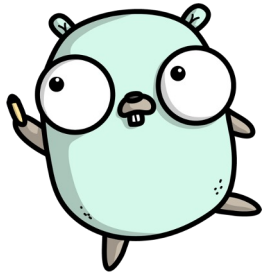
HA NOI UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND COMMUNICATION TECHNOLOGY

Introduction to Kubernetes

Viet-Trung Tran
(adapted from CNCF Kubernetes - An Introduction)

Before We Begin

- Requirements:
  - Minikube: https://github.com/kubernetes/minikube
  - kubectl: https://kubernetes.io/docs/tasks/tools/install-kubectl/
  - k8s-intro-tutorials repo: https://github.com/mrbobbytables/k8s-intro-tutorials



Containers

Container - What's in a name?

- Coming from the shipping industry

Shipping to software

Shipping containers

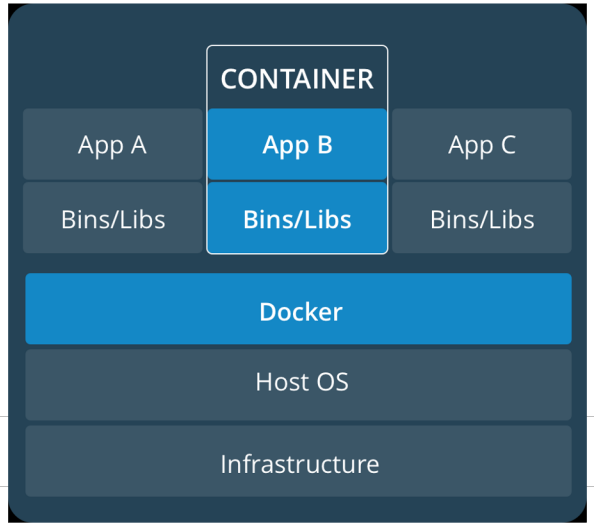
- Portability - can be used on any of supported types of ships
- Wide variety of cargo that can be packed inside
- Standard sizes - standard fittings on ships
- Many containers on a ship
- Isolates cargo from each other

Translated to software

- Portability - can be used on any supported system (system with container execution environment)
- Wide variety of software that can be packed inside
- Standard format
- Many containers to a physical node
- Isolates execution of one container from another

What is a container?

- Way to pack code and dependencies together
- Can run anywhere
- Execute multiple containers to a physical machine



Sounds familiar?

- Same concept as virtual machines
- Pack OS and software together, to run in isolated instances
- Can run anywhere the specific hypervisor runs
- Multiple VMs to a physical machine

How do VMs work?

- Hypervisor = layer between VM and kernel
- Emulates system calls
- Allows multiple types of operating systems on a machine (Windows on Linux)
- Overhead for hypervisor

Containers on the other hand ...

- Only contain application and application-related libraries and frameworks, that run on the host machine's kernel
- Smaller
- Lower overhead
- Differences in OS distributions and dependencies are abstracted - same kernel

Kubernetes – What? Why? How?

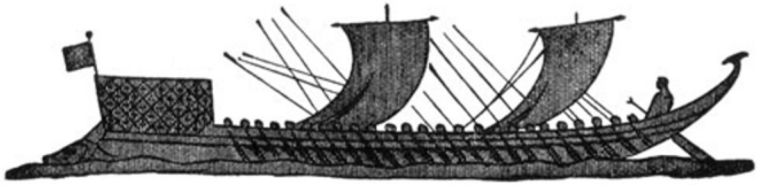
What is Kubernetes?

“Kubernetes” = Greek for governor, helmsman, captain

open-source container orchestration system

originally designed by Google, maintained by CNCF

aim to provide "platform for automating deployment, scaling and operations of application containers across clusters of hosts"



kubernetes

What Does Kubernetes do?

- Known as the linux kernel of distributed systems.
- Abstracts away the underlying hardware of the nodes and provides a uniform interface for workloads to be both deployed and consume the shared pool of resources.
- Works as an engine for resolving state by converging actual and the desired state of the system.

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.”

What can Kubernetes REALLY do?

- Autoscale Workloads
- Blue/Green Deployments
- Fire off jobs and scheduled cronjobs
- Manage Stateless and Stateful Applications
- Provide native methods of service discovery
- Easily integrate and support 3rd party apps

Most Importantly...

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

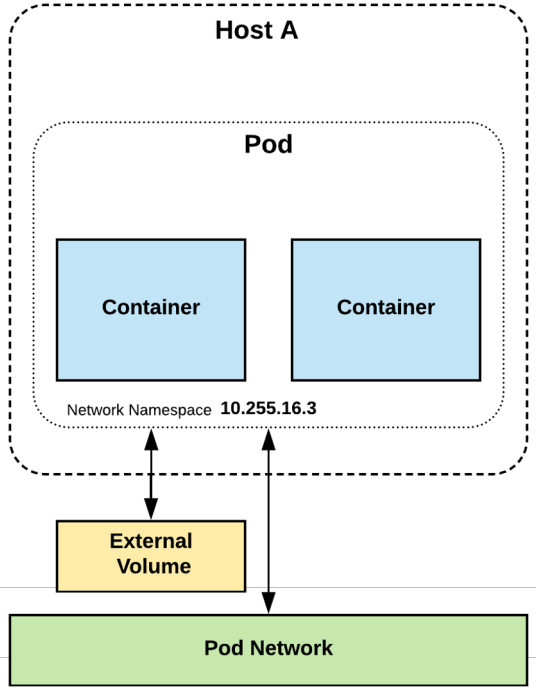
Who “Manages” Kubernetes?

- The CNCF is a child entity of the Linux Foundation and operates as a vendor neutral governance group.

A Couple Key Concepts...

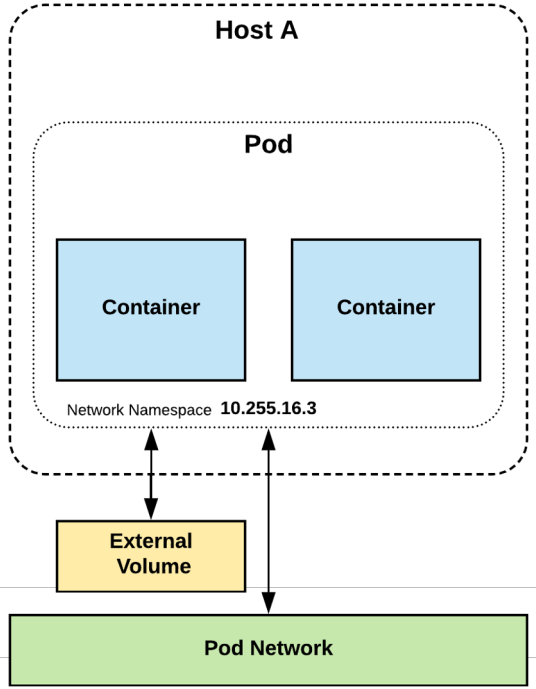
Pods

- Atomic unit or smallest “unit of work”of Kubernetes.
- Pods are one or MORE containers that share volumes, a network namespace, and are a part of a single context.



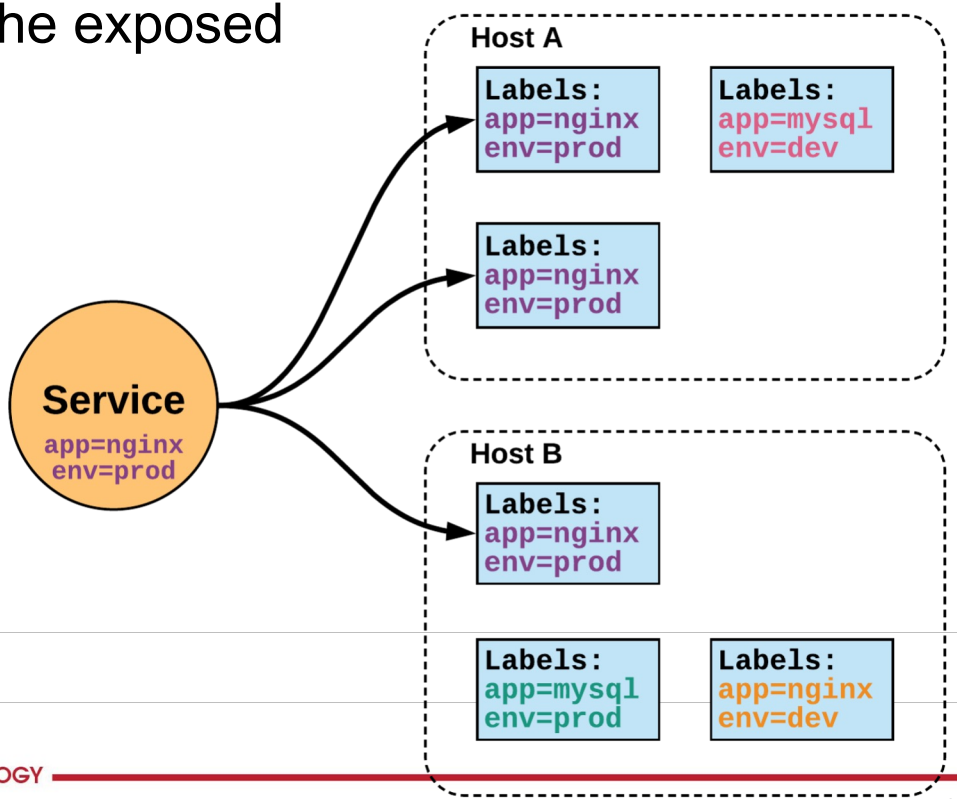
Pods

- They are also Ephemeral!



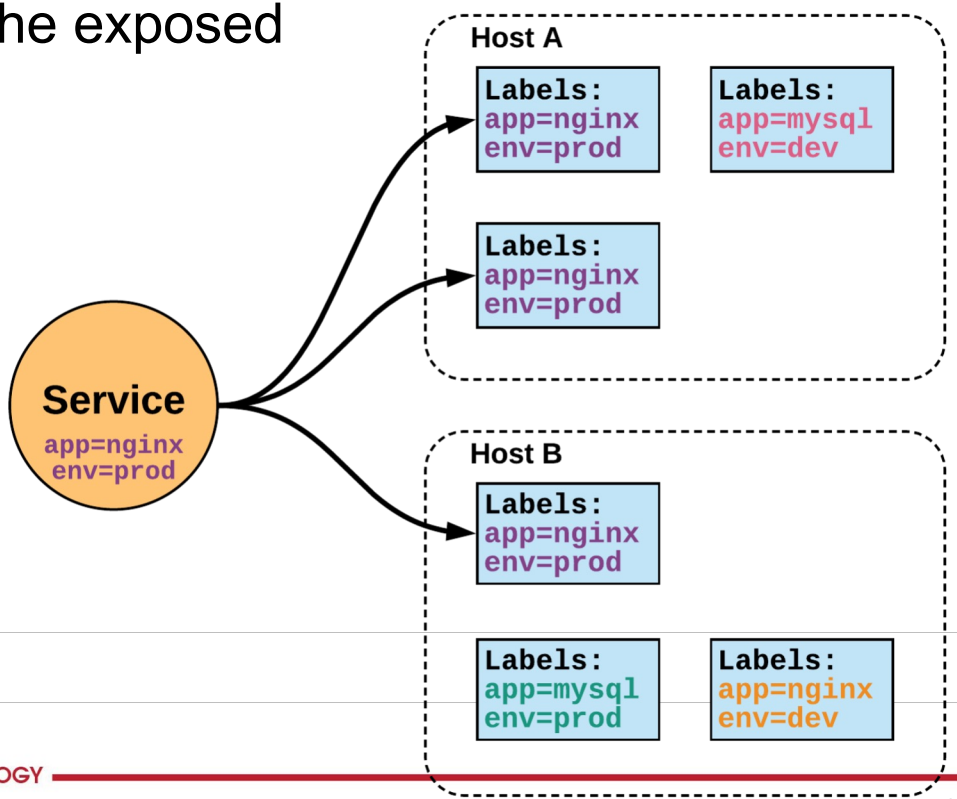
Services

- Unified method of accessing the exposed workloads of Pods.
- Durable resource
  - static cluster IP
  - static namespaced DNS name

