

Kubernetes Workshop

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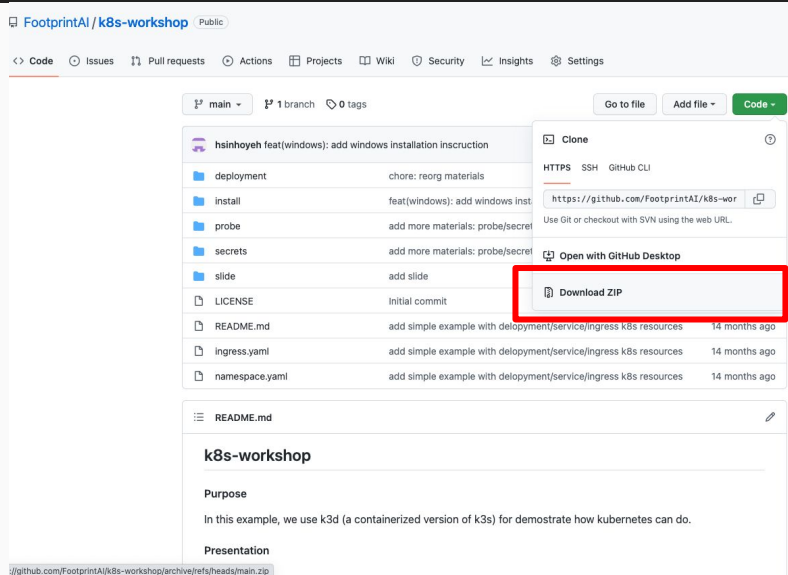
Download Slides

<https://reurl.cc/KbX59R>



Workshop materials

```
git clone https://github.com/FootprintAI/k8s-workshop
```



About me

- 2020 - Present at 信誠金融科技
 - Shrimping: A data-sharing platform
 - <https://get-shrimping.footprint-ai.com>
 - Tintin: a machine learning platform for everyone
 - <https://get-tintin.footprint-ai.com>
- 2016 - 2020 at IglooInsure (16M+ in series A+ 2020)
 - Provide digital insurance for e-economic world
 - Funded in KUL, Headquartered in Singapore
 - First employee/ Engineering Lead / Regional Head/ Chief Engineer
- 2013 - 2016 at Studio Engineering @ hTC
 - Principal Engineer on Cloud Infrastructure Team
- 2009 - 2012 at IIS @ Academia Sinica
 - Computer vision, pattern recognition, and data mining
- CS@CCU, CS@NCKU alumni



Agenda

- Pre-requirement
- Why Kubernetes
- What is Container
- What is Kubernetes
- Hands-on session
- QA

Pre-requirement

- Be comfortable with UNIX command line
 - Navigating directories with ``cd`` or ``tree``
 - Editing files, like ``vim``, ``nano``
 - Bash scripting, like env or looping
- Be an expert with ``Google``
 - <https://letmegooglethat.com/?q=you+can+google+it>
- It is totally OK if you don't know what is Docker and Kubernetes

孩子，您多久沒唸中文了？

荀子《儒效篇》

「不聞不若聞之，聞之不若見之，見之不若知之，知之不若行之；學至于行之而止矣。」

Why Kubernetes is important?

History Of Kubernetes

- Borg: the predecessor to Kubernetes
 - Google revealed the first time of its detail in an academic research paper, describing a “cluster manager that runs hundreds of thousands of jobs, from many thousands of different applications, across a number of clusters each with up to tens of thousands of machines.”[1]
 - A in-house cluster manager system inside Google for running every google services including Gmail, Google Maps, Google Docs...[2]
 - In a scale with ‘over 2 billion containers per week` [3]
- The very first version of Kubernetes was released in 2015
- The latest version is v1.23, released at 2022.

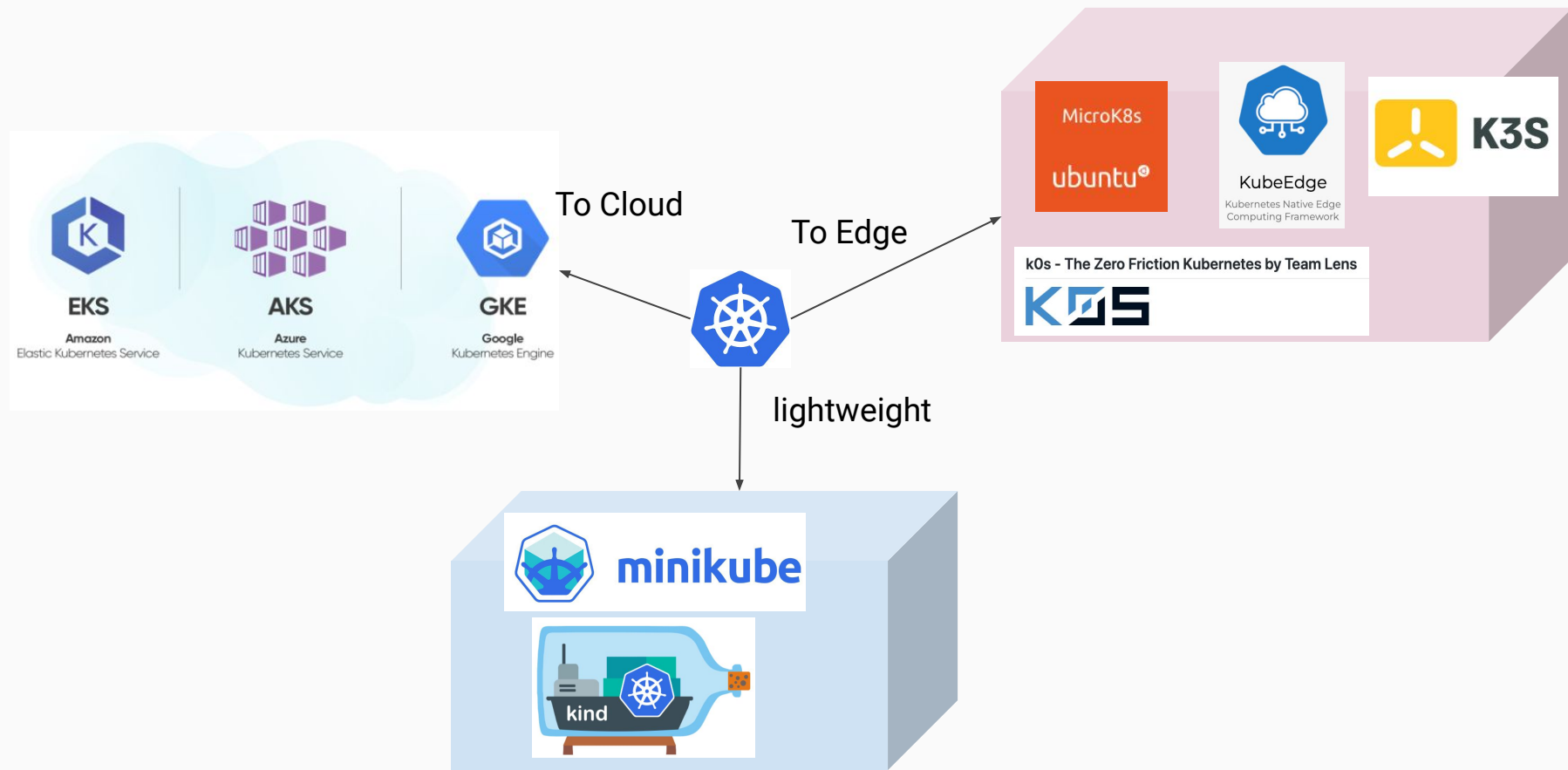


[1] <https://research.google/pubs/pub43438/>

[2] <https://www.wired.com/2016/04/want-build-empire-like-googles-os/>

[3] <https://cloud.redhat.com/blog/building-kubernetes-bringing-google-scale-container-orchestration-to-the-enterprise>

