Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Informatik

CAS Cloud and Platform Manager

Microservices, Containers und Mesh Networking

Niklaus Hirt
Cloud and DevOps Architect

nikh@ch.ibm.com

Rotkreuz, 10.12.2021

Who am I?

Niklaus Hirt

Passionate about tech for over 35 years

- High-school in Berne
- Degree in Computer Science at EPFL
- ELCA
- CAST
- IBM

✉ nikh@ch.ibm.com
@nhirt

Agenda – Microservices and Docker - Basic Concepts

Module 0: Prepare the Labs
Module 1: Microservices
Module 2: Containers with Docker
Module 3: Let’s get real
Module 4: Docker Hands-On
Lunch
Module 5: Kubernetes
Module 6: Mesh Networking
Module 7: Kubernetes Hands-On

Sources and documentation will be available here:

Online Course
https://niklaushirt.github.io/k8s_training_web/

Course Documents
https://github.com/niklaushirt/k8s_training_public

Course Files
https://github.com/niklaushirt/training

Kubernetes Workshop Series

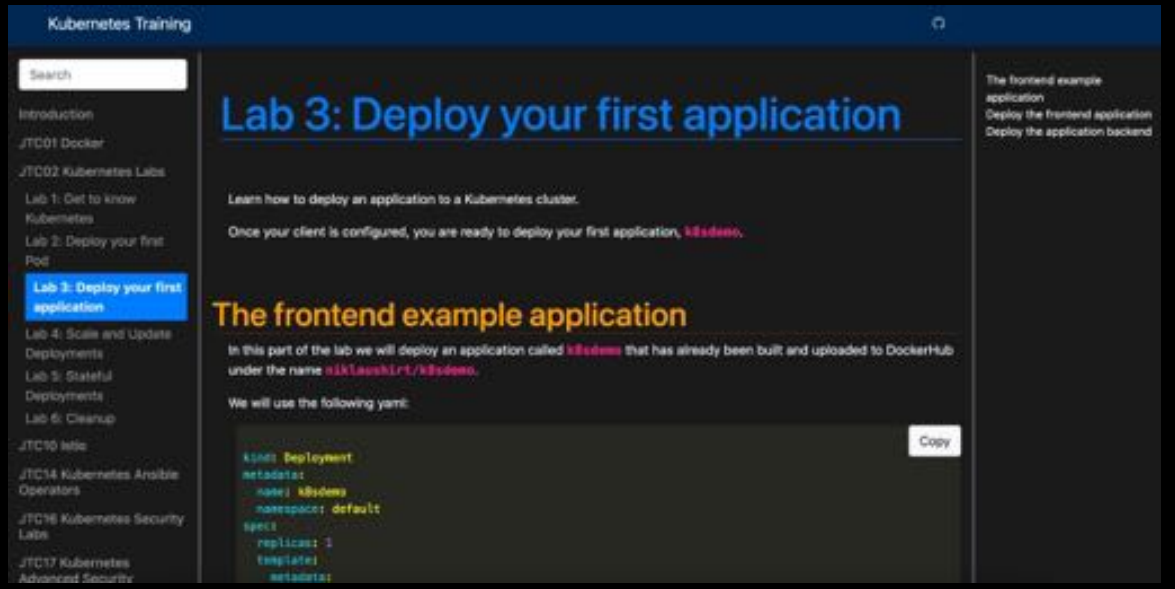
Prepare the Labs

00

Session Objectives

Attendees will run their own ***Personal Training Environment (PTE)*** in the VM.

Following the lectures there will be ***hands-on*** labs that each participant can complete in the PTE.



JTC90 Lab Setup

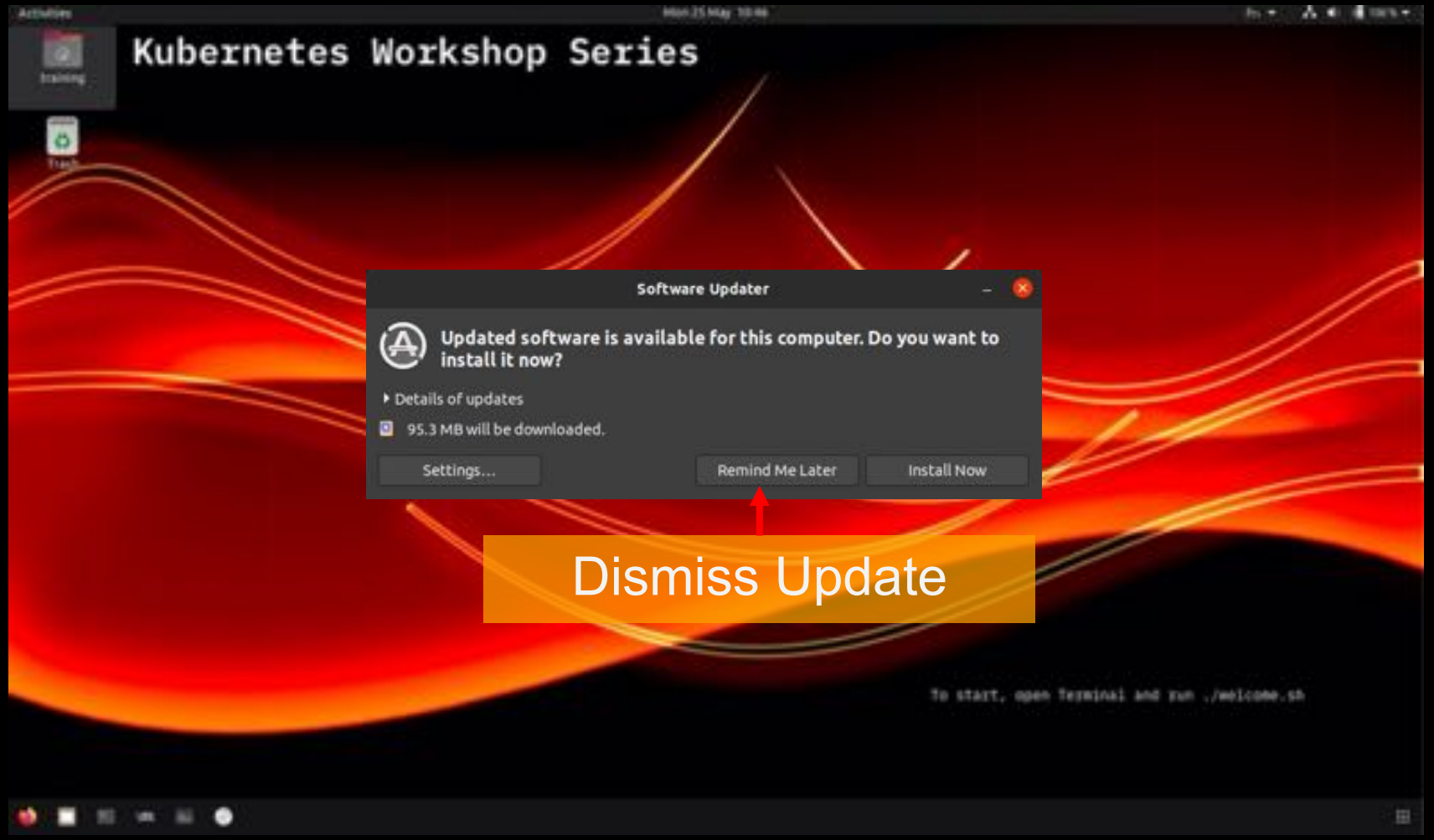
Task 1: Download Training VM

Task 2: Setup VMWare / VirtualBox

Task 3: Start Training VM

Task 4: Login / Check

Using your Personal Training Environment

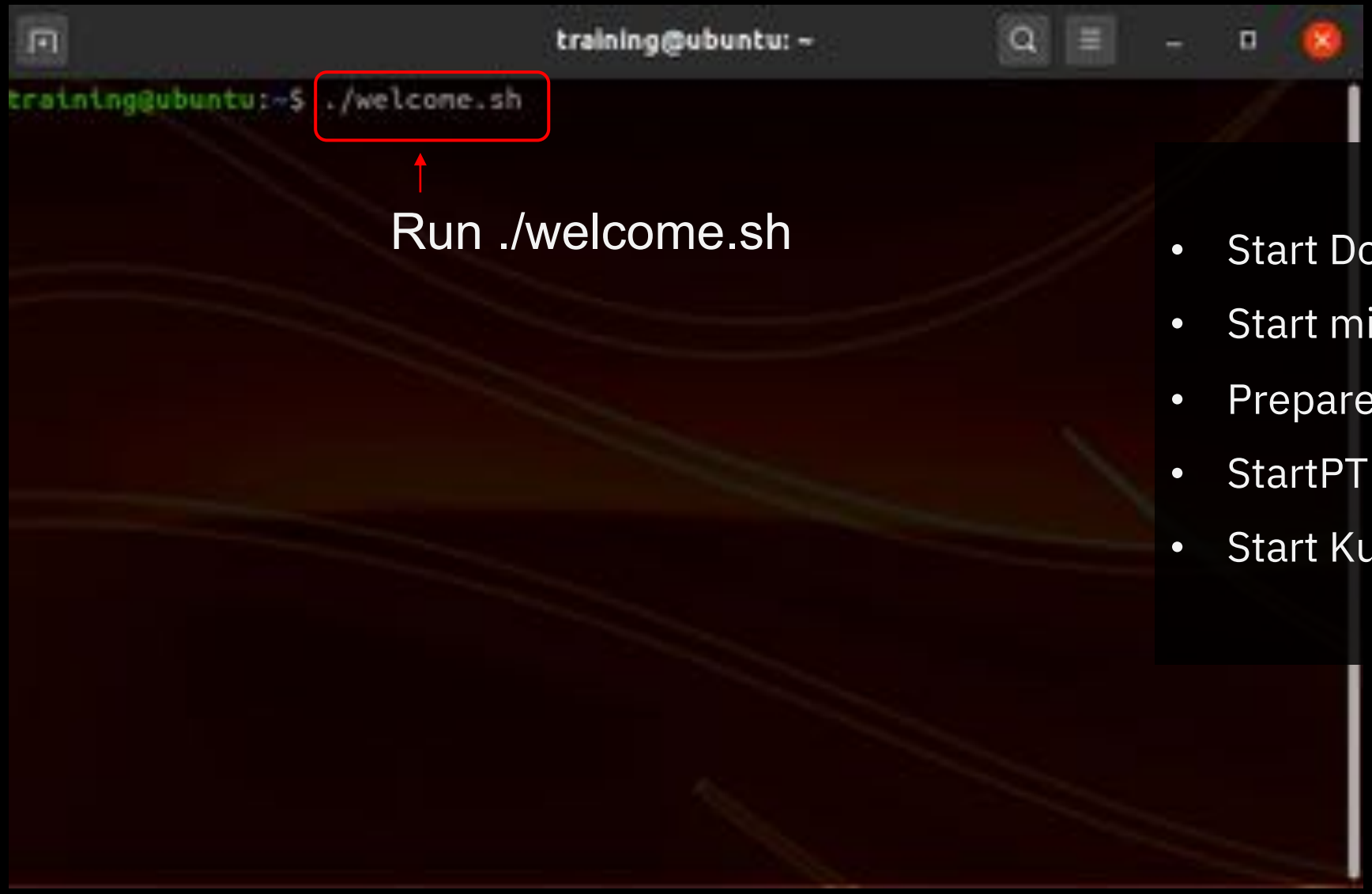


Using your Personal Training Environment

Using your Personal Training Environment

Start Terminal

Using your Personal Training Environment

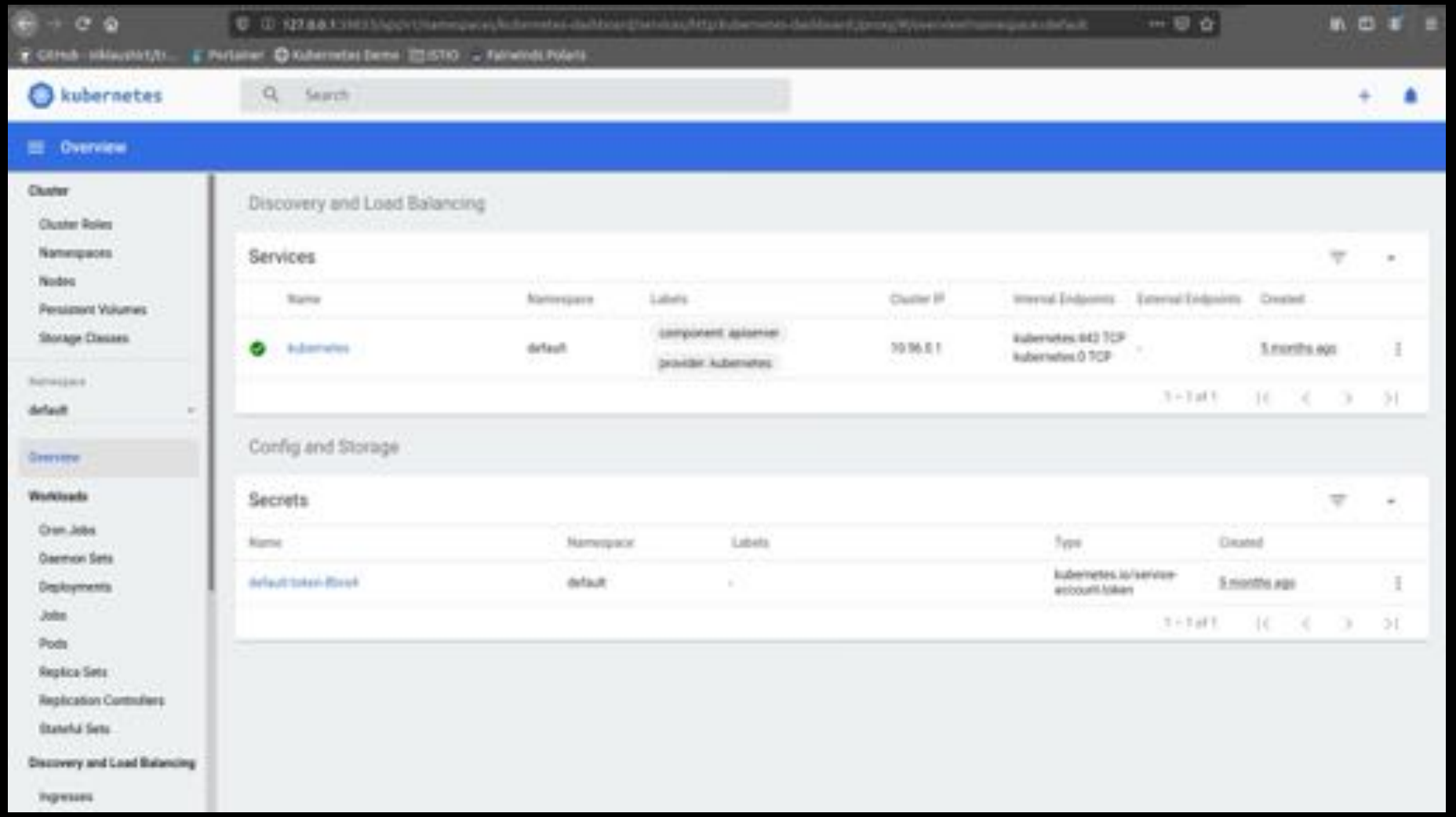


- Start Docker
- Start minikube
- Prepares networking
- StartPTE
- Start Kubernetes Dashboard

Using your Personal Training Environment

First your Online Course will open automatically

Using your Personal Training Environment



When completed, the Kubernetes Dashboard will open automatically

Using your Personal Training Environment

Troubleshooting

- If the startup script doesn’t work you can run ./resetEnvironment.sh
  (this can take up to 30 minutes as it has to redownload all Docker images)

- If you lose your Training Webpage go to https://niklaushirt.github.io/k8s_training_web/

JTC90 Lab Setup

EVERYBODY OK ?

Task 1: Download Training VM

Task 2: Setup VMWare / VirtualBox

Task 3: Start Training VM

Task 4: Login / Check

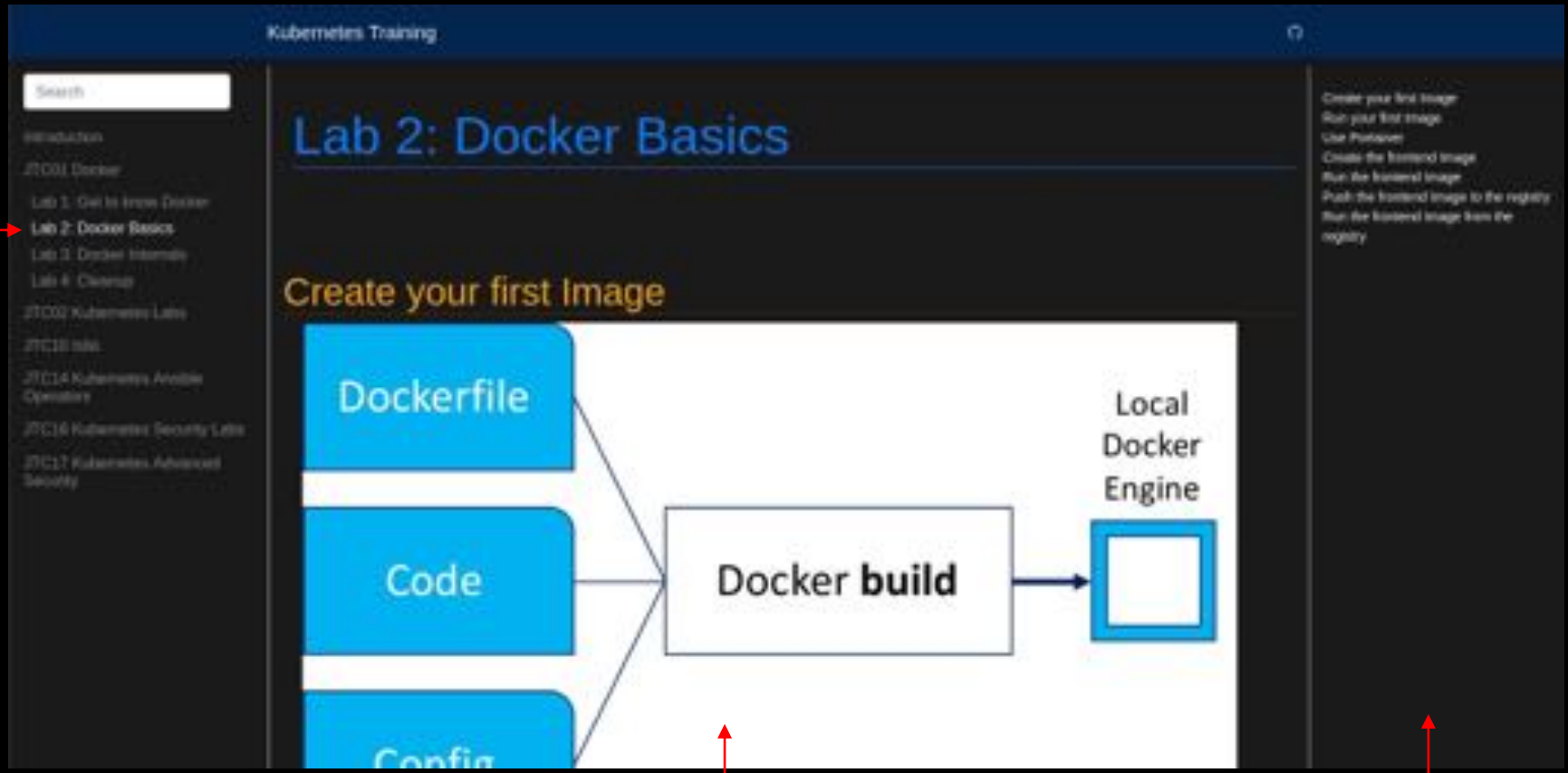
Using your Personal Training Environment

Select course to begin

Current course catalog

Using your Personal Training Environment

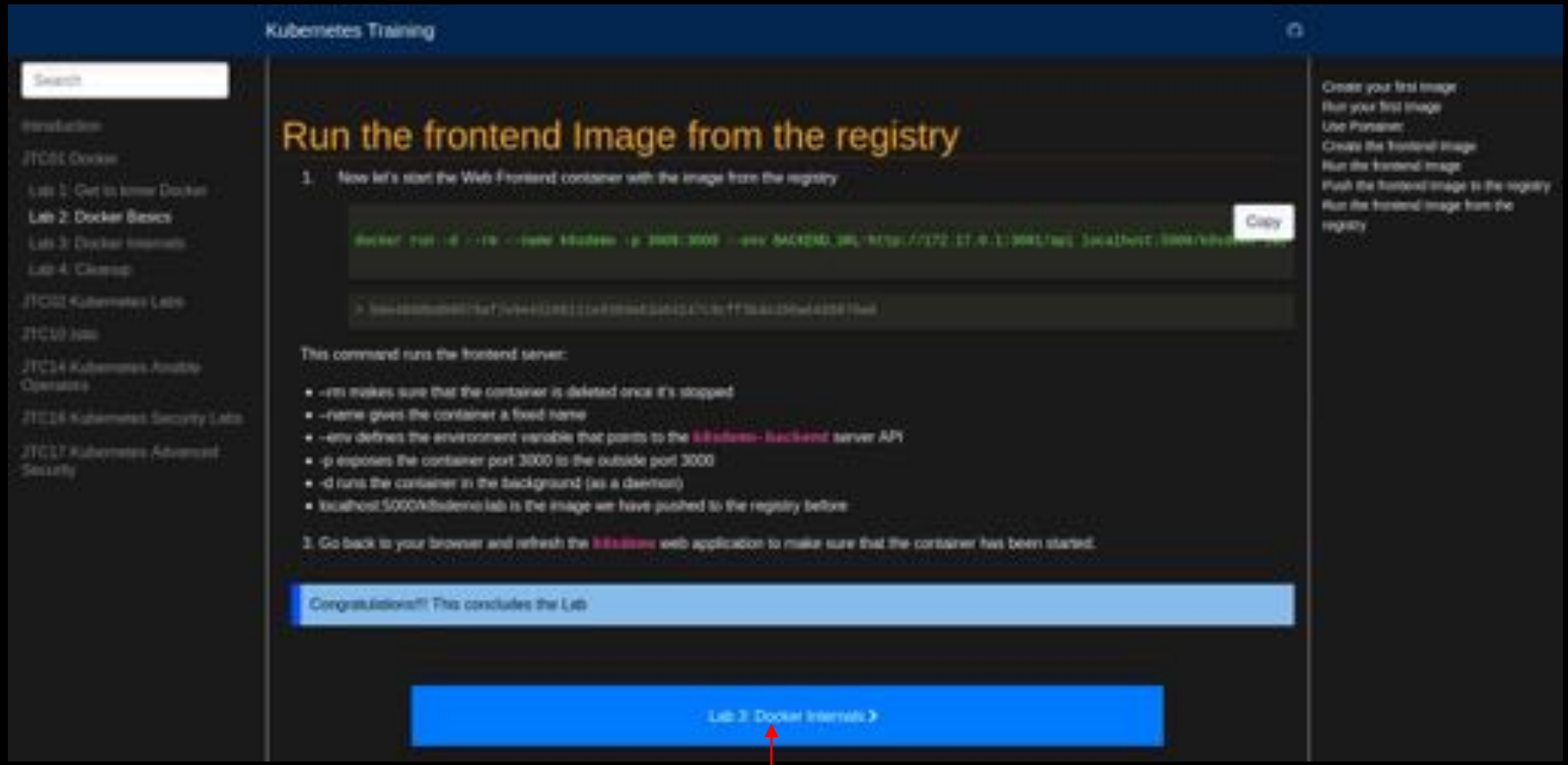
Labs for the Course



Course content - Tasks

Lab Steps

Using your Personal Training Environment



Click to go to the next Lab

Using your Personal Training Environment

Commands to be executed

Sample output

```
cd ~/training/demo-app/k8sdemo_backend

docker build -t k8sdemo-backend:lab .
```

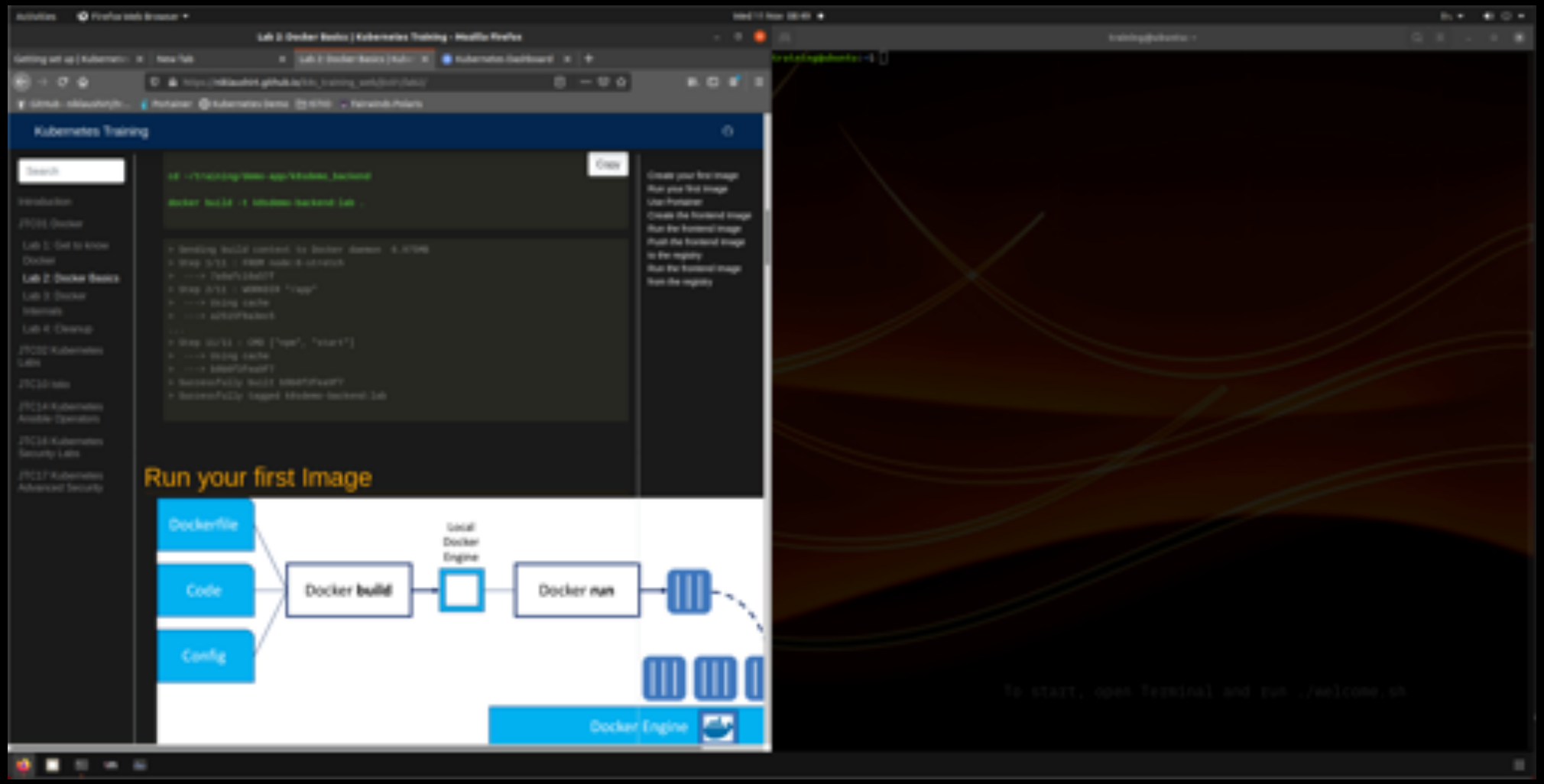
Copy

```
> Sending build context to Docker daemon  6.975MB
> Step 1/11 : FROM node:8-stretch
>  ---> 7a9afc10a57f
> Step 2/11 : WORKDIR "/app"
>  ---> Using cache
>  ---> a2515f8a3ec5
...
> Step 11/11 : CMD ["npm", "start"]
>  ---> Using cache
>  ---> b9b0f3fea9f7
> Successfully built b9b0f3fea9f7
> Successfully tagged k8sdemo-backend:lab
```

Using your Personal Training Environment

Sample Code
(json, yaml, …)

Using your Personal Training Environment



Tip 1: Work side by side

→ Just drag Firefox to the left screen edge and the Terminal to the right

Using your Personal Training Environment

Tip 2: Copy / Paste in the VM

CTRL-C / CTRL-P (Mac users be aware)

Tip 3: Copy / Paste in the Terminal (in the VM)

SHIFT-CTRL-C / SHIFT-CTRL-P

CTRL-C interrupts the currently running command

QUESTIONS?

Kubernetes Workshop Series
Microservices

01

Kodak

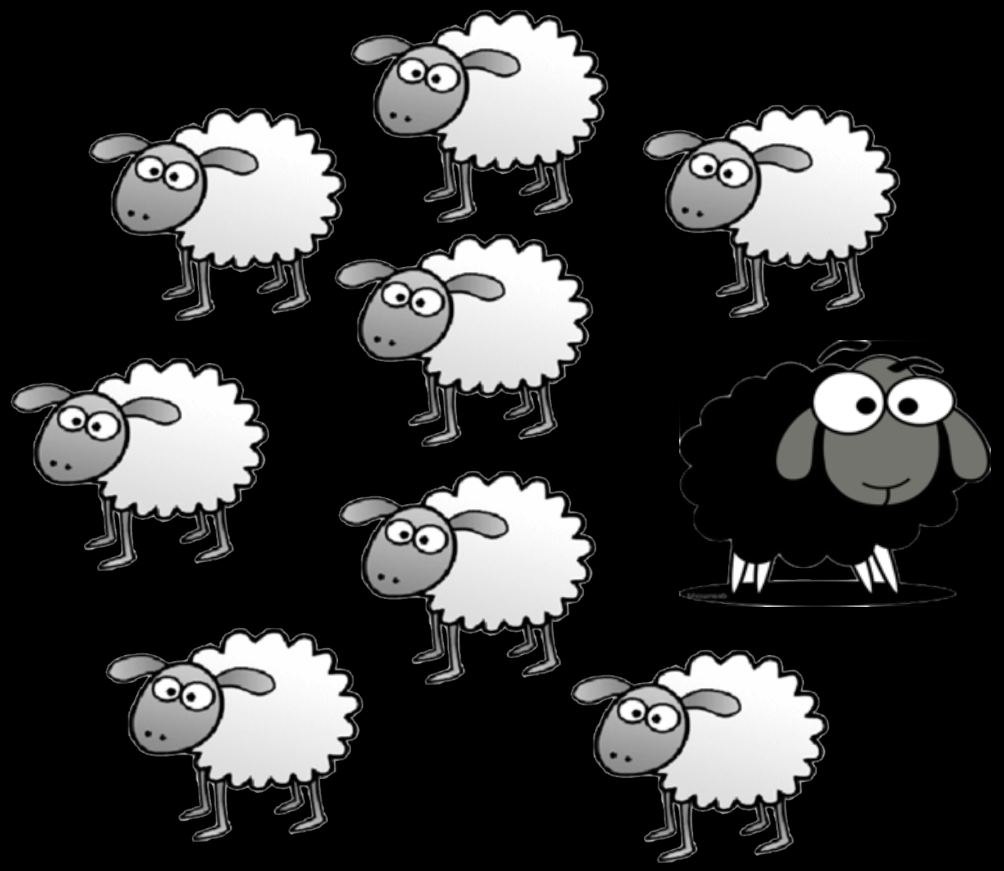
disruption

dɪsˈrʌpʃn/

noun

Business. a **radical change** in an industry, business strategy, etc., especially involving the introduction of a **new product or service** that creates a **new market**

Disruption is new reality



disruption

dɪsˈrʌpʃn/

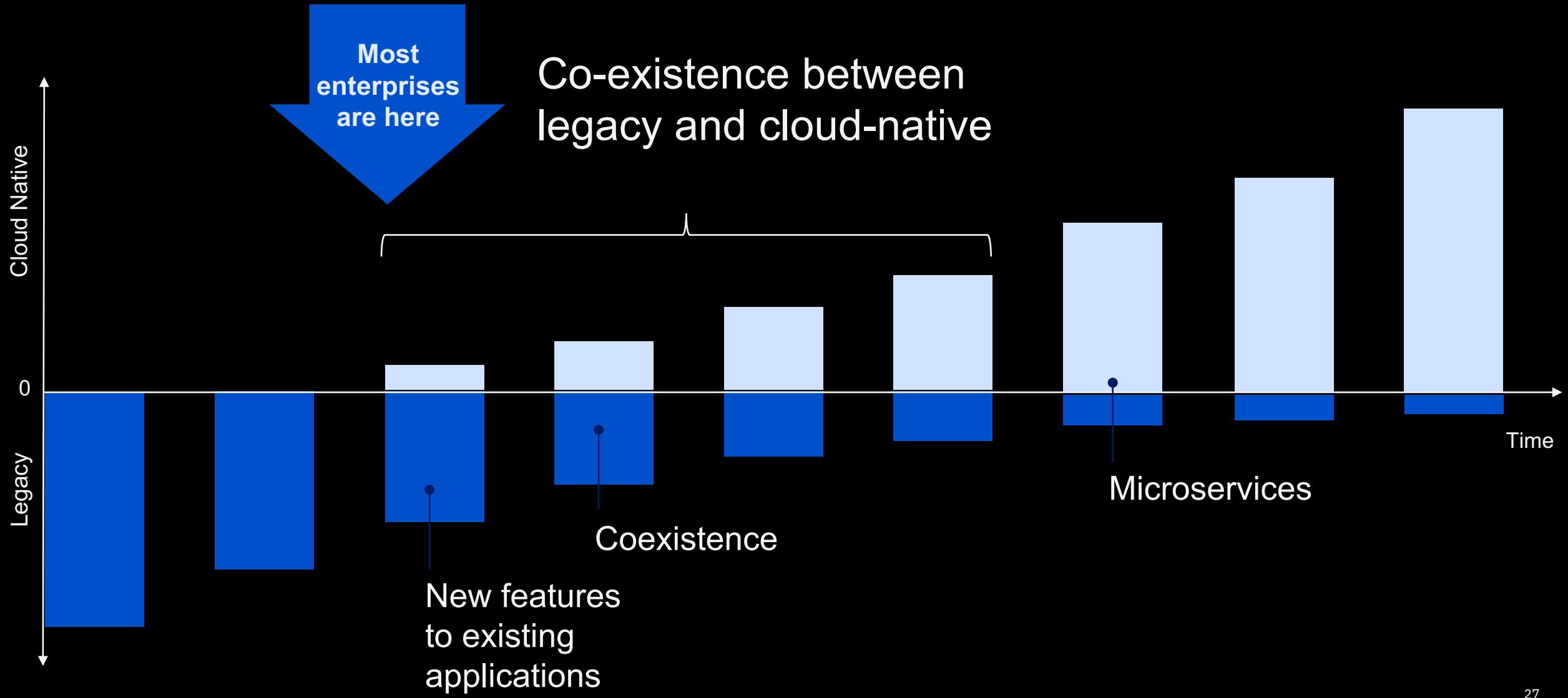
noun

Business. a **radical change** in an industry, business strategy, etc., especially involving the introduction of a **new product or service** that creates a **new market**

Digital Transformation is the new normal

Digital Transformation - Way to go

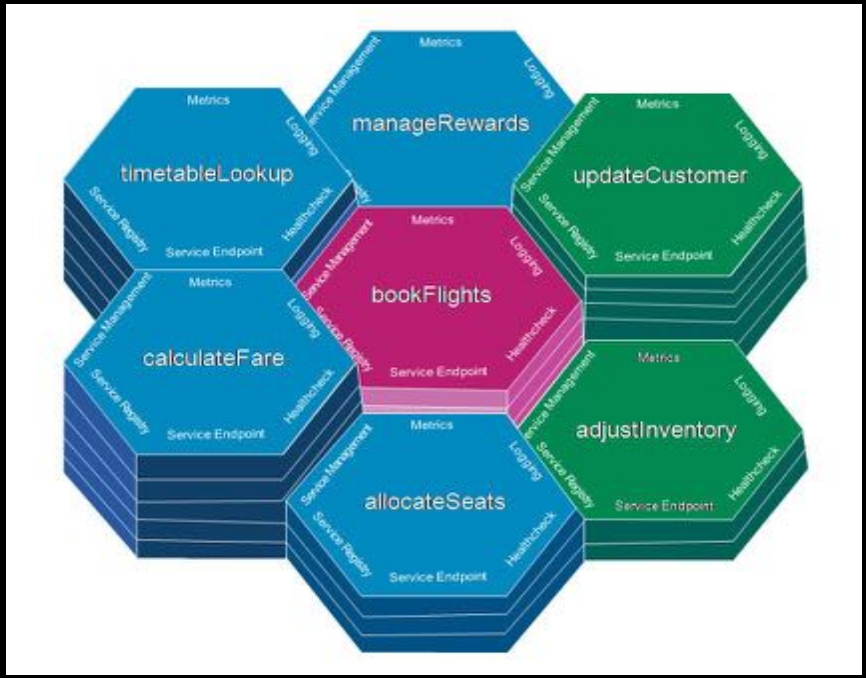
Cloud native and legacy apps will co-exist for the next 10+ years



How do you achieve digital transformation?