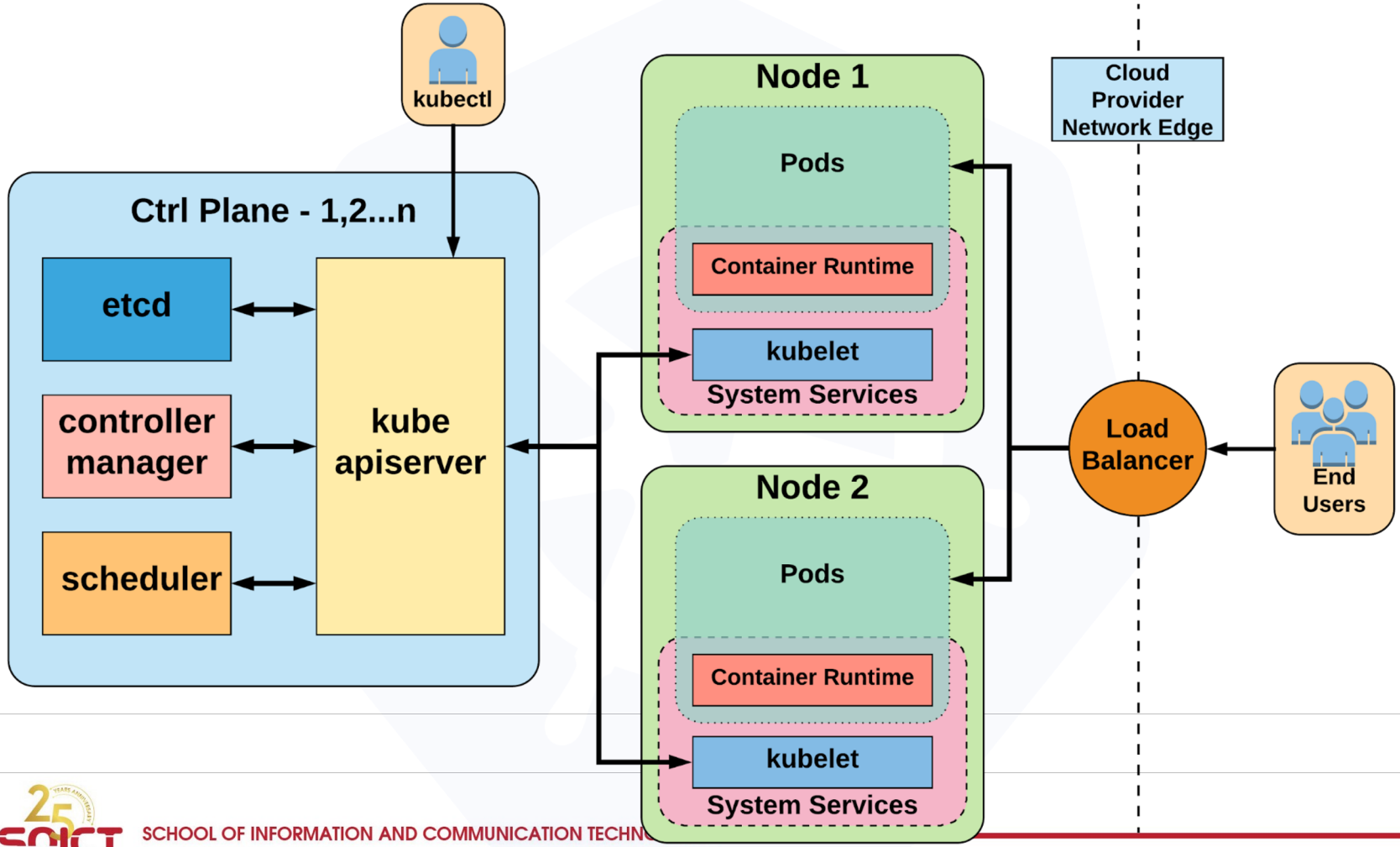


Services

- Unified method of accessing the exposed workloads of Pods.
- Durable resource
  - static cluster IP
  - static namespaced DNS name
- **NOT Ephemeral!**



Architecture Overview

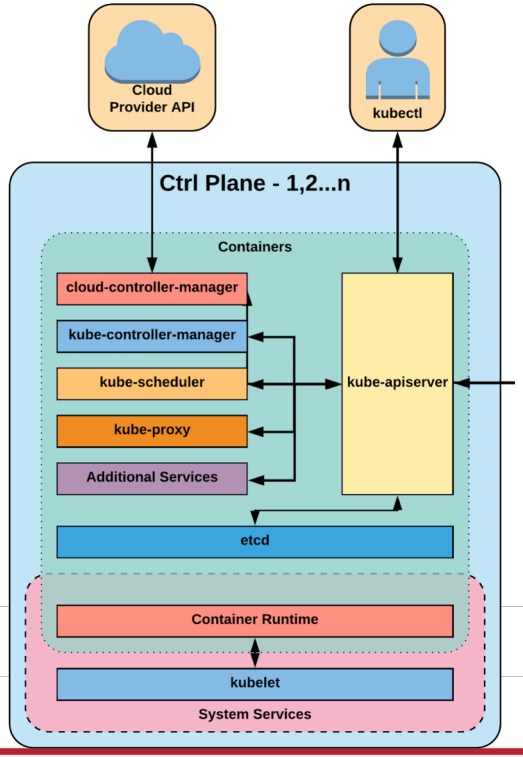

kubectl
Ctrl Plane - 1,2...n
etcd
controller manager
scheduler
kube apiserver
Node 1
Pods
Container Runtime
kubelet
System Services
Node 2
Pods
Container Runtime
kubelet
System Services
Cloud Provider Network Edge
Load Balancer
End Users

Control Plane Components

Architecture Overview

Control Plane Components

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



kube-apiserver

- Provides a forward-facing REST interface into the kubernetes control plane and datastore.
- All clients and other applications interact with kubernetes strictly through the API Server.
- Acts as the gatekeeper to the cluster by handling authentication and authorization, request validation, mutation, and admission control in addition to being the front-end to the backing datastore.

etcd

- etcd acts as the cluster datastore.
- Purpose in relation to Kubernetes is to provide a strong, consistent and highly available key-value store for persisting cluster state.
- Stores objects and config information.

etcd

- Uses “Raft Consensus” among a quorum of systems to create a fault-tolerant consistent “view” of the cluster.
- https://raft.github.io/

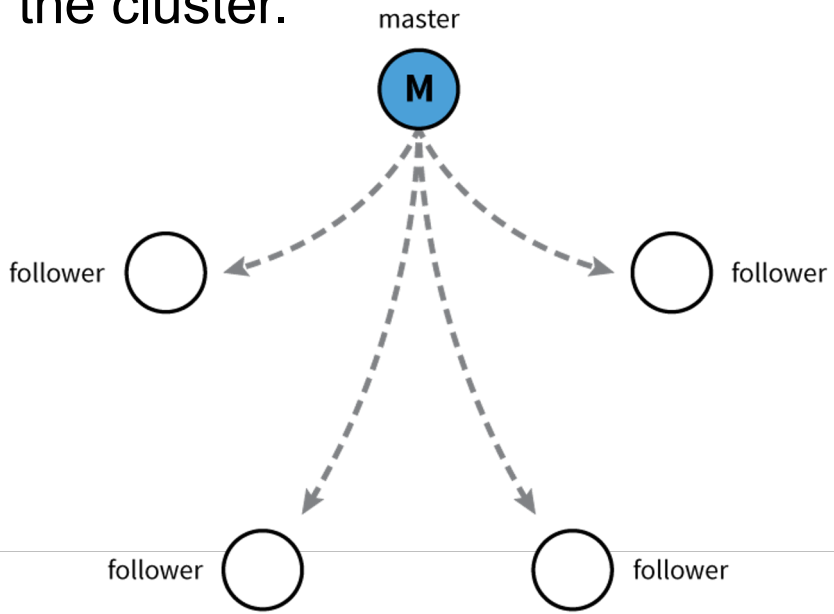


Image Source

kube-controller-manager

- Serves as the primary daemon that manages all core component control loops.
- Monitors the cluster state via the apiserver and steers the cluster towards the desired state.

- List of core controllers: https://github.com/kubernetes/kubernetes/blob/master/cmd/kube-controller-manager/app/controllermanager.go#L344

kube-scheduler

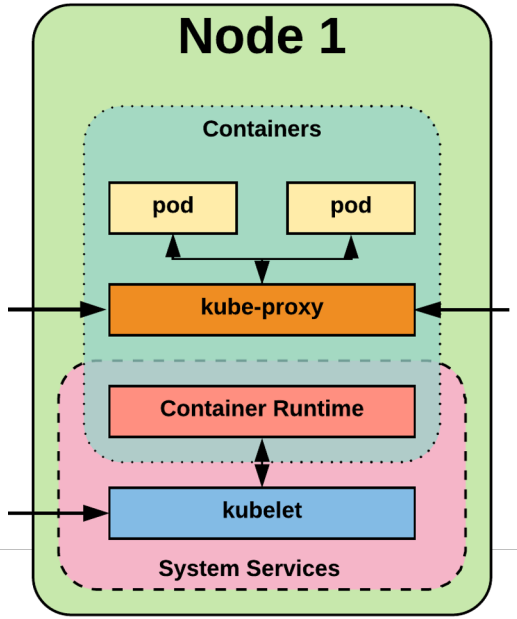
- Verbose policy-rich engine that evaluates workload requirements and attempts to place it on a matching resource.
- Default scheduler uses bin packing.
- Workload Requirements can include: general hardware requirements, affinity/anti-affinity, labels, and other various custom resource requirements.

Node Components

Architecture Overview

Node Components

- kubelet
- kube-proxy
- Container Runtime Engine



kubelet

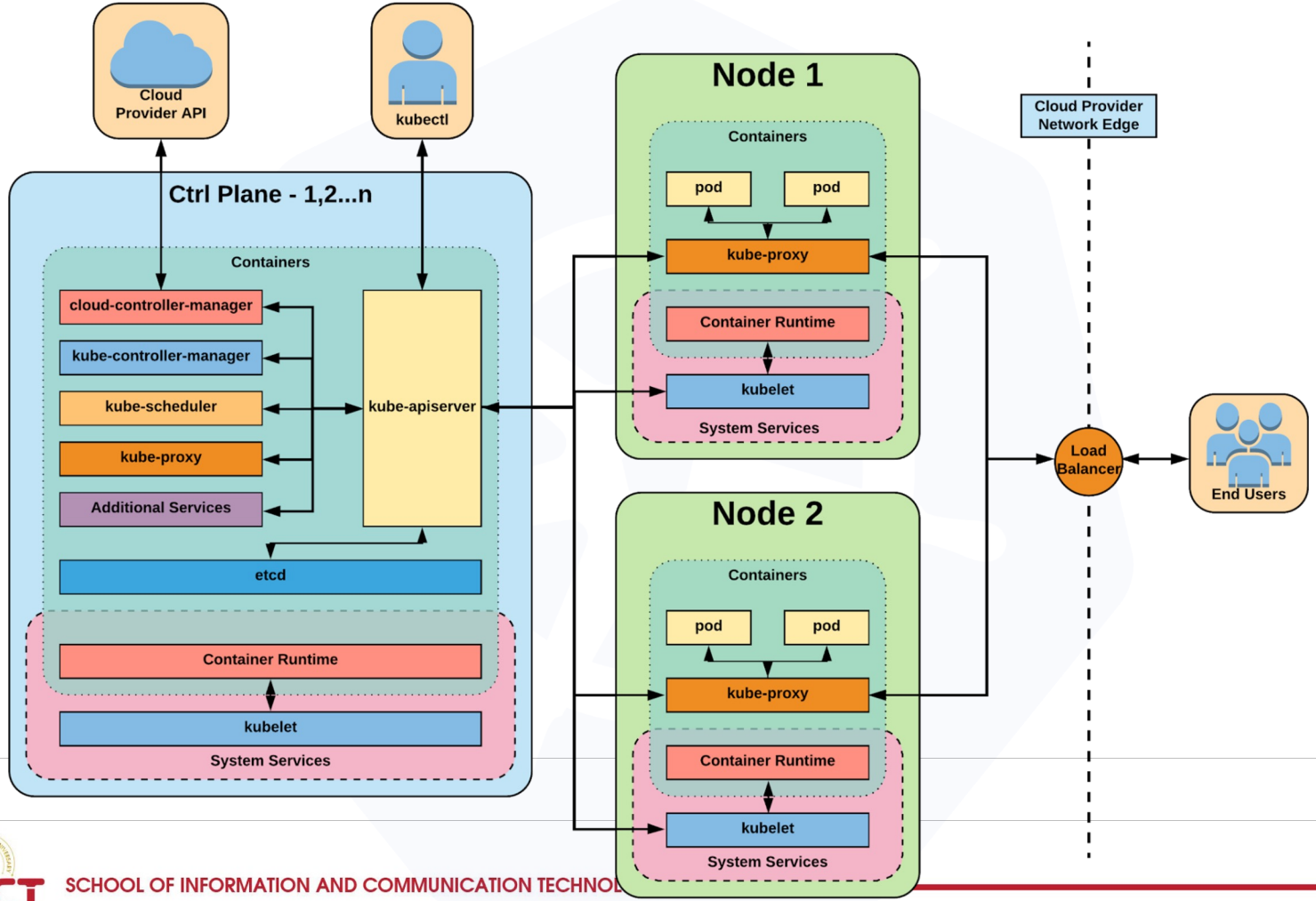
- Acts as the node agent responsible for managing the lifecycle of every pod on its host.
- Kubelet understands YAML container manifests that it can read from several sources:
  - file path
  - HTTP Endpoint
  - etcd watch acting on any changes
  - HTTP Server mode accepting container manifests over a simple API.

kube-proxy

- Manages the network rules on each node.
- Performs connection forwarding or load balancing for Kubernetes cluster services.
- Available Proxy Modes:
  - Userspace
  - iptables
  - ipvs (default if supported)

Container Runtime Engine

- A container runtime is a CRI (Container Runtime Interface) compatible application that executes and manages containers.
  - Containerd (docker)
  - Cri-o
  - Rkt
  - Kata (formerly clear and hyper)
  - Virtlet (VM CRI compatible runtime)


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

Networking

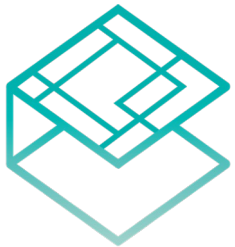
Architecture Overview

Kubernetes Networking

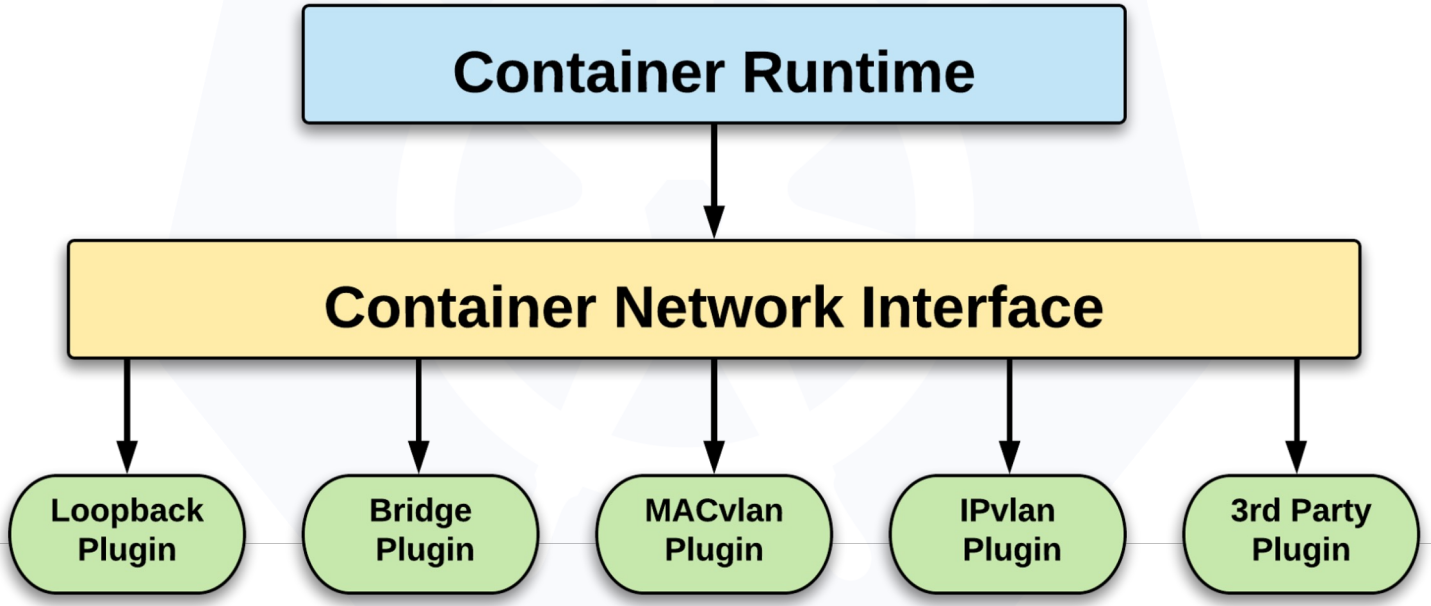
- Pod Network
  - Cluster-wide network used for pod-to-pod communication managed by a CNI (Container Network Interface) plugin.
- Service Network
  - Cluster-wide range of Virtual IPs managed by kube-proxy for service discovery.

