A Brief History of Container Orchestration

In this section we will cover

- Cloud Native
- The rise of DevOps
- Microservices
- Containers
- Orchestration

What is Cloud Native?

- Designing applications for the Cloud - *First*
- Designing for scalability
  - ability to handle large numbers of users
- And reliability
  - "99.999%" etc
  - assume failures

Cloud Native

- Using modern techniques
  - Microservices
  - Programmable infrastructure
- And modern technology
  - Containers
  - Dynamic orchestration platforms

Traditionally

- Developers created applications
- Operations hosted and maintained them

Led to a "wall"

- Developers "threw" software over the wall
  - little regard for complete testing or reliability
- Ops responsible for keeping things running
  - on call
  - pushed back heavily on software/libraries

Issues

- Slow updates
- Poor relations between Dev and Ops
- Problems with upgrades and releases

DevOps

- Acknowledges both Dev and Ops
  - are part of the same team
  - attempts to tear down the wall
- *Teams* become responsible for running services
  - made up of both Dev and Ops
  - on-call

Microservices

- System architecture that uses multiple small services
- Each one has a simple, well-defined job
- As opposed to "monolithic" architectures
- Lightweight Service-oriented architecture (SOA)
- Composable
  - Talk over APIs
  - REST & HTTP / gRPC
- May use multiple languages
- Scale *OUT* as opposed to *UP*

Containers

- Portable format for developing and deploying applications
- Almost synonymous with Microservices
- Also great fit for DevOps

Coordination Challenges

- Splitting a monolith into dozens of pieces..
- How do we manage all of these?

What is Orchestration?

"The planning or coordination of the elements of a situation to produce a desired effect, especially surreptitiously"

Oxford English Dictionary

*"The planning or coordination of **the elements of a situation** to produce a desired effect, especially surreptitiously"*

The Elements

- Containers
- Hosts
- Networking

*"The planning or coordination of the elements of a situation to **produce a desired effect**, especially surreptitiously"*

The Desired Effect

- Running application
- Automatically scaling
- Fault tolerance
  - e.g. Failover, node re-balancing, health checks
- Efficient use of resources
- Little manual intervention

*"The planning or coordination of the elements of a situation to produce a desired effect, **especially surreptitiously**"*

Surreptitiously

- Should happen in the background
- Complexity is hidden
- User doesn't need to know the details

Container Orchestrators

Common Components

- Container Runtime
- Resource Manager
- Scheduler
- Service Discovery
- Advanced Networking

Many Options

- Kubernetes
- Mesos, DC/OS
- Docker Swarm
- Plus others
  - Nomad
  - Fleet from CoreOS (no more)
  - PaaSs...

