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- Data Science
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- Python
- Spring Boot & Microservices
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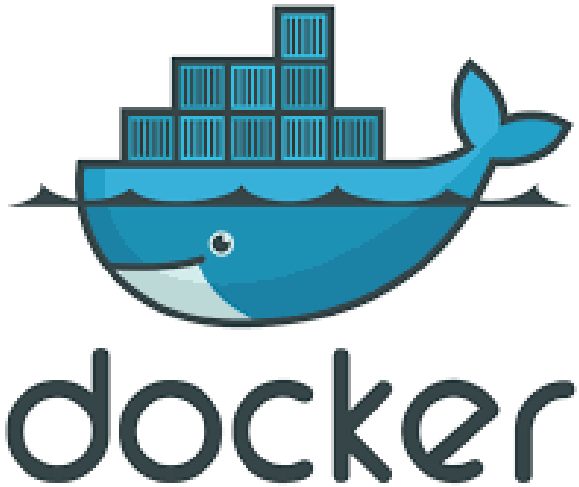
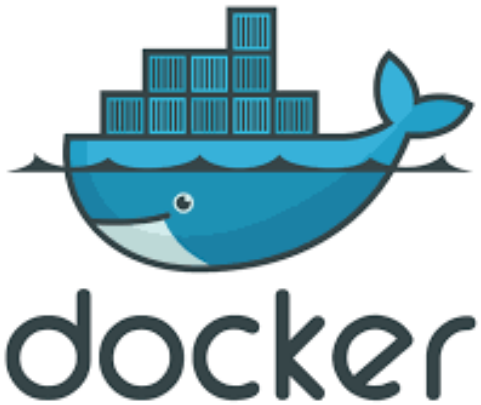
Docker & Kubernetes Workshop



Docker Overview

What is Docker?

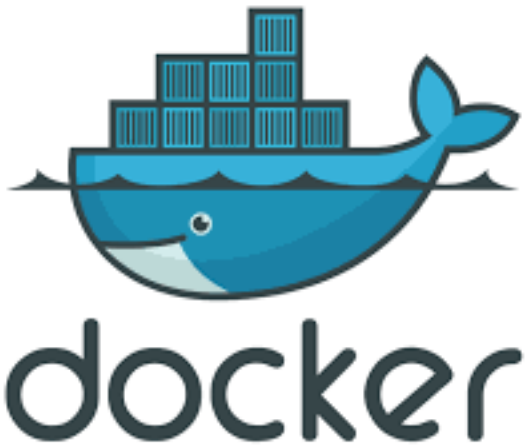


Docker is an open-source project that automates the deployment of applications inside software containers, by providing an additional layer of abstraction and automation of operating system–level virtualization on Linux.

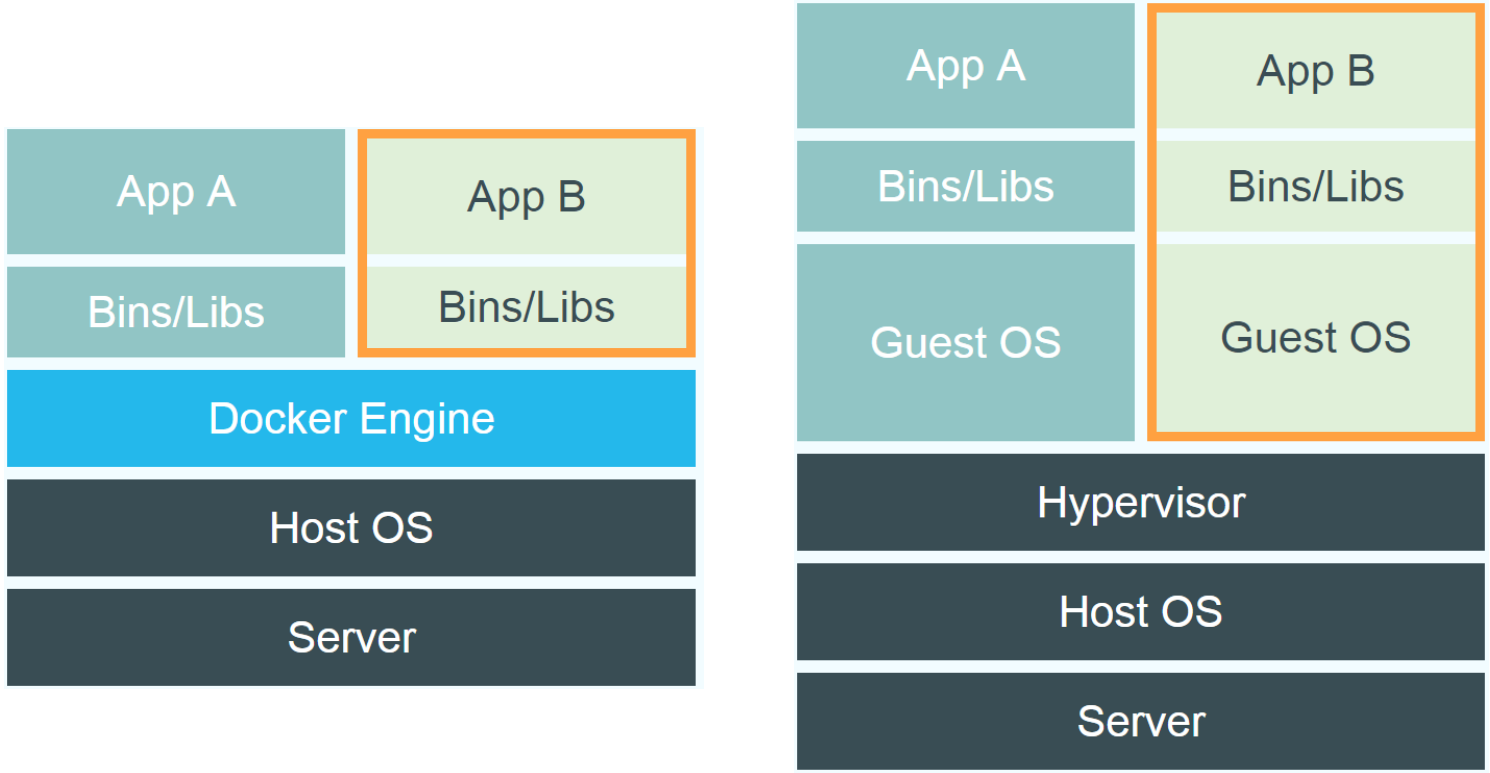
[Source: en.wikipedia.org]

Docker: Name

- Provide a uniformed wrapper around a software package: *«Build, Ship and Run Any App, Anywhere»*
- Similar to shipping containers: The container is always the same, regardless of the contents and thus fits on all trucks, cranes, ships, ...



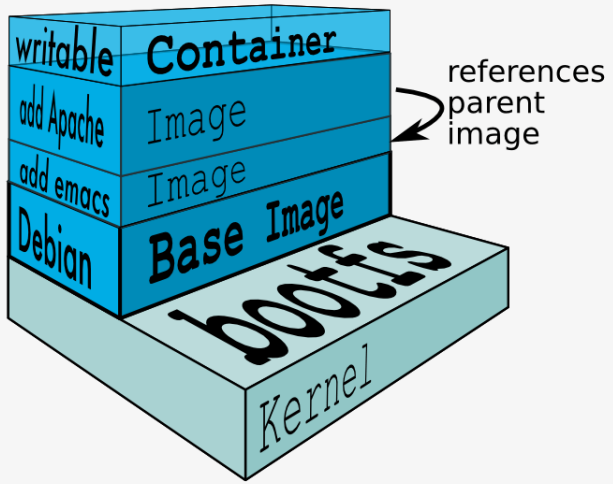
Docker vs. Virtual Machine



Source: https://www.docker.com/whatisdocker/

Docker Technology

- libvirt: Platform Virtualization
- LXC (LinuX Containers): Multiple isolated Linux systems (containers) on a single host
- Layered File System



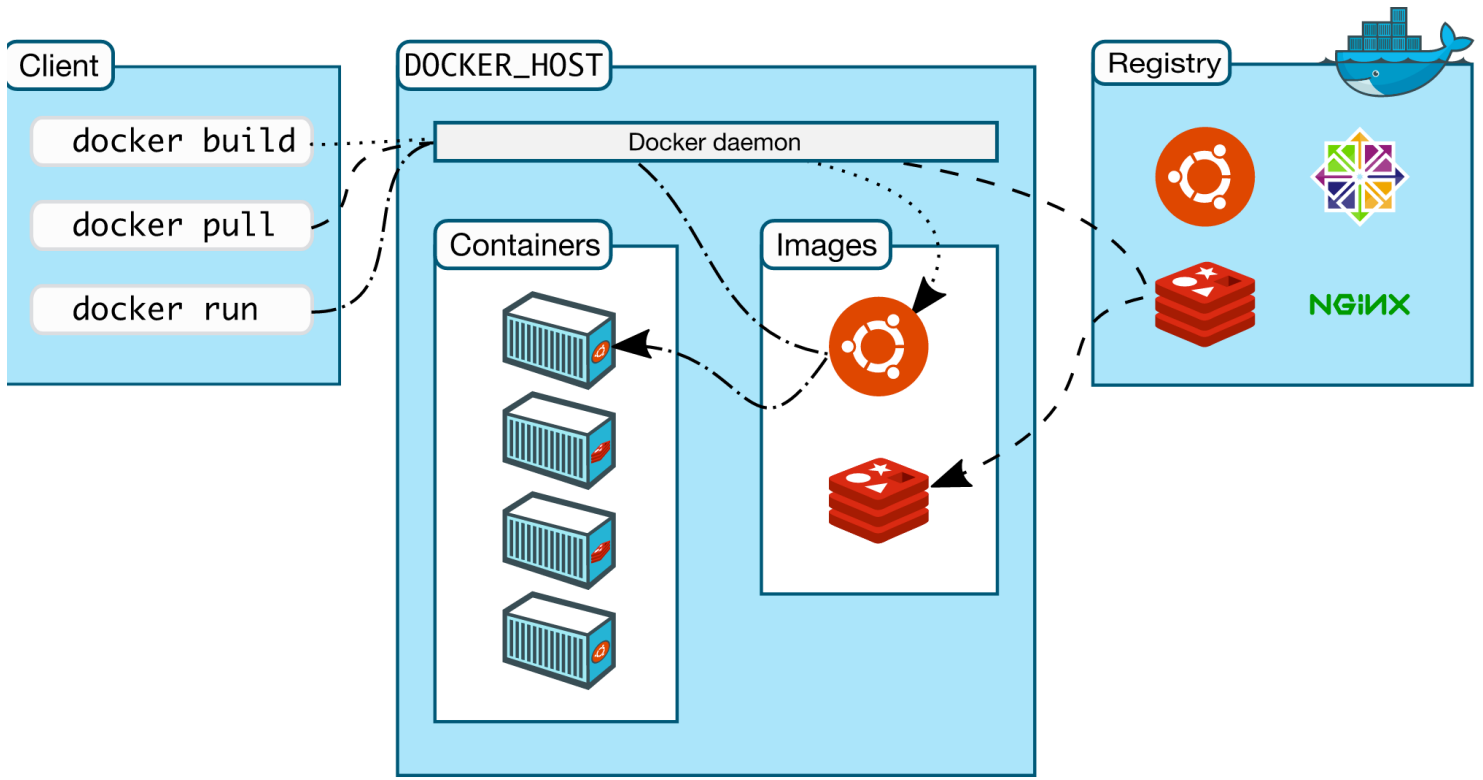
[Source: https://docs.docker.com/terms/layer/]

Containers

- Containers are operating system level virtualization
  - Allows for multiple isolated user space instances called containers
  - They share a single kernel
  - Can be added or removed at any time
- Containers consist of a self contained Linux file system
  - Can be from any Linux distribution which is compatible with the host kernel
  - Usually contain a single application such as a server
- Operating system level virtualization is lightweight
  - Is often used in Cloud Computing

Docker Architecture

- Docker uses a client-server architecture
- Client
  - Is the primary user interface which communicates using a REST API
  - Over HTTP
  - Over local Unix socket
- Server
  - Is the Docker daemon
  - Responsible for building, running, and distributing containers
- Registry
  - Responsible for the storage, management, and delivery of Docker Images
    - Docker Hub
    - Private
    - Other vendors



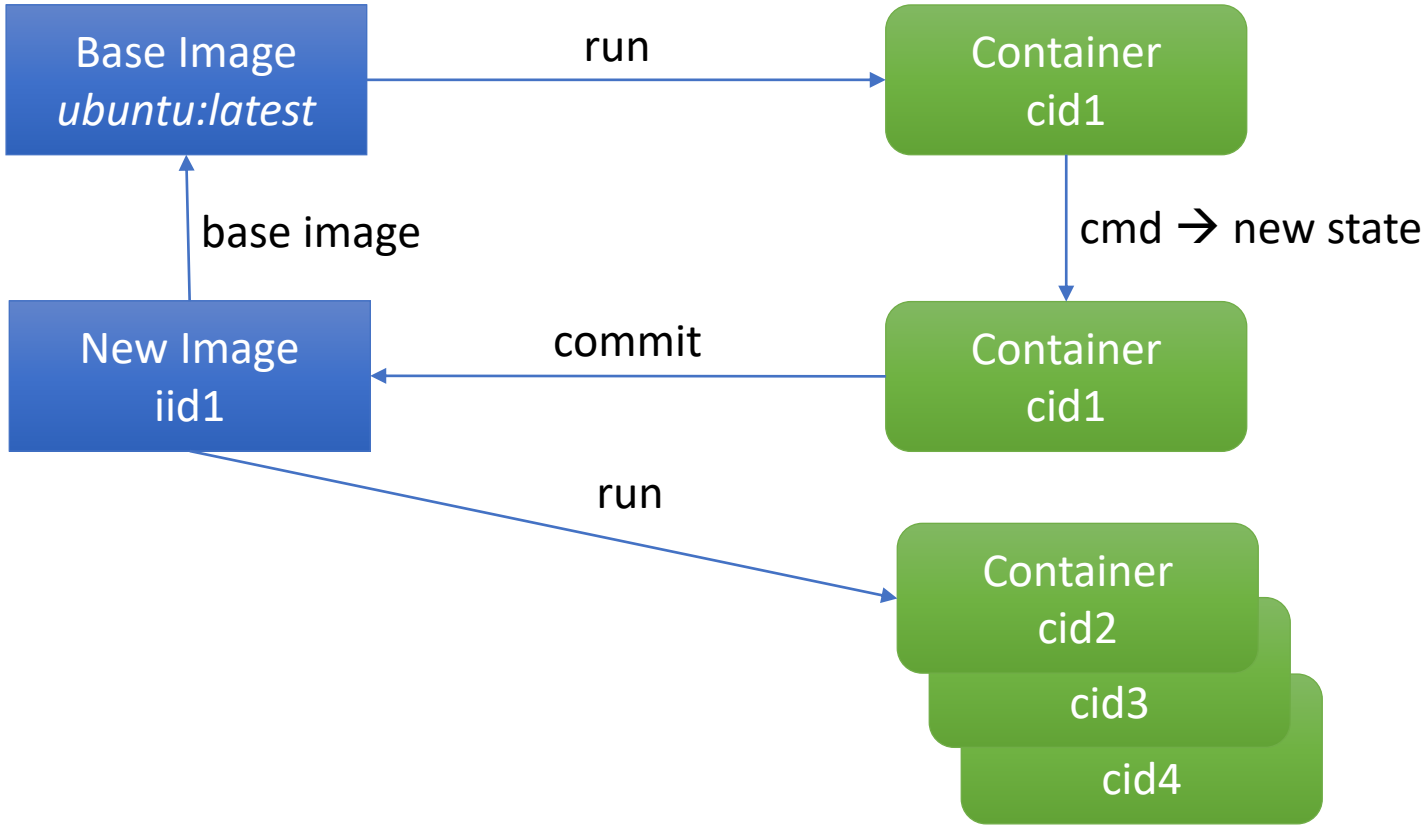
Terminology - Image

- Persisted snapshot that can be run
  - *images:* List all local images
  - *run*: Create a container from an image and execute a command in it
  - *tag*: Tag an image
  - *pull*: Download image from repository
  - *rmi*: Delete a local image
    - This will also remove intermediate images if no longer used

