Certified Kubernetes Application Developer

Setting the Base

Kubernetes is one of the most popular container orchestration tools in the industry.

It is used extensively in many medium to large-scale organizations.

PPT Version

Release Date = 20th May 2025

What this Course is All About?

This is a certification-specific course aimed at individuals who intend to gain the Certified Kubernetes Application Developer certification.

This is a perfect course for CKAD certification OR if you plan to start your journey in Kubernetes.

Certification is Beneficial

We will be covering all the domains for the Certified Kubernetes Administrator certification.

1. Application Design and Build
2. Application Deployment
3. Application Observability and Maintenance
4. Application Environment, Configuration and Security
5. Services and Networking

The Exciting Part

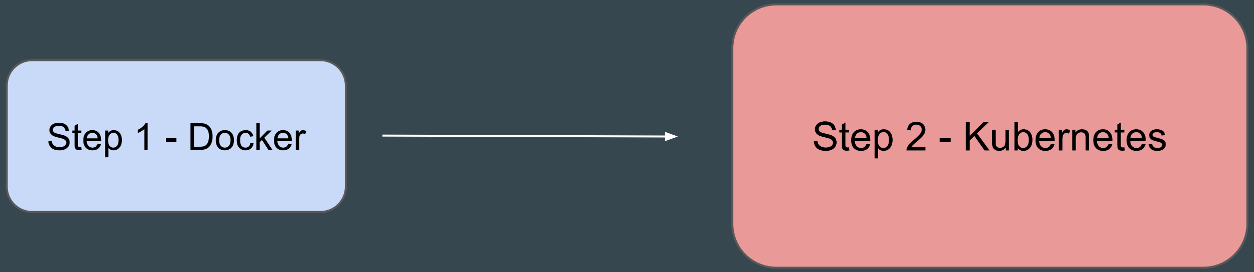
We have an exam preparation section to help you get prepared for the exam.

We also have practice tests available as part of the course.

Point to Note

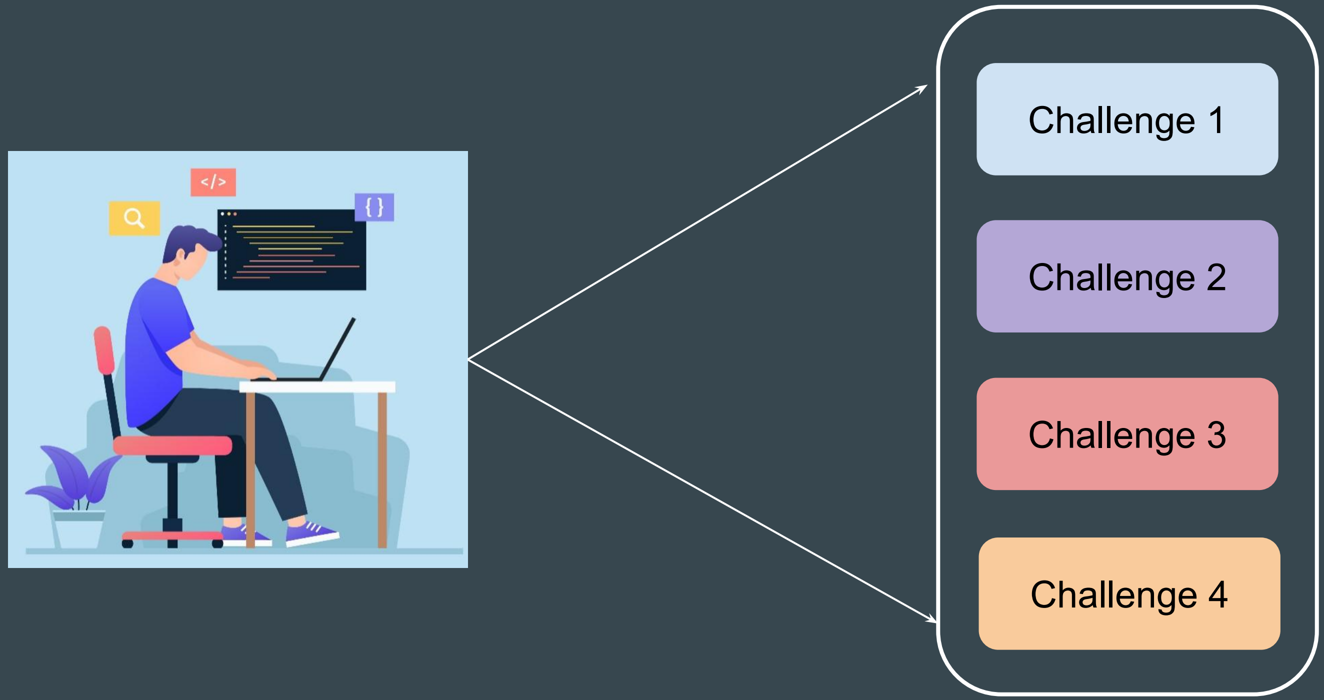
We start our journey on Kubernetes from absolute scratch.

Base Docker knowledge is a prerequisite for this Kubernetes.



Lab Based Exams

CKAD exam is a lab-based exam where you will have to solve multiple scenarios presented to you.



About Me

- DevSecOps Engineer - Defensive Security.
- Teaching is one of my passions.
- I have total of 16 courses, and around 400,000+ students now.

Something about me :-

- Certified Kubernetes [Security Specialist, Administrator, Application Developer]
- HashiCorp Certified [Terraform Professional [Vault and Consul Associate]
- AWS Certified [Advanced Networking, Security Specialty, DevOps Pro, SA Pro, …]
- RedHat Certified Architect (RHCA) + 13 more Certifications
- Part time Security Consultant

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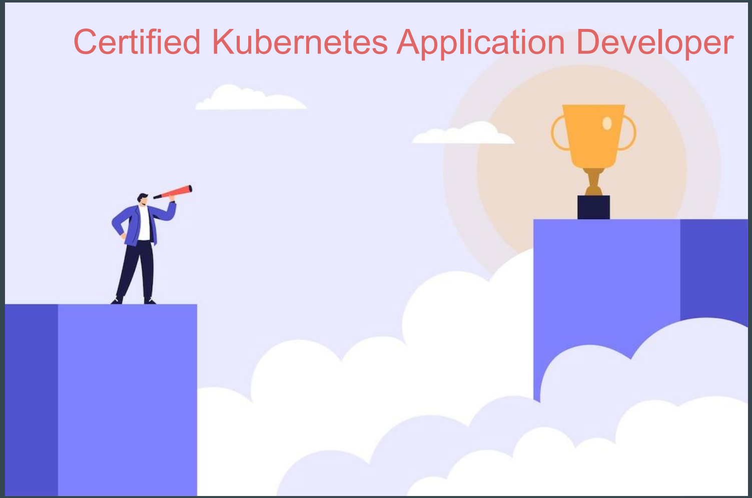
About the Course and Resources

1 - Aim of This Course

The primary aim of this course is to learn.

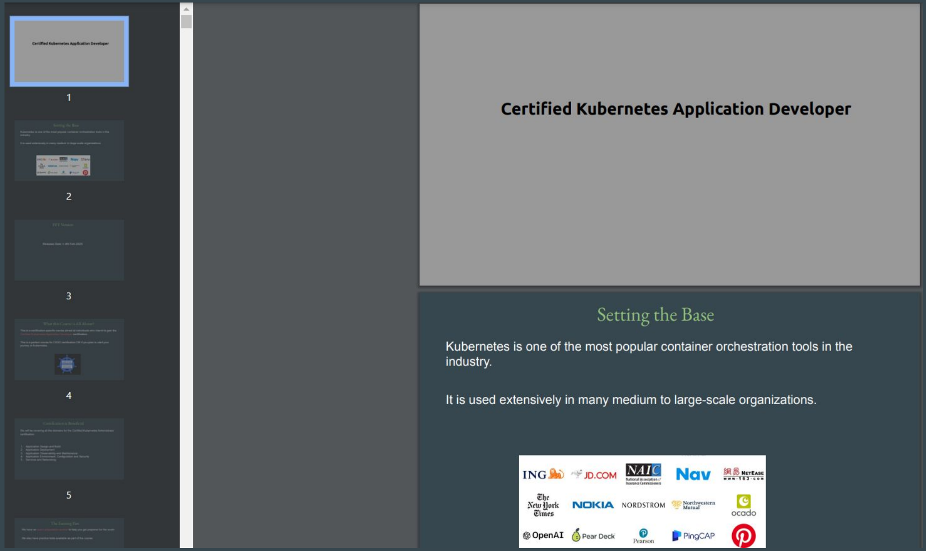
Certification is the byproduct of learning.



2 - PPT Slides PDF

ALL the slides that we use in this course is available to download as PDF.

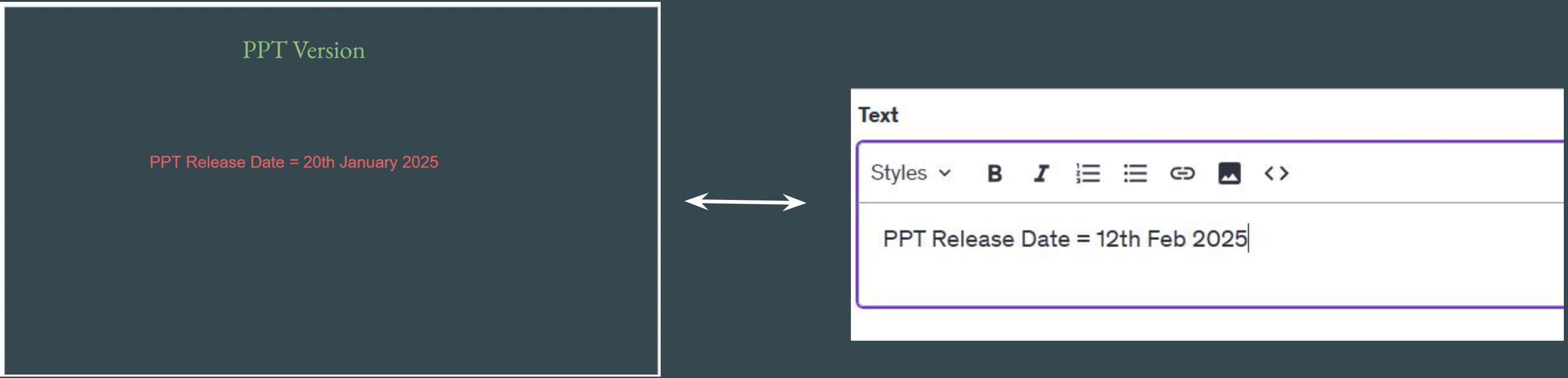
We have around 500 slides that are available to download.



3 - PPT Version

The course is updated regularly and so are the PPTs.

We add the PPT release date in the PPT itself and the lecture from which you download the PPTs.

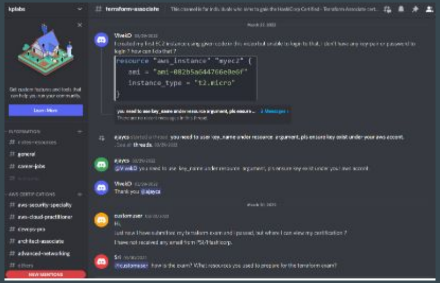


4 - Our Community (Optional)

You can join our Discord community for any queries / discussions. You can also connect with other students going through the same course in Discord (Optional)

Discord Link: https://kplabs.in/chat

Category: #ckad



5 - Course Resource - GitHub

All the code that we use during practicals have been added to our GitHub page.

Section Name in the Course and GitHub are same for easy finding of code.

Domain 1 - Core Concepts	.
Domain 2 - Workloads & Scheduling	.
Domain 3 - Services and Networking	.
Domain 4 - Security	.
Domain 5 - Storage	.
Domain 6 - Cluster Architecture, Installation & ...	.
Domain 7 - Logging and Monitoring	.
Domain 8 - Troubleshooting	.
practice-tests	Update core-concepts.md

6 - Local Structure

We use folder of kplabs-k8s as a base for creating and managing K8s files.

Visual Studio Code is the default code editor used for this course.

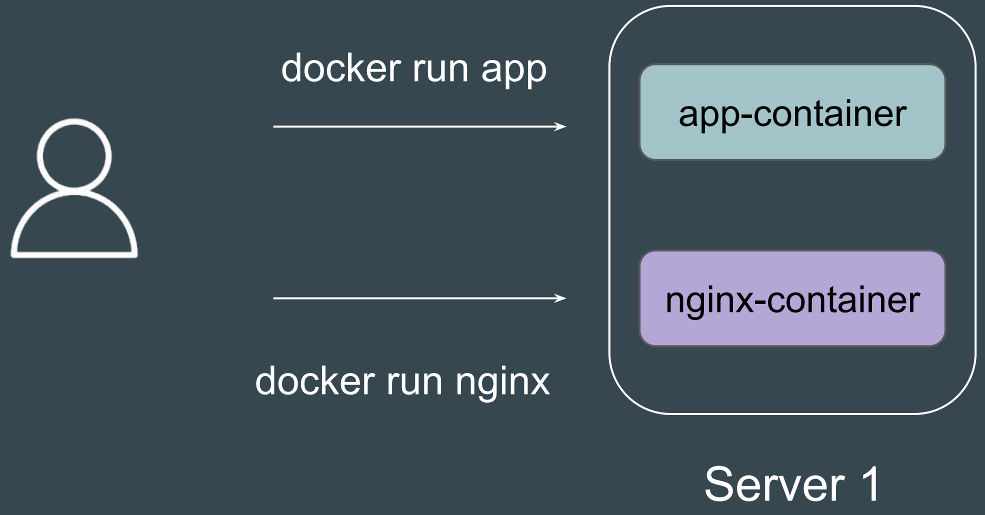
C: > kplabs-k8s > ! lb-service.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
  name: simple-service
spec:
  type: LoadBalancer
  selector:
    app: backend
  ports:
  - port: 80
    targetPort: 80
```

Overview of Container Orchestration

Setting the Base

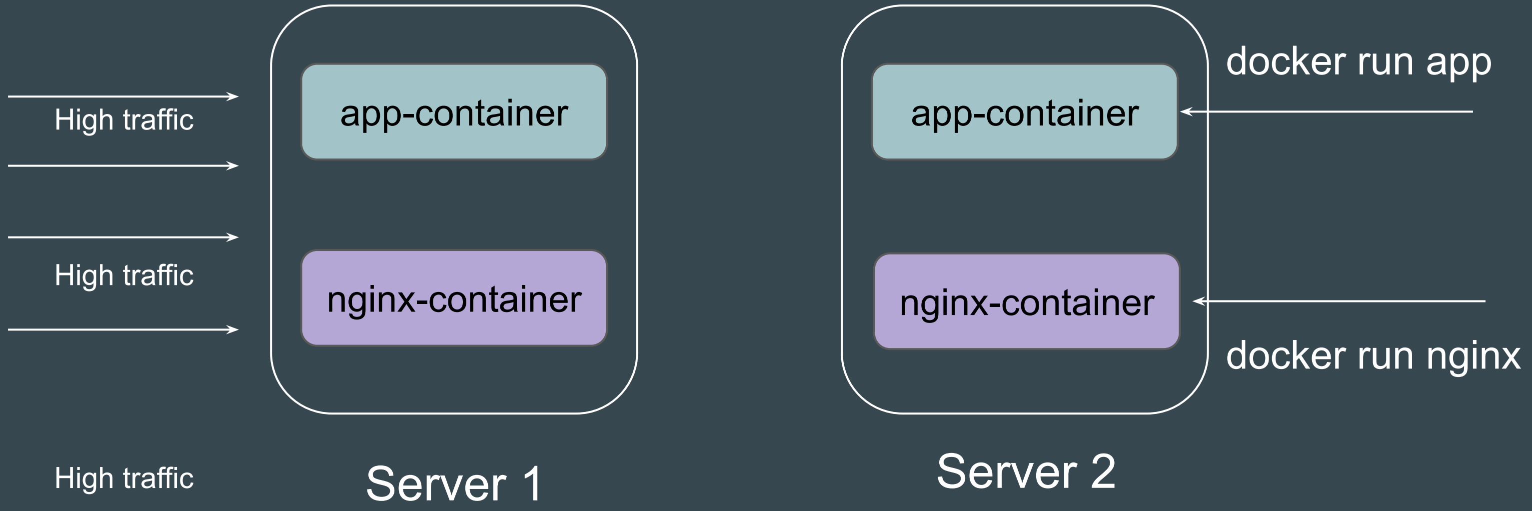
During the initial times, users relied on manual container management or basic scripts to handle tasks like deployment, scaling, networking, and monitoring.



Challenge 1 - Manual Scaling

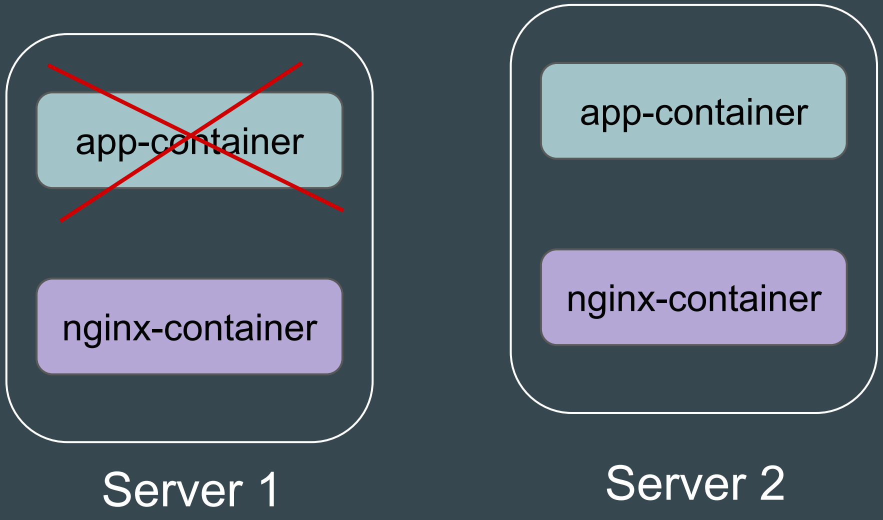
If an application needed to handle higher traffic, developers had to manually start additional containers.

This involved identifying which servers had enough resources, deploying new containers, etc.



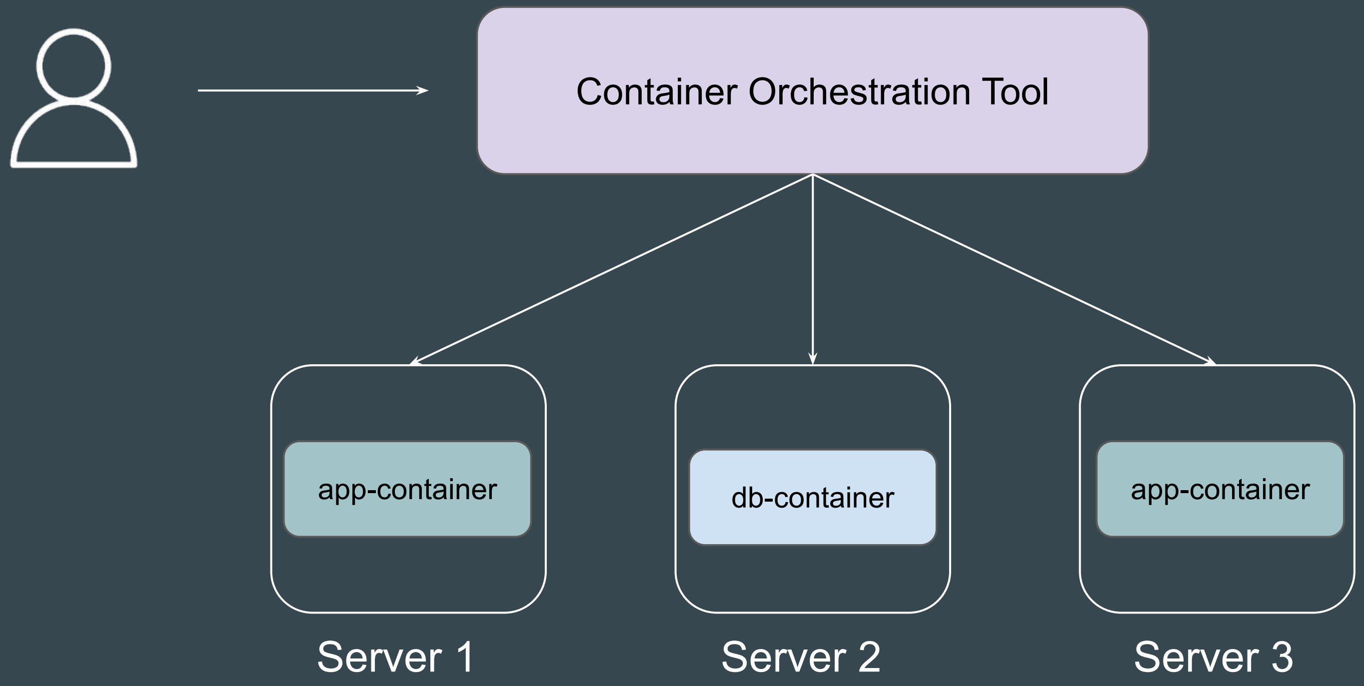
Challenge 2 - Lack of Fault Tolerance

If a container failed (e.g., due to a crash or resource exhaustion,), it wouldn't automatically restart without manual intervention in most of the cases.



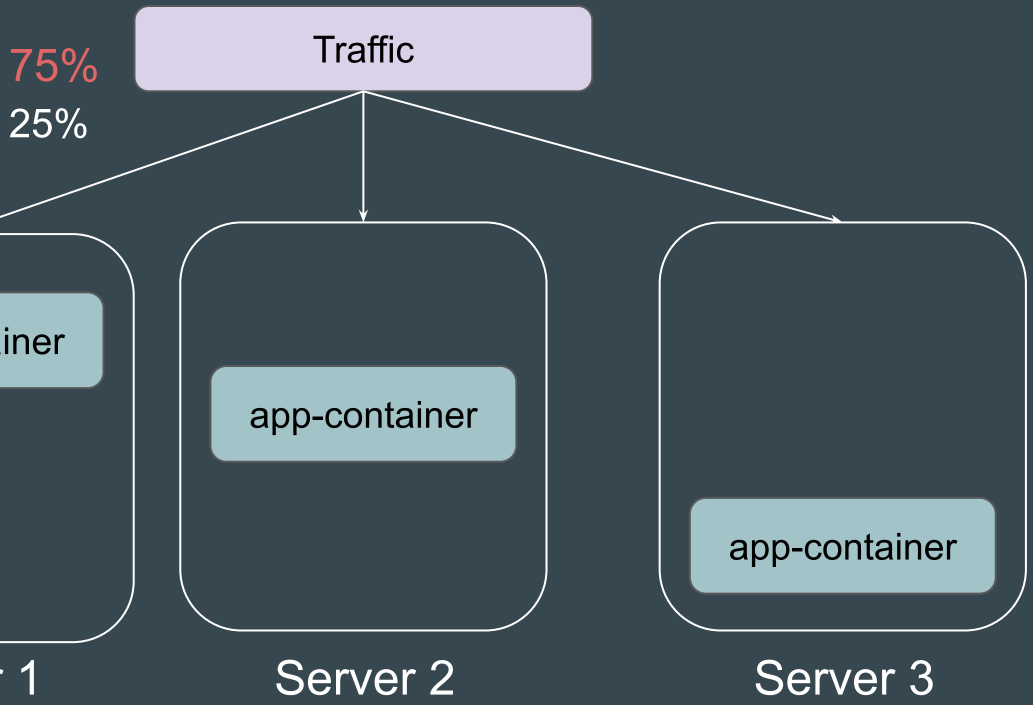
Introducing Container Orchestration

Container orchestration automates the deployment, management, scaling, and networking of containers.



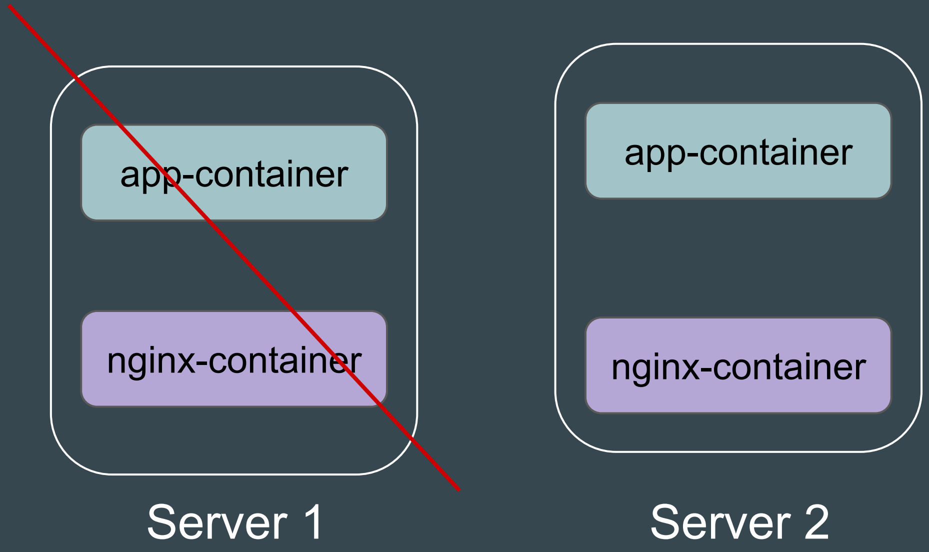
Solving Challenge - Scaling

Orchestration tools CAN automatically scale containers up or down based on defined policies and real-time traffic.



Solving Challenge - Fault Tolerance

Failed containers are automatically restarted or replaced to ensure high availability.



Container Orchestration is LOT More

Container orchestration is the process of automating the networking and management of containers so you can deploy applications at scale

- Provisioning and deployment
- Configuration and scheduling
- Resource allocation
- Load balancing and traffic routing
- Monitoring container health
- Keeping interactions between containers secure

Container Orchestration Tools

There are multiple set of Container Orchestration tools available in the Industry.

Based on the organization and requirement, you can choose tools per preference.

Docker Swarm

kubernetes

Amazon ECS

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Introduction to Kubernetes

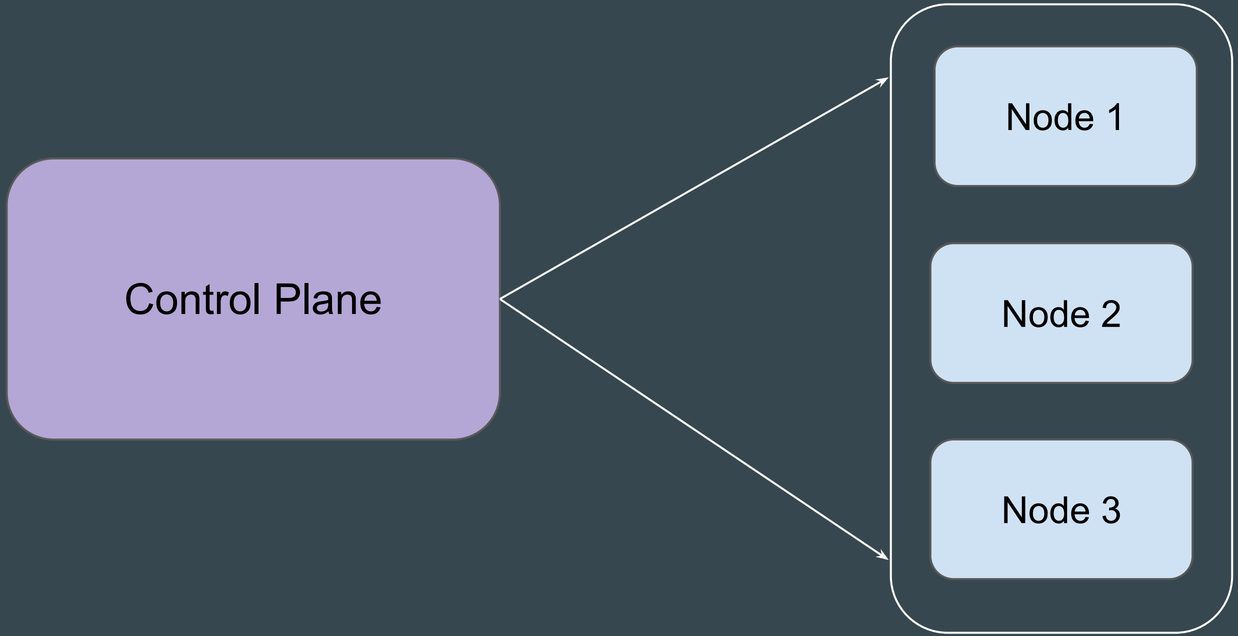
Setting the Base

Kubernetes (K8s) is an open-source container orchestration engine developed by Google.

It was originally designed by Google, and is now maintained by the Cloud Native Computing Foundation.

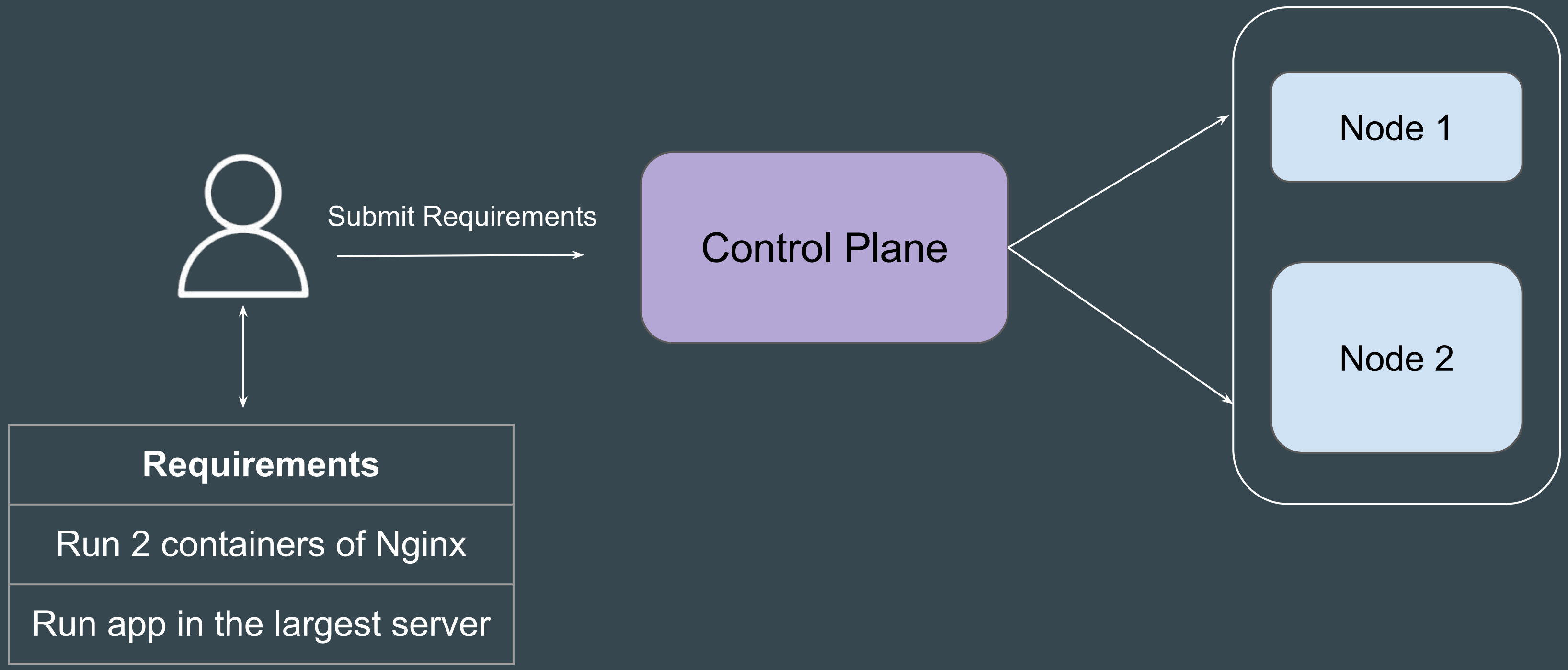
Architecture of Kubernetes

A Kubernetes cluster consists of a control plane + a set of worker machines, called nodes, that run containerized applications



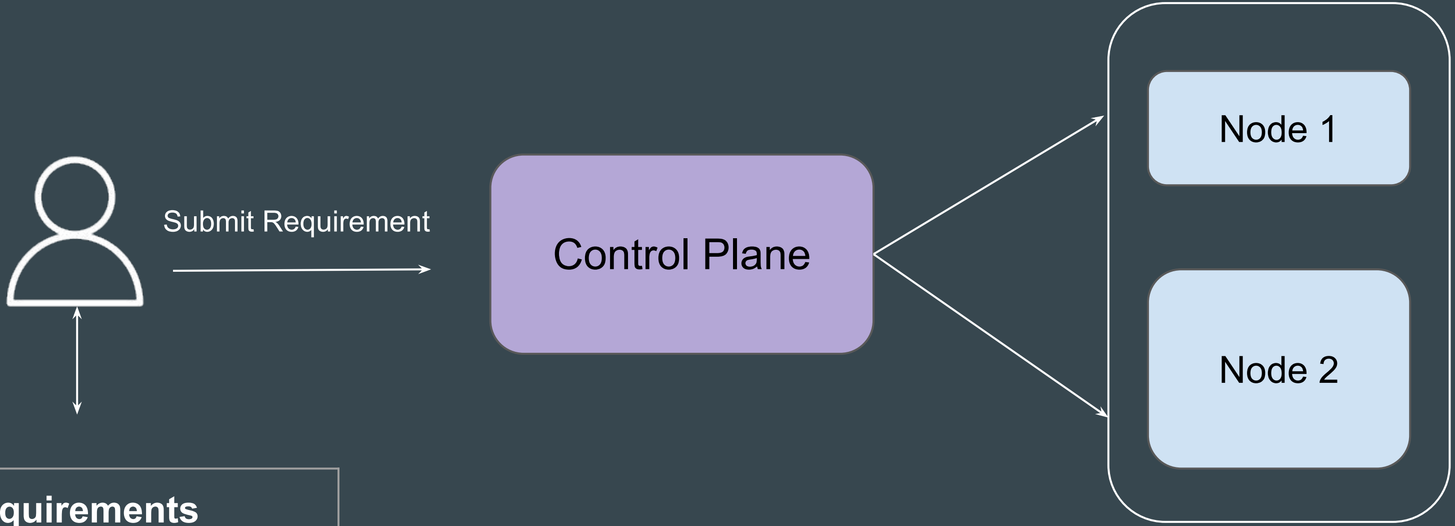
Basic Workflow

User communicates to Control Plane and provides necessary instructions to run containerized applications.



Example - Run 1 Container of Apache

If you have instructed Kubernetes to run 1 container of Apache, Kubernetes will launch it in one of the worker nodes and will regularly monitor the state of that container to ensure it always runs.



Requirements
Run 1 container of Apache

Kubernetes is Awesome

Kubernetes provides amazing set of features and is designed on the same principles that allow Google to run billions of containers a week.

Some of the popular features include:

- Pod Auto-Scaling
- Service discovery and load balancing
- Self-Healing of Containers
- Secret management
- Automated rollouts and rollbacks

Installation Options for Kubernetes

Analogy - Eating your Favorite Food Dish

You want to eat your favourite food dish.

What are the options:

1. Go to store, get ingredients and prepare from scratch.
2. Get ready-made mix, make it hot.
3. Order it from the restaurant.

Kubernetes Reference

You want to launch a Kubernetes cluster.

What are the options:

1. Go to K8s website, download individual components and integrate them one by one.

2. Use tools like Minikube, Kubeadm to quickly setup K8s cluster for you.

3. Use Managed Kubernetes Service.

Option 1 - Managed Kubernetes Service

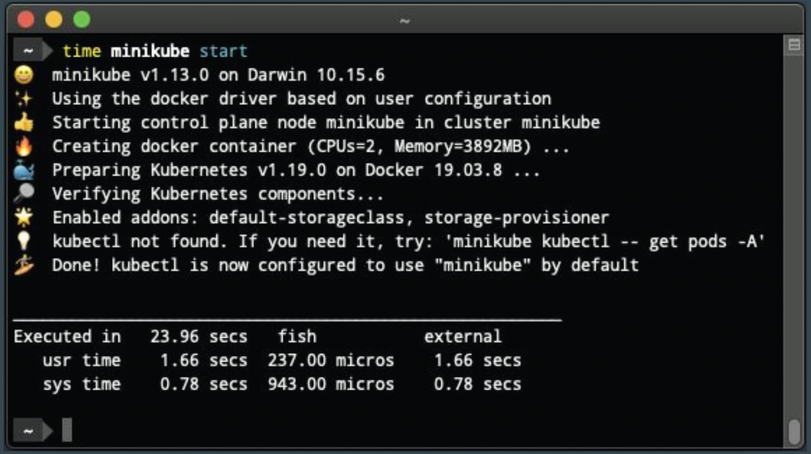
Various providers like AWS, IBM, GCP and others provides managed Kubernetes clusters.

Analogy: Order Ready-Made Food from Store.

Option 2 - K8s Development Tools

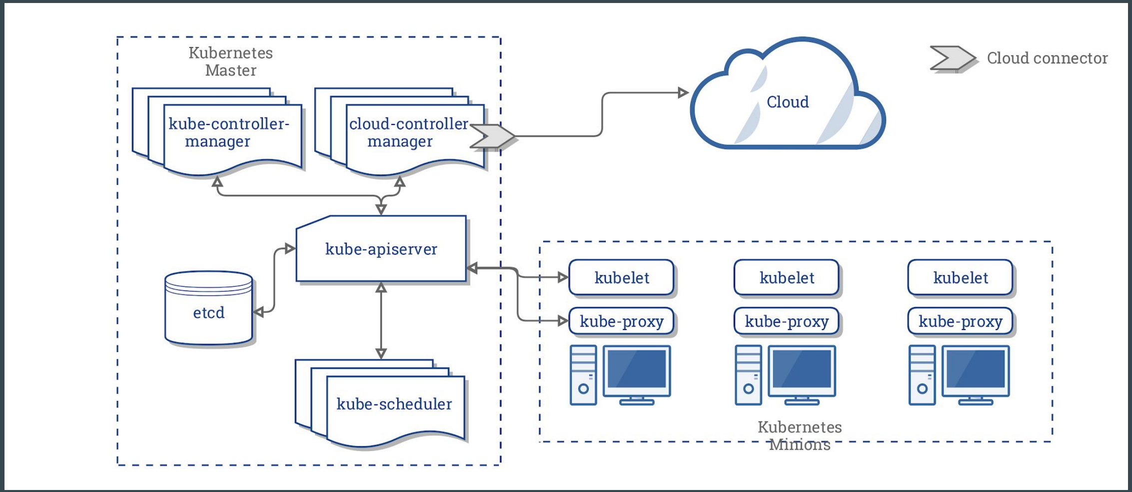
Various tools like Minikube, K3d allows you to quickly setup the Kubernetes for local testing.

Analogy: Get ready-made mix, make it hot.



Option 3 - Setup K8s from Scratch

In this approach, you install and configure each Kubernetes component individually.



Choosing Right Cloud Provider for Practicals

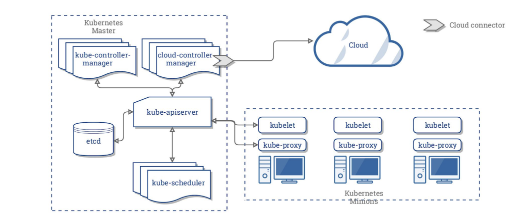
Installation Options for Kubernetes

There are three primary ways to configure Kubernetes.

1. Using Managed Kubernetes Service from a Provider

2. Use tools like Minikube, Kubeadm to quickly setup K8s cluster for you.

3. Setup Kubernetes Cluster from Scratch.



Constraints of Choosing Cloud Provider

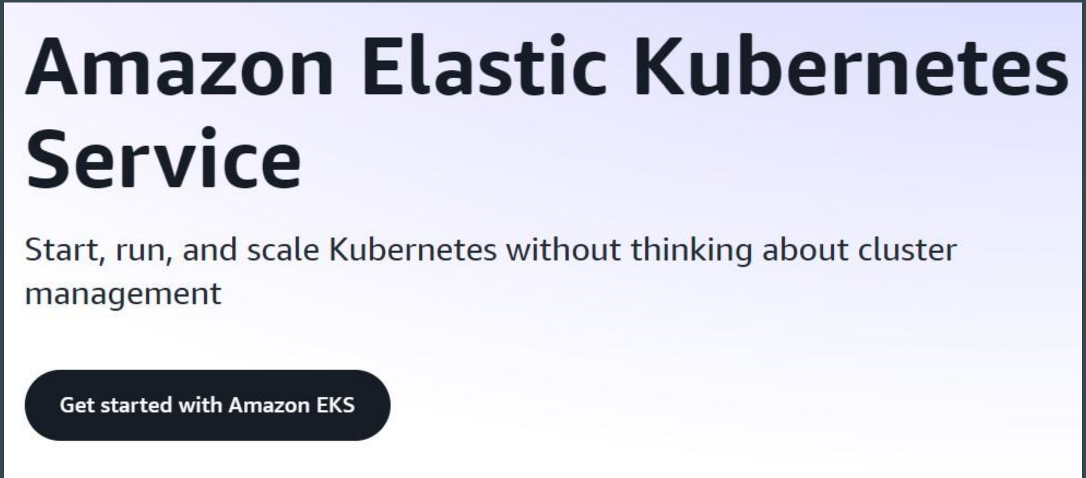
1. Easy to Use.

2. Cost Effective.

3. Free Credits to Get Started.

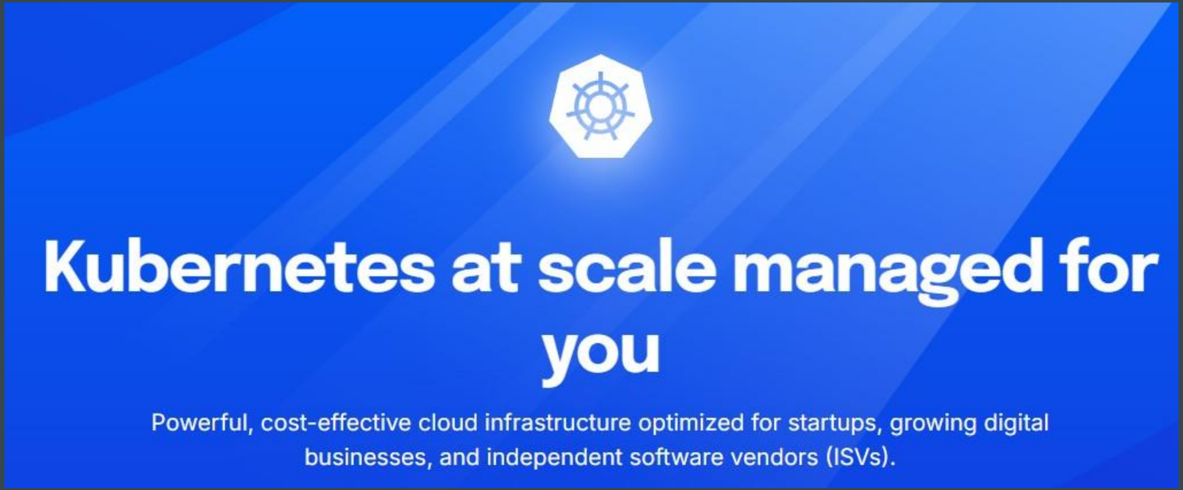
Option 1 - Amazon EKS

Managed Kubernetes service provided by AWS.



Option 2 - Digital Ocean

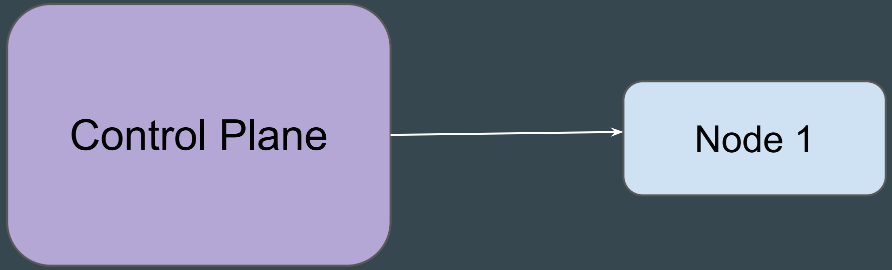
Managed Kubernetes service provided by Digital Ocean.



Why Digital Ocean?

Kubernetes Control Plane is completely free.

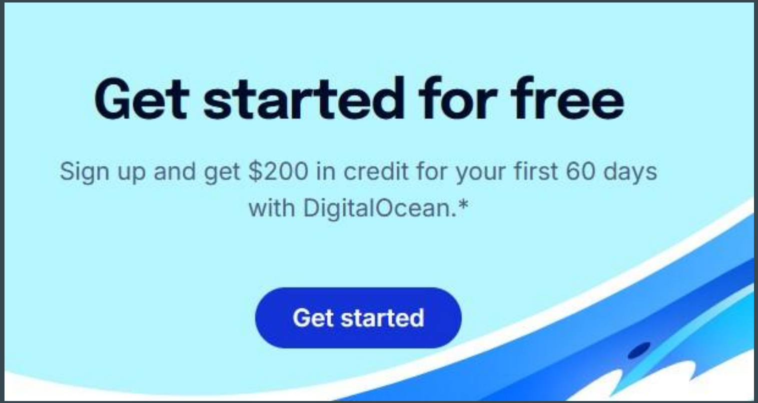
You will be charged only for the Worker Nodes that you run..



Initial Free Credits

Digital Ocean provides decent amount of free credits for new users.

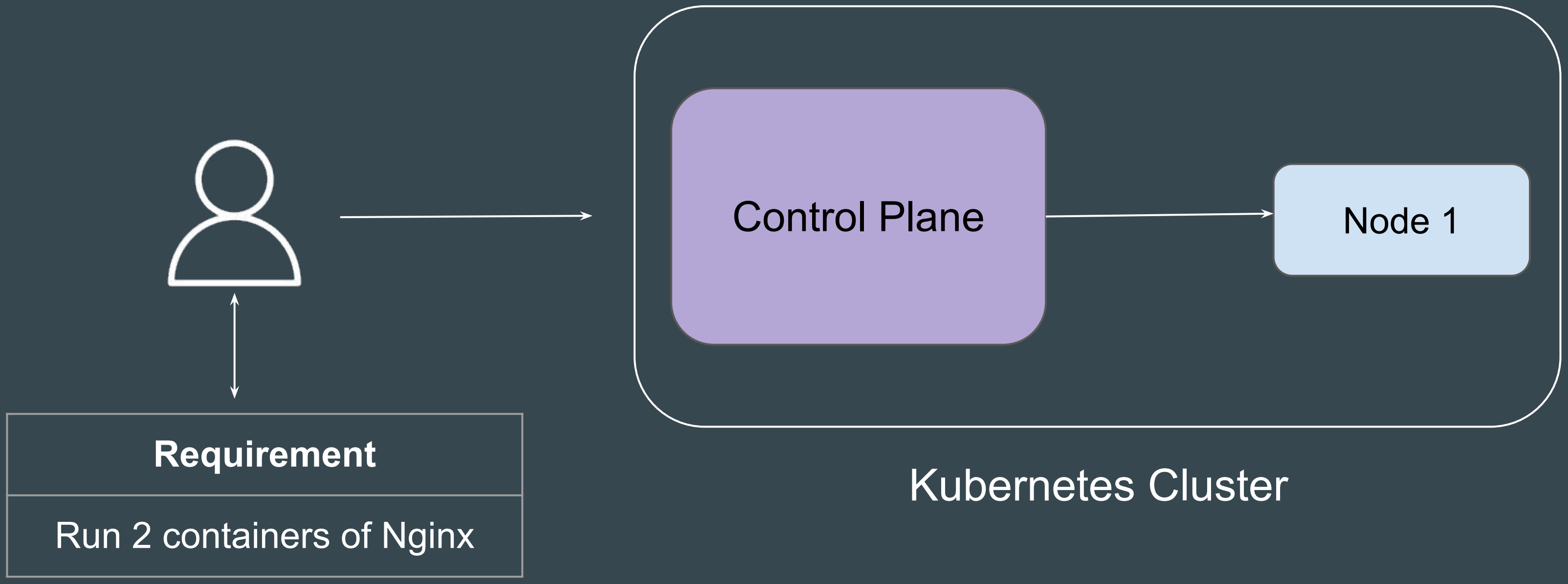
You can literally complete this entire course and ALL practicals for free.



Connectivity Options for Kubernetes

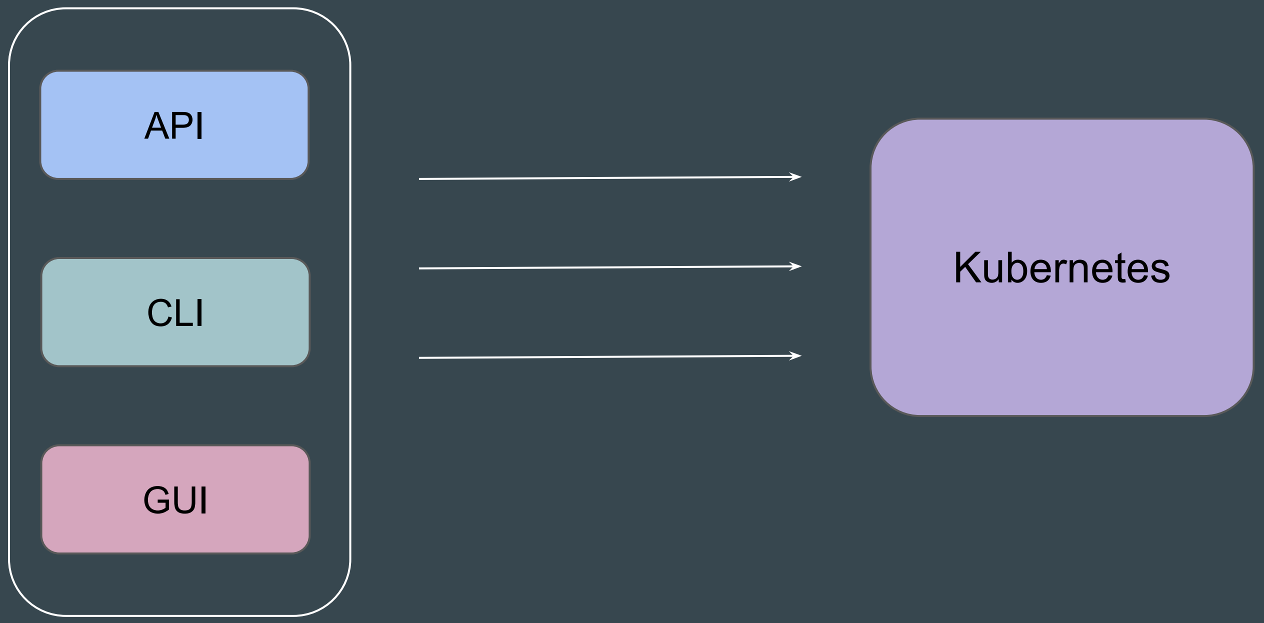
First Important Step - Connect to Cluster

The first important step after launching Kubernetes cluster is to connect to the Control Plane.



Options for Connectivity

There are three primary ways to connect to your Kubernetes cluster.



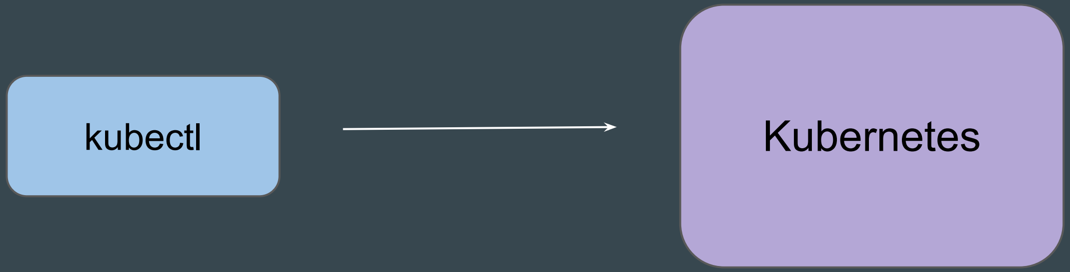
Option 1 - API

You can use utilities like curl to directly send request to to the API.

```
root@kubeadm-master:~# curl http://localhost:8080/api/v1/namespaces/default/pods
{
  "kind": "PodList",
  "apiVersion": "v1",
  "metadata": {
    "resourceVersion": "1346"
  },
  "items": [
    {
      "metadata": {
        "name": "nginx",
        "namespace": "default",
        "uid": "67850778-3e32-4364-9a91-04c2cb9644d8",
        "resourceVersion": "1338",
        "creationTimestamp": "2024-12-26T05:49:11Z",
        "labels": {
          "run": "nginx"
        },
```

Option 2 - CLI

To connect to Kubernetes using CLI, you need an important tool named kubectl

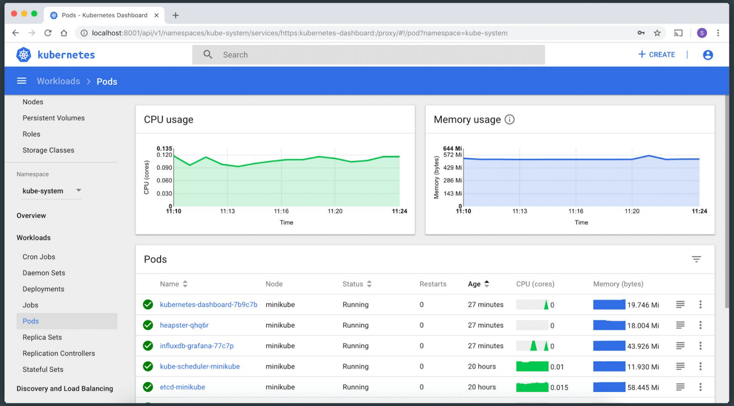



```
root@kubeadm-master:~# kubectl get pods
NAME     READY    STATUS     RESTARTS    AGE
nginx    1/1      Running    0           82s
```

Option 3 - GUI

Dashboard is a web-based Kubernetes user interface.

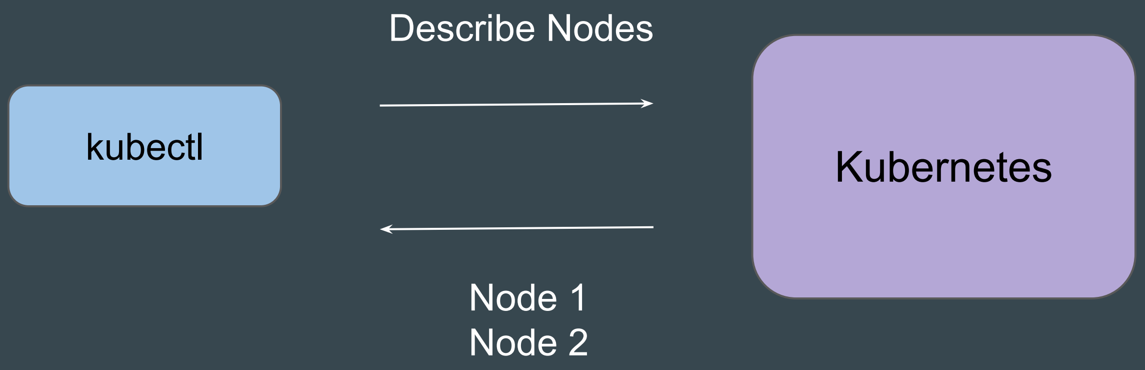
You can use Dashboard to deploy, troubleshoot containerized applications and manage the cluster resources



Overview of kubectl

Basics of Kubectl

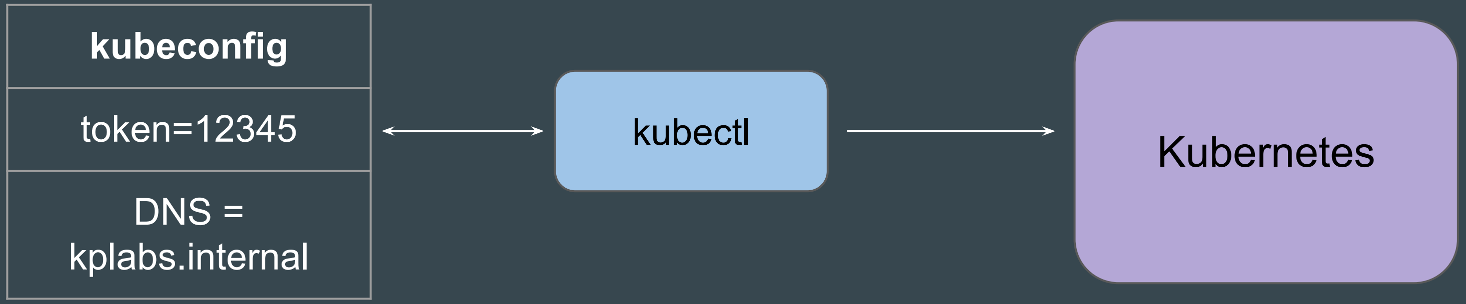
The Kubernetes command-line tool, kubectl, allows you to run commands against Kubernetes clusters.



Important Part - Authentication

Kubectl needs two important details while connecting to Kubernetes Cluster

1. DNS / IP Address of Kubernetes Control Plane
2. Authentication Credentials.



Default Path of Kubeconfig File

Kubectl by default will look for the kubeconfig file in a file named config inside .kube folder in your home directory.

~/.kube/config

```
root@kubeadm-master:~# ls -l ~/.kube/config
-rw------- 1 root root 5658 Dec 26 05:46 /root/.kube/config
```

Referencing to Custom Config File

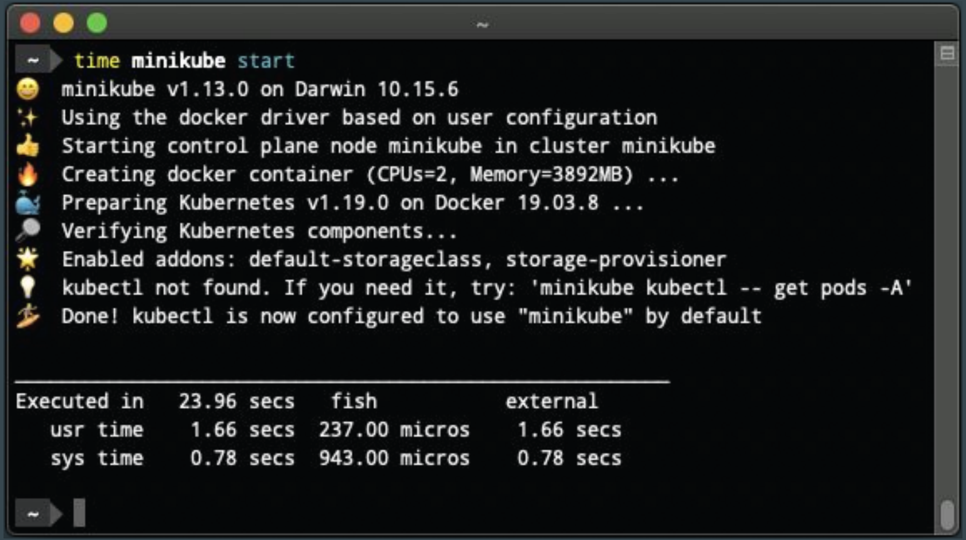
You can also refer to custom config file using the --kubeconfig flag

```
C:\kplabs-k8s>kubectl get nodes --kubeconfig "custom-kubeconfig"
NAME                   STATUS    ROLES    AGE    VERSION
pool-i625o5obd-eob8a   Ready     <none>   3h6m   v1.31.1
```

Configuring Kubernetes using Minikube

Basics of Minikube

minikube quickly sets up a local Kubernetes cluster on macOS, Linux, and Windows.

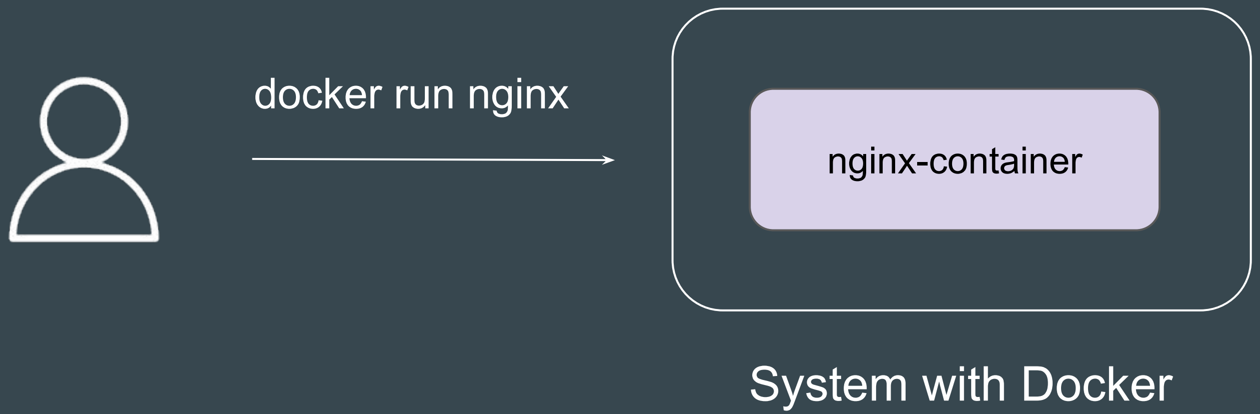


Basics of Kubernetes Pods

Setting the Base - Docker Analogy

You have recently installed Docker in your system.

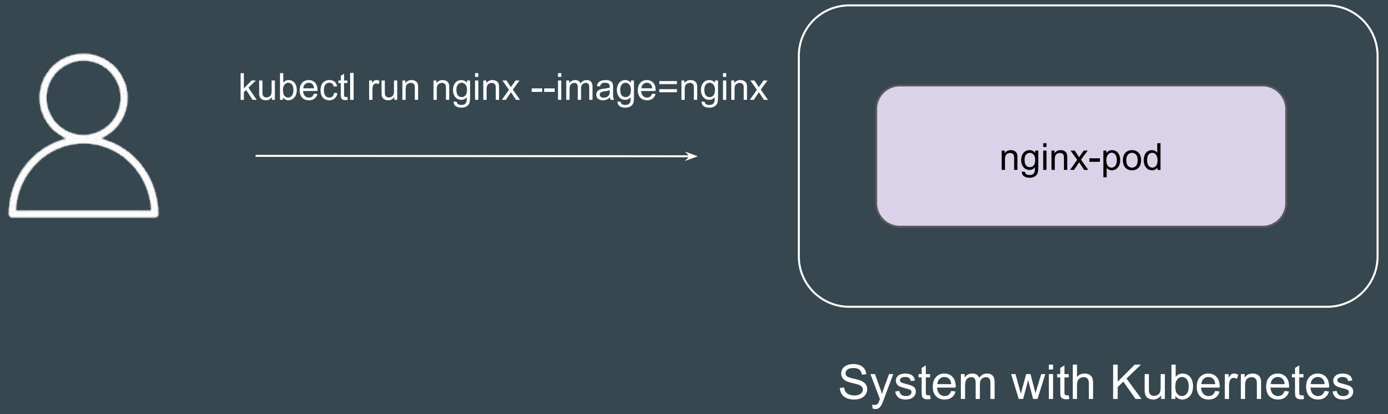
What is the first thing that you might do?



Setting the Base - Kubernetes Analogy

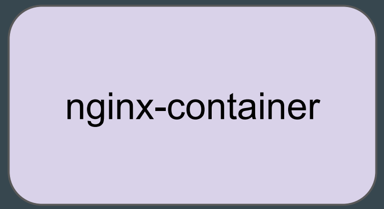
You have recently configured Kubernetes cluster.

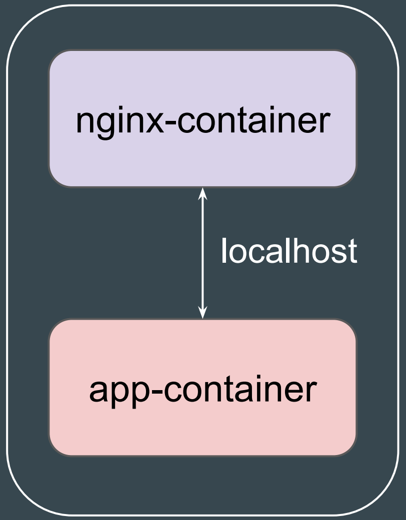
What is the first thing that you might do?



Difference Between Container and Pods

A Pod can contain one or more Docker containers that share the same network namespace and storage volumes





Pod

Comparison Table - Docker vs Kubernetes Commands

Docker Command	Kubernetes Command	Purpose
docker run nginx	kubectl run nginx --image=nginx	Create and run a container/pod
docker ps	kubectl get pods	List running containers/pods
docker logs <container>	kubectl logs <pod>	View logs
docker inspect <container>	kubectl describe pod <pod-name>	Get detailed info
docker exec -it <container> bash	kubectl exec -it <pod-name> -- bash	Execute interactive shell
docker rm <container>	kubectl delete pod <pod-name>	Remove container/pod

Points to Note - Kubernetes Pod

A Pod always runs on a Node.

A Node is a worker machine in Kubernetes.

Each Node is managed by the Kubernetes Control Plane.

A Node can have multiple pods.

Multiple Ways to Create Kubernetes Objects

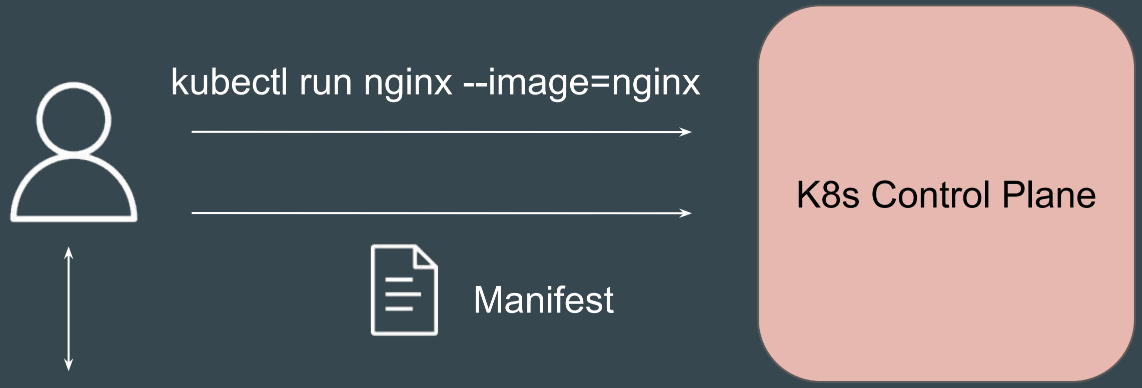
Setting the Base

We have been using simple approach of using kubectl command to create object like Pods in Kubernetes.