Kubernetes

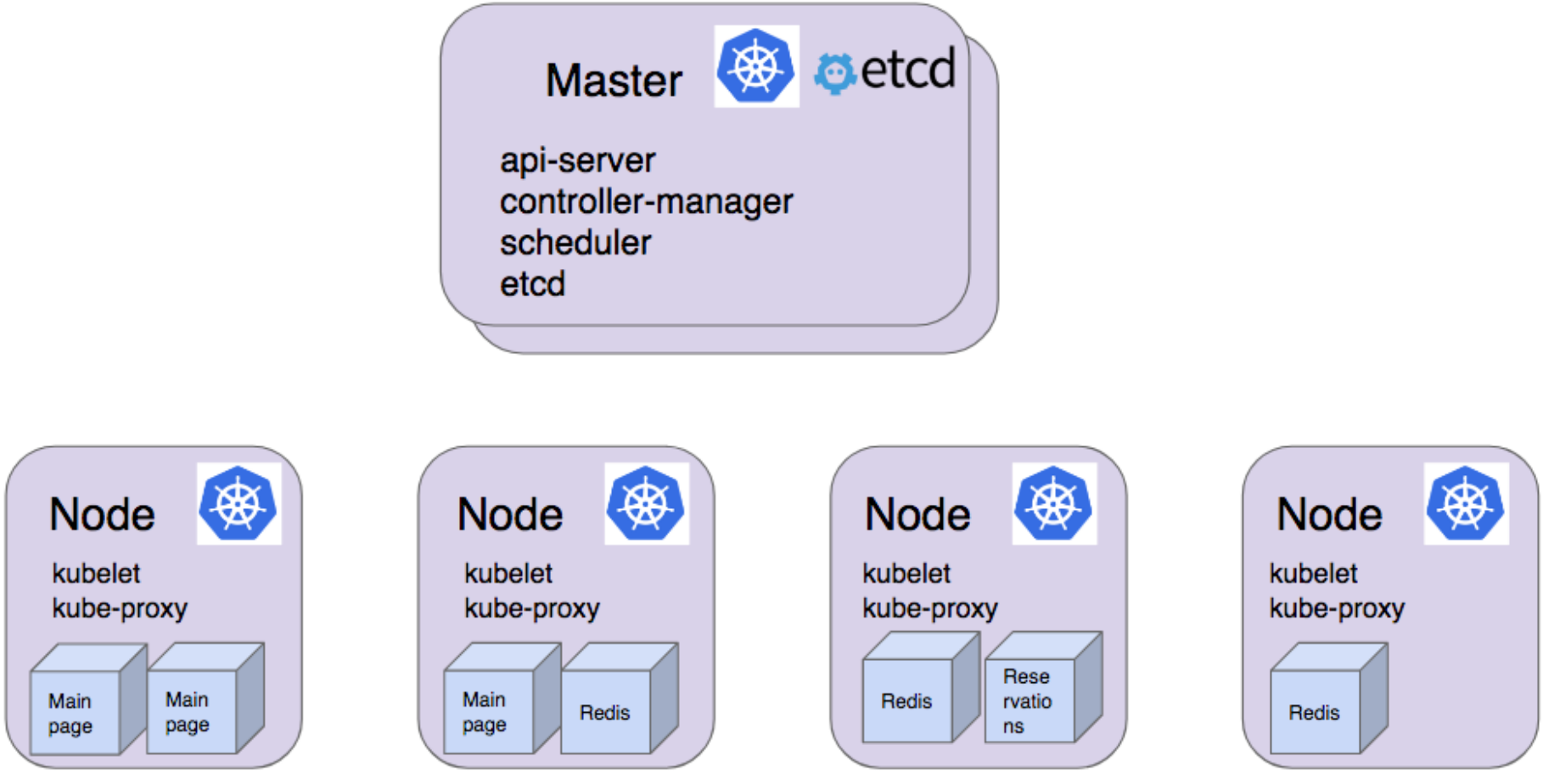
Background

- Open-source container orchestrator from Google
- Now part of Cloud Native Computing Foundation
- Popular and Active: >32K stars on Github

Features

- Based on Google's experience running containers
- Bakes in various features
  - Load-balancing, secret management
- Opinionated
  - Impact on application design

Architecture



Core Concepts

- Nodes
- Pods
- Labels & Selectors
- Services
- ReplicaSets
- Deployments
- Namespaces
- Jobs

Nodes

- Worker machine -- May be a VM or physical machine
- A Node can host one or multiple Pods
- Include Docker, kubelet and kube-proxy

Pods

- Groups of containers deployed and scheduled together
- Atomic unit (scaling and deployment)
- Containers in a pod share IP address
- Single container pods are common
- Pods are ephemeral

Flat networking space

- All pods, across all hosts, are in the same network space
  - Can see each other without NAT
- Simple cross host communication

Labels

- Key/Value pairs attached to objects
  - e.g: "version: dev", "tier: frontend"
- Objects include Pods, ReplicaSets, Services
- Label selectors then used to identify groups
- Used for load-balancing etc

Selectors

- Used to query labels
  - environment = production
  - tier != frontend
- Also set based comparisons
  - environment in (production, staging)
  - tier notin (frontend, backend)

Services

- Stable endpoints addressed by name
- Forward traffic to pods
- Pods are selected by labels
- Round-robin load-balancing
- Separates endpoint from implementation

