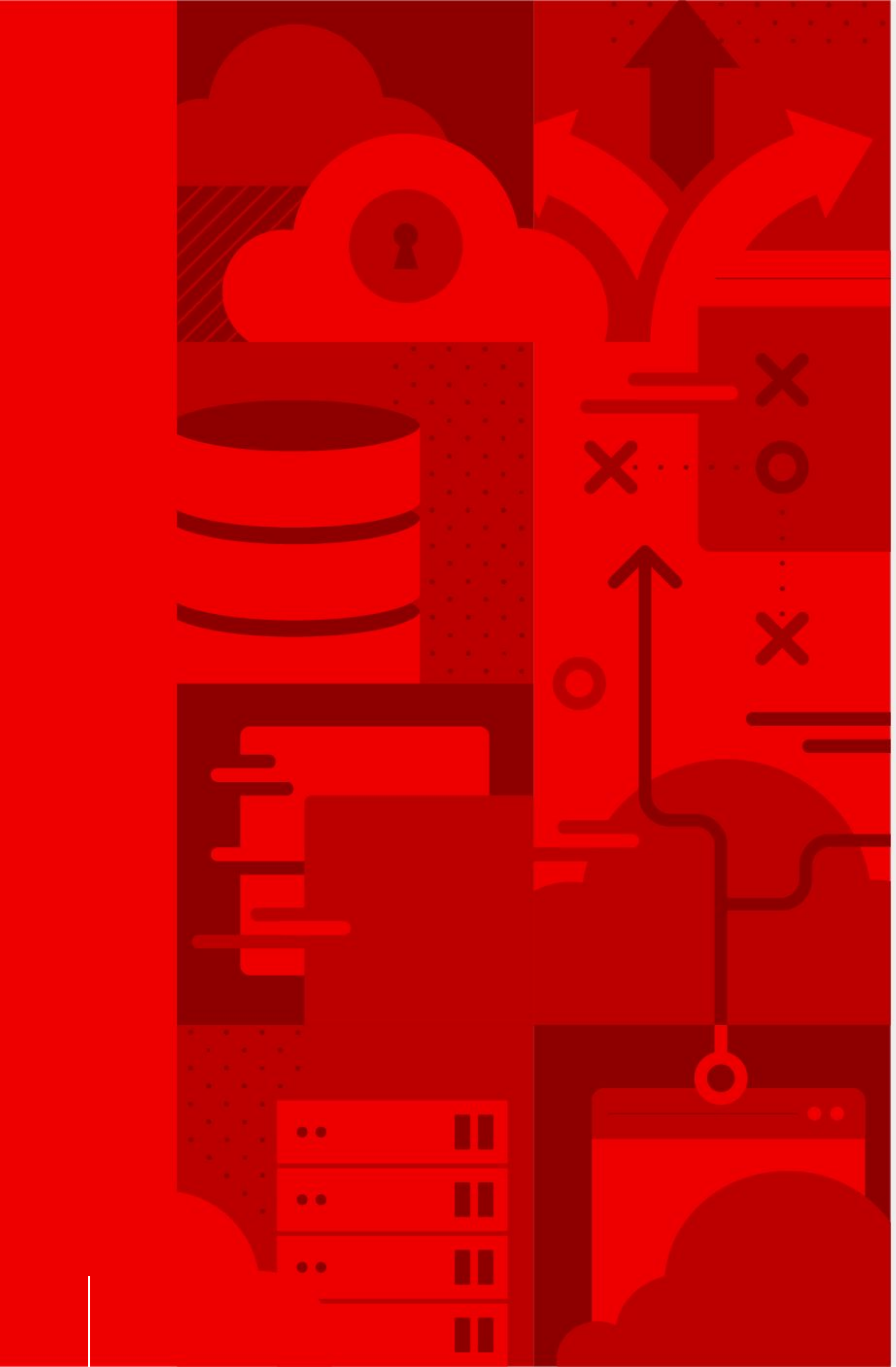


Kubernetes Patterns

Reusable Elements for Designing Cloud-Native Applications

Robert Sedor
Senior Cloud Platform Architect

Red Hat

Agenda

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

Dad Jokes

Q: Why was the developer unhappy at their job?

A: They wanted arrays

Q: Why was the function sad after a successful first call?

A: It didn’t get a callback

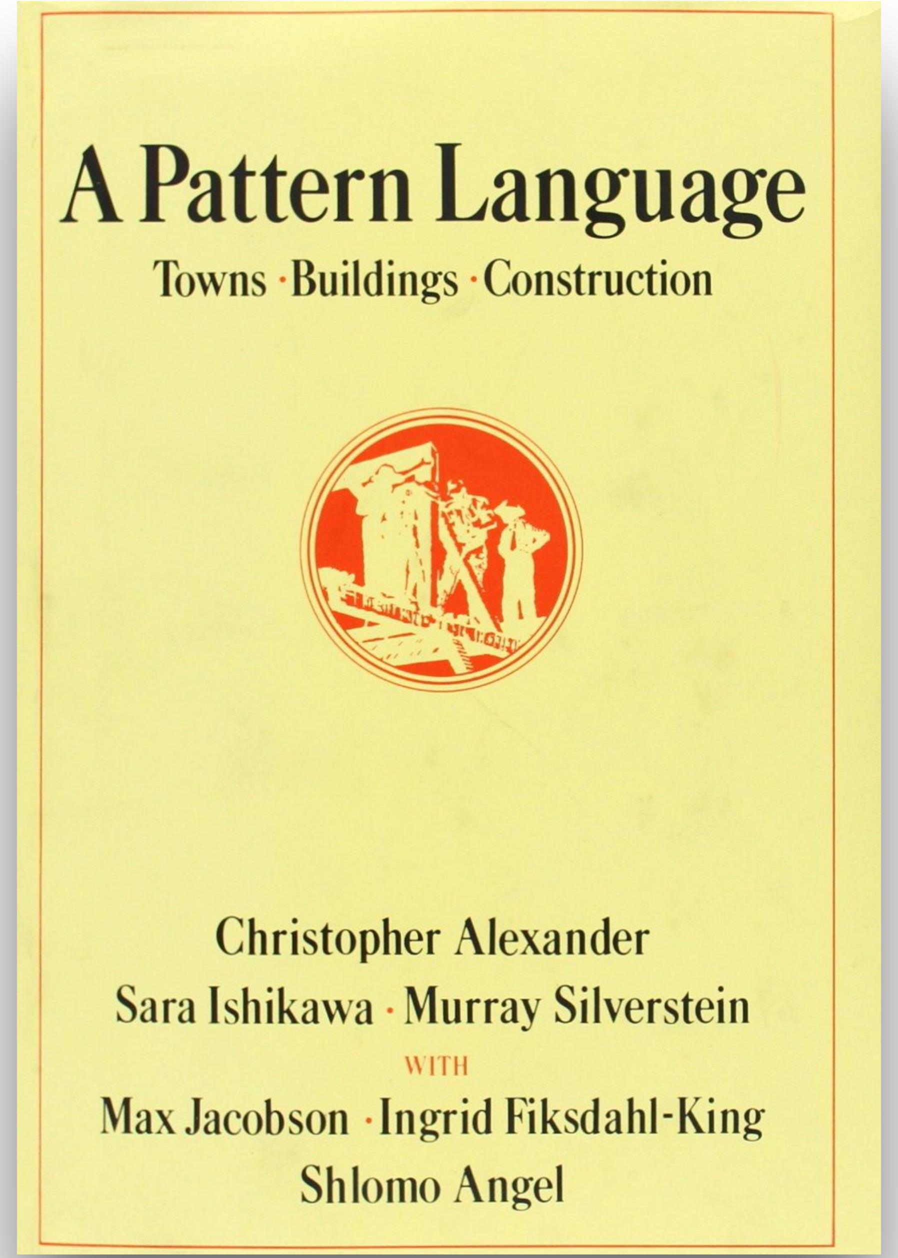
PATTERNS

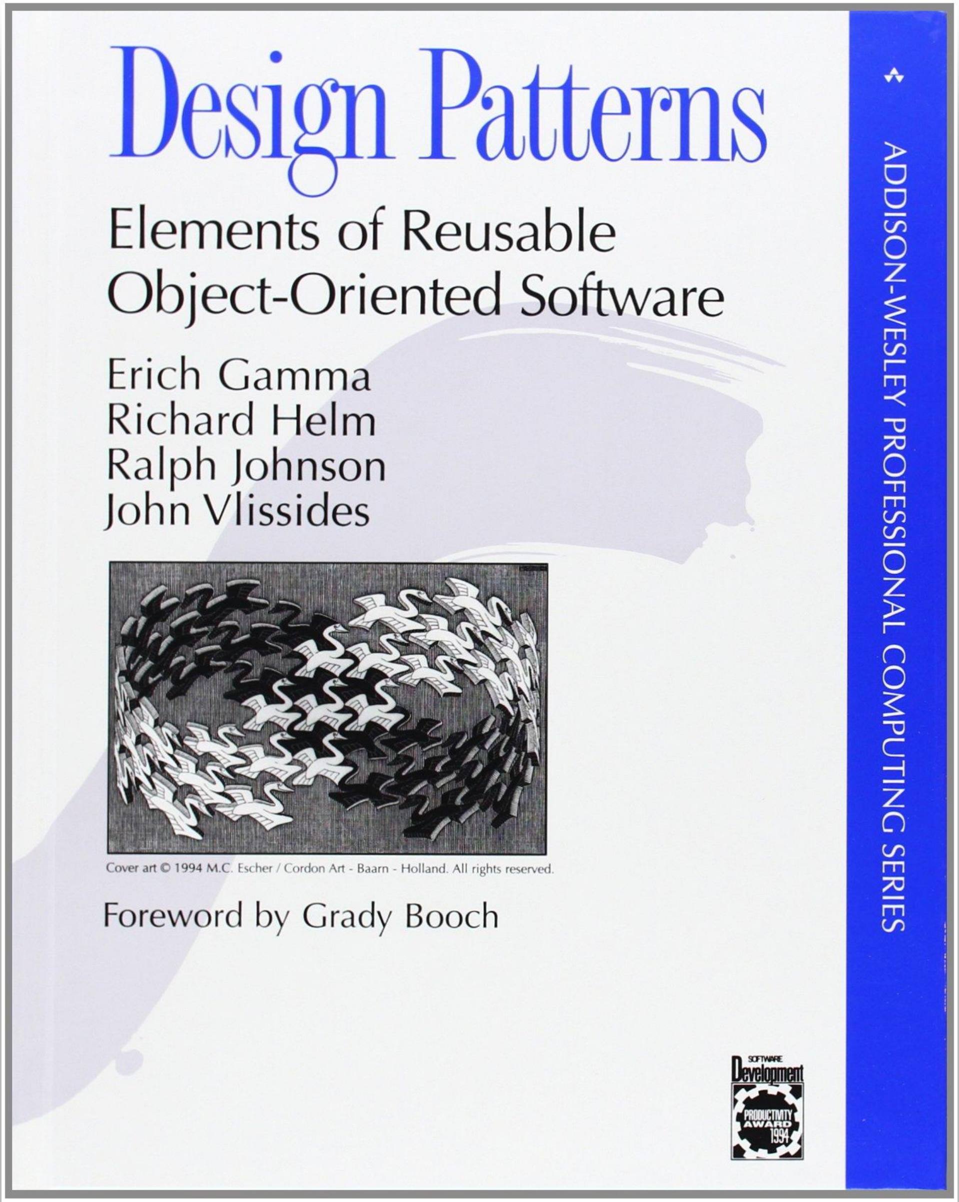
Design Patterns

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

Red Hat

Patterns


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
Cover art © 1994 M.C. Escher / Cordon Art - Baarn - Holland. All rights reserved.
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

Patterns

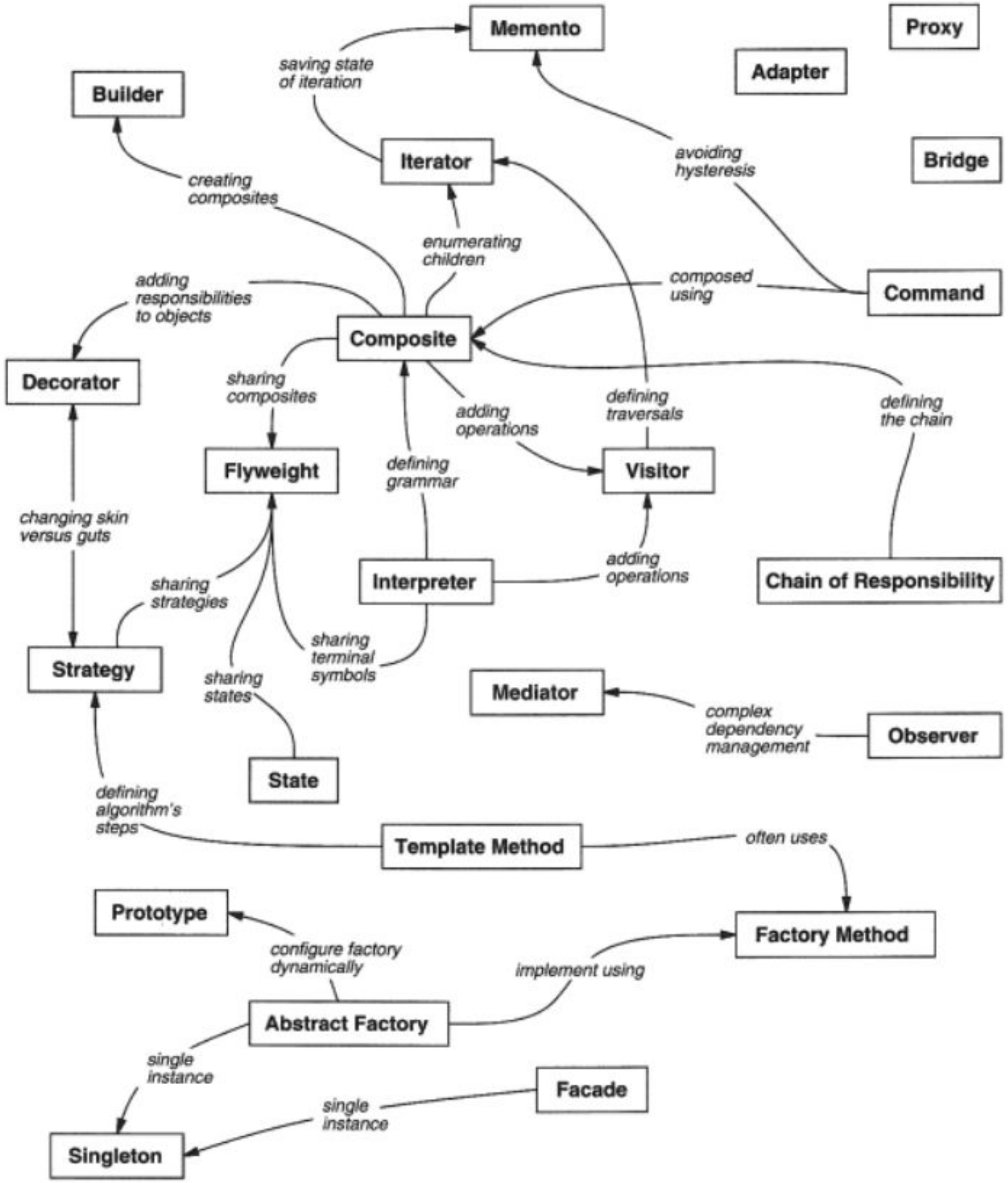
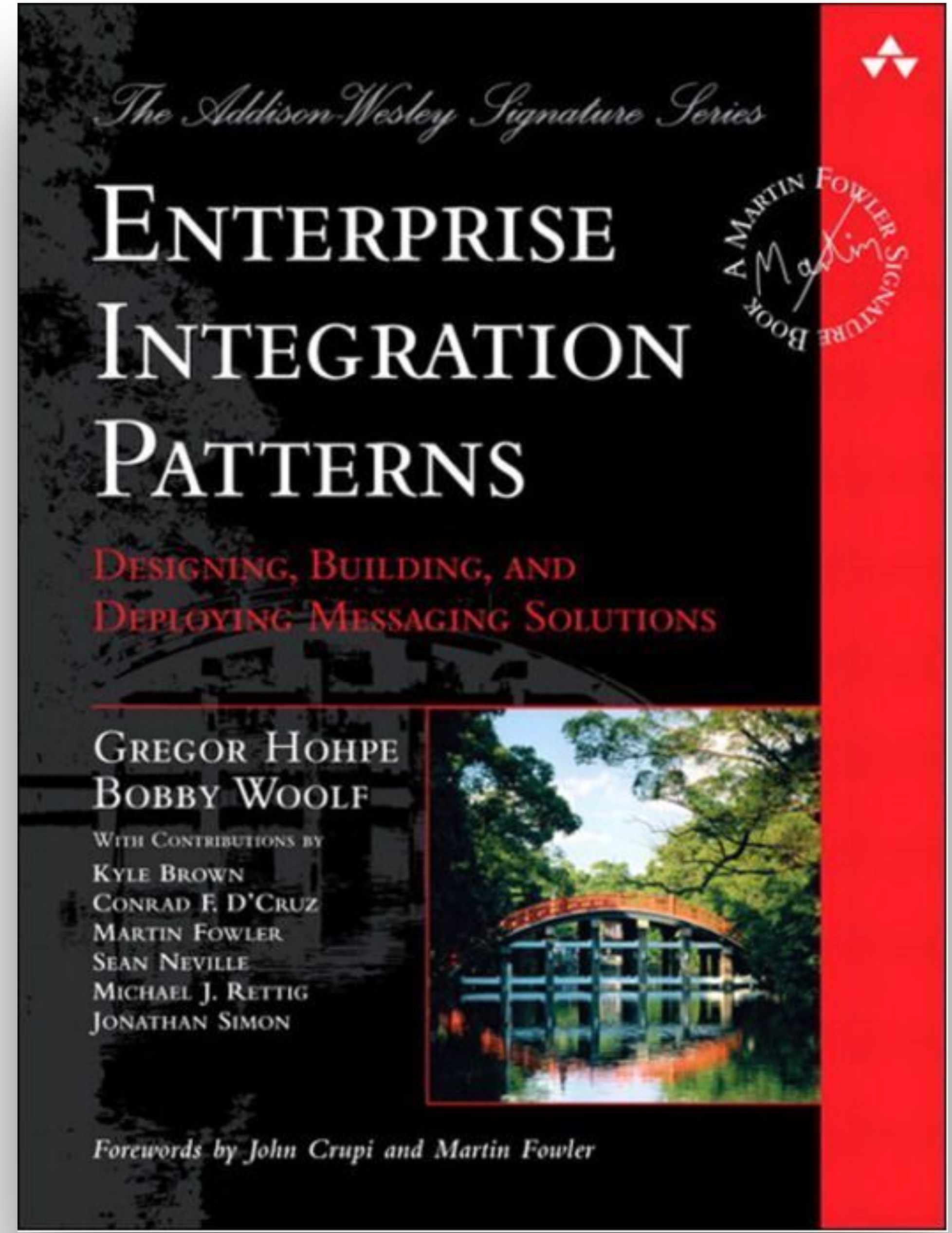


Figure 1.1: Design pattern relationships

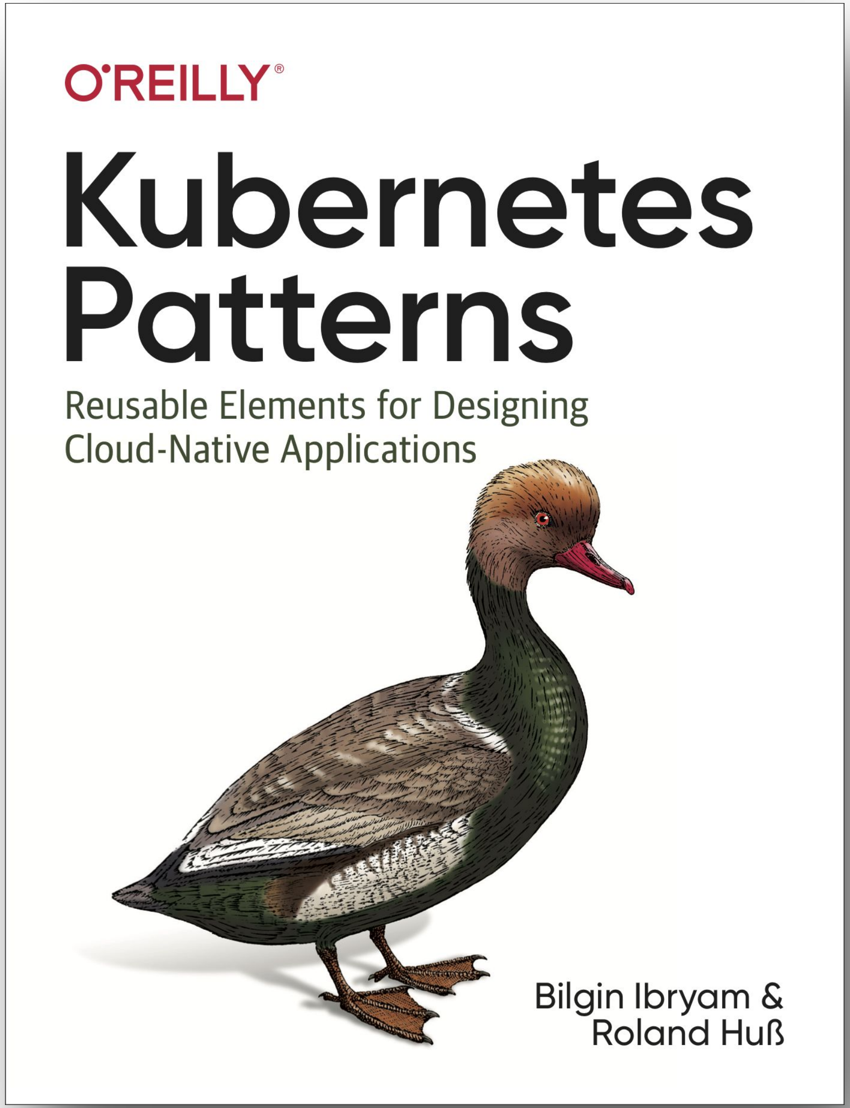
Design Patterns, Elements of Reusable Object-Oriented Software, E. Gamma et. al., 1994, p. 12

Red Hat

Patterns



The Addison-Wesley Signature Series
ENTERPRISE INTEGRATION PATTERNS
DESIGNING, BUILDING, AND DEPLOYING MESSAGING SOLUTIONS
A MARTIN FOWLER SIGNATURE BOOK
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



https://k8spatterns.io

https://www.redhat.com/cms/managed-files/cm-oreilly-kubernetes-patterns-ebook-f19824-201910-en.pdf