```
root@minikube:~# kubectl run nginx --image=nginx
pod/nginx created
```

2 Primary Ways to Create Object

Use kubectl run command or supply kubectl with Manifest file that contains information of resource to be created.



Requirement
Create Pod based on Nginx Image

Manifest File Example

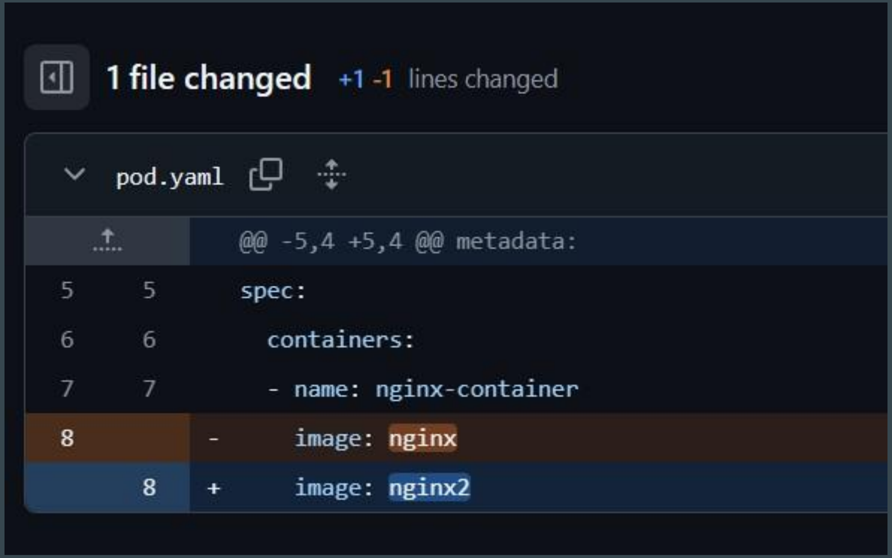
A Kubernetes manifest file is a YAML or JSON file that defines the desired state of a Kubernetes object.

! pod.yaml

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

Benefits of Manifest File - Version Control

Manifest files can be stored in version control systems like Git, allowing you to track changes to your infrastructure over time and easily roll back to previous versions.



Benefits of Manifest File - Multiple Resources

You can define multiple rest of dependent resource objects that you want to create in a single manifest file.

demo.yaml

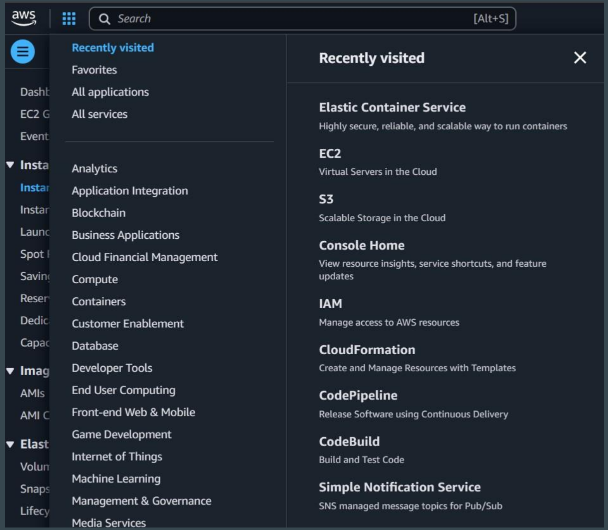
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx-pod
  labels:
    app: nginx
spec:
  containers:
  - name: nginx-container
    image: nginx:latest
    ports:
    - containerPort: 80

---
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  type: NodePort
  selector:
    app: nginx
  ports:
```

Basics of Kubernetes Resource Types

Sample Analogy - Hosting Provider

During the early times, one of the primary offerings of hosting providers was servers / virtual machines.

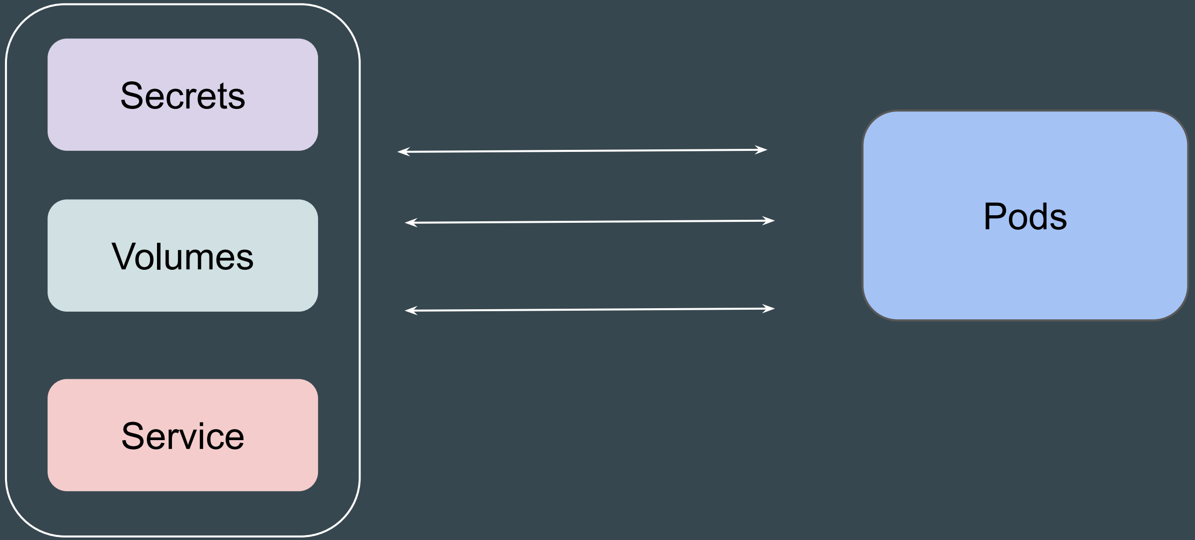
Nowadays, there are 100s of services offered by Cloud providers that aid in the entire lifecycle management of applications and custom use-cases of organizations.



Understanding from Kubernetes Perspective

Although Pods allow users to host custom applications in containers, it might not always be enough.

Based on use-case, Pod might also require access to other Kubernetes Objects.



Kubernetes Resource Types

Kubernetes has a broad set of resource types that organizations can use based on their requirements.

Pod
The smallest deployable unit in Kubernetes, representing a single instance of a running process.

Deployment
Manages multiple replicas of Pods and supports rolling updates.

Service
Exposes Pods to the network and provides stable load balancing.

ConfigMap
Stores non-sensitive configuration data for applications.

Secret
Stores sensitive data like passwords and keys securely.

PersistentVolume
Represents storage resources for persistent data in the cluster.

PersistentVolumeClaim
Requests a specific amount of storage from a PersistentVolume.

Ingress
Manages external HTTP and HTTPS traffic to Services in the cluster.

Namespace
Provides a way to group and isolate resources within the cluster.

Reference Screenshot

```
C:\Users\zealv>kubectl api-resources
NAME                                  SHORTNAMES
bindings
componentstatuses                     cs
configmaps                            cm
endpoints                             ep
events                                ev
limitranges                           limits
namespaces                            ns
nodes                                 no
persistentvolumeclaims                pvc
persistentvolumes                     pv
pods                                  po
podtemplates
replicationcontrollers                rc
resourcequotas                        quota
secrets
serviceaccounts                       sa
services                              svc
```

Basic Structure of a Manifest File

Sample - Pod Manifest File

! pod.yaml

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

Comparing Manifest Structure with Pod Manifest

manifest.yaml

```yaml
apiVersion: [API version]
kind: [Resource type]
metadata:
  name: [Resource name]
spec:
  [Resource-specific configuration]
```

pod.yaml

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

Basic Structure of Manifest File

```yaml
! manifest.yaml
apiVersion: [API version]
kind: [Resource type]
metadata:
  name: [Resource name]
spec:
  [Resource-specific configuration]
```

Component	Description
apiVersion	Specifies which version of the Kubernetes API to use
kind	Type of resource you are creating.
metadata	Information about resource
spec	Details about resource to be created

Generating Manifest File through CLI Command

Setting the Base

CLI commands are easy to run, and Manifest file provides a lot of benefits for organizations and team collaboration.

Finding an easier way to generate a manifest file is needed.

Kubectl Command

Generate

pod.yaml

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

Basics of Dry Runs

The --dry-run=client option allows you to validate a Kubernetes resource definition without actually applying it to the cluster.

```
C:\kplabs-k8s>kubectl run nginx --image=nginx --dry-run=client
pod/nginx created (dry run)
```

Exploring Output of Kubectl command

By default, when you run the basic kubectl command to create an object like Pod, in the output, it will just print the confirmation message.

```
C:\>kubectl run nginx --image=nginx
pod/nginx created
```

Kubectl with Output of YAML

When kubectl command is used with output of yaml, the command doesn't just create the resource in the cluster; it also prints the full YAML configuration of the created resource to your terminal.

```
C:\kplabs-k8s>kubectl run nginx --image=nginx -o yaml
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: "2025-01-01T04:11:42Z"
  labels:
    run: nginx
  name: nginx
  namespace: default
  resourceVersion: "1599760"
  uid: 2f321eaf-15b5-457d-8d58-d644ede8a6cc
spec:
  containers:
  - image: nginx
    imagePullPolicy: Always
    name: nginx
```

Combining Dry Run Output of YAML

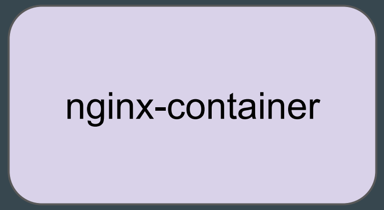
When --dry-run=client is combined with -o yaml, it will generate manifest file for you associated with the command without actually deploying the object in Kubernetes.

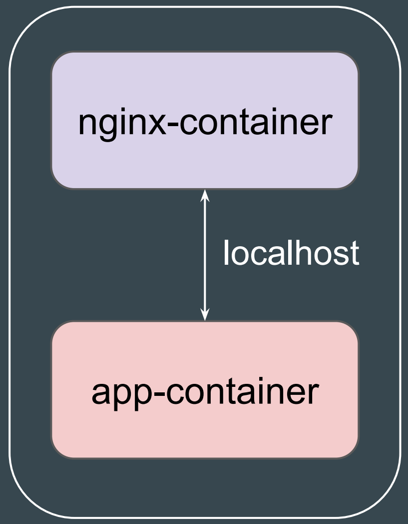
```
C:\>kubectl run nginx --image=nginx --dry-run=client -o yaml
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: null
  labels:
    run: nginx
  name: nginx
spec:
  containers:
  - image: nginx
    name: nginx
    resources: {}
  dnsPolicy: ClusterFirst
  restartPolicy: Always
status: {}
```

Multi-Container Pods

Difference Between Container and Pods

A Pod can contain one or more Docker containers that share the same network namespace and storage volumes





Pod

Default Option with kubectl Command

The kubectl run command allows us to run a single-container based Pods.

For Pods with multiple container, you need to use Manifest File based approach.

Multi-Container Pod Configuration

To create a multi-container based Pods, you can defined additional details in container definition.

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

! multi-container-pods.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: multi-container-pod
spec:
 containers:
 - name: nginx-container
   image: nginx
 - name: redis-container
   image: redis
```

Exec into a Container

By default, when you run the kubectl exec command, it will connect to the first container.

```
C:\kplabs-k8s>kubectl exec -it multi-container-pod -- bash
Defaulted container "nginx-container" out of: nginx-container, redis-container
root@multi-container-pod:/#
```

Exec into Other Containers in Pod

To connect with other containers of Pod, you can add -c flag with <container-name> as part of the kubectl exec command

```
C:\kplabs-k8s>kubectl exec -it multi-container-pod -c redis-container -- bash
root@multi-container-pod:/data#
```

Overview of Commands and Arguments

Setting the Base

Whenever a Docker Image is built, it can have a certain ENTRYPOINT / CMD instructions set that defines what container needs to run when it starts.

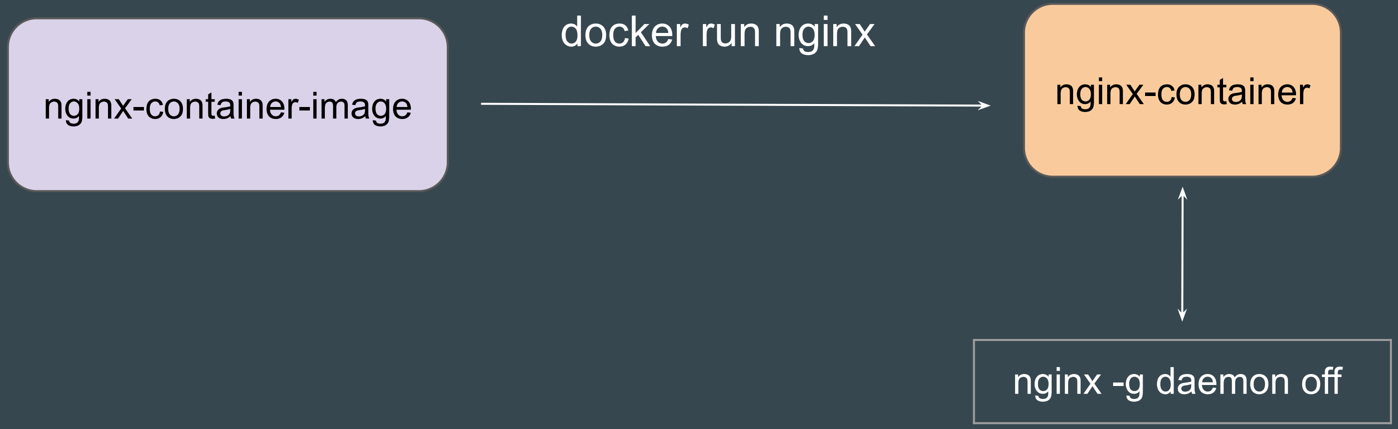
Dockerfile > ...

```
FROM nginx:1.10.1-alpine
COPY index.html /usr/share/nginx/html
EXPOSE 80
CMD ["nginx", "-g", "daemon off;"]
```

nginx-container-image

Running Docker Container from Image

Whenever a container starts from Docker Image, it uses the appropriate ENTRYPOINT / CMD Instructions to start the appropriate process inside the container.



Example 2 - Short Lived CMD Instruction

In the following example, a Docker image is built using a busybox image with CMD instruction that pings google.com three times.

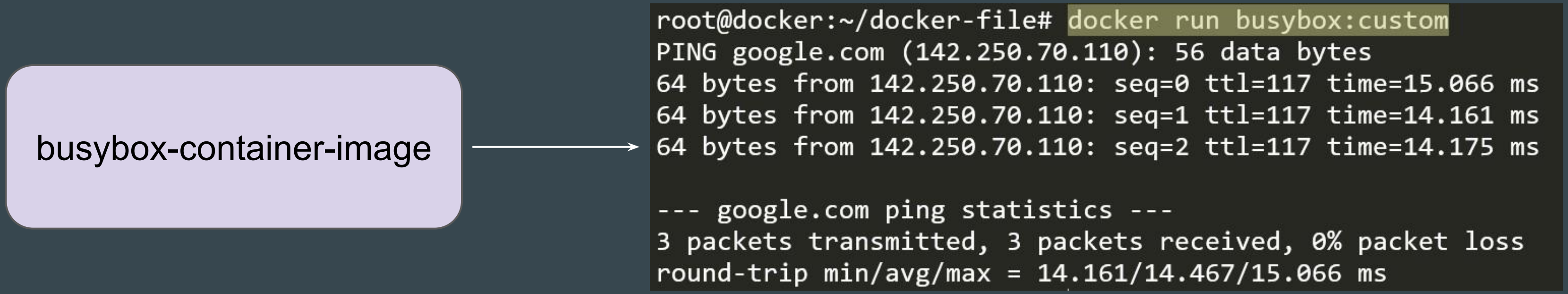
Dockerfile > ...

```dockerfile
FROM busybox:latest
CMD ["ping", "-c", "3", "google.com"]
```

What is no long running process in CMD?

Once ping finishes sending the 3 requests and receives the responses (or timeouts), there's nothing else defined in the CMD instruction.

Since there's no additional process keeping the container running, it exits as soon as the initial command finishes.



Entrypoint and CMD in Dockerfile

The ENTRYPOINT is always executed when the container starts.

If you provide a command when running the container, that command is appended as arguments to the ENTRYPOINT.

Dockerfile > ...

```
FROM ubuntu
ENTRYPOINT ["/bin/echo"]
CMD ["hello", "world"]
```

Example - Entrypoint vs CMD in Dockerfile

If you run docker run <image>, the output will be: hello world

If you run docker run <image> how are you, the output will be: how are you

```
Dockerfile > ...
FROM ubuntu
ENTRYPOINT ["/bin/echo"]
CMD ["hello", "world"]
```

```
root@docker:~# docker run demo
hello world
```

```
root@docker:~# docker run demo how are you
how are you
```

Command and Arguments in Kubernetes

When you create a Pod, you can define a command and arguments for the containers that run in the Pod.

The command field corresponds to ENTRYPOINT, and the args field corresponds to CMD in some container runtimes.

cmd-args.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: command-demo
spec:
  containers:
  - name: demo
    image: busybox
    command: ["/bin/echo"]
    args: ["hello", "world"]
```

Point to Note

The command argument defined overrides the default ENTRYPOINT.

The args(arguments) overrides the default CMD.

Commands and Arguments - Practical

Defining Commands and Arguments

The following command denotes the basic syntax to define command and arguments with kubectl run command:

```
kubectl run nginx --image=nginx --command -- <command> <args>
```

Example - Create Pod with Specific Command

```
C:\>kubectl run my-echo-pod --image=busybox:latest --command -- echo "Hello from kubectl run!"
pod/my-echo-pod created
```

```
C:\>kubectl get pods
NAME          READY   STATUS      RESTARTS   AGE
my-echo-pod   0/1     Completed   0          9s
```

```
C:\>kubectl logs my-echo-pod
Hello from kubectl run!
```

Defining in Manifest File

Use the command and args field to define the necessary commands and arguments.

! cmd-args.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: command-demo
spec:
  containers:
  - name: demo
    image: busybox
    command: ["/bin/echo"]
    args: ["hello", "world"]
```

More Clarity - Commands and Arguments

1 - Defining Commands and Arguments

In Kubernetes, when defining the command (or args) for a container in a Pod specification, there are two primary ways to specify them:

- Array (JSON array notation, square brackets []):
- Multi-Line YAML List (- for each new item)

! cmd-args.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
    - name: example-container
      image: busybox
      command: ["/bin/sh", "-c", "echo Hello Kubernetes!"]
```

! cmd-args.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
    - name: example-container
      image: busybox
      command:
        - "/bin/sh"
        - "-c"
        - "echo Hello Kubernetes!"
```

High-Level Comparison

Feature	Array Notation ([])	Multi-Line YAML List (-)
Syntax Style	JSON-style array with square brackets.	YAML-style list where each item is on a new line, prefixed with -.
Readability	Compact but harder to read for long commands.	More human-readable for long commands.
Preference	Suitable for short commands or when inline.	Preferred for long or complex commands.

Generic Recommendation

Use array notation ([]) for shorter commands.

Use multi-line YAML lists (-) for longer, more complex commands or when readability is a priority.

2 - Command and Arguments

The separation of command and args in Kubernetes is a design choice that provides flexibility and clarity when working with containerized applications.

However you can add everything in a single command as well.

! cmd-args.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: example-pod
spec:
  containers:
    - name: example-container
      image: busybox
      command: ["/bin/sh", "-c", "echo Hello Kubernetes!"]
```

General Recommendation

command is intended to specify the entrypoint or the main executable that will run in the container.

args is meant to define the arguments or parameters that are passed to the command.

By keeping them separate, the intent of the configuration becomes clearer

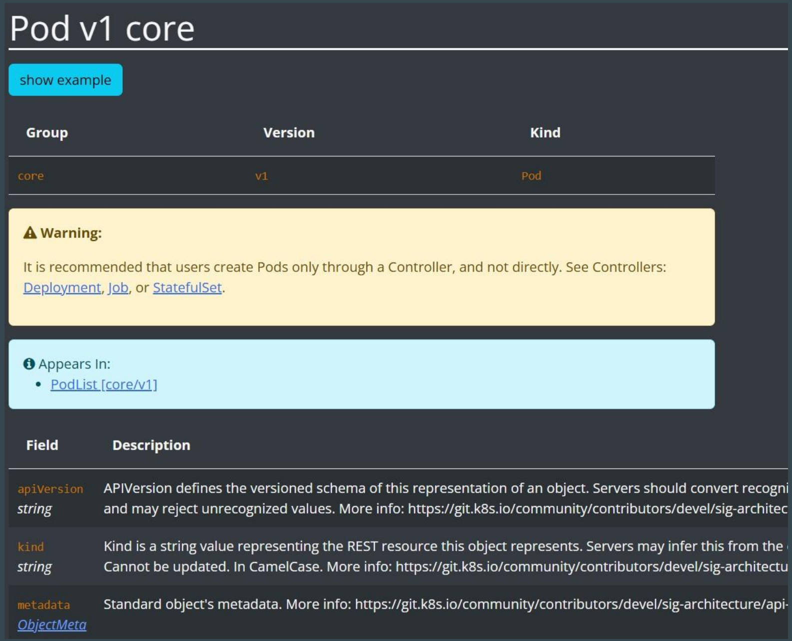
Points to Note

If a container image defines a default ENTRYPOINT, Kubernetes will use it unless you explicitly override it with command.

CLI Documentation for Kubernetes Resources

Kubernetes API Documentation

We generally refer to the Kubernetes API Documentation to understand various fields and associated descriptions for a specific resource.



Pod v1 core

show example

Group	Version	Kind
core	v1	Pod

Warning:

It is recommended that users create Pods only through a Controller, and not directly. See Controllers: Deployment, Job, or StatefulSet.

Appears In:

- PodList [core/v1]

Field	Description
apiVersion *string*	APIVersion defines the versioned schema of this representation of an object. Servers should convert recogni and may reject unrecognized values. More info: https://git.k8s.io/community/contributors/devel/sig-architec
kind *string*	Kind is a string value representing the REST resource this object represents. Servers may infer this from the Cannot be updated. In CamelCase. More info: https://git.k8s.io/community/contributors/devel/sig-architectu
metadata *ObjectMeta*	Standard object's metadata. More info: https://git.k8s.io/community/contributors/devel/sig-architecture/api-

CLI Documentation

You can also use kubectl explain to describe the fields associated with each supported API resource

```
C:\>kubectl explain pods
KIND:       Pod
VERSION:    v1

DESCRIPTION:
    Pod is a collection of containers that can run on a host. This resource is
    created by clients and scheduled onto hosts.

FIELDS:
  apiVersion    <string>
    APIVersion defines the versioned schema of this representation of an object.
    Servers should convert recognized schemas to the latest internal value, and
    may reject unrecognized values. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventions

  kind  <string>
    Kind is a string value representing the REST resource this object
    represents. Servers may infer this from the endpoint the client submits
    requests to. Cannot be updated. In CamelCase. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventions

  metadata      <ObjectMeta>
    Standard object's metadata. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventions

  spec  <PodSpec>
    Specification of the desired behavior of the pod. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventions
```

Similarity to API Doc Hyperlink to See Nested Fields

```
C:\>kubectl explain pods.metadata
KIND:       Pod
VERSION:    v1

FIELD: metadata <ObjectMeta>


DESCRIPTION:
    Standard object's metadata. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventi
    ObjectMeta is metadata that all persisted resources must have, which
    includes all objects users must create.

FIELDS:
  annotations   <map[string]string>
    Annotations is an unstructured key value map stored with a resource that may
    be set by external tools to store and retrieve arbitrary metadata. They are
    not queryable and should be preserved when modifying objects. More info:
    https://kubernetes.io/docs/concepts/overview/working-with-objects/annotations

  creationTimestamp     <string>
    CreationTimestamp is a timestamp representing the server time when this
    object was created. It is not guaranteed to be set in happens-before order
    across separate operations. Clients may not set this value. It is
    represented in RFC3339 form and is in UTC.

    Populated by the system. Read-only. Null for lists. More info:
    https://git.k8s.io/community/contributors/devel/sig-architecture/api-conventi

  deletionGracePeriodSeconds    <integer>
```

EXPOSE

Build once, use anywhere

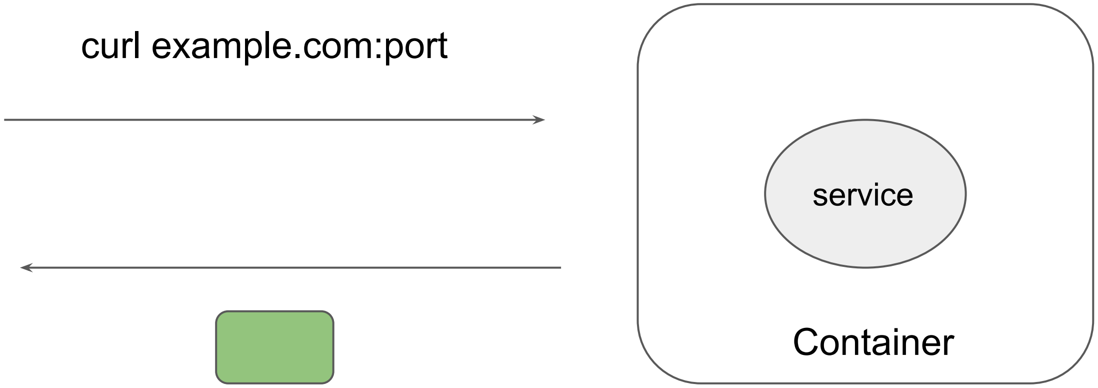
Overview of EXPOSE instruction

The EXPOSE instruction informs Docker that the container listens on the specified network ports at runtime.

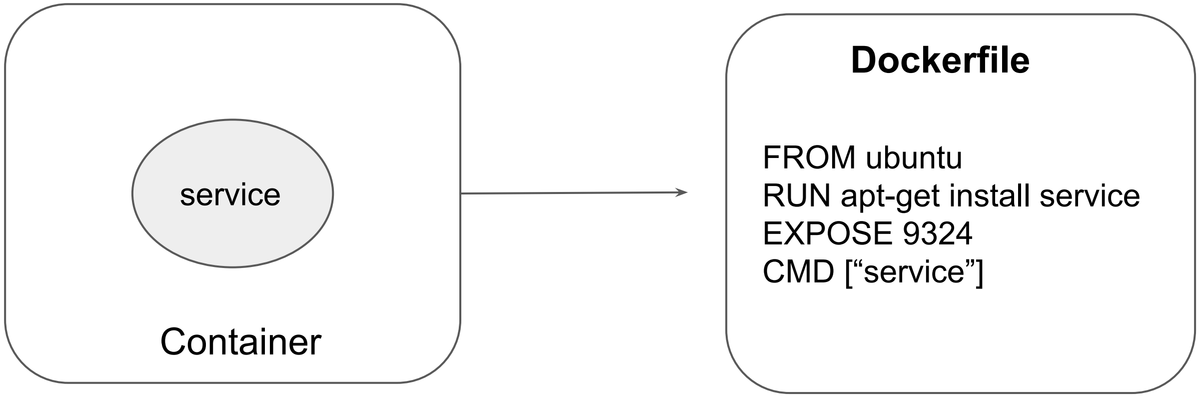
The EXPOSE instruction does not actually publish the port.

It functions as a type of documentation between the person who builds the image and the person who runs the container, about which ports are intended to be published.

Understanding the Use-Case



Understanding the Use-Case

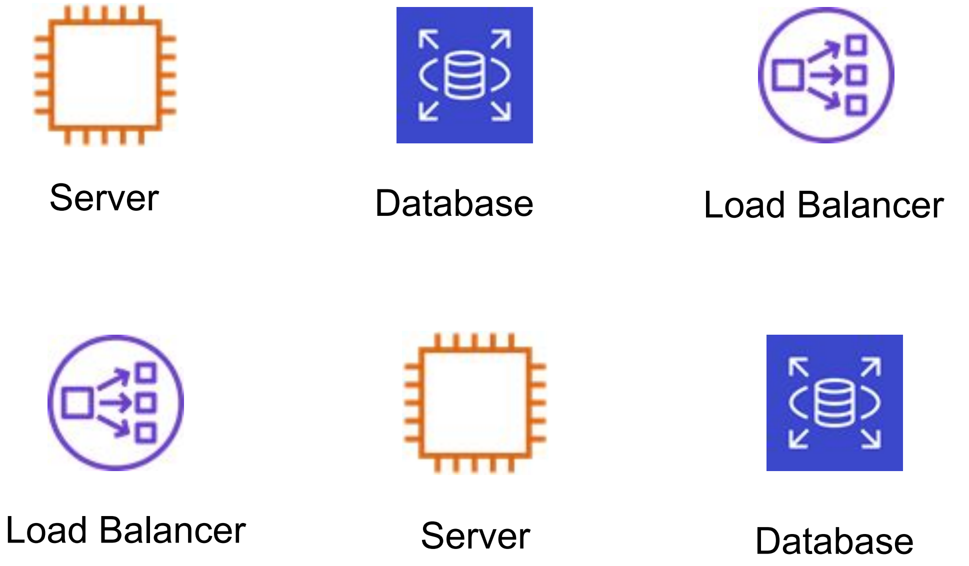


Labels and Selectors

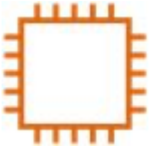
Let's get started

Overview of Labels

Labels are key/value pairs that are attached to objects, such as pods.



Adding Labels to Resource



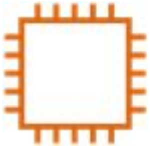
name: kplabs-gateway
env: production

name: kplabs-db
env: production

name: kplabs-elb
env: production

name: kp-elb
env: dev

name: kp-db
env: dev



name: kp-gateway
env: dev

Overview of Selectors

Selectors allows us to filter objects based on labels.

Example:

1. Show me all the objects which has label where **env: prod**

name: kplabs-gateway
env: production

name: kplabs-db
env: production

name: kplabs-elb
env: production

Overview of Selectors

Selectors allows us to filter objects based on labels.

Example:

2. Show me all the objects which has label where **env: dev**

Kubernetes Perspective

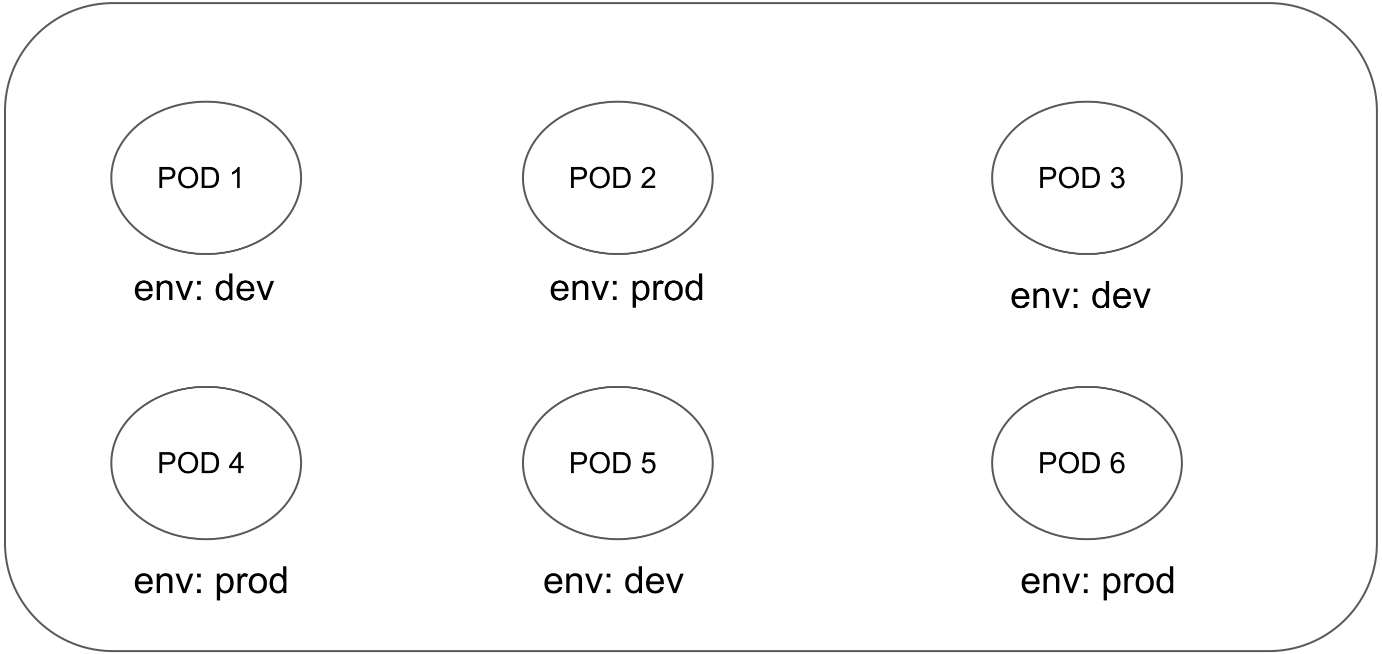
There can be multiple objects within a Kubernetes cluster.

Some of the objects are as follows:

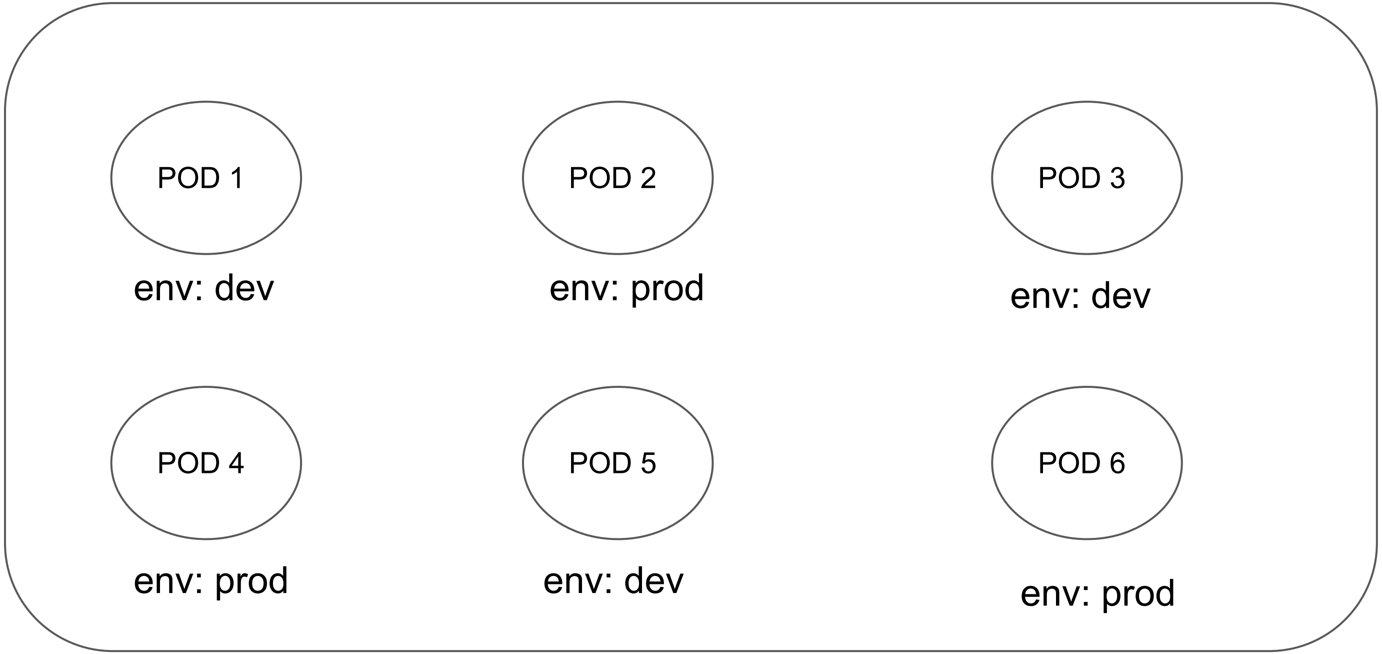
1. Pods
2. Services
3. Secrets
4. Namespaces
5. Deployments
6. Daemonsets

Kubernetes Perspective

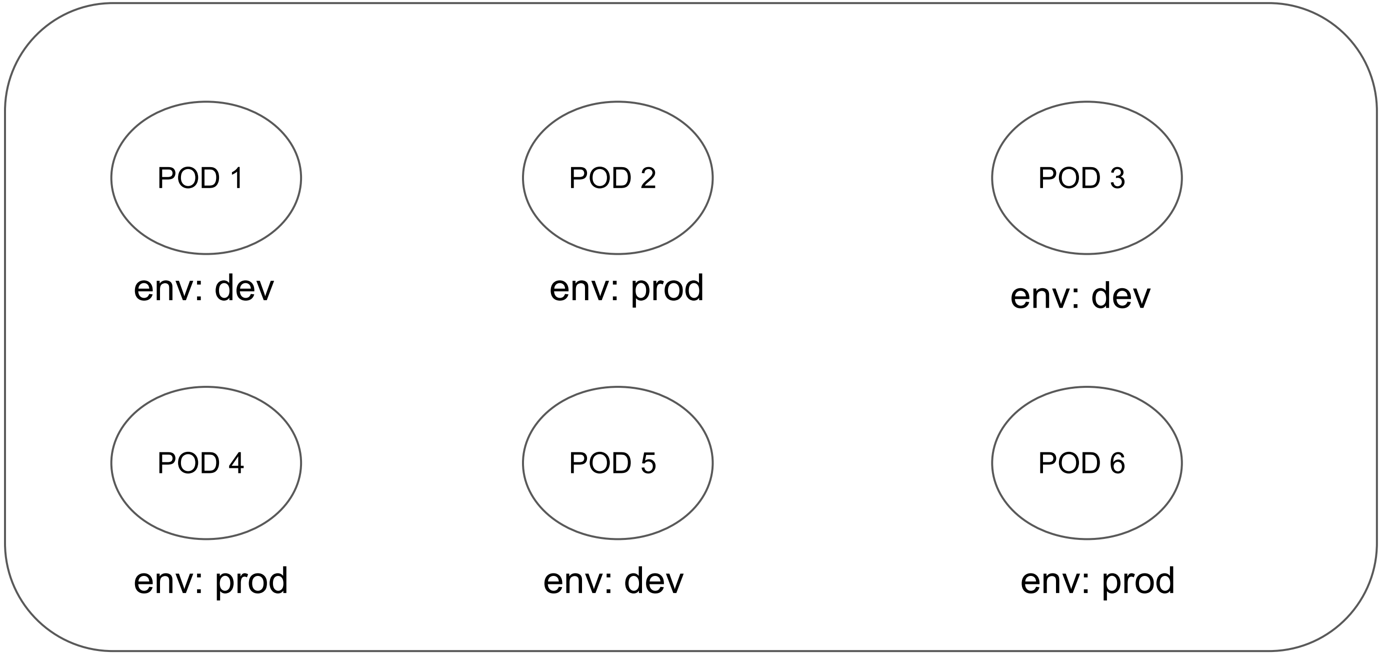
Assigning Labels to Kubernetes Objects



Selector: List All Pods from Dev Environment



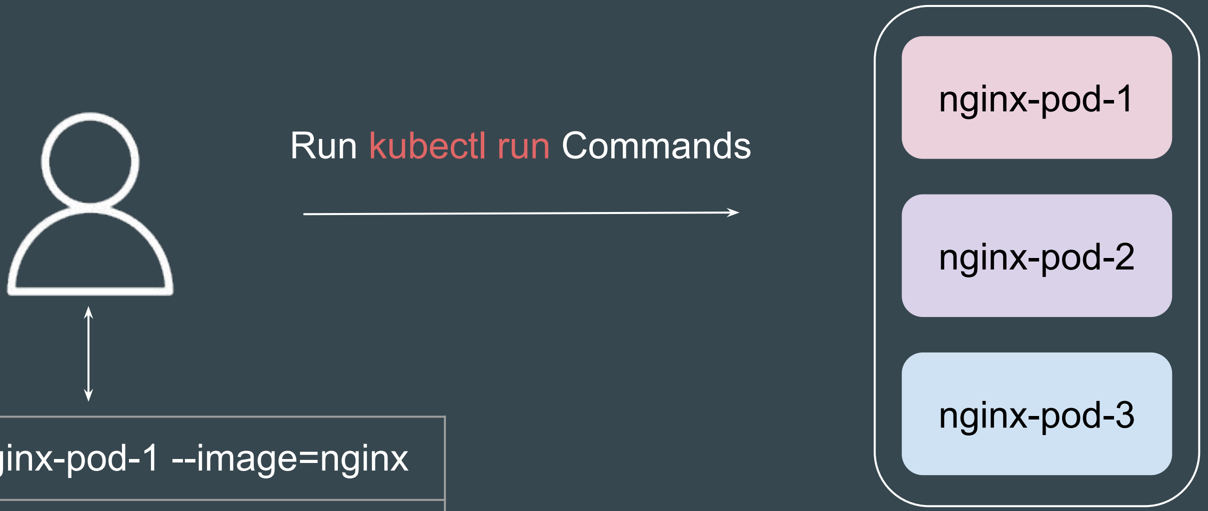
Selector: List All Pods from Production Environment



ReplicaSet

Setting the Base

There is a requirement to run 3 Pods based on Nginx image all the time.

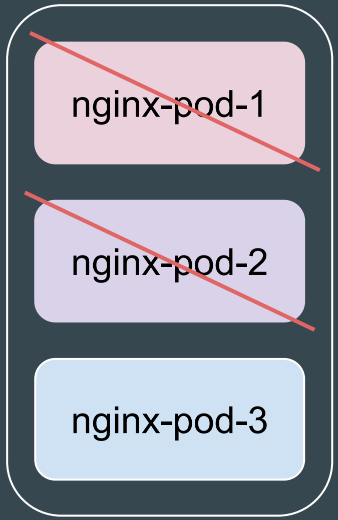


kubectl run nginx-pod-1 --image=nginx
kubectl run nginx-pod-2 --image=nginx
kubectl run nginx-pod-3 --image=nginx

Issue with the Manual Step - Part 1

If a Pod fails (node failure, process crash, etc.), Kubernetes will not automatically recreate it.

You would have to manually detect the failure and recreate the Pod.



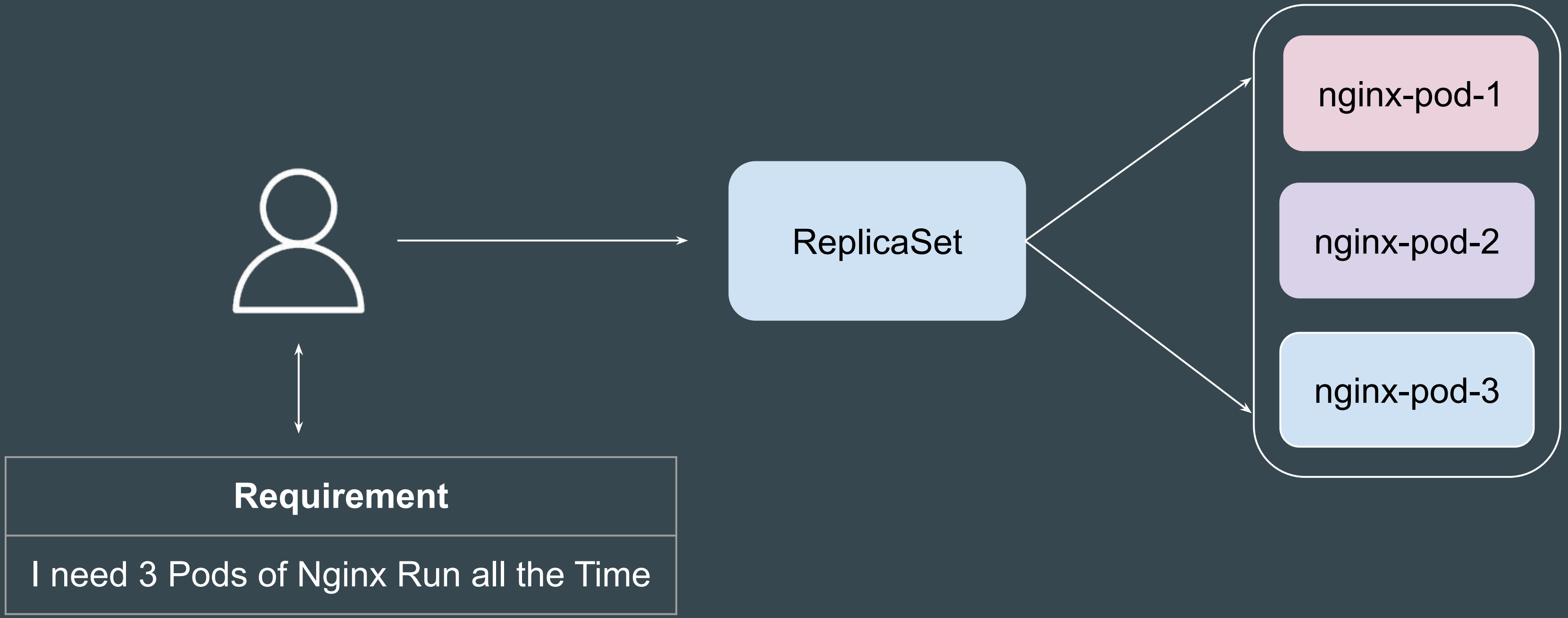
Issue with the Manual Step - Part 2

If you need to scale to more or fewer Pods, you would have to manually create or delete Pod definitions and apply the changes.

Example: Requirement is to run 20 Pods based on Nginx Image

Introducing Kubernetes ReplicaSet

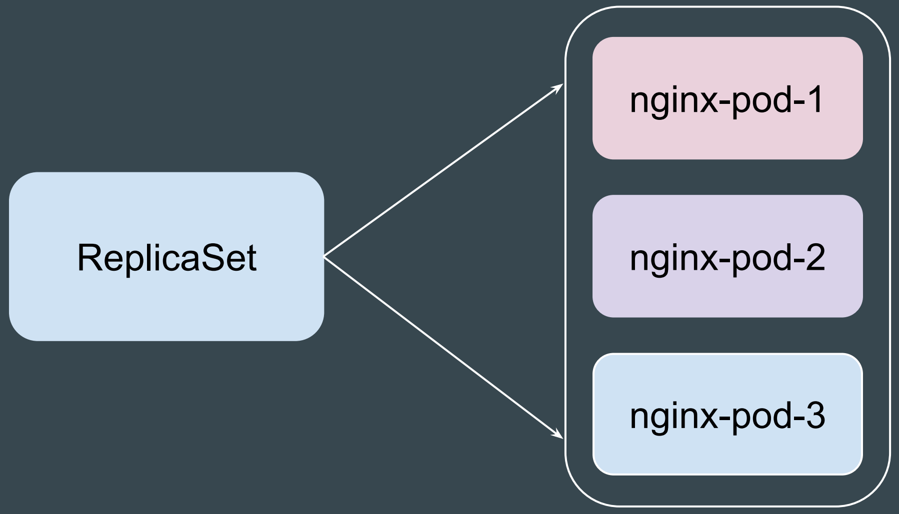
A ReplicaSet's purpose is to maintain a stable set of replica Pods running at any given time.



Challenges with ReplicaSets

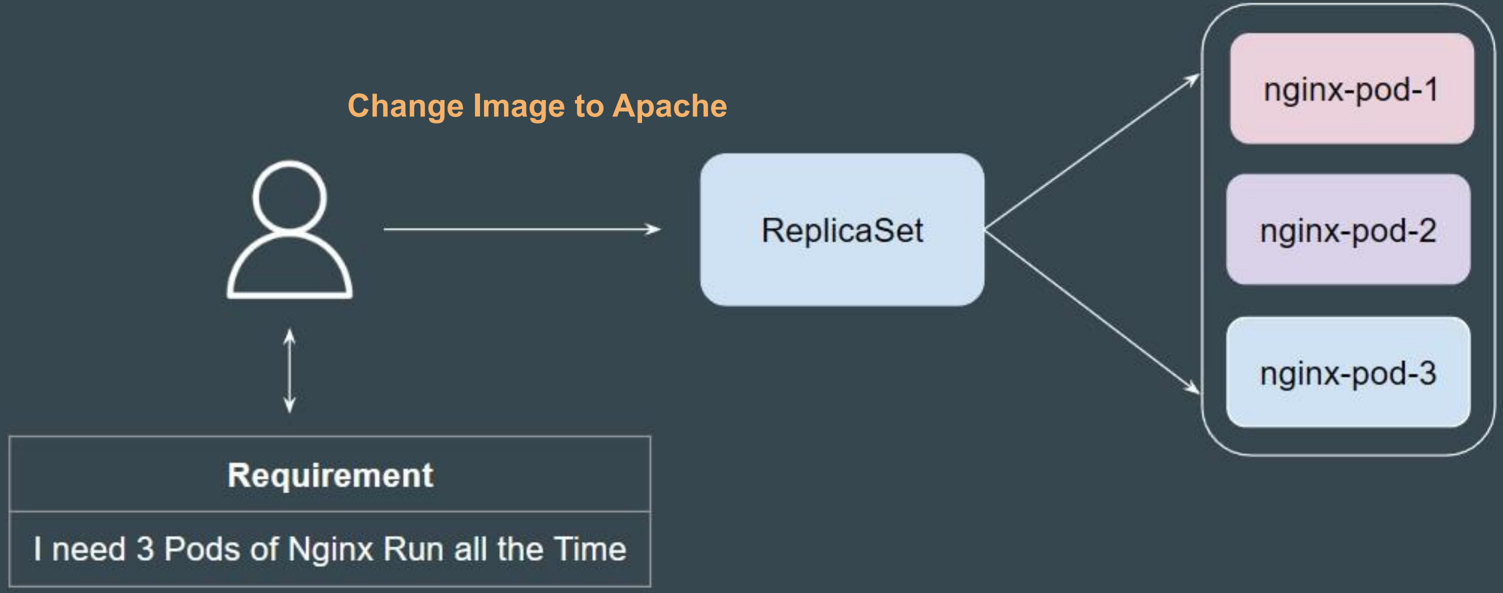
Setting the Base

ReplicaSets are primarily designed to maintain a specific state of running Pods, not to manage regular updates or changes to their configuration



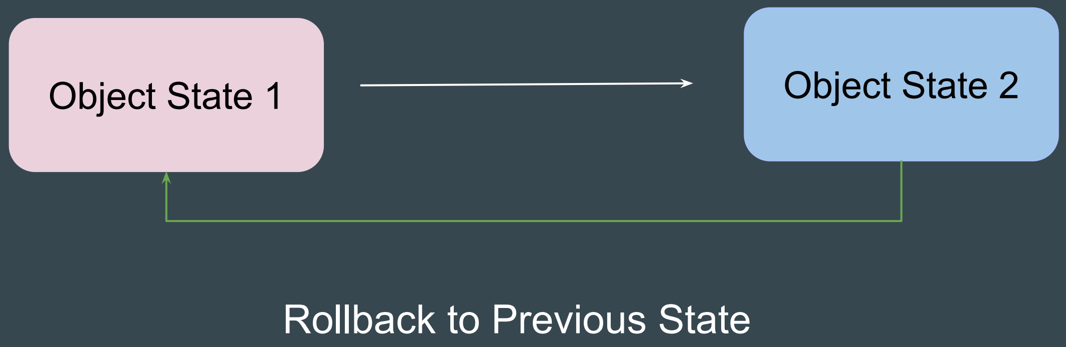
Challenge 1 - Updating Container Image

When you update the pod template (e.g., change the container image) in a ReplicaSet, the existing pods are not updated.



