O'REILLY®

Certified Kubernetes Application Developer (CKAD) Crash Course

Kubernetes 1.21 Edition

About the trainer

bmuschko

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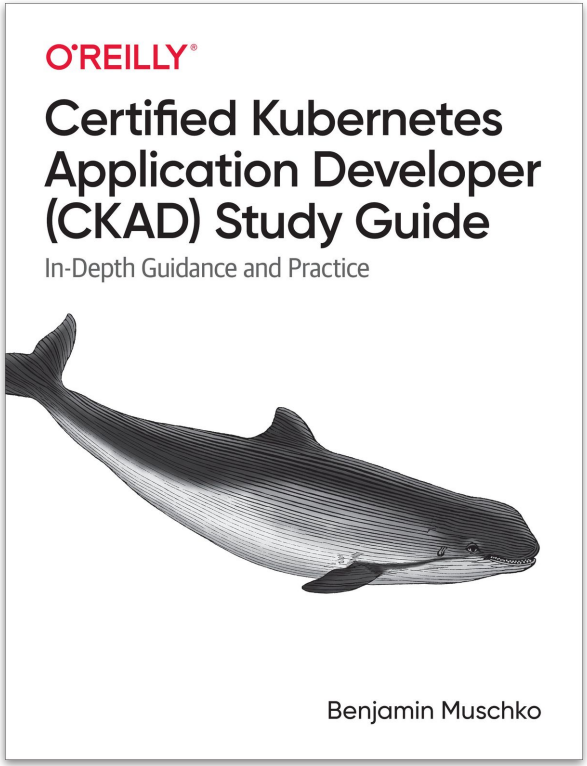


Companion study guide with practice questions

Released in February 2021

Online access on O'Reilly learning platform:

https://learning.oreilly.com/library/view/certified-kubernetes-application/9781492083726/

Exam Details and Resources

Objectives, Environment, Time Management

Exam Objectives

“Design, build, configure, and expose cloud native applications for Kubernetes”

The certification program allows users to demonstrate their competence in a hands-on, command-line environment.

https://www.cncf.io/certification/ckad/

The Curriculum

13% - Core Concepts

- Understand Kubernetes API primitives
- Create and configure basic Pods

10% Multi-Container Pods

- Understand Multi-Container Pod design patterns (e .g. ambassador, adapter, sidecar)

13% - Services & Networking

- Understand Services
- Demonstrate basic understanding of NetworkPolicies

20% - Pod Design

- Understand how to use Labels, Selectors, and Annotations
- Understand Deployments and how to perform rolling updates
- Understand Deployments and how to perform rollbacks
- Understand Jobs and CronJobs

18% - Configuration

- Understand ConfigMaps
- Understand SecurityContexts
- Define an application's resource requirements
- Create & consume Secrets
- Understand ServiceAccounts

18% - Observability

- Understand LivenessProbes and ReadinessProbes
- Understand container logging
- Understand how to monitor applications in Kubernetes
- Understand debugging in Kubernetes

8% - State Persistence

- Understand PersistentVolumeClaims for storage

Candidate Skills

kubernetes

Architecture & Concepts

`kubectl`

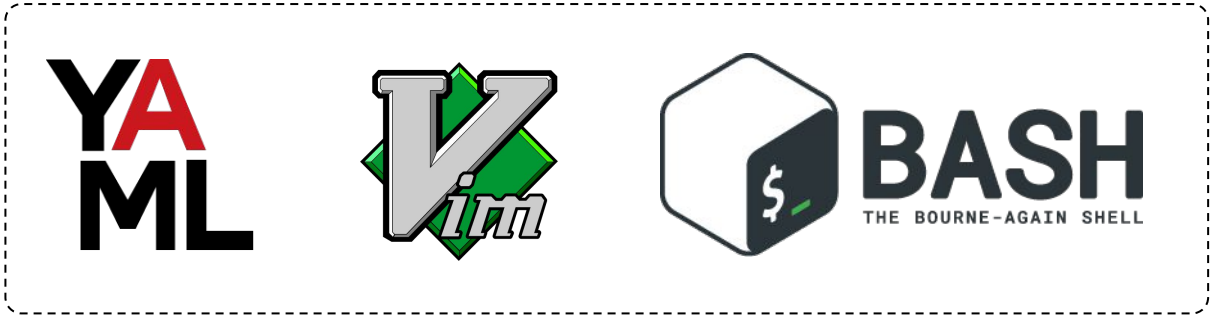
Running Commands

container runtime

Underlying Concepts

Exam Environment

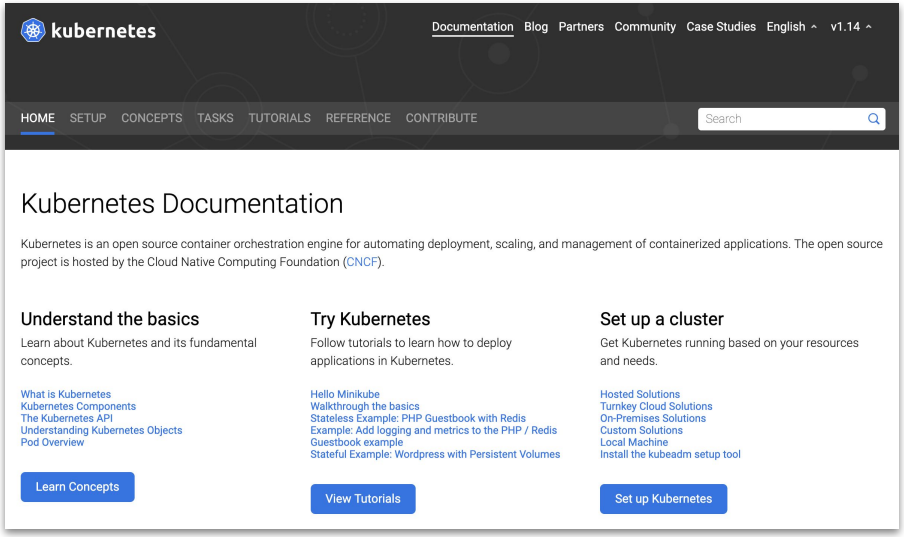
Online and proctored exam



The trinity of tooling you need to be familiar with

Using Documentation

Know where and how to find relevant documentation



https://kubernetes.io/docs

Getting Help on a Command

Render subcommands and options with `--help`

```
$ kubectl create --help
Create a resource from a file or from stdin.

JSON and YAML formats are accepted.

...
Available Commands:
...
  configmap           Create a configmap from a local file, directory or literal
value
  deployment          Create a deployment with the specified name.
...

Options:
...
```

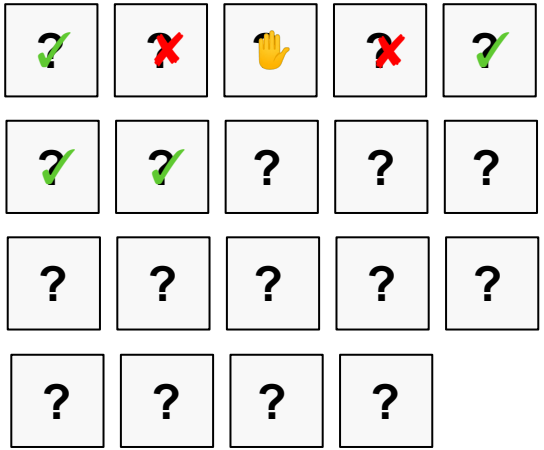
Zeroing in on Command Details

Drill into object details with the `explain` command

```
$ kubectl explain pods.spec
KIND:     Pod
VERSION:  v1

RESOURCE: spec <Object>

DESCRIPTION:
...

FIELDS:
...
```

Time Management

19 problems in 2 hours, use your time wisely!



Configuring Auto-Completion

Allowed during exam, configurable on-demand

```
$ kubectl cre<tab>
```

https://kubernetes.io/docs/tasks/tools/included/optional-kubectl-configs-bash-linux/

Using an Alias for kubectl

Your first action at the beginning of the exam


```
$ alias k=kubectl
$ k version
...
```

Setting a Context & Namespace

Questions will ask you to run a command on a specific cluster - Make sure to execute it!

```
$ kubectl config set-context <context-of-question>↵
--namespace=<namespace-of-question>
```

Internalize Resource Short Names

Some API resources provide a shortcut

```
$ kubectl get ns
```

Usage of `ns` instead of `namespaces`

```
$ kubectl describe pvc claim
```

Usage of `pvc` instead of `persistentvolumeclaim`

```
$ kubectl api-resources
```

Lists all API resources including their short names

Deleting Kubernetes Objects

Don’t wait for a graceful deletion of objects...

```
$ kubectl delete pod nginx --grace-period=0 --force
```

Understand and Practice bash

Practice relevant syntax and language constructs

```
$ if [ ! -d ~/tmp ]; then mkdir -p ~/tmp; fi; while true;↲
do echo $(date) >> ~/tmp/date.txt; sleep 5; done;
```

Finding Object Information

Filter configuration with context from a set of objects

```
$ kubectl describe pods | grep -C 10 "author=John Doe"
$ kubectl get pods -o yaml | grep -C 5 labels:
```

`grep` is your friend!

How to Prepare

Practice, practice, practice!

The key to cracking the exam

Q & A

BREAK

Core Concepts

Kubernetes API Primitives and Pod Management

Kubernetes Object Structure

Kubernetes Object

API Version *v1, apps/v1, ...*

Kind *Pod, Deployment, Quota, ...*

Metadata

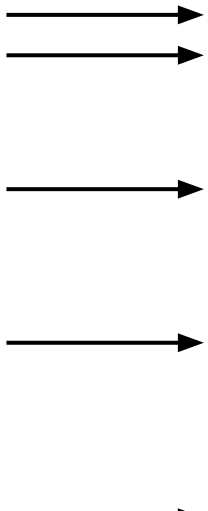
Name, Namespace, Labels, ...

Spec

Desired state

Status

Actual state



Object representation in YAML

```
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: null
  labels:
    run: nginx
  name: nginx
spec:
  containers:
  - image: nginx
    name: nginx
    resources: {}
  dnsPolicy: ClusterFirst
  restartPolicy: Never
status: {}
```

Object Management

Different approaches for different use cases

vs.

YAML

Imperative Object Management

Fast but requires detailed knowledge, no track record

```
$ kubectl create namespace ckad
$ kubectl run nginx --image=nginx -n ckad
$ kubectl edit pod/nginx -n ckad
```

Declarative Object Management

Suitable for more elaborate changes, tracks changes

```
$ vim ngix-pod.yaml
$ kubectl create -f ngix-pod.yaml
$ kubectl delete pod/nginx
```

Hybrid Approach

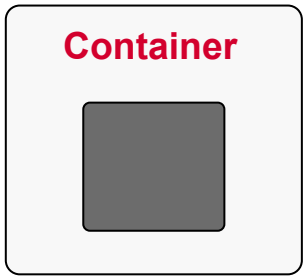
Generate YAML file with `kubectl` but make further edits

```
$ kubectl run nginx --image=nginx --dry-run=client↵
  -o yaml > ngix-pod.yaml
$ vim ngix-pod.yaml
$ kubectl create -f ngix-pod.yaml
```

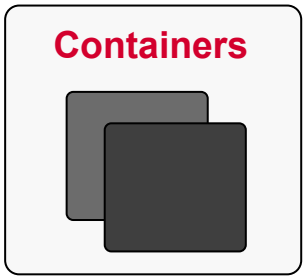
Understanding Pods

Wrapper around one or many containers

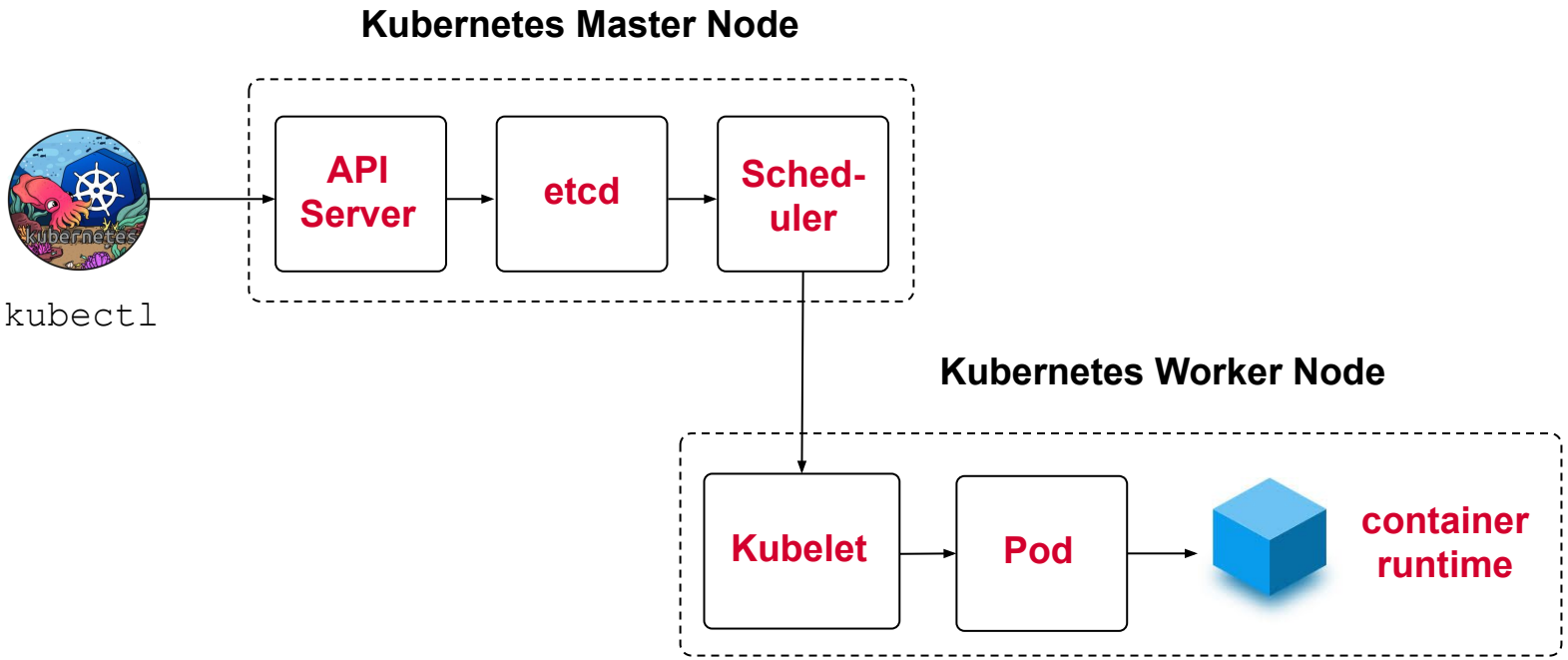
Single-container Pod



Multi-container Pod



Pod Creation Flow



Pod Lifecycle Phases

Phases and their meaning	
Pending	The Pod has been accepted by the Kubernetes system, but one or more of the container images has not been created.
Running	At least one container is still running, or is in the process of starting or restarting.
Succeeded	All containers in Pod terminated successfully.
Failed	Containers in Pod terminated, at least one failed with an error.
Unknown	State of the Pod could not be obtained.

