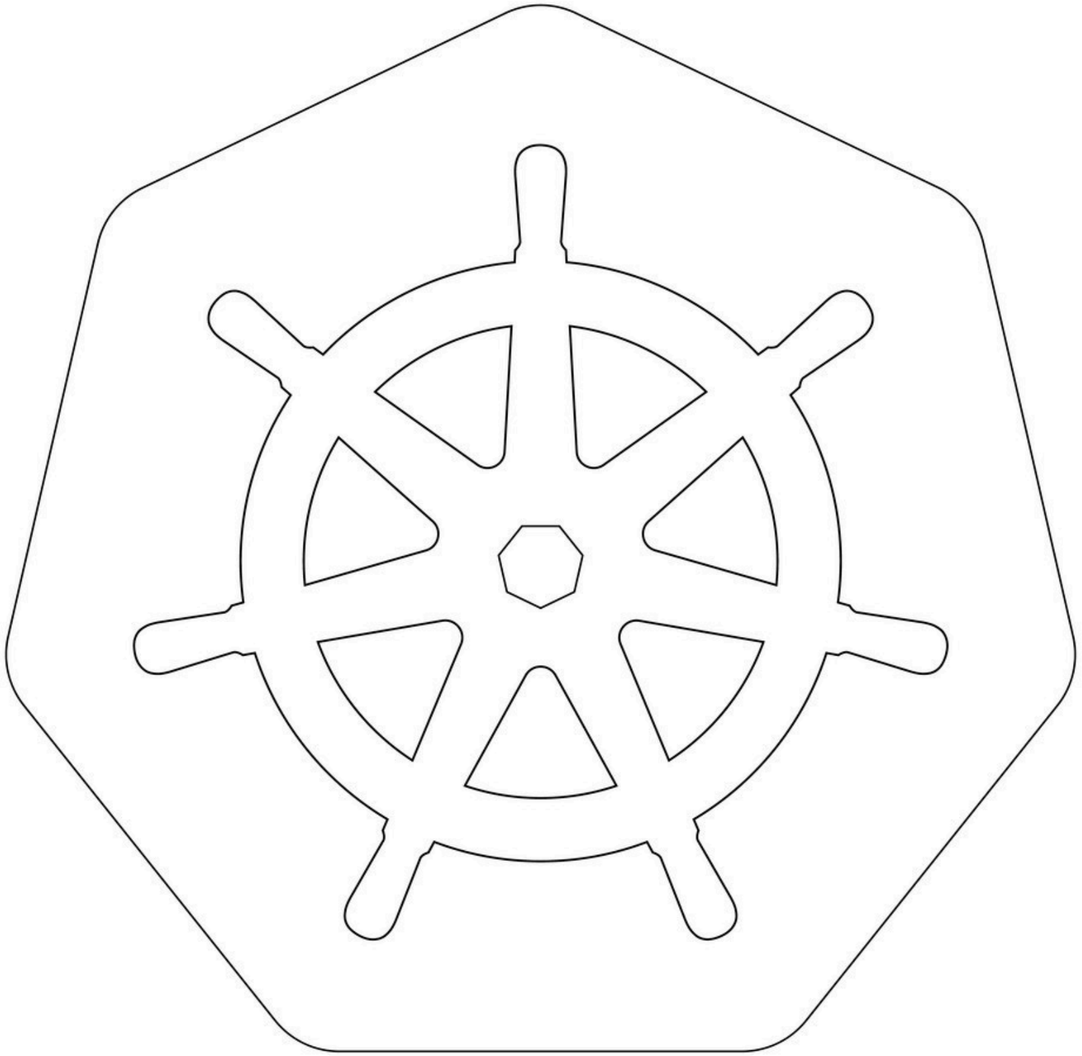
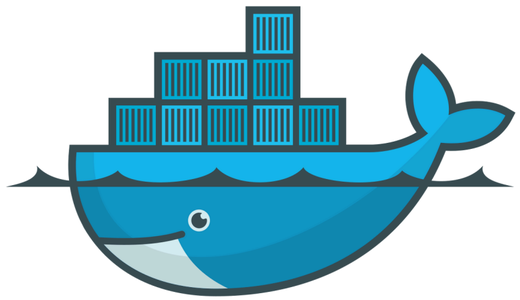


kubernetes

KUBERNETES:

KUBERNETES

K8S



WHY KUBERNETES

Earlier We used Docker Swarm as a container orchestration tool that we used to manage multiple containerized applications on our environments.

FEATURES	DOCKER SWARM	KUBERNETES
Setup	Easy	Complex
Auto Scaling	No Auto Scaling	Auto Scaling
Community	Good Community	Greater community for users like documentation, support and resources
GUI	No GUI	GUI

KUBERNETES:

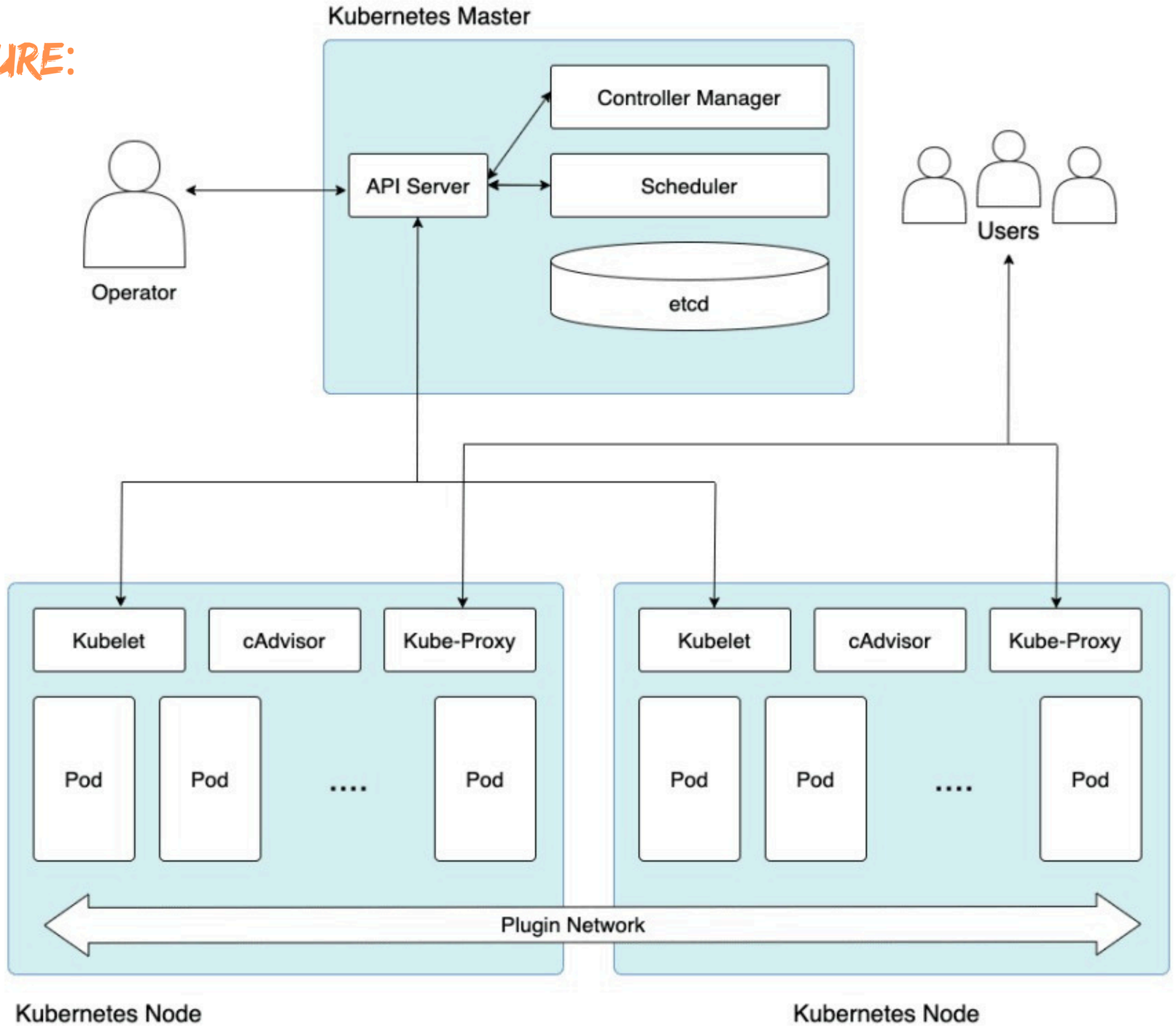
IT is an open-source container orchestration platform.
It is used to automates many of the manual processes like deploying, managing, and scaling containerized applications.
Kubernetes was developed by GOOGLE using GO Language.
Google donated K8's to CNCF in 2014.
1st version was released in 2015.

WHY KUBERNETES:

Containers are a good and easy way to bundle and run your applications. In a production environment, you need to manage the containers that run the applications and ensure that there is no downtime. In docker we used docker swarm for this. but any how docker has drawbacks!

so we moved to KUBERNETES.

AECHITECTURE:



HOW IT WORKS:

get pods

API-SERVER

ETCD
CLUSTER

Authenticate user → Validate Request → Retrieve Data

1 2 3

HOW POD CREATES:

create pods

1. Request

API-SERVER

5. Update the pod data

ETCD CLUSTER

2. Request

Scheduler

3. Find perfect Node to Create a Pod

4. Creates a pod in worker node

Kubelet

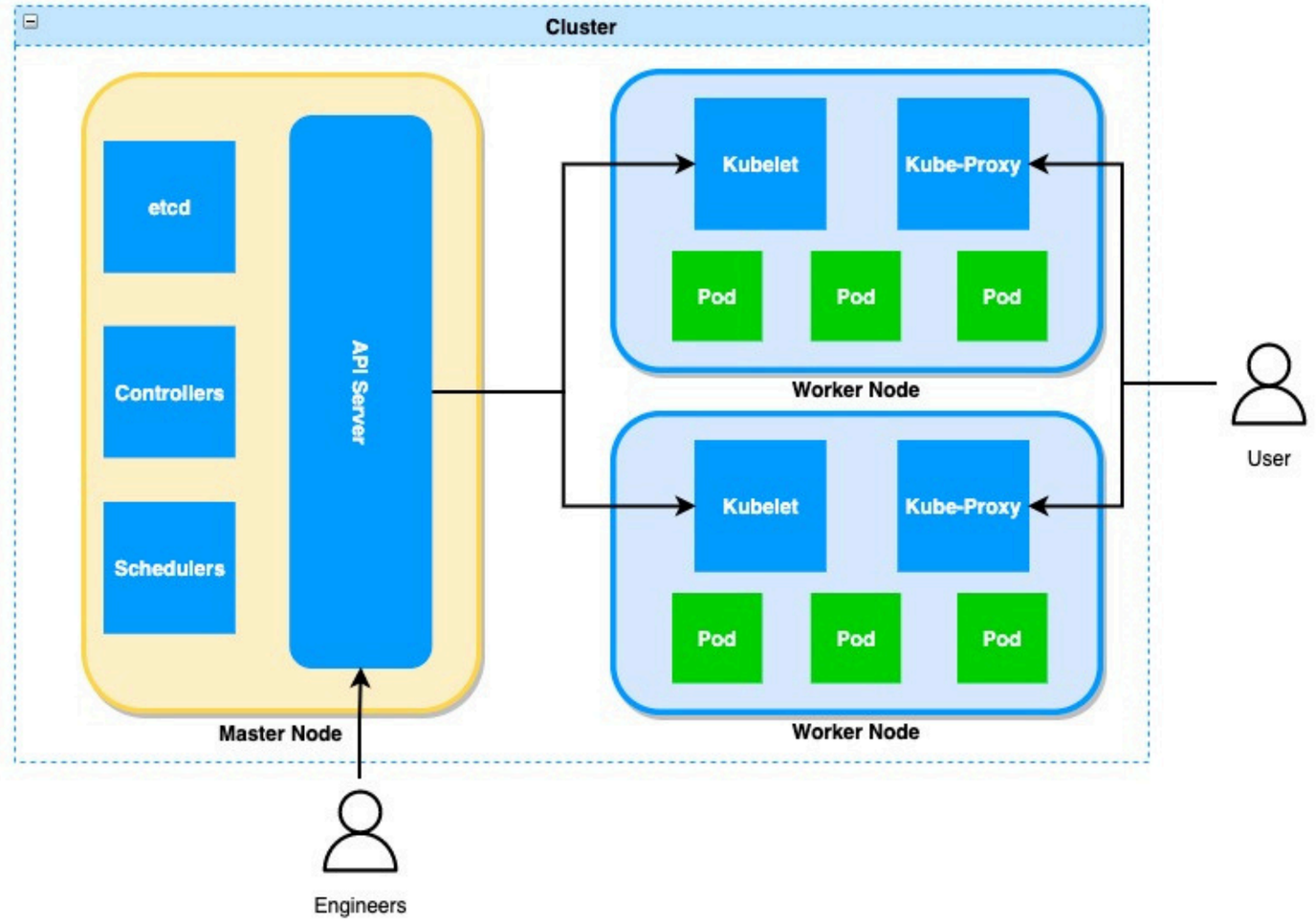
Worker Node

CLUSTER:

- It is a group of serversIt will have both manager and worker nodes.
- Master Node is used to assign tasks to Worker Nodes.
- Worker node will perform the task.
- we have 4 components in Master Node

  1.API Server
  2.ETCD
  3. Controllers-manager
  4. Schedulers
- we have 4 components in Worker Node.

  1. Kubelet
  2. Kube-Proxy
  3. Pod
  4. Container



API SERVER:

- It is used to accept the request from the user and store the request in ETCD.
- It is the only component that interacts with the ETCD directly

ETCD:

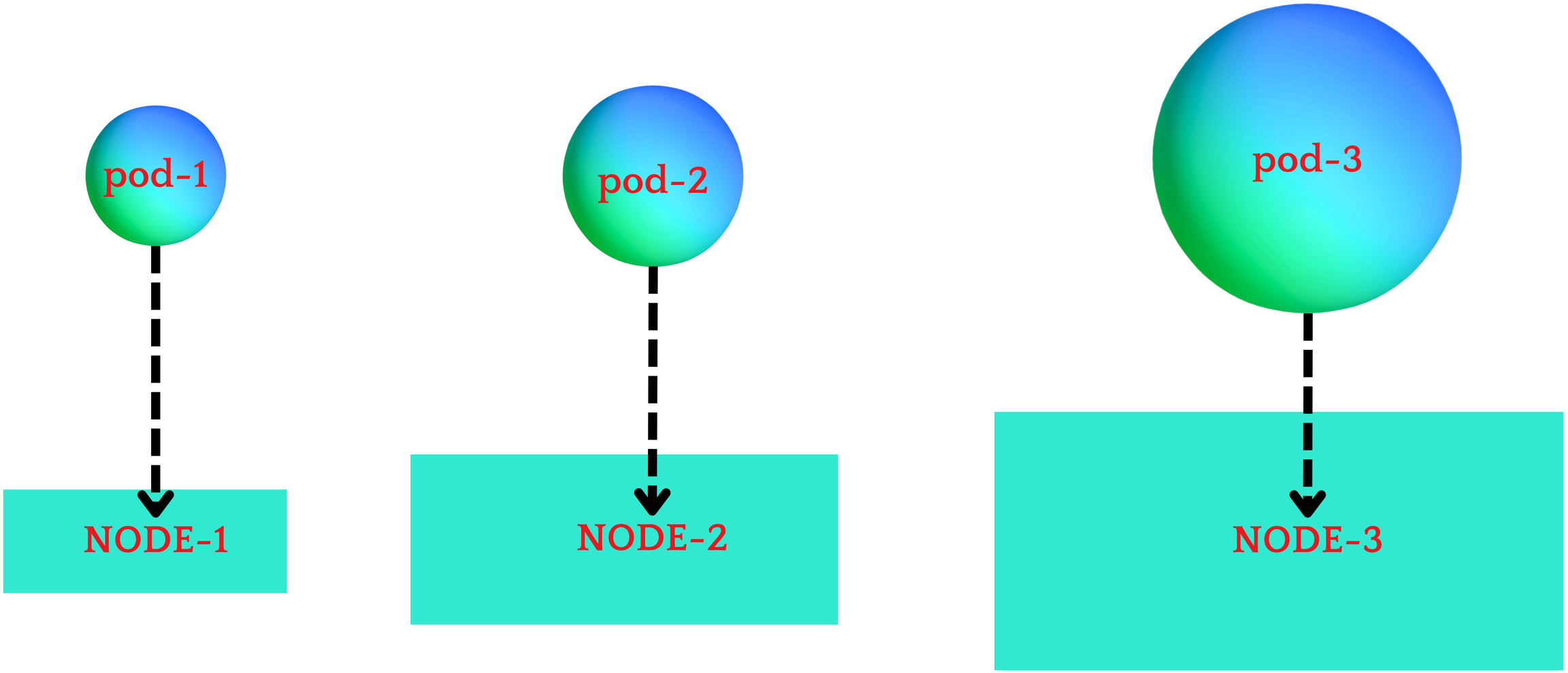
- It is like a database to our k8's
- it is used to store the requests of our cluster like pods, nodes, configs, secrets, roles etc..

SCHEDULER:

- It is used to search pending tasks which are present in ETCD.
- If any pending task found in ETCD, it will schedule in worker node.
- It will decide in which worker node our task should gets executed.
- It will decide by communication with the kubelet in worker node
- Scheduler always monitor API-Server
- The scheduler is a crucial component responsible for assigning pods to nodes
- This will ensure that pods are scheduled on suitable nodes that meet their resource requirements and constraints

HOW SCHEDULER DECIDES

The scheduler is going to decide the put the right pod in right node based on Size, Memory, CPU etc..



Just assume that we have 1 pod and 4 nodes just like the below image

Node-1	Node-2	Node-3	Node-4
2 CPU's	4 CPU's	10 CPU's	14 CPU's

Lets see How its decides

It Eliminates Node-1 & Node-2 because Node contains less CPU that pod

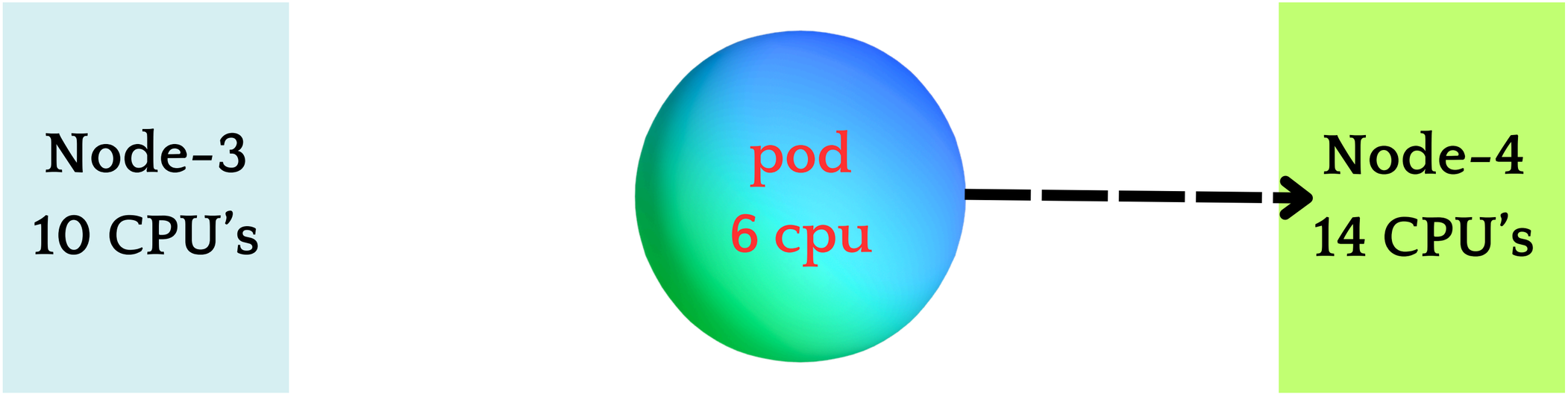
Node-1
2 CPU's

Node-2
4 CPU's

Node-3
10 CPU's

Node-4
14 CPU's

In the rest of these 2 nodes, scheduler decides based on CPU
Ex: If scheduler places the pod on Node-3 then Node-3 contains only 2 CPU's only
If scheduler places the pod on Node-4 then Node-4 contains only 4 CPU's.
So scheduler selects Node-4 to place a pod.



Not only CPU it selects based on different parameters like

- Resource Requirement limits
- Taints & Tolerations
- Node selector

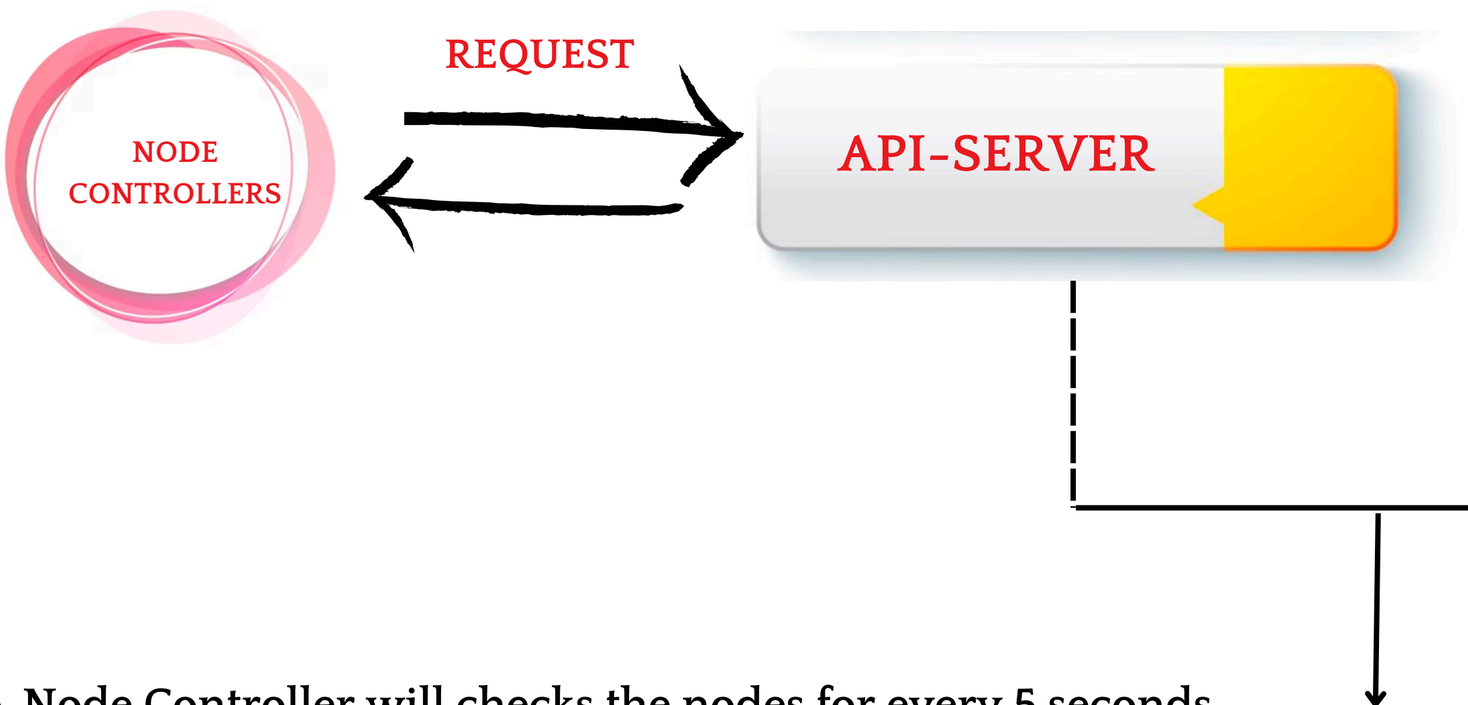
- Scheduler will do the following taks
    a. Pod Creation
    b. Pod scheduling
    c. Selecting Node
    d. Pod Running
    e. Kubelet Action

CONTROLLERS:

The controller Manager collects the data/information from the API Server of the Kubernetes cluster like the desired state of the cluster and then decides what to do by sending the instructions to the API Server.

