Kubernetes Operators, in Java?

Hold my mouse and look

Contents

whoami


Amstrad 64K Microcomputer (v1)
©1984 Amstrad Consumer Electronics plc
and Locomotive Software Ltd.
BASIC 1.0
Ready
AMSTRAD

$ whoami

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Java Champion

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Co-founder of JBCNConf

Software Engineer at Red Hat
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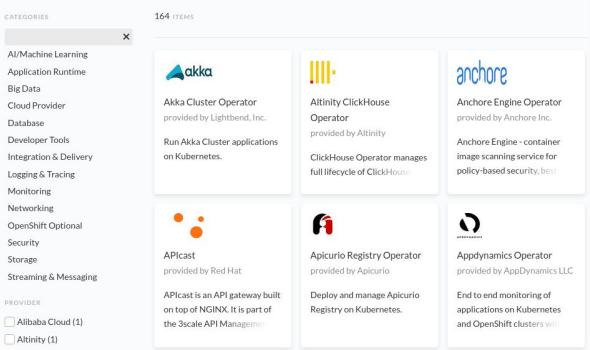
What can you expect ?

- ✓ my experience
- ✓ introductory knowledge
- ✗ magistral lecture
- ✗ This is **<NOT>** the way

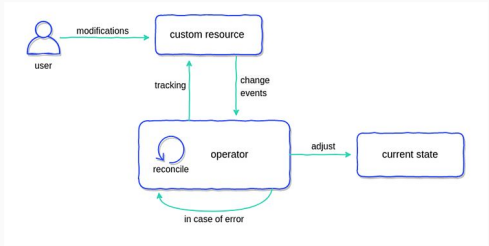
What’s the problem to solve

What is the problem to solve ?

1. You need an easy to use market to publish your app



2. You want something to help you to automate tasks :
   a. scaling
   b. upgrading
   c. complex tasks



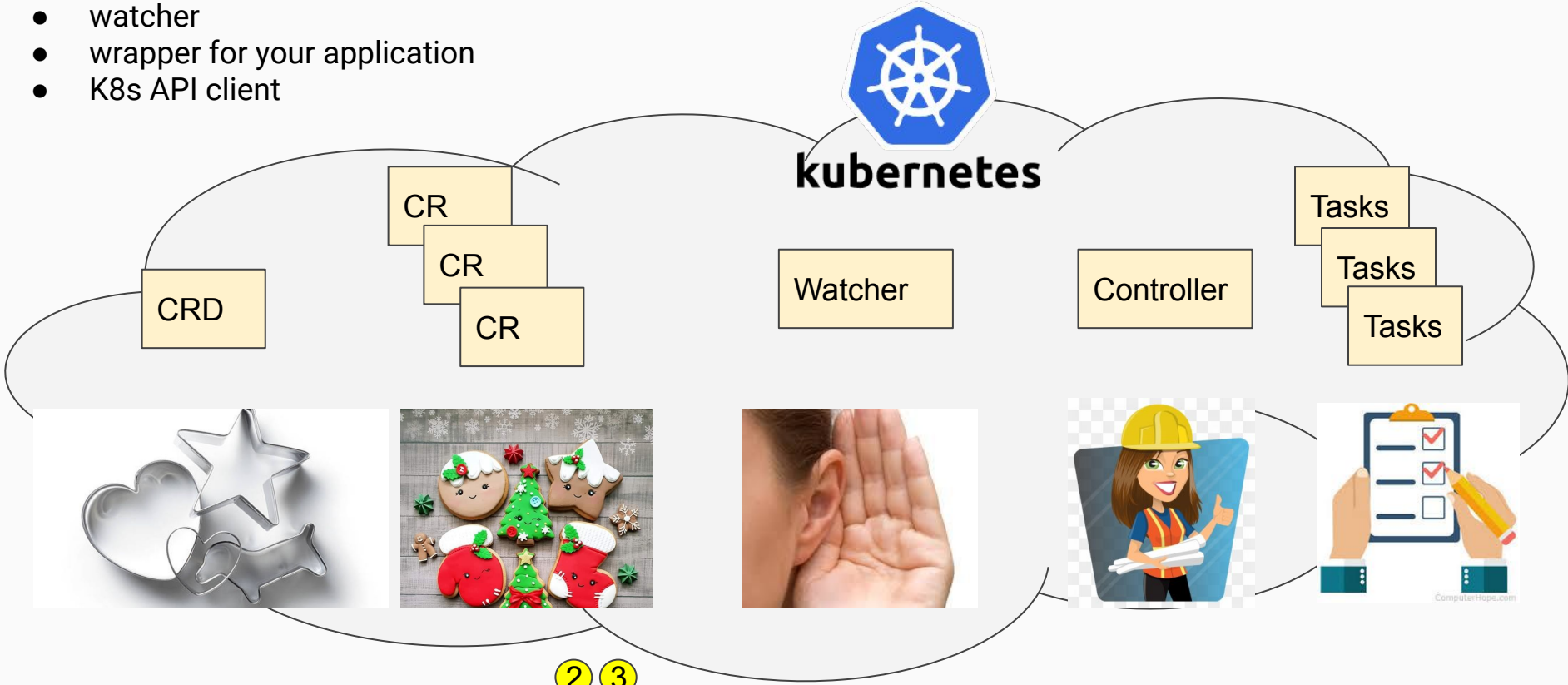
3. You want a “robot” to take care of issues
   a. pods falling
   b. health checks failing
   c. avoid night shifts

