Kubernetes (on Kubernetes Engine) - Basics to Advanced

Self-link: bit.ly/k8s-lab

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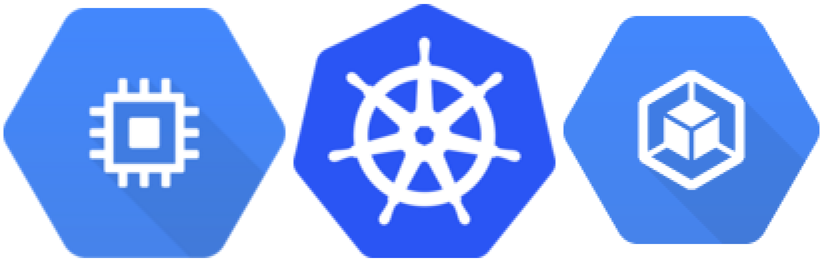
Introduction

Duration: 5:00

Hello everyone, thanks for coming today! Ready to learn Kubernetes? You will first become familiar with Compute Engine before working through a example Guestbook application, and then move on to more advanced Kubernetes experiments.



Kubernetes is an open source project (available on kubernetes.io) which can run on many different environments, from laptops to high-availability multi-node clusters, from public clouds to on-premise deployments, from virtual machines to bare metal.

For the purpose of this codelab, using a managed environment such as Google Kubernetes Engine (a Google-hosted version of Kubernetes running on Compute Engine) will allow you to focus more on experiencing Kubernetes rather than setting up the underlying infrastructure but you should feel free to use your favorite environment instead.

What is your experience level with Containers?

- I have just heard of Docker
- I played around with Docker
- I have containers in production
- I have already used container clustering technologies (kubernetes, mesos, swarm, ...)

Initial setup

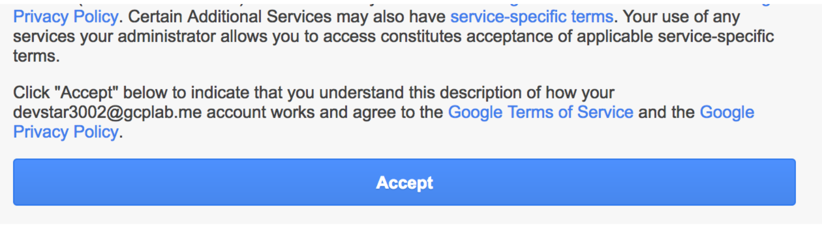
Duration: 5:00

Logging In

The instructor will provide you with a temporary username / password to login into Google Cloud Console.

Important: To avoid conflicts with your personal account, please open a new incognito window for the rest of this lab.

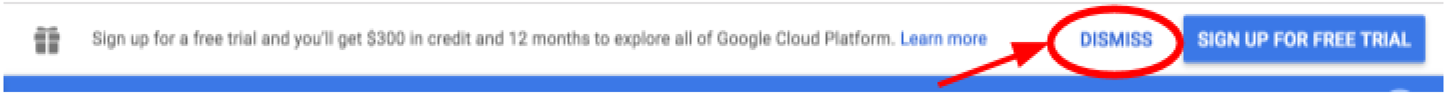
Login into the Cloud Console: https://console.cloud.google.com/ with the provided credentials. In **Welcome to your new account** dialog, click **Accept**



Privacy Policy. Certain Additional Services may also have service-specific terms. Your use of any services your administrator allows you to access constitutes acceptance of applicable service-specific terms.

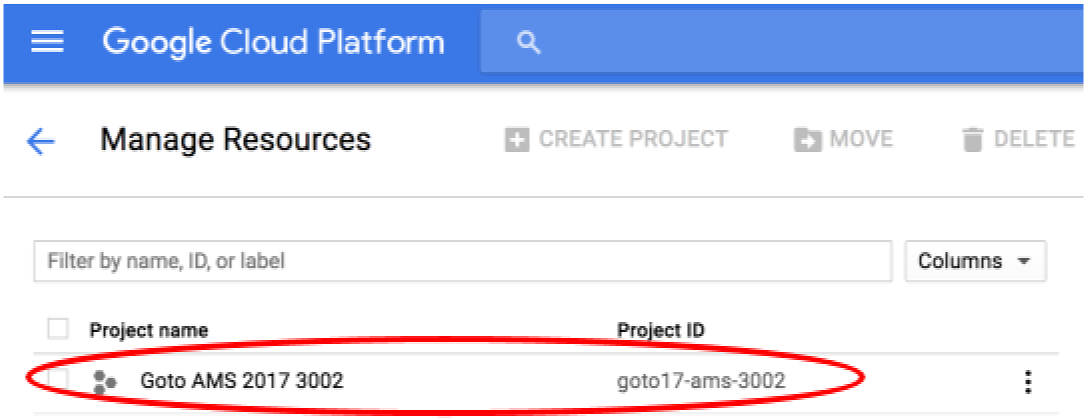
Click "Accept" below to indicate that you understand this description of how your devstar3002@gcplab.me account works and agree to the Google Terms of Service and the Google Privacy Policy.

If you see a top bar with Sign Up for Free Trial written on it - DO NOT SIGN UP FOR THE FREE TRIAL. Click **Dismiss** since you'll be using a pre-provisioned lab account. If you are doing this on your own account, then you may want the free trial.



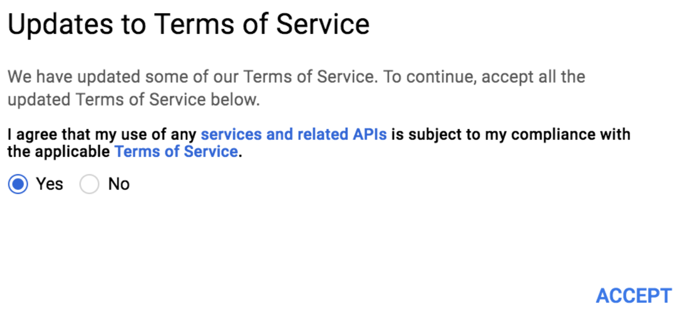
Sign up for a free trial and you'll get $300 in credit and 12 months to explore all of Google Cloud Platform. Learn more

You should see just one Project - click into it.



Project name	Project ID
Goto AMS 2017 3002	goto17-ams-3002

When prompted **Update to Terms of Service**, select **Yes** and click **Accept**.



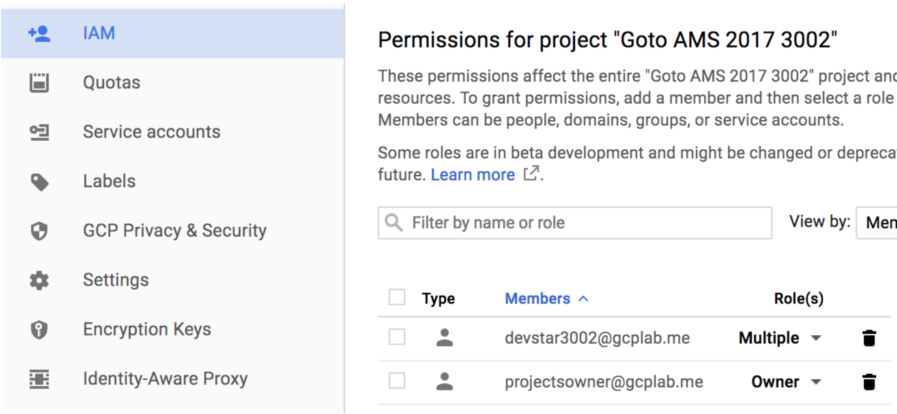
Updates to Terms of Service

We have updated some of our Terms of Service. To continue, accept all the updated Terms of Service below.

I agree that my use of any services and related APIs is subject to my compliance with the applicable Terms of Service.

● Yes ○ No

In the **IAM & Admin** page, wait for permissions to initialize (sometimes, refreshing the page speeds up the process :)



Permissions for project "Goto AMS 2017 3002"

These permissions affect the entire "Goto AMS 2017 3002" project and all of its resources. To grant permissions, add a member and then select a role for them. Members can be people, domains, groups, or service accounts.

Some roles are in beta development and might be changed or deprecated in the future. Learn more.

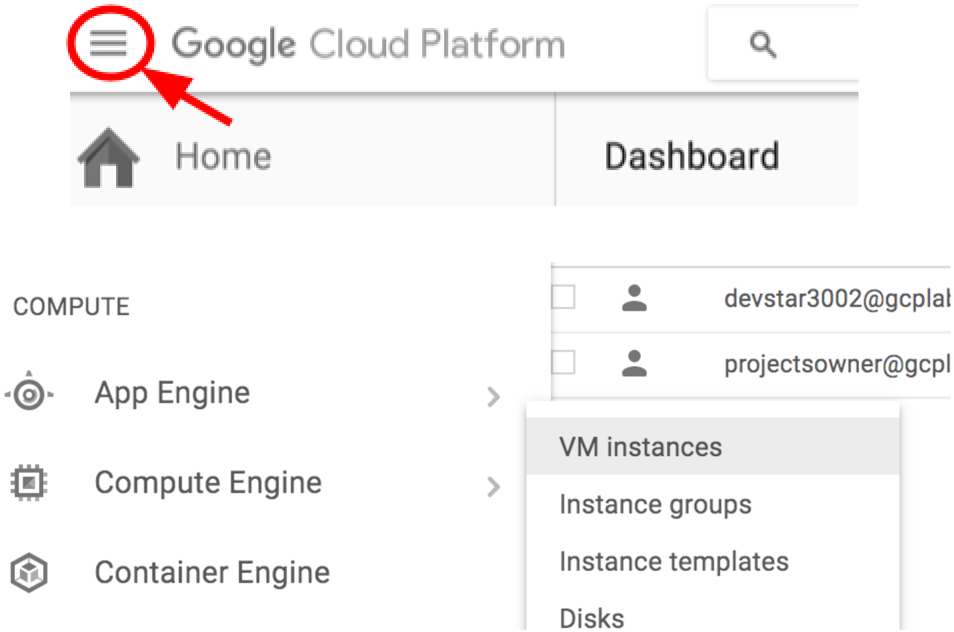
Filter by name or role View by: Members

Type	Members	Role(s)
☐	devstar3002@gcplab.me	Multiple
☐	projectsowner@gcplab.me	Owner

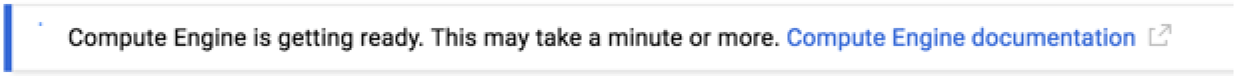
Enable Compute Engine

Note: Following step is mandatory for EVERY lab attendees.

