Certified Kubernetes Administrator (CKA) Master Cheat Sheet

Course Introduction

This course focuses on Administration part of the kubernetes.

Course Structure

- Lectures
- Demos
- Quizzes
- Practice Questions
- Q & A Section

Pre-Requisites

- Docker
- Basics of kubernetes
  - PODS, Deployments, Services ...
- YAML
- Setting up a basic lab environment with VirtualBox

Course Objectives

The objectives of this course are aligned to match the **`Certified Kubernetes Administration Exam (CKA)`**

- Core Concepts
  - Cluster Architecture
  - API Primitives
  - Services & Other Network Primitives
- Scheduling
  - Labels & Selectors
  - Daemon Sets
  - Resource Limits
  - Multiple Schedulers
  - Manual Scheduling
  - Scheduler Events

    - Configure Kubernetes Scheduler
- Logging & Monitoring
    - Monitor Cluster Components
    - Monitor Cluster Components Logs
    - Monitor Applications
    - Application Logs
- Application Lifecycle Management
    - Rolling Updates and Rollbacks in Deployments
    - Configuring Applications
    - Scale Applications
    - Self-Healing Applications
- Cluster Maintenance
    - Cluster Upgrade Process
    - Operating System Upgrades
    - Backup and Restore Methodologies
- Security
    - Authentication & Authorization
    - Kubernetes Security
    - Network Policies
    - TLS Certificates for Cluster Components
    - Image Security
    - Network Polices
    - Security Contexts
    - Secure Persistent Key Value Store
- Storage
    - Persistent Volumes
    - Access Modes for Volumes
    - Persistent Volume Claims
    - Kubernetes Storage Object
    - Configure Applications with Persistent Storage
- Networking
    - Pre-Requisites - Network, Switching, Routing, Tools
    - Pre-Requisites - Network Namespaces
    - Pre-Requisites - Networking in Docker
    - Networking Configuration on Cluster Nodes
    - Service Networking
    - POD Networking Concepts
    - Network Loadbalancer
    - Ingress
    - Cluster DNS

    - CNI
- Installation, Configuration & Validation
    - Design a Kubernetes Cluster
    - Install Kubnernetes Master and Nodes
    - Secure Cluster Communication
    - HA Kubernetes Cluster
    - Kubenetes Release Binaries
    - Provision Infrastructure
    - Choose a Network Solution
    - Kubernetes Infrastructure Config
    - Run & Analyze end-to-end test
    - Node end-to-end tests
- Troubleshooting
    - Application Failure
    - Control Plane Failure
    - Worker Node Failure
    - Networking

Practice Tests

CKA exam is a practical hands-on exam it is very important to practice what you learn. Which is why we build a custom solution that will give you access to a **`Real Kubernetes Environment`** right in your browser along with **`Quiz Portal`**

Core Concepts Section Introduction

In this section, we will take a look at the below

- Cluster Architecture
- API Primitives
- Services & Other Network Primitives

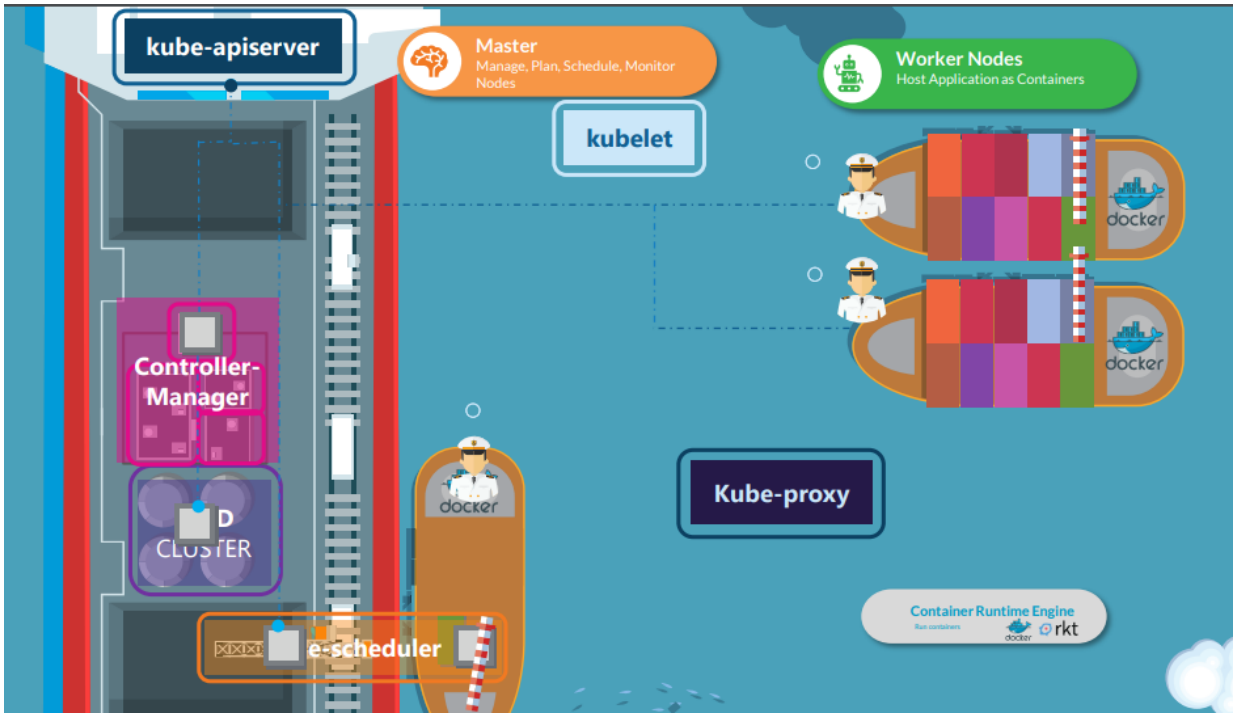
k8s reference docs:

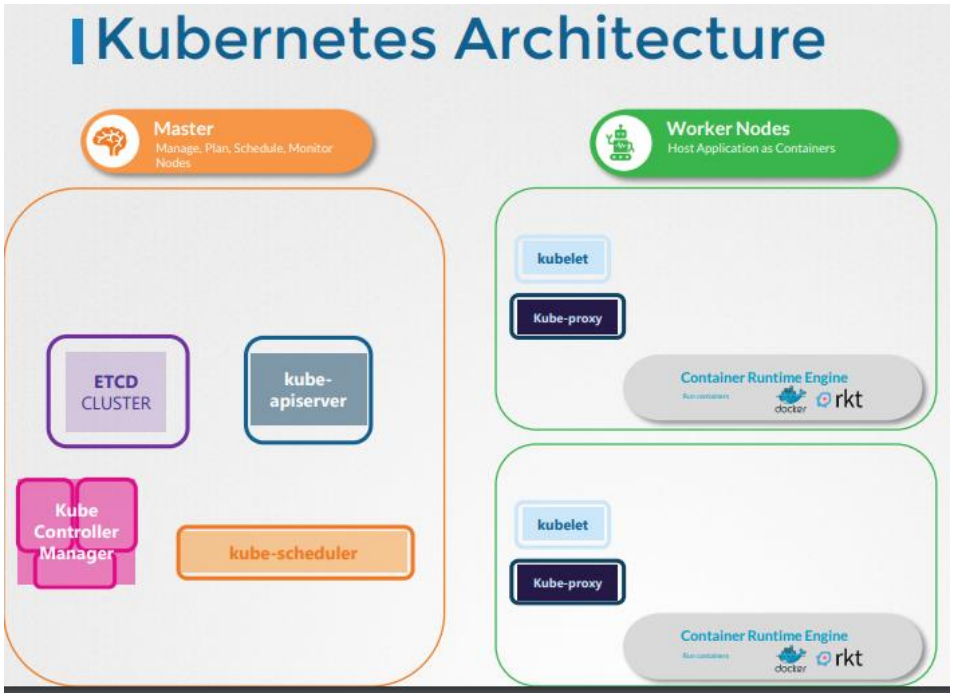
- https://kubernetes.io/docs/concepts/overview/kubernetes-api/
- https://kubernetes.io/docs/concepts/overview/working-with-objects/kubernetes-objects/
- https://kubernetes.io/docs/concepts/architecture/
- https://kubernetes.io/docs/concepts/overview/components/
- https://kubernetes.io/docs/concepts/services-networking/

Cluster Architecture

In this section , we will take a look at the kubernetes Architecture at high level.

- 10,000 Feet Look at the Kubernetes Architecture





K8s Reference Docs:

- https://kubernetes.io/docs/concepts/architecture/

ETCD for Beginners

In this section, we will take a quick look at introduction to ETCD for beginners.

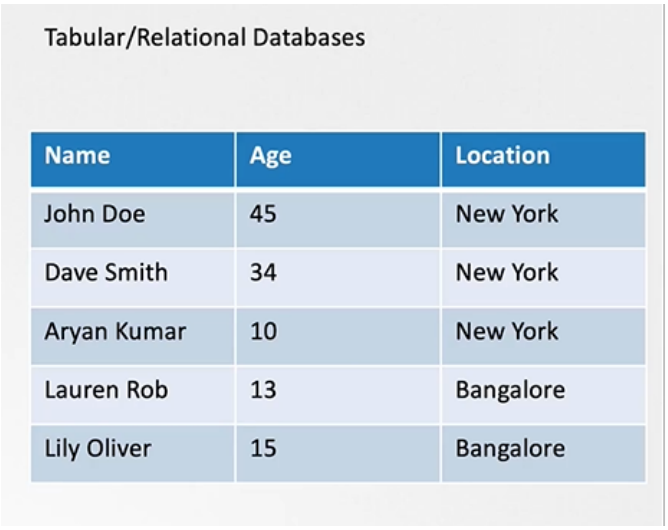
- What is ETCD?
- What is a Key-Value Store?
- How to get started quickly with ETCD?
- How to operate ETCD?

What is a ETCD?

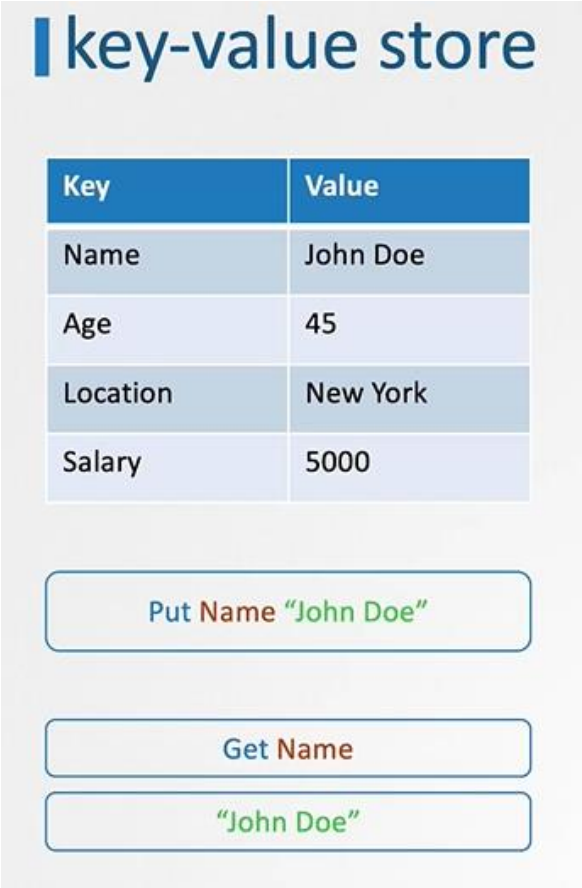
```
- ETCD is a distributed reliable key-value store that is simple, secure & Fast.
```

What is a Key-Value Store

- Traditionally, databases have been in tabular format, you must have heared about SQL or Relational databases. They store data in rows and columns



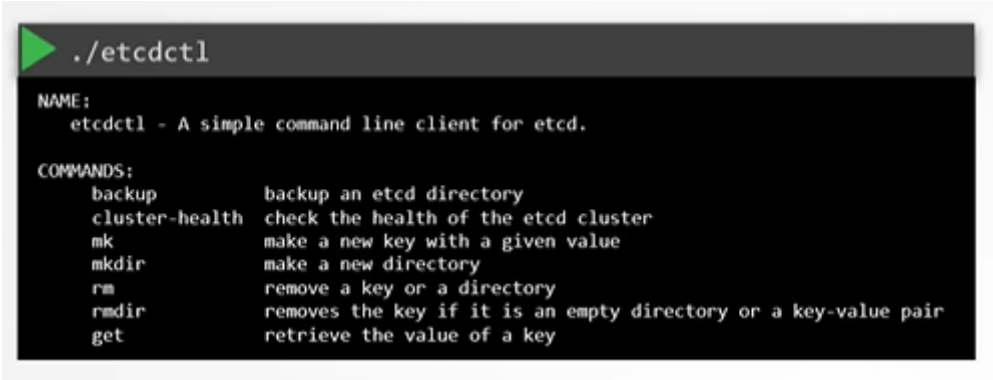
- A Key-Value Store stores information in a Key and Value format.



Install ETCD

- Its easy to install and get started with **ETCD**.
    - Download the relevant binary for your operating system from github releases page (https://github.com/etcd-io/etcd/releases)
    - `For Example: To download ETCD V3.3.11, run the below curl command`
    -
    - `$ https://github.com/etcd-io/etcd/releases/download/v3.3.11/etcd-v3.3.11-linux-amd64.tar.gz`
    - Extract it.
    - `$ tar xvzf etcd-v3.3.11-linux-amd64.tar.gz`
    - Run the ETCD Service
    - `$ ./etcd`
    - When you start **ETCD** it will by default listens on port **2379**
    - The default client that comes with **ETCD** is the **`etcdctl`** client. You can use it to store and retrieve key-value pairs.
    - `Syntax: To Store a Key-Value pair`
    - `$ ./etcdctl set key1 value1`
    - `Syntax: To retrieve the stored data`

- `$ ./etcdctl get key1`
- `Syntax: To view more commands. Run etcdctl without any arguments`
- `$ ./etcdctl`



- K8s Reference Docs:
  - https://kubernetes.io/docs/concepts/overview/components/
  - https://etcd.io/docs/
  - https://kubernetes.io/docs/tasks/administer-cluster/configure-upgrade-etcd/

ETCD in Kubernetes

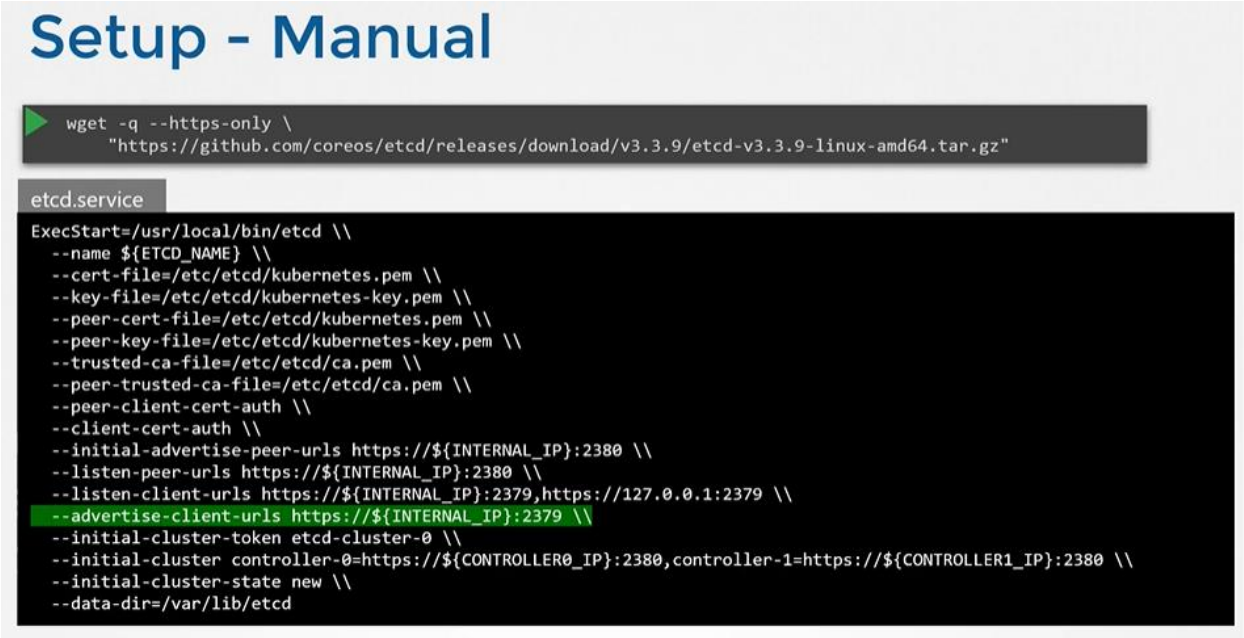
In this section, we will take a look at ETCD role in kubernetes

ETCD Datastore

- The ETCD Datastore stores information regarding the cluster such as **Nodes**, **PODS**, **Configs**, **Secrets**, **Accounts**, **Roles**, **Bindings** and **Others**.
- Every information you see when you run the **`kubectl get`** command is from the **ETCD Server**.

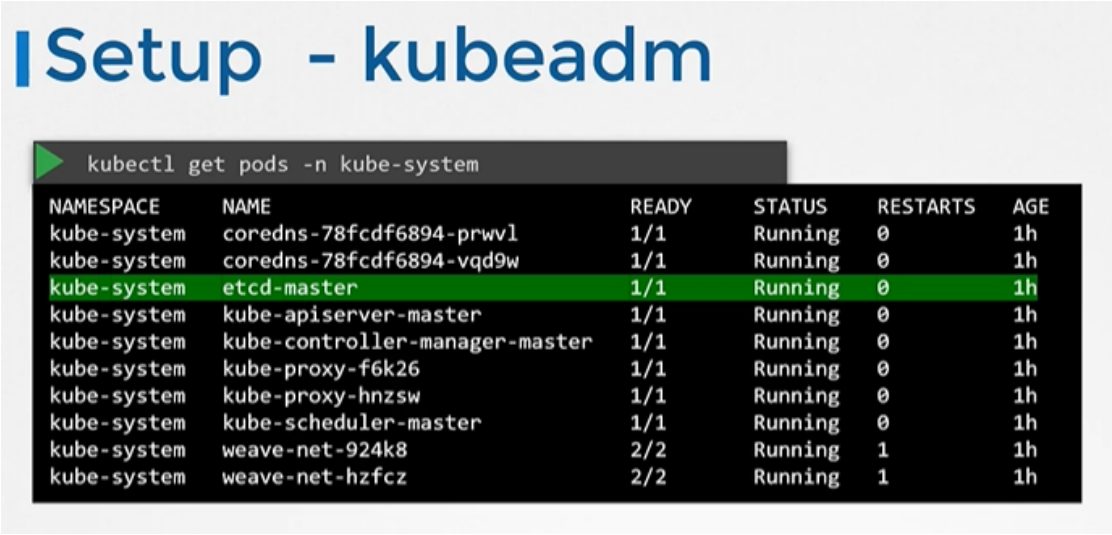
Setup - Manual

- If you setup your cluster from scratch then you deploy **ETCD** by downloading ETCD Binaries yourself
- Installing Binaries and Configuring ETCD as a service in your master node yourself.
- `$ wget -q --https-only "https://github.com/etcd-io/etcd/releases/download/v3.3.11/etcd-v3.3.11-linux-amd64.tar.gz"`



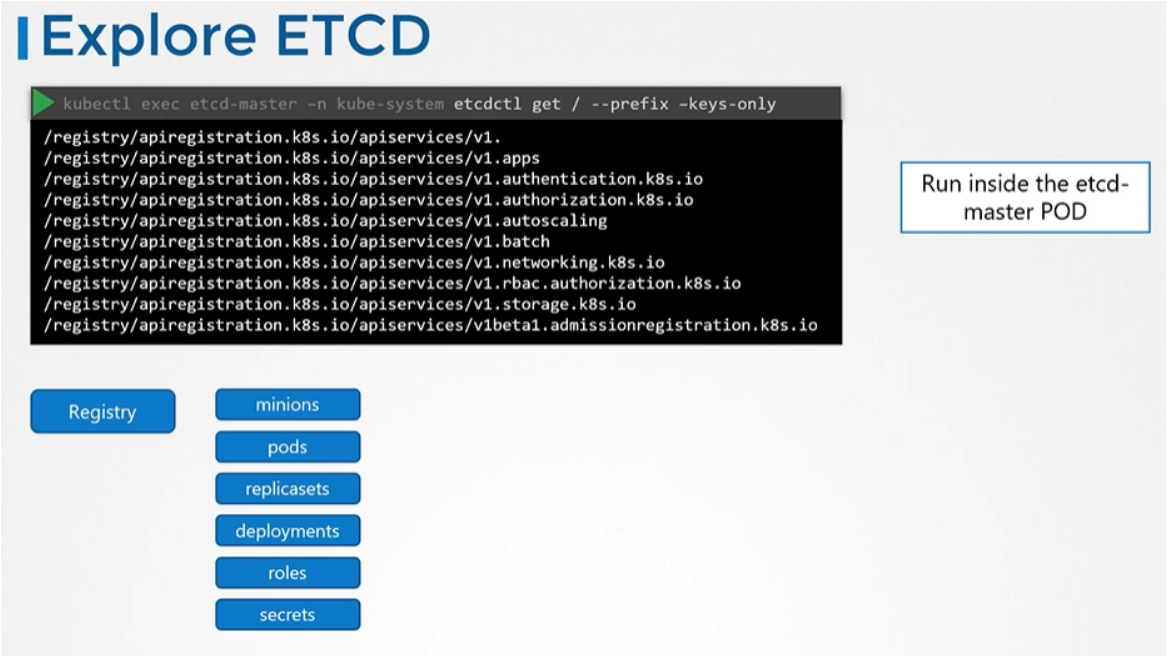
Setup - Kubeadm

- If you setup your cluster using **`kubeadm`** then kubeadm will deploy etcd server for you as a pod in **`kube-system`** namespace.
- `$ kubectl get pods -n kube-system`



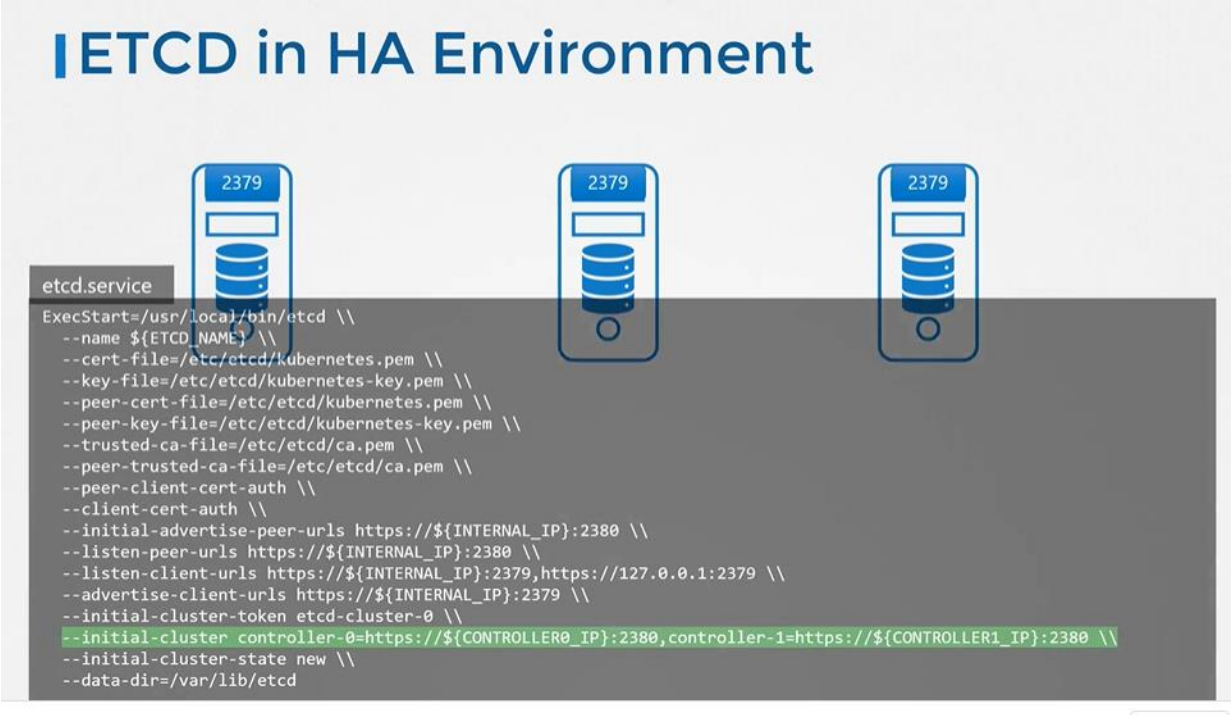
Explore ETCD

- To list all keys stored by kubernetes, run the below command
- `$ kubectl exec etcd-master -n kube-system etcdctl get / --prefix -key`
- Kubernetes Stores data in a specific directory structure, the root directory is the **`registry`** and under that you have varies kubernetes constructs such as **`minions`**, **`nodes`**, **`pods`**, **`replicasets`**, **`deployments`**, **`roles`**, **`secrets`** and **`Others`**.



ETCD in HA Environment

- In a high availability environment, you will have multiple master nodes in your cluster that will have multiple ETCD Instances spread across the master nodes.
- Make sure etcd instances know each other by setting the right parameter in the **`etcd.service`** configuration. The **`--initial-cluster`** option where you need to specify the different instances of the etcd service.



K8s Reference Docs:

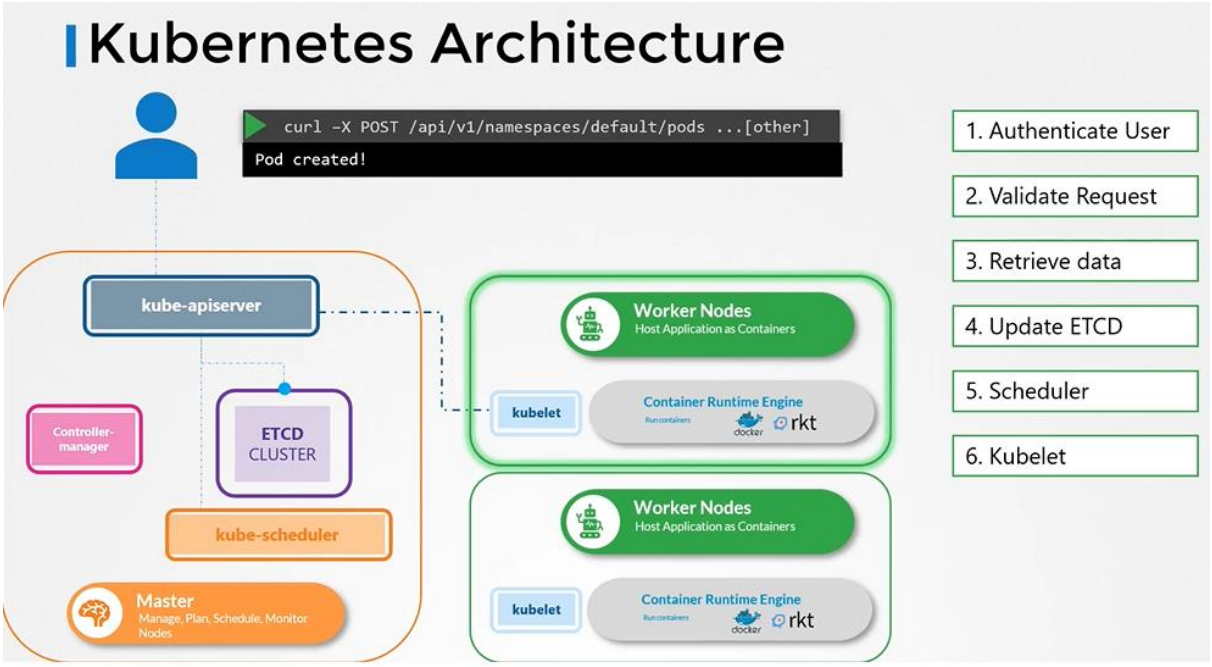
- https://kubernetes.io/docs/tasks/administer-cluster/configure-upgrade-etcd/
- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/setup-ha-etcd-with-kubeadm/
- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/high-availability/#stacked-control-plane-and-etcd-nodes
- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/high-availability/#external-etcd-nodes

Kube API Server

In this section, we will talk about kube-apiserver in kubernetes

Kube-apiserver is the primary component in kubernetes.

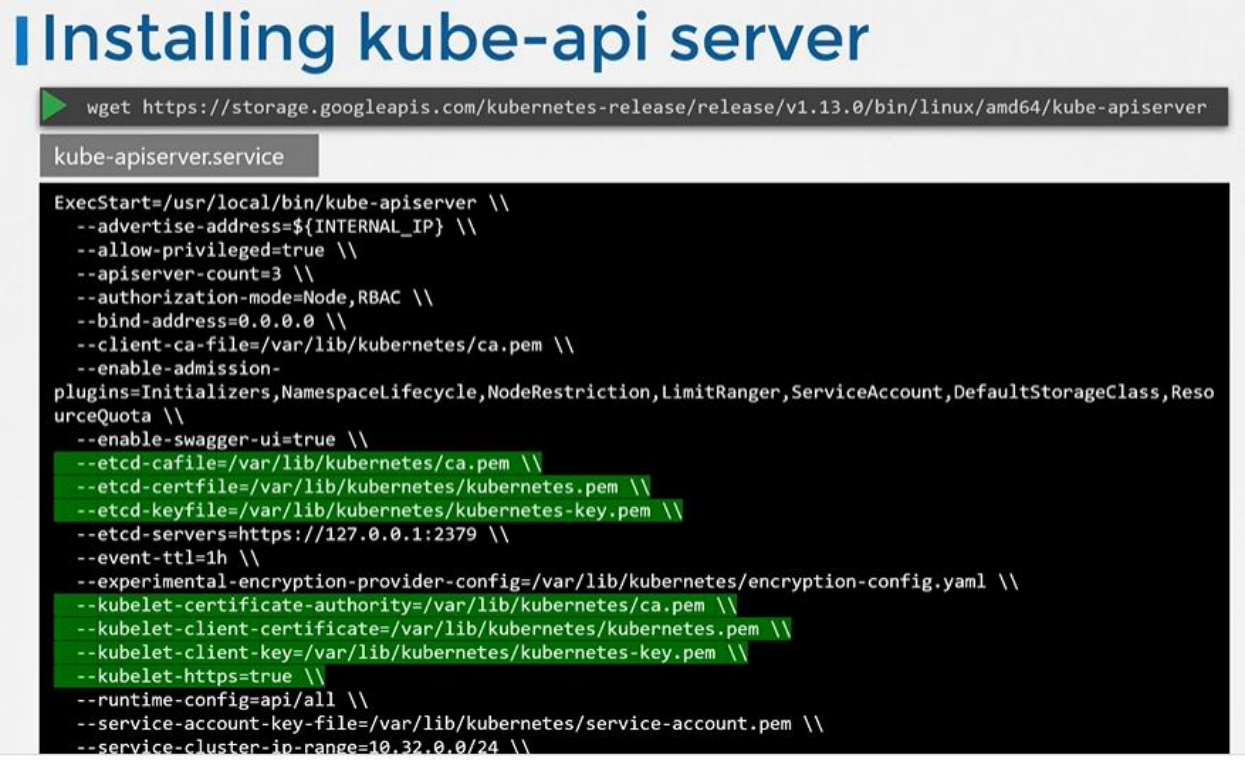
- Kube-apiserver is responsible for **`authenticating`**, **`validating`** requests, **`retrieving`** and **`Updating`** data in ETCD key-value store. In fact kube-apiserver is the only component that interacts directly to the etcd datastore. The other components such as kube-scheduler, kube-controller-manager and kubelet uses the API-Server to update in the cluster in their respective areas.



Installing kube-apiserver

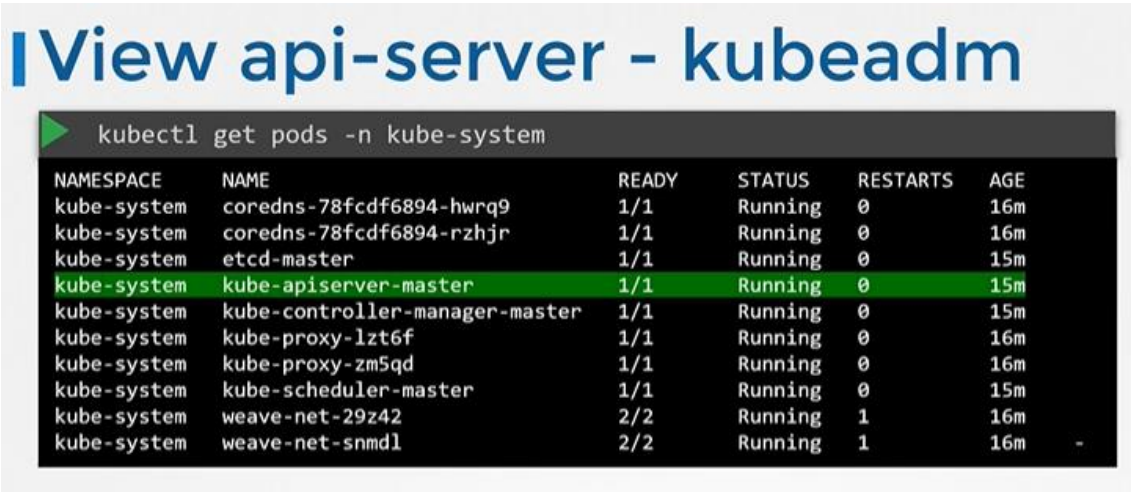
- If you are bootstrapping kube-apiserver using **`kubeadm`** tool, then you don't need to know this, but if you are setting up using the hardway then kube-apiserver is available as a binary in the kubernetes release page.

- For example: You can downlaod the kube-apiserver v1.13.0 binary here [kube-apiserver]
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.13.0/bin/linux/amd64/kube-apiserver`



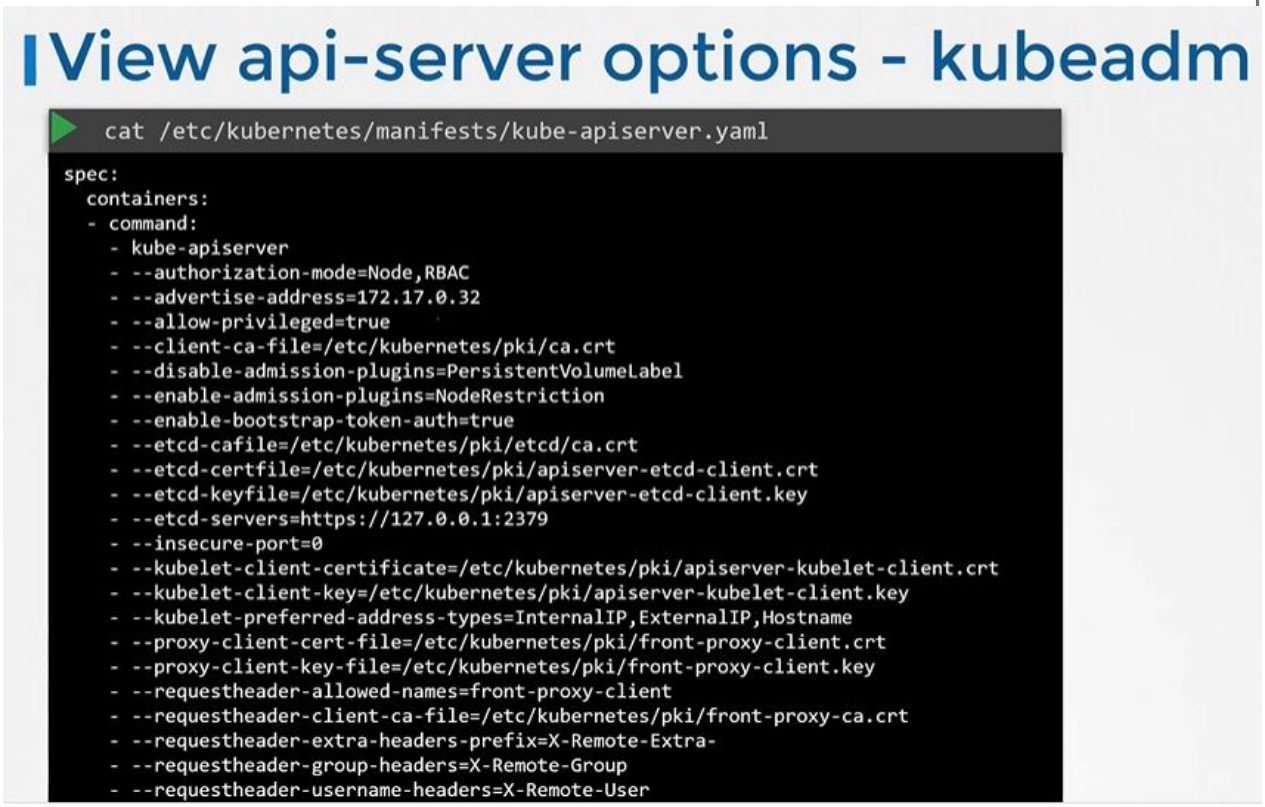
View kube-apiserver - Kubeadm

- kubeadm deploys the kube-apiserver as a pod in kube-system namespace on the master node.
- `$ kubectl get pods -n kube-system`



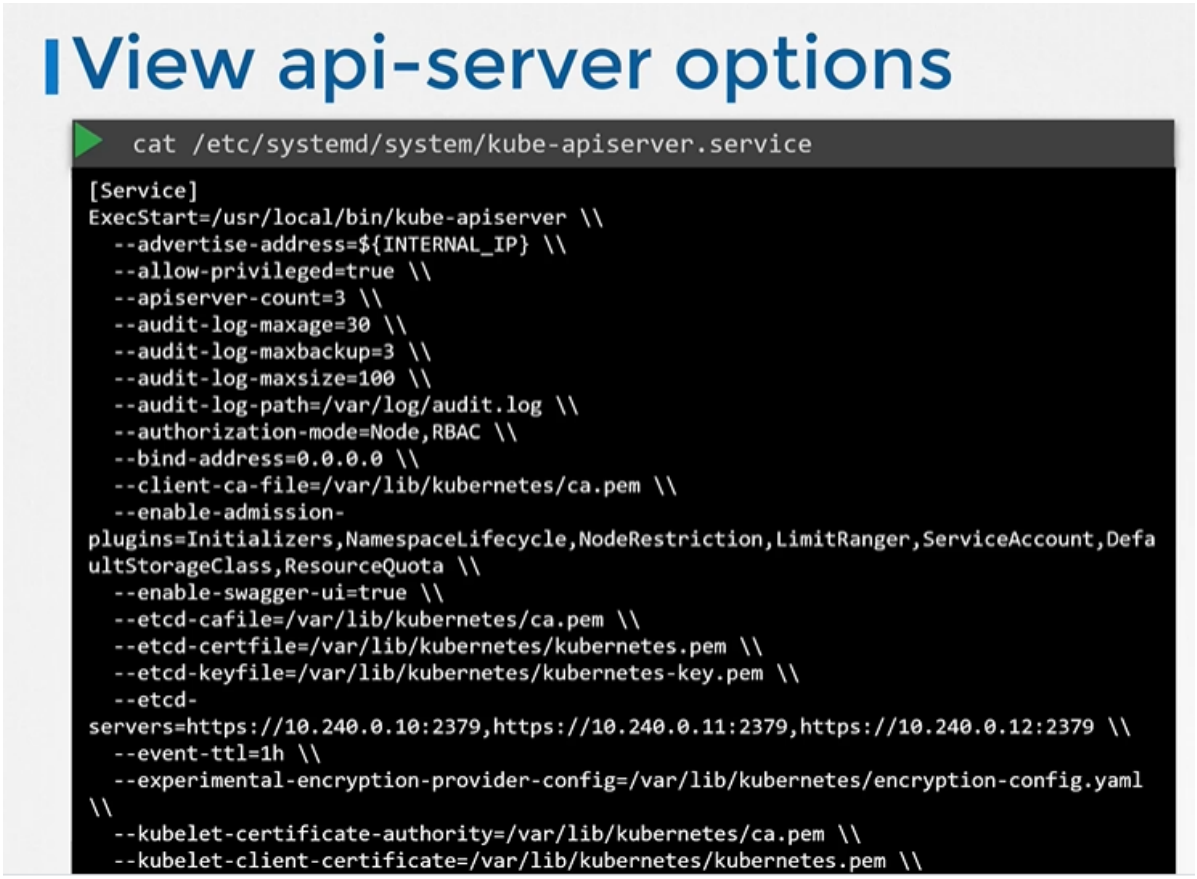
View kube-apiserver options - Kubeadm

- You can see the options with in the pod definition file located at **`/etc/kubernetes/manifests/kube-apiserver.yaml`**
- `$ cat /etc/kubernetes/manifests/kube-apiserver.yaml`

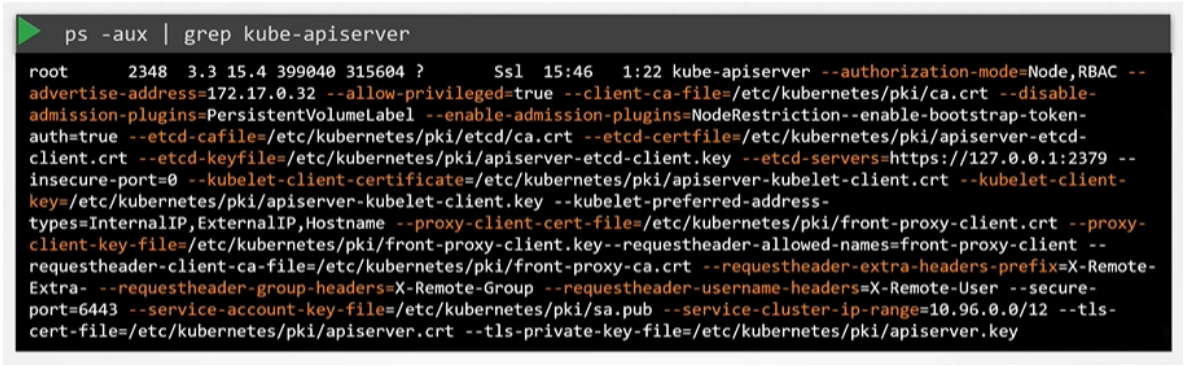


View kube-apiserver options - Manual

- In a Non-kubeadm setup, you can inspect the options by viewing the kube-apiserver.service
- `$ cat /etc/systemd/system/kube-apiserver.service`



- You can also see the running process and affective options by listing the process on master node and searching for kube-apiserver.
- `$ ps -aux | grep kube-apiserver`



K8s Reference Docs:

- https://kubernetes.io/docs/reference/command-line-tools-reference/kube-apiserver/
- https://kubernetes.io/docs/concepts/overview/components/
- https://kubernetes.io/docs/concepts/overview/kubernetes-api/
- https://kubernetes.io/docs/tasks/access-application-cluster/access-cluster/
- https://kubernetes.io/docs/tasks/administer-cluster/access-cluster-api/

Kube Controller Manager

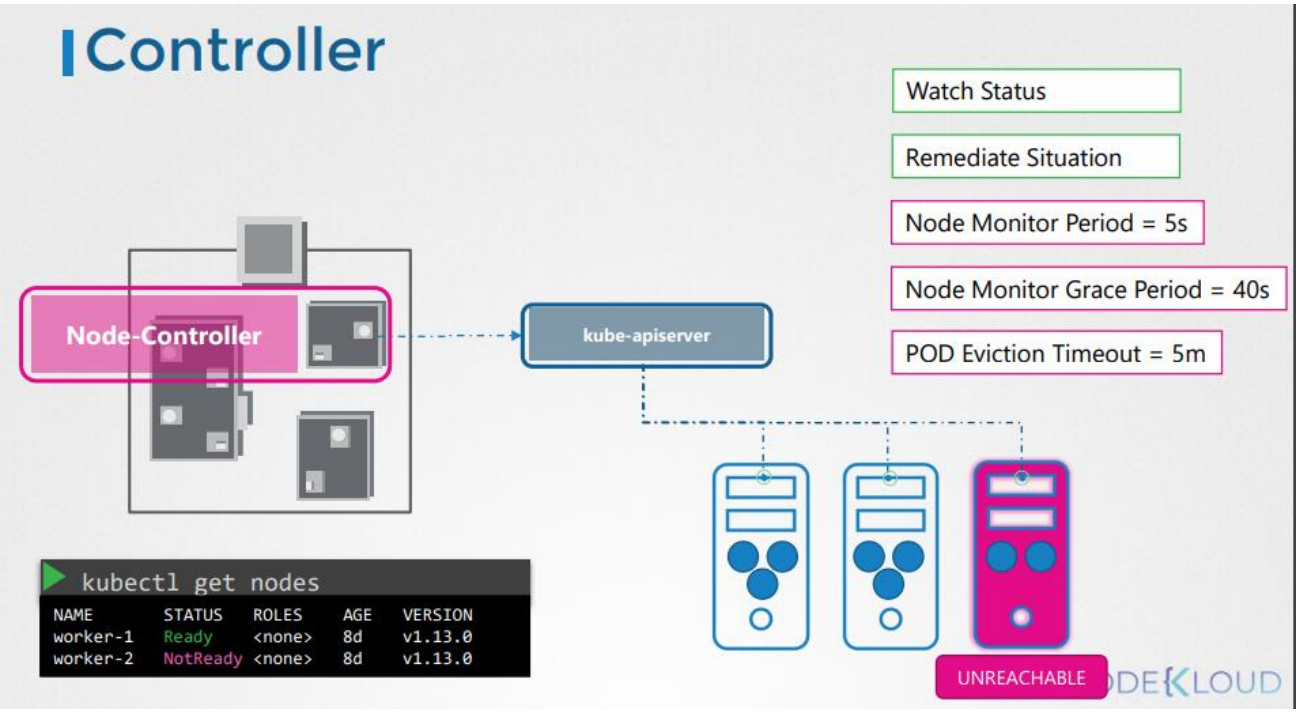
In this section, we will take a look at kube-controller-manager.

Kube Controller Manager manages various controllers in kubernetes.

- In kubernetes terms, a controller is a process that continuously monitors the state of the components within the system and works towards bringing the whole system to the desired functioning state.

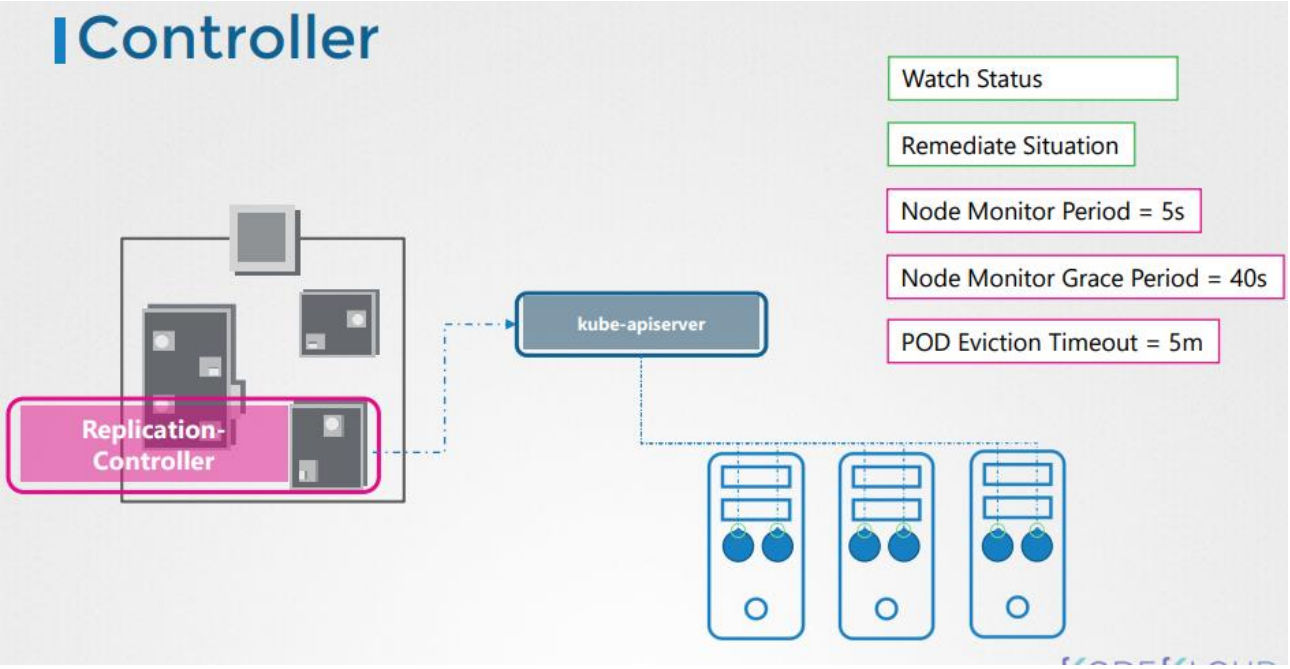
Node Controller

- Responsible for monitoring the state of the Nodes and taking necessary actions to keep the application running.



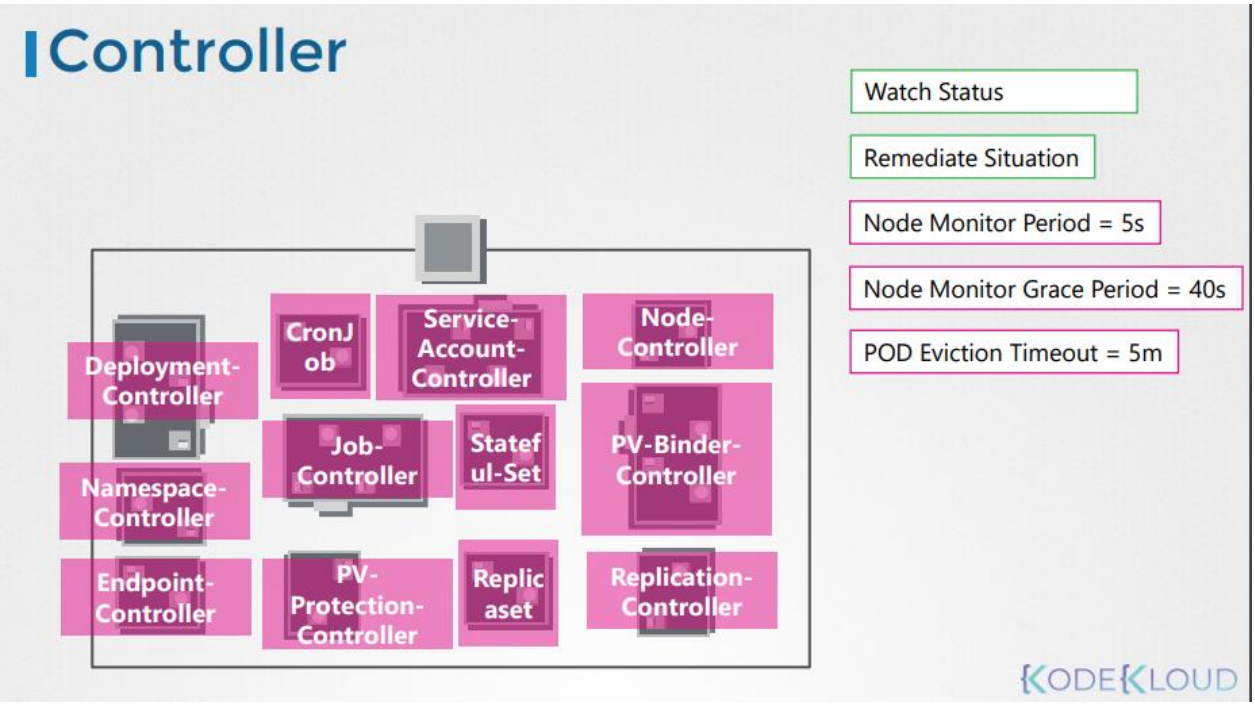
Replication Controller

- It is responsible for monitoring the status of replicasets and ensuring that the desired number of pods are available at all time within the set.



Other Controllers

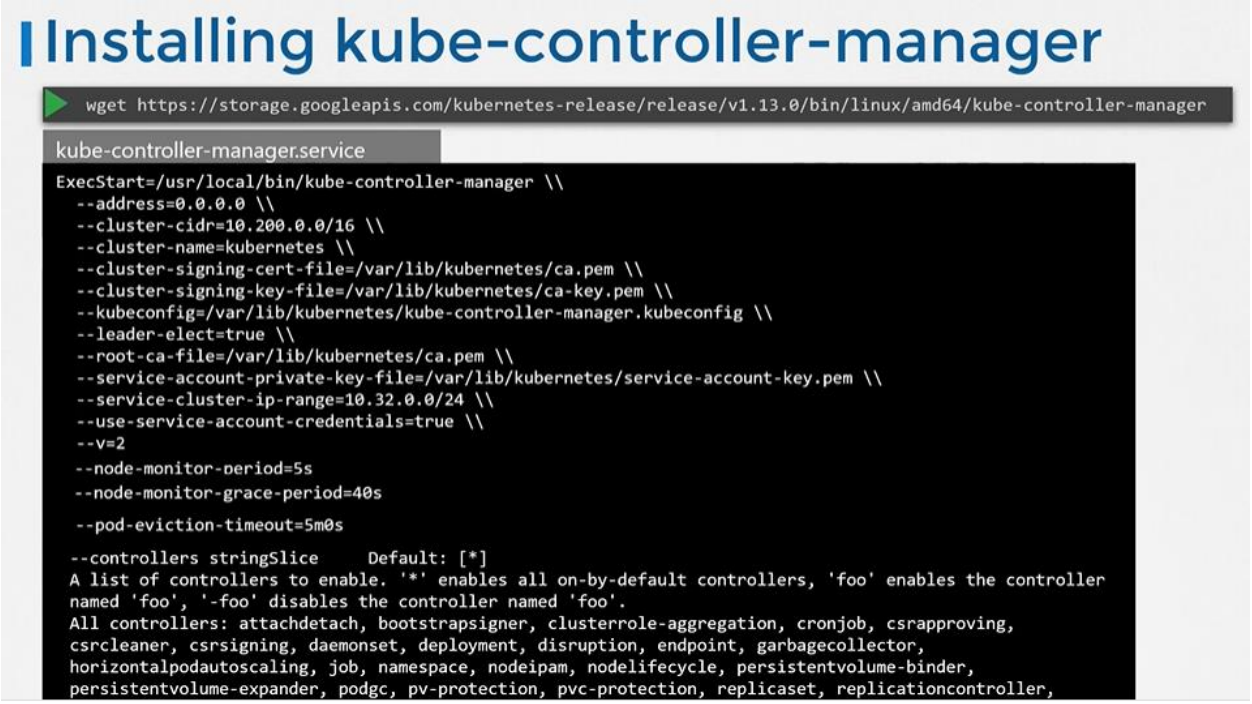
- There are many more such controllers available within kubernetes



Installing Kube-Controller-Manager

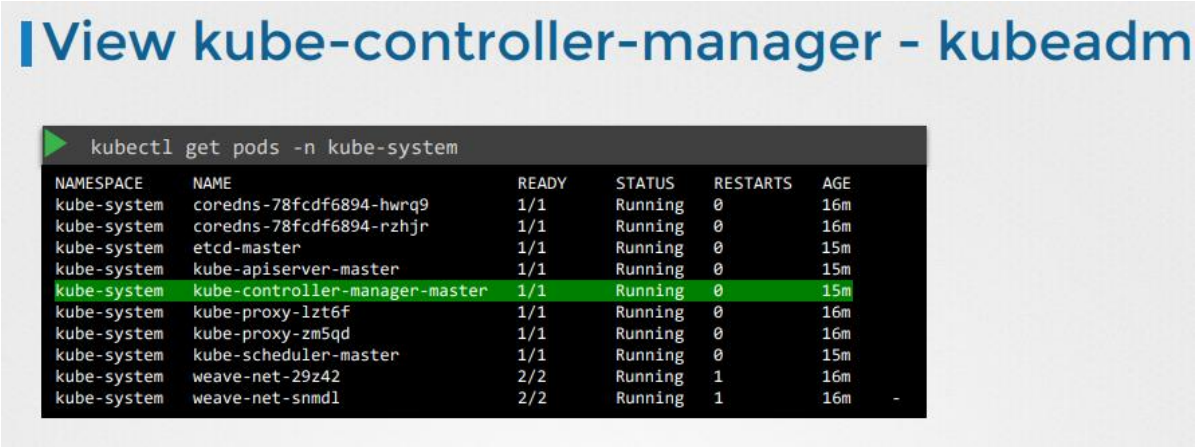
- When you install kube-controller-manager the different controllers will get installed as well.

- Download the kube-controller-manager binary from the kubernetes release page. For example: You can download kube-controller-manager v1.13.0 here [kube-controller-manager]
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.13.0/bin/linux/amd64/kube-controller-manager`
- By default all controllers are enabled, but you can choose to enable specific one from **`kube-controller-manager.service`**
- `$ cat /etc/systemd/system/kube-controller-manager.service`



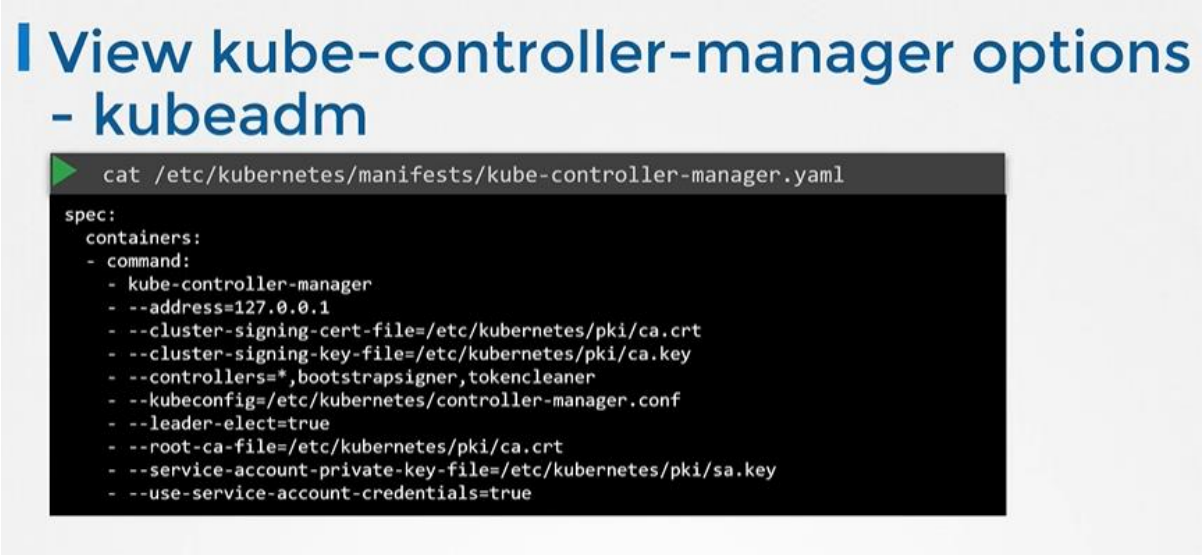
View kube-controller-manager - kubeadm

- kubeadm deploys the kube-controller-manager as a pod in kube-system namespace
- `$ kubectl get pods -n kube-system`



View kube-controller-manager options - kubeadm

- You can see the options within the pod located at **`/etc/kubernetes/manifests/kube-controller-manager.yaml`**
- `$ cat /etc/kubernetes/manifests/kube-controller-manager.yaml`



View kube-controller-manager options - Manual

- In a non-kubeadm setup, you can inspect the options by viewing the **`kube-controller-manager.service`**
- `$ cat /etc/systemd/system/kube-controller-manager.service`

- You can also see the running process and affective options by listing the process on master node and searching for kube-controller-manager.
- `$ ps -aux | grep kube-controller-manager`

```
ps -aux | grep kube-controller-manager
root      1994  2.7  5.1 154360 105024 ?       Ssl  06:45   1:25 kube-controller-manager --address=127.0.0.1 --cluster-signing-cert-file=/etc/kubernetes/pki/ca.crt --cluster-signing-key-file=/etc/kubernetes/pki/ca.key --controllers=*,bootstrapsigner,tokencleaner --kubeconfig=/etc/kubernetes/controller-manager.conf --leader-elect=true --root-ca-file=/etc/kubernetes/pki/ca.crt --service-account-private-key-file=/etc/kubernetes/pki/sa.key --use-service-account-credentials=true
```

K8s Reference Docs:

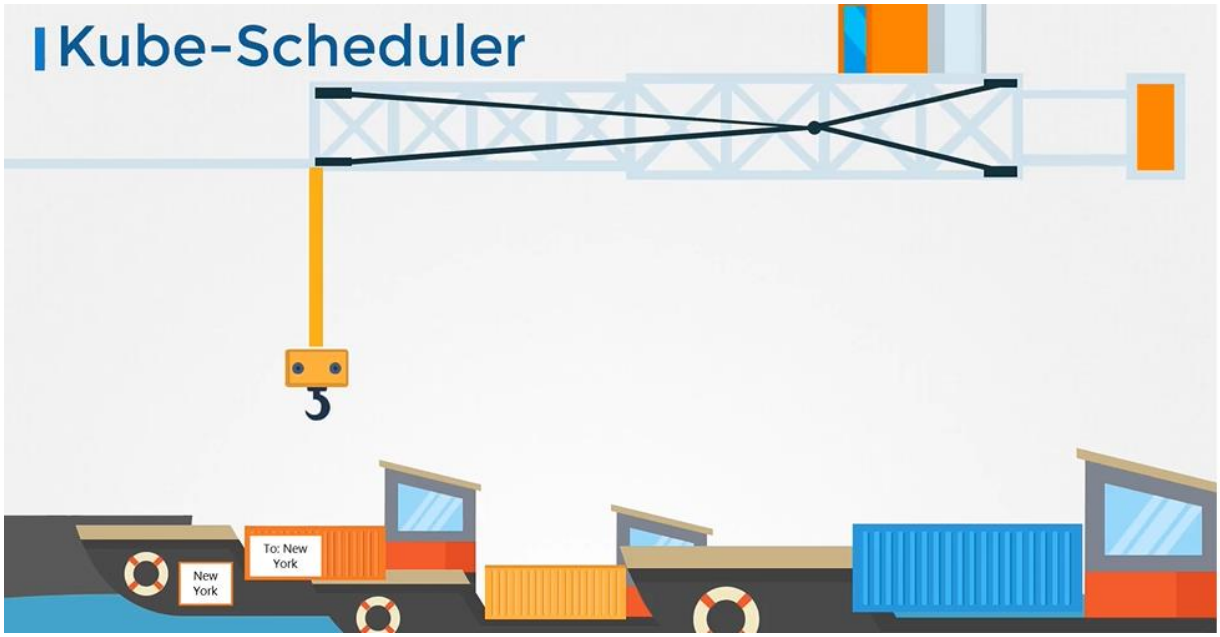
- https://kubernetes.io/docs/reference/command-line-tools-reference/kube-controller-manager/
- https://kubernetes.io/docs/concepts/overview/components/

Kube Scheduler

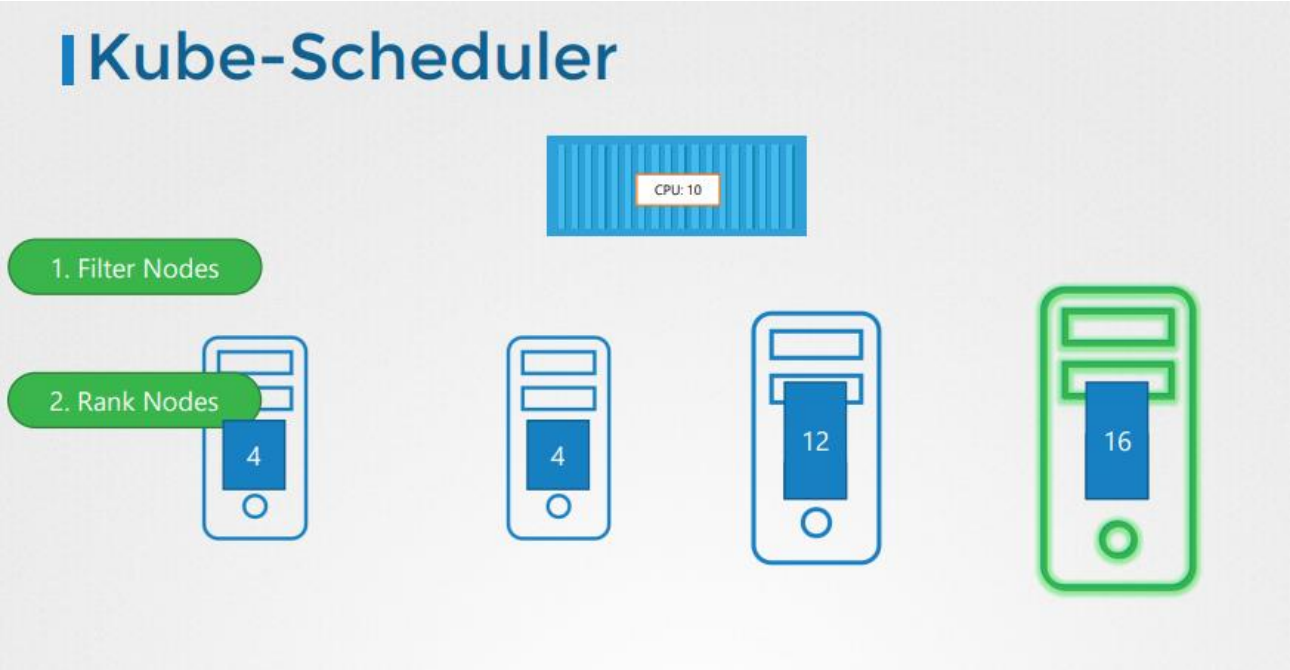
In this section, we will take a look at kube-scheduler.

kube-scheduler is responsible for scheduling pods on nodes.

- The kube-scheduler is only responsible for deciding which pod goes on which node. It doesn't actually place the pod on the nodes, that's the job of the **`kubelet`**.

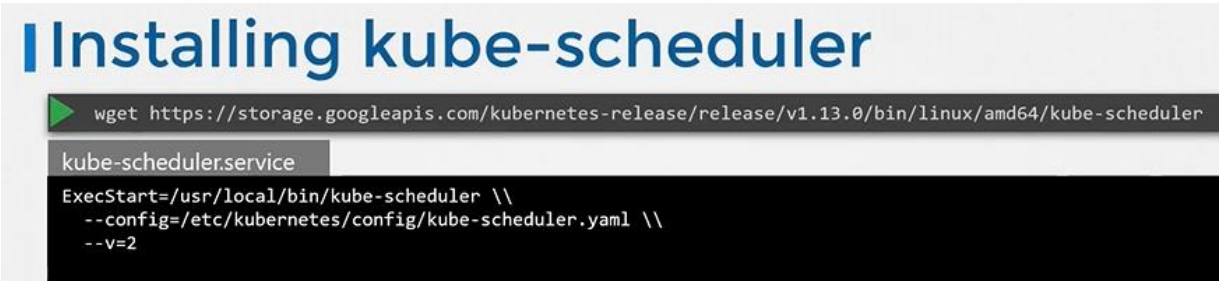


Why do you need a Scheduler?



Install kube-scheduler - Manual

- Download the kubescheduler binary from the kubernetes release pages [kube-scheduler](). For example: To download kube-scheduler v1.13.0, Run the below command.
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.13.0/bin/linux/amd64/kube-scheduler`
- Extract it
- Run it as a service



View kube-scheduler options - kubeadm

- If you set it up with kubeadm tool, kubeadm tool will deploy the kube-scheduler as pod in kube-system namespace on master node.
- `$ kubectl get pods -n kube-system`
- You can see the options for kube-scheduler in pod definition file that is located at **`/etc/kubernetes/manifests/kube-scheduler.yaml`**
- `$ cat /etc/kubernetes/manifests/kube-scheduler.yaml`

- You can also see the running process and affective options by listing the process on master node and searching for kube-apiserver.
- `$ ps -aux | grep kube-scheduler`

K8s Reference Docs:

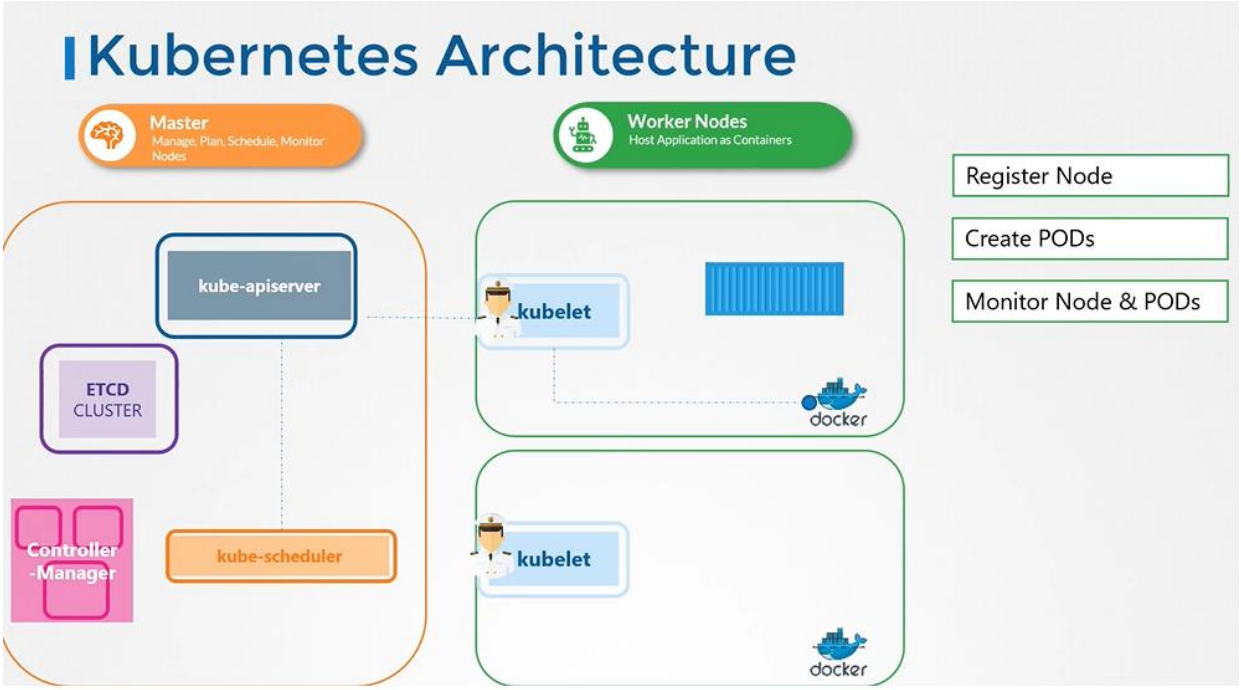
- https://kubernetes.io/docs/reference/command-line-tools-reference/kube-scheduler/
- https://kubernetes.io/docs/concepts/scheduling-eviction/kube-scheduler/
- https://kubernetes.io/docs/concepts/overview/components/
- https://kubernetes.io/docs/tasks/extend-kubernetes/configure-multiple-schedulers/

Kubelet

In this section we will take a look at kubelet.

Kubelet is the sole point of contact for the kubernetes cluster

- The **`kubelet`** will create the pods on the nodes, the scheduler only decides which pods goes where.

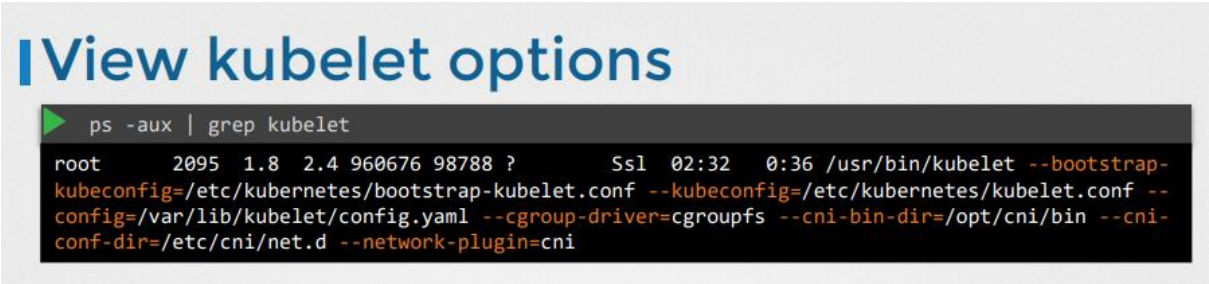


Install kubelet

- Kubeadm does not deploy kubelet by default. You must manually download and install it.
- Download the kubelet binary from the kubernetes release pages kubelet. For example: To download kubelet v1.13.0, Run the below command.
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.13.0/bin/linux/amd64/kubelet`
- Extract it
- Run it as a service

View kubelet options

- You can also see the running process and affective options by listing the process on worker node and searching for kubelet.
- `$ ps -aux |grep kubelet`



K8s Reference Docs:

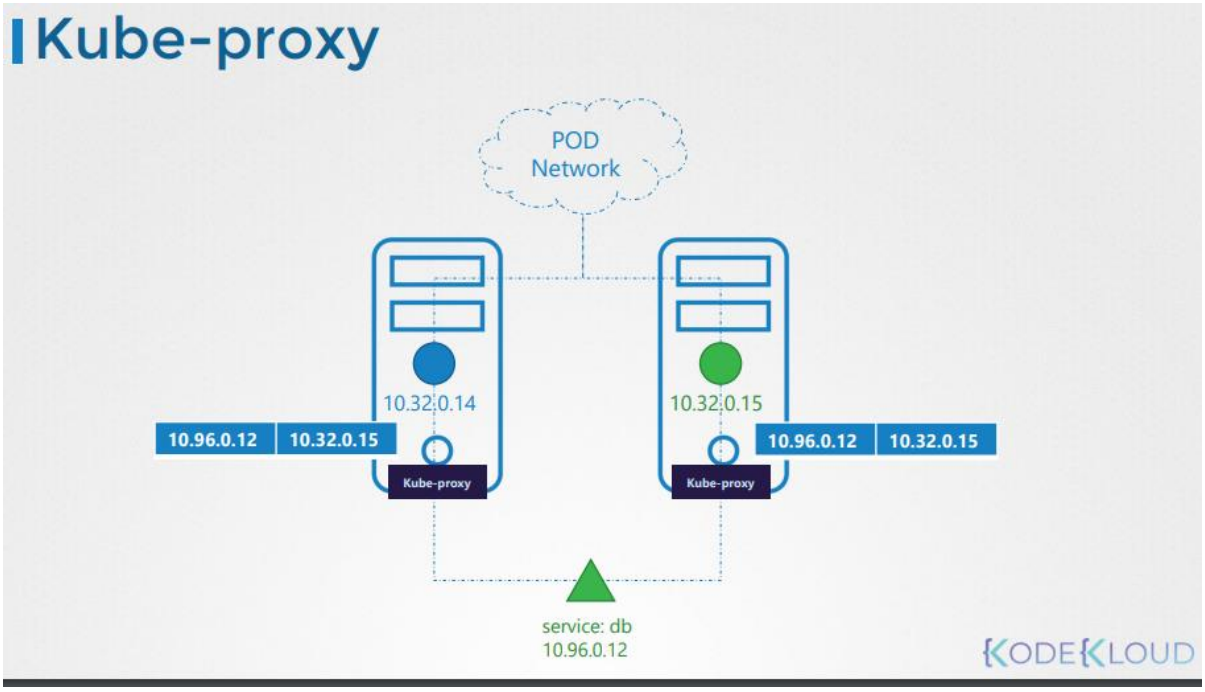
- https://kubernetes.io/docs/reference/command-line-tools-reference/kubelet/
- https://kubernetes.io/docs/concepts/overview/components/
- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/kubelet-integration/

Kube Proxy

In this section, we will take a look at kube-proxy.

Within Kubernetes Cluster, every pod can reach every other pod, this is accomplish by deploying a pod networking cluster to the cluster.

- Kube-Proxy is a process that runs on each node in the kubernetes cluster.

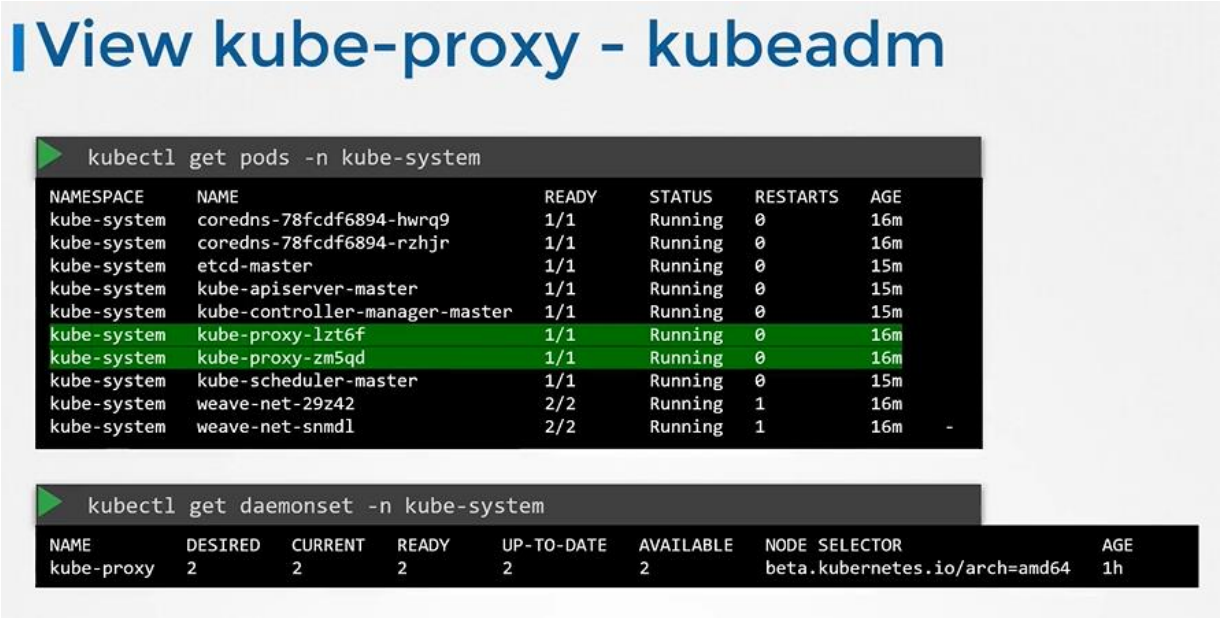


Install kube-proxy - Manual

- Download the kube-proxy binary from the kubernetes release pages kube-proxy. For example: To download kube-proxy v1.13.0, Run the below command.
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.13.0/bin/linux/amd64/kube-proxy`
- Extract it
- Run it as a service

View kube-proxy options - kubeadm

- If you set it up with kubeadm tool, kubeadm tool will deploy the kube-proxy as pod in kube-system namespace. In fact it is deployed as a daemonset on master node.
- `$ kubectl get pods -n kube-system`



K8s Reference Docs:

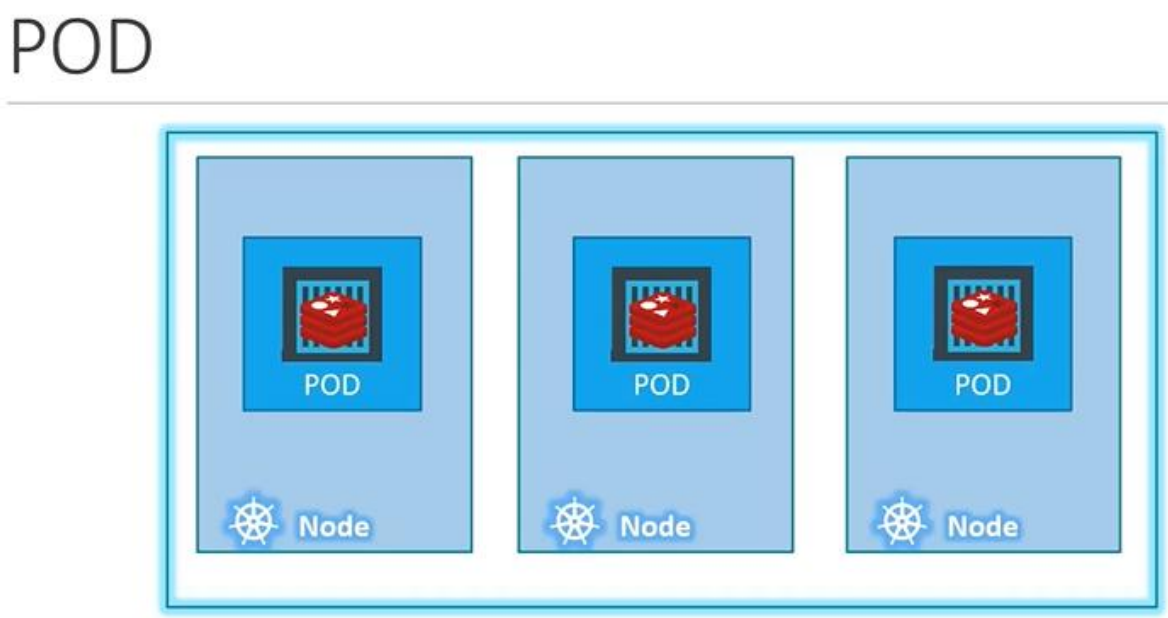
- https://kubernetes.io/docs/reference/command-line-tools-reference/kube-proxy/
- https://kubernetes.io/docs/concepts/overview/components/

Pods

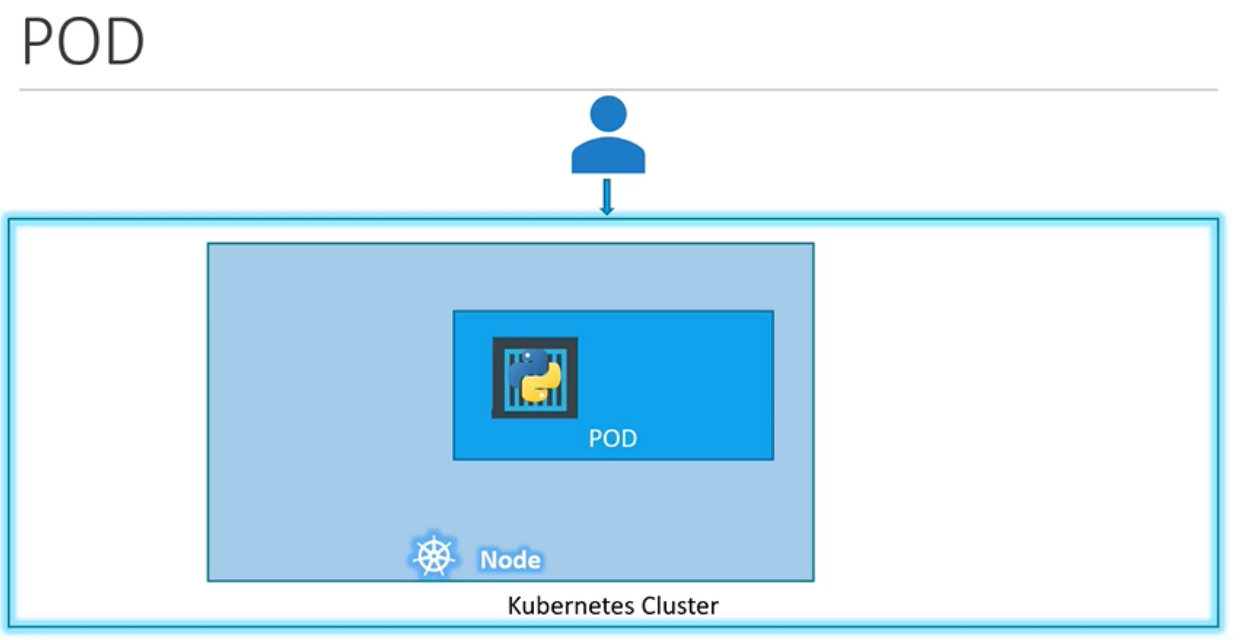
In this section, we will take a look at PODS.

- POD introduction
- How to deploy pod?

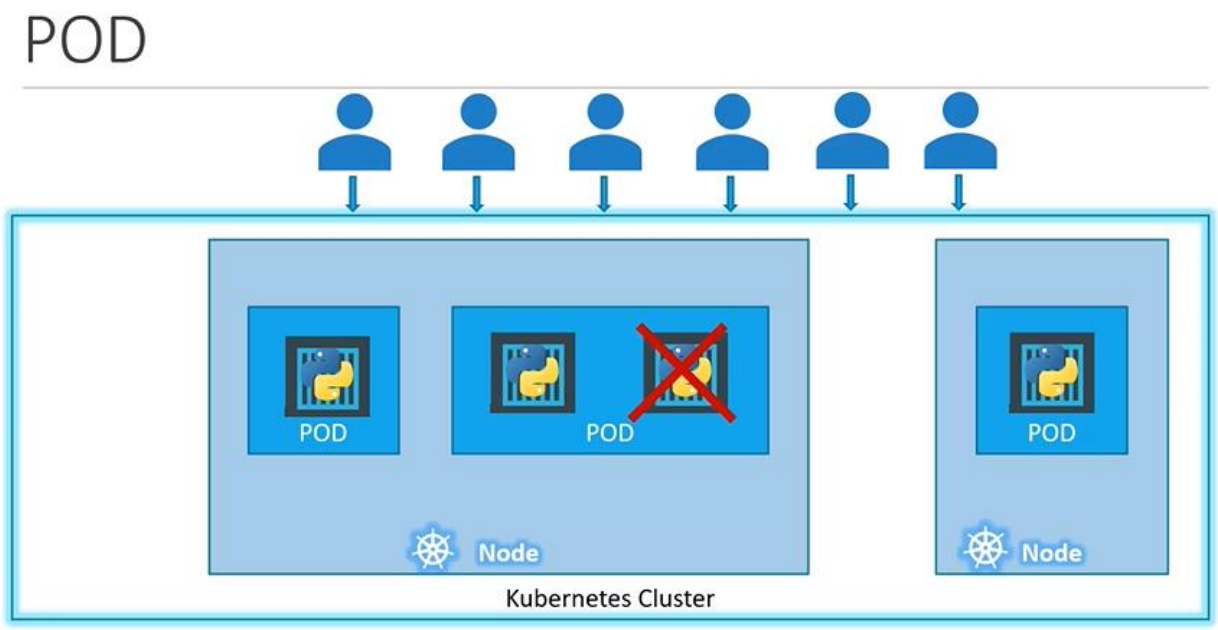
Kubernetes doesn't deploy containers directly on the worker node.



Here is a single node kubernetes cluster with single instance of your application running in a single docker container encapsulated in the pod.

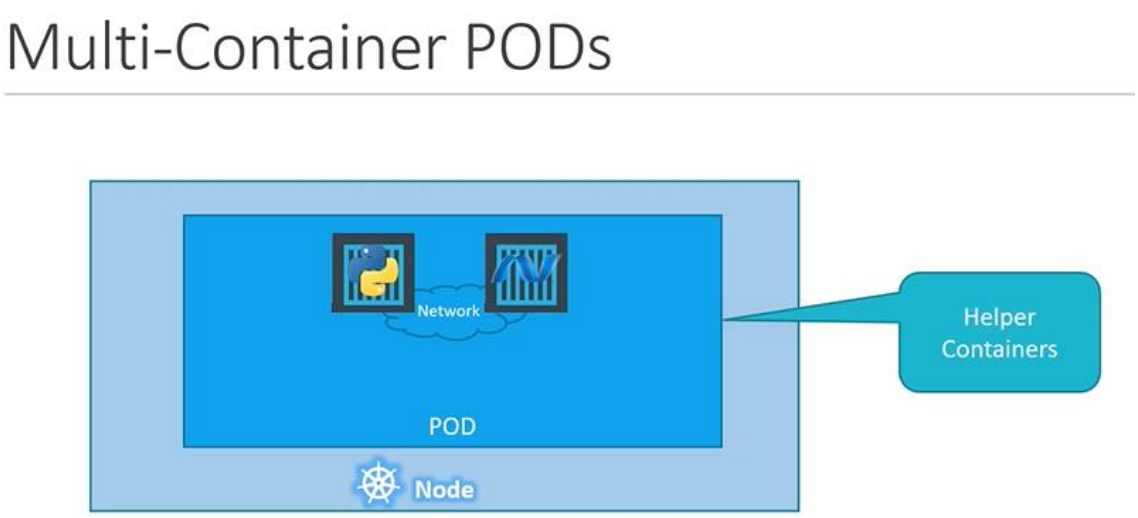


Pod will have a one-to-one relationship with containers running your application.

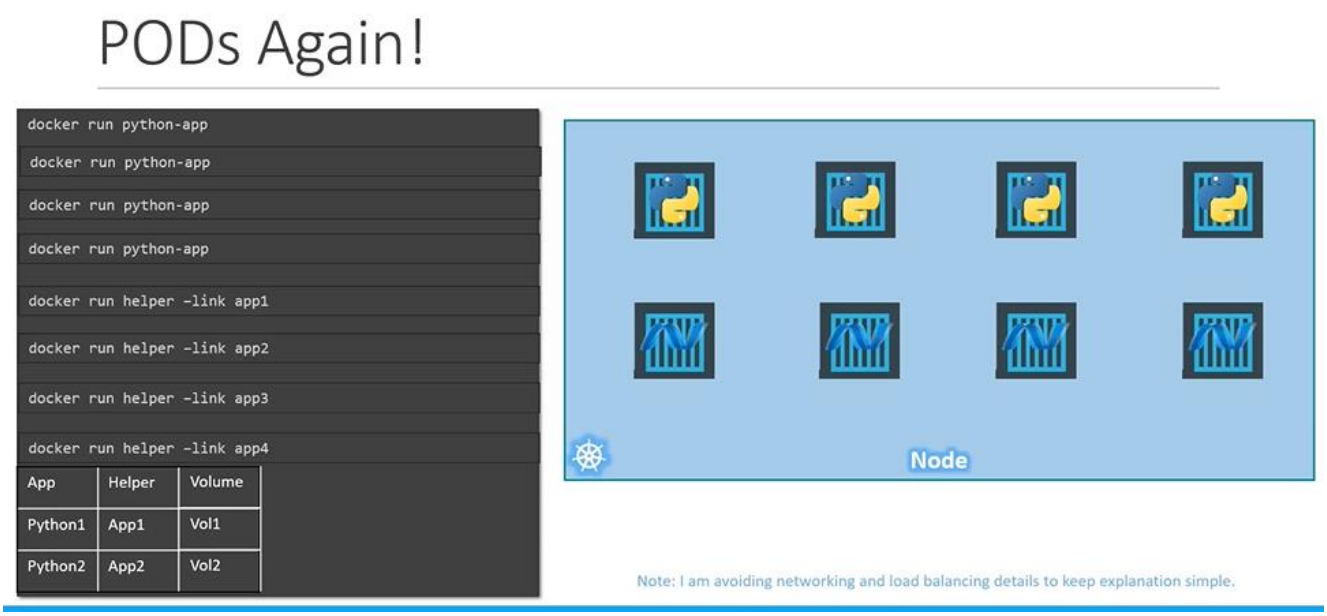


Multi-Container PODs

- A single pod can have multiple containers except for the fact that they are usually not multiple containers of the **`same kind`**.



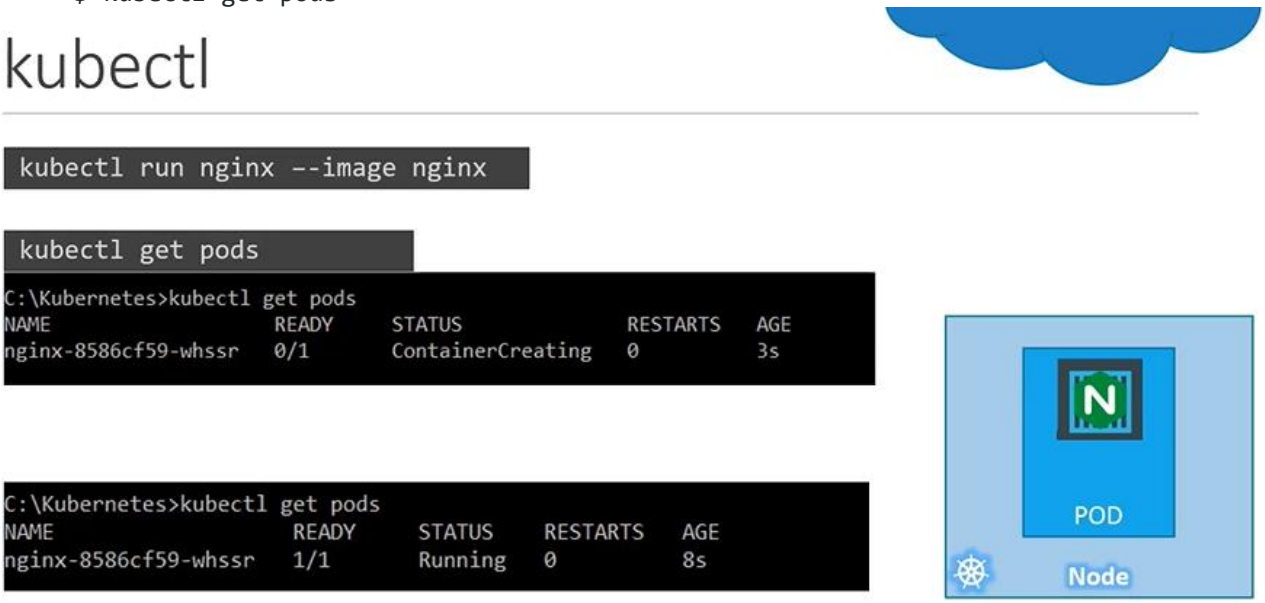
Docker Example (Docker Link)



How to deploy pods?

Lets now take a look to create a nginx pod using **`kubectl`**.