Adopt new **Processes**	Adopt new **Technology**	Adopt new **Tools**	Adopt **Cloud**
Continuous Integration	Architectural patterns (Microservices)	Git, Github, Gitlab	Docker, Kubernetes
Continuous Build	Frameworks (Java MicroProfile, Spring ...)	Jenkins	Virtualization, VMs
Continuous Deploy	Node.js , Swift	UrbanCode	Monitoring, Dashboards, Alerts
Agile Dev Models		Docker	
		Kubernetes	

Microservices

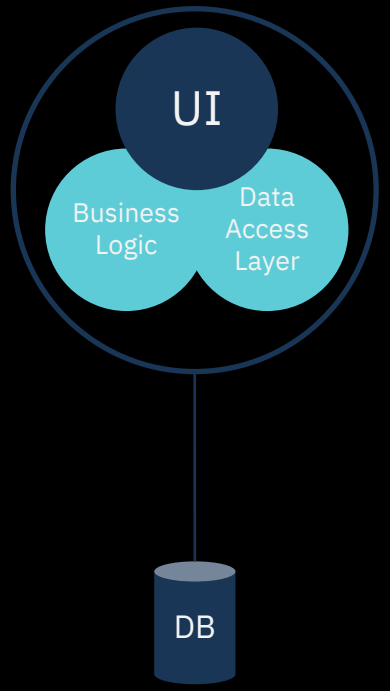


Decomposing an application into **single function modules** which are **independently deployed and operated**

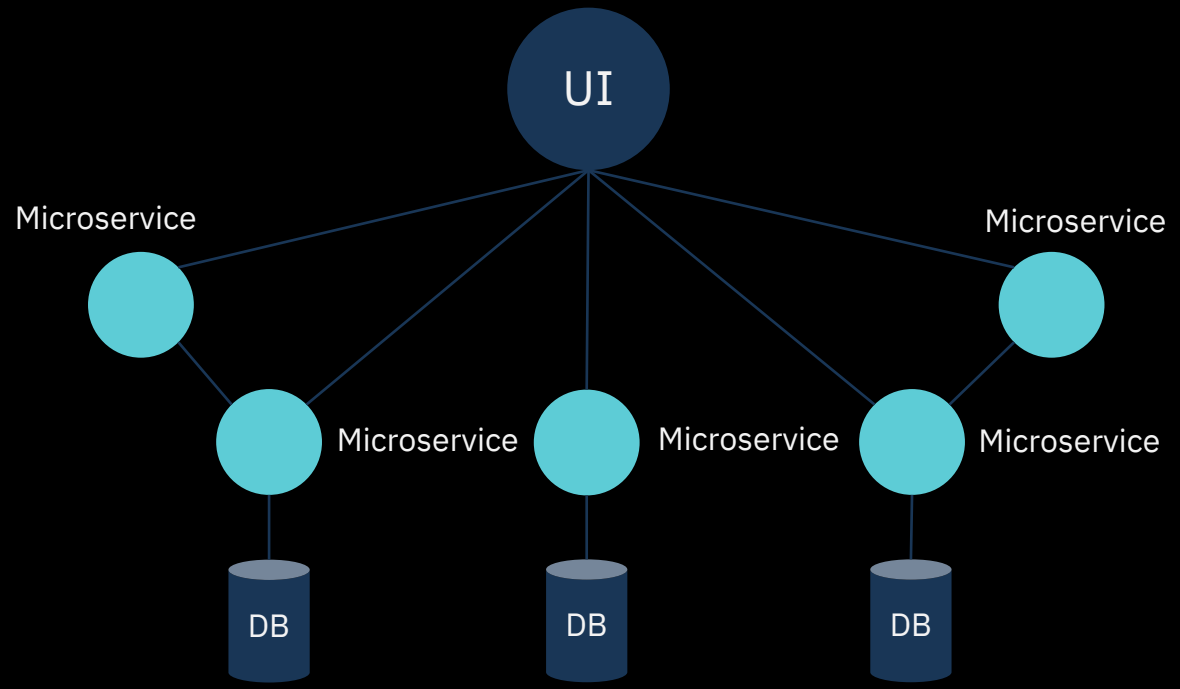
Accelerate delivery by minimizing communication and coordination between people

Microservices architecture

Simplistically, microservices architecture is about breaking down large silo applications into more manageable, fully decoupled pieces



Monolithic Architecture



Microservices Architecture
A microservice is a granular, decoupled component within a broader application

Microservices – key tenets

Large monoliths are **broken down into many small services**

- Each service runs its own process
- There is one service per container

Services are **optimized for a single function**

- There is only one business function per service
- The Single-responsibility Principle: A microservice should have one, and only one, reason to change

Communication via **REST API** and **message brokers**

- Avoid tight coupling introduced by communication through a database

Per-service continuous delivery (CI/CD)

- Services evolve at different rates
- Let the system evolve, but set architectural principles to guide that evolution

Per-service high availability and clustering decisions

- One size or scaling policy is not appropriate for all
- Not all services need to scale; others require autoscaling up to large numbers

Source: IBM Architecture Center

Microservices – advantages

In a microservices architecture each component:

- Is **developed independently** and has **limited, explicit dependencies** on other services
- Is developed by a **single, small team** in which all team members can understand the entire code base
- Is developed on its **own timetable** so new versions are delivered independently of other services
- **Scales and fails independently** which isolates any problems
- Can be developed in a different **language**
- **Manages its own data** to select the best technology and schema

Source: IBM Architecture Center

That said....

Microservices are hard

Microservices, when implemented incorrectly, can make poorly written applications even more dysfunctional

QUESTIONS?

Kubernetes Workshop Series

Docker

02

Everybody Loves Containers

A **standard way to package an application and all its dependencies** so that it can be moved between environments and run without changes

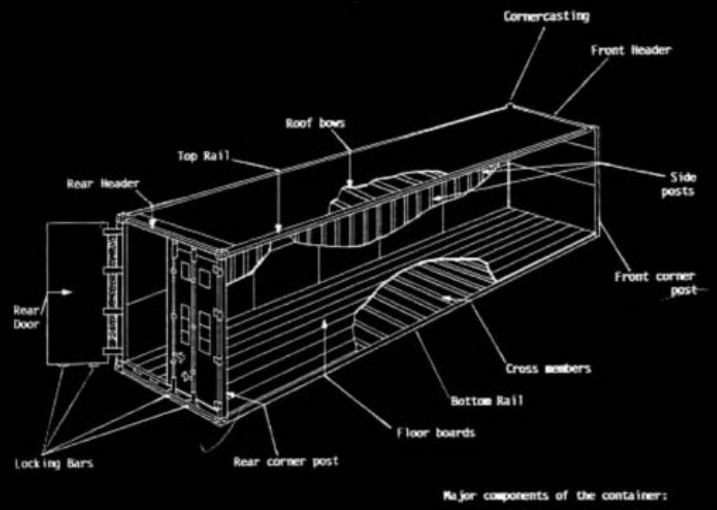
Containers work by **isolating the differences between applications** inside the container so that everything outside the container can be standardized

Microservices implementation with Containers

Why it works – separation of concerns

Development

- Worries about what's "**inside**" the container
  - Code
  - Libraries
  - Package Manager
  - Apps
  - Data
- All Linux servers look the same



Major components of the container:

Operations

- Worries about what's "**outside**" the container
  - Logging
  - Remote Access
  - Monitoring
  - Network Config
- All containers start, stop, copy, attach, migrate, etc… the same way

Clear ownership boundary between
Dev and IT Ops drives DevOps adoption and fosters agility

Container History

1979 chroot

2007 cgroups

2008 LXC

2011 warden

2012 docker

2014 kubernetes

2015 CLOUD NATIVE COMPUTING FOUNDATION

2018 containerd

https://containerd.io/

A chroot on Unix operating systems is an operation that changes the apparent root directory for the current running process and its children. A program that is run in such a modified environment cannot name (and therefore normally cannot access) files outside the designated directory tree. … The modified environment is called a "chroot jail".

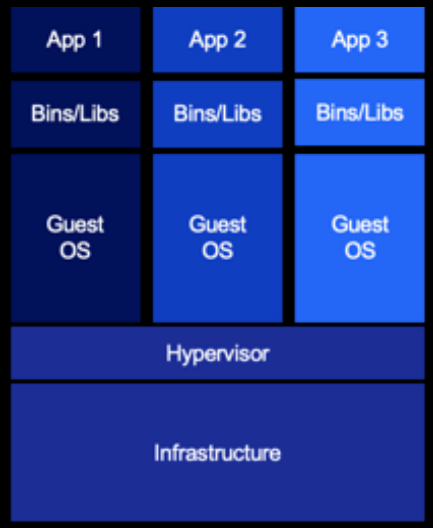
https://en.wikipedia.org/wiki/ChrootChr

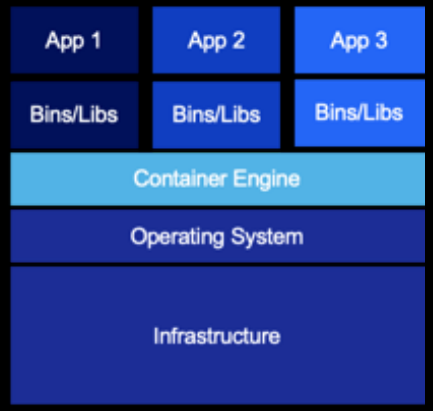
LXC (Linux Containers) is an operating-system-level virtualization environment for running multiple isolated Linux systems (containers) on a single Linux control host.

LXC combines kernel's **cgroups** and support for **isolated namespaces** to provide an isolated environment for applications.

https://en.wikipedia.org/wiki/LXC

VMs vs. Containers

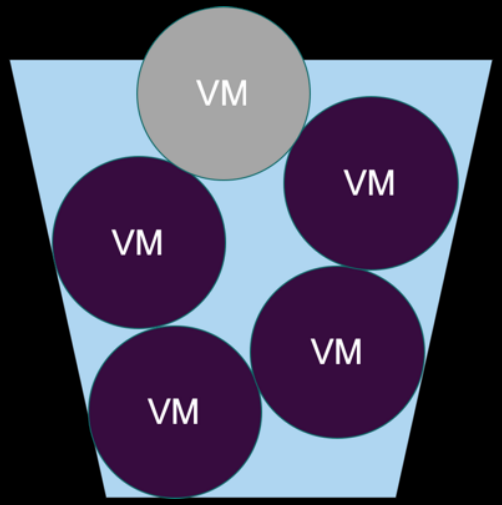


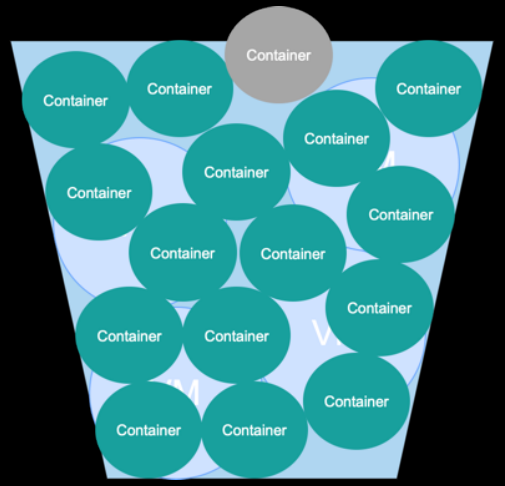


++ VM Isolation (OS)
- Complete OS
- Static Compute
- Static Memory

+ Container Isolation (Kernel)
+ Shared Kernel
+ Burstable Compute
+ Burstable Memory

VMs vs. Containers





++ VM Isolation (OS)
- Complete OS
- Static Compute
- Static Memory
- Low Resource Utilization

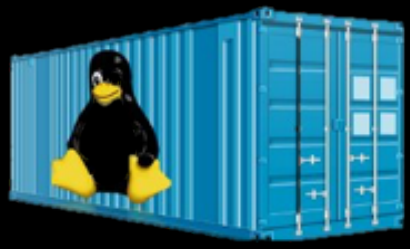
+ Container Isolation (Kernel)
+ Shared Kernel
+ Burstable Compute
+ Burstable Memory
+ High Resource Utilization

Advantages of Containers

Containers are **portable**

Containers are **easy to manage**

Containers provide **“just enough” isolation**



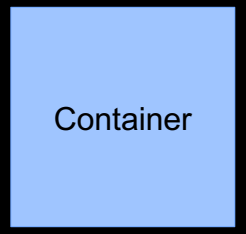
Containers use hardware **more efficiently**

Containers are **immutable**

Docker Components

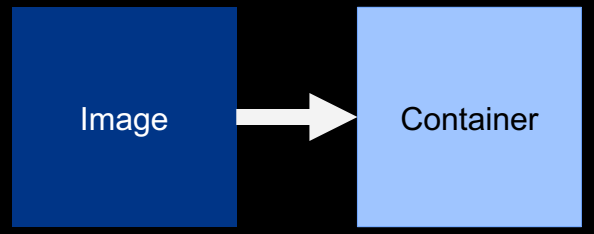
Container

Smallest compute unit



Docker Components

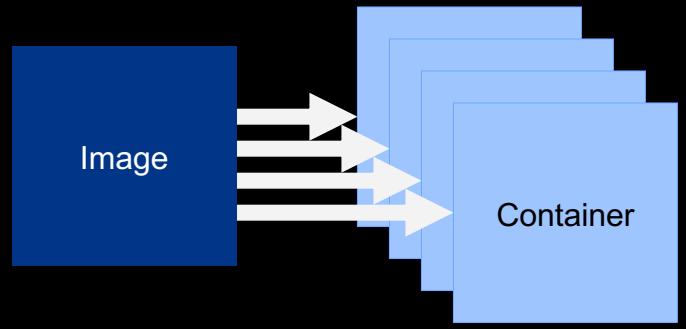
Containers
are created from
Images



one process per container

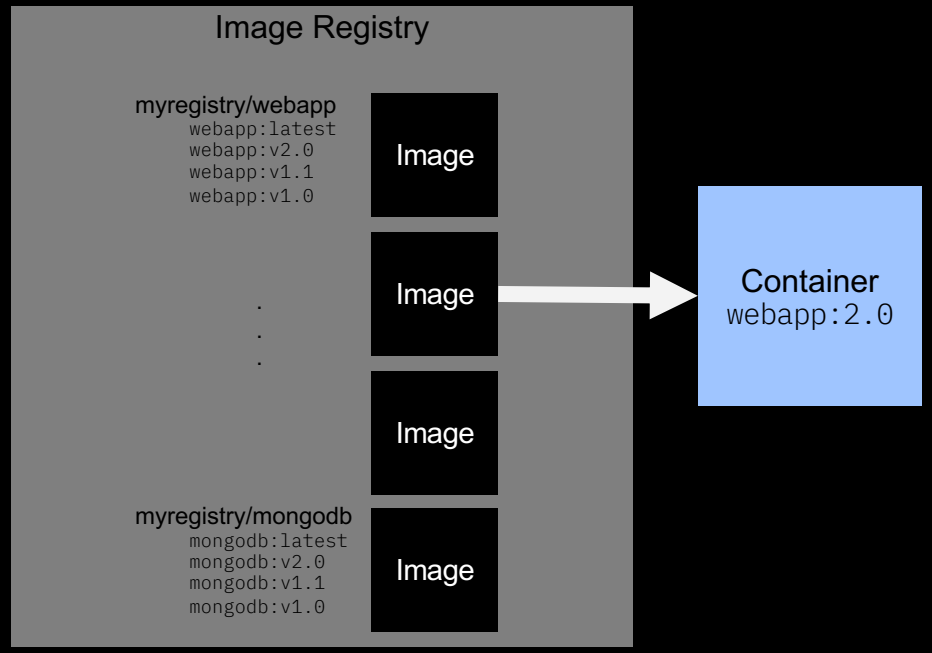
Docker Components

As **many Containers**
as needed can be created from
Images



Docker Components

The **Image Registry**
stores the versioned
Images
to create
Containers



Docker Components

Image

A read-only snapshot of a container stored in Docker Hub to be used as a template for building containers

Container

The standard unit in which the application service resides or transported

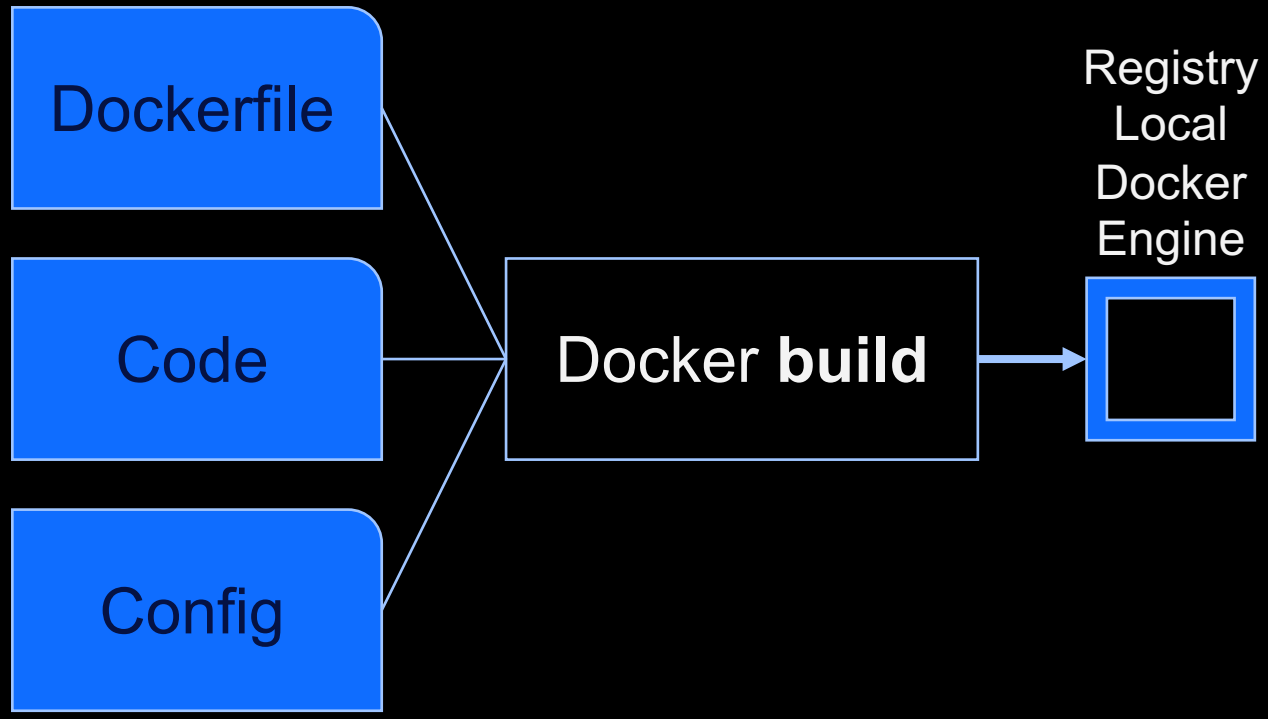
Docker Hub/Registry

Available in SaaS or Enterprise to deploy anywhere you choose
Stores, distributes, and shares container images

Docker Engine

A program that creates, ships, and runs application containers
Runs on any physical and virtual machine or server locally, in private or public cloud. Client communicates with Engine to execute commands

Docker Basics – Build

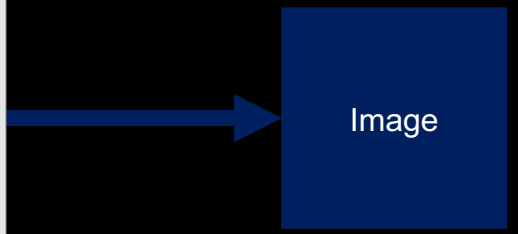


Docker Basics – Build - Dockerfile

Dockerfile

- Text based file describing:
  - Previous Layer
  - Environment Variables
  - Commands used to populate data/software/frameworks/etc...
  - Command to run when executed

```
# Pull base image
FROM tomcat:8-jre8

# Maintainer
MAINTAINER "youremailaddress"

# Run command
RUN apt-get update && apt-get -y upgrade

# Set variables
ENV myName John Doe

# Copy to images tomcat path
ADD web.xml /usr/local/tomcat/conf/
ADD yourwarfile.war /usr/local/tomcat/webapps/

# Run server
CMD ["catalina.sh", "run"]
```



Docker Basics – Build - Dockerfile

- A text file that builds an image using Docker directives

- FROM
- RUN
- COPY
- ENTRYPOINT
- LABEL
- ENV
- ARG
- USER
- EXPOSE

```
# Pull base image
FROM tomcat:8-jre8

# Maintainer
MAINTAINER "youremailaddress"

# Run command
RUN apt-get update && apt-get -y upgrade

# Set variables
ENV myName John Doe

# Copy to images tomcat path
ADD web.xml /usr/local/tomcat/conf/
ADD yourwarfile.war /usr/local/tomcat/webapps/

# Expose the port of the web application
EXPOSE 80

# Run server
CMD ["catalina.sh", "run"]
```

```
docker build –t myimage ./Dockerfile
```

Base Image from:
- hub.docker.com
- quay.io
- your own

Run commands
apt-get, yum, chown, mv, cp, ...

Set environment variables
Can be overriden when running

Add assets to the image
Jar, sources, golang app, ...

Expose a port of the process running in the container

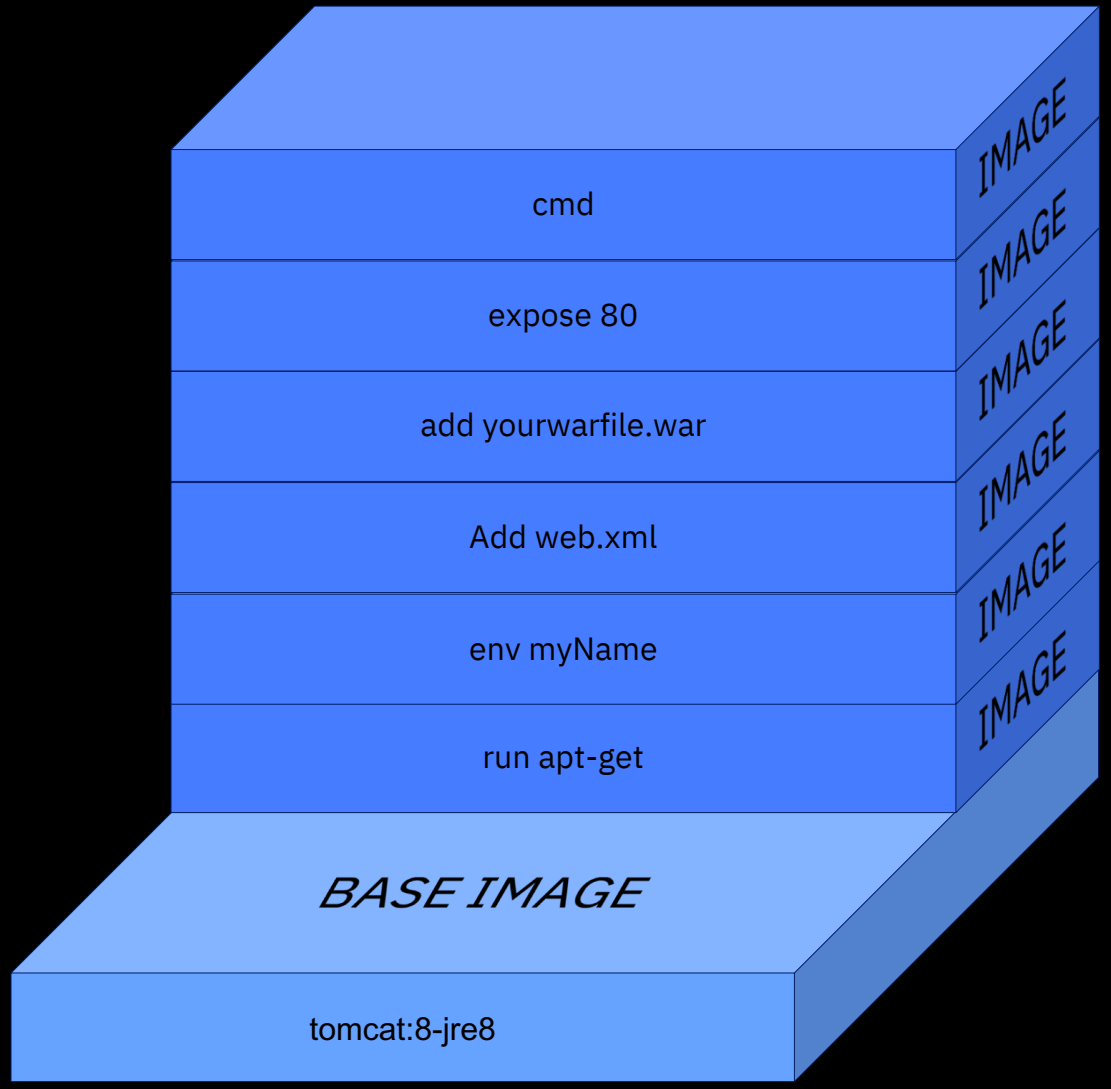
Startup command when image is being run

Docker Basics – Layered File System

Docker Layers
Inheritance

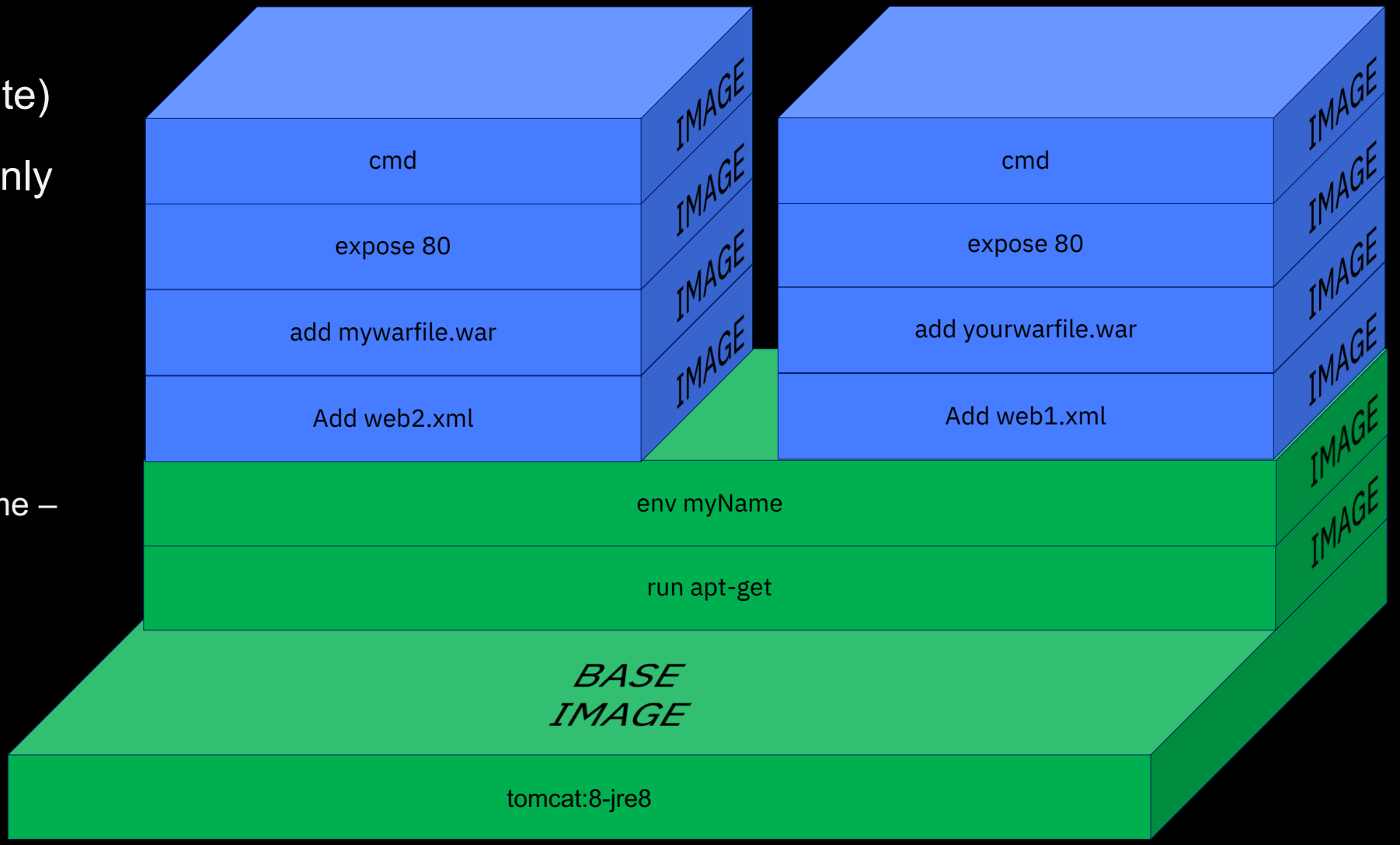
- Build on the work of those who came before you

```
# Pull base image
FROM tomcat:8-jre8

# Maintainer
MAINTAINER  youremailaddress"

# Run command
RUN apt-get update && apt-get -y upgrade

# Set variables
ENV myName John Doe

# Copy to images tomcat path
ADD web.xml /usr/local/tomcat/conf/
ADD yourwarfile.war /usr/local/tomcat/webapps/

# Expose the port of the web application
EXPOSE 80

# Run server
CMD ["catalina.sh", "run"]
```

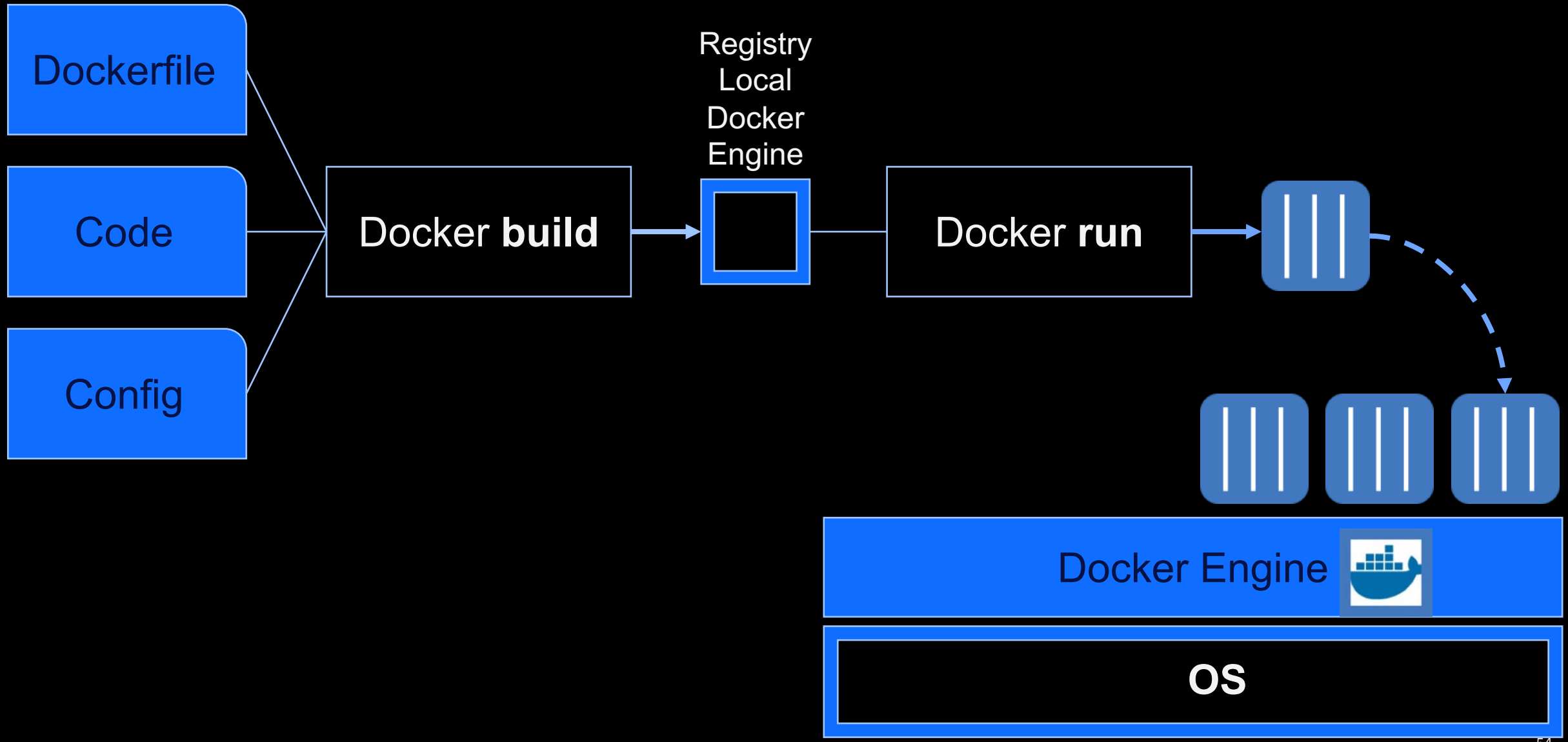


Docker Basics – Layered File System

- Docker uses a **layered filesystem** (copy-on-write)
- New files (& edits) are only visible to current/above layers
- Layers allow for reuse
  - More containers per host
  - Faster start-up/download time – base layers are "cached"



Docker Basics – Run



Docker Basics – Run

Docker Layers

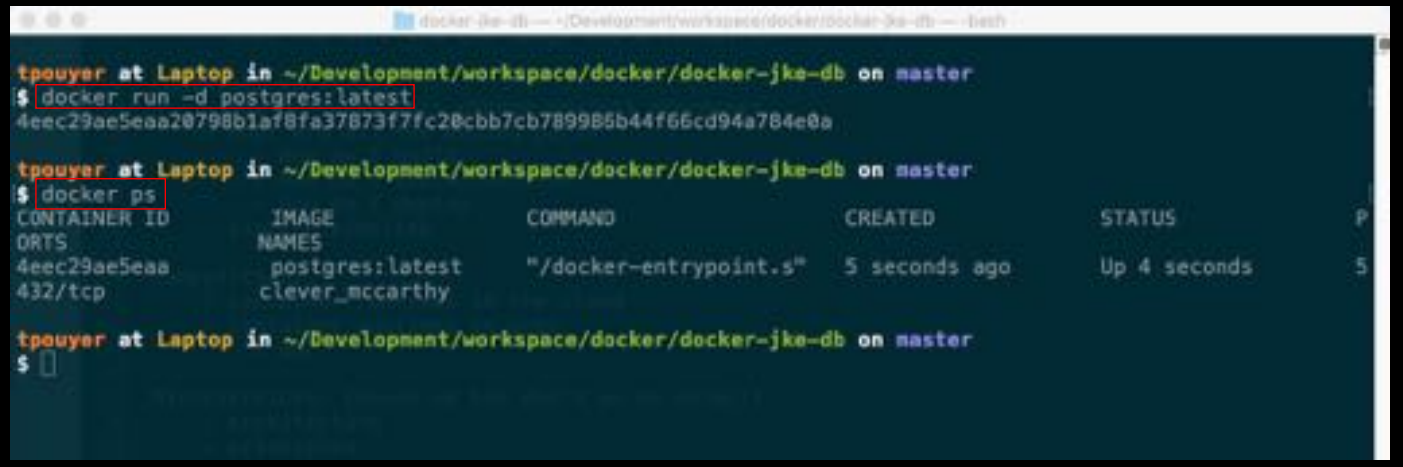
Inheritance

- The biggest difference between a container and an image is the **top writable layer**.
- All writes to the container that add new or modify existing data are stored in this writable layer.
- When a container is deleted, its writable layer is also deleted. The underlying image is unchanged.