Terminology - Container

- Runnable instance of an image
  - *ps:* List all running containers
  - *ps –a*: List all containers (incl. stopped)
  - *top*: Display processes of a container
  - *start*: Start a stopped container
  - *stop*: Stop a running container
  - *pause*: Pause all processes within a container
  - *rm*: Delete a container
  - *commit*: Create an image from a container

Image vs. Container



Dockerfile

- Create images automatically using a build script: «Dockerfile»
- Can be versioned in a version control system like Git or SVN, along with all dependencies
- Docker Hub can automatically build images based on dockerfiles on Github

Dockerfile Example

- Dockerfile:
  - FROM busybox:latest
    MAINTAINER Your Name (email@domain.com)
    CMD ["date"]
- docker build [DockerFileDir]
- docker inspect [imageId]

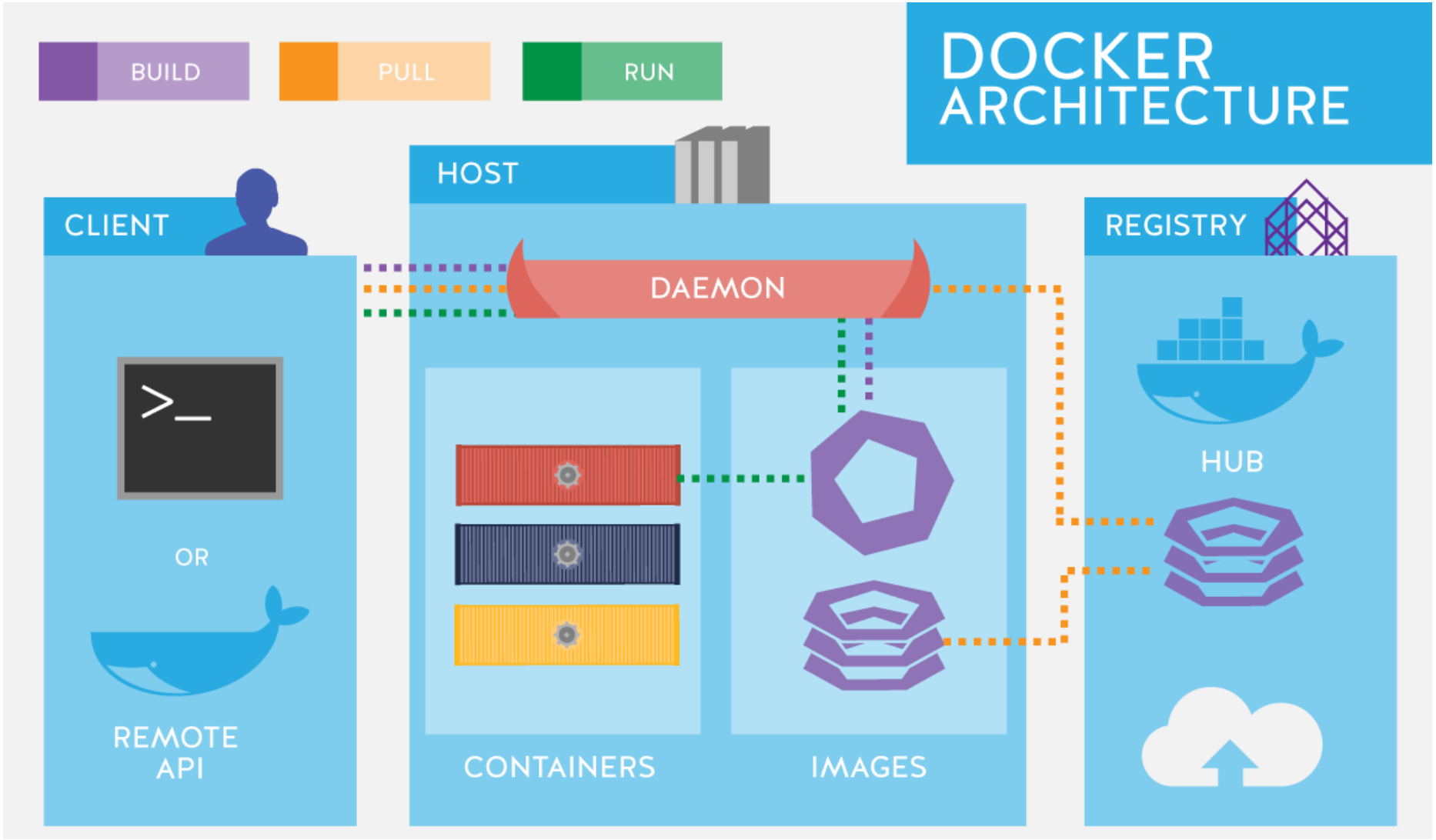
Mount Volumes

- docker run –ti **–v /hostLog:/log** ubuntu
- Run second container: Volume can be shared
  - docker run –ti --volumes-from firstContainerName ubuntu

Publish Port

- docker run –t –p 8080:80 ubuntu nc –l 80
  - Map container port 80 to host port 8080
  - Check on host: nc localhost 8080

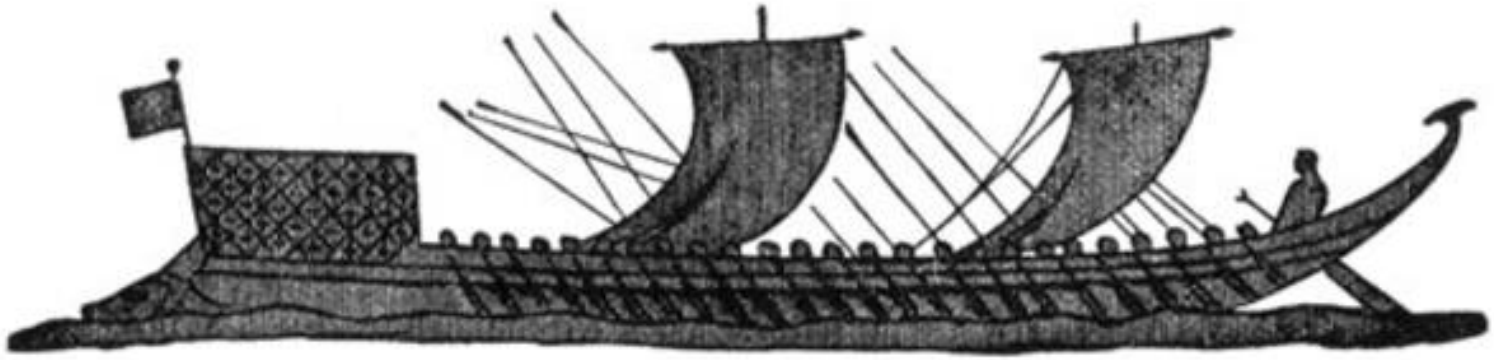
Docker Architecture



Kubernetes Overview

What Does “Kubernetes” Mean?

- Greek for “pilot” or “Helmsman of a ship”



What is Kubernetes?

- Project that was spun out of Google as an open source container orchestration platform.
- Built from the lessons learned in the experiences of developing and running Google's Borg and Omega.
- Designed from the ground-up as a loosely coupled collection of components centered around deploying, maintaining and scaling workloads.

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.

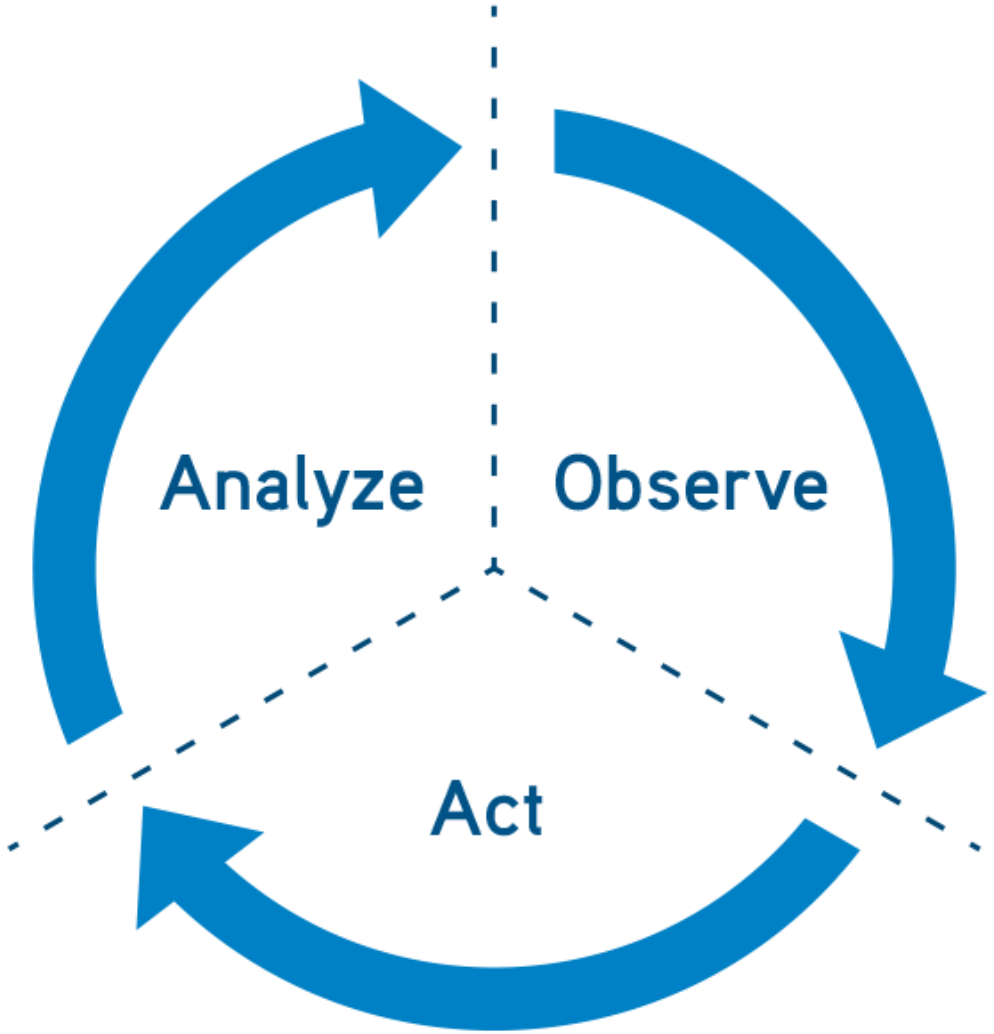
Decouples Infrastructure and Scaling

- 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.”

Kubernetes reconciliation loop



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!!!

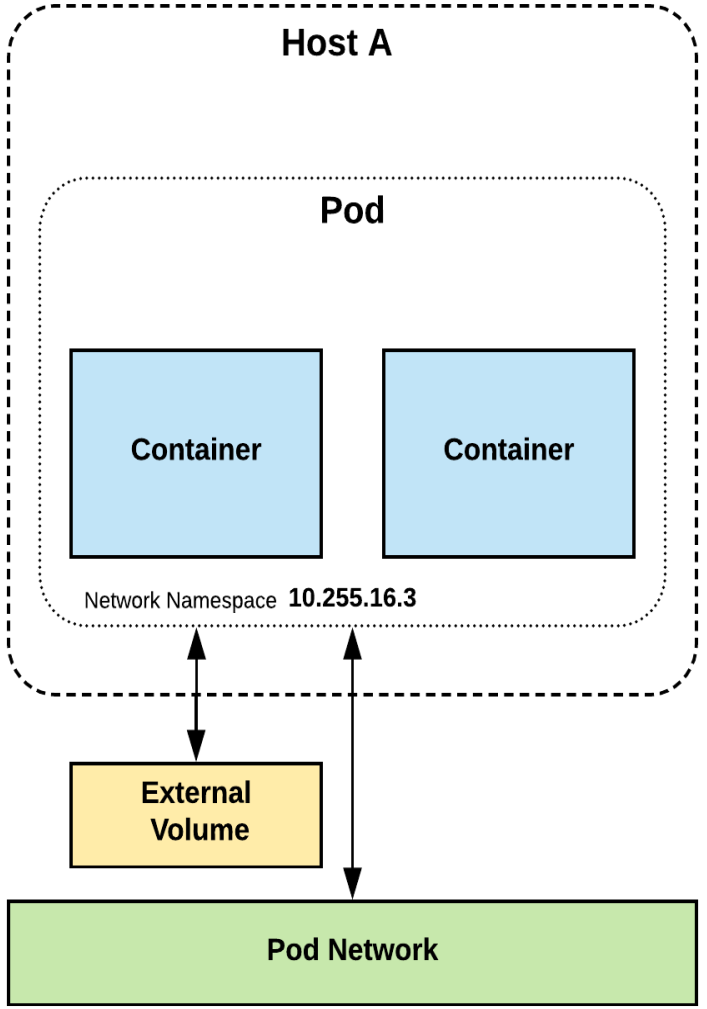
Who “Manages” Kubernetes?

- 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**.



