链滴

云原生的工作流引擎 ---argo

作者：Gakkiyomi2019

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Argo Workflows是一个开源的容器本机工作流引擎，用于在Kubernetes上协调并行作业。 Argo Workflows被实现为Kubernetes CRD（自定义资源定义）。跟其他传统的工作流引擎不同的是，他的**每个步骤都是一个容器**。将多步骤工作流建模为一系列任务，或者使用有向无环图（DAG）捕获任务之的依赖关系。

使用Kubernetes上的Argo Workflow，可以在短时间内轻松运行用于计算机学习或数据处理的计算集型作业。

安装argo

安装argo十分容易

第一步先创建namespace

```
kubectl create ns argo
```

第二步执行`kubectl -n argo apply -f install.yaml`


```
# This is an auto-generated file. DO NOT EDIT
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: clusterworkflowtemplates.argoproj.io
spec:
  group: argoproj.io
  names:
    kind: ClusterWorkflowTemplate
    listKind: ClusterWorkflowTemplateList
    plural: clusterworkflowtemplates
    shortNames:
    - clusterwftmpl
    - cwft
    singular: clusterworkflowtemplate
  scope: Cluster
  version: v1alpha1
  versions:
  - name: v1alpha1
    served: true
    storage: true
---
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: cronworkflows.argoproj.io
```

```yaml
spec:
  group: argoproj.io
  names:
    kind: CronWorkflow
    listKind: CronWorkflowList
    plural: cronworkflows
    shortNames:
    - cwf
    - cronwf
    singular: cronworkflow
  scope: Namespaced
  version: v1alpha1
  versions:
  - name: v1alpha1
    served: true
    storage: true
---
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: workfloweventbindings.argoproj.io
spec:
  group: argoproj.io
  names:
    kind: WorkflowEventBinding
    listKind: WorkflowEventBindingList
    plural: workfloweventbindings
    shortNames:
    - wfeb
    singular: workfloweventbinding
  scope: Namespaced
  version: v1alpha1
  versions:
  - name: v1alpha1
    served: true
    storage: true
---
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: workflows.argoproj.io
spec:
  additionalPrinterColumns:
  - JSONPath: .status.phase
    description: Status of the workflow
    name: Status
    type: string
  - JSONPath: .status.startedAt
    description: When the workflow was started
    format: date-time
    name: Age
    type: date
  group: argoproj.io
  names:
```

```yaml
    kind: Workflow
    listKind: WorkflowList
    plural: workflows
    shortNames:
    - wf
    singular: workflow
  scope: Namespaced
  subresources: {}
  version: v1alpha1
  versions:
  - name: v1alpha1
    served: true
    storage: true
---
apiVersion: apiextensions.k8s.io/v1beta1
kind: CustomResourceDefinition
metadata:
  name: workflowtemplates.argoproj.io
spec:
  group: argoproj.io
  names:
    kind: WorkflowTemplate
    listKind: WorkflowTemplateList
    plural: workflowtemplates
    shortNames:
    - wftmpl
    singular: workflowtemplate
  scope: Namespaced
  version: v1alpha1
  versions:
  - name: v1alpha1
    served: true
    storage: true
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: argo
---
apiVersion: v1
kind: ServiceAccount
metadata:
  name: argo-server
---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: argo-role
rules:
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
```

```yaml
  - get
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  labels:
    rbac.authorization.k8s.io/aggregate-to-admin: "true"
  name: argo-aggregate-to-admin
rules:
- apiGroups:
  - argoproj.io
  resources:
  - workflows
  - workflows/finalizers
  - workflowtemplates
  - workflowtemplates/finalizers
  - cronworkflows
  - cronworkflows/finalizers
  - clusterworkflowtemplates
  - clusterworkflowtemplates/finalizers
  verbs:
  - create
  - delete
  - deletecollection
  - get
  - list
  - patch
  - update
  - watch
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  labels:
    rbac.authorization.k8s.io/aggregate-to-edit: "true"
  name: argo-aggregate-to-edit
rules:
- apiGroups:
  - argoproj.io
  resources:
  - workflows
  - workflows/finalizers
  - workflowtemplates
  - workflowtemplates/finalizers
  - cronworkflows
  - cronworkflows/finalizers
  - clusterworkflowtemplates
  - clusterworkflowtemplates/finalizers
  verbs:
  - create
  - delete
  - deletecollection
  - get
  - list
```

```yaml
  - patch
  - update
  - watch
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  labels:
    rbac.authorization.k8s.io/aggregate-to-view: "true"
  name: argo-aggregate-to-view
rules:
- apiGroups:
  - argoproj.io
  resources:
  - workflows
  - workflows/finalizers
  - workflowtemplates
  - workflowtemplates/finalizers
  - cronworkflows
  - cronworkflows/finalizers
  - clusterworkflowtemplates
  - clusterworkflowtemplates/finalizers
  verbs:
  - get
  - list
  - watch