Docker Basics – Run

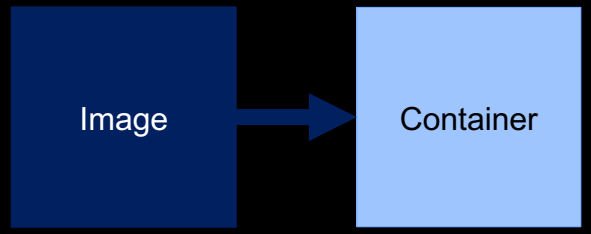
Docker run

- Local (containerd)



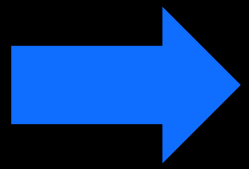

```
docker run -d -e MYVAR=foo -p 8080:80 myimage:1.0.0
docker run -ti myimage:1.0.0 /bin/bash
```

…



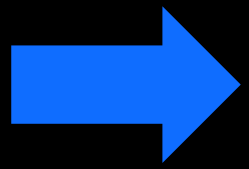
Docker Basics – Run – CMD vs ENTRYPOINT

CMD echo “Hello World”



```
mac> sudo docker run [image_name]
mac> Hello World

mac> sudo docker run [image_name] hostname
mac> my-host-name
```

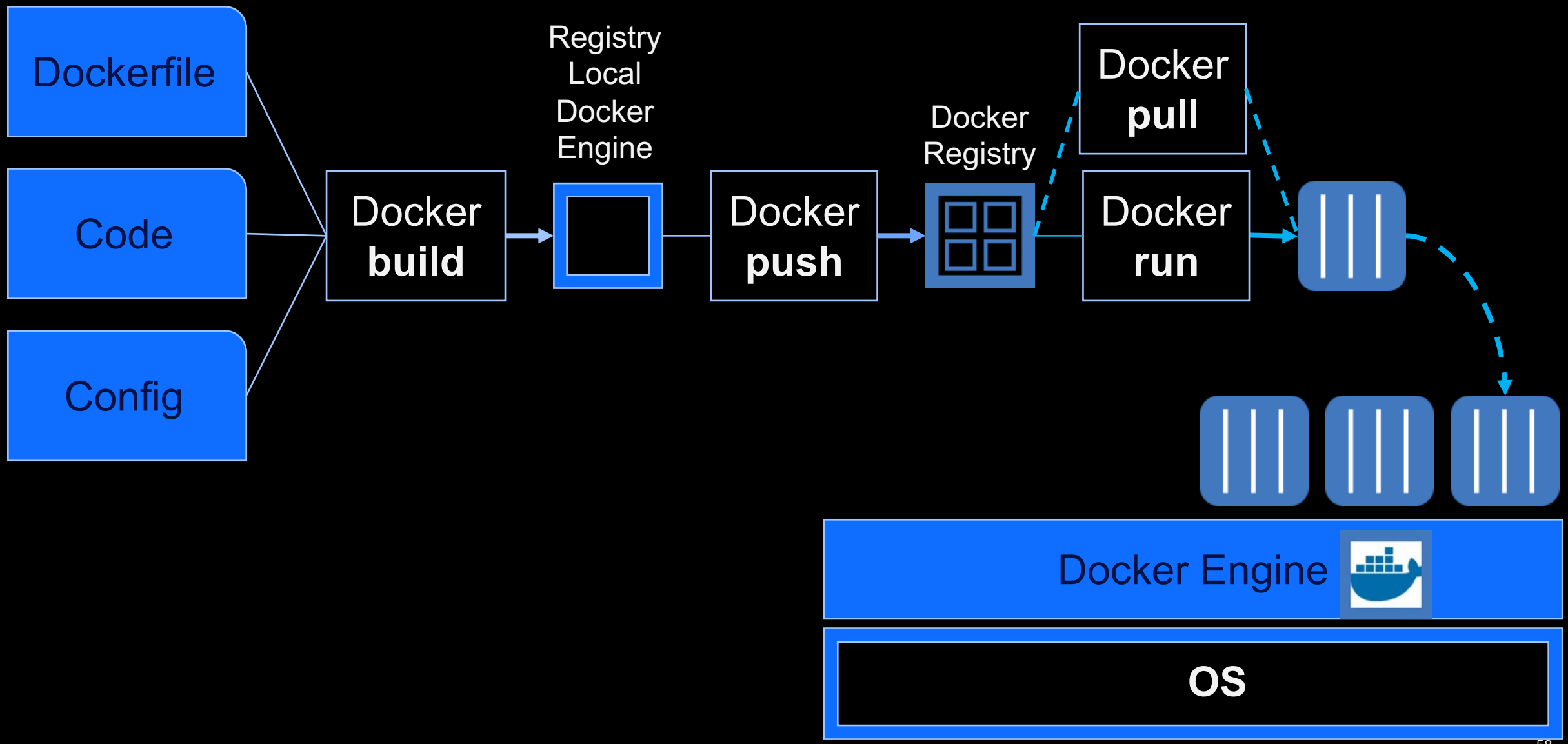
ENTRYPOINT echo "Hello World”



```
mac> sudo docker run [image_name]
mac> Hello World

mac> sudo docker run [image_name] hostname
mac> Hello World  hostname
```

https://phoenixnap.com/kb/docker-cmd-vs-entrypoint

Docker Basics – Store, Retrieve & Run with registry



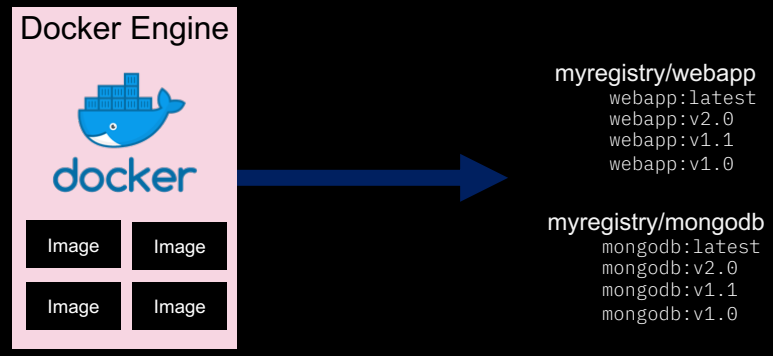
Docker Basics – Store & Retrieve

Docker Registry

- Private Local
- Public Docker Hub
- Private Shared

```
docker images
```

```
tpouyer at Laptop in ~/Development/workspace/docker/docker-jke-db on master
$ docker images
REPOSITORY                          TAG                 IMAGE ID            CREATED             SIZE
stackinabox/demo-docker             dev                 4e2a1f6cc1a4        25 hours ago        528.3 MB
stackinabox/demo-jke                1.1                 a596fbf2c3b7        3 days ago          672 MB
stackinabox/demo-jke                dev                 a596fbf2c3b7        3 days ago          672 MB
stackinabox/demo-jke                latest              a596fbf2c3b7        3 days ago          672 MB
stackinabx/demo-jke                 1.1                 a596fbf2c3b7        3 days ago          672 MB
stackinabx/demo-jke                 latest              a596fbf2c3b7        3 days ago          672 MB
stackinabox/jke-web                 latest              a4be0cdad8bc        4 days ago          462.3 MB
stackinabox/demo-jke-db             dev                 54bdbf42b999        4 days ago          327.5 MB
stackinabox/jke-db                  latest              54bdbf42b999        4 days ago          327.5 MB
stackinabox/urbancode-deploy-client 6.2.2.0             53c878fbf034        7 days ago          477 MB
websphere-liberty                   javaee7             7e27c3fb9c96        10 days ago         445.7 MB
mysql                               5.6                 a896fd82dcd5        13 days ago         327.5 MB
mysql                               latest              f3694c67abdb        13 days ago         400.1 MB

tpouyer at Laptop in ~/Development/workspace/docker/docker-jke-db on master
$
```



myregistry/webapp
- webapp:latest
- webapp:v2.0
- webapp:v1.1
- webapp:v1.0

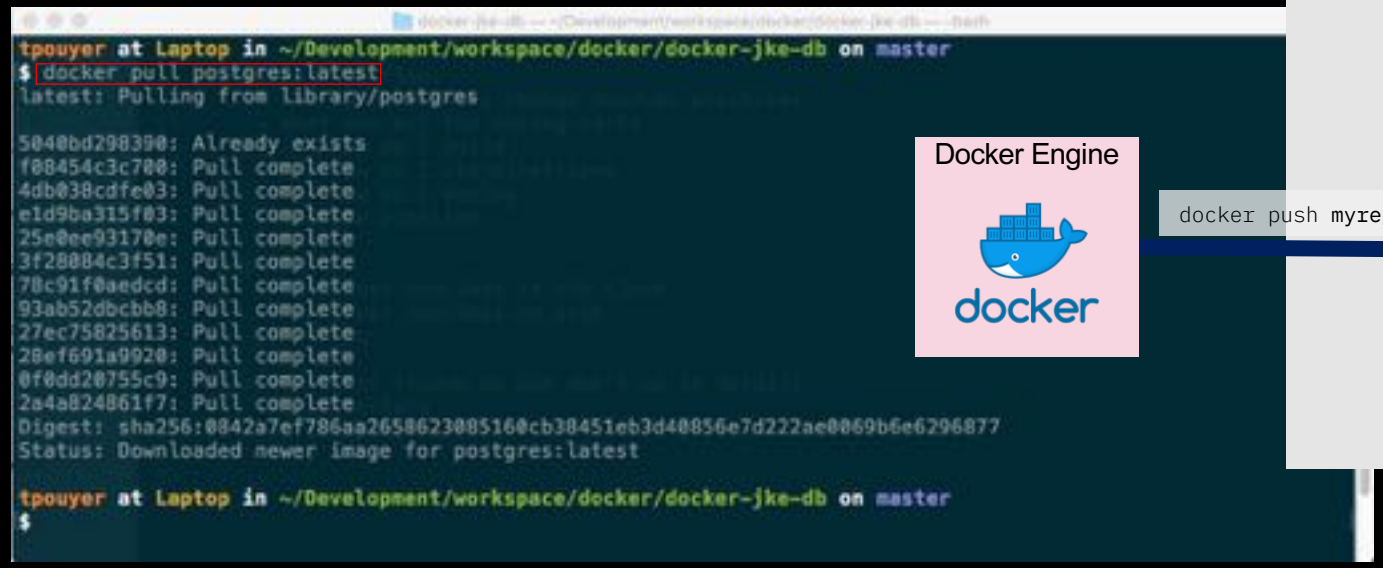
myregistry/mongodb
- mongodb:latest
- mongodb:v2.0
- mongodb:v1.1
- mongodb:v1.0

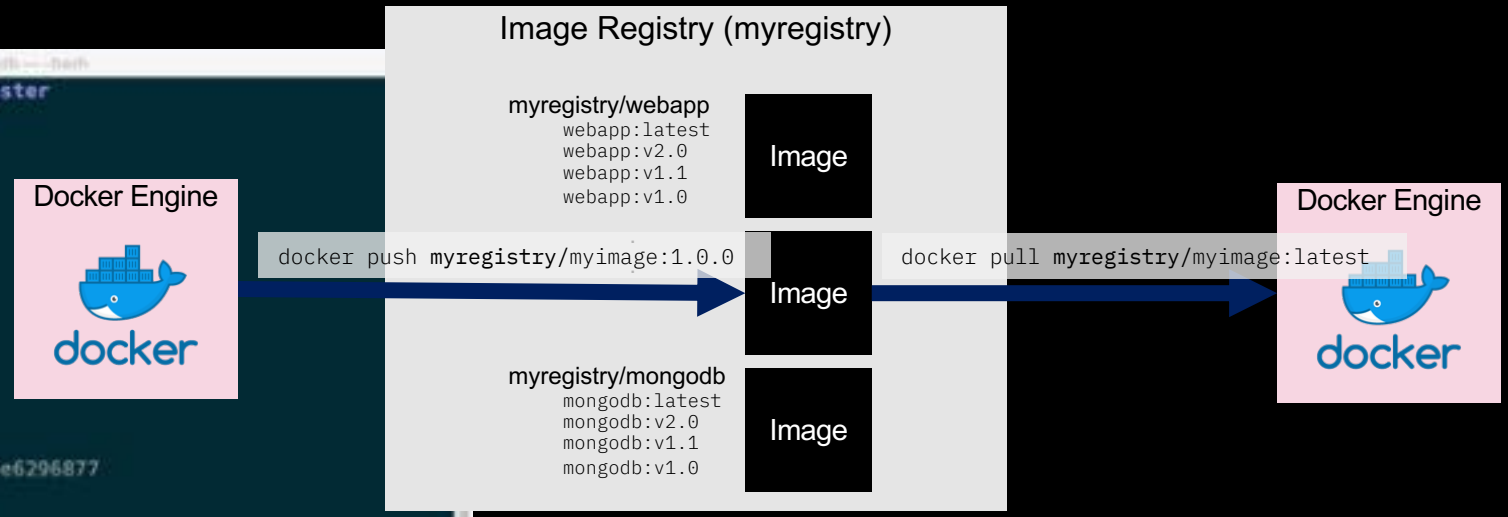
Docker Basics – Store & Retrieve with registry

Docker Registry

- Private Local
- Public Docker Hub
- Private Shared

```
docker tag myimage:1.0.0 myregistry/myimage:1.0.0
docker push myregistry/myimage:1.0.0

docker pull myregistry/myimage:latest
```





Docker Basics – Registries

Hosting image repositories

- You can define your own registry
- A registry is managed by a registry container

Public and Private registries

- Public Registry like **Quay** or **Docker Hub**
- **https://quay.io**
- **https://hub.docker.com**

Login into the registry

- Docker login domain:port

Docker Recap

- **Containers are not VMs**
- **Containers provide many benefits:**
  - Efficiency
  - Portability
  - Consistency
- **New challenges with containers:**
  - Production apps dependent on open-source projects
  - Existing tools may not be sufficient for container
  - Need to focus on business objectives

QUESTIONS?

Kubernetes Workshop Series

Let‘s get real

03

Microservices – Database refactoring

Containerizing your WAR file doesn’t mean you’re doing microservices.

- What is the domain? What is reality?
- Where are the transactional boundaries?
- How should microservices communicate across boundaries?
- What if we just turn the database inside out?

Source: https://martinfowler.com/bliki/BoundedContext.html

Microservices – breaking down the ~~monolith~~ beast

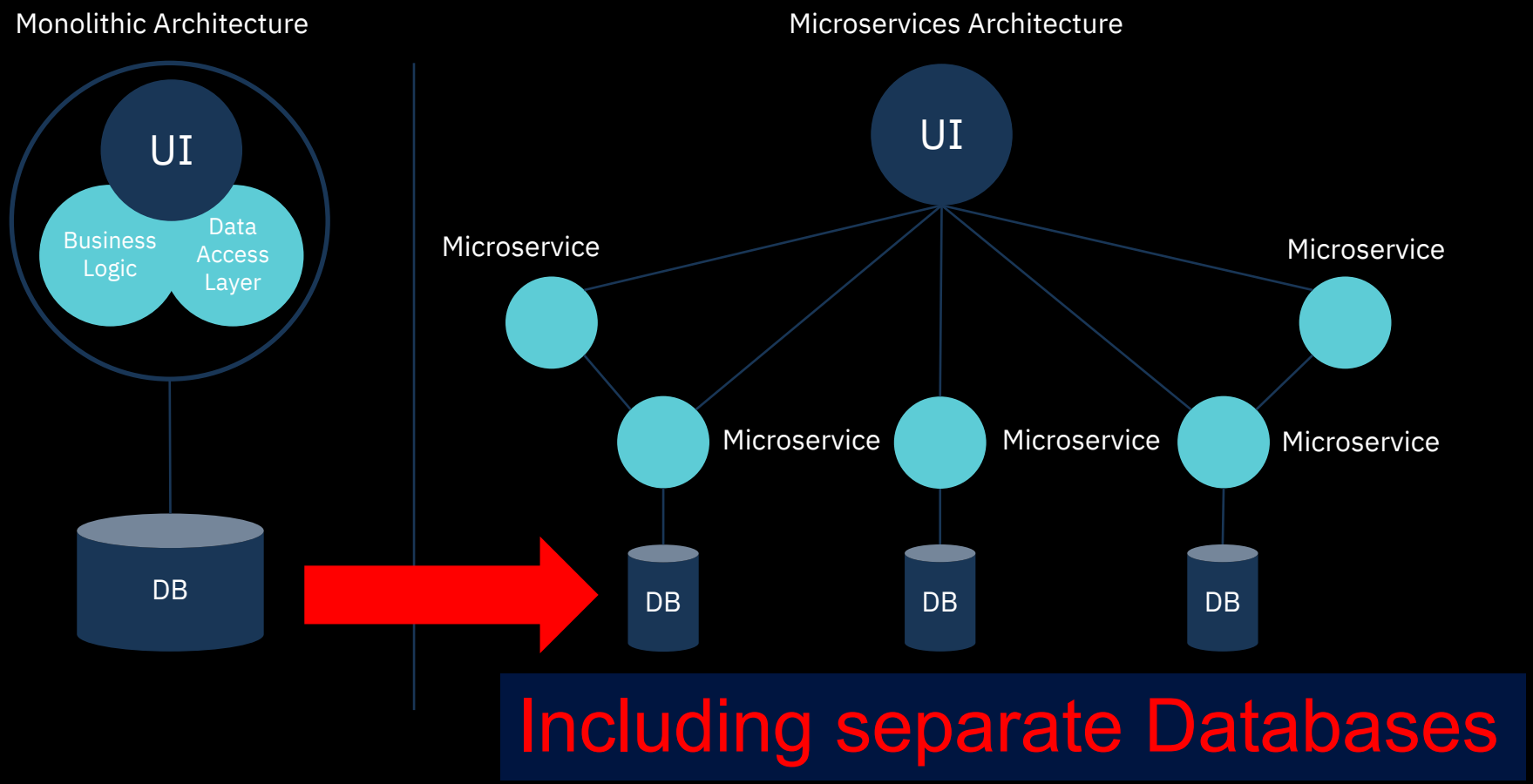
How to identify candidates

- Is there anything that is scaling differently than the rest of the system?
- Is there anything that feels “tacked-on”?
- Is there anything changing much faster than the rest of the system?
- Is there anything requiring more frequent deployments than the rest of the system?
- Is there a part of the system that a small team, operates independently?
- Is there a subset of tables in your datastore that isn’t connected to the rest of the system?

Source: https://www.simplethread.com/youre-not-actually-building-microservices/

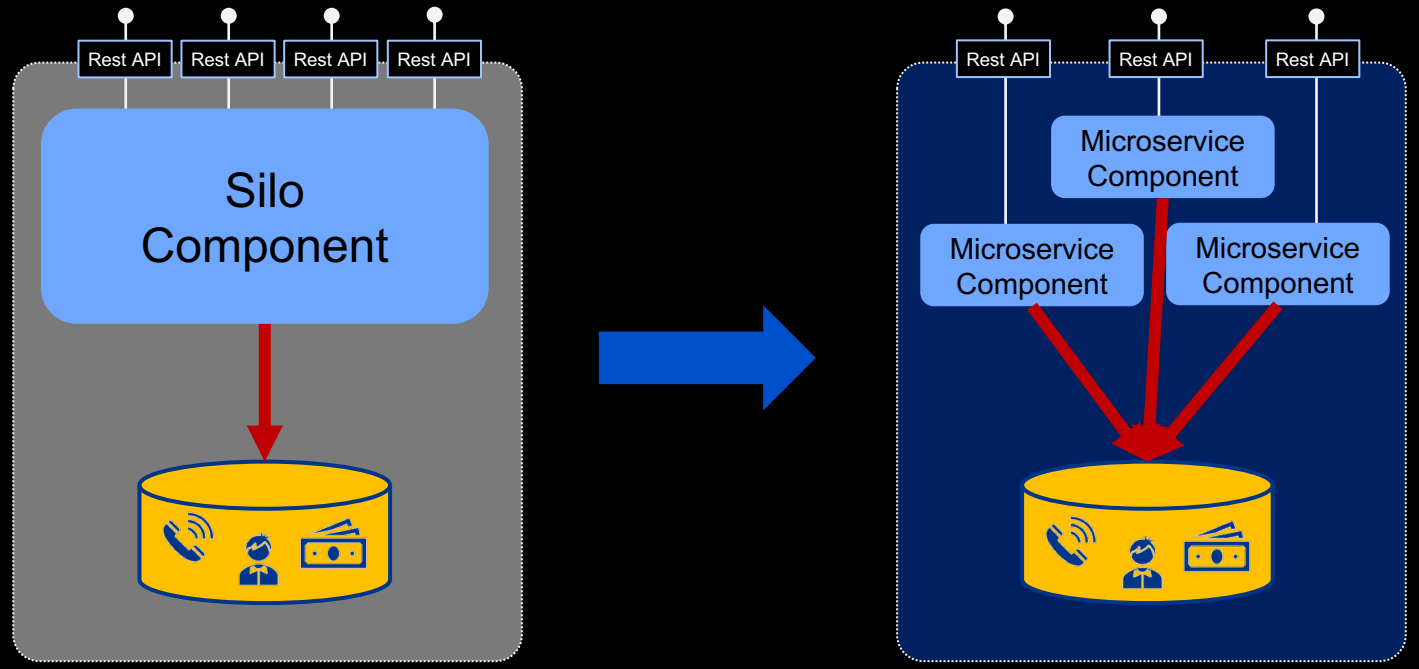
Microservices – Database refactoring

Simplistically, microservices architecture is about breaking down large silo applications into more manageable, fully decoupled pieces



Microservices – Database refactoring

Common mistake

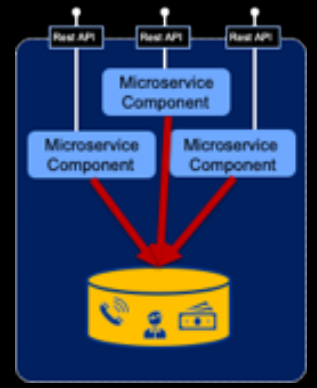


Source: IBM Architecture Center

Microservices – monolithic database

Challenges

- Inability to deploy your service changes independently through tight coupling.
- Schema changes need to be coordinated amongst all the services
- Difficult to scale individual services
- All your services have to use a relational database even when a no-SQL datastore would bring benefits
- Difficult to improve application performance (DB/Table size)

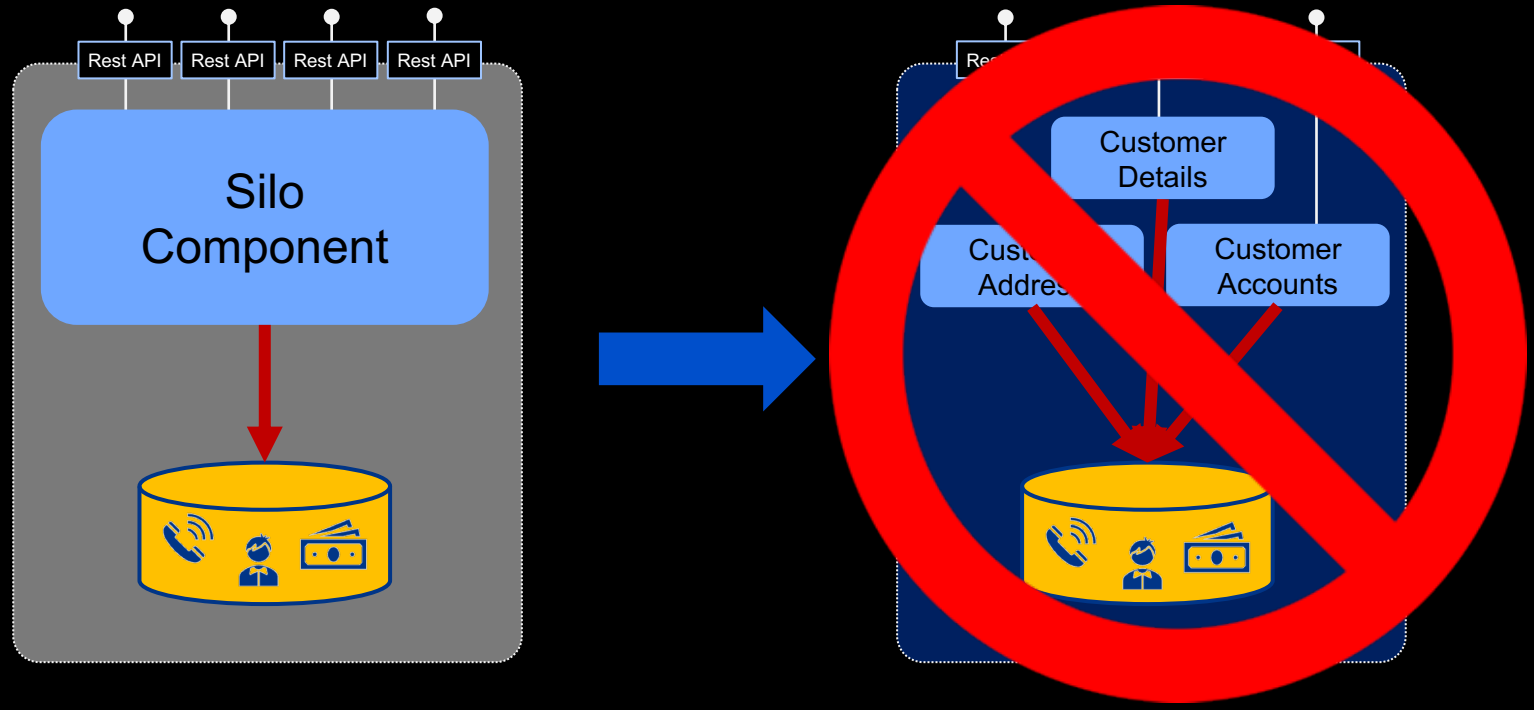


Source: https://dzone.com/articles/breaking-the-monolithic-database-in-your-microserv

Microservices – Database refactoring

Data Isolation

Each microservice must keep its own data. One typical error that happens in the beginning of a microservice transformation is the use of a centralized database, the same way it was used in the monolithic application. This creates a single point of failure and dependency between the microservices.

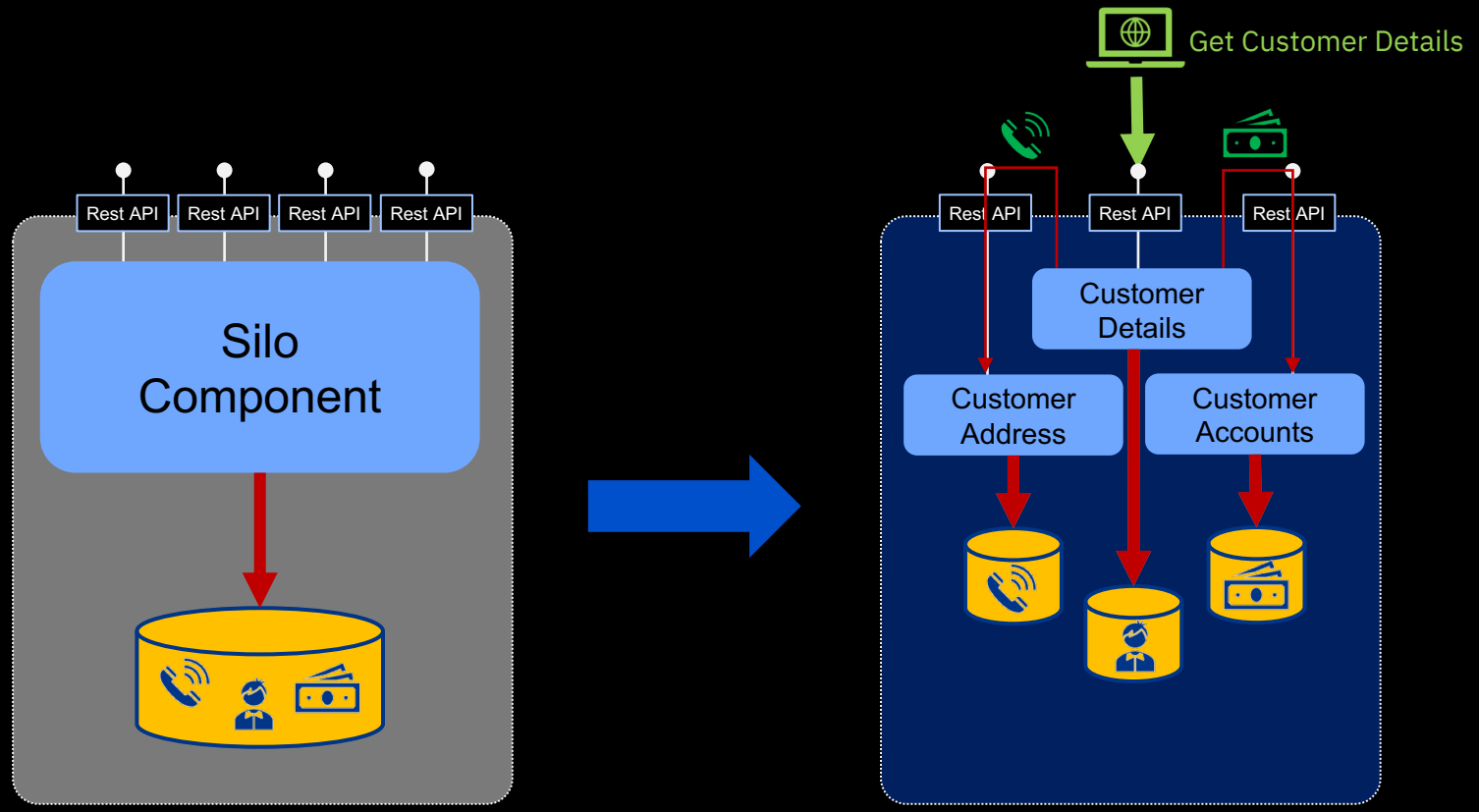


Source: IBM Architecture Center

Microservices – Database refactoring

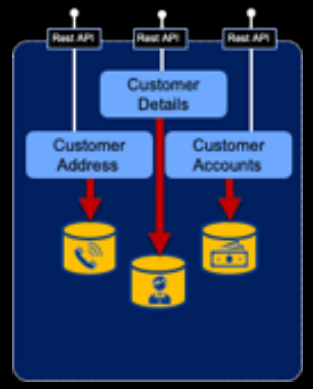
Data Isolation

Each microservice must keep its own data. One typical error that happens in the beginning of a microservice transformation is the use of a centralized database, the same way it was used in the monolithic application. This creates a single point of failure and dependency between the microservices.



Source: IBM Architecture Center

Microservices – per-service database

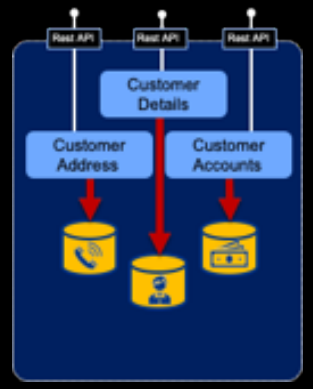


Benefits

- Avoid unexpected data modification – the API enforces consitency
- Make changes to our system without blocking progress of other parts of the system
- Make changes to the schema/databases at our leisure
- Store the data in a project-owned databases, using the appropriate technology
- Become much more scalable, fault tolerant, and flexible

Source: https://blog.christianposta.com/microservices/the-hardest-part-about-microservices-data/

Microservices – per-service database

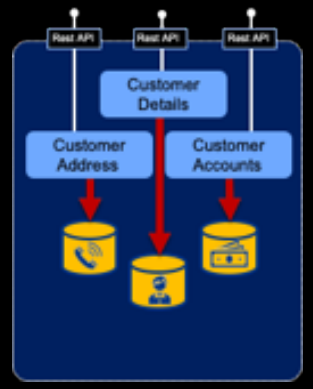


Drawbacks

- Costly to refactor
- Introduces latency
- Needs robust transaction handling by the service (cost!)
- More difficult to debug
- More difficult to operationalize
- More difficult to test (needs well designed API tests)

Source: https://blog.christianposta.com/microservices/the-hardest-part-about-microservices-data/

Microservices – per-service database



Benefits

- Avoid unexpected data modification – the API enforces consitency
- Make changes to our system without blocking progress of other parts of the system
- Store the data in a project-owned databases, using the appropriate technology
- Make changes to the schema/databases at our leisure
- Become much more scalable, fault tolerant, and flexible

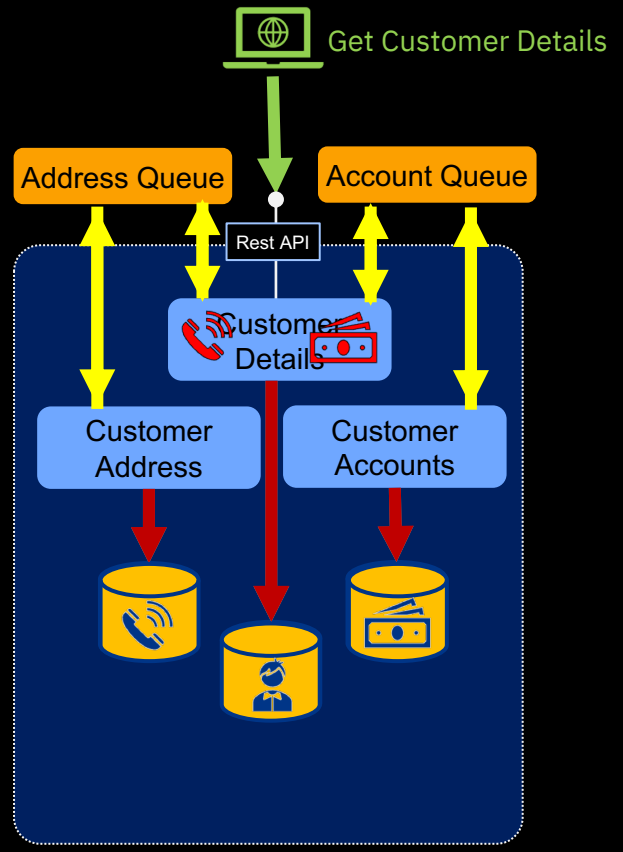
Source: https://blog.christianposta.com/microservices/the-hardest-part-about-microservices-data/

Event Driven Architecture

Microservices – one step further

Event-Driven Architecture

- Common pattern to maintain data consistency across different services.
- Avoid waiting for ACID transactions to complete
- Makes your application more available and performant
- Provides loose coupling between services

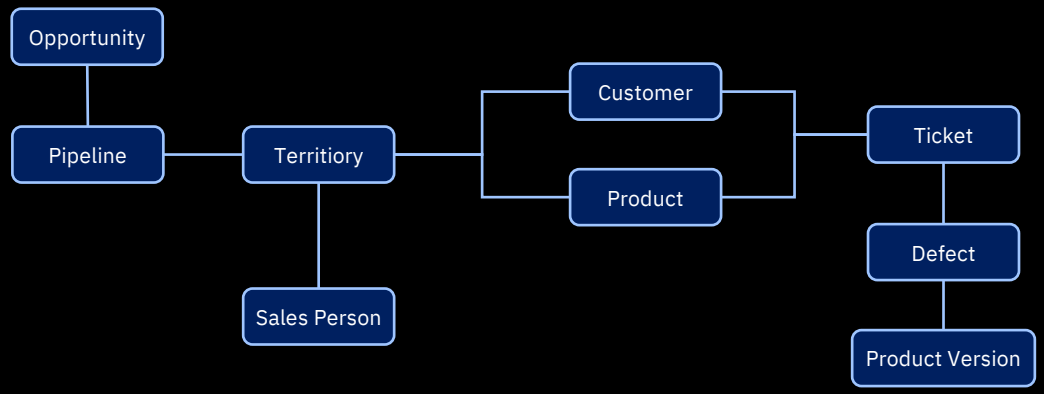


Source: https://dzone.com/articles/breaking-the-monolithic-database-in-your-microserv

Microservices – Bounded Context

Bounded Context is a central pattern in Domain-Driven Design

- DDD deals with large models by dividing them into different Bounded Contexts

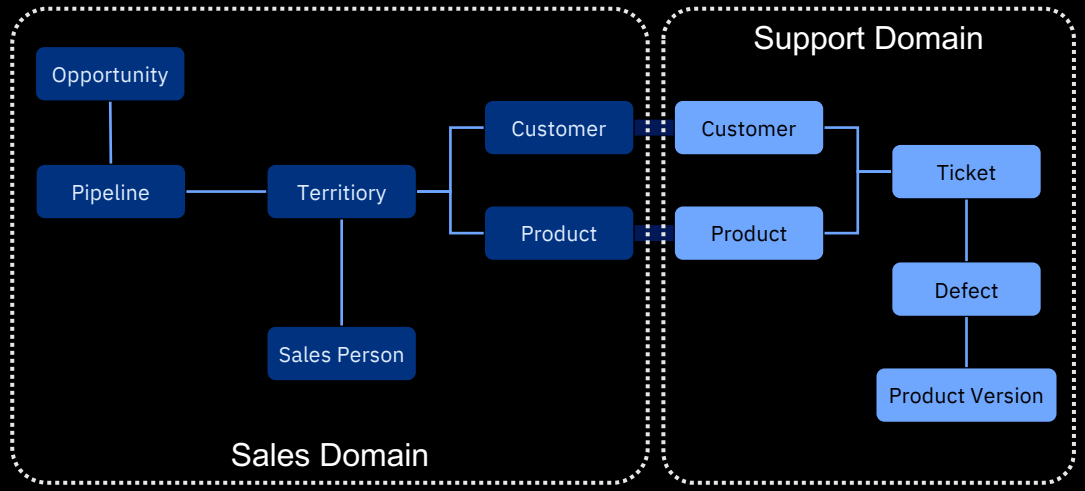


Source: https://martinfowler.com/bliki/BoundedContext.html

Microservices – Bounded Context

Bounded Context is a central pattern in Domain-Driven Design

- DDD deals with large models by dividing them into different Bounded Contexts
- Helps to build and refine a model that represents our domains, contained within a boundary that defines our context.

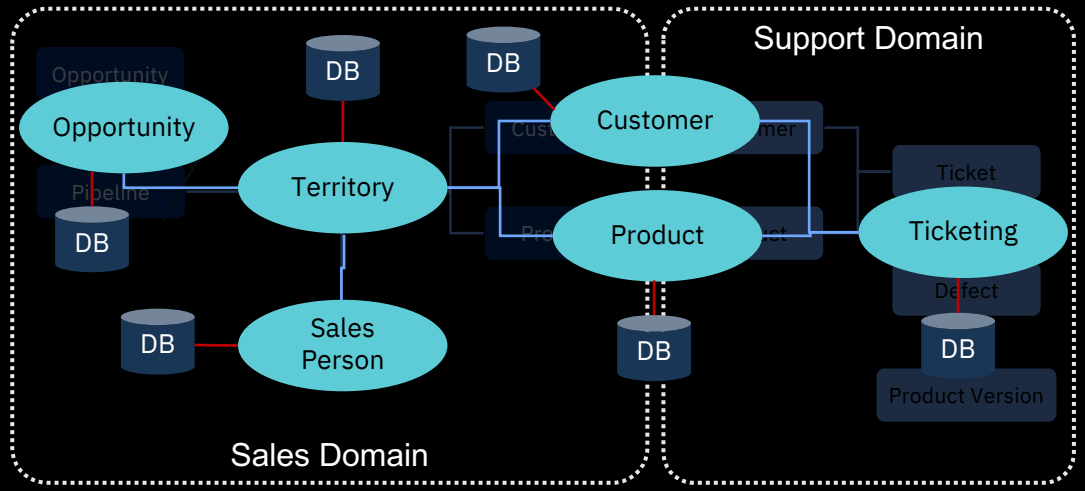


Source: https://martinfowler.com/bliki/BoundedContext.html

Microservices – Bounded Context

Bounded Context is a central pattern in Domain-Driven Design

- DDD deals with large models by dividing them into different Bounded Contexts
- Helps to build and refine a model that represents our domains, contained within a boundary that defines our context.
- These boundaries end up being our microservices



Source: https://martinfowler.com/bliki/BoundedContext.html

Microservices

Good or bad idea?

Microservices – reasons not to use them

Some thoughts

- If speed is your goal, microservices aren't the solution (MVP, doesn’t have to scale)
- Applications that require tight integration between individual components and services (real-time processing, …)
- At what point is it in its lifecycle? Mission-critical?
- Not all applications are large enough to break down into microservices

Source: https://blog.christianposta.com/microservices/when-not-to-do-microservices/

Microservices – reasons not to use them

How to detect antipatterns

- A change to one microservice often requires changes to other microservices
- Deploying one microservice requires other microservices to be deployed at the same time
- Your microservices are overly chatty
- The same developers work across a large number of microservices
- Many of your microservices share a datastore
- Your microservices share a lot of the same code or models

Source: https://www.simplethread.com/youre-not-actually-building-microservices/

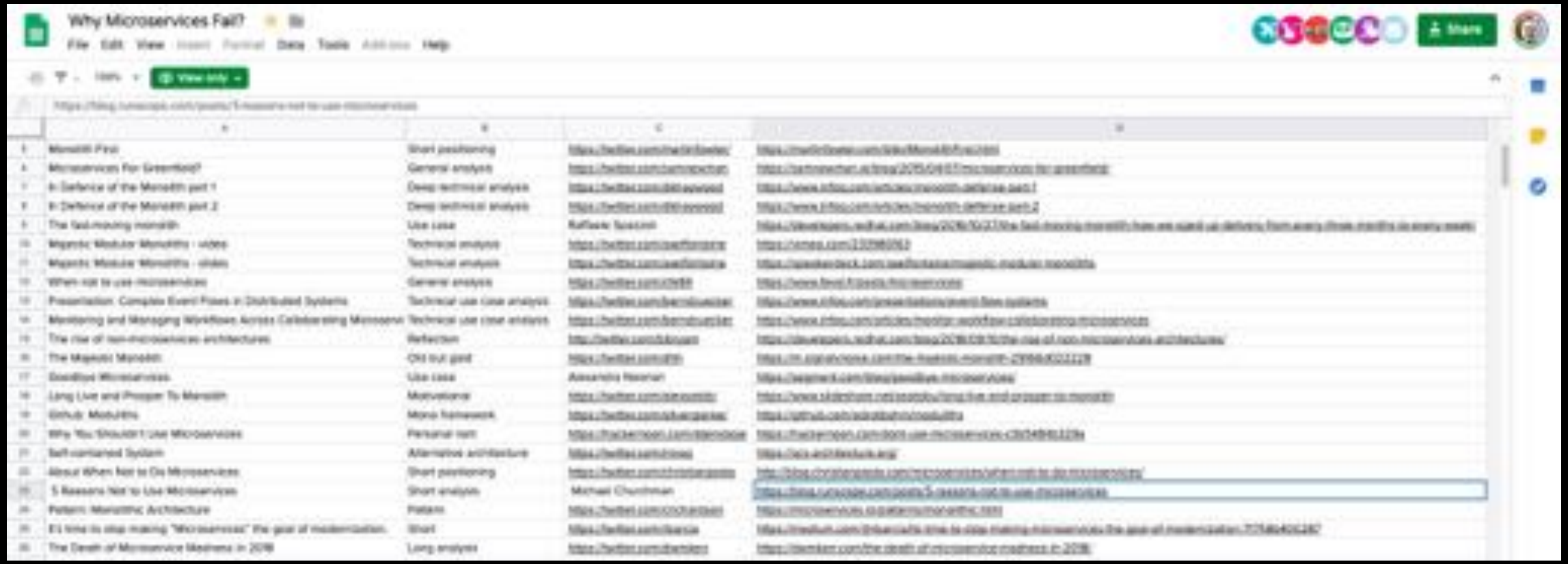
Microservices – reasons not to use them

What works for **large and complex** applications
does not always work at a **smaller scale**

What makes sense for a **new application**
does not always make sense when maintaining or
updating **existing applications**

Source: https://blog.runscope.com/posts/5-reasons-not-to-use-microservices

Microservices – reasons not to use them



https://docs.google.com/spreadsheets/d/1vjnjAII_8TZBv2XhFHra7kEQzQpOHSZpFIWDjynYYf0/edit?pli=1#gid=0

QUESTIONS?

Kubernetes Workshop Series
Docker - *Hands-On*

04

Starting Course JTC01 Docker

Select JTC01 course to begin

JTC01 Labs

Lab 1 : Docker basics

Lab 2 : Docker – Working with Containers

- Build a Docker image
- Run a Docker image
- Use the Portainer tool
- Deploy a more complex Docker application
- Push a Docker image into a registry

Lab 3 : Docker internals

READY SET GO!!!!