- To deploy a docker container by creating a POD.
- `$ kubectl run nginx --image nginx`
- To get the list of pods
- `$ kubectl get pods`



K8s Reference Docs:

- https://kubernetes.io/docs/concepts/workloads/pods/pod/
- https://kubernetes.io/docs/concepts/workloads/pods/pod-overview/
- https://kubernetes.io/docs/tutorials/kubernetes-basics/explore/explore-intro/

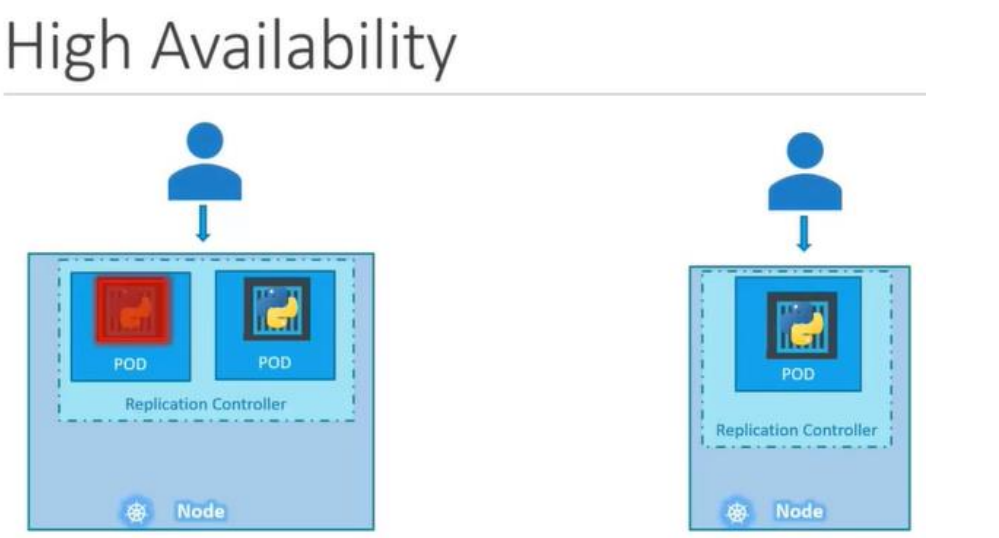
ReplicaSets

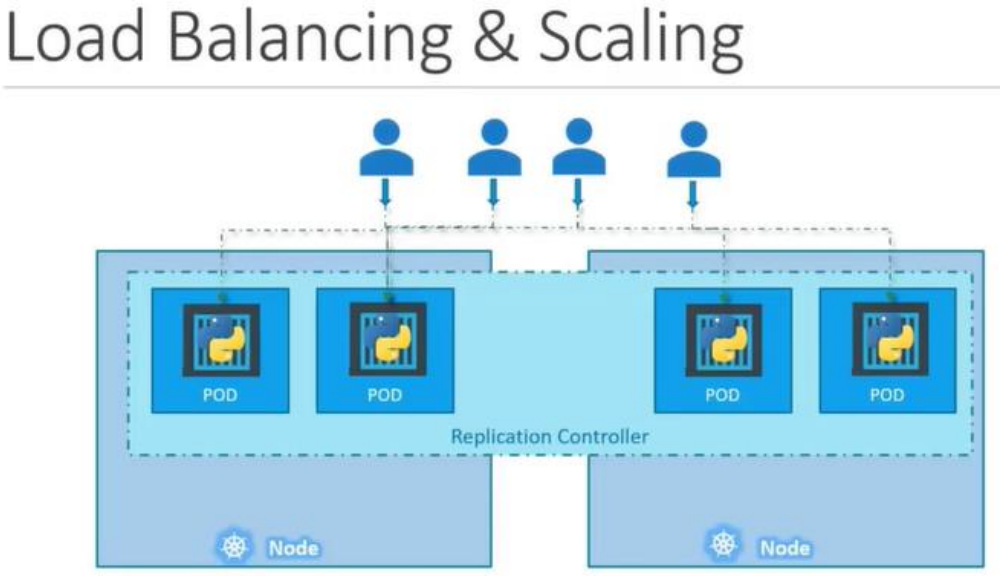
In this section, we will take a look at the below

- Replication Controller
- ReplicaSet

Controllers are brain behind kubernetes

What is a Replica and Why do we need a replication controller?





Difference between ReplicaSet and Replication Controller

- **`Replication Controller`** is the older technology that is being replaced by a **`ReplicaSet`**.
- **`ReplicaSet`** is the new way to setup replication.

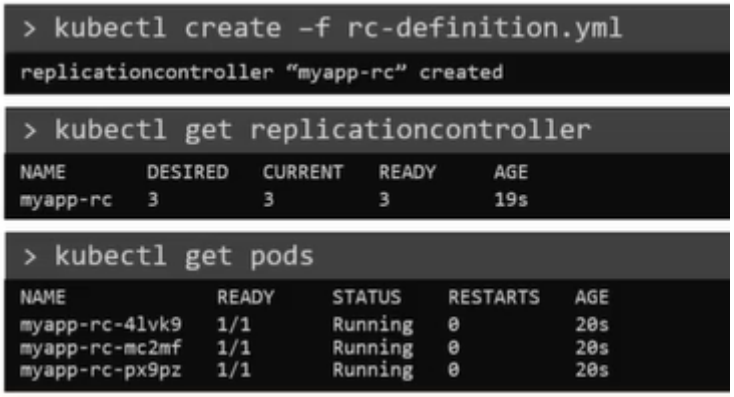
Creating a Replication Controller

Replication Controller Definition File


```
apiVersion: v1
kind: ReplicationController
metadata:
  name: myapp-rc
  labels:
    app: myapp
    type: front-end
spec:
 template:
    metadata:
      name: myapp-pod
      labels:
        app: myapp
        type: front-end
```

```
    spec:
     containers:
     - name: nginx-container
       image: nginx
replicas: 3
```

- To Create the replication controller
- `$ kubectl create -f rc-definition.yaml`
- To list all the replication controllers
- `$ kubectl get replicationcontroller`
- To list pods that are launch by the replication controller
- `$ kubectl get pods`



Creating a ReplicaSet

ReplicaSet Definition File

replicaset-definition.yml

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: myapp-replicaset
  labels:
      app: myapp
      type: front-end
spec:
 template:
    metadata:
     name: myapp-pod
     labels:
        app: myapp
        type: front-end
    spec:
      containers:
      - name: nginx-container
        image: nginx

 replicas: 3
 selector:
    matchLabels:
       type: front-end
```

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: myapp-replicaset
  labels:
    app: myapp
    type: front-end
spec:
 template:
    metadata:
      name: myapp-pod
      labels:
        app: myapp
        type: front-end
    spec:
     containers:
     - name: nginx-container
       image: nginx
 replicas: 3
```

```
selector:
  matchLabels:
   type: front-end
```

ReplicaSet requires a selector definition when compare to Replication Controller.

- To Create the replicaset
- `$ kubectl create -f replicaset-definition.yaml`
- To list all the replicaset
- `$ kubectl get replicaset`
- To list pods that are launch by the replicaset
- `$ kubectl get pods`

```
> kubectl create -f replicaset-definition.yml
replicaset "myapp-replicaset" created
> kubectl get replicaset
NAME            DESIRED   CURRENT   READY     AGE
myapp-replicaset   3         3         3         19s
> kubectl get pods
NAME                    READY     STATUS    RESTARTS   AGE
myapp-replicaset-9dd19   1/1       Running   0          45s
myapp-replicaset-9jtpx   1/1       Running   0          45s
myapp-replicaset-hq84m   1/1       Running   0          45s
```

Labels and Selectors

What is the deal with Labels and Selectors? Why do we label pods and objects in kubernetes?

How to scale replicaset

- There are multiple ways to scale replicaset
  - First way is to update the number of replicas in the replicaset-definition.yaml definition file. E.g replicas: 6 and then run

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: myapp-replicaset
  labels:
    app: myapp
    type: front-end
spec:
 template:
    metadata:
      name: myapp-pod
      labels:
        app: myapp
        type: front-end
    spec:
     containers:
     - name: nginx-container
       image: nginx
 replicas: 6
 selector:
   matchLabels:
    type: front-end
$ kubectl apply -f replicaset-definition.yaml
```

- Second way is to use **`kubectl scale`** command.

```
$ kubectl scale --replicas=6 -f replicaset-definition.yaml
```

- Third way is to use **`kubectl scale`** command with type and name

```
$ kubectl scale --replicas=6 replicaset myapp-replicaset
```

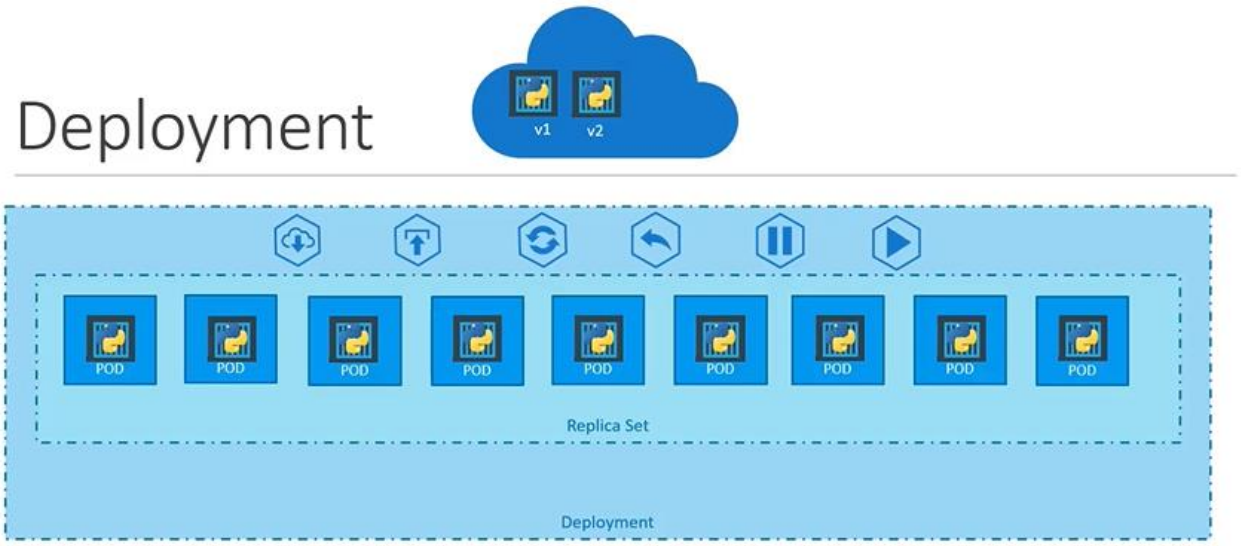
K8s Reference Docs:

- https://kubernetes.io/docs/concepts/workloads/controllers/replicaset/
- https://kubernetes.io/docs/concepts/workloads/controllers/replicationcontroller/

Deployments

In this section, we will take a look at kubernetes deployments

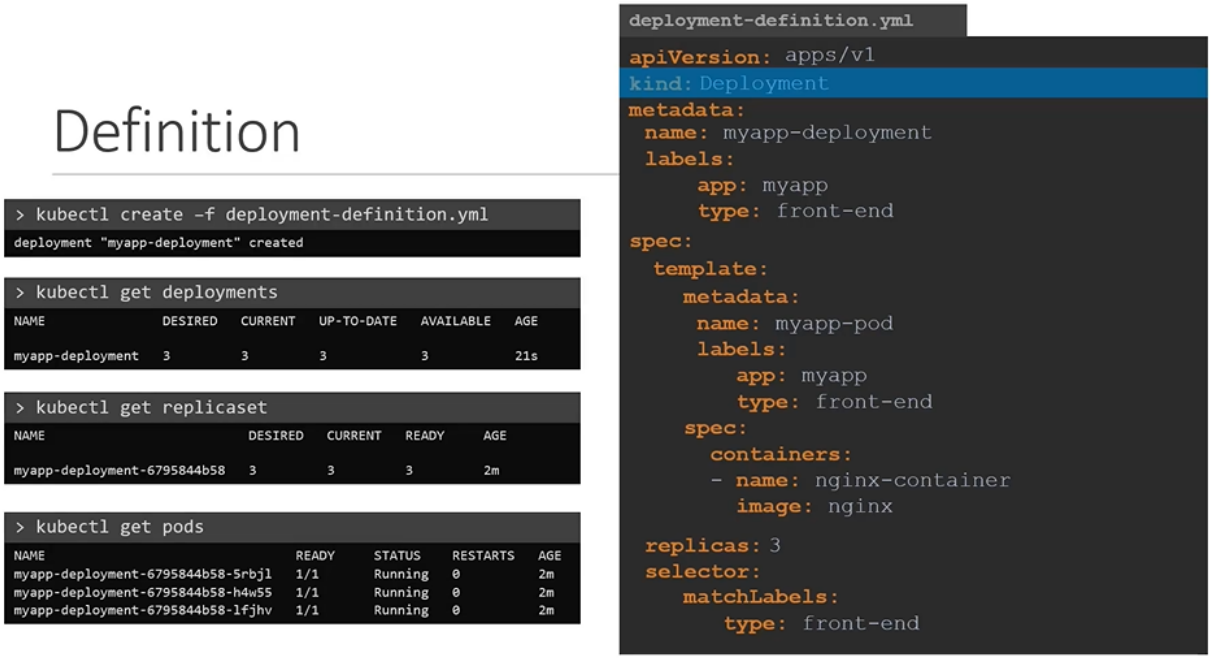
Deployment is a kubernetes object.



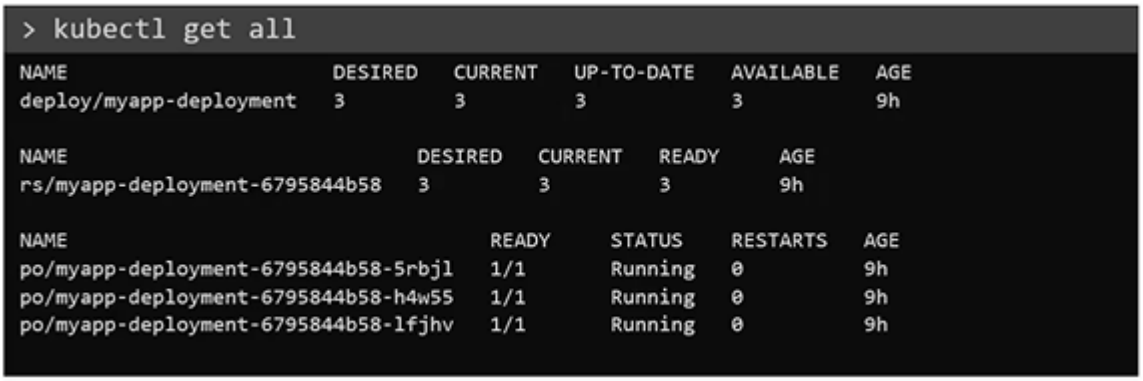
How do we create deployment?

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp-deployment
  labels:
    app: myapp
    type: front-end
spec:
 template:
    metadata:
      name: myapp-pod
      labels:
        app: myapp
        type: front-end
    spec:
     containers:
     - name: nginx-container
       image: nginx
 replicas: 3
 selector:
   matchLabels:
    type: front-end
```

- Once the file is ready, create the deployment using deployment definition file
- `$ kubectl create -f deployment-definition.yaml`
- To see the created deployment
- `$ kubectl get deployment`
- The deployment automatically creates a **`ReplicaSet`**. To see the replicasets
- `$ kubectl get replicaset`
- The replicasets ultimately creates **`PODs`**. To see the PODs
- `$ kubectl get pods`



- To see the all objects at once
- `$ kubectl get all`



K8s Reference Docs:

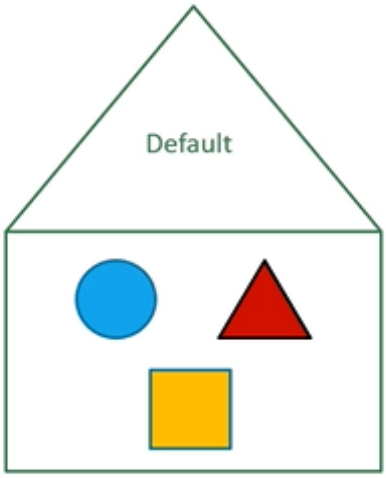
- https://kubernetes.io/docs/concepts/workloads/controllers/deployment/
- https://kubernetes.io/docs/tutorials/kubernetes-basics/deploy-app/deploy-intro/
- https://kubernetes.io/docs/concepts/cluster-administration/manage-deployment/
- https://kubernetes.io/docs/concepts/overview/working-with-objects/kubernetes-objects/

Namespaces

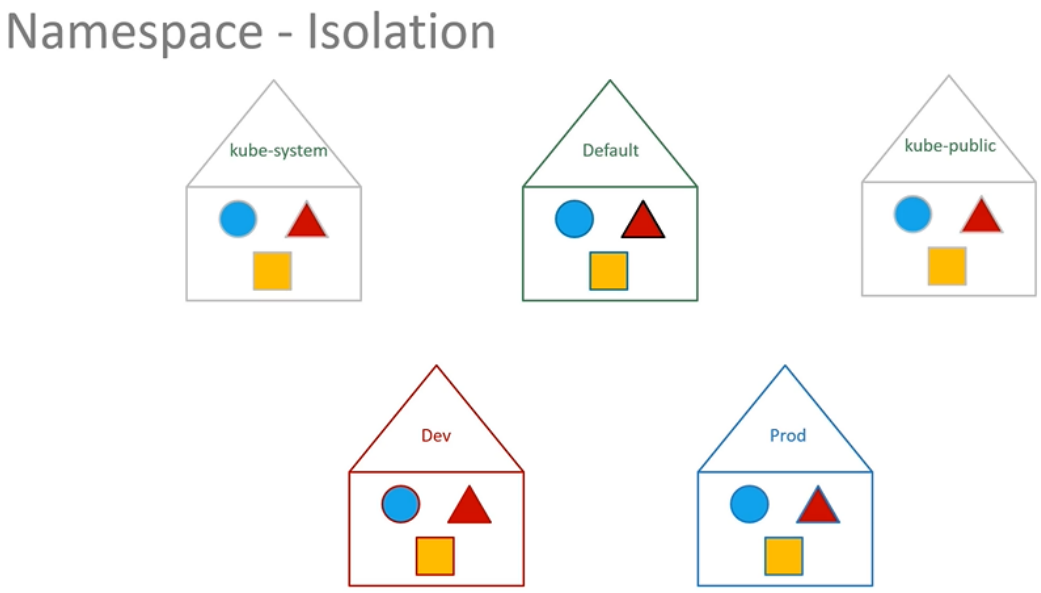
In this section, we will take a look at **`Namespaces`**

So far in this course we have created **`Objects`** such as **`PODs`**, **`Deployments`** and **`Services`** in our cluster. Whatever we have been doing we have been doing in a **`NAMESPACE`**.

- This namespace is the **`default`** namespace in kubernetes. It is automatically created when kubernetes is setup initially.



- You can create your own namespaces as well.

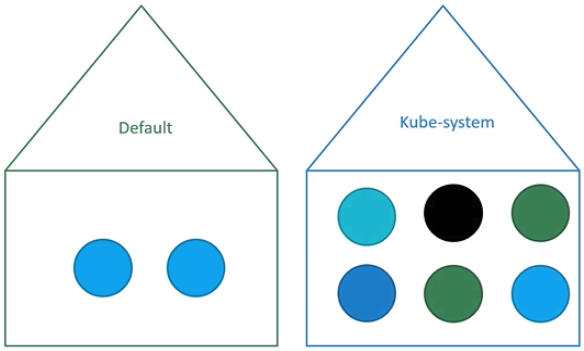


- To list the pods in default namespace

- `$ kubectl get pods`
- To list the pods in another namespace. Use **`kubectl get pods`** command along with the **`--namespace`** flag or argument.
- `$ kubectl get pods --namespace=kube-system`

```
> kubectl get pods
NAME      READY   STATUS    RESTARTS   AGE
Pod-1     1/1     Running   0          3d
Pod-2     1/1     Running   0          3d
```

```
> kubectl get pods --namespace=kube-system
NAME                              READY   STATUS    RESTAR
coredns-78fcdf6894-92d52          1/1     Running   7
coredns-78fcdf6894-jx25g          1/1     Running   7
etcd-master                       1/1     Running   7
kube-apiserver-master             1/1     Running   7
kube-controller-manager-master    1/1     Running   7
kube-flannel-ds-amd64-hz4cf       1/1     Running   14
kube-proxy-4b8tn                  1/1     Running   7
kube-proxy-98db4                  1/1     Running   7
kube-proxy-jjrbs                  1/1     Running   7
kube-scheduler-master             1/1     Running   7
```



- Here we have a pod definition file, when we create a pod with pod-definition file, the pod is created in the default namespace.

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
     app: myapp
     type: front-end
spec:
  containers:
  - name: nginx-container
    image: nginx
$ kubectl create -f pod-definition.yaml
```

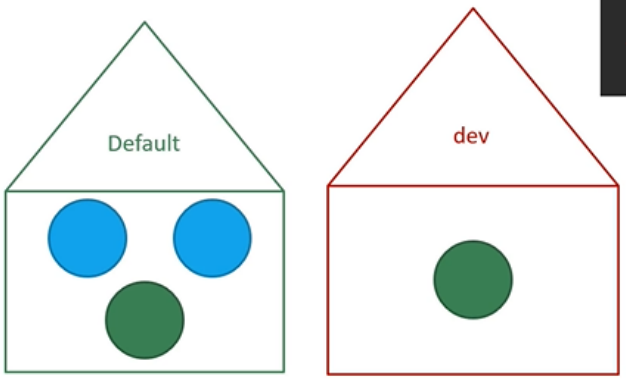
- To create the pod with the pod-definition file in another namespace, use the **--namespace** option.
- `$ kubectl create -f pod-definition.yaml --namespace=dev`

```
> kubectl create -f pod-definition.yml
pod/myapp-pod created
```

```
> kubectl create -f pod-definition.yml --namespace=dev
pod/myapp-pod created
```

pod-definition.yml

```
apiVersion: v1
kind: Pod

metadata:
 name: myapp-pod
 labels:
    app: myapp
    type: front-end
spec:
  containers:
  - name: nginx-container
    image: nginx
```



- If you want to make sure that this pod gets you created in the **dev** env all the time, even if you don't specify in the command line, you can move the **--namespace** definition into the pod-definition file.

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  namespace: dev
  labels:
     app: myapp
     type: front-end
spec:
  containers:
  - name: nginx-container
    image: nginx
```

pod-definition.yml

```yaml
apiVersion: v1
kind: Pod

metadata:
 name: myapp-pod
 namespace: dev

 labels:
    app: myapp
    type: front-end
spec:
  containers:
  - name: nginx-container
    image: nginx
```

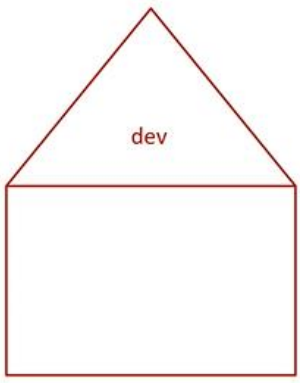
- To create a new namespace, create a namespace definition as shown below and then run **`kubectl create`**

```
apiVersion: v1
kind: Namespace
metadata:
  name: dev
$ kubectl create -f namespace-dev.yaml
```

Another way to create a namespace

```
$ kubectl create namespace dev
```

Create Namespace



namespace-dev.yml

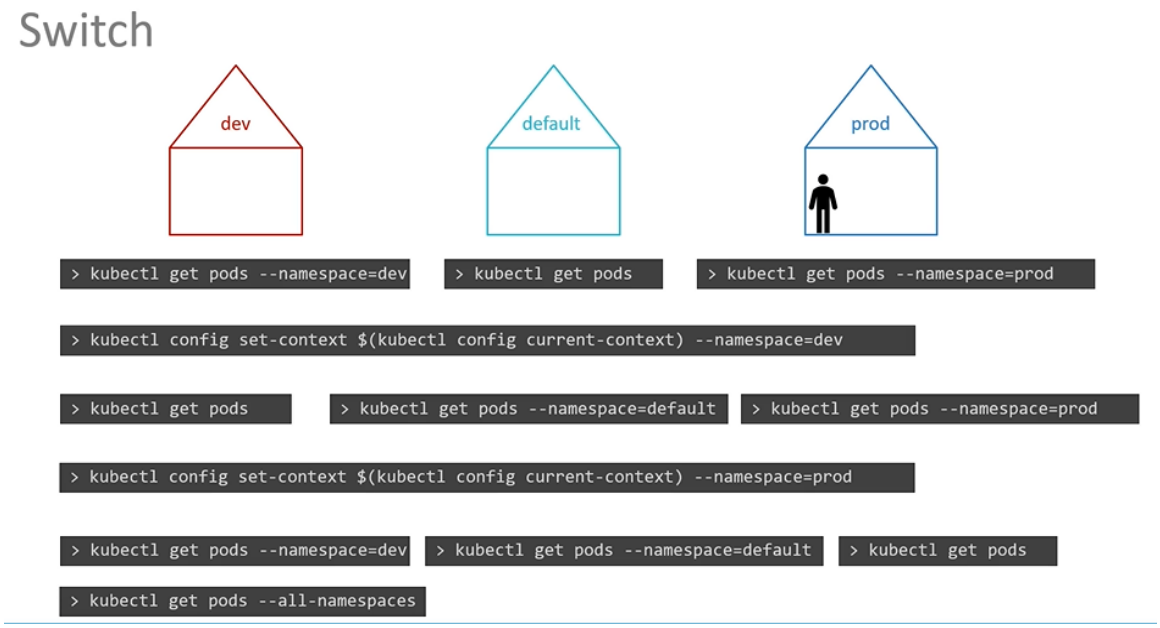
```yaml
apiVersion: v1
kind: Namespace
metadata:
    name: dev
```

```
> kubectl create -f namespace-dev.yml
namespace/dev created
```

```
> kubectl create namespace dev
namespace/dev created
```

- By default, we will be in a **`default`** namespace. To switch to a particular namespace permenently run the below command.
- `$ kubectl config set-context $(kubectl config current-context) --namespace=dev`

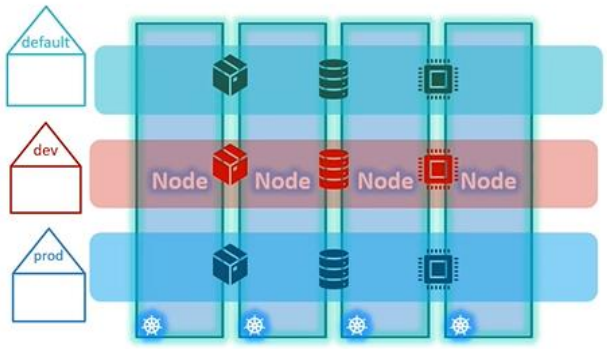
- To view pods in all namespaces
- `$ kubectl get pods --all-namespaces`



- To limit resources in a namespace, create a resource quota. To create one start with **`ResourceQuota`** definition file.

```
apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-quota
  namespace: dev
spec:
  hard:
    pods: "10"
    requests.cpu: "4"
    requests.memory: 5Gi
    limits.cpu: "10"
    limits.memory: 10Gi
$ kubectl create -f compute-quota.yaml
```

Resource Quota



Compute-quota.yaml

```yaml
apiVersion: v1
kind: ResourceQuota
metadata:
    name: compute-quota
    namespace: dev
spec:
  hard:
    pods: "10"
    requests.cpu: "4"
    requests.memory: 5Gi
    limits.cpu: "10"
    limits.memory: 10Gi
```

```
> kubectl create -f compute-quota.yaml
```

K8s Reference Docs:

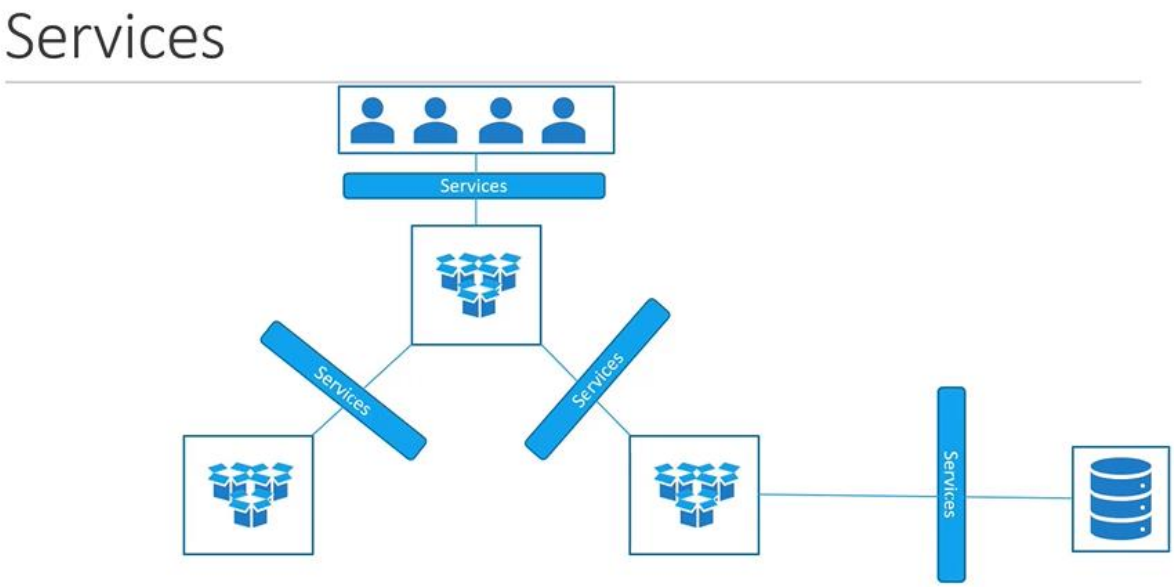
- https://kubernetes.io/docs/concepts/overview/working-with-objects/namespaces/
- https://kubernetes.io/docs/tasks/administer-cluster/namespaces-walkthrough/
- https://kubernetes.io/docs/tasks/administer-cluster/namespaces/
- https://kubernetes.io/docs/tasks/administer-cluster/manage-resources/quota-memory-cpu-namespace/
- https://kubernetes.io/docs/tasks/access-application-cluster/list-all-running-container-images/

Kubernetes Services

In this section we will take a look at **`services`** in kubernetes

Services

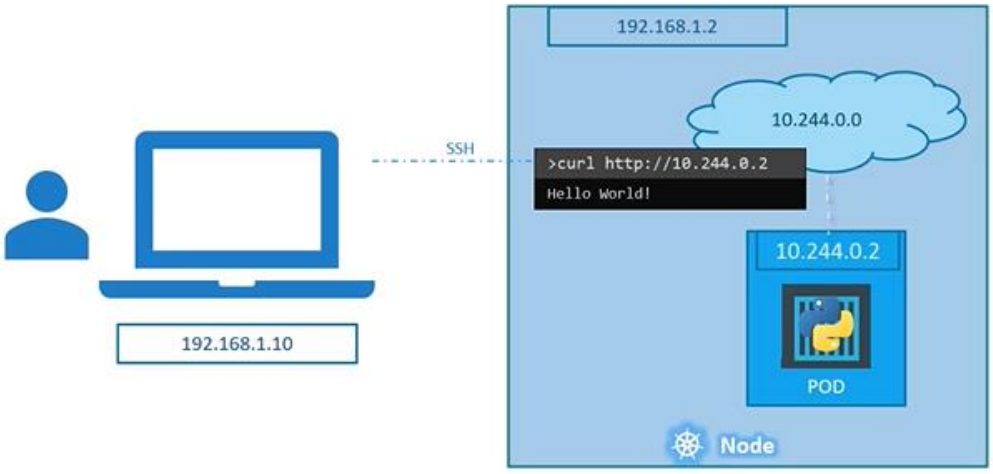
- Kubernetes Services enables communication between various components within and outside of the application.



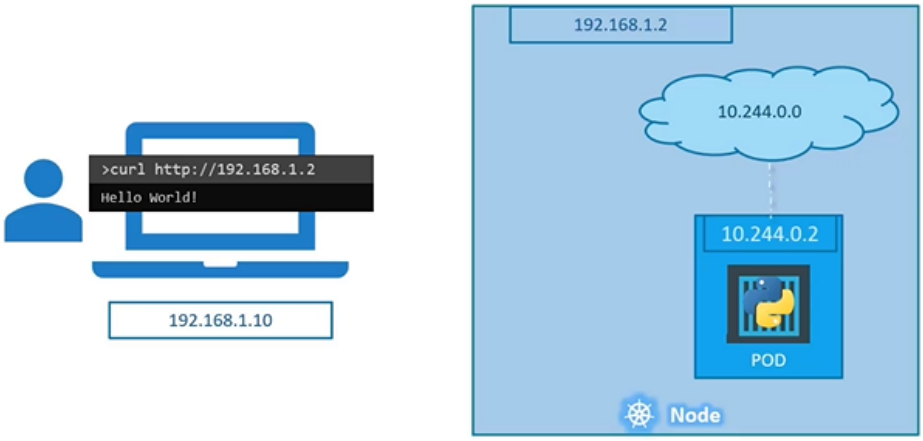
Let's look at some other aspects of networking

External Communication

- How do we as an **`external user`** access the **`web page`**?
    - From the node (Able to reach the application as expected)

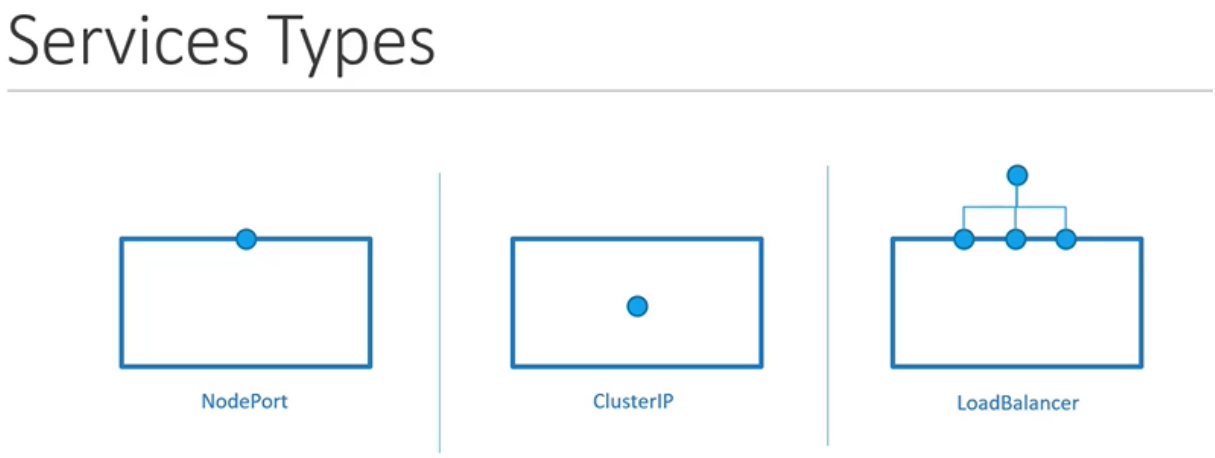


    - From outside world (This should be our expectation, without something in the middle it will not reach the application)



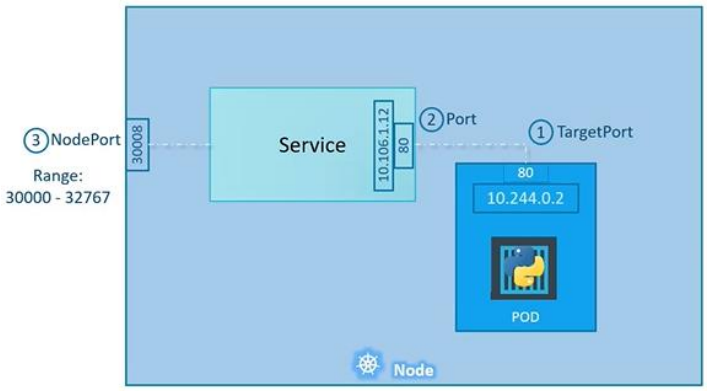
Service Types

There are 3 types of service types in kubernetes



1. NodePort
    - Where the service makes an internal POD accessible on a POD on the NODE.
    - `apiVersion: v1`
    - `kind: Service`
    - `metadata:`
    - `  name: myapp-service`
    - `spec:`
    - `  types: NodePort`
    - `  ports:`
    - `  - targetPort: 80`
    - `    port: 80`
    - `    nodePort: 30008`

Service - NodePort



service-definition.yml

```yaml
apiVersion: v1
kind: Service
metadata:
    name: myapp-service

spec:
    type: NodePort
    ports:
     - targetPort: 80
       port: 80
       nodePort: 30008
```

To connect the service to the pod

```yaml
apiVersion: v1
kind: Service
metadata:
 name: myapp-service
spec:
 types: NodePort
 ports:
 - targetPort: 80
   port: 80
   nodePort: 30008
 selector:
   app: myapp
   type: front-end
```

Service - NodePort

service-definition.yml

```yaml
apiVersion: v1
kind: Service
metadata:
    name: myapp-service

spec:
    type: NodePort
    ports:
     - targetPort: 80
       port: 80
       nodePort: 30008
    selector:
       app: myapp
       type: front-end
```

pod-definition.yml

```yaml
apiVersion: v1
kind: Pod

metadata:
 name: myapp-pod
 labels:


spec:
  containers:
  - name: nginx-container
    image: nginx
```

To create the service

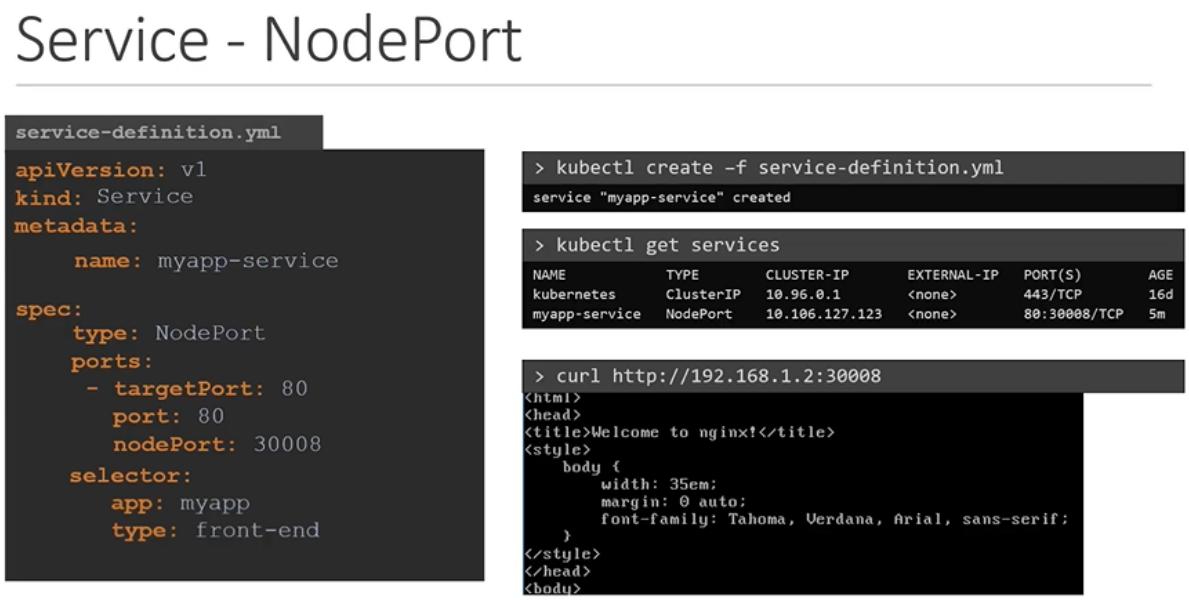
```
$ kubectl create -f service-definition.yaml
```

To list the services

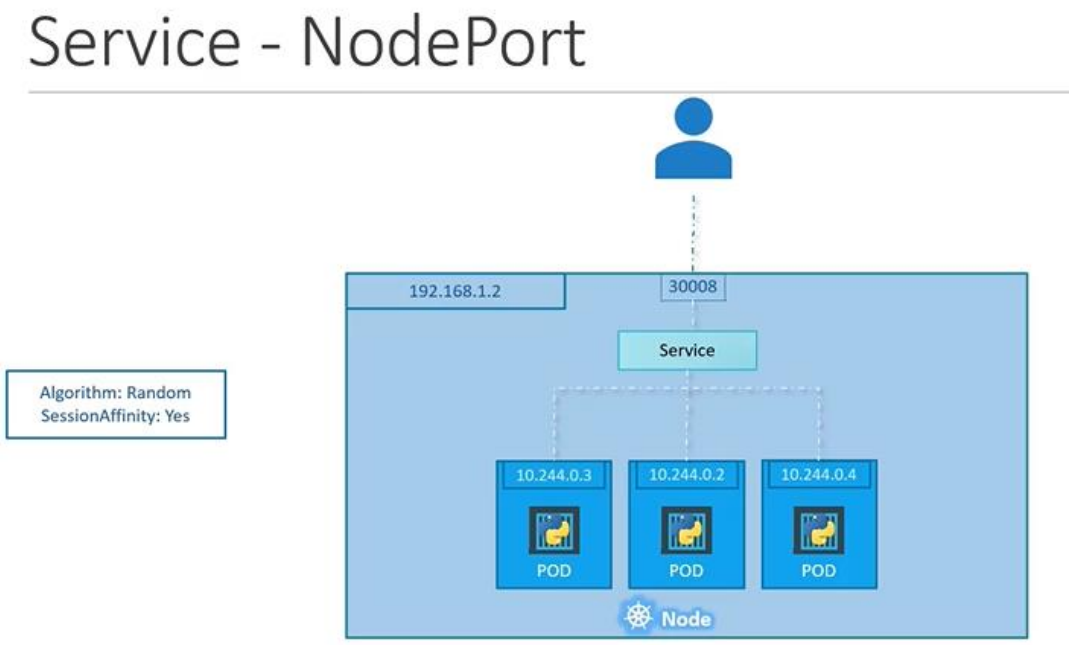
```
$ kubectl get services
```

To access the application from CLI instead of web browser

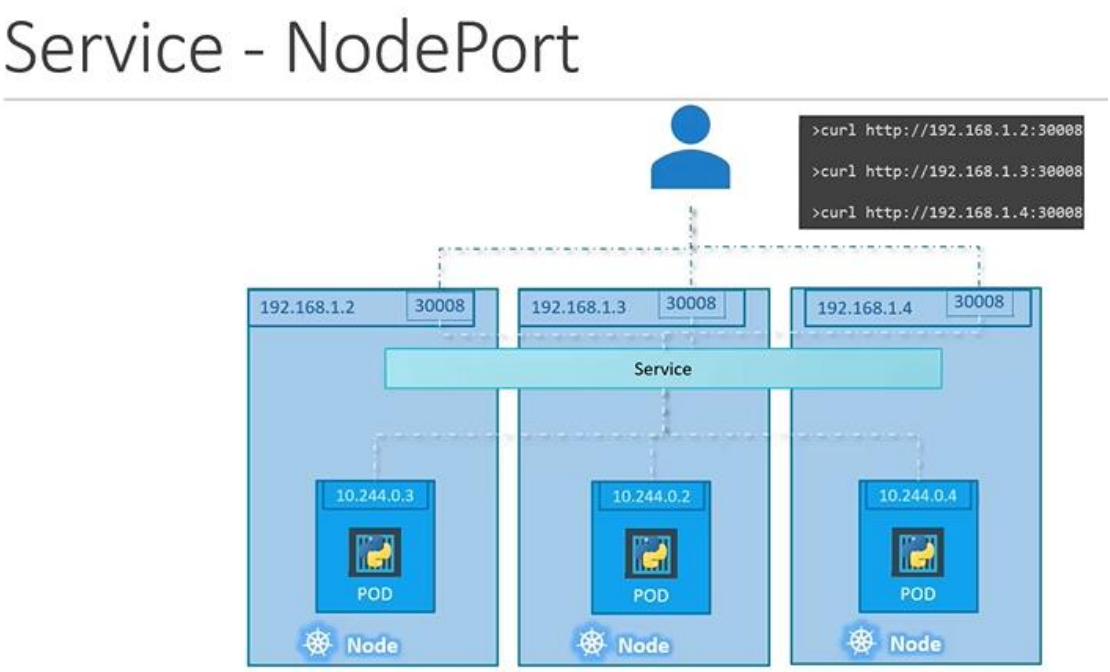
```
$ curl http://192.168.1.2:30008
```



A service with multiple pods



When Pods are distributed across multiple nodes



2. ClusterIP
    - In this case the service creates a **`Virtual IP`** inside the cluster to enable communication between different services such as a set of frontend servers to a set of backend servers.
3. LoadBalancer
    - Where the service provisions a **`loadbalancer`** for our application in supported cloud providers.

K8s Reference Docs:

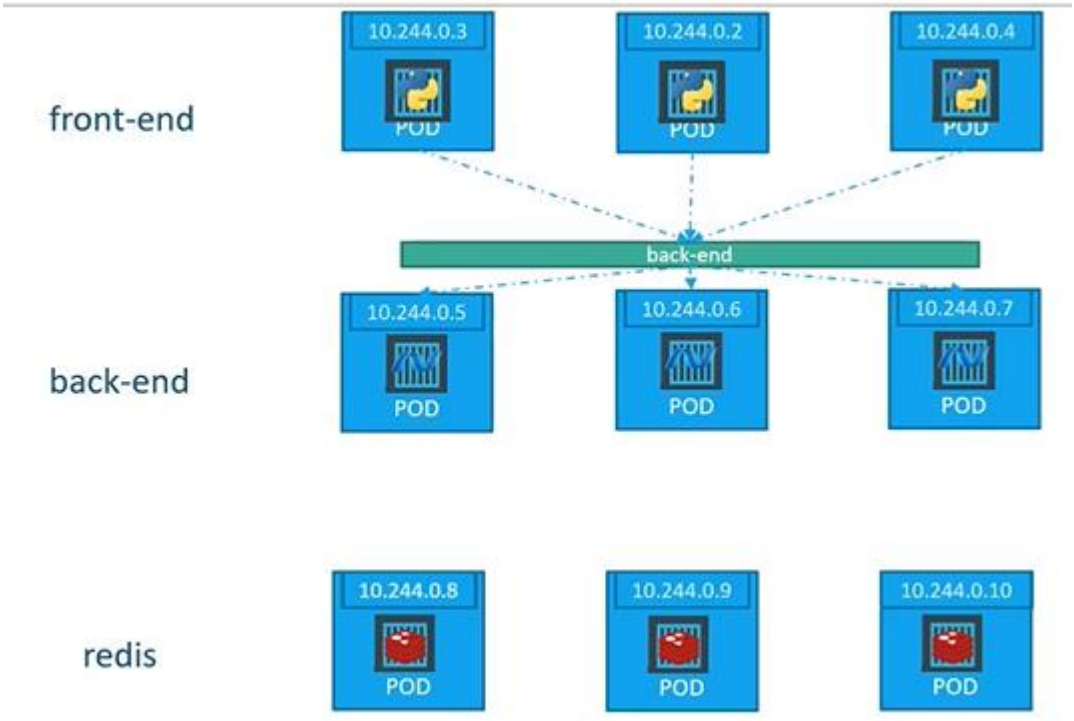
- https://kubernetes.io/docs/concepts/services-networking/service/
- https://kubernetes.io/docs/tutorials/kubernetes-basics/expose/expose-intro/

Kubernetes Services - ClusterIP

In this section we will take a look at **`services - ClusterIP`** in kubernetes

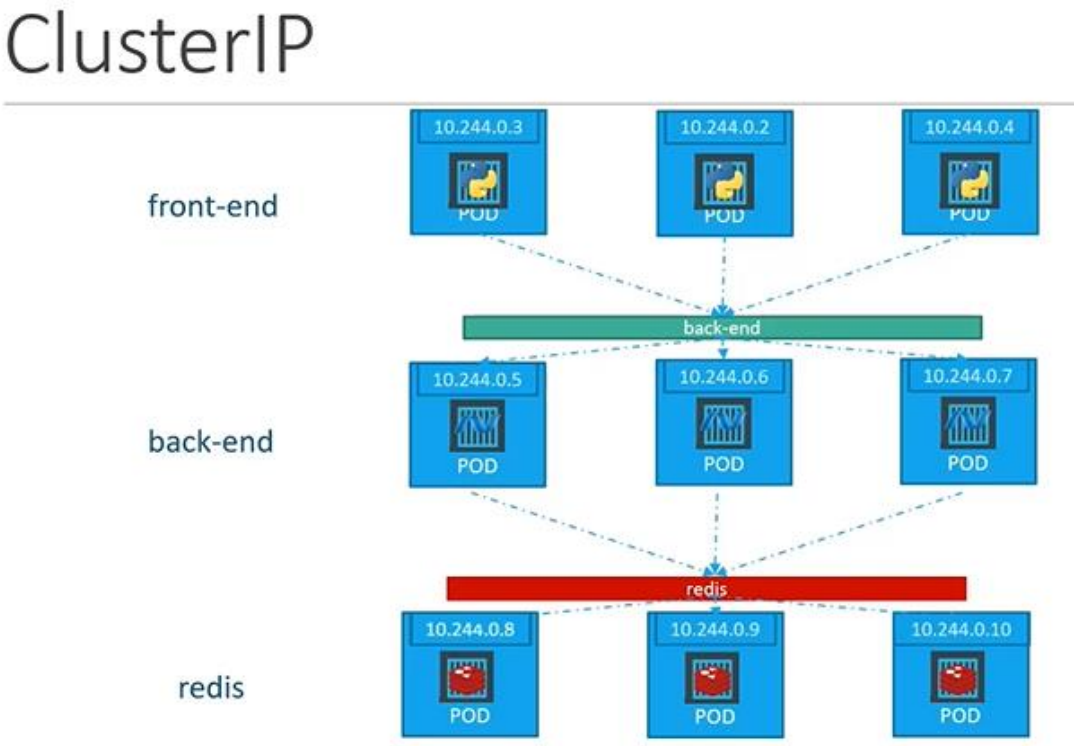
ClusterIP

- In this case the service creates a **`Virtual IP`** inside the cluster to enable communication between different services such as a set of frontend servers to a set of backend servers.



What is a right way to establish connectivity between these services or tiers

- A kubernetes service can help us group the pods together and provide a single interface to access the pod in a group.



To create a service of type ClusterIP

```
apiVersion: v1
kind: Service
metadata:
 name: back-end
spec:
 types: ClusterIP
 ports:
 - targetPort: 80
   port: 80
 selector:
   app: myapp
   type: back-end
$ kubectl create -f service-definition.yaml
```

To list the services

```
$ kubectl get services
```

K8s Reference Docs:

- https://kubernetes.io/docs/concepts/services-networking/service/
- https://kubernetes.io/docs/tutorials/kubernetes-basics/expose/expose-intro/

Manual Scheduling

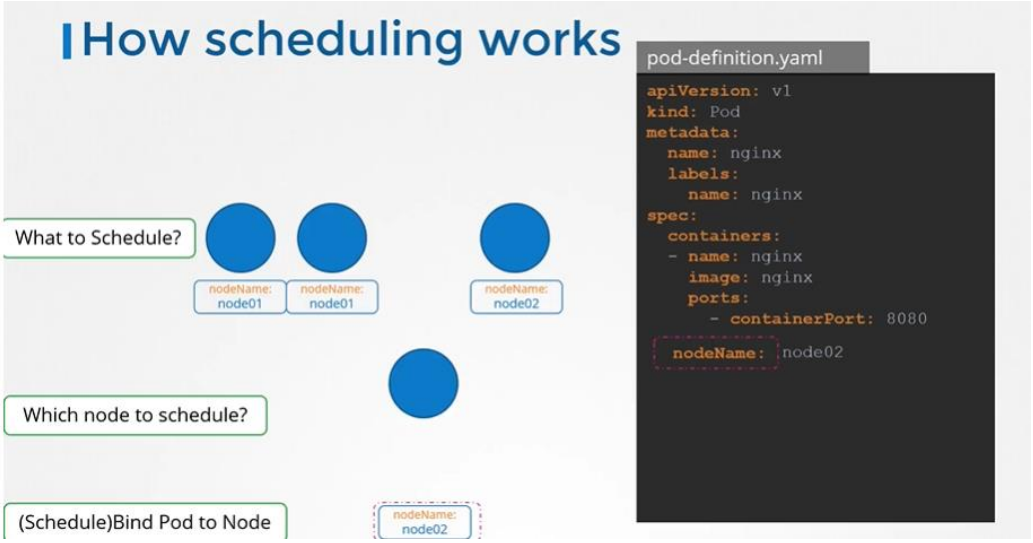
In this section, we will take a look at **`Manually Scheduling`** a **`POD`** on a node.

How Scheduling Works

- What do you do when you do not have a scheduler in your cluster?

- Every POD has a field called NodeName that by default is not set. You don't typically specify this field when you create the manifest file, kubernetes adds it automatically.
- Once identified it schedules the POD on the node by setting the nodeName property to the name of the node by creating a binding object.

```
apiVersion: v1
kind: Pod
metadata:
 name: nginx
 labels:
  name: nginx
spec:
 containers:
 - name: nginx
   image: nginx
   ports:
   - containerPort: 8080
 nodeName: node02
```

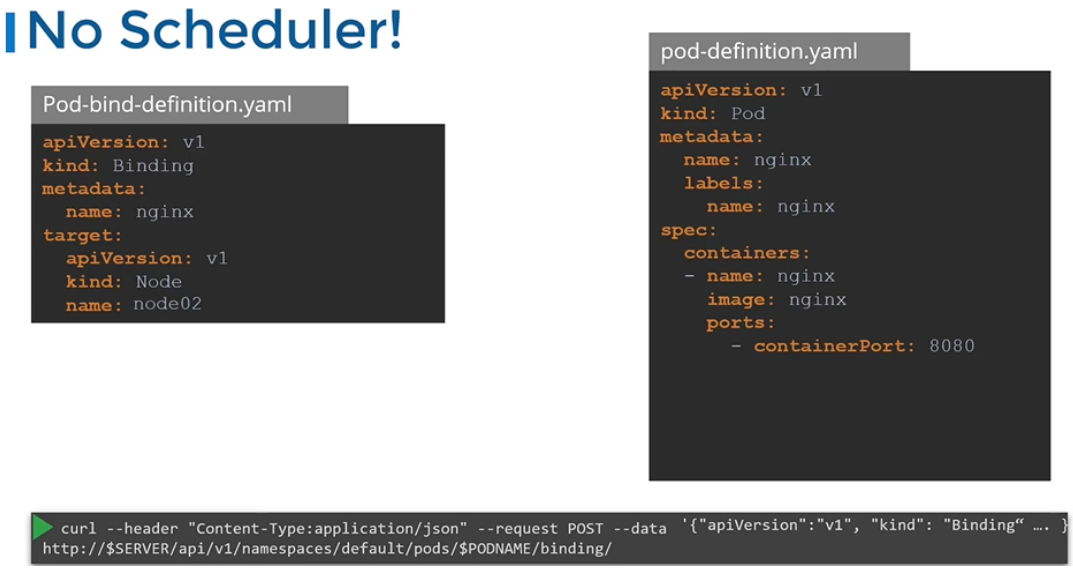


No Scheduler

- You can manually assign pods to node itself. Well without a scheduler, to schedule pod is to set **`nodeName`** property in your pod definition file while creating a pod.

- Another way

- apiVersion: v1
- kind: Binding
- metadata:
- name: nginx
- target:
- apiVersion: v1
- kind: Node
- name: node02
- apiVersion: v1
- kind: Pod
- metadata:
- name: nginx
- labels:
- name: nginx
- spec:
- containers:
- - name: nginx
- image: nginx
- ports:
- - containerPort: 8080



K8s Reference Docs:

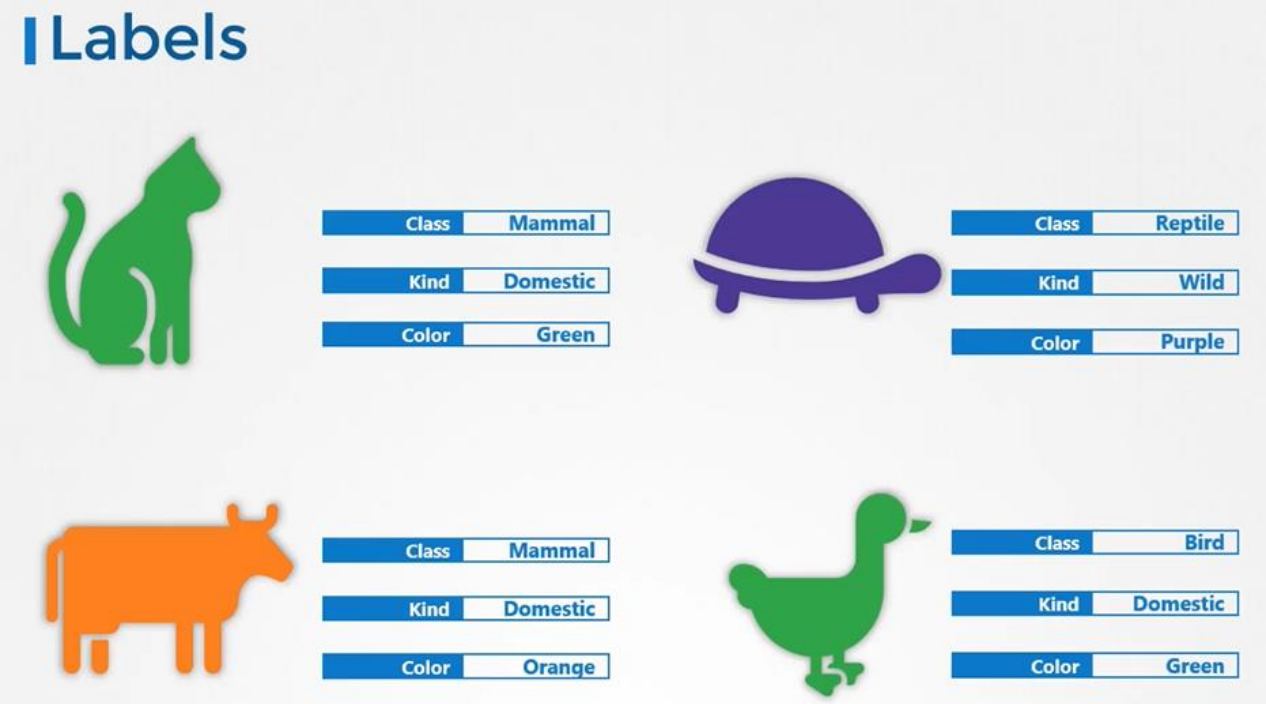
- https://kubernetes.io/docs/reference/using-api/api-concepts/
- https://kubernetes.io/docs/concepts/scheduling-eviction/assign-pod-node/#nodename

Labels and Selectors

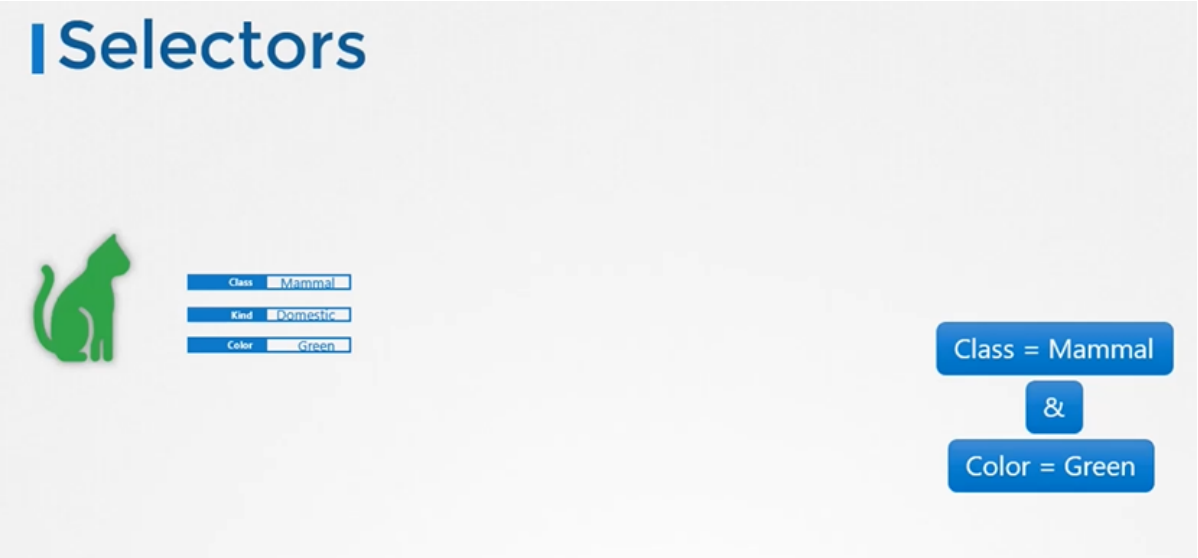
In this section, we will take a look at **`Labels and Selectors`**

Labels and Selectors are standard methods to group things together.

Labels are properties attached to each item.



Selectors help you to filter these items



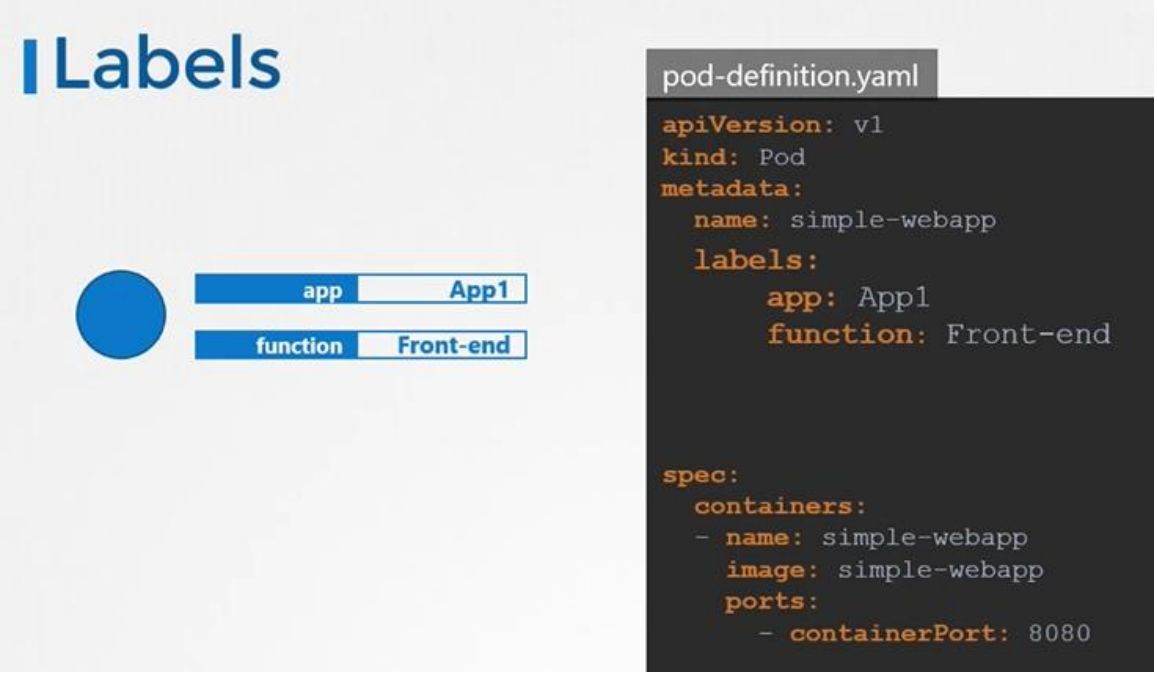
How are labels and selectors are used in kubernetes?

- We have created different types of objects in kubernetes such as **`PODs`**, **`ReplicaSets`**, **`Deployments`** etc.

How do you specify labels?

```
apiVersion: v1
kind: Pod
metadata:
 name: simple-webapp
 labels:
   app: App1
```

```
    function: Front-end
spec:
 containers:
 - name: simple-webapp
   image: simple-webapp
   ports:
   - containerPort: 8080
```

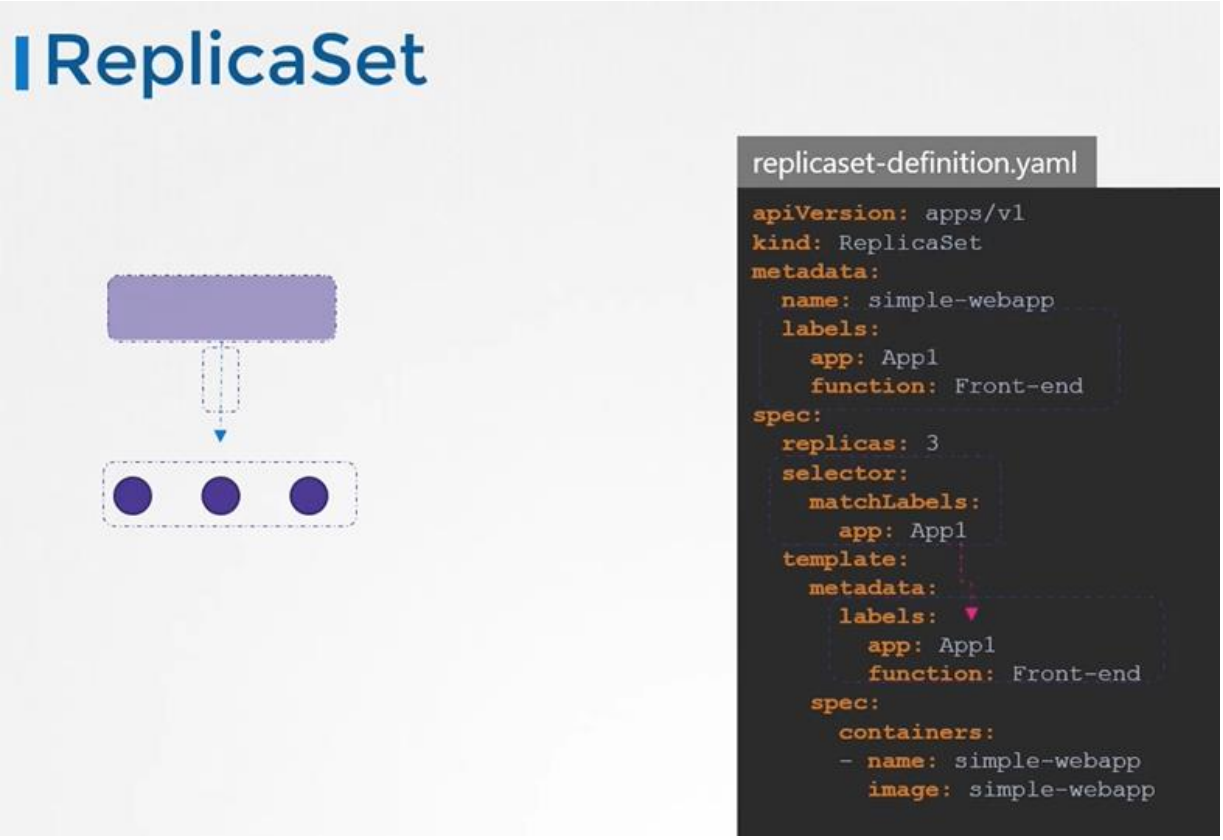


Once the pod is created, to select the pod with labels run the below command

```
$ kubectl get pods --selector app=App1
```

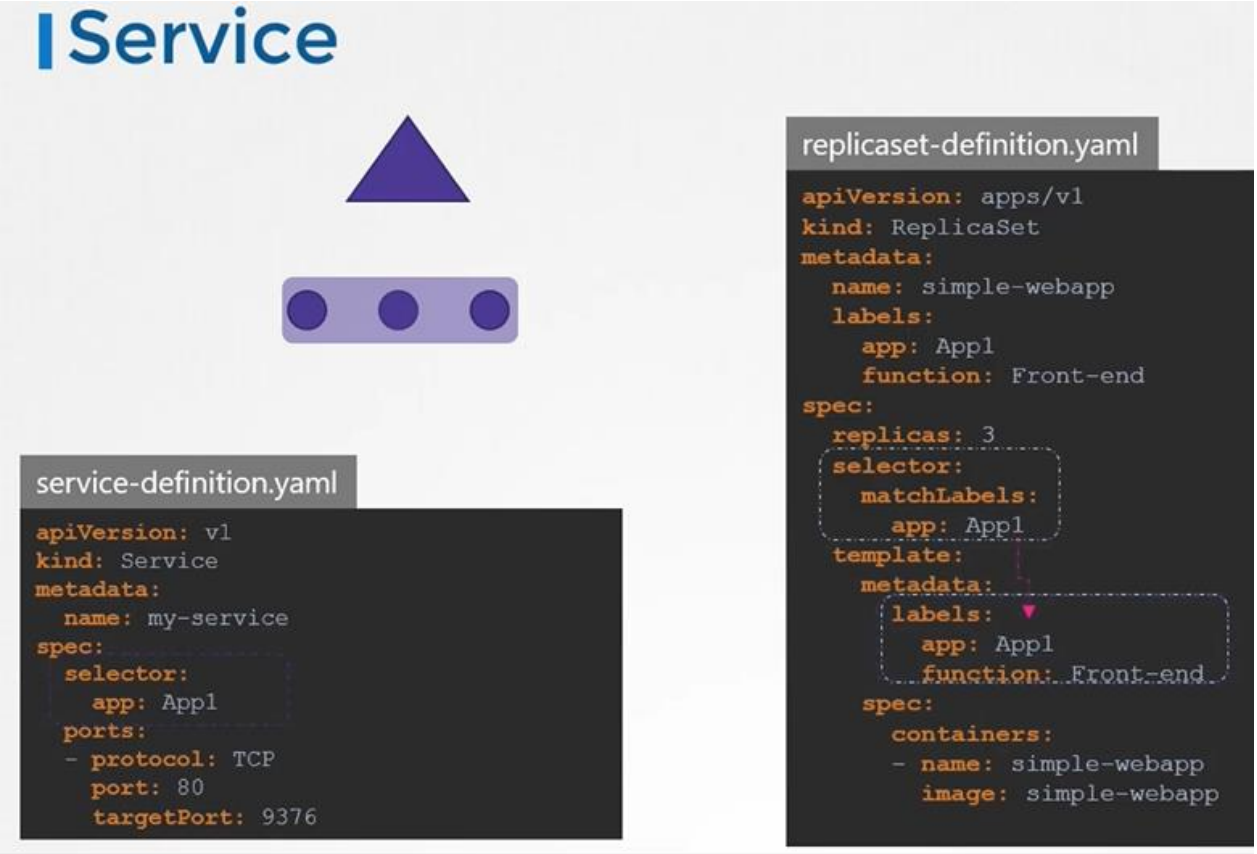
Kubernetes uses labels to connect different objects together

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: simple-webapp
  labels:
    app: App1
    function: Front-end
spec:
 replicas: 3
 selector:
   matchLabels:
    app: App1
template:
  metadata:
    labels:
      app: App1
      function: Front-end
  spec:
    containers:
    - name: simple-webapp
      image: simple-webapp
```



For services

```
apiVersion: v1
kind: Service
metadata:
 name: my-service
spec:
 selector:
   app: App1
 ports:
 - protocol: TCP
   port: 80
   targetPort: 9376
```

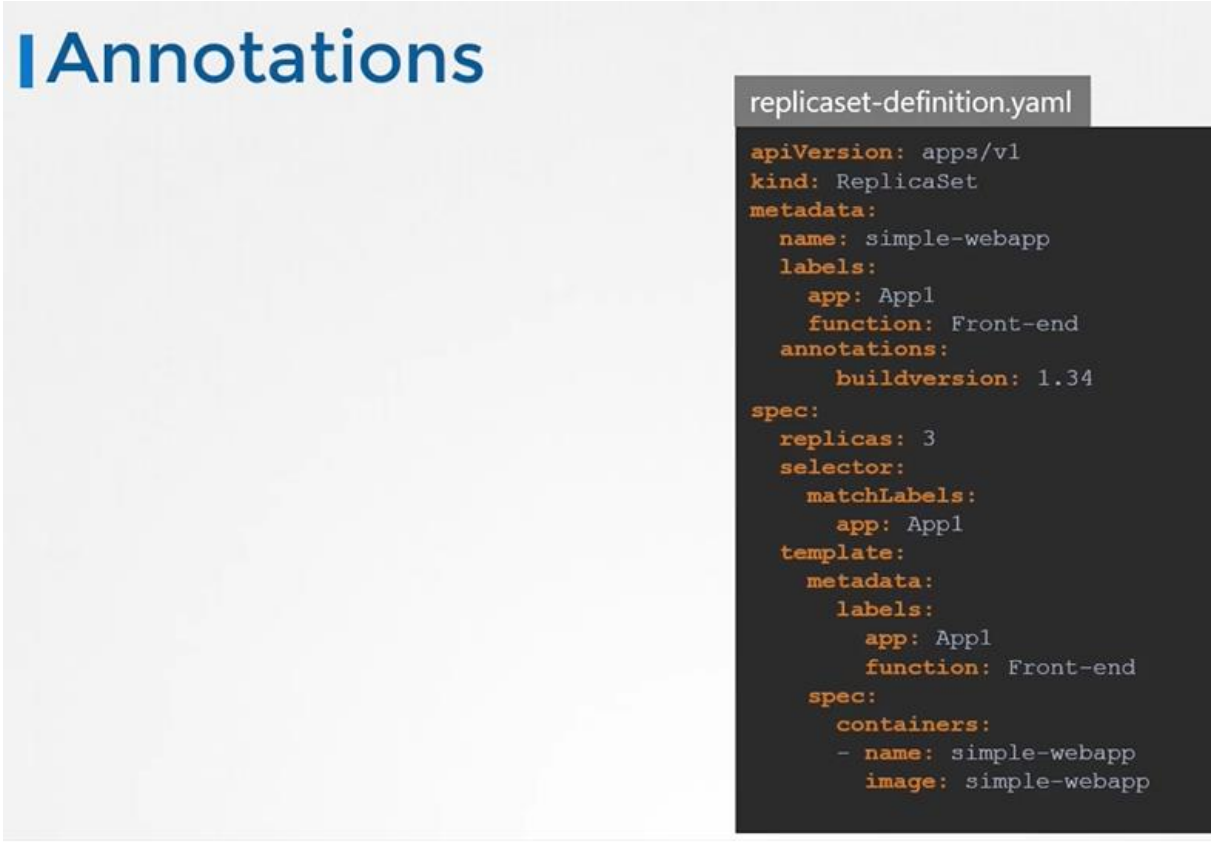


Annotations

- While labels and selectors are used to group objects, annotations are used to record other details for informative purpose.

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: simple-webapp
  labels:
    app: App1
    function: Front-end
  annotations:
     buildversion: 1.34
spec:
 replicas: 3
 selector:
   matchLabels:
    app: App1
template:
  metadata:
    labels:
      app: App1
      function: Front-end
  spec:
    containers:
    - name: simple-webapp
```

- `image: simple-webapp`



K8s Reference Docs:

- https://kubernetes.io/docs/concepts/overview/working-with-objects/labels/

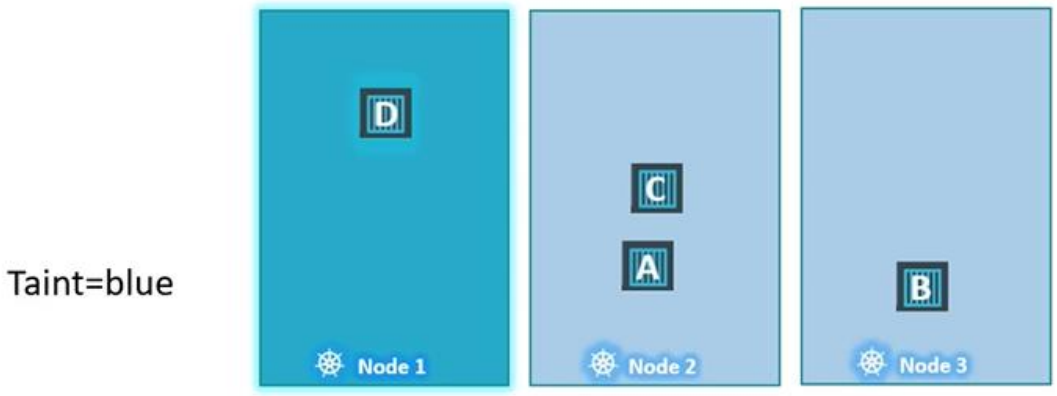
Taints and Tolerations

In this section, we will take a look at taints and tolerations.

- Pod to node relationship and how you can restrict what pods are placed on what nodes.

Taints and Tolerations are used to set restrictions on what pods can be scheduled on a node.

- Only pods which are tolerant to the particular taint on a node will get scheduled on that node.



Taints

- Use **`kubectl taint nodes`** command to taint a node.

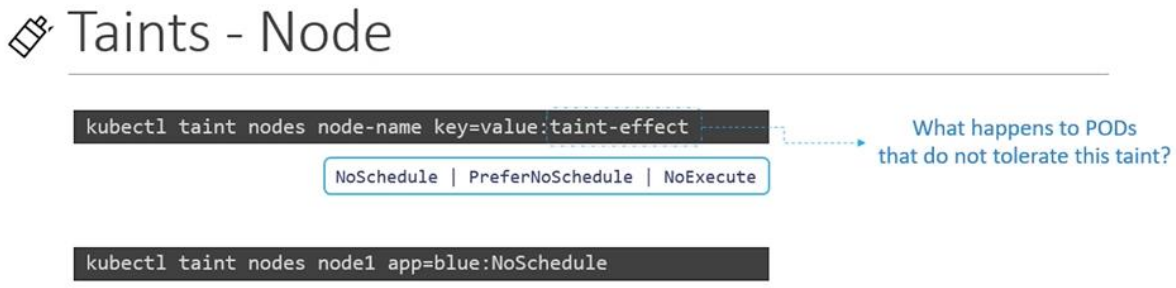
  Syntax

  ```
  $ kubectl taint nodes <node-name> key=value:taint-effect
  ```

  Example

  ```
  $ kubectl taint nodes node1 app=blue:NoSchedule
  ```

- The taint effect defines what would happen to the pods if they do not tolerate the taint.
- There are 3 taint effects
  - **`NoSchedule`**
  - **`PreferNoSchedule`**
  - **`NoExecute`**



Tolerations

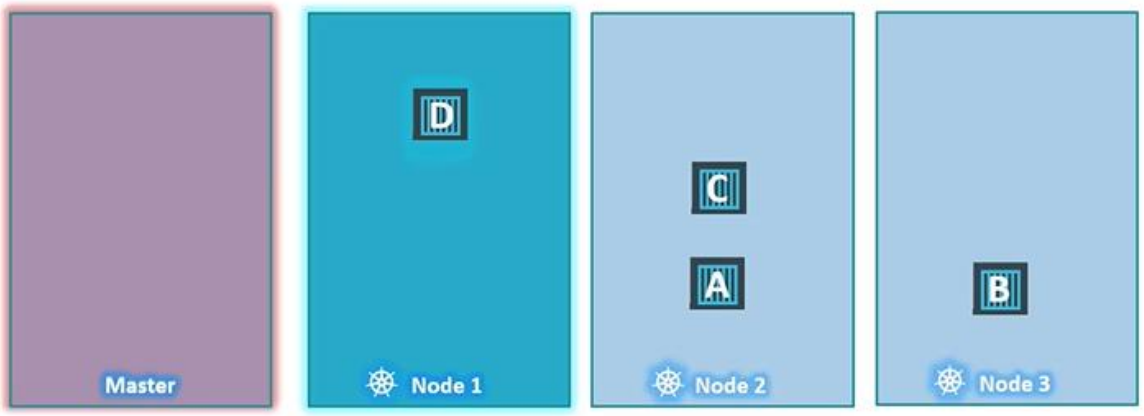
- Tolerations are added to pods by adding a **`tolerations`** section in pod definition.
- `apiVersion: v1`

```
kind: Pod
metadata:
 name: myapp-pod
spec:
 containers:
 - name: nginx-container
   image: nginx
 tolerations:
 - key: "app"
   operator: "Equal"
   value: "blue"
   effect: "NoSchedule"
```

Taints and Tolerations do not tell the pod to go to a particular node. Instead, they tell the node to only accept pods with certain tolerations.

- To see this taint, run the below command
- `$ kubectl describe node kubemaster |grep Taint`

```
kubectl describe node kubemaster | grep Taint
Taints:             node-role.kubernetes.io/master:NoSchedule
```



K8s Reference Docs

- https://kubernetes.io/docs/concepts/scheduling-eviction/taint-and-toleration/

Node Selectors

In this section, we will take a look at Node Selectors in Kubernetes

We add new property called Node Selector to the spec section and specify the label.

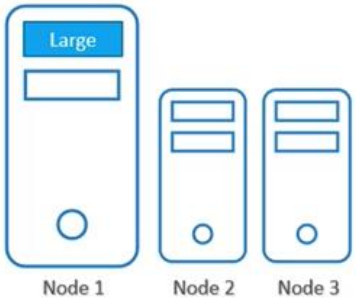
- The scheduler uses these labels to match and identify the right node to place the pods on.

```
apiVersion: v1
kind: Pod
metadata:
 name: myapp-pod
spec:
 containers:
 - name: data-processor
   image: data-processor
 nodeSelector:
  size: Large
```

Node Selectors

pod-definition.yml

```
apiVersion:
kind: Pod
metadata:
 name: myapp-pod
spec:
  containers:
  - name: data-processor
    image: data-processor

  nodeSelector:
    size: Large
```



- To label nodes

  Syntax

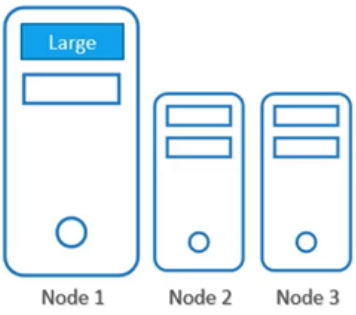
  ```
  $ kubectl label nodes <node-name> <label-key>=<label-value>
  ```

  Example

  ```
  $ kubectl label nodes node-1 size=Large
  ```

Label Nodes

```
kubectl label nodes <node-name> <label-key>=<label-value>
kubectl label nodes node-1 size=Large
```

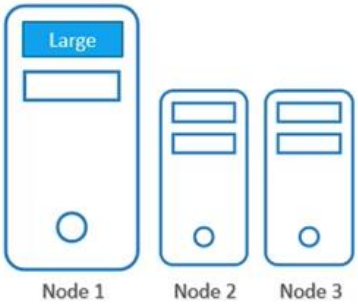


- To create a pod definition
- `apiVersion: v1`
- `kind: Pod`
- `metadata:`
- `  name: myapp-pod`

- spec:
- containers:
- - name: data-processor
- image: data-processor
- nodeSelector:
- size: Large
- $ kubectl create -f pod-definition.yml

Node Selectors

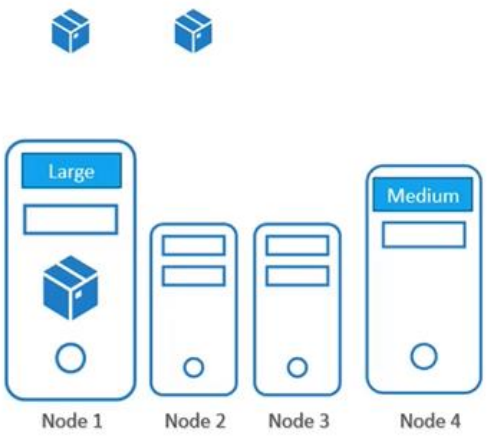
```
pod-definition.yml
apiVersion:
kind: Pod
metadata:
 name: myapp-pod
spec:
  containers:
  - name: data-processor
    image: data-processor

  nodeSelector:
    size: Large
```



Node Selector - Limitations

- We used a single label and selector to achieve our goal here. But what if our requirement is much more complex.

Node Selector - Limitations



- Large OR Medium?
- NOT Small

- For this we have **Node Affinity and Anti Affinity**

K8s Reference Docs

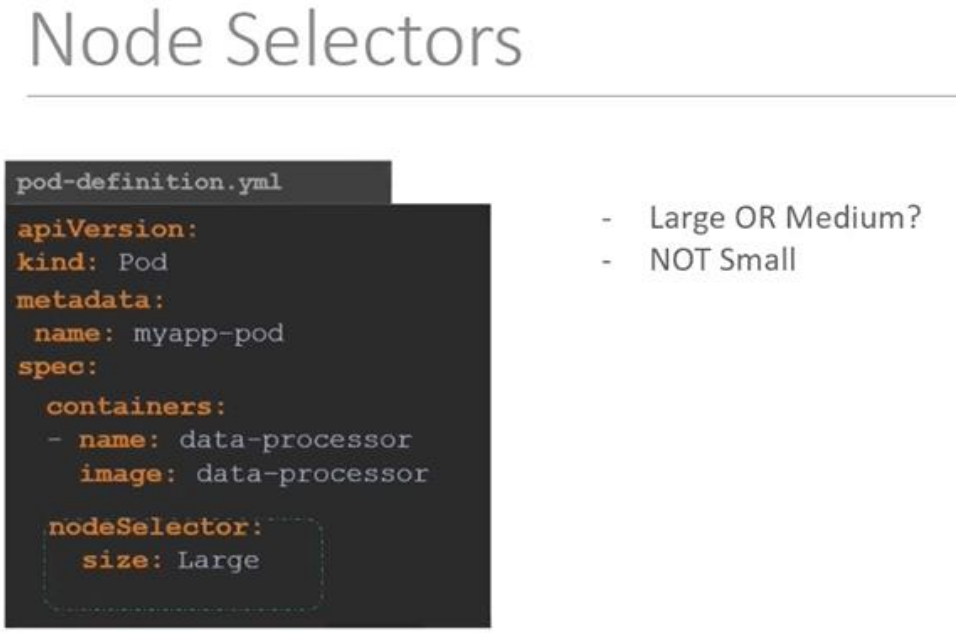
- https://kubernetes.io/docs/concepts/scheduling-eviction/assign-pod-node/#nodeselector

Node Affinity

In this section, we will talk about "Node Affinity" feature in kubernetes.

The primary feature of Node Affinity is to ensure that the pods are hosted on particular nodes.

- With **`Node Selectors`** we cannot provide the advance expressions.
- `apiVersion: v1`
- `kind: Pod`
- `metadata:`
- ` name: myapp-pod`
- `spec:`
- ` containers:`
- ` - name: data-processor`
- `  image: data-processor`
- ` nodeSelector:`
- `  size: Large`




```
apiVersion: v1
kind: Pod
metadata:
 name: myapp-pod
spec:
 containers:
 - name: data-processor
   image: data-processor
```

```
 affinity:
   nodeAffinity:
     requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
        - matchExpressions:
          - key: size
            operator: In
            values:
            - Large
            - Medium
```


```
apiVersion: v1
kind: Pod
metadata:
 name: myapp-pod
spec:
 containers:
 - name: data-processor
   image: data-processor
 affinity:
   nodeAffinity:
     requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
        - matchExpressions:
          - key: size
            operator: NotIn
            values:
            - Small
```

Node Affinity

pod-definition.yml

```
apiVersion:
kind:
metadata:
 name: myapp-pod
spec:
 containers:
  - name: data-processor
    image: data-processor
 affinity:
  nodeAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      nodeSelectorTerms:
      - matchExpressions:
        - key: size
          operator: NotIn
          values:
          - Small
```

```
apiVersion: v1
kind: Pod
metadata:
 name: myapp-pod
spec:
 containers:
 - name: data-processor
   image: data-processor
 affinity:
   nodeAffinity:
     requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
        - matchExpressions:
          - key: size
            operator: Exists
```

Node Affinity

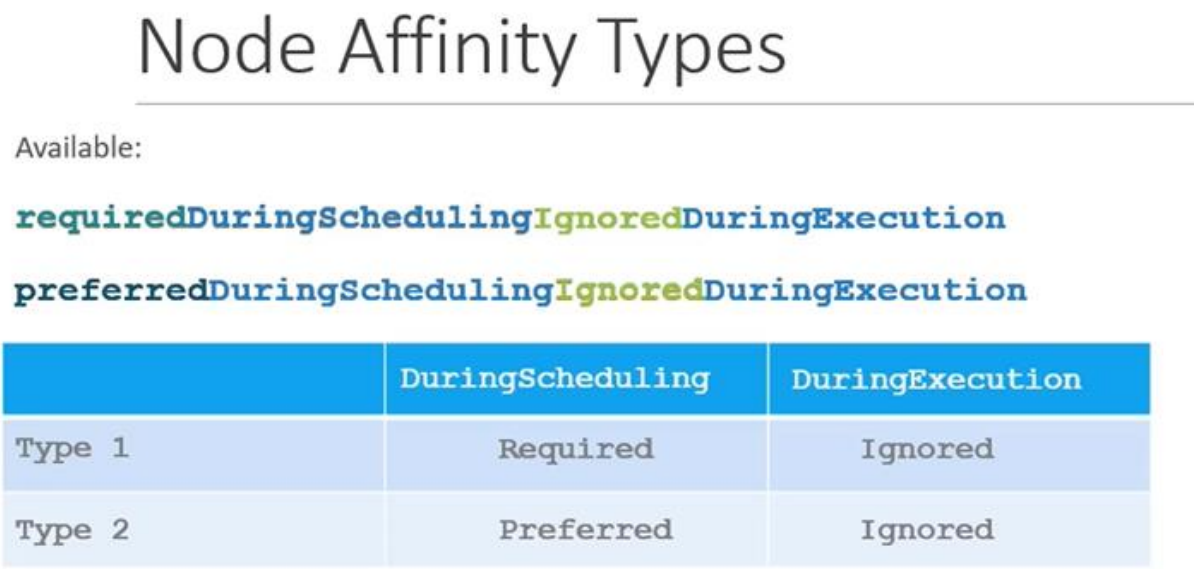
pod-definition.yml

```
apiVersion:
kind:
metadata:
 name: myapp-pod
spec:
 containers:
  - name: data-processor
    image: data-processor
 affinity:
  nodeAffinity:
    requiredDuringSchedulingIgnoredDuringExecution:
      nodeSelectorTerms:
      - matchExpressions:
        - key: size
          operator: Exists
```

Node Affinity Types

- Available
  - requiredDuringSchedulingIgnoredDuringExecution
  - preferredDuringSchedulingIgnoredDuringExecution
- Planned
  - requiredDuringSchedulingRequriedDuringExecution
  - preferredDuringSchedulingRequiredDuringExecution

Node Affinity Types States



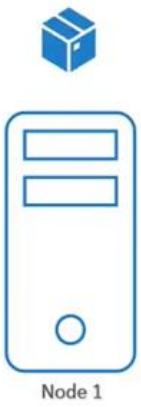
Node Affinity Types

Planned:

requiredDuringSchedulingRequiredDuringExecution

preferredDuringSchedulingRequiredDuringExecution

	DuringScheduling	DuringExecution
Type 1	Required	Ignored
Type 2	Preferred	Ignored
Type 3	Required	Required
Type 4	Preferred	Required



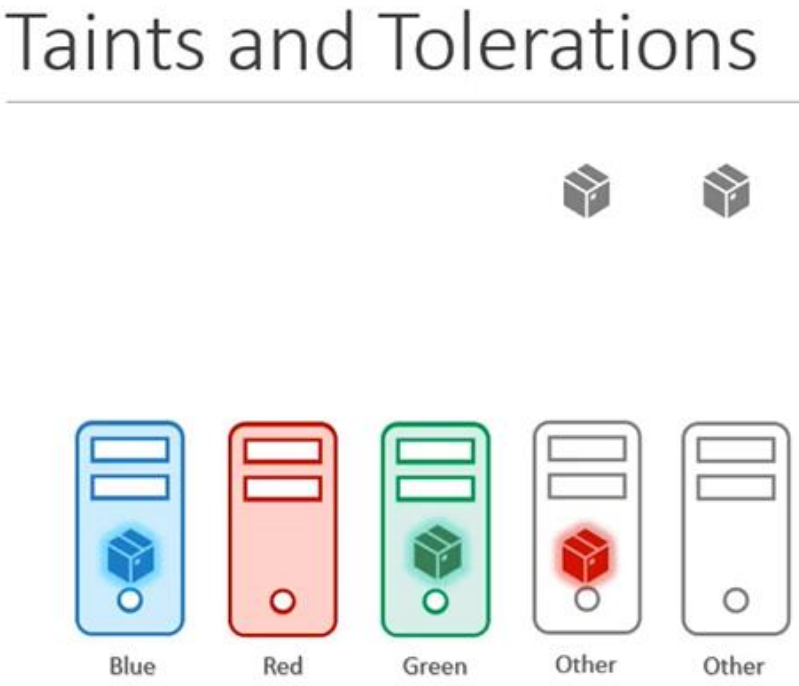
K8s Reference Docs

- https://kubernetes.io/docs/tasks/configure-pod-container/assign-pods-nodes-using-node-affinity/
- https://kubernetes.io/blog/2017/03/advanced-scheduling-in-kubernetes/

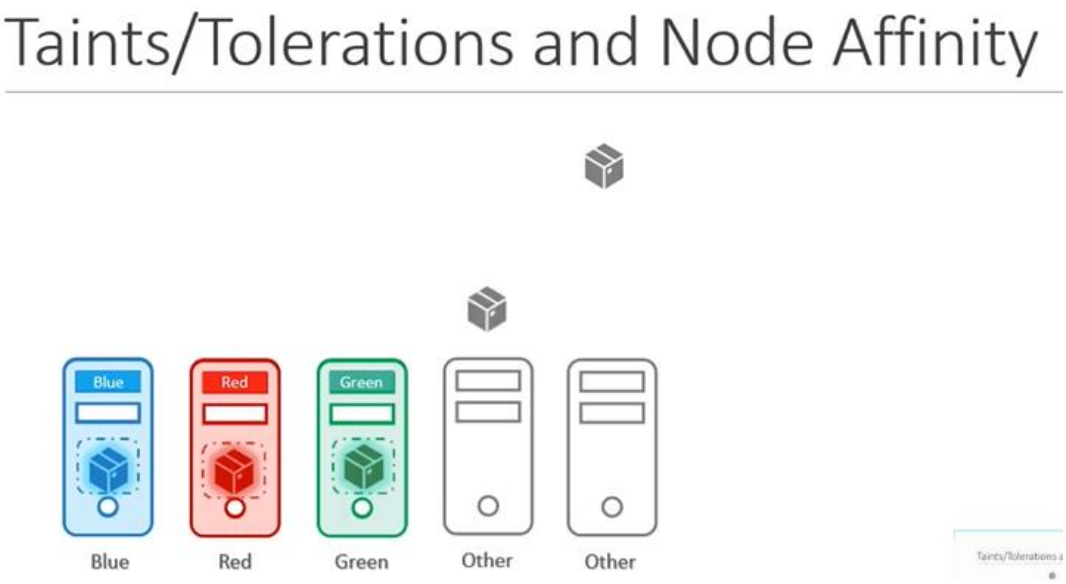
Taints and Tolerations vs Node Affinity

In this section, we will take a look at Taints and Tolerations vs Node Affinity

- Taints and Tolerations do not guarantee that the pods will only prefer these nodes; in this case, the red pods may end up on one of the other nodes that do not have a taint or toleration set.



- As such, a combination of taints and tolerations and node affinity rules can be used together to completely dedicate nodes for specific parts.



K8s Reference Docs:

- https://kubernetes.io/docs/concepts/scheduling-eviction/taint-and-toleration/
- https://kubernetes.io/docs/tasks/configure-pod-container/assign-pods-nodes-using-node-affinity/

Resource Limits

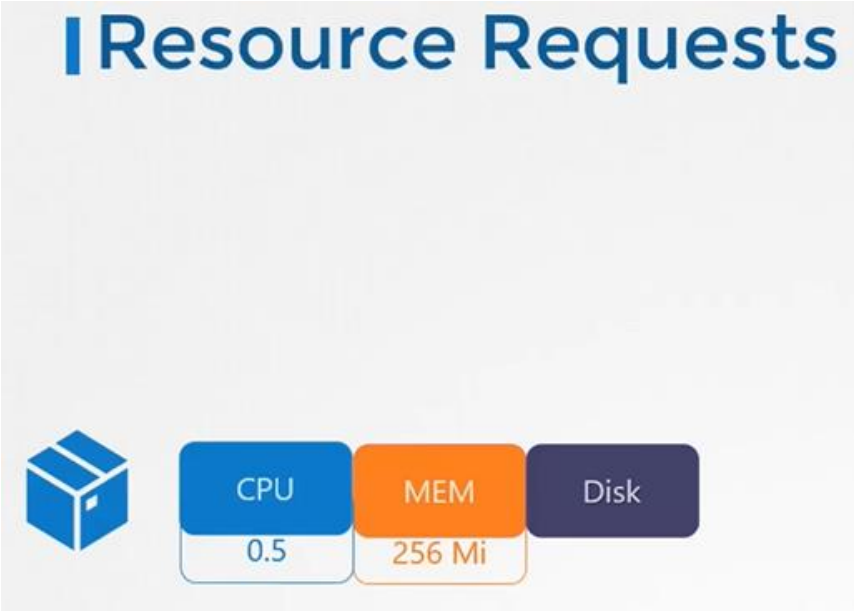
In this section we will take a look at Resource Limits

Let us take a look at 3 node kubernetes cluster.

- Each node has a set of CPU, Memory and Disk resources available.
- If there is no sufficient resources available on any of the nodes, kubernetes holds the scheduling the pod. You will see the pod in pending state. If you look at the events, you will see the reason as insufficient CPU.