Kubernetes Distributions Evolution

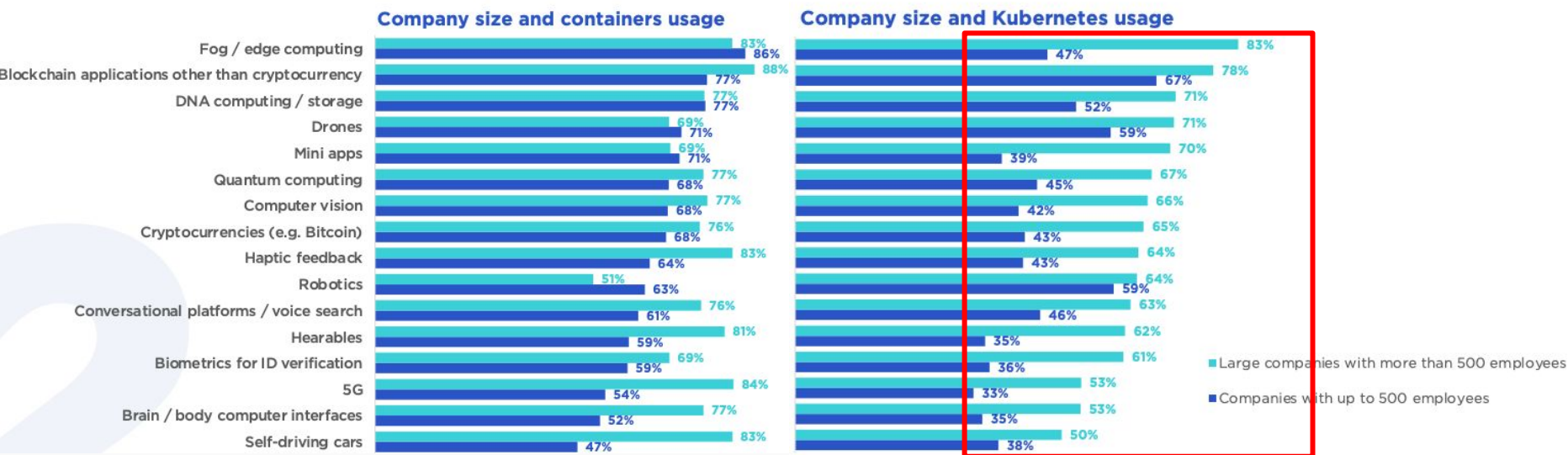


What is Kubernetes adoption rate so far?

