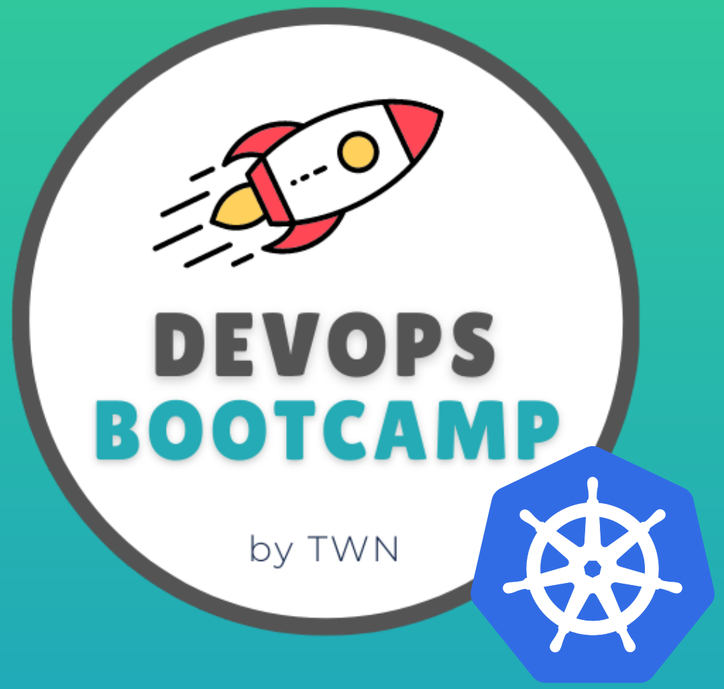


Container Orchestration with Kubernetes

Key Takeaways

TECHWORLD WITH NANA

Introduction to Kubernetes

TECHWORLD WITH NANA

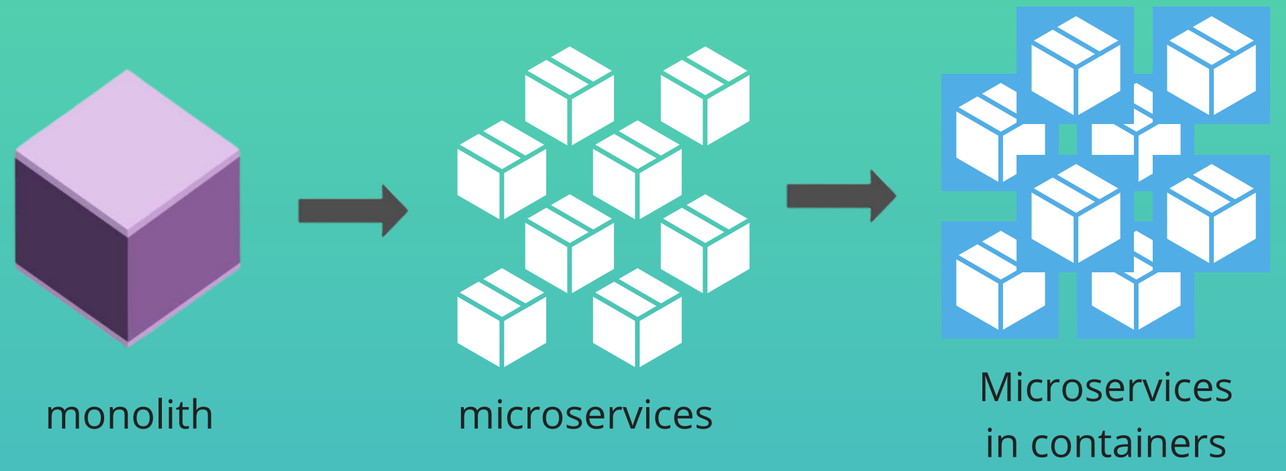
Official Definition

- Open source **container orchestration tool**
- Developed by **Google**
- **Automates** many processes involved in deploying, managing and scaling containerized applications

- **Most used** container orchestration platform
- Also known as "K8s" or "Kube"

The need for Kubernetes

- Trend from **Monolith to Microservices**
- Containers are the perfect host for microservice applications
- Resulted in an **increased usage of containers**



- Manually **managing hundreds or hundreds of 1000s containers** is a lot of effort

- Kubernetes automates many of those manual tasks and provides
  - **High Availability** or no downtime
  - Automatic **Scaling**
  - **Disaster Recovery** - Backup and Restore
  - **Self-Healing**

Core Kubernetes Components - 1

Kubernetes has many components, but these are the **main ones you need to know**:

POD

SERVICE

INGRESS

CONFIGMAP

SECRET

DEPLOYMENT

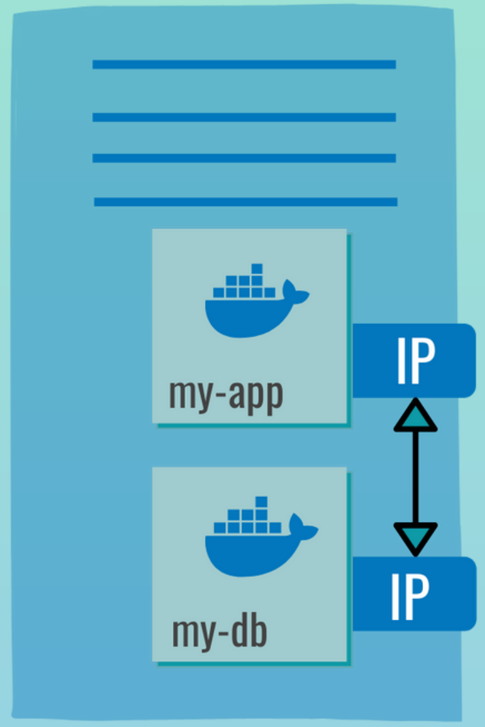
STATEFULSET

VOLUMES

Core Kubernetes Components - 2

POD

- Group of 1 or more containers
- Smallest unit of K8s
- An abstraction over container
- Usually 1 application/container per Pod
- Pods are ephemeral

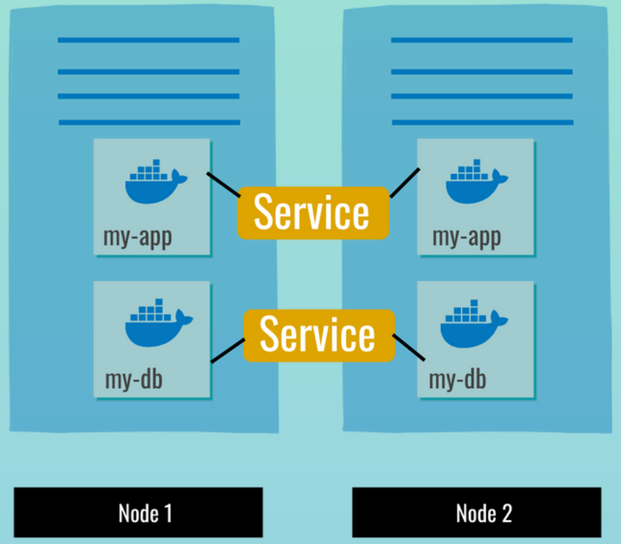


❌ New IP address assigned on re-creation

Core Kubernetes Components - 3

SERVICE

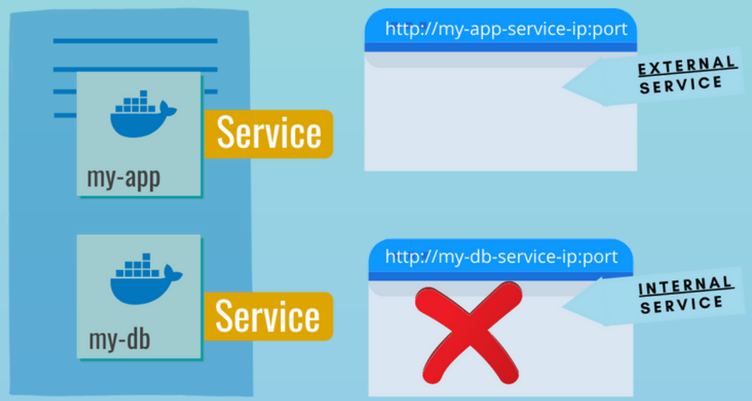
- Basically a static or **permanent IP address** that can be attached to each Pod
- Also serves as a **loadbalancer**
- **Lifecycles** of Service and Pod are **not connected**
- If Pod crashes, the Service and its IP address will be the same



Internal vs External Service

When creating a service you can specify its **type:**

- **Internal Service**: By default, for example a database, which should not be accessible from outside
- **External Service**: Application accessible through browser



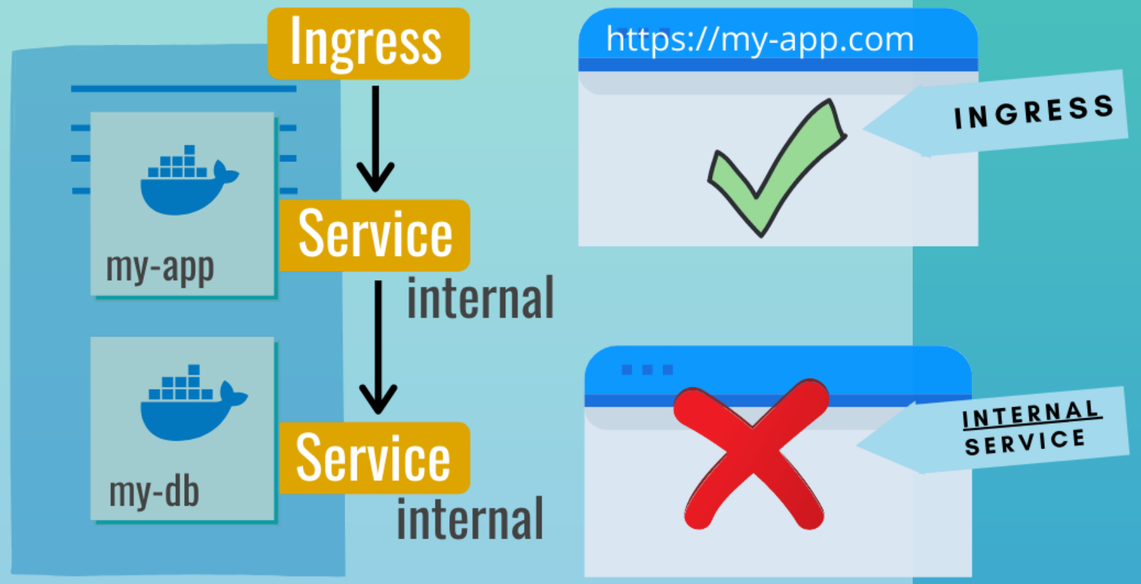
Core Kubernetes Components - 4

URL of external Service: → http://124.89.101.2:8080

URL of Ingress Service: → https://my-app.com

INGRESS

- Ingress is the **entrypoint to your K8s cluster**
- Request goes to Ingress first, which does the forwarding to the Service



TECHWORLD WITH NANA

Core Kubernetes Components - 5

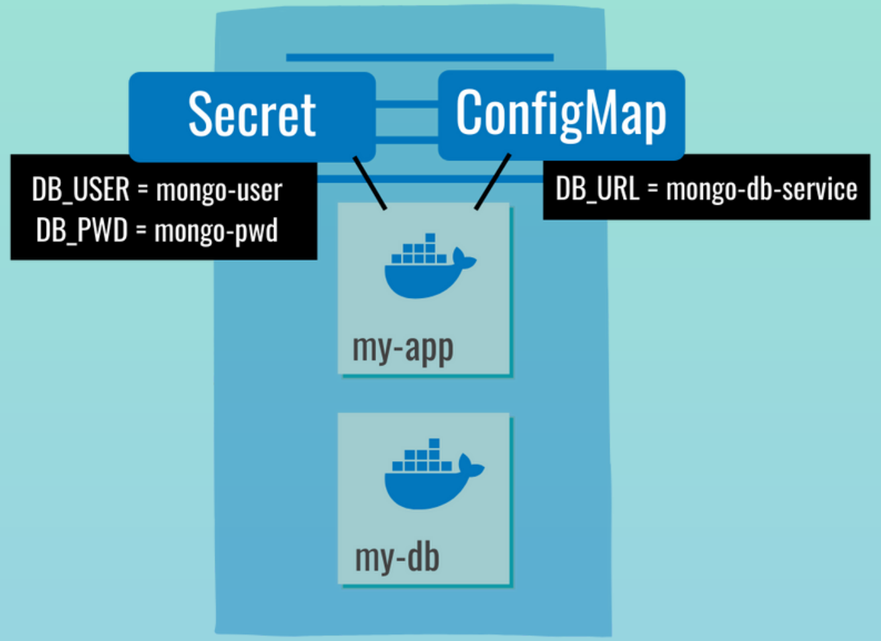
For **external configuration**, Kubernetes has these 2 components:

CONFIGMAP

- To **store non-confidential data** in key-value pairs

SECRET

- Similar to ConfigMap, but to **store sensitive data** such as passwords or tokens



- **Pods can consume** ConfigMaps and Secrets as environment variables, CLI arguments or as config files in a Volume

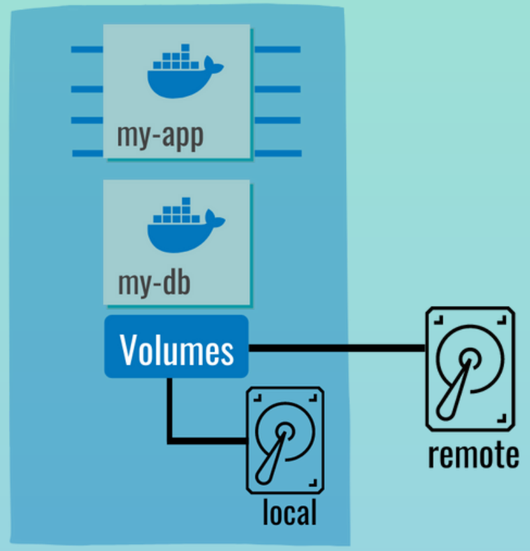
Storing the data in a Secret component doesn't automatically make it secure. There are built-in mechanisms (like encryption, defining authorization policies) for basic security, which are not enabled by default! Recommended to use third-party secret management tools, because the provided capabilities by K8s are not enough for most companies

Core Kubernetes Components - 6

When a container crashes, K8s restarts the container but with a clean state. Meaning your **data is lost**!

VOLUME

- Volume component basically **attaches a physical storage** on a hard drive to your Pod
- Storage could be either on a local server or outside the K8s cluster



Think of storage as an **external hard drive plugged in** to your K8s cluster

K8s doesn't manage any data persistence, meaning **you are responsible for backing up, replicating the data etc.**

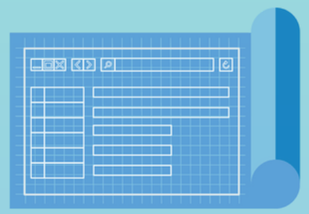
TECHWORLD WITH NANA

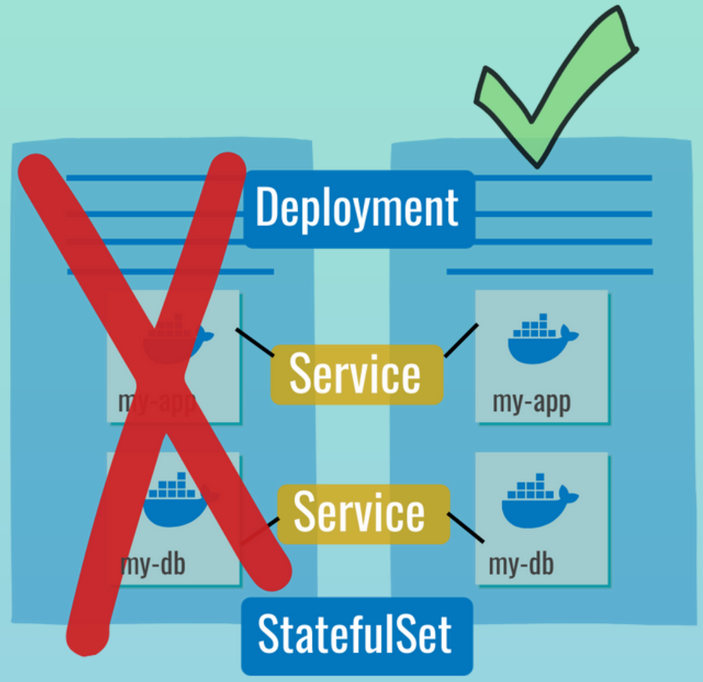
Core Kubernetes Components - 7

Deployment and StatefulSet are an abstraction of Pods

DEPLOYMENT

- **Blueprint for Pods**
- You work with Deployments and by defining the number of **replicas**, K8s creates Pods





STATEFULSET

- **Blueprint for stateful applications**
- Like databases etc
- In addition to **replicating features**, StatefulSet makes sure database reads and writes are synchronized to **avoid data inconsistencies**

Having load balanced replicas our setup is much **more robust**

TECHWORLD WITH NANA

Kubernetes Architecture

TECHWORLD WITH NANA

2 Types of Nodes

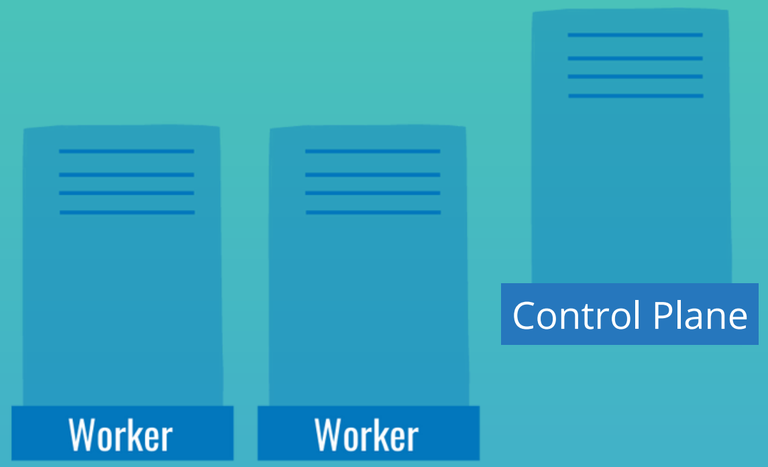
- A Kubernetes cluster consists of a set of worker machines, called "Nodes"