4. You want to have more control
   a. metrics
   b. encapsulate your app
   c. auto config tunning

What’s an Operator

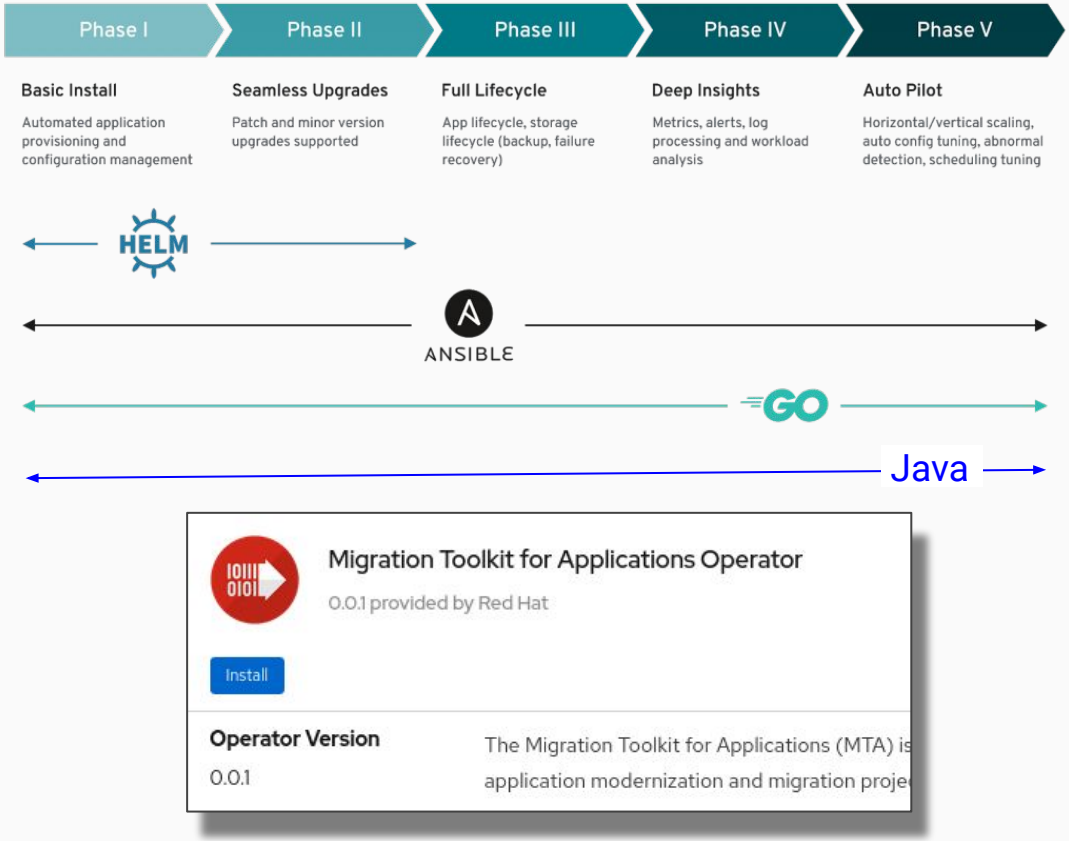
What's an Operator ?

- extension of the Kubernetes API
- watcher
- wrapper for your application
- K8s API client



Create an Operator

Create an Operator



Java
OpenJDK 11

Java Tools
Fabric8 K8s Client
JIB
Quarkus

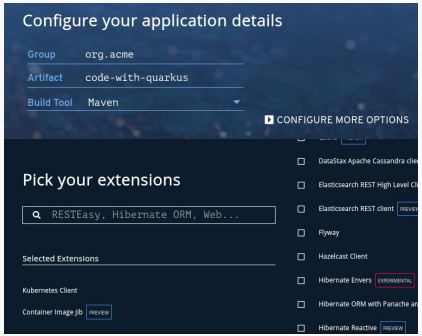
Tools
kubectl / oc
dive
podman

Registry
quay.io

Local Cluster
minikube
Kind

Create an Operator

1 Java app skeleton



2 RBAC & CRD yaml

Cluster wide
- CRD
- Namespace

Namespace wide
- ServiceAccount
- Role
- RoleBinding

3 K8s client Beans

namespace
kubernetesClient
crClient

4 Watcher on CRs

```
crClient.watch(controller);
```

5 Watcher on Deployments

```
k8Client
  .apps()
  .deployments()
  .inNamespace(namespace)
  .watch(depController);
```

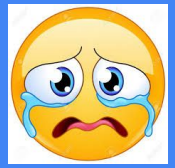
6 Build & Push & Deploy

```
./mvnw clean package -Pnative
-Dquarkus.native.container-build=true
-Dquarkus.container-image.push=true

kubectl apply -f deployment.yaml
```

