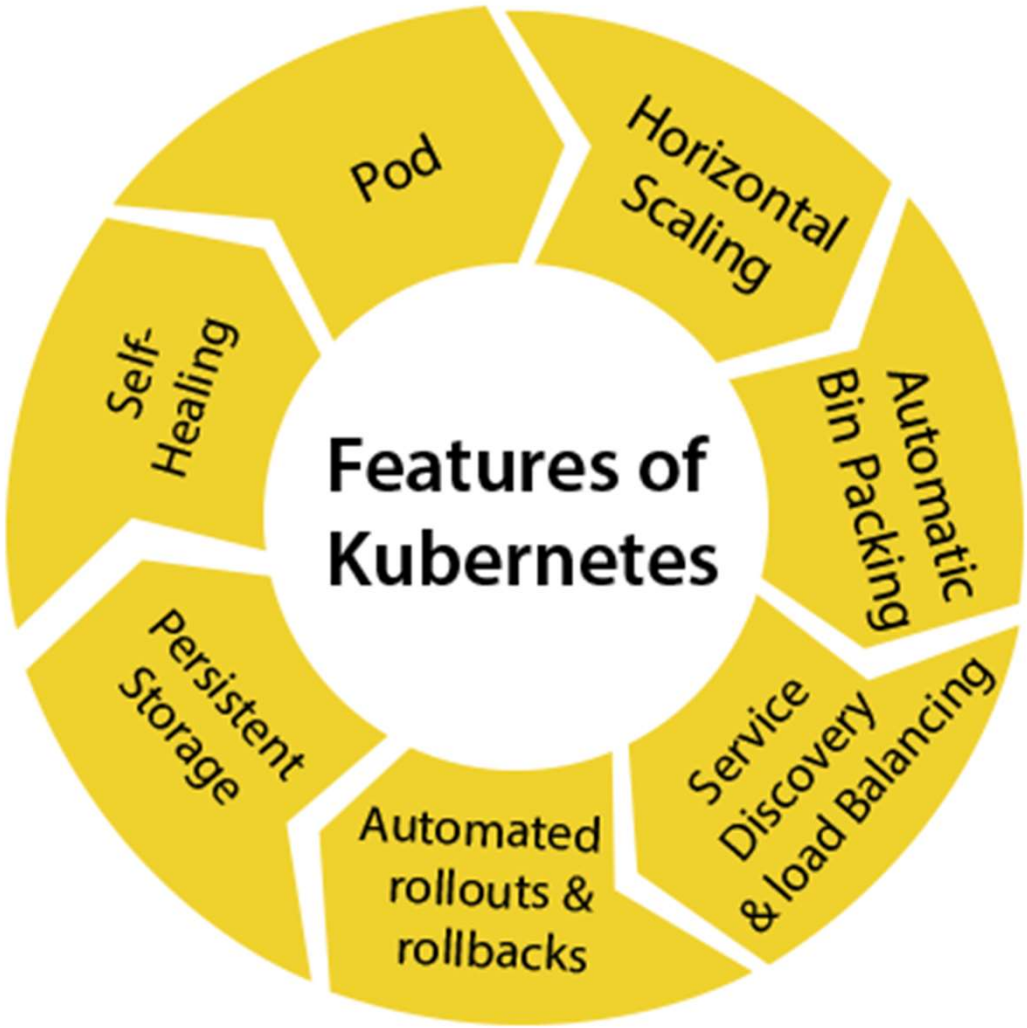
Introduction to Kubernetes

Features


Features of Kubernetes
Pod
Horizontal Scaling
Automatic Bin Packing
Service Discovery & load Balancing
Automated rollouts & rollbacks
Persistent Storage
Self-Healing

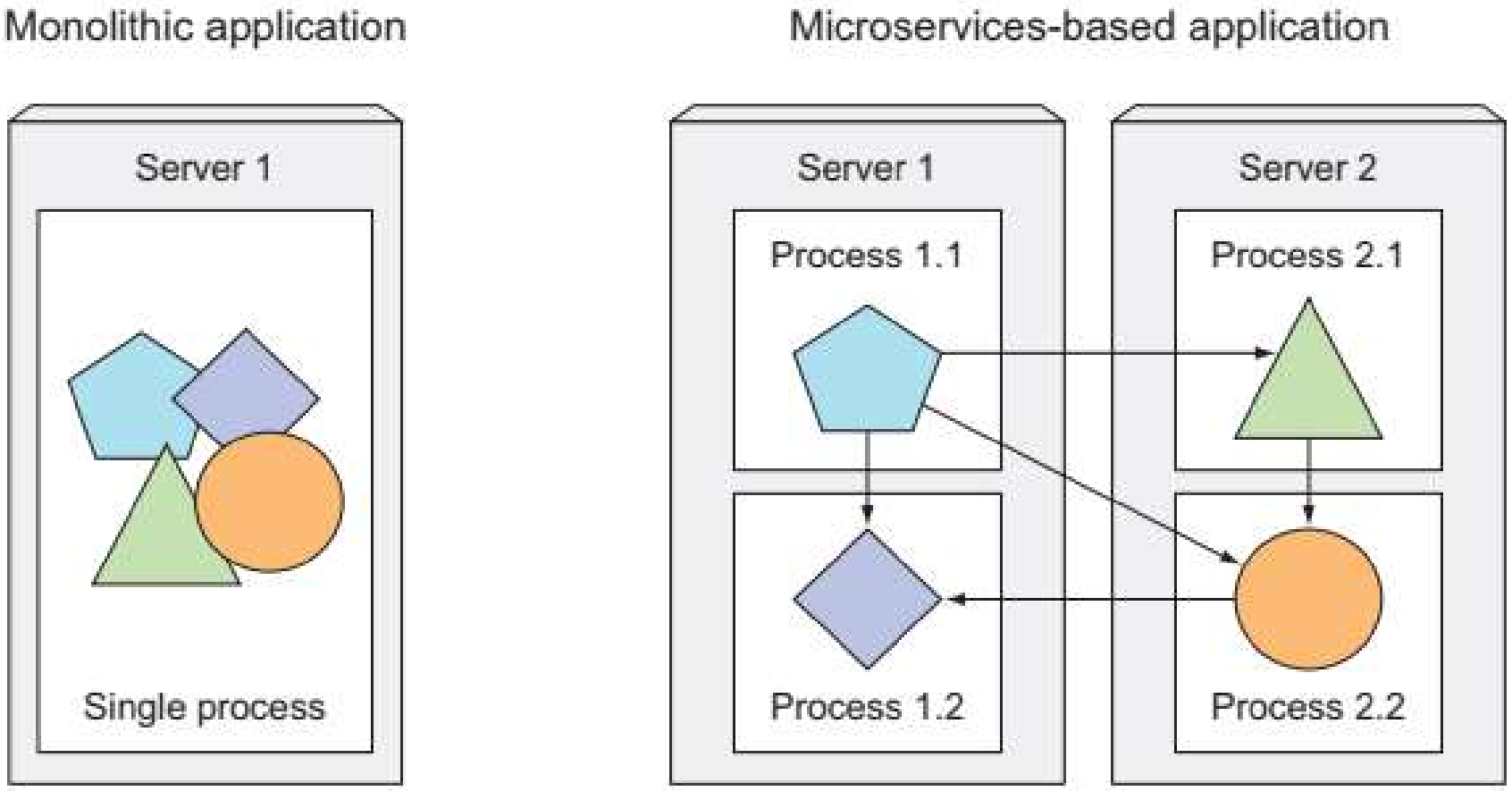
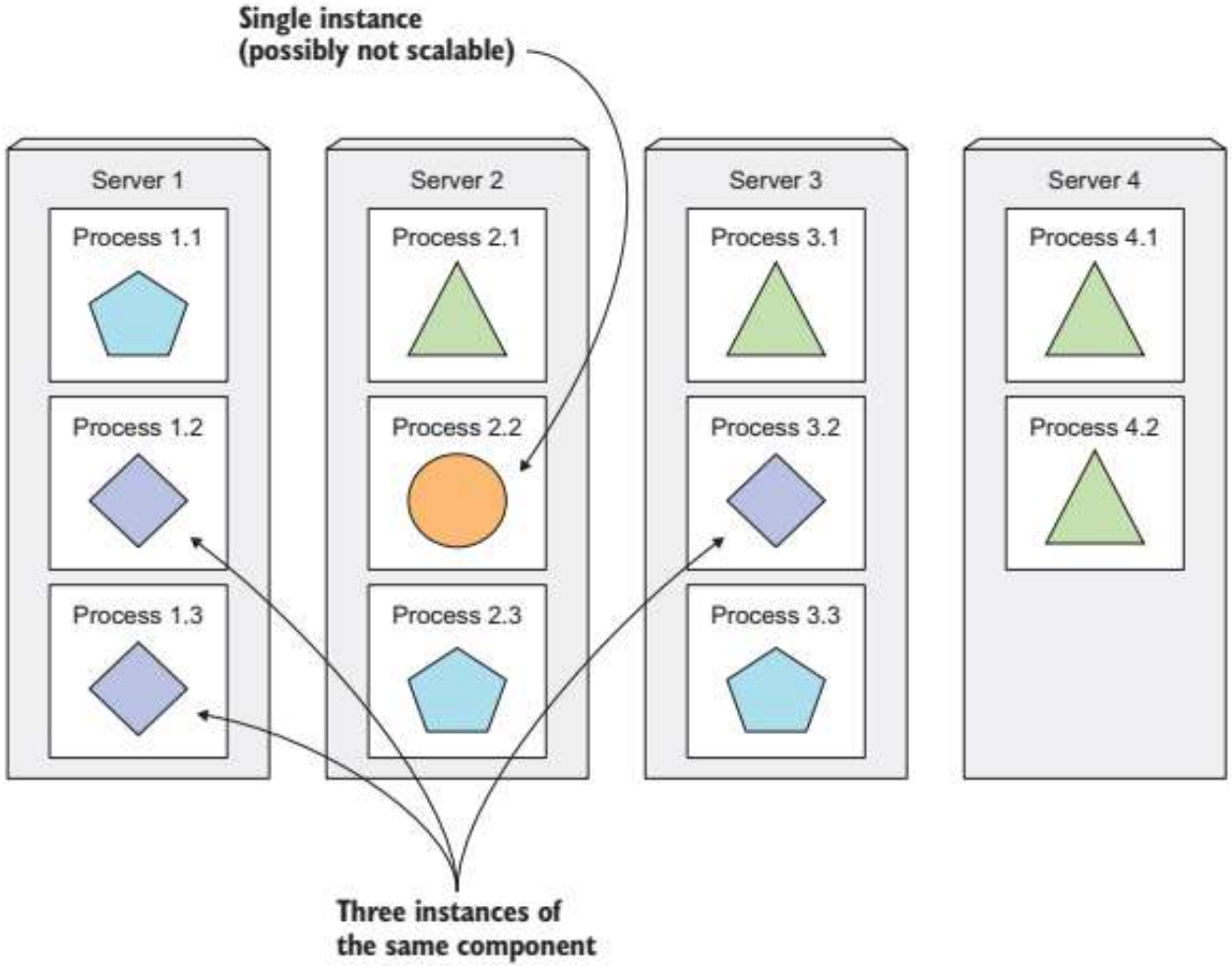
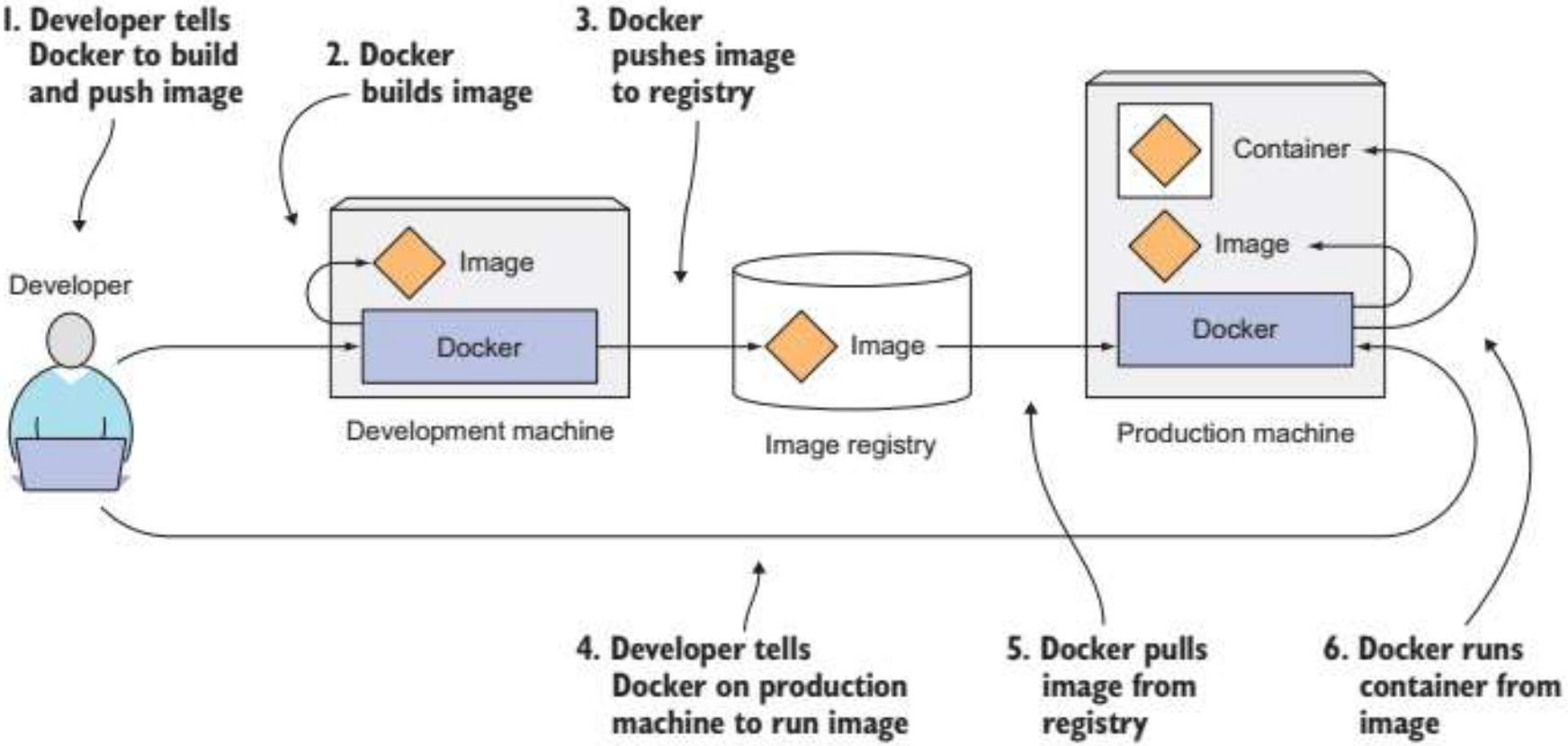
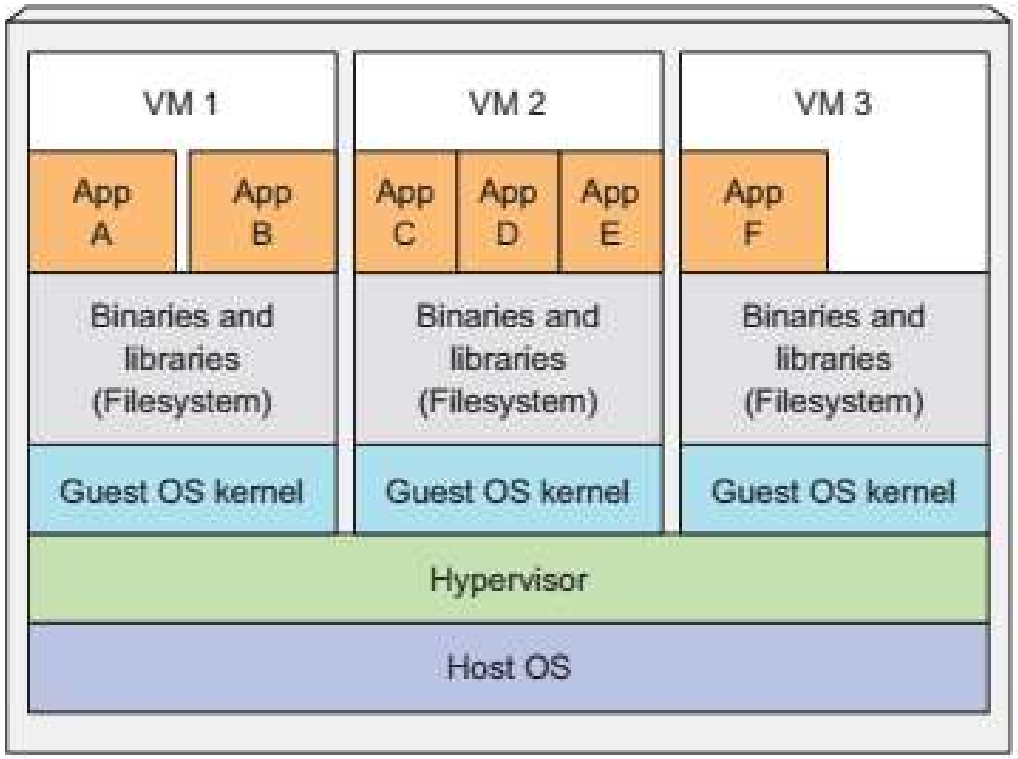


