CKA

Links

- https://www.cncf.io/certification/cka/
- https://github.com/cncf/curriculum
- https://www.cncf.io/certification/candidate-handbook
- http://training.linuxfoundation.org/go//Important-Tips-CKA-CKAD
- https://github.com/kodekloudhub/certified-kubernetes-administrator-course

Core Concepts

We're going to use an analogy of ships to understand the architecture of Kubernetes.

The purpose of Kubernetes is to host your applications in the form of containers in an automated fashion

so that you can easily deploy as many instances of your application as required and easily enable communication between different services within your application. So there are many things involved that work together to make this possible.

So let's take a 10000 feet look at the Kubernetes architecture.

We have two kinds of ships.

1. *cargo ships* that does the actual work of carrying containers across to sea and
2. *control ships* that are responsible for monitoring and managing the cargo ships.

The **Kubernetes cluster** consists of a set of nodes which may be physical or virtual, on-premise or on cloud, that host applications in the form of containers. These relate to the cargo ships. In this analogy, the worker nodes in the cluster are ships that can load containers.

But somebody needs to load the containers on the ships and not just load plan how to load identify the right ships store information about the ships monitor and track the location of containers on the ships manage the whole loading process etc..

This is done by the control ships that host different offices and departments monitoring equipments communication equipments cranes for moving containers between ships etc.

The control ships relate to the master node in the Kubernetes cluster. The master node is responsible for managing the Kubernetes cluster storing information regarding the different nodes planning which containers cause where monitoring the notes and containers on them etc. *The Master node does all of these using a set of components together known as the control plane components.*

Now there are many containers being loaded and unloaded from the ships on a daily basis. And so you need to **maintain information about** the different ships **what container is on which ship and what time it was loaded** etc. **All of these are stored in a highly available key value store known as Etcd**. The Etcd is a database that stores information in a key-value format. We will look more into what Etcd cluster actually is what data is stored in it and how it stores the data in one of the upcoming lectures.

When ships arrive you load containers on them using cranes the cranes identify the containers that need to be placed on ships. It identifies the right ship based on its size its capacity the number of containers already on the ship and any other conditions such as the destination of the ship. The type of containers it is allowed to carry etc. So those are **schedulers in a Kubernetes cluster** as scheduler **identifies the right node to place a container on based on the containers**.

Resource requirements the worker nodes capacity or any other policies or constraints such as tents and tolerations or node affinity rules that are on them. We will look at these in much more detail with examples and practice tests later in this course. We have a whole section on scheduling alone.

There are different offices in the dock that are assigned to special tasks or departments. For example the operations team takes care of ship handling traffic control etc. they deal with issues related to damages the routes the different ship state etc. The cargo team takes care of containers when continuous are damaged or destroyed. They make sure new containers are made available. You have these services office that takes care of the I.T. and communications between different ships. Similarly, in Kubernetes we have controllers available that take care of different areas.

The **node-controller** takes care of nodes. They're responsible for onboarding new nodes to the cluster handling situations where nodes become unavailable or get destroyed and the replication controller ensures that the desired number of containers are running at all times in your replication group.

So we have seen different components like the different offices the different ships the data store the cranes. But *how do these communicate with each other*? How does one office reach the other office and who manages them all at a high level.

The kube-apiserver is the primary management component of kubernetes. The kube-api server is responsible for orchestrating all operations within the cluster. *It exposes the Kubernetes API which is used by externals users to perform management operations* on the cluster as well as the various controllers to monitor the state of the cluster and make the necessary changes as required and by the worker nodes to communicate with the server.

Now we are working with containers here. Containers are everywhere so we need everything to be container compatible. Our applications are in the form of containers the different components that form the entire management system. On the master nodes could be hosted in the form of containers.

The DNS service networking solution can all be deployed in the form of containers. So we need these **software that can run containers and that's the container runtime engine. A popular one being Docker. So we need Docker or it's supported equivalent installed on all the nodes in the cluster including the master nodes.** if you wish to host the control plane components as containers. Now it doesn’t always have to be Docker.

Kubernetes supports other run time engines as well like ContainerD or Rocket.

let's now turn our focus onto the cargo ships. Now every ship has a captain. The captain is responsible for managing all activities on these ships. The captain is responsible for liaising with the master ships starting with letting the master ship know that they are interested in joining the group receiving information about the containers to be loaded on the ship and loading the appropriate containers as required sending reports back to the master about the status of this ship and the status of the containers on the ship etc.

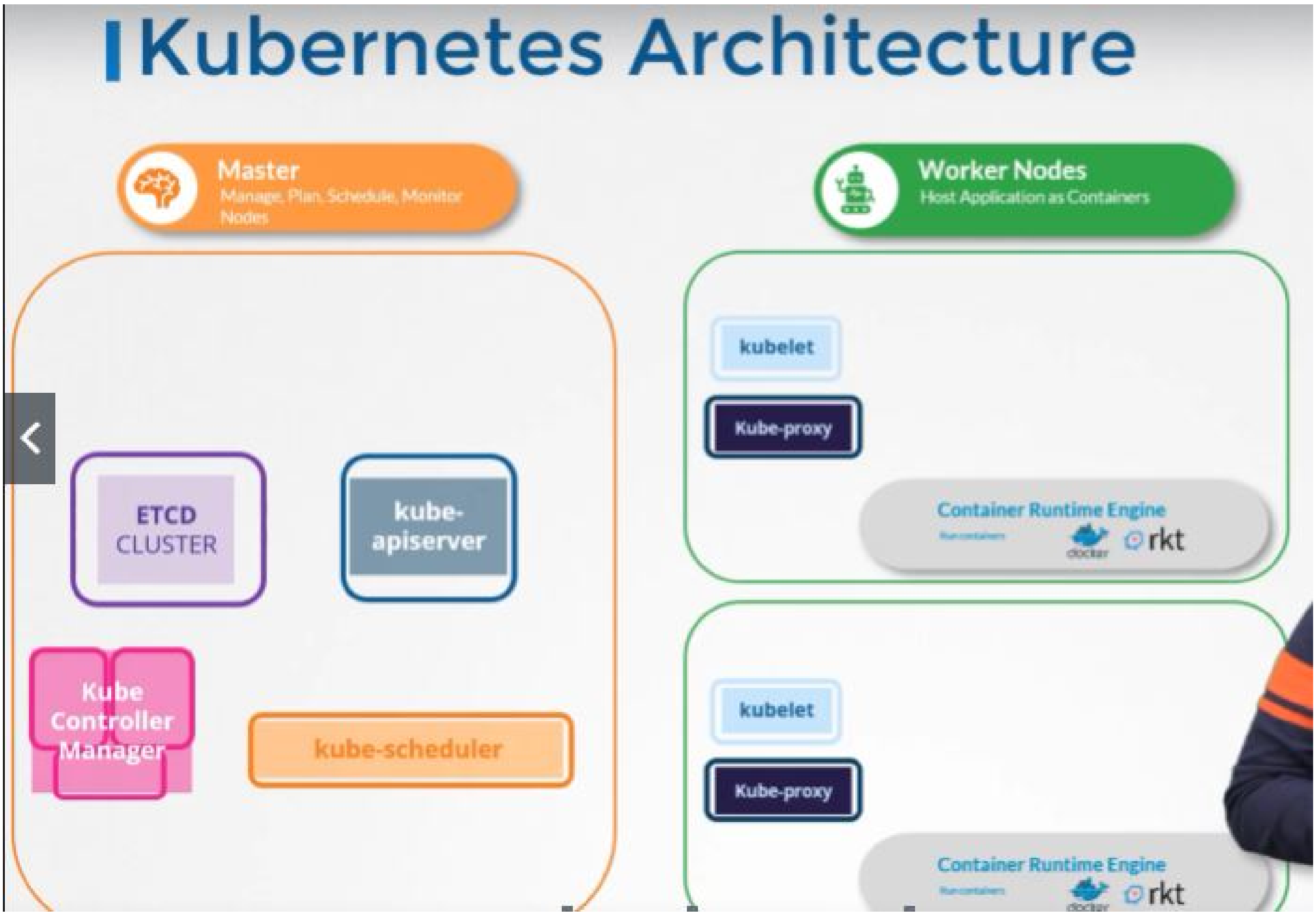
Now the captain of the ship is the **kubelet** in Kubernetes. **A kubelet is an agent that runs on each node in a cluster. It listens for instructions from the kube-api server and deploys or destroys containers on the nodes as required. The kube-api server periodically fetches status reports from the kubelet to monitor the state of nodes and containers on them.**

The kubelet was more of a captain on the ship that manages containers on the ship. But the *applications running on the worker nodes need to be able to communicate with each other*. For example you might have a web server running in one container on one of the nodes and a database server running on another container on another node. How would the web server reach the database server on the other node?

Communication between worker nodes are enabled by another component that runs on the worker node known as the Kube-proxy service. The Kube-proxy service ensures that the necessary rules are in place on the worker nodes to allow the containers running on them to reach each other.

So to summarize we have:

- **master** and **worker nodes**
  - on the master. We have the
    - **ETCD cluster** which stores information about the cluster
    - the **Kube scheduler** that is responsible for scheduling applications or containers on Nodes
    - We have different controllers that take care of different functions like the node control, replication, controller etc..
    - we have the **Kube api server** that is responsible for orchestrating all operations within the cluster.
  - on the worker node.
    - we have the **kubelet** that listens for instructions from the Kube-apiserver and manages containers and
    - the **kube-proxy** That helps in enabling communication between services within the cluster.



So that's a high level overview of the various components.

ETCD in k8s

In this lecture we will talk about ETCD's role in kubernetes.

ETCD is a distributed reliable key-value store that is Simple, Secure & Fast. Used to store and retrieve small chunks of data, such as config data that requires fast read and write.

1. Download binaries
2. extract
3. run ETCD Service; it uses port 2379

etcdctl --> command to interact with etcd key-value store: `etcdctl set key1 value1`. to get data: `etcdctl get key1`.

The ETCD datastore stores information regarding the cluster such as the 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. Every change you make to your cluster, such as adding additional nodes, deploying pods or replica sets are updated in the ETCD server. Only once it is updated in the ETCD server, is the change considered to be complete.

Depending on how you setup your cluster, ETCD is deployed differently. Throughout this section we discuss about two types of kubernetes deployment. One deployed from scratch, and other using kubeadm tool.

The practice test environments are deployed using the kubeadm tool and later in this course when we set up a cluster from scratch so it's good to know the difference between the two methods; if you set up your cluster from scratch then you deploy ETCD by downloading the ETCD binaries yourself, installing the binaries and *configuring ETCD as a service* in your master node yourself. There are many options passed into the service a number of them relate to certificates (we will learn more about these certificates how to create them and how to configure them later in this course - we have a whole sectionon TLS certificates). The others are about configuring ETCD as a cluster.

We will look at those options when we set up high availability in kubernetes the only option to note for now is the **advertised client url**. This is the address on which ETCD listens. It happens to be on the IP of the server and on **port 2379, which is the default port on which etcd listens**. *This is the URL that should be configured on the kube-api server when it tries to reach the etcd server.*

If you setup your cluster using kubeadm then kubeadm deploys the ETCD server for you as a POD in the kube-system namespace. You can explore the etcd database using the *etcdctl* utility within this pod. To list all keys stored by kubernetes, run the `etcdctl get` command like this. Kubernetes stores data in the specific directory structure the root directory is a registry and under that you have the various kubernetes constructs such as minions or nodes, pods, replicasets, deployments etc.

In a high availability environment you will have multiple master nodes in your cluster then you will have multiple ETCD instances spread across the master nodes. In that case, make sure to specify the ETCD instances know about each other by setting the right parameter in the ETCD service configuration. The initial-cluster option is where you must specify the different instances of the ETCD service.

etcdctl can interact with etcd server using 2 API versions, version 2 (default) and version 3.

etcdctl v2	etcdctl v3
etcdctl bakcup	etcdctl snapshot save
etcdctl cluster-health	etcdctl endpopint health
etcdctl mk	etcdctl get
etcdctl mkdir	etcdctl put
etcdctl set	

to set the right version of API, set the environment variable ETCDCTL_API: `export ETCDCTL_API=3`. also, you must specify the path to certificate files so that ETCDCTL can authenticate to the ETCD API server. the certificate files are available in the etcd-master at:

- --cacert /etc/kubernetes/pki/etcd/ca.crt
- --cert /etc/kubernetes/pki/etcd/server.crt
- --key /etc/kubernetes/pki/etcd/server.key

specify etcdctl api version and path certificate files: `kubectl exec etcd-master -n kube-system -- sh -c "ETCDCTL_API=3 etcdctl get / --prefix --keys-only --limit=10 --cacert /etc/kubernetes/pki/etcd/ca.crt --cert /etc/kubernetes/pki/etcd/server.crt --key /etc/kubernetes/pki/etcd/server.key"`

kube-api server

In this lecture we will talk about the Kube-API server in kubernetes.

Earlier we discussed that the Kube-api server is the *primary management component in kubernetes*. When you run a `kubectl command`, **the kubectl utility is infact reaching to the kube-apiserver**. The kube-api server first authenticates the request and validates it. It then retrieves the data from the ETCD cluster and responds back with the requested information.

You don't really need to use the kubectl command line. Instead, you could also invoke the API directly by sending a post request.

let's look at an example of creating a pod. when you do that the request is authenticated first and then validated. In this case:

1. the API server creates a POD object without assigning it to a node,
2. updates the information in the ETCD server
3. updates the user that the POD has been created.
4. The scheduler continuously monitors the API server and realizes that there is a new pod with no node assigned
5. the scheduler identifies the right node to place the new POD on and communicates that information back to the kube-apiserver.
6. The API server then updates the information in the ETCD cluster.
7. The API server then passes that information to the kubelet in appropriate worker node.
8. The kubelet then creates the POD on the node and instructs the container runtime engine to deploy the application image.
9. Once done, the kubelet updates the status back to the API server and
10. the API server then updates the data back in the ETCD cluster.

A similar pattern is followed every time a change is requested. **The kube-apiserver is at the center of all the different tasks that needs to be performed to make a change in the cluster**.

To summarize, the kube-api server is responsible for Authenticating and validating requests, retrieving and updating data in ETCD data store. in fact, *kube-api server is the only component that interacts directly with the etcd datastore*. The other components such as the scheduler, kube-controller-manager & kubelet uses the API server to perform updates in the cluster in their respective areas.

If you bootstrapped your cluster using kubeadm tool then you don't need to know this but if you are setting up the hard way, then kube-apiserver is available as a binary in the kubernetes release page. Download it and configure it to run as a service on your kubernetes master node. The kube-api server is run with a lot of parameters. Throughout this section we are going to take a peak at how to install and configure these individual components of the kubernetes architecture.

You don't have to understand all of the options right now but I think having a high level understanding on some of these now will make it easier later when we configure the whole cluster and all of its components from scratch.

The kubernetes architecture consists of a lot of different components working with each other, talking to each other in many different ways so they all need to know where the other components are. There are different modes of authentication, authorization, encryption and security. And that's why you have so many options.

When we go through the relevant section in the course we will pull up this file and look at the relevant options.

A lot of them are certificates that are used to secure the connectivity between different components.

The option ETCD-servers `etcd-servers=https://127.0.0.1:2379` is where you specify the location of the ETCD servers. This is how the kube-api server connects to the etcd servers.

So how do you view the kube-api server options in an existing cluster? It depends on how you set up your cluster.

If you set it up with kubeadm tool, kubeadm deploys the kube-api server as a pod in the kube-system namespace on the master node you can see the options within the pod definition file located at /etc/kubernetes/manifests folder.

In a non kubeadm setup, we can view the options of the kube-apiserver service located at /etc/systemd/system/kube-apiserver.service.You can also see the running process and the effective options by listing the process on the master node and searching for kube-apiserver `ps aux | grep kube-apiserver`.

kube controller manager

we will talk about Kube Controller Manager.

As we discussed earlier, the kube controller manager manages various controllers in Kubernetes. A controller is like an office or department within the master ship that have their own set of responsibilities. Such as an office for the Ships would be responsible for monitoring and taking necessary actions about the ships. Whenever a new ship arrives or when a ship leaves or gets destroyed another office could be one that manages the containers on the ships they take care of containers that are damaged or full of ships.

So these officers are

1. continuously on the lookout for the status of the ships and
2. take necessary actions to remediate the situation.

In the kubernetes terms a controller is a process that continuously monitors the state of various components within the system and works towards bringing the whole system to the desired functioning state. For example the **node controller** is responsible for monitoring the status of the nodes and taking necessary actions to keep the application running. **It does that through the kube-api server**.

The node controller checks the status of the nodes **every 5 seconds**. That way the node controller can monitor the health of the nodes - if it stops receiving heartbeat from a node the node is marked as **unreachable** but it waits for 40 seconds before marking it unreachable. after a node is marked unreachable it gives it five minutes to come back up - if it doesn't, it removes the PODs assigned to that node and provisions them on the healthy ones if the PODs are part of a replica set

The next controller is the **replication controller**. It is responsible for monitoring the status of replica sets and ensuring that the desired number of PODs are available at all times within the set. *If a pod dies it* *creates another one.*

Now those were just two examples of controllers. There are many more such controllers available within kubernetes. Whatever concepts we have seen so far in kubernetes such as deployments, Services, namespaces, persistent volumes and whatever intelligence is built into these constructs it is implemented through these various controllers.

As you can imagine this is kind of the brain behind a lot of things in kubernetes. Now how do you see these controllers and where are they located in your cluster. *They're all packaged into a single process known as* **kubernetes controller manager**. When you install the kubernetes controller manager the different controllers get installed as well.

So how do you install and view the kubernetes Controller manager? download the kube-controller-manager from the kubernetes release page. Extract it and run it as a service. When you run it as you can see there are a list of options provided this is where you provide additional options to customize your controller.

Remember: some of the default settings for node controller we discussed earlier such as the node monitor period, the grace period and the eviction timeout. These go in here as options.

There is an additional option called controllers that you can use to specify which controllers to enable. By default all of them are enabled but you can choose to enable a select few. So in case any of your controllers don't seem to work or exist this would be a good starting point to look at.

So how do you view the Kube-controller-manager server options? Again it depends on how you set up your cluster.

If you set it up with kubeadm tool, kubeadm deploys the kube-controller-manager as a pod in the kube-system namespace on the master node. You can see the options within the pod definition file located at etc/kubernetes/manifests folder.

In a non-kubeadm setup, you can inspect the options by viewing the kube-controller-manager service located at the services directory. You can also see the running process and the effective options by listing the process on the master node and searching for kube-controller-manager `ps aux | grep kube-controller-manager`.

kube scheduler

Only responsible for deciding which pod goes on which nodes; it doesn't place the pods on the nodes. that's the job of the kubelet; the kubelet, the captain of the ships, is who creates the pods on the ships.

Scheduler is used to decide which nodes the pods are placed on, depending on certain criteria. for instance pod dedicated to a specific application within the cluter.

the scheduler looks at each pods and tries to find the best node for it. for example, cpu requirements. the scheduler

1. filters the nodes that do not fit the profile for a pod
2. ranks the nodes to identify the best fit for the pod - priority function to give a score to the node. it ranks nodes higher based on the amount of resources that would be free if the pod is placed on the node (say, requirement is 10 cpus, and there are 2 nodes, **A** with 12 nodes and **B** with 16 nodes; node B would be ranked higher because there would be 6 free cpus in case the 10 cpu pod is assigned to it)

Installing - download, isntall and run as a service.

kubelet

the kubelet in the worker nodes registers the nodes with the k8s cluster. when it receives instruction to load a container or pod on the nodes, it requests the container runtime engine to pull the required image and run an isntance of it.

The kubelet also monitors the status of the POD and containers in it and reports to the kube-api server.

- register the node
- create PODs
- monitor node and PODs

installing kubectl:

- kubeadm installation method: kubeadm k8s deployment does not install the kubelet.
- manual install - kubelet has to be manually isntalled always - download installer, extract it and run it as a service. `ps aux | grep kubelet`

kube proxy

in a k8s cluster, any pod can reach any other pod - this is accomplished by using a pod networking solution to the cluster. a pod network is an internal virtual network that spans accross all the nodes in the cluster to which all the pods connect to.

it's better to use a service, which maintains the ip address, to ensure communication between nodes and pods.

kube-proxy is a process that runs on each node in the k8s cluster. it's job is to look for new services and each time a new service is created, it creates the appropriate rule to forward traffic to those services to the backend pods by using ip table rules.

download the binaries, install and run as a service. the kubeadm tool deploys kube proxy as a pod, as a daemon set.

pod

containers are encapsulated into a k8s object known as PODs. a POD is a single instance of an application. a POD is the smallest object that you can create in k8s.

PODs usually have a one to one relationship with containers running the app. you do not add additional containers to an existing POD to escale your app; you create a new POD - or delete the POD (escale down). from the outside to the in

1. cluster
2. node
3. pod
4. container

a single POD can have multiple containers, but not multiple containers of the same kind. we might have *helper containers*. supporting tasks for app, processing user data, a file... if a new POD is created, helper container is created as well.

containers can communicate with each other using localhost (loopback nic), same network space, and storage space.

how to deply pods: `kubectl run nginx --image nginx`. it creates a pod and deploys an image of the nginx docker image. it gets the image from the dockerhub repository. it can also be configured to pull images from a local repository.

`kubectl get pods` -- see pods and status - `kubectl describe pod <podname>`

pods with yaml

k8s uses yaml files as inputs for the creation of k8s objects. required structure:

- apiVersion <-- version of the k8s api version we are using to create the object - regularly for working for pods `v1`; for services `v1`, replicaSet `apps/v1`, deployment `apps/v1`
- kind <-- type of object we are trying to create - Pod, Service, ReplicaSet, Deployment
- metadata <-- data about the object, it's *name*, *labels*, etc... form of dictionary
- spec <-- additional info about the object we are creating.

Once the file is done `kubectl create -f <file>`

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
    app: myapp
spec:
  containers:
    - name: nginx-container
      image: nginx
    # - name: backend-container
    #   image: redis
```

replica sets

controllers: the processes that monitor k8s objects and respond accordingly. **Replicatoin Controller**. it helps to run multiple instance of a single pod in the k8s cluster, thus providing HA. even if you have a single pod the replication controller can help by automatically bringing up a new pod when the existing pod fails. the replication controller ensures that the specified number of pod are running at all times.

RC is also used to share the load between containers - RC can create pods on other nodes as well. The replication controller is older technology, being replaced by **replica sets**. replica sets is the new recommended way of setting up replication.

creating a replication controller:

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

- `kubectl create -f <file>`
- `kubectl get replicationcontroller`

what is a replica? a copy of a pod

```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
    spec:
      containers:
        - name: nginx-container
          image: nginx
  replicas: 3
  selector:
    matchLabels:
      type: front-end
```

mayor difference with replication controller is the "selector" field: it identifies what pods fall under it. RS can also manage pods that were not created as part of the rs creation (pods created before applying the replica set). replica sets can be used to monitor existing pods.

- `kubect get replicaset`

Labels and selectors

The role of the replica set is to monitor the pod and in case any on them were to fail, deploy new ones. the rs is a process that monitors the pod. the replica set knows which pod to monitor through the labels attached to pods, defined under the selector field.

to escale the number of replicas, we can simply update the rs config file `kubectl replace -f <file>`; to do this task manually, we can run `kubectl scale --replicas=6 <file>` or `kubectl scale --replicas=6 <type> <rsName>`<-- this does not update the rs definition file.

We can also use `kubectl edit <replicasetName>`, update the configuration there and then delte de pods; as they are being deleted and recreated, they will pick up the new configuration.

deployments

deployments are useful for

- deploying/creating new instances of an application
- updating an application (rolling updates)
- rolling back an update
- multiple changes to the environment (updating and creating new instances) - apply changes after a pause, then continue

deployments are k8s objects that are higher than replicasets. it allows for seamless update of the app.

creating a deployment through a definition file (similar to replica set):

```
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
```

`kubectl create -f <deploymentFile>` <<-- the deployment creates a replica set (get deployments = 1, get replicasets = 1) which create pods.

`kubectl get all`

https://linuxhandbook.com/kubectl-apply-vs-create/

creating yml files on the run

using `kubectl run` command can help in generating a yaml template. if your were asked to create a pod or deployment with specific name and image you can simply run the `kubectl run` command.

https://kubernetes.io/docs/reference/kubectl/conventions/

- creating an nginx pod: `kubectl run nginx --image=nginx`
- generate POD manifes yaml file (`-o yaml`) - don't create it (`--dry-run`): `kubectl run nginx --image=nginx --dry-run=client -o yaml`
- create a deployment: `kubectl create deployment --image=nginx nginx`
- generate deployment yaml file (`-o yaml`). don't create it (`--dry-run`): `kubectl create deployment --image=nginx nginx --dry-run=client -o yaml`
- generate deployment yaml file (`-o yaml`). don't create it (`--dry-run`) with 4 Replicas (`--replicas=4`): `kubectl create deployment --image=nginx nginx --dry-run=client --replicas=4 -o yaml > nginx-deployment.yaml`

we can create a new file and make necessary changes to it.

```
root@controlplane:~# kubectl create deployment --image=httpd:2.4-alpine
httpd-frontend --dry-run=client --replicas=3 -o yaml > own-file.yaml
root@controlplane:~#
root@controlplane:~#
root@controlplane:~#
root@controlplane:~#
root@controlplane:~# cat own-file.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    app: httpd-frontend
  name: httpd-frontend
spec:
  replicas: 3
  selector:
    matchLabels:
      app: httpd-frontend
  strategy: {}
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: httpd-frontend
```

```
    spec:
      containers:
      - image: httpd:2.4-alpine
        name: httpd
        resources: {}
status: {}
root@controlplane:~# kubectl create deployment --image=httpd:2.4-alpine
httpd-frontend ^Creplicas=3 -o yaml > own-file.yaml
root@controlplane:~# kubectl get deployments
NAME                  READY   UP-TO-DATE   AVAILABLE   AGE
deployment-1          0/2     2            0           5m26s
frontend-deployment   0/4     4            0           17m
root@controlplane:~# kubectl create deployment --image=httpd:2.4-alpine
httpd-frontend --replicas=3 -o yaml > own-file-r.yaml
root@controlplane:~# kubectl get deployments
NAME                  READY   UP-TO-DATE   AVAILABLE   AGE
deployment-1          0/2     2            0           5m52s
frontend-deployment   0/4     4            0           17m
httpd-frontend        0/3     3            0           4s
root@controlplane:~#
```

namespaces

default is the namespace that creates k8s. k8s creates a set of pods for internal purposes (networking solution, dns...) to isolate them from the user on another namespace named *kube-system*. a third namespace is created called *kube-public*; this is where resources that should be made available to all users are created.

resources on namespaces are isolated.

namespaces can have different sets of policies assigned, to define who can do what. you can also assign quotas/limits of resources to the namespaces.

resources within a namespace can refer to each other simply by their names (`mysql.connect("db-service")`). a pod can reach a resource on another namespace - we must append the name of the namespace to the name of the service (`mysql.connect("db-service.dev.svc.cluster.local")` <<<--- connecting from, say, default ns to dev ns). we can access the resources because a DNS entry is created when the service is created.

db-service	dev	svc	cluster.local
service name	namespace	service	domain

- to list pods on another ns: `kubectl get pods --namespace=<nsName>`
- create a pod on another ns: `kubectl create -f <file> --namespace=<nsName>` we can move this option directly to the pod definition file; under **metadata**, `namespace: dev` as a sibling of **name**. this ensures that resources are created on the same ns consistently.

creating a ns definition file

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

`kubectl create -f <fileName>`

Another way of creating a ns is by running `kubectl create namespace <nsName>`

to switch to another namespace: `kubectl config set-context $(kubectl config current-context) --namespace=dev`

to view pods on all ns: `kubectl get pods --all-namespaces`

contexts are used to manage multiple clusters and environments from the same management system.

to limit resources in a ns, create a *resource quota*

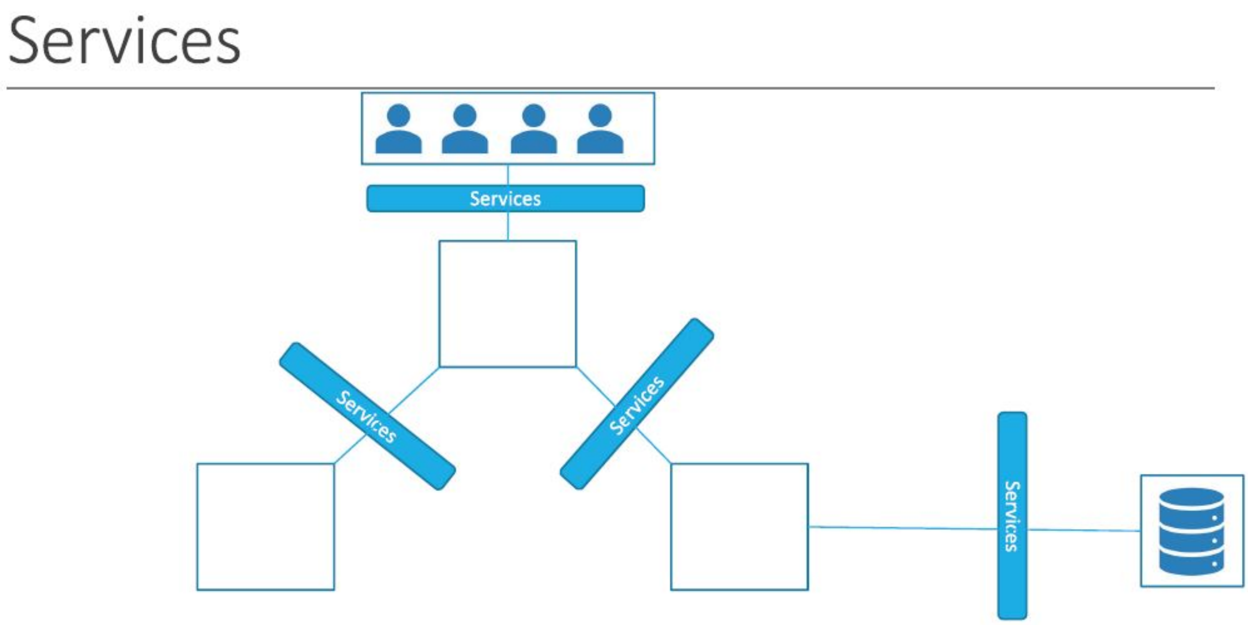
```yaml
apiVersion: v1
kind: ResourceQuota
metadata:
  name: compute-quota
  namespace: dev
spec:
  hard:
    pods: "10"
    requests.cpu: "4"
    requests.memory: 5Gi
    limits.cpu: "10"
    limits.memory: 10Gi
```

`kubectl create -f <file>`

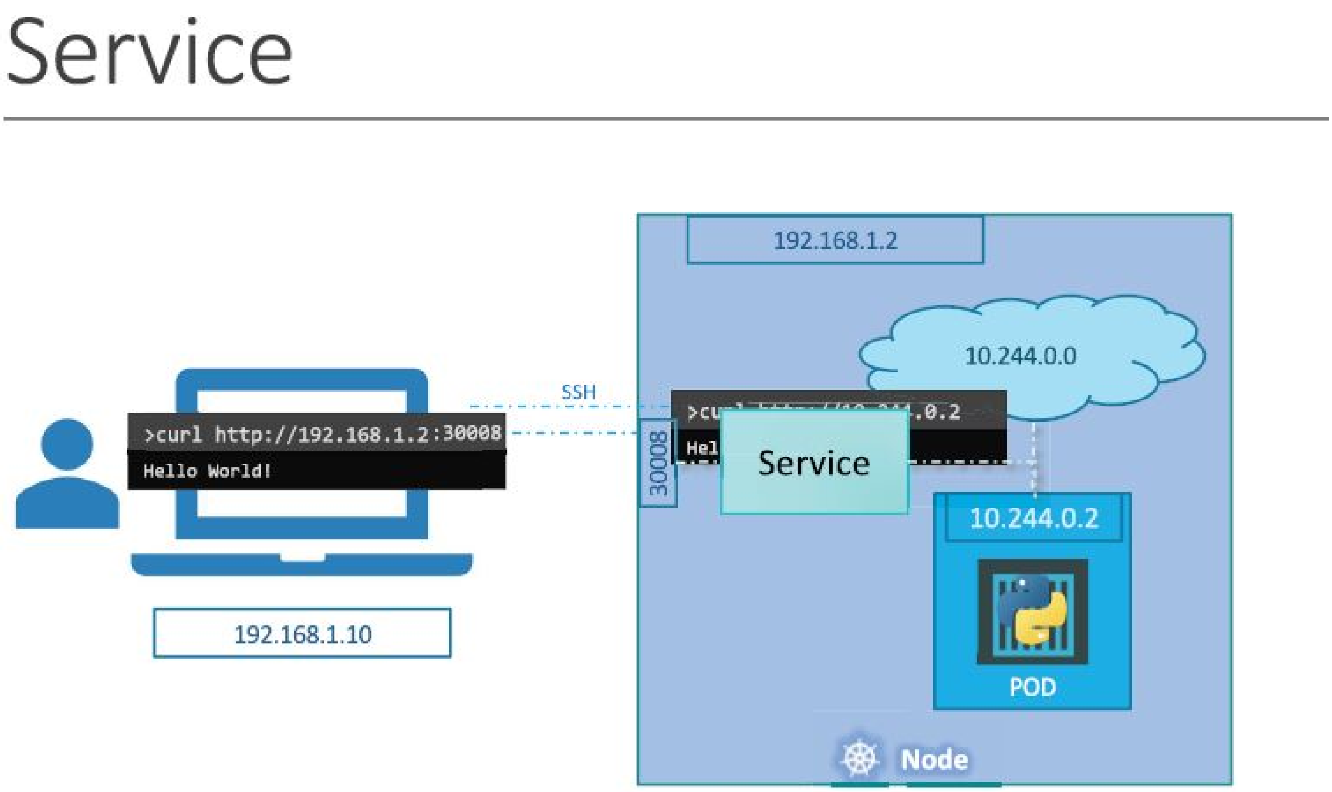
- `kubectl get ns`
- `kubectl -n research get pods` --> `-n` for namespace name

services

services enable communication between components and outside the app. they help us connect apps with other apps/users.



services are k8s objects with many uses. one of then is to listen to a port on the node and forward requests on that port to a port on the pod running the web app.



we can't reach the web page on the POD, which has a private IP 10.244.0.2; we can create a service on the node that listens to requests on port XXX; once the node reciebes a request on a certain port, the service will "translate" the address and reach the pod.

this is known as a **node-port** service - the service listens to a port on the node and forwards requests to the POD.

1. node-port: the service makes an internal port accesible on a port on the node

2. clusterIP: the service creates a virtual IP inside the cluster to enable communication between services, for instance, front end and back-end servers
3. load balancer: it creates a loand balancer for our app in supported cloud providers.

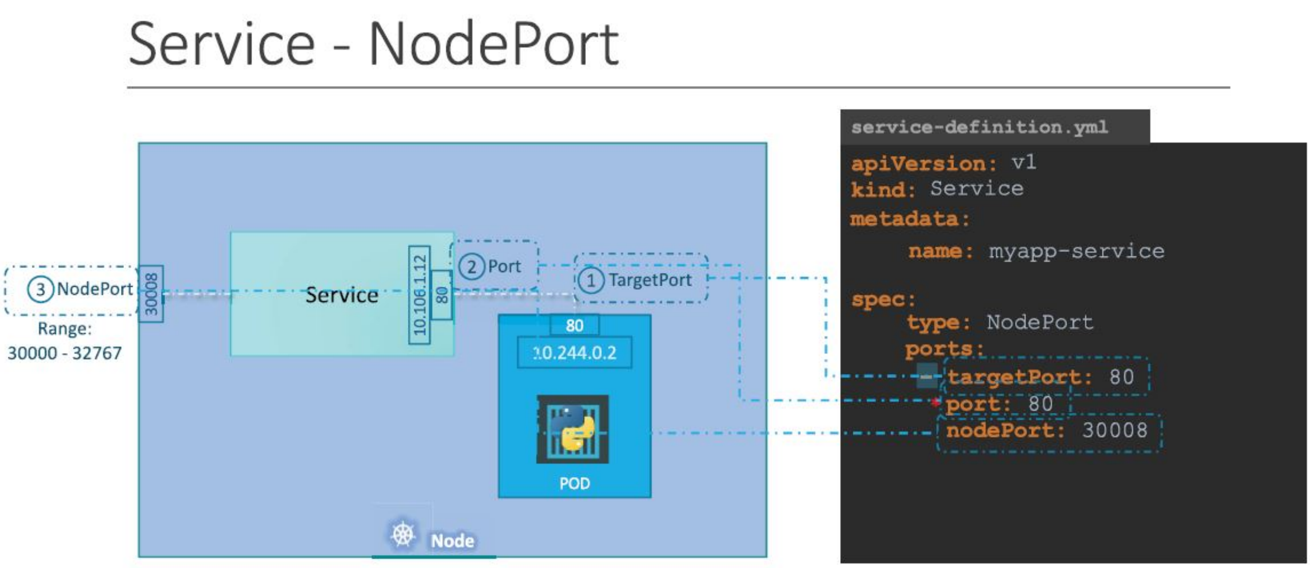
NodePort

in node port there are 3 ports involved:

1. the port on the POD where the web-server is running (port 80) <-- it is referred to as the **target port**
2. port on the service itself - it is simply referred to as the port; this naming convention takes the POV of the *service*. the service has its own ip, known as the **clusterIP** of the service.
3. the port on the node, which we use to reach it externally - known as the **NodePort**. by default port range for NodePort is between 30000 and 32767

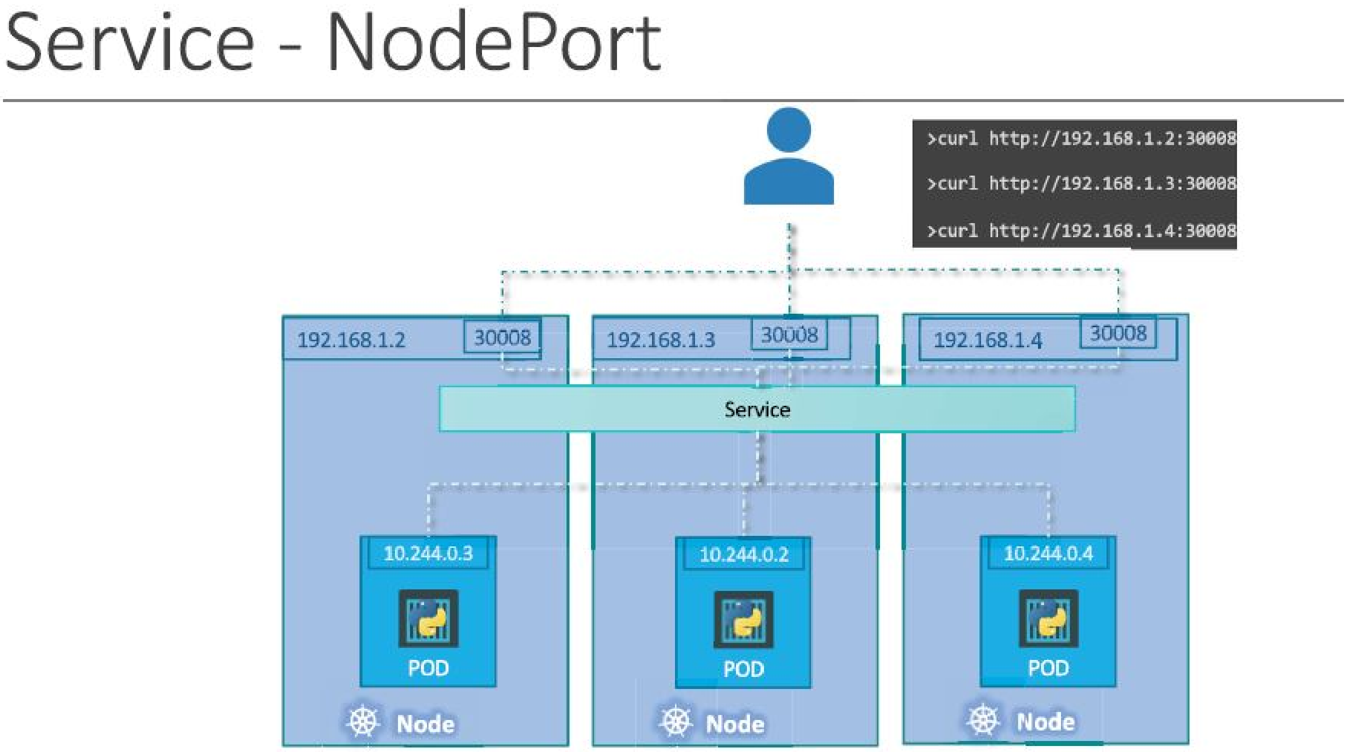
creating a service:

```
apiVersion: v1
kind: Service
metadata:
  name: myapp-service
spec:
  type: NodePort # could be ClusterIP or LoadBalancer
  ports:
  - targetPort: 80
    port: 80 # MANDATORY
    nodePort: 30008
  selector: # we use labels used to create the pod
    app: myapp      # these two fields are pulled from the POD def file,
metadata > labels
    type: front-end # having app and type creates the link between the
service and the POD
```



nodeport has a builtin *random* algorythm to distribute load in case there are multiple PODs; it also has SessionAffinity.

what happens when the app is distributed across *nodes*: k8s creates a service that spans across all the nodes in the cluster and maps the target port to the same nodeport on all the nodes of the cluster. this way allows you to access the application from any node in the cluster using the same port number.



ClusterIP

we can't rely on POD IP's to ensure communication between apps, since they are constantly being created.

clusterIP is a k8s service that allows us to group IPs together on a single interface. each ip gets an ip and name assigned to it inside the cluster and that's the information that should be used by other pod to access the service.

