10.96.28.176 example-prod.default.svc.cluster.local
```

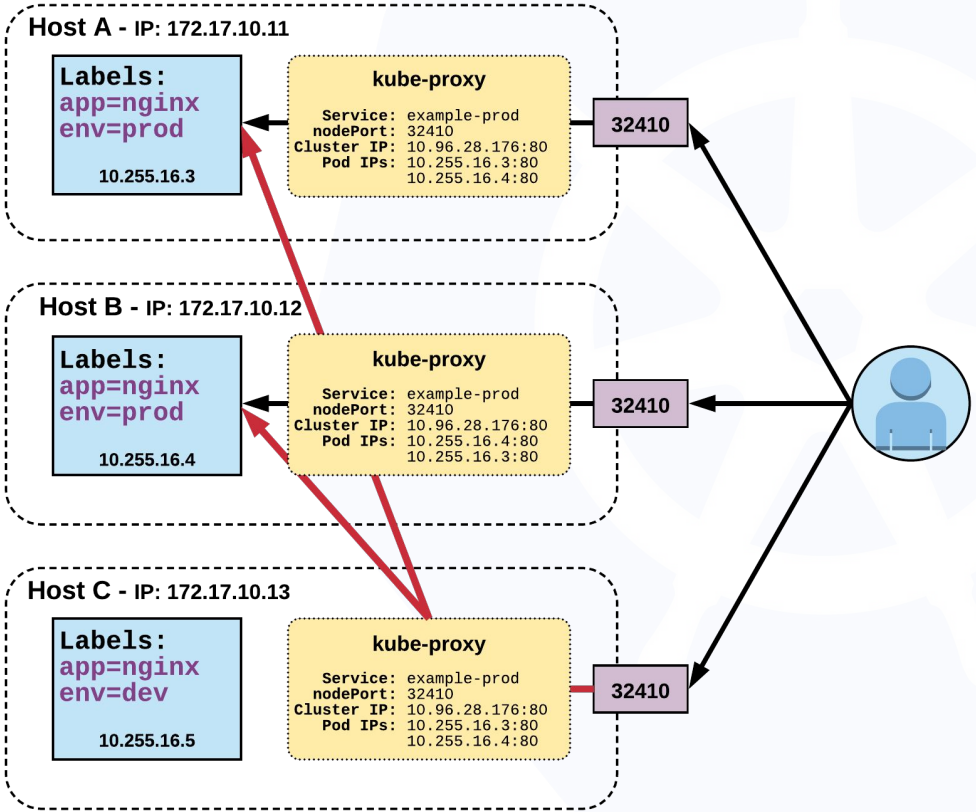


NodePort Service

- **NodePort** services extend the **ClusterIP** service and additionally exposes a port on every node.