Figure 1.1 Components inside a monolithic application vs. standalone microservices

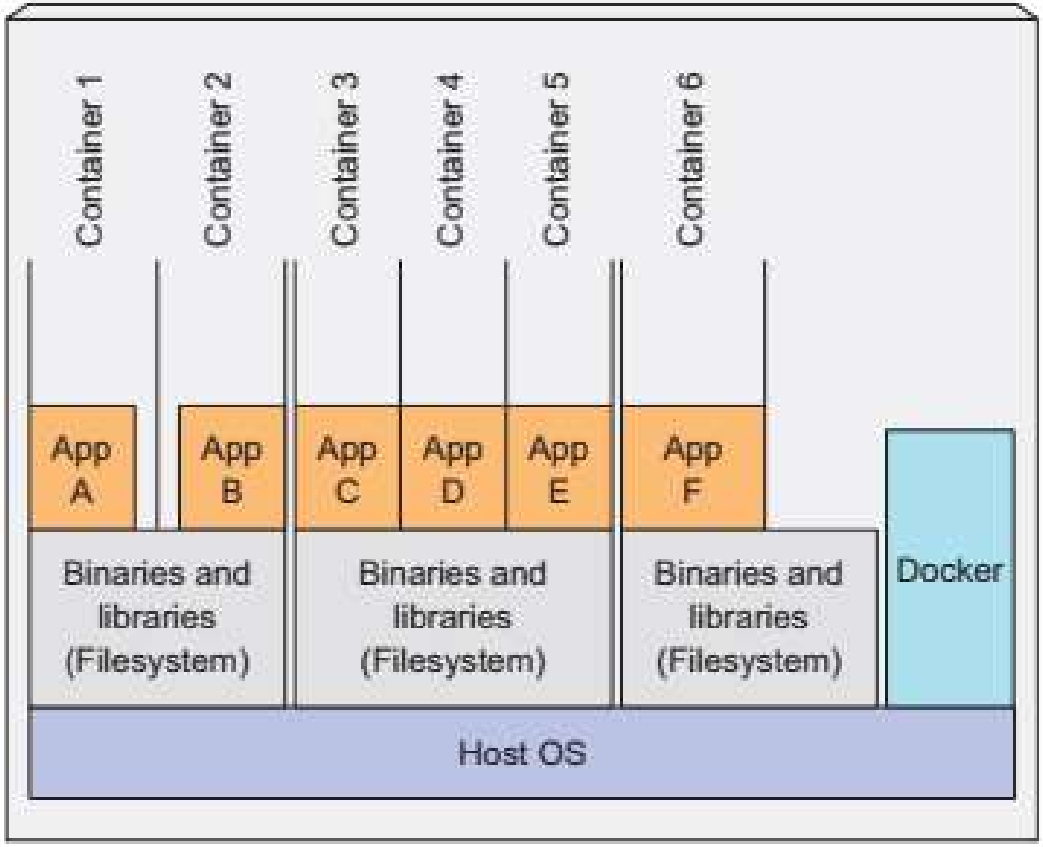

Single instance
(possibly not scalable)
Server 1
Process 1.1
Process 1.2
Process 1.3
Server 2
Process 2.1
Process 2.2
Process 2.3
Server 3
Process 3.1
Process 3.2
Process 3.3
Server 4
Process 4.1
Process 4.2
Three instances of
the same component


1. Developer tells Docker to build and push image
2. Docker builds image
3. Docker pushes image to registry
Developer
Image
Docker
Development machine
Image
Image registry
Container
Image
Docker
Production machine
4. Developer tells Docker on production machine to run image
5. Docker pulls image from registry
6. Docker runs container from image

Host running multiple VMs



Host running multiple Docker containers



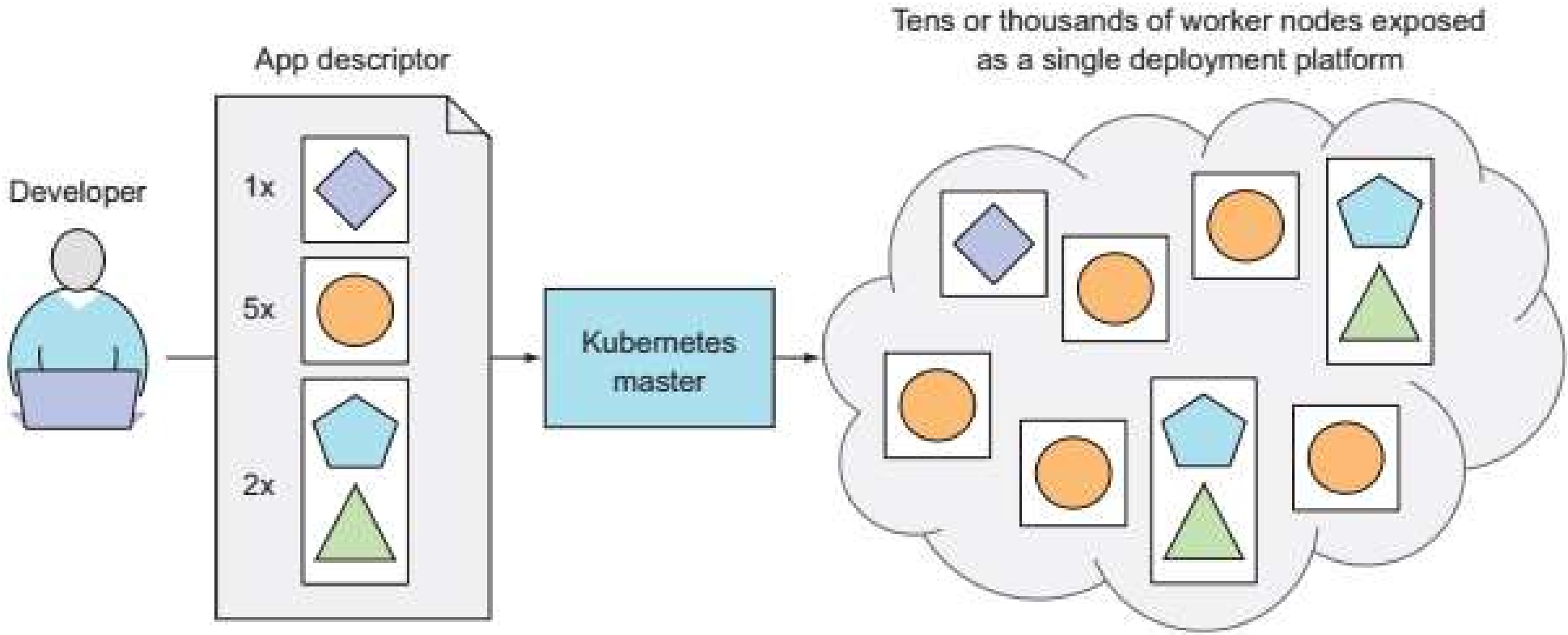


Figure 1.8 Kubernetes exposes the whole datacenter as a single deployment platform.

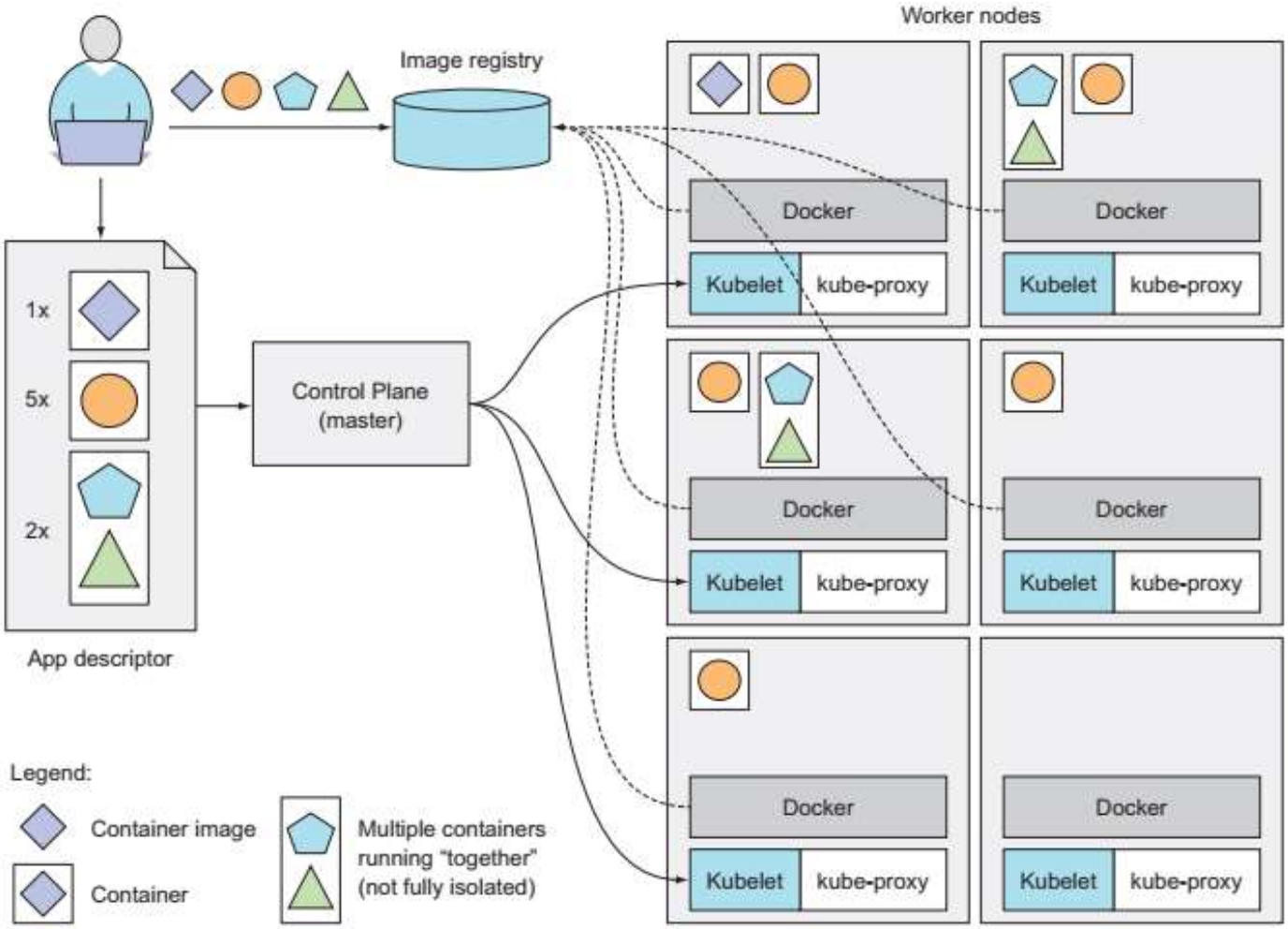


Figure 1.10 A basic overview of the Kubernetes architecture and an application running on top of it

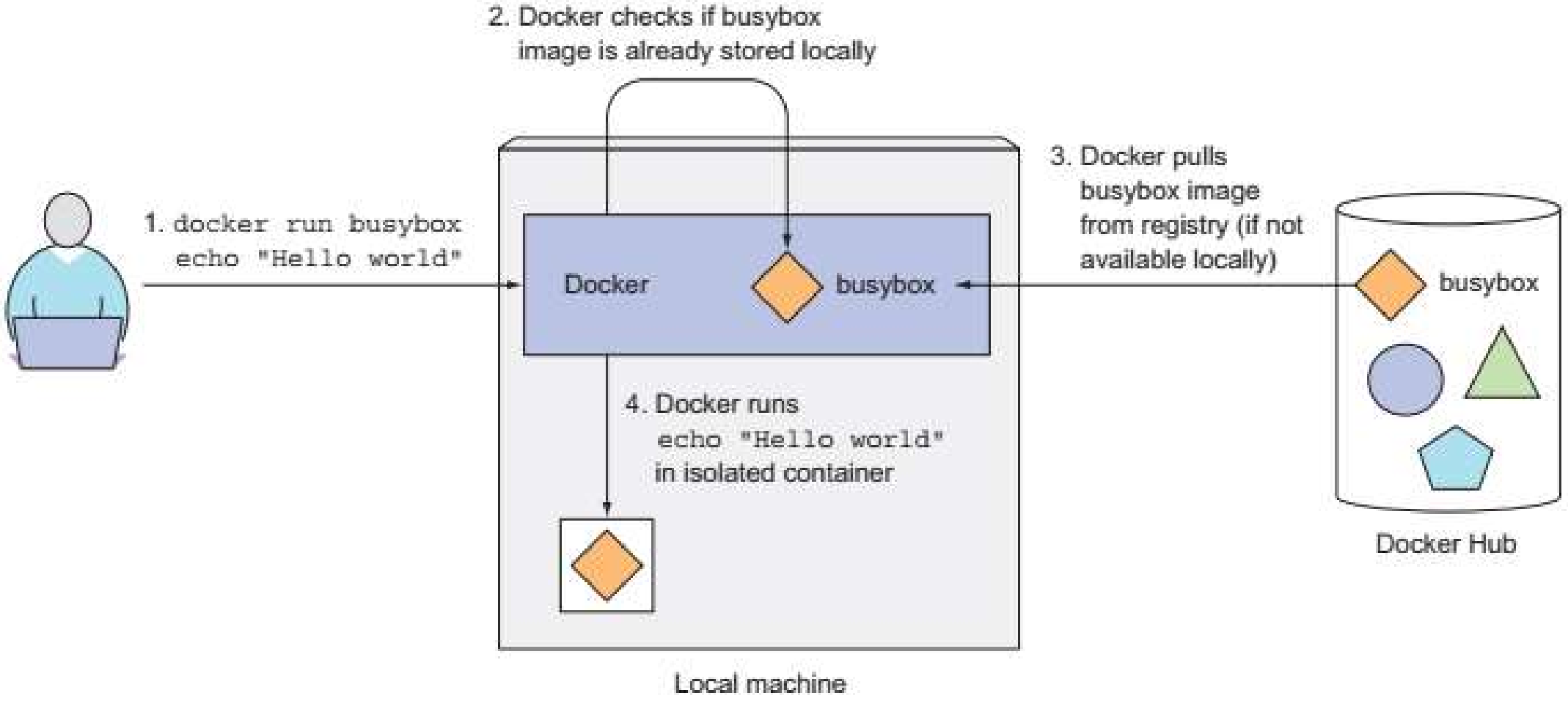


Figure 2.1 Running echo "Hello world" in a container based on the busybox container image