Worker Node

- The **containerized applications run on the Worker Nodes**
- Each Node runs multiple Pods on it
- Much more compute resources needed, because the actual workload runs on them

Control Plane

- **Manages** the Worker Nodes and the Pods in the cluster
- Much more important and needs to be replicated
- So in production, replicas run across multiple machines



Worker Node Components

Each worker node needs to have **3 processes installed:**

1) Container Runtime

- Software responsible for running containers
- For example containerd, CRI-O or Docker

2) Kubelet

- Agent that makes sure containers are running in a Pod
- Talks to underlying server (to get resources for Pod) and container runtime (to start containers in Pod)

3) Kube-proxy

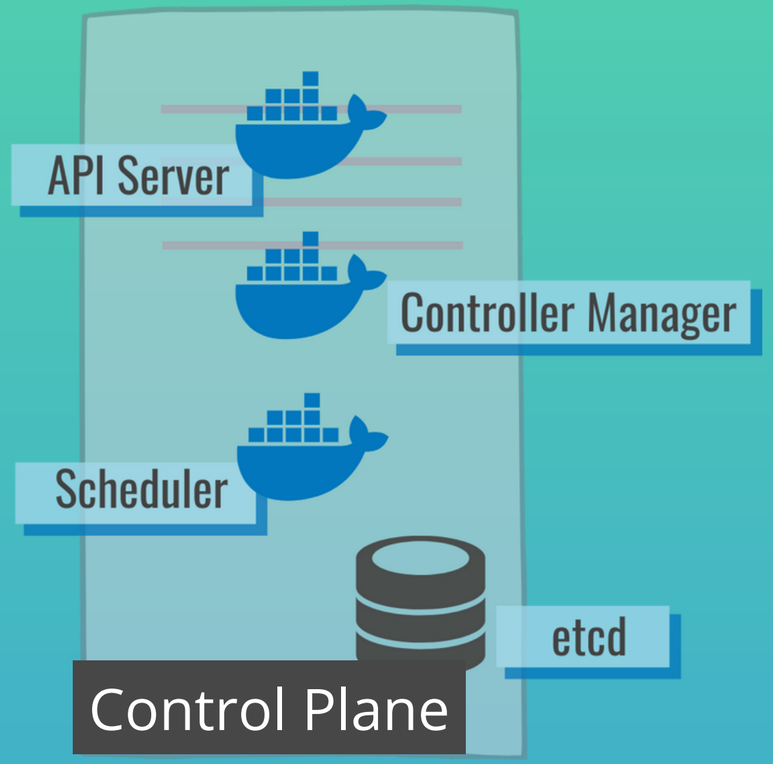
- A network proxy with **intelligent forwarding** of requests to the Pods

Control Plane Components - 1

- Each control plane needs to have **4 processes installed:**

  1) API Server
  2) Scheduler
  3) Controller Manager
  4) etcd

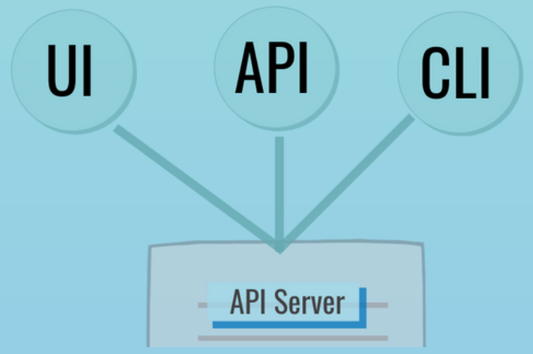
- Control Plane makes global decisions about the cluster
- Detects and responds to cluster events



Control Plane Components - 2

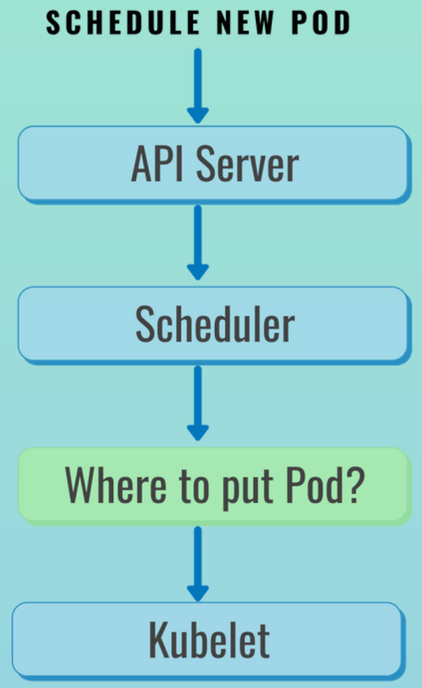
1) API Server

- The cluster gateway - **single entrypoint to the cluster**
- Acts as a gatekeeper for authentication, validating the request
- Clients to interact with the API server: UI, API or CLI



2) Scheduler

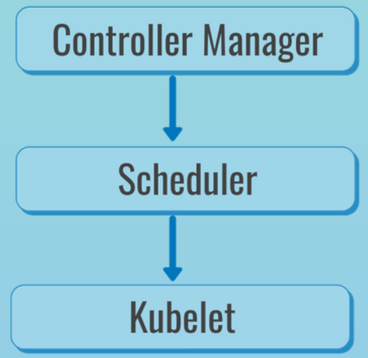
- **Decides** on which Node new Pod should be scheduled
- Factors taken into account for scheduling decisions: resource requirements, hardware/software/ policy constraints, data locality, ...



Control Plane Components - 3

3) Controller Manager

- **Detects state changes**, like crashing of Pods and tries to recover the cluster state as soon as possible
- For that it makes **request to the Scheduler** to reschedule those Pods and the same cycle happens



4) etcd

- K8s' backing **store for all cluster data**. A consistent, high-available key-value store
- Think of it as a cluster brain, every change in the cluster gets saved or updated into it
- **All other processes** like Scheduler, Controller Manager etc **work based on the data in etcd** as well as communicate with each other through etcd store

The **actual application data is NOT stored** in the etcd store

Increase Kubernetes Cluster Capacity

As your application grows and its demand for resources increases, you may actually **add more Nodes** to your cluster, thus forming a more powerful and robust cluster to meet your application resource requirements

Add a Control Plane Node

1. Get a fresh new server
2. Install all control plane processes on it
3. Join it to the K8s cluster using a K8s command

Add a Worker Node

1. Get a fresh new server
2. Install all the Worker Node processes, like container runtime, Kubelet and KubeProxy on it
3. Join it to the K8s cluster using a K8s command

TECHWORLD WITH NANA

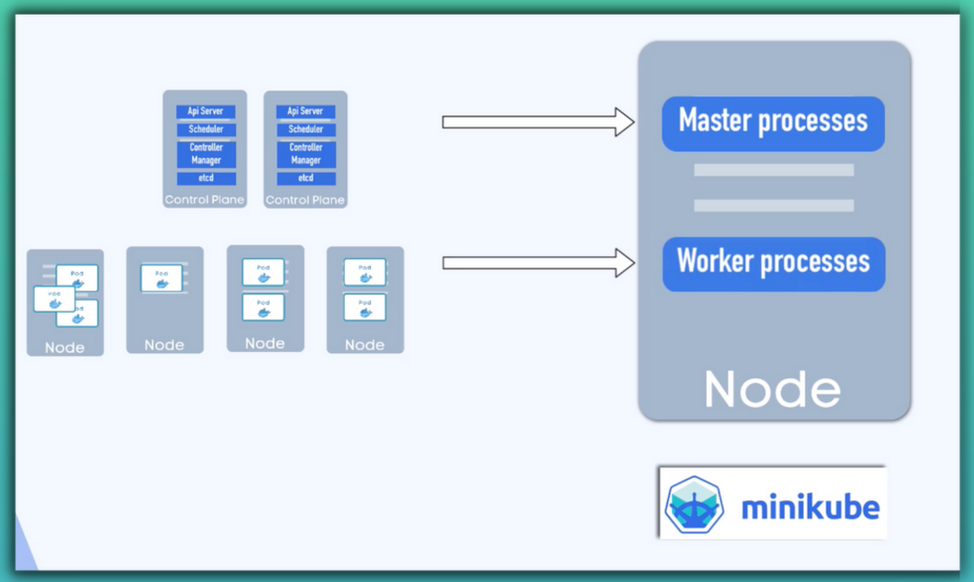
Deep Dive into Kubernetes

TECHWORLD WITH NANA

Minikube - Local Cluster Setup

- Minikube implements a local K8s cluster
- Useful for local K8s application development,

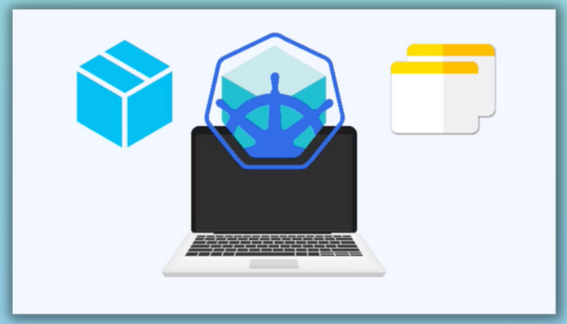
  because running a test cluster would be complex



✅ Control Plane and Worker

processes run on **ONE machine**

Run Minikube either as a **container** or **virtual machine** on your laptop



- So you need a container runtime or virtual

  machine manager on your laptop

Kubectl - Command Line Tool

- CLI Tool to **interact with your K8s cluster**
- In order for kubectl to access a K8s cluster, it needs a **kubeconfig file**, which is created automatically when deploying your minikube cluster
- By default, config file is located at ***~/.kube/config***

Basic kubectl commands:

```
kubectl get {k8s-component}
kubectl get nodes
kubectl get pods
kubectl get services
kubectl get deployment

kubectl create {k8s-component} {name} {options}
kubectl create deployment my-nginx-depl --image=nginx

kubectl edit {k8s-component} {name}
kubectl delete {k8s-component} {name}

kubectl logs {pod-name}
kubectl describe {pod-name}

kubectl exec -it {pod-name} -- bash
kubectl apply -f config-file.yaml
```

Get status of different components

CRUD

Debugging

K8s YAML Configuration File - 1

- Also called "Kubernetes manifest"
- Declarative: A manifest **specifies the desired state** of a K8s component
- Config files are in **YAML format**, which is user-friendly, but **strict indentation**!
- Config files should be stored in version control

Each configuration file has **3 parts**:

1) metadata

nginx-deployment.yaml

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels: ...
spec:
  replicas: 2
  selector: ...
  template: ...
```

nginx-service.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  selector: ...
  ports: ...
```

2) specification

- Attributes of "spec" are specific to the kind

TECHWORLD WITH NANA

K8s YAML Configuration File - 2

Current status: 1 replica

```yaml
status:
  availableReplicas: 1
  conditions:
  - lastTransitionTime: "2020-01-24T10:54:59Z"
    lastUpdateTime: "2020-01-24T10:54:59Z"
    message: Deployment has minimum availability.
    reason: MinimumReplicasAvailable
    status: "True"
    type: Available
  - lastTransitionTime: "2020-01-24T10:54:56Z"
    lastUpdateTime: "2020-01-24T10:54:59Z"
    message: ReplicaSet "nginx-deployment-7d64f4b
    reason: NewReplicaSetAvailable
    status: "True"
    type: Progressing
  observedGeneration: 1
  readyReplicas: 1
  replicas: 1
  updatedReplicas: 1
```

3) status

- **Automatically generated** and added by Kubernetes
- K8s gets this information from etcd, which holds the current status of any K8s component

Desired status: 2 replica

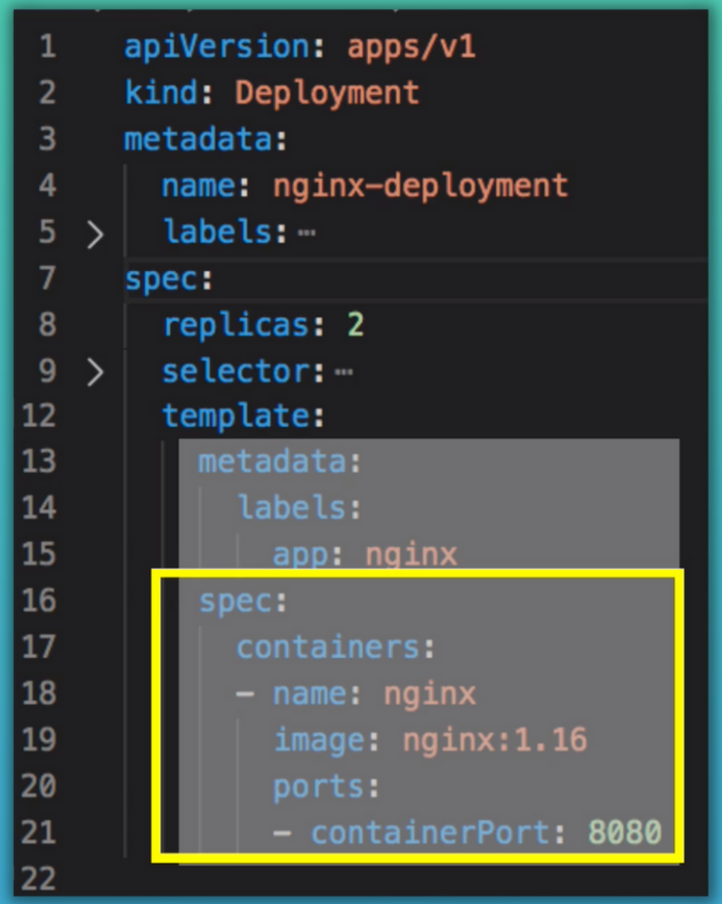
nginx-deployment.yaml

```yaml
1   apiVersion: apps/v1
2   kind: Deployment
3   metadata:
4     name: nginx-deployment
5     labels: …
7   spec:
8     replicas: 2
9     selector: …
12    template: …
22
```

TECHWORLD WITH NANA

Deployment Configuration File

- Deployment Configuration is a bit special



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels: ...
spec:
  replicas: 2
  selector: ...
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
      - name: nginx
        image: nginx:1.16
        ports:
        - containerPort: 8080
```

- Since it's an abstraction over Pod, we have the **Pod configuration inside Deployment configuration**
- Own "metadata" and "spec" section
- Blueprint for Pod

TECHWORLD WITH NANA

Labels & Selectors

Labels

- Labels are **key/value pairs** that are attached to resources, such as Pods.
- Used to specify identifying attributes that are meaningful and relevant to users

Label **Selectors**

- Labels do not provide uniqueness
- Via **selector the user can identify a set of resources**

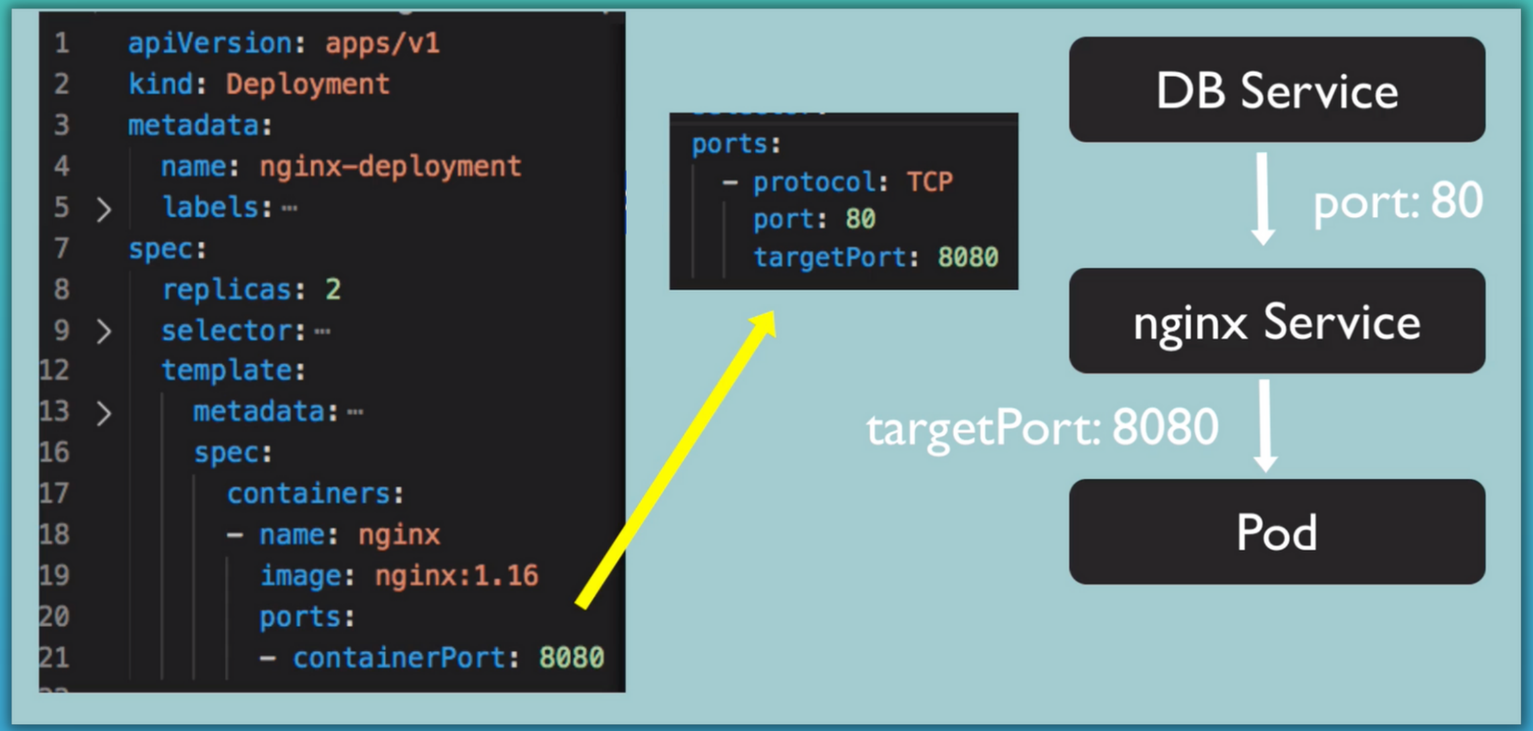
Connecting Services to Deployments

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: nginx-deployment
  labels:
    app: nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  selector:
    app: nginx
  ports:…
```

Ports in Service and Pod

- In Service component you need to specify:
  - **port** = the port where the service itself is accessible
  - **targetPort** = port, the container accepts traffic on
- In Deployment component:
  - **containerPort** = port, the container accepts traffic on