```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: NodePort
  selector:
    app: nginx
    env: prod
  ports:
  - nodePort: 32410
    protocol: TCP
    port: 80
    targetPort: 80
```

NodePort Service



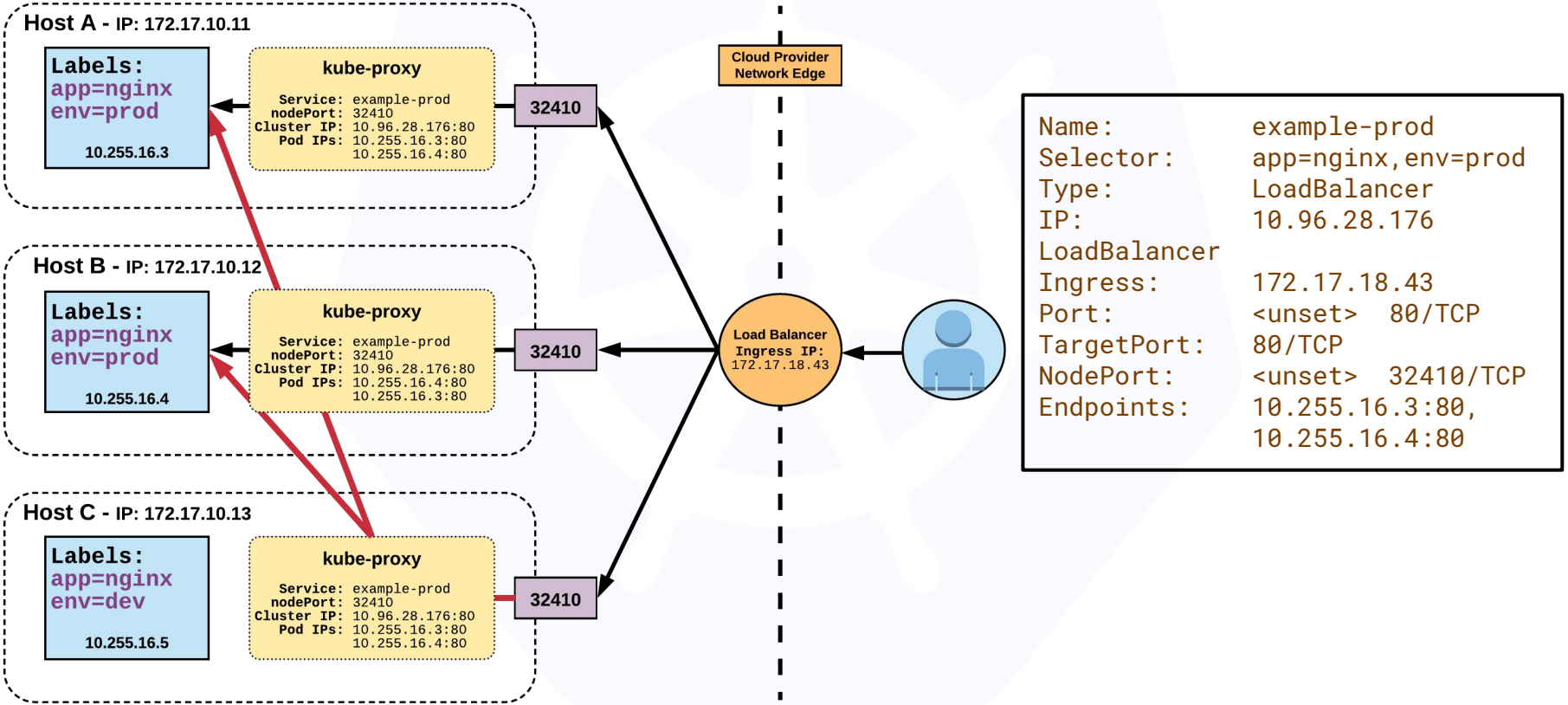

```
Name:          example-prod
Selector:      app=nginx,env=prod
Type:          NodePort
IP:            10.96.28.176
Port:          <unset>  80/TCP
TargetPort:    80/TCP
NodePort:      <unset>  32410/TCP
Endpoints:     10.255.16.3:80,
               10.255.16.4:80
```

LoadBalancer Service

- **LoadBalancer** services extend **NodePort** and works in conjunction with an external system to map a cluster external IP to the exposed service.