```yaml
apiVersion: v1
kind: Service
metadata:
  name: back-end
spec:
  type: ClusterIP # default service
  ports:
    - targetPort: 80  # where the backend is exposed
      port: 80  # where the service is exposed
  # to link the service to a set of ports we use selector
  # copy the label from pod def file
  selector:
    app: myapp
    type: back-end
```

LoadBalancer

cloud providers have native custom load balancers

```yaml
apiVersion: v1
kind: Service
metadata:
  name: myapp-service
spec:
  type: LoadBalancer # default service
  ports:
    - targetPort: 80
      port: 80
      nodePort: 30008
```

imperative vs declarative

in IaC there are two main approaches, imperative and declarative.

- imperative: specifying what and how to do it. set of instruction, step by step. checks need to be done manually.
  - `kubectl run --image=nginx nginx`
  - `kubectl create deployment --image=nginx nginx`
  - `kubectl expose deployment nginx --port 80`
  - `kubectl edit deployment nginx`
  - `kubectl scale deployment nginx --replicas=5`
  - `kubectl set image deployment nginx nginx=nginx:1.18`
  - `kubectl create -f <file>`
  - `kubectl replace -f <file>`
  - `kubectl delete -f <file>`
- declarative: you specify the final state; what to do. we state what we need. checks are done by the tool. updating only the config file. the declarative approach involves creating a set of files indicating the *expected state of app/services* on the k8s cluster and a simple `kubectl apply -f <file>`, k8s should be able to determine how to reach the indicated state. kubectl apply for creating, managing and updating. this command will look at the existing configuration and figure out what changes need to be made to the system.

within the imperative approach, there are two "ways":

1. running imperative commands to create or create objects - quick, no need to write yaml file. limited functionality, long commands
2. creating objects with definition or manifest files

best practice: update the configuration file, then `kubectl replace -f <modifiedConfigFile>` <<<---- this is imperative applies.

insted of using the `kubectl replace`, we use `kubectl apply` command - this commands knows NOT to create an object if it already exists (with *replace* if the object already exists, we will get an error). we can also input an entire directory so that all definition files on the directory are created.

when we want to make a change, we use `kubectl apply -f <filename>` and it knows that there is already a process with that information, but it looks for any changes to what is actually running and it *updates the object.*

- `--dry-run`: as soon as the command is run, the resource will be creted
- `--dry-run=client`: if you simply want to test your command - this will not crete the resource, instead, it will etll you whether the resource can be created and if your command is right.
- `-o yaml`: tils will output the resource definition in yaml format on the screen
- creating a pod: `kubectl run nginx --image=nginx`
- creating a pod definition file (but not actually doing it): `kubectl run nginx --image=nginx --dry-run=client -o yaml`
- creating a deployment: `kubectl create deployment --image=nginx nginx`
- creating a deployment definition file: `kubectl create deployment --image=nginx nginx --dry-run=client -o yaml`
- create deployment with 4 replicas: `kubectl create deployment nginx --image=nginx --replicas=4` - to scale the deployment: `kubectl scale deployment <depnam> --replicas=3`
- save the yaml def file to a file: `kubectl create deployment --image=nginx nginx --dry-run=client -o yaml > nginx-deployment.yaml`
- creating a service: `kubectl expose pod redis --port=6379 --name redis-service --dry-run=client -o yaml` <<<--- this will automtically use the pod's labels as selectors. another way of doing this is `kubectl create service clusterip redis --tcp=6379:6379 --dry-run=client -o yaml` (this will not use the pods labels s selectors, instead, it will assume selectors as **app=redis**)
- `kubectl run custom-nginx --image=nginx --port=8080`
- `ubectl create deployment redis-deploy --namespace=dev-ns --image=redis --replicas=2`
- `kubectl run httpd --image=httpd:alpine --port=80 --expose`
- https://github.com/kubernetes/kubernetes/issues/46191
- https://kubernetes.io/docs/reference/kubectl/conventions/

```
kubectl run redis --image=redis:alpine --labels="tier=db"
kubectl create svc clusterip redis-service --tcp=6379
kubectl create deploy webapp --image=kodekloud/webapp-color --replicas=3
kubectl run custom-nginx --image=nginx --port=8080
kubectl create ns dev-ns
kubectl create deploy redis-deploy --namespace=dev-ns --image=redis --
```

```
replicas=2
kubectl run httpd --image=httpd:alpine --port=80 --expose
```

kubectl apply

it's used to work on a declarative way; this command takes into account the **local configuration file**, **the live object definition file on k8s** and **the last applied configuration**.

if the object does not already exists, the object is created. when the object is created, an object, similar to the definition file we created locally, is created locally, but with additional fields to store the status of the object. this is the live configuration of the object in the cluster.

when we we create an object with kubectl apply, the local configuration file is converted into a json format and it is then stored as the last applied configuration - going forward, the three files are compared to identify what changes are to be made to the live object.

1. local file updated
2. `kubectl apply -f <file modified>`
3. the new values are compared to the live configuration file; if there is a difference, the live version is updated with the new value
4. json last applied configuration is updated

the last applied configuration file is used to "figure out" what fields are/were removed from the local file, the history of the file configuration.

- https://kubernetes.io/docs/tasks/manage-kubernetes-objects/declarative-config/

the last applied configuration information is stored within the live object configuration file as an annotation named *last-applied-configuration*. kubectl create or replace do not store the last applied configuration.

Scheduling

manual scheduling. ervery pod has a field called **nodeName** that by default it is not set. the scheduler goes over all the pods and looks for those that do not have this property set. those are the candidates for scheduling.

it then identifies the right node for the pod and sets the value of the property/field **nodeName** to be the corresponding node by creating a binding object.

if there is no scheduler, the pods remain in a status pending. we can manually assign pods to nodes. we can simply hardcode the field nodeName on the pod def file. we can only specify the node name when the pod is being created. k8s won't allow you to modify the nodeName property of a pod.

we can create a binding object and send a post request to the pods binding API

```
apiVersion: v1
kind: Binding
metadata:
```

```
    name: nginx
  target:
    apiVersion: v1
    kind: Node
    name: node02 # name of the node
```

then send a post request to the pod's binding API with the data set to the binding object in JSON format: `curl --header "Content-Type:application/json" --request POST --data '{"apiVersion":"v1", "kind": "Binding" } http://$SERVER/api/v1/namespaces/default/pods/$PODNAME/binding/'`

labels and selectors: standard method to group things together. also to apply filters based on criteria.

- labels are properties attached to items - undermetadata, create a section called *labels*.
- selectors help you filter the items. `kubectl get pods --selector app=App1`

Replica sets: to link the replicaset to the pod, we configure the selector field under the replica set > spec > selector > matchLabels (defined as) > app: App1 (as the pods will be defined). it's the same for other objects, say services. services use the selector to match the *pods* in the replica set def file.

Annotations: build version, names, emails...

- `kubectl get pods --show-labels`
- `kubectl get pods --selector env=dev --no-headers | wc -l`; `kubeclt get pods -l env=dev`
- `kubectl get all --selector env=prod --no-headers | wc -l`
- `kubectl get pod --selector env=prod,bu=finance,tier=frontend`

taints and tolerations

pod to node relationship, what pod goes to what node. taints and tolerations are used to set restrictions on what nodes can pods be scheduled.

when pods are created, the k8s scheduler tries to put them on the available worker nodes.

say we want pods to go or *not* go to a certain node.

first, we prevent all pods from being placed on the node by placing a *taint* on the node. by default, pods don't have tolerations which means that, unless specified otherwise, no pod can tolerate any taint, no pods can be placed on the node.

then we have to enable pods by specifying which pods are tolerant. we had a toleration to a pod for a specific taint.

- taints are set on nodes
- tolerations are set on pods

the taint is a key-value pair

`kubectl taint nodes node-name key=value:taint-effect` the taint effect defines what happens to the pod if they do not tolerate the taint. there are three *taint* effects:

1. NoSchedule: the pod will not be scheduled.
2. PreferNoSchedule: the system will try to avoid placing a pod on the node (but that is not guaranteed)
3. NoExecute: new pods will not be scheduled on the pod and existing pods on the node will be evicted if they do not tolerate the taint.

`kubectl taint nodes node1 app=blue:NoSchedule`

to add a toleration to pod throught the definition file, add a section called tolerations under *spec*:

```yaml
tolerations:
- key: "app"
  operator: "Equal"
  value: "blue"
  effect: "NoSchedule"
```

taints and toleratiosn are meant to restrict nodes from accepting certain pods. a node might be configured to accept only a certain toleration, but that does not mean that the pod *will always* be placed on that node if there are no tains applied to the other nodes.

tainsts and tolerations do not tell the pod to go to a particular node. it tells the node to only accept pods with certain tolerations.

if the requirement is to restrict a pod to a certain node, it is accomplished through a concept known as *node affinity*.

as regards master nodes: the scheduler does not schedule any pods on the master node because when the k8s is being set up, a taint is applied automatically that prevents any pods from being placed on the node.

`kubectl describe node kubemaster | grep Taint`

```yaml
---
apiVersion: v1
kind: Pod
metadata:
  name: bee
spec:
  containers:
    - name: bee
      image: nginx
  tolerations:
    - key: "spray"
      operator: "Equal"
      value: "mortein"
      effect: "NoSchedule"
```

- `kubectl run bee --image=nginx --restart=Never --=client -o yaml > bee.yaml`
- `kubectl explain pod --recursive | less` --> see options for pods
- `kubectl get pod -o wide`

remove a taint: `kubectl taint nodes node1 key1=value1:NoSchedule-`

if we don't know why a pod is not being created, we can use `kubectl describe pod <podName>` to search for any warnings or errors.

node selectors | node affinity

- node selectors: simpler, in the pod def file we add a new property called nodeSelector

```
nodeSelector:
  size: Large
```

size: Large - *labels* assigned to the nodes. the scheduler uses these labels to match and identify the right node to place the nods on.

labeling a node: `kubectl label nodes <nodeName> <labelKey>=<labelValue>` or on the node definition file. after labelling the node we can create the pod using the nodeSelector attribute.

limitations: it's simple, not much logic (either, or)

- node affinity: ensure that pods are hosted on a particular node. advanced capability to limit pod placement on specific pods.

place the pod either on Large or Medium sized pods - under *spec*

```
spec:
  affinity:
    nodeAffinity:
     requiredDuringSchedulingIgnoredDuringExecution:
       nodeSelectorTerms:
       - matchExpressions:
         - key: size
           operator: In
           values:
           - Large
           - Medium
#########################################################
    - matchExpressions:
        - key: size
    operator: NotIn
    values:
    - Small
#########################################################
    - matchExpressions:
        - key: size
    operator: Exists
# the exists operator will check if the label "size" exists on the node
# you don't need the value section for that - it does not compare the
values
```

what if node affinity cannot match a node with the given expression? this is solved by the long sentence (line 810). it is called the node affinity type - it defines the behaviour of the scheduler as regards node affinity and the stages in the life cycle of the pod

- Available
    - requiredDuringSchedulingIgnoredDuringExecution:
    - preferredDuringSchedulingIgnoredDuringExecution:
- Planned
    - requiredDuringSchedulingRequiredDuringExecution: this is still being develop - it will evict any pods upon a change in the environment (say a label).
- DuringScheduling: state when a pod does not exist and is created for the first time. when first created, the affinity rules created are considered to place a pod on the right node. what if we forgot to label the node? that's where the type of node affinity
    - Required: the scheduler will mandate that the pod be placed on the node with the given affinity rules. if it cannot find one, the pod will not be scheduled. this type will be used when the placement of the pod is *crucial*.
    - preferred: the placement of the pod is not as important as running the load itself. in case of a matching node not found, the scheduler will simply ignore node affinity rules and place the pod on any available node.
- DuringExecution: a pod has been running and a change is made to the environment that affects node affinity (label of a node, for instance). these changes will not impact the node once they have been scheduled (provisioned?).

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

```
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    app: red
  name: red
spec:
  replicas: 2
  selector:
    matchLabels:
      app: red
```

```
  strategy: {}
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: red
    spec:
      containers:
      - image: nginx
        name: nginx
        resources: {}
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
              nodeSelectorTerms:
              - matchExpressions:
                - key: node-role.kubernetes.io/master
                  operator: Exists
################################################################
      labels:
        app: blue
    spec:
      affinity:
        nodeAffinity:
          requiredDuringSchedulingIgnoredDuringExecution:
            nodeSelectorTerms:
            - matchExpressions:
              - key: color
                operator: In
                values:
                - blue
      containers:
      - image: nginx
        imagePullPolicy: Always
        name: nginx
```

- `kubectl get nodes <nodeName> --show-labels`
- `kubectl label nodes <nodeName> <key>=<value>`
- `kubectl scale deployment <depName> --replicas=<#>`

node affinity vs taints and toleration

to ensure that pods go to a especific node, taints/toleration and nodeAffinity are used in combination.

- nodes: taints and labels
- pods: toleration and selectors

resource allocation

scheduler takes into consideration the amount of resources each pod requires and those available on the nodes. if there are no more resources available, k8s avoids scheduling the pod - the pod will remain in pending state. checking the events will show the reason (insufficient cpu, memory...).

- cpu: default 0.5 cpu*
- mem: default 256 Mi*
- disk

*Minimum resource request

default values can be modified on the pod/deployment-definition files. also, for the pod to pick up those defaults you must have first set those as default values for request and limit by creating a *LimitRange* in that **namespace** (https://kubernetes.io/docs/tasks/configure-pod-container/assign-memory-resource):

```yaml
apiVersion: v1
kind: LimitRange
metadata:
  name: mem-limit-range
spec:
  limits:
  - default:
      memory: 512Mi
    defaultRequest:
      memory: 256Mi
    type: Container
# https://kubernetes.io/docs/tasks/administer-cluster/manage-resources/memory-default-namespace/

apiVersion: v1
kind: LimitRange
metadata:
  name: cpu-limit-range
spec:
  limits:
  - default:
      cpu: 1
    defaultRequest:
      cpu: 0.5
    type: Container
# https://kubernetes.io/docs/tasks/administer-cluster/manage-resources/cpu-default-namespace/
```

0.1 count of cpu can also be expressed as 100m. 1 count of cpu = 1 vcpu. docker container has no limit to the amount of resources it can consume on a node. unless otherwise specified, k8s limits containers to 1vcpu on the node. as regards mem, the default limit is set to 512 Mi

under *containers* add resources:

```yaml
spec:
  containers:
  - name: asdf
    image: nginx
    ports:
      - containerPort: 8080
```

```
      resources:
        requests:
          memory: "1Gi"
          cpu: 1
        limits:
          memory: "2Gi"
          cpu: 2
```

limits are set for each *container* within the *pod*.

execeeding the limits

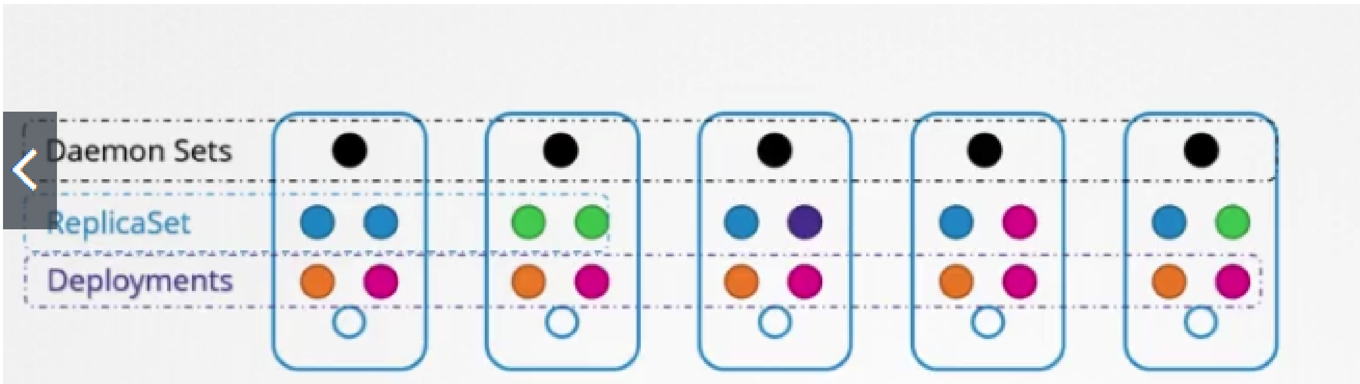
- cpu: k8s throttles the cpu so that it doesn't go beyond the specified limit
- memory: containers can use more memory than its limit. if it *constantly* tries to (and consumes?) consume more memory than it limits, the pod is terminated.

With Deployments you can easily edit any field/property of the POD template. Since the pod template is a child of the deployment specification, with every change the deployment will automatically delete and create a new pod with the new changes. So if you are asked to edit a property of a POD part of a deployment you may do that simply by running the command

`kubectl edit deployment my-deployment`

Daemon sets

daemon sets are similar to replica sets since they help in creating multiple instances of pods but they run a copy of the pod con each node of the cluster. whenever a new node is added to the cluster, a new pod is added to the node:



ds ensures that at least one copy of the pod is always present in all nodes in the cluster.

ds perfect monitoring agent, logs viewer. DS are applied at the cluster lvl (?); also used for deploying kube-proxy, and networking

ds-def.yml

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: monitoring-daemon
```

```yaml
spec:
  selector:
    matchLabels:
      app: monitoring-agent
  template:
    metadata:
      labels:
        app: monitoring-agent
    spec:
      containers:
      - name: monitoring-agent
        image: monitoring-agent
```

to describe a name space we have to specify the namespace: `--namespace=<nsName>`

An easy way to create a DaemonSet is to first generate a YAML file for a Deployment with the command `kubectl create deployment elasticsearch --image=k8s.gcr.io/fluentd-elasticsearch:1.20 -n kube-system --dry-run=client -o yaml > fluentd.yaml`. Next, remove the replicas and strategy fields from the YAML file using a text editor. Also, change the kind from **Deployment** to **DaemonSet**.

static pods

the kubelet relies on the kubeapi server for instruction on which pods to load on its node. we can configure the kubelet to create pods on the definition file stored on a directory `/etc/kubernetes/manifests`. it checks constantly to see if there are new files. kubelet can also restart the pod in case the pod crashes. if changes are made on the file, the pod is also updated. if the file is removed, the pod is deleted. these are static pods.

no replica sets, nor daemonsets, nor services can be created this way. only pods.

kubelet works at pod level and only understands pods.

we can change the location of where pod are stored. we have to modify the kubelet service line that contains `--pod-manifest-path=<xxxx>`. we replace this line with an external yaml file to indicate where these files will be stored: `--config=kubeconfig.yaml`. on that file `staticPodPath: /etc/kubernetes/manifests`.

kubeadm uses a similar architecture. it creates pods for each service, and they have -controlplane added to their name (rather than the typical static).

when in a cluster, the kubelet can still create static pods, while receiving orders to create pods from the kubeapi. the api server will be able to see the static pod. when the kubelet creates a static pod, if part of a cluster, it also creates a mirrored object in the kubeapi server; when we check from the kubeapi server, we see a read-only image of the pod; we can view details of the pod, but we can't edit anything.

Static PODs	DaemonSets
Created by the Kubelet	Created by Kube-API server (DaemonSet Controller)
Deploy Control Plane components as Static Pods	Deploy Monitoring Agents, Logging Agents on nodes
Ignored by the Kube-Scheduler	

Run the command `ps -aux | grep kubelet` and identify the config file - `--config=/var/lib/kubelet/config.yaml`. *Then check in the config file for staticPodPath.*

`kubectl run static-busybox --image=busybox --command sleep 1000 --dry-run=client --restart=Never -o yaml > file.yaml`

multiple schedulers

when creating a pod or deployment you can instruct k8s to have the pod scheduled by a specific scheduler. we can choose the scheduler name when creating it (**--scheduler-name=scheduler01**).

/etc/kubernetes/manifests/kube-scheduler.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: kube-scheduler
  namespace: kube-system
spec:
  containers:
  - command:
    - kube-scheduler
    - --address=127.0.0.1
    - --kubeconfig=/etc/kubernetes/scheduler.conf
    - --leader-elect=true
    image: k8s.gcr.io/kube-scheduler-amd64:v1.11.3
    name: kube-scheduler
```

my-custom-scheduler.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: my-custom-scheduler
  namespace: kube-system
spec:
  containers:
  - command:
    - kube-scheduler
    - --address=127.0.0.1
    - --kubeconfig=/etc/kubernetes/scheduler.conf
    - --leader-elect=true
    - --scheduler-name=my-custom-scheduler
    - --lock-object-name=my-custom-scheduler


    image: k8s.gcr.io/kube-scheduler-amd64:v1.11.3
    name: kube-scheduler
```

- leader-elect=true: choosing a leader who will have the final say.

`schedulerName: <schedulerName>` - same level as containers under spec

`kubectl get events`: lists all the events on the current nameSpace. to view the logs of the scheduler, we can check the logs of the pod: `kubectl logs my-custom-scheduler --name-space=kube-system`

lab

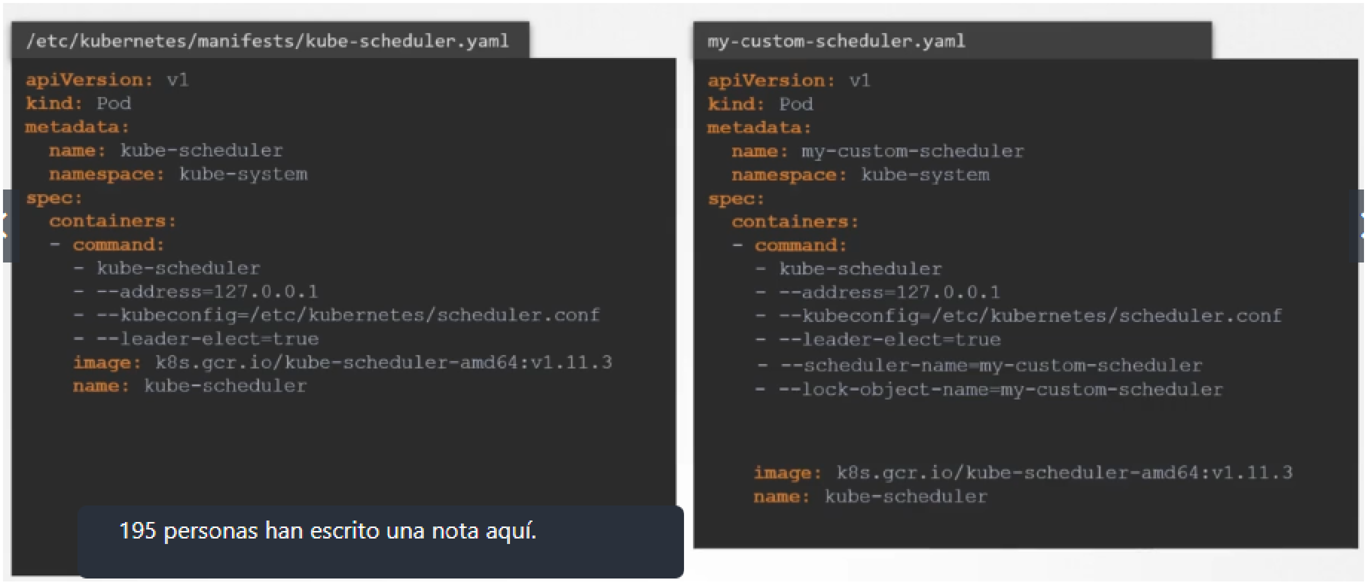
- `kubectl -n <nameSpace> get pods`
- `kubectl -n <nameSpace> describe pods <podName>`

- deploy additional scheduler: copy default /etc/kubernetes/manifests scheduler pod definition file. make these modifications: `leader-elect=false` and `--scheduler-name=<name>`; metadata: name: update the name| name of the container: update; kubectl create -f file.yaml.

configure scheduler

kube adm:

additional schedulers



- https://github.com/kubernetes/community/blob/master/contributors/devel/
- https://github.com/kubernetes/community/blob/master/contributors/devel/sig-scheduling/scheduler.md
- 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

resource consumption - what to monitor?

- metrics server - one metrics server per k8s cluster. it retrieves metrics from each of the k8s nodes and pods, aggregates them and stores them in memory (this service is an in-memory solution). it

  does not store information on the disk, you cannot see historical performance data. we need advanced monitoring soultion. the kubelect runs a subcomponent known as cAdvisor (container Advisor) responsible for retrieving performance metrics from PODs and exposing them through the kubelet api to make the metrics available for the metrics server . running minikube - `minikube addons enable metrics-server` - for all other environments, run `git clone https://github.com/kubernetes-incubator/metrics-serve` + `kubectl create -f deploy/1.8+/`; these commands deploys a number of pods, services and roles to allow the metrics server to pull the necessary data - to see data: `kubectl top node` `kubectl top pod`. kodekloud component: https://github.com/kodekloudhub/kubernetes-metrics-server.git
- prometheus and other monitoring apps

application logs

logging in docker: `docker run -d kodekloud/event-simulator` throw output to stdout. `docker logs -f ecf`

in k8s

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

`kubectl logs -f event-simulator-pod event-simulator` --> these logs are specific to the container running inside the pod; `kubectl logs -f <podName> <containerName>`

- `kubectl logs <podName> | grep -i whatever`

Application Lifecycle Management

rolling updates and rollbacks

when you first create a deployiment, it triggers a rollout - a new rollout creates a new deployment revision (revision 1). in the future, when the app is updated, a new rollout is triggered and a new deployment revision is created (revision 2).

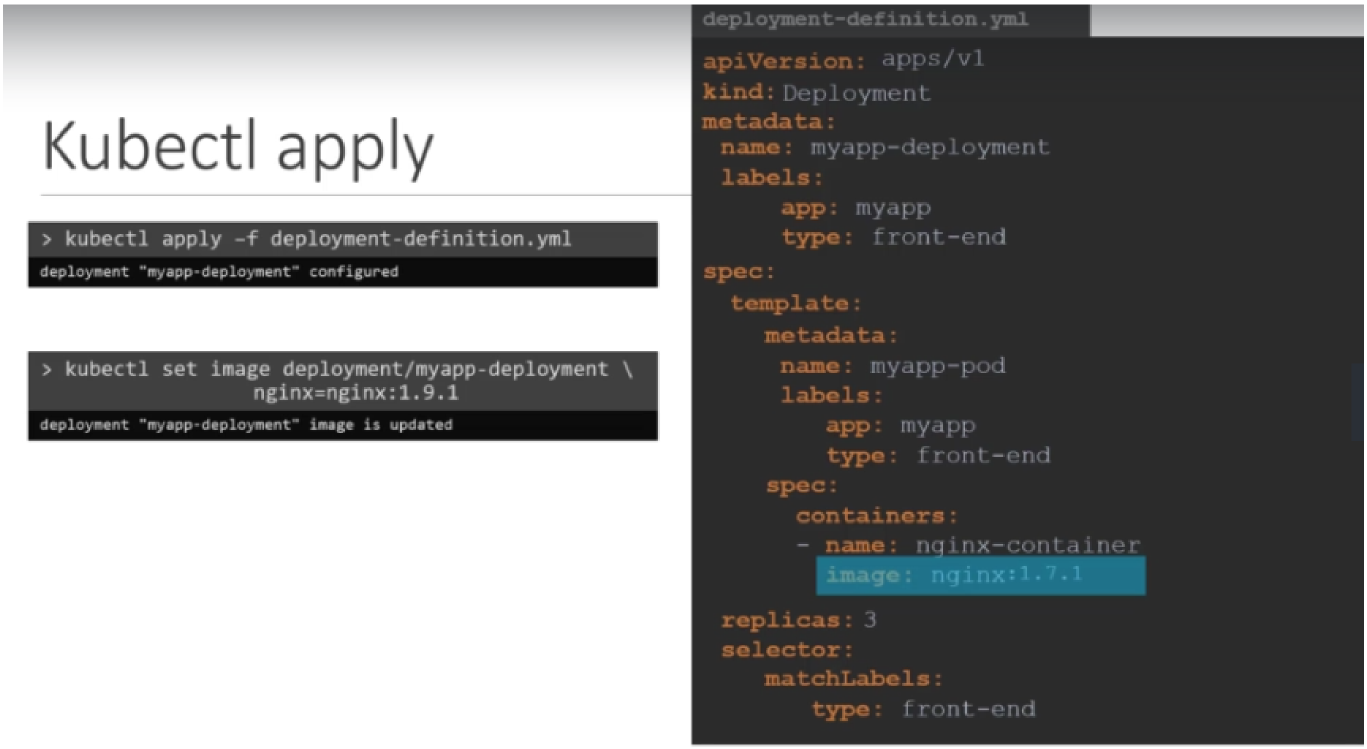
- `kubectl rollout status <deploymentName>` see the status of the rollout
- `kubectl rollout history <deploymentName>` revisions and history of the deployment

2 types of deplyment rollout strategies

1. Recreate: destroy current pods at once and create new ones with the new version. not the default

2. rolling-update: we do not destroy all pods at once, but rather we take one pod down and bring another back up - the app doesn't go down, upgrade is seamless. if we don't specify a specific strategy, k8s will assume it's a rolling update.

say we have a definition file with a deployment; we want to update the image, we simply update the def file and run `kubectl apply -f <defFile>`



we can specify the image with the command: `kubectl set image <deploymentName> nginx=nginx:1.9.1` but that will not update the definition file

when a new deployment is created, say with 5 replicas, it first creates a replica set automatically, which in turn creates the number of pod required to meet the number of replicas. when we update the application, the k8s deployment object creates a new replica set under the hood and starts deploying the containers there - at the same time, taking down the pod in the old replica set following a rolling update strategy - this is what we see when we issue the `kubectl get replicasets` command.

to bring back the previous version of the app, we can issue the `kubectl rollout undo <deploymentName>`. k8s will destroy the new pods in the replica set and bring back the old replica set

```
for i in {1..35}; do
   kubectl exec --namespace=kube-public curl -- sh -c 'test=`wget -qO- -T 2 http://webapp-service.default.svc.cluster.local:8080/info 2>&1` && echo "$test OK" || echo "Failed"';
   echo ""
done
```

commands and arguments in definition files - docker

a container lives as long as the process inside it is alive. if a process crashes the container dies. who defines what processes should be running on the container? on a docker image/file there is a line `CMD ["nginx"]`

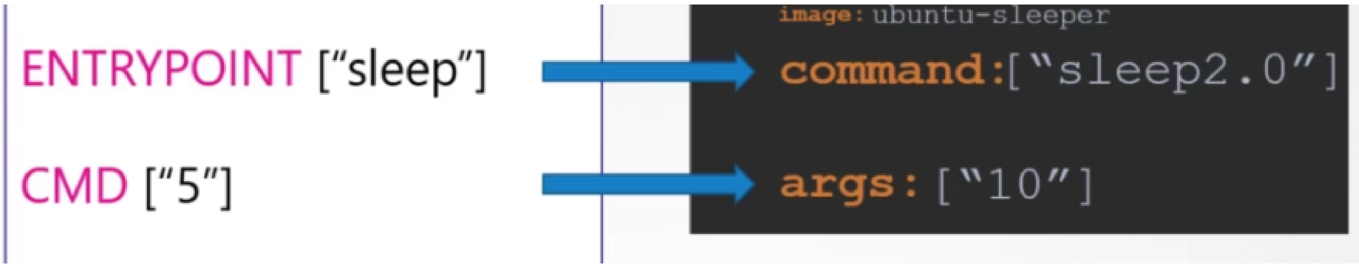
on a docker file, if we have the **CMD** option, when the container is built, that command gets executed; it is "hardcoded" what it does (correr un comando por defecto que es facilmente pisable - comando que se ejecuta cuando corre el contenedor, levantar servicios o servidores que se quedan corriendo). we can use **ENTRYPOINT** on the docker file and when we run the docker image, we need to specify a parameter that will be used when running the docker image (está pensado para que no pueda ser fácilmente sobreescribible - pensado para usar el contenedor como si fuera un ejecutable).

both CMD and ENTRYPOINT can be used; cmd would be the default parameter to be used in case no parameters are passed

in k8s pods

```
apiVersion: v1
kind: Pod
metadata:
  name: ubuntu-sleeper-pod
spec:
  containers:
  - name: ubuntu-sleeper-pod
    image: ubuntu-sleeper-pod
    command: ["sleep2.0"] # overwrites ENTRYPOINT in docker file
    args: ["10"] # anything that is appended to the docker run command will
go into this section
```

the args option in the pod def file overwrites the CMD instruction in the docker file. to overwrite the ENTRYPOINT (ep) we use the command field



it is not the command field that overwrites the CMD instruction in the docker file.

environment variables

```
spec:
  containers:
  - name: simple-web-app
    image: simple-web-app
  # plain key value pair
  env:
  - name: APP_COLOR
    value: pink
```

```yaml
    # configMap
    env:
    - name: APP_COLOR
      valueFrom:
        configMapKeyRef:
    # Secrets
    env:
    - name: APP_COLOR
      valueFrom:
        secretKeyRef:
```

`docker run -e APP_COLOR=pink simple-web-app`

env is a yaml array

when you have a lot of pod def files, it will become difficult to manage environment data stored within the query files. we can take this information outside the pod definition file and manage it centrally using configuration maps.

configMaps are used to pass configuration data in the form of key-value pairs in k8s. when a pod is created, inject the configMap into the pod so the key value pair are available for the application hosted inside the container in the pod.

there are 2 phases in configuring configMaps.