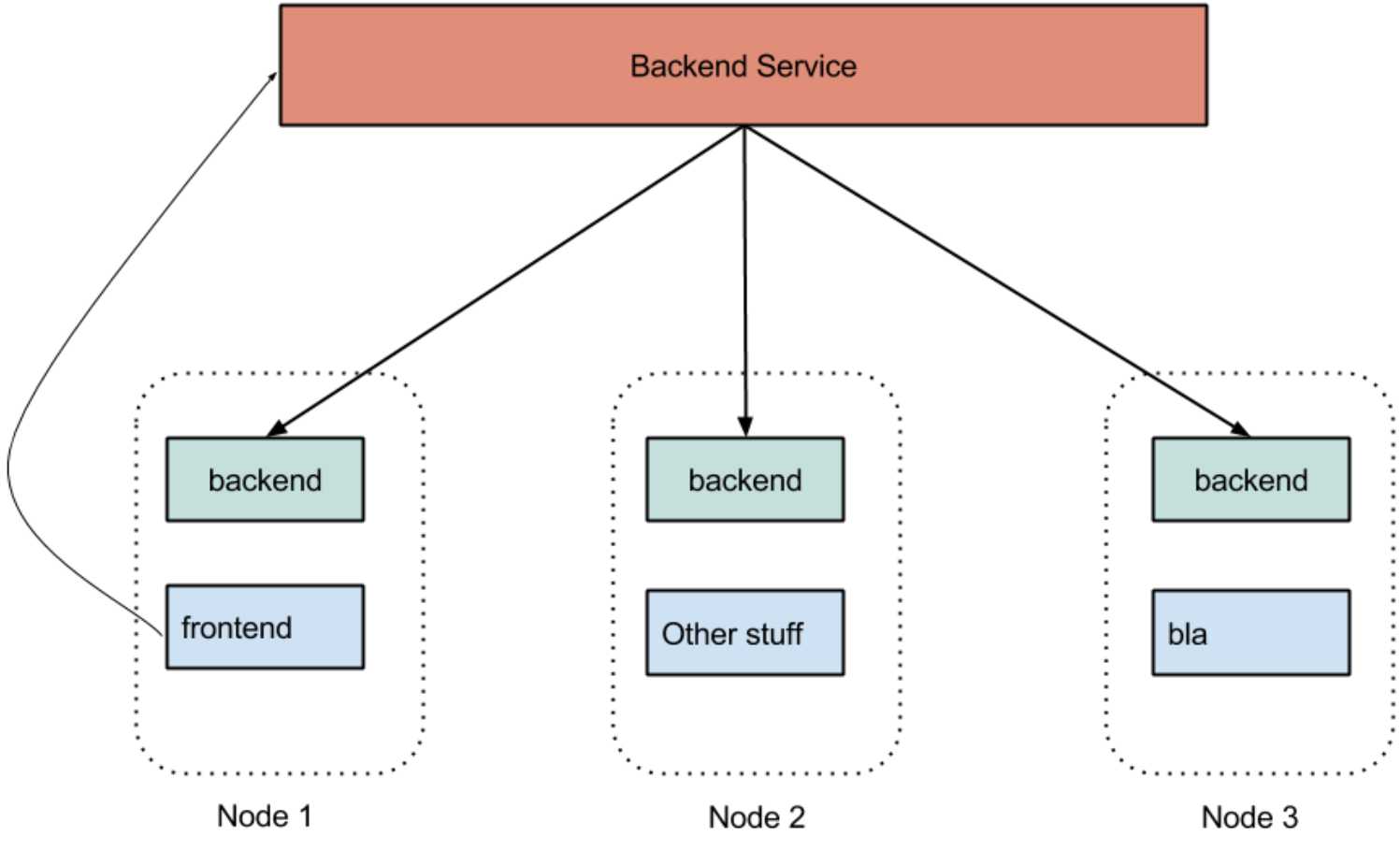
Service Types

- ClusterIP (default)
  - Uses internal IP for service
  - No external exposure
- NodePort
  - Service is externally exposed via port on host
  - Same port on every host
  - Port automatically chosen or can be specified