```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: LoadBalancer
  selector:
    app: nginx
    env: prod
  ports:
    protocol: TCP
    port: 80
    targetPort: 80
```

LoadBalancer Service



ExternalName Service

- **ExternalName** is used to reference endpoints OUTSIDE the cluster.
- It creates an internal **CNAME** DNS entry that aliases another.

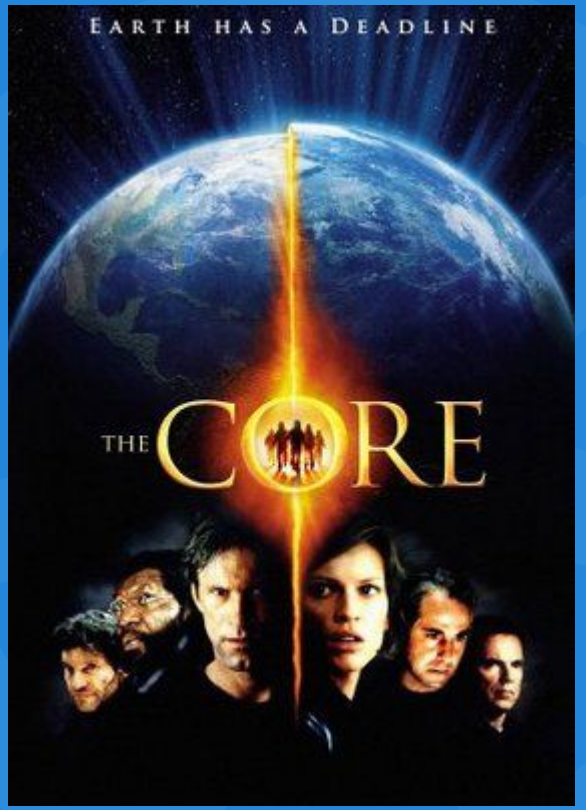
```yaml
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  type: ExternalName
  externalName: example.com
```

Lab

Exploring the Core

Lab

Exploring the Core



Workloads

- ReplicaSet
- Deployment

Workloads

Workloads within Kubernetes are higher level objects that manage Pods or other higher level objects.

In **ALL CASES** a Pod Template is included, and acts the base tier of management.

Pod Template

- Workload Controllers manage instances of Pods based off a provided template
- Pod Templates are Pod specs with limited metadata
- Controllers use Pod Templates to make actual pods

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-example
  labels:
    app: nginx
spec:
  containers:
  - name: nginx
    image: nginx
```

```yaml
template:
  metadata:
    labels:
      app: nginx
  spec:
    containers:
    - name: nginx
      image: nginx
```

ReplicaSet

- Primary method of managing pod replicas and their lifecycle
- Includes their scheduling, scaling, and deletion
- Their job is simple: **Always ensure the desired number of pods are running**

ReplicaSet

- `replicas:` The desired number of instances of the Pod.
- `selector:`The label selector for the **ReplicaSet** will manage **ALL** Pod instances that it targets; whether it's desired or not.

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: rs-example
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
      env: prod
  template:
    <pod template>
```

ReplicaSet

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: rs-example
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
      env: prod
  template:
    metadata:
      labels:
        app: nginx
        env: prod
    spec:
      containers:
      - name: nginx
        image: nginx:stable-alpine
        ports:
        - containerPort: 80
```

```
$ kubectl get pods
NAME                READY     STATUS    RESTARTS   AGE
rs-example-9l4dt    1/1       Running   0          1h
rs-example-b7bcg    1/1       Running   0          1h
rs-example-mkll2    1/1       Running   0          1h
```

```
$ kubectl describe rs rs-example
Name:         rs-example
Namespace:    default
Selector:     app=nginx,env=prod
Labels:       app=nginx
              env=prod
Annotations:  <none>
Replicas:     3 current / 3 desired
Pods Status:  3 Running / 0 Waiting / 0 Succeeded / 0 Failed
Pod Template:
  Labels:  app=nginx
           env=prod
  Containers:
   nginx:
    Image:        nginx:stable-alpine
    Port:         80/TCP
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Events:
  Type    Reason            Age   From                   Message
  ----    ------            ----  ----                   -------
  Normal  SuccessfulCreate  16s   replicaset-controller  Created pod: rs-example-mkll2
  Normal  SuccessfulCreate  16s   replicaset-controller  Created pod: rs-example-b7bcg
  Normal  SuccessfulCreate  16s   replicaset-controller  Created pod: rs-example-9l4dt
```

Deployment

- Declarative method of managing Pods via **ReplicaSets**
- Provide rollback functionality and update control
- Updates are managed through the **pod-template-hash** label.
- Each iteration creates a unique label that is assigned to both the **ReplicaSet** and subsequent Pods