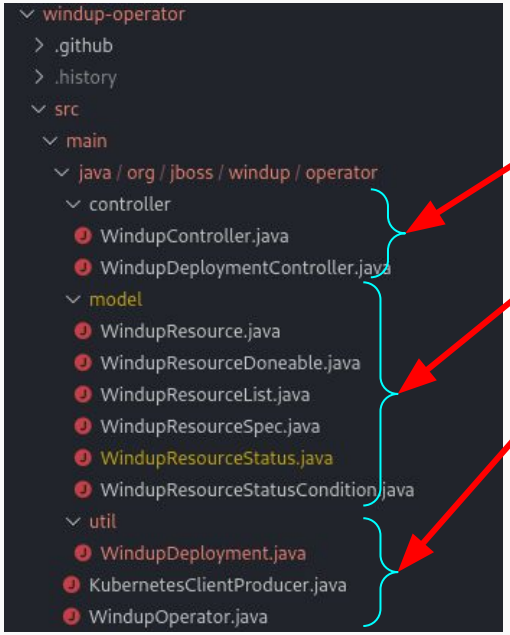
Java & Yaml

…. YES ……

…….. Yaml



Java skeleton



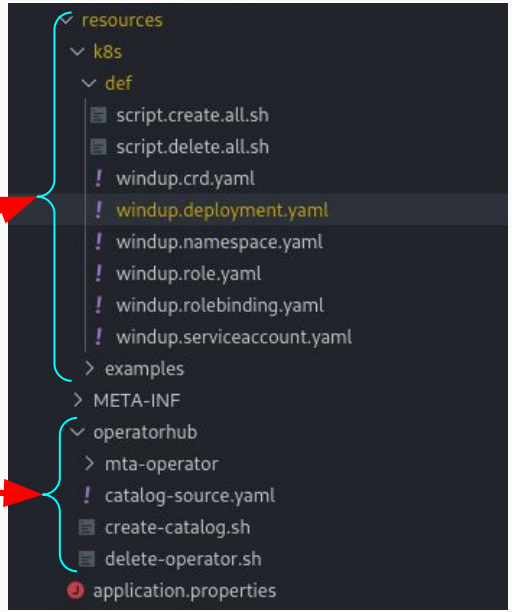
Controllers

Model definition

Beans & Clients

K8s scripts for manual deployment

Files for OperatorHub deployment



K8s Objects

CRD

```
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  name: windups.windup.jboss.org
  labels:
    application: windup
spec:
  group: windup.jboss.org
  scope: Namespaced
  preserveUnknownFields: false
  names:
    plural: windups
    singular: windup
    kind: Windup
  versions:
    - name: v1
      served: true
      storage: true
      subresources:
        status: {}
      schema:
        openAPIV3Schema:
          type: object
          properties:
            spec:
              type: object
              properties:
                hostname_http:
                  type: string
                  default: ""
                volumeCapacity:
                  type: string
                  default: "20G"
```

Role

```
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: windup-operator-role
  namespace: mta
  labels:
    application: windup
rules:
- apiGroups:
  - apps
  - extensions
  resources:
  - deployments
  verbs:
  - create
  - delete
  - get
  - list
  - watch
```

RoleBinding

```
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: windup-operator-role-binding
  namespace: mta
  labels:
    application: windup
subjects:
  - kind: ServiceAccount
  name: windup-operator
  namespace: mta
roleRef:
  kind: Role
  name: windup-operator-role
  apiGroup: rbac.authorization.k8s.io
```

ServiceAccount

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: windup-operator
  namespace: mta
  labels:
    application: windup
```

Deployment

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: windup-operator
  namespace: mta
  labels:
    application: windup
spec:
  selector:
    matchLabels:
      app: windup-operator
  replicas: 1
  template:
    metadata:
      labels:
        app: windup-operator
    spec:
      serviceAccountName: windup-operator
      containers:
      - image: quay.io/windupeng/windup-operator-native:latest
        name: windup-operator
        imagePullPolicy: Always
        env:
        - name: WATCH_NAMESPACE
          valueFrom:
            fieldRef:
              fieldPath: metadata.namespace
```

Clients

Global K8s client

```
@Produces
@Singleton
@IfBuildProfile("prod")
NamespacedKubernetesClient makeDefaultClient() {
  return new DefaultKubernetesClient();
}
```

CRD spedific client

```
@Produces
@Singleton
MixedOperation <WindupResource , ...
makeWindupCustomResource (NamespacedKubernetesClient  defaultClient ,
                          CustomResourceDefinitionContext
crdContext ,
                          @Named ("namespace") String namespace) {
  KubernetesDeserializer .registerCustomKind ("windup.jboss.org/v1" ,
                                  "Windup",
                            WindupResource .class);

  return defaultClient .inNamespace (namespace)
           .customResources (crdContext , WindupResource .class,
            WindupResourceList .class,
WindupResourceDoneable .class);
}
```

CRD context for the CRD client

```
@Produces
@Singleton
CustomResourceDefinitionContext makeCRDContext(NamespacedKubernetesClient defaultClient,
                                               @Named("namespace") String namespace) {
   InputStream fileStream =
KubernetesClientProducer.class.getResourceAsStream("/k8s/def/windup.crd.yaml");
   Resource<CustomResourceDefinition, DoneableCustomResourceDefinition> resource = defaultClient
          .inNamespace(namespace).apiextensions().v1().customResourceDefinitions().load(fileStream
          );
   CustomResourceDefinition windupCRD = resource.get();

   return new CustomResourceDefinitionContext.Builder()
               .withGroup(windupCRD.getSpec().getGroup())
               .withVersion(windupCRD.getSpec().getVersions().stream().findFirst()
                       .map(CustomResourceDefinitionVersion::getName).orElse(""))
               .withScope(windupCRD.getSpec().getScope())
               .withName(windupCRD.getMetadata().getName())
               .withPlural(windupCRD.getSpec().getNames().getPlural())
               .withKind(windupCRD.getSpec().getNames().getKind())
           .build();
   }
```

Namespace from where the operator is running

```
@Produces
@Singleton
@Named("namespace")
String findMyCurrentNamespace(NamespacedKubernetesClient client)  {
   return client.getConfiguration().getNamespace();
}
```