Usage of cloud native technologies across regions

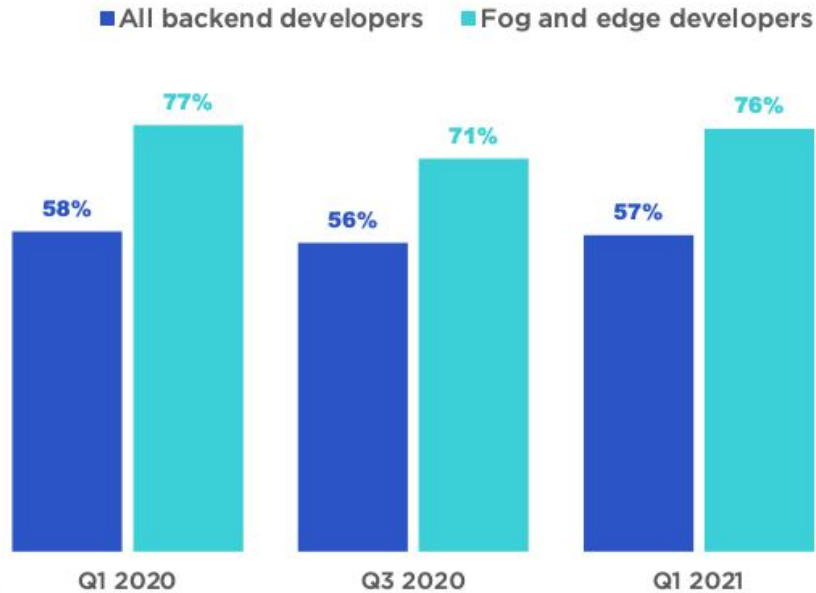


Container adoption rate vs Kubernetes among company size

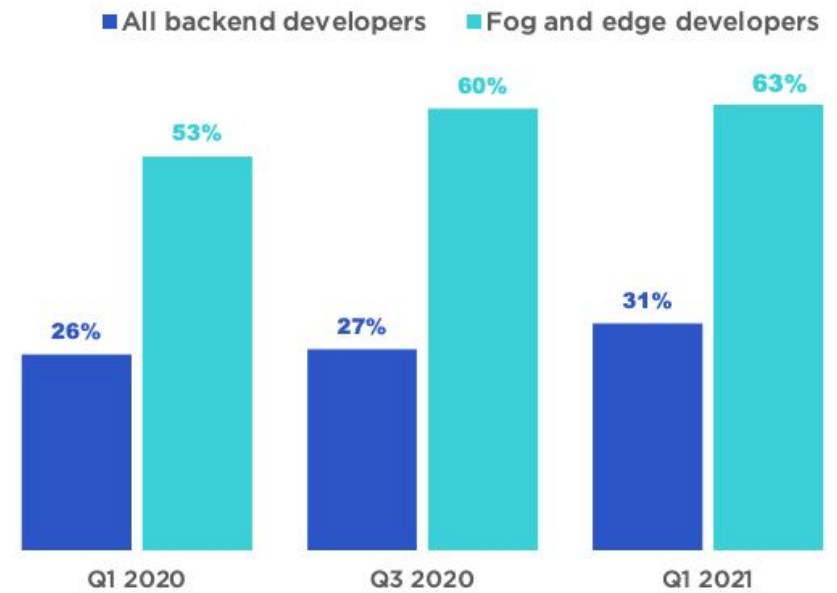


Container and Kubernetes adoption rate on edge computing

Containers usage




Kubernetes usage



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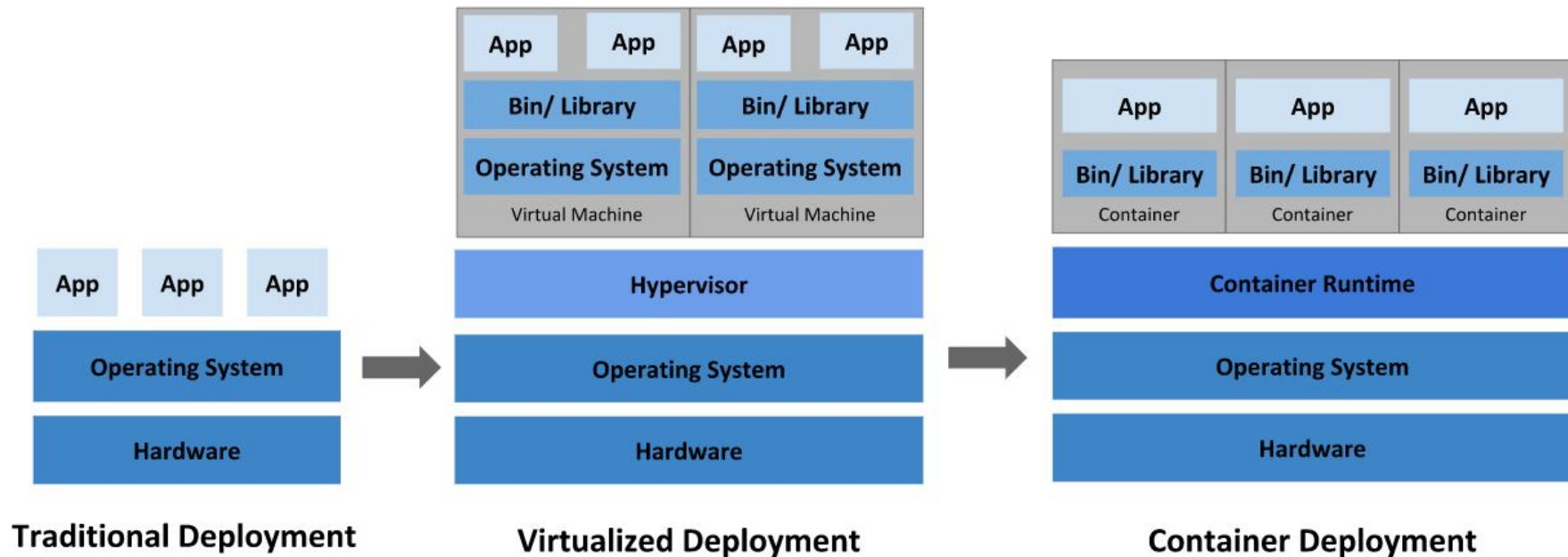
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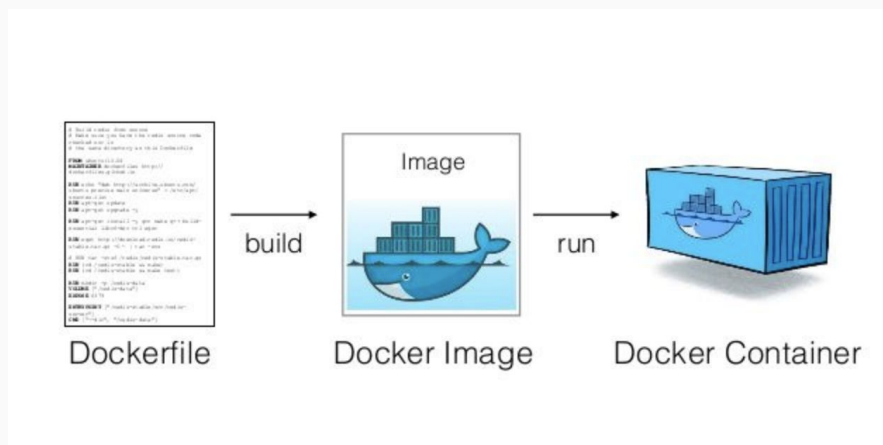
What is Container?

What is containerized deployment?



What is Container?

- Container
 - Container Image = Application code + dependencies
 - Runtime environment (cgroups, namespaces, env vars)
- Container Registry
 - Container repository



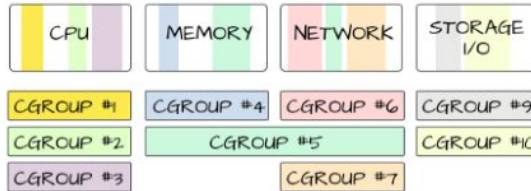
Ref: <https://medium.com/platformer-blog/practical-guide-on-writing-a-dockerfile-for-your-application-89376f88b3b5>

How container works?

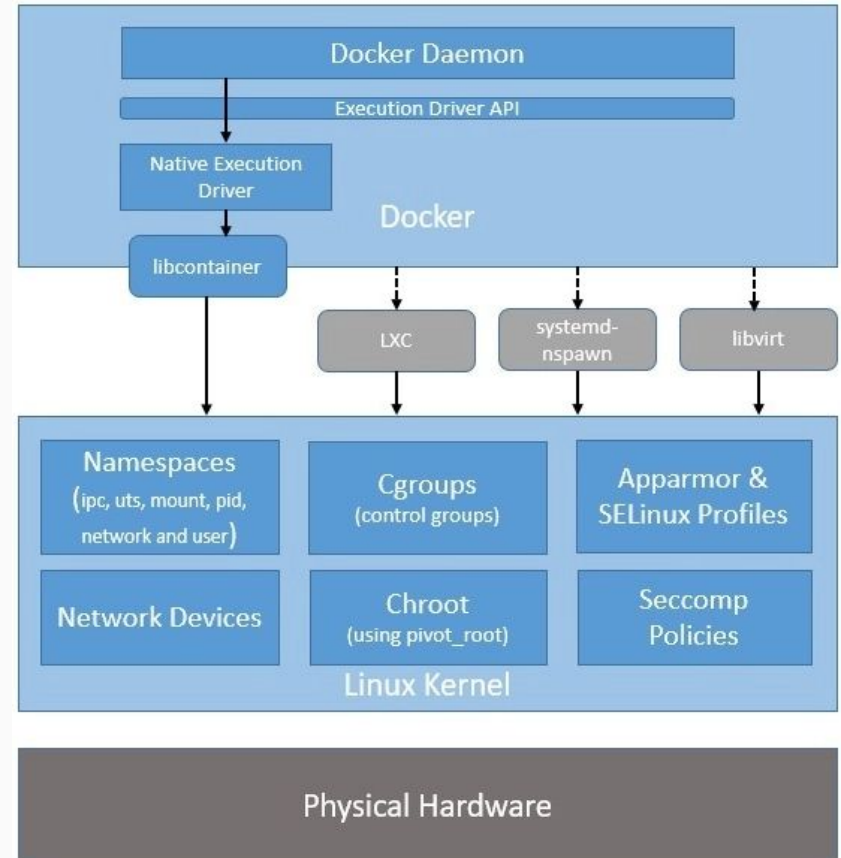
- Namespace for isolation
- Cgroups for resource limiting

Cgroups : Isolation and accounting

- cpu
- memory
- block i/o
- devices
- network
- numa
- freezer



Ref: <https://www.baeldung.com/linux/docker-containers-evolution>
<https://medium.com/@BeNitinAgarwal/understanding-the-docker-internals-7ccb052ce9fe>



What is Dockerfile?

- A dockerfile contains instructions needed to build a given image

```
FROM ubuntu:18.04
```

```
RUN apt-get update && apt-get install -y build-essential
```

```
COPY . /app
```

```
RUN make /app
```

```
CMD python /app/app.py
```

How to build a Docker Image

```
FROM php:7.0-apache
```

```
COPY index.php /var/www/html/index.php
```

```
EXPOSE 80
```

```
docker build -t footprintai/k8sworkshop:php-demo -f Dockerfile .
```

```
=> [internal] load metadata for docker.io/library/php:7.0-apache 4.6s
```

```
...
```

```
=> [2/2] COPY index.php /var/www/html/index.php
```

```
0.8s
```

```
=> exporting to image
```

```
0.2s
```

```
=> => exporting layers
```

```
0.1s
```

```
=> => writing image
```

```
sha256:e74d16d21b10069d0beba2cc6daf7cc011723d7e51523c3830e50b1bc5338e88 0.0s
```

```
=> => naming to docker.io/footprintai/k8sworkshop:php-demo 0.0s
```

Install Docker runtime

- [Windows] install Docker Desktop
- Install Docker on your host machine
 - <https://docs.docker.com/engine/install/ubuntu/>
- Or run the following command for installation
 - <https://github.com/FootprintAI/k8s-workshop/blob/main/install/dockerd.sh>

```
apt-get update
apt-get install -y apt-transport-https ca-certificates curl software-properties-common

curl -fsSL https://download.docker.com/linux/ubuntu/gpg | apt-key add -
add-apt-repository \
  "deb [arch=amd64] https://download.docker.com/linux/ubuntu \
  $(lsb_release -cs) \
  stable"
apt-get update
apt-get install -y docker-ce docker-ce-cli containerd.io
```

```
docker run -it ubuntu:20.04
```

```
root> apt-get update
```

```
root> apt-get install -y lsb-release
```

```
root> lsb_release -a
```

```
Distributor ID: Ubuntu
```

```
Description:  Ubuntu 20.04.2 LTS
```

```
Release:      20.04
```

```
Codename:     focal
```

