Introduction on Kubeflow

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Agenda

- Why Kubernetes is important?
- What is Kubernetes ?
- What is Kubeflow?
- How Kubeflow works?

Why Kubernetes is important?

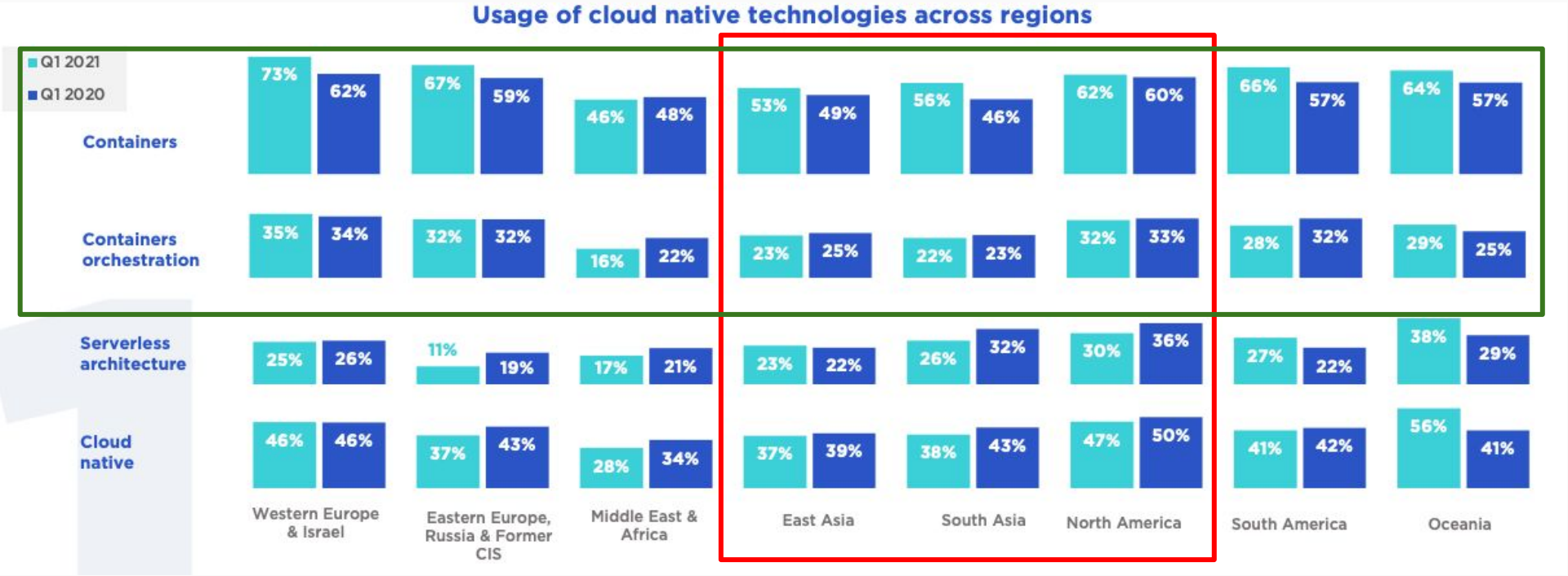
History Of Kubernetes

- 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

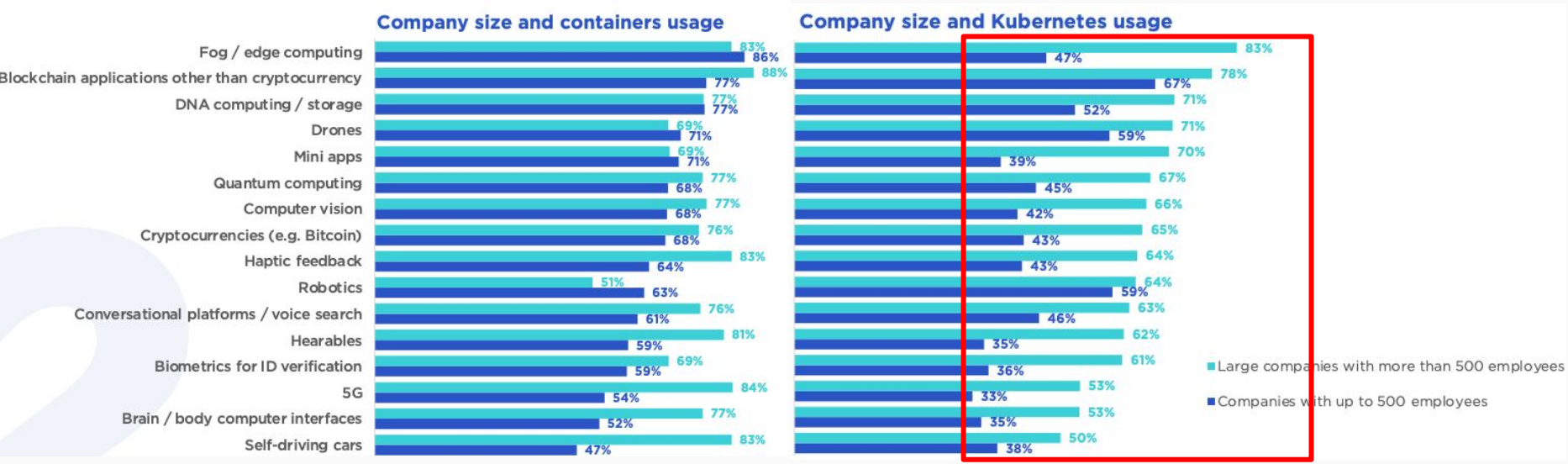
Kubernetes Distributions Evolution

What is Kubernetes adoption rate so far?



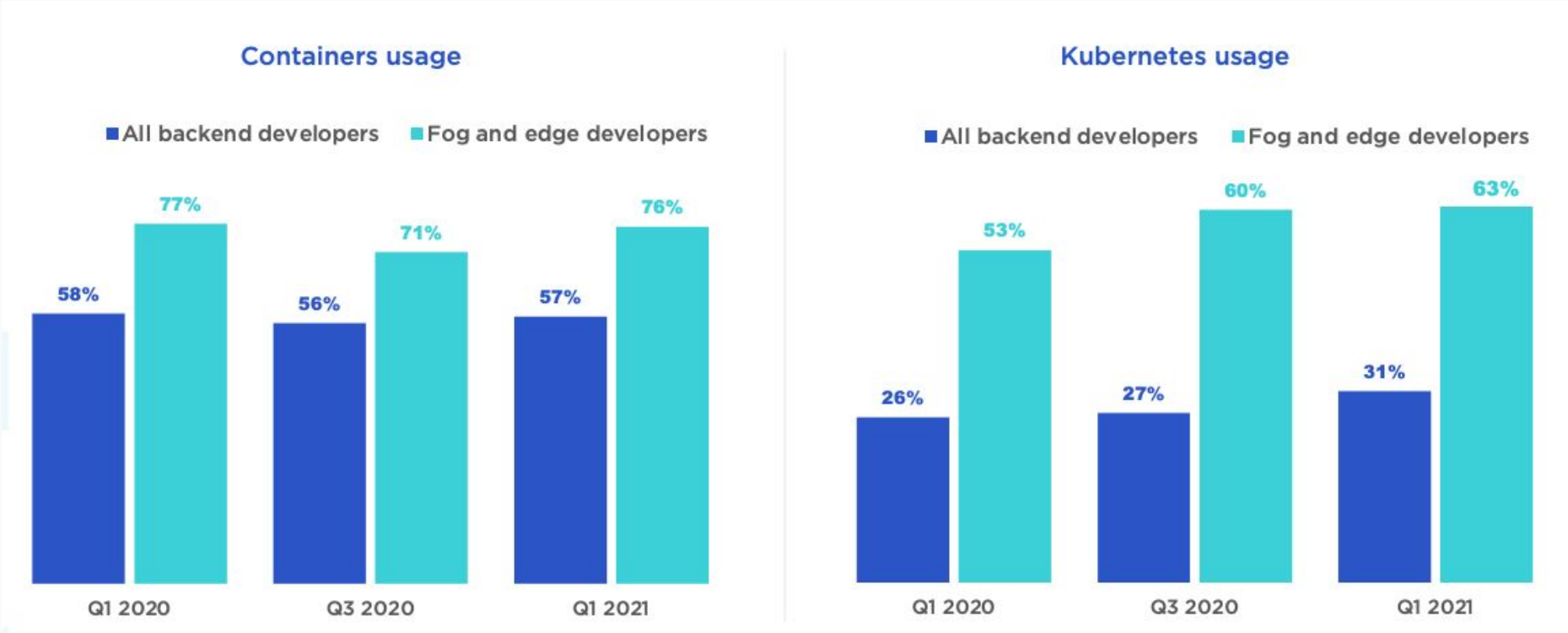
https://www.cncf.io/wp-content/uploads/2021/12/Q1-2021-State-of-Cloud-Native-development-FINAL.pdf

Container adoption rate vs Kubernetes among company size



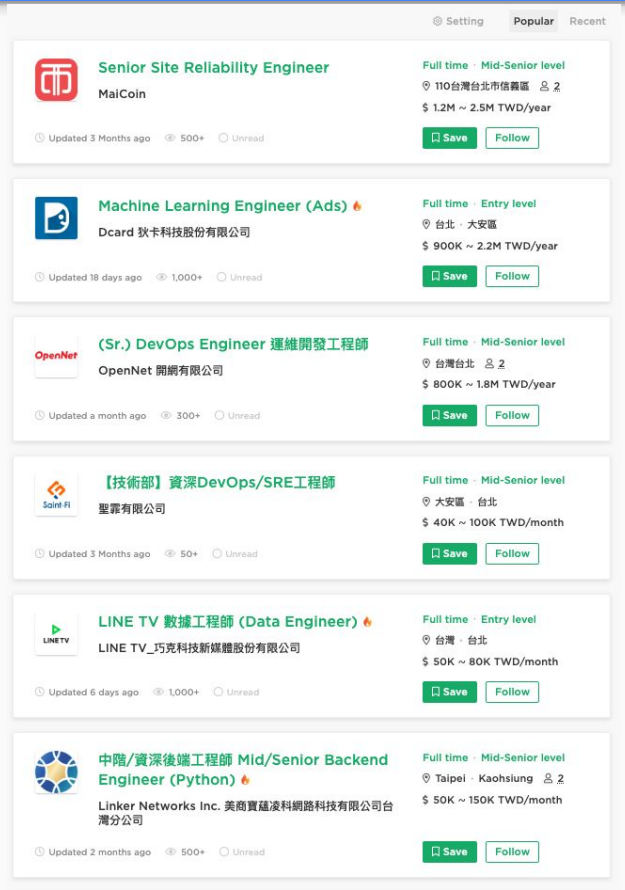
https://www.cncf.io/wp-content/uploads/2021/12/Q1-2021-State-of-Cloud-Native-development-FINAL.pdf

