Red Hat
Enterprise Linux

Writing a K8s Operator for Knative Functions

DevConf.CZ 2023

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PHYSICS

Red Hat

Agenda

1. **Introduction**
    a. PHYSICS project
2. **Serverless / Function as a Service (FaaS)**
    a. Knative
3. **Operator pattern**
4. **Hands on**
    a. Lab description
    b. Prizes
    c. Useful links

whoami

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Red Hat

Introduction

Red Hat Research

Research Interest Groups (RIGs)

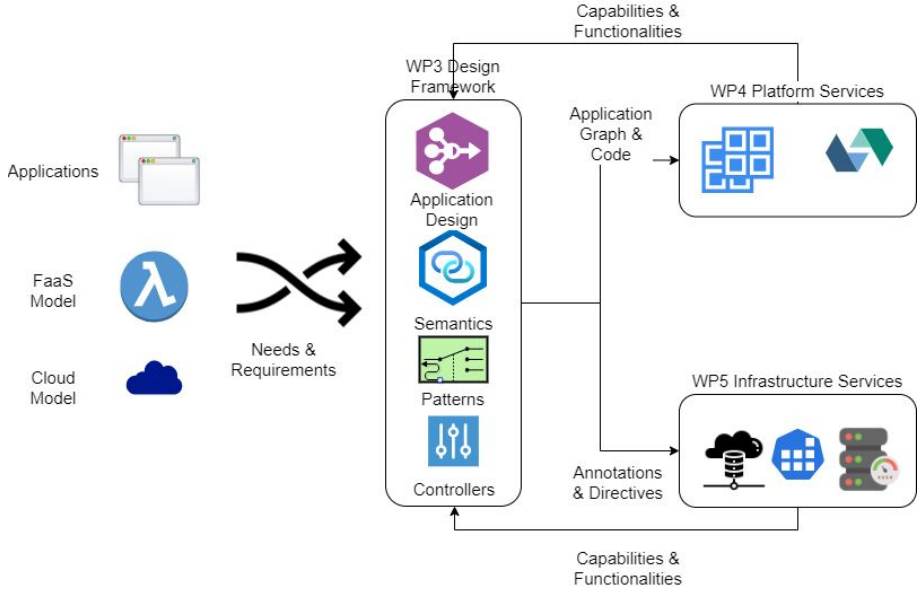
- EMEA
- Israel

European Commission | Horizon 2020 European Union funding for Research & Innovation

This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement no 101017047

Project Goals

Visual programming environment to create serverless workflows with reusable patterns and increased semantics



Platform-level functionalities to orchestrate and deploy FaaS workflows and optimize cloud/edge interplay

Provider-local resource management mechanisms to offer competitive and optimized services execution

This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement no 101017047

Challenges targeted by PHYSICS

- Abstract usage of **service offerings and clusters across the Continuum**
- Adaptation of code to new **serverless** computing paradigms
- Investigation of **space** (location of execution)-**time** (duration of execution) in the continuum
- Optimization of resource **selection** and operation (**global** and **local** level)
- Multiple Exploitation Channels and **Reusable** Artefacts

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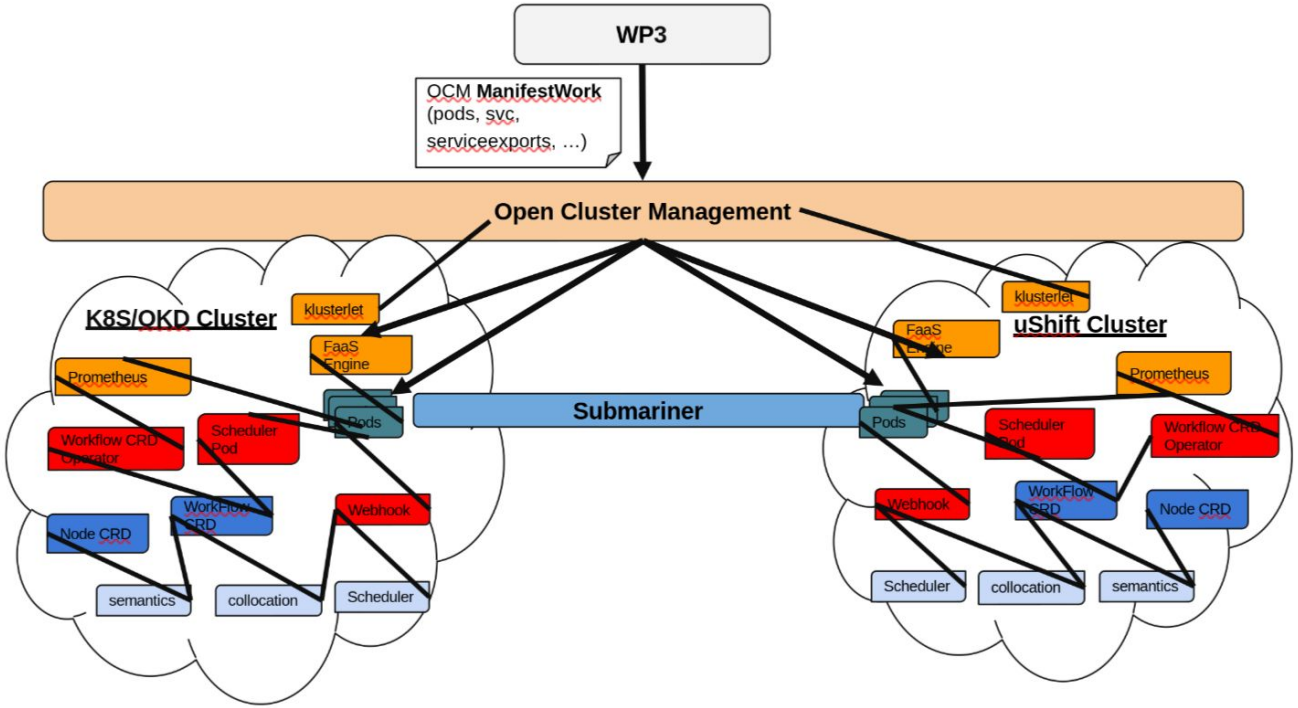
Architecture / Baseline technologies