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: argo-cluster-role
rules:
- apiGroups:
  - ""
  resources:
  - pods
  - pods/exec
  verbs:
  - create
  - get
  - list
  - watch
  - update
  - patch
  - delete
- apiGroups:
  - ""
  resources:
  - configmaps
  verbs:
  - get
  - watch
  - list
- apiGroups:
```

```
    - ""
    resources:
    - persistentvolumeclaims
    verbs:
    - create
    - delete
  - apiGroups:
    - argoproj.io
    resources:
    - workflows
    - workflows/finalizers
    verbs:
    - get
    - list
    - watch
    - update
    - patch
    - delete
    - create
  - apiGroups:
    - argoproj.io
    resources:
    - workflowtemplates
    - workflowtemplates/finalizers
    - clusterworkflowtemplates
    - clusterworkflowtemplates/finalizers
    verbs:
    - get
    - list
    - watch
  - apiGroups:
    - ""
    resources:
    - serviceaccounts
    verbs:
    - get
    - list
  - apiGroups:
    - argoproj.io
    resources:
    - cronworkflows
    - cronworkflows/finalizers
    verbs:
    - get
    - list
    - watch
    - update
    - patch
    - delete
  - apiGroups:
    - ""
    resources:
    - events
    verbs:
```

```yaml
  - create
  - patch
- apiGroups:
  - policy
  resources:
  - poddisruptionbudgets
  verbs:
  - create
  - get
  - delete
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  name: argo-server-cluster-role
rules:
- apiGroups:
  - ""
  resources:
  - configmaps
  verbs:
  - get
  - watch
  - list
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
- apiGroups:
  - ""
  resources:
  - pods
  - pods/exec
  - pods/log
  verbs:
  - get
  - list
  - watch
  - delete
- apiGroups:
  - ""
  resources:
  - events
  verbs:
  - watch
  - create
  - patch
- apiGroups:
  - ""
  resources:
  - secrets
  - serviceaccounts
```

```yaml
  verbs:
  - get
- apiGroups:
  - argoproj.io
  resources:
  - workflows
  - workfloweventbindings
  - workflowtemplates
  - cronworkflows
  - clusterworkflowtemplates
  verbs:
  - create
  - get
  - list
  - watch
  - update
  - patch
  - delete
---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: argo-binding
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: argo-role
subjects:
- kind: ServiceAccount
  name: argo
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: argo-binding
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: argo-cluster-role
subjects:
- kind: ServiceAccount
  name: argo
  namespace: argo
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: argo-server-binding
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: argo-server-cluster-role
subjects:
- kind: ServiceAccount
```

```yaml
  name: argo-server
  namespace: argo
---
apiVersion: v1
kind: ConfigMap
metadata:
  name: workflow-controller-configmap
---
apiVersion: v1
kind: Service
metadata:
  name: argo-server
spec:
  externalIPs:              # 暴露Service到外部IP
  - 192.168.1.146                 # IP
  ports:
  - name: web
    port: 2746
    targetPort: 2746
  selector:
    app: argo-server
---
apiVersion: v1
kind: Service
metadata:
  name: workflow-controller-metrics
spec:
  ports:
  - name: metrics
    port: 9090
    protocol: TCP
    targetPort: 9090
  selector:
    app: workflow-controller
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: argo-server
spec:
  selector:
    matchLabels:
      app: argo-server
  template:
    metadata:
      labels:
        app: argo-server
    spec:
      containers:
      - args:
        - server
        image: argoproj/argocli:v2.11.7
        name: argo-server
        ports:
```

```
        - containerPort: 2746
          name: web
        readinessProbe:
          httpGet:
            path: /
            port: 2746
            scheme: HTTP
          initialDelaySeconds: 10
          periodSeconds: 20
        volumeMounts:
        - mountPath: /tmp
          name: tmp
      nodeSelector:
        kubernetes.io/os: linux
      serviceAccountName: argo-server
      volumes:
      - emptyDir: {}
        name: tmp
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: workflow-controller
spec:
  selector:
    matchLabels:
      app: workflow-controller
  template:
    metadata:
      labels:
        app: workflow-controller
    spec:
      containers:
      - args:
        - --configmap
        - workflow-controller-configmap
        - --executor-image
        - argoproj/argoexec:v2.11.7
        command:
        - workflow-controller
        image: argoproj/workflow-controller:v2.11.7
        name: workflow-controller
      nodeSelector:
        kubernetes.io/os: linux
      serviceAccountName: argo
```