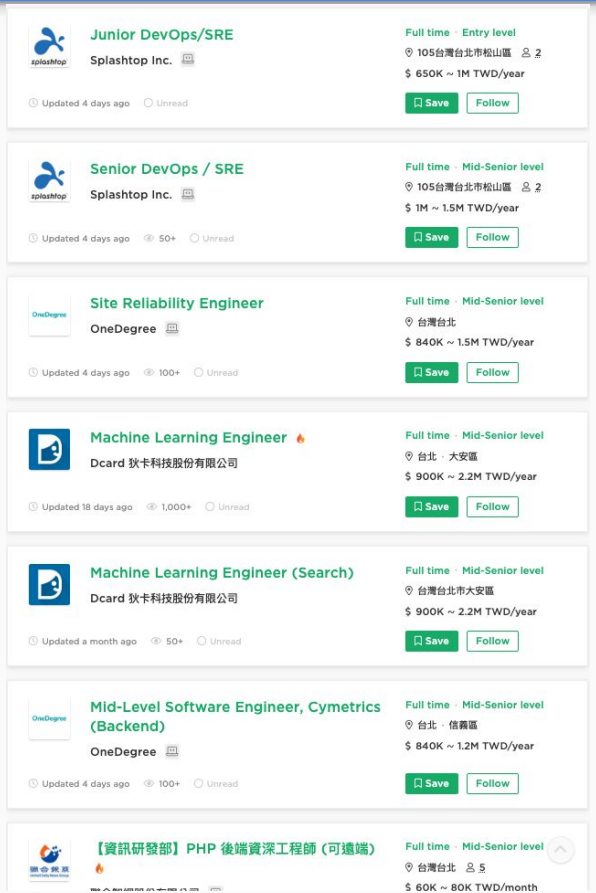
Container and Kubernetes adoption rate on edge computing



https://www.cncf.io/wp-content/uploads/2021/12/Q1-2021-State-of-Cloud-Native-development-FINAL.pdf

Relevant Jobs In Taiwan

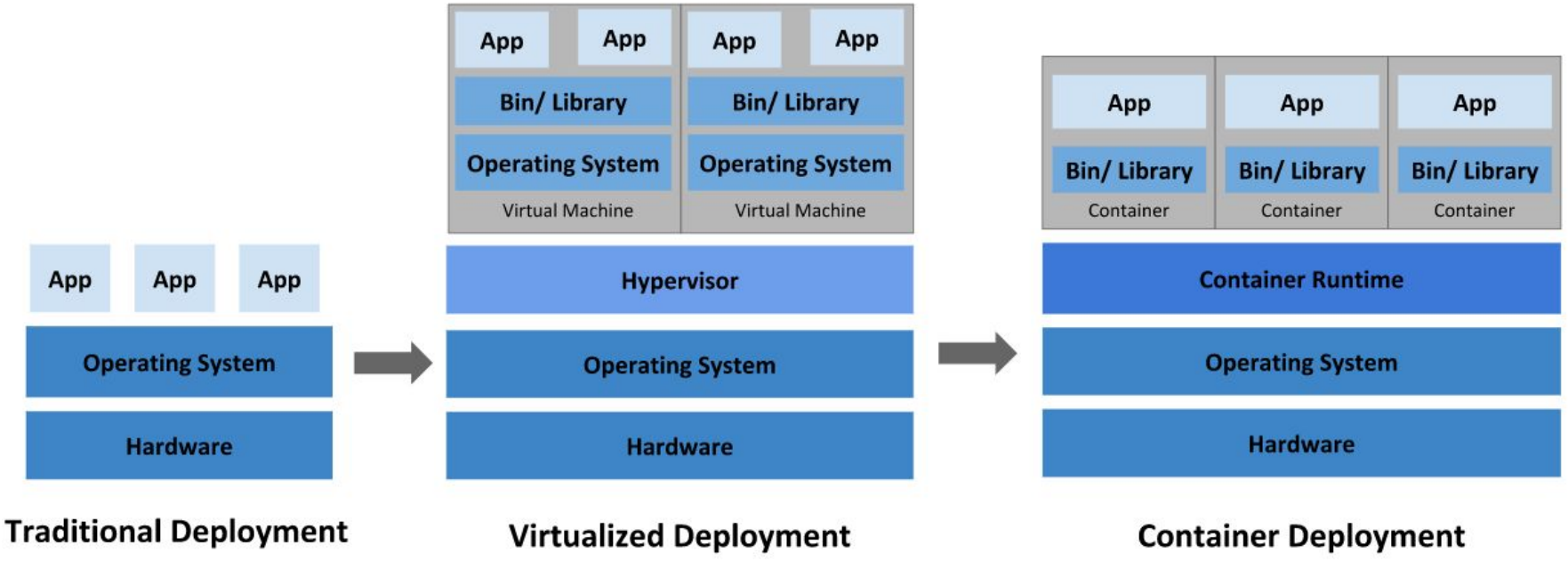




CakeResume: https://reurl.cc/j1qYnD

What is Container?

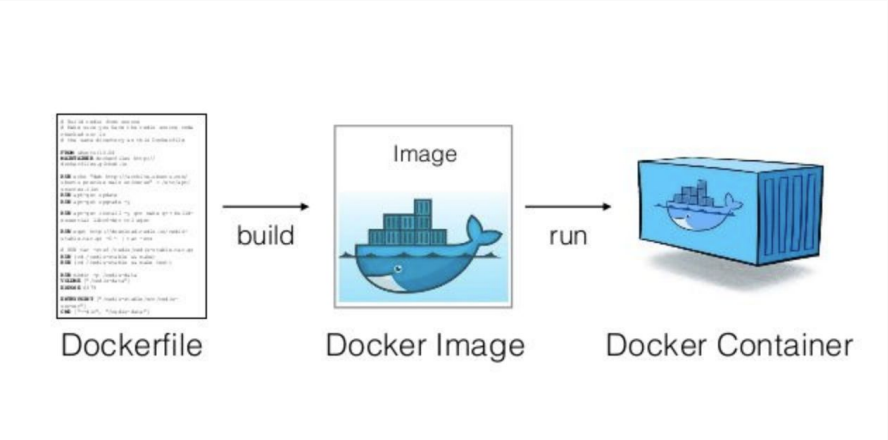
What is containerized deployment?



Ref: https://kubernetes.io/docs/concepts/overview/what-is-kubernetes/

What is Container?

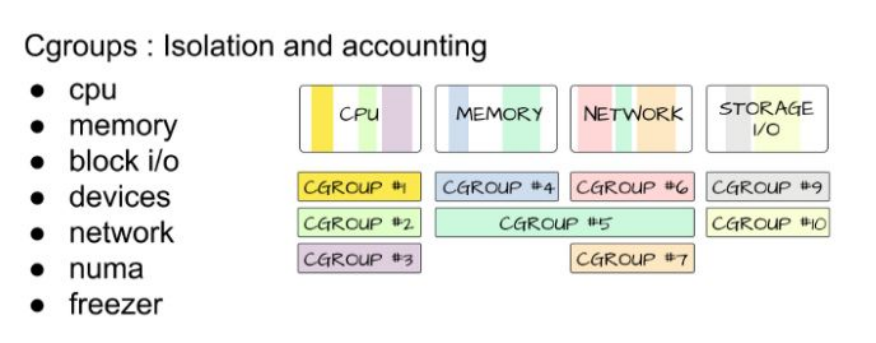
- Container
  - Container Image = Application code + dependencies
  - Runtime environment (cgroups, namespaces, env vars)
- Container Registry
  - Container repository

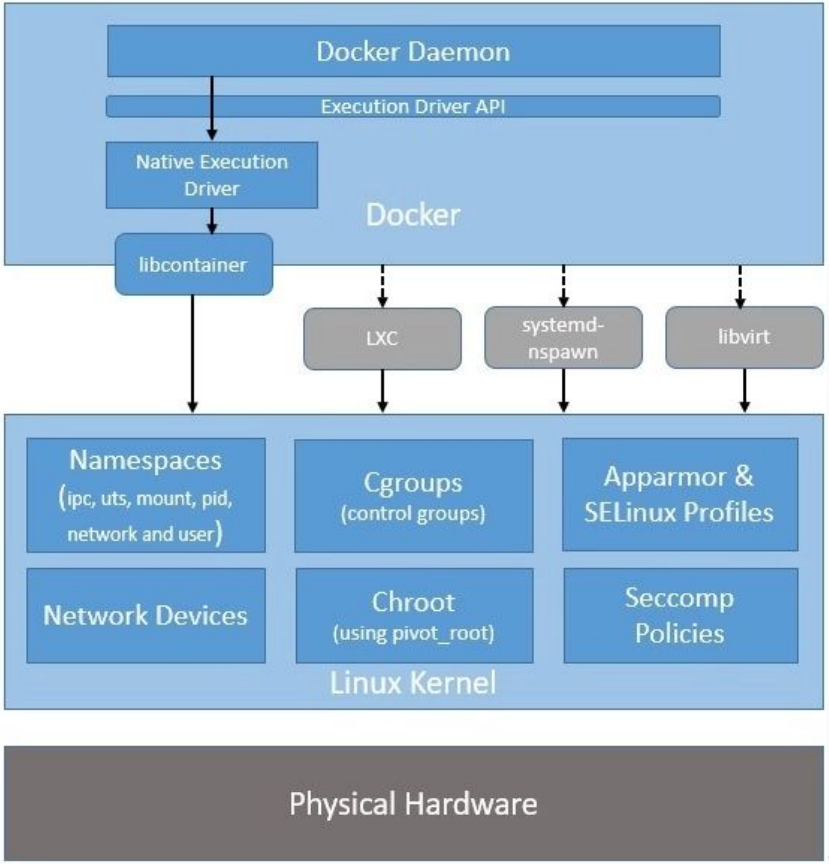


Ref: https://medium.com/platformer-blog/practical-guide-on-writing-a-dockerfile-for-your-application-89376f88b3b5

How container works?