Navigate to **Compute** → **Compute Engine** → **VM Instances**. This will enable some basic APIs.

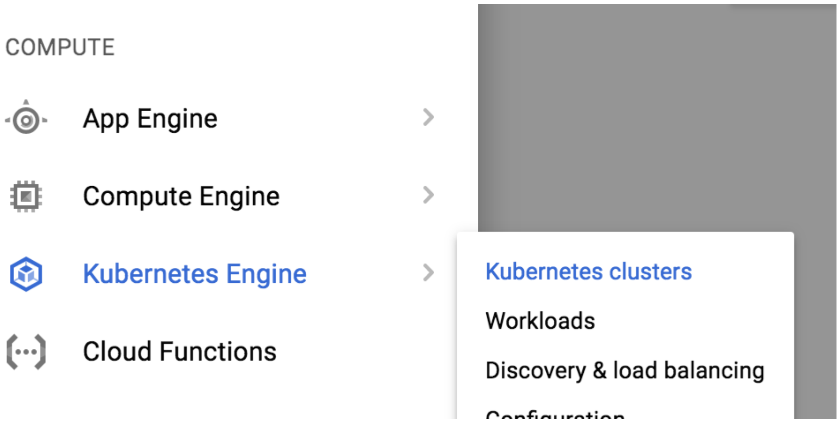


You will see the "Compute Engine is getting ready" message. Wait until this is done.


Compute Engine is getting ready. This may take a minute or more. Compute Engine documentation

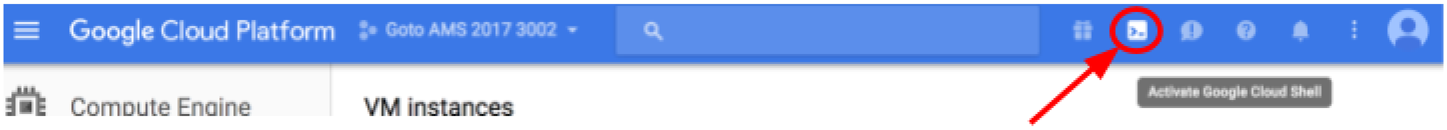
Enable Kubernetes Engine

Navigate to **Compute** → **Kubernetes Engine** → **Kubernetes Cluster**. This will enable additional APIs for Kubernetes Engine.

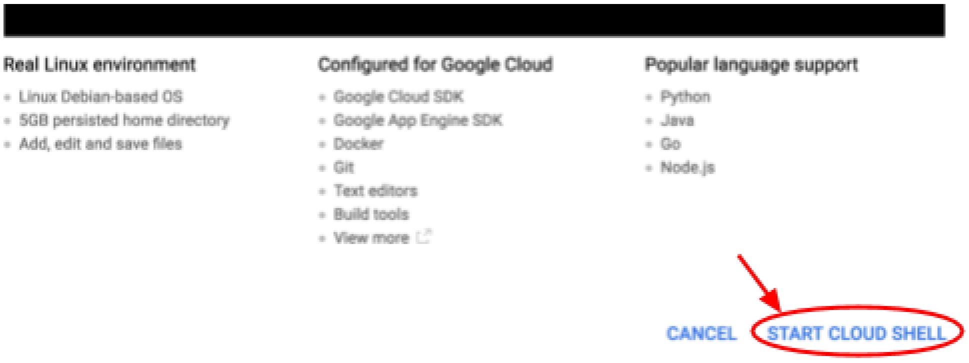


Cloud Shell

You will do most of the work from the Google Cloud Shell, a command line environment running in the Cloud. This Debian-based virtual machine is loaded with all the development tools you'll need (`docker`, `gcloud`, `kubectl` and others) and offers a persistent 5GB home directory. Open the Google Cloud Shell by clicking on the icon on the top right of the screen:



When prompted, click **Start Cloud Shell**:


[redacted]

Real Linux environment

- Linux Debian-based OS
- 5GB persisted home directory
- Add, edit and save files

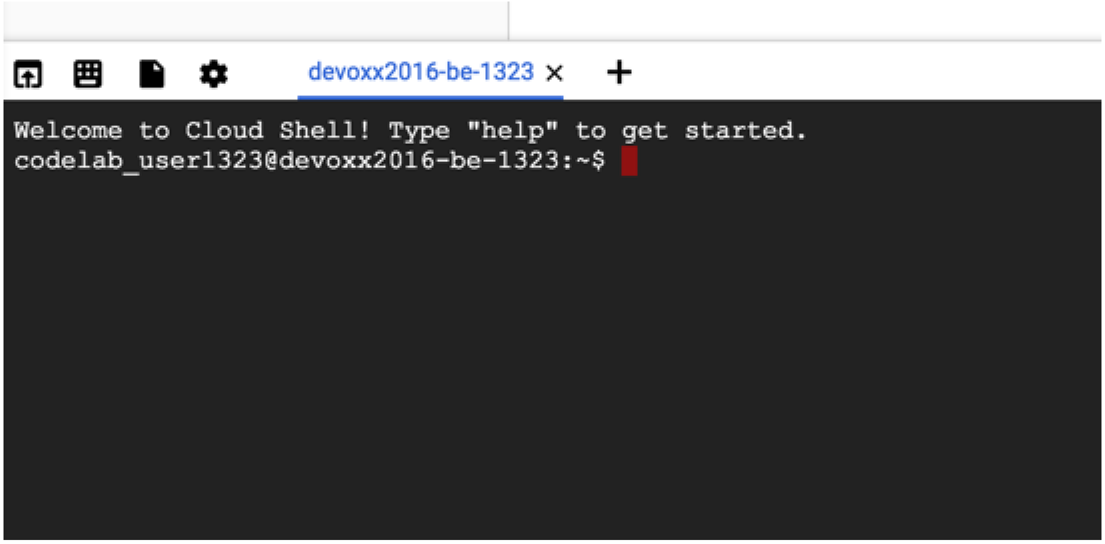
Configured for Google Cloud

- Google Cloud SDK
- Google App Engine SDK
- Docker
- Git
- Text editors
- Build tools
- View more

Popular language support

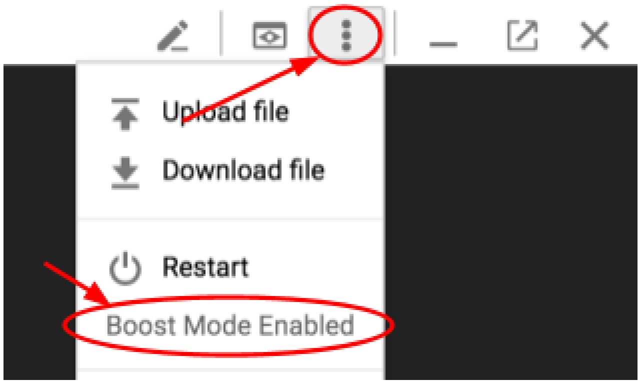
- Python
- Java
- Go
- Node.js

You should see the shell prompt at the bottom of the window:



```
Welcome to Cloud Shell! Type "help" to get started.
codelab_user1323@devoxx2016-be-1323:~$
```

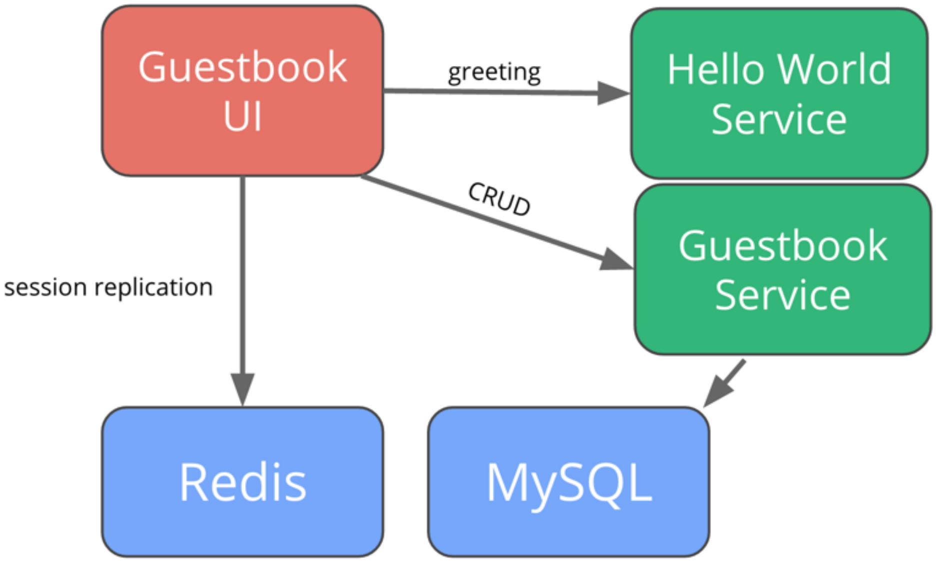
Next, enable **Boost Mode** for Cloud Shell. This will provision a larger VM instance for the shell. We'll need this in order to build and push Docker container faster:



Note: When you run `gcloud` on your own machine, the config settings would've been persisted across sessions. But in Cloud Shell, you will need to set this for every new session / reconnection.

Kubernetes - The Basics

We're going to work through this guestbook example. This example is built with Spring Boot, with a frontend using Spring MVC and Thymeleaf, and two microservices. It requires MySQL to store guestbook entries, and Redis to store session information.



Create your Kubernetes Cluster

Duration: 5:00

The first step is to create a cluster to work with. We will create a Kubernetes cluster using Google Kubernetes Engine.

First, set default region and zones:

```
$ gcloud config set compute/zone us-east1-d
$ gcloud config set compute/region us-east1
```

Note: For the lab, use the region/zone recommended by the instructor. Learn more about different zones and regions in Regions & Zones documentation.