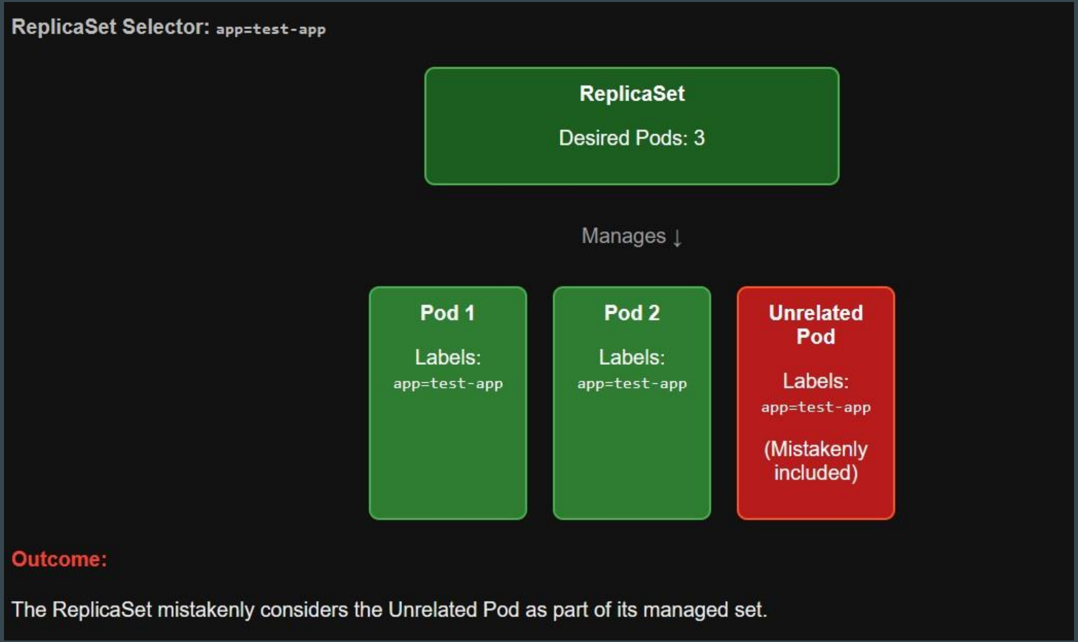
Challenge 2 - No Built-In Rollback Mechanism

ReplicaSets lack a rollback mechanism for reverting to a previous configuration in case of errors during an update.



Challenge 3 - Label Collision with ReplicaSet Selectors

When a ReplicaSet's selector matches labels of pods that it didn't create, it starts treating those pods as part of its managed set. This can cause unintended consequences.



Overview of Deployments

Simple Analogy - Camera and Lens

Think of the camera body as the ReplicaSet.

It is the core mechanism that controls and ensures that the right number of photos (or Pods) are being captured

Simple Analogy - Camera and Lens

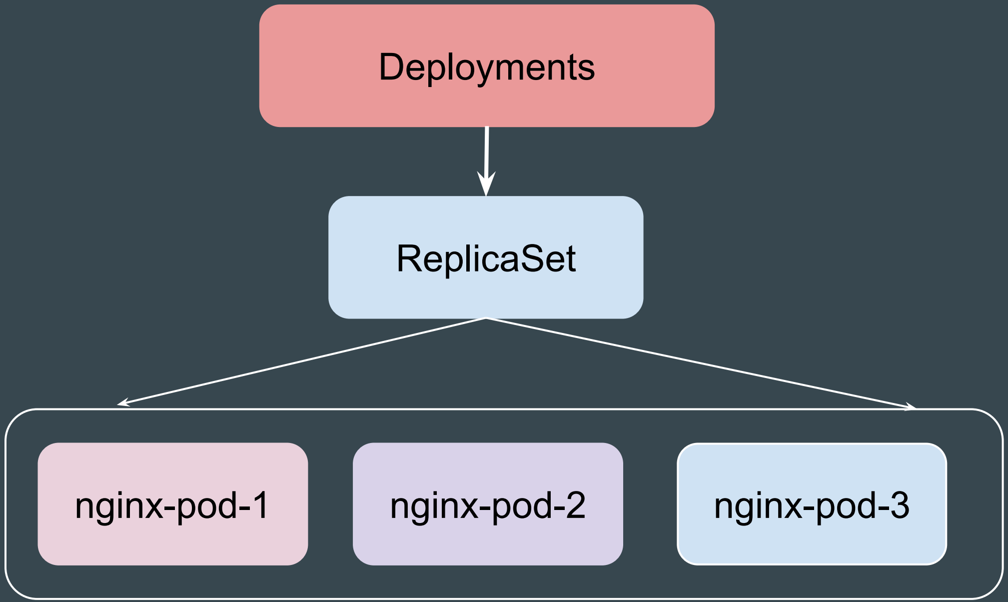
Now, imagine attaching a big, powerful lens to the camera body. The lens is the Deployment.

It doesn't just sit on top of the camera; it enhances and extends the camera's functionality, allowing for new perspectives.

Setting the Base

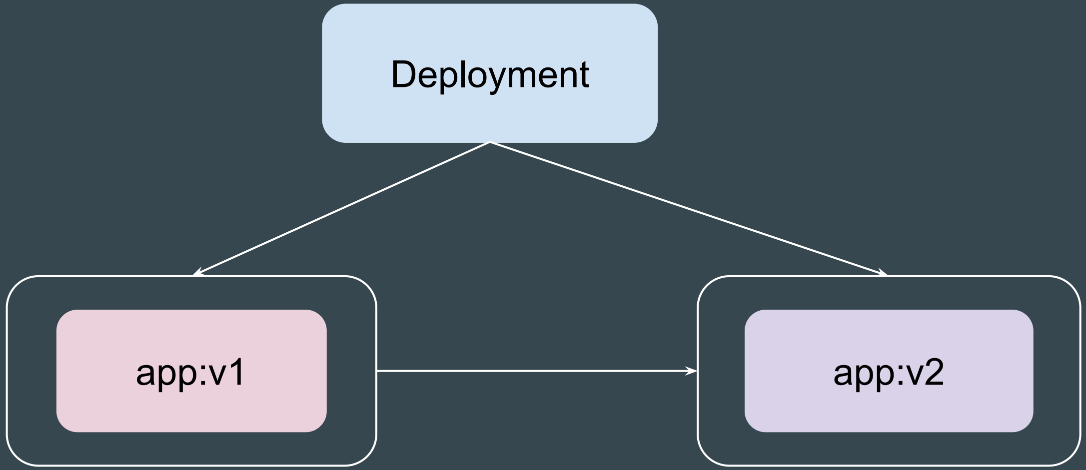
A Deployment is a higher-level abstraction built on top of ReplicaSets.

It not only manages ReplicaSets but also provides advanced features like rolling updates, rollbacks, and versioning.



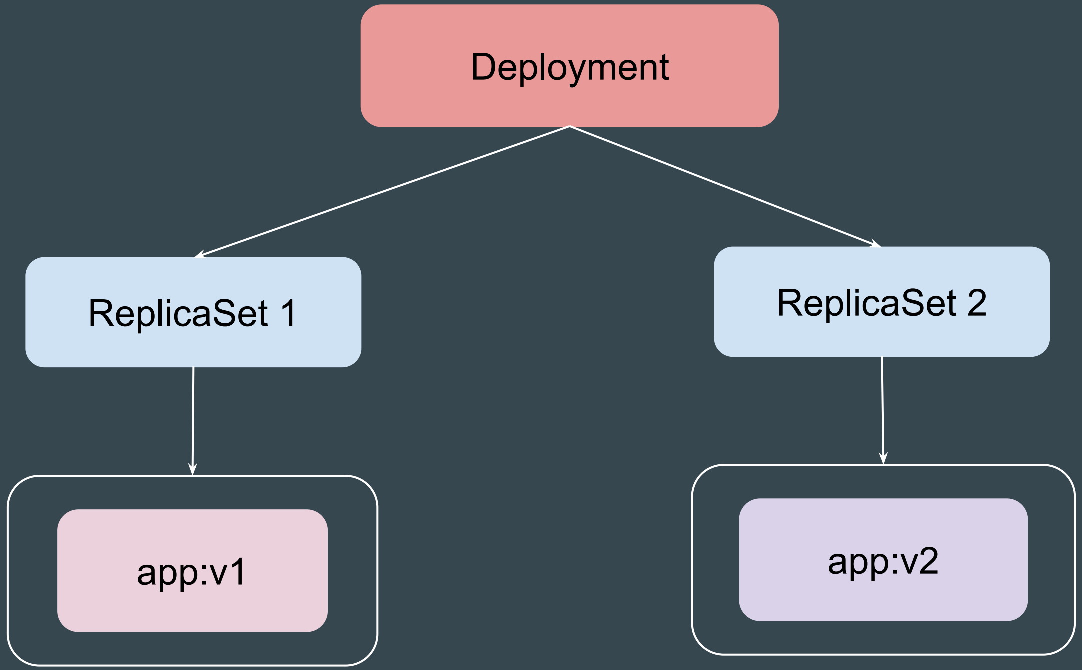
Use-Case: Update the Container Image

You can easily change the specifications like Container Image and other spec.



Use-Case: Rolling Update

Deployments will perform update in rollout manner to ensure that your app is not down.



Rollout History

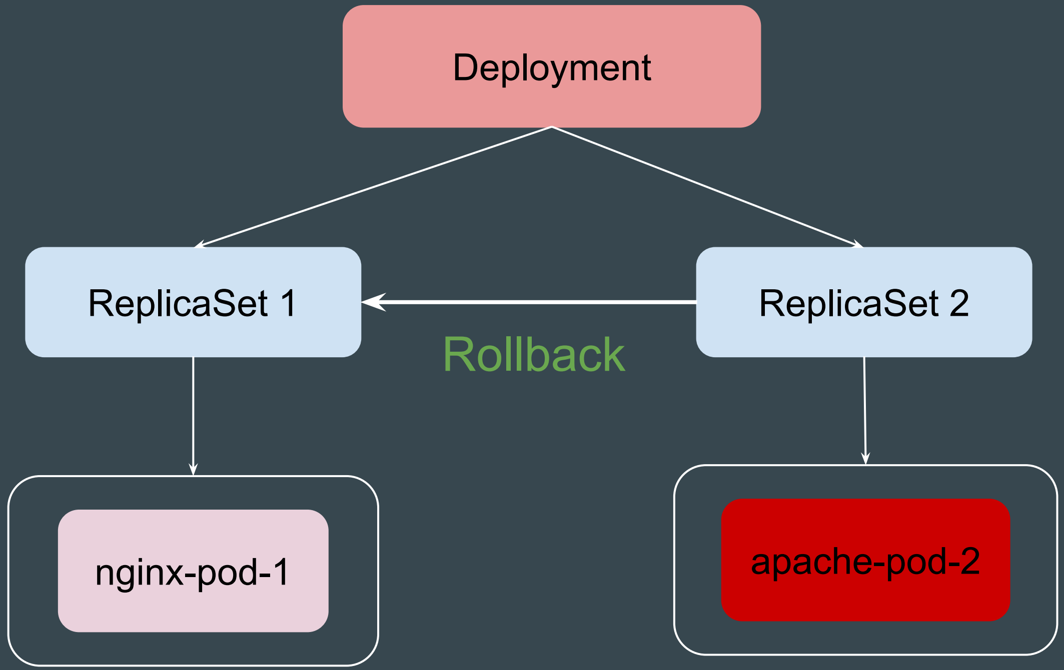
Deployment allows us to inspect the history of your deployments.

It provides a record of changes made to a deployment over time, enabling you to understand the evolution of your application and troubleshoot potential issues.

```
C:\>kubectl rollout history deployment/nginx-deployment
deployment.apps/nginx-deployment
REVISION  CHANGE-CAUSE
1         <none>
2         <none>
```

Rolling Back Changes

Sometimes, you may want to rollback a Deployment; for example, when the Deployment is not stable, such as crash looping



Key Differences - ReplicaSet and Deployments

Feature	ReplicaSet	Deployment
Abstraction Level	Lower-level	Higher-level
Primary Function	Ensures a specific number of replicas are running.	Manages ReplicaSets and handles updates.
Rolling Updates	Not supported	Supported with configurable strategies.
Rollbacks	Not supported	Supported with version history.
Use Case	Simple, static workloads.	Dynamic workloads with frequent updates.

maxSurge and maxUnavailable

Deployment Related Options

Overview of Deployment Configuration

While performing a rolling update, there are two important configuration to know.

Configuration Parameter	Description
maxSurge	Maximum Number of PODS that can be scheduled above original number of pods.
maxUnavailable	Maximum number of pods that can be unavailable during the update

Example Use-Case

Total PODS in Deployment 8.

maxSurge	maxUnavailable
25%	25%

maxSurge = 2 PODS

maxUnavailable = 2 PODS

At Most of 10 PODS (8 current pods + 2 maxSurge pods)

At Least of 6 PODS (6 current pods - 2 maxUnavailable pods)

Note

You can define the maxSurge and maxUnavailable in both the numeric and percentage terms;

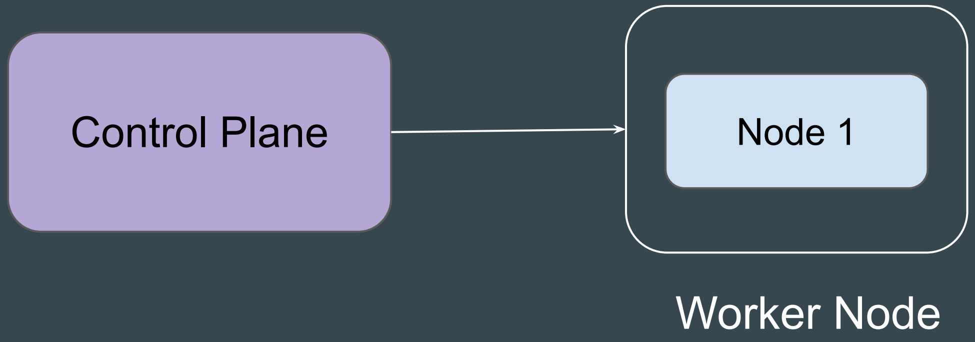
maxUnavailable: 0

maxSurge: 10%

Multiple Worker Nodes for Kubernetes

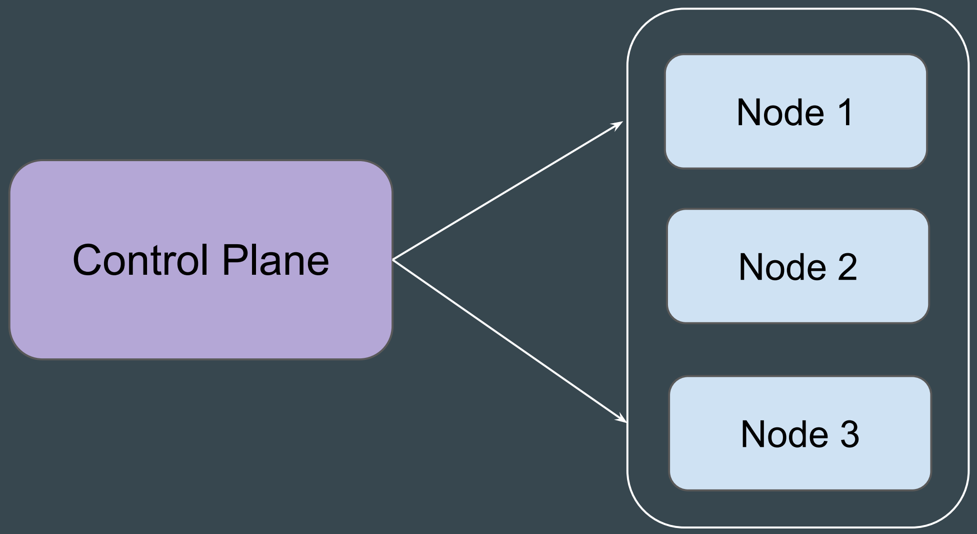
Understanding the Challenge

A single worker node might not have enough resources (CPU, memory) to handle the load of all the Pods.



Multiple Worker Nodes are Good

Adding more worker nodes allows you to distribute the workload across the worker nodes.



Other Benefits of Multiple Worker Nodes

If one worker node fails, the applications running on it will become unavailable.

With multiple worker nodes, Kubernetes can reschedule those applications onto healthy nodes, ensuring continuous service availability.

Point to Note - Worker Node Sizes

It is not necessary for ALL worker nodes to have same hardware specification.

Sample Example:

Worker Node	Hardware Specification
Worker Node 1	2GB of RAM and 2 core CPU
Worker Node 2	4GB of RAM and 4 core CPU
Worker Node 3	8GB of RAM and 8 core CPU

How to Check Worker Nodes in K8s Cluster

Use the kubectl get nodes command to get list of worker node as part of your cluster.

```
C:\>kubectl get nodes
NAME              STATUS   ROLES    AGE   VERSION
kplabs-k8s-eop82  Ready    <none>   16d   v1.31.1
```

```
C:\>kubectl get nodes
NAME              STATUS   ROLES    AGE     VERSION
kplabs-k8s-eop82  Ready    <none>   17d     v1.31.1
kplabs-k8s-est1m  Ready    <none>   3m13s   v1.31.1
kplabs-k8s-est1q  Ready    <none>   2m33s   v1.31.1
```

Point to Note

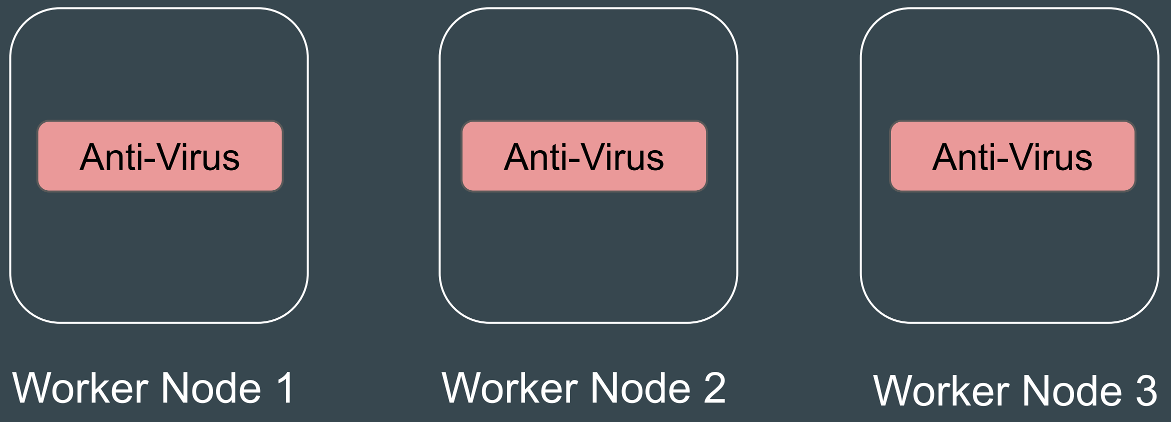
Depending on the type of environment that was used to create the Kubernetes cluster, the steps to add multiple worker nodes will change accordingly.

DaemonSet

Setting the Base

A DaemonSet can ensures that all Nodes run a copy of a Pod.

Whenever new nodes are added to the cluster, Pods will be created in them.



Common Type of Agents for Daemonset

1. Anti-Virus and Malware Scanning Agents

2. Log Collection Agents to collect logs from nodes.

3. Monitoring and Metrics Collection Agents to collect metrics about node

Rollout History

Deployment allows us to inspect the history of your deployments.

It provides a record of changes made to a deployment over time, enabling you to understand the evolution of your application and troubleshoot potential issues.

```
C:\>kubectl rollout history deployment/nginx-deployment
deployment.apps/nginx-deployment
REVISION  CHANGE-CAUSE
1         <none>
2         <none>
```

Step 1 - Adding Label to Nodes

Add appropriate labels to your nodes depending on their hardware type.

Step 2 - Use NodeSelector Configuration

Create a nodeSelector configuration to run pods only on nodes which has a label of size=Large

nodeSelector.yaml

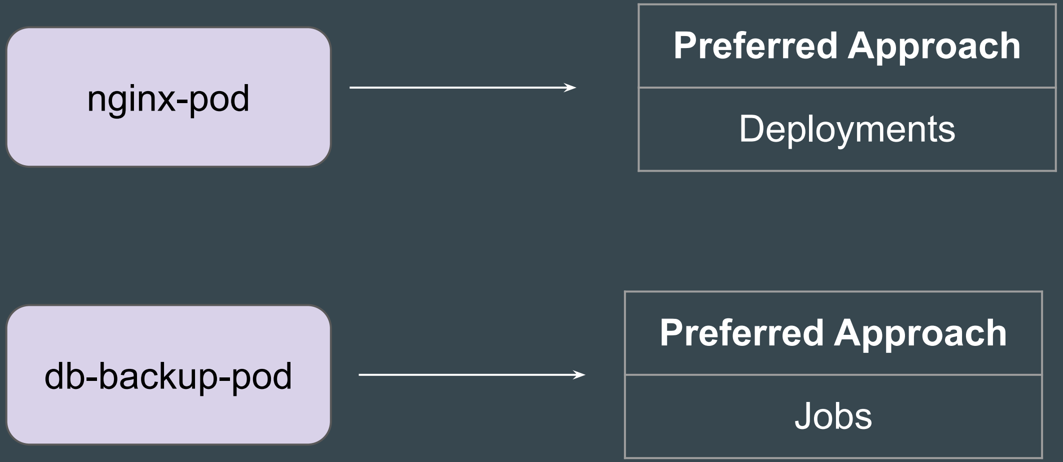
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: memory-intensive-app
spec:
  containers:
  - name: app
    image: nginx
  nodeSelector:
    size: Large
```

Overview of Jobs and CronJob

Setting the Base

Pods like web-servers are intended to run all the time.

Some Pods are intended to run for limited amount of time to complete some specific task like sending batch emails, database backups and then complete.



Understand Manual Approach

Use-Case: Processing a large dataset, and generating reports.

Manual Approach:

1. Create a Pod that performs the task.

2. Monitor the Pod, and handle retries to task if it fails.

3. Once completed, verify the logs.

4. Delete the Pod

Introduction to Jobs

Jobs automates the manual process for one time tasks, ensuring your task runs to completion and providing features like automatic retries and parallel execution.

Once the task is done, the Job is considered completed.

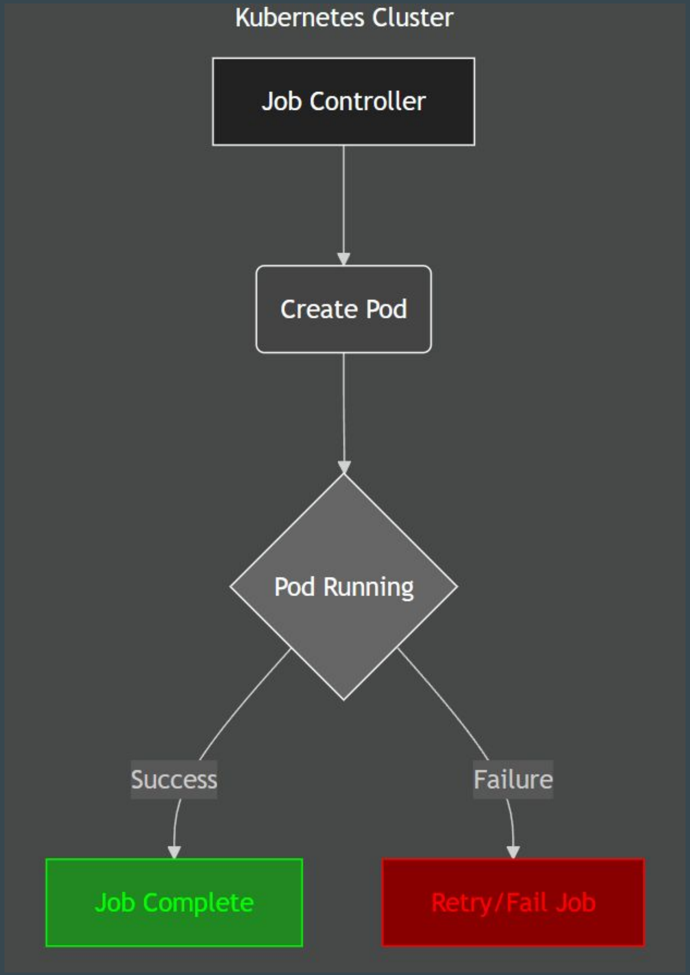
```
C:\kplabs-k8s>kubectl get jobs
NAME        STATUS     COMPLETIONS   DURATION   AGE
hello-job   Complete   1/1           10s        13s
```

Point to Note

A simple case is to create one Job object in order to reliably run one Pod to completion.

The Job object will start a new Pod if the first Pod fails or is deleted (for example due to a node hardware failure or a node reboot).

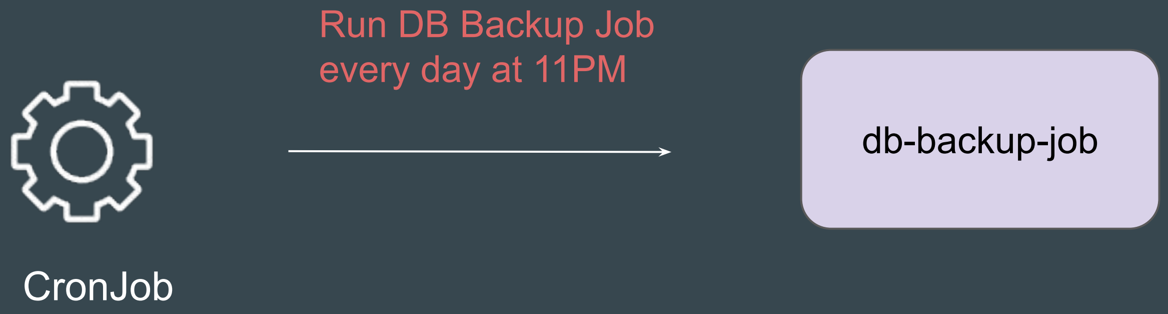
```
C:\kplabs-k8s>kubectl delete pod ping-job-5hkrq
pod "ping-job-5hkrq" deleted

C:\kplabs-k8s>kubectl get pods
NAME             READY   STATUS    RESTARTS   AGE
ping-job-648lf   1/1     Running   0          8s
```


Kubernetes Cluster
Job Controller
Create Pod
Pod Running
Success
Failure
Job Complete
Retry/Fail Job

CronJob

A CronJob creates Jobs on a repeating schedule.

You define a schedule using the familiar Cron format, and Kubernetes will automatically create and run Jobs at those specified times.



```
C:\>kubectl get cronjob
NAME              SCHEDULE      TIMEZONE    SUSPEND    ACTIVE    LAST SCHEDULE    AGE
backup-cronjob    0 23 * * *    <none>      False      0         <none>           83s
```

Practical - Jobs

Setting the Base

You can use the kubectl create job command to create Jobs.

```
C:\>kubectl create job --help
Create a job with the specified name.

Examples:
  # Create a job
  kubectl create job my-job --image=busybox

  # Create a job with a command
  kubectl create job my-job --image=busybox -- date

  # Create a job from a cron job named "a-cronjob"
  kubectl create job test-job --from=cronjob/a-cronjob
```

Reference Manifest File

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: ping-job
spec:
  template:
    spec:
      containers:
      - name: hello-container
        image: busybox:latest
        command: ["ping","-c", "30", "google.com"]
      restartPolicy: Never
```

Point to Note - Restart Policy

In a Job manifest, only a RestartPolicy equal to Never or OnFailure is allowed.

RestartPolicy	Description
OnFailure	Pods will restart only if they fail (exit with a non-zero status). This is useful for retrying failed tasks.
Never	Pods will not restart regardless of whether they fail or succeed. This is useful for tasks that should not be retried automatically.

Why is Always Not Allowed

Unlike Deployments or ReplicaSets, a Job does not support restartPolicy: Always.

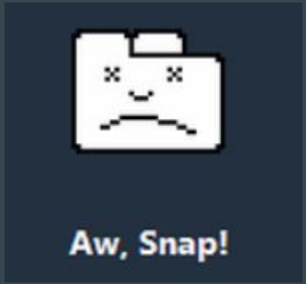
This is because Jobs are designed for finite, short-lived workloads, not for long-running services that need constant availability.

activeDeadlineSeconds in Jobs

Understanding the Challenge

A Job can have a bug that causes it to loop infinitely or get stuck.

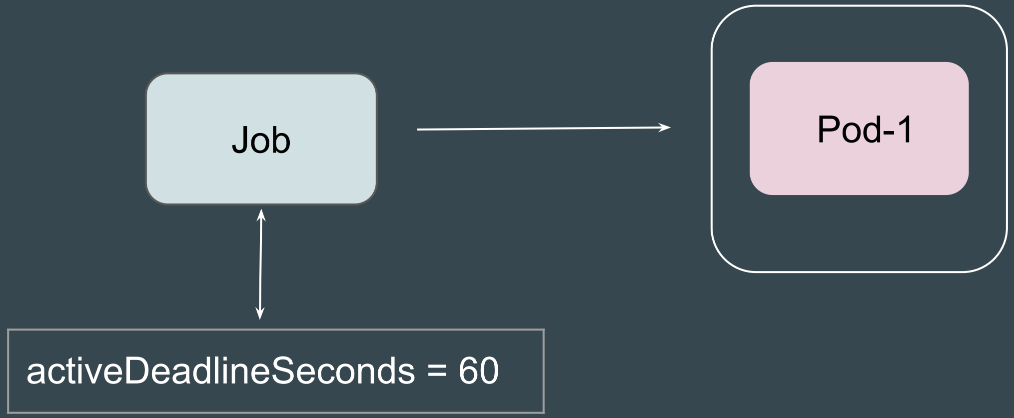
This will lead to unnecessary resource usage for longer duration of time.



Introduction to the Topic

The activeDeadlineSeconds field in a Kubernetes Job specifies the maximum duration a Job can actively run.

If the Job doesn't complete within this time, Kubernetes terminates all its Pods and marks the Job as failed with a deadline exceeded condition.



Point to Note

It's a crucial mechanism for preventing Jobs from running indefinitely due to unforeseen issues or bugs.

Reference Manifest File

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: ping-job-manifest
spec:
  activeDeadlineSeconds: 30
  template:
    metadata:
    spec:
      containers:
      - command:
        - ping
        - -c
        - "100"
        - google.com
        image: busybox:latest
        name: ping-job
      restartPolicy: Never
```

Practical - CronJob

Setting the Base

You can use the kubectl create cronjob command to create CronJob.

Specifying --schedule is important.

```
C:\>kubectl create cronjob --help
Create a cron job with the specified name.

Aliases:
cronjob, cj

Examples:
  # Create a cron job
  kubectl create cronjob my-job --image=busybox --schedule="*/1 * * * *"

  # Create a cron job with a command
  kubectl create cronjob my-job --image=busybox --schedule="*/1 * * * *" -- date
```

Format of Schedule

The schedule is written in Cron format.

```
|------------------------------- Minute (0-59)
|     |------------------------- Hour (0-23)
|     |     |------------------- Day of the month (1-31)
|     |     |     |------------- Month (1-12; or JAN to DEC)
|     |     |     |     |------- Day of the week (0-6; or SUN to SAT; or 7 for Sunday)
|     |     |     |     |
|     |     |     |     |
*     *     *     *     *
```

Crontab Schedule	Explaination
* * * * *	The asterisk (*) in each position means "every." This schedule translates to "every minute of every hour of every day of every month of every day of the week." It runs a job every single minute.
0 * * * *	The first field (minutes) is set to 0. This means "at minute 0 of every hour." So, this schedule runs a job at the beginning of every hour (e.g., 1:00, 2:00, 3:00, etc.).
0 9 1 * *	This schedule is more specific. It translates to "at minute 0 of hour 9 on the 1st of every month." It runs a job on the first day of each month at 9:00 AM.

Reference Manifest File

! cronjob.yaml

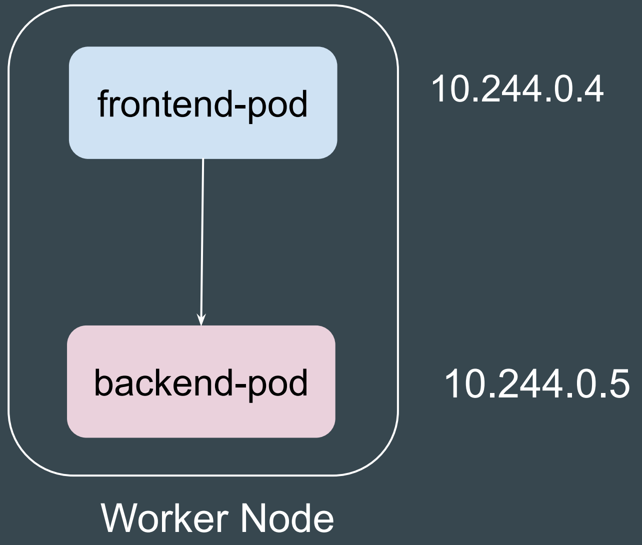
```yaml
apiVersion: batch/v1
kind: CronJob
metadata:
  name: backup-cronjob
spec:
  schedule: "0 23 * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: backup
            image: my-backup-tool:latest
          restartPolicy: OnFailure
```

Overview of Service

Setting the Base

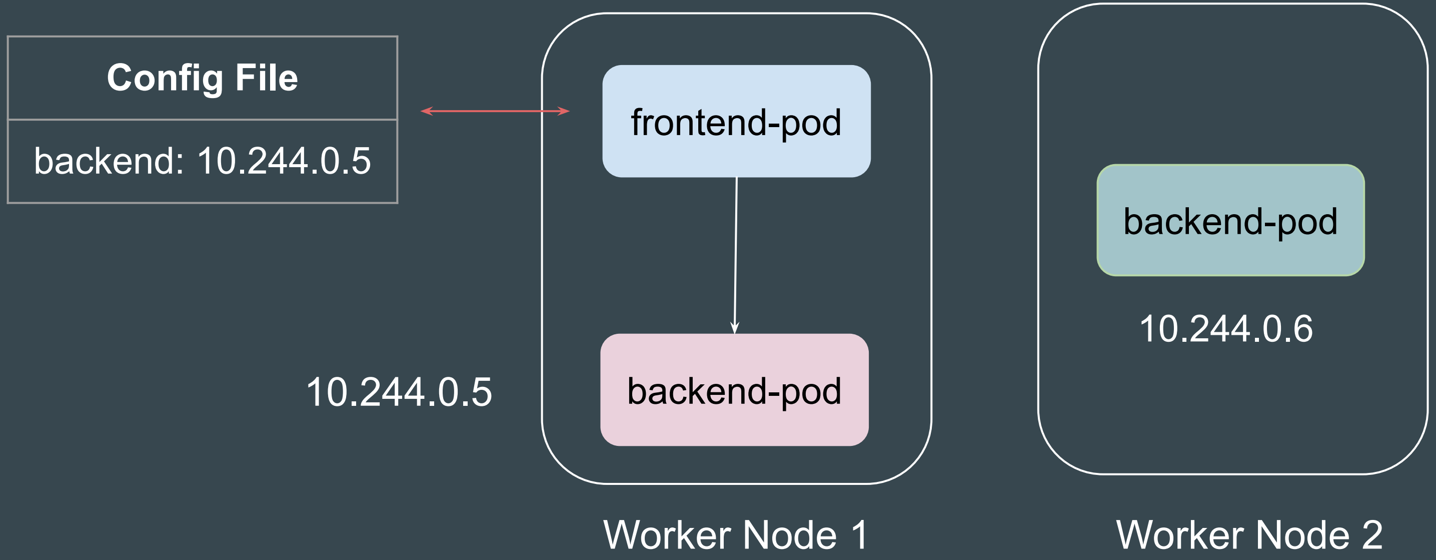
The Pods that get created in the Worker node have a private IP associated with them.

Pods in the same cluster can communicate with each other using Private IPs.



Use-Case: Frontend to Backend

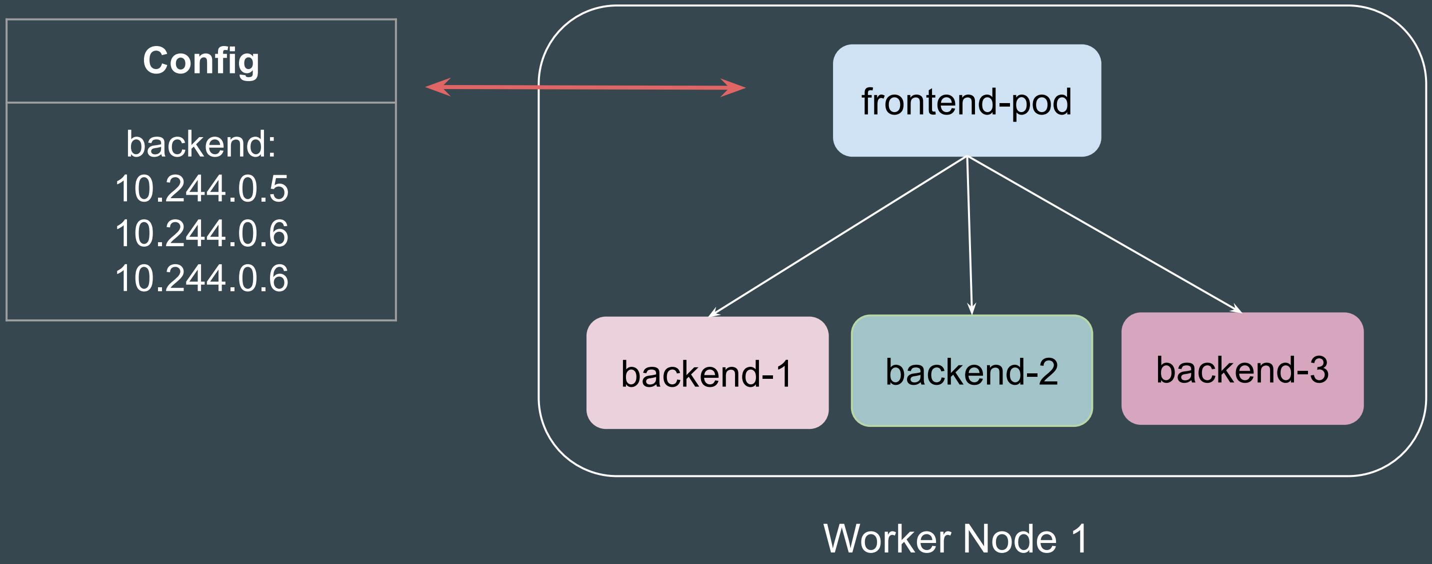
If the IP address of the backend pod is hardcoded in the front-end pod, it will create issues since Pods can be ephemeral.



Use-Case: Frontend to Backend

If backend pods are running as deployment, it is challenging to hardcode the IPs of each backend pod.

You would also like to distribute the traffic across all the backend pods.

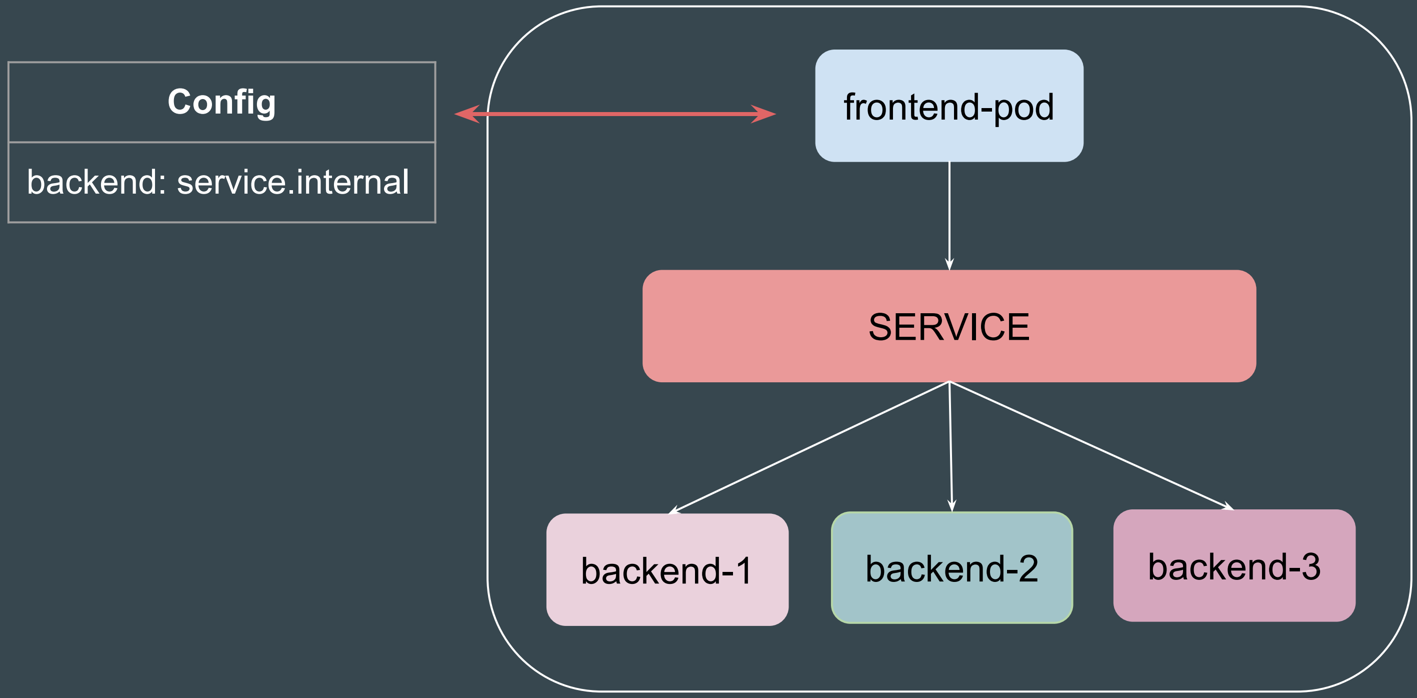


Reference Screenshot - Distributing Traffic

```
root@frontend-pod:/# curl service.internal
Backend Pod 2
root@frontend-pod:/# curl service.internal
Backend Pod 1
root@frontend-pod:/# curl service.internal
Backend Pod 2
root@frontend-pod:/# curl service.internal
Backend Pod 1
root@frontend-pod:/# curl service.internal
Backend Pod 2
root@frontend-pod:/# curl service.internal
Backend Pod 1
```

Introducing Service

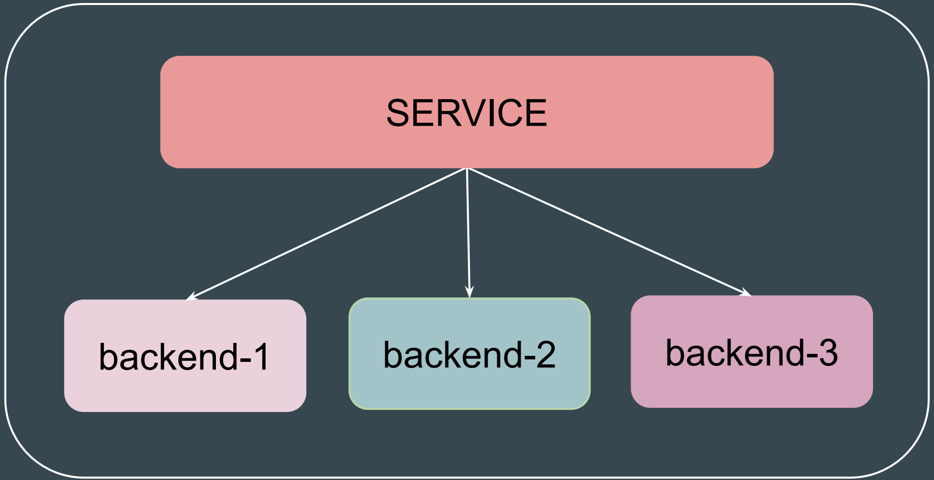
Service acts as a gateway that distributes incoming traffic between its endpoints.



Service and Deployments

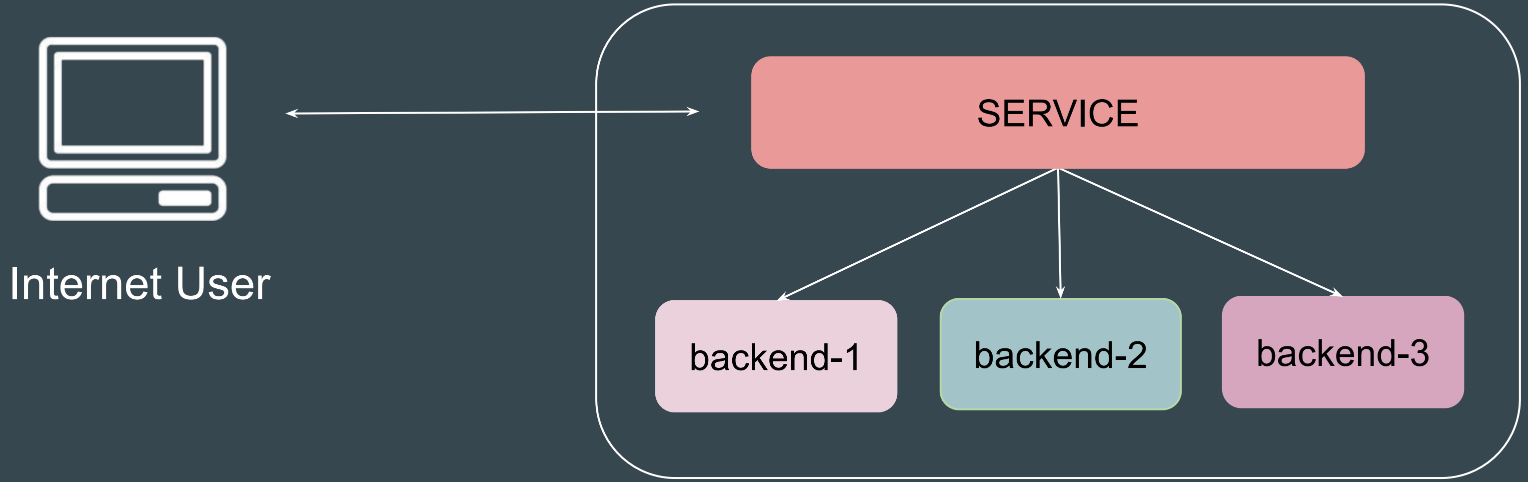
If you use a Deployment to run your app, that Deployment can create and destroy Pods dynamically.

Service can find the latest set of pods and route the traffic accordingly.



Points to Note

Using Service, users outside of Kubernetes cluster can also connect to the Pods internal to the cluster.



Benefits of Service

Pods are ephemeral, and their IPs change frequently. Services provide a stable endpoint.

Services distribute traffic across multiple Pod replicas.

Service enables exposing applications to external traffic like from the Internet.

Types of Services

Service Type	Key Features	Use-Cases
ClusterIP	Default Service type. Accessible only within the cluster.	Internal microservices communication
NodePort	Exposes service on a static port (30000-32767) on each Node.	Development testing, demo applications
LoadBalancer	Exposes service externally using cloud provider's load balancer	Production applications requiring external access
ExternalName	Maps service to external DNS name	External service integration

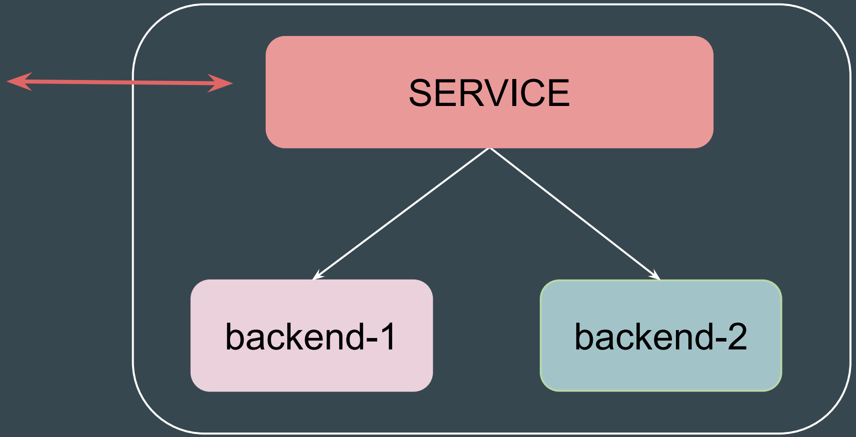
Practical - Service and Endpoints

Setting the Base

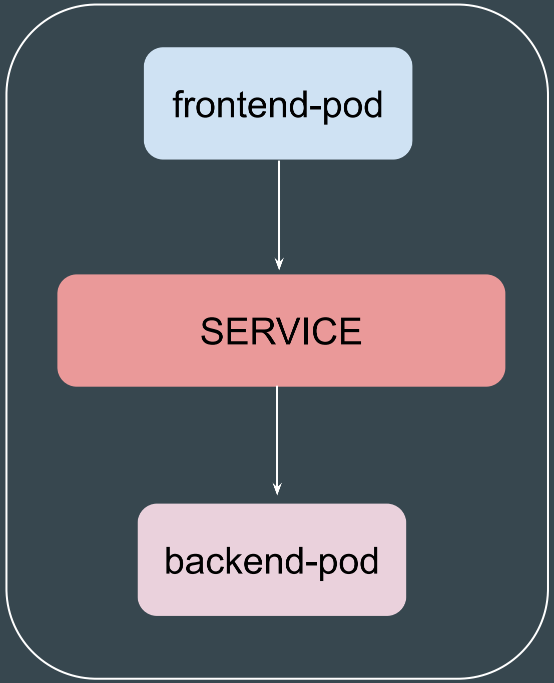
Service is a gateway that distributes the incoming traffic between its endpoints

Endpoints contain the address of underlying Pods to which the service will route the traffic to.

Endpoints
10.44.0.5
10.44.0.6



Architecture of Today's Video



Step 1 - Create Simple Service

Create a Simple Service in Kubernetes. This service will have its own IP.

```
C:\>kubectl describe service kplabs-service
Name:                     kplabs-service
Namespace:                default
Labels:                   <none>
Annotations:              <none>
Selector:                 <none>
Type:                     ClusterIP
IP Family Policy:         SingleStack
IP Families:              IPv4
IP:                       10.109.24.231
IPs:                      10.109.24.231
Port:                     <unset>  8080/TCP
TargetPort:               80/TCP
Endpoints:                <none>
Session Affinity:         None
Events:                   <none>
```

Step 2 - Create Endpoint for Service

Add appropriate endpoint to the service manually for service to route traffic to.

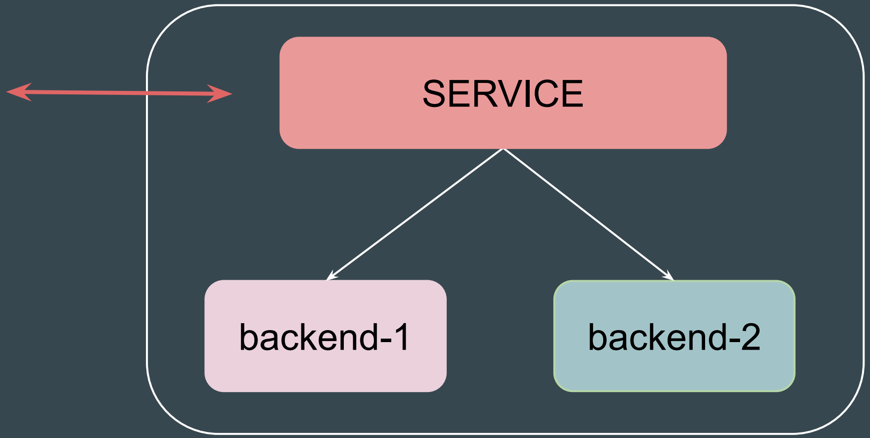
```
C:\>kubectl describe service kplabs-service
Name:                     kplabs-service
Namespace:                default
Labels:                   <none>
Annotations:              <none>
Selector:                 <none>
Type:                     ClusterIP
IP Family Policy:         SingleStack
IP Families:              IPv4
IP:                       10.109.12.34
IPs:                      10.109.12.34
Port:                     <unset>  8080/TCP
TargetPort:               80/TCP
Endpoints:                10.108.0.1:80
Session Affinity:         None
Events:                   <none>
```

Using Selector for Registering Service Endpoints

Setting the Base

In a simple manual workflow, you can create a service and manually add endpoints associated with that service.

Endpoints
10.44.0.5
10.44.0.6



Reference Manifest File

service.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
   name: simple-service
spec:
   ports:
   - port: 80
     targetPort: 80
```

endpoints.yaml

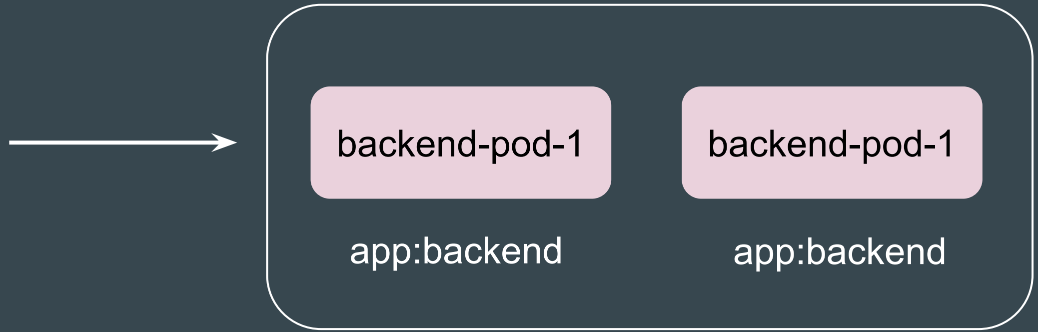
```yaml
apiVersion: v1
kind: Endpoints
metadata:
  name: simple-service
subsets:
  - addresses:
      - ip: 10.108.0.67
    ports:
      - port: 80
```

Better Approach - Selectors

You can also configure the Service to use Selectors to automatically add appropriate Pod IPs within its endpoint.

service-selector.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
  name: simple-service
spec:
  selector:
    app: backend
  ports:
  - port: 80
    targetPort: 80
```



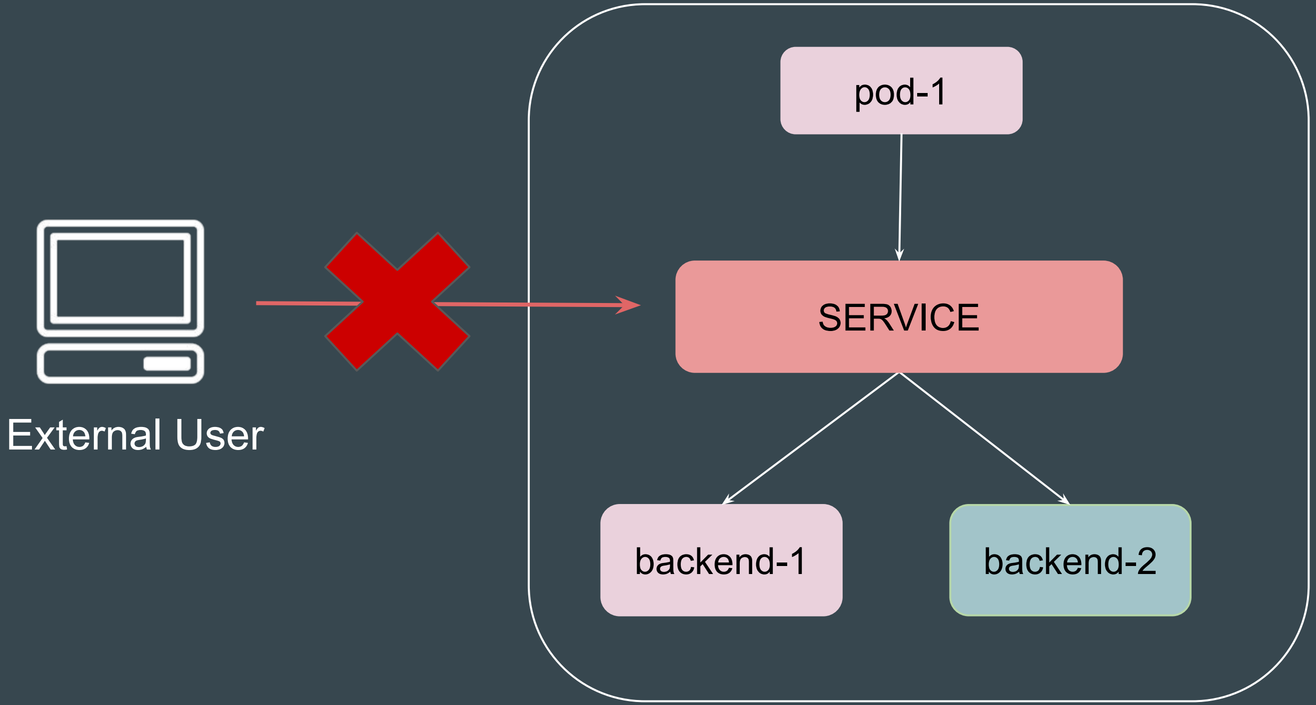
Service Type - ClusterIP

Types of Services

Service Type	Key Features	Use-Cases
ClusterIP	Default Service type. Accessible only within the cluster.	Internal microservices communication
NodePort	Exposes service on a static port (30000-32767) on each Node.	Development testing, demo applications
LoadBalancer	Exposes service externally using cloud provider's load balancer	Production applications requiring external access
ExternalName	Maps service to external DNS name	External service integration

Setting the Base

A Kubernetes Service of type ClusterIP provides an internal, stable IP address to expose your application only within the Kubernetes cluster.



Point to Note - Part 1

ClusterIP is a default service type. If you don't specify a type when creating a Service, Kubernetes defaults to ClusterIP.

service.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
   name: kplabs-service
spec:
   ports:
   - port: 8080
     targetPort: 80
```

```
C:\>kubectl get service
NAME             TYPE        CLUSTER-IP     EXTERNAL-IP    PORT(S)     AGE
kplabs-service   ClusterIP   10.109.12.34   <none>         8080/TCP    6m47s
kubernetes       ClusterIP   10.109.0.1     <none>         443/TCP     21d
```

Point to Note - Part 2

The ClusterIP Service gets a virtual IP address (also called the cluster IP) that remains stable as long as the Service exists.

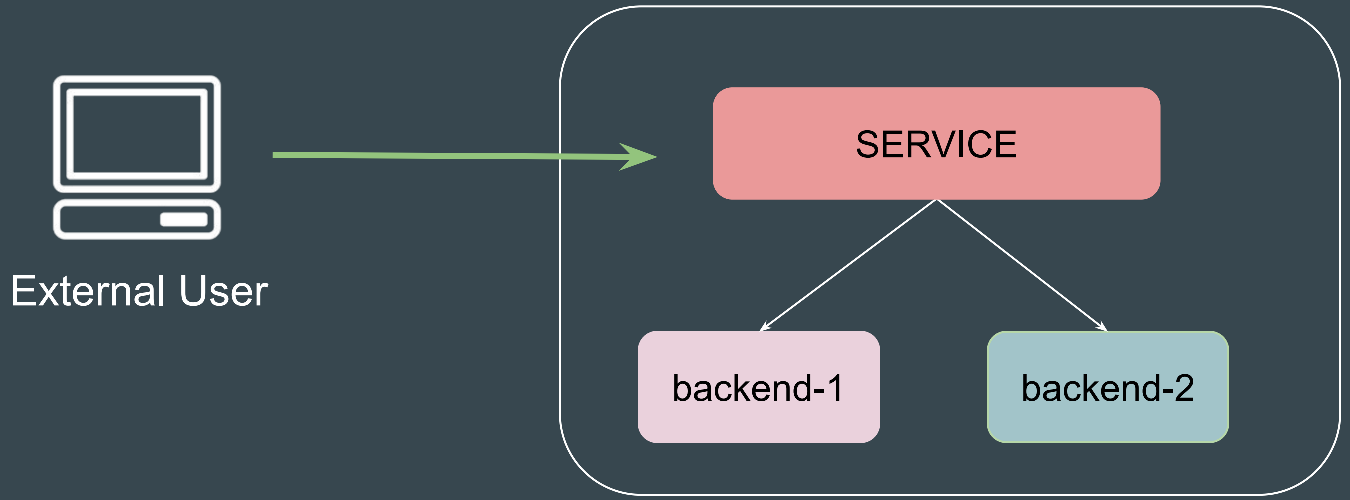
This IP can be used by other Pods inside the cluster to access the Service.

```
C:\>kubectl get service
NAME             TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)    AGE
kplabs-service   ClusterIP   10.109.12.34   <none>        8080/TCP   6m47s
kubernetes       ClusterIP   10.109.0.1     <none>        443/TCP    21d
```

Service Type - NodePort

Setting the Base

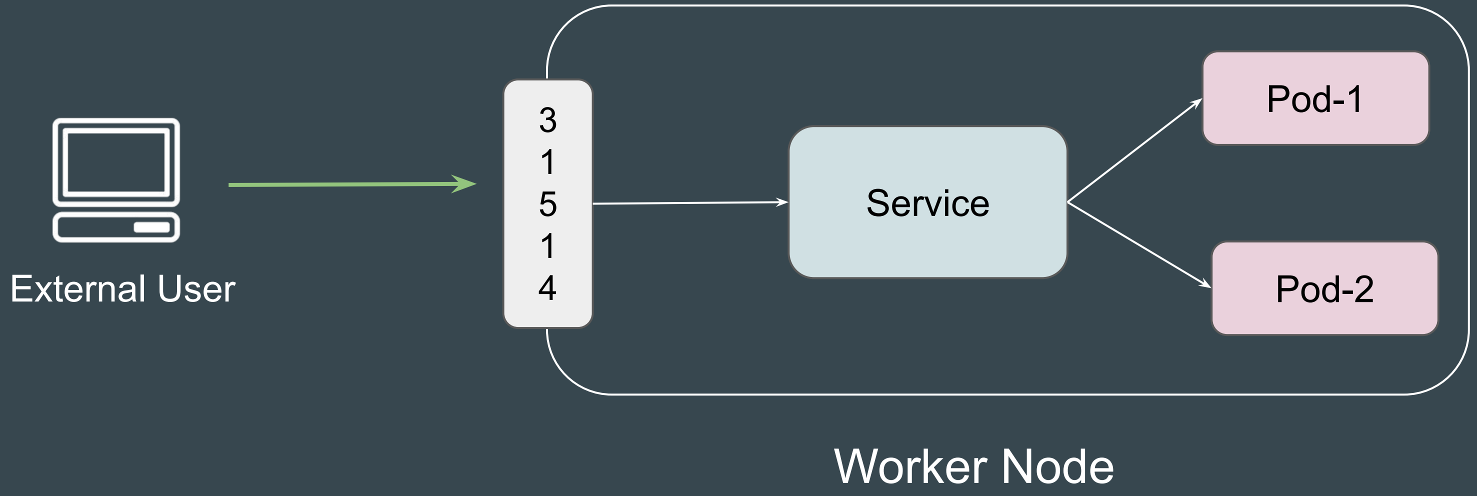
A NodePort is one of the service types used to expose your application to the external world.