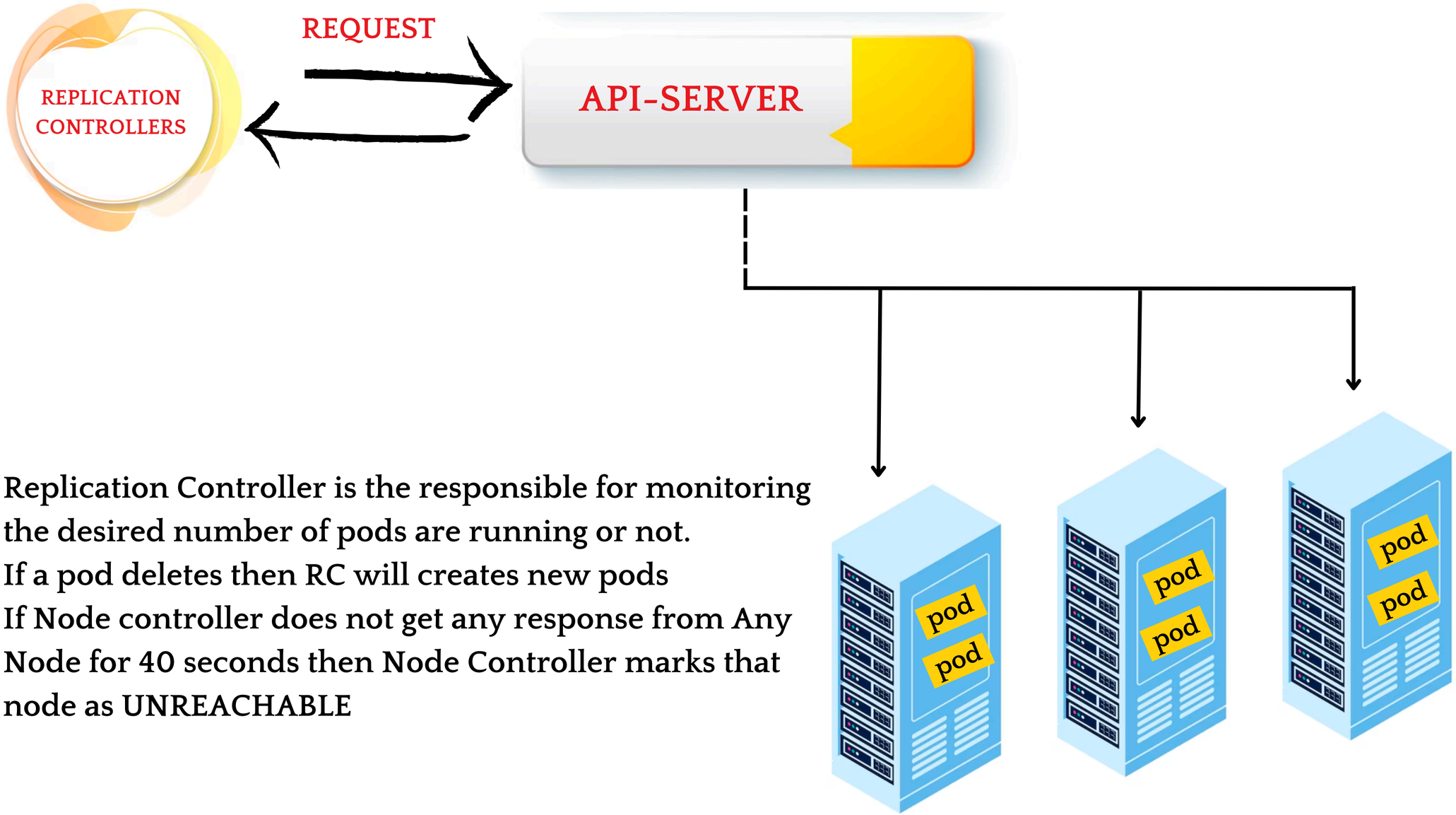
- Controller will do the following taks
    a. Replication Controller
    b. Node Controller
    c. Service Controller

HOW NODE CONTROLLER WORKS:



- Node Controller will checks the nodes for every 5 seconds through API-Server.
- It works like a heartbeat for our body.
- If Node controller does not get any response from Any Node for 40 seconds then Node Controller marks that node as UNREACHABLE

HOW REPLICATION CONTROLLER WORKS:



- Replication Controller is the responsible for monitoring the desired number of pods are running or not.
- If a pod deletes then RC will creates new pods
- If Node controller does not get any response from Any Node for 40 seconds then Node Controller marks that node as UNREACHABLE

KUBELET:

- kubelet is the primary component of the Worker Node which manages the Pods and regularly checks whether the pod is running or not.
- If pods are not working properly, then kubelet creates a new pod and replaces it with the previous one because the failed pod can’t be restarted hence, the IP of the pod might be changed

KUBE-PROXY

- kube-proxy contains all the network configuration of the entire cluster such as pod IP, Services, Deployments etc..
- It takes care of the load balancing and routing which comes under networking configuration.

POD: A group of one or more containers.

CONTAINER:

- It is a virtual machine which does not have any OS.
- it is used to run the applications in worker nodes.

KUBERNETES CLUSTER SETUP:

There are multiple ways to setup kubernetes cluster.

1.SELF MANAGER K8'S CLUSTER
a.mini kube (single node cluster)
b.kubeadm(multi node cluster)
c. KOPS

2. CLOUD MANAGED K8'S CLUSTER
a. AWS EKS
b.AZURE AKS
c.GCP GKS
d.IBM IKE

MINIKUBE:

It is a tool used to setup single node cluster on K8's.
It contains API Servers, ETCD database and container runtime
It helps you to containerized applications.
It is used for development, testing, and experimentation purposes on local.
Here Master and worker runs on same machine
It is a platform Independent.
By default it will create one node only.
Installing Minikube is simple compared to other tools.

NOTE: But we dont implement this in real-time

MINIKUBE SETUP:

REQUIREMENTS:

- 2 CPUs or more
- 2GB of free memory
- 20GB of free disk space
- Internet connection
- Container or virtual machine manager, such as: Docker.

UPDATE SERVER:

1 apt update -y

2 apt upgrade -y

INSTALL DOCKER:

3 sudo apt install curl wget apt-transport-https -y

4 sudo curl -fsSL https://get.docker.com -o get-docker.sh

sudo sh get-docker.sh

INSTALL MINIKUBE:

5 sudo curl -LO https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64

6 sudo mv minikube-linux-amd64 /usr/local/bin/minikube

7 sudo chmod +x /usr/local/bin/minikube

8 sudo minikube version

INSTALL KUBECTL:

9 sudo curl -LO "https://dl.k8s.io/release/$(curl -L -s https://dl.k8s.io/release/stable.txt)/bin/linux/amd64/kubectl"

10 sudo curl -LO "https://dl.k8s.io/$(curl -L -s https://dl.k8s.io/release/stable.txt)/bin/linux/amd64/kubectl.sha256"

11 sudo echo "$(cat kubectl.sha256) kubectl" | sha256sum --check

12 sudo install -o root -g root -m 0755 kubectl /usr/local/bin/kubectl

13 sudo kubectl version --client

14 sudo kubectl version --client --output=yaml

15 sudo minikube start --driver=docker --force

KUBECTL:

- kubectl is the CLI which is used to interact with a Kubernetes cluster.
- We can create, manage pods, services, deployments, and other resources
- We can also monitoring, troubleshooting, scaling and updating the pods.
- To perform these tasks it communicates with the Kubernetes API server.
- It has many options and commands, to work on.
- The configuration of kubectl is in the $HOME/.kube directory.
- The latest version is 1.28

SYNTAX:

kubectl [command] [TYPE] [NAME] [flags]

kubectl api-resources : to list all api resources

Lets start working on kubernetes!

Note:

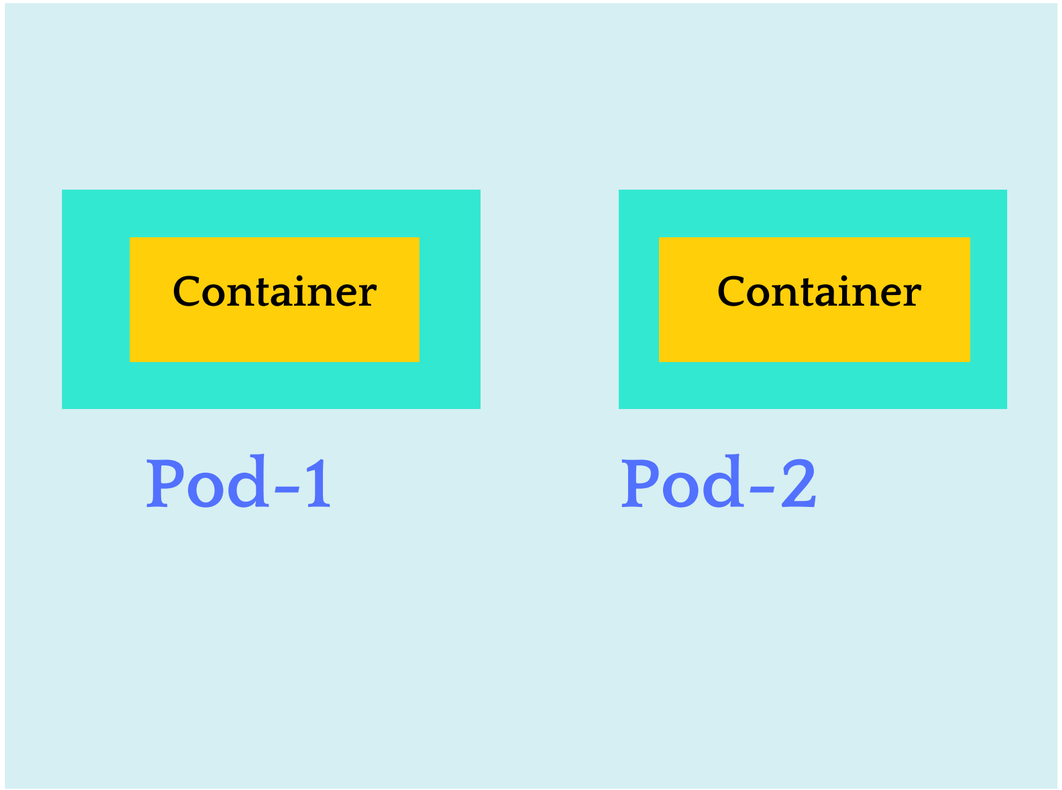
Kubernetes will not deploy the containers directly on worker nodes.
Kubernetes has a object called POD which contains containers.

Lets learn about PODS

POD:

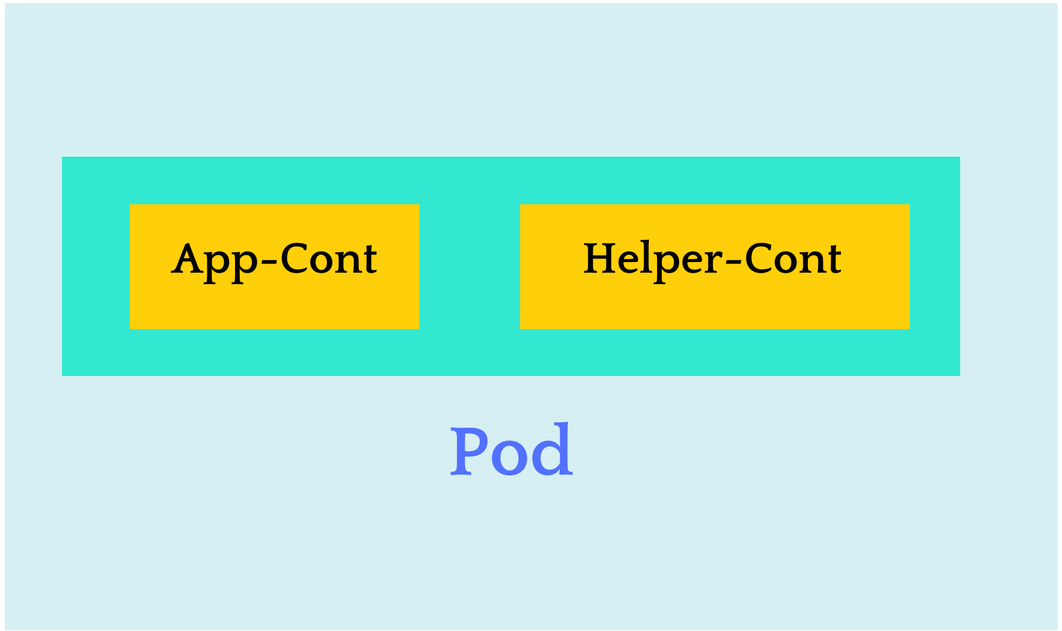
- It is a smallest object that we can create in K8's.
- It is a group of containers.
- Pod acts like a single instance for our application.
- Pods are ephemeral (short living objects)
- Mostly we can use single container inside a pod but if we required, we can create multiple containers inside a same pod.
- when we create a pod, containers inside pods can share the same network namespace, and can share the same storage volumes .
- While creating pod, we must specify the image, along with any necessary configuration and resource limits.
- K8's cannot communicate with containers, they can communicate with only pods.
- We can create this pod in two ways,
    - 1. Imperative(command)
    - 2. Declarative (Manifest file)

SINGLE CONTAINER POD



Basically, each pods needs only one container. But sometimes we need 2 containers in one pod.

MULTI CONTAINER POD



Helper containers are additional containers included in a pod to perform some tasks that support the primary container which are running in the pod.

How Helper container works:

- A helper container is used to collect the logs from the primary container.
- Helper containers can be used to run monitoring and metrics collection agents from the main application container.
- Helper containers can assist in syncing files or data between containers in a pod. For example, a pod might have a main application container and a helper container responsible for syncing configuration files or other shared resources.
- Security-related tasks, such as handling secrets, encryption, or authentication, can be done by helper container.

POD CREATION:

IMPERATIVE:

The imperative way uses kubectl command to create pod.
This method is useful for quickly creating and modifying the pods.
SYNTAX: kubectl run pod_name --image=image_name
COMMAND: *kubectl run pod-1 --image=nginx*

kubectl : command line tool run : action
pod-1 : name of pod
nginx : name of image

KUBECTL:

DECLARATIVE:

The Declarativ tive way we need to create a Manifest file in YAML Extension.
This file contains the desired state of a Pod.
It takes care of creating, updating, or deleting the resources.
This manifest file need to follow the yaml indentation.
YAML file consist of KEY-VALUE Pair.
Here we use create or apply command to execute the Manifest file.

SYNTAX: kubectl create/apply -f file_name

CREATE: if you are creating the object for first time we use create only.
APPLY: if we change any thing on files and changes need to apply the resources.

MANIFEST FILE:

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    ports:
    - containerPort: 80
```

apiVersion: This is the version of API from Kubernetes which is used to create objects.

kind: defines the object that we are creating.

metadata: data about the object like names, labels etc ...

spec: It is the specifications of the object

COMMANDS:

- To get all the pods: **kubetctl get pods (or) kubectl get pod (or) kubectl get po**
- To delete a pod: **kubectl delete pod pod_name**
- To get IP of a pod: **kubectl get po pod_name -o wide**
- To get IP of all pods: **kubectl get po -o wide**
- To get all details of a pod: **kubectl describe pod podname**
- To get all details of all pods: **kubectl describe po**
- To get the pod details in YAML format: **kubectl get pod pod-1 -o yaml**
- To get the pod details in JSON format: **kubectl get pod pod-1 -o json**
- To enter into a pod: **kubectl exec -it pod_name -c cont_name bash**
- To get the logging info of our pod: **kubectl logs pod_name**
- To get the logs of containers inside the pod: **kubectl logs pod_name -c cont-name**

KUBERNETES METRICS SERVER:

- It is used to monitor the Kubernetes components like Pods, Nodes & Deployments etc...
- The Kubernetes Metrics Server measures CPU and memory usage across the Kubernetes cluster like Pods & Nodes.

INSTALLATION:

DOWNLOAD THE FILE: kubectl apply -f https://github.com/kubernetes-sigs/metrics-server/releases/latest/download/components.yaml
SEE THE DEPLOYMENT: kubectl -n kube-system get deploy metrics-server
EDIT THE DEPLOYMENT : kubectl -n kube-system edit deploy metrics-server
Add these commands under the container args
- /metrics-server
- --kubelet-insecure-tls
- --kubelet-preferred-address-types=InternalIP

```
    k8s-app: metrics-server
spec:
  containers:
  - args:
    - --cert-dir=/tmp
    - --secure-port=4443
    - --kubelet-preferred-address-types=InternalIP,ExternalIP,Hostname
    - --kubelet-use-node-status-port
    - --metric-resolution=15s
    - /metrics-server
    - --kubelet-insecure-tls
    - --kubelet-preferred-address-types=InternalIP
```

MONITOR:

- Check the Node metrics: kubectl top nodes
- Now create some pods and check the pod metrics : kubectl top pod

Labels, Selectors, and Node Selectors:

Labels:

- Labels are used to organize Kubernetes Objects such as Pods, nodes, etc.
- You can add multiple labels over the Kubernetes Objects.
- Labels are defined in key-value pairs.
- Labels are similar to tags in AWS or Azure where you give a name to filter the resources quickly.
- You can add labels like environment, department or anything else according to you.

Label-Selectors:

- Once the labels are attached to the Kubernetes objects those objects will be filtered out with the help of labels-Selectors known as Selectors.

- The API currently supports two types of label-selectors equality-based and set-based. Label selectors can be made of multiple selectors that are comma-separated.

Node Selector:

Node selector means selecting the nodes. Node selector is used to choose the node to apply a particular command.

This is done by Labels where in the manifest file, we mentioned the node label name. While running the manifest file, master nodes find the node that has the same label and create the pod on that container.

Make sure that the node must have the label. If the node doesn’t have any label then, the manifest file will jump to the next node.

```
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
  labels:
    env: testing
    department: DevOps
spec:
  containers:
    - name: containers1
      image: ubuntu
      command: ["/bin/bash", "-c", "while true; do echo This is our Pod; sleep 5 ; done"]
```

To see the list of pods with labels: kubectl get pods --show-labels

Now, I want to list those pods that have the label env=testing.

kubectl get pods -l env=testing

kubectl get pods -l department!=DevOps

As we have discussed earlier, there are two types of label-selectors equality and set-based.

This is the example of equality based where we used equalsTo(=).

Now, Suppose I forgot to add the label through the declarative(via manifest) method. So, I can add labels after creating the pods as well which is known as the imperative(via command) method.

kubectl label pods Pod_name Location=India

As we discussed the type of label-selector, let's see the example of a set-based label-selector where we use in, notin, and exists.

Lets list all those pods that have an env label with value for either testing or development.

kubectl get pods -l 'env in (testing, development)'

we are trying to list all those pods that don't have the India or US value for the Location key in the Label.

kubectl get pods -l 'Location not in (India, US)'

We can also delete the pods as per the label.
Let's deleted all those pods that don't have the Chinda value for the location key in the Label.

kubectl delete pod -l Location!=China

WE DEPLOYED THE POD

LETS ACCESS OUR APPLICATION

I CANT ABLE TO ACCESS MY APPLICATION

The reason why we are not able to access the application: In Kubernetes, if you want to access the application we have to expose our pod. To Expose these pods we use Kubernetes services.

KUBERNETES SERVICES

- Service is a method for exposing Pods in your cluster.
- Each Pod gets its own IP address But we need to access from IP of the Node..
- If you want to access pod from inside we use Cluster-IP.
- If the service is of type NodePort or LoadBalancer, it can also be accessed. from outside the cluster.
- It enables the pods to be decoupled from the network topology, which makes it easier to manage and scale applications

TYPES:

- CLUSTER-IP
- NODE PORT
- LOAD BALANCER

TYPES OF SERVICES

- **ClusterIP**: A ClusterIP service provides a stable IP address and DNS name for pods within a cluster. This type of service is only accessible within the cluster and is not exposed externally.
- **NodePort**: A NodePort service provides a way to expose a service on a static port on each node in the cluster. This type of service is accessible both within the cluster and externally, using the node's IP address and the NodePort.
- **LoadBalancer**: A LoadBalancer service provides a way to expose a service externally, using a cloud provider's load balancer. This type of service is typically used when an application needs to handle high traffic loads and requires automatic scaling and load balancing capabilities.
- **ExternalName**: This is a similar object service to ClusterIP but it does have DNS CName instead of Selectors and labels. In other words, services will be mapped to a DNS name. You can view the Service YML file and see how to use this service.

COMPONENTS OF SERVICES

A service is defined using a Kubernetes manifest file that describes its properties and specifications. Some of the key properties of a service include:

- Selector: A label selector that defines the set of pods that the service will route traffic to.
- Port: The port number on which the service will listen for incoming traffic.
- TargetPort: The port number on which the pods are listening for traffic.
- Type: The type of the service, such as ClusterIP, NodePort, LoadBalancer, or ExternalName.

CLUSTER-IP:

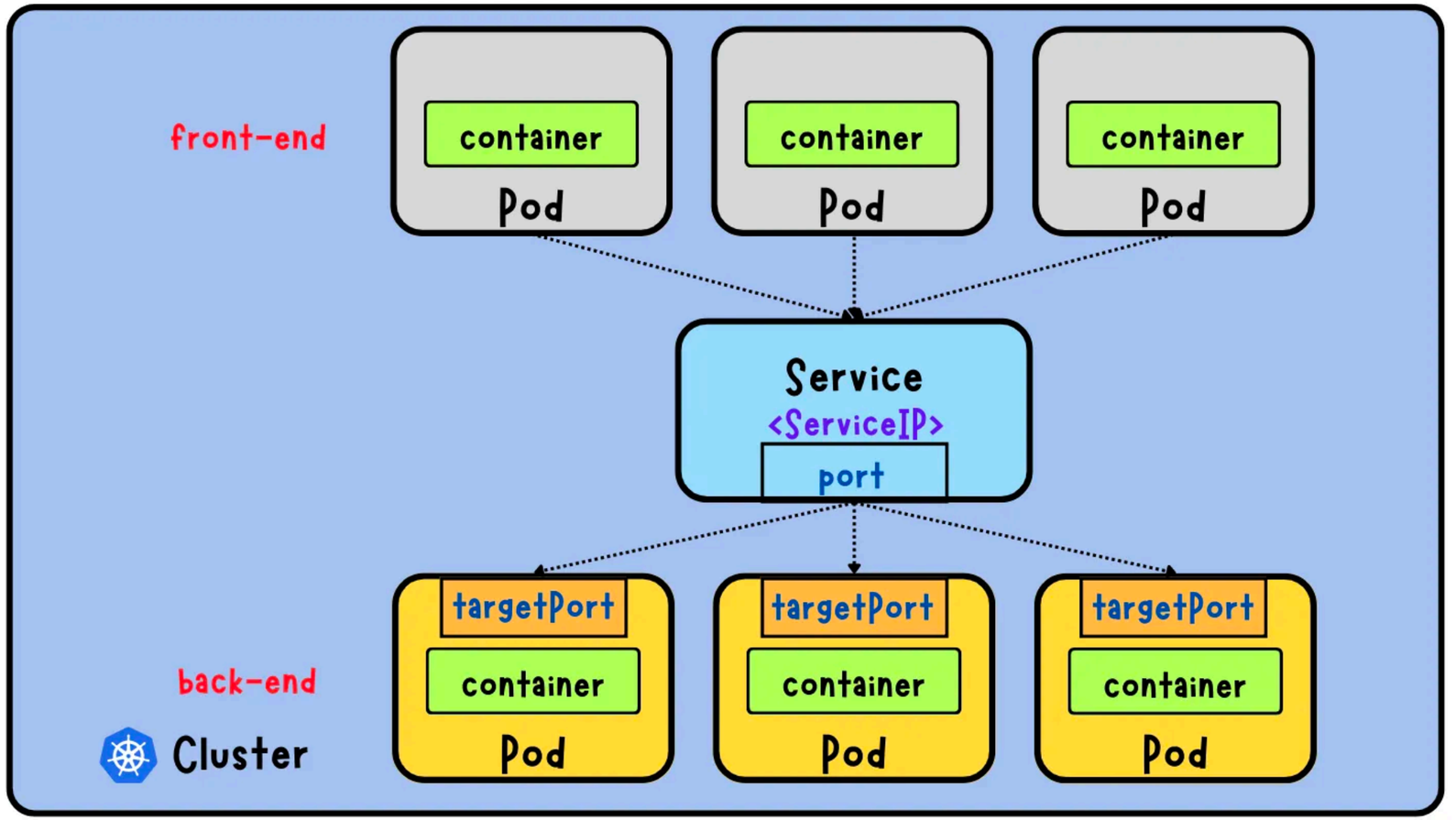
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: frontend
  labels:
    app: swiggy
spec:
  containers:
    - name: cont1
      image: rahamshaik/tic-tac-toe-1:latest
      ports:
      - containerPort: 80
```

- To deploy the application we create a container, which stores inside the pod.
- After container is created we will be not able to access the application.
- Because we cannot access the pods and ports from the cluster.
- To Avoid this we are creating the Services.

```yaml
---
apiVersion: v1
kind: Service
metadata:
  name: frontend
spec:
  type: ClusterIP
  selector:
    app: swiggy
  ports:
    - port: 80
      targetPort: 80
```

- In this code we are exposing the applcation. here we use clusterip service
- By using this we can access application inside the cluster only.
- But if we want to access the application from outside we need to use nodeport.
- ClusterIP will assign one ip for service to access the pod.
- Just Replace *ClusterIP=NodePort*
- kubectl apply -f filename.yml

Three Types of Services: ClusterIP



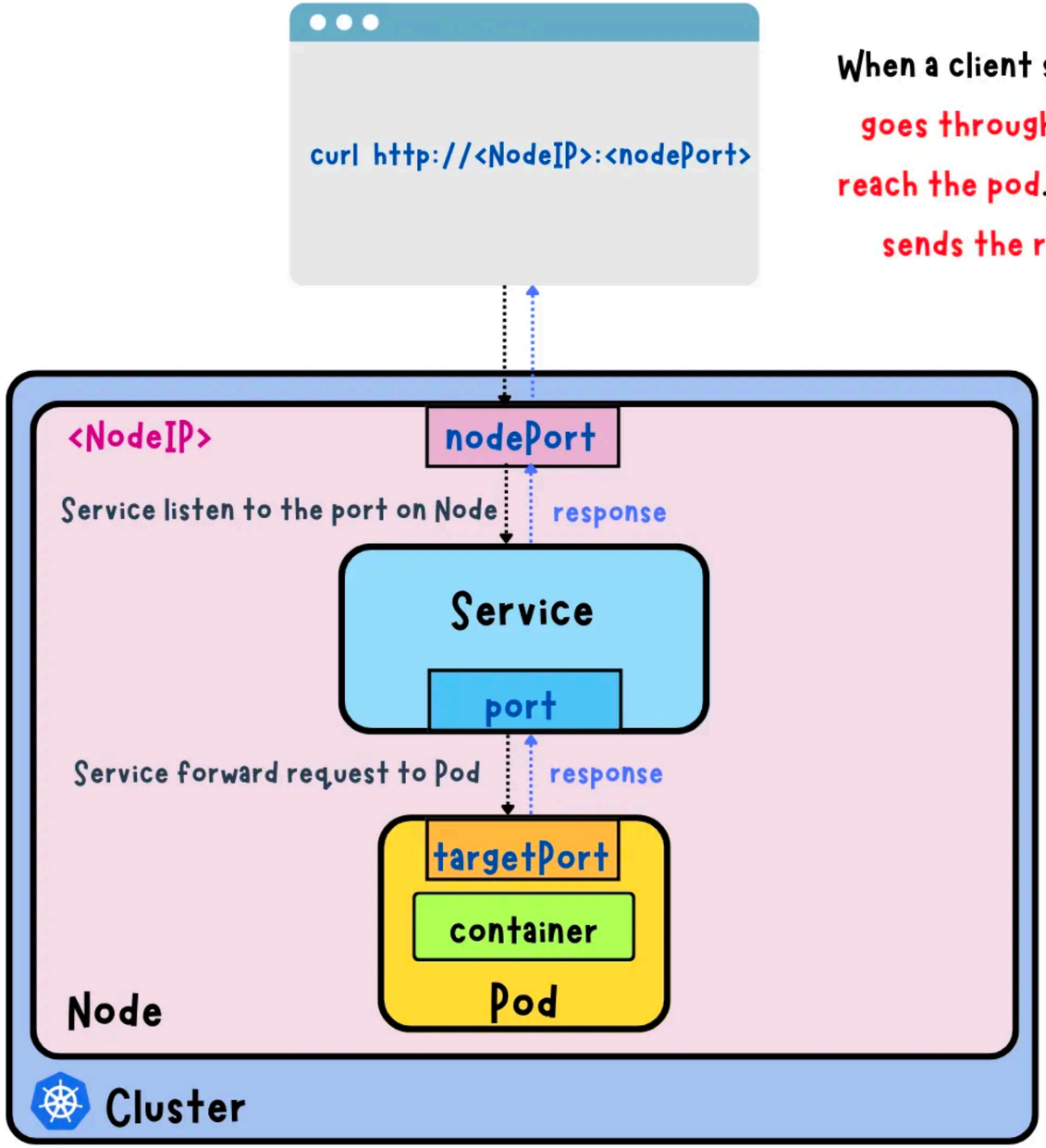
port: port on Service

targetPort: port on Pod (destination)

```yaml
---
apiVersion: v1
kind: Service
metadata:
  name: frontend
spec:
  type: NodePort
  selector:
    app: swiggy
  ports:
    - port: 80
      targetPort: 80
      nodePort: 30001
```