1. create the config map
2. inject them into the pod

creating a config map:

- imperative way

`kubectl create configmap <config-name> --from-literal=<key>=<value>`; example: `kubectl create configmap app-config --from-literal=APP_COLOR=blue --from-literal=APP_MOD=prod`

using a file: `kubectl create configmap <config-name> --from-file=<path-to-file>`

- declarative way

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: app-config
data: # rather than spec
  APP_COLOR: blue
  APP_MODE: prod
```

`kubectl create -f <file>`

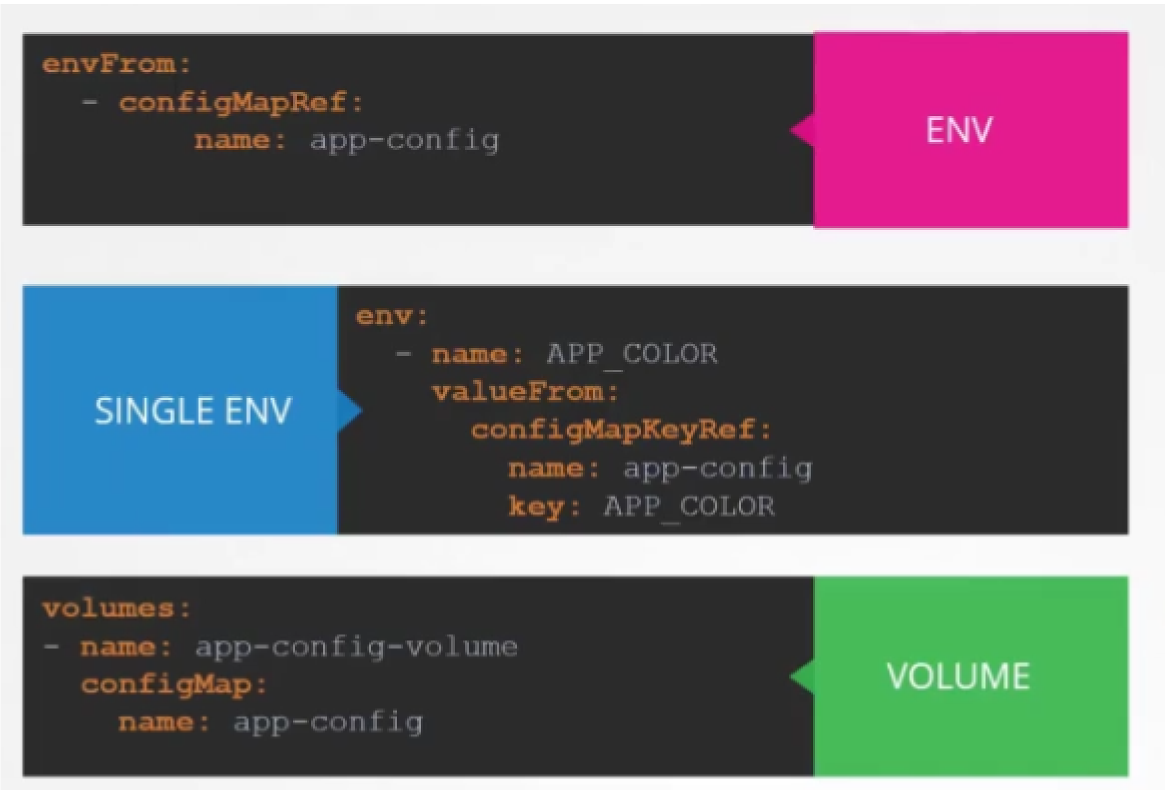
```
#app-config
APP_COLOR: blue
APP_MODE: prod
#mysql-config
port: 3306
max_allowrd_packet: 128M
#redis-config
port: 6379
rdb-compression: yes
```

names will be used to associate them with pods.

`kubectl get configmaps`; `kubectl describe configmaps`

```
apiVersion: v1
kind: Pod
metadata:
  name: ubuntu-sleeper-pod
spec:
  containers:
  - name: ubuntu-sleeper-pod
    image: ubuntu-sleeper-pod
    envFrom:
    - configMapRef:
        name: app-config
```

envFrom is a list.



secrets

secrets are used to store sensitve information like passwords or keys; they are similar to config maps except they are stored in a hash or enconded format.

1. create the secret
2. inject the secret in the pod

imperative:

`kubectl create secret generic <secretName> --from-literal=<key>=<value>`; `kubectl create secret generic <secretName> --from-file=<file>`

declarative

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: app-secret
data:
  DB_Host: mysql
  DB_User: root
  DB_Password: paswrd
```

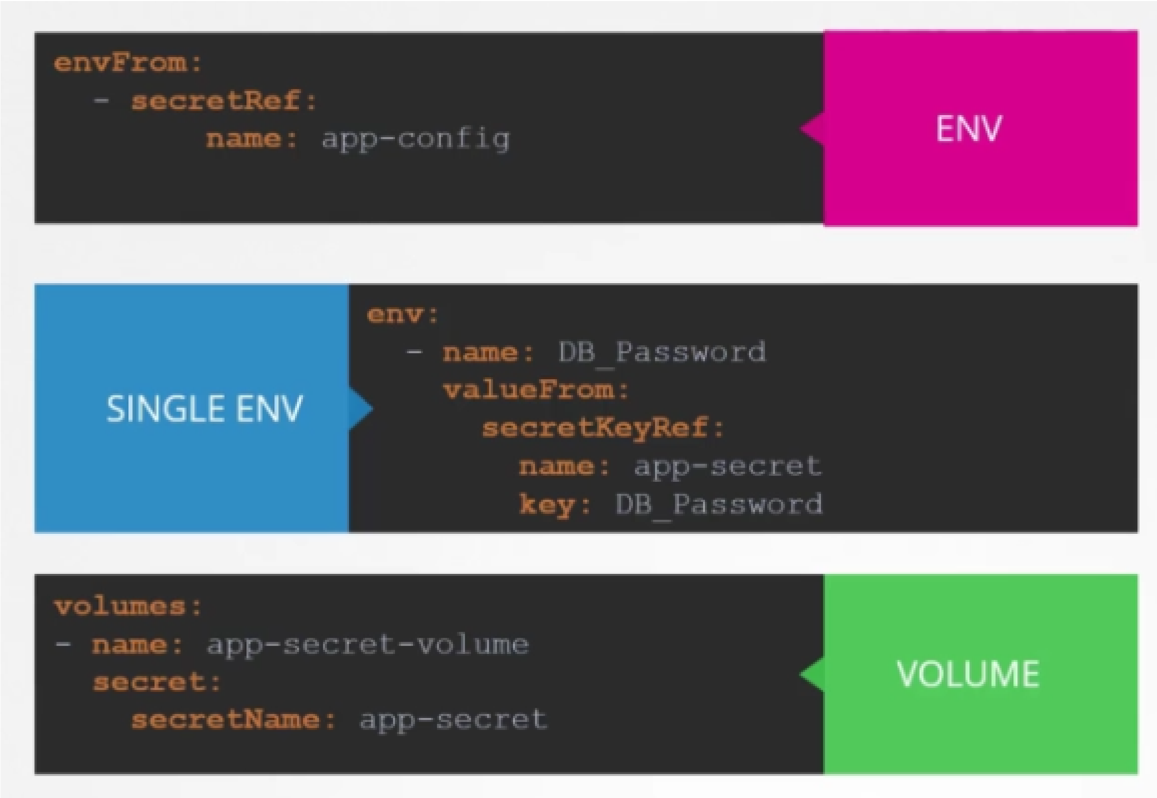
while creating a secret with the declarative approach we must specify the secret values in a hash format. to turn text into hash format in a linux host: `echo -n '<text>' | base64`

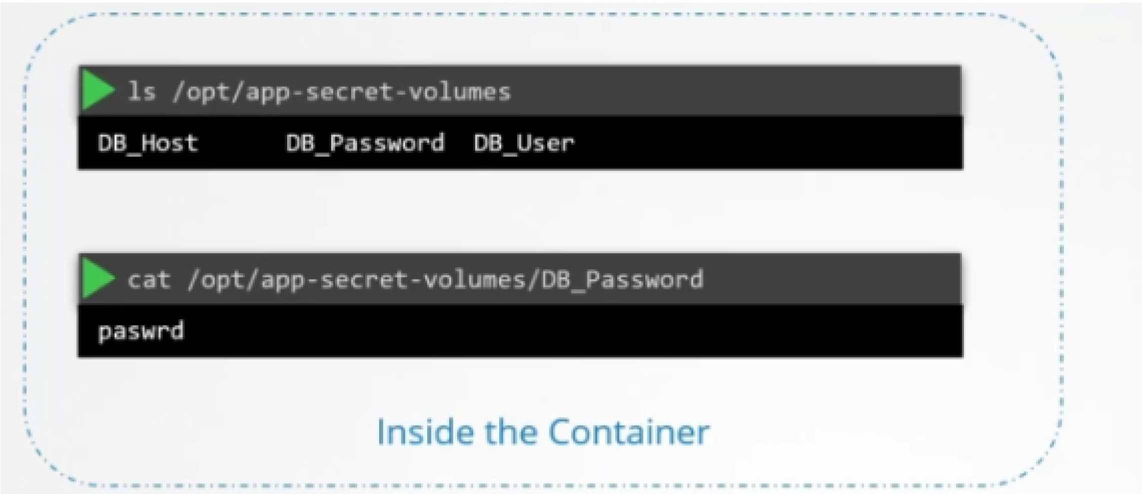
view the values of the secrets: `kubectl get secret <secretName> -o yaml`

decoding hash values: `echo -n '<hashedValue>' | base64 --decode`

injecting the secret:

```yaml
spec:
  containerse:
  - name: simple
    image: wharever
    envFrom:
    - secretRef:
        name: app-secret # name of the secret
```





- https://kubernetes.io/docs/concepts/configuration/secret
- https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data/
- https://kubernetes.io/docs/concepts/configuration/secret/#risks
- https://www.vaultproject.io/

multicontainer pods

related instances on the same pod, several containers on the same pod. they are created together and destroyed together. they have the same lifecycle. they share network (they can reach each other via localhost), storage.

```
spec:
  containers:
  - name: simple-web-app
    image: simple-web-app
```

```
  - name: log-agent
    image: log-agent
```

2 containers will be deployed when provisioning this pod.

3 multicontainer pod design:

1. sidecar pattern
2. adapter
3. ambassador

InitContainers: in a multi-contiainer pod, each container is expected to run a process that stays alive as long as the POD's lifecycle - if any of them fails, the POD restarts.

at imes you may want to run a process that runs to completion in a container, that is a task that will be run only one time when the pod is first created, or a process that waits for an external service or database to be up before the actual app starts. that's where **initContainers** come in.

a initContainer is configured in a pod like all othe rcontainers, except that it is specified inside a `initContainers` section:

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
    app: myapp
spec:
  containers:
  - name: myapp-container
    image: busybox:1.28
    command: ['sh', '-c', 'echo The app is running! && sleep 3600']
  initContainers:
  - name: init-myservice
    image: busybox
    command: ['sh', '-c', 'git clone <some-repository-that-will-be-used-by-application> ; done;']
```

when a pod is first created the initContainer is run, and the process in the initContainer must run to a completion before the real container hosting the application starts. you can configure multiple such initContainers - in that case each init container is run *one at a time in sequential order*. if any of the initContainers fail to complete, k8s restarts the pod repeatedly until the init container succeeds:

```
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
  labels:
```

```
    app: myapp
spec:
  containers:
  - name: myapp-container
    image: busybox:1.28
    command: ['sh', '-c', 'echo The app is running! && sleep 3600']
  initContainers:
  - name: init-myservice
    image: busybox:1.28
    command: ['sh', '-c', 'until nslookup myservice; do echo waiting for
myservice; sleep 2; done;']
  - name: init-mydb
    image: busybox:1.28
    command: ['sh', '-c', 'until nslookup mydb; do echo waiting for mydb;
sleep 2; done;']
```

k8s supports self-healing applications through ReplicaSets and Replication Controllers. The replication controller helps in ensuring that a POD is re-created automatically when the application within the POD crashes. It helps in ensuring enough replicas of the application are running at all times.

Kubernetes provides additional support to check the health of applications running within PODs and take necessary actions through Liveness and Readiness Probes.

cluster maintenance

take down nodes that are part of your cluster as part of maintenance purposes, kernel or software updates.

say a node goes down - the pods are not accessible. if there are enough replicas, app may remain accesible. if the node came back online immediately, the kubelet process starts and the pods come back online. however if the node was down for more than five minites, the pods are terminated - k8s considers them *dead*.

if the pod are part of a replica set then they are recreated on other nodes. the time it waits for a pod to come back online is known as the *pod eviction timeout*, and it's set in the control manager with a default value of 5 minutes `kube-controller-manager --pod-eviction-timeout=5m0s ...`. how long does the master node wait to consider the node dead.

when the pod comes back online, it comes back without any pods scheduled on it. if we know that the upgrade might take longer than the scheduled time to come back, we can drain the node `kubectl drain <nodeName>` - workloads are moved to other nodes in the cluster (actually pods are terminated and recreated on the new node). the node is also marked as unschedulable until you remove the restriction. to allow pods to be scheduled on the node `kubectl uncordon <nodeName>`.

the pods that were moved do not comeback immediately.

`kubectl cordon <nodeName>`: marks the node as unschedulable, it doesn't terminate or moves the pods; simply new pods cannot be scheduled on the node.

- `kubectl drain node01 --ignore-daemonsets` && `kubectl cordon node01`

k8s cluster versions

`kubectl get nodes`

k8s versions - v1.11.3

v1	11	3
major	minor	patch
	features and functionalities	bug fixes

major release july 2015.

coreDNS and ETCD cluster are separate projects

https://kubernetes.io/docs/concepts/overview/kubernetes-api/

Here is a link to kubernetes documentation if you want to learn more about this topic (You don't need it for the exam though):

https://github.com/kubernetes/community/blob/master/contributors/devel/sig-architecture/api-conventions.md

https://github.com/kubernetes/community/blob/master/contributors/devel/sig-architecture/api_changes.md

k8s core components:

- kube-apiserver
- controller-manager
- kube-scheduler
- kubeclt
- kube-proxy
- kubectl

all of these have to have the same version. components can belong to different release versions. none of the controllers should have a higher version than the api server:

k8s supports up to the 3 latest minor versions- recommended upgrade is one version at a time, do not jump minor versions.

upgradaing a clusters consists of two steps

1. upgrading your master nodes - while the master node is being upgraded, the control plane components (apiserver, scheduler...) go down briefly; worker nodes keep functioning normally. since the master is down all management functions are down; you can't access the cluster using kubectl or the api, no new apps...
2. upgrading the worker nodes
   1. upgrade them all at once, takes down the app - requires downtime
   2. one at a time, load is moved to other nodes while the node is being updated
3. add new nodes with the new software version and decommision old ones

kubeadm upgrade

- `kubeadm upgrade plan` - information
- `kubeadm upgrade apply`

kubeadm does not install nor upgrades kubelets. after we upgrade the control plane controllers we have to manually upgrade the kubelet version on each node. upgrande plan gives us the information to apply the upgrade on the nodes - but first we have to upgrade kubeadm on the cluster.

```
apt upgrade -y kubeadm=1.12.0-00 <<<---upgrade kubeadm
kubeadm upgrade plan <<<--- gives us the command to upgrade the cluster
kubeadm upgrade apply v1.12.0 <<<--- upgrade the cluster
```

when we run `kubectl get nodes` we see the version of the kubelets registered on the api server, not the version of the api server itself. then we upgrade the kubelet on the **master** node

```
```

```
apt upgrade -y kubelet=1.12.0-00
systemctl restart kubelet
```

then the worker nodes will have kubelet upgraded. first we have to empty them:

```
kubectl drain node1 <<<--- reschedule pod to other nodes and marks the node
as unschedulable
apt upgrade -y kubeadm=1.12.0-00
apt upgrade -y kubelet=1.12.0-00
kubeadm upgrade node ocnfig --kubelet-version v1.12.0
systemctl restart kubelet
kubectl uncordon node1
```

Demo

```
##############
##  MASTER  ##
##   NODE   ##
##############
apt update
apt-cache madison kubeadm <<<--- look for the latest version
apt-mark unhold kubeadm && apt-get update && apt-get isntall -y
kubeadm=1.19.0-00 && apt-mark hold kubeadm
kubeadm version <<<--- should be updated
sudo kubeadm upgrade plan <<<--- see actual version running and possible
update
sudo kubeadm upgrade appy v1.19.6 -y
kubectl drain controlplane(masternodename) --ignore-daemonsets
apt-mark unhold kubelet kubectl && apt-get update && apt-get install -y
kubelet=1.19.6-00 kubectl=1.19.6-00 && apt-mark hold kubelet kubectl
sudo systemctl daemon-reload
sudo systemctl restart kubelet
kubectl get nodes <<<--- should see new version
kubectl uncordon controlplane(masternodename)

##############
##  WORKER  ##
##  NODES   ##
##############
apt-mark unhold kubeadm && apt-get update && apt-get install -y
kubeadm=1.19.6-00 && apt-mark hold kubeadm
sudo kubeadm upgrade node
####
kubectl drain node1 <<<--- from the control plane node
####
apt-mark unhold kubelet kubectl && apt-get updrate && apt-get install -y
kubelet=1.19.6-00 && apt-mark hold kubelet kubectl
sudo systemctl daemon-reload
sudo systemctl restart kubelet
```

```
kubectl get nodes <<<--- should see new version
kubectl uncordon nodes
```

Practice test

```
apt update
apt install kubeadm=1.19.0-00
kubeadm upgrade apply v1.19.0
apt install kubelet=1.19.0-00
sudo systemctl daemon-reload
sudo systemctl restart kubelet

#########
solution
#########
apt install kubeadm=<version>(1.18.0-00)
kubeadm upgrade apply v<version>(v1.18.0 - upgrade the cluster)
kubectl version --short (cluster version)
apt isntall kubelet==<version>(1.18.0-00)
sudo systemctl daemon-reload
sudo systemctl restart kubelet
# node01
apt install kubeadm=<version>(1.18.0-00)
kubeadm upgrade node
apt isntall kubelet==<version>(1.18.0-00)
sudo systemctl daemon-reload
sudo systemctl restart kubelet
```

BUR

what to backup?

- resource configuration: imperative or declarative files (preferred). store these files on github (also backedup). query kube-api server (best option for managed cluster). save all resource configuration: `kubectl get all --all-namespaces -o yaml > all-deployed-services.yaml`. VELERO
- etcd cluster - all cluster related information is stored: state of the cluster, nodes and every other resources on the cluster. instead of backing up resources, you may choose to backup the ETCD server itself. the ETCD cluster is configured on the master node. while configuring it we specified a location where all the data will be stored (--data-dir=/var/lib/etcd). ETCD has a builtin backup solution `ETCDCTL_API=3 etcdctl snapshot save snapshot.db` - view status of the snapshot: `ETCDCTL_API=3 etcdctl snapshot status snapshot.db`. restoring:
  - stop the kube api server service `service kube-apiserver stop` - we need to restart the etcd cluster and the kubeapi server depends on it.
  - `ETCDCTL_API=3 etcdctl snapshot restore snapshot.db --data-dir /var/lib/etcd-from-backup` when restoring, etcdctl initialices a new cluster config and configures the members of etcd as new members in a new cluster. this is to prevent a new member from joining an existing cluster - on this example, the file at the end of the command is created. then we need to configure the etcd.servive to use that file as the new --data-dir.

  - `systemctl daemon-reload`
  - `service etcd restart`
  - `service kube-apiserver start`
- persistent storage:

for all **etcdctl** snapshot commands we have to specify the --cacert, --cert and --key.

To make use of etcdctl for tasks such as back up and restore, make sure that you set the ETCDCTL_API to 3.

You can do this by exporting the variable ETCDCTL_API prior to using the etcdctl client. This can be done as follows:

`export ETCDCTL_API=3`

For example, if you want to take a snapshot of etcd, use: `etcdctl snapshot save -h` and keep a note of the mandatory global options.

Since our ETCD database is TLS-Enabled, the following options are mandatory:

- `--cacert`: verify certificates of TLS-enabled secure servers using this CA bundle
- `--cert`: identify secure client using this TLS certificate file
- `--endpoints=[127.0.0.1:2379]`: This is the default as ETCD is running on master node and exposed on localhost 2379.
- `--key`: identify secure client using this TLS key file

Similarly use the help option for snapshot restore to see all available options for restoring the backup: `etcdctl snapshot restore -h`

```
root@controlplane:~# ETCDCTL_API=3 etcdctl snapshot save /opt/snapshot-pre-boot.db --cacert=/etc/kubernetes/pki/etcd/ca.crt --cert=/etc/kubernetes/pki/etcd/server.crt --key=/etc/kubernetes/pki/etcd/server.key
Snapshot saved at /opt/snapshot-pre-boot.db
###################################################
root@controlplane:~# etcdctl snapshot restore /opt/snapshot-pre-boot.db --cacert=/etc/kubernetes/pki/etcd/ca.crt --cert=/etc/kubernetes/pki/etcd/server.crt --key=/etc/kubernetes/pki/etcd/server.key --data-dir=/var/lib/etcd-from-backup
```

Solution

First Restore the snapshot:

root@controlplane:~# ETCDCTL_API=3 etcdctl --data-dir /var/lib/etcd-from-backup snapshot restore /opt/snapshot-pre-boot.db

```
2021-03-25 23:52:59.608547 I | mvcc: restore compact to 6466
2021-03-25 23:52:59.621400 I | etcdserver/membership: added member
```

```
8e9e05c52164694d [http://localhost:2380] to cluster cdf818194e3a8c32
root@controlplane:~#
```

Note: In this case, we are restoring the snapshot to a different directory but in the same server where we took the backup (the controlplane node) As a result, the only required option for the restore command is the --data-dir.

Next, update the /etc/kubernetes/manifests/etcd.yaml:

We have now restored the etcd snapshot to a new path on the controlplane - /var/lib/etcd-from-backup, so, the only change to be made in the YAML file, is to change the hostPath for the volume called etcd-data from old directory (/var/lib/etcd) to the new directory /var/lib/etcd-from-backup.

```
  volumes:
  - hostPath:
      path: /var/lib/etcd-from-backup
      type: DirectoryOrCreate
    name: etcd-data
```

With this change, /var/lib/etcd on the container points to /var/lib/etcd-from-backup on the controlplane (which is what we want)

When this file is updated, the ETCD pod is automatically re-created as this is a static pod placed under the /etc/kubernetes/manifests directory.

Note: as the ETCD pod has changed it will automatically restart, and also kube-controller-manager and kube-scheduler. Wait 1-2 to mins for this pods to restart. You can run a watch "docker ps | grep etcd" command to see when the ETCD pod is restarted.

Note2: If the etcd pod is not getting Ready 1/1, then restart it by kubectl delete pod -n kube-system etcd-controlplane and wait 1 minute.

Note3: This is the simplest way to make sure that ETCD uses the restored data after the ETCD pod is recreated. You don't have to change anything else.

If you do change --data-dir to /var/lib/etcd-from-backup in the YAML file, make sure that the volumeMounts for etcd-data is updated as well, with the mountPath pointing to /var/lib/etcd-from-backup (THIS COMPLETE STEP IS OPTIONAL AND NEED NOT BE DONE FOR COMPLETING THE RESTORE)

my notes

- address to reach ETCD cluster from the controlplane --listen-client-urls=127.0.0.1:2379
- server certificate: --cert-file=/etc/kubernetes/pki/etcd/server.crt
- etcd ca cert: --trusted-ca-file=/etc/kubernetes/pki/etcd/ca.crt

`ETCDCTL_API=3 etcdctl snapshot save /opt/snapshot-pre-boot.db --cacert=/etc/kubernetes/pki/etcd/ca.crt --cert=/etc/kubernetes/pki/etcd/server.crt --key=/etc/kubernetes/pki/etcd/server.key`; `ETCDCTL_API=3 etcdctl --data-dir`

`/var/lib/etcd-from-bur snapshot restore /opt/snapshot-pre-boot.db` - since it's the same server, only requires --data-dir arg

edit etc kubernetes manifests etcd.yaml; we have restored the etcd snapshot to a new path on the control plane, so the only change to be made in the yaml file is to change the hostPath for the volume called etcd-data to the new dir

Here's a quick tip. In the exam, you won't know if what you did is correct or not as in the practice tests in this course. You must verify your work yourself. For example, if the question is to create a pod with a specific image, you must run the the `kubectl describe pod` command to verify the pod is created with the correct name and correct image.

- https://kubernetes.io/docs/tasks/administer-cluster/configure-upgrade-etcd/#backing-up-an-etcd-cluster
- https://github.com/etcd-io/etcd/blob/master/Documentation/op-guide/recovery.md
- https://www.youtube.com/watch?v=qRPNuT080Hk

security in k8s

security primitives. the hosts that hold the cluster itself: all access to these hosts must be secured, root access disabled, password based access disabled (only ssh key authentication)...

securing k8s components. kube-apiserver is at the center of all operation in k8s. controlling access to the kube-apiserver is the first line of defense. we need to make two types of decisions. who has access to the cluster and what can they do.

1. who has access: it depends on the authentication method. username/passwd, username/token, certificates, external authentication (ldap), service accounts (for machines)
2. what can they do: RBAC (users are associated to groups with certain permissions), ABAC (attributes), node authorization, webhook mode...

All communication involving the kube-apiserver to the kublet, kube proxy, scheduler, controller manager, etcd cluster is secured using TLS encryption.

communication between applications within the cluster: by default, all pods can access all other pods in the cluster. we can restrict access by using network policies.

authentication

securing the cluster by securing the communication between components. securing access with authentication mechanisms.

1. admins: humans, aka user
2. developers: humans, aka user
3. application end users - access the apps on the cluster; managed by the application themselves internally
4. bots: service accounts

k8s does not manage user accounts natively, it relies on an external source, like a file with user details, or certificates or external certificate service (LDAP) kubernetes *CAN* manage service accounts. we can create and manage service accounts `kubectl create serviceaccount sa1` - `kubectl get servcieaccount`

all user access (admins and developers) is managed by the kube-apiserver, whether you are accessing via `kubectl` or `curl https://kube-server-ip:6443/`. the kube-api server authenticates the request before processing it

1. authenticate user: different mechanisms
    1. static password file: you can create a list of user and passwords using a csv file (passwordAasdf,user,u9991) as the source for user information. passwd,username,userID. we then pass the file as an option to the kube-apiserver: `--basic-auth-file=/etc/kubernetes/manifests/auth/static-file.csv`. after specifying this option (not there by default) you need to restart the kube-apiserver.service. setting up the cluster with kubeadm, we need to modify the yaml file under `/etc/kubernetes/manifests/kube-apiserver.yaml` the kube-apiserver pod definition file; this will restart the kube-apiserver pod. to access the kube-api server: `curl -v -k https://master-node-ip:6443/api/v1/pods -u "user1:passwrod"`. on the csv file we can have a fourth column, for groups. *NOT RECOMMENDED auth mechanism* - consider volume mount while providing the auth file in a kubeadm setup; setup RBAuthorization for the new users.
    2. static token file: it's another csv file, token,username,userID,groupID. we specify the `--token-auth-file=user-details.csv`. using curl: `curl -v -k https://master-node-ip:6443/api/v1/pods --header "Authorization: Bearer <token>"`. *NOT RECOMMENDED auth mechanism* - consider volume mount while providing the auth file in a kubeadm setup; setup RBAuthorization for the new users.
    3. certificates
    4. identity services (third parties, LDAP, kerberos)
2. process request

Setup basic authentication on Kubernetes (Deprecated in 1.19)

- Note: This is not recommended in a production environment. This is only for learning purposes. Also note that this approach is deprecated in Kubernetes version 1.19 and is no longer available in later releases

Follow the below instructions to configure basic authentication in a kubeadm setup.

Create a file with user details locally at */tmp/users/user-details.csv*

```
# User File Contents
password123,user1,u0001
password123,user2,u0002
password123,user3,u0003
password123,user4,u0004
password123,user5,u0005
```

Edit the kube-apiserver static pod configured by kubeadm to pass in the user details. The file is located at /etc/kubernetes/manifests/kube-apiserver.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
name: kube-apiserver
namespace: kube-system
spec:
containers:
- command:
  - kube-apiserver
    <content-hidden>
  image: k8s.gcr.io/kube-apiserver-amd64:v1.11.3
  name: kube-apiserver
  volumeMounts:
  - mountPath: /tmp/users
    name: usr-details
    readOnly: true
volumes:
- hostPath:
    path: /tmp/users
    type: DirectoryOrCreate
  name: usr-details
```

Modify the kube-apiserver startup options to include the basic-auth file

```yaml
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: null
  name: kube-apiserver
  namespace: kube-system
spec:
  containers:
  - command:
    - kube-apiserver
    - --authorization-mode=Node,RBAC
      <content-hidden>
    - --basic-auth-file=/tmp/users/user-details.csv
```

Create the necessary roles and role bindings for these users:

```yaml
---
kind: Role
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default
  name: pod-reader
rules:
- apiGroups: [""] # "" indicates the core API group
```

```
  resources: ["pods"]
  verbs: ["get", "watch", "list"]

---
# This role binding allows "jane" to read pods in the "default" namespace.
kind: RoleBinding
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  name: read-pods
  namespace: default
subjects:
- kind: User
  name: user1 # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role #this must be Role or ClusterRole
  name: pod-reader # this must match the name of the Role or ClusterRole
you wish to bind to
  apiGroup: rbac.authorization.k8s.io
```

Once created, you may authenticate into the kube-api server using the users credentials

`curl -v -k https://localhost:6443/api/v1/pods -u "user1:password123"`

TLS basics

a certificate is used to certificate trust between 2 parties within a transaction, a user trying to access a web-server. TLS certificates ensure that the communication between the user and the server is encrypted and the server is who it says it is. we must encrypt the data using a encryption keys. the data is encrypted using a key which is basically a set of random numbers and letters; you add the random information to the data and you encrypt it to a format that cannot be recognized.

the data is then sent to the server; when the server recieves the data, it is encrypted as well and cannot decrypt the data without the key. a copy of the key must also be sent to the server --> **symmetric encryption**. it is a secure way of encryption, but since ***it uses the same key to encrypt and decrypt the data*** and since 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.

that's where **asymmetric encryption** comes in. Instead of using a single key to encrypt and decrypt data, asymmetric encryption uses a pair of keys a private key and a public key.

- a key which is only with me: So it's private.
- A lock that anyone can access: So it's public.

The trick here is if you encrypt or lock the data with your lock you can only open it with the associated key. So your key must always be secure with you and not be shared with anyone else.

But the lock is public and may be shared with others but they can only lock something with it no matter what is locked. Using the public lock it can only be unlocked by your private key.

let’s look at an even simpler use case of securing SSH access to servers through key pairs. You have a server in your environment that you need access to. You don't want to use passwords as they're too risky. So you decide to use key pairs you generate a public and private key pair. You can do this by running the ssh_keygen command. It creates two files. Id_rsa is the private key and id_rsa.pub is the public key. Well, not a public key, a public lock. You then secure your server by locking down all access to it, except through a door that is locked using your public lock. It's usually done by adding an entry with your public key into the servers .ssh authorized_keys file.

So you see the look is public and anyone can attempt to break through. But as long as no one gets their hands on your private key, which is safe with you on your laptop, no one can gain access to the server. When you try to SSH you specify the location of your private key in your SSH command.

You see the problem we had earlier with symmetric encryption was that the key used to encrypt data had to be sent to the server over the network along with the encrypted data. And so there is a risk of the hacker getting the key to decrypt the data.

What if we could somehow get the key to the server safely. Once the key is safely made available to the server the server and client can safely continue communication with each other using symmetric encryption. to securely transfer the symmetric key from the client to the server, we use Asymmetric Encryption.

So, we generate a public and private key pair *on the server*.

Here we use the openssl command to generate a private and public key pair:

- `openssl genrsa -out my-bank.key 1024` --> private key
- `openssl rsa -in my-bank.ket -pubout > mybank.pem` --> public key

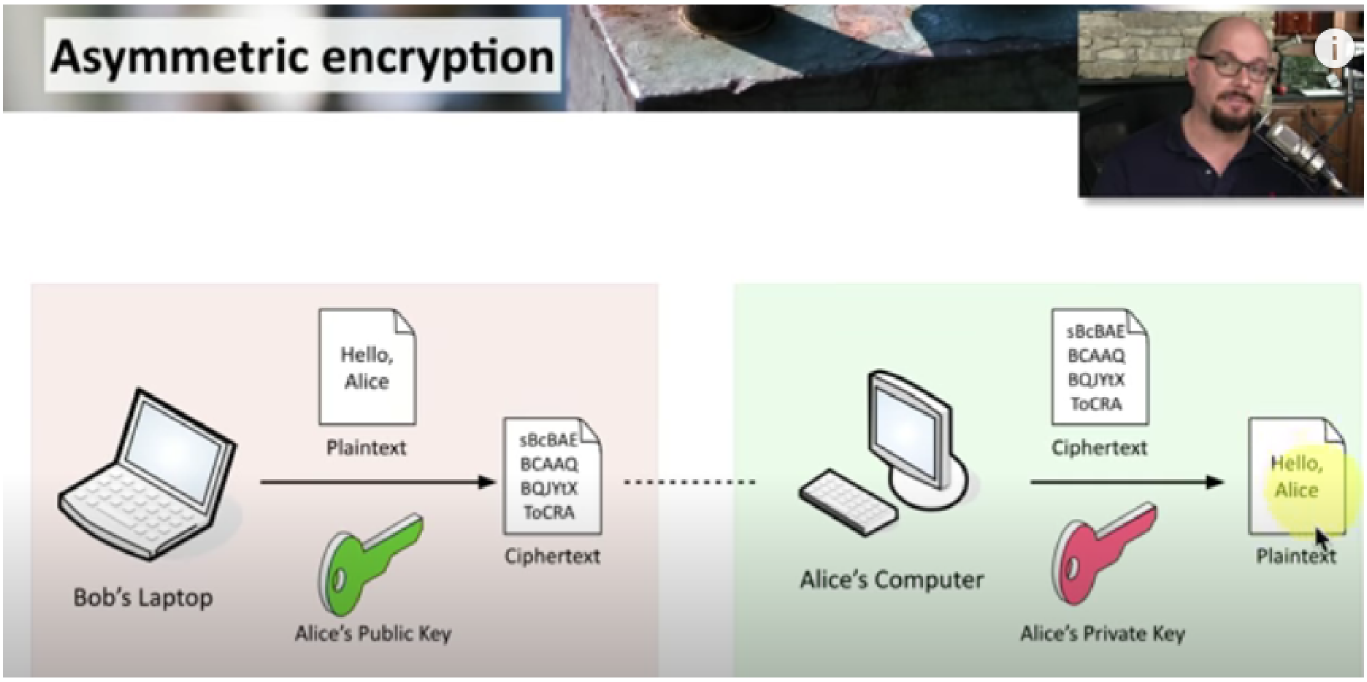
When the user first accesses the web server using https, he gets the public key from the server. Since the hacker is sniffing all traffic that is assumed he too gets a copy of the public key.