Inspecting a Pod's Status

```
$ kubectl describe pods nginx | grep Status:
Status:         Running
```

Get current status and event logs

```
$ kubectl get pods nginx -o yaml
...
status:
  conditions:
  ...
  containerStatuses:
    ...
    state:
      running:
        startedAt: 2019-04-24T16:56:55Z
  ...
  phase: Running
```

Get current lifecycle phase

Configuring Env. Variables

Injecting runtime behavior

```
apiVersion: v1
kind: Pod
metadata:
  name: spring-boot-app
spec:
  containers:
  - image: bmuschko/spring-boot-app:1.5.3
    name: spring-boot-app
    env:
    - name: SPRING_PROFILES_ACTIVE
      value: production
```

Commands and Arguments

Running a command inside of a container

```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - image: nginx:1.15.12
    name: nginx
    args:
    - /bin/sh
    - -c
    - echo hello world
```

Other Useful kubectl Commands

```
$ kubectl logs busybox
hello world
```

Dump the Pod's logs

```
$ kubectl exec nginx -it -- /bin/sh
# pwd
```

Connecting to a running Pod

EXERCISE

Creating a Pod
and Inspecting it

Q & A

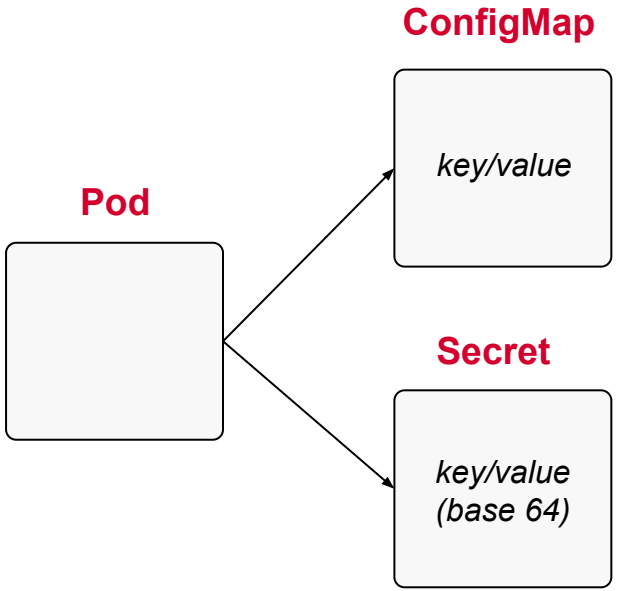
BREAK

Configuration

ConfigMaps, Secrets, Security Contexts, Resource Requirements and Service Accounts

Centralized Configuration Data

Injects runtime configuration through object references



Creating ConfigMaps (imperative)

Fast, easy and flexible, can point to different sources

```
# Literal values
$ kubectl create configmap db-config --from-literal=db=staging

# Single file with environment variables
$ kubectl create configmap db-config --from-env-file=config.env

# File or directory
$ kubectl create configmap db-config --from-file=config.txt
```

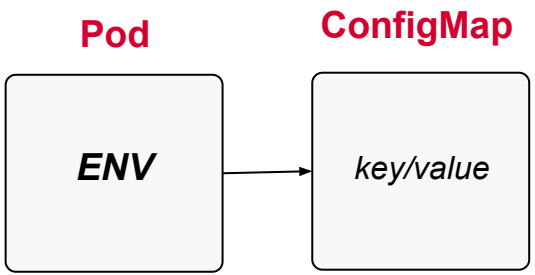
Creating ConfigMaps (declarative)

Definition of a ConfigMap is fairly short and on point

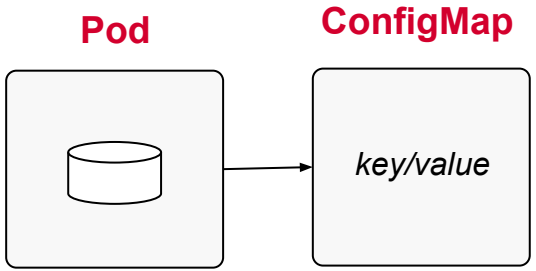
```
apiVersion: v1
data:
  db: staging
  username: jdoe
kind: ConfigMap
metadata:
  name: db-config
```

Mounting a ConfigMap

Two options for consuming data



Injected as environment variables



Mounted as volume

ConfigMap Env. Variables in Pod

Convenient if ConfigMap reflects the desired syntax

```
apiVersion: v1
kind: Pod
metadata:
  name: backend
spec:
  containers:
  - image: nginx
    name: backend
    envFrom:
      - configMapRef:
          name: db-config
```

```
$ kubectl exec -it nginx -- env
DB=staging
USERNAME=jdoe
...
```

ConfigMap in Pod as Volume

Each key becomes file in mounted directory

```
apiVersion: v1
kind: Pod
metadata:
  name: backend
spec:
  containers:
    - name: backend
      image: nginx
      volumeMounts:
      - name: config-volume
        mountPath: /etc/config
  volumes:
    - name: config-volume
      configMap:
        name: db-config
```

```
$ kubectl exec -it backend -- /bin/sh
# ls /etc/config
db
username
# cat /etc/config/db
staging
```

EXERCISE

Configuring a Pod
to Use a ConfigMap

Creating Secrets (imperative)

Similar usage to creation of ConfigMap

```
# Literal values
$ kubectl create secret generic db-creds ↲
  --from-literal=pwd=s3cre!

# File containing environment variables
$ kubectl create secret generic db-creds ↲
  --from-env-file=secret.env

# SSH key file
$ kubectl create secret generic db-creds ↲
  --from-file=ssh-privatekey=~/.ssh/id_rsa
```

Creating Secrets (declarative)

Value has to be base64-encoded manually

```
$ echo -n 's3cre!' | base64
czNjcmUh
```

```
apiVersion: v1
kind: Secret
metadata:
  name: mysecret
type: Opaque
data:
  pwd: czNjcmUh
```

Secret in Pod as Volume

Value has to be base64-encoded manually

```
apiVersion: v1
kind: Pod
metadata:
  name: backend
spec:
  containers:
    - name: backend
      image: nginx
      volumeMounts:
      - name: secret-volume
        mountPath: /etc/secret
  volumes:
    - name: secret-volume
      secret:
        secretName: mysecret
```

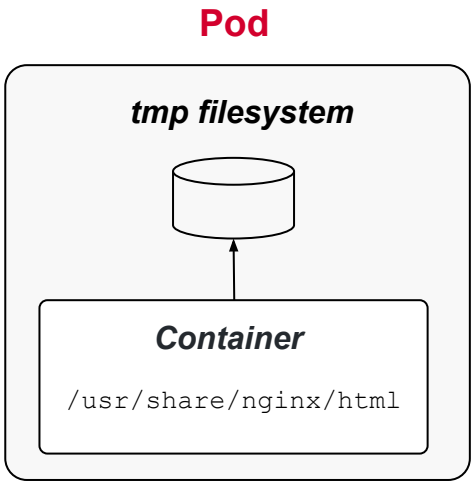
```
$ kubectl exec -it backend -- /bin/sh
# ls /etc/secret
pwd
# cat /etc/secret/pwd
s3cre!
```

EXERCISE

Configuring a Pod
to Use a Secret

Understanding Security Contexts

Privilege and access control settings for a Pod or container



“Create files with a specific Unix group ID”

“Run this container with a specific Unix user ID”

Defining a Security Context

Pod- vs. container-level definition

```
apiVersion: v1
kind: Pod
metadata:
  name: secured-pod
spec:
  securityContext:
    runAsUser: 1000
  containers:
  - image: nginx:1.18.0
    name: secured-container
    securityContext:
      runAsGroup: 3000
```

Defined on the Pod-level

Defined on the container-level

Security Context API

Only partial overlap for Pod- and container attributes

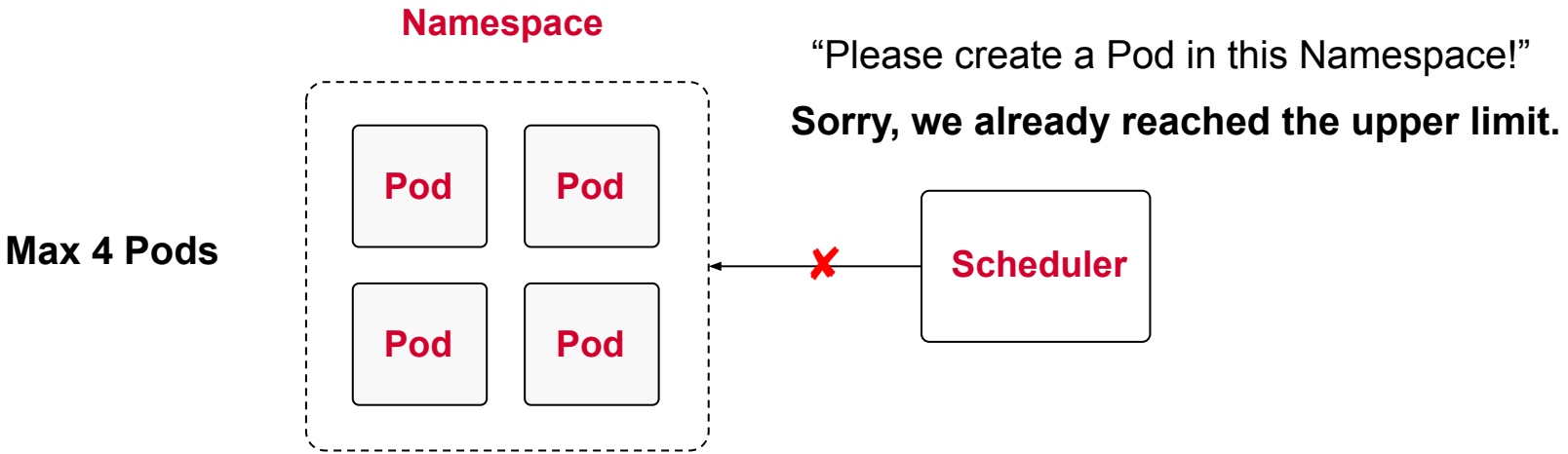
API	Description
PodSecurityContext	Defines Pod-level security attributes.
SecurityContext	Defines container-level security attributes.

EXERCISE

Creating a Security Context for a Pod

Defining Resource Boundaries

Defines # of Pods, CPU and memory usage per Namespace



Resource Units in Kubernetes

CPU units and memory as fixed-point number or power-of-two equivalents

Kubernetes measures CPU resources in millicores and memory resources in bytes. That's why you might see resources defined as `600m` or `100Mib`.

For a deep dive on those resource units, it's worth cross-referencing the section "Resource units in Kubernetes" in the official documentation.