第三步 安装 argo-cli

```
# Download the binary
curl -sLO https://github.com/argoproj/argo/releases/download/v2.11.7/argo-darwin-amd64.gz

# Unzip
gunzip argo-darwin-amd64.gz
```

Make binary executable
chmod +x argo-darwin-amd64

Move binary to path
mv ./argo-darwin-amd64 /usr/local/bin/argo

Test installation
argo version

如出现已下输出则 argo-cli 安装成功 我安装的是老版本 不用担心 是向下兼容的

```
[root@nap-146 argo]# argo version
argo: v2.6.3
  BuildDate: 2020-03-16T17:55:34Z
  GitCommit: 2e8ac609cba1ad3d69c765dea19bc58ea4b8a8c3
  GitTreeState: clean
  GitTag: v2.6.3
  GoVersion: go1.13.4
  Compiler: gc
  Platform: linux/amd64
```

然后使用kubectl get all -n argo查看argo-server的启动情况

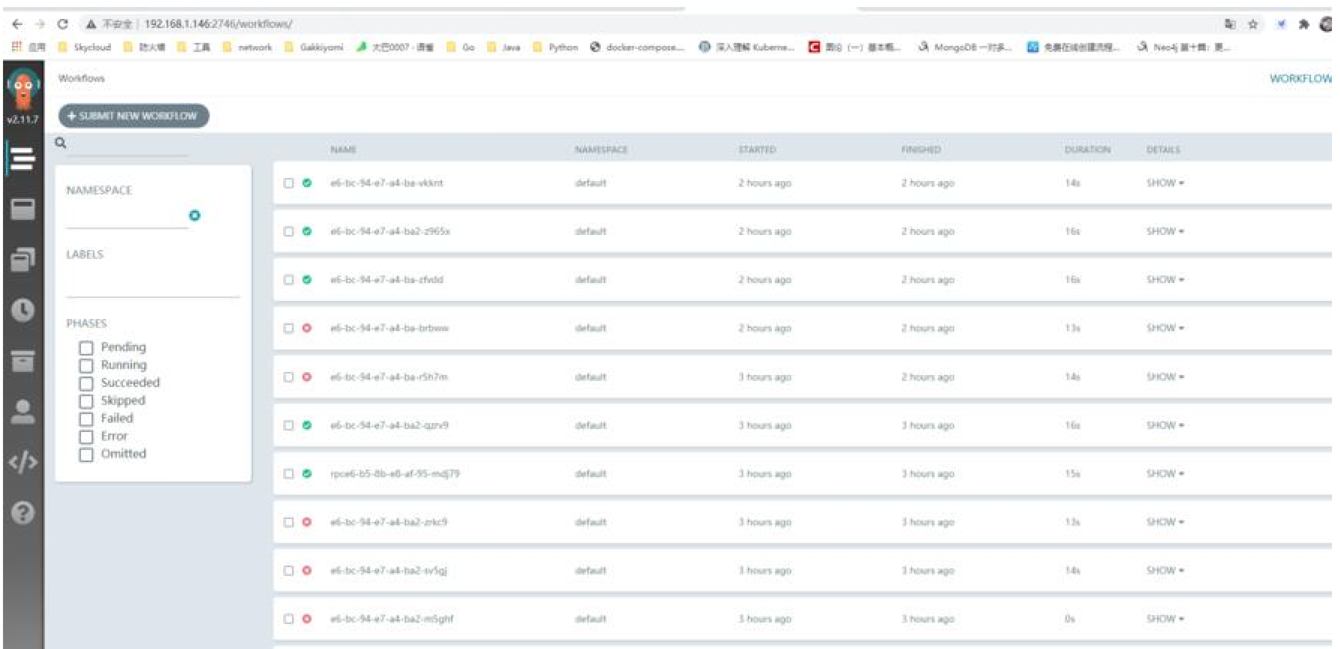
```
[root@nap-146 argo]# kubectl get all -n argo
NAME                                     READY   STATUS    RESTARTS   AGE
pod/argo-server-6dfdff89fd-fkzfj         1/1     Running   0          6h12m
pod/workflow-controller-6c8f6c7c94-9fxrc 1/1     Running   0          6h12m

NAME                                  TYPE        CLUSTER-IP     EXTERNAL-IP     PORT(S)    AGE
service/argo-server                   ClusterIP   10.101.19.18   192.168.1.146   2746/TCP   6h12m
service/workflow-controller-metrics   ClusterIP   10.99.24.53    <none>          9090/TCP   6h12m

NAME                                  READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/argo-server           1/1     1            1           6h12m
deployment.apps/workflow-controller   1/1     1            1           6h12m

NAME                                             DESIRED   CURRENT   READY   AGE
replicaset.apps/argo-server-6dfdff89fd           1         1         1       6h12m
replicaset.apps/workflow-controller-6c8f6c7c94   1         1         1       6h12m
[root@nap-146 argo]#
```

启动完毕后，我们可以访问暴露出来的argo-server-ui 界面访问argo-dashboard 默认端口**2746**



原文链接：云原生的工作流引擎 ---argo

遇到的问题

安装完argo 并且提交工作流后，发现工作流执行不成功，查看日志发现

```
Finished:           Tue Nov 03 14:15:01 +0800 (3 hours ago)
Duration:           7 seconds
Parameters:
  e7-ad-96-e7-95-a5-e9-80-89-e6-8b-a9__business: fangcong

STEP                                                                          PODNAME                              DURATION  MESSAGE
 ✖ e6-bc-94-e7-a4-ba-g5zpw (e6-bc-94-e7-a4-ba)                                                                               child 'e6-bc-94-e7-a4-ba-g5zpw-1847934558' failed
 └--- e7-ad-96-e7-95-a5-e9-80-89-e6-8b-a9 (94d8dcb7-2ae0-4403-a5df-1ca3b85fbe6d)  e6-bc-94-e7-a4-ba-g5zpw-1847934558  5s        failed to save outputs: pods "e6-bc-94-e7-a4-ba-g5zpw-18479
4558" is forbidden: User "system:serviceaccount:default:default" cannot patch resource "pods" in API group "" in the namespace "default"
[root@nap-146 argo]#
```

这是因为默认的工作流pod是在默认的namespace也就是default下执行的，而这个namespace下名default的默认的serviceAccount不具备操作资源的权限，则我们可以给他绑定权限

```
kind: ClusterRole
apiVersion: rbac.authorization.k8s.io/v1
metadata:
  namespace: default
  name: pod-reader
rules:
- apiGroups:
  - ""
  resources:
  - configmaps
  verbs:
  - get
  - watch
  - list
- apiGroups:
  - "batch"
  resources:
  - jobs
  verbs:
  - get
  - watch
  - list
  - create
- apiGroups:
  - ""
  resources:
  - secrets
  verbs:
  - get
- apiGroups:
  - ""
  resources:
  - pods
  - pods/exec
  - pods/log
  verbs:
  - get
  - list
  - watch
  - delete
  - patch
- apiGroups:
```

```yaml
  - ""
  resources:
  - events
  verbs:
  - watch
  - create
  - patch
- apiGroups:
  - ""
  resources:
  - secrets
  - serviceaccounts
  verbs:
  - get
- apiGroups:
  - argoproj.io
  resources:
  - workflows
  - workfloweventbindings
  - workflowtemplates
  - cronworkflows
  - clusterworkflowtemplates
  verbs:
  - create
  - get
  - list
  - watch
  - update
  - patch
  - delete
---
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: pod-reader-pod
  namespace: default
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: ClusterRole
  name: pod-reader
subjects:
- kind: ServiceAccount
  name: default
  namespace: default
```

然后执行kubectl apply -f role.yaml就可以解决这个问题

我们也可以在创建工作流的yaml指定我们创建好的有权限的serviceAccount

Hello World

我们可以使用官网的例子简单的开始第一个Workflow，一个Workflow基本也是这样的构造

- **generateName**： workflow会在k8s环境内产生一个job来执行workflow(job指的是k8s中一定会

束的任务)，然后job则会产生以generateName规定的字符为前缀的pod(比如上面的例子，它会产生whalesay-abcde字样的pod)

- **entrypoint**：这里规定了一个入口，即我们的workflow会以哪一个模板作为第一个模板来启动
- **templates**：定义了templates，templates是Argo中比较重要的一块，我们的Workflow运行都基于各种template

argo-helloworld

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: whalesay-
spec:
  entrypoint: whalesay

  templates:
  - name: whalesay              # name of the template
    container:
      image: docker/whalesay
      command: [cowsay]
      args: ["hello world"]
```

以上是一个官网给出的helloworld样例。它规定了workflow会调用一个docker/whalesay的容器来印helloworld。使用以下命令可以启动这个Workflow