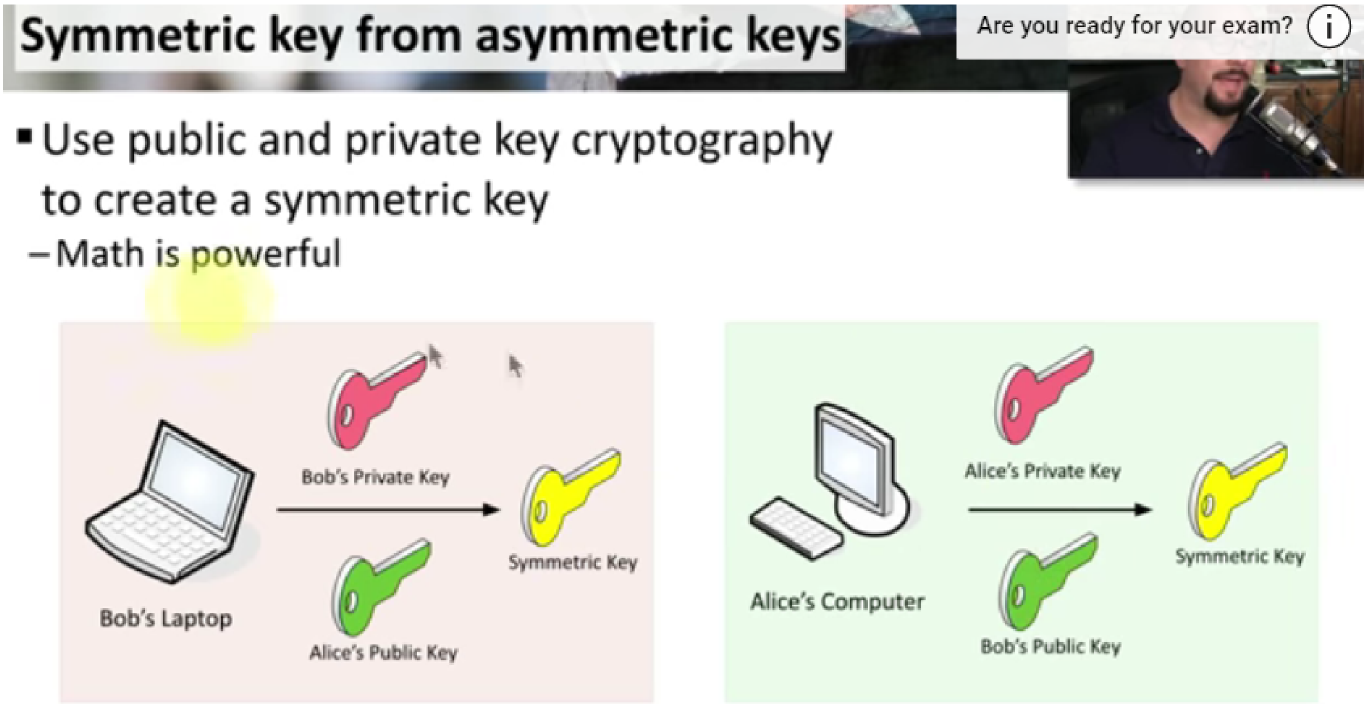
In fact the user's browser then encrypts the symmetric key using the public key provided by the server. The symmetric key is now secure - the user then sends this to the server. The hacker also gets a copy. the server uses the private key to decrypt the message and retrieve the symmetric key from it. However the hacker does not have the private key to decrypt and retrieve the symmetric key from the message it received. the hacker only has the public key with which he can only lock or encrypt a message and not decrypt the message. the symmetric key is now safely available only to the user and the server.

moment	action	server	user	hacker
0	user tries to access webserver	sends public key + CA to user	receives server's public key	receives server's public key
1	browser encrypts the symmetric key using the public key provided by the server			

moment	action	server	user	hacker
2	user sends user's symmetric key and the server's public key		sends a packet with symmetric key and server's public key	receives same packet with symmetric key and public server key
3	the server uses the private key to decrypt the message and retrieve the symmetric key from it			hacker doesn't have the private key so he can't decrypt the symmetric key
4	symmetric key is only available to the user and the server			

https://www.youtube.com/watch?v=pArLLJmgX10





they can now use the symmetric key to encrypt data and send to each other the receiver can use the same symmetric key to decrypt data and retrieve information. The hacker is left with the encrypted messages and public keys with which he CAN'T decrypt any data with asymmetric encryption. We have successfully transferred the symmetric keys from the user to the server and that's symmetric encryption.

```
Perfect the hacker now looks for new ways to hack into our account and so
he realizes that the only way he can get your credential is by getting you
to type it into a form he presents. So he creates a Web site that looks
exactly like your bank's web site. The design is the same. The graphics are
the same. The Web site is a replica of the actual bank's Web site. He hosts
the website on his own server. He wants you to think it's secure too. So he
generates his own set of public and private key pairs and configure them on
his web server.

And finally he somehow manages to tweak your environment or your network to
route your requests going to your bank's web site to his servers. When you
open up your browser and type the website address in you see a very
familiar page the same login page of your bank that you're used to seeing.

So you go ahead and type in the username and password. You made sure you
typed in HTTPS in the URL to make sure that communication is secure
encrypted your browser receives the key you send encrypted symmetric key
and then you send your credentials encrypted with the key and the receiver
decrypt the credentials with the same symmetric key you've been
communicating securely in an encrypted manner but with the hackers server.
As soon as you send in your credentials, you see a dashboard that doesn't
look very much like your bank's dashboard.
```

What if you could look at the key you received from the server and see if it is a legitimate key from the real bank server. **when the server sends the key it does not send the key alone. It sends a certificate that**

has the key in it. If you take a closer look at the certificate you will see that it is like an actual certificate.

But in a digital format it has information about who the certificate is issued to, the public key of that server, the location of that server etc. every certificate has a name on it the person or subject to whom the certificate is issued to.

That is very important as that is the field that helps you validate their identity.If this is for a web server this must match what the user types in the you are on his browser.

If the bank is known by any other names and if they like their users to access their application with the other names as well then all those names should be specified in the certificate under the subject alternative name section.

But you see anyone can generate a certificate like this. You could generate one for yourself saying you're Google and that's what the hacker did in this case. He generated a certificate saying he is your bank's web site. So how do you look at a certificate and verify if it is legit. That is where the most important part of the certificate comes into play *who signed and issued the certificate*.

If you generate the certificate then you will have to sign it yourself. That is known as a self-signed certificate. Anyone looking at the certificate you generated will immediately know that it is not a safe certificate because you have signed if you looked at the certificate you received from the hacker closely you would have noticed that it was a fake certificate that was signed by the hacker himself.

As a matter of fact your browser does that for you. All of the web browsers are built in with a Certificate validation mechanism, wherein the browser checks the certificate received from the server and validates it to make sure it is legitimate. if it identifies it to be a fake certificate then it actually warns you.

So then how do you create a legitimate certificate for your web servers that the web browsers will trust. How do you get your certificates signed by someone with **authority**. That's where *Certificate Authorities or CAs* comes in. They are well known organizations that can sign and validate your certificates for you. Some of the popular ones are Symantec, Digicert, Comodo, GlobalSign etc.

The way this works is you generate a **certificate signing a request or CSR** using the key you generated earlier and the domain name of your Web site. You can do this again using the open SSL command.

`openssl req -new -key my-bank.key -out my-bank.csr -subj "/C=US/ST=CA/O=MyOrg, Inc./CN=mydomain.com"`

This generates a my-bank.csr file which is the certificate signing request that should be sent to the CA for signing. It looks like this the certificate authorities verify your details and once it checks out they sign the certificate and send it back to you.

You now have a certificate signed by a CA that the process trust. if hacker tried to get his certificate signed the same way he would fail during the validation phase and his certificate would be rejected by the CA.

So the Web site that he's hosting won't have a valid certificate. The CAs use different techniques to make sure that you are the actual owner of that domain.

You now have a certificate signed by CA that the browsers trust. But how do the browsers know that the CA itself was legitimate. For example what if the certificate was signed by a fake CA.

In this case our certificate was signed by Symantec. How would the browser know Symantec is a valid CA and that the certificate was infact signed by Symantec and not by someone who says they are semantec. The CA is themselves have a set of public and private key pairs. The CA is use their private keys to sign the certificates the public keys of all the CAs are built in to the browsers. The browser uses the public key of the CA to validate that the certificate was actually signed by the CA themselves.

You can actually see them in the settings of your web browser, under certificates. They are under trusted CAs tab.

Now these are public CAs that help us ensure the public websites we visit, like our banks, email etc are legitimate.

However they don't help you validate sites hosted privately say within your organization. For example, for accessing your payroll or internal email applications. For that you can host your own private CAs.

Most of these companies listed here have a private offering of their services. A CA server that you can deploy internally within your company. You can then have the public key of your internal CA server installed on all your employees browsers and establish secure connectivity within your organization so let's summarize real quick.

We have seen why you may want to encrypt messages being sent over a network to encrypt messages. We use asymmetric encryption with a pair of public and private keys and admin uses a pair of keys to secure SSH connectivity to the servers. The server uses a pair of keys to secure HTTPS traffic. For this the server first sends a certificate signing request to a CA. The CA uses its private key to sign the CSR. Remember all users have a copy of the CAs public key.

The signed certificate is then sent back to the server the server configure is the web application with the signed certificate. Whenever a user accesses the web application the server first sends the certificate with its public key.

The user or rather the user's browser reads the certificate and uses the CA's public key to validate and retrieve the servers. Public key it then generates a symmetric key that it wishes to use going forward for all communication. The symmetric key is encrypted using the server as public key and sent back to the server the server uses its private key to decrypt the message and retrieve the symmetric key. The symmetric key is used for communication going forward so the administrator generates a key pair for securing SSH. the web server generates a key pair for securing the web site with HTTPS, the Certificate Authority generates its own set of key pair to sign certificates.

The end user though only generates a single symmetric key. Once he establishes trust with the Web site he uses his username and password to authenticate the Web server. with the servers key pairs the client was able to validate that the server is who they say they are but the server does not for sure know if the client is who they say they are. It could be a hacker impersonating a user by somehow gaining access to his credentials not over the network for sure as we have secured it already with TLS. May be some other means.

Anyway, So what can the server do to validate that the client is who they say they are. for this as part of the initial trust building exercise, The server can request a certificate from the client and so the client must generate a pair of keys and a signed certificate from a valid CA the client then sends the certificate to the server for it to verify that the client is who they say they are.

Now you must be thinking you have never generated a client's certificate to access a Web site. Well that's because TLS client certificates are not generally implemented on web servers; even if they are it's all implemented under the hood. So a normal user don't have to generate and manage certificates manually.

this whole infrastructure including the CA the servers the people and the process of generating distributing and maintaining digital certificates is known as public key infrastructure or PKI

finally let me clear up something before you leave I've been using the analogy of a key and lock for private and public keys. If I give you the impression that only the lock or the public key can encrypt data then please forgive me as it's not true.

These are in fact two related or paired keys. You can encrypt data with any one of them and only decrypt data with the other. You cannot encrypt data with one and decrypt with the same.

So you must be careful what you encrypt your data with. If encrypted data with your private key then remember anyone with your public key, which could really be anyone out there, will be able to decrypt and read your message.

Finally, a quick note on naming convention. Usually certificates with Public key are named crt or pem extension. So that’s server.crt, server.pem for server certificates or client.crt or client.pem for client certificates. And private keys are usually with extension .key, or –key.pem. For example server.key or server-key.pem. So just remember private keys have the word ‘key’ in them usually either as an extension or in the name of the certificate and one that doesn't have the word key in them is usually a public key or certificate.

tls in k8s

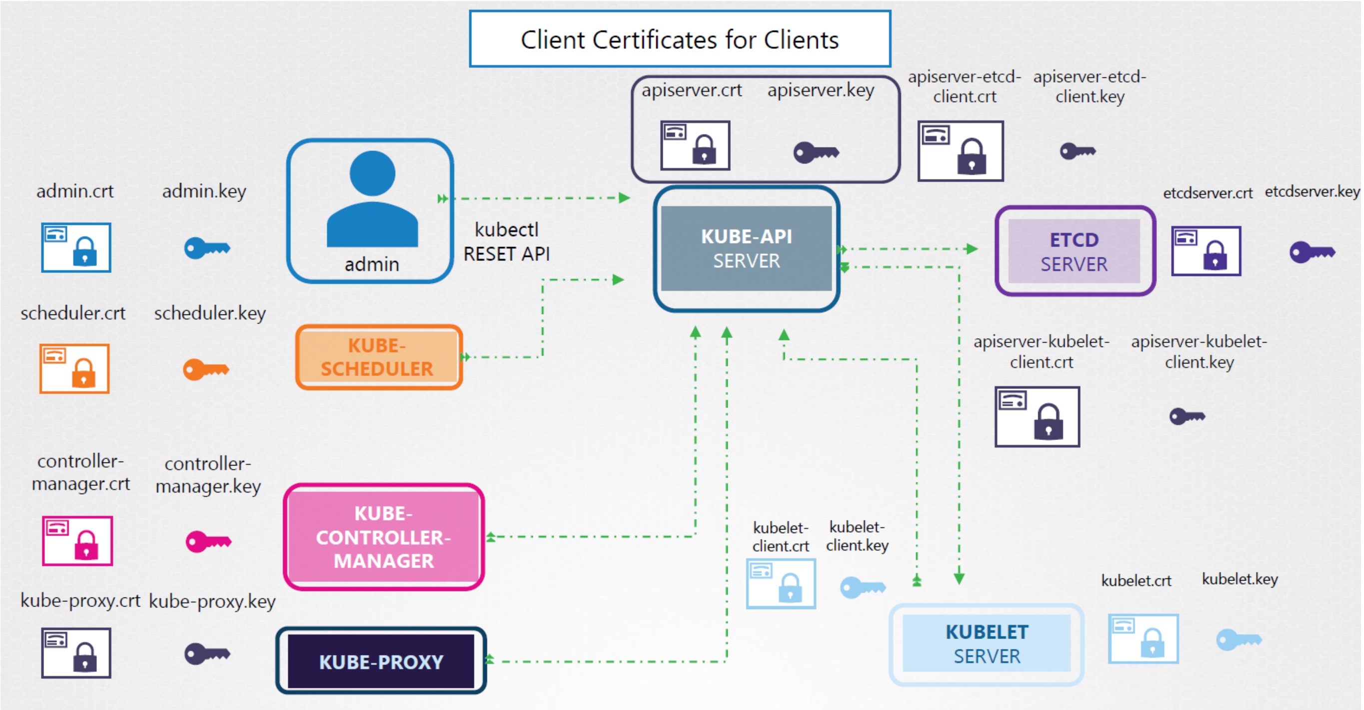
securing sk8s cluster with tls certificates. three types of certificates

1. server certificates: generated by the servers
2. root certificates: generated by a Certificate Authority
3. client certificates: generated by users

- *certificate* or public key: `.crt` or `.pem`
- *private key*: `.key` or `-key.pem`

communication between between all components of the k8s cluster also needs to be secured. requirement:

- servers use server ceretificates
- clients use client certificates



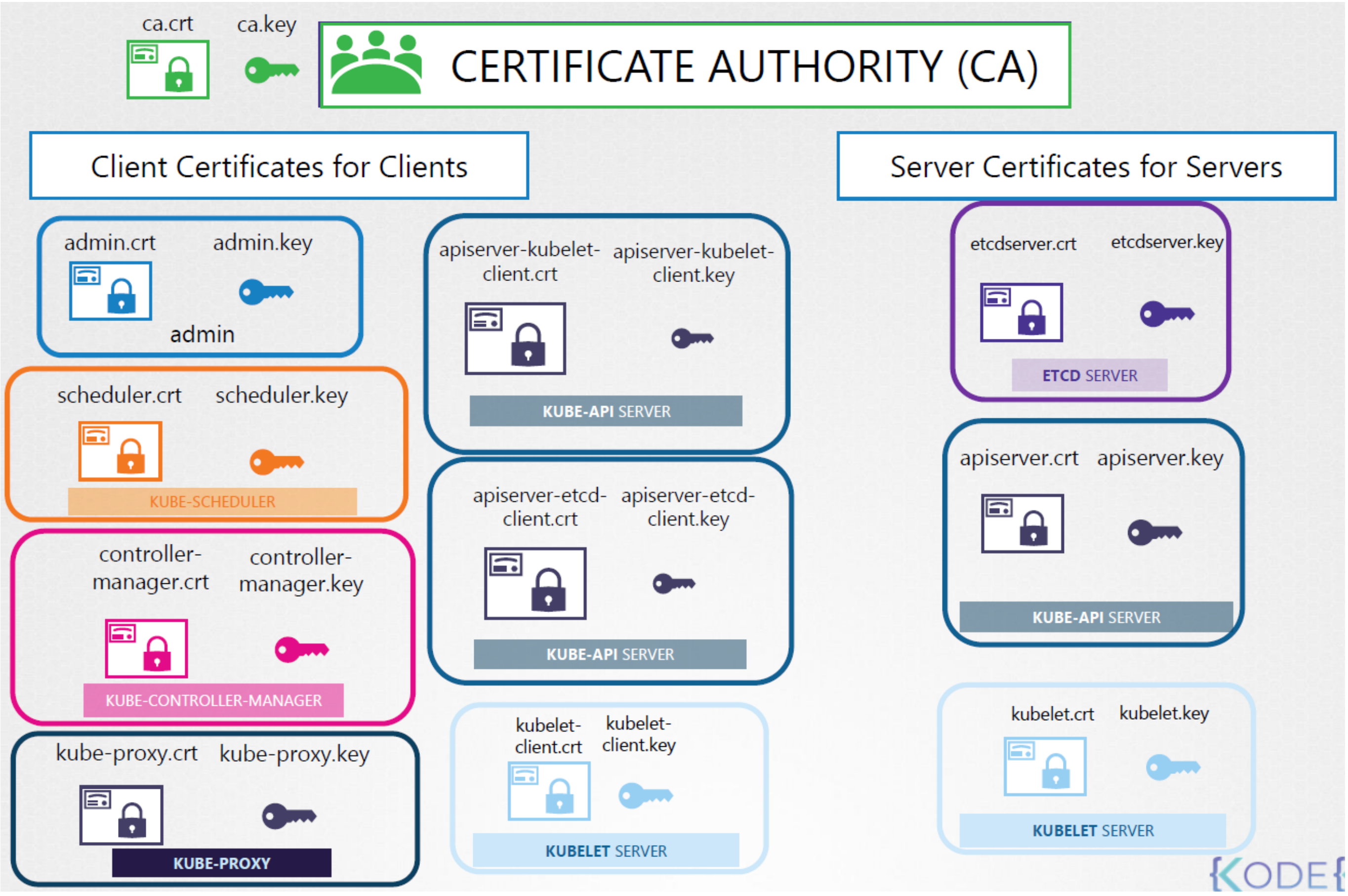
server certitifcates

- the *kube-apiserver* exposes an https service that other components as well as external users use to manage the k8s cluster. it is a server and it rerquires certificates to secure all communicatoin with its clients, so we create a certificate and key pair - **apiserver.crt** and **apiserver.key**. (we can create specific kets to access the etcd and kubelet servers - **apiserver-etcd-client.crt|key** and **apiserver-kubelet-client.crt|key**)
- *etcd* server also requires a pair of certificate and key pair - **etcdserver.crt** and **etcdserver.key**. the only component that talks to the etcd server is the kube-api server, so as far as the etcd server is concercened, the kube-apiserver is a client, so it needs to authenticate.
- *kubelet* component services that also expose an https api endpoint that the kubeapi-server talks to, to interact with the worker nodes. requires **kubelet.crt** and **kubelet.key**

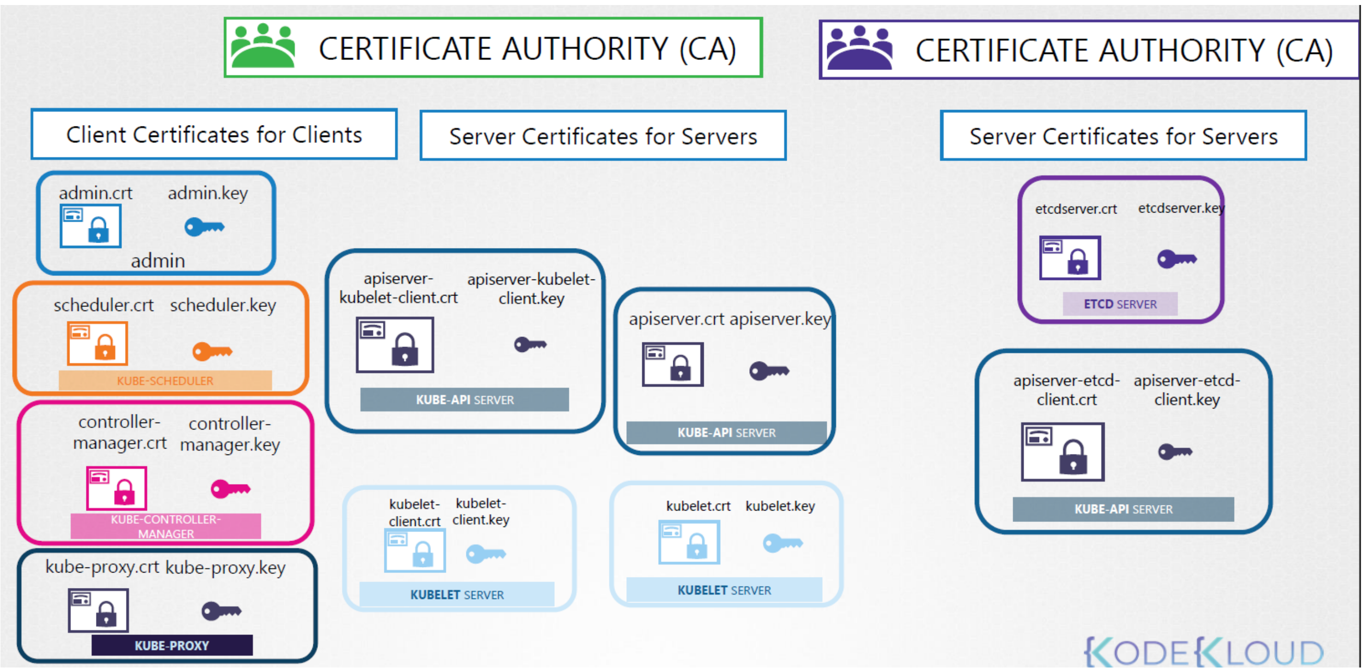
client certificates for clients

clients would be us, the admins, through kubectl or REST api.

- *admin*: certificate and key pair: **admin.crt** and **admin.key**
- *scheduler* talks to the kube-api server to look for pods that need scheduling and then get the right pods on the right worker nodes. the scheduler is a client that access the kube-apiserver. as far as the kube-apiserver is concerned, the scheduler is just another client (like admins), so the kube-apiserver needs to validate its identity: **scheduler.crt** and **scheduler.key**.
- *kube control manager* also requires access to the kube-apiserver so it also requires a certificate: **controller-manager.crt** and **controller-manager.key**.
- *kube-proxy*: requires client certificate: **kube-proxy.crt** and **kube-proxy.key**



k8s requires at least one CA for your cluster. we can have more than one; one specific to etcd and one for the rest of the cluster components. etcd server certificates and the etcd server client certificates (api-server client certificate) will be signed by the etcd server Certificate Authority (CA).



generating certificates for the cluster

there are different tools: easyrsa, **openssl**, cfssl.

Certificate authority (CA) key, csr and crt; root certificate - this will need to be copied on all clients

1. create a keys: `openssl genrsa -out ca.key 2048`
2. create certificate signing request: `openssl req -new -key ca.key -sub "/CN=KUBERNETES-CA" -out ca.csr` - it's like a certificate with all of your details but with no signature. CN common name, what the certificate will be used for.
3. sign certificate: `openssl x509 -req -in ca.csr -signkey ca.key -out ca.crt`

client certificates

admin user

1. create a keys: `openssl genrsa -out admin.key 2048`
2. create certificate signing request: `openssl req -new -key admin.key -sub "/CN=kube-admin" -out admin.csr` - it's like a certificate with all of your details but with no signature. CN common name, what the certificate will be used for. the name can be anything - it's the name that kubectl client authenticates with when you run the kubectl command (that is the name that will appear on audit logs).
3. sign certificate: `openssl x509 -req -in admin.csr -signkey admin.key -out admin.crt`

to differentiate the admin user account from a regular user account we need to specify it the group details for the user in the certificate, say a group called "system:master" with admin privileges. this information must appear when creating the csr: `openssl req -new -key admin.key -sub "/CN=kube-admin/O=system:masters" -out admin.csr`

kube scheduler: system component part of the k8s controlplane, so it's name must be prefixed with the keyword **SYSTEM**. the same applies for controller manager and kube-proxy.

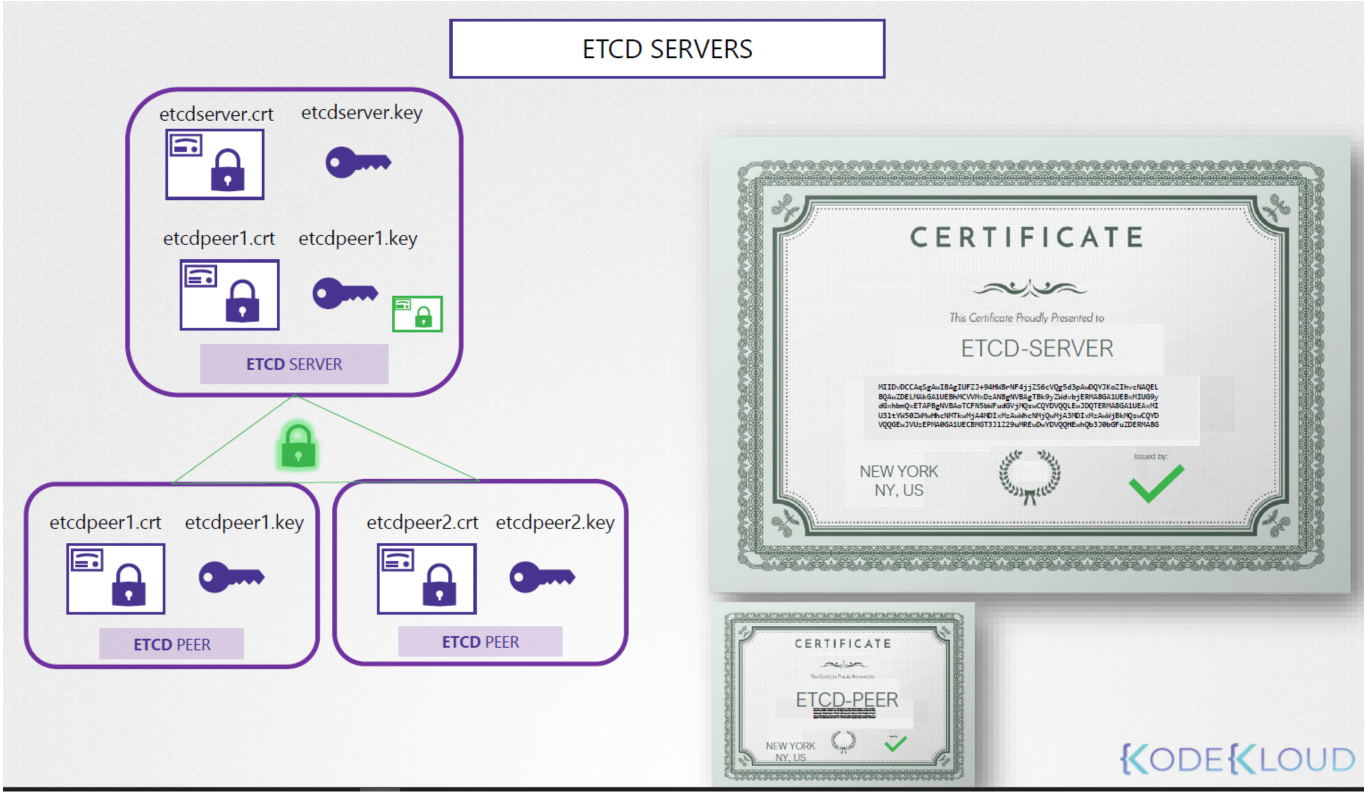
we can use the certificates we've created rather than username/password in the API calls: `curl https://kube-apiserver:6443/api/v1/pods --key admin.key --cert admin.crt --cacer ca.crt`. the other way is to move all these parameters to a config file called **kubeconfig**:

```yaml
# kube-config.yaml
apiVersion: v1
clusters:
- cluster:
    certificate-authority: ca.crt
    server: https://kube-apiserver:6443
  name: kubernetes
kind: Config
users:
- name: kubernetes-admin
  user:
    client-certificate: admin.crt
    client-key: admin.key
```

whenever you configure a server or a client with certificates, you will need to specify the CA root certificate as well.

server certificates

etcd server: same process, in case the etcd is formed by a cluster (HA environment), to ensure communication between the members of the cluster, we must create additional peer certificates. once created, we must specify them when starting the etcd server




```
cat etcd.yaml
- etcd
   - --advertise-client-urls=https://127.0.0.1:2379
   - --key-file=/path-to-certs/etcdserver.key
   - --cert-file=/path-to-certs/etcdserver.crt
   - --client-cert-auth=true
   - --data-dir=/var/lib/etcd
   - --initial-advertise-peer-urls=https://127.0.0.1:2380
   - --initial-cluster=master=https://127.0.0.1:2380
   - --listen-client-urls=https://127.0.0.1:2379
   - --listen-peer-urls=https://127.0.0.1:2380
   - --name=master
   - --peer-cert-file=/path-to-certs/etcdpeer1.crt
   - --peer-client-cert-auth=true
   - --peer-key-file=/etc/kubernetes/pki/etcd/peer.key
   - --peer-trusted-ca-file=/etc/kubernetes/pki/etcd/ca.crt
   - --snapshot-count=10000
   - --trusted-ca-file=/etc/kubernetes/pki/etcd/ca.crt
```

kube-api server -->> this is it's real name; but some just call it kubernetes. others, kubernetes.default, kubernetes.default.svc, kubernetes.default.svc.cluster.local, or the IP of the pod for the API server or the IP of the server. all of these must appear on the kube-api certificate. only then those other names can be used to establish a valid connection.

- `openssl genrsa -out apiserver.key 2048`
- `openssl req -new -key apiserver.key -sub "/CN=kube-apiserver" -out apiserver.csr`. to attach the alternate names, we need to create an openssl config file

```
[ req ]
req_extensions = v3_req
[ v3_req ]
basicConstraints = CA:FALSE
keyUsage = nonRepudiation,
subjectAlName = @alt_names
[ alt_names ]
DNS.1 = kubernetes
DNS.2 = kubernetes.default
DNS.3 = kubernetes.default.svc
DNS.4 = kubernetes.default.svc.cluter.local
IP.1 = 10.96.0.1
IP.2 = 172.17.0.87
```

`openssl req -new -key apiserver.key -sub "/CN=kube-apiserver" -out apiserver.csr -config openssl.cnf`

- `openssl x509 -req -in apiserver.csr -CA ca.crt -CAkey ca.key -out apiserver.crt`

```
ExecStart=/usr/local/bin/kube-apiserver \\
  --advertise-address=${INTERNAL_IP} \\
  --allow-privileged=true \\
  --apiserver-count=3 \\
  --authorization-mode=Node,RBAC \\
  --bind-address=0.0.0.0 \\
  --enable-swagger-ui=true \\
  --etcd-cafile=/var/lib/kubernetes/ca.pem \\
  --etcd-certfile=/var/lib/kubernetes/apiserver-etcd-client.crt \\
  --etcd-keyfile=/var/lib/kubernetes/apiserver-etcd-client.key \\
  --etcd-servers=https://127.0.0.1:2379 \\
  --event-ttl=1h \\
  --kubelet-certificate-authority=/var/lib/kubernetes/ca.pem \\
  --kubelet-client-certificate=/var/lib/kubernetes/apiserver-etcd-client.crt \\
  --kubelet-client-key=/var/lib/kubernetes/apiserver-etcd-client.key \\
  --kubelet-https=true \\
  --runtime-config=api/all \\
  --service-account-key-file=/var/lib/kubernetes/service-account.pem \\
  --service-cluster-ip-range=10.32.0.0/24 \\
  --service-node-port-range=30000-32767 \\
  --client-ca-file=/var/lib/kubernetes/ca.pem \\
  --tls-cert-file=/var/lib/kubernetes/apiserver.crt \\
  --tls-private-key-file=/var/lib/kubernetes/apiserver.key \\
  --v=2
```

CLIENT CERTS FOR ETCD

CLIENT CERTS FOR apiserver

CA

API

API

kubelet server: https api server that runs on each node. what the kube-api server talks to to send instructions and monitor de node. the certificates will be named after their nodes. once the certificates are created, used them on the kubelet-config.yaml file on each node:

```
kind: KubeletConfiguration
apiVersion: kubelet.config.k8s.io/v1beta1
authentication:
  x509:
    clientCAFile: "/var/lib/kubernetes/ca.pem" # <<<--- highlighted
authorization:
  mode: Webhook
clusterDomain: "cluster.local"
clusterDNS:
  - "10.32.0.10"
podCID: "${POD_CIDR}"
resolvConf: "/run/systed/resolve/resolv.conf"
runtimeRequestTimeout: "15m"
tlsCertFile: "/var/lib/kubelet/kubelet-node01.crt" # <<<--- highlighted
tlsPrivateKeyFile: "/var/lib/kubelet/kubelet-node01.key" # <<<---
highlighted
```

kubelet client cert: used to authenticate to the api-server. naming: `system:node:<nodeName>` - the nodes must be added to a group named **system:nodes**.

view certificate details

how was the k8s server configured? entirely manual work or using another tool? kubeadm?

- if manually configured: `cat /etc/systemd/system/kube-apiserver.service` to check which certificates are present and configured.
- automated provisining: `cat /etc/kubernetes/manifests/kube-apiserver.yaml`

to check the information on a .crt file: `openssl x509 -in /etc/kubernetes/pki/apiserver.crt -text -noout`. check

- **Subject**: name of the certificate
- **Alternate Name**
- **Validity**: Not After... expired?
- **Issuer**: CA who issued the certificate

checking logs: `journalctl -u etcd.service -l` if the service was configured at the server level. `kubectl logs etcd-master` if configured as a pod with kubeadm or `docker logs <contID>`

practice

- main tls certificate: `--tls-cert-file=/etc/kubernetes/pki/apiserver.crt`
- root ca for etcd is the same for the kube-apiserver config file as the path for the etcd file (just check if etcd root ca points to where it should)

TLS certificates and API

a CA server - to gain access to the cluster, we have to generate a key and a CSR (certificate signing request), send it to the CA server for it to sign it.

CA server is made up of a pair of key and certificate files. who has access to these files can sign any certificates for the k8s environment. since these files have to be secure, we can dedicate an entire node that is entirely secure to store them.

kubeadm creates these files on the master node.

automatically rotating and signing certificates. kubernetes has a builtin *CERTIFICATES API* that can do this. we can send a CSR directly to kubernetes through an API call; when the admin receives a CSR, they can create a k8s object called **CertificateSigningRequest** - all admins can view the sigining requests and approve them using kubectl commands.