Watchers

THE Operator

```
@ApplicationScoped
@Log
public class WindupOperator {
   @Inject
   WindupController windupController;
   @Inject
   WindupDeploymentController windupDeploymentController;
   @Inject
   KubernetesClient k8Client;
   @Inject
   MixedOperation<WindupResource, ….  crClient;

   @Named("namespace")
   String namespace;

   public void onStart(@Observes StartupEvent event) {
       log.info("Startup");

       log.info("Adding Windup watcher ....");
       crClient.watch(windupController);

       log.info("Adding Windup Deployments watcher ....");
       k8Client.apps().deployments().inNamespace(namespace)
          .watch(windupDeploymentController);
   }

}
```

CR Watcher

```
@Log
@ApplicationScoped
public class WindupController implements Watcher<WindupResource> {
   @Inject
   KubernetesClient k8sClient;

   private void onAdd(WindupResource resource) {
       if (!resource.isDeploying() && !resource.isReady()) {
           new WindupDeployment(resource, crClient,
                                k8sClient, namespace,
                                serviceAccount, ssoPublicKey)
                   .deploy();
       }
   }

   private void onUpdate(WindupResource newResource) {
       // Consolidate status of the CR
       if (newResource.deploymentsReady() == 3 &&
           !newResource.isReady()) {
          newResource.setReady(true);
         crClient.inNamespace(namespace)
                 .updateStatus(newResource);
       }
   }

   @Override
   public void eventReceived(Action action,
                             WindupResource resource) {
       if (action == Action.ADDED) onAdd(resource);
       if (action == Action.MODIFIED) onUpdate(resource);
       if (action == Action.DELETED) onDelete(resource);
   }
```

Deployments Watcher

```
@Log
@ApplicationScoped
public class WindupDeploymentController implements
Watcher<Deployment> {
   @Inject
   MixedOperation<WindupRe... crClient;

   @Named("namespace")
   String namespace;

   @Override
   public void eventReceived(Action action,
                             Deployment deployment) {
       updateCRStatus(deployment);
   }
```

Reconciliation

IF expected-status != current-status DO

- add more pods
- ...

IF expected-status == current-status DO

- set status = READY

on every Deployment UPDATE event

```
public class WindupDeploymentController implements Watcher<Deployment> {
   public void eventReceived(Action action, Deployment deployment) {
       updateCRStatus(deployment);
   }

   private void updateCRStatus(Deployment obj) {
       // Get the CR name where this deployment belongs to
       String crName = obj.getMetadata().getOwnerReferences()....

       if (!StringUtils.isBlank(crName)) {
           WindupResource cr = crClient.inNamespace(namespace).withName(crName).get();

           // We want 1 replica per deployment, so checking if there is 1 replica Ready
           cr.getOrAddConditionByType(obj.getMetadata().getName())
               .setStatus(Boolean.toString(obj.getStatus().getReadyReplicas() == 1))
               .setReason(WindupResource.DEPLOYMENT);

          // Sending the new status to K8s
           crClient.inNamespace(namespace).updateStatus(cr);
       }
   }
}
```

on every CR UPDATE event - caused by

```
public class WindupController implements Watcher<WindupResource> {

   private void onUpdate(WindupResource newResource) {
       // Consolidate status of the CR
       if (newResource.deploymentsReady() == 3 && !newResource.isReady()) {
           newResource.setReady(true);
           newResource.getOrAddConditionByType("Deploy")
                       .setStatus(Boolean.FALSE.toString());

           log.info("Setting this CR as Ready");
           crClient.inNamespace(namespace).updateStatus(newResource);
       }
   }
```

Test the Operator

Test the operator

Unit Tests

.. dah….tell me something I don’t know

Test the operator

Integration test

```
@QuarkusTest
public class WindupControllerTest {
   @Inject
   KubernetesMockServer server;

   @Inject
   MixedOperation<WindupResource...crClient;

   @Test
   public void onAddCR_shouldServerReceiveExactCalls() throws InterruptedException {
       InputStream fileStream = WindupControllerTest.class.getResourceAsStream("/windup.resource.yaml");
       WindupResource windupResource = Serialization.unmarshal(fileStream, WindupResource.class);
       crClient.inNamespace("test").create(windupResource);
       dispatcher.getRequests().clear();
       Awaitility
           .await()
           .atMost(5, TimeUnit.SECONDS)
           .untilAsserted(() -> assertEquals(2,
                                             dispatcher.getRequests().stream()
                                                 .filter(e-> "POST".equalsIgnoreCase(e.getMethod()) &&
                                                         e.getPath().indexOf("ingress") >= 0).count()));
       assertEquals(4, dispatcher.getRequests()
                               .stream().filter(e-> "PUT".equalsIgnoreCase(e.getMethod()) &&
                                                  e.getPath().indexOf("status") >= 0).count());
       assertEquals(3, dispatcher.getRequests().stream()
                               .filter(e-> "POST".equalsIgnoreCase(e.getMethod()) &&
                                       e.getPath().indexOf("deployments") >= 0).count());
   }
```

```
public class KubernetesCrudRecorderDispatcher extends
KubernetesCrudDispatcher {
 private List<RecordedRequest> requests = new ArrayList<>();
   @Override
   public MockResponse dispatch(RecordedRequest request) {
       requests.add(request);
       return super.dispatch(request);
   }
}
```

```
@Produces
   @Singleton
   @IfBuildProfile("test")
   KubernetesMockServer makeKubernetesServer
                    (KubernetesCrudRecorderDispatcher dispatcher) {
       MockWebServer webServer = new MockWebServer();
       KubernetesMockServer kubernetesServer = new
                                KubernetesMockServer(new Context(),
                                    webServer, new HashMap<>(),
                                    dispatcher, false);
       return kubernetesServer;
   }
```