How it Works

When you create a service of type NodePort, Kubernetes assigns a port from the NodePort range (default: 30000-32767) on all the nodes in the cluster..

Any traffic sent to <NodeIP>:NodePort is forwarded to the corresponding service



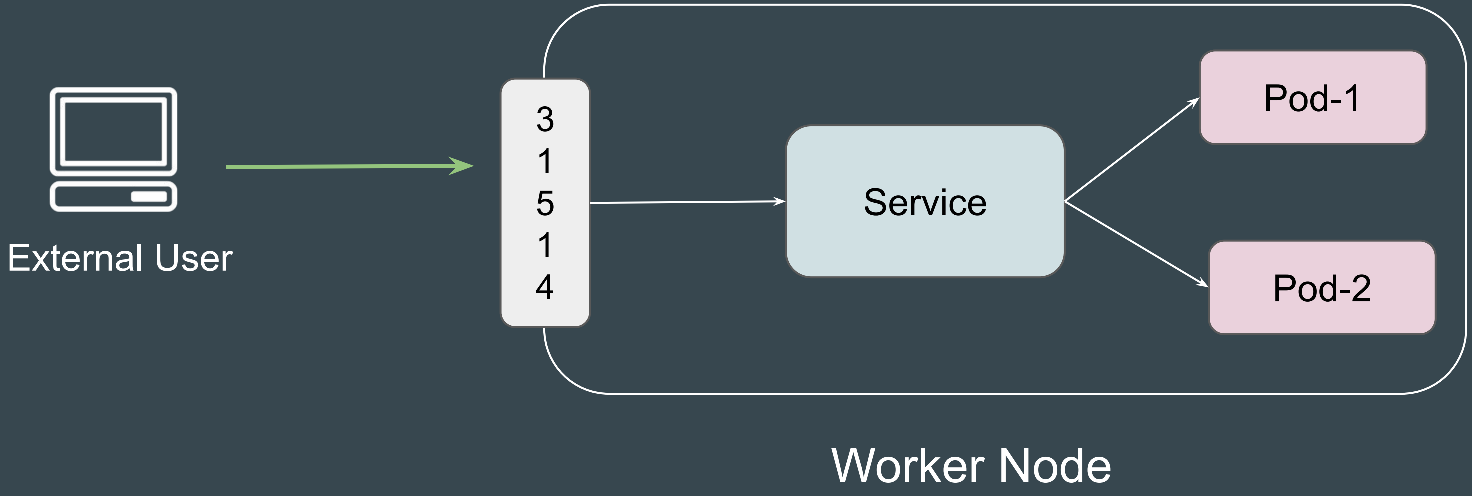
Reference Screenshot

```
C:\>kubectl get service
NAME            TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)        AGE
kubernetes      ClusterIP   10.109.0.1     <none>        443/TCP        22d
test-nodeport   NodePort    10.109.4.218   <none>        80:30537/TCP   10s
```

Service Type - LoadBalancer

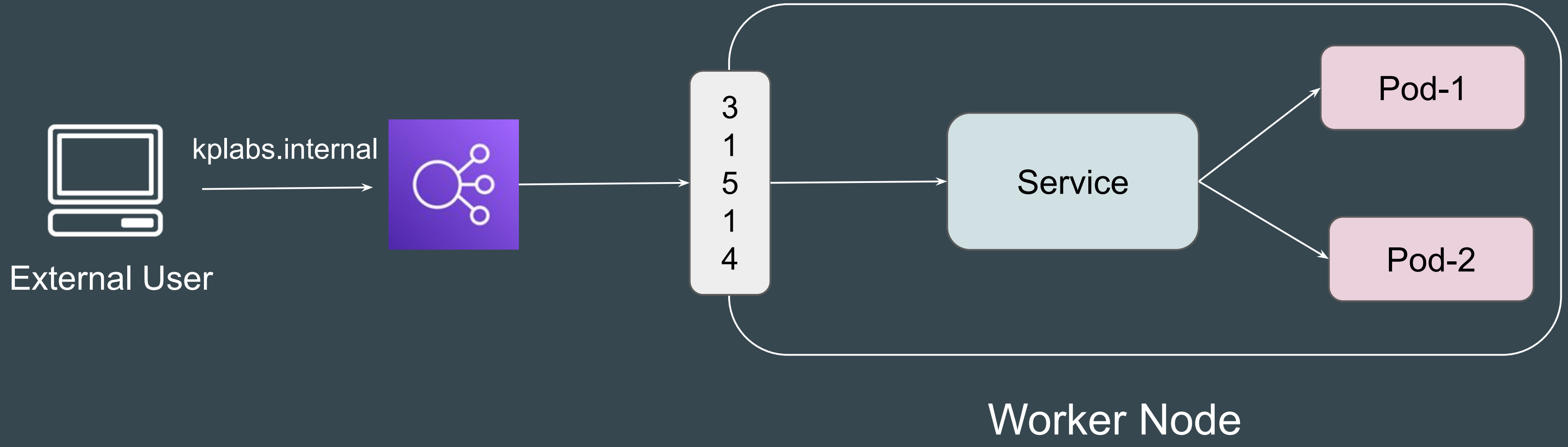
Challenge with NodePort

To access a NodePort based service, we had to make a request to DNS/IP:NodePort.



Introducing Load Balancer Service Type

This type creates an External Load Balancer in a Cloud Provider and routes the request received in Load Balancer to underlying NodePort.



Point to Note

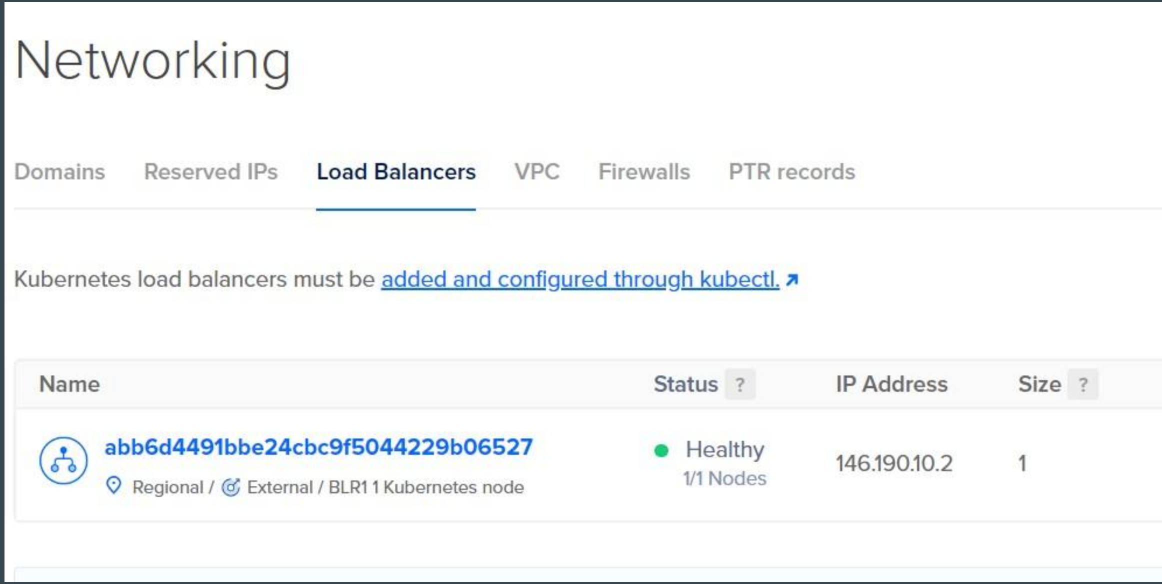
The LoadBalancer service automatically creates a NodePort service behind the scenes.

The external load balancer then directs traffic to these NodePorts, and the traffic is subsequently forwarded to the appropriate pods

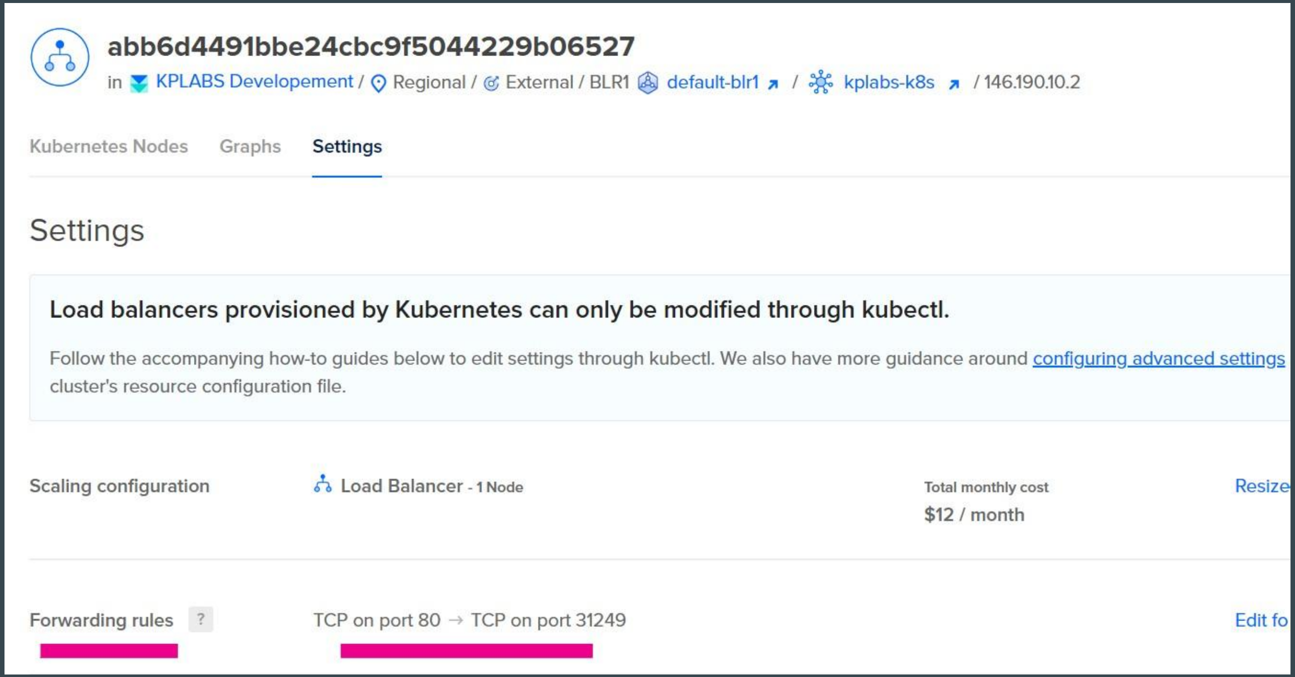
```
C:\>kubectl get service
NAME                   TYPE           CLUSTER-IP     EXTERNAL-IP    PORT(S)        AGE
kplabs-loadbalancer    LoadBalancer   10.109.1.176   146.190.10.2   80:31249/TCP   8m42s
kubernetes             ClusterIP      10.109.0.1     <none>         443/TCP        22d
```

Point to Note - Supported Provider

This service works only with supported cloud providers. For on-premises or custom setups, additional configuration is required.



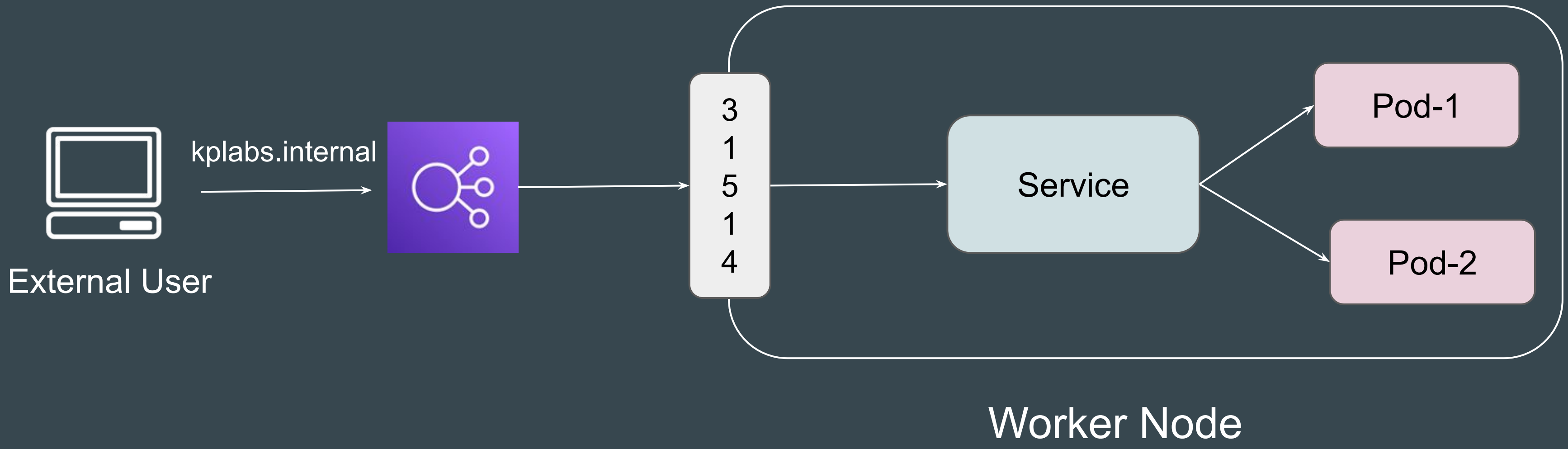
Reference Screenshot - Forwarding Rules



Ingress

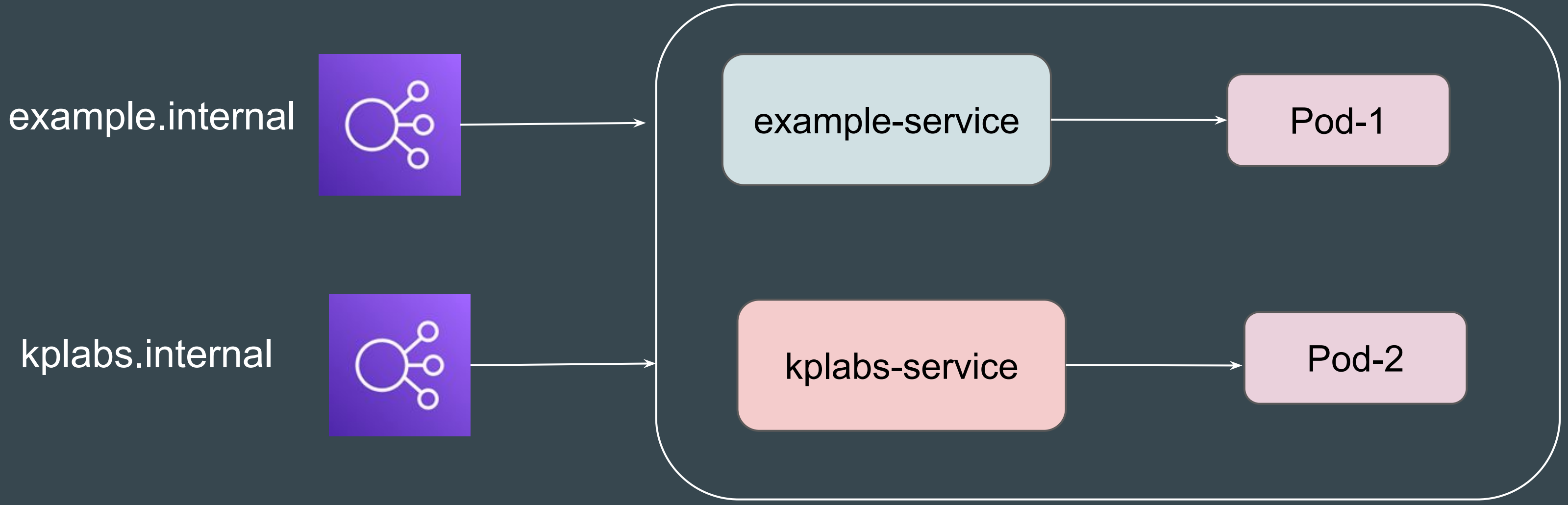
Challenge with Basic Configuration

When we use a LoadBalancer Service Type, the Load balancer forwards traffic to a NodePort associated with a single service.



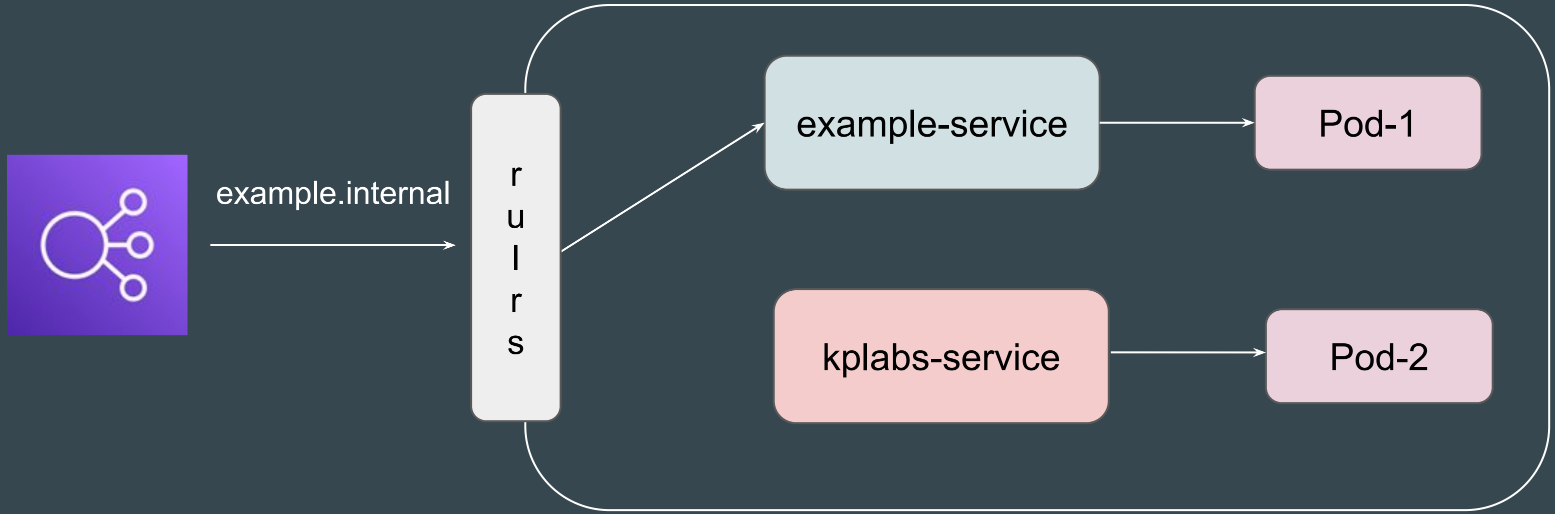
Multiple Service Scenario

In a scenario where you have multiple services for different websites, you might have to create multiple sets of load balancers for each service. This is expensive.



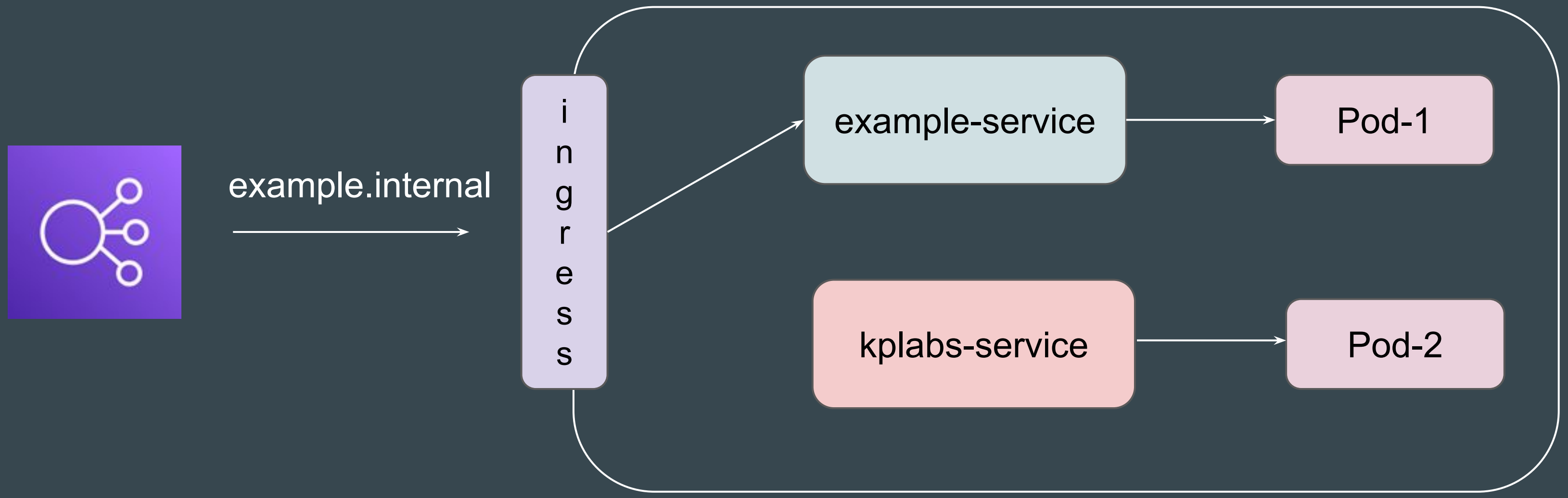
Ideal Approach

In an ideal approach, you want a single load balancer to handle requests for multiple services and a logic that can route traffic accordingly.

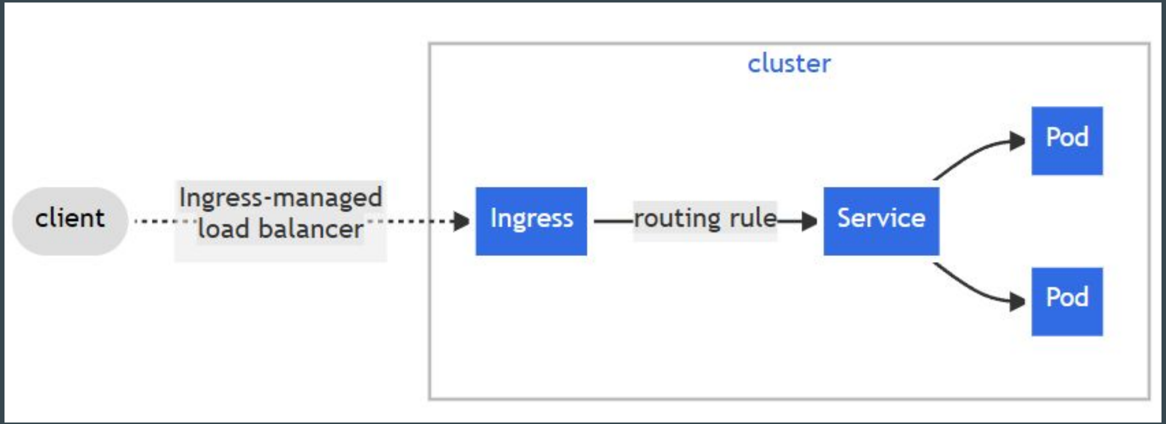


Introducing Ingress

Ingress acts as an entry point that routes traffic to specific services based on rules you define.



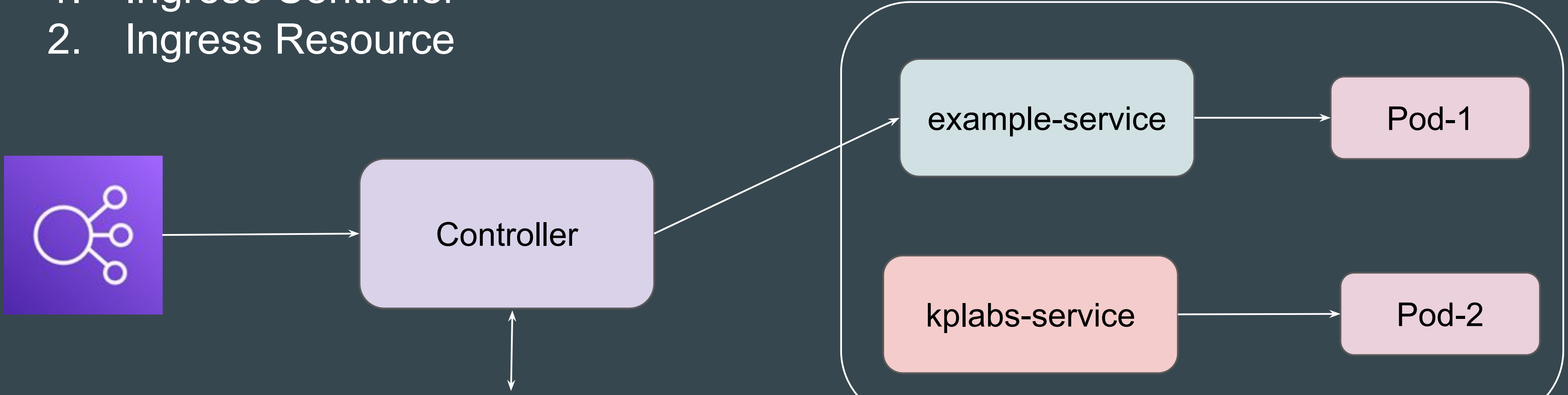
Reference Diagram



Components of Ingress

There are two sub-components of Ingress:

1. Ingress Controller
2. Ingress Resource

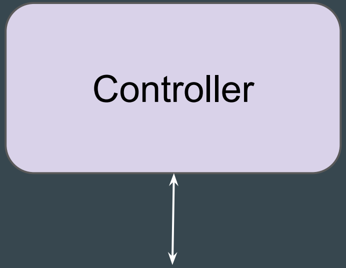


Rules	Forward
example.internal	example-service
kplabs.internal	kplabs-service

Components of Ingress

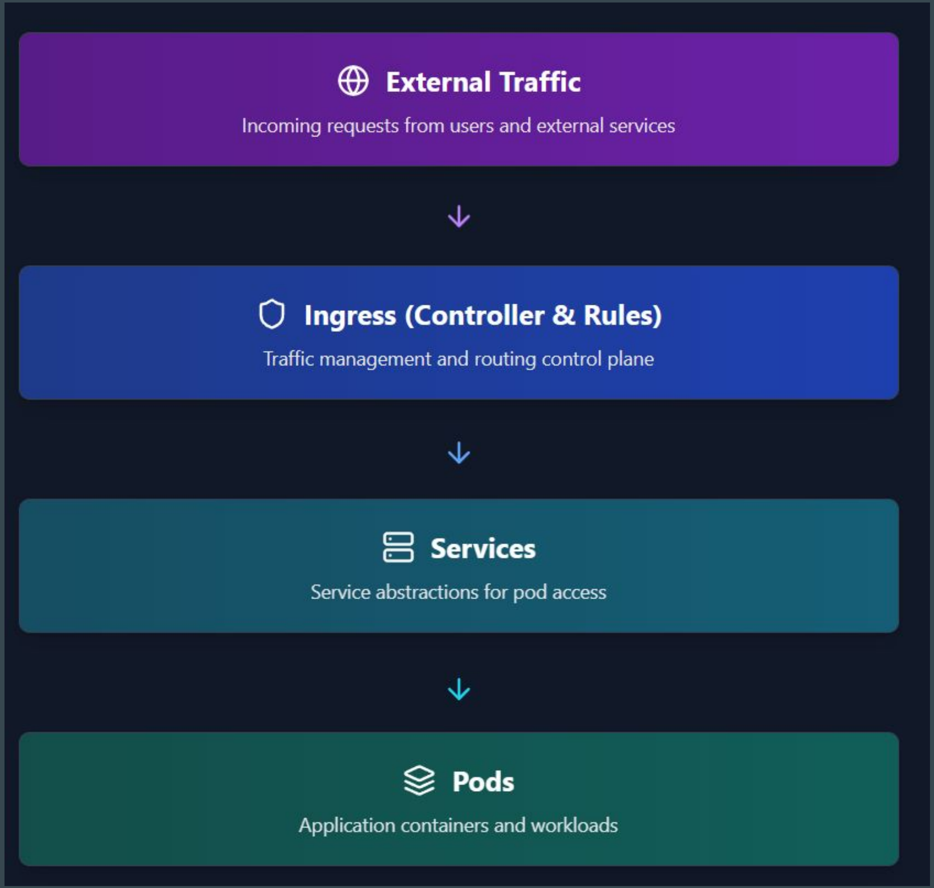
An Ingress Controller is a component that implements the rules defined in Ingress resources.

Ingress Controller is a running application within your cluster.



Rules	Forward
example.internal	example-service
kplabs.internal	kplabs-service

Reference Workflow Diagram



Key Difference Summarized

Ingress	Ingress Controllers
API object (rules, configuration)	Application (implements the rules)
Defines routing rules	Enforces routing rules, manages traffic flow

Ingress Rules - Practical

Scope of Today's Video

In today's video, our focus is going to be primarily on how to write appropriate Ingress Rules

Controller

Rules	Forward
example.internal	example-service
kplabs.internal	kplabs-service

Creating Ingress Rules

Use the kubectl create ingress command

```
Examples:
  # Create a single ingress called 'simple' that directs requests to foo.com/bar to svc
  # svc1:8080 with a TLS secret "my-cert"
  kubectl create ingress simple --rule="foo.com/bar=svc1:8080,tls=my-cert"

  # Create a catch all ingress of "/path" pointing to service svc:port and Ingress Class as "otheringress"
  kubectl create ingress catch-all --class=otheringress --rule="/path=svc:port"

  # Create an ingress with two annotations: ingress.annotation1 and ingress.annotations2
  kubectl create ingress annotated --class=default --rule="foo.com/bar=svc:port" \
  --annotation ingress.annotation1=foo \
  --annotation ingress.annotation2=bla

  # Create an ingress with the same host and multiple paths
  kubectl create ingress multipath --class=default \
  --rule="foo.com/=svc:port" \
  --rule="foo.com/admin/=svcadmin:portadmin"

  # Create an ingress with multiple hosts and the pathType as Prefix
  kubectl create ingress ingress1 --class=default \
  --rule="foo.com/path*=svc:8080" \
  --rule="bar.com/admin*=svc2:http"
```

Example 1 - Ingress with 1 Rule

Create an ingress rule that routes all traffic for the domain of kplabs.internal to be routed to kplabs-service on port 80

```
C:\>kubectl describe ingress demo-ingress
Name:             demo-ingress
Labels:           <none>
Namespace:        default
Address:
Ingress Class:    <none>
Default backend:  <default>
Rules:
  Host             Path  Backends
  ----             ----  --------
  kplabs.internal
                   /   kplabs-service:80 (10.108.0.113:80)
Annotations:       <none>
```

Example 2 - Ingress with 2 Rules

Create Ingress with two rules where traffic for kplabs.internal domain be routed to kplabs-service, and traffic for example.internal domain be routed to example-service.

```
C:\>kubectl describe ingress demo-ingress
Name:             demo-ingress
Labels:           <none>
Namespace:        default
Address:
Ingress Class:    <none>
Default backend:  <default>
Rules:
  Host              Path  Backends
  ----              ----  --------
  kplabs.internal
                    /   kplabs-service:80 (10.108.0.113:80)
  example.internal
                    /   example-service:80 (10.108.0.93:80)
Annotations:        <none>
```

Reference Manifest File

! ingress-kplabs.yaml

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: demo-ingress
spec:
  rules:
  - host: kplabs.internal
    http:
      paths:
      - backend:
          service:
            name: kplabs-service
            port:
              number: 80
        path: /
        pathType: Prefix
```

Controllers Maintained by Kubernetes

Kubernetes as a project supports and maintains AWS, GCE, and nginx ingress controllers

There are various other 3rd party controllers also available.

Ingress NGINX Controller

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Overview

ingress-nginx is an Ingress controller for Kubernetes using NGINX as a reverse proxy and load balancer.

Learn more about Ingress on the Kubernetes documentation site.

Get started

See the Getting Started document.

Do not use in multi-tenant Kubernetes production installations. This project assumes that users that can create Ingress objects are administrators of the cluster. See the FAQ for more.

Overview of Helm

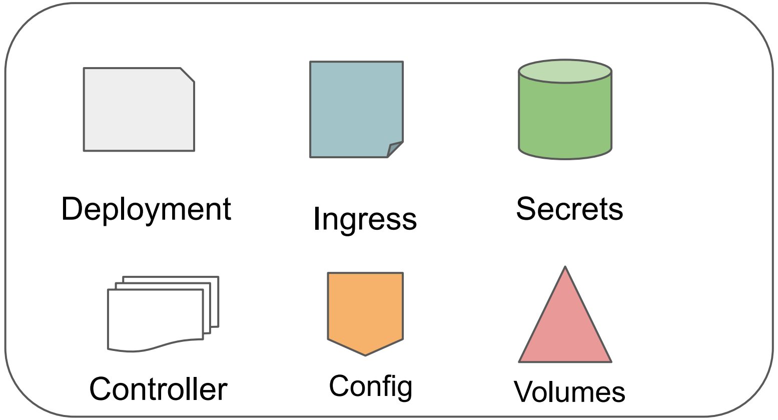
Package Manager for Kubernetes

Understanding Helm

Helm is one of the package manager for Kubernetes.

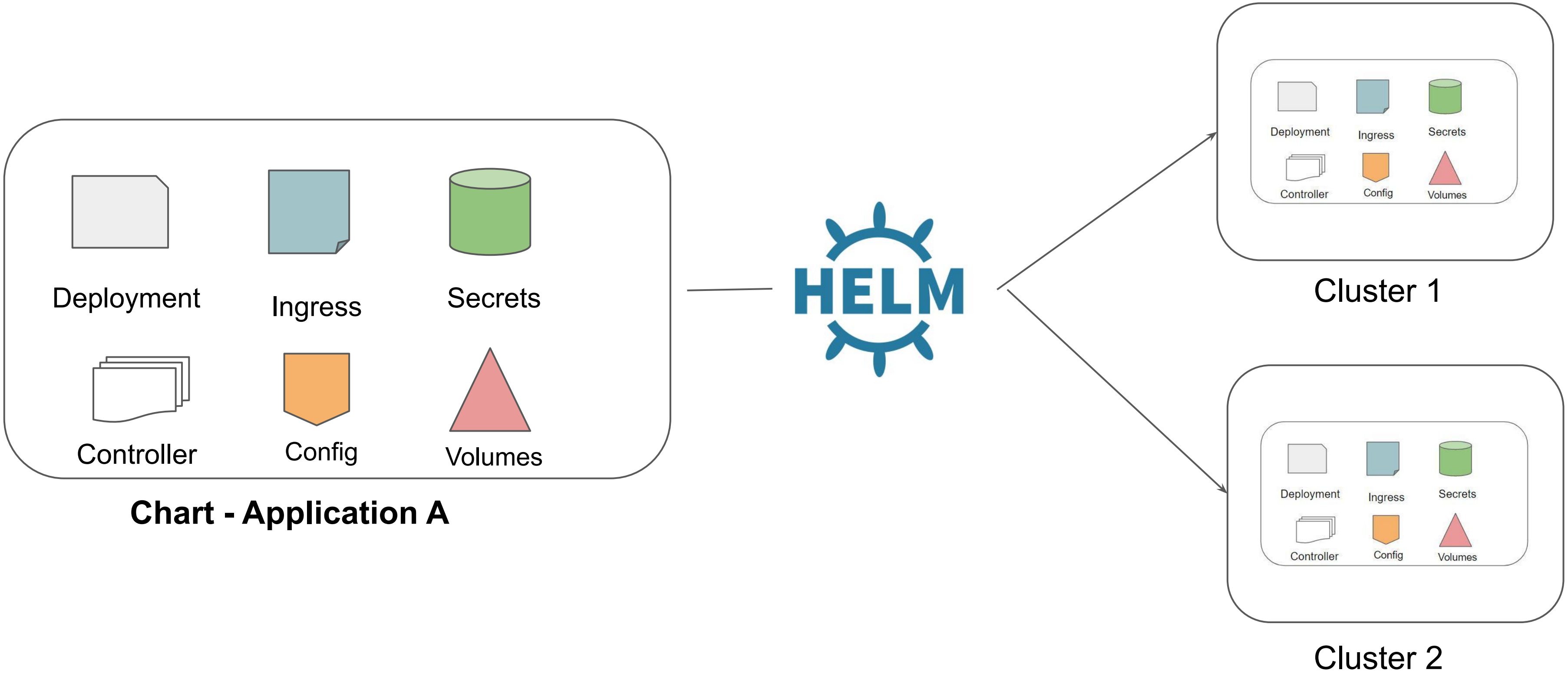
Kubernetes application can contain lot of lot of objects like:

Deployments, Secrets, LoadBalancers, Volumes, services, ingress and others.

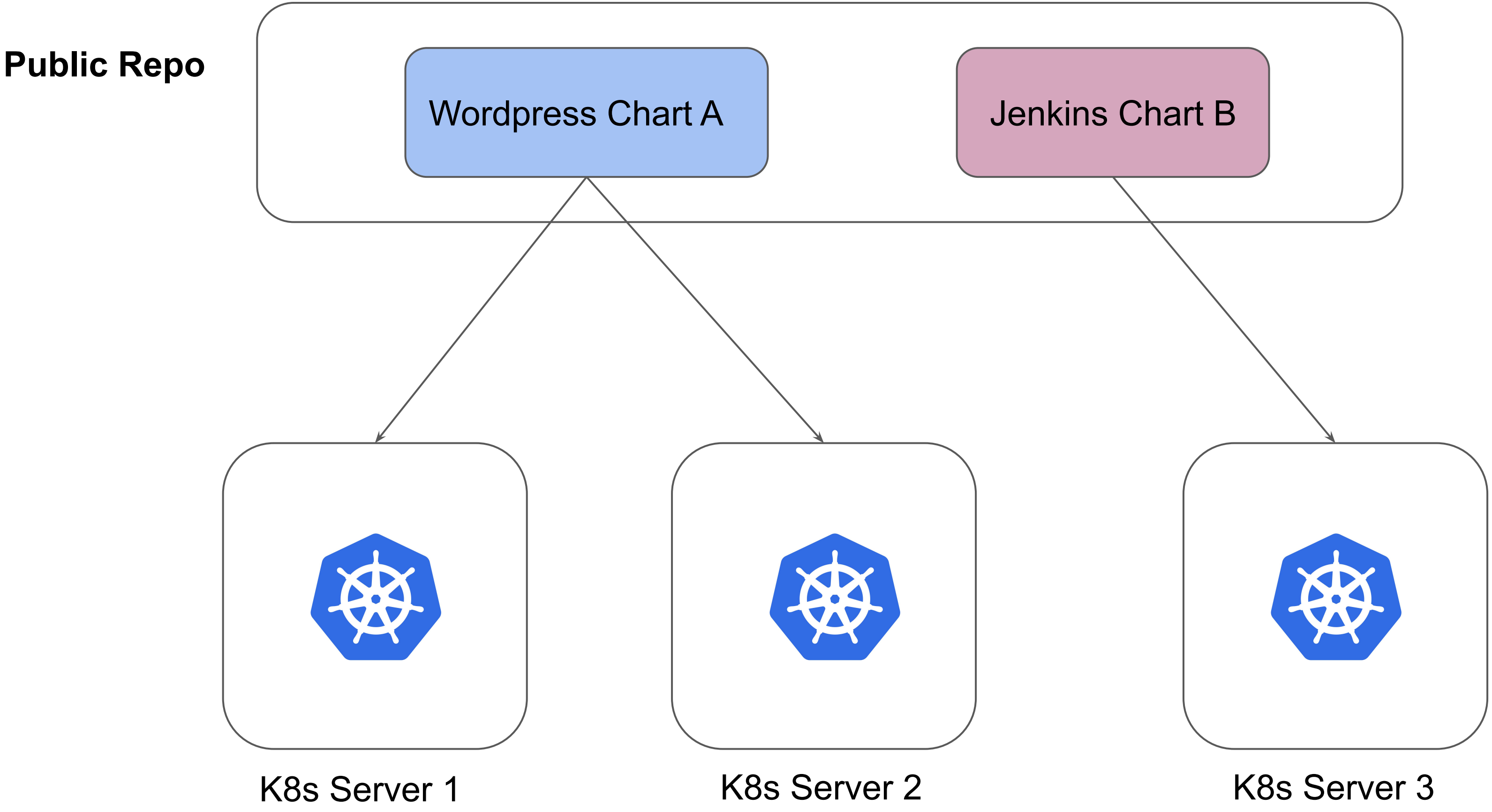


Application A

Deploying Helm Charts



Repository for Helm Charts



Revising Helm Concepts

A Chart is a Helm package.

It contains all of the resource definitions necessary to run an application, tool, or service inside of a Kubernetes cluster.

A Repository is the place where charts can be collected and shared

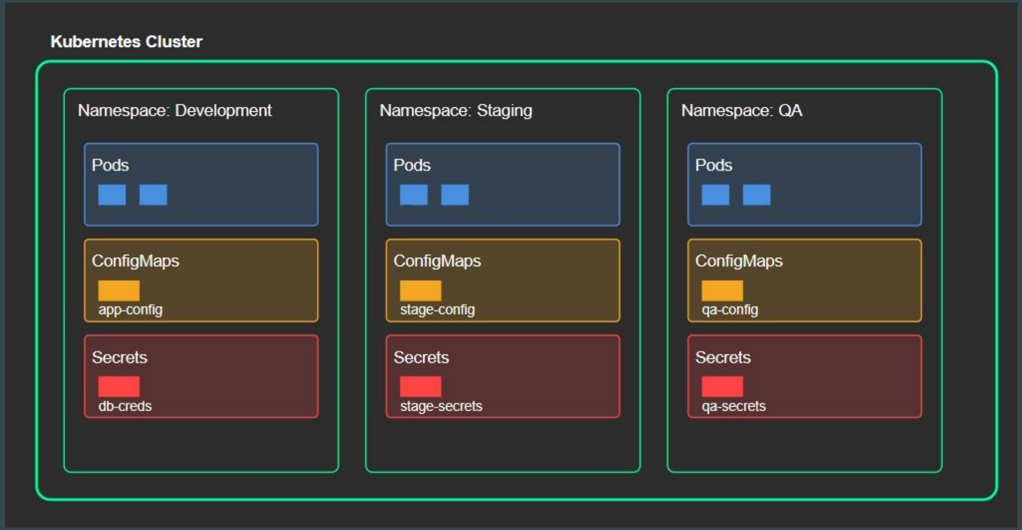
Helm Practical

Helm Command	**Description**
helm search <repo/hub> <keyword>	Provides the ability to search for Helm charts in the various places they can be stored including the Artifact Hub and repositories you have added.
helm repo add <name> <url>	Adds a Helm chart repository (e.g. nginx)
helm install <release> <chart>	Installs a chart as a release into Kubernetes
helm uninstall <release>	Uninstalls (deletes) a Helm release
helm list	Lists all installed Helm releases
helm template <release> <chart>	Renders Kubernetes manifests locally without installing

Namespaces

Setting the Base

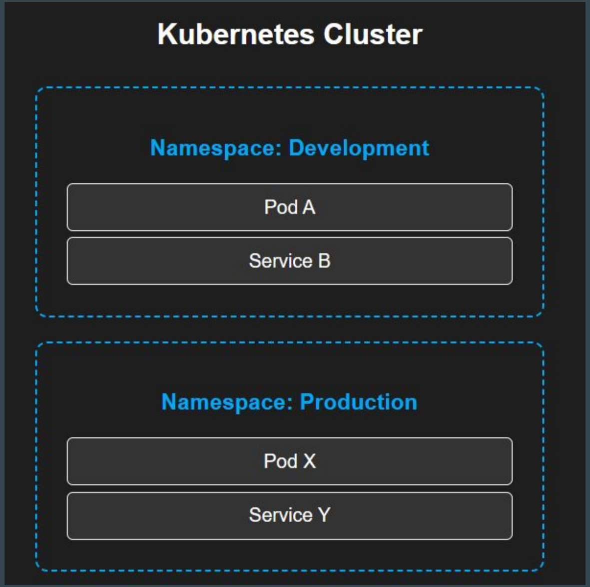
In Kubernetes, namespaces provide a mechanism for isolating groups of resources within a single cluster



Benefits of Namespace

Multiple teams or projects can share the same cluster without interfering with each other.

Separate different environments like, development, QA, staging.



Default Namespaces in Kubernetes

Kubernetes comes with the following default namespaces:

Namespace	Description
default	Used for resources with no specific namespace.
kube-system	The namespace for objects created by the Kubernetes system
kube-public	A namespace visible to all users, often used for publicly accessible data.
kube-node-lease	Used for node heartbeat leases

Reference Screenshot

```
C:\>kubectl get namespace
NAME              STATUS   AGE
default           Active   24d
kube-node-lease   Active   24d
kube-public       Active   24d
kube-system       Active   24d
```

Creating a new Namespace

Use the kubectl create namespace command to create a new namespace.

```
C:\>kubectl create namespace my-namespace
namespace/my-namespace created
```

Creating Resource in Specific Namespace

Use the -n <namespace> option to create and fetch resource in a specific namespace.

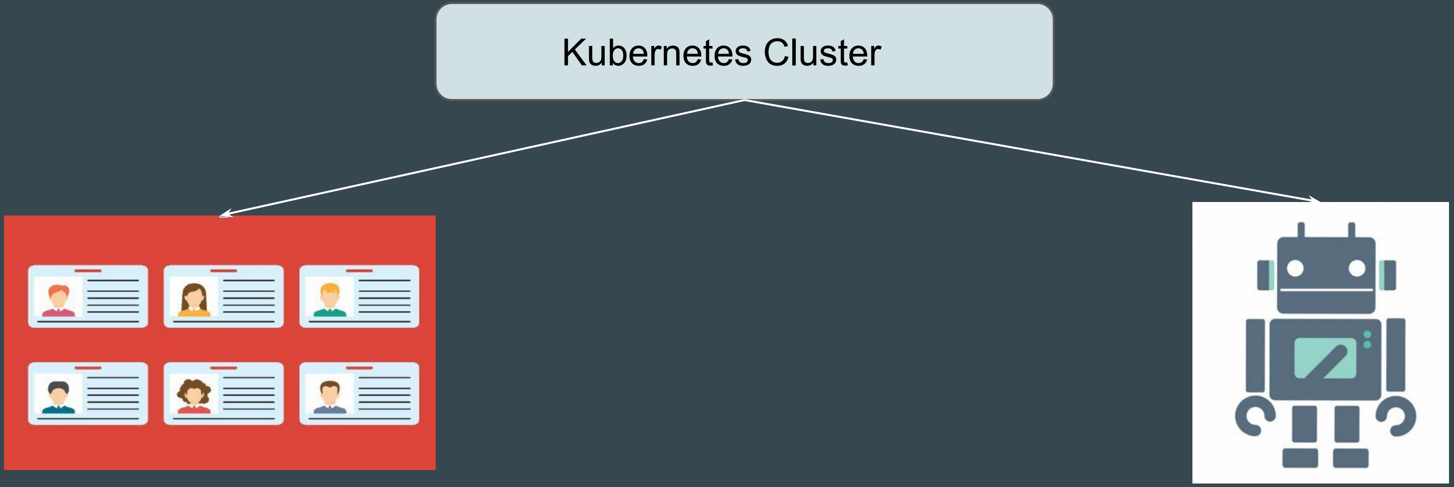
```
C:\>kubectl run test-pod --image=nginx -n my-namespace
pod/test-pod created
```

Service Accounts

Understanding the basics

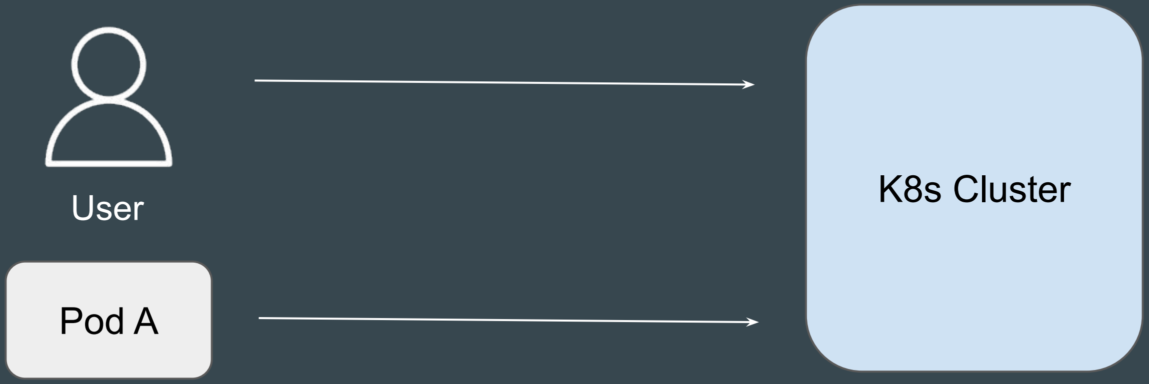
Kubernetes Clusters have two categories of accounts:

- User Accounts (For Humans).
- Service Accounts (For Applications)



Importance of Credentials

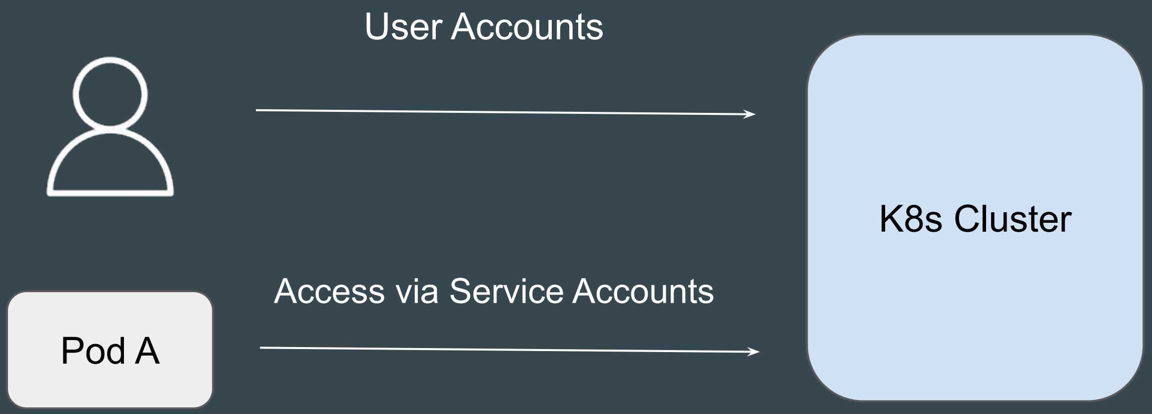
To connect to Kubernetes cluster, an entity needs to have some kind of authentication credentials.



Different Type of Credentials

Humans will use User Accounts to connect to Cluster.

Pods / Applications will use Service Accounts to connect to Cluster.



Service Accounts in K8s Cluster

Various different components of Kubernetes uses service accounts to communicate with the cluster

```
C:\Users\zealv>kubectl get serviceaccounts --all-namespaces
NAMESPACE         NAME                                   SECRETS   AGE
default           default                                0         5m57s
kube-node-lease   default                                0         5m57s
kube-public       default                                0         5m57s
kube-system       attachdetach-controller                0         5m57s
kube-system       certificate-controller                 0         6m1s
kube-system       cilium                                 0         4m22s
kube-system       cilium-operator                        0         4m22s
kube-system       cloud-controller-manager               0         5m54s
kube-system       cluster-autoscaler                     0         5m10s
kube-system       clusterrole-aggregation-controller     0         5m57s
kube-system       coredns                                0         102s
```

Service Accounts and Pods

Let's assume that a Service Account is associated with Pod A.

Pod A can use the token associated with the service account to perform some actions on Kubernetes cluster.

Service Accounts - Points to Note

Default Service Account

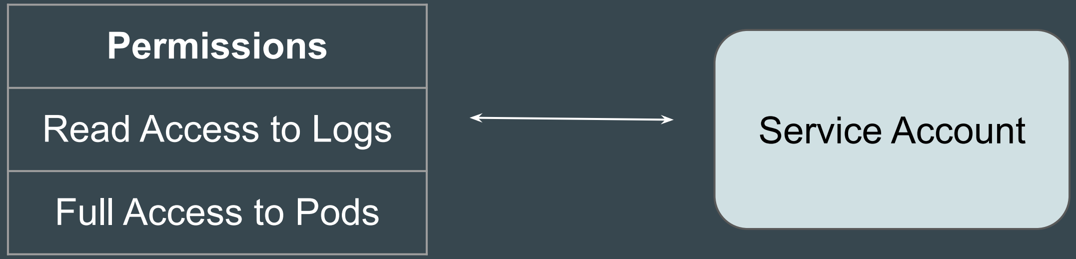
When you create a cluster, Kubernetes automatically creates a ServiceAccount object named default for every namespace in your cluster.

```
C:\Users\zealv>kubectl get serviceaccount
NAME      SECRETS   AGE
default   0         23m
```

Service Account and Permissions

Each Service Account in Kubernetes can be associated with certain permissions.

When Pod uses the service account, it can inherit the permissions.



Point to Note

The default service accounts in each namespace get no permissions by default other than the default API discovery permissions that Kubernetes grants to all authenticated principals if role-based access control (RBAC) is enabled

Assigning Pods to Service Accounts

If you deploy a Pod in a namespace, and you don't manually assign a ServiceAccount to the Pod, Kubernetes assigns the default ServiceAccount for that namespace to the Pod

Accessing Service Account Token

Service Account Token gets mounted inside the Pod inside the /var/run directory and can easily be accessed using cat command.

```
root@nginx:/# cat /var/run/secrets/kubernetes.io/serviceaccount/token
eyJhbGciOiJSUzI1NiIsImtpZCI6IlJLZWlNejJxdTh3NlY2SjhRZHVkSEZfMWxKazFoZmttb3JLNnNTNzZTdXMifQ.eyJhdWQiOlsic3lzdGVtOmtvbm5lY3Rpdm
l0eS1zZXJ2ZXIiXSwiZXhwIjoxNzI3NzU5OTY2LCJpYXQiOjE2OTYyMjM5NjYsImlzcyI6Imh0dHBzOi8va3ViZXJuZXRlcy5kZWZhdWx0LnN2Yy5jbHVzdGVyLmx
vY2FsIiwia3ViZXJuZXRlcy5pbyI6eyJuYW1lc3BhY2UiOiJkZWZhdWx0IiwicG9kIjp7Im5hbWUiOiJuZ2lueCIsInVpZCI6ImU3ZjUyYWY4LWM5MGUtNDY5Zi1i
MTg3LTc3MjliMmNhMmE5MyJ9LCJzZXJ2aWNlYWNjb3VudCI6eyJuYW1lIjoiZGVmYXVsdCIsInVpZCI6ImZlOTUzMTQ0LThjNDYtNDFlMy1iODFjLTMxMThkNTNhM
zAyOCJ9LCJ3YXJuYWZ0ZXIiOjE2OTYyMjc1NzN9LCJuYmYiOjE2OTYyMjM5NjYsInN1YiI6InN5c3RlbTpzZXJ2aWNlYWNjb3VudDpkZWZhdWx0OmRlZmF1bHQifQ
.i5jS2uEbNgj_1GA6LQh2YxQKEJsNjZbvoJh-Qjf-vH_flOw0KTVhmLPCL1UxCLfoI1NejT07Agckj3SFXyjEqmlvcbEYpLXt8eUjrhC8s6RalO5XGnpbt5uUy3GU
BYP4HnRE97OzzU3HyU2gMl4Kd8d8a9iiHb7yov82ph6moOPuuxCxBoWNo5edWMWnNDWLKLNOFX168oxAmQo8ZQI5k37INIE1oN5N2bzp7Y4OGv3CURK1X9O4B0YuT
UN8gSYZsHaQaVq8FT-Q_xGfGQbvjqUzi0rRaKNc9QJOBiIE3CKQN7PL6C0Lxyt_9LieJV438xPgwer2V_aNeHBWgU99oAroot@nginx:/#
```

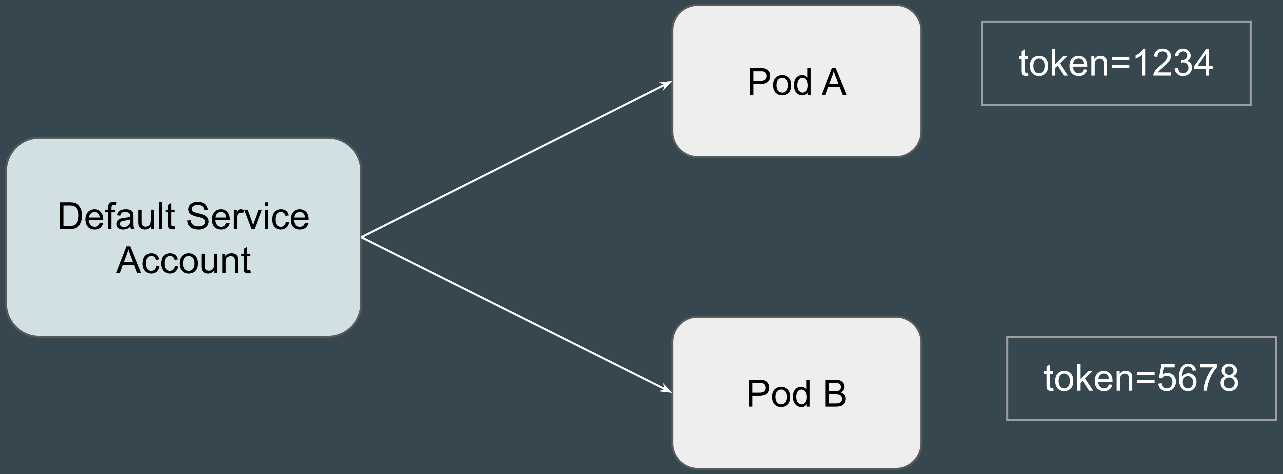
Connecting to K8s using Token

Using the Service Account Token, you can connect to the Kubernetes Cluster to perform operations.