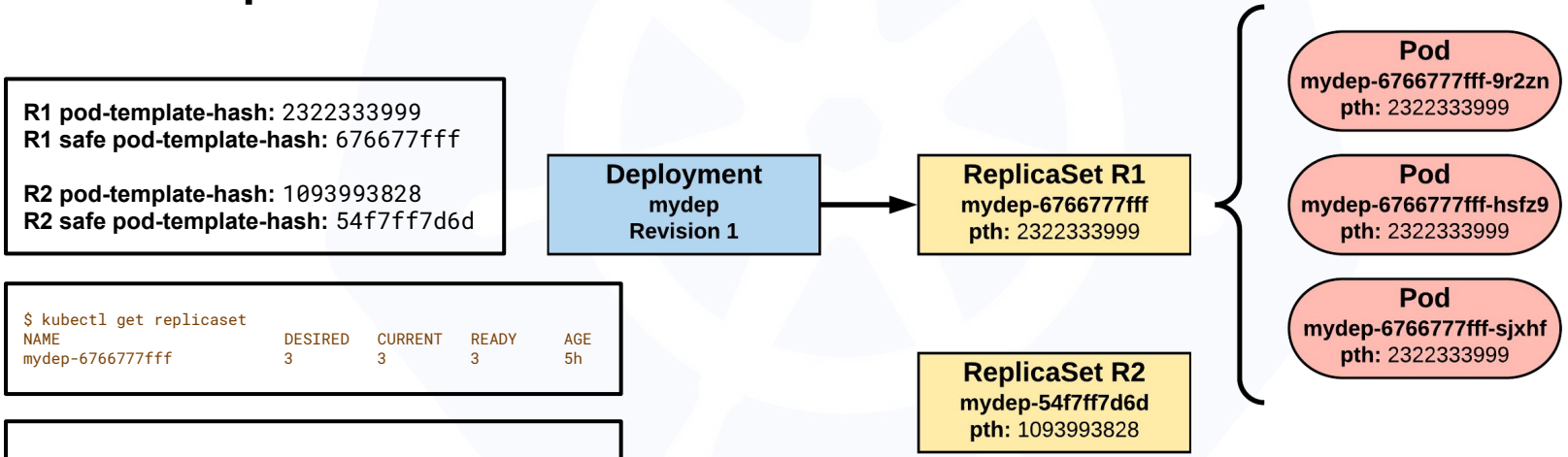
Deployment

- `revisionHistoryLimit:` The number of previous iterations of the Deployment to retain.
- `strategy:` Describes the method of updating the Pods based on the `type`. Valid options are `RollingUpdate` or `Recreate`.
  - `RollingUpdate:` Cycles through updating the Pods according to the parameters: `maxSurge` and `maxUnavailable`.
  - `Recreate:` All existing Pods are killed before the new ones are created.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: deploy-example
spec:
  replicas: 3
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: nginx
      env: prod
  strategy:
    type: RollingUpdate
    rollingUpdate:
      maxSurge: 1
      maxUnavailable: 0
  template:
    <pod template>
```

RollingUpdate Deployment

Updating pod template generates a new **ReplicaSet** revision.




```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY     AGE
mydep-6766777fff      3         3         3         5h
```