Creating a Resource Quota

Definition on the Namespace-level

```
apiVersion: v1
kind: ResourceQuota
metadata:
  name: app
spec:
  hard:
    pods: 2
    requests.cpu: "1"
    requests.memory: 1024m
    limits.cpu: "4"
    limits.memory: 4096m
```

```
$ kubectl create namespace rq-demo
$ kubectl create -f rq.yaml
--namespace=rq-demo
resourcequota/app created
$ kubectl describe quota --namespace=rq-demo
Name:             app
Namespace:        rq-demo
Resource          Used  Hard
--------          ----  ----
limits.cpu        0     4
limits.memory     0     4096m
pods              0     2
requests.cpu      0     1
requests.memory   0     1024m
```

Defining Container Constraints

Required if Namespace defines Resource Quota

```
apiVersion: v1
kind: Pod
metadata:
  name: mypod
spec:
  containers:
  - image: nginx
    name: mypod
    resources:
      requests:
        cpu: "0.5"
        memory: "512m"
      limits:
        cpu: "1"
        memory: "1024m"
```

Requires at least 0.5 CPU resources and 200m of memory

Limits resources to 1 CPU and 1024m of memory

EXERCISE

Defining a Pod’s Resource Requirements

Declaring Service Accounts

Provides identity for processes running in a Pod

```
apiVersion: v1
kind: Pod
metadata:
  name: app
spec:
  serviceAccountName: myserviceaccount
```

EXERCISE

Using a Service Account

Q & A

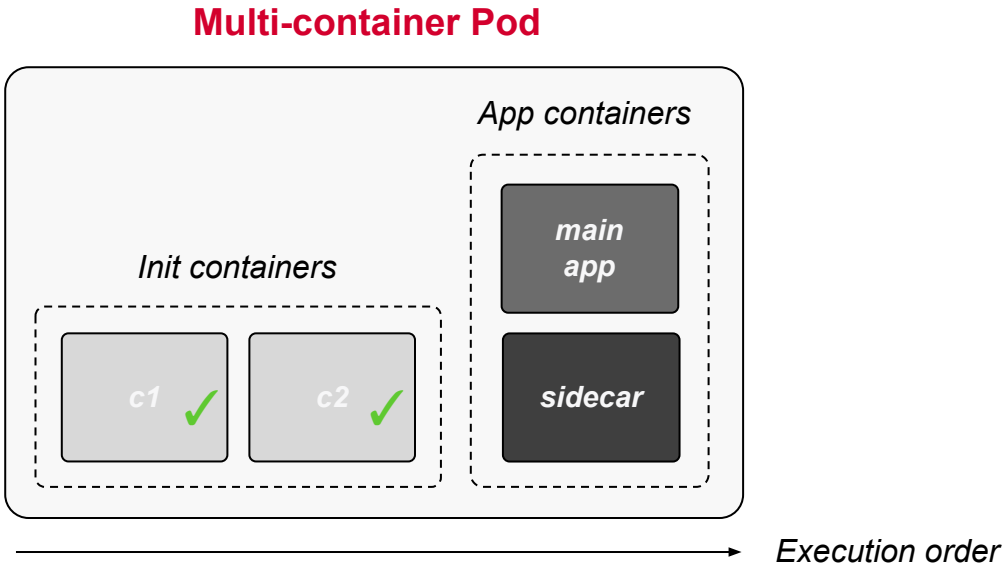
BREAK

Multi-Container Pods

Common Design Patterns

Init Container

Initialization logic before main application containers



Defining an Init Container

`initContainers` adjacent to `containers`

```
apiVersion: v1
kind: Pod
metadata:
  name: multi-container
spec:
  initContainers:
  - image: init:3.2.1
    name: app-initializer
  containers:
  - image: nginx
    name: web-server
```

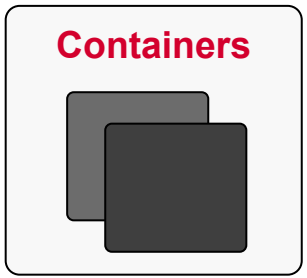
EXERCISE

Creating an Init Container

Defining Multiple Containers

Shared container lifecycle and resources

Multi-container Pod




```
apiVersion: v1
kind: Pod
metadata:
  name: multi-container
spec:
  containers:
  - image: nginx
    name: container1
  - image: alpine
    name: container2
```

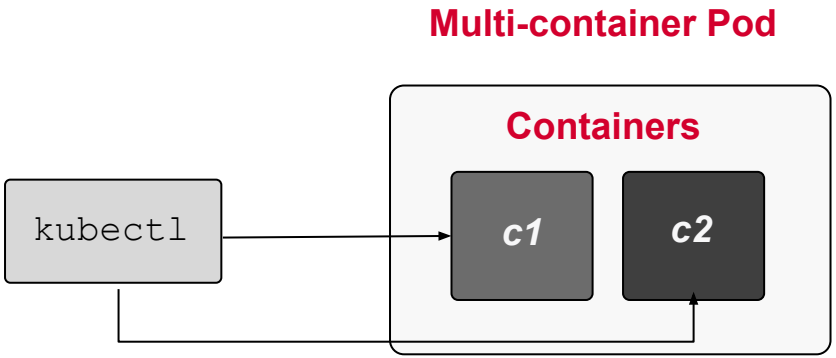
Targeting Different Containers

```
$ kubectl logs busybox --container=c1
```

Dump logs of container 1

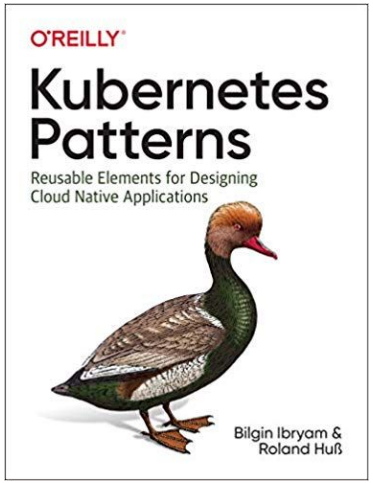
```
$ kubectl exec busybox -it --container=c2 -- /bin/sh
```

Log into container 2



Multi-Container Patterns

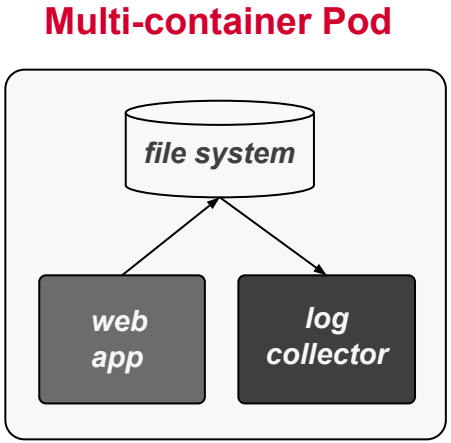
Understand patterns on a high-level



- Init container
- Sidecar
- Adapter
- Ambassador

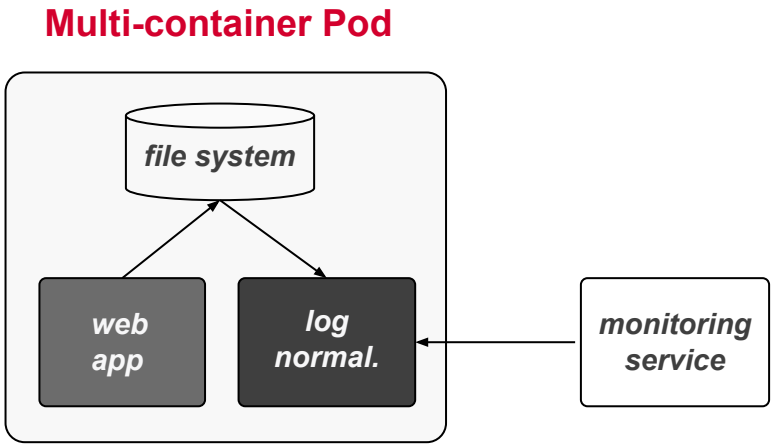
Sidecar Pattern

Enhance logic of main application container



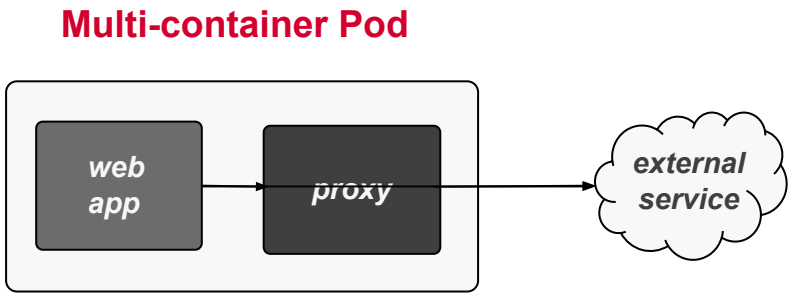
Adapter Pattern

Standardizes and normalizes application output read by external monitoring service



Ambassador Pattern

Proxy for main application container



EXERCISE

Implementing the
Adapter Pattern

Q & A

Observability

Probes, Logging, Monitoring and Debugging

Container Health

“How does Kubernetes know if a container is up and running?”

Probes can detect
and correct failures

Health Verification Methods

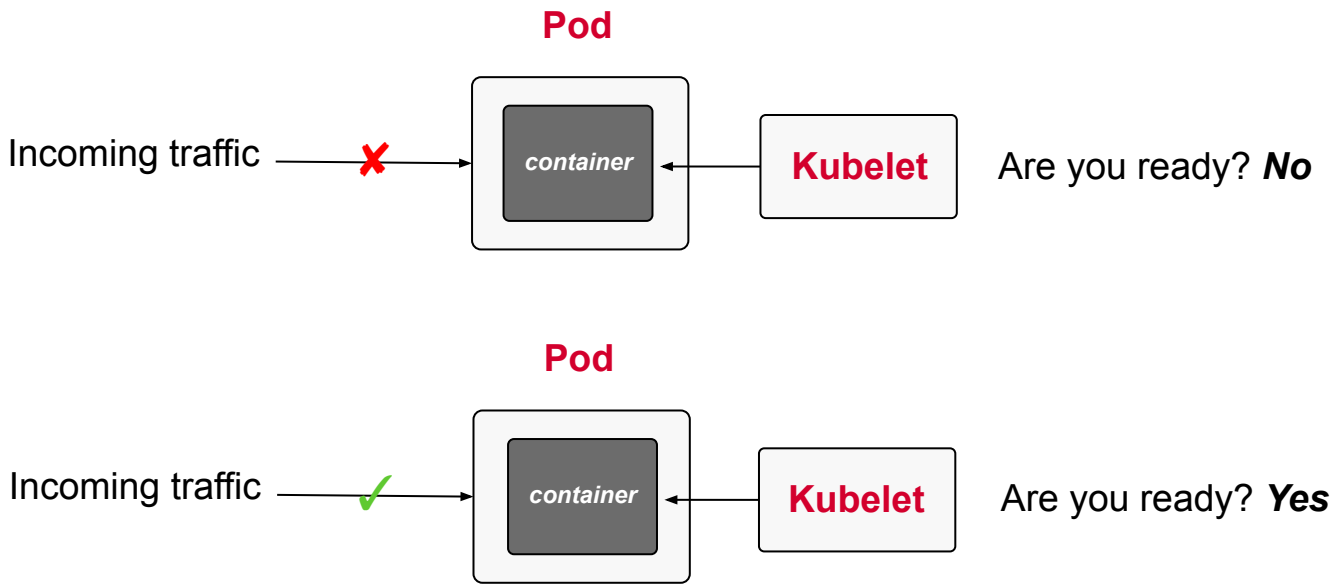
Method	Option	Description
Custom Command	`exec.command`	Executes a command inside of the container e.g. a cat command and checks its exit code. Kubernetes considers an zero exit code to be successful. A non-zero exit code indicates an error.
HTTP GET Request	`httpGet`	Sends an HTTP GET request to an endpoint exposed by the application. A HTTP response code in the range of 200 and 399 indicates success. Any other response code is regarded as an error.
TCP socket connection	`tcpSocket`	Tries to open a TCP socket connection to a port. If the connection could be established, the probing attempt was successful. The inability to connect is accounted for as an error.

Health Check Attributes

Attribute	Default Value	Description
`initialDelaySeconds`	`0`	Delay in seconds until first check is executed.
`periodSeconds`	`10`	Interval for executing a check (e.g., every 20 seconds).
`timeoutSeconds`	`1`	Maximum number of seconds until check operation times out.
`successThreshold`	`1`	Number of successful check attempts until probe is considered successful after a failure.
`failureThreshold`	`3`	Number of failures for check attempts before probe is marked failed and takes action.

Understanding Readiness Probes

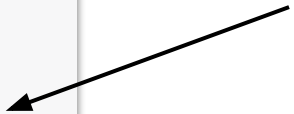
“Is application ready to serve requests?”