Red Hat

Patterns Structure

- Problem
- Patterns:
  - Name
  - Solution

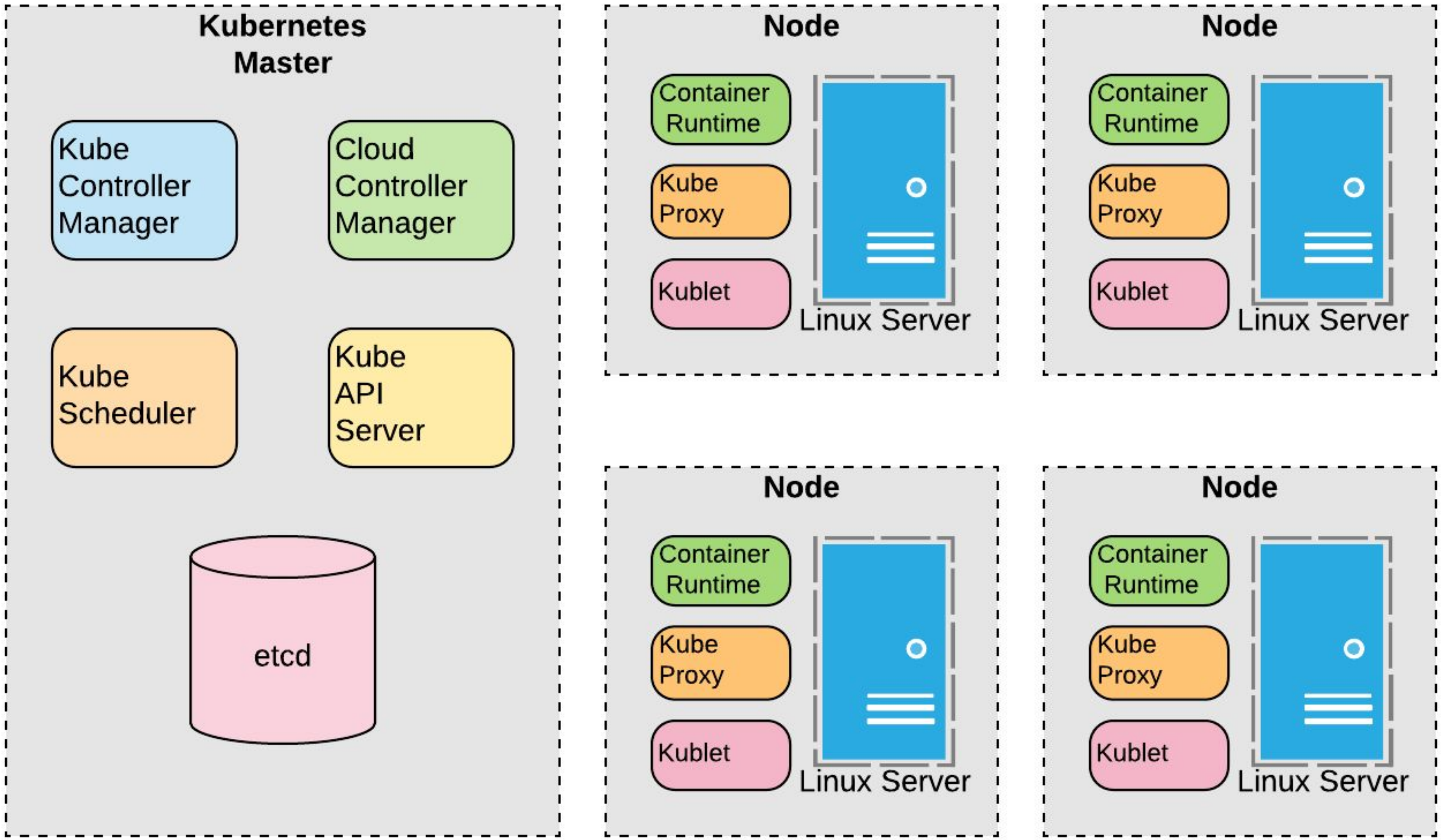
https://www.martinfowler.com/articles/writingPatterns.html

KUBERNETES

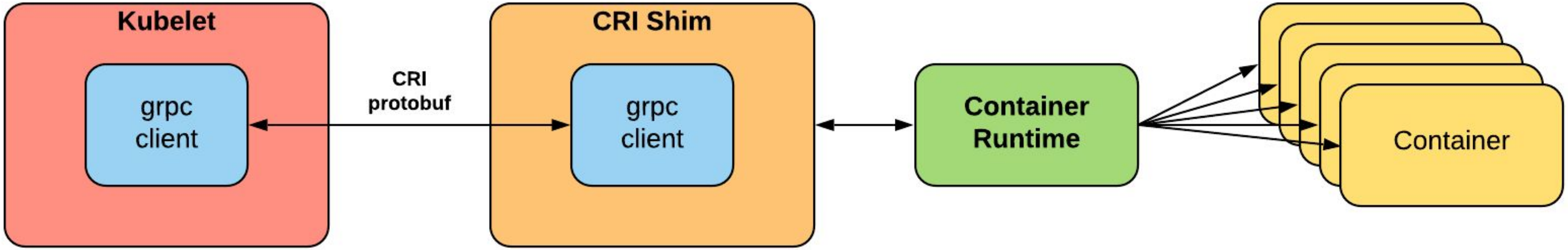
Kubernetes

- Open Source container orchestration system started by Google in 2014
  - ⎈ Scheduling
  - ⎈ Self-healing
  - ⎈ Horizontal and vertical scaling
  - ⎈ Service discovery
  - ⎈ Automated Rollout and Rollbacks
- Declarative resource-centric REST API

Kubernetes Architecture



Container Runtime



- **Container runtime:** Kubernetes runs containers through an interface called the **CRI** based on **gRPC**.
  - Any container runtime that implements CRI can be used on a node controlled by the kubelet

Red Hat

FOUNDATIONAL PATTERNS

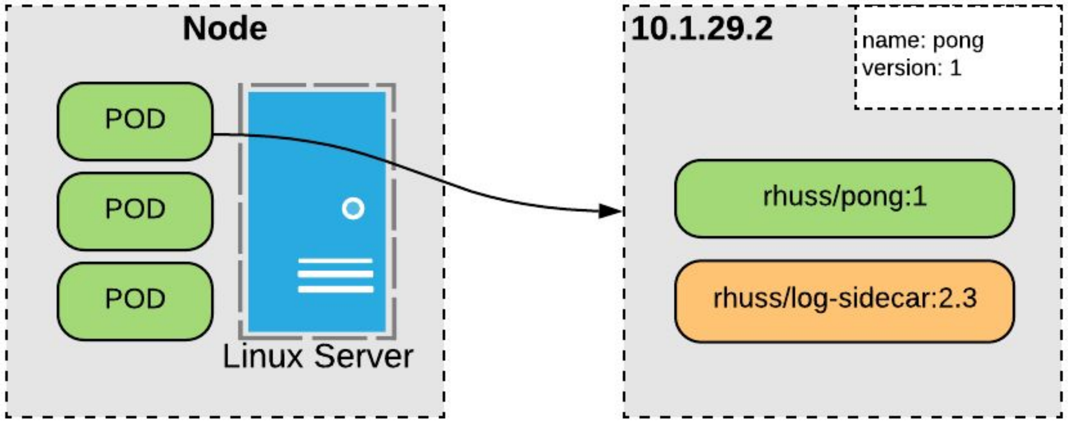
Automatable Unit

How can we create and manage applications with Kubernetes.

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

Pod

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



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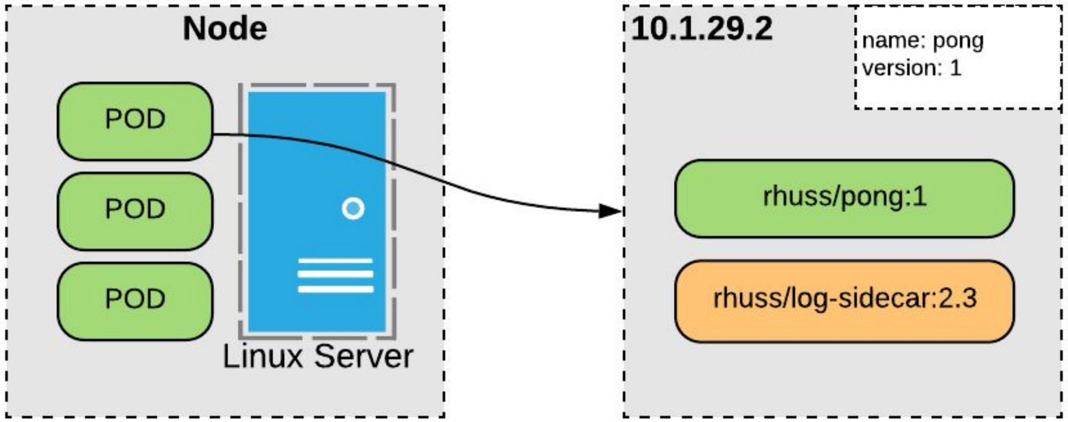
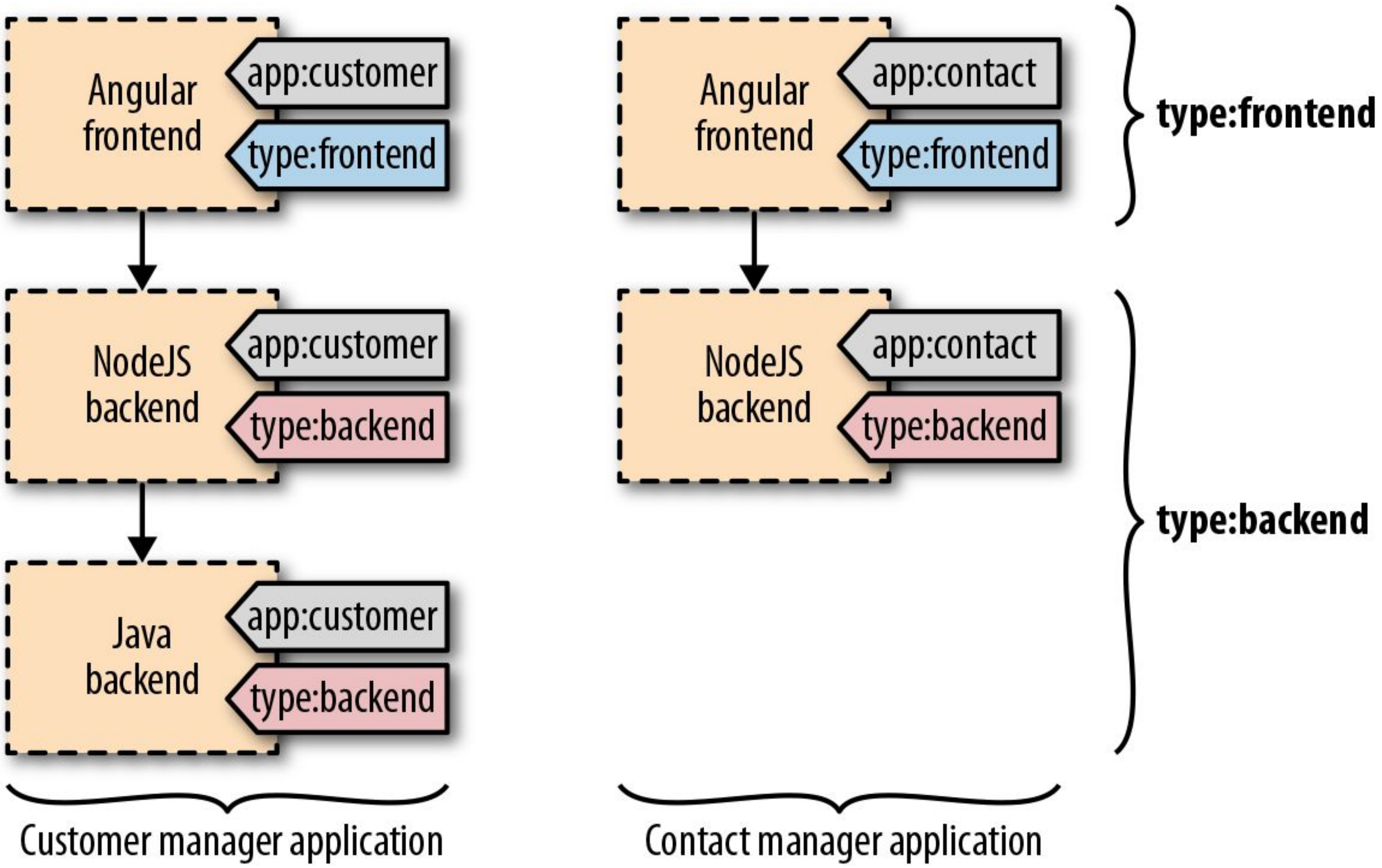
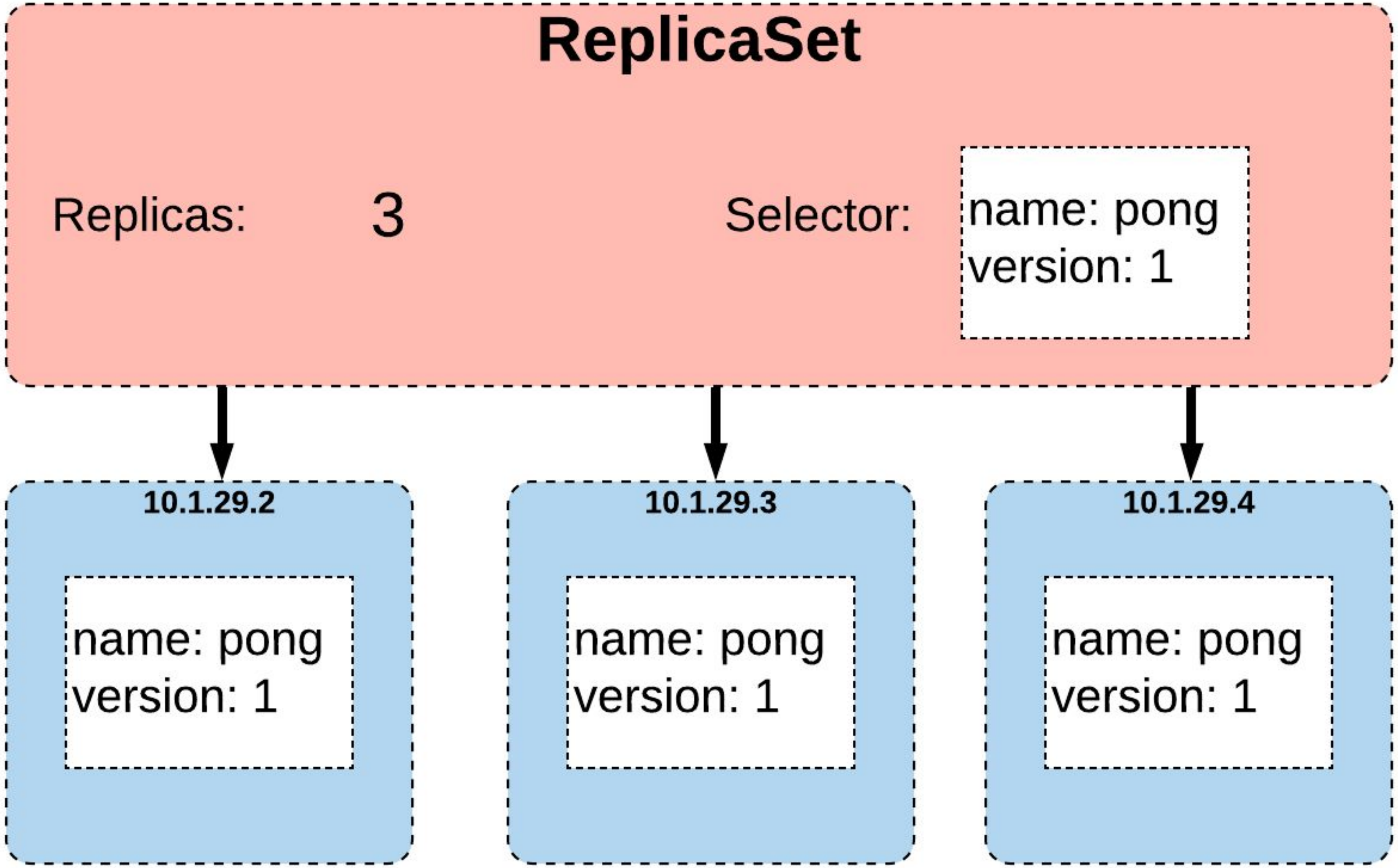
Pod Declaration

```yaml
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
```



Labels

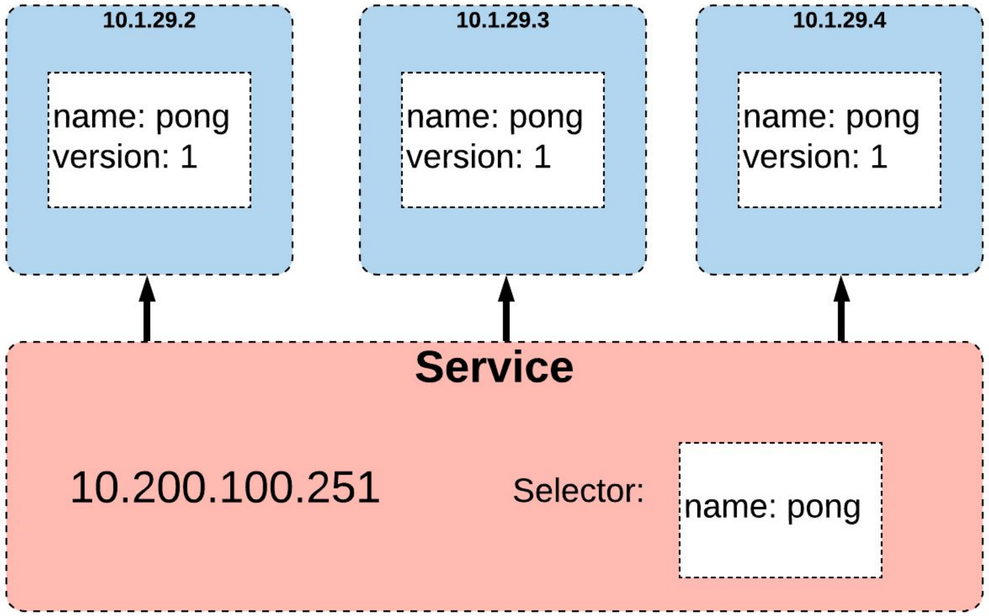

Angular frontend
app:customer
type:frontend
NodeJS backend
app:customer
type:backend
Java backend
app:customer
type:backend
Customer manager application
Angular frontend
app:contact
type:frontend
NodeJS backend
app:contact
type:backend
Contact manager application
type:frontend
type:backend



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



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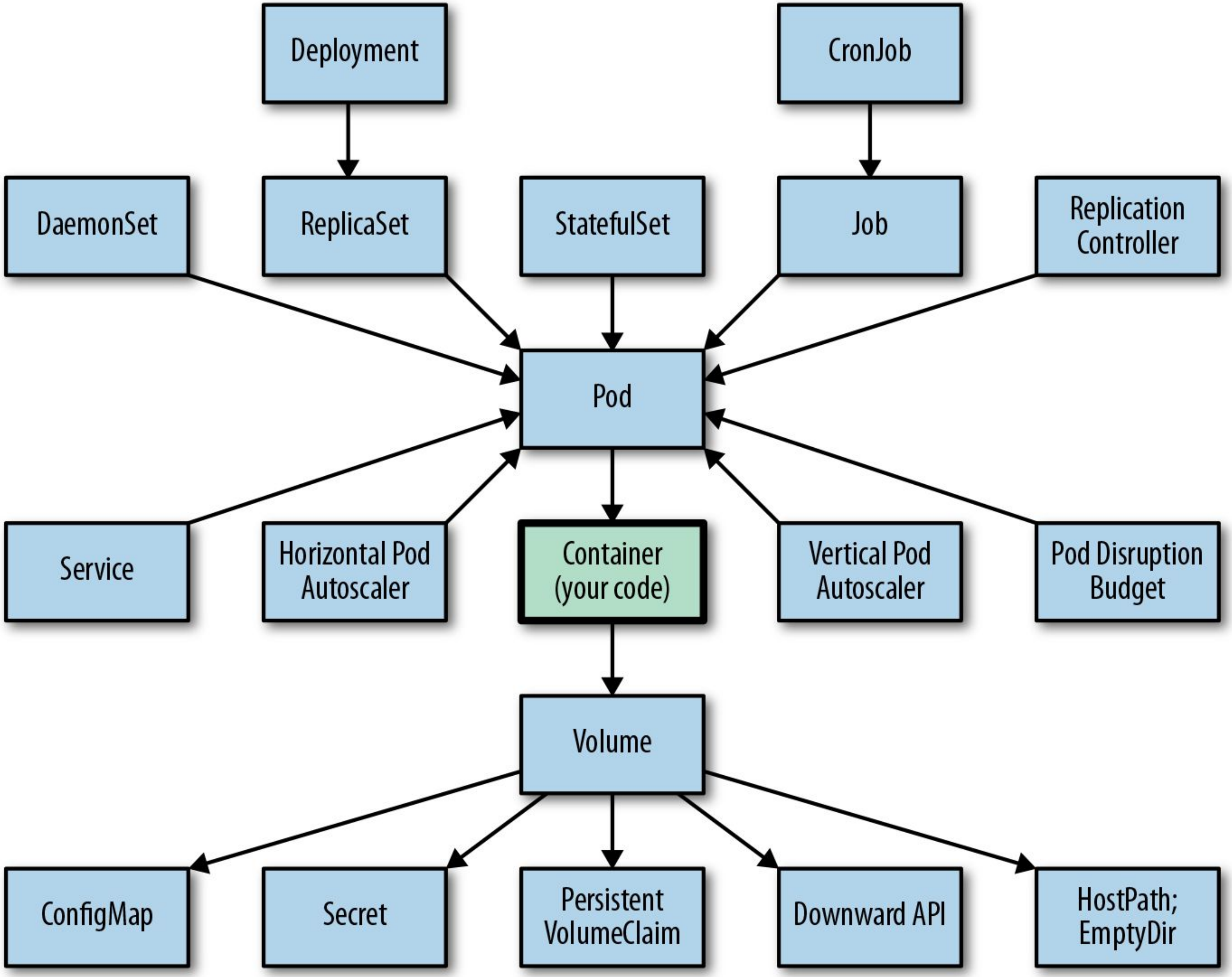

Deployment
CronJob
DaemonSet
ReplicaSet
StatefulSet
Job
Replication Controller
Pod
Service
Horizontal Pod Autoscaler
Container (your code)
Vertical Pod Autoscaler
Pod Disruption Budget
Volume
ConfigMap
Secret
Persistent VolumeClaim
Downward API
HostPath; EmptyDir

Predictable Demands

Application Requirements

How can we handle resource requirements deterministically?

- Declared requirements
  - Scheduling decisions
  - Capacity planning
  - Matching infrastructure services
- Runtime dependencies
  - Persistent Volumes
  - Host ports
  - Dependencies on **ConfigMaps** and **Secrets**

Resource Profiles

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

Resource Profile

```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
```

Quality-of-Service Classes

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

Declarative Deployment

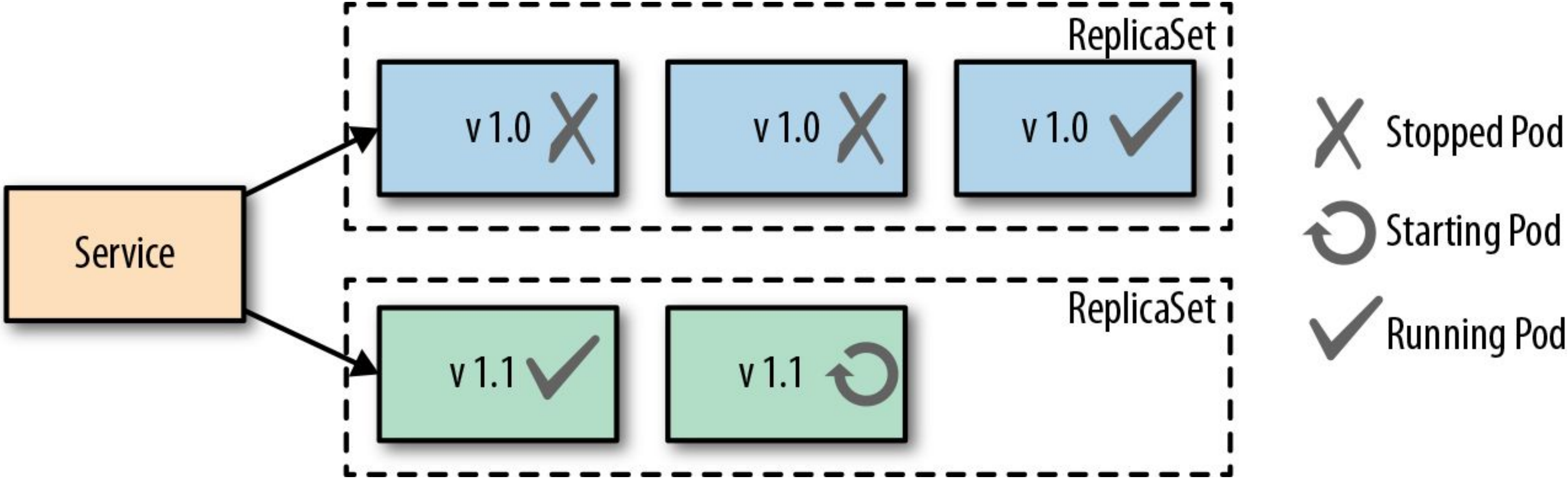
Deployment

How can applications be deployed and updated?