```
}root@nginx:/var/run/secrets/kubernetes.io/serviceaccount# curl -k -H "Authorization: Bearer $t" https://0f3570d8-03b7-45af-a
f4-4c1b90504be3.k8s.ondigitalocean.com/api/v1
{
  "kind": "APIResourceList",
  "groupVersion": "v1",
  "resources": [
    {
      "name": "bindings",
      "singularName": "binding",
      "namespaced": true,
      "kind": "Binding",
      "verbs": [
        "create"
      ]
    },
```

Points to Note

Even though 2 Pods use same service account, each Pod will receive different set of tokens.



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Service Accounts - Practical Scenarios

Creating Service Accounts

You can create new service account directly using kubectl.

```
C:\Users\zealv>kubectl create serviceaccount custom-token
serviceaccount/custom-token created
```

Mounting Custom Service Account to Pod

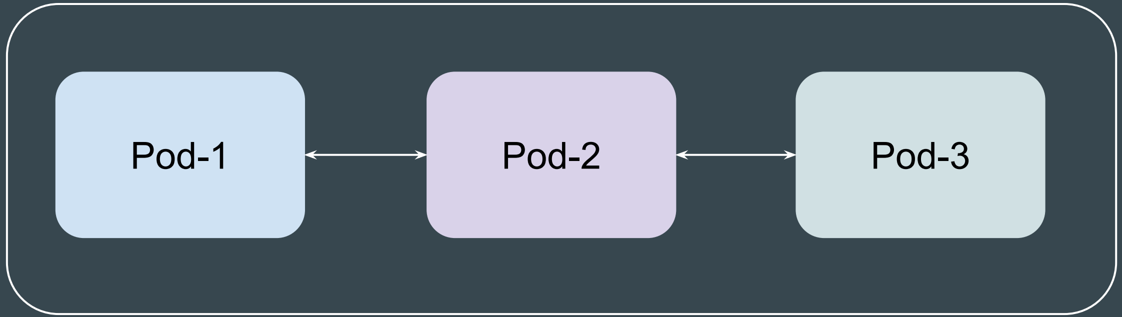
You can use serviceAccountName to specify custom service account token as part of the Pod.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
spec:
  serviceAccountName: custom-token
```

Overview of Network Policies

Understanding the Basics

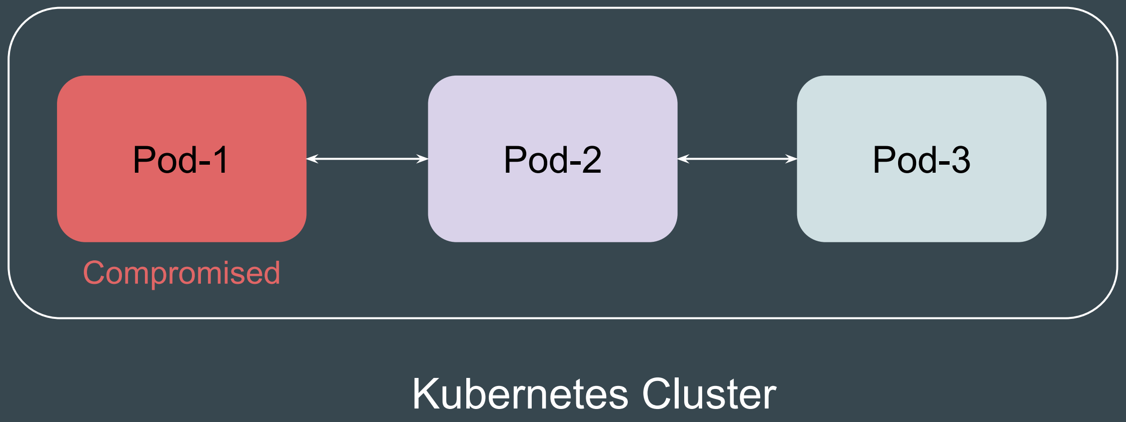
By default, Kubernetes allows all traffic between pods within a cluster. Network Policies help you lock down this open communication.



Kubernetes Cluster

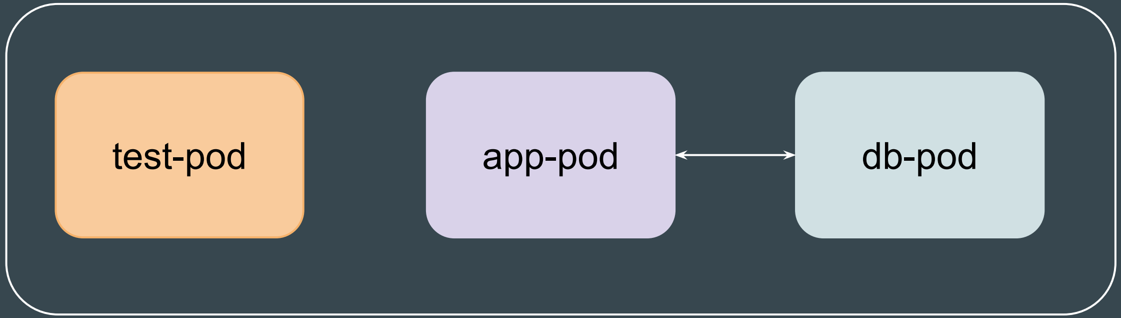
Understanding the Challenge

If a application inside any Pod gets compromised, attacker can essentially communicate with all other Pods easily over the network.



Ideal Scenario

You only want Pods that have genuine requirement to connect to other pods to be able to communicate.



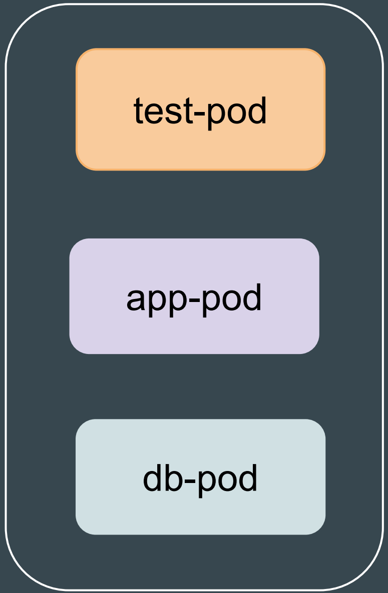
Kubernetes Cluster

Introducing Network Policies

Network Policies are a mechanism for controlling network traffic flow in Kubernetes clusters.

Source	Destination	Effect
app-pod	db-pod	Allow
test-pod	ALL	Deny

Network Policies

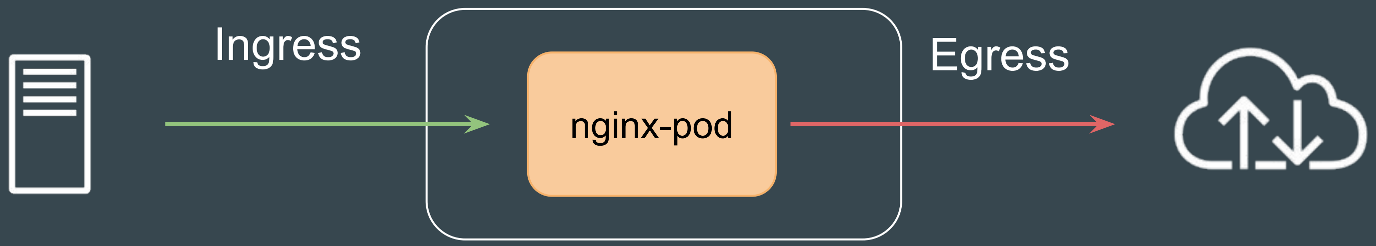


Types of Rules

There are two types of rules supported as part of Network policies:

1. Ingress Rules (Inbound Rule)

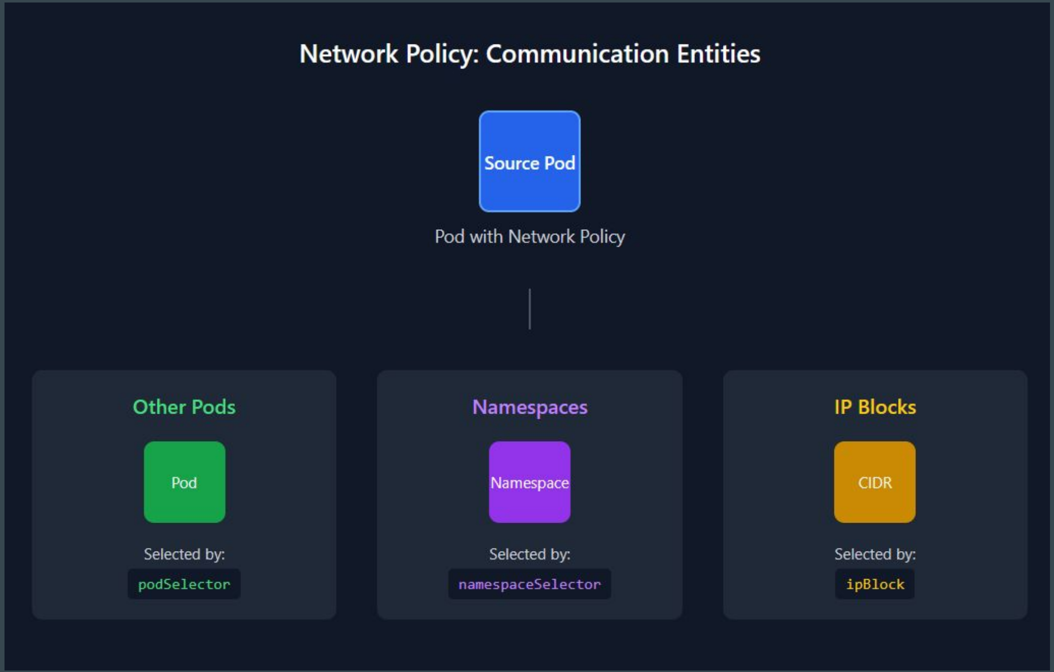
2. Egress Rules (Outbound Rule)



Supported Filtering Entities

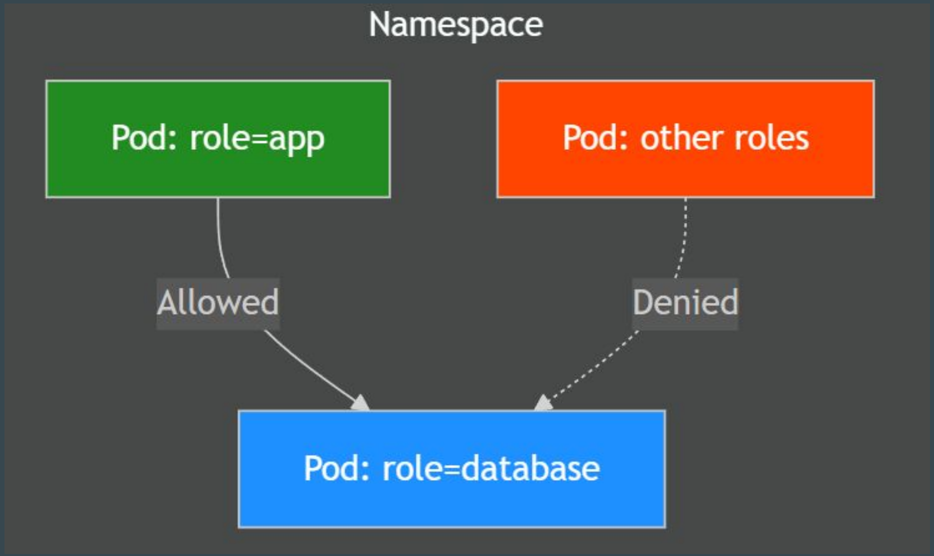
The entities that a Pod can communicate with are identified through a combination of the following three identifiers:

1. Other pods
2. Namespaces
3. IP Blocks



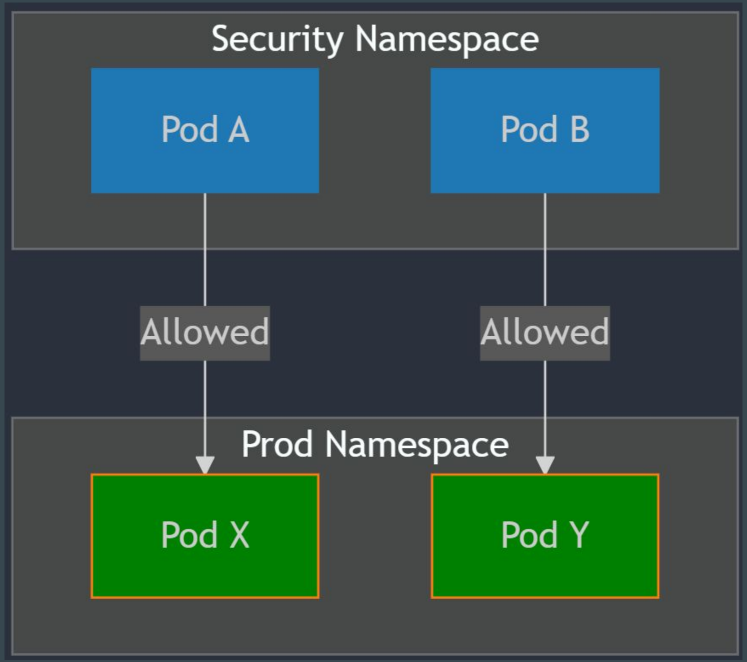
Example 1 - Pod Selector

Allow pods with label of role=app to connect to pods with labels of role=database



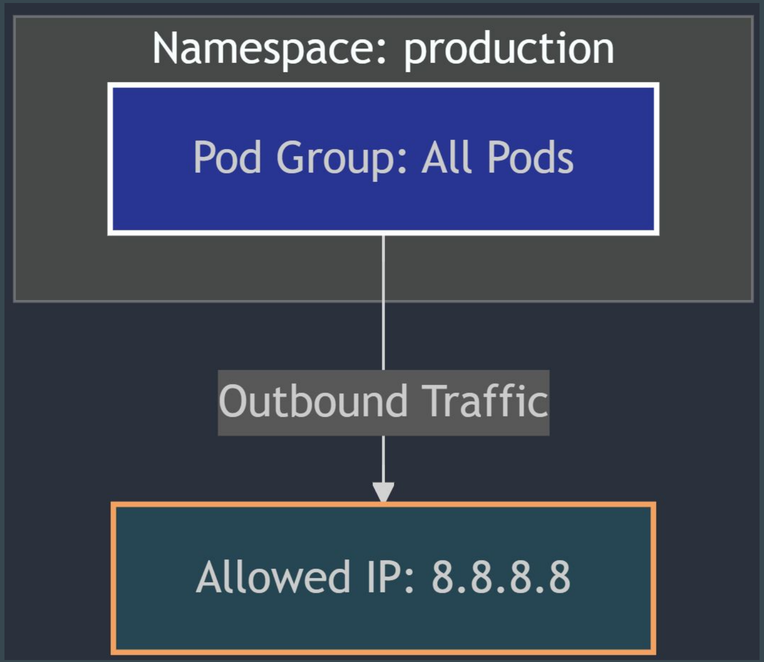
Example 2 - NameSpace Selector

Allow Pods from Security namespace to connect to Pods in Prod namespace.



Example 3 - ipBlock

Allow Pods from production namespace to connect to only 8.8.8.8 IP address outbound.



Support for Network Policy

Not all Kubernetes network plugins (CNIs) support NetworkPolicy.

The ability to enforce NetworkPolicies is a feature that must be implemented by the CNI plugin

Some Network Plugins like Calico, Cilium, etc supports Network policy.

Some Network plugins like kubenet, Flannel does NOT support network Policy

Network Policy and Managed K8s Cluster

Most managed Kubernetes services (like AKS, EKS, GKE) come with a CNI that supports NetworkPolicy by default.

However, it's always a good idea to check the documentation for your specific service to confirm.

Structure of Network Policy

Sample Network Policy

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          env: security
  egress:
  - to:
    - ipBlock:
        cidr: 8.8.8.8/32
```

Basic Mandatory Fields

As with all other Kubernetes config, a NetworkPolicy needs the following fields:

- apiVersion
- kind
- metadata

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
```

Contents of Spec

NetworkPolicy spec has all the information needed to define a particular network policy in the given namespace.

- podSelector
- policyTypes
- Ingress
- egress

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          env: security
  egress:
  - to:
    - ipBlock:
        cidr: 8.8.8.8/32
```

1 - Pod Selector

Each NetworkPolicy includes a podSelector which selects the grouping of pods to which the policy applies.

The example network policy applies to all pods that has label of env=production

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
```

Point to Note

An empty podSelector selects all pods in the namespace.

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector: {}
```

2 - Policy Types

Each NetworkPolicy includes a policyTypes list which may include either Ingress, Egress, or both.

The policyTypes field indicates whether or not the given policy applies to inbound traffic to selected pod, outbound traffic from selected pods, or both

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
```

3 - Ingress

Inside ingress, you can use various combinations of podSelector, nameSpace selector etc to define the rules.

Inbound traffic for Pods with label of env=production will be allowed from pods with label env=security.

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          env: security
```

4 - Egress

Inside Egress rule, you can use various combinations of podSelector, namespaceselector, ipBlock etc to define the rules.

Allow Outbound Traffic only to IP address of 8.8.8.8 for Pods having label of env=production

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          env: security
  egress:
  - to:
    - ipBlock:
        cidr: 8.8.8.8/32
```

Role of from and to

from	Used in an Ingress rule. Specifies the sources of incoming traffic allowed to the selected pods. Sources can be other pods, namespaces, or IP blocks.
to	Used in an Egress rule. Specifies the destinations of outgoing traffic allowed from the selected pods. Destinations can be other pods, namespaces, or IP blocks

Practical - Network Policies

Example 1 - Block All Ingress and Egress

Since no specific rules are defined for ingress or egress, Kubernetes denies all traffic by default

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: default-deny-all
  namespace: production
spec:
  podSelector: {}
  policyTypes:
  - Ingress
  - Egress
```

Points to Note - podSelector

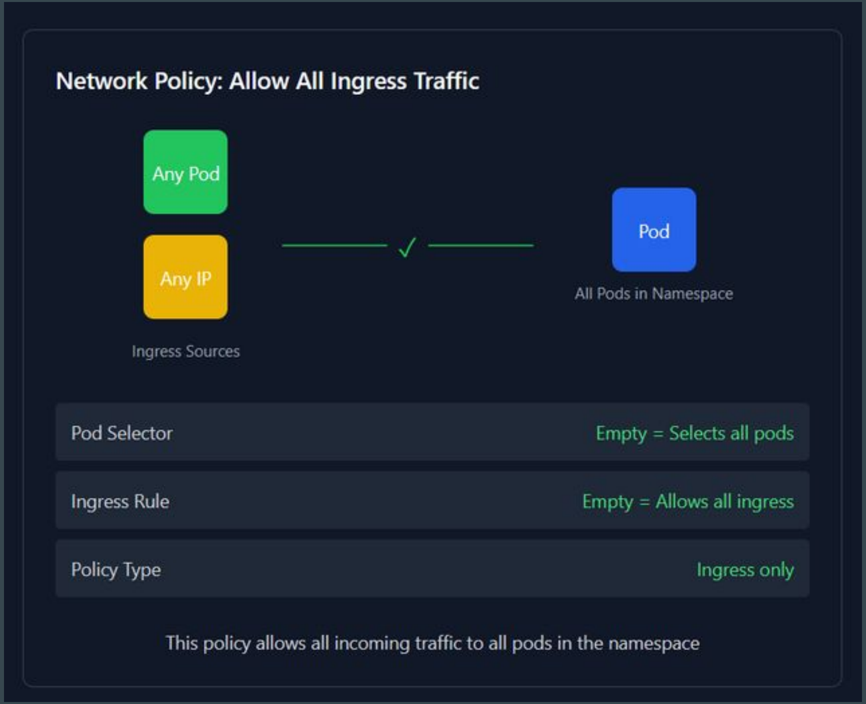
podSelector { }

This means the policy applies to all pods in the namespace because the selector is empty (matches all pods).

Example 2 - Allow Ingress Traffic

This policy allows all incoming traffic (ingress) to the selected pods.

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: allow-ingress
spec:
  podSelector: {}
  ingress:
  - {}
  policyTypes:
  - Ingress
```



Points to Note

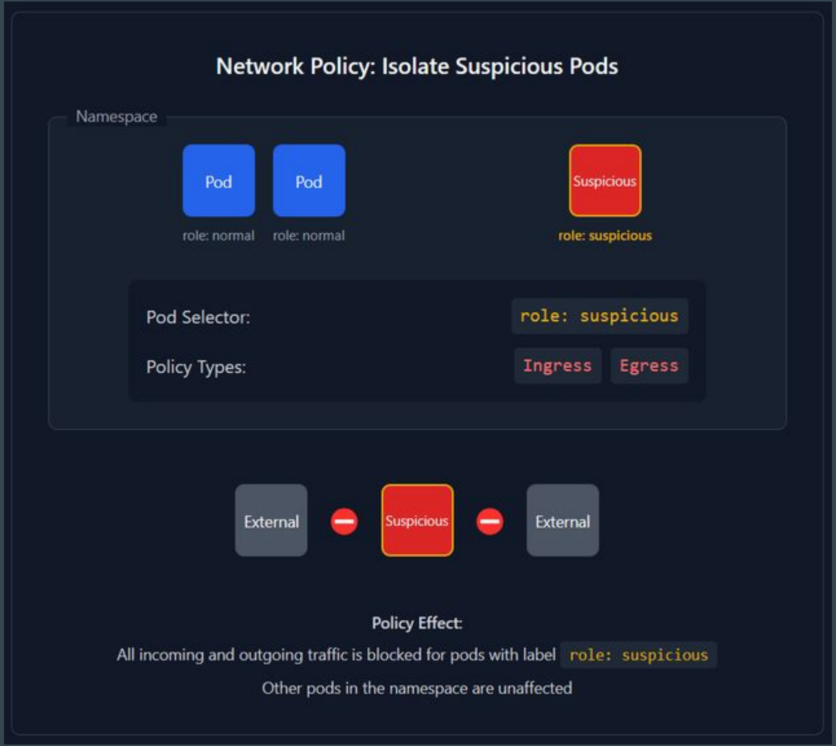
```
ingress:
  - {}
```

The empty {} means that there are no restrictions on the source of the traffic (any source is allowed).

Example 3 - Isolate Suspicious Pod

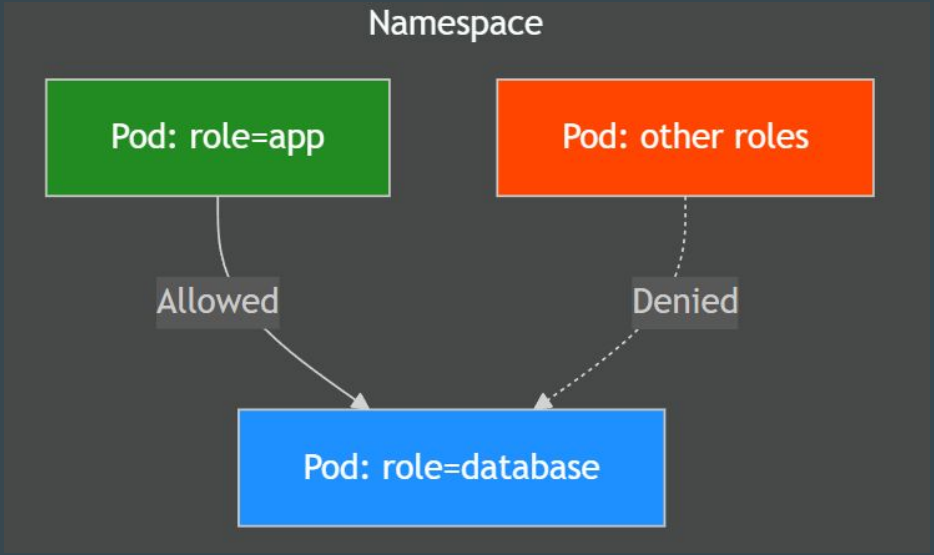
This policy blocks all ingress and egress access to pod with role=suspicious.

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: suspicious-pod
spec:
  podSelector:
    matchLabels:
      role: suspicious
  policyTypes:
  - Ingress
  - Egress
```



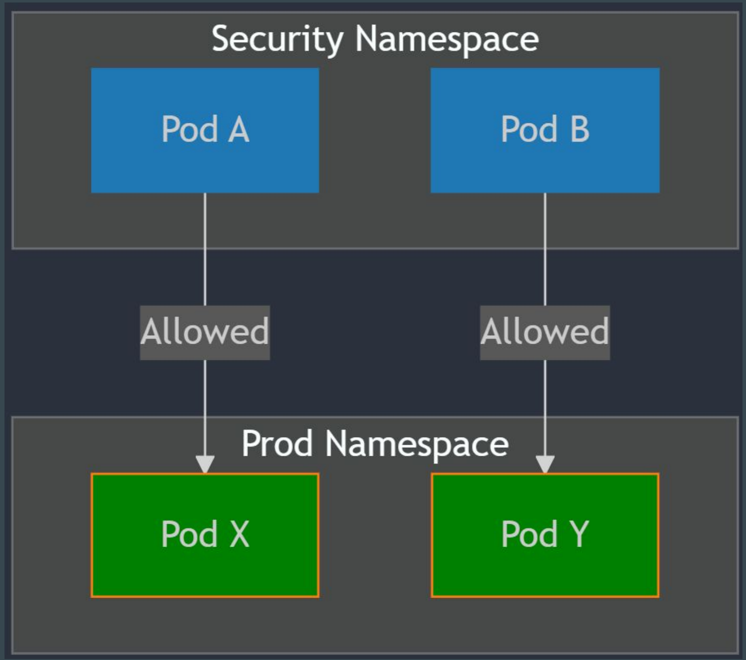
Example 4 - PodSelector

Allow pods with label of role=app to connect to pods with labels of role=database



Example 5 - Namespace Selector

Allow Pods from Security namespace to connect to Pods in Prod namespace.

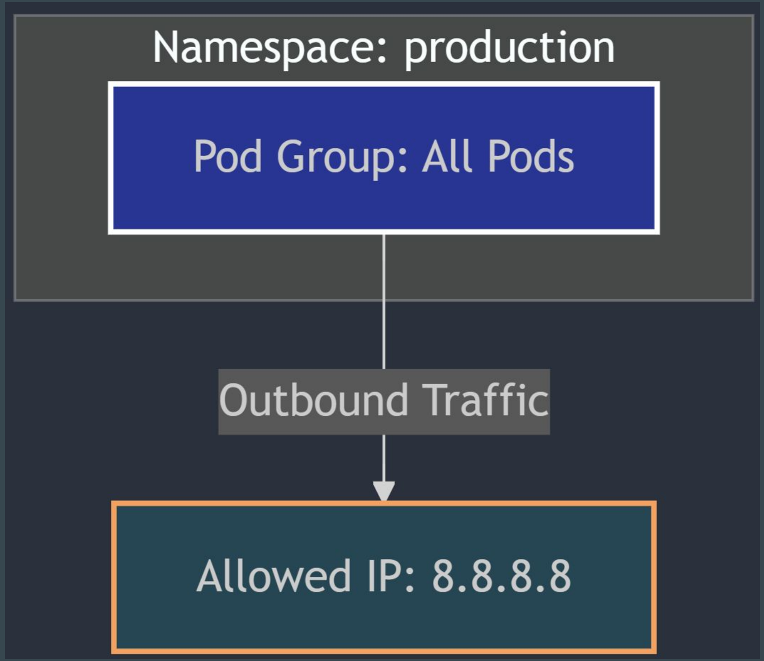


Example 5 - Reference Code

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: namespace-eselector
  namespace: production
spec:
  podSelector: {}
  ingress:
  - from:
    - namespaceSelector:
        matchLabels:
          kubernetes.io/metadata.name: security
  policyTypes:
  - Ingress
```

Example 6 - ipBlock

Allow Pods from production namespace to connect to only 8.8.8.8 IP address outbound.



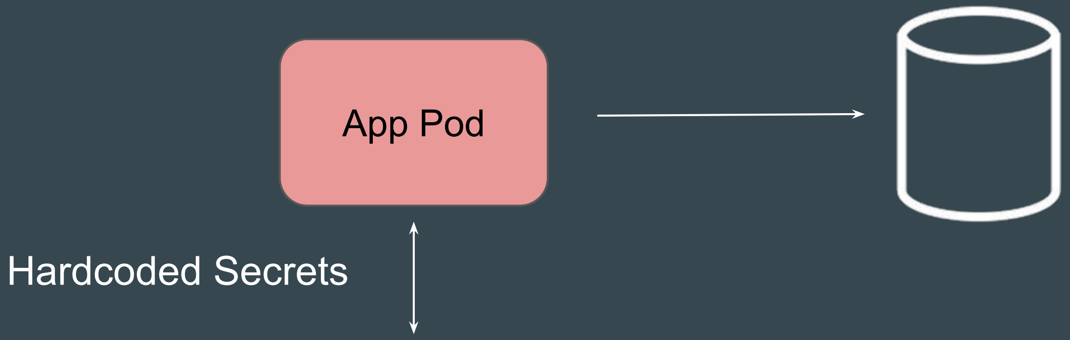
Example 6 - Reference Code

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: outbound-8888
spec:
  podSelector: {}
  egress:
  - to:
    - ipBlock:
        cidr: 8.8.8.8/32
  policyTypes:
  - Egress
```

Kubernetes Secrets

HardCoding Secrets Should be Avoided

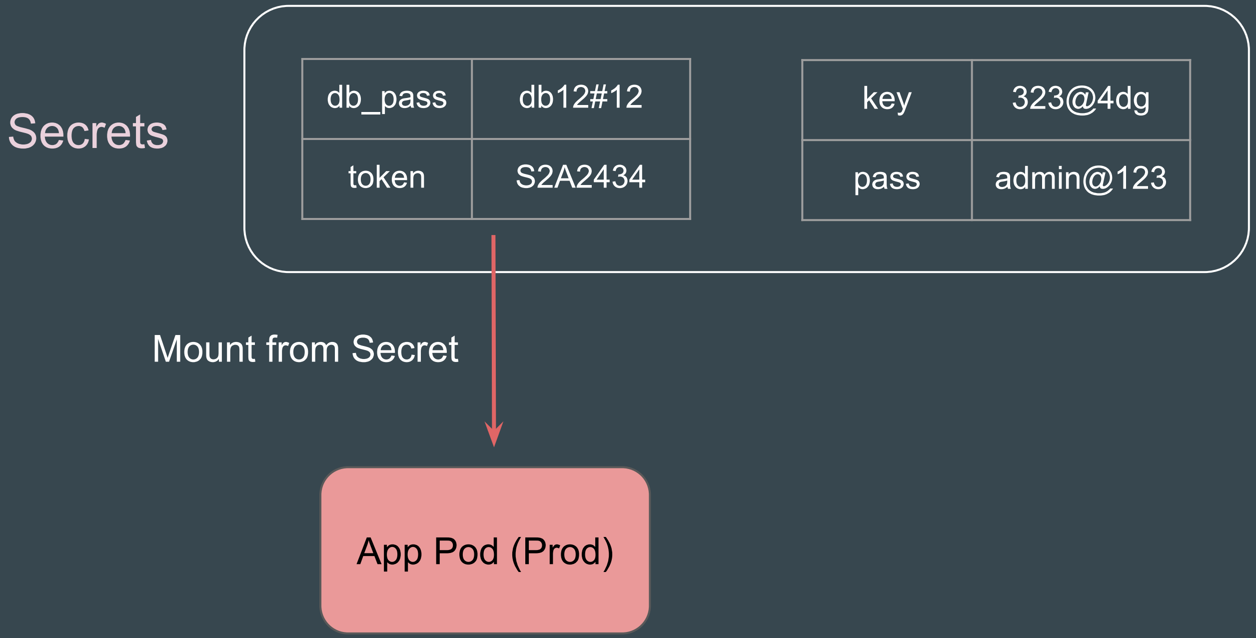
It is frequently observed that sensitive data like passwords, tokens, etc., are hard-coded as part of the container image.



Key	Value
db_user	dbadmin
db_pass	A1S323#

Introducing Secret

Kubernetes Secrets is a feature that allows us to store these sensitive data.



Reference Screenshot

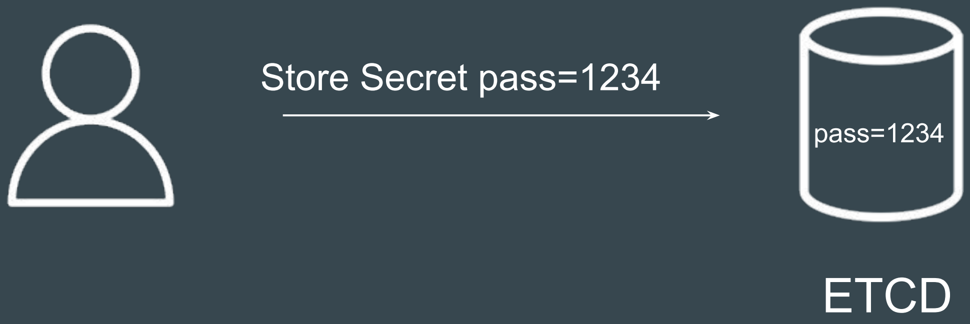
```
C:\>kubectl get secret
NAME        TYPE     DATA   AGE
my-secret   Opaque   1      22m
```

```
C:\>kubectl get secret my-secret -o yaml
apiVersion: v1
data:
  db_pass: QTIjMTI1U0A=
kind: Secret
metadata:
  creationTimestamp: "2025-01-16T02:34:21Z"
  name: my-secret
  namespace: default
  resourceVersion: "5877928"
  uid: d3c383cb-c2e3-4f9b-95ef-d1f0ec6a04be
type: Opaque
```

Point to Note - Part 1

By default, Secrets are not very secure as they are not stored in encrypted format in the data store (ETCD). You can setup this configuration manually.

You can also additionally protect access to secrets using RBAC for access control.



Point to Note - Part 2

When you view a secret, Kubectl will print the Secret in base64 encoded format.

You'll have to use an external base64 decoder to decode the Secret fully

```
C:\>kubectl get secret my-secret -o yaml
apiVersion: v1
data:
  db_pass: QTIjMTI1U0A=
kind: Secret
metadata:
  creationTimestamp: "2025-01-16T02:34:21Z"
  name: my-secret
  namespace: default
  resourceVersion: "5877928"
  uid: d3c383cb-c2e3-4f9b-95ef-d1f0ec6a04be
type: Opaque
```

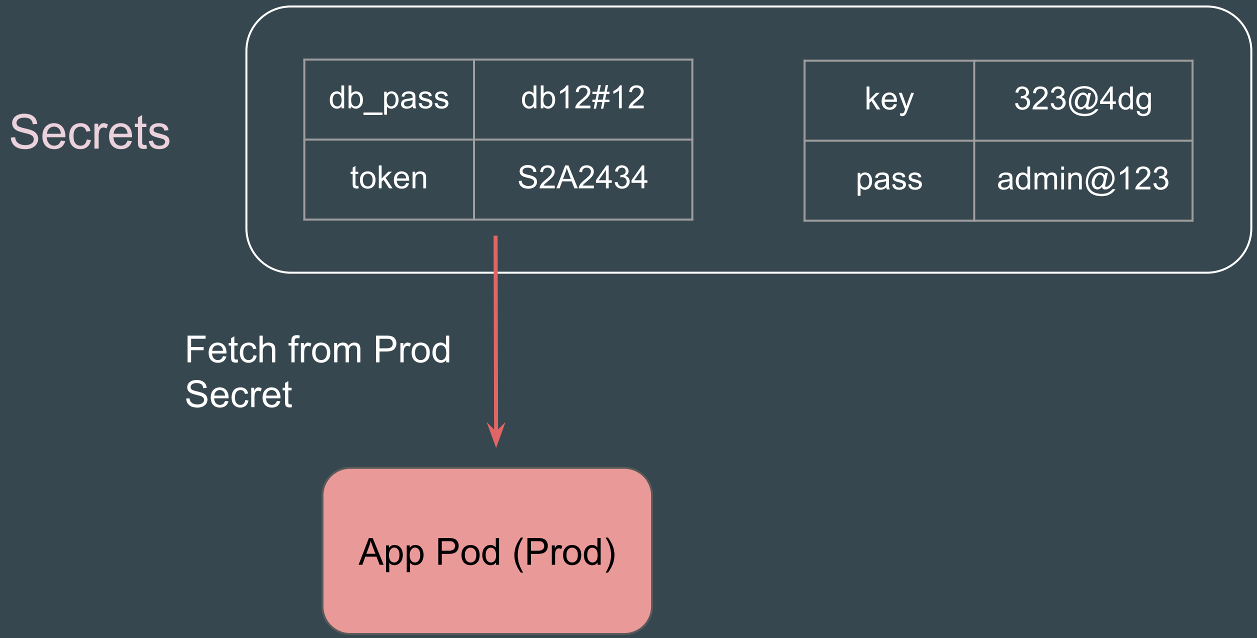
base64 encoded

Kubernetes Secrets - Practical

Two Parts of this Practical

First Part: Create Kubernetes Secret

Second Part: Mount the Secret inside the Pod.



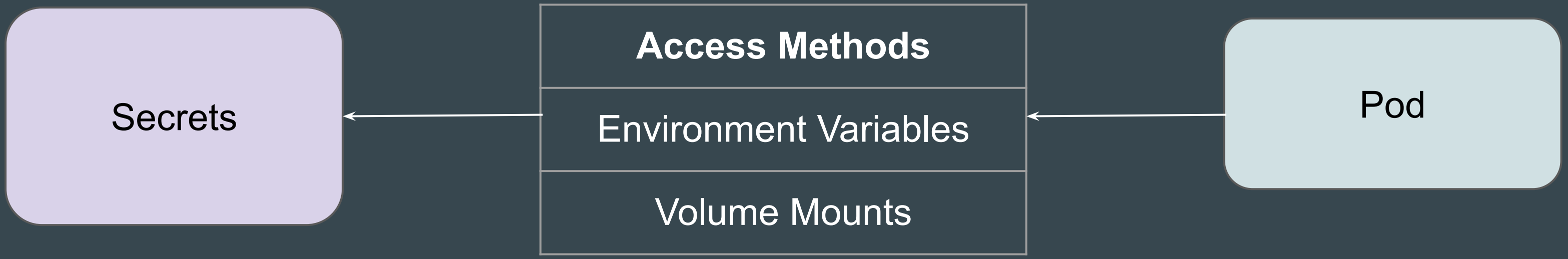
Part 1 - Create Secret

Use the kubectl create secret command to create secret in Kubernetes.

```
Examples:
  # Create a new secret named my-secret with keys for each file in folder bar
  kubectl create secret generic my-secret --from-file=path/to/bar

  # Create a new secret named my-secret with specified keys instead of names on disk
  kubectl create secret generic my-secret --from-file=ssh-privatekey=path/to/id_rsa
--from-file=ssh-publickey=path/to/id_rsa.pub

  # Create a new secret named my-secret with key1=supersecret and key2=topsecret
  kubectl create secret generic my-secret --from-literal=key1=supersecret --from-literal=key2=topsecret

  # Create a new secret named my-secret using a combination of a file and a literal
  kubectl create secret generic my-secret --from-file=ssh-privatekey=path/to/id_rsa --from-literal=passphrase=topsecret

  # Create a new secret named my-secret from env files
  kubectl create secret generic my-secret --from-env-file=path/to/foo.env --from-env-file=path/to/bar.env
```

Different Approaches for Reference

A Pod can reference the Secret in a variety of ways, such as in a volume mount or as an environment variable.



Part 1 - Mount Secret Inside Pod (Volume)

Using Volume Mounts, you can mount a specific secret inside a Pod.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: test-pod
spec:
  containers:
  - name: secretmount
    image: nginx
    volumeMounts:
    - name: secret-volume
      mountPath: "/etc/secrets"
      readOnly: true
  volumes:
  - name: secret-volume
    secret:
      secretName: firstsecret
```

Part 2 - Mount Secret Inside Pod (Env)

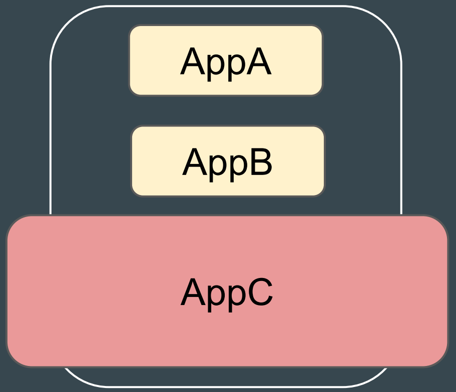
In this method, the values in the Secrets are exposed as environment variables to the container.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: secret-env
spec:
  containers:
  - name: secret-env
    image: nginx
    env:
      - name: SECRET_USERNAME
        valueFrom:
          secretKeyRef:
            name: firstsecret
            key: dbpass
```

Requests and Limits

Understanding the Challenge - Part 1

A specific pod may consume more resources than expected, affecting all pods in the node.



Worker Node

Understanding the Challenge - Part 2

A Pod requires a certain amount of memory and computing resources to run properly.

Example: AppC pod requires 512 MB of RAM and 2 core CPU to run optimally.

Introduction to the Topic

Requests and Limits are two ways in which we can control the amount of resource that can be assigned to a pod (resource like CPU and Memory)

Difference Between Request and Limit

Requests	Limits
The minimum amount of CPU or memory a container is guaranteed to get. Kubernetes uses this to schedule the pod on a node that has enough resources.	The maximum amount of CPU or memory a container is allowed to use. If a container exceeds this limit, it may be throttled (CPU) or killed (memory).

Advantages of Request and Limit

Advantages	Description
Prevents resource starvation	Ensures no single container consumes all resources on a node.
Ensures fair resource allocation	Helps share resources across containers in a cluster.
Avoids over-provisioning	Prevents wasting resources by capping usage.
Stability and performance	Improves stability and performance of your applications.

Reference Code

request-limit.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: kplabs-pod
spec:
  containers:
  - name: kplabs-container
    image: nginx
    resources:
      requests:
        memory: "128Mi"
        cpu: "0.5"
      limits:
        memory: "500Mi"
        cpu: "1"
```

Points to Note - Memory
128 mebibytes is the amount of memory requested by the container. When the container is scheduled onto a node, Kubernetes ensures that the node has at least this much memory available.
500Mi: This is the memory limit, meaning the container is not allowed to consume more than 500Mi of memory. If the container exceeds this memory usage, it might be terminated or throttled

Reference Code

request-limit.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: kplabs-pod
spec:
  containers:
  - name: kplabs-container
    image: nginx
    resources:
      requests:
        memory: "128Mi"
        cpu: "0.5"
      limits:
        memory: "500Mi"
        cpu: "1"
```

Points to Note - CPU
0.5: This refers to half a CPU core (or 50% of a single CPU core). This is the CPU requested by the container. Kubernetes ensures that the container gets at least this much CPU time on a node.
1: This is the CPU limit, meaning the container can use up to 1 full CPU core. If the container tries to use more than 1 CPU core, it will be throttled.

Explanation for Reference Screenshot

The container is guaranteed a minimum of 128Mi of memory (request) but cannot exceed 500Mi of memory (limit).

The container is guaranteed a minimum of 0.5 CPU cores (request) but cannot exceed 1 CPU core (limit).

Limit Ranges

Understanding the Challenge

Not every developer or team remembers (or bothers) to set resource requests and limits on every pod/container.

A user could set unreasonably high or low values (e.g., requesting 10 CPUs on a small cluster, or requesting 0.1Mi of memory, which is too little).

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: no-resource-limit
spec:
  containers:
  - name: busybox
    image: busybox
    command: ["sleep", "3600"]
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: too-much
spec:
  containers:
  - name: busybox
    image: busybox
    command: ["sleep", "3600"]
    resources:
      requests:
        cpu: "10"
        memory: "24Gi"
```

Introducing Limit Ranges

With a LimitRange, the cluster automatically applies default requests and limits when users omit them.

LimitRange can also enforce minimum and maximum thresholds for requests and limits.

```
C:\kplabs-k8s>kubectl describe limitrange resource-limits -n lr-demo
Name:       resource-limits
Namespace:  lr-demo
Type        Resource  Min  Max  Default Request  Default Limit  Max Limit/Request Ratio
----        --------  ---  ---  ---------------  -------------  -----------------------
Container   cpu       -    -    50m              500m           -
Container   memory    -    -    64Mi             256Mi          -
```

Use-Case 1 - Set Default Request / Limits

With a LimitRange, the cluster automatically applies default requests and limits when users omit them.

```yaml
apiVersion: v1
kind: LimitRange
metadata:
  name: resource-limits
  namespace: lr-demo
spec:
  limits:
  - default:
      cpu: "100m"
      memory: "128Mi"
    defaultRequest:
      cpu: "50m"
      memory: "64Mi"
    type: Container
```

Use-Case 2 - Minimum / Maximum Values Allowed

min: Minimum required per container

max: Maximum allowed per container

```yaml
apiVersion: v1
kind: LimitRange
metadata:
  name: stricter-limits
  namespace: lr-demo
spec:
  limits:
  - type: Container
    max:
      cpu: "100m"
      memory: "128Mi"
    min:
      cpu: "30m"
      memory: "50Mi"
```

Reference - Creating Pod with Below / Above min and max values

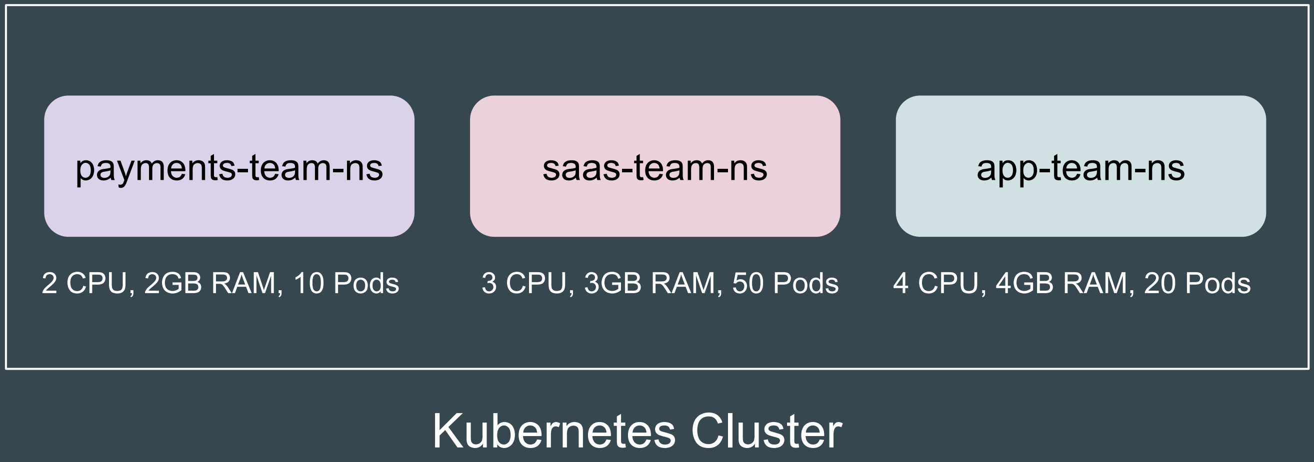
```
C:\kplabs-k8s>kubectl create -f test-pod-3.yaml
Error from server (Forbidden): error when creating "test-pod-3.yaml": pods "pod-below-min" is forbidden: minimum cpu usage pe
r Container is 30m, but request is 20m

C:\kplabs-k8s>kubectl create -f test-pod-4.yaml
The Pod "pod-above-max" is invalid: spec.containers[0].resources.requests: Invalid value: "256Mi": must be less than or equal
 to memory limit of 128Mi
```

Resource Quotas

Setting the Base

Resource Quotas limits the total resource consumption in a namespace.

They prevent a single team or application from consuming all resources in the cluster.



Resource Quota Categories

Category	Description
Compute	You can limit the total sum of compute resources that can be requested in a given namespace.
Storage	You can limit the total sum of storage resources that can be requested in a given namespace.
Object Count	You can set quota for the total number of one particular resource kind in the Kubernetes API

Compute

Limits on the total amount of CPU and memory (RAM) that can be requested or used by workloads for a specific namespace.

```
C:\kplabs-k8s>kubectl describe resourcequota mem-cpu-demo
Name:            mem-cpu-demo
Namespace:       default
Resource         Used  Hard
--------         ----  ----
limits.cpu       0     2
limits.memory    0     2Gi
requests.cpu     0     1
requests.memory  0     1Gi
```

Point to Note

Resource Quota requires that all pods explicitly specify CPU and memory requests and limits.

```
C:\kplabs-k8s>kubectl run test-pod --image=nginx -n quota-demo
Error from server (Forbidden): pods "test-pod" is forbidden: failed quota: mem-cpu-demo: must specify limits.cpu for: test-po
d; limits.memory for: test-pod; requests.cpu for: test-pod; requests.memory for: test-pod
```

Storage

Limits on storage resources such as persistent volume claims (PVCs), storage classes, and total storage requested.

```
C:\kplabs-k8s>kubectl describe resourcequota storage-quota
Name:                   storage-quota
Namespace:              default
Resource                Used  Hard
--------                ----  ----
persistentvolumeclaims  1     5
requests.storage        1Gi   10Gi
```

Object Count

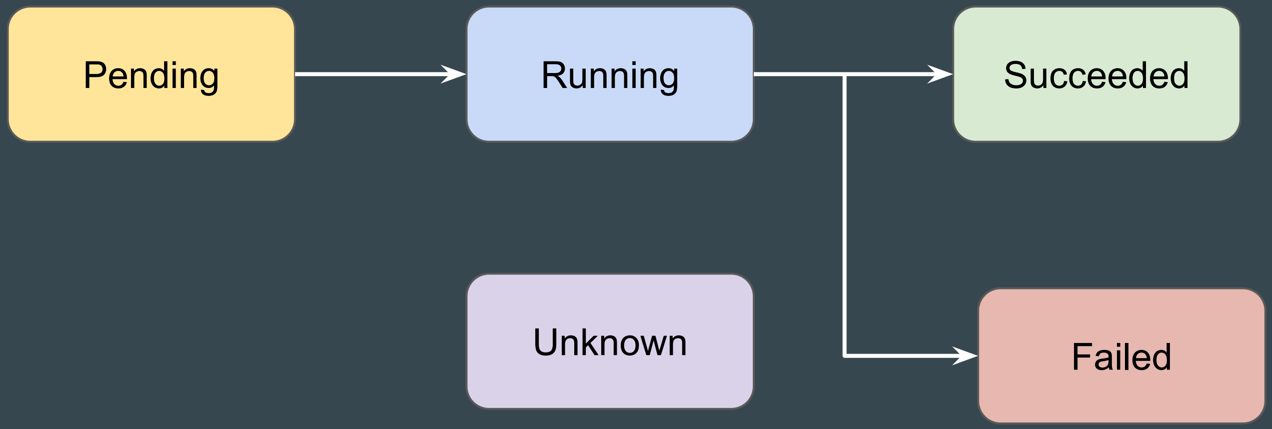
Limits on the number of Kubernetes objects like Pods, Services, ConfigMaps, Secrets, etc.

```
C:\kplabs-k8s>kubectl describe resourcequota object-count-quota
Name:                   object-count-quota
Namespace:              default
Resource                Used  Hard
--------                ----  ----
pods                    1     20
secrets                 1     3
services                1     10
services.loadbalancers  0     2
```

Pod Lifecycle Phases

Setting the Base

Kubernetes Pods go through several lifecycle phases, from creation to termination. Understanding these phases is crucial for debugging and managing workloads.



Phase - Pending

Pod accepted by Kubernetes, but containers not yet created.

Includes time spending in scheduling, downloading container images.

Pods can also stay in Pending phase if there are any issues with scheduling etc.

```
C:\kplabs-k8s>kubectl get pods
NAME       READY   STATUS    RESTARTS   AGE
app-pod    0/1     Pending   0          2s
```

Phase - Running

The Pod has been bound to a node, and all of the containers have been created.

At least one container is still running, or is in the process of starting or restarting.

```
C:\kplabs-k8s>kubectl get pods
NAME         READY   STATUS    RESTARTS   AGE
httpd-pod    1/1     Running   0          10s
nginx-pod    1/1     Running   0          25s
```

Phase - Succeeded

All containers in the Pod have terminated in success, and will not be restarted.

```
C:\kplabs-k8s>kubectl get pods
NAME        READY    STATUS      RESTARTS    AGE
test-pod    0/1      Completed   0           6s
```

Phase - Failed

All containers in the Pod have terminated, and at least one container has terminated in failure.

```
C:\kplabs-k8s>kubectl get pods
NAME      READY   STATUS   RESTARTS   AGE
app-pod   0/1     Error    0          4s
```

Phase - Unknown

For some reason the state of the Pod could not be obtained.

This phase typically occurs due to an error in communicating with the node where the Pod should be running.

Pod Status Field

The STATUS column in kubectl get pods does not always directly map to the five official Pod lifecycle phases.

The STATUS column provides a more human-readable summary of the pod's current state

```
C:\kplabs-k8s>kubectl get pods
NAME        READY   STATUS              RESTARTS   AGE
test-pod    0/1     ImagePullBackOff    0          88s
```

Sample Reference - Mapping Phase to Status

Phases	Status
Pending	Pending, ContainerCreating, ImagePullBackOff, ErrImagePull
Running	Running
Succeeded	Completed
Failed	Error, Failed

Container restart policy

Setting the Base

Restart policies can provide self-healing feature for containers.

They specify the condition under which a container inside a Pod can be automatically restarted.

Example: Restart container if there is any error.

```
C:\kplabs-k8s>kubectl get pods
NAME        READY    STATUS    RESTARTS         AGE
app-pod     0/1      Error     2 (28s ago)      33s
```

Restart Policies

Restart Policy	Description
Always	This policy instructs Kubernetes to restart a container whenever it terminates, regardless of whether the exit was due to a success (exit code 0) or a failure Always is the default Restart policy.
OnFailure	Kubernetes will only restart a container if it terminates with a non-zero exit code (indicating a failure)
Never	Kubernetes will not restart a container once it has terminated, regardless of the exit status (success or failure)

Reference - RestartPolicy in Manifest File

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: app-pod
spec:
  restartPolicy: Never
  containers:
  - name: busybox
    image: busybox
    command: ["false"]
```

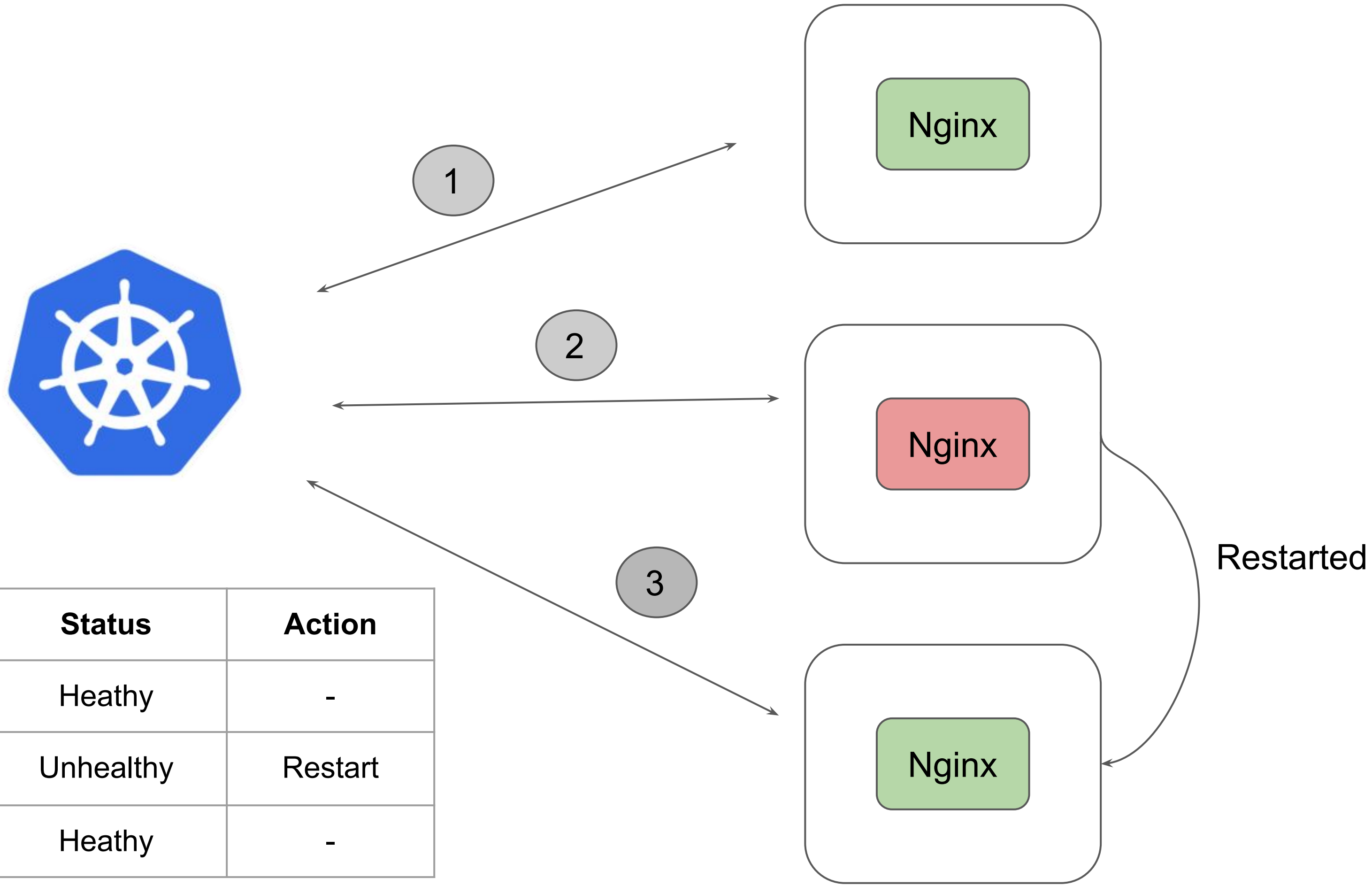
Liveness Probe

Health Checks

Overview of Liveness Probe

Many applications running for long periods of time eventually transition to broken states, and cannot recover except by being restarted.

Kubernetes provides liveness probes to detect and remedy such situations.



Probe	Status	Action
1	Heathy	-
2	Unhealthy	Restart
3	Heathy	-

Types of Probes

There are 3 types of probes which can be used with Liveness

- HTTP
- Command
- TCP

In this demo we had taken an example based on command.

Readiness Probe

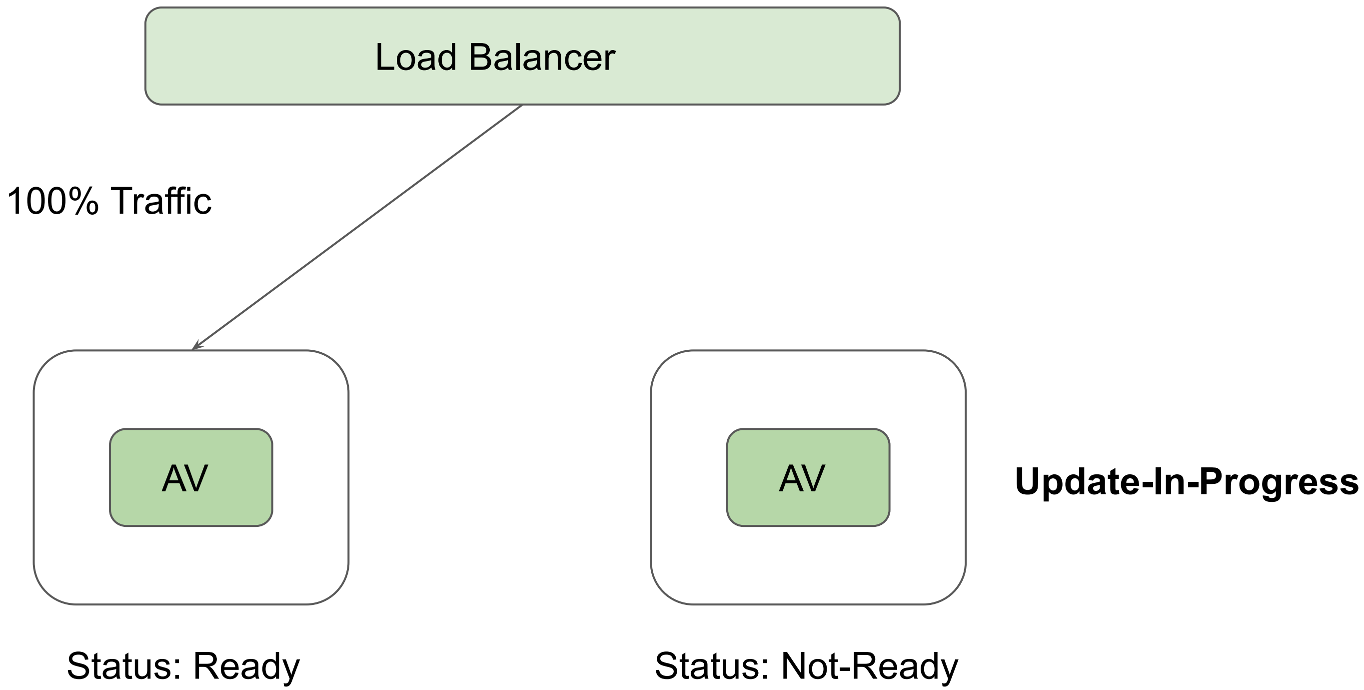
Readiness Checks

Overview of Readiness Probe

It can happen that an application is running but temporarily unavailable to serve traffic.

For example, application is running but it is still loading it's large configuration files from external vendor.

In such-case, we don't want to kill the container however we also do not want it to serve the traffic.


Load Balancer
100% Traffic
AV
AV
Update-In-Progress
Status: Ready
Status: Not-Ready

Overview of Readiness Probe

Syntax of Readiness Probe:

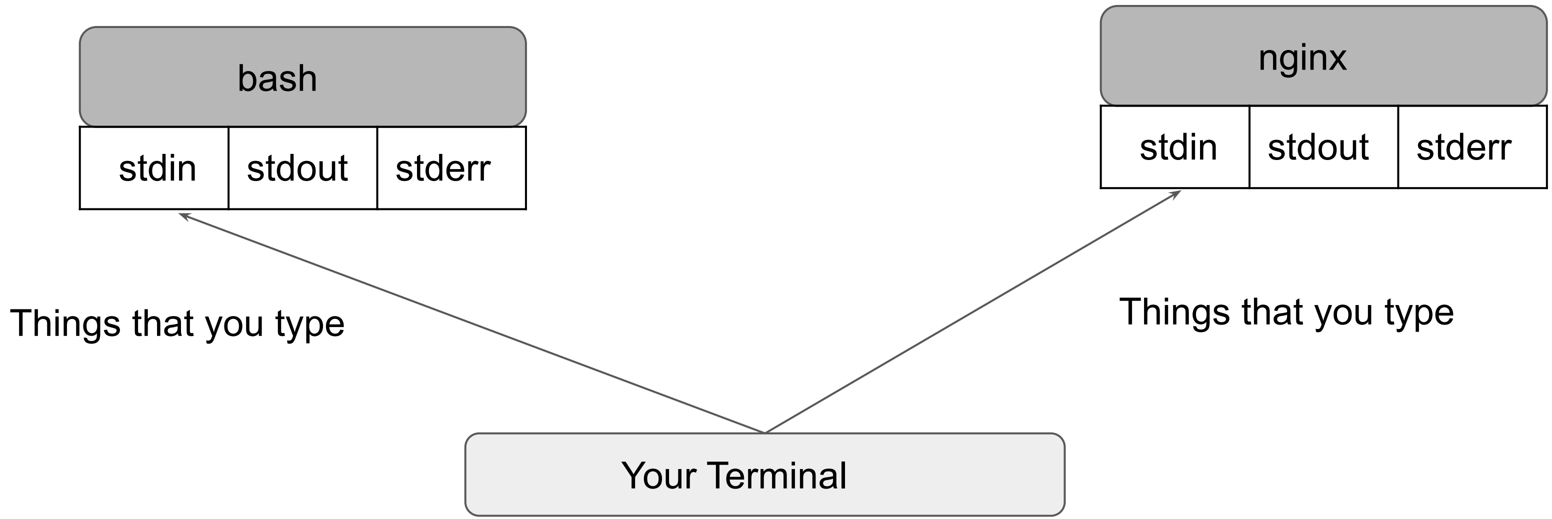
```
readinessProbe:
  exec:
    command:
    - cat
    - /tmp/healthy
  initialDelaySeconds: 5
  periodSeconds: 5
```

Logging Drivers

Build once, use anywhere

Getting Started

UNIX and Linux commands typically open three I/O streams when they run, called STDIN, STDOUT, and STDERR



Logging Drivers in Docker

There are a lot of logging driver options available in Docker, some of these include:

- json-file
- none
- syslog
- local
- journald
- splunk
- awslogs

The docker logs command is not available for drivers other than json-file and journald.

Metrics Server

Setting the Base

By default, Kubernetes does not provide resource usage metrics.

Metrics Server collects resource usage data (CPU and memory) from the kubelet on each node and makes it available via the Kubernetes Metrics API.

