Kubernetes Workshop

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Contents

1 Prerequiments

You need to feel good with Command Line Interface. You should understand what Docker is.

- Workstation with Linux or OSX recommended.
- Software
  - k3s
  - Kubernetes CLI
  - Docker
- Tools
  - jq (stedolan.github.io/jq/)
- Good to have
  - hub.docker.com account or alternative docker repository

1.1 How to install

- K3S - github.com/k3s-io/k3s
- Kubernes CLI - kubernetes.io/docs/tasks/tools/

1.2 Verify the setup

```
$ k3d cluster create --port "8080:8080@loadbalancer" \
                     --port "8000:80@loadbalancer" \
                     'k8s-w10i-workshop'

$ kubectl config use-context k3d-k8s-w10i-workshop

$ kubectl cluster-info

Kubernetes control plane is running at https://0.0.0.0:60602
CoreDNS is running at https://...
Metrics-server is running at https://...
```

1.3 Kubernetes CLI Basics

Let's learn first some basics regarding the *kubectl*:

```
kubectl get <ARTIFACT>
kubectl describe <ARTIFACT>
```

From the kubect ref kubernetes.io/docs/reference/kubectl/overview:

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

1. List the nodes (underlaying machines or virualmachines running k8s):

```
$ kubectl get nodes
```

What the names of our nodes are? . . .

2. Let's learn more about the node:

```
# the name of the node you saw from previous
# command
$ kubectl get nodes k3d-k8s-w10i-workshop-server-0
$ kubectl get nodes k3d-k8s-w10i-workshop-server-0 -o wide

# notice:
#   most of services have shortnames:
$ kubectl get no k3d-k8s-w10i-workshop-server-0
$ kubectl get node k3d-k8s-w10i-workshop-server-0
$ kubectl get nodes k3d-k8s-w10i-workshop-server-0
```

You can find the abbreviations with the command:

```
$ kubectl api-resources
```

3. Get more details:

```
$ kubectl describe nodes k3d-k8s-w10i-workshop-server-0
```

Note down:

- Container Runtime Version: . . .
- What the namespaces we have: . . .
- Note down name of two pods:
  - . . .
  - . . .

4. YAML and JSON output

```
$ kubectl get node k3d-k8s-w10i-workshop-server-0 -o yaml
$ kubectl get node k3d-k8s-w10i-workshop-server-0 -o json
```

Use *jq* to get the *kubeletVersion*, write down below:
. . .

5. Notice, `kubectl` provides support for jsonpath:

```
$ kubectl get node k3d-k8s-w10i-workshop-server-0 \
  -o jsonpath="{.status.daemonEndpoints.kubeletEndpoint.Port}"

$ kubectl get node k3d-k8s-w10i-workshop-server-0 \
  -o jsonpath="{.metadata.labels}"
```

Write down a command with jsonpath to get information on how many CPU we have allocated to our minikube:
. . .

6. All Kubernetes resources have labels attached:

```
# show me nodes that have the following label
$ kubectl get no  -l 'kubernetes.io/hostname'

# show me nodes running on linux
$ kubectl get no  -l 'kubernetes.io/os=linux'
```

Please find another label, you could select our node and run the command.

7. Recommendations for your local setup:

- `alias k=kubectl` or `alias kb=kubectl` (more ideas on github.com/prezto-contributions/prezto-kubectl)
- `kubectx` and `kubens` - github.com/ahmetb/kubectx

If you do not want to install kubectx, create an alias that will let you quickly check to which of kubernetes clusters, you are "connected":
`alias kctx='kubectl config current-context'`

2 Kubectl configuration file

Your kubectl configuration is in `${HOME}/.kube/config`, it contains tokens, certificates, aliases etc. You will need to edit this file very seldom.

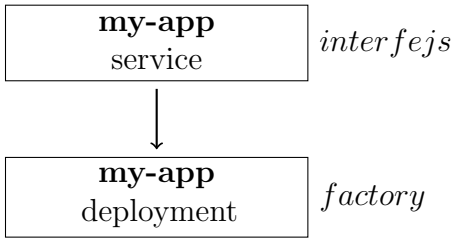
1. View `${HOME}/.kube/config`.

2. Find *certificate-authority*.

3. Note the main sections:
. . .
. . .
. . .

3 Task at Hand

Our goal today will be deployment of `intro-app` on Kubernetes. It is a simple web service. We will start with learning about the Kubernetes deployment and service as shown on the picture.