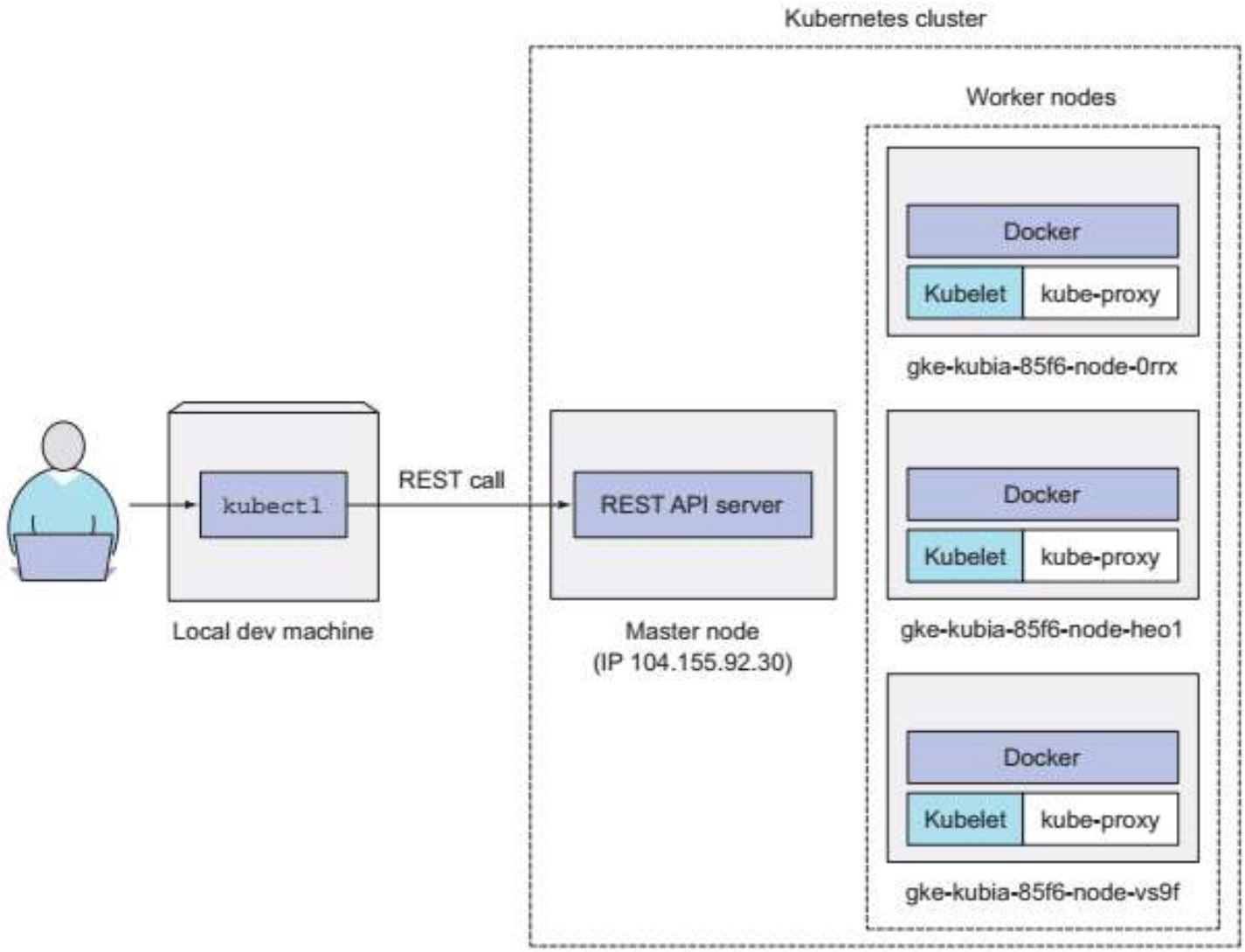


Figure 2.4 How you're interacting with your three-node Kubernetes cluster

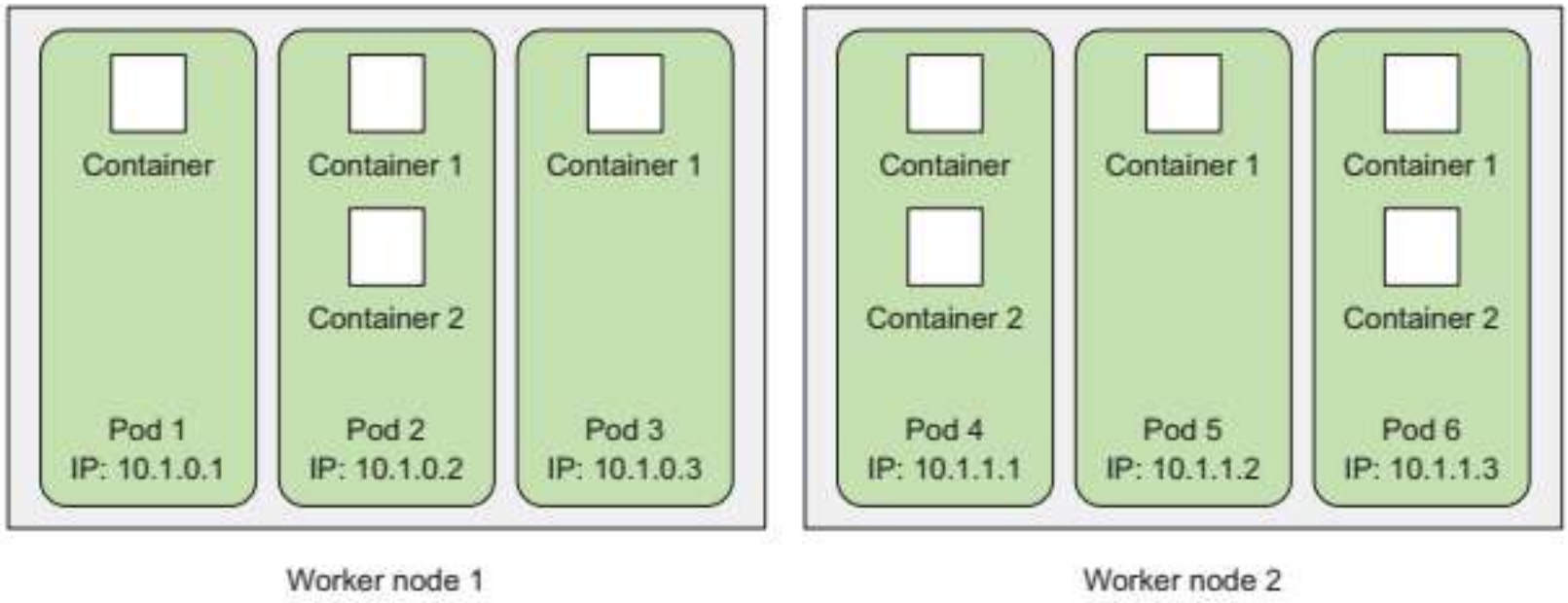


Figure 2.5 The relationship between containers, pods, and physical worker nodes

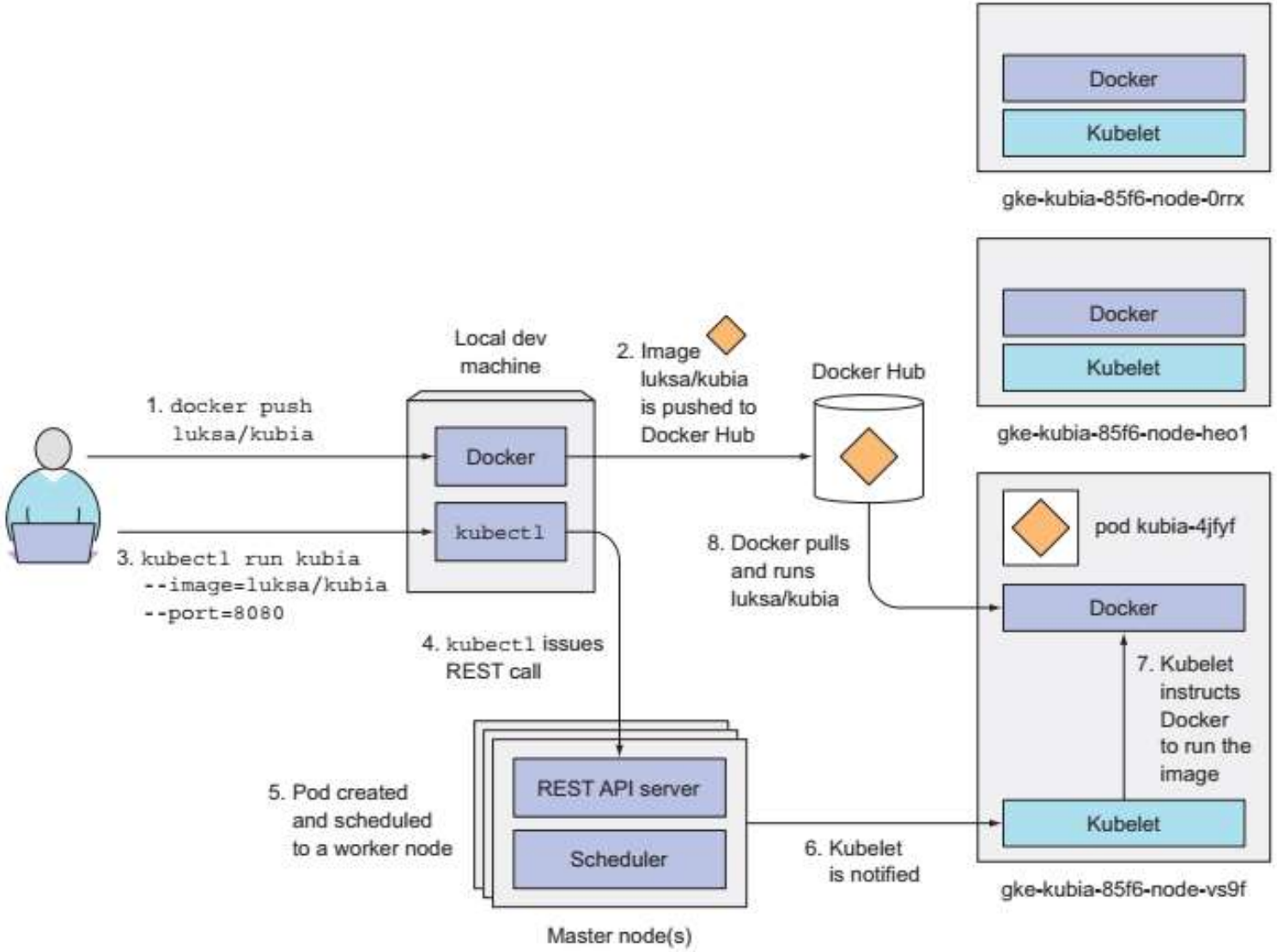


Figure 2.6 Running the `luksa/kubia` container image in Kubernetes

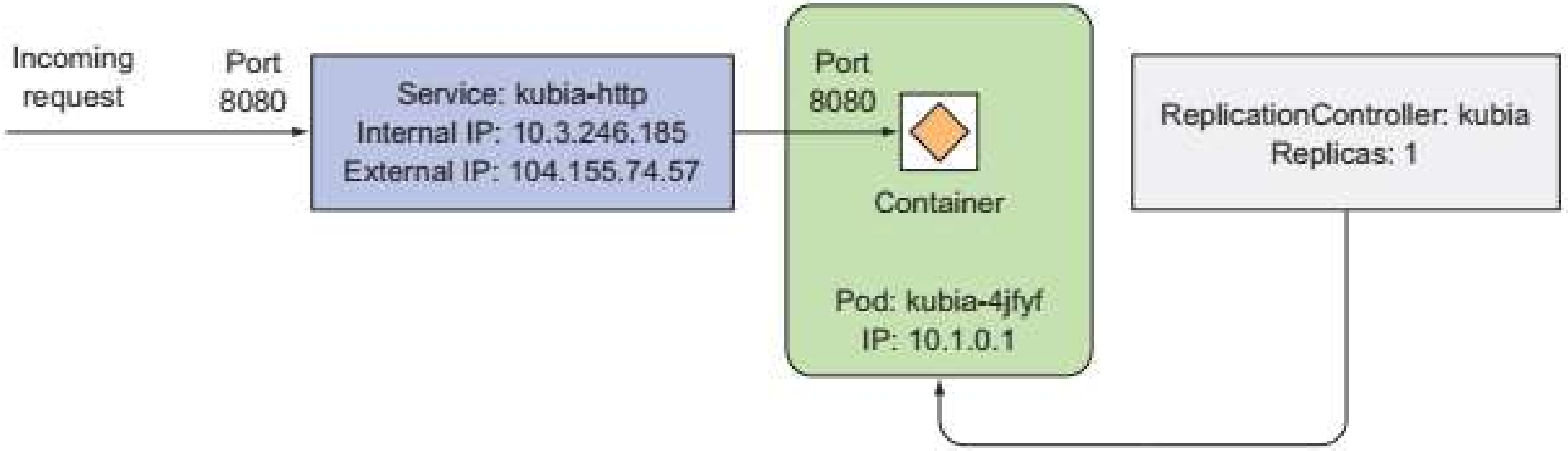


Figure 2.7 Your system consists of a ReplicationController, a Pod, and a Service.

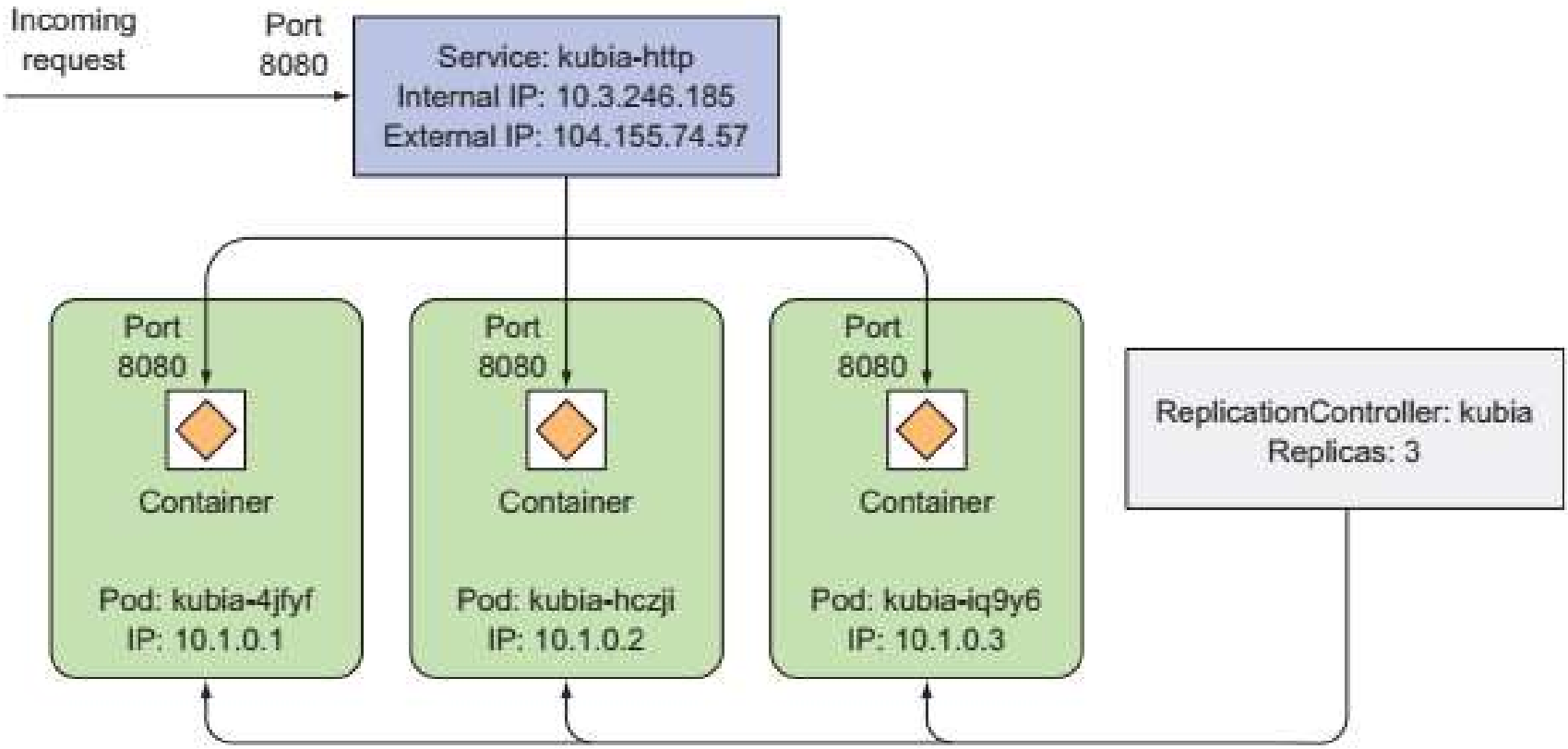


Figure 2.8 Three instances of a pod managed by the same ReplicationController and exposed through a single service IP and port.