This project has received funding from the European Union's horizon 2020
research and innovation programme under grant agreement no 101017047

Sunday, June 18 • 2:45pm - 3:20pm

Design & Deployment of FaaS apps at the edge-cloud

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The talk will focus on a design and development environment coming from the H2020 PHYSICS project, that aims to ease application evolution to the new FaaS model. It uses the Node-RED open source tool as the main function and workflow runtime. The goal of the environment is to enable a more user friendly and abstract function and workflow creation process for complex FaaS applications. To this end, it provides an extendable, pattern-enriched palette of ready-made, reusable functionalities such as workload parallelization, data collection at the edge, function orchestration creation among others. The environment embeds seamless DevOps processes for generating the deployable artefacts of the FaaS platform (Openwhisk). Annotation mechanisms are also available for the developer to dictate diverse execution options towards the deployment stacks, including sizing and locality considerations, as well as abilities for dynamic FaaS applications to continuously leverage the edge-cloud continuum.

This project has received funding from the European Union's horizon 2020 research and innovation programme under grant agreement no 101017047

Saturday, June 17 • 5:00pm - 5:35pm

Towards Container-layer-aware Scheduling Policies

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Serverless has been gaining popularity as a new way to program and deploy applications on clouds. Function as a service (FaaS) is an approach encompassed by serverless, extending the FaaS concept by avoiding server infrastructure management.
In this context, functions rely on containers, and deploying new containers can cause several overheads to the platforms and the function's execution (cold start delays).
Kubernetes-based platforms are used for serverless proposes, and K8S provides an ImageLocality mechanism to address it, but it relies on entire warm containers and not on layers.
Therefore, we propose and implement on K8S two new scheduling policies.The first is a ContainerLayer-Aware policy that optimizes function's placements by selecting machines with the biggest rate of container layers that can be shared. The second is a Multi-Objective policy for heterogeneous platforms that reduces at the same time the makespan and the data transferred by functions I/O and container layers.

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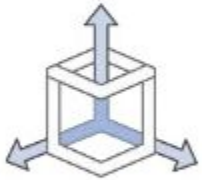
Knative

Serverless architectures

Removes the need for….

Provisioning
and Utilization

Operations
and Management



Scaling

Availability and
Fault Tolerance

The Core Serverless Traits

14

FaaS in the cloud

IBM Cloud Functions

Google Cloud Functions

Red Hat

FaaS in the K8s

OPENFAAS

Apache OpenWhisk

Red Hat

Knative

Bringing Serverless Applications to Kubernetes

SERVING

*A **request-driven** model that serves the **container** with your application and can "**scale to zero**"*

EVENTING

*Common **infrastructure** for consuming and producing **events** that will stimulate applications.*

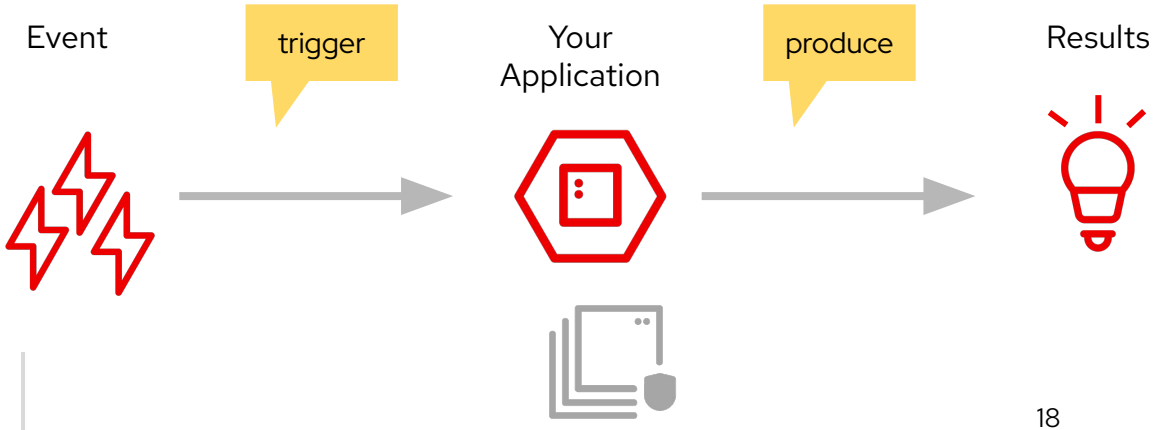
FUNCTIONS

*A **programming** model that lets you focus on **just your code** for faster iterations.*

CLIENT (kn)

*Allows you to create resources interactively from the **command line** or from within scripts*