Container Network Interface (CNI)

- Pod networking within Kubernetes is plumbed via the Container Network Interface (CNI).
- Functions as an interface between the container runtime and a network implementation plugin.
- CNCF Project
- Uses a simple JSON Schema.

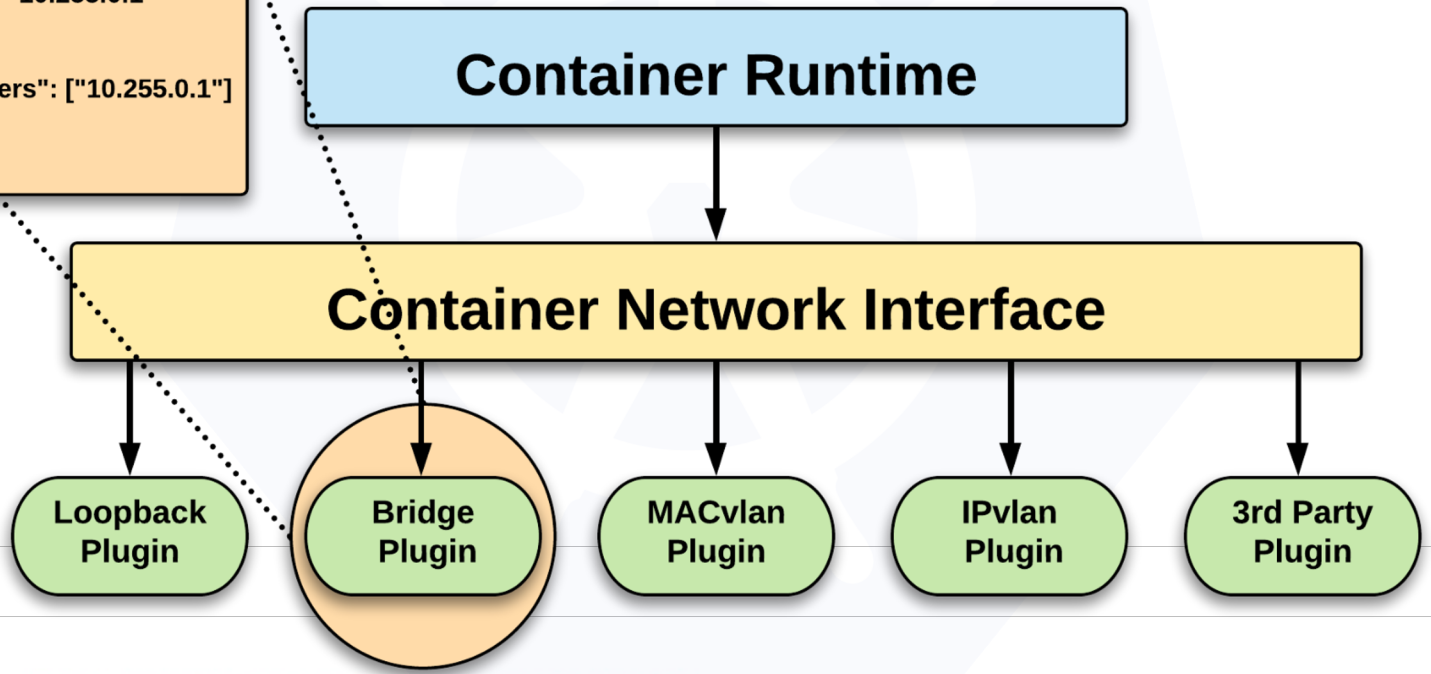


CNI Overview



CNI Overview

```
{
    "cniVersion": "0.3.1",
    "name": "examplenet",
    "type": "bridge",
    "bridge": "cni0",
    "ipam": {
        "type": "host-local",
        "subnet": "10.255.0.0/16",
        "gateway": "10.255.0.1"
    },
    "dns": {
        "nameservers": ["10.255.0.1"]
    }
}
```



CNI Plugins

- Amazon ECS
- Calico
- Cillium
- Contiv
- Contrail
- Flannel

- GCE
- kube-router
- Multus
- OpenVSwitch
- Romana
- Weave

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.

Fundamentals Applied

- Container-to-Container
  - Containers within a pod exist within the same network namespace and share an IP.
  - Enables intrapod communication over localhost.
- Pod-to-Pod
  - Allocated cluster unique IP for the duration of its life cycle.
  - Pods themselves are fundamentally ephemeral.

Fundamentals Applied

- Pod-to-Service
  - managed by kube-proxy and given a persistent cluster unique IP
  - exists beyond a Pod's lifecycle.
- External-to-Service
  - Handled by kube-proxy.
  - Works in cooperation with a cloud provider or other external entity (load balancer).

Concepts and Resources

The API and Object Model

Concepts and Resources

API Overview

- The REST API is the true keystone of Kubernetes.
- Everything within the Kubernetes is as an API Object.

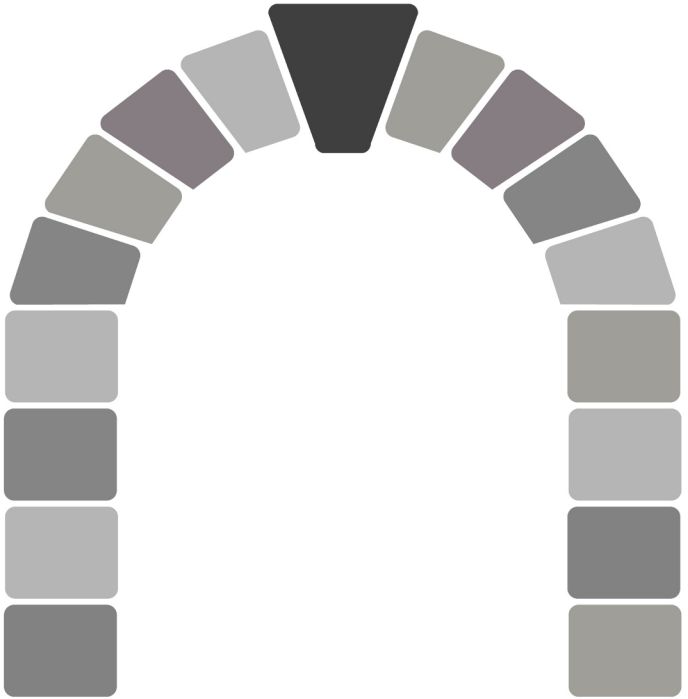


Image Source

API Groups

- Designed to make it extremely simple to both understand and extend.
- An API Group is a REST compatible path that acts as the type descriptor for a Kubernetes object.
- Referenced within an object as the apiVersion and kind.

Format:

```
/apis/<group>/<version>/<resource>
```

Examples:

```
/apis/apps/v1/deployments
/apis/batch/v1beta1/cronjobs
```

API Versioning

- Three tiers of API maturity levels.
- Also referenced within the object apiVersion.

Format:

`/apis/<group>/<version>/<resource>`

Examples:

`/apis/apps/v1/deployments`

`/apis/batch/v1beta1/cronjobs`

- Alpha: Possibly buggy and may change. Disabled by default.
- Beta: Tested and considered stable. However, API Schema may change. Enabled by default.
- Stable: Released, stable and API schema will not change. Enabled by default.

Object Model

- Objects are a “record of intent” or a persistent entity that represent the desired state of the object within the cluster.
- All objects MUST have 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.

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

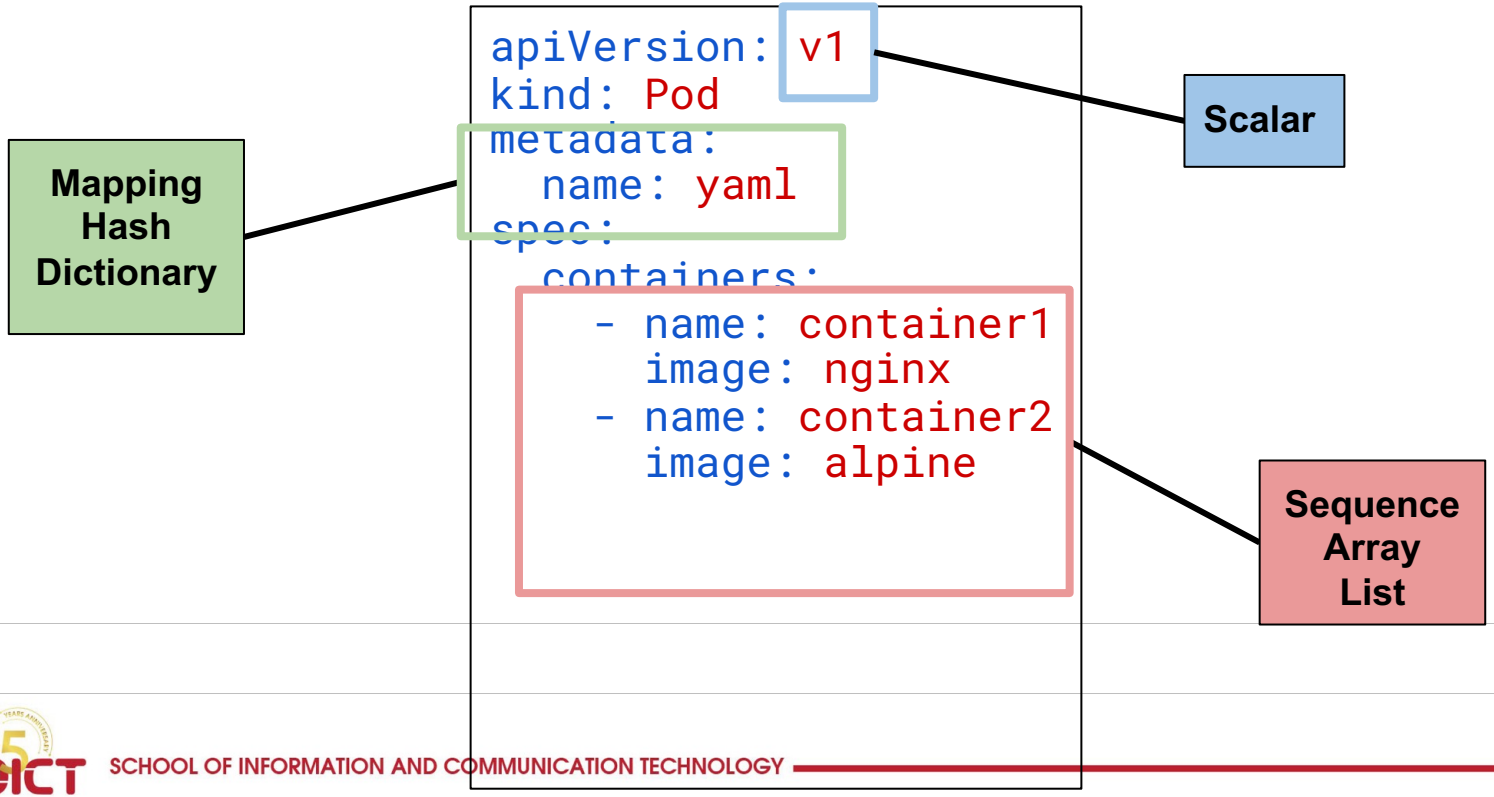
Object Expression - YAML

- Files or other representations of Kubernetes Objects are generally represented in YAML.
- A “Human Friendly” data serialization standard.
- Uses white space (specifically spaces) alignment to denote ownership.
- Three basic data types:
  - mappings - hash or dictionary,
  - sequences - array or list
  - scalars - string, number, boolean etc

Object Expression - YAML

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: yaml
spec:
  containers:
    - name: container1
      image: nginx
    - name: container2
      image: alpine
```

Object Expression - YAML



YAML vs JSON

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

```json
{
  "apiVersion": "v1",
  "kind": "Pod",
  "metadata": {
    "name": "pod-example"
  },
  "spec": {
    "containers": [
      {
        "name": "nginx",
        "image": "nginx:stable-alpine",
        "ports": [ { "containerPort": 80 } ]
      }
    ]
  }
}
```

Object Model - Workloads

- Workload related objects within Kubernetes have an additional two nested fields spec and status.
  - spec - Describes the desired state or configuration of the object to be created.
  - status - Is managed by Kubernetes and describes the actual state of the object and its history.

Workload Object Example

Example Object

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

Example Status Snippet

```yaml
status:
  conditions:
  - lastProbeTime: null
    lastTransitionTime: 2018-02-14T14:15:52Z
    status: "True"
    type: Ready
  - lastProbeTime: null
    lastTransitionTime: 2018-02-14T14:15:49Z
    status: "True"
    type: Initialized
  - lastProbeTime: null
    lastTransitionTime: 2018-02-14T14:15:49Z
    status: "True"
    type: PodScheduled
```

Using the API

(aka, using the CLI)

Lab - github.com/mrbobbytables/k8s-intro-tutorials/blob/master/cli

Core Objects

- Namespaces
- Pods
- Labels
- Selectors
- Services

Concepts and Resources

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.

