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KUBERNETES PATTERNS

Roland Huß, Red Hat, @ro14nd

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"**m**" for menu, "**?**" for other shortcuts

AGENDA

- Kubernetes
- Patterns
- Categories:
  - Foundational Patterns
  - Structural Patterns
  - Configurational Patterns
  - Advanced Patterns

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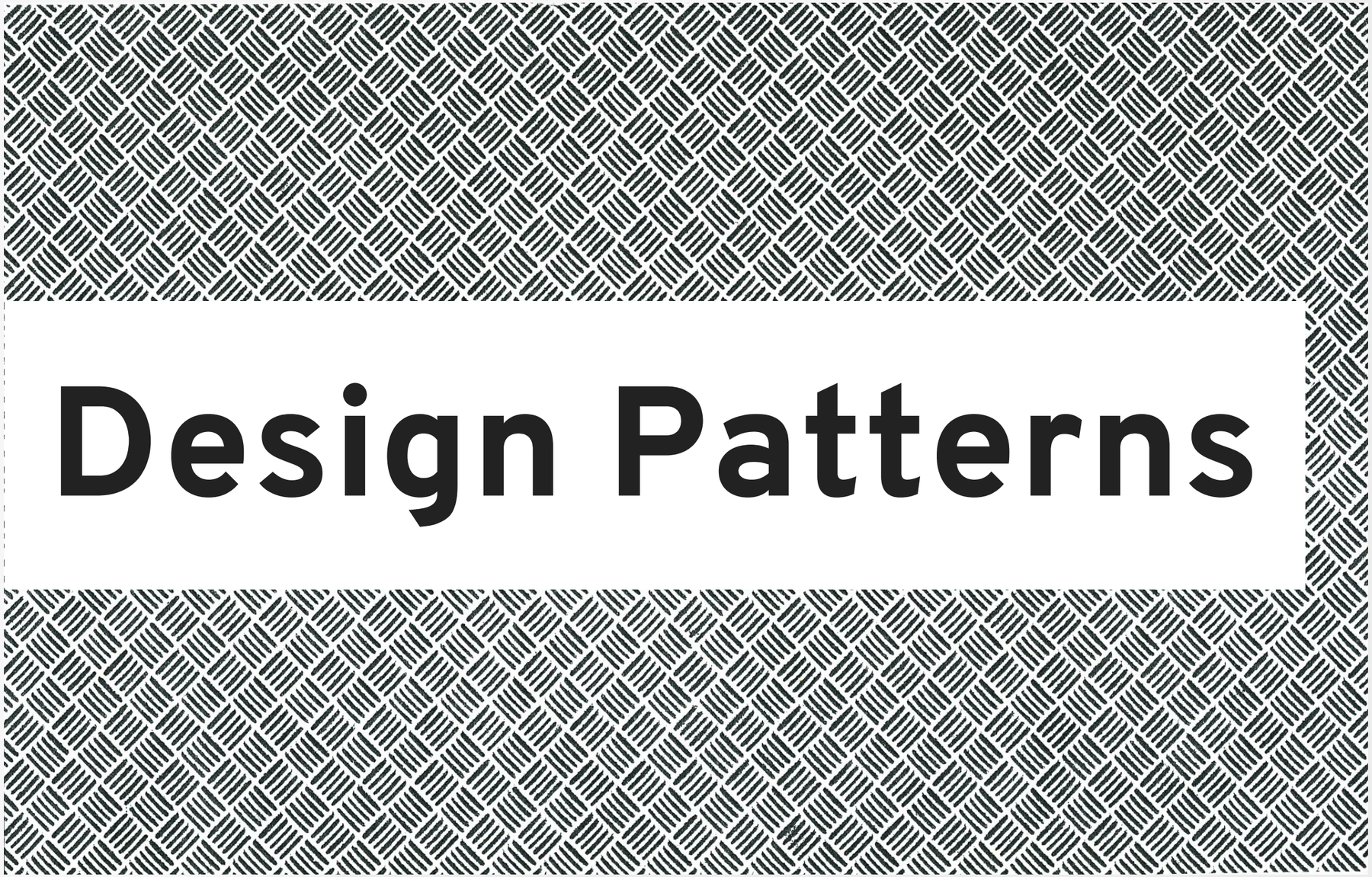
KUBERNETES

- Open Source container orchestration system
  - Scheduling
  - Horizontal scaling
  - Self-healing
  - Service discovery
  - Rollout and Rollbacks
- Declarative, resource-centric REST API



DESIGN PATTERN

A **Design Pattern** describes a **repeatable solution** to a software engineering **problem**.

A Pattern Language

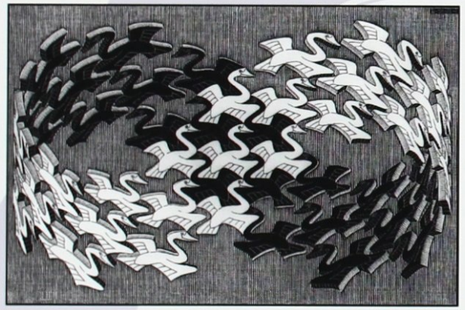
Towns · Buildings · Construction

Christopher Alexander
Sara Ishikawa · Murray Silverstein
WITH
Max Jacobson · Ingrid Fiksdahl-King
Shlomo Angel

Design Patterns

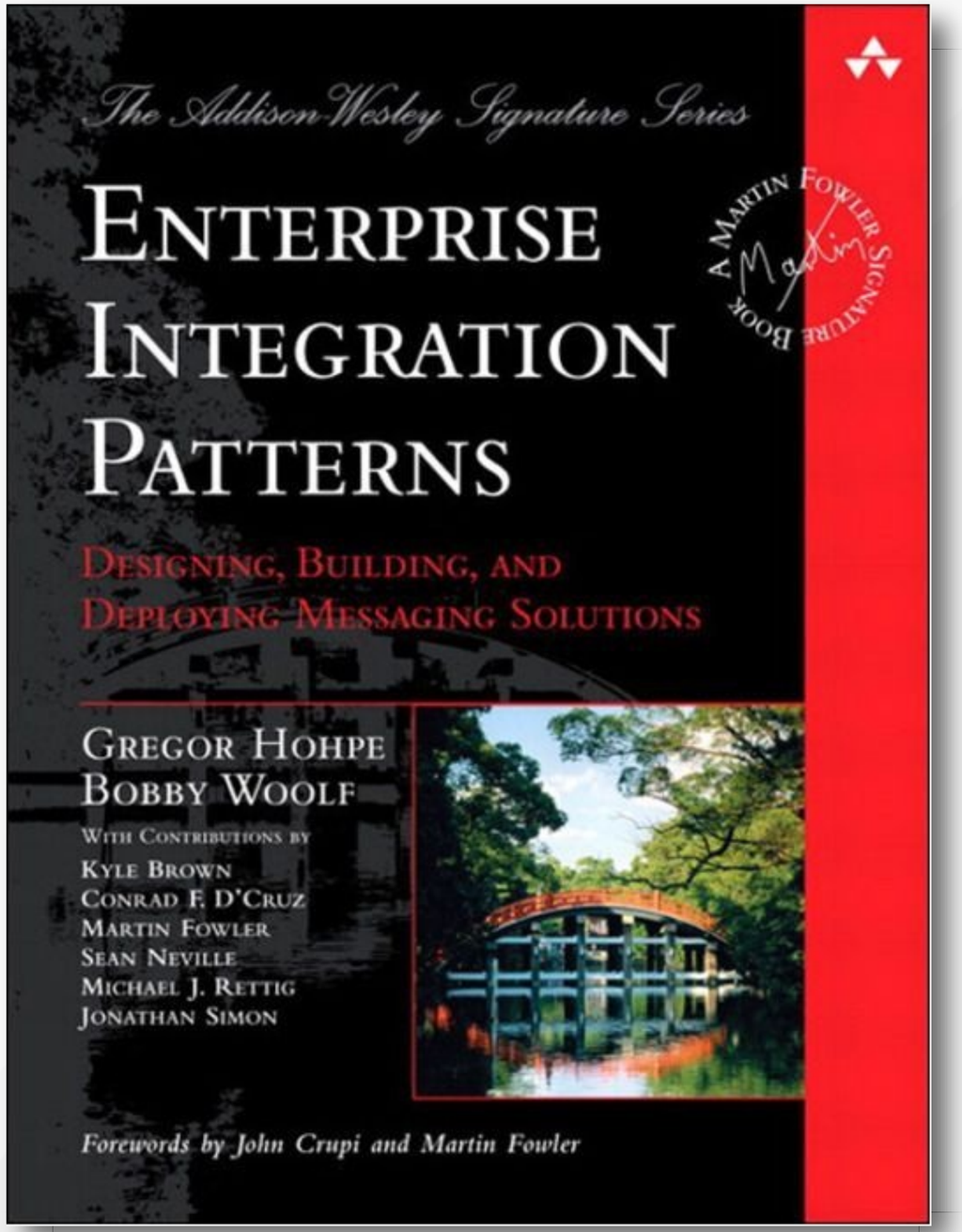
Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides

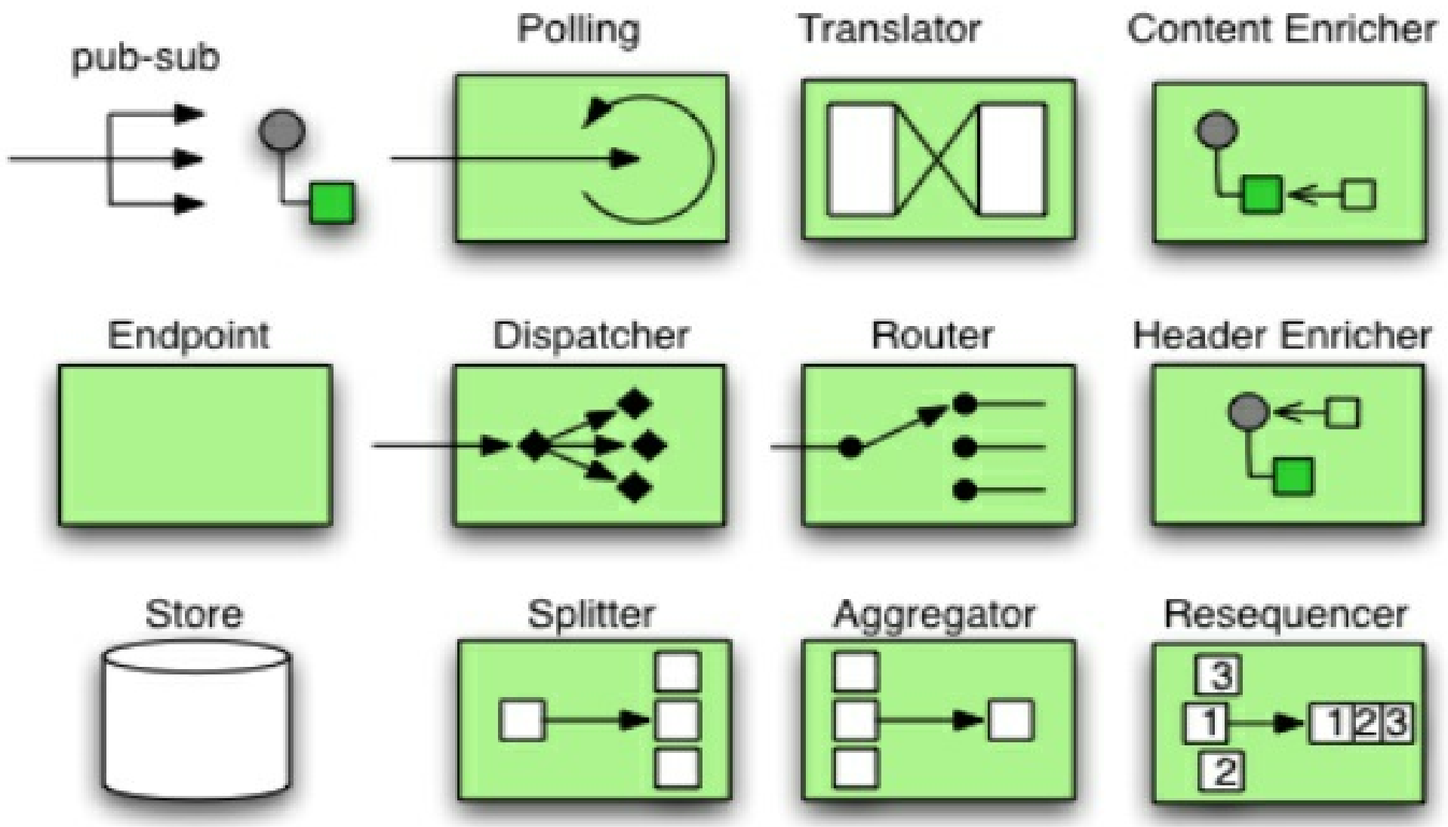


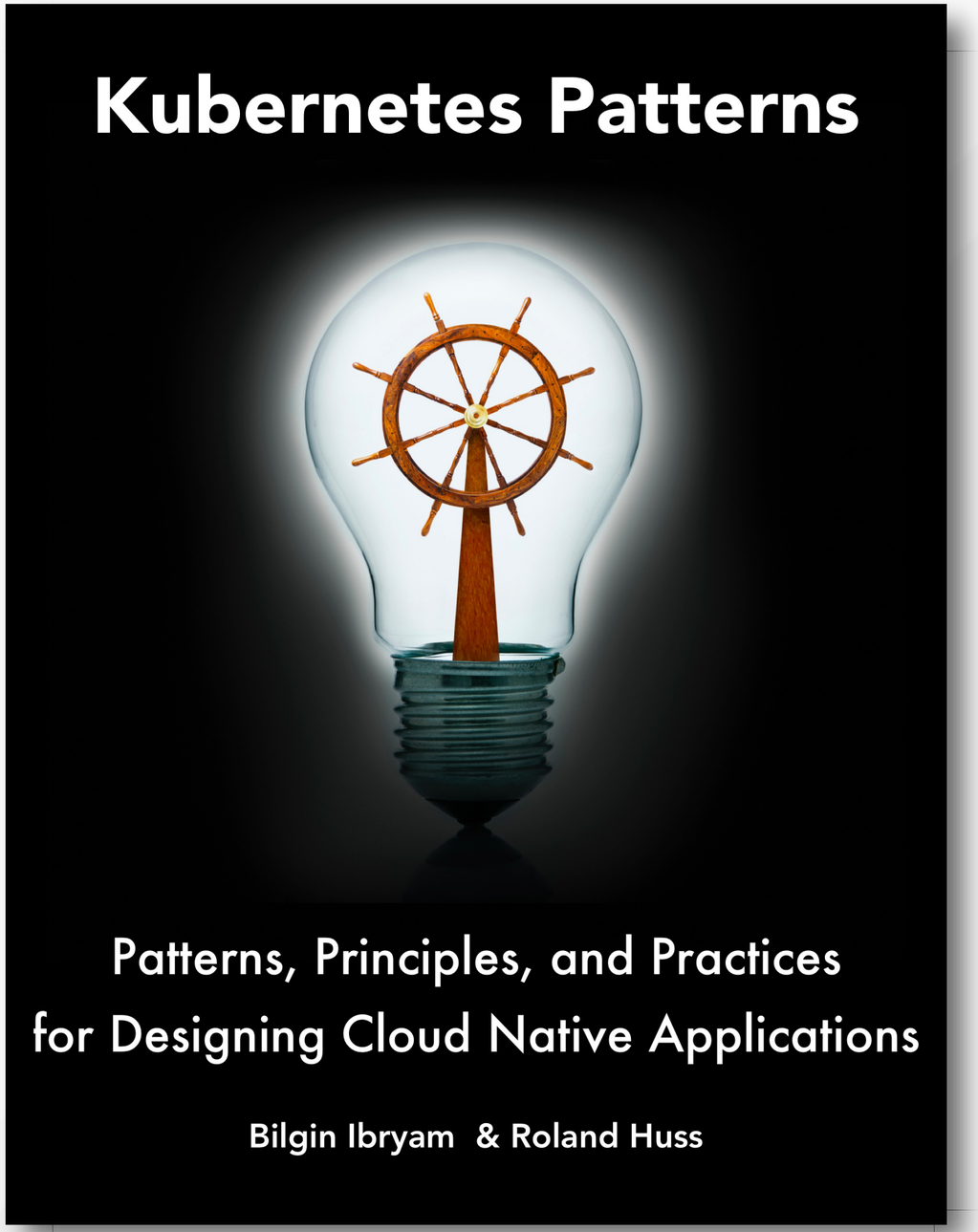
Foreword by Grady Booch

ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES


The Addison-Wesley Signature Series
A Martin Fowler Signature Book
Enterprise Integration Patterns
Designing, Building, and Deploying Messaging Solutions
Gregor Hohpe
Bobby Woolf
With Contributions by
Kyle Brown
Conrad F. D'Cruz
Martin Fowler
Sean Neville
Michael J. Rettig
Jonathan Simon
Forewords by John Crupi and Martin Fowler

Enterprise Integration Pattern





https://leanpub.com/k8spatterns

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STRUCTURE

- Problem
- Patterns:
  - Name
  - Solution
- http://www.martinfowler.com/articles/writingPatterns.html

FOUNDATIONAL PATTERNS

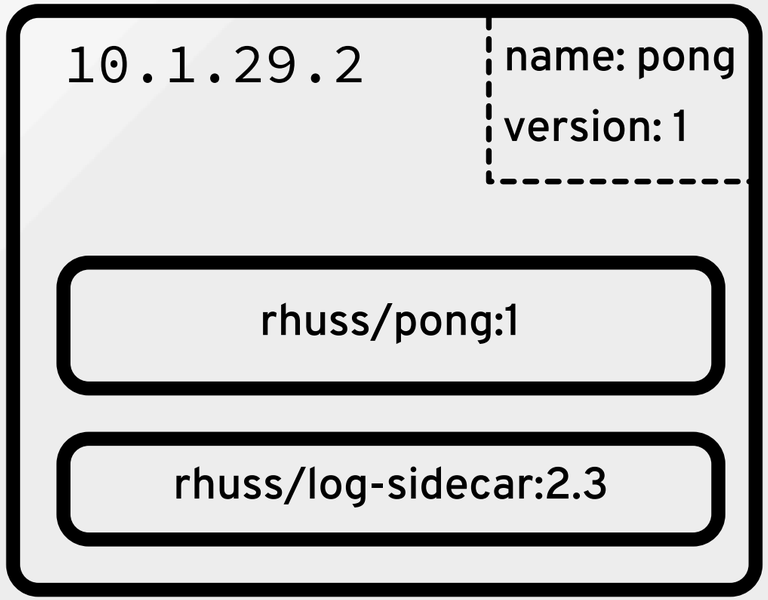
Automatable Unit

How can we create and manage applications with Kubernetes ?

- **Pods**: Atomic unit of containers
- **Services**: Entry point to pods
- Grouping via **Labels**, **Annotations**, **Namespaces**

POD

- Kubernetes Atom
- One or more containers sharing:
  - IP and ports
  - Volumes
- Ephemeral IP address