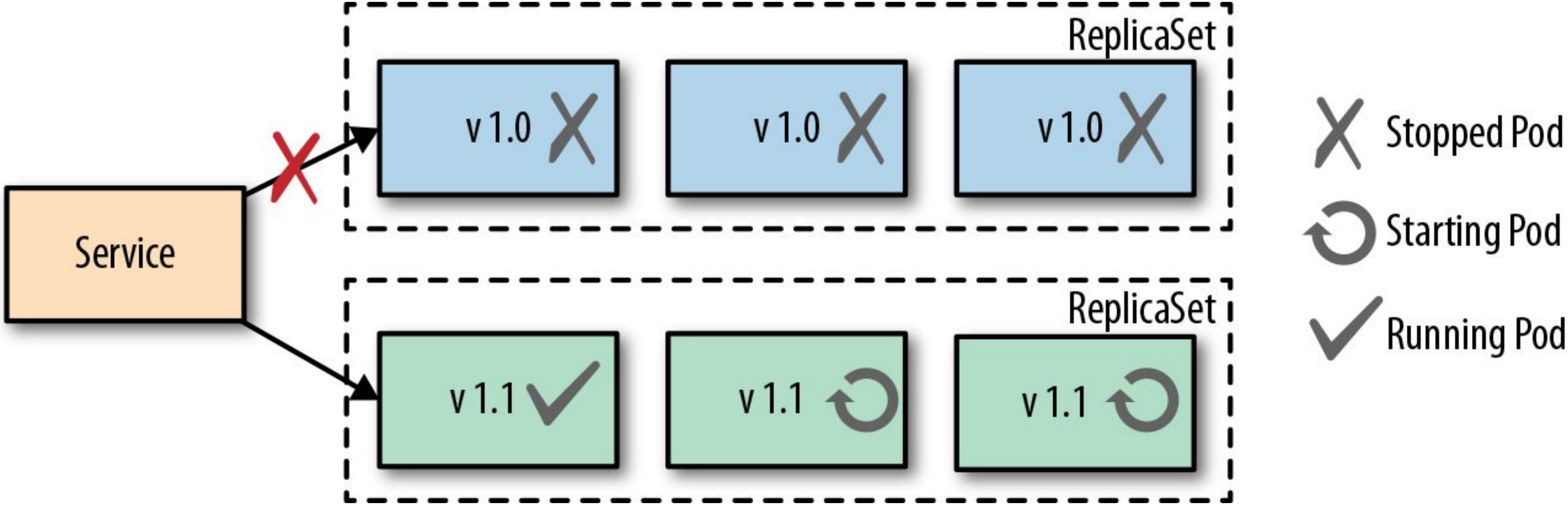
- **Declarative** vs. **Imperative** deployment
- Deployment Kubernetes Resource:
  - Holds template for **Pod**
  - Creates **ReplicaSet** on the fly
  - Allows rollback
  - Update strategies are declarable
  - Inspired by **DeploymentConfig** from OpenShift

Red Hat

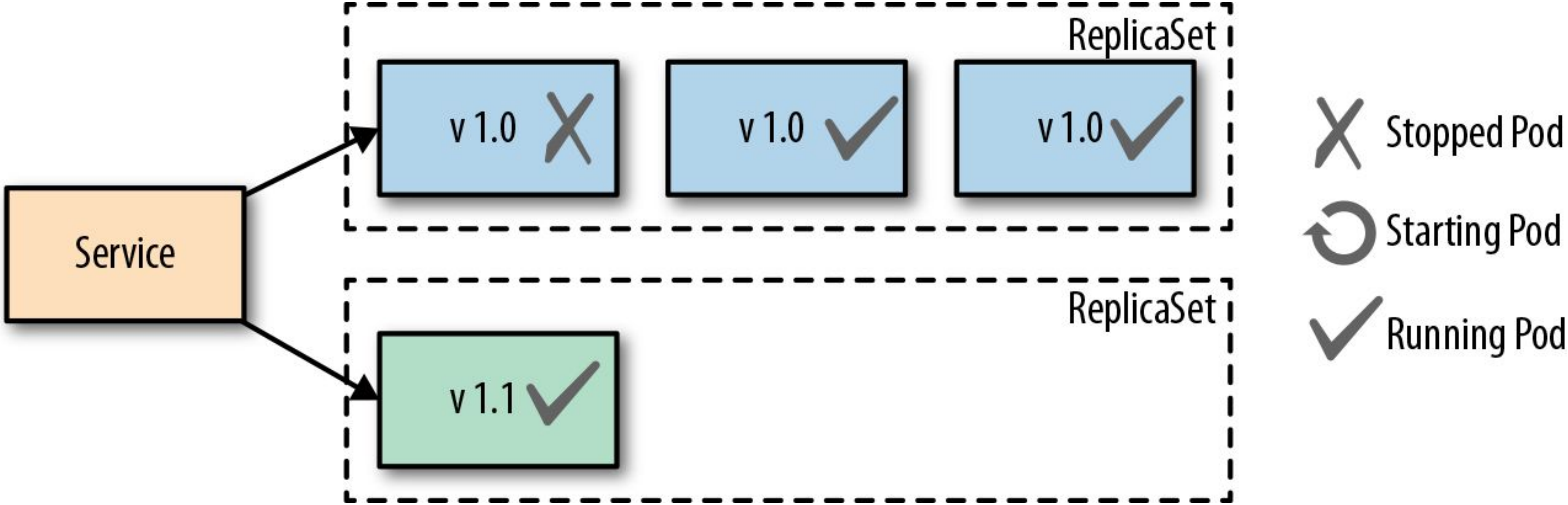
Rolling Deployment



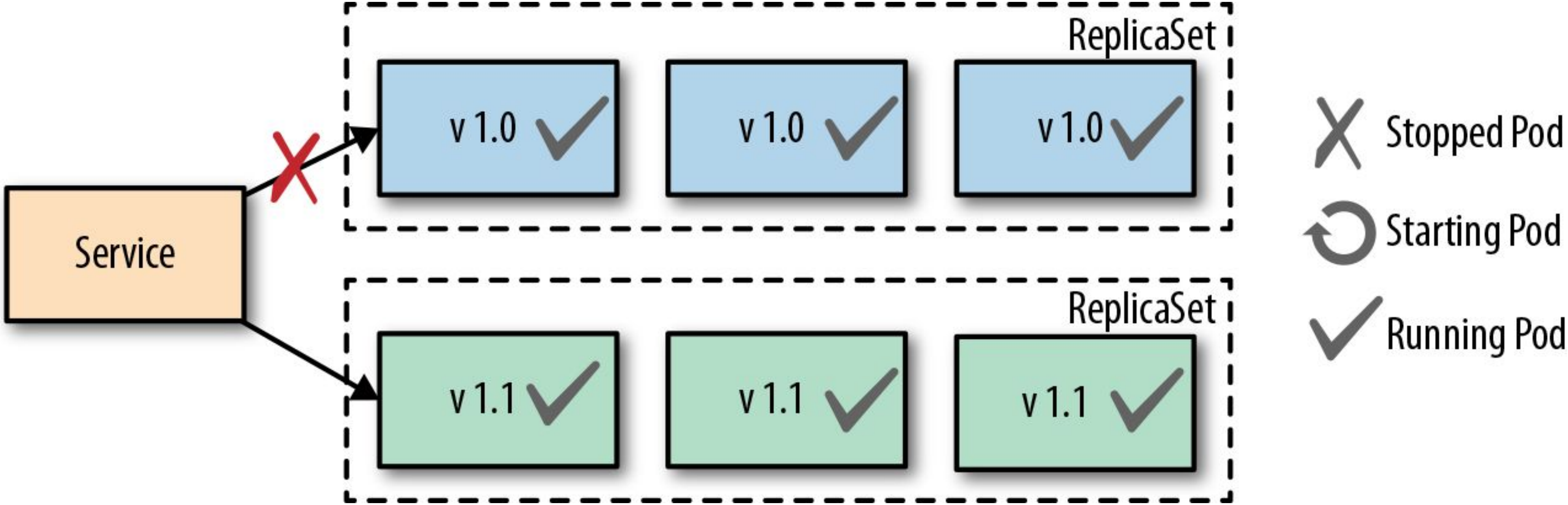
Fixed Deployment

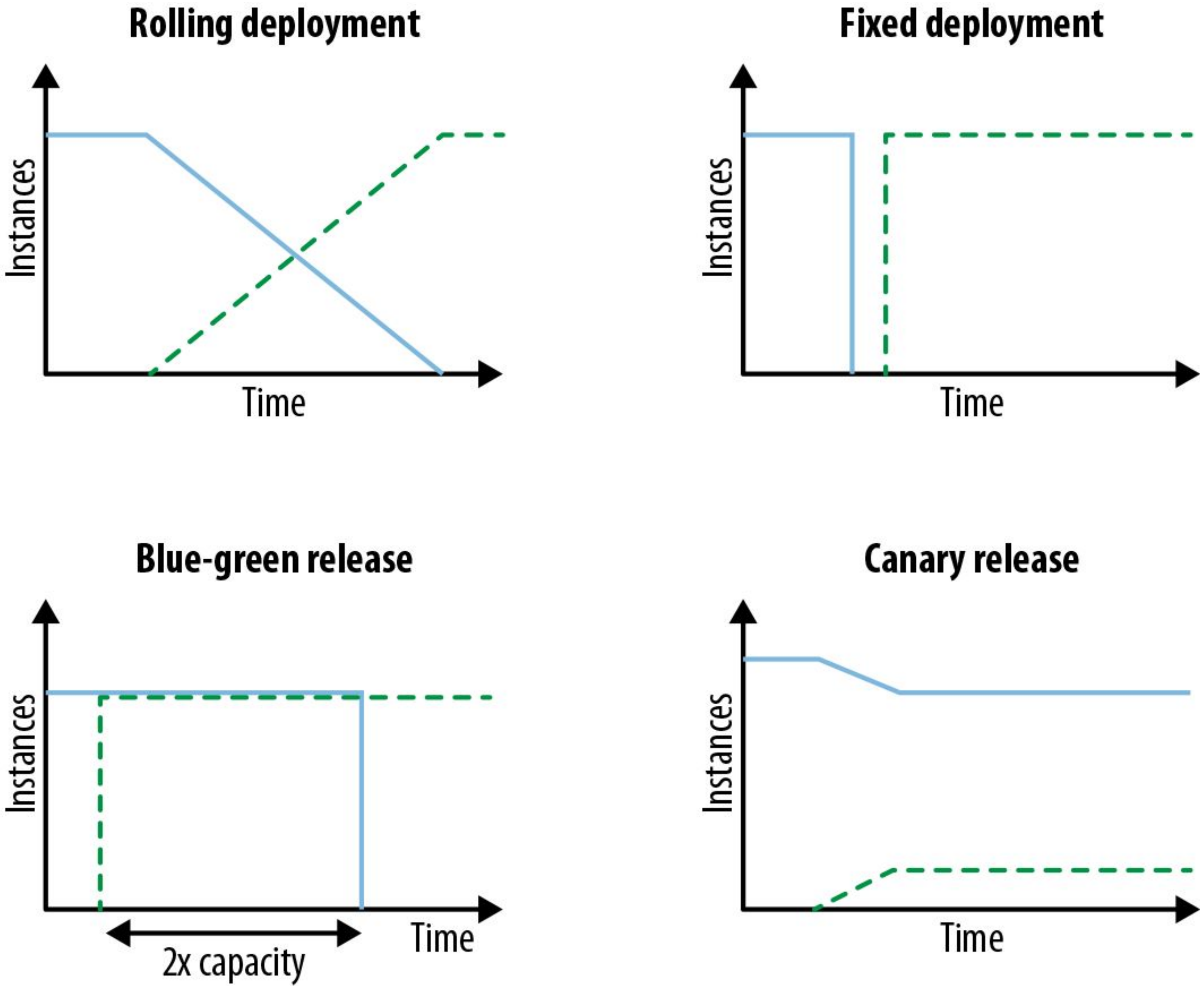


Canary Release



Blue-Green Release



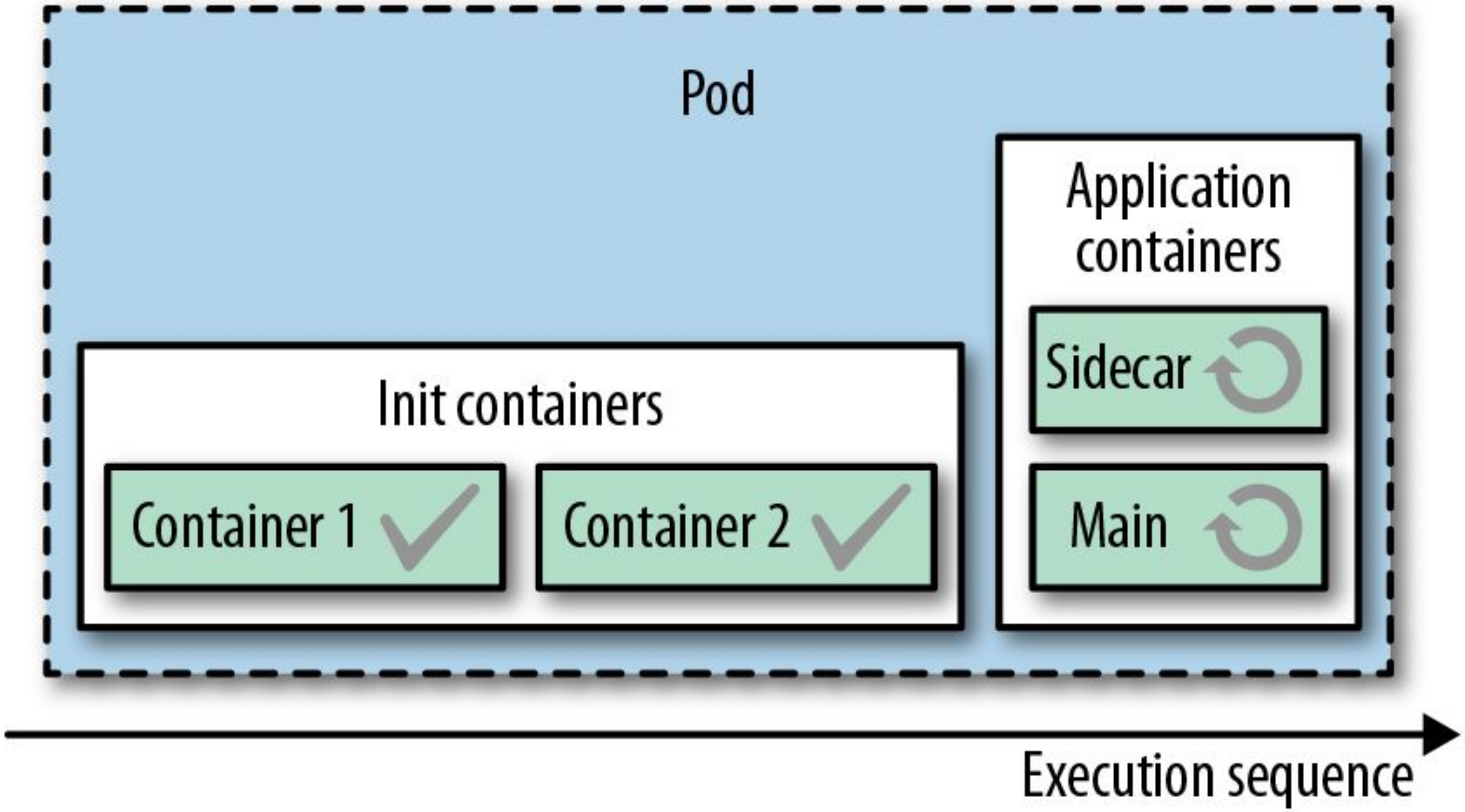

Rolling deployment
Instances
Time
Fixed deployment
Instances
Time
Blue-green release
Instances
2x capacity
Time
Canary release
Instances
Time

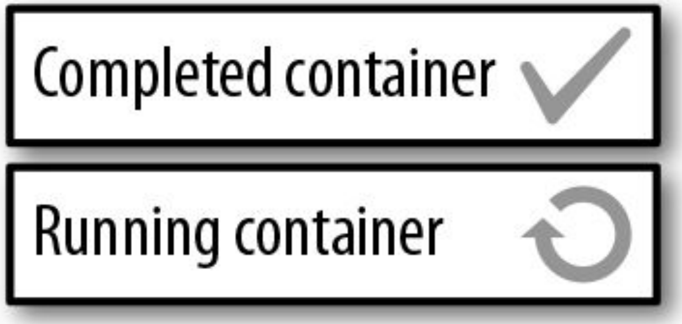
STRUCTURAL PATTERNS

Init Container

How can we initialize our containerized applications?

- Init Containers:
    - Part of a Pod
    - One shot actions before application starts
    - Needs to be idempotent
    - Has own resource requirements


Pod
Init containers
Container 1
Container 2
Application containers
Sidecar
Main
Execution sequence


Completed container
Running container

Init Container

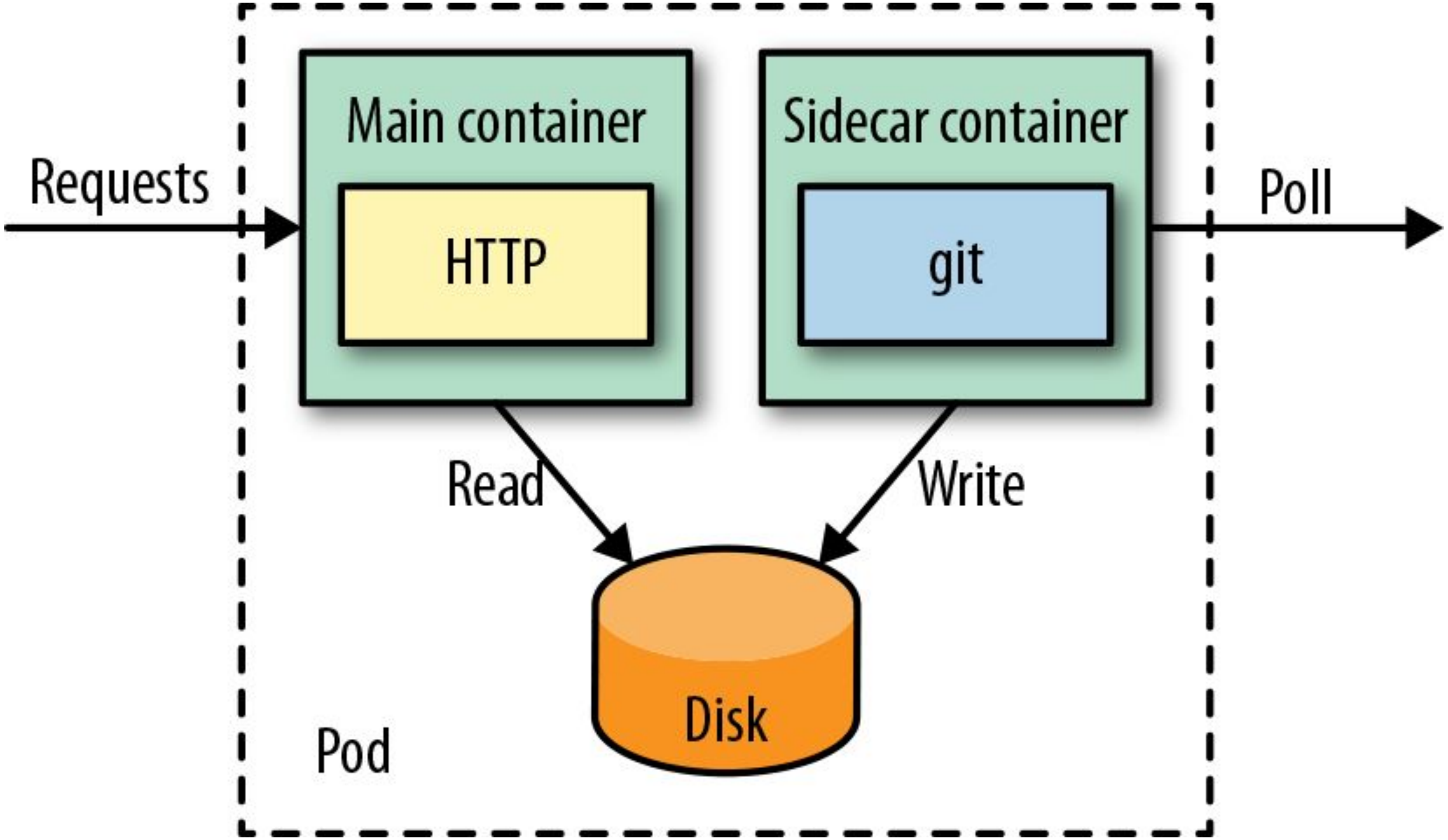
```yaml
apiVersion: v1
kind: Pod
....
spec:
  initContainers:
  - name: download
    image: axeclbr/git
    command: [ "git","clone","https://github.com/myrepo","/data"]
    volumeMounts:
    - mountPath: /var/lib/data
      name: source
  containers:
  - name: run
    image: docker.io/centos/httpd
    volumeMounts:
    - mountPath: /var/www/html
      name: source
  volumes:
  - emptyDir: {}
    name: source
```

Sidecar Pattern

How do we enhance the functionality of an application without changing it?