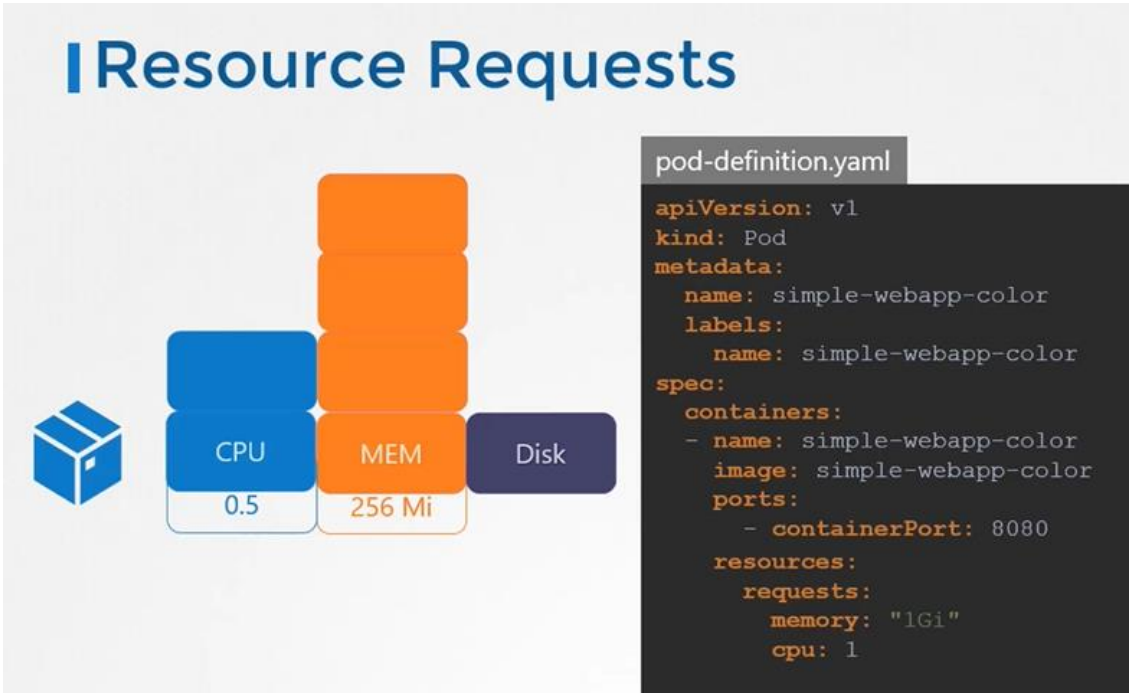
Resource Requirements

- By default, K8s assume that a pod or container within a pod requires **`0.5`** CPU and **`256Mi`** of memory. This is known as the **`Resource Request`** **for a container**.



- If your application within the pod requires more than the default resources, you need to set them in the pod definition file.

```
apiVersion: v1
kind: Pod
metadata:
  name: simple-webapp-color
  labels:
    name: simple-webapp-color
spec:
 containers:
 - name: simple-webapp-color
   image: simple-webapp-color
   ports:
    - containerPort:  8080
   resources:
     requests:
      memory: "1Gi"
      cpu: "1"
```

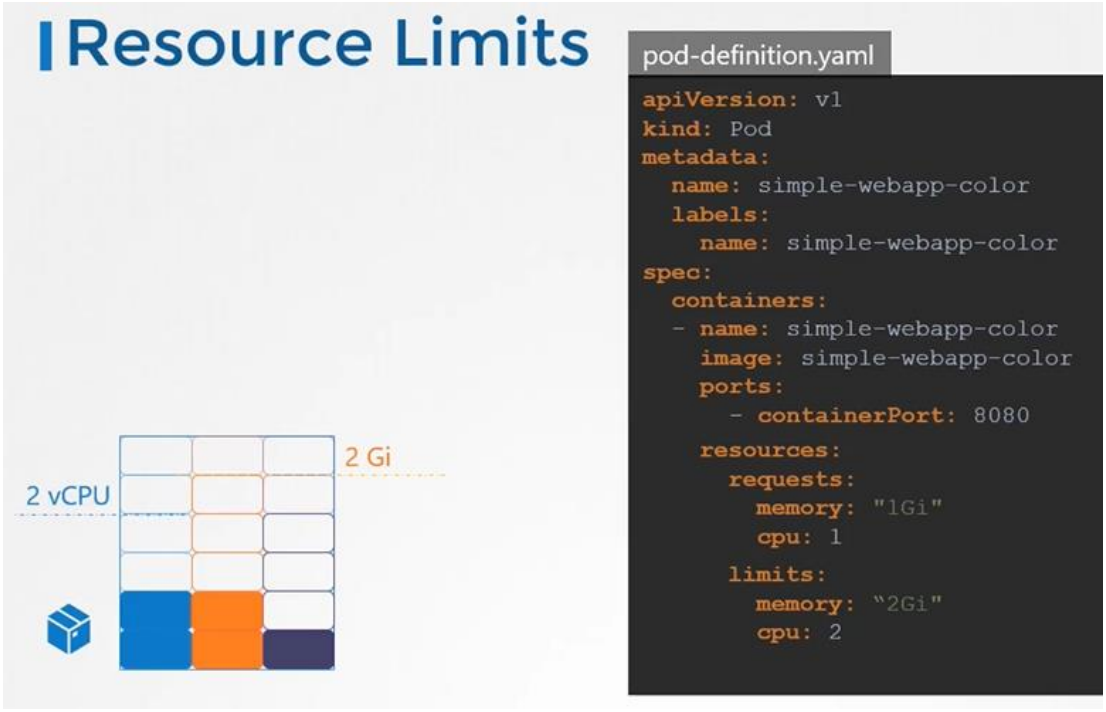


Resources - Limits

- By default, k8s sets resource limits to 1 CPU and 512Mi of memory

- You can set the resource limits in the pod definition file.

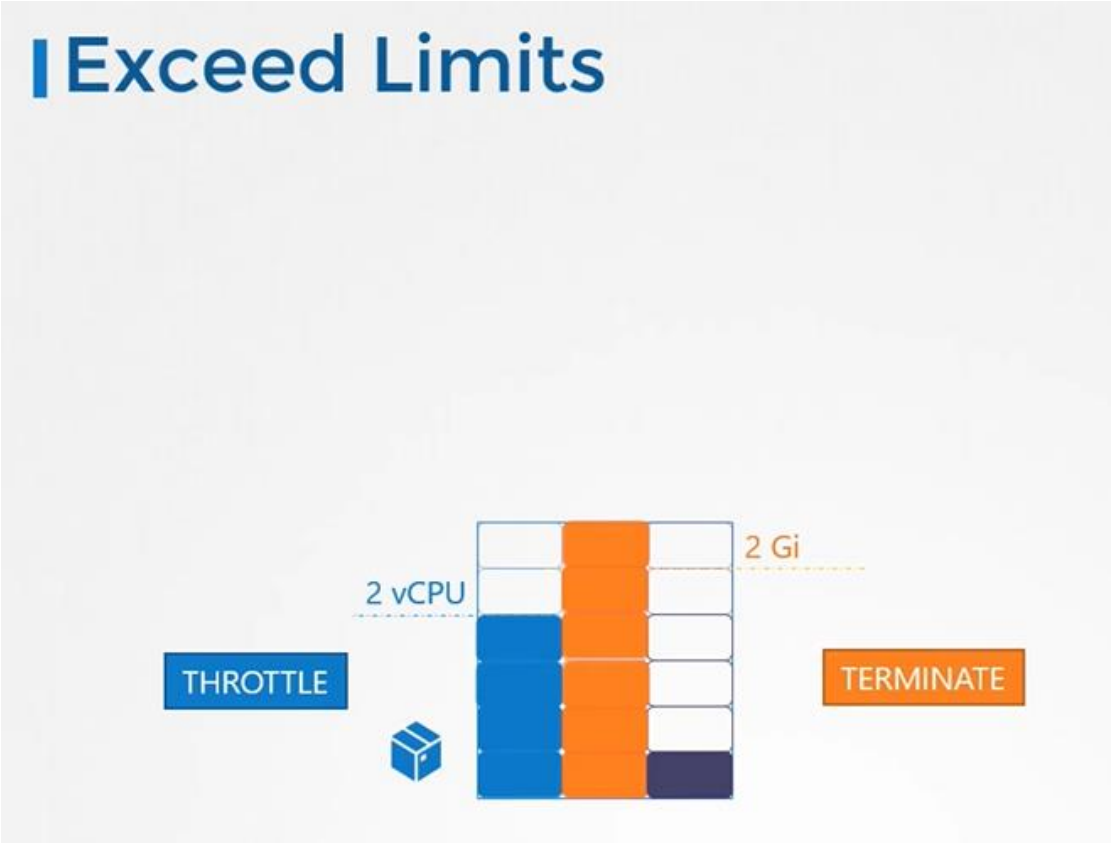
```
apiVersion: v1
kind: Pod
metadata:
  name: simple-webapp-color
  labels:
    name: simple-webapp-color
spec:
 containers:
 - name: simple-webapp-color
   image: simple-webapp-color
   ports:
    - containerPort:  8080
   resources:
     requests:
      memory: "1Gi"
      cpu: "1"
     limits:
       memory: "2Gi"
       cpu: "2"
```



Note: Remember Requests and Limits for resources are set per container in the pod.

Exceed Limits

- what happens when a pod tries to exceed resources beyond its limits?



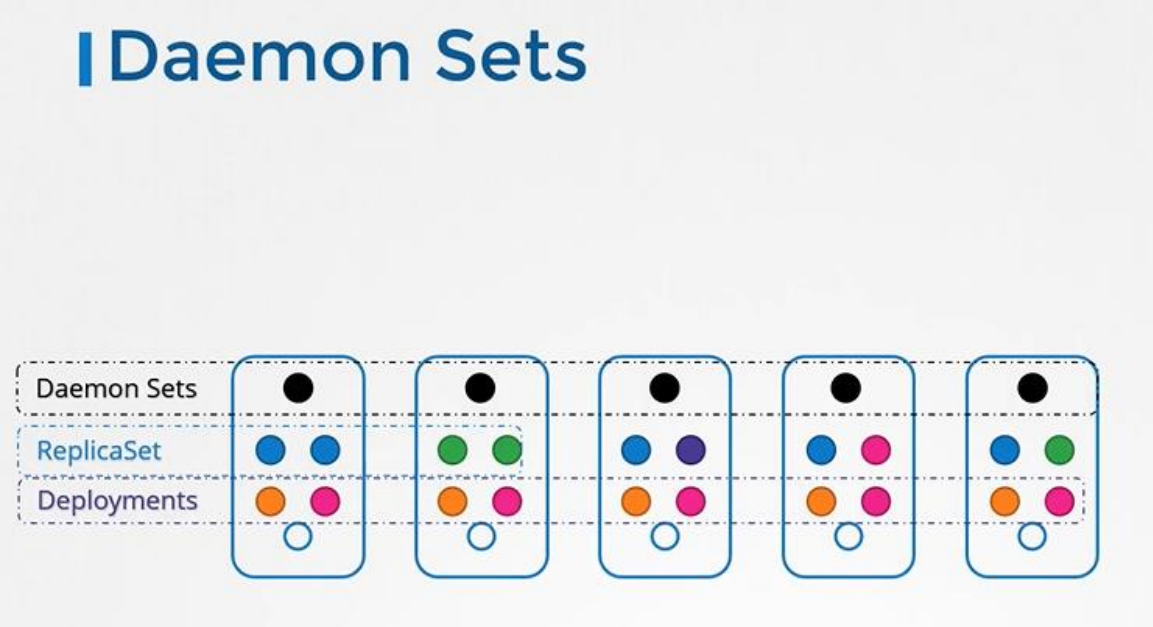
K8s Reference Docs:

- https://kubernetes.io/docs/concepts/configuration/manage-resources-containers/

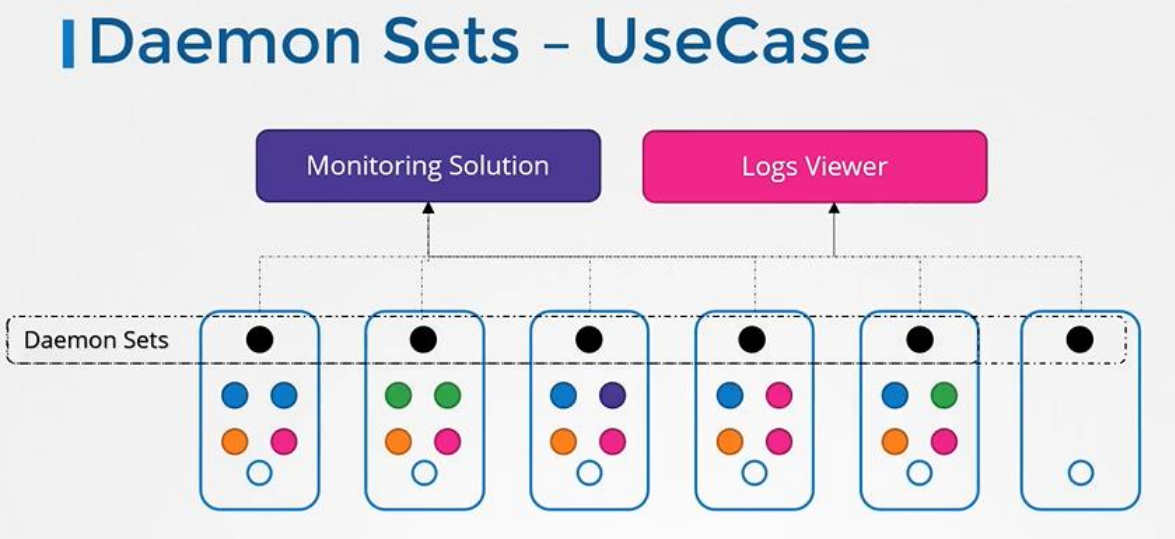
DaemonSets

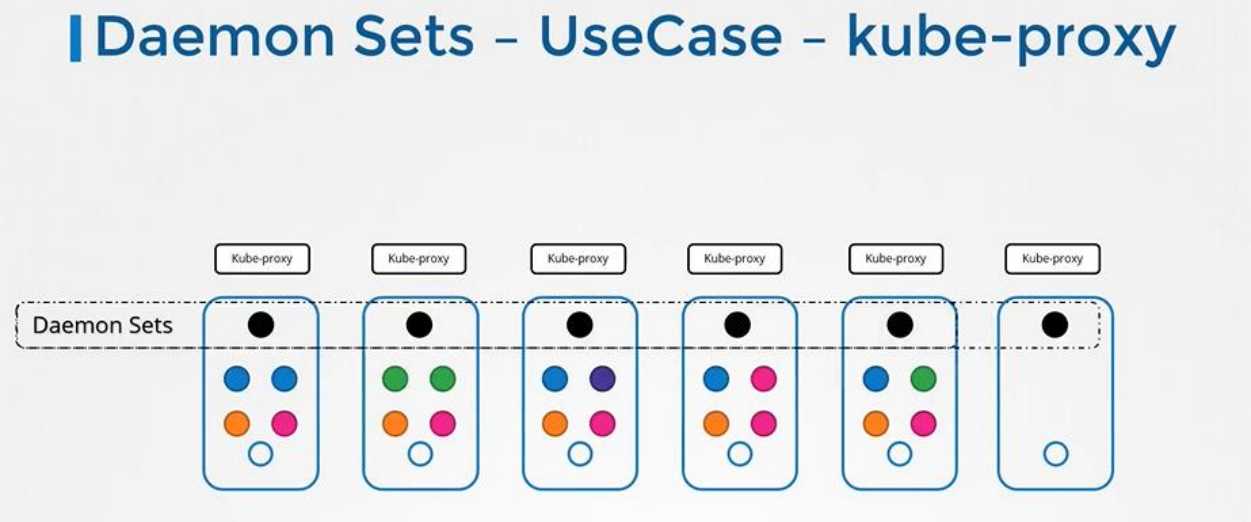
In this section, we will take a look at DaemonSets.

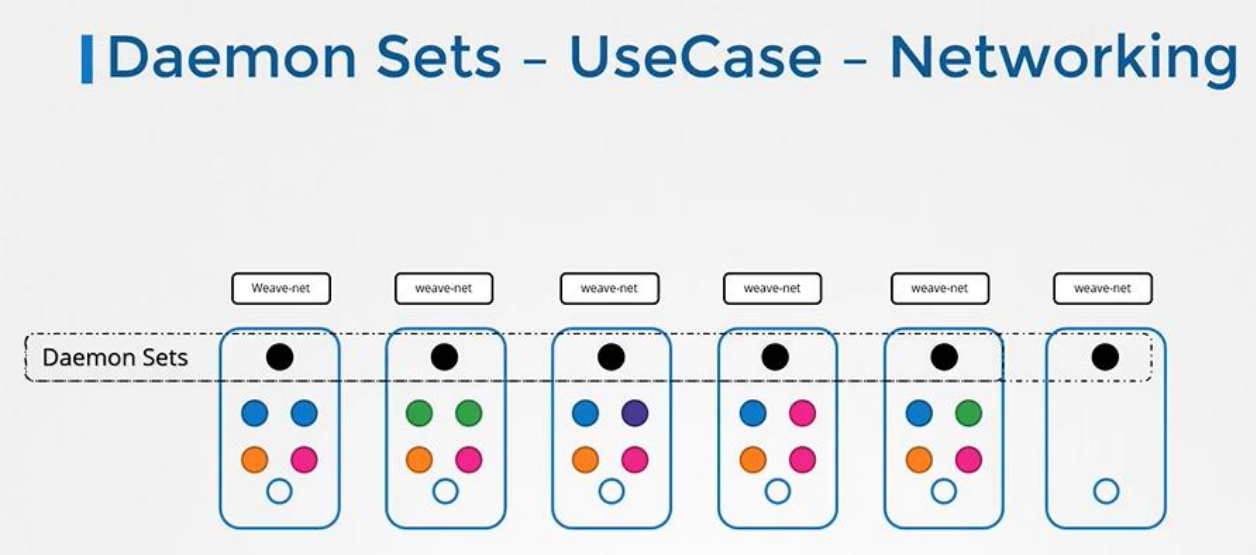
DaemonSets are like replicasets, as it helps in to deploy multiple instances of pod. But it runs one copy of your pod on each node in your cluster.



DaemonSets - UseCases





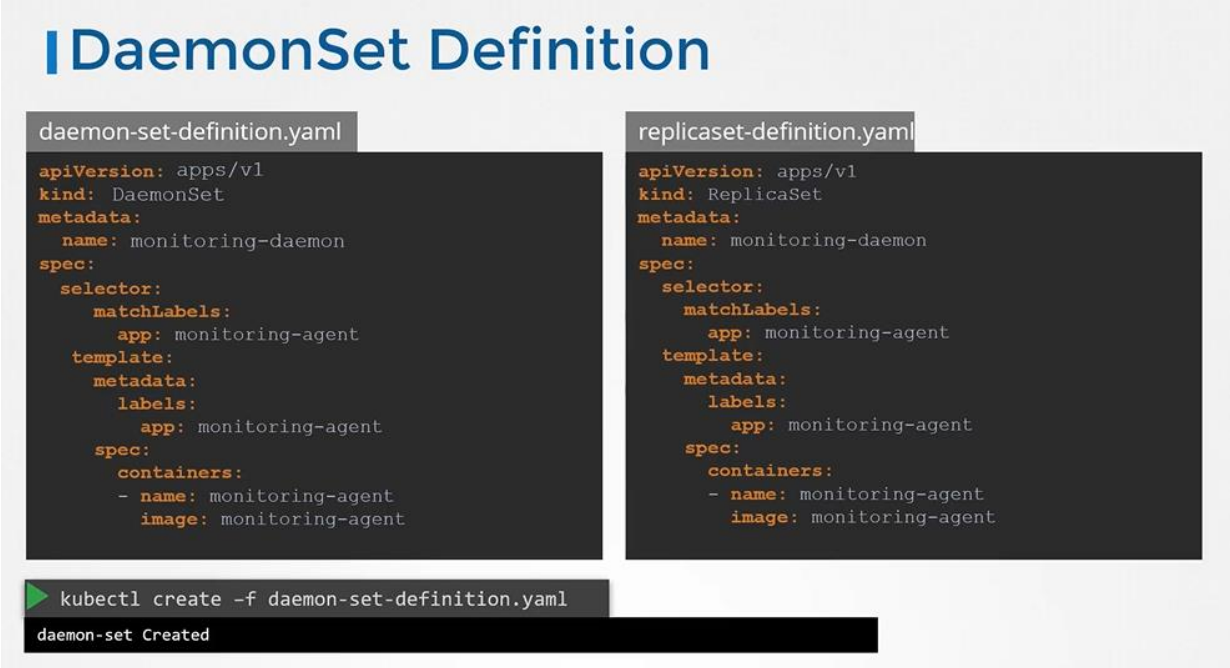


DaemonSets - Definition

- Creating a DaemonSet is similar to the ReplicaSet creation process.
- For DaemonSets, we start with apiVersion, kind as **`DaemonSets`** instead of **`ReplicaSet`**, metadata and spec.

```
apiVersion: apps/v1
kind: Replicaset
metadata:
  name: monitoring-daemon
  labels:
    app: nginx
spec:
  selector:
    matchLabels:
      app: monitoring-agent
  template:
    metadata:
     labels:
```

```
        app: monitoring-agent
    spec:
      containers:
      - name: monitoring-agent
        image: monitoring-agent
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: monitoring-daemon
  labels:
    app: nginx
spec:
  selector:
    matchLabels:
      app: monitoring-agent
  template:
    metadata:
     labels:
       app: monitoring-agent
    spec:
      containers:
      - name: monitoring-agent
        image: monitoring-agent
```



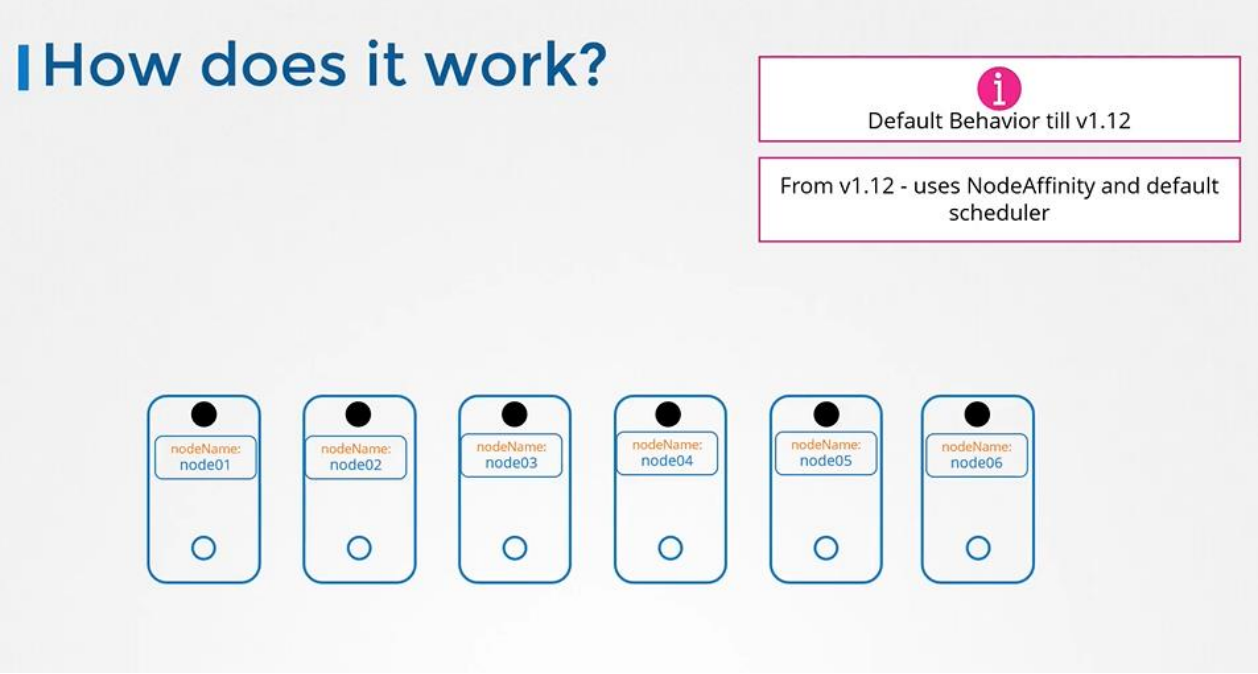
- To create a daemonset from a definition file
- `$ kubectl create -f daemon-set-definition.yaml`

View DaemonSets

- To list daemonsets
- `$ kubectl get daemonsets`

- For more details of the daemonsets
- `$ kubectl describe daemonsets monitoring-daemon`

How DaemonSets Works



K8s Reference Docs

- https://kubernetes.io/docs/concepts/workloads/controllers/daemonset/#writing-a-daemonset-spec

Static Pods

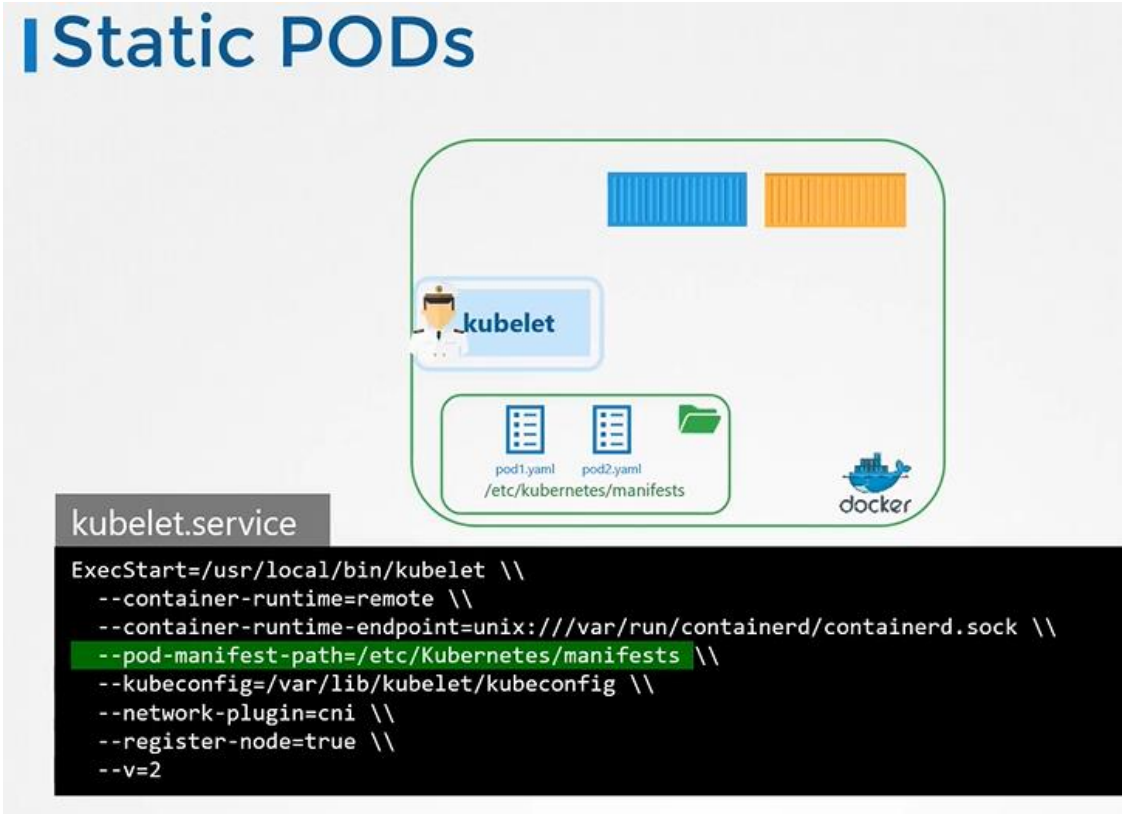
In this section, we will take a look at Static Pods

How do you provide a pod definition file to the kubelet without a kube-apiserver?

- You can configure the kubelet to read the pod definition files from a directory on the server designated to store information about pods.

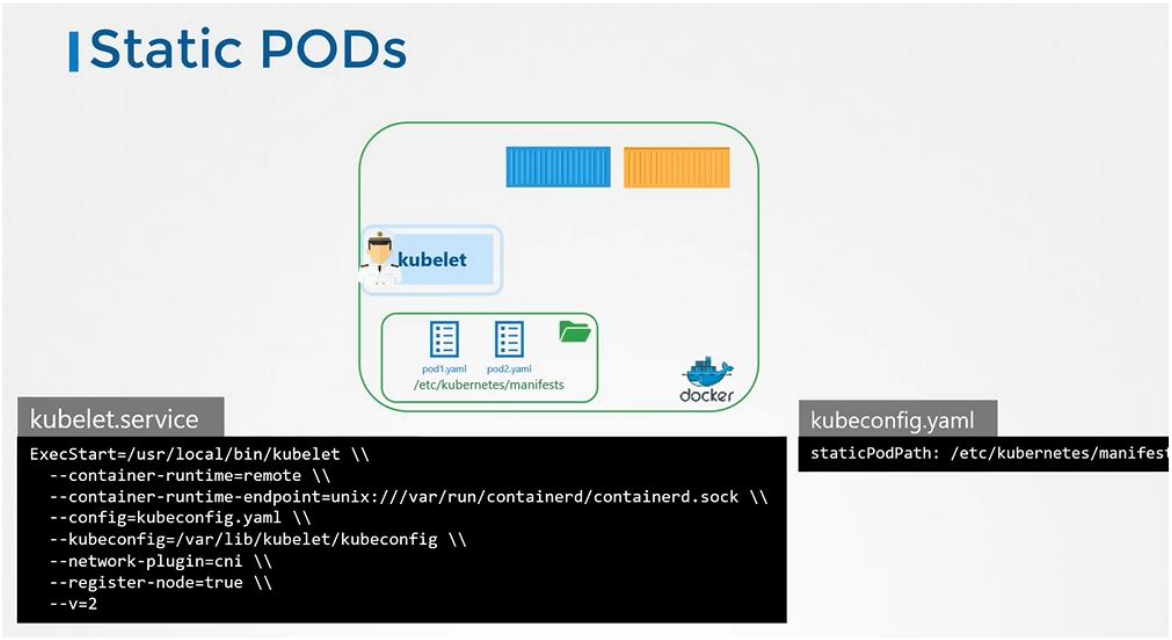
Configure Static Pod

- The designated directory can be any directory on the host and the location of that directory is passed in to the kubelet as an option while running the service.
    - The option is named as **`--pod-manifest-path`**.



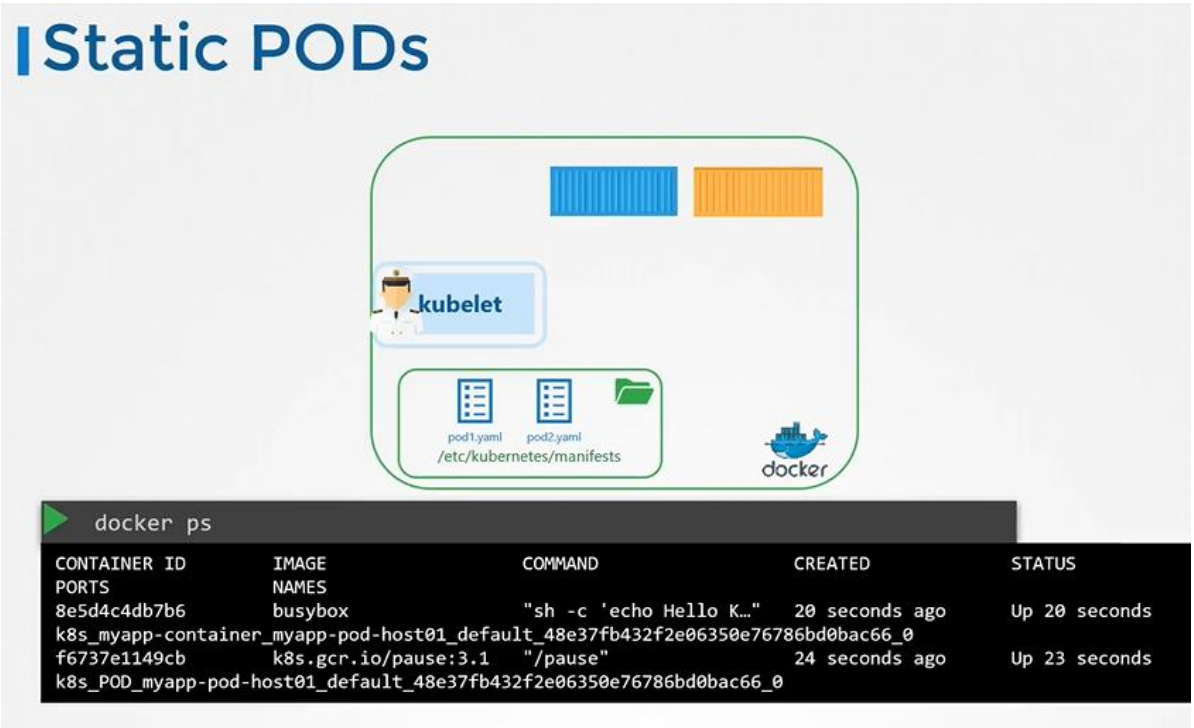
Another way to configure static pod

- Instead of specifying the option directly in the **`kubelet.service`** file, you could provide a path to another config file using the config option, and define the directory path as staticPodPath in the file.

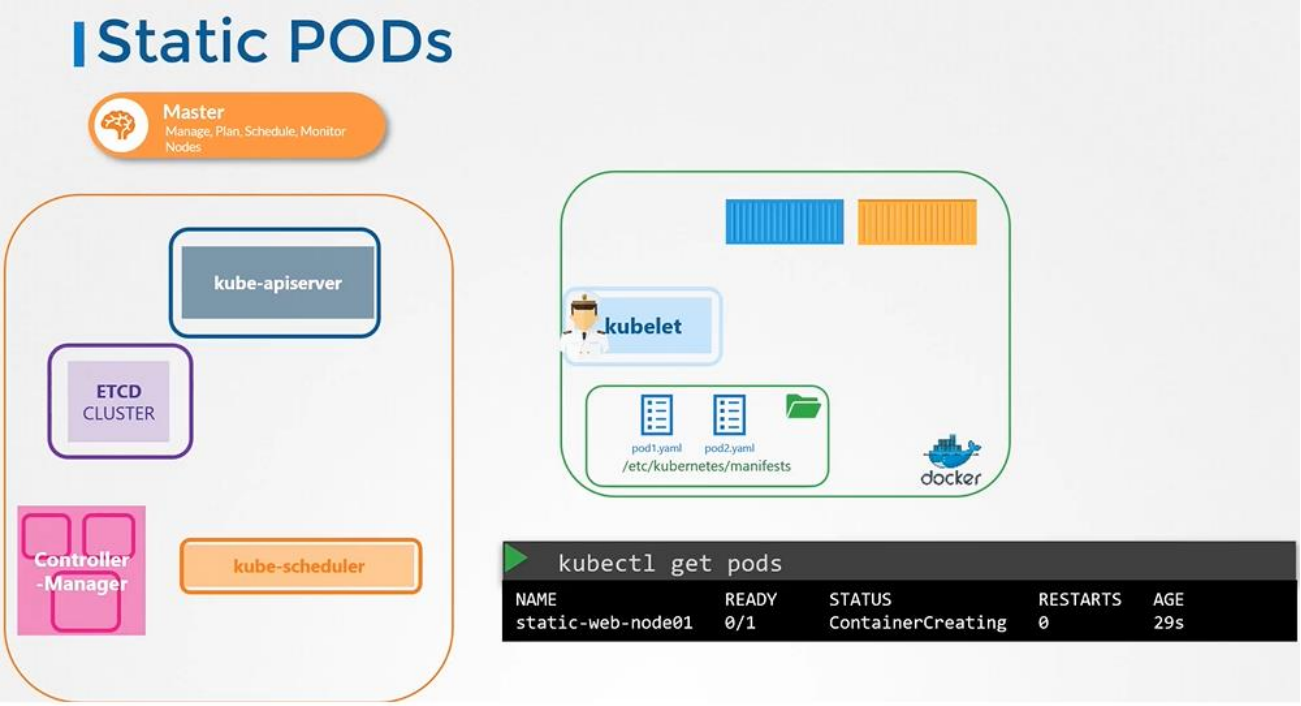


View the static pods

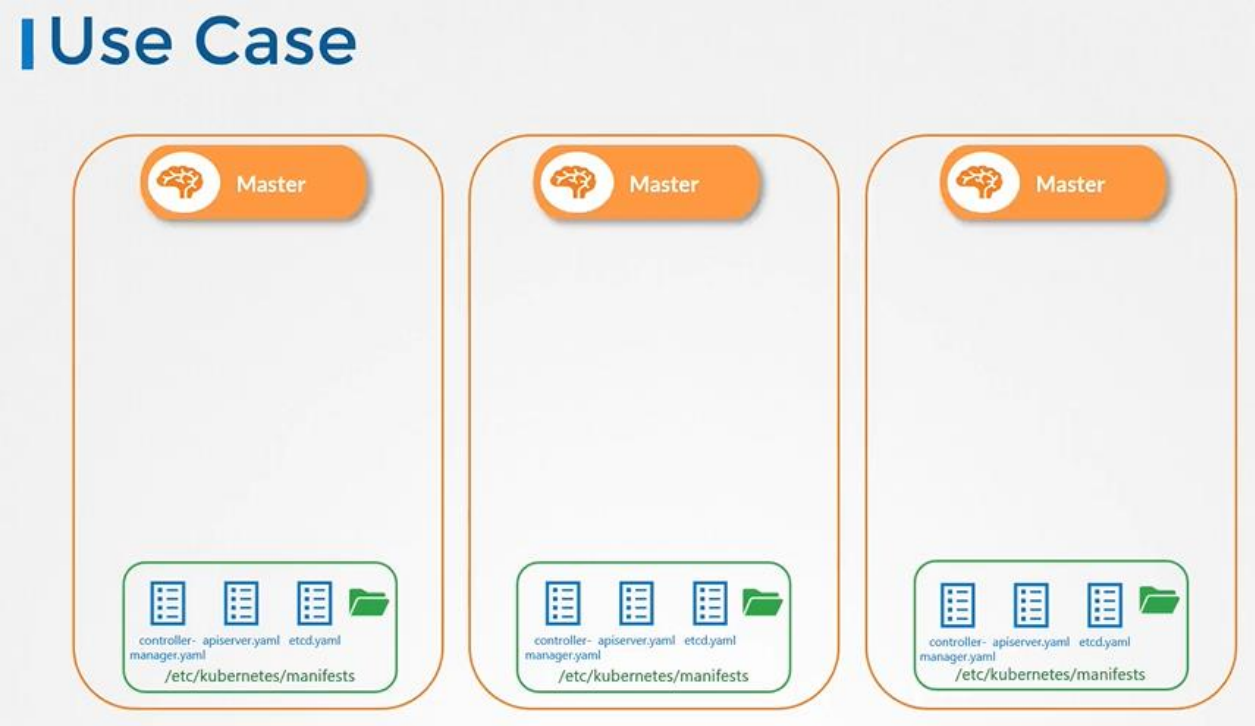
- To view the static pods
- `$ docker ps`

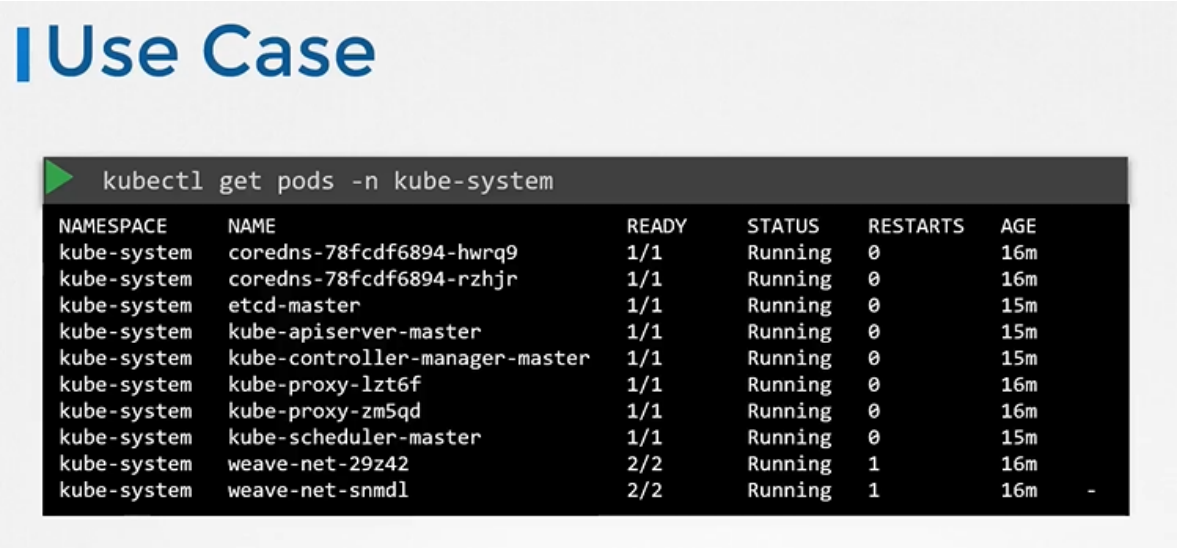


The kubelet can create both kinds of pods - the static pods and the ones from the api server at the same time.

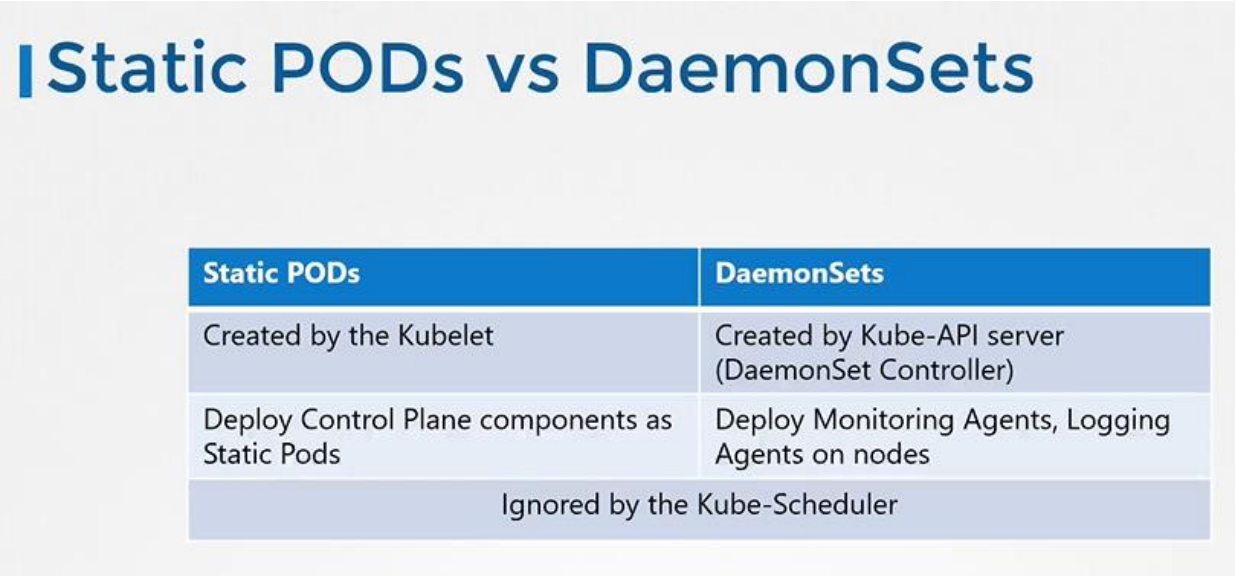


Static Pods - Use Case





Static Pods vs DaemonSets



K8s Reference Docs

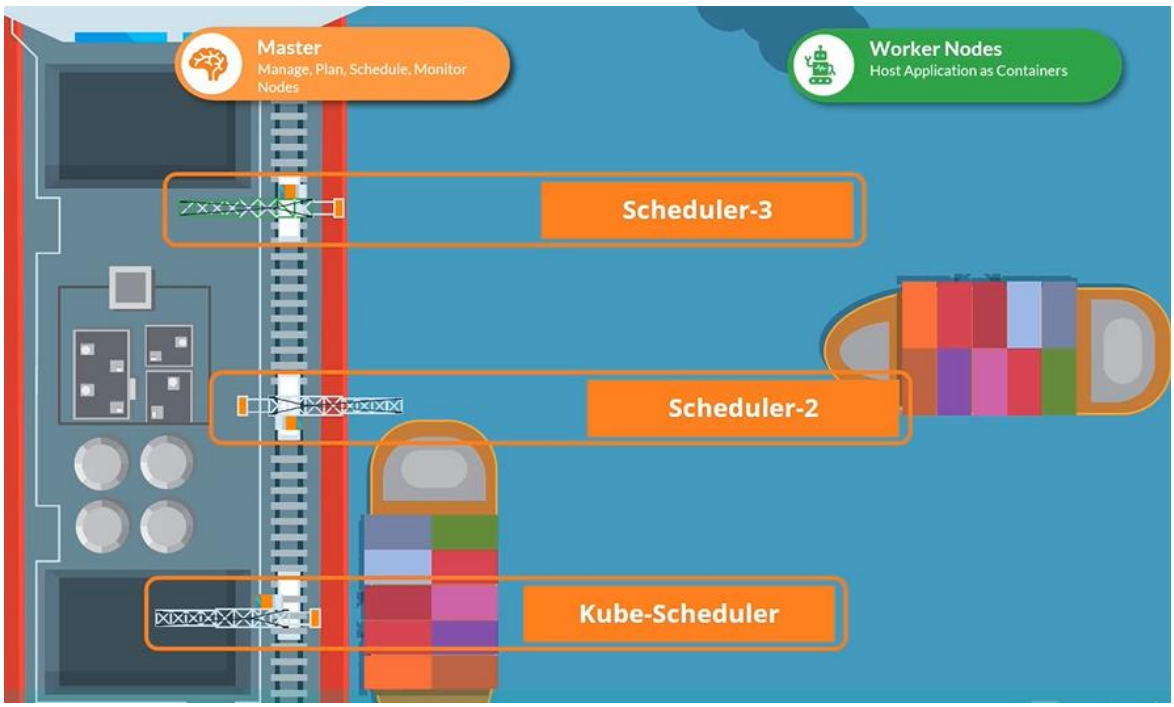
- https://kubernetes.io/docs/tasks/configure-pod-container/static-pod/

Multiple Schedulers

In this section, we will take a look at multiple schedulers

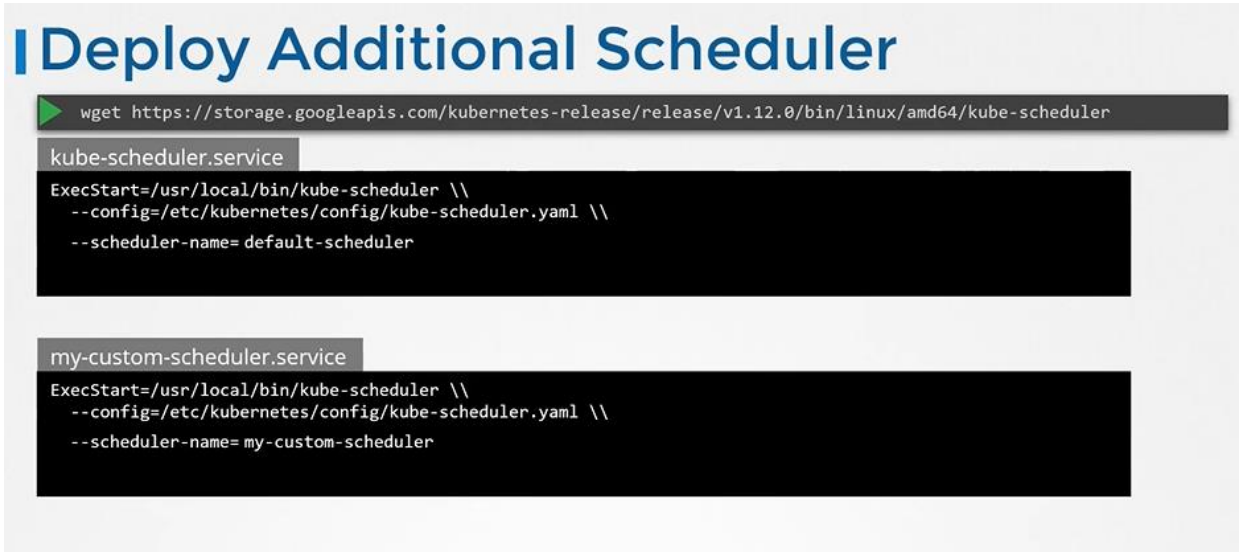
Custom Schedulers

- Your kubernetes cluster can schedule multiple schedulers at the same time.

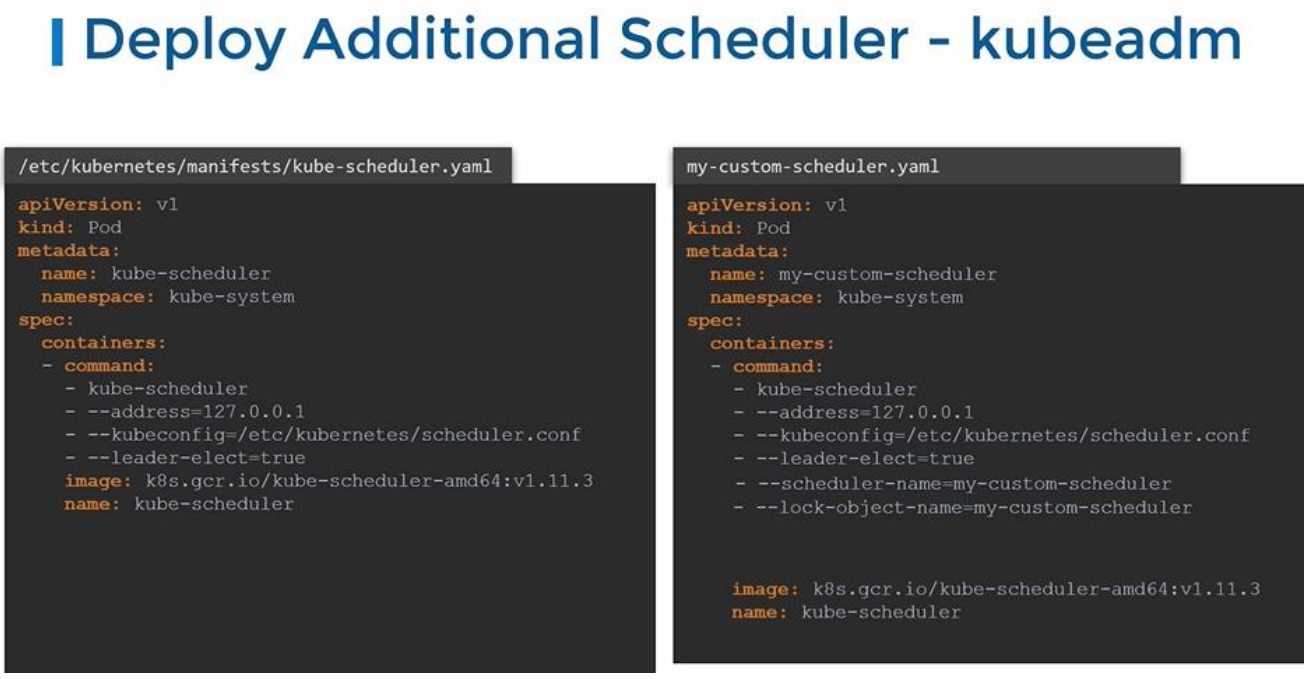


Deploy additional scheduler

- Download the binary
- `$ wget https://storage.googleapis.com/kubernetes-release/release/v1.12.0/bin/linux/amd64/kube-scheduler`



Deploy additional scheduler - kubeadm



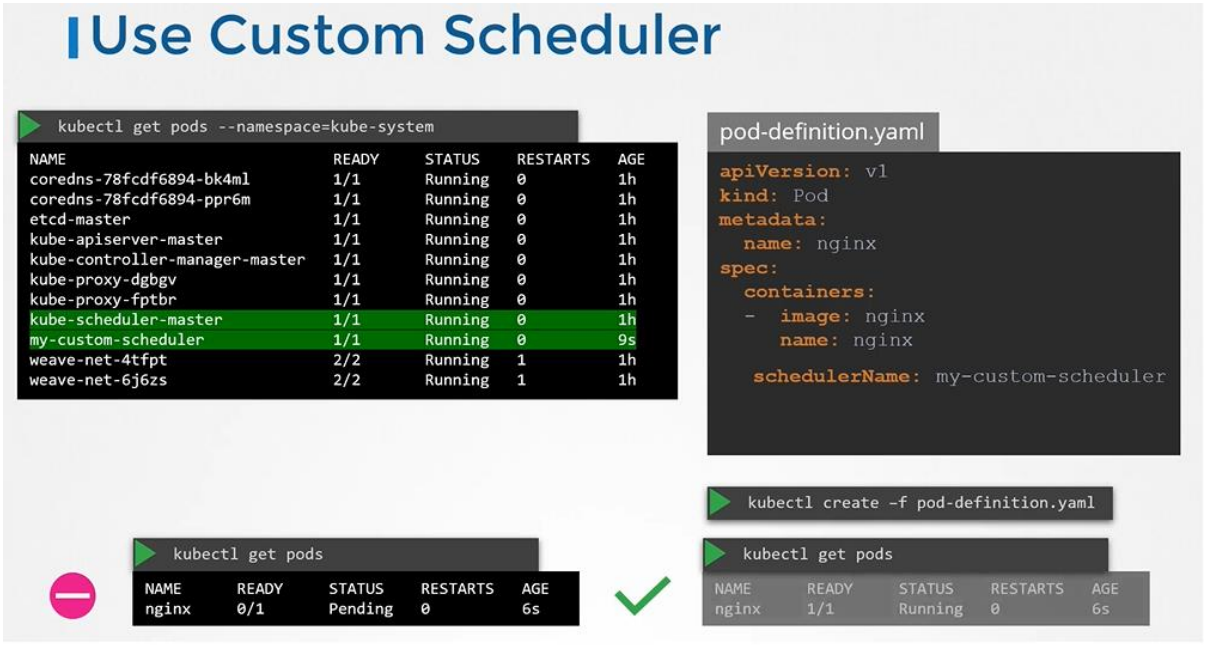
- To create a scheduler pod
- `$ kubectl create -f my-custom-scheduler.yaml`

View Schedulers

- To list the scheduler pods
- `$ kubectl get pods -n kube-system`

Use the Custom Scheduler

- Create a pod definition file and add new section called **`schedulerName`** and specify the name of the new scheduler
- `apiVersion: v1`
- `kind: Pod`
- `metadata:`
- `  name: nginx`
- `spec:`
- `  containers:`
- `  - image: nginx`
- `    name: nginx`
- `  schedulerName: my-custom-scheduler`



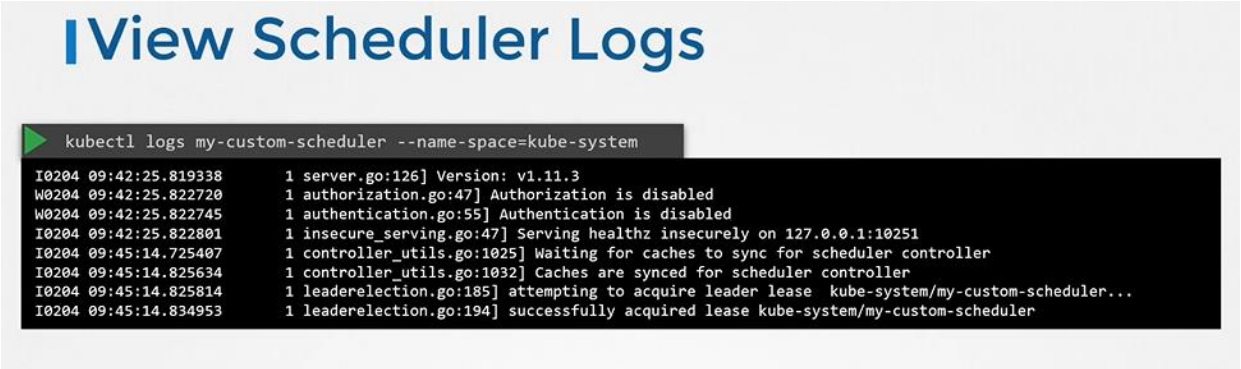
- To create a pod definition
- `$ kubectl create -f pod-definition.yaml`
- To list pods
- `$ kubectl get pods`

View Events

- To view events
- `$ kubectl get events`

View Scheduler Logs

- To view scheduler logs
- `$ kubectl logs my-custom-scheduler -n kube-system`

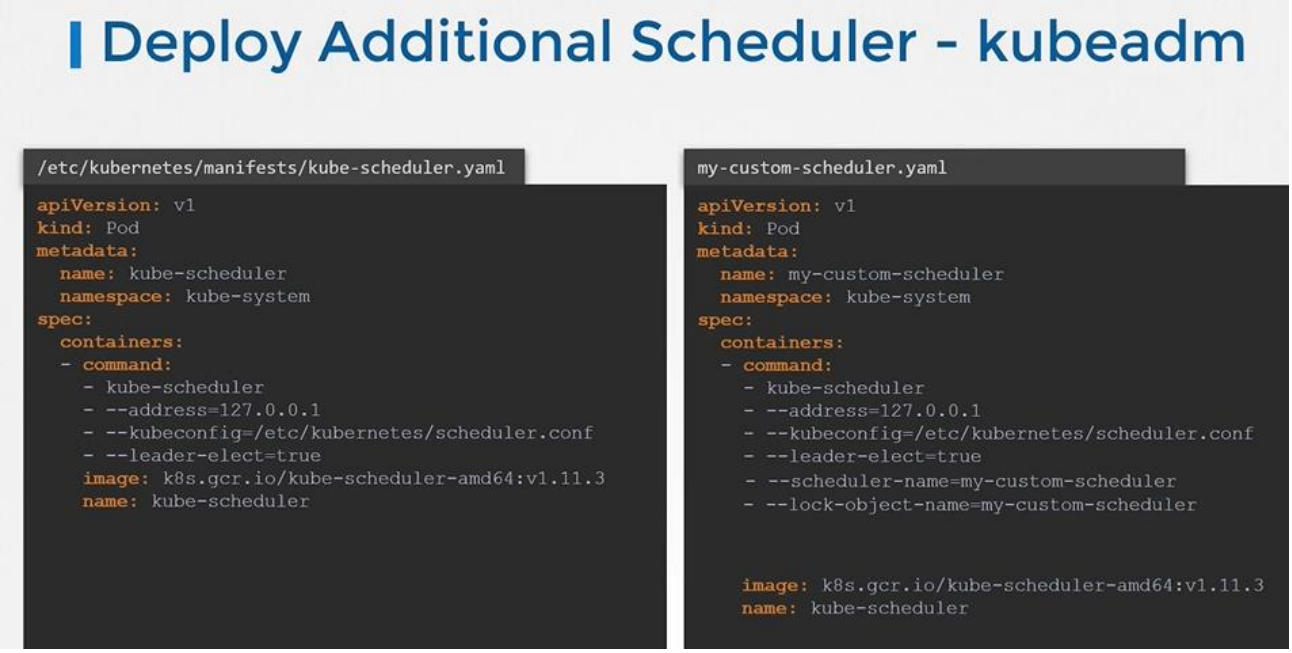


K8s Reference Docs

- https://kubernetes.io/docs/tasks/extend-kubernetes/configure-multiple-schedulers/

Configuring Kubernetes Schedulers

In this section, we will take a look at configuring kubernetes schedulers.



References

- https://kubernetes.io/blog/2017/03/advanced-scheduling-in-kubernetes/
- https://jvns.ca/blog/2017/07/27/how-does-the-kubernetes-scheduler-work/
- https://stackoverflow.com/questions/28857993/how-does-kubernetes-scheduler-work

Logging and Monitoring Section Introduction

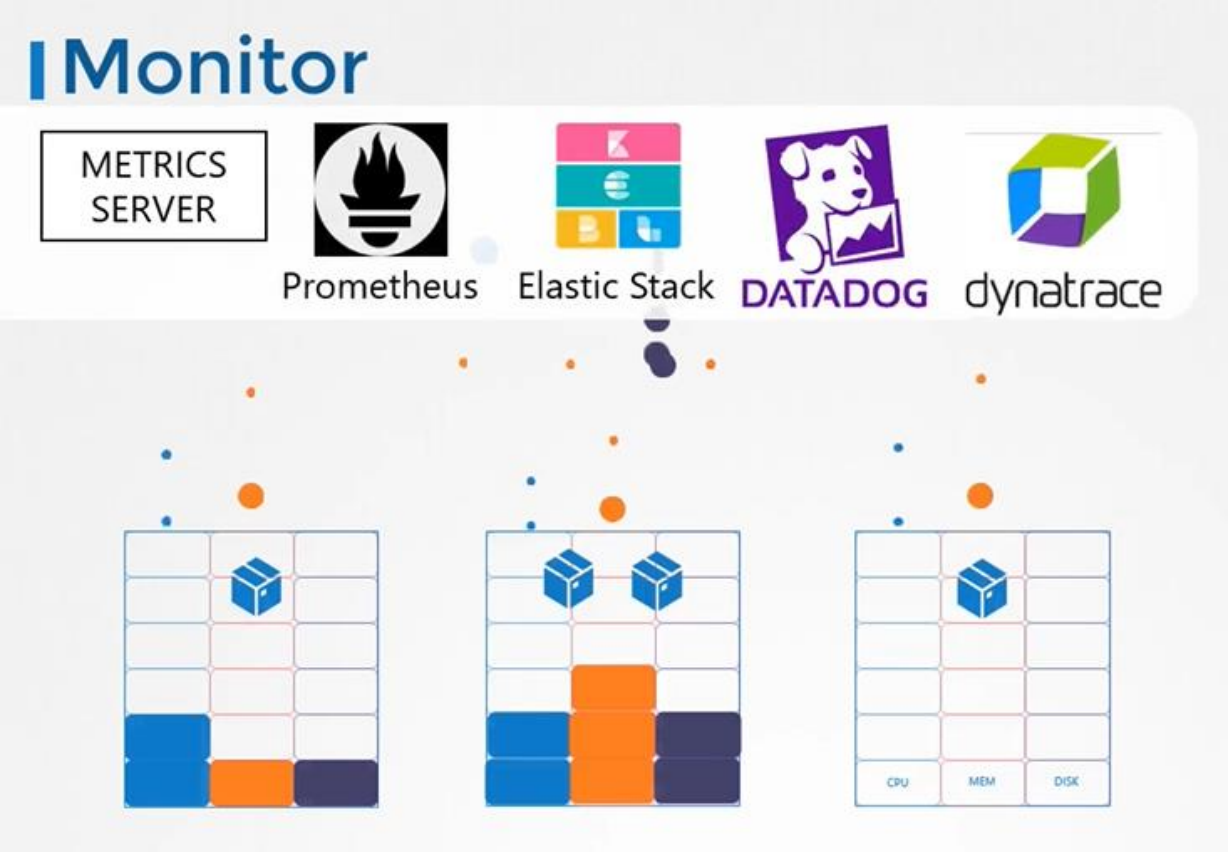
In this section, we will take a look at the below

- Monitor Cluster Components
- Monitor Applications
- Monitor Cluster Components Logs
- Application Logs

Monitor Cluster Components

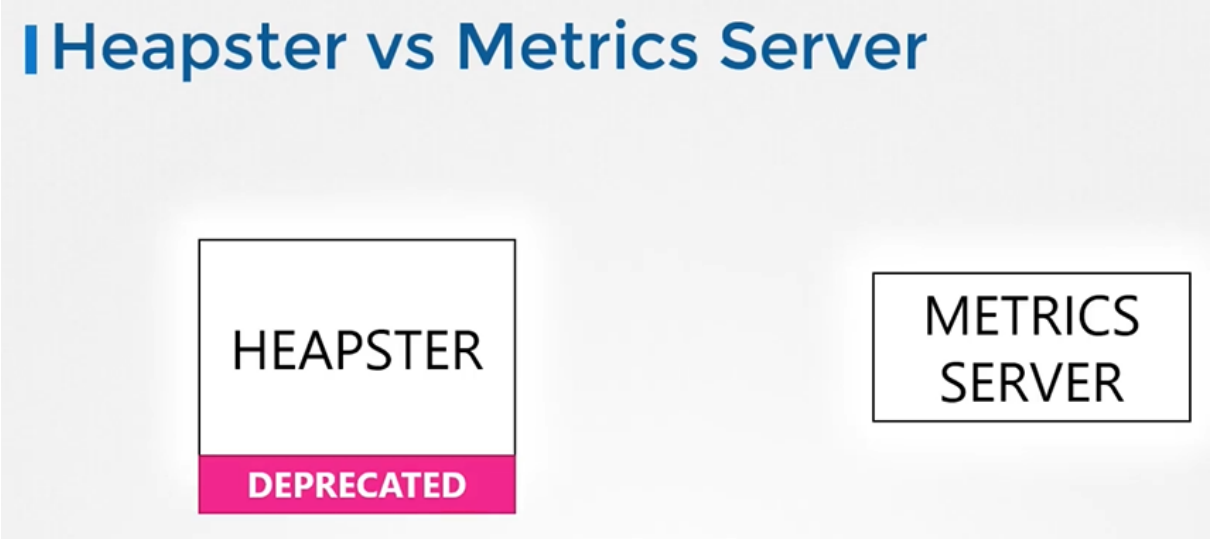
In this section, we will take a look at monitoring kubernetes cluster

How do you monitor resource consumption in kubernetes? or more importantly, what would you like to monitor?

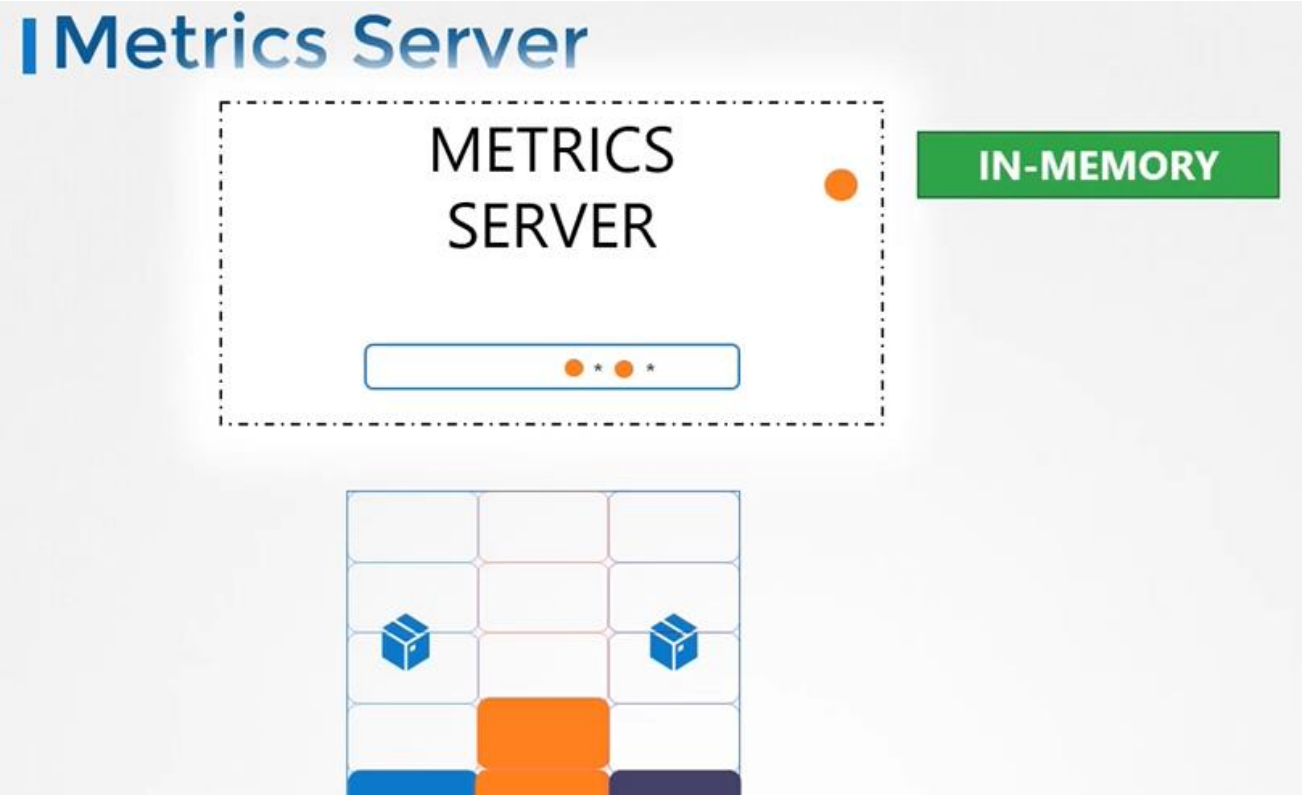


Heapster vs Metrics Server

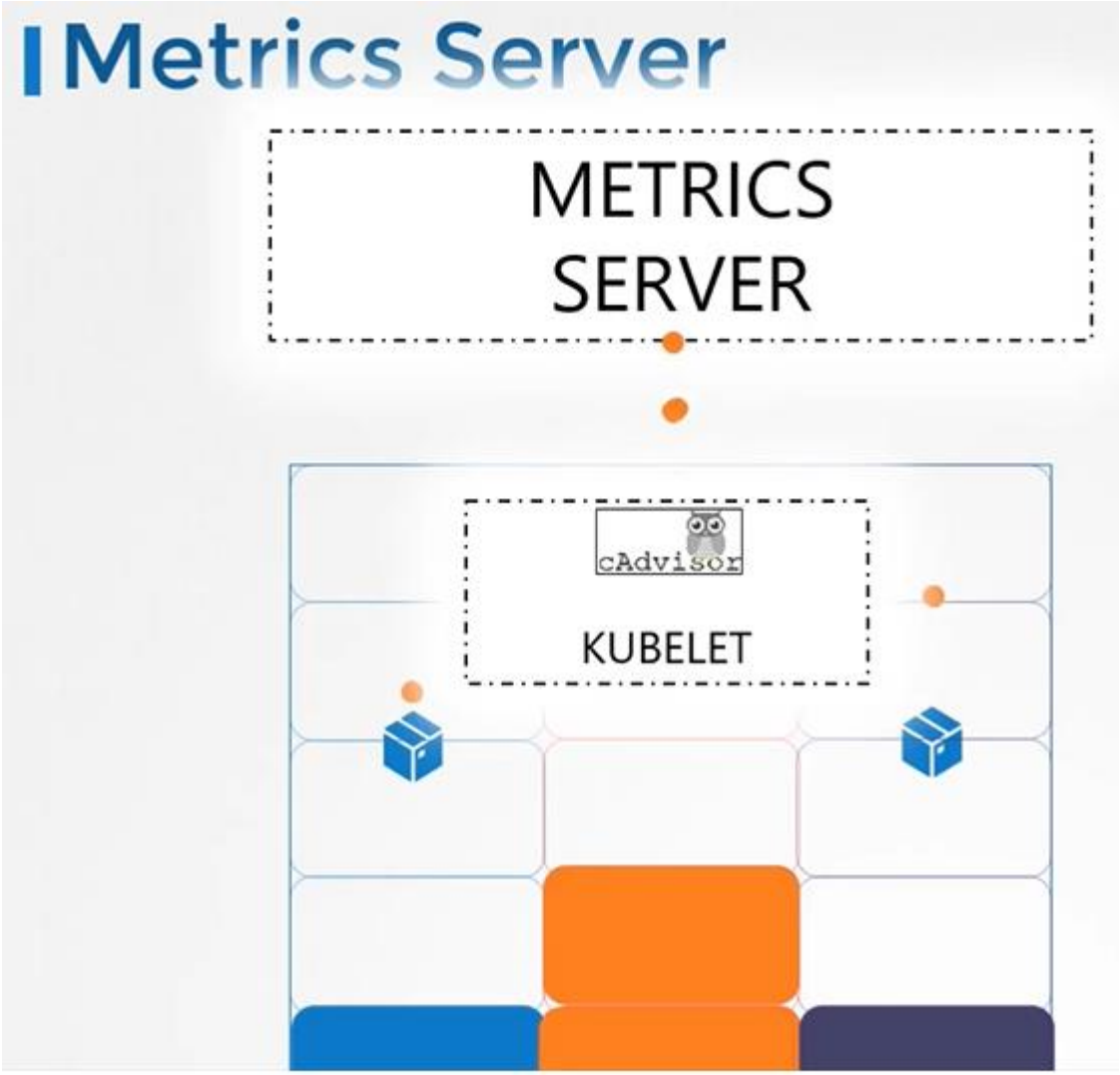
- Heapster is now deprecated and a slimmed down version was formed known as the **`metrics server`**.



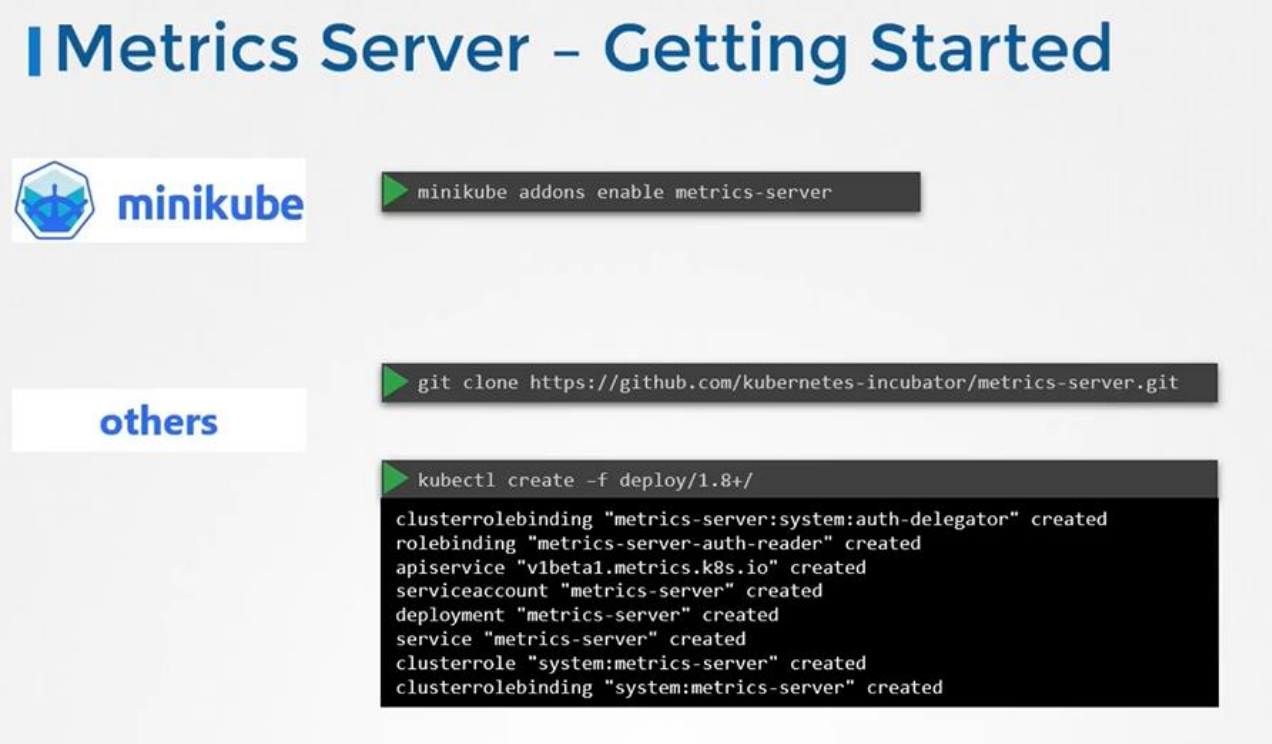
Metrics Server



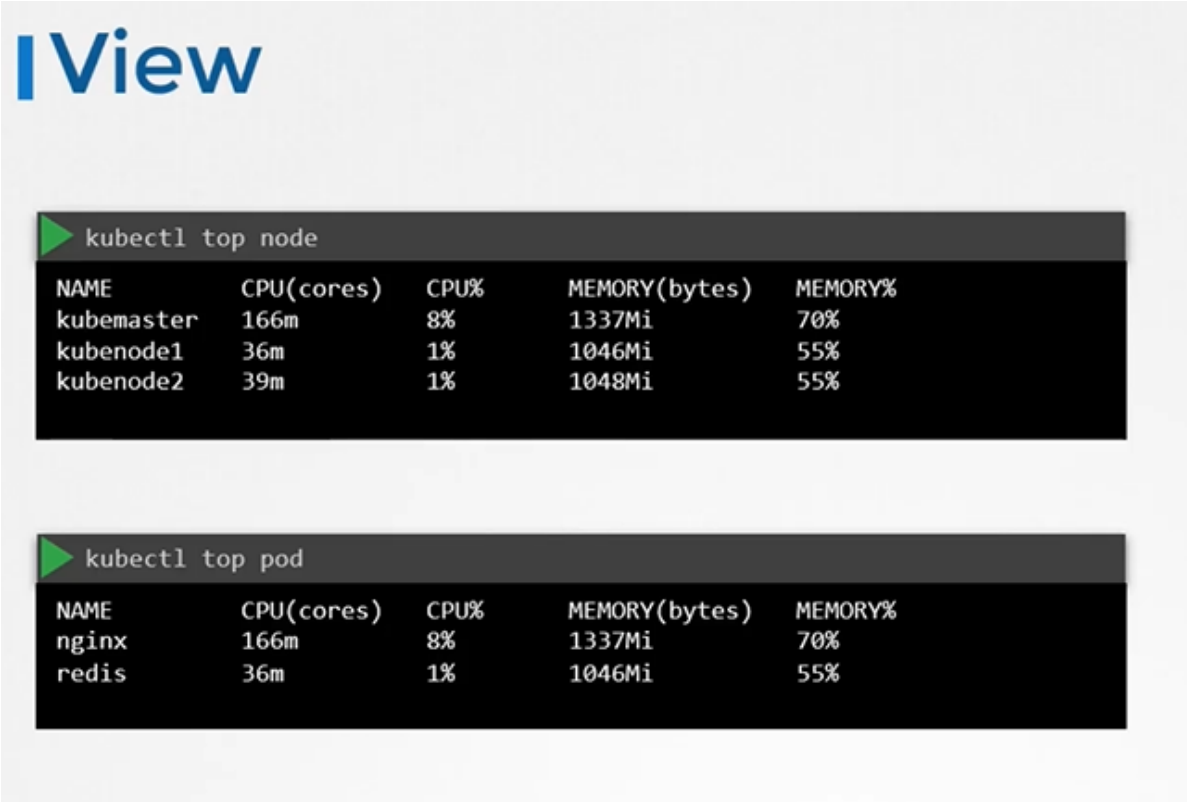
How are the metrics generated for the PODs on these nodes?



Metrics Server - Getting Started



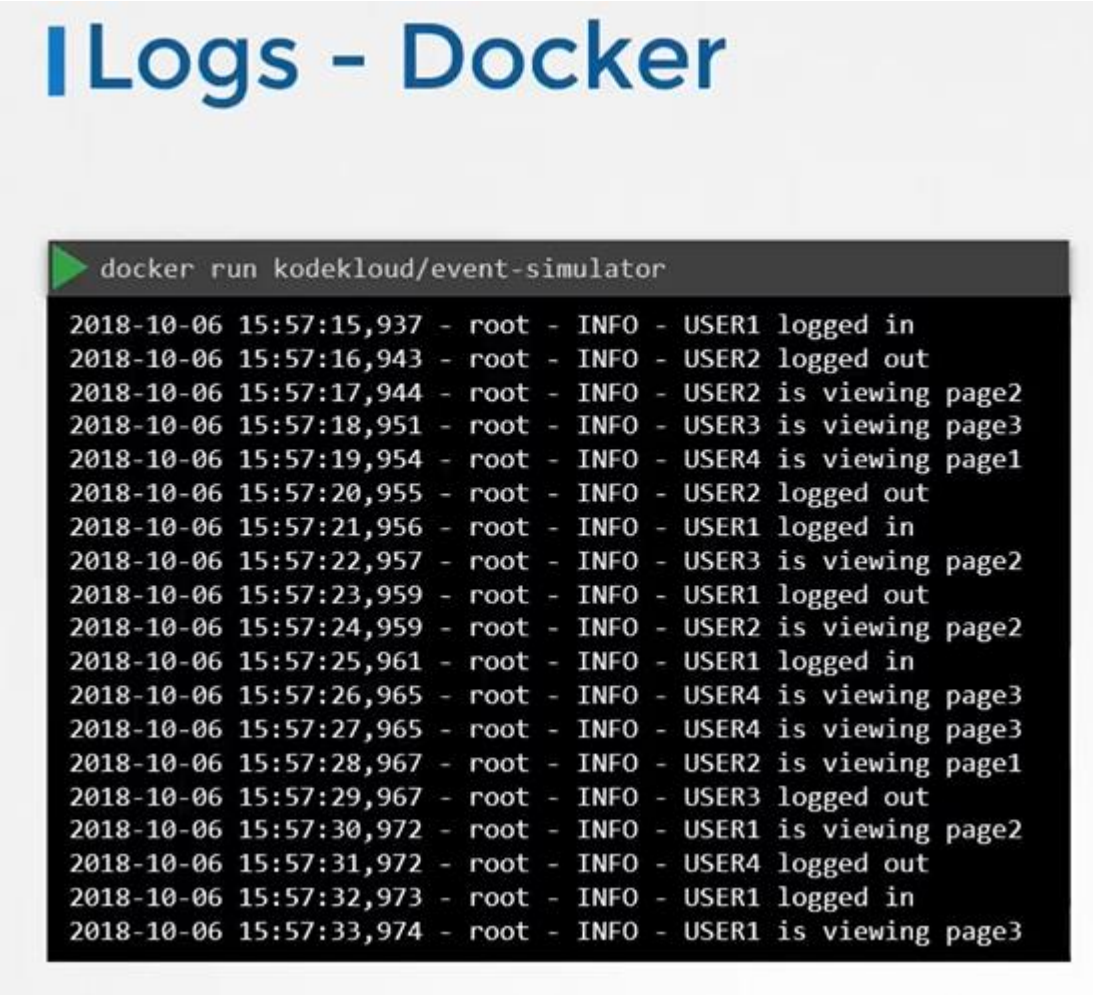
- Clone the metric server from github repo
- `$ git clone https://github.com/kubernetes-incubator/metrics-server.git`
- Deploy the metric server
- `$ kubectl create -f metric-server/deploy/1.8+/`
- View the cluster performance
- `$ kubectl top node`
- View performance metrics of pod
- `$ kubectl top pod`

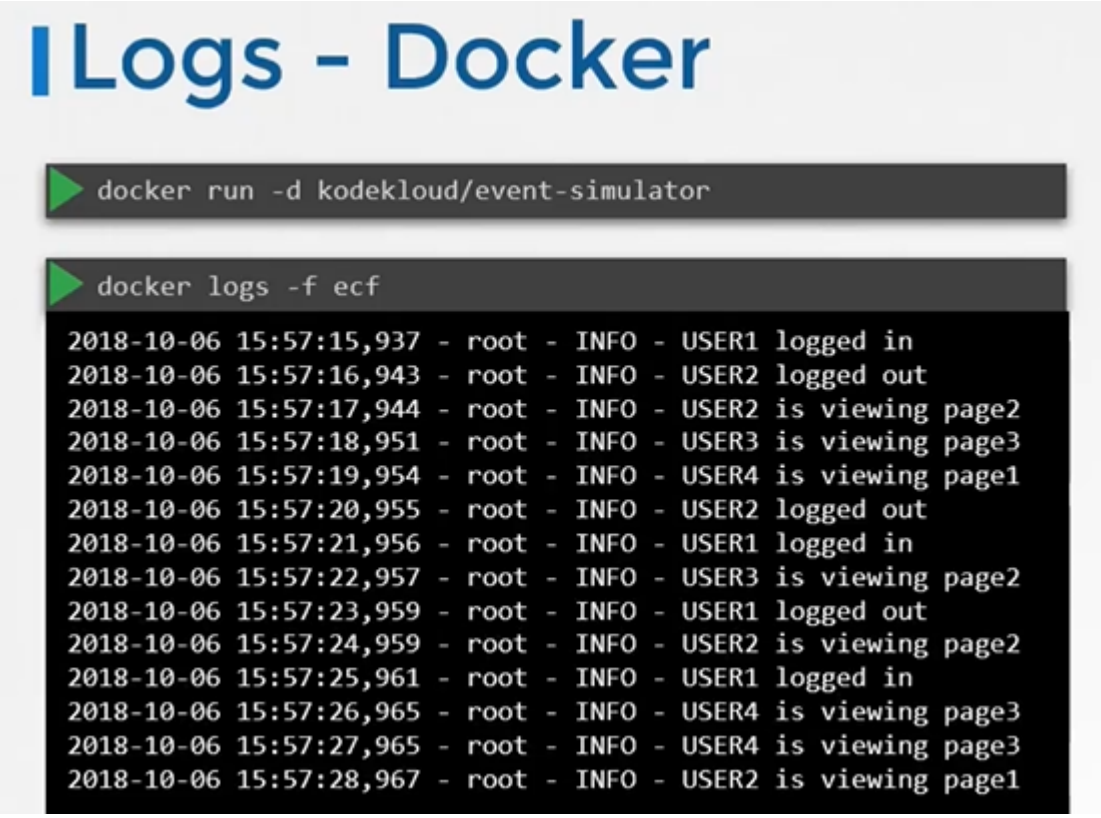


Managing Application Logs

In this section, we will take a look at managing application logs

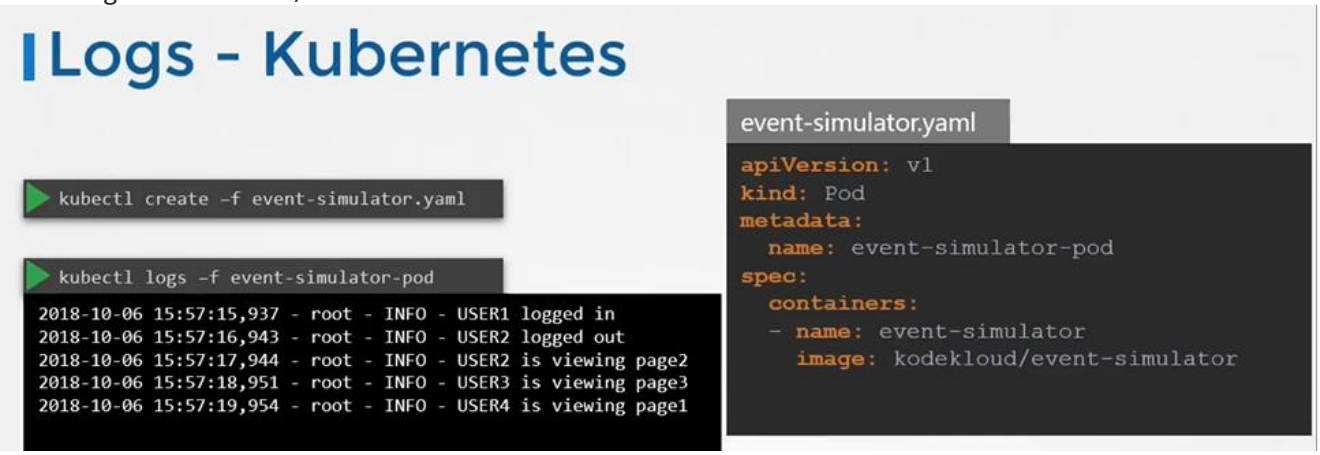
Let us start with logging in docker





Logs - Kubernetes

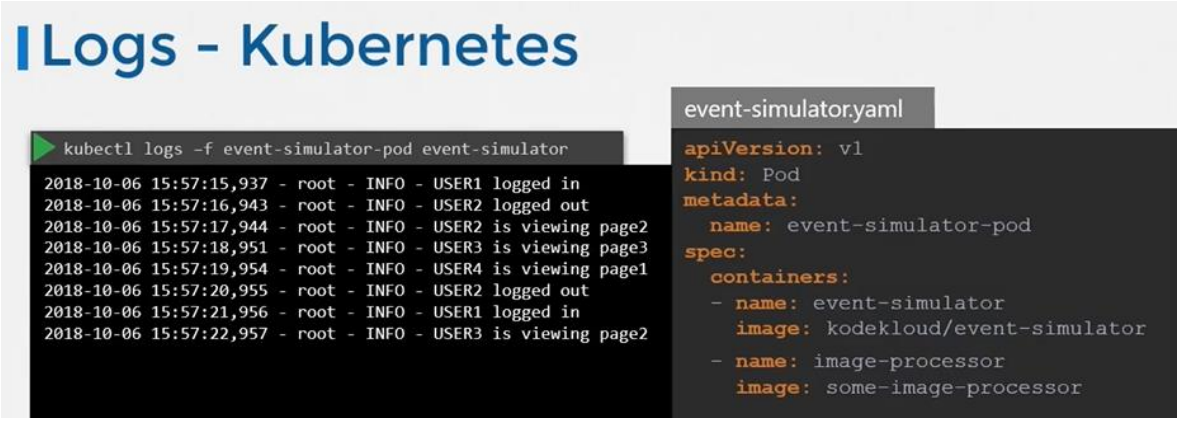
```
apiVersion: v1
kind: Pod
metadata:
  name: event-simulator-pod
spec:
  containers:
  - name: event-simulator
    image: kodekloud/event-simulator
```



- To view the logs
- `$ kubectl logs -f event-simulator-pod`

- If there are multiple containers in a pod then you must specify the name of the container explicitly in the command.