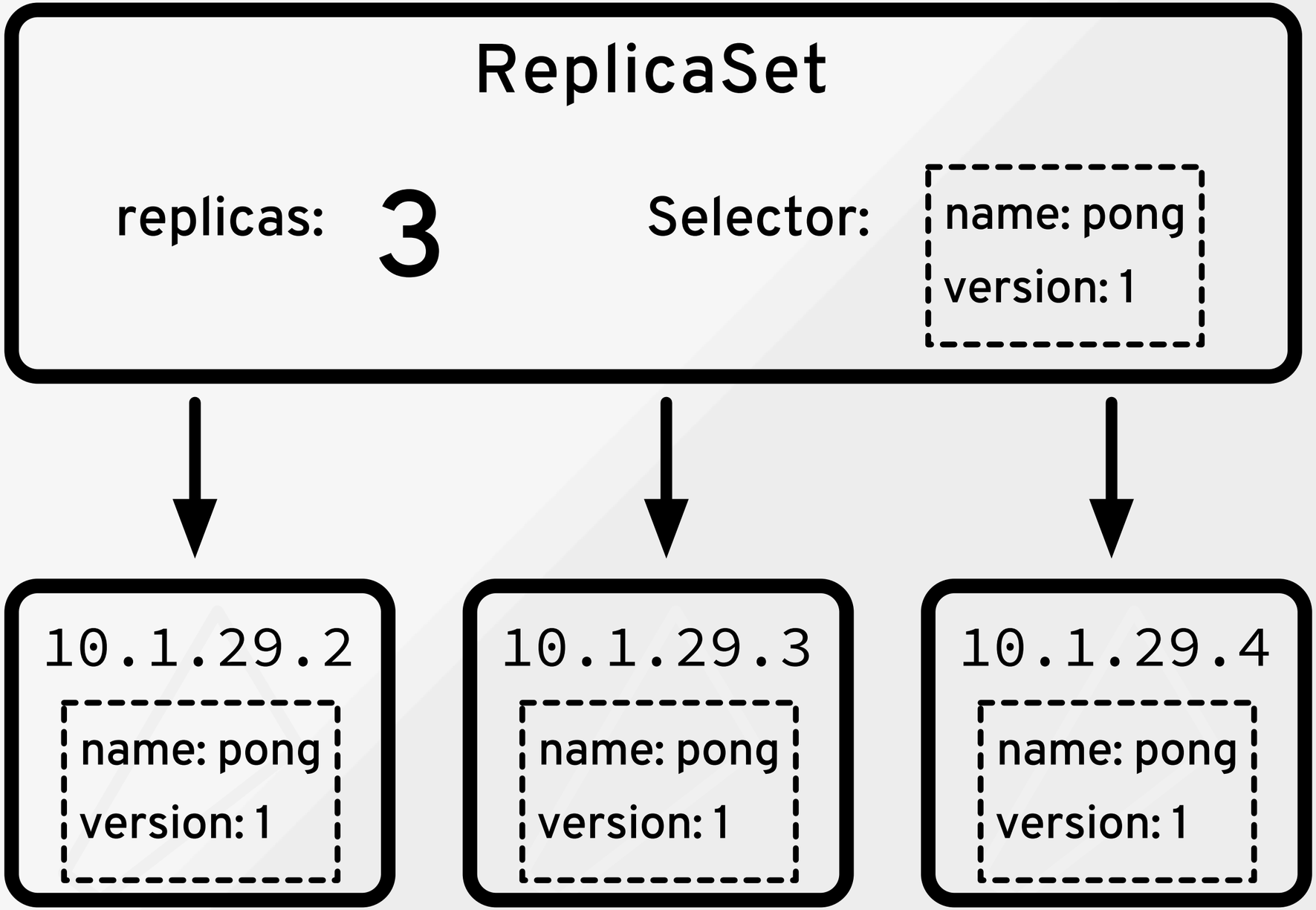


POD DECLARATION

```
apiVersion: v1
kind: Pod
metadata:
  name: pong
  labels:
    name: pong
    version: "1"
spec:
  containers:
  - image: "rhuss/pong:1"
    name: pong
    ports:
    - containerPort: 8080
  - image: "rhuss/log-sidecar:2.3"
    name: log
```

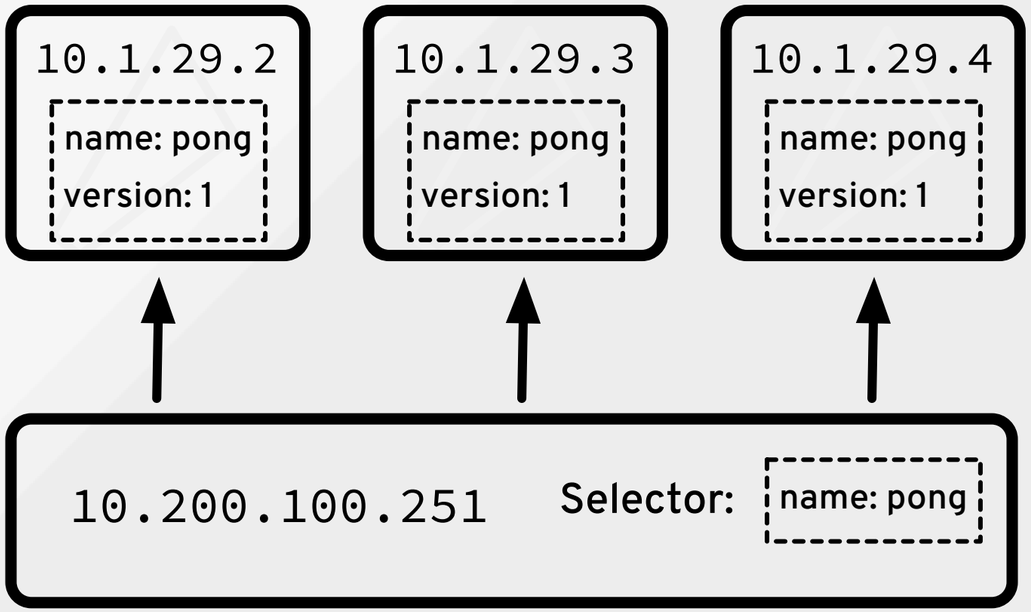
REPLICA SET

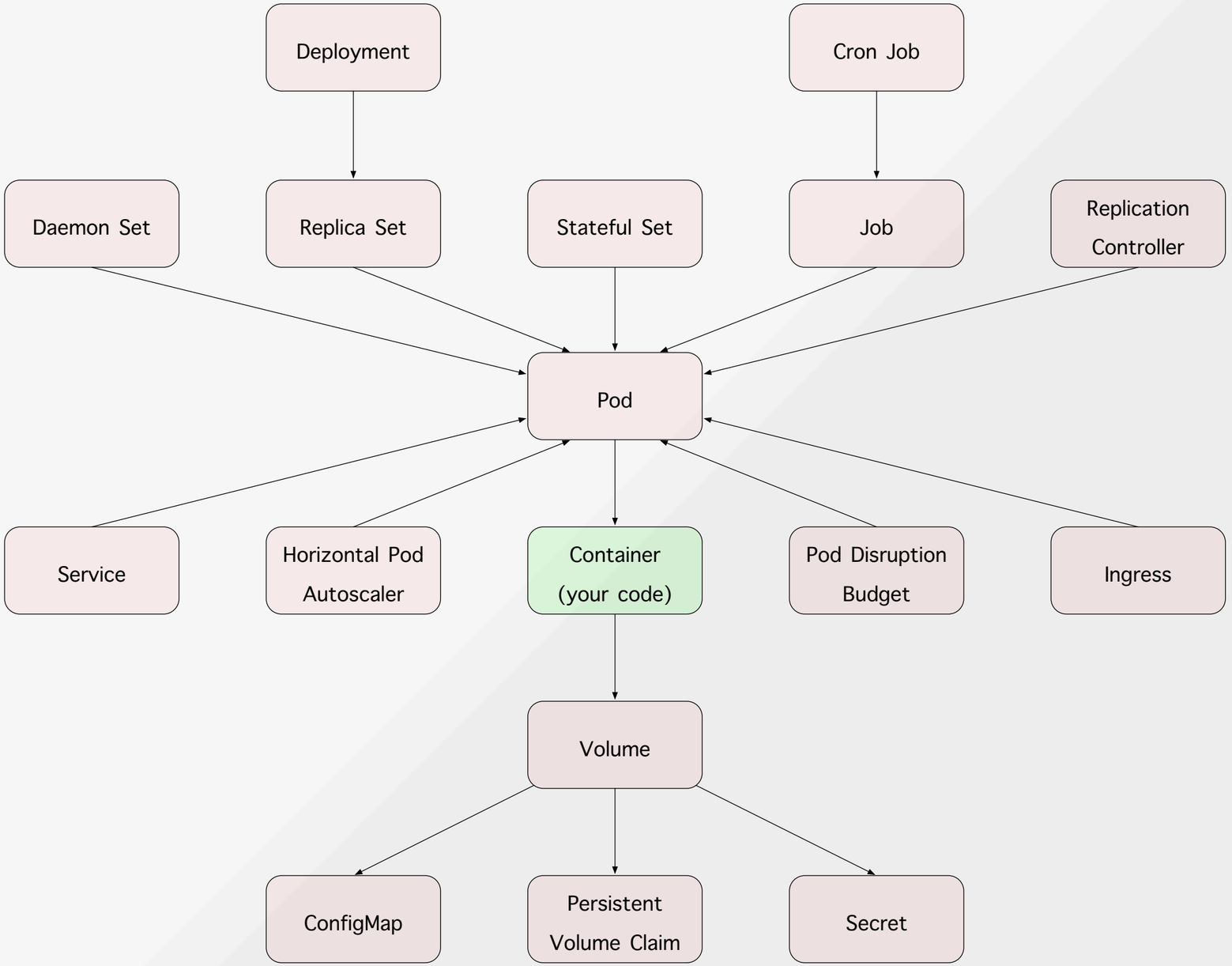
- Responsible for managing **Pods**
- `replicas` : Number of **Pod** copies to keep
- Label selector chooses **Pods**
- Holds a template for creating new **Pods**


ReplicaSet
replicas: 3
Selector:
name: pong
version: 1
10.1.29.2
name: pong
version: 1
10.1.29.3
name: pong
version: 1
10.1.29.4
name: pong
version: 1

SERVICE

- Entrypoint for a set of **Pods**
- **Pods** chosen by **Label** selector
- Permanent IP address




Deployment
Cron Job
Daemon Set
Replica Set
Stateful Set
Job
Replication Controller
Pod
Service
Horizontal Pod Autoscaler
Container (your code)
Pod Disruption Budget
Ingress
Volume
ConfigMap
Persistent Volume Claim
Secret

Predictable Demands

How can we handle resource requirements deterministically ?

- Requirements should be declared to help in:
  - Matching infrastructure services
  - Scheduling decisions
  - Capacity planning

RUNTIME DEPENDENCIES

- Persistent Volumes
- Host ports
- Configuration via `ConfigMaps` and `Secrets`

RESOURCE PROFILES

- Resources:
  - CPU, Network (compressible)
  - Memory (incompressible)
- App: Declaration of resource **requests** and **limits**
- Platform: Resource quotas and limit ranges