- Runtime collaboration of containers
- Connected via shared resources:
  - Network
  - Volumes
- Similar what AOP is for programming
- Separation of concerns

Sidecar

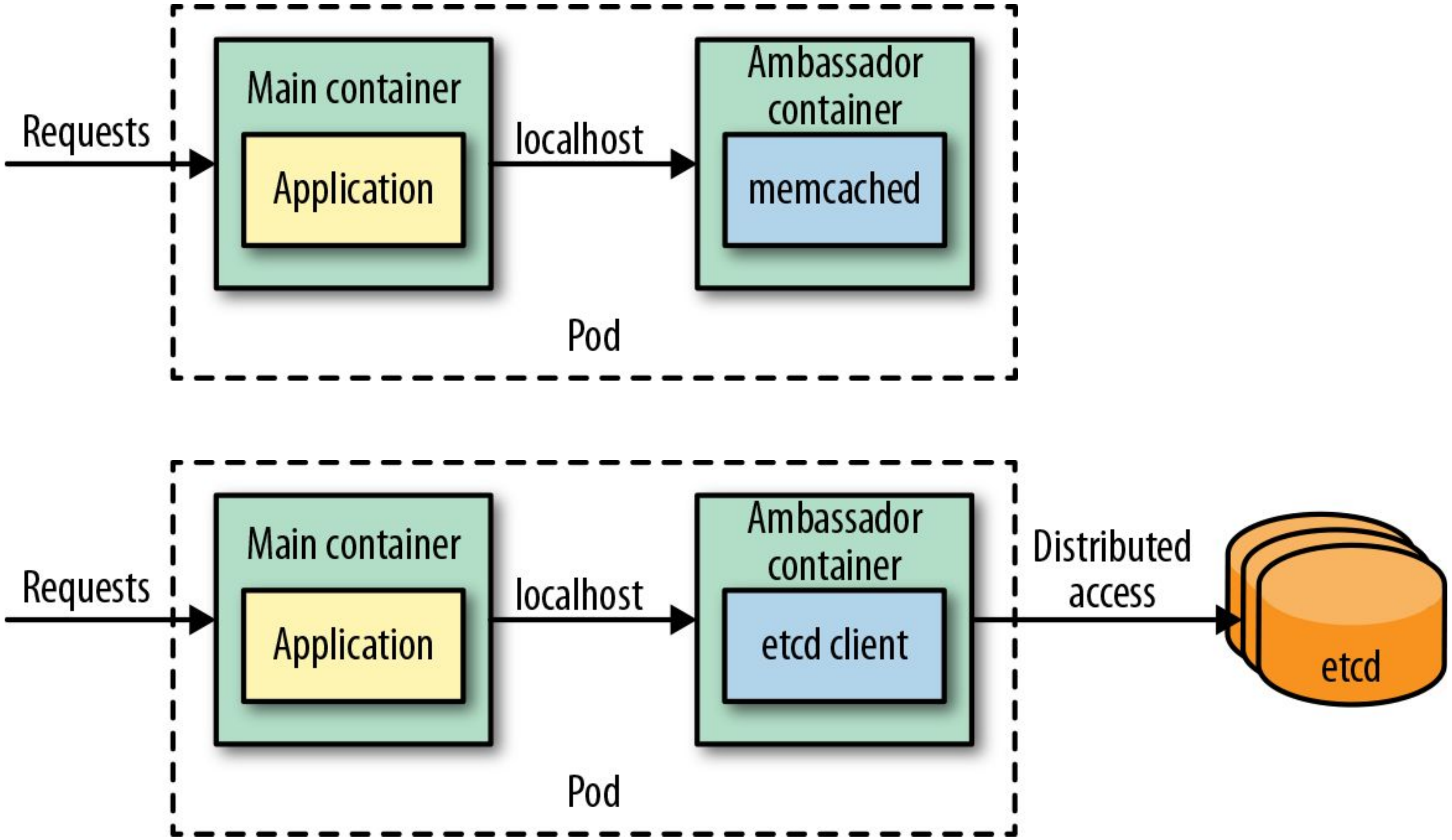

Requests
Main container
HTTP
Sidecar container
git
Poll
Read
Write
Disk
Pod

Ambassador Pattern

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

- Also known as **Proxy**
- Specialization of a Sidecar
- Examples for infrastructure services
  - Circuit breaker
  - Tracing

Ambassador

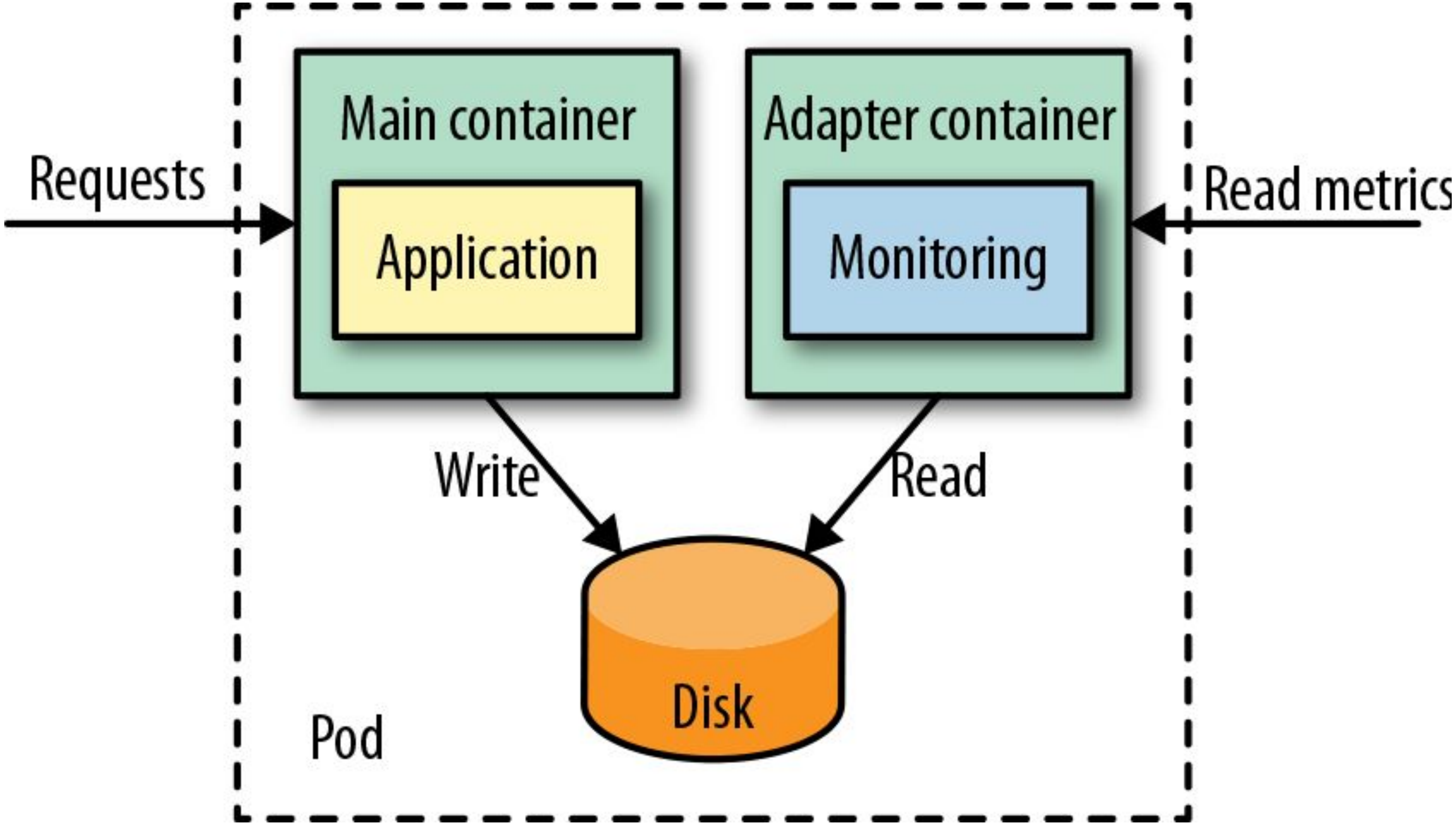

Requests
Main container
Application
localhost
Ambassador container
memcached
Pod
Requests
Main container
Application
localhost
Ambassador container
etcd client
Distributed access
etcd
Pod

Adapter Pattern

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

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

Adapter



Red Hat

CONFIGURATIONAL PATTERNS

Red Hat

How can applications be configured for different environments?

EnvVar Configuration

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

EnvVar Configuration

```yaml
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
```

ConfigMap

- Key-Value Map
- Use in Pods as:
  - environment variables
  - volumes with keys as file names and values as file content

```
kubectl create cm spring-boot-config \
   --from-literal=JAVA_OPTIONS=-Djava.security.egd=file:/dev/urandom \
   --from-file=application.properties
```

ConfigMap

```
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
```

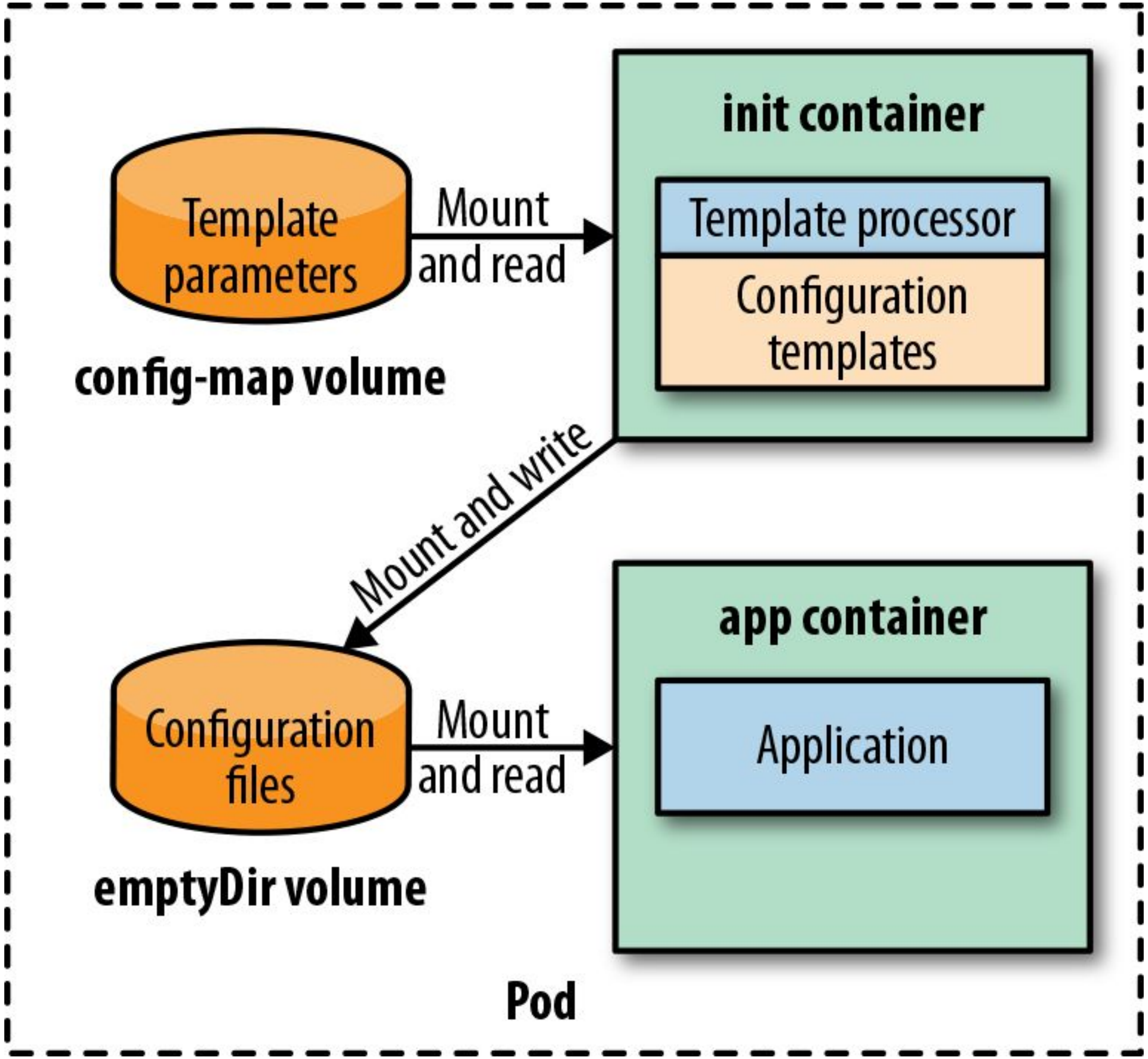
Secret

- Like ConfigMap but content Base64 encoded
- Secrets are ...
  - ... only distributed to nodes running Pods that need it
  - ... only stored in memory in a `tmpfs` and never written to physical storage
  - ... stored encrypted in the backend store (etcd)
- Access can be restricted with RBAC rules
- But: For high security requirements application based encryption is needed

Configuration Template

How to manage large and complex similar configuration data?

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

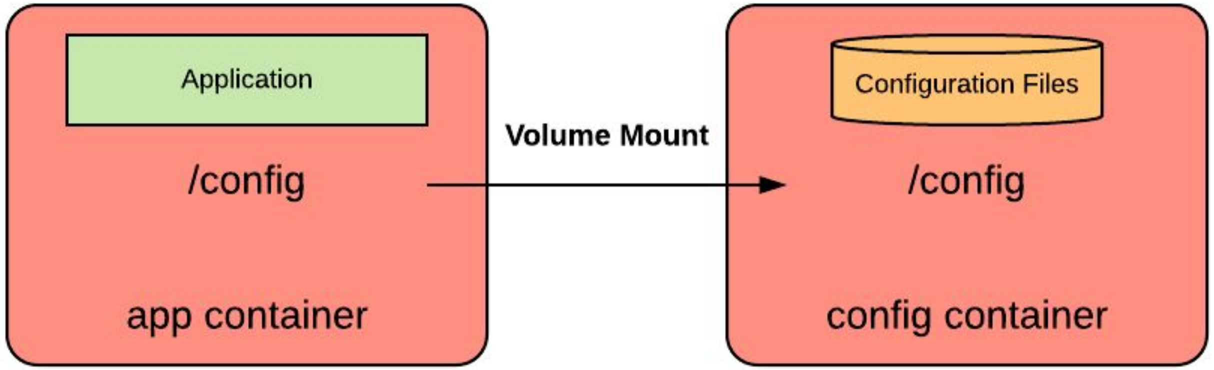

init container
Template processor
Configuration templates
Template parameters
Mount and read
config-map volume
Mount and write
app container
Application
Configuration files
Mount and read
emptyDir volume
Pod

Configuration Template

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

Immutable Configuration

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



- Not directly supported by Kubernetes

ADVANCED PATTERNS

Operator

How to encapsulate operational knowledge into executable software?

- We want to encapsulate operational knowledge so we can
  - Manage installations
  - Manage configuration
  - Manage updates and fail-overs

Definition

> An **operator** is a Kubernetes **controller** that understands two domains: Kubernetes and *something else*. By combining knowledge of both areas, it can **automate** tasks that usually require a human operator that understands both domains.

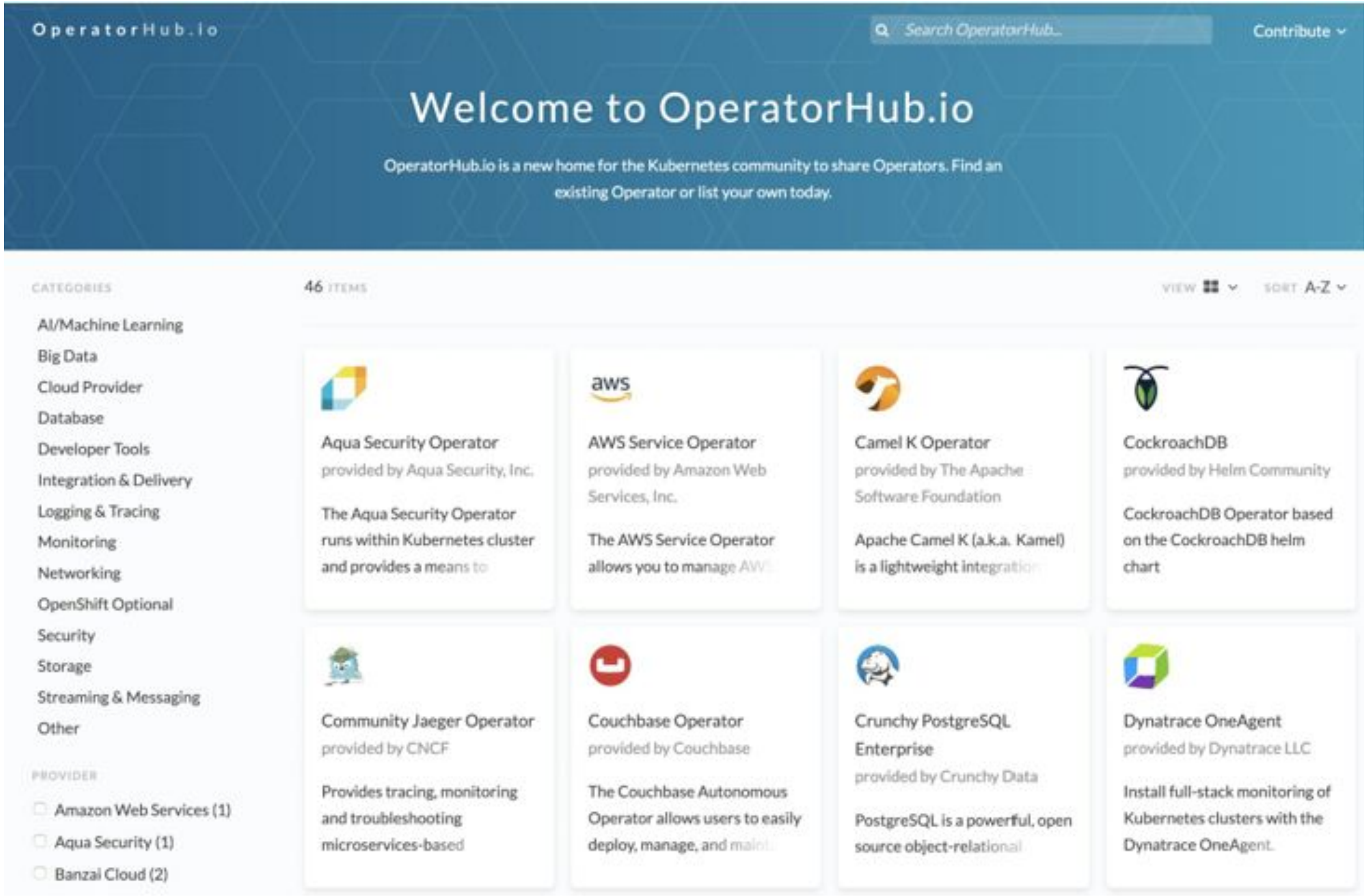
Jimmy Zelinskie
http://bit.ly/2FjIx1h

Technical:

Operator = Controller + CustomResourceDefinition

Red Hat

OperatorHub.io



Wrap Up

- Kubernetes offers a rich feature set to manage containerised applications
- Patterns can help in solving recurring Kubernetes, legacy application and Microservices challenges
- Patterns will continue to emerge

Thank you

https://k8spatterns.io

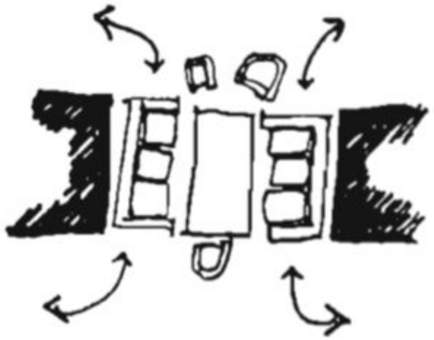
@ro14nd

@bibryam

@k8spatterns

Appendix

90 BEER HALL



The open alcove—supports the fluidity of the scene.

A Pattern Language, Christopher Alexander et. al, 1977, pp. 444

Kubernetes Architecture and Foundational Elements

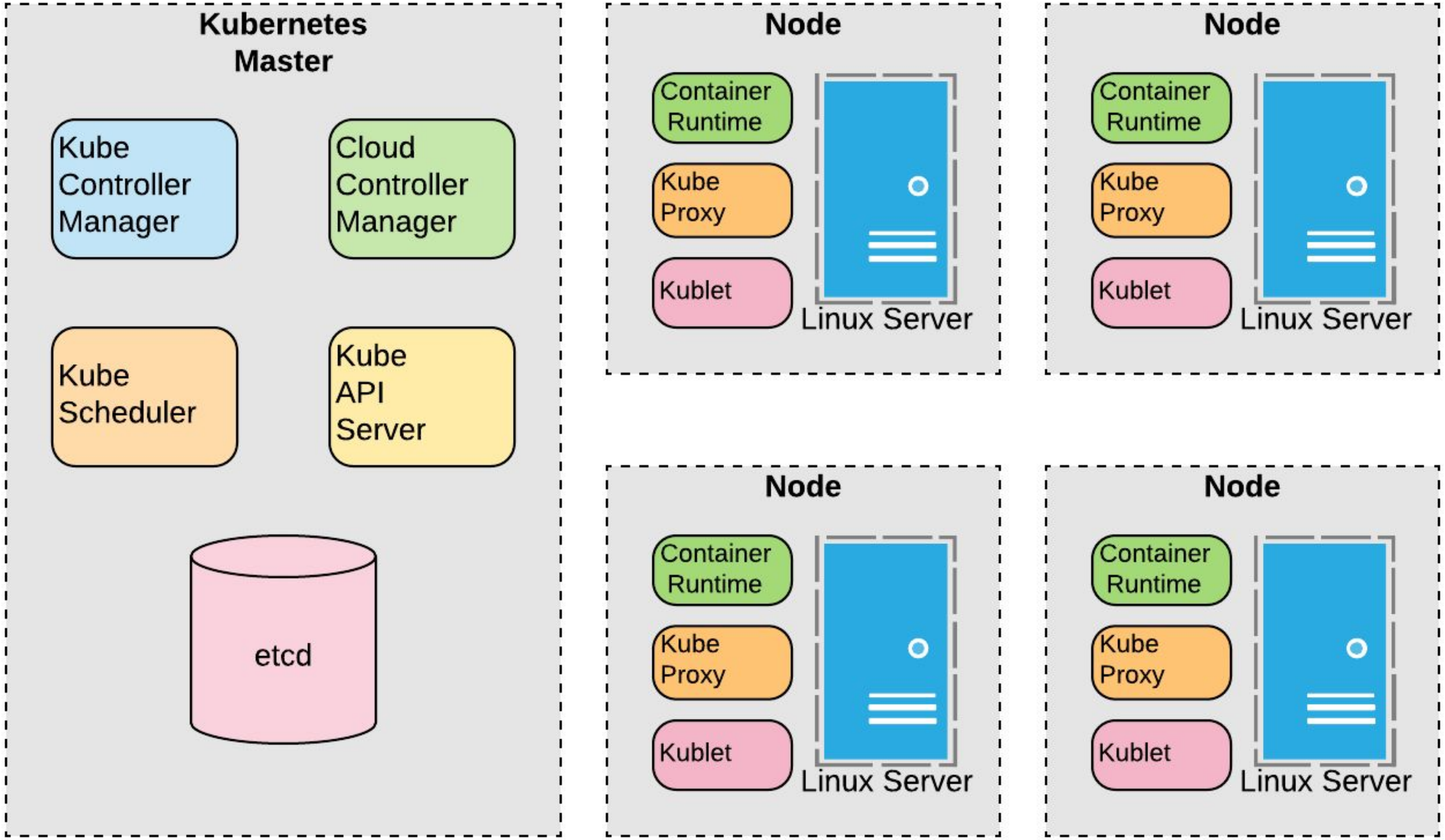
KUBERNETES

Kubernetes

- Open Source container orchestration system started by Google in 2014
  - Scheduling
  - Self-healing
  - Horizontal and vertical scaling
  - Service discovery
  - Automated Rollout and Rollbacks
- Declarative resource-centric REST API

Kubernetes Foundational Elements

Kubernetes Architecture



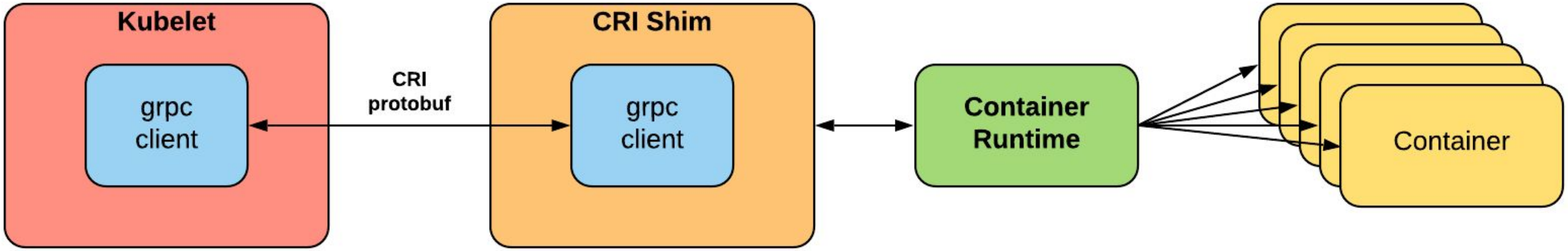
Control Plane Components

- **API Server:** kube-api-server exposes the Kubernetes API to the world. Stores cluster state in etcd
- **etcd metadata store:** a consistent and reliable distributed key-value store (https://coreos.com/etcd/)
- **Scheduler:** kube-scheduler schedules pods to worker nodes
- **Controller manager:** kube-controller manager is a single process that contains multiple controller watching for events and changes to the cluster
- **Cloud controller manager:** Embeds cloud-specific control loops.