```
C:\>kubectl top pods -A
NAMESPACE     NAME                               CPU(cores)   MEMORY(bytes)
default       curl                               0m           0Mi
default       nginx                              0m           2Mi
kube-system   cilium-fbqjm                       11m          205Mi
kube-system   coredns-86bbcb7bcf-88kqj           2m           16Mi
kube-system   coredns-86bbcb7bcf-lvcjd           2m           16Mi
kube-system   cpc-bridge-proxy-ebpf-8t7zc        1m           1Mi
kube-system   csi-do-node-j5bkg                  1m           10Mi
kube-system   do-node-agent-jjm5b                0m           21Mi
kube-system   hubble-relay-8cc9ccbbd-jj4jv       1m           23Mi
kube-system   hubble-ui-cc6cd98c6-76x9p          1m           22Mi
kube-system   konnectivity-agent-jj5ln           1m           11Mi
kube-system   kube-proxy-ebpf-8z6gk              0m           0Mi
kube-system   metrics-server-74bb687b8-8mpbn     3m           18Mi
```

kubectl top pods

kubectl top pods command shows the CPU and memory usage of all running pods in the cluster (or within a specific namespace).

```
C:\>kubectl top pods -A
NAMESPACE     NAME                                CPU(cores)   MEMORY(bytes)
default       curl                                0m           0Mi
default       nginx                               0m           2Mi
kube-system   cilium-fbqjm                        11m          205Mi
kube-system   coredns-86bbcb7bcf-88kqj            2m           16Mi
kube-system   coredns-86bbcb7bcf-lvcjd            2m           16Mi
kube-system   cpc-bridge-proxy-ebpf-8t7zc         1m           1Mi
kube-system   csi-do-node-j5bkg                   1m           10Mi
kube-system   do-node-agent-jjm5b                 0m           21Mi
kube-system   hubble-relay-8cc9ccbbd-jj4jv        1m           23Mi
kube-system   hubble-ui-cc6cd98c6-76x9p           1m           22Mi
kube-system   konnectivity-agent-jj5ln            1m           11Mi
kube-system   kube-proxy-ebpf-8z6gk               0m           0Mi
kube-system   metrics-server-74bb687b8-8mpbn      3m           18Mi
```

kubectl top nodes

kubectl top nodes command displays CPU and memory usage across all nodes in the Kubernetes cluster

```
root@k8s:~# kubectl top nodes
NAME                 CPU(cores)   CPU(%)   MEMORY(bytes)   MEMORY(%)
kind-control-plane   123m         12%      604Mi           30%
kind-worker          45m          4%       268Mi           13%
kind-worker2         41m          4%       211Mi           10%
```

Kubernetes Events

Let's Validate!

Overview of k8s Events

Kubernetes Events are created when other resources have state changes, errors, or other messages that should be broadcast to the system.

It provides insight into what is happening inside a cluster, such as what decisions were made by scheduler or why some pods were evicted from the node.

```
Events:
  Type    Reason     Age    From                             Message
  ----    ------     ----   ----                             -------
  Normal  Scheduled  9m33s  default-scheduler                Successfully assigned default/nginx-7bb7cd8db5-nzpzm to sec
ondary-nodes-btws
  Normal  Pulling    9m30s  kubelet, secondary-nodes-btws  Pulling image "nginx"
  Normal  Pulled     9m26s  kubelet, secondary-nodes-btws  Successfully pulled image "nginx"
  Normal  Created    9m26s  kubelet, secondary-nodes-btws  Created container nginx
  Normal  Started    9m26s  kubelet, secondary-nodes-btws  Started container nginx
```

Important Pointer

All the events are stored in the master server.

To avoid filling up master's disk, a retention policy is enforced: events are removed one hour after the last occurrence.

To provide longer history and aggregation capabilities, a third party solution should be installed to capture events.

Events and Namespaces

Events are namespaced.

Hence if you want event of a pod in "kplabs-namespace" then you will have to explicitly specify the --namespace kplabs-namespace.

To see events from all namespaces, you can use the --all-namespaces argument.

Field Selector

Let's Search!

Overview of Field Selector

Field selectors let you select Kubernetes resources based on the value of one or more resource fields

```
C:\Users\Zeal Vora>kubectl get pods  --all-namespaces --field-selector metadata.namespace!=default
NAMESPACE     NAME                                 READY   STATUS    RESTARTS        AGE
kube-system   cilium-jg5vs                         2/2     Running   0               3d
kube-system   cilium-mdm7m                         2/2     Running   0               3d
kube-system   cilium-nj598                         2/2     Running   0               11d
kube-system   cilium-operator-69676856c9-nvfjr     1/1     Running   2 (7d15h ago)   11d
kube-system   coredns-566f6cc75f-b4vmx             1/1     Running   0               11d
kube-system   coredns-566f6cc75f-cxsxq             1/1     Running   0               11d
kube-system   cpc-bridge-proxy-bc762               1/1     Running   0               3d
kube-system   cpc-bridge-proxy-svs6d               1/1     Running   0               3d
kube-system   cpc-bridge-proxy-vbzzc               1/1     Running   0               11d
kube-system   csi-do-node-vc7r4                    2/2     Running   0               11d
```

Default Configuration

By default, no selectors/filters are applied, meaning that all resources of the specified type are selected.

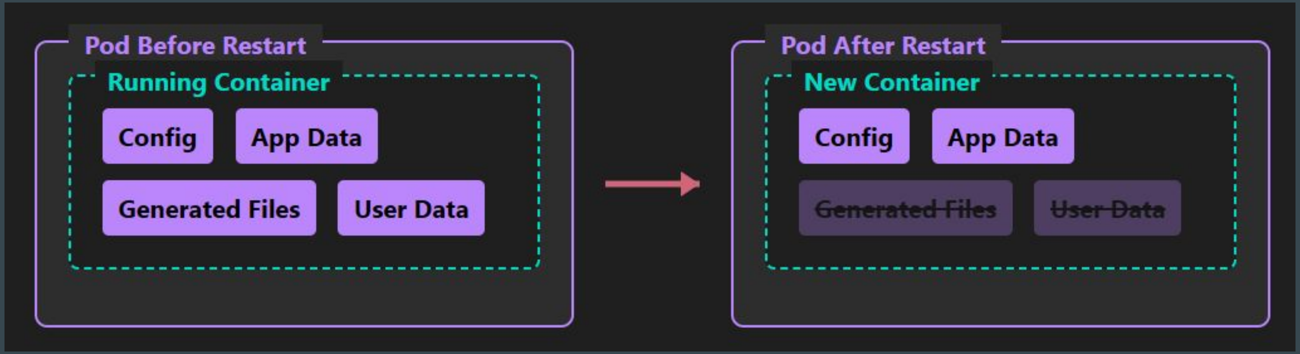
This makes the kubectl queries kubectl get pods and kubectl get pods --field-selector "" equivalent.

Volumes in Kubernetes

Understanding Challenge - State Persistence

When a container crashes or restarted, the container state is not saved so all of the files that were created during the lifetime of the container are lost.

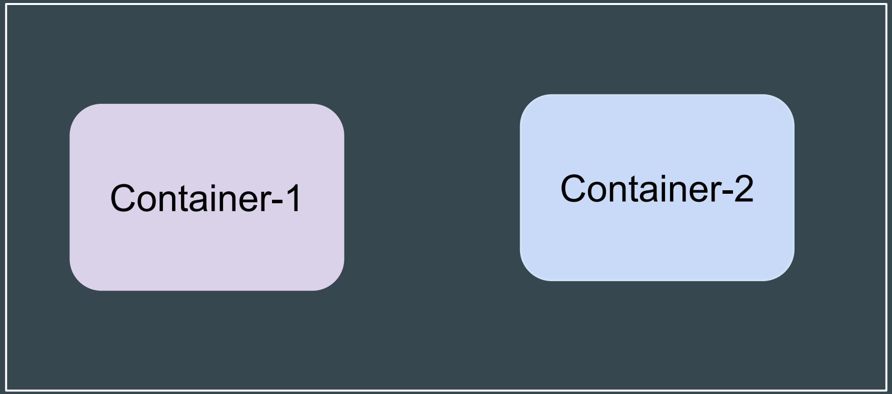
After a crash, kubelet restarts the container with a clean state.



Understanding Challenge - Shared Storage

Another problem occurs when multiple containers are running in a Pod and need to share files.

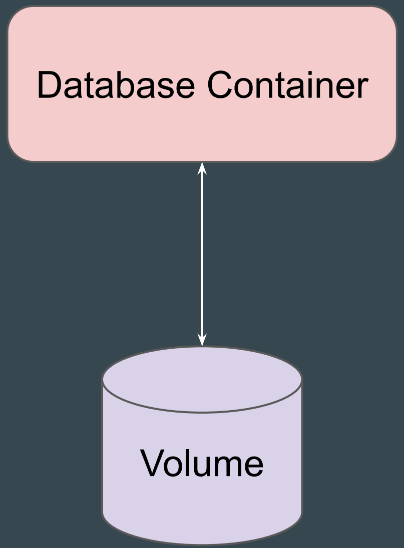
It can be challenging to set up and access a shared filesystem across all of the containers.



Multi-Container Pod

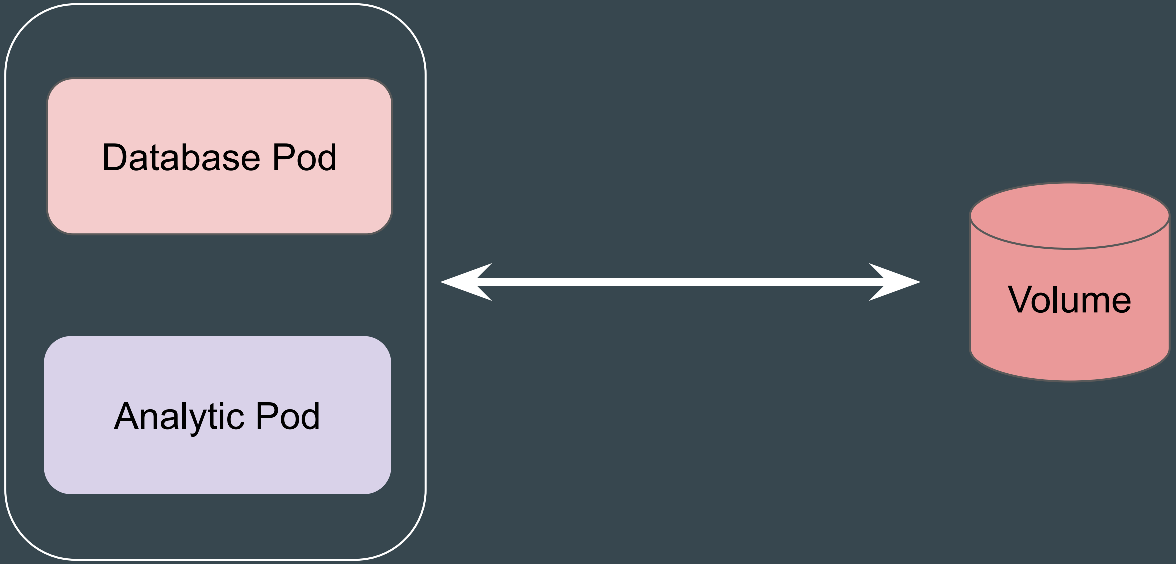
Introducing Volumes

Volumes can provide a way to store data that persists beyond the lifecycle of a container.



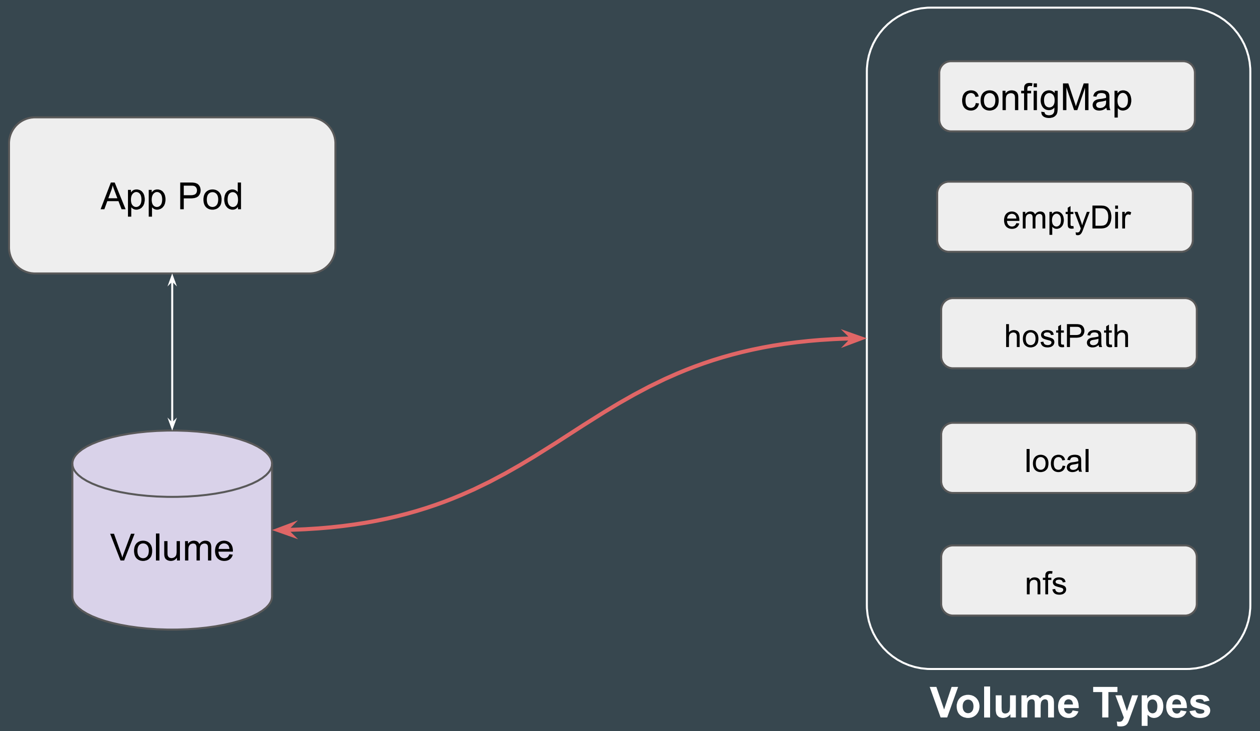
Benefit - Shared Storage

A single volume can be attached to multiple Pods.



Kubernetes Volumes

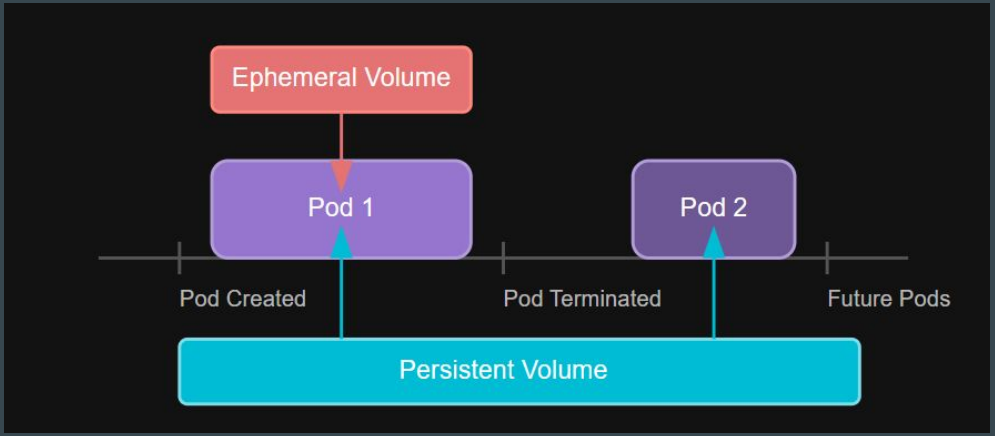
Kubernetes offers many volume types depending on the use-case.

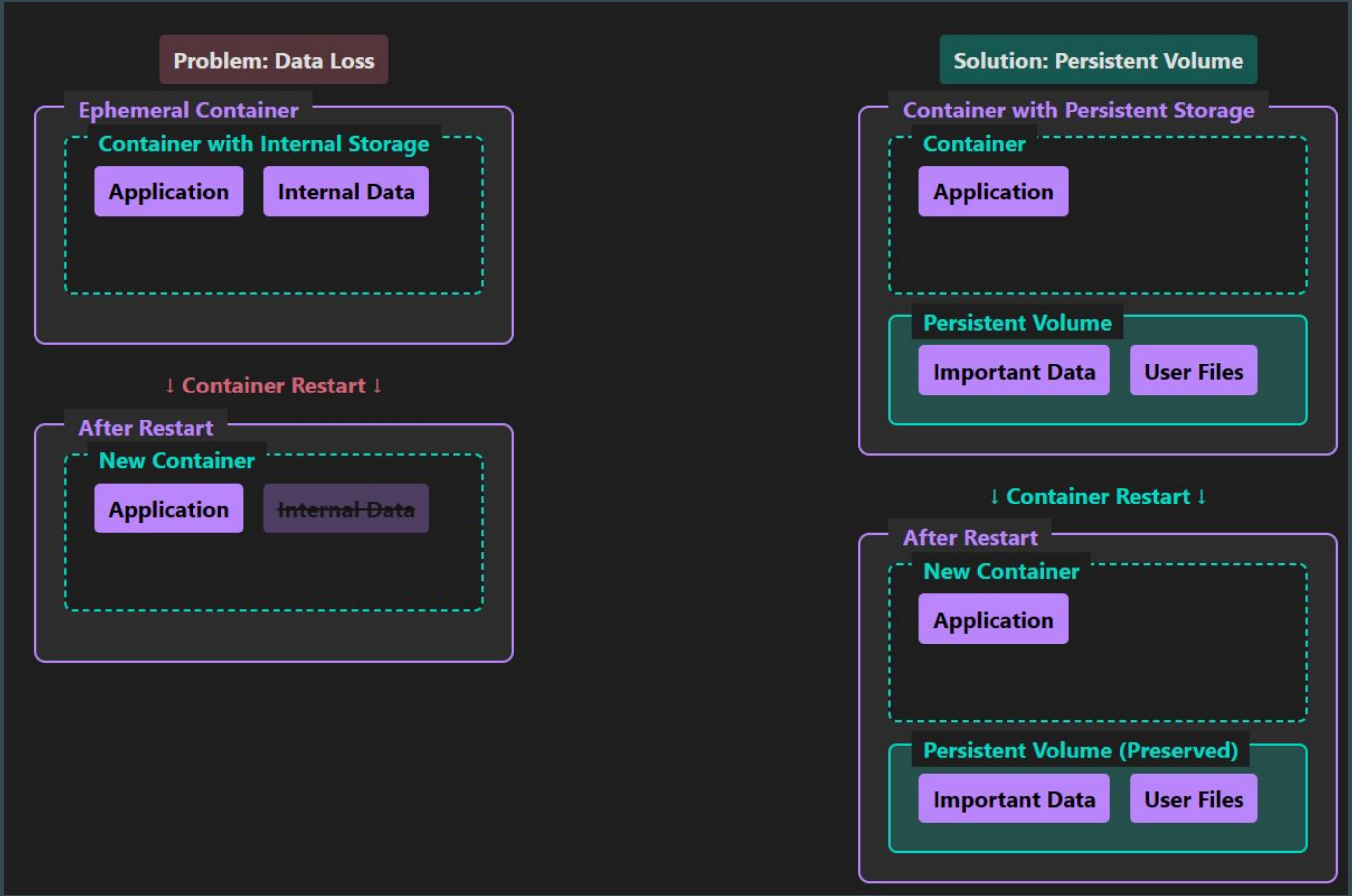


Ephemeral and Persistent Volumes

Ephemeral volume types have a lifetime linked to a specific Pod, BUT persistent volumes exist beyond the lifetime of any individual pod.

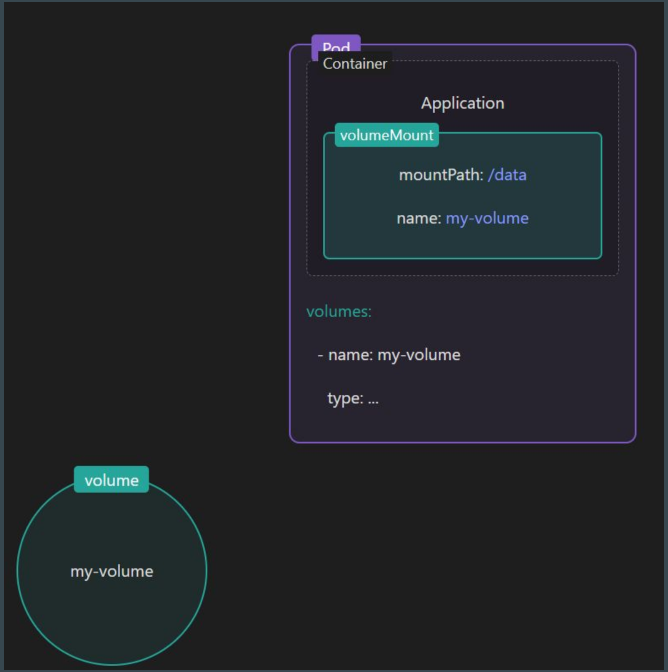
When a pod ceases to exist, Kubernetes destroys ephemeral volumes; however, Kubernetes does not destroy persistent volumes.

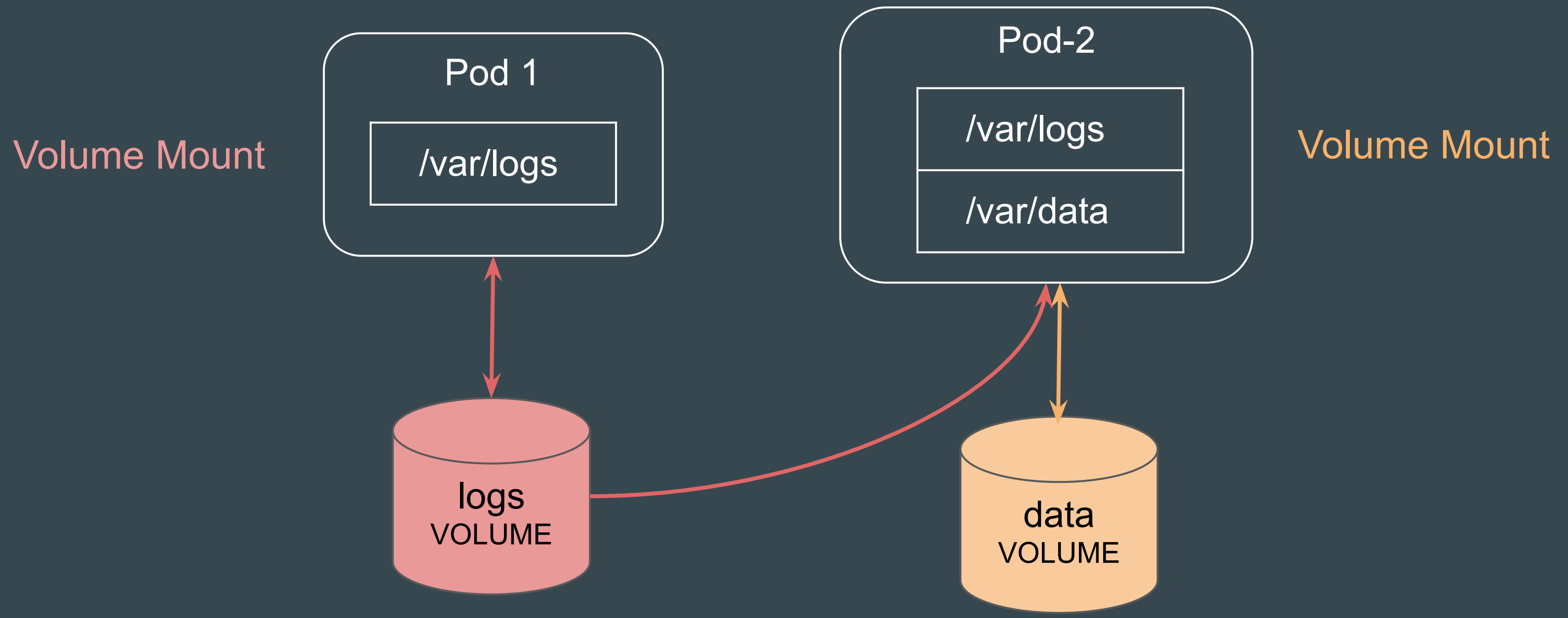



Problem: Data Loss
Ephemeral Container
Container with Internal Storage
Application
Internal Data
↓ Container Restart ↓
After Restart
New Container
Application
~~Internal Data~~
Solution: Persistent Volume
Container with Persistent Storage
Container
Application
Persistent Volume
Important Data
User Files
↓ Container Restart ↓
After Restart
New Container
Application
Persistent Volume (Preserved)
Important Data
User Files

Volume and Volume Mounts

To use a volume, specify the volumes to provide for the Pod in .spec.volumes and declare where to mount those volumes into containers in .spec.containers[*].volumeMounts.





Pod 1
/var/logs
Volume Mount
Pod-2
/var/logs
/var/data
Volume Mount
logs
VOLUME
data
VOLUME

Sample Reference Code

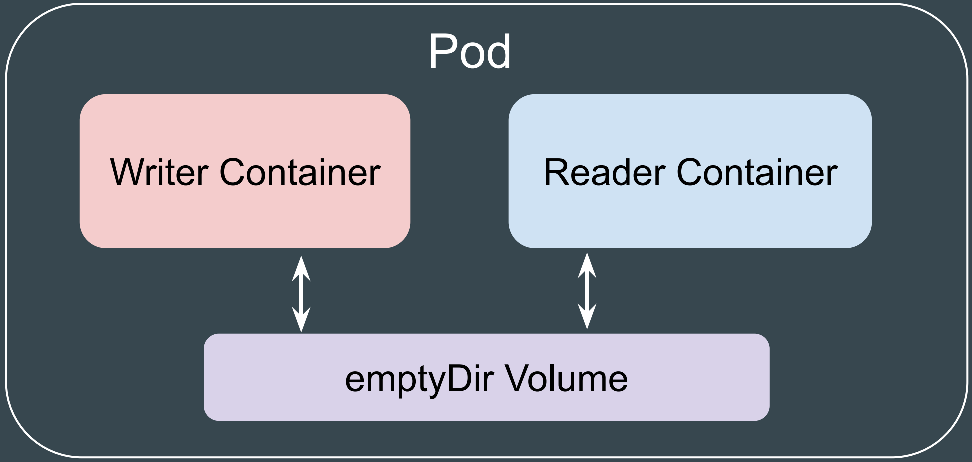
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: test-pd
spec:
  containers:
  - image: nginx:latest
    name: test-container
    volumeMounts:
    - mountPath: /my-data
      name: data-volume
  volumes:
  - name: data-volume
    emptyDir:
      sizeLimit: 500Mi
```

Volume Type - emptyDir

Setting the Base

An emptyDir volume is a temporary storage directory.

All containers in the Pod can read and write the same files in the emptyDir volume.



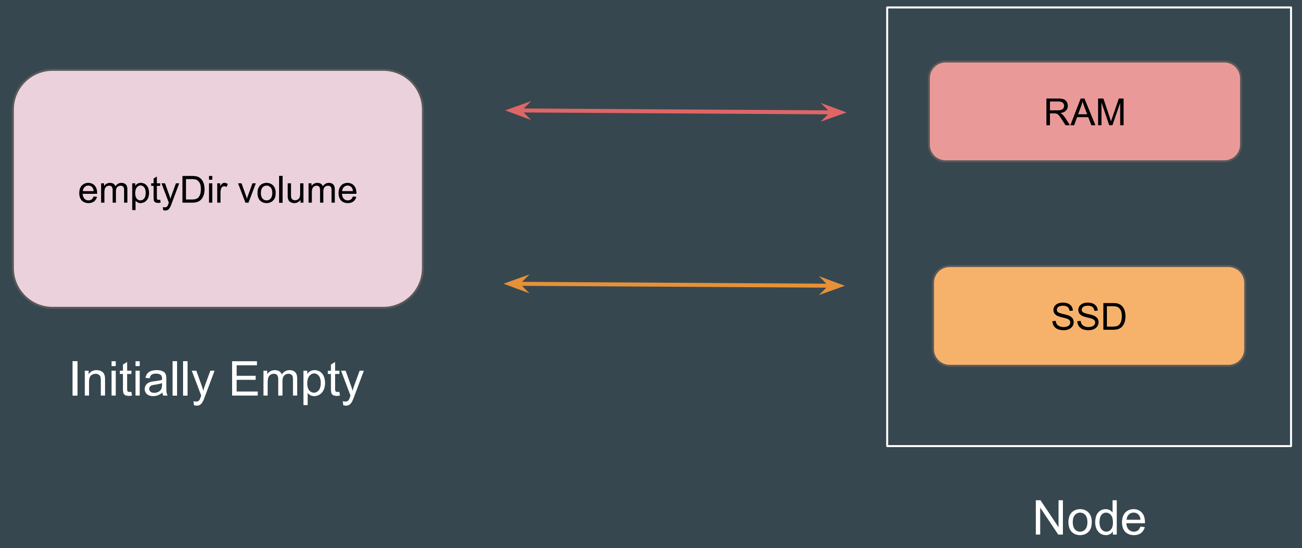
Key Features of emptyDir

It is deleted when the pod is removed.

It can use memory instead of disk for performance.

A container crashing does not remove a Pod from a node. The data in an emptyDir volume is safe across container crashes.

Workflow - EmptyDir

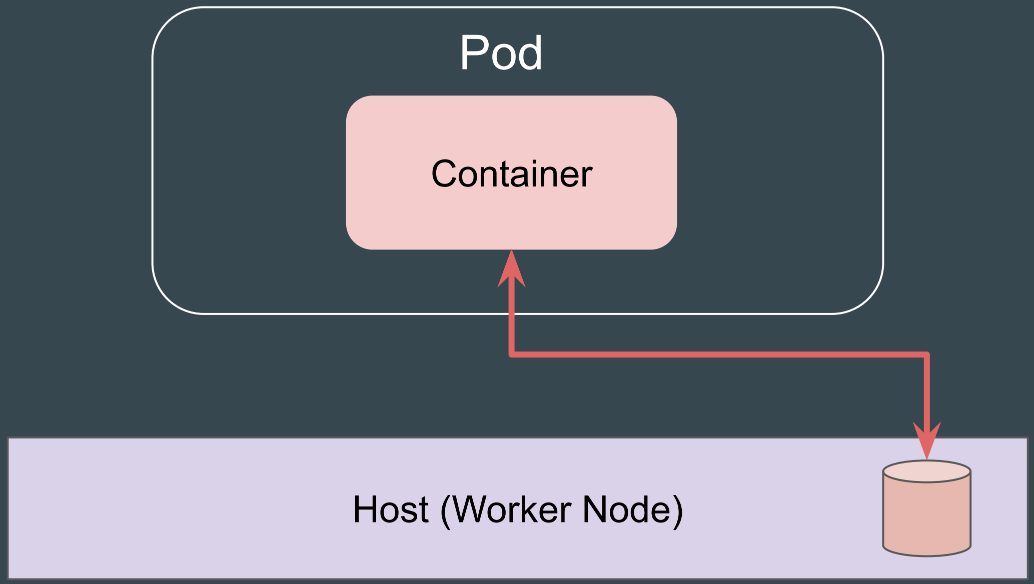


```yaml
apiVersion: v1
kind: Pod
metadata:
  name: emptydir-demo
spec:
  volumes:
    - name: shared-storage
      emptyDir: {}
  containers:
    - name: busybox-container-1
      image: busybox
      command: ["sleep", "36000"]
      volumeMounts:
        - name: shared-storage
          mountPath: /data

    - name: busybox-container-2
      image: busybox
      command: ["sleep", "36000"]
      volumeMounts:
        - name: shared-storage
          mountPath: /data
```

Volume Type - hostPath

Setting the Base

A hostPath volume mounts a file or directory from the host node's filesystem into your Pod.



Use-Cases of hostPath

Container needing access to worker node-specific logs like /var/logs for analysis.

Container that needs access to worker node-specific configuration files

Container that wants to write persistent data to a specific path in the node.

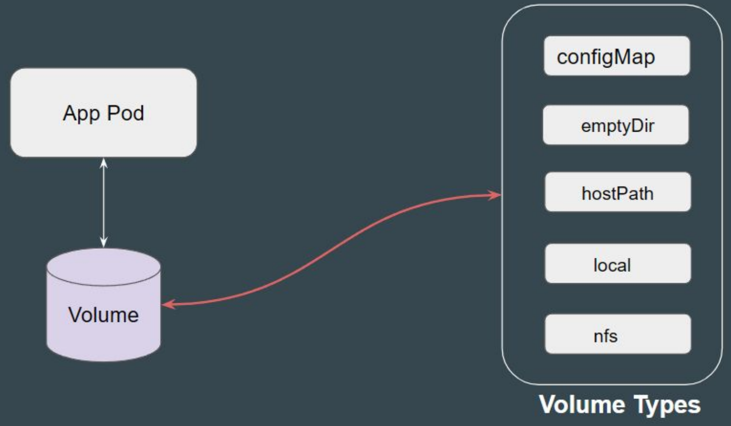
PersistentVolume and PersistentVolumeClaim

Setting the Base

Developers deploy application pods based on their their requirements.

Supplying storage specific configurations can introduce complexity due to the many different storage types and their settings

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nfs-client-pod
spec:
  containers:
    - name: app-container
      image: nginx
      volumeMounts:
        - name: nfs-volume
          mountPath: /mnt/nfs
  volumes:
    - name: nfs-volume
      nfs:
        server: 192.168.1.100
        path: /exported/path
        readOnly: false
```



Developer

Being a developer, my goal is to create a straightforward Pod manifest that includes volume information. I'd prefer not to handle storage provisioning and its associated configurations.

Storage Administrator

As a Storage Administrator, I am responsible for provisioning storage and managing its configurations. Developers can then reference this storage within their Pod specifications.

Overview of Persistent Volume

Persistent Volume is a piece of storage in the cluster that has been provisioned by an administrator or dynamically provisioned using Storage Classes.

Every volume is created can be of different type and specifications.

Volume 1
Size: Small
Speed: Fast

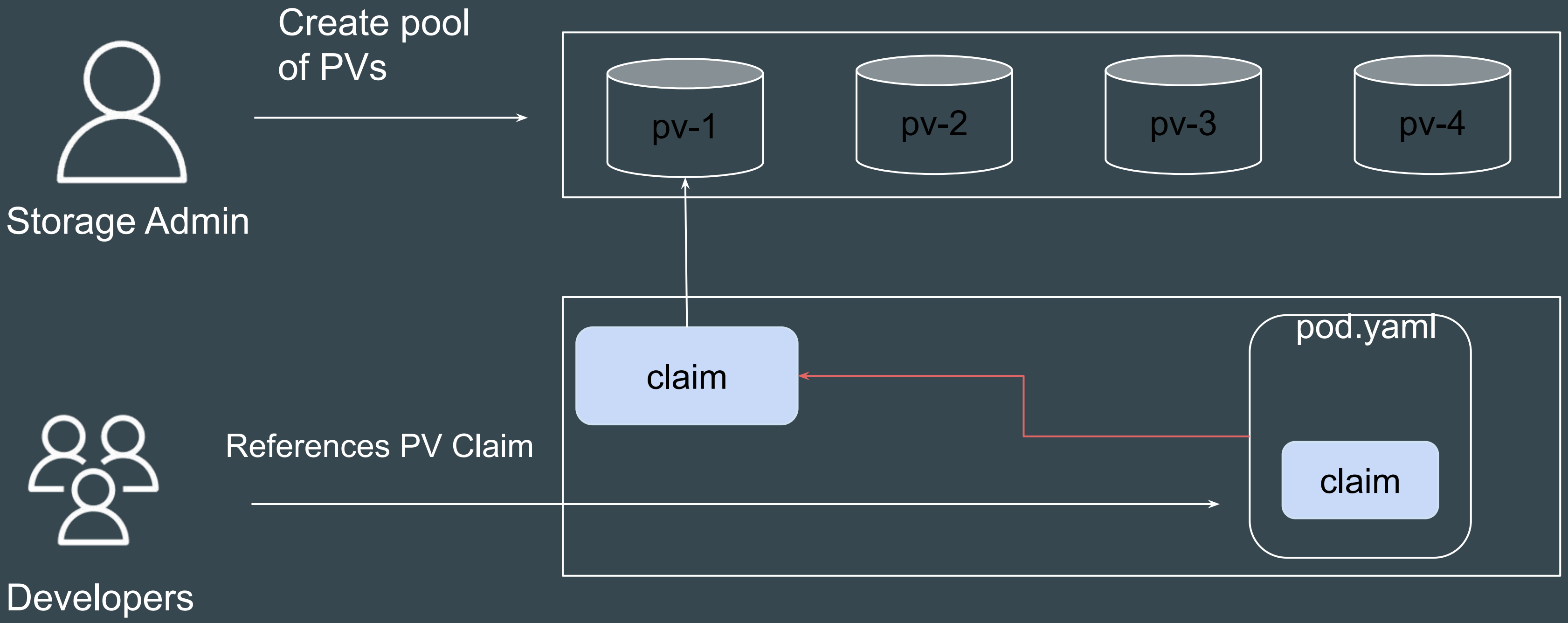
Volume 2
Size: Medium
Speed: Fast

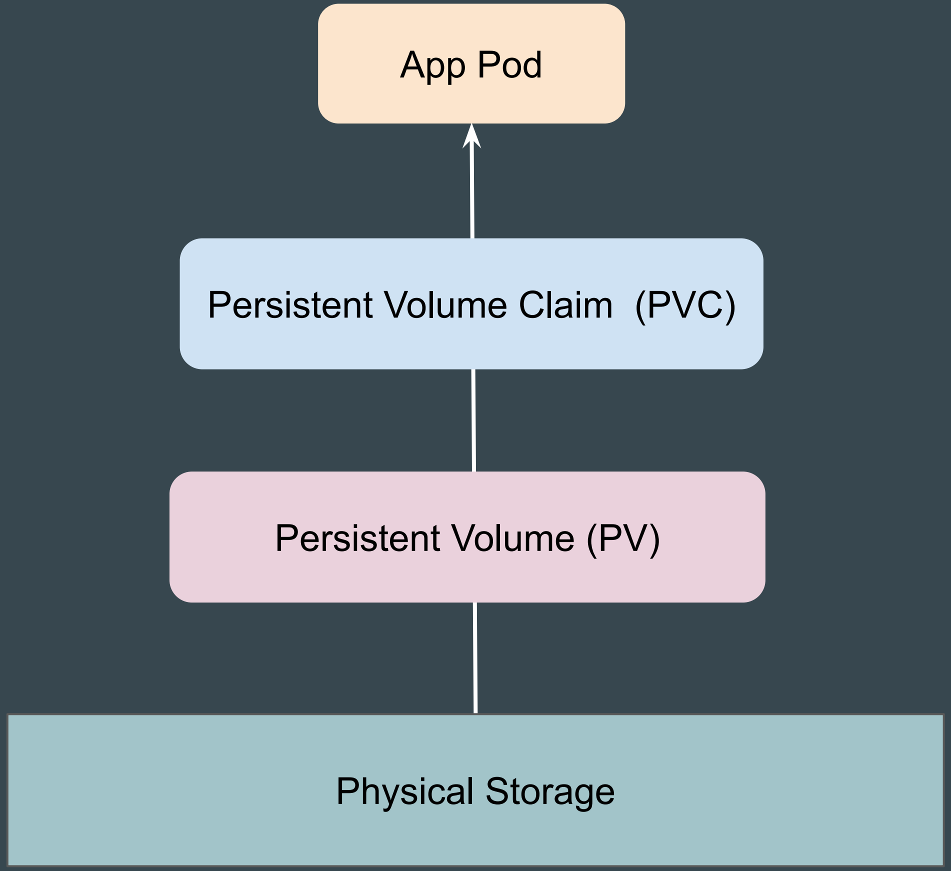
Volume 3
Size: Big
Speed: Slow

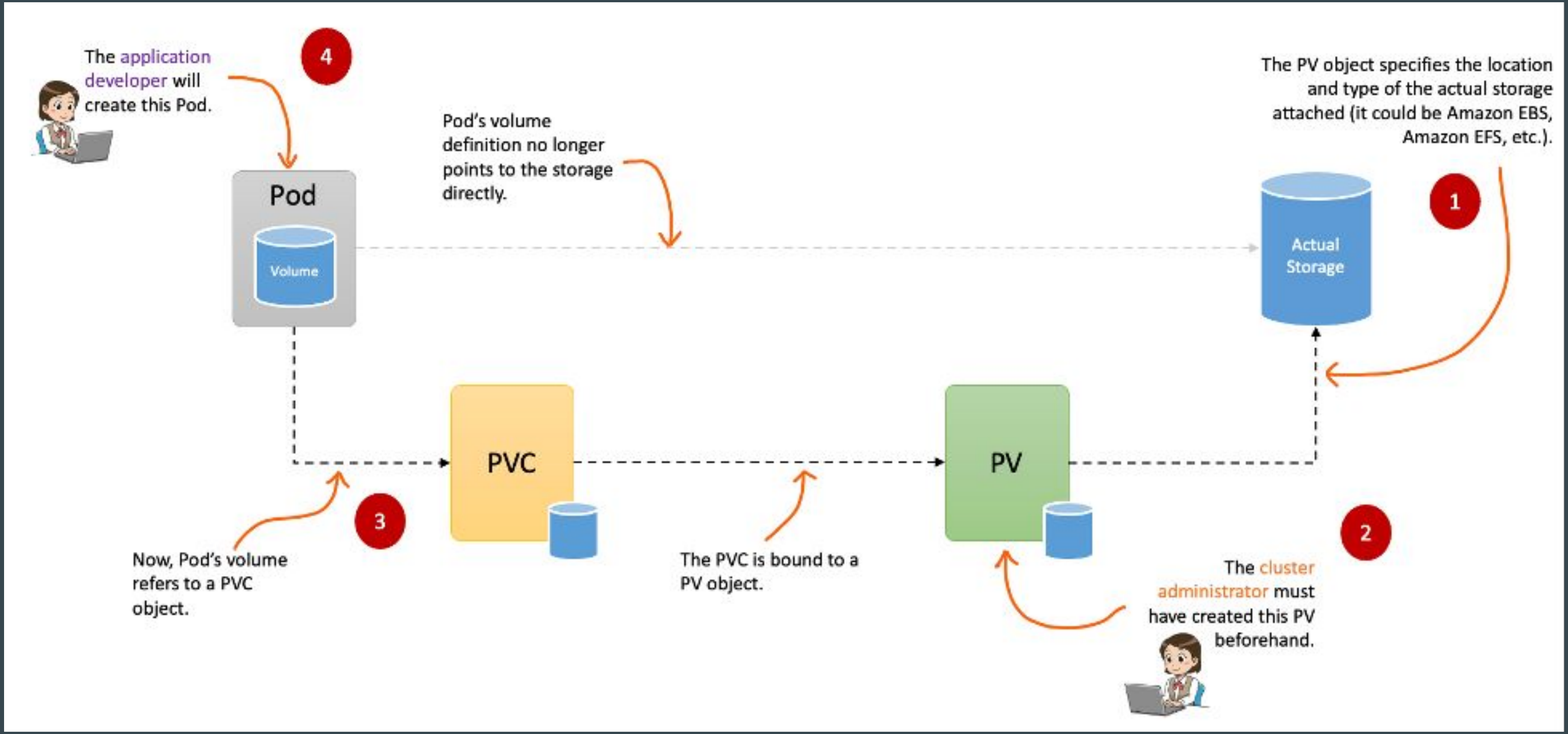
Volume 4
Size: VSmall
Speed: Ultra Fast

PersistentVolumeClaim

PersistentVolumeClaim (PVC) is a request for storage by a user (e.g., a developer). It specifies size, access modes, and other requirements.




App Pod
Persistent Volume Claim (PVC)
Persistent Volume (PV)
Physical Storage


The application developer will create this Pod.
4
Pod
Volume
Pod's volume definition no longer points to the storage directly.
The PV object specifies the location and type of the actual storage attached (it could be Amazon EBS, Amazon EFS, etc.).
1
Actual Storage
PVC
PV
3
Now, Pod's volume refers to a PVC object.
The PVC is bound to a PV object.
2
The cluster administrator must have created this PV beforehand.

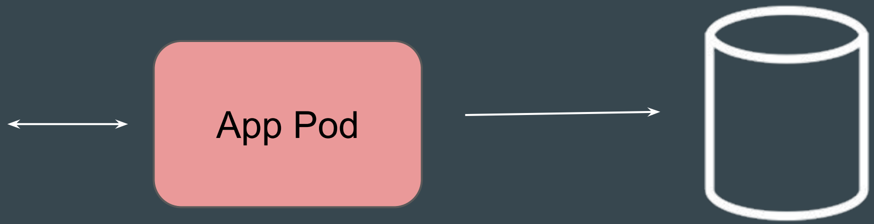
ConfigMaps

Understanding the Challenge - Part 1

Whenever an App pod gets deployed, it might need to connect to an external database to store data.

Issue: In many cases, these details are hard coded as part of the container image.

Key	Value
db_user	dbadmin
db_pass	A123#
db_url	172.31.10.30:3306



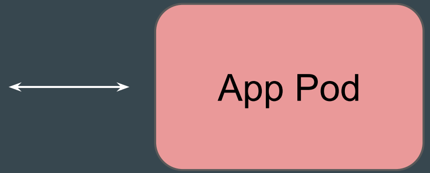
Hardcoded Data

Understanding the Challenge - Part 2

If a container has hardcoded data, any change to the data requires you to create a new set of Docker images and recreate the Pod

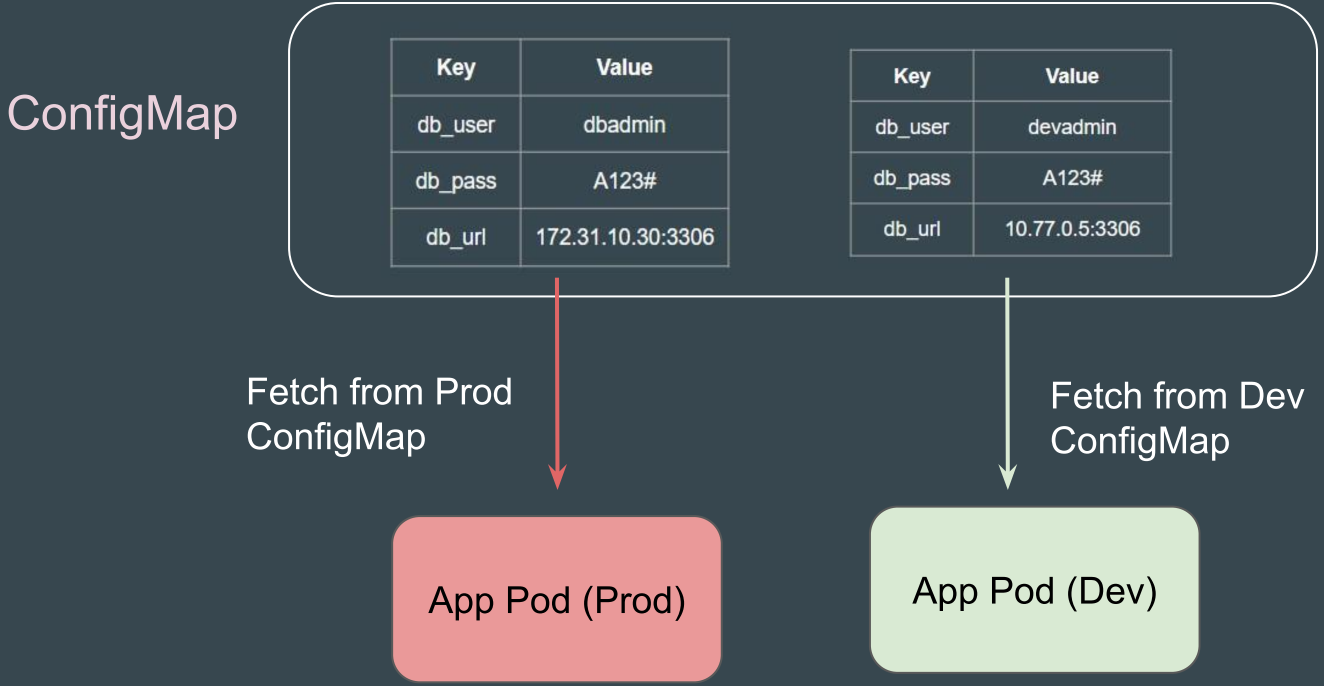
Key	Value
db_user	dbadmin
db_pass	A123#
db_url	172.31.10.30:3306

Hardcoded Data



Introduction to the ConfigMaps

A ConfigMap in Kubernetes is used to store key-value pairs of configuration data.



Key	Value
db_user	dbadmin
db_pass	A123#
db_url	172.31.10.30:3306

Key	Value
db_user	devadmin
db_pass	A123#
db_url	10.77.0.5:3306

Point to Note

The primary purpose of ConfigMap is to store non-sensitive configuration data, such as configuration files, environment variables, etc.

It stores data in plain-text and is not intended for sensitive information.

Practical Approach for Entire Workflow

Part 1: Create ConfigMap

Part 2: Configure Pod to use that appropriate ConfigMap

ConfigMap Practical - Part 1 (Create ConfigMap)

Command to Create ConfigMap

The kubectl create configmap command allows us to create ConfigMap from a file, directory, or specified literal value

```
Examples:
  # Create a new config map named my-config based on folder bar
  kubectl create configmap my-config --from-file=path/to/bar

  # Create a new config map named my-config with specified keys instead of file basenames on disk
  kubectl create configmap my-config --from-file=key1=/path/to/bar/file1.txt --from-file=key2=/path/to/bar/file2.txt

  # Create a new config map named my-config with key1=config1 and key2=config2
  kubectl create configmap my-config --from-literal=key1=config1 --from-literal=key2=config2

  # Create a new config map named my-config from the key=value pairs in the file
  kubectl create configmap my-config --from-file=path/to/bar

  # Create a new config map named my-config from an env file
  kubectl create configmap my-config --from-env-file=path/to/foo.env --from-env-file=path/to/bar.env
```

Approach 1 - From a Literal

The --from-literal option allows you to directly specify key-value pairs as command-line arguments.

```
C:\>kubectl create configmap dev-config --from-literal=db_user=dbadmin --from-literal=db_host=172.31.0.5
configmap/dev-config created
```

Approach 2 - From a File

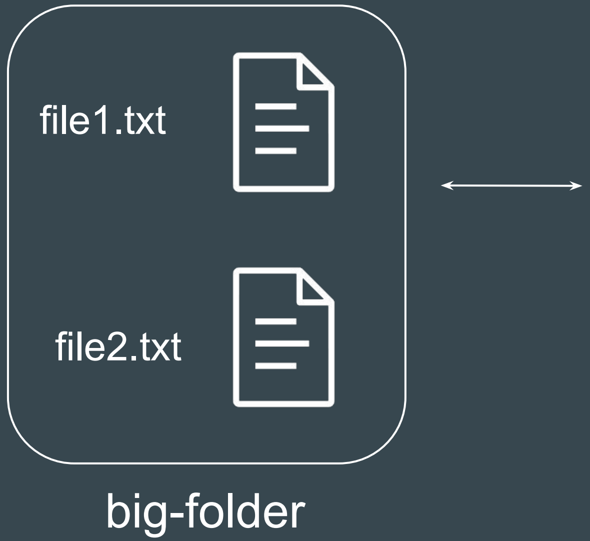
The --from-file option allows you to create a ConfigMap from the contents of one or more files.

large-file.txt

```
kubectl create configmap --from-file=large-file.txt
```

Approach 3 - From a Directory

You can also use the --from-file option with a directory instead of a single file.




```
kubectl create configmap demo --from-file=<path/to/directory>
```

Comparison of All the Methods

Method	Use-Case	Advantage	Disadvantage
--from-literal	Simple, one-off key-value pairs	Quick and easy for simple configurations	Not suitable for complex configurations or large amounts of data
--from-file (file)	Individual configuration files	Good for managing separate configuration files	Can become cumbersome for many files
--from-file (dir)	Multiple configuration files organized in a directory	Convenient for grouping related configuration files	Less control over individual key names (filenames are used as keys)

Type of Data In ConfigMap

In the ConfigMap manifest file, you can represent data in multiple distinct formats.

Simple Key Value pair

Multiline Block literal

! configmap.yaml

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: demo-configmap
data:
  key1: "value1"
  key2: "value2"

  essay: |
    This is the first line of the essay1.
    It spans multiple lines and contains various information.
    This is Line 3

  json_data: |
     {
       "name": "Alice",
       "age": 26,
       "skills": ["Kubernetes", "Docker", "DevOps"]
     }
```

Point to Note - Directory Approach

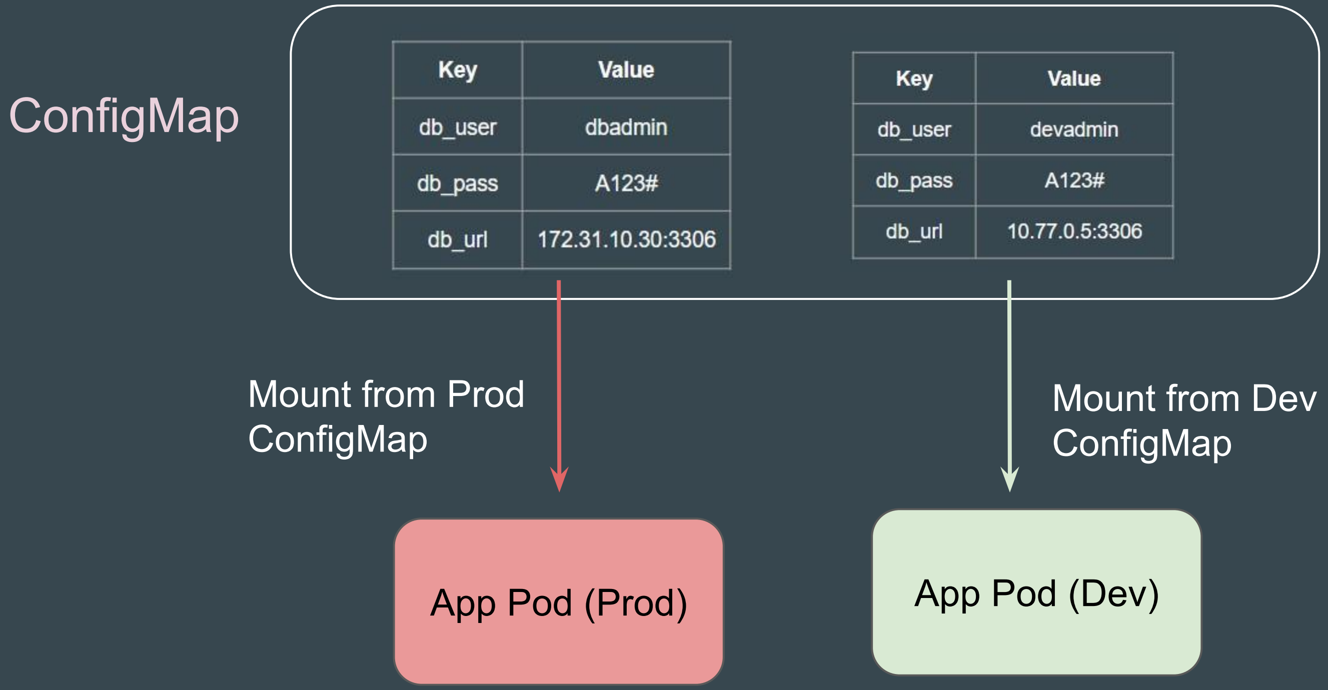
If you are referencing to an entire directory, Kubernetes will create a ConfigMap with each file in that directory becoming a key-value pair.