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: http-server
spec:
  containers:
  - image: nginx
    name: nginx
    resources:
      requests:
        cpu: 200m
        memory: 100Mi
      limits:
        cpu: 300m
        memory: 200Mi
```

QOS CLASSES

- **Best Effort**
  - No `requests` or `limits`
- **Burstable**
  - `requests` < `limits`
- **Guaranteed**
  - `requests` == `limits`

Declarative Deployment

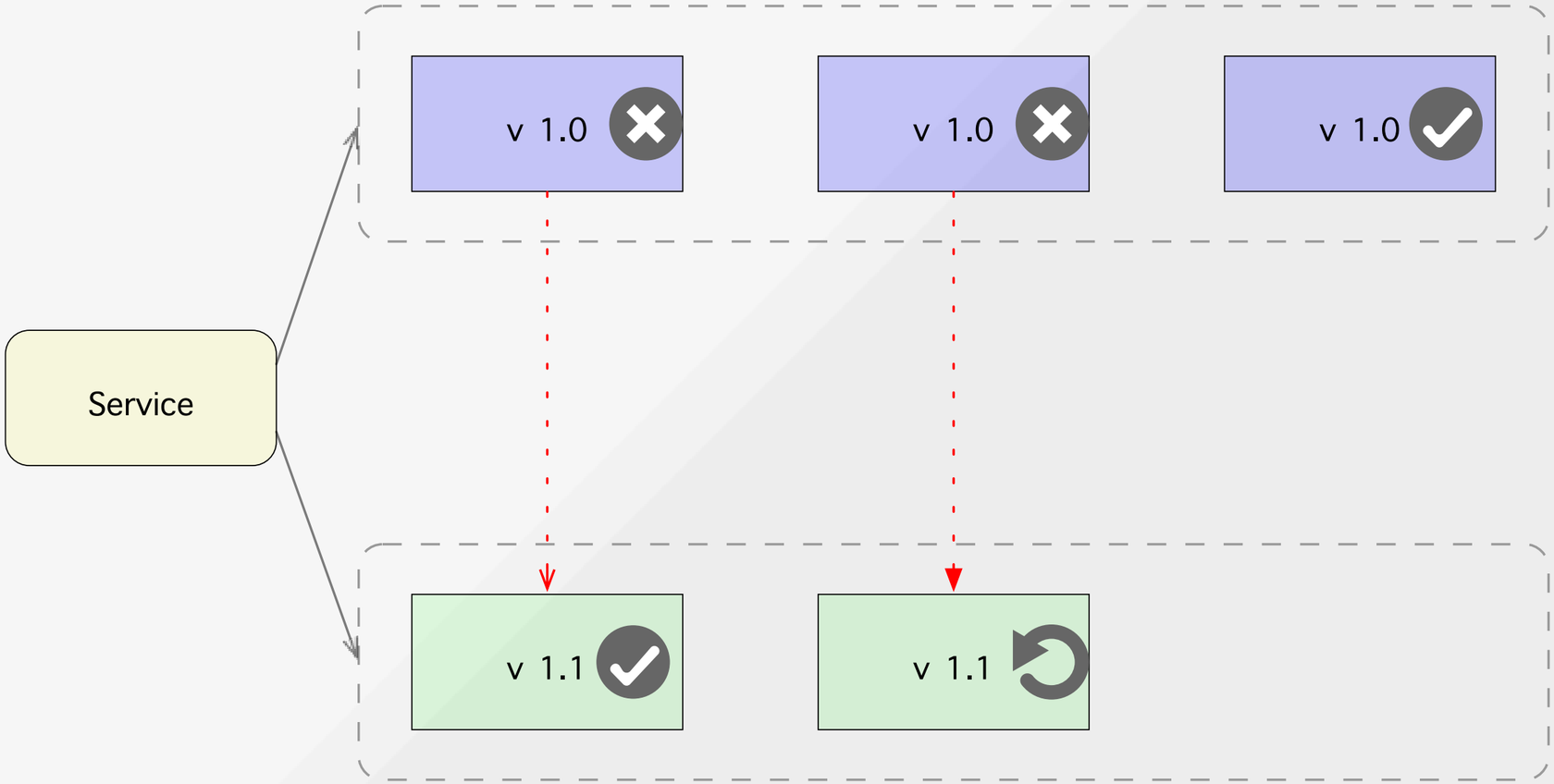
How can applications be deployed and updated ?

- **Declarative** versus **Imperative** deployment
- Various update strategies

DEPLOYMENT

- Holds template for `Pod`
- Creates `ReplicaSet` on the fly
- Allows rollback
- Update strategies declarable
- Inspired by `DeploymentConfig` from OpenShift

ROLLING



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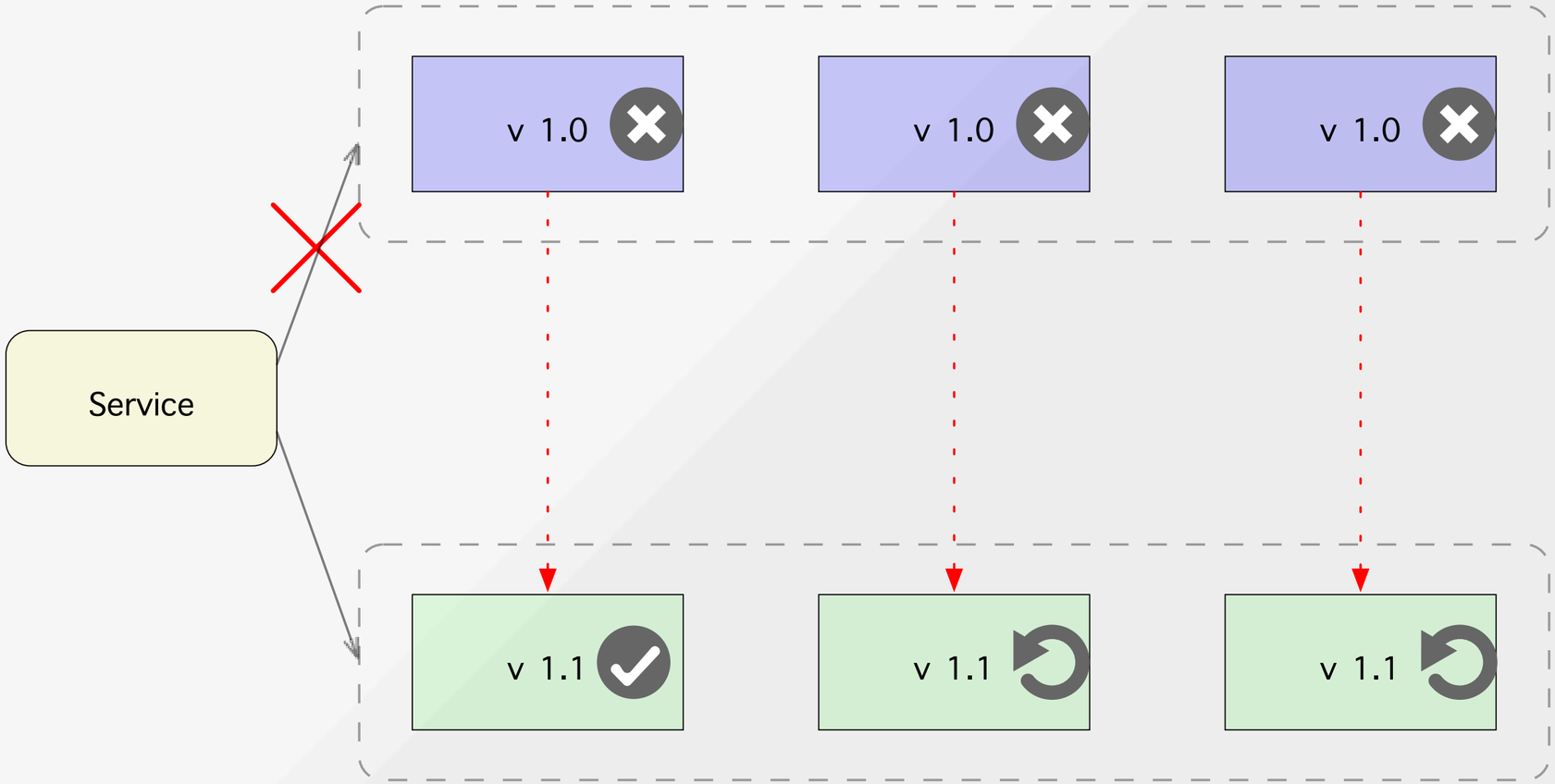
FIXED



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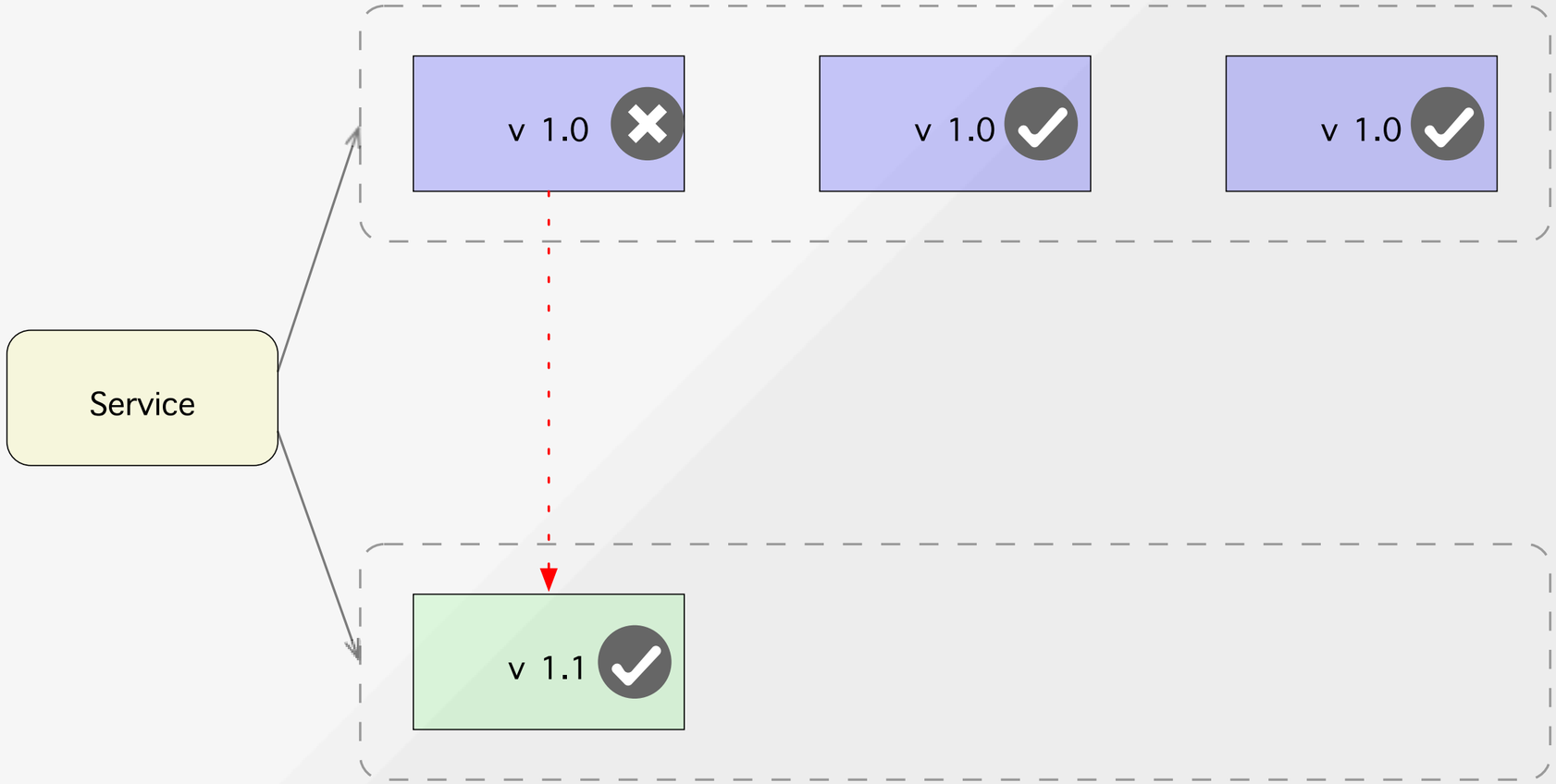
CANARY



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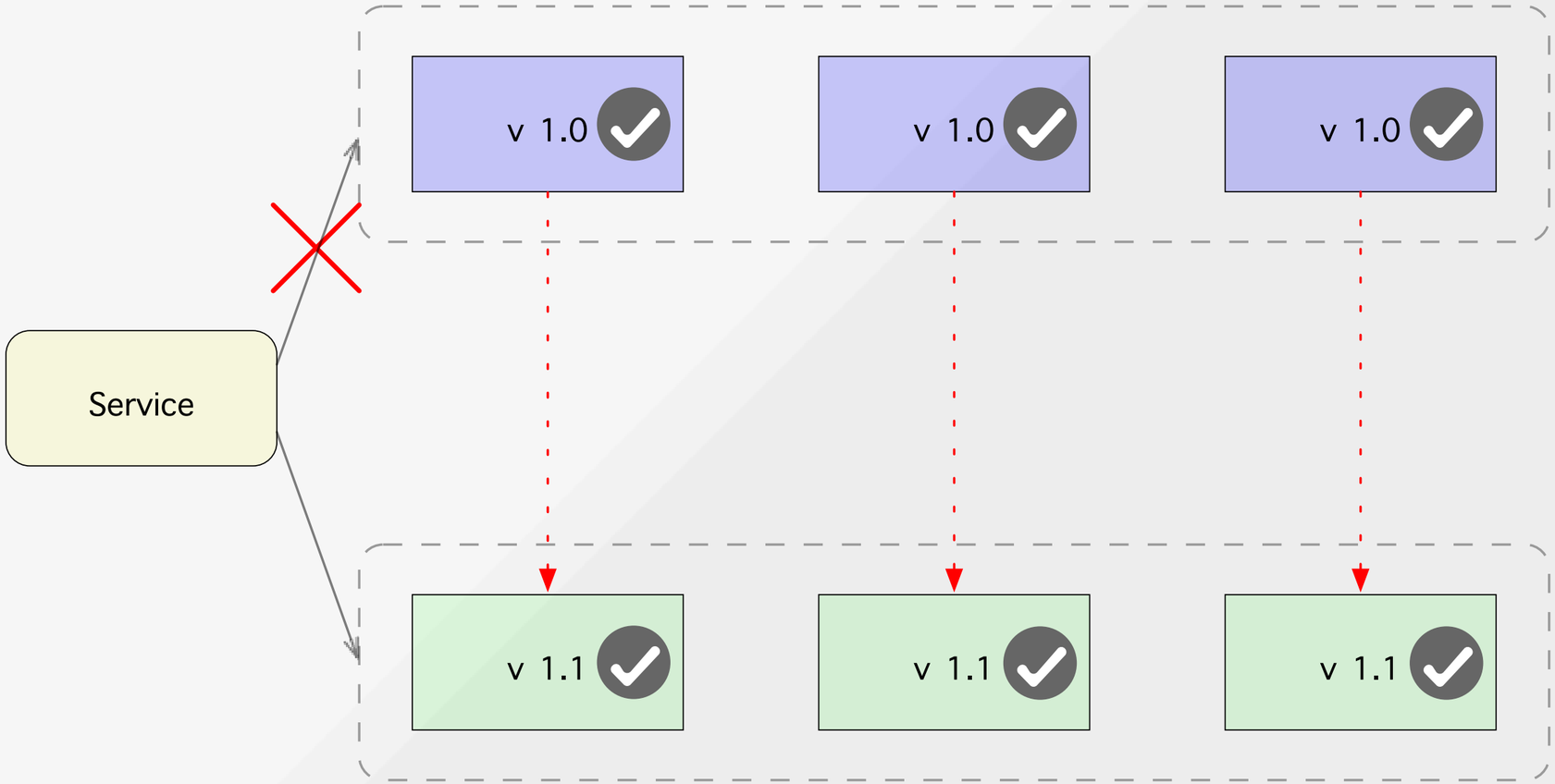
BLUE-GREEN



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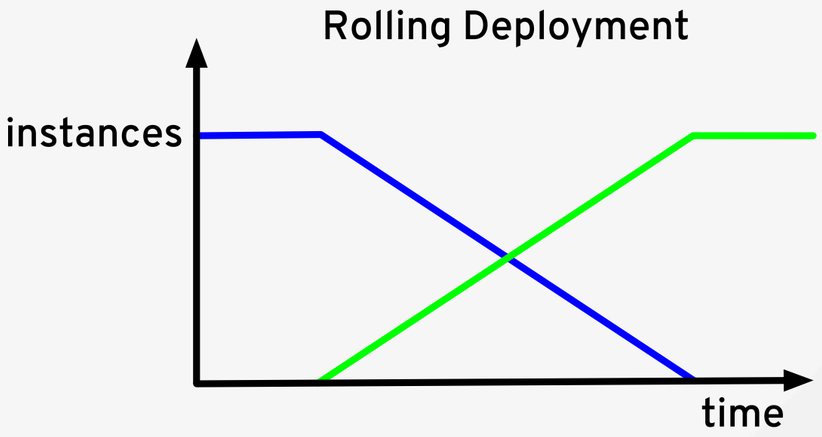
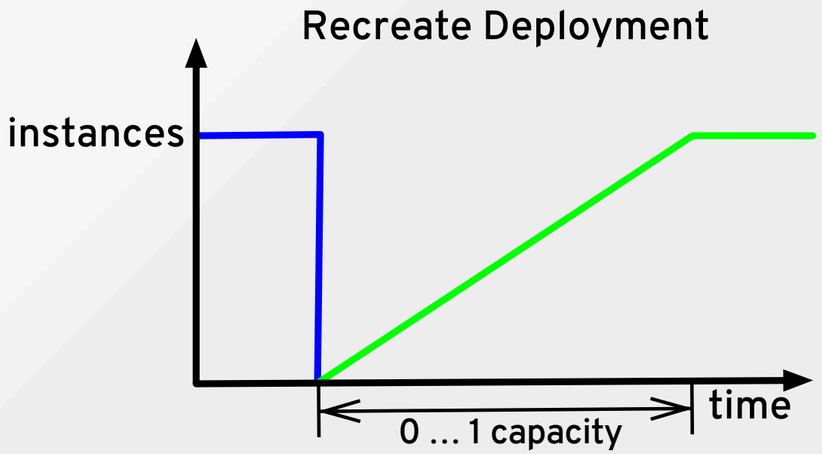
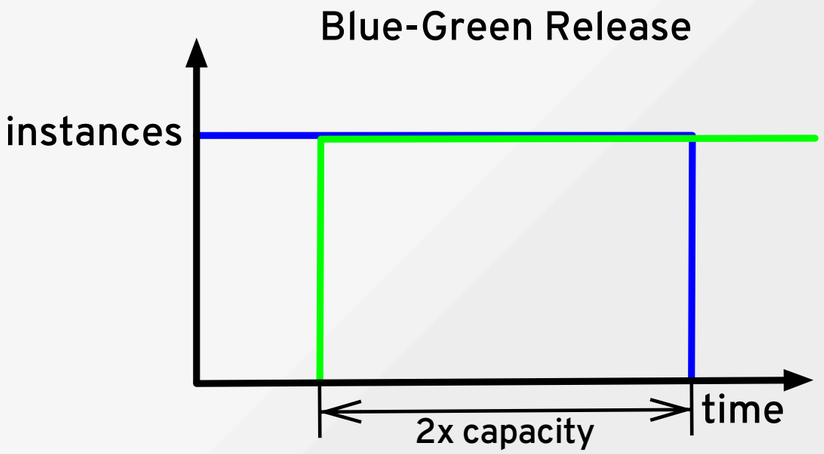
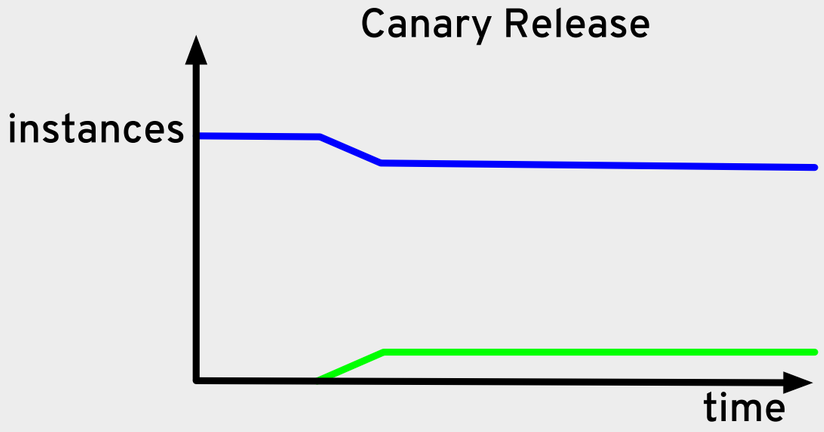
SUMMARY









