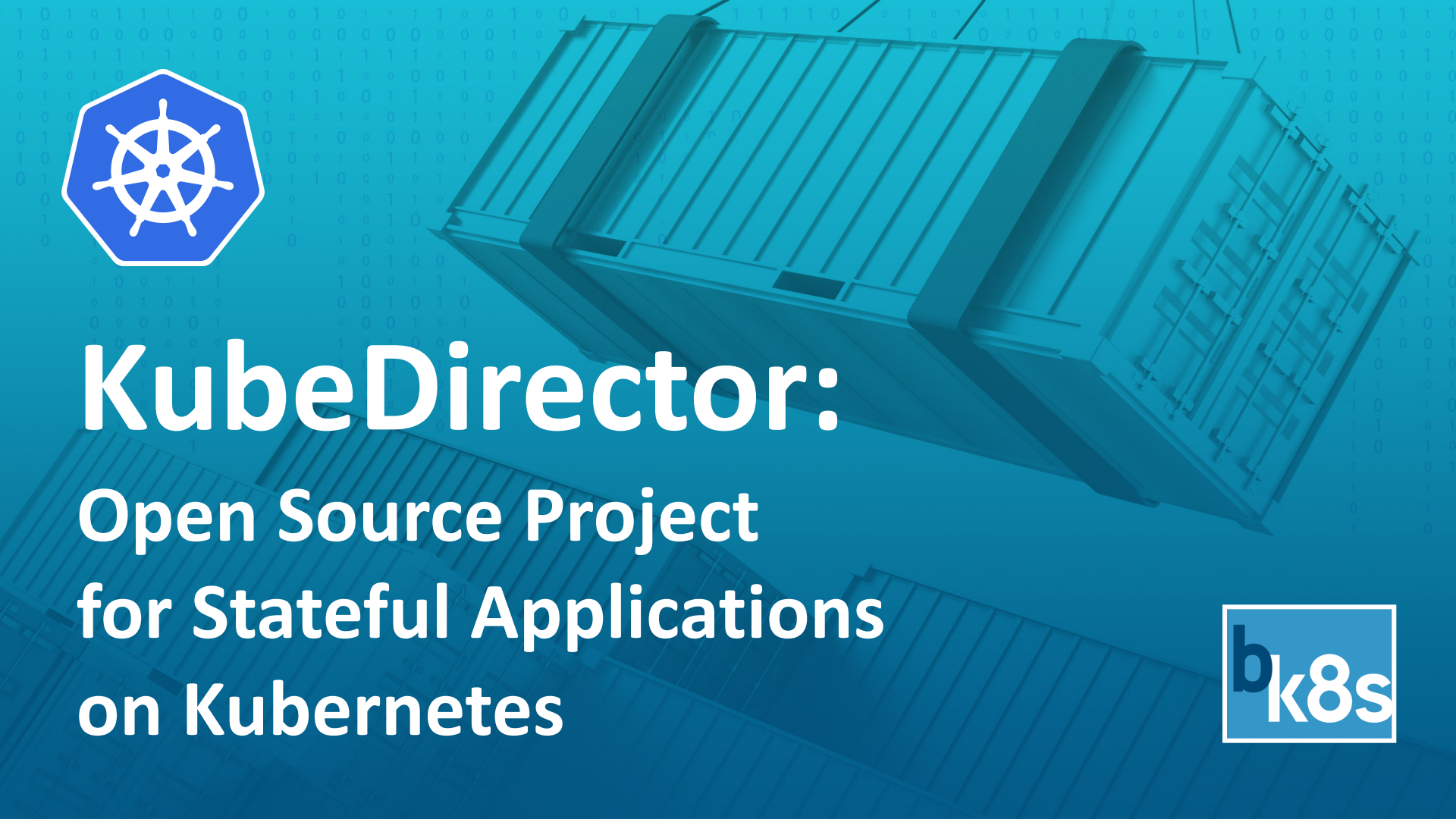
KubeDirector:
Open Source Project
for Stateful Applications
on Kubernetes
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Today's Speakers

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Agenda

- Kubernetes (K8s) and Stateful / Stateless Applications
- Complex Stateful Applications on Kubernetes
- BlueData, BlueK8s, and KubeDirector
- KubeDirector Deep Dive
- KubeDirector Demonstration
- Key Takeaways

What is Kubernetes (K8s?)