```yaml
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
```

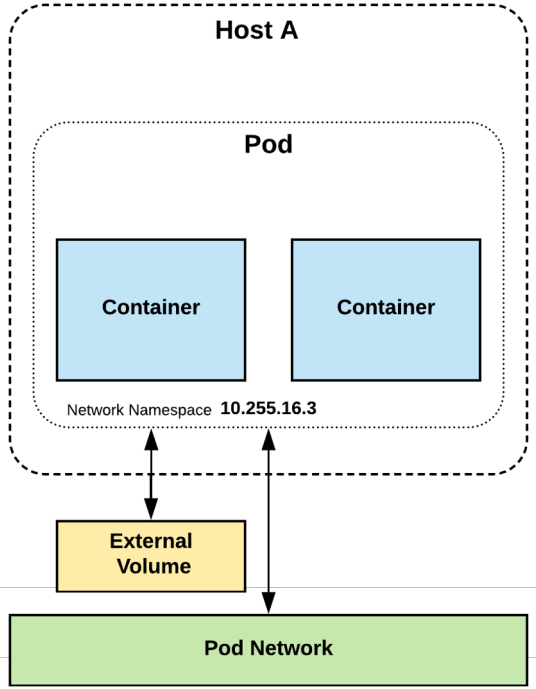
Default Namespaces

- default: The default namespace for any object without a namespace.
- kube-system: Acts as the 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>
```

Pod

- Atomic unit or smallest “unit of work”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.



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
    ports:
    - containerPort: 80
    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: {}
```

Key Pod Container Attributes

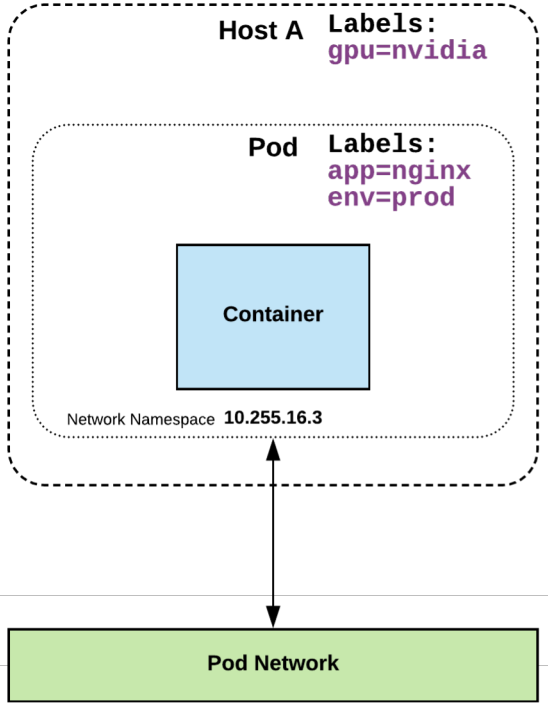
- `name` - The name of the container
- `image` - The container image
- `ports` - array of ports to expose. Can be granted a friendly name and protocol may be specified
- `env` - array of environment variables
- `command` – Entrypoint array (equiv to Docker `ENTRYPOINT`)
- `args` - Arguments to pass to the command (equiv to Docker `CMD`)

Container

```
name: nginx
image: nginx:stable-alpine
ports:
  - containerPort: 80
    name: http
    protocol: TCP
env:
  - name: MYVAR
    value: isAwesome
command: ["/bin/sh", "-c"]
args: ["echo ${MYVAR}"]
```

Labels

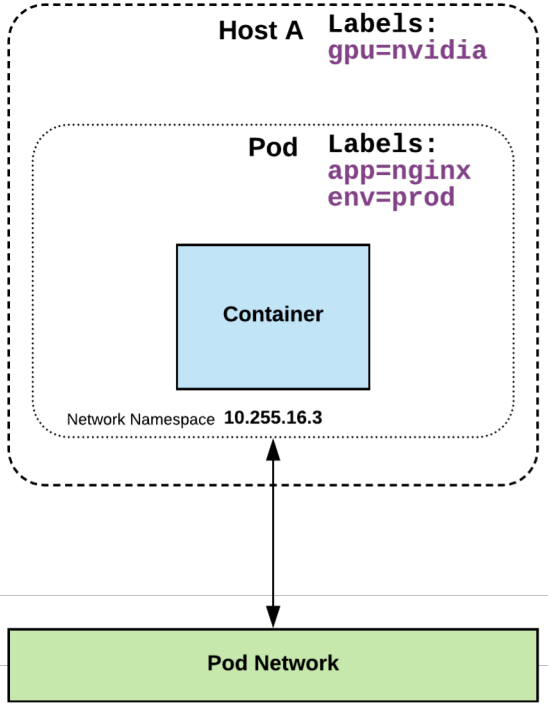
- key-value pairs that are used to identify, describe and group together related sets of objects or resources.
- NOT characteristic of uniqueness.
- Have a strict syntax with a slightly limited character set*.



* https://kubernetes.io/docs/concepts/overview/working-with-objects/labels/#syntax-and-character-set

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
```



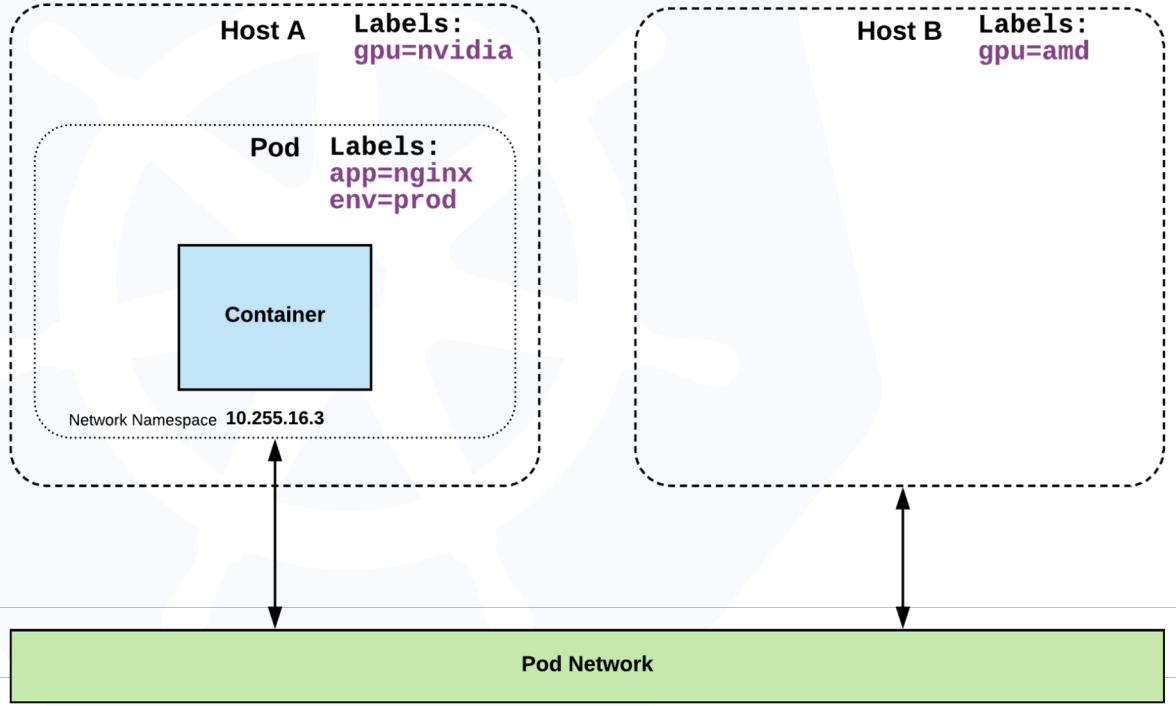
Selectors

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”]
```

Services

- Unified method of accessing the exposed workloads of Pods.
- Durable resource (unlike Pods)
  - static cluster-unique IP
  - static namespaced DNS name

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

Services

- Target Pods using equality based selectors.
- Uses kube-proxy to provide simple load-balancing.
- kube-proxy acts as a daemon that creates local entries in the host's iptables for every service.

Service Types

- There are 4 major service types:
  - ClusterIP (default)
  - NodePort
  - LoadBalancer
  - ExternalName

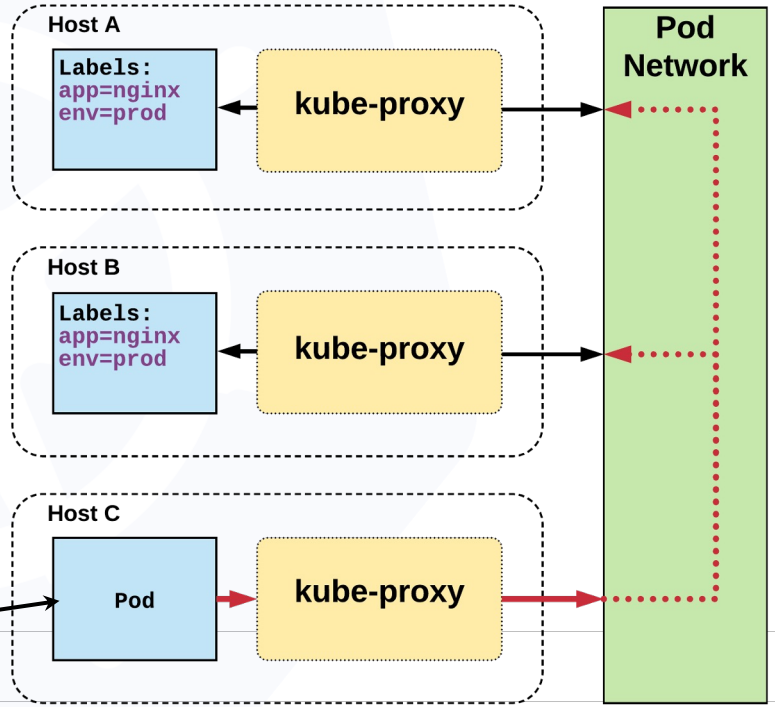
ClusterIP Service

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

```
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
```



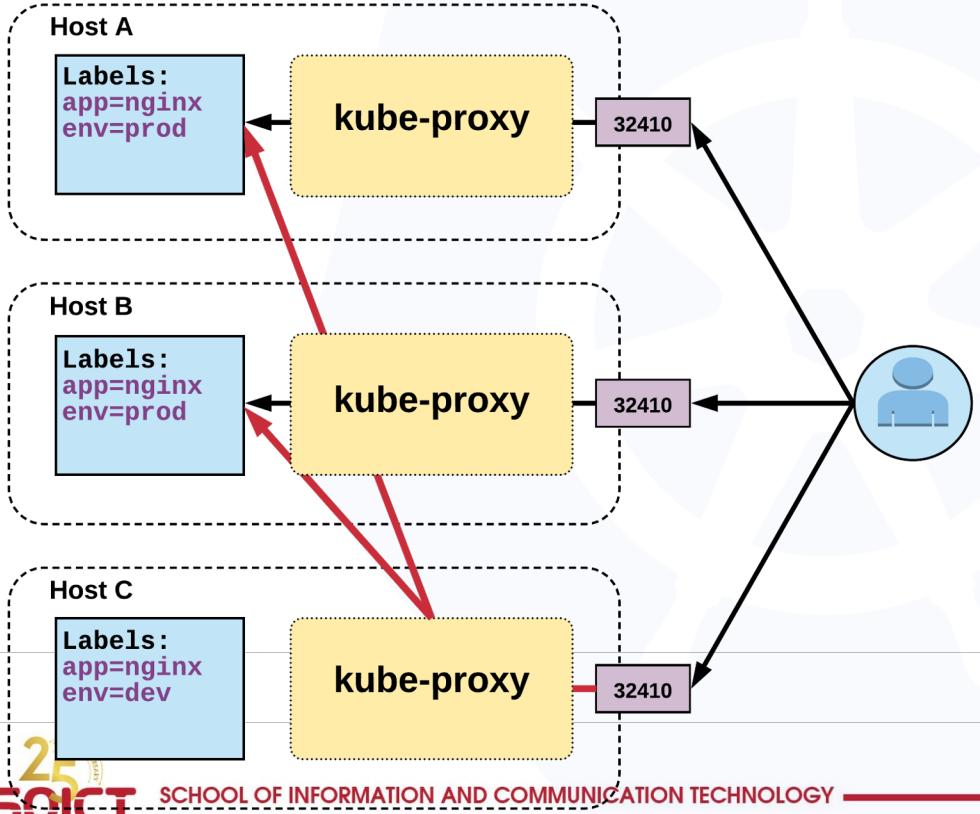