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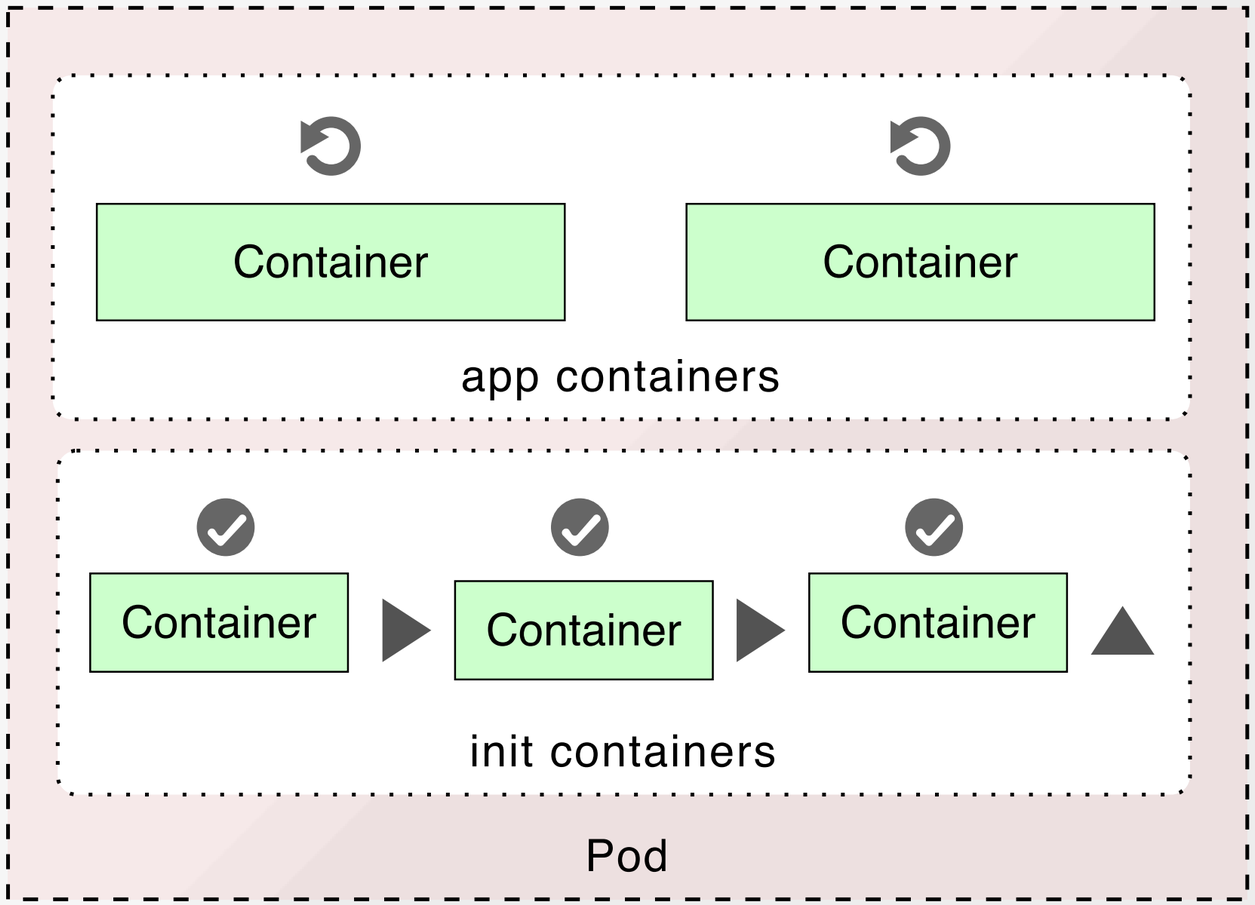
STRUCTURAL PATTERNS

Initializer

How can I initialize my containerized applications ?

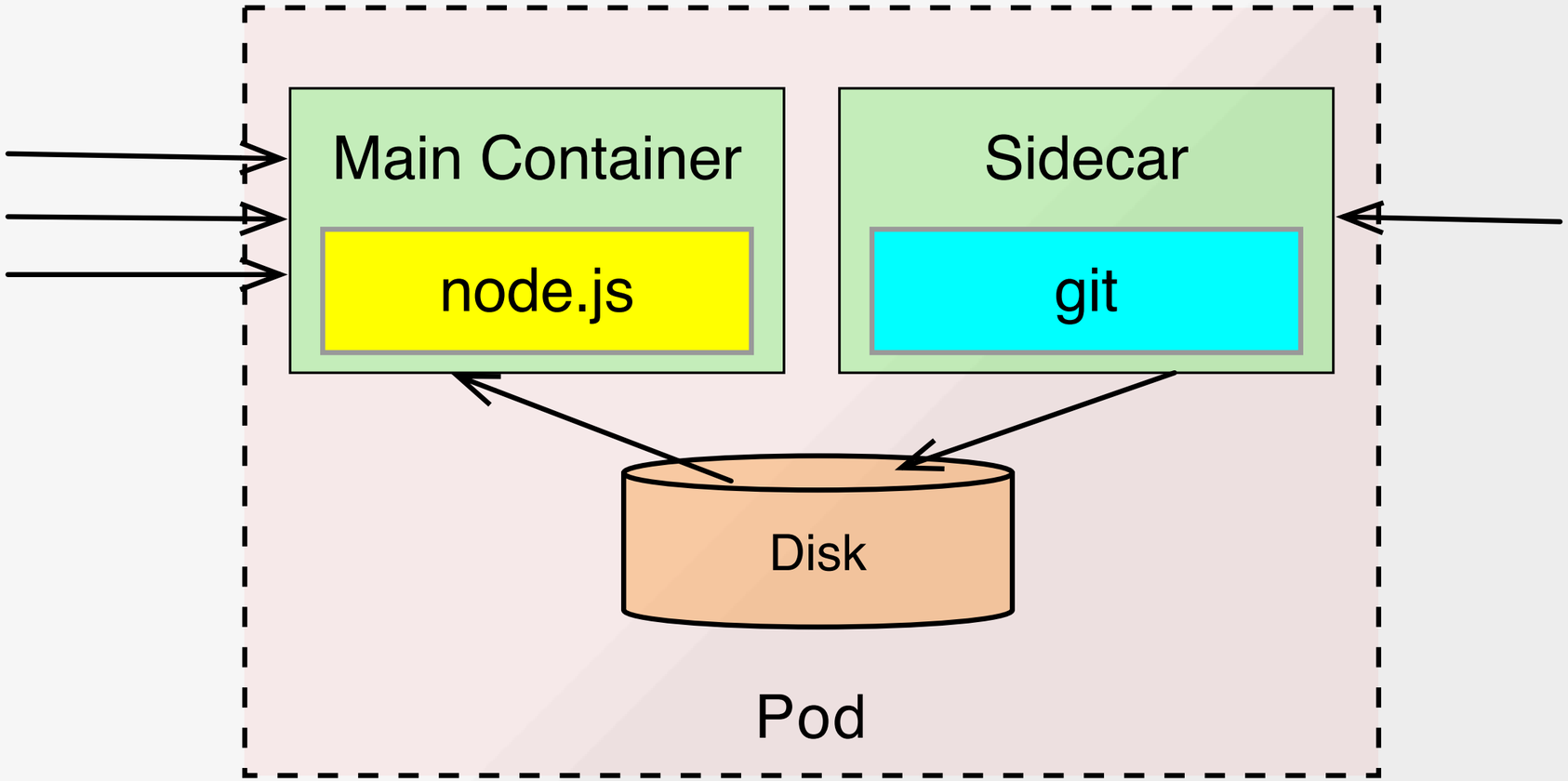
- Init container :
  - Part of a Pod
  - One shot action before Pod starts
  - Needs to be idempotent
  - Has own resource requirements


Container
Container
app containers
Container
Container
Container
init containers
Pod

Sidecar

How can I extend the functionality of an existing container ?

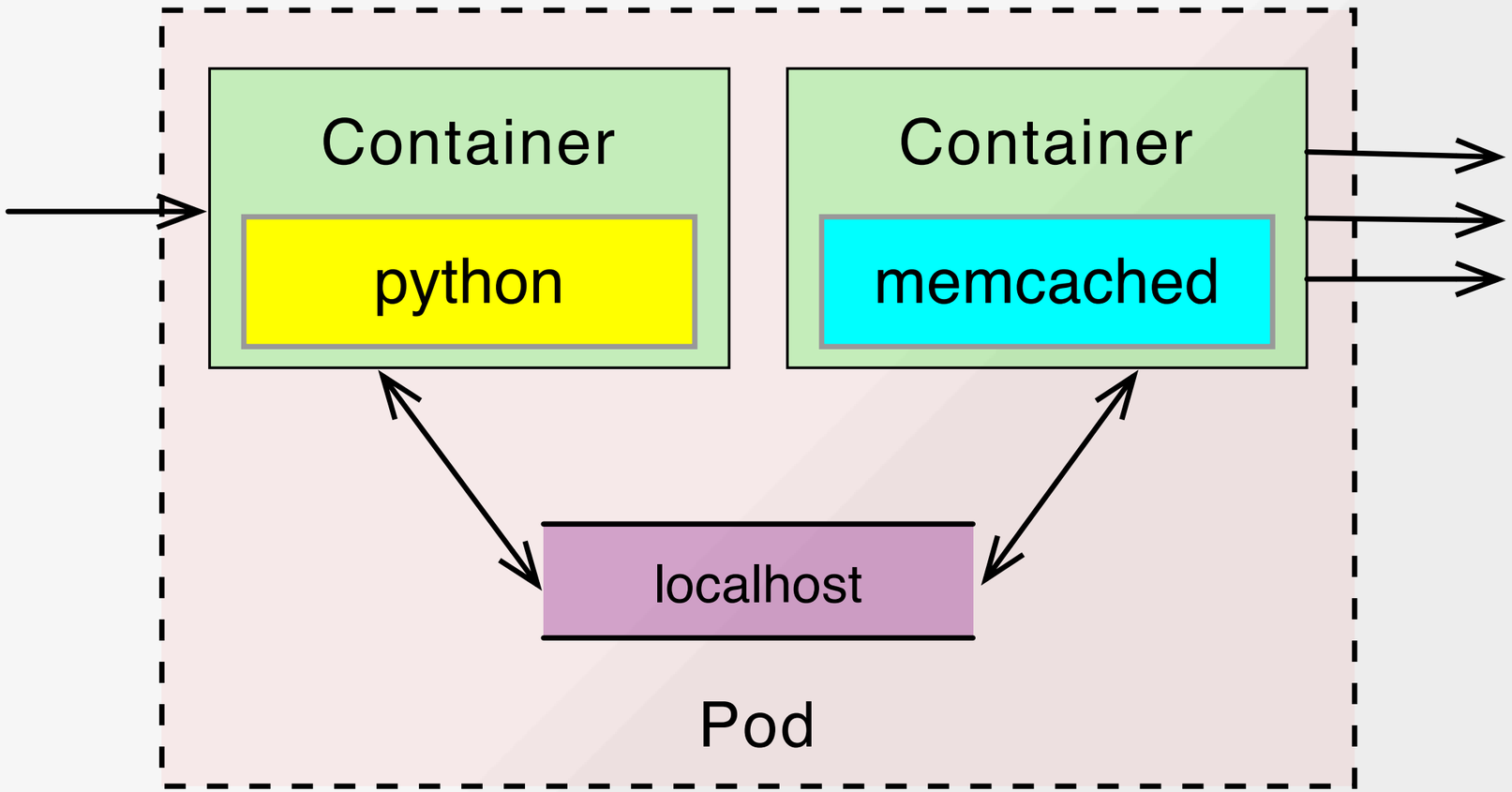
- Runtime collaboration of containers
- Connected via shared resources:
  - Network
  - Volumes


Main Container
node.js
Sidecar
git
Disk
Pod

Ambassador

How to decouple a container's access **to** the outside world ?

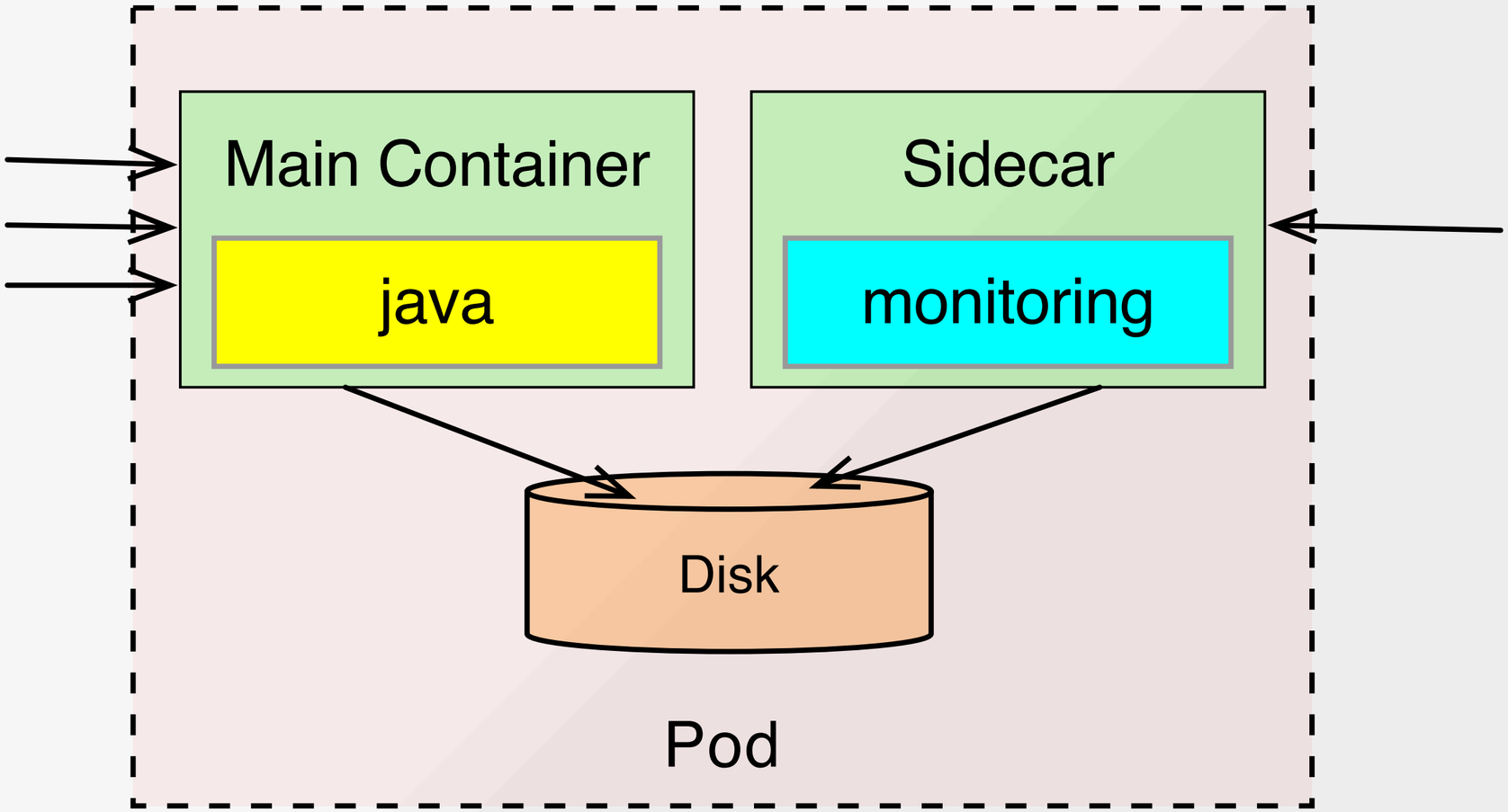
- Also known as **Proxy**
- Specialization of a Sidecar
- E.g. infrastructure services
  - Circuit breaker
  - Tracing


Container
python
Container
memcached
localhost
Pod

Adapter

How to decouple access to a container **from** the outside world ?

- Opposite of Ambassador
- Uniform access to application
- Examples:
  - Monitoring
  - Logging



CONFIGURATIONAL PATTERNS

How can applications be configured for different environments ?

EnvVar Configuration

- Universal applicable
- Recommended by the Twelve Factor App manifesto
- Can be only set during startup of application