- Namespace for isolation
- Cgroups for resource limiting





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 an container 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
```

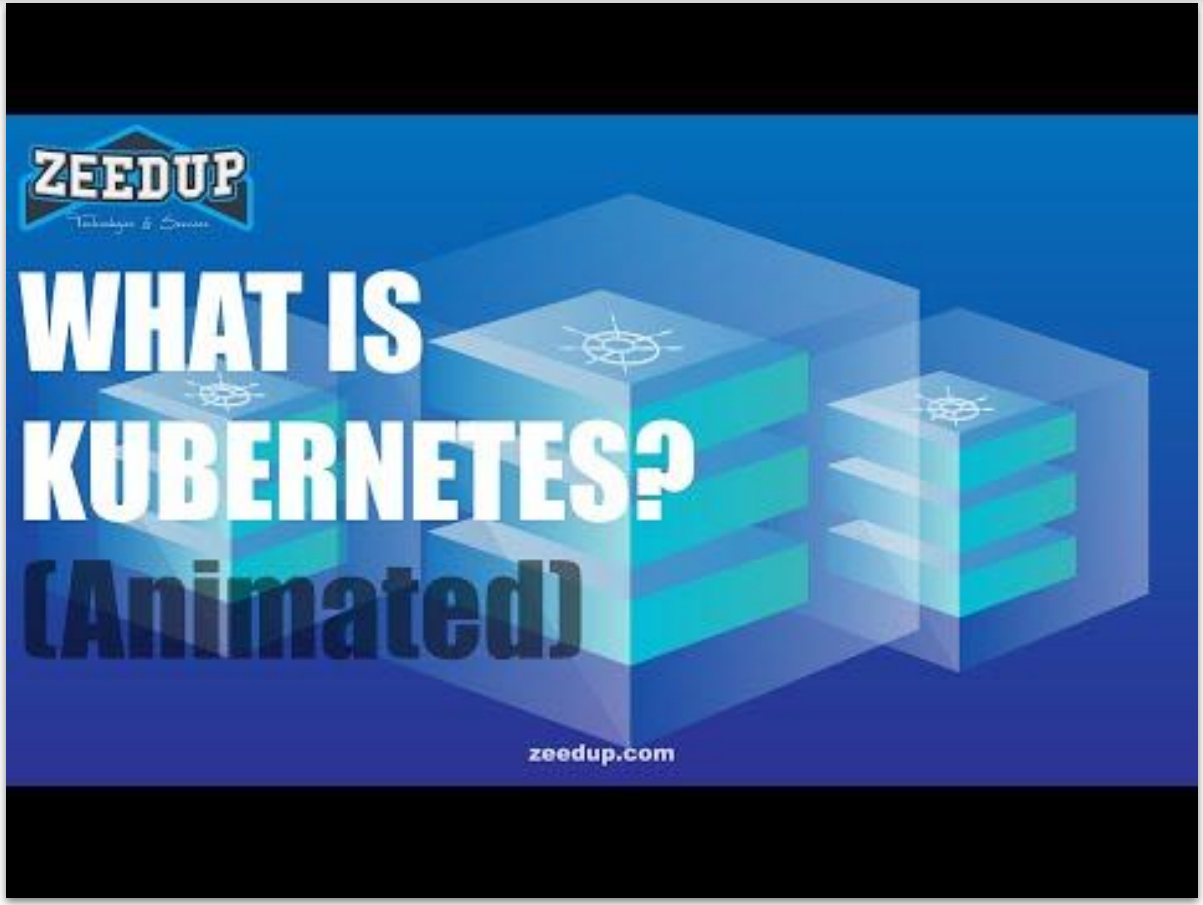
How to build a Docker Image

```
FROM php:7.0-apache

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

EXPOSE 80
```

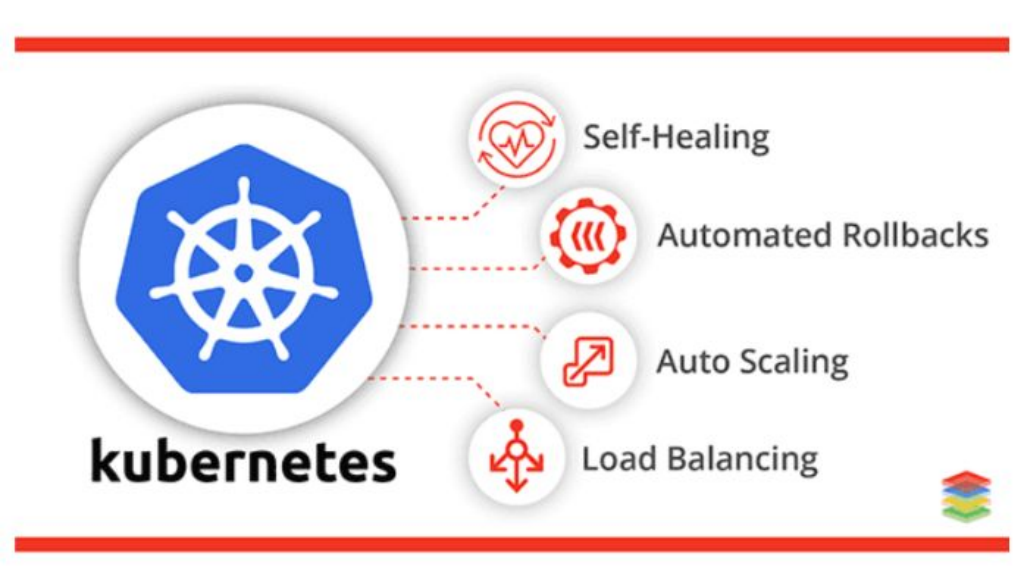
```
docker build -t footprintai/k8sworkshop:php-demo -f Dockerfile .