1. user creates a key: `openssl genrsa -out jaliaga.key 2048`
2. user creates a csr: `openssl req -new -key jaliaga.key -subj "/CN=jaliaga" -out jaliaga.csr`
3. user sends the request to the admin
4. admin takes the csr and creates a CertificateSigningRequest object
    1. creates manifest file (see below)
    2. encode the received csr: `cat jaliaga.csr | base64` (to decode it `echo "asddkfasf" | base64 --decode`)
5. review requests: `kubectl get csr`
6. approve requests: `kubectl certificate approve jaliaga` (`kubectl certificate deny jaliaga` && `kubectl delete csr jaliaga`)
7. this certificate can be extracted and shared with the user: `kubectl get csr jaliaga -o yaml`

```
apiVersion: certificates.k8s.io/v1beta1 # certificates.k8s.io/v1
kind: CertificateSigningRequest
metadata:
  name: jaliaga
spec:
  groups:
  - system:authenticated
  usages:
  - digital signature
  - key encipherment
  - server auth
  request: #base64 encoded request - one single line
```

the component responsible for all certificate operations is the *CONTROLLER MANAGER*. it has controllers called *csr-approving*, *csr-signing*...

if anyone wants to sign certificates, they must have the CA server root certificate and private key (`cat /etc/kubernetes/manifests/kube-controller-manager.yaml`). the controller-manager service configuration has two configuations we should look at: `--cluster-signing-cert-file` and `--cluster-signing-key-file`

kubeconfig

by default, kubectl looks for a file under `$HOME/.kube/config` where there should be a kubeconfig file specifying --server, --client-key, --client-certificate, --certificate-authority... the kubeconfig file has three sections:

1. clusters: the various k8s clusters you need access to (test, development, prod...).
2. contexts: join clusters and users; they define which user account will be used to access which cluster. Admin@Production context grants access to the production cluster as Admin user. Dev@Google... no users are created, we are using existing users with existing privileges and defyning which has access to which cluster.
3. users: user accounts with which you have access to different clusters (admin, dev user, prod user...) - these users may have different privileges on different clusters

- **--server** specification goes into the cluster section
- **--client-key**, **--client-certificate** and **--certificate-authority** go into the user section

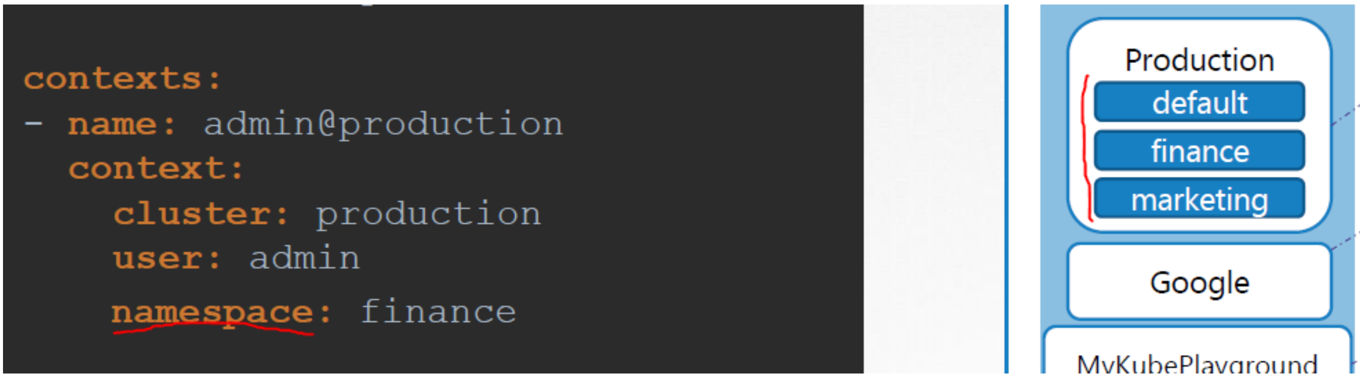
then we create a context that specifies `<user>@<cluster>`.

```
# kubeconfig file
apiVersion: v1
kind: Config
current-context: developer@development # <<<<----- DEFAULT context
clusters: # 1 fill this section
- name: my-kube-playground
  cluster:
    certificate-authority: ca.crt # full path
    server: https://my-kube-playground:6443

- name: development
  cluster:
    certificate-authority: ca.crt # full path
    server: https://development:6443

contexts:
- name: my-kube-admin@my-kube-playground
  context:
    cluster: my-kube-playground
    user: my-kube-admin

- name: developer@development
  context:
    cluster: development
    user: developer

users:  # 2 fill this section
- name: my-kube-admin
  user:
    client-certificate: admin.crt # full path
    client-key: admin.key # full paths

- name: developer
  user:
```

```
      client-certificate: dev.crt # full path
      client-key: dev.key # full paths
```

this file is left as is and it will be read by the kubectl command. how does kubectl know which context to use? field current-context. `kubectl config view` view information on the default config file; `kubectl config view --kubeconfig=my-custom-file`. to update the current context: `kubectl config use-context my-kube-admin@my-kube-playground` - this changes the default, the **current-context**.

namespaces + kubeconfig: we can specify the default namespace (when we switch to that ns) under contexts > context > add "namespace: wharever".

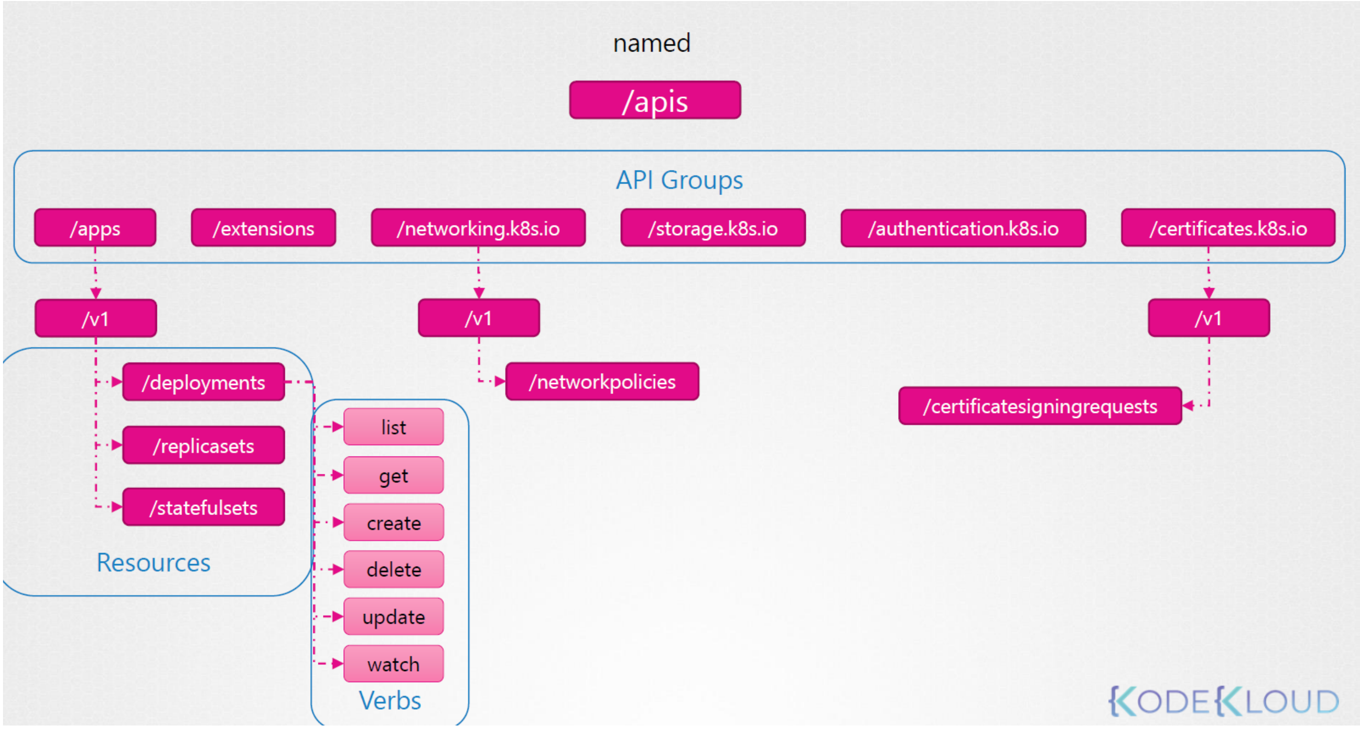


rather than specifying the ca full path, we can specify a field called **certificate-authority-data:** with the information on the CA encoded (`cat /etc/kubernetes/pki/ca.crt | base64`)

- using a context defined on a file: `kubectl config --kubeconfig=/root/my-kube-config use-context research`
- defining a custom kubeconfig file: ``

api groups

- `curl https://kube-master:6443:/version` viewing version of the cluster
- `curl https://kube-master:6443:/metrics` and `curl https://kube-master:6443:/healthz` to monitor the health of the cluster
- `curl https://kube-master:6443:/logs` integrating with third party apps
- `curl https://kube-master:6443:/api` - core group. all core functionalities exist
  - /v1
    - namespaces | pods | rc | events | endpoints | nodes | bindings | PV | PVC | configmaps | secrets | services
- `curl https://kube-master:6443:/apis` - named group. more organized. newer features will be made available through these named groups:
  - /apps | /extensions | networking.k8s.io | storage.k8s.io | authentication.k8s.io | certificates.k8s.io



- `curl http://localhost:6443 -k`
- `curl http://localhost:6443 -k | grep "name"` -- supported resource groups
- `curl http://localhost:6443 -k --key admin.key --cert admin.crt --cacer ca.crt`
- to avoid the previous line, we can start a `kubectl proxy` client - that command launches a local proxy on port **8001** and uses credentials from the kube proxy file to access the cluster.
- `curl http://localhost:8001 -k`

`kube proxy` (used to enable connectivity between pods and services accross different nodes in the cluster) vs `kubectl proxy` (http proxy service created by kubectl utility to access the kube api server)

authorization

what can users do once they've logged into the cluster. for instance, restricting certain accounts to be able to only view, rather than also being able to modify. restricting users to their namespaces can help us accomplish this. authorization mechanisms:

- node auth: the kube api is accessed by the users as well as the kubelets on other nodes. the requests (say for information about the state of the node) are handled by the *node authorizer*. for instance, kuebelets that try to gain access to the kube api and that are part of the system:node (they have that tag at the beginning of their certificate name) are allowed.
- ABAC (attribute) auth: external access, say a user. you associate a user or group of users with a set of permissions. say a user can: view, create and delete pods. we do this by creating a policy file in JSON format: `{"kind":"Policy", "spec":{"user": "dev-user", "namespace": "*", "resource": "pod", "apiGroup":"*"}}`. making changes to these files requires manual work an restarting the kube api server. ABAC difficult to manage
- RBAC auth: easier to manage. instead of directly associating a user/group with a set of permissions, we define a role. we create a role with a set of permissions required by, say, developers. then we associate the developers to that role. modifying a role takes effect immediately.
- webhook auth: checking with external apis for information

authorization modes:

- AlwaysAllow: no authorization checks
- AlwaysDeny: denies all requests

modes are set using the **--authorization-mode=** option on the kube-api server. if you don't specify this option, it's set by default to always allow.

`--authorization-mode=Node,RBAC,Webhook`: the request is authorized using each one on th e order specified (every time a request is denied, it goes to the next one - if one of the modules approves the request, no more checks and permission is granted). for example, when a user sends a request, it is first handled by the node authorizer, which only handles node requests - so it denies the request. whenever a module denies a request, it is forwarded to the next one in the chain. RBAC checks the user permissions and user is given access to the requested object.

RBAC

creating a role by creating a role object. role def file

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: developer
rules:
- apiGroups: [""] # for core groups we can leave this blank; for any other group we need to specify the group
  resources: ["pods"]
  verbs: ["list", "get", "create", "update", "delete"]
  # allow developers to create configmaps
- apiGroups: [""]
  resources: ["ConfigMap"]
  verbs: ["create"]
```

`kubectl create -f <file>.yaml`

the we need to create a link of the user to the role: a binding. links a user object to a role

```
# devuser-developer-binding.yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: devuser-developer
subjects: # user details
- kind: User
  name: dev-user
  apiGroup: rbac.authorization.k8s.io
roleRef:  # details of the role
  kind: Role
  name: developer
  apiGroup: rbac.authorization.k8s.io
```

`kubectl create -f <file>.yaml`

roles and role bindings fall under the scope of namespaces. to restrict ns access, modify config files.

- `kubectl get roles` to view roles
- `kubectl get rolebindigs`
- `kubectl describe role developer`
- `kubectl describe rolebinding devuser-developer-binding`

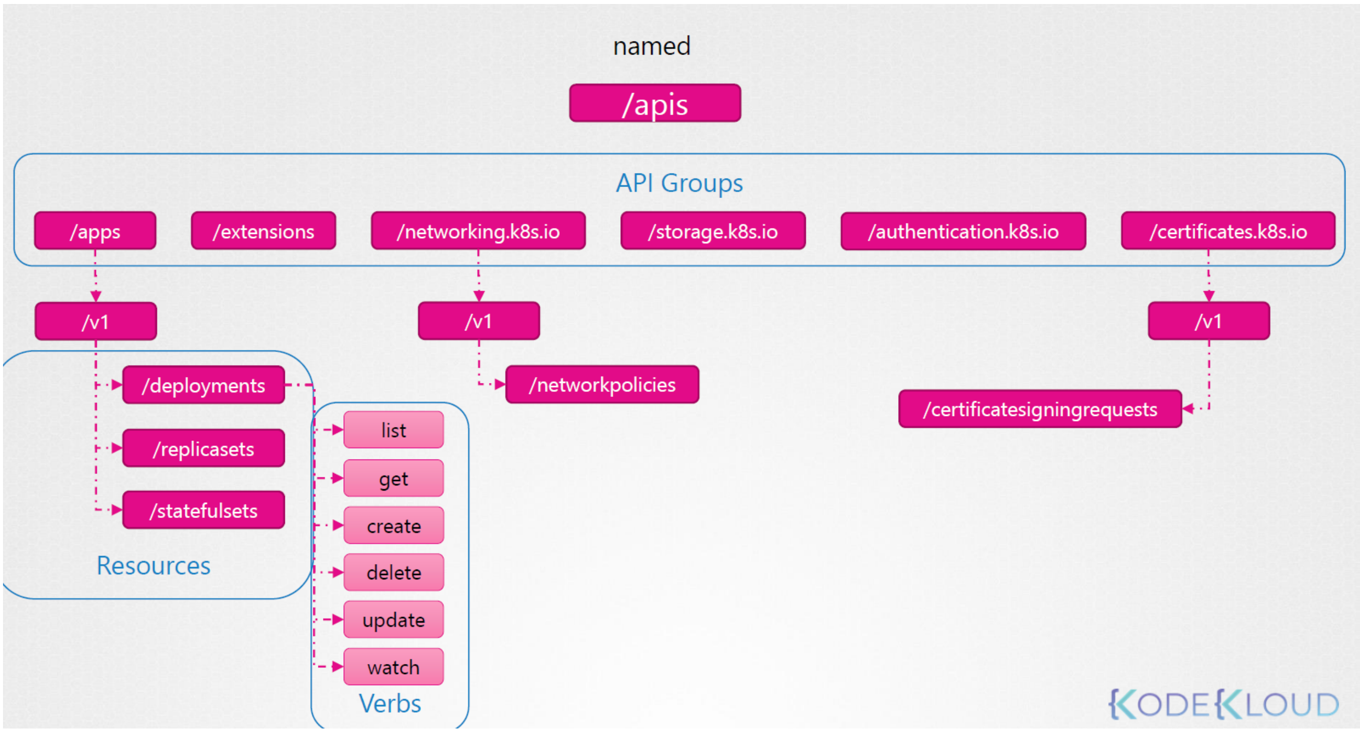
check my accesses:`kubectl auth can-i create deployments | delete nodes`; switch user **--as**: `kubectl auth can-i create deployments --as dev-user | create pods --as dev-user`; we can add **--namespace test** to check permissions especifically to that ns.

restrict access to the role, under rules, add `resourceNames: ["blue","orange"]` (in the example, there are 5 pods, all different colors)

cluster role and cluster role bindings

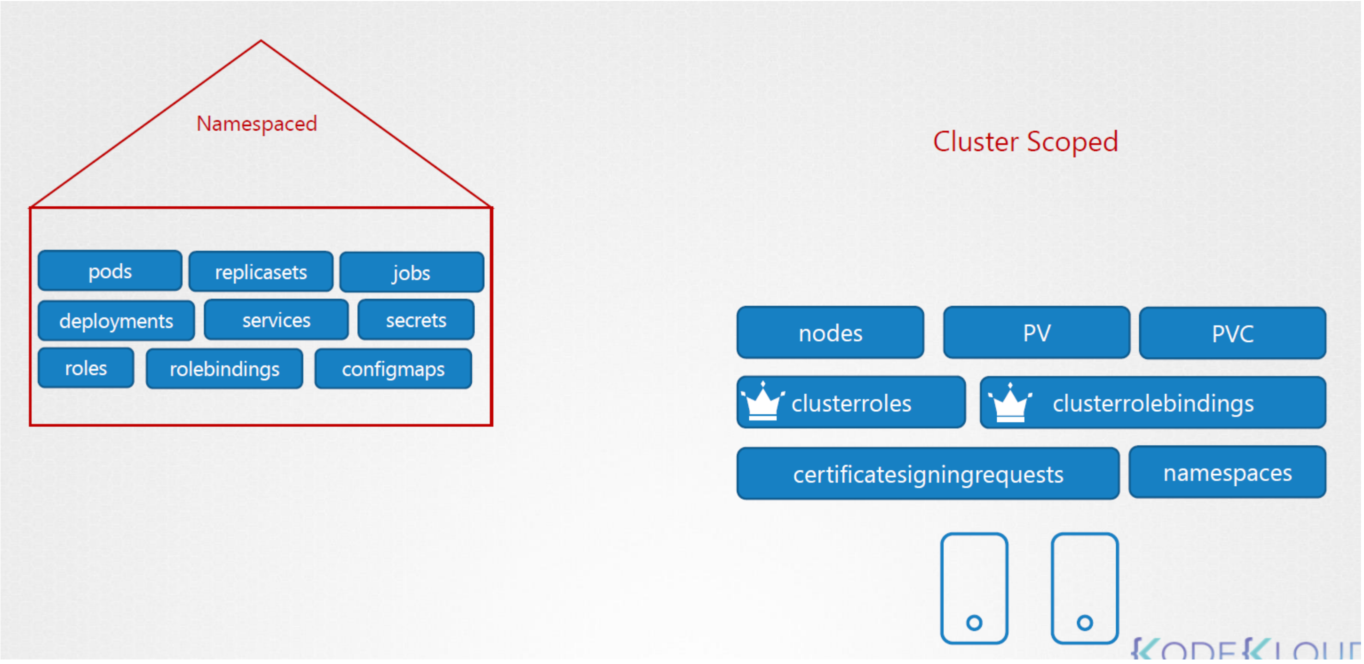
roles and rolebindings are namespaced, they are created within namespaces; if you don't specify the namespace, they are created in the default namespace and control access. we can't group nodes within a namespace.

resources are categorized as namespaced or cluster-scoped. cluster-scoped when you don't specify the namespace



- full list of namespaced resources: `kubectl api-resources --namespaced=true`
- full list of cluster-scoped resources: `kubectl api-resources --namespaced=false`

authorizing users to cluster wide resources: cluster roles and cluster role bindings. like roles but for cluster scoped resources we have to create a cluster role binding to link the user to the role



cluster-admin-role.yaml

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: cluster-administrator
rules:
- apiGroups: [""]
  resources: ["nodes"]
  verbs: ["list", "get", "create", "delete"]
```

cluster-admin-role-binding.yaml

```yaml
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-role-binding.yaml`

you can create a cluster role for namespaced resources as well. the user will have access to these resources accross all namespaces

image security

image names: `image: nginx`; docker image naming conventions.

registry	user/account	image/repository

registry	user/account	image/repository
docker.io (assumed by default)	nginx/	nginx
gcr.io (google)	kubernetes-e2e-test-images	dnsutils

private registry - following docker way of doing things, we need to first log into our docker registry: `docker login private-registry.io` + credentials. run images: `docker run|pull private-registry.io/apps/internal-app` - for a pod def file, we would use the full path.

as regards authentication for the docker runtime. we need to create a secret object with the credentials in it

- `kubectl create secret docker-registry private-reg-cred --docker-username=dock_user --docker-password=dock_password --docker-server=myprivateregistry.com:5000 --docker-email=dock_user@myprivateregistry.com`

```
containers:
- image: myprivateregistry.com:5000/nginx:alpine
  imagePullPolicy: IfNotPresent
  name: nginx
imagePullSecrets:
- name: private-reg-cred
```

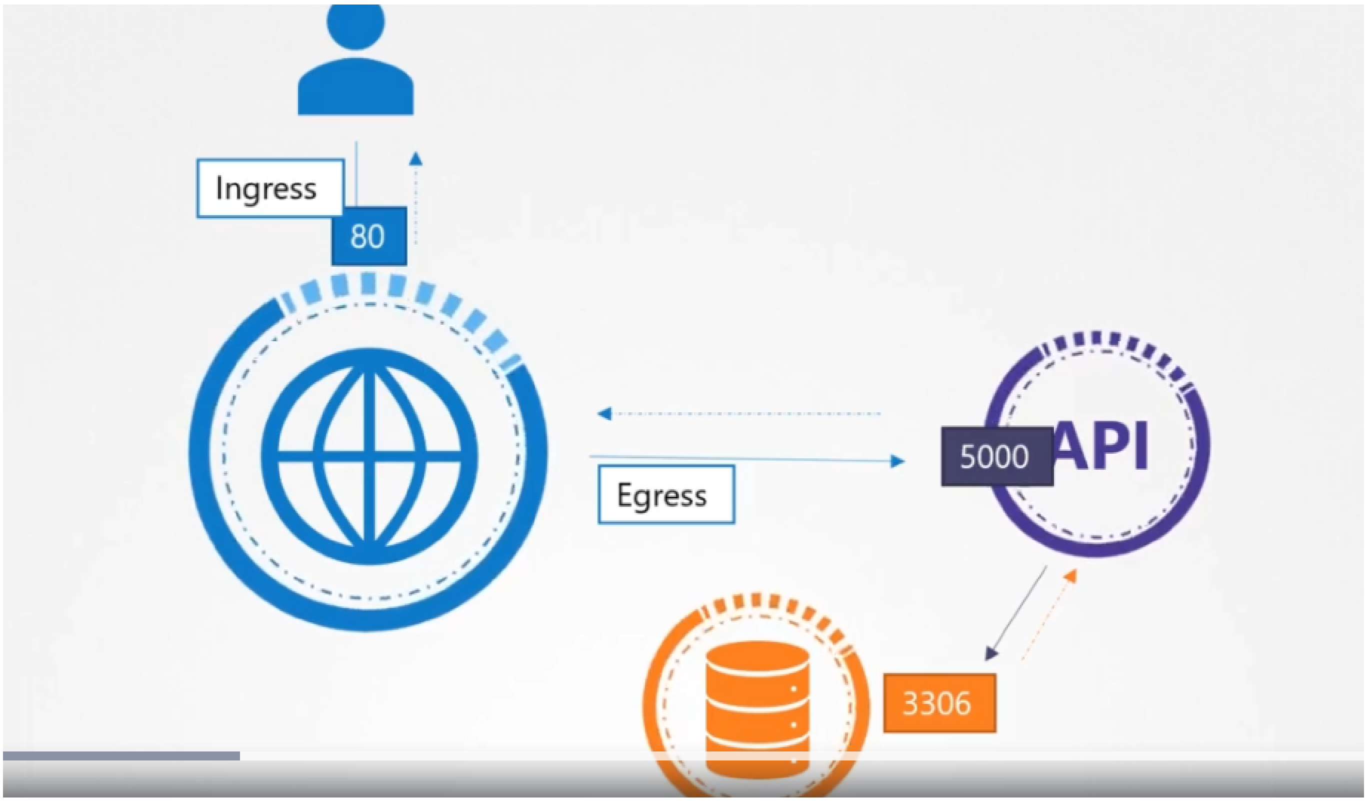
security contexts

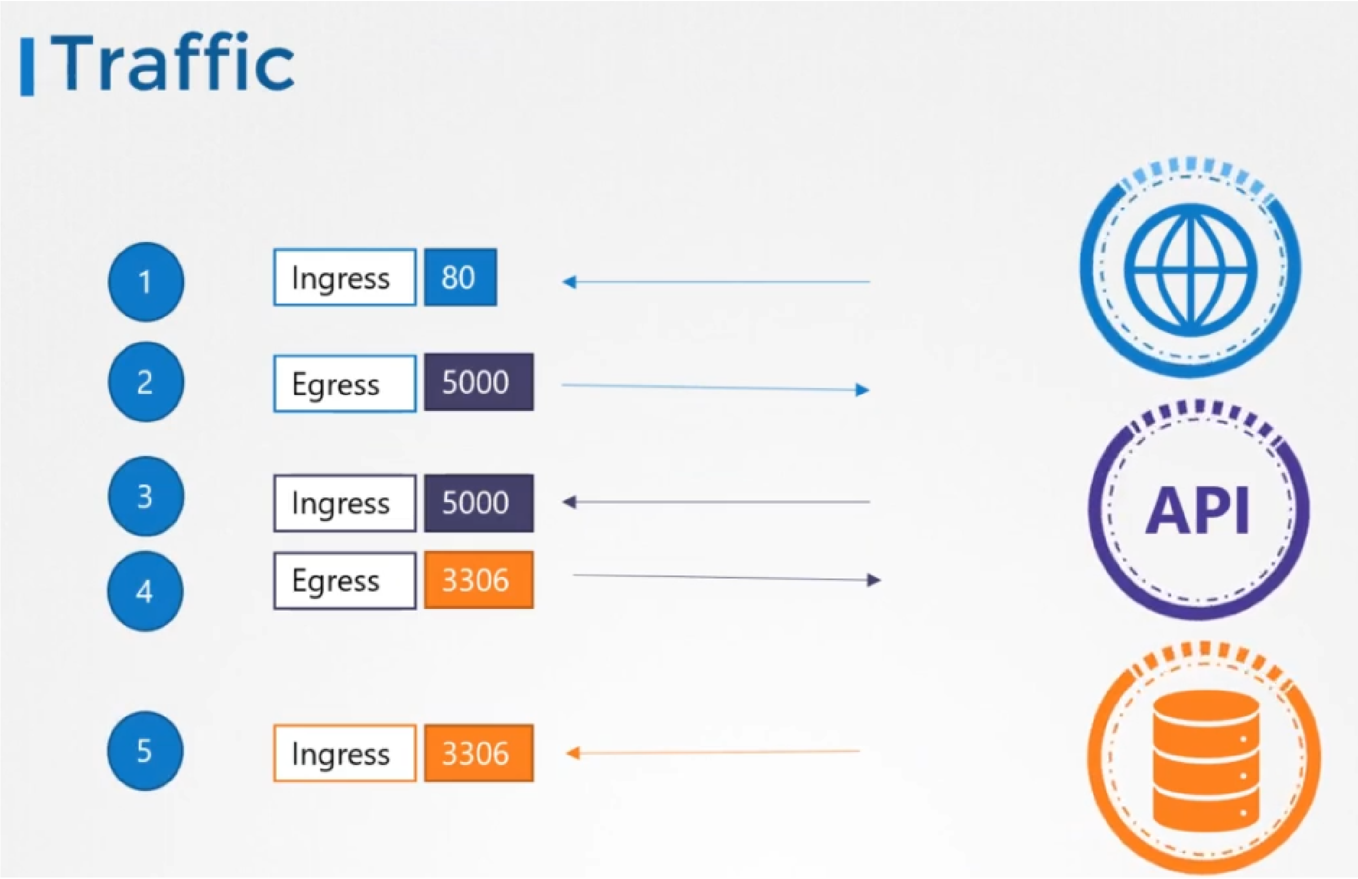
we can define security standards, id of the user, linux capability: `docker run --user=1001 ubuntu sleep 3600 | --cap-add MAC_ADMIN ubuntu`... these can be defined in k8s as well. settings can be configured at a container or pod level. configuration at pod level will carry over to all containers in the pod. if both are configured, settings on the containter will overwrite the pod settings for the container.

```yaml
# configuration at a pod level
apiVersion: v1
kind: Pod
metadata:
  name: web-pod
spec:
  jjjj
  containers:
  - name: ubuntu
    image: ubuntu
    command: ["sleep","3600"]
# configuration at a container level
apiVersion: v1
kind: Pod
metadata:
  name: web-pod
spec:
  containers:
  - name: ubuntu
    image: ubuntu
    command: ["sleep","3600"]
    securityContext:
      runAsUser: 1000
      capabilities: # only supported at container level and not at the POD level
        add: ["MAC_ADMIN"]
```

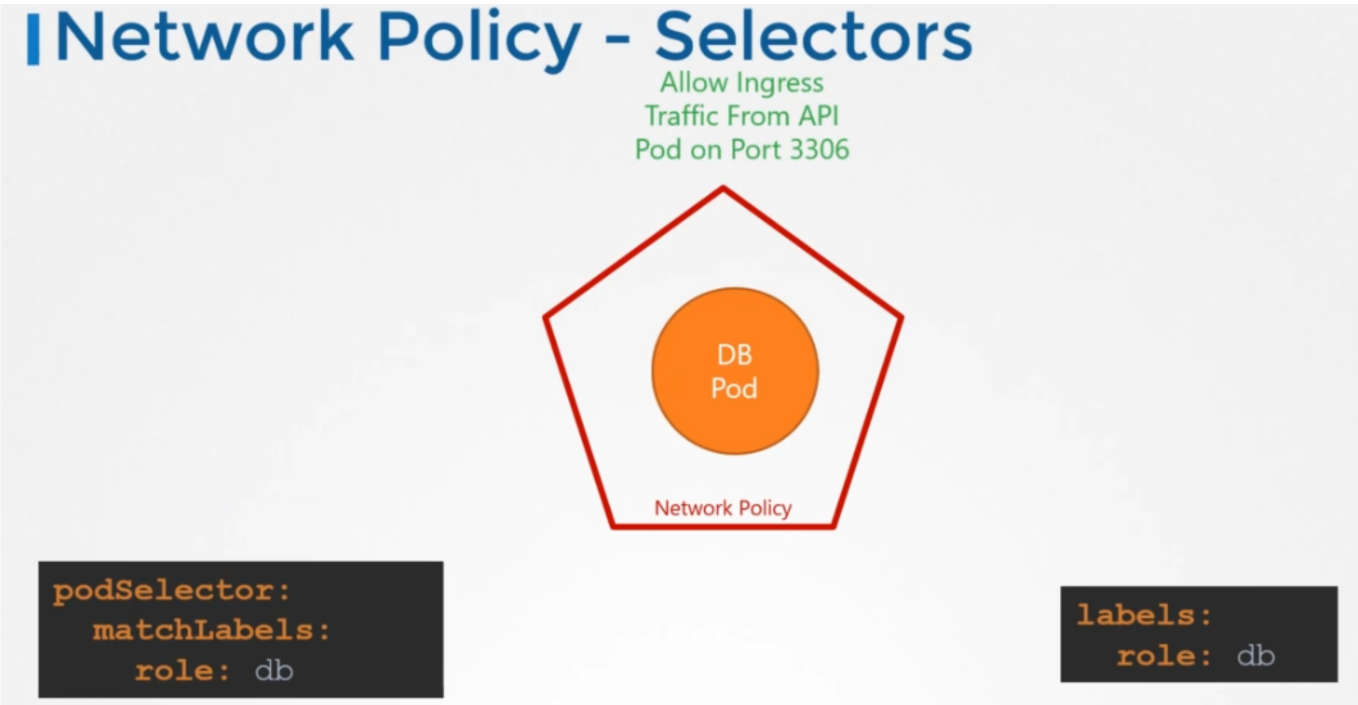
network policy

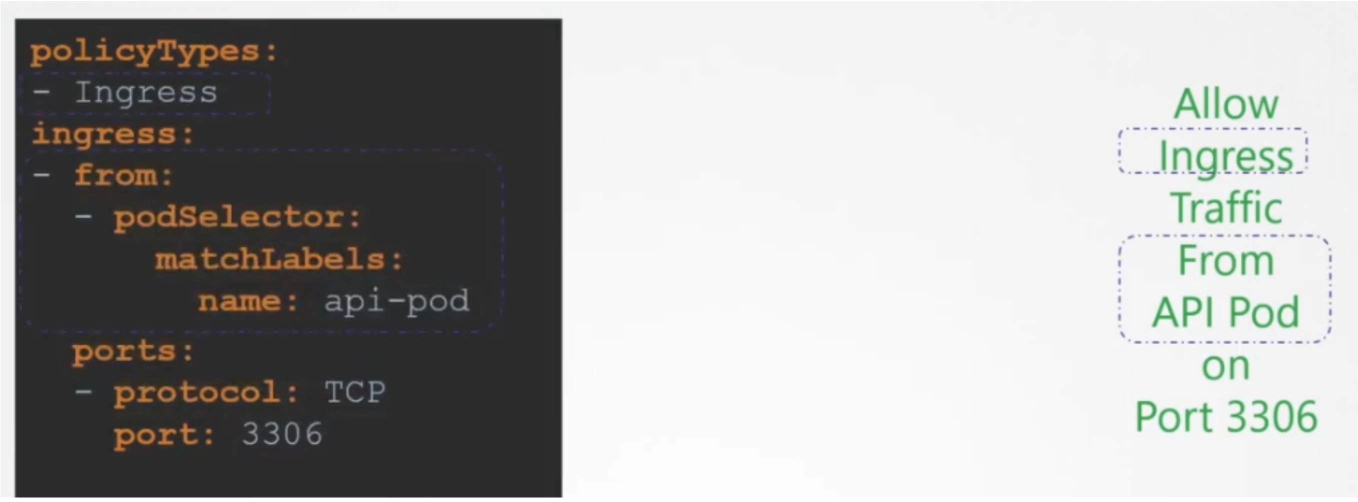
- traffic: ingress and egress.

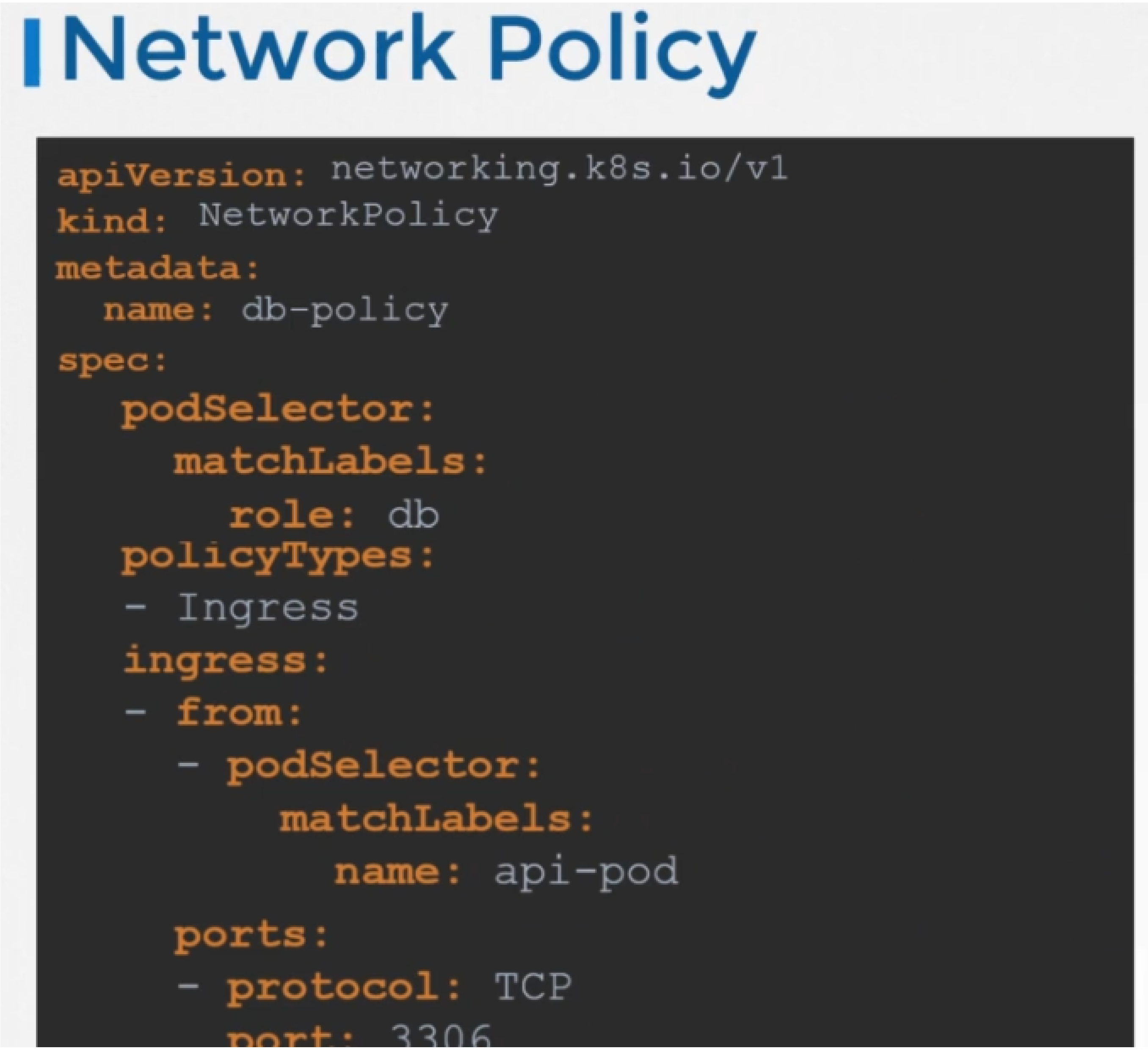




- network security: pods should be able to talk to each other, all can reach other via ips, svcs or names. All allow by default. svcs to allow communication between pods; we can implement a policy to prevent the front end pod to gain access to the db.
- a **network policy** is a k8s object - you link a network policy to one or more pod; you can define one or more rules within a network policy. allow ingress traffic coming from one pod - this policy only applies to whatever pod it is applied to - how do we apply the policy? similar to assigning replica sets to pods: labels and selectors







not all networking solution support network policies (flannel doesn't) - some that do: calico, romana, kube-router, weave-net...

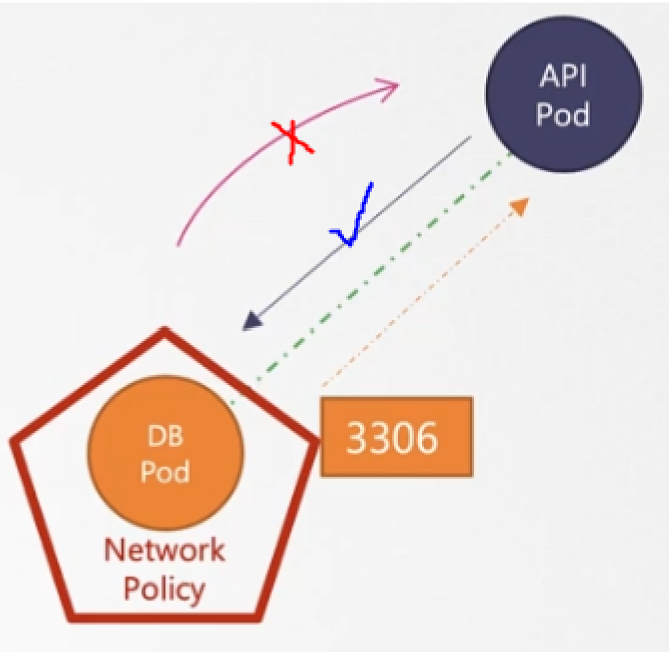
developing network policies

first we need to block everything from going in and out from the pod

```yaml
# assign policy to pod
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: db-policy
spec:
  podSelector:
    matchLables:
      role: db
  policyTypes:
  - Ingress
  ingress:
  - from:
    - podSelector:  # rule 1
        matchLabels:
          name: api-pod
      namespaceSelector:
        matchLabels:
          name: prod
    - ipBlock:      # rule 2
        cidr: 192.168.5.10/32
    ports:
    - protocol: TCP
      port: 3306
```

there are 2 rules - if either one of them is ok, the traffic is allowed; in case of the first rule, traffic will be allowed if both specification are ok (podSelector AND namespaceSelector).

if we create an Ingress policy, it enables traffic to return through the same road (?); we must consider the direction from where the request originates, no need to worry about the response.