The filename (without extension) becomes the key, and the file content becomes the value

ConfigMap Practical - Part 2 (Mounting to Pods)

Setting the Base

Once ConfigMaps is created, we also need to reference it to appropriate Pod.

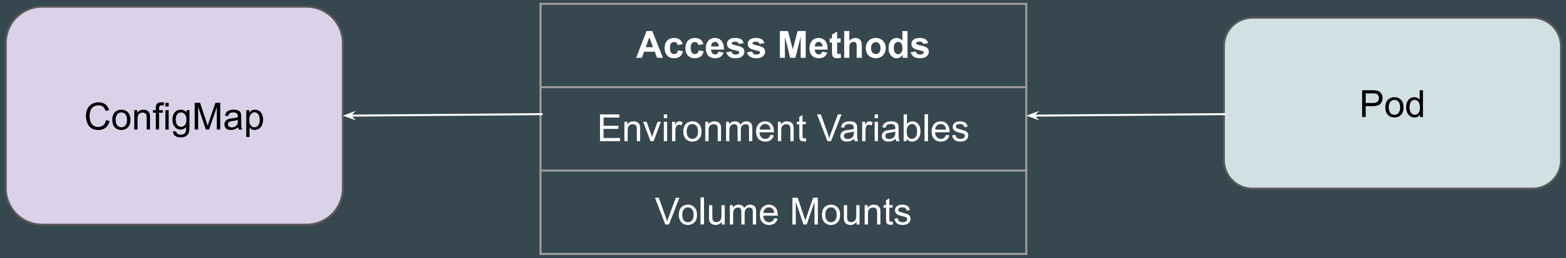


Key	Value
db_user	dbadmin
db_pass	A123#
db_url	172.31.10.30:3306

Key	Value
db_user	devadmin
db_pass	A123#
db_url	10.77.0.5:3306

Different Approaches for Reference

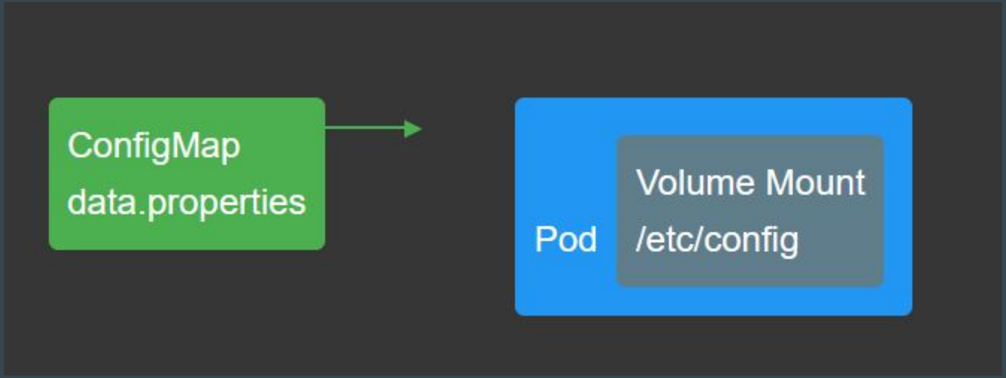
There are multiple ways through which a Pod can fetch the data of a ConfigMap.



Approach 1 - Volume Mount

In this method, the ConfigMap is mounted directly as a volume in the Pod.

Each key-value pair in the ConfigMap appears as a file in the volume.



Reference Manifest File

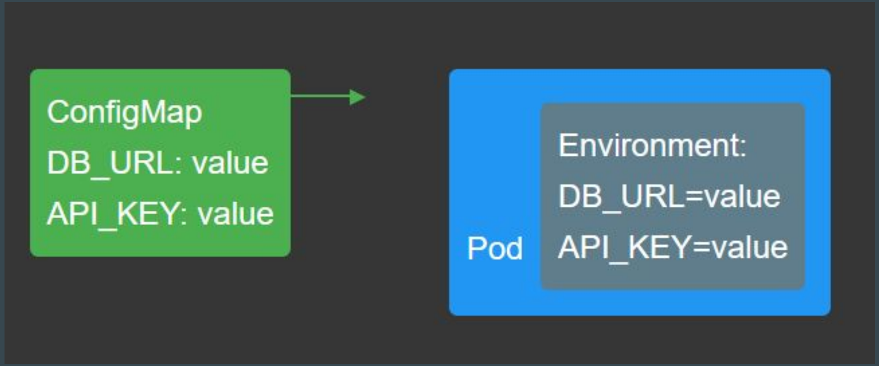
! pod-volume.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: app-pod
spec:
  containers:
    - name: app-container
      image: nginx
      volumeMounts:
        - name: config-volume
          mountPath: /etc/config
  volumes:
    - name: config-volume
      configMap:
        name: app-config
```

Approach 2 - Environment Variables

In this method, the values in the ConfigMap are exposed as environment variables to the container.

The application can then access these values using standard environment variable lookup.



Reference Screenshot

! pod-env.yaml

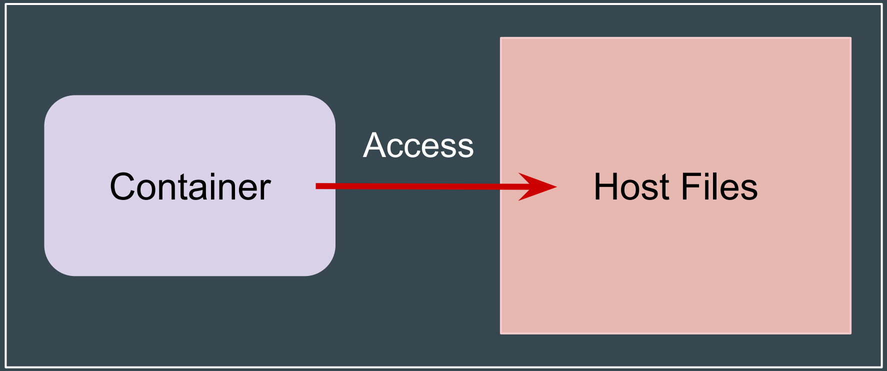
```yaml
apiVersion: v1
kind: Pod
metadata:
  name: app-pod
spec:
  containers:
    - name: app-container
      image: nginx
      env:
        - name: APP_MODE
          valueFrom:
            configMapKeyRef:
              name: app-config
              key: APP_MODE
        - name: APP_ENV
          valueFrom:
            configMapKeyRef:
              name: app-config
              key: APP_ENV
```

Security Context

Understanding the Challenge

Many times, the containers run with root user privileges.

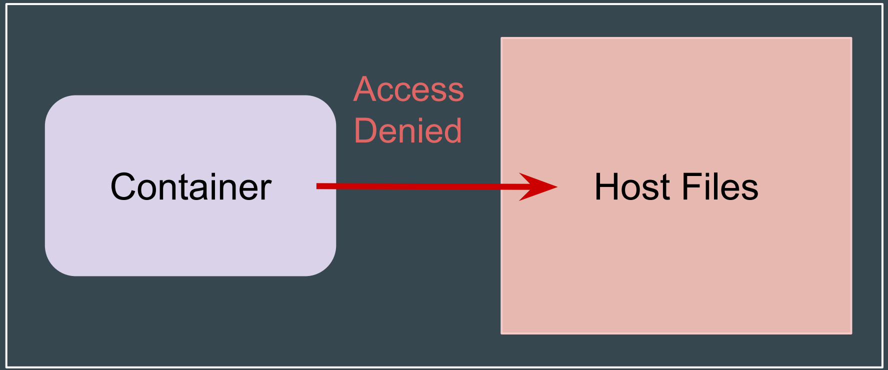
In case of container breakouts, an attacker can get full access to the host system.



Host System

Running Container with Non Root User

If the container runs with non-root privileges, it will be unable to modify the critical host files and will have limited access to the host system.



Host System

Introduction to Security Context

A security context defines privilege and access control settings for a Pod or Container.

Run as non-privileged user

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: better-pod
spec:
  securityContext:
    runAsUser: 1000
    runAsGroup: 1000
  containers:
  - name: better-container
    image: busybox
    command: ["sleep", "36000"]
```

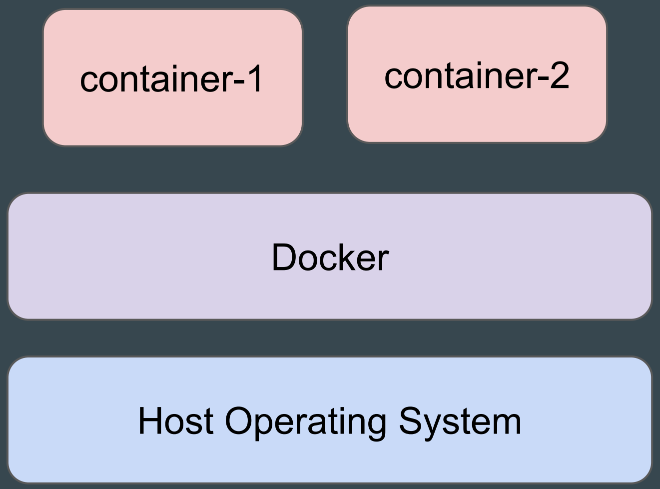
Comparison Table

Field	Description	Use-Case
runAsUser	Specifies the user ID (UID) a container's process runs as.	Use when you want the container to run as a specific user rather than the default (commonly root).
runAsGroup	Specifies the primary group ID (GID) a container's process runs as.	Use when you want the container's primary group to be a specific GID.
fsGroup	Specifies a group ID (GID) for volume-mounted files. Files created in mounted volumes will be owned by this GID.	Use when you need to control file permissions for a shared volume (e.g., for multiple containers in a Pod).

Privileged Pods

Setting the Base

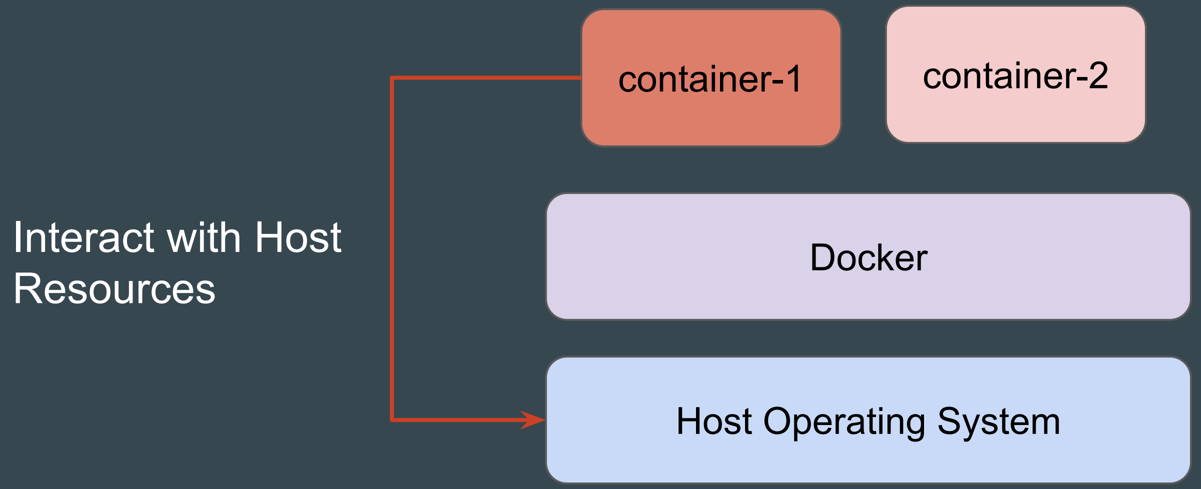
Kubernetes, by default, enforces strong security boundaries to isolate containers from the host system and from each other.



Introducing Privileged Pods

Certain workloads require elevated privileges to interact directly with the host system's resources or kernel capabilities.

This is where "Privileged Pods" come into play.



Why use Privileged Pods?

Tasks that require direct hardware access, such as loading kernel modules, manipulating network devices (e.g., creating custom network interfaces), or accessing specific device files.

Some networking tools that need deep system access to manage network interfaces, routing tables, or firewalls.

Example - Access to Host Device

```
/ # ls /dev
core        mqueue      pts         stderr      termination-log  zero
fd          null        random      stdin       tty
full        ptmx        shm         stdout      urandom
```

Non-Privileged Pod (Top) vs Privileged Pods (Bottom)

```
/ # ls /dev
autofs           loop7    tty     tty28   tty48   ttyS1        vcsu1
btrfs-control    mapper   tty0    tty29   tty49   ttyS2        vcsu2
bus              mem      tty1    tty3    tty5    ttyS3        vcsu3
core             mqueue   tty10   tty30   tty50   uhid         vcsu4
cpu_dma_latency  net      tty11   tty31   tty51   uinput       vcsu5
cuse             null     tty12   tty32   tty52   urandom      vcsu6
fd               nvram    tty13   tty33   tty53   userfaultfd  vda
full             port     tty14   tty34   tty54   vcs          vda1
fuse             ppp      tty15   tty35   tty55   vcs1         vda14
hpet             psaux    tty16   tty36   tty56   vcs2         vda15
hwrng            ptmx     tty17   tty37   tty57   vcs3         vdb
input            pts      tty18   tty38   tty58   vcs4         vfio
kmsg             random   tty19   tty39   tty59   vcs5         vga_arbiter
kvm              rfkill   tty2    tty4    tty6    vcs6         vhci
loop-control     rtc0     tty20   tty40   tty60   vcsa         vhost-net
```

Example - dmesg

```
/ # dmesg
dmesg: klogctl: Operation not permitted
```

Non-Privileged Pod (Top) vs Privileged Pods (Bottom)

```
[    0.000000] BIOS-provided physical RAM map:
[    0.000000] BIOS-e820: [mem 0x0000000000000000-0x000000000009fbff] usable
[    0.000000] BIOS-e820: [mem 0x000000000009fc00-0x000000000009ffff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000000f0000-0x00000000000fffff] reserved
[    0.000000] BIOS-e820: [mem 0x0000000000100000-0x000000007ffdafff] usable
[    0.000000] BIOS-e820: [mem 0x000000007ffdb000-0x000000007fffffff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000feffc000-0x00000000feffffff] reserved
[    0.000000] BIOS-e820: [mem 0x00000000fffc0000-0x00000000ffffffff] reserved
[    0.000000] printk: bootconsole [earlyser0] enabled
[    0.000000] NX (Execute Disable) protection: active
[    0.000000] SMBIOS 2.8 present.
[    0.000000] DMI: DigitalOcean Droplet/Droplet, BIOS 20171212 12/12/2017
[    0.000000] Hypervisor detected: KVM
[    0.000000] kvm-clock: Using msrs 4b564d01 and 4b564d00
[    0.000005] kvm-clock: using sched offset of 3783394224 cycles
[    0.001065] clocksource: kvm-clock: mask: 0xffffffffffffffff max_cycles: 0x1cd42e4dffb,
[    0.003421] tsc: Detected 1999.999 MHz processor
```

Deploying a Privileged Pod

You can configure a Pod to be privileged by setting privileged: true in securityContext.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: privileged-pod
spec:
  containers:
  - image: nginx
    name: privileged
    securityContext:
      privileged: true
```

Point to Note

Privileged containers are given all Linux capabilities, including capabilities that they don't require.

In most cases, you should avoid using privileged containers, and instead grant the specific capabilities required by your container using the capabilities field in the securityContext field

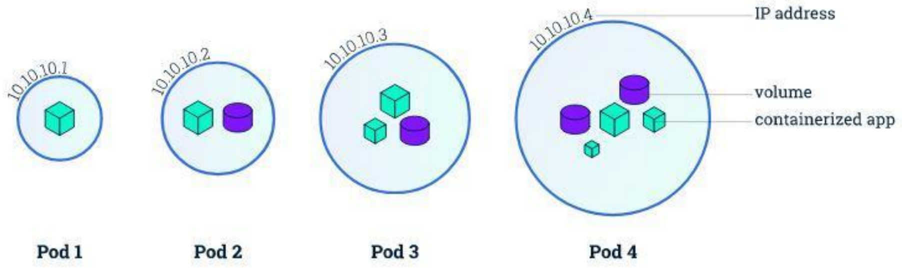
Multi-Container Pods

Let’s get started

Kubernetes POD

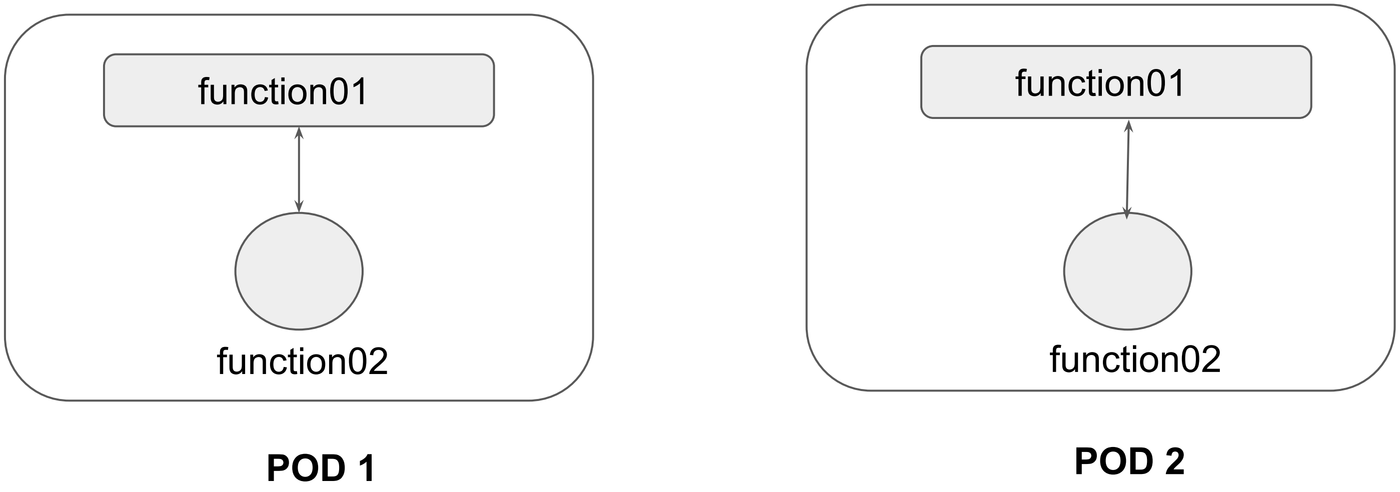
A Pod in Kubernetes represents a group of one or more application containers , and some shared resources for those containers.

A single pod can have multiple containers running.



Dealing with Tightly Coupled Application

Containers within a Pod share an IP address and port space, and can find each other via localhost.



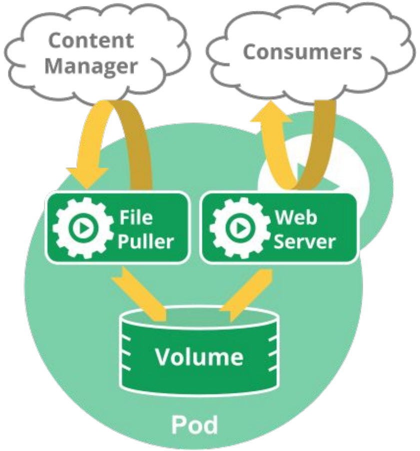
Multi-Container POD Patterns

Multi-Container Patterns

Overview of Sidecar Pattern

Sidecar pattern is nothing but running multiple container as part of a pod in a single node.

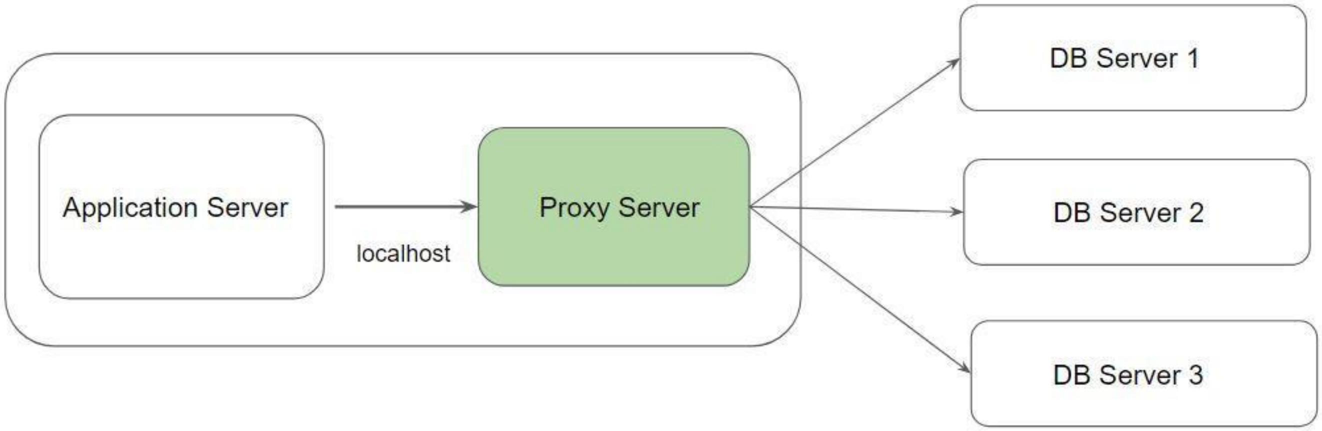
In below diagram we see that there is a web-server container which servers files from volumes and a separate sidecar container "file puller" which fetches and updates those files.



Overview of Sidecar Pattern

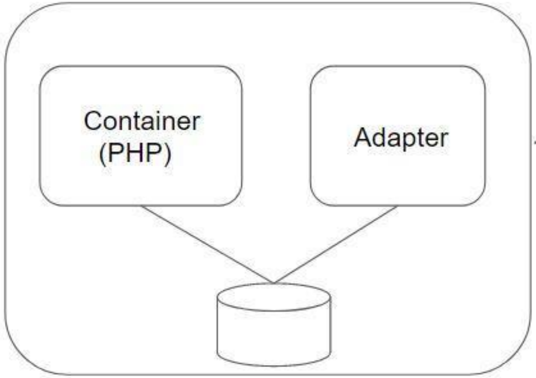
Ambassador Pattern

Ambassador Pattern is a type of sidecar pattern were the second container is primarily used to proxy the requests.



Sidecar Container - Adapter Pattern

Adapter Pattern is generally used to transform the application output to standardize / normalize it for aggregation.



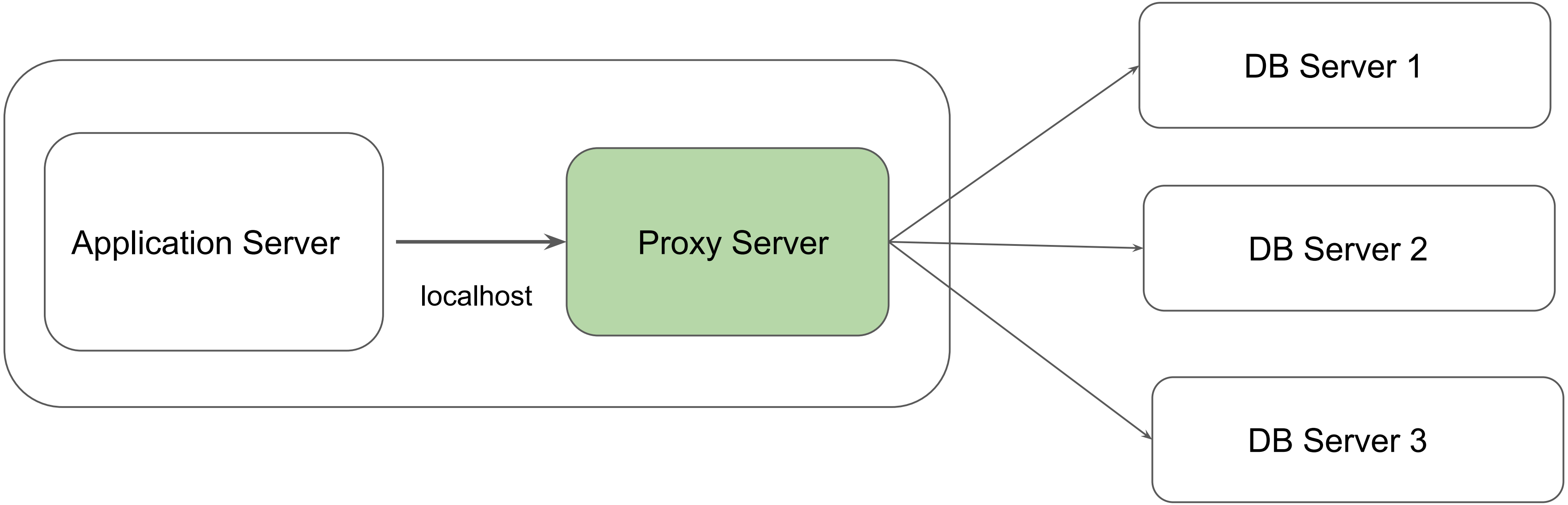
Container	[DATE] [HOST] [DURATION] 23-10-2019 node01.internal 300
Adapter	[PHP] [DATE] [HOST] [DURATION] PHP 23-10-2019 node01.internal 300

Ambassador Pattern

Multi-Container Patterns

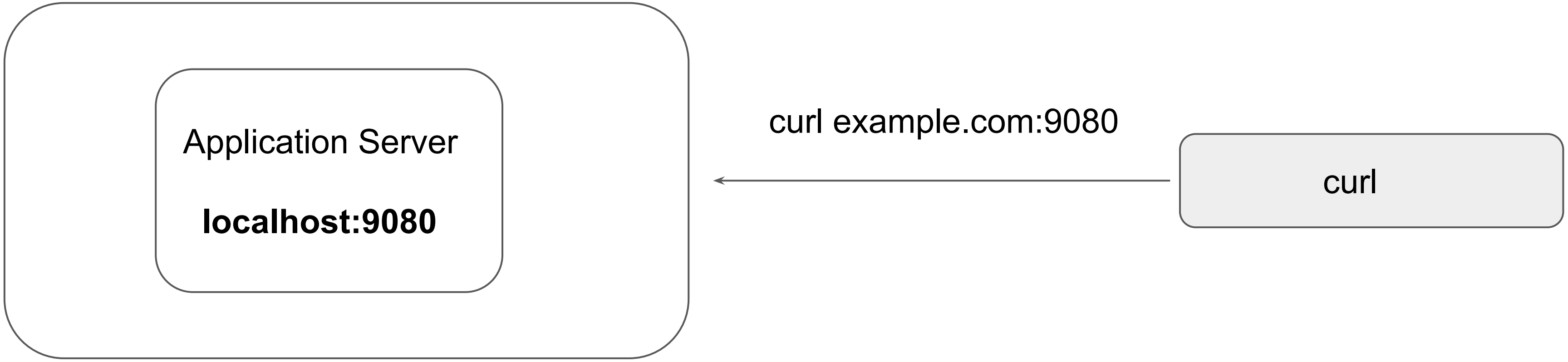
Overview of Ambassador Pattern

Ambassador Pattern is a type of sidecar pattern were the second container is primarily used to proxy the requests.



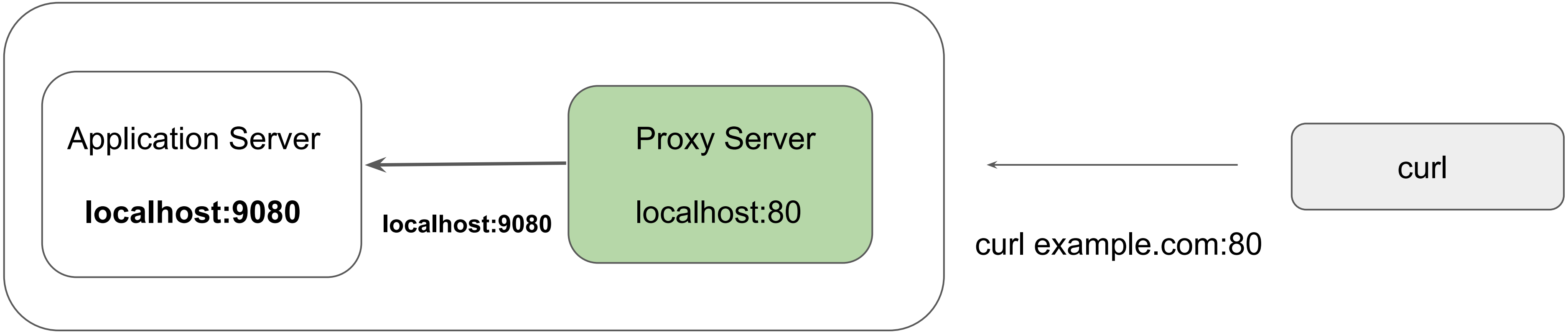
Different Architecture Pattern

- Your have a legacy application server which listens on port 9080.
- This port is hardcoded in the image and cannot be changed.
- You want external application sto call the application server on port 80



Solution - Ambassador Container

- Create a proxy server which listens on Port 80.
- Forward all the requests to port 9080.

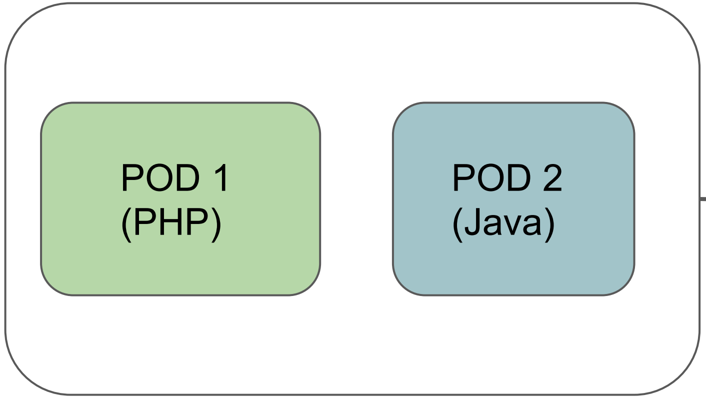


Adapter Pattern

Multi-Container Patterns

Overview of Adapter Pattern

Adapter Pattern is generally used to transform the application output to standardize / normalize it for aggregation.



POD 1	[DATE] [HOST] [DURATION] 23-10-2019 node01.internal 300
POD 2	[HOST] [DURATION] [DATE] node01.internal 300 23-10-2019

Standardizing Log Format

Within your logging application, you want to have a common standard format.

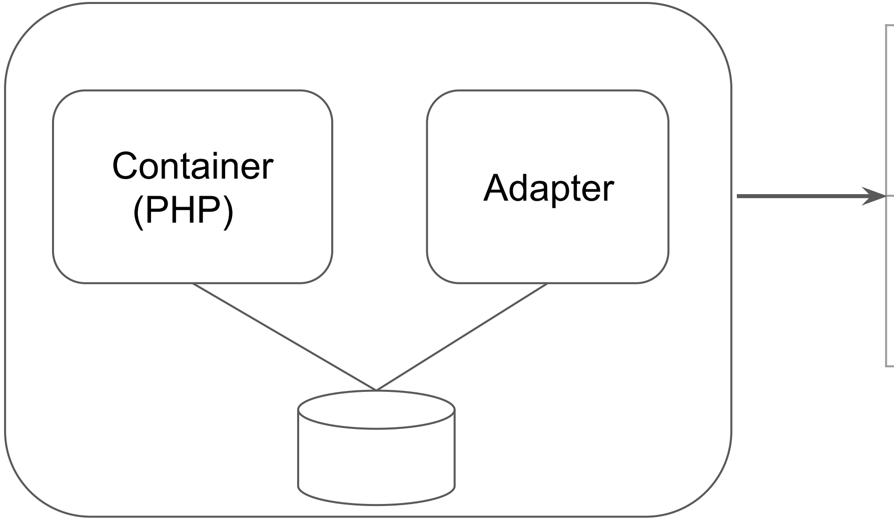
[PHP|JAVA] [DATE] [HOST] [DURATION]

PHP 23-10-2019 node01.internal 300

Transforming Logs

With Adapter Container, you can transform your logs to standardize it.

Since containers in PODS can share volumes, adapter container can easily access App logs.

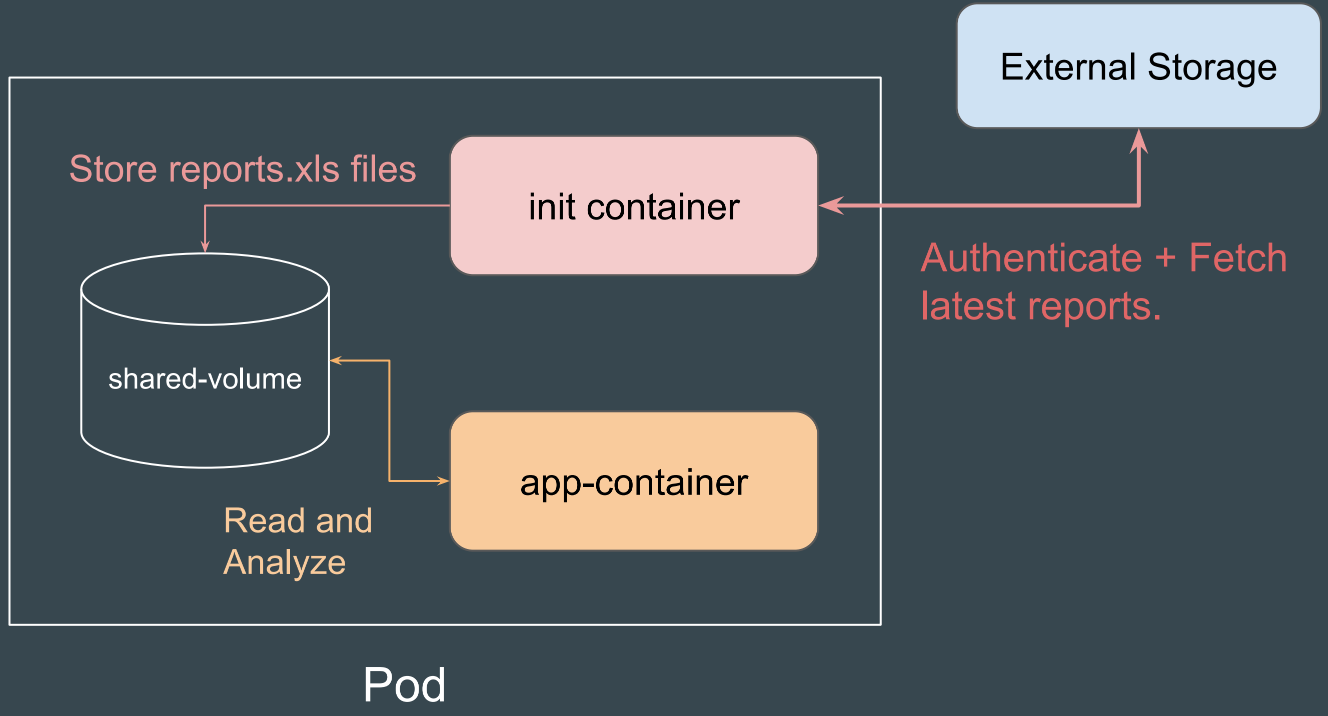


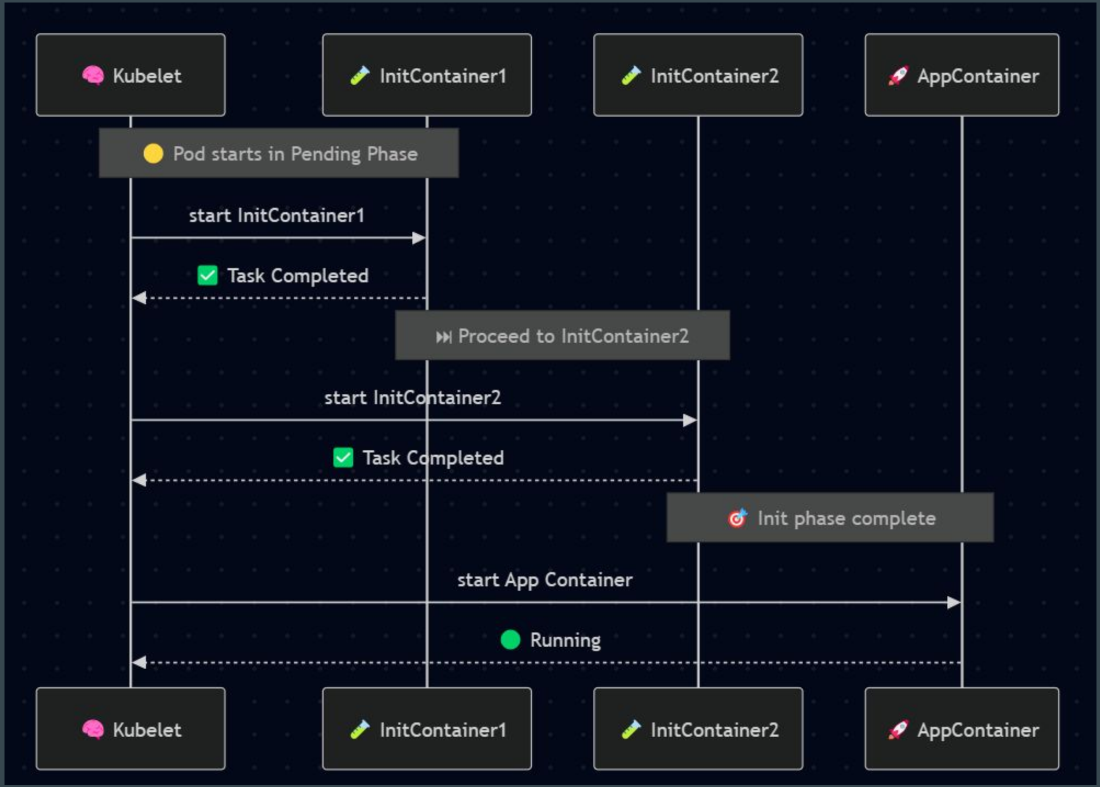
Container	[DATE] [HOST] [DURATION] 23-10-2019 node01.internal 300
Adapter	[PHP] [DATE] [HOST] [DURATION] PHP 23-10-2019 node01.internal 300

Init Containers

Setting the Base

Init Containers are specialized containers that run before app containers in a Pod.





Kubelet
InitContainer1
InitContainer2
AppContainer
Pod starts in Pending Phase
start InitContainer1
Task Completed
Proceed to InitContainer2
start InitContainer2
Task Completed
Init phase complete
start App Container
Running
Kubelet
InitContainer1
InitContainer2
AppContainer

Point to Note

Init containers are exactly like regular containers, except:

1. Init containers always run to completion.

2. Each init container must complete successfully before the next one starts.

If a Pod's init container fails, the kubelet repeatedly restarts that init container until it succeeds (default restart policy of Always)

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: myapp-pod
spec:
  containers:
  - name: app-container
    image: nginx
  initContainers:
  - name: check-google
    image: alpine/curl
    command: ["ping", "-c", "10", "google.com"]
  - name: check-kubernetes
    image: alpine/curl
    command: ["curl", "kubernetes.io"]
```

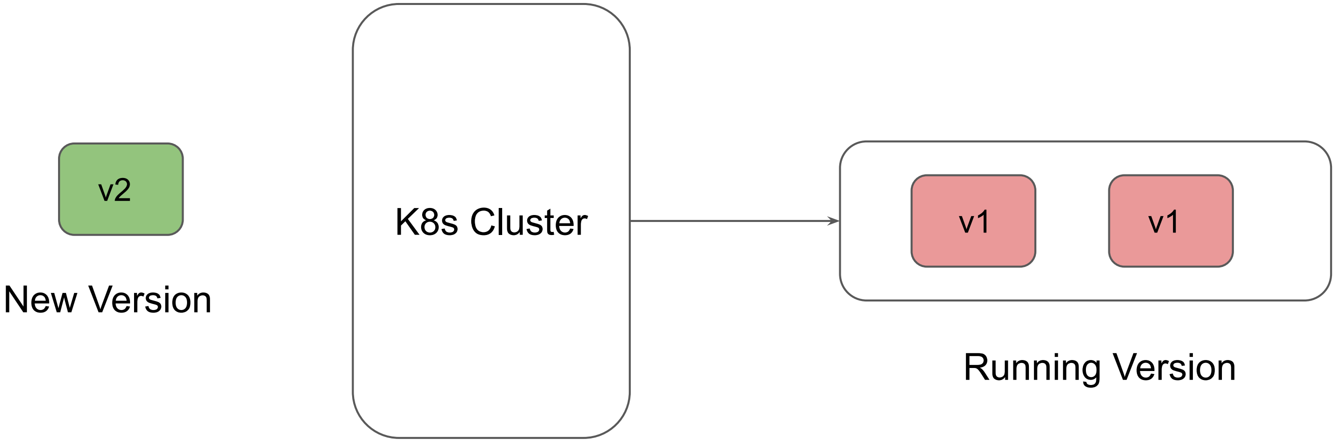
K8s Deployment Strategy

Deploying New Application Updates

Overview of Deployment Strategy

A deployment strategy is a way to change or upgrade an application

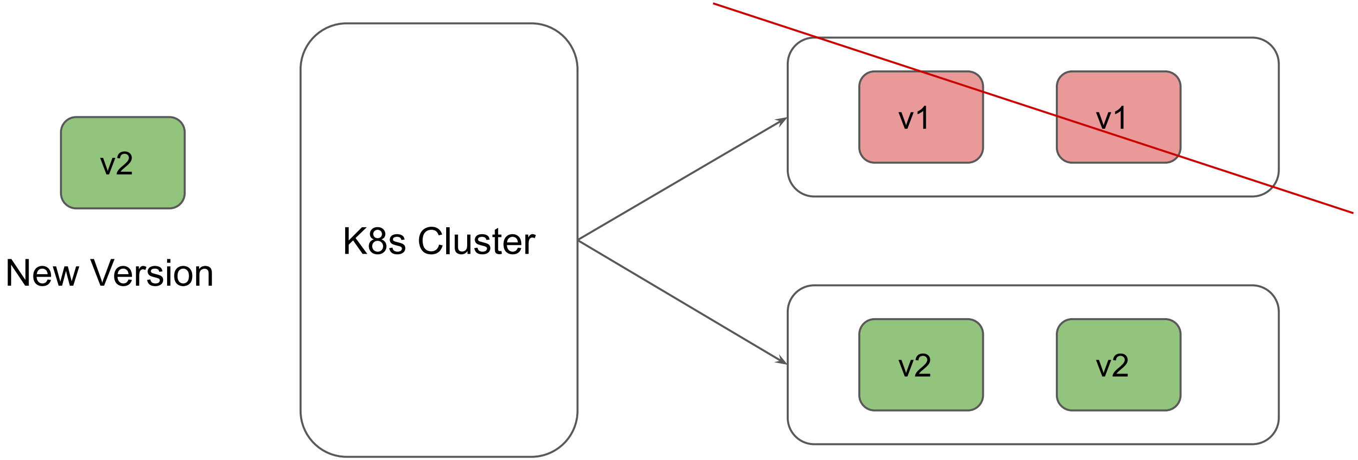
How will you deploy v2 of the application to the Kubernetes cluster?



Deployment Strategy - Recreate

All of the PODS get killed all at once and get replaced all at once with the new ones.

Recommended for Dev/Test environment.



Advantages and Disadvantages - Recreate

Advantages:

Overall easy to setup and deploy.

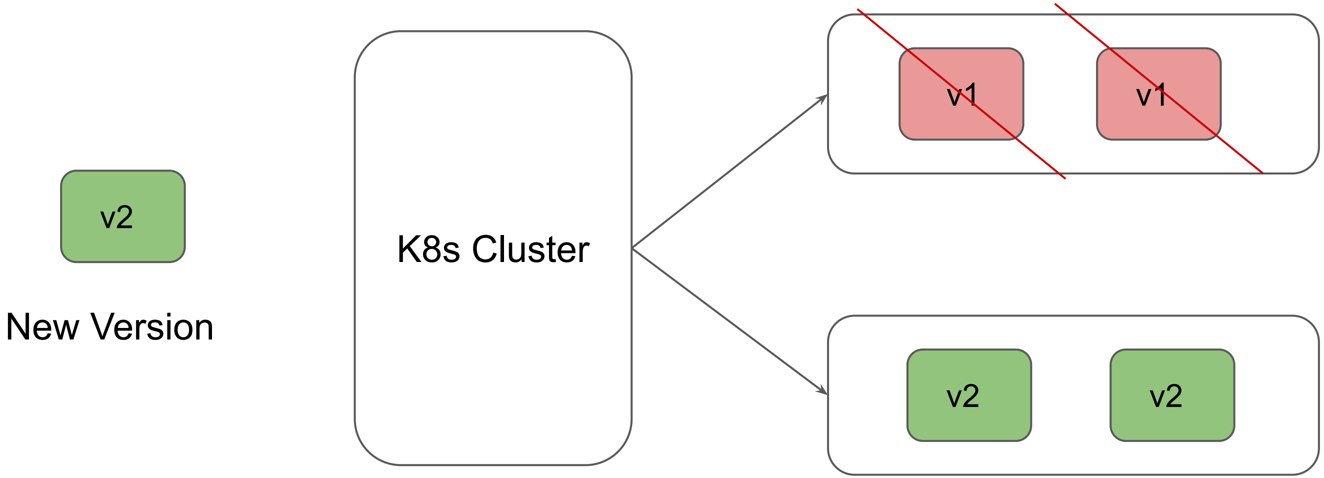
Disadvantages:

There will be certain amount of downtime for the users.

Traffic Pattern - Recreate Stratergy

Deployment Strategy - RollingUpdate

Your application is deployed to your environment one batch of instances at a time.



Traffic Pattern - Rolling Update Strategy

Advantages and Disadvantages - Recreate

Advantages:

New version is slowly released and can reduce the downtime.

Disadvantages:

Takes more amount of time for the overall rollout process.
No control over the traffic.

Blue Green Deployment Stratergy

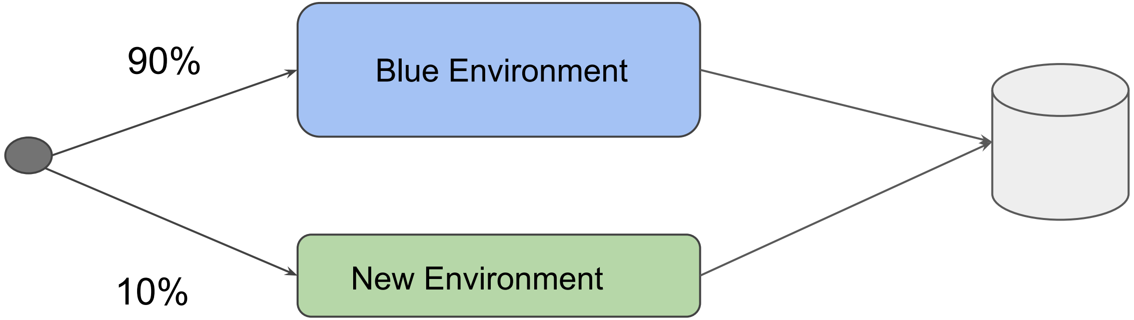
Blue environment is an existing environment in production receiving live traffic.

Green environment is parallel environment running different version of the application.

Deployment = Routing production traffic from blue to green environment.

Understanding Canary Deployment Model

Canary Deployment is a process where we deploy a new feature and shift some % of traffic to the new feature to perform some analysis to see if feature is successful.

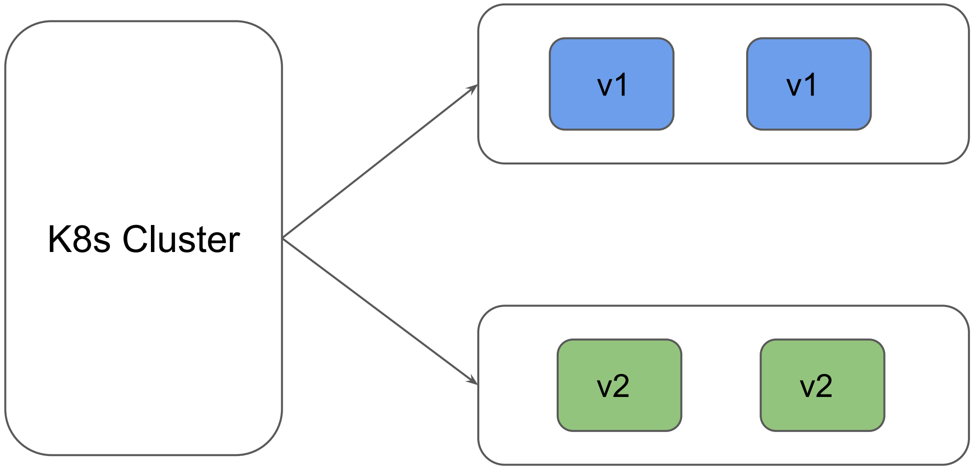


Blue/Green Deployments

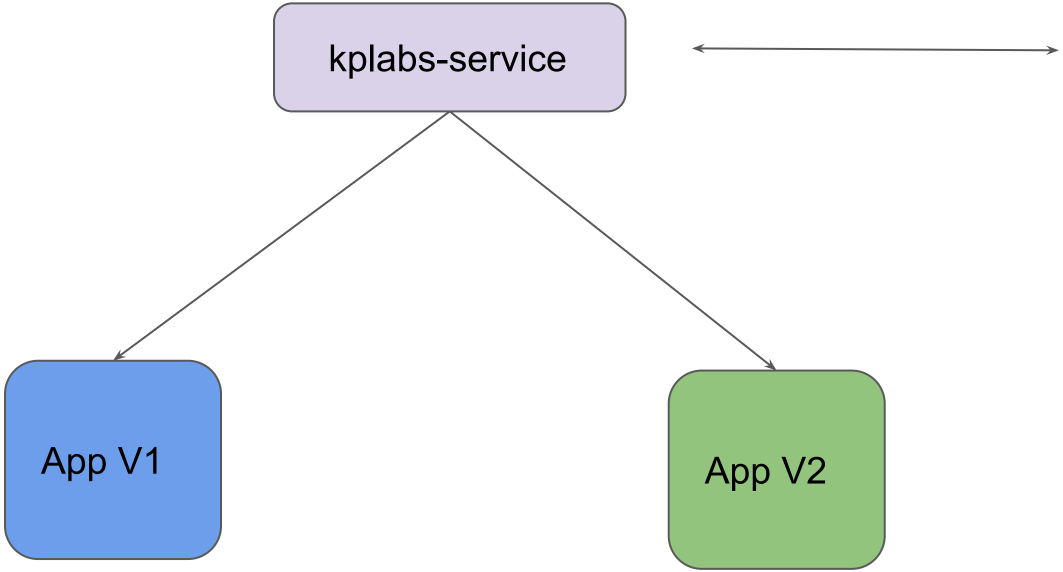
Deploying New Application Updates

Deployment Strategy - Blue Green

Blue-green deployment is a technique that reduces downtime and risk by running two identical production environments called Blue and Green.



Possible Implementation Method - 1




```yaml
apiVersion: v1
kind: Service
metadata:
 name: application-service
spec:
 type: NodePort
 ports:
 - name: http
   port: 80
   targetPort: 80
 selector:
   app: demo-app-v2
```

Advantages and Disadvantages - Blue/Green

Advantages:

Instantaneous rollouts and rollbacks if required.

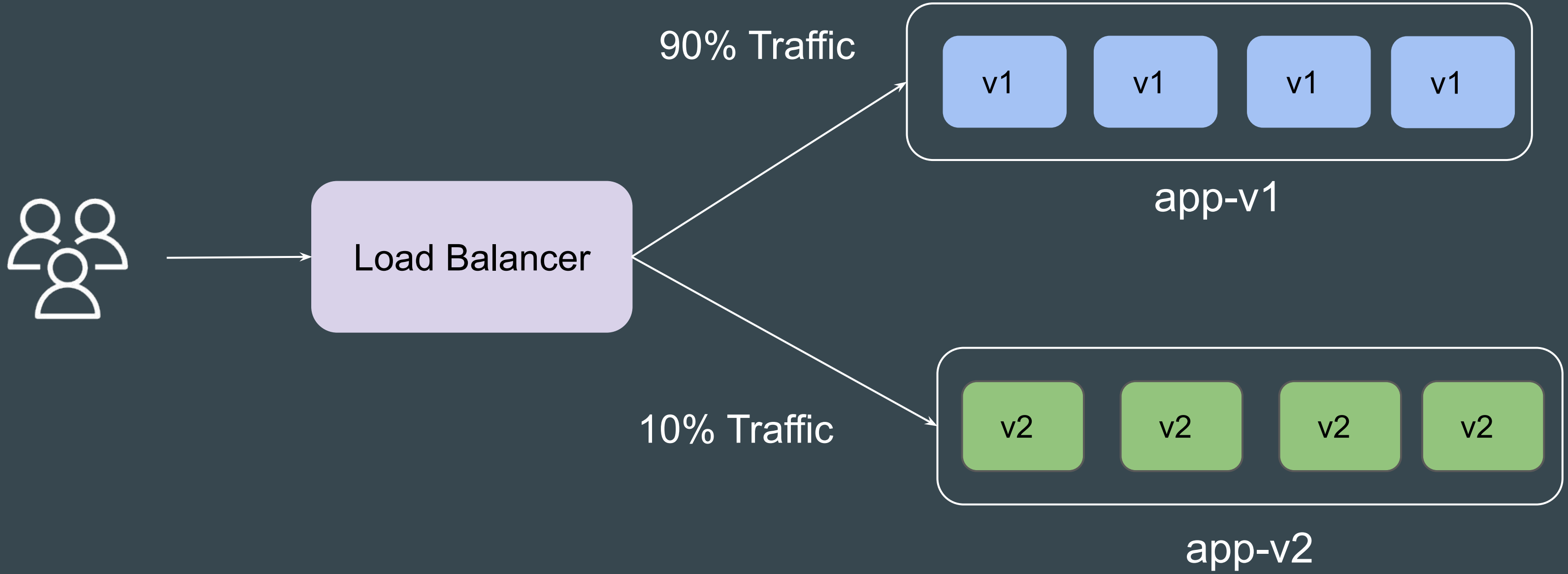
Disadvantages:

Requires double the amount of resources.

Canary Deployments

Setting the Base

Canary refers to a testing strategy where a new version of software is released to a small group of users before a wider rollout.



Benefit of Canary Deployment

Rolling out the new version to a small fraction of users allows you to catch issues before they affect all the users.

Increasing traffic to the new version step-by-step builds your confidence in its stability and performance, which ensures a smooth transition for all users.

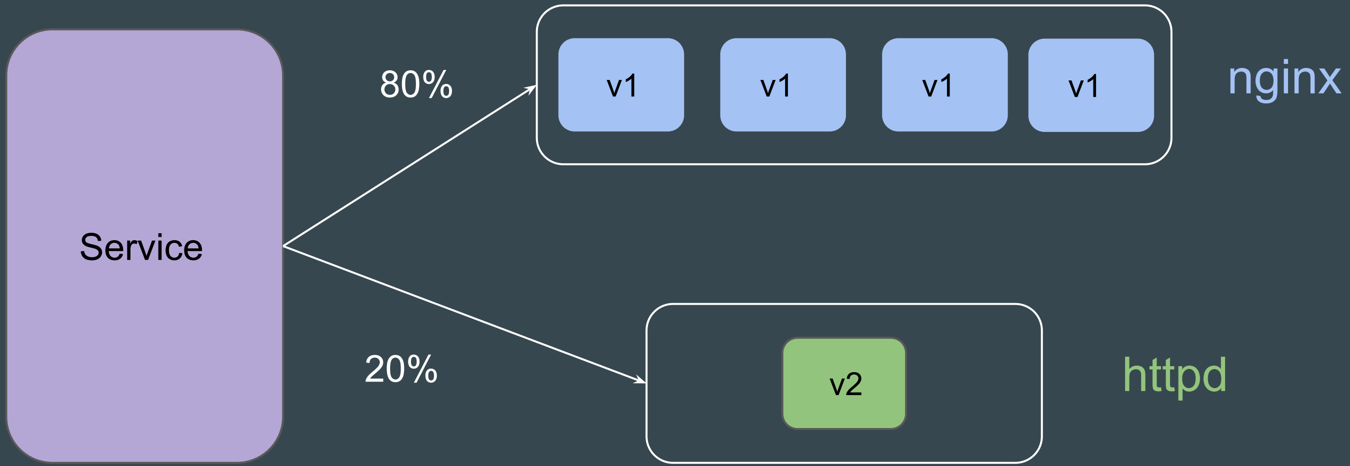
Easier to roll-back.

Exercise - Canary Deployment

The Requirement

Create canary deployment in a way that 20% of traffic goes to canary.

Total Pods for entire environment should be 5.



Traffic Split Formula

Canary Pods = round(Total Pods × (Desired Percentage / 100))

Since you can't have fractions of a pod, round the result.