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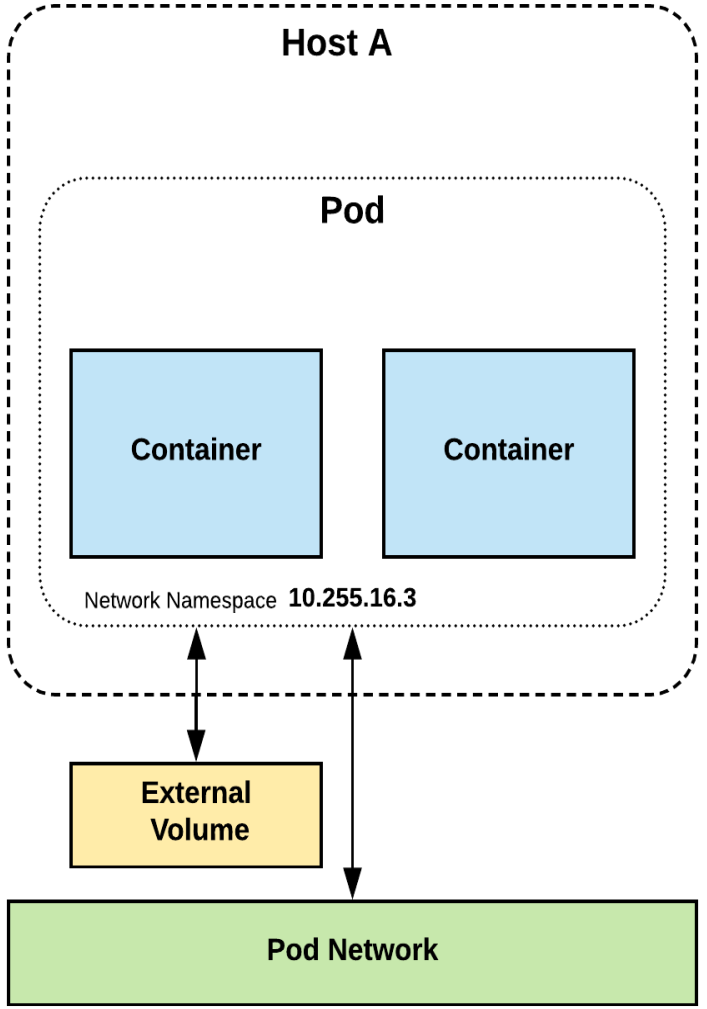
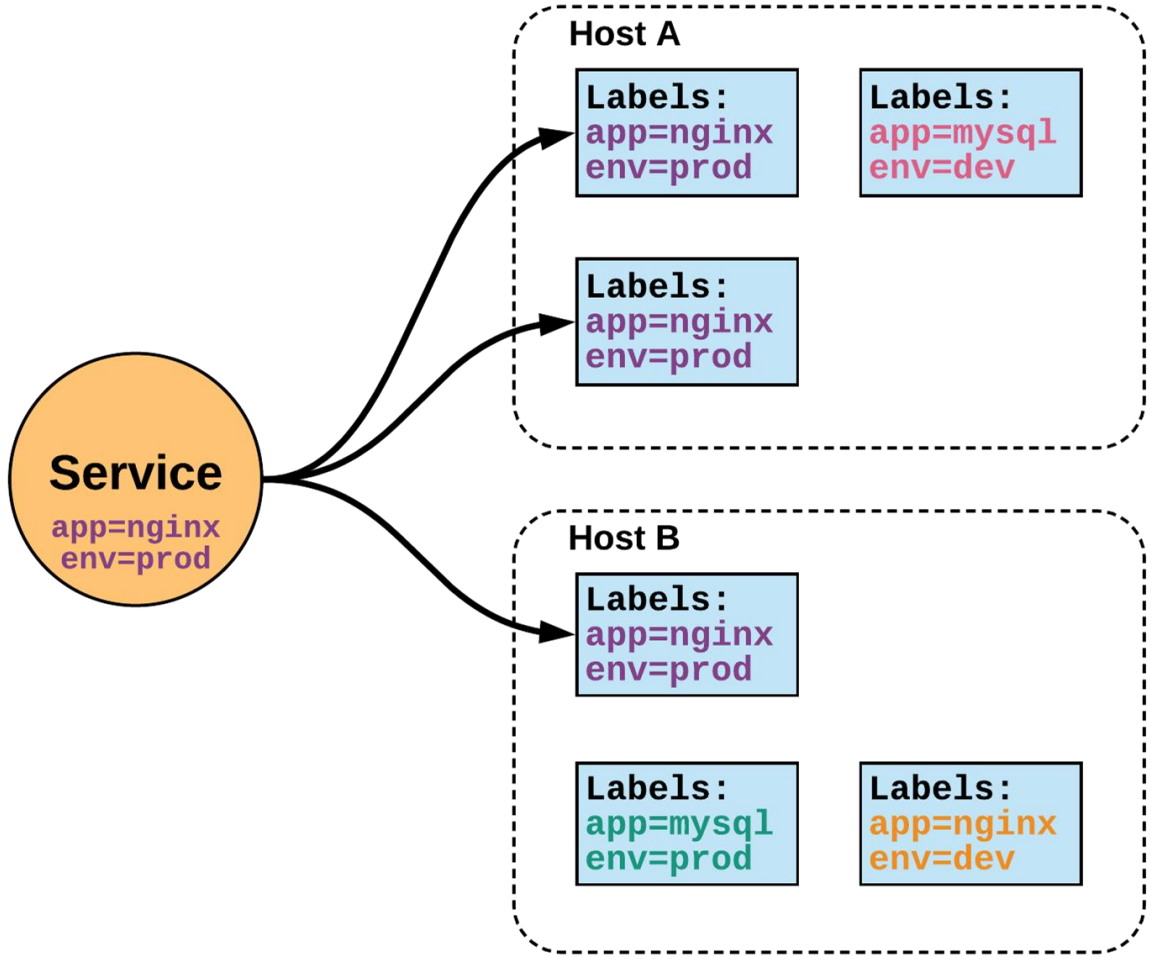
They are also Ephemeral!

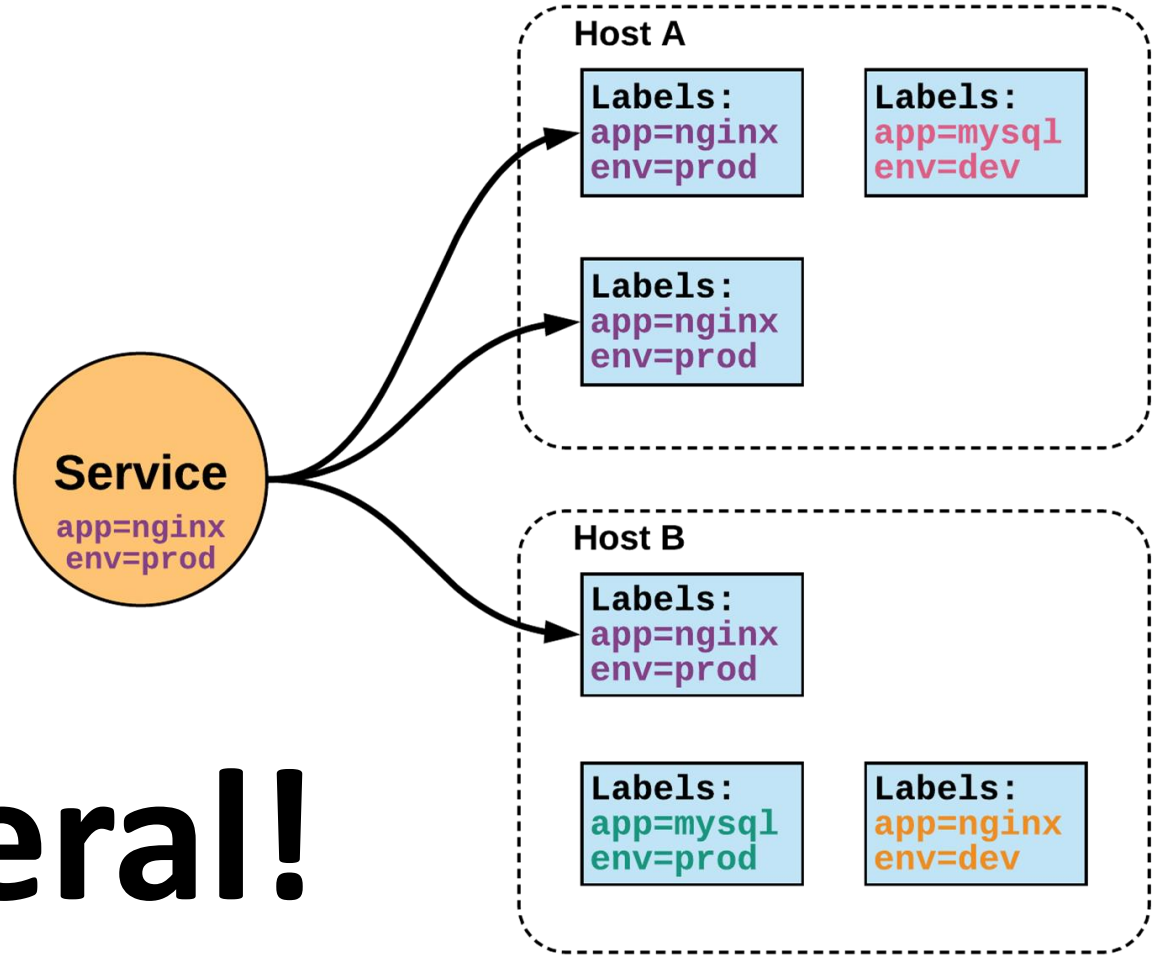


Services

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



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



NOT Ephemeral!

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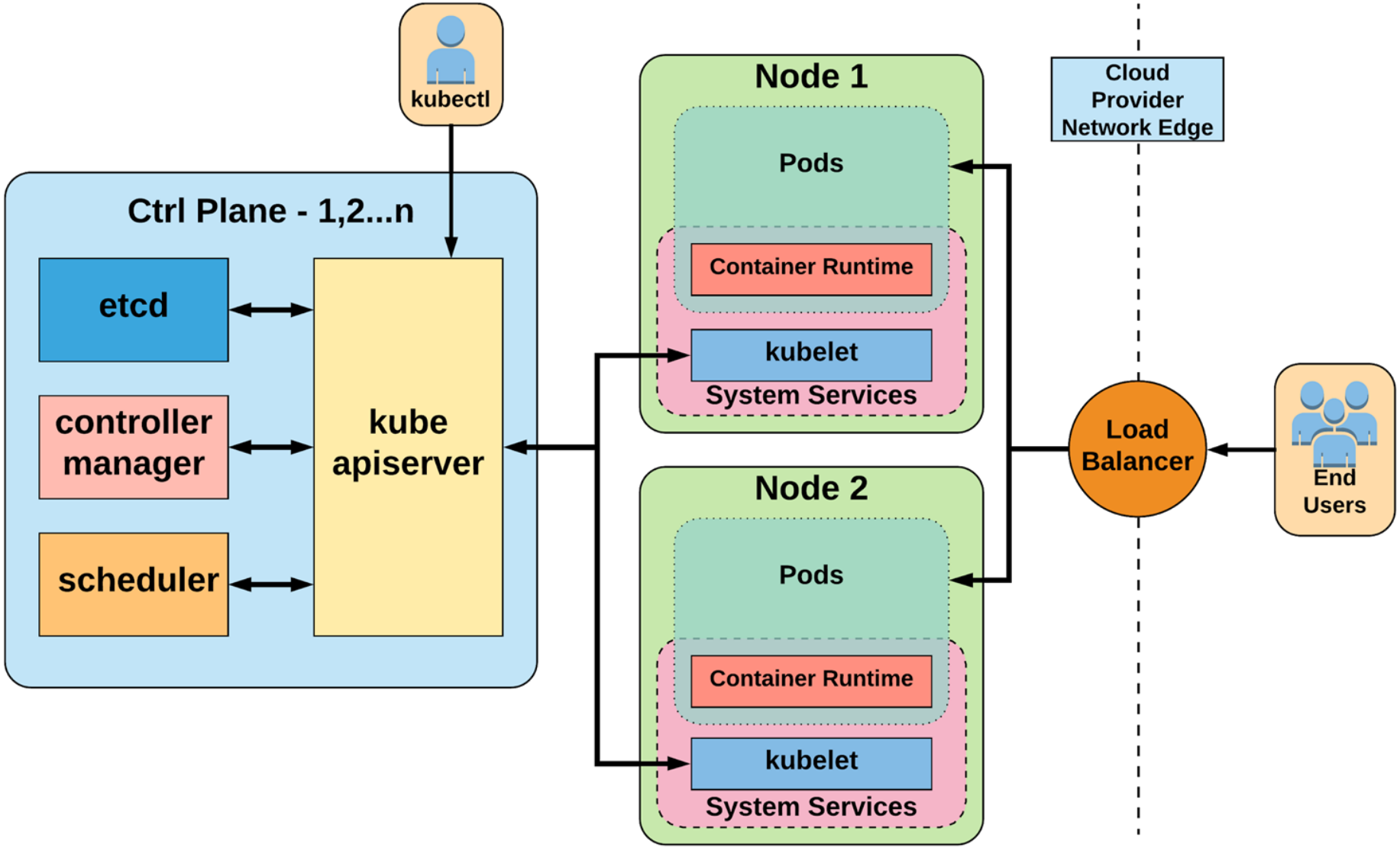
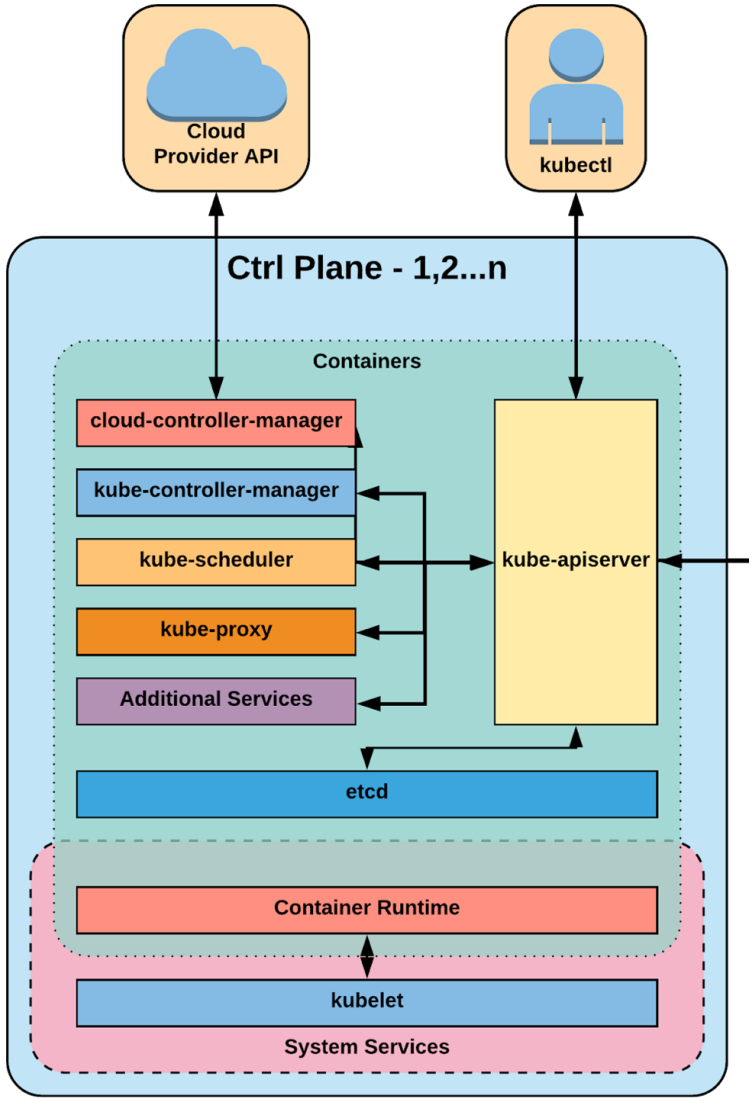
Architecture Overview

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.