- `$ kubectl logs -f <pod-name> <container-name>`
- `$ kubectl logs -f even-simulator-pod event-simulator`



K8s Reference Docs

- https://kubernetes.io/blog/2015/06/cluster-level-logging-with-kubernetes/

Application Lifecycle Management Section Introduction

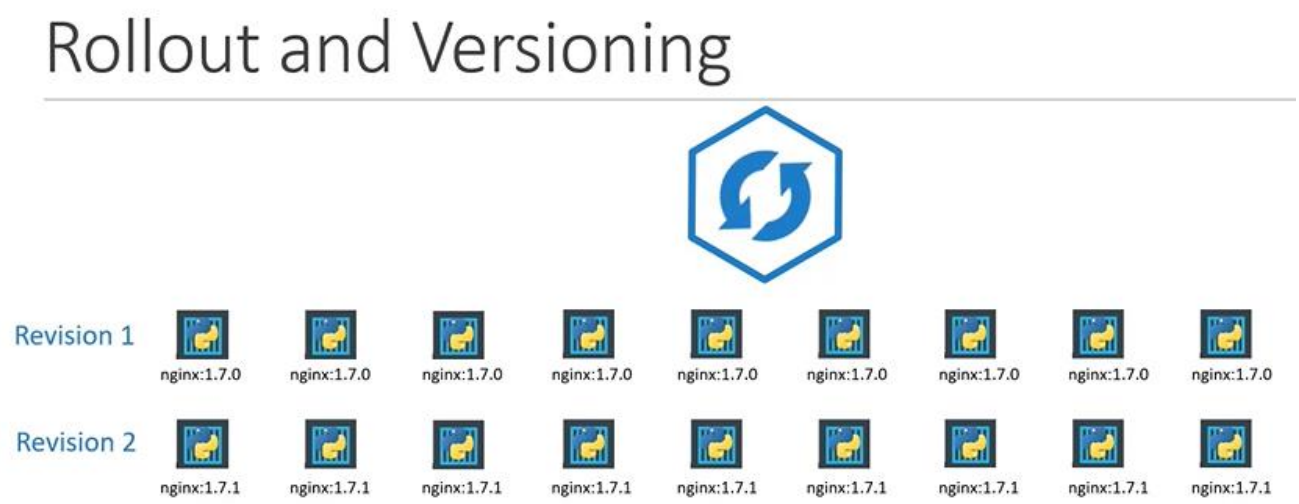
In this section, we will take a look at application lifecycle management

- Rolling Updates and Rollbacks in Deployments
- Configure Applications
- Scale Applications
- Self-Healing Application

Rolling Updates and Rollback

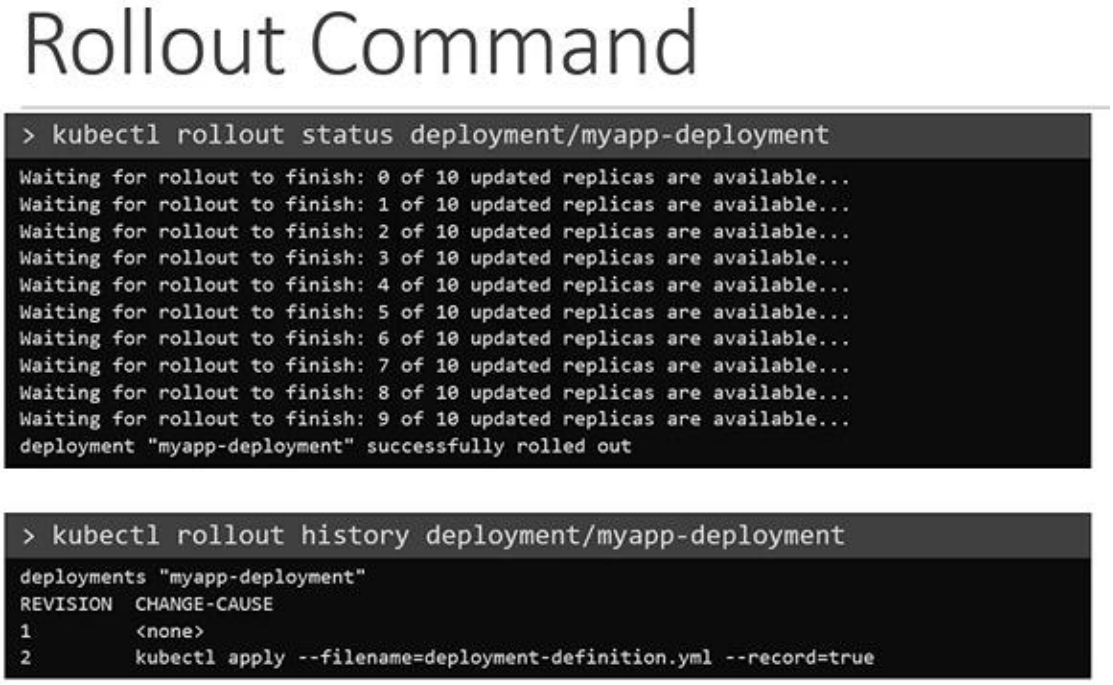
In this section, we will take a look at rolling updates and rollback in a deployment

Rollout and Versioning in a Deployment



Rollout commands

- You can see the status of the rollout by the below command
- `$ kubectl rollout status deployment/myapp-deployment`
- To see the history and revisions
- `$ kubectl rollout history deployment/myapp-deployment`



Deployment Strategies

- There are 2 types of deployment strategies

  i. Recreate
  ii. RollingUpdate (Default Strategy)

kubectl apply

- To update a deployment, edit the deployment and make necessary changes and save it. Then run the below command.

```
apiVersion: apps/v1
kind: Deployment
metadata:
 name: myapp-deployment
 labels:
  app: nginx
spec:
 template:
   metadata:
     name: myap-pod
     labels:
       app: myapp
       type: front-end
   spec:
    containers:
    - name: nginx-container
      image: nginx:1.7.1
 replicas: 3
 selector:
  matchLabels:
    type: front-end
```

```
$ kubectl apply -f deployment-definition.yaml
```

- Alternate way to update a deployment say for example for updating an image.

```
$ kubectl set image deployment/myapp-deployment nginx=nginx:1.9.1
```

Kubectl apply

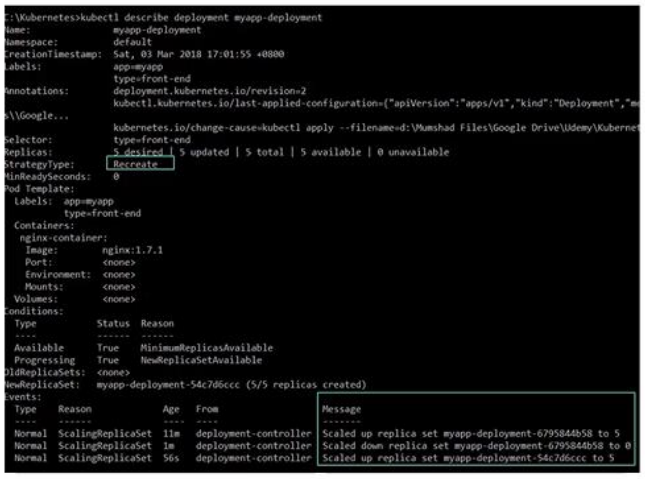
```
> kubectl apply -f deployment-definition.yml
deployment "myapp-deployment" configured
```

```
> kubectl set image deployment/myapp-deployment \
                  nginx=nginx:1.9.1
deployment "myapp-deployment" image is updated
```

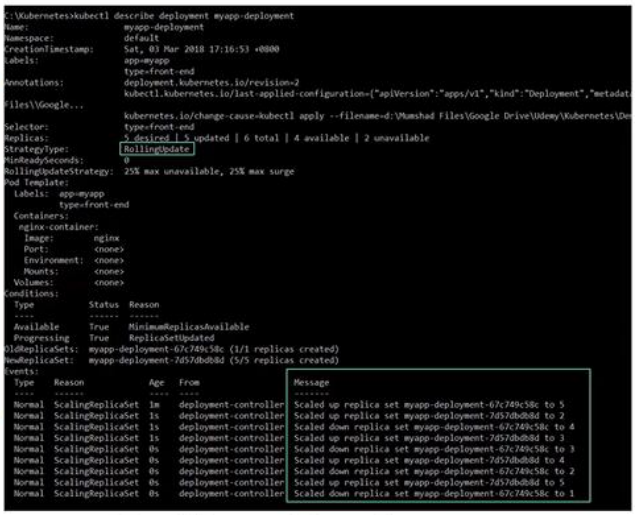
deployment-definition.yml

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp-deployment
  labels:
     app: myapp
     type: front-end
spec:
  template:
    metadata:
      name: myapp-pod
      labels:
        app: myapp
        type: front-end
    spec:
      containers:
      - name: nginx-container
        image: nginx:1.7.1
  replicas: 3
  selector:
    matchLabels:
      type: front-end
```

Recreate vs RollingUpdate



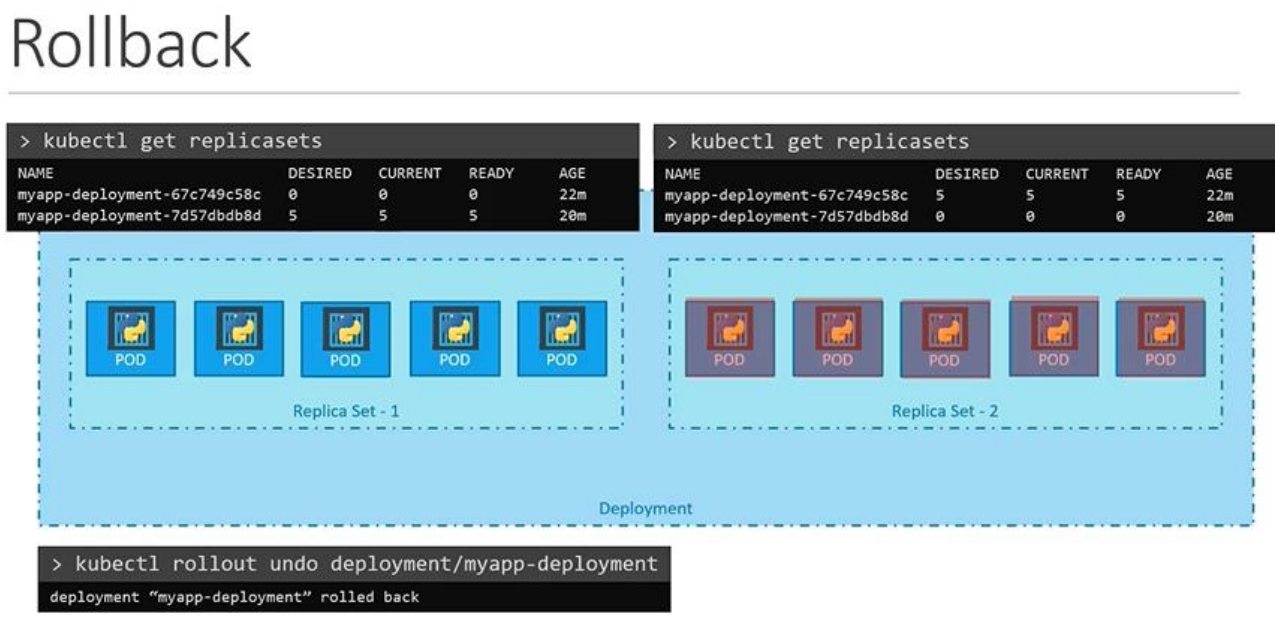
Recreate



RollingUpdate

Upgrades

Rollback



- To undo a change
- `$ kubectl rollout undo deployment/myapp-deployment`

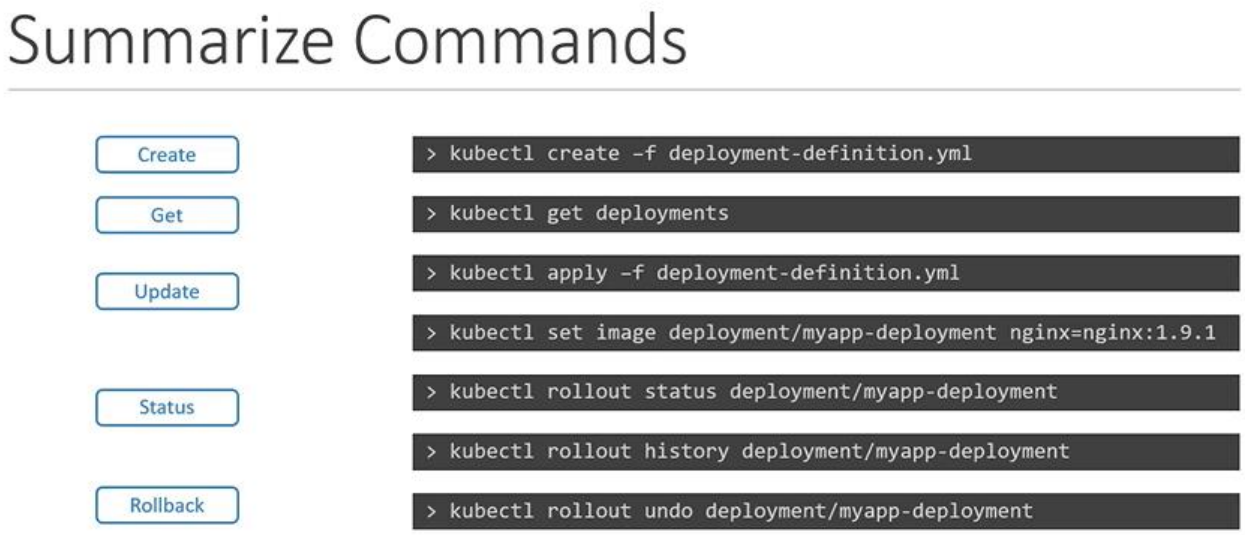
kubectl create

- To create a deployment

- `$ kubectl create deployment nginx --image=nginx`

Summarize kubectl commands

```
$ kubectl create -f deployment-definition.yaml
$ kubectl get deployments
$ kubectl apply -f deployment-definition.yaml
$ kubectl set image deployment/myapp-deployment nginx=nginx:1.9.1
$ kubectl rollout status deployment/myapp-deployment
$ kubectl rollout history deployment/myapp-deployment
$ kubectl rollout undo deployment/myapp-deployment
```



K8s Reference Docs

- https://kubernetes.io/docs/concepts/workloads/controllers/deployment
- https://kubernetes.io/docs/tasks/run-application/run-stateless-application-deployment

Commands and Arguments in Docker

In this section, we will take a look at commands and arguments in docker

- To run a docker container
- `$ docker run ubuntu`
- To list running containers
- `$ docker ps`
- To list all containers including that are stopped

- `$ docker ps -a`

```
docker run ubuntu
docker ps
CONTAINER ID    IMAGE    COMMAND    CREATED    STATUS    PORTS

docker ps -a
CONTAINER ID    IMAGE    COMMAND          CREATED          STATUS                      PORTS
45aacca36850    ubuntu   "/bin/bash"      43 seconds ago   Exited (0) 41 seconds ago
```

Unlike virtual machines, containers are not meant to host operating system.

- Containers are meant to run a specific task or process such as to host an instance of a webserver or application server or a database server etc.

How do you specify a different command to start the container?

- One Option is to append a command to the docker run command and that way it overrides the default command specified within the image.
- `$ docker run ubuntu sleep 5`
- This way when the container starts it runs the sleep program, waits for 5 seconds and then exists. How do you make that change permanent?

```
FROM Ubuntu

CMD sleep 5
```

- There are different ways of specifying the command either the command simply as is in a shell form or in a JSON array format.

- Now, build the docker image
- `$ docker build -t ubuntu-sleeper .`
- Run docker container
- `$ docker run ubuntu-sleeper`

Entrypoint Instruction

- The entrypoint instruction is like the command instruction as in you can specify the program that will be run when the container starts and whatever you specify on the command line.

K8s Reference Docs

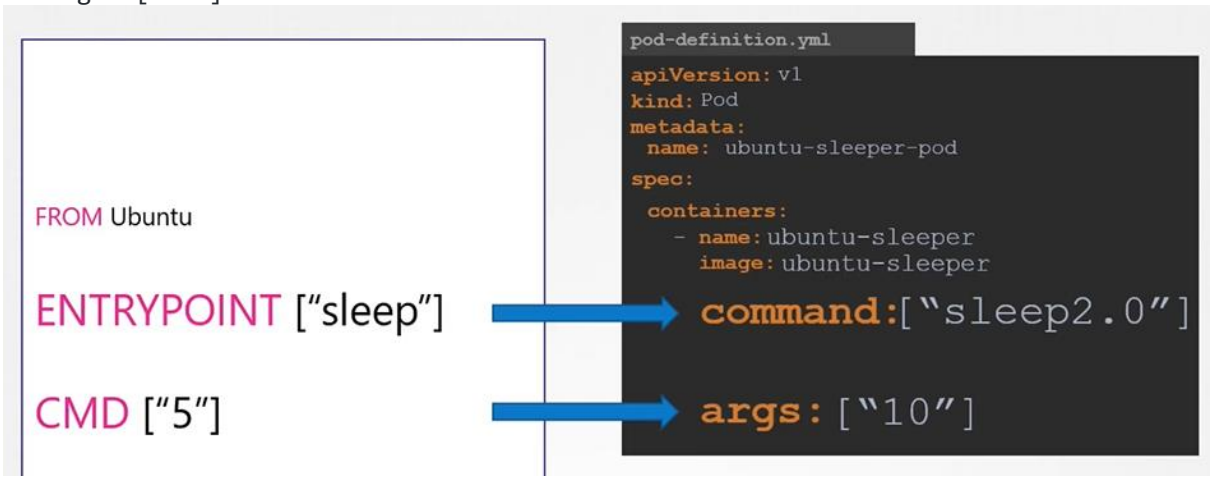
- https://docs.docker.com/engine/reference/builder/#cmd

Commands and Arguments in Kubernetes

In this section, we will take a look at commands and arguments in kubernetes

- Anything that is appended to the docker run command will go into the **`args`** property of the pod definition file in the form of an array.
- The command field corresponds to the entrypoint instruction in the Dockerfile so to summarize there are 2 fields that correspond to 2 instructions in the Dockerfile.
- `apiVersion: v1`

```
kind: Pod
metadata:
  name: ubuntu-sleeper-pod
spec:
 containers:
 - name: ubuntu-sleeper
   image: ubuntu-sleeper
   command: ["sleep2.0"]
   args: ["10"]
```



K8s Reference Docs

- https://kubernetes.io/docs/tasks/inject-data-application/define-command-argument-container/

Configure Environment Variables In Applications

ENV variables in Docker

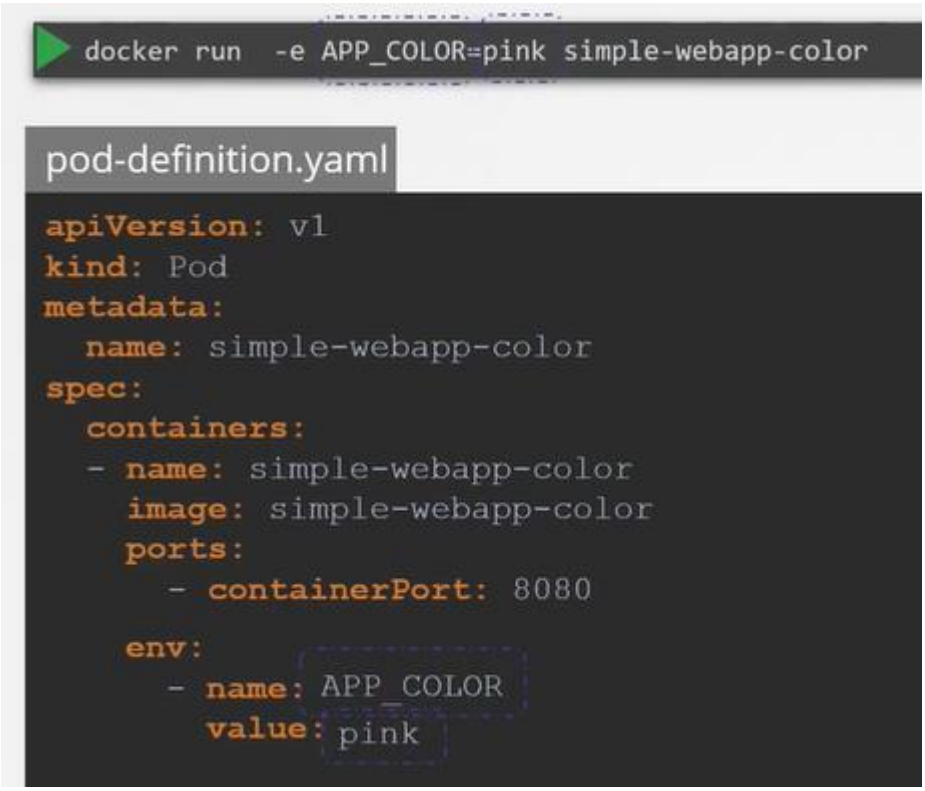
```
$ docker run -e APP_COLOR=pink simple-webapp-color
```

ENV variables in kubernetes

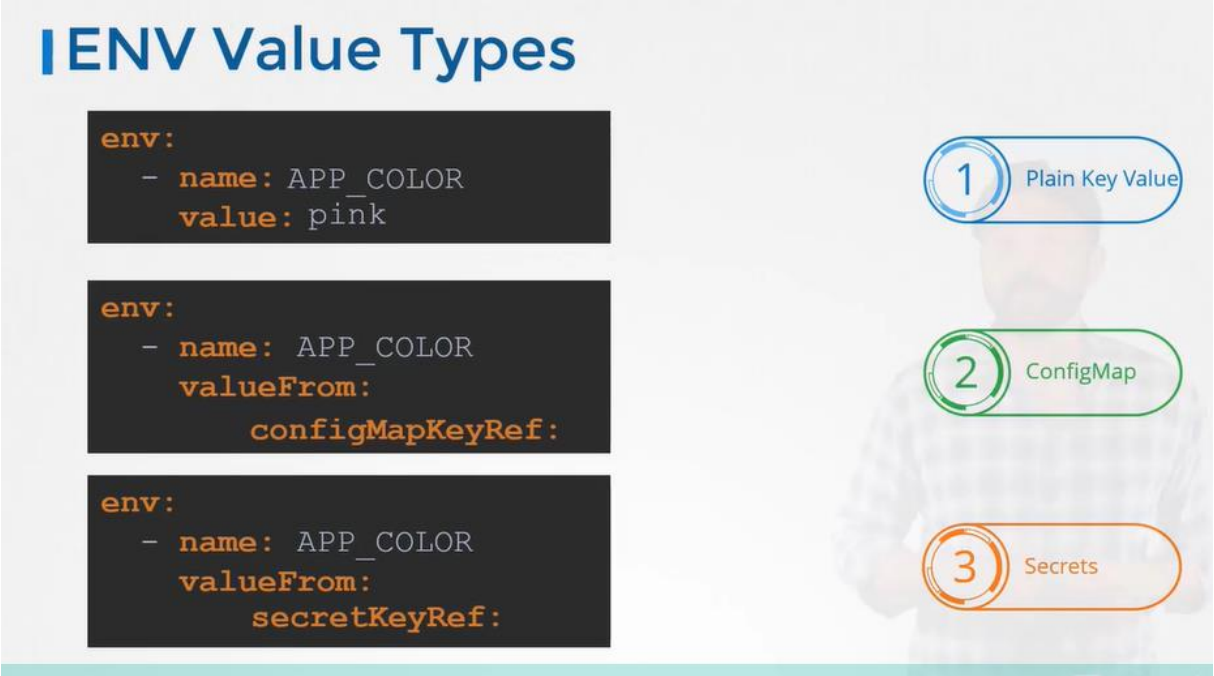
- To set an environment variable set an **env** property in pod definition file.

```
apiVersion: v1
kind: Pod
metadata:
  name: simple-webapp-color
spec:
 containers:
 - name: simple-webapp-color
   image: simple-webapp-color
   ports:
   - containerPort: 8080
```

```
    env:
    - name: APP_COLOR
      value: pink
```



- There are other ways of setting the environment variables such as **`ConfigMaps`** and **`Secrets`**



K8s Reference Docs

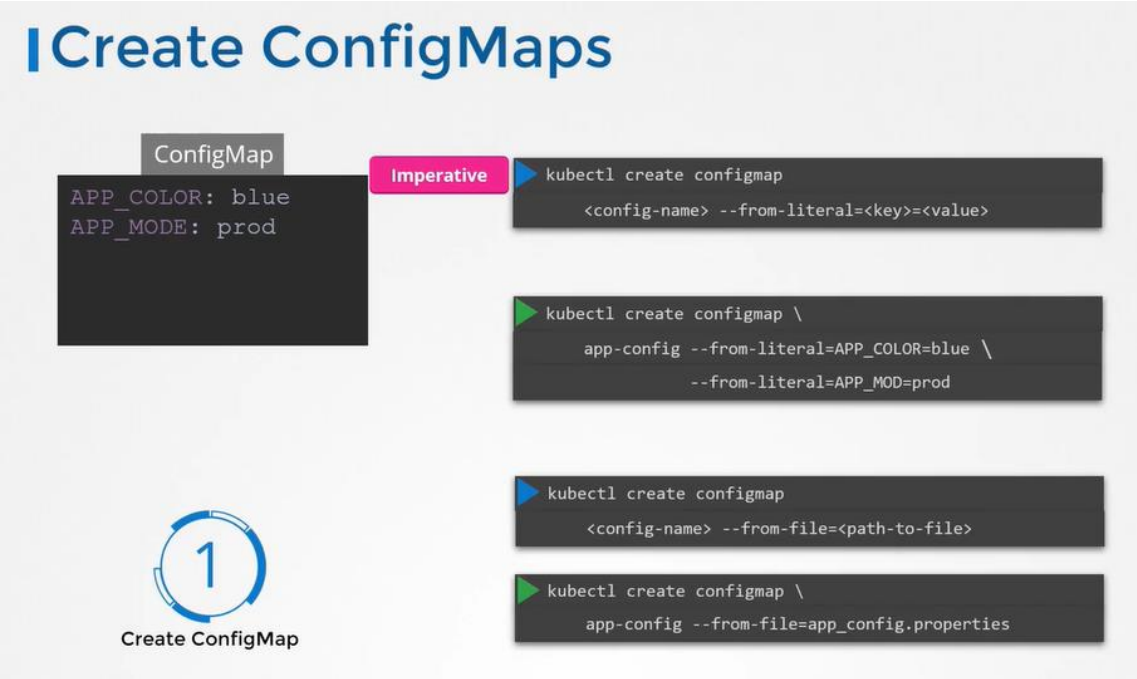
- https://kubernetes.io/docs/tasks/inject-data-application/define-environment-variable-container/

Configure ConfigMaps in Applications

In this section, we will take a look at configuring configmaps in applications

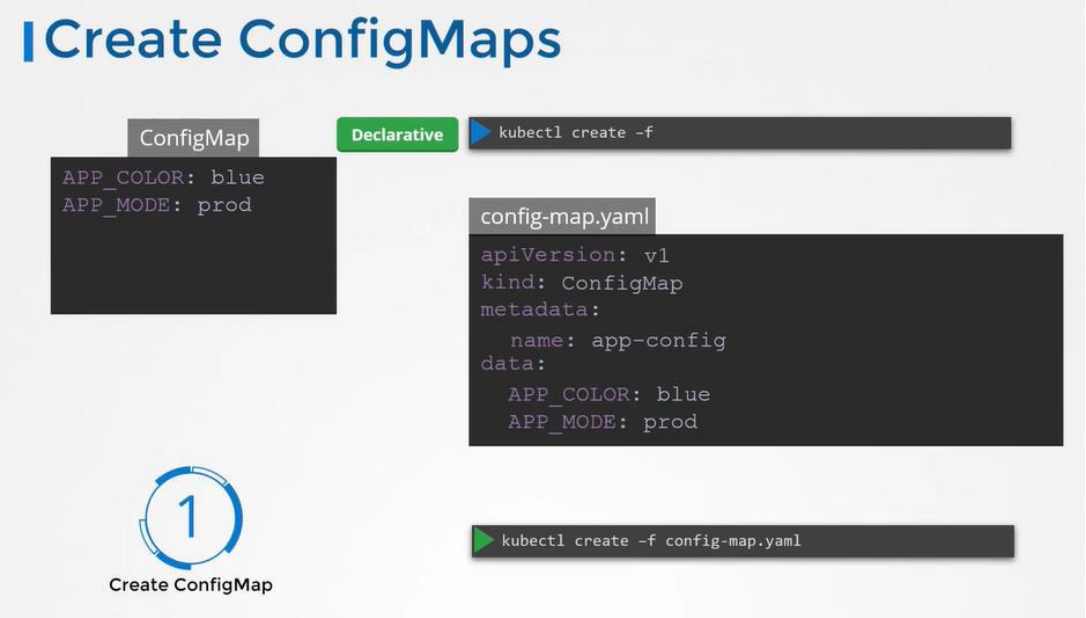
ConfigMaps

- There are 2 phases involved in configuring ConfigMaps.
  - First, create the configMaps
  - Second, Inject then into the pod.
- There are 2 ways of creating a configmap.
  - The Imperative way
  - `$ kubectl create configmap app-config --from-literal=APP_COLOR=blue --from-literal=APP_MODE=prod`
  - `$ kubectl create configmap app-config --from-file=app_config.properties (Another way)`



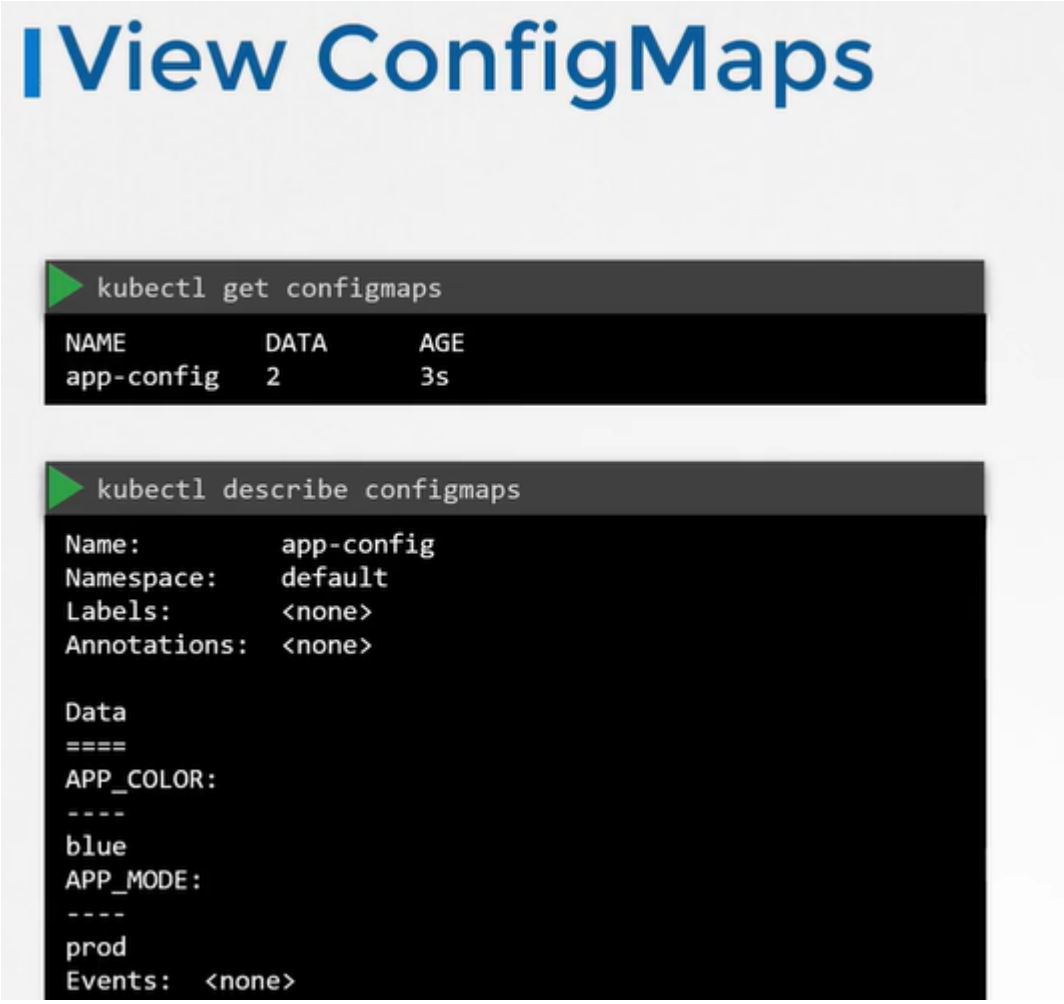
  - The Declarative way
  - `apiVersion: v1`
  - `kind: ConfigMap`
  - `metadata:`
  - `  name: app-config`

- data:
- APP_COLOR: blue
- APP_MODE: prod
- Create a config map definition file and run the 'kubectl create` command to deploy it.
- $ kubectl create -f config-map.yaml



View ConfigMaps

- To view configMaps
- $ kubectl get configmaps (or)
- $ kubectl get cm
- To describe configmaps
- $ kubectl describe configmaps

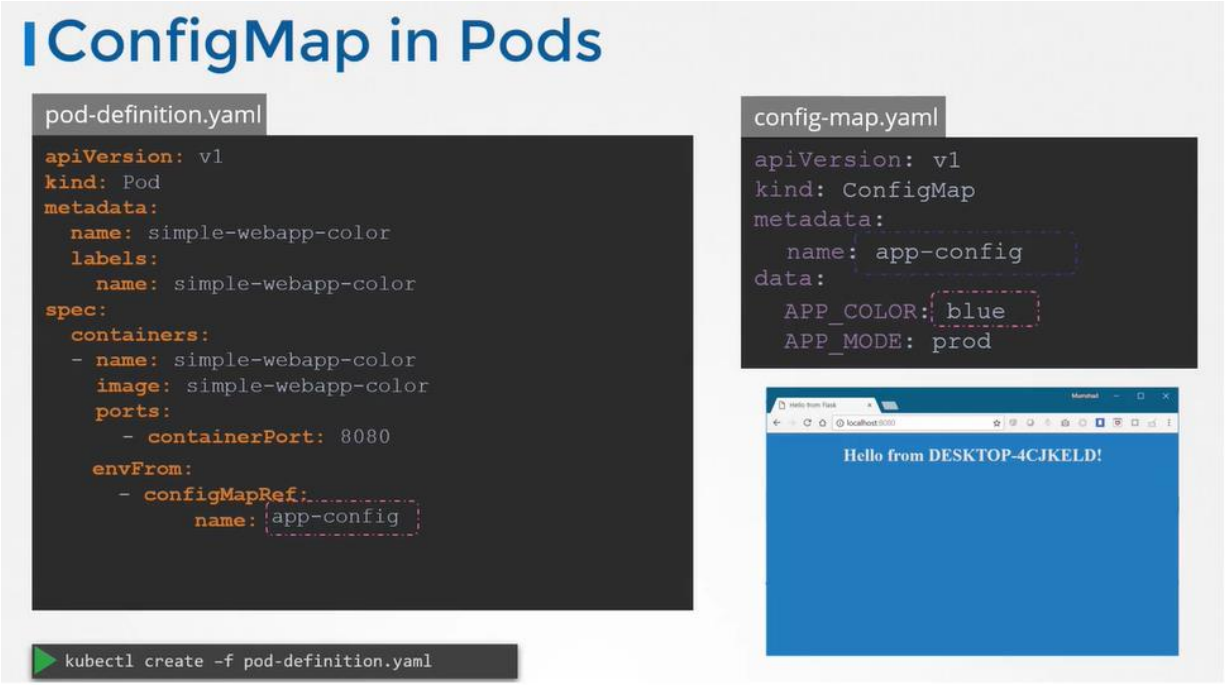


ConfigMap in Pods

- Inject configmap in pod

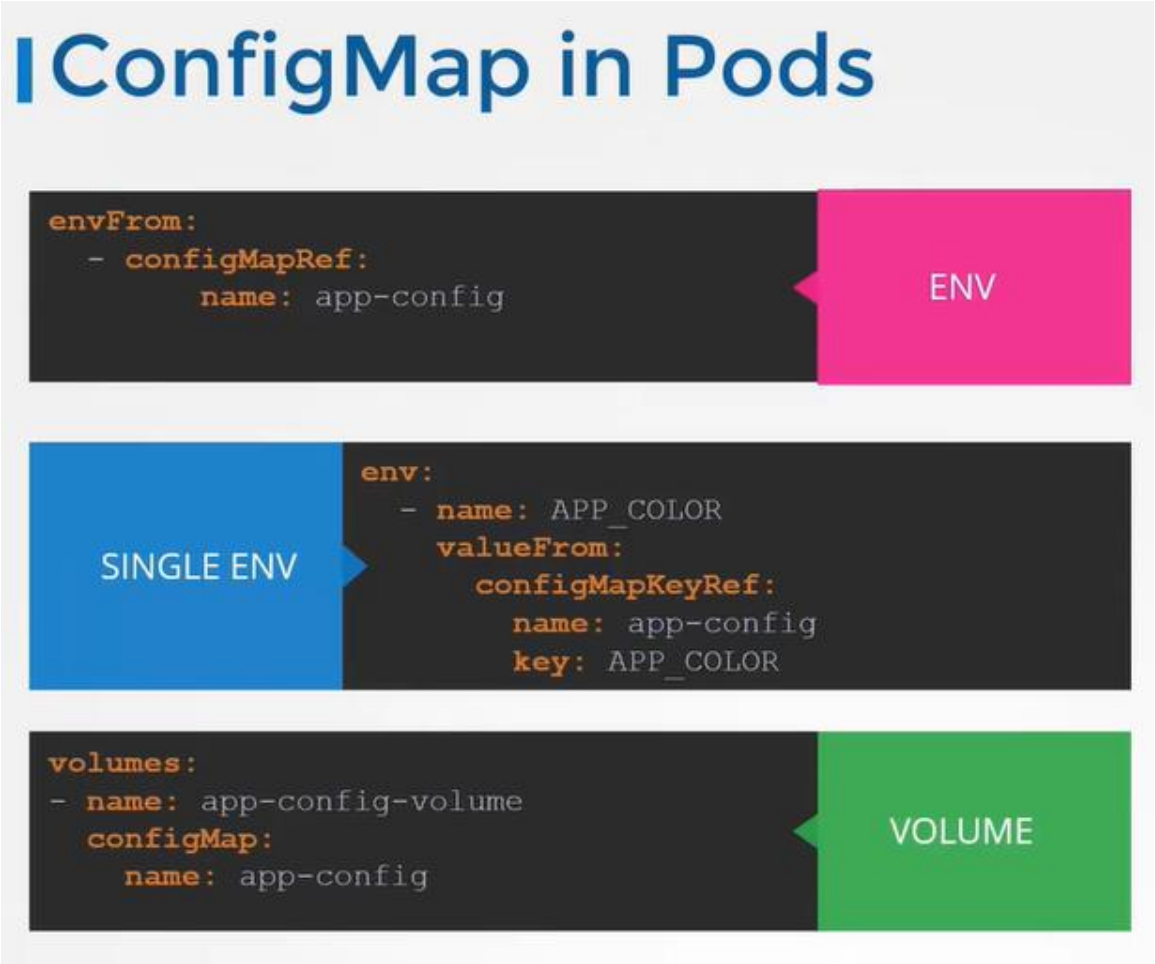
```
apiVersion: v1
kind: Pod
metadata:
  name: simple-webapp-color
spec:
 containers:
 - name: simple-webapp-color
   image: simple-webapp-color
   ports:
   - containerPort: 8080
   envFrom:
   - configMapRef:
       name: app-config
apiVersion: v1
kind: ConfigMap
metadata:
  name: app-config
data:
  APP_COLOR: blue
```

- `  APP_MODE: prod`
- `$ kubectl create -f pod-definition.yaml`



There are other ways to inject configuration variables into pod

- You can inject it as a **`Single Environment Variable`**
- You can inject it as a file in a **`Volume`**



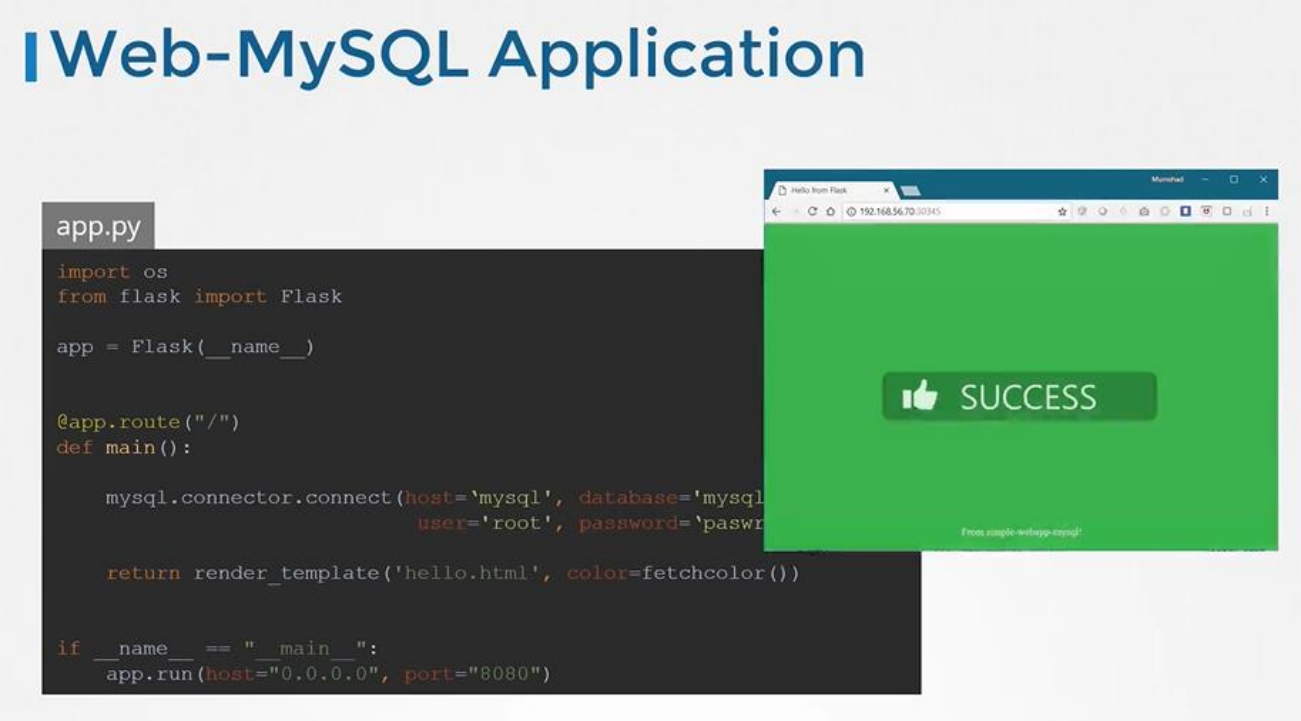
K8s Reference Docs

- https://kubernetes.io/docs/tasks/configure-pod-container/configure-pod-configmap/
- https://kubernetes.io/docs/tasks/configure-pod-container/configure-pod-configmap/#define-container-environment-variables-using-configmap-data
- https://kubernetes.io/docs/tasks/configure-pod-container/configure-pod-configmap/#create-configmaps-from-files

Secrets

In this section, we will take a look at secrets in kubernetes

Web-Mysql Application



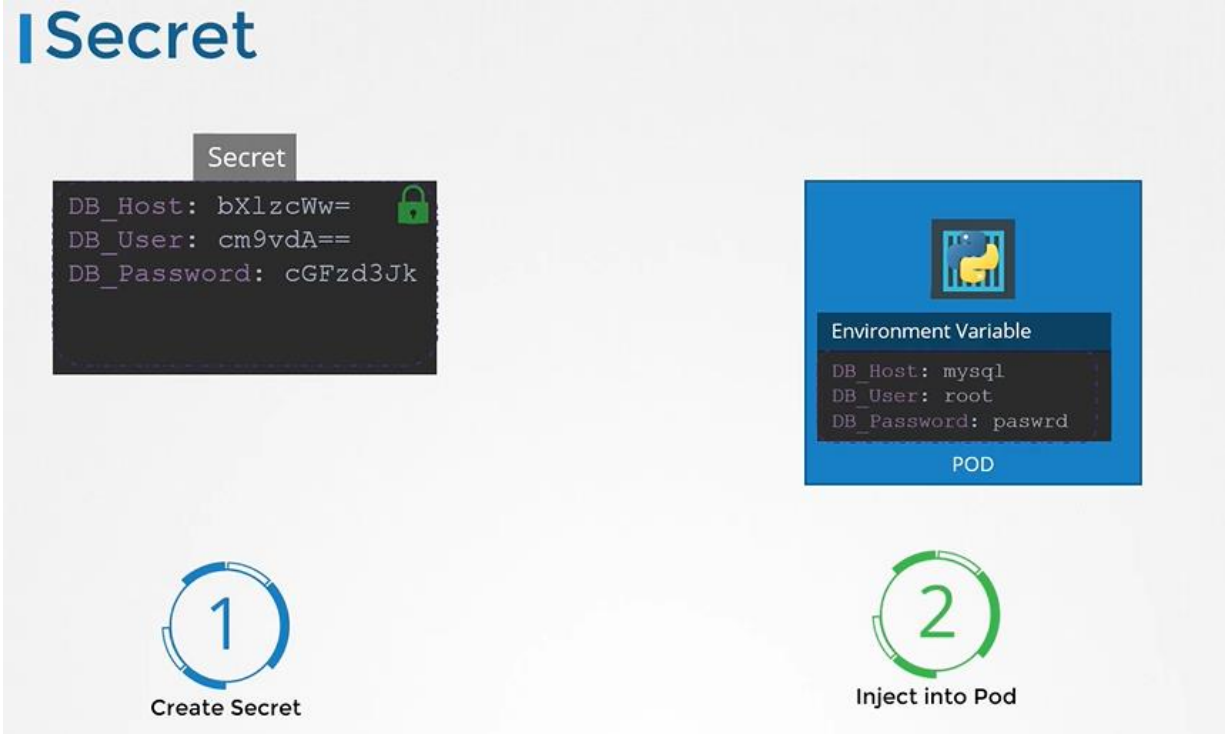
- One way is to move the app properties/envs into a configmap. But the configmap stores data into a plain text format. It is definitely not a right place to store a password.

- apiVersion: v1
- kind: ConfigMap
- metadata:
- name: app-config
- data:
- DB_Host: mysql
- DB_User: root
- DB_Password: paswrd

- Secrets are used to store sensitive information. They are similar to configmaps but they are stored in an encrypted format or a hashed format.

There are 2 steps involved with secrets

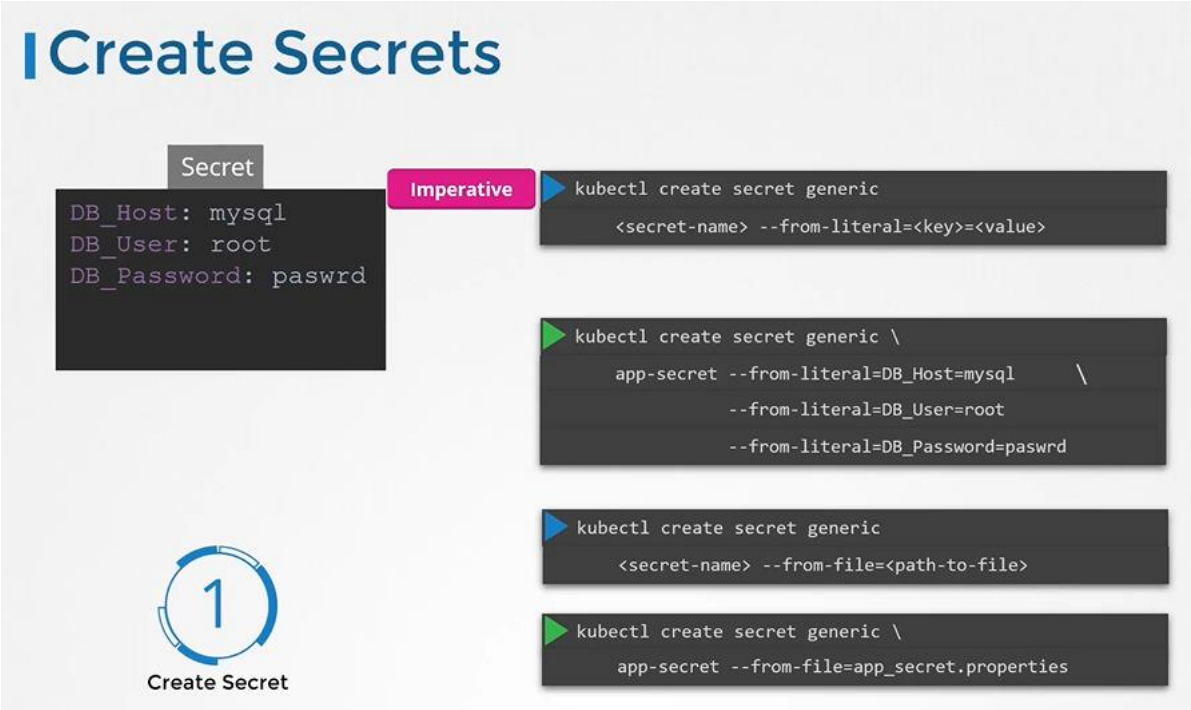
- First, Create a secret
- Second, Inject the secret into a pod.



There are 2 ways of creating a secret

- The Imperative way

- `$ kubectl create secret generic app-secret --from-literal=DB_Host=mysql --from-literal=DB_User=root --from-literal=DB_Password=paswrd`
- `$ kubectl create secret generic app-secret --from-file=app_secret.properties`

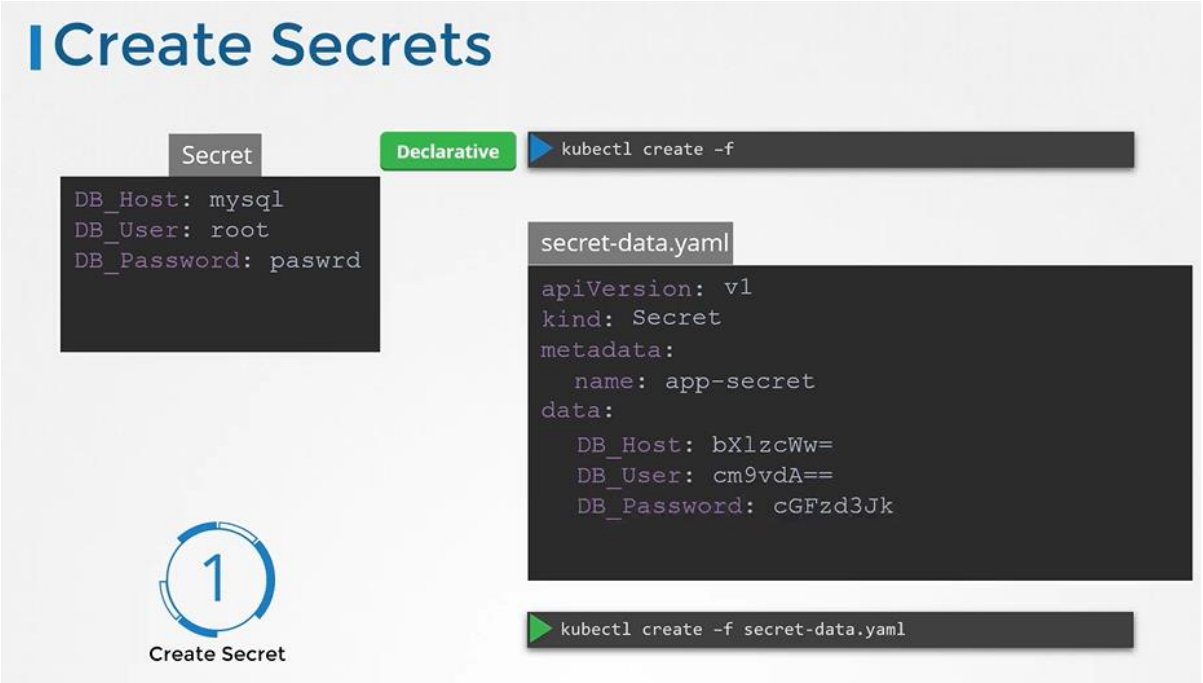


- The Declarative way

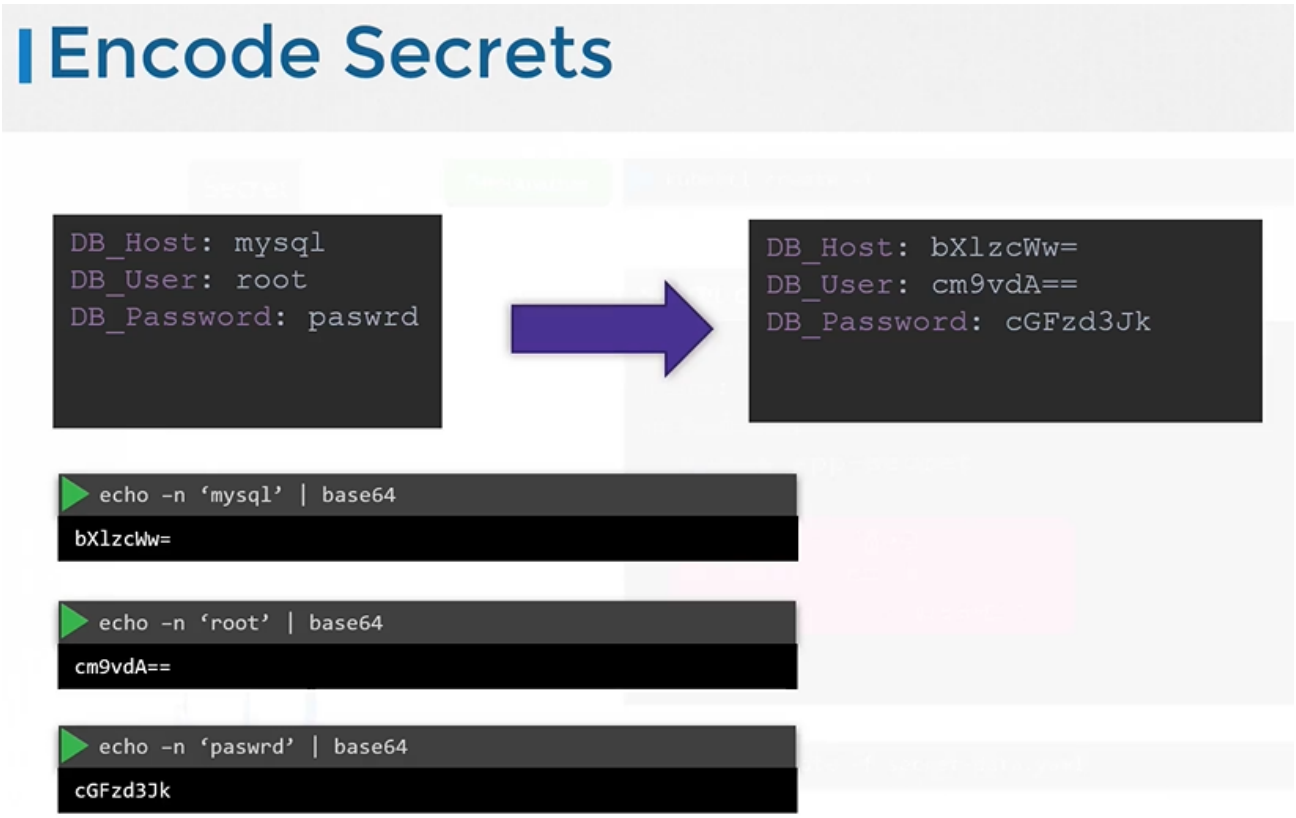
- Generate a hash value of the password and pass it to secret-data.yaml definition value as a value to DB_Password variable.
- $ echo -n "mysql" | base64
- $ echo -n "root" | base64
- $ echo -n "paswrd"| base64

  Create a secret definition file and run `kubectl create` to deploy it

```
apiVersion: v1
kind: Secret
metadata:
 name: app-secret
data:
  DB_Host: bX1zcWw=
  DB_User: cm9vdA==
  DB_Password: cGFzd3Jk
$ kubectl create -f secret-data.yaml
```



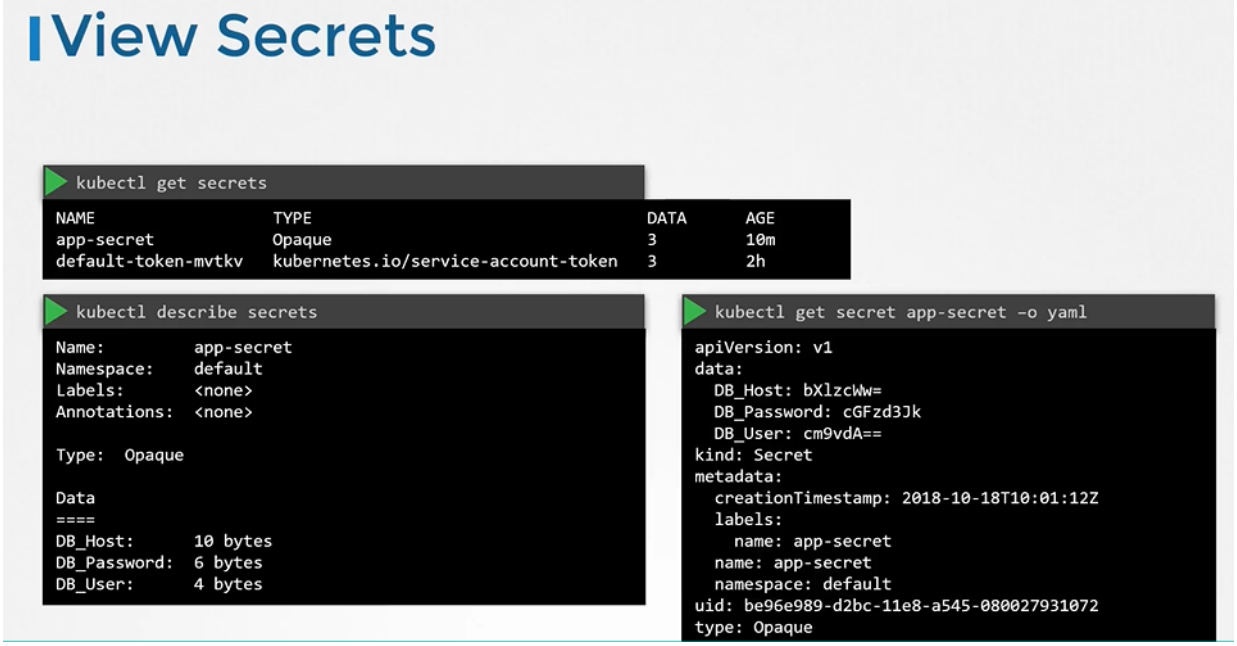
Encode Secrets



View Secrets

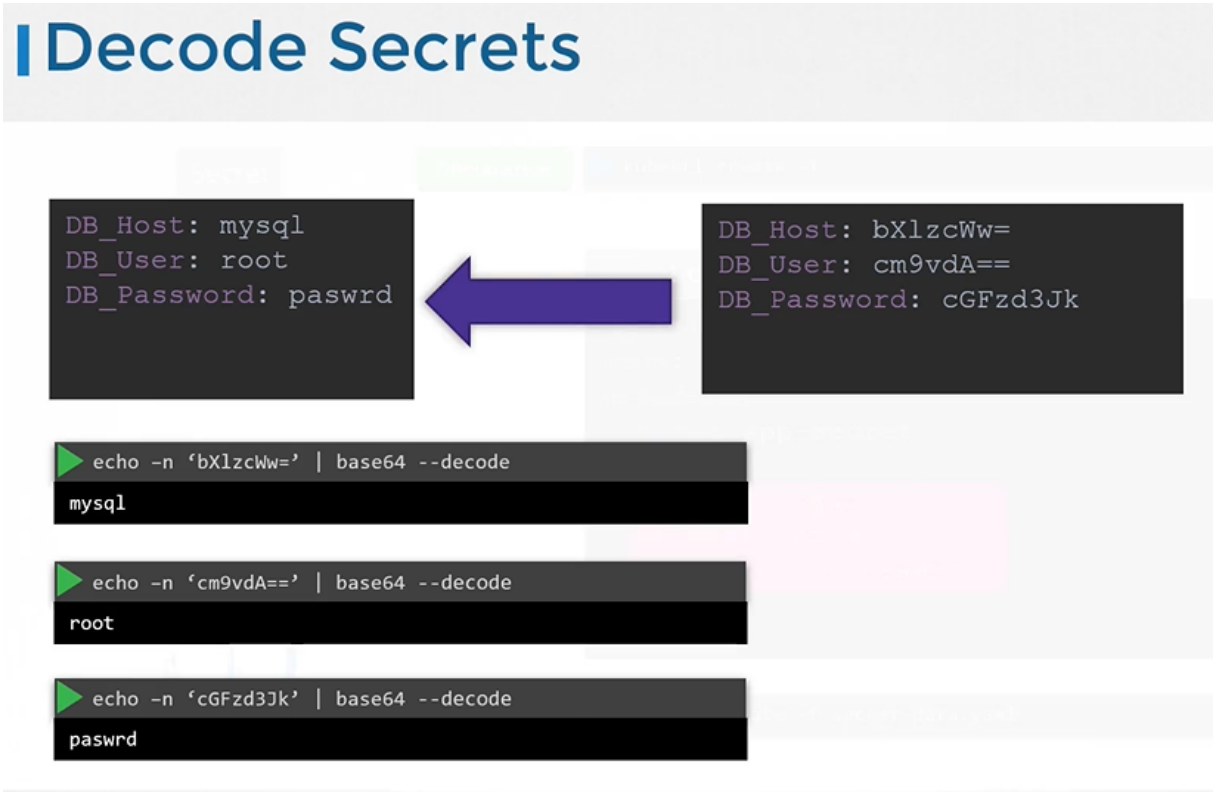
- To view secrets

- `$ kubectl get secrets`
- To describe secret
- `$ kubectl describe secret`
- To view the values of the secret
- `$ kubectl get secret app-secret -o yaml`



Decode Secrets

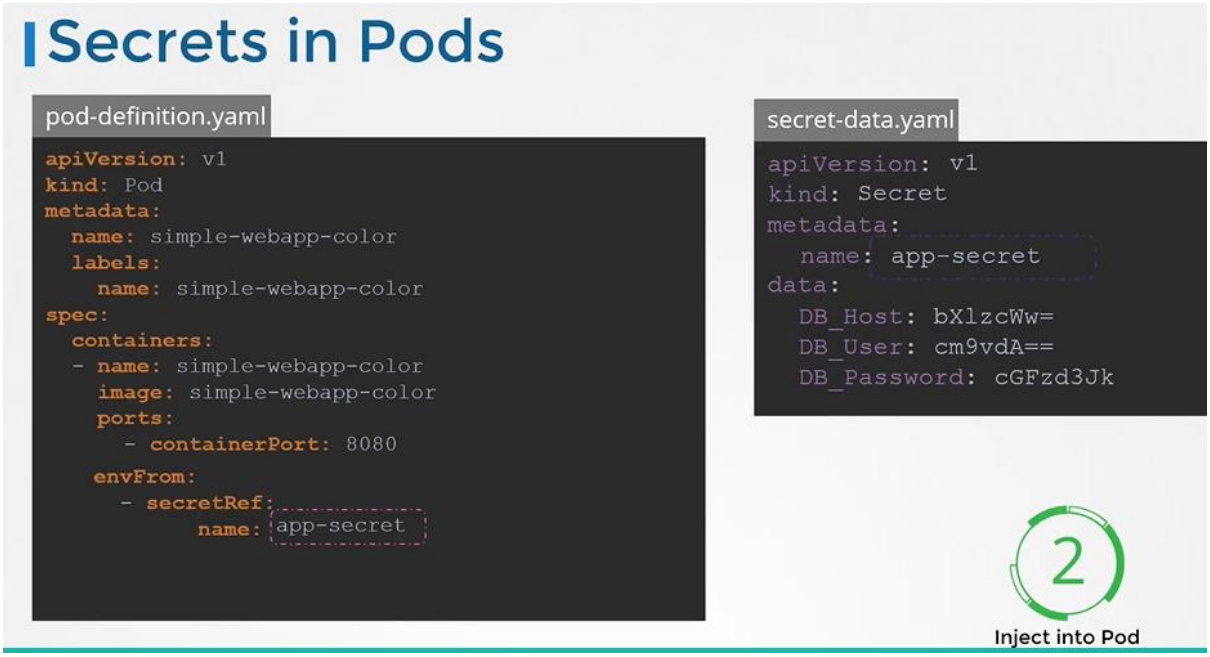
- To decode secrets
- `$ echo -n "bX1zcWw=" | base64 --decode`
- `$ echo -n "cm9vdA==" | base64 --decode`
- `$ echo -n "cGFzd3Jk" | base64 --decode`



Configuring secret with a pod

- To inject a secret to a pod add a new property **`envFrom`** followed by **`secretRef`** name and then create the pod-definition

```
apiVersion: v1
kind: Secret
metadata:
 name: app-secret
data:
  DB_Host: bX1zcWw=
  DB_User: cm9vdA==
  DB_Password: cGFzd3Jk
 apiVersion: v1
 kind: Pod
 metadata:
   name: simple-webapp-color
 spec:
  containers:
  - name: simple-webapp-color
    image: simple-webapp-color
    ports:
    - containerPort: 8080
    envFrom:
    - secretRef:
        name: app-secret
$ kubectl create -f pod-definition.yaml
```

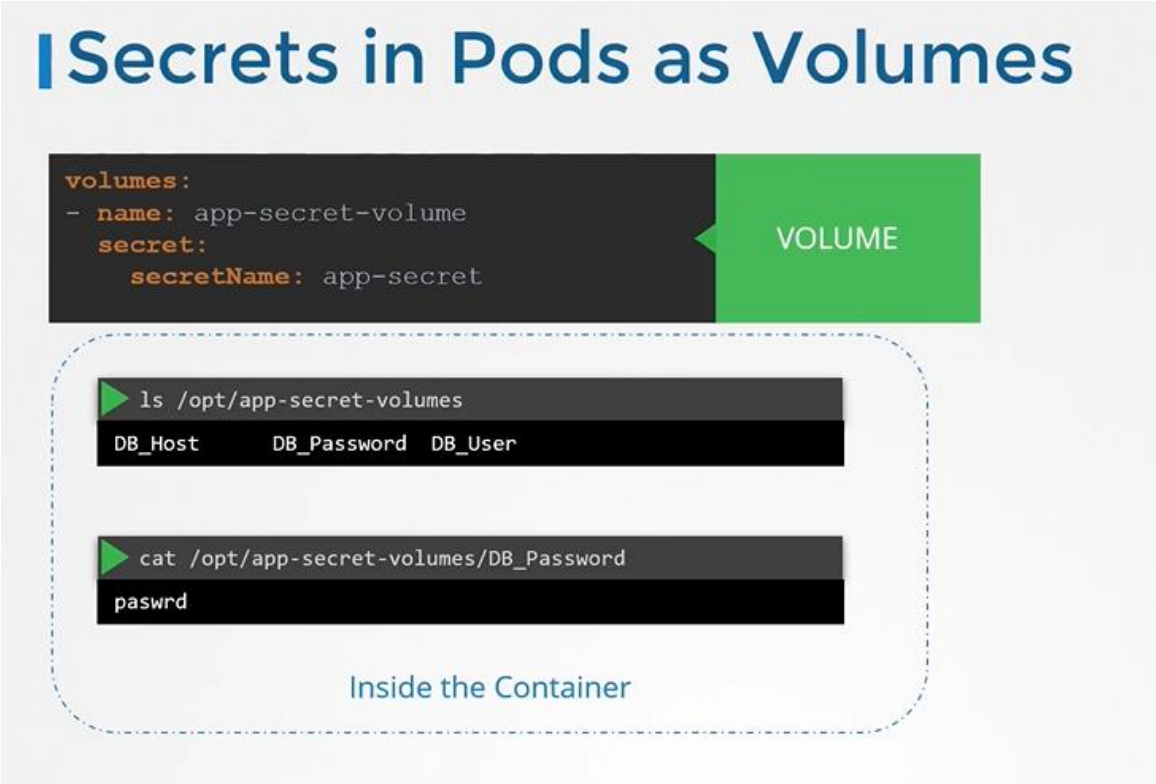


There are other ways to inject secrets into pods.

- You can inject as **`Single ENV variable`**
- You can inject as whole secret as files in a **`Volume`**

Secrets in pods as volume

- Each attribute in the secret is created as a file with the value of the secret as its content.



K8s Reference Docs

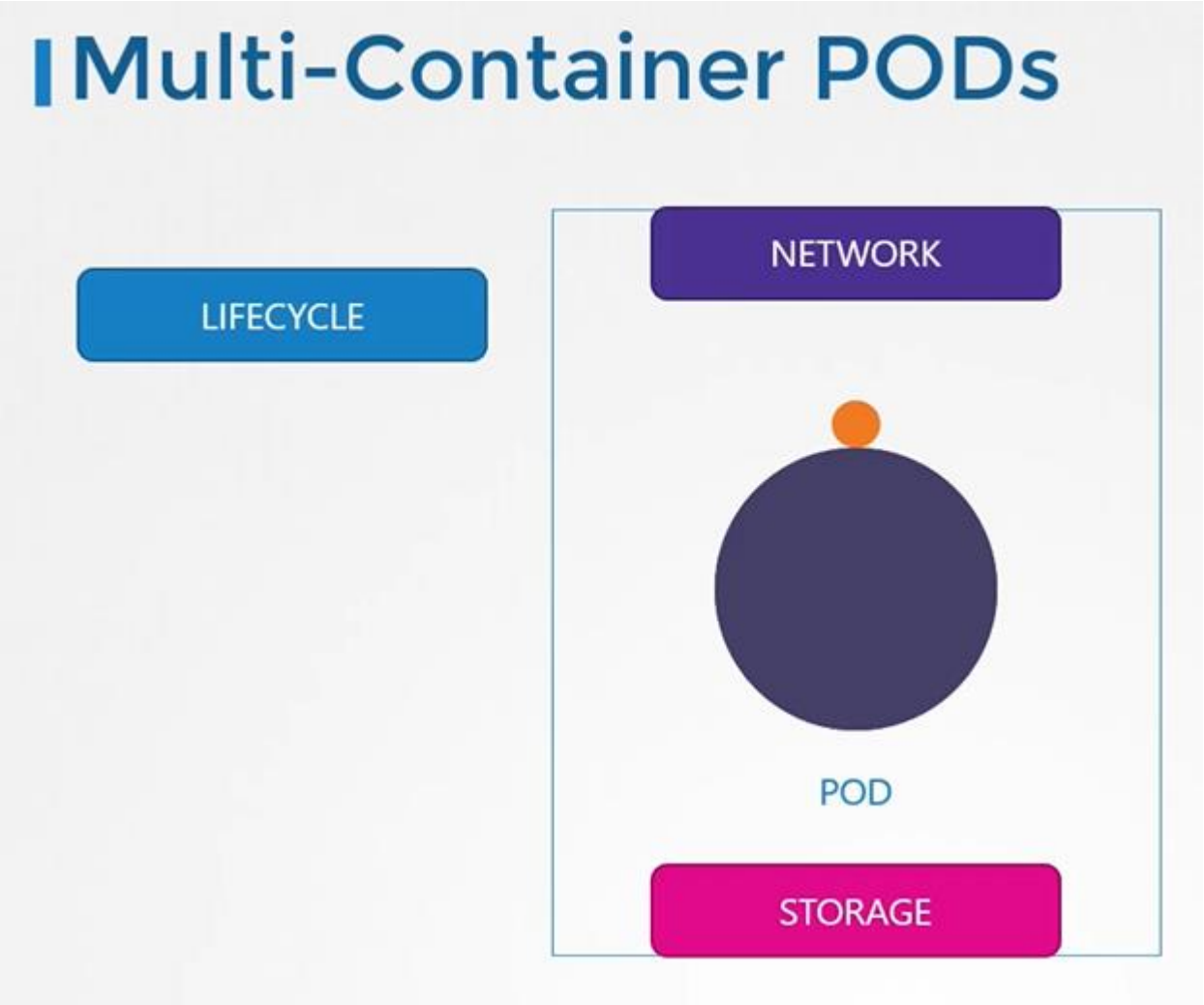
- https://kubernetes.io/docs/concepts/configuration/secret/
- https://kubernetes.io/docs/concepts/configuration/secret/#use-cases
- https://kubernetes.io/docs/tasks/inject-data-application/distribute-credentials-secure/

Multi-Container Pods

In this section, we will take a look at multi-container pods

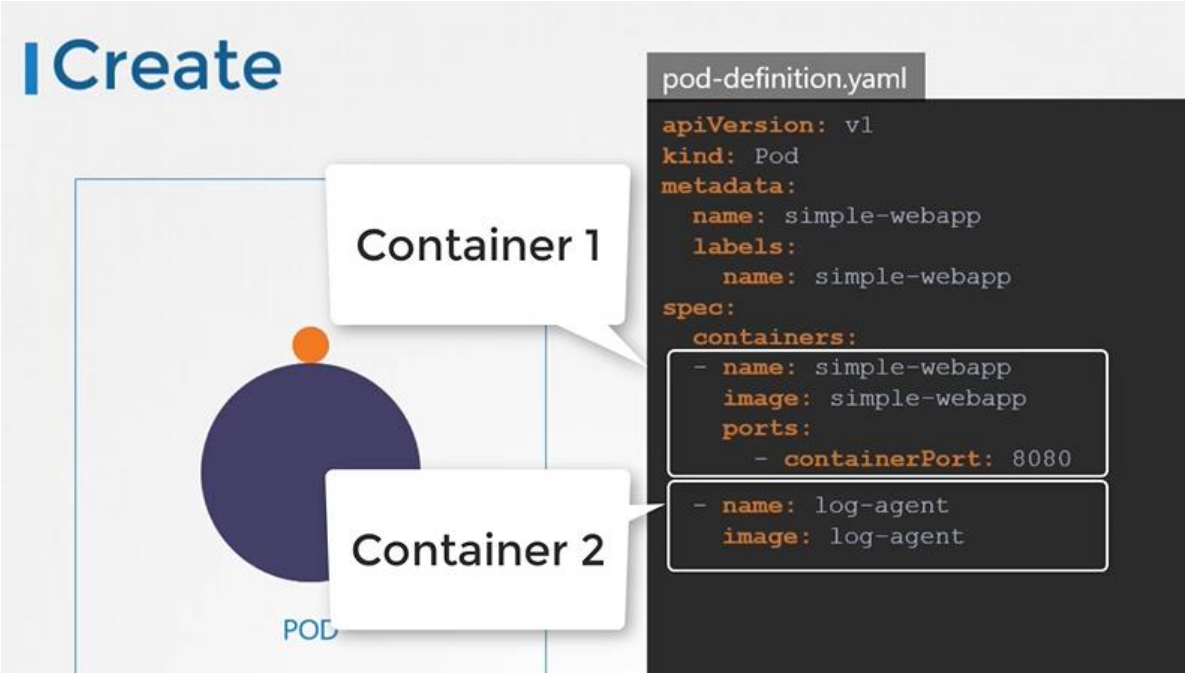
Monolith and Microservices

Multi-Container Pods



- To create a new multi-container pod, add the new container information to the pod definition file.

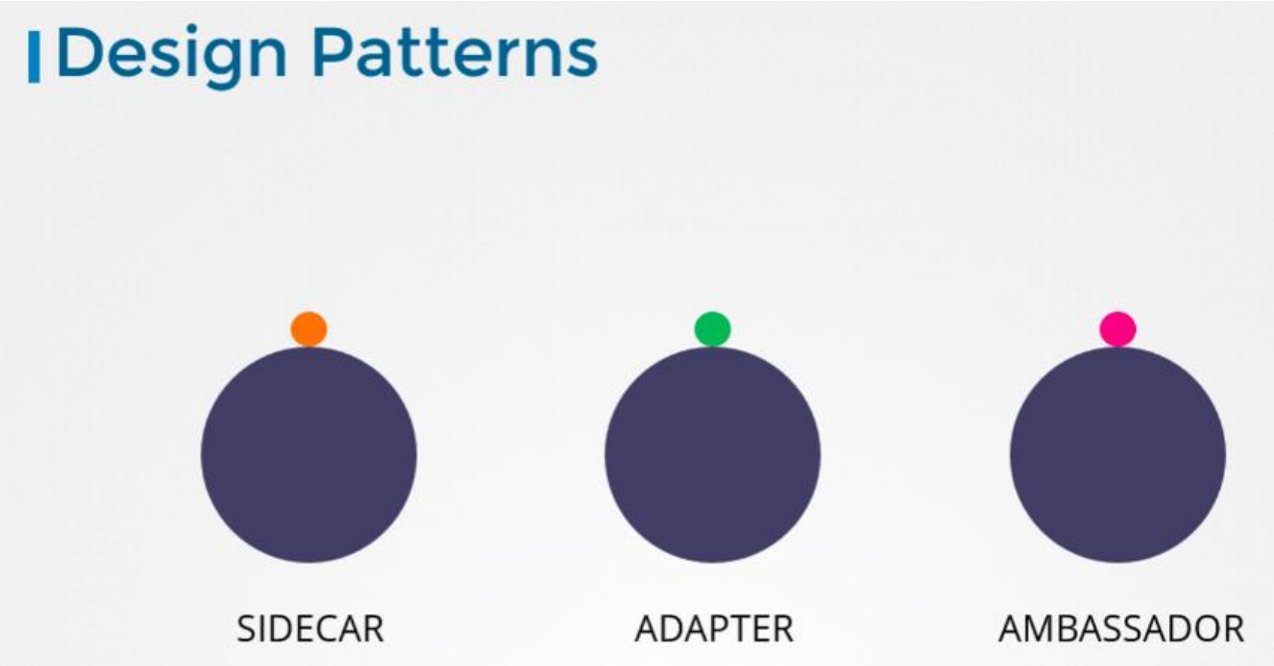
```
apiVersion: v1
kind: Pod
metadata:
  name: simple-webapp
  labels:
    name: simple-webapp
spec:
  containers:
  - name: simple-webapp
    image: simple-webapp
    ports:
    - ContainerPort: 8080
  - name: log-agent
    image: log-agent
```



K8s Reference Docs

- https://kubernetes.io/docs/tasks/access-application-cluster/communicate-containers-same-pod-shared-volume/

Multi-Container Pods Design Patterns



K8s Reference Docs

- https://kubernetes.io/blog/2015/06/the-distributed-system-toolkit-patterns/

Init-Containers

K8s Reference Docs

- https://kubernetes.io/docs/concepts/workloads/pods/init-containers/
- https://kubernetes.io/docs/tasks/configure-pod-container/configure-pod-initialization/

Cluster Maintenance Section Introduction

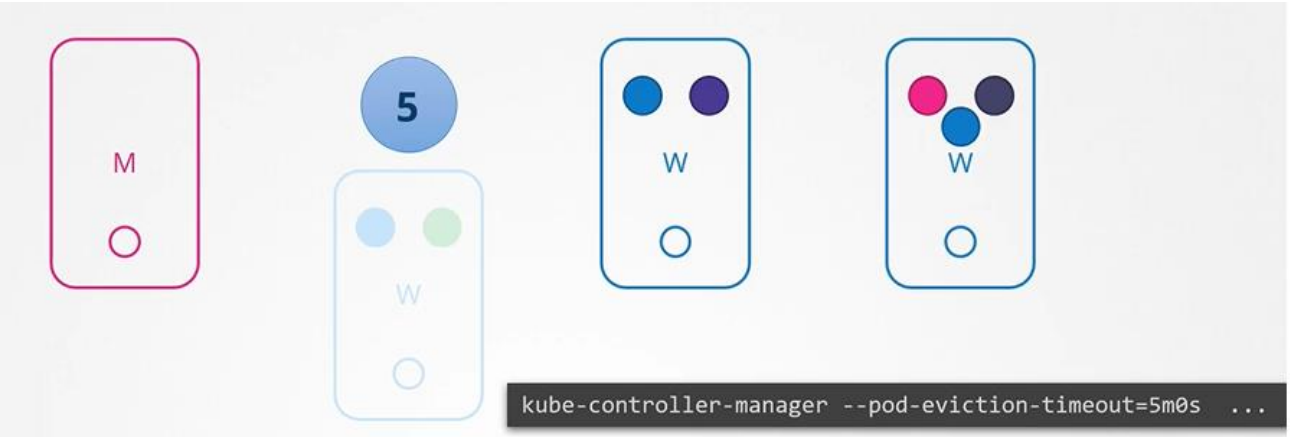
In this section, we will take a look at cluster maintenance

- Cluster Upgrade Process
- Operating System Upgrades
- Backup and Restore Methodologies

OS Upgrades

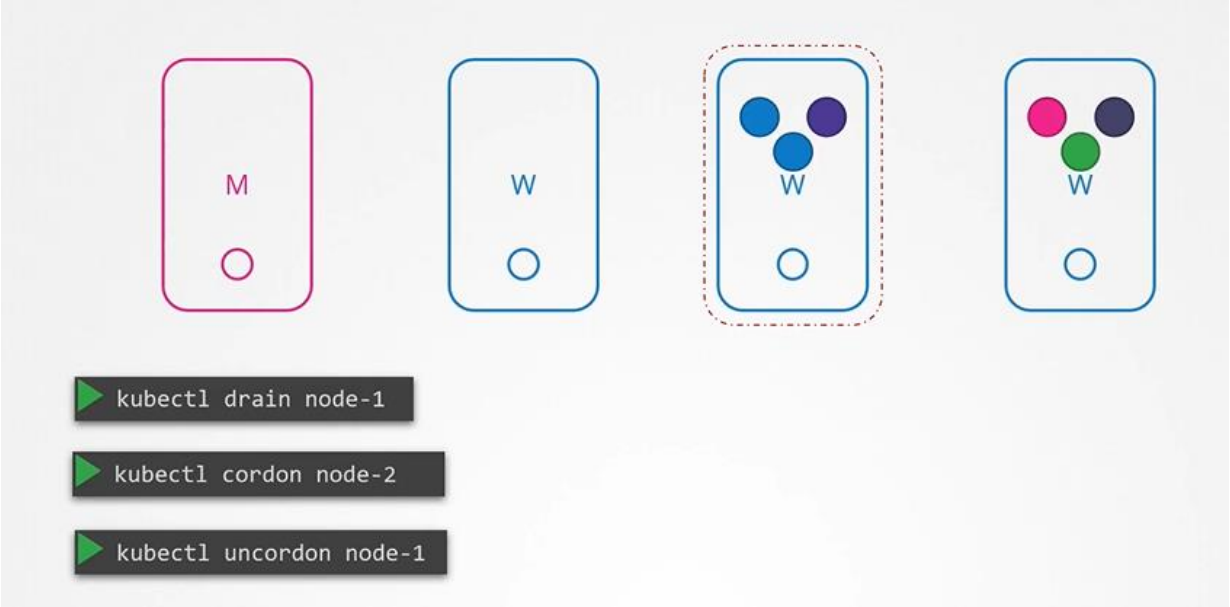
In this section, we will take a look at os upgrades.

If the node was down for more than 5 minutes, then the pods are terminated from that node



- You can purposefully **`drain`** the node of all the workloads so that the workloads are moved to other nodes.
- `$ kubectl drain node-1`

- The node is also cordoned or marked as unschedulable.
- When the node is back online after a maintenance, it is still unschedulable. You then need to uncordon it.
- `$ kubectl uncordon node-1`
- There is also another command called cordon. Cordon simply marks a node unschedulable. Unlike drain it does not terminate or move the pods on an existing node.



K8s Reference Docs

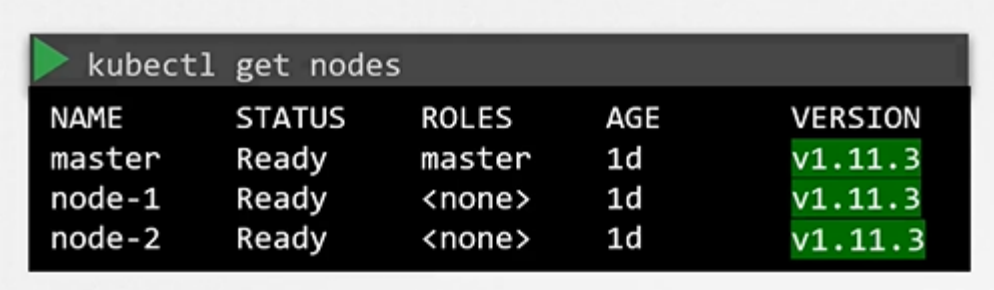
- https://kubernetes.io/docs/tasks/administer-cluster/safely-drain-node/

Kubernetes Software Versions

In this section, we will take a look at various kubernetes releases and versions

We can see the kubernetess version that we installed

`$ kubectl get nodes`

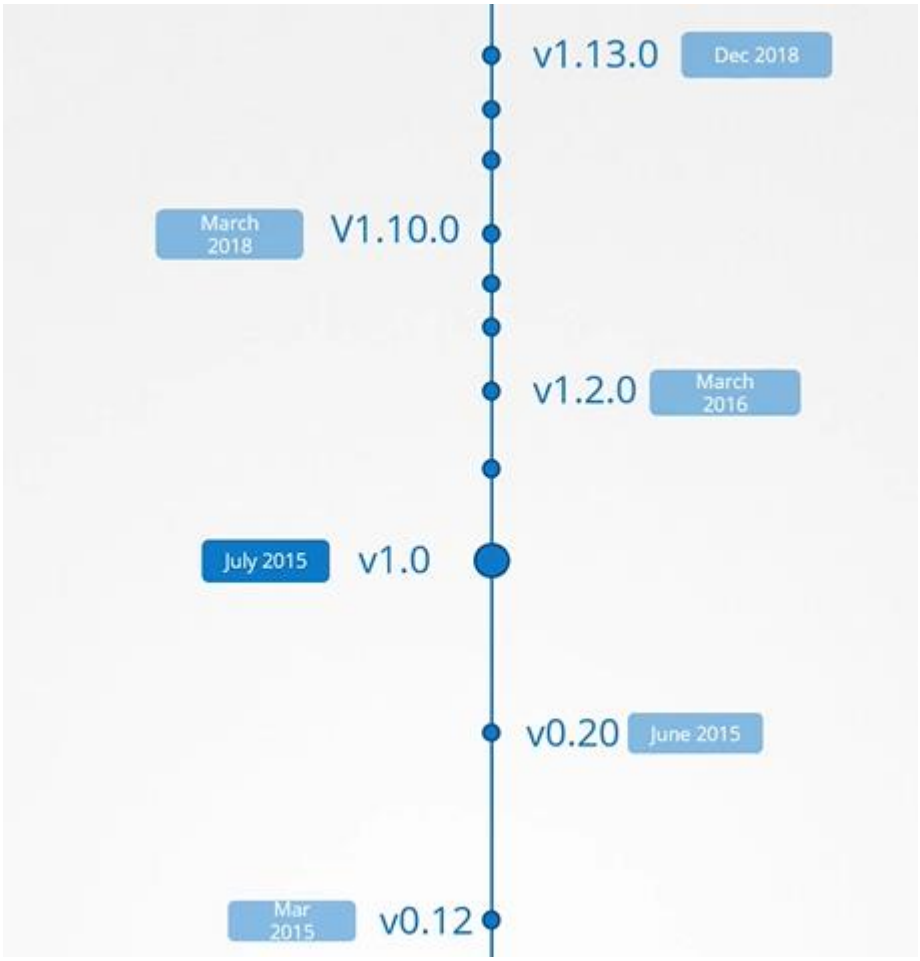


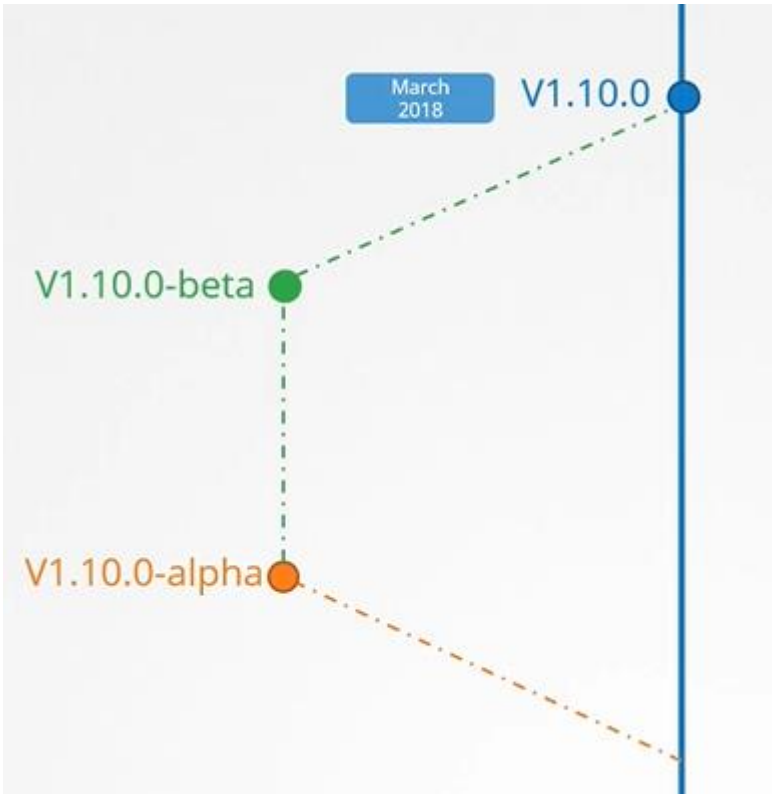
Let's take a closer look at the version number

- It consists of 3 parts
    - First is the major version
    - Second is the minor version
    - Finally, the patch version

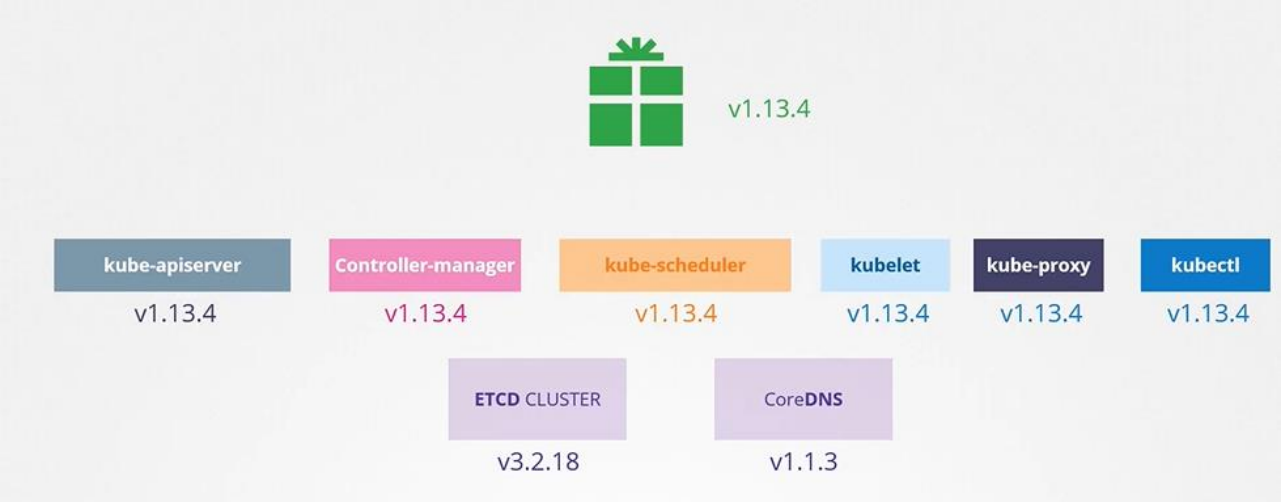
Kubernetes follows a standard software release versioning procedure

- You can find all kubernetes releases at https://github.com/kubernetes/kubernetes/releases


v1.13.0
Dec 2018
March 2018
V1.10.0
v1.2.0
March 2016
July 2015
v1.0
v0.20
June 2015
Mar 2015
v0.12


March 2018
V1.10.0
V1.10.0-beta
V1.10.0-alpha

Downloaded package has all the kubernetes components in it except `ETCD Cluster` and `CoreDNS` as they are seperate projects.



References

- https://github.com/kubernetes/community/blob/master/contributors/design-proposals/release/versioning.md
- https://github.com/kubernetes/community/blob/master/contributors/design-proposals/api-machinery/api-group.md
- https://blog.risingstack.com/the-history-of-kubernetes/
- https://kubernetes.io/docs/setup/release/version-skew-policy/

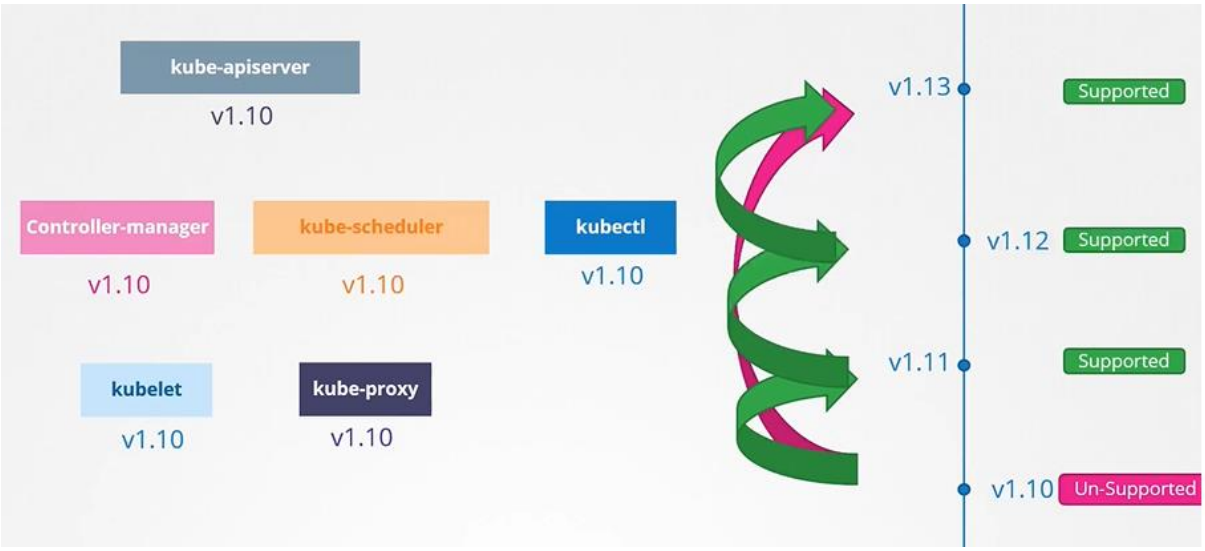
Cluster Upgrade Introduction

Is it mandatory for all of the kubernetes components to have the same versions?

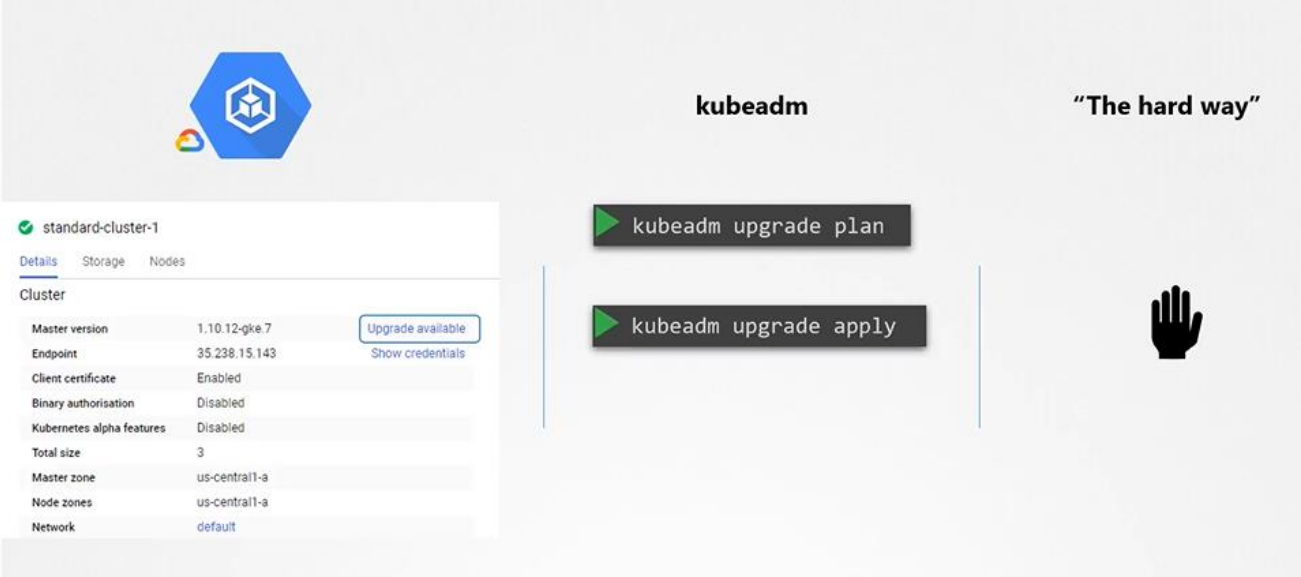
- No, The components can be at different release versions.

At any time, kubernetes supports only up to the recent 3 minor versions

- The recommended approach is to upgrade one minor version at a time.



Options to upgrade k8s cluster



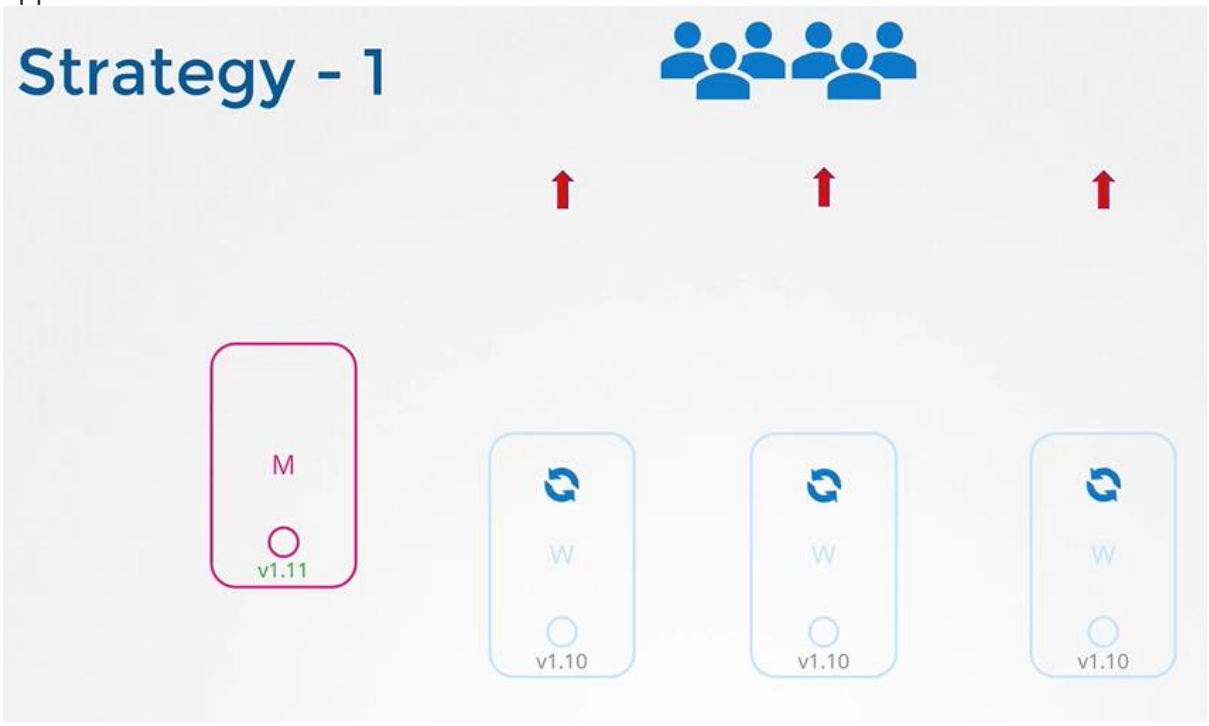
Upgrading a Cluster

- Upgrading a cluster involves 2 major steps

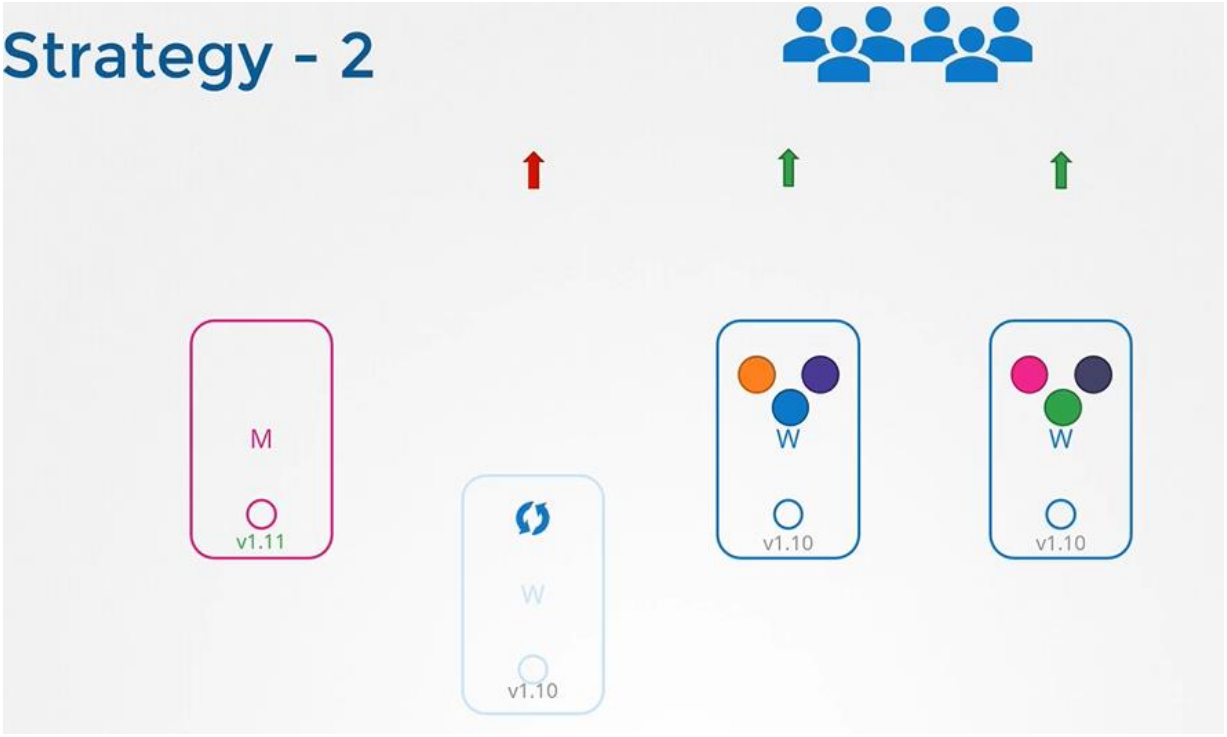
There are different strategies that are available to upgrade the worker nodes

- One is to upgrade all at once. But then your pods will be down and users will not be able to access the

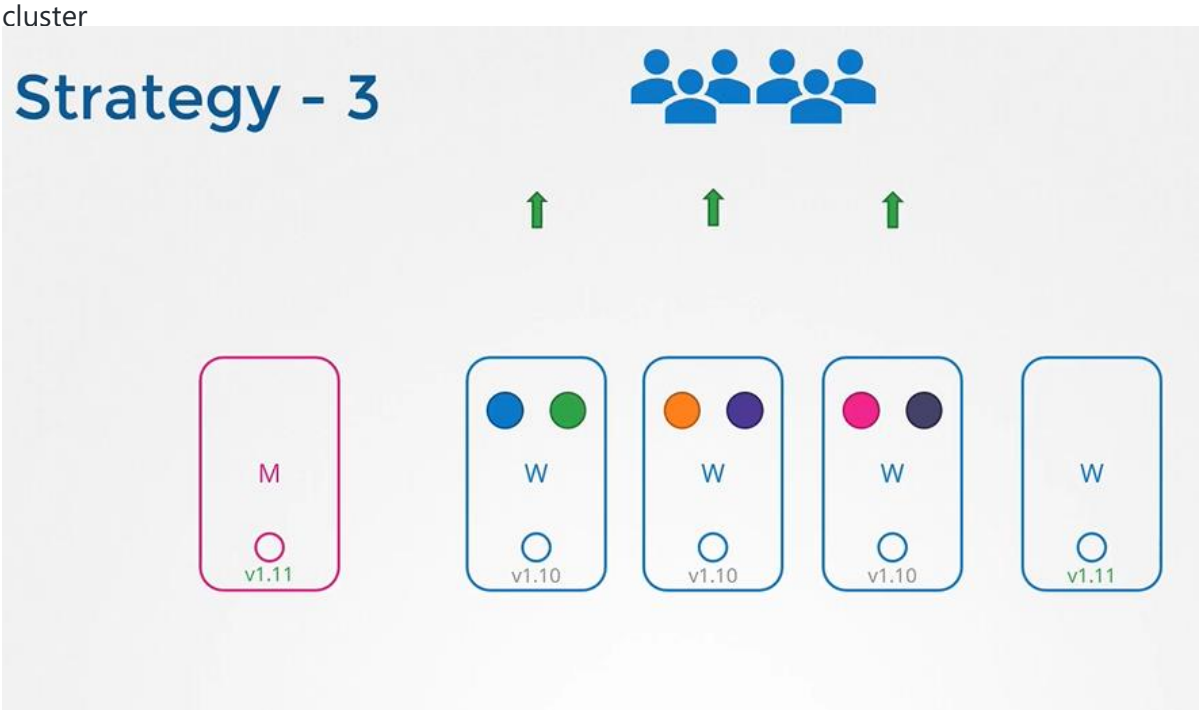
applications.



- Second one is to upgrade one node at a time.

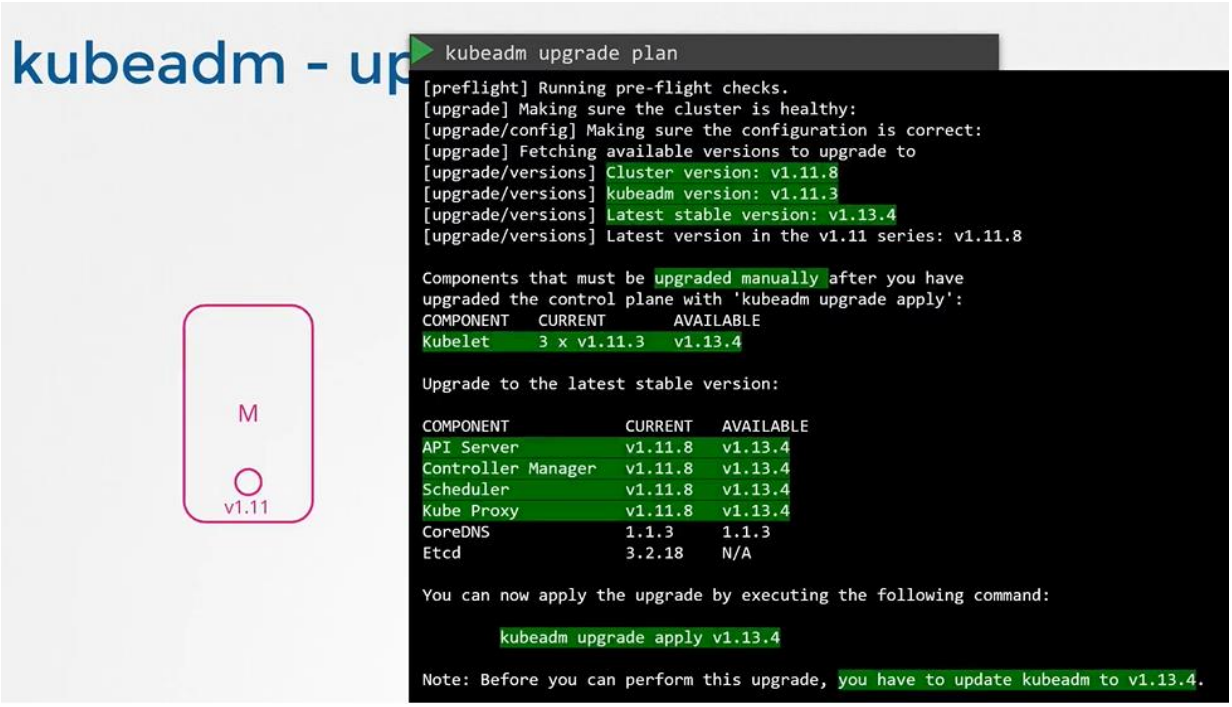


- Third one would be to add new nodes to the cluster



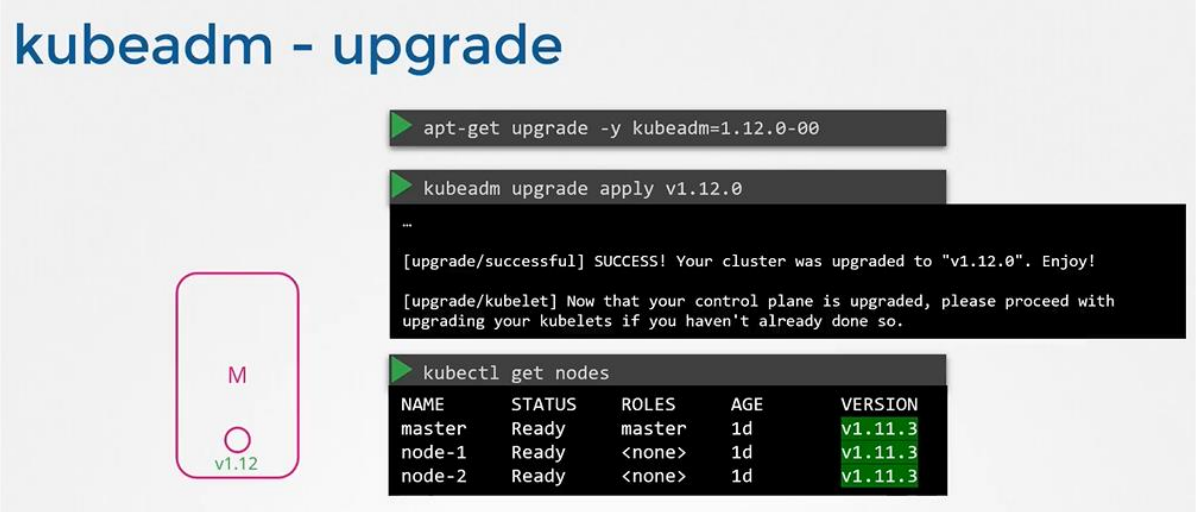
kubeadm - Upgrade master node

- kubeadm has an upgrade command that helps in upgrading clusters.
- `$ kubeadm upgrade plan`

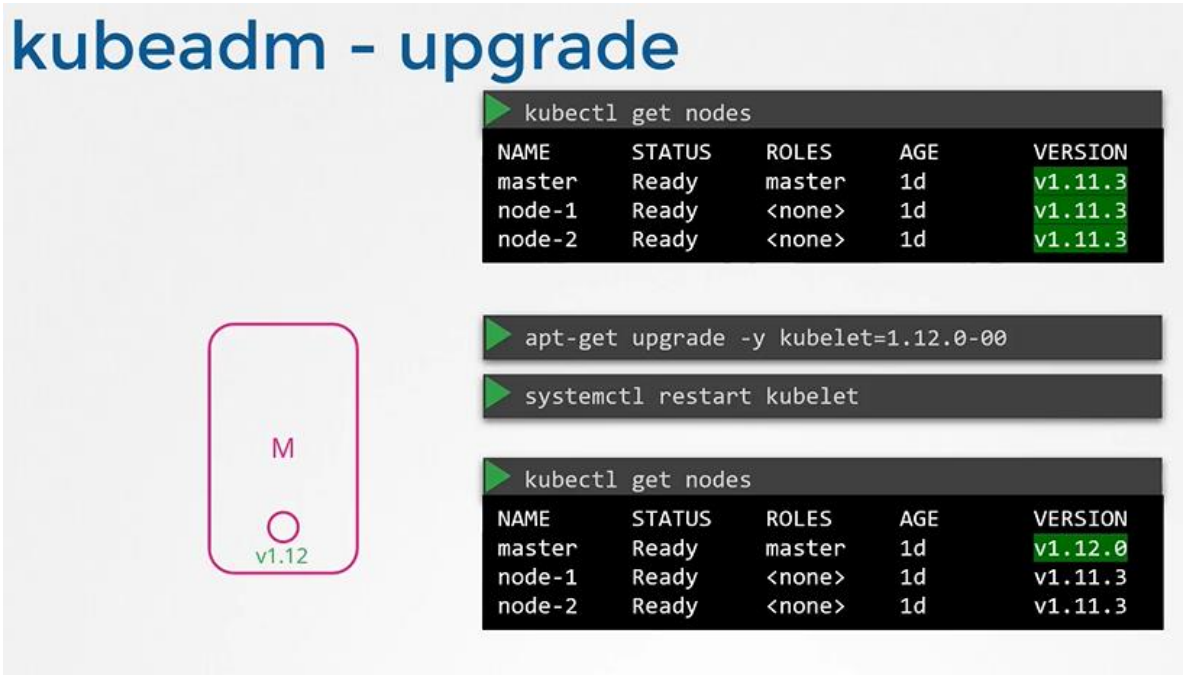


- Upgrade kubeadm from v1.11 to v1.12

- `$ apt-get upgrade -y kubeadm=1.12.0-00`
- Upgrade the cluster
- `$ kubeadm upgrade apply v1.12.0`
- If you run the 'kubectl get nodes' command, you will see the older version. This is because in the output of the command it is showing the versions of kubelets on each of these nodes registered with the API Server and not the version of API Server itself
- `$ kubectl get nodes`

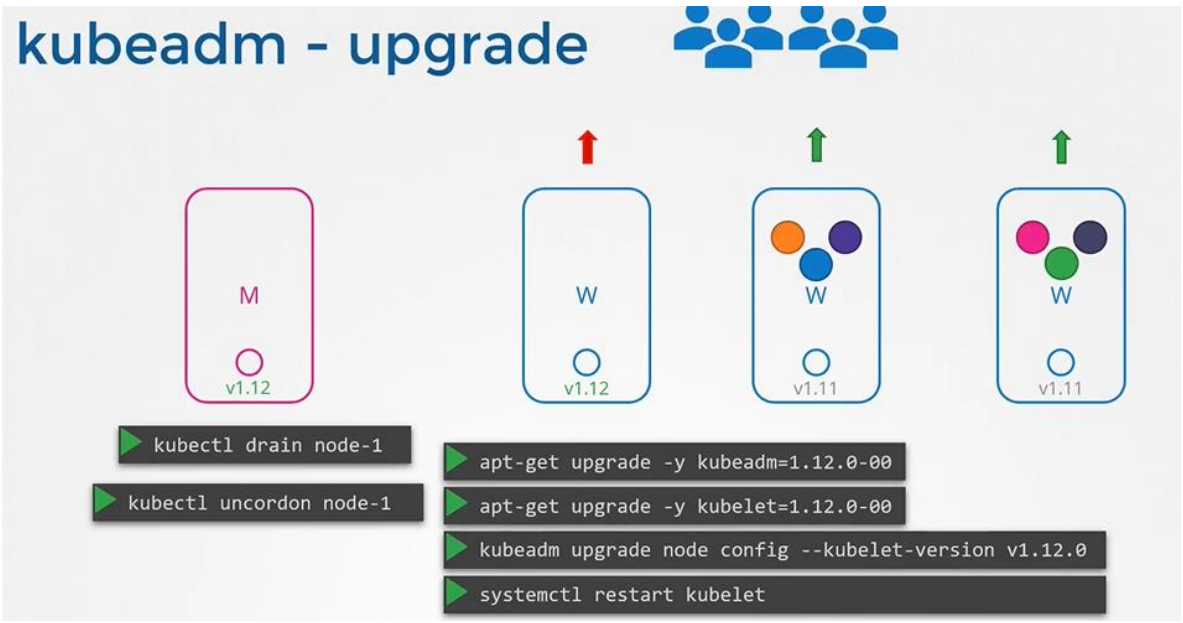


- Upgrade 'kubelet' on the master node
- `$ apt-get upgrade kubelet=1.12.0-00`
- Restart the kubelet
- `$ systemctl restart kubelet`
- Run 'kubectl get nodes' to verify
- `$ kubectl get nodes`

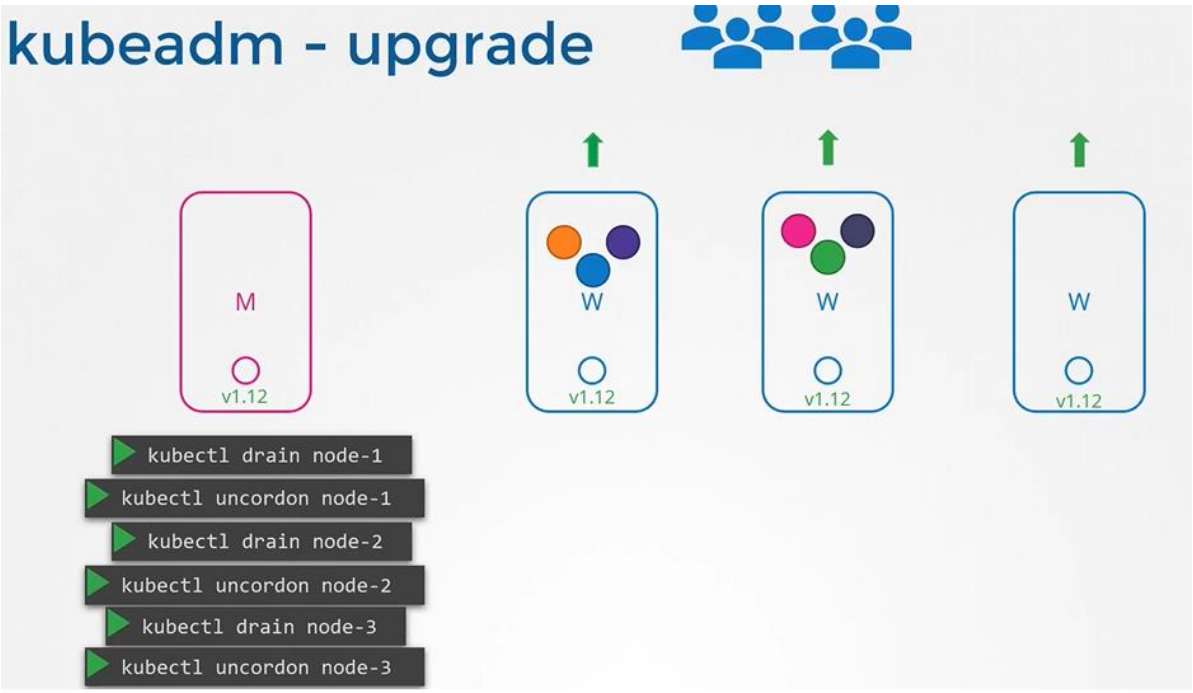


kubeadm - Upgrade worker nodes

- From master node, run 'kubectl drain' command to move the workloads to other nodes
- `$ kubectl drain node-1`
- Upgrade kubeadm and kubelet packages
- `$ apt-get upgrade -y kubeadm=1.12.0-00`
- `$ apt-get upgrade -y kubelet=1.12.0-00`
- Update the node configuration for the new kubelet version
- `$ kubeadm upgrade node config --kubelet-version v1.12.0`
- Restart the kubelet service
- `$ systemctl restart kubelet`
- Mark the node back to schedulable
- `$ kubectl uncordon node-1`



- Upgrade all worker nodes in the same way



K8s Reference Docs

- https://kubernetes.io/docs/tasks/administer-cluster/kubeadm/kubeadm-upgrade/
- https://kubernetes.io/docs/reference/setup-tools/kubeadm/kubeadm-upgrade/

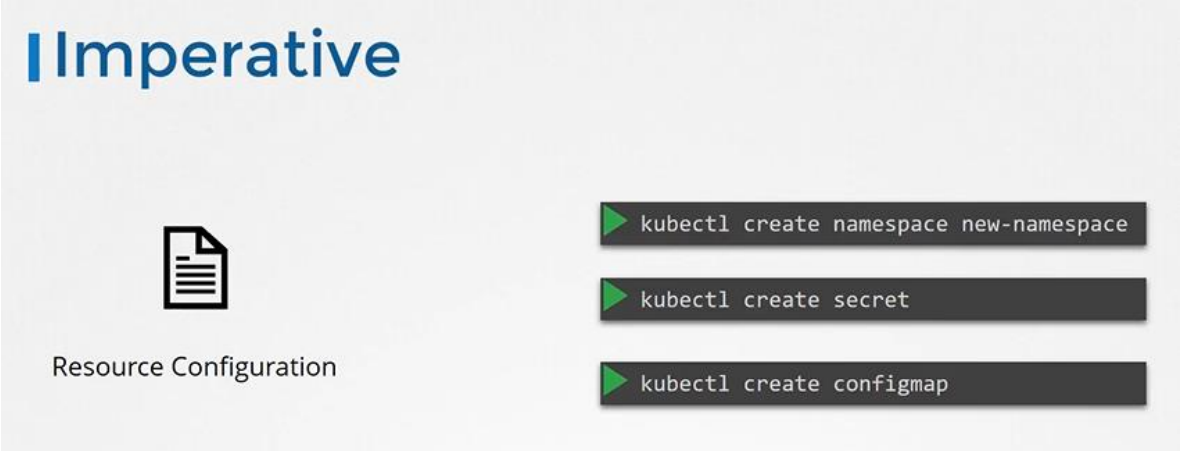
Backup and Restore Methods

In this section, we will take a look at backup and restore methods

Backup Candidates

Resource Configuration

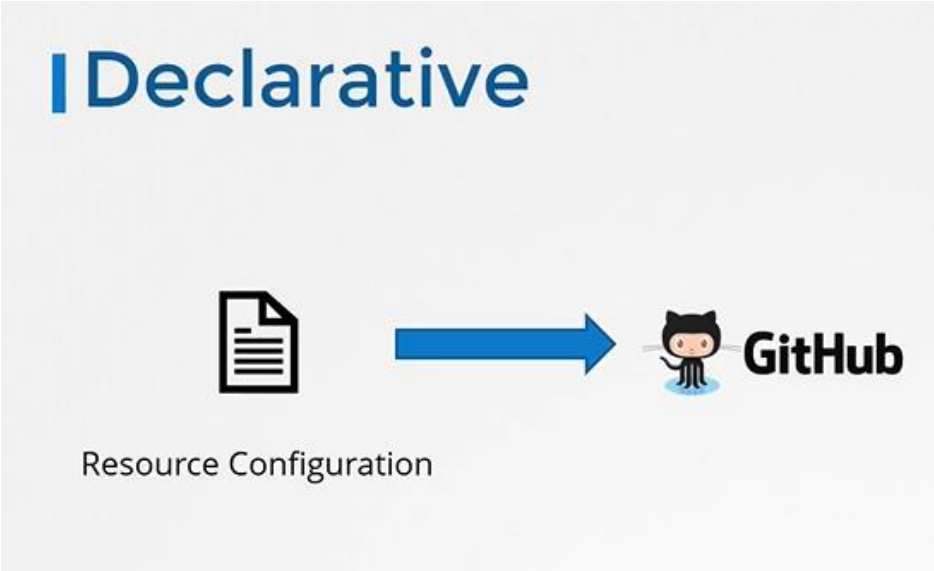
- Imperative way



- Declarative Way (Preferred approach)

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
    app: myapp
    type: front-end
spec:
  containers:
  - name: nginx-container
    image: nginx
```