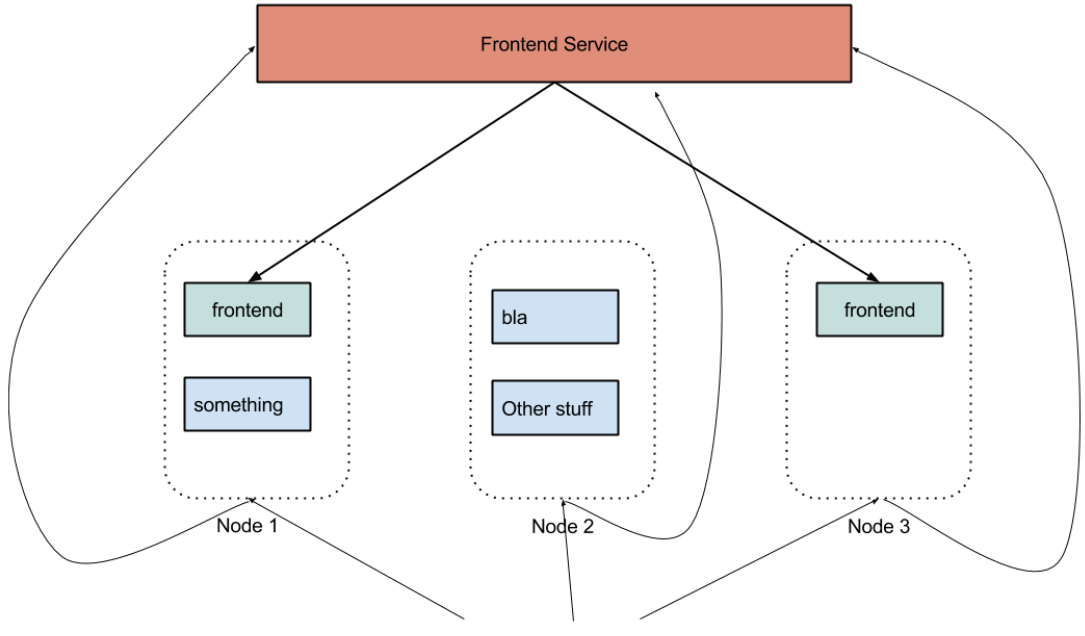
Service Types

- LoadBalancer
  - Exposes service externally
  - Implementation dependent on cloud provider
- ExternalName
  - For forwarding to resources outside of k8s

Cluster IP Service Diagram


Backend Service
backend
frontend
backend
Other stuff
backend
bla
Node 1
Node 2
Node 3

NodePort Service Diagram

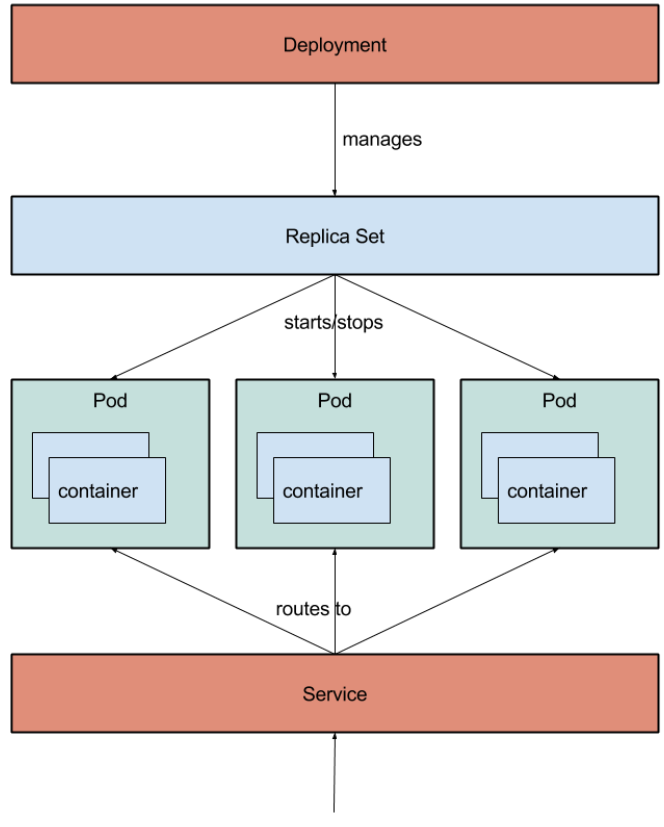

Frontend Service
frontend
something
bla
Other stuff
frontend
Node 1
Node 2
Node 3