- In this code we are exposed the application from anywhere (inside & outside)
- We need to Give public ip of node where pod is running.
- Node Port Range= 30000 - 32767
- here i hae defined port number as 30001
- if we dont specify the port it will assign automatically.
- kubectl apply -f filename.yml.
- NodePort expose service on a static port on each node.
- NodePort services are typically used for smaller applications with a lower traffic volume.
- To avoid this we are using the LoadBalancer service.
- Just Replace *NodePort=LoadBalancer*

Three Types of Services: NodePort



When a client sends a request to a NodePort service, it goes through the NodePort, Port, and TargetPort to reach the pod. The pod then processes the request and sends the response back through the same ports.

nodePort: port on Node

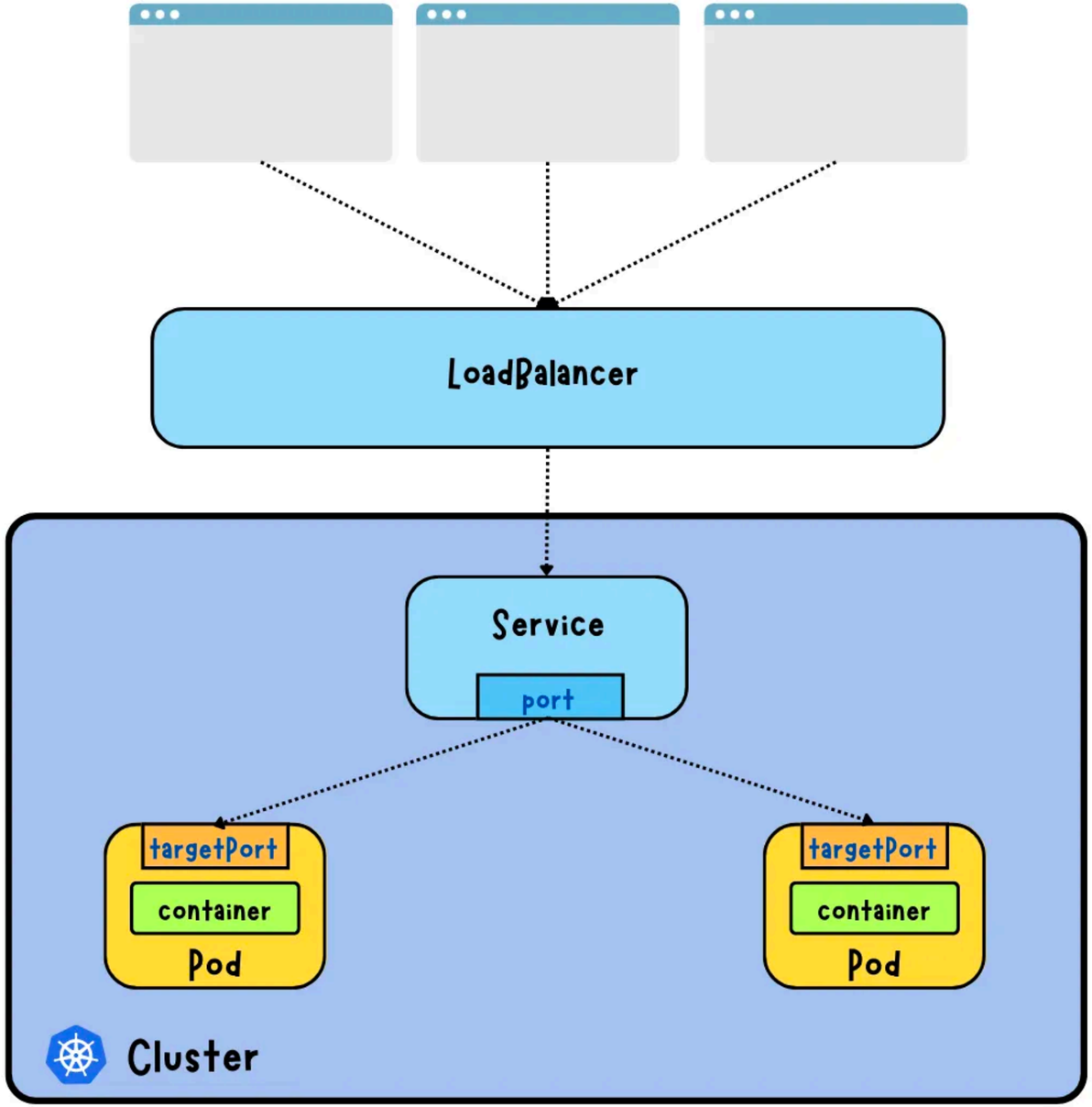
port: port on Service

targetPort: port on Pod (destination)

```yaml
apiVersion: v1
kind: Service
metadata:
  name: frontend
spec:
  type: LoadBalancer
  selector:
    app: swiggy
  ports:
    - port: 80
      targetPort: 80
```

- In LoadBalaner we can expose application externally with the help of Cloud Provider LoadBalancer.
- it is used when an application needs to handle high traffic loads and requires automatic scaling and load balancing capabilities.
- After the LoadBalancer service is created, the cloud provider will created the Load Balancer.
- This IP address can be used by clients outside the cluster to access the service.
- The LoadBalancer service also automatically distributes incoming traffic across the pods that match the selector defined in the YAML manifest.
- access : publicip:port and LB url
- http://a0dce056441c04035918de4bfb5bff97-40528368.us- east-1.elb.amazonaws.com/

Three Types of Services: LoadBalancer



ExternalName:

```
apiVersion: v1
kind: Service
metadata:
 name: k8-service
 namespace: dev
spec:
 type: ExternalName
 externalName: k8.learning.com
```

COMMANDS FOR SERVICES:

1. Creates a new service based on the YAML file

kubectl create -f filename

2. Create a ClusterIP service

kubectl create service clusterip <service-name> --tcp=<port>:<targetPort>

3. Create a NodePort service

kubectl create service nodeport <service-name> --tcp=<port>:<targetPort>
--node-port=<nodePort>

4. Create a LoadBalancer service

kubectl create service **loadbalancer** <service-name> --tcp=<port>:<targetPort>

5. Create a service for a pod

```
kubectl expose pod <pod-name> --name=<service-name> \
 --port=<port> --target-port=<targetPort> --type=<service-type>
```

6. Create a service for a deployment

```
kubectl expose deployment <deployment-name> --name=<service-name> \
 --port=<port> --target-port=<targetPort> --type=<service-type>
```

7. Retrieve a list of services that have been created

```
kubectl get services
```

8. Retrieve detailed information about a specific service

```
kubectl describe services <service-name>
```

THE DRAWBACK

In the above both methods we can be able to create a pod
but what if we delete the pod ?

once you delete the pod we cannot able to access the pod,
so it will create a lot of difficulty in Real time

NOTE: Self healing is not Avaliable here.

To overcome this on we use some Kubernetes components called RC, RS, DEPLOYMENTS, DAEMON SETS, etc ...

REPLICAS IN KUBERNETES:

- Before Kubernetes, other tools did not provide important and customized features like scaling and replication.
- When Kubernetes was introduced, replication and scaling were the premium features that increased the popularity of this container orchestration tool.
- Replication means that if the pod's desired state is set to 3 and whenever any pod fails, then with the help of replication, the new pod will be created as soon as possible. This will lead to a reduction in the downtime of the application.
- Scaling means if the load becomes increases on the application, then Kubernetes increases the number of pods according to the load on the application.

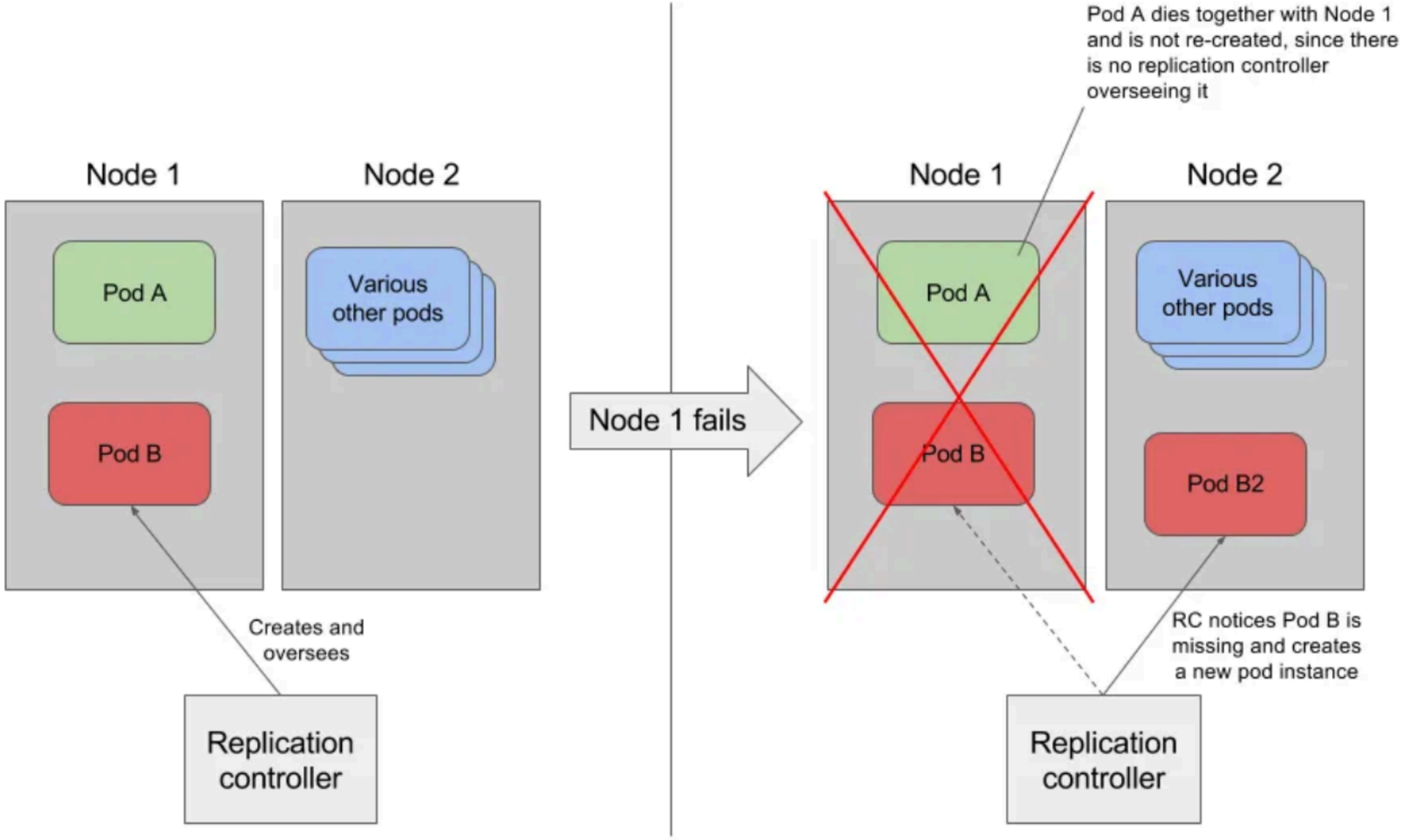
- ReplicationController is an object in Kubernetes that was introduced in v1 of Kubernetes which helps to meet the desired state of the Kubernetes cluster from the current state. ReplicationController works on equality-based controllers only.

- ReplicaSet is an object in Kubernetes and it is an advanced version of ReplicationController. ReplicaSet works on both equality-based controllers and set-based controllers.

REPLICATION CONTROLLER:

- Replication controller can run specific number of pods as per our requirement.
- It is the responsible for managing the pod lifecycle
- It will make sure that always pods are up and running.
- If there are too many pods, RC will terminates the extra pods.
- If there are too less RC will create new pods.
- This Replication controller will have slef-healing capability, that means automatically it will creates.
- If a pod is failed, terminated or deleted then new pod will get created automatically. Replication Controllers use labels to identify the pods that they are managing.
- We need to specifies the desired number of replicas in YAML file.

REPLICATION CONTROLLER:



```yaml
apiVersion: v1
kind: ReplicationController
metadata:
  name: my-replicationcontroller
spec:
  replicas: 3
  selector:
    app: my-app
  template:
    metadata:
      labels:
        app: my-app
    spec:
      containers:
        - name: my-container
          image: my-image:latest
          ports:
          - containerPort: 80
```

SELECTOR: It select the resources based on labels. Labels are key value pairs.

This will helps to pass a command to the pods with lable app=nginx

```
apiVersion: v1
kind: ReplicationController
metadata:
  name: myreplica
spec:
  replicas: 2
  selector:
    Location: India
  template:
    metadata:
      name: testpod6
      labels:
        Location: India
    spec:
     containers:
       - name: c00
         image: ubuntu
         command: ["/bin/bash", "-c", "while true; do echo ReplicationController Example; sleep 5 ; done"]
```

TO EXECUTE : kubectl create -f file_name.yml

TO GET : kubectl get rc

TO DESCRIBE : kubectl describe rc/nginx

TO SCALE UP : kubectl scale rc rc_name --replicas 5

TO SCALE DOWN : kubectl scale rc rc_name --replicas 2 (drops from 5 to 2)

TO DELETE REPLICA CONTROLLER : kubectl delete rc rc_name

IF WE DELETE RC, PODS ARE ALSO GETS DELETED, BUT IF WE DON'T WANT TO DELETE PODS, WE WANT TO DELETE ONLY REPLICA SETS THEN

kubectl delete rc rc_name --cascade=orphan

kubectl get rc rc_name

kubectl get pod

Now we deleted the RC but still pods are present, if we want to assign this pods to another RC use the same selector which we used on the RC last file.

THE DRAWBACK

RC used only equality based selector
ex: env=prod

here we can assign only one value (equality based selector)

We are not using these RC in recent times, because RC is replaced by RS(Replica Set)

REPLICASET:

- it is nothing but group of identical pods. If one pod crashes automatically replica sets gives one more pod immediately.
- it uses labels to identify the pods
- Difference between RC and RS is selector and it offers more advanced functionality.
- The key difference is that the replication controller only supports ***equality-based selectors*** whereas the replica set supports ***set-based selectors***.
- it monitoring the number of replicas of a pod running in a cluster and creating or deleting new pods.
- It also provides better control over the scaling of the pod.
- A ReplicaSet identifies new Pods to acquire by using its selector.
- we can provide multiple values to same key.
- ex: env in (prod,test)

```yaml
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: my-replicaset
spec:
  replicas: 3
  selector:
    matchLabels:
      app: my-app
  template:
    metadata:
      labels:
        app: my-app
    spec:
      containers:
        - name: my-container
          image: my-image:latest
          ports:
          - containerPort: 80
```

- Replicas: Number of pod copies we need to create
- Matchelabel: label we want to match with pods
- Template: This is the template of pod.
- Note: give apiVersion: apps/v1 on top

- Labels : mandatory to create RS (if u have 100 pods in a cluster we can inform which pods we need to take care by using labels) if u labeled some pods a raham then all the pods with label raham will be managed.

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: myrs
spec:
  replicas: 2
  selector:
    matchExpressions:
      - {key: Location, operator: In, values: [India, US, Russia]}
      - {key: env, operator: NotIn, values: [testing]}
  template:
    metadata:
      name: testpod7
      labels:
        Location: Russia
    spec:
     containers:
       - name: container1
         image: ubuntu
         command: ["/bin/bash", "-c", "while true; do echo ReplicaSet Example; sleep 5 ; done"]
```

COMMANDS:

TO EXECUTE	:	kubectl create -f replicaset-nginx.yaml
TO LIST	:	kubectl get replicaset/rs
TO GET INFO	:	kubectl get rs -o wide
TO GET IN YAML	:	kubectl get rs -o yaml
TO GET ALL RESOURCES	:	kubectl get all

Now delete a pod and do list now it will be created automatically

TO DELETE A POD	:	Kubectl delete po pod_name
TO DELETE RS	:	kubectl delete rs
TO SHOW LABLES OF RS	:	Kubectl get po –show-labels
TO SHOW POD IN YAML	:	Kubectl get pod -o yaml

THE DRAWBACK

Here Replica set is an lower level object which focus on maintaining desired number of replica pods.

To manage this replica set we need a higher-level object called deployment which provide additional functionality like rolling updates and roll backs.

Deployments use ReplicaSets under the hood to manage the actual pods that run the application.

DEPLOYMENT:

- It has features of Replicaset and some other extra features like updating and rollbacking to a particular version.
- The best part of Deployment is we can do it without downtime.
- you can update the container image or configuration of the application.
- Deployments also provide features such as versioning, which allows you to track the history of changes to the application.
- It has a pause feature, which allows you to temporarily suspend updates to the application
- Scaling can be done manually or automatically based on metrics such as CPU utilization or requests per second.
- Deployment will create ReplicaSet, ReplicaSet will created Pods.
- If you delete Deployment, it will delete ReplicaSet and then ReplicaSet will delete Pods.

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    run: nginx
  name: nginx-deploy
spec:
  replicas: 2
  selector:
    matchLabels:
      run: nginx
  template:
    metadata:
      labels:
        run: nginx
    spec:
      containers:
      - image: nginx
        name: nginx
```

- Replicas: Number of pod copies we need to create
- Matchelabel: label we want to match with pods
- Template: This is the template of pod.

- Labels : mandatory to create RS (if u have 100 pods in a cluster we can inform which pods we need to take care by using labels) if u labeled some pods a raham then all the pods with label raham will be managed.

MANIFEST FILE:

To create a replica set : kubectl create -f replicaset-nginx.yaml

To see a deployment : kubectl get deployment/deploy

To see full details of deployment : kubectl get deploy -o wide

To view in YAML format : kubectl get deploy -o yaml

To get all info : kubectl describe deploy

COMMAND TO CREATE DEPLOYMENT:

kubectl create deployment deployment-name --image=image-name --replicas=4

Now delete a pod and do list now it will be created automatically

To delete a pod: Kubectl delete po pod_name

To check logs : kubectl logs pod_name

To delete a deployment : kubectl delete deploy deploy_name

When you inspect the Deployments in your cluster, the following fields are displayed:

- ***NAME*** lists the names of the Deployments in the namespace.
- ***READY*** displays how many replicas of the application are available to your users. It follows the pattern ready/desired.
- ***UP***-TO-DATE displays the number of replicas that have been updated to achieve the desired state.
- ***AVAILABLE*** displays how many replicas of the application are available to your users.
- ***AGE*** displays the amount of time that the application has been running.

UPDATING A DEPLOYMENT:

update the container image:

kubectl set image deployment/deployment-name my-container=image-name

or

kubectl edit deployment/deployment-name

To roll back:

kubectl rollout status deployment/deployment-name

To check the status:

kubectl rollout status deployment/deployment-name

To get the history:

kubectl rollout history deployment/deployment-name

To rollback specific version:

kubectl rollout undo deployment/deployment-name --to-revision=number

PAUSE/UNPAUSE A DEPLOYMENT:

To pause a pod in deployment:

kubectl rollout pause deployment/deployment-name

To un-pause a pod in deployment:

kubectl rollout resume deployment/deployment-name

DEPLOYMENT SCALING:

Lets assume we have 3 pods, if i want to scale up it to 10 pods (manual scaling)
kubectl scale deployment/nginx-deployment --replicas=10

Lets assume we have 10 pods, if i want to scale down it to 5 pods (manual scaling)
kubectl scale deployment/nginx-deployment --replicas=5

KUBERNETES AUTO-SCALING:

As you know, to run the application we need CPU and memory. Sometimes, there will be a chance where the CPU gets loaded, and this might fail the server or affect the application. Now, we can't afford the downtime of the applications. To avoid this, we need to increase the number of servers or increase the capacity of servers.

Let's understand with a real-time example:

Just take an example we have some OTT platforms like Netflix, Prime, Aha & Hotstar. If any web show or movie is coming on the platform the audience is eagerly waiting for that. Then, the OTT platform can't handle the lot of users that might crash the application. This will lead to a loss of business and the OTT platform can't afford this business loss. Now, they have two options to solve this.

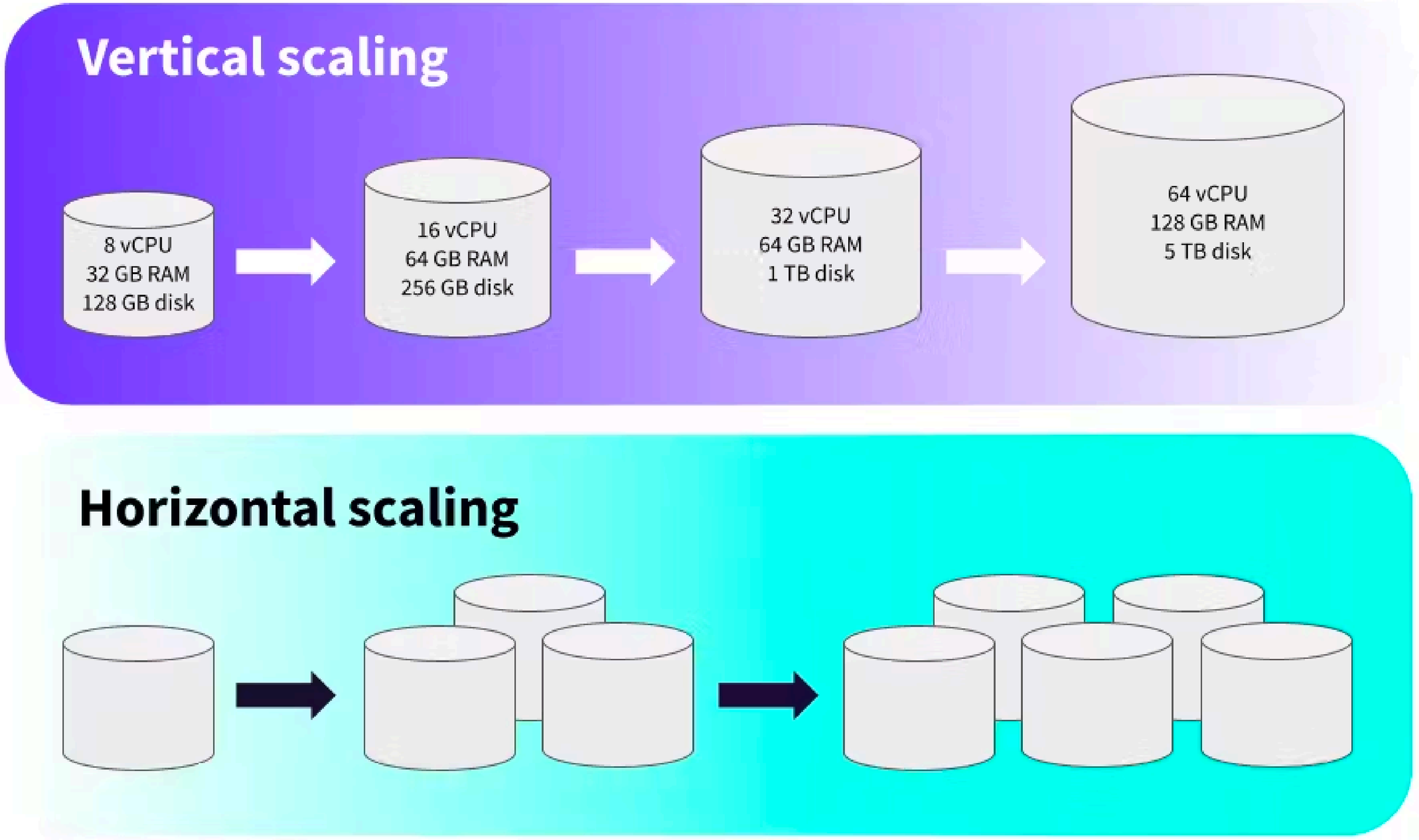
- First, The Platform knows that they need a particular amount of servers such as 100. So, they can buy those servers forever but in this situation, when the load decreases then the other servers will become unused. Now, if the server is unused, still they have paid for those servers which is not a cost-effective method.

- Second, The Platform doesn’t know when the load will increase. So, they have one option which is autoscaling in which when the CPU utilization crosses a particular number, it creates new servers. So, the platform can handle loads easily which is very cost effective as well.

Types of Autoscaling

- Horizontal Pod AutoScaling: In this type of scaling, the number of servers will increase according to CPU utilization. In this, you define the minimum number of servers, maximum number of servers, and CPU utilization. If the CPU utilization crosses more than 50% then, it will add the one server automatically.

- Vertical Pod AutoScaling: In this type of scaling, the server will remain the same in numbers but the server's configuration will increase such as from 4GB RAM to 8GM RAM, and the same with the other configurations. But this is not cost-effective and business-effective. So, we use Horizontal Pod AutoScaling.


Vertical scaling
8 vCPU
32 GB RAM
128 GB disk
16 vCPU
64 GB RAM
256 GB disk
32 vCPU
64 GB RAM
1 TB disk
64 vCPU
128 GB RAM
5 TB disk
Horizontal scaling

Key Features of Horizontal Pod AutoScaler:

- By default, Kubernetes does not provide AutoScaling. If you need AutoScaling, then you have to create hpa(Horizontal Pod AutoScaling) and vpa(Vertical Pod AutoScaling) objects.
- Kubernetes supports the autoscaling of the pods based on Observed CPU Utilization.
- Scaling only supports Scalable objects like Controller, deployment, or ReplicaSet.
- HPA is implemented as a Kubernetes API resource and a controller.
- The Controller periodically adjusts the number of replicas in a replication controller or deployment to match the observed average CPU utilization to the target specified in the manifest file or command.

We can perform HPA through two types:

1. **Imperative way**: In this way, you will create hpa object by command only.
2. **Declarative way**: In this way, you will create a proper manifest file and then create an object by applying the manifest file.

