Kubernetes in the Cloud (Part 3): (Almost) Everything You Need to Know about Stateful Workloads

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SNIA-At-A-Glance

185 industry leading organizations

2,000 active contributing members

50,000 IT end users & storage pros worldwide

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What We Do

- **Educate** vendors and users on cloud storage, data services and orchestration
- **Support & promote** business models and architectures: OpenStack, Software Defined Storage, Kubernetes, Object Storage
- **Understand** Hyperscaler requirements. Incorporate them into standards and programs
- **Collaborate** with other industry associations
Kubernetes in the Cloud Series

• Kubernetes in the Cloud (Part 1)
  • What is Kubernetes? Why would you want to use it?
  • How does Kubernetes help in a multi-cloud/private cloud environment?
  • How does Kubernetes orchestrate & manage storage? Can Kubernetes use Docker?
  • How do we provide persistence and data protection?
  • On demand at: http://bit.ly/KubeCloud1

• Kubernetes in the Cloud (Part 2)
  • Persistent storage and how to specify it
  • Ensuring application portability between Private and Public Clouds
  • Building a self-service infrastructure (Helm, Operators)
  • Selecting Block, File, Object (Traditional Storage, SDS)
Agenda

• Kubernetes is a Platform for mostly stateless work
• Why stateful work is challenging
  • The lifecycle is more complicated
  • Container's learning curve + tools
  • Security is paramount
• 5 Ways to run Stateful work on Kubernetes
• Questions
• Links & Resources
“Kubernetes is becoming the Linux of the cloud”

- Jim Zemlin, Executive Director at the Linux Foundation
Dockerizing MySQL at Uber Engineering

Joakim Recht
Kelsey Hightower 🔄
@kelseyhightower

Kubernetes has made huge improvements in the ability to run stateful workloads including databases and message queues, but I still prefer not to run them on Kubernetes.

9:04 AM · Feb 13, 2018 · Twitter Web Client
Secrets Management

How to commit code without leaking
Risks

- In the API server secret data is stored in etcd; therefore:
  - Administrators should enable encryption at rest for cluster data (requires v1.13 or later)
  - Administrators should limit access to etcd to admin users
  - Administrators may want to wipe/shred disks used by etcd when no longer in use
  - If running etcd in a cluster, administrators should make sure to use SSL/TLS for etcd peer-to-peer communication.
- If you configure the secret through a manifest (JSON or YAML) file which has the secret data encoded as base64, sharing this file or checking it in to a source repository means the secret is compromised. Base64
Encrypt secrets at rest,
Use RBAC,
and other best practices...
Use proven tools
Kubernetes External Secrets

- kubernetes
- secret-management
- secrets-management
- aws
- aws-secrets-manager

- 92 commits
- 8 branches
- 7 releases
- 12 contributors

Branch: master

- Flydiverny and jeffpearce feat: allow setting type in external secret to support other than Opa...
- bin
  - refactor: use watch api and instant poll new or modified secrets (#107)
- charts/kubernetes-external-secrets
  - chore: remove events interval milliseconds references (#129)
- config
  - refactor: use watch api and instant poll new or modified secrets (#107)
- examples
  - feat: allow setting type in external secret to support other than Opa...
Learn about secrets management and data protection with HashiCorp Vault
Getting Started

Vault secures, stores, and tightly controls access to tokens, passwords, certificates, API keys, and other secrets in modern computing. Get started here.

- **Install Vault** →
  2 MIN | The first step to using Vault is to get it installed.

- **Starting the Server** →
  5 MIN | After installing Vault, the next step is to start the server.

- **Your First Secret** →
  5 MIN | With the Vault server running, let's read and write our first secret.