- A good practice is to store resource configurations on source code repositories like github.



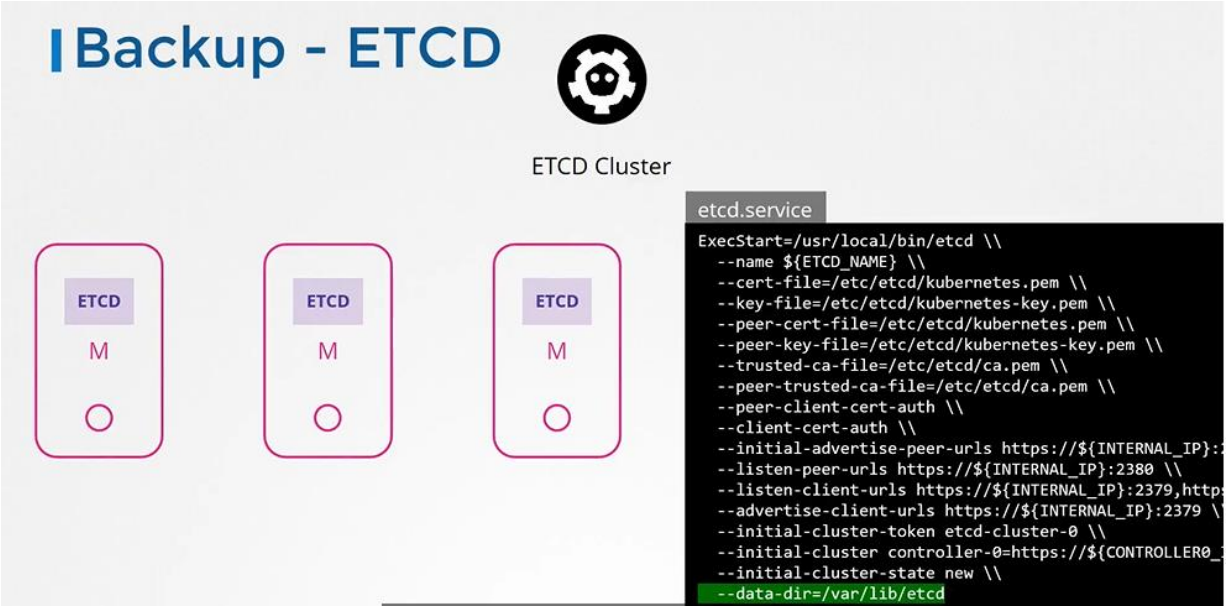
Backup - Resource Configs

```
$ kubectl get all --all-namespaces -o yaml > all-deploy-services.yaml (only for few resource groups)
```

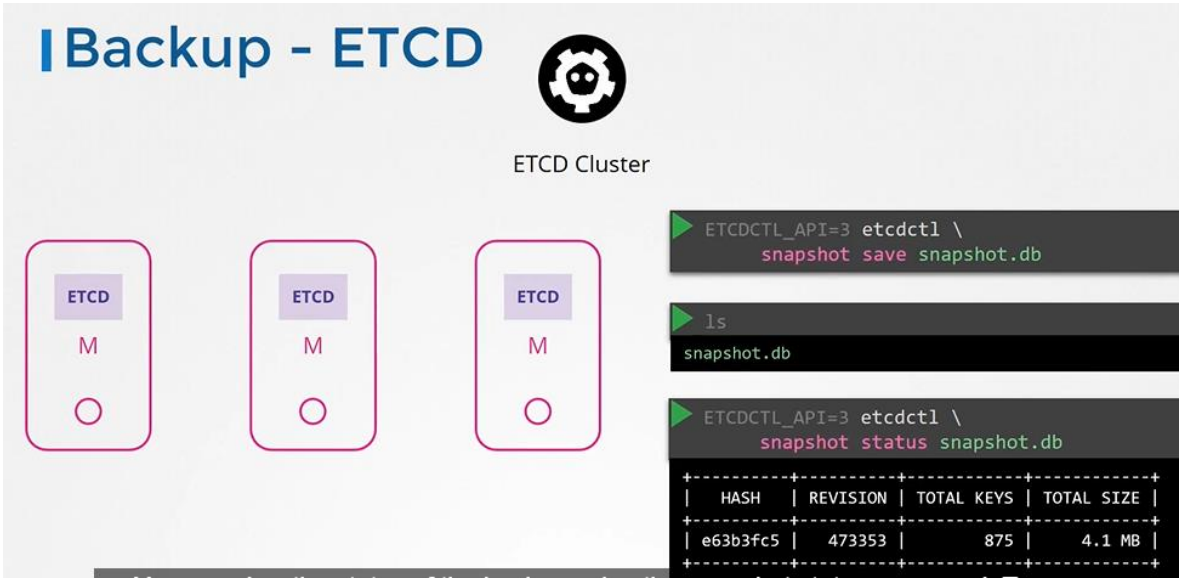
- There are many other resource groups that must be considered. There are tools like **`ARK`** or now called **`Velero`** by Heptio that can do this for you.

Backup - ETCD

- So, instead of backing up resources as before, you may choose to backup the ETCD cluster itself.

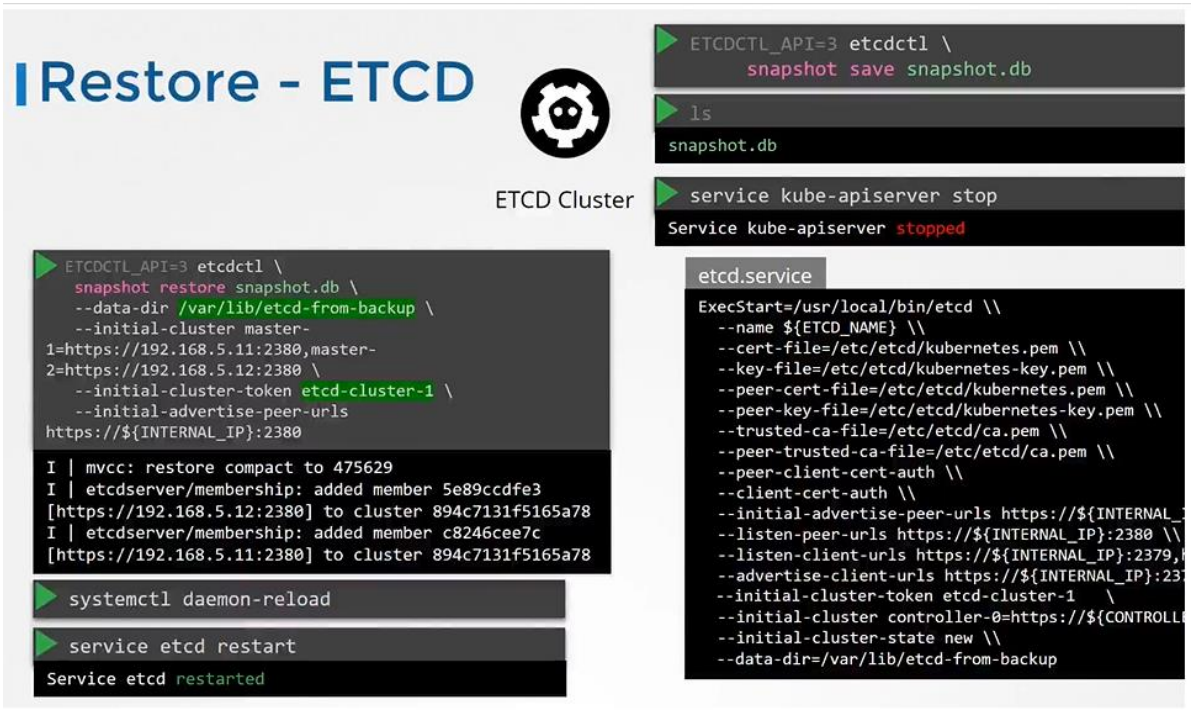


- You can take a snapshot of the etcd database by using **`etcdctl`** utility snapshot save command.
- `$ ETCDCTL_API=3 etcdctl snapshot save snapshot.db`
- `$  ETCDCTL_API=3 etcdctl snapshot status snapshot.db`



Restore - ETCD

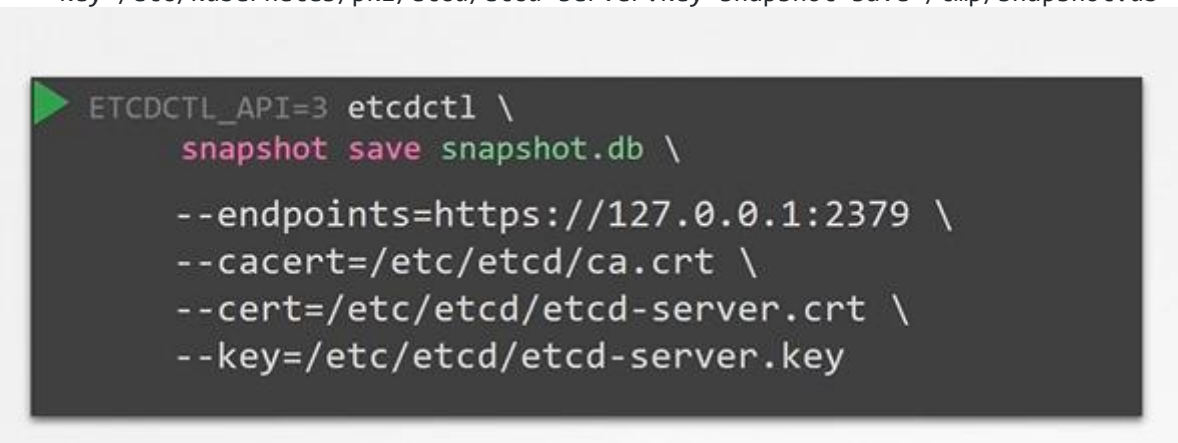
- To restore etcd from the backup at later in time. First stop kube-apiserver service
- `$ service kube-apiserver stop`
- Run the etcdctl snapshot restore command
- Update the etcd service
- Reload system configs
- `$ systemctl daemon-reload`
- Restart etcd
- `$ service etcd restart`



- Start the kube-apiserver
- `$ service kube-apiserver start`

With all etcdctl commands specify the cert,key,cacert and endpoint for authentication.

```
$ ETCDCTL_API=3 etcdctl --endpoints=https://[127.0.0.1]:2379 --
cacert=/etc/kubernetes/pki/etcd/ca.crt \
  --cert=/etc/kubernetes/pki/etcd/etcd-server.crt \
  --key=/etc/kubernetes/pki/etcd/etcd-server.key snapshot save /tmp/snapshot.db
```



K8s Reference Docs

- https://kubernetes.io/docs/tasks/administer-cluster/configure-upgrade-etcd/

Security Section Introduction

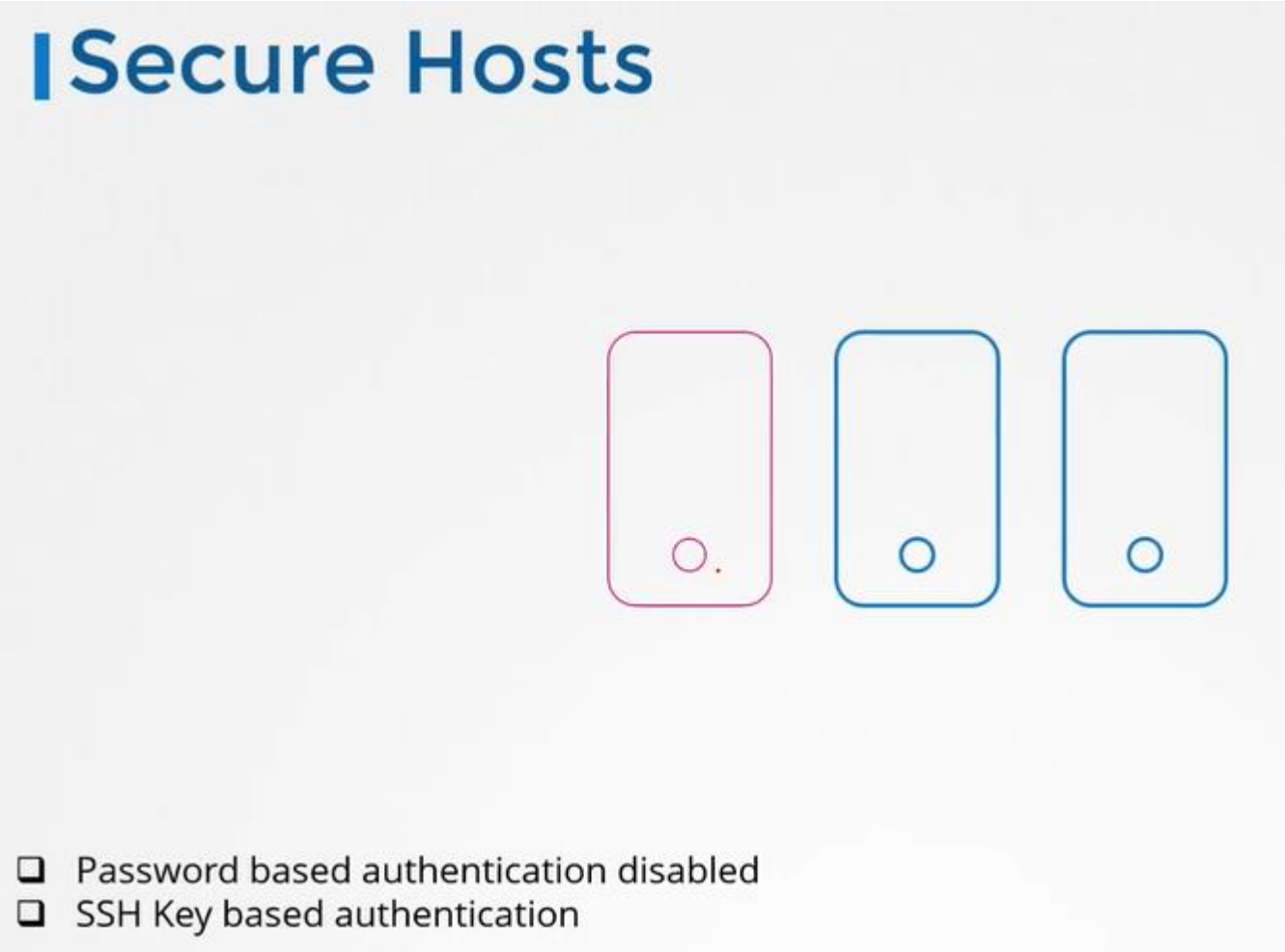
In this section, we will take a look at security section introduction

- Kubernetes Security Primitives
- Authentication
- TLS certificates for cluster components
- Secure Persistent key-value store
- Authorization
- Images Security
- Security Contexts
- Network Policies

Kubernetes Security Primitives

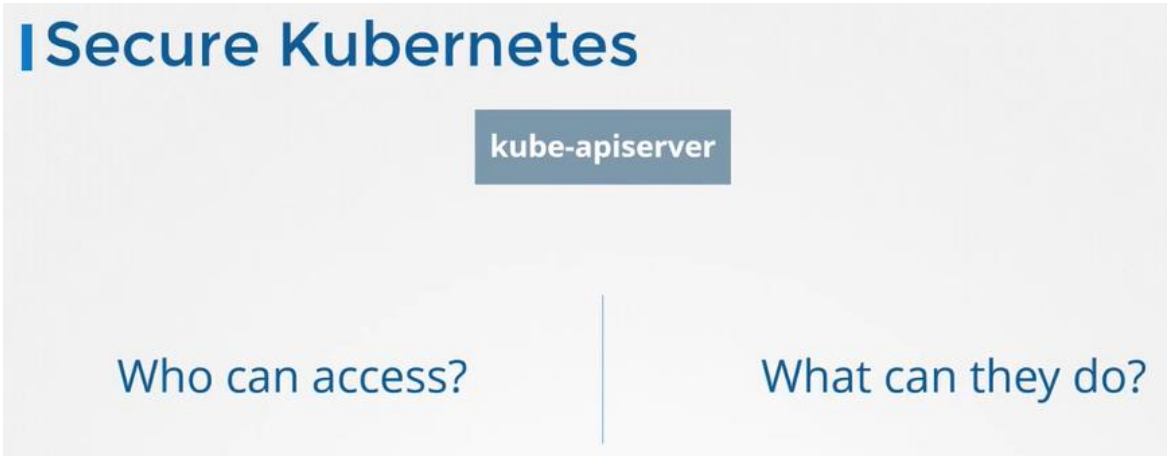
In this section, we will take a look at kubernetes security primitives

Secure Hosts



Secure Kubernetes

- We need to make two types of decisions.
    - Who can access?
    - What can they do?



Authentication

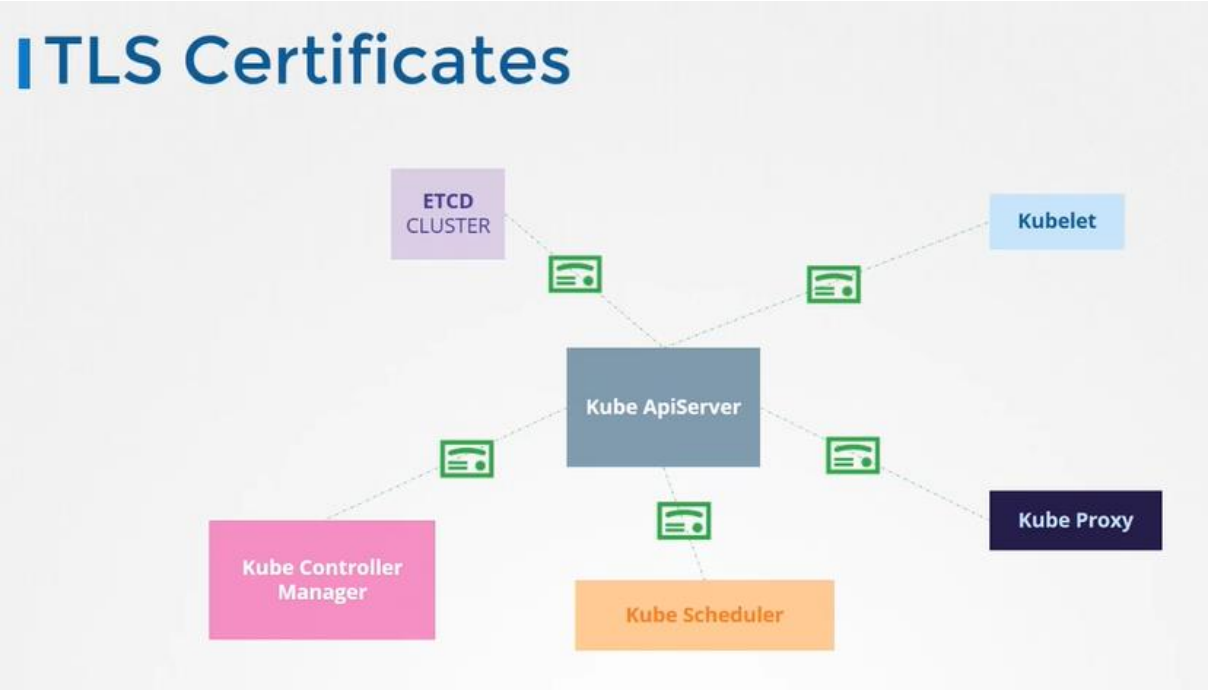
- Who can access the API Server is defined by the Authentication mechanisms.

Authorization

- Once they gain access to the cluster, what they can do is defined by authorization mechanisms.

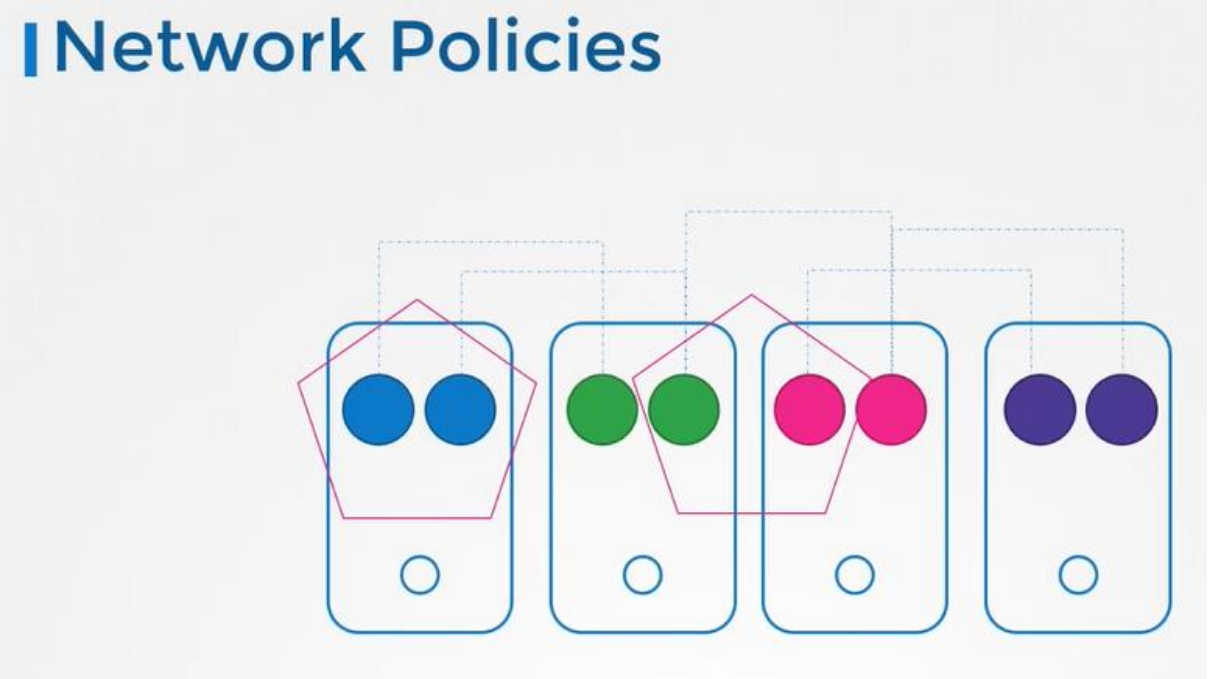
TLS Certificates

- All communication with the cluster, between the various components such as the ETCD Cluster, kube-controller-manager, scheduler, api server, as well as those running on the working nodes such as the kubelet and kubeproxy is secured using TLS encryption.



Network Policies

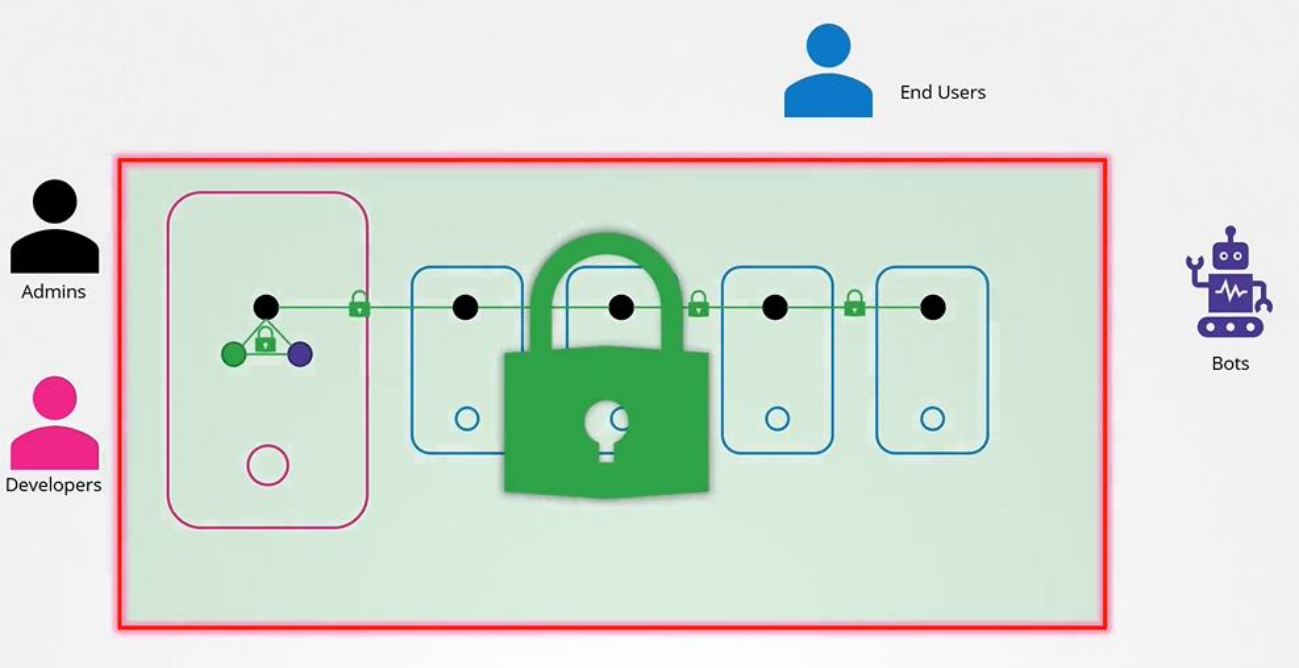
What about communication between applications within the cluster?



Authentication

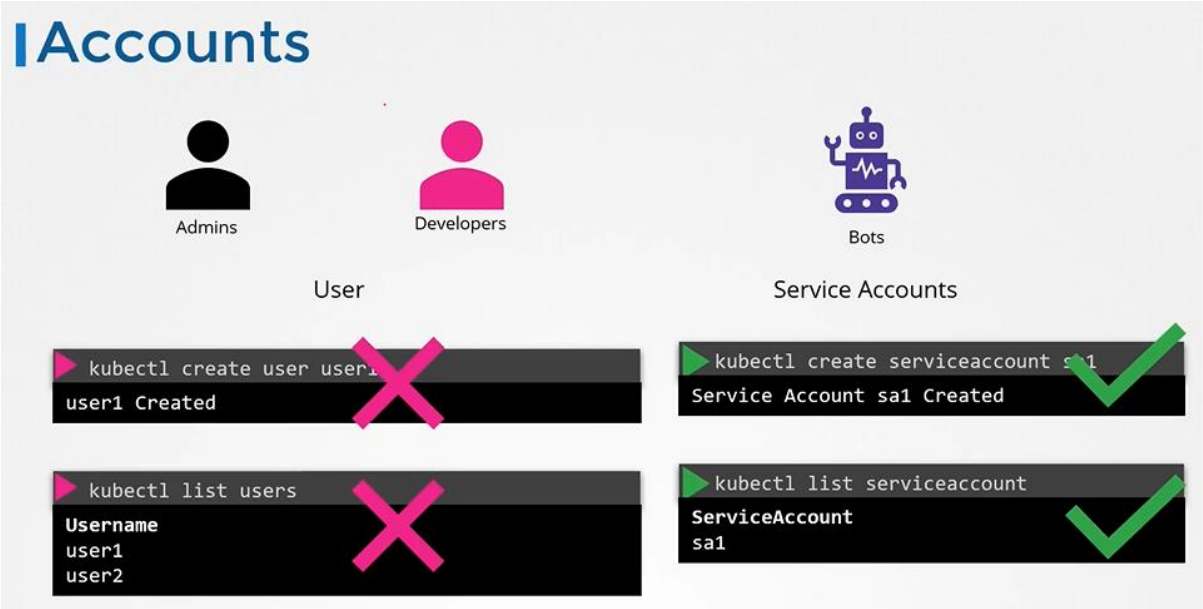
In this section, we will take a look at authentication in a kubernetes cluster

Accounts

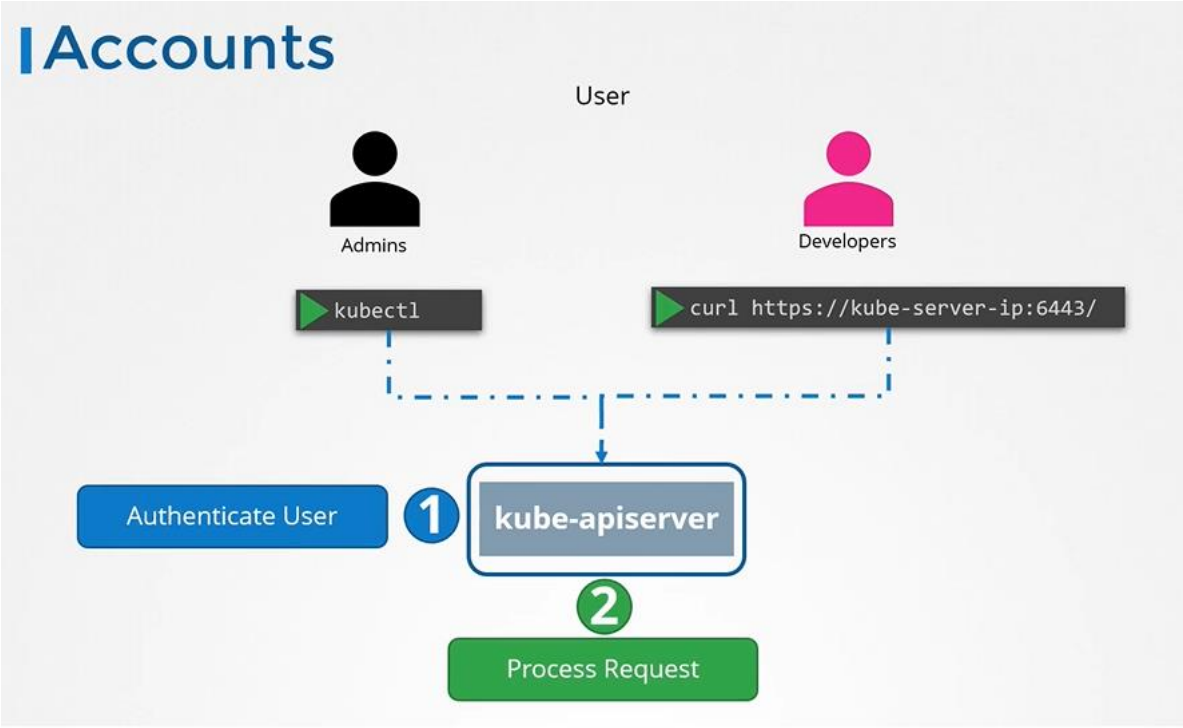


Different users that may be accessing the cluster security of end users who access the applications deployed on the cluster is managed by the applications themselves internally.

- So, we left with 2 types of users
    - Humans, such as the Administrators and Developers
    - Robots such as other processes/services or applications that require access to the cluster.

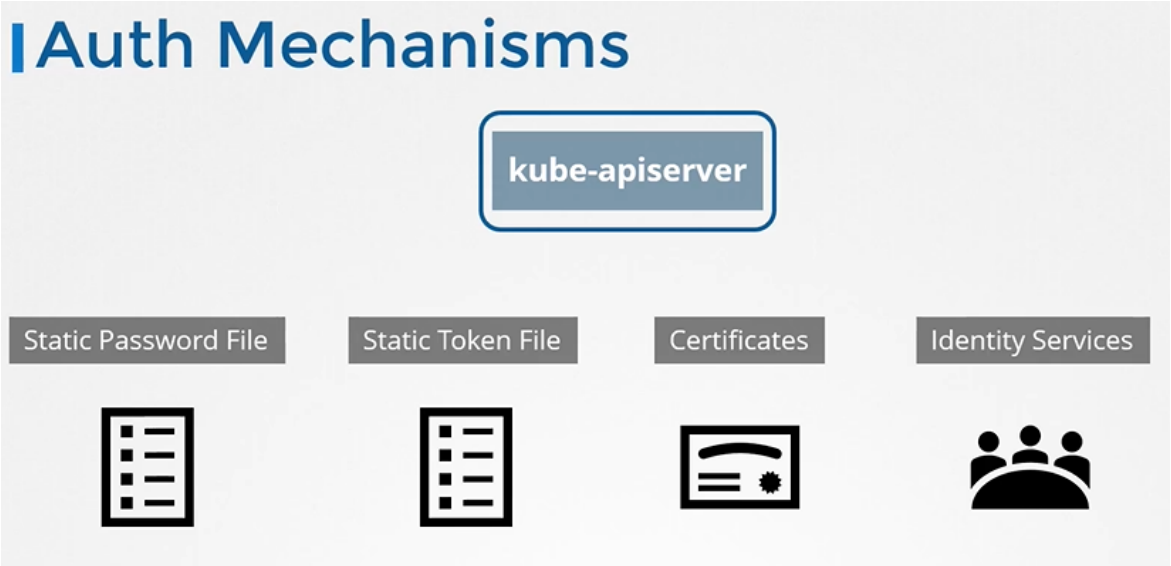


- All user access is managed by apiserver and all of the requests goes through apiserver.

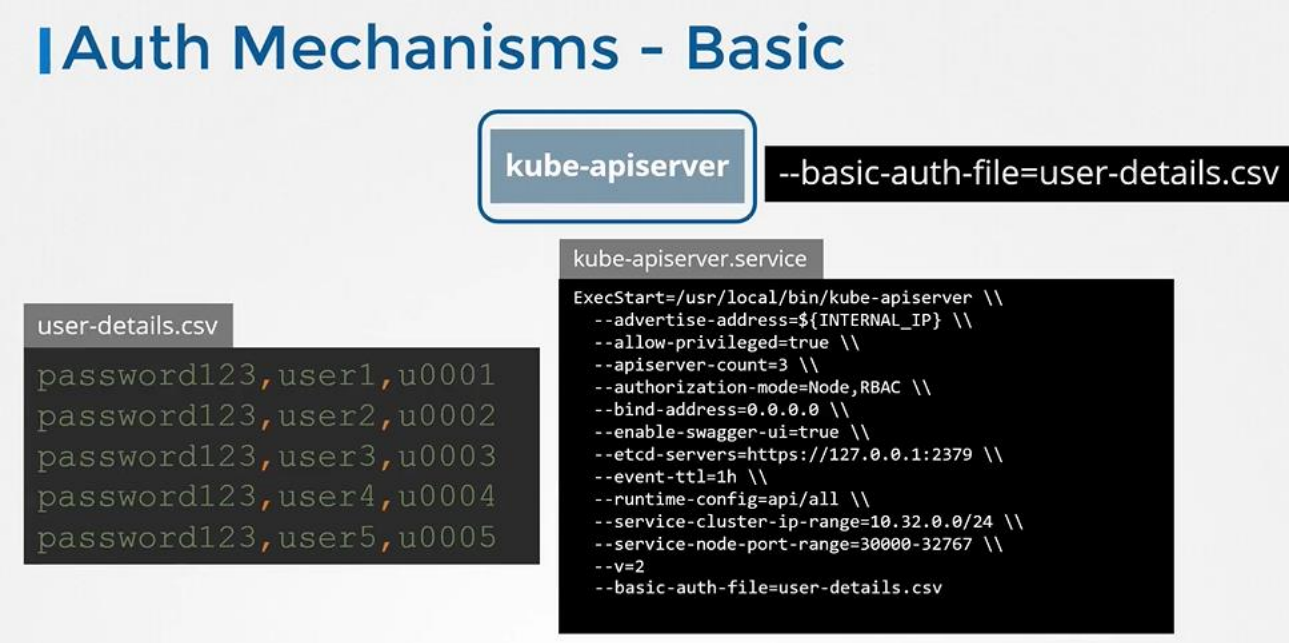


Authentication Mechanisms

- There are different authentication mechanisms that can be configured.

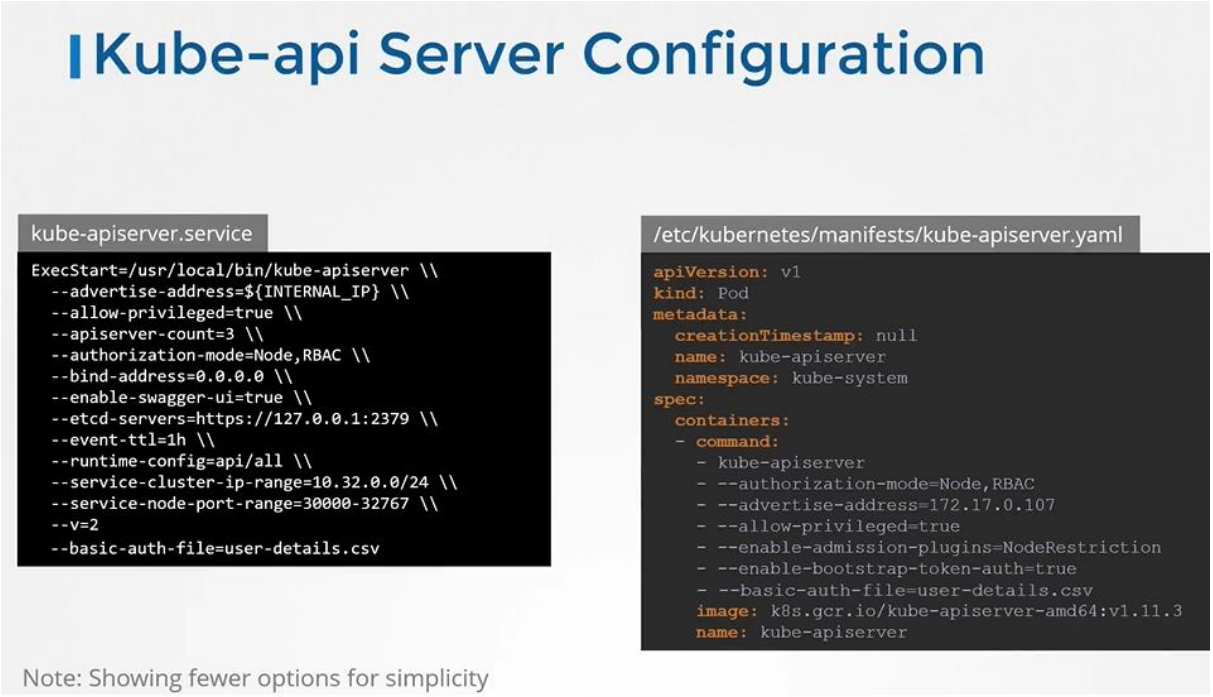


Authentication Mechanisms - Basic



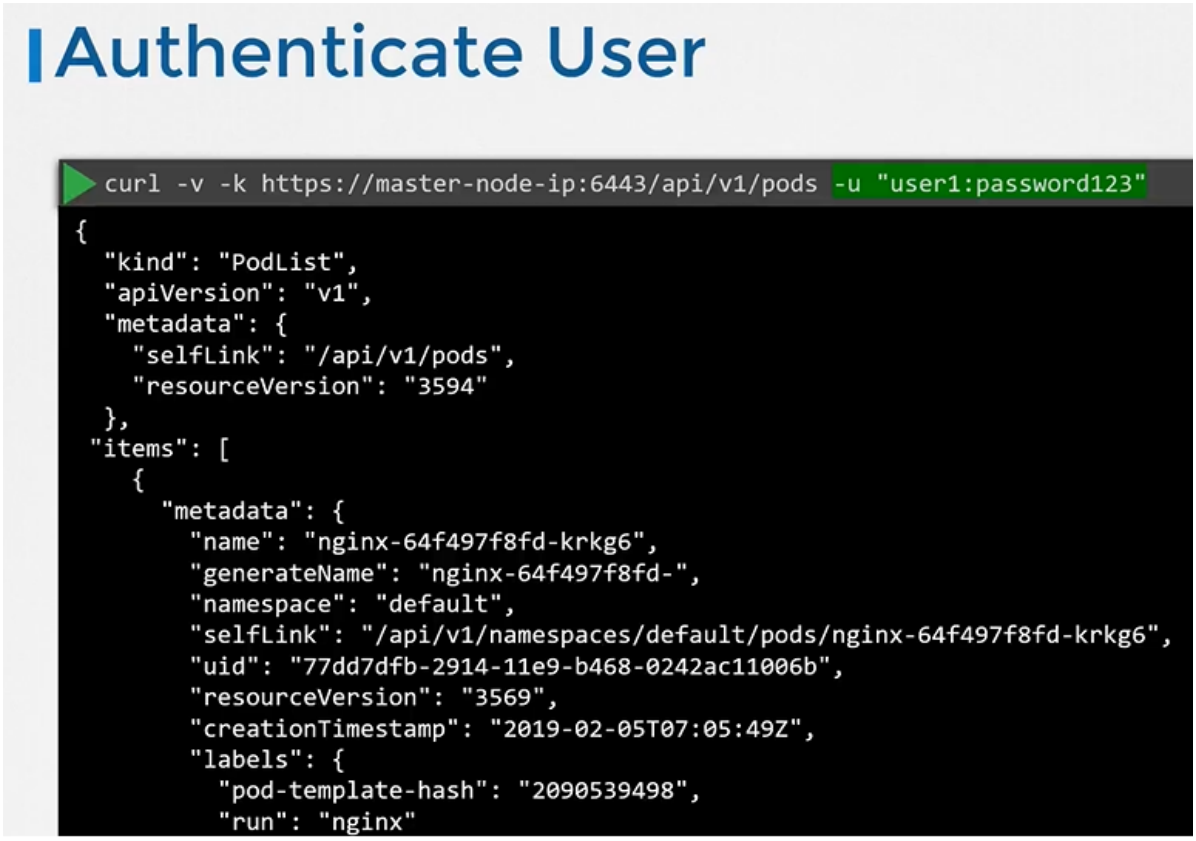
kube-apiserver configuration

- If you set up via kubeadm then update kube-apiserver.yaml manifest file with the option.

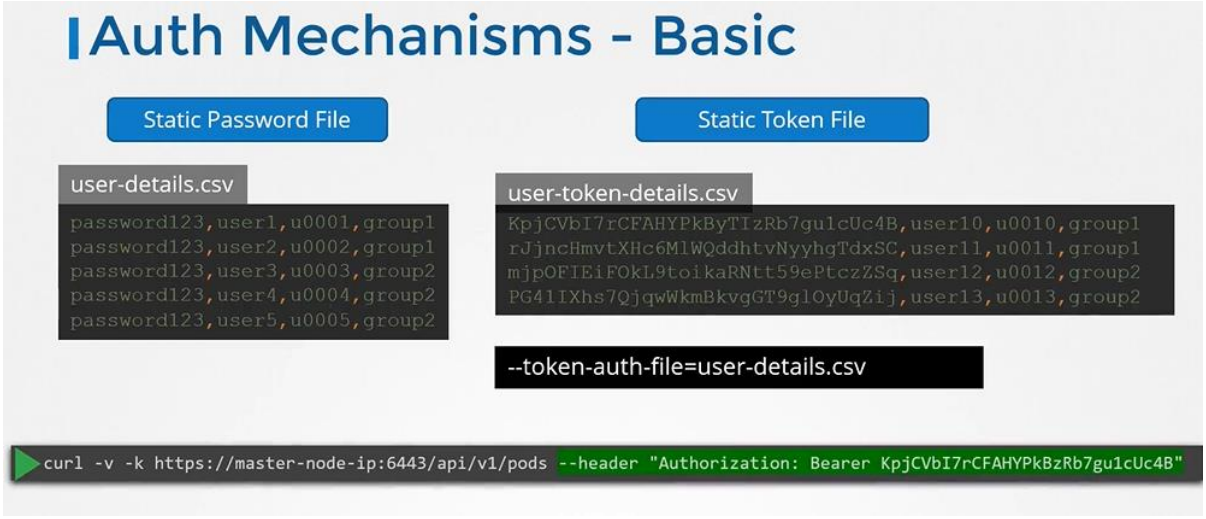


Authenticate User

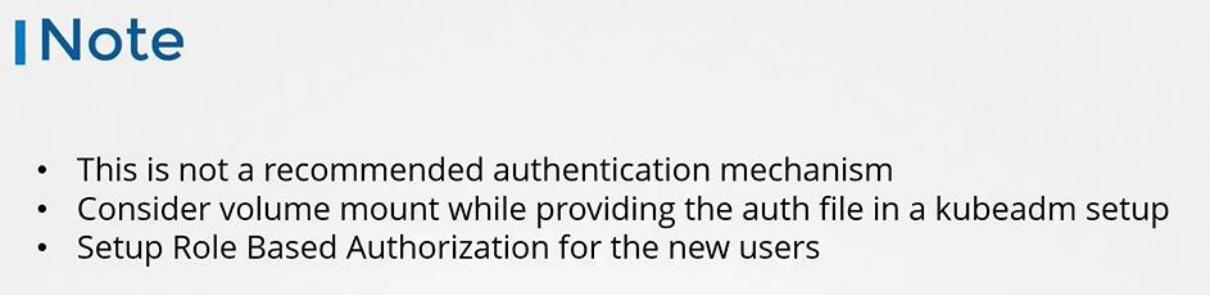
- To authenticate using the basic credentials while accessing the API server specify the username and password in a curl command.
- `$ curl -v -k http://master-node-ip:6443/api/v1/pods -u "user1:password123"`



- We can have additional column in the user-details.csv file to assign users to specific groups.



Note



K8s Reference Docs

- https://kubernetes.io/docs/reference/access-authn-authz/authentication/

TLS Certificates

In this section, we will take a look at TLS certificates

- What are TLS certificates?
- How does kubernetes use certificates?
- How to generate them?
- How to configure them?
- How to view them?
- How to troubleshoot issues related to certificates

TLS Basics

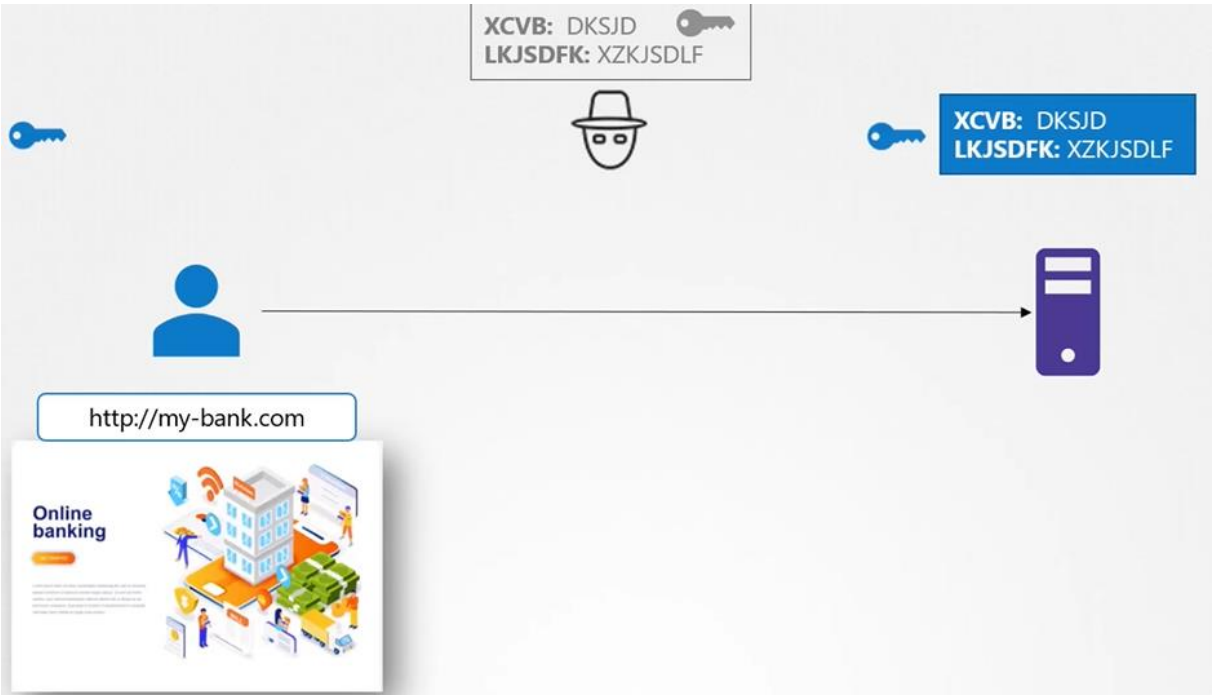
In this section, we will take a look at TLS Basics

Certificate

- A certificate is used to guarantee trust between 2 parties during a transaction.
- Example: when a user tries to access web server, tls certificates ensure that the communication between them is encrypted.

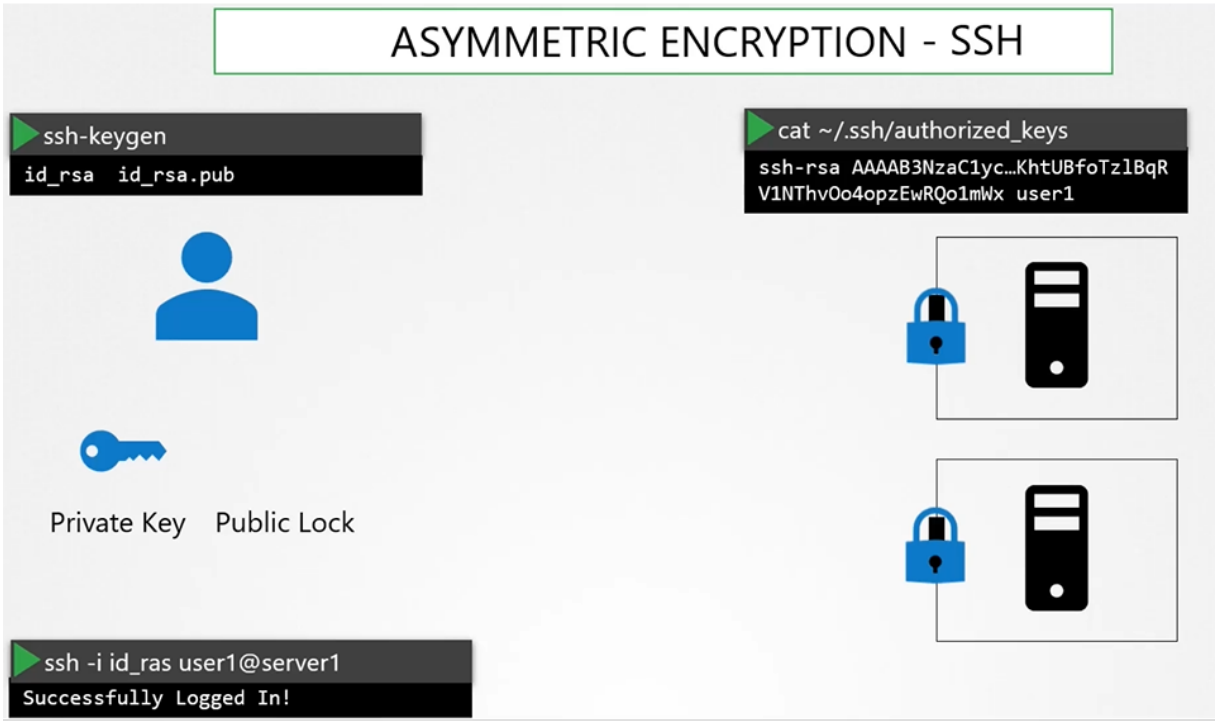
Symmetric Encryption

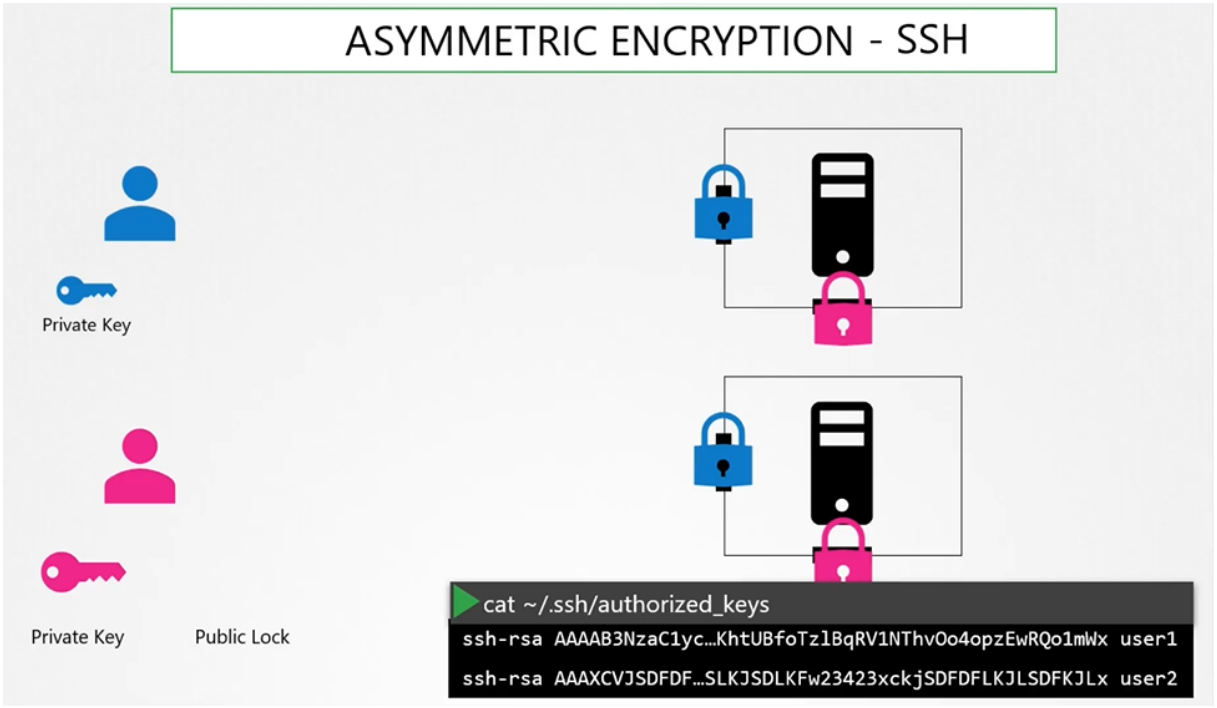
- It is a secure way of encryption, but it uses the same key to encrypt and decrypt the data and the key has to be exchanged between the sender and the receiver, there is a risk of a hacker gaining access to the key and decrypting the data.

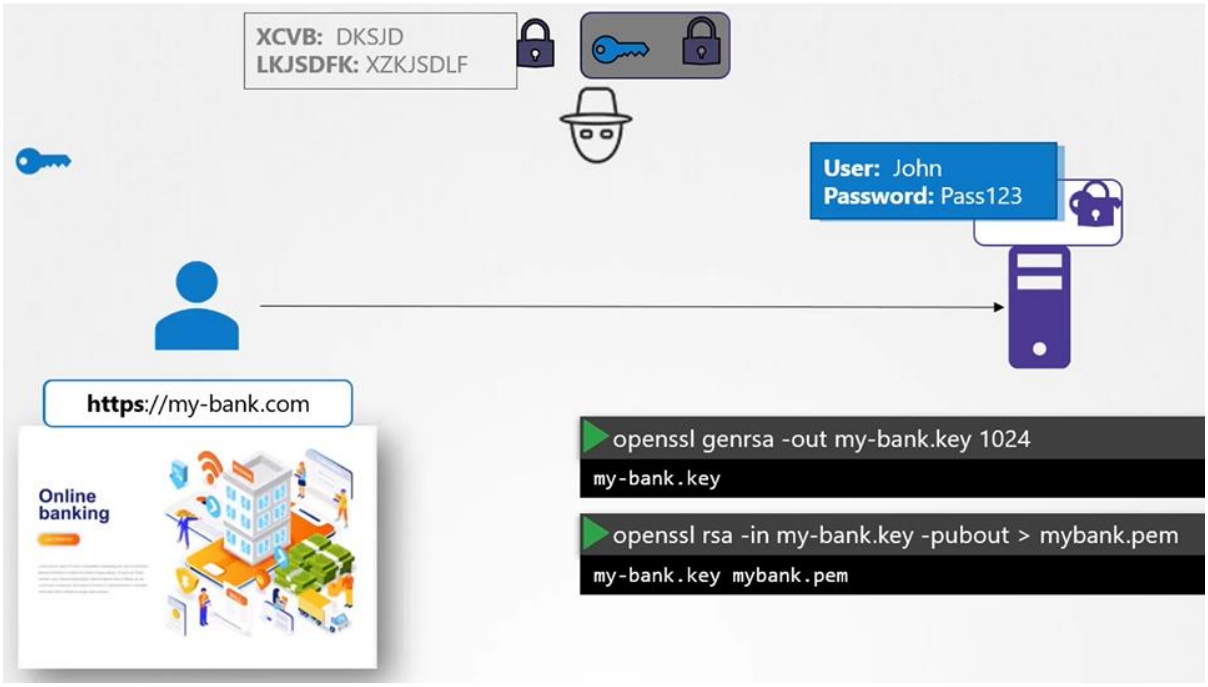


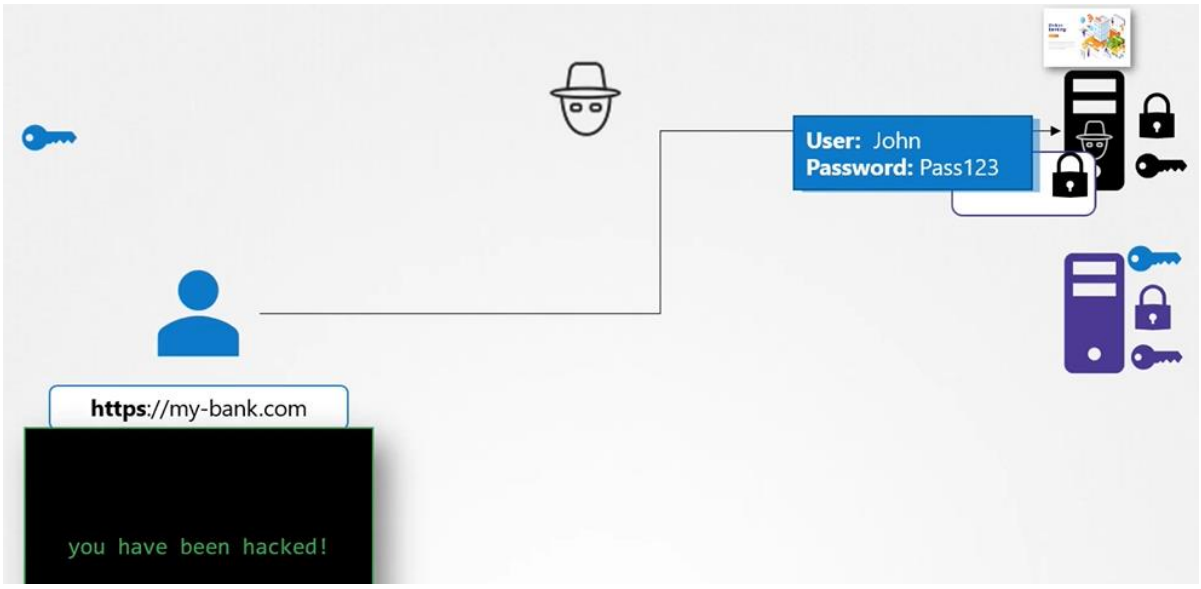
Asymmetric Encryption

- Instead of using single key to encrypt and decrypt data, asymmetric encryption uses a pair of keys, a private key and a public key.


ASYMMETRIC ENCRYPTION - SSH
ssh-keygen
id_rsa id_rsa.pub
cat ~/.ssh/authorized_keys
ssh-rsa AAAAB3NzaC1yc…KhtUBfoTzlBqR
V1NThvOo4opzEwRQo1mWx user1
Private Key
Public Lock
ssh -i id_ras user1@server1
Successfully Logged In!


ASYMMETRIC ENCRYPTION - SSH
Private Key
Private Key
Public Lock
cat ~/.ssh/authorized_keys
ssh-rsa AAAAB3NzaC1yc…KhtUBfoTzlBqRV1NThvOo4opzEwRQo1mWx user1
ssh-rsa AAAXCVJSDFDF…SLKJSDLKFw23423xckjSDFDFLKJLSDFKJLx user2



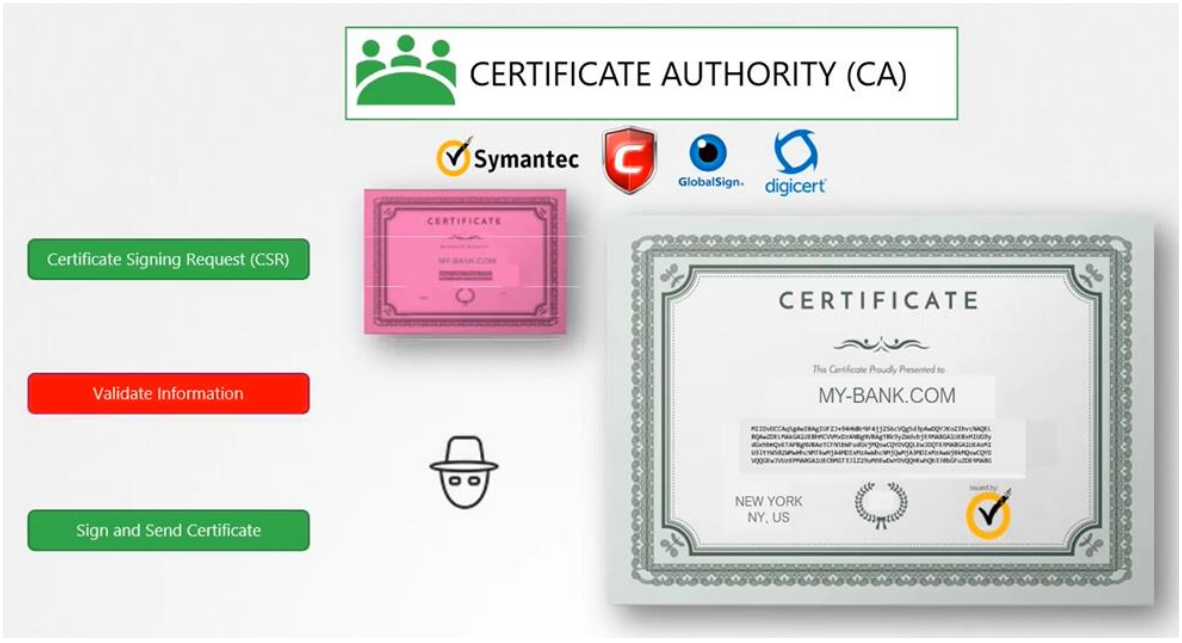


How do you look at a certificate and verify if it is legit?

- who signed and issued the certificate.
- If you generate the certificate then you will have it sign it by yourself; that is known as self-signed certificate.

How do you generate legitimate certificate? How do you get your certificates singed by someone with authority?

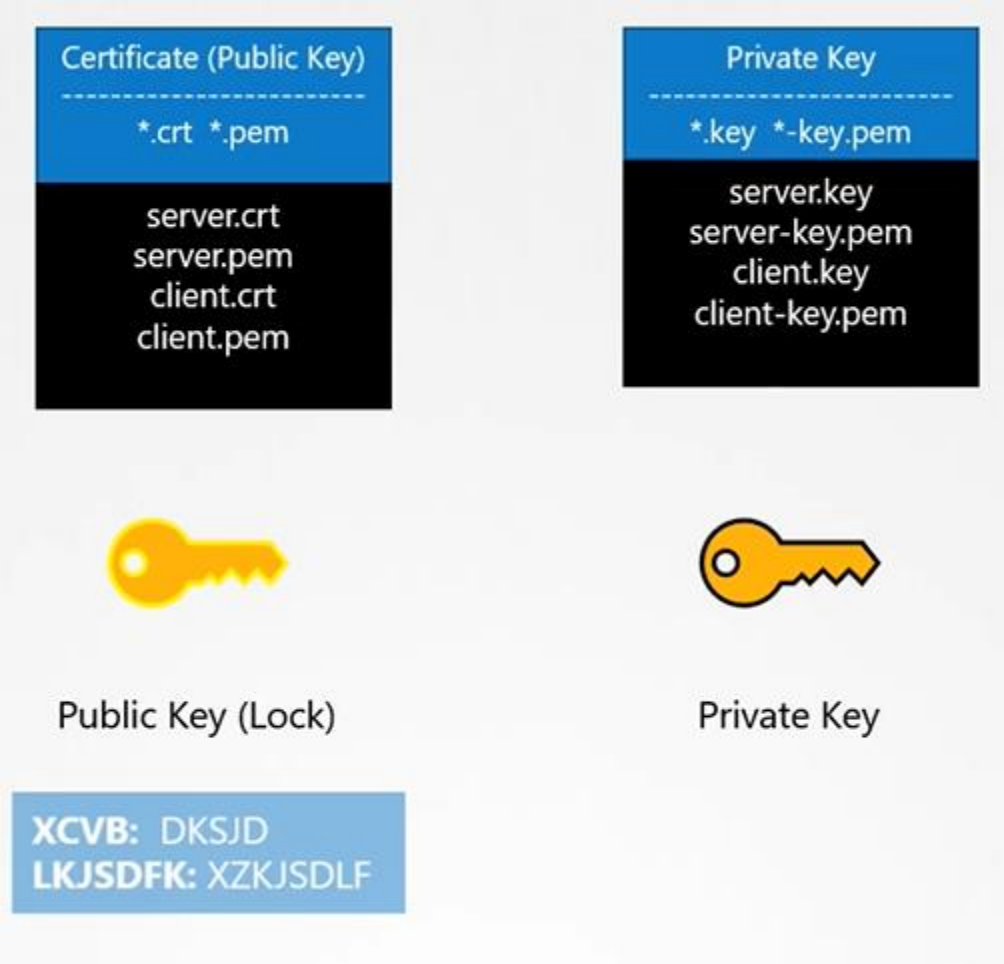
- That's where **`Certificate Authority (CA)`** comes in for you. Some of the popular ones are Symantec, DigiCert, Comodo, GlobalSign etc.


CERTIFICATE AUTHORITY (CA)
Symantec
GlobalSign.
digicert
Certificate Signing Request (CSR)
Validate Information
Sign and Send Certificate
CERTIFICATE
This Certificate Proudly Presented to
MY-BANK.COM
NEW YORK
NY, US


CERTIFICATE AUTHORITY (CA)
Symantec
GlobalSign.
digicert
Symantec
Private CA
https://my-bank.com
Online
banking
CERTIFICATE
This Certificate Proudly Presented to
MY-BANK.COM
NEW YORK
NY, US

Public Key Infrastructure

Certificates naming convention



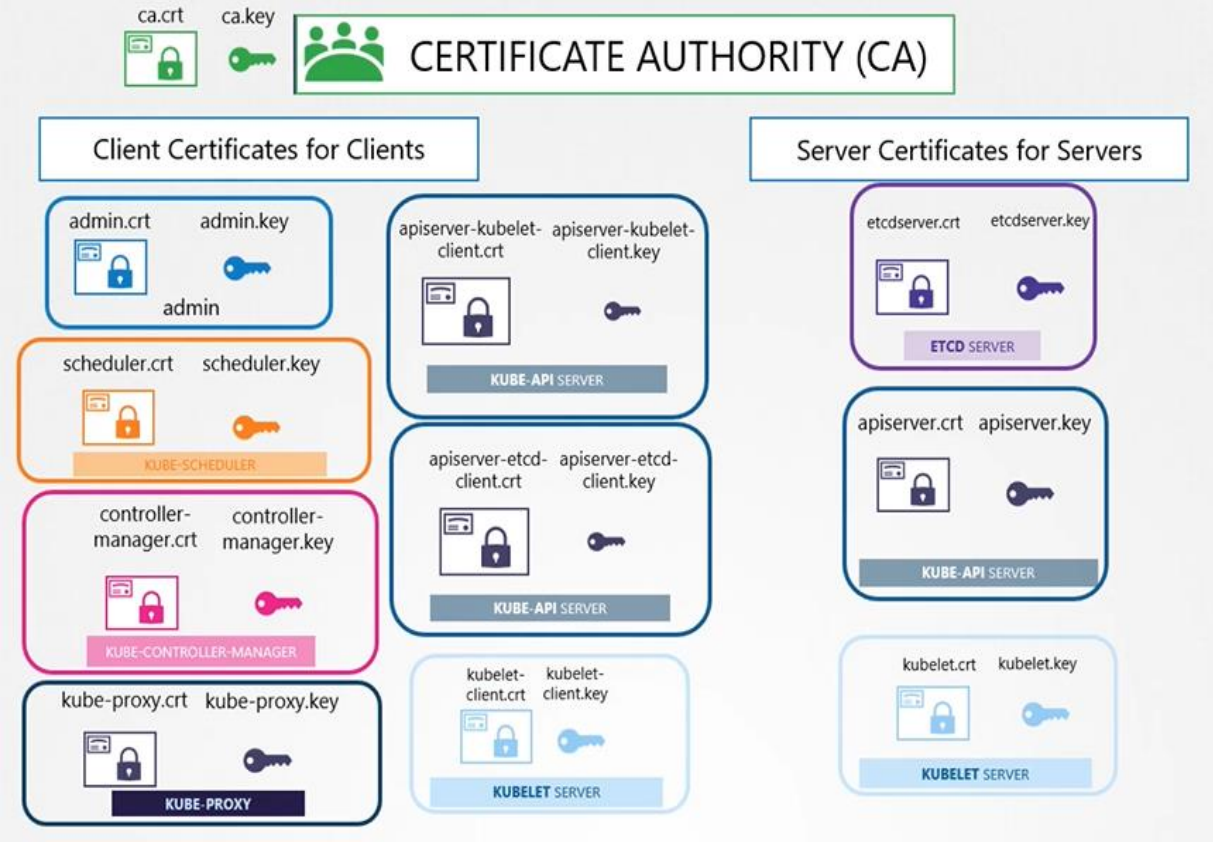
TLS in Kubernetes

In this section, we will take a look at TLS in kubernetes

The two primary requirements are to have all the various services within the cluster to use server certificates and all clients to use client certificates to verify they are who they say they are.

- Server Certificates for Servers
- Client Certificates for Clients

Let's look at the different components within the k8s cluster and identify the various servers and clients and who talks to whom.



TLS in kubernetes - Certificate Creation

In this section, we will take a look at TLS certificate creation in kubernetes

Generate Certificates

- There are different tools available such as easyrsa, openssl or cfssl etc. or many others for generating certificates.