```
$ kubectl get pods
NAME                        READY     STATUS    RESTARTS   AGE
mydep-6766777fff-9r2zn      1/1       Running   0          5h
mydep-6766777fff-hsfz9      1/1       Running   0          5h
mydep-6766777fff-sjxhf      1/1       Running   0          5h
```

RollingUpdate Deployment

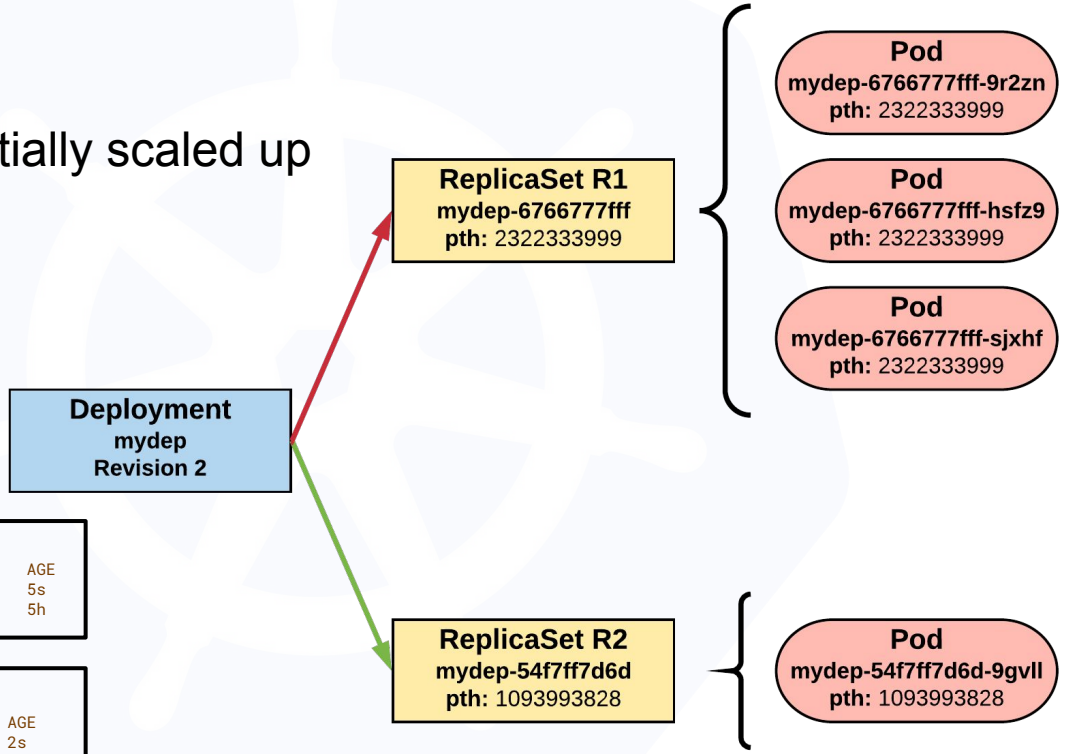
New **ReplicaSet** is initially scaled up based on `maxSurge`.

R1 pod-template-hash: 2322333999
R1 safe pod-template-hash: 676677fff

R2 pod-template-hash: 1093993828
R2 safe pod-template-hash: 54f7ff7d6d

```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d      1         1         1       5s
mydep-6766777fff      2         3         3       5h
```

```
$ kubectl get pods
NAME                        READY   STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll      1/1     Running   0          2s
mydep-6766777fff-9r2zn      1/1     Running   0          5h
mydep-6766777fff-hsfz9      1/1     Running   0          5h
mydep-6766777fff-sjxhf      1/1     Running   0          5h
```



RollingUpdate Deployment

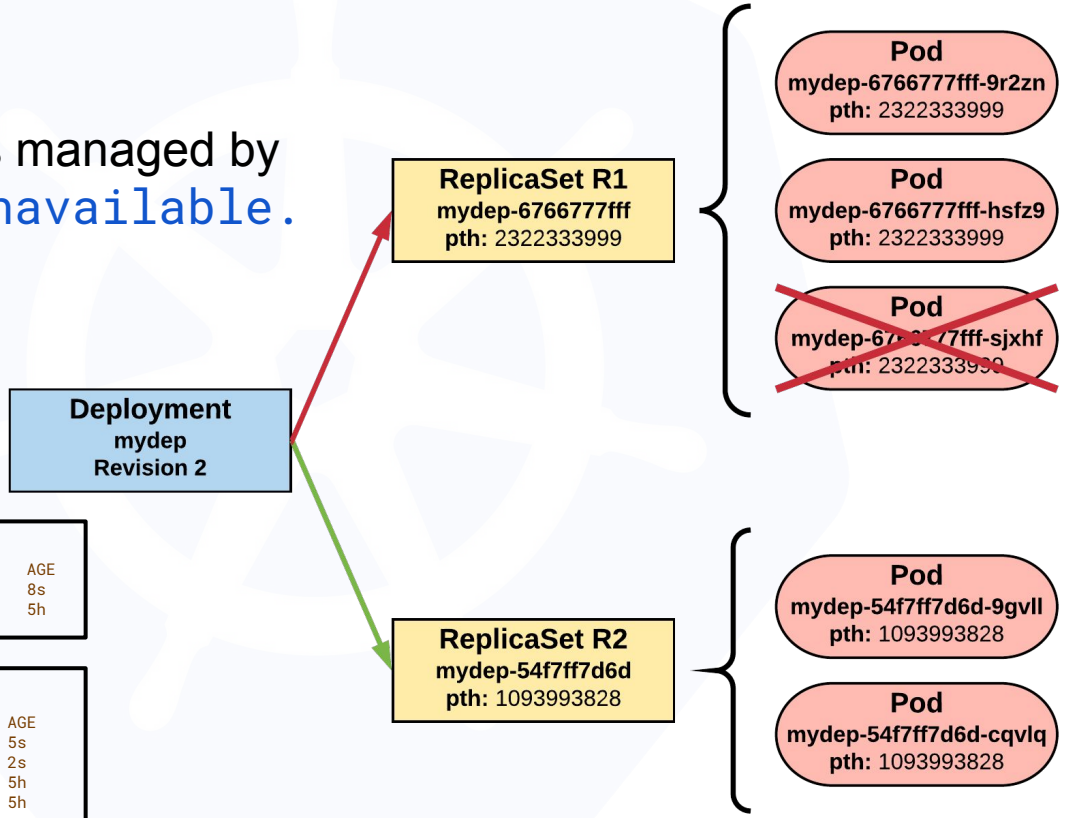
Phase out of old Pods managed by `maxSurge` and `maxUnavailable`.

R1 pod-template-hash: 2322333999
R1 safe pod-template-hash: 676677fff

R2 pod-template-hash: 1093993828
R2 safe pod-template-hash: 54f7ff7d6d