4 What are the namespaces?

```
$ kubectl get ns
$ kubectl get namespaces
```

Notice:

- you can create namespaces to better organize your components
- you might define resource restrictions per namespaces
- effect the name: *<service-name>.<namespace-name>.svc.cluster.local*. We will talk about it later.

To change the selected namespace for our commands:

```
$ kubectl config set-context \
  $(kubectl config current-context) \
  --namespace <namespace-name>
```

You can specify namespace explicitly with the kubectl CLI:

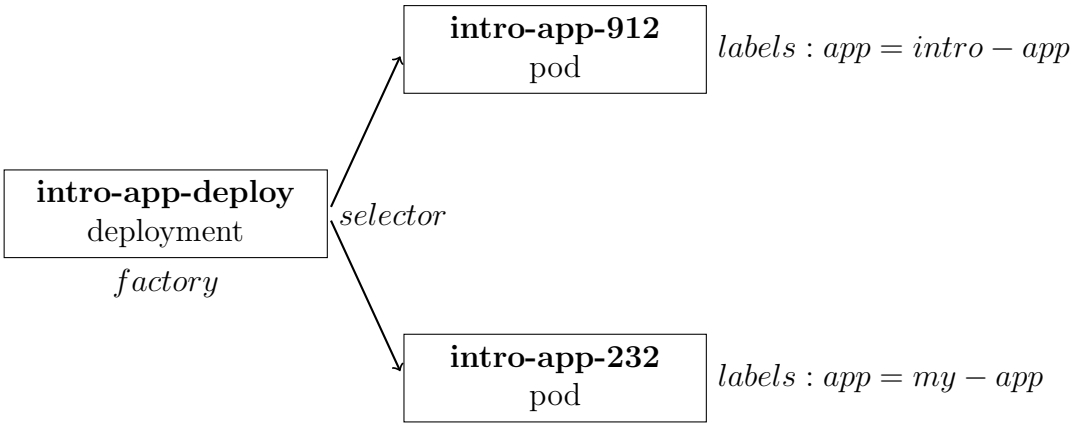
```
$ kubectl get pods --namespace=kube-system
$ kubectl get pods -n kube-system
$ kubectl get po -n default
```

Notice: you can check `kubectl api-resources` to see which resources are namespaced and which not.

5 Kubernetes deployments.yaml

Let's get instances of our application running. We use an application docker image built on the top of official nginx (hub.docker.com/_/nginx), you will find Dockerfiles in `manifests/dockers`.

0. The Kubernetes deployment resource as a factory that creates pods based on a template definition. The deployment uses labels to "find" its pods. If any pod is missing, Kubernetes will schedule missing number of pods.



Notice: `deployment` (apps/v1) uses `replicasets` (`k get rs`) under the hood.

1. Let's understand the deployment manifest `manifests/kube-deployment.yaml`(showing a minimal manifest):

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: intro-app-deploy
  labels:
    app_deploy: intro-app
spec:
  replicas: 1
  selector:
    matchLabels:
```

```
      app: intro-app
  template:
    metadata:
      labels:
        app: intro-app
    spec:
      containers:
      - name: app
        image: wojciech11/api-status:1.0.0
        env:
          - name: DB_NAME
            value: user
        ports:
        - containerPort: 80
```

Notice: the postfix `-deploy` is not the best practise, just to make it more explicit what-is-what during the training.

Hints:

- if your repo is private, you need to define `imagePullSecrets` (check official docs[1]).
- You can forge Kubernetes to pull Docker image every time with `imagePullPolicy: Always`, not recommended but might be helpful during the development. You MUST NOT use this setting in **production**.

2. Let's get our application running by creating the Kubernetes deployment that will start the app for us:

```
# declarative
$ kubectl apply -f manifests/kube-deployment.yaml
deployment.apps/intro-app-deploy created

# imperative way (alternative to the previous command):
$ kubectl create -f manifests/kube-deployment.yaml
deployment.apps/intro-app-deploy created
```

[1] kubernetes.io/docs/tasks/configure-pod-container/pull-image-private-registry/

If you want to know more about the difference, checks docs:

- Imperative config - kubernetes.io/docs/concepts/overview/object-management-kubectl/imperative-config,
- Declarative config - kubernetes.io/docs/concepts/overview/object-management-kubectl/declarative-config/.

3. List deployments to see whether there is your deployment resource:

```
# deploy, deployment, deployments
$ kubectl get deploy

NAME               READY   UP-TO-DATE   AVAILABLE   AGE
intro-app-deploy   1/1     1            1           19s

$ kubectl get deploy -o wide
# notice the selector
```

4. Check the details about the Kubernetes deployment:

```
$ kubectl describe deploy <DEPLOYMENT_NAME>
```

Notice fields for update strategy (more about it later) and replicas.

5. Where is our app? The pods:

```
# "po" = "pod" or "pods"
$ kubectl get po
$ kubectl get po -n default

$ kubectl describe po <POD_NAME>
```

6. Find the following information:

- How many containers are in the pod? . . .
- What is the IP of your app pod? . . .

- What is ReplicatSet? . . .
- Ready? . . .
- Restart Count? . . .
- Events? . . .

Notice: we will discus other fields – QoS, Conditions (Ready), Node-Selector, and Tolerations – later. 7. Increase the number of pods, modify the YAML

manifest and apply the changes. Check wherher you see more pods `kubectl get po`. If the answer is yes, please scale down your deployment to one pod instance. 8. What does it happen when you delete one of the pods?

```
$ kubectl delete po intro-app-65db4-...
$ kubectl get po
```

6 Check whether app works with port forwarding

We can see the app running but does it work? We did not expose our application outside the cluster, so we need another mechanism at this moment. Kubernetes provide us `port-forward` to forward port from the pod to local machine port.

1. Find the port our application listen on[2].

2. Setup the port forwarding:

```
kubectl port-forward <POD_NAME> <LOCAL_PORT_NUMBER>:<POD_PORT_NUMBER>

# let's choose 8080 as the local port
$ kubectl port-forward <POD_NAME> 8080:<POD_PORT_NUMBER>

# in a separate terminal:
```

[2]Notice: the deployment manifest does not enforce the port number the application listen on.

```
$ curl 127.0.0.1:8080

<html>
<h1>1.0.0</h1>
</html>

# if you prefer httpie (httpie.io)
$ http 127.0.0.1:8080
```

You will use `port-forward` very often as one of the first steps of many debugging sessions for why-client-cannot-connect-to-my-service-from-outside.

The `port-forward` can take also as a parameter also Kubernetes service or deployment[3].

Let's learn about services and ingresses first, later we see how we can modify our deployment and update the application.

7 Get your application logs

Let's keep the port-forwarding running and open the second terminal to examinate logs:

```
$ kubectl logs <POD NAME>

$ kubectl logs <POD NAME> -f # -f as in tail -f ;)
```

Send few requests with `curl` to see new entries in the logs. You will use this command a lot, so check the command help `k logs --help`.

[3] kubernetes.io/docs/tasks/access-application-cluster/port-forward-access-application-cluster

8 Opening console in your container

Sometimes, you would like to check your appliacation from within the container. Let's see how we can achieve it with Kubernetes

1. Get the console:

```
# check the pod name
$ kubectl exec -it intro-app-... -- /bin/bash
```

Let's print env variables:

```
$ kubectl exec -it intro-app-65d /bin/bash

root@intro#$ printenv

root@intro#$ printenv | grep DB
```

2. Add tool for debugging - curl:

```
root@intro#$ apt-get update && apt-get install -qq curl
```

3. Does it work?

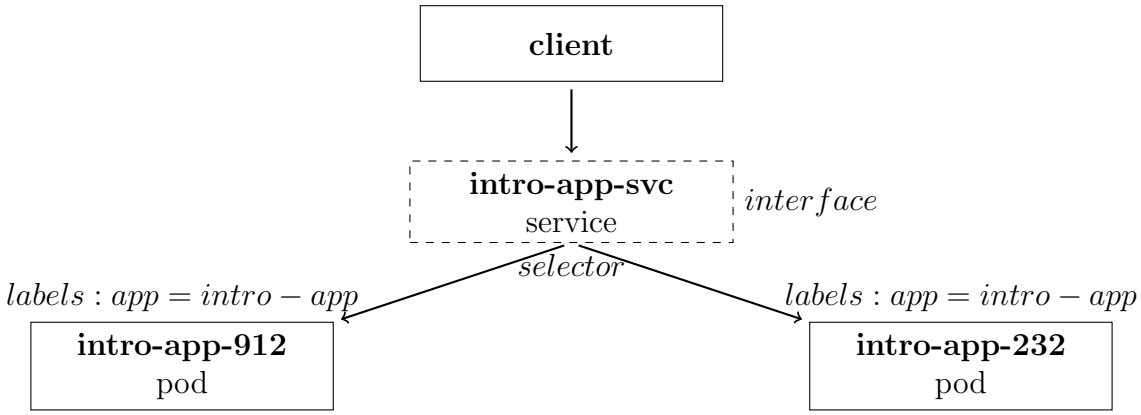
```
# does it work?
root@intro#$ curl 127.0.0.1