- Open source “**platform**” for container orchestration
- Platform **building blocks** vs. turnkey platform
  - https://kubernetes.io/docs/concepts/overview/what-is-kubernetes/#what-kubernetes-is-not
- Top use case is **stateless / microservices** deployments
- Evolving for **stateful** applications

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Stateless Applications on K8s

- **Stateless**
  - Each application service instance is configured identically
  - All information stored remotely
  - “Remotely” refers to some persistent storage that has a life span different from that of the container
  - Frequently referred to as ***“cattle”***

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Stateful Applications on K8s?

- **Stateful**
  - Each application service instance is configured differently
  - Critical information stored locally
  - “Locally” means that the application running in the container accesses the information via file system reads/writes rather than some remote access protocol
  - Frequently referred to as ***“pets”***

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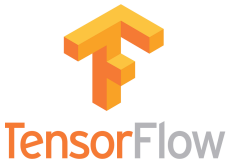
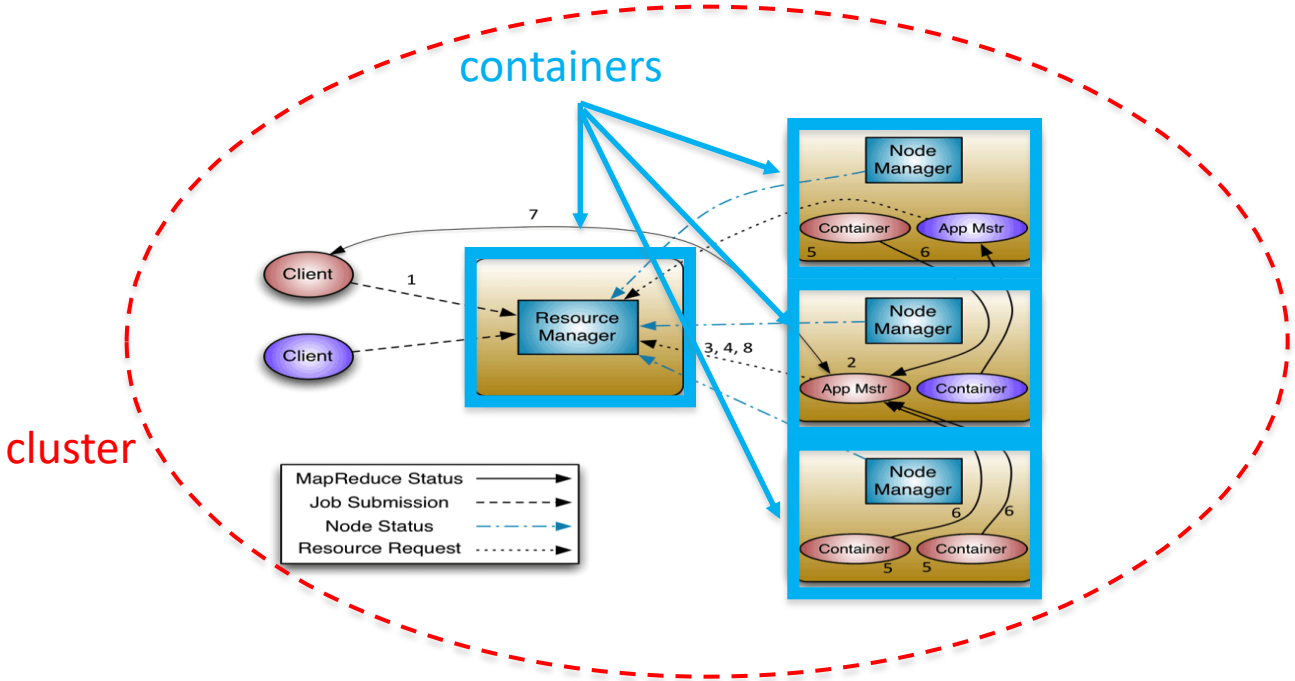
Complex Stateful Applications