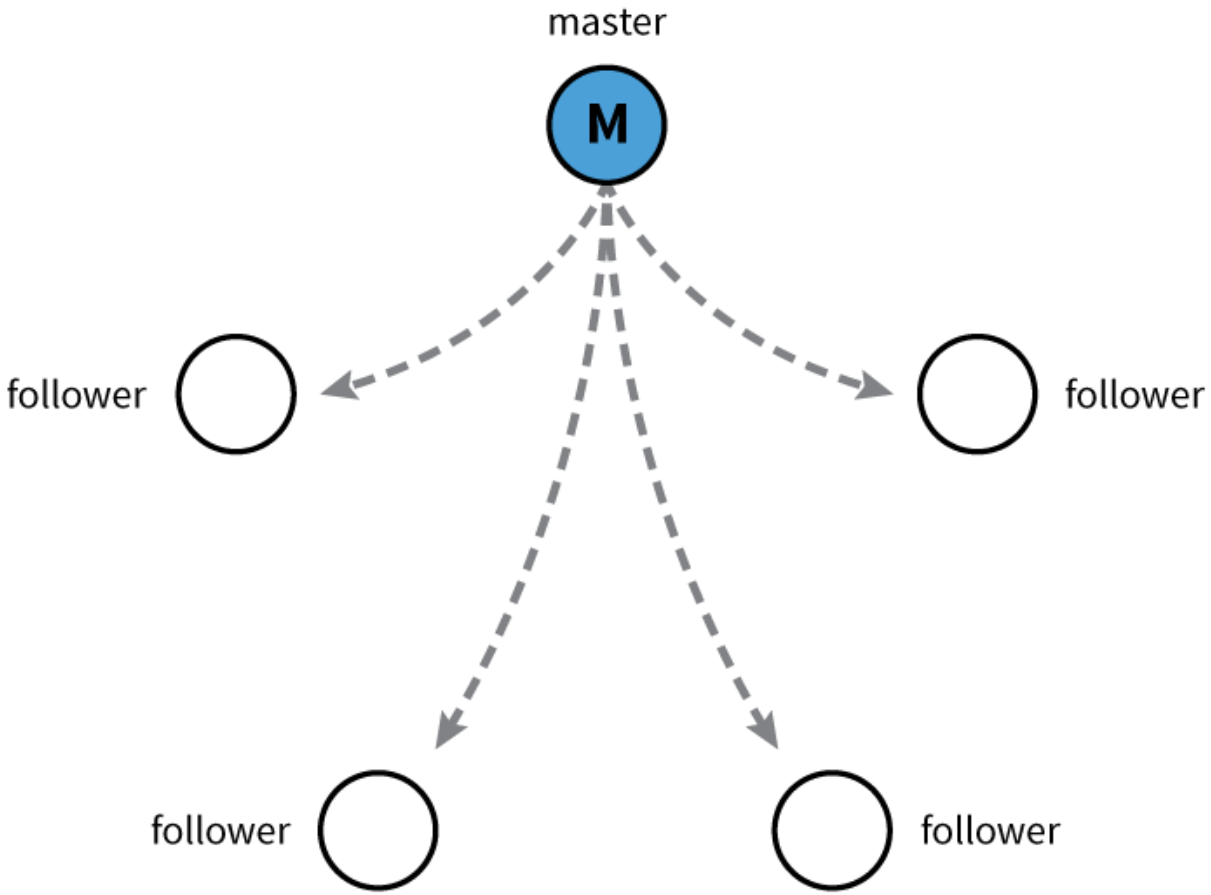
etcd

- **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/



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**.

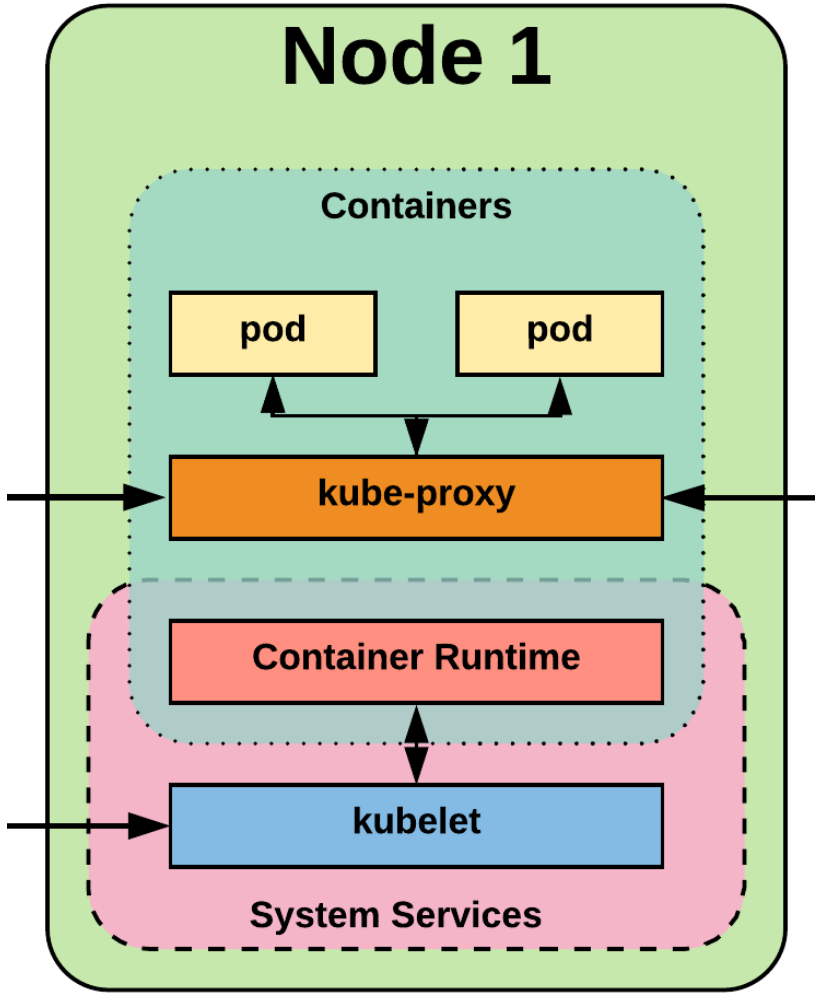
List of core controllers:
https://github.com/kubernetes/kubernetes/blob/master/cmd/kube-controller-manager/app/controllermanager.go#L344

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

- **kubelet**
- **kube-proxy**
- **Container Runtime Engine**



kubelet

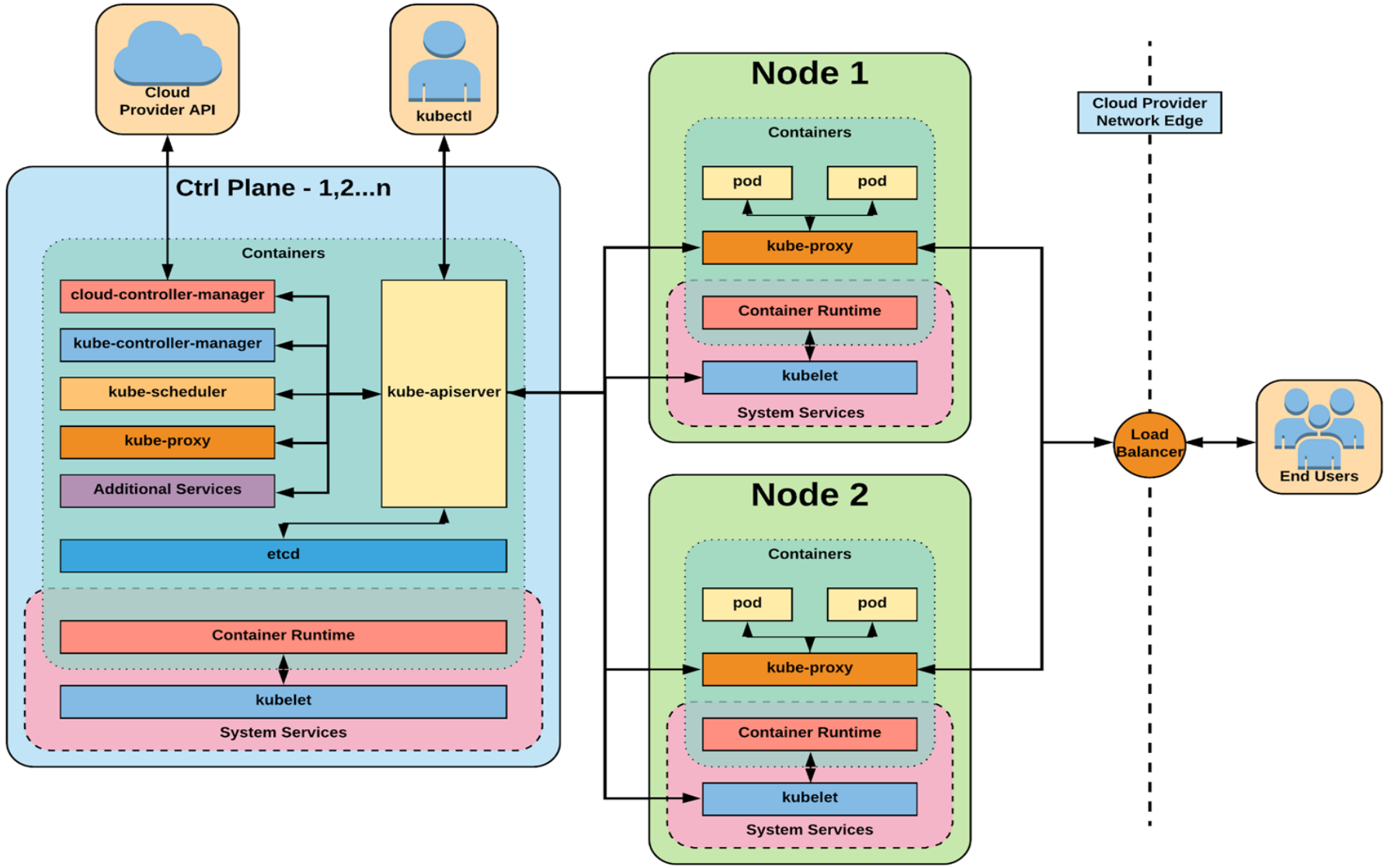
- Acts as the node agent responsible for managing the lifecycle of every pod on its host.
- Kubelet understands YAML container manifests that it can read from several sources:
  - file path
  - HTTP Endpoint
  - etcd watch acting on any changes
  - HTTP Server mode accepting container manifests over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

kube-proxy

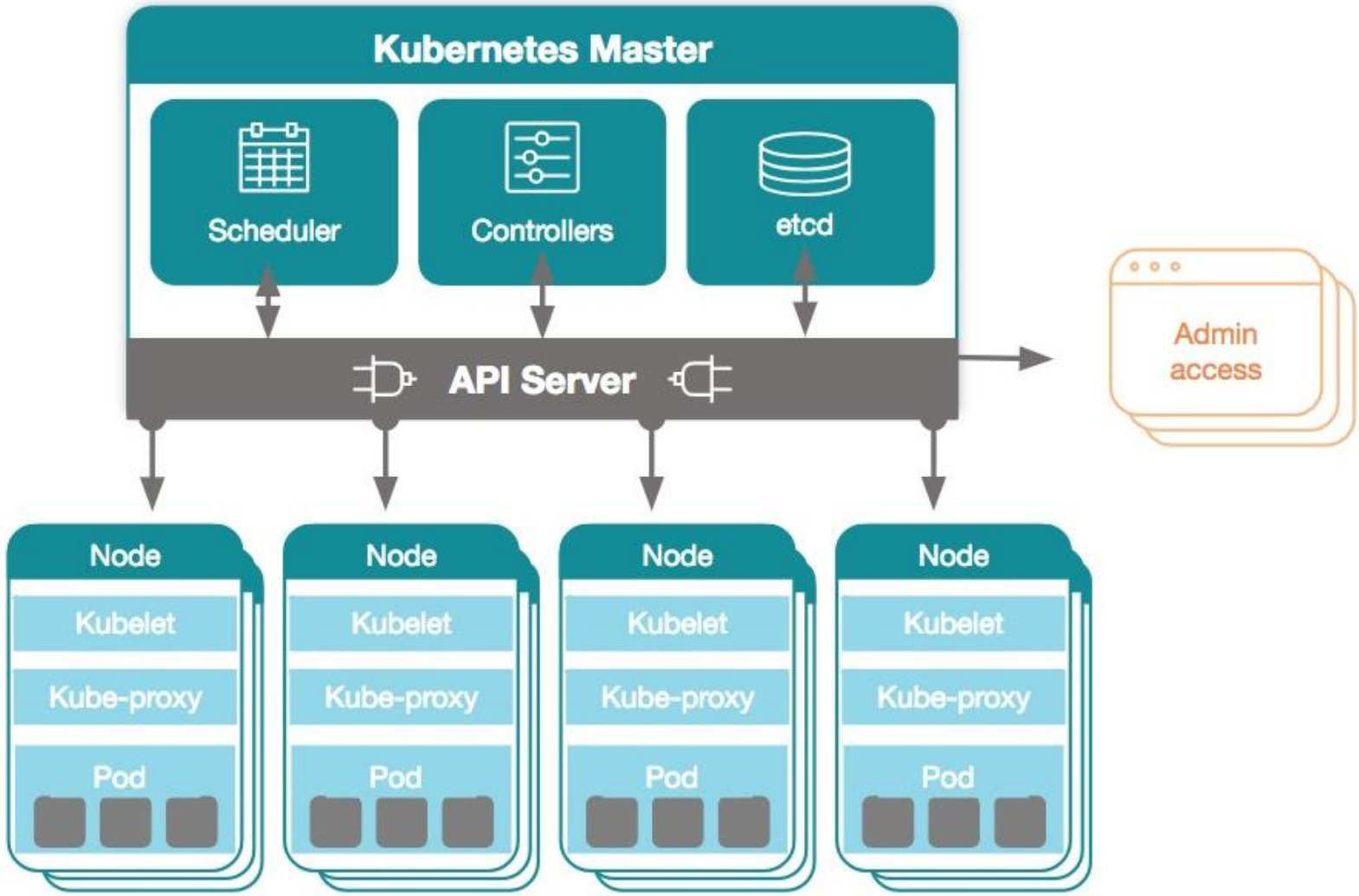
- Manages the network rules on each node.
- Performs connection forwarding or load balancing for Kubernetes cluster services.
- Available Proxy Modes:
  - Userspace
  - iptables
  - ipvs (default if supported)

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)