Defining a Readiness Probe

HTTP probes are very helpful for web applications

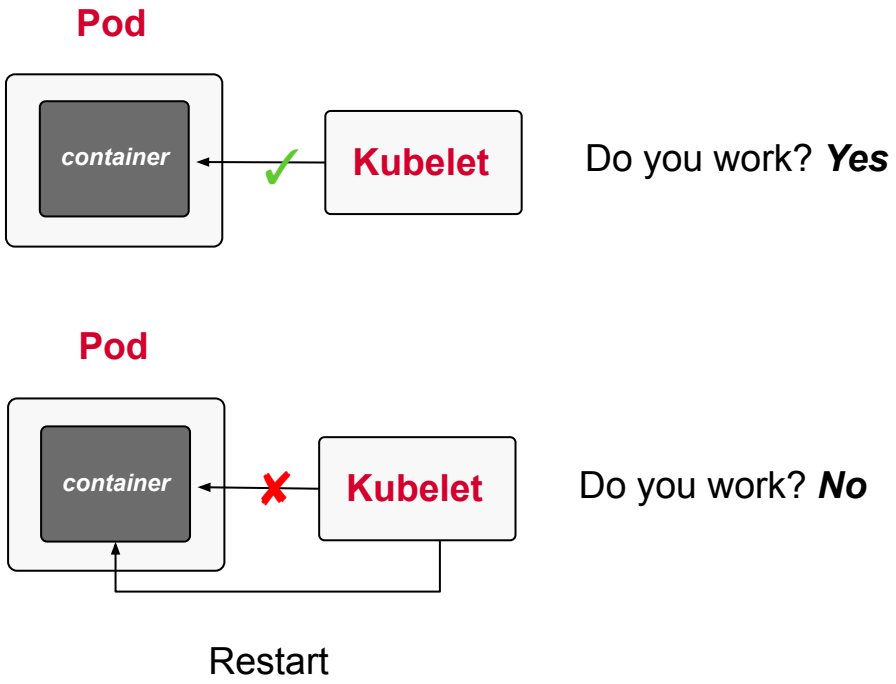
```
apiVersion: v1
kind: Pod
metadata:
  name: web-app
spec:
  containers:
  - name: web-app
    image: eshop:4.6.3
    readinessProbe:
      httpGet:
        path: /
        port: 8080
      initialDelaySeconds: 5
      periodSeconds: 2
```



Successful if HTTP status code is between 200 and 399

Understanding Liveness Probes

“Does the application still function without errors?”



Defining a Liveness Probe

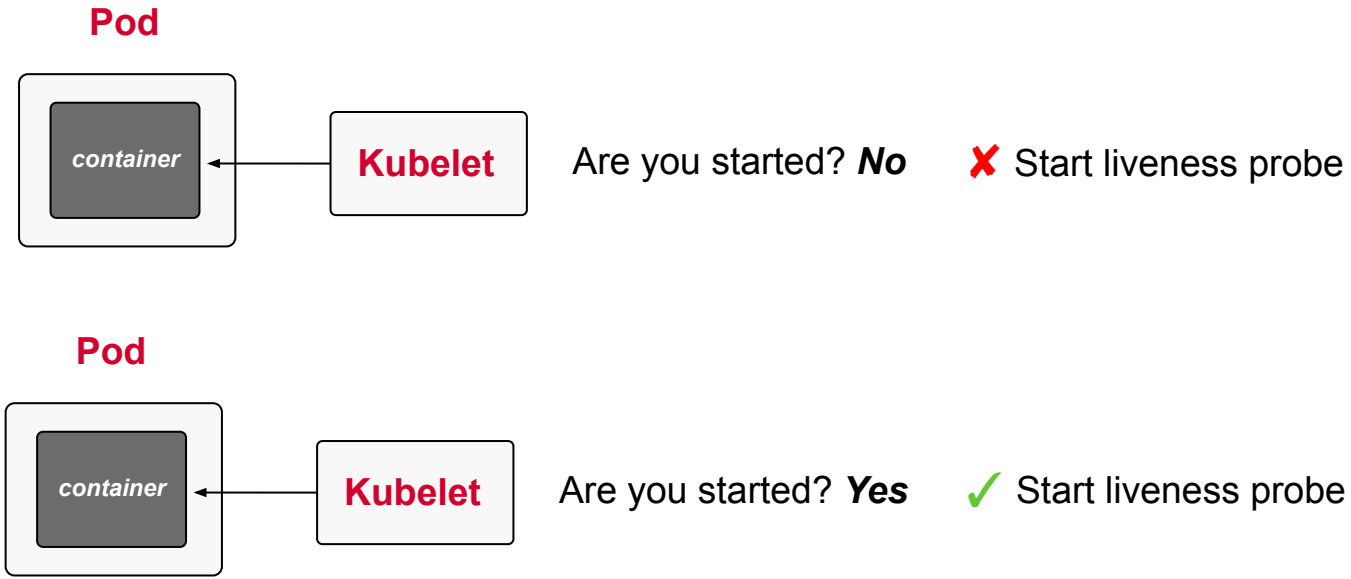
An event log can be queried with a custom command

```
apiVersion: v1
kind: Pod
metadata:
  name: web-app
spec:
  containers:
  - name: web-app
    image: eshop:4.6.3
    livenessProbe:
      exec:
        command:
        - cat
        - /tmp/healthy
      initialDelaySeconds: 10
      periodSeconds: 5
```

It makes sense to delay the initial check as the application to fully start up first

Understanding Startup Probes

“Legacy application may need longer to start. Hold off on probing.”



Defining a Startup Probe

TCP socket connection if exposed by application

```
apiVersion: v1
kind: Pod
metadata:
  name: startup-pod
spec:
  containers:
  - image: httpd:2.4.46
    name: http-server
    startupProbe:
      tcpSocket:
        port: 80
      initialDelaySeconds: 3
      periodSeconds: 15
```

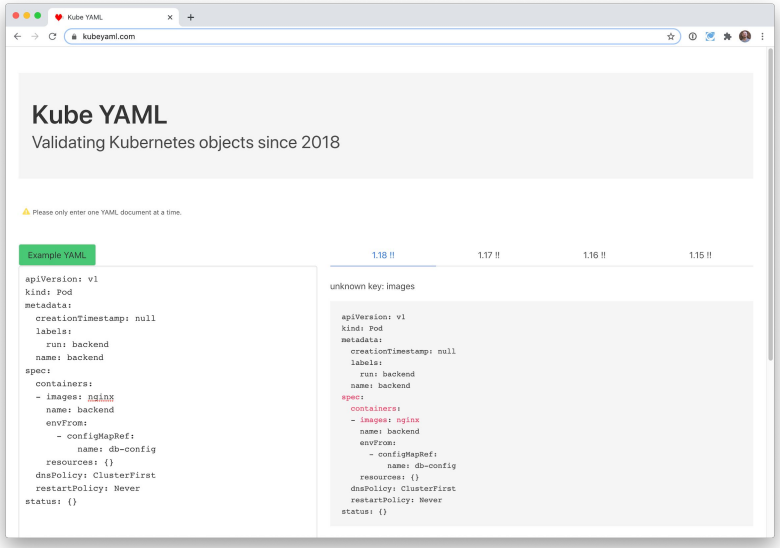
Tries to open a TCP socket connection to a port

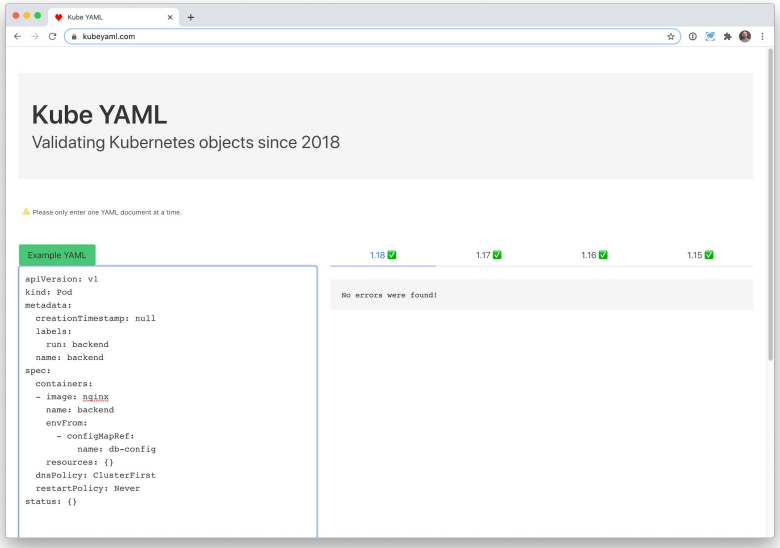
EXERCISE

Defining a Pod’s
Readiness and
Liveness Probe

Debugging YAML Manifests

Not available during exam but helpful for practice





Common Pod Error Statuses

Status	Root cause	Potential fix
`ImagePullBackOff` or `ErrImagePull`	Image could not be pulled from registry	Check correct image name, check that image name exists in registry, verify network access from node to registry, ensure proper
`CrashLoopBackOff`	Application or command run in container crashes	Check command executed in container, ensure that image can properly execute (e.g. by creating a container with Docker)
`CreateContainerConfigError`	ConfigMap or Secret references by container cannot be found	Check correct name of the configuration object, verify the existence of the configuration object in the namespace

Debugging Existing Pods

It's crucial to know how to debug and fix errors

```
$ kubectl get all
```

"What's running on a high-level?" *Pod xyz shows failure.*

```
$ kubectl describe pod xyz
```

"What exactly is the issue?" *Event shows* `CrashLoopBackOff`.

```
$ kubectl logs xyz
```

"Does an output indicate root cause?" *Misconfiguration in image.*

```
$ kubectl exec xyz -it --
/bin/sh
```

"Does config look correct?" *Directory is missing.*

EXERCISE

Fixing a
Misconfigured Pod

Q & A

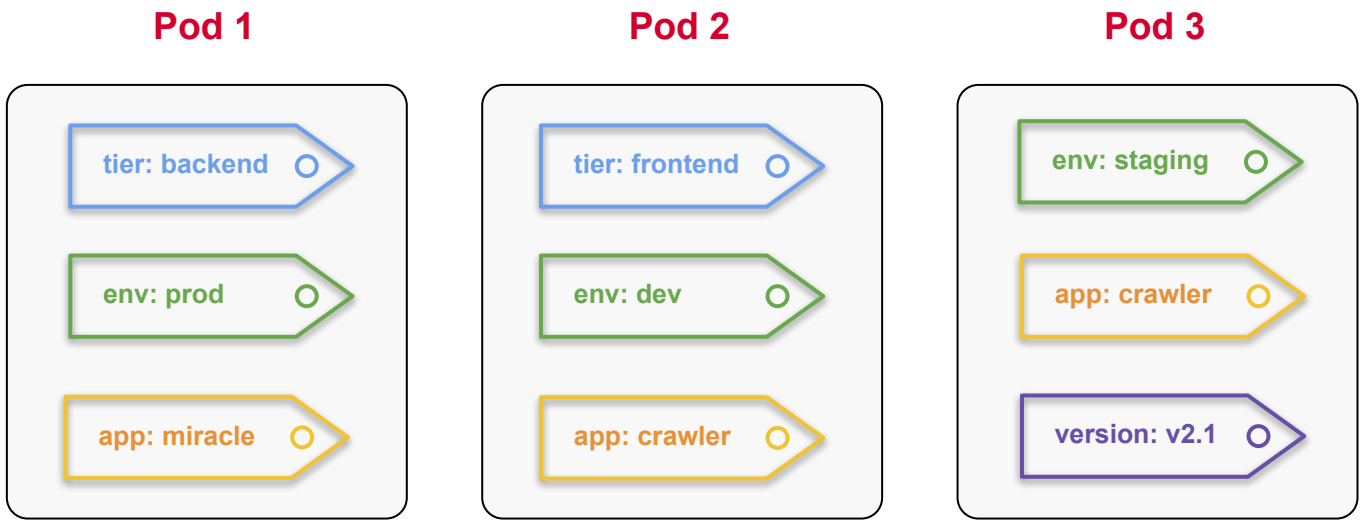
BREAK

Pod Design

Labels & Annotations, Deployments, Jobs and CronJobs

Purpose of Labels

Essential to querying, filtering and sorting Kubernetes objects



Assigning Labels

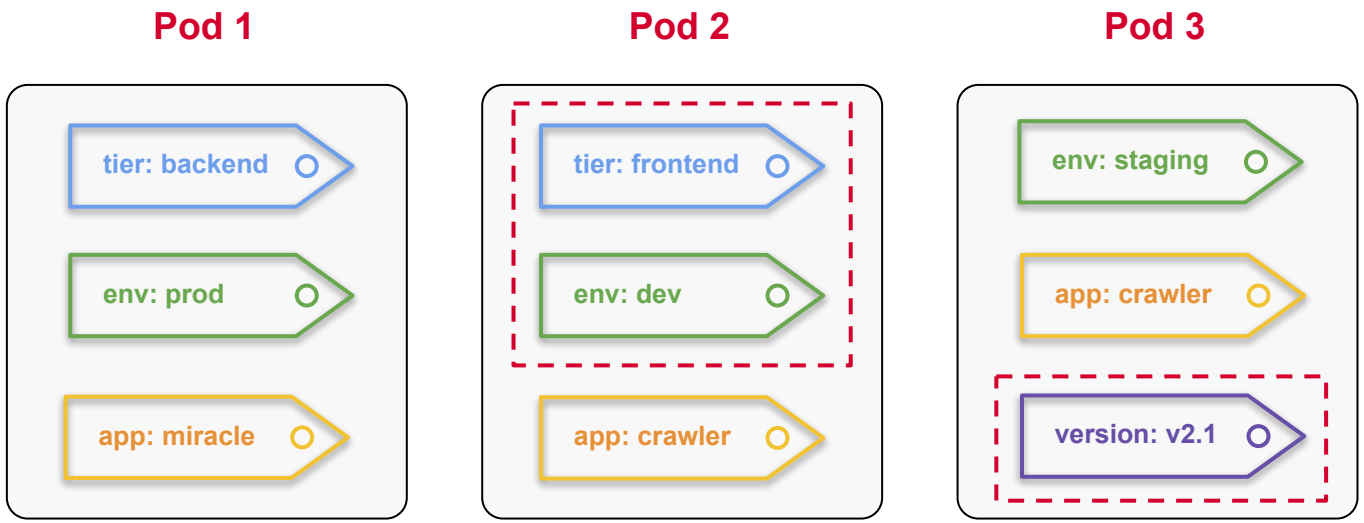
Defined in the `metadata` section of a Kubernetes object definition

```
apiVersion: v1
kind: Pod
metadata:
  name: pod1
  labels:
    tier: backend
    env: prod
    app: miracle
spec:
  ...
```

```
$ kubectl label pod nginx tier=backend
env=prod app=miracle
$ kubectl get pods --show-labels
NAME  ... LABELS
pod1  ... tier=backend,env=prod,app=miracle
```