- Big Data / AI / Machine Learning / Deep Learning
- What do all these applications have in common?
  - Require large amounts of data
  - Use distributed processing, multiple tools / services
  - When on-prem, typically deployed on bare-metal
  - Do ***not*** have a cloud native architecture
    - No microservices
    - Application instance-specific state



Example: Hadoop in Containers

Running Hadoop **clusters** in containers:



Kubernetes – Components

- Objects
- Pods
- Statefulsets
- PersistentVolumes
- Operators
- Custom Resource Definitions

kubernetes

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Kubernetes – Operators

- Operator
  - A way of packaging, deploying, and managing a given application
- Operator Framework
  - A set of developer and runtime tools to help accelerate the writing of a Operator
- Operator SDK
  - An SDK that further hides the complexities of the Kubernetes API

Source: https://coreos.com/operators

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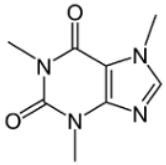
Kubernetes – Operators

OPERATOR FRAMEWORK

- Application-specific means a new operator needs to be written for each application



Caffe2

Spark

HIVE

Keras

mxnet

APACHE kafka

TensorFlow

H_2O.ai

torch

BigDL

hadoop

cassandra

theano

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What to Do?

- There needs to be an easier way to deploy and manage clusters running complex stateful applications

BlueK8s and KubeDirector

- BlueK8s is an Apache open source initiative focused on bringing enterprise support for complex stateful applications to Kubernetes
- A series of open source projects will be rolled out under the BlueK8s umbrella
  - The first major project is “KubeDirector”: https://github.com/bluek8s/kubedirector

Source: www.bluedata.com/blog/2018/07/operation-stateful-bluek8s-and-kubernetes-director

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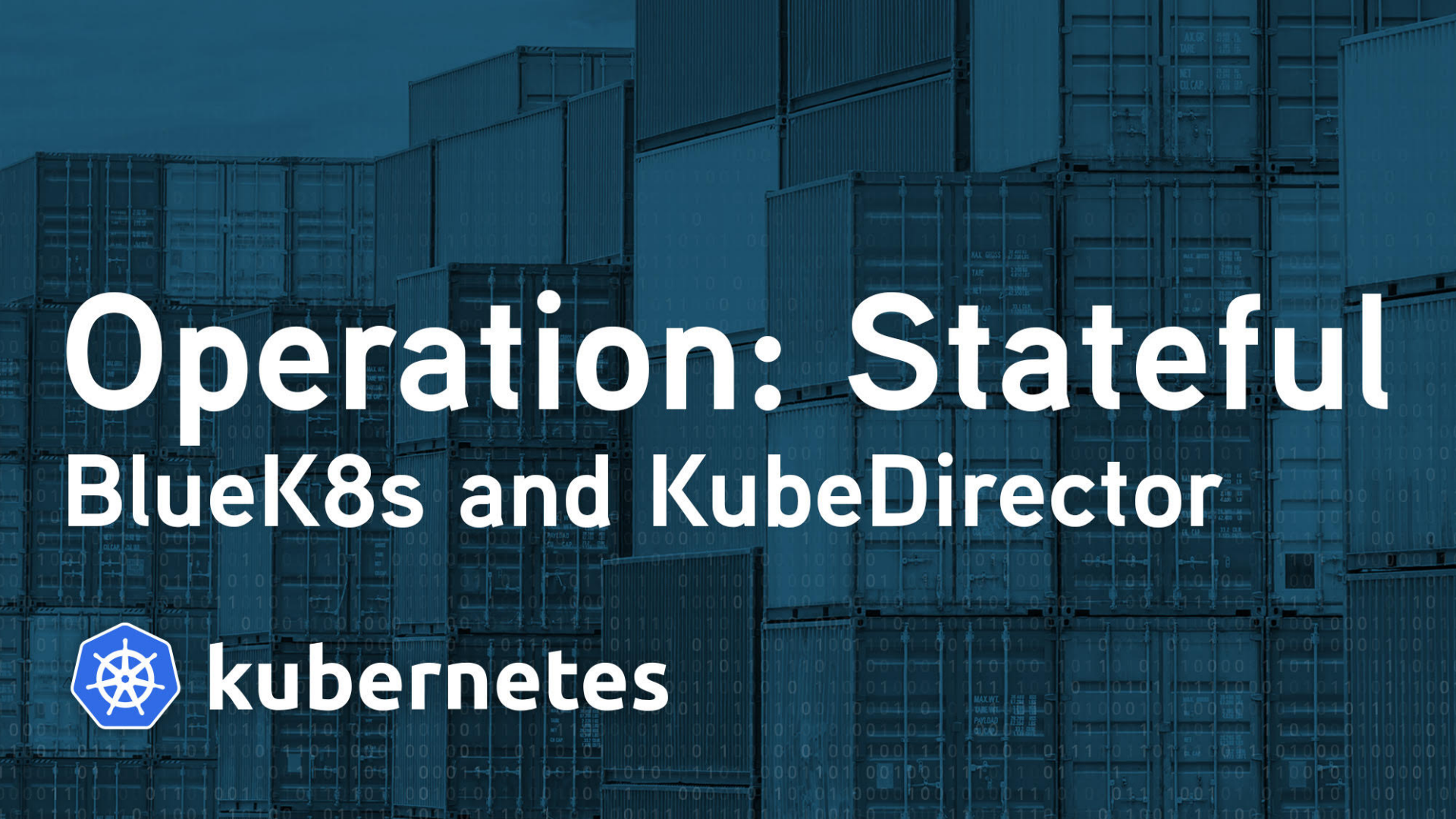
Operation: Stateful
BlueK8s and KubeDirector
kubernetes