Browser Request Flow through the K8s components

Example Setup:

- Mongo Express as UI
- MongoDB as database
- User updates entries in database via browser
- ConfigMap and Secret holds the MongoDB's endpoint (Service name of MongoDB) and credentials (user, pwd), which gets injected to MongoExpress Pod, so MongoExpress can connect to the DB

K8s Components needed in this setup

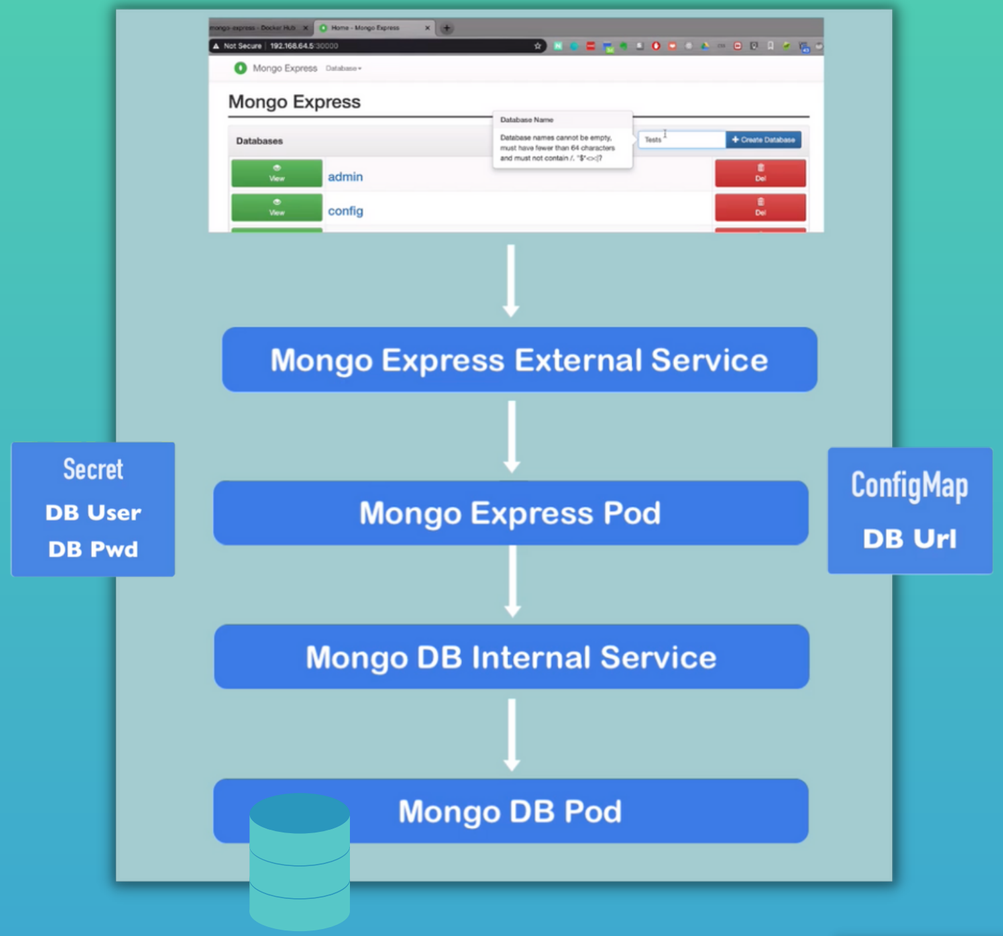
2 Deployment / Pod

2 Services

1 ConfigMap

1 Secret

URL: IP address of Node + Port of external Service



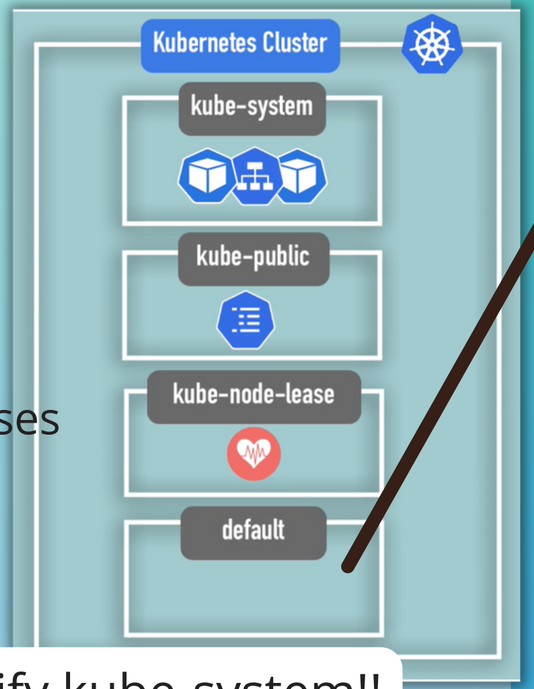
TECHWORLD WITH NANA

Namespaces - 1

- Namespaces provide a **mechanism for isolating groups of resources** within a single cluster
- Names of resources need to be unique within a namespace, but not across namespaces
- Like a virtual cluster inside a cluster

Namespaces per default

- Namespaces per default, when you install K8s
- "kube-system" has control plane processes running



DON'T modify kube-system!!

"Default" namespace

- Start deploying your application in the default namespace called "default"

Create a new namespace

- Via **kubectl** command: *kubectl create namespace my-ns*
- Via **configuration file**:

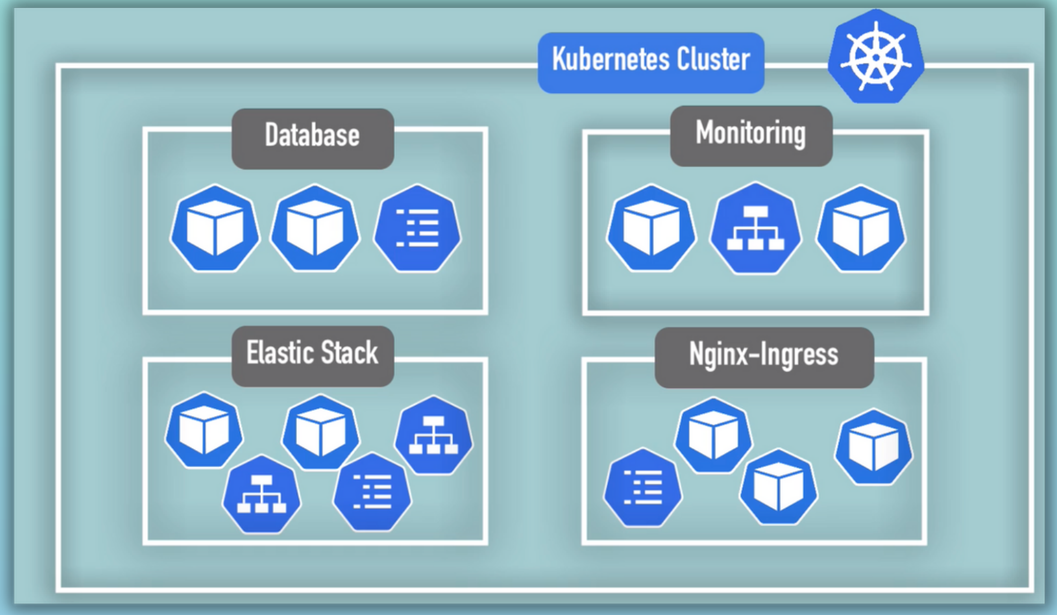
```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: mysql-configmap
  namespace: my-namespace
data:
  db_url: mysql-service.database
```

Namespaces - 2

Use Cases for when to use namespaces:

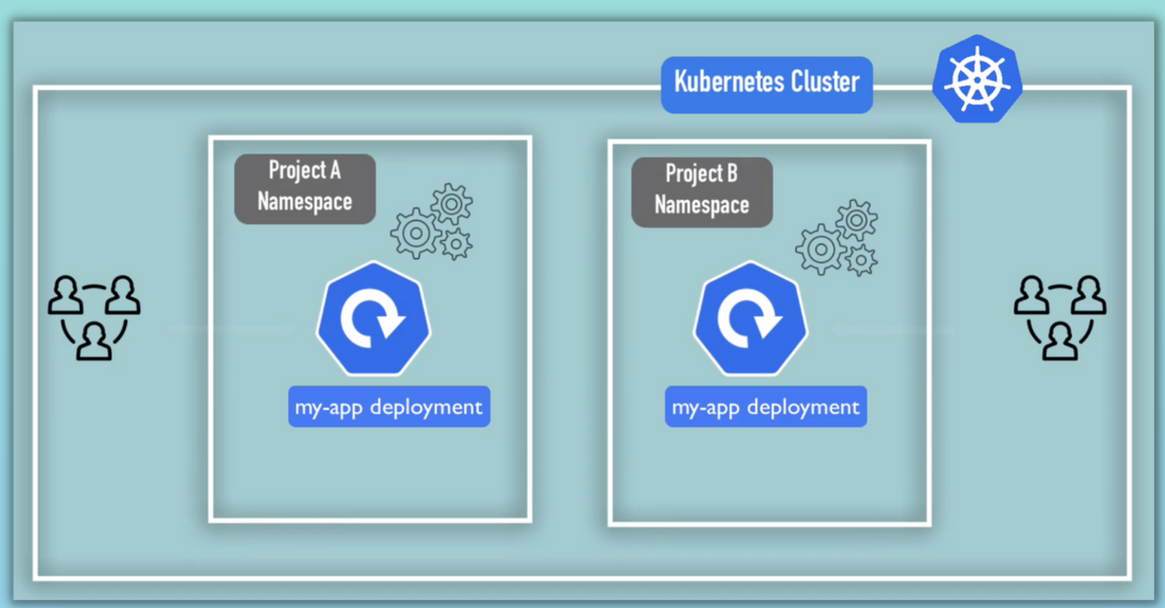
1 - Group resources logically

- Instead of having all in the "default" namespace



2 - Isolate team resources

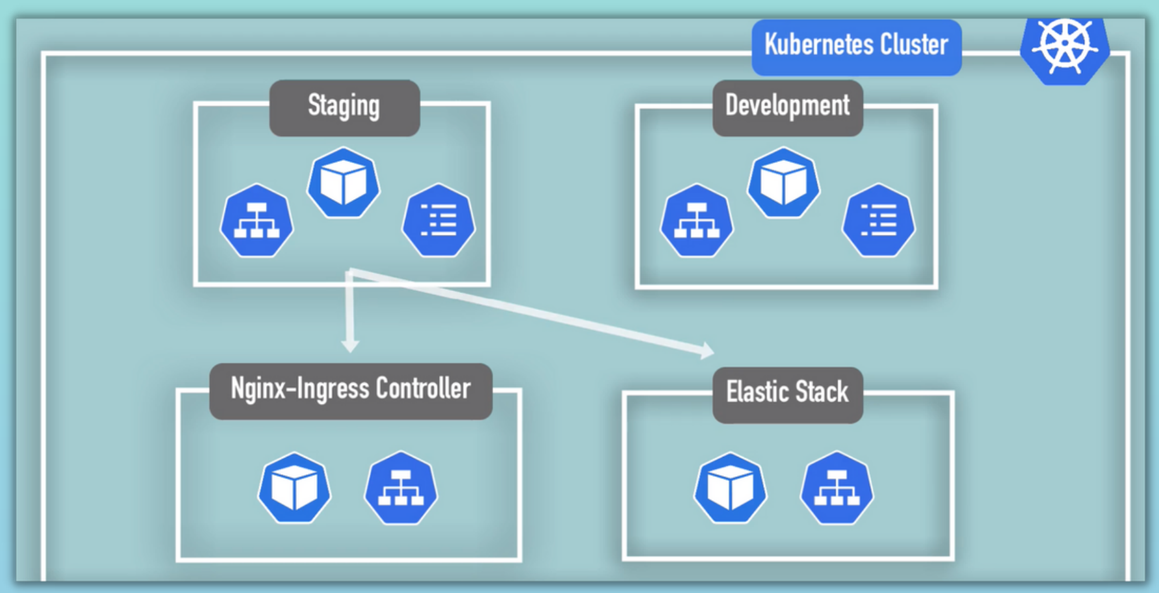
- To avoid conflicts



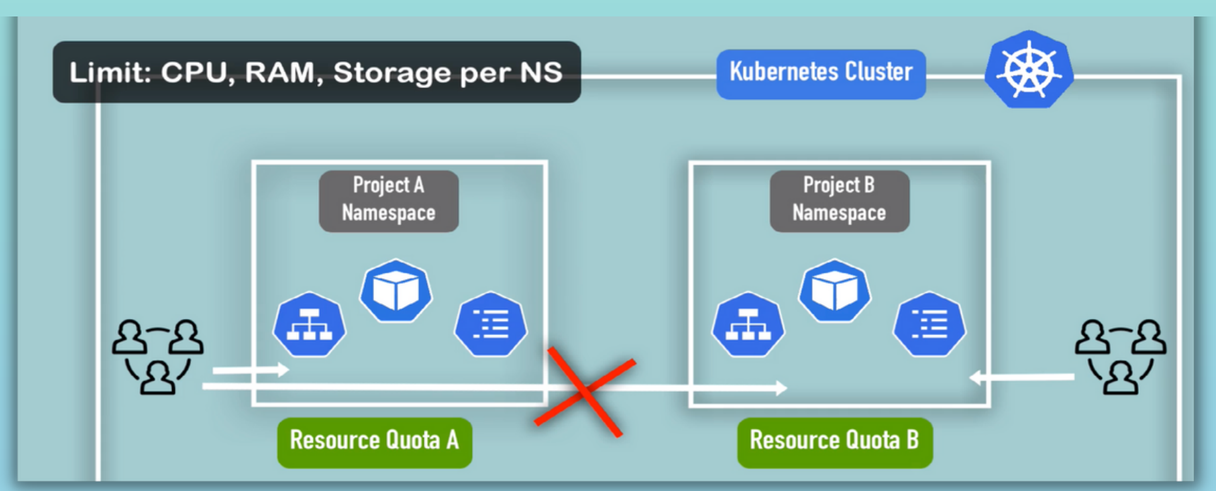
Namespaces - 3

Use Cases for when to use namespaces:

3 - Share resources between different environments



4 - Limit permissions and compute resources for teams

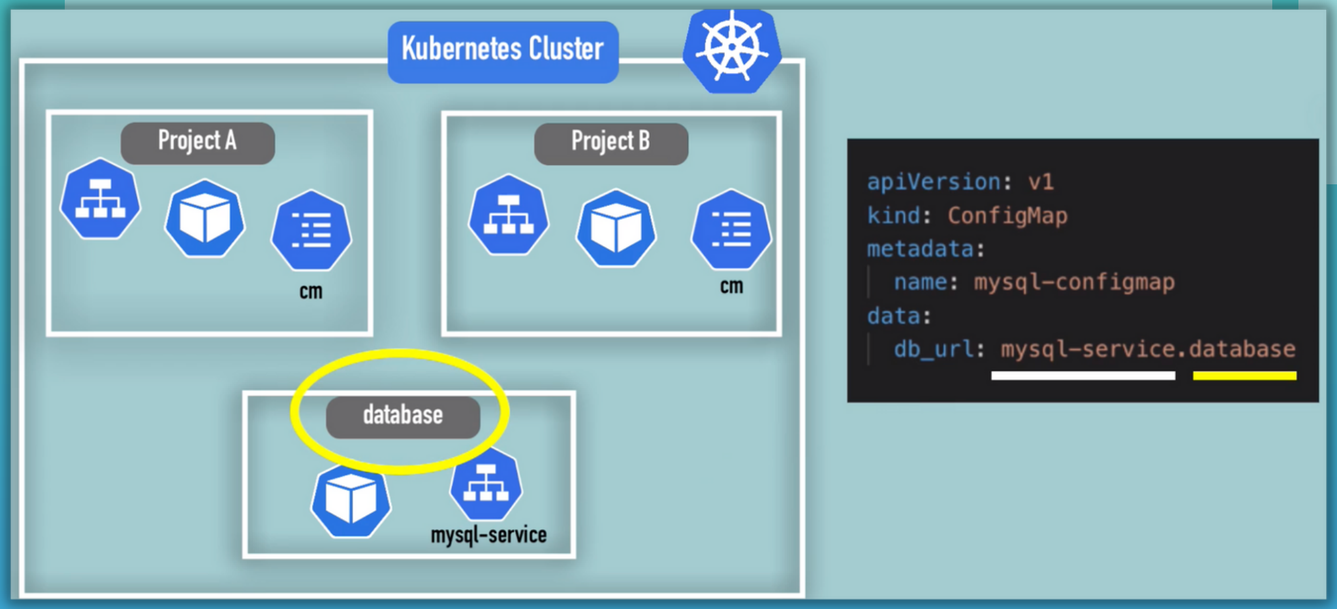


Namespaces - 4

- There are resources, which can't be created within a namespace, called cluster-wide resources:

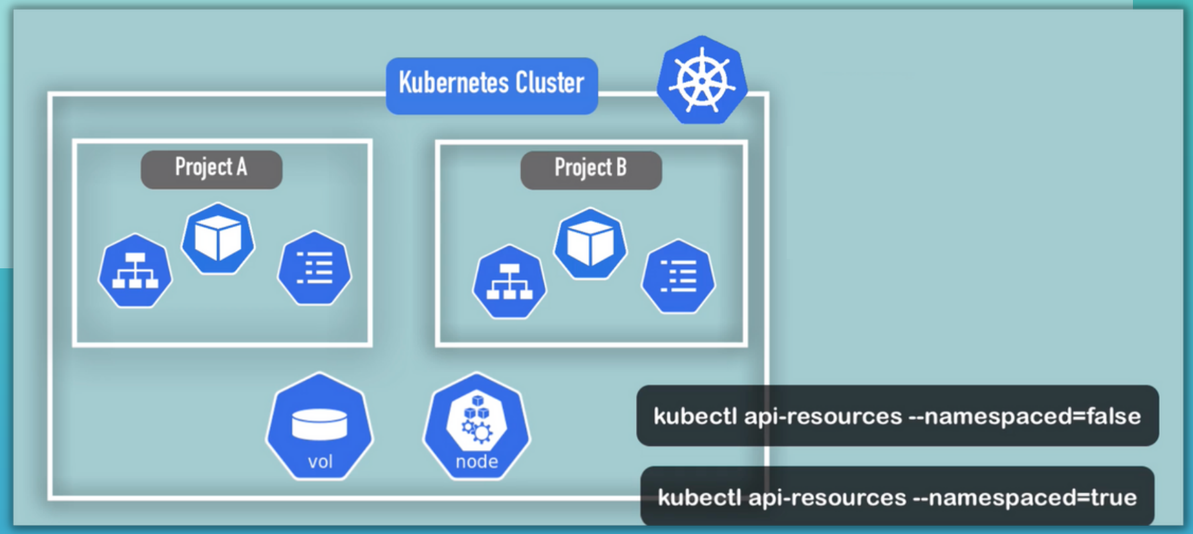
Namespaced resources

- Most K8s resources (e.g. pods, services, etc.) are in some namespaces
- Access service in another namespace:



Cluster-wide resources

- Live globally in a cluster, you can't isolate them
- Low-level resources, like Volumes, Nodes



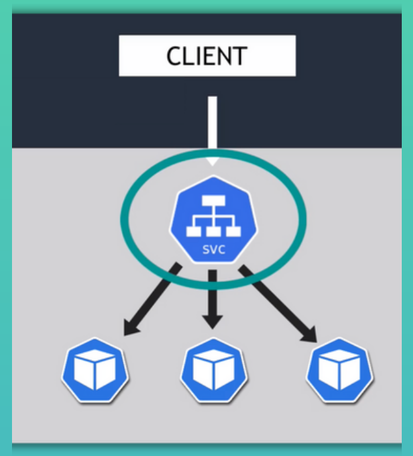
TECHWORLD WITH NANA

Deep Dive into Kubernetes Services

TECHWORLD WITH NANA

Kubernetes Services - 1

- Abstract way to expose an application running on a set of Pods
- Different types of services:



Why Service?