```yaml
# egress example
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: db-policy
spec:
  podSelector:
    matchLables:
      role: db
  policyTypes:
  - Ingress
  - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          name: api-pod
    ports:
    - protocol: TCP
      port: 3306
  egress:
  - to:
    - ipBlock:
      cidr:
    ports:
      - protocol: TCP
        port: 80
```

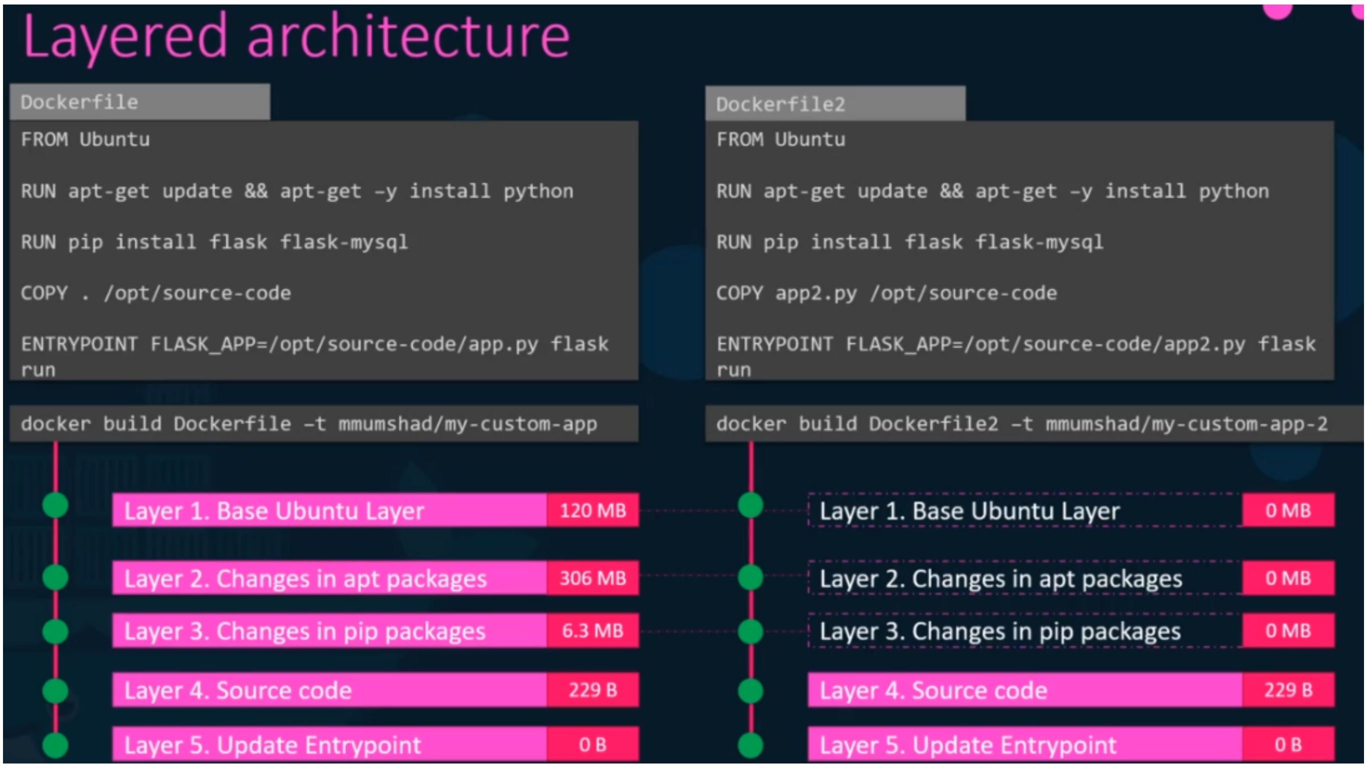
storage

storage on docker

storage drivers and volume drivers

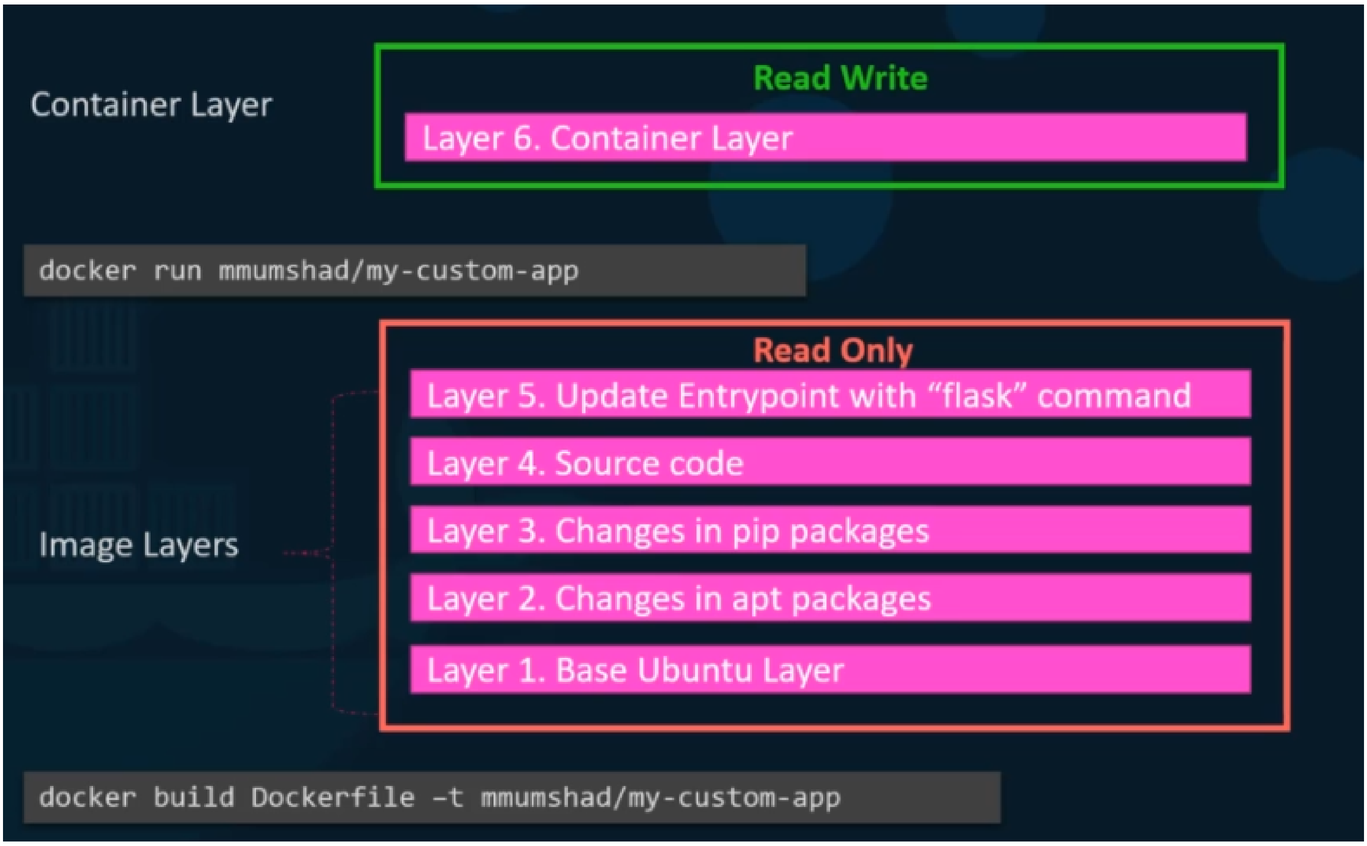
how docker stores data on the local fs. docker creates a folder structure under **/var/lib/docker**. where docker stores data by default (images, containers...).

layered architecture: each line of architecture creates a new layer in the image. each layer stores the changes of the previous layer



once the docker image is completed, the files that make up that image become read only and cannot be modified. to make modifications we need to build a new container.

when we run a container using **docker run**, docker creates a container based on these layers and creates a new writable layer on top of these layers. on this layer is that modified information is stored. when the container is destroyed, all the modified information is destroyed. the same image layer is shared with all containers created using this image.



we can modify the files on the read only/image layer; if we do that, docker creates a copy of the file on the container/read-write layer and we will be modifying a different version of the file --> **copy-on-write**. the image will be remain the same until we rebuild the image.

persist data (since once the container is removed, it's content is also removed): **persistent *volumes***. `docker volume create <nameOfTheVolume>` - this creates a folder under the /var/lib/docker/volumes/*nameOfTheVolume*. we can mount the volume when running the image: `docker run -v <nameOfTheVolume>:<locationInsideContainer> <image>` - `docker run -v data_volume:/var/lib/mysql mysql`. this will create a new container and mount the data volume into the indicated location inside the container - all data written on the DB is in fact being written on the volume on the docker host. if the container is destroyed, the data is still persistent. --> **volume mount**

there's no need to actually create the volume before hand, we can just add the -v option and docker will create the volume. there's also no need to create it under the default /var/lib/docker directory; we can specify the full path on the docker host (where we want to create the volume): `docker run -v /data/mysql:/var/lib/mysql mysql` --> **bind mount** (which means mounting any directory on the docker host on the container).

the -v option is old school - the new way of doing this is: `docker run --mount type=bind,source=/data/mysql,target=/var/lib/mysql mysql`.

docker uses storage drivers to enable layered architecture - AUFS, ZFS, BTRFS, Device Mapper, Overlay, Overlay2. docker will choose the best storage driver available automatically based on the OS. different drivers offer different perfomance and stability.

storage drivers help managing storage and containers. to create persistant storage, we need to create volumes. volume are not handled by storage drivers - they are handled by volume drivers/plugins. the default volume driver plugin is `Local`; it helps create a volume on the docker host and store it's data under /var/lib/docker/volume. there are besides other third party solutions: Azure File Storage, Convoy, DigitalOcean Block Storage, Flocker, gce-docekr, GluterFS, NetApp, RexRay, Portworx, VMware vSphere Storage.

we can specify the volume driver when running a container: `docker run -it --name mysql --volume-driver rexray/ebs --mount src=ebs-vol,target=/var/lib/mysql mysql` data will remain on the clound once we exit.

container storage interface (cri)

standard that defines how an orchestration solution like k8s would communicate with container runtimes (docker, rkt, cri-o). new containers can work independently of k8s but adhere to this standard.

to extend support to different network solutions, we have container network interface - CNI (weaveworks, flannel, cilium) standard.

CSI container storage interface (porworx, amazon EBS, dell, glusterFS) was develop to provide multiple storage solution. with CSI we can develop our own storage solutions for our own storage to work with k8s. this is not a k8s specific standard. it is meant to be an universal standard.

CSI defines a set of RPCs (remote procedure calls) that will be called by the container orchestrator - these must be implemented by the stg drivers.

volumes

docker containers are meant to be transient in nature. last for a short period of time. destroyed once finished; the same happens to the data inside the container. to persist data, we attach a volume to the container when they are created. the data is persistent on the volume.

in k8s, the pods created are transient as well. data gets deleted when the the container dies. to make data persistent, we attach a volume to the pod. the data generated is stored in the volume and remains.

when we create a volume we can choose to store the volume in different ways. for instance, using a directory on the host:

```
# pod def file
spec:
  containers:
  - image: alpine
    name: alpine
    #we have to mount the directory on the container
    volumeMounts:
    - mountPath: /opt
      name: data-volume
  volumes:
  - name: data-volume
    hostPath:
      path: /data
      type: Directory
  # this works fine on a single node cluster, not recommended when
  # there are several nodes since the pod would use each node's /data  dir
  # and they might (will) not have the same information
```

for multinode cluster there are several storage solution (NFS, cloud...). for aws ebs:

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

persistent volumes

on a large environment, instead of having volumes defined on pod (object?) definition files, we can create a large pool of storage to allow users to use the parts that they need: **Persistent volumes (PVs)**. a persistent volume is a cluster wide pool of storage volumes configured by an admin to be used to deploy apps on the cluster. users can select storage using **persistent volume claims (PVCs)**.

pv def file

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-vol1
spec:
  accessModes:  # defines how a volume should be mounted on the host.
    - ReadWriteOnce   # ReadOnlyMany | ReadWriteMany
  capacity:     # amount of storage reserverd for the volume
    storage: 1Gi
  hostPath:     # <<<--- do not use this option on prod environment
    path: /tmp/data
# kubectl create -f <file>.yaml
```

`kubectl get persistentvolume`

persistent volume claim

to make storage available to a node. pvs and pvcs are 2 separate objects. admin creates PVs and user/app owner creates PVCs to use the storage. once pvcs are created, k8s binds the pvs to the claims based on the request and properties set on the volume. every pvc is bound to a single volume (pv).

during the binding process, k8s tries to find a PV that has

- sufficient capacity
- access modes
- volume modes
- storage class
- selector
- ...

if there multiple matches for a claim and we want to make a specific choice, we can use labels and selectors to bind to the right volumes.

there is a one-one relationship between PVs and PVCs - if we create a pvc that is smaller than the pv, no other claims can use the reamining unallocated space on the pv. if there are no pv available, the pvc will remain in a *pending* state until new pv are created (it will automatically attach the pending pvc to the new pv).

```
# pvc
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
```

```yaml
  name: myclaim
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 500Mi
# kubectl create -f <file>.yaml
```

`kubectl get persistentvolumeclaim` status either pending or bound. `kubectl delete persistentvolumeclaim <persistentvolumeclaim>`. if we delete the pvc, the pv will, by default remain existing: `persistentVolumeReclaimPolicy: Retain`; the persistent volume will remain until it's manually deleted. it is not available to reuse by any other pvcs. another option is **Delete** to automatically delete de pv when the claim is deleted. third option is **Recycle**, the data in the data volume will be scrubbed before making it available to other claims.

Once you create a PVC use it in a POD definition file by specifying the PVC Claim name under persistentVolumeClaim section in the volumes section like this:

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

The same is true for ReplicaSets or Deployments. Add this to the pod template section of a Deployment on ReplicaSet.

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

- `kubectl exec webapp -- cat /log/app.log`

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: webapp
spec:
  containers:
  - name: event-simulator
```

```yaml
    image: kodekloud/event-simulator
    env:
    - name: LOG_HANDLERS
      value: file
    volumeMounts:
    - mountPath: /log
      name: log-volume

  volumes:
  - name: log-volume
    hostPath:
      # directory location on host
      path: /var/log/webapp
      # this field is optional
      type: Directory
```

```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-log
spec:
  persistentVolumeReclaimPolicy: Retain
  accessModes:
    - ReadWriteMany
  capacity:
    storage: 100Mi
  hostPath:
    path: /pv/log
# pvc

apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: claim-log-1
spec:
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 50Mi
```

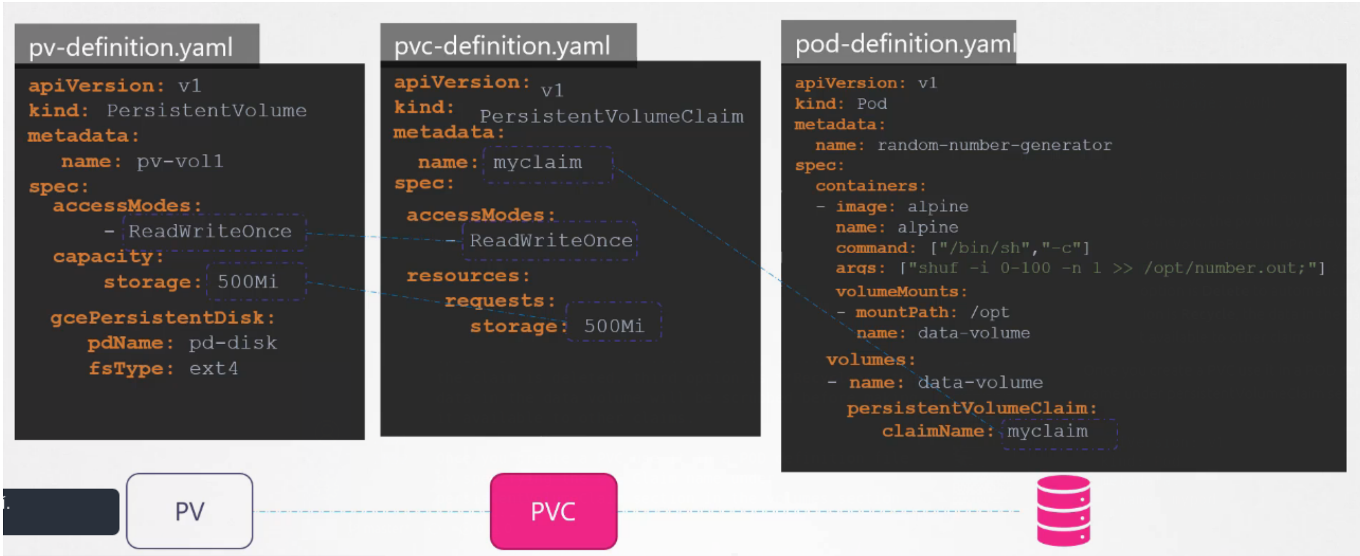
065

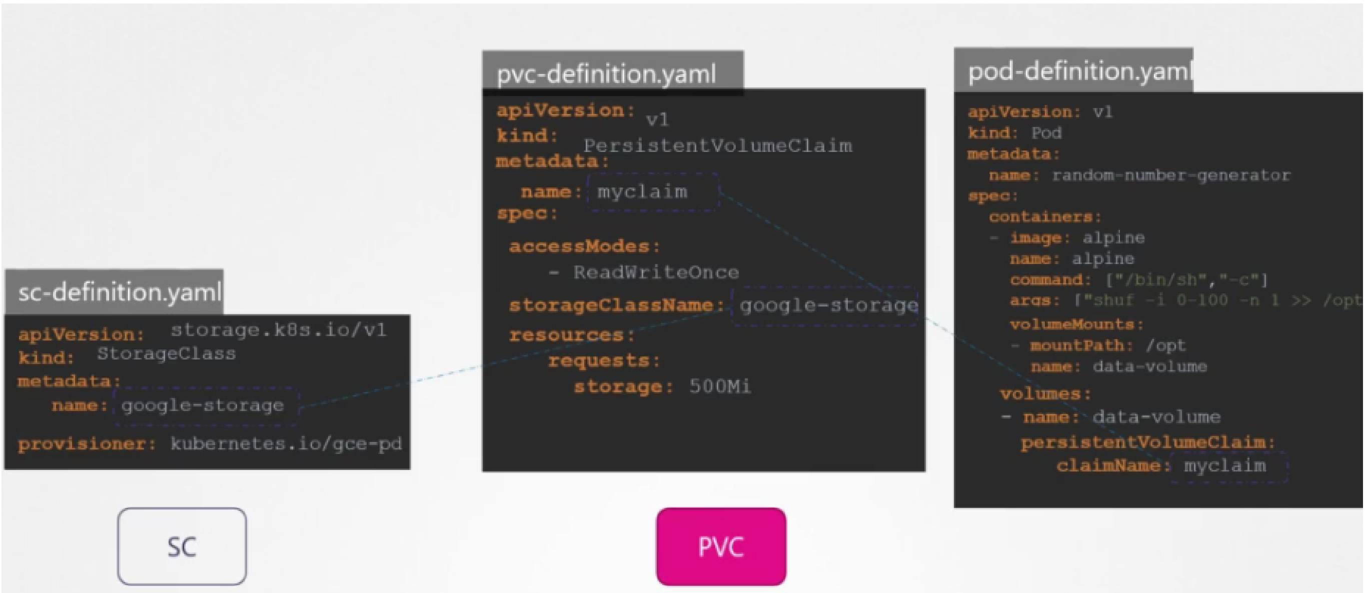
storage class

- static provisioning: manually provisioning a volume/disk on a node/cloud.
- dynamic provisioning: with storage classes we can define a provisioner and attach that when the claim is made.

066

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





this replaces the pv file; the provisioner creates it for us (we still need it but it is automatically created/provisioned by the storage class). there are specific parameters that we can specify depending on our requirements. we can create different definition files for each class that we want.

```
root@controlplane:~# cat 7.yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
        name: local-pvc
spec:
  accessModes:
  - ReadWriteOnce
```

```
  storageClassName: local-storage
  resources:
    requests:
      storage: 500Mi
```

The Storage Class called local-storage makes use of VolumeBindingMode set to WaitForFirstConsumer. This will delay the binding and provisioning of a PersistentVolume until a Pod using the PersistentVolumeClaim is created

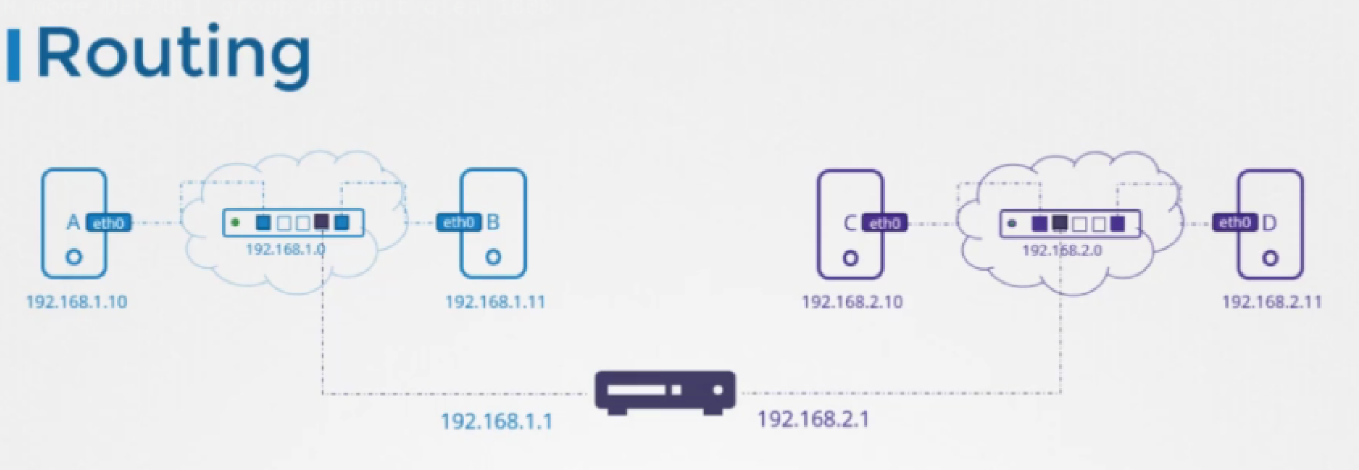
```
# root@controlplane:~# cat 7.yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: local-pvc
spec:
  accessModes:
  - ReadWriteOnce
  storageClassName: local-storage
  resources:
    requests:
      storage: 500Mi

#root@controlplane:~#
# root@controlplane:~# cat 11.yaml
apiVersion: v1
kind: Pod
metadata:
  labels:
    run: nginx
  name: nginx
spec:
  containers:
  - image: nginx:alpine
    name: nginx
    volumeMounts:
    - mountPath: "/var/www/html"
      name: local-pvc
  volumes:
  - name: local-pvc
    persistentVolumeClaim:
      claimName: local-pvc
#root@controlplane:~#
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: delayed-volume-sc
provisioner: kubernetes.io/no-provisioner
volumeBindingMode: WaitForFirstConsumer
```

networking

linux networking basics

switch: create a network through a switch, for that we need a network interface `ip link` - assign ip to link `ip addr add 192.168.1.11/24 dev wlp3s0`.

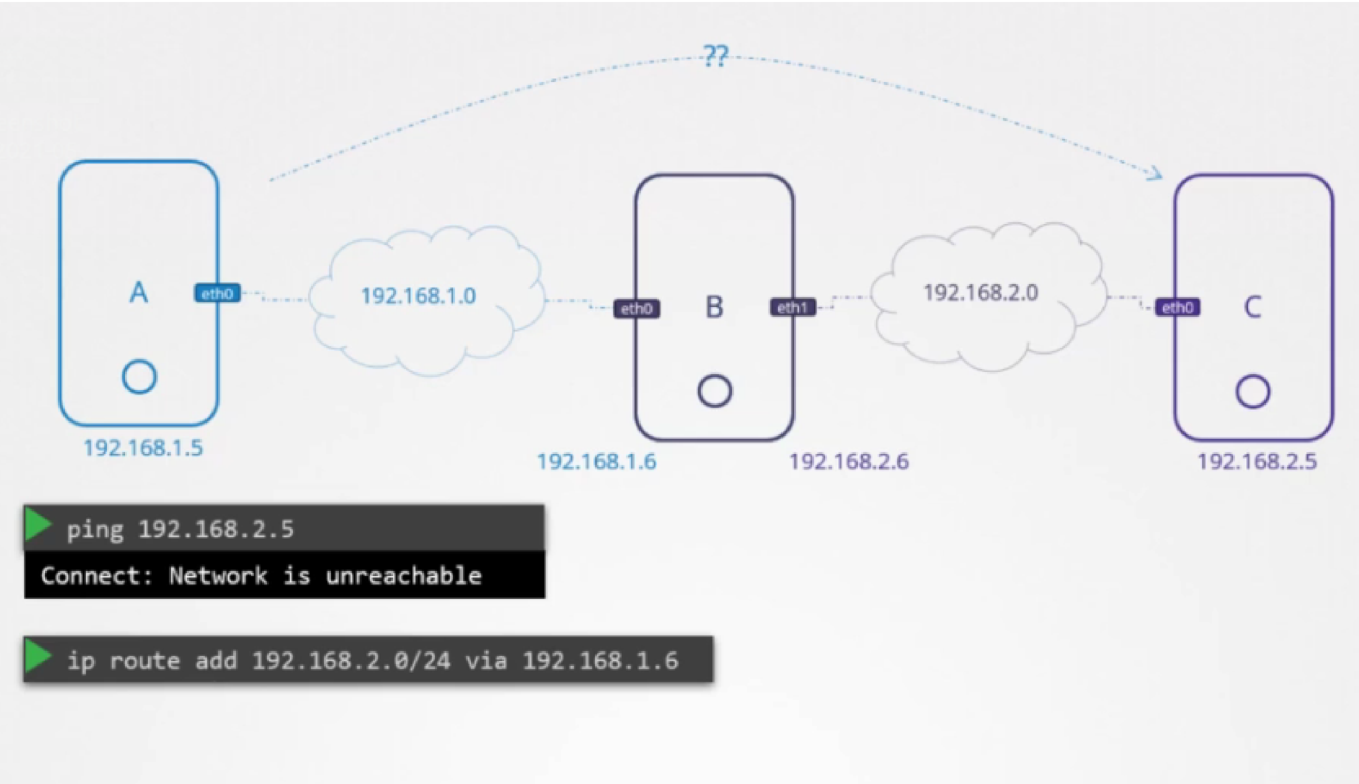
a router helps connecting two networks (connects to the switch)



how does a system know where another system is on the network? that is why we configure the systems with a *gateway*, or route. a door to the outside world, **to other networks or the internet**. the systems need to know where that door is located. to see existing routing configuration `route` command. routing table. example on how to add a route `ip route add 192.168.2.0 via 192.168.1.1`.

access to the internet - instead of adding each network ip to the routing table we can configure that any network that you don't know the route to, use a specific router -- **default gateway**.

linux host as a router



if pinging does not return a "network unreachable" message, routing is fine, but in linux, by default, packets are not forwarded from one interface to the next (security reasons). this is configured on `/proc/sys/net/ipv4/ip_forward` if 0, no packet forwarding, if 1, packet forwarding is enabled. this is not a persistent change - we need to modify the `/etc/sysctl.conf - net.ipv4.ip_forward = 1`.