Simplified Architectural View



Optional Services - Architecture Overview

- cloud-controller-manager
- Cluster DNS
- Kube Dashboard
- Heapster / Metrics API Server

cloud-controller-manager

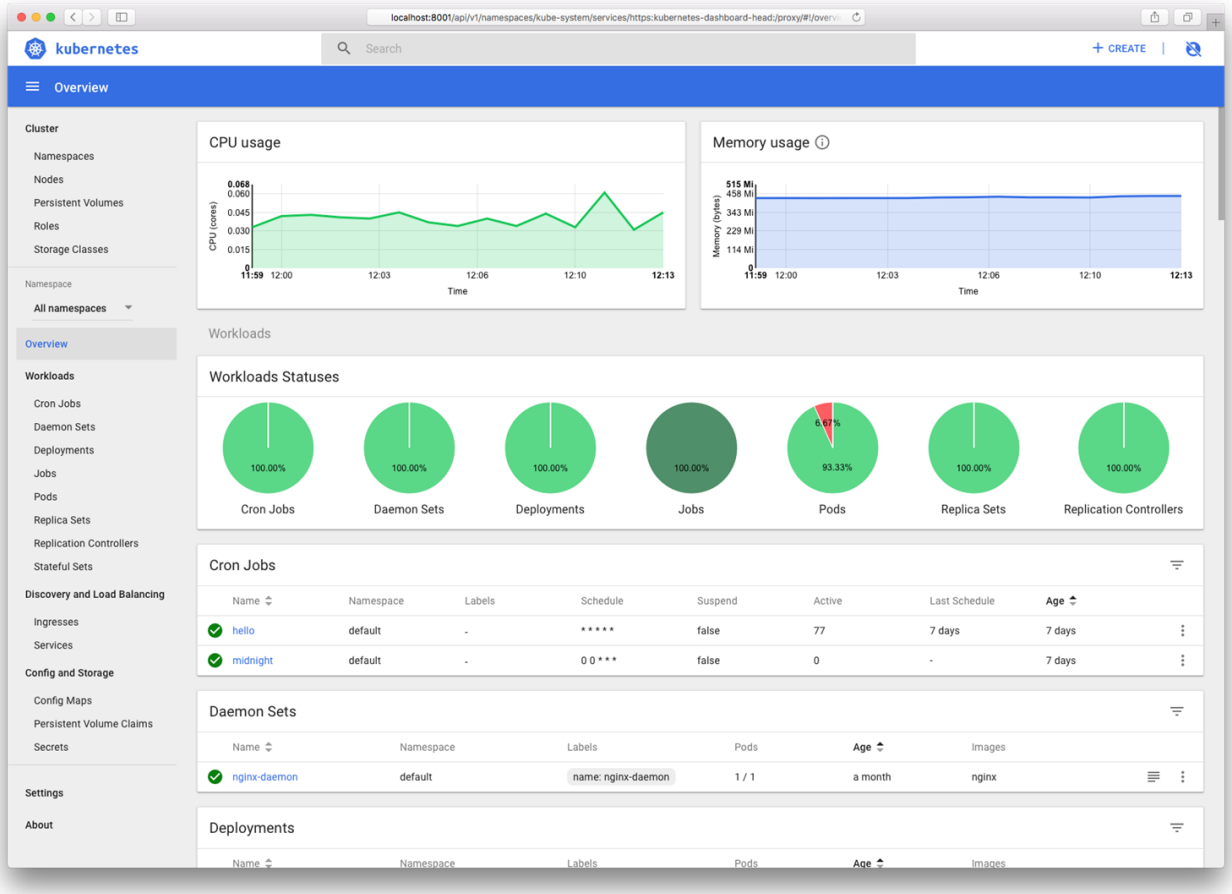
- Daemon that provides cloud-provider specific knowledge and integration capability into the core control loop of Kubernetes.
- The controllers include Node, Route, Service, and add an additional controller to handle things such as PersistentVolume Labels.

Cluster DNS

- Provides Cluster Wide DNS for Kubernetes Services.
  - Built on top of CoreDNS

Kube Dashboard

- A limited, general purpose web front end for the Kubernetes Cluster.



Metrics API Server

- Provides metrics for use with other Kubernetes Components.
  - Metrics API (current)

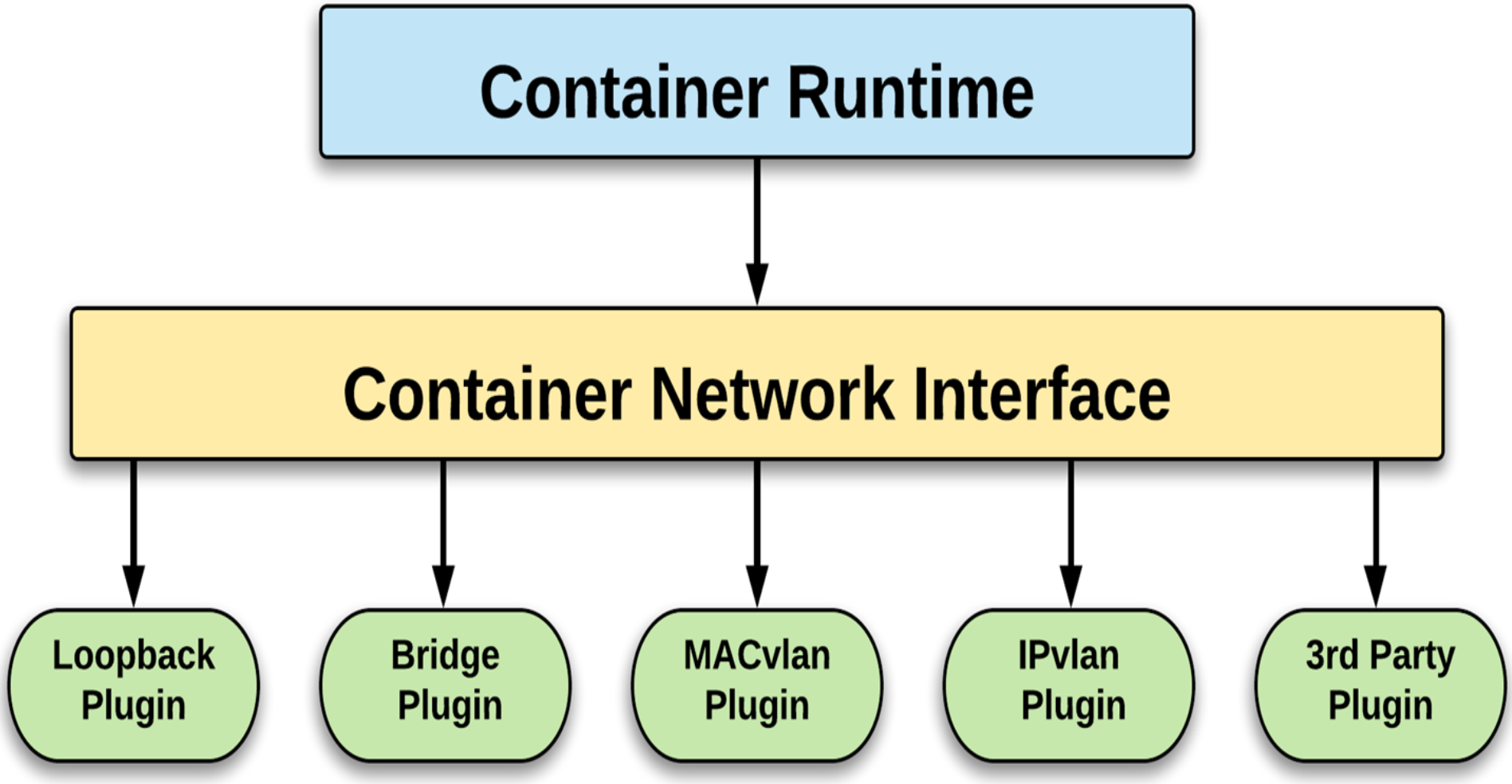
- **Pod Network**
  - Cluster-wide network used for pod-to-pod communication managed by a CNI (Container Network Interface) plugin.

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

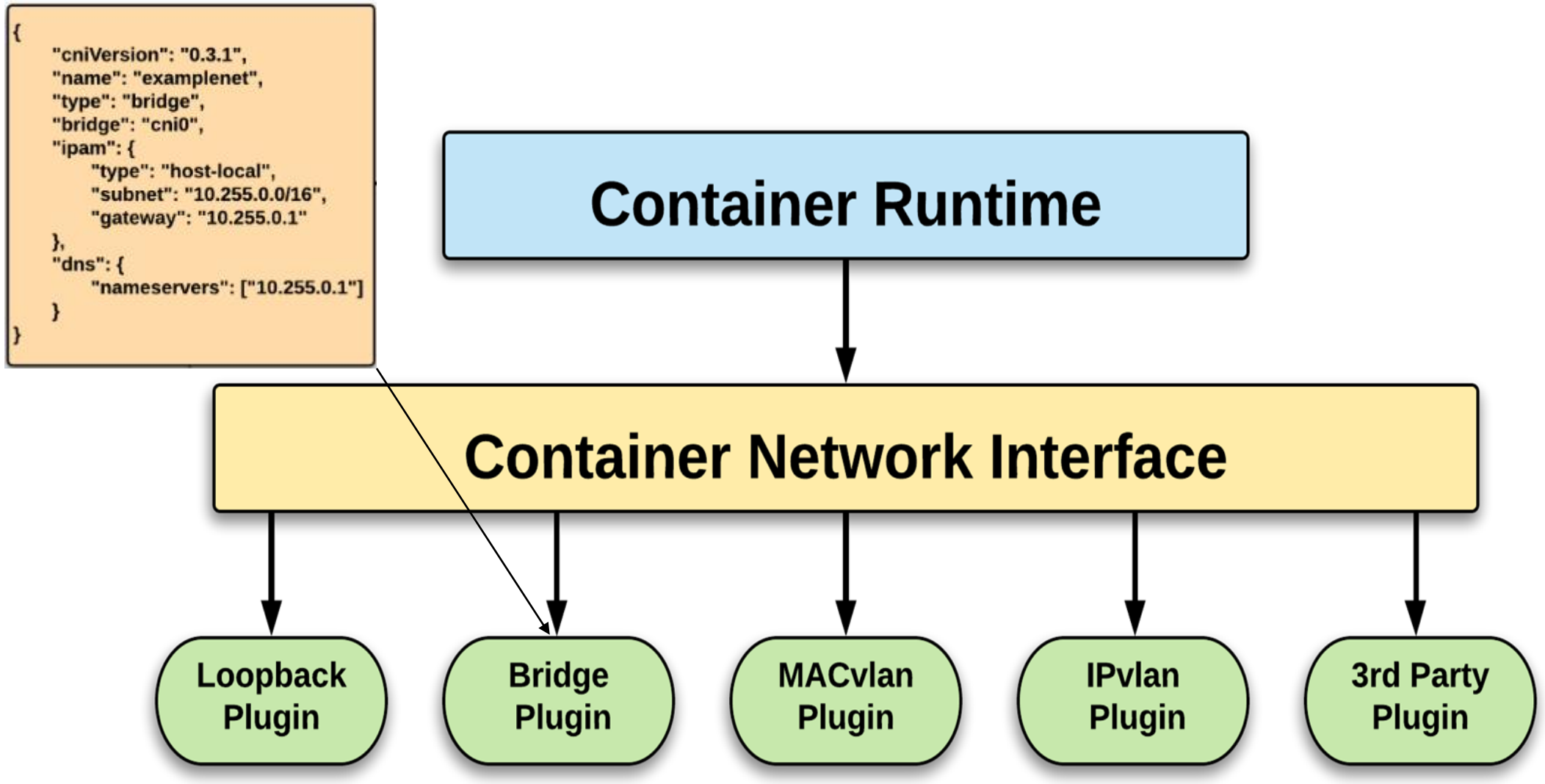
Container Network Interface (CNI)

- 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



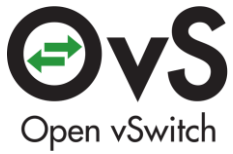
CNI Overview



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.

- **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.

- **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

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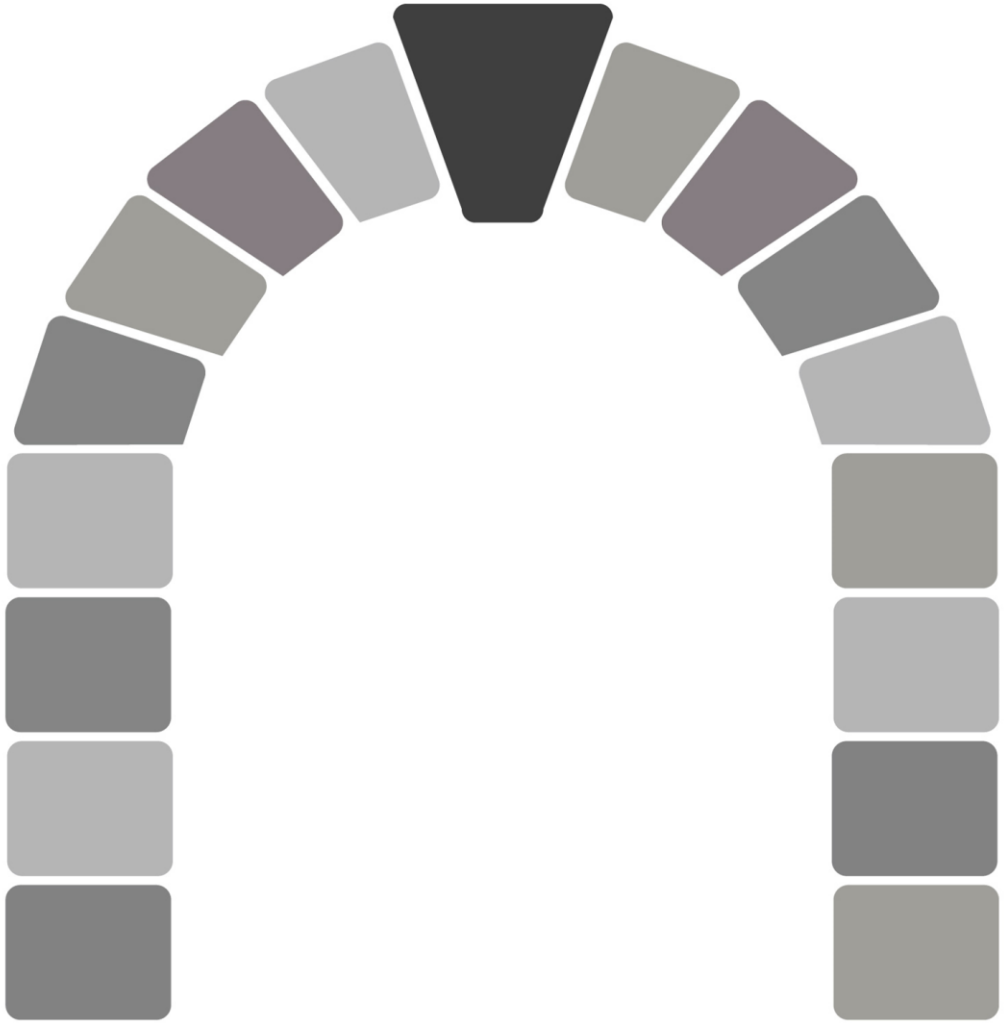
The API and Object Model

API Overview

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

- **Everything** within the Kubernetes is as an **API Object**.



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.