Selecting Labels

Querying objects from the CLI or via `spec.selector`



Querying by CLI

You can specify equality-based and set-based requirements

```
# Tier is "frontend" AND is "development" environment
$ kubectl get pods  -l tier=frontend,env=dev --show-labels
NAME   ... LABELS
pod2   ... app=crawler,env=dev,tier=frontend

# Has the label with key "version"
$ kubectl get pods  -l version --show-labels
NAME   ... LABELS
pod3   ... app=crawler,env=staging,version=v2.1

# Tier is in set "frontend" or "backend" AND is "development" environment
$ kubectl get pods  -l 'tier in (frontend,backend),env=dev' --show-labels
NAME   ... LABELS
pod2   ... app=crawler,env=dev,tier=frontend
```

Selecting Resources in YAML

Grouping resources by label selectors

Equality-based

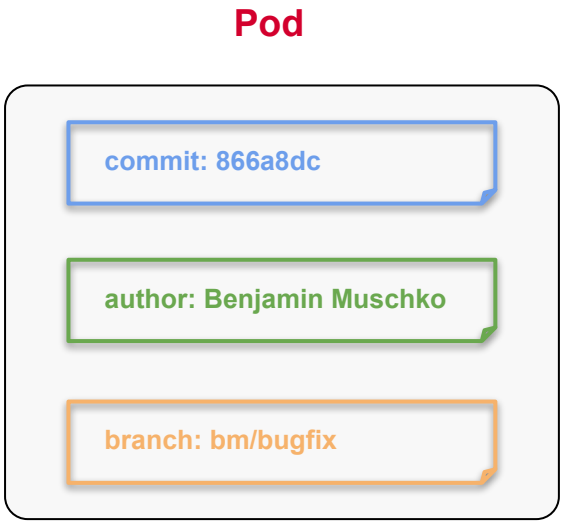
```
apiVersion: v1
kind: Service
metadata:
  name: app-service
  ...
spec:
  ...
  selector:
    tier: frontend
    env: dev
```

Equality- and set-based

```
apiVersion: batch/v1
kind: Job
metadata:
  name: my-job
spec:
  ...
  selector:
    matchLabels:
      version: v2.1
    matchExpressions:
      - {key: tier, operator: In,↲
         values: [frontend,backend]}
```

Purpose of Annotations

Descriptive metadata without the ability to be queryable



Assigning Annotations

Defined in the `metadata` section of a Kubernetes object definition

```
apiVersion: v1
kind: Pod
metadata:
  name: my-pod
  annotations:
    commit: 866a8dc
    author: 'Benjamin Muschko'
    branch: 'bm/bugfix'
spec:
  ...
```

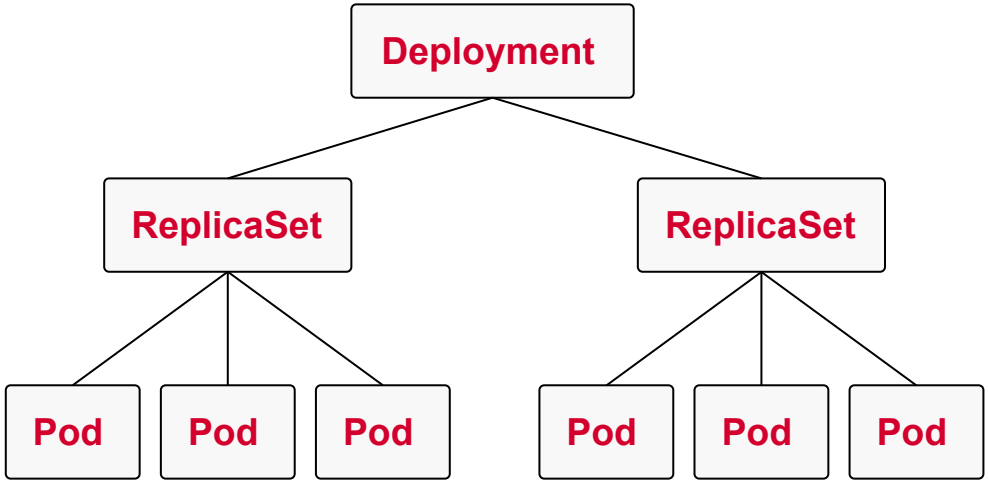
```
$ kubectl annotate pod nginx
commit='866a8dc' author='Benjamin Muschko'
branch='bm/bugfix'
$ kubectl describe pods my-pod
Name:         my-pod
Namespace:    default
...
Annotations:  author: Benjamin Muschko
              branch: bm/bugfix
              commit: 866a8dc
...
```

EXERCISE

Defining and
Querying Labels
and Annotations

Understanding Deployments

Scaling and replication features for a set of Pods



Creating a Deployment

The `create` command supports `replicas` option with 1.19+

```
$ kubectl create deployment my-deploy --image=nginx --replicas=3↵
  --dry-run=client -o yaml > deploy.yaml
$ vim deploy.yaml
$ kubectl create -f deploy.yaml
deployment.apps/my-deploy created
```

Creating a Deployment

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app: my-deploy
  name: my-deploy
spec:
  replicas: 3
  selector:
    matchLabels:
      app: my-deploy
  template:
    metadata:
      labels:
        app: my-deploy
    spec:
      containers:
      - image: nginx
        name: nginx
```

The number of Pods running a specific set of containers

Selects the Pods for this deployment

The labels of the Pods

Inspecting Deployment State

Indicator between desired state and actual state

```
$ kubectl get deployments
NAME                          READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/my-deploy     3       3            3           25m
```

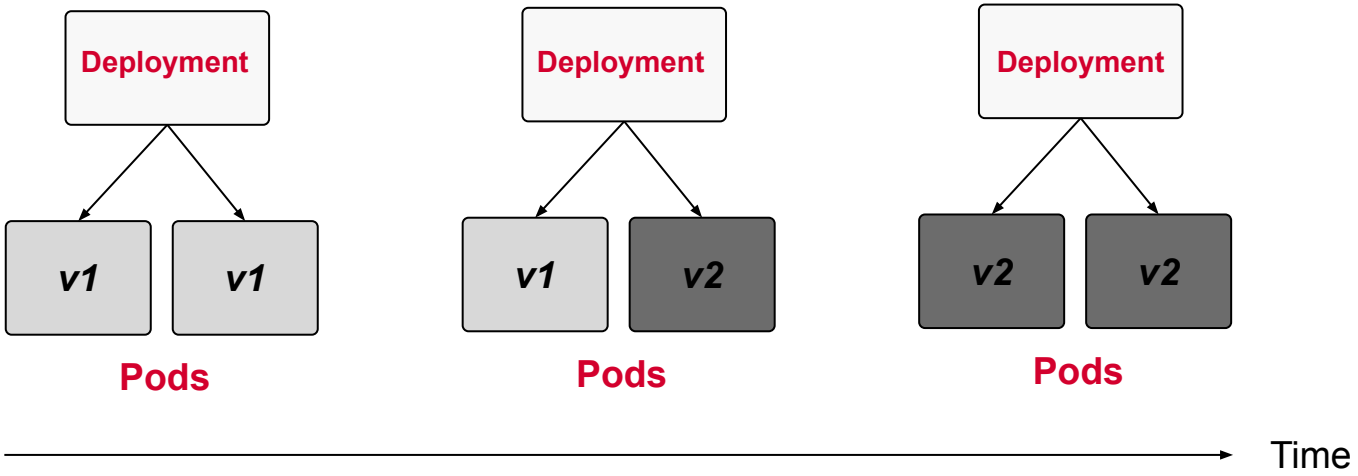
Underlying Replication Feature

Automatically created by Deployment, not meant to be modified

```
$ kubectl get replicasets
NAME                    DESIRED   CURRENT   READY   AGE
my-deploy-7786f96d67    3         3         3       6h

$ kubectl describe deploy my-deploy
...
OldReplicaSets:  <none>
NewReplicaSet:   my-deploy-7786f96d67 (3/3 replicas created)
...

$ kubectl describe replicasets my-deploy-7786f96d67
...
Controlled By:  Deployment/my-deploy
...
```

Rolling Updates

“Look ma, shiny new features. Let’s deploy them to production!”



Rollout Revision Log

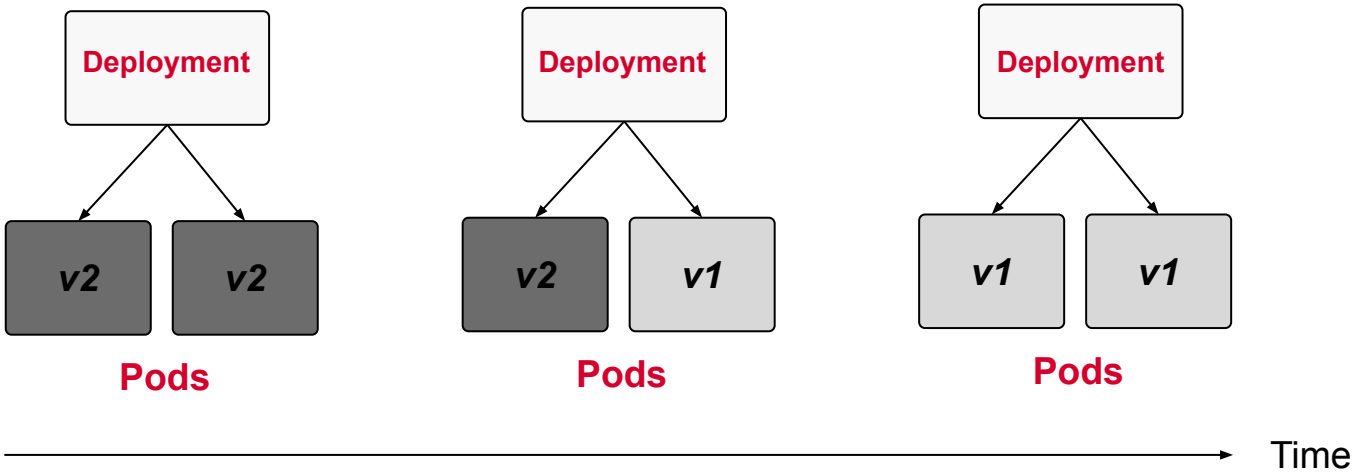
```
# Check initial deployment revisions
$ kubectl rollout history deployments my-deploy
deployment.extensions/my-deploy
REVISION  CHANGE-CAUSE
1         <none>

# Make a change to the deployment
$ kubectl edit deployments my-deploy

# Revision history indicates changed version
$ kubectl rollout history deployments my-deploy
deployment.extensions/my-deploy
REVISION  CHANGE-CAUSE
1         <none>
2         <none>
```

Rendering Revision Details

```
$ kubectl rollout history deployments my-deploy --revision=2
deployment.extensions/my-deploy with revision #2
Pod Template:
  Labels:    app=my-deploy
    pod-template-hash=1365642048
  Containers:
   nginx:
    Image:   nginx:latest
    Port:    <none>
    Host Port:   <none>
    Environment: <none>
    Mounts:  <none>
  Volumes:   <none>
```

Rolling Back

“Bug in the application. Let’s revert to the previous version!”

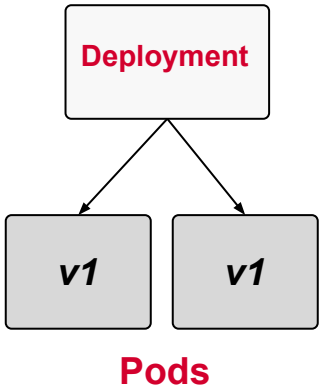


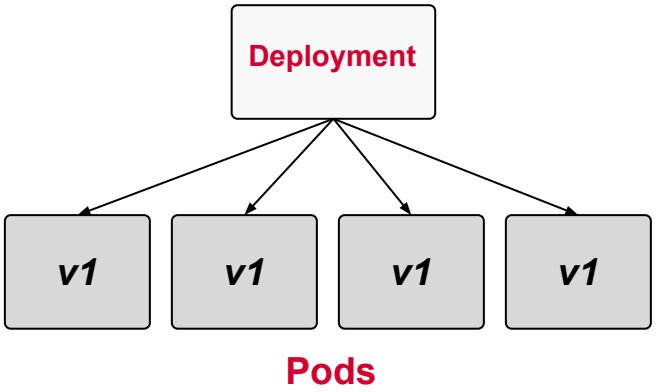
Rolling Back to a Revision

```
# Roll back to previous revision
$ kubectl rollout undo deployments my-deploy
deployment.extensions/my-deploy