# can we get outside
root@intro#$ curl -I wbarczynski.pl

# can we reach other services:
root@intro#$ telnet kube-dns.kube-system 53
```

4. Assuming we resolve our issue, let's clean up by deleting the pod we install utilites for debugging:

```
$ kubectl delete po intro-app-65db4-...
```

9 Kubernetes Service

Our factory, I mean the deployment defines how we create our application instanes as pods. The service, how we expose it to be consumed. We have three types of Services: LoadBalancer, ClusterIP (the most commonly used), NodePort, and ExternalName (CNAME to an external service).



1. Let's go through the (pretty basic) manifest `manifests/kube-service.yaml` (again the *-svc* prefix for the clarity):

```
apiVersion: v1
kind: Service
metadata:
  name: intro-app-svc
  labels:
    me: wojtek
spec:
  ports:
  - port: 8080
    targetPort: 80
    protocol: TCP
    name: http
  selector:
    app: intro-app
  type: LoadBalancer
```

2. Deploy:

```
$ kubectl create -f manifests/kube-service.yaml
$ kubectl apply -f manifests/kube-service.yaml
```

3. Let's call our service through loadbalancer that we exposed on `8080`:

```
# http 127.0.0.1:8080
$ curl -s -D - 127.0.0.1:8080
HTTP/1.1 200 OK
Server...

<html>
<h1>1.0.0</h1>
</html>
```

Notice: on AWS, Azure, or GCP, we would get the loadbalancer created and public IP assigned. You would than use annotations to specify the loadbalancer configuration, for example: docs.aws.amazon.com/eks/latest/userguide/network-load-balancing.html.

4. Let's list the services and get more details about our newly created service:

```
$ kubectl get services
$ kubectl get svc -o wide
$ kubectl describe svc intro-app-svc
```

Please note down:

- Endpoints (where this IP comes from?) . . .
- Selector . . .
- IP . . .

5. Short recap with the trainer - service types:

- ClusterIP with and without IP (headless)
- LoadBalanced

- ExternalName

6. How does the service work? Let's use busybox[4] docker to see how we can access the service from a different app.

```
$ kubectl run busybox --image=busybox:1.28.4 --rm \
    --restart=OnFailure -ti -- /bin/nslookup intro-app-svc

$ kubectl run -i --tty busybox-wget --rm \
    --image=busybox:1.28.4 -- sh

/# wget -O- intro-app-svc
/# wget -O- intro-app-svc.default
/# wget -O- intro-app-svc.default.svc
/# wget -O- kubernetes-dashboard.kube-system
```

By the way, the service info is also injected as environment variables. I did not have so far a need to use this information:

```
$ kubectl run busybox --image=busybox \
  --rm --restart=OnFailure -ti -- printenv | grep -i intro_app_svc
```

You could also run nslookup from within our app pods:

```
$ kubectl exec -it intro-app-deploy-5d556d9f4b-vslp9 \
    -- /bin/bash

/# apt-get update && apt-get install dnsutils -qq
/# nslookup intro-app-svc
```

7. You will use ClusterIP service with Ingress controller more often than Loadbalancer service.

[4] "The Swiss Army Knife of Embedded Linux" - `hub.docker.com/_/busybox`

10 Modyfing kubernetes deployment and service

Avoid editing files on kubernetes, always modify a yaml and apply the changes.

1. Change the number of pods running to 2 with:

```
$ kubectl edit deploy
```

```
$ kubectl get po
```

2. Change the value of label `me` to your name in the service definition.

3. Modify the `depoyment.yml` to get 3 pods, use: `kubectl apply -f`

4. Add one more label to service.

5. What does happen if we add one more selector, apply it:

```
apiVersion: v1
kind: Service
metadata:
  name: intro-app-svc
  labels:
    me: wojtek
spec:
  ports:
  - port: 8080
    targetPort: 80
    protocol: TCP
  selector:
    app: intro-app
    break: the-connection-with-pods
  type: LoadBalancer
```

Can we connect?