 => [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
```

What is Kubernetes?

Kubernetes 3D Introduction animation for beginners



Kubernetes Feature Highlighted



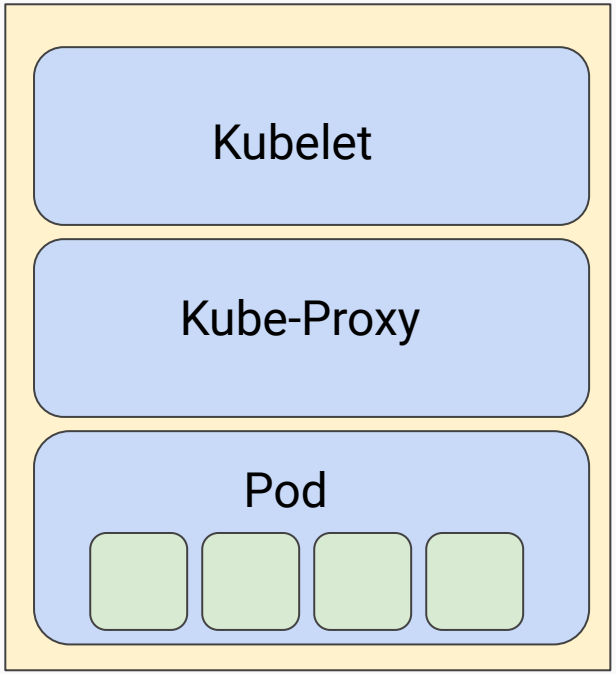
Ref: https://medium.com/swlh/kubernetes-the-evolution-of-a-technology-revolution-805302172ea6

What is Kubernetes?

- High level concepts
  - **Node** are machine that run containerized applications.
  - **Pod** are unit for application workload.
  - **Scheduler** schedules pods to run on nodes.
  - **Deployment/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.

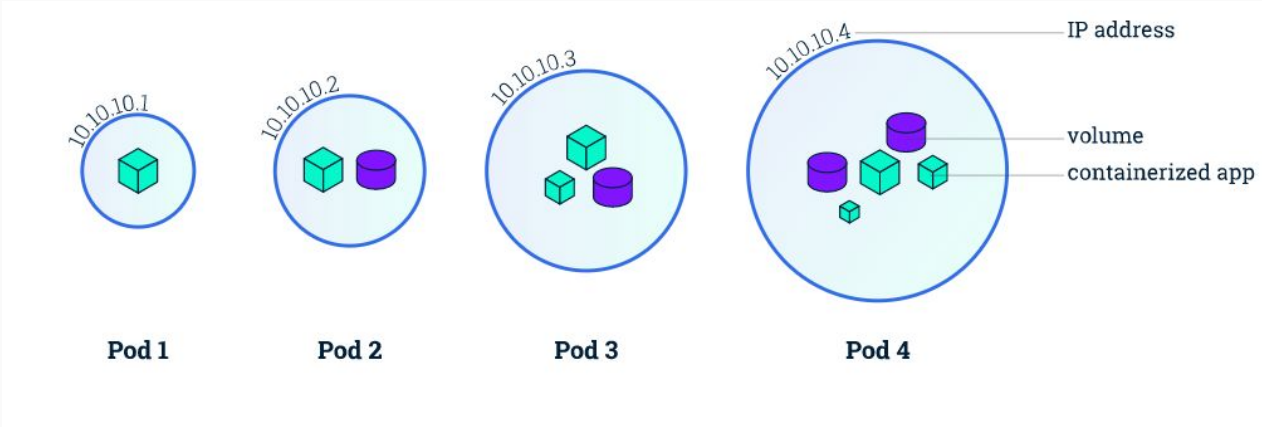
What is a Node?

- Container runtime
  - Docker / CRI-o
- 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?

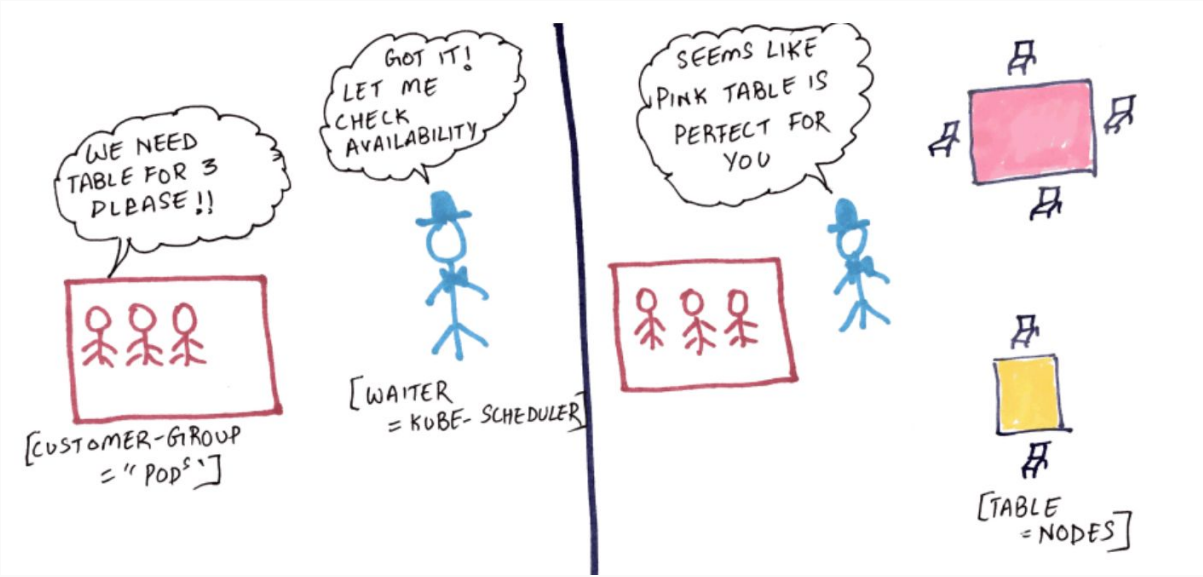
- A pod represents a logical application, it could contains a or multiple containers.
- A pod has unique IP address, persistent storage volume, and a configuration on how container should run
- Containers inside the same pod shares namespaces.
  - Containers inside the same pod ca locate each other and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



Ref: https://kubernetes.io/docs/tutorials/kubernetes-basics/explore/explore-intro/

What is a Scheduler?

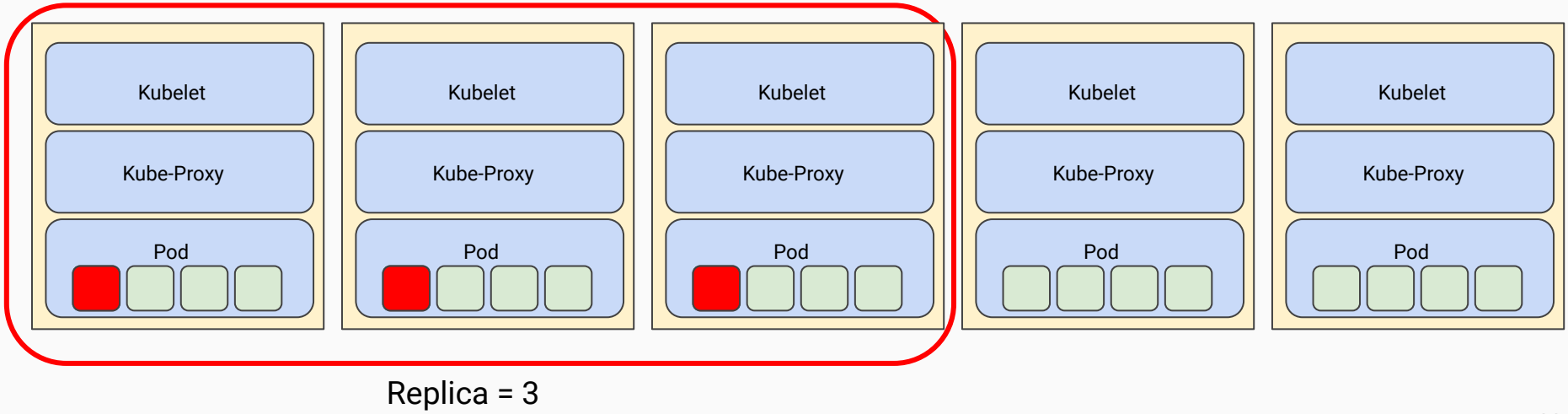
- The scheduler determines (filtering & scoring) which Nodes are valid placements for each Pod in the scheduling queue according to constraints and available resources.



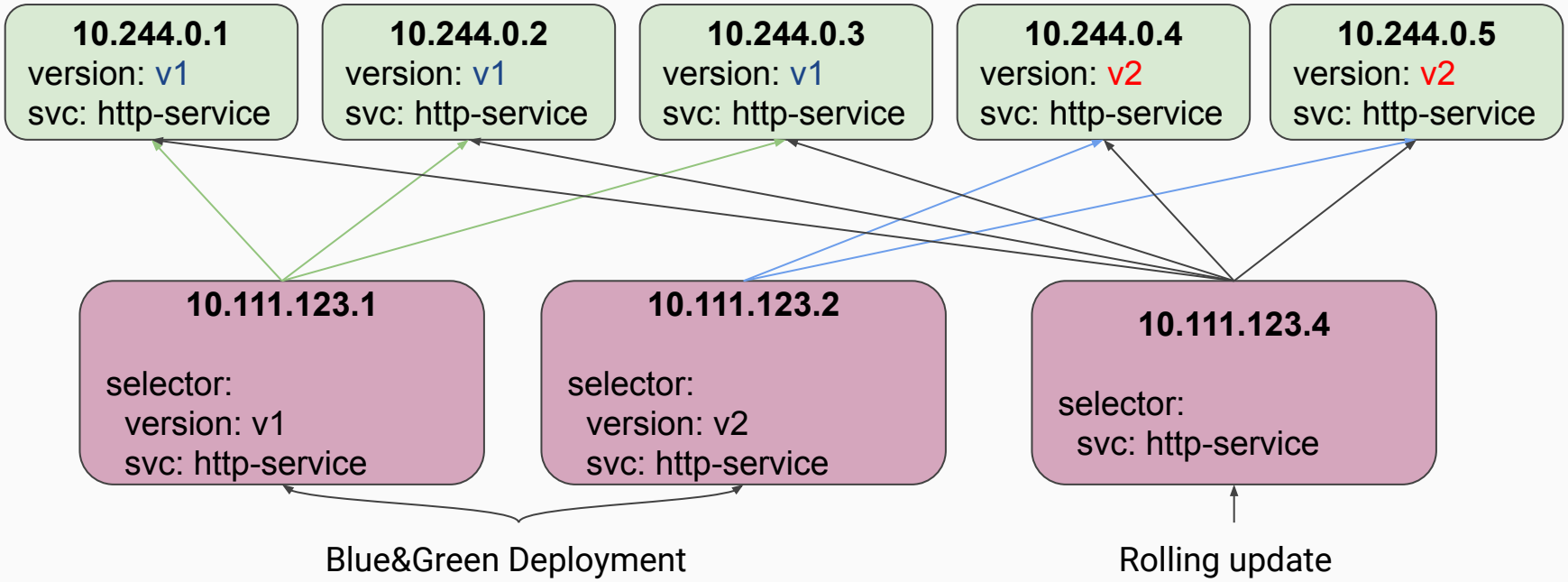
Ref: https://dev.to/ranand12/kubernetes-scheduler-visually-explained-in-plain-english-with-a-story-1g4c

What is Replica Set?

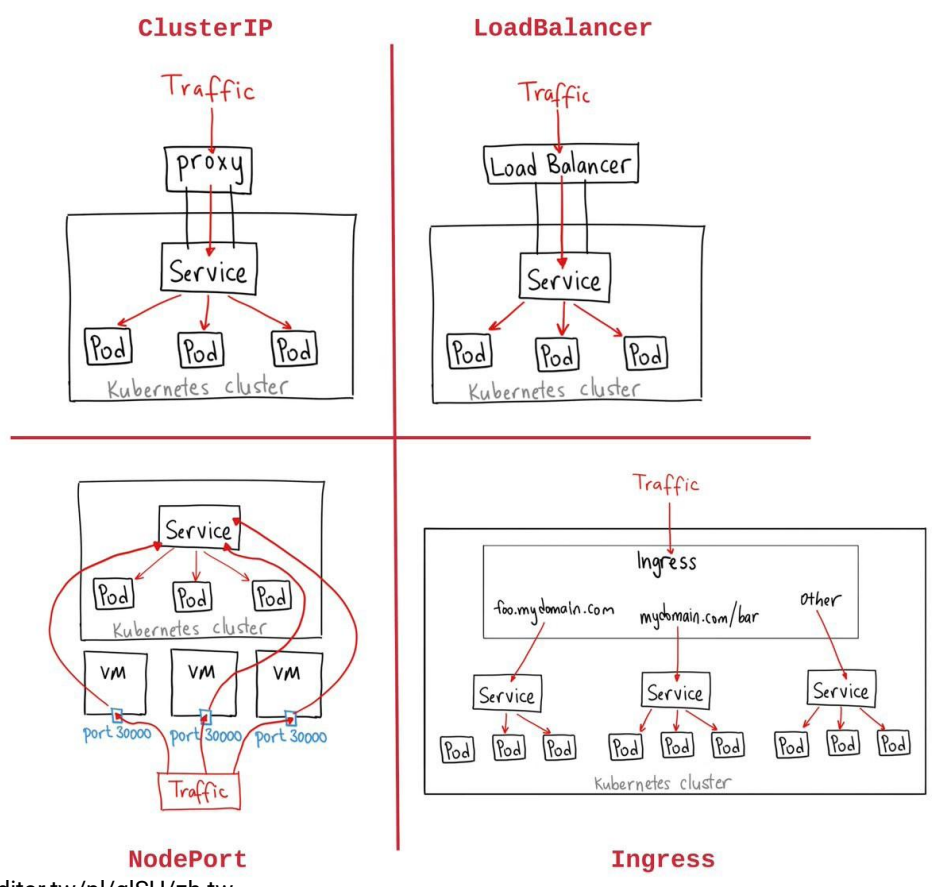
- Manage a replicated set of pods
- Create pods from a template
- Ensure the desired number of pods running
- Online resizing and self-healing



What is Service?



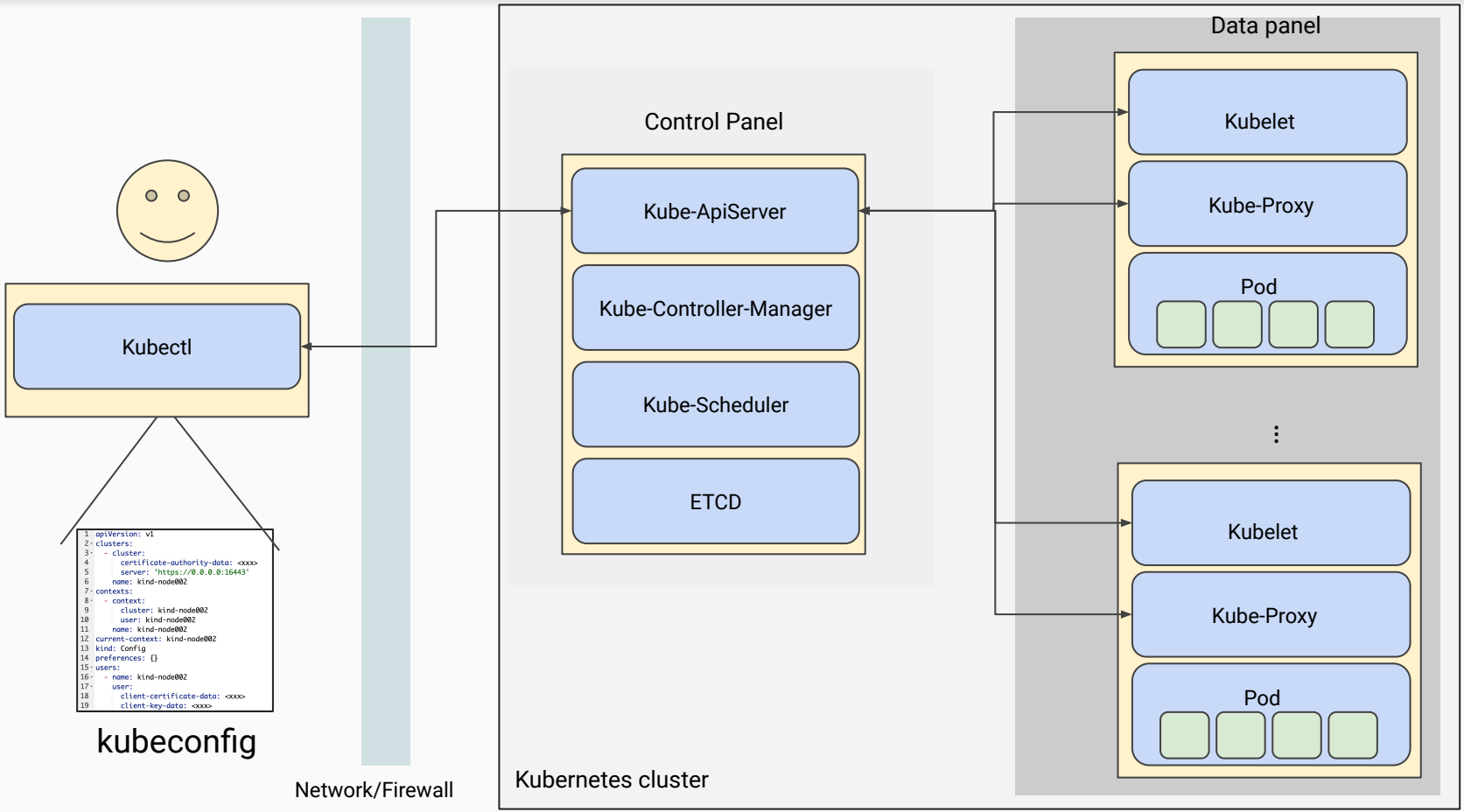
What is Service?



Ref: https://www.mdeditor.tw/pl/glSH/zh-tw

How Kubectl works?

What is Kubectl? (1/2)



What is Kubectl? (2/2)

// when you key in this command on console

kubectl get pods

// it will be translated into

kubectl --kubeconfig=~/.kube/config get pods

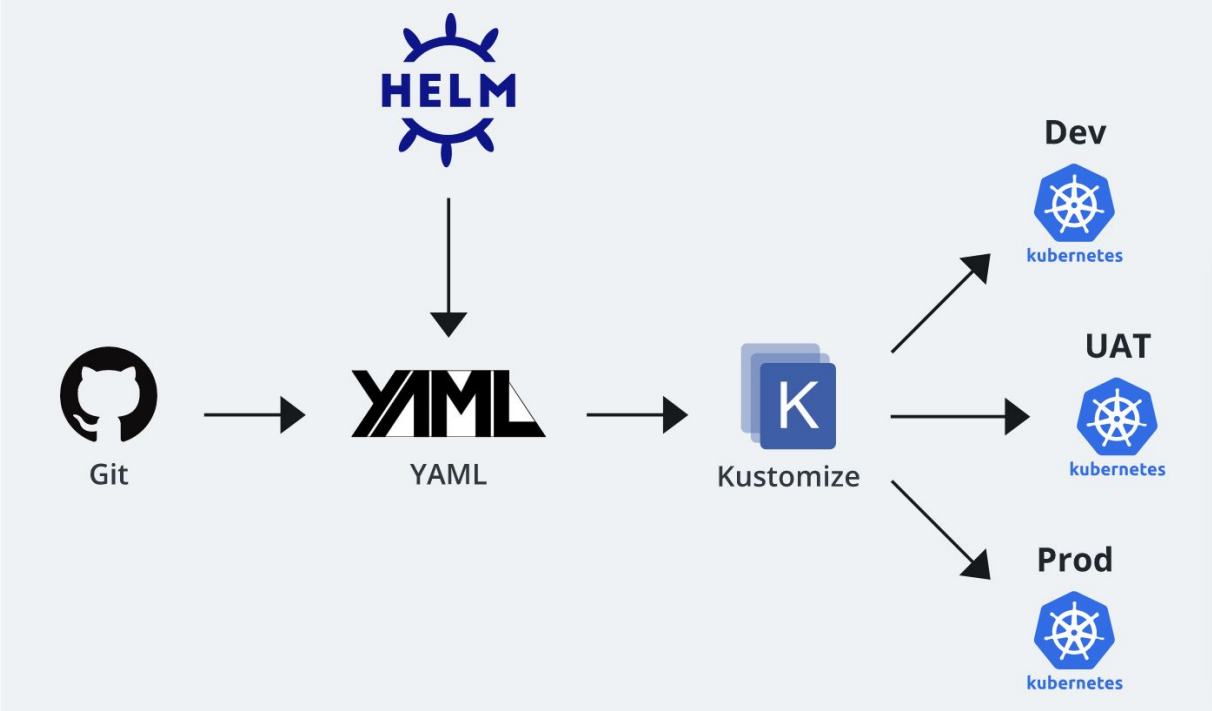
// so it is totally okay to talk to any kube-control panel by specifying kube config path, only if you know how to talk with them