- Stable IP address
- Loadbalancing
- Loose coupling
- Within & Outside Cluster

3 Service type attributes

ClusterIP

```
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  type: ClusterIP
```

NodePort

```
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  type: NodePort
```

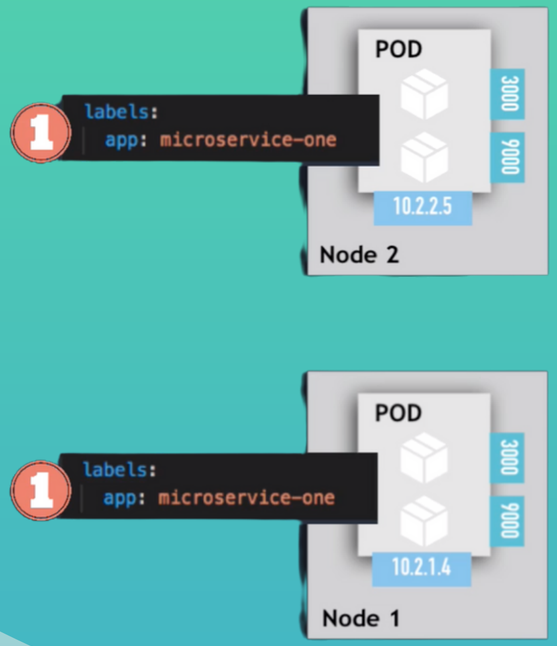
LoadBalancer

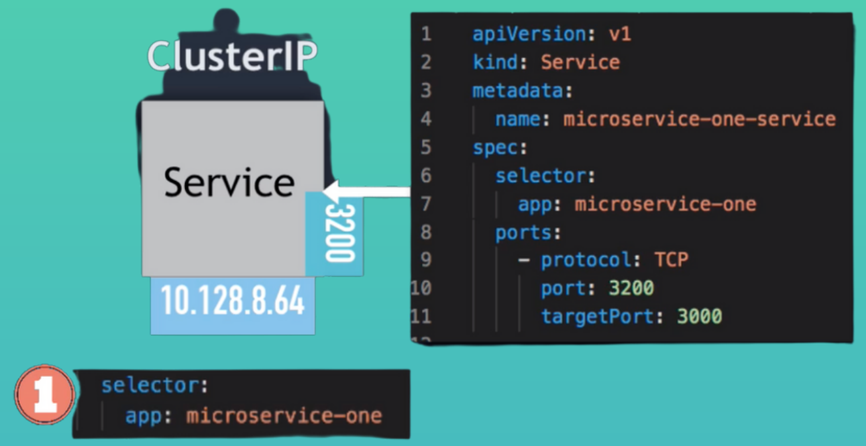
```
apiVersion: v1
kind: Service
metadata:
  name: my-service
spec:
  type: LoadBalancer
```

- ClusterIP is the **default type**, when you don't specify a type

Kubernetes Services - 2

- Service defines a logical set of Pods
- The set of Pods targeted by a Service is **determined by a selector**





This creates a new Service named "miroservice-one-service", which **targets port 3000 on any Pod with the *app=microservice-one* label**.

PORTS:

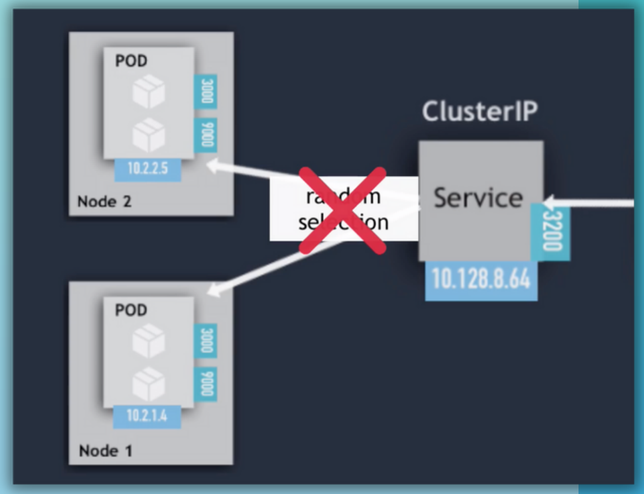
- The service port is arbitrary
- targetPort must **match the port the container is listening at**

ClusterIP Service & its subtypes

- ClusterIP is an internal service, not accessible from outside the cluster
- All Pods in the cluster can talk to this internal service

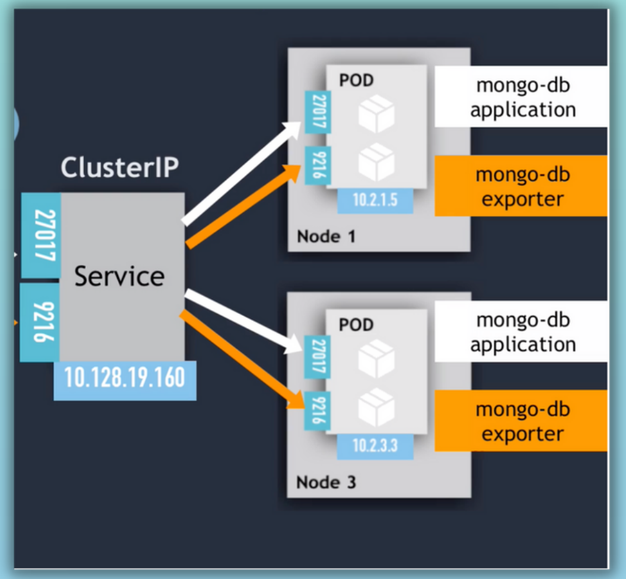
Headless Internal Service

- When client needs to **communicate with 1 specific Pod directly, instead of randomly selected**
- Use Case: When Pod **replicas are not identical**. For example stateful apps, like when only master is allowed to write to database



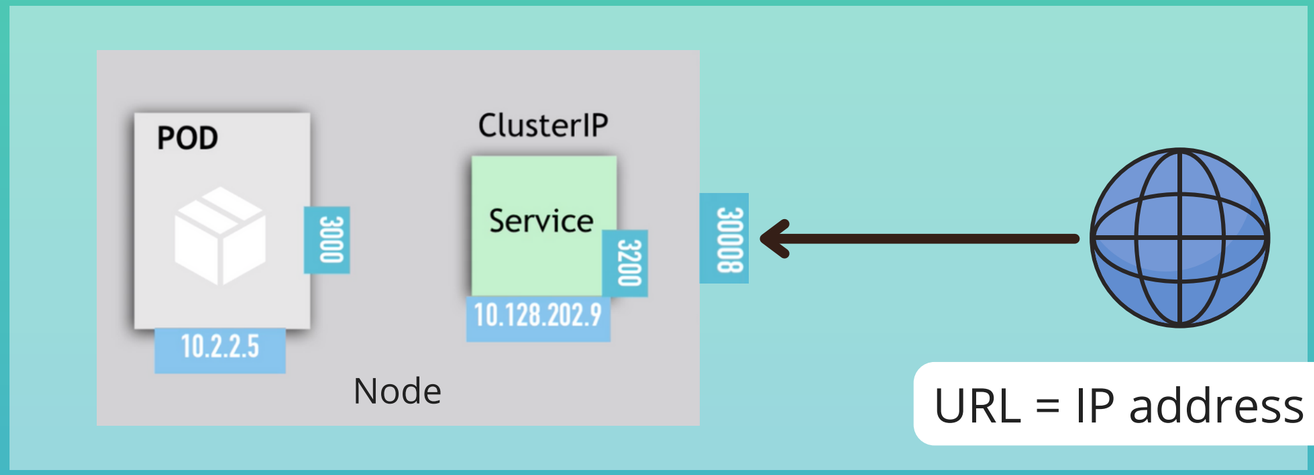
Multi-Port Internal Service

- When you need to expose more than 1 port
- K8s lets you configure multiple port definitions on a Service
- In that case, you must give all of your ports names so that these are unambiguous



NodePort Service

- Unlike internal Service, is accessible directly from outside cluster
- **Exposes** the Service **on each Node's IP at a static port**




```yaml
apiVersion: v1
kind: Service
metadata:
  name: ms-service-nodeport
spec:
  type: NodePort
  selector:
    app: microservice-one
  ports:
    - protocol: TCP
      port: 3200
      targetPort: 3000
      nodePort: 30008
```

URL = IP address of Worker Node : nodePort

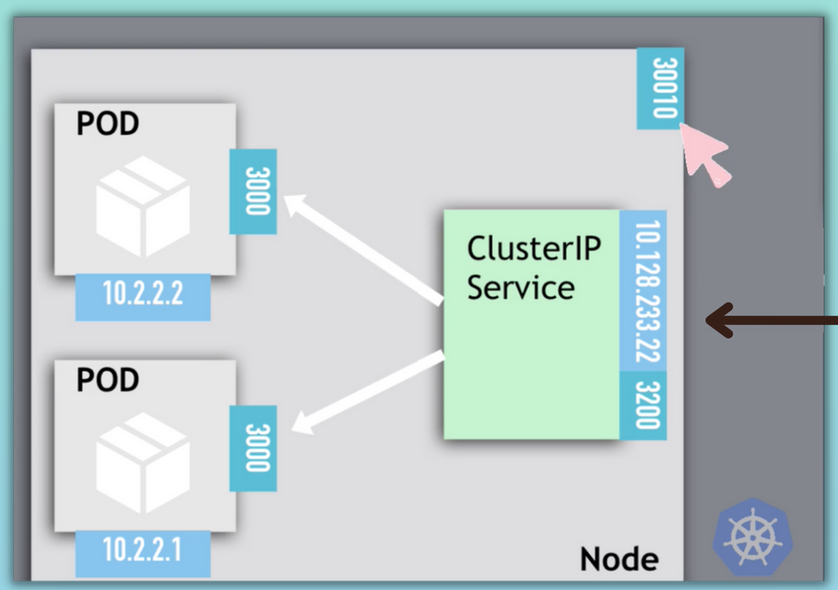
- A ClusterIP Service, to which the NodePort Service routes, is automatically created

```
[k8s-services]$ kubectl get svc
NAME                      TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)          AGE
kubernetes                ClusterIP   10.128.0.1       <none>        443/TCP          20m
mongodb-service           ClusterIP   10.128.204.105   <none>        27017/TCP        10m
mongodb-service-headless  ClusterIP   None             <none>        27017/TCP        2m8s
ms-service-nodeport       NodePort    10.128.202.9     <none>        3200:30008/TCP   8s
```

Not Secure: External traffic has access to fixed port on each Worker Node

Loadbalancer Service

- **Exposes** the Service **externally using a cloud provider's load balancer**
- NodePort and ClusterIP Services, to which the external load balancer routes, are automatically created



More secure, more efficient with 1 entry point

Loadbalancer

```
spec:
  type: LoadBalancer
  selector:
    app: microservice-one
  ports:
    - protocol: TCP
      port: 3200
      targetPort: 3000
      nodePort: 30010
```

```
[k8s-services]$ kubectl get svc
NAME                        TYPE           CLUSTER-IP       EXTERNAL-IP     PORT(S)
kubernetes                  ClusterIP      10.128.0.1       <none>          443/TCP
mongodb-service             ClusterIP      10.128.204.105   <none>          27017/TCP
mongodb-service-headless    ClusterIP      None             <none>          27017/TCP
ms-service-loadbalancer     LoadBalancer   10.128.233.22    172.104.255.5   3200:30010/TCP
ms-service-nodeport         NodePort       10.128.202.9     <none>          3200:30008/TCP
```

Ingress - 1

- External Services are a way to access applications in K8s from outside
- **In production a better alternative is Ingress**!
- Not a Service type, but acts as the entry point for your cluster
- **More intelligent and flexible**: Let's you consolidate your routing rules into a single resource as it can expose multiple services under the same IP address

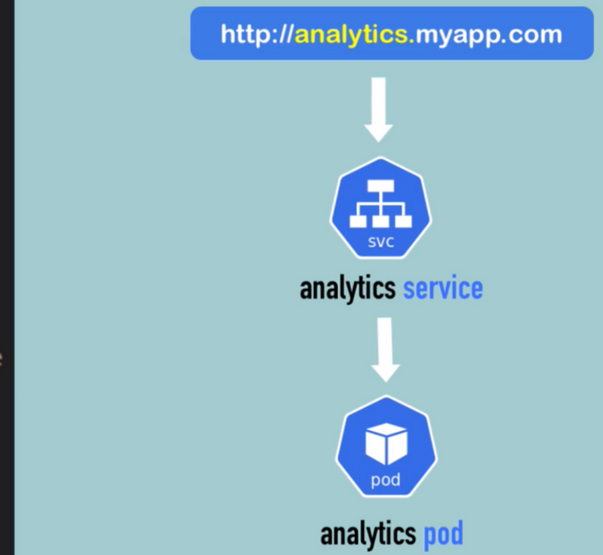
```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: myapp-ingress
spec:
  rules:
  - host: myapp.com
    http:
      paths:
      - backend:
          serviceName: myapp-internal-service
          servicePort: 8080
```

TECHWORLD WITH NANA

Ingress - 2

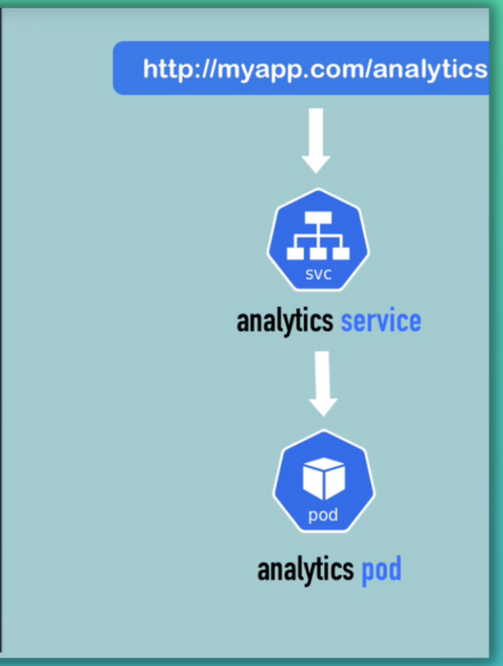
- Configure **multiple sub-domains or domains:**

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: name-virtual-host-ingress
spec:
  rules:
  - host: analytics.myapp.com
    http:
      paths:
        backend:
          serviceName: analytics-service
          servicePort: 3000
  - host: shopping.myapp.com
    http:
      paths:
        backend:
          serviceName: shopping-service
          servicePort: 8080
```



- Configure **multiple paths for same host:**

```yaml
kind: Ingress
metadata:
  name: simple-fanout-example
  annotations:
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - host: myapp.com
    http:
      paths:
      - path: /analytics
        backend:
          serviceName: analytics-service
          servicePort: 3000
      - path: /shopping
        backend:
          serviceName: shopping-service
          servicePort: 8080
```



- Configure **TLS**

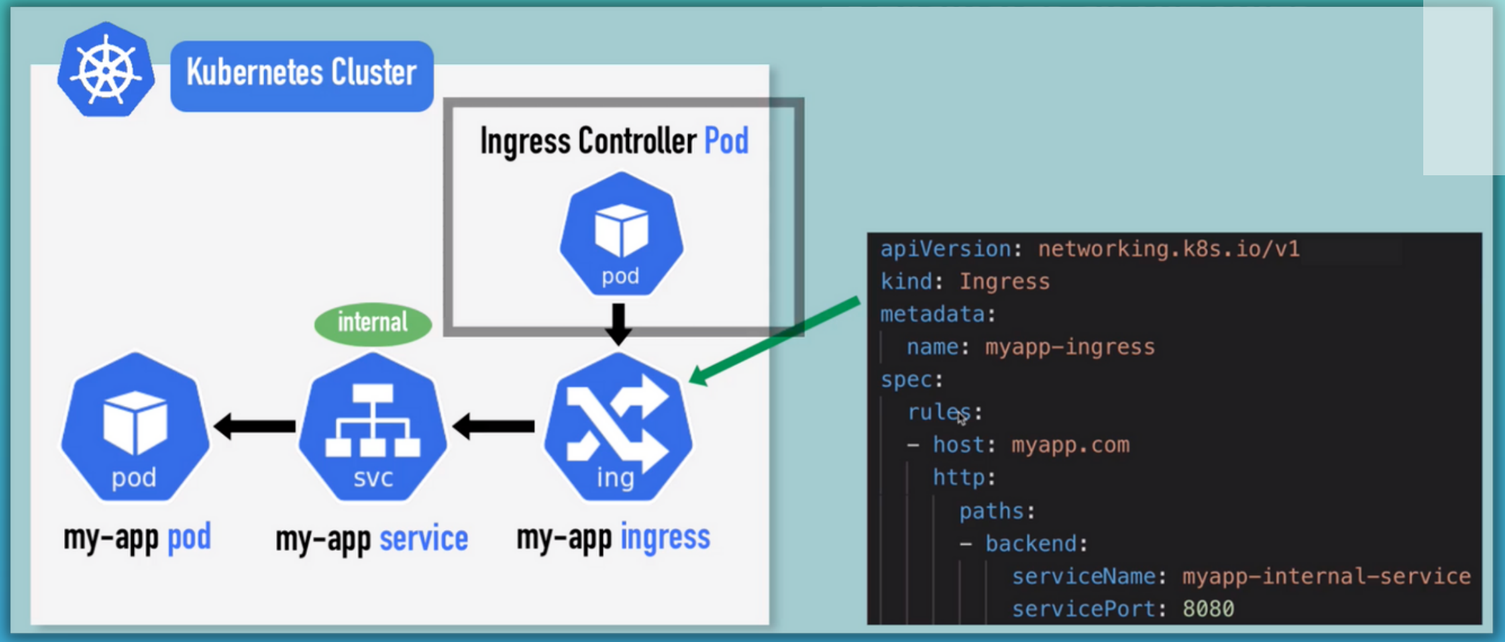
Certificate - https://