Create a Kubernetes cluster in Google Cloud Platform is very easy! Use Kubernetes Engine to create a cluster:

```
$ gcloud container clusters create guestbook \
      --cluster-version 1.8.7-gke.1 \
      --num-nodes 4 \
      --scopes cloud-platform
```

This will take a few minutes to run. Behind the scenes, it will create Google Compute Engine instances, and configure each instance as a Kubernetes node. These instances don't include the Kubernetes Master node. In Google Kubernetes Engine, the Kubernetes Master node is managed service so that you don't have to worry about it!

The scopes parameter is important for this lab. Scopes determine what Google Cloud Platform resources these newly created instances can access. By default, instances are able to read from Google Cloud Storage, write metrics to Google Cloud Monitoring, etc. For our lab, we add the `cloud-platform` scope to give us more privileges, such as writing to Cloud Storage as well.

While this goes on you might enjoy watching this short video https://youtu.be/7vZ9dRKRMyc!

You can see the newly created instances in the **Compute Engine → VM Instances** page.

Get the Guestbook source

Duration: 3:00

Start by cloning the GitHub repository for the Guestbook application:

```
$ git clone https://github.com/saturnism/spring-boot-docker
```

And move into the kubernetes examples directory.

```
$ cd spring-boot-docker/examples/kubernetes-1.2
```

We will be using the `yaml` files in this directory. Every file describes a resource that needs to be deployed into Kubernetes. Without giving much detail on its contents, but you are definitely encouraged to read them and see how pods, services, and others are declared. We'll talk a couple of these files in detail.

Deploy Redis

Duration: 5:00

A Kubernetes pod is a group of containers, tied together for the purposes of administration and networking. It can contain one or more containers. All containers within a single pod will share the same networking interface, IP address, volumes, etc. All containers within the same pod instance will live and die together. It's especially useful when you have, for example, a container that runs the application, and another container that periodically polls logs/metrics from the application container.

You can start a single Pod in Kubernetes by creating a Pod resource. However, a Pod created this way would be known as a Naked Pod. If a Naked Pod dies/exits, it will not be restarted by Kubernetes. A better way to start a pod, is by using a higher-level construct such as Replication Controller, Replica Set, or a Deployment.

Prior to Kubernetes 1.2, Replication Controller is the preferred way deploy and manage your application instances. Kubernetes 1.2 introduced two new concepts - Replica Set, and Deployments.

Replica Set is the next-generation Replication Controller. The only difference between a Replica Set and a Replication Controller right now is the selector support. Replica Set supports the new set-based selector requirements whereas a Replication Controller only supports equality-based selector requirements.

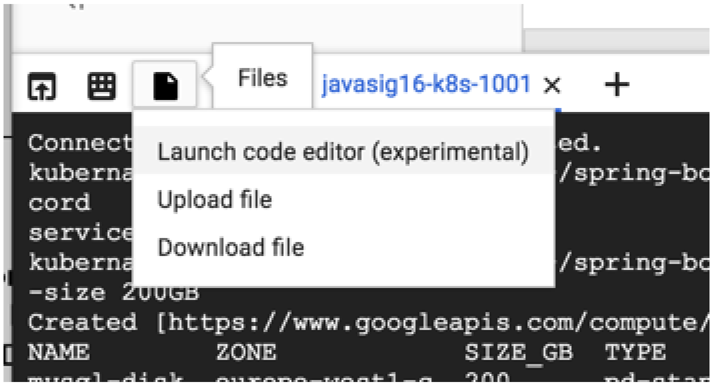
For example, Replication Controller can only select pods based on equality, such as "environment = prod", whereas Replica Sets can select using the "in" operator, such as "environment in (prod, qa)". Learn more about the different selectors in the Labels guide.

Deployment provides declarative updates for Pods and Replica Sets. You only need to describe the desired state in a Deployment object, and the Deployment controller will change the actual state to the desired state at a controlled rate for you. You can use deployments to easily:

- Create a Deployment to bring up a Replica Set and Pods.
- Check the status of a Deployment to see if it succeeds or not.
- Later, update that Deployment to recreate the Pods (for example, to use a new image, or configuration).
- Rollback to an earlier Deployment revision if the current Deployment isn't stable.
- Pause and resume a Deployment.

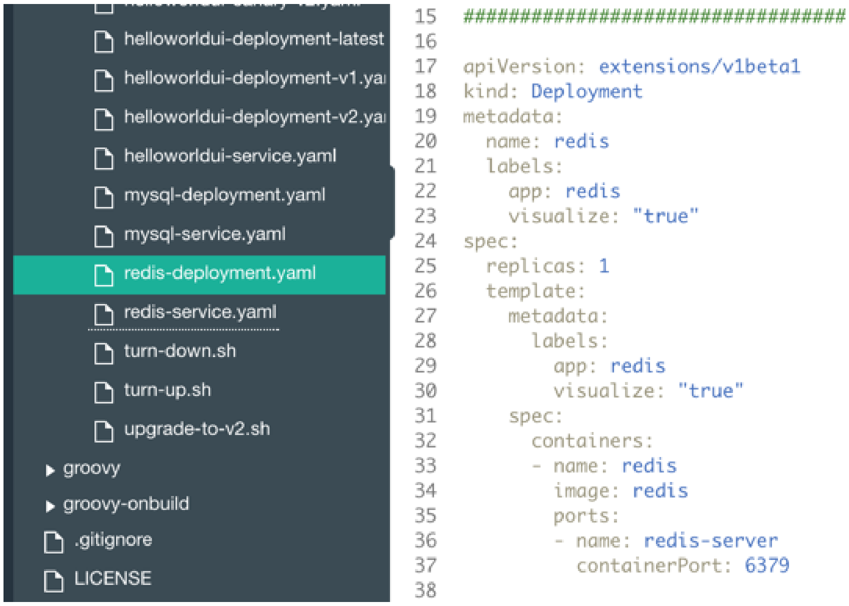
In this lab, because we are working with Kubernetes 1.2+, we will be using Deployment extensively.

Open the `redis-deployment.yaml` to examine the deployment descriptor. You can use your favorite editor such as `vi`, `emacs`, or `nano`, but you can also use Cloud Shell's built-in code editor:



```
Connect                                          ed.
kuberne                                          /spring-bo
cord
service
kuberne                                          /spring-bo
-size 200GB
Created [https://www.googleapis.com/compute/
NAME         ZONE               SIZE_GB  TYPE
```

If you the Cloud Shell Code Editor, a new window will be opened, and you can navigate to open the file:



```yaml
##################################

apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: redis
  labels:
    app: redis
    visualize: "true"
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: redis
        visualize: "true"
    spec:
      containers:
      - name: redis
        image: redis
        ports:
        - name: redis-server
          containerPort: 6379

```

The instructors will explain the descriptor in detail. You can read more about Deployment in the Kubernetes Deployment Guide.

First create a Pod using `kubectl`, the Kubernetes CLI tool:

```
$ kubectl apply -f redis-deployment.yaml --record
```

You should see a Redis instance running:

```
$ kubectl get pods
NAME           READY     STATUS    RESTARTS   AGE
redis-....     1/1       Running   0          20s
```

Note down the Pod name, you can kill this Redis instance::

```
$ kubectl delete pod redis-...
pod "redis-..." deleted
```

Kubernetes will automatically restart this pod for you:

```
$ kubectl get pods
NAME           READY     STATUS    RESTARTS   AGE
redis-....     1/1       Running   0          20s
```

Kubernetes is container format agnostic. In your lab, we are working with Docker containers. Keep in mind that Kubernetes work with other container formats too. You can see that the Docker container is running on one of the machines. First, find the node name that Kubernetes scheduled this container to:

```
$ kubectl get pods -owide
NAME        READY     STATUS    RESTARTS   AGE       NODE
redis-...   1/1       Running   0          2m        gke-guestbook-...
```

The value under the label NODE is the name of the node.

You can then SSH into that node:

```
$ gcloud compute ssh <NODE NAME>
WARNING: The private SSH key file for Google Compute Engine does not exist.
WARNING: You do not have an SSH key for Google Compute Engine.
WARNING: [/usr/bin/ssh-keygen] will be executed to generate a key.
This tool needs to create the directory [/home/kubernaut1119/.ssh]
before being able to generate SSH keys.

Do you want to continue (Y/n)? Y

Generating public/private rsa key pair.
Enter passphrase (empty for no passphrase): [Hit Enter]
Enter same passphrase again: [Hit Enter]
Your identification has been saved in /home/kubernaut1119/.ssh/google_compute_engine.
Your public key has been saved in /home/kubernaut1119/.ssh/google_compute_engine.pub.
The key fingerprint is:
…
```

```
someuser@<node-name>:~$
```

You can then use docker command line to see the running container:

```
someuser@<node-name>:~$ sudo docker ps
CONTAINER ID        IMAGE           COMMAND                CREATED             STATUS
67672e8118fd        redis:latest    "/entrypoint.sh        About an hour ago   Up
055d4b03a1a5        gcr.io/…        "/pause"               5 minutes ago       Up
...
someuser@<node-name>:~$ exit
```

There are other containers running too. The interesting one is the pause container. The atomic unit Kubernetes can manage is actually a Pod, not a container. A Pod can be composed of multiple tightly-coupled containers that is guaranteed to scheduled onto the same node, and will share the same Pod IP address, and can mount the same volumes.. What that essentially means is that if you run multiple containers in the same Pod, they will share the same namespaces.

A pause container is how Kubernetes use Docker containers to create shared namespaces so that the actual application containers within the same Pod can share resources.

Important: Make sure you exit from the SSH before you continue.

```
someuser@<node-name>:~$ exit
```

You can also launch a command or start a shell directly within the container using `kubectl exec` command. Let's open a shell inside of the Redis container:

```
$ kubectl exec -ti redis-... /bin/bash
root@redis...:/data# ls /
bin  boot  data  dev  etc  home ...
```

The Pod name is automatically assigned as the hostname of the container:

```
root@redis...:/data# hostname
redis-....
root@helloworld-...:/app/src# hostname -i
10.104.1.5
root@helloworld-...:/app/src# exit
```

Each Pod is also automatically assigned an ephemeral internal IP address:

```
root@helloworld-...:/data# hostname -i
10.104.1.5
```

Important: make sure you exit from the container shell before you continue.

```
root@helloworld-...:/data# exit
```

Lastly, any of the container output to STDOUT and STDERR will be accessible as Kubernetes logs:

```
$ kubectl logs redis-...
```

You can tail the logs too:

```
$ kubectl logs -f redis-...
```

Deploy a Redis Service

Duration: 3:00

Each Pod has a unique IP address - but the address is ephemeral. The Pod IP addresses are not stable and it can change when Pods start and/or restart. A service provides a single access point to a set of pods matching some constraints. A Service IP address is stable.