```yaml
apiVersion: v1
clusters:
  - cluster:
      certificate-authority-data: <xxx>
      server: 'https://0.0.0.0:16443'
    name: kind-node002
contexts:
  - context:
      cluster: kind-node002
      user: kind-node002
    name: kind-node002
current-context: kind-node002
kind: Config
preferences: {}
users:
  - name: kind-node002
    user:
      client-certificate-data: <xxx>
      client-key-data: <xxx>
```

Declarative Management with Kubectl

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: static-html-deployment
  namespace: demo1
  labels:
    app: http-service
    version: v1
spec:
  replicas: 1
  selector:
    matchLabels:
      app: http-service
      version: v1
  template:
    metadata:
      labels:
        app: http-service
        version: v1
    spec:
      containers:
      - name: main
        image: footprintai/k8sworkshop:static-html-demo
        imagePullPolicy: IfNotPresent
        ports:
        - containerPort: 80
```

Kustomize: create a overwrite layer on existing resources (1/2)

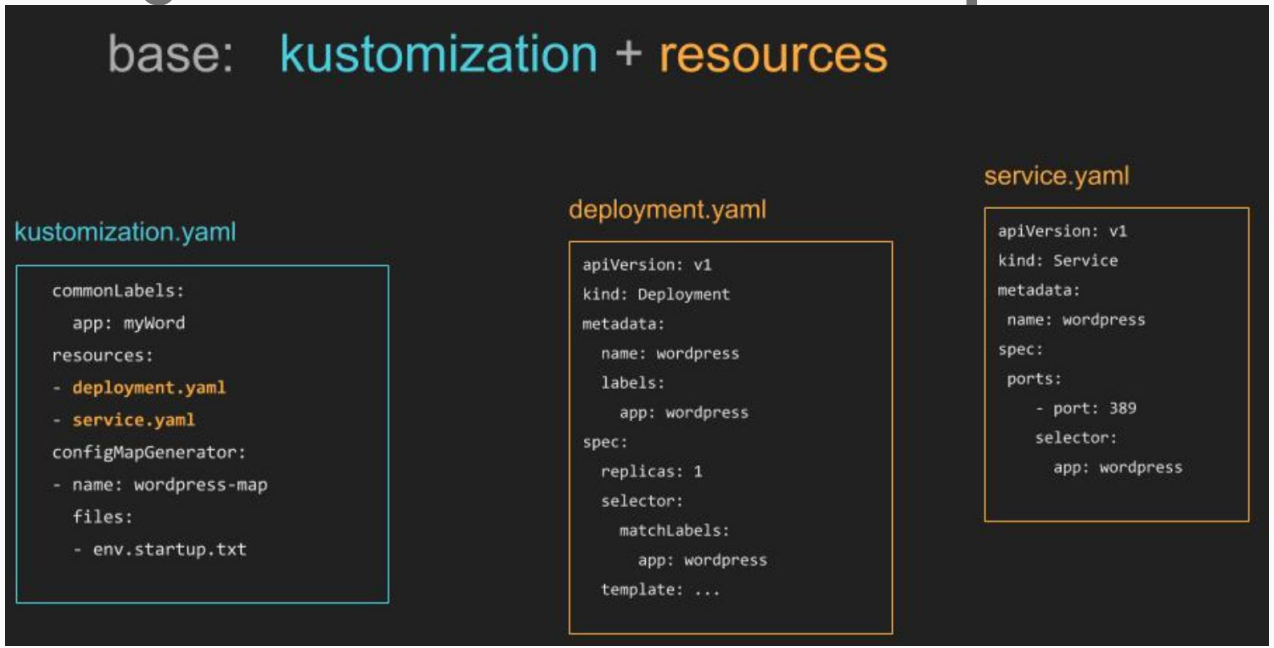


Ref: https://www.densify.com/kubernetes-tools/kustomize

Kustomize: create a overwrite layer on existing resources (2/2)

An environment configuration =

base configuration + environment **specific** configuration



What is MLOPs?

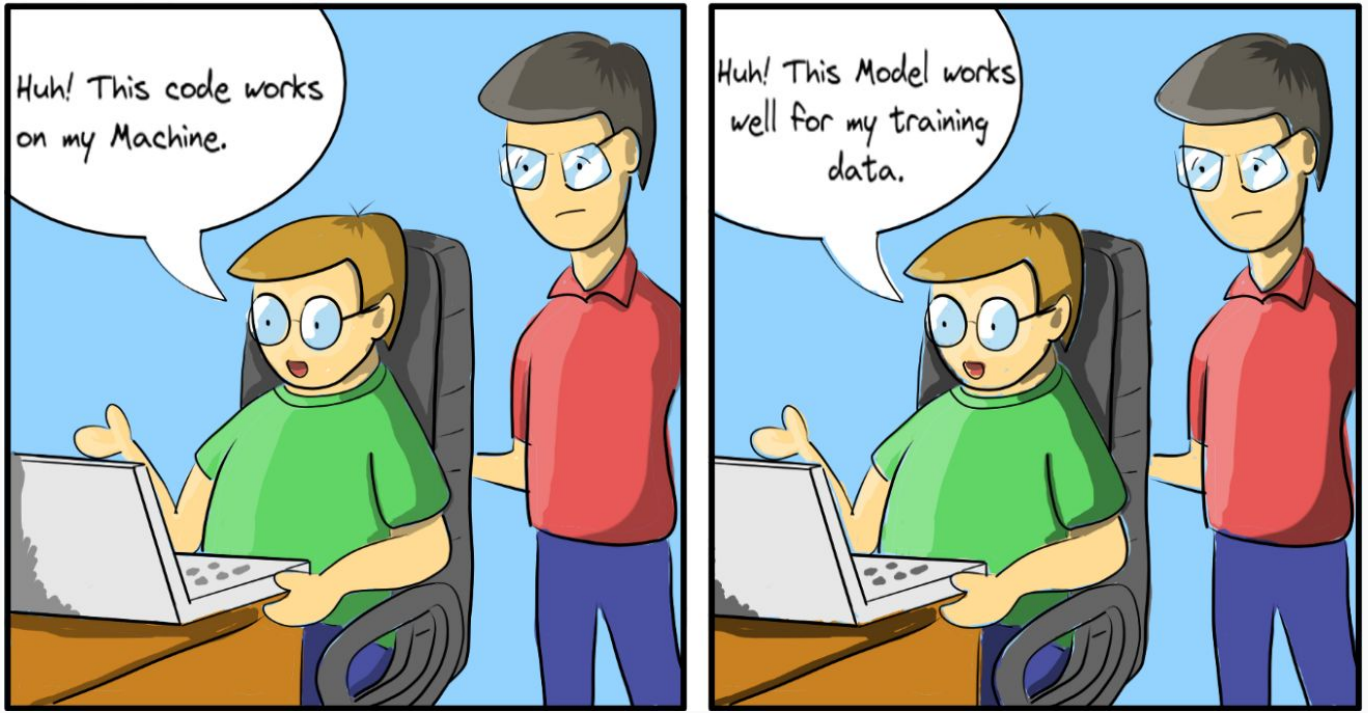
What is deployment automation in Machine learning?