ReplicaSets

- ReplicaSets monitor status of Pods
  - define number of pods to run
  - start/stop pods as needed

Deployments

- Deployments start ReplicaSets
- Rollout/Rollback & Updates


Deployment
manages
Replica Set
starts/stops
Pod
container
Pod
container
Pod
container
routes to
Service

Namespaces

- Resources can be partitioned into namespaces
- Logical groups
- System resources run in their own namespace
- Normally only use one namespace

Jobs

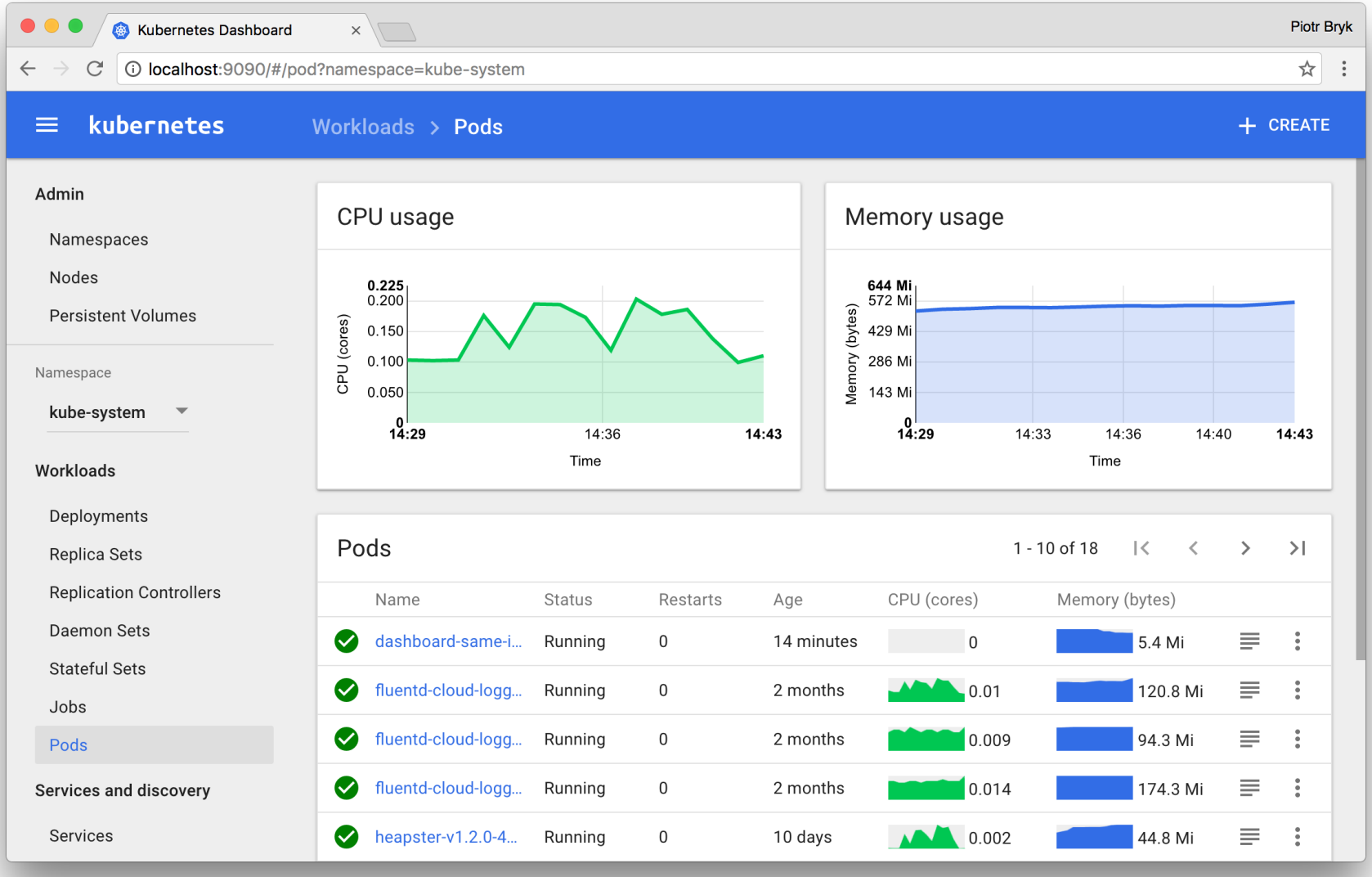
- Typically for performing batch processing
- Spins up short-lived pods
- Ensures given number run to completion