```
kind: Pod
spec:
 containers:
 - env:
   - name: DB_HOST
     value: "prod-database.prod.intranet"
   - name: DB_PASSWORD
     valueFrom:
       secretKeyRef:
         name: "db-passwords"
         key: "monogdb.password"
   - name: DB_USER
       valueFrom:
         configMapKeyRef:
           name: "db-users"
           key: "mongodb.user"
   image: acme/bookmark-service:1.0.4
```

Configuration Resource

- `ConfigMap` and `Secret` : Intrinisic K8s resources
- Can be used in two ways:
  - Reference for environment variables
  - Files mapped to a volume

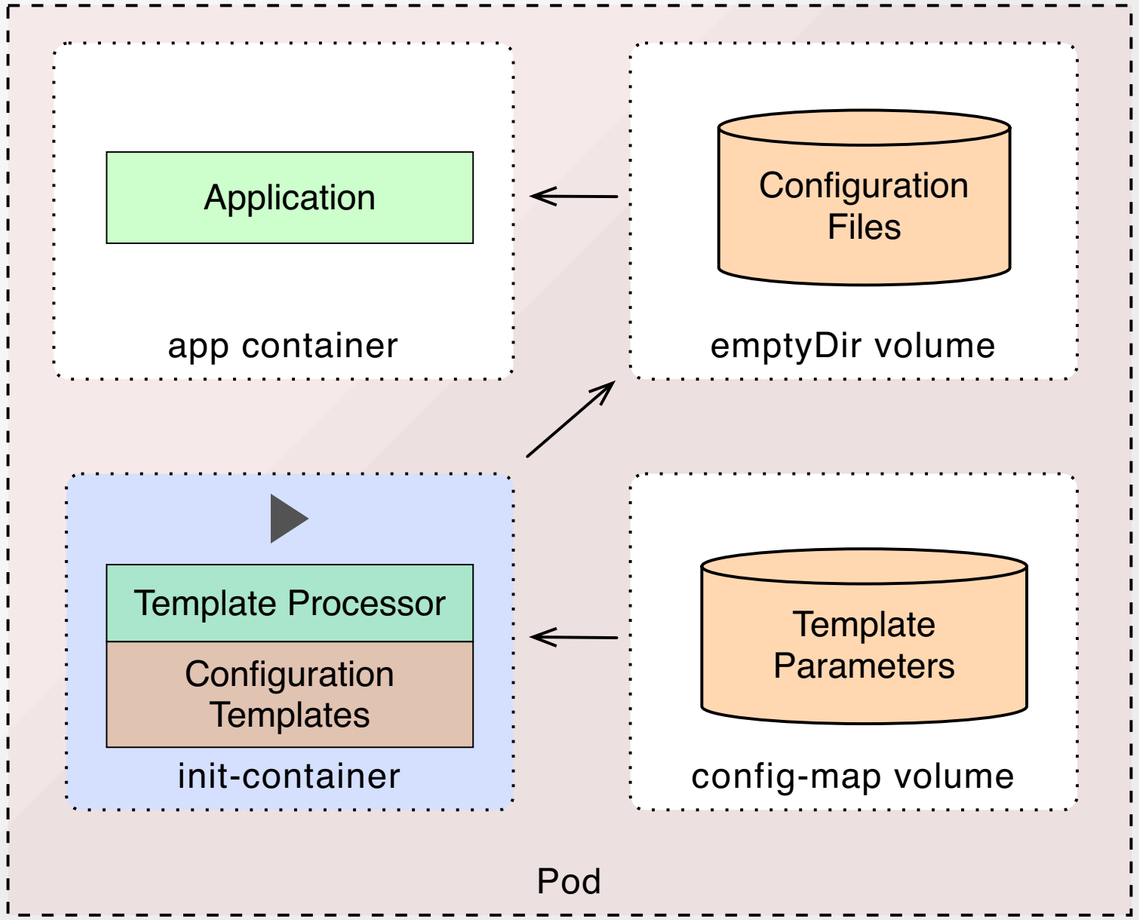
```
kind: ConfigMap
metadata:
  name: spring-boot-config
data:
  JAVA_OPTIONS: "-Xmx512m"
  application.properties: |
    welcome.message=Hello !!!
    server.port=8080
```