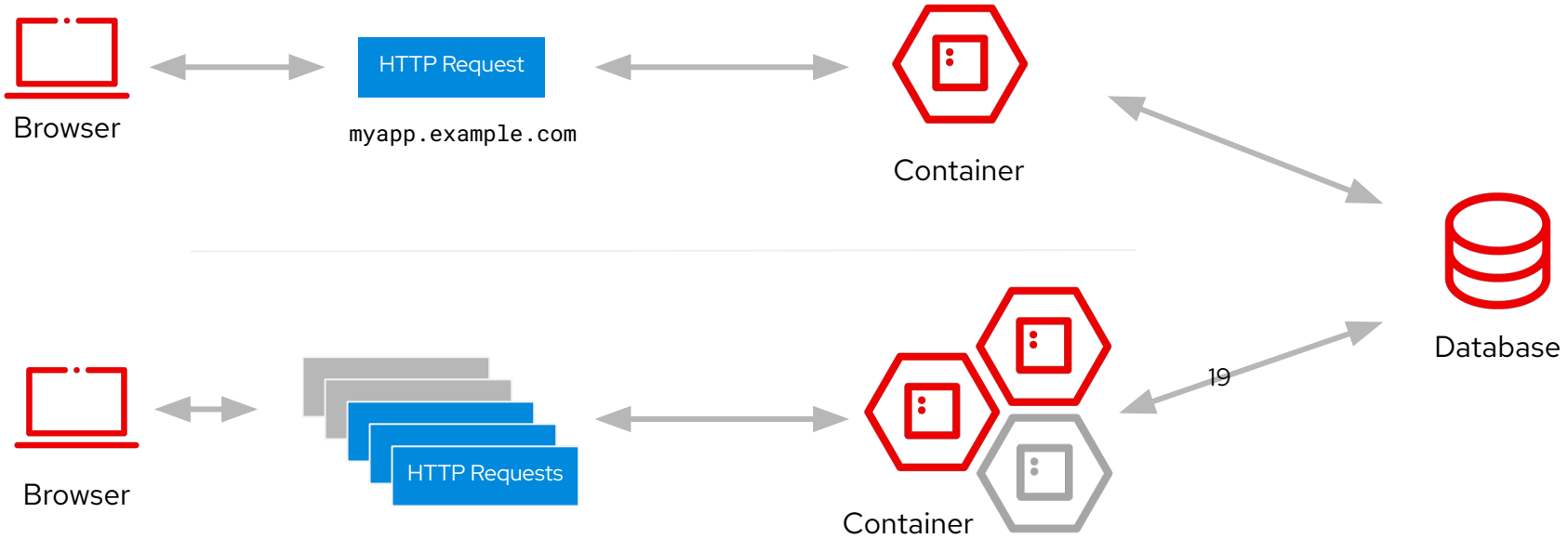
The "Serverless Pattern"



- HTTP Requests
- Kafka Messages
- Image Uploaded
- New Order
- Login from user

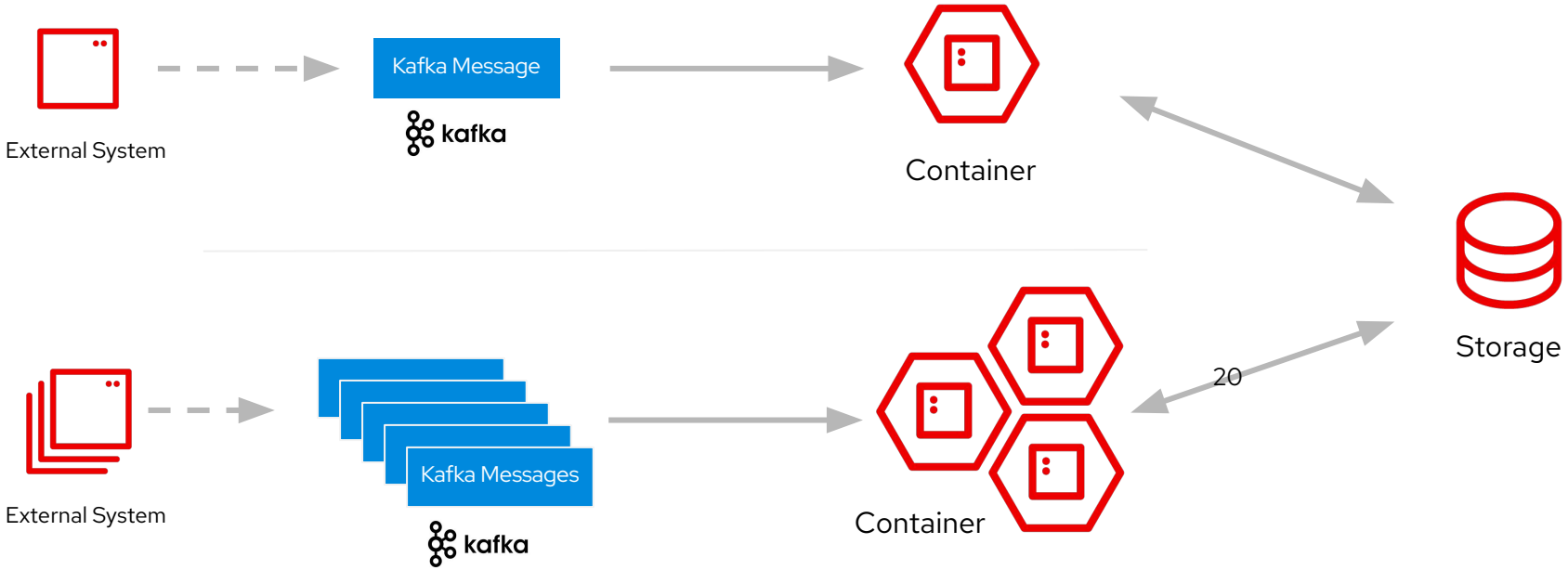
The "Serverless Pattern"