MLOps is the process of taking an experimental Machine Learning model into a production system by including continuous development practice of DevOps in the software field.

Ref: https://en.wikipedia.org/wiki/MLOps

Source: https://www.kubeflow.org/

A common scenario that we both experienced.



Ref: https://towardsdatascience.com/a-gentle-introduction-to-mlops-7d64a3e890ff

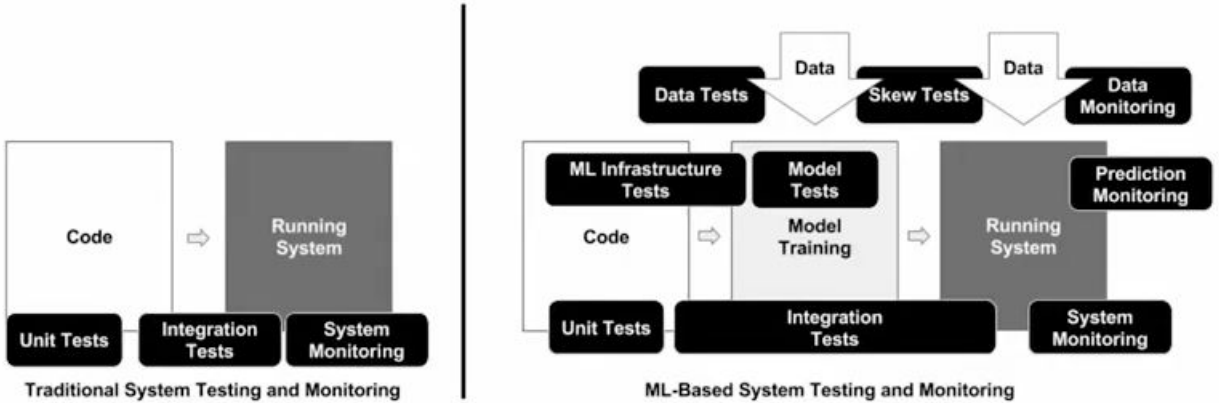
Building & deploying real-world ML application is *hard* and *costly* because of *lack of tooling* that covers end-to-end ML development & deployment

- CloudNext'19

Source CloudNext'19: https://www.youtube.com/watch?v=TZ1lGrJLEZ0

How Involving Machine Learning model could change the current software design?

Traditional vs. ML infused systems

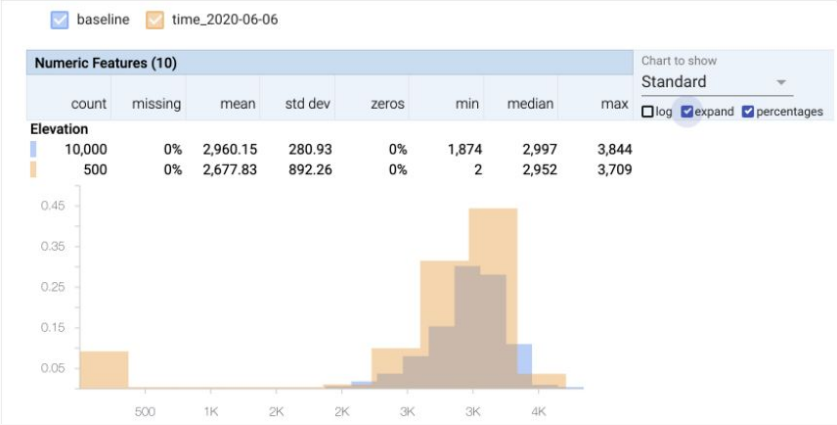


ML introduces two new assets into the software development lifecycle – **data** and **models**.

Ref: DevOps Enterprise Summit' 19 https://www.youtube.com/watch?v=pqppGvTJm-A

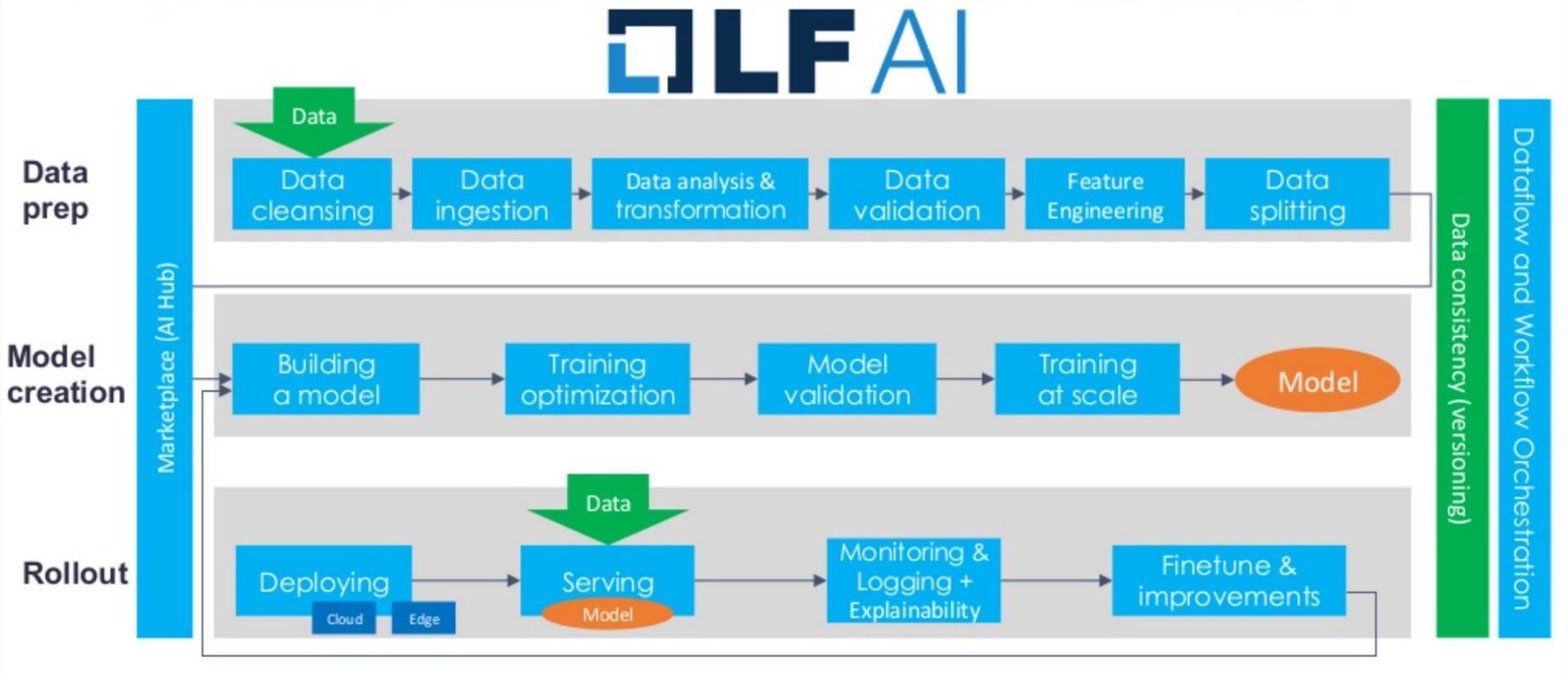
Why we should care about drifting?

- Data drifting
  - A skew grows between training data and serving data.
  - The discrepancies between training data and serving data can usually be classified as schema skews or distribution skews
- Concept drifting
  - The interpretation of the relationship between the input predictors and the target feature evolves



Ref: https://cloud.google.com/architecture/ml-modeling-monitoring-analyzing-training-server-skew-in-ai-platform-prediction-with-tfdv

Real-world Machine Learning Application - End-to-End ML LifeCycle



Source: https://www.slideshare.net/AnimeshSingh/advanced-model-inferencing-leveraging-kubeflow-serving-knative-and-istio-196096385

Why machine learning on Kubernetes?