```
/ # nslookup example-prod.default.svc.cluster.local

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.
- Exposes a port on every node's IP.
- Port can either be statically defined, or dynamically taken from a range between 30000-32767.

```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



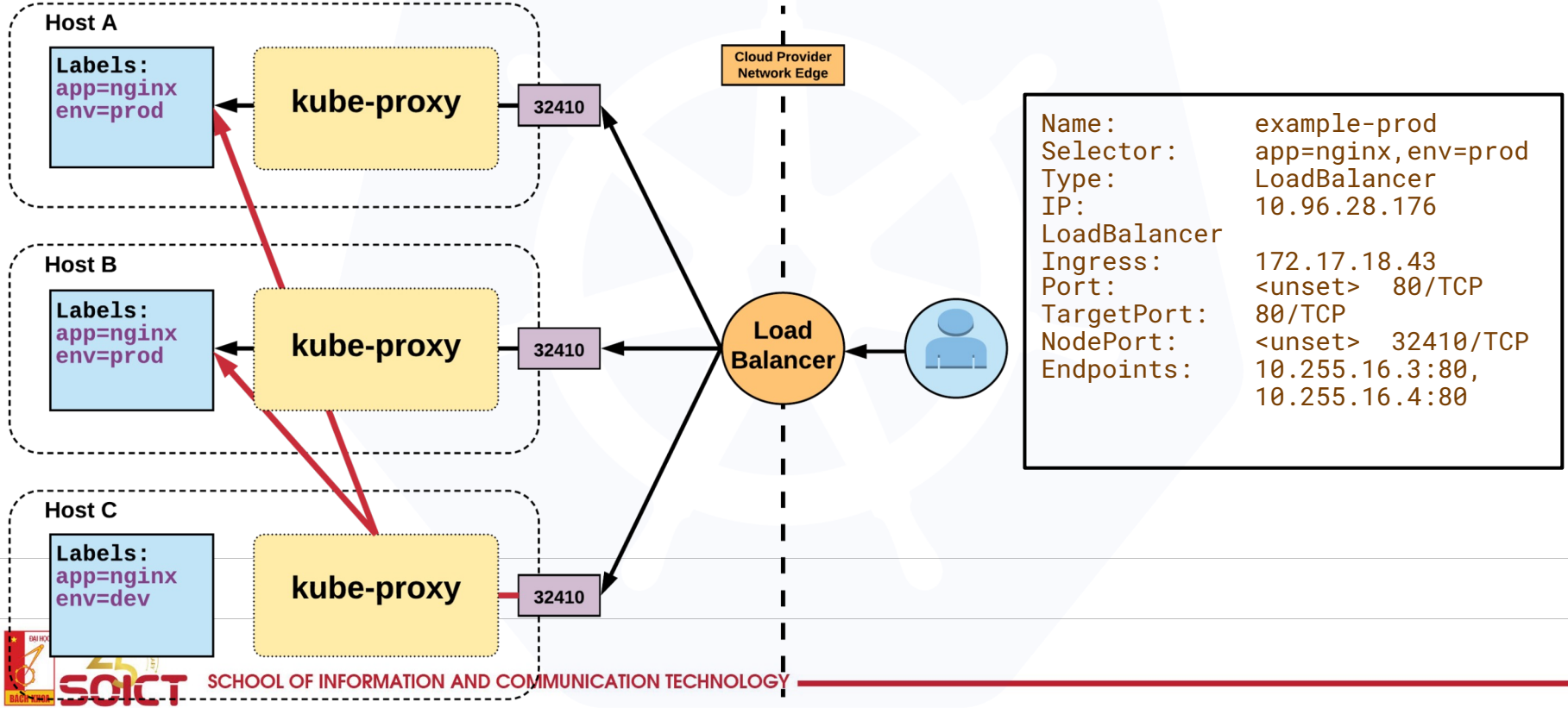

```
Name:           example-prod
Selector:       app=nginx,env=prod
Type:           NodePort
IP:             10.96.28.176
Port:           <unset>  80/TCP
TargetPort:     80/TCP
NodePort:       <unset>  32410/TCP
Endpoints:      10.255.16.3:80,
                10.255.16.4:80
```

LoadBalancer Service

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

LoadBalancer Service



ExternalName Service

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

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

Exploring the Core

Lab - github.com/mrbobbytables/k8s-intro-tutorials/blob/master/core

Workloads

- ReplicaSet
- Deployment
- DaemonSet
- StatefulSet
- Job
- CronJob

Concepts and Resources

Lab - github.com/mrbobbytables/k8s-intro-tutorials/blob/master/workloads

Using Workloads

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

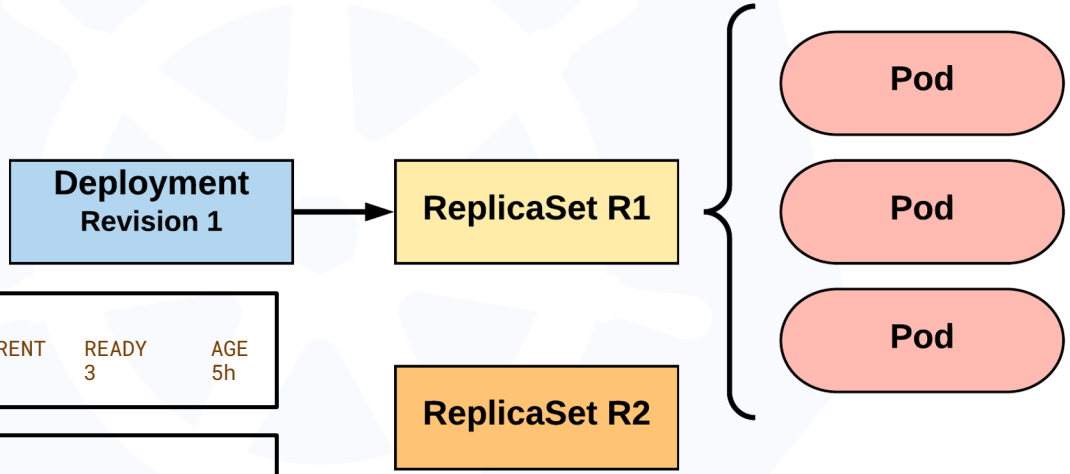
- `revisionHistoryLimit:` The number of previous iterations of the Deployment to retain.
- `strategy:` Describes the method of updating the Pods based on the `type`. Valid options are `Recreate` or `RollingUpdate`.
  - `Recreate:` All existing Pods are killed before the new ones are created.
  - `RollingUpdate:`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

```yaml
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.

R1 pod-template-hash:
`676677fff`
R2 pod-template-hash:
`54f7ff7d6d`



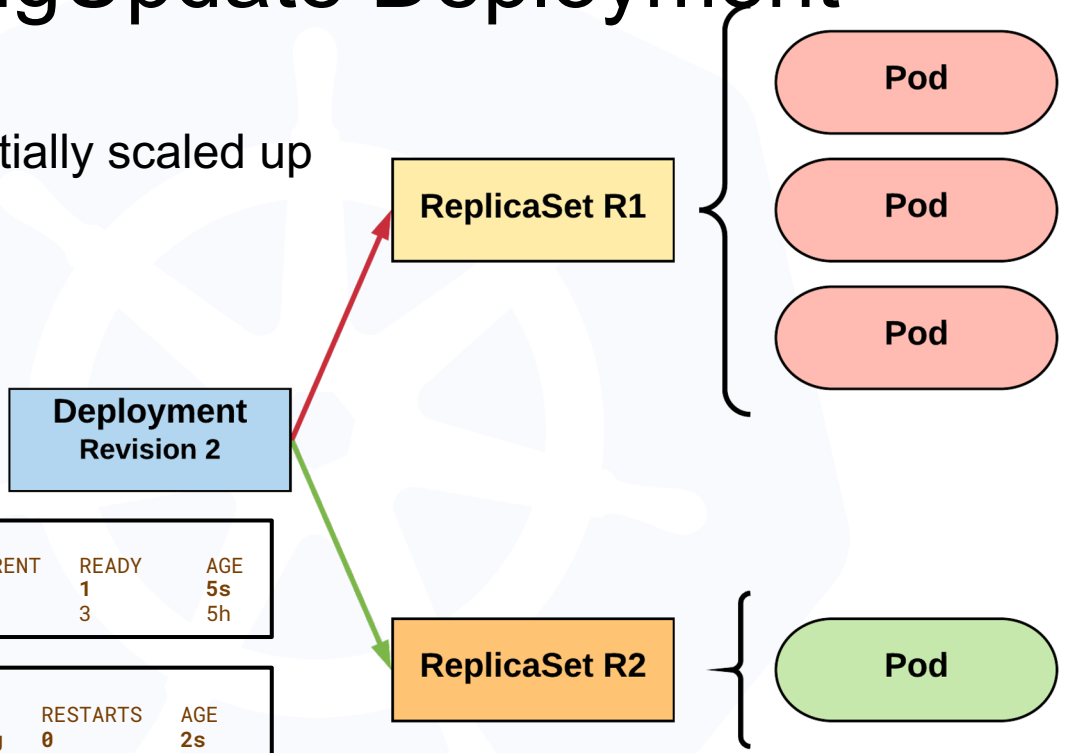

```
$ kubectl get replicaset
NAME                  DESIRED   CURRENT   READY   AGE
mydep-6766777fff      3         3         3       5h
```

```
$ 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:
`676677fff`
R2 pod-template-hash:
`54f7ff7d6d`



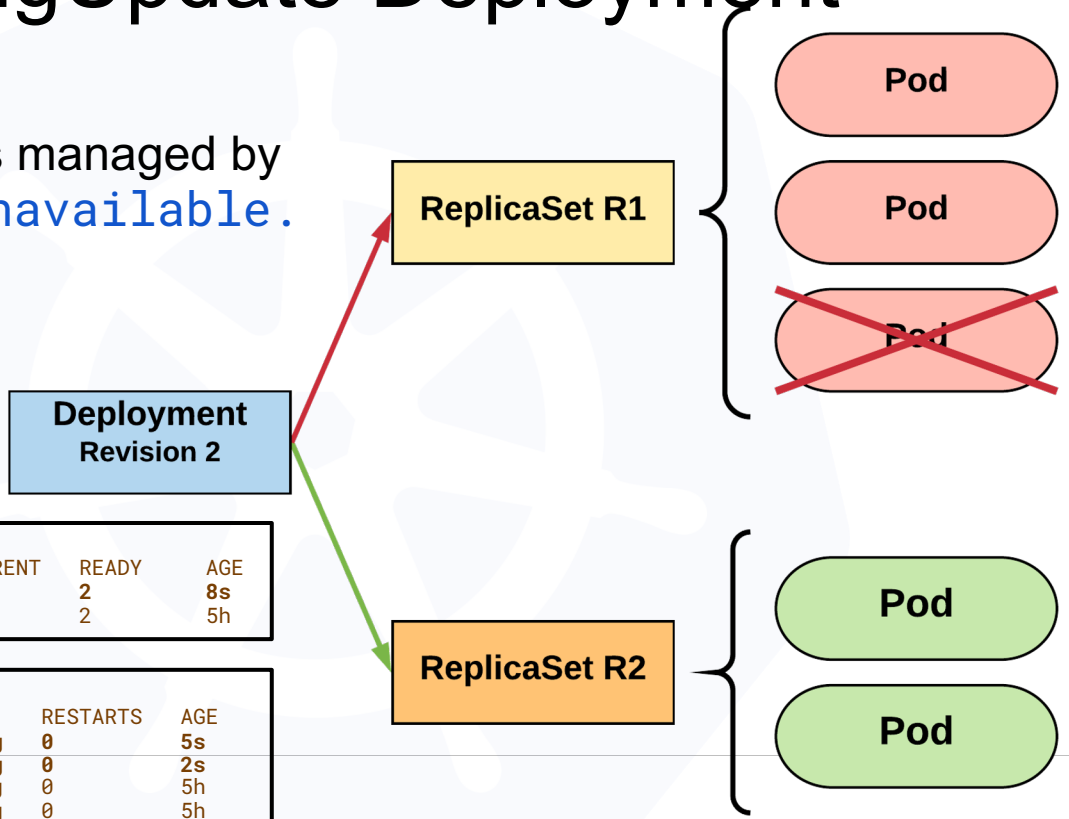

```
$ kubectl get replicaset
NAME                DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d    1         1         1       5s
mydep-6766777fff    2         3         3       5h
```

```
$ 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:
`676677fff`
R2 pod-template-hash:
`54f7ff7d6d`



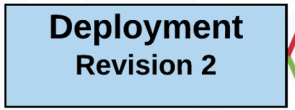

```
$ kubectl get replicaset
NAME                DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d    2         2         2       8s
mydep-6766777fff    2         2         2       5h
```

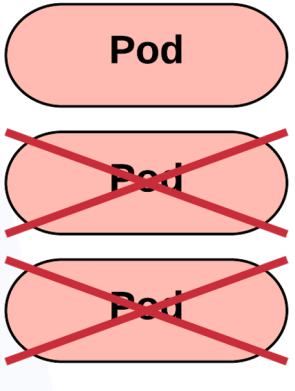
```
$ kubectl get pods
NAME                      READY   STATUS    RESTARTS   AGE
mydep-54f7ff7d6d-9gvll    1/1     Running   0          5s
mydep-54f7ff7d6d-cqvlq    1/1     Running   0          2s
mydep-6766777fff-9r2zn    1/1     Running   0          5h
mydep-6766777fff-hsfz9    1/1     Running   0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

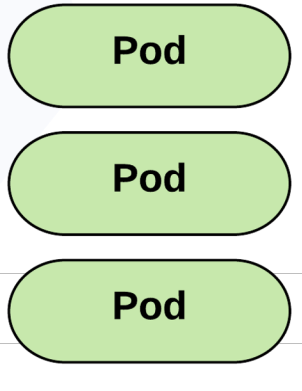
RollingUpdate Deployment

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

R1 pod-template-hash:
`676677fff`
R2 pod-template-hash:
`54f7ff7d6d`







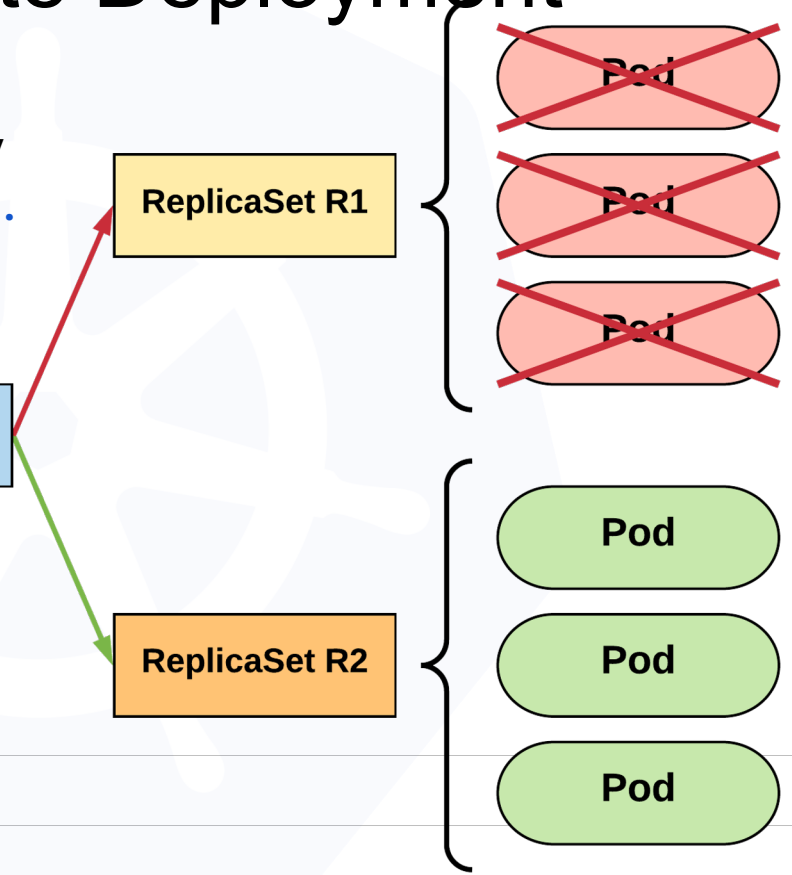