Test the operator

Local test (using Kind) : local-test.sh

```
mvn clean package -Pnative -Dquarkus.container-image.build=true -DskipTests "-Dquarkus.container-image.tag=$containertag"    # Build the operator
kind load docker-image quay.io/windupeng/windup-operator-native:$containertag   # Load new image into the Kind cluster

# Execute all objects
kubectl apply -f windup.namespace.yaml
kubectl apply -f windup.serviceaccount.yaml
kubectl apply -f windup.role.yaml
kubectl apply -f windup.rolebinding.yaml
kubectl apply -f windup.crd.yaml

# Deploy Operator image just create above
sed "s/windup-operator-native:latest/windup-operator-native:$containertag/g" ../../../../test/resources/windup.deployment.yaml | kubectl apply -f -

# Create the CR to trigger the Operator
kubectl apply -f ../../../../test/resources/windup-test.yaml

sleep 20
num=`kubectl get all,ing,pvc -n mta -o name | wc -l` # Request all objects in the namespace
# 4 deployments (including operator), 2 ingresses, 3 services, 2 pvc, 4 pods (including operator), 4 replicaset
echo "num $num"
if [ "$num" -gt "19" ];  # Checking the number of objectes created by the Operator
 then echo "Test not passed";
fi
if [ "$num" -eq "19" ];
 then echo "Test OK";
fi
```

CI Test

CI test (using Github Actions and Minikube)

```yaml
name: MTA Operator E2E Tests

on: [pull_request,push]

jobs:
  minikube:
   name: K8S
   runs-on: ubuntu-latest
   steps:
     - name: Checkout
       uses: actions/checkout@v2.0.0

     - name: Setup Minikube-Kubernetes
       uses: manusa/actions-setup-minikube@v2.0.1
       with:
         minikube version: v1.13.1
         kubernetes version: 'v1.19.2'
         github token: ${{ secrets.GITHUB_TOKEN }}
         start args: ' --force'

     - name: setup-graalvm-ce
       uses: rinx/setup-graalvm-ce@v0.0.5
       with:
         graalvm-version: "20.1.0"
         java-version: "java11"
         native-image: "true"
```

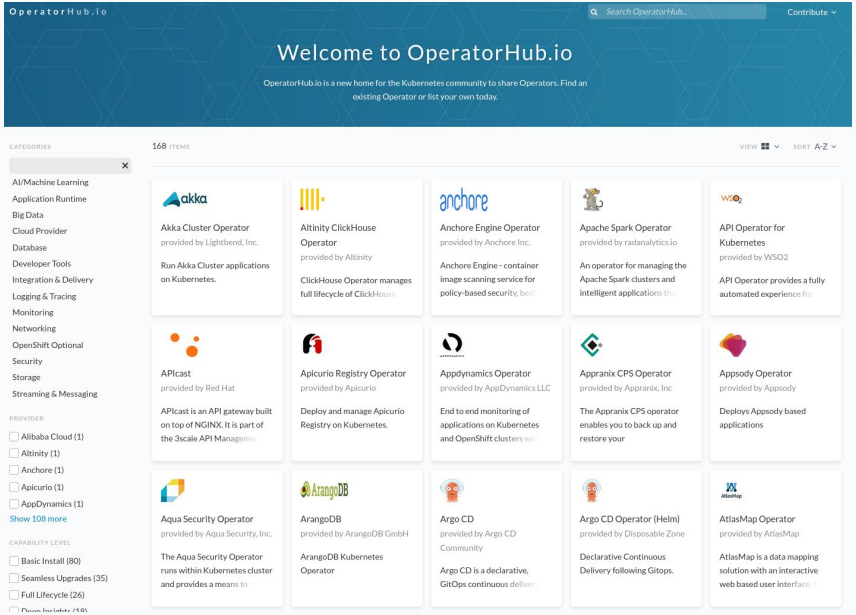
```yaml
      - name: Build operator image and push it to the minikube
        run: cd ${{github.workspace}} &&
             eval $(minikube -p minikube docker-env) &&
             mvn clean package -Pnative
                 -Dquarkus.container-image.build=true -DskipTests
                 -Dquarkus.native.container-runtime=docker

      - name: Deploy Objects and Operator
        run: cd ${{github.workspace}} &&
            cd src/main/resources/k8s/def &&
            kubectl apply -f windup.namespace.yaml &&
            kubectl apply -f windup.serviceaccount.yaml &&
            kubectl apply -f windup.role.yaml &&
            kubectl apply -f windup.rolebinding.yaml &&
            kubectl apply -f windup.crd.yaml &&
            kubectl apply -f windup.deployment.yaml &&
            # Deploy CR to trigger Operator
            kubectl apply -f windup-test.yaml
      - name: Sleep for 30 seconds to allow objects to be created
        uses: jakejarvis/wait-action@master
        with:
          time: '30s'

      - name: Get and store number of k8s objects on mta namespace
        id: getobjects
        run: echo "::set-output name=value::$(kubectl get
all,ing,pvc -n mta -o name | wc -l)"
        shell: bash
```

```yaml
- name: Operator Test
      uses: therussiankid92/gat@v1.3
      with:
        assertion: should.equal
        expected: 19
        actual: ${{steps.getobjects.outputs.value}}
```