- **Secrets Engines** →
  5 MIN | Secrets engines create, read, update, and delete secrets.
Getting Started With CRI-O and Kubeadm
Learn how to deploy a CRI-O based Kubeadm cluster

Running Stateful Services on Kubernetes
Learn how to run stateful services on Kubernetes

Use Kubernetes To Manage Secrets And Passwords
Learn how Kubernetes can help keep secrets secure

Deploy Docker Compose Files with Kompose
Learn how to use Kompose to deploy existing Docker Compose definitions
Operating Kubernetes Clusters and Applications Safely

Download this eBook published by O'Reilly Media

Written by Liz Rice from Aqua Security and Michael Hausenblas from Red Hat

Kubernetes has fundamentally changed the way DevOps teams create, manage, and operate container-based applications. In this eBook, you will learn how to:

- Secure your Kubernetes clusters and applications
- Implement best practices for security in Kubernetes
- Understand the latest security trends in the Kubernetes community

Get the O'Reilly Media Book
DB on a VM
The best option, for most
Running a DB on a VM just needs some knowledge of ...

○ Services
Editor's note: Today is the sixth installment in a seven-part video and blog series from Google Developer Advocate Sandeep Dinesh on how to get the most out of your Kubernetes environment.

If you're like most Kubernetes users, chances are you use services that live outside your cluster. For example, maybe you use the Twilio API to send text messages, or maybe the Google Cloud Vision API to do image analysis.

If your applications in your different environments connect to the same external endpoint, and have no plans to bring the external service into your Kubernetes cluster, it is perfectly fine to use the external service endpoint directly in your code. However, there are many scenarios where this is not the case.
kind: Service
apiVersion: v1
metadata:
  name: mongo
spec:
  type: ExternalName
  externalName: ds149763.mlab.com
kind: Service
apiVersion: v1
metadata:
  name: mongo
spec:
  type: ClusterIP
  ports:
    - port: 27017
      targetPort: 27017

---

kind: Endpoints
apiVersion: v1
metadata:
  name: mongo
subsets:
  - addresses:
        - ip: 10.240.0.4
          ports:
            - port: 27017
That’s it! Super easy, and all of your old automation, monitoring, etc still work
DB in k8s via StatefulSet

Warning: can be problematic
StatefulSets need some knowledge of...

- Init Containers
- Persistent Volumes (PV)
- PV Claims (PVC)
- Storage Classes
- Services
- Pods
- ConfigMaps
StatefulSets need some knowledge of...

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- Persistent Volumes (PV)
- PV Claims (PVC)
- Storage Classes
- Services
- Pods
- ConfigMaps

Complexity!
Kubernetes Storage Terminology

Storage Class
To achieve dynamic volume creation, the admin must define a k8s StorageClass (e.g.: gold, silver).

Provision a volume
1. The user creates a claim for volume (PVC).
2. The "Provisioner" (vendor specific) listens to new PVC requests, and dynamically creates the volume on the storage system (if no PV already matched)
   - The PV is created with "Driver" setting. The Driver(vendor specific) handles the volume attach/detach to the node.

Create a stateful POD
1. The user creates a POD with the new PVC.
2. K8s triggers the "Driver" in order to attach the PV to the node.
3. The volume is now mapped and mounted to the node.
4. k8s starts the POD with the PV mounted to /data inside the container.

✅ The stateful container is UP

https://kubernetes.io/docs/concepts/storage/volumes/
Run a Single-Instance Stateful Application

This page shows you how to run a single-instance stateful application in Kubernetes using a PersistentVolume and a Deployment. The application is MySQL.

- Objectives
- Before you begin
- Deploy MySQL
- Accessing the MySQL instance
- Updating
- Deleting a deployment
Be sure you’re thinking about Day 2 operations, not just the installation
Storing backups

Restoring from backup

Be sure you’re thinking about Day 2 operations, not just the installation

Deleting the stateful app (and reclaiming resources)

Upgrading the stateful app

Scaling the stateful app
You absolutely need **failover** and **replication**; containers fail for all sorts of silly reasons
DB in k8s via Operator

Introduces complexity, but sometimes worth it
“Application specific operational knowledge captured in software”
More specifically, an Operator is just:

**CRDs + automation**
More specifically, an Operator is just:

**C}RD}S + automation**

A native Kubernetes object, that gives you the power to customize the behavior of Kubernetes.
How can you create an Operator?