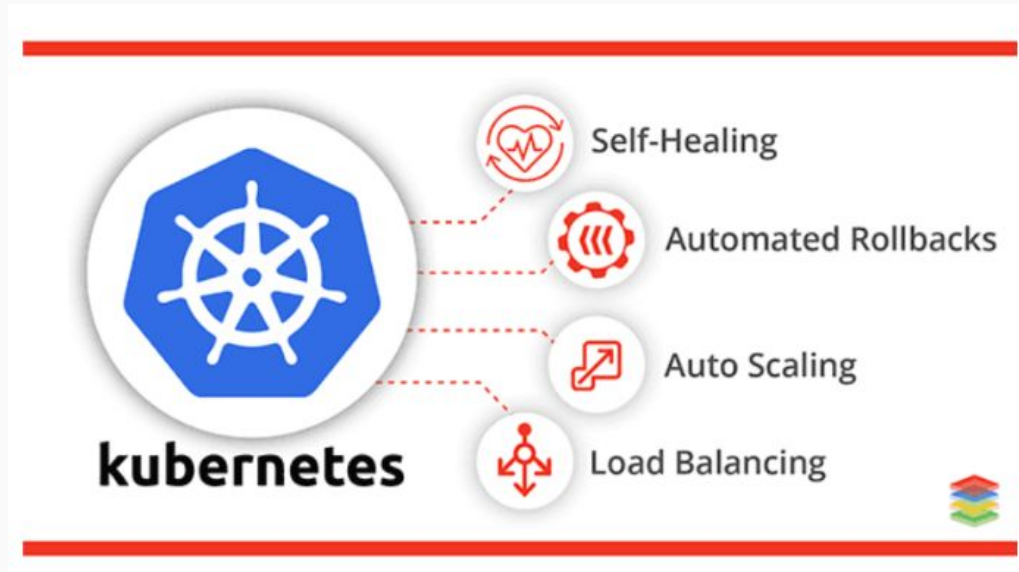
```
// port mapping: export port 8080 onto host  
docker run -it -p 8080:8080 ubuntu:20.04
```

```
// volume mount: mount host folder to a container  
docker run -it -v /tmp:/container-folder ubuntu:20.04
```

```
// daemon mode: run container as a daemon(background process)  
docker run -itd ubuntu:20.04 bash
```

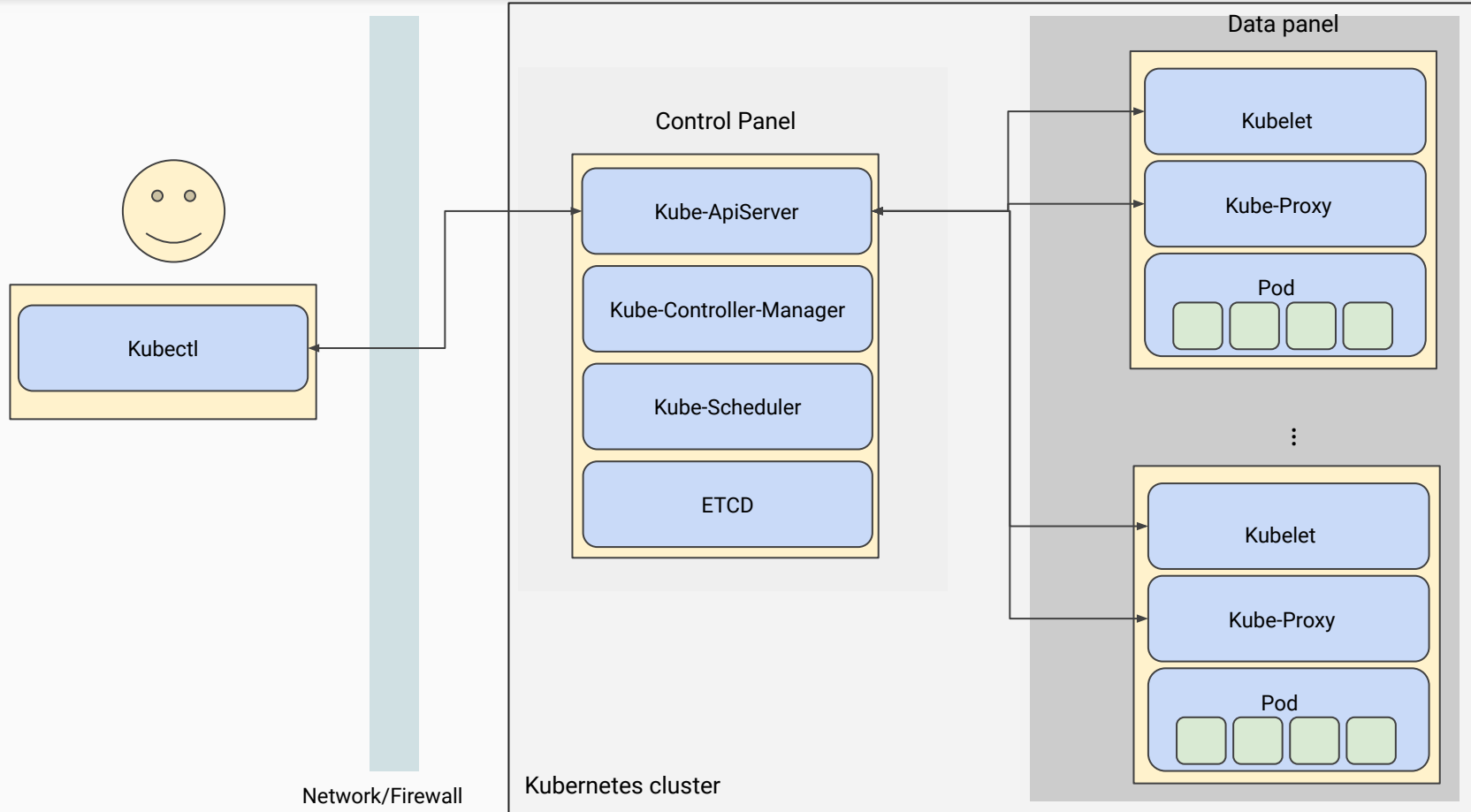
What is Kubernetes?

Kubernetes Feature Highlighted



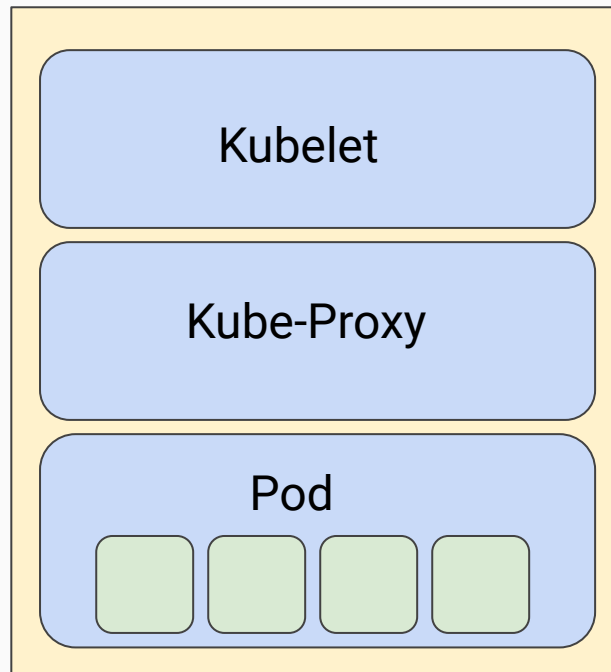
- High level concepts
 - **Node** are machine that run containerized applications.
 - **Pod** are unit for application workload.
 - **Scheduler** schedules pods to run on nodes.
 - **Replica Set** ensures that a specified number of pod replicas are running at any one time.
 - **Service** is an abstract way to expose an application running on a set of Pods as a network service.