```
$ kubectl get replicaset
NAME                DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d    3         3         3       10s
mydep-6766777fff    0         1         1       5h
```

```
$ 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:
`676677fff`
R2 pod-template-hash:
`54f7ff7d6d`



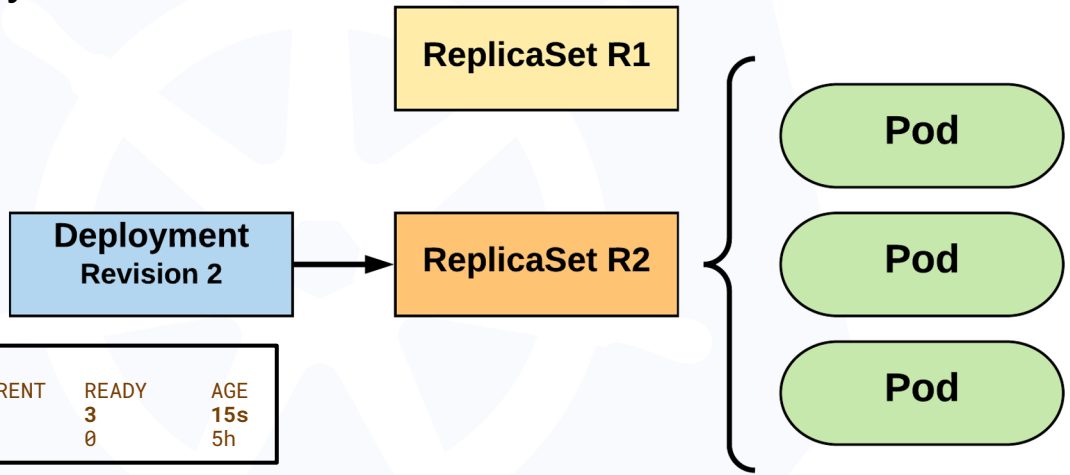

```
$ kubectl get replicaset
NAME                DESIRED   CURRENT   READY   AGE
mydep-54f7ff7d6d    3         3         3       13s
mydep-6766777fff    0         0         0       5h
```

```
$ 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:
676677fff
R2 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
```

DaemonSet

- Ensure that all nodes matching certain criteria will run an instance of the supplied Pod.
- They **bypass** default scheduling mechanisms.
- Are ideal for cluster wide services such as log forwarding, or health monitoring.
- Revisions are managed via a **controller-revision-hash** label.

DaemonSet

- `revisionHistoryLimit:` The number of previous iterations of the DaemonSet to retain.
- `updateStrategy:` Describes the method of updating the Pods based on the `type`. Valid options are `RollingUpdate` or `OnDelete`.
  - `RollingUpdate:` Cycles through updating the Pods according to the value of `maxUnavailable`.
  - `OnDelete:` The new instance of the Pod is deployed **ONLY** after the current instance is deleted.

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: ds-example
spec:
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: nginx
  updateStrategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 1
  template:
    spec:
      nodeSelector:
        nodeType: edge
      <pod template>
```

DaemonSet

- `spec.template.spec.nodeSelector:` The primary selector used to target nodes.
- **Default Host Labels:**
  - kubernetes.io/hostname
  - beta.kubernetes.io/os
  - beta.kubernetes.io/arch
- **Cloud Host Labels:**
  - failure-domain.beta.kubernetes.io/zone
  - failure-domain.beta.kubernetes.io/region
  - beta.kubernetes.io/instance-type

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: ds-example
spec:
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: nginx
  updateStrategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 1
  template:
    spec:
      nodeSelector:
        nodeType: edge
      <pod template>
```

DaemonSet

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: ds-example
spec:
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: nginx
  updateStrategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 1
  template:
    metadata:
      labels:
        app: nginx
    spec:
      nodeSelector:
        nodeType: edge
      containers:
      - name: nginx
        image: nginx:stable-alpine
        ports:
        - containerPort: 80
```

```
$ kubectl get pods
NAME                READY     STATUS    RESTARTS   AGE
ds-example-x8kkz    1/1       Running   0          1m
```

```
$ kubectl describe ds ds-example
Name:           ds-example
Selector:       app=nginx,env=prod
Node-Selector:  nodeType=edge
Labels:         app=nginx
                env=prod
Annotations:    <none>
Desired Number of Nodes Scheduled: 1
Current Number of Nodes Scheduled: 1
Number of Nodes Scheduled with Up-to-date Pods: 1
Number of Nodes Scheduled with Available Pods: 1
Number of Nodes Misscheduled: 0
Pods Status:  1 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  48s   daemonset-controller  Created pod: ds-example-x8kkz
```

DaemonSet

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: ds-example
spec:
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: nginx
  updateStrategy:
    type: RollingUpdate
    rollingUpdate:
      maxUnavailable: 1
  template:
    metadata:
      labels:
        app: nginx
    spec:
      nodeSelector:
        nodeType: edge
      containers:
      - name: nginx
        image: nginx:stable-alpine
        ports:
        - containerPort: 80
```

```
$ kubectl get pods
NAME                READY     STATUS    RESTARTS   AGE
ds-example-x8kkz    1/1       Running   0          1m
```

```
$ kubectl describe ds ds-example
Name:           ds-example
Selector:       app=nginx,env=prod
Node-Selector:  nodeType=edge
Labels:         app=nginx
                env=prod
Annotations:    <none>
Desired Number of Nodes Scheduled: 1
Current Number of Nodes Scheduled: 1
Number of Nodes Scheduled with Up-to-date Pods: 1
Number of Nodes Scheduled with Available Pods: 1
Number of Nodes Misscheduled: 0
Pods Status:  1 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  48s   daemonset-controller  Created pod: ds-example-x8kkz
```

StatefulSet

- Tailored to managing Pods that must persist or maintain state.
- Pod identity including **hostname**, **network**, and **storage WILL** be persisted.
- Assigned a unique ordinal name following the convention of '<*statefulset name*>-<*ordinal index*>'.

StatefulSet

- Naming convention is also used in Pod's network Identity and Volumes.
- Pod lifecycle will be ordered and follow consistent patterns.
- Revisions are managed via a **controller-revision-hash** label

StatefulSet

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: sts-example
spec:
  replicas: 2
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: stateful
  serviceName: app
  updateStrategy:
   type: RollingUpdate
   rollingUpdate:
     partition: 0
  template:
    metadata:
      labels:
        app: stateful
```

<continued>

<continued>

```
    spec:
      containers:
      - name: nginx
        image: nginx:stable-alpine
        ports:
        - containerPort: 80
        volumeMounts:
        - name: www
          mountPath: /usr/share/nginx/html
  volumeClaimTemplates:
  - metadata:
      name: www
    spec:
      accessModes: [ "ReadWriteOnce" ]
      storageClassName: standard
      resources:
        requests:
          storage: 1Gi
```

StatefulSet

```yaml
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: sts-example
spec:
  replicas: 2
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: stateful
  serviceName: app
  updateStrategy:
   type: RollingUpdate
   rollingUpdate:
     partition: 0
  template:
    <pod template>
```

- `revisionHistoryLimit:` The number of previous iterations of the StatefulSet to retain.
- `serviceName:` The name of the associated headless service; or a service without a **ClusterIP**.

Headless Service

<StatefulSet Name>-<ordinal>.<service name>.<namespace>.svc.cluster.local

```yaml
apiVersion: v1
kind: Service
metadata:
  name: app
spec:
  clusterIP: None
  selector:
    app: stateful
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

```
$ kubectl get pods
NAME            READY     STATUS    RESTARTS
AGE
sts-example-0   1/1       Running   0
11m
sts-example-1   1/1       Running   0
11m
```

```
/ # dig app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> app.default.svc.cluster.local +noall +answer
;; global options: +cmd
app.default.svc.cluster.local. 2 IN A        10.255.0.5
app.default.svc.cluster.local. 2 IN A        10.255.0.2
```

```
/ # dig sts-example-0.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-0.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-0.app.default.svc.cluster.local. 20 IN A 10.255.0.2
```

```
/ # dig sts-example-1.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-1.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-1.app.default.svc.cluster.local. 30 IN A 10.255.0.5
```

Headless Service

<StatefulSet Name>-<ordinal>.<service name>.<namespace>.svc.cluster.local

```yaml
apiVersion: v1
kind: Service
metadata:
  name: app
spec:
  clusterIP: None
  selector:
    app: stateful
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

```
$ kubectl get pods
NAME            READY   STATUS    RESTARTS
AGE
sts-example-0   1/1     Running   0
11m
sts-example-1   1/1     Running   0
11m
```

```
/ # dig app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> app.default.svc.cluster.local +noall +answer
;; global options: +cmd
app.default.svc.cluster.local. 2 IN A        10.255.0.5
app.default.svc.cluster.local. 2 IN A        10.255.0.2
```

```
/ # dig sts-example-0.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-0.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-0.app.default.svc.cluster.local. 20 IN A 10.255.0.2
```

```
/ # dig sts-example-1.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-1.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-1.app.default.svc.cluster.local. 30 IN A 10.255.0.5
```

Headless Service

<StatefulSet Name>-<ordinal>.<service name>.<namespace>.svc.cluster.local

```yaml
apiVersion: v1
kind: Service
metadata:
  name: app
spec:
  clusterIP: None
  selector:
    app: stateful
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

```
/ # dig app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> app.default.svc.cluster.local +noall +answer
;; global options: +cmd
app.default.svc.cluster.local. 2 IN A        10.255.0.5
app.default.svc.cluster.local. 2 IN A        10.255.0.2
```

```
/ # dig sts-example-0.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-0.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-0.app.default.svc.cluster.local. 20 IN A 10.255.0.2
```

```
$ kubectl get pods
NAME              READY     STATUS    RESTARTS
AGE
sts-example-0     1/1       Running   0
11m
sts-example-1     1/1       Running   0
11m
```

```
/ # dig sts-example-1.app.default.svc.cluster.local +noall +answer

; <<>> DiG 9.11.2-P1 <<>> sts-example-1.app.default.svc.cluster.local +noall +answer
;; global options: +cmd
sts-example-1.app.default.svc.cluster.local. 30 IN A 10.255.0.5
```

StatefulSet

- `updateStrategy:` Describes the method of updating the Pods based on the `type`. Valid options are `OnDelete` or `RollingUpdate`.
  - `OnDelete:` The new instance of the Pod is deployed **ONLY** after the current instance is deleted.
  - `RollingUpdate:` Pods with an ordinal greater than the `partition` value will be updated in one-by-one in reverse order.

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: sts-example
spec:
  replicas: 2
  revisionHistoryLimit: 3
  selector:
    matchLabels:
      app: stateful
  serviceName: app
  updateStrategy:
   type: RollingUpdate
   rollingUpdate:
     partition: 0
  template:
    <pod template>
```

StatefulSet

```
    spec:
      containers:
      - name: nginx
        image: nginx:stable-alpine
        ports:
        - containerPort: 80
        volumeMounts:
        - name: www
          mountPath:
/usr/share/nginx/html
  volumeClaimTemplates:
  - metadata:
      name: www
    spec:
      accessModes: [ "ReadWriteOnce" ]
      storageClassName: standard
      resources:
        requests:
          storage: 1Gi
```

- `volumeClaimTemplates:` Template of the persistent volume(s) request to use for each instance of the StatefulSet.

VolumeClaimTemplate

<Volume Name>-<StatefulSet Name>-<ordinal>

```
volumeClaimTemplates:
 - metadata:
     name: www
   spec:
     accessModes: [ "ReadWriteOnce" ]
     storageClassName: standard
     resources:
       requests:
         storage: 1Gi
```

Persistent Volumes associated with a StatefulSet will **NOT** be automatically garbage collected when it's associated StatefulSet is deleted. They must manually be removed.

