Kubernetes

DevOps Training

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Introduction

Intro - What is Kubernetes?

Kubernetes or **K8s** was a project spun out of Google as a open source next-gen container scheduler designed with the lessons learned from developing and managing Borg and Omega.

Kubernetes was designed from the ground-up as a loosely coupled collection of components centered around deploying, maintaining, and scaling applications.

Intro - What Does Kubernetes do?

Kubernetes is a portable, extensible, open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation

Kubernetes is the linux kernel of distributed systems.

It abstracts away the underlying hardware of the nodes and provides a uniform interface for applications to be both deployed and consume the shared pool of resources.

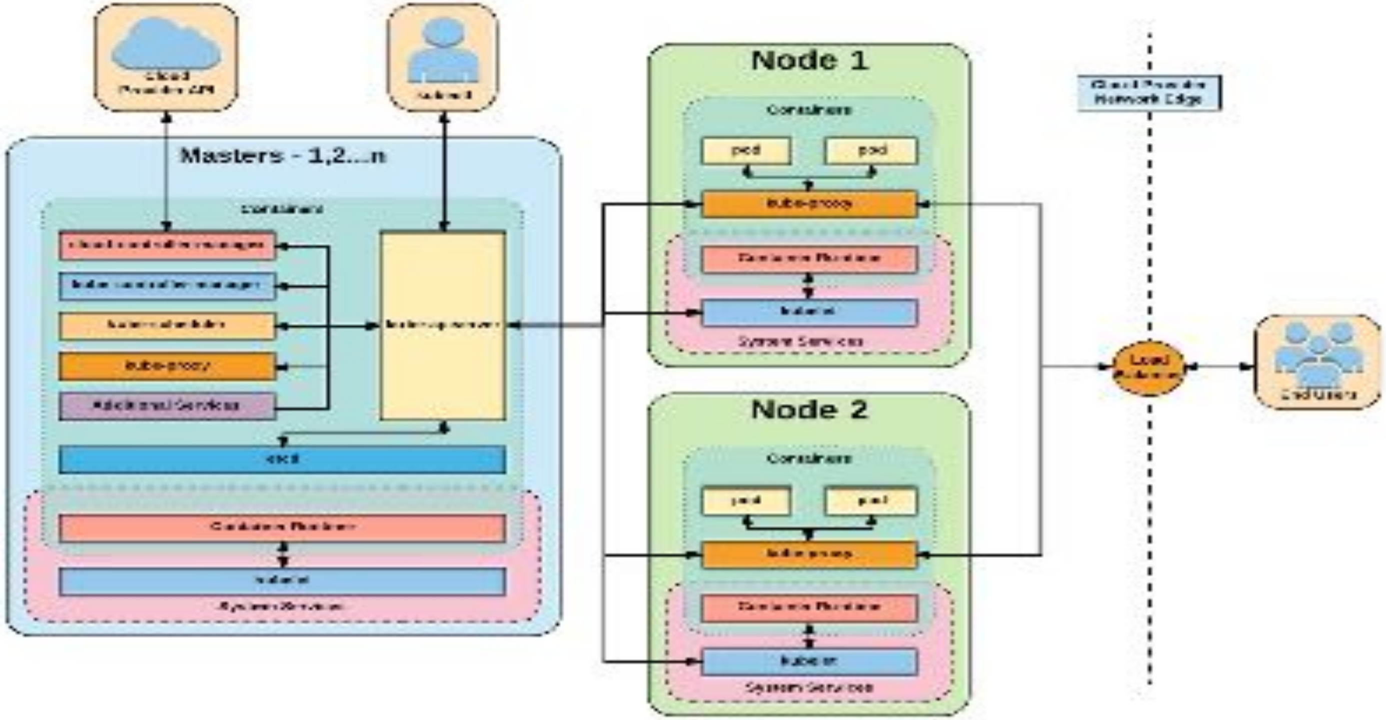
Kubernetes Architecture

Architecture Overview

Masters - Acts as the primary control plane for Kubernetes. Masters are responsible at a minimum for running the API Server, scheduler, and cluster controller. They commonly also manage storing cluster state, cloud-provider specific components and other cluster essential services.