Example:

If you want 20% canary traffic with 10 total pods:

Canary Pods = round(10 × (20/100) = 2

Custom Resource Definitions

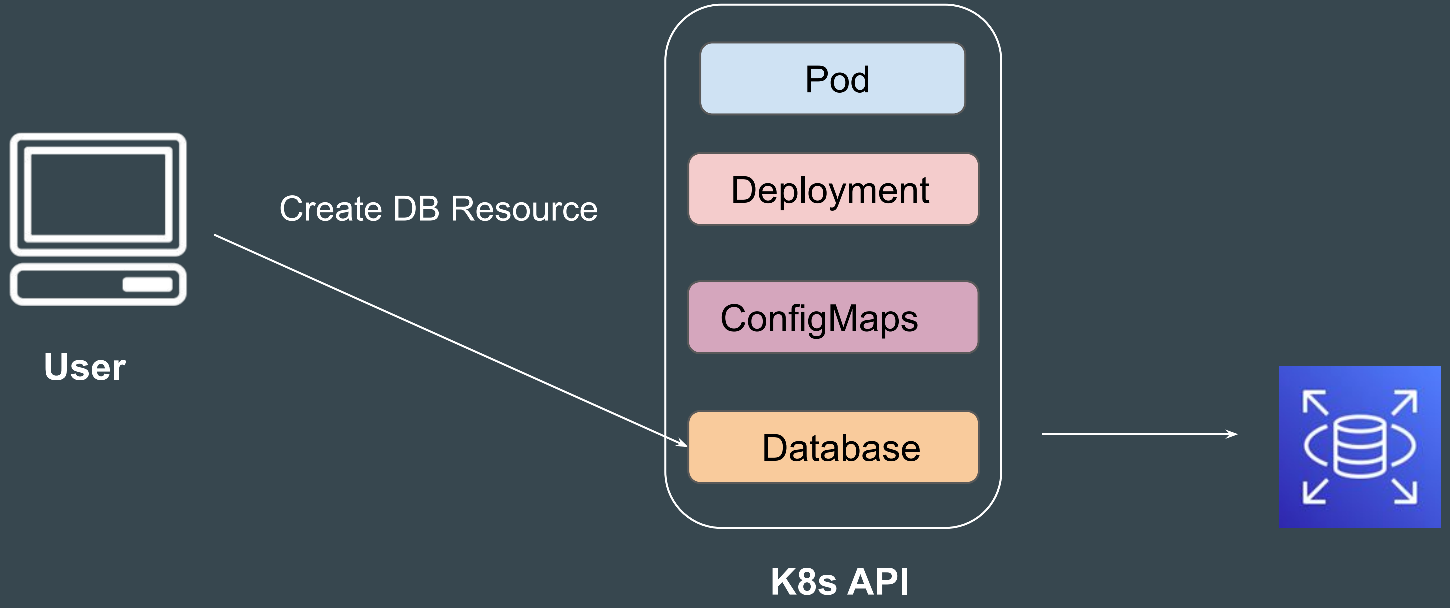
Setting the Base

A resource is an endpoint in the Kubernetes API that stores a collection of API objects of a certain kind.

```
C:\>kubectl api-resources
NAME                     SHORTNAMES   APIVERSION   NAMESPACED   KIND
bindings                              v1           true         Binding
componentstatuses        cs           v1           false        ComponentStatus
configmaps               cm           v1           true         ConfigMap
endpoints                ep           v1           true         Endpoints
events                   ev           v1           true         Event
limitranges              limits       v1           true         LimitRange
namespaces               ns           v1           false        Namespace
nodes                    no           v1           false        Node
persistentvolumeclaims   pvc          v1           true         PersistentVolumeClaim
persistentvolumes        pv           v1           false        PersistentVolume
pods                     po           v1           true         Pod
podtemplates                          v1           true         PodTemplate
replicationcontrollers   rc           v1           true         ReplicationController
resourcequotas           quota        v1           true         ResourceQuota
secrets                               v1           true         Secret
serviceaccounts          sa           v1           true         ServiceAccount
services                 svc          v1           true         Service
```

Basics of CRDs

A Custom Resource Definition allows you to extend the Kubernetes API by defining your own custom resource types.



Step 1 - Create Custom Resource Definition

To create a CRD, you need to create a file, that defines your object kinds.

Applying a CRD into the cluster makes the Kubernetes API server to serve the specified custom resource.

```yaml
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  name: databases.kplabs.internal
spec:
  group: kplabs.internal
  names:
    kind: Database
    listKind: DatabaseList
    plural: databases
    singular: database
  scope: Namespaced
  versions:
    - name: v1
      served: true
      storage: true
      schema:
```

Step 2 - Create Custom Objects

After the CustomResourceDefinition object has been created, you can create custom objects.

Applying a CRD into the cluster makes the Kubernetes API server to serve the specified custom resource.

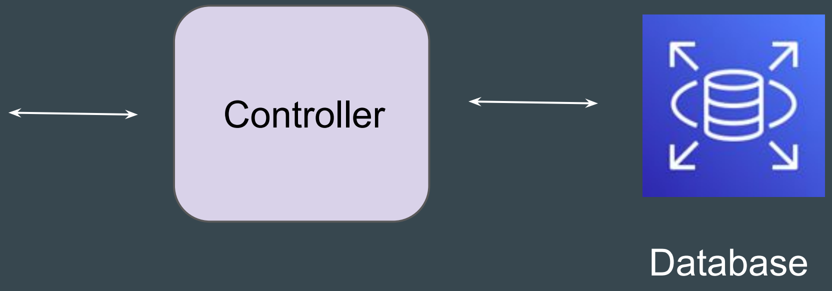
```yaml
apiVersion: kplabs.internal/v1
kind: Database
metadata:
  name: my-database
spec:
  name: test-db
  replicas: 3
```

Importance of Custom Controller

A controller tracks at least one Kubernetes resource type.

These objects have a spec field that represents the desired state.

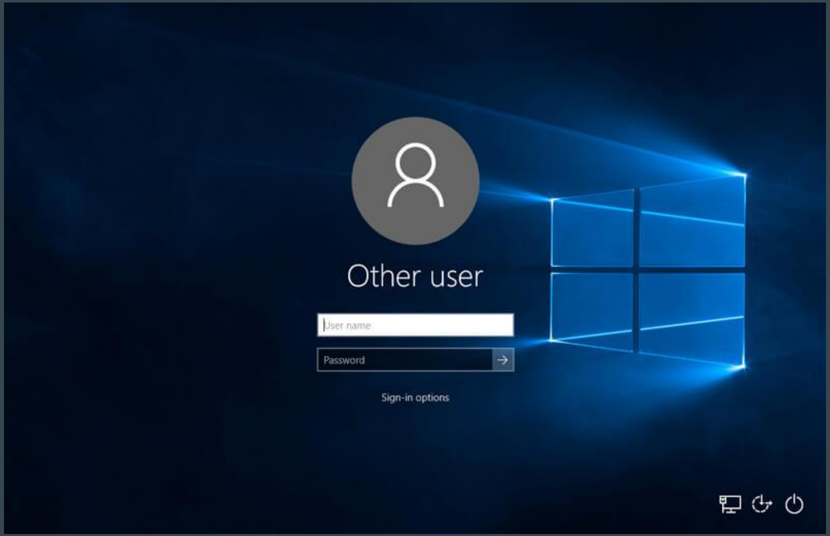
```yaml
apiVersion: kplabs.internal/v1
kind: Database
metadata:
  name: my-database
spec:
  name: test-db
  replicas: 3
```



Authentication in Kubernetes

Basics of Authentication

Authentication is the process of verifying a user's identity before granting them access to a system or resource



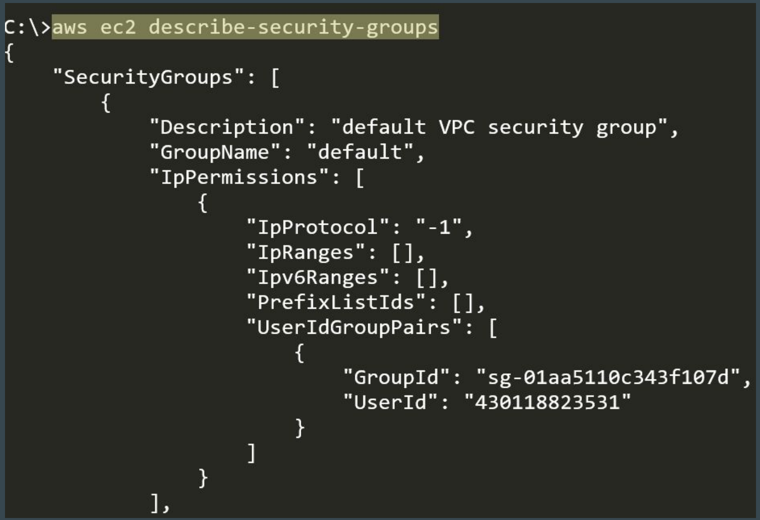
Accessing Resources in Kubernetes

To access resources in Kubernetes cluster, we have to authenticate first.

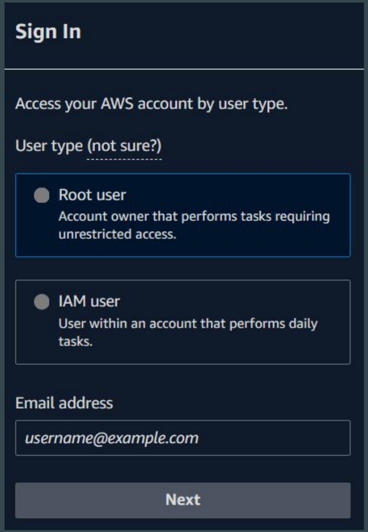
Analogy of AWS

In AWS, you can authenticate using multiple set of methods.

1. Username and Passwords.
2. Access Key and Secret Keys



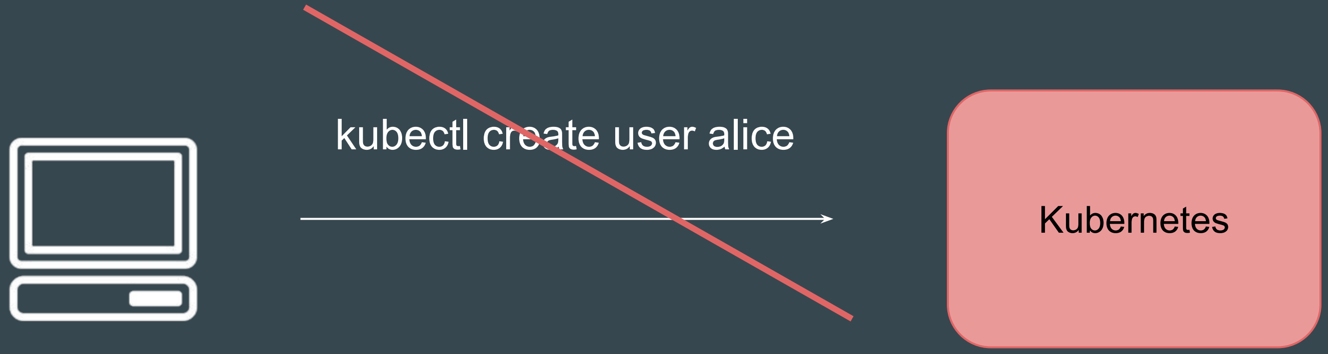
```
C:\>aws ec2 describe-security-groups
{
    "SecurityGroups": [
        {
            "Description": "default VPC security group",
            "GroupName": "default",
            "IpPermissions": [
                {
                    "IpProtocol": "-1",
                    "IpRanges": [],
                    "Ipv6Ranges": [],
                    "PrefixListIds": [],
                    "UserIdGroupPairs": [
                        {
                            "GroupId": "sg-01aa5110c343f107d",
                            "UserId": "430118823531"
                        }
                    ]
                }
            ],
```



Point to Note - Kubernetes

Kubernetes does not manage the user accounts natively.

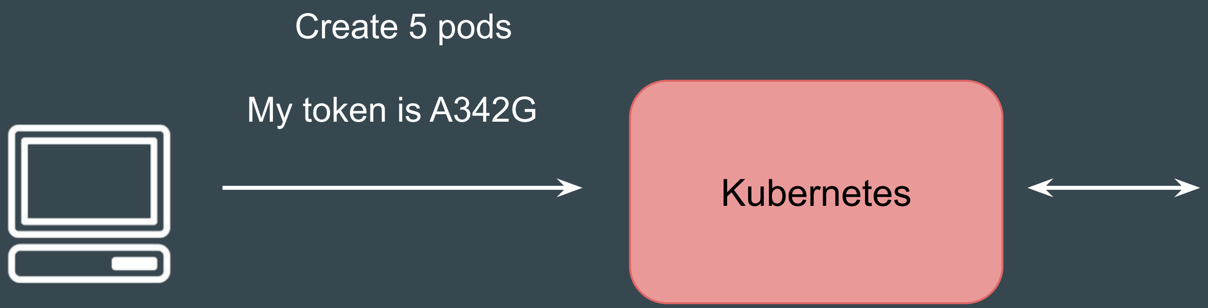
Normal users cannot be added to a cluster through an API call



Authentication in Kubernetes

Kubernetes supports several authentication methods such as:

Client Certificates, Static Token Authentication, Service Account Tokens etc



token	user
A342G	alice
BPRQ	bob

Example 1 - Static Token File

The API server reads bearer tokens from a file provided.

The token file is a csv file with a minimum of 3 columns: token, user name, user uid

```
root@control-plane:~# cat /root/token.csv
Dem0Passw0rd#,bob,01,admins
```

```
[Service]
ExecStart=/usr/local/bin/kube-apiserver --advertise-address=165.22.212.16 --etcd-cafile=/root/certificates/ca.crt --etcd-cert
file=/root/certificates/etcd.crt --etcd-keyfile=/root/certificates/etcd.key --etcd-servers=https://127.0.0.1:2379 --service-a
ccount-key-file=/root/certificates/service-account.crt --service-cluster-ip-range=10.0.0.0/24 --service-account-signing-key-f
ile=/root/certificates/service-account.key --service-account-issuer=https://127.0.0.1:6443  --token-auth-file /root/token.csv
```

Example 2 - X509 Certificates

Uses the client certificates for authentication.

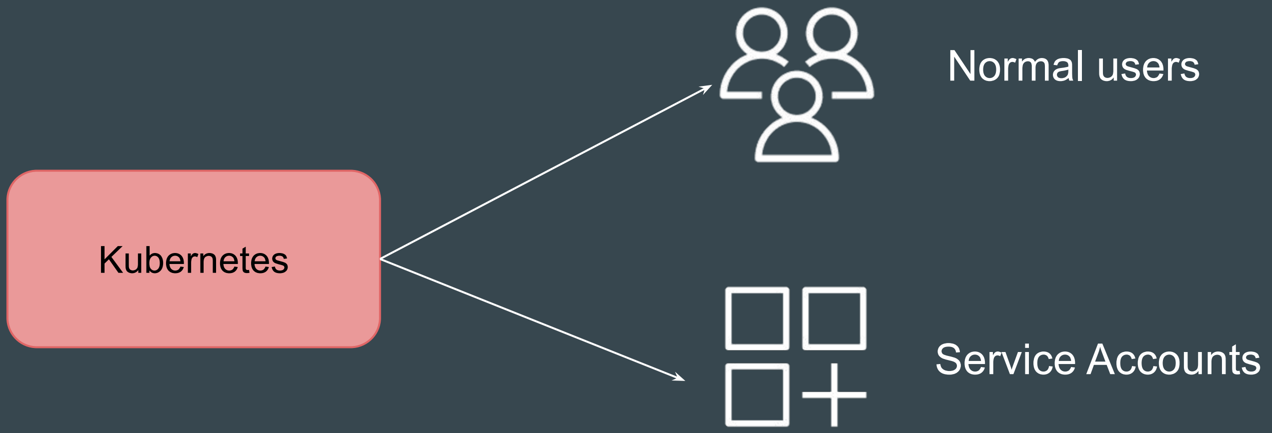

```yaml
kind: Config
preferences: {}
users:
- name: kubernetes-admin
  user:
    client-certificate-data: LS0tLS1CRUdJTiBDRVJUSUZJQ0FURS0tLS0tCk1JSUR
QVFFTEJRQXdGVEVUTUJFR0ExVUUKQXhNS2EzVmlaWEp1WlhSbGN6QWVGdzB5TlRBeE1qVXdN
kJBb1RGbXQxWW1WaFpHMDZZMngxYzNSbGNpMWhaRzFwYm5NeEdUQVhCZ05WQkFNVEVHdDFZb
FRVUFBNElCRHdBd2dnRUtBb0lCQVFER0laWjkKNnQ0ZC90NGhUNWpxb2p6SjRBT2JObnRTQ0
rTGtXaXoveCszTWdyREJwNGNheDJqS0ZTU0dNbU5udUZnTlNMR2lGaS9yK3IyR2MyUUJaN3N
RGtOQWVzd1BIVUVQcWc1RFQ5MU50eXpiUHdjN0UwdkEwODgKQUdYV3FKMWhTN291VmNhTmE0
2srLzFydgpubGIwMllrT1EwWUsvMU9jSEI3UEZQZ2lWb1AvWVErK2xqNEgyWWpzUkE4UmFTT
FHalZqQlVNQTRHQTFVZER3RUIvd1FFQXdJRm9EQVRCZ05WSFNVRUREQUsKQmdnckJnRUZCQW
OUlNMQkNtVktpK0xadwpGWUdtWXc1aGRRWkxNQTBHQ1NxR1NJYjNEUUVCQ3dVQUE0SUJBUUE
TDIxdXN0UWJtZ3pubUN6cndyQXpwdHZwLzFORUY0MkpTVjBpem8veW1JWFZEVmJJMW8KSVI0
nVabEdYZDYxbUNZTkwyckdpeE9BZgp0L0R3OUZVcVdtcnVsaUp1cEJOMHNBeVZ4dUUxSDNYU
lxMDNIUjdTUUY2NGV5SHB4SUt4QnoyNWJ3cVhETytEdnJjR3piUE5EcW9WUGFidWJZQzBKdU
vNktzd25zOUlqMEdBcFFFRlYzUGdoejU5Ci0tLS0tRU5EIENFUlRJRklDQVRFLS0tLS0K
    client-key-data: LS0tLS1CRUdJTiBSU0EgUFJJVkFURSBLRVktLS0tLQpNSUlFb2d
aW0rdnF3RXpvVS9Sa1J5TFNWCnJZUVVicCs1cCtJdk1Qb2lRZDRQTXBDNUZvcy84ZnR6SUt3
```

Categories of Users

Kubernetes Clusters have two categories of users:

1. Normal Users (for humans)

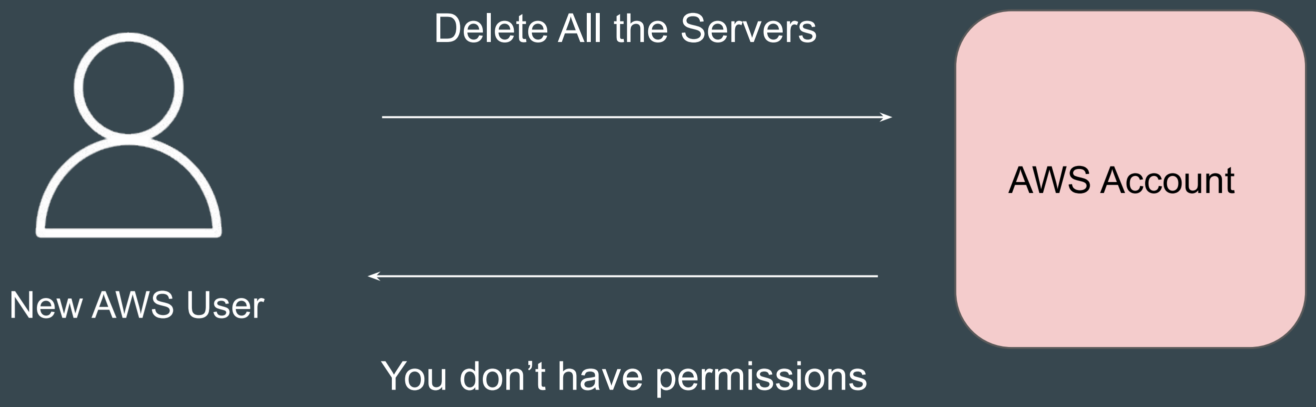
2. Service Accounts (for apps)



Authorization

Basics of Authorization

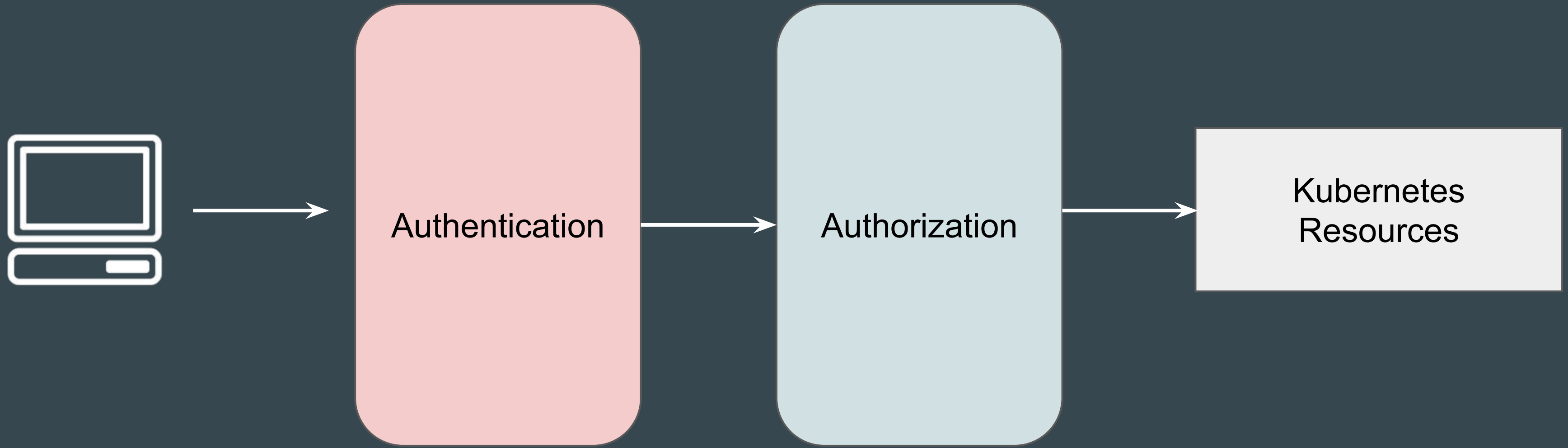
Authorization is the process of determining what an authenticated user or entity is allowed to do



Authorization in Kubernetes

Kubernetes authorization takes place following authentication.

Usually, a client making a request must be authenticated (logged in) before its request can be allowed.



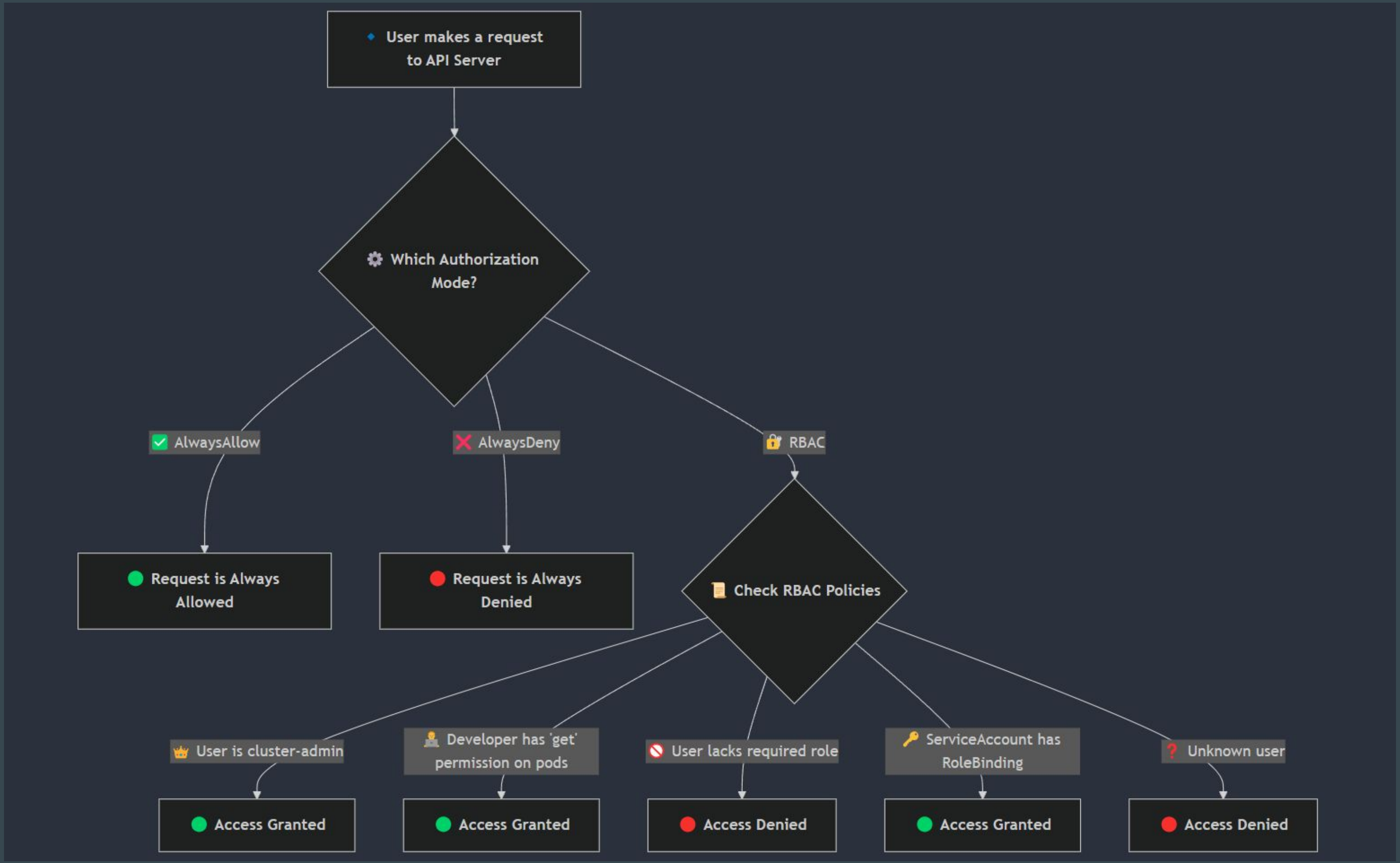
Authorization Modes

The Kubernetes API server may authorize a request using one of several authorization modes. Some of these include:

Authorization Mode	Description
AlwaysAllow	This mode allows all requests, which brings security risks. Use this authorization mode only for testing.
AlwaysDeny	This mode blocks all requests. Use this authorization mode only for testing.
RBAC	Defines set of permissions based on which access is granted. Recommended for Production.

Point to Note

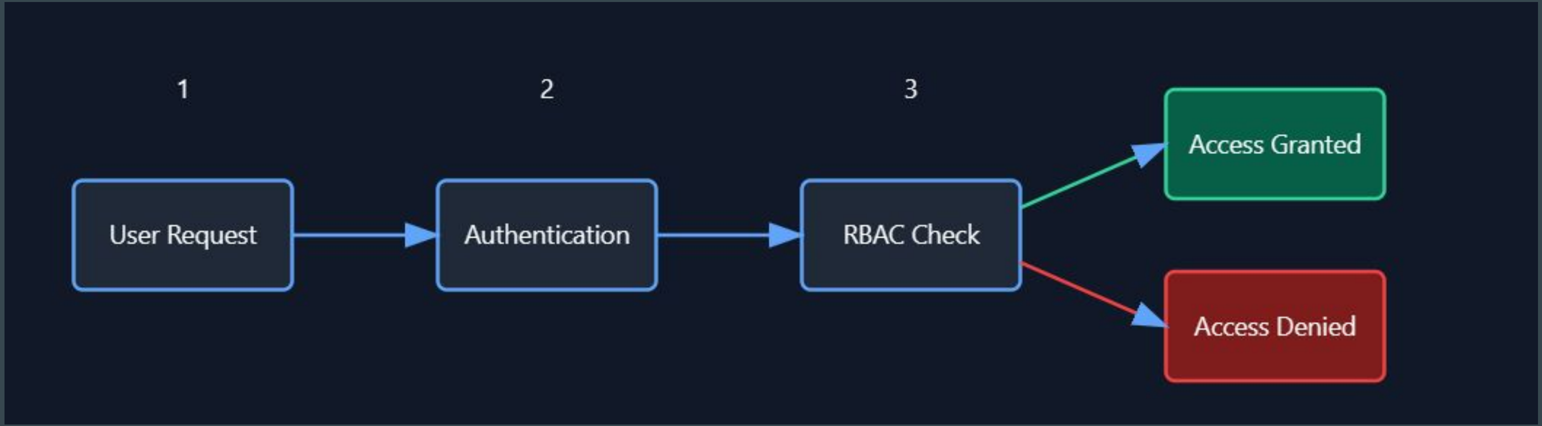
In Kubernetes, if the authorization mode is not explicitly defined in the API server configuration, the default mode used is AlwaysAllow.


User makes a request to API Server
Which Authorization Mode?
AlwaysAllow
AlwaysDeny
RBAC
Request is Always Allowed
Request is Always Denied
Check RBAC Policies
User is cluster-admin
Developer has 'get' permission on pods
User lacks required role
ServiceAccount has RoleBinding
Unknown user
Access Granted
Access Granted
Access Denied
Access Granted
Access Denied

Role-Based Access Control (RBAC)

Setting the Base

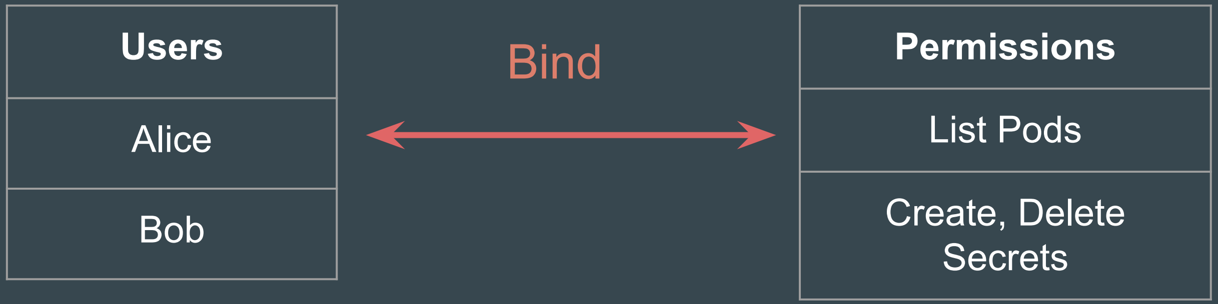
RBAC allows us to control what actions users and service accounts can perform on resources within your cluster.



Basic Workflow

In the below diagram, we have a list of users in Table 1 and list of permissions in Table 2.

We have to bind these together for users to get the defined permissions.

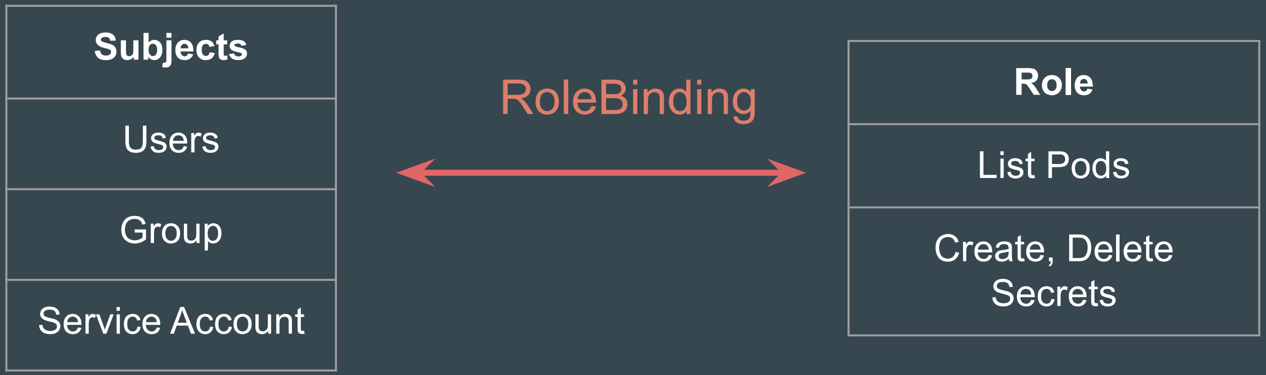


3 Important Concept

Role defines a set of permissions.

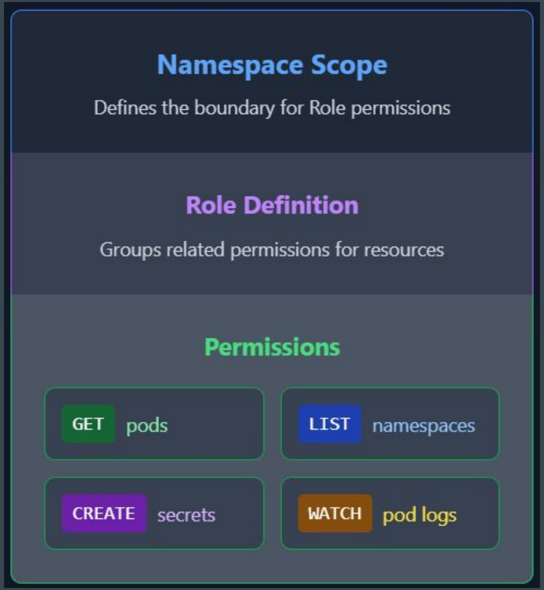
Subjects can be user, groups, service account.

RoleBinding ties the permission defined in the role to subjects like Users.



Introducing Roles

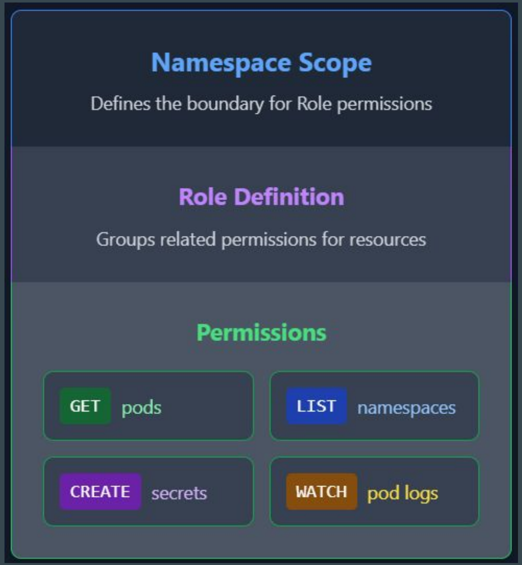
A Role always sets permissions within a particular namespace.



Introducing RoleBinding

RoleBinding associates a Role with a user, group, or service account within a specific namespace.

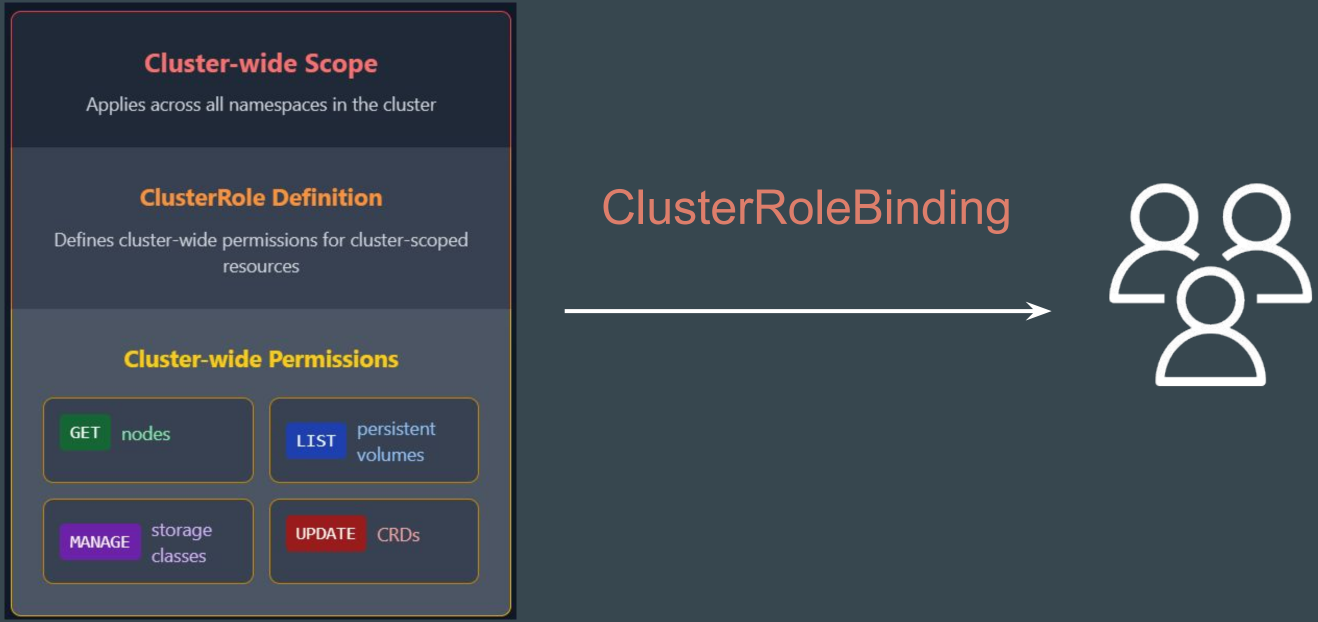
It grants the defined permissions to the subjects in that namespace.



RoleBinding

ClusterRole and ClusterRoleBinding

Similar to Role and RoleBinding, but the main difference is that the permissions granted by a ClusterRole apply across all namespaces in the cluster. ClusterRoleBinding connects ClusterRole to Subjects.



Practical - Role and RoleBinding

Basic Structure of Role Manifest

The following image represents the basic structure of the first part of a Role manifest file.

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: pod-read-only
  namespace: default
```

Defining Rules in Role Manifest

The rules field is a list of policies that define the permissions granted by the Role.

Each rule specifies which actions (verbs) are allowed on which resources (API objects).

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: pod-read-only
  namespace: default
rules:
- apiGroups: [""]
  resources: ["pods"]
  verbs: ["list"]
```

1 - API Groups

apiGroups specify which API group the rule applies to.

Kubernetes APIs are categorized into different API groups.

API Groups	Description
"" (empty string)	Refers to the core API group (e.g., pods, services, configmaps etc).
apps	Refers to the apps API group (e.g., deployments, daemonsets,replicasets)
batch	Includes Jobs, CronJobs.
networking.k8s.io	Handles Ingress and Network Policies.

2 - Resources

This field specifies which Kubernetes resources the rule applies to.

These resources belong to the specified API group.

```
C:\>kubectl api-resources --api-group="apps"
NAME                  SHORTNAMES   APIVERSION   NAMESPACED   KIND
controllerrevisions                apps/v1      true         ControllerRevision
daemonsets            ds           apps/v1      true         DaemonSet
deployments           deploy       apps/v1      true         Deployment
replicasets           rs           apps/v1      true         ReplicaSet
statefulsets          sts          apps/v1      true         StatefulSet
```

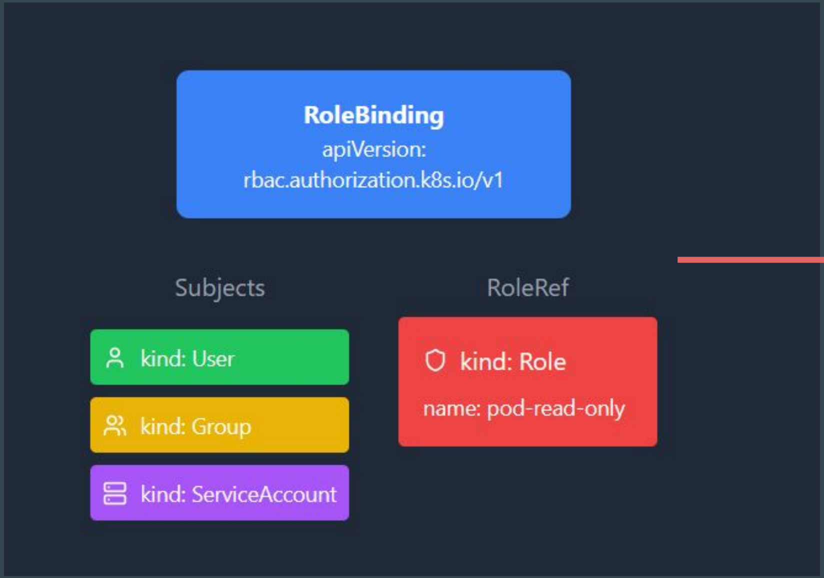
3 - Verbs

Verb specifies what actions (operations) are allowed on the specified resources.

Common Verbs	Description
get	Read a specific resource.
list	List all resources of that type.
create	Create a new resource.
delete	Modify an existing resource.
update	Remove a resource.
watch	Observe changes to a resource.

Structure - RoleBinding

While defining RoleBinding, we have to define subjects and Role Reference.




```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: pod-rolebinding
subjects:
- kind: User
  name: bob
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: Role
  name: pod-read-only
  apiGroup: rbac.authorization.k8s.io
```

Generate Role Manifest File

```
C:\>kubectl create role pod-reader --verb=list --resource=pods --dry-run=client -o yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  creationTimestamp: null
  name: pod-reader
rules:
- apiGroups:
  - ""
  resources:
  - pods
  verbs:
  - list
```

Generate Role Binding Manifest File

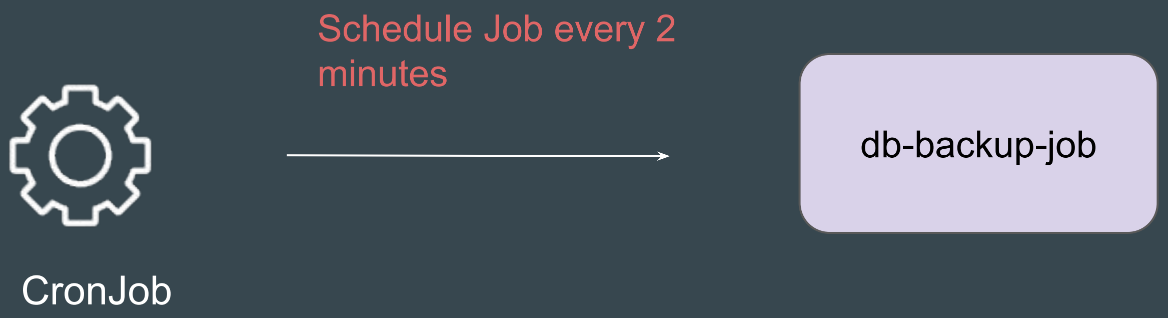
```
C:\>kubectl create rolebinding pod-reader --role=pod-reader --user=bob --dry-run=client -o yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  creationTimestamp: null
  name: pod-reader
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: pod-reader
subjects:
- apiGroup: rbac.authorization.k8s.io
  kind: User
  name: bob
```

Important Pointers for Exam

CronJobs

Be very familiar with creating CronJobs with different sets of customizations.

successfulJobsHistoryLimit, failedJobsHistoryLimit, activeDeadlineSeconds, startingDeadlineSeconds



Docker Image Management

Be familiar with basic Docker commands.

1. Build and tag new Docker Images (image:1.2.3)

2. Create an archive of an existing Docker image (image export).

Reference Docker Commands	Description
docker build -t my-app:latest .	Build Docker Image from a Dockerfile
docker save -o my-app.tar my-app:latest	Save Image to a Tar file

Request and Limits

You should be able to set the resource requests and limits at the pod/deployment level based on the requirements.

request-limit.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: kplabs-pod
spec:
  containers:
  - name: kplabs-container
    image: nginx
    resources:
      requests:
        memory: "128Mi"
        cpu: "0.5"
      limits:
        memory: "500Mi"
        cpu: "1"
```

Introducing Limit Ranges

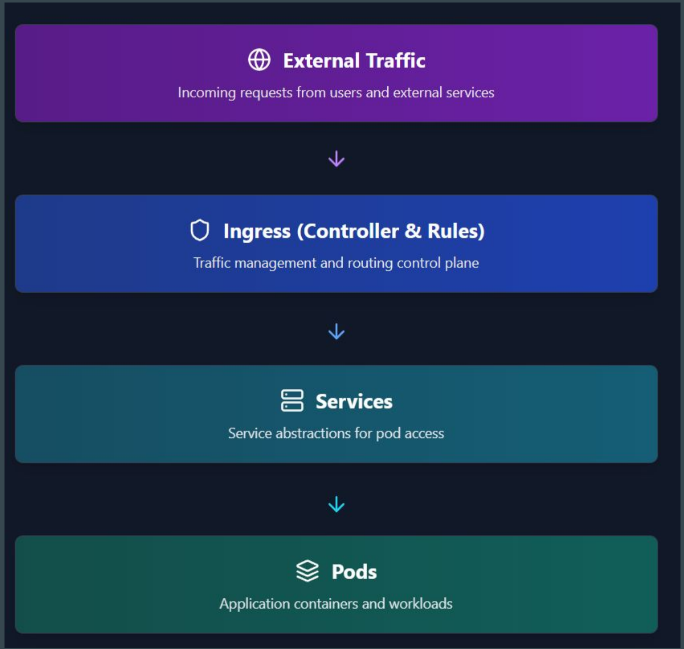
With a LimitRange, the cluster automatically applies default requests and limits when users omit them and enforce minimum and maximum thresholds for requests and limits.

```yaml
apiVersion: v1
kind: LimitRange
metadata:
  name: resource-limits
  namespace: lr-demo
spec:
  limits:
  - default:
      cpu: "100m"
      memory: "128Mi"
    defaultRequest:
      cpu: "50m"
      memory: "64Mi"
    type: Container
```

```yaml
apiVersion: v1
kind: LimitRange
metadata:
  name: stricter-limits
  namespace: lr-demo
spec:
  limits:
  - type: Container
    max:
      cpu: "100m"
      memory: "128Mi"
    min:
      cpu: "30m"
      memory: "50Mi"
```

Ingress

Know how to debug the entire traffic workflow (ingress -> controller -> service - Pods). Be familiar with targetPort and containerPort.



Service Accounts

Application pods can use a specific ServiceAccount to authenticate to Kubernetes.

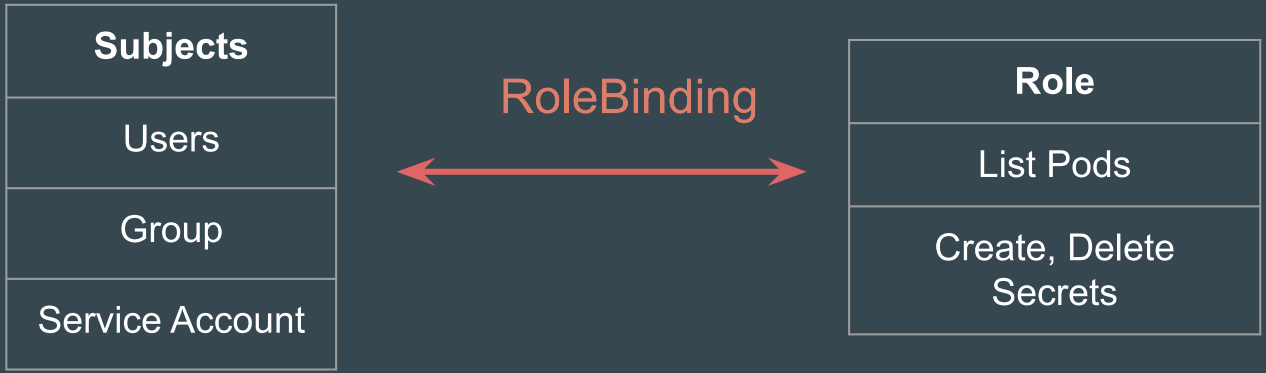
Each service account is bound to a Kubernetes namespace.

RBAC

Role defines a set of permissions.

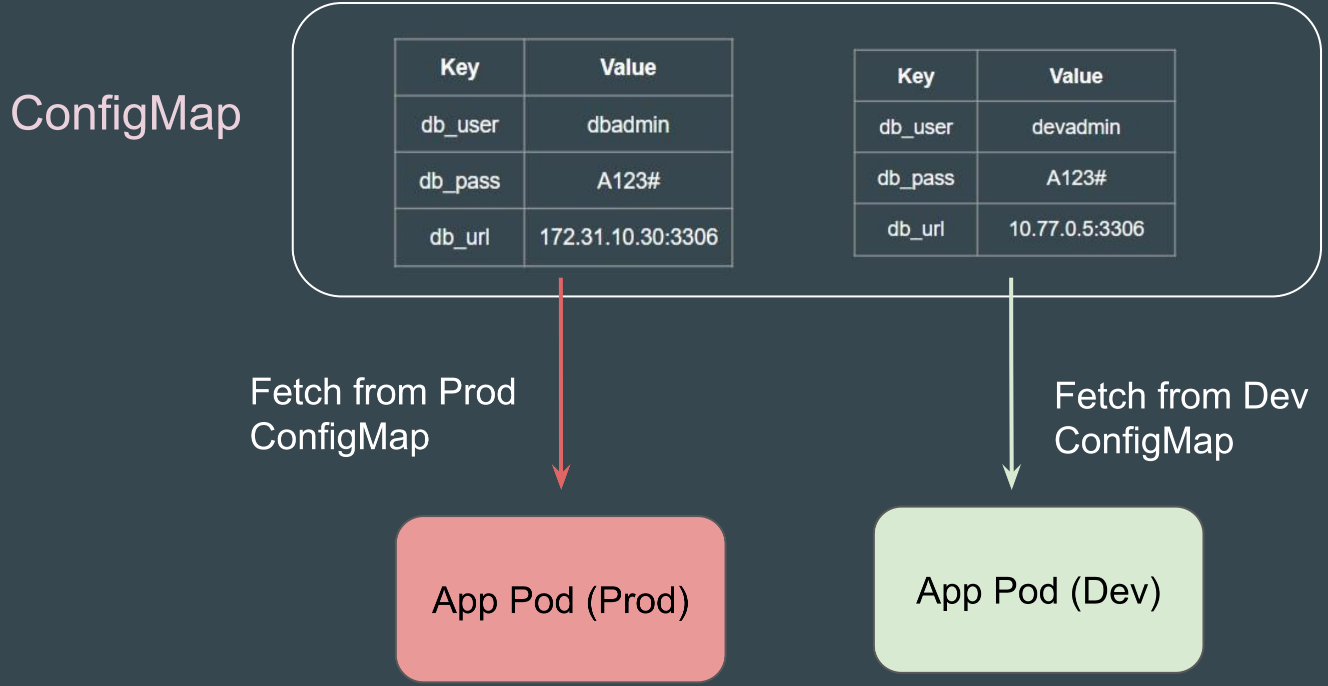
Subjects can be user, groups, service account.

RoleBinding ties the permission defined in the role to subjects like Users.



Introduction to the ConfigMaps

A ConfigMap in Kubernetes is used to store key-value pairs of configuration data.

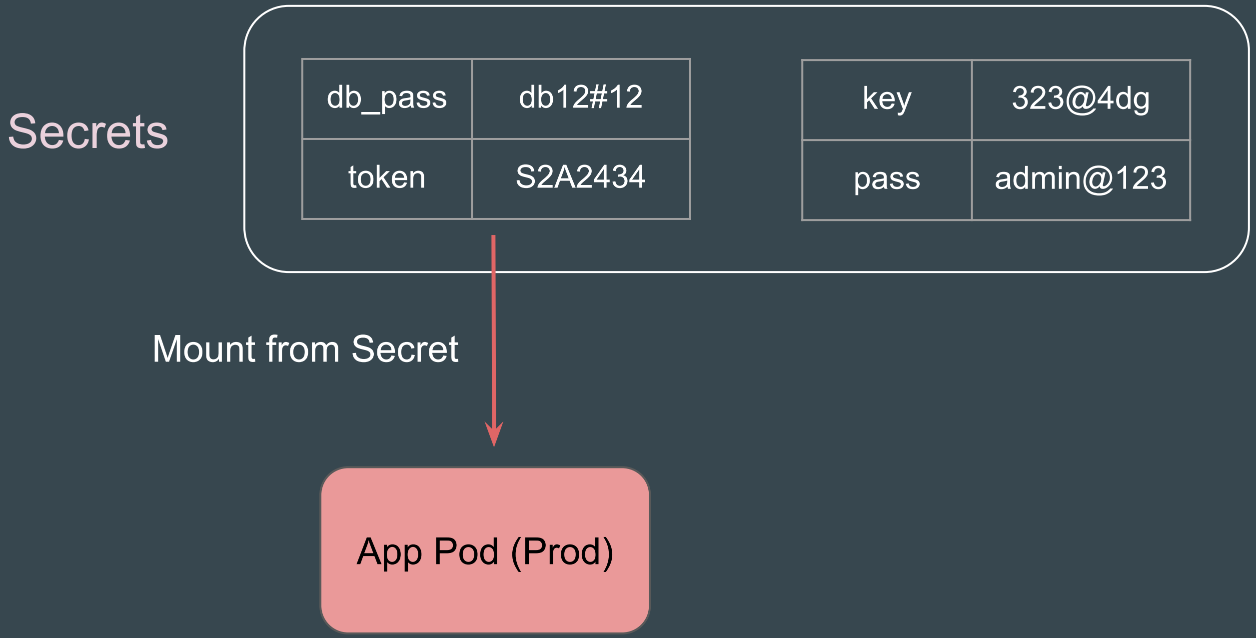


Key	Value
db_user	dbadmin
db_pass	A123#
db_url	172.31.10.30:3306

Key	Value
db_user	devadmin
db_pass	A123#
db_url	10.77.0.5:3306

Introducing Secret

Kubernetes Secrets is a feature that allows us to store these sensitive data.

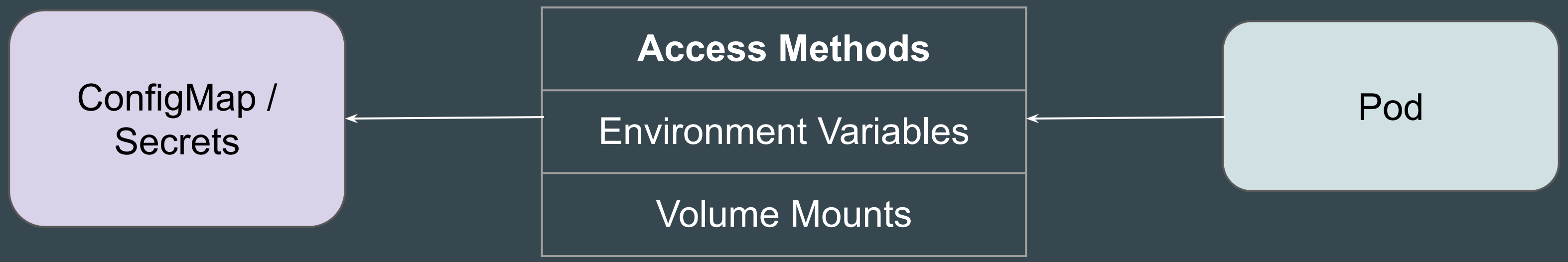


Mounting ConfigMaps and Secrets

Be familiar on how to mount ConfigMaps and Secrets inside the Pods.

1. Mount ConfigMap as a file inside Pod.

2. Mount keys of Secrets as environment variable inside the container.



Introduction to Security Context

A security context defines privilege and access control settings for a Pod or Container (runAsUser, Privilege Escalation use-cases)

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: better-pod
spec:
  securityContext:
    runAsUser: 1000
    runAsGroup: 1000
  containers:
  - name: better-container
    image: busybox
    command: ["sleep", "36000"]
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: privileged-pod
spec:
  containers:
  - image: nginx
    name: privileged
    securityContext:
      privileged: true
```

Liveness and Readiness Probes

Be familiar with how to configure liveness and readiness probes based on requirements -- especially using httpGet.

```yaml
apiVersion: v1
kind: Pod
metadata:
  labels:
    test: liveness
  name: liveness-http
spec:
  containers:
  - name: liveness
    image: nginx:latest
    args:
    - liveness
    livenessProbe:
      httpGet:
        path: /healthz
        port: 8080
      initialDelaySeconds: 3
      periodSeconds: 3
```

Kubernetes Services

Service Type	Key Features	Use-Cases
ClusterIP	Default Service type. Accessible only within the cluster.	Internal microservices communication
NodePort	Exposes service on a static port (30000-32767) on each Node.	Development testing, demo applications
LoadBalancer	Exposes service externally using cloud provider's load balancer	Production applications requiring external access

Pods and Environment Variables

When you create a Pod, you can set environment variables for the containers that run in the Pod.

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: envar-demo
spec:
  containers:
  - name: busybox
    image: busybox:latest
    command: ["sleep","3600"]
    env:
    - name: DB_HOST
      value: "prod-db.kplabs.internal"
    - name: DB_PASS
      value: "notsosecretpassword"
```

```
/ # echo $DB_HOST
prod-db.kplabs.internal
/ # echo $DB_PASS
notsosecretpassword
/ #
```

Deployment Updates Strategy

While performing a rolling update, there are two important configuration to know.

Configuration Parameter	Description
maxSurge	Maximum number of pods that can be scheduled above the original number of pods.
maxUnavailable	Maximum number of pods that can be unavailable during the update.

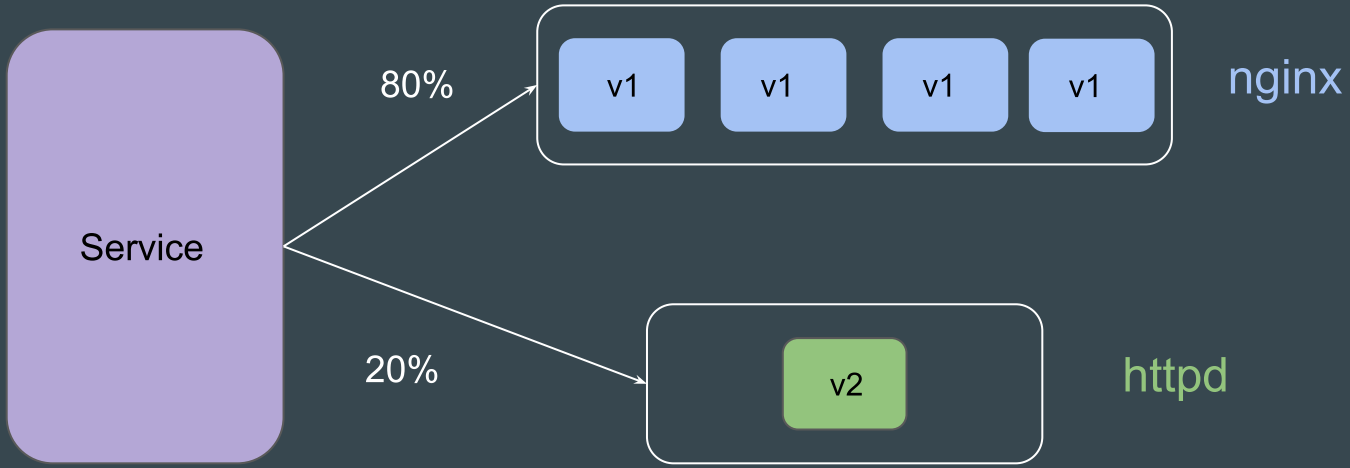
Common Deployment Commands

Commands to Know	Description
kubectl set image deployment/nginx busybox=busybox	Update image of an existing deployment.
kubectl rollout undo deployment/abc	Roll back to the previous version of deployment
kubectl rollout restart deployment/nginx	Restart a deployment

Canary Deployment

Based on a requirement, exams might ask you to create a Canary deployment.

Canary Pods = round(Total Pods × (Desired Percentage / 100))



Troubleshooting Application Failures

Be familiar with troubleshooting scenarios.

Example Use-Case:

An application pod is failing. Troubleshoot and fix the issue.

kubectl logs <pod-name>
kubectl describe pod <pod-name>

Network Policies

Be familiar with the basics of network policies and how they can be associated with pods.

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector: {}
```

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: demo-network-policy
spec:
  podSelector:
    matchLabels:
      env: production
  policyTypes:
    - Ingress
    - Egress
  ingress:
  - from:
    - podSelector:
        matchLabels:
          env: security
  egress:
  - to:
    - ipBlock:
        cidr: 8.8.8.8/32
```

Restart Policies

Restart Policy	Description
Always	This policy instructs Kubernetes to restart a container whenever it terminates, regardless of whether the exit was due to a success (exit code 0) or a failure Always is the default Restart policy.
OnFailure	Kubernetes will only restart a container if it terminates with a non-zero exit code (indicating a failure)
Never	Kubernetes will not restart a container once it has terminated, regardless of the exit status (success or failure)

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