Data Plane Components

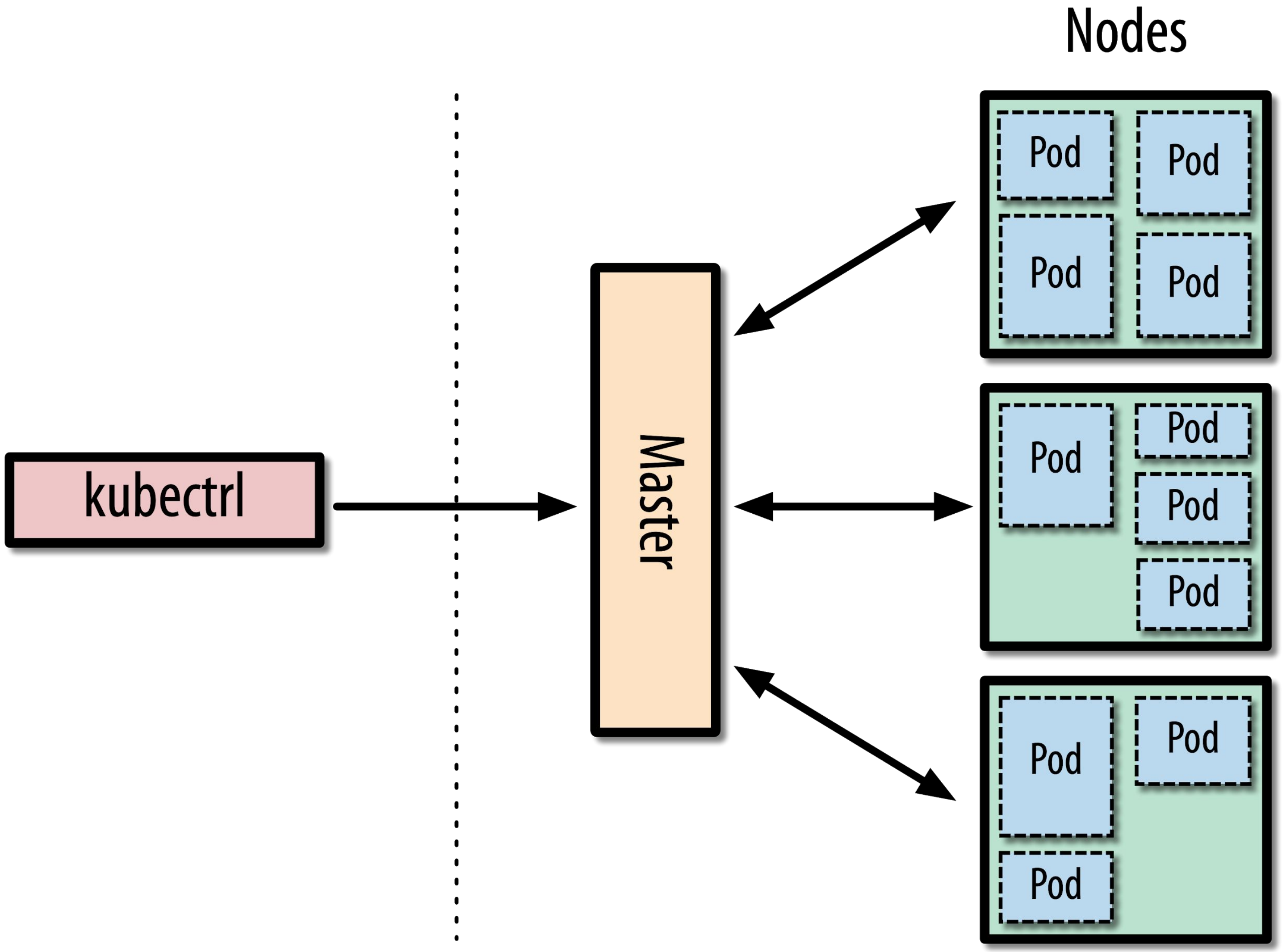
- **A collection of nodes that run containerized workloads as pods**
- **kubelet:** Responsible for communicating with the API server and running and managing pods on the node
- **kube-proxy:** Responsible for the networking of the node. Fronts services and can forward TCP and UDP packets and also discovers addresses of services via DNS or environment variables
- **Kubectl:** The command-line interface (CLI) to the Kubernetes cluster (kubectl <command> --help)

Data Plane Components

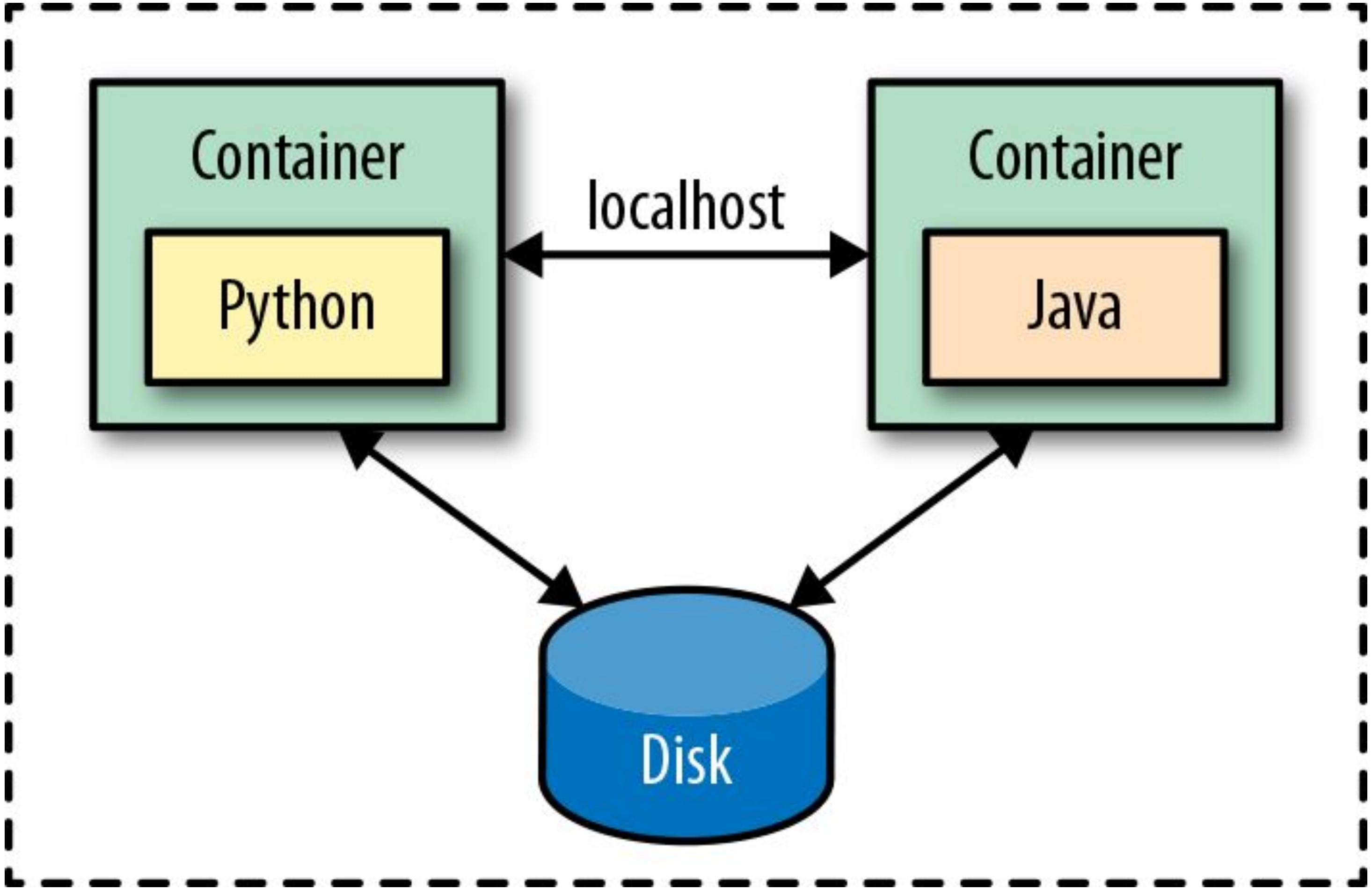


- **Container runtime:** Kubernetes runs containers through an interface called the **CRI** based on **gRPC**.
  - Any container runtime that implements CRI can be used on a node controlled by the kubelet

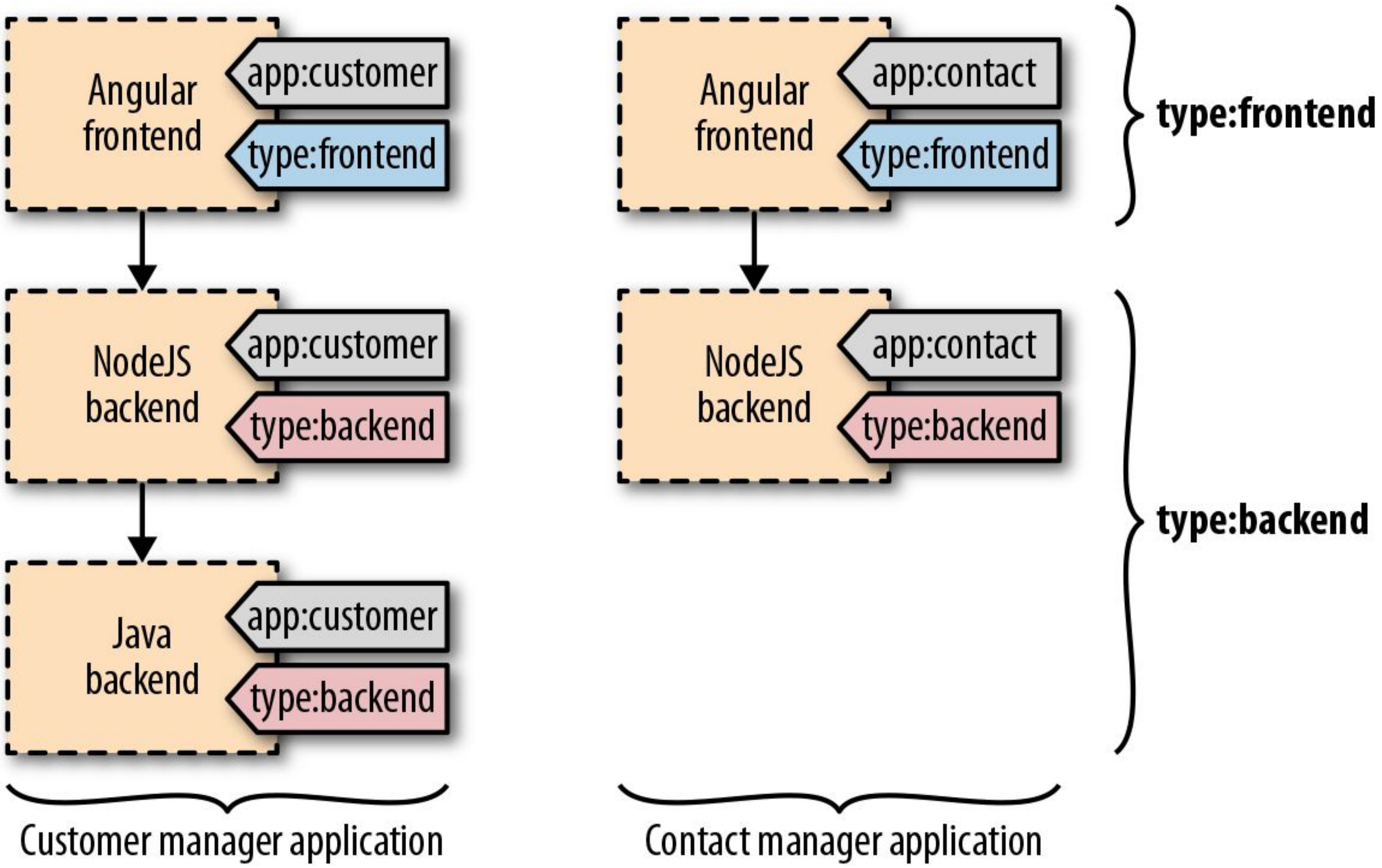
Architecture



Pod



Labels



Red Hat

Health Probe Pattern

Monitoring Health

How to communicate an application’s health state to Kubernetes?

- Process health checks
  - Checks running process
  - Restarts container if container process died
- Application provided Health Probes
  - **Liveness Probe:** Check application health
  - **Readiness Probe:** Check readiness to process requests

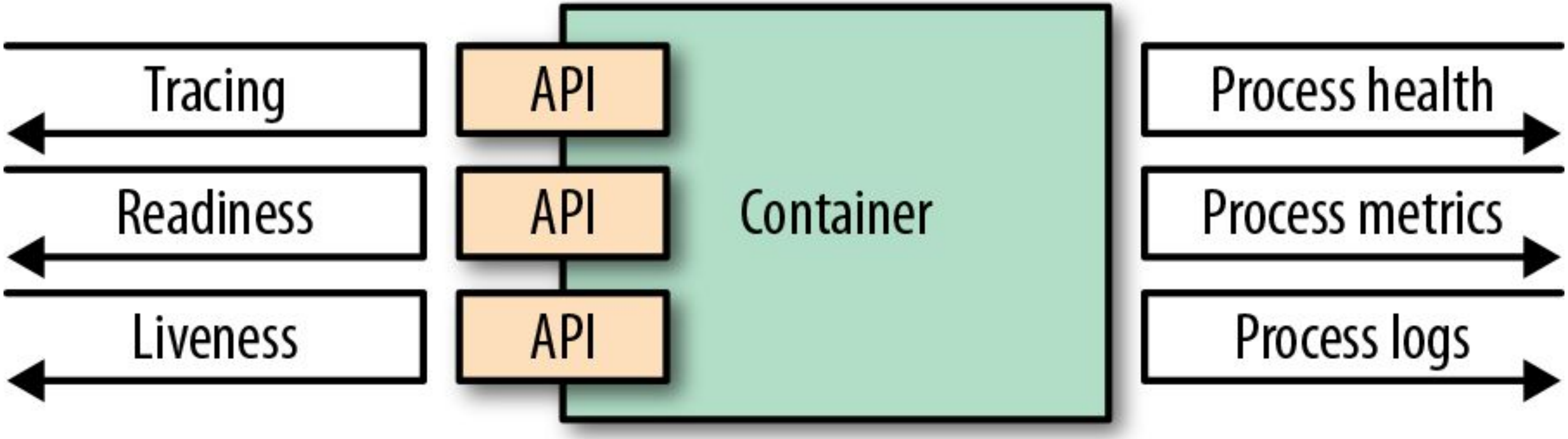
Red Hat

Liveness & Readiness

- Liveness Probe
  - Restarting containers if liveness probes fail
- Readiness Probe
  - Removing from service endpoint if readiness probe fails
- Probe methods
  - HTTP endpoint
  - TCP socket endpoint
  - Unix command’s return value

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pod-with-readiness-check
spec:
  containers:
  - image: k8spatterns/random-generator:1.0
    name: random-generator
    livenessProbe:
      httpGet:
        path: /actuator/health
        port: 8080
      initialDelaySeconds: 30
    readinessProbe:
      exec:
        command: [ "stat", "/var/run/random-generator-ready" ]
```

Container Observability Options

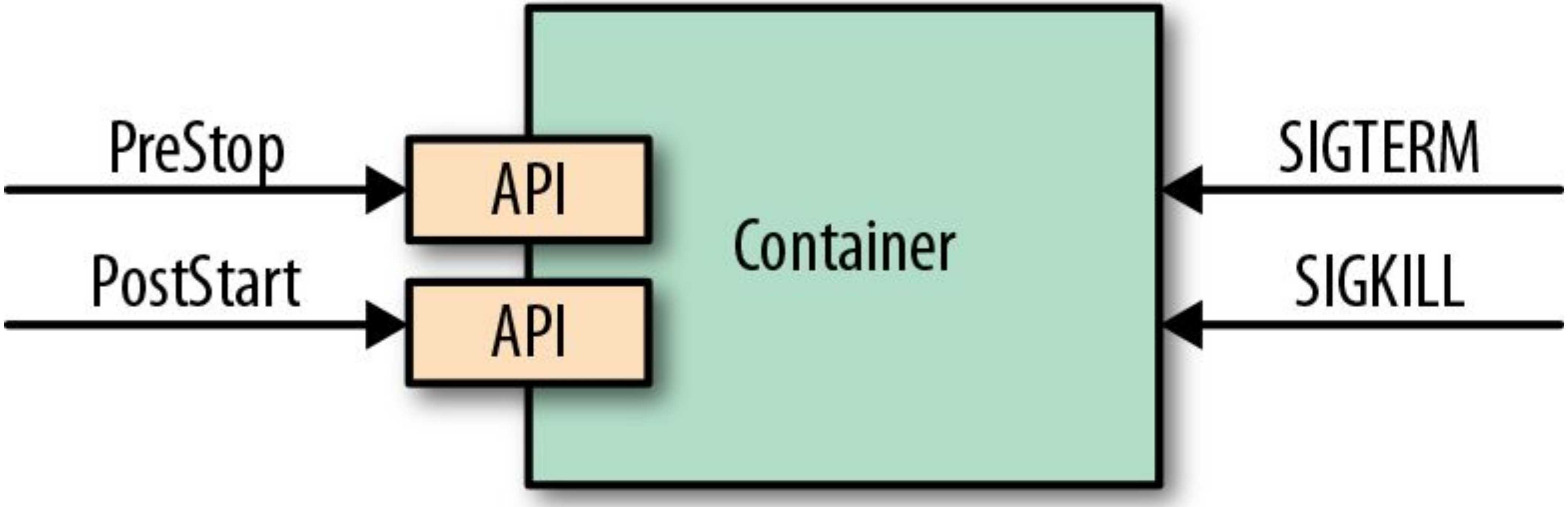


Managed Lifecycle Pattern

Lifecycle Events

How applications should react on lifecycle events?

Managed Container Lifecycle



Lifecycle Events

- SIGTERM
  - Initial event issued when a container is going to shutdown
  - Application should listen to this event to cleanup properly and then exit
- SIGKILL
  - Final signal sent after a grace period which can’t be catched
  - `terminationGracePeriodSeconds`: Time to wait after SIGTERM (default: 30s)

Lifecycle Hooks

- `postStart`
  - Called after container is created
  - Runs in parallel to the main container
  - Keeps Pod in status *Pending* until exited successfully
  - **exec** or **httpGet** handler types (like *Health Probe*)
- preStop
  - Called before container is stopped
  - Same purpose & semantics as for SIGTERM

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: pre-stop-hook
spec:
  containers:
  - image: k8spatterns/random-generator:1.0
    name: random-generator
    lifecycle:
      postStart:
        exec:
          command:
          - sh
          - -c
          - sleep 30 && echo "Wake up!" > /tmp/postStart_done
      preStop:
        httpGet:
          port: 8080
          path: /shutdown
```

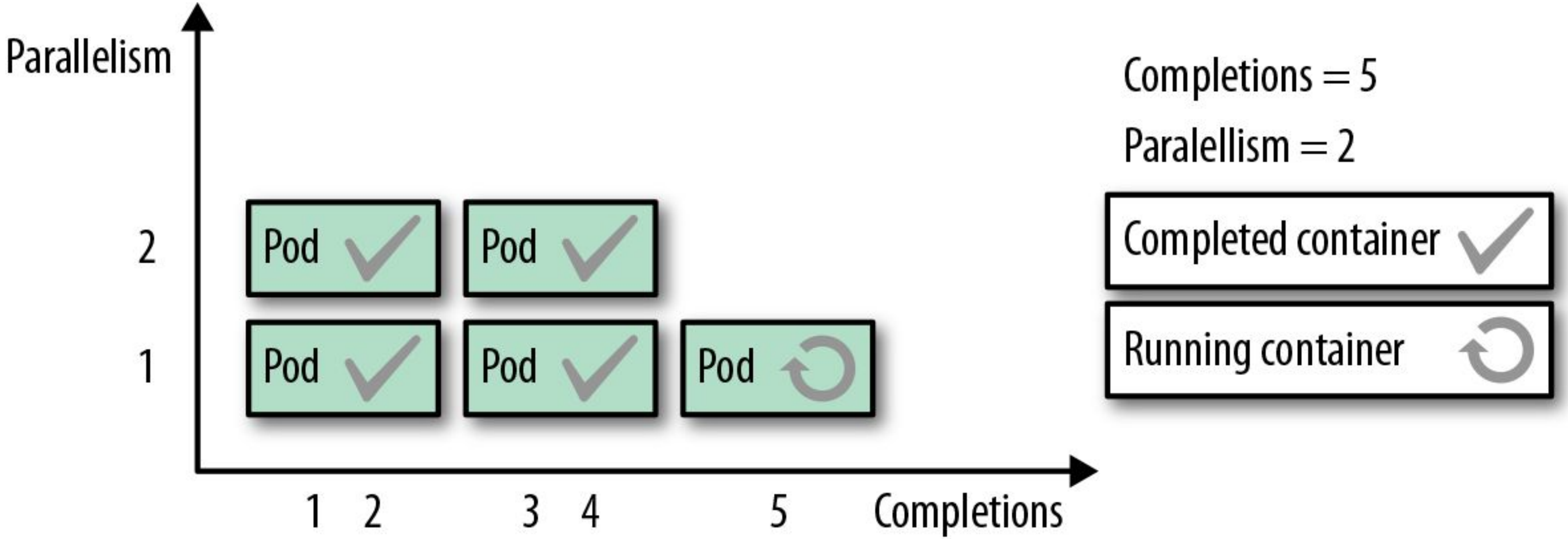
Batch Job Pattern

Job

How to run short-lived Pods reliably until completion?

- Resource for a predefined *finite* unit-of-work
- Survives cluster restarts and node failures
- Support for multiple Pod runs
- .spec.completions
  - How many Pods to run to complete Job
- .spec.parallelism
  - How many Pods to run in parallel

Parallel Batch Job



Job Types

- Single Pod Job
  - completions = 1 and parallelism = 1
- Fixed completion count Jobs
  - completions > 1
  - One Pod per work item
- Work queue Jobs
  - completions = 1 and parallelism > 1
  - All Pods need to finish, with at least one Pod exciting successfully
  - Pods needs to coordinate to shutdown in a coordinate fashion

Stateful Service Pattern

Distributed Stateful Services

How to manage stateful workloads?