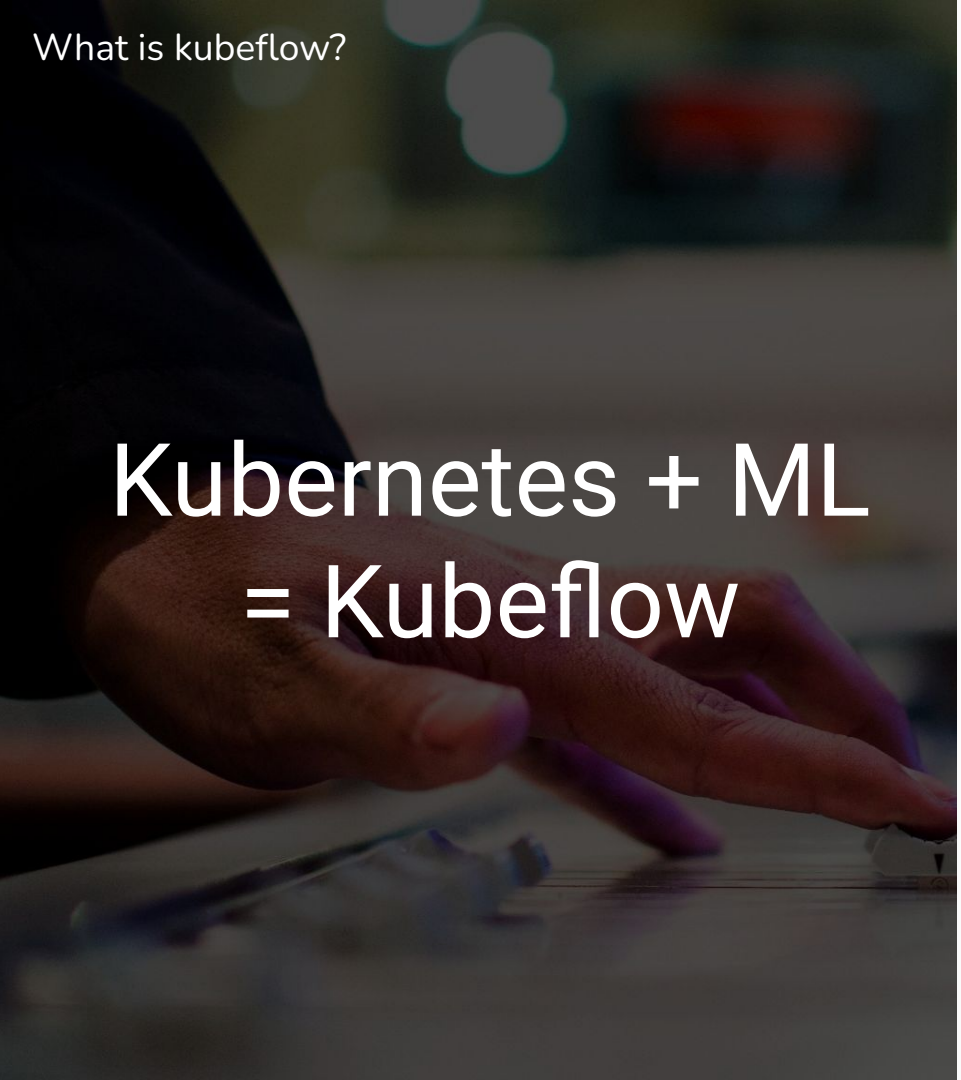
- Composability
  - Each stage are independent systems and are able to compose together
- Portability
  - Dev/Staging/Prod
  - Laptop/Edge/Cloud environment
- Scalability
  - Hyperparameter tuning, production workloads

Oh, you want to use ML on K8s?

Before that, can you become an expert in:

- Containers
- Packaging
- Kubernetes service endpoints
- Persistent volumes
- Scaling
- Immutable deployments
- GPUs, Drivers & the GPL
- Cloud APIs
- DevOps
- ...

Source: @aronchick

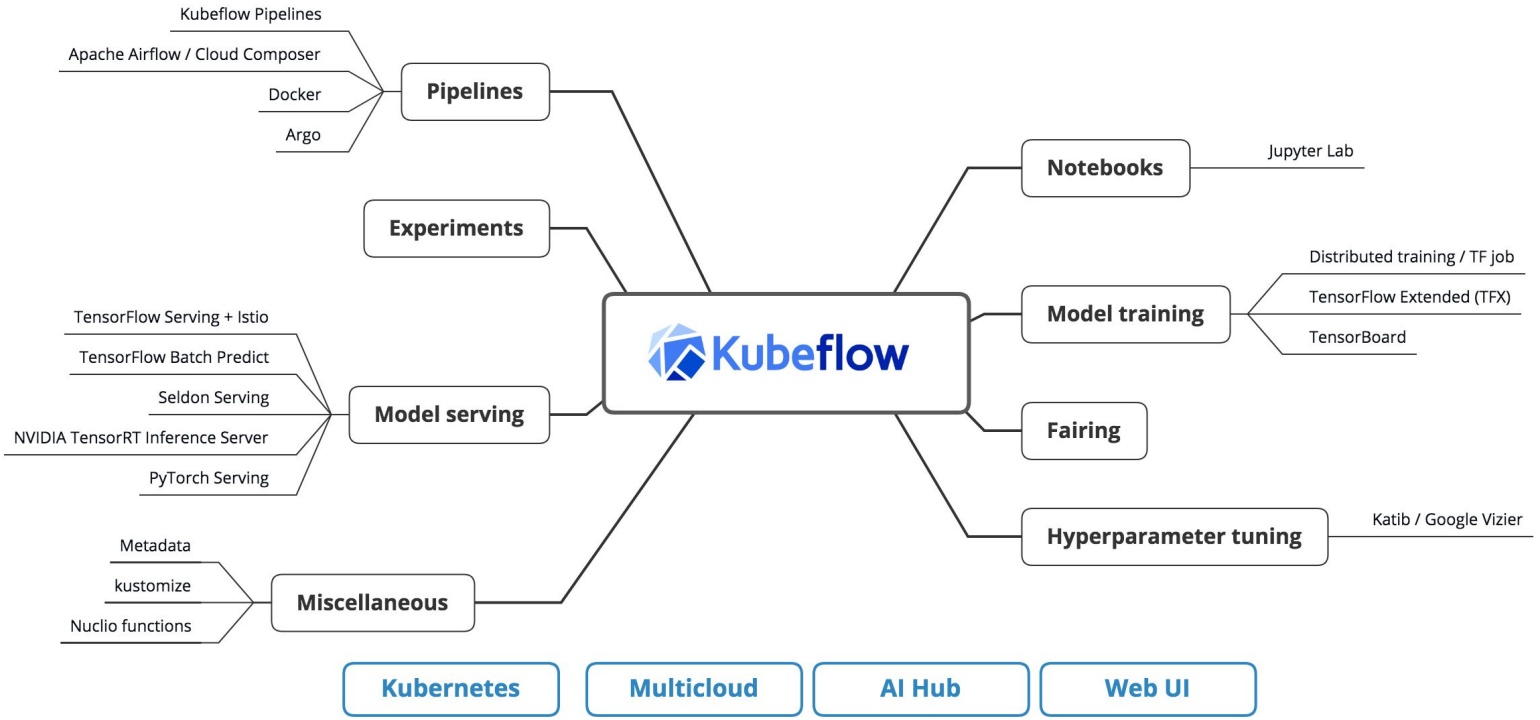


Kubernetes + ML = Kubeflow

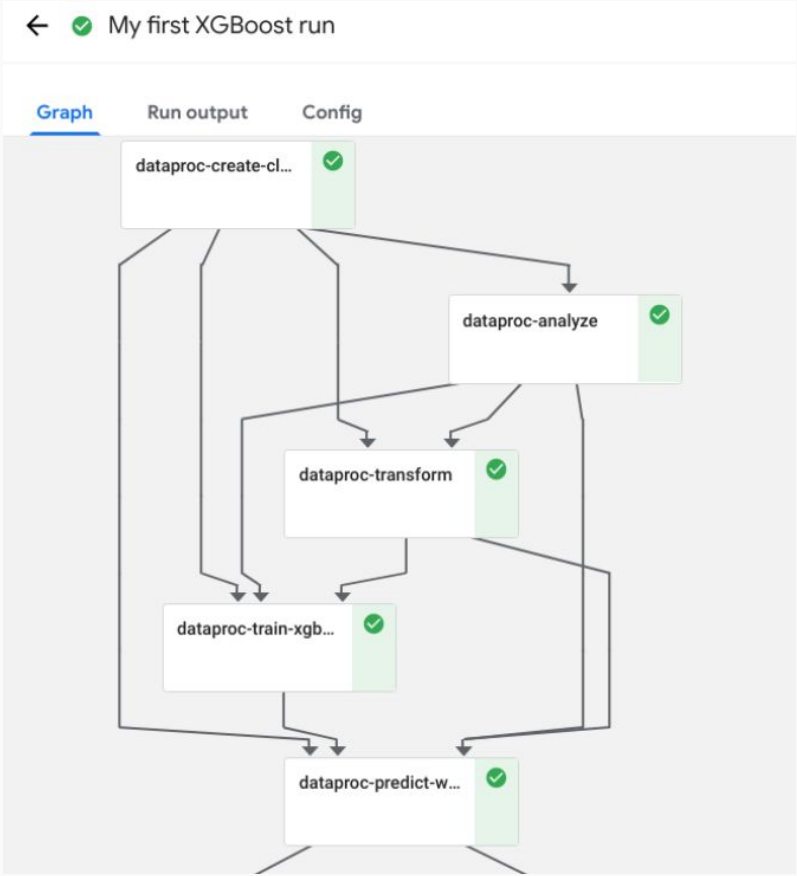
The Kubeflow project is dedicated to making deployments of machine learning (ML) workflows on Kubernetes simple, portable and scalable.

Source: https://www.kubeflow.org/

Architectures



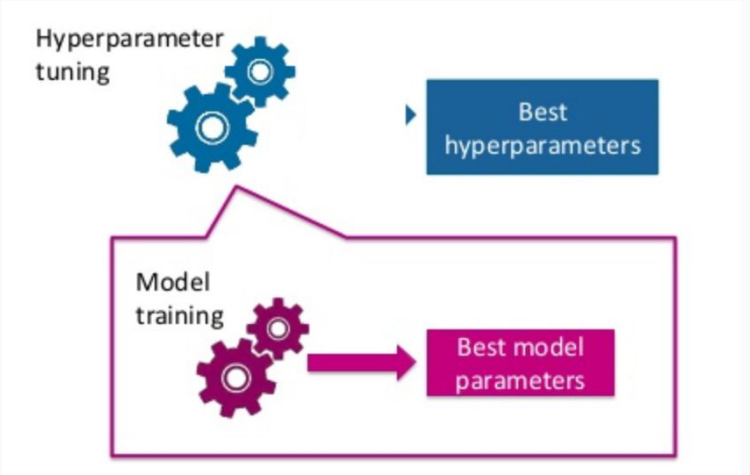
Kubeflow Pipelines



Source:
https://www.kubeflow.org/docs/pipelines/overview/pipelines-overview/

Hyperparameter tuning

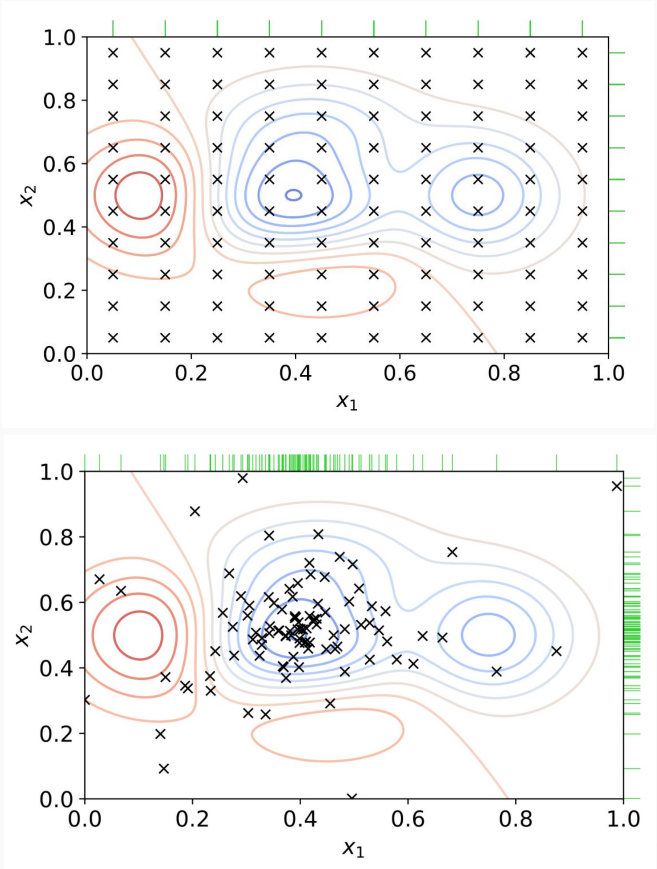
- Model Parameter vs Hyperparameter
  - Model parameters that will learn on its own during training process by the ML model, ex: weights and biases for a classifier.
  - Hyperparameter that directly control the behavior of training algorithm.