Operators, by their nature, are application-specific, so the hard work is going to be encoding all of the application operational domain knowledge into a reasonable configuration resource and control loop. There are some common patterns that we have found while building operators that we think are important for any application:

1. Operators should install as a single deployment e.g.

   ```bash
   kubectl create -f https://coreos.com/operators/etcd/latest/deployment.yaml
   ```
   and take no additional action once installed.

2. Operators should create a new third party type when installed into Kubernetes. A user will create new application instance using this type.

3. Operators should leverage built-in Kubernetes primitives like Services and Replica Sets when possible to leverage well-tested and well-understood code.

4. Operators should be backwards compatible and always understand previous versions of resources a user has created.

5. Operators should be designed so application instances continue to run unaffected if the Operator is stopped or removed.

6. Operators should give users the ability to declare a desired version and orchestrate application upgrades based on the desired version. Not upgrading software is a common source of operational bugs and security issues and Operators can help users more confidently address this burden.

7. Operators should be tested against a "Chaos Monkey" test suite that simulates potential failures of Pods, configuration, and networking.
An example of a complex application being started

```
etcd --name infra1 --listen-client-urls http://127.0.0.1:2379 \
--advertise-client-urls http://127.0.0.1:2379 --listen-peer-urls http://127.0.0.1:12380 \
--initial-advertise-peer-urls http://127.0.0.1:12380 --initial-cluster-token etcd-cluster-1 \
--initial-cluster
'infra1=http://127.0.0.1:12380,infra2=http://127.0.0.1:22380,infra3=http://127.0.0.1:32380' \
--initial-cluster-state new --enable-pprof
```
An example

Version Compatibility

You must run `cbbackupmgr` from a Couchbase Server installation with the same major and minor version as the host cluster. For example, to back up data from (or restore data to) a cluster running Couchbase Server 5.5, you must run `cbbackupmgr` from a Couchbase Server 5.5 node.
So, why not use an operator for everything?
The OperatorHub is a marketplace. Operators there should package everything you need.
Operator Framework

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

 Repositories: 24
 People: 16

Pinned repositories

- **operator-sdk**
  SDK for building Kubernetes applications. Provides high level APIs, useful abstractions, and project scaffolding.
  - Go: 1.9k
  - 434

- **operator-lifecycle-manager**
  A management framework for extending Kubernetes with Operators
  - Go: 339
  - 143

- **operator-metering**
  Operator metering is responsible for collecting metrics and other information about what's happening in a Kubernetes cluster, and providing a way to create reports on the collected data.
  - Go: 166
  - 37
Are Operators owned by Red Hat?

No, they’re open source.
Should I use a configMap or a custom resource?

Use a ConfigMap if any of the following apply:

- There is an existing, well-documented config file format, such as a `mysql.cnf` or `pom.xml`.
- You want to put the entire config file into one key of a configMap.
- The main use of the config file is for a program running in a Pod on your cluster to consume the file to configure itself.
DB via cloud managed service

Leverage and expose managed services
AWS Service Operator for Kubernetes Now Available

The AWS Service Operator is an open source project in developer preview which allows you to manage your AWS resources directly from Kubernetes using the standard Kubernetes CLI, `kubectl`. It does so by modeling AWS Services as Custom Resource Definitions (CRDs) in Kubernetes and applying those definitions to your cluster. This means that a developer can model their entire application architecture from container to ingress to AWS services, backing it from a single YAML manifest. We anticipate that the AWS Service Operator will help reduce the time it takes to create new applications, and assist in keeping applications in the desired state.