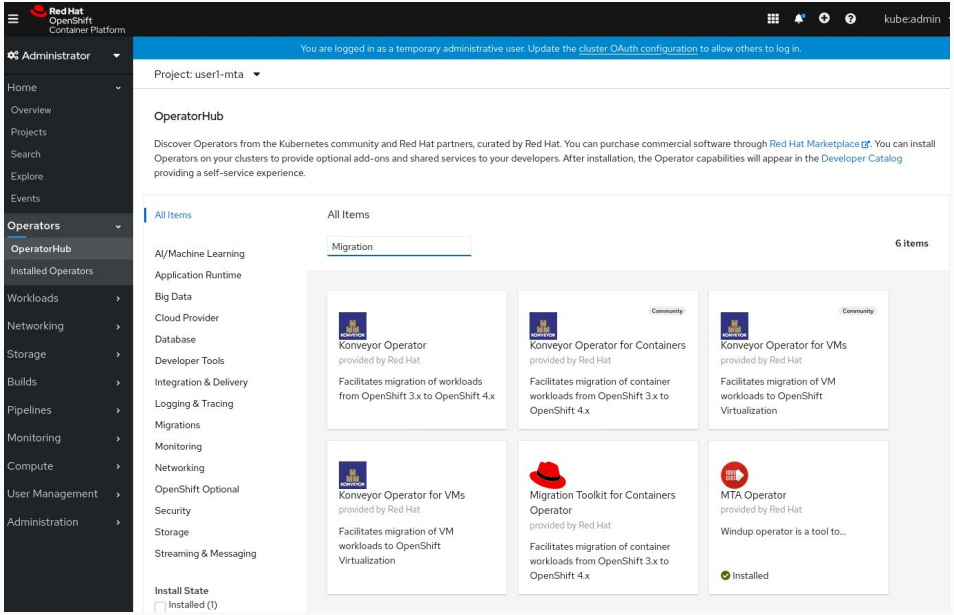
Publish Operator

Publish the Operator

Operatorhub.io



Openshift internal Operatorhub

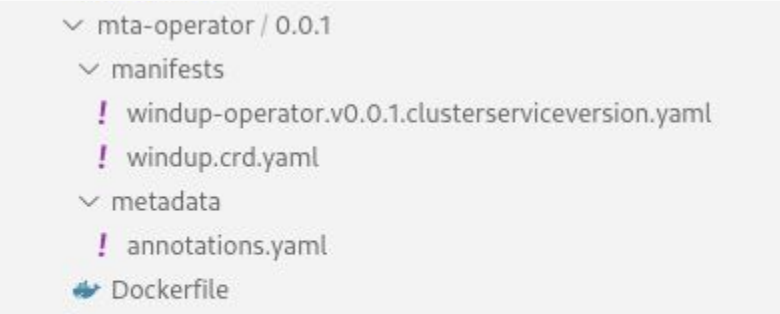


Files to publish the operator

Submit PR to https://github.com/operator-framework/community-operators.git

Folder

- community-operators : Appear in Openshift OperatorHub
- upstream-community-operators : Appear in operatorhub.io web site
  100% compatible vanilla Kubernetes



CSV : cluster service version
contains visual info, rbac, deployment

CRD : crds being used

annotations : for the bundle

Dockerfile : to create the bundle image

Cluster Service Version

```yaml
apiVersion: operators.coreos.com/v1alpha1
kind: ClusterServiceVersion
metadata:
 name: windup-operator.0.0.1
 namespace: placeholder
 annotations:
   alm-examples: >-
     [  # Yaml with the CR we used before , for each CRD ]
   capabilities: Basic Install
   categories: Modernization & Migration
   certified: "false"
   containerImage: quay.io/windupeng/myoperator:0.0.1
   ...
spec:
 description: > # Multiline description
 version: 0.0.1
 maturity: alpha
 icon: # Base64 of the image
customresourcedefinitions:
   owned:
     - description: > # CRD multiline description
       displayName: Migration Toolkit for Applications
       kind: Windup
       name: windups.windup.jboss.org
       version: v1
 displayName: Migration Toolkit for Applications Operator
 provider:
   name: Red Hat
```

```yaml
    deployments:
      - name: windup-operator.0.0.1
        spec:
          replicas: 1
          selector:
            matchLabels:
              name: windup-operator
          template:
            metadata:
              labels:
                name: windup-operator
            spec:
              serviceAccountName: windup-operator
              containers:
                - name: windup-operator
                  image: quay.io/windupeng/myoperator:0.0.1
                  imagePullPolicy: Always
                  env:
                    - name: WATCH_NAMESPACE
                      valueFrom:
                        fieldRef:
                          fieldPath: metadata.namespace
                      resources:
                        limits:
                          cpu: 1
                          memory: 200Mi
                        requests:
                          cpu: 100m
                          memory: 50Mi
          strategy:
            type: Recreate
```