What is Kubectl?



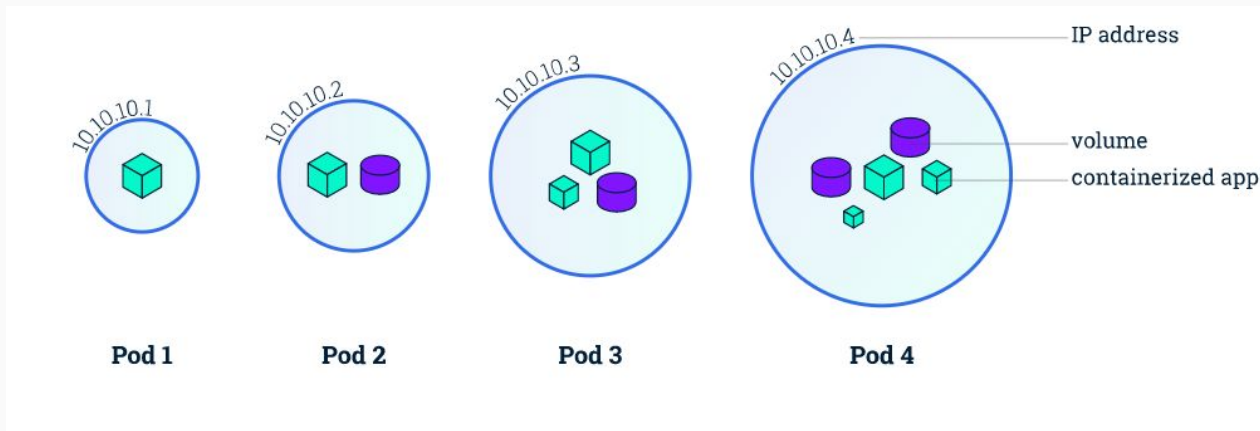
What is a Node?

- Container runtime
 - Docker
- Kubelet
 - Primary node agent running on each node
 - It register the node with api server and manage pods according to PodSpec.
- Kube-Proxy
 - Network proxy runs on each node. This reflects services as defined in the Kubernetes API on each node and can do simple TCP, UDP, and SCTP stream forwarding or round robin forwarding across a set of backends.



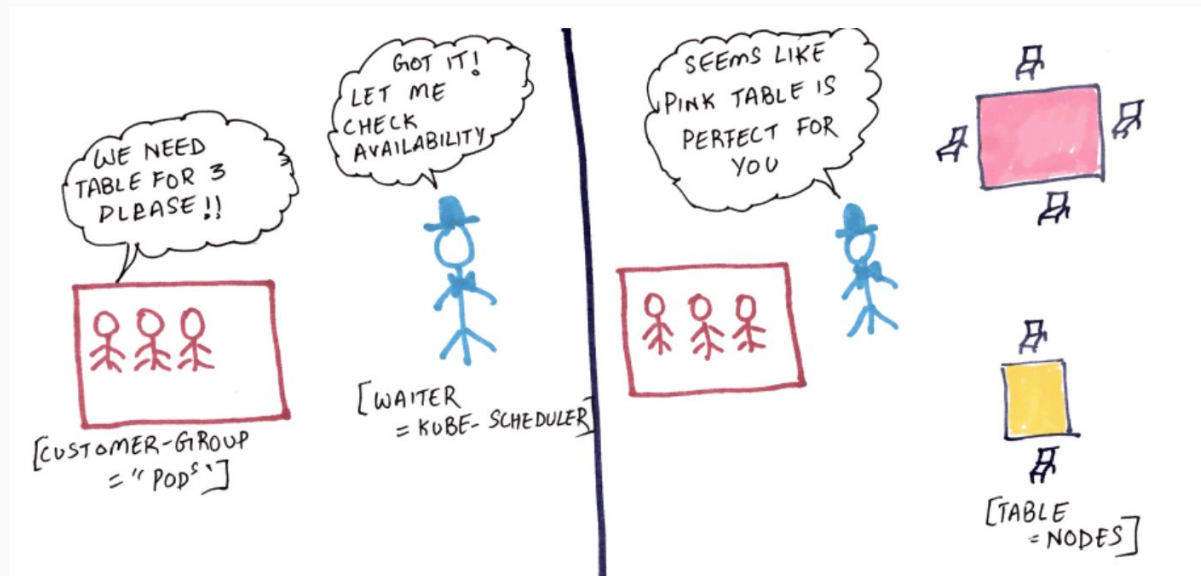
What is a Pod?

- A pod represents a logical application, it could contains a or multiple containers.
- A pod has unique IP address, persistent storage volume, and a configuration on how container should run
- Containers inside the same pod shares namespaces.
 - Containers inside the same pod can locate each other and communicate via localhost



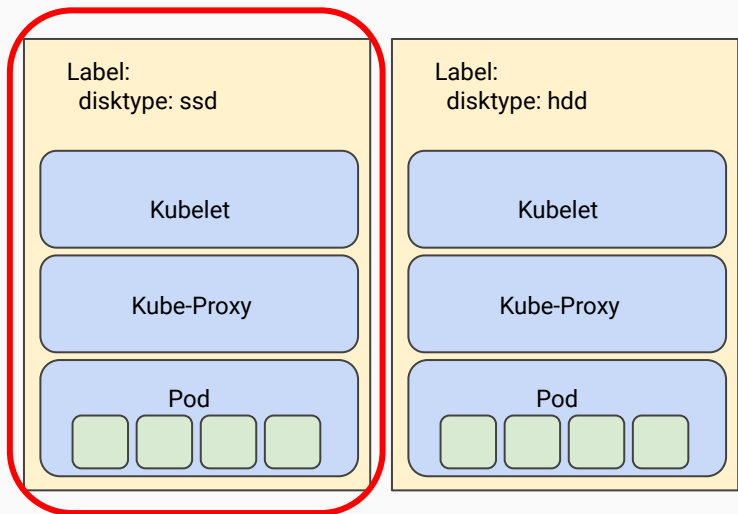
What is a Scheduler?

- The scheduler determines (filtering & scoring) which Nodes are valid placements for each Pod in the scheduling queue according to constraints and available resources.



What is a Scheduler?

- nodeSelector
 - Recommended way for node selection constraints
 - Filter by node labels



```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    env: test
spec:
  containers:
    - name: nginx
      image: nginx
      imagePullPolicy: IfNotPresent
  nodeSelector:
    disktype: ssd
```

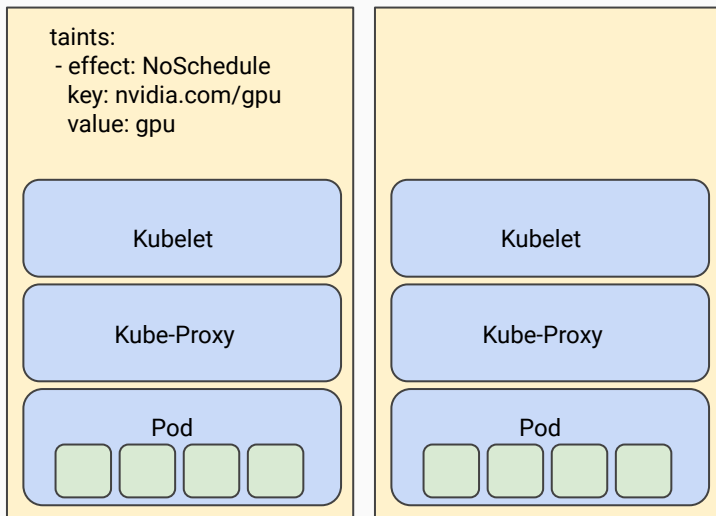
What is a Scheduler?