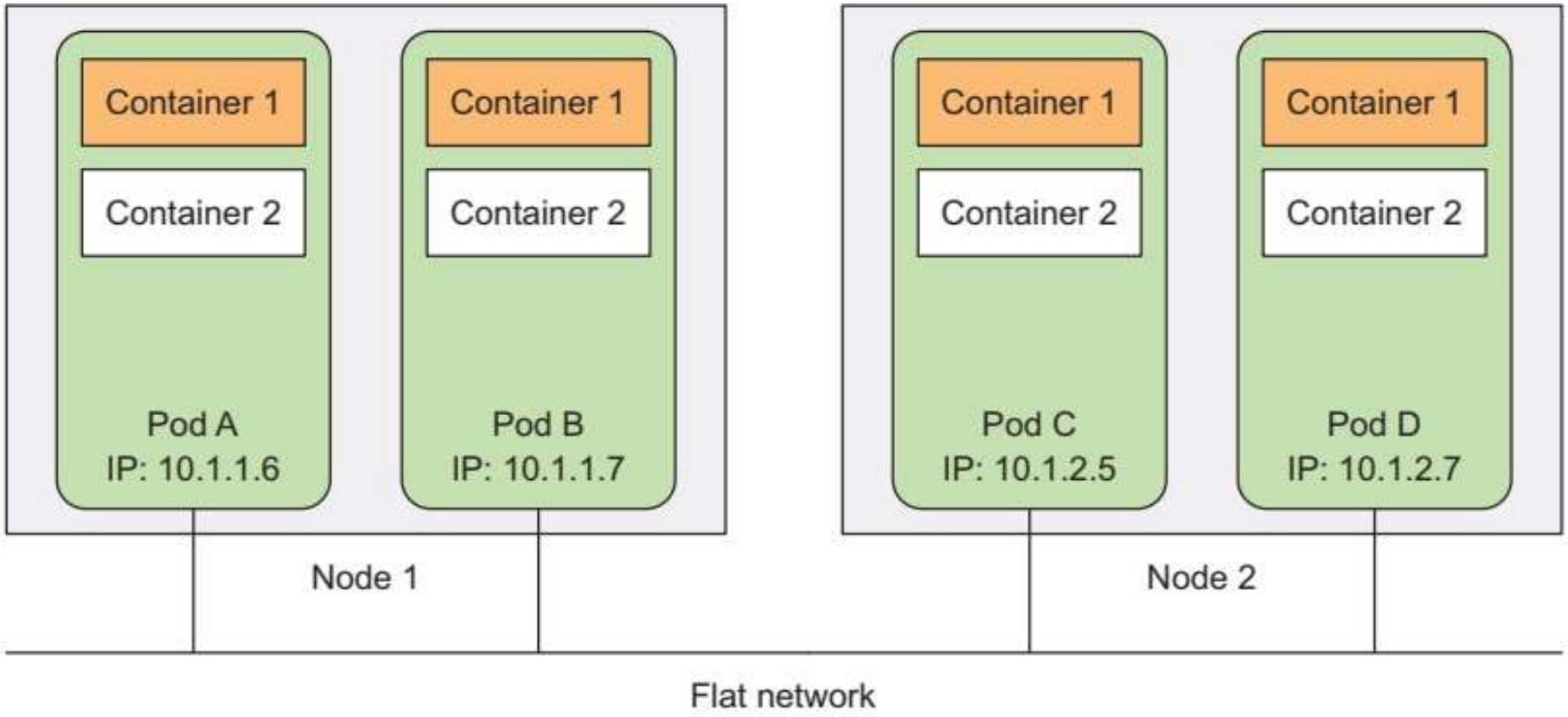
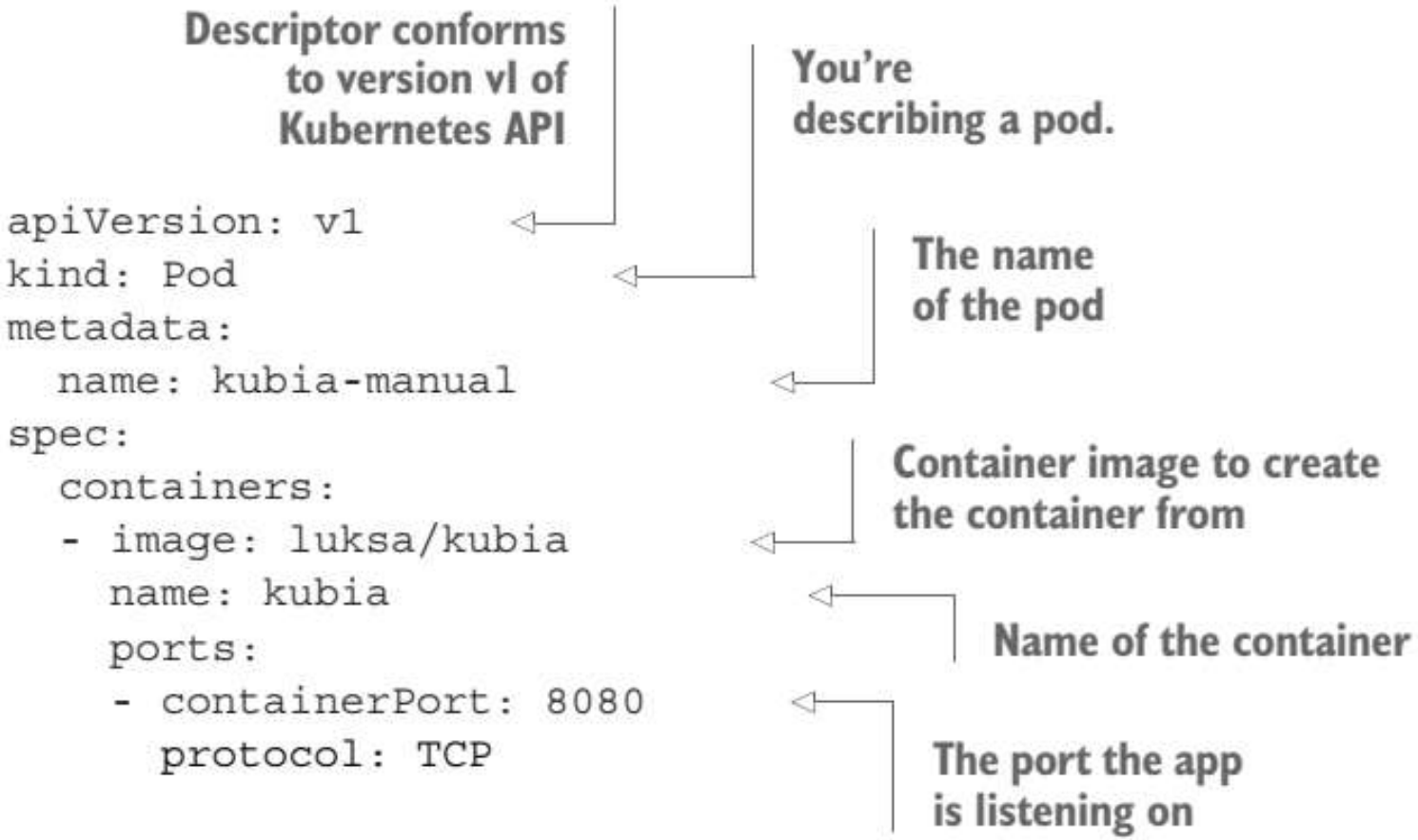


Figure 3.2 Each pod gets a routable IP address and all other pods see the pod under that IP address.

Listing 3.2 A basic pod manifest: kubia-manual.yaml



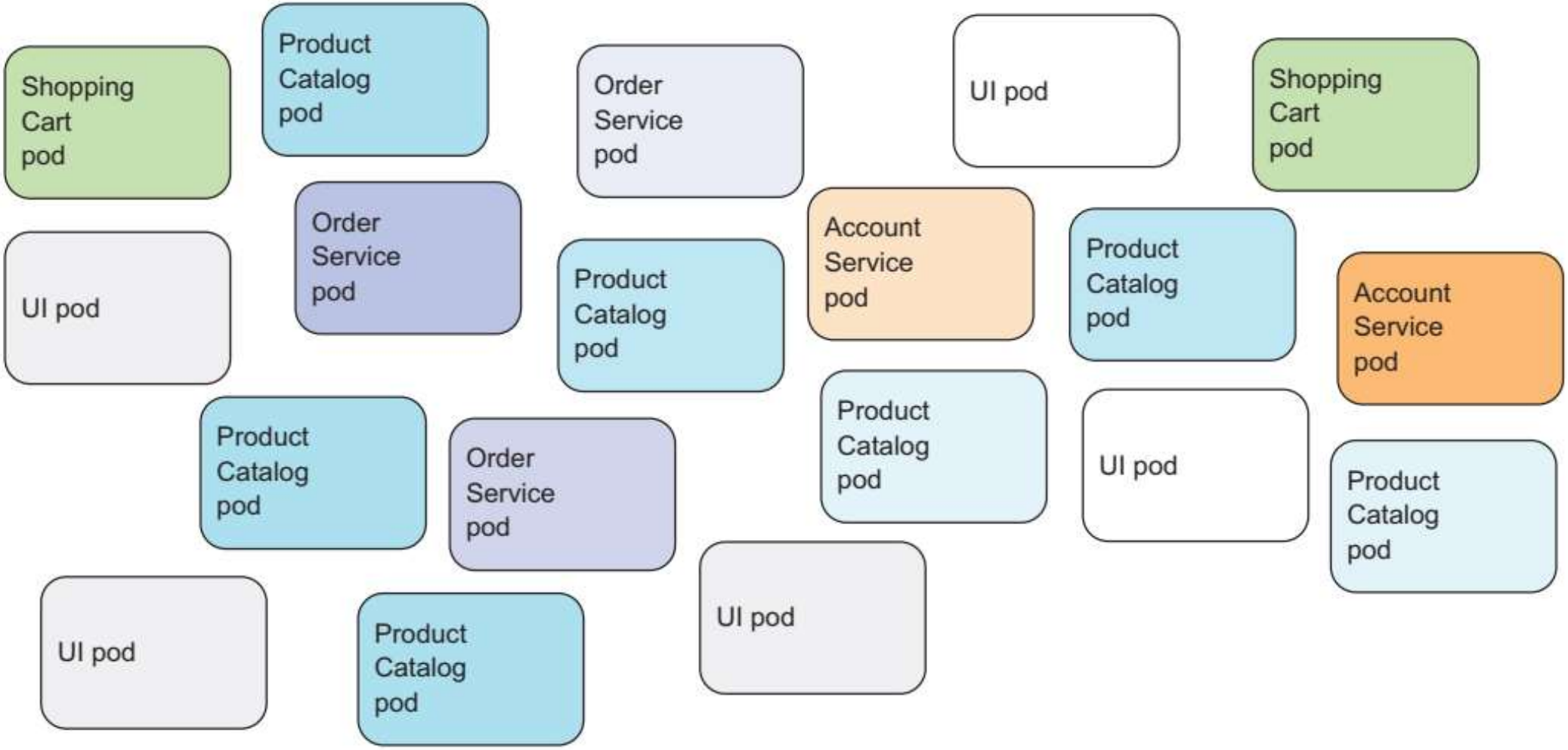


Figure 3.6 Uncategorized pods in a microservices architecture

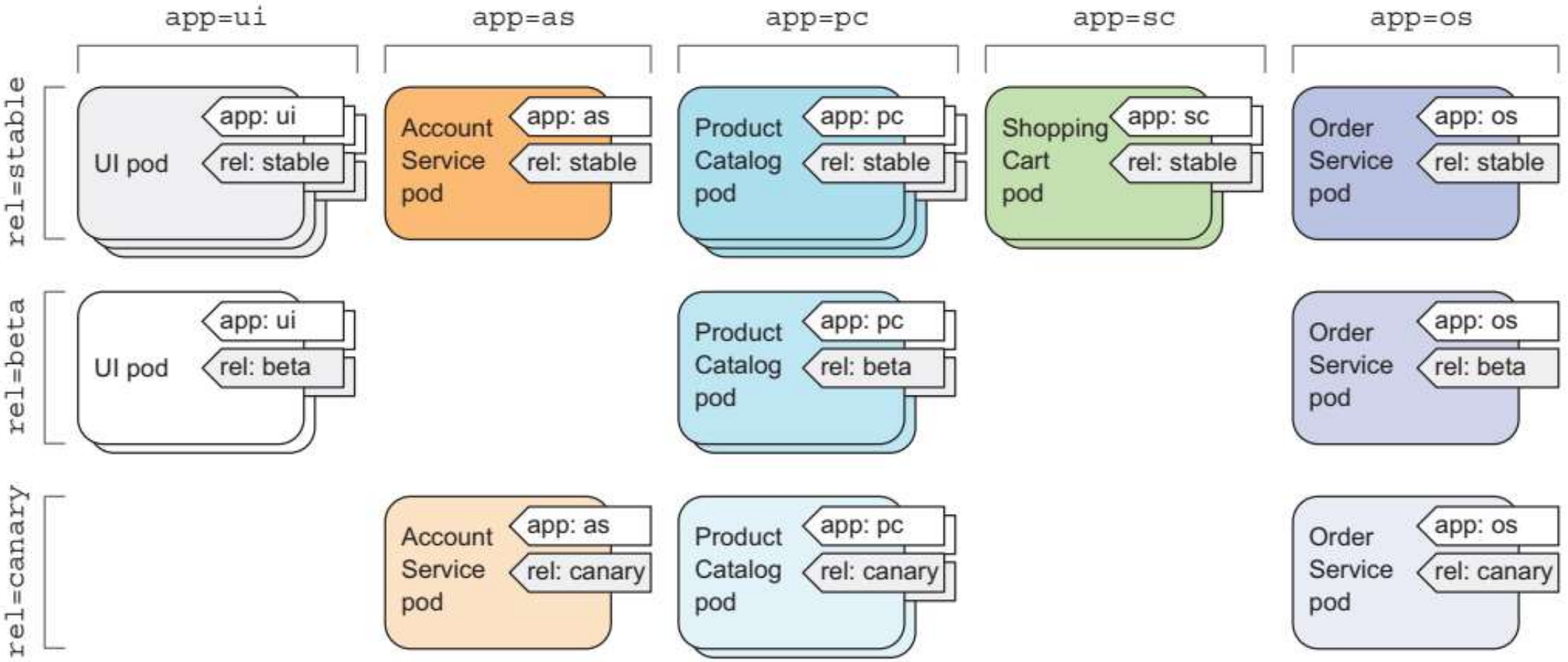


Figure 3.7 Organizing pods in a microservices architecture with pod labels

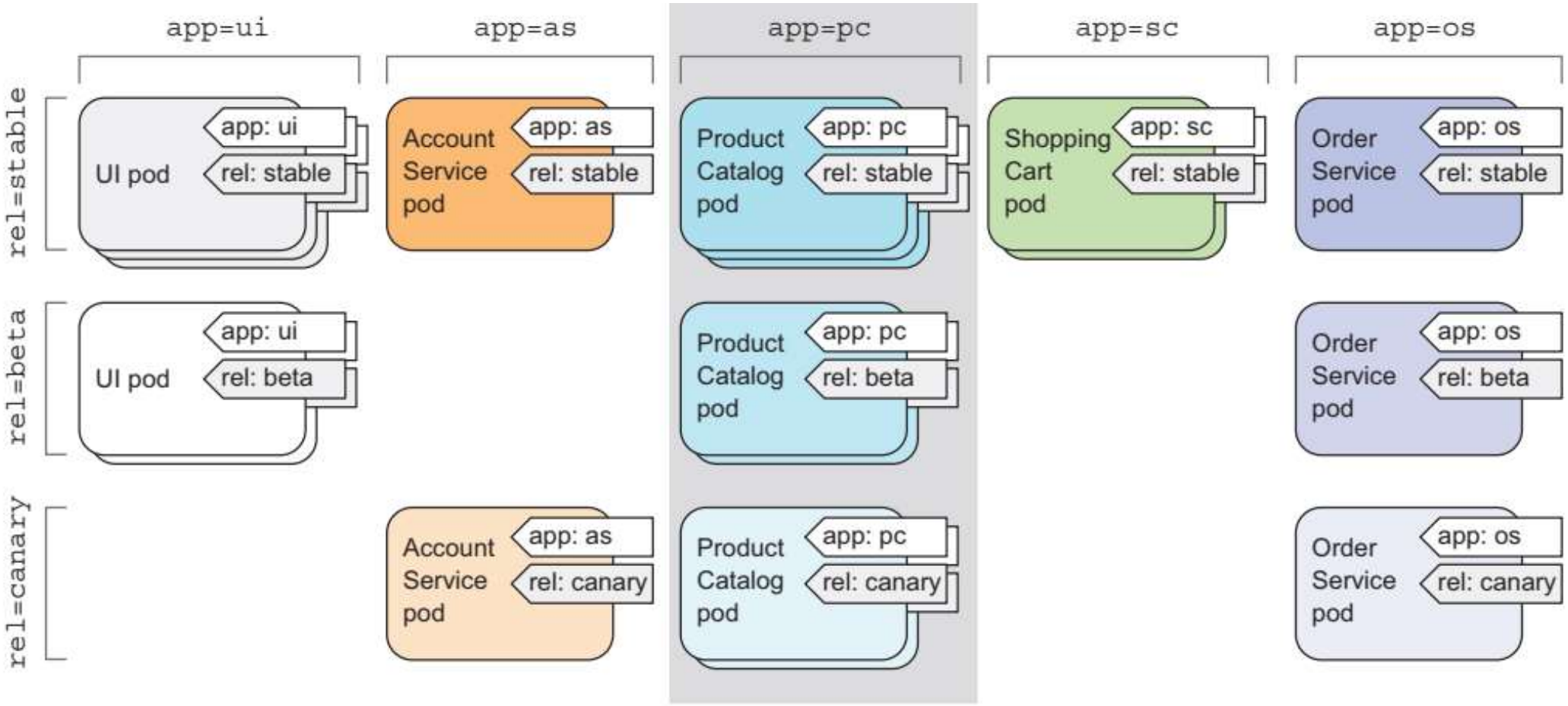


Figure 3.8 Selecting the product catalog microservice pods using the "app=pc" label selector