To perform HPA, we need one Kubernetes component which is a metrics server. To download this, use the below command.

curl -LO https://github.com/kubernetes-sigs/metrics-server/releases/latest/download/components.yaml

Now, edit the components.yml file
add **hostNetwork: true** under spec: line and,
add **- --kubelet-insecure-tls** under the metric-resolutions line,
then save the file.

- Now, you have to apply this by the below command
- kubectl apply -f components.yml
- To validate, run the command below
- kubectl get pods -n kube-system
- If the metrics-server pod is running then, you are ready to scale.

```
ubuntu@ip-172-31-63-3:~$ kubectl get pods -n kube-system
NAME                                READY   STATUS    RESTARTS         AGE
coredns-5d78c9869d-rd7dr            1/1     Running   4 (3d20h ago)    7d2h
etcd-minikube                       1/1     Running   4 (3d20h ago)    7d2h
kube-apiserver-minikube             1/1     Running   4 (3d20h ago)    7d2h
kube-controller-manager-minikube    1/1     Running   4 (3d20h ago)    7d2h
kube-proxy-r9jfx                    1/1     Running   4 (3d20h ago)    7d2h
kube-scheduler-minikube             1/1     Running   4 (3d20h ago)    7d2h
metrics-server-6b4694c468-rpxrk     1/1     Running   0                61s
storage-provisioner                 1/1     Running   9 (7m29s ago)    7d2h
ubuntu@ip-172-31-63-3:~$
```

DEPLOYMENT SCALING:

Lets assume we have 3 pods, if i want to scale it to 10 pods (**manual scaling**)

kubectl scale deployment/nginx-deployment --replicas=10

Assume we have HPA(**Horizontal POD Auto-scaling**) enabled in cluster.

So if we want to give the min and max count of replicas

kubectl autoscale deployment/nginx-deployment --min=10 --max=15

Now if we want to assign cpu limit for it

kubectl autoscale deployment/nginx-deployment --min=10 --max=15 --cpu-percent=80

Manual scaling means we can define the replicas (--repicas=5)

HPA automatically scale the replicas based on cpu metrics

DEPLOYMENT SCALING:

Now run kubectl get rs : you will get the new deployment.
kubectl get pod
You see that the number of old replicas is 3, and new replicas is 0.
Next time you want to update these Pods, you only need to update the Deployment's Pod template again.
While updating pods, 75% will be available and 25% will be unavailable during updates

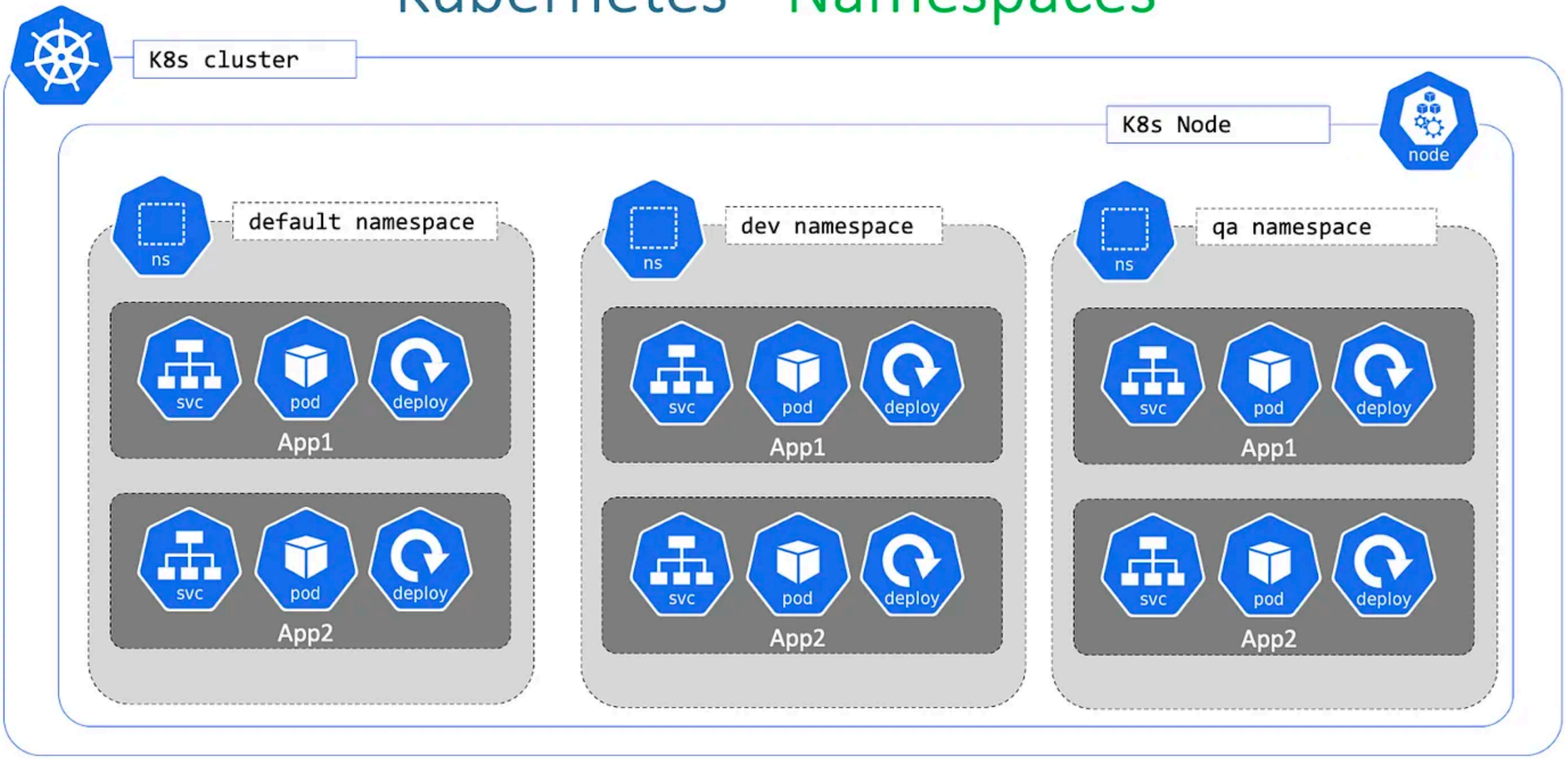
Lets assume, if we have 4 pods, while trying to update them atleast 3 of them are available and 1 should be updated in the mean time.

DAEMON-SET:

- It is used to run a copy a pod to each worker node.
- It is used to perform some tasks like monitoring, Log collection etc.. that need to run on every node of the cluster.
- A DaemonSet ensures that all eligible nodes run a copy of a Pod
- When you create daemon set k8s schedules one copy of pod in each node.
- If we added new node it will copy the pod automatically to new node.
- If I remove on node from cluster the pod in that node also removed.
- Deleting a DaemonSet will clean up the Pods it created.
- Daemon-set does not contains replicas, because bydefault it will create only 1 pod in each node.
- Daemon sets will not used for deployments on real-time, it is only to schedule pods.

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: example-daemonset
spec:
  selector:
    matchLabels:
      app: example-app
  template:
    metadata:
      labels:
        app: example-app
    spec:
      containers:
      - name: example-container
        image: nginx:latest
```

Kubernetes - Namespaces



NAMESPACE:

- Namespaces are used to group the components like pods, services, and deployments.
- This can be useful for separating environments, such as development, staging, and production, or for separating different teams or applications.
- In real-time all the frontend pods are mapped to one namespace and backend pods are mapped to another namespace.
- It represents the cluster inside the cluster.
- You can have multiple namespaces within one Kubernetes cluster, and they are all logically isolated from one another.
- Namespaces provide a logical separation of cluster resources between multiple users, teams, projects, and even customers.

- Within the same Namespace, Pod to Pod communication.
- Namespaces are only hidden from each other but are not fully isolated from each other.
- Nodes and Kubernetes Volumes do not come under the namespaces and are visible to every namespace.
- One service in a Namespace can talk to another service in another Namespace.
- The name of resources within one namespace must be unique.
- When you delete a namespace all the resources will gets deleted.
- There are some pre-existed Kubernetes namespaces are present in our cluster.
- To see the list of names spaces : kubectl get ns
    a. default
    b. kube-system
    c. kube-public

Default:

- As the name suggests, whenever we create any Kubernetes object such as pod, replicas, etc it will create in the default namespace.

kube-system

- This namespace contains the Kubernetes components such as kube-controller-manager, kube-scheduler, kube-dns or other controllers.

kube-public

- This namespace is used to share non-sensitive information that can be viewed by any of the members who are part of the Kubernetes cluster.

When should we consider Kubernetes Namespaces?

- **Isolation**: When there are multiple numbers of projects running then we can consider making namespaces and put the projects accordingly in the namespaces.

- **Organization**: If there is only one Kubernetes Cluster which has different environments to keep isolated. If something happens to the particular environment then it won't affect the other environments.

- **Permission**: If some objects are confidential and must need access to the particular persons then, Kubernetes provides RBAC roles as well which we can use in the namespace. It means that only authorized users can access the objects within the namespaces.

COMMANDS:

- kubectl get ns : *used to get namespaces*
- kubectl create ns mustafa : *used to create new namespace*
- kubectl config set-context --current --namespace=mustafa :*to check to namespace*
- kubectl config view --minify | grep namespace : *to verify the name space.*

CREATE A POD IN NS (IMPERATIVE):

1.***Create a namespace -*** kubectl create namespace mustafa

2.***create a pod in ns -*** kubectl run nginx --image=nginx --namespace mustafa

(or)

kubectl run nginx --image=nginx -n development

3. ***To check the pods:*** kubectl get pod -n mustafa

(or)

kubectl get pod --namespace mustafa

CREATE A POD IN NS (DECLARATIVE):

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  namespace: mustafa
~
```

When you delete a namespace all the resources will gets deleted.

kubectl get pods -n mustafa : *used to get pods from namespace*

kubectl describe pod nginx -n development : *describe a pod in namespace*

kubectl delete pod nginx -n development : *delete a pod in namespace*

POD FILE

```yaml
---
apiVersion: v1
kind: Pod
metadata:
  name: frontendnew
  labels:
    app: swiggy
  namespace: mustafa
spec:
  containers:
    - name: cont1
      image: rahamshaik/cycle:latest
      ports:
        - containerPort: 80
~
```

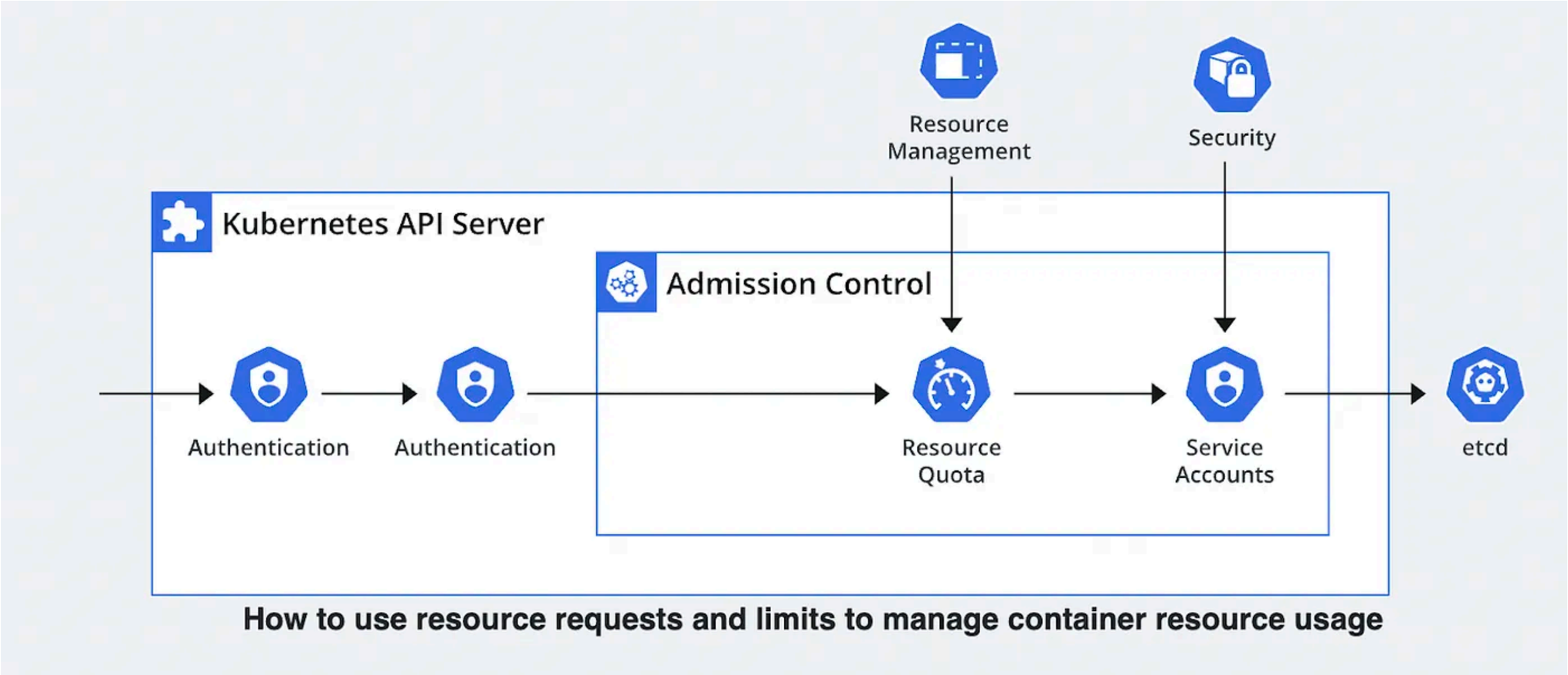
NODEPORT FILE

```yaml
---
apiVersion: v1
kind: Service
metadata:
  name: frontendnew
  namespace: mustafa
spec:
  type: NodePort
  selector:
    app: swiggy
  ports:
    - port: 80
      targetPort: 80
      nodePort: 30003
```

Before going to deploy this file we need to create mustafa namespace.

Here i just mentioned namespace in normal manifest file

RESOURCE QUOTA:

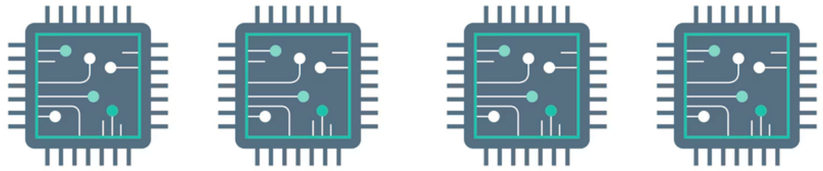


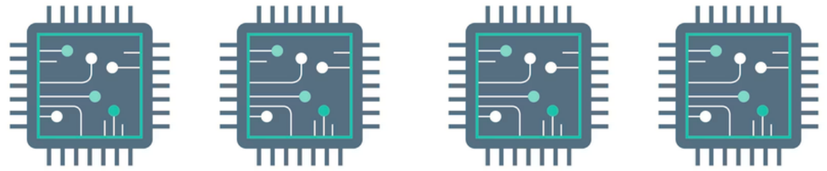
ResourceQuota is one of the rich features of Kubernetes that helps to manage and distribute resources according to the requirements.

Just assume that we have 2 teams (Team-A & Team-B) who are working on single kubernetes cluster.

Team-A

Team-B

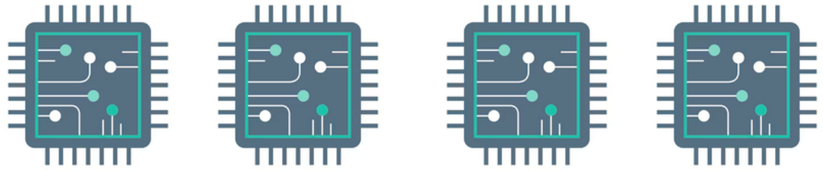




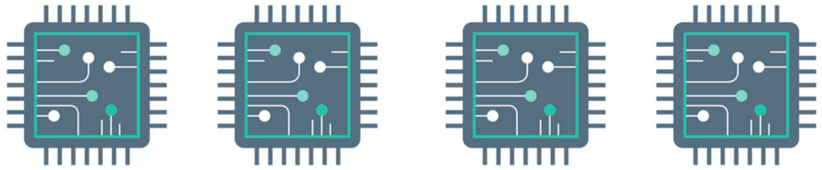
In this situation Team-A needs more CPU’s & Memory because of heavy workload tasks.

Team-A

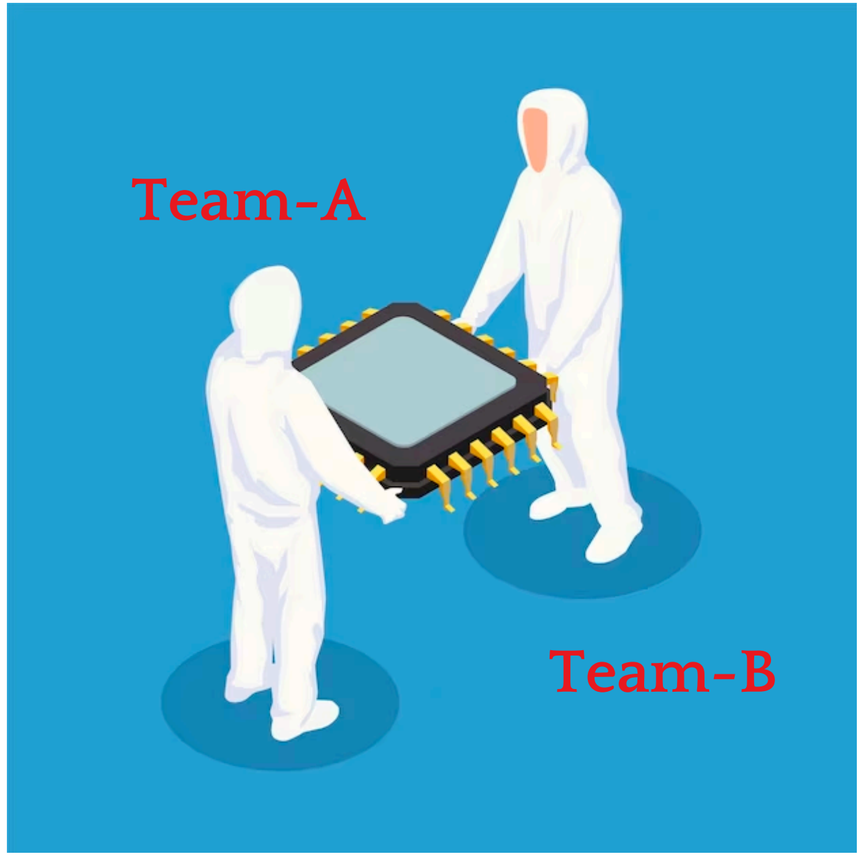
We need more CPU’s & Memory,
Because we have more work to do



Team-B

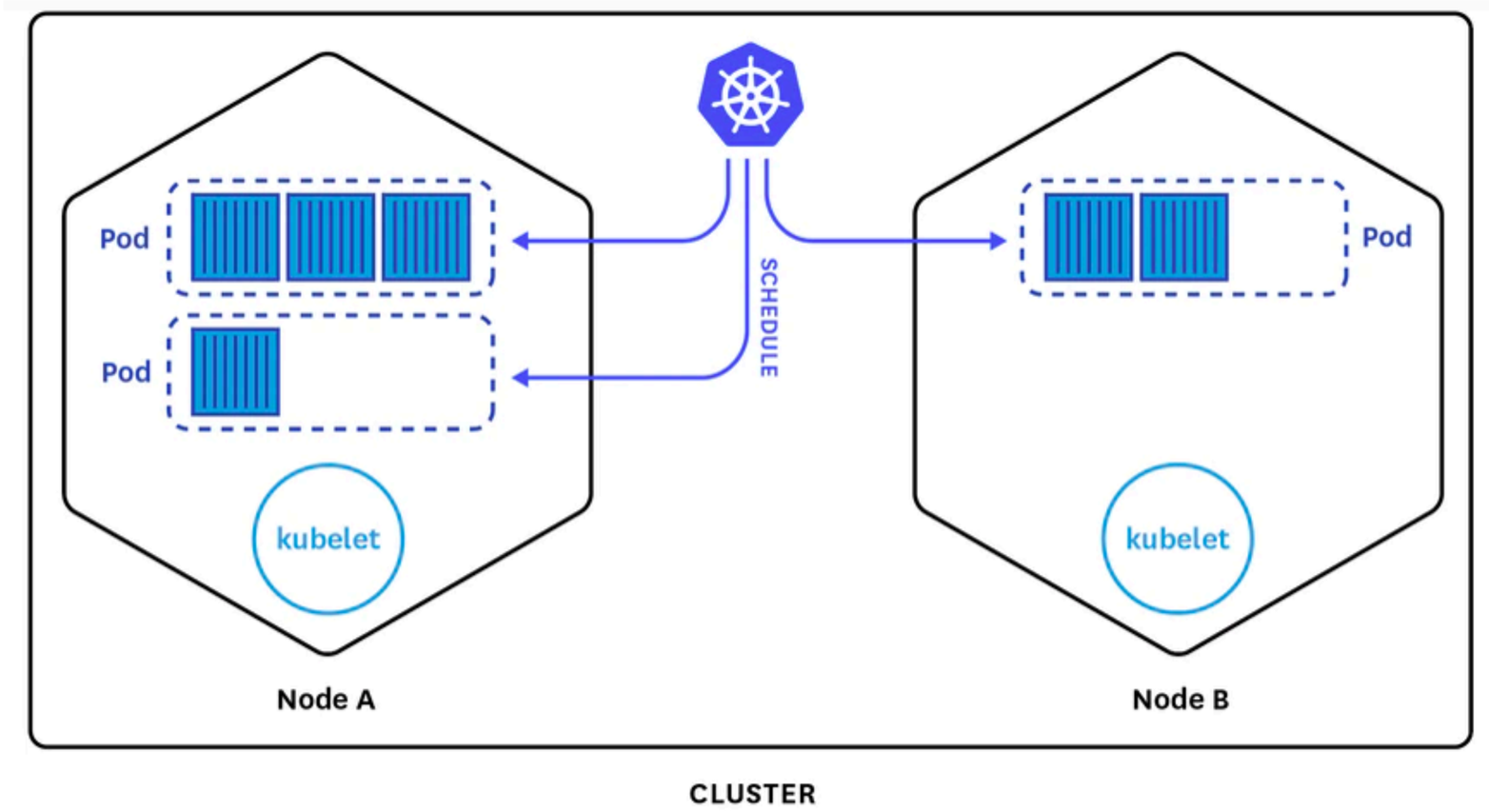


If the CPUs and other resources go to another team then it might increase the chance of failure.



To resolve this issue, we can allocate particular CPU cores and Memory to every project.

- By default pod in Kubernetes will run with no limits on CPU and memory.
- You can specify the RAM, Memory, or CPUs for each container and pod.
- The scheduler decides which node will create pods, if the node has enough CPU resources available then, the node will place the pods.
- CPU is specified in units of cores and memory is specified in units of bytes.



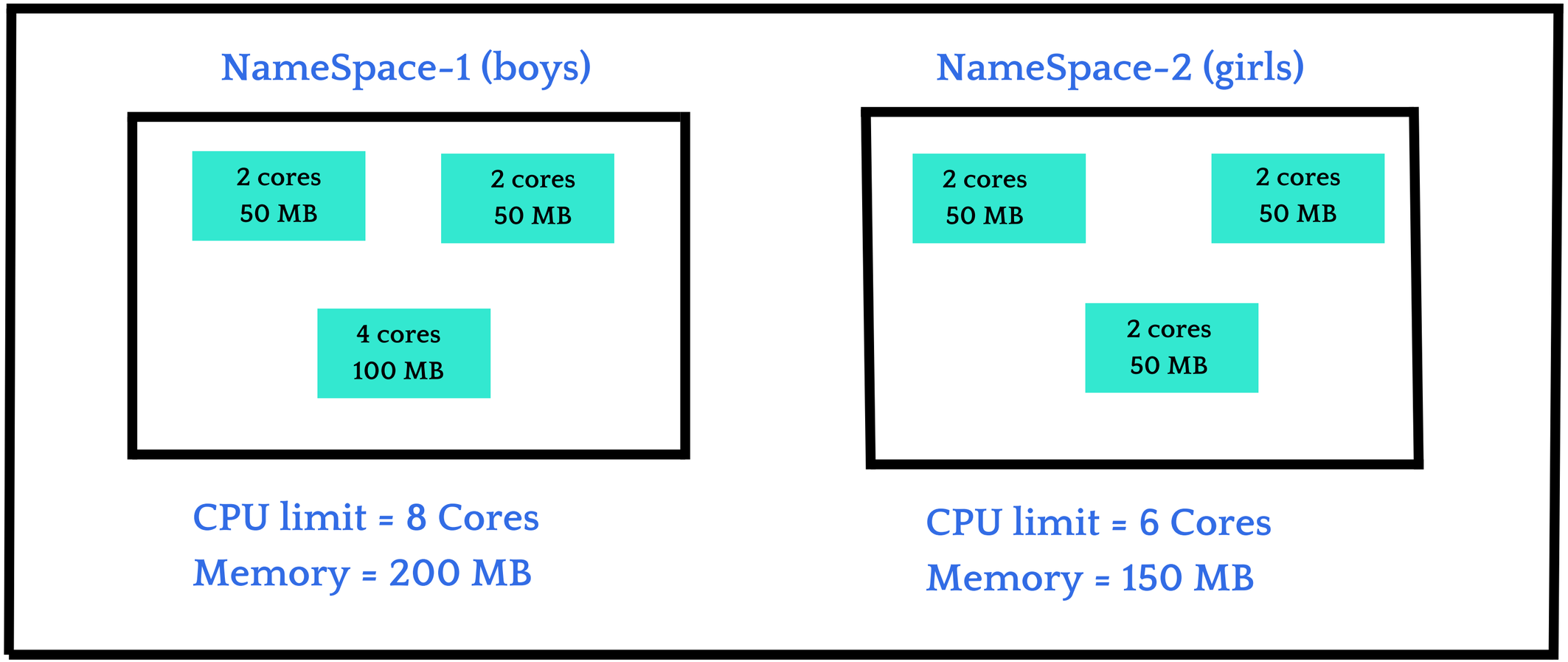
- As you know, the Kubernetes cluster can be divided into namespaces and if we create a container with no CPU limits then the container will have default limits.
- A namespace can be assigned to ResourceQuota objects, this will help to limit the amount of usage to the objects within the namespaces. You can limit the computer (CPU), Memory, and Storage.
- Restrictions that a resource-quotas imposes on namespaces
- Every container that is running on the namespace must have its own CPU limit.
- The total amount of CPU used by all the containers in the namespace should not exceed a specified limit.