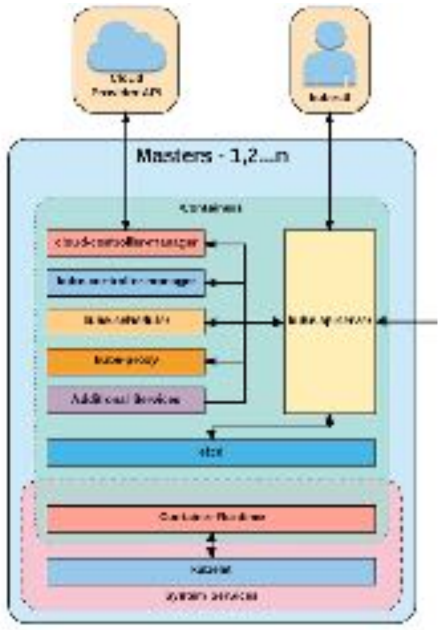
Nodes - Are the 'workers' of a Kubernetes cluster. They run a minimal agent that manages the node itself, and are tasked with executing workloads as designated by the master.

Architecture Overview



Master Components

Master Components



- Kube-apiserver
- Etcd
- Kube-controller-manager
- Cloud-controller-manager
- Kube-scheduler

kube-apiserver

The apiserver provides a forward facing REST interface into the kubernetes control plane and datastore. All clients, including nodes, users and other applications interact with kubernetes **strictly** through the API Server.

It is the true core of Kubernetes acting 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; providing a strong, consistent and highly available key-value store used for persisting cluster state.

kube-controller-manager

The controller-manager is the primary daemon that manages all core component control loops. It 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#L332

cloud-controller-manager

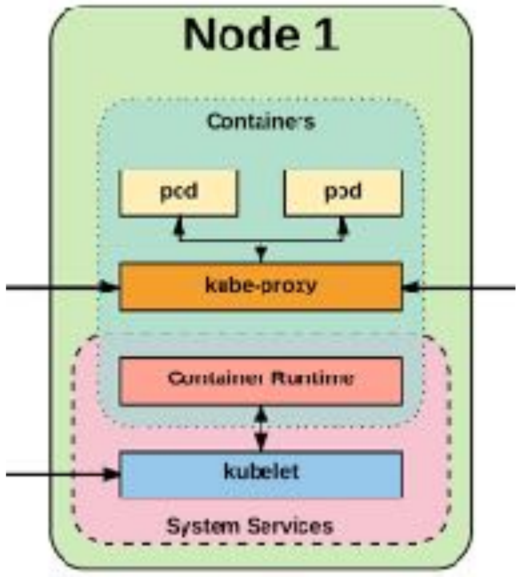
The cloud-controller-manager is a daemon that provides cloud-provider specific knowledge and integration capability into the core control loop of Kubernetes. The controllers include Node, Route, Service, and add an additional controller to handle PersistentVolumeLabels .

kube-scheduler

Kube-scheduler is a verbose policy-rich engine that evaluates workload requirements and attempts to place it on a matching resource. These requirements can include such things as general hardware reqs, affinity, anti-affinity, and other custom resource requirements.

Node Components

Node Components



- Kubelet
- Kube-proxy
- Containerruntime engine

kubelet

Acts as the node agent responsible for managing pod lifecycle 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 and performs connection forwarding or load balancing for Kubernetes cluster services.

Available Proxy Modes:

- Userspace
- iptables
- ipvs (alpha in 1.8)

Container Runtime

With respect to Kubernetes, 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)

Additional Services

Kube-dns - Provides cluster wide DNS Services. Services are resolvable to *<service>.<namespace>.svc.cluster.local*.

Heapster - Metrics Collector for kubernetes cluster, used by some resources such as the Horizontal Pod Autoscaler. (required for kubedashboard metrics)

Kube-dashboard - A general purpose web based UI for kubernetes.

Networking

Networking - Fundamental Rules

1) All Pods can communicate with all other Pods without NAT
2) All nodes can communicate with all Pods (and vice-versa) without NAT.
3) The IP that a Pod sees itself as is the same IP that others see it as.

Networking - Fundamentals Applied

Containers in a pod exist within the same network namespace and share an IP; allowing for intrapod communication over *localhost*.

Pods are given a cluster unique IP for the duration of its lifecycle, but the pods themselves are fundamentally ephemeral.

Services are given a persistent cluster unique IP that spans the Pods lifecycle.

External Connectivity is generally handed by an integrated cloud provider or other external entity (load balancer)

Networking - CNI

Networking within Kubernetes is plumbed via the Container Network Interface (CNI), an interface between a container runtime and a network implementation plugin.