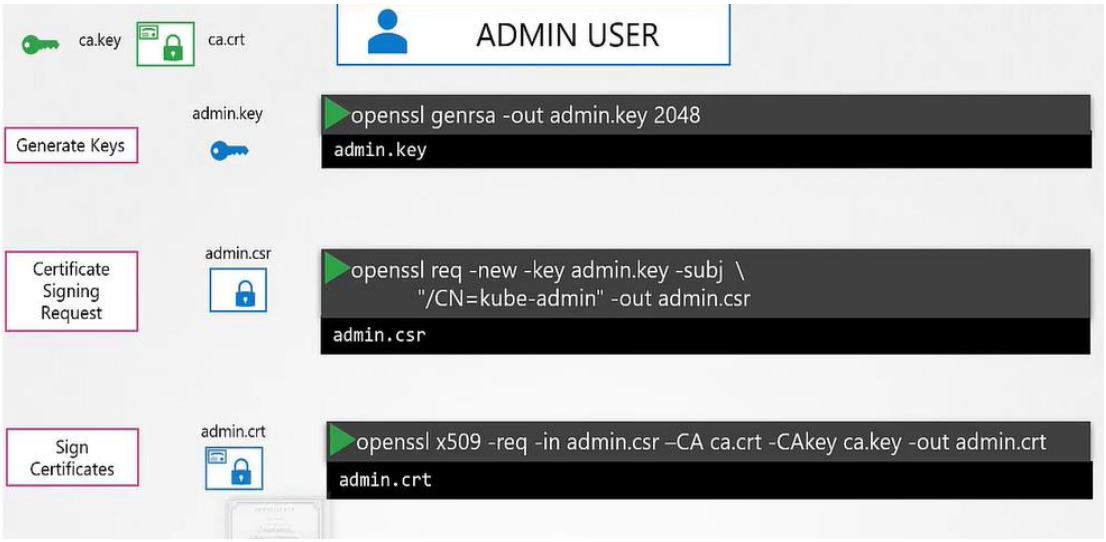
Certificate Authority (CA)

- Generate Keys
- `$ openssl genrsa -out ca.key 2048`
- Generate CSR
- `$ openssl req -new -key ca.key -subj "/CN=KUBERNETES-CA" -out ca.csr`
- Sign certificates
- `$ openssl x509 -req -in ca.csr -signkey ca.key -out ca.crt`

Generating Client Certificates

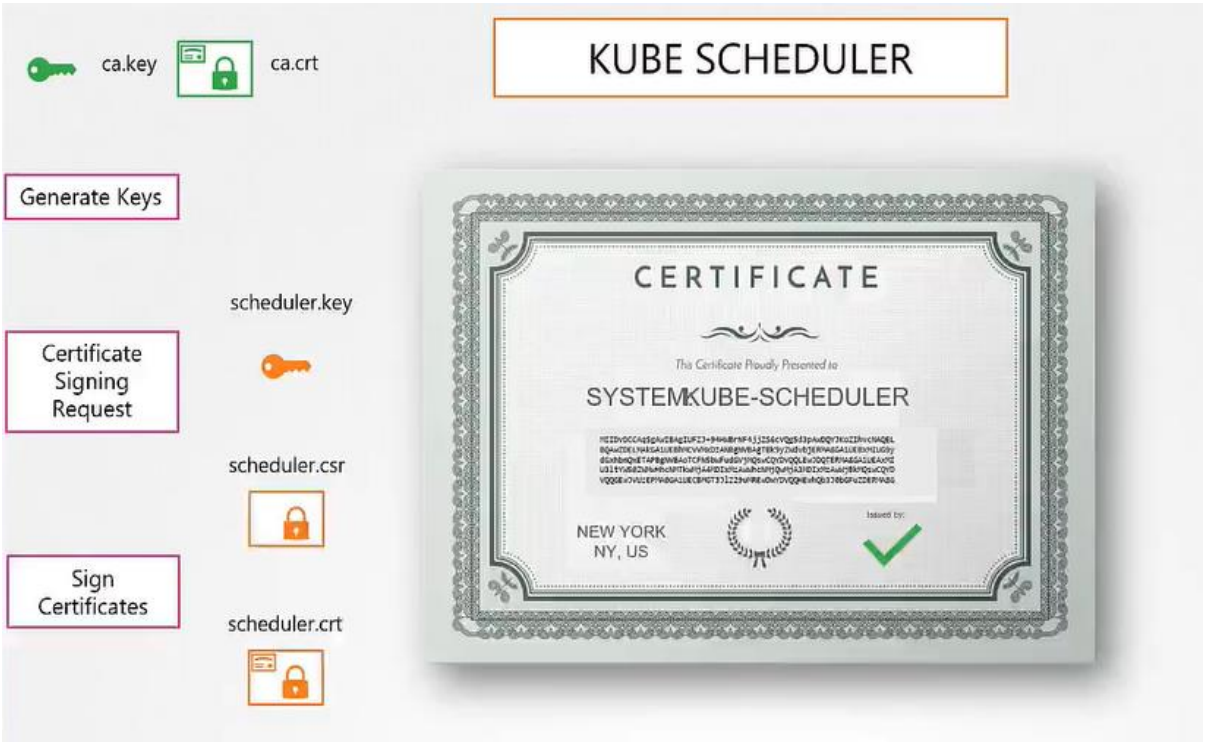
Admin User Certificates

- Generate Keys
- `$ openssl genrsa -out admin.key 2048`
- Generate CSR
- `$ openssl req -new -key admin.key -subj "/CN=kube-admin" -out admin.csr`
- Sign certificates
- `$ openssl x509 -req -in admin.csr -CA ca.crt -CAkey ca.key -out admin.crt`



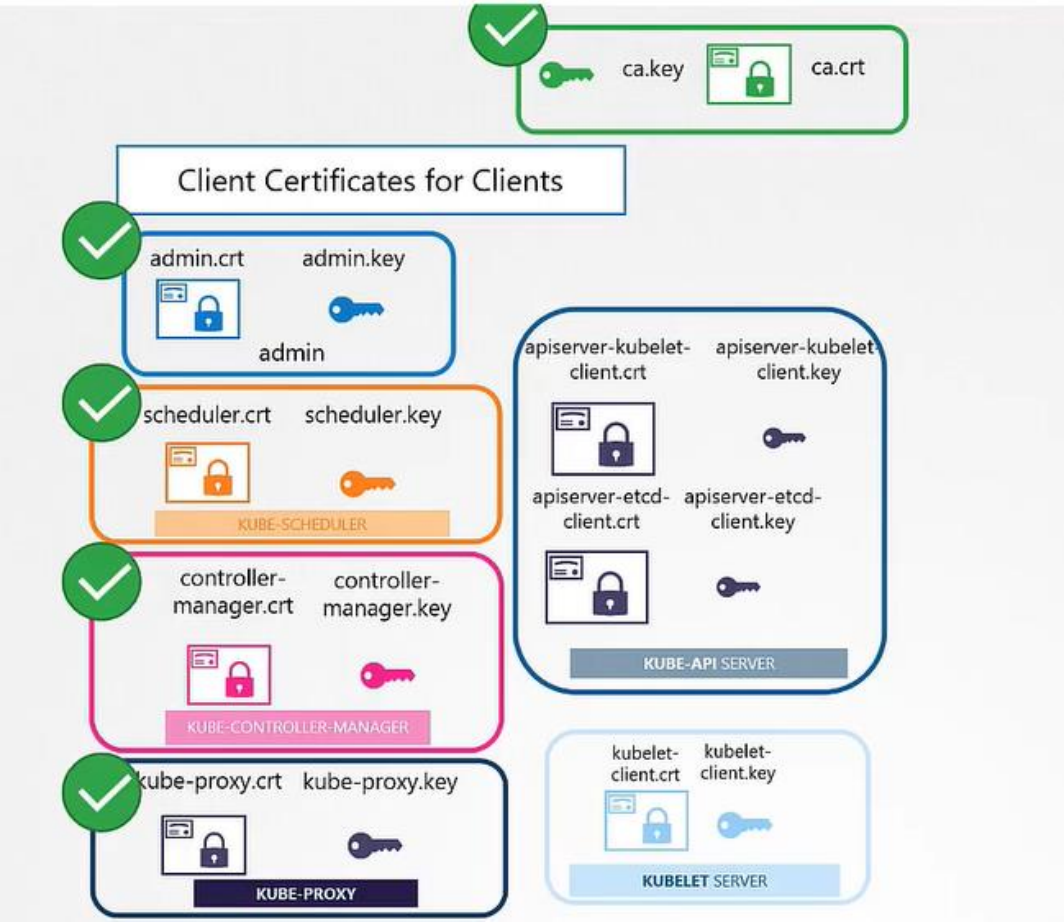
- Certificate with admin privilages
- `$ openssl req -new -key admin.key -subj "/CN=kube-admin/O=system:masters" -out admin.csr`

We follow the same procedure to generate client certificate for all other components that access the kube-apiserver.



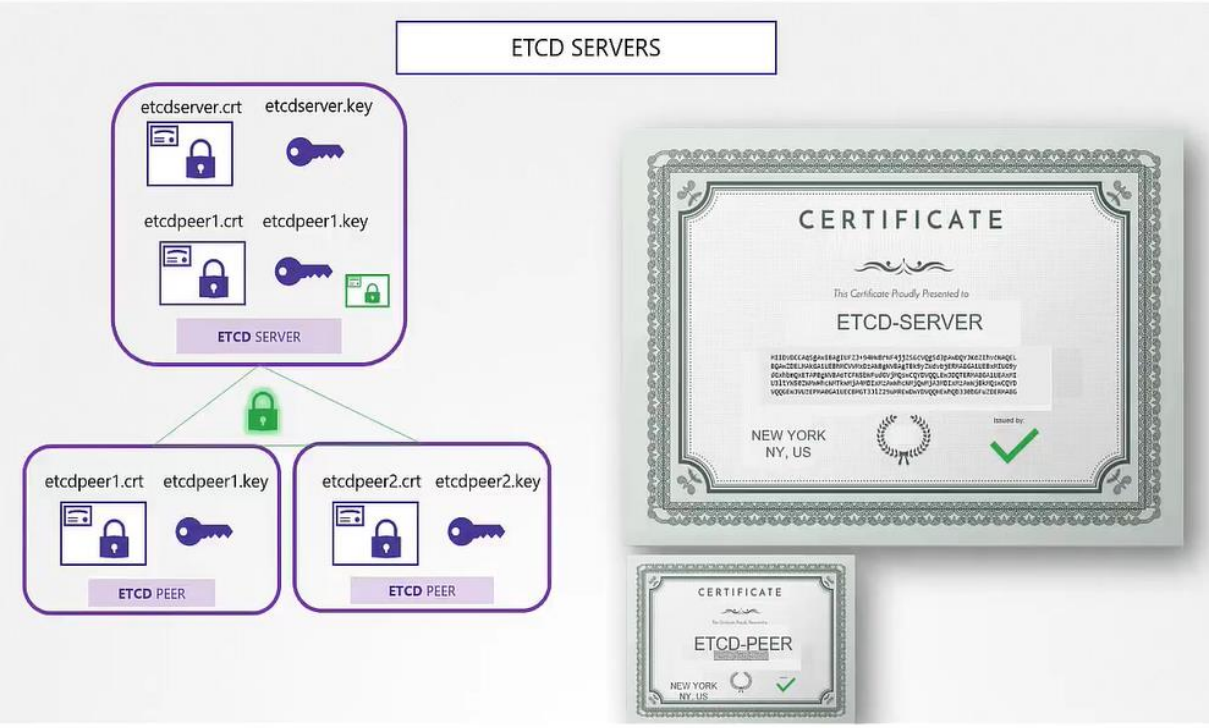

ca.key
ca.crt
KUBE CONTROLLER MANGER
Generate Keys
controller-manager.key
Certificate Signing Request
controller-manager.csr
Sign Certificates
controller-manager.crt
CERTIFICATE
This Certificate Proudly Presented to
SYSTEMKUBE-CONTOLLER-MANAGER
NEW YORK
NY, US
issued by:


ca.key
ca.crt
KUBE PROXY
Generate Keys
kube-proxy.key
Certificate Signing Request
kube-proxy.csr
Sign Certificates
kube-proxy.crt
CERTIFICATE
This Certificate Proudly Presented to
KUBE-PROXY
NEW YORK
NY, US

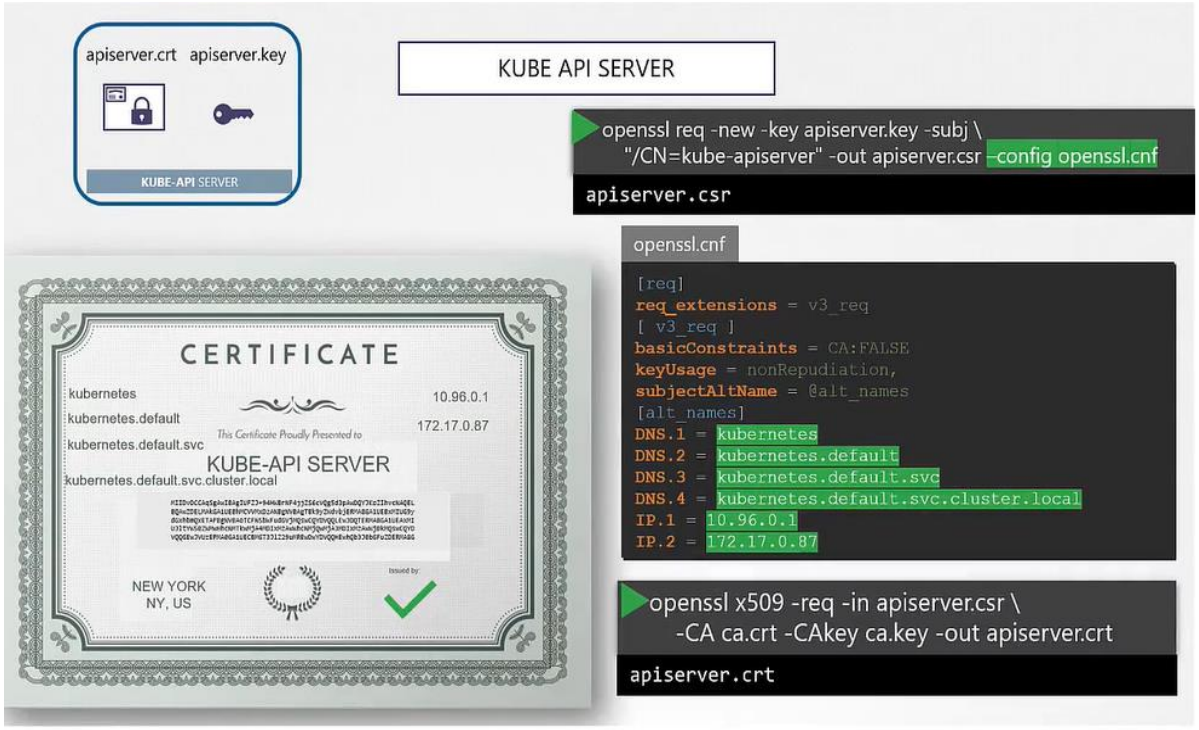

ca.key
ca.crt
Client Certificates for Clients
admin.crt
admin.key
admin
scheduler.crt
scheduler.key
KUBE-SCHEDULER
controller-manager.crt
controller-manager.key
KUBE-CONTROLLER-MANAGER
kube-proxy.crt
kube-proxy.key
KUBE-PROXY
apiserver-kubelet-client.crt
apiserver-kubelet-client.key
apiserver-etcd-client.crt
apiserver-etcd-client.key
KUBE-API SERVER
kubelet-client.crt
kubelet-client.key
KUBELET SERVER

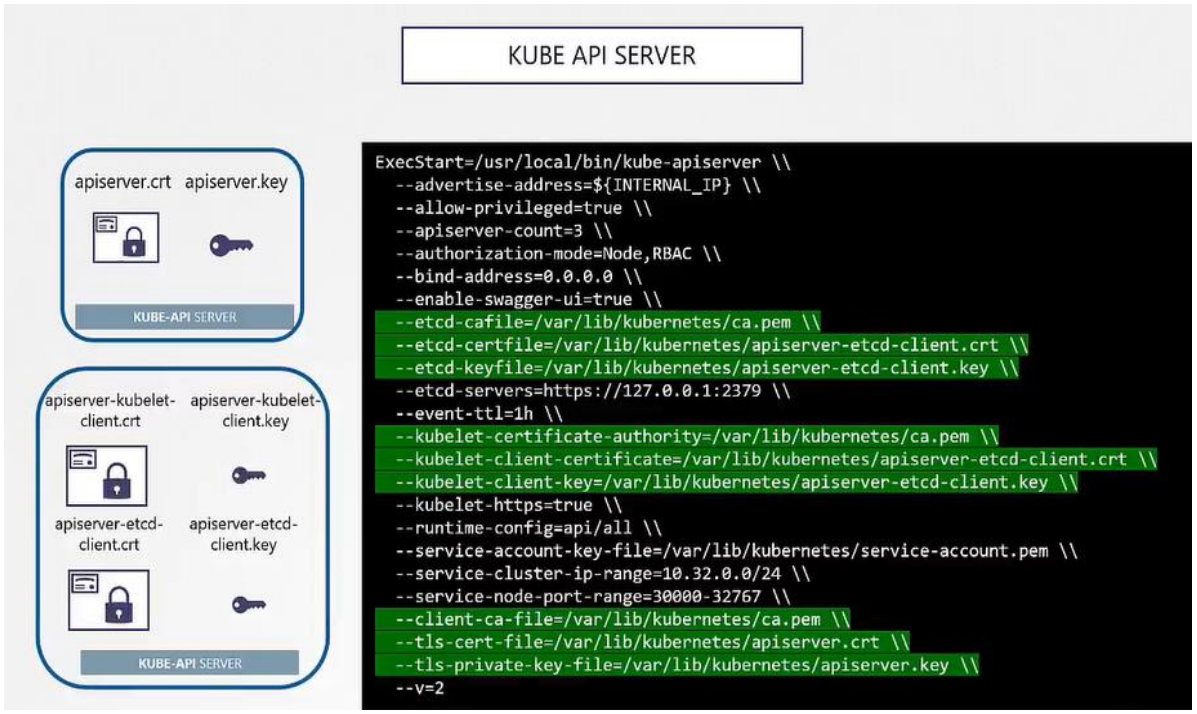
Generating Server Certificates

ETCD Server certificate

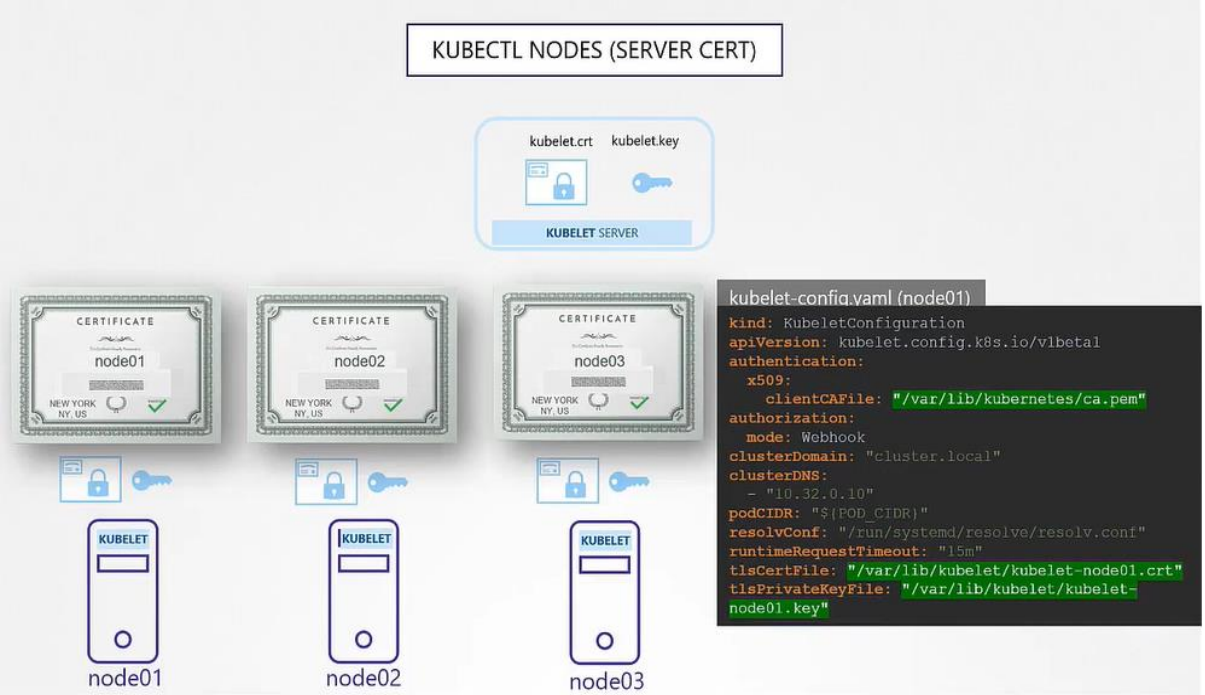


Kube-apiserver certificate

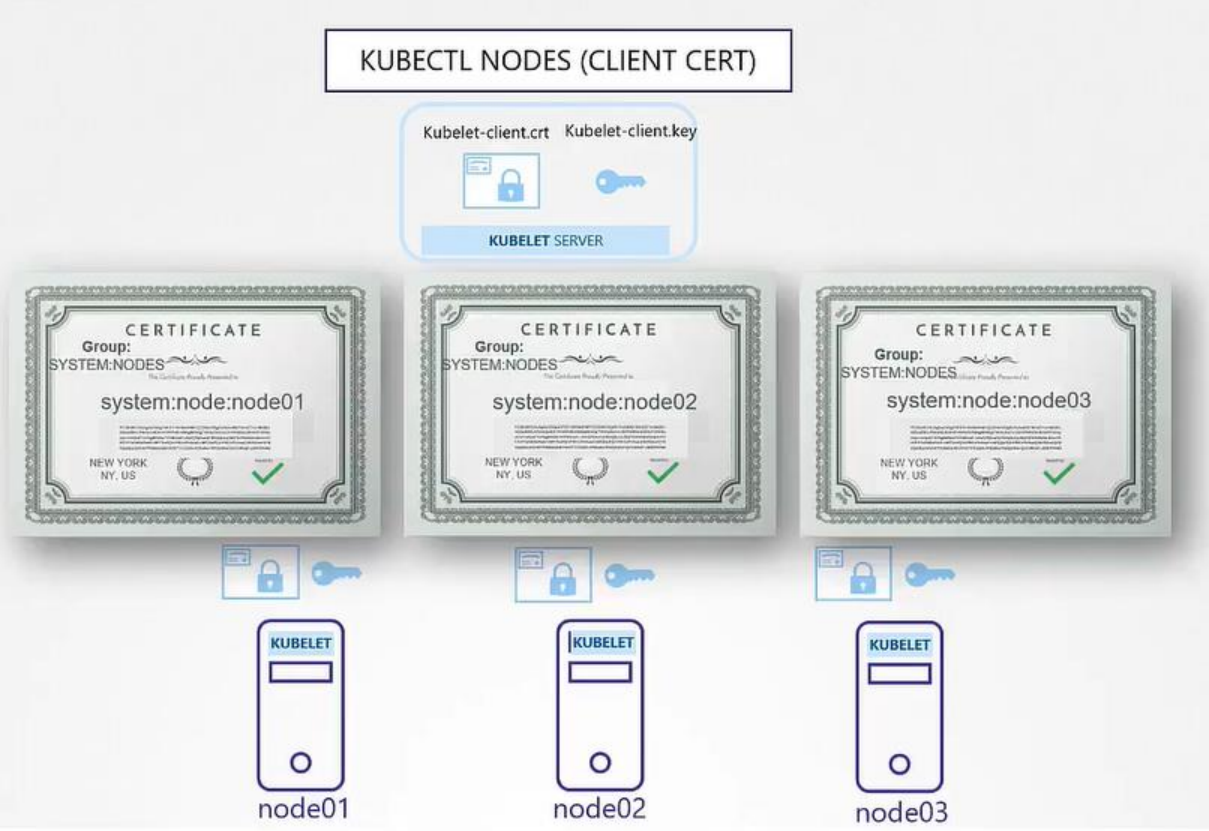




Kubectl Nodes (Server Cert)



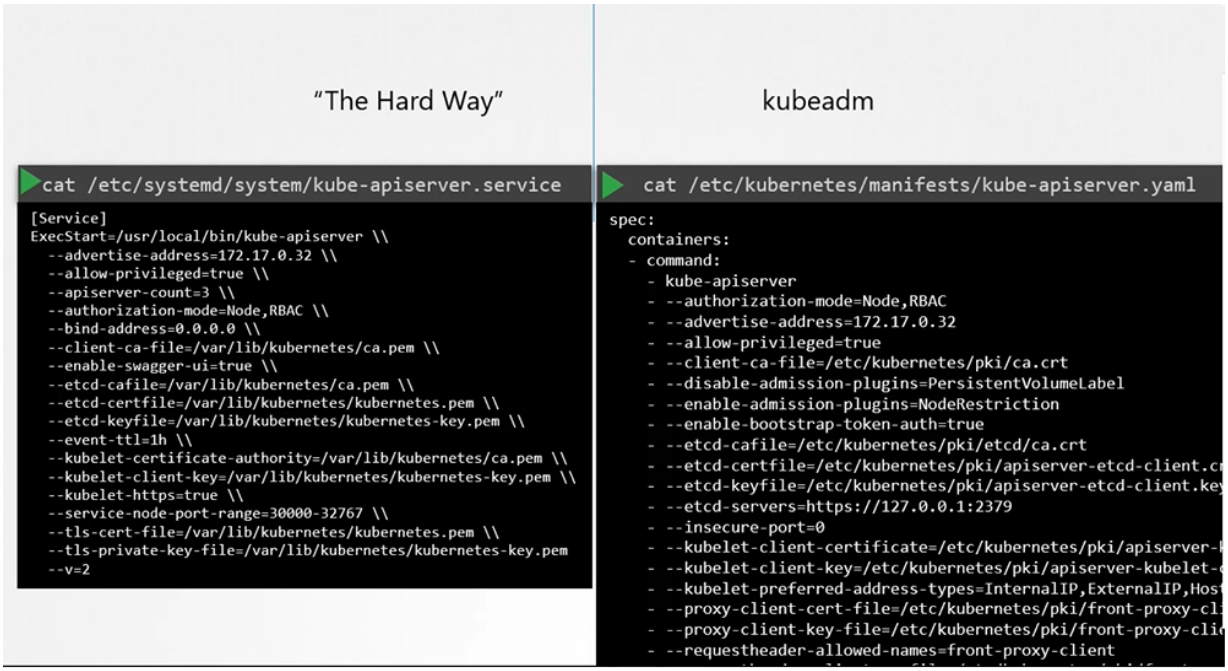
Kubectl Nodes (Client Cert)



View Certificate Details

In this section, we will take a look how to view certificates in a kubernetes cluster.

View Certs



```
cat /etc/kubernetes/manifests/kube-apiserver.yaml
spec:
  containers:
  - command:
    - kube-apiserver
    - --authorization-mode=Node,RBAC
    - --advertise-address=172.17.0.32
    - --allow-privileged=true
    - --client-ca-file=/etc/kubernetes/pki/ca.crt
    - --disable-admission-plugins=PersistentVolumeLabel
    - --enable-admission-plugins=NodeRestriction
    - --enable-bootstrap-token-auth=true
    - --etcd-cafile=/etc/kubernetes/pki/etcd/ca.crt
    - --etcd-certfile=/etc/kubernetes/pki/apiserver-etcd-client.crt
    - --etcd-keyfile=/etc/kubernetes/pki/apiserver-etcd-client.key
    - --etcd-servers=https://127.0.0.1:2379
    - --insecure-port=0
    - --kubelet-client-certificate=/etc/kubernetes/pki/apiserver-kubelet-client.crt
    - --kubelet-client-key=/etc/kubernetes/pki/apiserver-kubelet-client.key
    - --kubelet-preferred-address-types=InternalIP,ExternalIP,Hostname
    - --proxy-client-cert-file=/etc/kubernetes/pki/front-proxy-client.crt
    - --proxy-client-key-file=/etc/kubernetes/pki/front-proxy-client.key
    - --secure-port=6443
    - --service-account-key-file=/etc/kubernetes/pki/sa.pub
    - --service-cluster-ip-range=10.96.0.0/12
    - --tls-cert-file=/etc/kubernetes/pki/apiserver.crt
    - --tls-private-key-file=/etc/kubernetes/pki/apiserver.key
```

- To view the details of the certificate
- `$ openssl x509 -in /etc/kubernetes/pki/apiserver.crt -text -noout`

/etc/kubernetes/pki/apiserver.crt

```
openssl x509 -in /etc/kubernetes/pki/apiserver.crt -text -noout
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number: 3147495682089747350 (0x2bae26a58f090396)
    Signature Algorithm: sha256WithRSAEncryption
        Issuer: CN=kubernetes
        Validity
            Not Before: Feb 11 05:39:19 2019 GMT
            Not After : Feb 11 05:39:20 2020 GMT
        Subject: CN=kube-apiserver
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:d9:69:38:80:68:3b:b7:2e:9e:25:00:e8:fd:01:

                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Key Usage: critical
                Digital Signature, Key Encipherment
            X509v3 Extended Key Usage:
                TLS Web Server Authentication
            X509v3 Subject Alternative Name:
                DNS:master, DNS:kubernetes, DNS:kubernetes.default,
DNS:kubernetes.default.svc, DNS:kubernetes.default.svc.cluster.local, IP
Address:10.96.0.1, IP Address:172.17.0.27
```

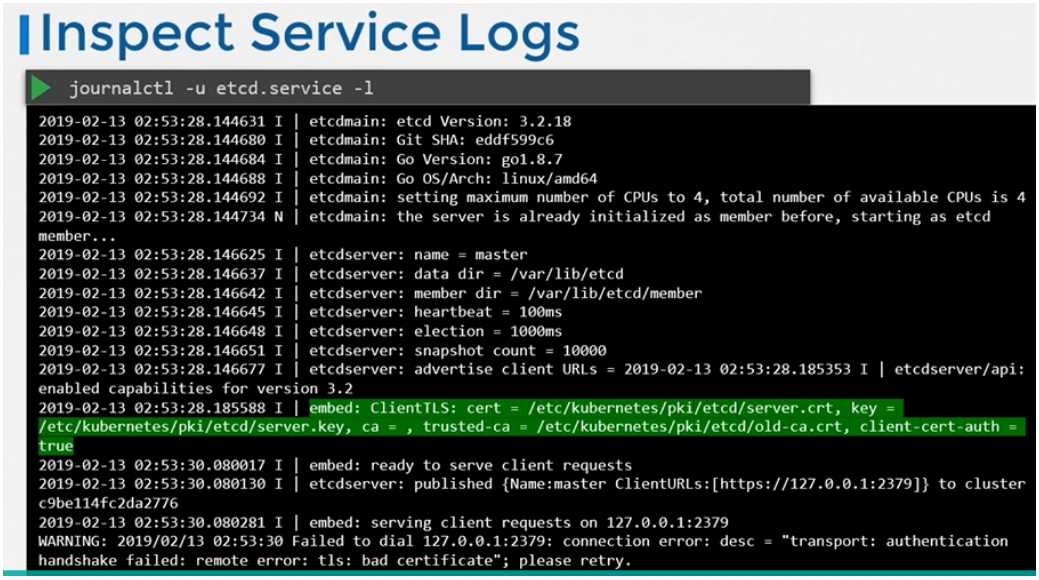
Follow the same procedure to identify information about of all the other certificates

kubeadm

Certificate Path	CN Name	ALT Names	Organization	Issuer	Expiration
/etc/kubernetes/pki/apiserver.crt	kube-apiserver	DNS:master DNS:kubernetes DNS:kubernetes.default DNS:kubernetes.default.svc IP Address:10.96.0.1 IP Address:172.17.0.27		kubernetes	Feb 11 05:39:20 2020
/etc/kubernetes/pki/apiserver.key					
/etc/kubernetes/pki/ca.crt	kubernetes			kubernetes	Feb 8 05:39:19 2029
/etc/kubernetes/pki/apiserver-kubelet-client.crt	kube-apiserver-kubelet-client		system:masters	kubernetes	Feb 11 05:39:20 2020
/etc/kubernetes/pki/apiserver-kubelet-client.key					
/etc/kubernetes/pki/apiserver-etcd-client.crt	kube-apiserver-etcd-client		system:masters	self	Feb 11 05:39:22 2020
/etc/kubernetes/pki/apiserver-etcd-client.key					
/etc/kubernetes/pki/etcd/ca.crt	kubernetes			kubernetes	Feb 8 05:39:21 2017

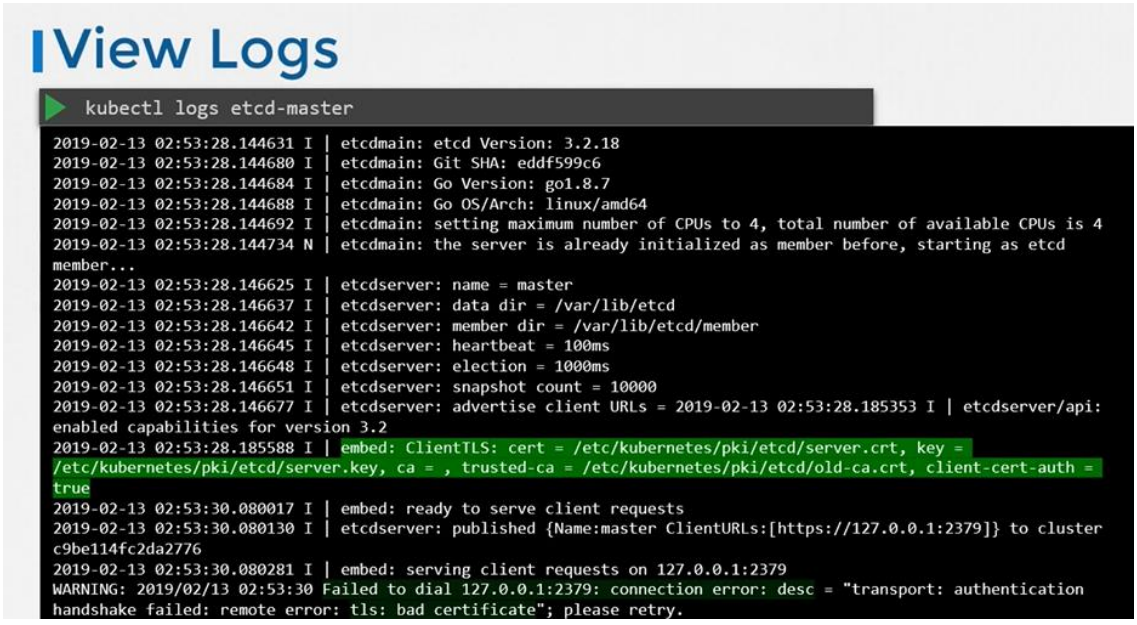
Inspect Server Logs - Hardware setup

- Inspect server logs using journalctl
- `$ journalctl -u etcd.service -l`



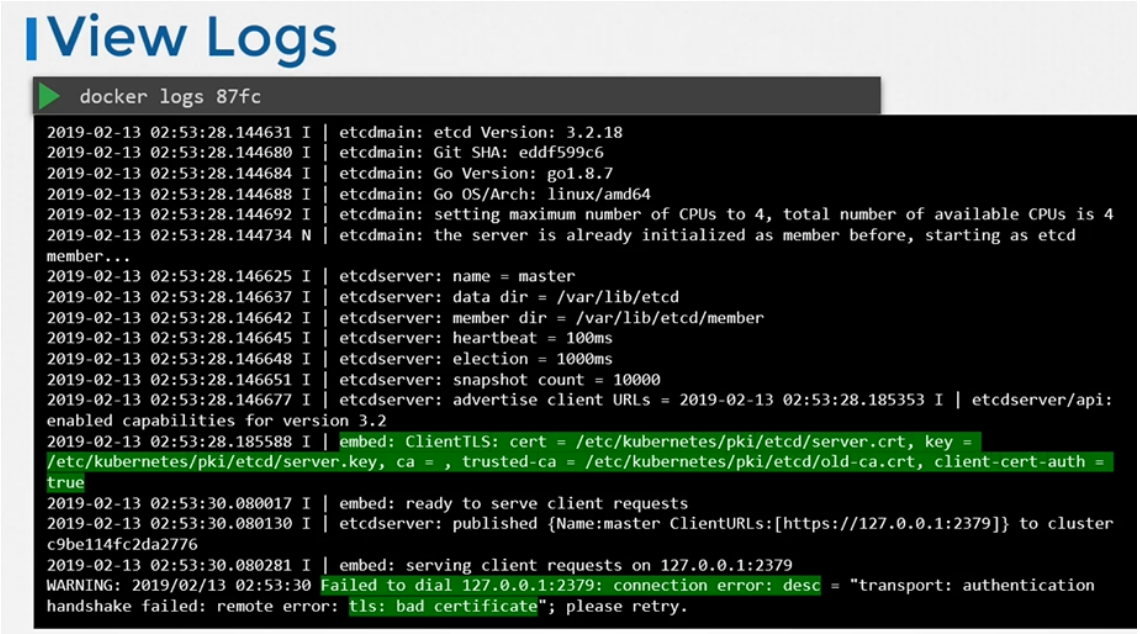
Inspect Server Logs - kubeadm setup

- View logs using kubectl
- `$ kubectl logs etcd-master`



- View logs using docker ps and docker logs

- `$ docker ps -a`
- `$ docker logs <container-id>`



K8s Reference Docs

- https://kubernetes.io/docs/setup/best-practices/certificates/#certificate-paths

Certificate API

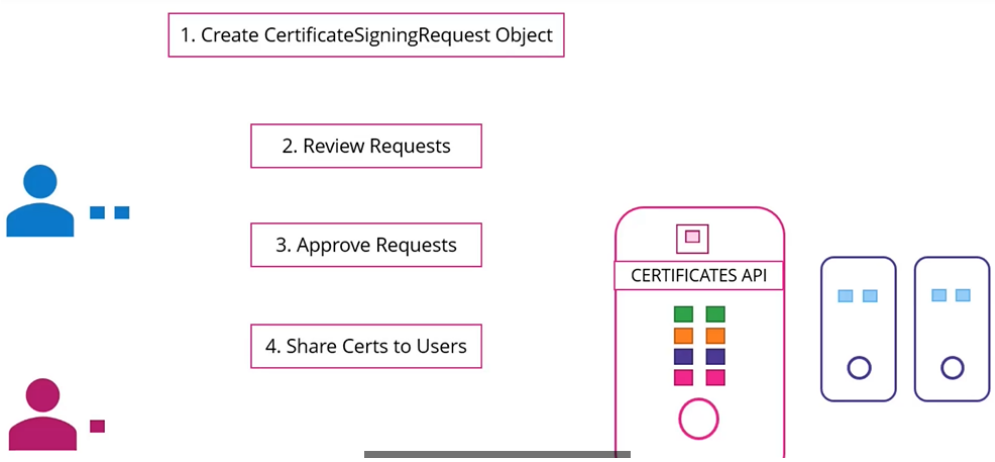
In this section, we will take a look at how to manage certificates and certificate API's in kubernetes

CA (Certificate Authority)

- The CA is really just the pair of key and certificate files that we have generated, whoever gains access to these pair of files can sign any certificate for the kubernetes environment.

Kubernetes has a built-in certificates API that can do this for you.

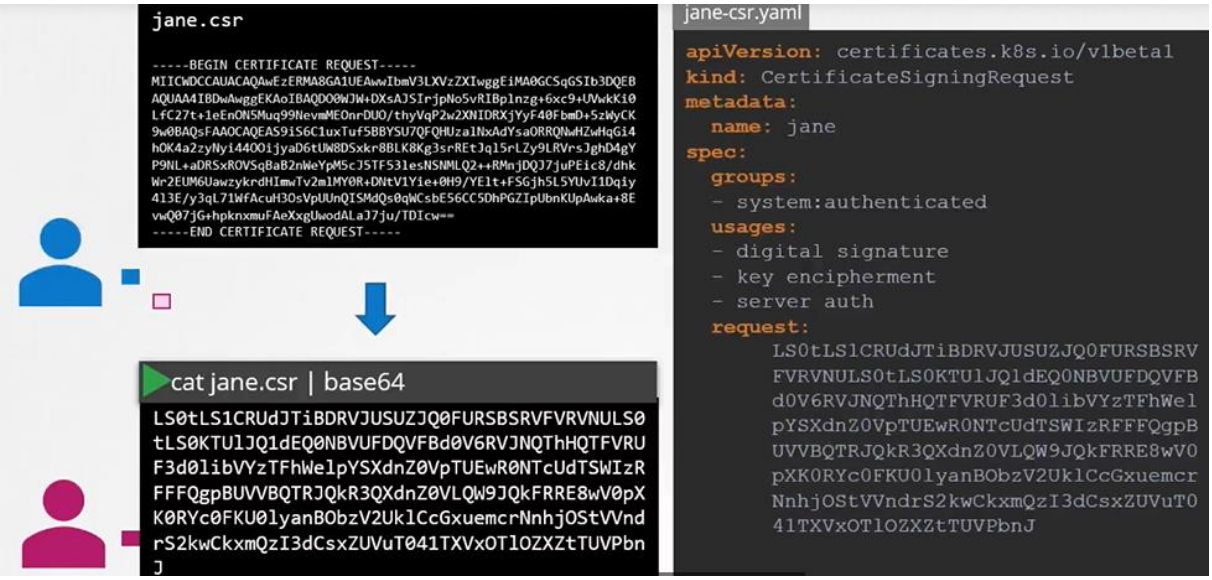
- With the certificate API, we now send a certificate signing request (CSR) directly to kubernetes through an API call.



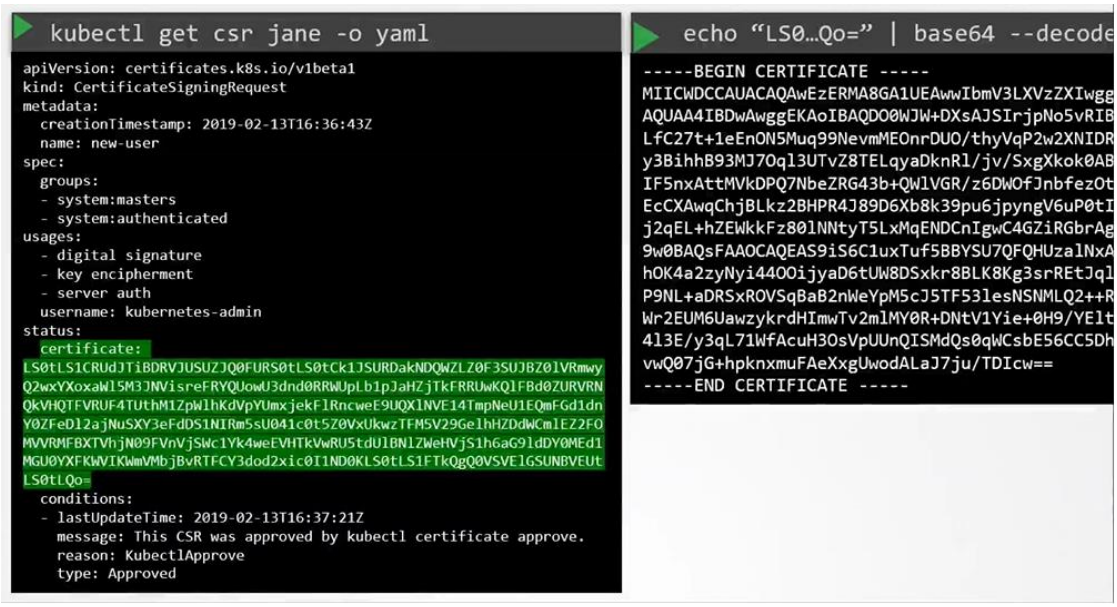
This certificate can then be extracted and shared with the user.

- A user first creates a key
- `$ openssl genrsa -out jane.key 2048`
- Generates a CSR
- `$ openssl req -new -key jane.key -subj "/CN=jane" -out jane.csr`
- Sends the request to the administrator and the adminsitrator takes the key and creates a CSR object, with kind as "CertificateSigningRequest" and a encoded "jane.csr"
- `apiVersion: certificates.k8s.io/v1beta1`
- `kind: CertificateSigningRequest`
- `metadata:`
- `  name: jane`
- `spec:`
- `  groups:`
- `  - system:authenticated`
- `  usages:`
- `  - digital signature`
- `  - key encipherment`
- `  - server auth`
- `  request:`
- `    <certificate-goes-here>`

$ cat jane.csr |base64 $ kubectl create -f jane.yaml



- To list the csr's
- `$ kubectl get csr`
- Approve the request
- `$ kubectl certificate approve jane`
- To view the certificate
- `$ kubectl get csr jane -o yaml`
- To decode it
- `$ echo "<certificate>" |base64 --decode`



All the certificate releated operations are carried out by the controller manager.

- If anyone has to sign the certificates they need the CA Servers, route certificate and private key. The controller manager configuration has two options where you can specify this.


```
cat /etc/kubernetes/manifests/kube-controller-manager.yaml
spec:
  containers:
  - command:
    - kube-controller-manager
    - --address=127.0.0.1
    - --cluster-signing-cert-file=/etc/kubernetes/pki/ca.crt
    - --cluster-signing-key-file=/etc/kubernetes/pki/ca.key
    - --controllers=*,bootstrapsigner,tokencleaner
    - --kubeconfig=/etc/kubernetes/controller-manager.conf
    - --leader-elect=true
    - --root-ca-file=/etc/kubernetes/pki/ca.crt
    - --service-account-private-key-file=/etc/kubernetes/pki/sa.key
    - --use-service-account-credentials=true
```

K8s Reference Docs

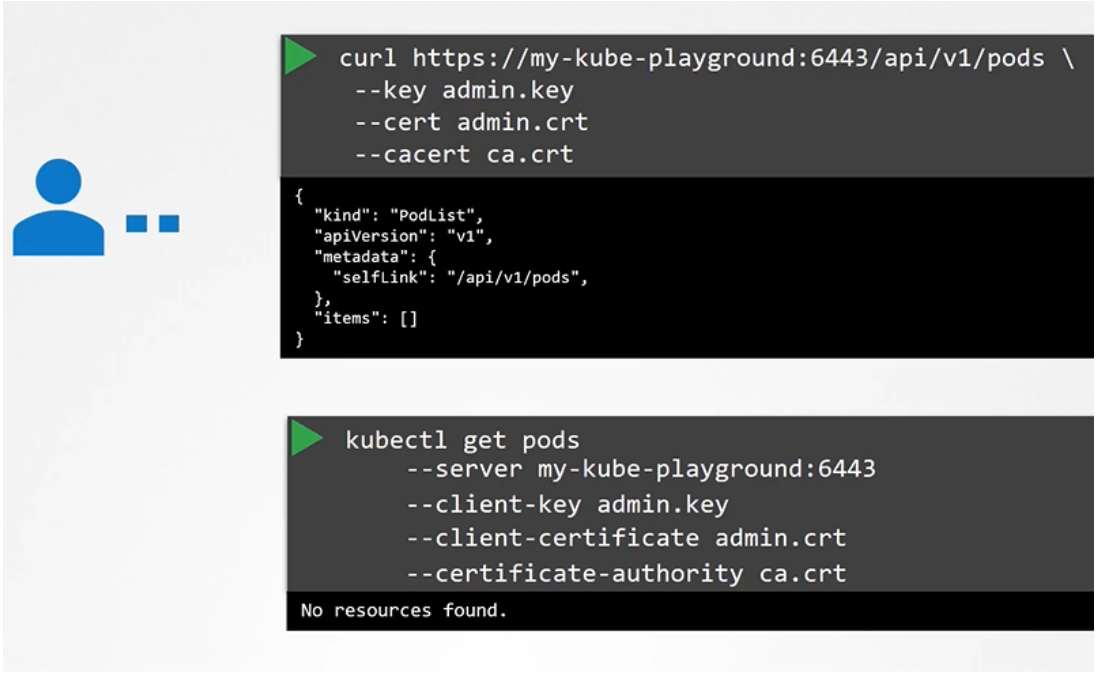
- https://kubernetes.io/docs/reference/access-authn-authz/certificate-signing-requests/
- https://kubernetes.io/docs/tasks/tls/managing-tls-in-a-cluster/

KubeConfig

In this section, we will take a look at kubeconfig in kubernetes

Client uses the certificate file and key to query the kubernetes Rest API for a list of pods using curl.

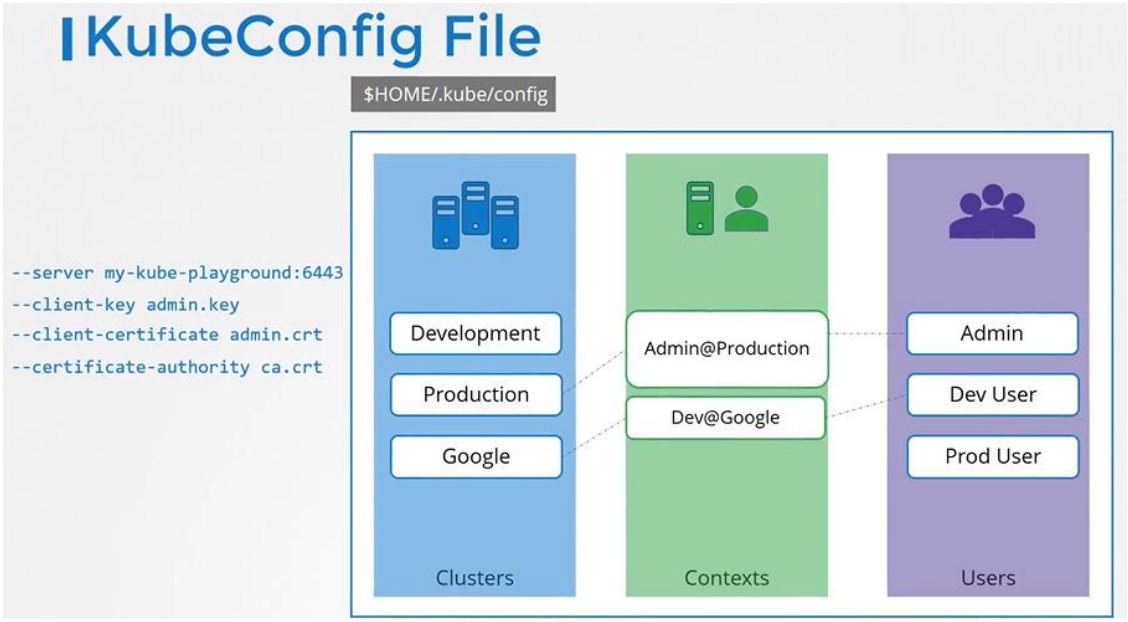
- You can specify the same using kubectl

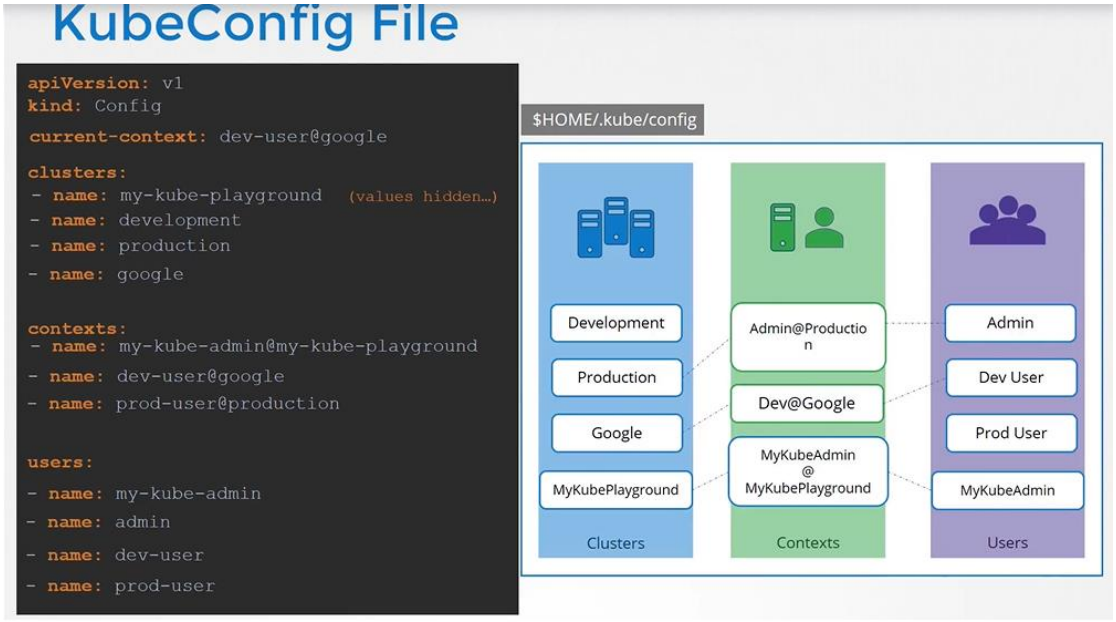


- We can move these information to a configuration file called kubeconfig. And the specify this file as the kubeconfig option in the command.
- `$ kubectl get pods --kubeconfig config`

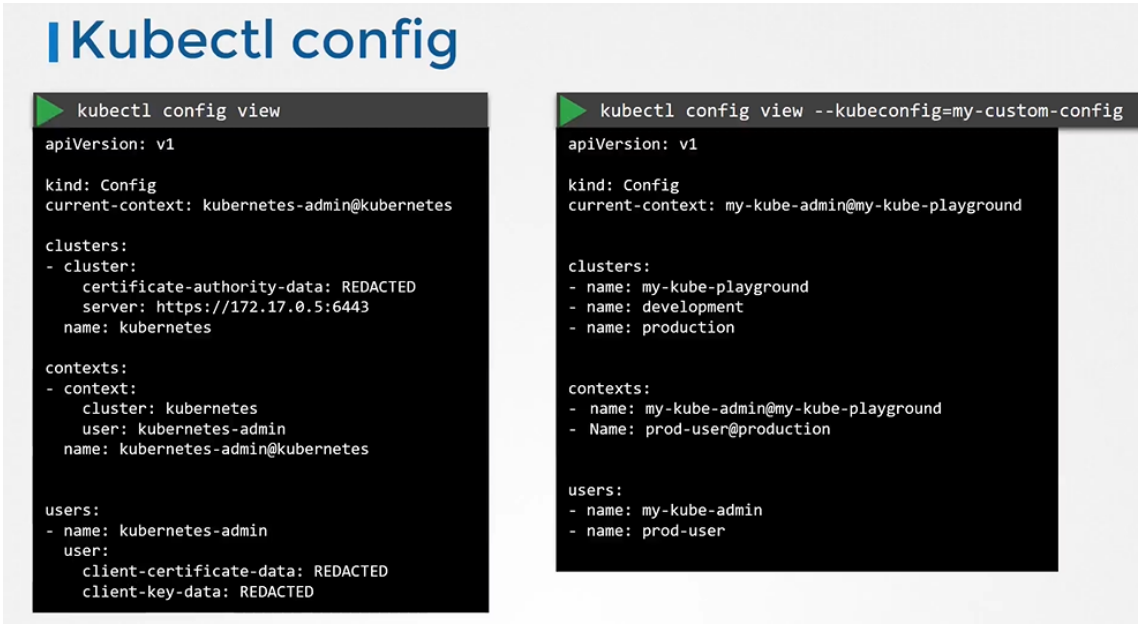
Kubeconfig File

- The kubeconfig file has 3 sections
    - Clusters
    - Contexts
    - USers

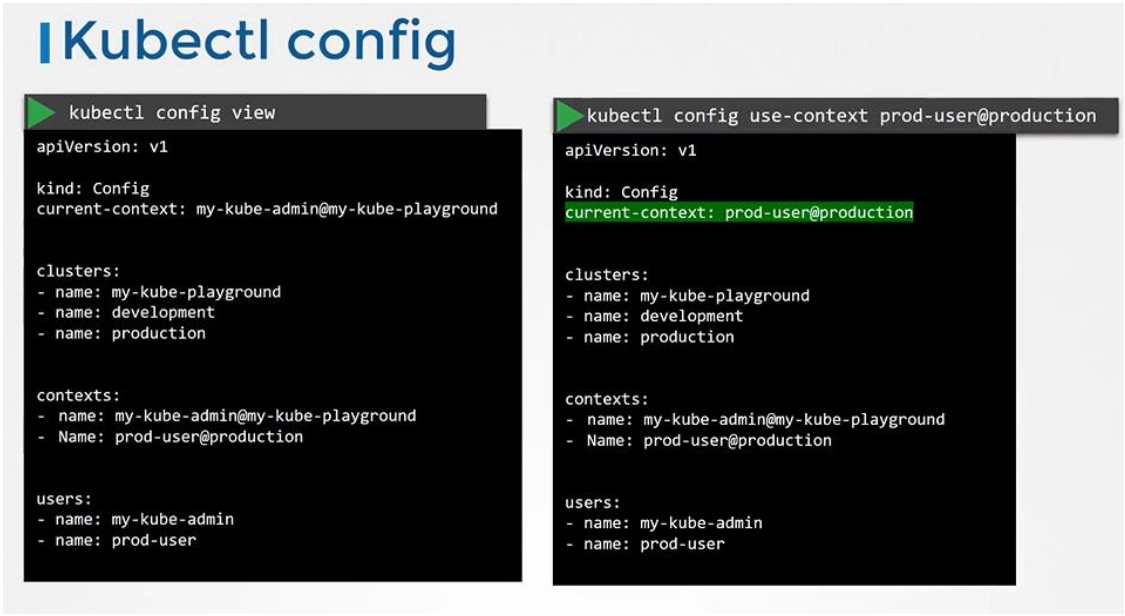




- To view the current file being used
- `$ kubectl config view`
- You can specify the kubeconfig file with kubectl config view with "--kubeconfig" flag
- `$ kubectl config veiw --kubeconfig=my-custom-config`



- How do you update your current context? Or change the current context
- `$ kubectl config view --kubeconfig=my-custom-config`



- kubectl config help
- `$ kubectl config -h`

Kubectl config

```
kubectl config -h
```

```
Available Commands:
  current-context Displays the current-context
  delete-cluster  Delete the specified cluster from the kubeconfig
  delete-context  Delete the specified context from the kubeconfig
  get-clusters    Display clusters defined in the kubeconfig
  get-contexts    Describe one or many contexts
  rename-context  Renames a context from the kubeconfig file.
  set             Sets an individual value in a kubeconfig file
  set-cluster     Sets a cluster entry in kubeconfig
  set-context     Sets a context entry in kubeconfig
  set-credentials Sets a user entry in kubeconfig
  unset           Unsets an individual value in a kubeconfig file
  use-context     Sets the current-context in a kubeconfig file
  view            Display merged kubeconfig settings or a specified kubeconfig file
```

What about namespaces?

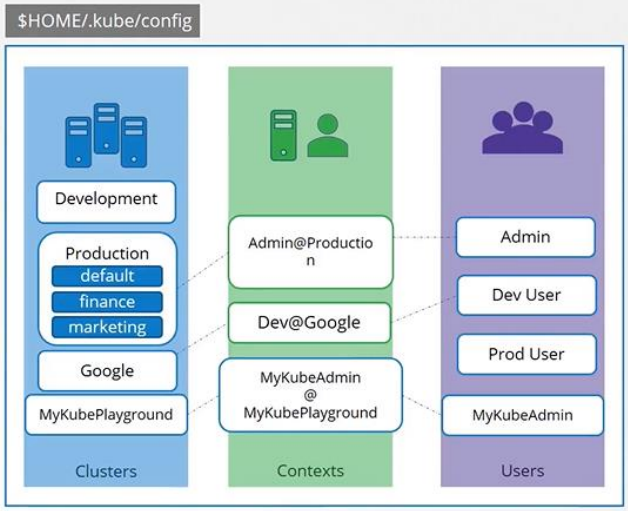
Namespaces

```
apiVersion: v1
kind: Config

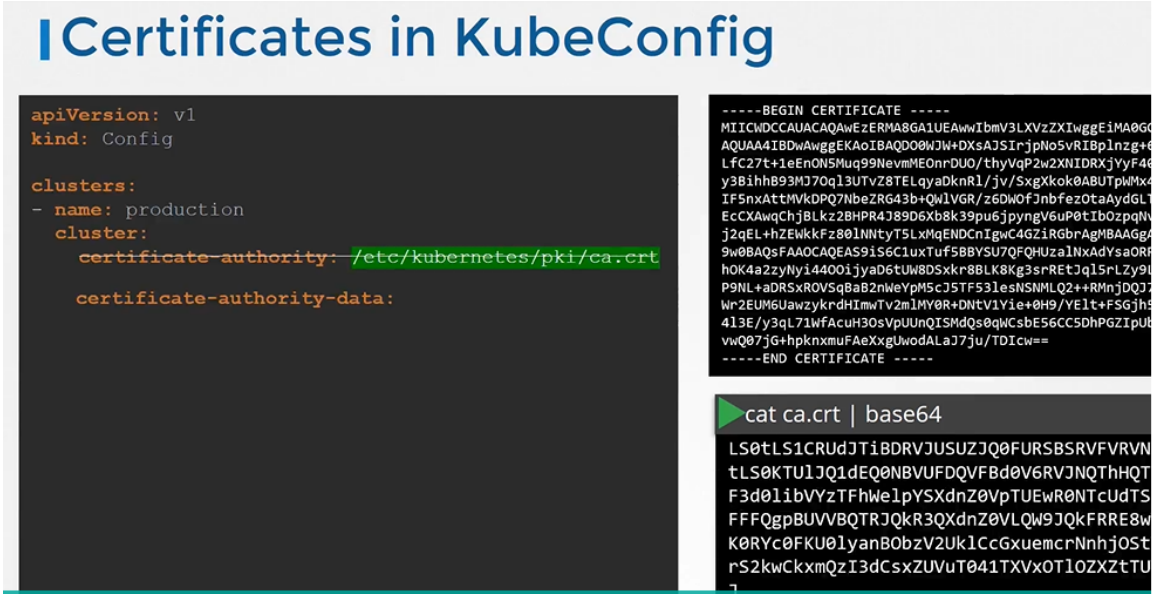
clusters:
- name: production
  cluster:
    certificate-authority: ca.crt
    server: https://172.17.0.51:6443

contexts:
- name: admin@production
  context:
    cluster: production
    user: admin
    namespace: finance

users:
- name: admin
  user:
    client-certificate: admin.crt
    client-key: admin.key
```



Certificates in kubeconfig



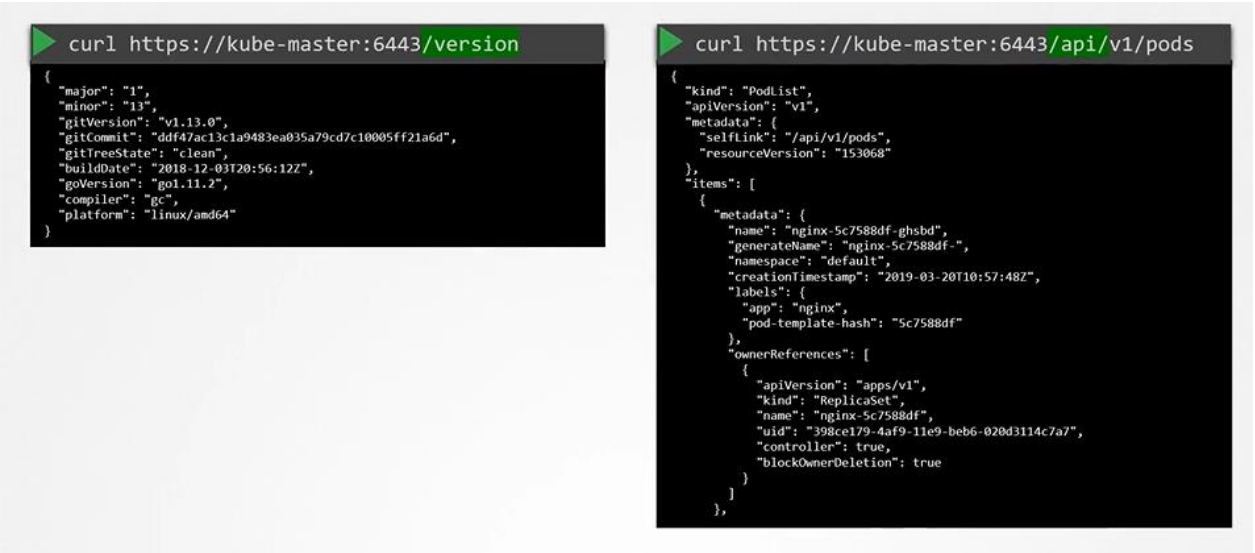
K8s Reference Docs

- https://kubernetes.io/docs/tasks/access-application-cluster/configure-access-multiple-clusters/
- https://kubernetes.io/docs/reference/generated/kubectl/kubectl-commands#config

API Groups

In this section, we will take a look at API Groups in kubernetes

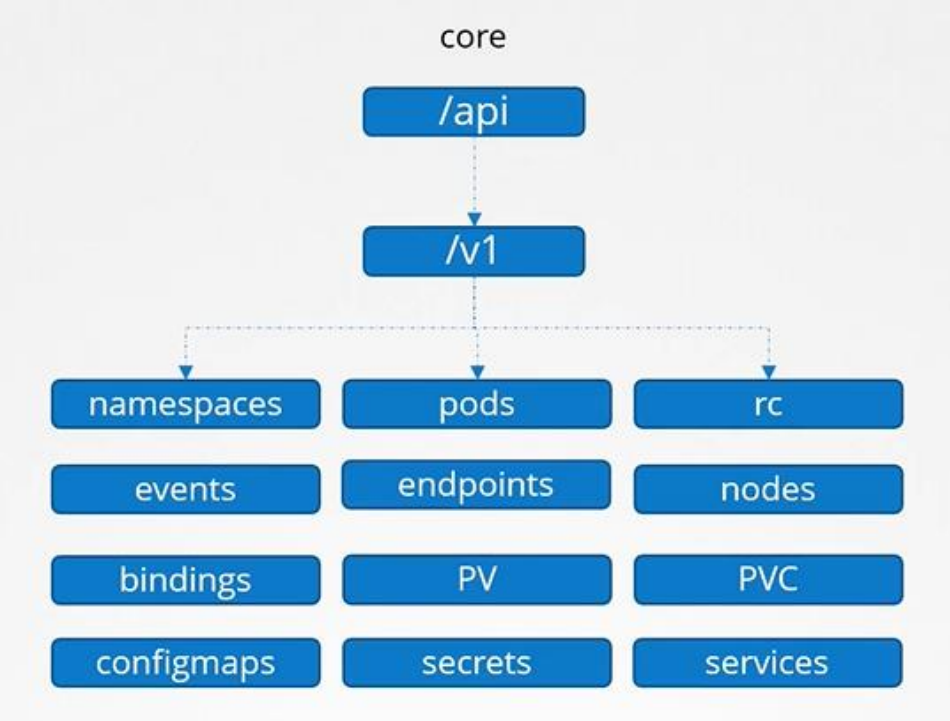
To return version and list pods via API's



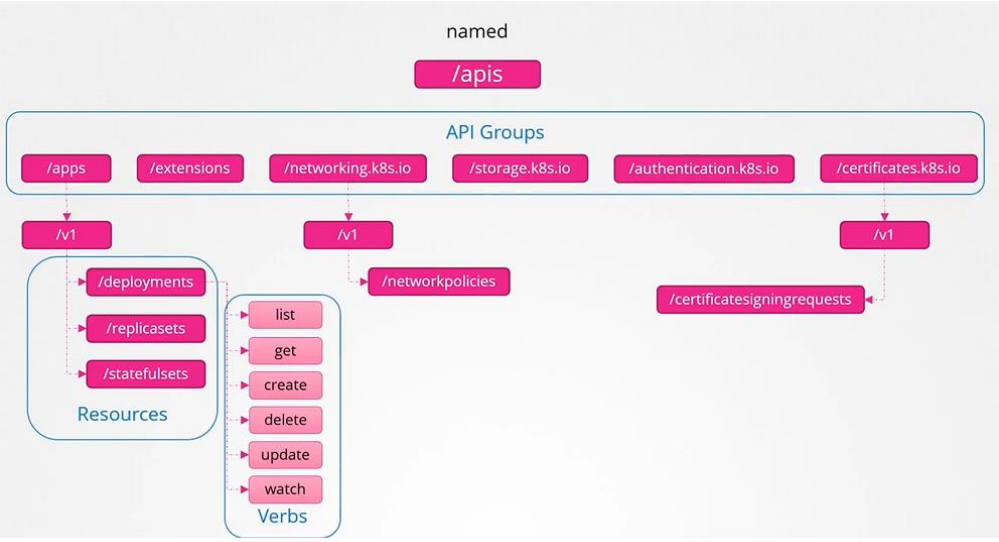
- The kubernetes API is grouped into multiple such groups based on thier purpose. Such as one for **`APIs`**, one for **`healthz`**, **`metrics`** and **`logs`** etc.

API and APIs

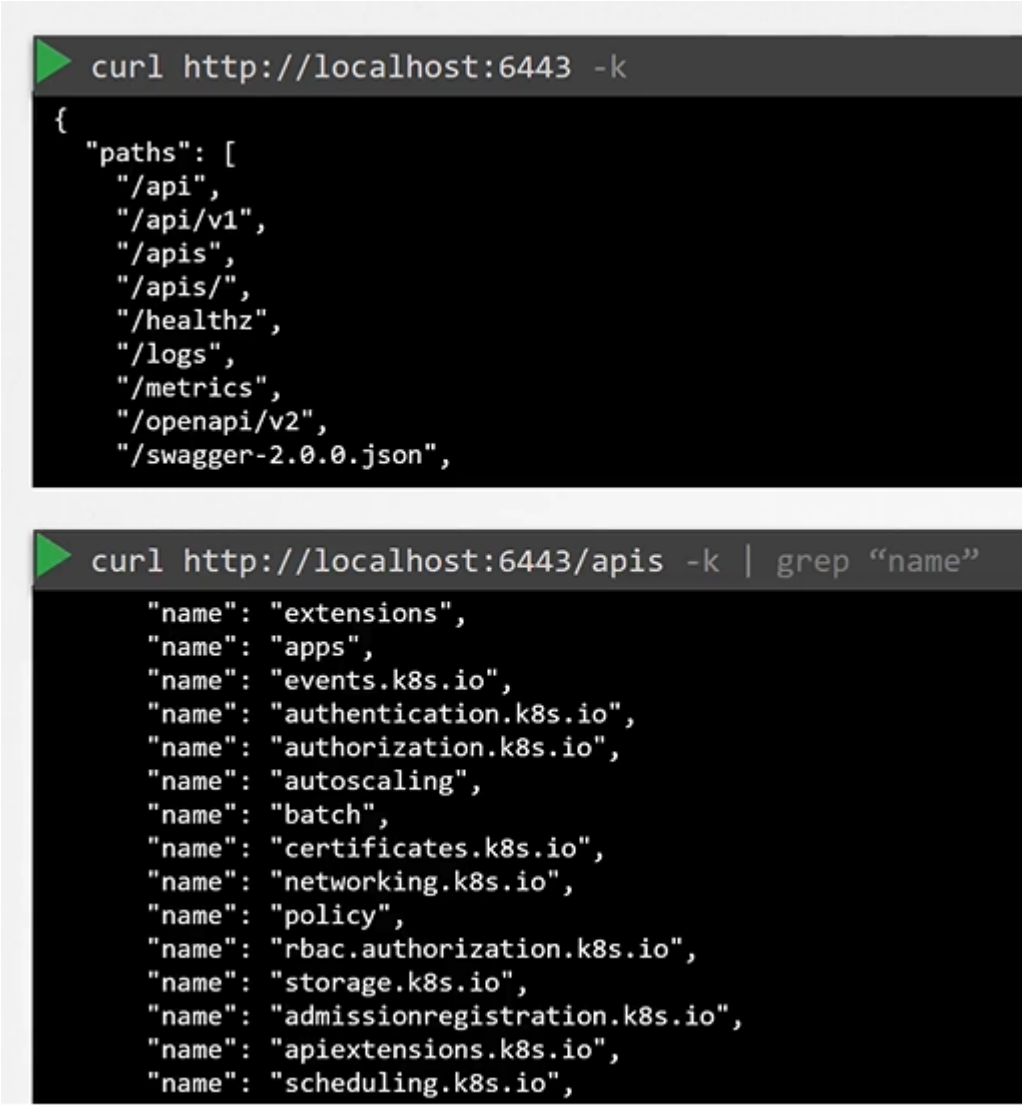
- These APIs are catagorized into two.
    - The core group - Where all the functionality exists



    - The Named group - More organized and going forward all the newer features are going to be made available to these named groups.

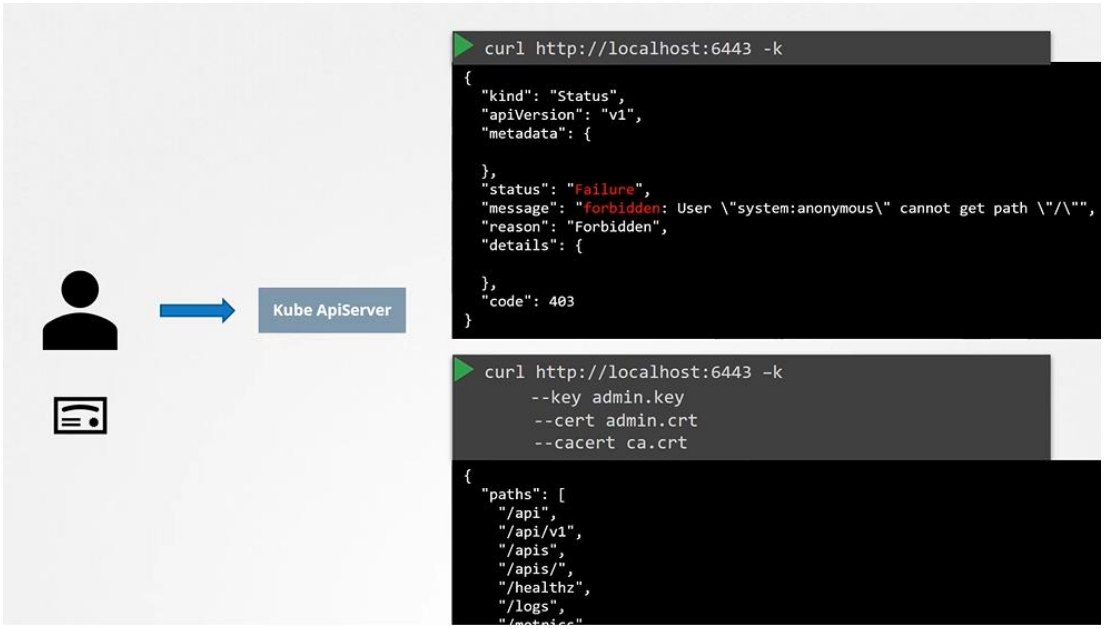


- To list all the api groups

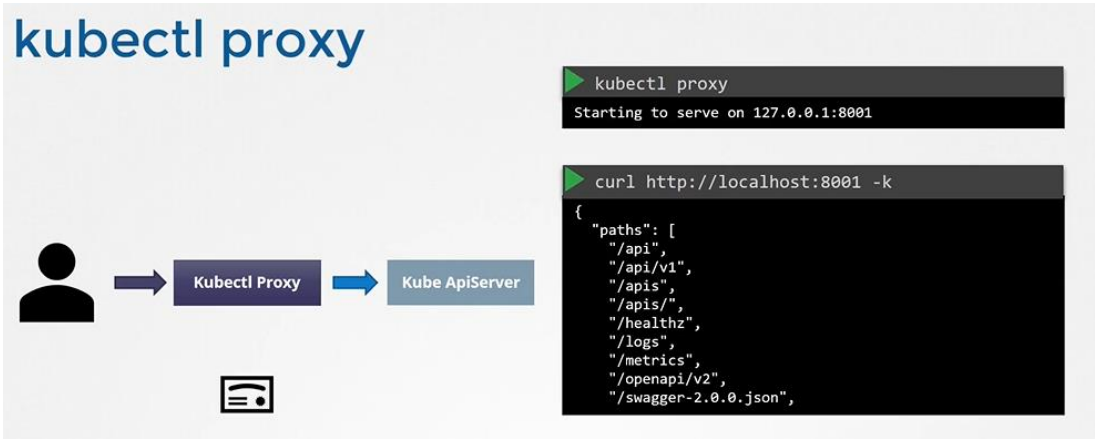


Note on accessing the kube-apiserver

- You have to authenticate by passing the certificate files.

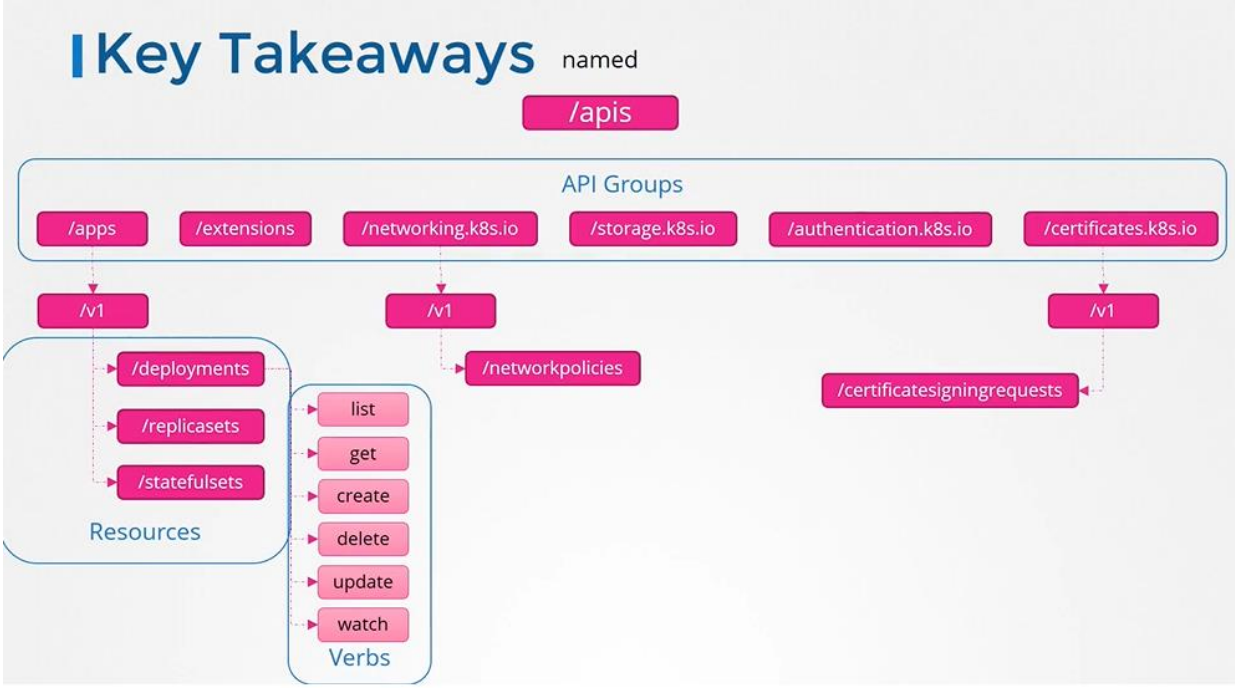


- An alternate is to start a **kubeproxy** client



kube proxy vs kubectl proxy

Key Takeaways



K8s Reference Docs

- https://kubernetes.io/docs/concepts/overview/kubernetes-api/
- https://kubernetes.io/docs/reference/using-api/api-concepts/
- https://kubernetes.io/docs/tasks/extend-kubernetes/http-proxy-access-api/

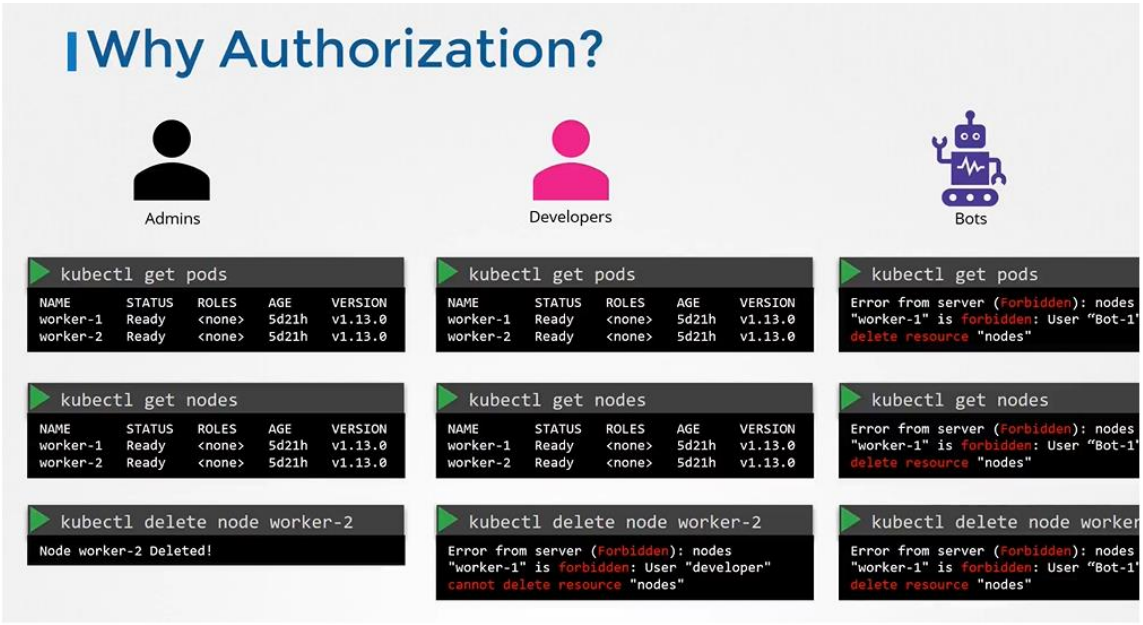
Authorization

In this section, we will take a look at authorization in kubernetes

Why do you need Authorization in your cluster?

- As an admin, you can do all operations

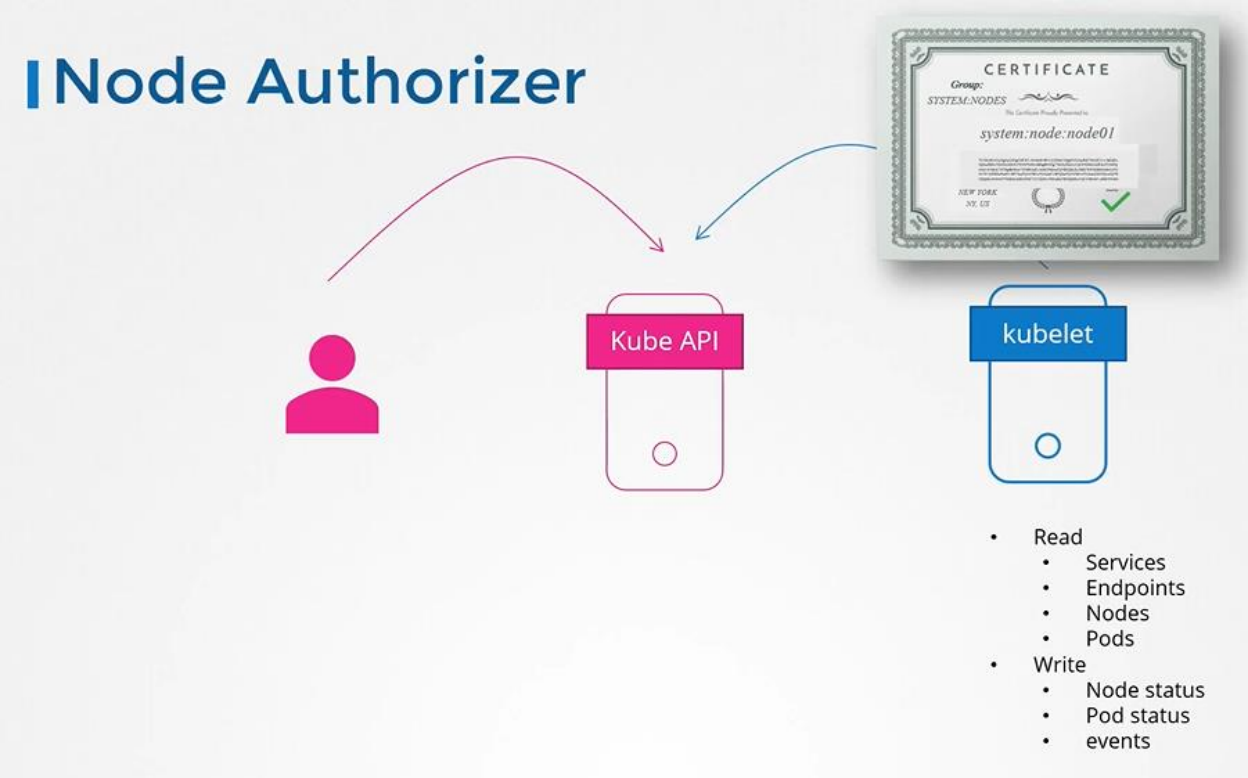
- `$ kubectl get nodes`
- `$ kubectl get pods`
- `$ kubectl delete node worker-2`



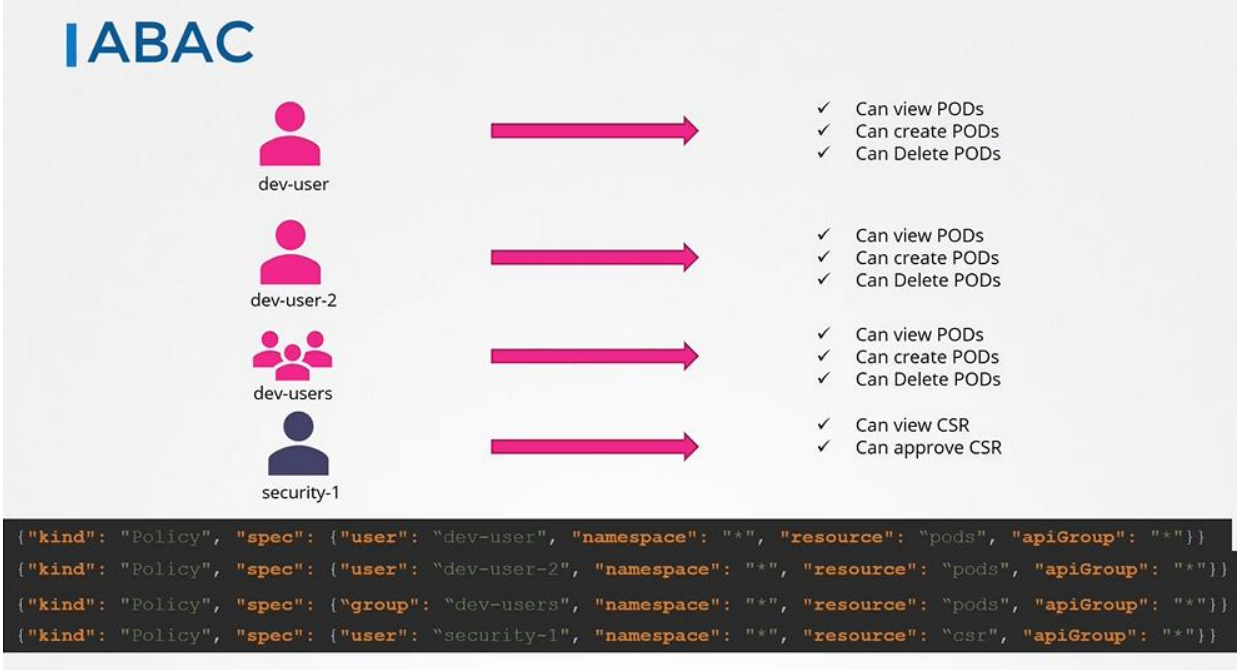
Authorization Mechanisms

- There are different authorization mechanisms supported by kubernetes
  - Node Authorization
  - Attribute-based Authorization (ABAC)
  - Role-Based Authorization (RBAC)
  - Webhook

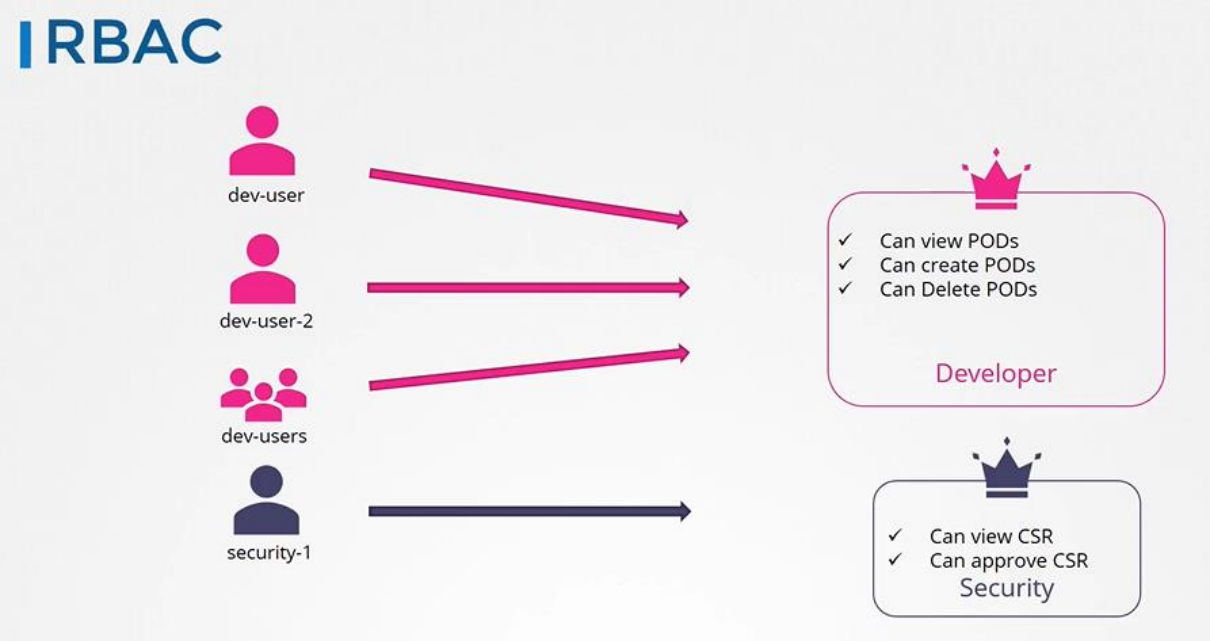
Node Authorization



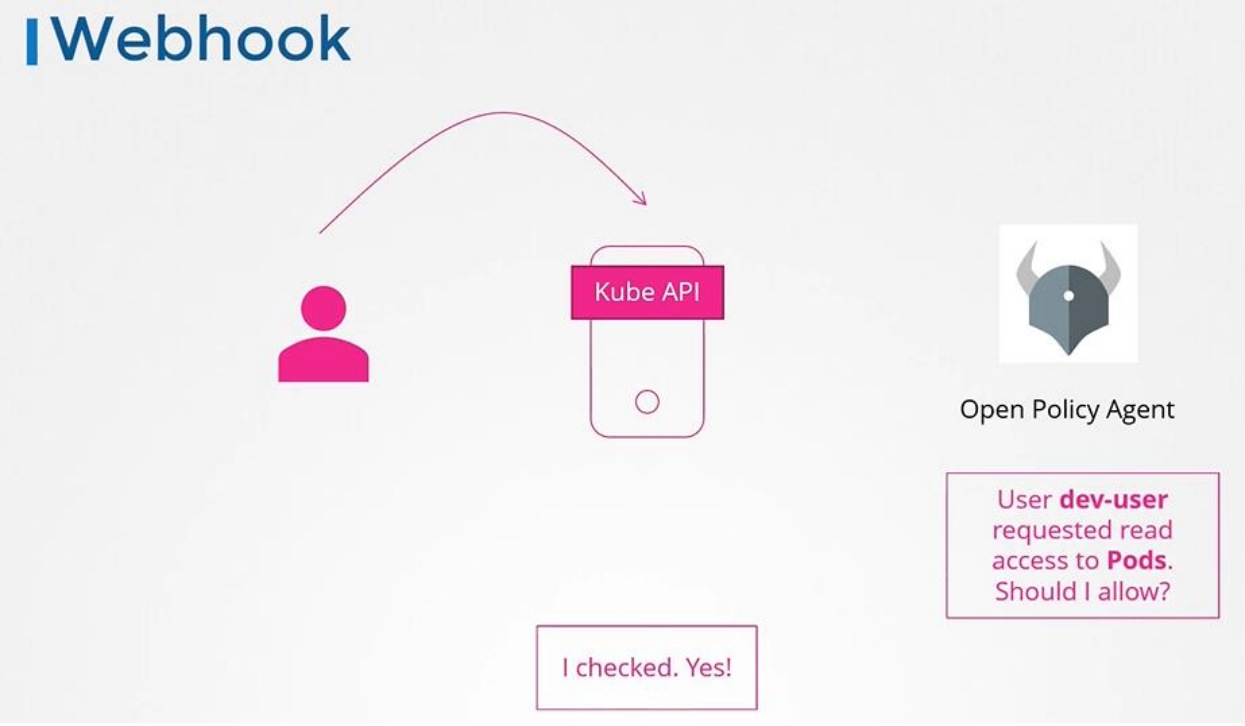
ABAC



RBAC

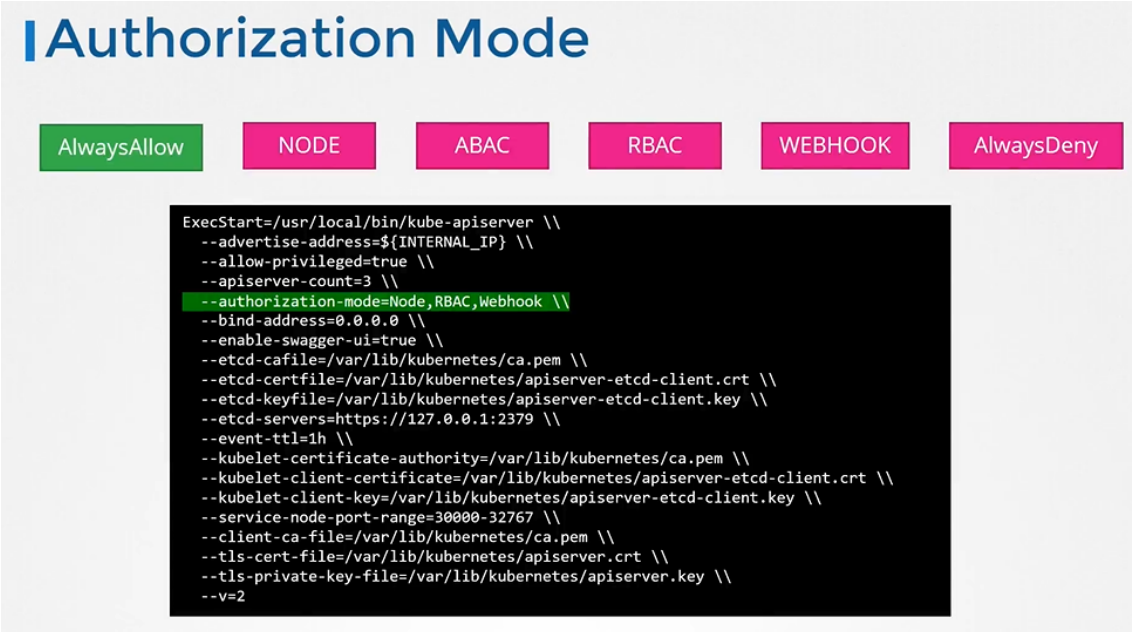


Webhook



Authorization Modes

- The mode options can be defined on the kube-apiserver



- When you specify multiple modes, it will authorize in the order in which it is specified

K8s Reference Docs

- https://kubernetes.io/docs/reference/access-authn-authz/authorization/

RBAC

In this section, we will take a look at RBAC

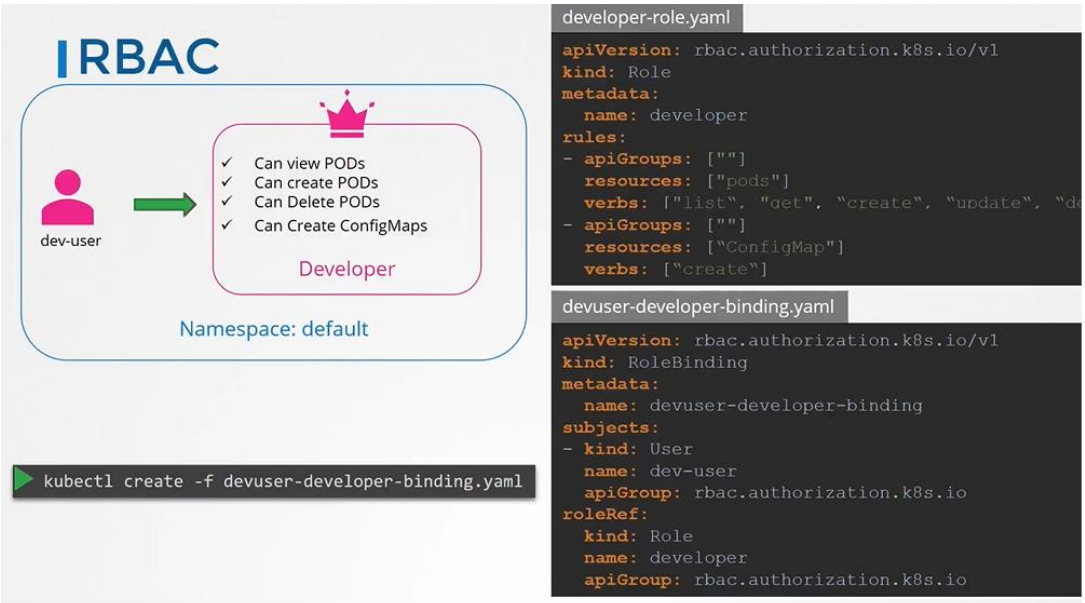
How do we create a role?

- Each role has 3 sections
  - apiGroups
  - resources
  - verbs
- create the role with kubectl command
- `$ kubectl create -f developer-role.yaml`

The next step is to link the user to that role.