# Check rollout status
$ kubectl rollout status deployments my-deploy
deployment "my-deploy" successfully rolled out

# Revision history indicates changed version
$ kubectl rollout history deployments my-deploy
deployment.extensions/my-deploy
REVISION  CHANGE-CAUSE
2         <none>
3         <none>
```

Manually Scaling a Deployment

“Load is increasing. We need to scale up the application.”



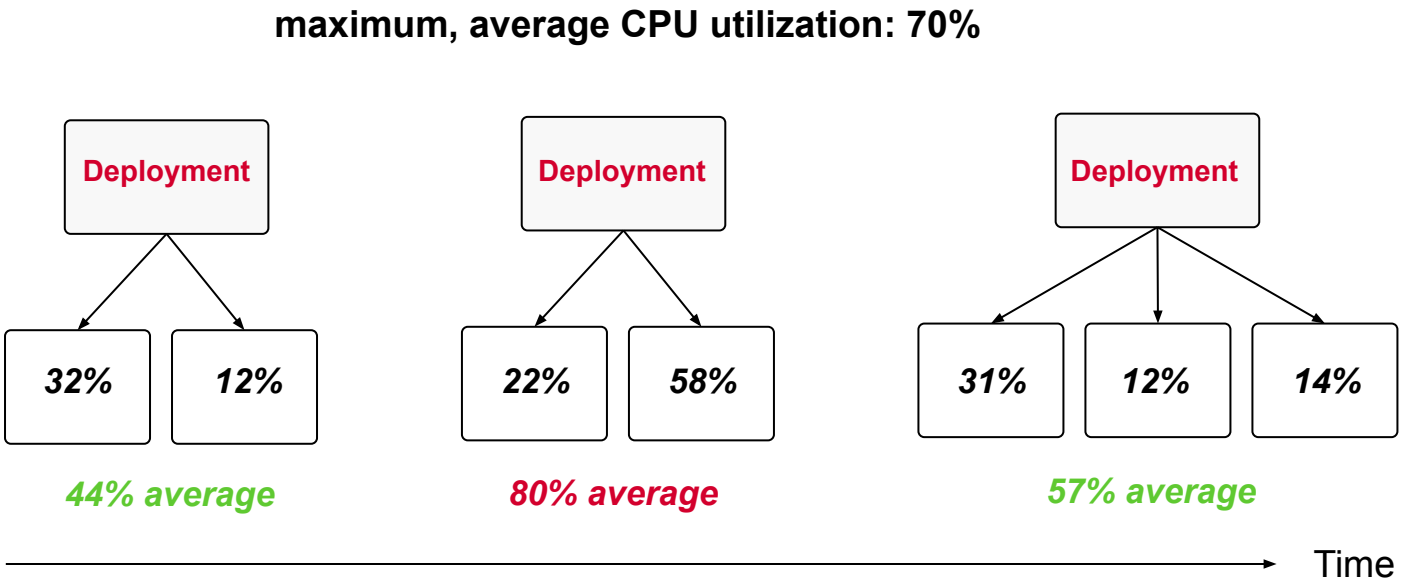


Providing a Specific # of Replicas

```
# Check current deployment replicas
$ kubectl get deployments my-deploy
NAME         READY   UP-TO-DATE   AVAILABLE   AGE
my-deploy    2       2            2           9h

# Scaling from 2 to 4 replicas
$ kubectl scale deployment my-deploy --replicas=4
deployment.extensions/my-deploy scaled

# Check the changed deployment replicas
$ kubectl get deployment my-deploy
NAME         READY   UP-TO-DATE   AVAILABLE   AGE
my-deploy    4       4            4           9h
```

Autoscaling a Deployment

“Don’t make me think. Autoscale based on CPU utilization.”



Create Horizontal Pod Autoscaler

```
# Maintain average CPU utilization across all Pods of 70%
$ kubectl autoscale deployments my-deploy --cpu-percent=70 ↲
  --min=1 --max=10
horizontalpodautoscaler.autoscaling/my-deploy autoscaled

# Check the current status of autoscaler
$ kubectl get hpa my-deploy
NAME         REFERENCE               TARGETS          MINPODS ↲
MAXPODS   REPLICAS   AGE
my-deploy   Deployment/my-deploy   0%/70%           1 ↲
10        4          23s
```

EXERCISE

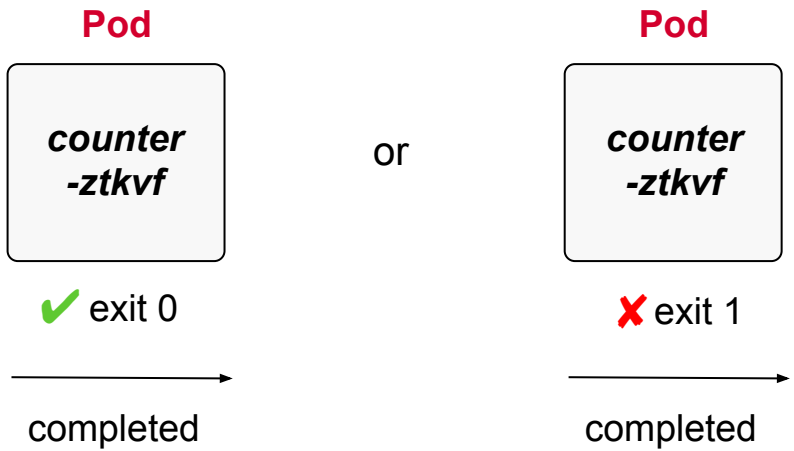
Performing Rolling Updates and Scaling a Deployment

Pods vs. Jobs vs. CronJobs

Infinite vs. one-time vs. periodic processes

Understanding Jobs

Job is complete when specific number of completions is reached



Creating a Job (imperative)

"Increment a counter and render its value on the terminal"

```
$ kubectl create job counter --image=nginx -- /bin/sh -c↵
  'counter=0; while [ $counter -lt 3 ]; do↵
  counter=$((counter+1)); echo "$counter"; sleep 3; done;'
job.batch/counter created
```

Creating a Job (declarative)

```
apiVersion: batch/v1
kind: Job
metadata:
  name: counter
spec:
  completions: 1
  parallelism: 1
  backoffLimit: 6
  template:
    spec:
      restartPolicy: OnFailure
      containers:
      - args:
        - /bin/sh
        - -c
        - ...
        image: nginx
        name: counter
```

Define # of successful completions and whether task should be run in parallel

How many times do we try before Job is marked failed?

Restart Pod upon failure or start a new Pod

Creating a Job (mixed approach)

The `create` command does not provide parameters yet

```
$ kubectl create job counter --image=nginx --dry-run=client↲
  -o yaml -- /bin/sh -c 'counter=0; while [ $counter -lt 3 ];↲
  do counter=$((counter+1)); echo "$counter"; sleep 3; done;'↲
  > job.yaml
$ vim job.yaml
$ kubectl create -f job.yaml
job.batch/counter created
```

Different Types of Jobs

```
spec.completions: x
spec.parallelism: y
```

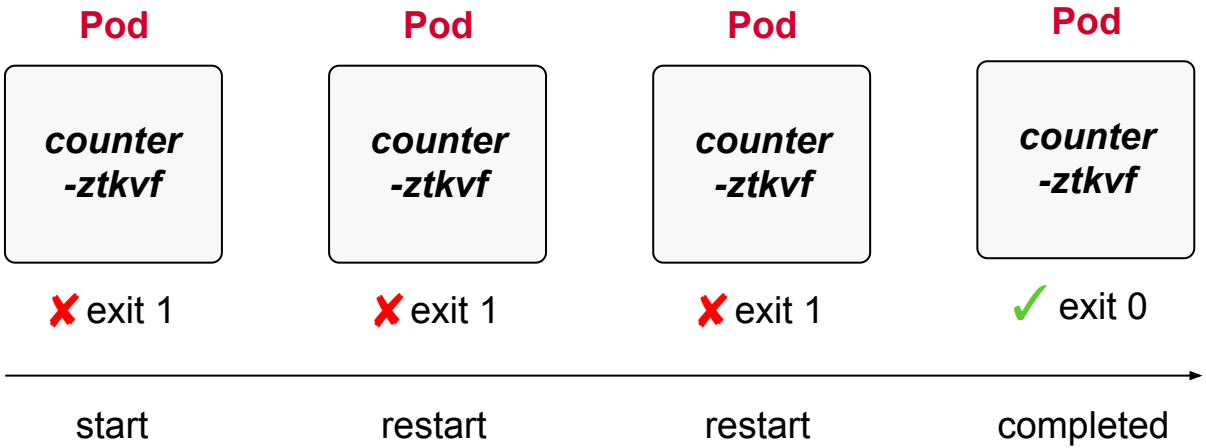
Type	Completion criteria
Non-parallel	Complete as soon as its Pod terminates successfully
Parallel with fixed completion count	Complete when specified number of tasks finish successfully
Parallel with a work queue	Once at least one Pod has terminated with success and all Pods are terminated

Inspecting Jobs

```
# List all jobs
$ kubectl get jobs
NAME      DESIRED   SUCCESSFUL   AGE
counter   1         1            3m

# Identify correlating Pods
$ kubectl get pods
NAME                        READY   STATUS      RESTARTS   AGE
counter-924lc               0/1     Completed   0          22m

# Get the logs of the Pod
$ kubectl logs counter-924lc
1
2
3
```

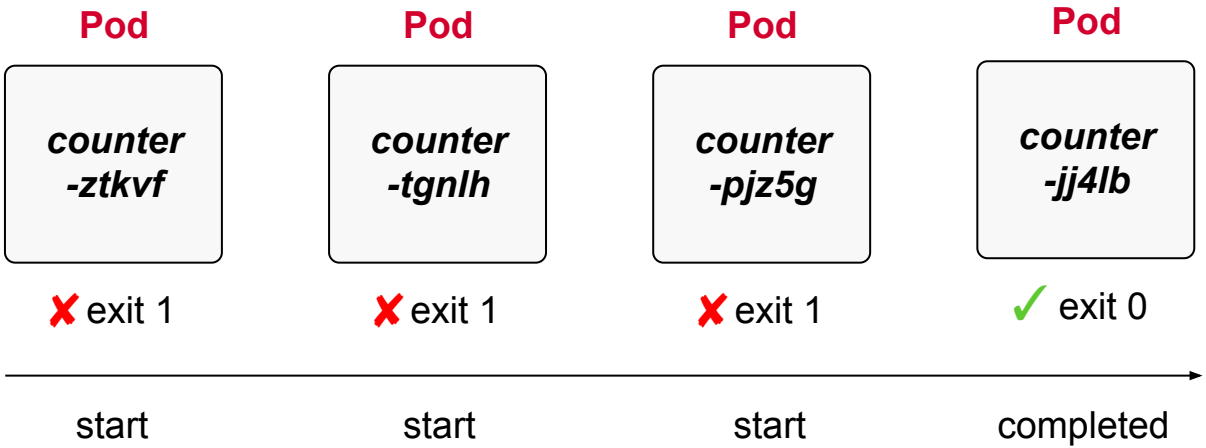
Restarting a Container on Failure

`spec.template.spec.restartPolicy: OnFailure`



New Pod on Failure

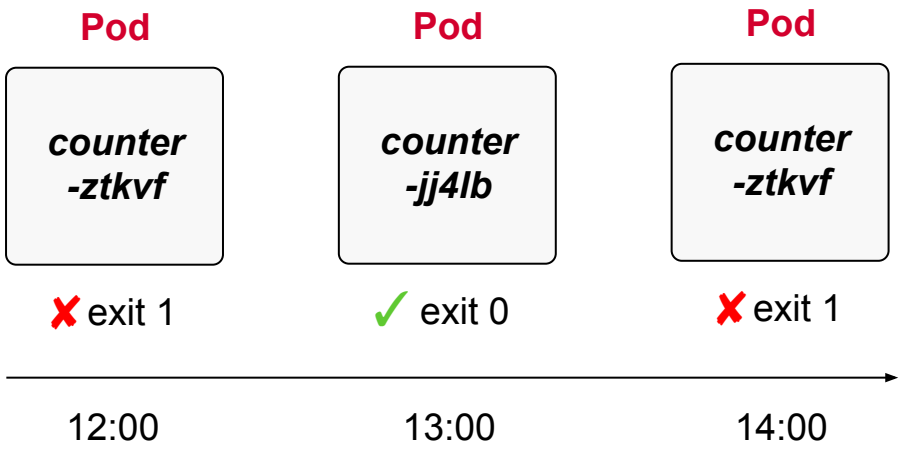
`spec.template.spec.restartPolicy: Never`



Understanding CronJobs

Similar to Job but task is run on a predefined schedule

```
spec.schedule: "0 * * * *"
```



Creating a CronJob (imperative)

"Every hour increment a counter and render its value on the terminal"

```
$ kubectl create cronjob counter --image=nginx↲
  --schedule="*/1 * * * *" -- /bin/sh -c 'counter=0;↲
  while [ $counter -lt 3 ]; do counter=$((counter+1));↲
  echo "$counter"; sleep 3; done;'
job.batch/counter created
```

Creating a CronJob (declarative)

```
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: counter
spec:
  schedule: "*/1 * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          restartPolicy: Never
          containers:
          - args:
            - /bin/sh
            - -c
            - ...
            image: nginx
            name: counter
```

The crontab expression used to run CronJob periodically

Run in a new Pod

Inspecting CronJobs