- Node affinity
 - similar to nodeSelector
 - But offer more fine-grant control

```
apiVersion: v1
kind: Pod
metadata:
  name: with-node-affinity
spec:
  affinity:
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
          - matchExpressions:
              - key: kubernetes.io/e2e-az-name
                operator: In
                values:
                  - e2e-az1
                  - e2e-az2
            preferredDuringSchedulingIgnoredDuringExecution:
              - weight: 1
                preference:
                  matchExpressions:
                    - key: another-node-label-key
                      operator: In
                      values:
                        - another-node-label-value
        containers:
          - name: with-node-affinity
            image: k8s.gcr.io/pause:2.0
```


What is a Scheduler? (1/3)

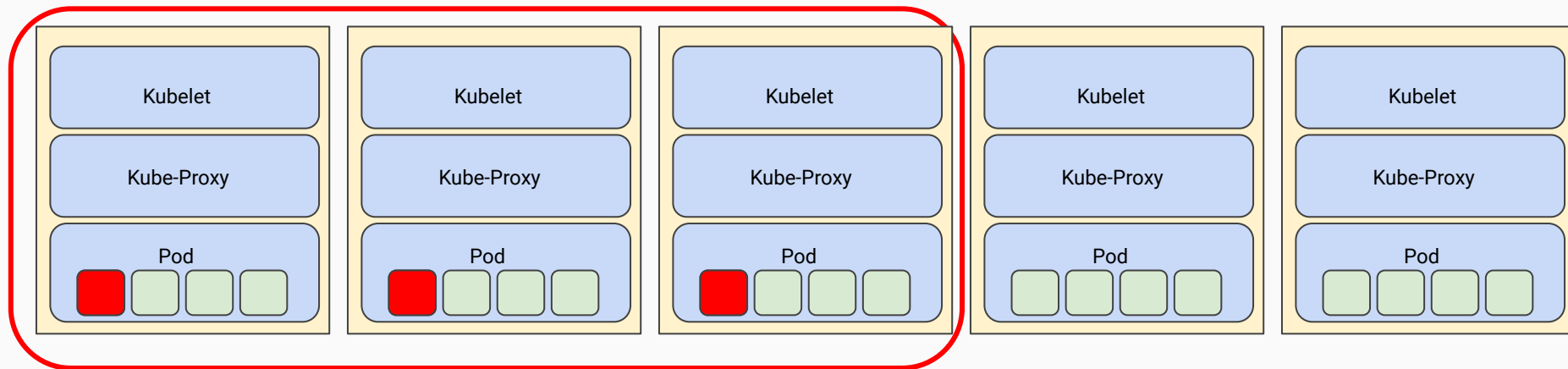
- Taints and tolerations
 - Taint allows a node to repel a set of pods
 - Tolerations allows (but do not require) the pods to schedule onto nodes with matching taints



```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    env: test
spec:
  containers:
    - name: nginx
      image: nginx
      imagePullPolicy: IfNotPresent
  tolerations:
    - key: "nvidia.com/gpu"
      operator: "Equal"
      value: "gpu"
      effect: "NoSchedule"
```

What is Replica Set?

- Manage a replicated set of pods
- Create pods from a template
- Ensure the desired number of pods running
- Online resizing and self-healing

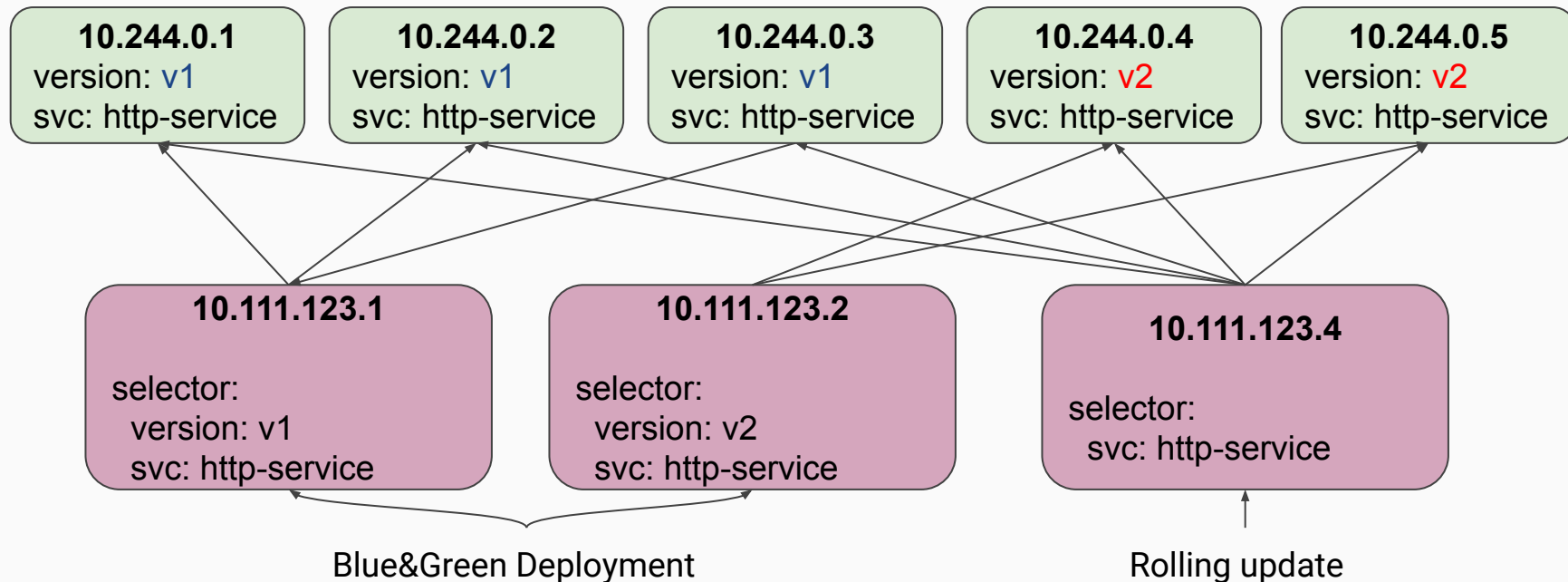


Replica = 3

What is Service?

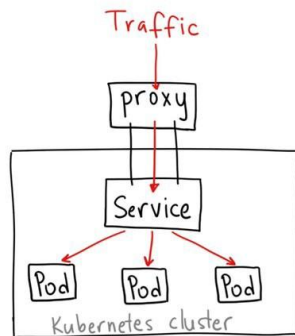
- As pods keeps creating/destroying in the cluster, service provides an abstraction way to expose applications to the world.
 - Service is a proxy runs on each Node,
 - Each service has its own virtual IP.
 - Service use dynamic backend based on label queries
- In-cluster domain name
- Different service type:
 - LoadBalancer
 - Nodeport
 - ClusterIP

What is Service?