```
argo submit helloworld.yaml
```

就可以看到workflow的启动，登录ui也可以看到此时有workflow的执行，打印helloworld

查看执行结果

使用 argo watch <workflowName> 持续监控工作流状态

使用argo logs <workflowName> 查看日志输出

```
[root@nap-146 argo]# argo watch whalesay-45drx
Name:                whalesay-45drx
Namespace:           default
ServiceAccount:      default
Status:              Succeeded
Created:             Tue Nov 03 17:41:48 +0800 (1 minute ago)
Started:             Tue Nov 03 17:41:48 +0800 (1 minute ago)
Finished:            Tue Nov 03 17:42:19 +0800 (1 minute ago)
Duration:            31 seconds

STEP                          PODNAME         DURATION  MESSAGE
 ✔ whalesay-45drx (whalesay)  whalesay-45drx  30s
[root@nap-146 argo]# argo logs whalesay-45drx
 _____________
< hello world >
 -------------
    \
     \
      \
                    ##        .
              ## ## ##       ==
           ## ## ## ##      ===
       /""""""""""""""""___/ ===
  ~~~ {~~ ~~~~ ~~~ ~~~~ ~~ ~ /  ===- ~~~
       \______ o          __/
        \    \        __/
          \____\______/
[root@nap-146 argo]#
```

步骤操作

步骤操作包含了比较多的模块类型，它提供了各种常见的对于步骤之间的操作，基本满足了我们对于骤间操作的需求

container

这也是一个最常见的templates类型，它会创建一个容器，然后使用容器来完成我们的任务

```
- name: whalesay              # name of the template
  container:
    image: docker/whalesay
    command: [cowsay]
    args: ["hello world"]
```

script

有时我们只希望我们的模板来运行一个脚本，那么Argo提供了**Scripts**来让我们运行脚本。

Script允许我们使用**source**标签来创建一个脚本(临时文件)，然后这个临时文件的名称将会作为参数递给command来执行。

使用script，会将运行脚本的标准输出分配给输出参数result，让其他的步骤来调用

针对不同的开发着，我们可以用不同的镜像来支持不同的执行方式

```
# shell脚本
```

```
- name: gen-random-int-bash
  script:
    image: debian:9.4
    command: [bash]
    source: |                                         # Contents of the here-script
      cat /dev/urandom | od -N2 -An -i | awk -v f=1 -v r=100 '{printf "%i\n", f + r * $1 / 65536}'

# python脚本
- name: gen-random-int-python
  script:
    image: python:alpine3.6
    command: [python]
    source: |
      import random
      i = random.randint(1, 100)
      print(i)

# js脚本
- name: gen-random-int-javascript
  script:
    image: node:9.1-alpine
    command: [node]
    source: |
      var rand = Math.floor(Math.random() * 100);
      console.log(rand);
```

steps

steps规定了执行的步骤，有并行也有串行模式，它以双横杠(- -)的形式来定义串行，然后以单横杠的式来定义并行

```
- name: hello-hello-hello
  steps:
  - - name: hello1            # hello1 is run before the following steps
      template: whalesay
      arguments:
        parameters:
        - name: message
          value: "hello1"
  - - name: hello2a           # double dash => run after previous step
      template: whalesay
      arguments:
        parameters:
        - name: message
          value: "hello2a"
    - name: hello2b           # single dash => run in parallel with previous step
      template: whalesay
      arguments:
        parameters:
        - name: message
          value: "hello2b"
```

dag

DAG是一个有向无环图，Argo使用DAG来定义一些比较复杂的workflow关系

```yaml
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: dag-diamond-
spec:
  entrypoint: diamond
  templates:
  - name: echo
    inputs:
      parameters:
      - name: message
    container:
      image: alpine:3.7
      command: [echo, "{{inputs.parameters.message}}"]
  - name: diamond
    dag:
      tasks:
      - name: A
        template: echo
        arguments:
          parameters: [{name: message, value: A}]
      - name: B
        dependencies: [A]
        template: echo
        arguments:
          parameters: [{name: message, value: B}]
      - name: C
        dependencies: [A]
        template: echo
        arguments:
          parameters: [{name: message, value: C}]
      - name: D
        dependencies: [B, C]
        template: echo
        arguments:
          parameters: [{name: message, value: D}]
```

如上所示，上面的dag定义了一个钻石类型的图 A -> (B C) -> D

loop

使用loop我们可以定义循环

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: loops-
spec:
  entrypoint: loop-example
  templates:
  - name: loop-example
    steps:
    - - name: print-message
        template: whalesay
        arguments:
          parameters:
          - name: message
            value: "{{item}}"
        withItems:              # invoke whalesay once for each item in parallel
        - hello world           # item 1
        - goodbye world         # item 2

  - name: whalesay
    inputs:
      parameters:
      - name: message
    container:
      image: docker/whalesay:latest
      command: [cowsay]
      args: ["{{inputs.parameters.message}}"]
```

这个例子中，我们通过withItems传入了两个参数，然后Workflow就会并行执行这个templates两次依次使用我们给出的参数

当然我们也可以动态的使用循环，循环的参数基于其他模板来控制

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: loops-param-result-
spec:
  entrypoint: loop-param-result-example
  templates:
  - name: loop-param-result-example
    steps:
    - - name: generate
        template: gen-number-list
    # Iterate over the list of numbers generated by the generate step above
    - - name: sleep
        template: sleep-n-sec
        arguments:
          parameters:
          - name: seconds
```

```
          value: "{{item}}"
        withParam: "{{steps.generate.outputs.result}}"

  # Generate a list of numbers in JSON format
  - name: gen-number-list
    script:
      image: python:alpine3.6
      command: [python]
      source: |
        import json
        import sys
        json.dump([i for i in range(20, 31)], sys.stdout)

  - name: sleep-n-sec
    inputs:
      parameters:
      - name: seconds
    container:
      image: alpine:latest
      command: [sh, -c]
      args: ["echo sleeping for {{inputs.parameters.seconds}} seconds; sleep {{inputs.parameters.
econds}}; echo done"]
```