Motivation

- Why create KubeDirector? Why use it?
  - E.g. why not app-specific operators, Helm, Kubeflow…
- Reframed: which architecture enables features we want (current or future)?
- Find sweet spot for users between two extremes:
  - Direct use of K8s APIs & “generic” deployment
  - Hardcoded application-specific solutions
- Abstractions + features guided by domain focus

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Domain Focus

- Interested in best supporting apps that:
  - Are scale-out
  - May have “non cloud-native” service architecture
  - Have stateful cluster members
  - Need to access data lakes
  - Have user roles w/ distinct workflows and privileges
  - Integrate w/ enterprise services for authentication, certificate and license management, etc.

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KubeDirector Overview

- KubeDirector is a K8s “custom controller”
- Watches for custom resources (CRs) to appear/change
- Creates/modifies standard K8s resources (StatefulSets etc.) in response, to implement specs from CRs
- Differs from normal Kubernetes Operator pattern:
  - No app-specific logic in KubeDirector code
  - App deployment is data-driven from external app definitions
  - Supports interactions among different apps + other objects

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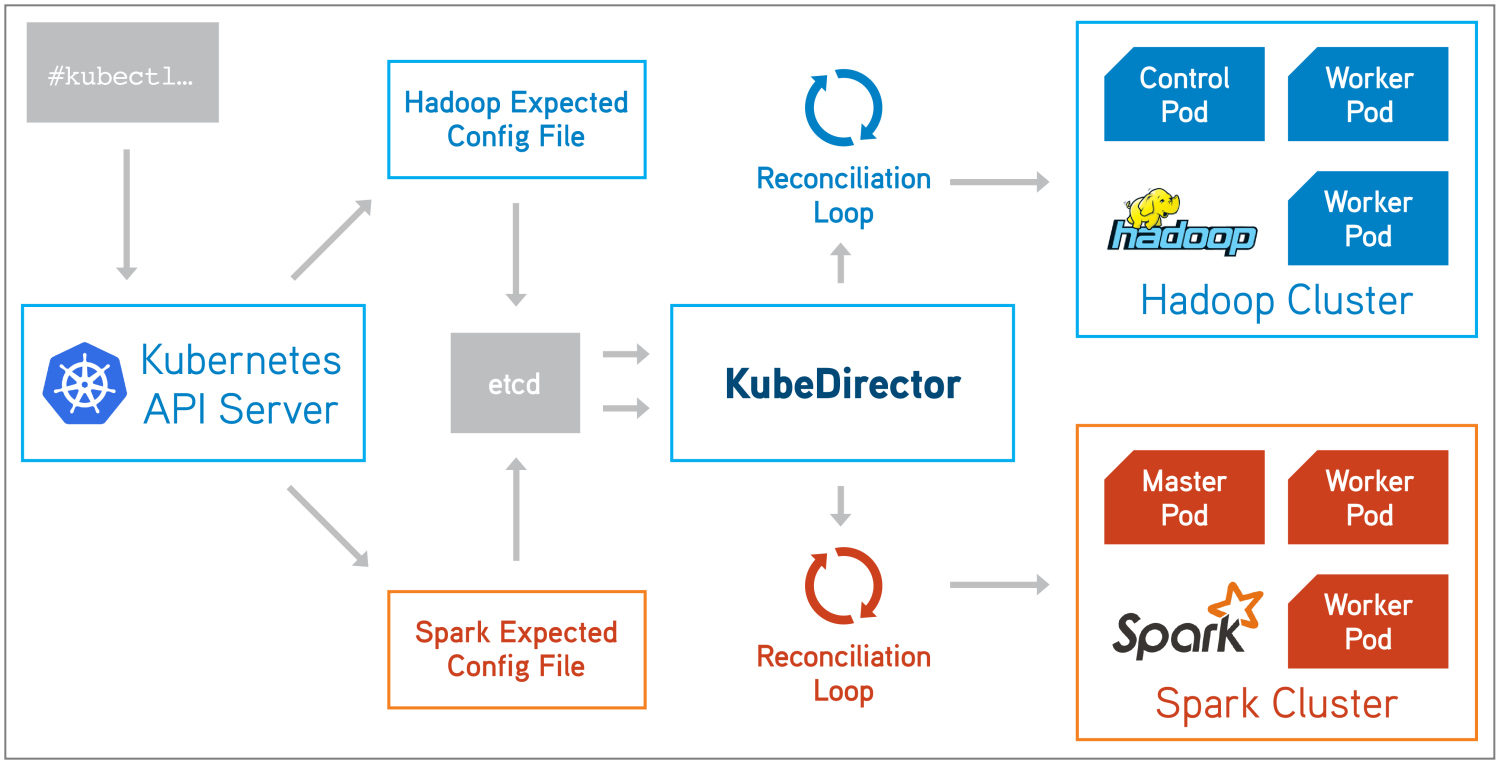
Deploy KubeDirector to K8s

kubectl create -f kubedirector/deployment.yaml



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Separation of Concerns

- Application experts (on-site or elsewhere)
  - Responsible for making app images/metadata/configscripts
  - No need to write Go code or understand Operator concepts
- Administrators (on-site)
  - Select which apps are available to end users
  - Change app versions independently of KubeDirector upgrade
- End users
  - Pick from menu of applications and config choices

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Alternatives Comparison 1/2

- Support distinctions between IT, app expert, project manager, and data scientist
  - Unlike Helm 2/3 & Kubeflow
- Integrate with K8s user authentication and ACLs
  - Unlike Helm 2 (Tiller)
- Support post-deployment autoremediation, autoscale, and other lifecycle events w/ app-specific logic
  - Unlike Helm 3 & Kubeflow

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Alternatives Comparison 2/2

- Also a couple of behaviors not found in app-specific operators, and not a picnic in other solutions:
  - Support end-user import of new application types
  - Apply common features across multiple application types from different developers