More & More

- Volumes
- Stateful Sets
- Ingress
- Annotations
- Daemon Sets
- Horizontal Pod Autoscaling
- Network Policies
- Resource Quotas
- Secrets
- Security Context
- Service Accounts
- ...

Dashboard

- Simple Web User Interface
- Good *high-level* overview of the cluster
- Can drill down into details
- Useful for debugging


Kubernetes Dashboard
Piotr Bryk
localhost:9090/#/pod?namespace=kube-system
kubernetes
Workloads > Pods
CREATE
Admin
Namespaces
Nodes
Persistent Volumes
Namespace
kube-system
Workloads
Deployments
Replica Sets
Replication Controllers
Daemon Sets
Stateful Sets
Jobs
Pods
Services and discovery
Services
CPU usage
0.225
0.200
0.150
0.100
0.050
0
CPU (cores)
14:29
14:36
14:43
Time
Memory usage
644 Mi
572 Mi
429 Mi
286 Mi
143 Mi
0
Memory (bytes)
14:29
14:33
14:36
14:40
14:43
Time
Pods
1 - 10 of 18
Name
Status
Restarts
Age
CPU (cores)
Memory (bytes)
dashboard-same-i...
Running
0
14 minutes
0
5.4 Mi
fluentd-cloud-logg...
Running
0
2 months
0.01
120.8 Mi
fluentd-cloud-logg...
Running
0
2 months
0.009
94.3 Mi
fluentd-cloud-logg...
Running
0
2 months
0.014
174.3 Mi
heapster-v1.2.0-4...
Running
0
10 days
0.002
44.8 Mi

Kubernetes Configuration

Configuring a Cluster

- Use configuration files to manage resources
- Specified in YAML or JSON
  - YAML tends to be more user-friendly
- Can be combined
- Should be stored in version control

Pod Example

```
apiVersion: v1
   kind: Pod
   metadata:
     name: hello-node
     labels:
       app: hello-node
   spec:
     containers:
       - name: hello-node
         image: hello-node:v1
         ports:
           - containerPort: 8080
```

Service Example

```yaml
apiVersion: v1
kind: Service
metadata:
  name: railsapp
spec:
  type: NodePort
  selector:
    app: railsapp
  ports:
    - name: http
      nodePort: 36000
      targetPort: 80
      port: 80
      protocol: TCP
```

Get Hands on!

Introducting Kubectl

`kubectl` is the command line interface (CLI) tool for sending commands to a Kubernetes cluster.

We will use this tool to deploy, view, and access an application on our cluster.

Step 1: Kubectl Basics

- The format of a kubectl command is:

```
kubectl [action] [resource]
```

- This performs the specified action (like `create`, `describe`) on the specified resource (like `node`, `container`).
- Use `--help` after the command to get additional info about possible parameters

```
$ kubectl get nodes --help
```

Check that kubectl is configured to talk to your cluster, by running the kubectl version command:

```
$ kubectl version
```

You can see both the client and the server versions.