```
# again, let's connect through LB
$ curl -s -D - 127.0.0.1:8080
```

What has changed?

```
$ kubectl describe svc intro-app-svc
```

Notice: very very very common issue that selectors do not match labels.

6. Fix your service.

11 Updating service

Let's update our app from the version `1.0.0` to `2.0.0`:

1. Change in the deployment file and apply changes.

2. You can also change it with set image:

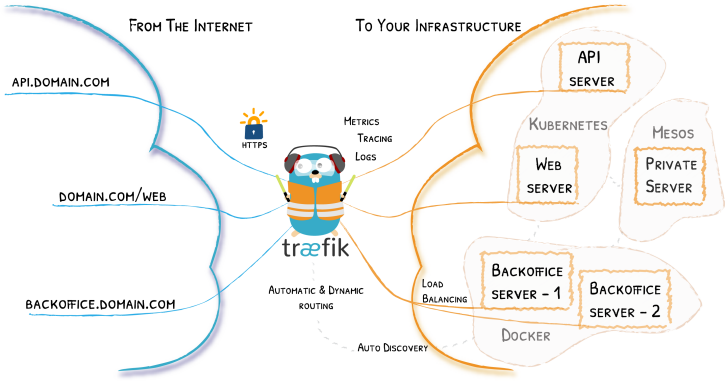
```
$ kubectl set image deployment/<DEPLOYMENT_NAME> \
  <CONTAINER_NAME>=<DOCKER_IMAGE_NAME>:<VERSION>
```

3. Change two times from `1.0.0` to `2.0.0` and back:

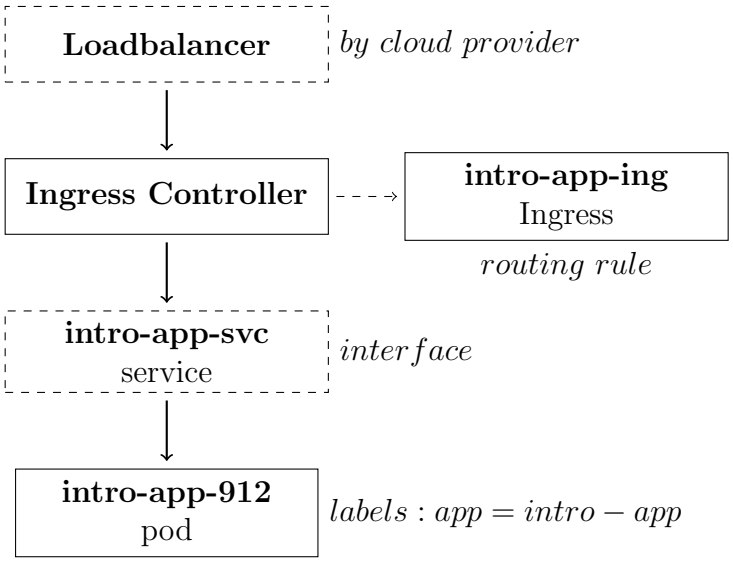
```
$ curl -I  curl -s -D - 127.0.0.1:8080
```

12 Kubernetes Ingress

The purpose of the ingress controller is to provide reverse proxy service to hide details how our application is implemented:



In most of scenarios, you will use the ingress controller, so we will have:



1. Let's set up the neccessary configuration for already installed `traefik` in the cluster:

```
# let's remote the previous service definition
$ kubectl delete -f manifests/kube-service.yaml
```

```
# check the files before applying
$ kubectl apply -f  manifests/ingress
```

2. Let go over the `manifest/ingress/kube-ingress.yaml`:

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: intro-app-ing
  annotations:
    kubernetes.io/ingress.class: traefik
    traefik.ingress.kubernetes.io/router.middlewares:
    ↪  default-intro-app-ing@kubernetescrd
spec:
  rules:
  - host: my.app
    http:
      paths:
        - path: /echo
          pathType: Prefix
          backend:
            service:
              name: intro-app-svc
              port:
                number: 80
```

3. Now, it is time to call our service. You can print the logs from your pod to verify that the requests are reaching your pod. Let's access our service as our customers would do:

```
$ curl --header 'Host: my.app' http://127.0.0.1:8000/echo
```

4. Now, after verifing that our ingress is working, let's look closer into the ingress:

```
# "ing" or "ingress"
$ kubectl get ing
$ kubectl describe ing <ingress name>
```

5. Let's open a dashboard of our ingress controller - `traefik`:

```
$ kubectl get po -n kube-system
$ kubeclt get po -l 'app.kubernetes.io/instance=traefik'
$ kubectl describe po traefik-97b44b794-tf5kf -n kube-system
k port-forward -n kube-system traefik-97b44b794-tf5kf 9000:9000
```

Open in your browser: http://127.0.0.1:9000/dashboard/, choose `HTTP`, and select our rule from the list.