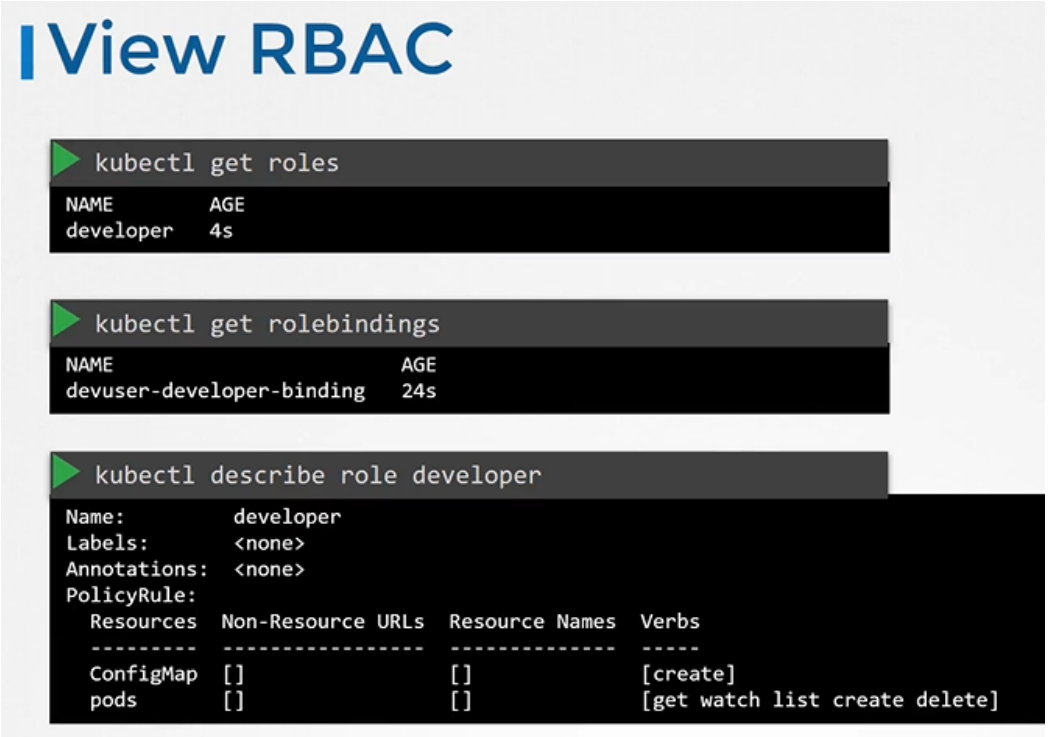
- For this we create another object called **`RoleBinding`**. This role binding object links a user object to a role.
- create the role binding using kubectl command
- `$ kubectl create -f devuser-developer-binding.yaml`
- Also note that the roles and role bindings fall under the scope of namespace.

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: developer
rules:
- apiGroups: [""] # "" indicates the core API group
  resources: ["pods"]
  verbs: ["get", "list", "update", "delete", "create"]
- apiGroups: [""]
  resources: ["ConfigMap"]
  verbs: ["create"]
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: devuser-developer-binding
subjects:
- kind: User
  name: dev-user # "name" is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role
  name: developer
  apiGroup: rbac.authorization.k8s.io
```

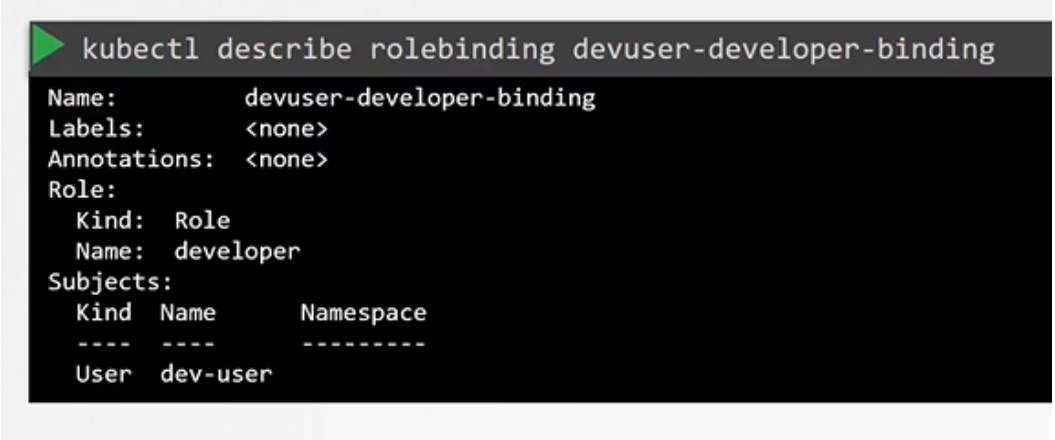


View RBAC

- To list roles
- `$ kubectl get roles`
- To list rolebindings
- `$ kubectl get rolebindings`
- To describe role
- `$ kubectl describe role developer`



- To describe rolebinding
- `$ kubectl describe rolebinding devuser-developer-binding`

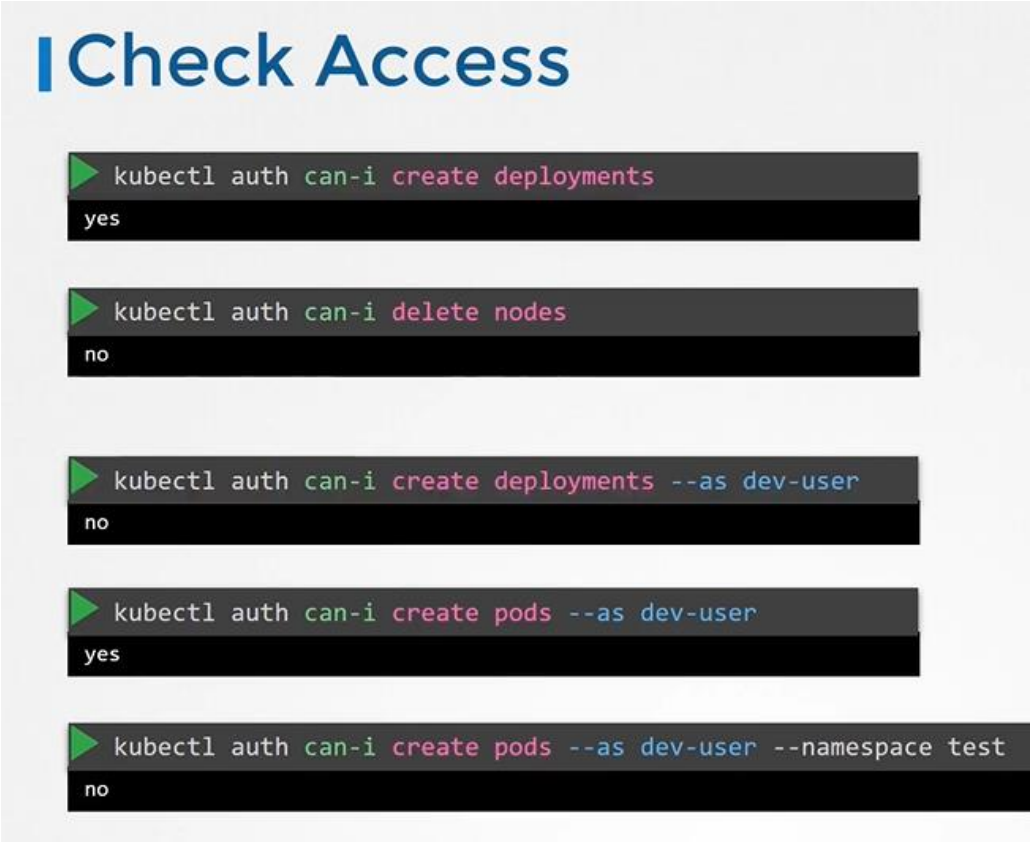


What if you being a user would like to see if you have access to a particular resource in the cluster.

Check Access

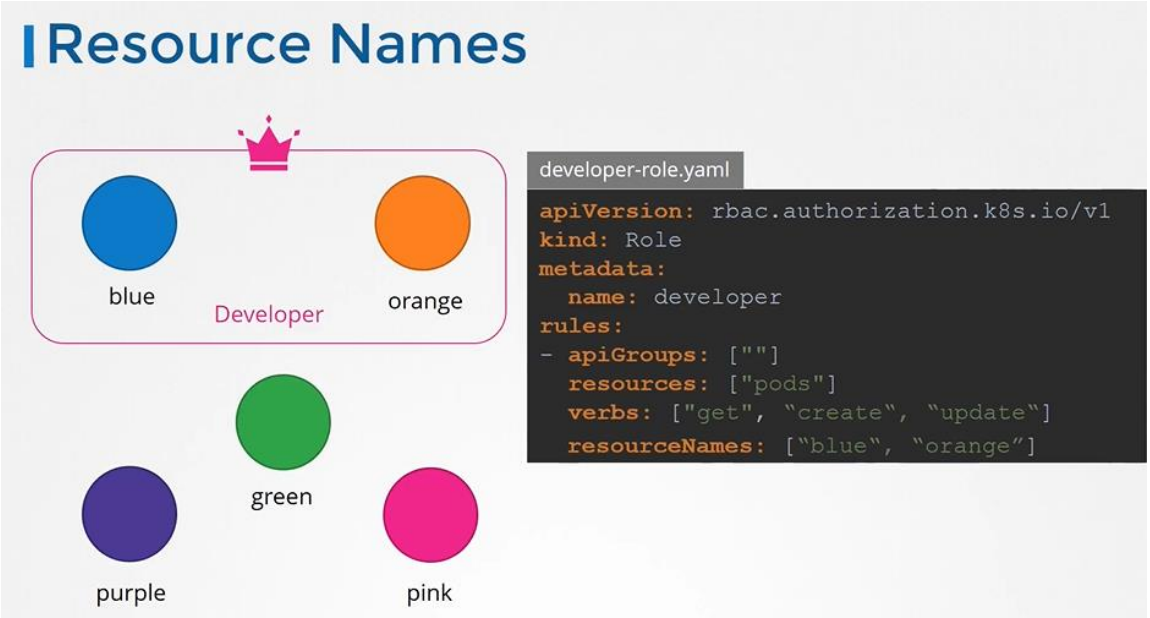
- You can use the kubectl auth command

- `$ kubectl auth can-i create deployments`
- `$ kubectl auth can-i delete nodes`
- `$ kubectl auth can-i create deployments --as dev-user`
- `$ kubectl auth can-i create pods --as dev-user`
- `$ kubectl auth can-i create pods --as dev-user --namespace test`



Resource Names

- Note on resource names we just saw how you can provide access to users for resources like pods within the namespace.
- `apiVersion: rbac.authorization.k8s.io/v1`
- `kind: Role`
- `metadata:`
- `  name: developer`
- `rules:`
- `- apiGroups: [""] # "" indicates the core API group`
- `  resources: ["pods"]`
- `  verbs: ["get", "update", "create"]`
- `  resourceNames: ["blue", "orange"]`



K8s Reference Docs

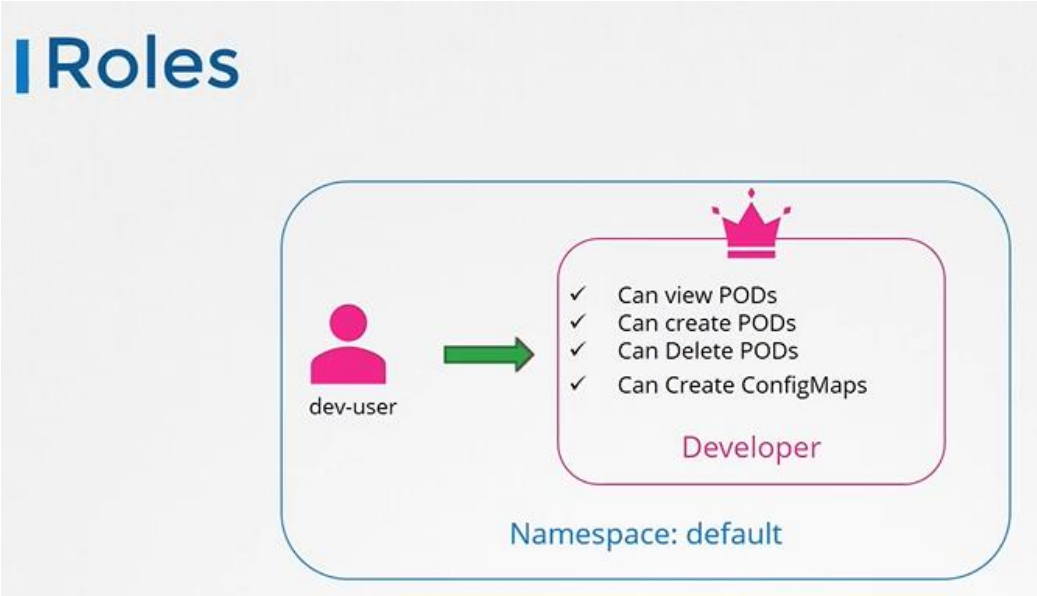
- https://kubernetes.io/docs/reference/access-authn-authz/rbac/
- https://kubernetes.io/docs/reference/access-authn-authz/rbac/#command-line-utilities

Cluster Roles

In this section, we will take a look at cluster roles

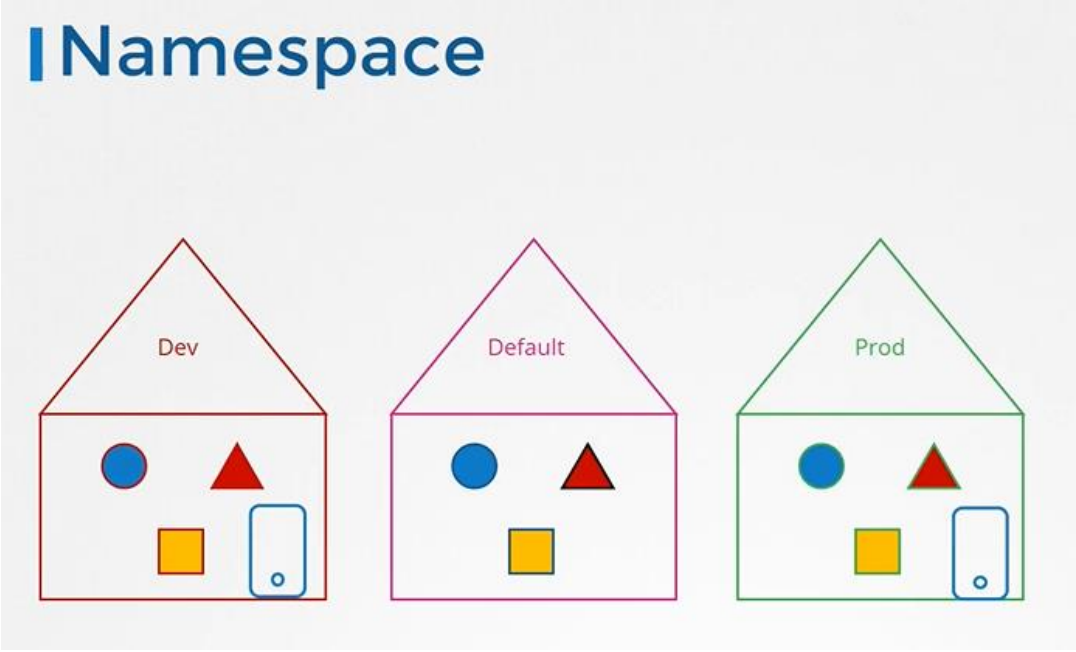
Roles

- Roles and Rolebindings are namespaced meaning they are created within namespaces.



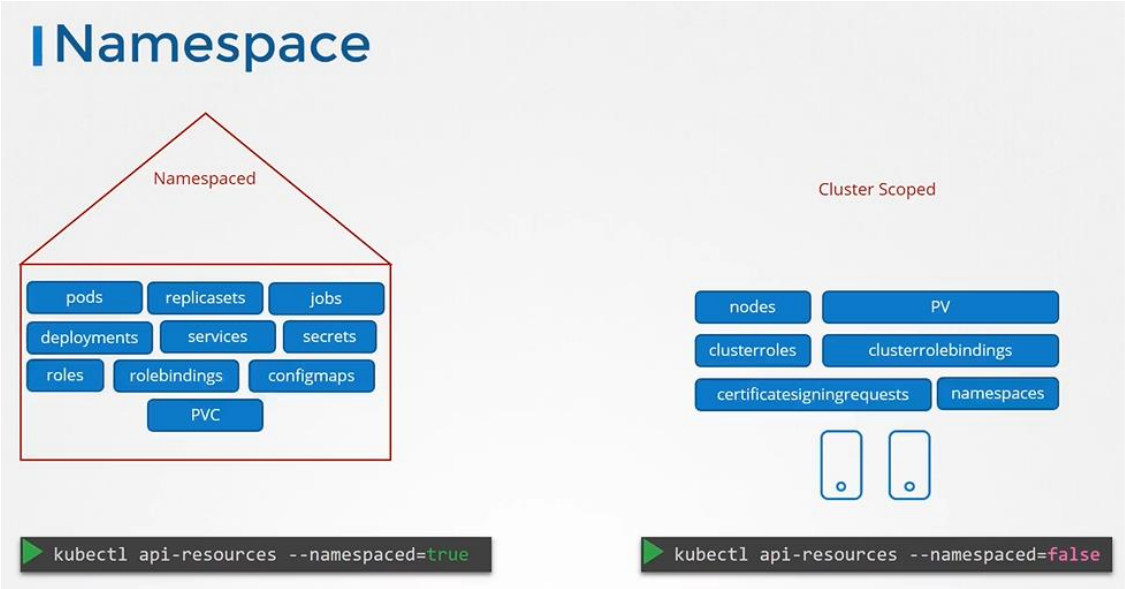
Namespaces

- Can you group or isolate nodes within a namespace?
    - No, those are cluster wide or cluster scoped resources. They cannot be associated to any particular namespace.



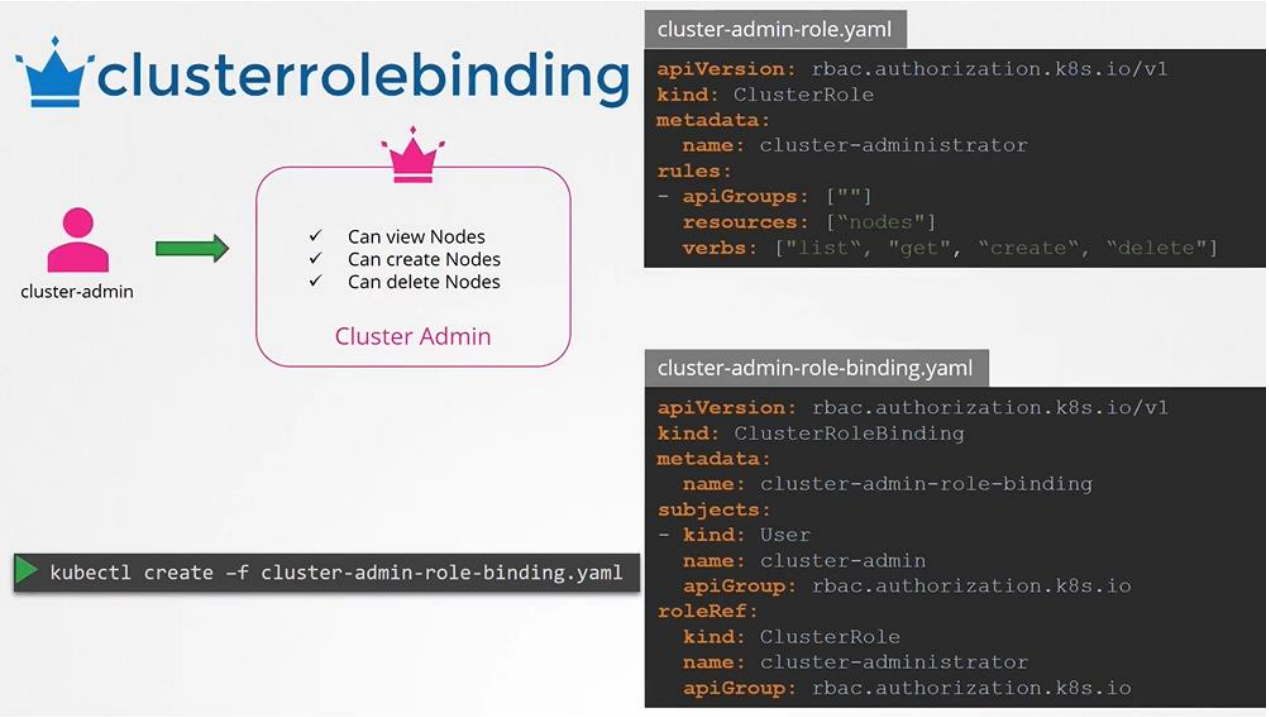
- So the resources are categorized as either namespaced or cluster scoped.
- To see namespaced resources
- `$ kubectl api-resources --namespaced=true`
- To see non-namespaced resources

- `$ $ kubectl api-resources --namespaced=false`



Cluster Roles and Cluster Role Bindings

- Cluster Roles are roles except they are for a cluster scoped resources. Kind as **`CLusterRole`**
- `apiVersion: rbac.authorization.k8s.io/v1`
- `kind: ClusterRole`
- `metadata:`
- `  name: cluster-administrator`
- `rules:`
- `- apiGroups: [""] # "" indicates the core API group`
- `  resources: ["nodes"]`
- `  verbs: ["get", "list", "delete", "create"]`
- `apiVersion: rbac.authorization.k8s.io/v1`
- `kind: ClusterRoleBinding`
- `metadata:`
- `  name: cluster-admin-role-binding`
- `subjects:`
- `- kind: User`
- `  name: cluster-admin`
- `  apiGroup: rbac.authorization.k8s.io`
- `roleRef:`
- `  kind: ClusterRole`
- `  name: cluster-administrator`
- `  apiGroup: rbac.authorization.k8s.io`
- `$ kubectl create -f cluster-admin-role.yaml`
- `$ kubectl create -f cluster-admin-role-binding.yaml`



- You can create a cluster role for namespace resources as well. When you do that user will have access to these resources across all namespaces.

K8s Reference Docs

- https://kubernetes.io/docs/reference/access-authn-authz/rbac/#role-and-clusterrole
- https://kubernetes.io/docs/reference/access-authn-authz/rbac/#command-line-utilities

Image Security

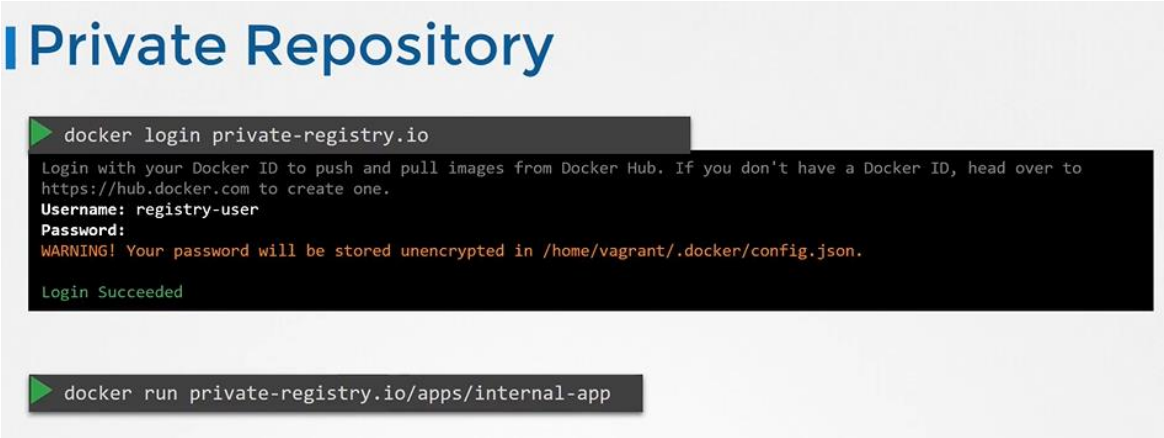
In this section we will take a look at image security

Image

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

Private Registry

- To login to the registry
- `$ docker login private-registry.io`
- Run the application using the image available at the private registry
- `$ docker run private-registry.io/apps/internal-app`

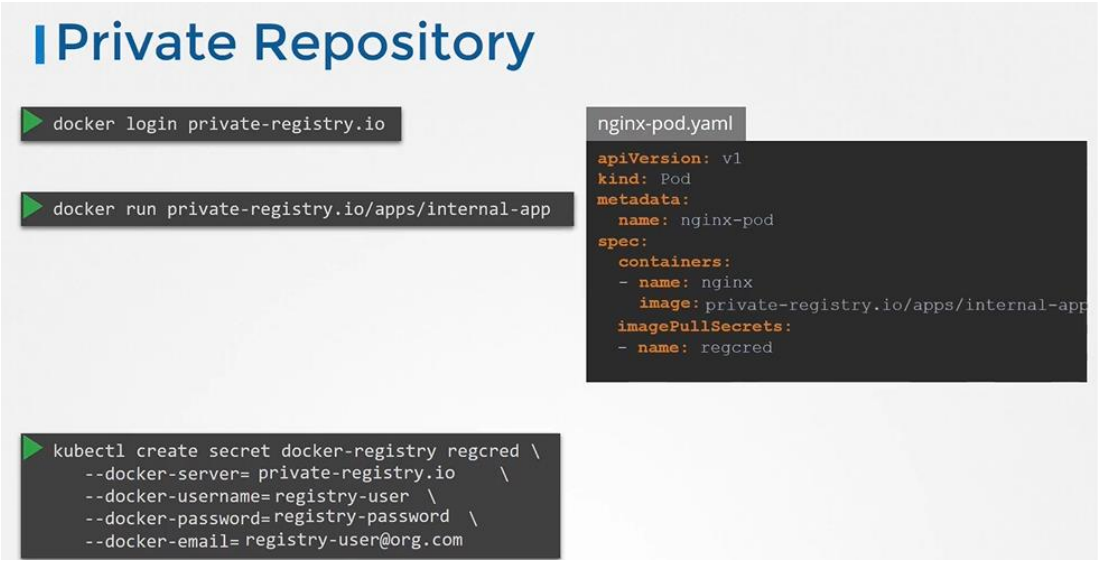


- To pass the credentials to the docker untaged on the worker node for that we first create a secret object with credentials in it.

```
$ kubectl create secret docker-registry regcred \
  --docker-server=private-registry.io \
  --docker-username=registry-user \
  --docker-password=registry-password \
  --docker-email=registry-user@org.com
```

- We then specify the secret inside our pod definition file under the imagePullSecret section

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx-pod
spec:
  containers:
  - name: nginx
    image: private-registry.io/apps/internal-app
  imagePullSecrets:
  - name: regcred
```



K8s Reference Docs

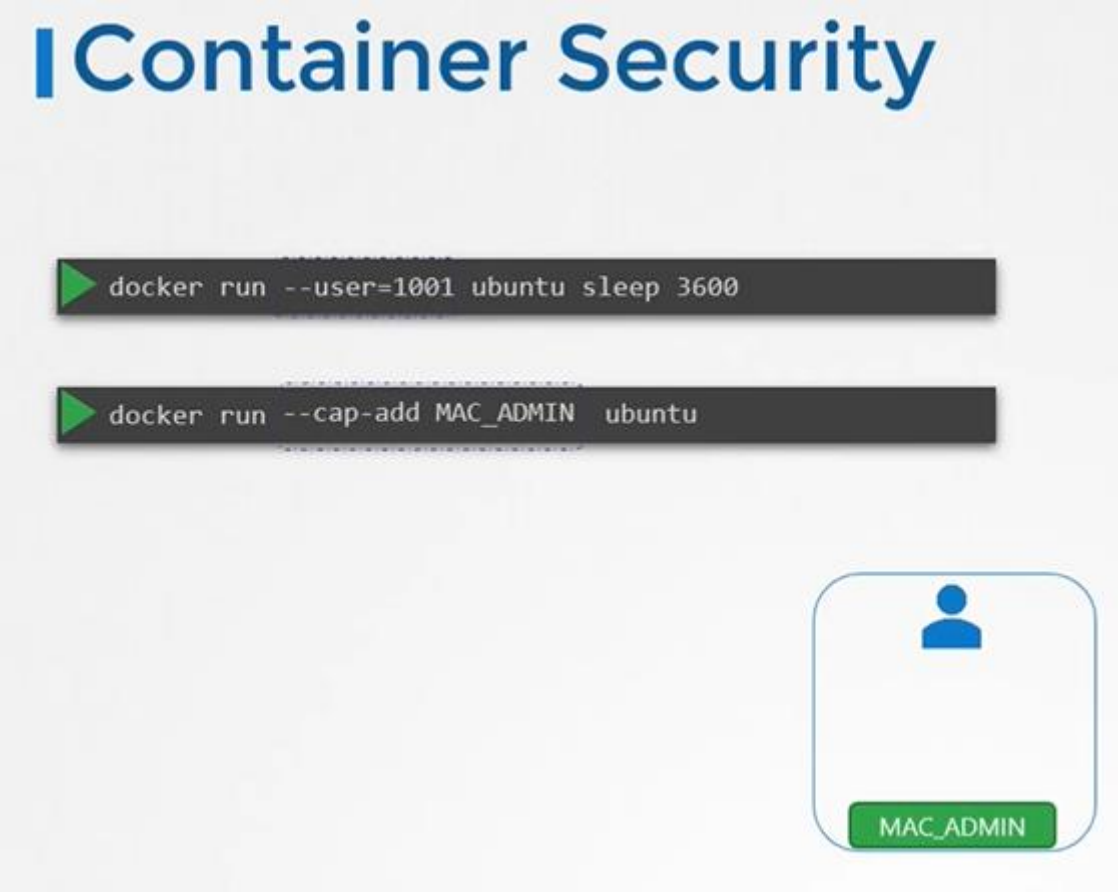
- https://kubernetes.io/docs/concepts/containers/images/

Security Context

In this section, we will take a look at security context

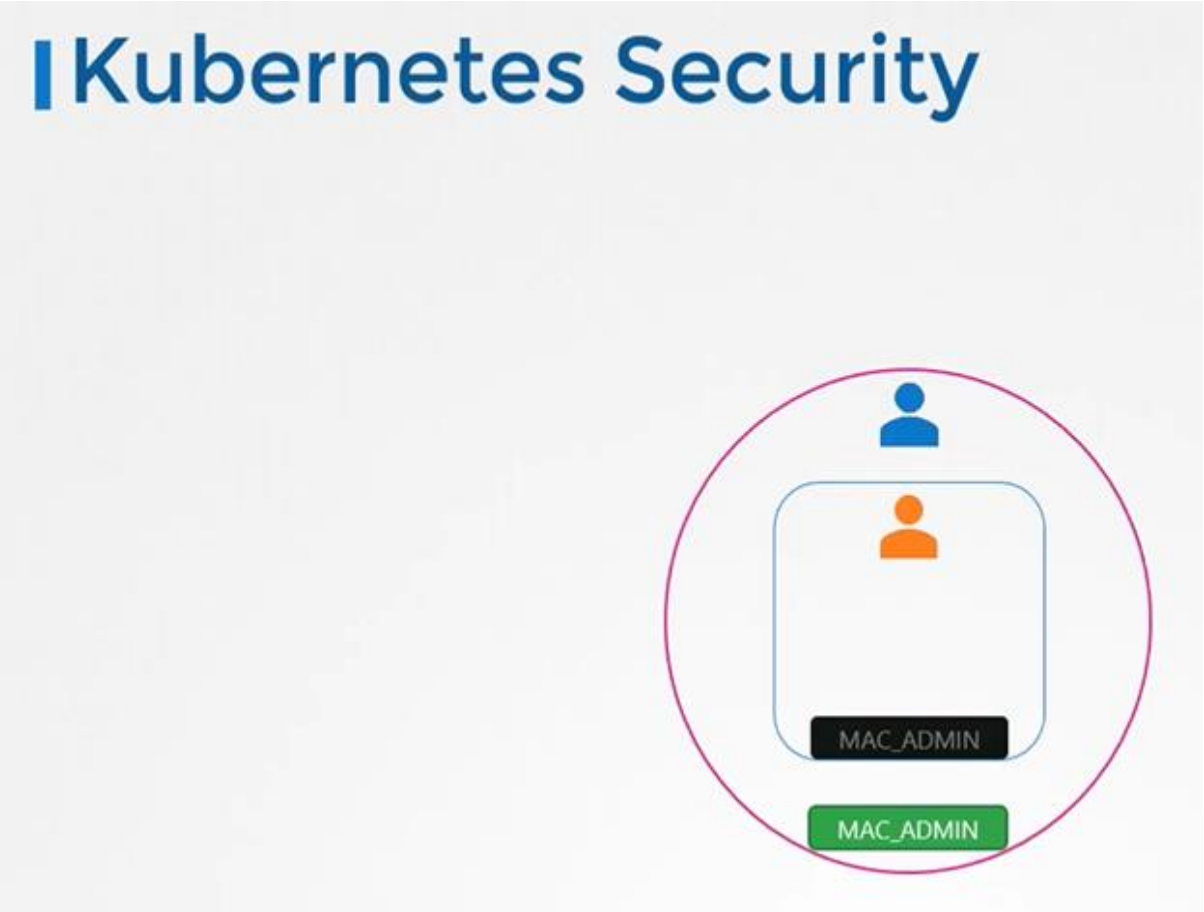
Container Security

```
$ docker run --user=1001 ubuntu sleep 3600
$ docker run -cap-add MAC_ADMIN ubuntu
```



Kubernetes Security

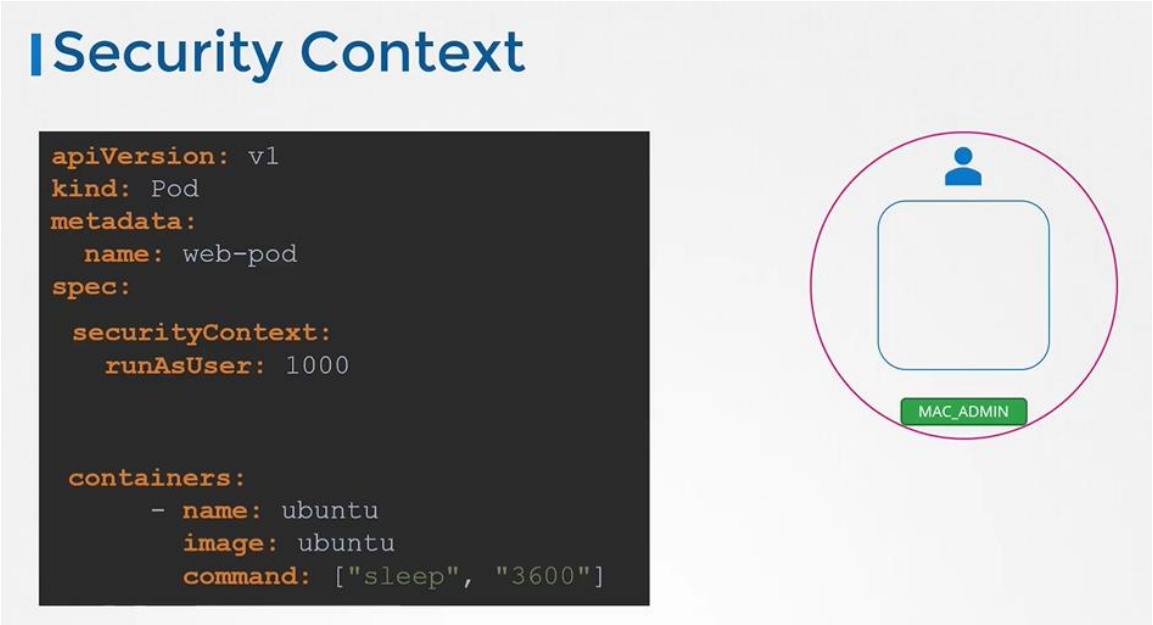
- You may choose to configure the security settings at a container level or at a pod level.



Security Context

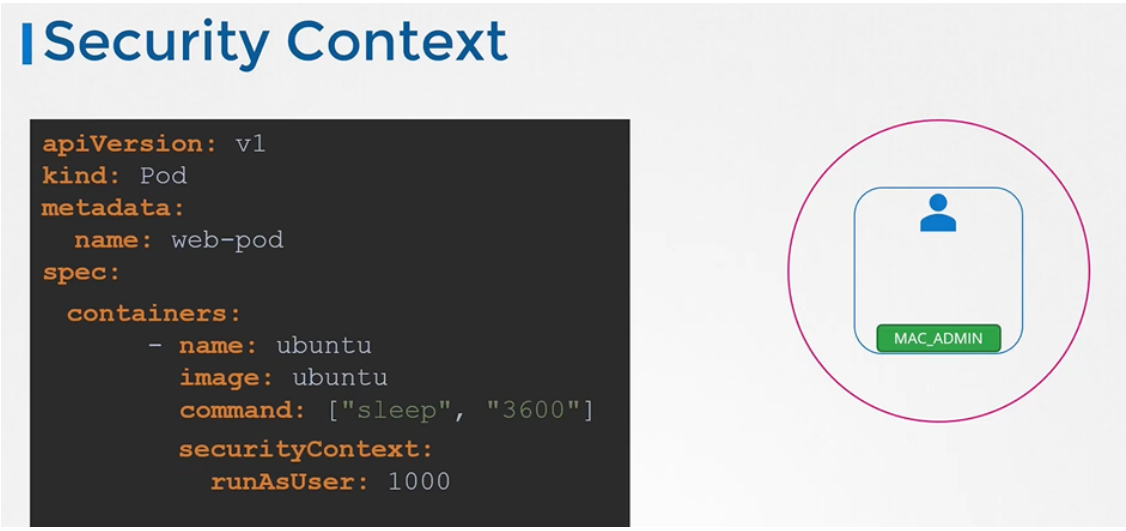
- To add security context on the container and a field called **`securityContext`** under the spec section.

```
apiVersion: v1
kind: Pod
metadata:
  name: web-pod
spec:
  securityContext:
    runAsUser: 1000
  containers:
  - name: ubuntu
    image: ubuntu
    command: ["sleep", "3600"]
```



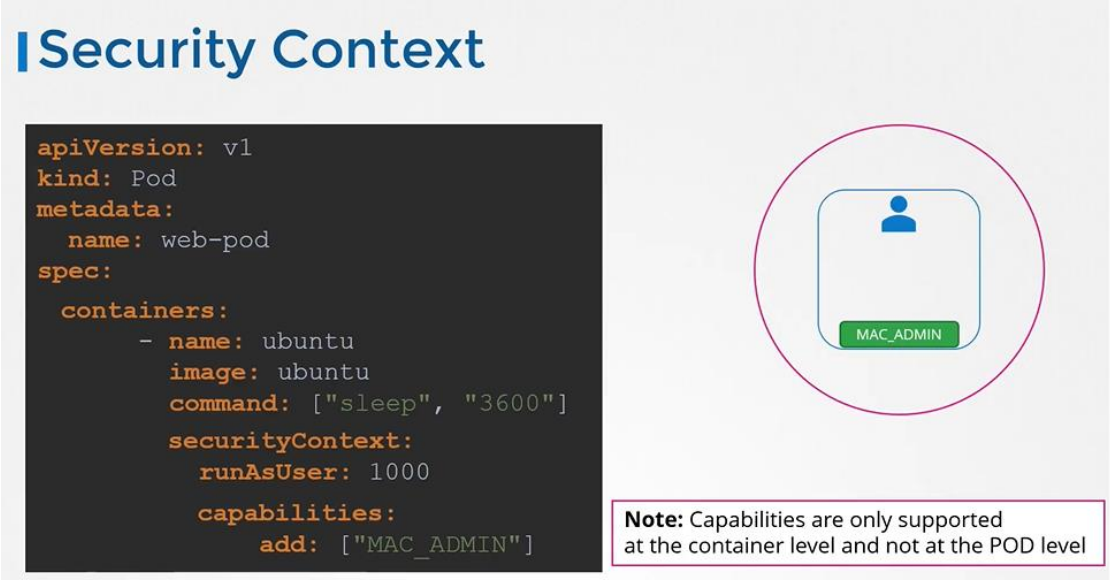
- To set the same context at the container level, then move the whole section under container section.

- apiVersion: v1
- kind: Pod
- metadata:
- name: web-pod
- spec:
- containers:
- - name: ubuntu
- image: ubuntu
- command: ["sleep", "3600"]
- securityContext:
- runAsUser: 1000



- To add capabilities use the **capabilities** option
- apiVersion: v1
- kind: Pod

```
metadata:
  name: web-pod
spec:
  containers:
  - name: ubuntu
    image: ubuntu
    command: ["sleep", "3600"]
    securityContext:
      runAsUser: 1000
      capabilities:
        add: ["MAC_ADMIN"]
```

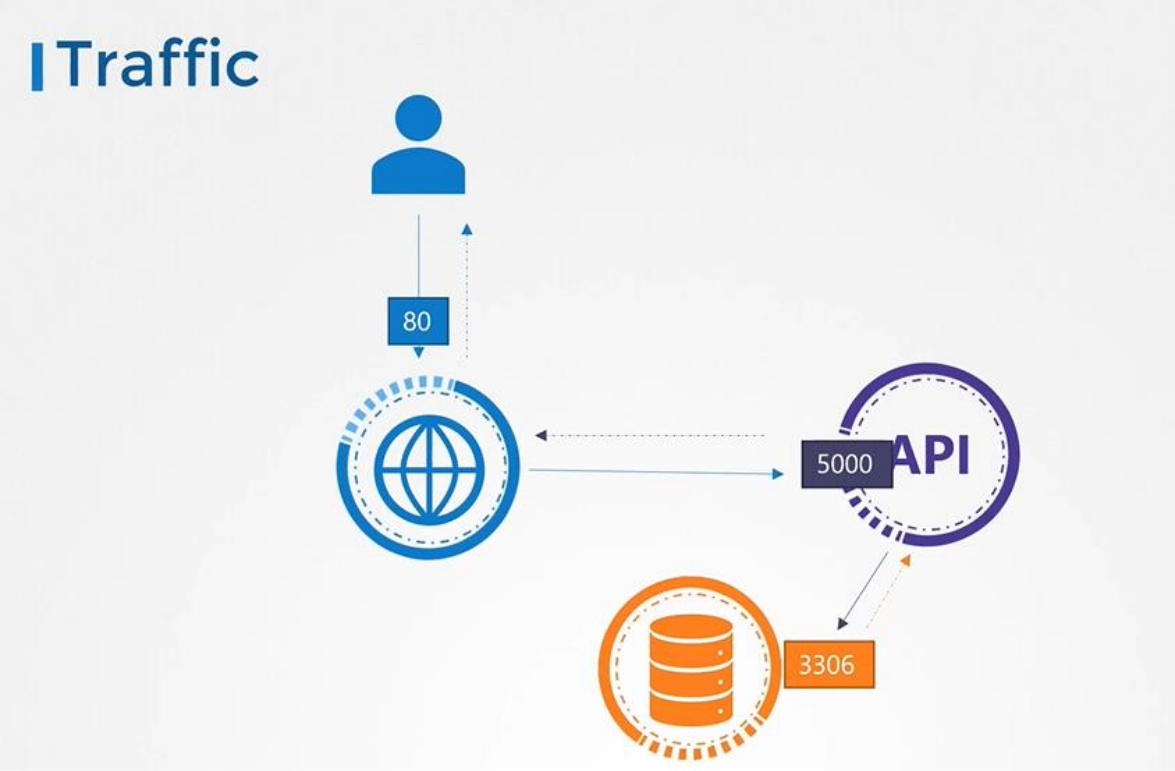


K8s Reference Docs

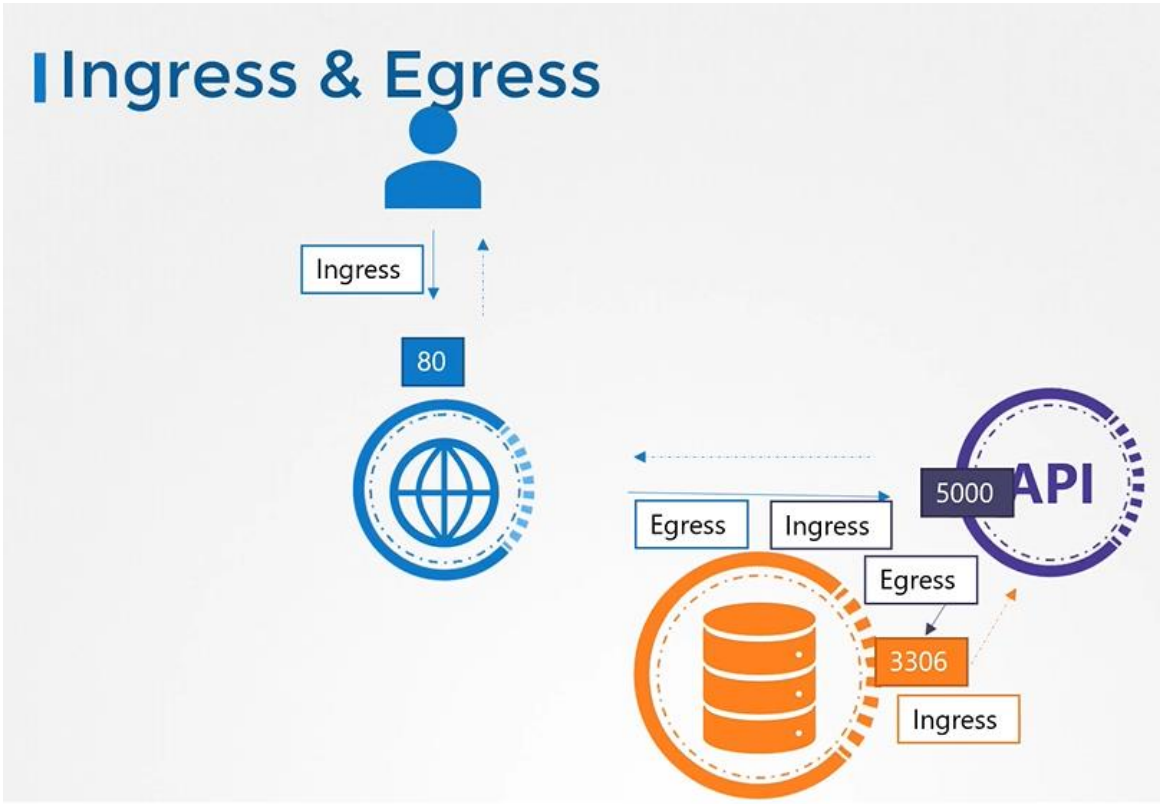
- https://kubernetes.io/docs/tasks/configure-pod-container/security-context/

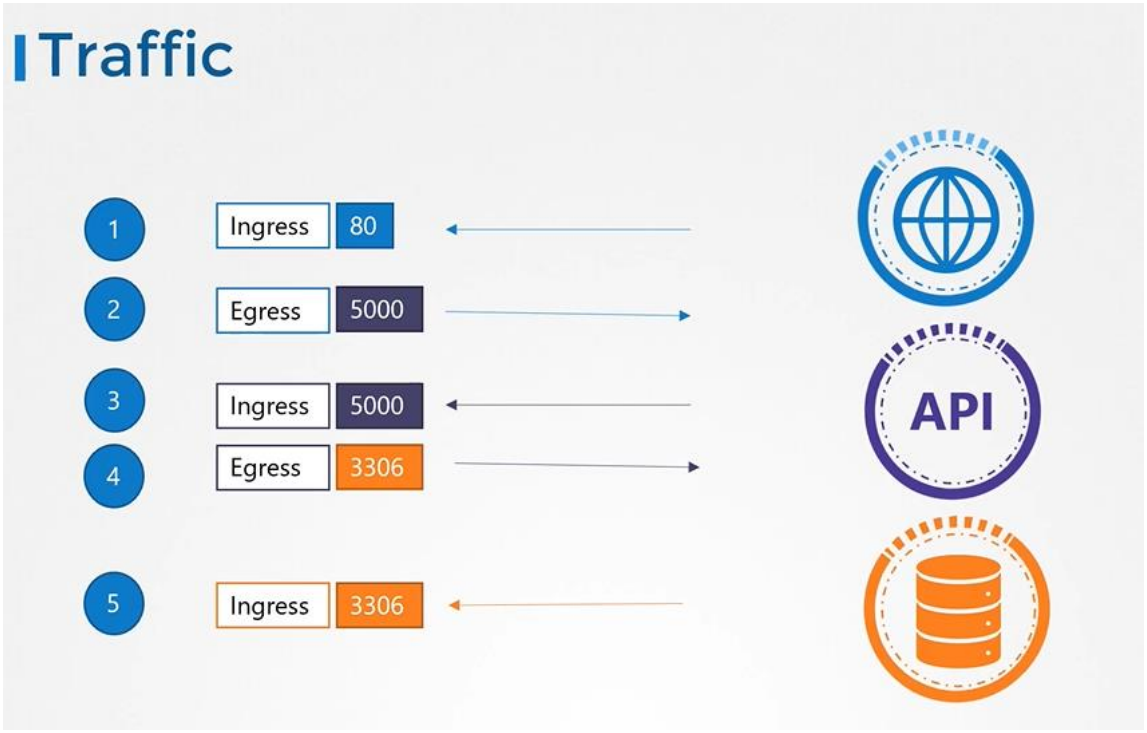
Network Policies

Trafic flowing through a webserver serving frontend to users an app server serving backend API and a database server

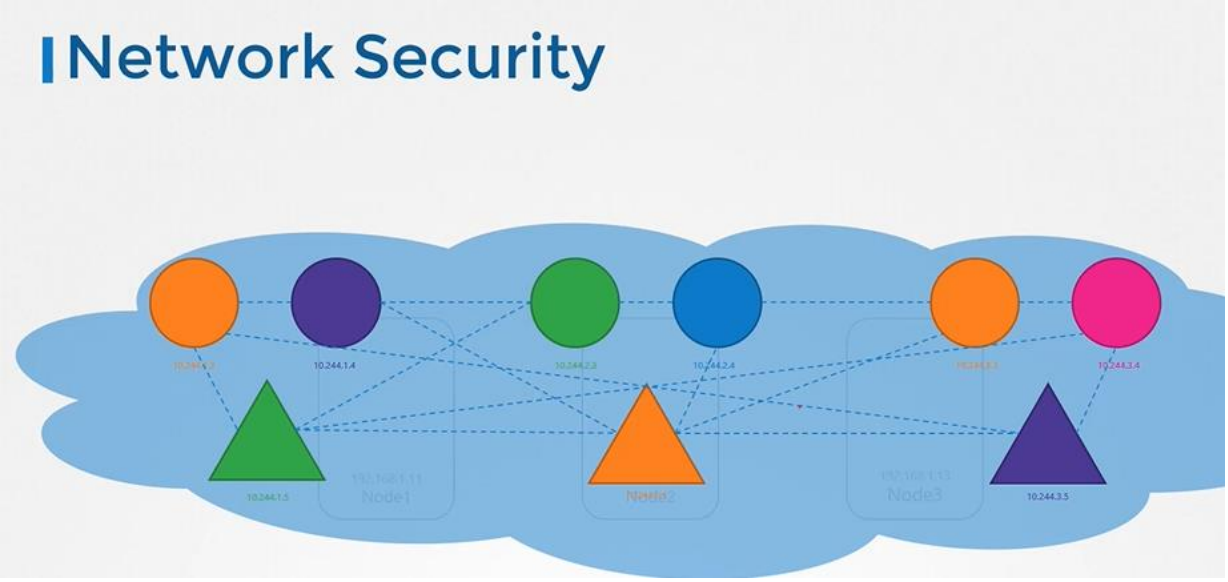


- There are two types of traffic
    - Ingress
    - Egress

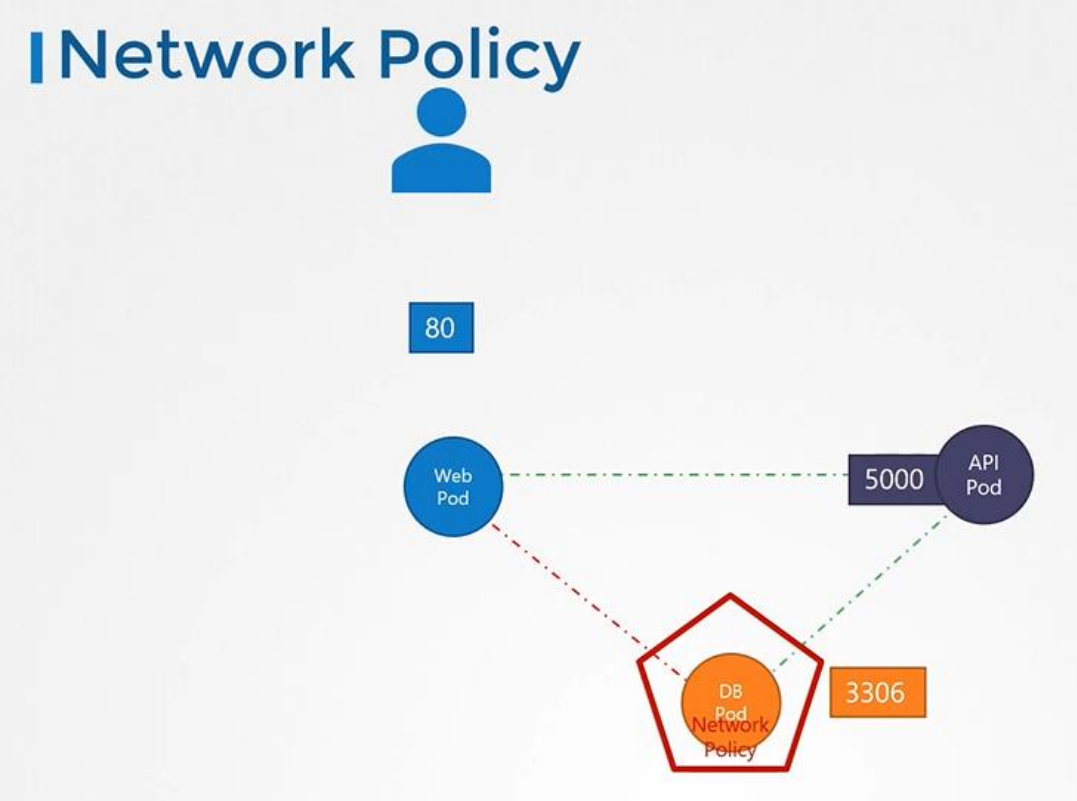

Ingress & Egress
Ingress
80
5000
API
Egress
Ingress
Egress
3306
Ingress

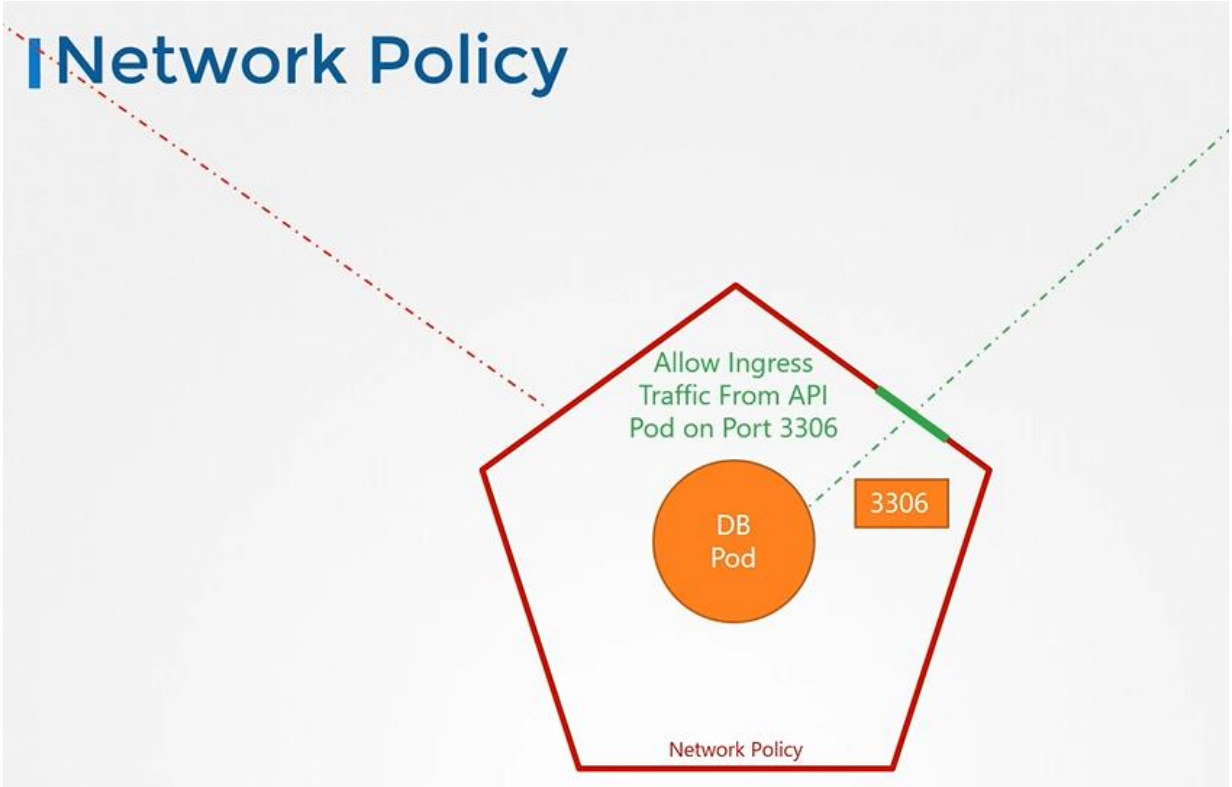

Traffic
1
Ingress
80
2
Egress
5000
3
Ingress
5000
4
Egress
3306
5
Ingress
3306
API

Network Security

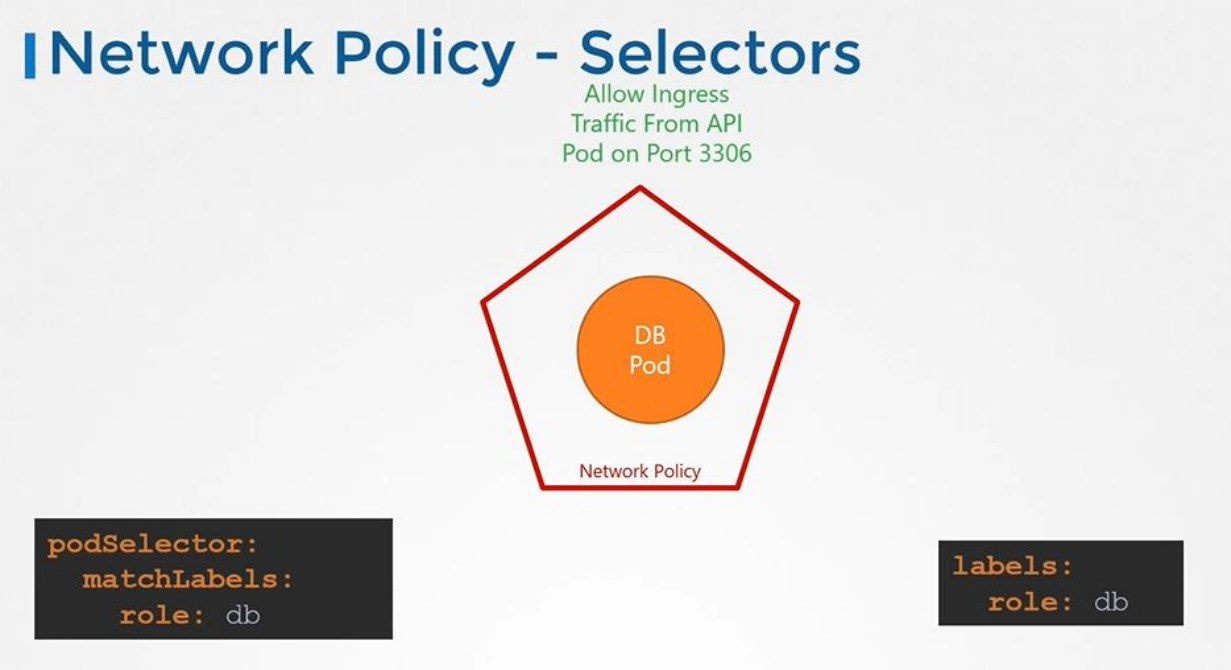


Network Policy





Network Policy Selectors



Network Policy Rules

Create network policy

- To create a network policy
- apiVersion: networking.k8s.io/v1
- kind: NetworkPolicy
- metadata:
- name: db-policy
- spec:
- podSelector:
- matchLabels:
- role: db
- policyTypes:
- - Ingress
- ingress:
- - from:
- - podSelector:
- matchLabels:
- role: api-pod
- ports:
- - protocol: TCP
- port: 3306

$ kubectl create -f policy-definition.yaml

![npol3](../../images/npol3.PNG)

![npol4](../../images/npol4.PNG)

Note

K8s Reference Docs

- https://kubernetes.io/docs/concepts/services-networking/network-policies/
- https://kubernetes.io/docs/tasks/administer-cluster/declare-network-policy/

Storage Section Introduction

In this section, we will take a look at **Storage**

- Introduction of Docker Storage
- Persistent Volume Claim
- Persistent Volume
- Storage Class

Introduction to Docker Storage

In this section, we will take a look at **Docker storage**.

- To understand storage in the container orchestration tools like **Kubernetes**, It is important to first understand how storage works with containers. Understanding how storage works with **Docker** first and getting all the basics right will later make it so much easier to understand how it works in **Kubernetes**.

- If you are new to **Docker** then you can learn some basics of docker from the course Docker for the absolute beginner course, that is free.

Docker Storage

- There are two concepts comes into the docker, Storage drivers and Volume drivers plugins.

We will first discuss about Storage drivers.

Docker Reference Docs

- https://docs.docker.com/storage/storagedriver/
- https://docs.docker.com/storage/volumes/

Storage in Docker

In this section, we will take a look at docker **Storage driver and Filesystem**.

- We are going to see where and how Docker stores data and how it manages filesystem of the containers.

Filesystem

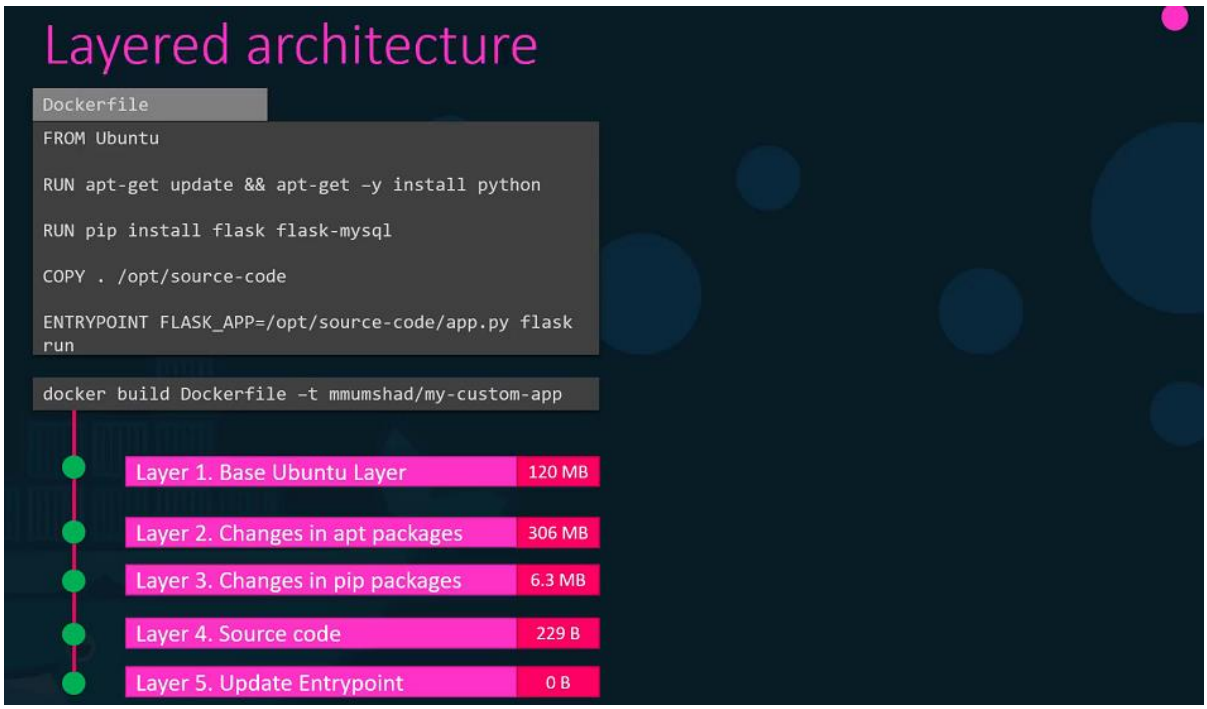
- Let's see how Docker stores data on the local file system. At the first time, When you install Docker on a system, it creates this directory structures at /var/lib/docker.

- `$ cd /var/lib/docker/`
-

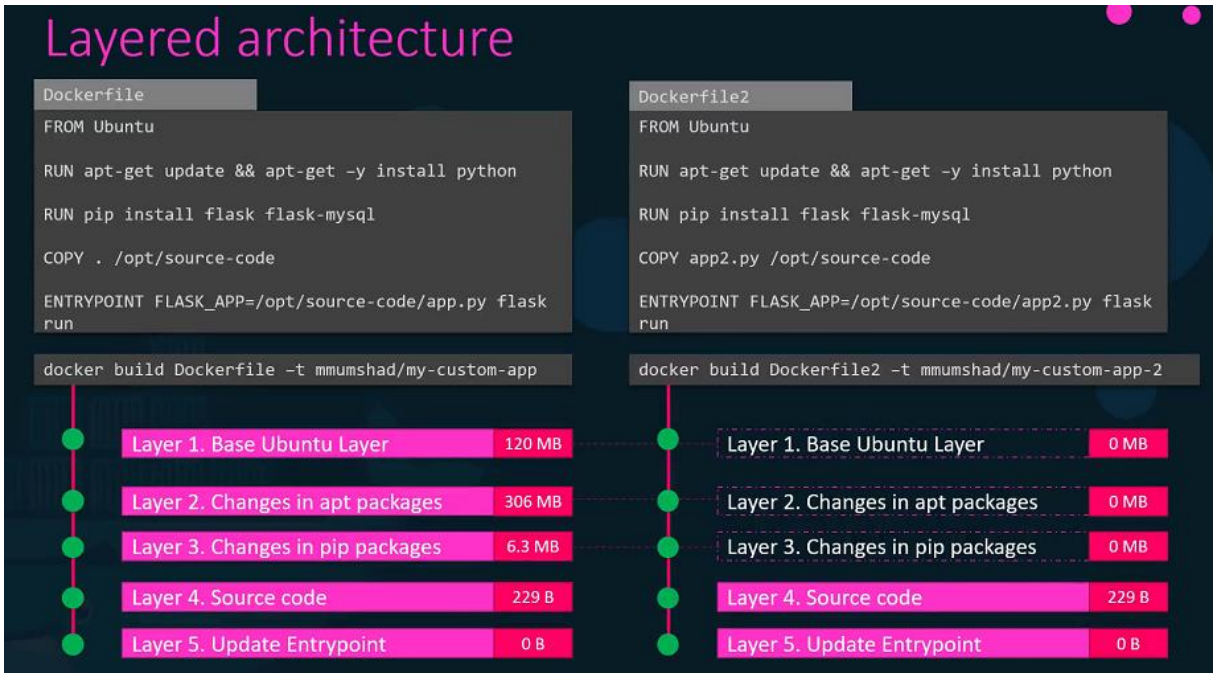
- You have multiple directories under it called aufs, containers, image, volumes etc.
- This is where Docker stores all its data by default.
- All files related to containers are stored under the containers directory and the files related to images are stored under the image directory. Any volumes created by the Docker containers are created under the volumes directory.
- For now, let's just understand where Docker stores its files of an image and a container and in what format.
- To understand that we need to understand Dockers layered architecture.

Layered Architecture

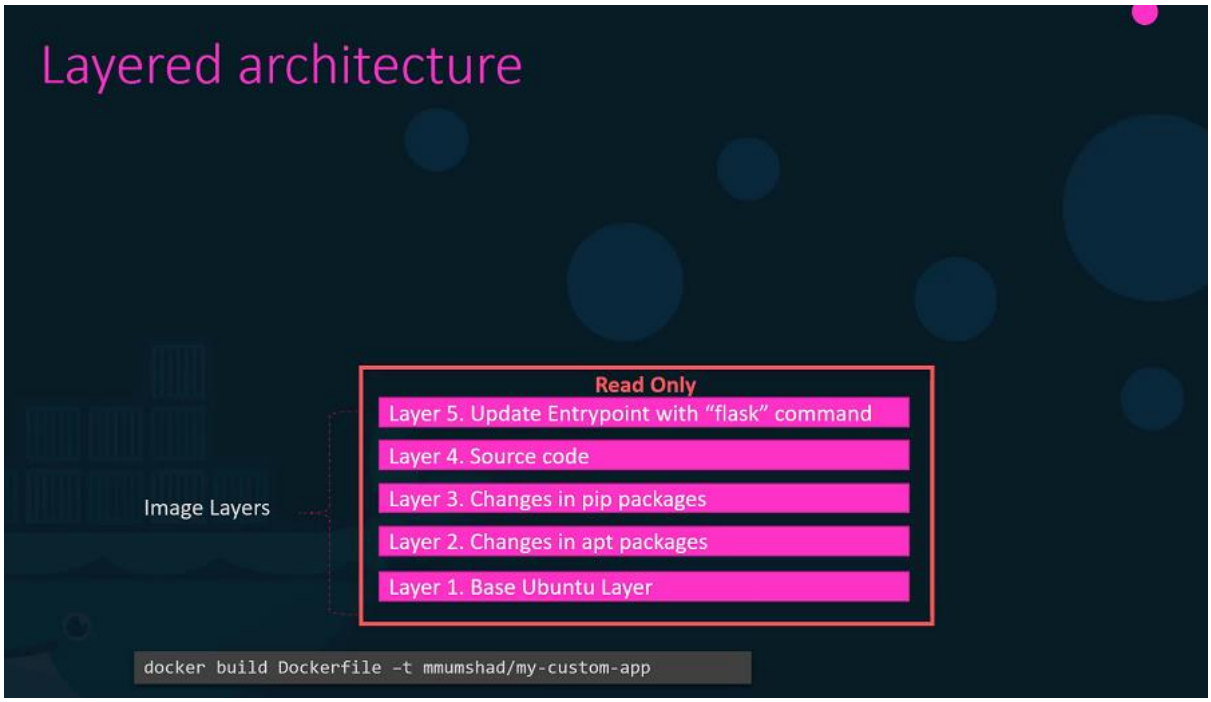
- When docker builds images, it builds these in a layered architecture. Each line of instruction in the Docker file creates a new layer in the Docker image with just the changes from the previous layer.
- As you can see in the image, layer-1 is the Ubuntu base layer, layer-2 install the packages, layer-3 install the python packages, layer-4 update the source code, layer-5 updates the entry point of the image. Since each layer only stores the changes from the previous layer. It is reflected in the size as well.



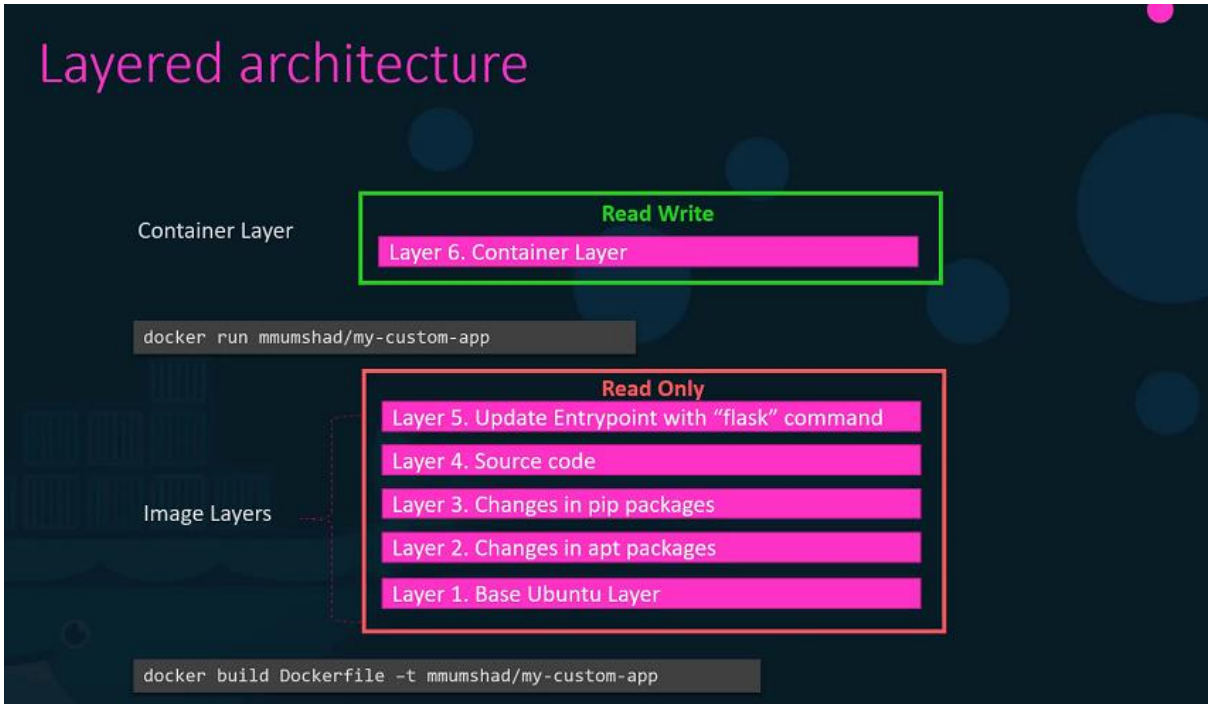
- For better understanding the advantages of this layered architecture, Let's take a different Dockerfile, this is very similiar to our first application. only source code and entry point is differnet to create this application.
- When image builds, docker is not going to build first three layers instead of it reuses the same three layers it built for the first application from the cache. Only creates the last two layers with the new sources and the new entry point.
- This way, Docker builds images faster and efficiently saves disk spaces. This is also applicable, if you were to update your application code. Docker simply reuses all the previous layers from the cache and quickly rebuild the application image by updating the latest source code.



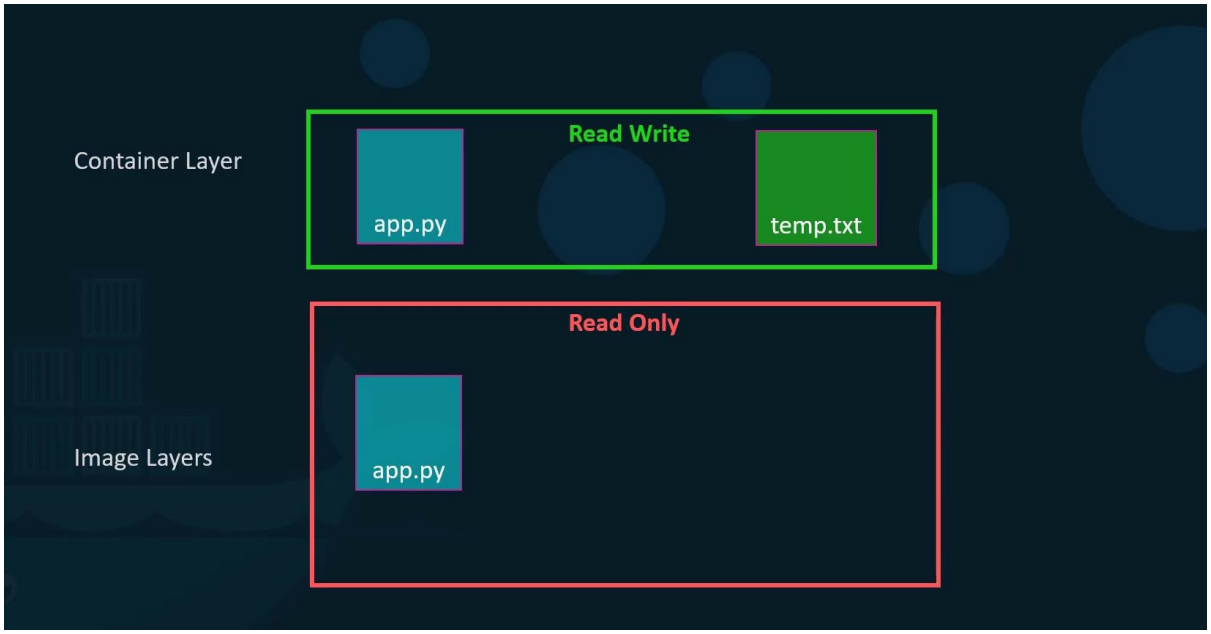
- Let's rearrange the layers bottom up so we can understand it better. All of these layers are created when we run the Docker build command to form the final Docker image. Once the build is complete, you cannot modify the contents of these layers and so they are read-only and you can only modify them by initiating a new build.



- When you run a container based off of this image, using the **Docker run** command Docker creates a container based off of these layers and creates a new writeable layer on top of the image layer. The writeable layer is used to store data created by the container such as log files written by the applications, any temporary files generated by the container.



- When the container is destroyed, this layer and all of the changes stored in it are also destroyed. Remember that the same image layer is shared by all containers created using this image.
- If I will create a new file called temp.txt in the newly created container, which is read and write.
- The files in the image layer are read-only meaning you cannot edit anything in those layers.



- Let's take an example of our application code. Since we bake our code into the image, the code is part of the image and as such, its read-only. After running a container, what if I wish to modify the source code.
- Yes, I can still modify this file, but before I saved the modified file, Docker automatically creates a copy of the file in the read-write layer and I will then be modifying a different version of the file in the read-write layer. All future modifications will be done on this copy of the file in the read-write layer. This is called copy-on-right mechanism.
- The Image layer being a read-only just means that the files in these layers will not be modified in the image itself. So, the image will remain the same all the time until you rebuild the image using the Docker build command. If container destroyed then all of the data that was stored in the container layer also gets deleted.

Volumes

- To get a persistent data in the containers, we need to create a volume using the `docker volume create` command. So, when I run the `docker volume create data_volume` command, it creates a directory called data_volume under the `/var/lib/docker/` volumes directory.
- `$ docker volume create data_volume`
-

- `$ ls -l /var/lib/docker/volumes/`
-
- `drwxr-xr-x 3 root root  4096 Aug 01 17:53 data_volume`
-
- `$ docker volume ls`
-
- `DRIVER              VOLUME NAME`
- `  local               data_volume`
- When I run the Docker container using the `docker run` command, I could mount this volume inside the Docker containers, with `-v` options.
- So when I do a `docker run -v` then specify my newly created volume name followed by a colon(:) and the location inside my container, which is the default location where MySQL stores data and that is `/var/lib/mysql` and at the last image name of MySQL. This will create a new container and mount the data volume.
- `$ docker run -v data_volume:/var/lib/mysql mysql`

- Even if the container is destroyed, the data is still available.

- What if you didn't create the Docker volume before the Docker run command. In this image, Docker will automatically create a volume named data_volume2 and mount it to the container.

- `$ docker run -v data_volume2:/var/lib/mysql mysql`
-
- `$ docker volume ls`
-
- `  DRIVER              VOLUME NAME`
- `  local               data_volume`
- `  local               data_volume2`
- You should be able to see all these volumes if you list the contents of the `/var/lib/docker` volumes directory. This is called **Volume mounting**.

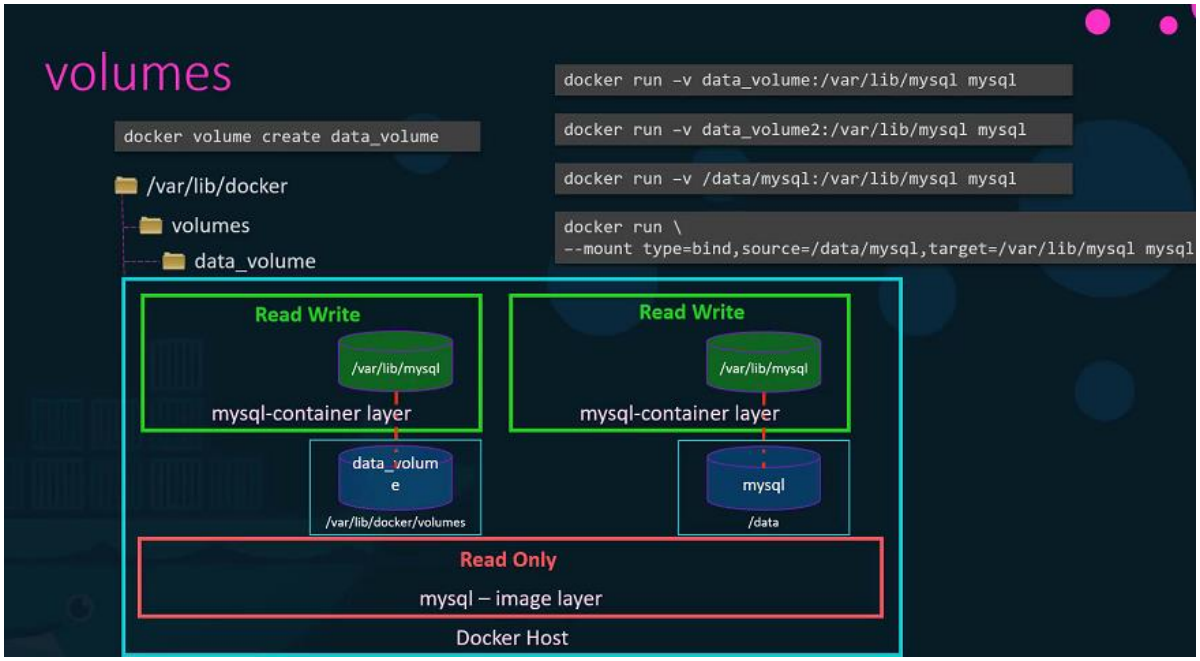
- What if we had our data already at another location?

- Let's say we have some external storage on the Docker host at `/data` path and we would like to store database data on that volume and not in the default `/var/lib/docker` volumes directory. In that case, we would run a container using the command `docker run -v`. But in this case, we will provide the complete path to the directory we would like to mount. That is `/data/mysql` and so it will create a container and mount the directory to the container. This is called **Bind mounting**.

- So there are two types of mounts, volume mount and bind mount.

    - Volume mount, mounts of volume from the volumes directory and bind mount, mounts indirectly from any location on the Docker host.
- Instead of `-v` option, we can preferred `--mount` option.
- `$ mkdir -p /data/mysql`

-
- `$ docker run --mount type=bind,source=/data/mysql,target=/var/lib/mysql mysql`
- So, who is responsible for doing all of these Operations?
- Maintaining of layered architecture, creating a writeable layer, moving files across layers to enable copy and write etc. It's the **Storage Drivers**.
- Docker uses storage drivers to enable layered architecture.



Common Storage Drivers

- AUFS
- ZFS
- BTRFS
- Device Mapper
- Overlay
- Overlay2
- To Selection of the storage drivers depends on the underlying OS. Docker will choose the best storage driver available automatically based on the operating system.

Docker References

- https://docs.docker.com/storage/
- https://docs.docker.com/engine/reference/commandline/volume_create/
- https://docs.docker.com/engine/reference/commandline/volume_ls/

Volume Driver Plugins in Docker

In this section, we will take a look at **Volume Driver Plugins in Docker**

- We discussed about Storage drivers. Storage drivers help to manage storage on images and containers.
- We have already seen that if you want to persist storage, you must create volumes. Volumes are not handled by the storage drivers. Volumes are handled by volume driver plugins. The default volume driver plugin is local.
- The local volume plugin helps to create a volume on Docker host and store its data under the `/var/lib/docker/volumes/` directory.
- There are many other volume driver plugins that allow you to create a volume on third-party solutions like Azure file storage, DigitalOcean Block Storage, Portworx, Google Compute Persistent Disks etc.

- When you run a Docker container, you can choose to use a specific volume driver, such as the RexRay EBS to provision a volume from the Amazon EBS. This will create a container and attach a volume from the AWS cloud. When the container exits, your data is safe in the cloud.

```
$ docker run -it --name mysql --volume-driver rexray/ebs --mount src=ebs-
vol,target=/var/lib/mysql mysql
```

Docker Reference Docs

- https://docs.docker.com/engine/extend/legacy_plugins/
- https://github.com/rexray/rexray

Container Storage Interface

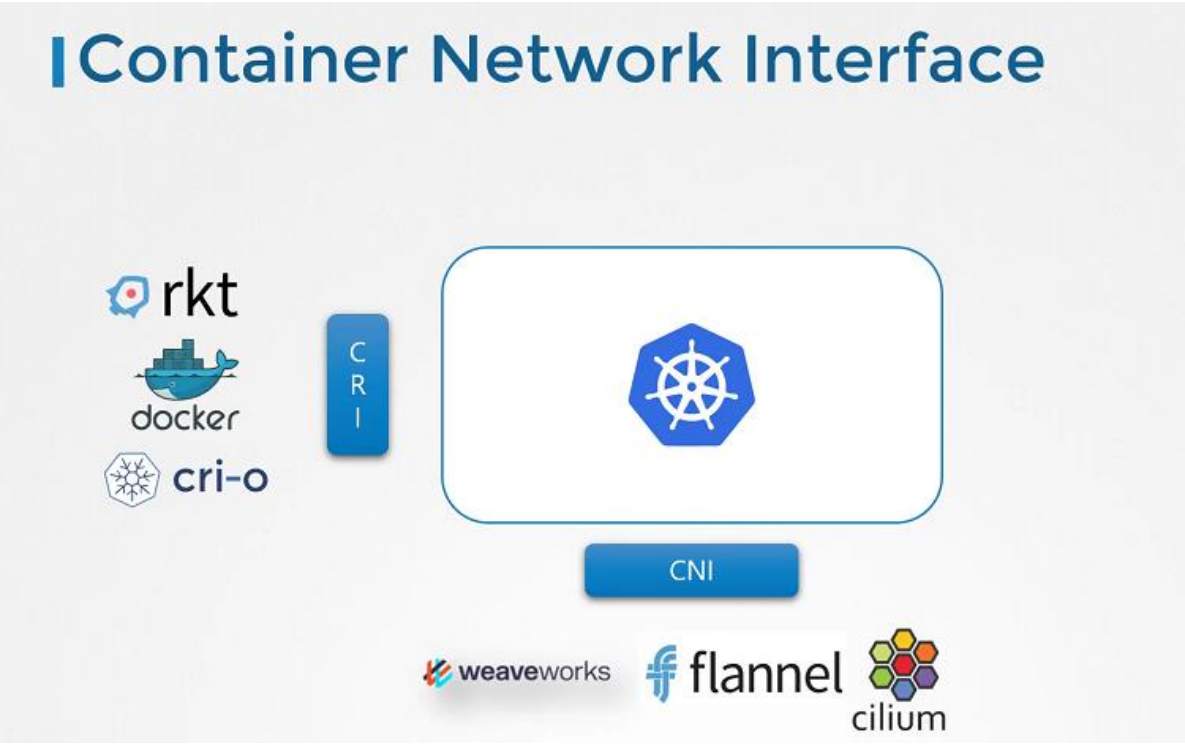
In this section, we will take a look at **Container Storage Interface**

Container Runtime Interface

- Kubernetes used Docker alone as the container runtime engine, and all the code to work with Docker was embedded within the Kubernetes source code. Other container runtimes, such as rkt and CRI-O.
- The Container Runtime Interface is a standard that defines how an orchestration solution like Kubernetes would communicate with container runtimes like Docker. If any new container runtime interace is developed, they can simply follow the CRI standards.

Container Networking Interface

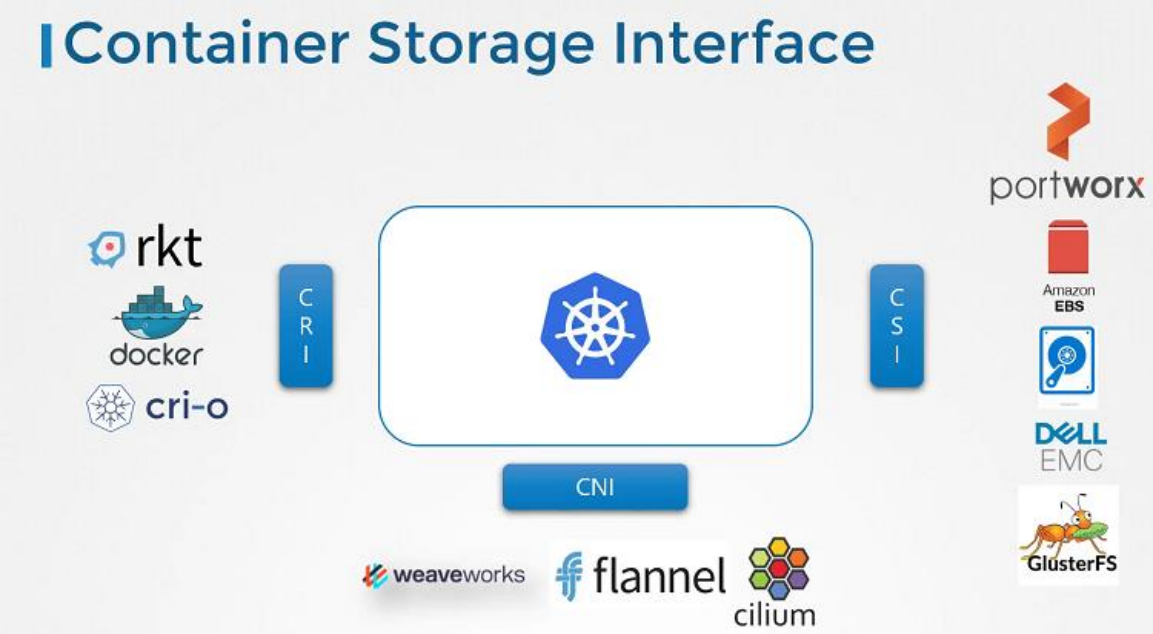
- To support different networking solutions, the container networking interface was introduced. Any new networking vendors could simply develop their plugin based on the CNI standards and make their solution work with Kubernetes.



Container Storage Interface

- The container storage interface was developed to support multiple storage solutions. With CSI, you can now write your own drivers for your own storage to work with Kubernetes. Portworx, Amazon EBS, Azure Disk, GlusterFS etc.

- CSI is not a Kubernetes specific standard. It is meant to be a universal standard and if implemented, allows any container orchestration tool to work with any storage vendor with a supported plugin. Kubernetes, Cloud Foundry and Mesos are onboard with CSI.
- It defines a set of RPCs or remote procedure calls that will be called by the container orchestrator. These must be implemented by the storage drivers.



Container Storage Interface

- https://github.com/container-storage-interface/spec
- https://kubernetes-csi.github.io/docs/
- http://mesos.apache.org/documentation/latest/csi/
- https://www.nomadproject.io/docs/internals/plugins/csi#volume-lifecycle

Volumes

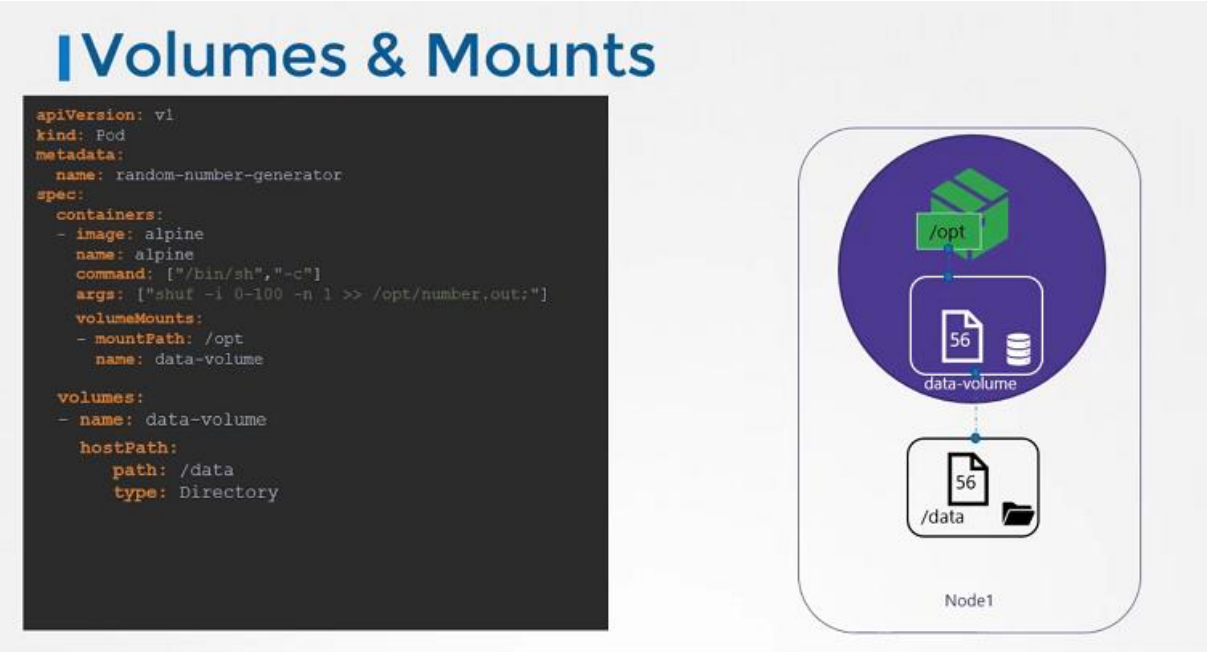
In this section, we will take a look at **Volumes**

- We discussed about Docker storage, If we don't attach the volume in the container runtime, when container destroyed and then all data will be lost. So, We need to persist data into the Docker container so we attach a volume to the containers when they are created.

- The data are processed by the container is now placed in this volume thereby retaining it permanently. Even if the container is deleted the data remains in the volume.

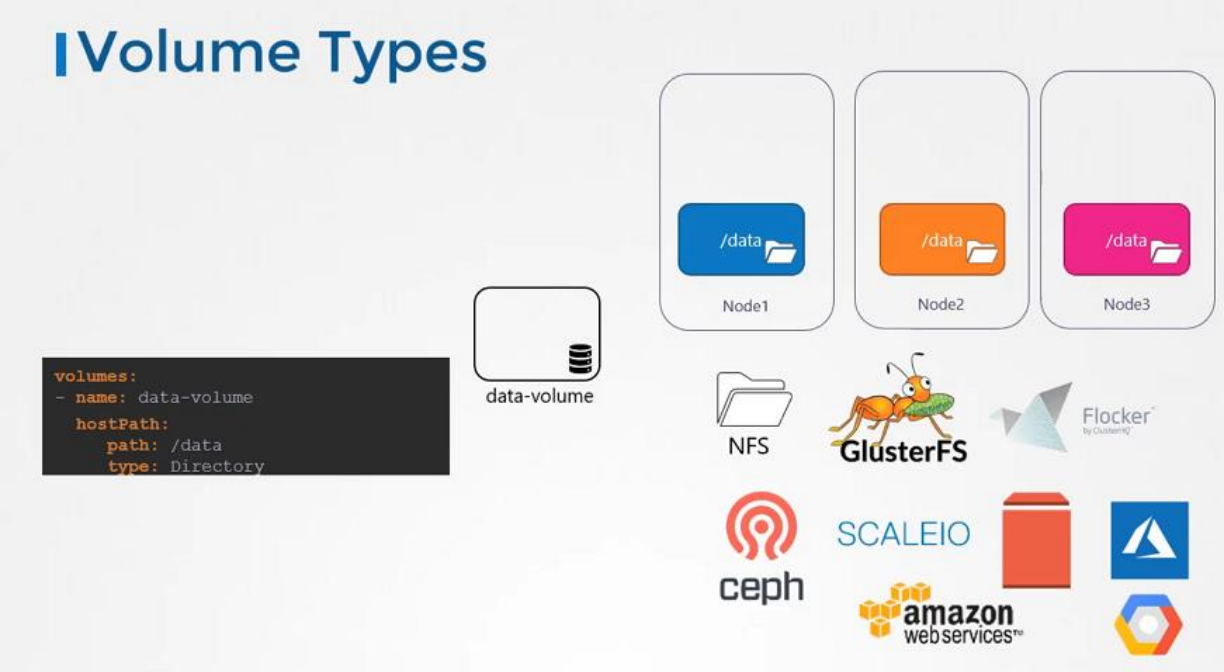
- In the Kubernetes world, the PODs created in Kubernetes are transient in nature. When a POD is created to process data and then deleted, the data processed by it gets deleted as well.

- For example, We create a simple POD that generated a random between 1 and 100 and writes that to a file at `/opt/number.out`. To persist into the volume.
- We create a volume for that. In this case I specify a path `/data` on the host. Files are stored in the directory data on my node. We use the volumeMounts field in each container to mount the data-volume to the directory `/opt` within the container. The random number will now be written to `/opt` mount inside the container, which happens to be on the data-volume which is in fact `/data` directory on the host. When the pod gets deleted, the file with the random number still lives on the host.