条件控制

条件的控制需要用到when的关键字

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: coinflip-
spec:
  entrypoint: coinflip
  templates:
  - name: coinflip
    steps:
    # flip a coin
    - - name: flip-coin
        template: flip-coin
    # evaluate the result in parallel
    - - name: heads
        template: heads                 # call heads template if "heads"
        when: "{{steps.flip-coin.outputs.result}} == heads"
      - name: tails
        template: tails                 # call tails template if "tails"
        when: "{{steps.flip-coin.outputs.result}} == tails"

  # Return heads or tails based on a random number
  - name: flip-coin
    script:
      image: python:alpine3.6
      command: [python]
      source: |
        import random
```

```
        result = "heads" if random.randint(0,1) == 0 else "tails"
        print(result)

  - name: heads
    container:
      image: alpine:3.6
      command: [sh, -c]
      args: ["echo \"it was heads\""]

  - name: tails
    container:
      image: alpine:3.6
      command: [sh, -c]
      args: ["echo \"it was tails\""]
```

在这个例子中，Workflow通过when来判断第一步获取的值是head还是tails，根据获取的值来条件断下一步会执行的步骤

重试

重试模块会定义如果Job执行出现failures或errors时的情况，

- limit:指重试的最大次数
- retryOn:指定重启策略
  - Always: errors 和 failures时重启
  - OnFailure: failures时重启，默认采用
  - OnError： error时重启
- backoff:定义重启的一些参数

```
# This example demonstrates the use of retry back offs
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: retry-backoff-
spec:
  entrypoint: retry-backoff
  templates:
  - name: retry-backoff
    retryStrategy:
      limit: 10
      retryPolicy: "Always"
      backoff:
        duration: "1"      # Must be a string. Default unit is seconds. Could also be a Duration, e.g.
 "2m", "6h", "1d"
        factor: 2
        maxDuration: "1m"  # Must be a string. Default unit is seconds. Could also be a Duration,
e.g.: "2m", "6h", "1d"
    container:
      image: python:alpine3.6
      command: ["python", -c]
      # fail with a 66% probability
```

```
      args: ["import random; import sys; exit_code = random.choice([0, 1, 1]); sys.exit(exit_code)
]
```

以上的例子定义了一个会重启的任务

```
Name:                retry-backoff-5dmfc
Namespace:           default
ServiceAccount:      default
Status:              Failed
Message:             Max duration limit exceeded
Created:             Wed Nov 04 16:03:49 +0800 (1 minute ago)
Started:             Wed Nov 04 16:03:49 +0800 (1 minute ago)
Finished:            Wed Nov 04 16:04:51 +0800 (1 second ago)
Duration:            1 minute 2 seconds

STEP                                              PODNAME                          DURATION  MESSAGE
 ✖ retry-backoff-5dmfc (retry-backoff)                                                        Max duration limit exceeded
 ├-✖ retry-backoff-5dmfc(0) (retry-backoff)  retry-backoff-5dmfc-3561301773  4s        failed with exit code 1
 ├-✖ retry-backoff-5dmfc(1) (retry-backoff)  retry-backoff-5dmfc-675801568   4s        failed with exit code 1
 ├-✖ retry-backoff-5dmfc(2) (retry-backoff)  retry-backoff-5dmfc-3359676155  4s        failed with exit code 1
 ├-✖ retry-backoff-5dmfc(3) (retry-backoff)  retry-backoff-5dmfc-2890049918  4s        failed with exit code 1
 └-✖ retry-backoff-5dmfc(4) (retry-backoff)  retry-backoff-5dmfc-2890888561  6s        failed with exit code 1
[root@nap-146 argo]#
```

递归

argo 也是支持递归的,我们只要将步骤的下一步指定为本步骤即可

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: coinflip-recursive-
spec:
  entrypoint: coinflip
  templates:
  - name: coinflip
    steps:
    # flip a coin
    - - name: flip-coin
        template: flip-coin
    # evaluate the result in parallel
    - - name: heads
        template: heads                 # call heads template if "heads"
        when: "{{steps.flip-coin.outputs.result}} == heads"
      - name: tails                     # keep flipping coins if "tails"
        template: coinflip
        when: "{{steps.flip-coin.outputs.result}} == tails"

  - name: flip-coin
    script:
      image: python:alpine3.6
      command: [python]
      source: |
        import random
        result = "heads" if random.randint(0,1) == 0 else "tails"
        print(result)

  - name: heads
    container:
```

```
    image: alpine:3.6
    command: [sh, -c]
    args: ["echo \"it was heads\""]
```

在以上的步骤中，step执行会做一个判断，如果一直是反面，会递归执行直到为正面

```
Name:                coinflip-recursive-sqxgh
Namespace:           default
ServiceAccount:      default
Status:              Succeeded
Created:             Wed Nov 04 16:09:07 +0800 (52 seconds ago)
Started:             Wed Nov 04 16:09:07 +0800 (52 seconds ago)
Finished:            Wed Nov 04 16:09:59 +0800 (now)
Duration:            52 seconds

STEP                                                 PODNAME                                 DURATION  MESSAGE
 ✔ coinflip-recursive-sqxgh (coinflip)
 ├---✔ flip-coin (flip-coin)                         coinflip-recursive-sqxgh-2806503635     7s
 ├---○ heads (heads)                                                                                   when 'tails == heads' evaluated false
 └-✔ tails (coinflip)
   ├---✔ flip-coin (flip-coin)                       coinflip-recursive-sqxgh-173262645      6s
   ├---○ heads (heads)                                                                                 when 'tails == heads' evaluated false
   └-✔ tails (coinflip)
     ├---✔ flip-coin (flip-coin)                     coinflip-recursive-sqxgh-2320567327     6s
     ├---○ heads (heads)                                                                               when 'tails == heads' evaluated false
     └-✔ tails (coinflip)
       ├---✔ flip-coin (flip-coin)                   coinflip-recursive-sqxgh-594497401      5s
       ├---○ heads (heads)                                                                             when 'tails == heads' evaluated false
       └-✔ tails (coinflip)
         ├---✔ flip-coin (flip-coin)                 coinflip-recursive-sqxgh-3099621723     5s
         ├---○ heads (heads)                                                                           when 'tails == heads' evaluated false
         └-✔ tails (coinflip)
           ├---✔ flip-coin (flip-coin)               coinflip-recursive-sqxgh-2691537501     6s
           ├---✔ heads (heads)                       coinflip-recursive-sqxgh-248941824      6s
           └-○ tails (coinflip)                                                                        when 'heads == tails' evaluated false
[root@nap-146 argo]#
```