- Non-shared persistent Storage
- Unique and stable network address
- Unique identity
- Defined instance order
- Minimal availability

StatefulSet

- Similar to ReplicaSet
- Additional Elements
  - servicveName - reference to headless Service
  - volumeClaimTemplates - template for creating instance unique PVCs
- Assinged PVs are **not** automically deleted
- Headless service for creating DNS entries for each instance's Pod

Headless Service

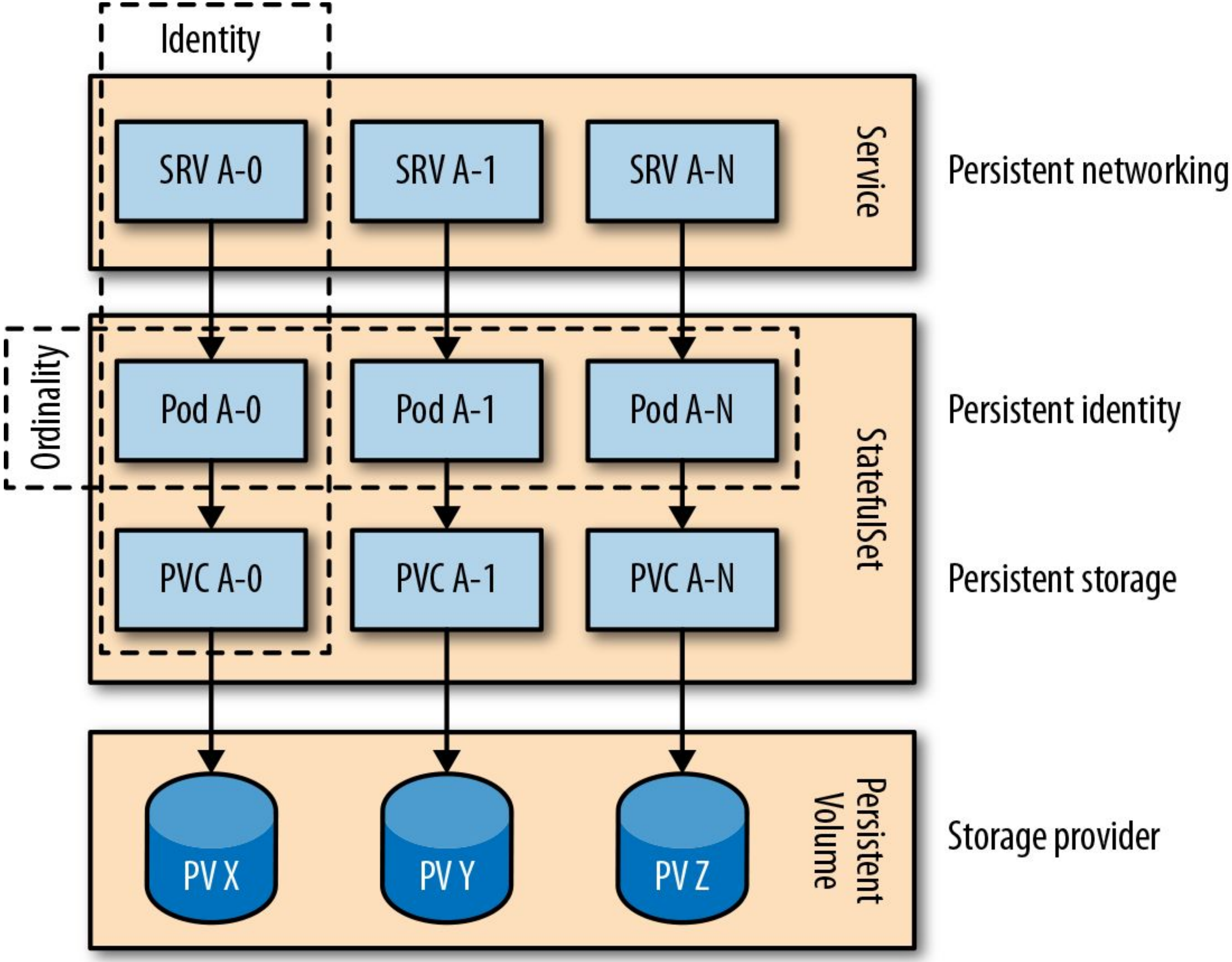
```yaml
apiVersion: v1
kind: Service
metadata:
  name: random-generator
spec:
  clusterIP: None
  selector:
    app: random-generator
  ports:
  - name: http
    port: 8080
```

rg-0.random-generator.default.svc.cluster.local
rg-1.random-generator.default.svc.cluster.local
...

Stateful Service

```yaml
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: rg
spec:
  serviceName: random-generator
  replicas: 2
  selector:
    matchLabels:
      app: random-generator
  template:
    metadata:
      labels:
        app: random-generator
    spec:
      containers:
      - image: k8spatterns/random-generator:1.0
        name: random-generator
        name: http
        volumeMounts:
        - name: logs
          mountPath: /logs
  volumeClaimTemplates:
  - metadata:
      name: logs
    spec:
      resources:
        requests:
          storage: 10Mi
```

Stateful Service



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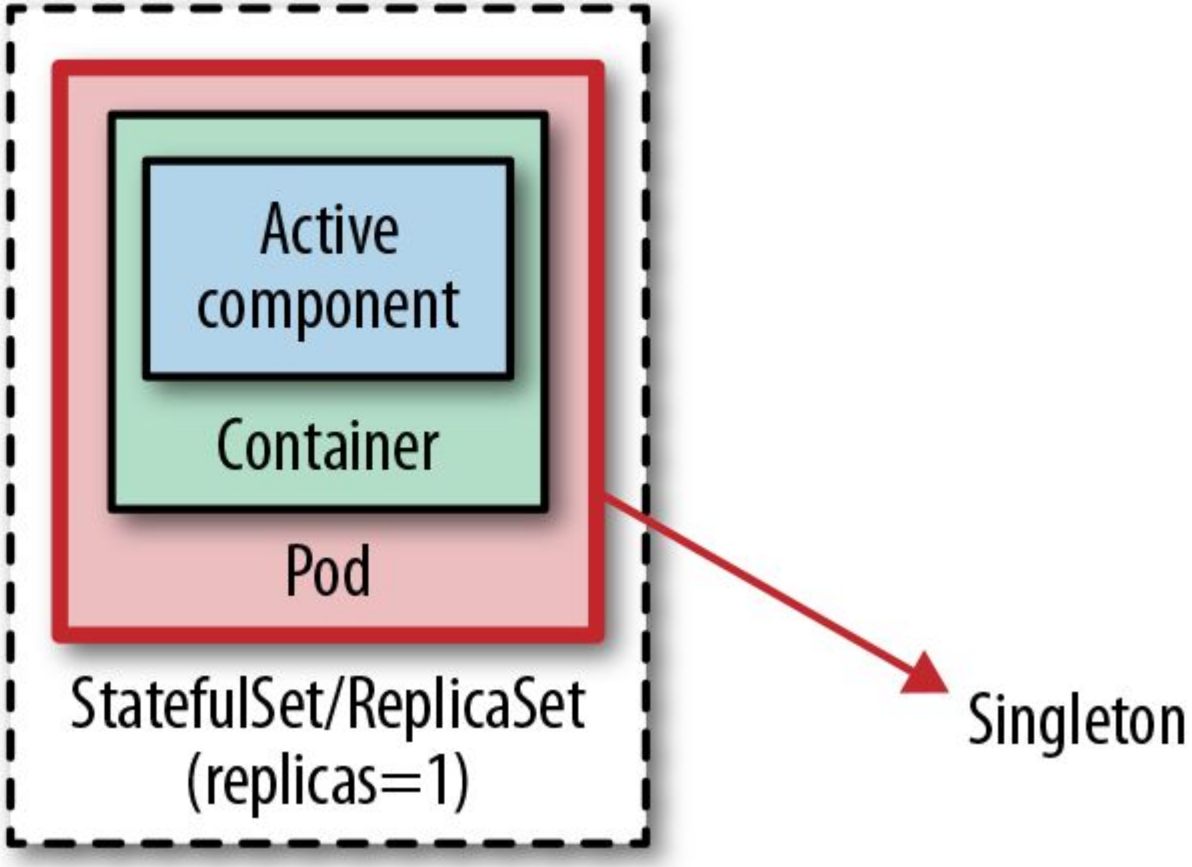
Singleton Service Pattern

Singleton Service

How to ensure that only one application instance is active?

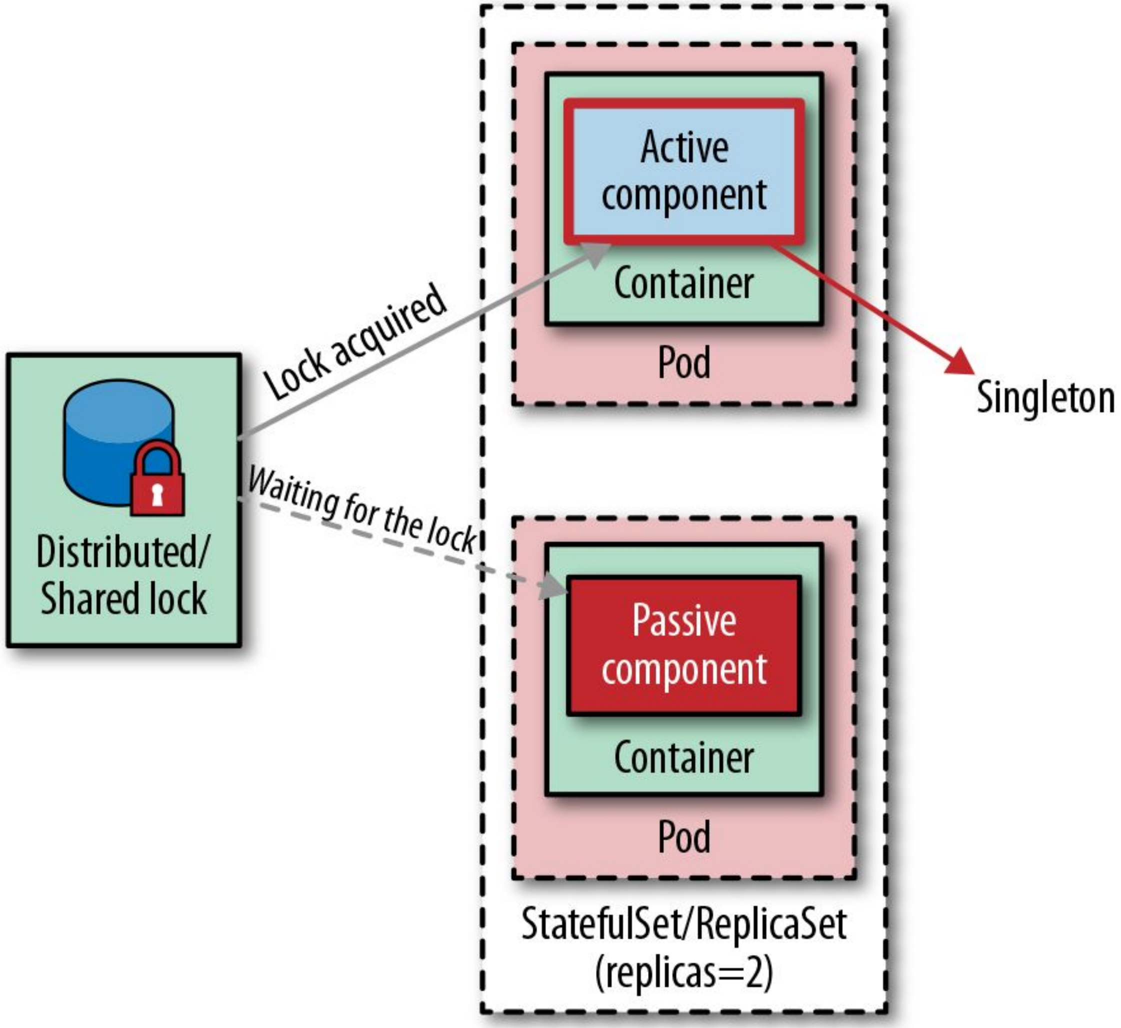
Out-of-Application Locking



Out-of-Application Locking

- ReplicaSet with 1 replica
- Highly available Pod which is monitored and restarted in case of failures
- ReplicaSet favors availability over consistency
  → more than one Pod can exists temporarily
- Alternative: StatefulSet with 1 replica

In-Application Locking



Red Hat

In-Application Locking

- Distributed lock shared by simultaneously running applications
- *Active-Passive* topology
- Distributed lock implementations e.g.
    - Zookeeper
    - Consul
    - Redis
    - etcd

Pod Disruption Budget

Ensures a certain number of Pods will not *voluntarily* be evicted from a node

```yaml
apiVersion: policy/v1beta1
kind: PodDisruptionBudget
metadata:
  name: random-generator-pdb
spec:
  selector:
    matchLabels:
      app: random-generator
  minAvailable: 2
```

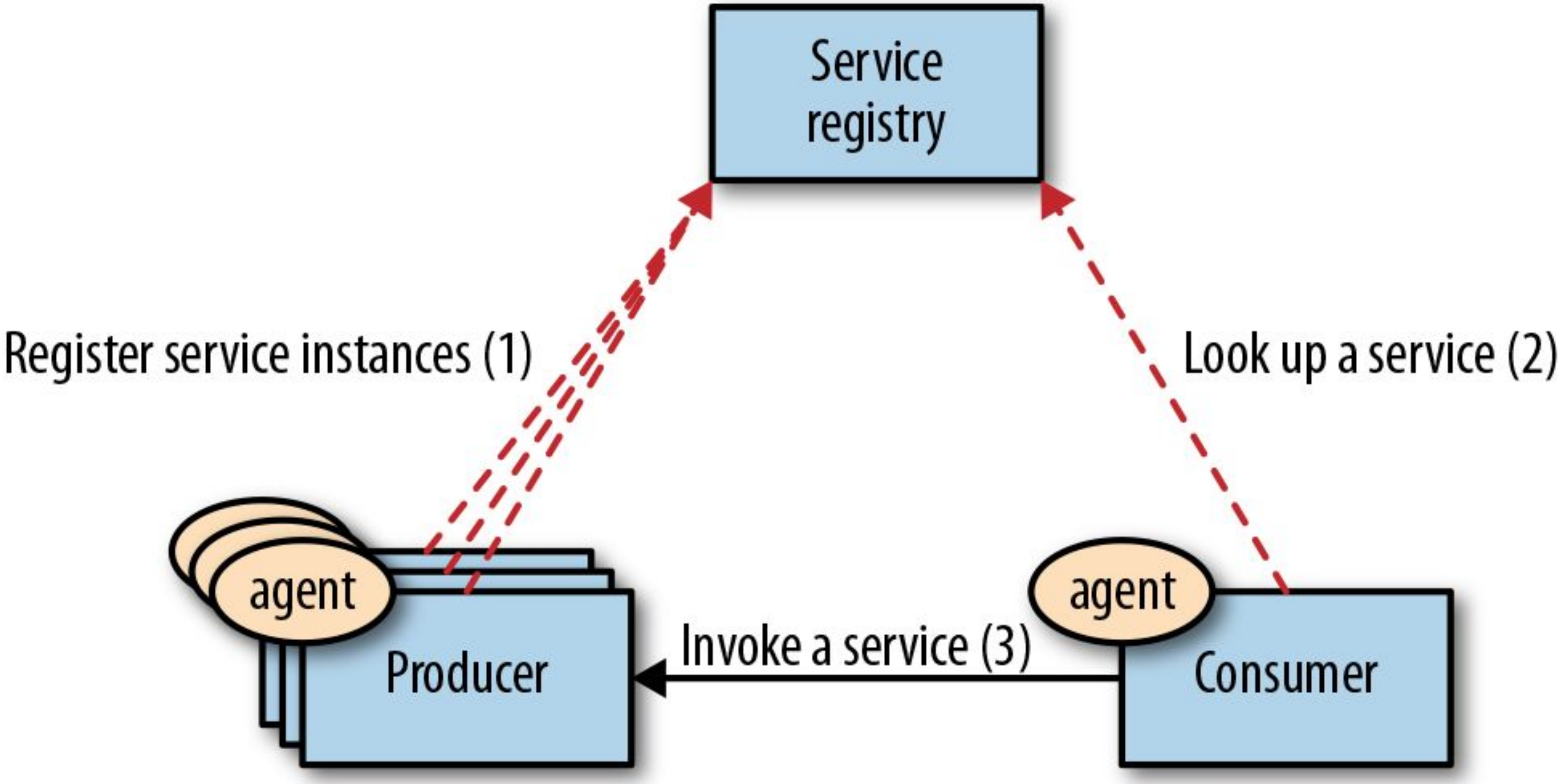

Red Hat

Service Discovery Pattern

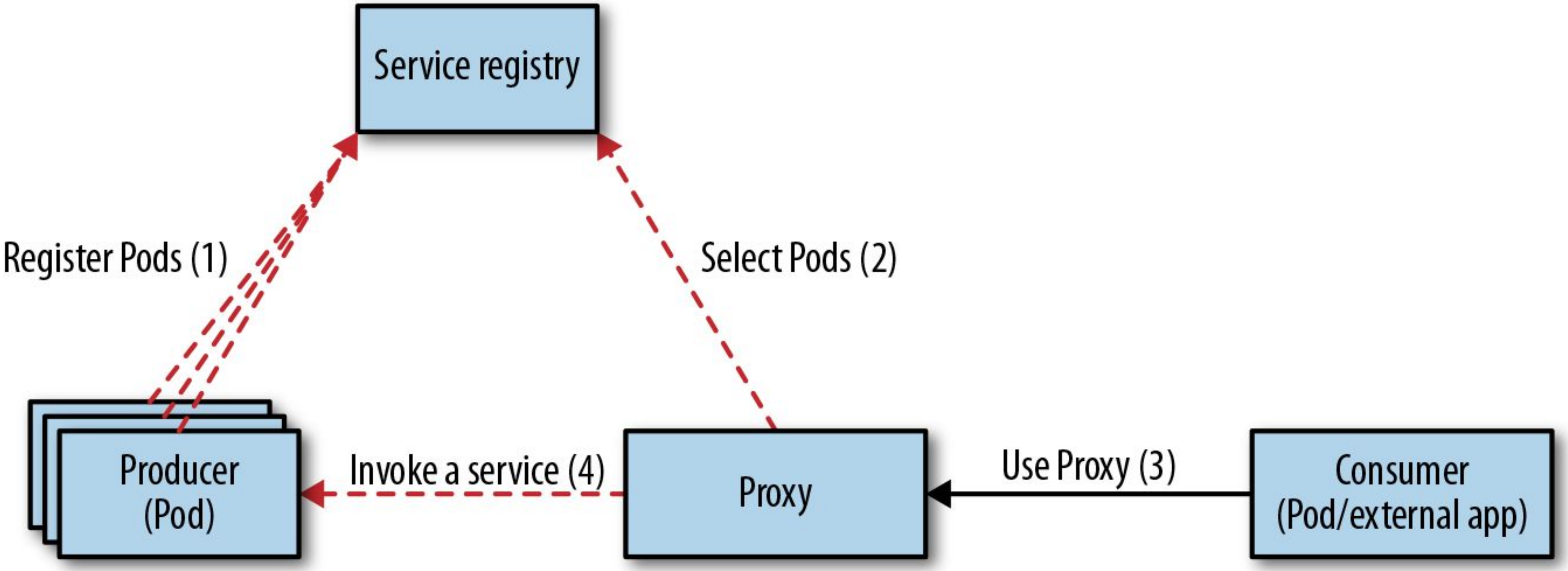
Service Discovery

How to discover and use services?

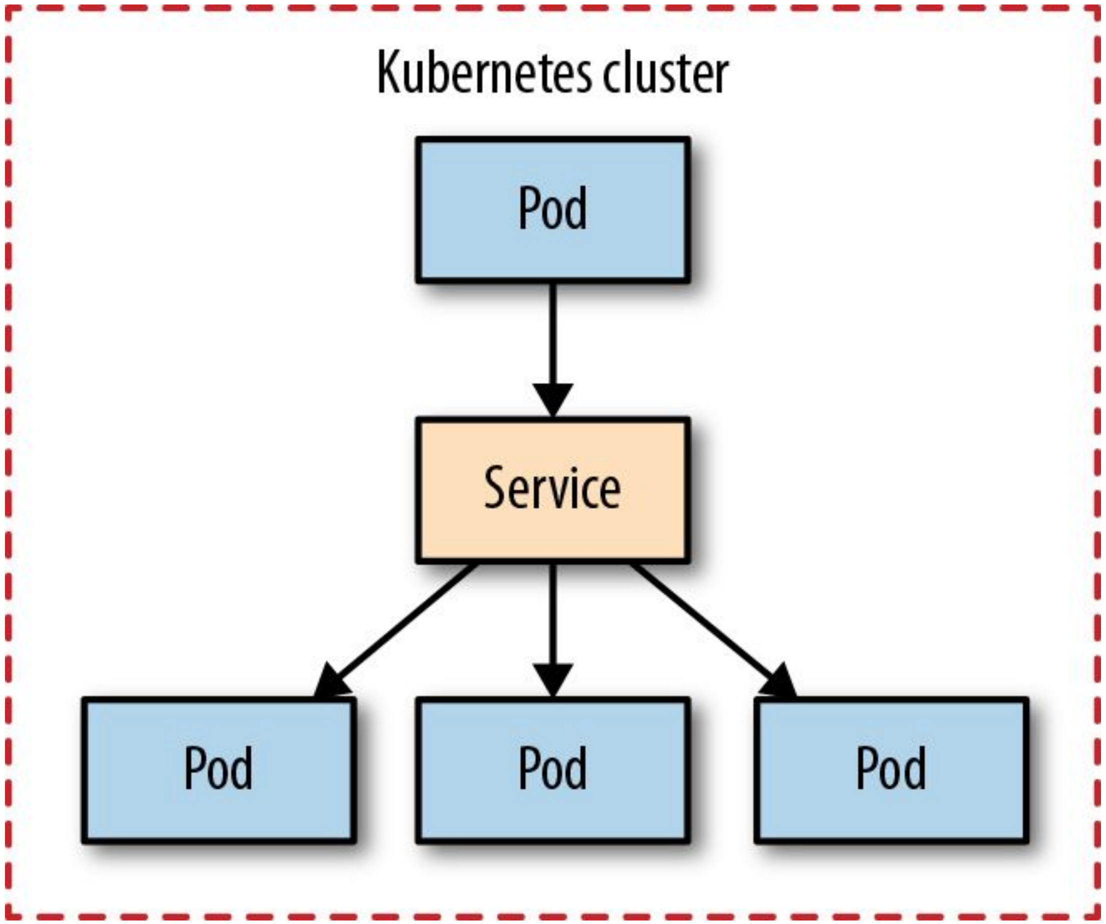
Client-side Service Discovery (non Kubernetes)



Server-side Service Discovery (Kubernetes)