A serverless web application



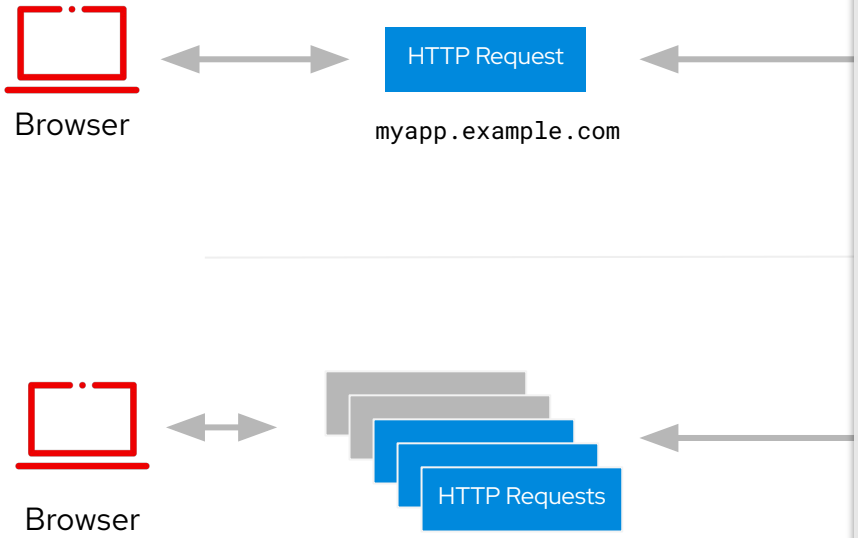
The "Serverless Pattern"

Processing a Kafka message



The "Serverless Pattern"

A serverless web application

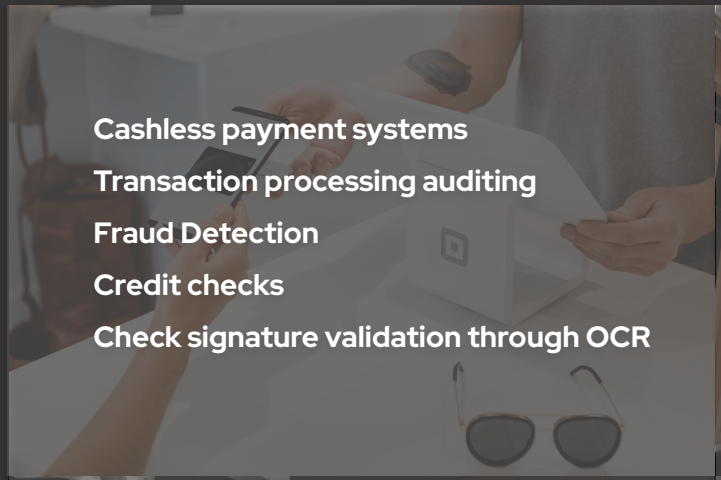


Benefits of this model:

- No need to setup auto-scaling and load balancers
  - Scale down and save resources when needed.
  - Scale up to meet the demand.
- No tickets to configure SSL for applications
- Enable Event Driven Architectures (EDA) patterns
- Enable teams to associate cost with IT
- Modernize existing applications to run as serverless containers

Where Serverless?

- Application with unpredictable or bursty number of requests.
- Maximum resource utilization to reduce the carbon footprint
- Building event-driven, loosely coupled systems
- Low barrier for Developers (Kubernetes is hard)
- A/B testing or canary deployments
- Seasonal or periodic workload.
- microservices or containers and want to leverage serverless



Cashless payment systems
Transaction processing auditing
Fraud Detection
Credit checks
Check signature validation through OCR

Product thumbnail generation
Chatbots and CRM functions
Marketing Campaign notifications
Sales Audit
Content Push

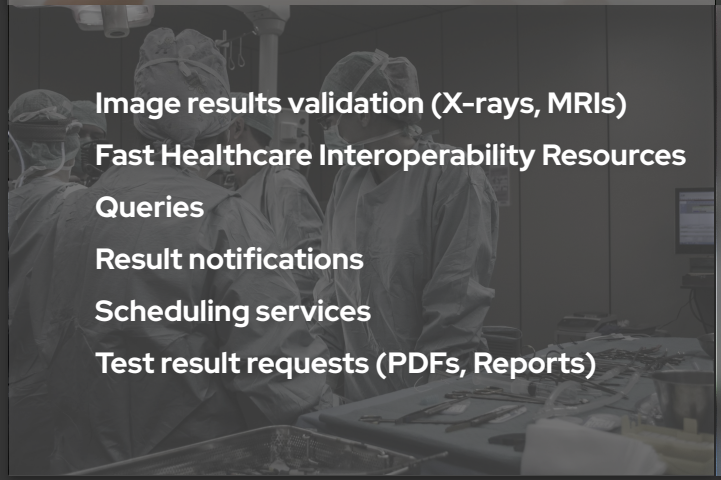
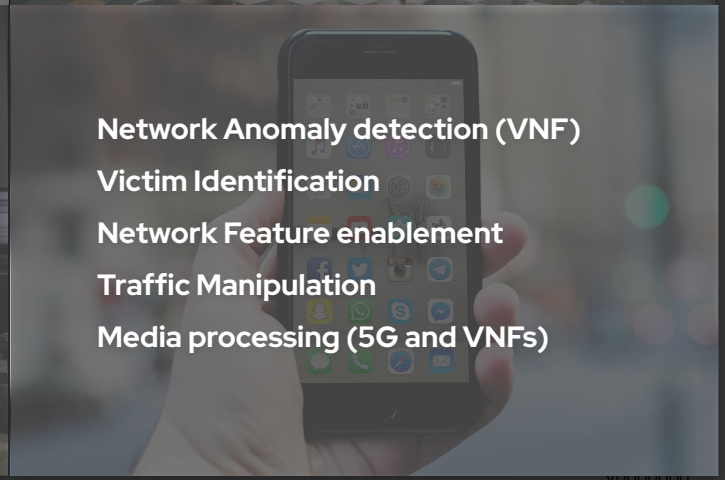


Image results validation (X-rays, MRIs)
Fast Healthcare Interoperability Resources
Queries
Result notifications
Scheduling services
Test result requests (PDFs, Reports)