Duration: 60 mins

QUESTIONS?

Kubernetes Workshop Series

Kubernetes

05

What happened so far...
Everybody Loves Containers

A **standard way to package an application and all its dependencies** so that it can be moved between environments and run without changes

Containers work by **isolating the differences between applications** inside the container so that everything outside the container can be standardized

Everybody Loves Containers

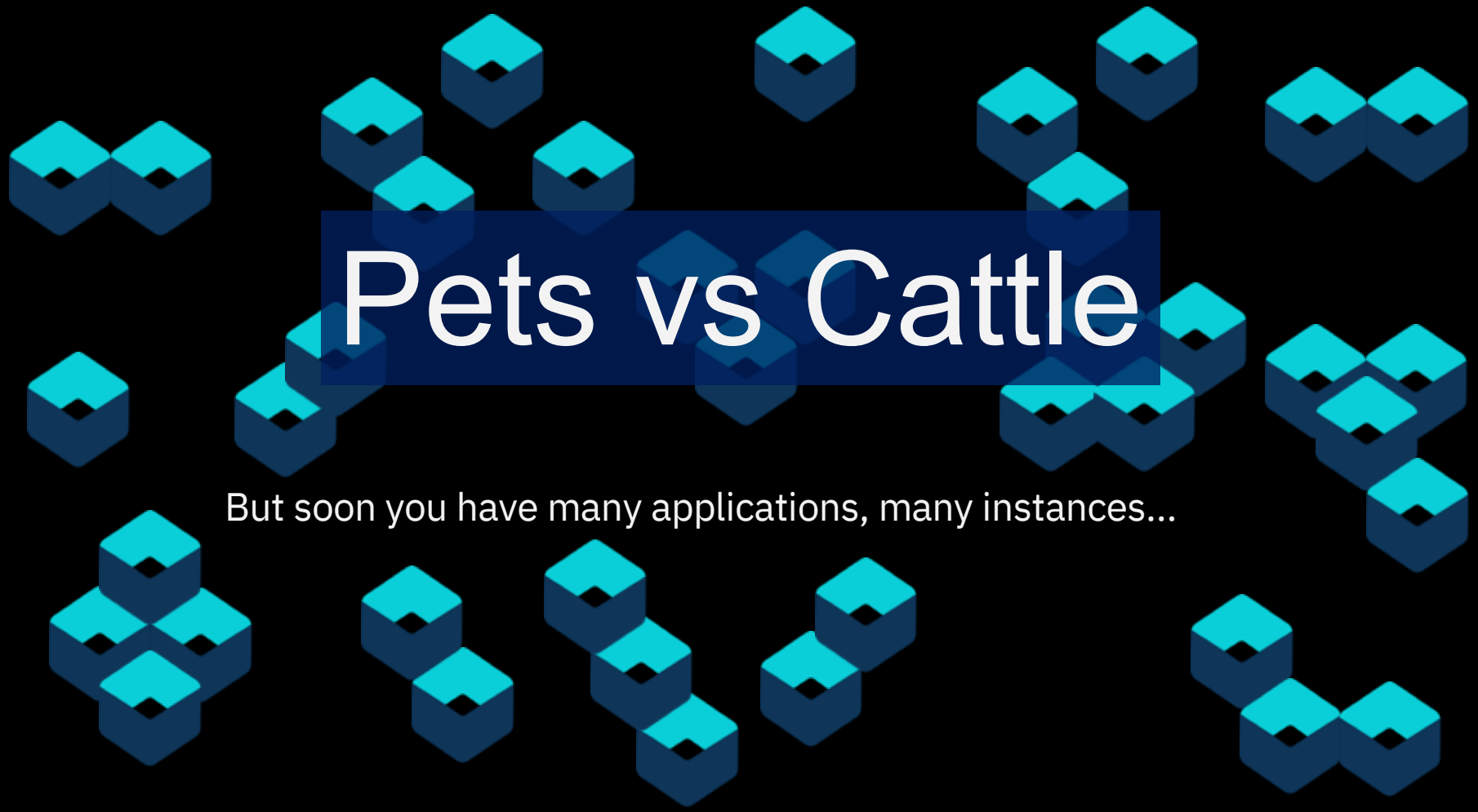
But when you go

From this….

To this….

Everyone’s container journey starts with one container....

At first the growth is easy to handle....



Pets vs Cattle

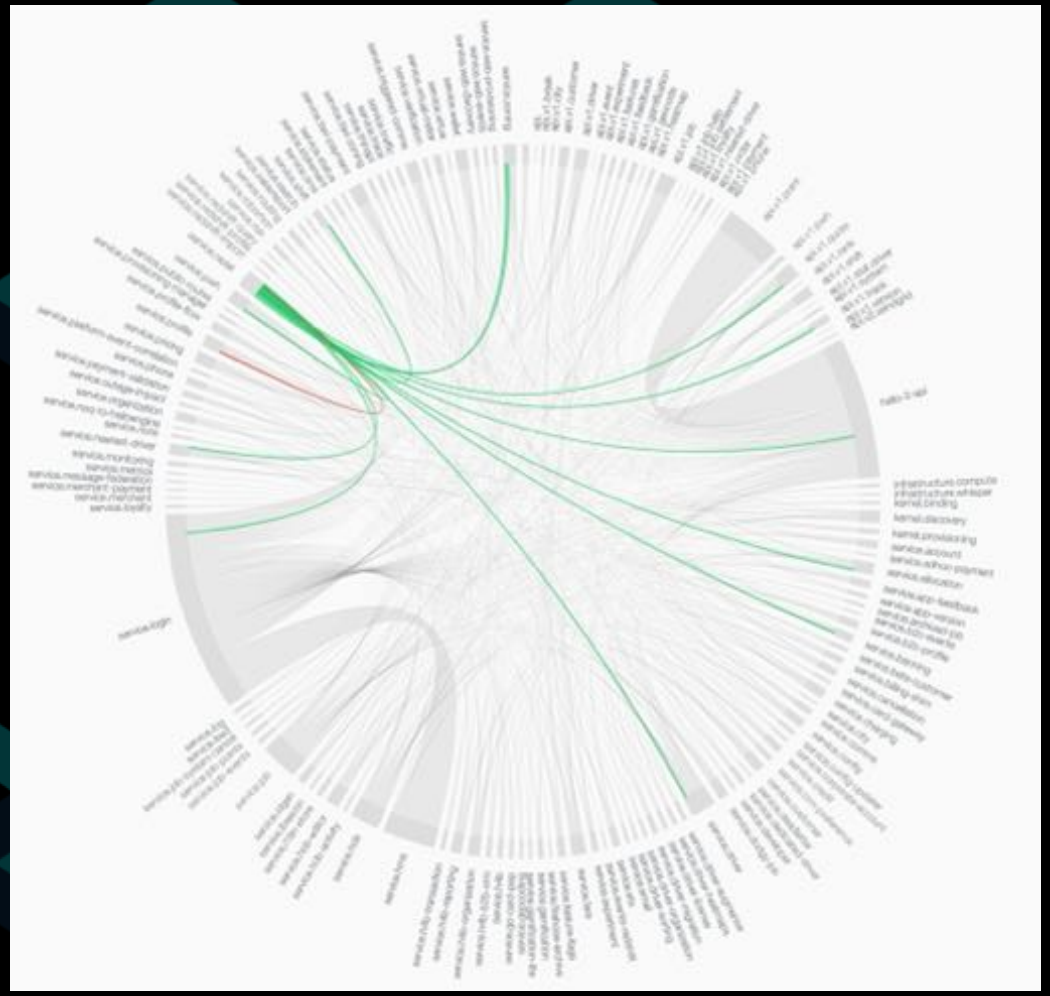
But soon you have many applications, many instances...

The trade off

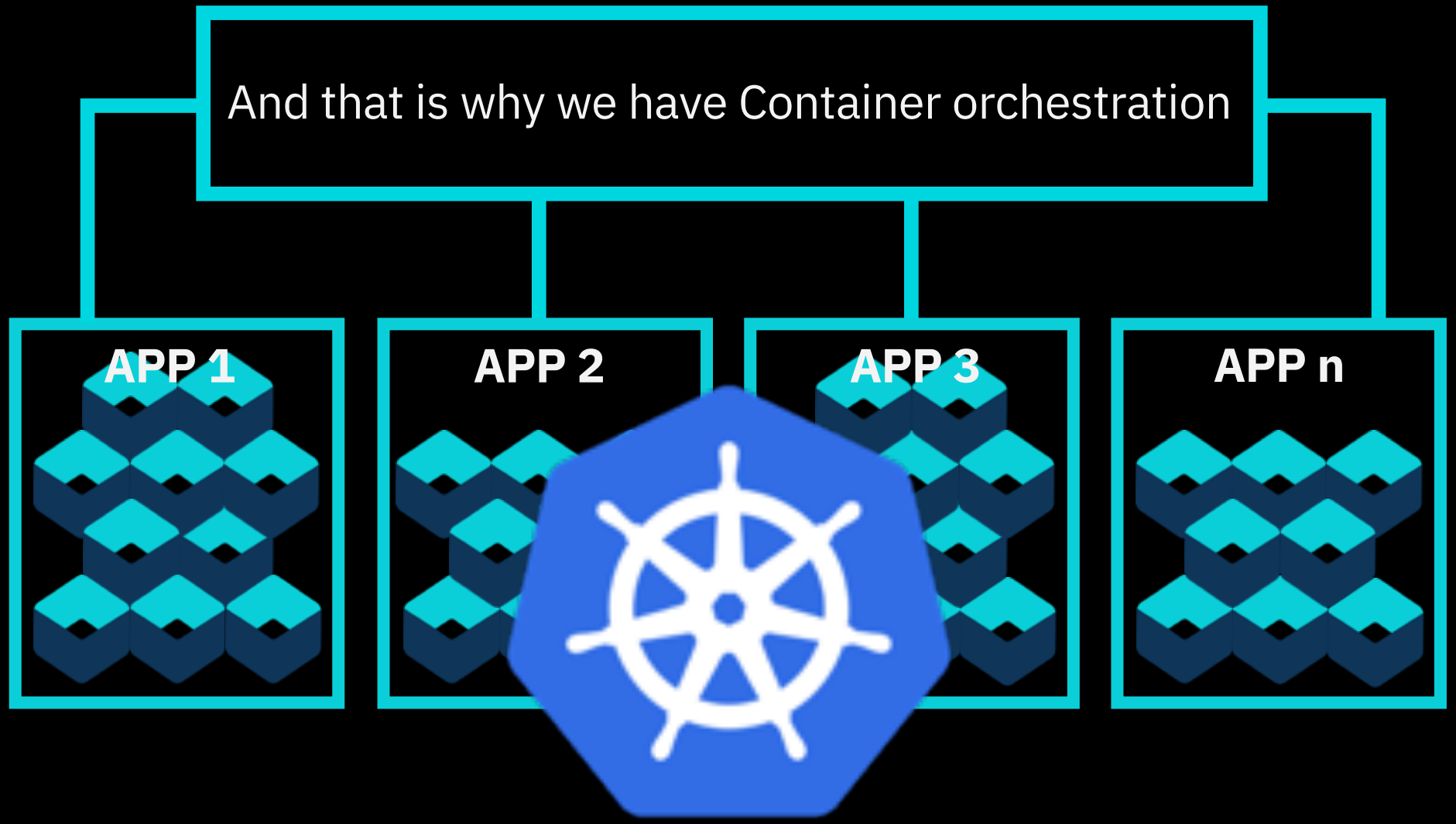
Improved delivery velocity

in exchange for

increased operational complexity



Enter Kubernetes (K8s)



Kubernetes – Declarative System

Imperative Systems

In an imperative system, **the user** knows the desired state and **the user** determines the sequence of commands to transition the system to the desired state.

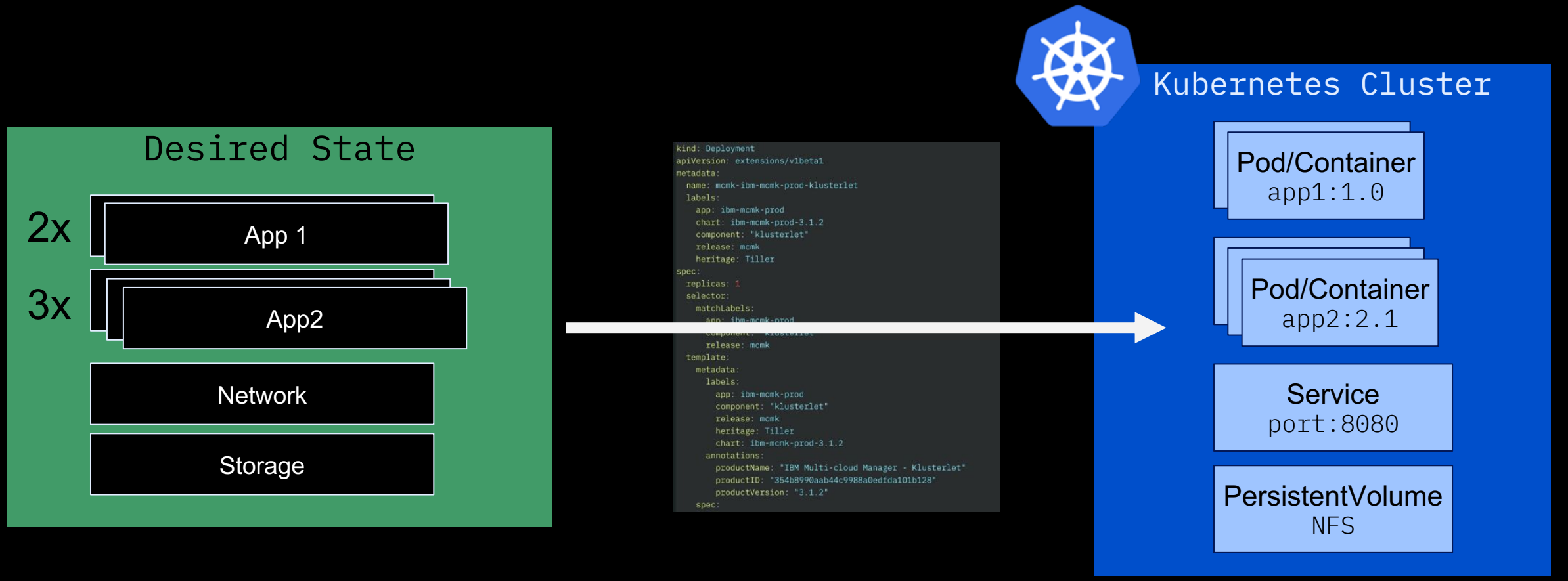
Declarative Systems

By contrast, in a declarative system, **the user** knows the desired state, supplies a representation of the desired state to the system, then **the system** reads the current state and determines the sequence of commands to transition the system to the desired state.

Kubernetes – Declarative System

The Desired State

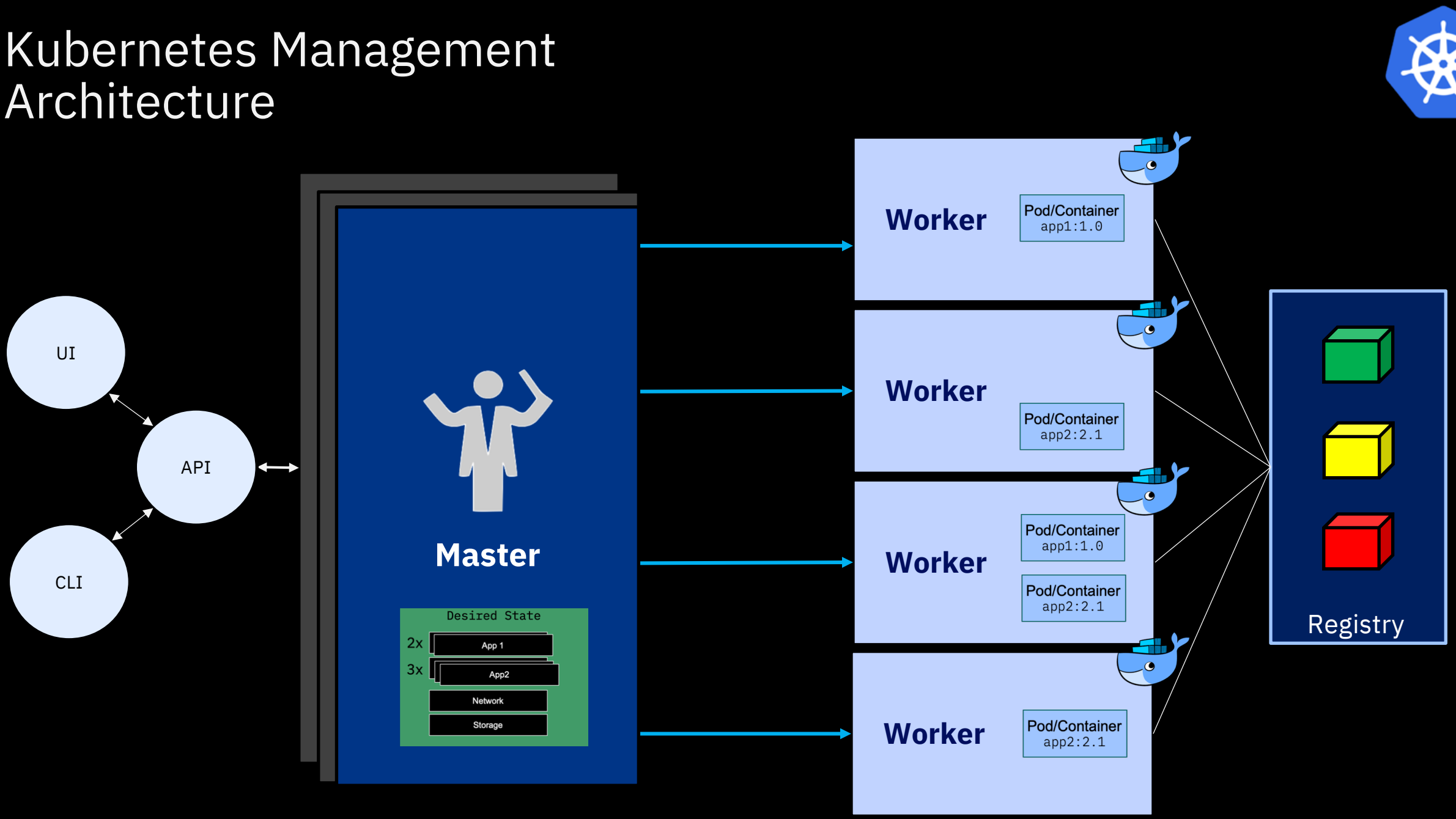
Kubernetes ensures that all the containers running across the cluster are in the desired state at any moment.



Kubernetes Strengths

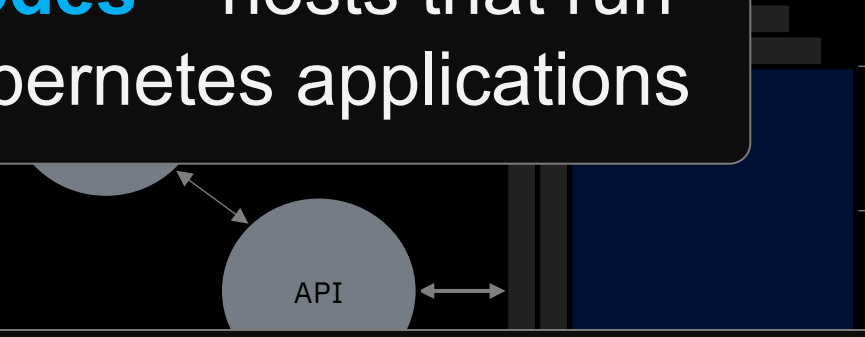
- Kubernetes has a **clear governance model** managed by the Linux Foundation
- A growing and **vibrant** Kubernetes **ecosystem**
- Kubernetes **avoids dependency and vendor lock-in**
- Kubernetes supports a **wide range of deployment options**

Kubernetes Management Architecture



Kubernetes Management Architecture

Nodes – hosts that run Kubernetes applications



Master nodes
- Controls and manages the cluster
- Kubectl (command line)
- REST API (communication with workers)
- Scheduling and replication logic

Worker nodes
- Hosts the K8s services
- **kubelet** (K8s agent that accepts commands from the master)
- **kubeproxy** (network proxy service responsible for routing activities)
- Docker host

- Controller Manager Server
- Scheduler

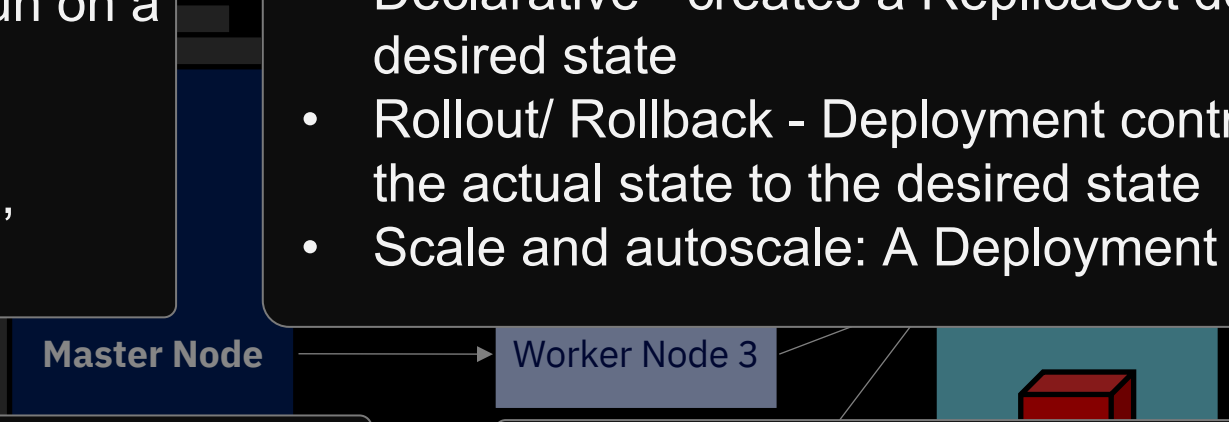
Kubernetes Management Architecture

Pods

- Smallest deployment unit in K8s
- Collection of containers that run on a worker node
- Each has its own IP
- Pod shares a PID namespace, network, and hostname

Deployment

- A set of pods to be deployed together
- Declarative - creates a ReplicaSet describing the desired state
- Rollout/ Rollback - Deployment controller changes the actual state to the desired state
- Scale and autoscale: A Deployment can be scaled



ReplicaSet

- Ensures availability and scalability
- Maintains the number of pods as requested by user
- Uses a template that describes specifically what each pod should contain

Service

- Collections of pods exposed as an endpoint
- A service provides a way to refer to a set of Pods (selected by labels) with a single static IP address

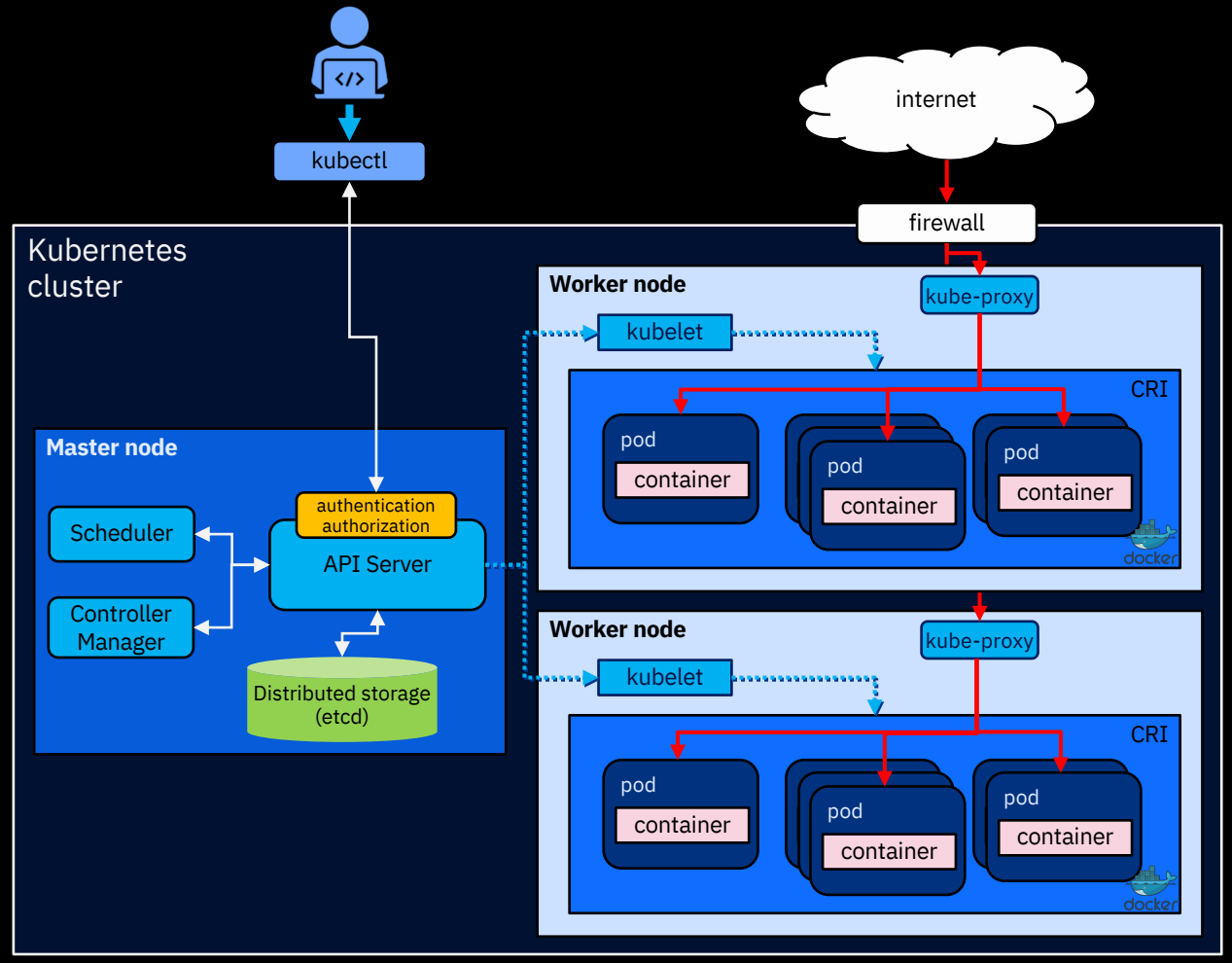
Kubernetes Cluster Architecture

Master node

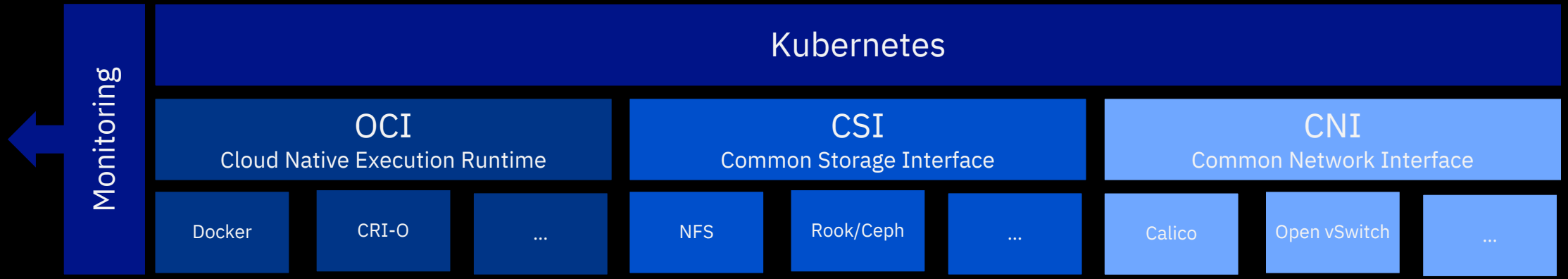
- Node that manages the cluster
- Scheduling, replication & control
- Multiple nodes for HA

Worker nodes

- Node where pods are run
- Docker engine
- kubelet agent accepts & executes commands from the master to manage pods
- kube-proxy – routes inbound or ingress traffic



Kubernetes Cluster Layers



Master Node Components

Etcd

- A highly-available key value store
- All cluster data is stored here

API Server

- Exposes API for managing Kubernetes
- Used by kubectrl CLI

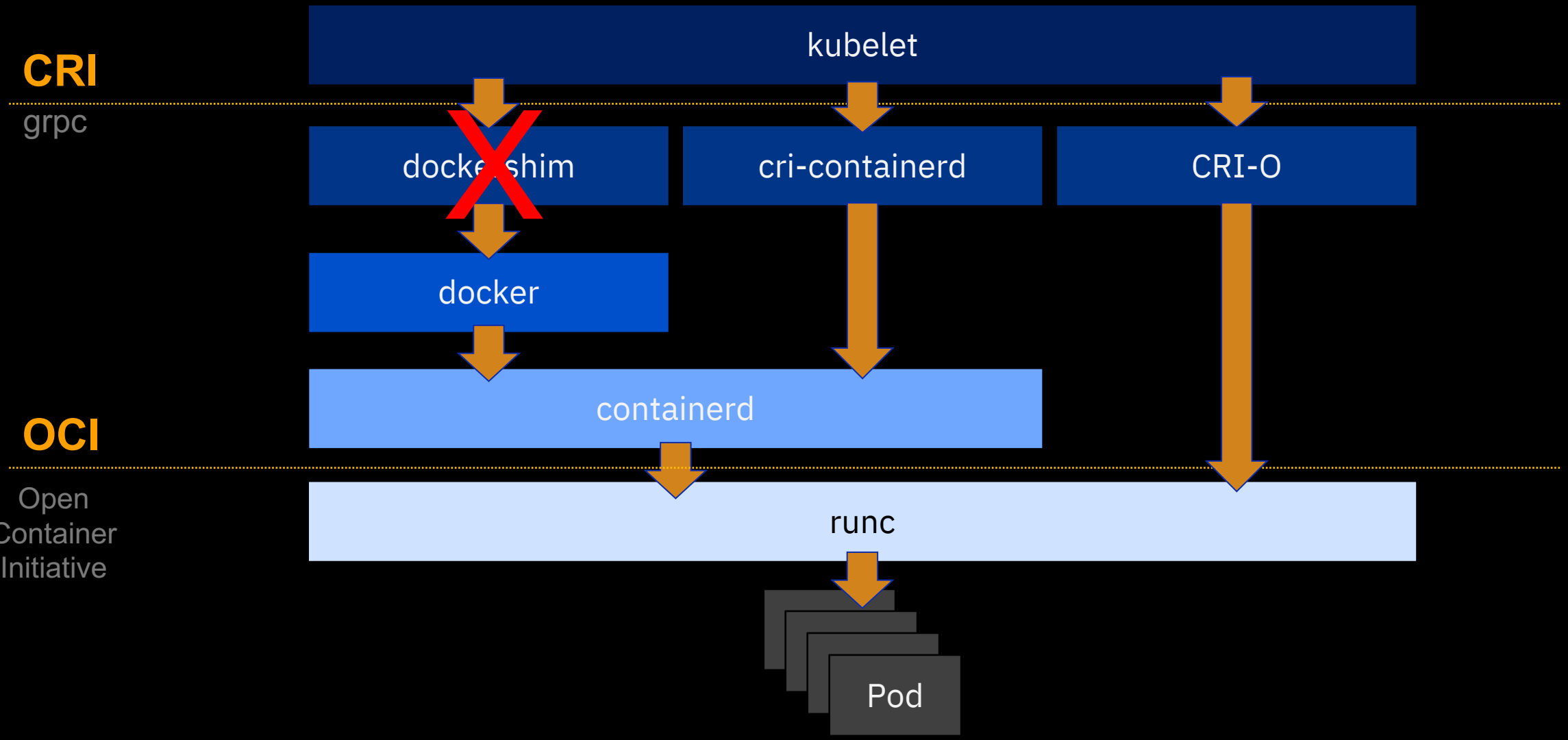
Controller manager

- Daemon that runs controllers, which are the background threads that handle routine tasks in the cluster
- Node Controller – Responsible for noticing and responding when nodes go down
- Replication Controller – Replaced by ReplicaSet
- Endpoints Controller – Populates the Endpoints object (that is, joins services and pods)
- Service Account & Token Controllers – Create default accounts and API access tokens for new namespaces

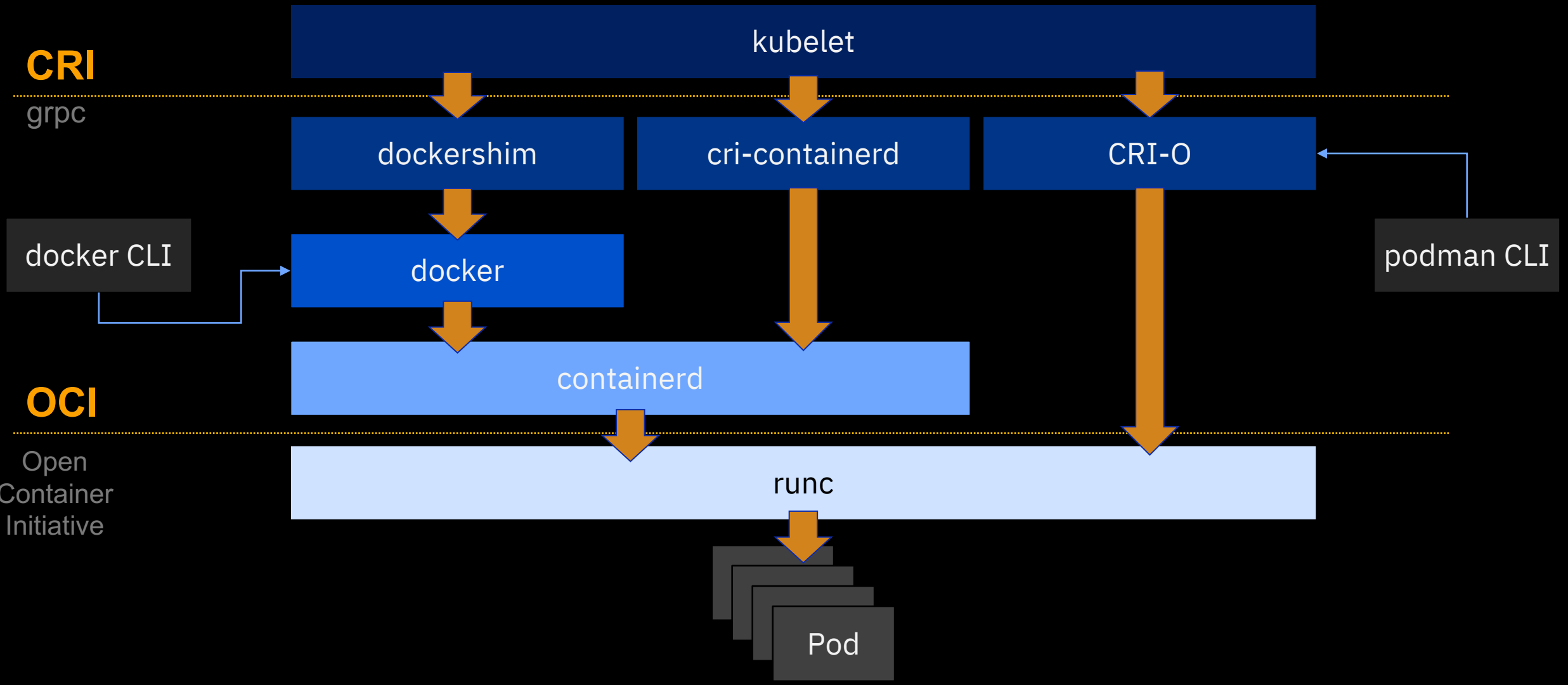
Scheduler

- Selects the worker node each pods runs in

Kubernetes – Common Runtime Interface



Kubernetes – Common Runtime Interface



Container History

1979 chroot

A chroot on Unix operating systems is an operation that changes the apparent root directory for the current running process and its children. A program that is run in such a modified environment cannot name (and therefore normally cannot access) files outside the designated directory tree. … The modified environment is called a "chroot jail".

https://en.wikipedia.org/wiki/ChrootChr

2007 cgroups

2008 LXC

LXC (Linux Containers) is an operating-system-level virtualization environment for running multiple isolated Linux systems (containers) on a single Linux control host.

LXC combines kernel's **cgroups** and support for **isolated namespaces** to provide an isolated environment for applications.

https://en.wikipedia.org/wiki/LXC

2011 warden

2012 

2014 

2015 

https://containerd.io/

2018 

2019 

2020 

Kubernetes – Why CRI-O?

cri-o

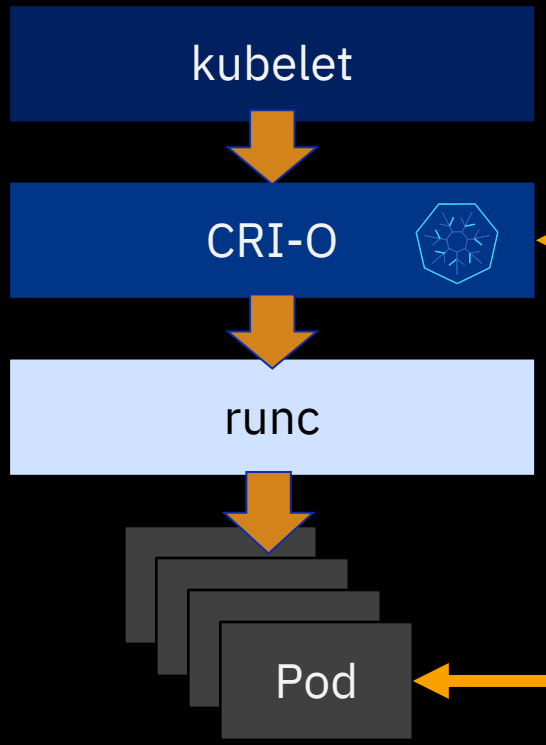
- **A Truly Open Project:** Operated as part of the broader Kubernetes community. Contributors from companies including Red Hat, SUSE, Intel, Google, Alibaba, IBM and more.

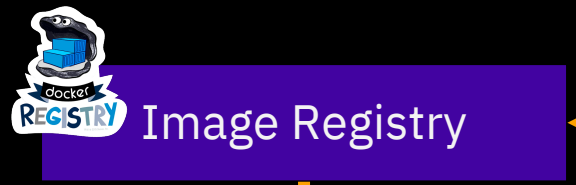
- **Lightweight:** CRI-O is made of lots of small components. In comparison, the Docker Engine is a heavyweight daemon which is communicated to using the docker CLI tool in a client/server fashion.

- **More Securable:** As CRI-O containers are children of the process that spawned it (not the daemon) they're fully compatible with tooling like cgroups & security constraints to provide an extra layer of protection to your containers. Every container run using the Docker CLI is a 'child' of that large Docker Daemon. This complicates or outright prevents the use of this tooling.

- **Aligned with Kubernetes:** As an official Kubernetes project, CRI-O releases in lock step with Kubernetes, with similar version numbers. ie. CRI-O 1.11.x works with Kubernetes 1.11.x.