Open the `redis-service.yaml` to examine the service descriptor. The important part about this file is the `selector` section. This is how a service knows which pod to route the traffic to, by matching the selector labels with the labels of the pods:

```
kind: Service
apiVersion: v1
metadata:
  name: redis
  labels:
    app: redis
    visualize: "true"
spec:
  ports:
    - port: 6379
      targetPort: 6379
  selector:
    app: redis
```

The instructors will explain the descriptor in detail. You can read more about Service in the Kubernetes Services Guide.

Create the Redis service:

```
$ kubectl apply -f redis-service.yaml --record
```

And check it:

```
$ kubectl get services
```

```
NAME         CLUSTER-IP      EXTERNAL-IP   PORT(S)    AGE
kubernetes   10.107.240.1    <none>        443/TCP    13m
redis        10.107.247.16   <none>        6379/TCP   52s
```

Deploy MySQL and Service

Duration: 4:00

MySQL uses persistent storage. Rather than writing the data directly into the container image itself, our example stores the MySQL in a Google Compute Engine disk. Before you can deploy the pod, you need to create a disk that can be mounted inside of the MySQL container:

```
$ gcloud compute disks create mysql-disk --size 200GB
Created [...].
NAME       ZONE           SIZE_GB TYPE        STATUS
mysql-disk europe-west1-c 200     pd-standard READY
```

Note: If you see the message that the disk is not formatted - don't worry. It'll be formatted automatically when it's being used in the later step.

Open the `mysql-deployment.yaml` to examine the service descriptor. The important part about this file is the `volumes` and `volumeMounts` section. This is how a service knows which Pod to route the traffic to, by matching the selector labels with the labels of the Pods.

This section describes that the Pod needs use a Google Compute Engine Persistent Disk that you created earlier, and also mounting that disk into a path specific to the MySQL container:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  name: mysql
  labels:
    app: mysql
    visualize: "true"
spec:
  replicas: 1
  template:
    ...
    spec:
      containers:
      - name: mysql
        ...
        volumeMounts:
        - name: mysql-persistent-storage
          mountPath: /var/lib/mysql
      volumes:
```

```
      - name: mysql-persistent-storage
        gcePersistentDisk:
          # This GCE PD must already exist.
          pdName: mysql-disk
          fsType: ext4
```

The instructors will explain the descriptor in detail. You can read more about Volumes in the Kubernetes Volumes Guide.

You can then deploy both the MySQL Pod and the Service with a single command:

```
$ kubectl apply -f mysql-deployment.yaml -f mysql-service.yaml --record
```

Lastly, you can see the Pods and service status via the command line. Recall the command you can use to see the status (hint: `kubectl get …`). Make sure the status is `Running` before continuing.

In Kubernetes 1.4+, volume provision can be automatic in supported cloud platforms. Rather than creating a disk ahead of the time, you can simply say you need a volume - Kubernetes will automatically create the disk behind the scenes. See Kubernetes Persistent Volumes design.

You can find example of automatic provisioning in this repository: https://github.com/saturnism/spring-boot-docker/tree/master/examples/kubernetes-1.3.

Deploy Microservices

Duration: 5:00

We have two separate services to deploy:

- the Guestbook service (that writes to the MySQL database)
- a Hello World service

Both services are containers whose images contain self-executing JAR files. The source is available in the `examples` directory if you are interested in seeing it.

When deploying these microservices instances, we want to make sure that:

- We can scale the number of instances once deployed.
- If any of the instances becomes unhealthy and/or fails, we want to make sure they are restarted automatically.
- If any of the machines that runs the service is down (scheduled or unscheduled), we need to reschedule the microservice instances to another machine.

First, deploy the Hello World:

```
$ kubectl apply -f helloworldservice-deployment-v1.yaml \
                 -f helloworldservice-service.yaml \
                 --record
```

Once created, you can see the replicas with:

```
$ kubectl get deployment
NAME                 DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
helloworld-service   2         2         2            0           28s
mysql                1         1         1            1           2m
redis                1         1         1            1           11m
```

You can see the pods running:

```
$ kubectl get pods
NAME                                READY     STATUS              RESTARTS   AGE
helloworld-service-1726325642-fva3a   1/1       Running             0          1m
helloworld-service-1726325642-ujq2o   1/1       Running             0          1m
mysql-3871635011-82u7v              1/1       Running             0          2m
redis-2107737895-mnxr6              1/1       Running             0          11m
```

The Deployment, behind the scenes, creates a Replica Set. A Replica Set ensures the number of replicas (instances) you need to run at any given time. You can also see the Replica Set:

```
$ kubectl get rs
NAME                            DESIRED   CURRENT   AGE
helloworld-service-1726325642   2         2         2m
mysql-3871635011                1         1         4m
redis-2107737895                1         1         13m
```

Notice that because we also used Deployment to deploy both MySQL and Redis - each of those deployments created its own Replica Set as well.

Our descriptor file specified 2 replicas. So, if you delete one of the pods (and now you only have 1 replica rather than 2), the Replica Set will notice that and start another pod for you to meet the configured 2 replicas specification. Find a helloworld-service pod, and delete it. Let's try it!

Lastly, let’s create the Guestbook Service replication controller and service too!

```
$ kubectl apply -f guestbookservice-deployment.yaml \
                -f guestbookservice-service.yaml \
                --record
```

A word on networking

Duration: 7:00

Since we are running two instances of the Hello World Service (one instance in one pod), and that the IP addresses are not only unique, but also ephemeral - how will a client reach our services? We need a way to discover the service.

In Kubernetes, Service Discovery is a first class citizen. We created a Service that will:

- act as a load balancer to load balance the requests to the pods, and
- provide a stable IP address, allow discovery from the API, and also create a DNS name!

If you login into a container (find and use the Redis container), you can access the `helloworldservice` via the DNS name:

```
$ kubectl exec -ti guestbook-service... /bin/bash
root@guestbookservice:/# wget -qO- http://helloworld-service:8080/hello/Ray
{"greeting":"Hello Ray from helloworld-service-... with
1.0","hostname":"helloworld-service-...","version":"1.0"}root@red
is:/data#
root@guestbookservice:/# exit
```

Deploy the Frontend

Duration: 5:00

You know the drill by now. We first need to create the replication controller that will start and manage the frontend pods, followed by exposing the service. The only difference is that this time, *the service needs to be externally accessible*. In Kubernetes, you can instruct the underlying infrastructure to create an external load balancer, by specifying the Service Type as a `LoadBalancer`.

You can see it in the `helloworldui-service.yaml`:

```
kind: Service
apiVersion: v1
metadata:
  name: helloworldui
  labels:
    name: helloworldui
    visualize: "true"
spec:
  type: LoadBalancer
  ports:
    - port: 80
      targetPort: http
  selector:
    name: helloworldui
```

Let’s deploy both the replication controller and the service at the same time:

```
$ kubectl apply -f helloworldui-deployment-v1.yaml \
                 -f helloworldui-service.yaml \
                 --record
```

You can find the public IP in the output in a minute or two:

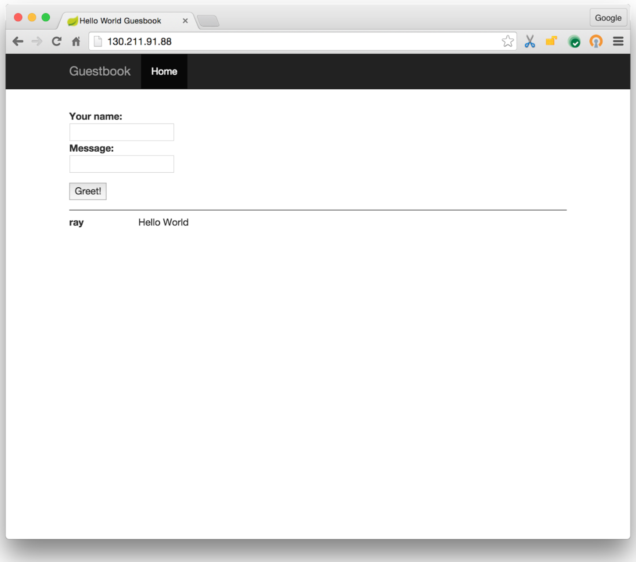
```
$ kubectl get services helloworld-ui
```

```
NAME            TYPE            CLUSTER-IP      EXTERNAL-IP      PORT(S)       ...
helloworld-ui   LoadBalancer    10.47.243.24    X.X.X.X          80:31624/TCP   9m
```

Note: The external load balancer may take a minute or two to create. Please retry the command above until the `EXTERNAL-IP` entry shows up.

You can now access the guestbook via the ingress IP address by navigating the browser to `http://INGRESS_IP/`.

You should see something like this:



ray Hello World

Scaling In and Out

Duration: 5:00

Scaling the number of replicas of our Hello World service is as simple as running :

```
$ kubectl scale deployment helloworld-service --replicas=4
```

You can very quickly see that the replication controller has been updated:

```
$ kubectl get deployment
NAME                 DESIRED    CURRENT    UP-TO-DATE    AVAILABLE    AGE
guestbook-service    2          2          2             2            18m
helloworld-service   4          4          4             2            24m
helloworld-ui        2          2          2             2            4m
mysql                1          1          1             1            26m
redis                1          1          1             1            35m

$ kubectl get pods
```

```
NAME                       READY     STATUS              RESTARTS   AGE
guestbook-service-...      1/1       Running             0          18m
guestbook-service-...      1/1       Running             0          18m
helloworld-service-...     0/1       ContainerCreating   0          25s
helloworld-service-...     1/1       Running             0          19m
helloworld-service-...     1/1       Running             0          24m
helloworld-service-...     0/1       ContainerCreating   0          25s
...
```

Let's scale out even more!