```yaml
spec:
  tls:
  - hosts:
    - myapp.com
    secretName: myapp-secret-tls
  rules:
    - host: myapp.com
      http:
        paths:
        - path: /
          backend:
            serviceName: myapp-internal-service
            servicePort: 8080
```

Ingress - 3

How to configure Ingress in your cluster

- You need an **implementation for Ingress**
- Which is Ingress Controller



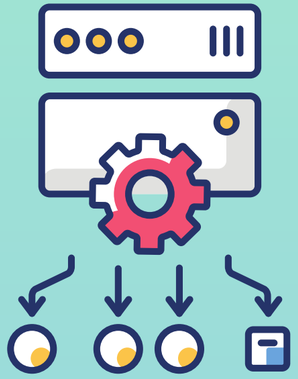
Ingress Controller

- Evaluates all the rules
- Manages redirections
- Entry point to the cluster
- Many third-party implementations
- K8s Nginx Ingress Controller

TECHWORLD WITH NANA

Ingress - 4

Before Ingress Controller you still need 1 load balancer



- **Option 1 - Cloud service provider**: have out-of-the-box K8s solutions
- **Option 2 - Bare Metal**: You need to configure some kind of entry point. Either inside the cluster or outside as separate server

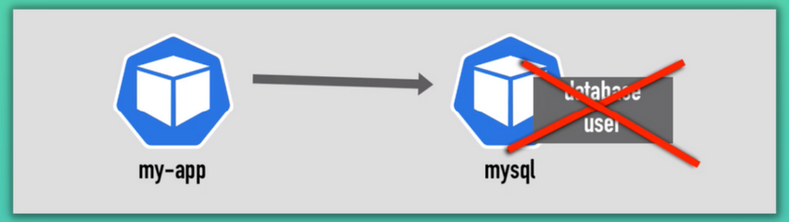
Source: https://kubernetes.io/docs/concepts/services-networking/ingress/

Deep Dive into Kubernetes Volumes

TECHWORLD WITH NANA

Volumes - 1

- K8s offers no data persistence out of the box



- At its core, a **volume is a directory** (with some data in it), **which is accessible to the containers in a Pod**
- K8s supports **many types of volumes**
- Ephemeral volume types have a lifetime of a Pod, persistent volumes exist beyond the lifetime of a Pod
- In this lecture we talk about **persistent volumes**, with these storage requirements:

Storage Requirements

- Storage that **doesn't depend on pod lifecycle**
- Storage must be **available on all Nodes**
- Storage needs to **survive** even if **cluster crashes**

Volumes - 2

- The way to persist data in K8s using Volumes is with these 3 resources:

Persistent Volume (PV)

- **Storage** in the cluster that has been provisioned by an administrator or dynamically provisioned using Storage Classes

Storage Class (SC)

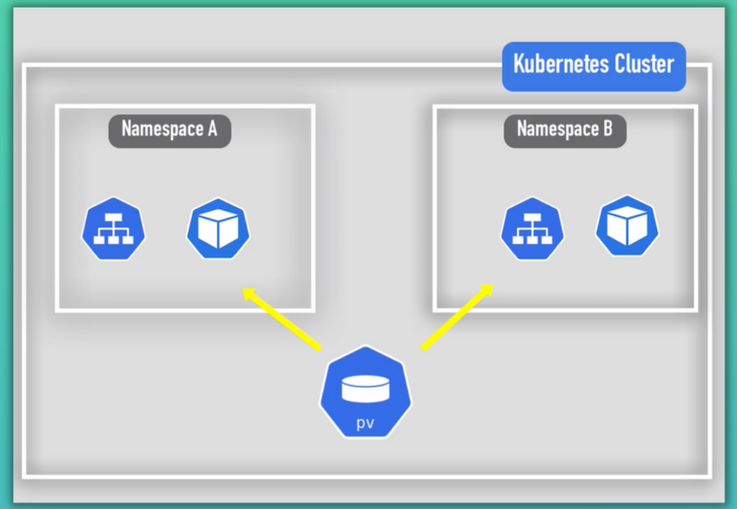
- SC **provisions PV dynamically** when PVC claims it

Persistent Volume Claim (PVC)

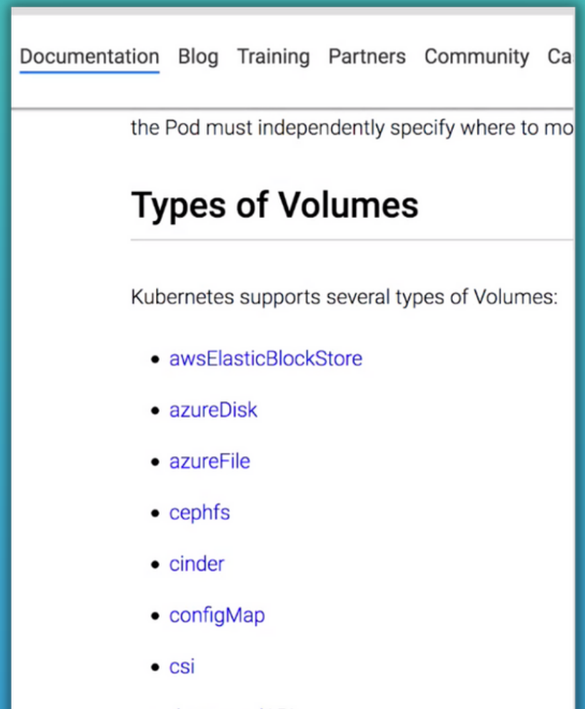
- A **request for storage by a user**
- Similar to Pods. While Pods consume node resources, PVCs consume PV resources

Persistent Volume - 1

- Persistent Volumes are **NOT namespaced,** so PV resource is accessible to the whole cluster:



- Depending on storage type, **spec attributes differ**
- In official documentation you can find a complete list of storage backends supported by K8s:



- Configuration Example

```yaml
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-name
spec:
  capacity:
    storage: 5Gi
  volumeMode: Filesystem
  accessModes:
    - ReadWriteOnce
  persistentVolumeReclaimPolicy: Recycle
  storageClassName: slow
  mountOptions:
    - hard
    - nfsvers=4.0
  nfs:
    path: /dir/path/on/nfs/server
    server: nfs-server-ip-address
```

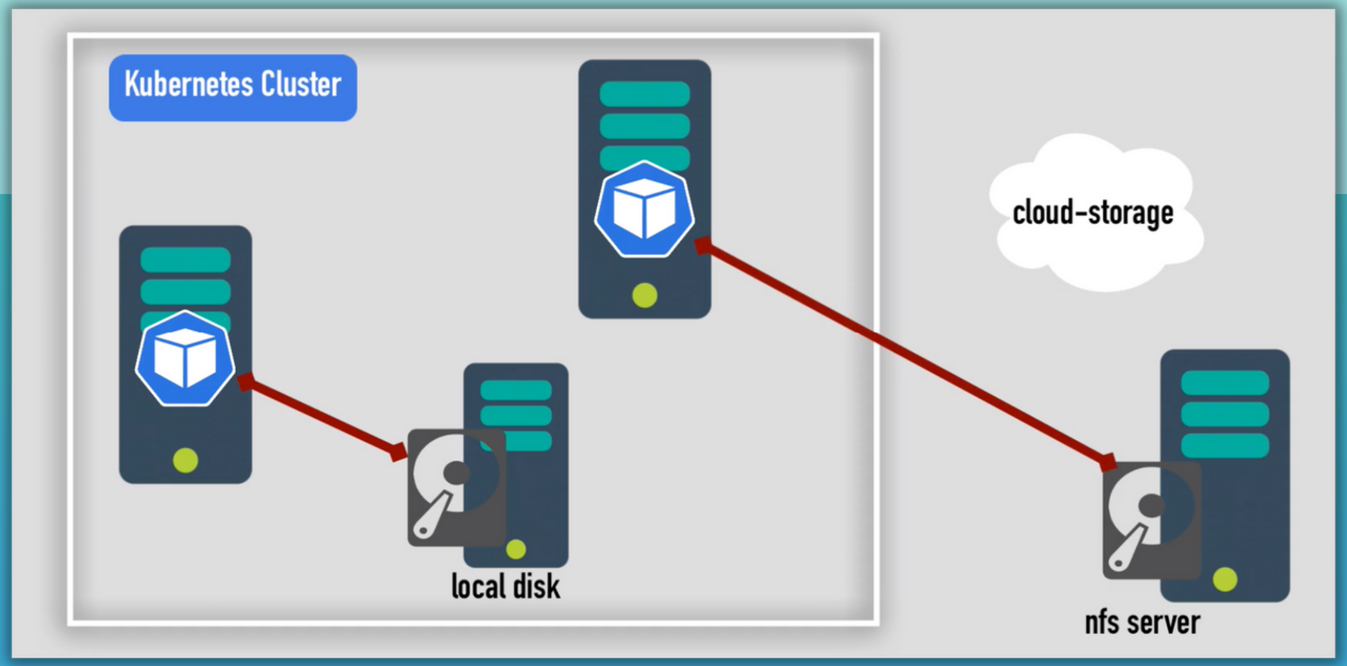
TECHWORLD WITH NANA

Persistent Volume - 2

Local vs Remote Volume Types

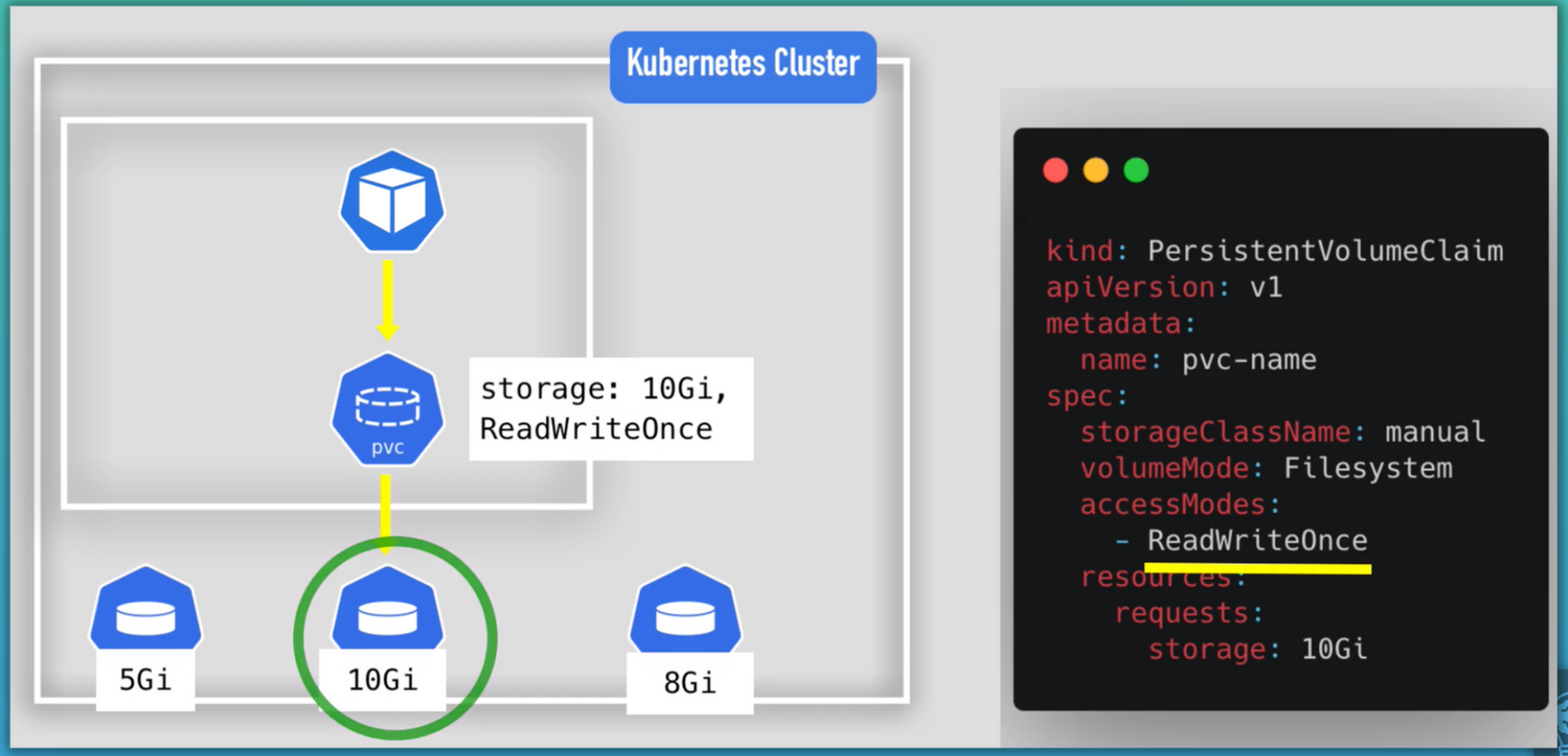
For DB persistence use **remote storage**!

- Each volume type has its own use case!
- **Local volume types** violate 2. and 3. requirement for data persistence:
  - ❌ Being tied to 1 specific Node
  - ❌ Not surviving cluster crashes



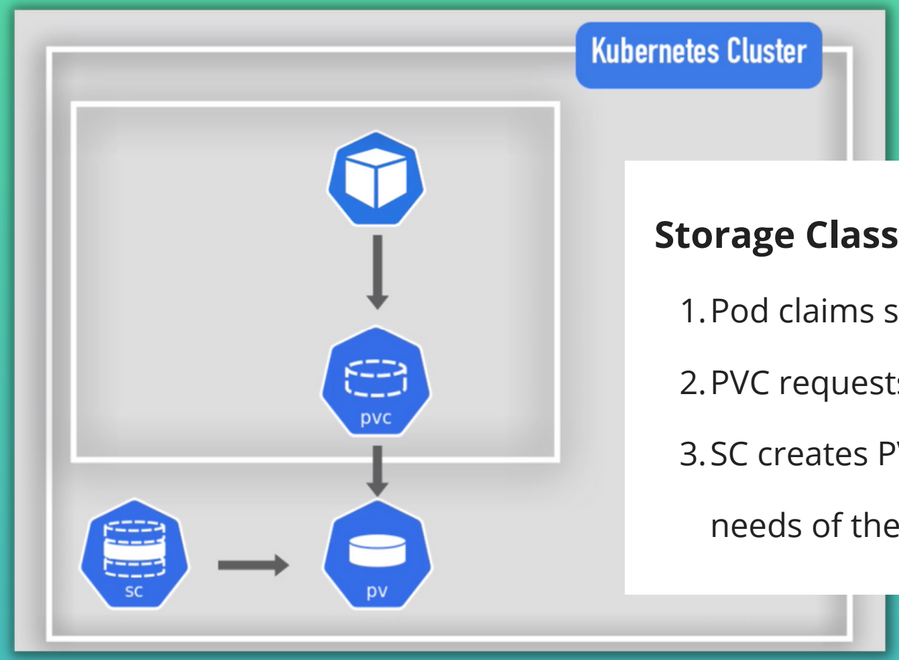
Persistent Volume Claim

- Request for storage by a user
- Claims can **request specific size and access modes** (e.g. they can be mounted ReadWriteOnce, ReadOnlyMany or ReadWriteMany).



Storage Class

- Provisions PV dynamically



Storage Class Usage

1. Pod claims storage via PVC
2. PVC requests storage from SC
3. SC creates PV that meets the needs of the Claim

- **StorageBackend is defined in the SC resource**
  - via "provisioner" attribute
  - each storage backend has own provisioner
  - internal provisioner - "kubernetes.io"
  - external provisioner
  - configure parameters for storage we want to request for PV

```yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: storage-class-name
provisioner: kubernetes.io/aws-ebs
parameters:
  type: io1
  iopsPerGB: "10"
  fsType: ext4
```

Deep Dive into StatefulSets

TECHWORLD WITH NANA

StatefulSet

- Used to **manage stateful applications**, like databases
- Manages the deployment and scaling of a set of Pods and **provides guarantees about the ordering and uniqueness of these Pods**

Stateless Applications

- Doesn't depend on previous data
- Deployed using Deployment

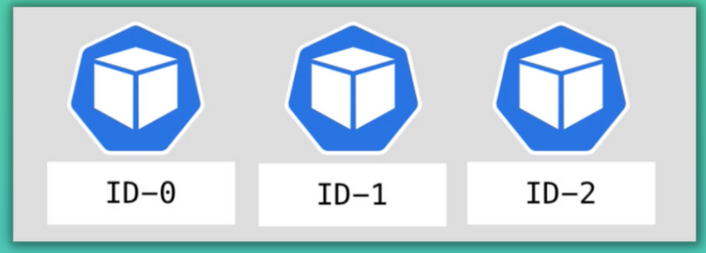
Stateful Applications

- Update data based on previous data
- Query data
- Depends on most up-to-date data/state

Both manage Pods based on container specification

Deployment vs StatefulSet

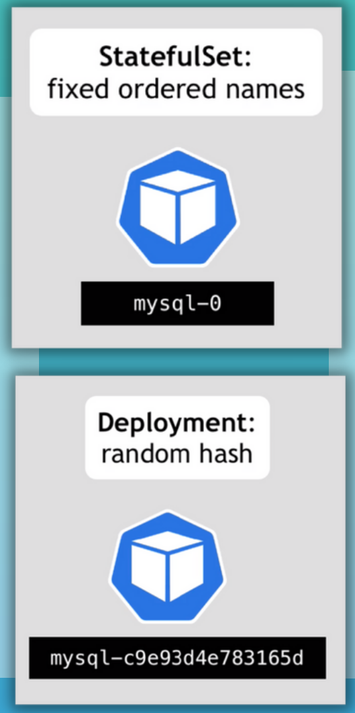
- Unlike a Deployment, a StatefulSet maintains a **sticky identity** for each of their Pods
- These pods are created from the **same spec, but are not interchangeable**: each has a persistent identifier that it maintains across any rescheduling



$(statefulset name)-$(ordinal)

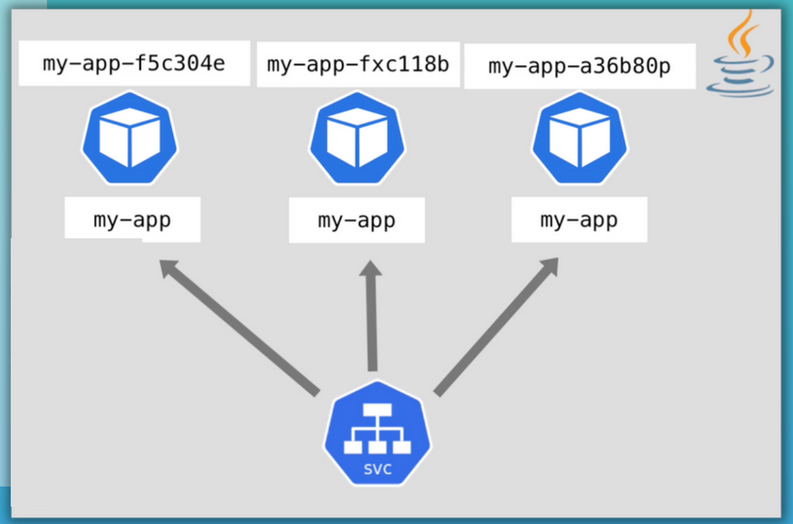
Pods created from StatefulSet

- More difficult
- Can't be created/deleted at same time
- Can't be randomly addressed

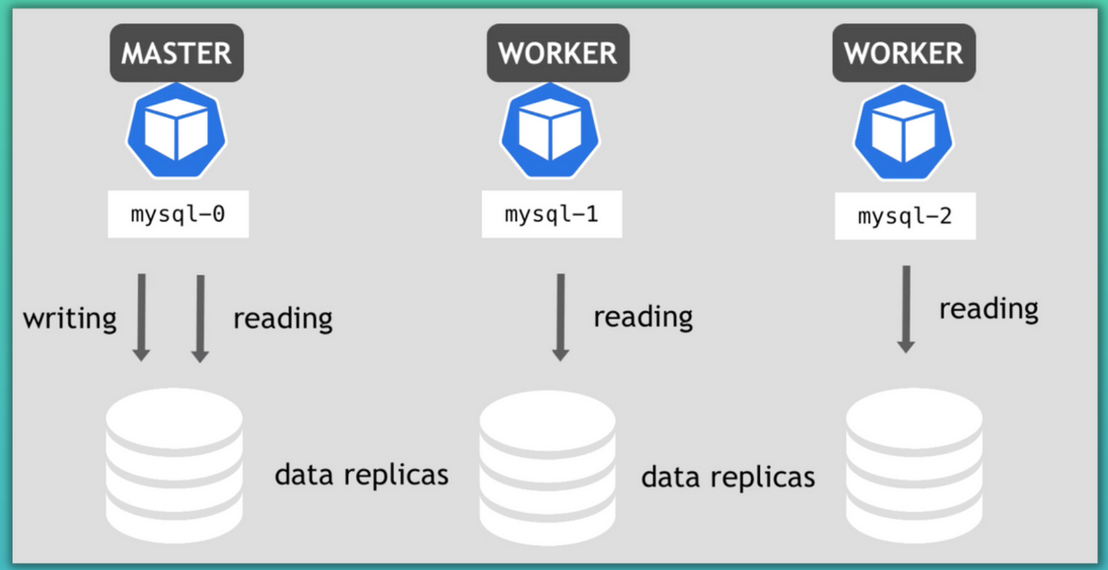


Pods created from Deployment

- Identical and interchangeable
- Created in random order with random hashes
- 1 Service that load balances to any Pod

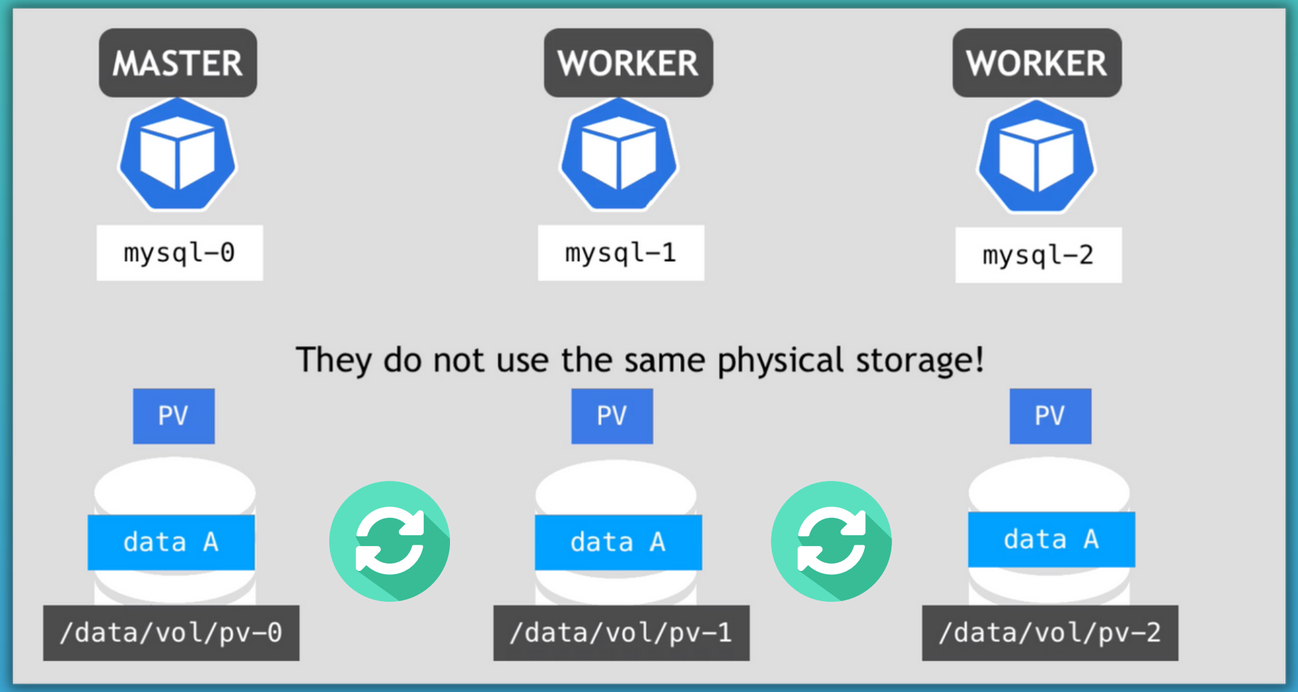


Scaling database applications



- Only 1 replica, can make changes
- So replicas are not identical

- Each replica has its own storage
- These storages are constantly synchronized



Managed K8s Service

TECHWORLD
WITH NANA

Kubernetes on Cloud platform

2 options to create a Kubernetes cluster on a cloud platform

Create **own cluster from scratch**

- You need to manage everything yourself
- Not practical, when you want to setup things fast and easy

Use **Managed** K8s Service

- You only care about Worker Nodes
- Everything pre-installed
- Control Plane Nodes created and managed by cloud provider
- You only pay for the Worker Nodes
- Use cloud native load balancer for Ingress controller
- Use cloud storage
- Less effort and time

TECHWORLD WITH NANA

Example Managed Kubernetes Services

- **AWS**: Elastic Kubernetes Service (EKS)
- **Azure**: Azure Kubernetes Service (AKS)
- **Google**: Google Kubernetes Engine (GKE)
- **Linode**: Linode Kubernetes Engine (LKE)

Helm Package Manager

TECHWORLD WITH NANA

Helm - Package Manager

- Helm is the **package manager for Kubernetes**. Think of it like apt/yum for Kubernetes
- Packages YAML files and distributes them in public and private repositories

Helm

- Tool that installs and manages K8s applications
- This is done via Charts, so Helm manages these Charts

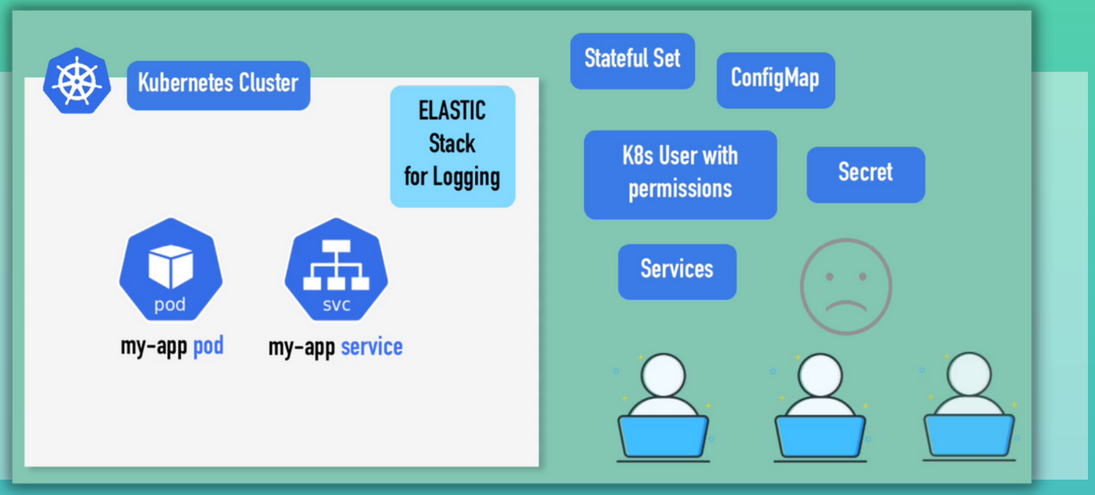
Helm Chart

- **Helm package** that contain
  - description of the package *Chart.yaml*
  - 1 or more templates, which contain K8s manifest files
- You can create your own Helm Charts with Helm, push to Helm Repository
- Download and use existing ones

Helm Charts

Why Helm Charts?

- Instead of everyone creating their own K8s config files, **1 bundle** of all needed K8s manifests



Use existing official Charts:

- Many of these created by the official sources. Mysql Chart from Mysql or ElasticSearch Chart from ElasticSearch

Sharing Helm Charts:

- Charts are hosted on their own repositories
- There are public repos, but you can have own private repos in your company. E.g. Nexus

`helm search <keyword>` or Helm Hub website

TECHWORLD WITH NANA

Helm as Templating Engine - 1

- Helm **renders the templates** and communicates with the Kubernetes API

How to:

1. Define a common blueprint
2. Dynamic values are replaced by placeholders

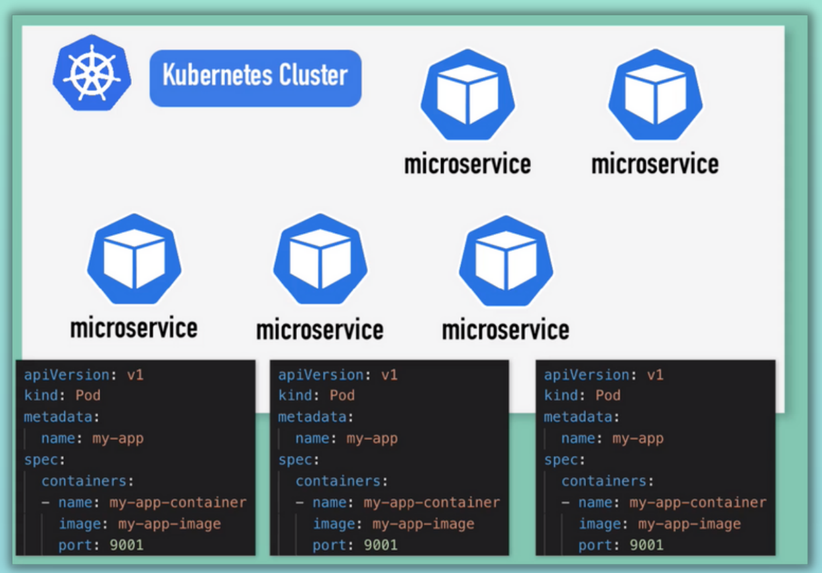
Helm Chart Structure

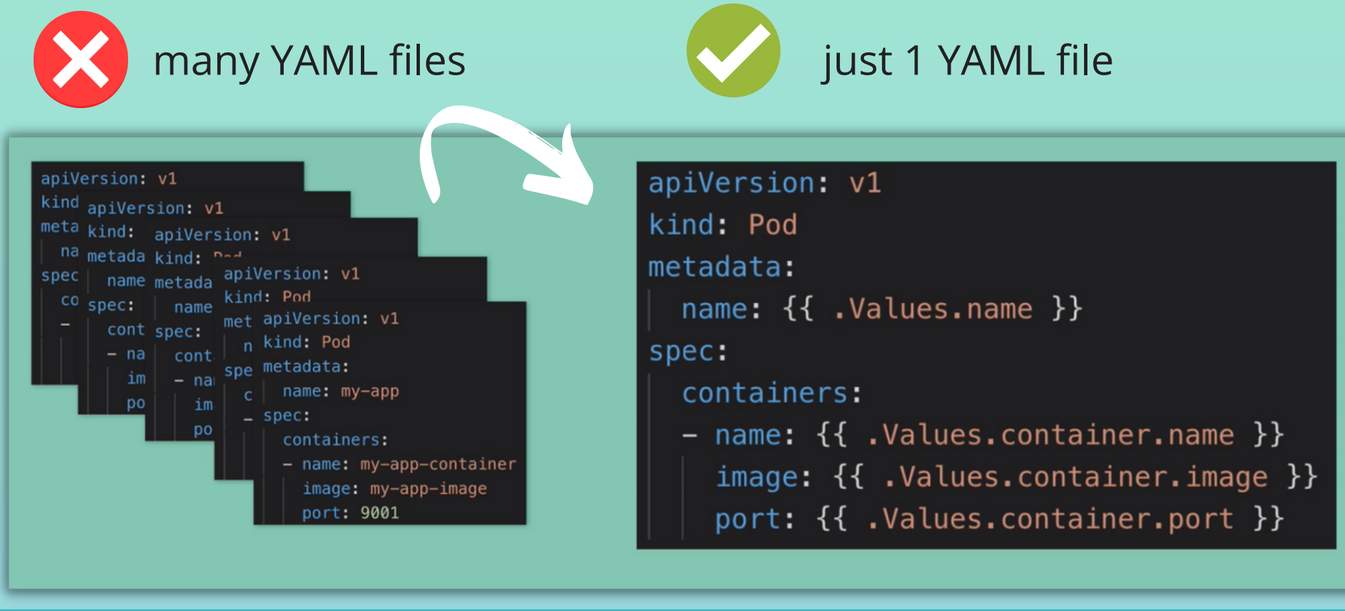
Top level ***mychart*** folder	→	name of chart
Chart.yaml	→	meta info about chart
values.yaml	→	values for the template files
charts folder	→	chart dependencies
templates folder	→	the actual template files

```
mychart/
  Chart.yaml
  values.yaml
  charts/
  templates/
  ...
```

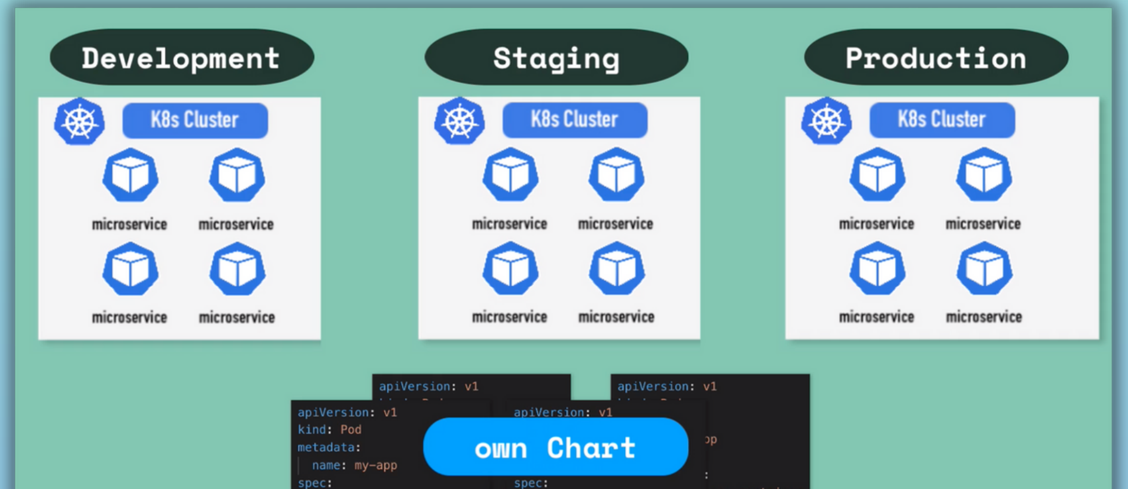
Helm as Templating Engine - 2

- Many values are the same!





- Another use case: **Deploy** the same bundle of K8s YAML files **across multiple clusters**:

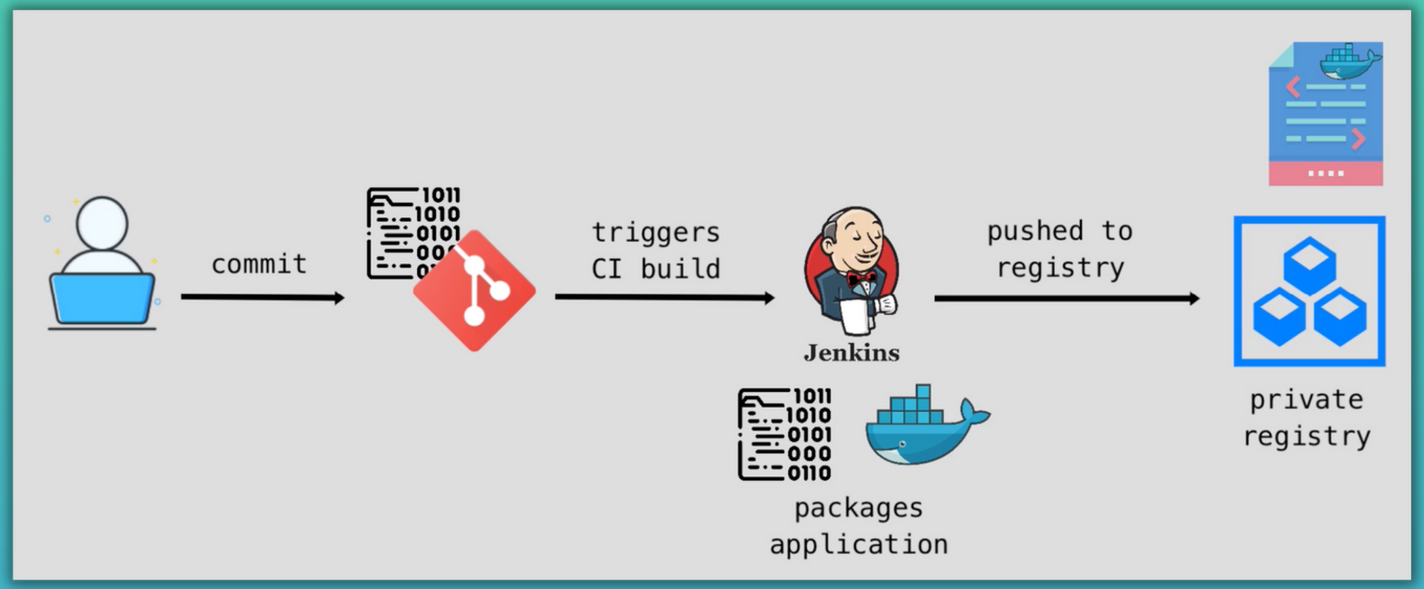


TECHWORLD WITH NANA

CD - Jenkins & Kubernetes

TECHWORLD WITH NANA

Pull Docker Images into K8s cluster



- **PRIVATE REPO**: For K8s to fetch the Docker Image into K8s cluster, it **needs explicit access**

- **PUBLIC REPO**: For public images, like mongodb etc. pulled from public repositories **no credentials needed**

Steps to pull image from Private Registry

1 - Create Secret Component

- Contains credentials for Docker registry