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

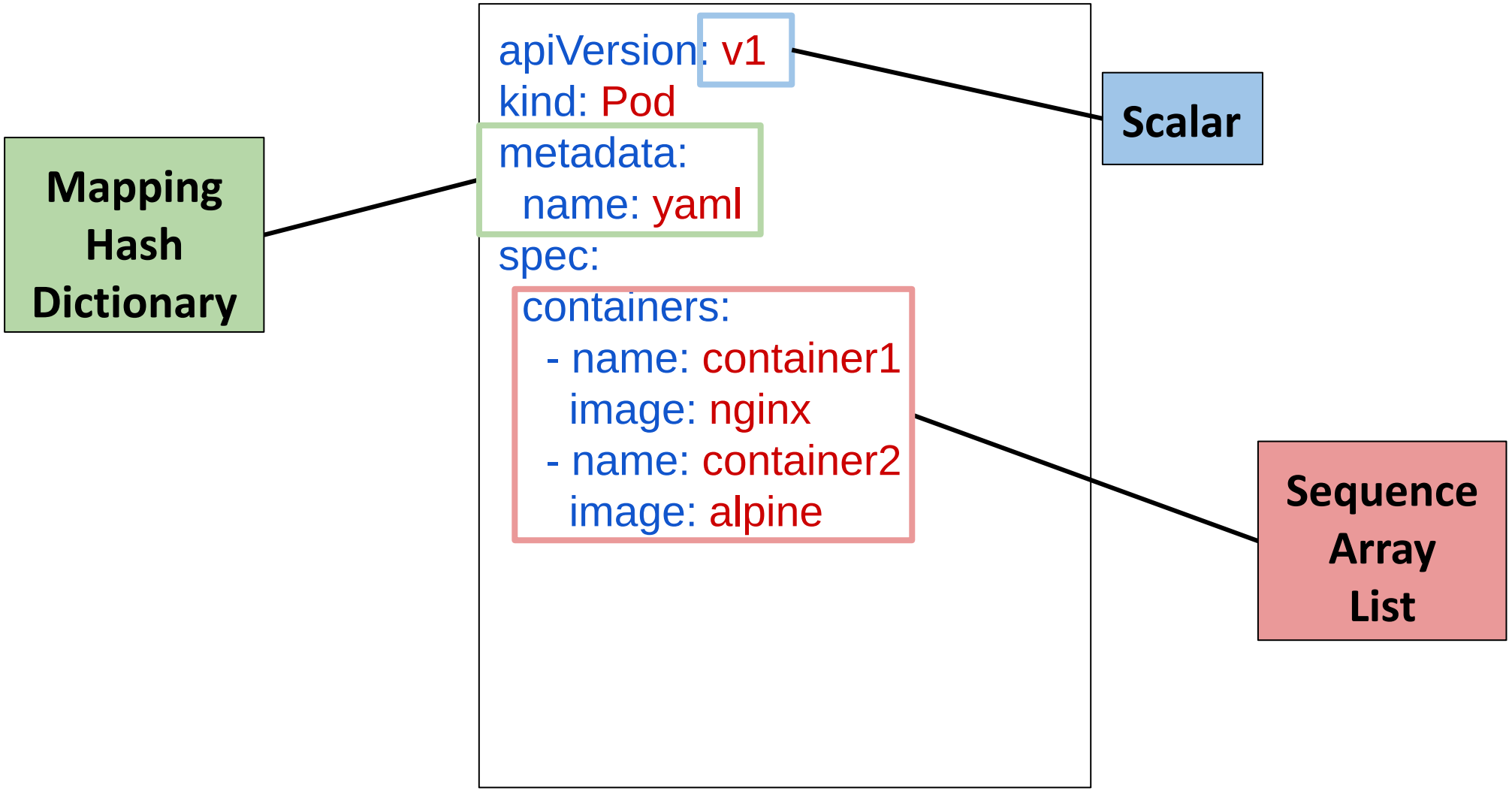
Object Expression - YAML

- 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

```
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

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

Example Status Snippet

```
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
```

Core Objects - Concepts and Resources

- **Namespaces**
- **Pods**
- **Labels**
- **Selectors**
- **Services**

Cognixia®

- 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
```

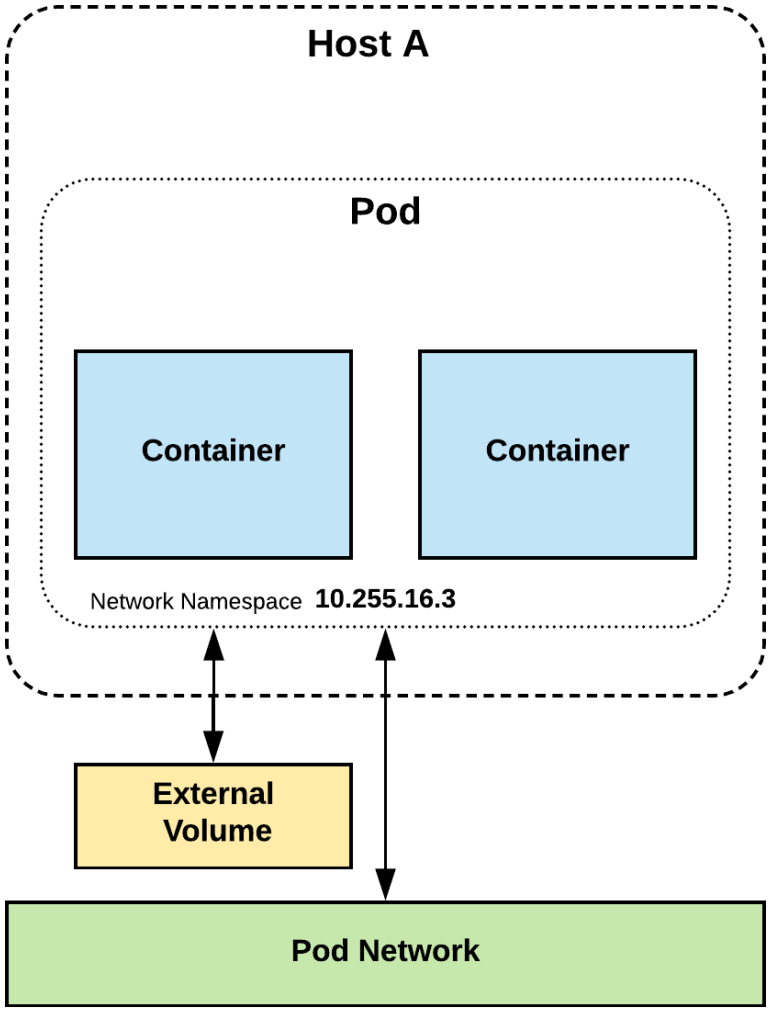
Default Namespaces

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

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

```
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

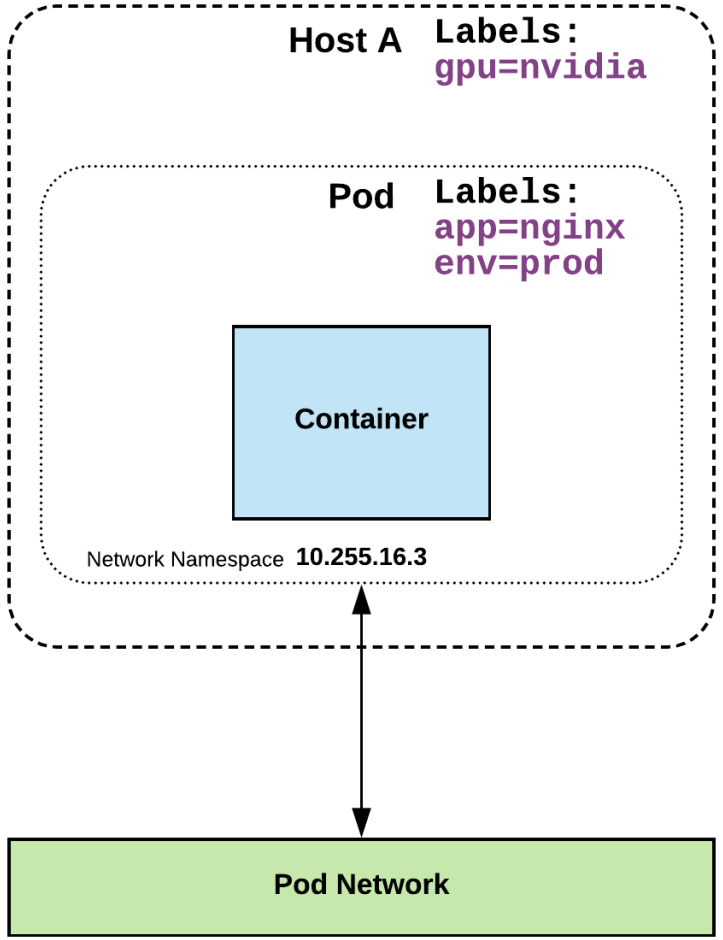
- name - The name of the container
- image - The container image
- ports - array of ports to expose. Can be granted a friendly name and protocol may be specified
- env - array of environment variables
- command - Entrypoint array (equiv to Docker ENTRYPOINT)
- args - Arguments to pass to the command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

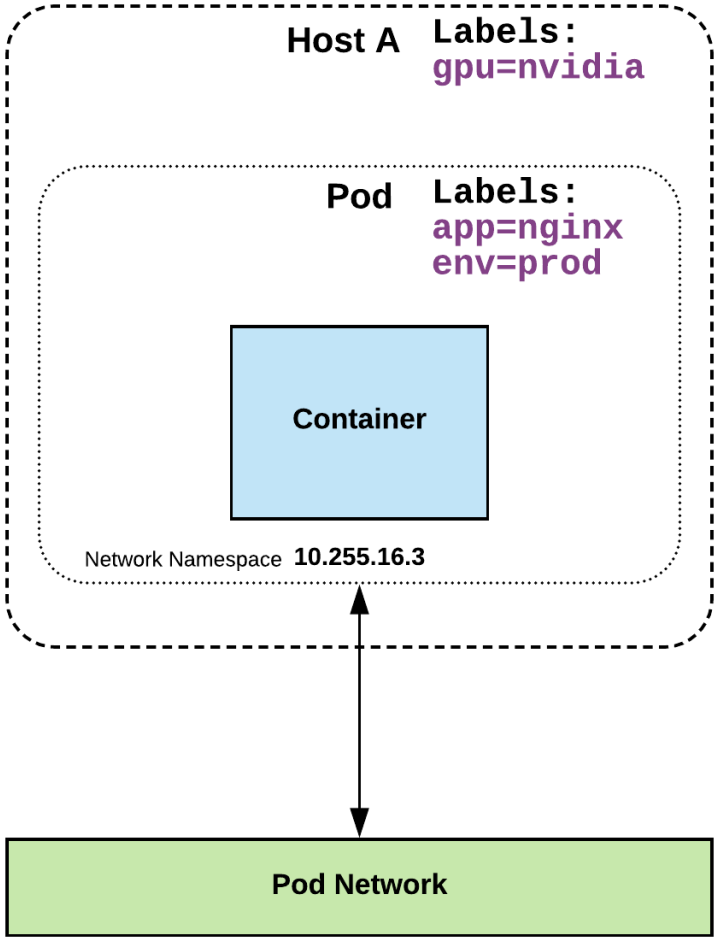
Labels

- 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*.



Label Example

```
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
```



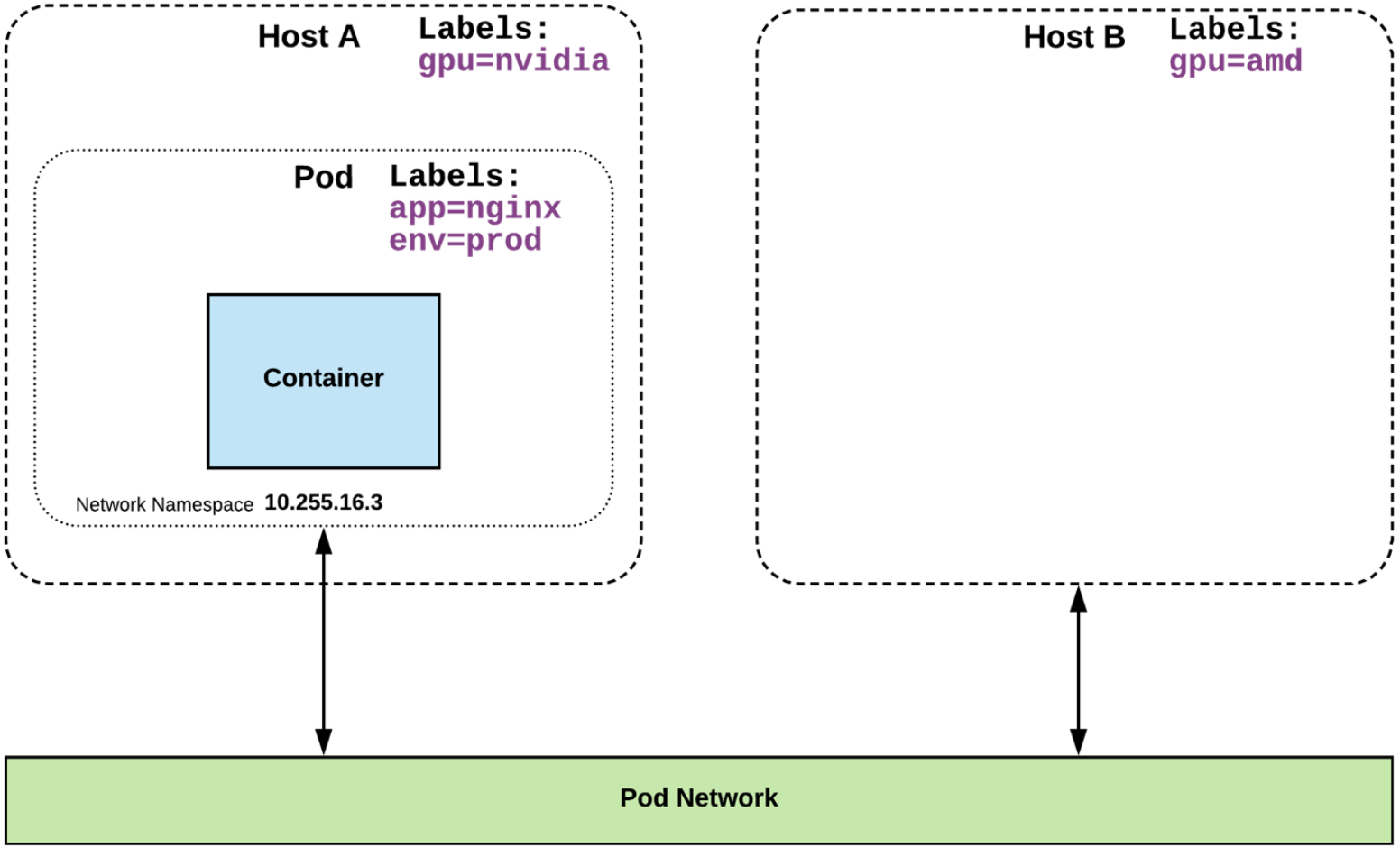
Selectors

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