```
# List all cron jobs
$ kubectl get cronjobs
NAME      SCHEDULE      SUSPEND   ACTIVE   LAST SCHEDULE   AGE
counter   */1 * * * *   False     0        26s             1h

# Watch Pods executing the scheduled command
$ kubectl get jobs --watch
NAME                  COMPLETIONS   DURATION   AGE
counter-1557334380    1/1           3s         2m24s
counter-1557334440    1/1           3s         84s
counter-1557334500    1/1           3s         24s
counter-1557334560    0/1           0s         0s
counter-1557334560    0/1           0s         0s
counter-1557334560    1/1           4s         4s
counter-1557334380    1/1           3s         3m10s
```

EXERCISE

Creating a
Scheduled
Container Operation

Q & A

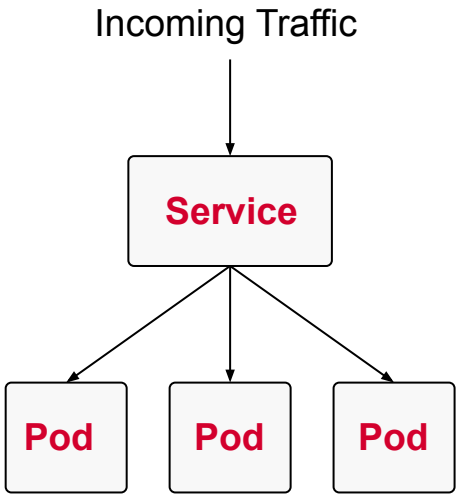
BREAK

Services & Networking

Services and Network Policies

Understanding Services

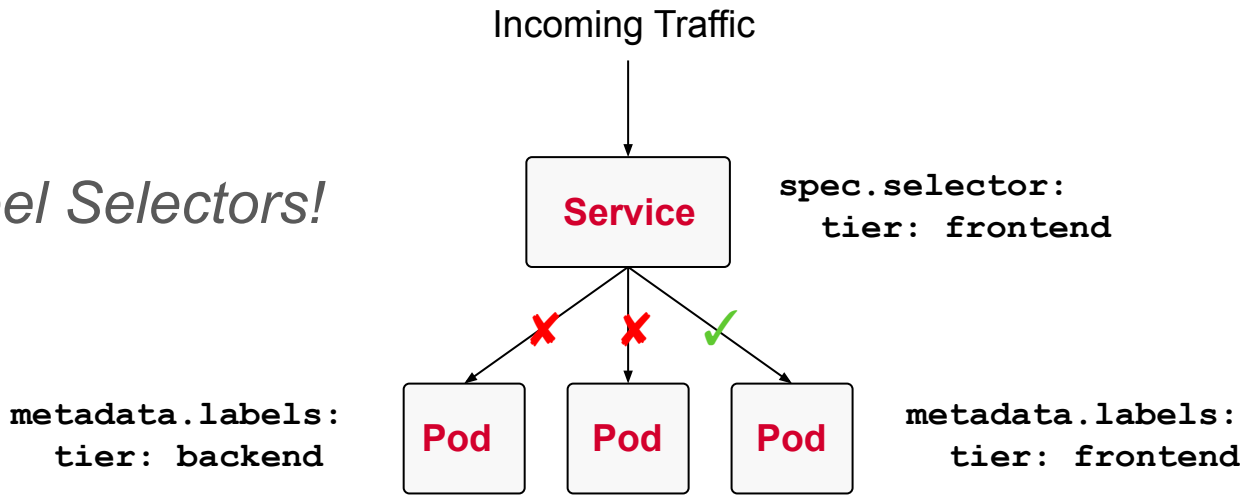
Enables network access for a set of Pods



Request Routing

“How does a service decide which Pod to forward the request to?”

Label Selectors!



Creating a Service (imperative)

“Create a Service with explicit type”

```
$ kubectl create service clusterip nginx --tcp=80:80
service/nginx created
```

Creating a Service (imperative)

“Create a Pod and expose it with a Service”

```
$ kubectl run nginx --image=nginx --port=80 --expose
service/nginx created
pod/nginx created
```

Creating a Service (declarative)

```
apiVersion: v1
kind: Service
metadata:
  name: nginx
spec:
  selector:
    tier: frontend
  ports:
  - port: 3000
    protocol: TCP
    targetPort: 80
  type: ClusterIP
```

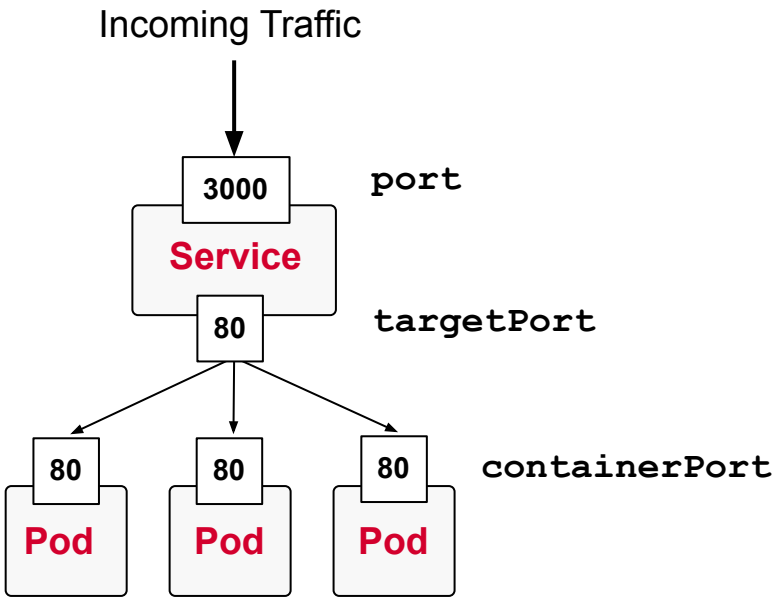
Determines the Pod(s) for routing traffic

Maps incoming port to port of the Pod

Specifies how to expose the Service (inside/outside of cluster or LoadBalancer)

Port Mapping

“How to map the service port to the container port in Pod?”



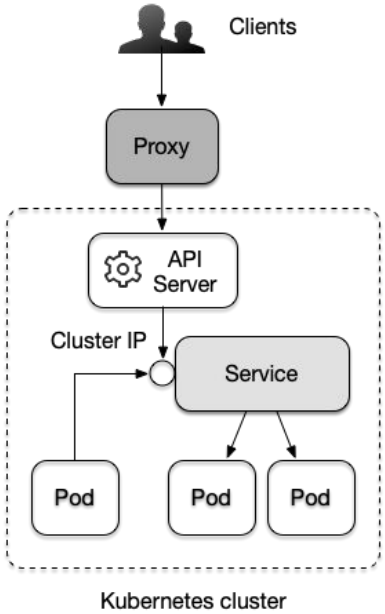
Different Types of Services

Type	Behavior
`ClusterIP`	Exposes the service on a cluster-internal IP. Only reachable from within the cluster.
`NodePort`	Exposes the service on each node's IP at a static port. Accessible from outside of the cluster.
`LoadBalancer`	Exposes the service externally using a cloud provider's load balancer.
`ExternalName`	Map a Service to a DNS name.

```
spec.type: xyz
```

ClusterIP Service Type

Only reachable from within the cluster or API service via proxy

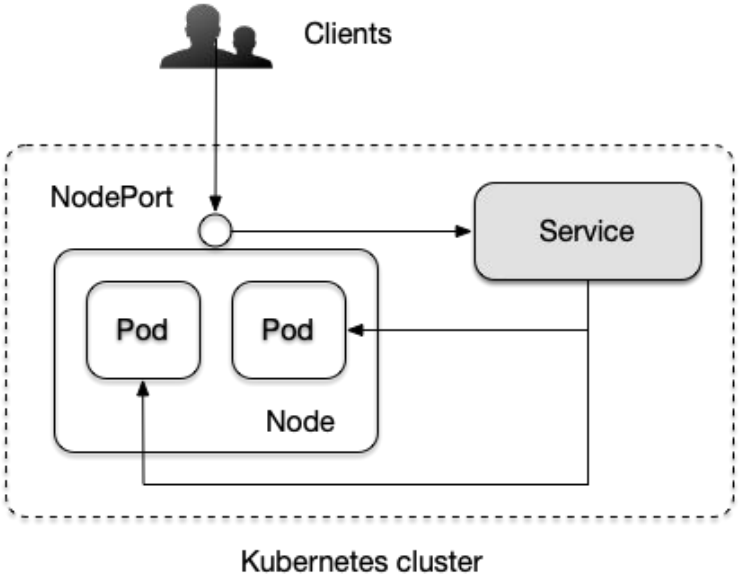


Exposes the Service on a cluster-internal IP address.

Can also be reached by proxy from outside of the cluster using the `kubectl proxy` command.

NodePort Service Type

Accessible from outside of the cluster

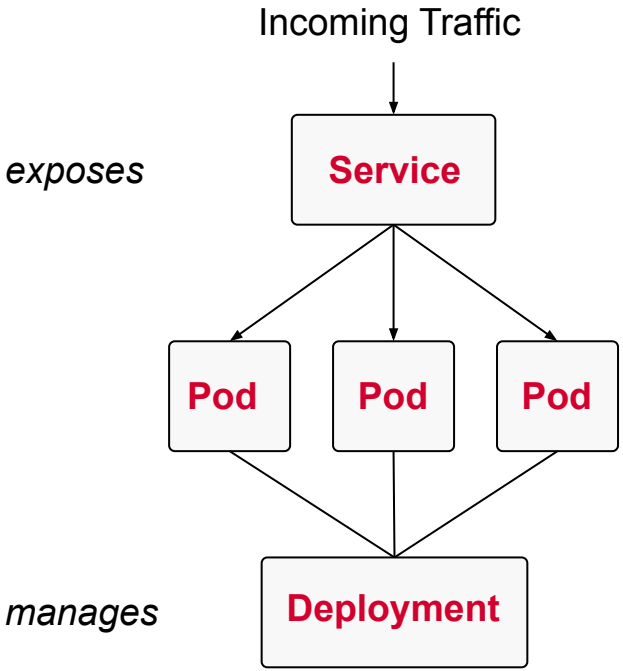


Node's IP address + port number in the range of 30000 and 32767, assigned automatically upon the creation of the Service.

Inspecting a Service

```
# Only reachable from within the cluster
$ kubectl get service nginx
NAME    TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)    AGE
nginx   ClusterIP   10.105.201.83   <none>        80/TCP     3h

# Accessible from outside of the cluster
$ kubectl get service nginx
NAME    TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)          AGE
nginx   NodePort    10.105.201.83   <none>        80:30184/TCP     3h
```

Deployments and Services



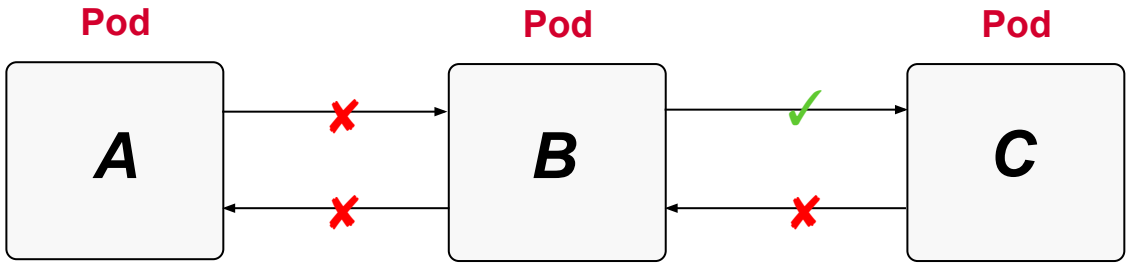
Two distinct concepts that complement each other

EXERCISE

Routing Traffic to Pods from Inside and Outside of a Cluster

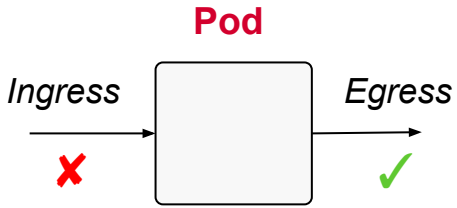
Understanding Network Policies

“Network Policies control traffic from and to the Pod”



Network Policy Rules

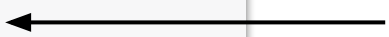
Which Pod does the rule apply to? ✔



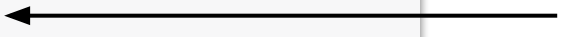
Which direction of traffic?
Who is allowed?

Creating a Network Policy

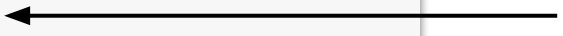
```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: my-network-policy
spec:
  podSelector:
    matchLabels:
      tier: frontend
  policyTypes:
  - Ingress
  - Egress
  ingress:
  - from:
    ...
  egress:
  - to:
    ...
```



Label selection for Pods



Inbound/outbound traffic



Who can connect to Pod?
Where can Pod connect to?

General Rule of Thumb

Start by denying all access and allowing access as needed

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

Applies to all Pods

Inbound/outbound traffic is blocked

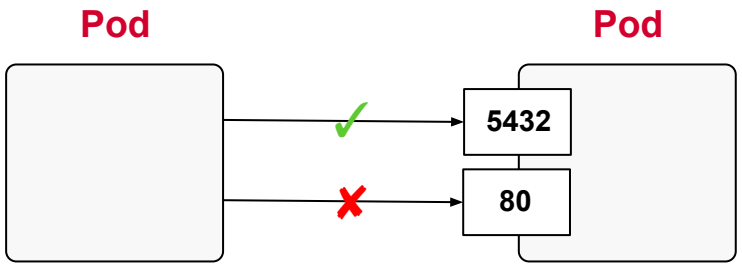
Behavior of `from`/`to` Selectors

Select by Namespace, Pod and IP address