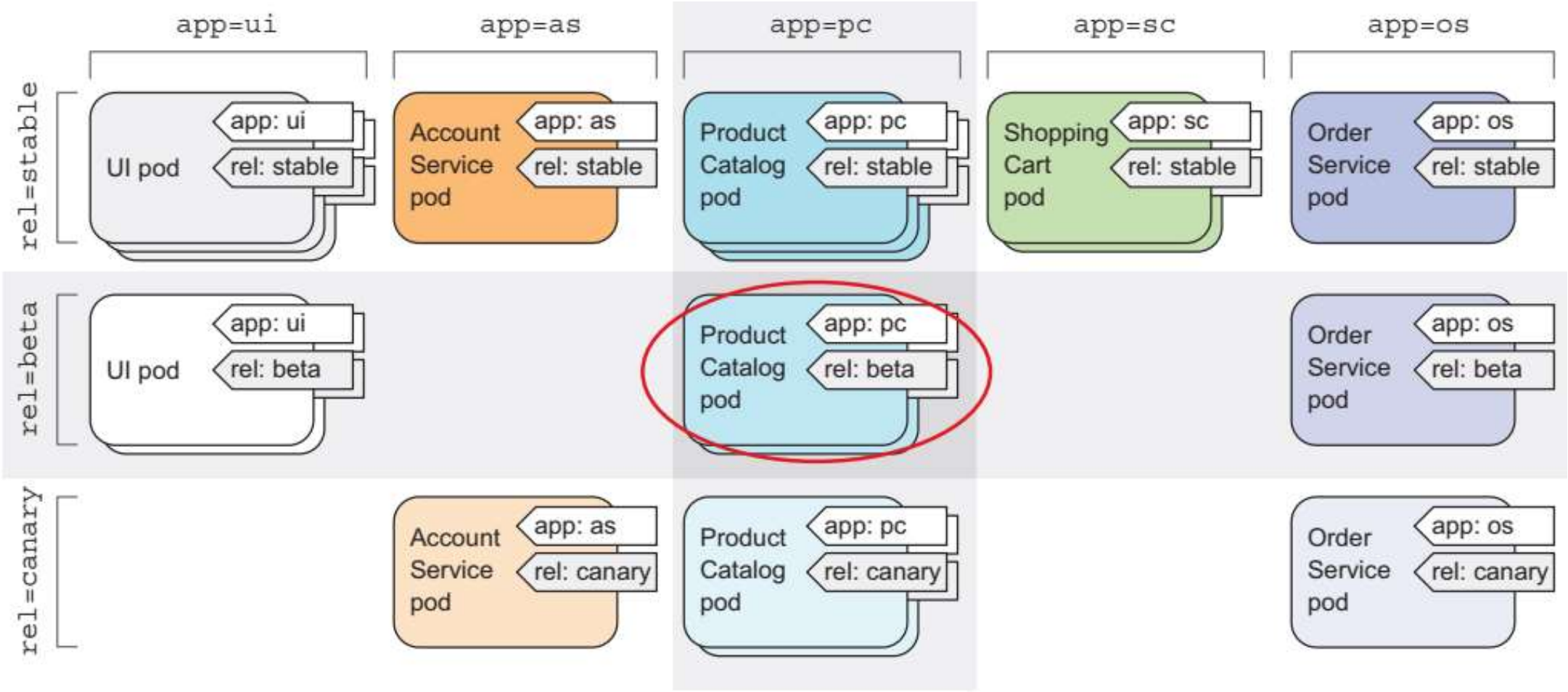


Figure 3.9 Selecting pods with multiple label selectors

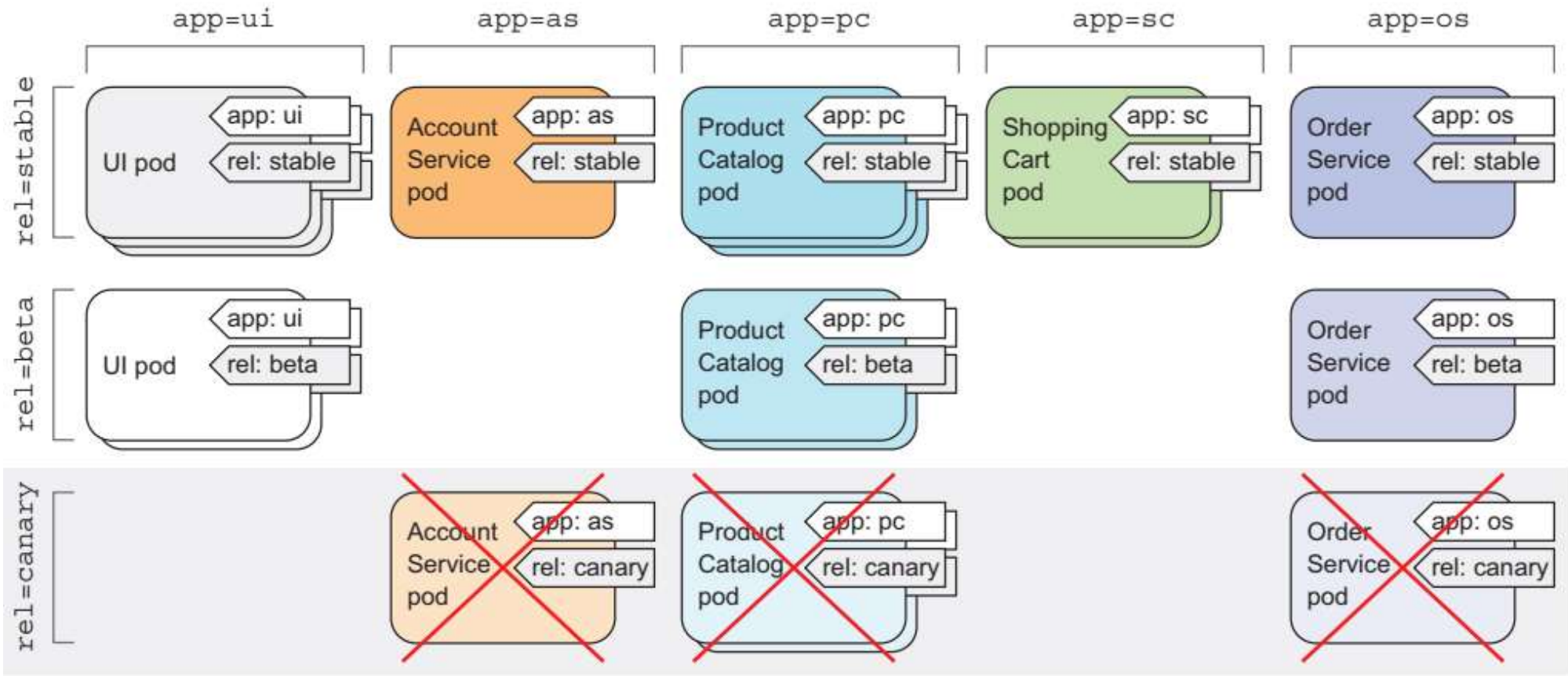


Figure 3.10 Selecting and deleting all canary pods through the `rel=canary` label selector

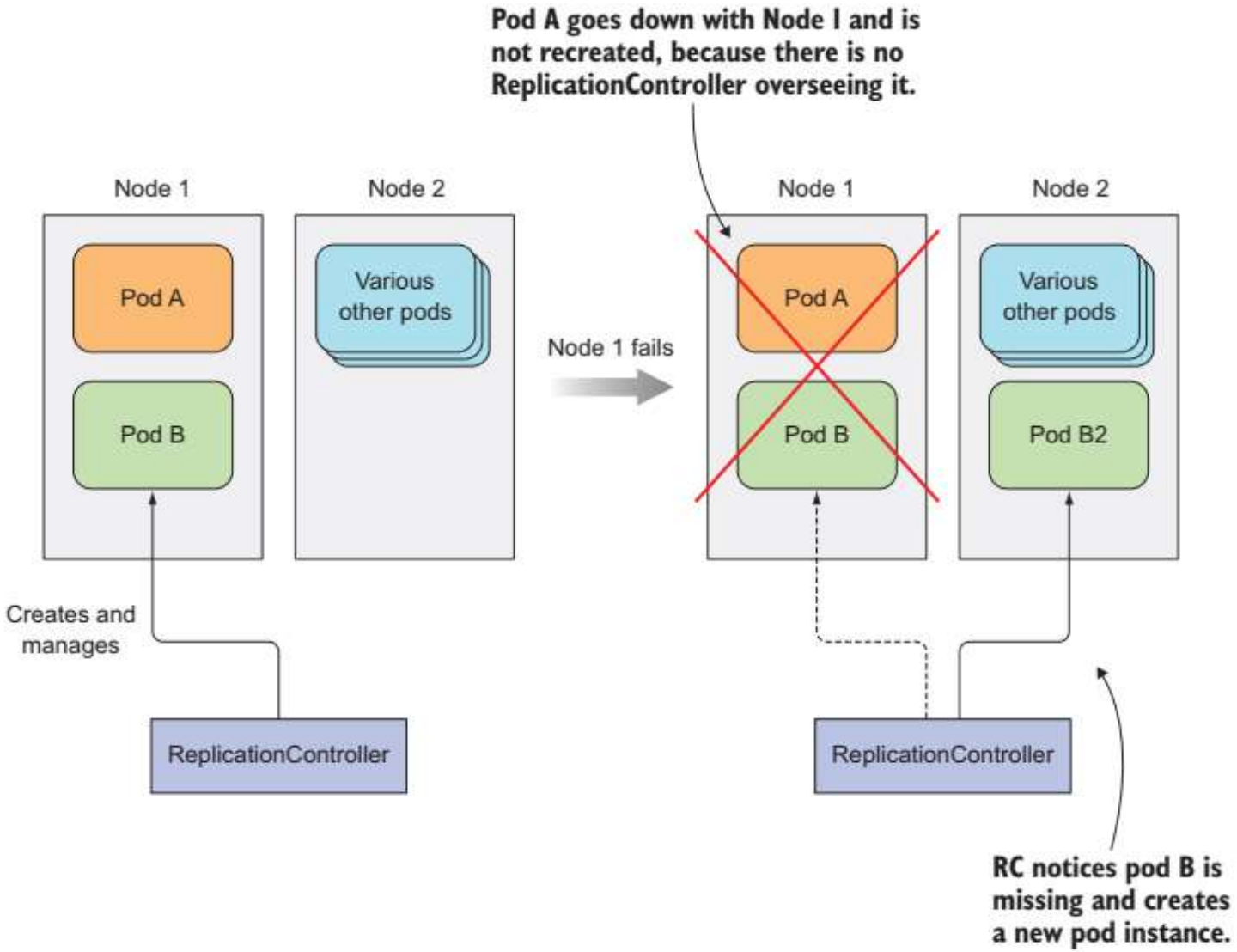


Figure 4.1 When a node fails, only pods backed by a ReplicationController are recreated.

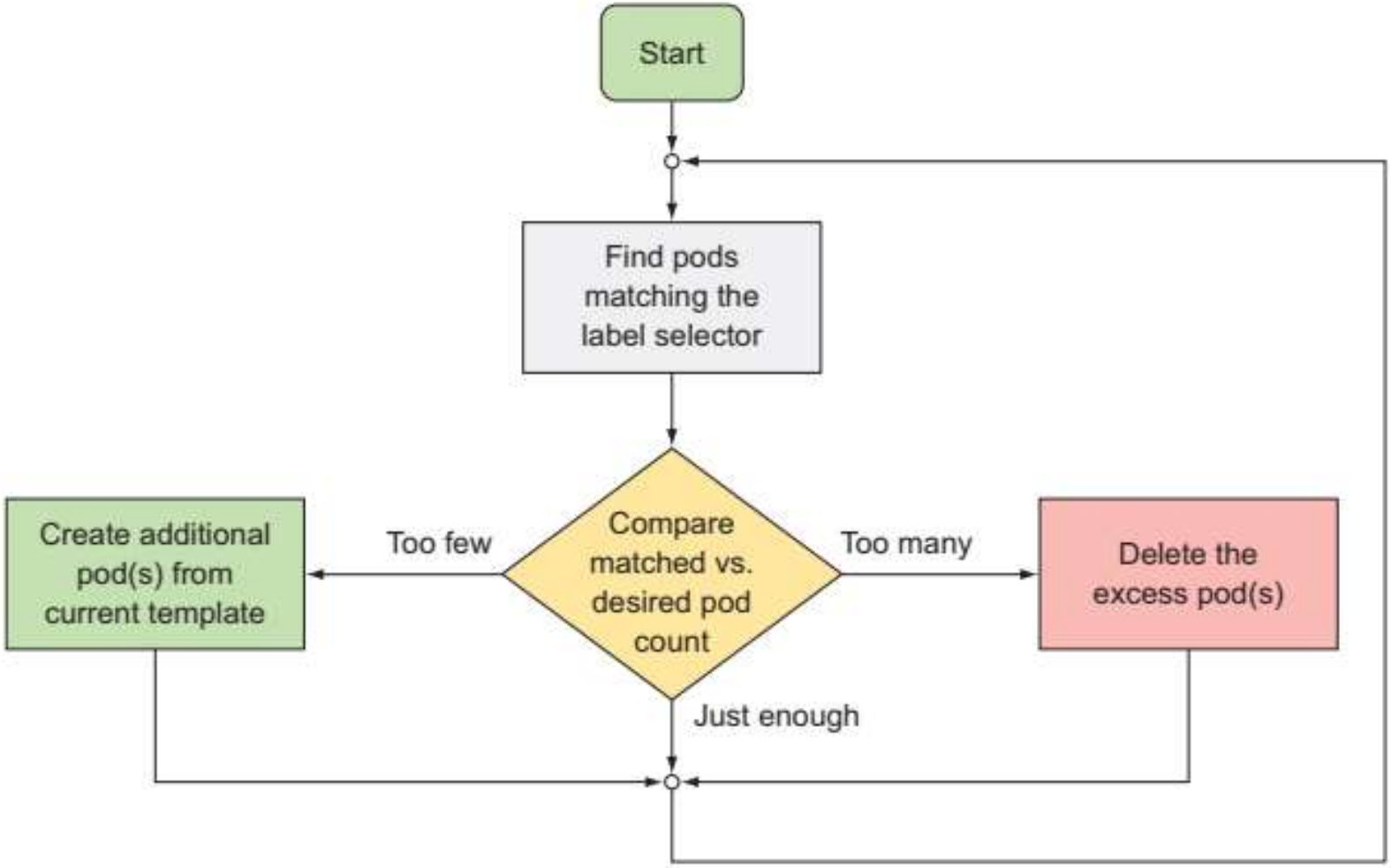


Figure 4.2 A ReplicationController's reconciliation loop

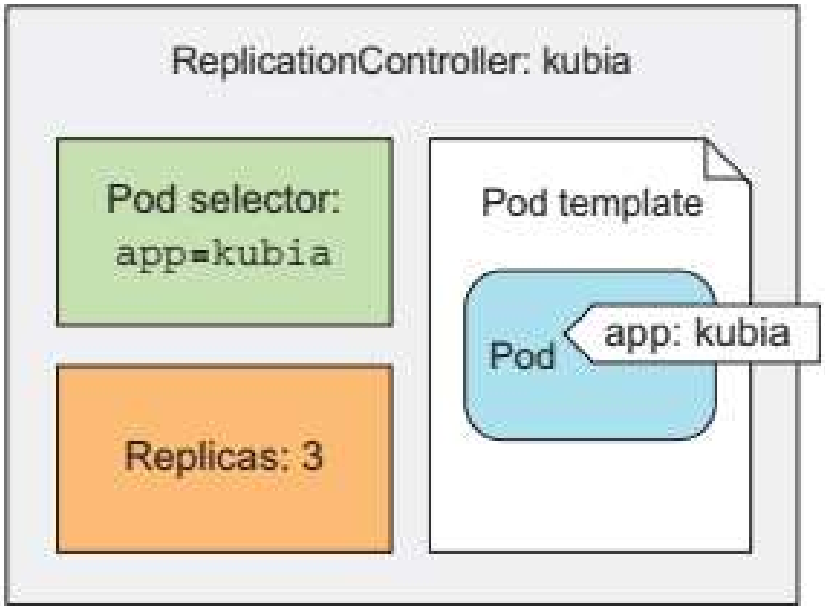


Figure 4.3 The three key parts of a ReplicationController (pod selector, replica count, and pod template)

Listing 4.4 A YAML definition of a ReplicationController: kubia-rc.yaml

```
apiVersion: v1
kind: ReplicationController
metadata:
  name: kubia
spec:
  replicas: 3
  selector:
    app: kubia

  template:
    metadata:
      labels:
        app: kubia
    spec:
      containers:
      - name: kubia
        image: luksa/kubia
        ports:
        - containerPort: 8080
```

This manifest defines a ReplicationController (RC)