```
my-registry-key       kubernetes.io/dockerconfigjson       1
```

- docker login token is stored in dockerconfig file

2 - Configure Deployment

- Use Secret using imagePullSecrets

```
      app: my-app
  spec:
    replicas: 1
    selector:
      matchLabels:
        app: my-app
    template:
      metadata:
        labels:
          app: my-app
      spec:
        containers:
        - name: my-app
          image: 664574038682.dkr.ecr.eu-central-1.amazonaws.co
          imagePullPolicy: Always
          ports:
            - containerPort: 3000
```

Kubernetes Operators

TECHWORLD WITH NANA

Kubernetes Operators - 1

- Stateful applications need **constant management and syncing after deployment**. So stateful applications, like database need to be operated
- Instead of a human operator, you have an **automated scripted operator**

- Stateless applications:

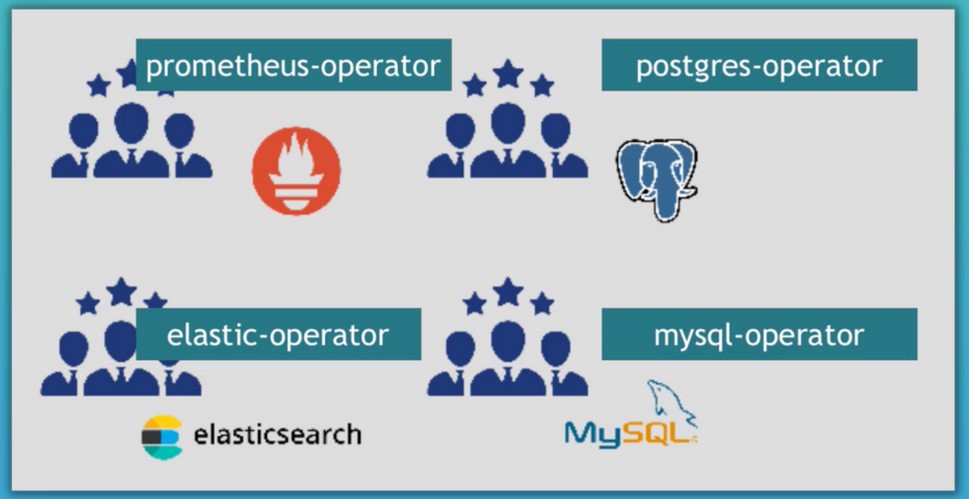
Is **managed by Kubernetes**

Operators

- Stateful applications:

K8s can't automate the process natively

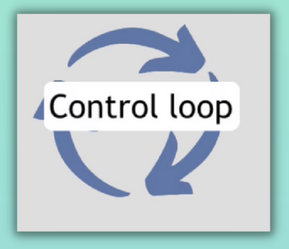
Operators are created by official maintainers



Kubernetes Operators - 2

How it works:

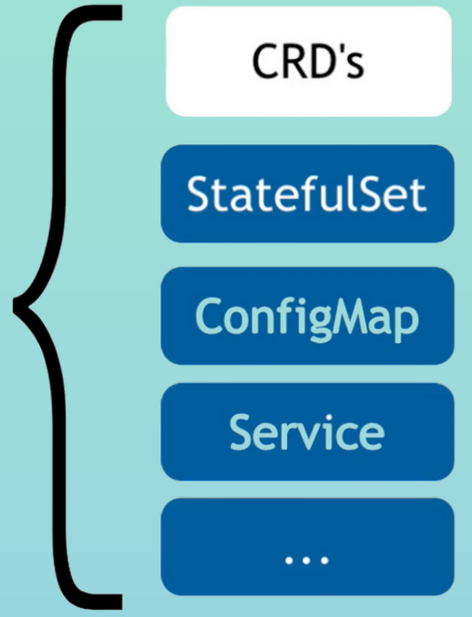
- Control loop mechanism



- Makes use of CRD's

Custom **R**esource **D**efinitions

- Custom K8s component (extends the K8s API)



- Include domain/App-specific-knowledge, e.g. mysql:
  - How to create mysql cluster
  - How to run it
  - How to synchronize the data
  - How to update

Secure your Cluster - Authentication & Authorization

TECHWORLD WITH NANA

Layers of Security

- In K8s, you must be **authenticated (logged in)** before your request can be **authorized (granted permission to access)**

Authentication

- K8s doesn't manage Users natively
- No K8s resources exist for representing normal user accounts
- Admins can choose from different authentication strategies

Authorization

- K8s supports multiple authorization modules, such as ABAC mode, RBAC Mode and Webhook mode
- On cluster creation, admins configure the authorization modules that should be used
- K8s checks each module, and if any module authorizes the request, then the request can proceed

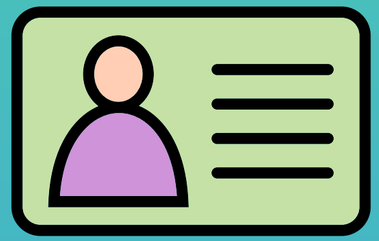
Authentication

- API server handles authentication of all the requests
- Available **authentication strategies**:

Client Certificates

Static Token File

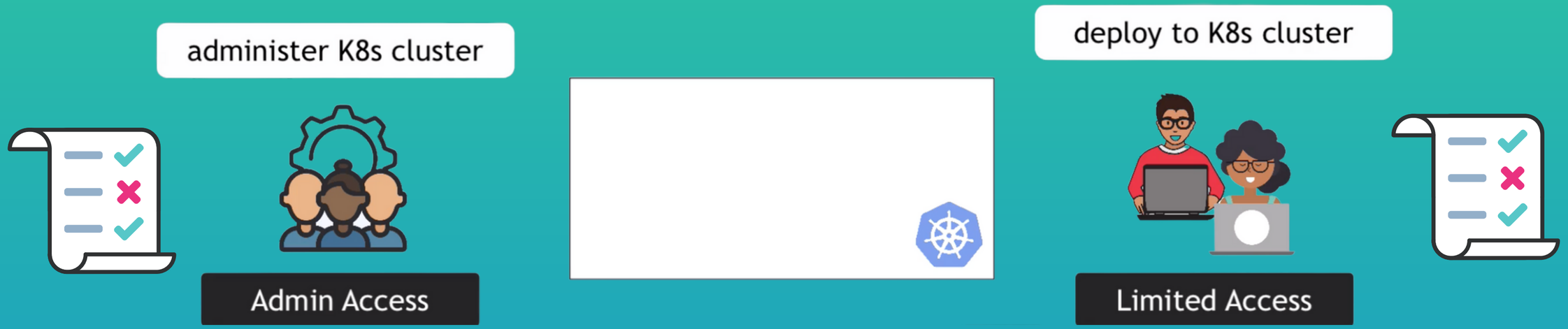
3rd Party Identitiy Service, like LDAP



- A csv file with a minimum of 3 columns: token, user name, user uid, followed by optional group names

Authorization

- As a security best practice, we only want to give people or services **just enough permission** to do their tasks: **Least Privilege Rule**



- Admins need cluster-wide access to do tasks like configure namespaces etc.

- Developers need only limited access for example to deploy applications to 1 specific namespace

Authorization with RBAC - 1

Role-**b**ased **a**ccess **c**ontrol (RBAC)

- A method of regulating access to resources based on the roles of users within the organization
- Enabling RBAC: `kube-apiserver --authorization-mode=RBAC --other-options`
- 4 kinds of K8s resources: ClusterRole, Role, ClusterRoleBinding, RoleBinding

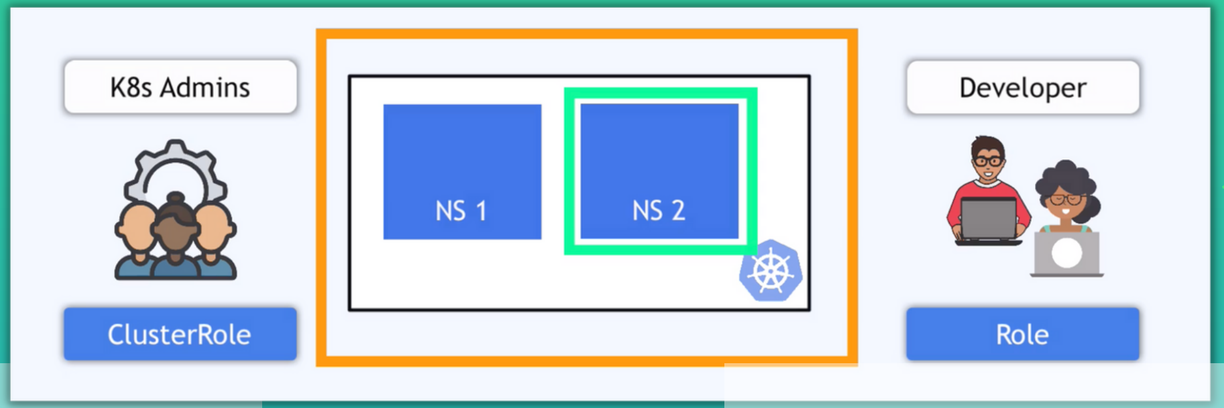
Role and ClusterRole

- Contains rules that represent a **set of permissions**
- Permissions are additive

RoleBinding and ClusterRoleBinding

- **Link ("Bind")** a Role or ClusterRole to a **User or Group**

Authorization with RBAC - 2



ClusterRole

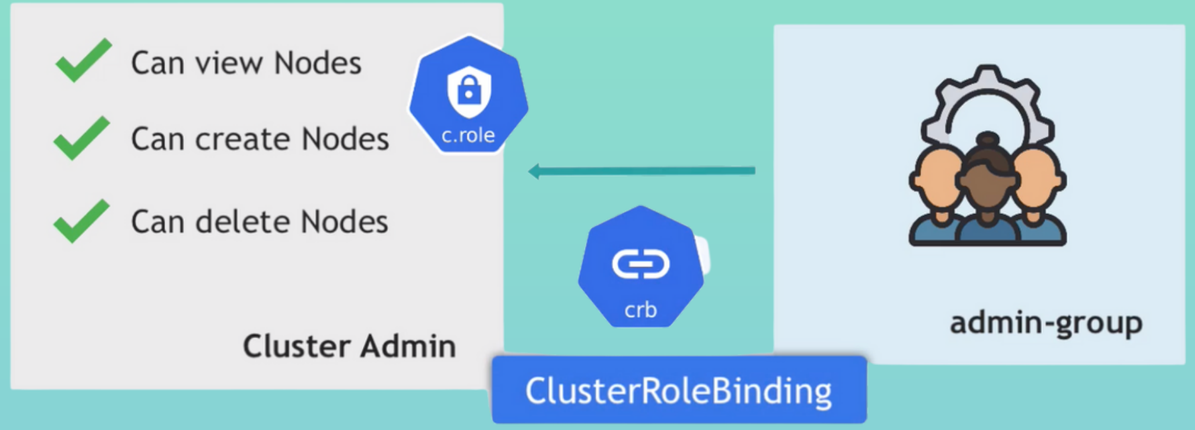
- Define permissions **cluster wide**
- For example: configure cluster-wide volumes, namespaces

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: developer
rules:
- apiGroups: [""]
  resources: ["pods"]
  verbs: ["get", "create", "list"]
- apiGroups: [""]
  resources: ["secrets"]
  verbs: ["get"]
```

Role

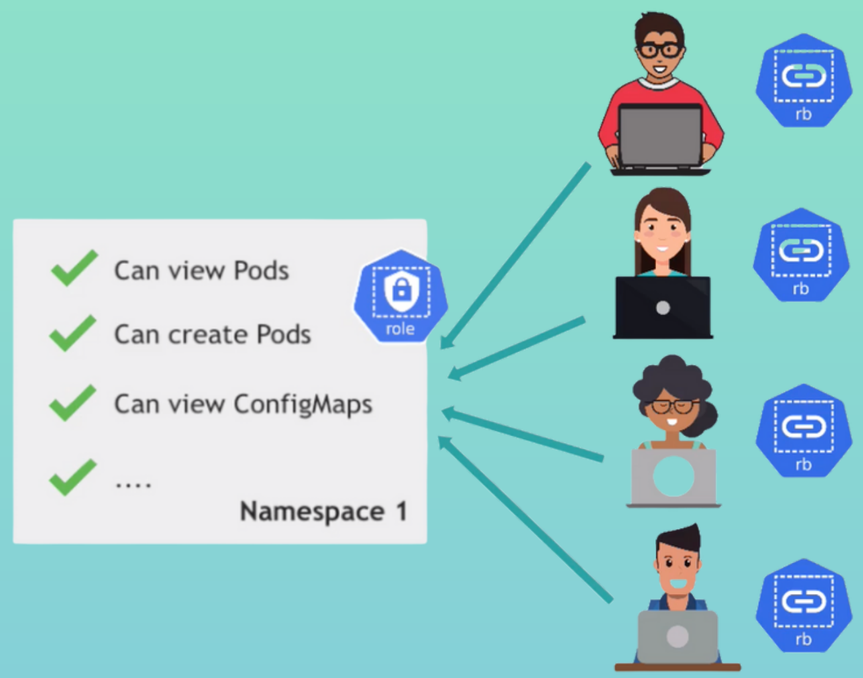
- Define **namespaced** permissions through Role
- Bound to a specific namespace
- **What resources** in that namespace you can access
- **What action** you can do with this resource

Authorization with RBAC - 3



ClusterRoleBinding

- **Link ("Bind")** ClusterRole to a User or Group



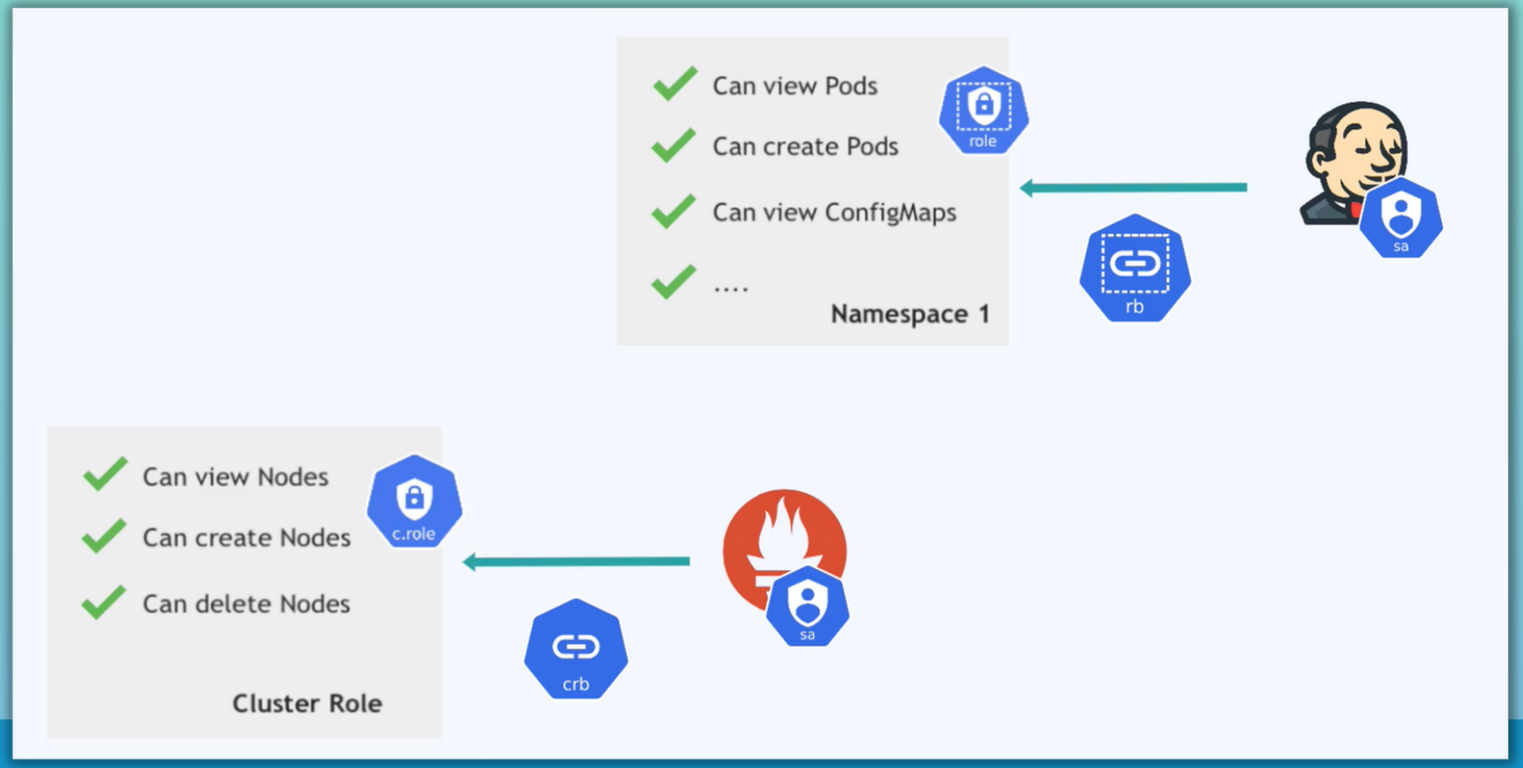
RoleBinding

- **Link ("Bind")** Role to a User or Group

Authorization for Applications

- **ServiceAccounts** provide an identity for processes that run in a Pod, for example Jenkins or Prometheus