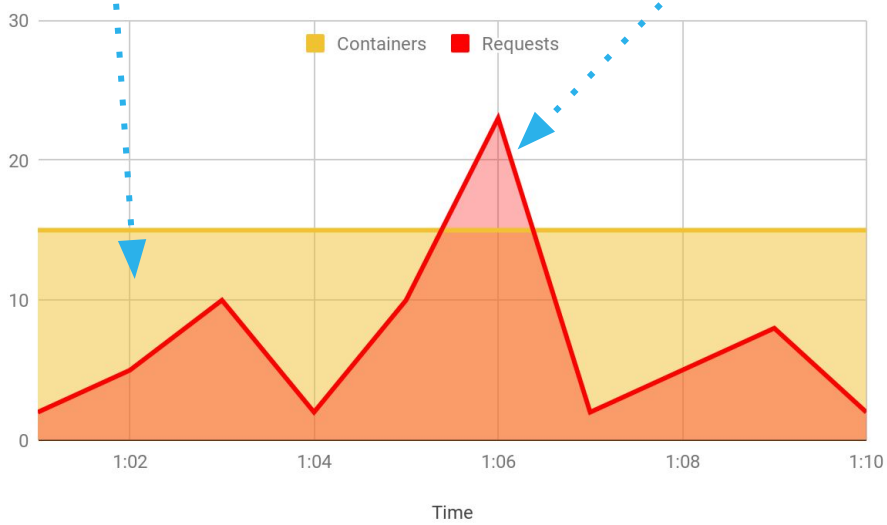


Network Anomaly detection (VNF)
Victim Identification
Network Feature enablement
Traffic Manipulation
Media processing (5G and VNFs)

Serverless Operational Benefits

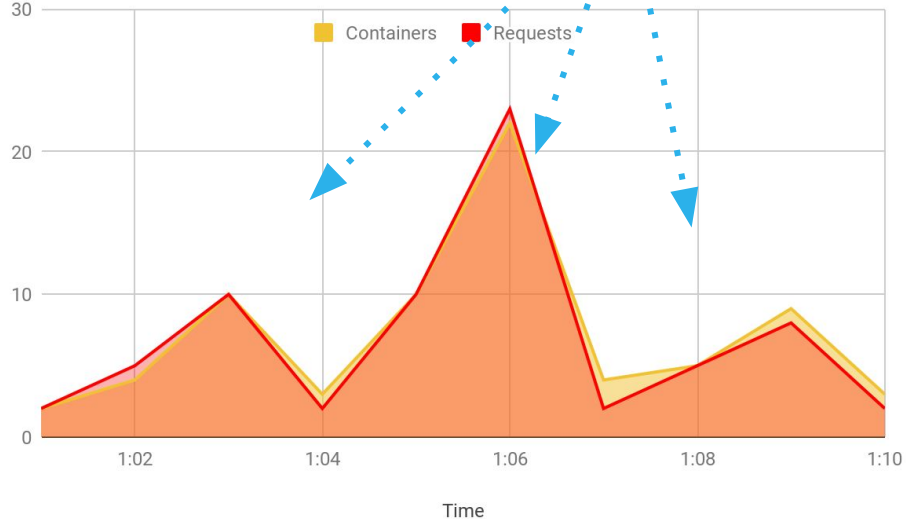
Over provisioning
Time in capacity planning
IT cost of idle resources