```
$ kubectl get pvc
NAME                STATUS    VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS   AGE
www-sts-example-0   Bound     pvc-d2f11e3b-18d0-11e8-ba4f-080027a3682b   1Gi        RWO            standard       4h
www-sts-example-1   Bound     pvc-d3c923c0-18d0-11e8-ba4f-080027a3682b   1Gi        RWO            standard       4h
```

Job

- Job controller ensures one or more pods are executed and successfully terminate.
- Will continue to try and execute the job until it satisfies the completion and/or parallelism condition.
- Pods are **NOT** cleaned up until the job itself is deleted.*

Job

- `backoffLimit:` The number of failures before the job itself is considered **failed**.
- `completions:` The total number of successful completions desired.
- `parallelism:` How many instances of the pod can be run concurrently.
- `spec.template.spec.restartPolicy:` Jobs only support a `restartPolicy` of type `Never` or `OnFailure`.

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: job-example
spec:
  backoffLimit: 4
  completions: 4
  parallelism: 2
  template:
    spec:
      restartPolicy: Never
    <pod-template>
```

Job

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: job-example
spec:
  backoffLimit: 4
  completions: 4
  parallelism: 2
  template:
    spec:
      containers:
      - name: hello
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["echo hello from $HOSTNAME!"]
      restartPolicy: Never
```

```
$ kubectl get pods --show-all
NAME                READY     STATUS      RESTARTS   AGE
job-example-dvxd2   0/1       Completed   0          51m
job-example-hknns   0/1       Completed   0          52m
job-example-tphkm   0/1       Completed   0          51m
job-example-v5fvq   0/1       Completed   0          52m
```

```
$ kubectl describe job job-example
Name:           job-example
Namespace:      default
Selector:       controller-uid=19d122f4-1576-11e8-a4e2-080027a3682b
Labels:         controller-uid=19d122f4-1576-11e8-a4e2-080027a3682b
                job-name=job-example
Annotations:    <none>
Parallelism:    2
Completions:    4
Start Time:     Mon, 19 Feb 2018 08:09:21 -0500
Pods Statuses:  0 Running / 4 Succeeded / 0 Failed
Pod Template:
  Labels:  controller-uid=19d122f4-1576-11e8-a4e2-080027a3682b
           job-name=job-example
  Containers:
   hello:
    Image:  alpine:latest
    Port:   <none>
    Command:
      /bin/sh
      -c
    Args:
      echo hello from $HOSTNAME!
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Events:
  Type    Reason            Age   From            Message
  ----    ------            ----  ----            -------
  Normal  SuccessfulCreate  52m   job-controller  Created pod: job-example-v5fvq
  Normal  SuccessfulCreate  52m   job-controller  Created pod: job-example-hknns
  Normal  SuccessfulCreate  51m   job-controller  Created pod: job-example-tphkm
  Normal  SuccessfulCreate  51m   job-controller  Created pod: job-example-dvxd2
```

CronJob

An extension of the Job Controller, it provides a method of executing jobs on a cron-like schedule.

CronJobs within Kubernetes use **UTC ONLY**.

CronJob

- `schedule:` The cron schedule for the job.
- `successfulJobHistoryLimit:` The number of successful jobs to retain.
- `failedJobHistoryLimit:` The number of failed jobs to retain.

```
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: cronjob-example
spec:
  schedule: "*/1 * * * *"
  successfulJobsHistoryLimit: 3
  failedJobsHistoryLimit: 1
  jobTemplate:
    spec:
      completions: 4
      parallelism: 2
      template:
        <pod template>
```

CronJob

```yaml
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: cronjob-example
spec:
  schedule: "*/1 * * * *"
  successfulJobsHistoryLimit: 3
  failedJobsHistoryLimit: 1
  jobTemplate:
    spec:
      completions: 4
      parallelism: 2
      template:
        spec:
          containers:
          - name: hello
            image: alpine:latest
            command: ["/bin/sh", "-c"]
            args: ["echo hello from $HOSTNAME!"]
          restartPolicy: Never
```

```
$ kubectl get jobs
NAME                           DESIRED   SUCCESSFUL   AGE
cronjob-example-1519053240     4         4            2m
cronjob-example-1519053300     4         4            1m
cronjob-example-1519053360     4         4            26s
```

```
$ kubectl describe cronjob cronjob-example
Name:                          cronjob-example
Namespace:                     default
Labels:                        <none>
Annotations:                   <none>
Schedule:                      */1 * * * *
Concurrency Policy:            Allow
Suspend:                       False
Starting Deadline Seconds:     <unset>
Selector:                      <unset>
Parallelism:                   2
Completions:                   4
Pod Template:
  Labels:  <none>
  Containers:
   hello:
    Image:  alpine:latest
    Port:   <none>
    Command:
      /bin/sh
      -c
    Args:
      echo hello from $HOSTNAME!
    Environment:     <none>
    Mounts:          <none>
  Volumes:           <none>
Last Schedule Time:  Mon, 19 Feb 2018 09:54:00 -0500
Active Jobs:         cronjob-example-1519052040
Events:
  Type    Reason            Age   From                Message
  ----    ------            ----  ----                -------
  Normal  SuccessfulCreate  3m    cronjob-controller  Created job cronjob-example-1519051860
  Normal  SawCompletedJob   2m    cronjob-controller  Saw completed job: cronjob-example-1519051860
  Normal  SuccessfulCreate  2m    cronjob-controller  Created job cronjob-example-1519051920
  Normal  SawCompletedJob   1m    cronjob-controller  Saw completed job: cronjob-example-1519051920
  Normal  SuccessfulCreate  1m    cronjob-controller  Created job cronjob-example-1519051980
```

Using Workloads

Lab - github.com/mrbobbytables/k8s-intro-tutorials/blob/master/workloads

Storage

- Volumes
- Persistent Volumes
- Persistent Volume Claims
- StorageClass

Concepts and Resources

Storage

Pods by themselves are useful, but many workloads require exchanging data between containers, or persisting some form of data.

For this we have **Volumes**, **PersistentVolumes**, **PersistentVolumeClaims**, and **StorageClasses**.

Volumes

- Storage that is tied to the **Pod's Lifecycle**.
- A pod can have one or more types of volumes attached to it.
- Can be consumed by any of the containers within the pod.
- Survive Pod restarts; however their durability beyond that is dependent on the Volume Type.

Volume Types

- awsElasticBlockStore
- azureDisk
- azureFile
- cephfs
- configMap
- csi
- downwardAPI
- emptyDir
- fc (fibre channel)
- flocker
- gcePersistentDisk
- gitRepo
- glusterfs
- hostPath
- iscsi
- local
- nfs
- persistentVolumeClaim
- projected
- portworxVolume
- quobyte
- rbd
- scaleIO
- secret
- storageos
- vsphereVolume

Persistent Volume Supported

Volumes

- `volumes:` A list of volume objects to be attached to the Pod. Every object within the list must have it's own unique `name`.
- `volumeMounts:` A container specific list referencing the Pod volumes by `name`, along with their desired `mountPath`.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: volume-example
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    volumeMounts:
    - name: html
      mountPath: /usr/share/nginx/html
      ReadOnly: true
  - 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: {}
```

Volumes

- `volumes:` A list of volume objects to be attached to the Pod. Every object within the list must have it's own unique `name`.
- `volumeMounts:` A container specific list referencing the Pod volumes by `name`, along with their desired `mountPath`.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: volume-example
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    volumeMounts:
    - name: html
      mountPath: /usr/share/nginx/html
      ReadOnly: true
  - 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: {}
```

Volumes

- `volumes:` A list of volume objects to be attached to the Pod. Every object within the list must have it's own unique `name`.
- `volumeMounts:` A container specific list referencing the Pod volumes by `name`, along with their desired `mountPath`.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: volume-example
spec:
  containers:
  - name: nginx
    image: nginx:stable-alpine
    volumeMounts:
    - name: html
      mountPath: /usr/share/nginx/html
      ReadOnly: true
  - 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: {}
```

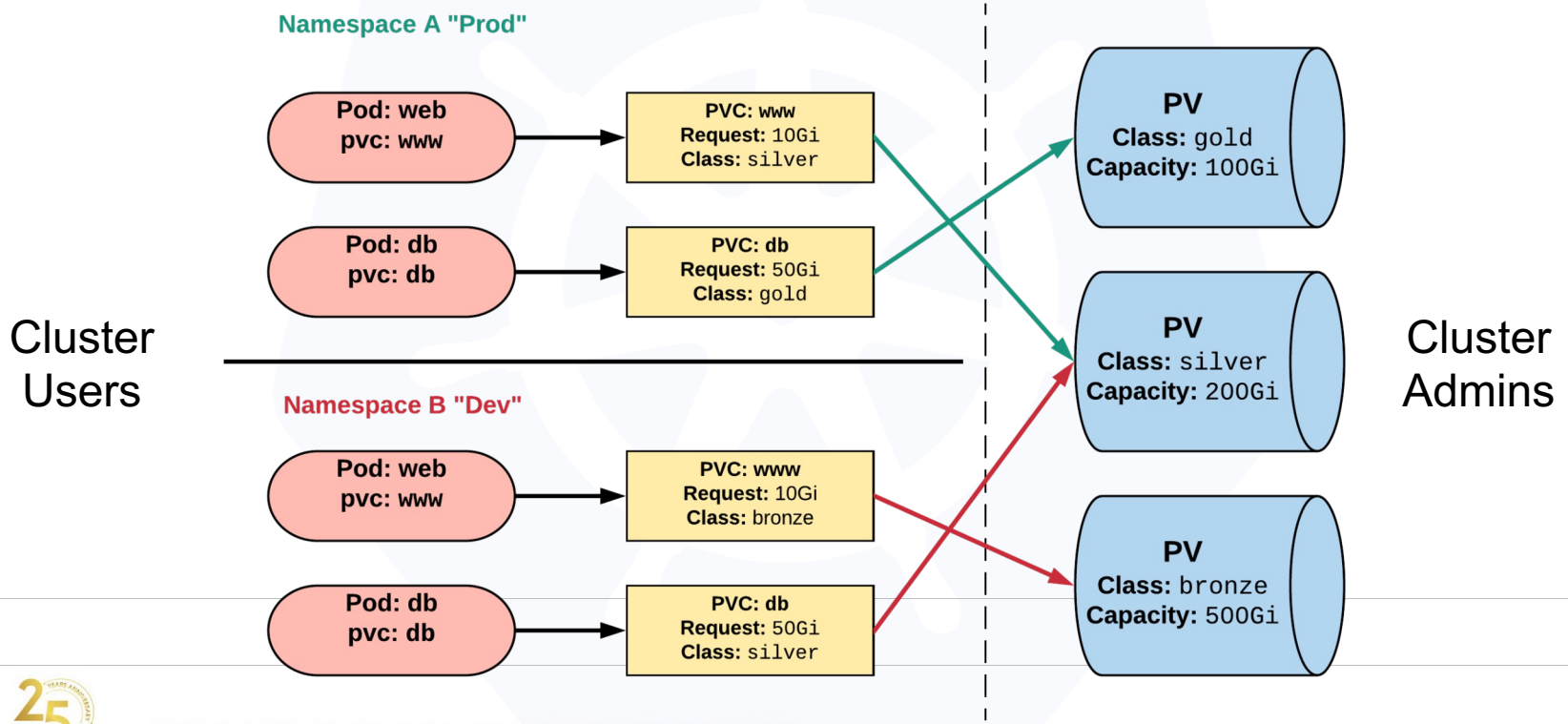
Persistent Volumes

- A **PersistentVolume** (PV) represents a storage resource.
- PVs are a **cluster wide resource** linked to a backing storage provider: NFS, GCEPersistentDisk, RBD etc.
- Generally provisioned by an administrator.
- Their lifecycle is handled independently from a pod
- **CANNOT** be attached to a Pod directly. Relies on a **PersistentVolumeClaim**

PersistentVolumeClaims

- A **PersistentVolumeClaim** (PVC) is a **namespaced** request for storage.
- Satisfies a set of requirements instead of mapping to a storage resource directly.
- Ensures that an application's '*claim*' for storage is portable across numerous backends or providers.

Persistent Volumes and Claims



PersistentVolume

- `capacity.storage:` The total amount of available storage.
- `volumeMode:` The type of volume, this can be either `Filesystem` or `Block`.
- `accessModes:` A list of the supported methods of accessing the volume. Options include:
  - `ReadWriteOnce`
  - `ReadOnlyMany`
  - `ReadWriteMany`

```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: nfsserver
spec:
  capacity:
    storage: 50Gi
  volumeMode: Filesystem
  accessModes:
    - ReadWriteOnce
    - ReadWriteMany
  persistentVolumeReclaimPolicy: Delete
  storageClassName: slow
  mountOptions:
    - hard
    - nfsvers=4.1
  nfs:
    path: /exports
    server: 172.22.0.42
```

PersistentVolume

- `persistentVolumeReclaimPolicy:` The behaviour for PVC's that have been deleted. Options include:
  - `Retain` - manual clean-up
  - `Delete` - storage asset deleted by provider.
- `storageClassName:` Optional name of the storage class that PVC's can reference. If provided, **ONLY** PVC's referencing the name consume use it.
- `mountOptions:` Optional mount options for the PV.