```
kind: Pod
spec:
  containers:
  - name: web
    volumeMounts:
    - name: config-volume
      mountPath: /etc/config
    # ...
  volumes:
    - name: config-volume
      configMap:
        name: spring-boot-config
```

Configuration Template

- `ConfigMap` not suitable for large configuration
- Managing similar configuration
- Ingredients:
  - Init-container with template processor and templates
  - Parameters from a `ConfigMap` Volume

CONFIGURATION TEMPLATE



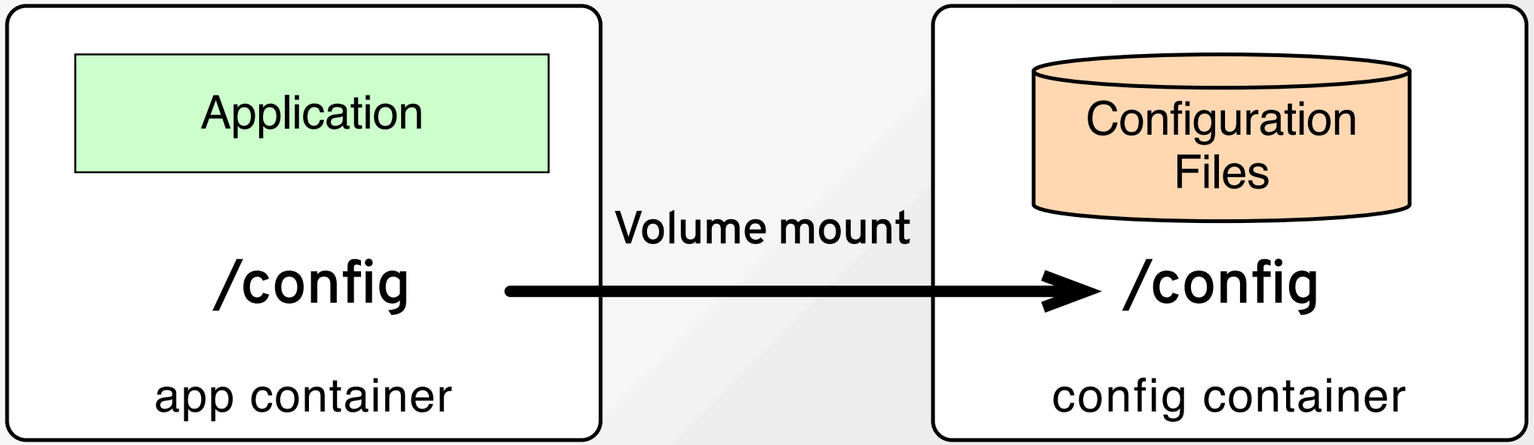
DISCUSSION

- Good for large, similar configuration sets per environment
- Parameterisation via ConfigMaps easy
- More complex

Immutable Configuration

- Configuration is put into a container itself
- Configuration container is linked to application container during runtime

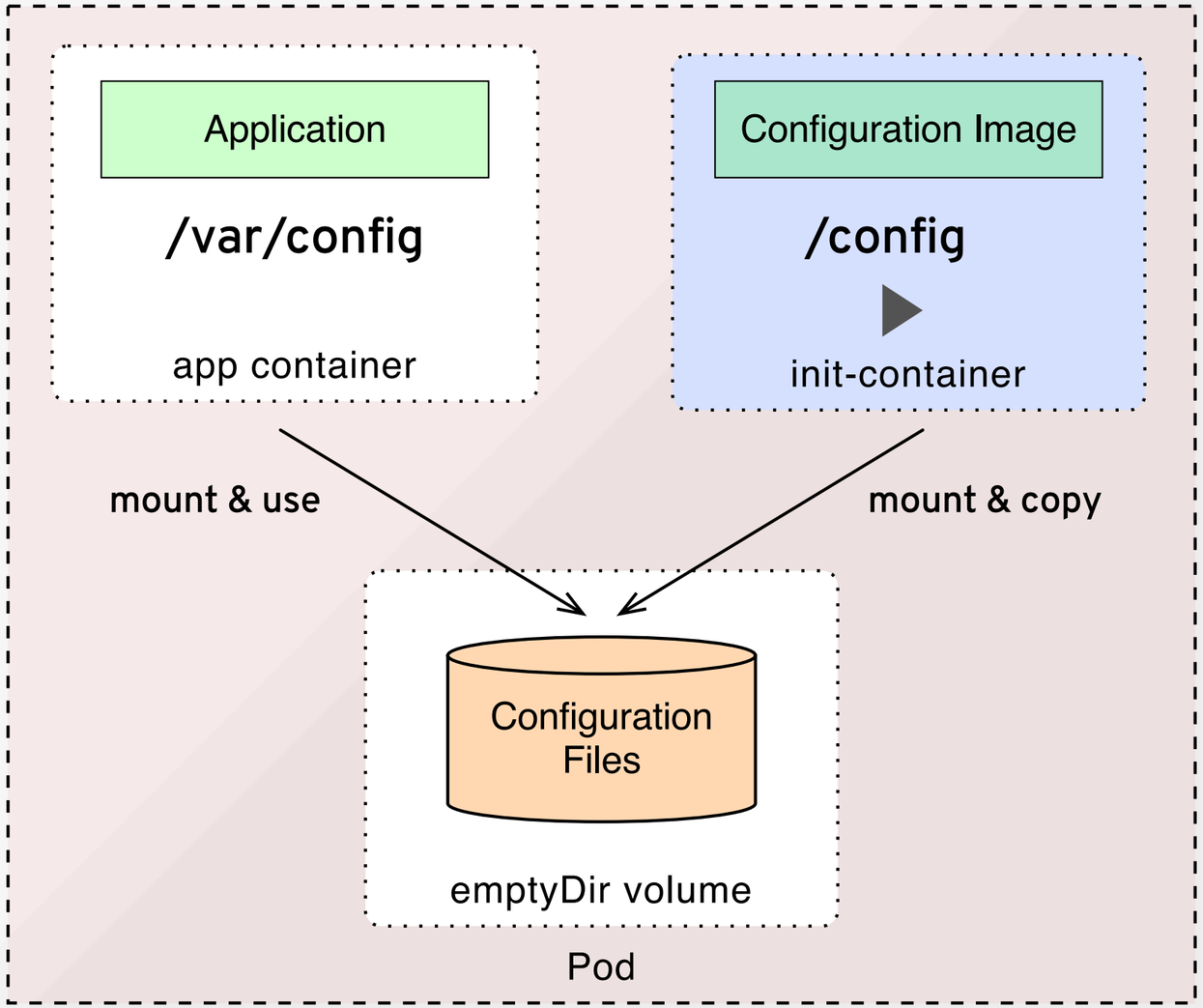
CONTAINER VOLUMES



- Not directly supported by K8s
- docker-flexvol : K8s FlexVolume driver for Docker volumes