```
$ kubectl scale deployment helloworld-service --replicas=15
```

Let’s take a look at the status of the Pods:

```
$ kubectl get pods
NAME                                         READY     STATUS    RESTARTS   AGE
guestbook-service-3803699114-d73go    1/1       Running   0          21m
guestbook-service-3803699114-qnhsf    1/1       Running   0          21m
helloworld-service-1726325642-0yot3   1/1       Running   0          1m
helloworld-service-1726325642-2xlqg   1/1       Running   0          2m
helloworld-service-1726325642-4izw5   1/1       Running   0          1m
helloworld-service-1726325642-cal7t   1/1       Running   0          1m
helloworld-service-1726325642-de1h4   1/1       Running   0          22m
helloworld-service-1726325642-il7aj   0/1       Pending   0          1m
helloworld-service-1726325642-m901w   1/1       Running   0          1m
helloworld-service-1726325642-nz6py   1/1       Running   0          1m
helloworld-service-1726325642-ptdbp   0/1       Pending   0          1m
helloworld-service-1726325642-tftbh   1/1       Running   0          1m
helloworld-service-1726325642-ujq2o   1/1       Running   0          27m
helloworld-service-1726325642-z25ba   1/1       Running   0          2m
helloworld-ui-1131581392-qa1sy        1/1       Running   0          6m
helloworld-ui-1131581392-yyuuw        1/1       Running   0          6m
mysql-3871635011-82u7v                1/1       Running   0          28m
redis-2107737895-mnxr6                1/1       Running   0          37m
```

Oh no! Some of the Pods are in the `Pending` state! That is because we only have four physical nodes, and the underlying infrastructure has run out of capacity to run the containers with the requested resources.

Pick a Pod name that is associated with the Pending state to confirm the lack of resources in the detailed status:

```
$ kubectl describe pod helloworld-service...
Name:                           helloworldui-service...
Namespace:                      default
Image(s):                       saturnism/spring-boot-helloworld-ui:v1
Node:                           /
Labels:                         name=helloworldui, ...
Status:                         Pending
...
Events:
  FirstSeen     LastSeen        Count   From                        SubobjectPath   Type
Reason                  Message
  ---------     --------        -----   ----                        -------------
--------        ------                  -------
  1m            1m              2       {default-scheduler }                        Warning
FailedScheduling        pod (helloworld-service-172632564
2-ptdbp) failed to fit in any node
fit failure on node (gke-guestbook-default-pool-8de71693-e0hx): Node didn't have enough
resource: CPU, requested: 100, used: 920, capacity: 1000
fit failure on node (gke-guestbook-default-pool-8de71693-6r1e): Node didn't have enough
resource: CPU, requested: 100, used: 1000, capacity: 1000
```

Note: At this point, you may be wondering how did we specify how much CPU/memory each pod should use? How do we know how much CPU/memory each node can support? We'll get into this in the later section of the lab!

The good news is that we can easily spin up another Compute Engine instance to append to the cluster. First, find the Compute Engine Instance Group that’s managing the Kubernetes nodes (the name is prefixed with “`gke-`”). But you can resize the cluster simply from the command line:

```
$ gcloud container clusters resize guestbook --size=5
Pool [default-pool] for [guestbook] will be resized to 5.
Do you want to continue (Y/n)?  Y
```

You can see a new Compute Engine instance is starting:

```
$ gcloud compute instances list
gke-guestbook-default-pool-3a020500-2t4q  europe-west1-c  n1-standard-1
10.240.0.3   130.211.64.214   RUNNING
...
gke-guestbook-default-pool-3a020500-t1ud  europe-west1-c  n1-standard-1
10.240.0.6   146.148.13.23    STAGING
...
```

Once the new instance has joined the Kubernetes cluster, you’ll should be able to see it with this command:

```
$ kubectl get nodes
NAME                               LABELS                           STATUS
gke-guestbook-a3e896df-node-3d99   kubernetes.io/hostname=...   Ready
gke-guestbook-a3e896df-node-dt8a   kubernetes.io/hostname=...   Ready
gke-guestbook-a3e896df-node-rqfg   kubernetes.io/hostname=...   Ready
gke-guestbook-a3e896df-node-vt3l   kubernetes.io/hostname=...   Ready
gke-guestbook-a3e896df-node-vt34   kubernetes.io/hostname=...   Ready
```

Use `kubectl get pods` to see the that the `Pending` pods have been scheduled.

Once you see they are scheduled, reduce the number of replicas back to 2 so that we can free up resources for the later labs:

```
$ kubectl scale deployment helloworld-service --replicas=2
```

Rolling Update

Duration: 7:00

It’s easy to update & rollback.

In this lab, we'll switch to the `examples/helloworld-ui` directory and make a minor change to the `templates/index.html` (e.g., change the background color, title, etc.). You can use your favorite editors, or use the Cloud Shell Code Editor that you used in the previous section.

After modifying the file, you'll rebuild the container and upload it to the Google Container Registry.

First, look up your Project ID:

```
# Find the Project ID
$ gcloud config get-value core/project
Your active configuration is: [cloudshell-XXXX]
yourproject-XXXX                    ← this is your Project ID!
```

Set the Project ID as an environmental variable:

```
$ export PROJECT_ID=$(gcloud config get-value core/project)
$ echo ${PROJECT_ID}
yourproject-XXXX
```

Change into the Helloworld UI source directory:

```
$ cd ~/spring-boot-docker/examples/helloworld-ui
```

Make some changes to `templates/index.html`. Changing the background is always a fun one to try. Once you've made the changes, build and push a new version of the Docker container:

```
$ docker build -t gcr.io/${PROJECT_ID}/helloworld-ui:v2 .
$ gcloud docker -- push gcr.io/${PROJECT_ID}/helloworld-ui:v2
```

Note: Because the Cloud Shell is running inside of a small VM instance it’s not the fastest when it comes to extracting and buffering the container images! Once you start the push, it’s a good time to take a break or … why not watch another video? This one about Google Container Registry: https://www.youtube.com/watch?v=9CDb9ZSsfV4 !

Because we are managing our Pods with Deployment, it simplifies re-deployment with a new image and configuration. To use Deployment to update to Helloworld UI 2.0, first, edit the Deployment:

```
$ kubectl edit deployment helloworld-ui --record
```

Note: By default this is going to use `vi` as the editor! If you don't want to use `vi`, you can set the environmental variable `EDITOR` or `KUBE_EDITOR` to point to your favorite editor. E.g., `EDITOR=nano kubectl edit deployment helloworld-ui`.

You can then edit the Deployment directly in the editor. Change the image to the one you just created:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
…
spec:
…
  template:
    …
    spec:
      …
      containers:
      - image: gcr.io/MAKE_SURE_TO_REPLACE_THIS_WITH_PROJECT_ID/helloworld-ui:v2
      ...
```

Save and exit the editor, and you should see the message:

```
deployment "helloworld-ui" edited
```

That's it! Kubernetes will then perform a rolling update to update all the versions from 1.0 to 2.0.

Note: In this lab, we use `kubectl edit` extensively to interactively update descriptors. You can use `kubectl patch` or `kubectl set` commands to make updates too. This is great for scripting the updates.

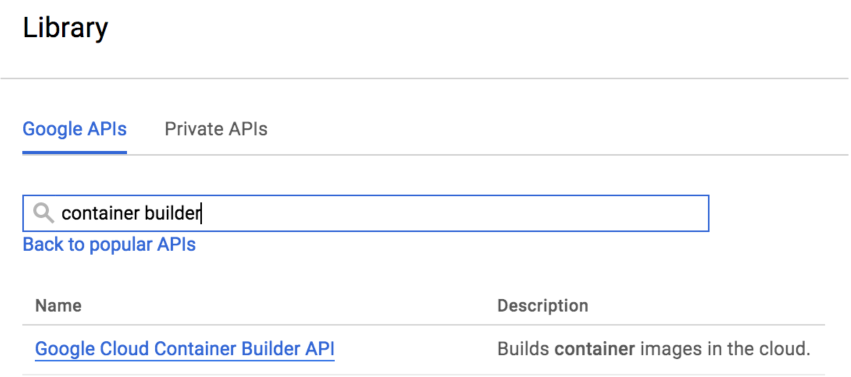
For example, to update the image, you can do:

```
kubectl set image deployment/helloworld-ui \
  helloworld-ui=gcr.io/${PROJECT_ID}/helloworld-ui:v2
```

Google Cloud Container Builder

In the previous exercise, we built the container with regular Docker commands (`docker build …`), and then manually pushed the image into Google Cloud Platform's Container Registry. It's also possible to defer both steps to the server side Container Builder, which can build and push the container image without having local installation of Docker.

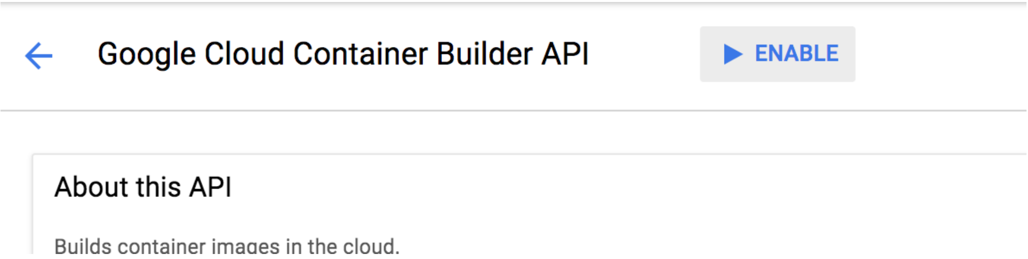
First, enable Container Builder API in **API Manager > Library.**
Search for **Container Builder**, click into **Google Cloud Container Builder API**:



container builder

Name	Description
Google Cloud Container Builder API	Builds **container** images in the cloud.

Finally, click **Enable API**:



Google Cloud Container Builder API

About this API

Builds container images in the cloud.

Note: Alternatively, you can also enable APIs directly from command line, for example:

```
$ gcloud services enable cloudbuild.googleapis.com
```

Once the Google Cloud Container Builder API is enabled, you can run the following command to build and push your image all from the Container Builder service:

```
$ gcloud container builds submit . -t gcr.io/${PROJECT_ID}/helloworld-ui:v3
```

Note: You can also trigger automatic container builds from a source repository event. For example, you can trigger a new container build whenever you commit code to a repository branch, or whenever you created a new release tag for a repository.