Exit handlers

Argo可以定义一个出口，它会直接退出工作流，无论成功与否。

常见于:

- 工作流运行后清理
- 发送工作流状态的通知（例如，电子邮件/ Slack）
- 将通过/失败状态发布到webhook结果（例如GitHub构建结果）
- 重新提交或提交另一个工作流程

```
spec:
  entrypoint: intentional-fail
  onExit: exit-handler                  # invoke exit-hander template at end of the workflow
  templates:
  - name: exit-handler
    steps:
    - - name: notify
        template: send-email
      - name: celebrate
        template: celebrate
        when: "{{workflow.status}} == Succeeded"
      - name: cry
        template: cry
        when: "{{workflow.status}} != Succeeded"
```

在这里使用Onexit参数指定了结束模板，则执行exit-handler这个模板时，无论是否成功，都会直接束

timeout

Argo定义了一个超时的限定，如果容器超时了，则直接结束Job

```
- name: sleep
  container:
    image: alpine:latest
    command: [sh, -c]
    args: ["echo sleeping for 1m; sleep 60; echo done"]
  activeDeadlineSeconds: 10
```

suspending

```
- name: approve
  suspend: {}

- name: delay
  suspend:
    duration: 20
```

如果我们使用了duration关键字，它会等待20秒后才唤醒执行

```
argo resume WORKFLOW    # 这里的Workflow是指workflow的pod容器名
```

参数操作

参数传递对于工作流也是一个比较关键的问题。对于工作流来说，不同tempaltes之间的传递，是通过jnja来定义。目前Argo只接受以下几种前缀

- item
- steps
- inputs
- outputs
- workflow
- tasks

parameters

通常的参数传递是通过parameters关键字来定义的

```
- name: whalesay
  inputs:
    parameters:
    - name: message       # parameter declaration
  container:
    # run cowsay with that message input parameter as args
    image: docker/whalesay
    command: [cowsay]
    args: ["{{inputs.parameters.message}}"]
```

arguments

我们可以通过arguments关键字来定义一个全局参数

```
entrypoint: whalesay
arguments:
  parameters:
  - name: message
    value: hello world
  - name: os-list                                      # a list of items
    value: |
      [
        { "image": "debian", "tag": "9.1" },
        { "image": "debian", "tag": "8.9" },
        { "image": "alpine", "tag": "3.6" },
        { "image": "ubuntu", "tag": "17.10" }
      ]
```

在启动任务时，我们可以通过-p的参数来做实际参数，如果没有指定，则会使用默认参数（argumen
中定义）

```
argo submit arguments.yaml -p messgae="helloworld" -p oslist=[{ "image": "ubuntu", "tag": "
7.10" }]
```

step间的传参

对于step间的传参，是通过step关键字来定义的

```
- name: test
  steps:
  - - name: A
      template: A
  - - name: B
      template: B
      when: "\"{{steps.A.outputs.result}}\" == \"B\""
    - name: C
      template: C
      when: "\"{{steps.A.outputs.result}}\" == \"C\""
```

在以上例子中，定义了一个step，它会首先执行A步骤，然后根据启动结果，如果输出是B，则执行B
骤，否则执行C步骤

dag间的传参

对于Dag，其实它与step是十分相似的

```
dag:
  tasks:
  - name: ip
    template: param
    arguments:
      parameters: [{name: request, value: "ip"}, {name: ip, value: "{{inputs.parameters.ip}}"}]
  - name: port
```

```
    template: param
    arguments:
      parameters: [{name: request, value: "port"}, {name: ip, value: "{{inputs.parameters.ip}}"}]
  - name: username
    template: param
    arguments:
      parameters: [{name: request, value: "username"}, {name: ip, value: "{{inputs.parameters.ip}}
}]
  - name: password
    template: param
    arguments:
      parameters: [{name: request, value: "password"}, {name: ip, value: "{{inputs.parameters.ip}}
}]
  - name: server
    template: server
    dependencies: [ip, port, username, password]
    arguments:
      parameters:
      - name: ip
        value: "{{tasks.ip.outputs.result}}"
      - name: password
        value: "{{tasks.password.outputs.result}}"
      - name: username
        value: "{{tasks.username.outputs.result}}"
      - name: port
        value: "{{tasks.port.outputs.result}}"
```

在上面的例子中，dag并行执行(ip, port, username, password)四个步骤，然后将执行的结果传递给s rver模块，然后server模块会以这四个参数来完成工作。

script result

当我们运行一个script时，运行的标准输出会以result的方式来传递

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: scripts-bash-
spec:
  entrypoint: bash-script-example
  templates:
  - name: bash-script-example
    steps:
    - - name: generate
        template: gen-random-int-bash
    - - name: print
        template: print-message
        arguments:
          parameters:
          - name: message
            value: "{{steps.generate.outputs.result}}"  # The result of the here-script