Source: https://towardsdatascience.com/understanding-hyperparameters-and-its-optimisation-techniques-f0debba07568

Hyperparameter tuning

- Algorithms
  - Grid Search (top)
  - Random Search
  - Bayesian Optimization
  - Gradient-based optimization (bottom)
  - … and more

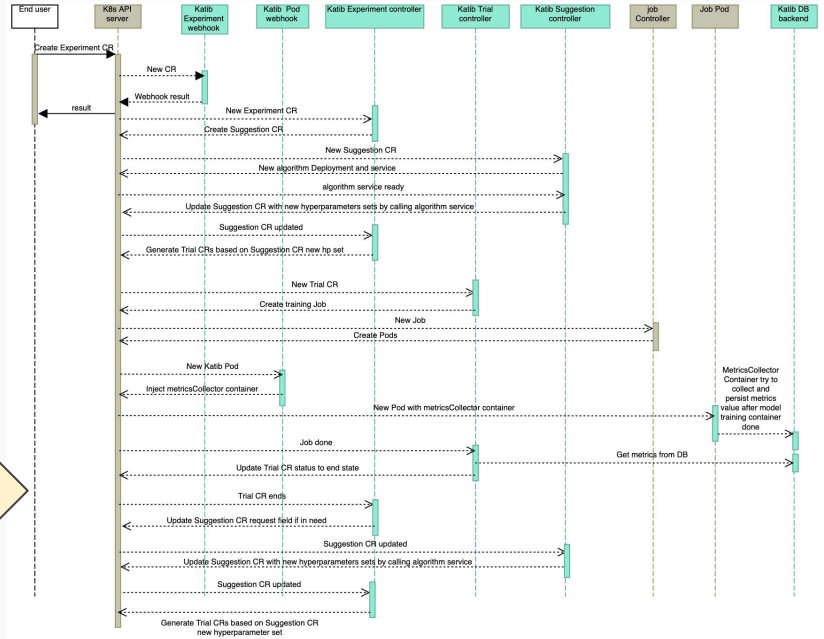


Source: https://en.wikipedia.org/wiki/Hyperparameter_optimization

Kubeflow Katib

- All works that katib has been doing can be described the following pseudocode and then, in reality, turn into the flow diagram below.

```
PROGRAM KATIB:
        exp = CreateExperiment();
        WHILE exp.objective is NOT reached:
            DO sugst = exp.CreateSuggestion();
                metrics = exp.CreateTrials(sugst.Assignments);
                exp.Report(metrics);
END.
```



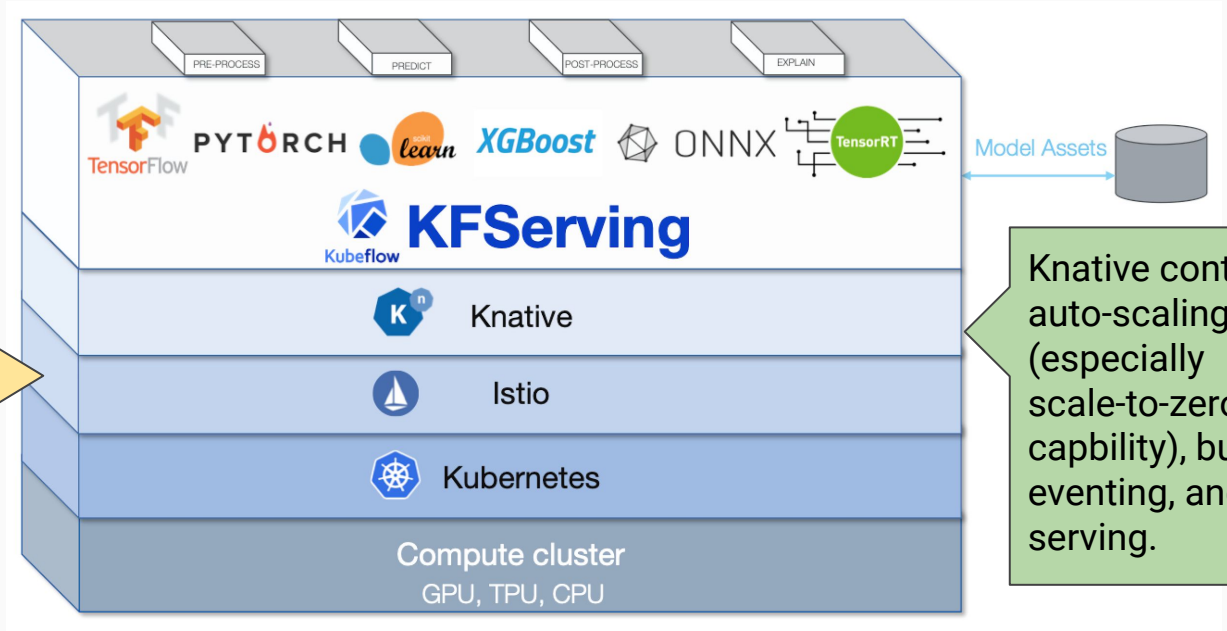
Source: https://github.com/kubeflow/katib/blob/master/docs/workflow-design.md

Model Serving

- How hard it could be to serve ML models in production scale?
  - Scale vs Cost
  - Seamless Rollout
  - Canary Rollouts
  - Service/Model monitoring

Source: https://unsplash.com/@srd844?utm_source=medium&utm_medium=referral

KServe

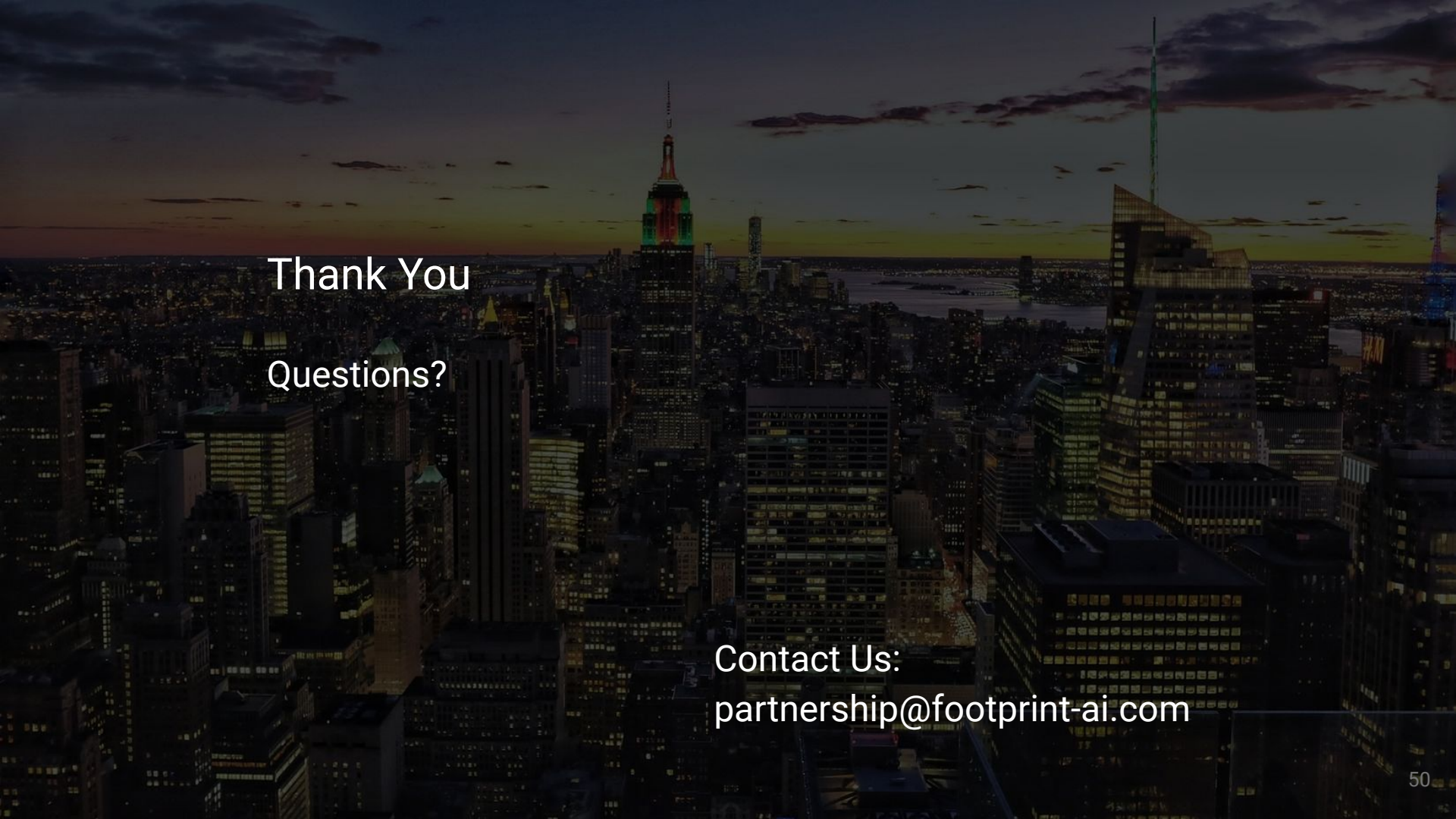


Istio is a service mesh, controlling who can access what services.

Knative controls auto-scaling (especially scale-to-zero capbility), building, eventing, and serving.

Source: https://towardsdatascience.com/understanding-hyperparameters-and-its-optimisation-techniques-f0debba07568

Quote: The best engineers are Lazy.



Thank You

Questions?

Contact Us:
partnership@footprint-ai.com