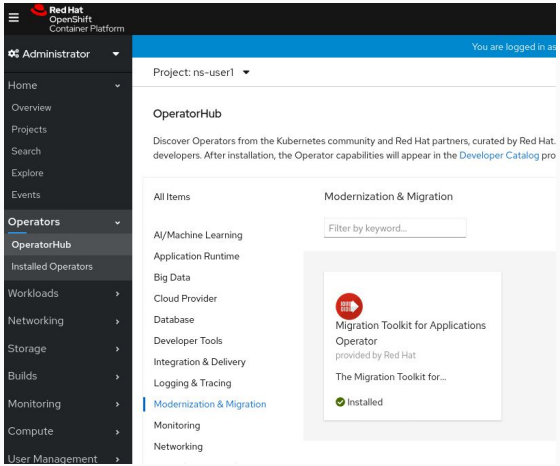
```yaml
    strategy: deployment
  installModes:
    - supported: true
      type: OwnNamespace
    - supported: true
      type: SingleNamespace
    - supported: false
      type: MultiNamespace
    - supported: false
      type: AllNamespaces
  keywords:
    - monitoring
    - security
    - alerting
    - metric
    - troubleshooting
    - run-time
    - migration
    - modernization
```

Test the operator on Openshift Operatorhub

Using project https://github.com/operator-framework/operator-registry

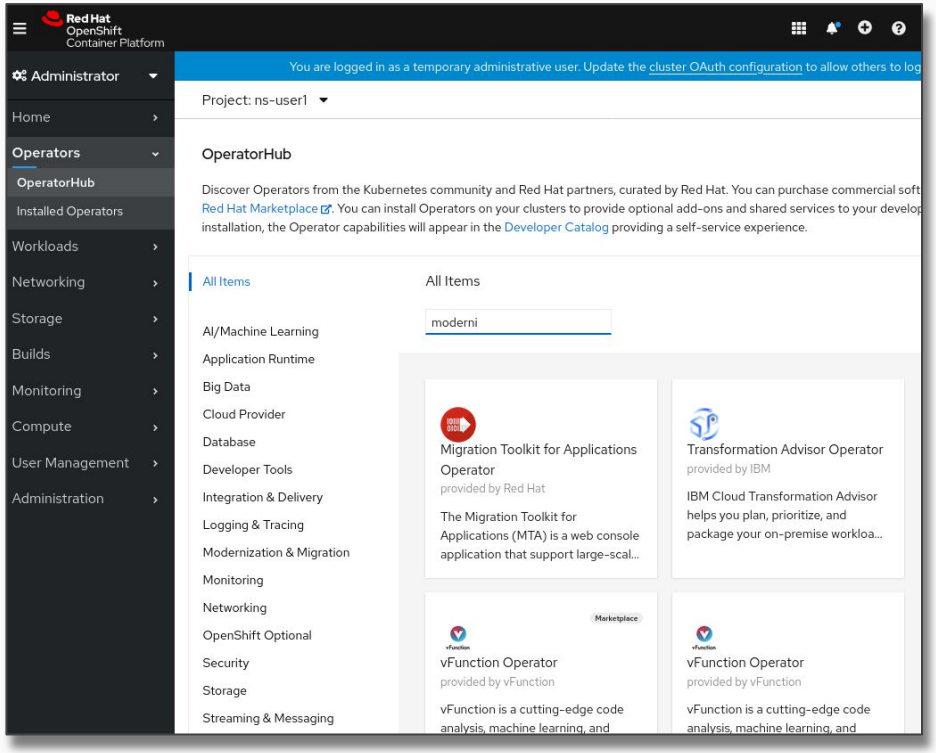
```
#!/bin/sh -x

# everytime you test you need to increase this version number
# it only affects your test, has no other purposes
version=0.0.1

# Create operator bundle image
podman build -f mta-operator/0.0.1/Dockerfile -t mta-operator-bundle:$version
               mta-operator/0.0.1/
podman tag mta-operator-bundle:$version
          quay.io/windupeng/mta-operator-bundle:$version
podman push quay.io/windupeng/mta-operator-bundle:$version

# Install operator-registry
# git clone https://github.com/operator-framework/operator-registry
# cd operator-registry
# make build

# Build operator catalog
operator-registry/bin/opm index add --bundles
              quay.io/windupeng/mta-operator-bundle:$version \
              --from-index quay.io/openshift-community-operators/catalog:latest \
              --tag quay.io/windupeng/mta-operator-test-catalog:$version
podman push  quay.io/windupeng/mta-operator-test-catalog:$version

sleep 20

oc apply -f catalog-source.yaml
```

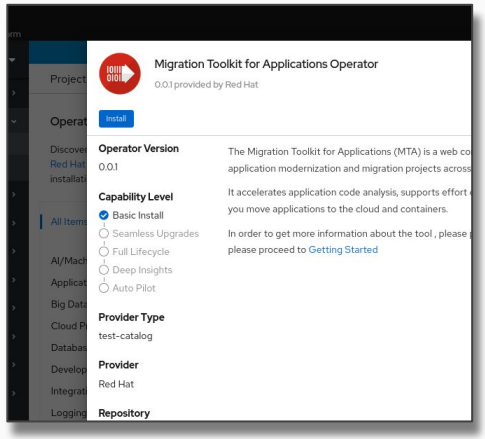
1. build bundle image
2. tag image
3. push image
4. build catalog image
5. push image
6. deploy catalog into OCP