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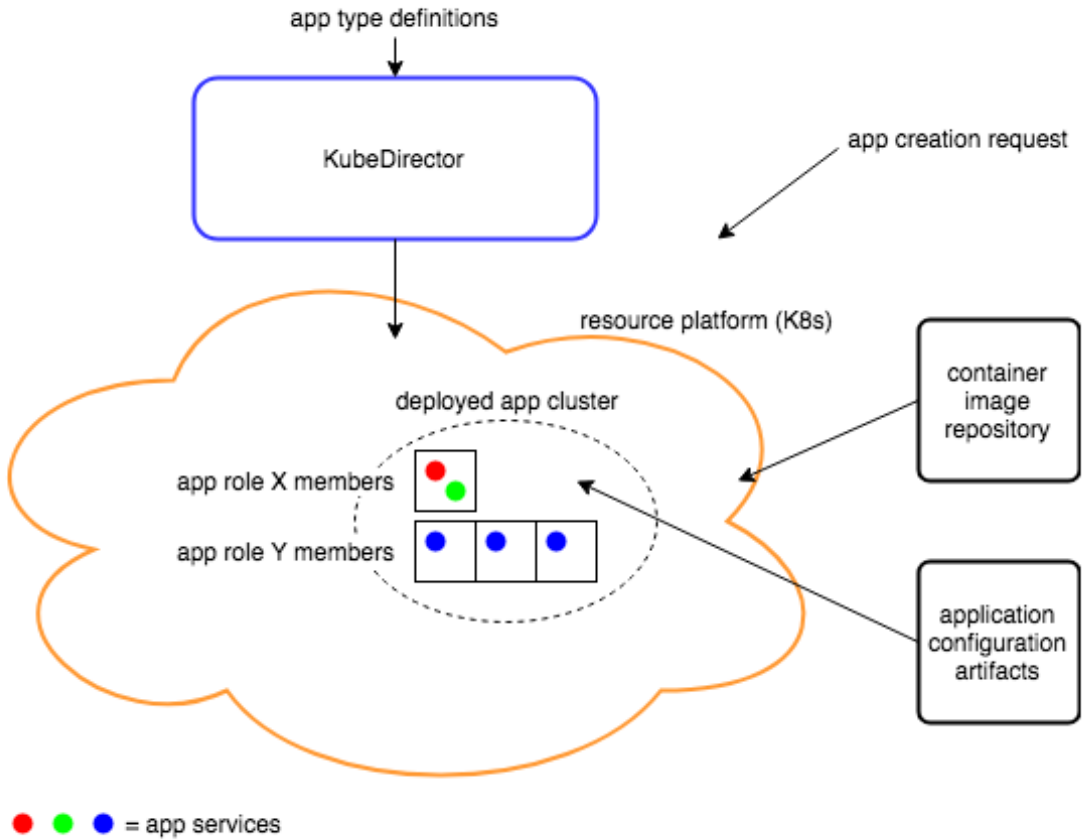
KubeDirector Concepts



Custom Resource Definitions

- Primary CRD: KubeDirectorCluster
  - Models any kind of application instance launchable by KubeDirector
- Other CRDs for related objects, e.g.
  - App definitions (KubeDirectorApp)
  - DataTaps and other shared storage
  - Config sets for AD/LDAP integration for containers
  - Machine Learning models
- This talk will concentrate on KubeDirectorCluster/App

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• KubeDirector Administration
• Application Preparation
• Application Instance Deployment

Deployment

- Create custom resource definitions (CRDs) in your K8s cluster
- Deploy KubeDirector
  - Normally runs in a Pod on same K8s cluster
  - Authenticates to K8s API w/ privileged service account
- Configure KubeDirector global settings
  - E.g. supply app definitions, set types of service & storage

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• KubeDirector Administration
• **Application Preparation**
• Application Instance Deployment

App Definition Metadata

- App identifier/description/version
- Service endpoints
- Available “roles”, and container image per role
- Available deploy-time choices, and their effects on services per role
- Info for optional runtime setup package
- And more!