The name of this ReplicationController

The desired number of pod instances

The pod selector determining what pods the RC is operating on

The pod template for creating new pods

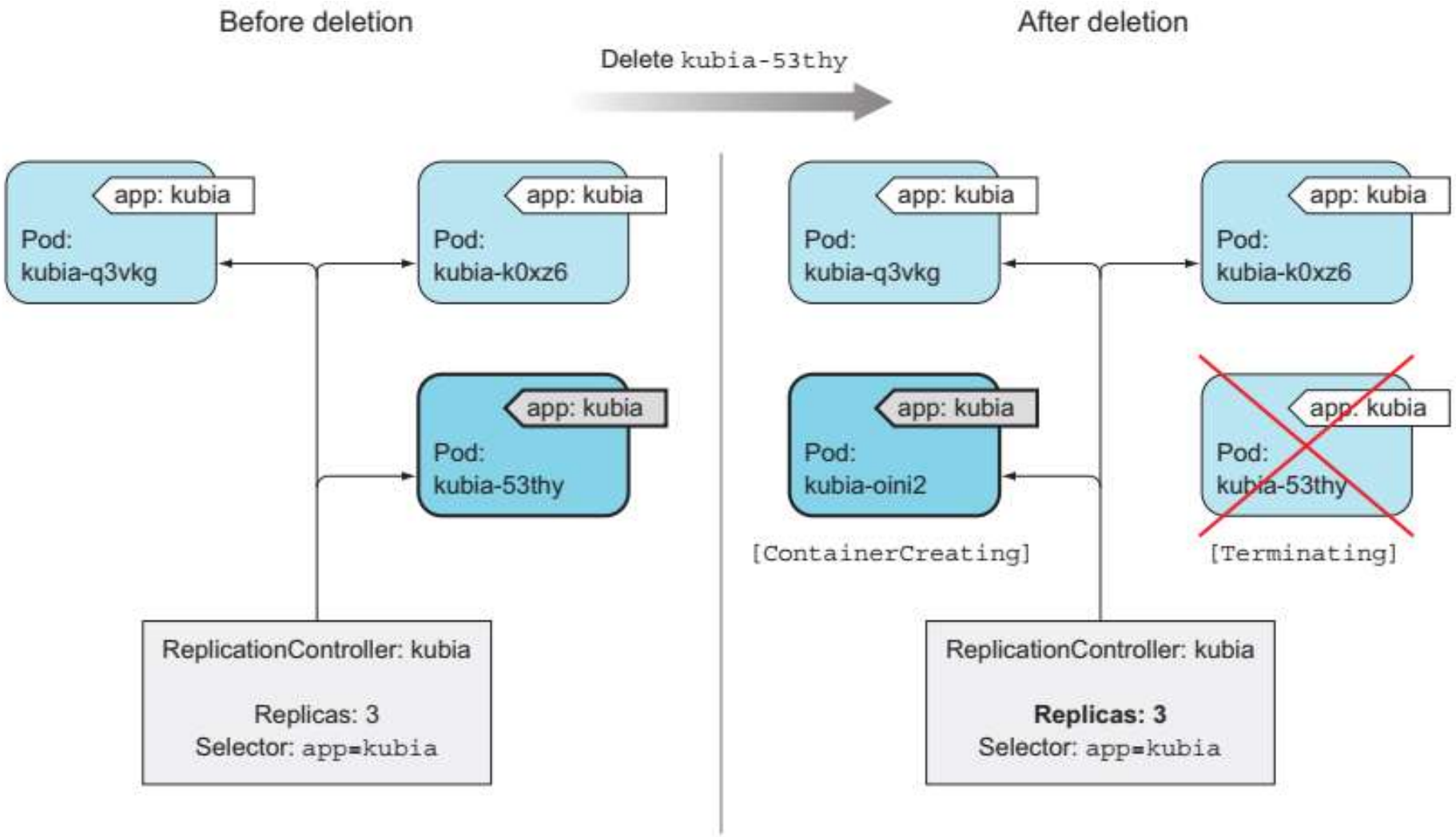


Figure 4.4 If a pod disappears, the ReplicationController sees too few pods and creates a new replacement pod.

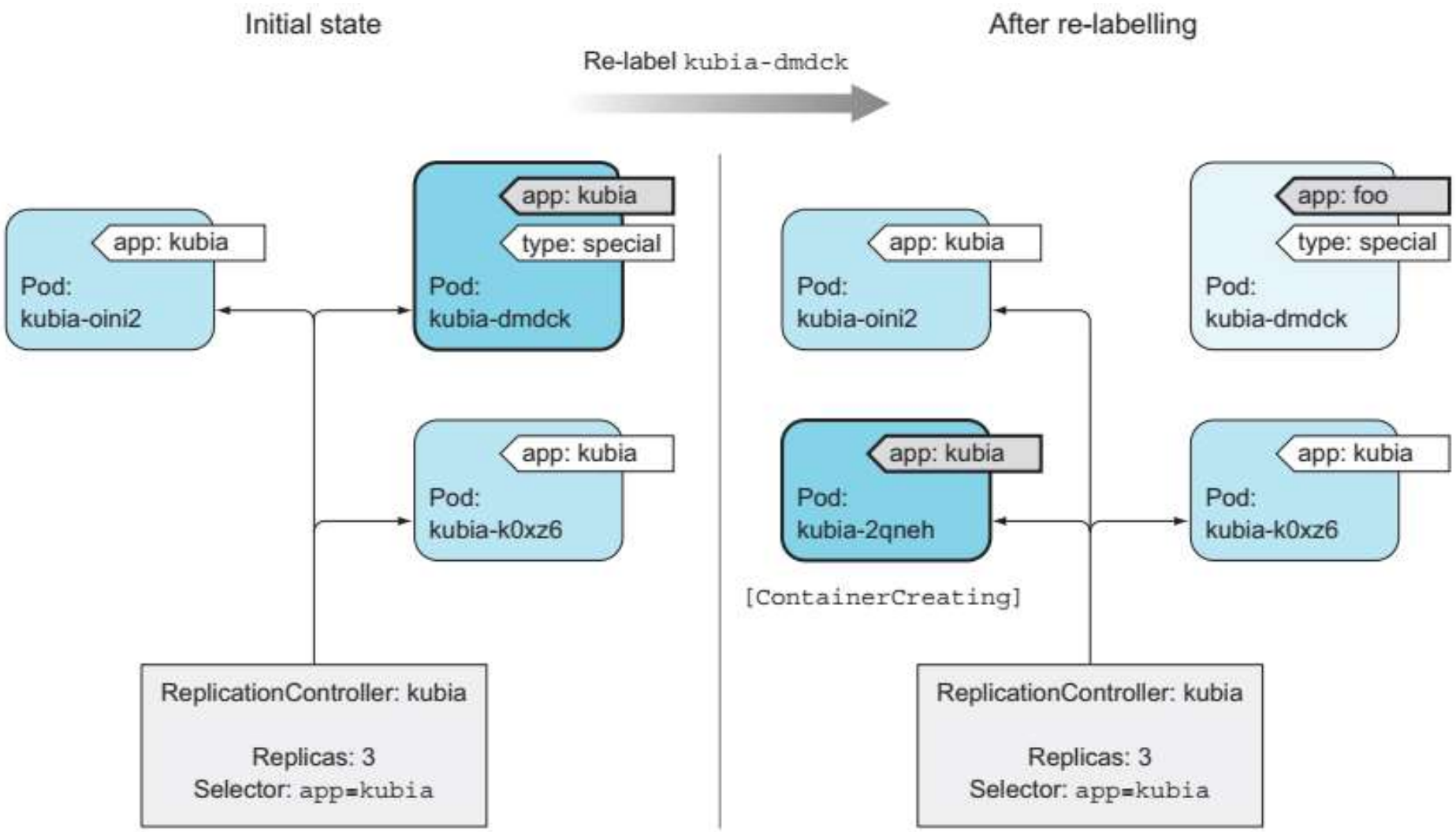


Figure 4.5 Removing a pod from the scope of a ReplicationController by changing its labels

Services

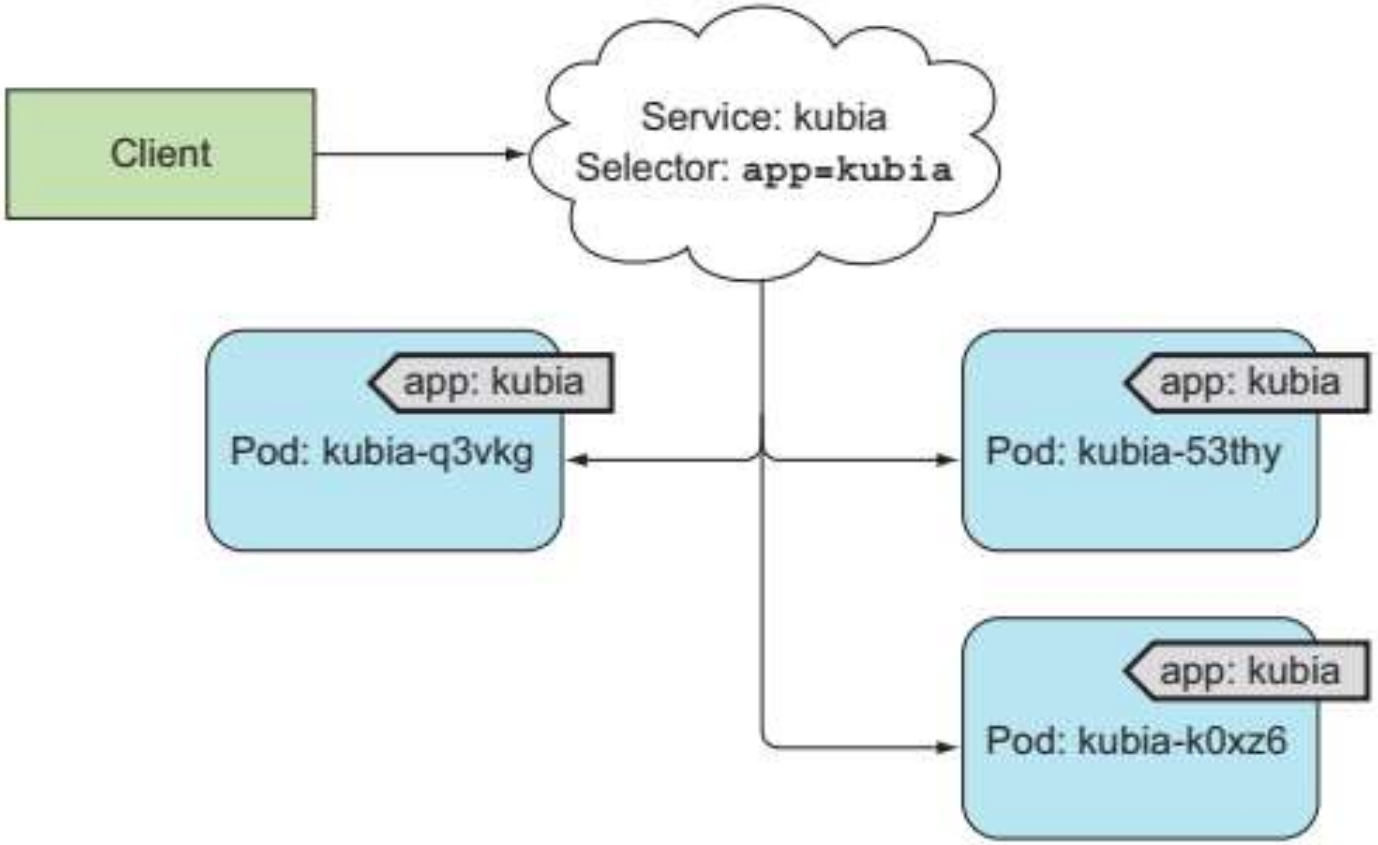


Figure 5.2 Label selectors determine which pods belong to the Service.

Listing 5.1 A definition of a service: kubia-svc.yaml

```
apiVersion: v1
kind: Service
metadata:
  name: kubia
spec:
  ports:
  - port: 80
    targetPort: 8080
  selector:
    app: kubia
```

The port this service will be available on

The container port the service will forward to

All pods with the app=kubia label will be part of this service.

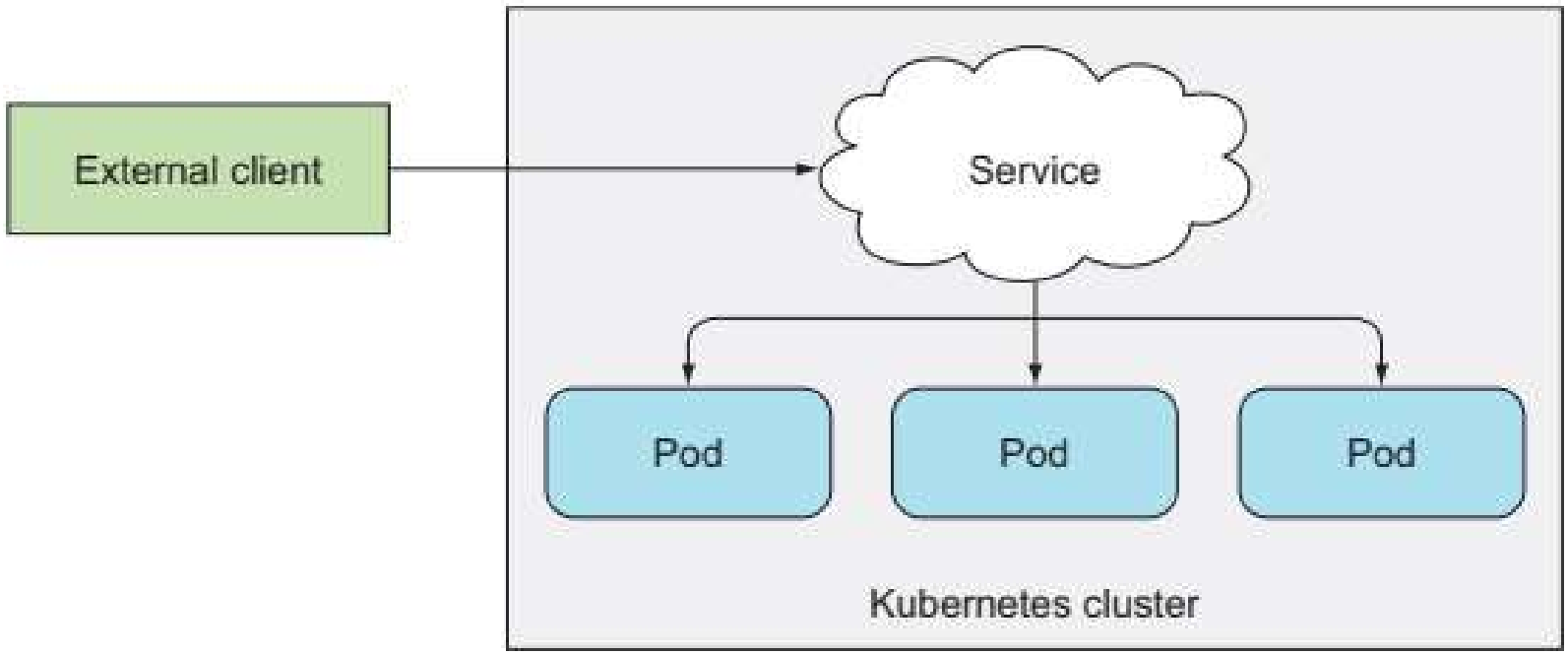
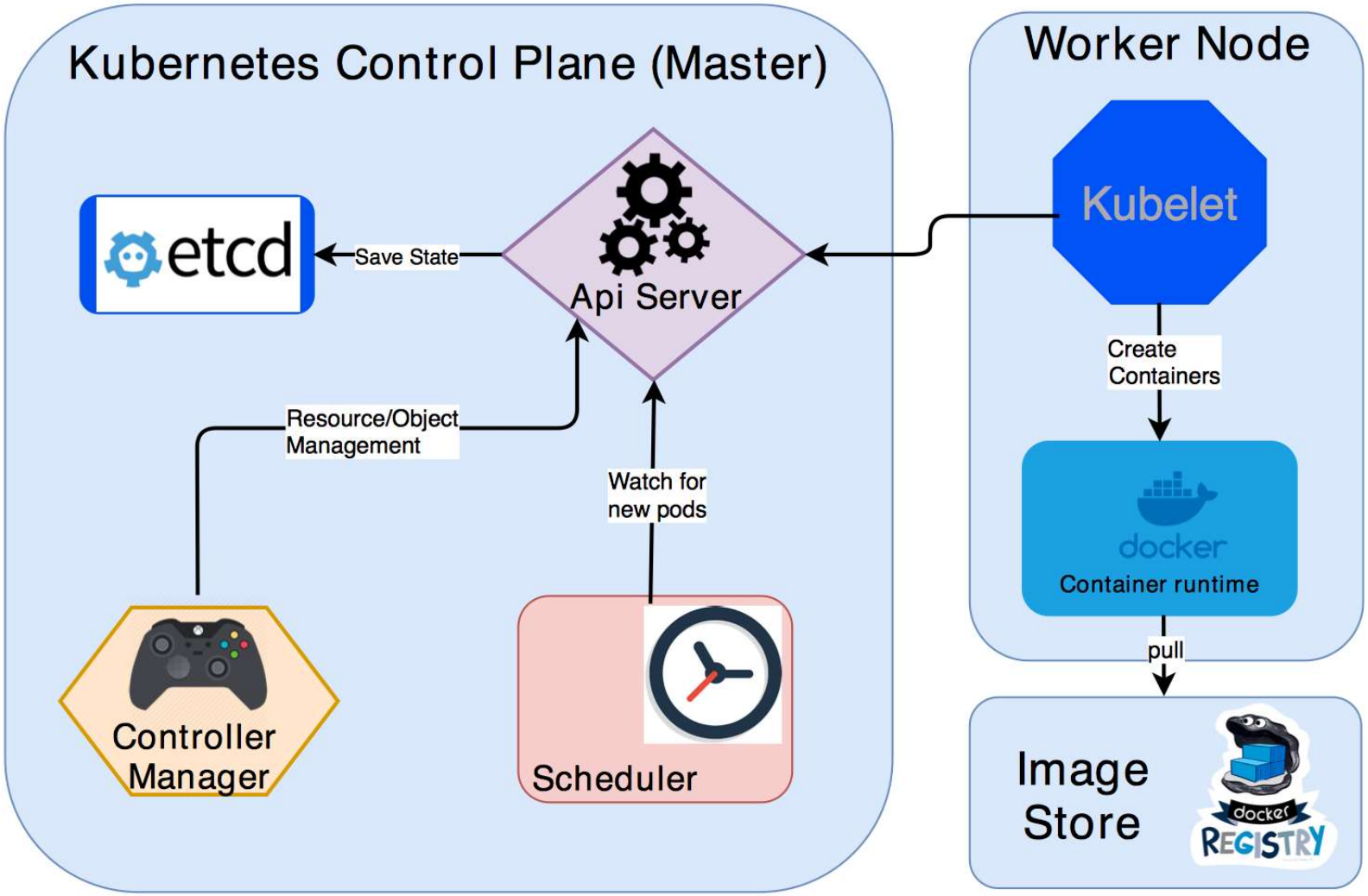


Figure 5.5 Exposing a service to external clients

Kubernetes Architecture



Kubernetes Architecture

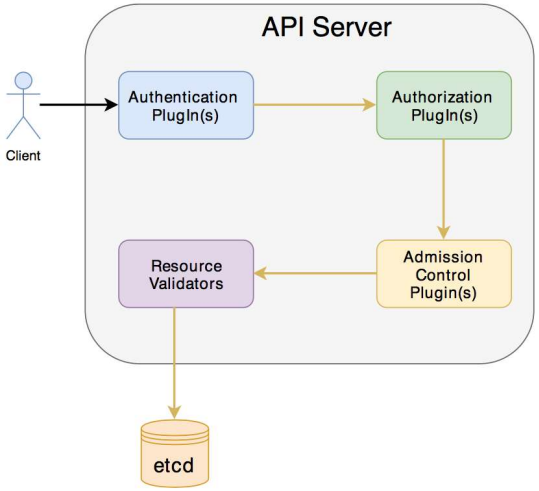
- A Kubernetes cluster consists of two main components:
  - Master (Control Plane)
  - Worker Nodes.
- Master has following components. These components are responsible for maintaining the state of the cluster:
  - etcd distributed key value store.
  - API Server.
  - Controller Manager
  - Scheduler
- Every worker node consists of the following components.
- These components are responsible for deploying and running the application containers.
  - Kubelet
  - Container Runtime (Docker)

Master Components

- etcd:
  - Stores the cluster status and metadata.
  - A distributed key value store
  - Provides reliable way of storing data across a cluster of machines.
  - API Server directly talk to etcd store.
  - K8s stores all its data under /registry directory in etcd.
- Api Server:
  - The central place for all other components.
  - Api Server will take care about validating the object before saving the information to etcd.
  - The client for the Api Server can be either kubectl (command line tool) or a Rest Api client.