Kubernetes – CRI-O



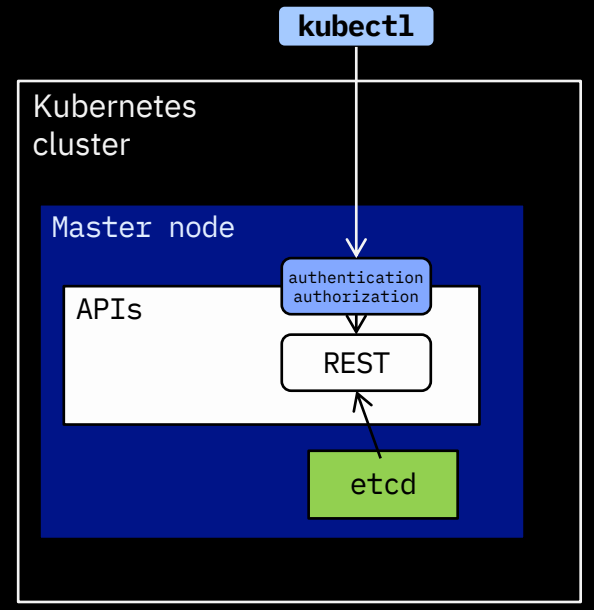


kubectl – talking to the Cluster

`kubectl` is a command line interface for running commands against Kubernetes clusters (read state, create objects, …).

`kubectl` looks for a file named `config` in the `$HOME/.kube` directory. It contains all the information needed to communicate with your cluster.

```
training@ubuntu:~/training/demo-app/k8sdemo$ kubectl config view
apiVersion: v1
clusters:
- cluster:
    certificate-authority: /home/training/.minikube/ca.crt
    server: https://172.17.0.4:8443
  name: minikube
contexts:
- context:
    cluster: minikube
    user: minikube
  name: minikube
current-context: minikube
kind: Config
preferences: {}
users:
- name: minikube
  user:
    client-certificate: /home/training/.minikube/profiles/minikube/client.crt
    client-key: /home/training/.minikube/profiles/minikube/client.key
```

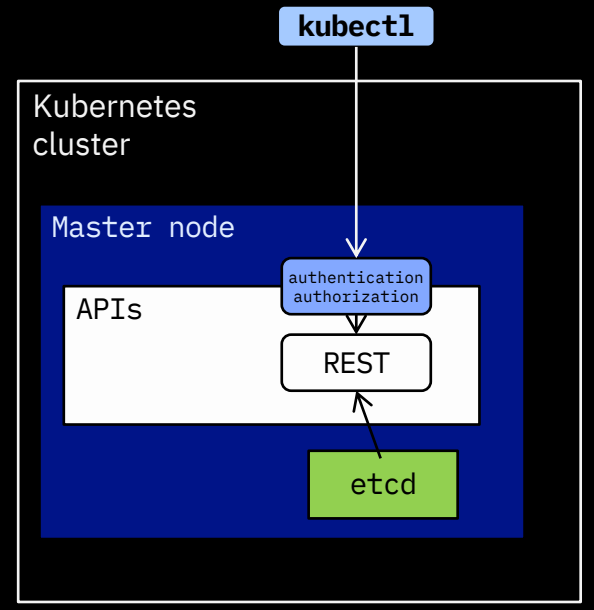


kubectl – talking to the Cluster

`kubectl` is a command line interface for running commands against Kubernetes clusters.

kubectl [command] [TYPE] [NAME]

kubectl create -f example.yaml	Create objects in yaml file
kubectl apply -f example.yaml	Modify objects in yaml file
kubectl delete -f example.yaml	Delete objects in yaml file
kubectl get pods	List Pods in Namespace
kubectl describe nodes <node-name>	Details about K8s object
kubectl logs <pod-name>	Get the logs for a Pod

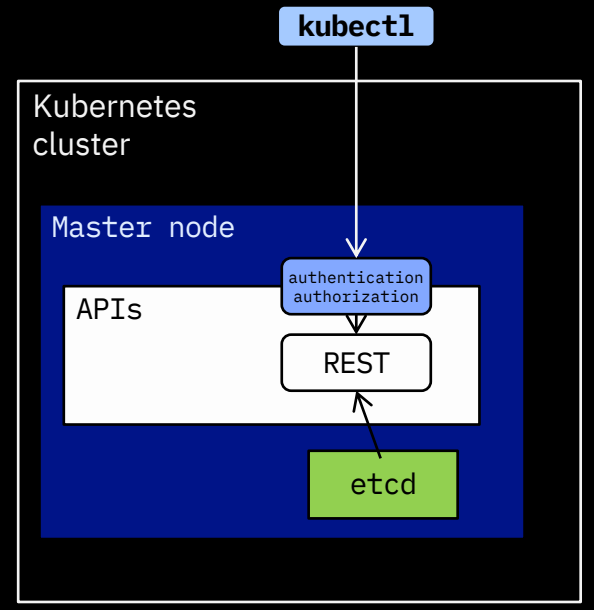


kubectl – talking to the Cluster

`kubectl` is a command line interface for running commands against Kubernetes clusters (read state, create objects, …).

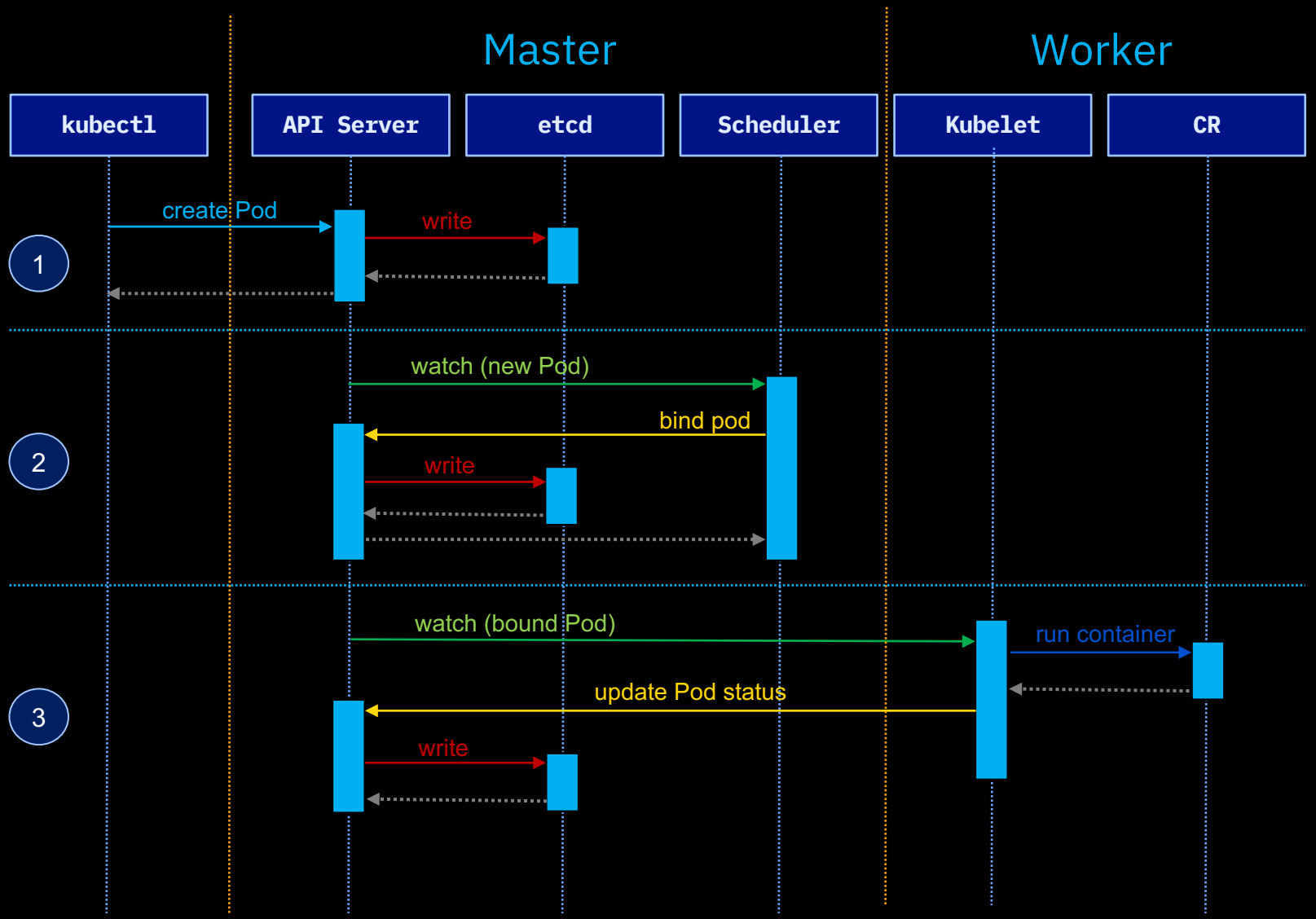
- Kubernetes uses etcd as a key-value database store.
- It stores the configuration of the Kubernetes cluster in etcd.
- It also stores the *actual* state of the system and the *desired* state of the system in etcd.

- Anything you might read from a `kubectl get xyz` command is coming from etcd.
- Any change you make via `kubectl create` will cause an entry in etcd to be updated.



kubectl – talking to the Cluster

What does this actually do: `kubectl run nginx --image=nginx:1.7.9`



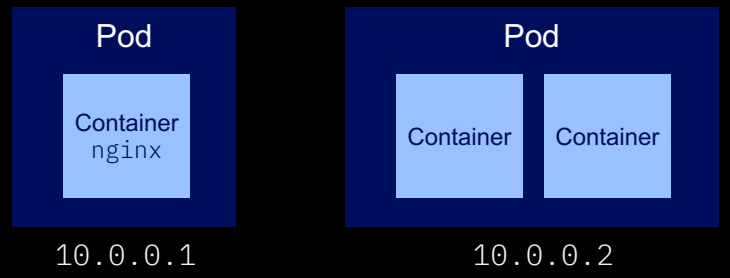
1. Create a Pod via the API Server and the API server writes it to etcd
2. The scheduler notices an “unbound” Pod and decides which node to run that Pod on. It writes that binding back to the API Server.
3. The Kubelet notices a change in the set of Pods that are bound to its node. It, in turn, runs the container via the container runtime (i.e. Docker).

The Kubelet monitors the status of the Pod via the container runtime. As things change, the Kubelet will reflect the current status back to the API Server

Pod

- A group of one or more containers is called a pod.
- Containers in a pod are deployed together, and are started, stopped, and replicated as a group.
- Containers in pod share the same network interface.
- Applications in the same pod
  - Share IP Address and port space
  - Share the same hostname
  - Can communicate using native IPC
  - Can share mounted storage
- Applications in different pods
  - Have different IP Addresses
  - Have different hostnames
  - Pods running on the same node might as well be on different servers
- **When designing pods ask, "Will these containers work correctly if they land on different machines?"**

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    ports:
    - containerPort: 80
```



Creating a Pod

~~kubectl run nginx --image= nginx:1.7.9~~

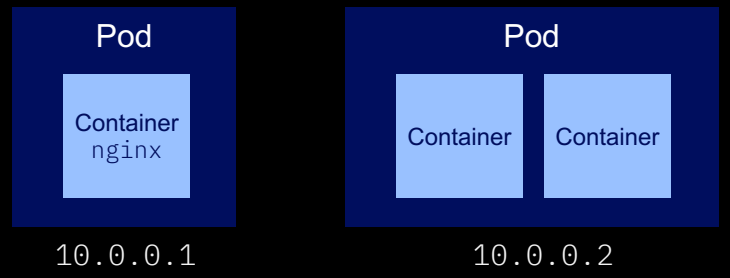
Or

kubectl create –f example.yaml

```
kubectl get pods
NAME                     READY   STATUS    RESTARTS   AGE
nginx-5bd87f76c-vxc79    1/1     Running   0          29s
```

example.yaml

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.7.9
    ports:
    - containerPort: 80
```



Naming

Name

- Each resource object by type has a unique name

Namespace

- **Resource isolation**: Each namespace is a virtual cluster within the physical cluster
  - Resource objects are scoped within namespaces
  - Low-level resources are not in namespaces: nodes, persistent volumes, and namespaces themselves
  - Names of resources need to be unique within a namespace, but not across namespaces
- **Resource quotas**: Namespaces can divide cluster resources
- Initial namespaces
  - `default` – The default namespace for objects with no other namespace
  - `kube-system` – The namespace for objects created by the Kubernetes system

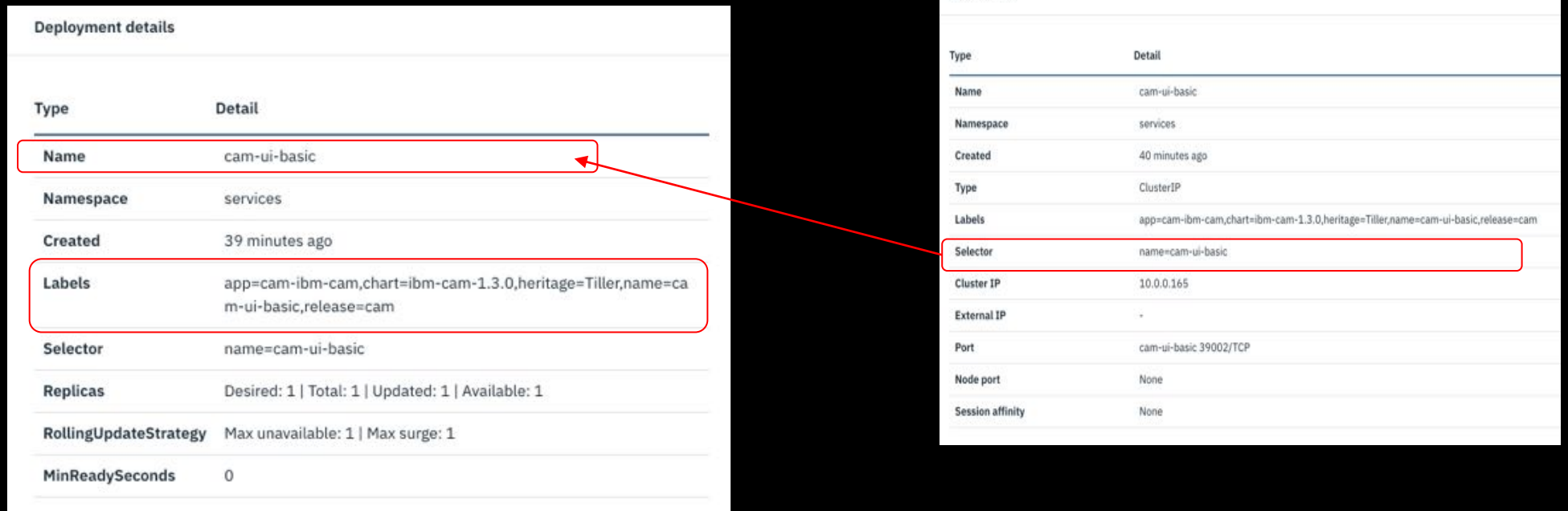
Configuring Resources and Containers

Label

- **Metadata** assigned to Kubernetes resources (pods, services, etc.)
- Key-value pairs for identification
- Critical to Kubernetes as it relies on querying the cluster for resources that have certain labels

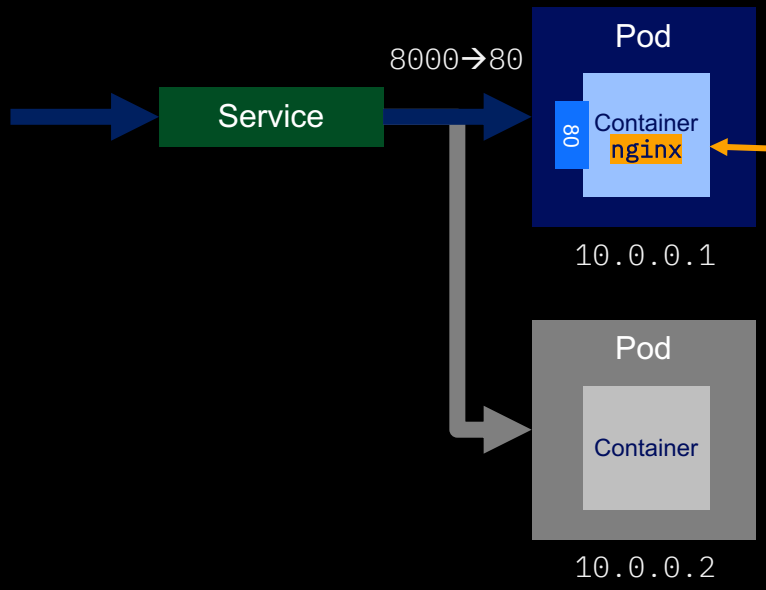
Selector

- An expression that **matches labels** to identify related resources



Service

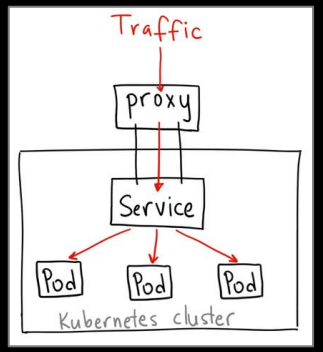
- A service provides a way to refer to a set of Pods (selected by labels) with a single static IP address.
- Creates an entry in the Kubernetes DNS



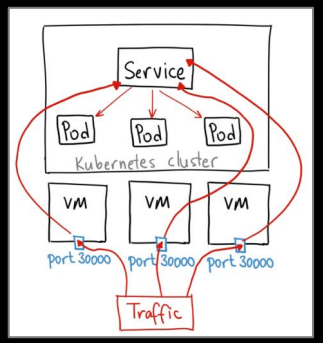

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  ports:
  - port: 8000
    targetPort: 80
    protocol: TCP
  selector:
    app: nginx
```

Service

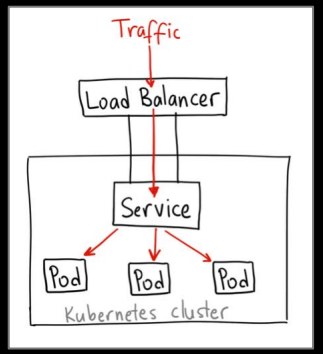
ClusterIP: This type exposes the service on the cluster internal IP. This means that the service is only reachable from within the cluster.



NodePort: This type exposes the service on each Node's static IP address.



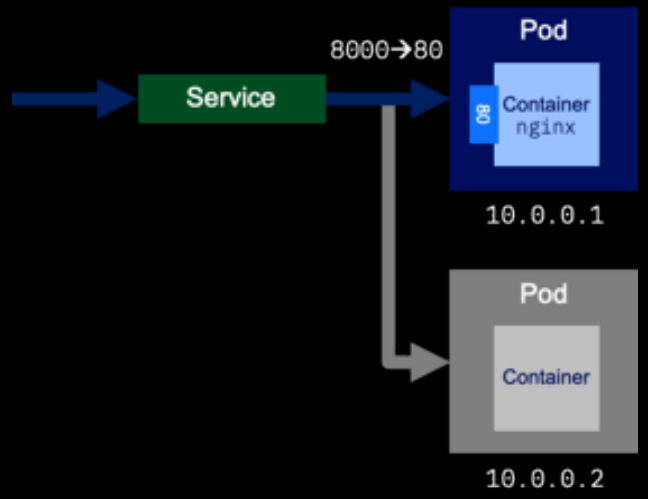
LoadBalancer: This service type exposes a service using the cloud provider load balancer.



Creating a Service

```
kubectl expose deployment nginx --type="NodePort" --port=8000 --target-port=80
or
kubectl create –f example.yaml
```

```
kubectl get services
NAME         TYPE         CLUSTER-IP        EXTERNAL-IP   PORT(S)          AGE
nginx        NodePort     10.106.115.135    <none>        8000:32499/TCP   6s
```



example.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
  name: nginx-service
spec:
  ports:
  - port: 8000
    targetPort: 80
    protocol: TCP
  selector:
    app: nginx
```

Service Access

So a Kubernetes service with the name ***k8s-demo-service*** in namespace ***default*** could be addressed:

When referred from the same namespace

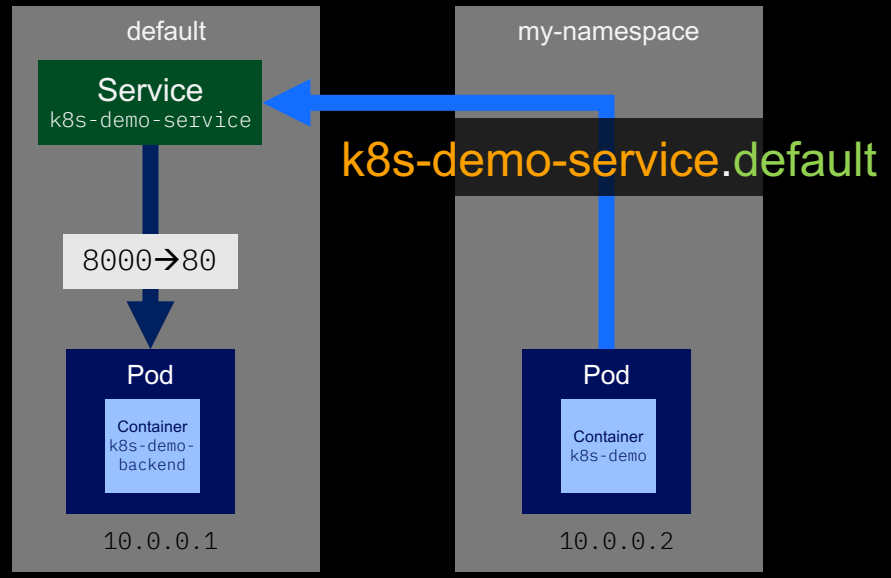
k8s-demo-service

When referred from another namespace

k8s-demo-service.default

Fully qualified name

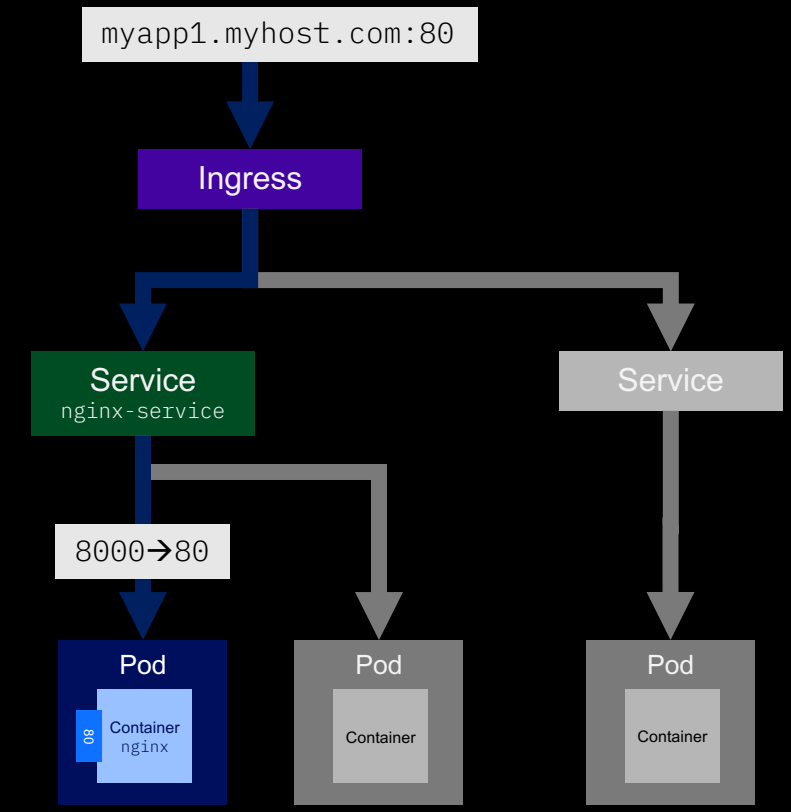
k8s-demo-service.default.svc.cluster.local



Ingress

An ingress can be configured to give services externally-reachable URLs, load balance traffic, terminate SSL, and offer name based virtual hosting. An ingress controller is responsible for fulfilling the ingress, usually with a loadbalancer.

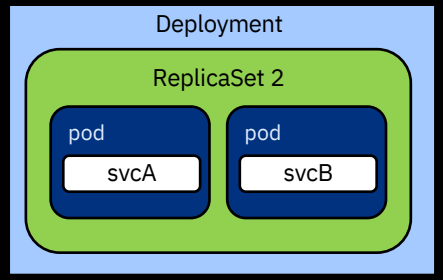
```
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: nginx-ingress
  annotations:
    ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - host: myapp1.myhost.com
    http:
      paths:
      - backend:
          serviceName: nginx-service
          servicePort: 80
```



Deployments & ReplicaSets

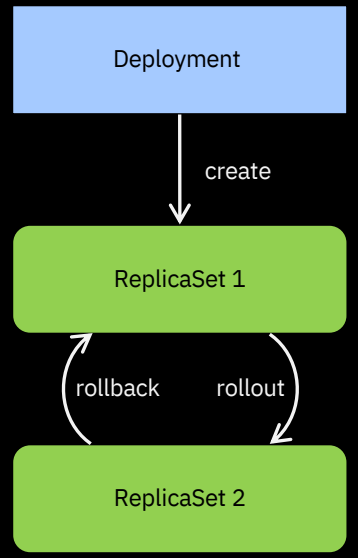
Deployment

- A set of **pods to be deployed together**, such as an application
- **Declarative**: Revising a Deployment **creates a ReplicaSet** describing the desired state
- **Rollout**: Deployment controller changes the actual state to the desired state at a controlled rate
- **Rollback**: Each Deployment revision can be rolled back
- **Scale** and autoscale: A Deployment can be scaled



ReplicaSet

- Cluster-wide pod manager that **ensures the proper number of pods are running** at all times.
- A set of pod templates that describe a set of pod replicas
- Uses a template that describes specifically what each pod should contain
- Ensures that a specified number of pod replicas are running at any given time

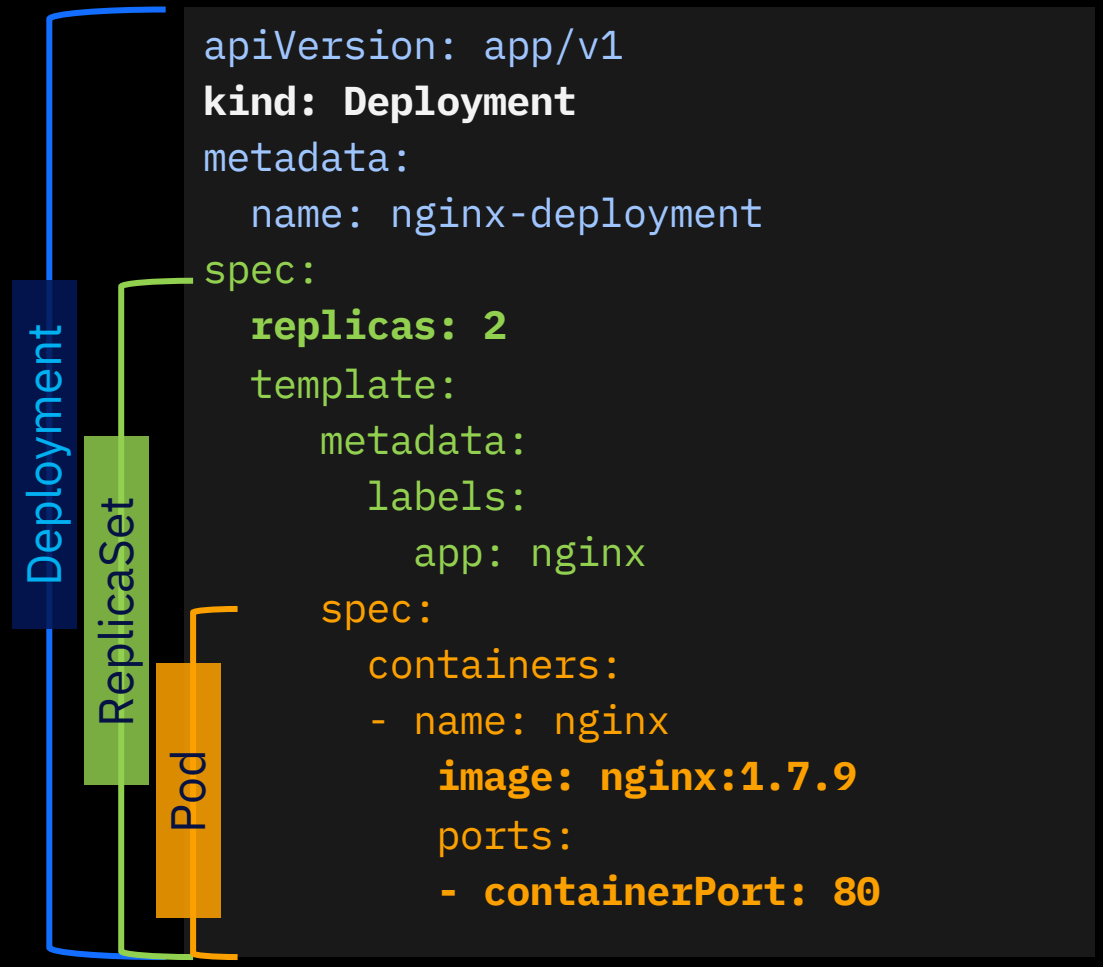


Deployment

- A Deployment object defines a Pod creation template and **desired replica count**.
- Create or delete Pods as needed to meet the replica count.
- Manage safely **rolling out changes** to your running Pods.

```
kubectl create –f example.yaml
```

example.yaml



StatefulSet, DaemonSet, Job...

StatefulSet

- Intended to be used with stateful applications and distributed systems.
  - Pods are created sequentially
  - Ordinal index and stable network identity

DaemonSet

- Ensures that all (or some) nodes run a copy of a pod
  - running a cluster storage daemon
  - running a logs collection daemon
  - running a node monitoring daemon

Job

- Creates one or more pods and ensures that a specified number of them successfully terminate

Cron Job

- Manage time based jobs, once at a specified in time, or repeatedly at a specified time point

Resource Quota

- Limits resource consumption per namespace
- Limit can be number of resource objects by type (pods, services, etc.)
- Limit can be total amount of compute resources (CPU, memory, etc.)
- Overcommit is allowed; contention is handled on a first-come, first-served basis

Configuring Resources and Containers

ConfigMap

- Configuration values to be used by containers in a pod
- Stores configuration outside of the container image, making containers more reusable

Secret

- Sensitive info that containers need to read or consume
- Encrypted in special volumes mounted automatically

Configuring Resources and Containers

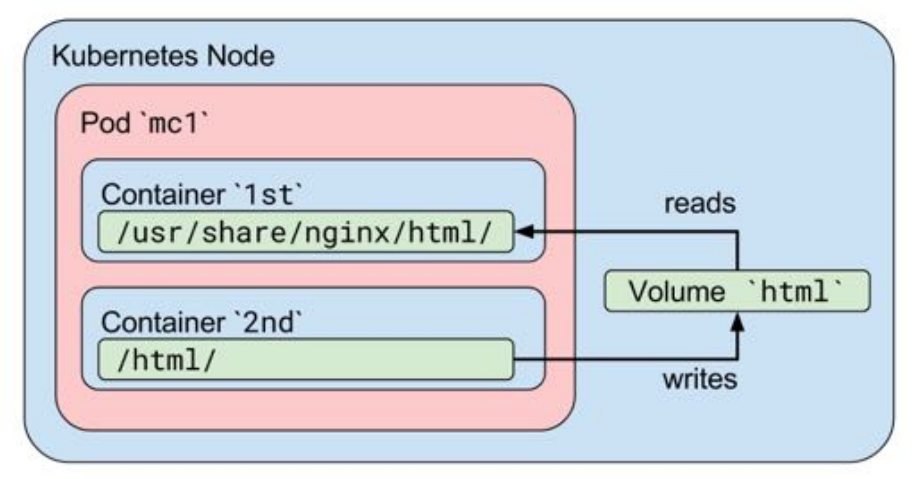
```yaml
apiVersion: extensions/v1beta1
kind: ConfigMap
apiVersion: v1
metadata:
  name: example-config
data:
  allowed: '"true"'
  enemies: aliens
  lives: "3"
```

```yaml
kind: Deployment
spec:
  containers:
    - name: test-container
      image: xxx
      ...
    env:
        - name: SPECIAL_LEVEL_KEY
          valueFrom:
            configMapKeyRef:
              name: example-config
              key: enemies
```

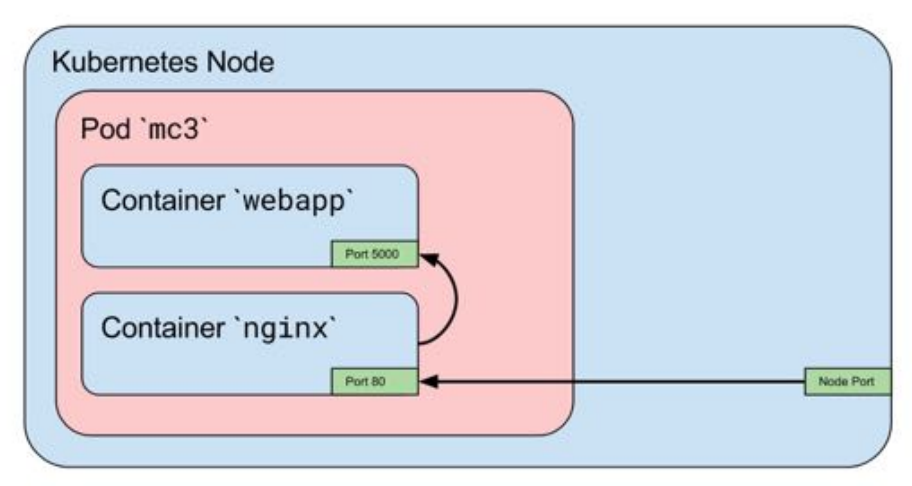
Can be used as normal environment variable (here SPECIAL_LEVEL_KEY=aliens)

Multi-Container Pod Design Patterns

Shared Volumes

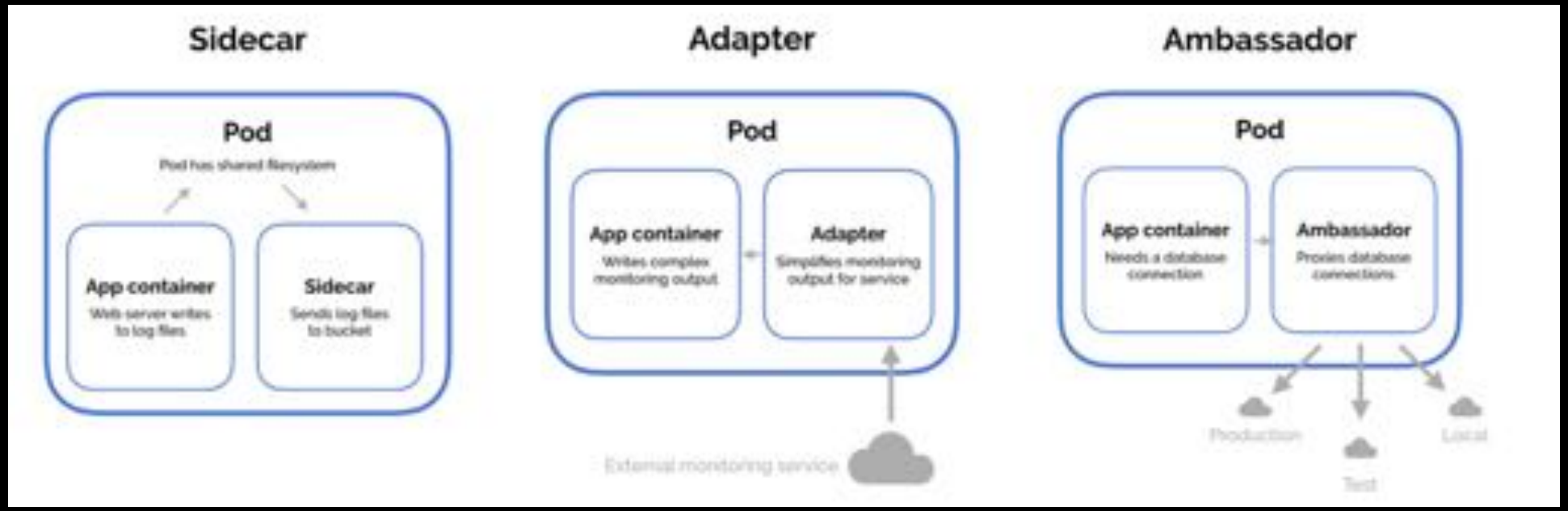


No Network isolation



In what order containers are being started in a Pod?

Multi-Container Pod Design Patterns



Sidecar pattern
The sidecar pattern consists of a main application—i.e. your web application—plus a helper container with a **responsibility that is essential to your application**, but is not necessarily part of the application itself.

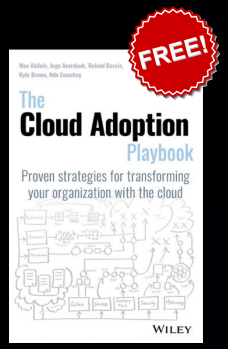
Adapter pattern
The adapter pattern is used to standardize and normalize application output or **monitoring data** for aggregation.

Ambassador pattern
The ambassador pattern is a useful way to connect containers with the outside world (**proxy**).

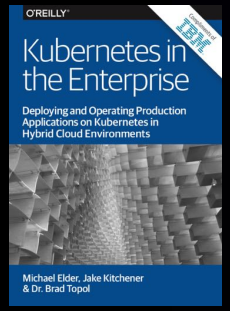
https://matthewpalmer.net/kubernetes-app-developer/articles/multi-container-pod-design-patterns.html

QUESTIONS?