```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d      2         2         2       8s
mydep-6766777fff      2         2         2       5h
```

```
$ kubectl get pods
NAME                  READY     STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll   1/1       Running   0          5s
mydep-54f7ff7d6d-cqvlq   1/1       Running   0          2s
mydep-6766777fff-9r2zn   1/1       Running   0          5h
mydep-6766777fff-hsfz9   1/1       Running   0          5h
```



RollingUpdate Deployment

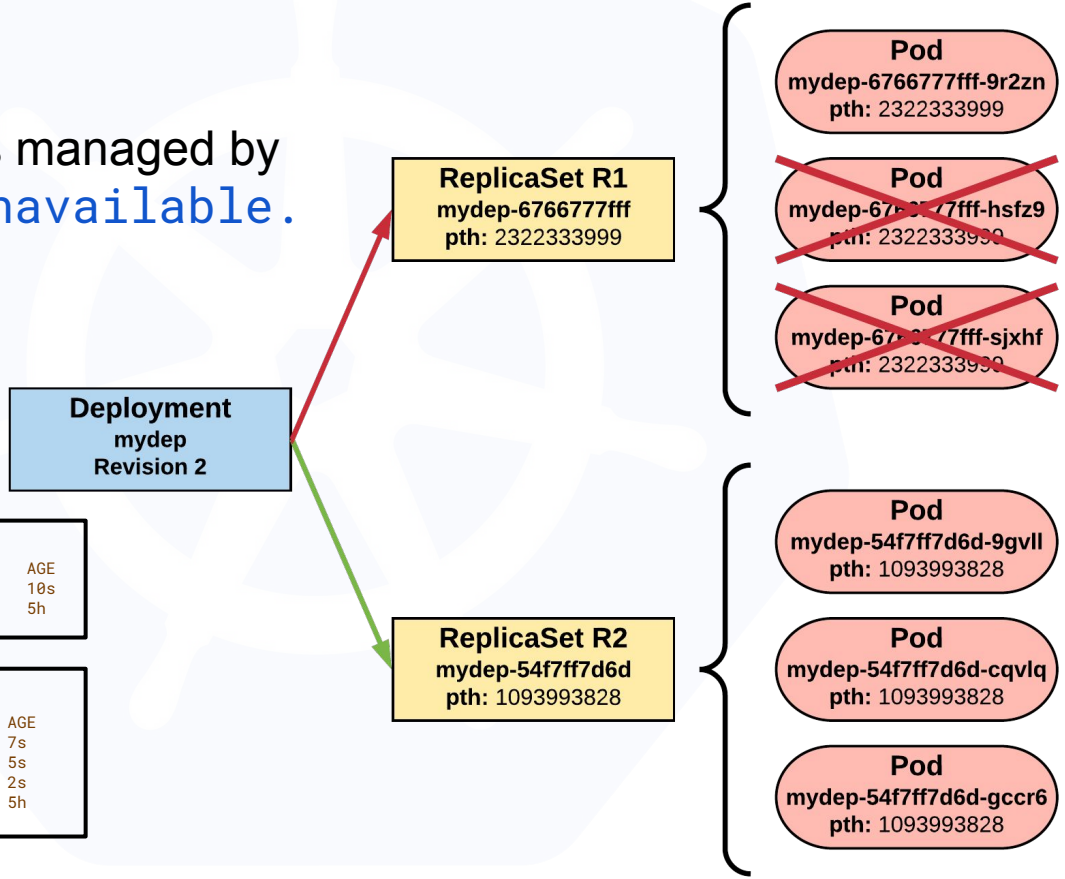
Phase out of old Pods managed by `maxSurge` and `maxUnavailable`.

R1 pod-template-hash: 2322333999
R1 safe pod-template-hash: 676677fff

R2 pod-template-hash: 1093993828
R2 safe pod-template-hash: 54f7ff7d6d