Master Components

- Api Server:
  - Several plugin's are invoked by Api Server before creating/deleting/updating the object in etcd.
- Scheduler:
  - Allocate what node the pods needs to be created
- Controller Manager:
  - Make sure the actual state of the system converges towards the desired state.
  - Watch the API Server for changes to resources/objects and perform necessary actions like create/update/delete of the resource.



Worker Node components

- Kubelet
  - The agent that runs on each node in the cluster.
  - Monitors the Api Server for Pods
  - Start the pod’s containers by instructing to docker runtime.
  - Monitors the status of running containers and reports to api server
  - Also do health checks for the container and restart if needed.
- Docker
  - Container runtime used by Kubelet for spinning up Containers

Other components

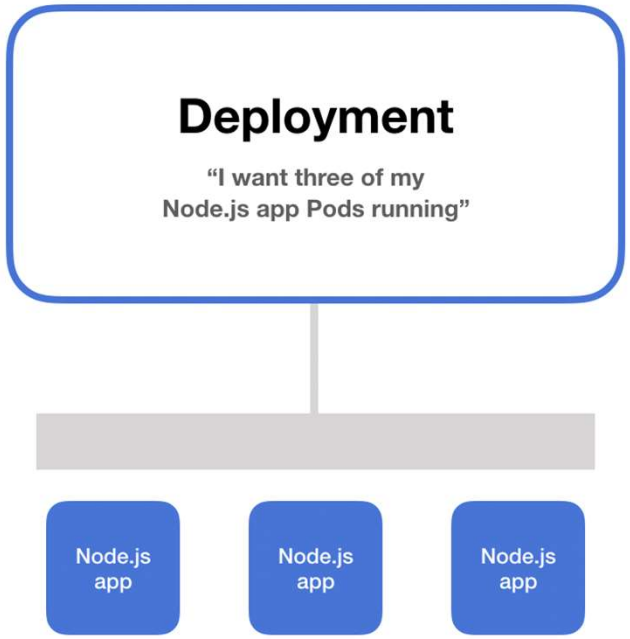
- Nodes:
  - Machine on which Kubernetes is installed.
  - This is where containers inside the pods will be launched by Kubernetes.
- Master Node:
  - Responsible for managing the cluster
  - A Kubernetes cluster also contains one or more master nodes that run the Kubernetes control plane
- Pod
  - Smallest deployable unit that can be managed by Kubernetes.
  - A logical group of one or more containers that share the same IP address

Kubernetes namespaces

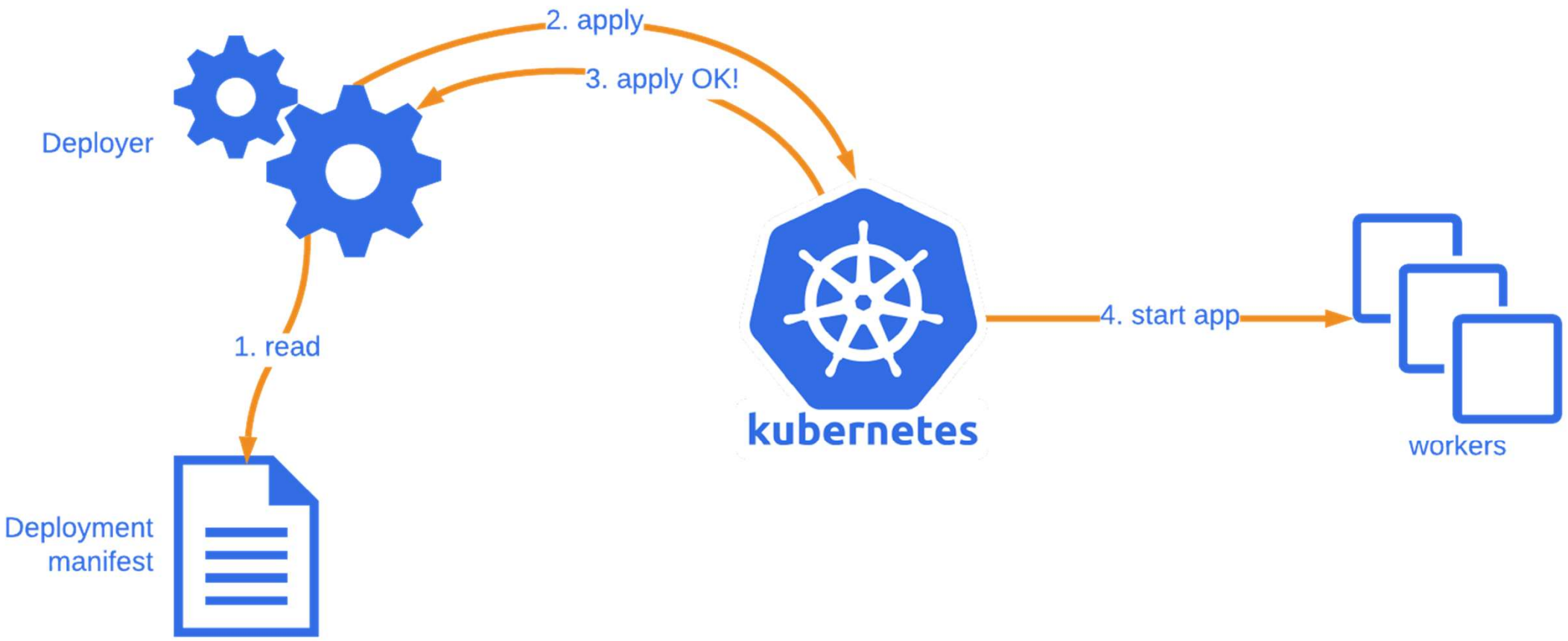
- Provide for a scope of Kubernetes resource, carving up your cluster in smaller units
  - $ kubectl get ns
  - $ kubectl describe ns default
  - $kubectl create namespace test

Kubernetes deployment

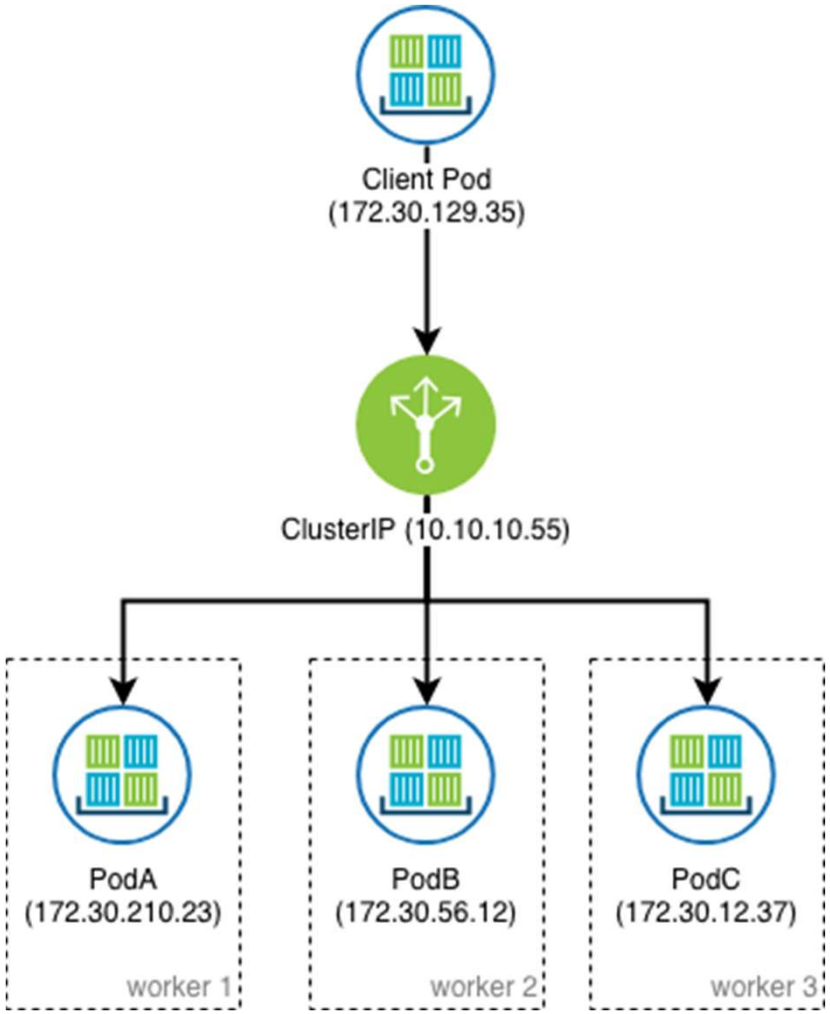
- Everyone running applications on Kubernetes cluster uses a deployment.
- It’s what you use to scale, roll out, and roll back versions of your applications.
- With a deployment, you tell Kubernetes how many copies of a Pod you want running. The deployment takes care of everything else.



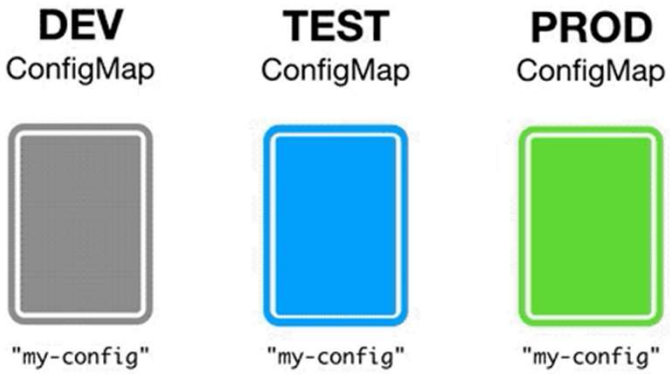
Kubernetes deployment



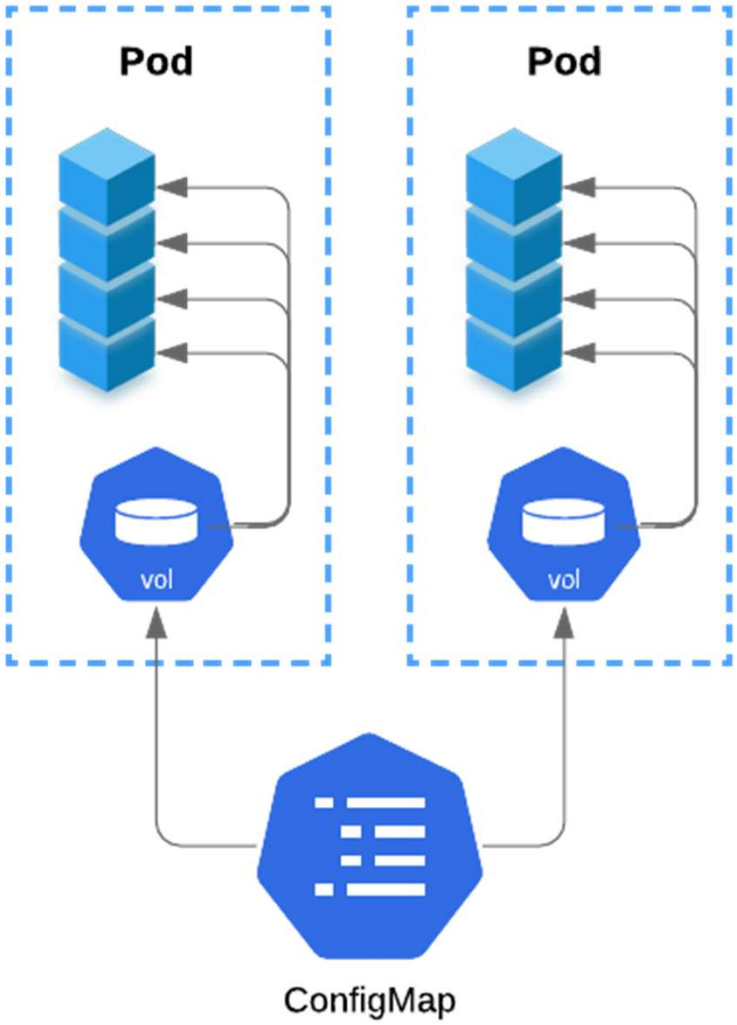
Service


Client Pod
(172.30.129.35)
ClusterIP (10.10.10.55)
PodA
(172.30.210.23)
worker 1
PodB
(172.30.56.12)
worker 2
PodC
(172.30.12.37)
worker 3

Config Map


DEV
ConfigMap
"my-config"
TEST
ConfigMap
"my-config"
PROD
ConfigMap
"my-config"

Config Map



Security Best Practices

Build-Time Security

Image Scanning

- Make sure that container images are free of vulnerabilities

Host Operating System Hardening

- Adequate controls to restrict system calls and file system access
- Have strong isolation between processes.