Compatible CNI Network Plugins:

- Calico
- Cillium
- Contiv
- Contrail
- Flannel
- GCE
- kube-router
- Multus
- OpenVSwitch
- OVN
- Romana
- Weave

Kubernetes Concepts

Kubernetes Concepts - Core

Cluster - A collection of hosts that aggregate their available resources including cpu, ram, disk, and their devices into a usable pool.

Master - The master(s) represent a collection of components that make up the control plane of Kubernetes. These components are responsible for all cluster decisions including both scheduling and responding to cluster events.

Node - A single host, physical or virtual capable of running pods. A node is managed by the master(s), and at a minimum runs both kubelet and kube-proxy to be considered part of the cluster.

Namespace - A logical cluster or environment. Primary method of dividing a cluster or scoping access.

Concepts - Core (cont.)

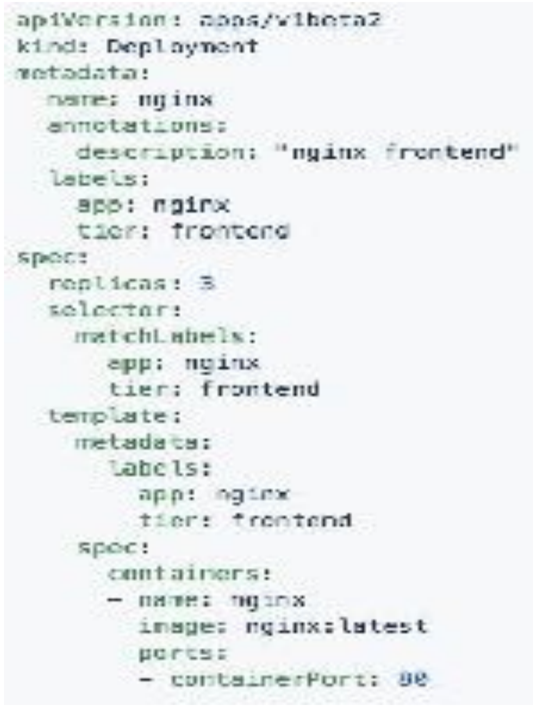
Label - Key-value pairs that are used to **identify**, describe and group together related sets of objects. Labels have a strict syntax and available character set. *

Annotation - Key-value pairs that contain **non-identifying** information or metadata. Annotations do not have the the syntax limitations as labels and can contain structured or unstructured data.

Selector - Selectors use labels to filter or select objects. Both equality-based (=, ==, !=) or simple key-value matching selectors are supported.

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

Labels, and Annotations, and Selectors



```
apiVersion: apps/v1beta2
kind: Deployment
metadata:
  name: nginx
  annotations:
    description: "nginx frontend"
  labels:
    app: nginx
    tier: frontend
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
      tier: frontend
  template:
    metadata:
      labels:
        app: nginx
        tier: frontend
    spec:
      containers:
      - name: nginx
        image: nginx:latest
        ports:
        - containerPort: 80
```

Labels:
 app: nginx
 tier: frontned

Annotations
 description: “nginxfrontend”

Selector:
 app: nginx
 tier: frontend

Concepts - Workloads

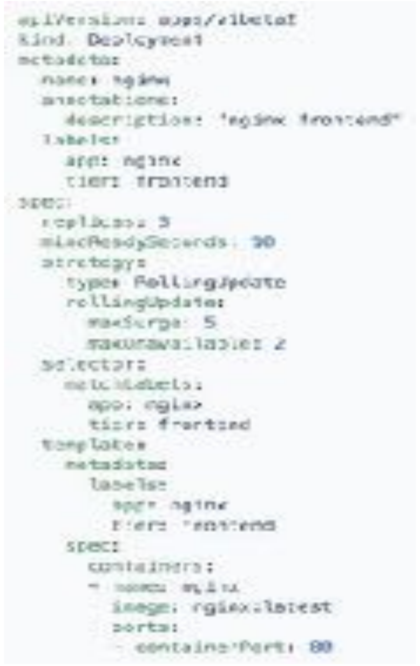
Pod - A pod is the smallest unit of work or management resource within Kubernetes. It is comprised of one or more containers that share their storage, network, and context (namespace, cgroups etc).

ReplicationController - Method of managing pod replicas and their lifecycle. Their scheduling, scaling, and deletion.