```
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
```

Selectors Example

```
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
```



Selectors 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.

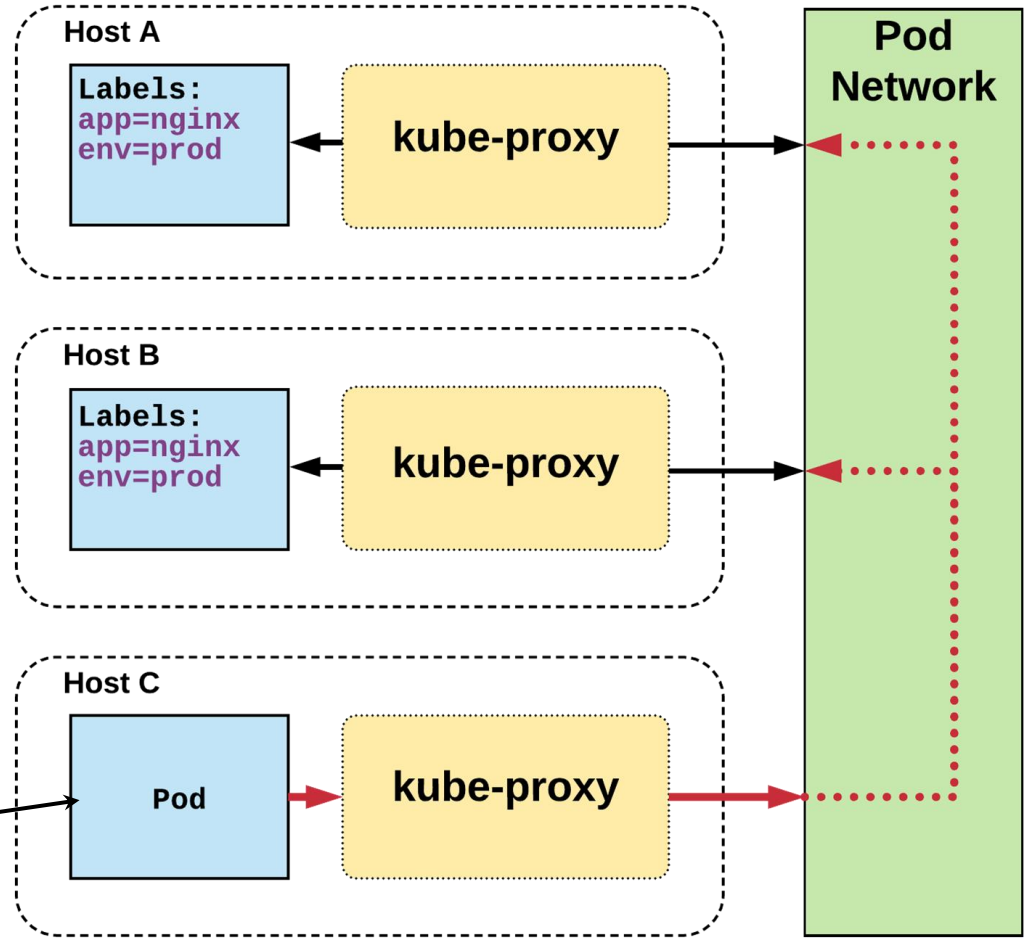
```
apiVersion: v1
kind: Service
metadata:
  name: example-prod
spec:
  selector:
    app: nginx
    env: prod
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

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
```

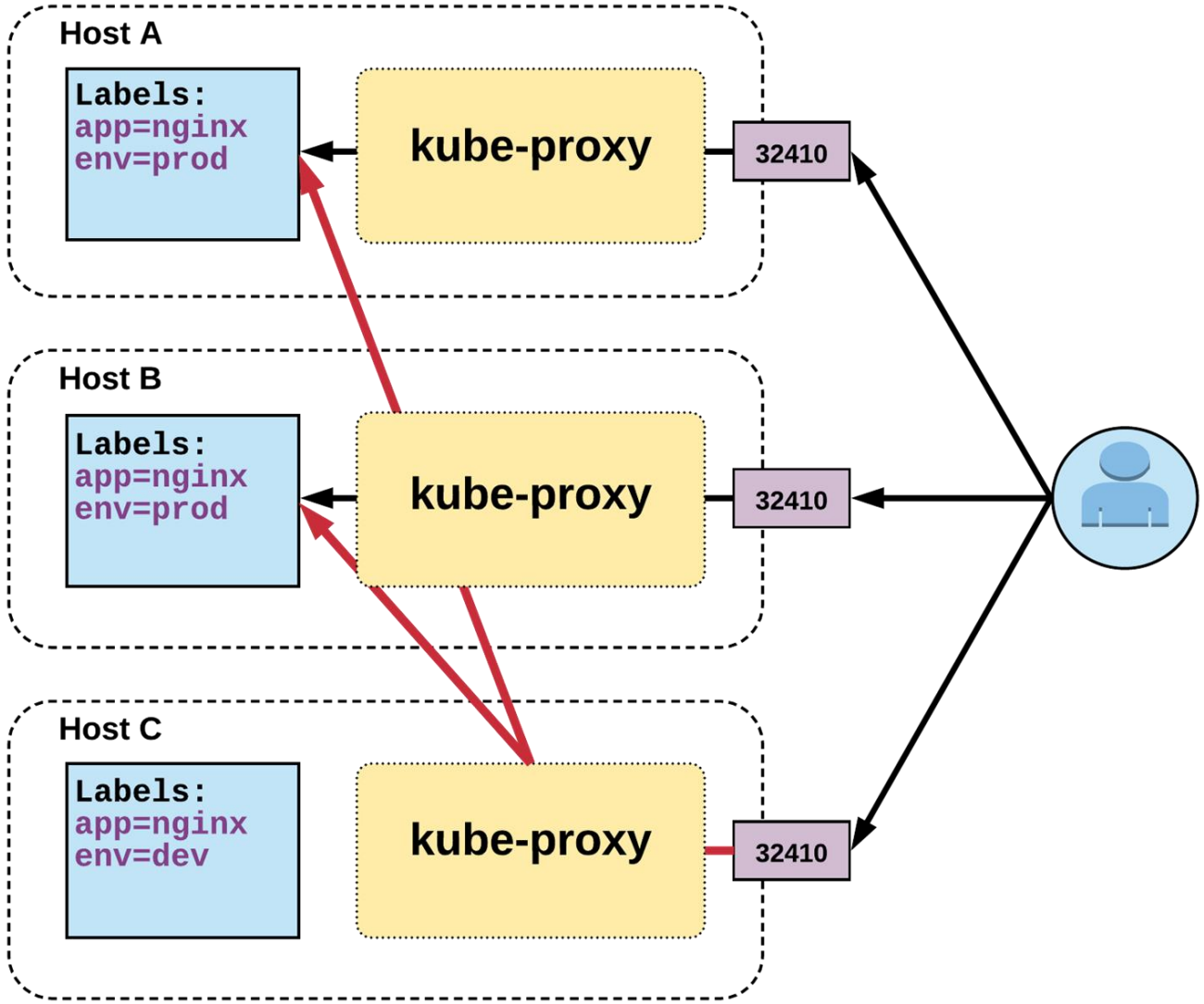


NodePort Service

- **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.

```
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



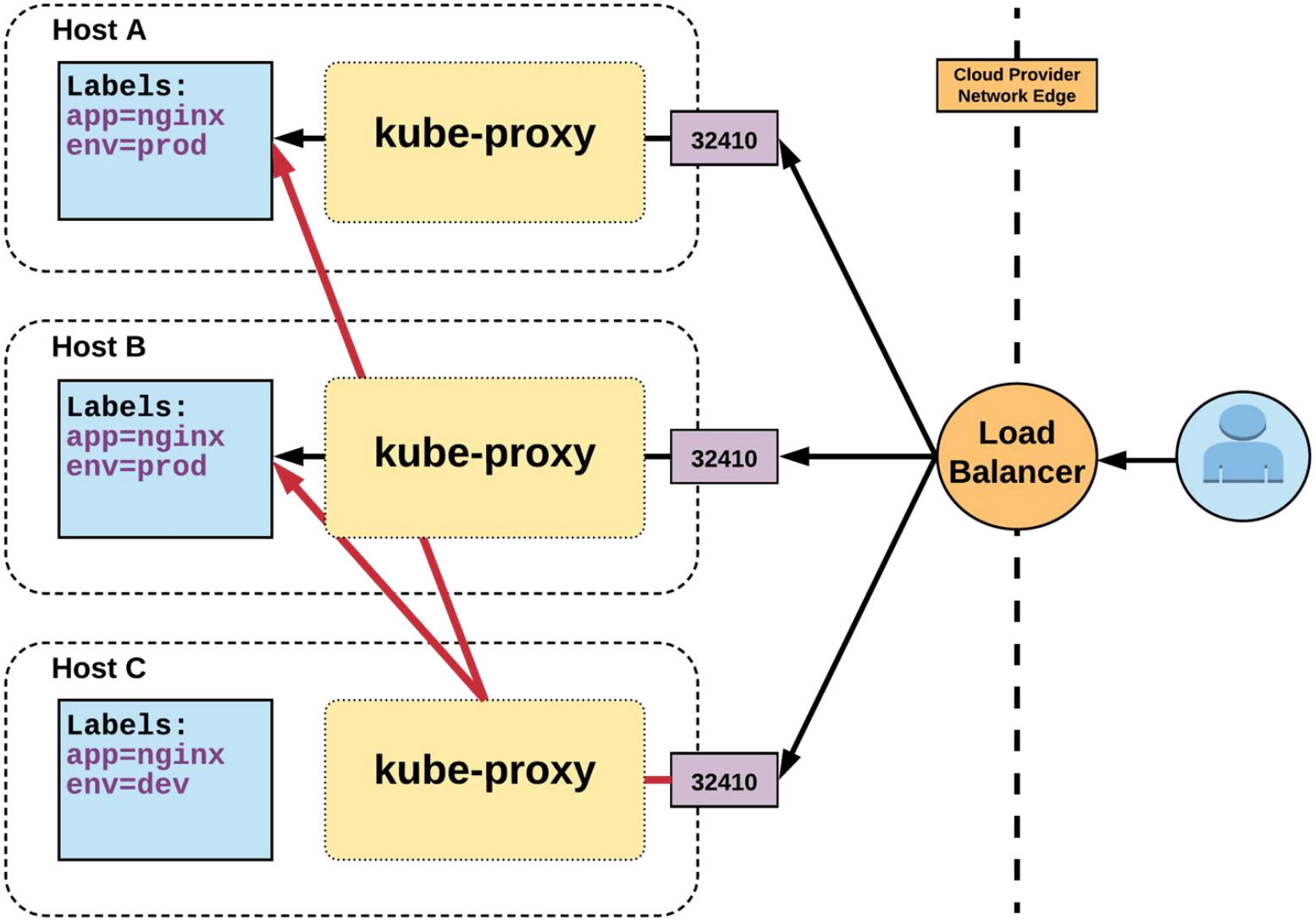

```
Name:                   example-prod
Selector:               app=nginx,env=prod
Type:                   NodePort
IP:             10.96.28.176
Port:                   <unset>  80/TCP
TargetPort:             80/TCP
NodePort:               <unset>  32410/TCP
Endpoints:              10.255.16.3:80,
10.255.16.4:80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

LoadBalancer Service

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

```
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




```
Name:                   example-prod
Selector:               app=nginx,env=prod
Type:                   LoadBalancer
IP:             10.96.28.176
LoadBalancer
Ingress:                172.17.18.43
Port:           <unset>  80/TCP
TargetPort:             80/TCP
NodePort:               <unset>  32410/TCP
Endpoints:              10.255.16.3:80,
                10.255.16.4:80
```

ExternalName Service

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

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

Exploring the Core

Workloads - Concepts and Resources

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

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.

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

```
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-9l4d
```

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

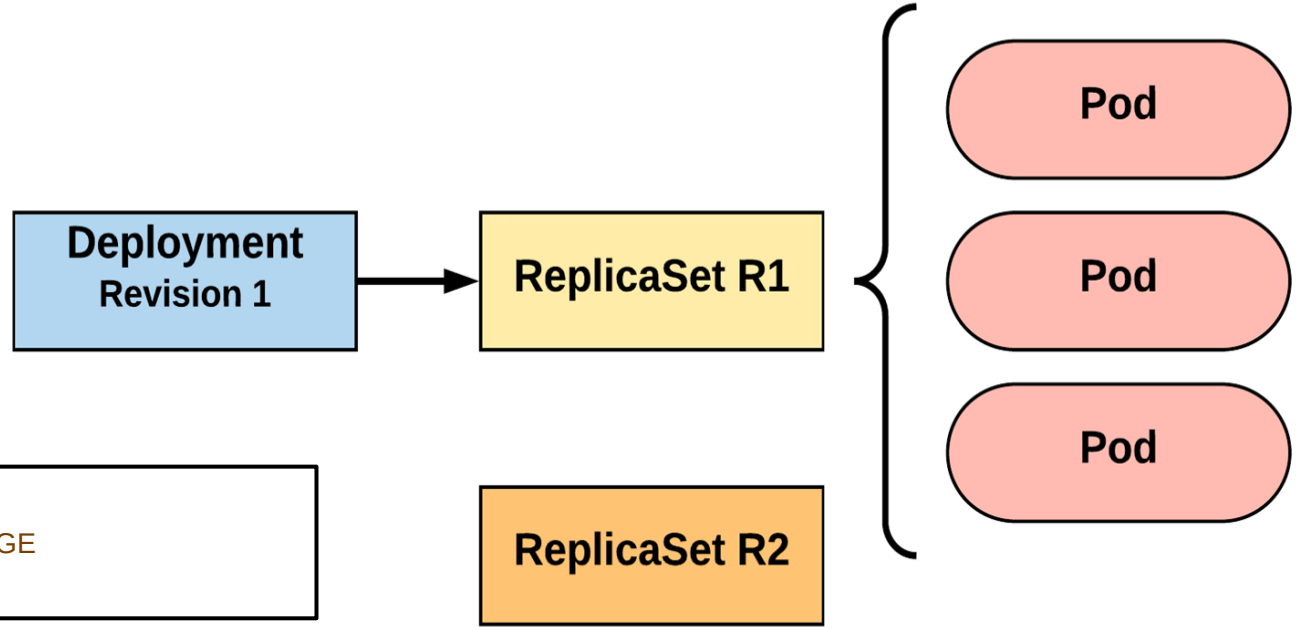
- revisionHistoryLimit: The number of previous iterations of the Deployment to retain.
- strategy: Describes the method of updating the Pods based on the type. Valid options are Recreate or RollingUpdate.
  - Recreate: All existing Pods are killed before the new ones are created.
  - RollingUpdate: Cycles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

```
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
```