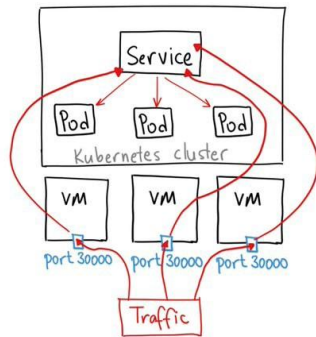
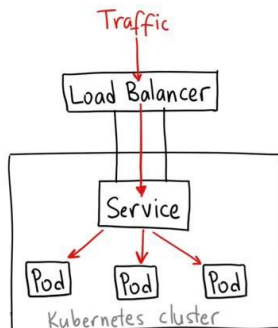


What is Service?

ClusterIP

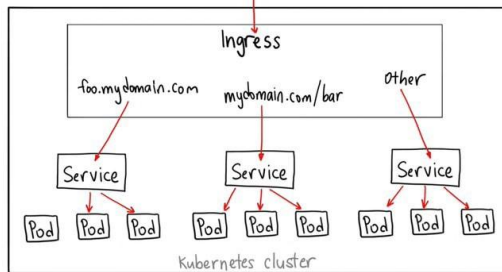


LoadBalancer



NodePort

Traffic



Ingress

Hands-on Session

Install Kubernetes

- Minikube: local kubernetes
 - <https://minikube.sigs.k8s.io/docs/start/>
- K3d: containerized k3s cluster
 - <https://github.com/rancher/k3d>
- Kind: Kubernetes IN Docker
 - <https://kind.sigs.k8s.io/>

```
// install kubectl, a cli interface for kubernetes v1.21.2
// We use kind as example, but you can also try other installations.

// see commands from
https://github.com/FootprintAI/k8s-workshop/blob/main/install/kind.sh

// install kubectl
curl -LO https://dl.k8s.io/release/v1.21.2/bin/linux/amd64/kubectl
mv ./kubectl /usr/local/bin/kubectl

// install kind
curl -Lo ./kind https://kind.sigs.k8s.io/dl/v0.12.0/kind-linux-amd64 && \
  chmod +x ./kind && \
  mv ./kind /usr/local/bin/kind

// create kind cluster
kind create cluster [--config kind-config.yaml ]

// create pseudo pod
kubectl --generator=run-pod/v1 run ubuntu --rm -i --tty --image=ubuntu:20.04 -- bash
```


Hands on: build container image (1/3)

```
cd k8s-workshop/deployment/static-html
```

```
docker build -t footprintai/k8sworkshop:static-html-demo -f Dockerfile
```

```
[+] Building 9.9s (8/8) FINISHED
```

```
=> [internal] load build definition from Dockerfile 0.3s
```

```
=> [internal] load metadata for docker.io/library/nginx:alpine 3.6s
```

```
=> [auth] library/nginx:pull token for registry-1.docker.io 0.0s
```

```
=> [1/2] FROM docker.io/library/nginx:alpine@sha256:5a0df7fb7c8c03e4d31 5.1s
```

```
=> [2/2] COPY . /usr/share/nginx/html 0.3s
```

```
=> => writing image
```

```
sha256:0957d9469e456017ac3b0cf00ee70c25f6c569f3202dc8d8f1a794745dbcddb9 0.0s
```

```
=> => naming to docker.io/footprintai/k8sworkshop:static-html-demo 0.0s
```

Hands on: Create Deployment Resources

Create a Deployment Resource

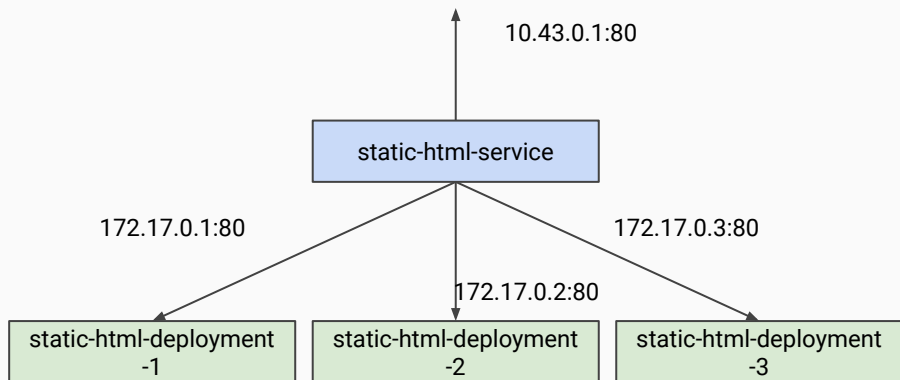
```
1  apiVersion: apps/v1
2  kind: Deployment
3  metadata:
4    name: static-html-deployment
5    namespace: demo1
6    labels:
7      app: http-service
8      version: v1
9  spec:
10   replicas: 1
11   selector:
12     matchLabels:
13       app: http-service
14       version: v1
15   template:
16     metadata:
17       labels:
18         app: http-service
19         version: v1
20   spec:
21     containers:
22     - name: main
23       image: footprintai/k8sworkshop:static-html-demo
24       imagePullPolicy: IfNotPresent
25       ports:
26       - containerPort: 80
```

Create a Deployment Resource With Rolling Update

```
1  apiVersion: apps/v1
2  kind: Deployment
3  metadata:
4    name: static-html-deployment
5    namespace: demo1
6    labels:
7      app: http-service
8      version: v1
9  spec:
10   replicas: 1
11   selector:
12     matchLabels:
13       app: http-service
14       version: v1
15   strategy:
16     type: RollingUpdate
17     rollingUpdate:
18       maxSurge: 1
19       maxUnavailable: 1
20   template:
21     metadata:
22       labels:
23         app: http-service
24         version: v1
25   spec:
26     containers:
27     - name: main
28       image: footprintai/k8sworkshop:static-html-demo
29       imagePullPolicy: IfNotPresent
30       ports:
31       - containerPort: 80
```

Hands on: Create Service Resources

Create a Service Resource

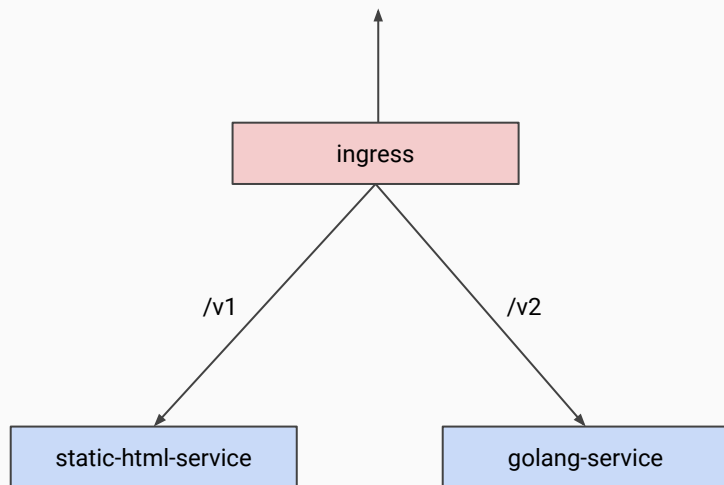


```
1  apiVersion: v1
2  kind: Service
3  metadata:
4    name: static-html-service
5    namespace: demo1
6    labels:
7      app: http-service
8      version: v1
9  spec:
10   ports:
11     - port: 80
12       targetPort: 80
13       protocol: TCP
14   selector:
15     app: http-service
16     version: v1
```

Hands on: Create Ingress Resources

Ingress expose two default ports:

- :80 -> http
- :443 -> https



```
1  apiVersion: networking.k8s.io/v1
2  kind: Ingress
3  metadata:
4    name: nginx
5    namespace: demo1
6    annotations:
7      ingress.kubernetes.io/ssl-redirect: "false"
8      ingress.kubernetes.io/rewrite-target: /
9  spec:
10   rules:
11     - http:
12       paths:
13         - path: /v1
14           pathType: Prefix
15           backend:
16             service:
17               name: static-html-service
18               port:
19                 number: 80
20         - path: /v2
21           pathType: Prefix
22           backend:
23             service:
24               name: golang-service
25               port:
26                 number: 80
```