13 Containers vs Pods

Please answer the following questions:

- How many containers can a Pod has?
- Do containers share disk?
- Do container share port space?
- What does `1/1` mean in the output of `kubectl get po`?

14 Fail-over

Let's see what happens when our application crashes.

1. Open console.

2. Force restart:

```
# should work
kill 1

# always works
kill -9 1
```

Repeat 5 times. Observer the output from: `kubectl get po`.

15 How to debug in nutshell

Good to ship a minimum of debugging tools in your container, such as, curl or telnet.
Happy debugging path:

```
$ kubectl describe ing
$ kubectl describe svc
$ kubectl exec -it <pod name> /bin/bash

# curl, telnet, ...
$ kubectl describe po <pod name>

$ kubectl logs <pod name>
$ kubectl logs <pod name> -f
$ kubectl logs <pod name> --tail=100

$ kubectl logs -n kube-system <pod for your ingress controller>

$ kubectl get events
```

Notice: To improve the observability, start with monitoring (e.g., Prometheus) and Kubernetes probes (we will cover them later).

16 Kubernetes configmap

With configmaps, we can deliver values for environment variables or files. Let's change the page in our application:

1. Copy `index.html`:

```
$ cp manifests/dockers/site-1.0.0/index.html index.html
```

2. Edit `index.html` Add your name after the version number:

```
<html>
<h1>1.0.0-Natalia</h1>
</html>
```

3. Let's create a configmap:

```
$ kubectl create cm intro-app-index-html --from-file index.html
```

4. Check the commands:

```
# "cm" "configmap"
$ kubectl describe cm intro-app-index-html
$ kubectl get cm intro-app-index-html -o yaml
$ kubectl get cm intro-app-index-html -o json
```

5. To make our new index file available, we need to mount it:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: intro-app-deploy
  labels:
    app_deploy: intro-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: intro-app
  template:
    metadata:
      labels:
        app: intro-app
    spec:
      containers:
      - name: app
        image: wojciech11/api-status:1.0.0
        ports:
        - containerPort: 80
        volumeMounts:
        - mountPath: "/usr/share/nginx/html"
          name: "html-content"
      volumes:
      - name: html-content
        configMap:
          name: index-html
```

5. Let's do a smoke test:

```
$ curl --header 'Host: my.app'  "http://127.0.0.1:8000/echo"
```

6. We can also set environment values, let's create new configmap:

```
$ kubectl create configmap intro-app \
  --from-literal=db.name=mydb
```

7. .. and use it:

```
        env:
        - name: DB_NAME
          valueFrom:
            configMapKeyRef:
              name: intro-app
              key: db.name
```

8. Open a console in your pods and check whether the ENV variable is set:

```
\# printenv | grep DB_NAME
```

9. More examples you will find in the documentation.

```
      envFrom:
      - configMapRef:
          name: db-config
```

and the corresponding configmap:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: db-config
  namespace: default
data:
  DB_NAME: mydb
  DB_USERNAME: myuser
```

also:

```
$ kubectl create configmap intro-app \
    --from-literal=DB_NAME=mydb \
    --from-literal=DB_USERNAME=myuser
```

Recomendation: Keep everything minimal.

17 Kubernetes secret

Secrets are very similar to configmaps. They provide better security (kind-of) than configmaps.