Under provisioning
Lost business revenue
Poor quality of service



NOT Serverless

More applications
Direct line between IT
costs & business revenue

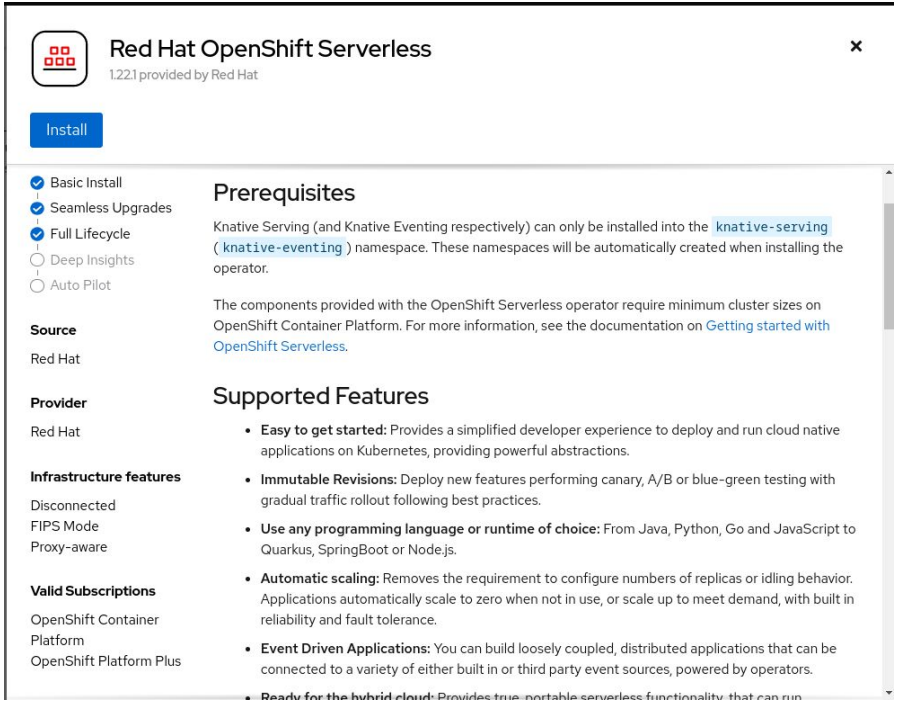


with Serverless

Installation experience

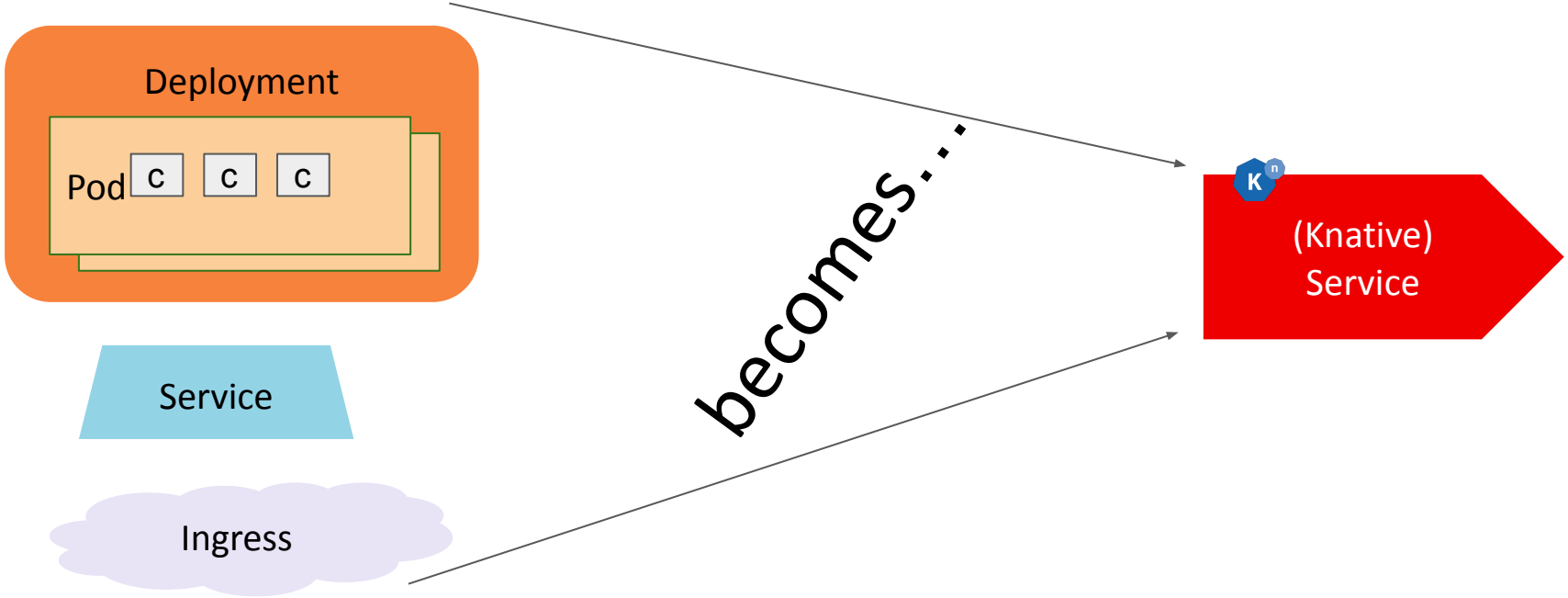
"Easy day 1 and even better for day 2"

- Click Install experience
- Developer & admin experience in Console
- Built-in event sources
- No external dependencies.
- ***"Just works."***



Simplify application development/deployment on K8

Reduce developer toil and cognitive overhead with **Knative tools**



Kubernetes

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
name: frontend
labels:
  app: guestbook
spec:
selector:
  matchLabels:
    app: guestbook
    tier: frontend
replicas: 1
template:
  metadata:
    labels:
      app: guestbook
      tier: frontend
  spec:
    containers:
    - image: markusthoemmes/guestbook
      name: guestbook
      resources:
        requests:
          cpu: 100m
          memory: 100Mi
      env:
      - name: GET_HOSTS_FROM
        value: dns
      ports:
      - containerPort: 80
```



```yaml
apiVersion: extensions/v1beta1
kind: HorizontalPodAutoscaler
metadata:
 name: guestbook
 namespace: default
spec:
 scaleRef:
   kind: ReplicationController
   name: guestbook
   namespace: default
   subresource: scale
 minReplicas: 1
 maxReplicas: 10
 cpuUtilization:
   targetPercentage: 50
```

```yaml
---
apiVersion: v1
kind: Service
metadata:
name: frontend-service
labels:
  app: guestbook
  tier: frontend
spec:
ports:
- port: 80
selector:
  app: guestbook
  tier: frontend
---
apiVersion: route.openshift.io/v1
kind: Route
metadata:
name: frontend-route
spec:
to:
  kind: Service
  name: frontend-service
```

~70 lines

Knative

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
name: frontend
spec:
template:
  metadata:
    labels:
      app: guestbook
      tier: frontend
  spec:
    containers:
    - image: markusthoemmes/guestbook
      resources:
        requests:
          cpu: 100m
          memory: 100Mi
      env:
      - name: GET_HOSTS_FROM
        value: dns
      ports:
      - containerPort: 80
```

22 lines

Knative Functions

Powerful Developer experience

- ✓ Local Developer Experience
- ✓ IDE Developer Experience
- ✓ Offers multiple build strategies
- ✓ Deploy as Knative Service
- ✓ Project templates
- ✓ Support for Cloud Events/HTTP
- ✓ On cluster build using Tekton/Pipelines
- ✓ **Runtimes:**