Lets understand the ResourceQuota with funny scenario. Assume that there is medical college which has 25 seats only. So the college management assigned 10 seats for girls and 15 seats for boys who has more than 80% in Intermediate.

15 seats

10 seats

College (cluster)



Also we have a condition that students must has min 80% in Intermediate. In the same way pod/container must contains the CPU limits. All the pods/containers in the namespace should not exceed a specified limit.

There are two types of restrictions that need to be mentioned while using ResourceQuota

- **Limit**: Limit specifies that the container, pod, or namespace will have the limit resources where if the objects will exceed the limit then, the object won't create.

- **Request**: The request specifies that the container, pod, or namespace needs a particular amount of resources such as CPU and memory. But if the request is greater than the limit then, Kubernetes won't allow the creation of pods or containers.

Now, there are some conditions or principles for requests and limit which needs to be understood.

1. If the requests and limits are given in the manifest file, it works accordingly.
2. If the requests are given but the limit is not provided then, the default requests will be used.
3. If the requests are not provided but the limit is provided then, the requests will be equal to the limit.

If the requests and limits are given in the manifest file, it works accordingly.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
  - name: example-container
    image: nginx
    resources:
      requests:
        memory: "64Mi"
        cpu: "250m"
      limits:
        memory: "128Mi"
        cpu: "500m"
```

Describe the pod and you will get limits and requests of the container

If the requests are given but the limit is not provided then, the default limit will be used.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
  - name: example-container
    image: nginx
    resources:
      requests:
        memory: "64Mi"
        cpu: "250m"
```

Describe the pod and you will get only requests of the container

If the requests are not provided but the limit is provided then, the requests will be equal to the limit.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
  - name: example-container
    image: nginx
    resources:
      limits:
        memory: "128Mi"
        cpu: "500m"
```

Describe the pod and you will get only limits of the container

Hands on : Resource Quota

create a ResourceQuota:

```yaml
apiVersion: v1
kind: ResourceQuota
metadata:
  name: res-quota
spec:
  hard:
    limits.cpu: "200m"
    requests.cpu: "150m"
    limits.memory: "38Mi"
    requests.memory: "12Mi"
```

rq.yml

That means now we can create the pods within these limits in default namespace

To see list of RQ : kubectl get resourcequota

```
root@ip-172-31-15-56:~/manifests# kubectl get resourcequota
NAME        AGE     REQUEST                                                 LIMIT
res-quota   4m53s   requests.cpu: 0/150m, requests.memory: 0/12Mi   limits.cpu: 0/200m, limits.memory: 0/38Mi
```

Now lets try to create a pod with then limits an see the resource quota again

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
  - image: nginx
    name: res-pod
    resources:
      requests:
        memory: "5Mi"
        cpu: "50m"
      limits:
        memory: "12Mi"
        cpu: "100m"
```

We can observer here, my pod occupies the cpu and memory from the resource qouta

pod.yml

To see list of RQ : kubectl get resourcequota

```
root@ip-172-31-15-56:~/manifests# kubectl get resourcequota
NAME        AGE   REQUEST                                      LIMIT
res-quota   12m   requests.cpu: 50m/150m, requests.memory: 5Mi/12Mi   limits.cpu: 100m/200m, limits.memory: 12Mi/38Mi
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
spec:
  containers:
  - image: nginx
    name: res-pod
    resources:
      requests:
        memory: "32Mi"
        cpu: "200m"
      limits:
        memory: "64Mi"
        cpu: "400m"
```

If we execute this pod, we will get an error because the pod limits and requests are greater than the resource quota limits and requests.

CONFIG MAPS:

- ConfigMap is used to store the configuration data in key-value pairs within Kubernetes.
- But the data should be non confidential data.
- This is one of the ways to decouple the configuration from the application to get rid of hardcoded values.
- Also, if you observe some important values keep changing according to the environments such as development, testing, production, etc ConfigMap helps to fix this issue to decouple the configurations
- So we can set the configuration of data of application separately
- But it does not provider security and encryption. If we want to provide encryption use secrets in Kubernetes.
- Limit of config map data in only 1 MB (we cannot store more than that)
- But if we want to store a large amount of data in config maps we have to mount a volume or use a separate database or file service.

USE CASES IN CONFIG MAPS:

- **Configure application settings**: By using this config maps, we can store the configuration data that helps to run our application like database connections and environment variables
- **Configuring a pod or container**: It is used to send a configuration data to a pod or container at runtime like CLI or files.
- **Sharing configuration data across multiple resources:** By using this configuration data multiple resources can access, such as a common configuration file for different pods or services.
- **We can store the data:** By using this config maps, we can store the data like IP address, URL's and DNS etc...

SOME POINTS ABOUT CONFIGMAPS:

- Creating the configMap is the first process which can be done by commands only or a YAML file.
- After creating the configMap, we use the data in the pod by injecting the pods.
- After injecting the pods, if there is any update in the configuration we can modify the configMap, and the changes will be reflected in the injected pod.

Creating ConfigMap from literal:

we have created the configMap through — from-literal which means you just need to provide the key value instead of providing the file with key-value pair data.

kubectl create cm my-first-cm --from-literal=Course=DevOps --from-literal=Cloud=AWS --from-literal=Trainer=Mustafa

To get Config Maps: kubectl get cm
To descibe: kubectl describe configmap/configmap-name
To delete: kubectl delete configmap/configmap

CREATE A CONFIG-MAPS FROM FILE:

We have created one file first.conf which has some data, and created the configMap with the help of that file.

cat config-map-data.txt
Name=Mustafa
Course=Python
Duration=60 days

command to create config map: kubectl create cm cm-name --from-file=filename
To descibe: kubectl describe configmap/configmap-name
To delete: kubectl delete configmap/configmap

CREATE A CONFIG-MAPS FROM ENV FILE:

We have created one environment file first.env which has some data in key-value pairs, and created the configMap with the help of the environment file.

cat one.env

Tool=Kubernetes

Topic=Config Maps

Course=DevOps

command to create config map: kubectl create cm cm-name --from-env-file=one.env

To descibe: kubectl describe configmap/one.env

To delete: kubectl delete configmap/one.env

CREATE A FOLDER FOR CONFIG-MAPS:

We have created multiple files in a directory with different extensions that have different types of data and created the configMap for the entire directory.

mkdir folder1
cat folder1/file1.txt
key1=value1
key2=23

cat folder2/file2.txt
key1=value1
key2=23

command to create config map:

kubectl create cm mummy --from-file=folder1/

CREATE A YAML FOR CONFIG-MAPS:

The imperative way is not very good if you have to repeat the same tasks again and again. Now, we will look at how to create configMap through the YAML file.

command to create config map: kubectl create -f one.yml

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: my-config
data:
  DATABASE_URL: "mysql://db.example.com:3306/mydb"
  API_KEY: "your-api-key"
```

Injecting CM into the pod with specific key pairs:

we have created four types of configMaps
but here, we will learn how to use those configMaps by injecting configMaps into the pods.

Create a file for pod and execute it
Inside the pod.yml we have to declare any valuefrom our configmap

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **env**
That will print the list of environments.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      env:
       - name: FirstValue
         valueFrom:
           configMapKeyRef:
             key: Name
             name: babu
```

POD.YML

kubectl apply -f pod.yml

Injecting multiple CMs with specific and multiple values:

Lets add multiple key pairs from different files.

Create a file for pod and execute it
Inside the pod.yml we have to declare any value from any configmaps

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **env**
That will print the list of environments.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      env:
       - name: FirstValue
         valueFrom:
           configMapKeyRef:
             key: Name
             name: Config-Map-1
       - name: SecondValue
         valueFrom:
           configMapKeyRef:
             key: Course
             name: Config-Map-2

       - name: ThirdValue
         valueFrom:
           configMapKeyRef:
             key: Duration
             name: Config-Map-3
```

Injecting the environment file cm's to pod:

Create a file for pod and execute it
Inside the pod.yml we have to declare a configmap name which was created with env file

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **env**
That will print the list of environments.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: firstcontainer
      envFrom:
       - configMapRef:
            name: my-cm-env
```

POD.YML

kubectl apply -f pod.yml

Injecting cm in the pod with the entire proper file:

Create a file for pod and execute it
Inside the pod.yml we have to declare a configmap name which was created with normal file

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **ls**
You will find a folder called env-values.

In side the folder you will get file names as keys
open the file using **cat** then we will get labels

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      volumeMounts:
      - name: my-volume
        mountPath: "/env-values"
        readOnly: true
  volumes:
    - name: my-volume
      configMap:
            name: my-cm-1
```

POD.YML
kubectl apply -f pod.yml

Injecting cm and creating a file in the pod with the selected key pairs

This concept also will works as same as previous topic. But Inside the pod we can declare the filenames by our own inside the env-values folder.

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **ls**
You will find a folder called env-values.

In side the folder you will get file names as file1 and file2.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      volumeMounts:
      - name: test
        mountPath: "/env-values"
        readOnly: true
  volumes:
    - name: test
      configMap:
            name: babu
            items:
             - key: Name
               path: "file1"
             - key: Occupation
               path: "file2"
```

POD.YML
kubectl apply -f pod.yml

SECRETS:

- There are lot of confidential information that needs to be stored on the server such as database usernames, passwords, or API Keys.
- To keep all the important data secure, Kubernetes has a Secrets feature that encrypts the data.
- Secrets can store data up to 1MB which would be enough.
- Secrets can be created via imperative or declarative ways.
- Secrets are stored in the /tmps directory and can be accessible to pods only.
- After creating the Secrets, applications need to use the credentials or database credentials which will be done by injecting with the pods.

Creating Secret from literal:

we have created the Secrets through --from-literal which means you just need to provide the key value instead of providing the file with key-value pair data.

you can see the key and encrypted value because Kubernetes encrypts the secrets.

kubectl create secret generic my-secret --from-literal=username=sm7243

To get Config Maps: kubectl get secret
To descibe: kubectl describe secret/my-secret
To Get in yaml : kubectl get secret my-secret -o yaml
To delete: kubectl delete secret/my-secret

Secrets from file:

We have created one file first.conf which has some data, and created the Secrets with the help of that file.

cat first.conf

username=sm7234

password=admin@123

kubectl create secret generic secret-from-file --from-file=first.conf

To get Config Maps: kubectl get secret

To descibe: kubectl describe secret/secret-from-file

To Get in yaml : kubectl get secret secret-from-file -o yaml

To delete: kubectl delete secret/secret-from-file

Secrets from env-file:

We have created one environment file first.env which has some data in key-value pairs, and created the Secrets with the help of the environment file.

cat mustafa.env
Name=mustafa
Place=Hyderabad
Compamy=TCS

kubectl create secret generic secret-from-env --from-env-file=mustafa.env

To get secrets: kubectl get secret
To descibe: kubectl describe secret/secret-from-env
To Get in yaml : kubectl get secret secret-from-env -o yaml
To delete: kubectl delete secret/secret-from-env

CREATE A FOLDER FOR SECRETS:

We have created multiple files in a directory with a different extension that has different types of data and created the Secrets for the entire directory.

mkdir folder1

cat folder1/file1.txt

Name=Mustafa

Place=Hyderabad=23

cat folder2/file2.txt

database=mysq1

password=mypassword

command to create secret:

kubectl create secret generic secret-from-folder --from-file=folder1/

To Get in yaml : kubectl get secret secret-from-env -o yaml

Injecting Secret with a pod for a particular key pairs:

we have created four types of Secrets but
here, we will learn how to use those Secrets
by injecting Secrets to the pods.

Create a file for pod and execute it
Inside the pod.yml we have to declare any value
from our secret

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **env**
That will print the list of environments.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      env:
        - name: value-1
          valueFrom:
            secretKeyRef:
              key: username
              name: my-secret
```

POD.YML

kubectl apply -f pod.yml

Injecting the environment file secrets to pod:

Create a file for pod and execute it
Inside the pod.yml we have to declare a secret name which was created with env file

After creating the pod, enter into the pod using **kubectl exec -it pod_name /bin/bash**
Once you entered into pod give a command **ls**
You will find a folder called secret-values.

In side the folder you will get file names as keys
open the file using **cat** then we will get labels

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      volumeMounts:
        - name: my-volume
          mountPath: "/secrets-values"
  volumes:
    - name: my-volume
      secret:
            secretName: secret-from-env
```

POD.YML

kubectl apply -f pod.yml

Injecting secret and creating a file in the pod with the selected key pairs

This concept also will works as same as previous topic. But Inside the pod we can declare the filenames by our own inside the env-values folder.

After creating the pod, enter into the pod using
kubectl exec -it pod_name /bin/bash
Once you entered into pod give a command **ls**
You will find a folder called secret-values.

In side the folder you will get file names as file1 and file2.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
    - image: nginx
      name: cont-1
      volumeMounts:
        - name: test
          mountPath: "/secrets-values"
  volumes:
    - name: test
      secret:
            secretName: secret-from-env
            items:
             - key: Company
               path: "file1"
             - key: Name
               path: "file2"
```

POD.YML
kubectl apply -f pod.yml

There are 2 possible ways to store the data in config maps

DATA	BINARY DATA
• Stores data in plain text • used to store configuration, script and other text based data • Encoded in UFT-8 format • Decoding in not necessary	• Stores data in binary data • stores non-text data like images, videos or binary files • Encoded in BASE-64 format • Here you need to decode data from BASE-64 format before using

INIT CONTAINERS:

- The init container is a special type of container that runs before the main containers in a pod start.
- Its primary purpose is to perform initialization tasks or setup activities that need to be completed before the main application containers start running.
- If a pod fails due to Init Containers then, Kubernetes restarts the init Container until it will succeed.

Use cases:

- To Install the dependencies before running the application on the main container
- Clone a git repository into the volume
- Generate configuration files dynamically
- Database Configuration

lets create a new pod in which we have created two containers and the first container is initcontainer.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: initcontainer
spec:
  initContainers:
  - name: container1
    image: ubuntu
    command: ["bin/bash", "-c", "Welcome to DevOps class > /tmp/xchange/testfile; sleep 15"]
    volumeMounts:
      - name: xchange
        mountPath: "/tmp/xchange"
  containers:
  - name: container2
    image: ubuntu
    command: ["bin/bash", "-c", "while true; do echo `cat /tmp/data/testfile`; sleep 10; done"]
    volumeMounts:
      - name: xchange
        mountPath: /tmp/data
  volumes:
  - name: xchange
    emptyDir: {}
```

Now check the logs of the pod : kubectl logs -f pod/pod-name
we can see 2 containers are running inside the pod

If we execute the above pod file, 2 containers will gets created.
container-1 : prints the data and save the data in **/tmp/xchange/testfile** file
container-2 : prints the data
check the list of pods for every 15 seconds.

```
root@ip-172-31-15-56:~/manifests# kubectl get po
NAME              READY   STATUS     RESTARTS   AGE
initcontainer     0/1     Init:0/1   0          9s
root@ip-172-31-15-56:~/manifests# kubectl get po
NAME              READY   STATUS    RESTARTS   AGE
initcontainer     1/1     Running   0          30s
```

when we create the pod, cont-1 command will gets executed and after 15 seconds cont-2 will be in running state then cont-2 command will gets executed.

describe the pods for every 15 sec we will see the difference

If we describe the pod, we can see cont-1 status is running and cont-2 status is waiting

```
IPs:
  IP:  10.244.0.22
Init Containers:
  container1:
    Container ID:  docker://740957eb906f3ee4e7ccb766a360677bd77a698e2e3badd5c178b36754f181ce
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:2b7412e6465c3c7fc5bb21d3e6f1917c167358449fecac8176c6e496e5c1f05f
    Port:          <none>
    Host Port:     <none>
    Command:
      bin/bash
      -c
      Welcome to DevOps class > /tmp/xchange/testfile; sleep 15
    State:          Running
      Started:      Thu, 23 Nov 2023 13:08:33 +0000
    Ready:          False
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /tmp/xchange from xchange (rw)
      /var/run/secrets/kubernetes.io/serviceaccount from kube-api-access-7rdl4 (ro)
Containers:
  container2:
    Container ID:
    Image:         ubuntu
    Image ID:
    Port:          <none>
    Host Port:     <none>
    Command:
      bin/bash
      -c
      while true; do echo `cat /tmp/data/testfile`; sleep 10; done
    State:          Waiting
```

if we describe the same pod after 15 seconds container-2 is also in running state.

when the container 2 is running check the logs of the pod : kubectl logs -f pod/initcontainer

KUBERNETES JOBS:

It is a resource that is used to achieve a particular work like backup script and, once the work is completed the pod will be deleted.

Use cases:

- Database backup script needs to run
- Running batch processes
- Running the task on the scheduled interval
- Log Rotation

Key Features:

- One-time Execution: If you have a task that needs to be executed one time whether it’s succeed or fail then the job will be finished.
- Parallelism: If you want to run multiple pods at the same time.
- Scheduling: If you want to schedule a specific number of pods after a specific time.
- Restart Policy: You can specify whether the Job should restart if fails.

Work completed and pod deleted:

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: testjob
spec:
  template:
    metadata:
      name: testjob
    spec:
      containers:
        - image: ubuntu
          name: container1
          command: ["bin/bash", "-c", "sudo apt update; sleep 130"]
      restartPolicy: Never
~
```

job.yml

kubectl create -f job.yml

By executing the above file, it will creates the job and job will automatically creates pod.
check the list of pods and job

1. kubectl get po
2. kubectl get jobs

Inside the pod, the container will gets updated and it will sleep for 130 seconds, After 130 seconds then the pod will gets deleted.

To execute the multiple commands, use the below manifest file

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: testjob
spec:
  template:
    metadata:
      name: testjob
    spec:
      containers:
        - image: ubuntu
          name: container1
          command: ["/bin/sh", "-c"]
          args:
            - |
              sudo apt update -y
              touch kops.pdf
              mkdir mustafa
              sleep 90
      restartPolicy: Never
```

This pod will creates the file and folder and after 90 seconds the pod will gets deleted.

Create and run the pods simultaneously and delete once the work is completed.

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: testjob
spec:
  parallelism: 3 # Create 3 pods and run simultaneously
  activeDeadlineSeconds: 10 # Pods will terminate after 10 secs(10+30(command sleep time))
  template:
    metadata:
      name: testjob
    spec:
      containers:
        - image: ubuntu
          name: container1
          command: ["bin/bash", "-c", "sudo apt update; sleep 30"]
      restartPolicy: Never
```

The above manifest file will creates 3 pods and it will execute the commands.

activeDeadlineSeconds are used to terminate the pods after 10 seconds.

After 30 seconds all the pods will gets deleted.

```
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS              RESTARTS   AGE
testjob-7mlc2   0/1     ContainerCreating   0          2s
testjob-h7dc9   0/1     ContainerCreating   0          2s
testjob-t468v   0/1     ContainerCreating   0          2s
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS              RESTARTS   AGE
testjob-7mlc2   0/1     ContainerCreating   0          5s
testjob-h7dc9   0/1     ContainerCreating   0          5s
testjob-t468v   1/1     Running             0          5s
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS    RESTARTS   AGE
testjob-7mlc2   1/1     Running   0          7s
testjob-h7dc9   1/1     Running   0          7s
testjob-t468v   1/1     Running   0          7s
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS        RESTARTS   AGE
testjob-7mlc2   1/1     Terminating   0          10s
testjob-h7dc9   1/1     Terminating   0          10s
testjob-t468v   1/1     Terminating   0          10s
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS        RESTARTS   AGE
testjob-7mlc2   1/1     Terminating   0          16s
testjob-h7dc9   1/1     Terminating   0          16s
testjob-t468v   1/1     Terminating   0          16s
root@ip-172-31-47-75:~/manifests# kubectl get po
NAME            READY   STATUS        RESTARTS   AGE
testjob-7mlc2   1/1     Terminating   0          18s
testjob-h7dc9   1/1     Terminating   0          18s
testjob-t468v   1/1     Terminating   0          18s
root@ip-172-31-47-75:~/manifests# kubectl get po
No resources found in default namespace.
root@ip-172-31-47-75:~/manifests#
```

As we can observe the logs here, when i run the manifest file in first 2 seconds the pods are in creating state.

After 7 seconds the pods are in running state.

After 10 seconds the pods are in terminating state

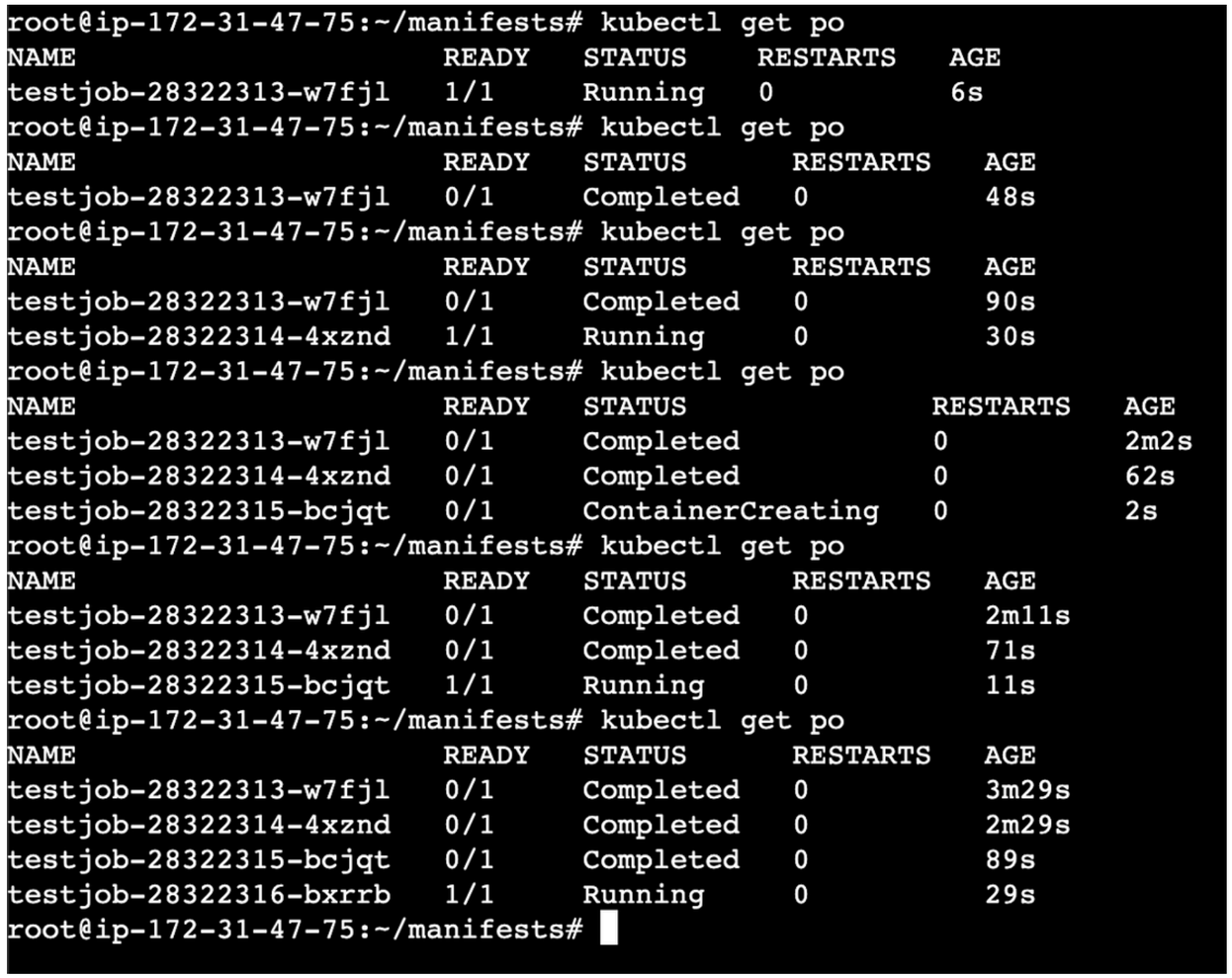
After 40 seconds all the pods will automatically deleted.

Even the pods are deleted, jobs will be present.

Scheduling a pod after each minute:

```yaml
apiVersion: batch/v1
kind: CronJob
metadata:
  name: testjob
spec:
  schedule: "* * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
            - image: ubuntu
              name: container1
              command: ["bin/bash", "-c", "sudo apt update; sleep 30"]
          restartPolicy: Never
```

The above manifest file for every one minute new pod will gets creates and it will execute the commands. After 30 seconds pods will gets deleted. After 1 min new pod created.



As we can observe the logs here, when i run the manifest file one pod is created.

After 30 seconds the pods completes it work

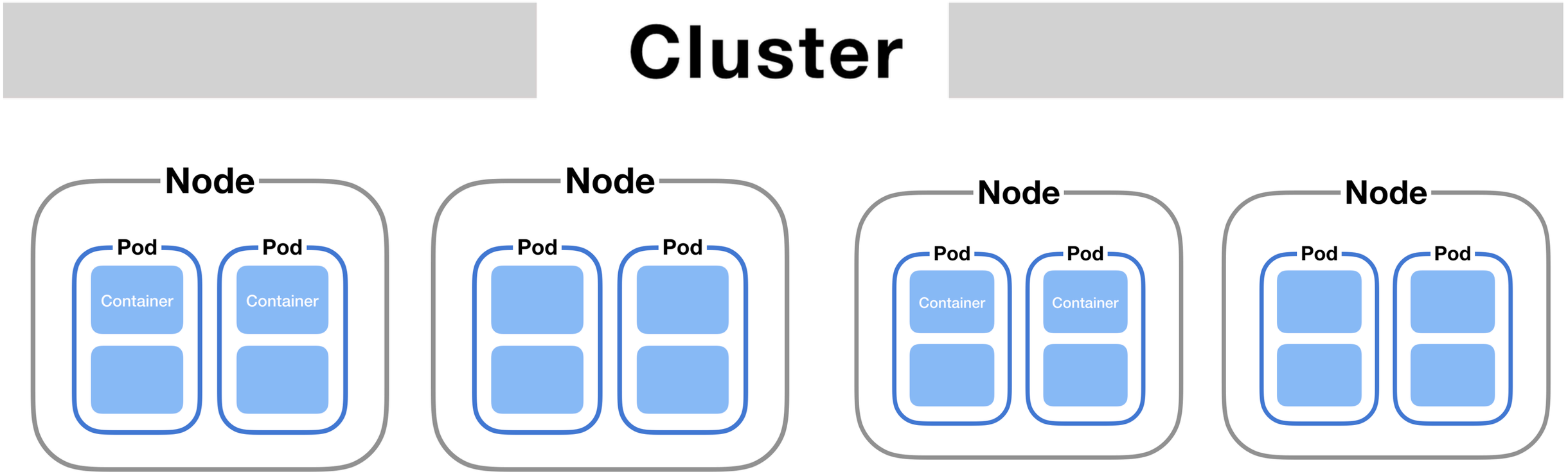
After 60 seconds the new pod will gets created automatically.

STATELESS APPLICATION

Last night i had a call with mobile customer care, and i explained my issue with her and requested to resolve the issue. She asked to stay on call for some time. Meanwhile the call was dropped due to network issues

Again i called to same number, but this time another person pick the call. He don't know what the conversation we had with the first person. Again i had to repeat the details of my problem to the second person, though it is an inconvenience but it still works out

Kubernetes Deployment suits perfectly here. Let's assume you deployed your stateless application as a Deployment with 10 Pod replicas running in multiple worker nodes.



If one of those Pods running in a particular worker node got terminated due to some issue

The ReplicaSet Controller takes care of replacing the bad Pod with a new healthy Pod either on the same node or on a different node.

Here replicaSet's will only take care of those 10 pods are running in the cluster or not.
It doesn't take care of in which worker node they are running!

If pod 1 got terminated from node 1, then new pod will gets replaced on either node 2 or node 1 or anywhere in the cluster.

This is possible because, the stateless application Pod 1 hasn’t stored any data on worker node 1, hence can be easily replaced by new pod running on a different worker node 2

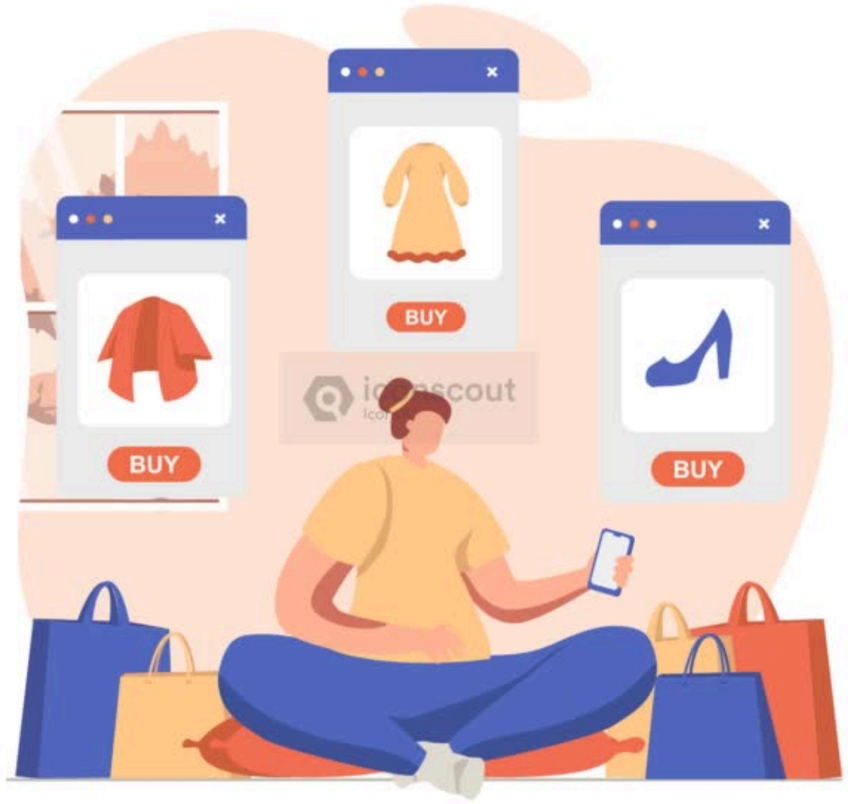
If the pod is not storing the data then we called it as **STATELESS**

STATELESS APPLICATION:

- It can't store the data permanently.
- The word STATELESS means no past data.
- It depends on non-persistent data means data is removed when Pod, Node or Cluster is stopped.
- Non-persistent mainly used for logging info (ex: system log, container log etc..)
- In order to avoid this problem, we are using stateful application.

- A stateless application can be deployed as a set of identical replicas, and each replica can handle incoming requests independently without the need to coordinate with other replicas.

Let’s say you want to order some some products in Amazon, you added some products to your shopping cart. After you added the book(s) to your shopping cart, If forgot to switch off the stove in kitchen and you closed the web browser hurry.



Well, you can anytime re-login to amazon portal and resume from where you left last time, as the amazon portal will ensure all items added to the Shopping cart are persisted in database.

Technically, if Amazon is using a ShoppingCart that runs in a Pod,
When i added some products on my cart that will stores on one pod and after some time when i resumed back to the amazon portal that will shows all the products from the different pod.

The interesting thing to understand here is, the StatefulSet Controller managed to bind the exact same Persistent Volume to two Shopping Cart Pods associated to that customer at two different point of time.

STATEFUL APPLICATION:

- Stateful applications are applications that store data and keep tracking it.

Example of stateful applications:

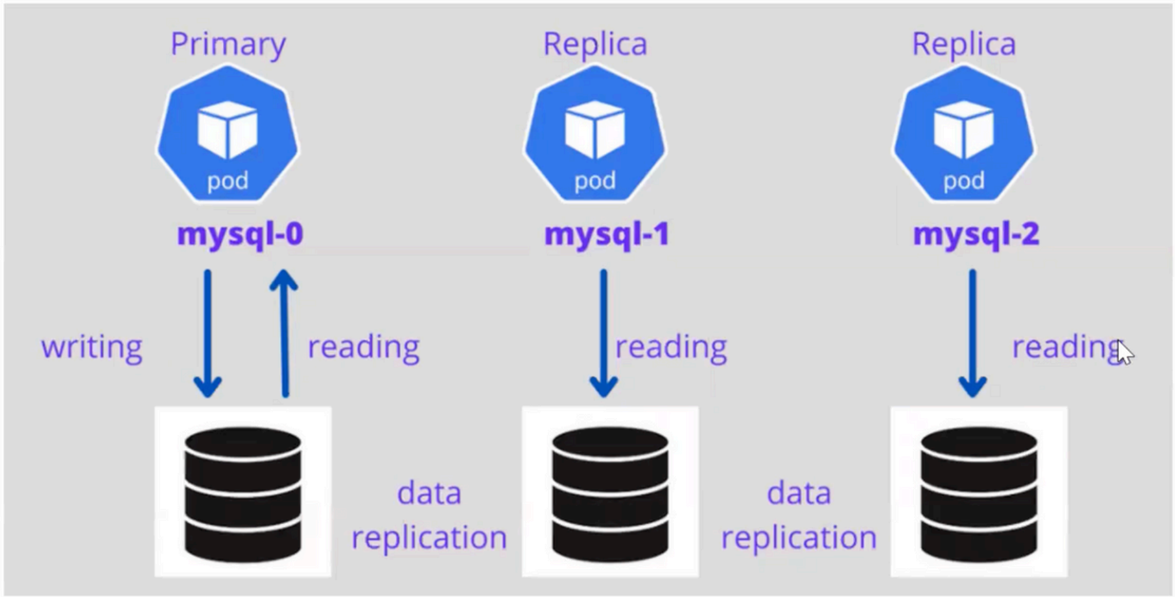
- All RDS databases (MySQL, SQL)
- Elastic search, Kafka , Mongo DB, Redis etc...
- Any applicaiton that stores data

To get the code for stateful application use this link:
https://github.com/devops0014/k8s-stateful-set-application.git

STATEFUL SET

- A StatefulSet is the Kubernetes controller used to run the stateful application as containers (Pods) in the Kubernetes cluster.
- StatefulSets assign a sticky identity-an orginal number starting from zero-to each Pod instead of assigning random IDs for each replica Pod.
- A new Pod is created by cloning the previous Pod's data. If the previous Pod is in the pending state, then the new Pod will not be created.
- If you delete a Pod, it will delete the Pod in reverse order, not in random order.

StatefulSet



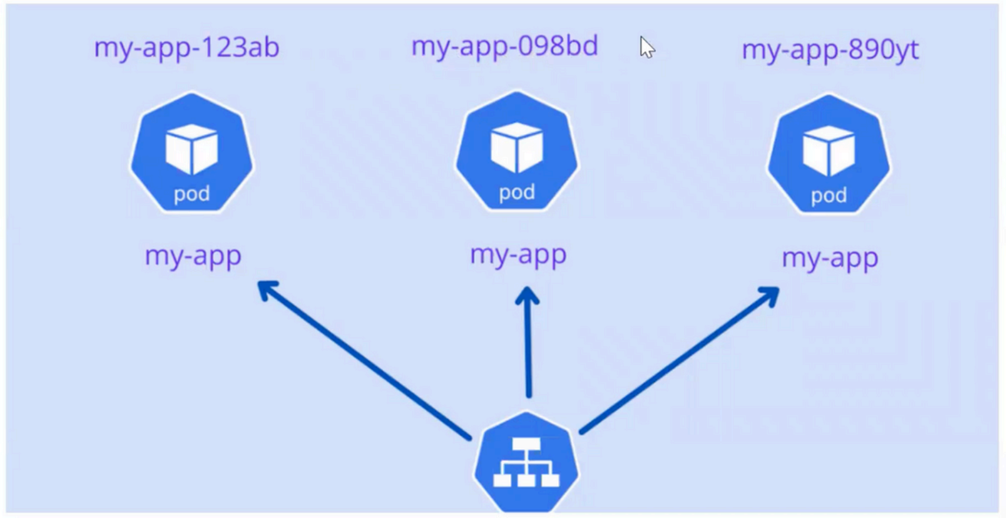
- Lets assume we deployed 3 replicas in a node,
- 1st pod is primary pod, remaining pods are secondary pods.
- Primary pod is having both read and write access
- But secondary pod is having only read access
- If we insert some data in primary pod, we can access the data from any pod i.e.. pod will share the data each other

DEPLOYMENT VS STATEFUL SET

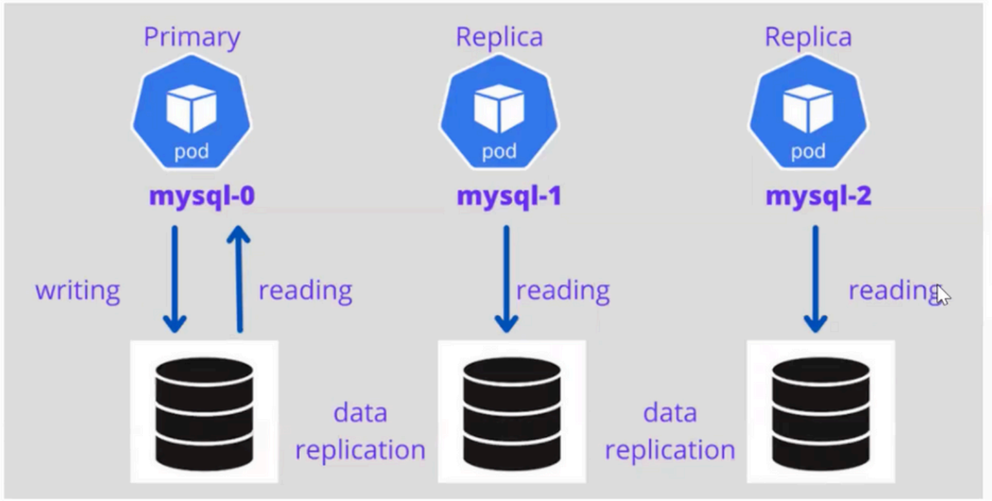
deployment cannot give the numbers or index for resources
but the stateful set will give the sticky identities called index numbers

when we delete pods in stateful set last pod will be deleted first
and primary pod deletes last

Deployment



StatefulSet



DEPLOYMENT	STATEFUL SET
• It will create POD's with random ID's • Scale down the POD's in random ID's • POD's are stateless POD's • We use this for application deployment	• It will create POD's with sticky ID's • Scale down the POD's in reverse order • POD's are stateful POD's • We use this for database deployment

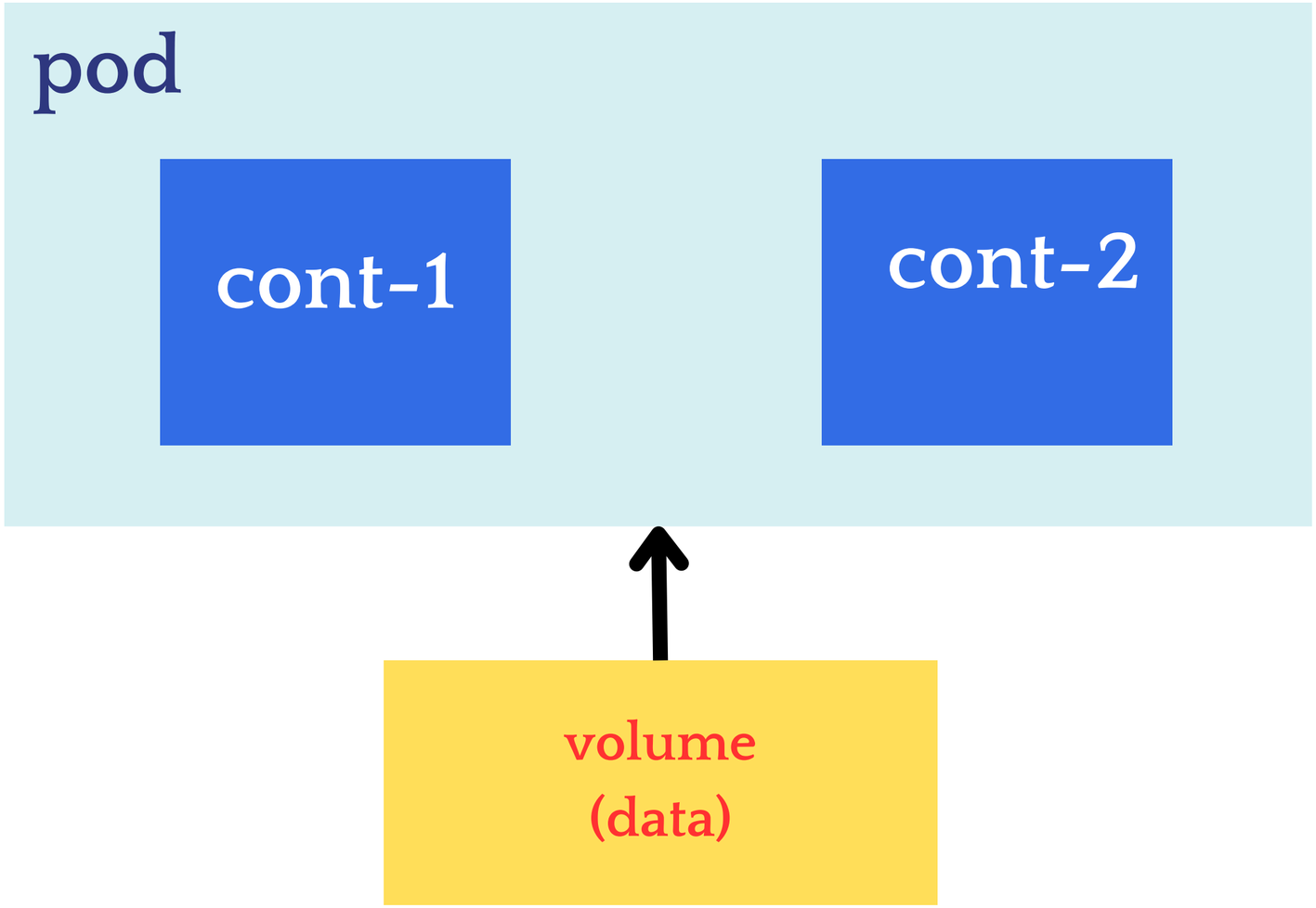
K8'S VOLUME AND LIVENESS PROBES:

Basically these K8's will works on short living data. So lets unveil the power of volumes like EmptyDir, HostPath, PV & PVC.

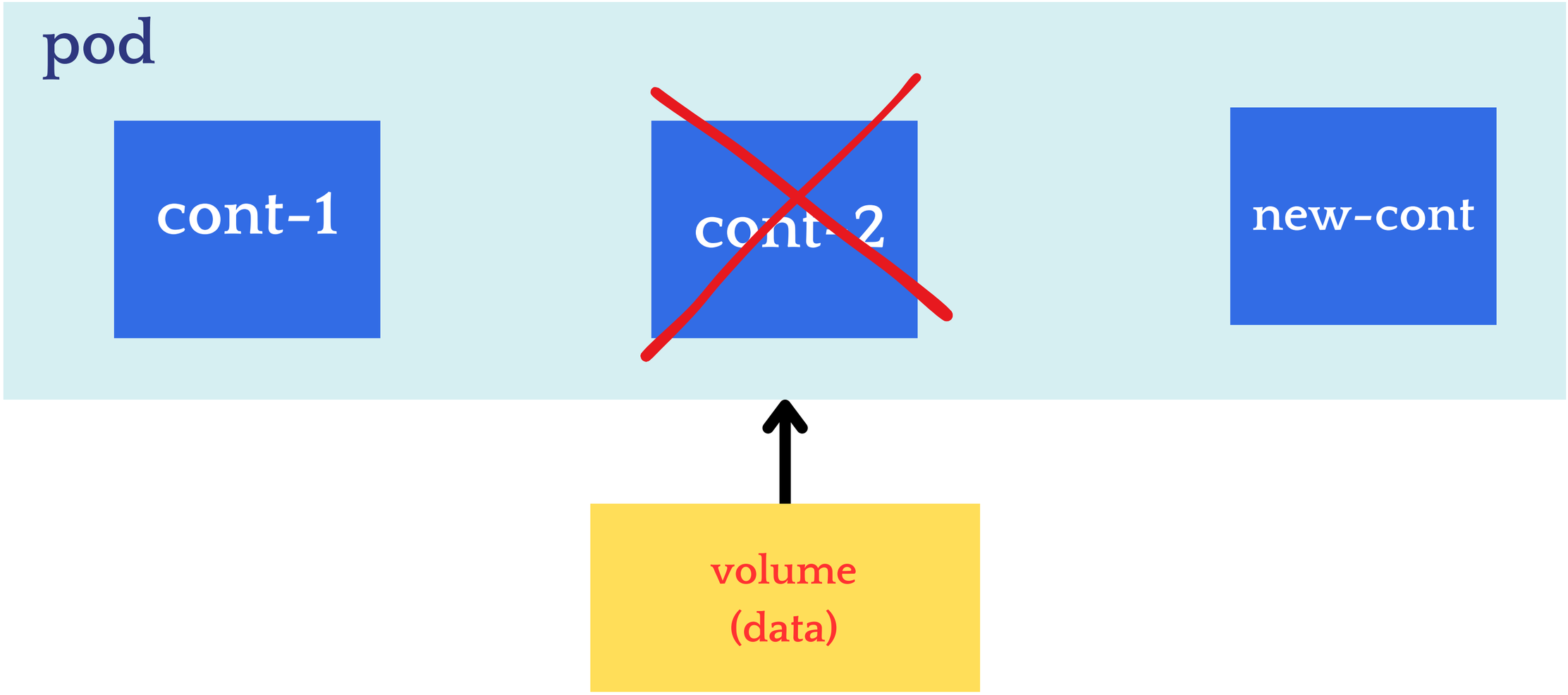
The data is a very important thing for an application. In K8's, data is kept for a short time in the applications in the pods/containers. By default the data will no longer available. To overcome this we will use Kubernetes Volumes.

But before going into the types of Volumes. Let’s understand some facts about pods and containers' short live data.

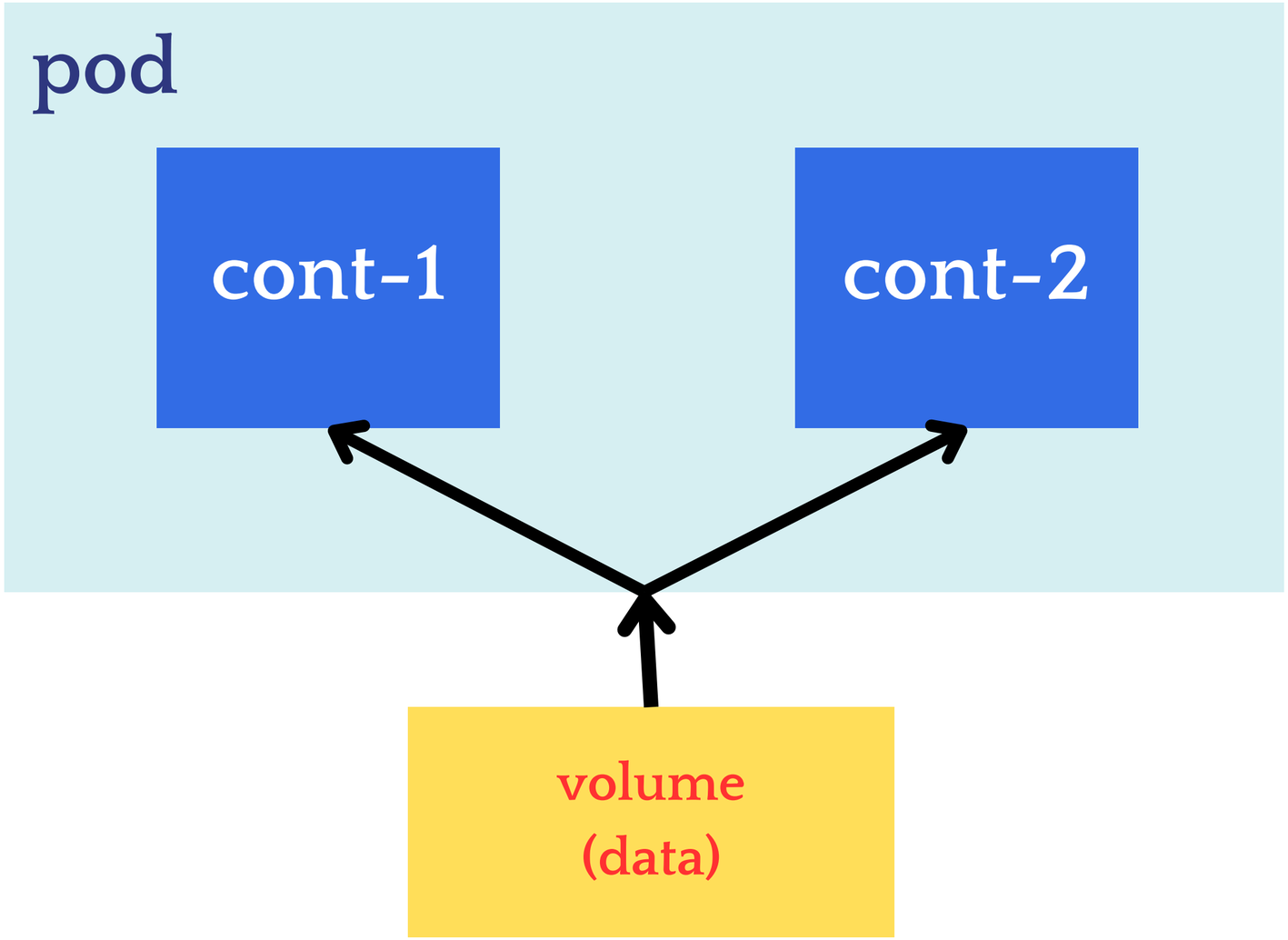
- The volumes reside inside the Pod which stores the data of all containers in that pod.



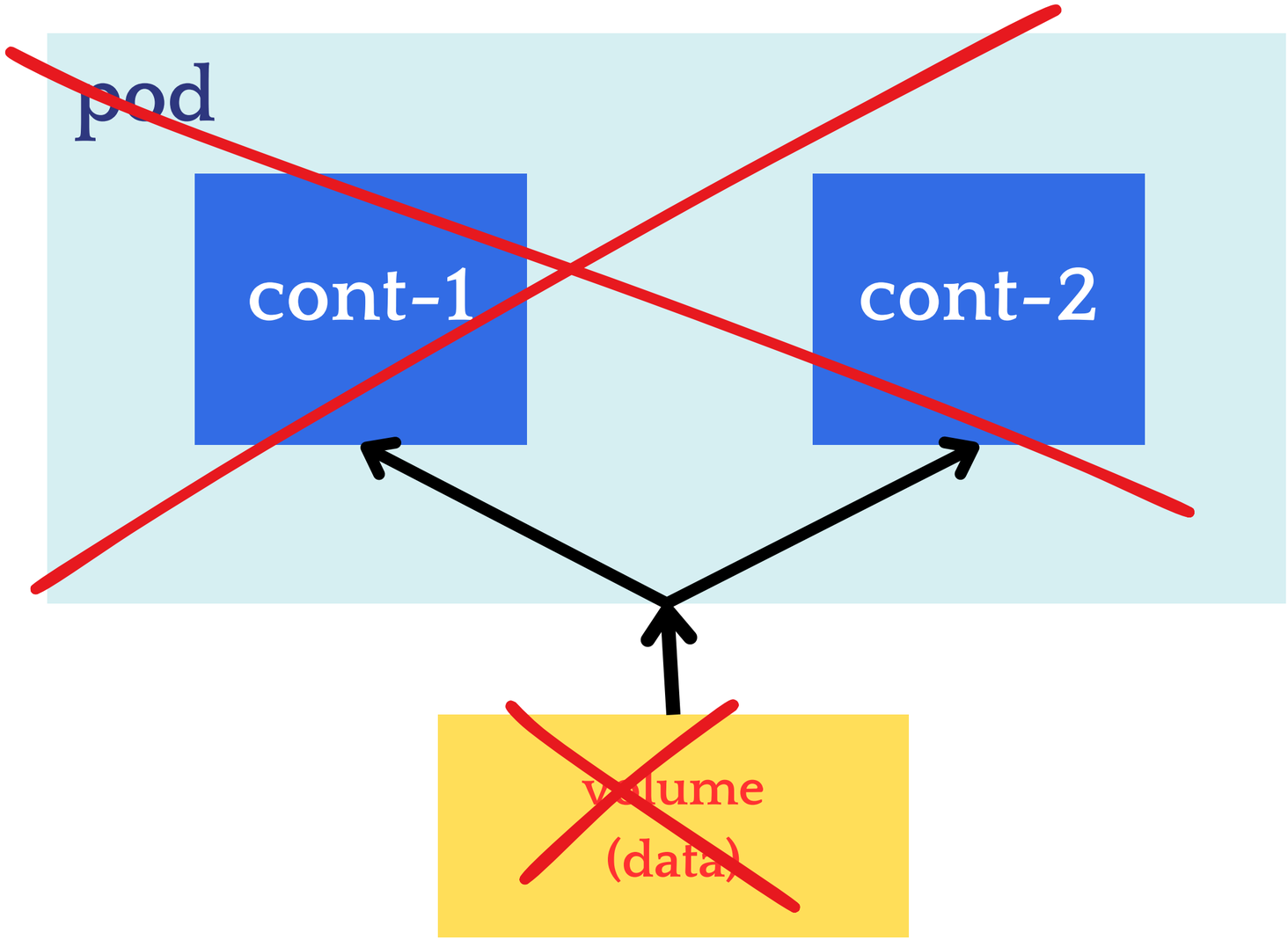
- If the container gets deleted, then the data will persist and it will be available for the new container which was created recently.



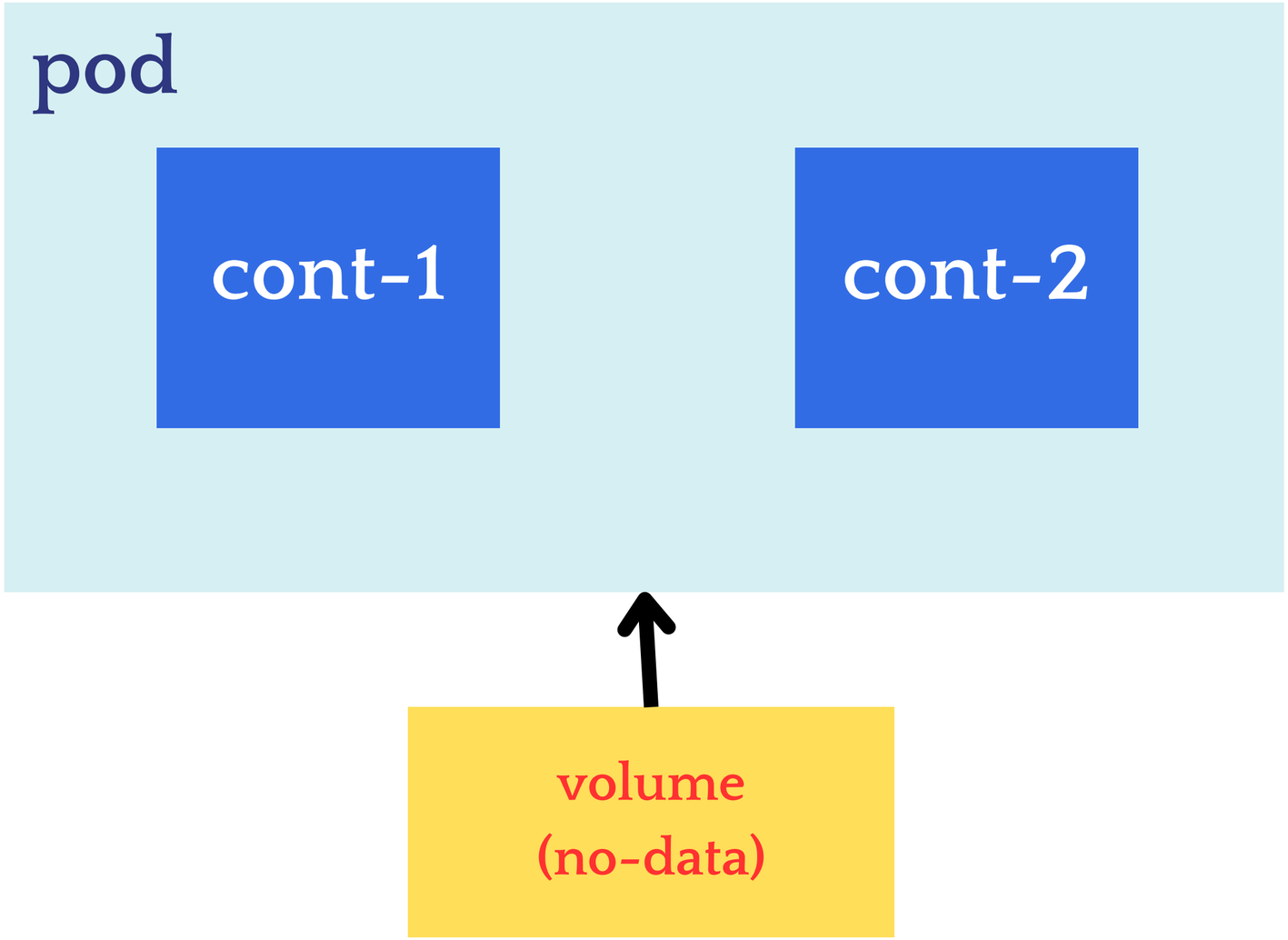
- Multiple containers within a pod can share one volume because the volume is attached to the pod.



- If the Pod gets deleted, then the volume will also get deleted which leads to a loss of data for all containers permanently.



- After deleting the pod, the new pod will be created with volume but this time volumes don’t have any previous data or any data.



Types of volumes:

1. EmptyDir
2. HostPath
3. Persistent Volume
4. Persistent Volume Claim(PVC)

1. EMPTY DIR:

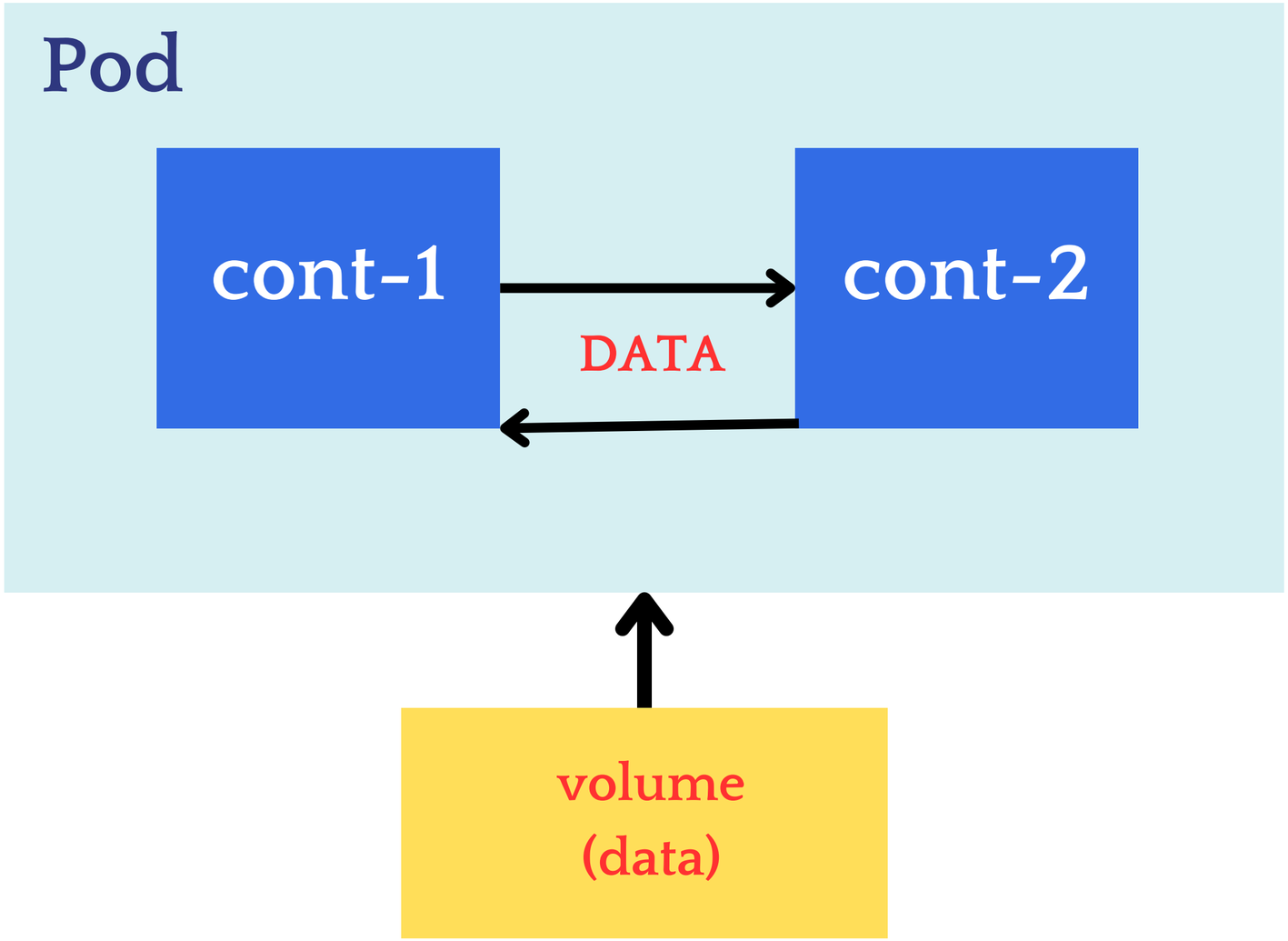
- This volume is used to share the volumes between multiple containers within a pod instead of the host machine or any Master/Worker Node.
- EmptyDir volume is created when the pod is created and it exists as long as a pod.
- There is no data available in the EmptyDir volume type when it is created for the first.
- Containers within the pod can access the other containers' data. However, the mount path can be different for each container.
- If the Containers get crashed then, the data will still persist and can be accessible by other or newly created containers.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-1
spec:
  containers:
  - name: container1
    image: ubuntu
    command: ["/bin/bash", "-c", "while true; do echo Welcome to DevOps classes; sleep 5 ; done"]
    volumeMounts:
      - name: myvolume
        mountPath: "/tmp/container1"
  - name: container2
    image: centos
    command: ["/bin/bash", "-c", "while true; do echo This is Kubernetes classes; sleep 5 ; done"]
    volumeMounts:
      - name: myvolume
        mountPath: "/tmp/container2"
  volumes:
  - name: myvolume
    emptyDir: {}
```