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App Definition Example 1/3

```
apiVersion: kubedirector.bluedata.io/v1alpha1
kind: KubeDirectorApp
metadata:
  name: spark221e2

spec:
  label:
    name: Spark 2.2.1 on centos7x with Jupyter
  default_image_repo_tag: docker.io/bluedata/sparkbase:2.0
  default_config_package:
    package_url: https://s3.amazonaws.com/mybucket/spark221e2/appconfig.tgz
```

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App Definition Example 2/3

```
roles:
- id: controller
  cardinality: 1
- id: worker
  cardinality: 0+

services:
- id: spark
  label:
    name: Spark master
  endpoint:
    port: 7077
- id: spark_master_ui
  label:
    name: Spark master (web UI)
  endpoint:
    port: 8080
    is_dashboard: true
    url_scheme: http
- id: spark_worker_ui
  label:
    name: Spark worker (web UI)
  endpoint:
    port: 8081
    is_dashboard: true
    url_scheme: http
```

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App Definition Example 3/3

```
config:

 selected_roles:
 - controller
 - worker

 role_services:
 - role_id: controller
   service_ids:
   - spark
   - spark_master_ui
 - role_id: worker
   service_ids:
   - spark_worker_ui
```

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Application Setup Package

- Optional tgz injected into each container, contains:
  - Entrypoint script
  - Standard script functions for reading deployment info
  - Any artifacts (config file templates etc.) required for setup
- Entrypoint script will be invoked at lifecycle events:
  - This container has just been created
  - Some other member(s) added to or removed from the cluster

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Setup Script Actions

- Perform any setup that requires runtime info
  - E.g. FQDNs of other member(s) of the cluster
- Enable and start appropriate services
  - Can query the role of current node
  - Services-to-start depend on role and deploy-time choices
- Can use features of KubeDirector Agent in future

- KubeDirector Administration
- Application Preparation
- **Application Instance Deployment**

Custom Resource Creation

```
apiVersion: "kubedirector.bluedata.io/v1alpha1"
kind: "KubeDirectorCluster"
metadata:
  name: "spark-instance"
spec:
  app: spark221e2
  roles:
  - id: controller
    resources:
      limits:
        memory: "4Gi“
  - id: worker
    members: 2
```