```
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx
    volumeMounts:
    - name: test
      mountPath: /data
    ports:
    - containerPort: 80
  volumes:
  - name: test
    flexVolume:
      driver: "dims.io/docker-flexvol"
      options:
        image: "my-container-image"
        name: "/data-store"
```

INITIALIZER



- Dockerfile for init container:

```
FROM busybox

ADD dev.properties /config-src/demo.properties
# ... add more to /config-src

# Using a shell here in order to resolve wildcards
ENTRYPOINT [ "sh", "-c", \
        "cp /config-src/* $1", "--" ]
```

- Build config image:

```
docker build -t k8spatterns/config-dev:1 .
```

```
spec:
 initContainers:
 - image: k8spatterns/config-dev:1
   name: init
   args:
   - "/config"
   volumeMounts:
   - mountPath: "/config"
     name: config-directory

 containers:
 - image: k8spatterns/demo:1
   name: demo
   volumeMounts:
   - mountPath: "/config"
     name: config-directory

 volumes:
 - name: config-directory
   emptyDir: {}
```

DISCUSSION

- Immutable Configuration ...
  - can be versioned
  - can be distributed via a registry
  - is immutable
  - can be arbitrary large
- Parameterisation via OpenShift Templates

ADVANCED PATTERNS

Custom Controller

How can I extend the platform itself without changing it ?

- Watching resources by registering for Kubernetes events
- Reacting on changes in resource **declarations**

CONTROLLER

- Managed pod listening for Kubernetes API events
- **State Reconciliation** : Make the current state like the declared desired state
- Often used in combination with **CustomResources**

CATEGORIES

- **Extension Controller** : Extend the Kubernetes platform itself
- **Application Controller** : Combine Kubernetes with an application specific domain

Custom Resource

How can I manage custom domain specific resources ?

- **Custom Resource Definition** (CRD) managed by Kubernetes
- Accessible via the Kubernetes API
- Watched by Custom Controllers

EXAMPLE CRD

```
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: prometheuses.monitoring.coreos.com
spec:
  group: monitoring.coreos.com
  names:
    kind: Prometheus
    plural: prometheuses
  scope: Namespaced
  version: v1
  validation: ....
```

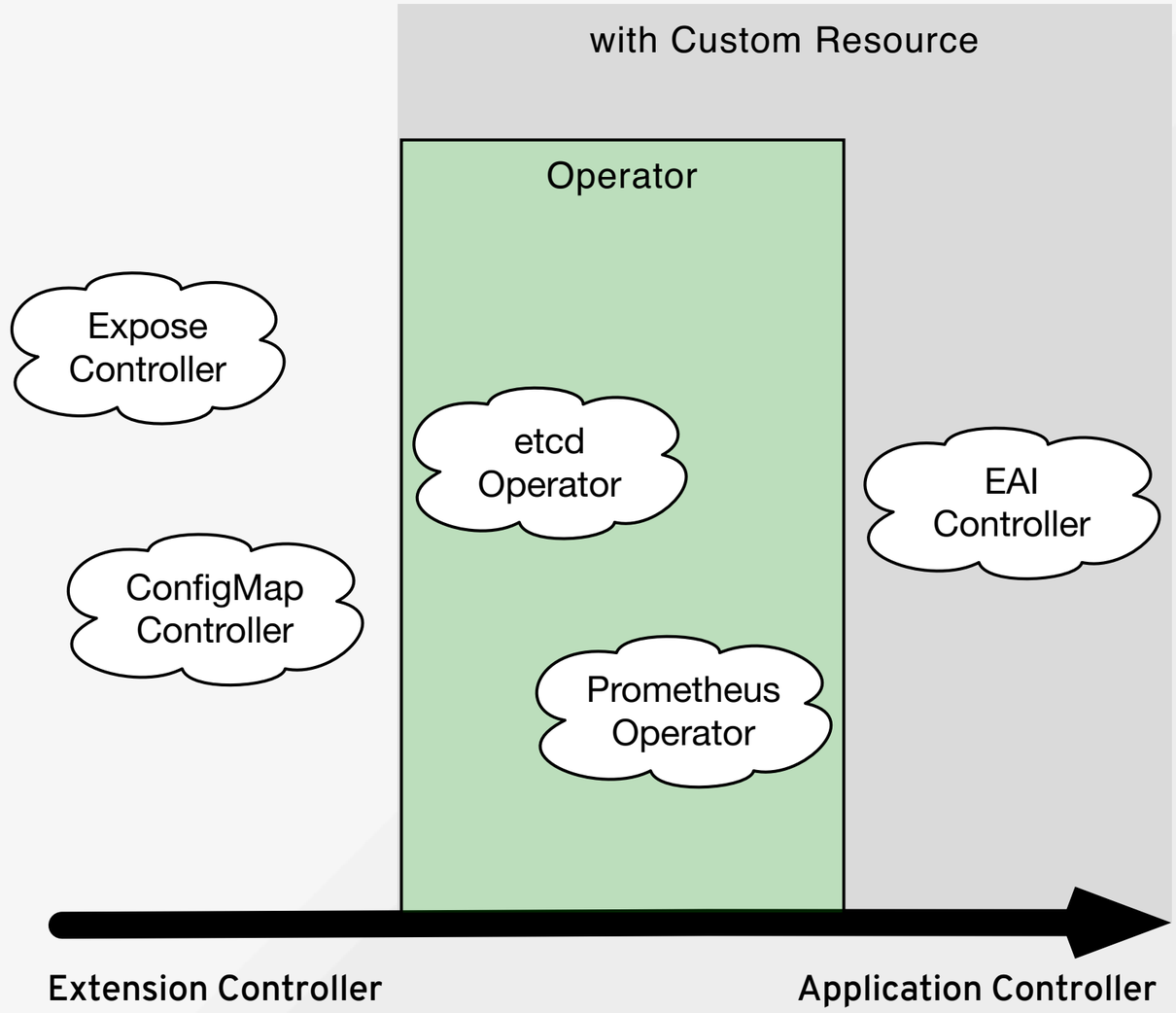
EXAMPLE CRD

```
apiVersion: monitoring.coreos.com/v1
kind: Prometheus
metadata:
  name: prometheus
spec:
  serviceMonitorSelector:
    matchLabels:
      team: frontend
  resources:
    requests:
      memory: 400Mi
```

OPERATORS

- Combine Custom Controller and Custom Resource
- Manages and deploys custom Kubernetes application
- Operator Framework by CoreOS:
  - Operator SDK
  - Operator Lifecycle Manager
  - Operator Metering

SPECTRUM



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WRAP UP

- Kubernetes offers a rich feature set to manage containerised applications.
- Patterns can help in solving recurring Kubernetes challenges.
- More and more patterns are emerging.

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QUESTIONS ?

Twitter	ro14nd
Book	https://leanpub.com/k8spatterns
Slides	https://github.com/ro14nd-talks/kubernetes-patterns

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