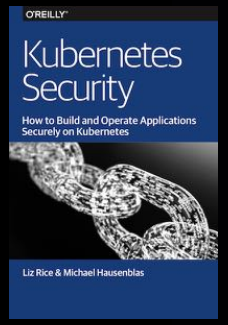
Kubernetes – Some Reading Tips



The de facto guide to improving your enterprise with the cloud, created by distinguished members of our Solution Engineering team
http://ibm.biz/playbook



Deploying and Operating Production Applications on Kubernetes in Hybrid Cloud Environments
https://ibm.co/2LQketN (excerpt)



https://kubernetes-security.info/

Kubernetes Workshop Series

Mesh Networking

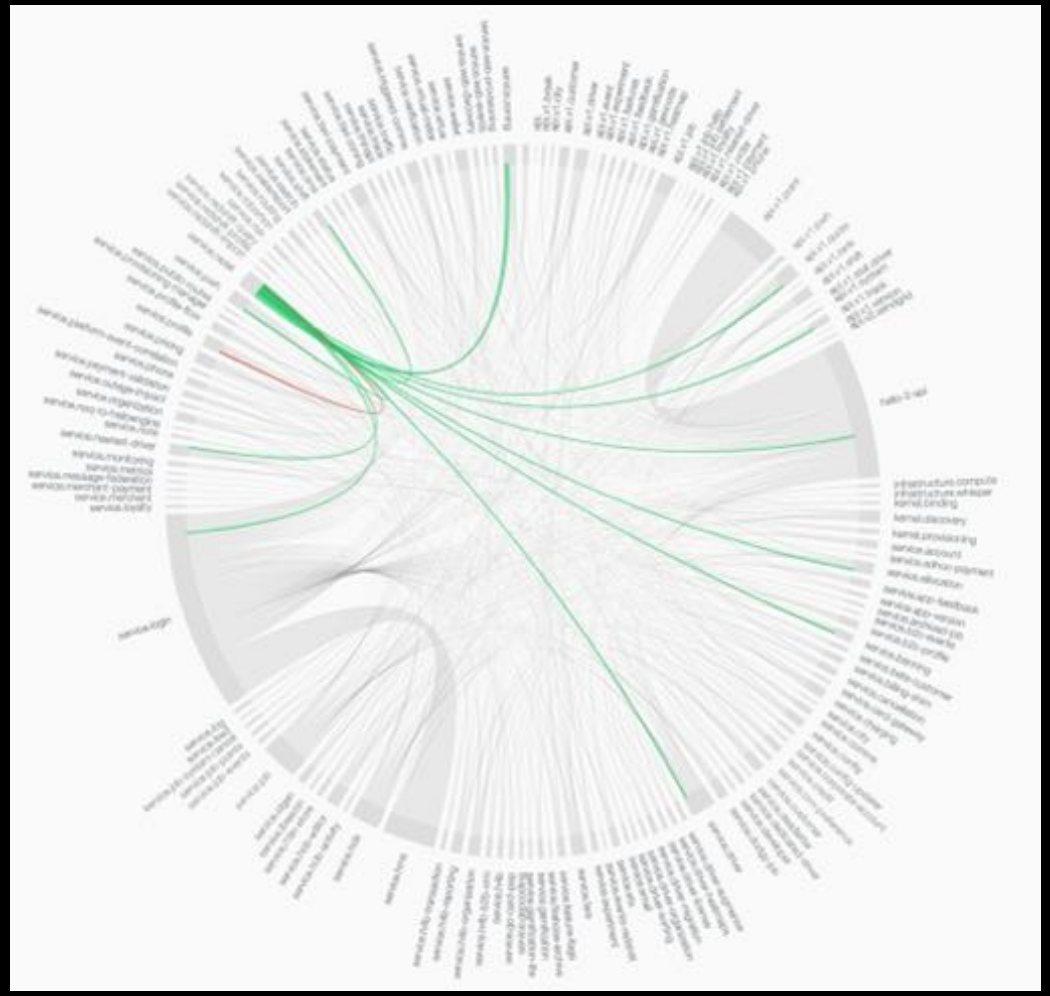
06

The trade off

Improved delivery velocity

in exchange for

increased operational complexity



Addressing DevOps Challenges

#	CHALLENGE	
CHALLENGE 1	ROLL OUT NEW VERSION WITHOUT DOWNTIME OR CHANGING CODE	
CHALLENGE 2	HOW TO DO CANARY TESTING	
CHALLENGE 3	HOW TO DO A/B TESTING	
CHALLENGE 4	THINGS DON'T ALWAYS GO CORRECTLY IN PRODUCTION…	
CHALLENGE5	HOW CAN I LIMIT RATE FOR SOME OF MY SERVICES?	
CHALLENGE 6	I NEED TO VIEW AND MONITOR WHAT IS GOING ON WHEN CRISIS ARISES	
CHALLENGE 7	HOW CAN I SECURE MY SERVICES?	

Service Mesh

Dedicated infrastructure layer
to make
service-to-service communication
fast, safe and reliable

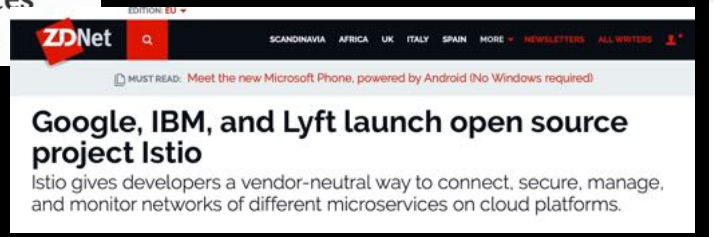
Istio

A service mesh designed to connect, manage and secure micro services


Forbes

3,859 views | May 25, 2017, 01:39am

Google, IBM And Lyft Want To Simplify Microservices Management With Istio

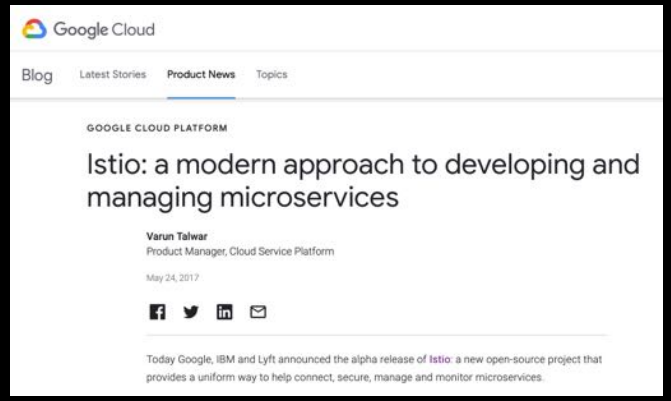

ZDNet

SCANDINAVIA AFRICA UK ITALY SPAIN MORE NEWSLETTERS ALL WRITERS

MUST READ: Meet the new Microsoft Phone, powered by Android (No Windows required)

Google, IBM, and Lyft launch open source project Istio

Istio gives developers a vendor-neutral way to connect, secure, manage, and monitor networks of different microservices on cloud platforms.


Google Cloud

Blog Latest Stories Product News Topics

GOOGLE CLOUD PLATFORM

Istio: a modern approach to developing and managing microservices

Varun Talwar
Product Manager, Cloud Service Platform

May 24, 2017

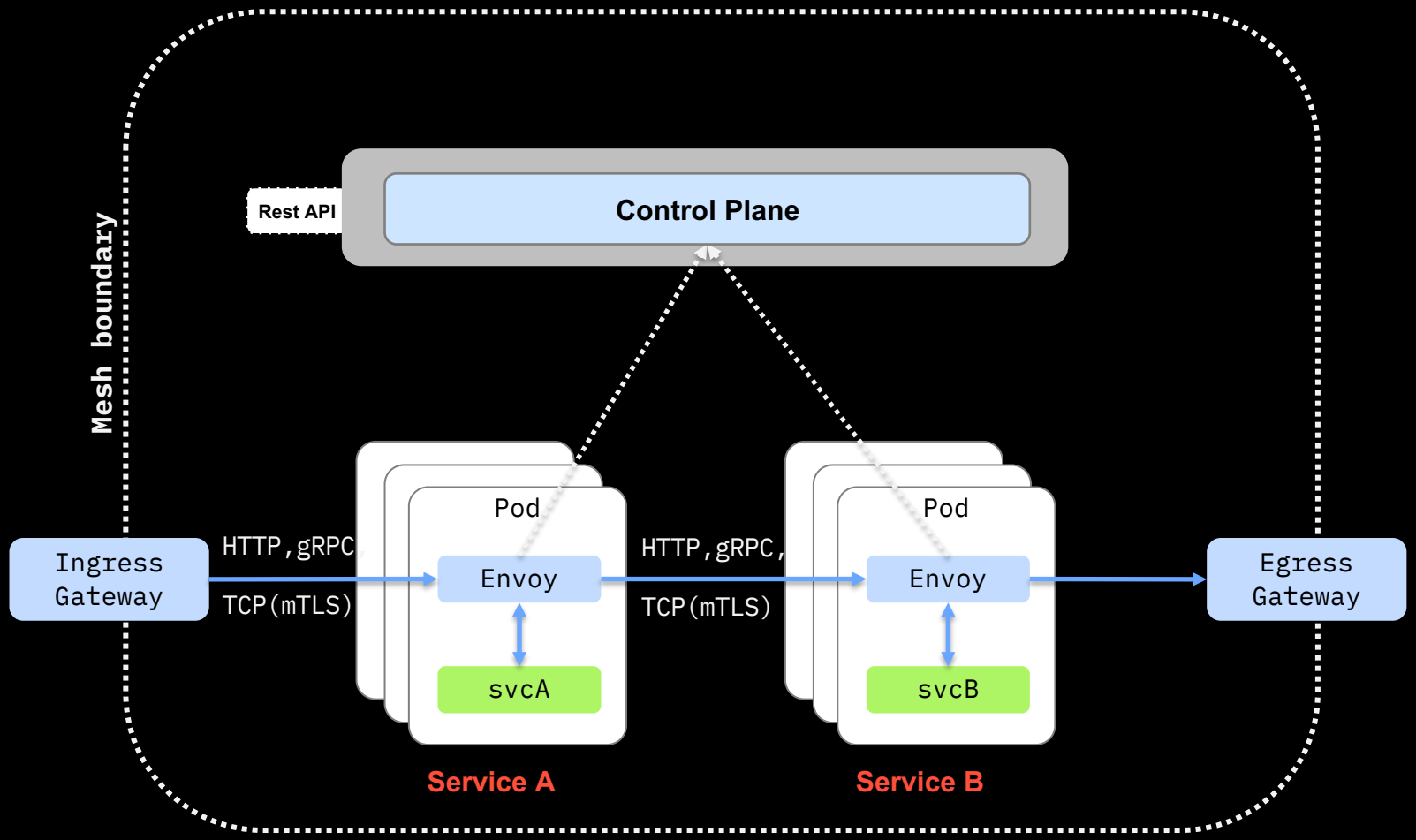
Today Google, IBM and Lyft announced the alpha release of Istio: a new open-source project that provides a uniform way to help connect, secure, manage and monitor microservices.

Launched in May 2017 by Google, Lyft and IBM

Open Source

Zero Code Changes

ISTIO - Architecture



Istio control plane traffic. Request routing rules, resilience configuration (circuit breakers, timeouts, retries), policies (ACLs, rate limits, auth), and metrics/reports from proxies.

User/application traffic. HTTP/1.1, HTTP/2, gRPC, TCP with or without TLS

ISTIO
Gateway

Load balancer operating at the edge of the mesh receiving incoming HTTP/TCP connections

- Configures ports to expose externally
- Maps each exposed port to a request destination
- Each gateway can have one or more Virtual Services that defines these request destinations

Gateway is attached to Istio Ingress Controller (which can be the Kubernetes Ingress Controller)

Request destinations

- Ports for the gateway to expose and hosts for the corresponding services
- Attributes: **servers**

```yaml
kind: Gateway
metadata:
  name: helloworld-gateway
spec:
  selector:
    istio: ingressgateway
  servers:
  - hosts:
    - myapp.demo.com
    port:
      name: http
      number: 80
      protocol: HTTP
```

ISTIO

Custom resource definitions


```
kind: Gateway
metadata:
  name: helloworld-gateway
spec:
  selector:
    istio: ingressgateway
  servers:
  - hosts:
    - myapp.demo.com
    port:
      name: http
      number: 80
      protocol: HTTP
```

http://myapp.demo.com

POD
helloworld

version = **v1**

SERVICE
helloworld

selector
app: helloworld

ISTIO
Virtual Service

Request sources
- Hosts that sources can invoke
- Attributes: **hosts** and **gateways**

Route destinations
- Subset of the destination
- Attributes: **route** and **destination**

Protocol selection
- How to connect to the destination subset
- Attributes: **http**, **tcp**, **tls**

Routing rules
- Additional routing attributes, applied for the route destinations
- Attributes: **weight** and **match**

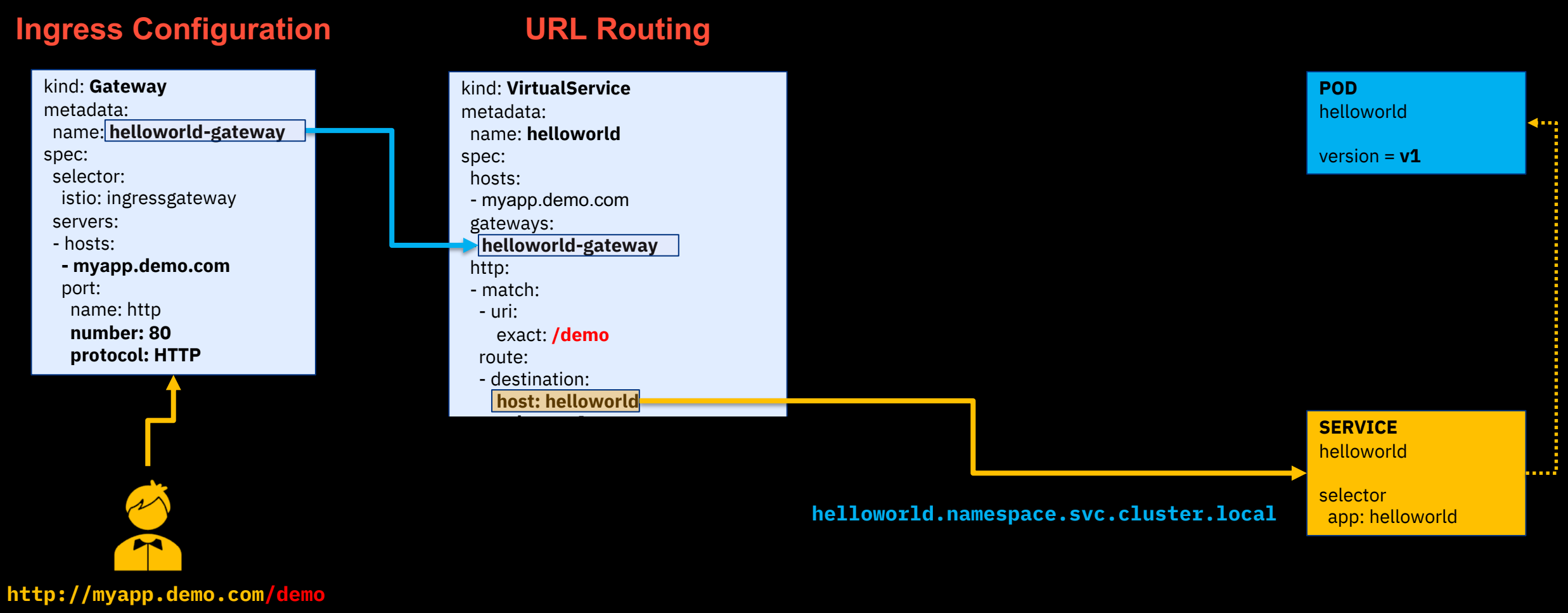
HTTP traffic policy
- Protocol-specific connection quality of service
- Attributes: **timeout**, **retries**, **fault**, **rewrite**, and **redirect**

Istio

```
kind: VirtualService
metadata:
  name: helloworld
spec:
  hosts:
  - myapp.demo.com
  gateways:
  - helloworld-gateway
  http:
  - match:
    - uri:
        exact: /demo
    route:
    - destination:
        host: helloworld
```

ISTIO

Custom resource definitions



ISTIO
Destination Rule

Istio

Destination host
- Host that route destinations can select
- Attribute: **host**

Host subset
- Identify a subset of service endpoints
- Attribute: **labels**

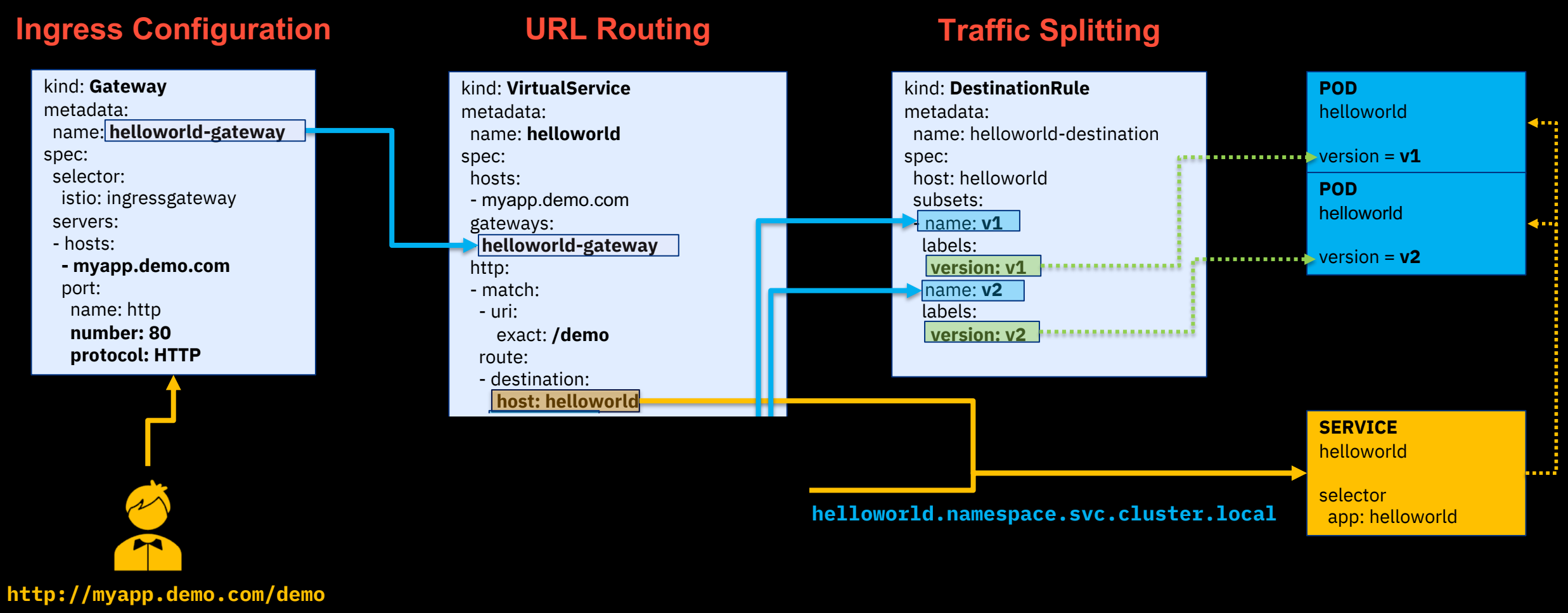
Traffic policy
- Influence expected quality of service for destinations
- Attributes: **trafficPolicy**
  loadBalancer,connectionPool, outlierDetection, and tls

Traffic policy can be applied to a port
- Attribute: **portLevelSettings**

```
kind: DestinationRule
metadata:
  name: helloworld-destination
spec:
  host: helloworld
  subsets:
  - name: v1
    labels:
      version: v1
  - name: v2
    labels:
      version: v2
  trafficPolicy:
    tls:
      mode: SIMPLE
    connectionPool:
      tcp:
        maxConnections: 100
```

ISTIO

Custom resource definitions



ISTIO
Virtual Service

Request sources
- Hosts that sources can invoke
- Attributes: **hosts** and **gateways**

Route destinations
- Subset of the destination
- Attributes: **route** and **destination**

Protocol selection
- How to connect to the destination subset
- Attributes: **http**, **tcp**, **tls**

Routing rules
- Additional routing attributes, applied for the route destinations
- Attributes: **weight** and **match**

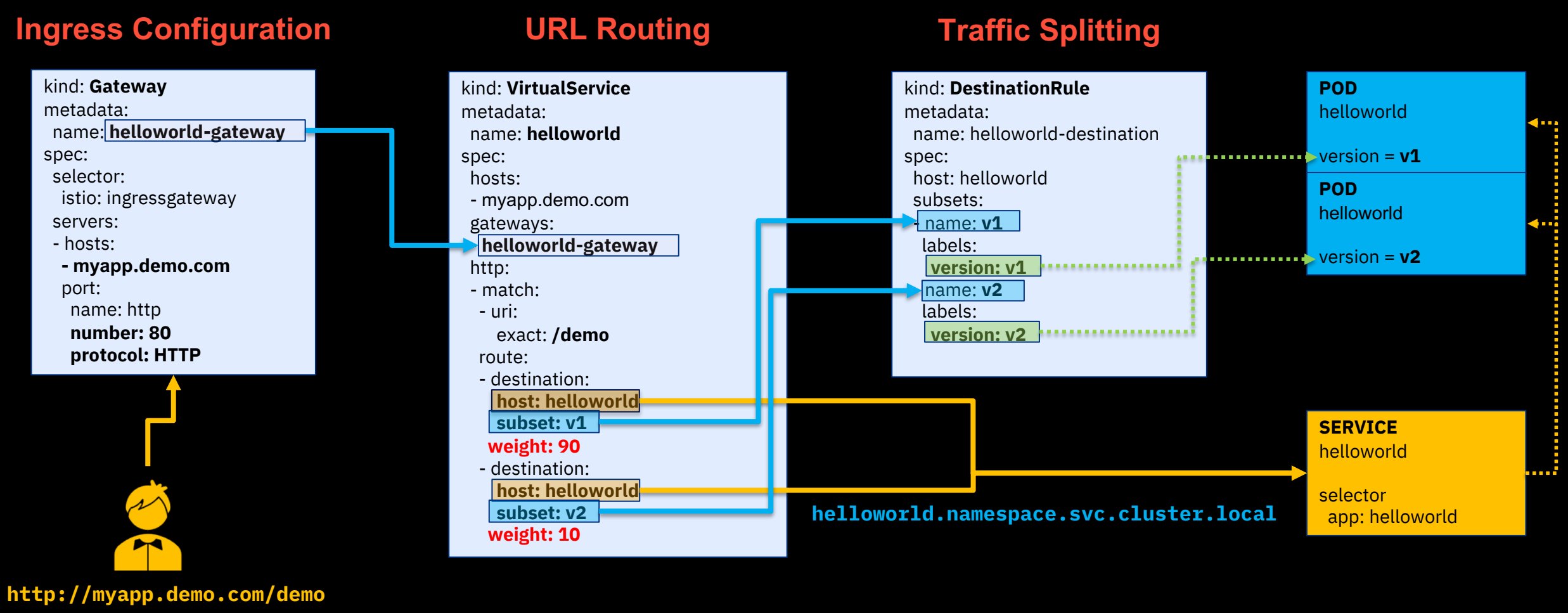
HTTP traffic policy
- Protocol-specific connection quality of service
- Attributes: **timeout**, **retries**, **fault**, **rewrite**, and **redirect**

Istio

```
kind: VirtualService
metadata:
  name: helloworld
spec:
  hosts:
  - myapp.demo.com
  gateways:
  - helloworld-gateway
  http:
  - match:
    - uri:
        exact: /demo
    route:
    - destination:
        host: helloworld
        subset: v1
      weight: 90
    - destination:
        host: helloworld
        subset: v2
      weight: 10
```

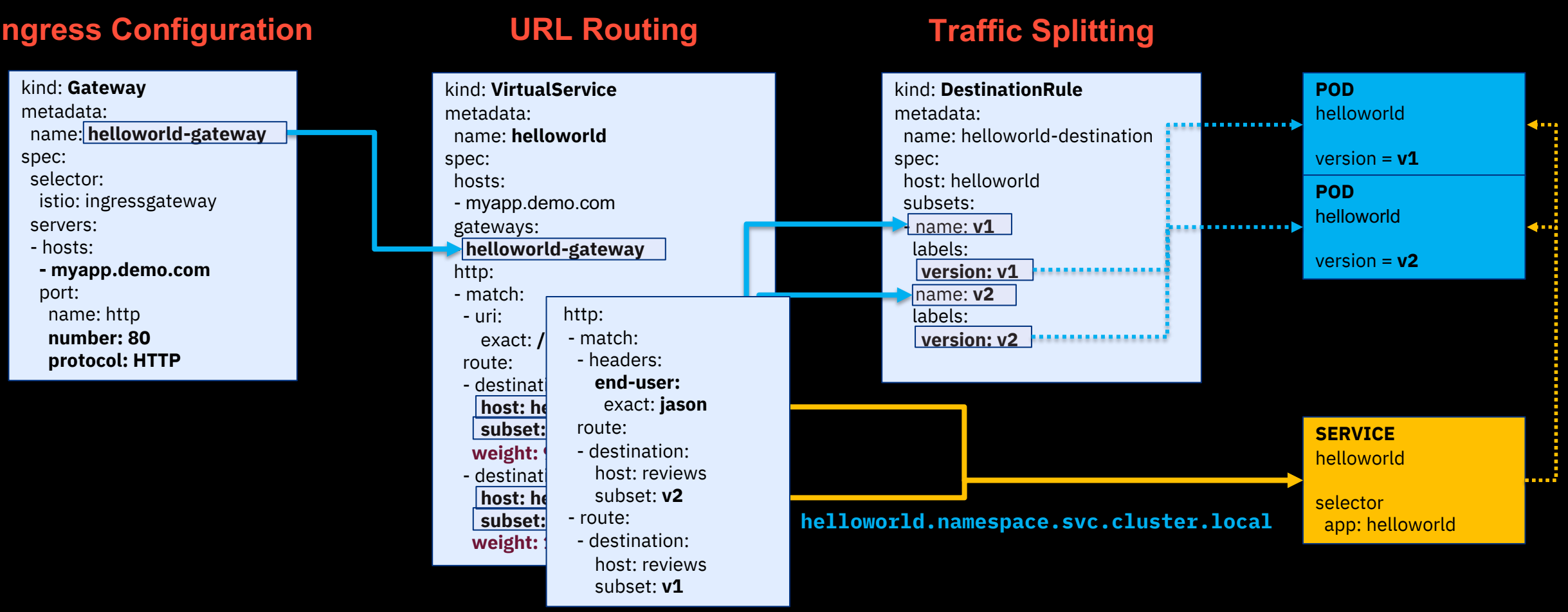
ISTIO

Custom resource definitions



ISTIO

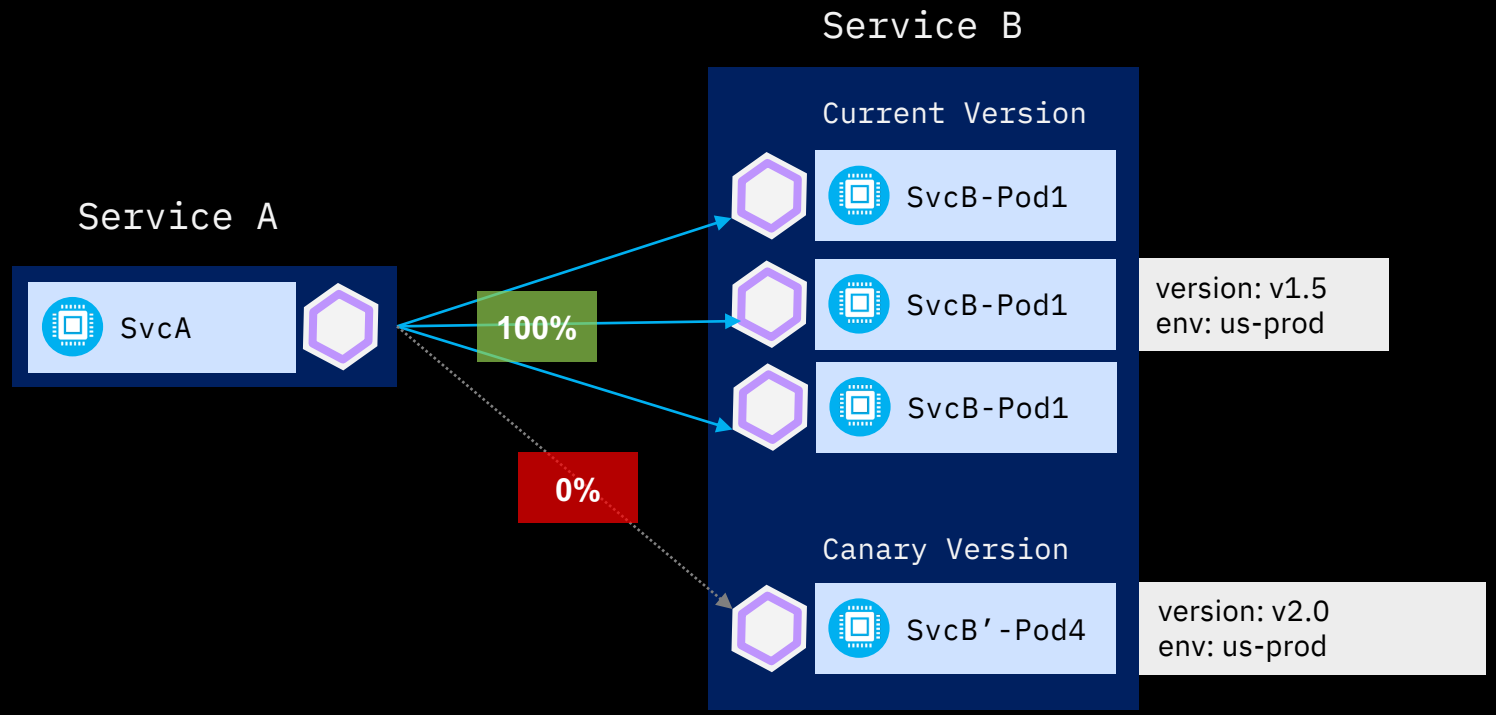
Custom resource definitions



Addressing DevOps Challenges

#	CHALLENGE	ISTIO SOLUTION
CHALLENGE 1	ROLL OUT NEW VERSION WITHOUT DOWNTIME OR CHANGING CODE	TRAFFIC CONTROL
CHALLENGE 2	HOW TO DO CANARY TESTING	TRAFFIC SPLITTING
CHALLENGE 3	HOW TO DO A/B TESTING	TRAFFIC STEERING
CHALLENGE 4	THINGS DON'T ALWAYS GO CORRECTLY IN PRODUCTION…	TRAFFIC MIRRORING RESILIENCY RESILIENCY TESTING
CHALLENGE5	HOW CAN I LIMIT RATE FOR SOME OF MY SERVICES?	RATE LIMITING
CHALLENGE 6	I NEED TO VIEW AND MONITOR WHAT IS GOING ON WHEN CRISIS ARISES	TELEMETRY
CHALLENGE 7	HOW CAN I SECURE MY SERVICES?	AUTHENTICATION AUTHORIZATION CALICO

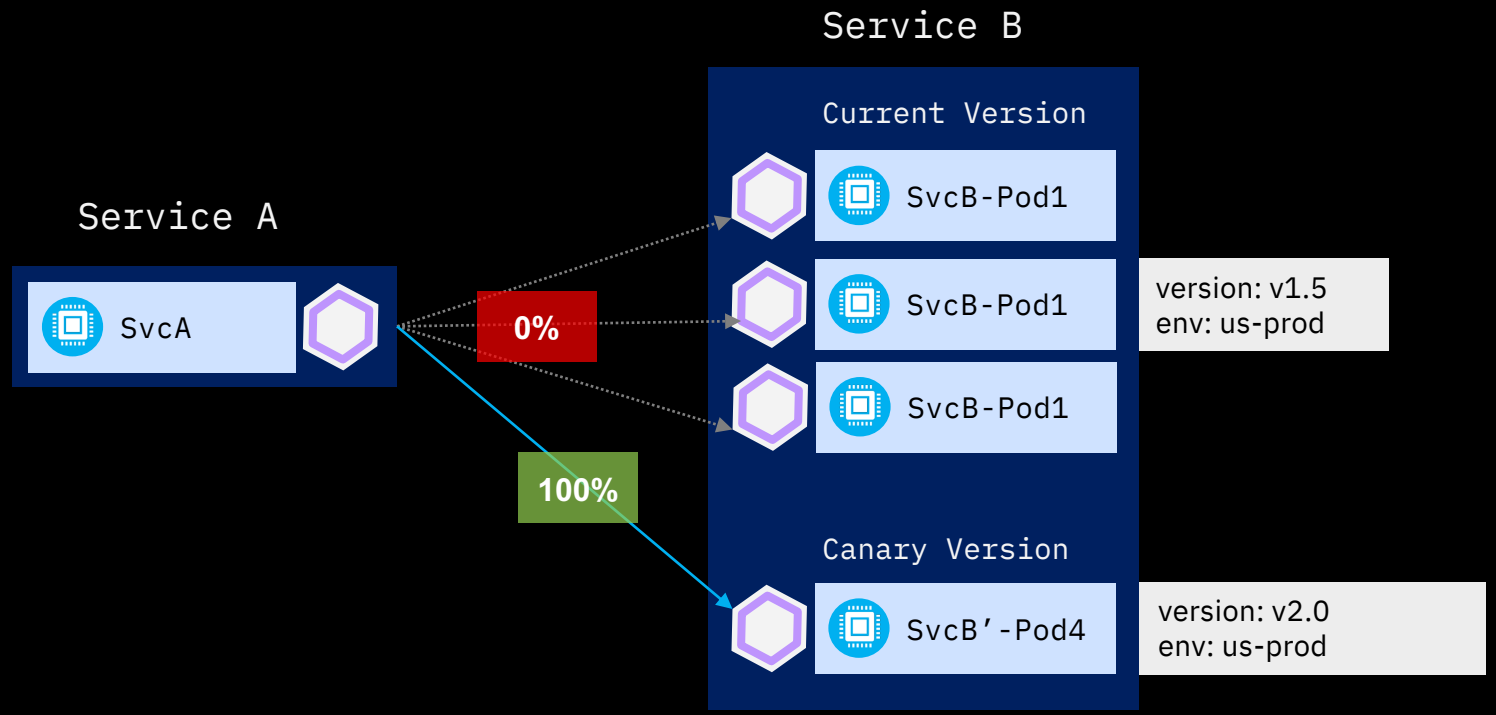
Traffic Control




```
kind: VirtualService
destination:
  serviceB.cluster.local
match:
  source:
    serviceA.cluster.local
route:
  - labels:
    version: v1.5
    env: us-prod
  weight: 100
```

CHALLENGE 1
ROLL OUT NEW VERSION WITHOUT DOWNTIME OR CHANGING CODE

Traffic Control

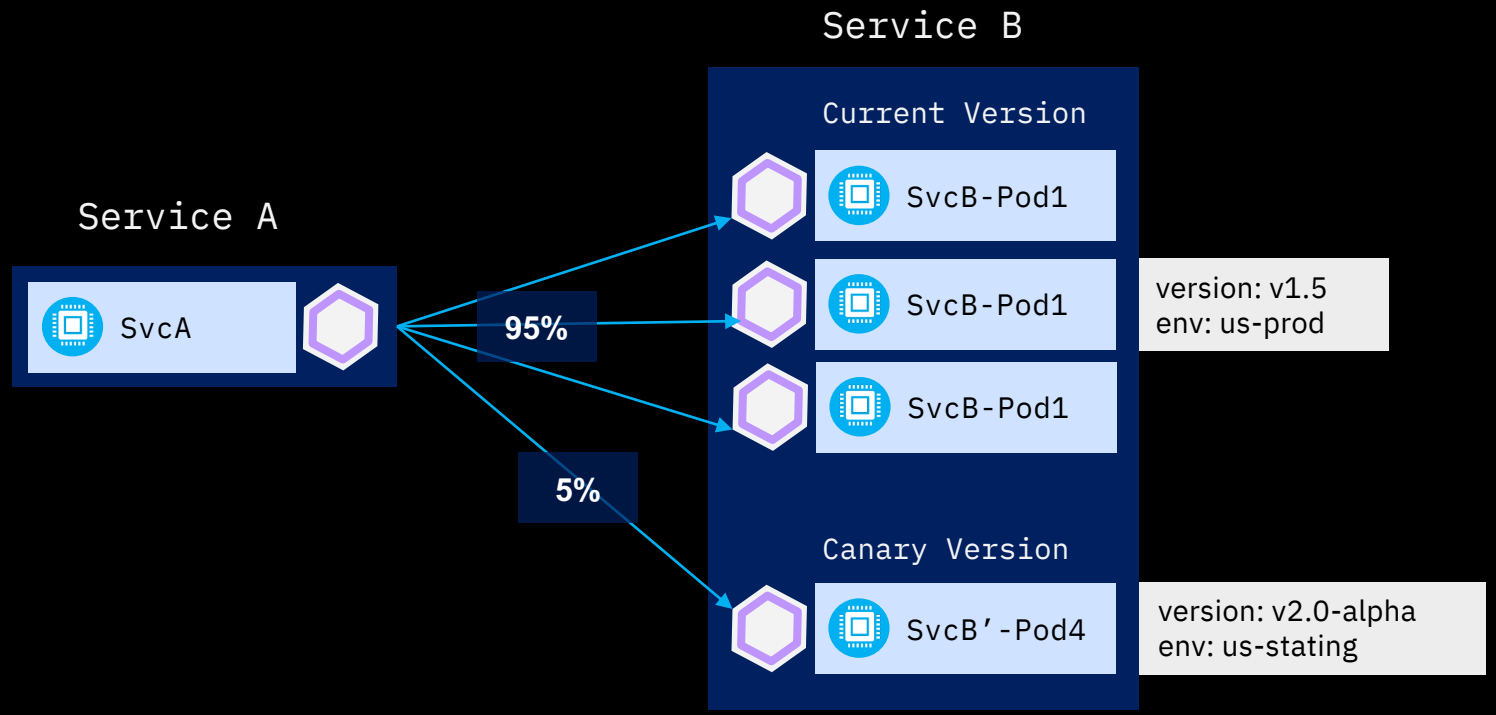



```
kind: VirtualService
destination:
  serviceB.cluster.local
match:
  source:
    serviceA.cluster.local
route:
  - labels:
    version: v2.0
    env: us-prod
  weight: 100
```

Update

CHALLENGE 1
ROLL OUT NEW VERSION WITHOUT DOWNTIME OR CHANGING CODE

Traffic Splitting

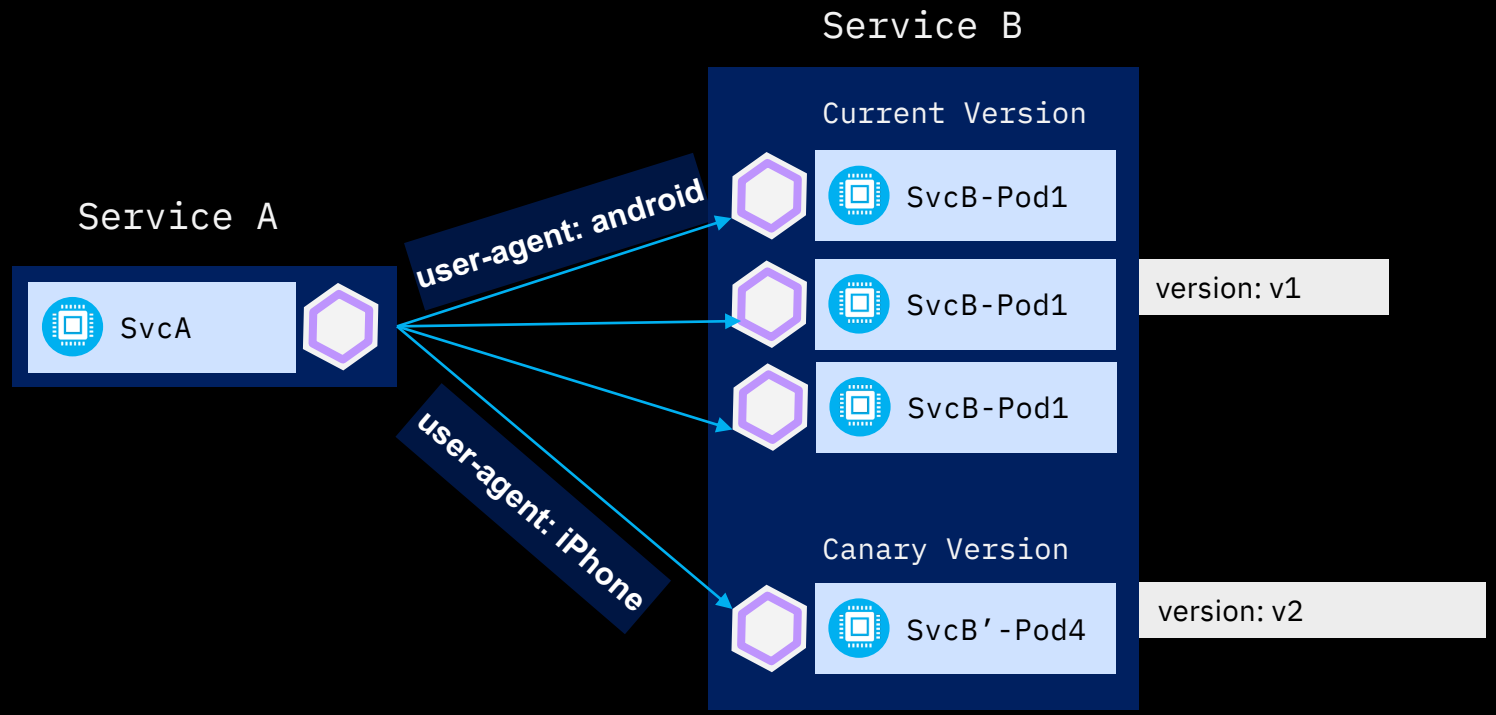



```
kind: VirtualService
destination:
  serviceB.cluster.local
match:
  source:
    serviceA.cluster.local
route:
  - labels:
    version: v1.5
    env: us-prod
  weight: 95
  - labels:
    version: v2.0-alpha
    env: us-staging
  weight: 5
```

CHALLENGE 2
HOW TO DO CANARY TESTING

Routing not based on the request content.
Staged rollouts with %-based traffic splits.