In the above file, it will creates 2 containers inside a pod. if you create a file in any container, then the file will be available on both the containers.

kubectl exec -i -t devops --container cont-1 -- /bin/bash

By using the above command create a file in cont-1 and it will be available on cont-2 as well

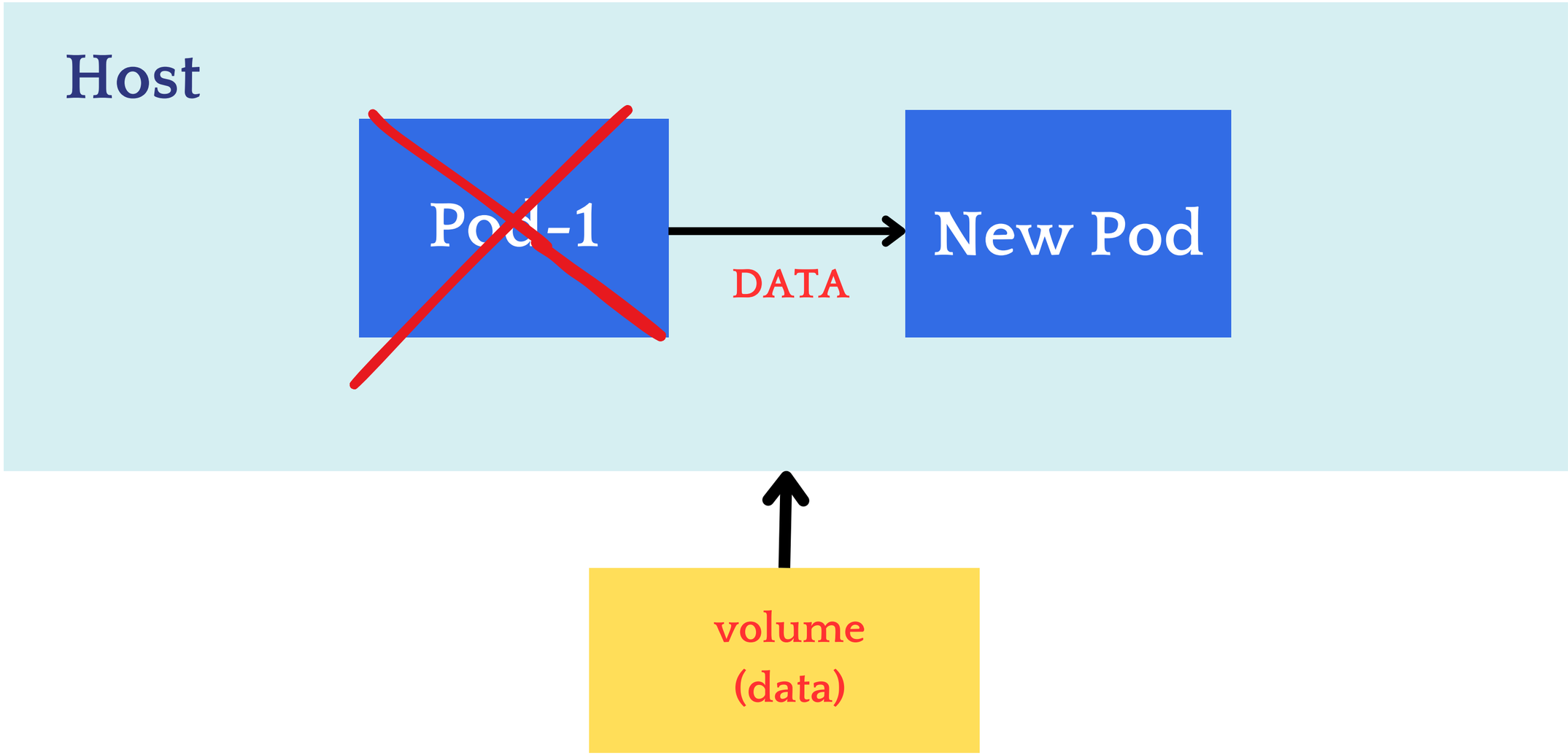

Pod
cont-1
cont-2
DATA
volume
(data)

2. HOSTPATH:

- This volume type is the advanced version of the previous volume type EmptyDir.
- In EmptyDir, the data is stored in the volumes that reside inside the Pods only where the host machine doesn’t have the data of the pods and containers.
- hostpath volume type helps to access the data of the pods or container volumes from the host machine.
- hostpath replicates the data of the volumes on the host machine and if you make the changes from the host machine then the changes will be reflected to the pods volumes(if attached).

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: hostpath
spec:
  containers:
  - name: container1
    image: ubuntu
    command: ["/bin/bash", "-c", "while true; do echo This is Kubernets class; sleep 5 ; done"]
    volumeMounts:
    - mountPath: "/tmp/cont"
      name: hp-vm
  volumes:
  - name: hp-vm
    hostPath:
      path: /tmp/data
```

In the above file, it will creates a pod. if you create a file in container, by using the command
docker exec -it pod-1 -c container1 /bin/bash
file will gets created. Now even if you delete the pod then another pods will gets created with same data.
Because we are using HostPath which creates local volume in our host machine.


Host
Pod-1
New Pod
DATA
volume
(data)

PERSISTENT VOLUME:

- Persistent means always available.
- Persistent Volume is an advanced version of EmptyDir and hostPath volume types.
- Persistent Volume does not store the data over the local server. It stores the data on the cloud or some other place where the data is highly available.
- In previous volume types, if pods get deleted then the data will be deleted as well. But with the help of Persistent Volume, the data can be shared with other pods or other worker node's pods as well after the deletion of pods.
- PVs are independent of the pod lifecycle, which means they can exist even if no pod is using them.
- With the help of Persistent Volume, the data will be stored on a central location such as EBS, Azure Disks, etc.

PERSISTENT VOLUME:

- One Persistent Volume is distributed across the entire Kubernetes Cluster. So that, any node or any node's pod can access the data from the volume accordingly.
- In K8S, a PV is a piece of storage in the cluster that has been provisioned by an administrator.
- If you want to use Persistent Volume, then you have to claim that volume with the help of the manifest YAML file.
- When a pod requests storage via a PVC, K8S will search for a suitable PV to satisfy the request.
- If a PV is found that matches the request, the PV is bound to the PVC and the pod can use the storage.
- If no suitable PV is found, K8S then PVC will remain unbound (pending).

PERSISTENT VOLUME CLAIM:

- To get the Persistent Volume, you have to claim the volume with the help of PVC.
- When you create a PVC, Kubernetes finds the suitable PV to bind them together.
- After a successful bound to the pod, you can mount it as a volume.
- Once a user finishes its work, then the attached volume gets released and will be used for recycling such as new pod creation for future usage.
- If the pod is terminating due to some issue, the PV will be released but as you know the new pod will be created quickly then the same PV will be attached to the newly created Pod.
- After bounding is done to pod you can mount it as a volume. The pod specifies the amount and type of storage it needs, and the cluster provisions a persistent volume that matches the request. If its not matches then it will be in pending state.

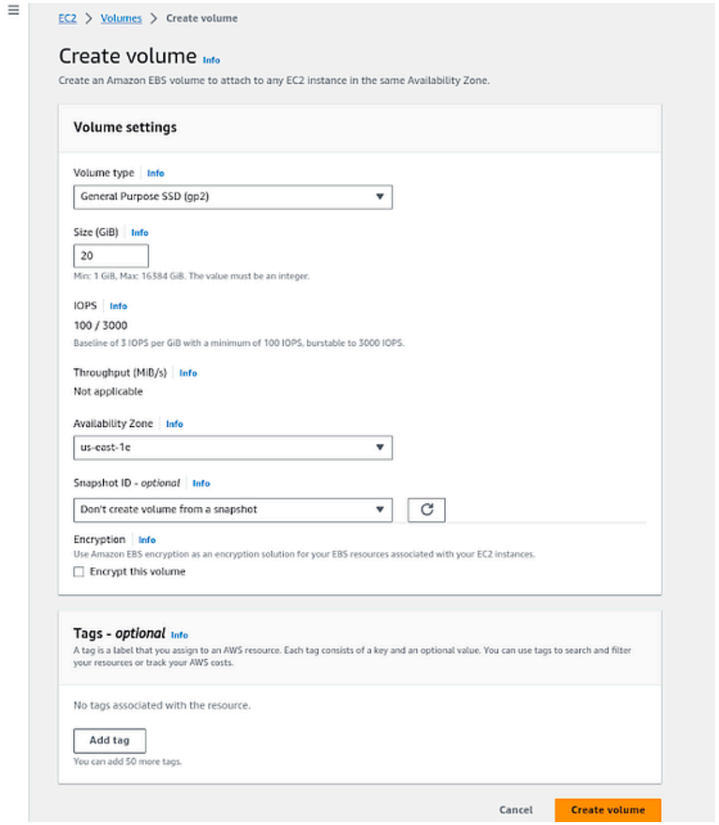
FACTS ABOUT EBS:

Now, As you know the Persistent Volume will be on Cloud. So, there are some facts and terms and conditions are there for EBS because we are using AWS cloud for our K8 learning. So, let's discuss it as well:

- EBS Volumes keeps the data forever where the emptydir volume did not. If the pods get deleted then, the data will still exist in the EBS volume.
- The nodes on which running pods must be on AWS Cloud only(EC2 Instances).
- Both(EBS Volume & EC2 Instances) must be in the same region and availability zone.
- EBS only supports a single EC2 instance mounting a volume

Create an EBS volume by clicking on ‘Create volume’.

Pass the Size for the EBS according to you, and select the Availability zone where your EC2 instance is created, and click on Create volume.



Now, copy the volume ID and paste it into the PV YML file

PV file:

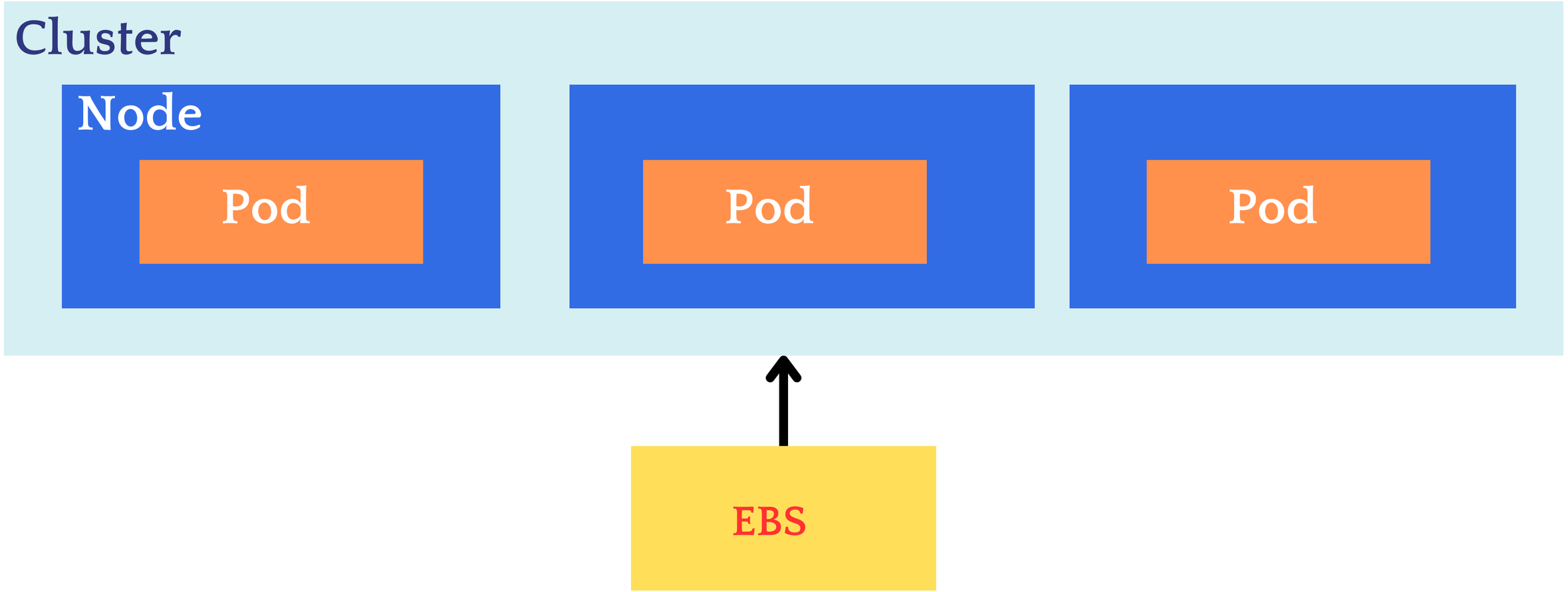
```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: myebsvol
spec:
  capacity:
    storage: 1Gi
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Recycle
  awsElasticBlockStore:
    volumeID: vol-0a0232b56c59cc682
    fsType: ext4
```

PVC file:

```yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: myebsvolclaim
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pvdeploy
spec:
  replicas: 1
  selector:
    matchLabels:
     app: mypv
  template:
    metadata:
      labels:
        app: mypv
    spec:
      containers:
      - name: shell
        image: centos
        command: ["bin/bash", "-c", "sleep 10000"]
        volumeMounts:
        - name: mypd
          mountPath: "/tmp/persistent"
      volumes:
        - name: mypd
          persistentVolumeClaim:
            claimName: myebsvolclaim
```

we have logged in to the created container (**kubectl exec -it pod_name -c shell /bin/bash**)and created one file with some text.



we have deleted the pod, and then because of replicas the new pod was created quickly. Now, we have logged in to the newly created pod and checked for the file that we created in the previous step, and as you can see the file is present which is expected.

vim pv.yml

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: my-pv
spec:
  capacity:
    storage: 10Gi
  accessModes:
    - ReadWriteOnce
  awsElasticBlockStore:
    volumeID: vol-0e5bdf9400dbb7b57
    fsType: ext4
```

vim pvc.yml

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: my-pvc
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 10Gi
```

kubectl apply -f pv.yml
kubectl apply -f pvc.yml
kubectl get pv,pvc

vim deploy.yml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: pvdeploy
spec:
  replicas: 1
  selector:
    matchLabels:
     app: swiggy
  template:
    metadata:
      labels:
        app: swiggy
    spec:
      containers:
      - name: raham
        image: centos
        command: ["bin/bash", "-c", "sleep 10000"]
        volumeMounts:
        - name: mypd
          mountPath: "/tmp/persistent"
      volumes:
        - name: mypd
          persistentVolumeClaim:
            claimName: my-pvc
```

kubectl apply -f deploy.yml
kubectl get deploy
kubectl get rs
kubectl get po

kubectl exec pvdeploy-86c99cf54d-d8rj4 -it -- /bin/bash
cd /tmp/persistent/
ls
vim raham
exit

now delete the pod and new pod will created then in that pod you will see the same content.

Access Modes

access modes determine how many pods can access a Persistent Volume (PV) or a Persistent Volume Claim (PVC) simultaneously. There are several access modes that can be set on a PV or PVC, including:

- **ReadWriteOnce:** This access mode allows a single pod to read and write to the PV or PVC. This is the most common access mode, and it's appropriate for use cases where a single pod needs exclusive access to the storage.
- **ReadOnlyMany:** This access mode allows multiple pods to read from the PV or PVC, but does not allow any of them to write to it. This access mode is useful for cases where many pods need to read the same data, such as when serving a read-only database.
- **ReadWriteMany:** This access mode allows multiple pods to read and write to the PV or PVC simultaneously. This mode is appropriate for use cases where many pods need to read and write to the same data, such as a distributed file system.
- **Execute:** This access mode allows the pod to execute the data on the PV or PVC but not read or write to it. This mode is useful for use cases where the data is meant to be executed by the pods only, such as application code.

PROBES (HEALTHCHECK):

PROBES: used to determine the health and readiness of containers running within pods. Probes are 3 types:

1. **Readiness probes** are used to indicate when a container is ready to receive traffic.
2. **Liveness probes** are used to determine whether a container is still running and responding to requests.
3. **Startup Probe** are used to determines whether the application within the container has started successfully. It's used to delay the liveness and readiness probes until the application is ready to handle traffic.

WHY PROBES?

- In K8s, its common to scale up and scale down the pods. But when the pod is created newly it will take some time to start the container and run the applications.
- If a pod is not ready to receive traffic, it may receive requests that it cannot handle, that causes downtime for our application.
- Similarly, if a container is not running correctly, it may not be able to respond to requests, resulting in the pod being terminated and replaced with a new one.
- To overcome this issues, we are using Probes.

TYPES OF PROBES:

There are several types of probes that can be used in Kubernetes which includes HTTP, TCP, and command probes.