Rollback a Deployment

Duration: 10:00

You can see your deployment history:

```
$ kubectl rollout history deployment helloworld-ui
REVISION        CHANGE-CAUSE
1               <none>
2               kubectl edit deployment helloworld-ui --record
```

Because when we edited the Deployment, we supplied the `--record` argument, the Change Cause value is automatically recorded with the command line that was executed.

You can rollback a Deployment to a previous revision:

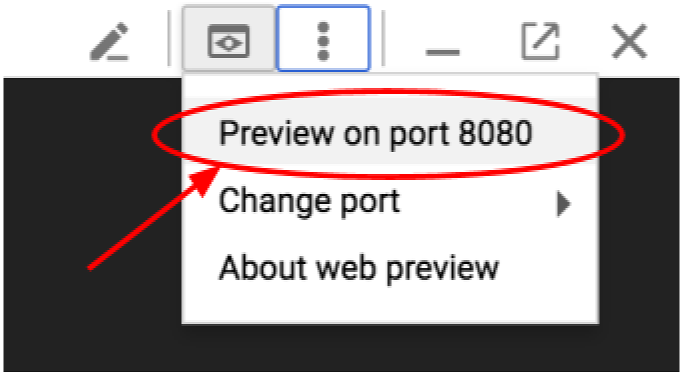
```
$ kubectl rollout undo deployment helloworld-ui
deployment "helloworld-ui" rolled back
```

Kubernetes Dashboard

~~You can access the Kubernetes Dashboard via a secure proxied connection. First, start the proxy to listen on port 8080:~~

```
~~$ kubectl proxy -p 8080~~
```

~~This will establish a secure connection to the Kubernetes master server, but accessible from the machine's port 8080. Because we ran this command line in the Cloud Shell environment, to get to this port, we need to use the Web Preview function of Cloud Shell:~~



~~This will open a URL that connects to the Cloud Shell machine's port 8080, for example:~~

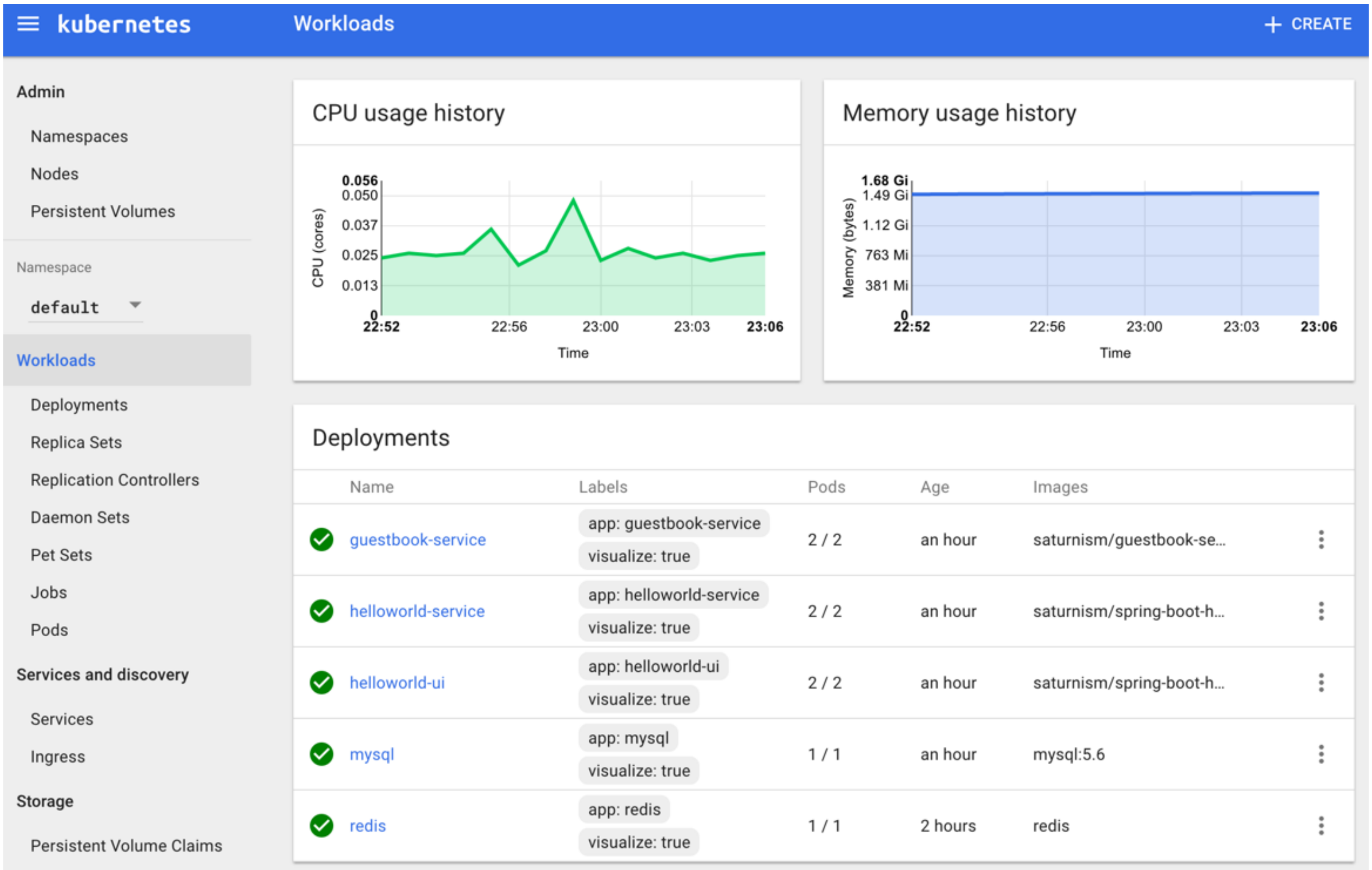
```
~~https://8080-dot-3042746-dot-devshell.appspot.com/?authuser=0~~
```

~~This URL will establish a connection to the Kubernetes proxy running inside of Cloud Shell that's listening on port 8080.~~

~~Replace the path portion of the URL, and navigate to:~~

```
~~https://.../api/v1/namespaces/kube-system/services/kubernetes-dashboard/proxy~~
```

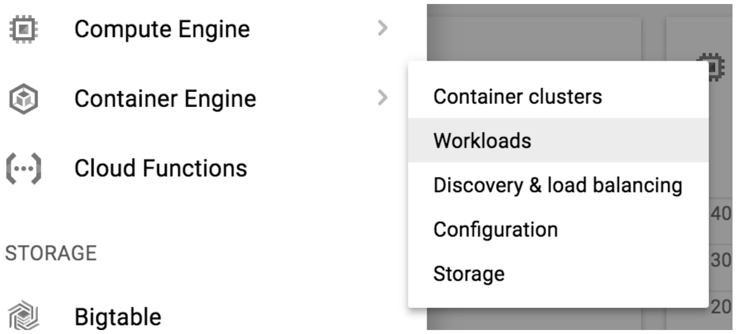
~~This should open up the Kubernetes Dashboard:~~



Deployments

Name	Labels	Pods	Age	Images
✓ guestbook-service	app: guestbook-service visualize: true	2 / 2	an hour	saturnism/guestbook-se...
✓ helloworld-service	app: helloworld-service visualize: true	2 / 2	an hour	saturnism/spring-boot-h...
✓ helloworld-ui	app: helloworld-ui visualize: true	2 / 2	an hour	saturnism/spring-boot-h...
✓ mysql	app: mysql visualize: true	1 / 1	an hour	mysql:5.6
✓ redis	app: redis visualize: true	1 / 1	2 hours	redis

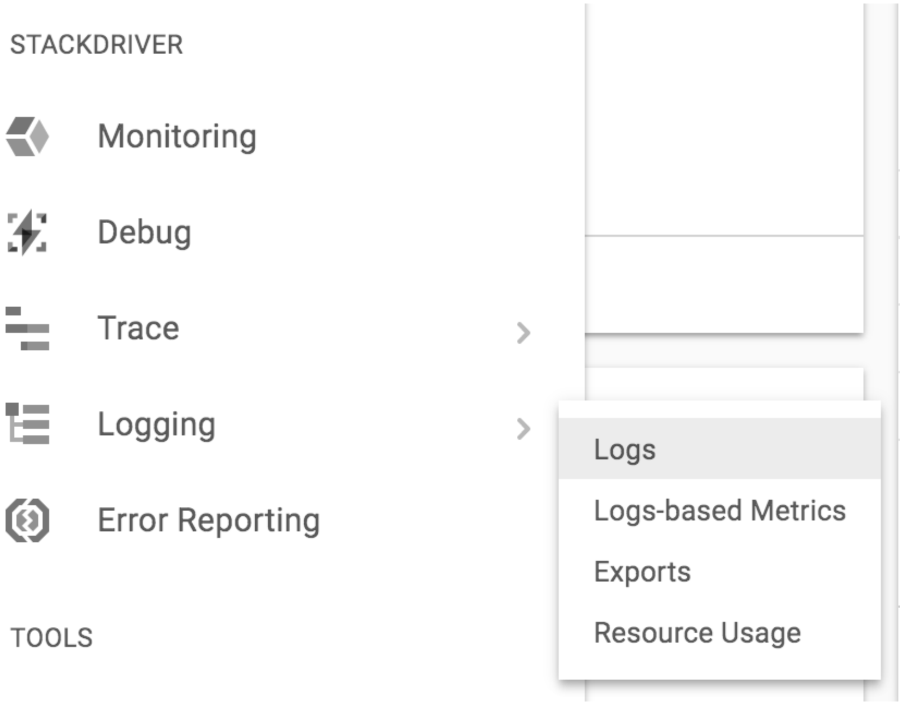
You can also access Google Cloud's Kubernetes dashboard by navigating to **Compute** → **Kubernetes Engine** → **Workloads**