ReplicaSet - Next Generation ReplicationController. Supports set-based selectors.

Deployment - A declarative method of managing stateless Pods and ReplicaSets. Provides rollback functionality in addition to more granular update control mechanisms.

Deployment

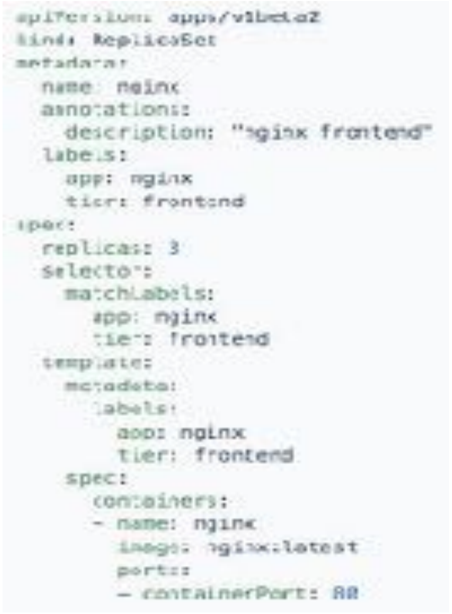


```
apiVersion: apps/v1beta1
kind: Deployment
metadata:
  name: nginx
  annotations:
    description: "nginx frontend"
  labels:
    app: nginx
    tier: frontend
spec:
  replicas: 3
  minReadySeconds: 90
  strategy:
    type: RollingUpdate
    rollingUpdate:
      maxSurge: 5
      maxUnavailable: 2
  selector:
    matchLabels:
      app: nginx
      tier: frontend
  template:
    metadata:
      labels:
        app: nginx
        tier: frontend
    spec:
      containers:
      - name: nginx
        image: nginx:latest
        ports:
        - containerPort: 80
```

Contains configuration of how updates or 'deployments' should be managed in addition to the pod template used to generate the ReplicaSet.

ReplicaSet

Generated ReplicaSet from Deployment spec.



```
apiVersion: apps/v1beta2
kind: ReplicaSet
metadata:
  name: nginx
  annotations:
    description: "nginx frontend"
  labels:
    app: nginx
    tier: frontend
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
      tier: frontend
  template:
    metadata:
      labels:
        app: nginx
        tier: frontend
    spec:
      containers:
      - name: nginx
        image: nginx:latest
        ports:
        - containerPort: 80
```

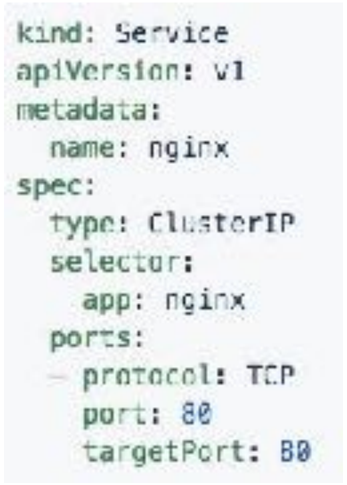
Concepts - Network

Service - Services provide a method of exposing and consuming L4 Pod network accessible resources. They use label selectors to map groups of pods and ports to a cluster-unique virtual IP.

Ingress - An ingress controller is the primary method of exposing a cluster service (usually http) to the outside world. These are load balancers or routers that usually offer SSL termination, name-based virtual hosting etc.