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: nfsserver
spec:
  capacity:
    storage: 50Gi
  volumeMode: Filesystem
  accessModes:
    - ReadWriteOnce
    - ReadWriteMany
  persistentVolumeReclaimPolicy:
Delete
  storageClassName: slow
  mountOptions:
    - hard
    - nfsvers=4.1
  nfs:
    path: /exports
    server: 172.22.0.42
```

PersistentVolumeClaim

- `accessModes:` The selected method of accessing the storage. This **MUST** be a subset of what is defined on the target PV or Storage Class.
  - `ReadWriteOnce`
  - `ReadOnlyMany`
  - `ReadWriteMany`
- `resources.requests.storage:` The desired amount of storage for the claim
- `storageClassName:` The name of the desired Storage Class

```yaml
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-sc-example
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
  storageClassName: slow
```

PVs and PVCs with Selectors

```yaml
kind: PersistentVolume
apiVersion: v1
metadata:
  name: pv-selector-example
  labels:
    type: hostpath
spec:
  capacity:
    storage: 2Gi
  accessModes:
    - ReadWriteMany
  hostPath:
    path: "/mnt/data"
```

```yaml
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-selector-example
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  selector:
    matchLabels:
      type: hostpath
```

PVs and PVCs with Selectors

```yaml
kind: PersistentVolume
apiVersion: v1
metadata:
  name: pv-selector-example
  labels:
    type: hostpath
spec:
  capacity:
    storage: 2Gi
  accessModes:
    - ReadWriteMany
  hostPath:
    path: "/mnt/data"
```

```yaml
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc-selector-example
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 1Gi
  selector:
    matchLabels:
      type: hostpath
```

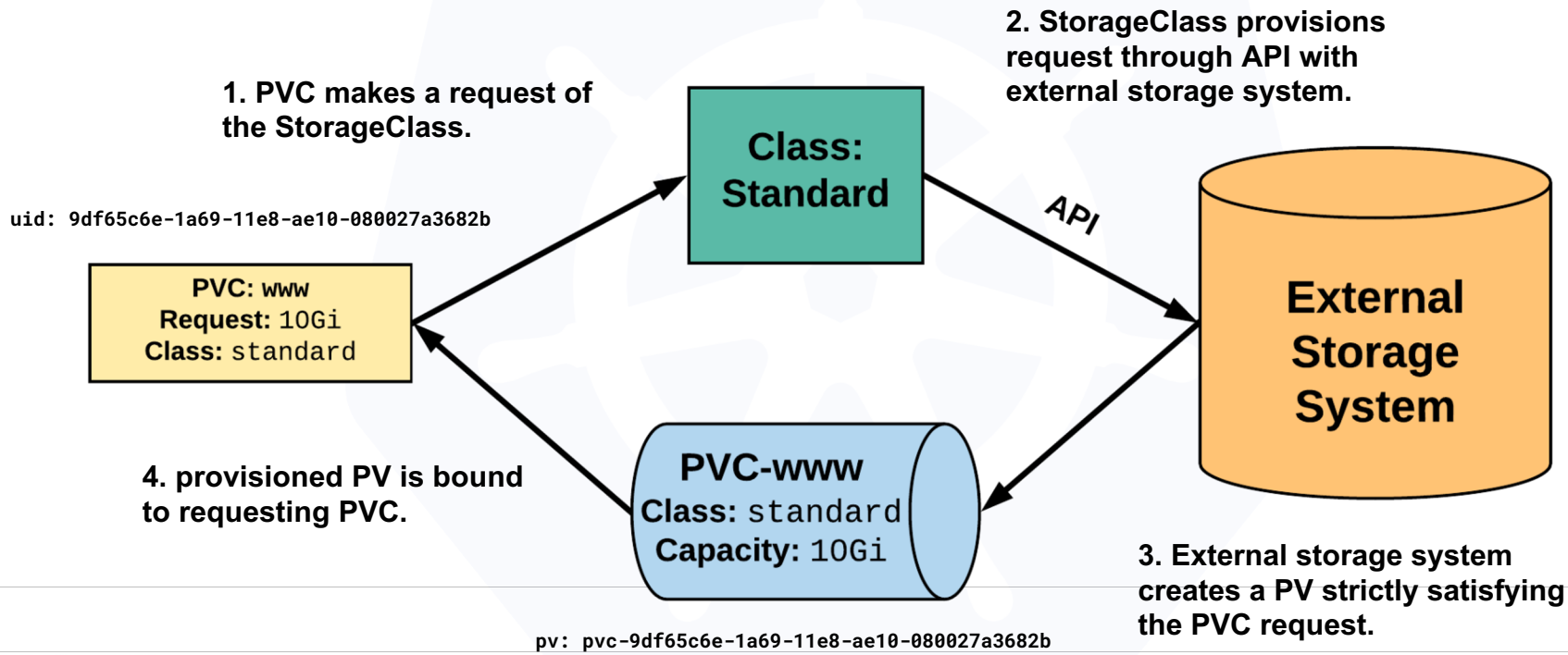
PV Phases

Available	Bound	Released	Failed
PV is ready and available to be consumed.	The PV has been bound to a claim.	The binding PVC has been deleted, and the PV is pending reclamation.	An error has been encountered attempting to reclaim the PV.

StorageClass

- Storage classes are an abstraction on top of an external storage resource (PV)
- Work hand-in-hand with the external storage system to enable **dynamic provisioning** of storage
- Eliminates the need for the cluster admin to pre-provision a PV

StorageClass



StorageClass

- `provisioner:` Defines the '*driver*' to be used for provisioning of the external storage.
- `parameters:` A hash of the various configuration parameters for the provisioner.
- `reclaimPolicy:` The behaviour for the backing storage when the PVC is deleted.
  - `Retain` - manual clean-up
  - `Delete` - storage asset deleted by provider

```
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: standard
provisioner: kubernetes.io/gce-pd
parameters:
  type: pd-standard
  zones: us-central1-a, us-central1-b
reclaimPolicy: Delete
```

Available StorageClasses

- AWSElasticBlockStore
- AzureFile
- AzureDisk
- CephFS
- Cinder
- FC
- Flocker
- GCEPersistentDisk
- Glusterfs
- iSCSI
- Quobyte
- NFS
- RBD
- VsphereVolume
- PortworxVolume
- ScaleIO
- StorageOS
- Local

Internal Provisioner

Working with Volumes

Lab - github.com/mrbobbytables/k8s-intro-tutorials/blob/master/storage

Configuration

- ConfigMap
- Secret

Concepts and Resources

Configuration

Kubernetes has an integrated pattern for decoupling configuration from application or container.

This pattern makes use of two Kubernetes components: **ConfigMaps** and **Secrets.**

ConfigMap

- Externalized data stored within kubernetes.
- Can be referenced through several different means:
  - environment variable
  - a command line argument (via env var)
  - injected as a file into a volume mount
- Can be created from a manifest, literals, directories, or files directly.

ConfigMap

`data:` Contains key-value pairs of ConfigMap contents.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: manifest-example
data:
  state: Michigan
  city: Ann Arbor
  content: |
    Look at this,
    its multiline!
```

ConfigMap Example

All produce a **ConfigMap** with the same content!

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: manifest-example
data:
  city: Ann Arbor
  state: Michigan
```

```
$ kubectl create configmap literal-example \
> --from-literal="city=Ann Arbor" --from-literal=state=Michigan
configmap “literal-example” created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap dir-example --from-file=cm/
configmap "dir-example" created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap file-example --from-file=cm/city --from-file=cm/state
configmap "file-example" created
```

ConfigMap Example

All produce a **ConfigMap** with the same content!

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: manifest-example
data:
  city: Ann Arbor
  state: Michigan
```

```
$ kubectl create configmap literal-example \
> --from-literal="city=Ann Arbor" --from-literal=state=Michigan
configmap "literal-example" created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap dir-example --from-file=cm/
configmap "dir-example" created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap file-example --from-file=cm/city --from-file=cm/state
configmap "file-example" created
```

ConfigMap Example

All produce a **ConfigMap** with the same content!

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: manifest-example
data:
  city: Ann Arbor
  state: Michigan
```

```
$ kubectl create configmap literal-example \
> --from-literal="city=Ann Arbor" --from-literal=state=Michigan
configmap “literal-example” created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap dir-example --from-file=cm/
configmap "dir-example" created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap file-example --from-file=cm/city --from-file=cm/state
configmap "file-example" created
```

ConfigMap Example

All produce a **ConfigMap** with the same content!

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: manifest-example
data:
  city: Ann Arbor
  state: Michigan
```

```
$ kubectl create configmap literal-example \
> --from-literal="city=Ann Arbor" --from-literal=state=Michigan
configmap “literal-example” created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap dir-example --from-file=cm/
configmap "dir-example" created
```

```
$ cat info/city
Ann Arbor
$ cat info/state
Michigan
$ kubectl create configmap file-example --from-file=cm/city --from-file=cm/state
configmap "file-example" created
```

Secret

- Functionally identical to a ConfigMap.
- Stored as **base64 encoded content.**
- Encrypted at rest within etcd (**if configured!**).
- Ideal for username/passwords, certificates or other sensitive information that should not be stored in a container.
- Can be created from a manifest, literals, directories, or from files directly.

Secret

- `type:` There are three different types of secrets within Kubernetes:
  - `docker-registry` - credentials used to authenticate to a container registry
  - `generic/Opaque` - literal values from different sources
  - `tls` - a certificate based secret
- `data:` Contains key-value pairs of base64 encoded content.

```
apiVersion: v1
kind: Secret
metadata:
  name: manifest-secret
type: Opaque
data:
  username: ZXhhbXBsZQ==
  password: bXlwYXNzd29yZA==
```

Secret Example

All produce a **Secret** with the same content!

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: manifest-example
type: Opaque
data:
  username: ZXhhbXBsZQ==
  password: bXlwYXNzd29yZA==
```

```
$ kubectl create secret generic literal-secret \
> --from-literal=username=example \
> --from-literal=password=mypassword
secret "literal-secret" created
```

```
$ cat info/username
example
$ cat info/password
mypassword
$ kubectl create secret generic dir-secret --from-file=secret/
Secret "file-secret" created
```

```
$ cat secret/username
example
$ cat secret/password
mypassword
$ kubectl create secret generic file-secret --from-file=secret/username --from-file=secret/password
Secret "file-secret" created
```

Secret Example

All produce a **Secret** with the same content!

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: manifest-example
type: Opaque
data:
  username: ZXhhbXBsZQ==
  password: bXlwYXNzd29yZA==
```

```
$ kubectl create secret generic literal-secret \
> --from-literal=username=example \
> --from-literal=password=mypassword
secret "literal-secret" created
```

```
$ cat info/username
example
$ cat info/password
mypassword
$ kubectl create secret generic dir-secret --from-file=secret/
Secret "file-secret" created
```

```
$ cat secret/username
example
$ cat secret/password
mypassword
$ kubectl create secret generic file-secret --from-file=secret/username --from-file=secret/password
Secret "file-secret" created
```

Secret Example

All produce a **Secret** with the same content!

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: manifest-example
type: Opaque
data:
  username: ZXhhbXBsZQ==
  password: bXlwYXNzd29yZA==
```

```
$ kubectl create secret generic literal-secret \
> --from-literal=username=example \
> --from-literal=password=mypassword
secret "literal-secret" created
```

```
$ cat info/username
example
$ cat info/password
mypassword
$ kubectl create secret generic dir-secret --from-file=secret/
Secret "file-secret" created
```

```
$ cat secret/username
example
$ cat secret/password
mypassword
$ kubectl create secret generic file-secret --from-file=secret/username --from-file=secret/password
Secret "file-secret" created
```

Secret Example

All produce a **Secret** with the same content!

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: manifest-example
type: Opaque
data:
  username: ZXhhbXBsZQ==
  password: bXlwYXNzd29yZA==
```

```
$ kubectl create secret generic literal-secret \
> --from-literal=username=example \
> --from-literal=password=mypassword
secret "literal-secret" created
```

```
$ cat info/username
example
$ cat info/password
mypassword
$ kubectl create secret generic dir-secret --from-file=secret/
Secret "file-secret" created
```

```
$ cat secret/username
example
$ cat secret/password
mypassword
$ kubectl create secret generic file-secret --from-file=secret/username --from-file=secret/password
Secret "file-secret" created
```

Injecting as Environment Variable

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-env-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["printenv CITY"]
        env:
        - name: CITY
          valueFrom:
            configMapKeyRef:
              name: manifest-example
              key: city
      restartPolicy: Never
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-env-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["printenv USERNAME"]
        env:
        - name: USERNAME
          valueFrom:
            secretKeyRef:
              name: manifest-example
              key: username
      restartPolicy: Never
```

Injecting as Environment Variable

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-env-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["printenv CITY"]
        env:
        - name: CITY
          valueFrom:
            configMapKeyRef:
              name: manifest-example
              key: city
      restartPolicy: Never
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-env-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["printenv USERNAME"]
        env:
        - name: USERNAME
          valueFrom:
            secretKeyRef:
              name: manifest-example
              key: username
      restartPolicy: Never
```

Injecting in a Command

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-cmd-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["echo Hello ${CITY}!"]
        env:
        - name: CITY
          valueFrom:
            configMapKeyRef:
              name: manifest-example
              key: city
      restartPolicy: Never
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-cmd-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["echo Hello ${USERNAME}!"]
        env:
        - name: USERNAME
          valueFrom:
            secretKeyRef:
              name: manifest-example
              key: username
      restartPolicy: Never
```

Injecting in a Command

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-cmd-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["echo Hello ${CITY}!"]
        env:
        - name: CITY
          valueFrom:
            configMapKeyRef:
              name: manifest-example
              key: city
      restartPolicy: Never
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-cmd-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["echo Hello ${USERNAME}!"]
        env:
        - name: USERNAME
          valueFrom:
            secretKeyRef:
              name: manifest-example
              key: username
      restartPolicy: Never
```

Injecting as a Volume

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-vol-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["cat /myconfig/city"]
        volumeMounts:
        - name: config-volume
          mountPath: /myconfig
      restartPolicy: Never
      volumes:
      - name: config-volume
        configMap:
          name: manifest-example
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-vol-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["cat /mysecret/username"]
        volumeMounts:
        - name: secret-volume
          mountPath: /mysecret
      restartPolicy: Never
      volumes:
      - name: secret-volume
        secret:
          secretName: manifest-example
```

Injecting as a Volume

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: cm-vol-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["cat /myconfig/city"]
        volumeMounts:
        - name: config-volume
          mountPath: /myconfig
      restartPolicy: Never
      volumes:
      - name: config-volume
        configMap:
          name: manifest-example
```

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: secret-vol-example
spec:
  template:
    spec:
      containers:
      - name: mypod
        image: alpine:latest
        command: ["/bin/sh", "-c"]
        args: ["cat /mysecret/username"]
        volumeMounts:
        - name: secret-volume
          mountPath: /mysecret
      restartPolicy: Never
      volumes:
      - name: secret-volume
        secret:
          secretName: manifest-example
```

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/c/KubernetesCommunity
- **Official CNCF Youtube Channel**
  https://www.youtube.com/c/cloudnativefdn
- **Track to becoming a CKA/CKAD (Certified Kubernetes Administrator/Application Developer)**
  https://www.cncf.io/certification/expert/
- **Awesome Kubernetes**
  https://ramitsurana.gitbooks.io/awesome-kubernetes/content/