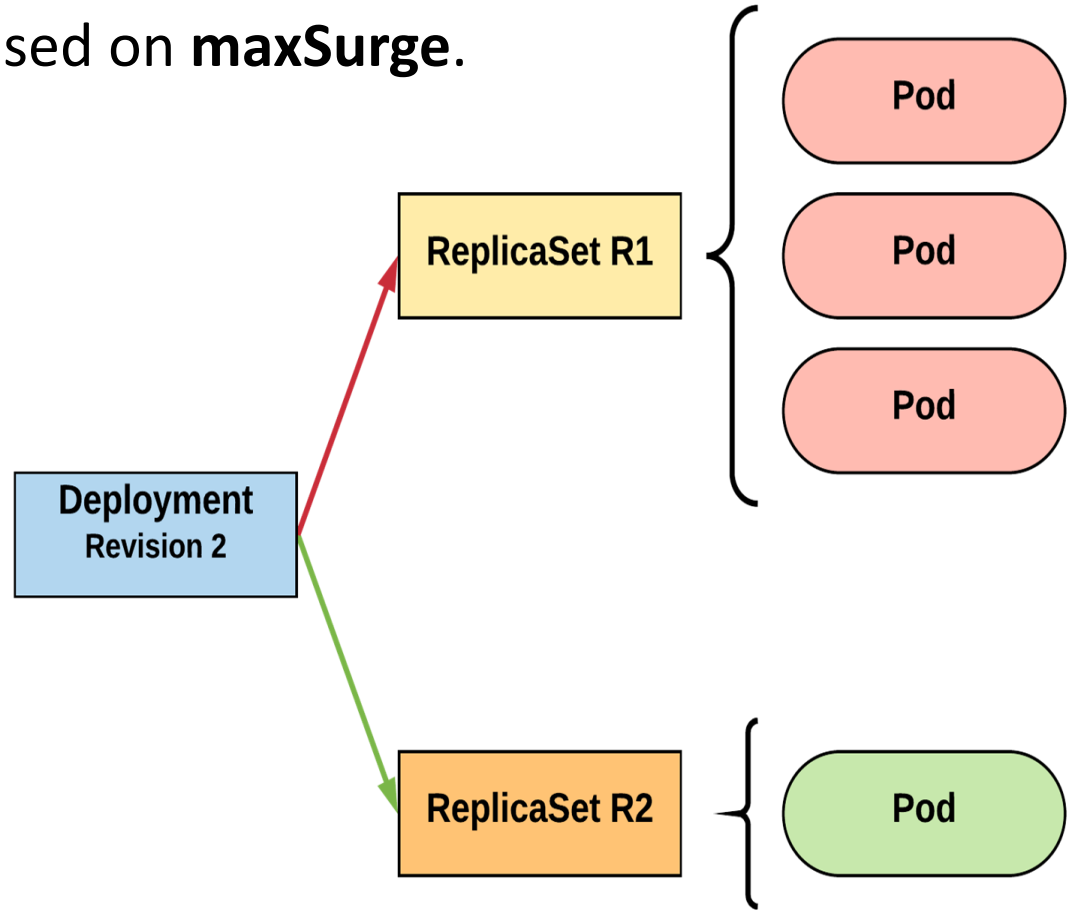
RollingUpdate Deployment Types

- New ReplicaSet ias 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
```



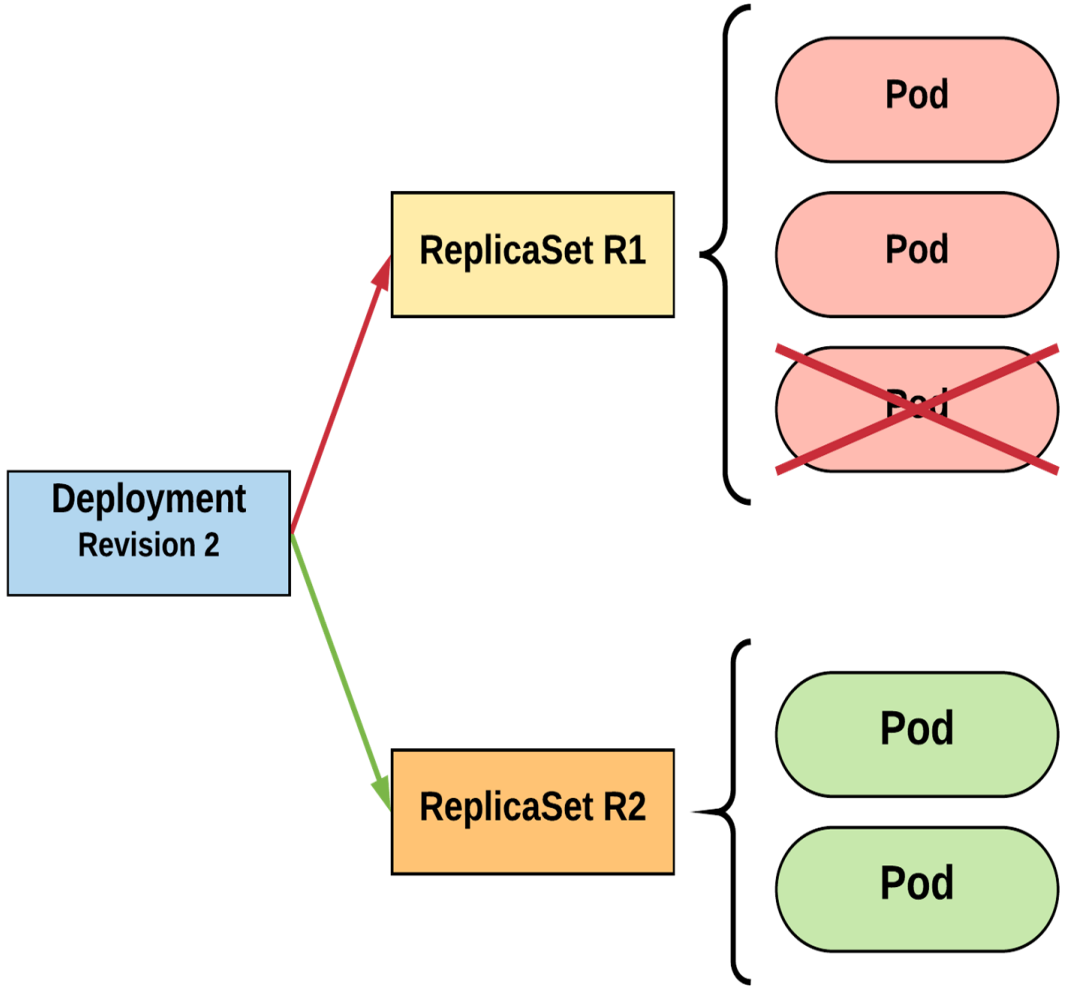
RollingUpdate Deployment

- 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
```



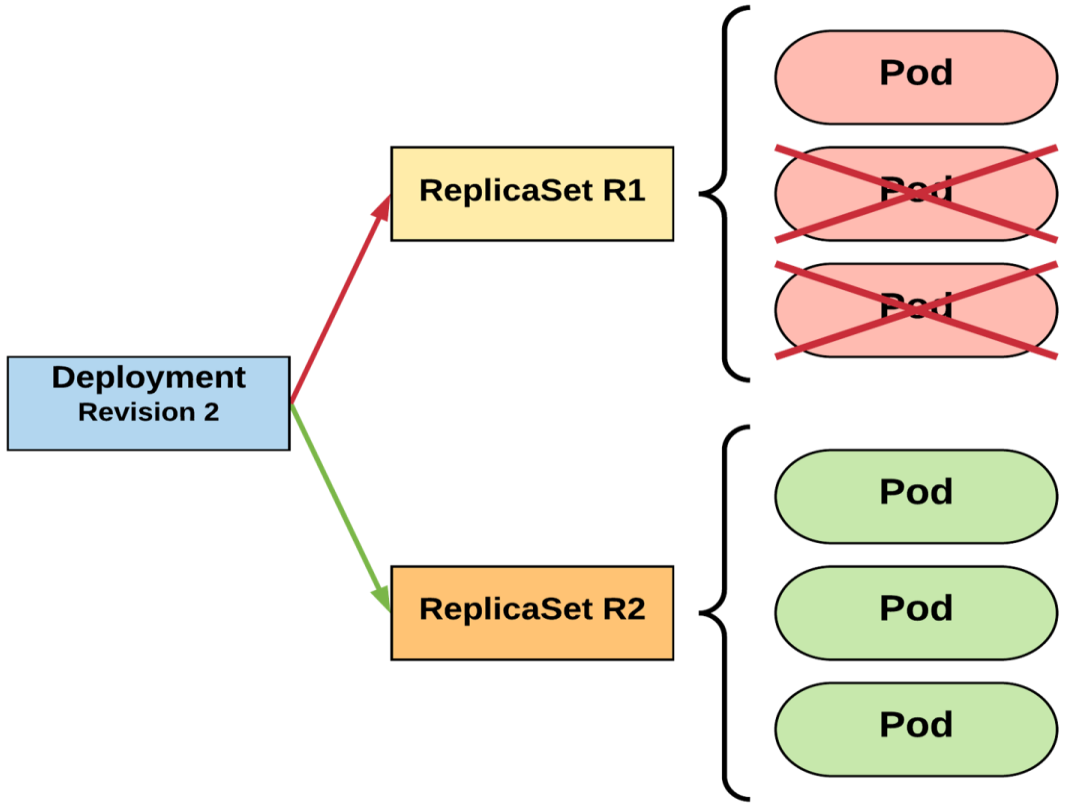
RollingUpdate Deployment

- 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
```



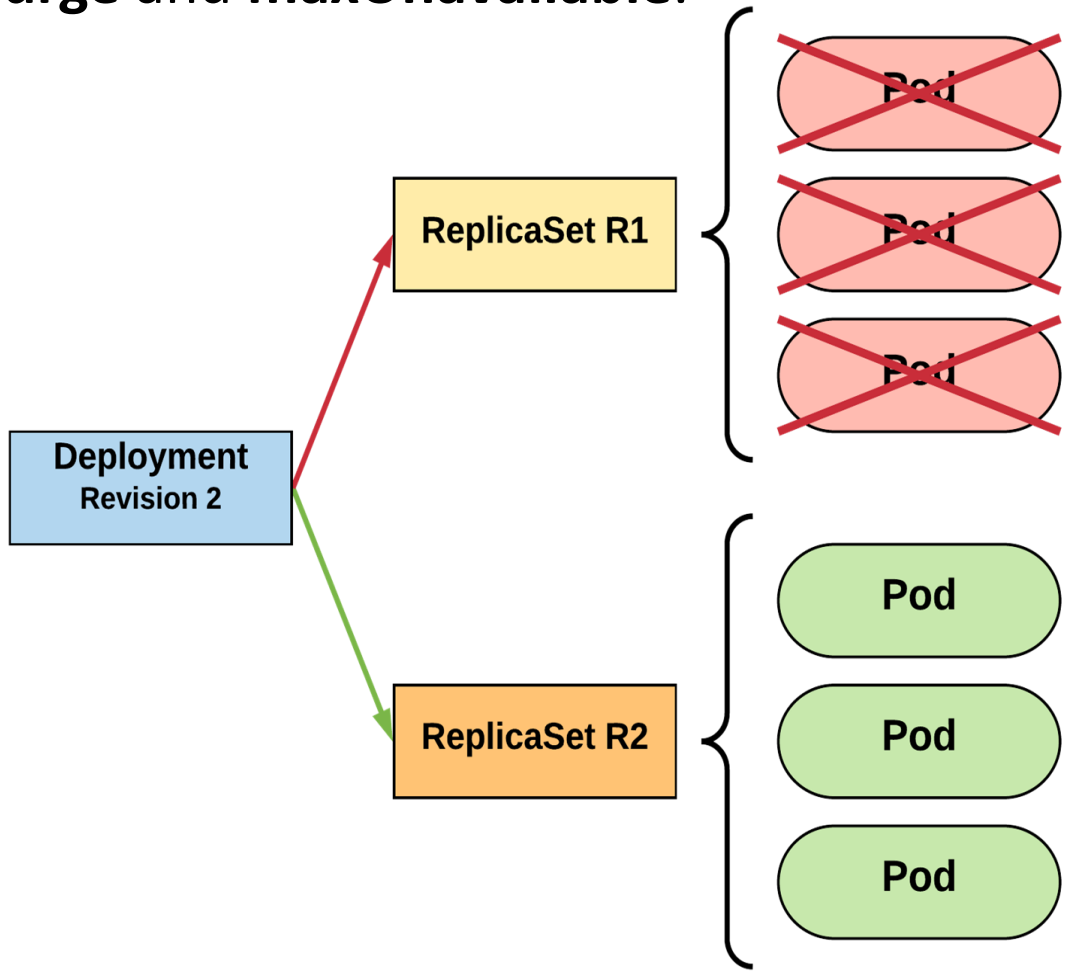
RollingUpdate Deployment

- 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
```



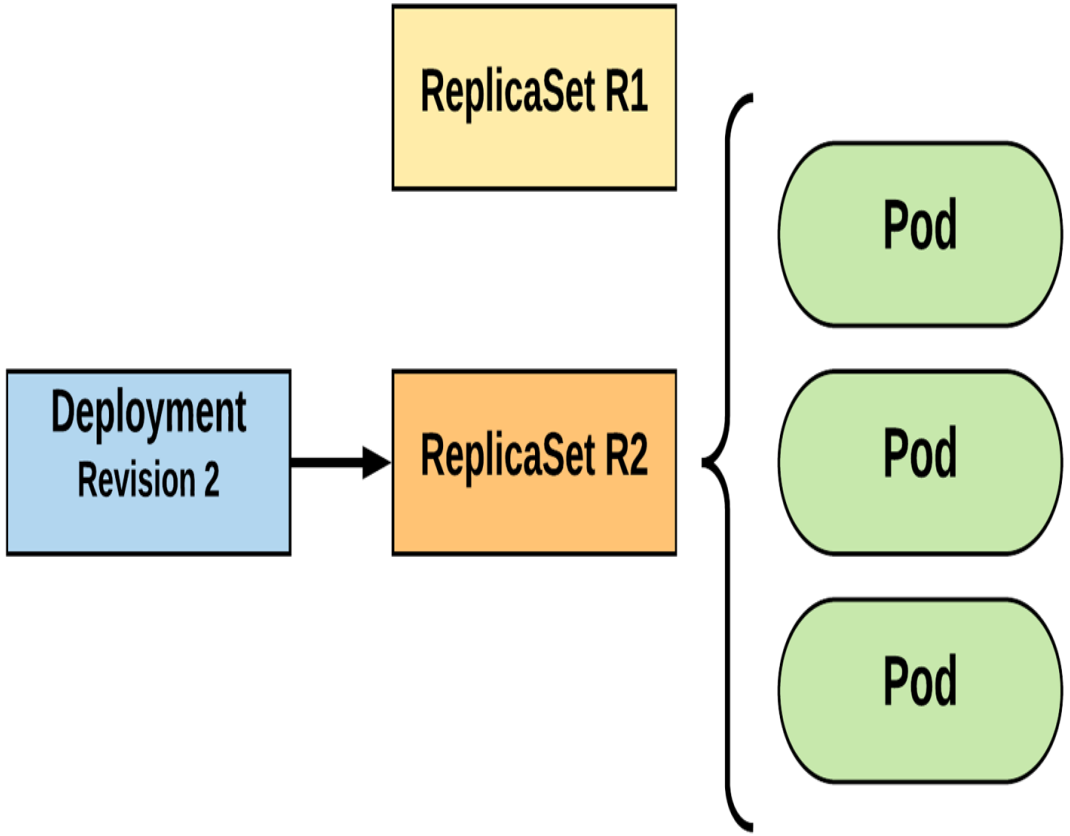
RollingUpdate Deployment

- 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
```

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.

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

Job

```
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

```
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
```

Storage - Concepts and Resources

- Storage
- Volumes
- Persistent Volumes
- Persistent Volume Claims

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.

```
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.

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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.

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```
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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: {}
```

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THANK YOU