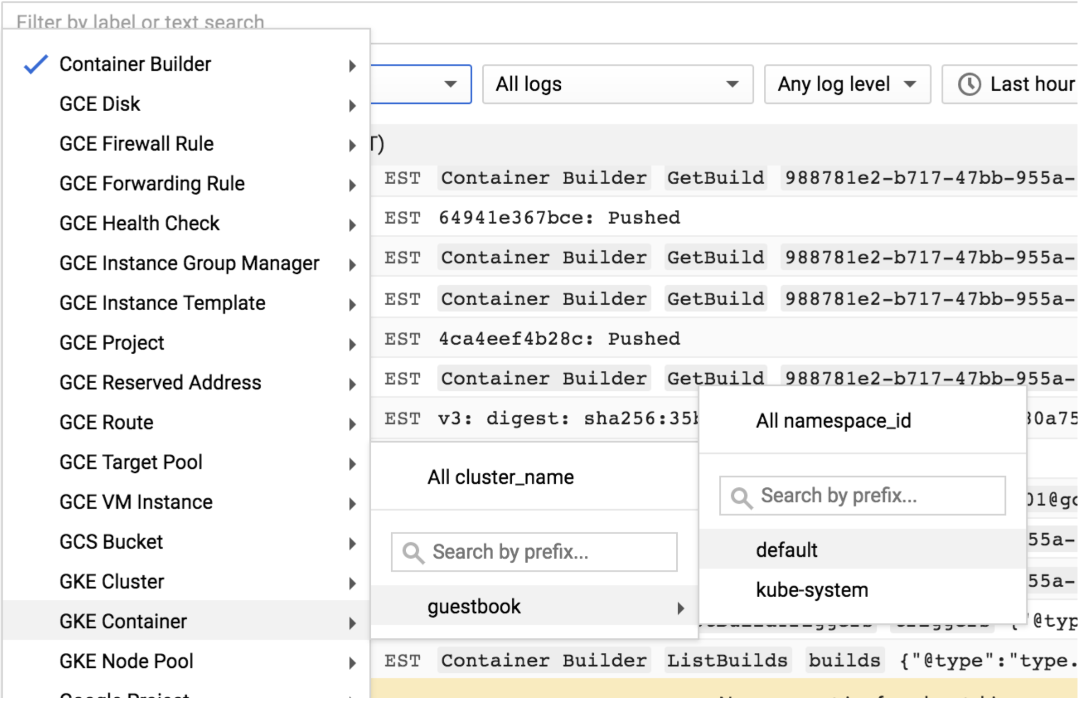
Google Cloud Logging

Duration: 3:00

During the lab, you've used `kubectl logs` command to retrieve the logs of a container running inside of Kubernetes. When you use Google Kubernetes Engine to run managed Kubernetes clusters, all of the logs are automatically forwarded and stored in Google Cloud Logging. You can see all the log output from the pods by navigating to **Stackdriver** → **Logging** → **Logs** in the Google Cloud console:



Once in the logging console, you can navigate to **Kubernetes cluster** > **guestbook** > **default** to see all of the logs collected from STDOUT:



```
EST  Container Builder  GetBuild  988781e2-b717-47bb-955a-
EST  64941e367bce: Pushed
EST  Container Builder  GetBuild  988781e2-b717-47bb-955a-
EST  Container Builder  GetBuild  988781e2-b717-47bb-955a-
EST  4ca4eef4b28c: Pushed
EST  Container Builder  GetBuild  988781e2-b717-47bb-955a-
EST  v3: digest: sha256:35
EST  Container Builder  ListBuilds  builds  {"@type":"type.
```

From here, you can optionally export the logs into Google BigQuery for further log analysis, or setup log-based alerting. We won’t get to do this during the lab today.

Kubernetes - The Advanced

Namespaces

A single cluster can be carved into multiple namespaces. Resource names (like Deployment, Service, etc) need to be unique within a namespace, but can be reused in different namespaces. E.g,, you can create a namespace *staging* and a namespace *qa*. You can deploy exactly the same application into both namespaces. Each namespace can also have its own resource constraint. E.g., *qa* namespace can be assigned 10 CPU cores limit while *staging* namespace can have more.

Create a new namespace:

```
$ kubectl create ns staging
```

See what's deployed there:

```
$ kubectl --namespace=staging get pods
No resources found.
```

Let's deploy something!

```
$ kubectl --namespace=staging apply -f ~/spring-boot-docker/examples/kubernetes-1.6
deployment "guestbook-service" created
service "guestbook-service" created
deployment "helloworld-service" created
service "helloworld-service" created
deployment "helloworld-ui" created
service "helloworld-ui" created
deployment "mysql" created
persistentvolumeclaim "mysql-pvc" created
service "mysql" created
deployment "redis" created
service "redis" created
```

The entire application is now deployed into staging namespace:

```
$ kubectl --namespace=staging get pods
guestbook-service-448345361-c0z1x     1/1       Running   0          1m
guestbook-service-448345361-tl660     1/1       Running   0          1m
helloworld-service-3269930993-4lhlt   1/1       Running   0          1m
helloworld-service-3269930993-svgpc   1/1       Running   0          1m
helloworld-ui-3002276840-43zjd        1/1       Running   0          1m
helloworld-ui-3002276840-vmnk8        1/1       Running   0          1m
mysql-4118493817-tjn78                1/1       Running   0          1m
redis-2180715406-4t6br                1/1       Running   0          1m
```

Find the frontend UI public IP address:

```
$ kubectl --namespace=staging get svc helloworld-ui
```

```
NAME            CLUSTER-IP     EXTERNAL-IP      PORT(S)        AGE
helloworld-ui   10.3.250.216   X.X.X.X          80:31116/TCP   2m
```

Open the browser and see the staging environment.

If you ever need to remove an entire environment under a namespace, simply delete the namespace:

```
$ kubectl delete namespace staging
namespace "staging" deleted
```

This will propagate and delete every resource under this namespace, including automatically provisioned external load balancers, and volumes. The operations are asynchronous. Even though the command line says the namespace was deleted - the resources are still being deleted asynchronously.

Manage Compute Resources

You can specify the resource needs for each of the containers within the Deployment descriptor file. By default, each container is given 10% of a CPU and no memory use restrictions. You can see the current resource by describing a Pod instance, look for the Requests/Limits lines.

```
$ kubectl describe pod helloworld-ui-...
Name:           helloworld-ui-3230519151-cusci
Namespace:      default
Node:           gke-guestbook-default-pool-ad6862db-tvu0/10.132.0.4
Start Time:     Mon, 07 Nov 2016 23:51:56 +0100
Labels:         app=helloworld-ui
                pod-template-hash=3230519151
                version=1.0
                visualize=true
Status:         Running
IP:             10.104.1.6
Controllers:    ReplicaSet/helloworld-ui-3230519151
Containers:
  helloworld-ui:
    Container ID:
docker://03c6b58d866c721611ebdabbd243716437119a2b300d513a3c040abf73c26b6d
    Image:              saturnism/spring-boot-helloworld-ui:v1
    Image ID:
docker://sha256:e3757c8390a74528641c71ec43077a00811dd8dca24de9738a678aa51bb6e4fb
    Port:               8080/TCP
    Requests:
      cpu:              100m
    State:              Running
      Started:          Mon, 07 Nov 2016 23:53:01 +0100
```

In Kubernetes, you can reserve capacity by setting the Resource Requests to reserve more CPU and memory:

First, edit the deployment:

```
$ kubectl edit deployment helloworld-ui
```

Add the CPU and memory requests explicitly:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  ...
spec:
  ...
  template:
    ...
    spec:
      containers:
      - name: helloworld-ui
        image: saturnism/spring-boot-helloworld-ui:v1
        ...
        ~~resources: {} ## Find this & Remove. Replace with the following:~~
        resources:
          requests:
            cpu: 200m
            memory: 128Mi
        ...
```

In Kubernetes, CPU can be divided into milli-cores (0.1% of a CPU). 1000m means one thousand milli-cores, which is 1 CPU. In this example, 500m means 50% of a CPU.

If the application need to consume more CPU - that's OK as well, the applications are allowed to burst. You can also set an upper limit to how much the application burst by setting the Resource Limit:

First, edit the deployment:

```
$ kubectl edit deployment helloworld-ui
```

Add the CPU and memory limits:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  ...
spec:
  ...
  template:
    ...
    spec:
      containers:
      - name: helloworld-ui
        image: saturnism/spring-boot-helloworld-ui:v1
        resources:
          requests:
            ...
          limits:
            cpu: 500m
            memory: 256Mi
        ...
```

Note: Wait a minute! Even though this deployment didn't have any resource limits configured, but we clearly saw that it defaulted to a request of 100m of CPU. How did that happen?

You can apply a "default" resource limits on via namespaces. We initially deployed all the workload into the default namespace. That namespace has a default limit range of 100m of CPU.

```
$ kubectl describe ns default
```

You can see the actual Limit Range configuration:

```
$ kubectl get limitrange limits -oyaml
```

Health Checks

Duration: 10:00

During rolling update, a pod is removed as soon as a newer version of pod is up and ready to serve. By default, without health checks, Kubernetes will route traffic to the new pod as soon as the pods starts. But, it's most likely that your application will take some time to start, and if you route traffic to the application that isn't ready to serve, your users (and/or consuming services) will see errors. To avoid this, Kubernetes comes with two types of checks: Liveness Probe, and Readiness Probe.

After a container starts, it is not marked as Healthy until the Liveness Probe succeeds. However, if the number of Liveness Probe failures exceeds a configurable failure threshold, Kubernetes will mark the pod unhealthy and attempt to restart the pod.

When a pod is Healthy doesn't mean it's ready to serve. You may want to warm up requests/cache, and/or transfer state from other instances. You can further mark when the pod is Ready to serve by using a Readiness Probe.

Let's add a Liveness Probe to our Helloworld Service by editing the Deployment:

```
$ kubectl scale deployment helloworld-service --replicas=2
$ kubectl edit deployment helloworld-service --record
```

In the editor, add both a liveness probe and a readiness probe.

```
apiVersion: extensions/v1beta1
kind: Deployment
…
spec:
…
```

```
  template:
    …
    spec:
      …
      containers:
      - image: saturnism/spring-boot-helloworld-service:...
        livenessProbe:
          initialDelaySeconds: 30
          httpGet:
            path: /hello/healthcheck
            port: 8080
        readinessProbe:
          httpGet:
            path: /hello/ready
            port: 8080
```

Note: You can configure both Liveness Probe and Readiness Probe by checking via a HTTP GET request, a HTTPS GET request, TCP port connectivity, or even a shell script! See the Liveness and Readiness Probe Guide more information.

Note: In a production scenario, the Liveness Probe and the Readiness Probe will probably be different. Your application may be alive, but it's not ready to serve. E.g., you may want to preload cache after startup, but don't serve until the cache is preloaded.