```
ip link
ip addr
ip route
route
ip addr add <ip>/<range> dev <ip link name>
cat /proc/sys/net/ipv4/ip_forward
```

dns config

`/etc/hosts` --> dns. whatever we input on /etc/hosts is the source of truth for the host. name resolution means translating names into actual ip addresses.

DNS host - centrally manages the name resolution. all hosts use that server for name resolution (all configuration is hosted on /etc/hosts?). how to point our host to a dns server - `/etc/resolv.conf` (where we configure the dns server that will be used by the host). add an entry to the file with the dns server ip addr - `nameserver <ip>`, should be configured on all hosts. we still can hardcode/configure hosts under /etc/hosts.

the host first looks for the address on the etc-hosts file; then on the etc-resolv.conf file. that order can be changed. it is defined on the /etc/nsswitch.conf `hosts: files mdns4_minimal [NOTFOUND=return] dns` - files means etc-hosts; dns means the dns server.

we can add on the dns server an entry that is default: `Forward All to 8.8.8.8`.

www.	google.	com
subdomain (mail, drive, maps, www...)	domain name	top level domain - the purpose of the webpage

Record types

A	web-server	192.168.1.1
AAAA	web-server	2001:0db8:85a3:0000:0000:8a2e:0370:7334
CNAME	food.web-server	eat.web-server.hungry.web-server

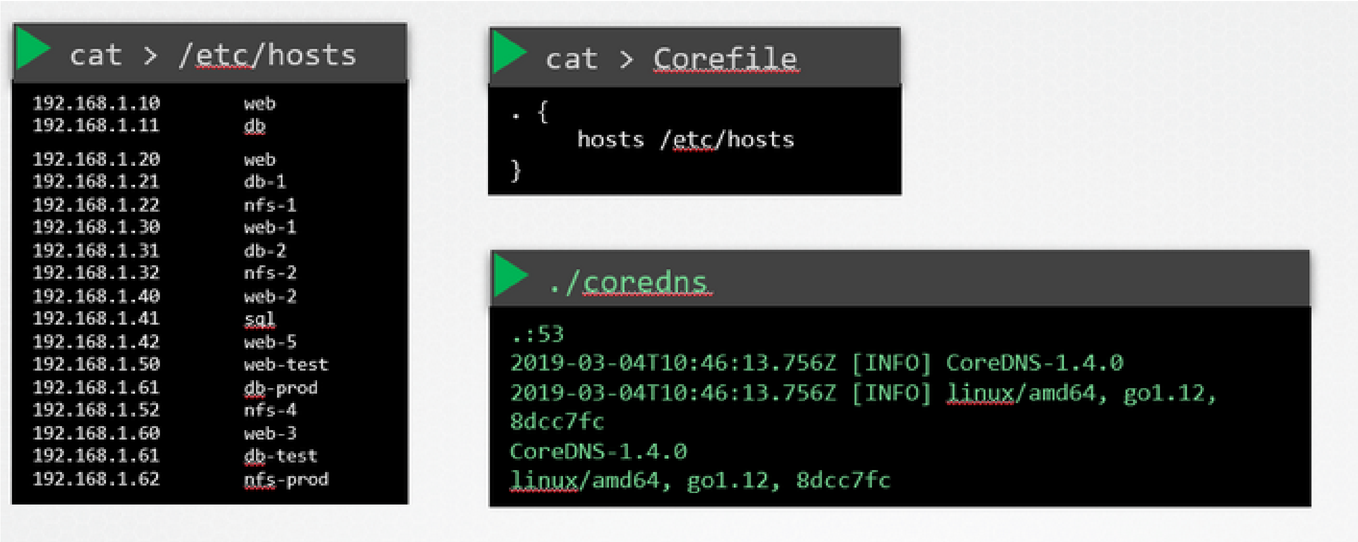
to test dns - `nslookup <webpage>`; `dig <webpage>` returns more results.

coreDNS

- `wget https://github.com/coredns/coredns/releases/download/v1.4.0/coredns_1.4.0_linux_adm64.tgz`

- `tar -xzvf coredns_1.4.0_linux_amd64.tgz`
- `./coredns` --> this s tarts the DNS server; by default listens on port 53

CoreDNS loads it's configuration from a file named Corefile.



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

network namespaces

used in docker to implement network isolation. on a linux host, we can create a namespace: `ip netns add red|blue` view namespaces `ip netns`. view specific ns nics | run specific command within a ns: `ip netns exec red ip link` or `ip -n red link`.

arp table: protocol to resolve ip addresses to MAC addresses (physical address of the device - globally unique #). whenever a device needs to communicate with another device on a LAN, it needs the MAC address for that device. devices use ARP to acquire the MAC address for that device. an IP address is used to locate a device on a network and the MAC is what identifies the actual device.

to find the MAC address, a computer (say A) will first look at its internal list, ARP cache, to see if the IP address for another computer (say B) already has a matching MAC address.

computer A will send a broadcast message on the network asking everydevice which computer has the specific IP address and will ask for its MAC address. the computer that has the matching IP address will respond back and reveal its MAC address. once computer A has compt B MAC address, communication can flow between the 2.

computer A stores the MAC address on its ARP cache. makes a network more efficient - stores IP to MAC address association.

2 types of ARP entries:

- Dynamic: created automatically when a device sends out a broadcast message out on the network requesting a MAC address; they are *not* permanent and they are flushed periodically.
- Static: someone manually enters an IP to MAC address association using the ARP command `arp -s <ipAddress> <MACAddress>`. used to avoid unnecessary broadcast traffic

connecting namespaces via a virtual cable (or pipe) with 2 interfaces on either end. to "create the cable" `ip link add veth-red type veth peer name veth-blue` (links created are **veth-red** and **veth-blue** - to delete de cable we can delete just one of the links and the virtual cable dies entirely `ip -n red link del veth-red`); then we need to attach each nic to the appropriate ns: `ip link set veth-red netns red` (the same for blue). assign ip address: `ip -n red addr add 192.168.15.1/24 dev veth-red` and `ip -n blue addr add 192.168.15.2/24 dev veth-blue` - bring links up `ip -n <nsName> link set <linkName-veth-blue> up`. ns can reach each other `ip netns exec red ping 192.168.15.2`. checking ARP table: `ip netns exec red arp`.

how do we enable all ns to communicate with each other (say we have more than 2). we need to create a virtual switch connecting the network. we can use several tools like *linux bridge* or *open vswitch*.

with linux bridge, to create an internal virtual bridge network we add a new virtual link to the host: `ip link add v-net-0 type bridge`. bring it up `ip link set dev v-net-0 up`. namespaces can now connect to this virtual switch. connecting namespaces to the virtual switch

- `ip link add veth-red type veth peer name veth-red-br`
- `ip link set veth-red netns red`
- `ip link set veth-red-br master v-net-0`
- `ip -n red addr add 192.168.0.17/24 dev veth-red`
- `ip -n red link set veth-red up`

connection through the host: add an ip addr to the link we created for the switch `ip addr 192.168.0.10/24 dev v-net-0`

adding NAT functionality to the host: `iptables -t nat -A POSTROUTING -s 192.168.15.0/24 -j MASQUERADE`

docker networking

when you run a container there are different networking options.

- none: the container doesn't have a network. container not attached to a network, can't reach the outside world, and no one from the outside can reach it - `docker run --network none nginx`
- host: the container is attached to the host's network `docker run --network host nginx`. if we deploy an app on the container on port 80, the host can reach it using localhost:80. if we deploy a second instance with the same port, it won't work and the container will crash. two processes cannot listen on the same port at the same time
- bridge: an internal private network is created which the docker host and containers attach to. the network has by default an address 172.17.0.0 and each device get their own internal private address within the network. when docker is installed on the host, it creates an internal private network called bridge (`docker network ls`). on the host, this network is called **docker0** (but docker calls it *bridge*). docker does something similar to what we do when we do "ip link add docker0 type bridge". the network starts as down. this bridge network is like an interface to the host, but for the containers within the host it's more like a *switch*. the interface docker0 gets an ip 172.17.0.1. whenever a container is created, docker creates a network namespace for it (see namespaces `ip netns`).

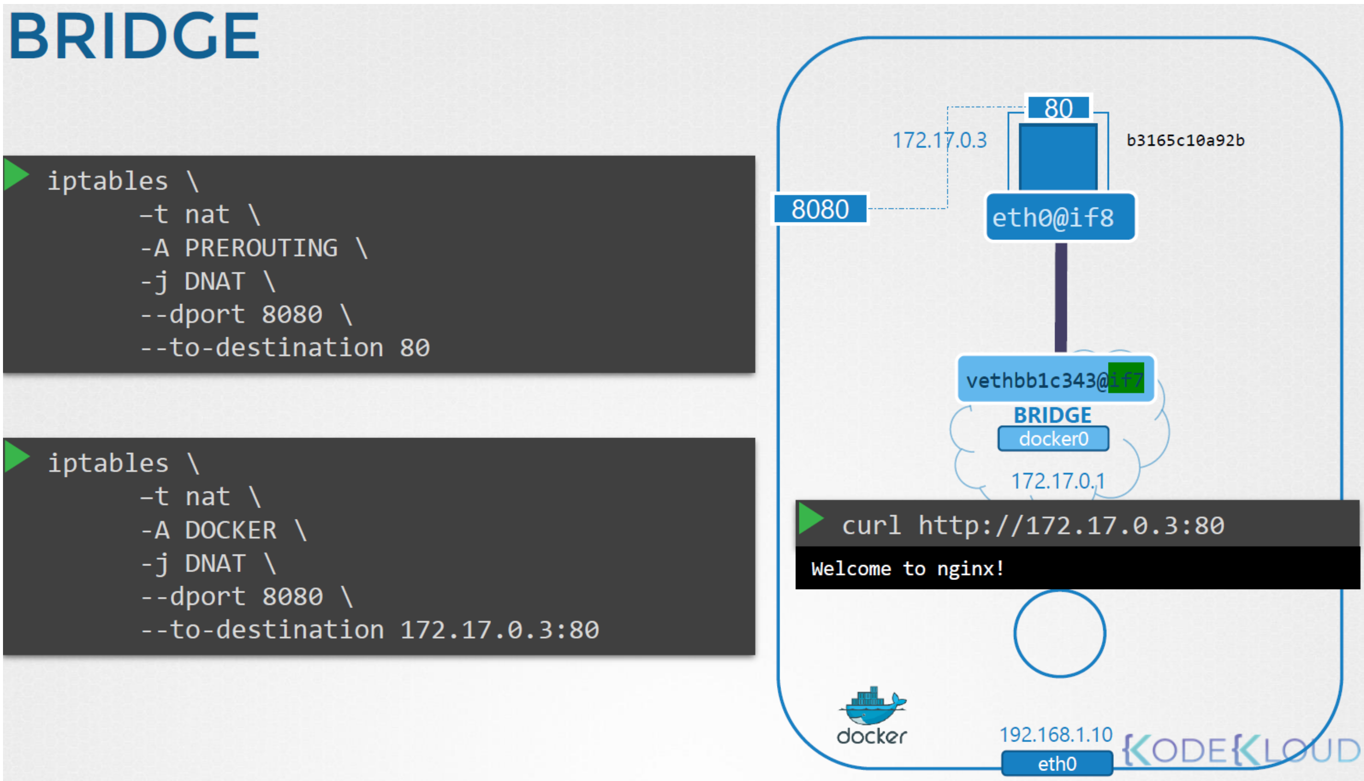
`docker inspect <contID>`

how does docker attach the container to the bridge network? (container and namespace mean the same thing). it creates as virtual cable with 2 interfaces on each end. one end attached to the bridge adapter and one end attached to the docker container

`ip -n <contID> addr` view container ip.

interface pairs can be identified using their numbers (odd and even form a pair).

port mapping: to allow external users access to apps hosted on containers, docker provides a port mapping option. tell docker to map port 8080 on the host to port 80 on the container `docker run -p 8080:80 nginx` (on the host `curl http://localhost:8080`). docker does this by modifying the iptables:

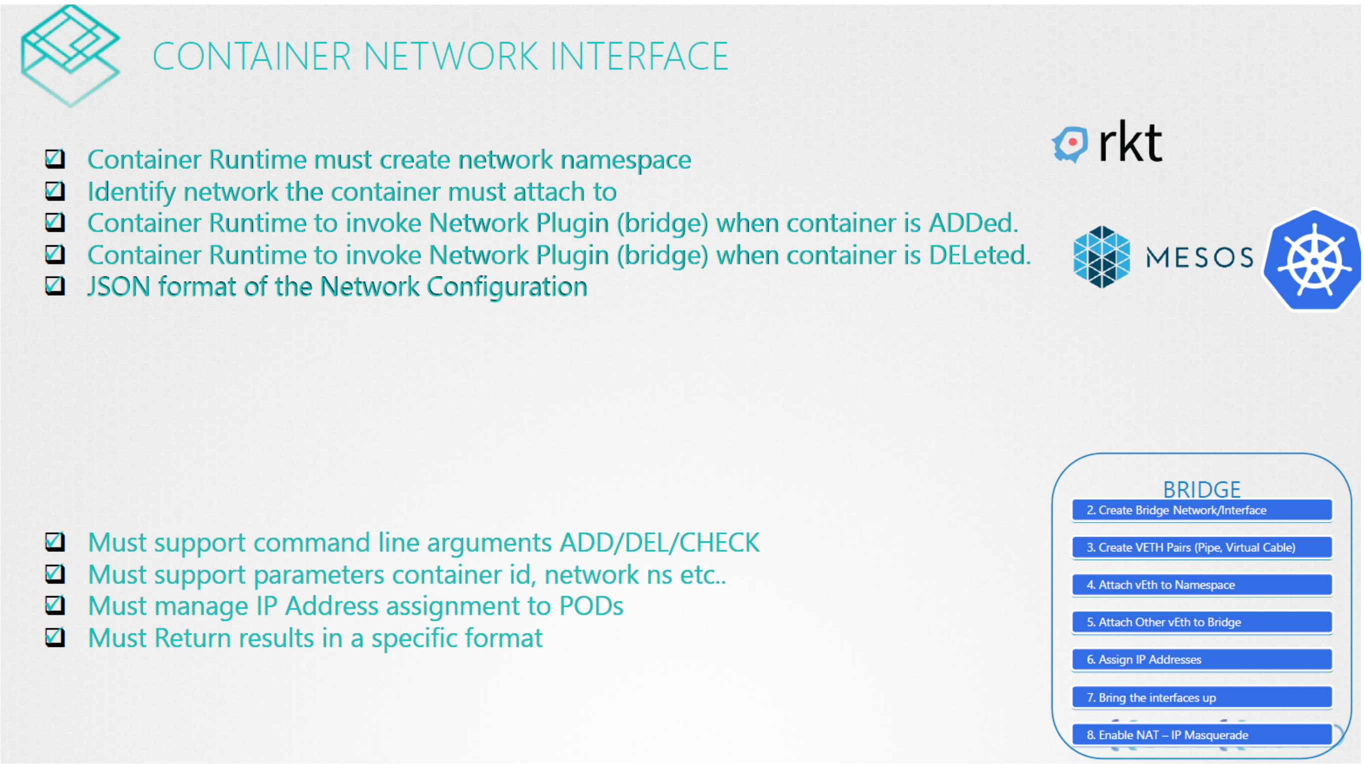


see rules: `iptables -nvL -t nat`

CNI - container networking interface

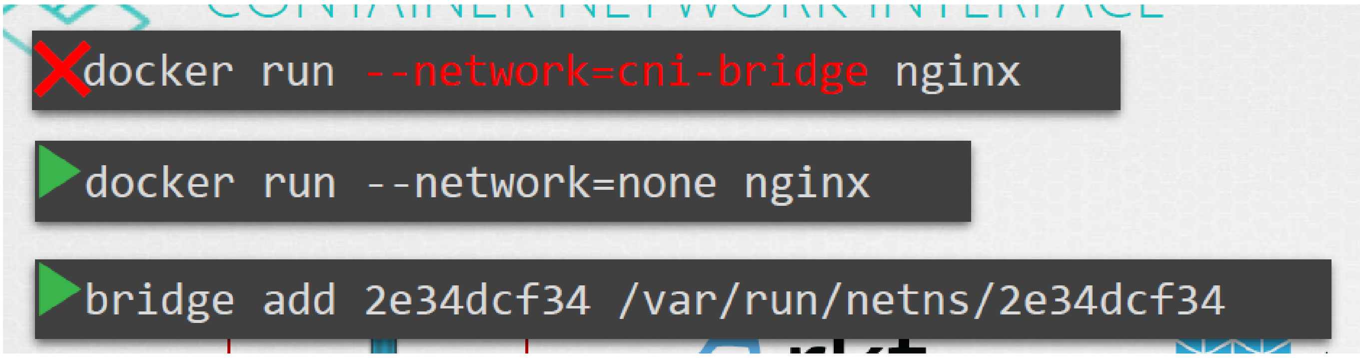
standard sollution for container networking --> bridge (program or script) `bridge add <contID> <bridgenetwork|namespace>` - container runtime will use this config as default.

CNI: set of standards that define a set of standards about how programs should be developped to solve networking challenges in a container runtime environment. programs are called *plugins*. bridge would be a plugin for cni. also cni defines how cont runtime should invoke plugins.



docker does not implement cni standards, it uses its own standards: CNM (container network model)

we can create a docker container without networking and then attack it to the bridge network (this is how k8s does it):



cluster networking

all nodes must have a nic, a host-name, a unique MAC (careful when cloning). ports that need to be open.

- master: needs to accept connections on 6443 (kube-api).
- kubelets on master and worker nodes listen on port 10250

- kube-scheduler needs port 10251
- kube-controller needs port 10252
- etcd server: 2379
- etcd needs addtional port 2380 so different etcd clients can communicate with each other
- worker nodes expose services for external access on ports 30000-32767

```
ip link
ip addr
ip addr add 192.168.1.10/24 dev eth0
ip route
ip route add 192.168.1.10/24 via 192.168.2.1
cat /proc/sys/net/ipv4/ip_forward # should say 1
arp
netstat -plnt
route
```

- https://kubernetes.io/docs/concepts/cluster-administration/addons/
- https://kubernetes.io/docs/concepts/cluster-administration/networking/#how-to-implement-the-kubernetes-networking-model

In the CKA exam, for a question that requires you to deploy a network addon, unless specifically directed, you may use any of the solutions described in the link above.

However, the documentation currently does not contain a direct reference to the exact command to be used to deploy a third party network addon.

The links above redirect to third party/ vendor sites or GitHub repositories which cannot be used in the exam. This has been intentionally done to keep the content in the Kubernetes documentation vendor-neutral.

At this moment in time, there is still one place within the documentation where you can find the exact command to deploy weave network addon:

- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/high-availability/#steps-for-the-first-control-plane-node

```
ip r # look for default
netstat -natulp | grep kube-scheduler
netstat -natulp | grep etcd | grep LISTEN
```

pod networking

k8s expects that each pod receives:

- it's own unique IP addr
- every pod should be able to communicate with every other pod in the same node
- every pod should be able to communicate with every other pod on the other nodes without NAT

how to do this on our own:

```
ip link add v-net-0 type bridge
ip link set dev v-net-0 up
ip addr add 192.168.15.5/24 dev v-net-0
ip link add veth-red type veth peer name veth-red-br
ip link set veth-red netns red
ip -n red addr add 192.168.15.1 dev veth-red
ip -n red link set veth-red up
ip link set veth-red-br master v-net-0
ip netns exec blue ip route add 192.168.1.0/24 via 192.168.15.5
iptables -t nat -A POSTROUTING -s 192.168.15.0/24 -j MASQUERADE
```

when containers are created k8s creates namespaces. to enable connection between them we attach these ns to a network - which one? bridge network; we need to create a bridge network on each node

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

and then bring them up

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

attach an ip addr to the bridge network

`ip addr add 10.244.1.1/24 dev v-net-0` on another node 10.244.2.1 and 10.244.3.1

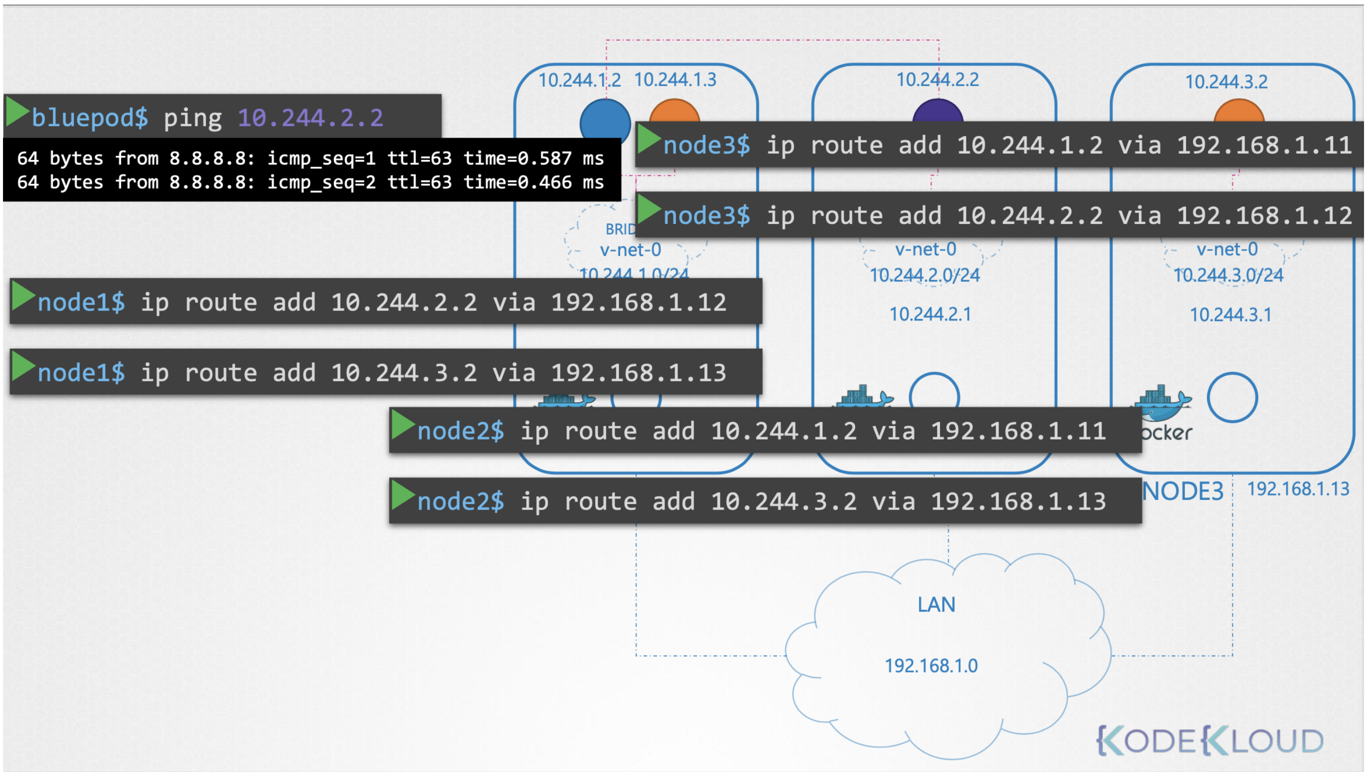
each container

```
# create veth pair
ip link add ...
# attach veth pair
ip link set ...
ip link set ...
# assign ip address
ip -n <namespace> addr add ...
ip -n <namespace> route add ...
# bring up interface
ip -n <namespace> link set ...
```

at this stage, pods can reach each other; now we have to enable communication across nodes.

add a route on node1 to route traffic via the second node's ip

`node1$ ip route add <destination-pod-ip> via <node-ip>`



rather than using individual node networking configurations, a better solution would be to a routing table on the router.

network	gateway
10.244.1.0/24	192.168.1.11
10.244.2.0/24	192.168.1.12
10.244.3.0	192.168.1.13

to reach private network `<network-column>` go through `<node-ip>`.

this "makes up" a large network - 10.244.0.0/16. ponele.

so this was manually work - CNI is supposed to do this for us. we need to follow CNI standards. it tells us that we need to have an ADD) section and a DEL) section

```
ADD)
  ip -n <namespace> link set ...
DEL)
  ip link del ...
```

the kubelet on each node is reponsible for creating containers; whenever container is created, the kubelet looks at `--cni-conf-dir=/etc/cni/net.d` config file and identifies the script; then it looks at the `--cni-bin-dir=/etc/cni/bin` and then our script is executed `./net-script-sh add <container> <namespace>`

where do we specify the cni component to be used? kubelet

```
ps aux | grep kubelet
ls /opt/cni/bin
ls /etc/cni/net.d
```

`cat /etc/cni/net.d/10-bridge.conf` this config follows cni configuration:

- **isGateway**: should bridged network get an ip address?
- **ipMasq**: add NAT rule?
- **ipam**: where we specify the subnet and range of ip addresses

weave cni

weave deploys an agent on the nodes. each agent, or peer, stores a topology of the entire setup; they know the nodes and ips of the other nodes. weave creates its own bridge networks and assigns ip addresses to each network

`kubectl exec <podname> ip route`

a pod can be connected to several bridged networks.

when a pod is trying to reach another pod on another node, weave intercepts that packet and identifies that it's on a separate network; it then encapsulates this packet into a new with a new source and destination and sends it across the network; on the other side, the weave agent intercepts the packet decapsulates it and delivers the packet to the right pod

weave can be deployed as daemons/services on each node or k8s can deploy it as pods on the cluster

```
kubeclt apply -f "https://cloud.weave.works/k8s/net?k8s-version=$(kubectl version | base64 | tr -d '\n')
kubectl get pods -n kube-system
kubectl logs <weave-pod-name> weave -n kube-system
```

- all binaries of CNI supported plugins: `/opt/cni/bin`
- `ls /etc/cni/net.d`

ipam

ip address management. how are virtual bridge networks in the nodes assigned an ip subnet and how are the pods assigned an ip, where this information is stored.

the cni plugin has to take care of assigning ip addresses to the pods. cni has 2 built-in plugins we can use for this task.

- dhcp
- host-local

we still have to invoke either of those plugins. we can also make this dynamic. the cni config file has a section called ipam where we can specify the type of plugin to be used:

```
{
  "cniVersion": "0.2.0",
  "name": "mynet",
  "type": "net-script",
  "bridge": "cni0"
  "isGateway": true,
  "ipMasq": true,
  "ipam": {
    "type": "host-local"
    "subnet": "10.244.0.0/16",
    "routes": [
      {"dst": "0.0.0.0/0"}
    ]
  }
}
```

weave by default allocates the ip addresses 10.32.0.0/12 for the entire network. the peers decide to split the ip addresses and assigns each portion to a node. pods created on each node will have a portion of that range.

```
ls /etc/cni/net.d/ # checking networking solution
ifconfig # interface created by cni
kubectl exec -ti <podName> -- sh # log into pod
ip r # default gateway
```

service networking

when a service is created, it is accesible by all pods in the cluster -- *clusterIP* service.

nodePort service: besides being accesible by other pod, this kind of service exposes the application on a port on all nodes on the cluster.

everytime we create a service, kube-proxy is involved. services are not created/assigned to a node, they are cluster wide objects. services are just virtual objects, they don't have ns, nics, services...

when we create a service, it is assigned an ip from an ip range. the kube-proxy gets the ip address and creates forwarding rules on each node in the cluster. any traffic should go to XX pod. once in place, whenever a pod tries to reach the ip of the service, it is forwarded to the pod's ip address, which is accessible from every node in the cluster.

kube-proxy creates the rules through userspace (kube-proxy listens on a port for each service and proxy's connection to the pod), ipvs or iproutes.

`kube-proxy --proxy-mode [userspace | iptables | ipvs ] ...`

range for service IPs is specified on `kube-api-server --service-cluster-ip-range ipNet` - default is 10.0.0.0/24 to see the actual config: `ps aux | grep kube-api-server`

see rules created by kube-proxy: `iptables -L -t net | grep db-service`

according to this output, traffic going to ip 10.103.132.104:3306 should be redirected to 10.244.1.2:336

we can check the logs to see what kube-proxy does when creating the rules: `cat /var/log/kube-proxy.log`

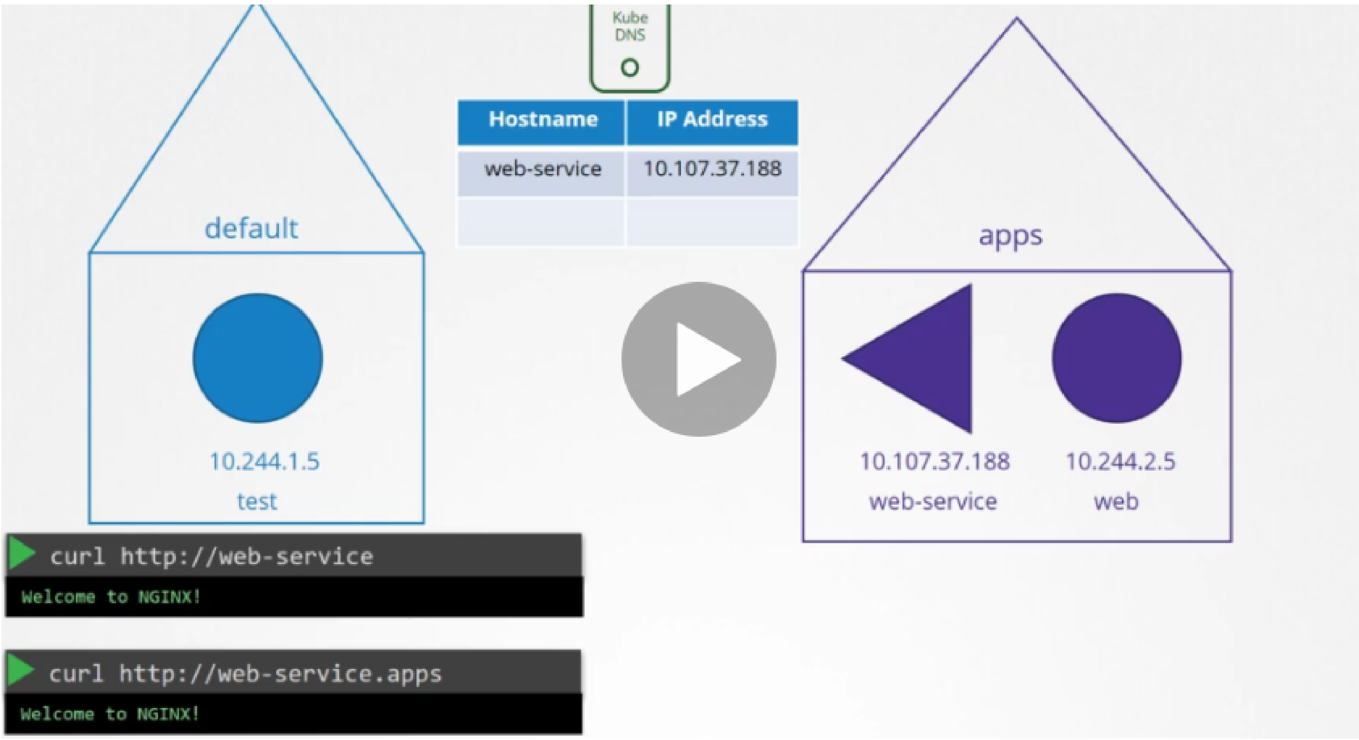
```
kubectl -n kube-system logs <pod> -c weave | grep ipalloc-range
cat /etc/kubernetes/manifests/kube-apiserver.yaml | grep cluster-ip-range
kubectl logs kube-proxy-gsw6z -n kube-system | egrep -i
"userspace|ipvs|iptables|firewalld"
```

cluster DNS

nslookup, dig... dns resolution within the cluster. k8s desploys a builtin dns server by default when we set up the cluster. we don't care much about nodes, we focus on services and pods.

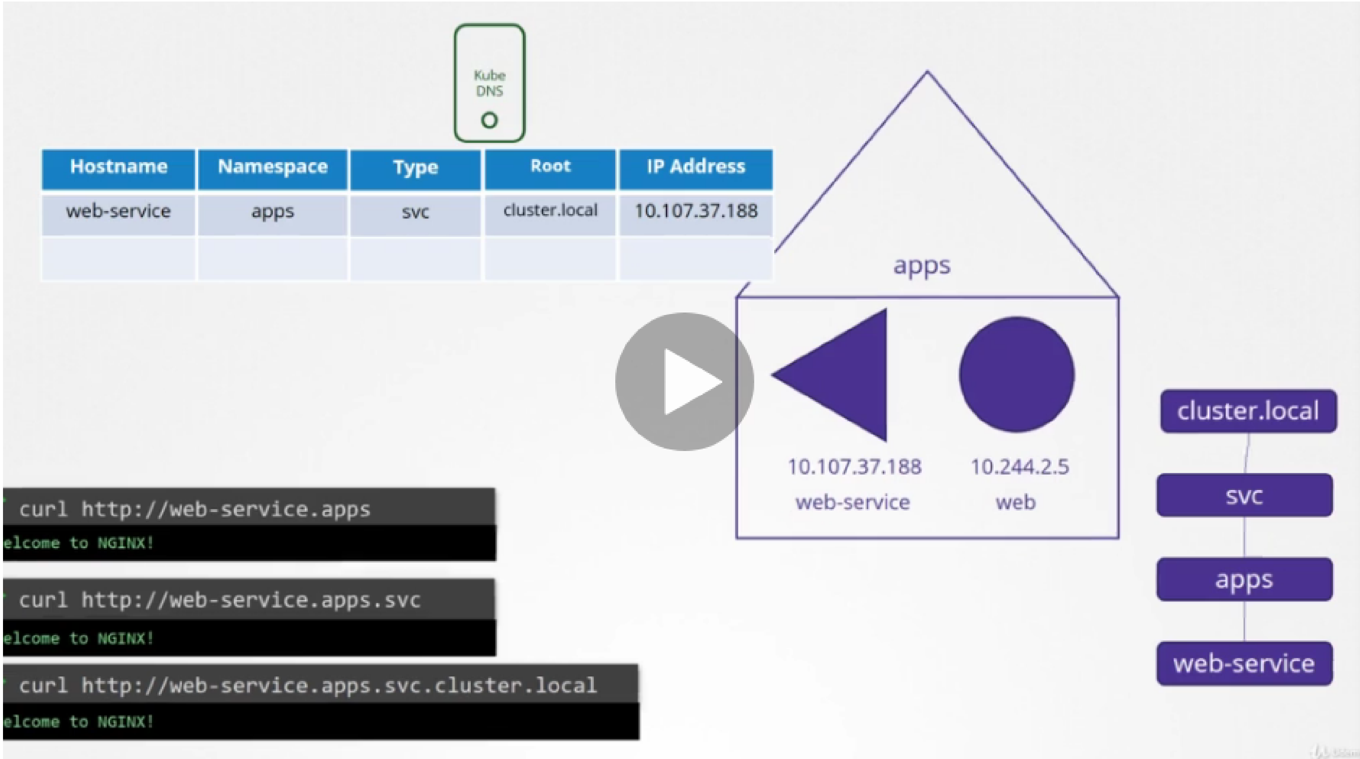
whenever a service is created, the k8s dns service creates a record for the service; it maps the service name to the ip address. so within the cluster, every pod can reach the service using it's name. this is the case if service and pod are on the same namespace.

if there are multiple namespaces, we would need the name and it's namespace (web-service --> name of the service, apps--> name of the namespace)



web-service.apps --> this is a subdomain. all the services are grouped together into another subdomain called `svc`. the dns server keeps a record also about the namespaces (subdomains, we are calling them). all pods and services for a namespace are grouped together within a subdomain; all services are further grouped together into another subdomain called svc. so we can reach the service with the subdomain `web-service.apps.svc`.

furthermore, all services and pods are grouped together into a root domain for the cluster: `cluster.local`. we can access the service using: `web-service.apps.svc.cluster.local` --> this is the FQDN for the service.



what about pods? records for pods are not created by default. we can enable record cretion by defult. it does not use the pod's name, rather the pod's ip replacing dots with dashes - `192.168.0.1` --> `192-168-0-1`. type is set to pod, rather than to svc.

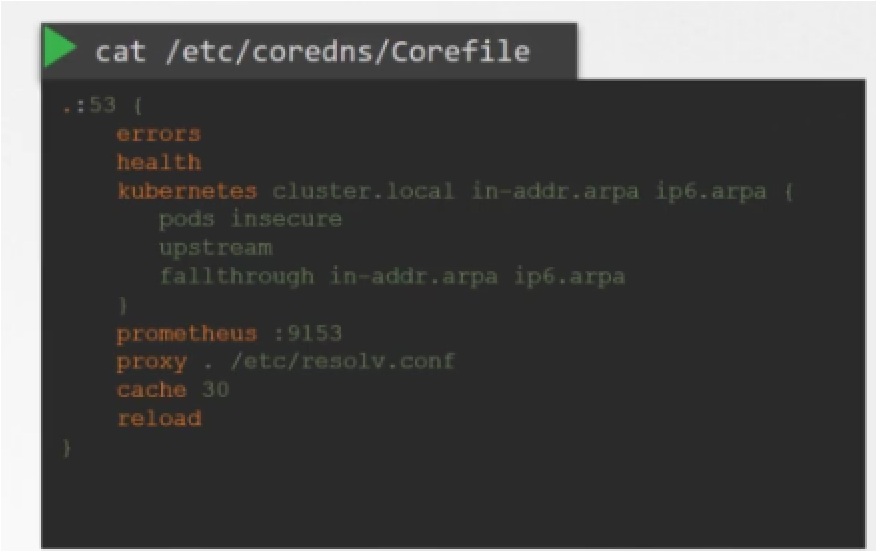
`cluster-local` is the root domain.

coredns in k8s

k8s doesn't create an entry for pod to map pod names to their ip addresses; it does do that for services (svc to ip). for pods, k8s forms hostnames with the ip addresses, replacing dots with dashes.

k8s deploys a dns server within the cluster. previous to version 1.12, it was called kube-dns; after this version the recommended server is coredns.

the coredns server is deployed as a pod in the kube-system namespace - a replica set with 2 pods (for redundancy); a replica set withing a deployment. this coredns pod runs the coredns executable. coredns requires a configuration file `/etc/coredns/<file>`. whithin the file we have plugins configured (in orange):



in the kubernetes plugin is where the top level domain of the cluster is set - in this case, cluster.local.

the pods section is responsible for creating a record for pods in the cluster (converting ips into the dash format) - it is disabled but we can enable it by adding `pods insecure`.

Any record that this DNS server can't solve (for example say a POD tries to reach www.google.com) it is forwarded to the nameserver specified in the coredns pods /etc/resolv.conf file. *The /etc/resolv.conf file is set to use the nameserver from the kubernetes Node.* Also note, that this core file is passed into the pod has a configMap object. That way if you need to modify this configuration you can edit the ConfigMap object.

`kubectl get configmap -n kube-system`

We now have the coredns pod up and running using the appropriate kubernetes plugin. It watches the kubernetes cluster for new PODs or services, and every time a pod or a service is created it adds a record for it in its database.

Next step is for the pod to point to the coreDNS server. What address do the PODs use to reach the DNS server? When we deploy CoreDNS solution, It also creates a service to make it available to other components within a cluster. The service is named `kube-dns` by default. *The IP address of this service is configured as nameserver on the PODs.*

Now you don't have to configure this yourself. The DNS configurations on PODs are done by kubernetes automatically when the PODs are created.

Want to guess which kubernetes component is responsible for that? The kubelet.

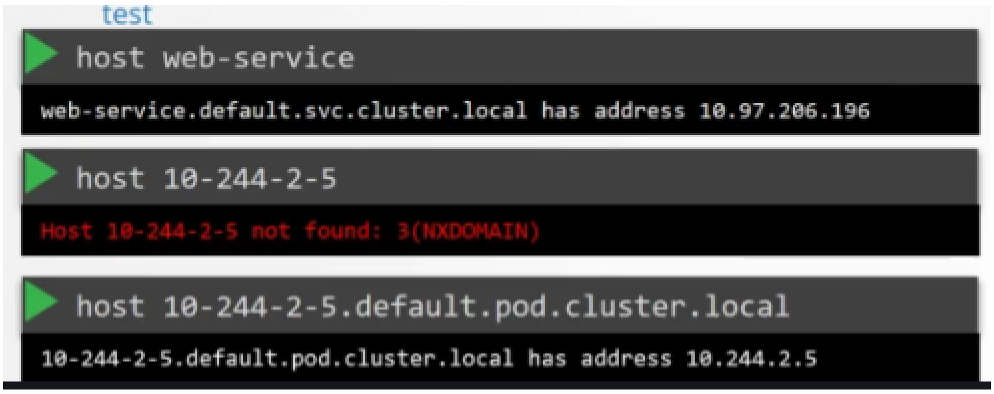
If you look at the config file of the kubelet (`cat /var/lib/kubelet/config.yaml`) you will see the IP of the DNS server and domain in it. Once the pods are configured with the right nameserver, you can now resolve other pods and services. You can access the web-service using just web-service, or web-service.default or web-service.default.svc or web-service.default.svc.cluster.local.

You can access the web-service using just web-service, or web-service.default or web-service.default.svc or web service.default.svc.cluster.local. If you try to manually lookup the web-service using nslookup or the host command web-service command, it will return the fully qualified domain name of the web-service, which happens to be web-service.default.svc.cluster.local. will return the fully qualified domain name of the web-service, which happens to be web-service.default.svc.cluster.local.

But you didn't ask for that you just set up service. So how did it look up for the full name. It so happens, the resolv.conf file also has a search entry which is set to default.svc.cluster.local as well as svc.cluster.local and cluster.local.

This allows you to find the service using any name. web-service or web-service.default or web-service.default.svc.

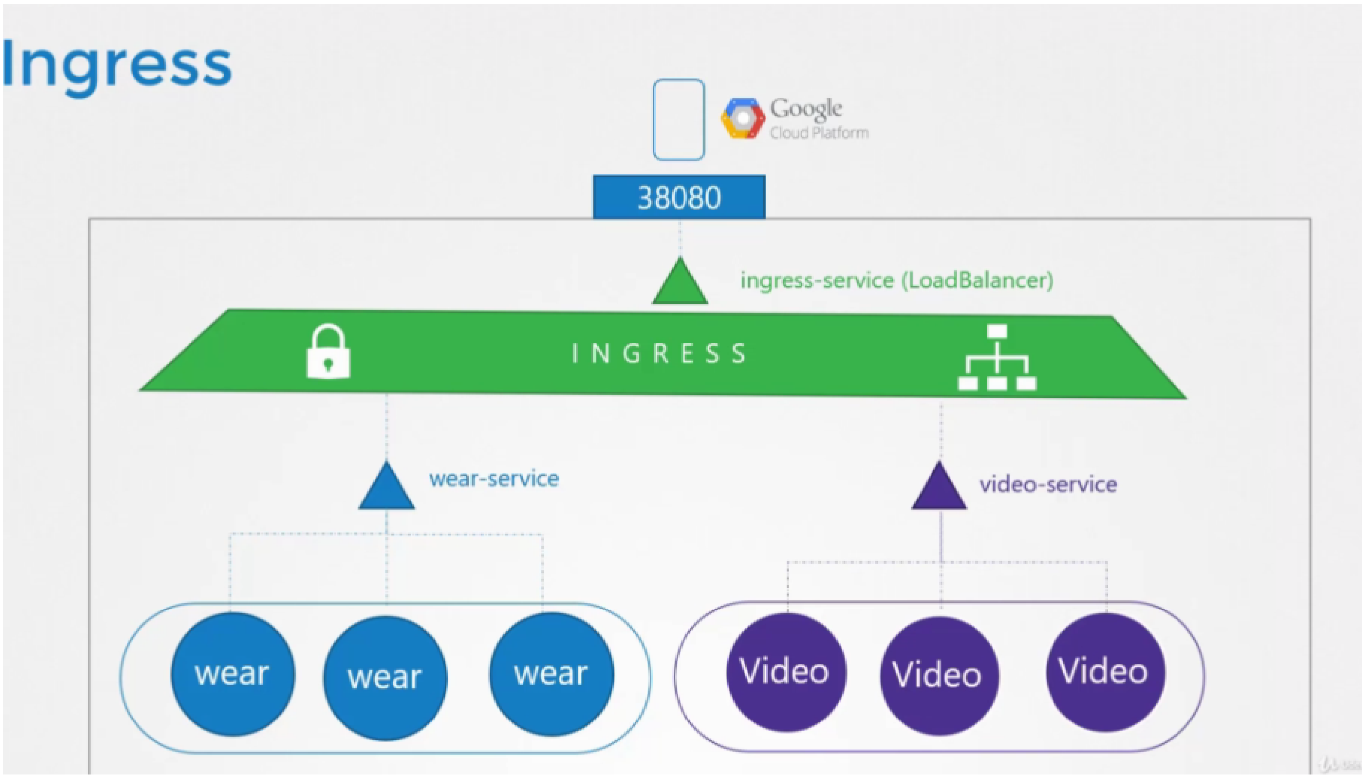
However, notice that it only has search entries for service . So you won't be able to reach a pod the same way. For that you need to specify the full FQDN of the pod:

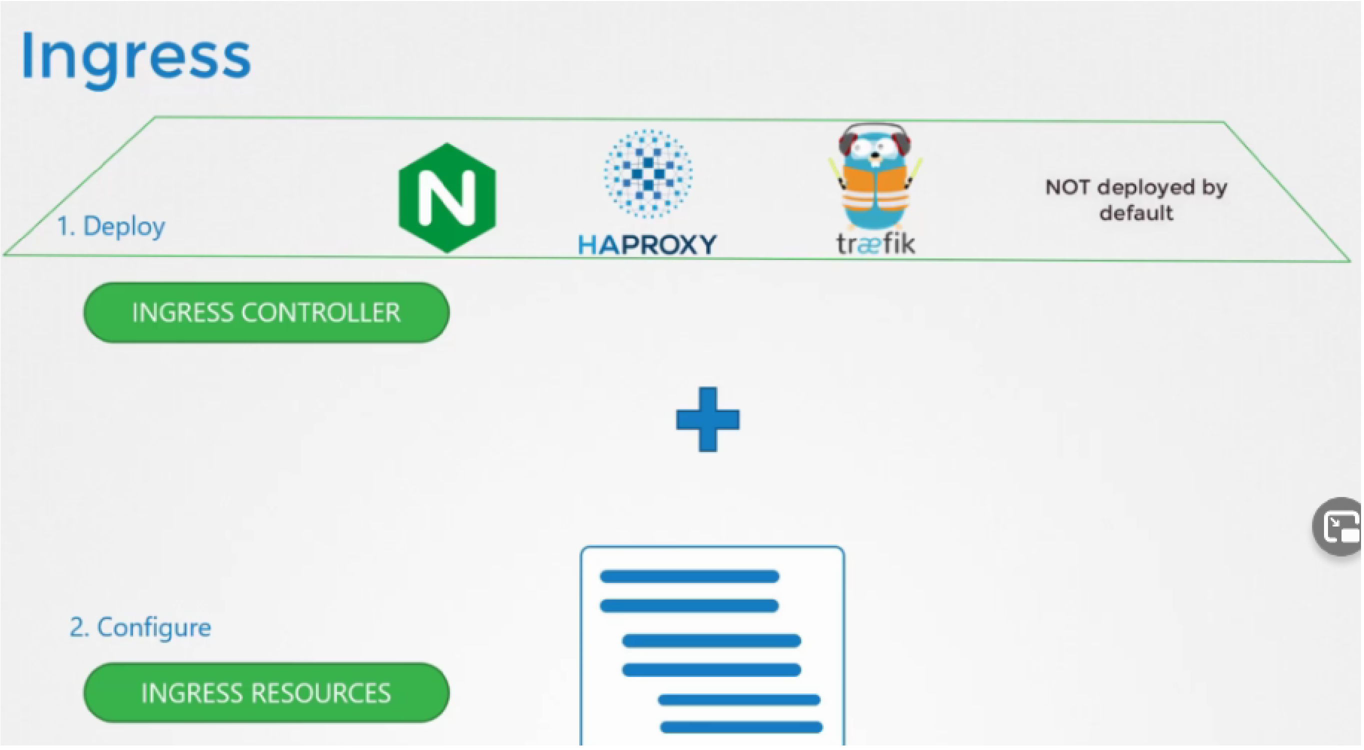