Service

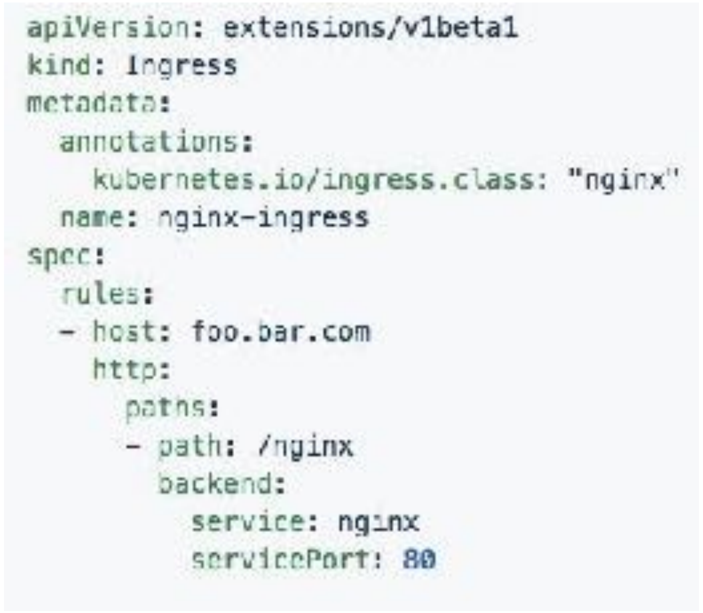
- Acts as the unified method of accessing replicated pods.
- Four major Service Types:
  - CluterIP - Exposes service on a strictly cluster-internal IP (default)
  - NodePort - Service is exposed on each node's IP on a statically defined port.
  - LoadBalancer - Works in combination with a cloud provider to expose a service outside the cluster on a static external IP.
  - ExternalName - used to references endpoints **OUTSIDE** the cluster by providing a static internally referenced DNS name.



```
kind: Service
apiVersion: v1
metadata:
  name: nginx
spec:
  type: ClusterIP
  selector:
    app: nginx
  ports:
  - protocol: TCP
    port: 80
    targetPort: 80
```

Ingress Controller

- Deployed as a pod to one or more hosts
- Ingress controllers are an external controller with multiple options.
  - Nginx
  - HAproxy
  - Contour
  - Traefik
- Specific features and controller specific configuration is passed through annotations.



```yaml
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  annotations:
    kubernetes.io/ingress.class: "nginx"
  name: nginx-ingress
spec:
  rules:
  - host: foo.bar.com
    http:
      paths:
      - path: /nginx
        backend:
          service: nginx
          servicePort: 80
```

Concepts - Storage

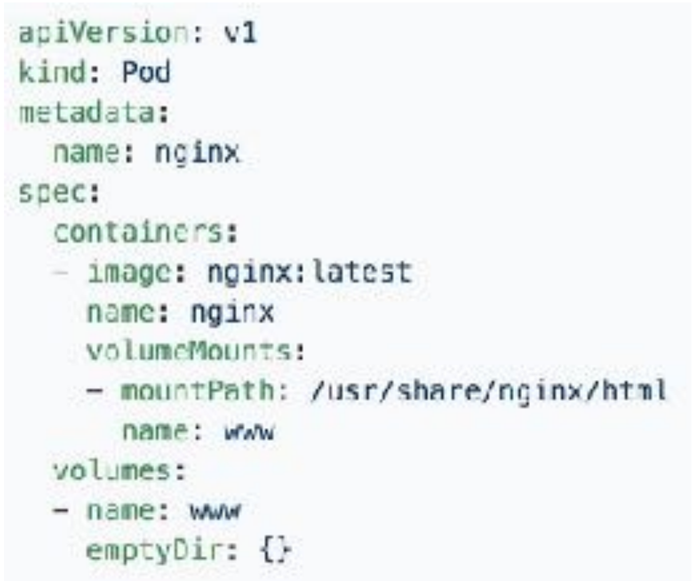
Volume - Storage that is **tied to the Pod Lifecycle**, consumable by one or more containers within the pod.

PersistentVolume - A PersistentVolume (PV) represents a storage resource. PVs are commonly linked to a backing storage resource, NFS, GCEPersistentDisk, RBD etc. and are provisioned ahead of time. Their lifecycle is handled independently from a pod.

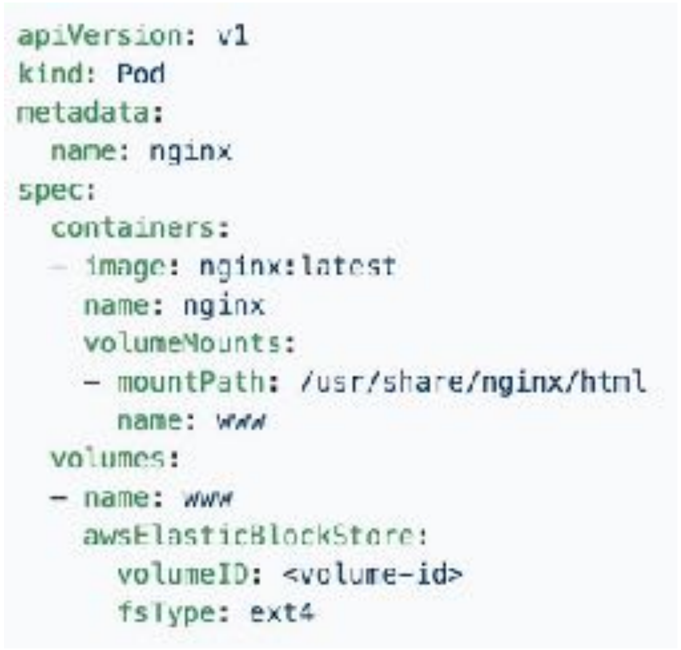
PersistentVolumeClaim - A PersistentVolumeClaim (PVC) is a request for storage that satisfies a set of requirements instead of mapping to a storage resource directly. Commonly used with dynamically provisioned storage.