Have you ever tried to integrate Amazon DynamoDB with an application running in Kubernetes? How about deploying an SQS bucket for a needs list? If so, chances are you will have this need now integrated in your current AWS setup. With AWS Service Operator, you can deploy and manage AWS services directly from Kubernetes, simplifying your deployment process.
AWS Service Operator allows you to create AWS resources using kubectl.
apiVersion: service-operator.aws/v1alpha1
kind: DynamoDB
metadata:
  name: example-table-name
spec:
  hashAttribute:
    name: user_id
    type: S
  rangeAttribute:
    name: created_at
    type: S
  readCapacityUnits: 5
  writeCapacityUnits: 5
Config Connector overview

Contents
Introduction
How Config Connector works

Beta

This product or feature is in a pre-release state and might change or have limited support. For more information, see Product launch stages.

Config Connector is a Kubernetes addon that allows you to manage your Google Cloud Platform (GCP) resources through Kubernetes configuration.

Introduction
Operators make it easy to procure cloud resources, just like any other k8s resource
DB via Service Broker / Catalog

He's dead, Jim (Caution! Achtung!)
Service Catalog lets you provision cloud services directly from the comfort of native Kubernetes tooling. This project is in incubation to bring integration with service brokers to the Kubernetes ecosystem via the Open Service Broker API.

Documentation

Our goal is to have extensive use-case and functional documentation.

See the Service Catalog documentation on the main Kubernetes site, and svc-cat.io.

For details on broker servers that are compatible with this software, see the Open Service Broker API project's Getting Started guide.

Video links

- Service Catalog Intro
Project Status

We are currently working toward a beta-quality release to be used in conjunction with Kubernetes 1.9. See the milestones list for information about the issues and PRs in current and future milestones.
Operators accomplish the same thing, but they're easier.
In conclusion
Storage

- We have **not** used the word "Storage" much
- A lot of our techniques are based on ideas from parts 1 & 2
- Data must be stored somewhere
- Persistent Volumes (PV), PVCs, and other concepts are hidden here, but they are an important part of everything covered today
Kubernetes Storage Terminology

**Persistent Volume Claim (PVC)**
- Name = mongo
- Size = 10
- Storage Class = gold
- Access mode = R/Wonce

**StorageClass**
- Name = gold
- Capabilities = <flash, compression, dedup, thin, mirroring>
- Provisioner = <name>

**Persistent Volume (PV)**
- Name = PVC-ID
- Driver = <name>

**Node Pod**
- Container
  - PVC = mongo
  - Mountpoint = /vol/mountpoint

---

**Storage Class**
To achieve dynamic volume creation, the admin must define a k8s **StorageClass** (e.g.: gold, silver).

**Provision a volume**
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✔ The stateful container is UP
Summary

Security is paramount

- There are a lot of wonderful online resource
- Read best practices on Kubernetes.io docs
- Use HashiCorp Vault or your cloud's KMS for secret
- Learn about Kubernetes and Security from:
  - KataCoda in-browser tutorials
  - The past SNIA webcasts in this series
- Buy or exchange your info for the Kubernetes Security book
Five ways to run *Stateful* workloads on Kubernetes

1. on VM (*easier*)
2. on k8s via StatefulSet (*harder*)
3. on k8s via Operator (*harder*)
4. via Cloud Managed Service (*easier*)
5. via Service Broker (*harder*)
Summary

Five ways to run *Stateful* workloads on Kubernetes

1. on VM (*easier*)
2. on k8s via StatefulSet (*harder*)
3. on k8s via Operator (*harder*)
4. via Cloud Managed Service (*easier*)
5. via Service Broker (*harder*)
Kelsey's guide to running traditional databases on Kubernetes. Strongly consider using a managed service.
Resources & Links, Part 1

1. https://twitter.com/kubernetesio/status/840257886202683392
2. https://www.youtube.com/watch?v=4x1r3Osu1Kg
2. https://kubernetes.io/docs/concepts/extend-kubernetes/api-extension/custom-resources/
7. https://operatorhub.io
9. https://kubernetes.io/docs/concepts/extend-kubernetes/api-extension/custom-resources/#should-i-use-a-configmap-or-a-custom-resource
12. https://cloud.google.com/config-connector/docs/overview

Find all these links in our blog at: http://bit.ly/KubeLinks
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Questions
Thank You