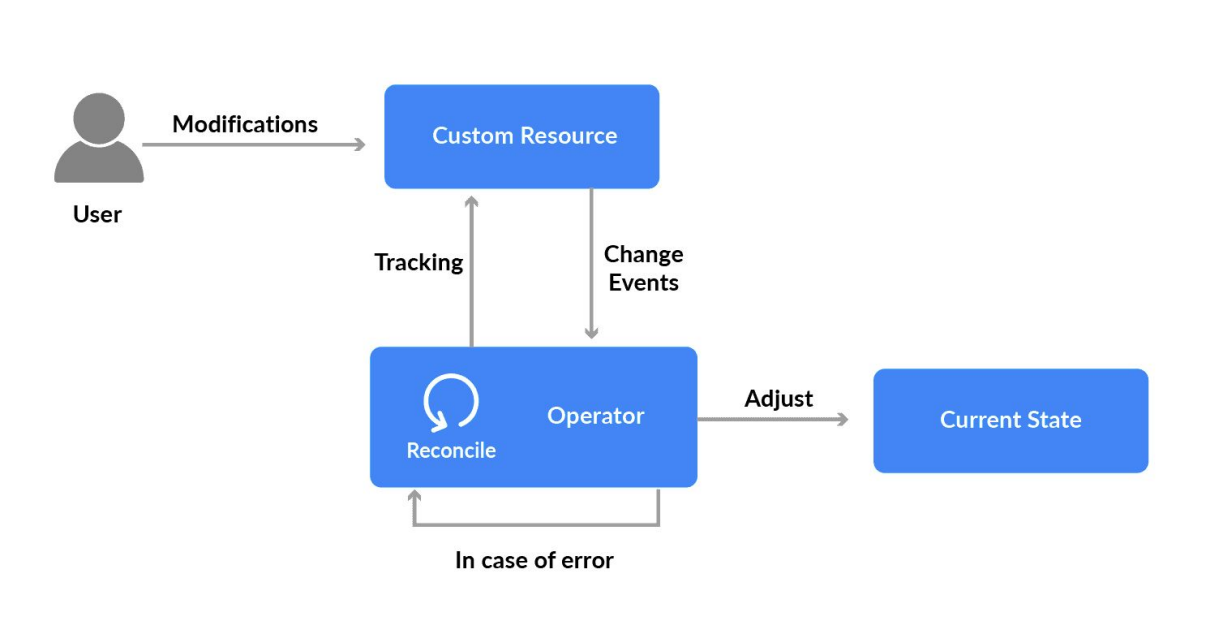

```
$ kn func help
Usage:
  func [command]

Available Commands:
  build       Build a Function project as a container image
  completion  Generate completion scripts for bash, fish and zsh
  config      Configure the Function
  create      Create a Function project
  delete      Undeploy a Function
  deploy      Deploy a Function
  help        Help about any command
  info        Show details of a Function
  invoke      Invoke a Function
  list        List Functions
  repository  Manage installed template repositories
  run         Run the Function locally
  version     Show the version
```

Operator pattern

Example: Kafka operator

```
apiVersion: kafka.strimzi.io/v1beta2
kind: Kafka
metadata:
  labels:
    app: my-cluster
  name: my-cluster
  namespace: myproject
spec:
  # ...
  kafka:
    replicas: 3
    # ...
```

Operator pattern

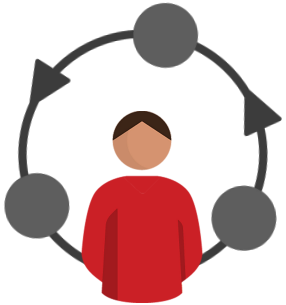


Kubernetes Operators

Operators simplify management of complex applications on Kubernetes

- Encode human operational knowledge
- **Automatically patch, upgrade, recover, and tune container-based apps and services**
- Kubernetes-native
- Purpose-built for a specific application or service
- Enable “day 2” management

Encoding and automating Ops knowledge



WITHOUT OPERATORS: REACTIVE

Continually checks for anomalies

Alert humans for response

Requires manual change to fix

WITH OPERATORS: PROACTIVE

Continually adjusts to optimal state

Automatically acts in milliseconds

OPERATOR FRAMEWORK

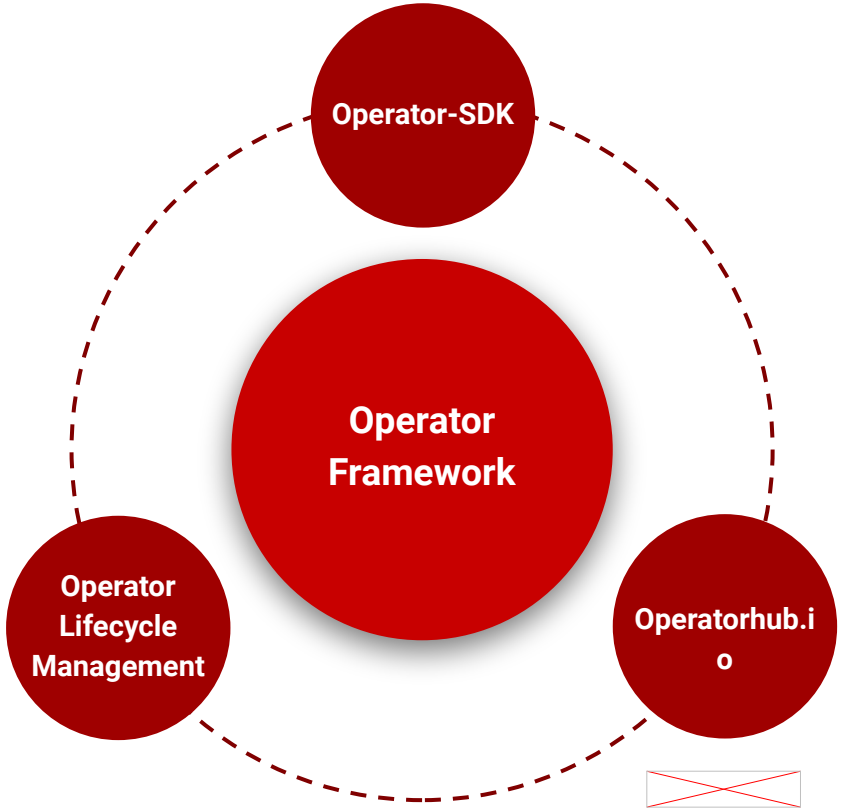
The Operator Framework is an open source toolkit to build and manage Kubernetes Operators, in an effective, automated, and scalable way.