Volume Storage Options

- In the volumes, hostPath volume type is fine with the single node. It's not recomended for use with the multi node cluster.
- In the Kubernetes, it supports several types of standard storage solutions such as NFS, GlusterFS, CephFS or public cloud solutions like AWS EBS, Azure Disk or Google's Persistent Disk.




```
volumes:
- name: data-volume
  awsElasticBlockStore:
    volumeID: <volume-id>
    fsType: ext4
```

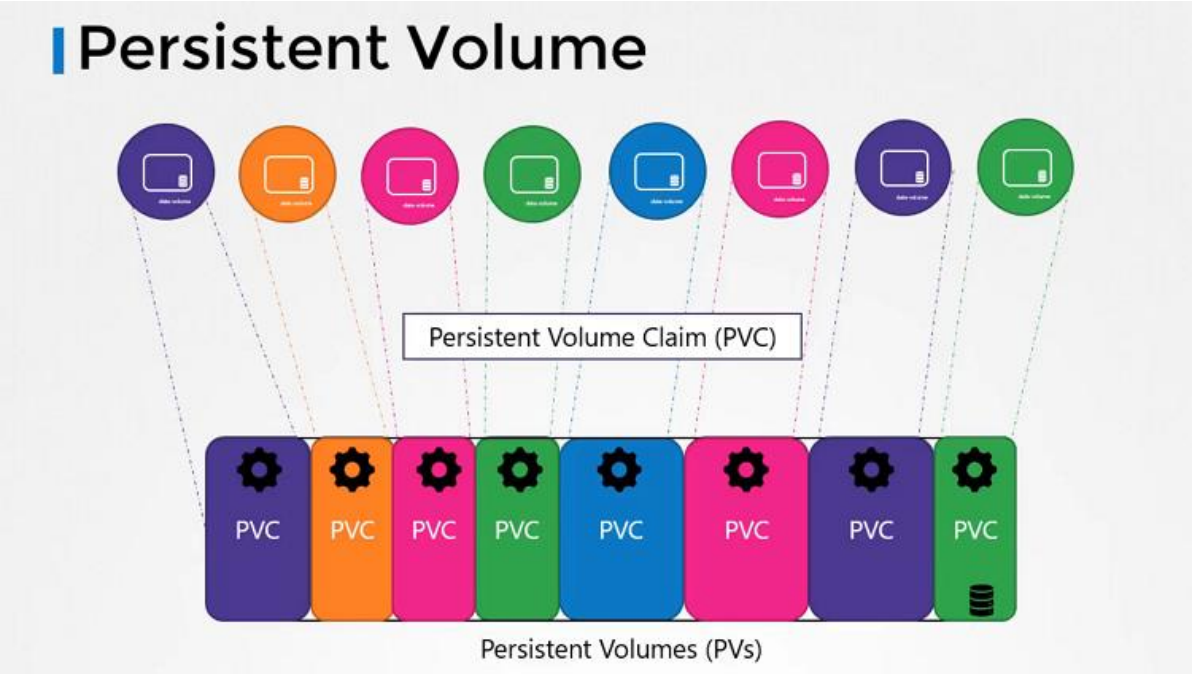
Kubernetes Volumes Reference Docs

- https://kubernetes.io/docs/concepts/storage/volumes/
- https://kubernetes.io/docs/tasks/configure-pod-container/configure-volume-storage/
- https://unofficial-kubernetes.readthedocs.io/en/latest/concepts/storage/volumes/
- https://kubernetes.io/docs/reference/generated/kubernetes-api/v1.18/#volume-v1-core

Persistent Volumes

In this section, we will take a look at **Persistent Volumes**

- In the large evnironment, with a lot of users deploying a lot of pods, the users would have to configure storage every time for each Pod.
- Whatever storage solution is used, the users who deploys the pods would have to configure that on all pod definition files in his environment. Every time a change is to be made, the user would have to make them on all of his pods.



- A Persistent Volume is a cluster-wide pool of storage volumes configured by an administrator to be used by users deploying application on the cluster. The users can now select storage from this pool using Persistent Volume Claims.

```
pv-definition.yaml

kind: PersistentVolume
apiVersion: v1
metadata:
  name: pv-vol1
spec:
  accessModes: [ "ReadWriteOnce" ]
  capacity:
   storage: 1Gi
  hostPath:
   path: /tmp/data
$ kubectl create -f pv-definition.yaml
persistentvolume/pv-vol1 created

$ kubectl get pv
NAME      CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS      CLAIM
STORAGECLASS   REASON   AGE
pv-vol1   1Gi        RWO            Retain           Available
3min

$ kubectl delete pv pv-vol1
persistentvolume "pv-vol1" deleted
```

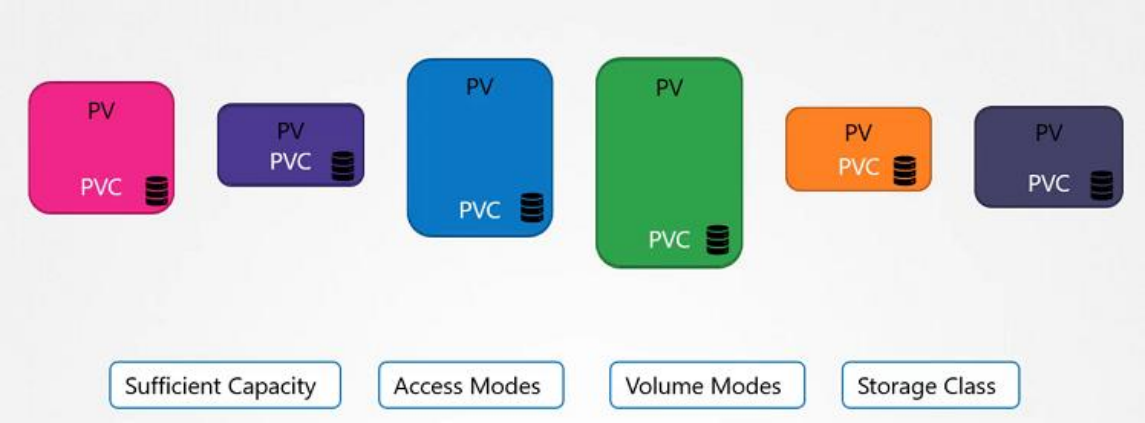
Kubernetes Persistent Volumes

- https://kubernetes.io/docs/concepts/storage/persistent-volumes/
- https://portworx.com/tutorial-kubernetes-persistent-volumes/

Persistent Volume Claims

In this section, we will take a look at **Persistent Volume Claim**

- Now we will create a Persistent Volume Claim to make the storage available to the node.
- Volumes and Persistent Volume Claim are two separate objects in the Kubernetes namespace.
- Once the Persistent Volume Claim created, Kubernetes binds the Persistent Volumes to claim based on the request and properties set on the volume.



- If properties not matches or Persistent Volume is not available for the Persistent Volume Claim then it will display the pending state.

```
pvc-definition.yaml

kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: myclaim
spec:
  accessModes: [ "ReadWriteOnce" ]
  resources:
   requests:
     storage: 1Gi
pv-definition.yaml

kind: PersistentVolume
apiVersion: v1
metadata:
    name: pv-vol1
spec:
    accessModes: [ "ReadWriteOnce" ]
    capacity:
     storage: 1Gi
    hostPath:
     path: /tmp/data
```

Create the Persistent Volume

```
$ kubectl create -f pv-definition.yaml
persistentvolume/pv-vol1 created

$ kubectl get pv
NAME      CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS      CLAIM
STORAGECLASS   REASON   AGE
pv-vol1   1Gi        RWO            Retain           Available
10s
```

Create the Persistent Volume Claim

```
$ kubectl create -f pvc-definition.yaml
persistentvolumeclaim/myclaim created

$ kubectl get pvc
NAME      STATUS    VOLUME   CAPACITY   ACCESS MODES   STORAGECLASS   AGE
myclaim   Pending                                                    35s

$ kubectl get pvc
NAME      STATUS   VOLUME    CAPACITY   ACCESS MODES   STORAGECLASS   AGE
myclaim   Bound    pv-vol1   1Gi        RWO                           1min
```

Delete the Persistent Volume Claim

```
$ kubectl delete pvc myclaim
```

Delete the Persistent Volume

```
$ kubectl delete pv pv-vol1
```

Kubernetes Persistent Volume Claims Reference Docs

- https://kubernetes.io/docs/concepts/storage/persistent-volumes/#persistentvolumeclaims
- https://kubernetes.io/docs/reference/generated/kubernetes-api/v1.18/#persistentvolumeclaim-v1-core
- https://docs.cloud.oracle.com/en-us/iaas/Content/ContEng/Tasks/contengcreatingpersistentvolumeclaim.htm

Using PVC in PODs

In this section, we will take a look at **Using PVC in PODs**

- In this case, Pods access storage by using the claim as a volume. Persistent Volume Claim must exist in the same namespace as the Pod using the claim.

- The cluster finds the claim in the Pod's namespace and uses it to get the Persistent Volume backing the claim. The volume is then mounted to the host and into the Pod.
- Persistent Volume is a cluster-scoped and Persistent Volume Claim is a namespace-scoped.

Create the Persistent Volume

```
pv-definition.yaml

kind: PersistentVolume
apiVersion: v1
metadata:
    name: pv-vol1
spec:
    accessModes: [ "ReadWriteOnce" ]
    capacity:
     storage: 1Gi
    hostPath:
     path: /tmp/data
$ kubectl create -f pv-definition.yaml
```

Create the Persistent Volume Claim

```
pvc-definition.yaml

kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: myclaim
spec:
  accessModes: [ "ReadWriteOnce" ]
  resources:
   requests:
     storage: 1Gi
$ kubectl create -f pvc-definition.yaml
```

Create a Pod

```
pod-definition.yaml

apiVersion: v1
kind: Pod
metadata:
  name: mypod
spec:
  containers:
    - name: myfrontend
      image: nginx
      volumeMounts:
      - mountPath: "/var/www/html"
        name: web
  volumes:
    - name: web
      persistentVolumeClaim:
```

```
        claimName: myclaim
$ kubectl create -f pod-definition.yaml
```

List the Pod,Persistent Volume and Persistent Volume Claim

```
$ kubectl get pod,pvc,pv
```

References Docs

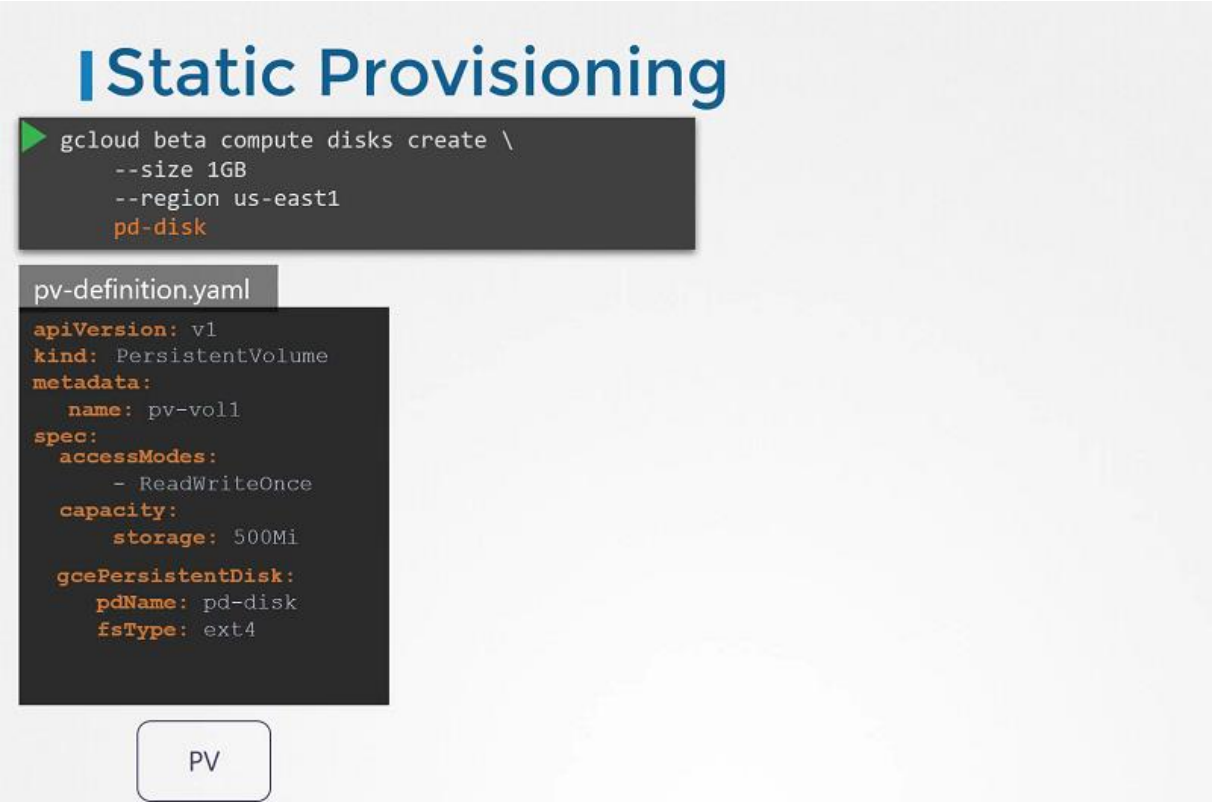
- https://kubernetes.io/docs/concepts/storage/persistent-volumes/#claims-as-volumes

Storage Class

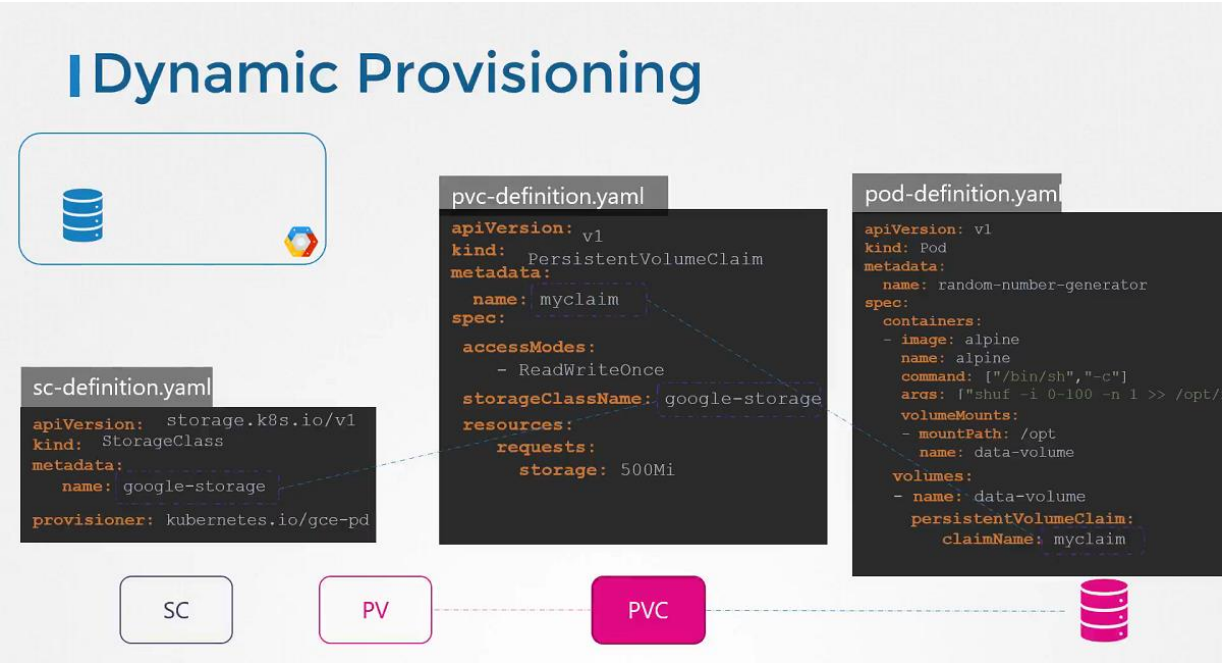
In this section, we will take a look at **Storage Class**

- We discussed about how to create Persistent Volume and Persistent Volume Claim and We also saw that how to use into the Pod's volume to claim that volume space.
- We created Persistent Volume but before this if we are taking a volume from Cloud providers like GCP, AWS, Azure. We need to first create disk in the Google Cloud as an example.
- We need to create manually each time when we define in the Pod definition file. that's called **Static Provisioning**.

Static Provisioning



Dynamic Provisioning



- No we have a Storage Class, So we no longer to define Persistent Volume. It will create automatically when a Storage Class is created. It's called **Dynamic Provisioning**.

```
sc-definition.yaml

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
   name: google-storage
provisioner: kubernetes.io/gce-pd
```

Create a Storage Class

```
$ kubectl create -f sc-definition.yaml
storageclass.storage.k8s.io/google-storage created
```

List the Storage Class

```
$ kubectl get sc
NAME             PROVISIONER            RECLAIMPOLICY   VOLUMEBINDINGMODE
ALLOWVOLUMEEXPANSION   AGE
google-storage   kubernetes.io/gce-pd   Delete          Immediate           false
20s
```

Create a Persistent Volume Claim

```
pvc-definition.yaml

kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: myclaim
spec:
  accessModes: [ "ReadWriteOnce" ]
  storageClassName: google-storage
  resources:
   requests:
     storage: 500Mi
$ kubectl create -f pvc-definition.yaml
```

Create a Pod

```
pod-definition.yaml

apiVersion: v1
kind: Pod
metadata:
  name: mypod
spec:
  containers:
    - name: frontend
      image: nginx
      volumeMounts:
      - mountPath: "/var/www/html"
        name: web
  volumes:
    - name: web
```

```
      persistentVolumeClaim:
        claimName: myclaim
$ kubectl create -f pod-definition.yaml
```

Provisioner

Kubernetes Storage Class Reference Docs

- https://kubernetes.io/docs/concepts/storage/storage-classes/
- https://cloud.google.com/kubernetes-engine/docs/concepts/persistent-volumes#storageclasses
- https://docs.aws.amazon.com/eks/latest/userguide/storage-classes.html

Section Introduction

In this section, we will take a look at **Networking Section**

- Prerequisite
  - Switching, Routing and Gateways
    - Switching
    - Routing
    - Default Gateway
  - DNS
    - DNS Configuration on Linux
  - CoreDNS
  - Network Namespace

    - Docker Networking
    - CNI
- Cluster Networking
- Pod Networking
- CNI in Kubernetes
- CoreDNS
- Ingress

Pre-requisite Switching Routing Gateways

In this section, we will take a look at **Switching, Routing and Gateways**

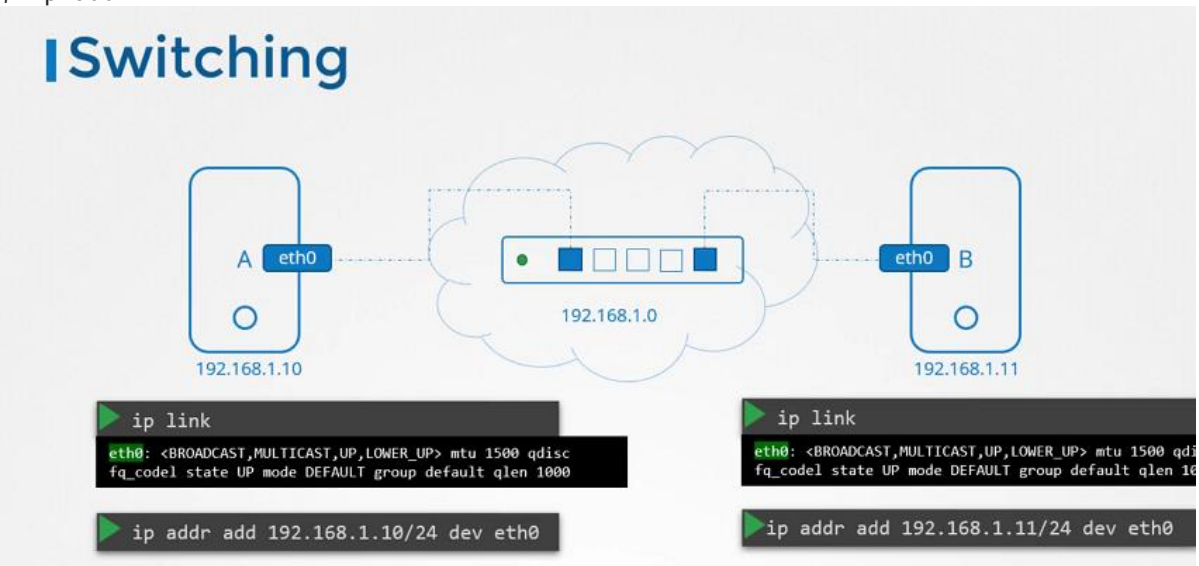
Switching

- To see the interface on the host system

```
$ ip link
```

- To see the IP Address interfaces.

```
$ ip addr
```



Routing

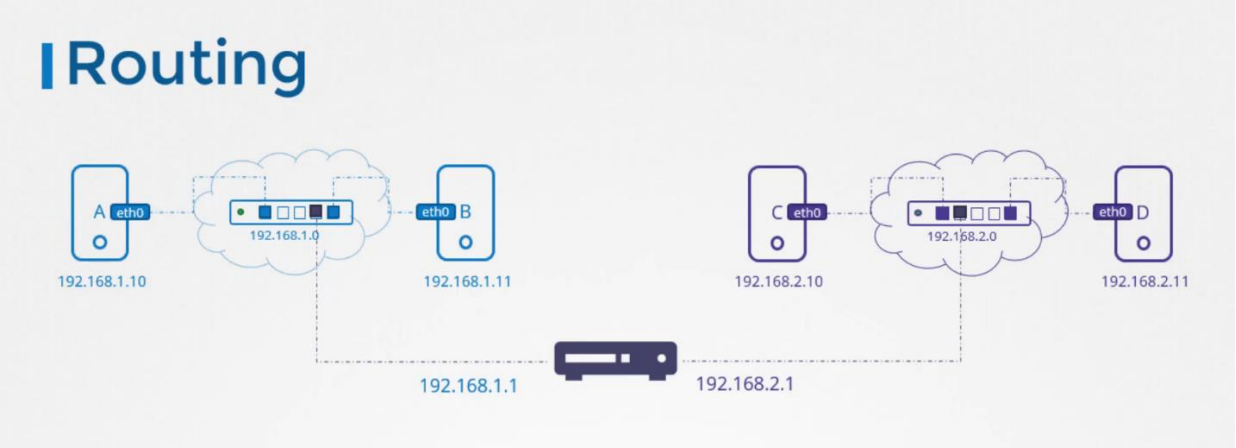
- To see the existing routing table on the host system.

```
$ route
$ ip route show
or
```

```
$ ip route list
```

- To add entries into the routing table.

```
$ ip route add 192.168.1.0/24 via 192.168.2.1
```



Gateways

- To add a default route.

```
$ ip route add default via 192.168.2.1
```

- To check the IP forwarding is enabled on the host.

```
$ cat /proc/sys/net/ipv4/ip_forward
0

$ echo 1 > /proc/sys/net/ipv4/ip_forward
```

- Enable packet forwarding for IPv4.

```
$ cat /etc/sysctl.conf

# Uncomment the line
net.ipv4.ip_forward=1
```

- To view the sysctl variables.

```
$ sysctl -a
```

- To reload the sysctl configuration.

```
$ sysctl --system
```

Pre-requisite DNS

In this section, we will take a look at **DNS in the Linux**

Name Resolution

- With help of the `ping` command. Checking the reachability of the IP Addr on the Network.

```
$ ping 172.17.0.64
PING 172.17.0.64 (172.17.0.64) 56(84) bytes of data.
64 bytes from 172.17.0.64: icmp_seq=1 ttl=64 time=0.384 ms
64 bytes from 172.17.0.64: icmp_seq=2 ttl=64 time=0.415 ms
```

- Checking with their hostname

```
$ ping web
ping: unknown host web
```

- Adding entry in the `/etc/hosts` file to resolve by their hostname.

```
$ cat >> /etc/hosts
172.17.0.64  web


# Ctrl + c to exit
```

- It will look into the `/etc/hosts` file.

```
$ ping web
PING web (172.17.0.64) 56(84) bytes of data.
64 bytes from web (172.17.0.64): icmp_seq=1 ttl=64 time=0.491 ms
64 bytes from web (172.17.0.64): icmp_seq=2 ttl=64 time=0.636 ms

$ ssh web

$ curl http://web
```

DNS

- Every host has a DNS resolution configuration file at `/etc/resolv.conf`.

```
$ cat /etc/resolv.conf
nameserver 127.0.0.53
options edns0
```

- To change the order of dns resolution, we need to do changes into the `/etc/nsswitch.conf` file.

```
$ cat /etc/nsswitch.conf

hosts:          files dns
networks:       files
```

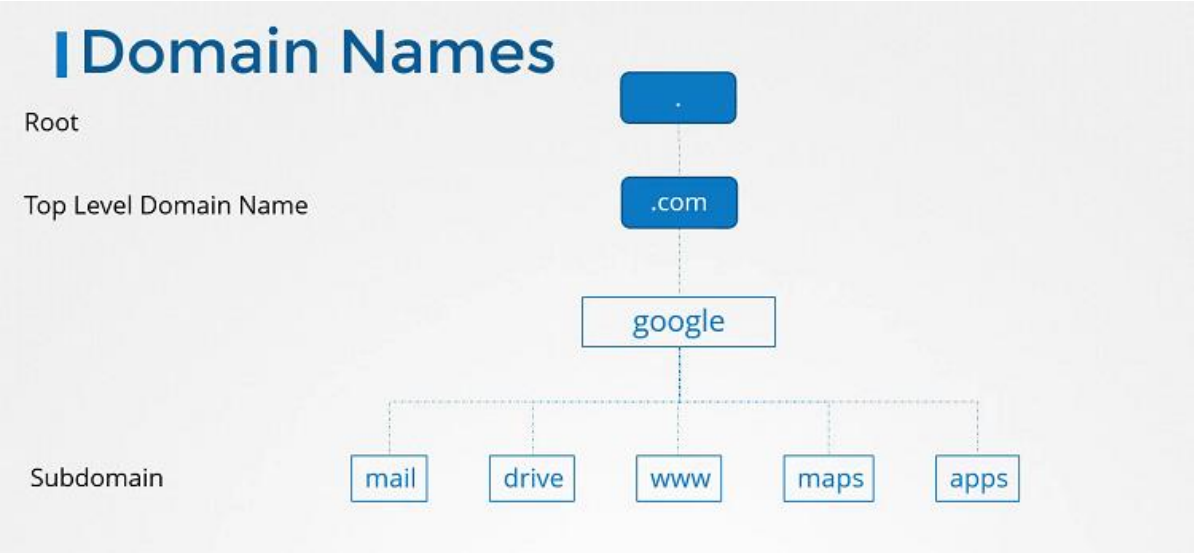
- If it fails in some conditions.

```
$ ping wwww.github.com
ping: www.github.com: Temporary failure in name resolution
```

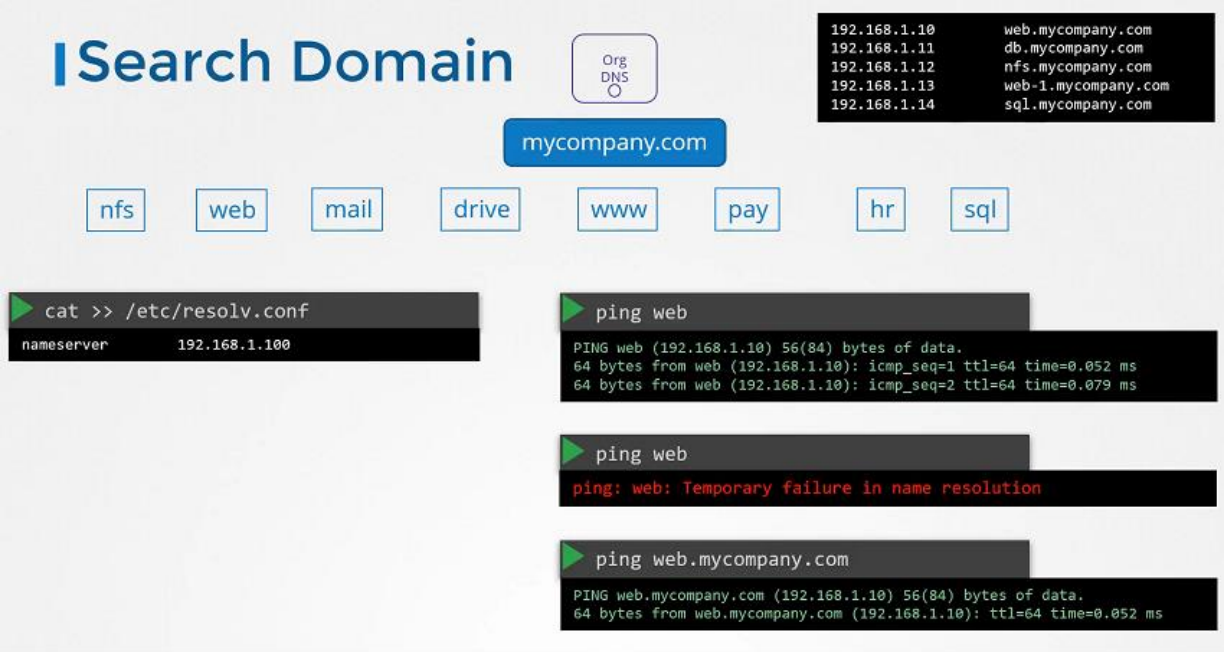
- Adding well known public nameserver in the `/etc/resolv.conf` file.

```
$ cat /etc/resolv.conf
nameserver   127.0.0.53
nameserver   8.8.8.8
options edns0
$ ping www.github.com
PING github.com (140.82.121.3) 56(84) bytes of data.
64 bytes from 140.82.121.3 (140.82.121.3): icmp_seq=1 ttl=57 time=7.07 ms
64 bytes from 140.82.121.3 (140.82.121.3): icmp_seq=2 ttl=57 time=5.42 ms
```

Domain Names



Search Domain



Record Types

Networking Tools

- Useful networking tools to test dns name resolution.

nslookup

```
$ nslookup www.google.com
Server:         127.0.0.53
Address:        127.0.0.53#53

Non-authoritative answer:
Name:   www.google.com
Address: 172.217.18.4
```

```
Name:    www.google.com
```

dig

```
$ dig www.google.com

; <<>> DiG 9.11.3-1 ...
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 8738
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 65494
;; QUESTION SECTION:
;www.google.com.                        IN      A

;; ANSWER SECTION:
www.google.com.         63      IN      A       216.58.206.4

;; Query time: 6 msec
;; SERVER: 127.0.0.53#53(127.0.0.53)
```

Pre-requisite CoreDNS

In this section, we will take a look at **CoreDNS**

Installation of CoreDNS

```
$ wget
https://github.com/coredns/coredns/releases/download/v1.7.0/coredns_1.7.0_linux_am
d64.tgz
coredns_1.7.0_linux_amd64.tgz
```

Extract tar file

```
$ tar -xzvf coredns_1.7.0_linux_amd64.tgz
coredns
```

Run the executable file

- Run the executable file to start a DNS server. By default, it's listen on port 53, which is the default port for a DNS server.

```
$ ./coredns
```

Configuring the hosts file

- Adding entries into the `/etc/hosts` file.

- CoreDNS will pick the ips and names from the `/etc/hosts` file on the server.

```
$ cat > /etc/hosts
192.168.1.10    web
192.168.1.11    db
192.168.1.15    web-1
192.168.1.16    db-1
192.168.1.21    web-2
192.168.1.22    db-2
```

Adding into the Corefile

```
$ cat > Corefile
. {
        hosts   /etc/hosts
}
```

Run the executable file

```
$ ./coredns
```

References Docs

- https://github.com/kubernetes/dns/blob/master/docs/specification.md
- https://coredns.io/plugins/kubernetes/
- https://github.com/coredns/coredns/releases

Pre-requisite Network Namespaces

In this section, we will take a look at **Network Namespaces**

Process Namespace

On the container
```
$ ps aux
```
On the host
```
$ ps aux
```

Network Namespace

```
$ route
$ arp
```

Create Network Namespace

```
$ ip netns add red

$ ip netns add blue
```

- List the network namespace

```
$ ip netns
```

Exec in Network Namespace

- List the interfaces on the host

```
$ ip link
```

- Exec inside the network namespace

```
$ ip netns exec red ip link
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN mode DEFAULT group default qlen
1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00

$ ip netns exec blue ip link
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN mode DEFAULT group default qlen
1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
```

- You can try with other options as well. Both works the same.

```
$ ip -n red link
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN mode DEFAULT group default qlen
1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
```

ARP and Routing Table

On the host

```
$ arp
Address                  HWtype  HWaddress           Flags Mask            Iface
172.17.0.21              ether   02:42:ac:11:00:15   C                     ens3
172.17.0.55              ether   02:42:ac:11:00:37   C                     ens3
```

On the Network Namespace

```
$ ip netns exec red arp
Address                  HWtype  HWaddress           Flags Mask            Iface

$ ip netns exec blue arp
Address                  HWtype  HWaddress           Flags Mask            Iface
```

On the host

```
$ route
```

On the Network Namespace

```
$ ip netns exec red route
```

```
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface

$ ip netns exec blue route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
```

Virtual Cable

- To create a virtual cable

```
$ ip link add veth-red type veth peer name veth-blue
```

- To attach with the network namespaces

```
$ ip link set veth-red netns red

$ ip link set veth-blue netns blue
```

- To add an IP address

```
$ ip -n red addr add 192.168.15.1/24 dev veth-red

$ ip -n blue addr add 192.168.15.2/24 dev veth-blue
```

- To turn it up ns interfaces

```
$ ip -n red link set veth-red up

$ ip -n blue link set veth-blue up
```

- Check the reachability

```
$ ip netns exec red ping 192.168.15.2
PING 192.168.15.2 (192.168.15.2) 56(84) bytes of data.
64 bytes from 192.168.15.2: icmp_seq=1 ttl=64 time=0.035 ms
64 bytes from 192.168.15.2: icmp_seq=2 ttl=64 time=0.046 ms

$ ip netns exec red arp
Address                  HWtype  HWaddress           Flags Mask            Iface
192.168.15.2             ether   da:a7:29:c4:5a:45   C                     veth-
red

$ ip netns exec blue arp
Address                  HWtype  HWaddress           Flags Mask            Iface
192.168.15.1             ether   92:d1:52:38:c8:bc   C                     veth-
blue
```

- Delete the link.

```
$ ip -n red link del veth-red
```

On the host

```
# Not available
```

```
$ arp
Address                  HWtype  HWaddress           Flags Mask            Iface
172.16.0.72              ether   06:fe:61:1a:75:47   C                     ens3
172.17.0.68              ether   02:42:ac:11:00:44   C                     ens3
172.17.0.74              ether   02:42:ac:11:00:4a   C                     ens3
172.17.0.75              ether   02:42:ac:11:00:4b   C                     ens3
```

Linux Bridge

- Create a network namespace

```
$ ip netns add red

$ ip netns add blue
```

- To create a internal virtual bridge network, we add a new interface to the host

```
$ ip link add v-net-0 type bridge
```

- Display in the host

```
$ ip link
8: v-net-0: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN mode DEFAULT
group default qlen 1000
    link/ether fa:fd:d4:9b:33:66 brd ff:ff:ff:ff:ff:ff
```

- Currently it's down, so turn it up

```
$ ip link set dev v-net-0 up
```

- To connect network namespace to the bridge. Creating a virtual cabel

```
$ ip link add veth-red type veth peer name veth-red-br

$ ip link add veth-blue type veth peer name veth-blue-br
```

- Set with the network namespaces

```
$ ip link set veth-red netns red

$ ip link set veth-blue netns blue

$ ip link set veth-red-br master v-net-0

$ ip link set veth-blue-br master v-net-0
```

- To add an IP address

```
$ ip -n red addr add 192.168.15.1/24 dev veth-red

$ ip -n blue addr add 192.168.15.2/24 dev veth-blue
```

- To turn it up `ns` interfaces

```
$ ip -n red link set veth-red up

$ ip -n blue link set veth-blue up
```

- To add an IP address

```
$ ip addr add 192.168.15.5/24 dev v-net-0
```

- Turn it up added interfaces on the host

```
$ ip link set dev veth-red-br up
$ ip link set dev veth-blue-br up
```

On the host

```
$ ping 192.168.15.1
```

On the ns

```
$ ip netns exec blue ping 192.168.1.1
Connect: Network is unreachable

$ ip netns exec blue route

$ ip netns exec blue ip route add 192.168.1.0/24 via 192.168.15.5

# Check the IP Address of the host
$ ip a

$ ip netns exec blue ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.

$ iptables -t nat -A POSTROUTING -s 192.168.15.0/24 -j MASQUERADE

$ ip netns exec blue ping 192.168.1.1

$ ip netns exec blue ping 8.8.8.8

$ ip netns exec blue route

$ ip netns exec blue ip route add default via 192.168.15.5

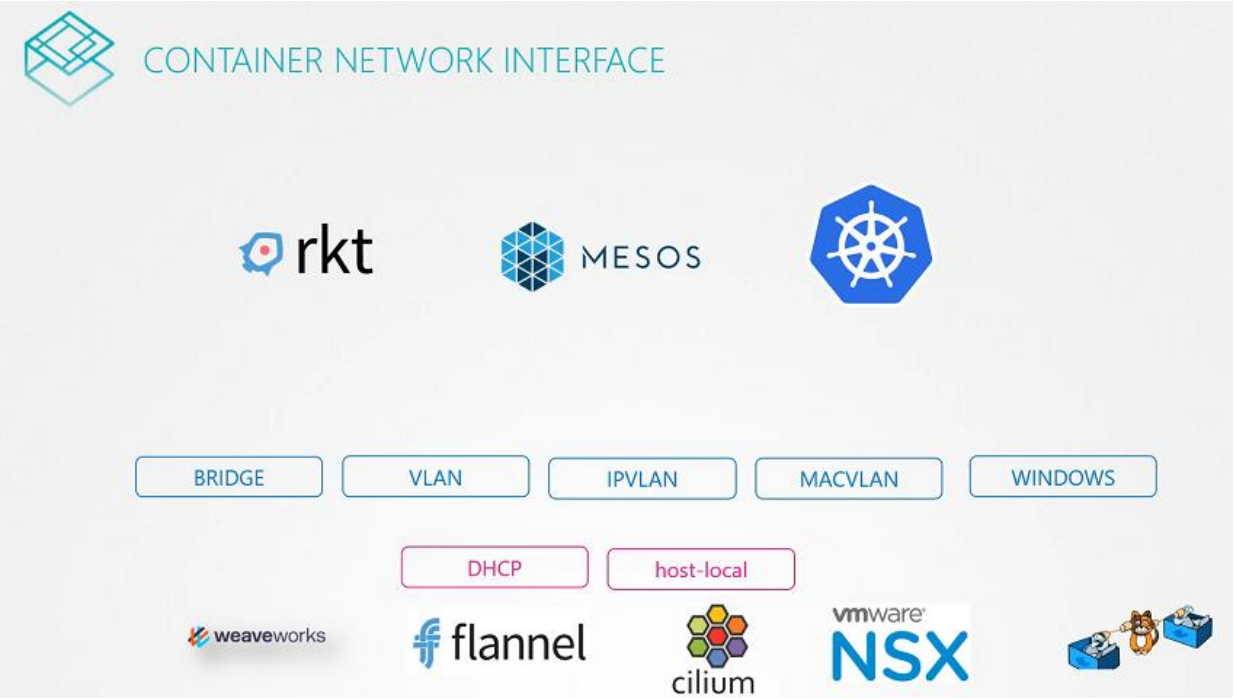
$ ip netns exec blue ping 8.8.8.8
```

- Adding port forwarding rule to the iptables

```
$ iptables -t nat -A PREROUTING --dport 80 --to-destination 192.168.15.2:80 -j
DNAT
$ iptables -nvL -t nat
```

Pre-requisite CNI

In this section, we will take a look at **Pre-requisite Container Network Interface(CNI)**



Third Party Network Plugin Providers

- Weave
- Calico
- Flannel
- Cilium

To view the CNI Network Plugins

- CNI comes with the set of supported network plugins.

```
$ ls /opt/cni/bin/
bridge  dhcp  flannel  host-device  host-local  ipvlan  loopback  macvlan  portmap
ptp  sample  tuning  vlan
```

References Docs

- https://kubernetes.io/docs/concepts/extend-kubernetes/compute-storage-net/network-plugins/

Pre-requisite Cluster Networking

In this section, we will take a look at **Pre-requisite of the Cluster Networking**

- Set the unique hostname.
- Get the IP addr of the system (master and worker node).

- Check the Ports.

IP and Hostname

- To view the hostname

```
$ hostname
```

- To view the IP addr of the system

```
$ ip a
```

Set the hostname

```
$ hostnamectl set-hostname <host-name>
```

```
$ exec bash
```

View the Listening Ports of the system

```
$ netstat -nltp
```

References Docs

- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/install-kubeadm/#check-required-ports
- https://kubernetes.io/docs/concepts/cluster-administration/networking/

Pod Networking

In this section, we will take a look at **Pod Networking**

- To add bridge network on each node

node01
```
$ ip link add v-net-0 type bridge
```
node02
```
$ ip link add v-net-0 type bridge
```
node03
```
$ ip link add v-net-0 type bridge
```

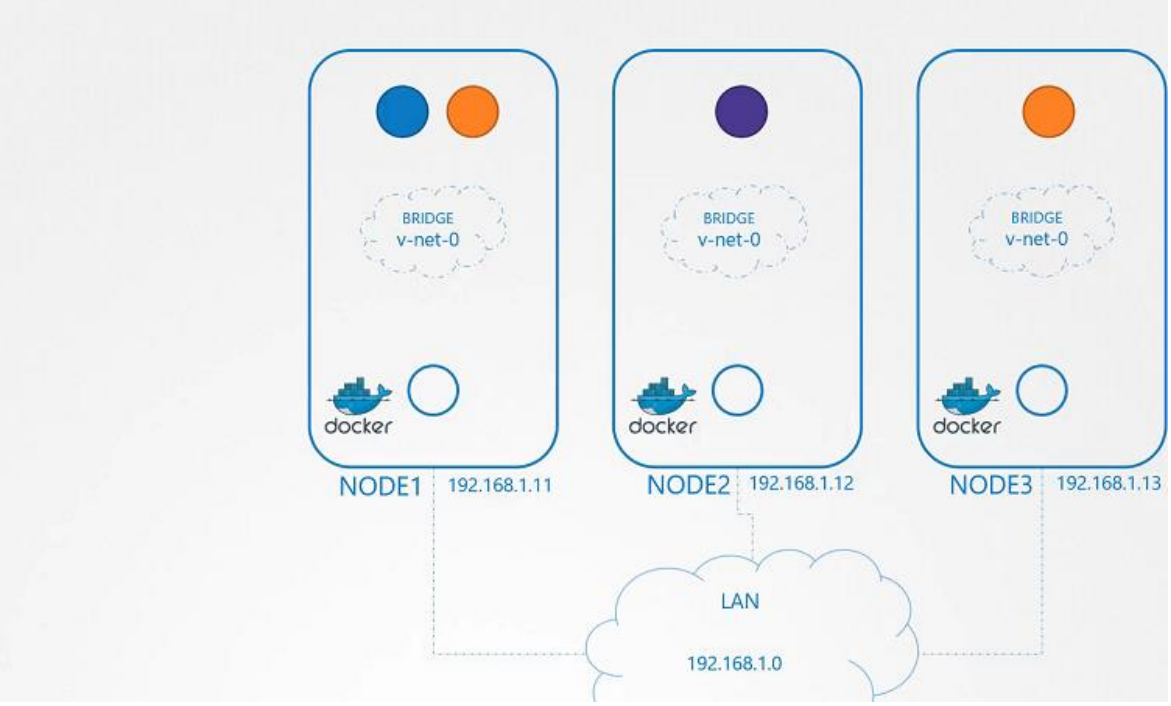
- Currently it's down, turn it up.

node01
```
$ ip link set dev v-net-0 up
```
node02
```
$ ip link set dev v-net-0 up
```

node03
```
$ ip link set dev v-net-0 up
```

- Set the IP Addr for the bridge interface

node01
```
$ ip addr add 10.244.1.1/24 dev v-net-0
```
node02
```
$ ip addr add 10.244.2.1/24 dev v-net-0
```
node03
```
$ ip addr add 10.244.3.1/24 dev v-net-0
```



- Check the reachability

```
$ ping 10.244.2.2
Connect: Network is unreachable
```

- Add route in the routing table

```
$ ip route add 10.244.2.2 via 192.168.1.12
```
node01
```
$ ip route add 10.244.2.2 via 192.168.1.12

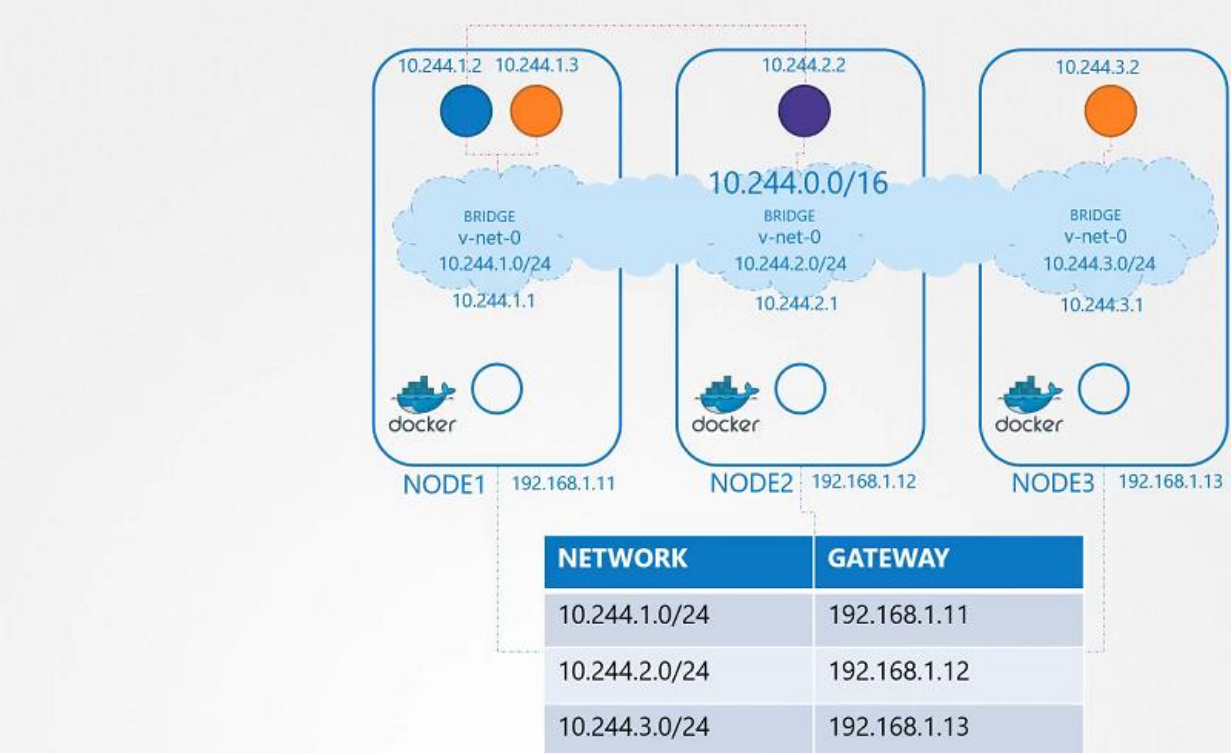
$ ip route add 10.244.3.2 via 192.168.1.13
```
node02
```
$ ip route add 10.244.1.2 via 192.168.1.11

$ ip route add 10.244.3.2 via 192.168.1.13
```

node03
```
$ ip route add 10.244.1.2 via 192.168.1.11
```

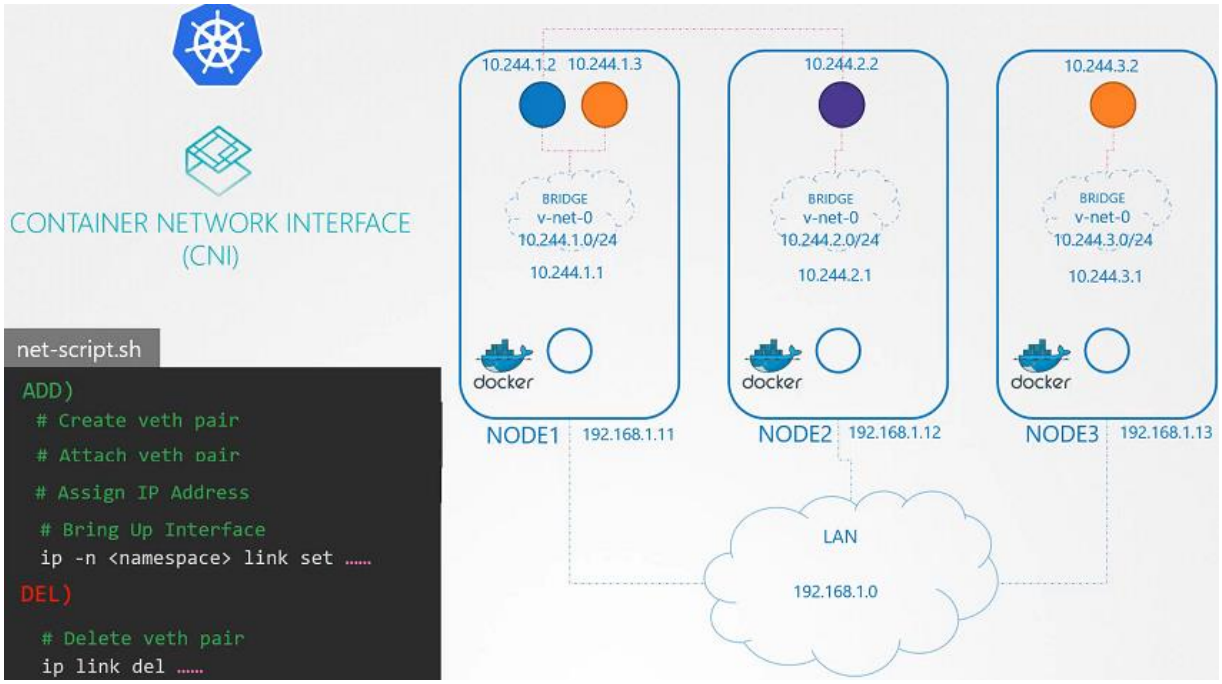
```
$ ip route add 10.244.2.2 via 192.168.1.12
```

- Add a single large network



NETWORK	GATEWAY
10.244.1.0/24	192.168.1.11
10.244.2.0/24	192.168.1.12
10.244.3.0/24	192.168.1.13

Container Network Interface



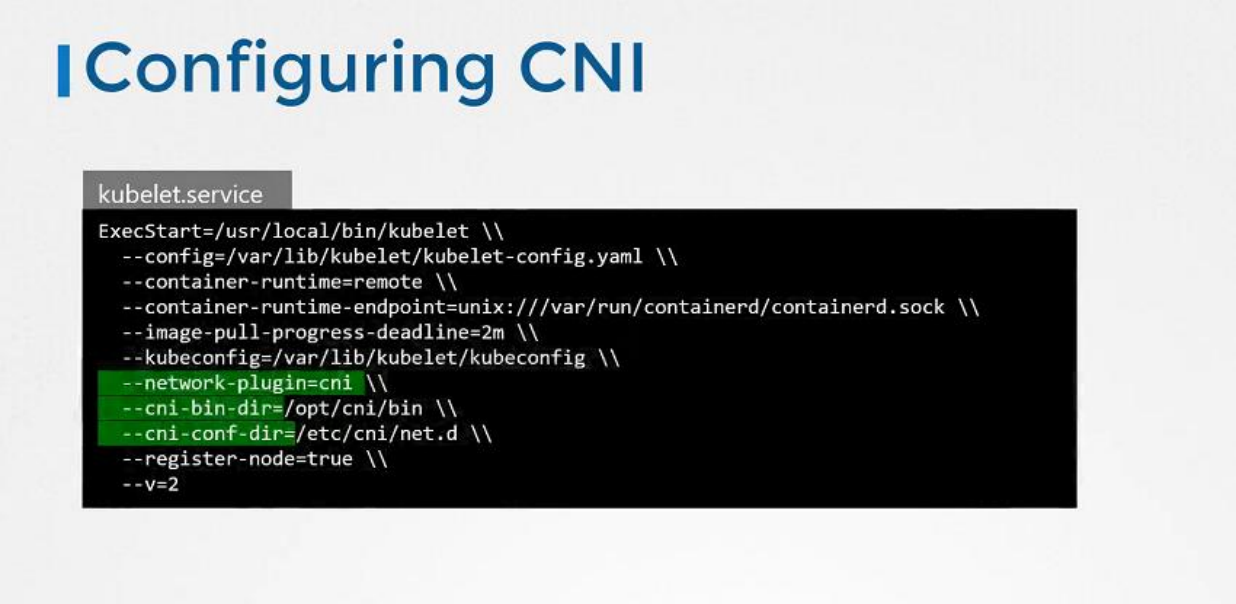
References Docs

- https://kubernetes.io/docs/concepts/workloads/pods/

CNI in Kubernetes

In this section, we will take a look at **Container Networking Interface (CNI) in Kubernetes**

Configuring CNI



- Check the status of the Kubelet Service

```
$ systemctl status kubelet.service
```

View Kubelet Options

```
$ ps -aux | grep kubelet
```

Check the Supportable Plugins

- To check the all supportable plugins available in the `/opt/cni/bin` directory.

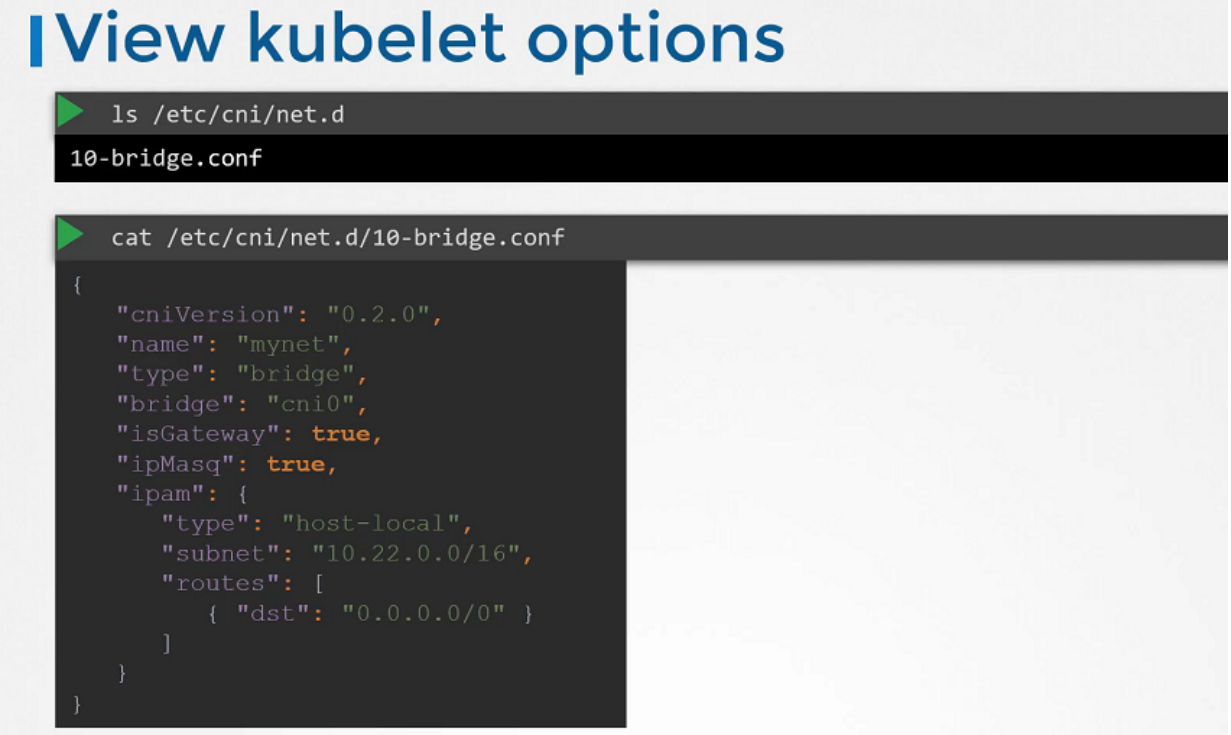
```
$ ls /opt/cni/bin
```

Check the CNI Plugins

- To check the cni plugins which kubelet needs to be used.

```
ls /etc/cni/net.d
```

Format of Configuration File



References Docs

- https://kubernetes.io/docs/reference/command-line-tools-reference/kubelet/
- https://kubernetes.io/docs/concepts/extend-kubernetes/compute-storage-net/network-plugins/

CNI weave

In this section, we will take a look at "CNI Weave in the Kubernetes Cluster"

Deploy Weave

- Installing weave net onto the Kubernetes cluster with a single command.

```
$ kubectl apply -f "https://cloud.weave.works/k8s/net?k8s-version=$(kubectl
version | base64 | tr -d '\n')"
serviceaccount/weave-net created
clusterrole.rbac.authorization.k8s.io/weave-net created
clusterrolebinding.rbac.authorization.k8s.io/weave-net created
role.rbac.authorization.k8s.io/weave-net created
rolebinding.rbac.authorization.k8s.io/weave-net created
daemonset.apps/weave-net created
```

Weave Peers

```
$ kubectl get pods -n kube-system
NAME                                    READY   STATUS             RESTARTS
AGE
coredns-66bff467f8-894jf                1/1     Running            0
52m
coredns-66bff467f8-nck5f                1/1     Running            0
52m
etcd-controlplane                       1/1     Running            0
52m
kube-apiserver-controlplane             1/1     Running            0
52m
kube-controller-manager-controlplane    1/1     Running            0
52m
kube-keepalived-vip-mbr7d               1/1     Running            0
52m
kube-proxy-p2mld                        1/1     Running            0
52m
kube-proxy-vjcwp                        1/1     Running            0
52m
kube-scheduler-controlplane             1/1     Running            0
52m
weave-net-jgr8x                         2/2     Running            0
45m
weave-net-tb9tz                         2/2     Running            0
45m
```

View the logs of Weave Pod's

```
$ kubectl logs weave-net-tb9tz weave -n kube-system
```

View the default route in the Pod

```
$ kubectl run test --image=busybox --command -- sleep 4500
pod/test created

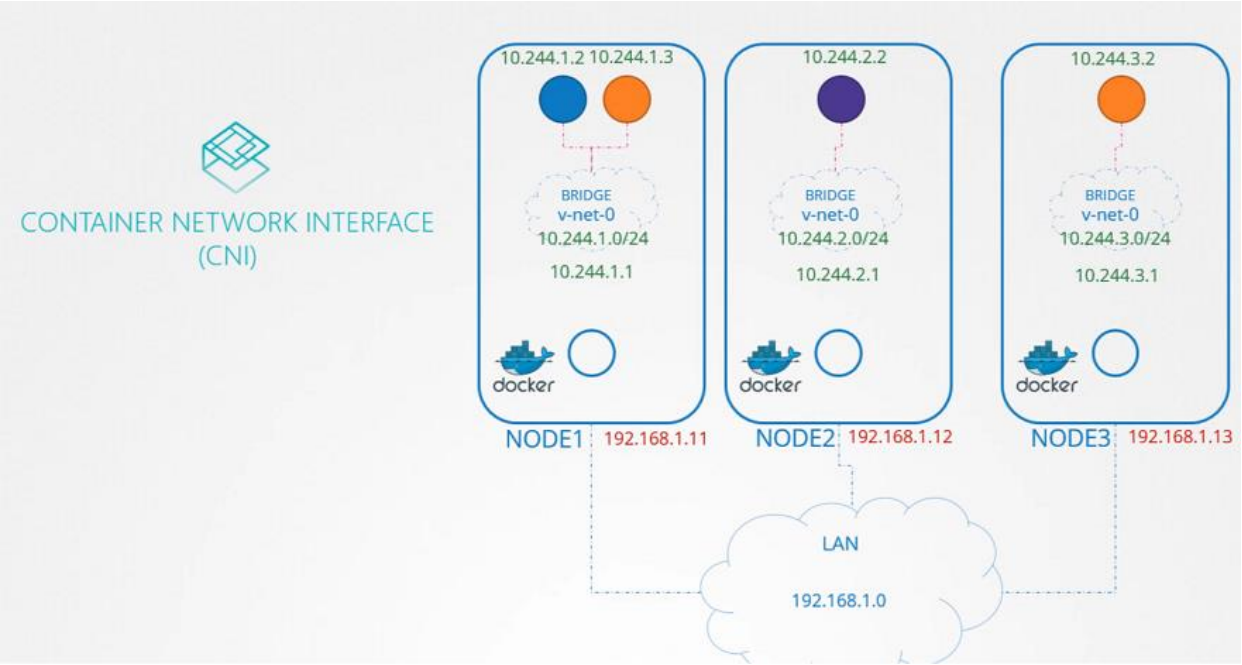
$ kubectl exec test -- ip route
default via 10.244.1.1 dev eth0
```

References Docs

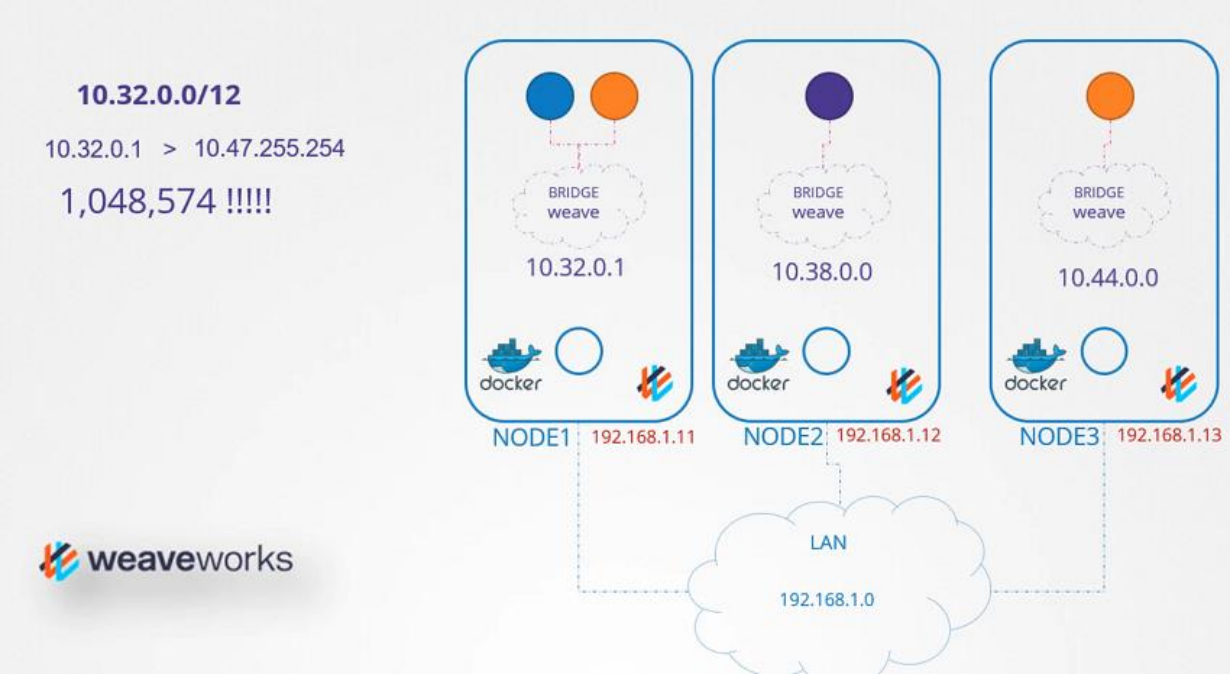
- https://kubernetes.io/docs/concepts/cluster-administration/addons/
- https://www.weave.works/docs/net/latest/kubernetes/kube-addon/

IPAM weave

- IP Address Management in the Kubernetes Cluster



- How weaveworks Manages IP addresses in the Kubernetes Cluster



References Docs

- https://www.weave.works/docs/net/latest/kubernetes/kube-addon/
- https://kubernetes.io/docs/concepts/cluster-administration/networking/

DNS in Kubernetes

In this section, we will take a look at **DNS in the Kubernetes Cluster**

Pod DNS Record

- The following DNS resolution:

```
<POD-IP-ADDRESS>.<namespace-name>.pod.cluster.local
```

Example

```
# Pod is located in a default namespace

10-244-1-10.default.pod.cluster.local
# To create a namespace
$ kubectl create ns apps

# To create a Pod
$ kubectl run nginx --image=nginx --namespace apps

# To get the additional information of the Pod in the namespace "apps"
$ kubectl get po -n apps -owide
NAME    READY   STATUS    RESTARTS   AGE   IP           NODE     NOMINATED NODE
READINESS GATES
nginx   1/1     Running   0          99s   10.244.1.3   node01   <none>
<none>

# To get the dns record of the nginx Pod from the default namespace
$ kubectl run -it test --image=busybox:1.28 --rm --restart=Never -- nslookup 10-
244-1-3.apps.pod.cluster.local
Server:    10.96.0.10
Address 1: 10.96.0.10 kube-dns.kube-system.svc.cluster.local

Name:      10-244-1-3.apps.pod.cluster.local
Address 1: 10.244.1.3
pod "test" deleted

# Accessing with curl command
$ kubectl run -it nginx-test --image=nginx --rm --restart=Never -- curl -Is
http://10-244-1-3.apps.pod.cluster.local
HTTP/1.1 200 OK
Server: nginx/1.19.2
```

Service DNS Record

- The following DNS resolution:

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

Example

```
# Service is located in a default namespace

web-service.default.svc.cluster.local
```

- Pod, Service is located in the `apps` namespace

```
# Expose the nginx Pod
```

```
$ kubectl expose pod nginx --name=nginx-service --port 80 --namespace apps
service/nginx-service exposed

# Get the nginx-service in the namespace "apps"
$ kubectl get svc -n apps
NAME            TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
nginx-service   ClusterIP   10.96.120.174   <none>        80/TCP    6s

# To get the dns record of the nginx-service from the default namespace
$ kubectl run -it test --image=busybox:1.28 --rm --restart=Never -- nslookup
nginx-service.apps.svc.cluster.local
Server:    10.96.0.10
Address 1: 10.96.0.10 kube-dns.kube-system.svc.cluster.local

Name:      nginx-service.apps.svc.cluster.local
Address 1: 10.96.120.174 nginx-service.apps.svc.cluster.local
pod "test" deleted

# Accessing with curl command
$ kubectl run -it nginx-test --image=nginx --rm --restart=Never -- curl -Is
http://nginx-service.apps.svc.cluster.local
HTTP/1.1 200 OK
Server: nginx/1.19.2
```

References Docs

- https://kubernetes.io/docs/concepts/services-networking/dns-pod-service/
- https://kubernetes.io/docs/tasks/administer-cluster/dns-debugging-resolution/

CoreDNS in Kubernetes

In this section, we will take a look at **CoreDNS in the Kubernetes**

To view the Pod

```
$ kubectl get pods -n kube-system
NAME                                   READY   STATUS    RESTARTS   AGE
coredns-66bff467f8-2vghh               1/1     Running   0          53m
coredns-66bff467f8-t5nzm               1/1     Running   0          53m
```

To view the Deployment

```
$ kubectl get deployment -n kube-system
NAME                   READY   UP-TO-DATE   AVAILABLE   AGE
coredns                2/2     2            2           53m
```

To view the configmap of CoreDNS

```
$ kubectl get configmap -n kube-system
NAME                                 DATA   AGE
```

```
coredns                                 1      52m
```

CoreDNS Configuration File

```
$ kubectl describe cm coredns -n kube-system

Corefile:
---
.:53 {
    errors
    health {       lameduck 5s
    }
    ready
    kubernetes cluster.local in-addr.arpa ip6.arpa {
       pods insecure
       fallthrough in-addr.arpa ip6.arpa
       ttl 30
    }
    prometheus :9153
    forward . /etc/resolv.conf
    cache 30
    loop
    reload
}
```

To view the Service

```
$ kubectl get service -n kube-system
NAME       TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)                  AGE
kube-dns   ClusterIP   10.96.0.10   <none>        53/UDP,53/TCP,9153/TCP   62m
```

To view Configuration into the kubelet

```
$ cat /var/lib/kubelet/config.yaml | grep -A2  clusterDNS
clusterDNS:
- 10.96.0.10
clusterDomain: cluster.local
```

To view the fully qualified domain name

- With the `host` command, we will get fully qualified domain name (FQDN).

```
$ host web-service
web-service.default.svc.cluster.local has address 10.106.112.101

$ host web-service.default
web-service.default.svc.cluster.local has address 10.106.112.101

$ host web-service.default.svc
web-service.default.svc.cluster.local has address 10.106.112.101

$ host web-service.default.svc.cluster.local
web-service.default.svc.cluster.local has address 10.106.112.101
```

To view the `/etc/resolv.conf` file

```
$ kubectl run -it --rm --restart=Never test-pod --image=busybox -- cat
/etc/resolv.conf
nameserver 10.96.0.10
search default.svc.cluster.local svc.cluster.local cluster.local
options ndots:5
pod "test-pod" deleted
```

Resolve the Pod

```
$ kubectl get pods -o wide
NAME      READY   STATUS    RESTARTS   AGE     IP           NODE     NOMINATED
NODE   READINESS GATES
test-pod   1/1     Running   0          11m     10.244.1.3   node01   <none>
<none>
nginx      1/1     Running   0          10m     10.244.1.4   node01   <none>
<none>

$ kubectl exec -it test-pod -- nslookup 10-244-1-4.default.pod.cluster.local
Server:    10.96.0.10
Address 1: 10.96.0.10 kube-dns.kube-system.svc.cluster.local

Name:      10-244-1-4.default.pod.cluster.local
Address 1: 10.244.1.4
```

Resolve the Service

```
$ kubectl get service
NAME          TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)   AGE
kubernetes    ClusterIP   10.96.0.1        <none>        443/TCP   85m
web-service   ClusterIP   10.106.112.101   <none>        80/TCP    9m

$ kubectl exec -it test-pod -- nslookup web-service.default.svc.cluster.local
Server:    10.96.0.10
Address 1: 10.96.0.10 kube-dns.kube-system.svc.cluster.local

Name:      web-service.default.svc.cluster.local
Address 1: 10.106.112.101 web-service.default.svc.cluster.local
```

References Docs

- https://kubernetes.io/docs/concepts/services-networking/dns-pod-service/#services
- https://kubernetes.io/docs/concepts/services-networking/dns-pod-service/#pods

Ingress

In this section, we will take a look at **Ingress**

- Ingress Controller
- Ingress Resources

Ingress Controller

- Deployment of **Ingress Controller**

ConfigMap

```
kind: ConfigMap
apiVersion: v1
metadata:
  name: nginx-configuration
```

Deployment

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: ingress-controller
spec:
  replicas: 1
  selector:
    matchLabels:
      name: nginx-ingress
  template:
    metadata:
      labels:
        name: nginx-ingress
    spec:
      serviceAccountName: ingress-serviceaccount
      containers:
        - name: nginx-ingress-controller
          image: quay.io/kubernetes-ingress-controller/nginx-ingress-
controller:0.21.0
          args:
            - /nginx-ingress-controller
            - --configmap=$(POD_NAMESPACE)/nginx-configuration
          env:
            - name: POD_NAME
              valueFrom:
                fieldRef:
                  fieldPath: metadata.name
            - name: POD_NAMESPACE
              valueFrom:
                fieldRef:
                  fieldPath: metadata.namespace
          ports:
            - name: http
              containerPort: 80
            - name: https
              containerPort: 443
```

ServiceAccount

- ServiceAccount require for authentication purposes along with correct Roles, ClusterRoles and RoleBindings.

- Create a ingress service account

```
$ kubectl create -f ingress-sa.yaml
serviceaccount/ingress-serviceaccount created
```

Service Type - NodePort

```
# service-Nodeport.yaml

apiVersion: v1
kind: Service
metadata:
  name: ingress
spec:
  type: NodePort
  ports:
  - port: 80
    targetPort: 80
    protocol: TCP
    name: http
  - port: 443
    targetPort: 443
    protocol: TCP
    name: https
  selector:
    name: nginx-ingress
```

- Create a service

```
$ kubectl create -f service-Nodeport.yaml
```

- To get the service

```
$ kubectl get service
```

Ingress Resources

```
Ingress-wear.yaml

apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: ingress-wear
spec:
     backend:
        serviceName: wear-service
        servicePort: 80
```

- To create the ingress resource

```
$ kubectl create -f Ingress-wear.yaml
ingress.extensions/ingress-wear created
```

- To get the ingress

```
$ kubectl get ingress
NAME           CLASS    HOSTS   ADDRESS   PORTS   AGE
ingress-wear   <none>   *                 80      18s
```

Ingress Resource - Rules

- 1 Rule and 2 Paths.

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: ingress-wear-watch
spec:
  rules:
  - http:
      paths:
      - path: /wear
        backend:
          serviceName: wear-service
          servicePort: 80
      - path: /watch
        backend:
          serviceName: watch-service
          servicePort: 80
```

- Describe the earlier created ingress resource

```
$ kubectl describe ingress ingress-wear-watch
Name:             ingress-wear-watch
Namespace:        default
Address:
Default backend:  default-http-backend:80 (<none>)
Rules:
  Host        Path  Backends
  ----        ----  --------
  *
              /wear    wear-service:80 (<none>)
              /watch   watch-service:80 (<none>)
Annotations:  <none>
Events:
  Type    Reason  Age   From                      Message
  ----    ------  ----  ----                      -------
  Normal  CREATE  23s   nginx-ingress-controller  Ingress default/ingress-wear-
watch
```

- 2 Rules and 1 Path each.

```
# Ingress-wear-watch.yaml

apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: ingress-wear-watch
spec:
  rules:
```

```
  - host: wear.my-online-store.com
    http:
      paths:
      - backend:
          serviceName: wear-service
          servicePort: 80
  - host: watch.my-online-store.com
    http:
      paths:
      - backend:
          serviceName: watch-service
          servicePort: 80
```

References Docs

- https://kubernetes.io/docs/concepts/services-networking/ingress/
- https://kubernetes.io/docs/concepts/services-networking/ingress-controllers/
- https://thenewstack.io/kubernetes-ingress-for-beginners/

Ingress Annotations and rewrite-target

In this section, we will take a look at **Ingress annotations and rewrite-target**

- Different Ingress controllers have different options to customize the way it works. Nginx Ingress Controller has many options but we will take a look into the one of the option "Rewrite Target" option.

- Kubernetes Version 1.18

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: test-ingress
  namespace: critical-space
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - http:
      paths:
      - path: /pay
        backend:
          serviceName: pay-service
          servicePort: 8282
```

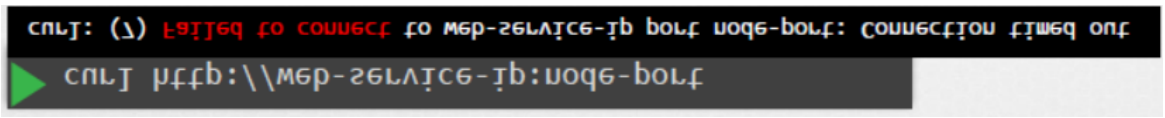
Reference Docs

- https://kubernetes.github.io/ingress-nginx/user-guide/nginx-configuration/annotations/
- https://kubernetes.github.io/ingress-nginx/examples/

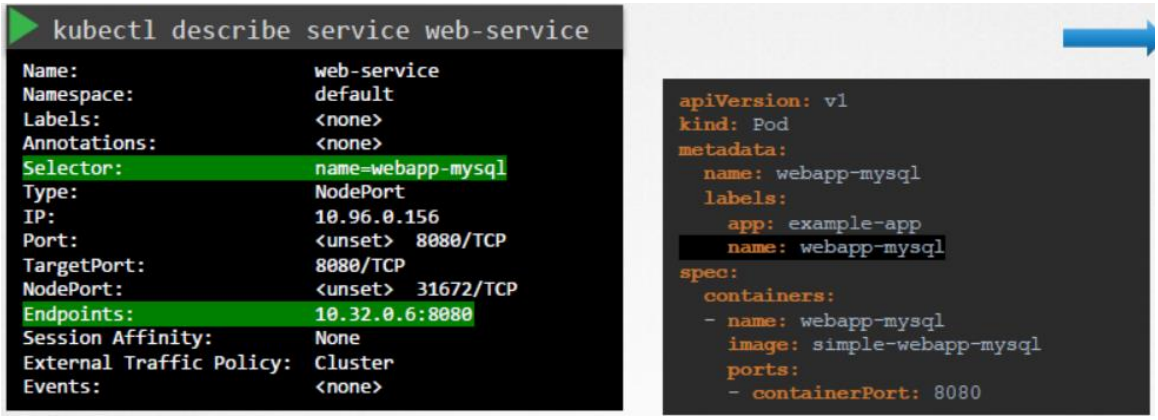
- https://kubernetes.github.io/ingress-nginx/examples/rewrite/
- https://github.com/kubernetes/ingress-nginx/blob/master/docs/troubleshooting.md

Application Failure

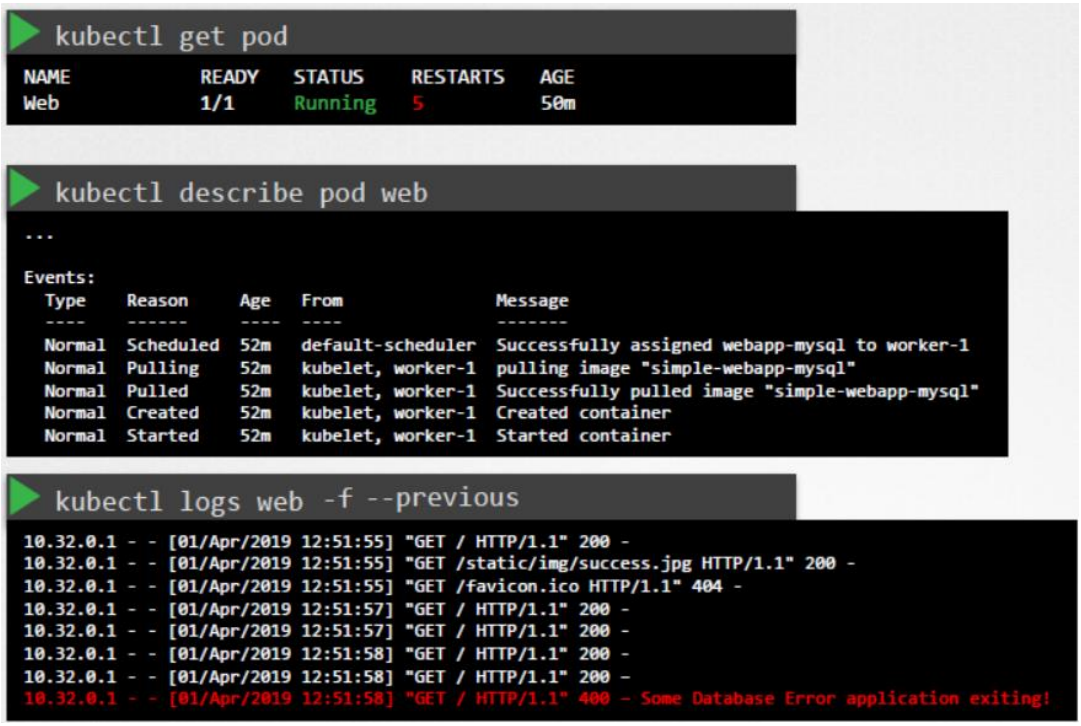
- In this lecture we will go step by step in troubleshooting Application failure.
- To check the Application/Service status of the webserver
- `curl http://web-service-ip:node-port`



- To check the endpoint of the service and compare it with the selectors
- `kubectl describe service web-service`



- To check the status and logs of the pod
- `kubectl get pod`
- `kubectl describe pod web`
- `kubectl logs web`
- To check the logs of the previous pod
- `kubectl logs web -f --previous`



Hands on Labs

- Lets Troubleshoot the Application

Control Plane Failure

- In this lecture we will use how to troubleshoot the Control Plane components.
- To check the status of the nodes if they are healthy
- `kubectl get nodes`
- To check the status of the pods if the are running
- `kubectl get pods`
- To check the status of all the pods of the Control Plane components(if they are deployed with kubeadm tool) and make sure they are **`Running`**
- `kubectl get pods -n kube-system`

```
kubectl get pods -n kube-system
NAME                              READY     STATUS    RESTARTS   AGE
coredns-78fcdf6894-5dntv          1/1       Running   0          1h
coredns-78fcdf6894-knpzl          1/1       Running   0          1h
etcd-master                       1/1       Running   0          1h
kube-apiserver-master             1/1       Running   0          1h
kube-controller-manager-master    1/1       Running   0          1h
kube-proxy-fvbpj                  1/1       Running   0          1h
kube-proxy-v5r2t                  1/1       Running   0          1h
kube-scheduler-master             1/1       Running   0          1h
weave-net-7kd52                   2/2       Running   1          1h
weave-net-jtl5m                   2/2       Running   1          1h
```

- If the Control Plane components are deployed as services then check the status of all the components

```
service kube-apiserver status
● kube-apiserver.service - Kubernetes API Server
   Loaded: loaded (/etc/systemd/system/kube-apiserver.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2019-03-20 07:57:25 UTC; 1 weeks 1 days ago
     Docs: https://github.com/kubernetes/kubernetes
 Main PID: 15767 (kube-apiserver)
    Tasks: 13 (limit: 2362)
```

```
service kube-controller-manager status
● kube-controller-manager.service - Kubernetes Controller Manager
   Loaded: loaded (/etc/systemd/system/kube-controller-manager.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2019-03-20 07:57:25 UTC; 1 weeks 1 days ago
     Docs: https://github.com/kubernetes/kubernetes
 Main PID: 15771 (kube-controller)
    Tasks: 10 (limit: 2362)
```

```
service kube-scheduler status
● kube-scheduler.service - Kubernetes Scheduler
   Loaded: loaded (/etc/systemd/system/kube-scheduler.service; enabled; vendor preset: enabled)
   Active: active (running) since Fri 2019-03-29 01:45:32 UTC; 11min ago
     Docs: https://github.com/kubernetes/kubernetes
 Main PID: 28390 (kube-scheduler)
    Tasks: 10 (limit: 2362)
```

- To check the status of **kube-apiserver**
- `service kube-apiserver status`
- To check the status of **kube-controller-manager**
- `service kube-controller-manager status`
- To check the status of **kube-scheduler**
- `service kube-scheduler status`

```
service kubelet status
● kubelet.service - Kubernetes Kubelet
   Loaded: loaded (/etc/systemd/system/kubelet.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2019-03-20 14:22:06 UTC; 1 weeks 1 days ago
     Docs: https://github.com/kubernetes/kubernetes
 Main PID: 1281 (kubelet)
    Tasks: 24 (limit: 1152)

service kube-proxy status
● kube-proxy.service - Kubernetes Kube Proxy
   Loaded: loaded (/etc/systemd/system/kube-proxy.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2019-03-20 14:21:54 UTC; 1 weeks 1 days ago
     Docs: https://github.com/kubernetes/kubernetes
 Main PID: 794 (kube-proxy)
    Tasks: 7 (limit: 1152)
```

- To check the status of **kubelet**
- `service kubelet status`
- To check the status of **kube-proxy** on the worker nodes.
- `service kube-proxy status`

- To check the logs of the Control Plane components deployed as Pods:

- `kubectl logs kube-apiserver-master -n kube-system`

```
kubectl logs kube-apiserver-master -n kube-system
I0401 13:45:38.190735       1 server.go:703] external host was not specified, using 172.17.0.117
I0401 13:45:38.194290       1 server.go:145] Version: v1.11.3
I0401 13:45:38.819705       1 plugins.go:158] Loaded 8 mutating admission controller(s) successfully in the following order:
NamespaceLifecycle,LimitRanger,ServiceAccount,NodeRestriction,Priority,DefaultTolerationSeconds,DefaultStorageClass,MutatingAdmissionWebhook.
I0401 13:45:38.819741       1 plugins.go:161] Loaded 6 validating admission controller(s) successfully in the following order:
LimitRanger,ServiceAccount,Priority,PersistentVolumeClaimResize,ValidatingAdmissionWebhook,ResourceQuota.
I0401 13:45:38.821372       1 plugins.go:158] Loaded 8 mutating admission controller(s) successfully in the following order:
NamespaceLifecycle,LimitRanger,ServiceAccount,NodeRestriction,Priority,DefaultTolerationSeconds,DefaultStorageClass,MutatingAdmissionWebhook.
I0401 13:45:38.821410       1 plugins.go:161] Loaded 6 validating admission controller(s) successfully in the following order:
LimitRanger,ServiceAccount,Priority,PersistentVolumeClaimResize,ValidatingAdmissionWebhook,ResourceQuota.
I0401 13:45:38.985453       1 master.go:234] Using reconciler: lease
W0401 13:45:40.900380       1 genericapiserver.go:319] Skipping API batch/v2alpha1 because it has no resources.
W0401 13:45:41.370677       1 genericapiserver.go:319] Skipping API rbac.authorization.k8s.io/v1alpha1 because it has no resources.
W0401 13:45:41.381736       1 genericapiserver.go:319] Skipping API scheduling.k8s.io/v1alpha1 because it has no resources.

sudo journalctl -u kube-apiserver
Mar 20 07:57:25 master-1 systemd[1]: Started Kubernetes API Server.
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.553377   15767 flags.go:33] FLAG: --address="127.0.0.1"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558273   15767 flags.go:33] FLAG: --admission-control="[]"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558325   15767 flags.go:33] FLAG: --admission-control-config-file=""
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558339   15767 flags.go:33] FLAG: --advertise-address="192.168.5.11"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558353   15767 flags.go:33] FLAG: --allow-privileged="true"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558365   15767 flags.go:33] FLAG: --alsologtostderr="false"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558413   15767 flags.go:33] FLAG: --anonymous-auth="true"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558425   15767 flags.go:33] FLAG: --api-audiences="[]"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558442   15767 flags.go:33] FLAG: --apiserver-count="3"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558454   15767 flags.go:33] FLAG: --audit-dynamic-configuration="false"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558464   15767 flags.go:33] FLAG: --audit-log-batch-buffer-size="10000"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558474   15767 flags.go:33] FLAG: --audit-log-batch-max-size="1"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558484   15767 flags.go:33] FLAG: --audit-log-batch-max-wait="0s"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558495   15767 flags.go:33] FLAG: --audit-log-batch-throttle-burst="0"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558504   15767 flags.go:33] FLAG: --audit-log-batch-throttle-enable="false"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558514   15767 flags.go:33] FLAG: --audit-log-batch-throttle-qps="0"
Mar 20 07:57:25 master-1 kube-apiserver[15767]: I0320 07:57:25.558528   15767 flags.go:33] FLAG: --audit-log-format="json"
```

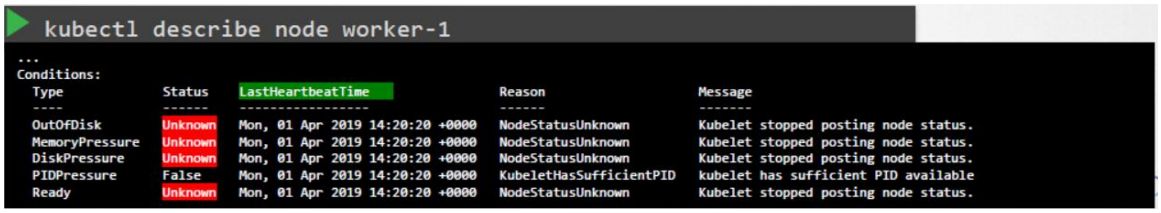
- To check the logs of the Control Plane components deployed as SystemD Service

  `sudo journalctl -u kube-apiserver`

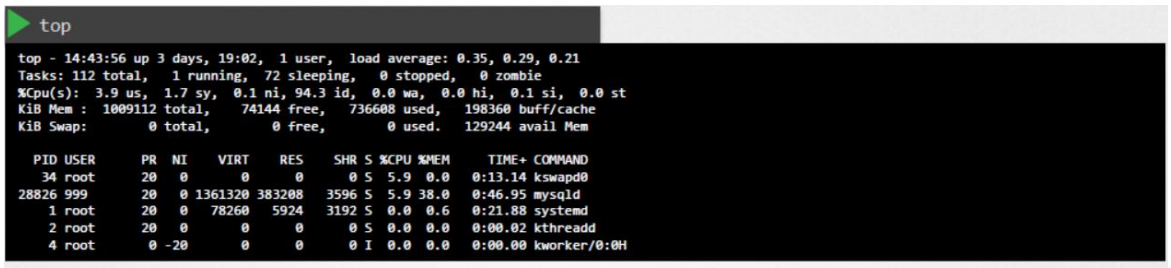
Worker Node Failure

- Lets check the status of the Nodes in the cluster, are they **Ready** or **NotReady**
- `kubectl get nodes`

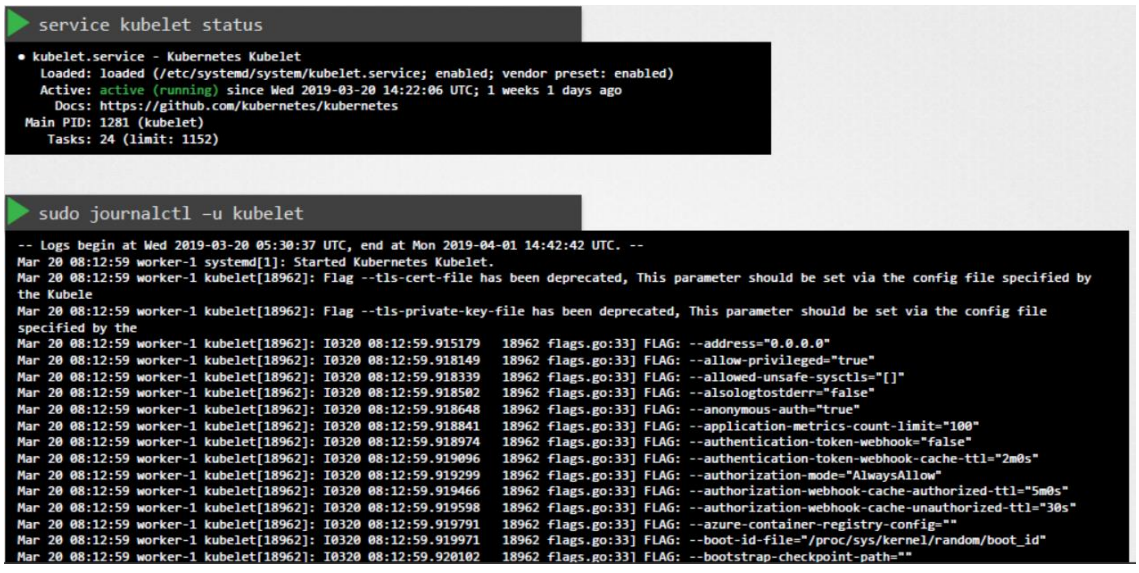
- If they are **`NotReady`** then check the **`LastHeartbeatTime`** of the node to find out the time when node might have crashed
- `kubectl describe node worker-1`



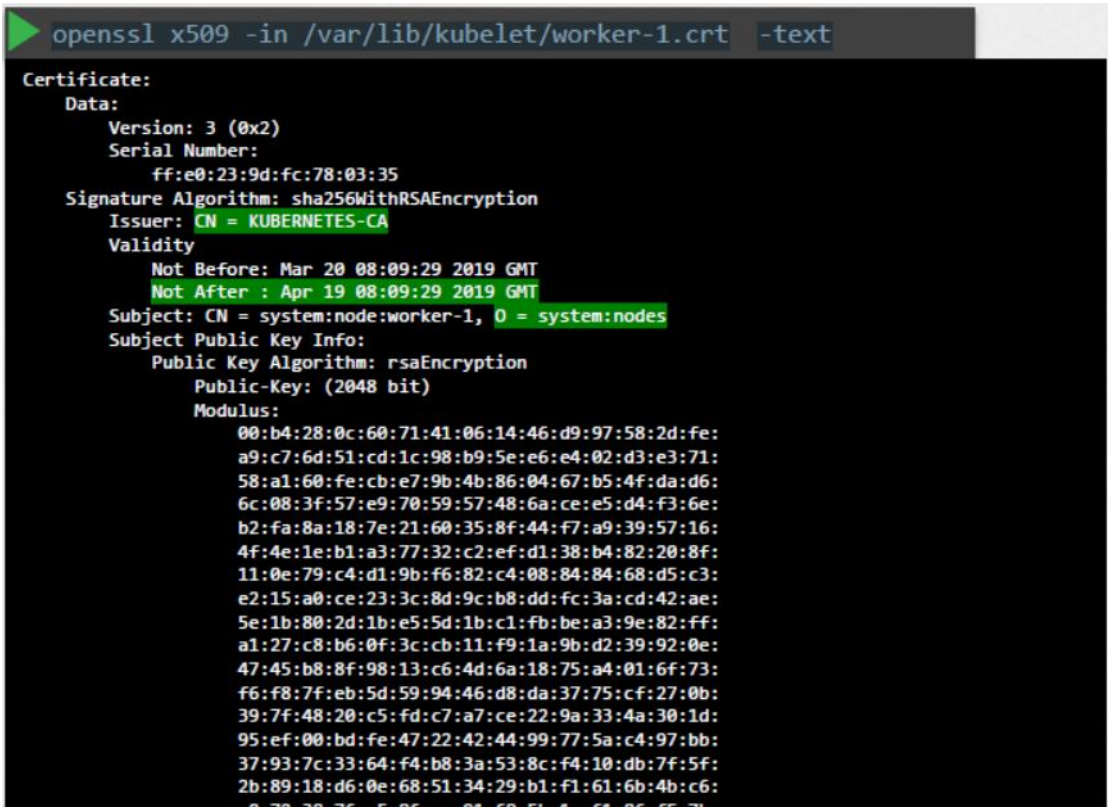
- Check the possible **`CPU`** and **`MEMORY`** using **`top`** and **`df -h`**



- Check the status and the logs of the **`kubelet`** for the possible issues.
- `serivce kubelet status`
- `sudo journalctl –u kubelet`



- Check the **`kubelet`** Certificates, they are not expired, and in the right group and issued by the right CA.
- `openssl x509 -in /var/lib/kubelet/worker-1.crt -text`



Advance Kubectl Commands

- To get the output of **`kubectl`** in a json format:
- `kubectl get nodes -o json`
- `kubectl get pods -o json`

- To get the image name used by pod via json path query:
- `kubectl get pods -o=jsonpath='{.items[0].spec.containers[0].image}'`
- To get the names of node in the cluster:
- `kubectl get pods -o=jsonpath='{.items[*].metadata.name}'`

- To get the architecture of node in the cluster:
- `kubectl get pods -o=jsonpath='{.items[*].status.nodeInfo.architecture}'`
- To get the count of the cpu of node in the cluster:
- `kubectl get pods -o=jsonpath='{.items[*].status.status.capacity.cpu}'`

Loops - Range

- To print the output in a separate column (one column with node name and other with CPU count):

- ```
  kubectl get nodes -o=custom-columns=NODE:.metadata.name
  ,CPU:.status.capacity.cpu
  ```

- Kubectl comes with a **`sort by`** property which can be combined with json path query to **`sort`** by name or **`CPU count`**
- `kubectl get nodes --sort-by=.metadata.name`

`kubectl get nodes --sort-by=..status.capacity.cpu`
  ```