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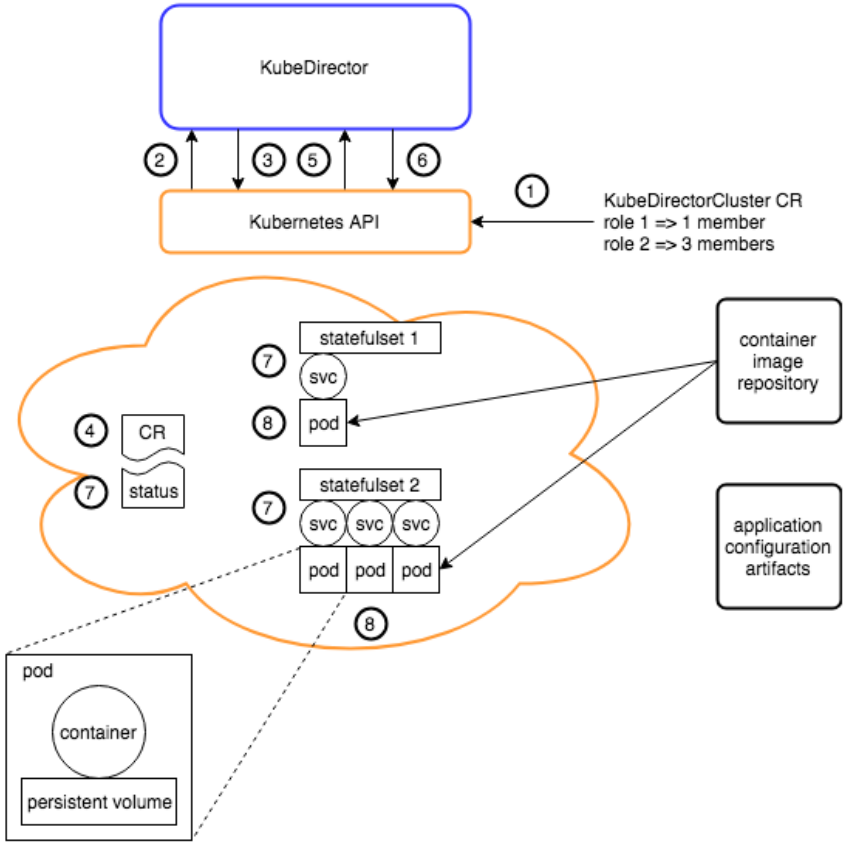
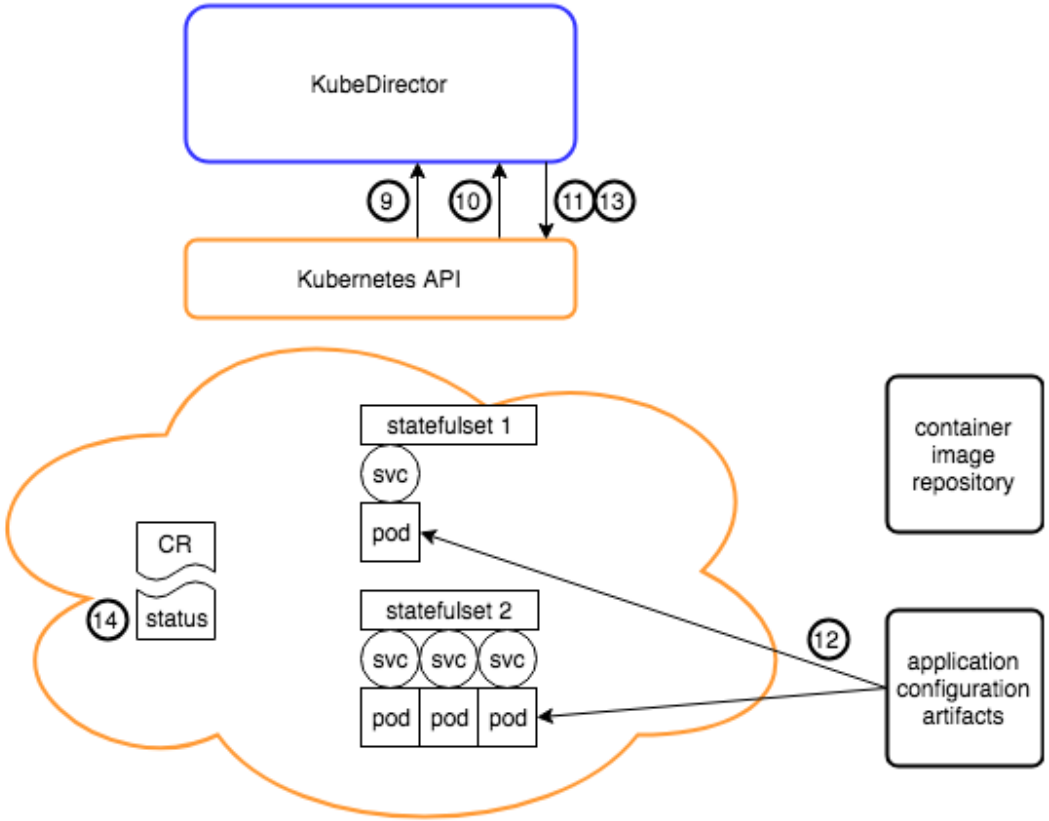
Cluster Creation Sequence 1/2



Cluster Creation Sequence 2/2



Other Operations

- Shrink & expand of role member count is handled similarly
- All resources are automatically cleaned up if CR is deleted (because CR is their “owner”)
- End user can read the CR to see current status, service objects, event history, etc.

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Key Takeaways

- Running complex stateful applications on Kubernetes is challenging today
- The goal of BlueK8s and KubeDirector is to make it easier to run such applications on Kubernetes
- Learn more about KubeDirector:
  - https://github.com/bluek8s/kubedirector/wiki

Join the KubeDirector Community!

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https://github.com/bluek8s