Hands on: Create Secret and Configmap Resources

Example:

- <https://github.com/FootprintAI/k8s-workshop/blob/main/secrets/secure-monolith.yaml>

Secret

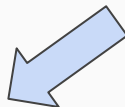
- Secret is an API object holding sensitive information like password, token, key

ConfigMap

- ConfigMap is an API object holding non-sensitive information

Both Secret and ConfigMap are key-value pairs.

```
46 volumes:
47   - name: "tls-certs"
48     secret:
49       secretName: "tls-certs"
50   - name: "nginx-proxy-conf"
51     configMap:
52       name: "nginx-proxy-conf"
53       items:
54         - key: "proxy.conf"
55           path: "proxy.conf"
```



```
1  apiVersion: v1
2  kind: Pod
3  metadata:
4    name: "secure-monolith"
5    labels:
6      app: monolith
7  spec:
8    containers:
9      - name: nginx
10        image: "nginx:1.9.14"
11        lifecycle:
12          preStop:
13            exec:
14              command: ["/usr/sbin/nginx","-s","quit"]
15        volumeMounts:
16          - name: "nginx-proxy-conf"
17            mountPath: "/etc/nginx/conf.d"
18          - name: "tls-certs"
19            mountPath: "/etc/tls"
20      - name: monolith
21        image: "kelseyhightower/monolith:1.0.0"
22        ports:
23          - name: http
24            containerPort: 80
25          - name: health
26            containerPort: 81
```

Hands on: Resource Limit and Probe

Example:

- <https://github.com/FootprintAI/k8s-workshop/blob/main/probe/healthy-probe.yaml>

Resource Limit

- Provision resources for the pod to prevent resource overusage

Probe

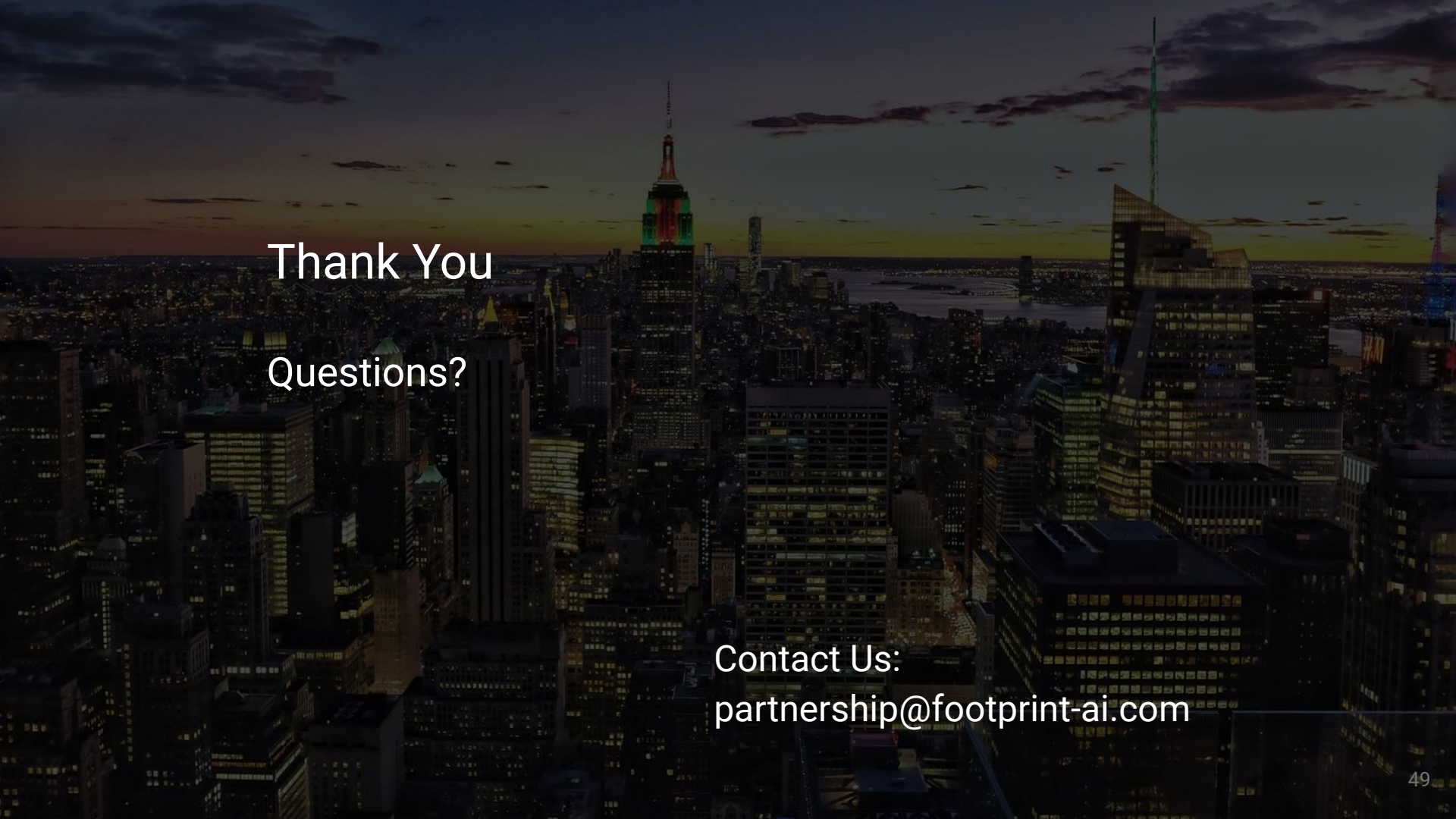
- Health check for the pod
- LivenessProbe: to know when the container is running
- ReadinessProbe: to know when the container are ready to accept traffics

```
1 #ref: https://github.com/evry-bergen/kubernetes-worksh
2 apiVersion: v1
3 kind: Pod
4 metadata:
5   name: "healthy-monolith"
6   namespace: demo1
7   labels:
8     app: monolith
9 spec:
10  containers:
11    - name: monolith
12      image: kelseyhightower/monolith:1.0.0
13      ports:
14        - name: http
15          containerPort: 80
16        - name: health
17          containerPort: 81
18      resources:
19        limits:
20          cpu: 0.2
21          memory: "10Mi"
22      livenessProbe:
23        httpGet:
24          path: /healthz
25          port: 81
26          scheme: HTTP
27        initialDelaySeconds: 5
28        periodSeconds: 15
29        timeoutSeconds: 5
30      readinessProbe:
31        httpGet:
32          path: /readiness
33          port: 81
34          scheme: HTTP
35        initialDelaySeconds: 5
36        timeoutSeconds: 1
```

Q&A

One minute takeaway

- Dockerfile
 - Docker container and docker daemon
 - Pod/Service/Deployment concepts
-
- And it is just a beginning ...

An aerial photograph of the New York City skyline at dusk. The sky is a mix of dark blue and orange, with scattered clouds. The city is densely packed with skyscrapers, many of which are illuminated with their lights. The Empire State Building is prominent in the center, with its top lit in red and green. The Hudson River is visible in the background, with the New York-New York Hotel & Casino's replica of the Empire State Building on the right side of the image.

Thank You
Questions?

Contact Us:
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- Documentations

- <https://kubernetes.io/docs/home/>
- <https://docs.docker.com/>

- Kubectl cheatsheet

- <https://kubernetes.io/docs/reference/kubectl/cheatsheet/>

- Tutorials

- <https://qconuk2019.container.training>