```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d      3         3         3       10s
mydep-6766777fff      0         1         1       5h
```

```
$ kubectl get pods
NAME                  READY     STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll   1/1       Running   0          7s
mydep-54f7ff7d6d-cqvlq   1/1       Running   0          5s
mydep-54f7ff7d6d-gccr6   1/1       Running   0          2s
mydep-6766777fff-9r2zn   1/1       Running   0          5h
```



RollingUpdate Deployment

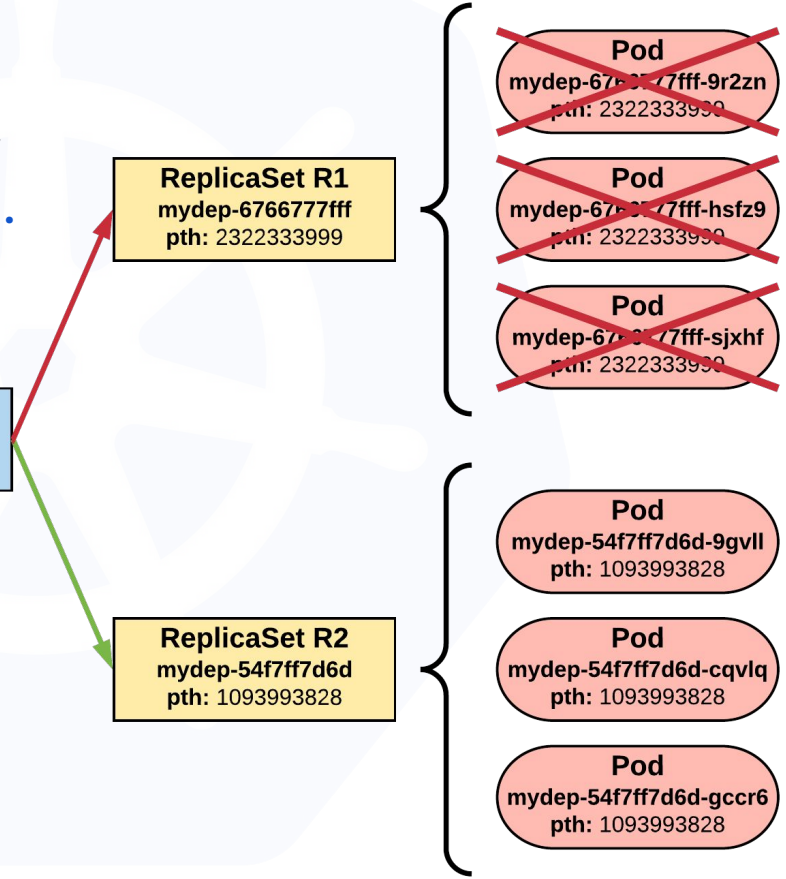
Phase out of old Pods managed by `maxSurge` and `maxUnavailable`.

R1 pod-template-hash: 2322333999
R1 safe pod-template-hash: 676677fff

R2 pod-template-hash: 1093993828
R2 safe pod-template-hash: 54f7ff7d6d