If you see the YML file, there is one condition if the file healthy is not present in **/tmp** directory then livenessProbe will recreate the container. So, we have deleted that file.

After deleting the file, if you run **kubectl describe pod <pod-name>** you will see in the last two lines that the container is failing because the condition is not meeting.

```yaml
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: mylivenessprobe
spec:
  containers:
  - name: liveness
    image: ubuntu
    args:
    - /bin/sh
    - -c
    - touch /tmp/healthy; sleep 1000
    livenessProbe:
      exec:
        command:
        - cat
        - /tmp/healthy
      initialDelaySeconds: 5
      periodSeconds: 5
      timeoutSeconds: 30
```

- Once you create a pod, then describe this pod using **kubectl describe pod pod-name**
- After that enter into the pod **kubectl exec -it pod_name -c cont_name /bin/bash**
- Check the file is created or not using **cat /tmp/healthy**
- Now check the health status **echo $?** If it returns 0 then application is running into the container.
- there is one condition if the file healthy is not present in /tmp directory then livenessProbe will recreate the container. So, we have deleted that file.
- After deleting the file, if you run **kubectl describe pod pod-name** you will see in the last two lines that the container is failing because the condition is not meeting.

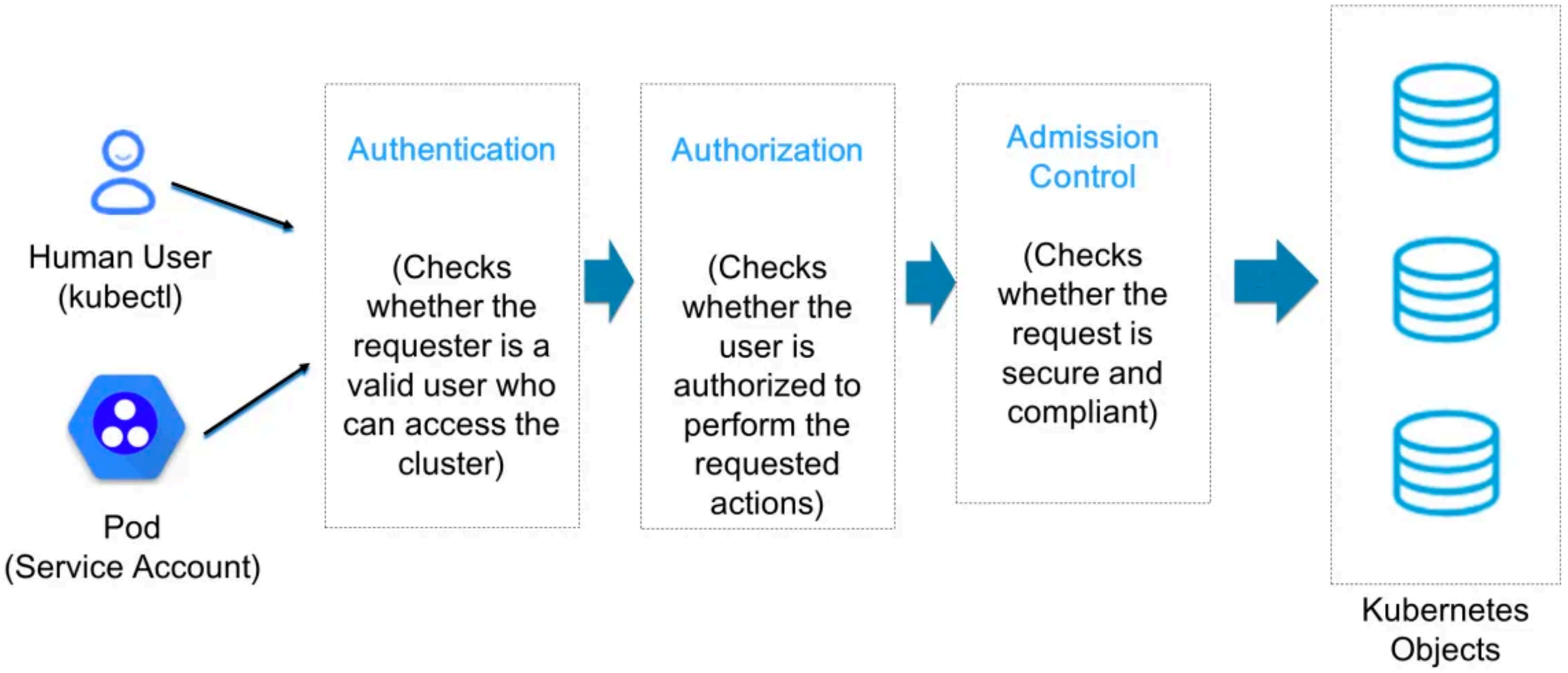
RBAC (Role Based Access Control):

I am a Developer
I want to see the pods

I am a Developer
I want to delete the pods

I am a DevOps Guy
I want to create, delete the pods

Role-Based Access Control (RBAC) is a critical security feature in Kubernetes that allows you to define and manage access to resources based on roles and permissions. RBAC ensures that only authorized users, processes, or services can interact with specific resources within a Kubernetes cluster.


Human User
(kubectl)
Pod
(Service Account)
Authentication
(Checks whether the requester is a valid user who can access the cluster)
Authorization
(Checks whether the user is authorized to perform the requested actions)
Admission Control
(Checks whether the request is secure and compliant)
Kubernetes Objects

In Kubernetes, there are two types of accounts

1. User Account
2. Service Account

User account: User accounts are used to log into a Kubernetes cluster and manipulate resources therein. Each user account is associated with a unique set of credentials, which are used to authenticate the service's requests.

Service Account: Kubernetes Service Accounts are specialised accounts used by applications and services running on Kubernetes to interact with the Kubernetes API.

Which account type should you use?

Use a user account if:

- You need to log into the cluster to administer it
- You need to access resources that are owned by the user.

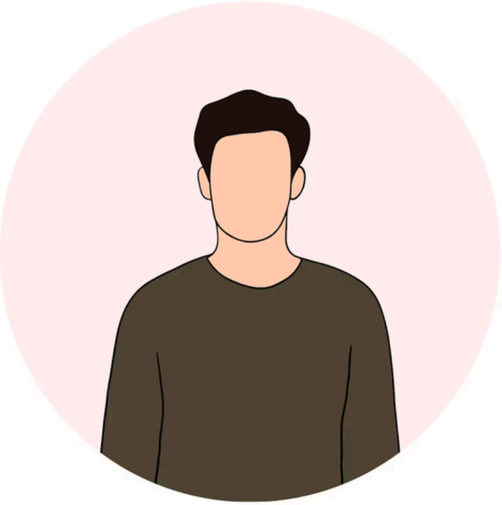
Use a service account if:

- You are running a service and need to authenticate its requests
- You need to access resources that are owned by the service

Lets do some hands on:

Lets create a user, But Kubernetes API will not allow us to create user directly. so there are multiple ways to create user

- client certificates
- bearer tokens
- authenticating proxy
- HTTP basic auth.



I will choose client certificate to create a user which is very easy to create.
This certificates are used to create users. When a user perform any command like **kubectl get po** then K8's API will authenticate and authorize the request.

authentication: permission to login
authorization: permission to work on resources

Steps to create certificate.

- lets create a folder: **mkdir mustafa-user && cd mustafa-user**
- Generate a key using openssl : **openssl genrsa -out mustafa.key 2048**
- Generate a Client Sign Request (CSR) : **openssl req -new -key mustafa.key -out mustafa.csr -subj "/CN=mustafa/O=group1"**
- Generate the certificate (CRT): **openssl x509 -req -in mustafa.csr -CA ~/.minikube/ca.crt -CAkey ~/.minikube/ca.key -CAcreateserial -out mustafa.crt -days 500**

Steps to create user.

- lets create a user: **kubectl config set-credentials mustafa --client-certificate=mustafa.crt --client-key=mustafa.key**

Till now we created user and certificates, but we didn’t add that user to our cluster. Lets do it!

- Set a context entry in kubeconfig: **kubectl config set-context my-context --cluster=minikube --user=mustafa**

Context is used to switch the users in K8s cluster. Because in K8s we cant switch using users, we will add users to context and we will use context to switch b/w users.

- To see the user: **kubectl config view**
- Switch to devops user: **kubectl config use-context my-context**
- Now lets check to create some resources
  - kubectl get po
  - kubectl run pod-1 --image=nginx
  - kubectl create ns dev
- ok! thats cool, thats won’t work, just come back to minikube config and perform same commands, that will work. (**kubectl config use-context minikube**)
- because we created user and attached that user to cluster. But we didn’t mention permissions for that user. minikube context is a admin user which will have all permissions by default
- so lets create a role and attach that role to user.

There are four components to RBAC in Kubernetes:

1. roles
2. Cluster roles
3. role bindings
4. ClusterRoles

1. Roles are the basic building blocks of RBAC. A role defines a set of permissions for a user or group. For example, you might create a role called “admin” that gives the user or group full access to all resources in the cluster.

(or)

Role is a set of permissions that define what actions (verbs) are allowed on specific resources (API groups and resources) within a particular Namespace.
Roles are Namespace-scoped, meaning they apply only to resources within that Namespace.

2. ClusterRoles are special roles that apply to all users in the cluster. For example, you might create a ClusterRole called “cluster-admin” that gives the user or group full access to all resources in the cluster.
These are not Namespace-specific. They define permissions for cluster-wide resources.

3. Role bindings connect users/groups to roles. For example, you might bind the “admin” role to the “admin” user. This would give the “admin” user all the permissions defined in the “admin” role.
It grants the permissions to particular namespaces only.

4. ClusterRoleBindings similar to RoleBindings, ClusterRoleBindings associate ClusterRoles with users/groups across the entire cluster.
These are not Namespace-specific. They grants the permissions for cluster-wide resources.

Lets create a namespace called dev : **kubectl create ns dev**
Now lets create a role that gives permissions to K8s resources

```yaml
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  namespace: dev
  name: dev-role
rules:
- apiGroups: ["*"] # "" indicates the core API group
  resources: ["pods", "deployments"]
  verbs: ["get", "list", "watch", "delete", "create"]
```

Imperative way : **kubectl create role admin --verb=get,list,watch,create,update,delete --resource=pods,deployments -n dev**

Check it : **kubectl get role -n dev**

Now attach this role to user (Role binding):

```yaml
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: dev-rolebinding
  namespace: dev
subjects:
- kind: User
  name: mustafa # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role #this must be Role or ClusterRole
  name: dev-role # must match the name of the Role
  apiGroup: rbac.authorization.k8s.io
```

Imperative way : **kubectl create rolebinding role-binding-name --role=role-name --user=user-name**

Check it : **kubectl get rolebinding -n dev**

we can also check with the permissions : kubectl can-i delete pod --as mustafa

So far we added role and attached that role to user (role binding), Now when we go to dev namespace and login as devops user, we will able to work with pods and deployments only.

Switch to dev ns: **kubectl config set-context --current --namespace=dev**
Login as devops user using context : **kubectl config use-context my-context**

make sure to check check the configs before going to test the role (**kubectl config view --minify)**

```
contexts:
- context:
    cluster: minikube
    namespace: dev
    user: mustafa
  name: my-context
```

Now we can able to work with pods and deployments.

Note: for only one namespace (dev).

Mustafa user cant get any resources from any other namespaces because we used rolebinding. If mustafa want to access the resources from all namespaces we can use clusterrolebinding

First lets change the context to minikube and go to default namespace

Lets create cluster role:

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: dev-clusterrole
rules:
- apiGroups: ["*"] # "" indicates the core API group
  resources: ["pods", "deployments"]
  verbs: ["get", "list", "watch", "delete", "create"]
```

Imperative way : **kubectl create clusterrole my-cluster-role --verb=get,list,create,update,delete --resource=pods,services**

Check it : **kubectl get clusterrole**

Lets create cluster role binding:

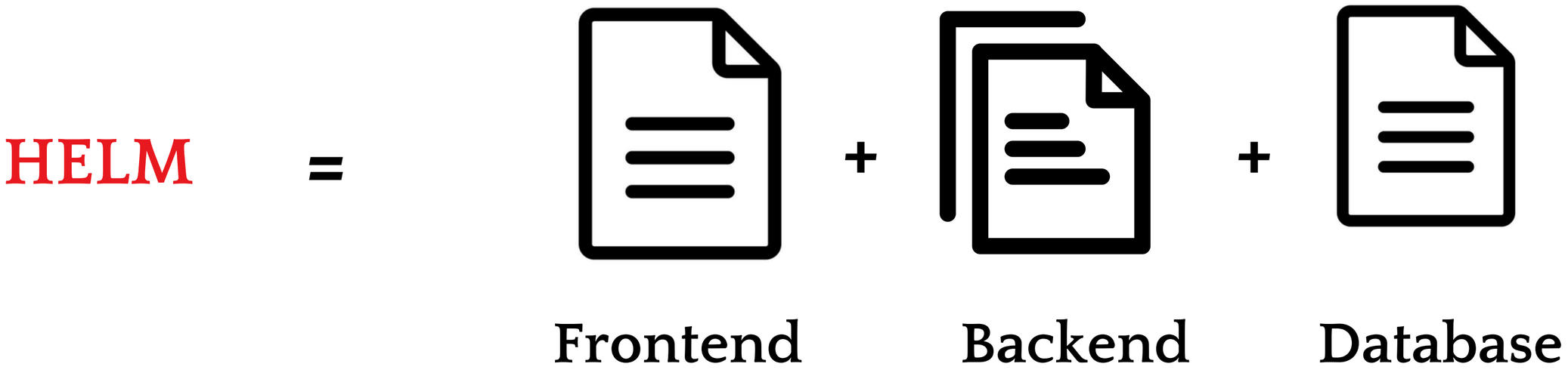
```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: dev-clusterrolebinding
subjects:
- kind: User
  name: mustafa # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: ClusterRole #this must be Role or ClusterRole
  name: dev-clusterrole # must match the name of the Role
  apiGroup: rbac.authorization.k8s.io
```

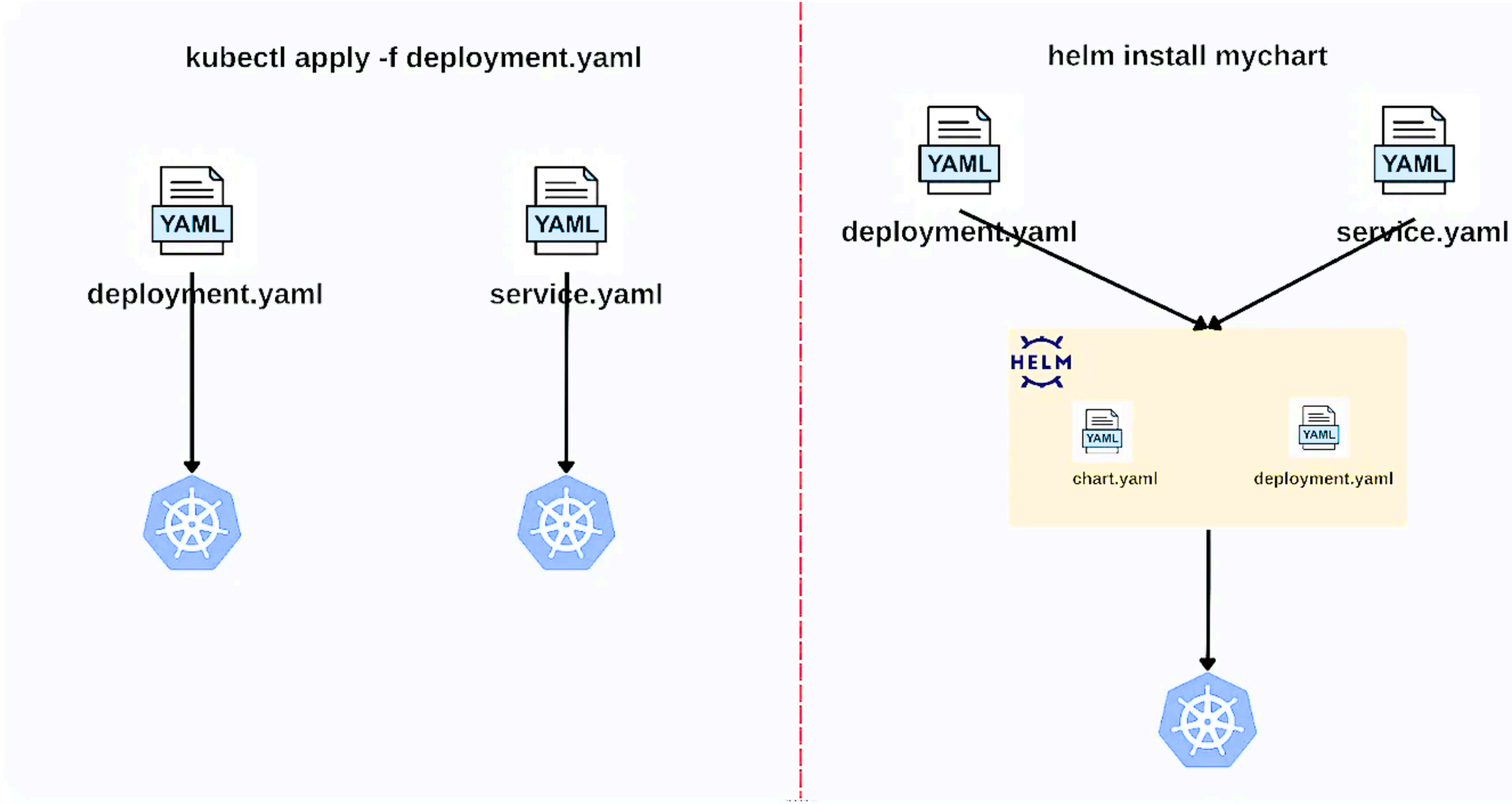
Imperative way : **kubectl create clusterrolebinding cluster-binding-name --clusterrole=role-name --user=user-name**
Check it : **kubectl get clusterrolebinding**

After creating the clusterrole and attached that role to cluster role binding, its time to check weather mustafa user can have access to work with resources in all namespaces or not.

HELM

Helm is a Kubernetes package manager in which the multiple numbers of YAML files such as the backend, and frontend come under one roof(helm) and deploy using helm.




kubectl apply -f deployment.yaml
YAML
deployment.yaml
YAML
service.yaml
helm install mychart
YAML
deployment.yaml
YAML
service.yaml
HELM
YAML
chart.yaml
YAML
deployment.yaml

- Lets say if you want to deploy an application called paytm. It contains multiple services. So we need to deploy each service, for that we have to write 2 manifest(deployment & service) files for each service.
- At the end we can see multiple YAML files which makes more confusion and messy.
- Instead of maintaining those multiple YAML files we can do this by implementing HELM. It will deploy our entire application.
- HELM is a package manager for kubernetes which makes deployment simple.

Key Concepts of HEML:

- Charts: In Helm, a chart is a collection of pre-configured Kubernetes resources that describe a related set of services. Charts can include deployment configurations, service definitions, ingress rules, and more. Think of a chart as a package that encapsulates everything needed to run a specific application.
- Templates: Helm uses Go templating to dynamically generate Kubernetes manifest files from chart templates. This means you can parameterize and customize your resources based on user-defined values or other inputs. This templating mechanism allows you to create reusable and flexible configurations.

- Values: Values are customizable parameters that can be injected into chart templates during deployment. You can define default values in a values.yaml file and override them when installing or upgrading a chart. This allows you to configure your application differently for various environments or use cases.
- Repositories: Helm repositories are collections of packaged charts that users can install. The Helm CLI can search, fetch, and install charts from these repositories. You can also create your own private repository to store custom charts.

Advatnages of HEML:

It will save the time

Helps to automate the application deployment

Better scalability

Perform rollback at anytime

Increase the speed of deployment.

Install HEML:

- curl -fsSL -o get_helm.sh https://raw.githubusercontent.com/helm/helm/main/scripts/get-helm-3
- chmod 700 get_helm.sh
- ./get_helm.sh
- helm version

HELM commands:

- To list all helm repos : helm repo list
- To download any repo : helm repo add repo_name url (**helm repo add myhelm https://charts.helm.sh/stable**)
- To remove a repo from helm : helm repo remove repo-names

Deploy a sample Nginx page using HELM:

1. Create a helm chart : helm create devops

   Now we can see devops folder will gets created.

```
[root@ip-172-31-17-125 ~]# helm create devops
Creating devops
[root@ip-172-31-17-125 ~]# ll
total 0
drwxr-xr-x 4 root root 93 Jan 25 08:49 devops
[root@ip-172-31-17-125 ~]#
```

2. Enter into the folder and open **values.yml** file
3. Change the service type from **ClusterIP to NodePort** on line 43

4. Now install helm : helm install mustafa .

here dot(.) represents that pwd where our Chart.yaml present

mustafa is release name

```
[root@ip-172-31-17-125 devops]# helm install mustafa .
NAME: mustafa
LAST DEPLOYED: Thu Jan 25 08:52:10 2024
NAMESPACE: default
STATUS: deployed
REVISION: 1
NOTES:
1. Get the application URL by running these commands:
  export NODE_PORT=$(kubectl get --namespace default -o jsonpath="{.spec.ports[0].nodePort}" services mustafa-devops)
  export NODE_IP=$(kubectl get nodes --namespace default -o jsonpath="{.items[0].status.addresses[0].address}")
  echo http://$NODE_IP:$NODE_PORT
[root@ip-172-31-17-125 devops]#
```

5. Now we can see pods, deployments, services will be created automatically.

Now we can access those nginx page using slaveip:node-port

6. To get helm release list : helm list (or) helm ls

6. Now lets scale up the replicas in values.yml (change value from 1 to 4)
7. To update those changes we will use : helm upgrade mustafa .
8. Now lets see the pods count, it will gets increased from 1 to 4.
9. Now we can see the release using the command helm list then revision(version) will gets increased from 1 to 2
10. To rollback to prev revision : helm rollback mustafa 1

The above command will rollback to 1st version

Once we perform the above command we can see the pods count will be scaledown from 4 to 1 again.

General commands about HELM:

- To uninstall helm : helm uninstall mustafa
- If you want to dry-run the chart before installation : helm install devops --debug --dry-run .
- Validate all the YAML files in our HELM charts : helm list .
- To get template of our helm : helm template .
- To see the history of a release : helm history mustafa

GITOPS:

GitOps is a way of managing software infrastructure and deployments using Git as the source of truth.

Git as the Source of Truth: In GitOps, all our configurations like (deployments, services, secrets etc..) are stored in git repository.

Automated Processes: Whenever we make any changes in those YAML files gitops tools like (Argo CD/ Flux) will detects and apply those changes on kubernetes cluster. It ensures that the live infrastructure matches the configurations in the Git repository.

Here, we can clearly observe that continuous deployment. Whenever we make any changes in git, it will automatically reflects in kubernetes cluster.

WITHOUT ARGO CD:

Before ARGO CD, we deployed applications manually by installing some third party tools like kubectl, helm etc...

If we are working with KOPS, we need to provide our configuration details (RBAC) or If we are working on EKS, we need to provide our IAM credentials.

If we deploy any application, there is no GUI to see the status of the deployment.

so we are facing some security challenges and need to install some third party tools.

Points to be noted:

1. Once if we implement ArgoCD, if we make any changes manually in our cluster using the kubectl command, Kubernetes will reject those request from that user. Because when we apply changes manually, ArgoCD will check the actual state of the cluster with the desired state of the cluster (GitHub).
2. If we make any changes in the GitHub like increasing the replicas in deployment ArgoCD will take the changes and applies in our cluster. So that we can track each and every change and it will maintain the history.
3. We can easily rollback using git if something went wrong.
4. If our entire cluster gets deleted due to some network or other issues, we don’t need to worry about it, because all our configuration files are safely stored in GitHub. So we can easily re-apply those configuration files.

Access controls:

1. In K8s, we use RBAC concept to give cluster permissions which is high configurations and high maintenance. But in ArgoCD, just look over here

ops team

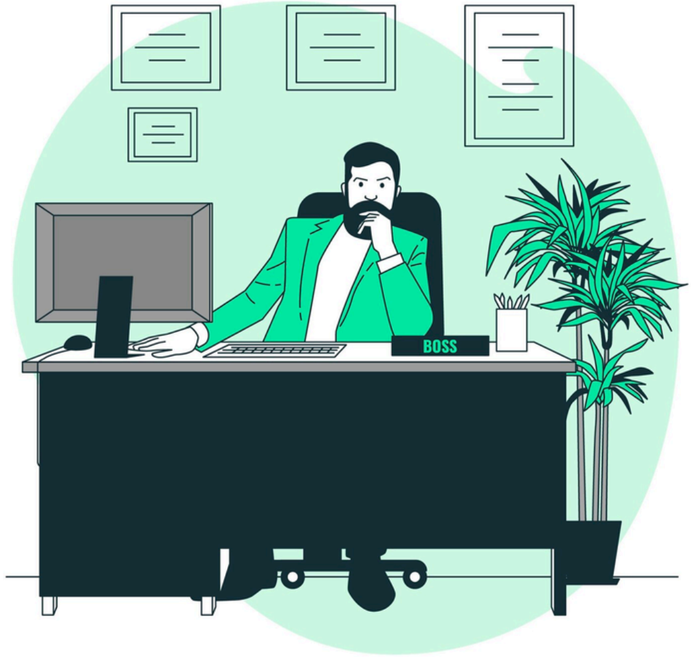
fresher

devops

merge request

merge request

merge request



The boss
(Admin)
Person who accepts pull requst

FEATURES:

- Automated deployment of applications to specified target environments
- Ability to manage and deploy to multiple clusters
- Multi-tenancy and RBAC policies for authorization
- Rollback/Roll-anywhere to any application configuration committed in the Git repository
- Health status analysis of application resources
- Automated configuration drift detection and visualization
- Automated or manual syncing of applications to its desired state
- Web UI which provides a real-time view of application activity
- CLI for automation and CI integration
- Webhook integration (GitHub, BitBucket, GitLab)
- Access tokens for automation
- PreSync, Sync, PostSync hooks to support complex application rollouts (e.g.blue/green & canary upgrades)
- Audit trails for application events and API calls
- Prometheus metrics
- Parameter overrides for overriding helm parameters in Git.

FINAL PROJECT:

- CREATE A CLUSTER IN KOPS WITH 1 MASTER & 2 WORKERS
- CREATE A NAME SPACE
- CREATE A DEPLOYMENT WITH IN THE NAMESPACE
- INCREASE THE REPLICAS
- EXPOSE IT USING NODE PORT
- ACCESS THE APPLICATION