StorageClass - Storage classes are an abstraction on top of an external storage resource. These will include a provisioner, provisioner configuration parameters as well as a PV reclaimPolicy.

Volumes

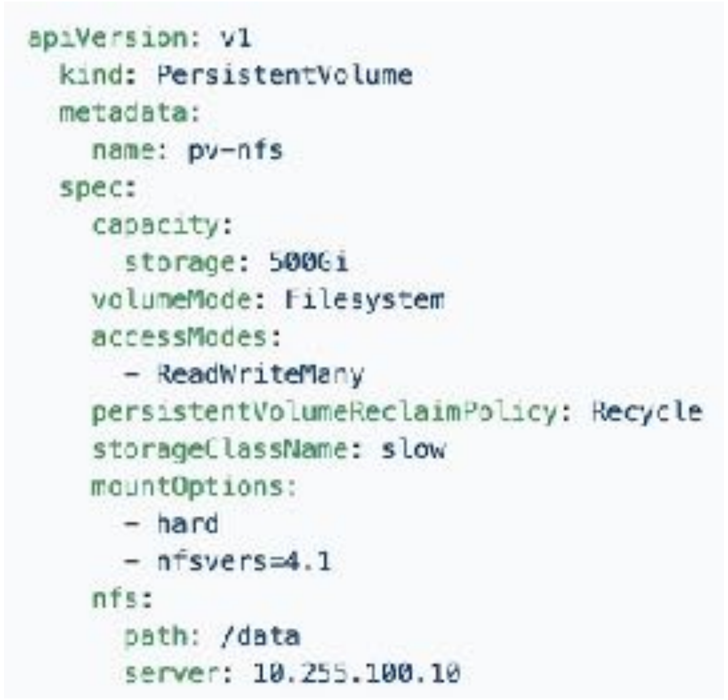


```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:latest
    name: nginx
    volumeMounts:
    - mountPath: /usr/share/nginx/html
      name: www
  volumes:
  - name: www
    emptyDir: {}
```



```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:latest
    name: nginx
    volumeMounts:
    - mountPath: /usr/share/nginx/html
      name: www
  volumes:
  - name: www
    awsElasticBlockStore:
      volumeID: <volume-id>
      fsType: ext4
```

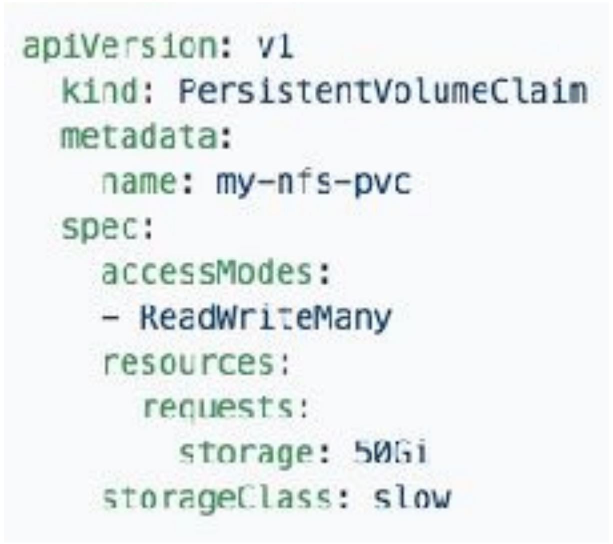
Persistent Volumes



```
apiVersion: v1
  kind: PersistentVolume
  metadata:
    name: pv-nfs
  spec:
    capacity:
      storage: 500Gi
    volumeMode: Filesystem
    accessModes:
      - ReadWriteMany
    persistentVolumeReclaimPolicy: Recycle
    storageClassName: slow
    mountOptions:
      - hard
      - nfsvers=4.1
    nfs:
      path: /data
      server: 10.255.100.10
```