```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d      3         3         3       13s
mydep-6766777fff      0         0         0       5h
```

```
$ kubectl get pods
NAME                  READY     STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll   1/1       Running   0          10s
mydep-54f7ff7d6d-cqvlq   1/1       Running   0          8s
mydep-54f7ff7d6d-gccr6   1/1       Running   0          5s
```

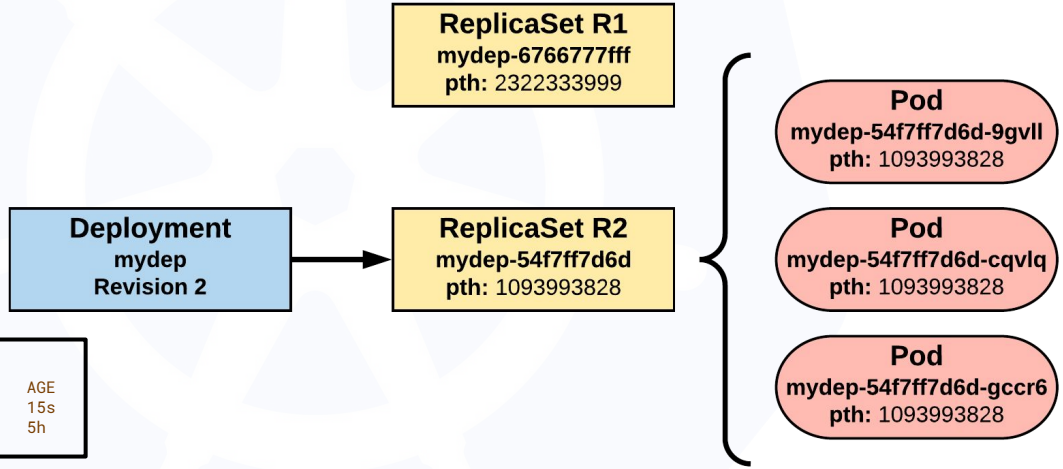


RollingUpdate Deployment

Updated to new deployment revision completed.

R1 pod-template-hash: 2322333999
R1 safe pod-template-hash: 676677fff

R2 pod-template-hash: 1093993828
R2 safe pod-template-hash: 54f7ff7d6d




```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY     AGE
mydep-54f7ff7d6d      3         3         3         15s
mydep-6766777fff      0         0         0         5h
```

```
$ kubectl get pods
NAME                  READY     STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll   1/1       Running   0          12s
mydep-54f7ff7d6d-cqvlq   1/1       Running   0          10s
mydep-54f7ff7d6d-gccr6   1/1       Running   0          7s
```

Lab

Using Workloads

Where to go From Here

Links

- Free Kubernetes Courses
  https://www.edx.org/
- Interactive Kubernetes Tutorials
  https://www.katacoda.com/courses/kubernetes
- Learn Kubernetes the Hard Way
  https://github.com/kelseyhightower/kubernetes-the-hard-way
- Official Kubernetes Youtube Channel
  https://www.youtube.com/channel/UCZ2bu0qutTOM0tHYa_jkIwg
- Official CNCF Youtube Channel
  https://www.youtube.com/channel/UCvqbFHwN-nwalWPjPUKpvTA
- Track to becoming a CKA/CKAD (Certified Kubernetes Administrator/Application Developer)
  https://www.cncf.io/certification/expert/
- Awesome Kubernetes
  https://www.gitbook.com/book/ramitsurana/awesome-kubernetes/details