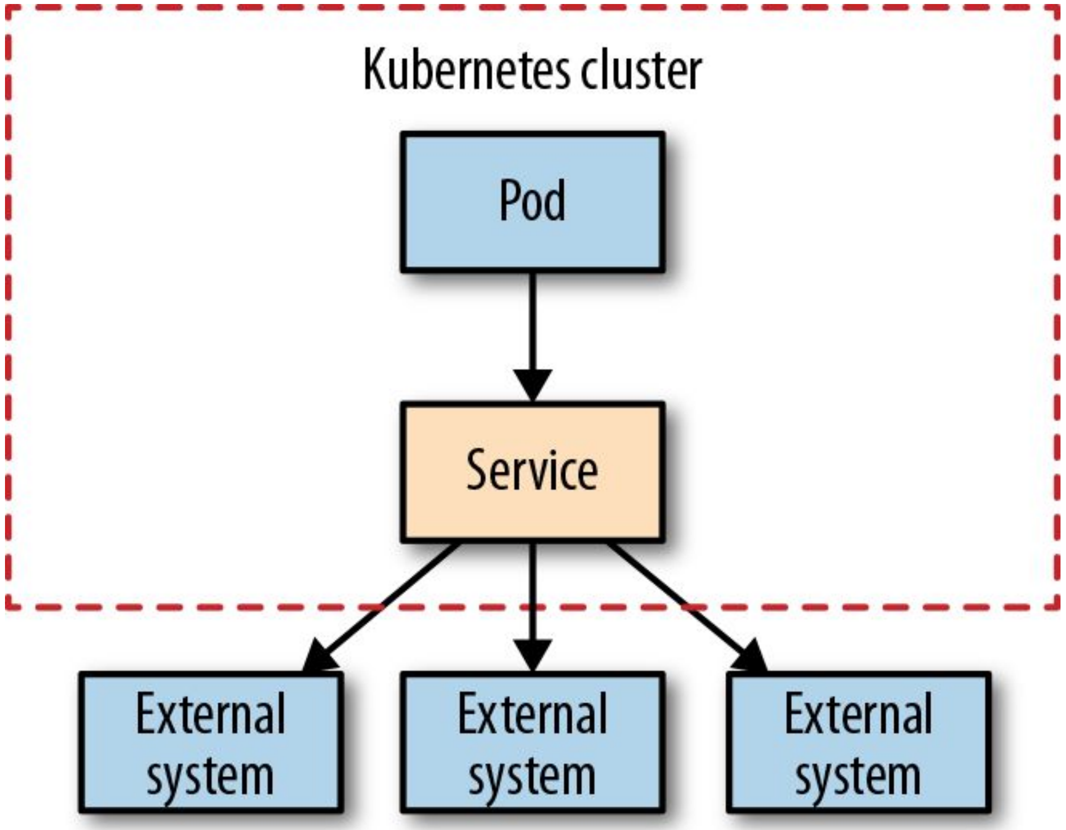


Internal Service Discovery



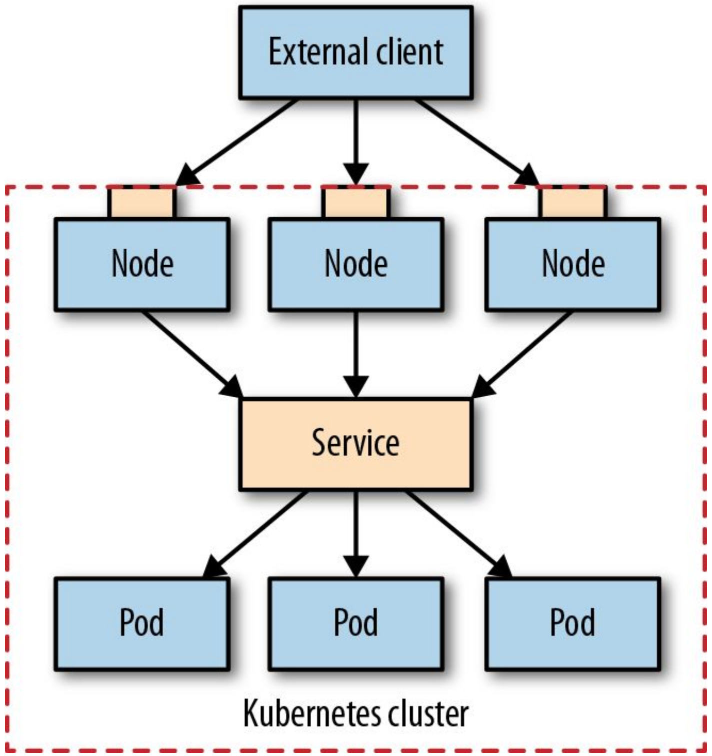
- Discovery through DNS lookups
- Pods picked by label selector
- Multiple ports per Service
- Session affinity on IP address
- Successful readiness probes required for routing
- Virtual IP address for each Service

Manual Service Discovery

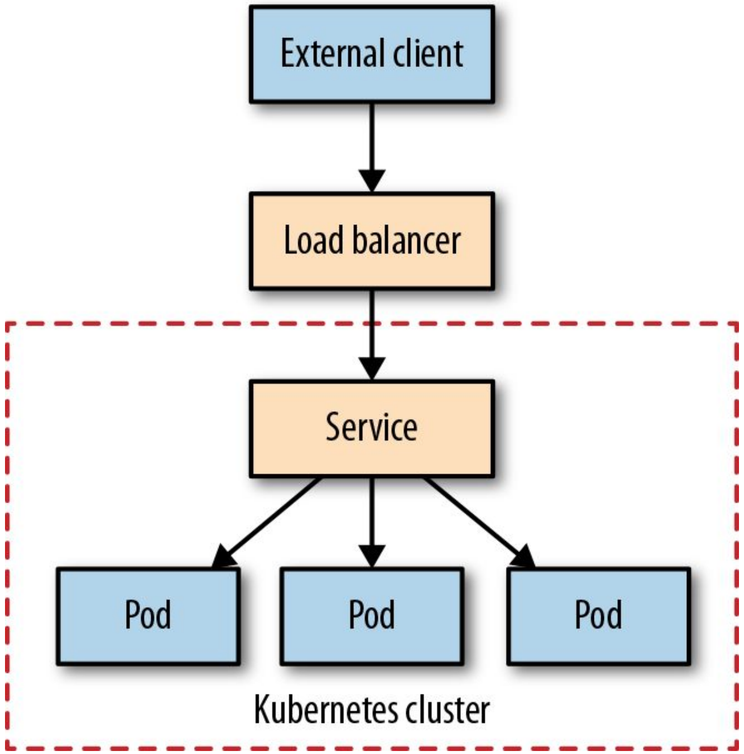


- Service without selector
- Manually creating Endpoint resource with the same name as the Service
- Service of type **`ExternalName`** map are registered as DNS CNAMEs

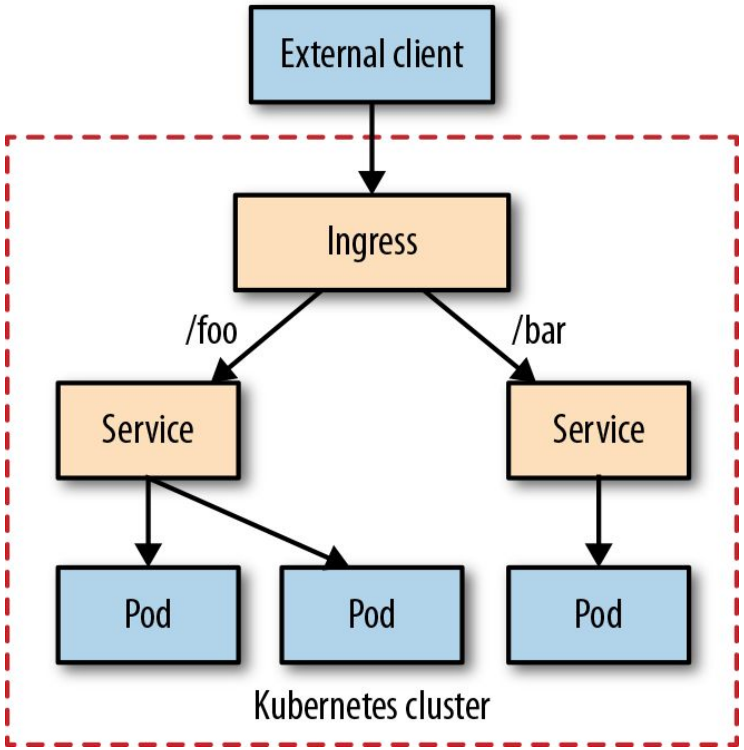
Node Port



Load Balancer



Ingress



Ingress

```yaml
apiVersion: extensions/v1beta1
kind: Ingress
metadata:
  name: random-generator
spec:
  rules:
  - http:
      paths:
      - path: /
        backend:
          serviceName: random-generator
          servicePort: 8080
      - path: /cluster-status
        backend:
          serviceName: cluster-status
          servicePort: 80
```

Name	Configuration	Client type	Summary
ClusterIP	`type: ClusterIP` `.spec.selector`	Internal	The most common internal discovery mechanism
Manual IP	`type: ClusterIP` `kind: Endpoints`	Internal	External IP discovery
Manual FQDN	`type: ExternalName` `.spec.externalName`	Internal	External FQDN discovery
Headless Service	`type: ClusterIP` `.spec.clusterIP: None`	Internal	DNS-based discovery without a virtual IP
NodePort	`type: NodePort`	External	Preferred for non-HTTP traffic
LoadBalancer	`type: LoadBalancer`	External	Requires supporting cloud infrastructure
Ingress	`kind: Ingress`	External	L7/HTTP-based smart routing mechanism

Controller Pattern

Controller

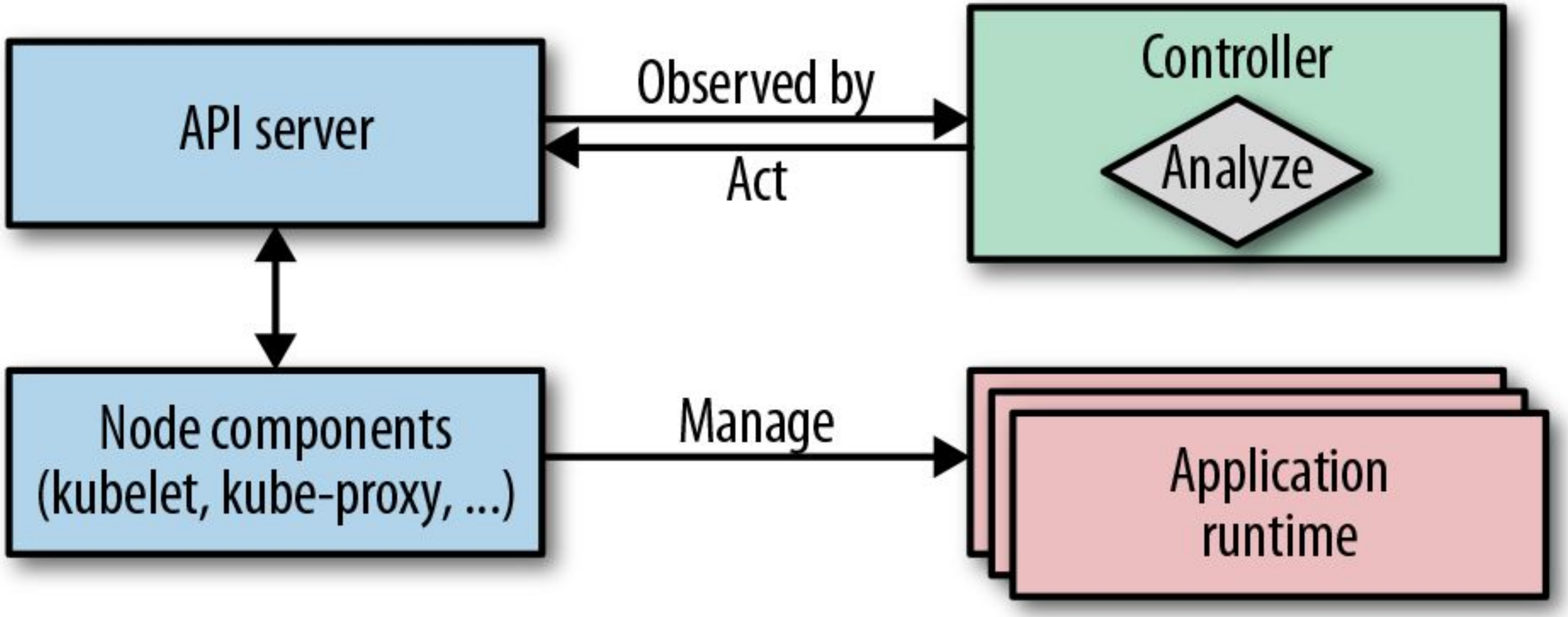
How to get from the current state to the declared target state?

State Reconciliation

- Kubernetes as distributed state manager
- Make the **actual** state more like the declared **target** state.

🔎 ***Observe*** - Discover the actual state
🤔 ***Analyze*** - Determine difference to target state
🔨 ***Act***- Perform actions to drive the actual to the desired state

Observe - Analyze - Act



Common Triggers

- Labels
  - Indexed by backend
  - Suitable for selector-like functionality
  - Limitation on characterset for names and values
- Annotations
  - No syntax restrictions
  - Not indexed
- ConfigMaps
  - Good for complex structured state declarations
  - Simple alternative to CustomResourceDefinitions

ConfigMap Watch Controller

```
namespace=${WATCH_NAMESPACE:-default}
base=http://localhost:8001
ns=namespaces/$namespace

curl -N -s $base/api/v1/${ns}/configmaps?watch=true | \
while read -r event
do
  type=$(echo "$event" | jq -r '.type')
  config_map=$(echo "$event" | jq -r '.object.metadata.name')
  annotations=$(echo "$event" | jq -r '.object.metadata.annotations')

  if [ $type = "MODIFIED" ]; then
    # Restart Pods using this ConfigMap
    # ...
  fi
done
```

Elastic Scale Pattern

Scaling

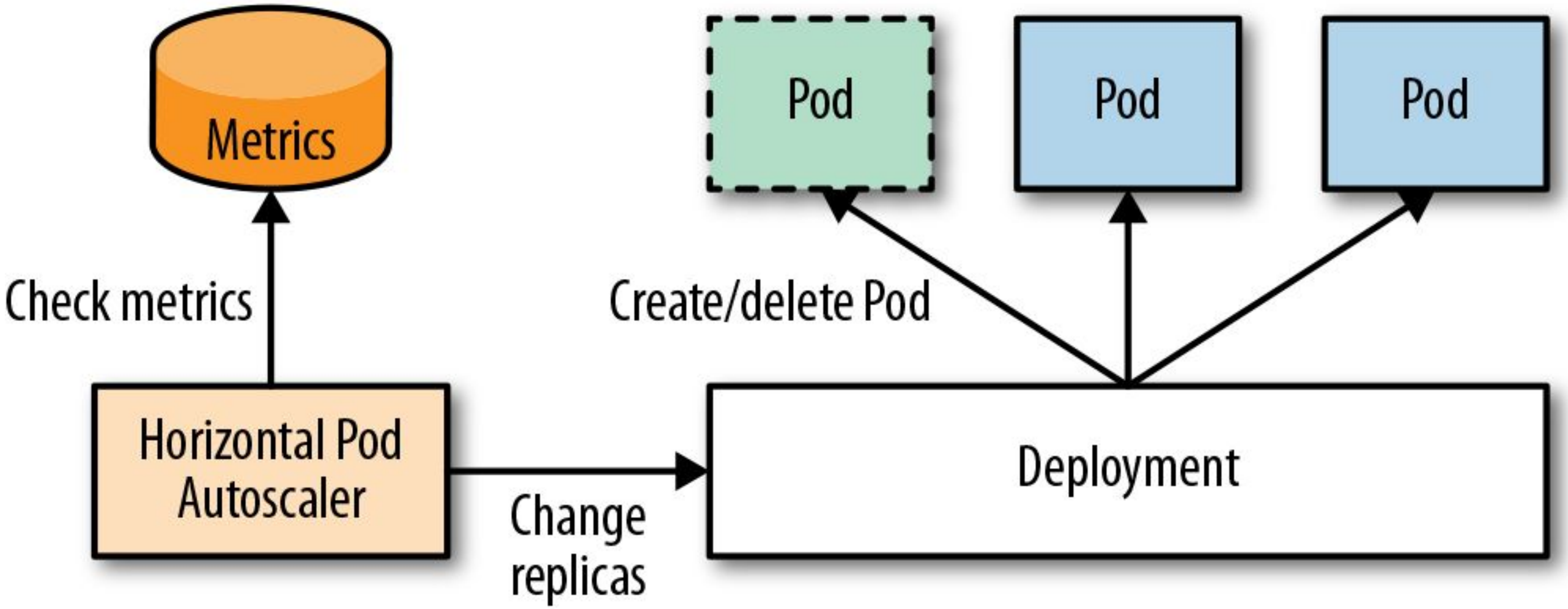
How to automatically react to dynamically changing resource requirements?

- **Horizontal:** Changing replicas of a Pod
- **Vertical:** Changing resource constraints of containers in a single Pod
- **Cluster:** Adding new nodes to a cluster
- **Manual:** Changing scale parameters manually,. imperatively or declaratively
- **Automatic:** Change scaling parameters based on observed metrics

Scaling

- **Horizontal**: Changing replicas of a Pod
- **Vertical:** Changing resource constraints of containers in a single Pod
- **Cluster**: Adding new nodes to a cluster
- **Manual**: Changing scale parameters manually,. imperatively or declaratively
- **Automatic**: Change scaling parameters based on observed metrics

Horizontal Pod Autoscaler (HPA)




```
kubectl autoscale deployment random-generator --cpu-percent=50 --min=1 --max=5
```

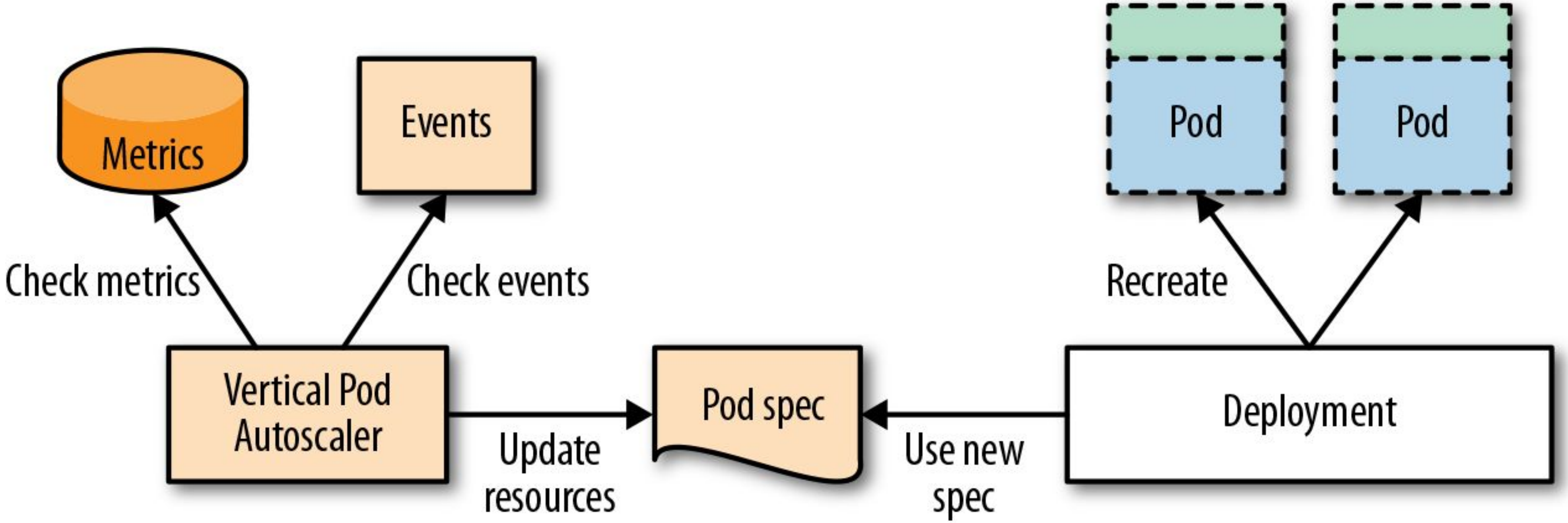
HorizontalPodAutoscaler

```yaml
apiVersion: autoscaling/v2beta2
kind: HorizontalPodAutoscaler
metadata:
  name: random-generator
spec:
  minReplicas: 1
  maxReplicas: 5
  scaleTargetRef:
    apiVersion: extensions/v1beta1
    kind: Deployment
    name: random-generator
  metrics:
  - resource:
      name: cpu
      target:
        averageUtilization: 50
        type: Utilization
    type: Resource
```

HPA: Metrics & Challenges

- Metrics
  - **Standard Metrics** - CPU & Memory Pod data obtained from Kubernetes metrics server
  - **Custom Metrics** - Metrics delivered via an aggregated API server at the `custom.metrics.k8s.io` API path
  - **External Metrics** - Metrics obtained from outside the cluster
- Challenges
  - **Metric Selection** - Correlation between metric value and replica counts
  - **Preventing Thrashing** - Windowing to avoid scaling on temporary spikes
  - **Delayed Reaction** - Delay between cause and scaling reaction

Vertical Pod Autoscaler (VPA)



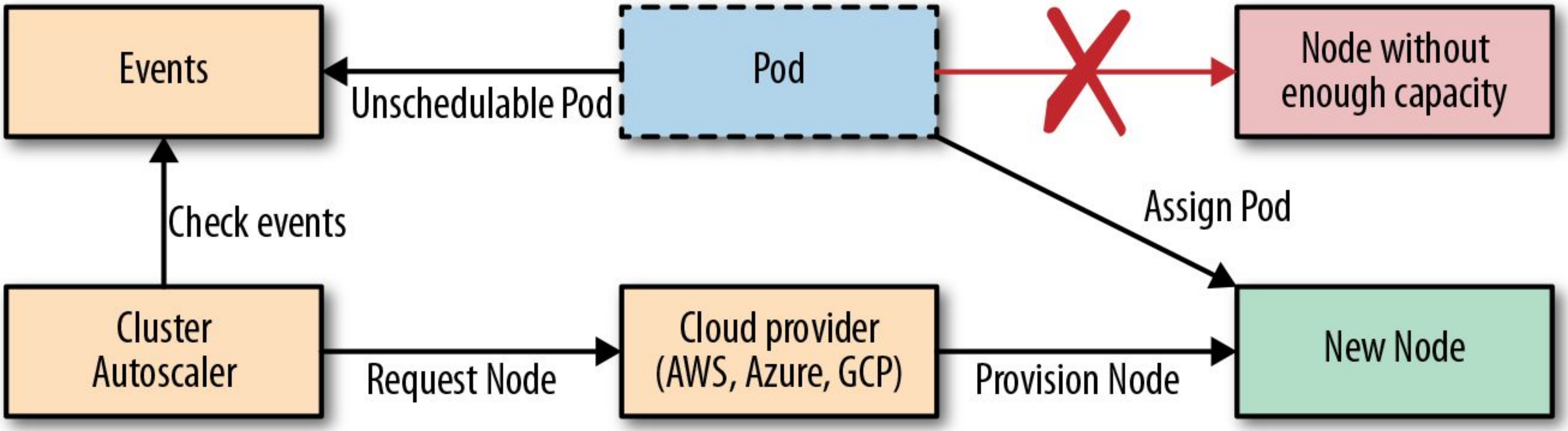
VerticalPodAutoscaler

```yaml
apiVersion: poc.autoscaling.k8s.io/v1alpha1
kind: VerticalPodAutoscaler
metadata:
  name: random-generator-vpa
spec:
  selector:
    matchLabels:
      app: random-generator
  updatePolicy:
    updateMode: "Off"
```

VPA: Update Mode

- `updateMode: Off`
  - Recommendations are stored in the `status:` section of the VPA resource
  - No changes to the selected resources are performed
- `updateMode: Initial`
  - Recommendations are applied during creation of a Pod
  - Influences scheduling decission
- `updateMode: Auto`
  - Automatically restarts Pods with updated resources based on recommendation