Traffic Steering

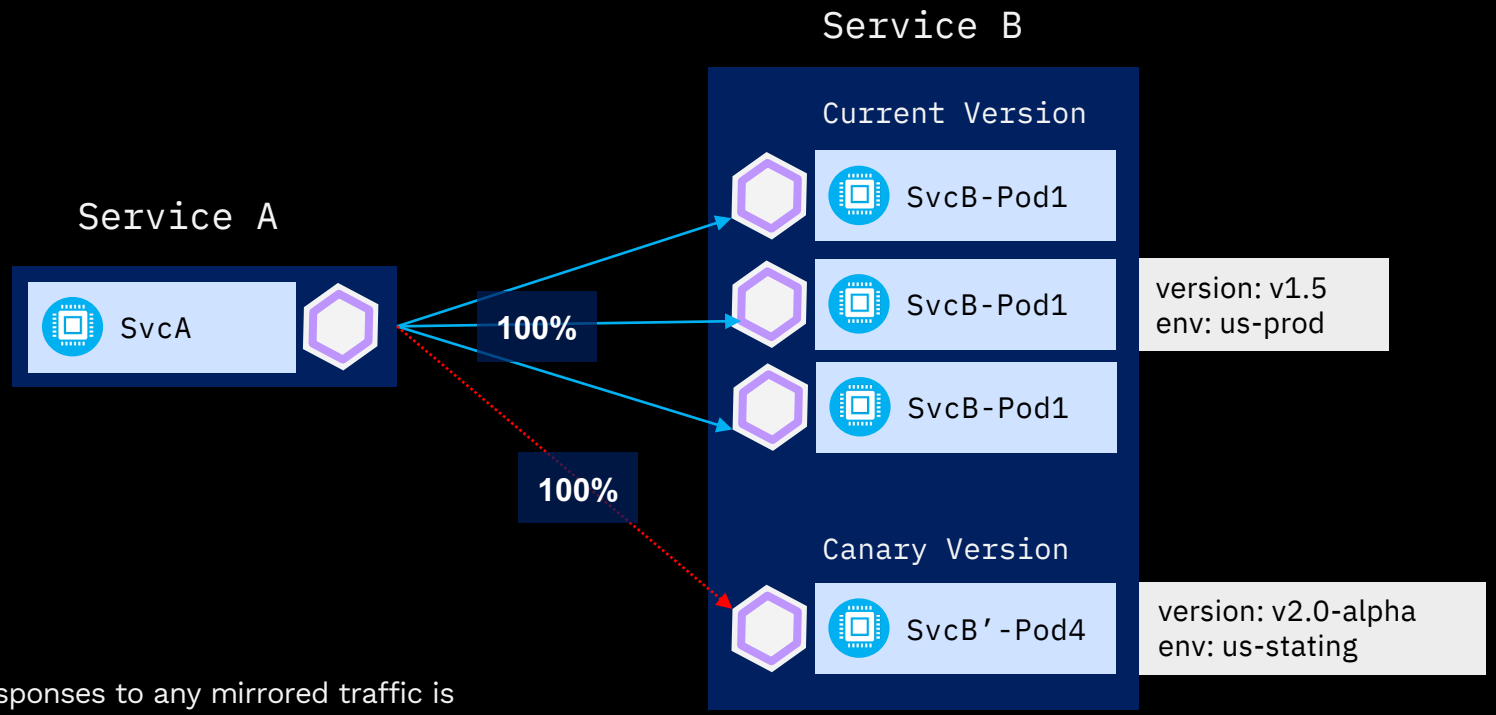



```
kind: VirtualService
destination:
 serviceB.cluster.local
match:
  httpHeaders:
    user-agent:
      regex:
        ^(.*?;)?(iPhone)(;.*)?$
 route:
- labels:
  version: v2
```

Routing based on the request content

CHALLENGE 3
HOW TO DO A/B TESTING

Traffic Mirroring



Responses to any mirrored traffic is ignored;
traffic is mirrored as "fire-and-forget"
You'll need to have the 0-weighted route to hint to Istio to create the proper Envoy

```
kind: VirtualService
destination:
  serviceB.cluster.local
match:
  source:
    serviceA.cluster.local
route:
  - labels:
    version: v1.5
    env: us-prod
  weight: 100
  - labels:
    version: v2.0-alpha
    env: us-staging
  weight: 0
  mirror:
    name: httpbin
    labels:
      version: v2.0-alpha
      env: us-staging
```

CHALLENGE 4
THINGS DON'T ALWAYS GO CORRECTLY IN PRODUCTION...

Resiliency

Istio adds fault tolerance to your application without any changes to code

```
// Circuit breakers
destination: serviceB.example.cluster.local
policy:
- labels:
    version: v1
  circuitBreaker:
    simpleCb:
      maxConnections: 100
      httpMaxRequests: 1000
      httpMaxRequestsPerConnection: 10
      httpConsecutiveErrors: 7
      sleepWindow: 15m
      httpDetectionInterval: 5m
```

Resilience features

- Timeouts
- Retries with timeout budget
- Circuit breakers
- Health checks
- AZ-aware load balancing w/ automatic failover
- Control connection pool size and request load

CHALLENGE 4
THINGS DON'T ALWAYS GO CORRECTLY IN PRODUCTION...

Resiliency
Circuit Breakers

Istio

Connection pool

- Limits connections for reviews to invoke ratings
- **Limited to 1 concurrent connection, 1 request per connection (One concurrent request total)**
  - While requests are using all of the connections in a pool, any new requests are rejected

Outlier detection

- **If there are 3 requests in 2 seconds, reviews will be ejected for 3 minutes**
  - Request 1 will take more than 2 seconds, blocking the connection during that time
  - Request 2 won't get a connection, which will generate the first error
  - Request 3 won't get a connection, which will generate the second error, causing ejection

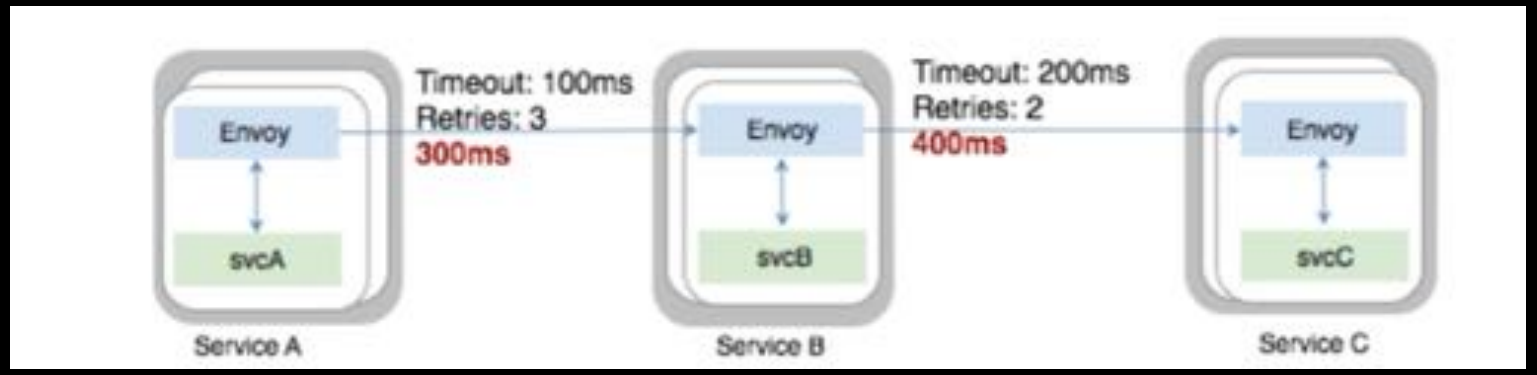
```
kind: DestinationRule
host: reviews
trafficPolicy:
  connectionPool:
    tcp:
      maxConnections: 1
    http:
      http1MaxPendingRequests: 1
      maxRequestsPerConnection: 1
  outlierDetection:
    consecutiveErrors: 2
    interval: 2s
    baseEjectionTime: 3m
    maxEjectionPercent: 100
```

CHALLENGE 4
THINGS DON'T ALWAYS GO CORRECTLY IN PRODUCTION...

Resiliency
Fault injection

Fault injection can be used for testing
- Faults are caused on a percentage of requests
- Faults can cause a request delay or failure

In this example, ratings is being invoked
- All of the requests from bar have a 2 second timeout
- 40% of the requests from bar also have a 5 second delay



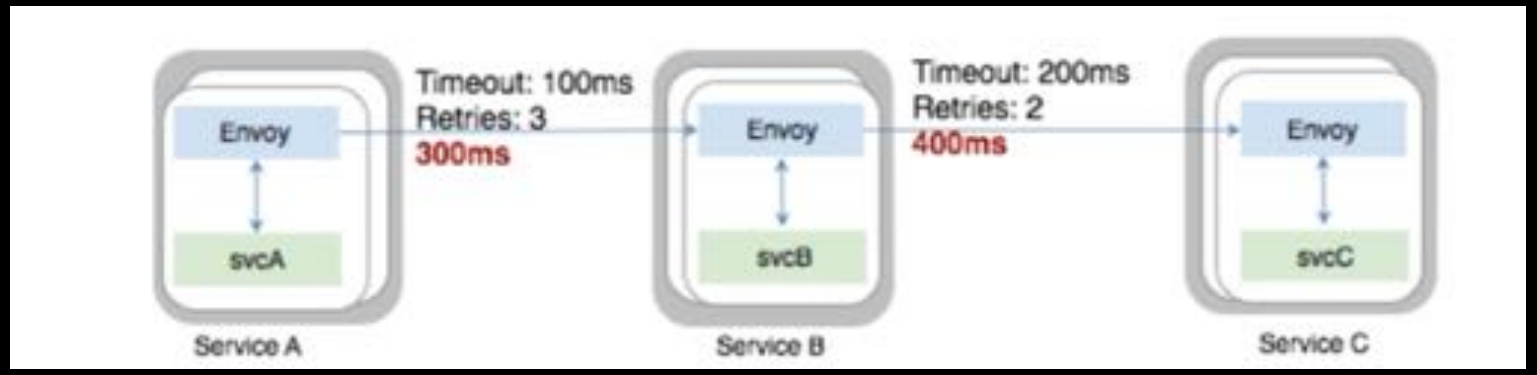

```
kind: VirtualService
hosts:
  - ratings
http:
- match:
  - headers:
      end-user:
        exact: bar
  fault:
    delay:
      percent: 40
      fixedDelay: 5s
  timeout: 2s
  route:
  - destination:
      host: ratings
```

CHALLENGE 4
HOW DO I INJECT FAULT TO MY MICROSERVICES TO PREPARE MYSELF?

Resiliency
Fault injection

Fault injection can be used for testing
- Faults are caused on a percentage of requests
- Faults can cause a request delay or failure

In this example, ratings is being invoked
- 20% of the requests from foo get an HTTP 500 error
- All other requests (not foo or bar) have a 4 second timeout




```
kind: VirtualService
hosts:
  - ratings
http:
- match:
  - headers:
      end-user:
        exact: foo
  fault:
    abort:
      percent: 20
      httpStatus: 500
  route:
  - destination:
      host: ratings
- route:
  - destination:
      host: ratings
  timeout: 4s
```

Timeout is measured after the host is invoked, it is calculated after delay period has passed.

The 40% of requests from bar will time out after 7 seconds (5 sec delay + 2 sec timeout)

CHALLENGE 4
HOW DO I INJECT FAULT TO MY MICROSERVICES TO PREPARE MYSELF?

Rate limiting

Istio protects your application from rogue actors by imposing ratelimits

```
Quotas:
- name: requestcount.quota.istio-system
  maxAmount: 5000
  validDuration: 1s
  overrides:
  - dimensions:
      destination: ratings
      source: reviews
      sourceVersion: v3
    maxAmount: 1
    validDuration: 1s
  - dimensions:
      destination: ratings
    maxAmount: 100
    validDuration: 1s
```

Rate limit

- Configurable limits with overrides
- Multiple rate limiting backends
- Conditional rate limiting

CHALLENGE 5
HOW CAN I LIMIT RATE FOR SOME OF MY SERVICES?

Rate limiting

Every distinct rate limit configuration represents a counter.
If the number of requests in the last validDuration duration exceed maxAmount, Mixer returns a RESOURCE_EXHAUSTED message to the proxy.

Global rate limit of 500 calls per second.

If “reviews” is called, it’s limited to one call every 5 seconds.

If “reviews” is called from 10.28.11.20, it’s limited to 99 calls per seconds.

```
kind: handler
quotas:
- name: requestcountquota.instance.istio-system
  maxAmount: 500
  validDuration: 1s

  overrides:

  - dimensions:
      destination: reviews
    maxAmount: 1
    validDuration: 5s

  - dimensions:
      destination: productpage
      source: "10.28.11.20"
    maxAmount: 99
    validDuration: 1s
```

CHALLENGE 5
HOW CAN I LIMIT RATE FOR SOME OF MY SERVICES?

Telemetry

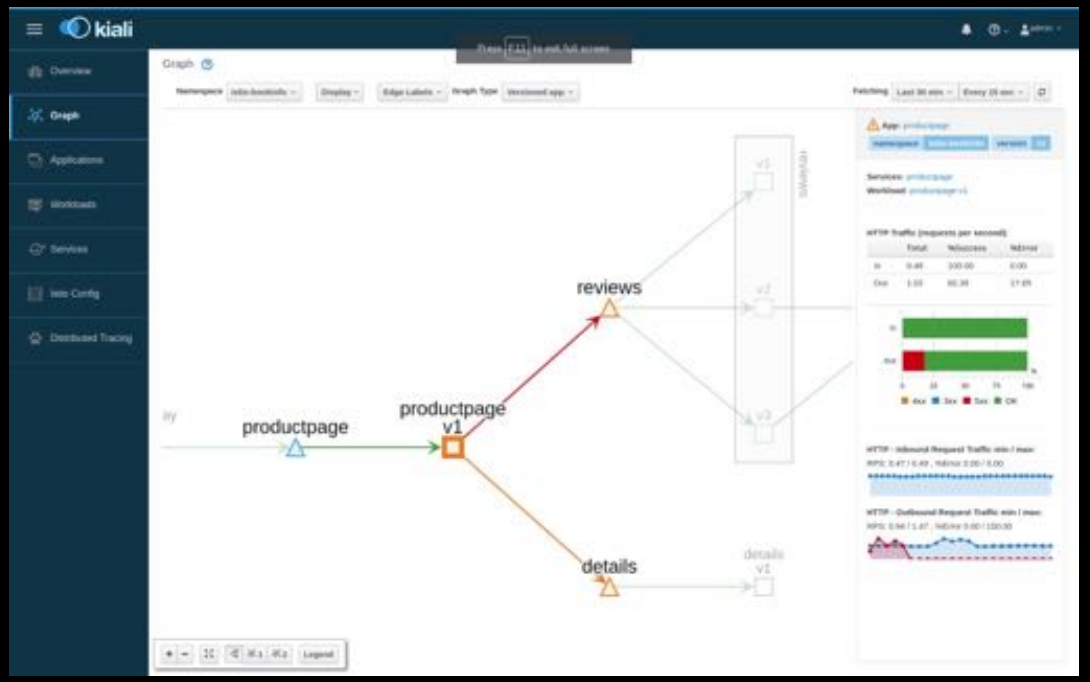
- Monitoring & tracing should not be an afterthought in the infrastructure

- Goals
  - Metrics without instrumenting apps
  - Consistent metrics across fleet
  - Trace flow of requests across services
  - Portable across metric backend providers

CHALLENGE 6
I NEED TO VIEW WHAT IS GOING ON WHEN CRISIS ARISES

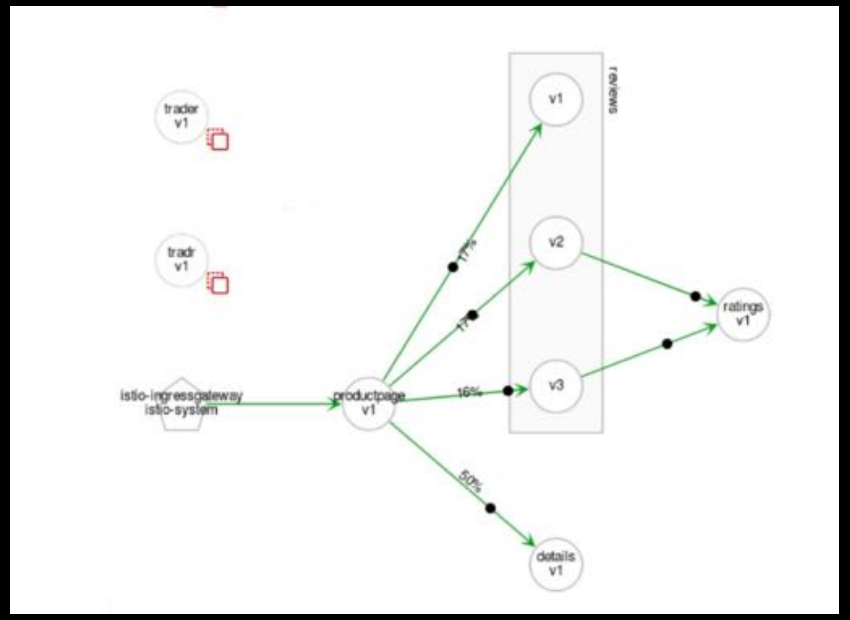
Kiali

Kiali (greek κιάλι)
monocular or *spyglass*
Visualise the service mesh topology, features like circuit breakers or request rates



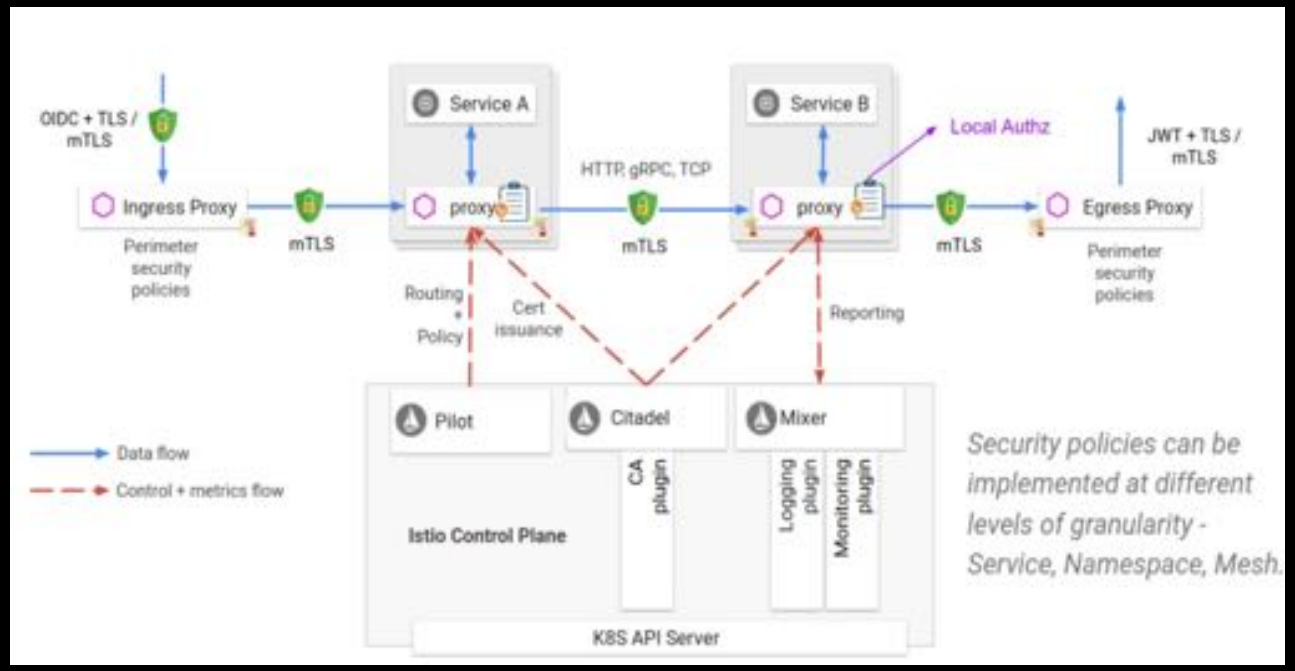
Features

- **Graph**
  - Health
  - Types
  - Side Panel
  - Traffic Animation
- **Applications, Workloads and Services**
  - Detailed Metrics
- **Traffic Routing**
- **Istio compliance**
- **Istio Configuration**



CHALLENGE 6
I NEED TO VIEW WHAT IS GOING ON WHEN CRISIS ARISES

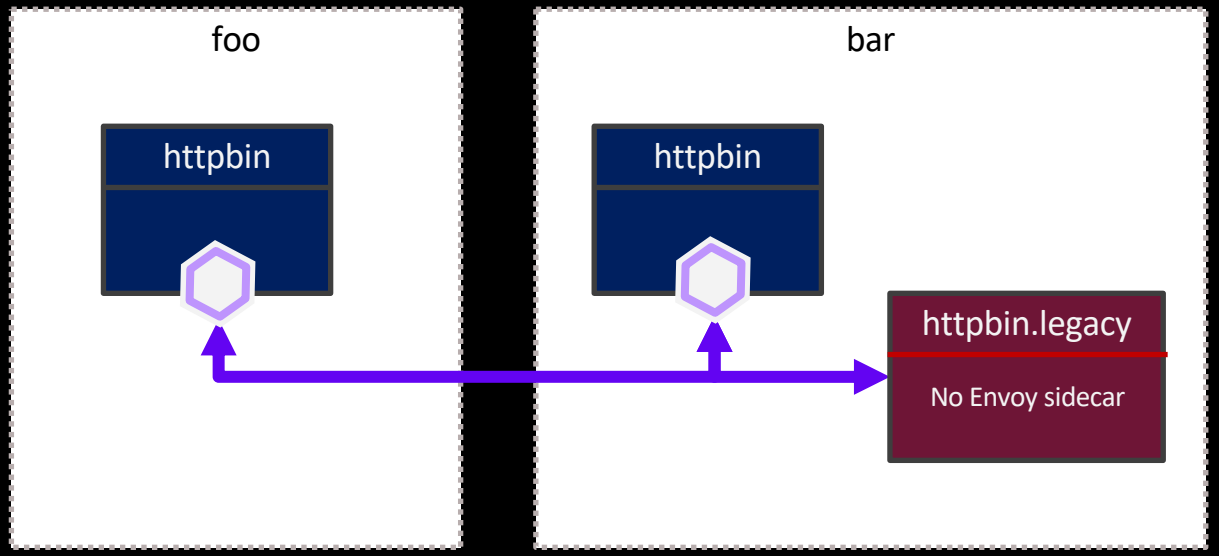
Security



- **Authentication**
  - Transport authentication, also known as service-to-service authentication
  - Origin authentication, also known as end-user authentication
- **Authorization**
  - Based on RBAC
  - Namespace-level, service-level and method-level access control for services

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Security - Authentication

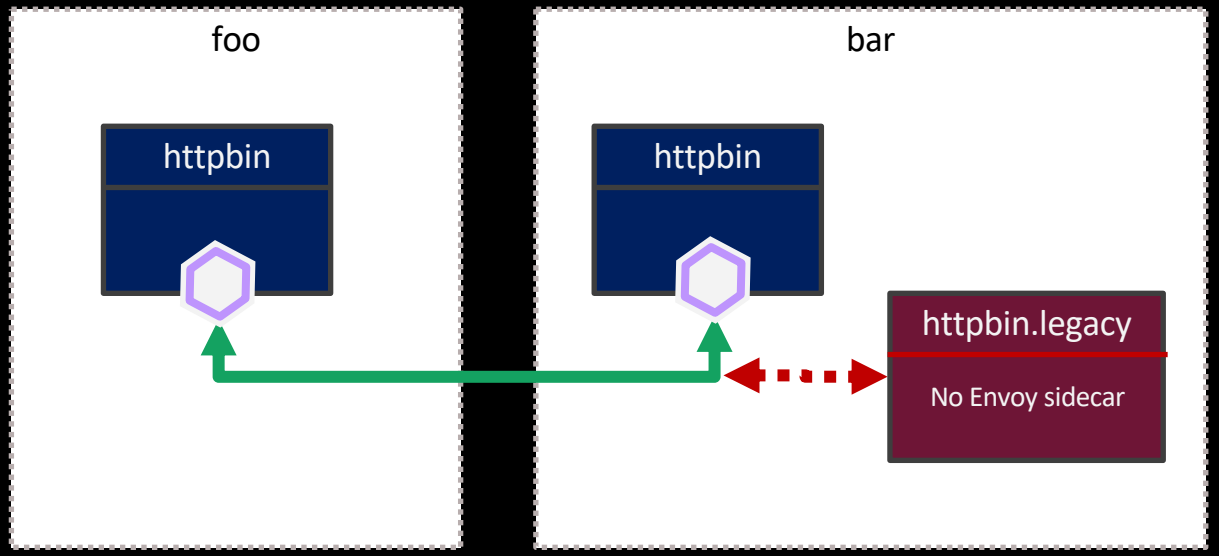


EXAMPLE

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Not encrypted
Encrypted (TLS)
No communication

Security - Authentication

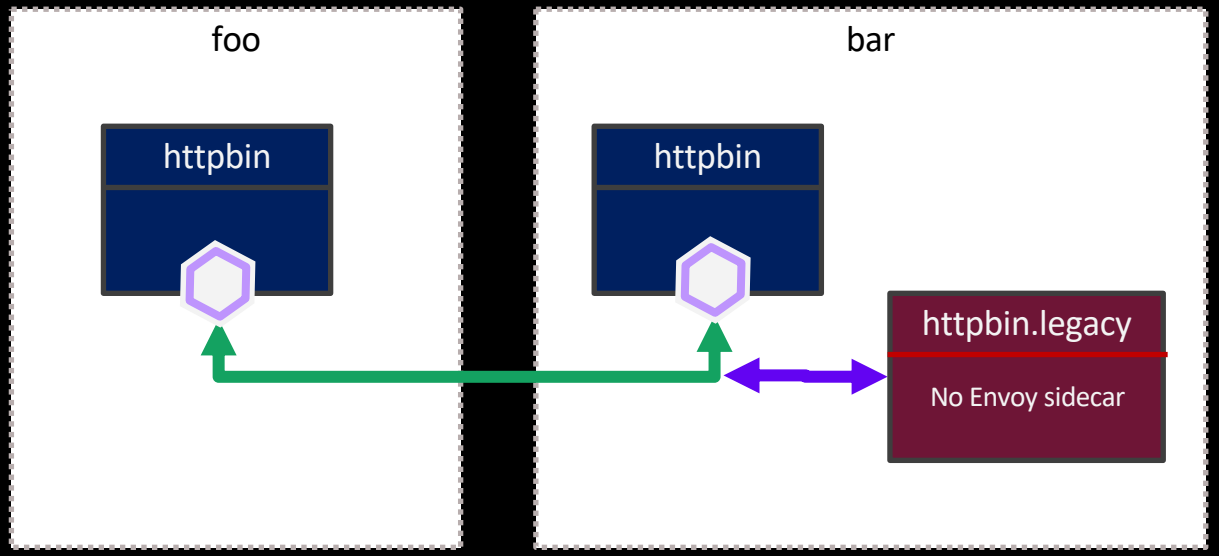



```
kind: DestinationRule
metadata:
  name: "default"
spec:
  host: "*.local"
  trafficPolicy:
    tls:
      mode: ISTIO_MUTUAL
```

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Not encrypted
Encrypted (TLS)
No communication

Security - Authentication




```
kind: DestinationRule
metadata:
 name: "httpbin-legacy"
spec:
 host: "httpbin.legacy.svc.cluster.local"
 trafficPolicy:
   tls:
     mode: DISABLE
```

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Not encrypted
Encrypted (TLS)
No communication

Security - Authorization

Istio Role Based Access

- **OFF**: Istio authorization is disabled.
- **ON**: enabled for all services in the mesh.
- **ON_WITH_INCLUSION**: enabled for all services specified in the inclusion field.
- **ON_WITH_EXCLUSION**: enabled for all services except the ones in the exclusion field.

```
kind: RbacConfig
metadata:
  name: my-user
spec:
  mode: 'ON_WITH_INCLUSION'
  inclusion:
    services:
    - "webapp.default.svc.cluster.local"
    - "frontend.default.svc.cluster.local"
    - "feedback.default.svc.cluster.local"
```

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Security - Authorization

Istio Role Based Access

- **services**: A list of service names.
- **methods**: A list of HTTP method names (GET, POST,…)
- **paths**: HTTP paths (in the form of /packageName.serviceName/methodName)
- **constraints**: additional conditions for your rules.

```
kind: ServiceRole
metadata:
  name: service-viewer
spec:
  rules:
  - services:
    - "webapp.default.svc.cluster.local"
    - "frontend.default.svc.cluster.local"
    methods: ["GET", "HEAD"]
    paths: ["*"]
    constraints:
    - key: request.headers[version]
      values: ["v1", "v2"]
```

CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

Security - Authorization

Access for:

- Service in **Namespace “default” only accessible by authenticated users** and services
- User: "*" assigns the ServiceRole to all (both authenticated and unauthenticated)

```
kind: ServiceRoleBinding
metadata:
  name: binding-products-all-authenticated-users
spec:
  subjects:
  - properties:
      source.principal: "*"
  - properties:
      source.namespace: "default”
  roleRef:
    kind: ServiceRole
    name: ”service-viewer"
```

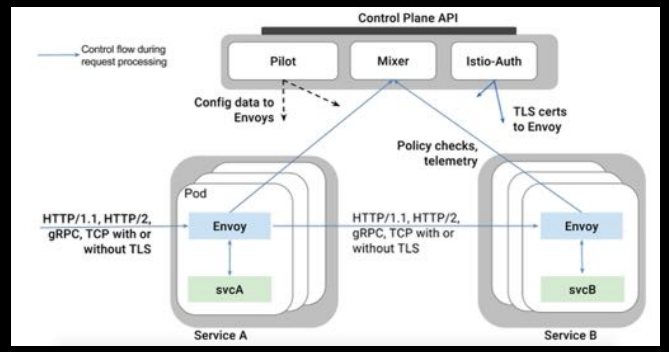
CHALLENGE 7
HOW CAN I SECURE MY SERVICES?

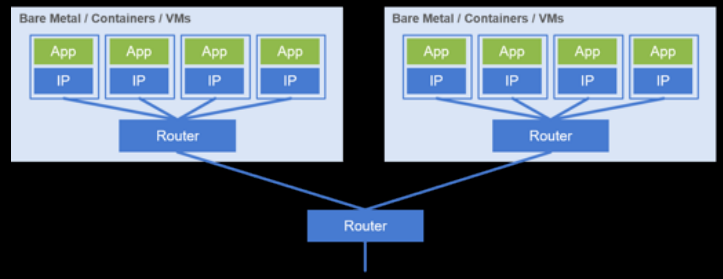
Security
Using Istio in concert with Calico

Istio

PROJECT CALICO

“RPC” — L7	Layer	“Network” — L3-4
Userspace	Implementation	Kernel
Pod	Enforcement Point	Node

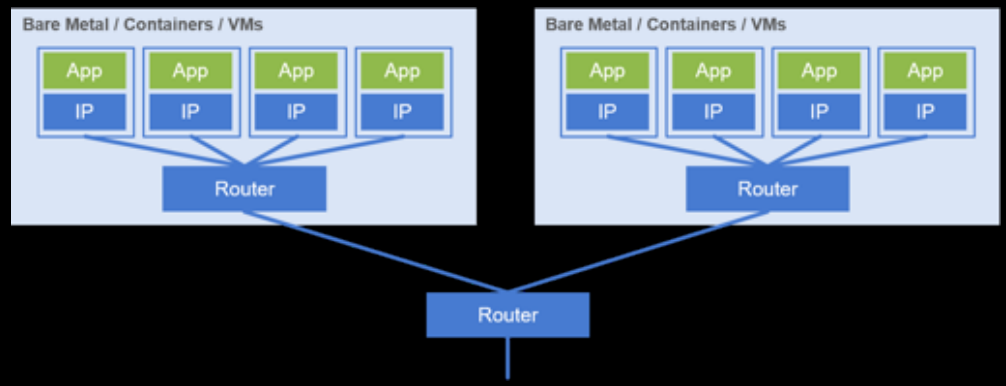




Security
Using Istio in concert with Calico

Operates at **Layer 3**, which is the network layer

- Has the advantage of being **universal** (DNS, SQL, real-time streaming, ...)
- Can extend beyond the service mesh (including to **bare metal or VM** endpoints not under the control of Kubernetes).
- Calico's policy is enforced at the host node, outside the network namespace of the guest pods.
- Based on **iptables**, which are packet filters implemented in the standard Linux kernel, it is extremely fast.



Security
Using Istio in concert with Calico

“RPC” — L7	Layer	“Network” — L3-4
Userspace	Implementation	Kernel
Pod	Enforcement Point	Node
Ideal for applying policy in support of operational goals, like service routing, retries, circuit-breaking, etc	Strengths	Universal, highly efficient, and isolated from the pods, making it ideal for applying policy in support of security goals

Service Mesh - Bad Idea ?

A Service Mesh is not always the right solution…

- **Service Meshes are Opinionated**
  They are a *platform* solution. “Work their way”
- **Service Meshes are Complex**
  Adds considerable complexity with sidecars and control plane
- **Service Meshes can be Slow**
  Routing traffic through a series of proxies can get painfully slow (about 700 nodes → reflector)
- **Service Meshes are for Developers**
  Focused primarily on Developer view.

https://glasnostic.com/blog/comparing-service-meshes-linkerd-vs-istio

QUESTIONS?

Sources and documentation will be available here:

Online Course
https://niklaushirt.github.io/k8s_training_web/

Course Documents
https://github.com/niklaushirt/k8s_training_public

Course Files
https://github.com/niklaushirt/training

Do you want to go further?

Online Course
https://niklaushirt.github.io/k8s_training_web/

Course Videos – Kubernetes: from zero to hero
https://www.youtube.com/channel/UCIS0jmGOQrG2AKKPkTJYj9w/videos

THANK YOU!!!!

Niklaus Hirt


nikh@ch.ibm.com


@nhirt

Kubernetes Workshop Series

Kubernetes - *Hands-On*

07

Starting Course JTC02 Kubernetes

Select JTC02 course to begin

JTC02 Labs

Lab 1: Refresher/overview over Kubernetes.

Lab 2: Running your first Pod on Kubernetes.

Lab 3: Deploy a Web Application

Lab 4: Scale an application on Kubernetes

Lab 5: Basics of persisting data in Kubernetes

READY SET GO!!!!

Duration: 60 mins

QUESTIONS?

Sources and documentation will be available here:

Online Course
https://niklaushirt.github.io/k8s_training_web/

Course Documents
https://github.com/niklaushirt/k8s_training_public

Course Files
https://github.com/niklaushirt/training

Do you want to go further?

Online Course
https://niklaushirt.github.io/k8s_training_web/

Course Videos – Kubernetes: from zero to hero
https://www.youtube.com/channel/UCIS0jmGOQrG2AKKPkTJYj9w/videos

THANK YOU!!!!

Niklaus Hirt


nikh@ch.ibm.com


@nhirt

ANNEX

If time permits

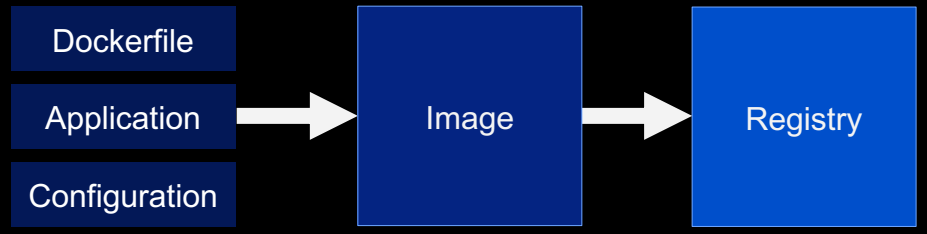
Kubernetes Workshop Series

Kubernetes - *Applied*

08

..but how do I use this for real?