  - name: gen-random-int-bash
    script:
```

```
      image: debian:9.4
      command: [bash]
      source: |                                         # Contents of the here-script
        cat /dev/urandom | od -N2 -An -i | awk -v f=1 -v r=100 '{printf "%i\n", f + r * $1 / 65536}'

  - name: gen-random-int-python
    script:
      image: python:alpine3.6
      command: [python]
      source: |
        import random
        i = random.randint(1, 100)
        print(i)

  - name: gen-random-int-javascript
    script:
      image: node:9.1-alpine
      command: [node]
      source: |
        var rand = Math.floor(Math.random() * 100);
        console.log(rand);

  - name: print-message
    inputs:
      parameters:
      - name: message
    container:
      image: alpine:latest
      command: [sh, -c]
      args: ["echo result was: {{inputs.parameters.message}}"]
```

比如上面的例子，generate这个模块执行完成之后，print模块会获取generate模块的输出结果作为数来执行

```
Name:                scripts-bash-k9dzx
Namespace:           default
ServiceAccount:      default
Status:              Succeeded
Created:             Wed Nov 04 16:56:43 +0800 (52 seconds ago)
Started:             Wed Nov 04 16:56:43 +0800 (52 seconds ago)
Finished:            Wed Nov 04 16:57:35 +0800 (now)
Duration:            52 seconds

STEP                                          PODNAME                         DURATION  MESSAGE
 ✔ scripts-bash-k9dzx (bash-script-example)
 ├---✔ generate (gen-random-int-bash)         scripts-bash-k9dzx-2604563108   29s
 └---✔ print (print-message)                  scripts-bash-k9dzx-3203141995   19s
[root@nap-146 argo]# argo logs scripts-bash-k9dzx-2604563108
47
[root@nap-146 argo]# argo logs scripts-bash-k9dzx-3203141995
result was: 47
[root@nap-146 argo]#
```

output Parameters

我们可以使用步骤的输出作为参数传递

```
apiVersion: argoproj.io/v1alpha1
```

```
kind: Workflow
metadata:
  generateName: output-parameter-
spec:
  entrypoint: output-parameter
  templates:
  - name: output-parameter
    steps:
    - - name: generate-parameter
        template: whalesay
    - - name: consume-parameter
        template: print-message
        arguments:
          parameters:
          # Pass the hello-param output from the generate-parameter step as the message input
o print-message
          - name: message
            value: "{{steps.generate-parameter.outputs.parameters.hello-param}}"

  - name: whalesay
    container:
      image: docker/whalesay:latest
      command: [sh, -c]
      args: ["echo -n hello world > /tmp/hello_world.txt"]  # generate the content of hello_world
txt
    outputs:
      parameters:
      - name: hello-param       # name of output parameter
        valueFrom:
          path: /tmp/hello_world.txt    # set the value of hello-param to the contents of this hello
world.txt

  - name: print-message
    inputs:
      parameters:
      - name: message
    container:
      image: docker/whalesay:latest
      command: [cowsay]
      args: ["{{inputs.parameters.message}}"]
```

在上面的例子中，whalesay模块会将执行结果打印到hello-world.txt文本，然后将这个文本的内容定输出结果然后consume-parameter模块会去获取whalesay模块的输出结果做为输入参数

资源操作

Argo可以操作的资源也有很多，它不仅仅是能操作容器，kubernetes的资源、容器资源、计算资源也均可调配

Secret

```
volumes:
  - name: my-secret-vol
```

```
    secret:
      secretName: my-secret     # name of an existing k8s secret
templates:
  - name: whalesay
    container:
      image: alpine:3.7
      command: [sh, -c]
      args: ['
        echo "secret from env: $MYSECRETPASSWORD";
        echo "secret from file: `cat /secret/mountpath/mypassword`"
      ']
      env:
      - name: MYSECRETPASSWORD  # name of env var
        valueFrom:
          secretKeyRef:
            name: my-secret     # name of an existing k8s secret
            key: mypassword     # 'key' subcomponent of the secret
      volumeMounts:
      - name: my-secret-vol     # mount file containing secret at /secret/mountpath
        mountPath: "/secret/mountpath"
```

在这里，我们使用了Secret作为一个volume供模板调用

daemon

使用守护进程可以使得作业在后台运行，他们的存在使得有的工作可以跨工作流运行

```
- name: influxdb
  daemon: true                        # start influxdb as a daemon
  retryStrategy:
    limit: 10                      # retry container if it fails
  container:
    image: influxdb:1.2
    readinessProbe:                   # wait for readinessProbe to succeed
      httpGet:
        path: /ping
        port: 8086
```

在这里使用了daemon: true来开启daemon，以保护influxdb持续运行

sidecar

边车模式，指著容器在同一容器中同时执行另一个容器来支持主容器的工作。Argo也支持边车模式，以启动一个辅助容器来协助作业的进行

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: sidecar-nginx-
spec:
  entrypoint: sidecar-nginx-example
  templates:
  - name: sidecar-nginx-example
```

```
    container:
      image: appropriate/curl
      command: [sh, -c]
      # Try to read from nginx web server until it comes up
      args: ["until `curl -G 'http://127.0.0.1/' >& /tmp/out`; do echo sleep && sleep 1; done && 
at /tmp/out"]
    # Create a simple nginx web server
    sidecars:
    - name: nginx
      image: nginx:1.13
```

```
sleep
sleep
sleep
sleep
sleep
sleep
sleep
sleep
sleep
sleep
sleep
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
  0     0    0     0    0     0      0      0 --:--:-- --:--:-- --:--:--     0<!DOCTYPE html
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>
<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>
<p><em>Thank you for using nginx.</em></p>
</body>
</html>
100   612  100   612    0     0   597k      0 --:--:-- --:--:-- --:--:--  597k
```