```
...
ingress:
- from:
  - podSelector:
      matchLabels:
        tier: backend
...
```

Allow incoming traffic from Pod that matches the label `tier=backend`

Restricting Access to Ports

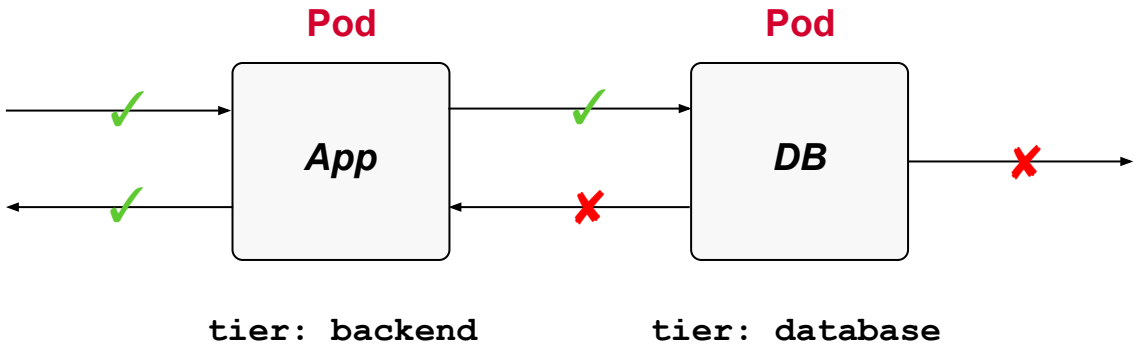


By default all ports are open

```
...
ingress:
- from:
  - podSelector:
      matchLabels:
        tier: backend
  ports:
  - protocol: TCP
    port: 5432
...
```

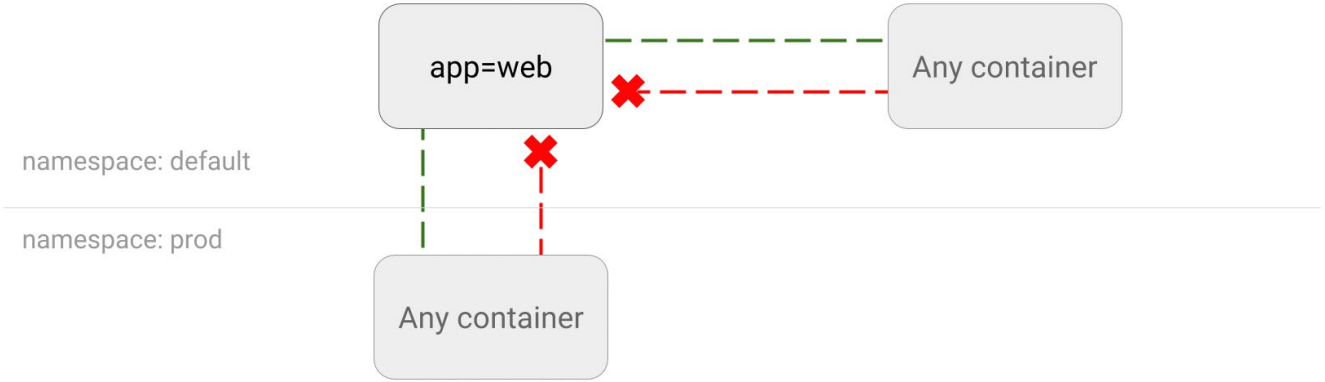
Representative Use Case

“Application makes request to database but database cannot make any outgoing requests.”



Additional Learning Resource

Network Policies explained by use case and visualization



https://github.com/ahmetb/kubernetes-network-policy-recipes

EXERCISE

Restricting Access
to and from a Pod

Q & A

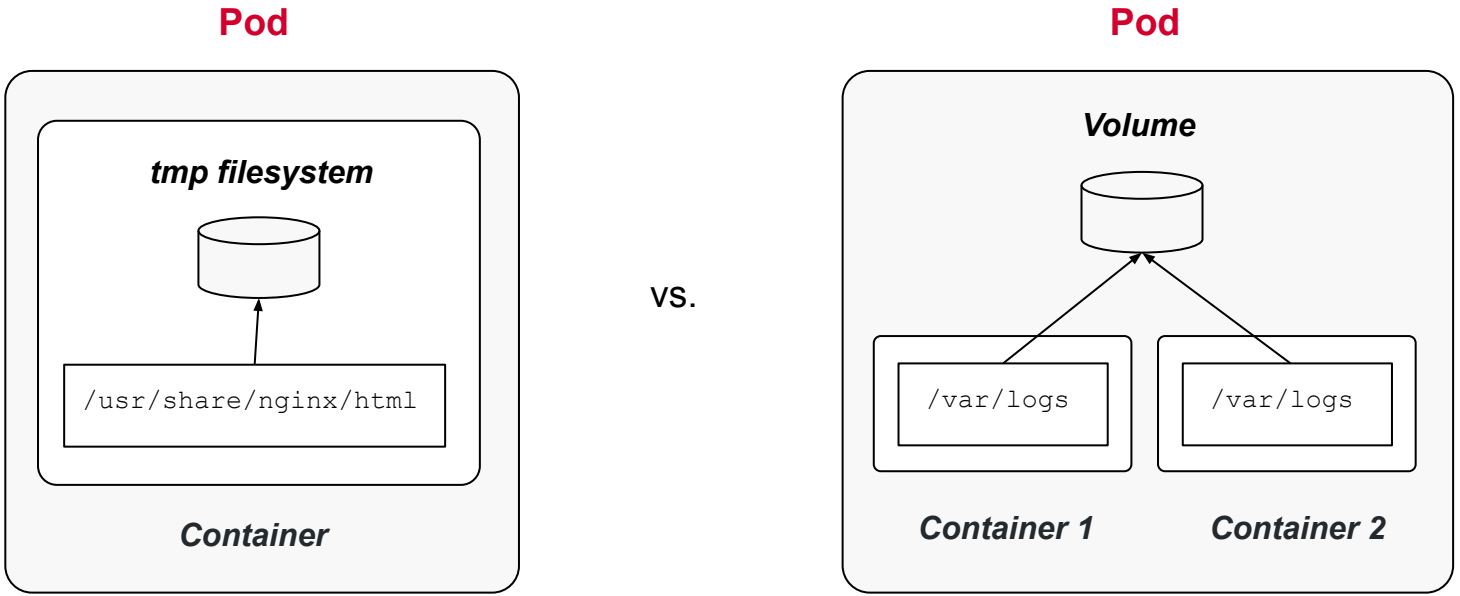
BREAK

State Persistence

Persistent Volumes and Claims

Understanding Volumes

Persist data that outlives a Pod restart



Types of Volumes

Type	Description
`emptyDir`	Empty directory in Pod. Only persisted for the lifespan of a Pod.
`hostPath`	File or directory from the host node's filesystem into your Pod.
`configMap, secret`	Provides a way to inject configuration data and secrets into Pods.
`nfs`	An existing NFS (Network File System) share to be mounted into your Pod. Preserves data after Pod restart.
Cloud provider solutions	Provider-specific implementation for AWS, GCE or Azure.

Creating a Volume

```
apiVersion: v1
kind: Pod
metadata:
  name: my-container
spec:
  volumes:
  - name: logs-volume
    emptyDir: {}
  containers:
  - image: nginx
    name: my-container
    volumeMounts:
    - mountPath: /var/logs
      name: logs-volume
```

Define Volume with a type

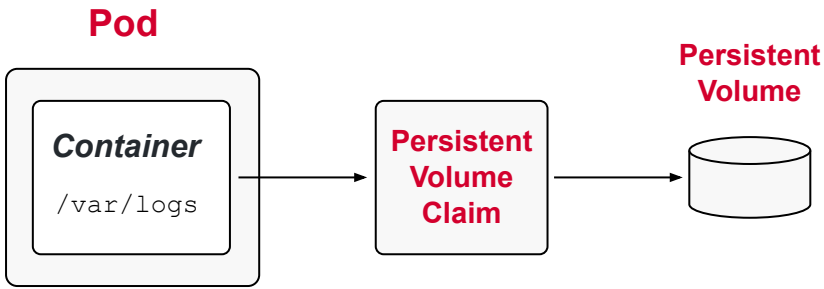
Mount Volume to a path

Using a Volume

```
# Create Pod with mounted Volume
$ kubectl create -f pod-with-vol.yaml
pod/my-container created

# Shell into container and use Volume
$ kubectl exec -it my-container -- /bin/sh
# cd /var/logs
# pwd
/var/logs
# touch app-logs.txt
# ls
app-logs.txt
```

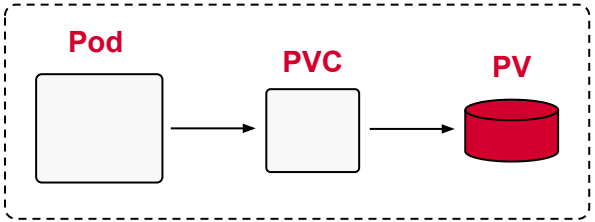
Understanding PersistentVolumes

Persist data that outlives a Pod, node, or cluster restart



Creating a PersistentVolume

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv
spec:
  capacity:
    storage: 512m
  accessModes:
    - ReadWriteOnce
  hostPath:
    path: /data/config
```



Defines a specific storage capacity

Read and/or write access
How many nodes can access volume?

Access Mode & Reclaim Policy

Configuration options for PersistentVolume

Access Mode

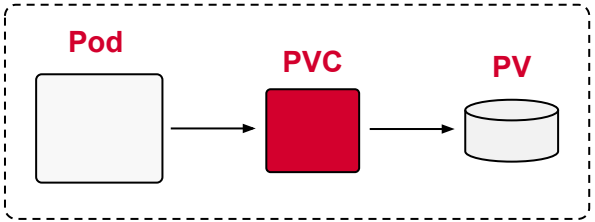
Type	Description
`ReadWriteOnce`	Read-write access by a single node.
`ReadOnlyMany`	Read-only access by many nodes.
`ReadWriteMany`	Read-write access by many nodes.

Reclaim Policy

Type	Description
`Retain`	Default. When PVC is deleted, PV is “released” and can be reclaimed.
`Delete`	Deletion removes PV and associated storage.
`Recycle`	Deprecated. Use dynamic binding instead.

Creating a Claim

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 256m
```

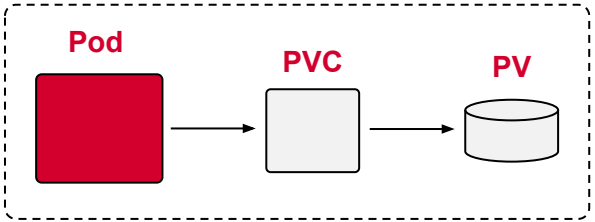


Read and/or write access
How many nodes can access volume?

Defines a specific storage capacity

Mounting a Claim

```
apiVersion: v1
kind: Pod
metadata:
  creationTimestamp: null
  name: app
spec:
  volumes:
    - name: configpvc
      persistentVolumeClaim:
        claimName: pvc
  containers:
  - image: nginx
    name: app
    volumeMounts:
      - mountPath: "/data/app/config"
        name: configpvc
```



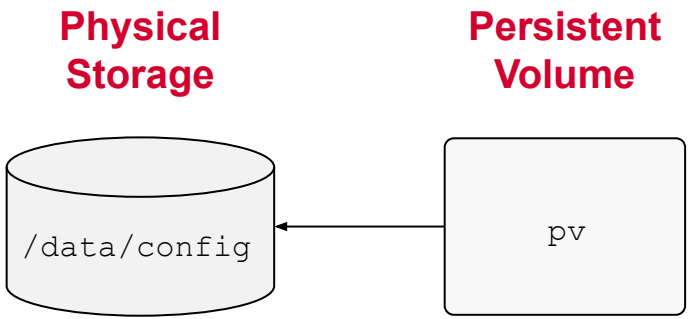
References the Volume with the claim name

Mounts Volume to path

Static Provisioning

Requires the physical storage to exist before PersistentVolume

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv
spec:
  capacity:
    storage: 512m
  accessModes:
    - ReadWriteOnce
  storageClassName: shared
  hostPath:
    path: /data/config
```



Dynamic Provisioning

Creates PersistentVolume object automatically via storage class

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: standard
provisioner: kubernetes.io/aws-ebs
```

```
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: pvc
spec:
  accessModes:
    - ReadWriteMany
  resources:
    requests:
      storage: 256m
  storageClassName: standard
```

EXERCISE

Creating a
Persistent Volume
with Static Binding

Q & A

Summary & Wrap Up

Last words of advice...

Gaining confidence

- Run through practice exams as often as you can
- Read through online documentation start to end
- Know your tools (especially vim, bash, YAML)
- Pick time you are most comfortable, get enough sleep
- Take your first attempt easy but give it your best

Q & A

O'REILLY®

Thank you