- PVs are a cluster-wide resource
- Not directly consumable by a Pod
- PV Parameters:
  - Capacity
  - accessModes
    - ReadOnlyMany (ROX)
    - ReadWriteOnce (RWO)
    - ReadWriteMany (RWX)
  - persistentVolumeReclaimPolicy
    - Retain
    - Recycle
    - Delete
  - StorageClass

Persistent Volume Claims



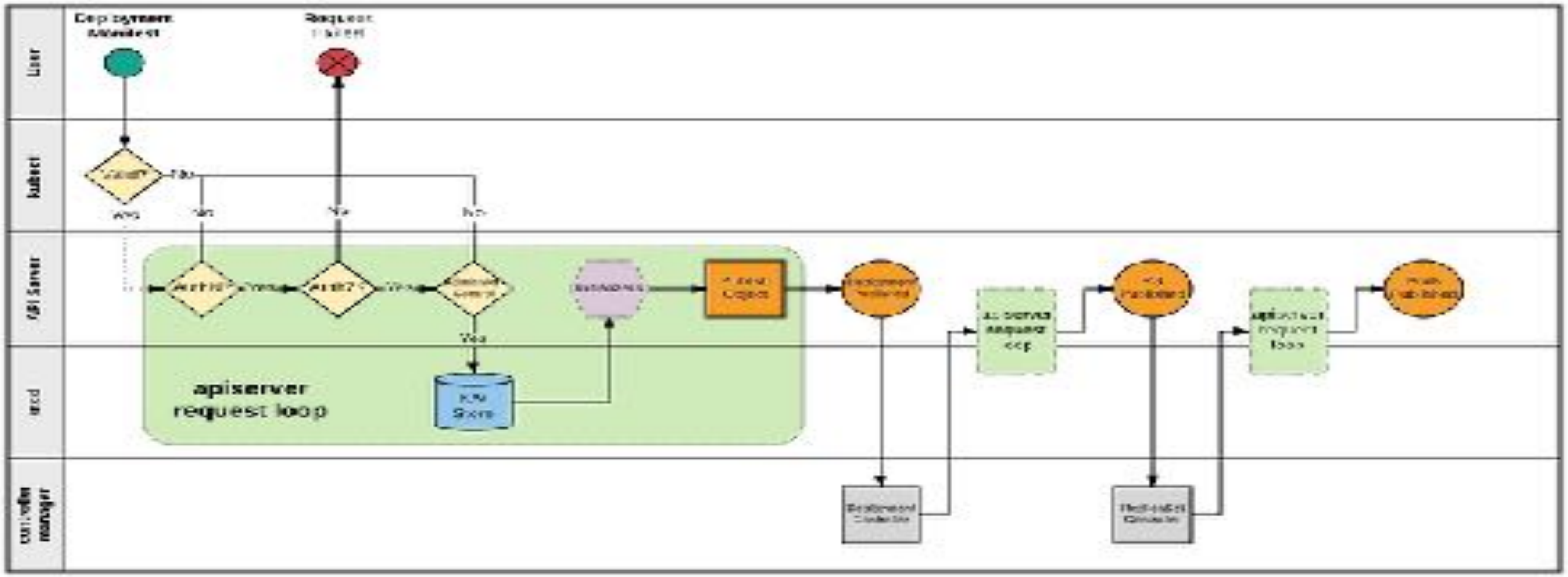
```
apiVersion: v1
  kind: PersistentVolumeClaim
  metadata:
    name: my-nfs-pvc
  spec:
    accessModes:
    - ReadWriteMany
    resources:
      requests:
        storage: 50Gi
    storageClass: slow
```

- PVCs are scoped to namespaces
- Supports accessModes like PVs
- Uses resource request model similar to Pods
- Claims will consume storage from matching PVs or StorageClasses based on *storageClass* and selectors.

Behind the scenes

Behind The Scenes

Deployment From Beginning to End


User
Kubectl
API Server
etcd
controller manager
Deployment Manifest
Request Failed
Valid?
No
Yes
No
No
No
Auth N?
Yes
Auth Z?
Yes
Admission Control
Yes
Create Object
K/V Store
apiserver request loop
Deployment Published
Deployment Controller
apiserver request loop
RS Published
ReplicaSet Controller
apiserver request loop
Pods Published

THANK YOU!

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