Cluster Autoscaler



Cluster Autoscaler

- Scale-Up
  - Adding a new node if a Pod is marked as *unschedulable* because of scarce resources.
  - Cluster API: Kubernetes API for dynamically managing node groups.
- Scale-Down
  - ... more than half of a nodes capacity is unused
  - ... all movable Pods can be placed on other nodes
  - ... no other reasons to prevent node deletion
  - ... no Pods that can not be moved

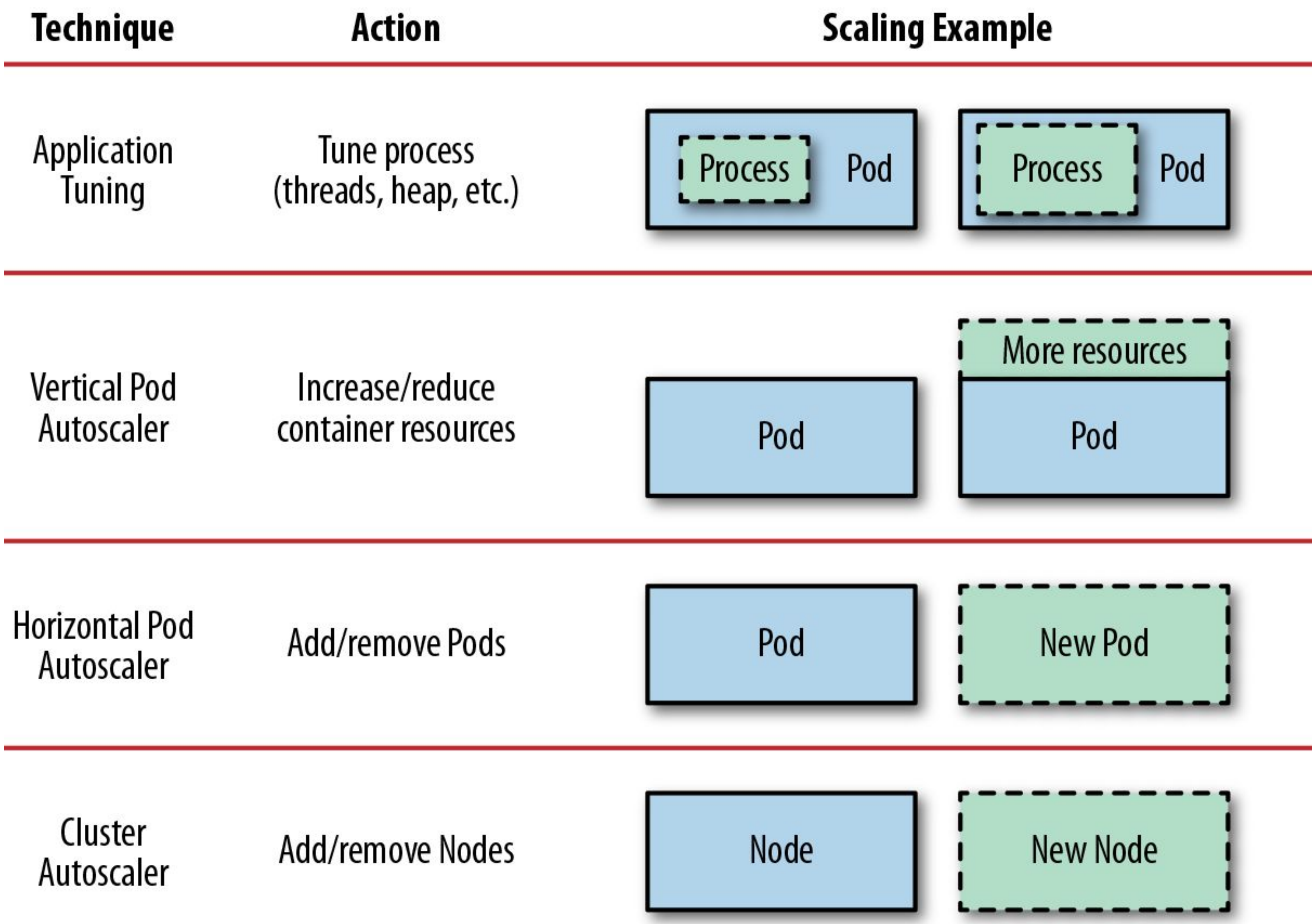

Technique
Action
Scaling Example
Application Tuning
Tune process (threads, heap, etc.)
Process
Pod
Process
Pod
Vertical Pod Autoscaler
Increase/reduce container resources
Pod
More resources
Pod
Horizontal Pod Autoscaler
Add/remove Pods
Pod
New Pod
Cluster Autoscaler
Add/remove Nodes
Node
New Node

Image Builder Pattern

(OpenShift)

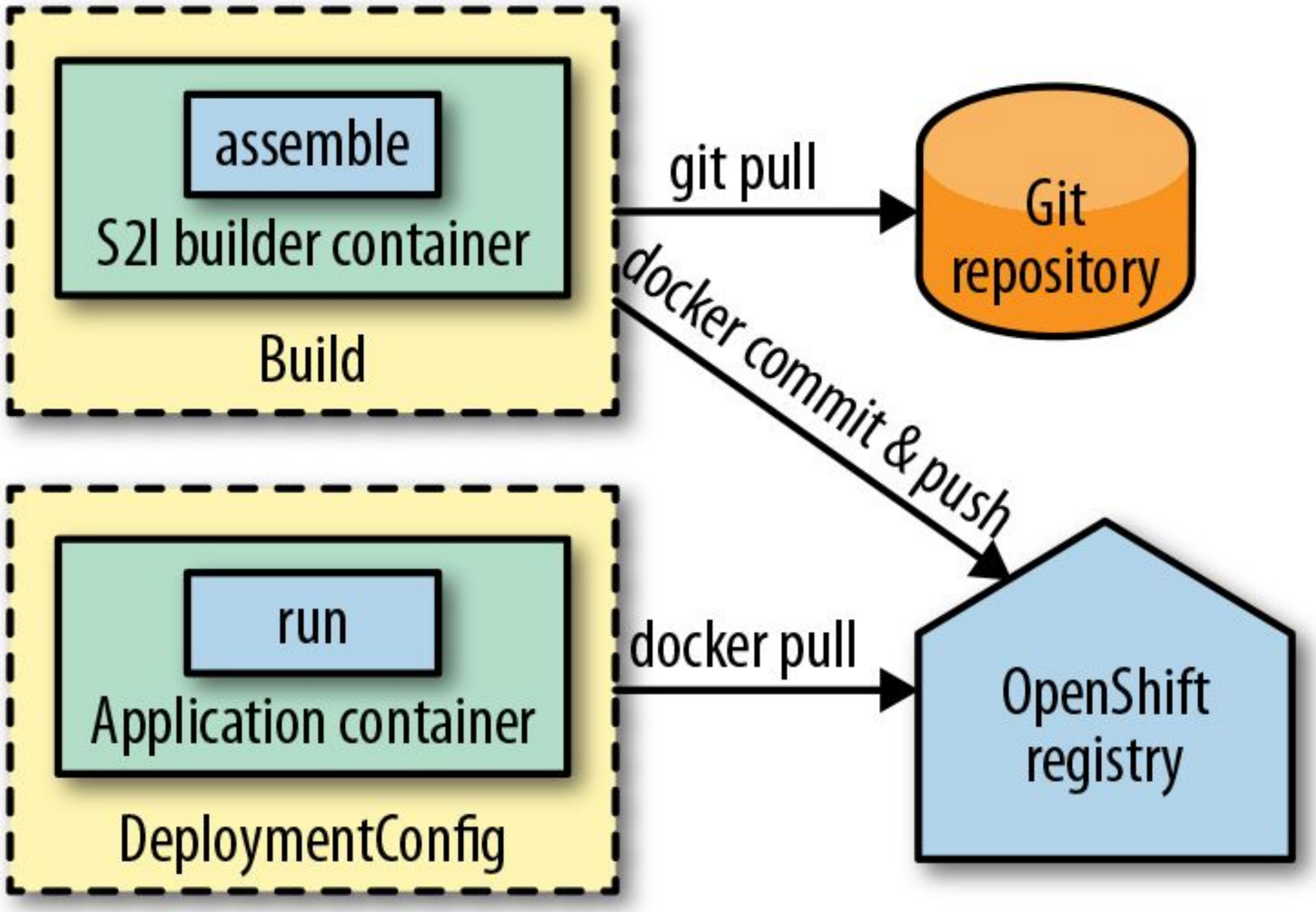
Image Builder

How to build container images within the cluster?

OpenShift Build

- Build types:
  - Source-to-Image (S2I)
  - Docker
  - Pipeline
  - Custom
- Source can be from
  - Git
  - Container Image
  - Secret
  - Binary Input when starting build
- ImageStreams connect build with deployment

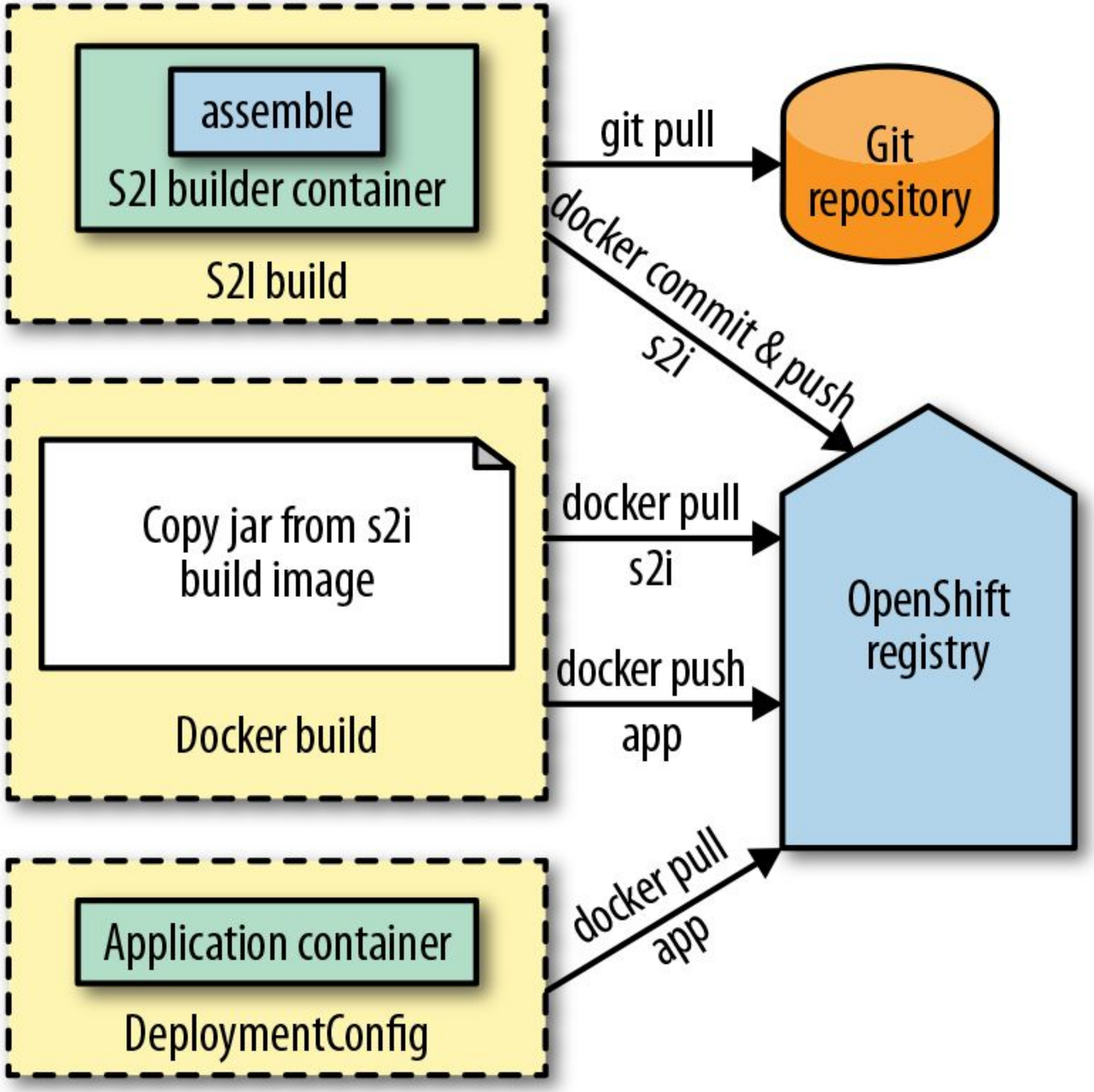
OpenShift S2I Build



BuildConfig

```yaml
apiVersion: v1
kind: BuildConfig
metadata:
  name: random-generator-build
spec:
  source:
    git:
      uri: https://github.com/k8spatterns/random-generator
  strategy:
    sourceStrategy:
      from:
        kind: DockerImage
        name: fabric8/s2i-java
  output:
    to:
      kind: ImageStreamTag
      name: random-generator-build:latest
  triggers:
  - type: ImageChange
```

S2I Chained Build



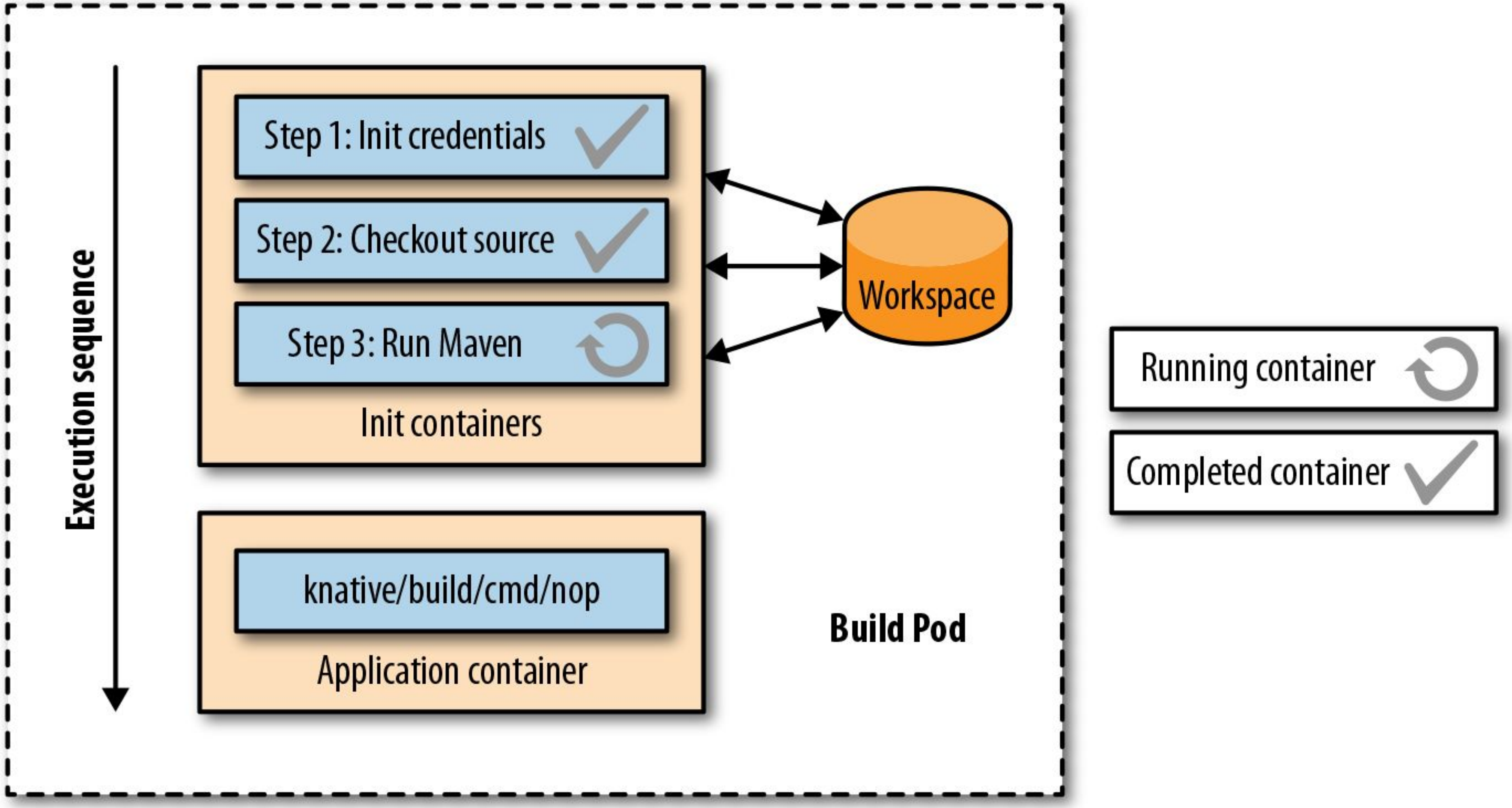
Knative

- **Knative serving**
  - Scale-to-Zero
- **Knative eventing**
  - Event infrastructure for triggering services
- **Knative build**
  - Transforming source to container image
- Build templates allows reusing build strategies

Build

```yaml
apiVersion: build.knative.dev/v1alpha1
kind: Build
metadata:
  name: random-generator-build-jib
spec:
  source:
    git:
      url: https://github.com/k8spatterns/random-generator.git
      revision: master
  steps:
  - name: build-and-push
    image: gcr.io/cloud-builders/mvn
    args:
    - compile
    - com.google.cloud.tools:jib-maven-plugin:build
    - -Djib.to.image=registry/k8spatterns/random-generator
    workingDir: /workspace
```

Knative Build



Red Hat

Operator Pattern

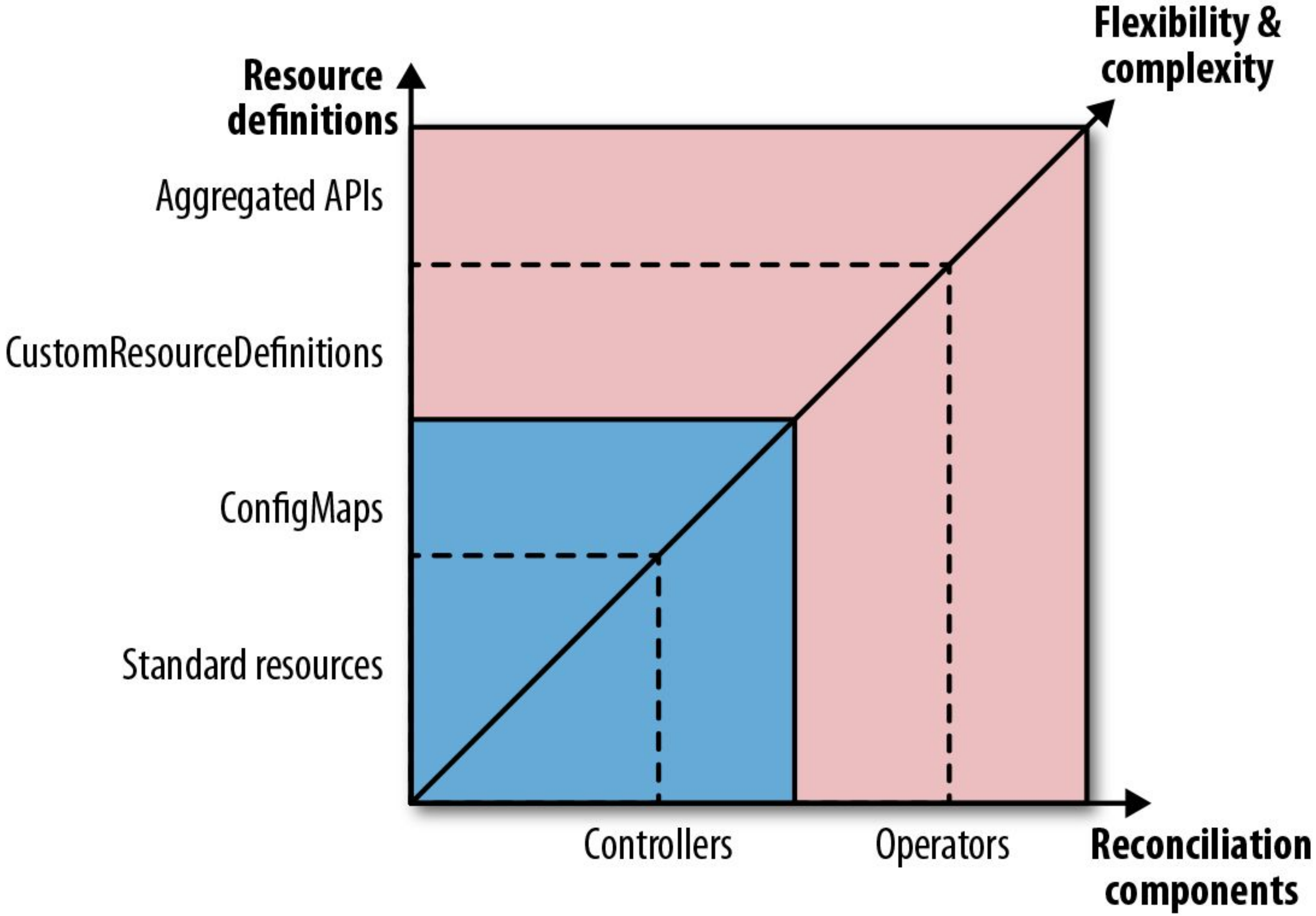
CustomResourceDefinition

Custom resource is modelling a custom domain and managed through the Kubernetes API

```
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: configwatchers.k8spatterns.io
spec:
  scope: Namespaced
  group: k8spatterns.io
  version: v1
  names:
    kind: ConfigWatcher
    plural: configwatchers
  validation:
    openAPIV3Schema:
    ...
```

Custom Resource

```yaml
kind: ConfigWatcher
apiVersion: k8spatterns.io/v1
metadata:
  name: webapp-config-watcher
spec:
  configMap: webapp-config
  podSelector:
    app: webapp
```


Resource definitions
Flexibility & complexity
Aggregated APIs
CustomResourceDefinitions
ConfigMaps
Standard resources
Controllers
Operators
Reconciliation components

CRD Classification

- Installation CRDs
  - Installing and operating applications
  - Backup and Restore
  - Monitoring and self-healing
  - Example: Prometheus for installing Prometheus & components
- Application CRDs
  - Application specific domain concepts
  - Example: ServiceMonitor for registering Kubernetes service to be scraped by Prometheus

Operator Development

- Operator can be implemented in any language
- Frameworks:
    - Operator Framework (Golang, Helm, Ansible)
      https://github.com/operator-framework
    - Kubebuilder (Golang)
      https://github.com/kubernetes-sigs/kubebuilder
    - Metacontroller (Language agnostic)
      https://metacontroller.app/
    - jvm-operators (Java, Groovy, Kotlin, ...)
      https://github.com/jvm-operators

Configuration Template

Red Hat

Preparing Configuration during Startup

- Init Container ...
    - ... contains a template processor
    - ... holds the configuration template
    - ... picks up template parameter from a ConfigMap
    - ... stores final configuration on a shared volume
- Main Container ....
    - ... accesses created configuration from shared volume

```yaml
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: wildfly-cm-template
spec:
  replicas: 1
  template:
    spec:
      initContainers:
      - image: k8spatterns/config-init
        name: init
        volumeMounts:
        - mountPath: "/params"
          name: wildfly-parameters
        - mountPath: "/out"
          name: wildfly-config
```

```yaml
containers:
- image: jboss/wildfly:10.1.0.Final
  name: server
  volumeMounts:
  - mountPath: "/config"
    name: wildfly-config
volumes:
- name: wildfly-parameters
  configMap:
    name: wildfly-params-cm
- name: wildfly-config
  emptyDir: {}
```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