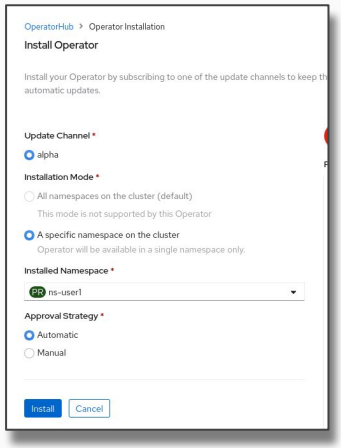


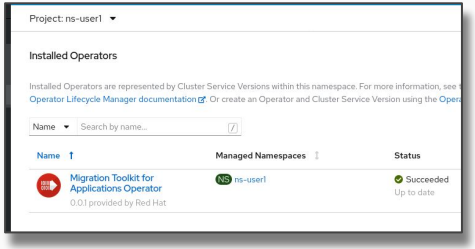
Execution flow

Execution Summary : Operator installation by cluster wide admin

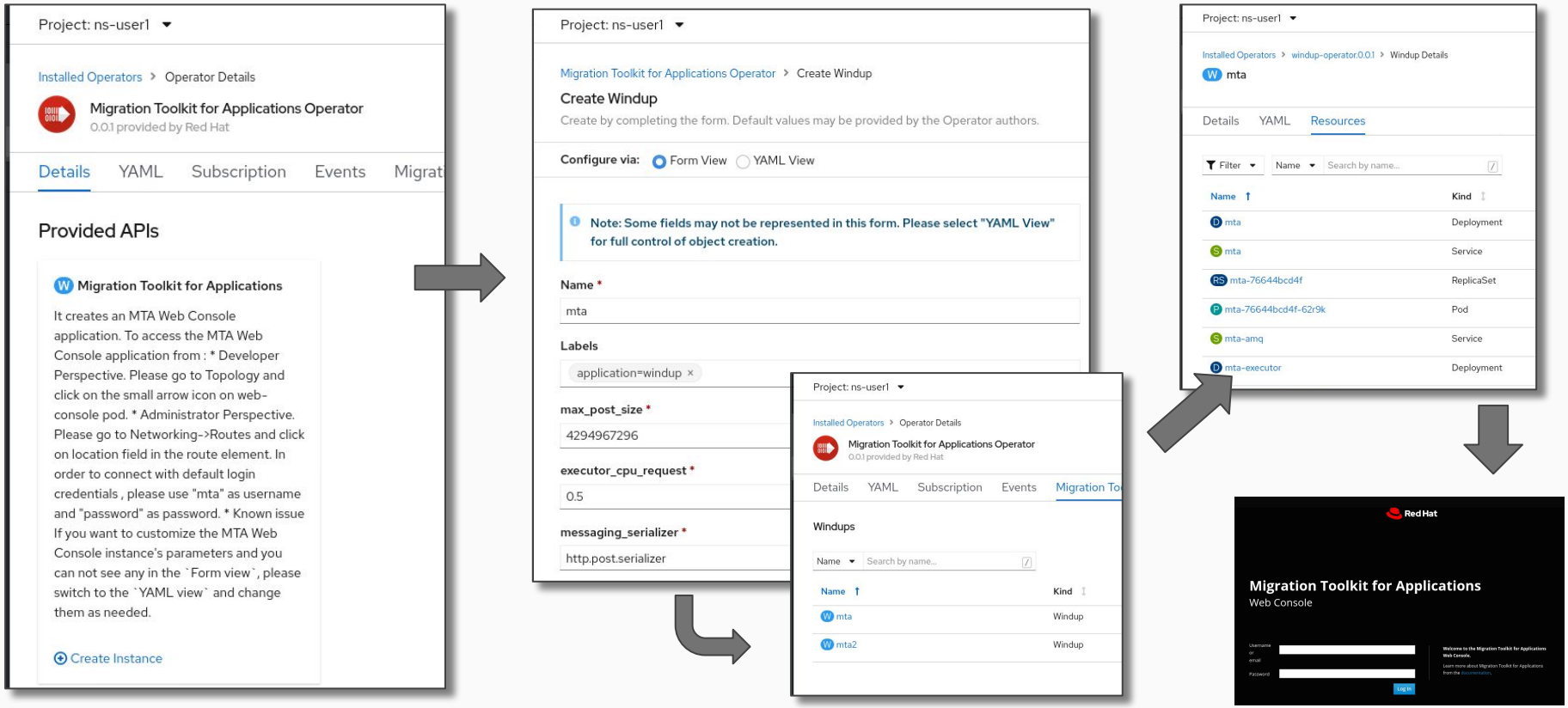








Execution Summary : CR creation by user



References

References

Windup Operator Github project : github.com/windup/windup-operator

Kubernetes API reference : https://kubernetes.io/docs/reference/

Fabric8 Kubernetes client : https://github.com/fabric8io/kubernetes-client // https://quarkus.io/guides/kubernetes

Fabric8 Kubernetes mock-server : https://itnext.io/mock-kubernetes-api-server-in-java-using-fabric8-kuber……

Quarkus https://quarkus.io

OperatorHub project https://github.com/operator-framework/community-operators
https://github.com/operator-framework/operator-registry

JIB https://quarkus.io/guides/container-image

dive https://github.com/wagoodman/dive

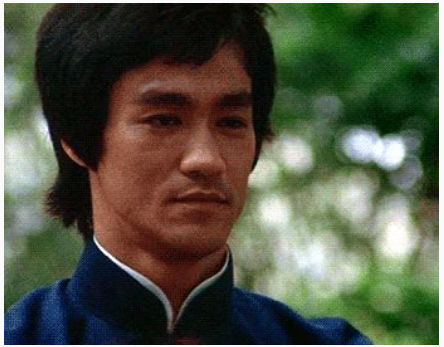
podman https://podman.io/

Minikube https://minikube.sigs.k8s.io/docs

Quay.io https://quay.io

Kind https://kind.sigs.k8s.io/docs/

Thank you



Thank you :)

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