To view how to reach the cluster, run the `cluster-info` command:

```
$ kubectl cluster-info

Kubernetes master is running at https://35.205.211.112
GLBCDefaultBackend is running at https://35.205.211.112/api/v1/namesp
Heapster is running at https://35.205.211.112/api/v1/namespaces/kube-
KubeDNS is running at https://35.205.211.112/api/v1/namespaces/kube-s
KubeRegistry is running at https://35.205.211.112/api/v1/namespaces/k
kubernetes-dashboard is running at https://35.205.211.112/api/v1/name
Metrics-server is running at https://35.205.211.112/api/v1/namespaces
Grafana is running at https://35.205.211.112/api/v1/namespaces/kube-s
InfluxDB is running at https://35.205.211.112/api/v1/namespaces/kube-
```

To further debug and diagnose cluster problems, use:

```
kubectl cluster-info dump
```

Step 2: Deploy an Application

Let's run our first application on Kubernetes with the kubectl run command. The `run` command creates a new deployment for the specified container. This is the simplest way of deploying a container.

```
$ kubectl run hello-kubernetes \
--image=gcr.io/google_containers/echoserver:1.4 --port=8080

deployment "hello-kubernetes" created
```

This performed a few things:

- Searched for a suitable node.
- Scheduled the application to run on that node.
- Configured the cluster to reschedule the instance on a new node when needed.

List your deployments

```
$ kubectl get deployments

NAME        DESIRED   CURRENT   UP-TO-DATE   AVAILABLE
hello-kubernetes   1         1         1            1
```

We see that there is 1 deployment running a single instance of your app.

Gather information about the status of your objects (pods, deployments, services, etc) using

```
kubectl get <object>
```

and

```
kubectl describe <object>
```

Step 3: Make the App Visible

By default applications are only visible inside the cluster. We can create a proxy to connect to our application.

Start by finding out the pod name:

```
$ kubectl get pod

NAME                                   READY     STATUS    RESTARTS
hello-kubernetes-624527933-nth9d   1/1       Running   0
```

Create a proxy for the pod

```
$ kubectl port-forward <POD NAME> 8080 &
```

We now have a connection between our host and the Kubernetes cluster.

Step 4: Access the App

To see the output of our application, run a curl request to the local port:

```
$ curl http://localhost:8080

CLIENT VALUES:
client_address=127.0.0.1
command=GET
real path=/
query=nil
request_version=1.1
request_uri=http://0.0.0.0:8080/

SERVER VALUES:
server_version=nginx: 1.10.0 - lua: 10001

HEADERS RECEIVED:
accept=*/*
host=0.0.0.0:8080
```

Step 5: Clean Up

`port-forward` is meant for testing services that are not exposed. To expose the application, use a Service (covered later).

Kill port forward

```
$ kill %2
```

Delete old Deployment

```
$ kubectl delete deployment hello-kubernetes
```

Step 6: Create a new Deployment & Service

```
$ kubectl run hello --image=gcr.io/google_containers/echoserver:1.4 \
   --port=8080 \
   --expose \
   --service-overrides='{ "spec": { "type": "NodePort" } }'

service "hello" created
deployment "hello" created
```

This creates a new Deployment and Service of type:NodePort. A random high port will be allocated to which we can connect.

View the Service

```
$ kubectl get service

NAME                CLUSTER-IP      EXTERNAL-IP   PORT(S)           AGE
hello                10.0.122.112    <nodes>       8080:30659/TCP    10m
```

We can see the port on which it is exposed, but what is the external IP?

To find the IP on which to call we need information on the nodes (use the EXTERNAL-IPs from any node):

```
$ kubectl get nodes -o wide

NAME                          STATUS                     AGE       V
kubernetes-master             Ready,SchedulingDisabled   17m       v
kubernetes-minion-group-c9bz  Ready                      17m       v
kubernetes-minion-group-cfzx  Ready                      17m       v
kubernetes-minion-group-ftw1  Ready                      17m       v
```

Access the external IP with Curl:

```
$ curl 35.189.206.159:30659

CLIENT VALUES:
client_address=10.132.0.3
command=GET
real path=/
query=nil
request_version=1.1
request_uri=http://35.187.76.71:8080/

SERVER VALUES:
server_version=nginx: 1.10.0 - lua: 10001

HEADERS RECEIVED:
accept=*/*
host=35.187.76.71:8080
```

Step 7: Clean Up

Delete the Deployment

```
$ kubectl delete deploy hello
```

Delete the Service

```
$ kubectl delete svc hello
```

What have we Learned?

- The history of Container Orchestration.
- Basics of Kubernetes.
- How to deploy a simple application on to our own cluster.

Next up, a real application!