Minimizing the Attack Surface: Base Container Images

- Use an image with the minimal software packages

Deploy-Time Security

Harden Your Kubernetes Clusters

- Review current configuration and identify gaps with security best practices
- Set up Role Based Access Control (RBAC) to define access to the cluster

Integrating Security Tools with Kubernetes Clusters

Secure etcd

Runtime Security

Network Security Controls

- Kubernetes-native network policy solution - Calico

Enterprise Security Controls

- Encrypt data in transit
- Automate compliance reports
- Aim for continuous compliance

Threat Defence

- Aggregate by pods
  - Group together “similar” pods communicating on a certain port
- Leverage machine learning
- Use threat intelligence
  - Leverage databases of known malicious IPs and domains to identify malicious traffic in your cluster

Kubernetes Security Fundamentals

Network Policy

- Like a virtual firewall set up within each pod
- Pod accepts or rejects network traffic according to the policy

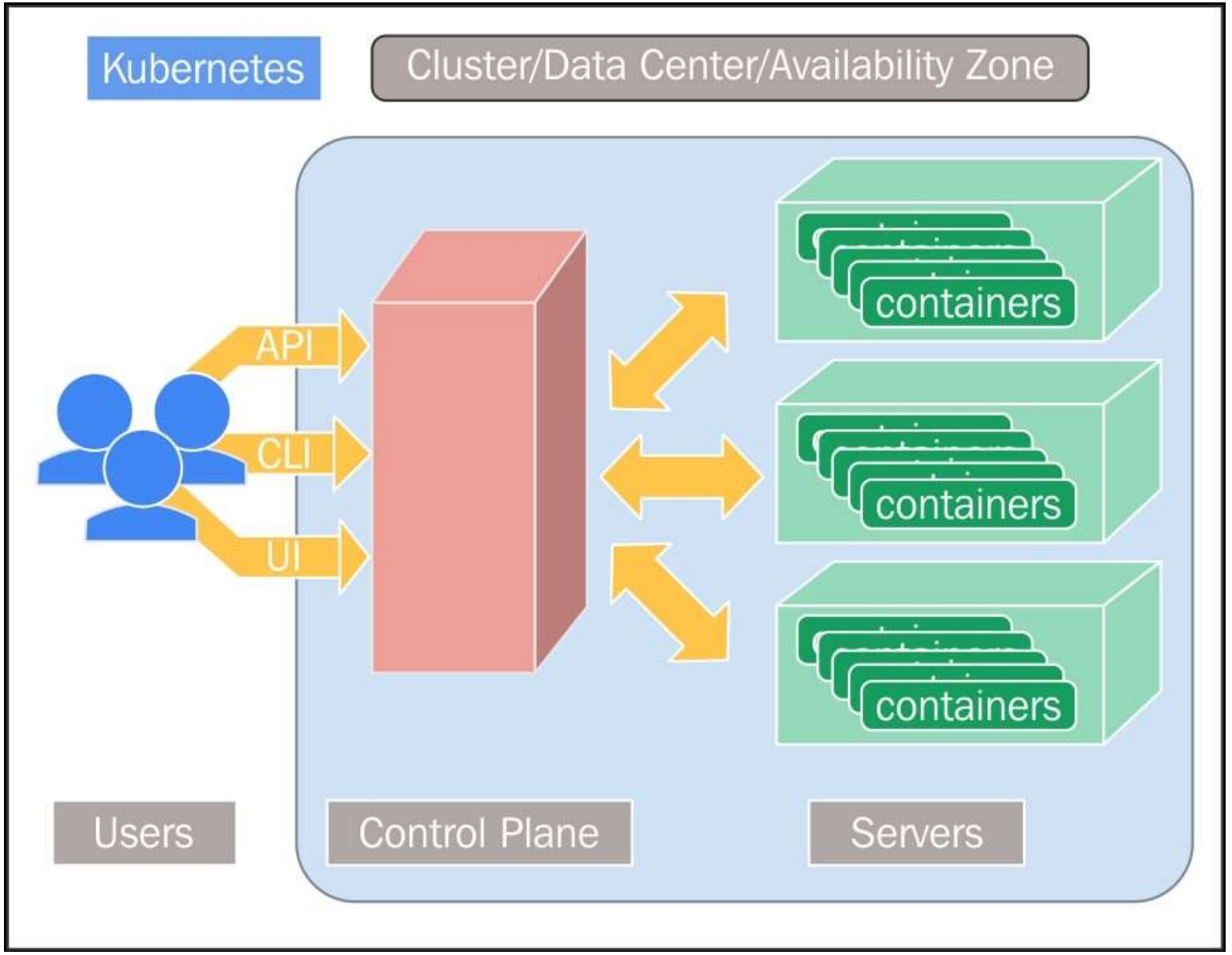
Kubernetes Secrets

Kubernetes RBAC

Authentication

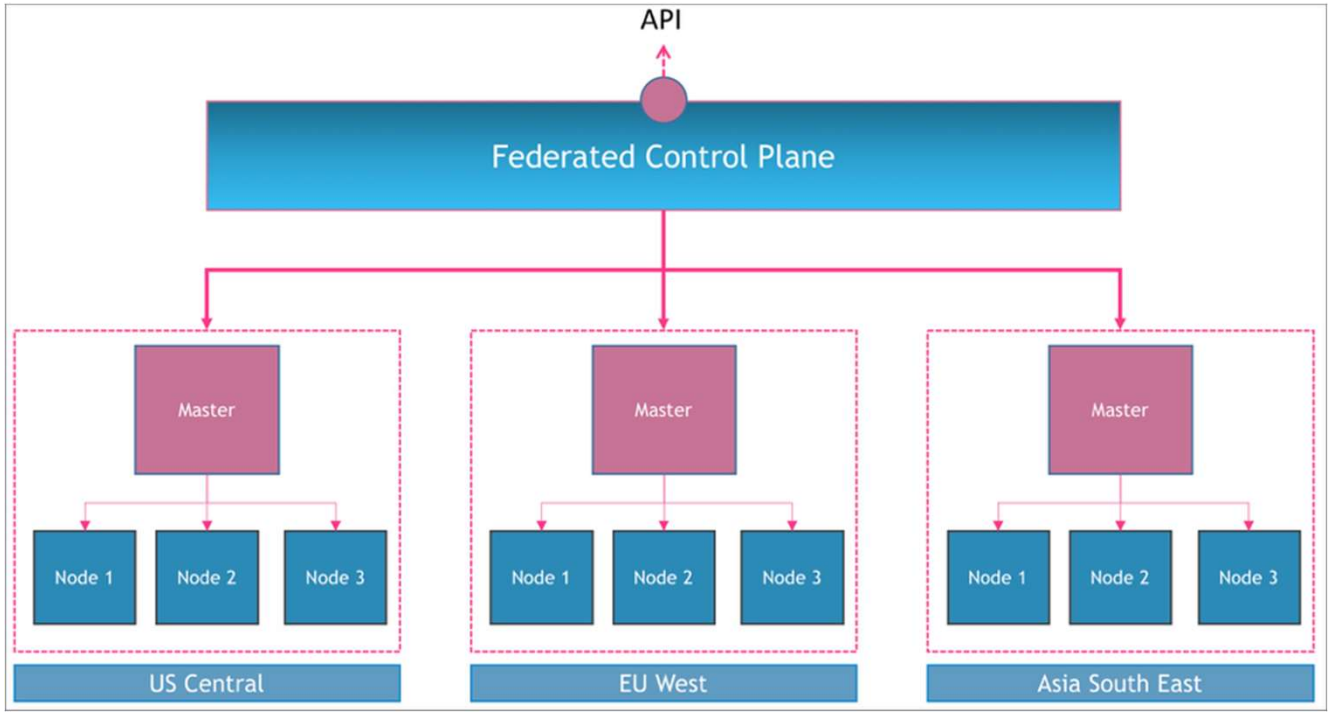
TLS For Kubernetes Ingress

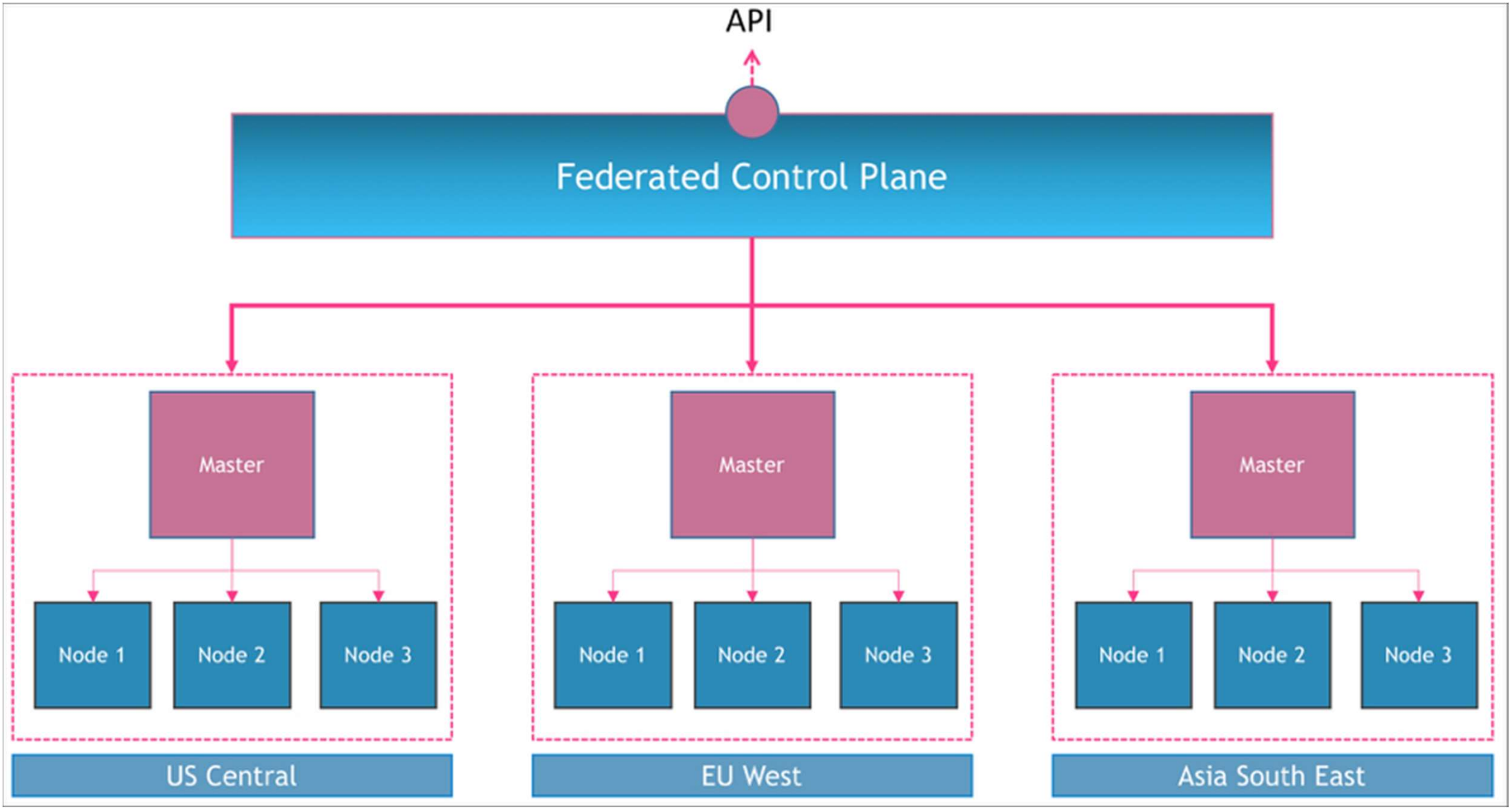
Kubernetes Federation

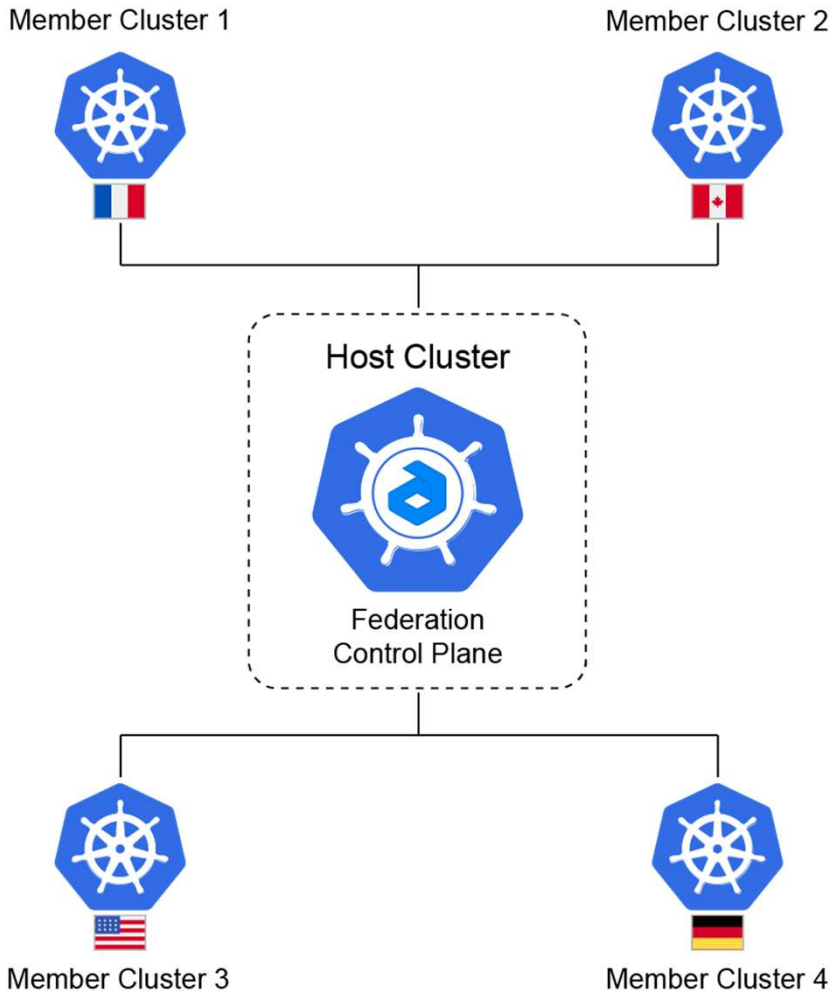

Kubernetes
Cluster/Data Center/Availability Zone
API
CLI
UI
containers
containers
containers
Users
Control Plane
Servers

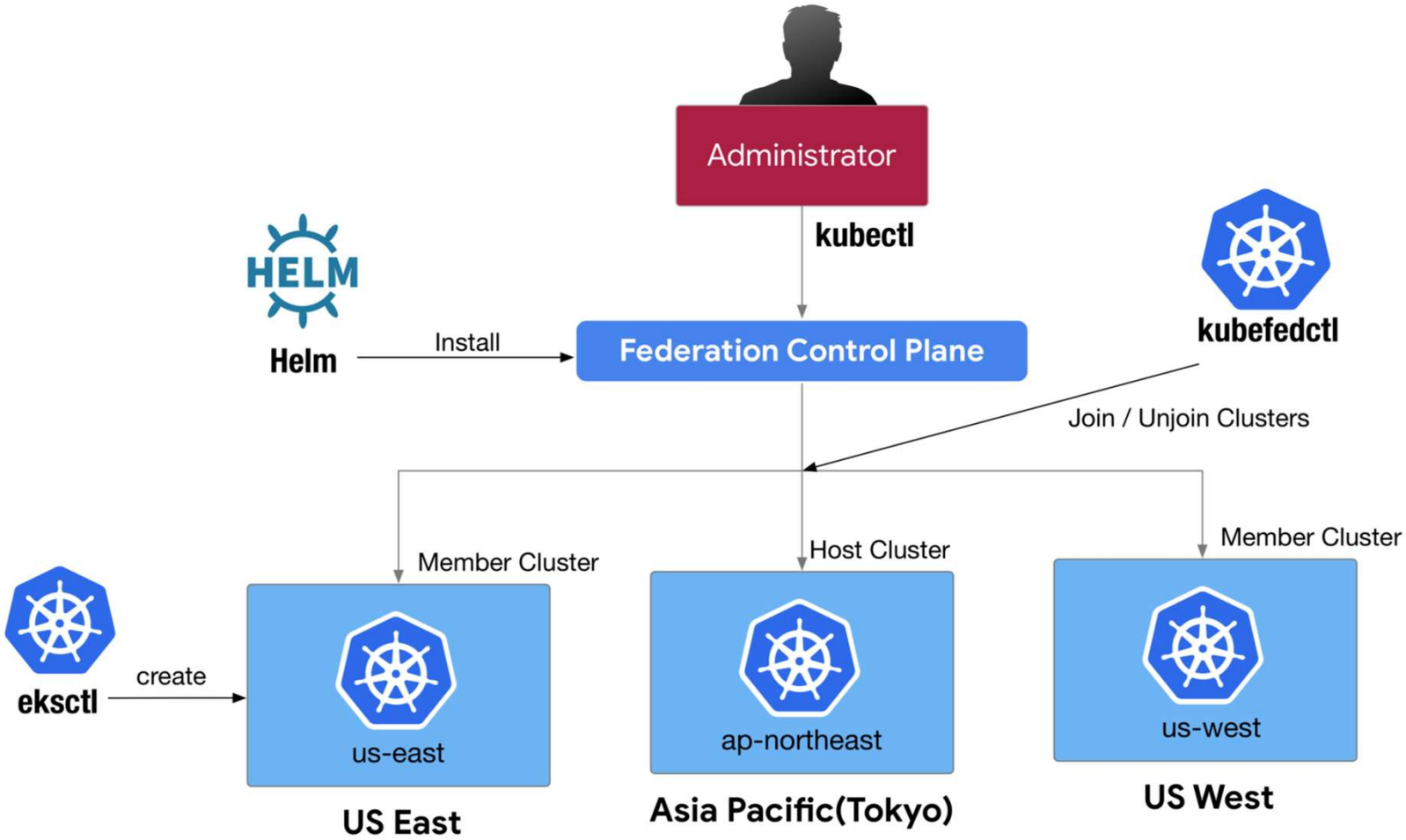
What is Kubernetes Cluster Federation?

- Enables the loose coupling of multiple independent Kubernetes clusters.
- To aggregate the resources and services of multiple clusters into a single, logical entity
- Keeps each cluster isolated and independent.




API
Federated Control Plane
Master
Master
Master
Node 1
Node 2
Node 3
Node 1
Node 2
Node 3
Node 1
Node 2
Node 3
US Central
EU West
Asia South East


Member Cluster 1
Member Cluster 2
Host Cluster
Federation
Control Plane
Member Cluster 3
Member Cluster 4


Administrator
kubectl
HELM
Helm
Install
Federation Control Plane
kubefedctl
Join / Unjoin Clusters
Member Cluster
Host Cluster
Member Cluster
eksctl
create
us-east
ap-northeast
us-west
US East
Asia Pacific(Tokyo)
US West

Thanks