Minimal Application – Container Image




```
FROM node:8-stretch

# Change working directory
WORKDIR "/app"

# Update packages and install dependency packages for services
RUN apt-get update \
&& apt-get dist-upgrade -y \
&& apt-get clean \
&& echo 'Finished installing dependencies'

# Install npm production packages
COPY package.json /app/
RUN cd /app; npm install --production

COPY . /app

ENV NODE_ENV production
ENV BACKEND_URL
https://api.nasa.gov/planetary/apod\?api_key\=DEMO_KEY
ENV PORT 3000

EXPOSE 3000

CMD ["npm", "start"]
```

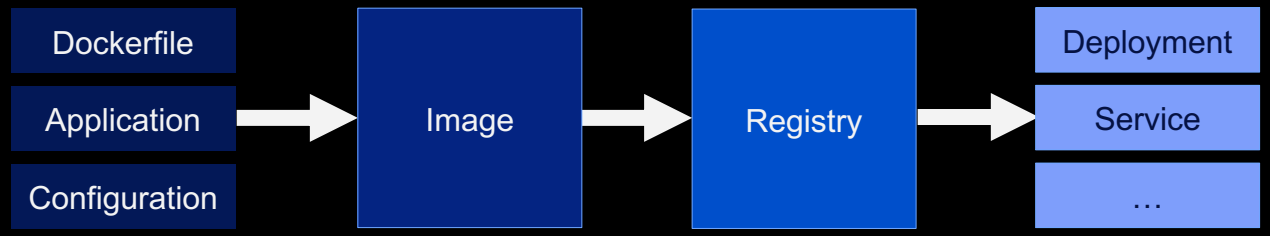
Minimum components you need:

- Built Application or source
  (NodeJS, Java, Golang, ...)
- Dockerfile

  → Use the right base image for your app

```
docker build –t niklaushirt/k8s-demo:1.0 .
docker push niklaushirt/k8s-demo:1.0
```

Minimal Application – Kubernetes Manifests

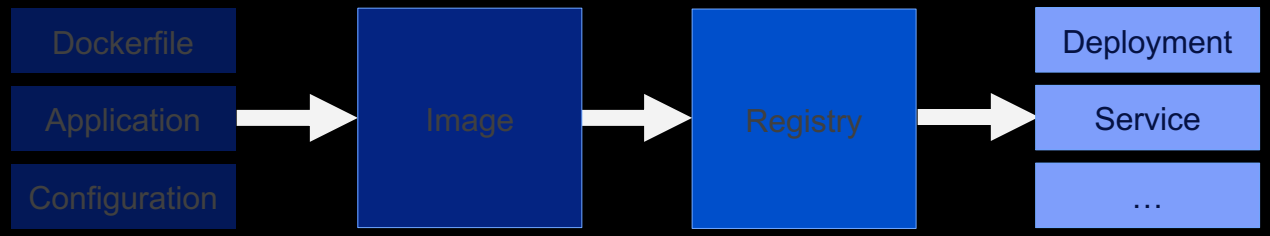



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service

Minimal Application – Kubernetes Manifests

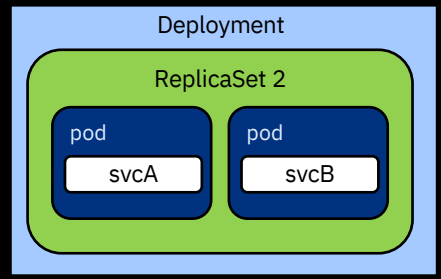


Deployment

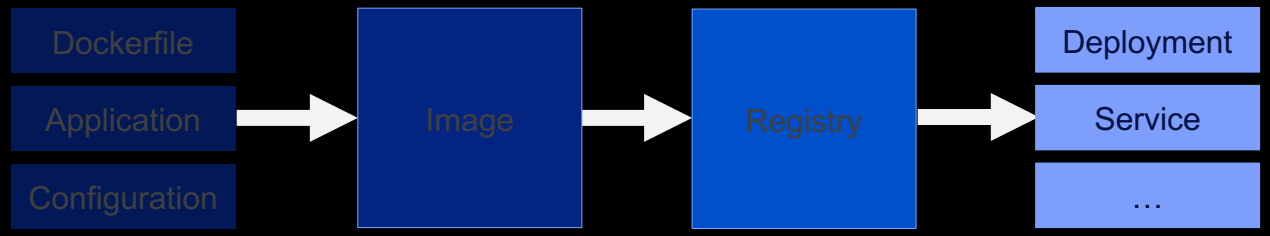
```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests



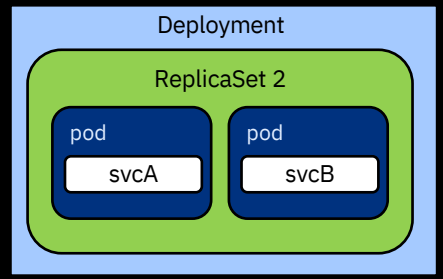
Deployment

ReplicaSet

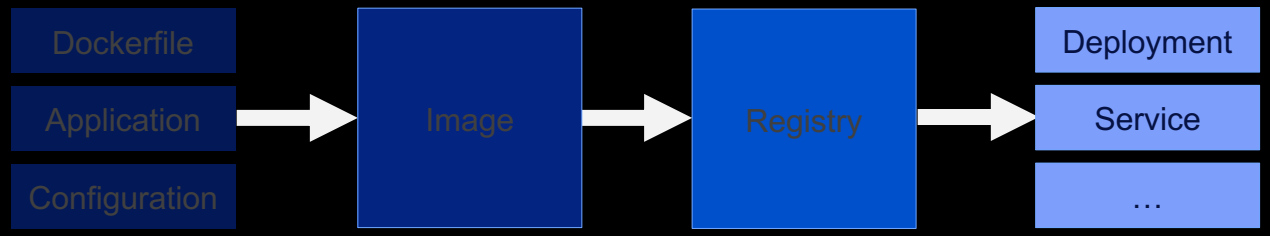
```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests



Deployment

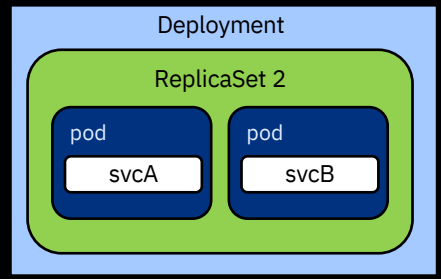
ReplicaSet

Pod

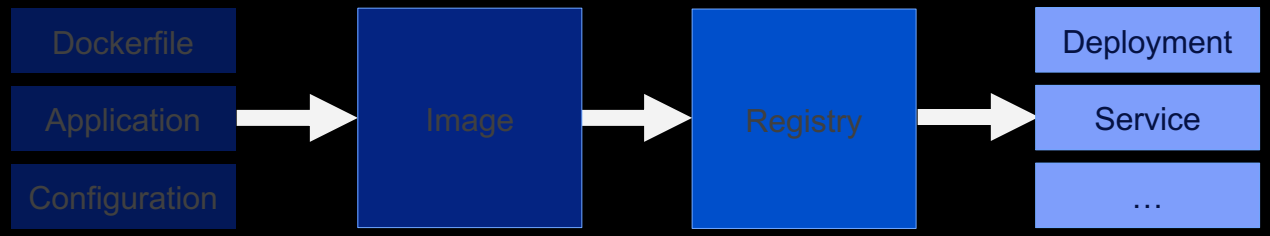
```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests



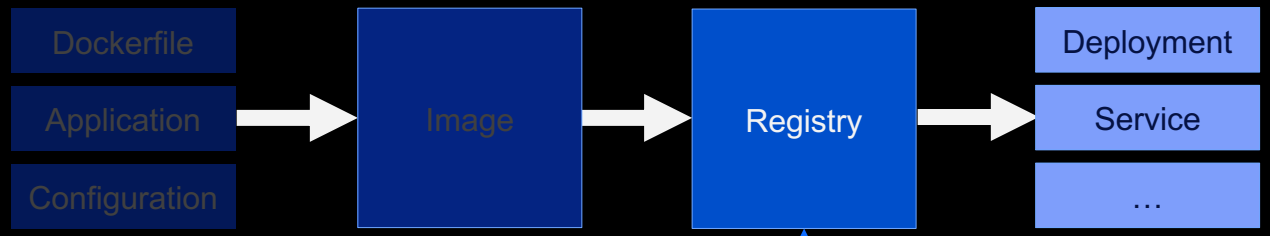

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service

Selectors must use the label of the deployment!!

Minimal Application – Kubernetes Manifests




```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

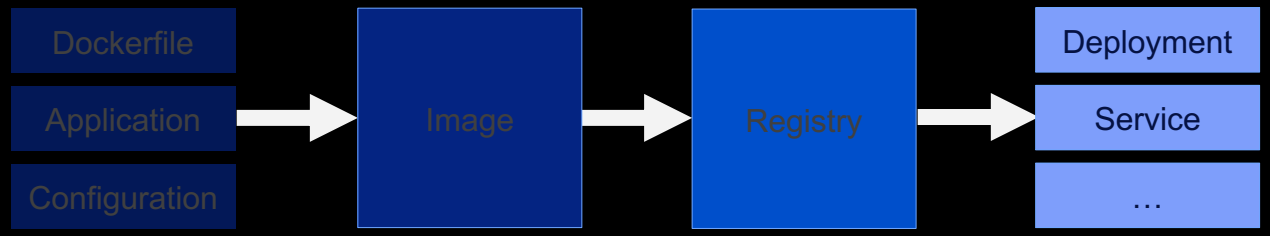
Minimum components you need:

- Deployment
- Service

imagePullPolicy:

IfNotPresent: only pulled if not already present locally
Always: every time the kubelet launches a container

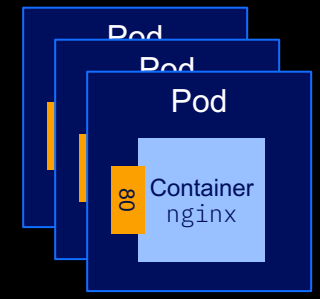
Minimal Application – Kubernetes Manifests



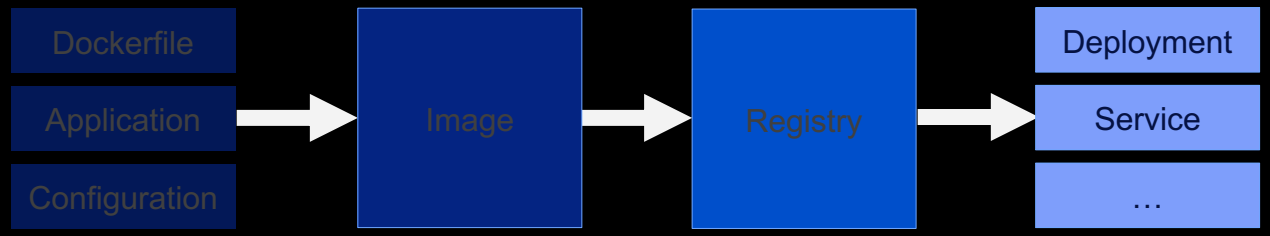

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests

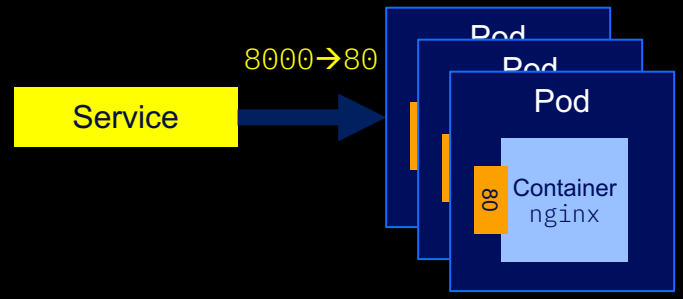



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

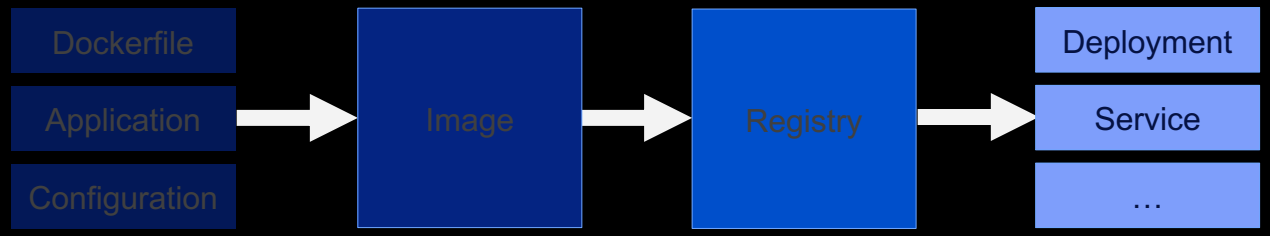
```yaml
apiVersion: v1
kind: Service
metadata:
  name: k8s-demo-service
spec:
  ports:
  - port: 8000
    targetPort: 80
    protocol: TCP
  selector:
    app: k8s-demo
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests

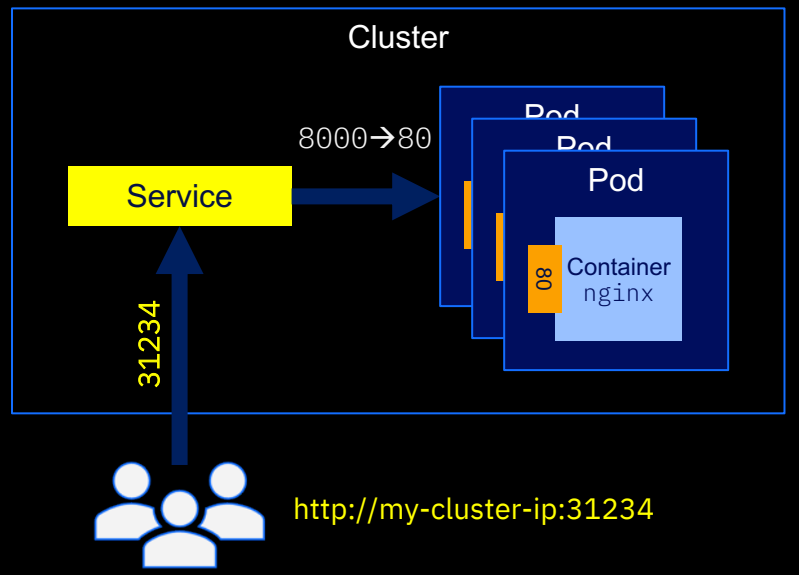



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        imagePullPolicy: Always
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

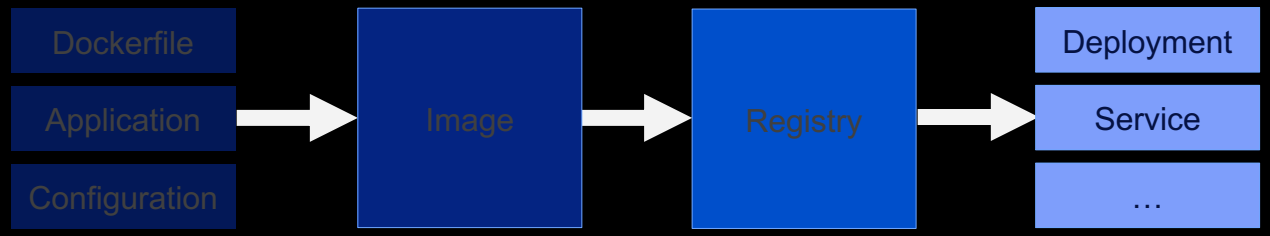
```yaml
apiVersion: v1
kind: Service
metadata:
  name: k8s-demo-service
spec:
  type: NodePort
  ports:
  - port: 8000
    targetPort: 80
    nodePort: 31234
    protocol: TCP
  selector:
    app: k8s-demo
```

Minimum components you need:

- Deployment
- Service



Minimal Application – Kubernetes Manifests

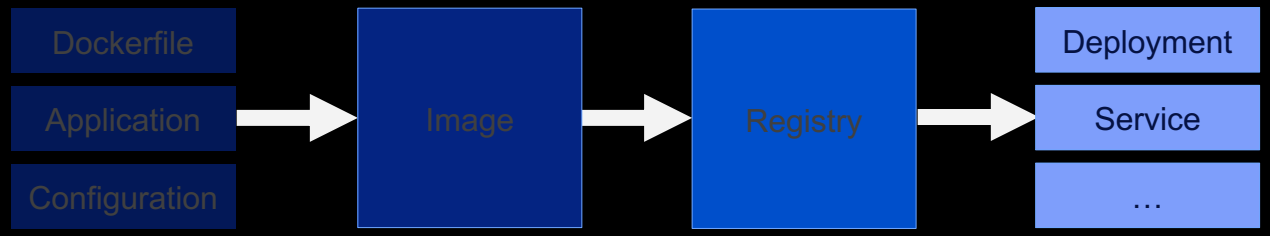



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
…
spec:
…
template:
…
  resources:
    requests:
      memory: 60Mi
      cpu: 10m
    limits:
      memory: 500Mi
      cpu: 100m
```

Minimum components you need:

- Deployment
- Service

Minimal Application – Kubernetes Manifests

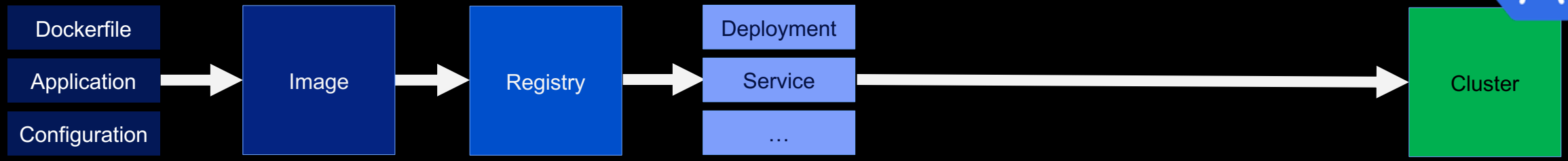



```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
…
spec:
…
template:
…
  env:
    - name: PORT
      value : "3000"
    - name: APPLICATION_NAME
      value: k8sdemo
    - name: BACKEND_URL
      value: http
```

Minimum components you need:

- Deployment
- Service

Minimal Application – Kubernetes Manifests




```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: k8s-demo-service
spec:
  ports:
  - port: 8000
    targetPort: 80
    protocol: TCP
  selector:
    app: k8s-demo
```

Minimum components you need:

- Deployment
- Service

```
kubectl apply -f deployoment.yaml
kubectl apply -f service.yaml
```

Minimal Application – Helm


```yaml
apiVersion: v1
name: k8s-demo
description: Demo App for the training.
keywords:
  - Training
maintainers:
  - name: Niklaus Hirt

version: 1.10.0
appVersion: 19.0.0.6

home: https://github.com/niklaushirt
icon: https://github.com/niklaushirt/logo-01.png
sources:
  - https://github.com/niklaushirt/charts/tree/master/stable
```

Minimum components we need:

Chart.yaml

Basic information about the chart

Templates (yaml)

Kubernetes deployment manifests (yaml) with placeholders for external parameters

values.yaml

A set of variables that will be passed on at deploy time to the deployment manifest templates

Minimal Application – Helm


```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: {{ .Values.replicas }}
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: {{ .Values.image.name }}:{{ .Values.image.tag }}
        ports:
        - containerPort: 80
```

Minimum components we need:

Chart.yaml

Basic information about the chart

Templates (yaml)

Kubernetes deployment manifests (yaml) with placeholders for external parameters

values.yaml

A set of variables that will be passed on at deploy time to the deployment manifest templates

Minimal Application – Helm


```yaml
apiVersion: v1
image:
  name:
    - niklaushirt/k8s-demo
  tag: 1.0
  pullPolicy: IfNotPresent
replicas: 1
```

Minimum components we need:

Chart.yaml

Basic information about the chart

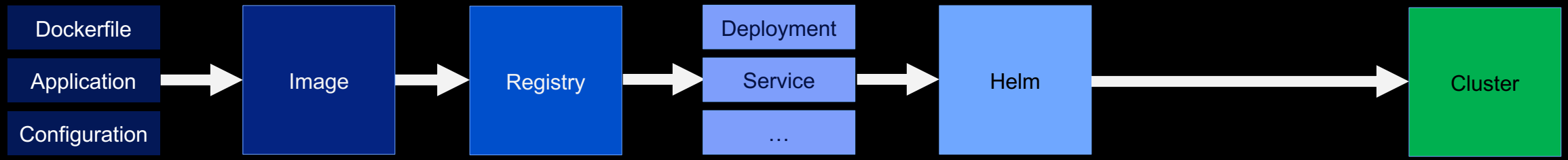
Templates (yaml)

Kubernetes deployment manifests (yaml) with placeholders for external parameters

values.yaml

A set of variables that will be passed on at deploy time to the deployment manifest templates

Minimal Application – Helm



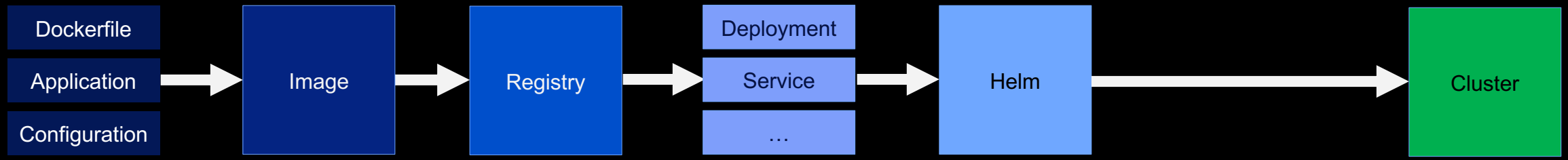

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: {{ .Values.replicas }}
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: {{ .Values.image.name }}:{{ .Values.image.tag }}
        ports:
        - containerPort: 80
```

```yaml
apiVersion: v1
image:
  name:
    - niklaushirt/k8s-demo
  tag: 1.0
  pullPolicy: IfNotPresent
replicas: 1
```

```
helm install k8s-demo
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 1
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimal Application – Helm



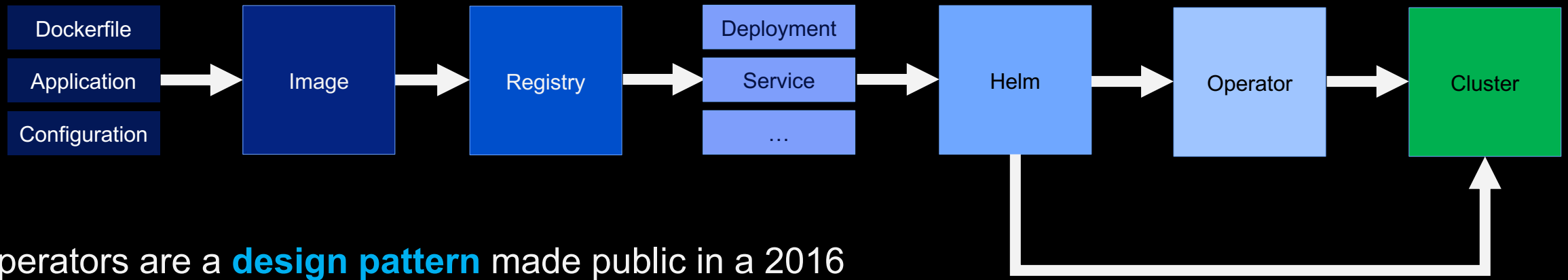

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: {{ .Values.replicas }}
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: {{ .Values.image.name }}:{{ .Values.image.tag }}
        ports:
        - containerPort: 80
```

```yaml
apiVersion: v1
image:
  name:
    - niklaushirt/k8s-demo
  tag: 1.0
  pullPolicy: IfNotPresent
~~replicas: 1~~
```

```
helm install --set replicas=3 k8s-demo
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: k8s-demo-deployment
  labels:
    app: k8s-demo
spec:
  replicas: 3
  selector:
    matchLabels:
      app: k8s-demo
  template:
    metadata:
      labels:
        app: k8s-demo
    spec:
      containers:
      - name: k8s-demo
        image: niklaushirt/k8s-demo:1.0
        ports:
        - containerPort: 80
```

Minimal Application – Operators



Operators are a **design pattern** made public in a 2016 CoreOS blog post.

The goal of an Operator is to put **operational knowledge into software**.

Operators implement and automate common
Day-1 (installation, configuration, etc) and
Day-2 (re-configuration, update, backup, failover, restore, etc.) **activities**
in a piece of software running inside your Kubernetes cluster, by integrating natively with Kubernetes concepts and APIs.

More about this in three weeks JTC14 – Kubernetes Operators

K9s – the Norton Commander of Kubernetes

Preinstalled in the training VM

For dumb people like me
(who just don't get vi)

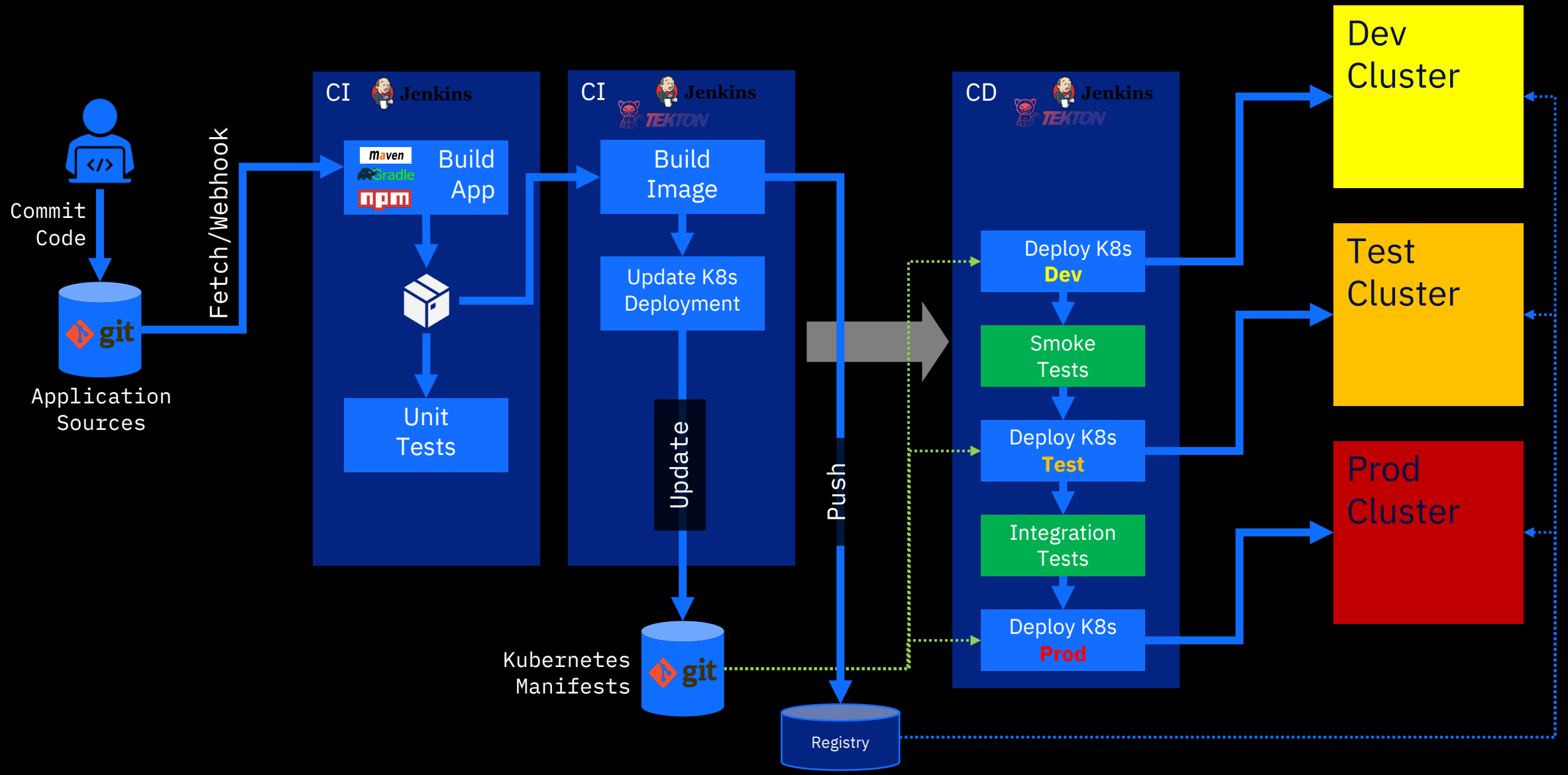
```
KUBE_EDITOR="nano" k9s
```

I did create an alias in .bashrc/.zshrc

```
alias k9s='KUBE_EDITOR="nano" k9s'
```

https://github.com/derailed/k9s

Kubernetes – CI/CD Pipeline - GitOps



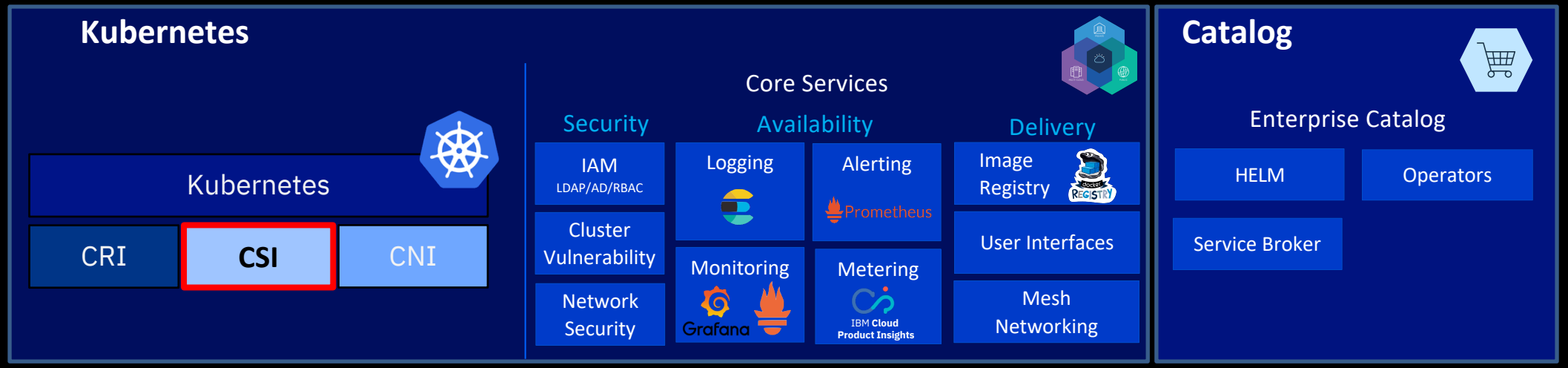
QUESTIONS?

Kubernetes Workshop Series

Container State

09

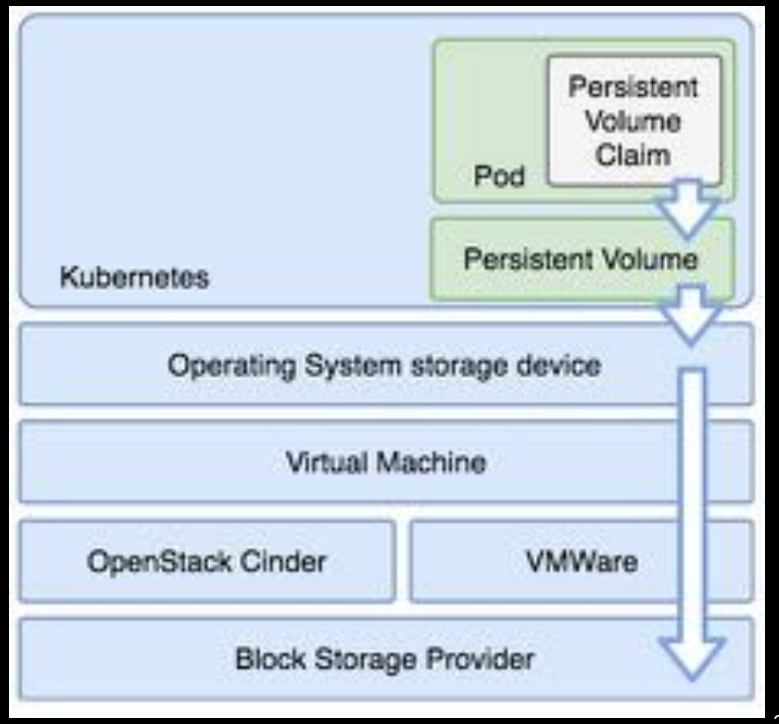
Kubernetes – Storage



Kubernetes Persistent Storage Support:
HostPath, NFS, GlusterFS, vSphereVolume, ….

Access Modes:

- ReadWriteOnce – the volume can be mounted as read-write by a single node
- ReadOnlyMany – the volume can be mounted read-only by many nodes
- ReadWriteMany – the volume can be mounted as read-write by many nodes



Kubernetes – Common Storage Interface

The PersistentVolume subsystem provides an API for users and administrators that abstracts details of how storage is provided from how it is consumed.

PersistentVolume (PV) is a piece of storage in the cluster that has been provisioned by an administrator or dynamically provisioned using Storage Classes

PersistentVolumeClaim (PVC) is a request for storage by a user. It is similar to a Pod. Pods consume node resources and PVCs consume PV resources. Pods can request specific levels of resources (CPU and Memory). Claims can request specific size and access modes (e.g., they can be mounted once read/write or many times read-only).

Provisioning

There are two ways PVs can be provisioned:

- **Static**
  A cluster administrator manually creates a number of PVs. They carry the details of the real storage, which is available for use by cluster users.

- **Dynamic**
  When none of the static PVs the administrator created match a user's PersistentVolumeClaim, the cluster may try to dynamically provision a volume specially for the PVC if there is a storage solution that supports it.

Binding

A user creates a PersistentVolumeClaim with a specific amount of storage requested and with certain access modes.
The cluster watches for new PVCs, tries to find a matching PV and binds them together.
Once bound, PersistentVolumeClaim binds are exclusive, regardless of how they were bound.

Using

Pods use claims as volumes.

Deleting

PersistentVolume (PVs) that are bound to PVCs are/can not removed from the system.

If a user deletes a PVC in active use by a Pod, the PVC is not removed until all Pods that are using the PVC are being terminated.

Reclaiming

The reclaim policy for a PersistentVolume tells the cluster what to do with the volume after it has been released of its claim.

Retain

When the PersistentVolumeClaim is deleted, the PersistentVolume still exists and the volume is considered “released”.
An administrator can manually reclaim the volume.

Delete

Removes both the PersistentVolume object from Kubernetes, as well as the associated storage asset in the external infrastructure

Recycle (deprecated)

Performs a basic scrub (rm -rf /thevolume/*) on the volume and makes it available again for a new claim.

Storage Class

Provides a way for administrators to describe the “classes” of storage they offer.
Different classes might have different quality-of-service levels, backup policies, …

VolumeBindingMode

Volume binding and dynamic provisioning occurs once the PersistentVolumeClaim is created.
This may result in unschedulable Pods

```
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: fast
provisioner: kubernetes.io/vsphere-volume
parameters:
    diskformat: zeroedthick
    datastore: VSANDatastore
reclaimPolicy: Retain (or Delete, Reclaim)
volumeBindingMode: Immediate (or WaitForFirstConsumer)
```

Kubernetes – Common Storage Interface

- GlusterFS
- Rook/Ceph
- OpenEBS
- NFS

GlusterFS

Gluster is a scalable, distributed network filesystem. Using common off-the-shelf hardware, you can create large, distributed storage solutions for media streaming, data analysis, and other data- and bandwidth-intensive tasks. Gluster is free.

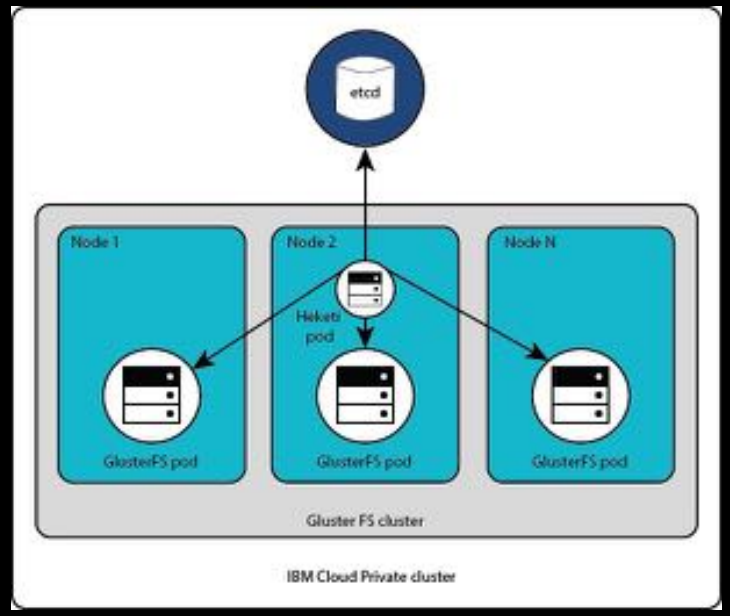
Physical install

- Format and mount the bricks
- Installing GlusterFS
- Configure the trusted pool
- Set up a GlusterFS volume
- Install Heketi & Topology (for dynamic provisioning)
- Create K8s Storage Class

Or container based

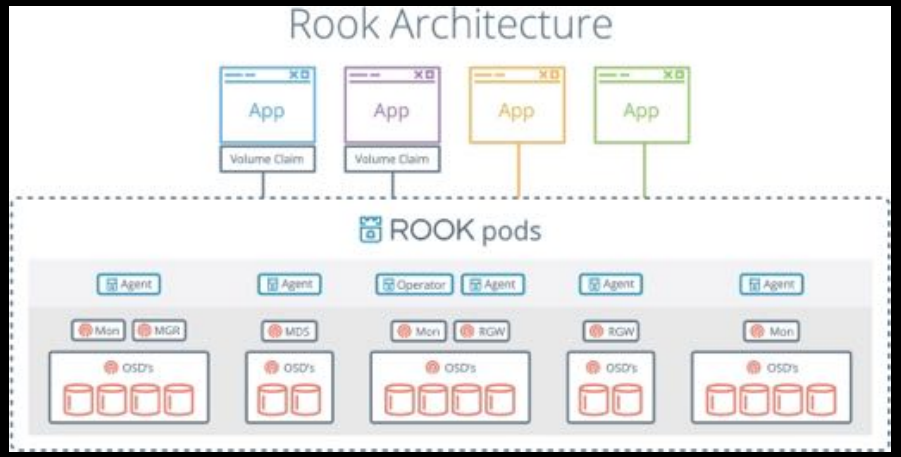
- https://hub.docker.com/r/glusterfs/gluster_centos
- Must run as priviledged → OpenShift?

https://docs.gluster.org/en/latest/Quick-Start-Guide/Quickstart/



Rook/Ceph

Rook turns distributed storage systems into self-managing, self-scaling, self-healing storage services.
Ceph is a highly scalable distributed storage solution for **block storage**, **object storage**, and **shared file systems** with years of production deployments.



Install on K8s

- git clone https://github.com/rook/rook.git
- kubectl create -f common.yaml
- kubectl create -f operator(-openshift).yaml
- kubectl create -f cluster-test.yaml
- kubectl create -f csi/rbd/storageclass-test.yaml

cassandra	crds: Set annotations pods, deployments and so on
ceph	We were defaulting to `ext4` at first and then moved to
cockroachdb	crds: Set annotations pods, deployments and so on
edgefs	edgefs image version update in examples and docs
minio	minio: add necessary update verb in minio RBAC
nfs	NFS: Fix operator.yaml line endings
noobaa	Rook-NooBaa Design Doc
yugabytedb	yugabytedb: Documentation, user guides & examples

https://rook.io/docs/rook/v0.9/ceph-quickstart.html

OpenEBS

OpenEBS is truly Kubernetes native.
It adopts Container Attached Storage (CAS) approach, where each workload is provided with a dedicated storage controller. It implements granular storage policies and isolation that enable users to optimize storage for each specific workload.

Install on K8s

- sudo apt-get install open-iscsi
- kubectl apply -f https://openebs.github.io/charts/openebs-operator.yaml
- kubectl create -f csi/rbd/storageclass-test.yaml
- kubectl apply -f openebs-storageclasses.yaml

https://docs.openebs.io/docs/next/installation.html

QUESTIONS?