```
kubectl -n kube-system get svc
kubectl -n kube-system describe deployments.apps coredns
kubectl describe configmap coredns -n kube-system
```

ingress

svc vs ingress

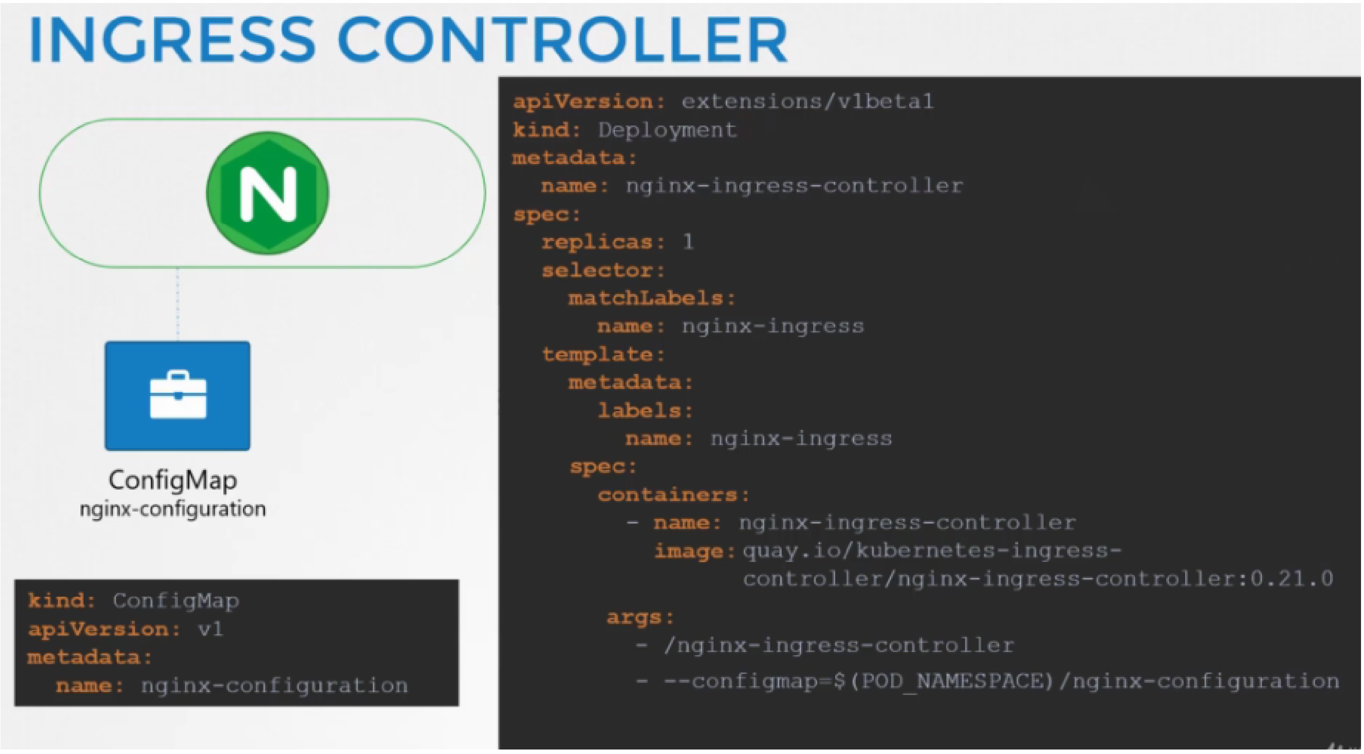




ingress controller - not deployed by default.

- gce -- supported by k8s
- ngninx -- supported by k8s
- istio
- traefik

ingress controller is deployed as another deployment.



also add at the same level of args

```
    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
```

then the service to expose the ingress controller to the world - a nodeport svc:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-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
```

to do this we also need a service account with the correct set of permissions.

summary:

- deployment of nginx ingress controller
- service
- configMap
- Auth

then creating ingress resources - a set of rules applied on the ingress controller. for instance, forwarding traffic to a single application or route traffic to different apps based on the URL, route based on the domain... again the ingress resource is created with a definition file

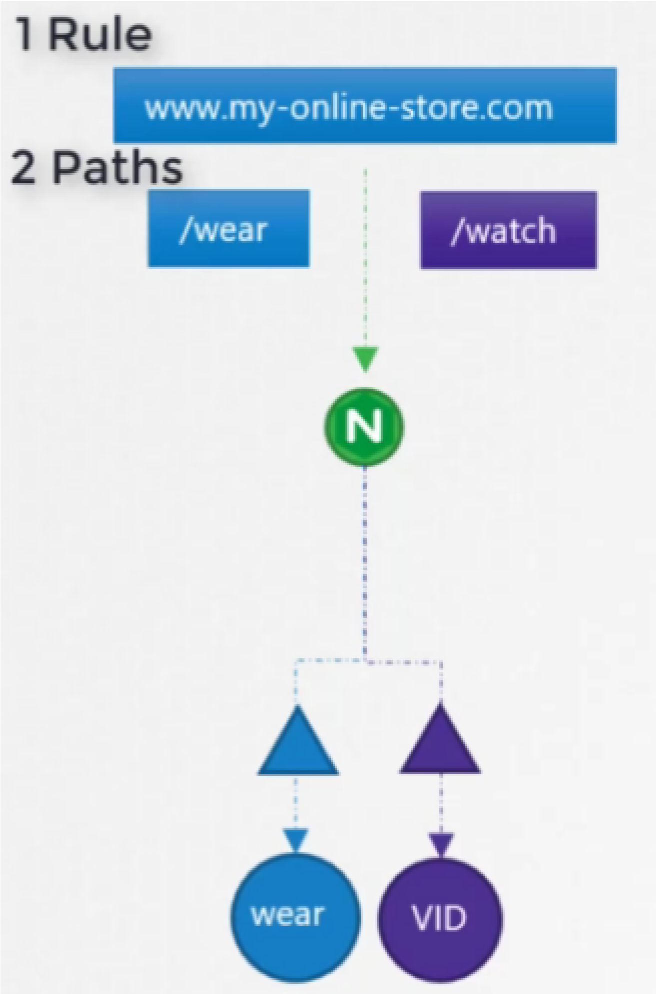
```yaml
# ingress-wear.yaml
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: ingress-wear
spec:
  backend:
    serviceName: wear-service
    servicePort: 80
```

`kubectl get ingress`

rules are used to route traffic when there are several services. rules are at the top of each domain name (?) and within each rule we have different paths based on the url.

configuring ingress resources in k8s. we are trying to create a rule with 2 paths

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



ingress resource example using domain names:

```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
```

since we have 2 domain names we create 2 rules (previously 1 rule for 2 paths). if we do not use the host field, k8s will default to a star, all the incoming traffic to that rule without matching the host name.


```
kubectl edit ingress --namespace app-space
```

annotations and rewrite-target

Different ingress controllers have different options that can be used to customise the way they work. NGINX Ingress controller has many options that can be seen here.

Our watch app displays the video streaming webpage at `http://<watch-service>:<port>/`. Our wear app displays the apparel webpage at `http://<wear-service>:<port>/`

We must configure Ingress to achieve this. When a user visits the URL on the left, the request should be forwarded internally to the URL on the right. Note that the /watch and /wear URL paths are what we configure on the ingress controller so we can forward users to the appropriate application in the backend. The applications don't have this URL/Path configured on them:

- `http://<ingress-service>:<ingress-port>/watch` --> `http://<watch-service>:<port>/`
- `http://<ingress-service>:<ingress-port>/wear` --> `http://<wear-service>:<port>/`

Without the rewrite-target option, this is what would happen:

- `http://<ingress-service>:<ingress-port>/watch` --> `http://<watch-service>:<port>/watch`
- `http://<ingress-service>:<ingress-port>/wear` --> `http://<wear-service>:<port>/wear`

Notice that watch and wear at the end of the target URLs. The target applications are not configured with /watch or /wear paths. They are different applications built specifically for their purpose, so they don't expect /watch or /wear in the URLs. And as such the requests would fail and throw a 404 not found error.

To fix that we want to "ReWrite" the URL when the request is passed on to the watch or wear applications. We don't want to pass in the same path that user typed in. So we specify the rewrite-target option. This rewrites the URL by replacing whatever is under rules->http->paths->path which happens to be /pay in this case with the value in rewrite-target. This works just like a search and replace function. For example: replace(path, rewrite-target) - In our case: replace("/path","/")

```
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
```

In another example given here, this could also be: replace("/something(/|$)(.*)", "/$2")

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /$2
  name: rewrite
  namespace: default
spec:
  rules:
  - host: rewrite.bar.com
    http:
      paths:
      - backend:
          serviceName: http-svc
          servicePort: 80
        path: /something(/|$)(.*)
```

```
#controlplane $ cat ingress-controller.yaml
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: ingress-controller
  namespace: ingress-space
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
            - --default-backend-service=app-space/default-http-backend
          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
#controlplane $
#controlplane $ cat svc.yaml
# kubectl -n ingress-space expose deployment ingress-controller --name
ingress --port 80 --target-port 80 --type NodePort --dry-run=client -o yaml
> lefile.yam
apiVersion: v1
kind: Service
metadata:
  name: ingress
  namespace: ingress-space
spec:
  type: NodePort
  selector:
    name: nginx-ingress
  ports:
  - port: 80
    targetPort: 80
    nodePort: 30080
#controlplane $
#controlplane $ cat resource-ingress.yaml
apiVersion: extensions/v1beta1
# apiVersion: networking.k8s.io/v1beta1
kind: Ingress
metadata:
```

```
  name: ingress
  namespace: app-space
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - http:
      paths:
      - path: /wear
        backend:
          serviceName: wear-service
          servicePort: 8080
      - path: /watch
        backend:
          serviceName: video-service
          servicePort: 8080
#controlplane $
```

design and install k8s cluster

- kube api listes on 6443; use a load balancer to split traffic between several master nodes. they can both be active at the same time
- scheduler/controller manager: between the 2 nodes, one must be active and the other on standby. leader-elect
  - kube-controller-manager: when the controller manager is configured we can specify `kube-controller-manager --leader-elect true [other options]`. when the process starts, it tires to gain a lease and lock the kube-controller-manager endpoint - the process that first updates the endpoint with its information becomes the active; the other becomes passive. the active controller holds the lease according to the duration specified on the `--leader-elect-lease-duration 15s` config (default is 15). the active process renews the lease according to the config of `--leader-elect-renew-deadline 10s` (default). by default processes try to become leaders every 2s: `--leader-elect-retry-period 2s`
  - the scheduler has similar command line options
- ETCD: there are 2 topologies: 1) the etcd is part of the master nodes -- stacked topology (easier to setup, easier to manage, fewer servers, *risk during failures*) 2) etcd is separated from the control plane nodes and run on their own set of servers -- external ETCD topology (less risky, harder to setup, more servers). ETCD usually listens on port 2379

the kube-api server is the only one that talks to etcd - there is a configuration on the kube-api server specification: `cat /etc/systemd/system/kube-apiserver.service | grep etcd-servers` - as a list if there are several etcd servers.

etcd in HA

information is stored in the form of files or pages; each individual file contains all the information related to the object it describes/stores. changes to one file does not affect the others.

distributed - accross different servers holding the same information. we can read and write on any server that the information must be the same, same consistent copy of the data at the same time.

with reads, information is the same across nodes. as regards writes - only one instance is responsible of writing the data and the replicating it. one node becomes the leader and the other nodes become workers. if the request to write is sent through a worker node, the worker node sends the request to the leader, who then replicates the data.

selection of the leader through the RAFT protocol. raft algorythm uses random timers for initiating requests. a random timer is kicked off on the three managers; the first one to finish the timer sends out a request to the other nodes for permissions to be the leader; the other managers, on receivin the request, responde with their vote and the node assumes the leader role.

as elected as leader, it sends out notifications at regular intervals to other masters informing them that it is continuing to assume the role of the leader. in case the other nodes do not receive a notification from the leader (leader is down or loosing network connectivity) the nodes initiate a new election process among themselves and a new leader is elected.

a write request arrives to the leader who processes it and replicates it to other nodes in the cluster. the write request is considered to be completed only when it has been replicated on the other ETCD nodes. the etcd cluster is HA - even if we lose a node, it can still function; if a new write request comes in and an etcd instnace is unavailable - the write is considered to be complete when the write was replicated on *most* instances of the cluster (2/3, write is completed). when there is quorum, the minimum number of nodes that need to be available for the cluster to function (total number of nodes/2 +1). if there are 2 instances, the quorum is 2 - if one instance fails, the write request won't be process since there is no quorum. so a minimum HA ETCD topology requires 3 instances and then on, **odd numbers** (preferred in case there is in place network segmentation).

when the node that was down comes back up, the data is replicated to the node.

```
wget -q --https-only
"https://github.com/coreos/etcd/releases/download/v3.3.9/etcd-v3.3.9-linux-amd64.tar.gz"
tar -xvf etcd-v3.3.9-linux-amd64.tar.gz
mv etcd-v3.3.9-linux-amd64.tar.gz/etcd* /usr/local/bin/
mkdir -p /etc/etcd /var/lib/etcd
cp ca.pem kubernetes-key.pem kubernetes.pem /etc/etcd/
```

then configure the etcd service:

089

use the `etcdctl` utility to store and retrieve data. there are to etcdctl version, v2 (default) and v3 (we'll use 3 - `export ETCDCTL_API=3`). `etcdctl put name john` create data; `etcdctl get name` retrieve data; `etcdctl get / --prefix --keys-only` get all keys

kubernetes the hard way: https://www.youtube.com/watch?v=uUupRagM7m0&list=PL2We04F3Y_41jYdadX55fdJplDvgNGENo; https://github.com/mmumshad/kubernetes-the-hard-way

kubernetes the kubeadm way

1. several nodes (1 master, 2 nodes)
2. install container runtime - docker
3. install kubeadm on all the nodes
4. initialize master server
5. deploy the pod network
6. join nodes to he master

- vagrant file: https://github.com/kodekloudhub/certified-kubernetes-administrator-course
- docu https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/install-kubeadm/

needs vagrant and virtual box

```
git clone https://github.com/kodekloudhub/certified-kubernetes-
administrator-course
vagrant status
vagrant up
vagrant ssh <nodeName>
lsmod | grep br_netfilter ****(if no result)****
sudo modprobe br_netfilter ****(on all nodes)****
****(create new kernel parameters on all nodes)****
cat <<EOF | sudo tee /etc/sysctl.d/k8s.conf
net.bridge.bridge-nf-call-ip6tables = 1
net.bridge.bridge-nf-call-iptables = 1
EOF
sudo sysctl --system
sudo apt-get update && apt-get install -y apt-transport-https ca-
certificates curl software-properties-common gnupg2
curl -fsSl https://download.docker.com/linux/ubuntu/gpg | apt-key add -
sudo-apt-repository "deb [arch=amd64]
https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable"
sudo apt-get update && apt-get install -y containerd.io=1.2.13-1 docker-
ce=5:19.03.8~3-0~ubuntu-$(lsb_release -cs) docker-ce-cli=5:19.03.8~3-
0~ubuntu-$(lsb_release -cs)
cat > /etc/docker/daemon.json <<EOF
{
  "exec-opts": ["native.cgroupdriver=systemd"],
  "log-driver": "json-file",
  "log-opts": {
    "max-size": "100m"
  },
  "storage-driver": "overlay2"
}
EOF
mkdir -p /etc/systemd/system/docker.service.d
systemctl daemon-reload
systemctl restart docker
systemctl status docker
sdo apt-get update && sudo apt-get install -y apt-transport-https curl
sudo curl -fsSLo /usr/share/keyrings/kubernetes-archive-keyring.gpg
https://packages.cloud.google.com/apt/doc/apt-key.gpg
echo "deb [signed-by=/usr/share/keyrings/kubernetes-archive-keyring.gpg]
https://apt.kubernetes.io/ kubernetes-xenial main" | sudo tee
```

```
/etc/apt/sources.list.d/kubernetes.list
sudo apt-get update
sudo apt-get install -y kubelet kubeadm kubectl
sudo apt-mark hold kubelet kubeadm kubectl
```

- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/install-kubeadm/
- https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/create-cluster-kubeadm/

```
****only on the master****
kubeadmin init --pod-network-cidr 10.244.0.0/16 --apiserver-advertise-
address=192.168.56.2
****regular user****
mkdir -p $HOME/.kube
sudo cp -i /etc/kubernetes/admin.conf $HOME/.kube/config
sudo chown #(id -u):$(id -g) $HOOME/.kube/config
****copy kubeadm join command****
****deploy network solution****
kubectl apply -f "https://cloud.weave.works/k8s/net?k8s-version=$(kubectl
version | base64 | tr -d '\n')"
****run join command on each worker nodes****
```

https://www.weave.works/docs/net/latest/install/installing-weave/

```
sudo curl -L git.io/weave -o /usr/local/bin/weave
sudo chmod a+x /usr/local/bin/weave
```

`kubeadm token create --print-join-command`

end to end section

https://www.youtube.com/watch?v=-ovJrIIED88&list=PL2We04F3Y_41jYdadX55fdJplDvgNGENo&index=18

golang must be installed: `go get -u k8s.io/test-infra/kubetest`; run `kubetest --extract=v1.11.3` (version must match kubernetes version that is actually running); `cd kubernetes`, `export KUBE_MASTER_IP="192.168.26.10:6443"`, `export KUBE_MASTER=kube-master` and `kubetest --test --provider=skeleton > test` skeleton is for local cluster; we should say google cloud, AWS or Azure. takes 12hrs!

`kubetest --test --provider=skeleton --test_args="--ginkgo.focus=Secrets" > testout1` or `kubetest --test --provider=skeleton --test_args="--ginkgo.focus=\[Conformance\]" > testout1`

troubleshooting

app failure

have a mental map of how the connections are made and check each link

```
curl http://web-service-ip:node-port
kubectl describe service web-service
```

check selectors on the def file and the ones running on the pod

```
kubectl get pod
kubectl describe pod <pod-name>
kubectl logs <pod-name> -f --previous ****to check the logs when it
failed****
kubectl -n gamma get ep
```

https://kubernetes.io/docs/tasks/debug-application-cluster/debug-application/

control plane failure

```
kubectl get nodes
kubectl get pods
kubectl get pods -n kube-system
service kube-apiserver status
service kube-controller-manager status
service kube-scheduler status
service kubelet status
service kube-proxy status

kubectl logs <controlplanecomponent> -n kube-system
sudo journalctl -u kube-apiserver

cat /etc/systemd/system/kubelet.service.d/10-kubeadm.conf
cd /etc/kubernetes/manifests    <--- KUBEADM config file
cat /var/lib/kubelet/config.yaml
cat /etc/kubernetes/kubelet.conf
```

https://kubernetes.io/docs/tasks/debug-application-cluster/debug-cluster

worker node failure

```
kubectl get nodes
kubectl describe node <nodeName>
service kubelet status
sudo journalctl -u kubelet
kubectl cluster-info
openssl x509 -in /var/lib/kubelet/worker-1.crt -text
```

network troubleshooting

Kubernetes uses CNI plugins to setup network. The **kubelet** is responsible for executing plugins as we mention the following parameters in kubelet configuration.

- `cni-bin-dir`: Kubelet probes this directory for plugins on startup
- `network-plugin`: The network plugin to use from `cni-bin-dir`. It must match the name reported by a plugin probed from the plugin directory.

There are several plugins available and these are some.

1. Weave Net: These is the only plugin mentioned in the kubernetes documentation. To install `kubectl apply -f "https://cloud.weave.works/k8s/net?k8s-version=$(kubectl version | base64 | tr -d '\n')"` You can find this in following documentation : https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/high-availability/

2. Flannel: To install, `kubectl apply -f https://raw.githubusercontent.com/coreos/flannel/2140ac876ef134e0ed5af15c65e414cf26827915/Documentation/kube-flannel.yml` Note: As of now flannel does not support kubernetes network policies.

3. Calico: To install `curl https://docs.projectcalico.org/manifests/calico.yaml -O`. Apply the manifest using the following command. `kubectl apply -f calico.yaml` Calico is said to have most advanced cni network plugin.

In CKA and CKAD exam, you won't be asked to install the cni plugin. But if asked you will be provided with the exact url to install it. If not, you can install weave net from the documentation https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/high-availability/

Note: If there are multiple CNI configuration files in the directory, the kubelet uses the configuration file that comes first by name in lexicographic order.

DNS in Kubernetes

Kubernetes uses CoreDNS. CoreDNS is a flexible, extensible DNS server that can serve as the Kubernetes cluster DNS.

Memory and Pods: In large scale Kubernetes clusters, CoreDNS's memory usage is predominantly affected by the number of Pods and Services in the cluster. Other factors include the size of the filled DNS answer cache, and the rate of queries received (QPS) per CoreDNS instance.

Kubernetes resources for coreDNS are:

- a service account named coredns,
- cluster-roles named coredns and kube-dns
- clusterrolebindings named coredns and kube-dns,
- a deployment named coredns,
- a configmap named coredns and a
- service named kube-dns.

While analyzing the coreDNS deployment you can see that the the Corefile plugin consists of important configuration which is defined as a configmap.

Port 53 is used for for DNS resolution.

```
kubernetes cluster.local in-addr.arpa ip6.arpa {
    pods insecure
    fallthrough in-addr.arpa ip6.arpa
    ttl 30
}
```

This is the backend to k8s for cluster.local and reverse domains. `proxy . /etc/resolv.conf` Forward out of cluster domains directly to right authoritative DNS server.

Troubleshooting issues related to coreDNS

- If you find CoreDNS pods in pending state first check network plugin is installed.
- coredns pods have CrashLoopBackOff or Error state

If you have nodes that are running SELinux with an older version of Docker you might experience a scenario where the coredns pods are not starting. To solve that you can try one of the following options:

1. Upgrade to a newer version of Docker.
2. Disable SELinux.
3. Another cause for CoreDNS to have CrashLoopBackOff is when a CoreDNS Pod deployed in Kubernetes detects a loop.
4. Modify the coredns deployment to set allowPrivilegeEscalation to true:

```
kubectl -n kube-system get deployment coredns -o yaml | \
  sed 's/allowPrivilegeEscalation: false/allowPrivilegeEscalation: true/g'
| \
  kubectl apply -f -
```

There are many ways to work around this issue, some are listed here:

1. Add the following to your kubelet config yaml: resolvConf: `<path-to-your-real-resolv-conf-file>` This flag tells kubelet to pass an alternate resolv.conf to Pods. For systems using systemd-resolved, /run/systemd/resolve/resolv.conf is typically the location of the "real" resolv.conf, although this can be different depending on your distribution.
2. Disable the local DNS cache on host nodes, and restore /etc/resolv.conf to the original.
3. A quick fix is to edit your Corefile, replacing forward . /etc/resolv.conf with the IP address of your upstream DNS, for example forward . 8.8.8.8. But this only fixes the issue for CoreDNS, kubelet will continue to forward the invalid resolv.conf to all default dnsPolicy Pods, leaving them unable to resolve DNS.

- If CoreDNS pods and the kube-dns service is working fine, check the kube-dns service has valid endpoints. `kubectl -n kube-system get ep kube-dns`

If there are no endpoints for the service, inspect the service and make sure it uses the correct selectors and ports.

Kube-Proxy

kube-proxy is a network proxy that runs on each node in the cluster. kube-proxy maintains network rules on nodes. **These network rules allow network communication to the Pods from network sessions inside or outside of the cluster**. *In a cluster configured with kubeadm, you can find kube-proxy as a daemonset.*

kubeproxy is responsible for watching services and endpoint associated with each service. When the client is going to connect to the service using the virtual IP the kubeproxy is responsible for sending traffic to actual pods.

If you run a `kubectl describe ds kube-proxy -n kube-system` you can see that the kube-proxy binary runs with following command inside the kube-proxy container.

```
Command:
  /usr/local/bin/kube-proxy
  --config=/var/lib/kube-proxy/config.conf
  --hostname-override=$(NODE_NAME)
```

So it fetches the configuration from a configuration file ie, `/var/lib/kube-proxy/config.conf` and we can override the hostname with the node name of at which the pod is running.

In the config file we define the clusterCIDR, kubeproxy mode, ipvs, iptables, bindaddress, kube-config etc.

Troubleshooting issues related to kube-proxy

1. Check kube-proxy pod in the kube-system namespace is running.
2. Check kube-proxy logs.
3. Check configmap is correctly defined and the config file for running kube-proxy binary is correct.
4. kube-config is defined in the config map.
5. check kube-proxy is running inside the container

```
# netstat -plan | grep kube-proxy
tcp        0      0 0.0.0.0:30081           0.0.0.0:*               LISTEN
1/kube-proxy
tcp        0      0 127.0.0.1:10249         0.0.0.0:*               LISTEN
1/kube-proxy
tcp        0      0 172.17.0.12:33706       172.17.0.12:6443
ESTABLISHED 1/kube-proxy
tcp6       0      0 :::10256                :::*                    LISTEN
1/kube-proxy
```

References:

- Debug Service issues: https://kubernetes.io/docs/tasks/debug-application-cluster/debug-service/
- DNS Troubleshooting: https://kubernetes.io/docs/tasks/administer-cluster/dns-debugging-resolution/

it seems obvious at this point, but... kubelet = kube-apiserver

- `kubectl -n kube-system get ep kube-dns`

other topics

json-path

- https://kodekloud.com/p/json-path-quiz
- https://mmumshad.github.io/json-path-quiz/index.html#!/?questions=questionskub1
- https://mmumshad.github.io/json-path-quiz/index.html#!/?questions=questionskub2

Dictionary:

```
# LIST/ARRAY
- blue car
- ugly cat
# DICTIONARY
# dictionary within a dictionary
color: blue
model:
  name: corvette
  year: 1995
price: 20,000
```

JSON PATH

- [] --> array
- {} --> dictionary

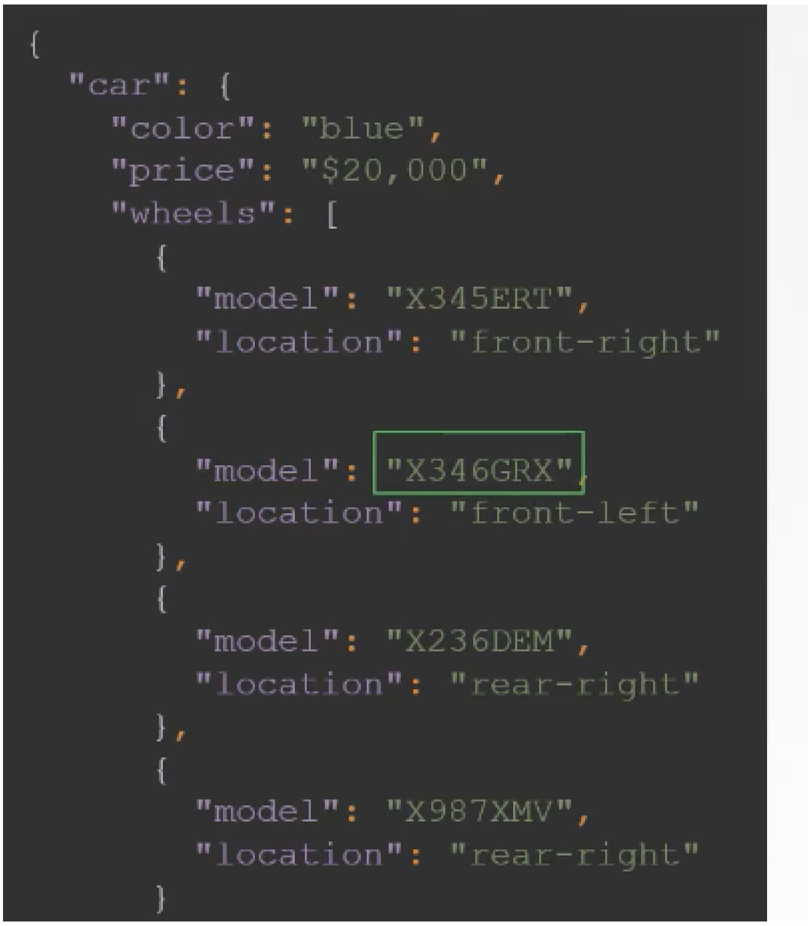
https://www.json2yaml.com

json path is a query language that helps us parse data represented in a json or yaml format. for any given data, we make a query aiming at getting filtered results

```
{
  "car": {
    "color": "blue",
    "price": "$20,000"
  }
}
# query to get car details
car
# result
{
  "color": "blue",
  "price": "$20,000"
}
# using dot-notation
car.price
"blue"
```

top level element of a dictionary, that usually has no name is known as the root element - it is denoted by the `$` - `$.color`.

all query results are return with the form of an json array, that is, between []. to get an element `$[0]` --> the first element, `$[0,3]`



```
{
  "car": {
    "color": "blue",
    "price": "$20,000",
    "wheels": [
      {
        "model": "X345ERT",
        "location": "front-right"
      },
      {
        "model": "X346GRX",
        "location": "front-left"
      },
      {
        "model": "X236DEM",
        "location": "rear-right"
      },
      {
        "model": "X987XMV",
        "location": "rear-right"
      }
```

`$.car.wheels[1.model]`

conditions or criteria. getting numbers from array bigger than 40:

- check if= `?()`
- each item in the list: `@`
- in or nin - `@ in [ 40, 43, 45 ]`

`$[?( @ > 40 )]`

`$.car.wheels[?(@.location == "rear-right")].model`

`$[*].model` --> get all models; `$.*.wheels[*].model`

`$.prizes.[?(@.year == 2014 )].laureates[*].firstname`

1 to 4 - NOT INCLUDING THE FORTH ELEMENT: `$[0:3]` - including the 4th element: `$[0:4]` - to specify the increment, add another semicolon: `$[0:8:2]` - latest element is `$[-1:0]` or `$[-1:]`

JSON PATH in k8s

use with kubectl, which communicates with the kube-apiserver. the kube-api server speaks JSON and sends JSON data, that then kubectl converts into human redeable format.

to perform queries using JSON PATH query sytax, we need to

1. identify the kubectl command that will return raw data, all the data that we then want to filter - to see how the data is received add the `-o json` flag to teh command
2. study the json output
3. form the JSON PATH query to get the information we want (no need to add $): `.items[0].spec.containers[0].image`
4. use the JSON PATH query with kubectl command `kubectl get pods -o=jsonpath='{ .items[0].spec.containers[0].image }'`

we can string several search results in a single command placing one after the other in between {}. we can format the output by `{"\n"}`, `{"\t"}\t`

loop method: `'{range .items[*]}{.metadata.name}{"\t"}{.status.capacity.cpu}{"\n"}{end}'`

another way of doing this is by: `kubectl get nodes -o=custom-columns=<COLUMN NAME>:<JSON PATH>`, for instance `-o=custom-columns=NODE:.detadata.name,CPU:.status.capacity.cpu`

sorting: `kubectl get nodes --sort-by=.metadata.name`

If it's square brackets its an array/list. If its curly brackets it is a dictionary.

random queries

```
$.status.containerStatuses[?(@.name == "redis-container")].restartCount
$.[*].spec.containers[*].name
$.[?(@.kind == "Pod")].metadata.name
```

```
kubectl get nodes -o=jsonpath='{.items[*].metadata.name}' >
/opt/outputs/node_names.txt
kubectl config view --kubeconfig=my-kube-config -o jsonpath="
kubectl get pv
kubectl get pv -o=custom-
columns=NAME:.metadata.name,CAPACITY:.spec.capacity.storage --sort-
by=.spec.capacity.storage > /opt/outputs/pv-and-capacity-sorted.txt
```