1. Create a secret with database password:

```
$ kubectl create secret generic intro-app-secret \
  --from-literal="db.password=nomoresecrets"
```

2. Bind it to environment variable in the deployment:

```
    env:
      - name: DB_PASSWORD
        valueFrom:
          secretKeyRef:
            name: intro-app-secret
            key: db.password
```

3. Please deliver `cert.crt` to your application and mount it at `/usr/secet`, find how to do it find on
kubernetes.io/docs/concepts/configuration/secret/ :

```
$ echo "CERT" > cert.crt
$ kubectl create secret generic intro-app-cert \
    --from-file cert.crt
```

18 Your own app

We have prepared two simple application in Python and Golang, your task is to deploy them on the Kubernetes cluster. Please create an user on hub.docker.com:
Applications:

- Python
- Golang

Create, following the instruction of the trainer, the following resources:

1. Deployment with DB_USERNAME as an env variable
2. ConfigMap with a field DB_NAME
3. Secret
4. Service
5. Ingress, path: `/hello`

19 Quick look on the configuration

We will cover it in a separate workshop (that covers CI/CD), here is a quick start.

1. envsubst or similar approaches
2. kustomize
3. Helm

Let's see each of these popular approaches.

1. envsubst or similar approach. Let's imagine, we want to generate ingress resources with differenet host names:

```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: login-app
spec:
  rules:
  - host: ${HOST}
    http:
      paths:
        - path: /login
          backend:
            serviceName: login-app
            servicePort: 80
```

and the command:

```
$ export HOST=example.com
$ envsubst < my-k8s.tmpl.yaml > my-k8s.yaml
```

2. kustomize - overlay:

```
.
├── base
│   ├── kube-deployment.yaml
│   ├── kube-service.yaml
│   └── kustomization.yaml
├── dev
│   ├── image.yaml
│   ├── kustomization.yaml
│   └── scale.yaml
├── production
│   ├── image.yaml
│   ├── kustomization.yaml
│   └── scale.yaml
└── staging
    ├── image.yaml
    ├── kustomization.yaml
    └── scale.yaml
```

and the commands:

```
$ cd manifest/kustomize/kubernetes

$ export ENV_NAME=dev
$ kubectl kustomize ${ENV_NAME}

$ kubectl kustomize staging
$ kubectl kustomize production
```

3. Helm - use just what you need. If possible move configMaps to the component repo. Let's go through `manifests/helm/deployment`:

```
$ cd manifest/helm/deployment
```

```
$ export APP_NAME=my-app
$ export APP_VERSION=snapshot-9911

$ helm template "${APP_NAME}" deployment_v2 \
   --set image.tag="${APP_VERSION}" \
   --version "${APP_VERSION}"

# in CI/CD, dry run for safety :)
$ helm template "${APP_NAME}" deployment_v2 \
   --set image.tag="${APP_VERSION}" \
   --version "${APP_VERSION}" | kubectl apply -f - --dry-run=server

# in CI/CD, again --dry-run for safety
$ helm install "${APP_NAME}" deployment_v2 \
   --set image.tag="${APP_VERSION}" \
   --version "${APP_VERSION}" --dry-run --debug
```

Lean towards:

1. Not templating if it is not going to change.
2. Push as many setting as possible to the component repo.
3. It is OK, if you create Kubernetes secrets manually in the beggining.

20 Next

- Liveness/Readiness probes - https://github.com/wojciech12/talk_zero_downtime_deployment
- Resource, Limits and QoS
- RBAC

21 Outlook

What could be the next steps in learning k8s.
What you could learn next.
Next course *Immediate (Developer)*:

1. Liveness/Readiness probes
2. Monitoring with Prometheus
3. Resource and Limits, QoS for your pods, schedule policies
4. Statefulsets
5. DaemonSets
6. Taints and Tolerations
7. Node affinity

Observability plus with Istio demo as what might the future be:

1. Monitoring
2. Logging
3. Traceability

Advance (Developer):

1. Zero-downtime deployment strategies
2. Horizontal scaling (beta: vertical pod scaling for the pets)
3. Continuous Deployment and Integration
4. TravisCI and Gitlab

Network and Security:

1. RBAC deep dive
2. Networking - Internal Loadbalancing - https://kubernetes.io/docs/concepts/services-networking/
3. Restricting Egress/Ingress with Network Policies

Kubernetes customization

1. Write your first CRD
2. Operators
3. Plugins to kubectl

CloudNative Ecosystem

1. Observability: Prometheus stack
2. Observability: EFK
3. Observability: Tracing

4. Ingress Controllers: Traefik, ... , talk about standard and controller-specific annotations
5. Cert-manager
6. Operators for etcd and Vault
7. Kubeless

More

1. Istio
2. Operators for ...

Optionals

1. Google Kubernetes Engine - GKE
2. Azure Kubernetes Service - AKS
3. Amazon Elastic Kubernetes - EKS

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