For Builders and the community

- Easily create application on Kubernetes via a common method
- Provide standardized set of tools to build consistent apps

For application consumers and Kubernetes users

- Keep installed apps up to date for security reasons and app lifecycle management
- Consume of cloud-native / kube-native applications more secure and easier



Choosing the right tool

HELM

Implementation is declarative and simple

Operator functionality is limited to Helm features

Operator manifest bundle files (CRD, RBAC, Operator Deployment) are automatically generated

ANSIBLE

Implementation is declarative and human-readable

Ansible can express almost any operator functionality

Operator manifest bundle files (CRD, RBAC, Operator Deployment) are automatically generated

GO

Implementation is imperative and more complex

There is no limit on the functionality you want to implement

Operator manifest bundle files (CRD, RBAC, Operator Deployment) are generated from the Go source code

Hands on

Lab description

Goal:

- Create a golang operator that deploys an existing knative function
  - The Knative function has previously been built and pushed to a private registry
- Extend the operator to build, push and deploy a function located on a github repository

Example CRD:

```
apiVersion: knf.example.com/v1alpha1
kind: KnativeFunction
metadata:
  name: knativefunction-sample
spec:
  name: test-function
  image: localhost:50000/kn-user/test-hw@sha256:79c456
  maxscale: "2"
  minscale: "1"
  concurrency: 1
```

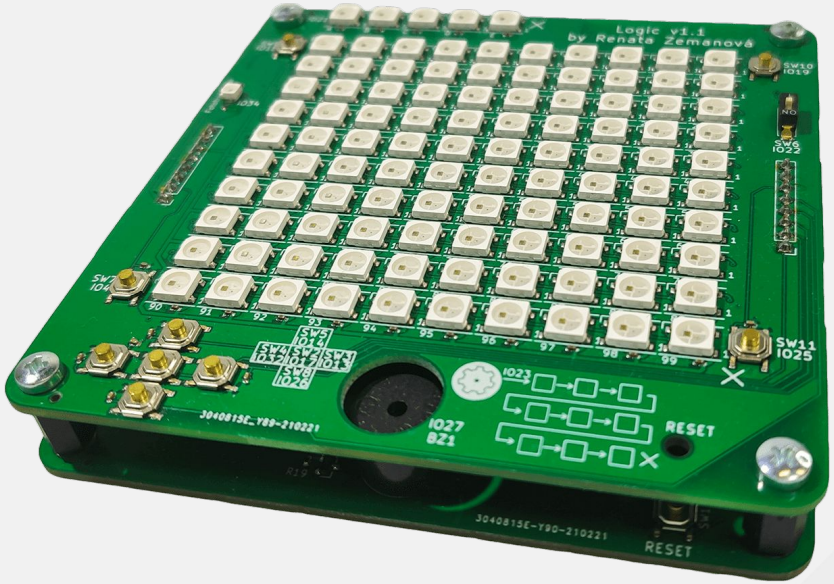
Example output:

```
$ kubectl get knativefunction
NAME                     AGE
knativefunction-sample   5m8s

$ kubectl get ksvc
NAME           URL
test-function  http://test-function.default.127.0.0.1.sslip.io

$ curl http://test-function.default.127.0.0.1.sslip.io
DevConf.cz 2023!
```


Prizes

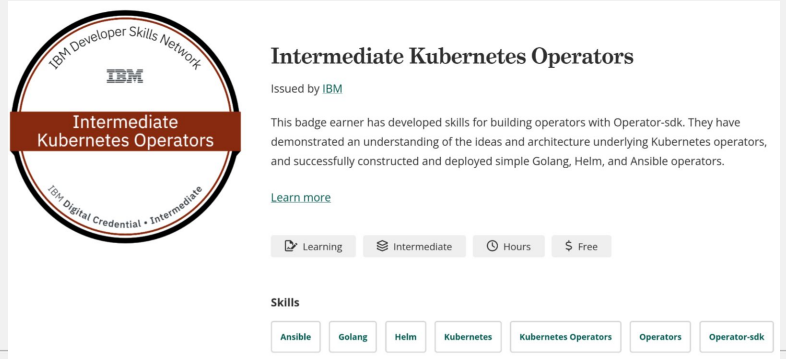
3 **Logic** I **Robotárna** boards - [github]

- Universal programmable toy designed for teaching programming
- Resembles a game console
- It has 100 RGB LEDs that can serve as a display, it has numerous buttons and a buzzer
- Powered by ESP32 microcontroller
- Kids can create custom games and learn programming while doing so
- Possible to run multiplayer games as the on-board processor features both, WiFi and Bluetooth 4



Useful links

- Knative documentation: https://knative.dev/docs/
- Knative.dev/client Golang API: https://pkg.go.dev/knative.dev/client
- Operator SDK - Go Operator tutorial: https://sdk.operatorframework.io/docs/building-operators/golang/tutorial/
- Example memcached operator: https://github.com/operator-framework/operator-sdk/tree/master/testdata/go/v3/memcached-operator
- Intermediate Kubernetes Operators on IBM Developer Skills Network: https://courses.course-dev.skills.network/courses/course-v1:IBMSkillsNetwork+CO0201EN+2021T1/course/



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