Artifacts

在Argo中也有集成一些比较常用的库，比如http和git

```
templates:
- name: hardwired-artifact
  inputs:
    artifacts:
    # Check out the master branch of the argo repo and place it at /src
    # revision can be anything that git checkout accepts: branch, commit, tag, etc.
    - name: argo-source
```

```
      path: /src
      git:
        repo: https://github.com/argoproj/argo.git
        revision: "master"
    # Download kubectl 1.8.0 and place it at /bin/kubectl
    - name: kubectl
      path: /bin/kubectl
      mode: 0755
      http:
        url: https://storage.googleapis.com/kubernetes-release/release/v1.8.0/bin/linux/amd64/
ubectl
```

Resource

Argo可以操作k8s资源 创建一个job

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: k8s-jobs-
spec:
  entrypoint: pi-tmpl
  templates:
  - name: pi-tmpl
    resource:                   # indicates that this is a resource template
      action: create            # can be any kubectl action (e.g. create, delete, apply, patch)
      successCondition: status.succeeded > 0
      failureCondition: status.failed > 3
      manifest: |               #put your kubernetes spec here
        apiVersion: batch/v1
        kind: Job
        metadata:
          generateName: pi-job-
        spec:
          template:
            metadata:
              name: pi
            spec:
              containers:
              - name: pi
                image: perl
                command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
              restartPolicy: Never
          backoffLimit: 4
```

可以使用以下Argo Workflow修改此Crontab：

```
apiVersion: "stable.example.com/v1"
kind: CronTab
spec:
  cronSpec: "* * * * */5"
  image: my-awesome-cron-image

apiVersion: argoproj.io/v1alpha1
```

```
kind: Workflow
metadata:
  generateName: k8s-patch-
spec:
  entrypoint: cront-tmpl
  templates:
  - name: cront-tmpl
    resource:
      action: patch
      mergeStrategy: merge                 # Must be one of [strategic merge json]
      manifest: |
        apiVersion: "stable.example.com/v1"
        kind: CronTab
        spec:
          cronSpec: "* * * * */10"
          image: my-awesome-cron-image
```

docker

Argo实现了Docker in Docker的形式

```
- name: dind-sidecar-example
  container:
    image: docker:17.10
    command: [sh, -c]
    args: ["until docker ps; do sleep 3; done; docker run --rm debian:latest cat /etc/os-release"]
    env:
    - name: DOCKER_HOST               # the docker daemon can be access on the standard port
n localhost
      value: 127.0.0.1
  sidecars:
  - name: dind
    image: docker:17.10-dind          # Docker already provides an image for running a Docker d
emon
    securityContext:
      privileged: true                # the Docker daemon can only run in a privileged container
    # mirrorVolumeMounts will mount the same volumes specified in the main container
    # to the sidecar (including artifacts), at the same mountPaths. This enables
    # dind daemon to (partially) see the same filesystem as the main container in
    # order to use features such as docker volume binding.
    mirrorVolumeMounts: true
```

以上工作流实现了主容器运行等待容器创建，边车容器启动一个容器并将这个容器镜像交给主容器资源

volumes

在Argo中，我们也可以直接传递容器卷，方便处理大量数据

```
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: volumes-pvc-
spec:
```

```
  entrypoint: volumes-pvc-example
  volumeClaimTemplates:                # define volume, same syntax as k8s Pod spec
  - metadata:
      name: workdir                    # name of volume claim
    spec:
      accessModes: [ "ReadWriteOnce" ]
      resources:
        requests:
          storage: 1Gi                 # Gi => 1024 * 1024 * 1024

  templates:
  - name: volumes-pvc-example
    steps:
    - - name: generate
        template: whalesay
    - - name: print
        template: print-message

  - name: whalesay
    container:
      image: docker/whalesay:latest
      command: [sh, -c]
      args: ["echo generating message in volume; cowsay hello world | tee /mnt/vol/hello_world
txt"]
      # Mount workdir volume at /mnt/vol before invoking docker/whalesay
      volumeMounts:                    # same syntax as k8s Pod spec
      - name: workdir
        mountPath: /mnt/vol

  - name: print-message
    container:
      image: alpine:latest
      command: [sh, -c]
      args: ["echo getting message from volume; find /mnt/vol; cat /mnt/vol/hello_world.txt"]
      # Mount workdir volume at /mnt/vol before invoking docker/whalesay
      volumeMounts:                    # same syntax as k8s Pod spec
      - name: workdir
        mountPath: /mnt/vol
```

在上面的例子中，workflow初始化了一个容器卷，然后下面的whalesay和print-message模块都调了这个容器卷

不过大多数情况下，我们会去调用一个已存在的卷

```
# Define Kubernetes PVC
kind: PersistentVolumeClaim
apiVersion: v1
metadata:
  name: my-existing-volume
spec:
  accessModes: [ "ReadWriteOnce" ]
  resources:
    requests:
      storage: 1Gi
```

```
---
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: volumes-existing-
spec:
  entrypoint: volumes-existing-example
  volumes:
  # Pass my-existing-volume as an argument to the volumes-existing-example template
  # Same syntax as k8s Pod spec
  - name: workdir
    persistentVolumeClaim:
      claimName: my-existing-volume

  templates:
  - name: volumes-existing-example
    steps:
    - - name: generate
        template: whalesay
    - - name: print
        template: print-message

  - name: whalesay
    container:
      image: docker/whalesay:latest
      command: [sh, -c]
      args: ["echo generating message in volume; cowsay hello world | tee /mnt/vol/hello_world
txt"]
      volumeMounts:
      - name: workdir
        mountPath: /mnt/vol

  - name: print-message
    container:
      image: alpine:latest
      command: [sh, -c]
      args: ["echo getting message from volume; find /mnt/vol; cat /mnt/vol/hello_world.txt"]
      volumeMounts:
      - name: workdir
        mountPath: /mnt/vol
```

在上面的例子中，我们外部已经定义了一个pvc，然后在workflow中,我们通过声明一个pvc为卷来调它

总结

argo是一个云原生的基于k8s的工作流引擎，如果基础环境是k8s的话，不管是ci/cd 还是其他工作流途，argo都是非常好的选择，上手非常简单，使用yaml作为模板语法 与k8s几乎一模一样。