- A RoleBinding or ClusterRoleBinding can also **bind a role to a ServiceAccount**



Microservices in Kubernetes

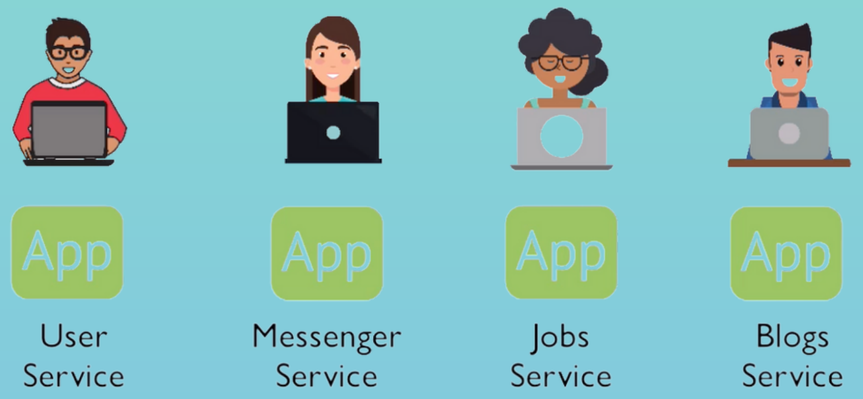
TECHWORLD WITH NANA

Introduction to Microservices

- Microservices are an architectural approach to software development
- Software is **composed of small independent services** (instead of having a huge monolith)
- Each business functionality is **encapsulated** into own Microservice (MS)

Benefits

- Each MS can be developed, packaged and released **independently**
- Changes in 1 MS doesn't affect other MS
- Less interconnected logic, **loosely coupled**
- Each MS can be developed by separate developer teams

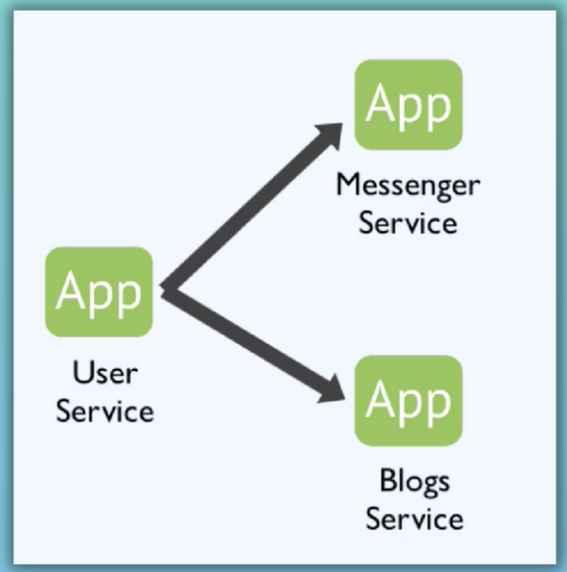


Communication between Microservices

- Communication between those services can happen in different ways:

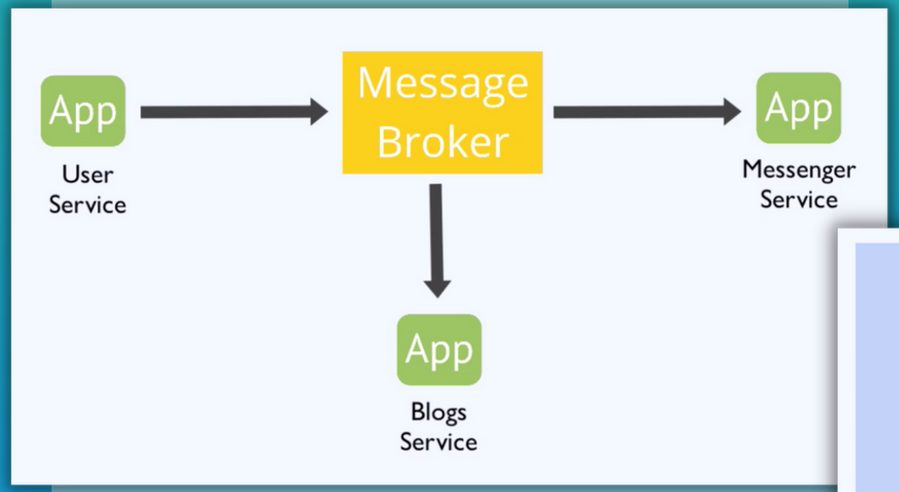
Service-to-Service API Calls

- Direct communication



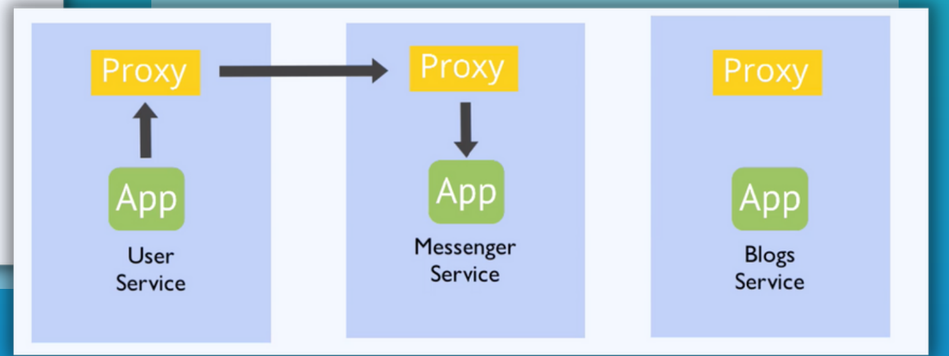
Message-Based Communication

- Communication through a message broker, like Rabbitmq or Redis

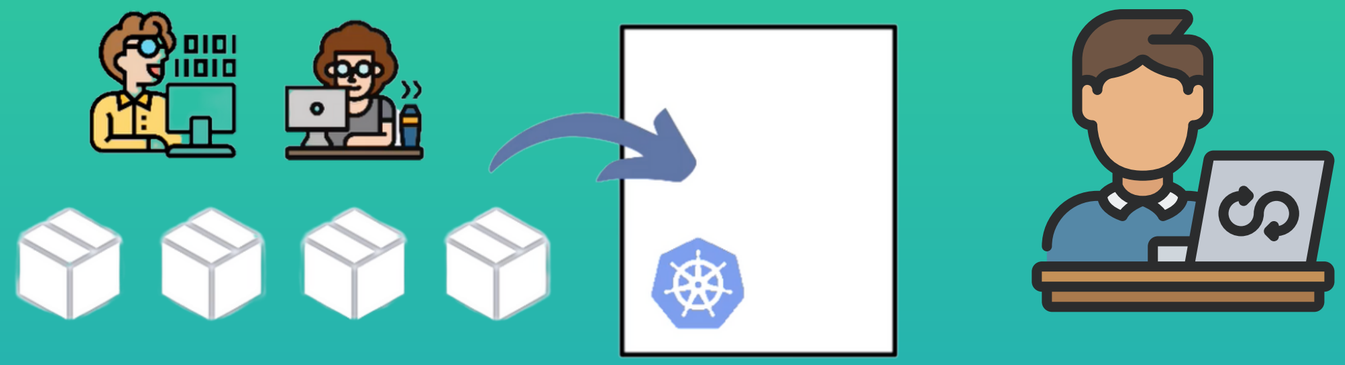


Service Mesh Architecture

- Platform layer on top of the infrastructure layer, like Istio, Linkerd, HashiCorp Consul
- Enables managed, observable and secure communication



DevOps Task: Deploy Microservices App - 1



- Developers develop the microservice applications
- As a DevOps engineer your task would be to **deploy the existing microservices application** in a K8s cluster

Information you need from developer:

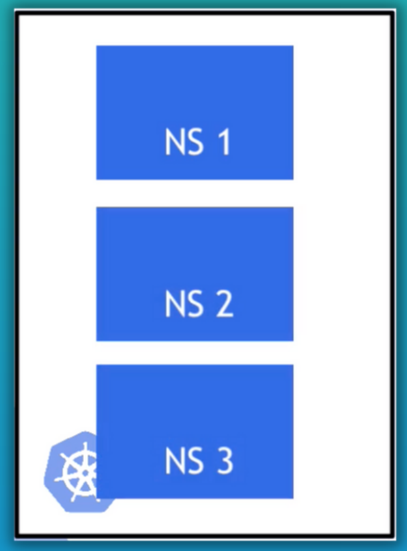
1. Which services you need to deploy?
2. Which service is talking to which service?
3. How are they communicating?
4. Which database are they using? 3rd party services
5. On which port does each service run?

DevOps Task: Deploy Microservices App - 2

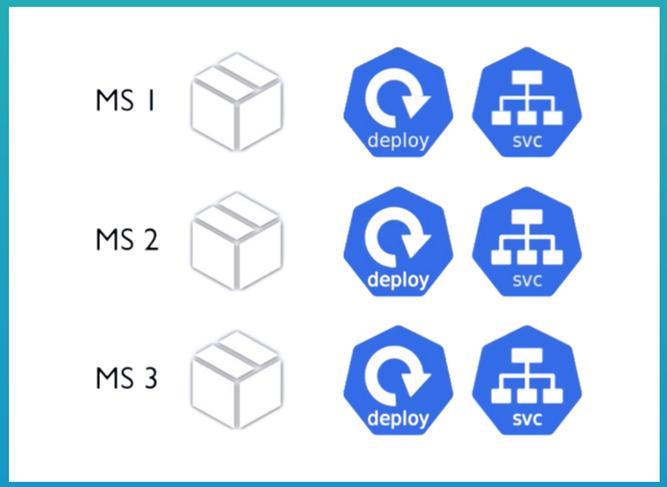
HOW TO

1. **Prepare K8s environment**
    a. Deploy any 3rd party apps
    b. Create Secrets and ConfigMaps for microservices
2. **Create Deployment and Service for each microservices**

1)



2)



When deploying multiple similar services to K8s, you can **use helm chart with 1 common template and replace specific values for each service on the fly** during deployment

Kubernetes Production & Security Best Practices

Best Practices - 1

- Specify a pinned version on each container image

Why? Otherwise, latest version is fetched, which makes it unpredictable and intransparent as to which versions are deployed in the cluster

- Configure a liveness probe on each container

Why? K8s knows the Pod state, not the application state. Sometimes pod is running, but container inside crashed. With liveness probe we can let K8s know when it needs to restart the container

- Configure a readiness probe on each container

Why? Let's K8s know if application is ready to receive traffic

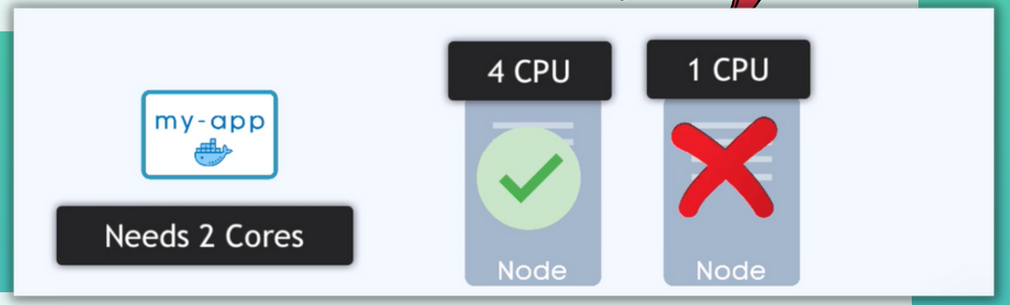
```yaml
spec:
  containers:
  - name: service
    image: gcr.io/google-samples/microservices-demo/emailserv
    ports:
    - containerPort: 8080
    env:
    - name: PORT
      value: "8080"
    livenessProbe:
      periodSeconds: 5
      exec:
        command: ["/bin/grpc_health_probe", "-addr=:8080"]
    readinessProbe:
      periodSeconds: 5
      exec:
        command: ["/bin/grpc_health_probe", "-addr=:8080"]
```

TECHWORLD WITH NANA

Best Practices - 2

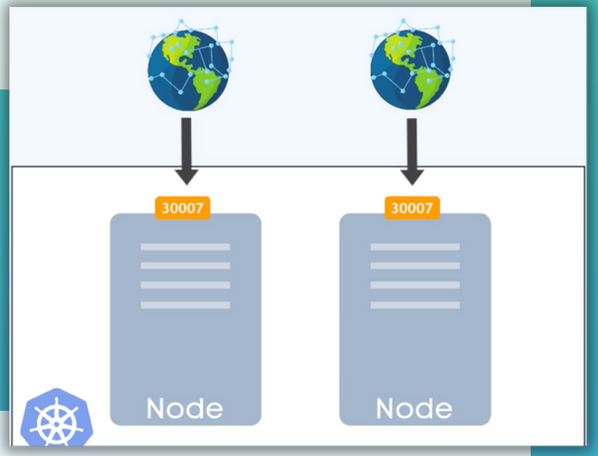
- Configure resource limits & requests for each container

Why? To make sure 1 buggy container doesn't eat up all resources, breaking the cluster



- Don't use NodePort in production

Why? NodePort exposes Worker Nodes directly, multiple points of entry to secure. Better alternative: Loadbalancer or Ingresss



- Always deploy more than 1 replica for for each application

Why? To make sure your application is always available, no downtime for users!

TECHWORLD WITH NANA

Best Practices - 3

- Always have more than 1 Worker Node

Why? Avoid single point of failure with just 1 Node

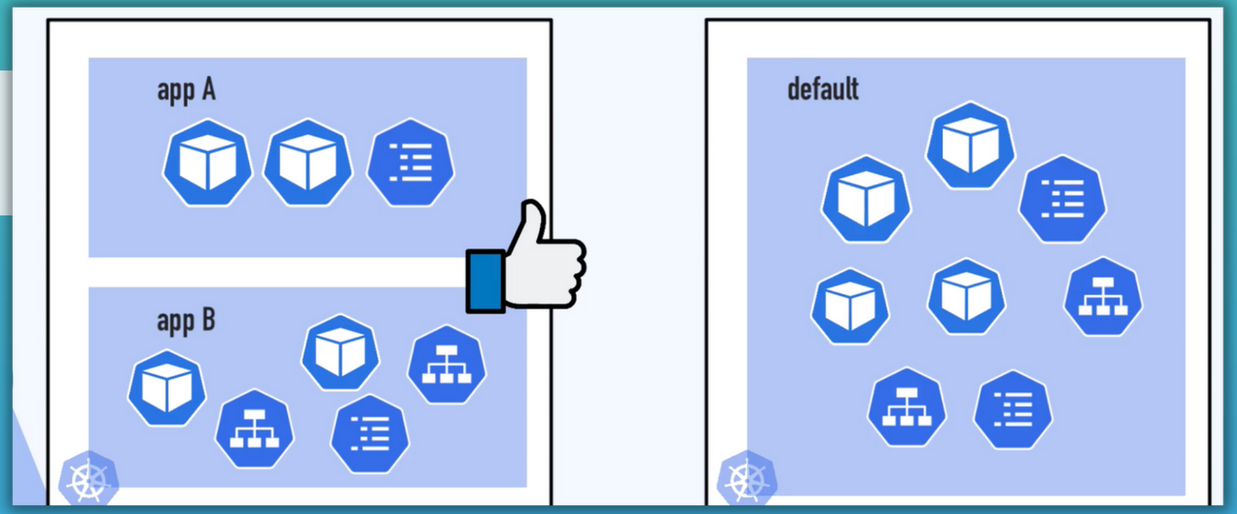
- Label all your K8s resources

Why? Have an identifier for your components to group pods and reference in Service e.g.

- Use namespaces to group your resources

Why? To organize resources and to define

access rights based on namespaces e.g.

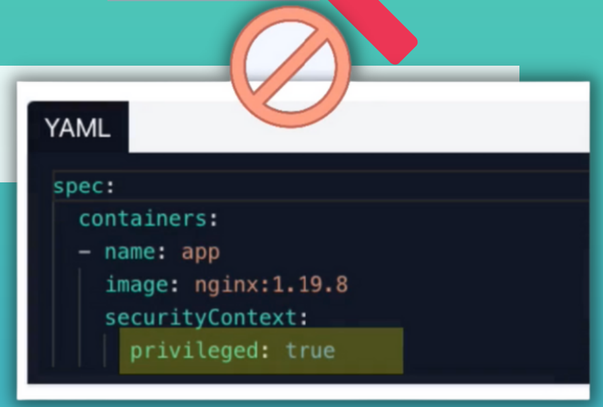


Security Best Practices

- Ensure Images are free of vulnerabilities

Why? Third-party libraries or base images can have known vulnerabilities. You can do manual vulnerability scans or better automated scans in CI/CD pipeline

- No root access for containers



Why? With root access they have access to host-level resources. Much more damage possible, if container gets **hacked!**

- Keep K8s version up to date

Why & How? Latest versions include patches to previous security issues etc.

Upgrade with zero downtime by having multiple nodes and pod replicas on different nodes