Graceful Shutdown

Duration: 5:00

When a pod needs to be deleted (such as reducing the number of replicas), Kubernetes will send the SIGTERM signal to the process. The process should perform all the cleanups. However, we cannot wait forever for the process to exit. By default, Kubernetes waits 30 seconds before sending the final SIGKILL signal to kill the process. If your process needs more or less time, you can configure this through termination grace periods configuration (see guide).

Optionally, you can also ask Kubernetes to execute a shutdown command via the pre-stop lifecycle hook. Read through the Lifecycle Hooks and Termination Notice Guide the learn more - we won't implement this during the lab.

Configuring Your Application

Duration: 20:00

The Helloworld Service is configured to return a message that uses the following template, configured in the `examples/helloworld-service/application.properties` file:

```
$ cd ~/spring-boot-docker/examples/helloworld-service
```

See the `application.properties` file:

```
greeting=Hello $name from $hostname with $version
```

There are several ways to update this configuration. We'll go through a couple of them, including:

- Environmental variable
- Command line argument
- and, Config Map

Environmental Variable

Spring applications can read the override configuration directly from an environmental variable. In this case, the environmental variable is defaulted to `GREETING`. You can specify the environmental variable directly in the Deployment as well, by first edit the Deployment:

```
$ kubectl edit deployment helloworld-service --record
```

In the editor, add the environmental variable:

```
apiVersion: extensions/v1beta1
kind: Deployment
…
spec:
…
  template:
    …
    spec:
      …
      containers:
      - image: saturnism/spring-boot-helloworld-service:...
        env:
        - name: GREETING
          value: Hello $name from envvar!
      ...
```

Again, through the use of Deployments, it'll rolling update all the replicas with the new configuration! If you were to refresh the application, you'll notice that there are no intermittent errors because we also have health checks and readiness checks in place.

Check the application to see it is using the new Greeting string.

Command Line Argument

Next, let's add a configuration via the command line arguments. Remove the environmental variable configurations. You know the drill, edit the Deployment, and add the following section:

```
apiVersion: extensions/v1beta1
kind: Deployment
…
spec:
…
```

```
  template:
    …
    spec:
      …
      containers:
      - image: saturnism/spring-boot-helloworld-service:...
        ~~env:~~
        ~~- name: GREETING~~
          ~~value: Hello $name from envvar!~~
        args:
        - --greeting=Hello $name from args
      ...
```

Note: Yes, there are 3 dashes. The first dash is required by YAML to indicate that this is a list element, followed by a space and two more dashes that is actually passed into the command line argument.

Check the application and submit a name and message to see it is using the new greeting string.

Using ConfigMap

In this section, we'll use Kubernetes 1.2's new feature, ConfigMap, to configure the application. You can store multiple text-based configuration files inside of a single ConfigMap configuration. In our example, we'll store Spring's `application.properties` into a ConfigMap entry.

First, update the `examples/helloworld-service/application.properties` with a new configuration value:

```
greeting=Hello $name from ConfigMap
```

Next, create a ConfigMap entry with this file:

```
$ cd ~/spring-boot-docker/examples/helloworld-service
$ kubectl create configmap greeting-config --from-file=application.properties
configmap "greeting-config" created
```

Let's take a look inside the newly created entry:

```
$ kubectl edit configmap greeting-config
```

You'll see that the `application.properties` is now part of the YAML file:

```
apiVersion: v1
data:
  application.properties: |
    greeting=Hello $name from ConfigMap
kind: ConfigMap
...
```

You can, of course, edit this ConfigMap in the editor too. If you do, edit only the value for the `greeting` variable.

There are several ways to access the values in this ConfigMap:

- Mount the entries (in our case, `application.properties`) as a file.
- Access from the Kubernetes API (we won't cover this today).

Let's mount the configurations as files under a specific directory, e.g., `/etc/config/application.properties`.

First, edit the Helloworld Service Deployment:

```
$ kubectl edit deployment helloworld-service --record
```

In the editor, add volumes and volume mounts (important - indentation matters!):

```
apiVersion: extensions/v1beta1
kind: Deployment
…
spec:
…
  template:
    …
    spec:
      volumes:
      - name: config-volume
        configMap:
          name: greeting-config
      containers:
      - image: saturnism/spring-boot-helloworld-service:...
        args:
        - --spring.config.location=/etc/config/application.properties
        volumeMounts:
        - name: config-volume
          mountPath: /etc/config
      ...
```

This will make the configuration file available as the file `/etc/config/application.properties` and tell Spring Boot to use that file for configuration. Let's verify by going into the pod itself (remember how to do this by using `kubectl exec`?):

First, find the pod name:

```
$ kubectl get pods
NAME                                  READY     STATUS    RESTARTS   AGE
...
helloworld-service-2258836722-arv2f   1/1       Running   0          1m
helloworld-service-2258836722-exlll   1/1       Running   0          1m
...
```

Then, run a shell inside the pod, and see what's in `/etc/config`:

```
$ kubectl exec -ti helloworld-service-... /bin/bash
```

```
root@helloworldservice-...:/app/src# ls /etc/config
application.properties
root@helloworldservice-...:/app/src# cat /etc/config/application.properties
…
root@helloworldservice-...:/app/src# exit
```

Check the application to see it is using the new greeting string.

Last, but not least, you can also specify simple key/value pairs in ConfigMap, and then expose them directly as environmental variables too. See the ConfigMap guide for more examples.

Fun thing to try, edit the content of the ConfigMap:

```
$ kubectl edit configmap greeting-config
```

You'll see that the `application.properties` is now part of the YAML file:

```
apiVersion: v1
data:
  application.properties: |
    greeting=Hello $name from ConfigMap Updated
kind: ConfigMap
...
```

If you go back into the same pod, and see the content of /etc/config/application.properties, you'll see that it's also updated:

```
$ kubectl exec -ti helloworld-service-... /bin/bash
root@helloworldservice-...:/app/src# cat /etc/config/application.properties
…
root@helloworldservice-...:/app/src# exit
```

Note: Don't forget to exit out of the pod environment!

Even though ConfigMap content is automatically updated in the filesystem of the container, it's not the recommended way to update configurations. To provide new configurations, it's better to create a new ConfigMap, e.g., `greeting-config-v2`, then update the deployment to point to the new configuration.

Managing Credentials

Duration: 20:00

ConfigMap is great to store text-based configurations. Depending on your use cases, it may not be the best place to store your credentials (which sometimes may be a binary file rather than text). Secrets can be used to hold sensitive information, such as passwords, OAuth tokens, and SSH keys. Entries in Secrets are Base64 encoded. However, Secrets are not additionally encrypted when stored in Kubernetes.

In this section, we'll create a Secret that contains the MySQL username and password. We'll subsequently update both the MySQL Replication Controller and the Guestbook Service to refer to the same credentials.

First, let's create a Secret with username and password the command line:

```
$ kubectl create secret generic mysql-secret \
      --from-literal=username=root --from-literal=password=yourpassword
secret "mysql-secret" created
```

If you look into the newly created Secret, you'll see that the values are Base64 encoded:

```
$ kubectl edit secret mysql-secret
```

In the Editor, you'll see:

```
apiVersion: v1
data:
  password: eW91cnBhc3N3b3Jk
  username: YXBw
kind: Secret
...
```

In the pods, you can access these values a couple of ways:

- Mount each entry as a file under a directory (similar to what we did with ConfigMap)
- Use Downward API to expose each entry as an Environmental Variable (which you can also do with ConfigMap).

Next, configure the Guestbook Service, by editing the Deployment and updating the Environmental Variables too:

```
$ kubectl edit deployment guestbook-service
```

Then, add a couple of Environmental Variables:

```
apiVersion: extensions/v1beta1
kind: Deployment
…
spec:
  …
  template:
  …
    spec:
      …
      containers:
      - image: saturnism/guestbook-service:latest
        env:
        - name: SPRING_DATASOURCE_USERNAME
          valueFrom:
            secretKeyRef:
              name: mysql-secret
              key: username
        - name: SPRING_DATASOURCE_PASSWORD
          valueFrom:
            secretKeyRef:
              name: mysql-secret
              key: password
...
```

And that's it!

Once the deployment is completed, check that the application is still working.

Note: Keep in mind that Secrets are not encrypted at rest by default. It's good to keep in mind that there are other credential alternatives. For example, you can integrate with Vault, or using a Sealed Secrets.

~~Restricting Network Access with Network Policy~~

~~By default, any Pod in the Kubernetes cluster is able to connect to any other pods, or any of the services. You'll need to rely on application-level security to ensure that a Pod from a Customer application doesn't have the credentials to access a Pod of the HR application via a remote call.~~

~~Kubernetes 1.7 introduced stable support for Network Policy. It's a way to declaratively configure which group of Pods can access what at the network L4 layer. However, enforcing the Network Policy requires a plugin that will enact on the configuration. There are a number of plugins out there, including Calico, Romana and Weave Net.~~

~~Kubernetes Engine has beta support for Network Policy using the Calico plugin. It must be enabled explicitly at the cluster creation, or enabled explicitly on existing cluster. Let's enable Network Policy on our cluster:~~

```
~~$ gcloud beta container clusters update guestbook \~~
~~    --update-addons=NetworkPolicy=ENABLED~~
```

~~Then, ensure that every node in the cluster is applying the Network Policy addon:~~

```
~~$ gcloud beta container clusters update guestbook --enable-network-policy~~
~~Enabling/Disabling Network Policy causes a rolling update of all~~
~~cluster nodes, similar to performing a cluster upgrade.  This~~
~~operation is long-running and will block other operations on the~~
~~cluster (including delete) until it has run to completion.~~
~~Do you want to continue (Y/n)?  Y [enter]~~

~~Updating guestbook...done.~~
```

~~This will take a few minutes since it'll update and restart each of the nodes in the cluster.~~

Autoscaling

Duration: 5:00

Kubernetes 1.2 has built-in Horizontal Pod Autoscaling based on CPU utilization (and custom metrics!). We will only cover autoscaling based on CPU utilization in this lab, since the custom metrics scaling is still in Alpha.

To set up horizontal autoscaling is extremely simple:

```
$ kubectl autoscale deployment helloworld-service --min=2 --max=10 --cpu-percent=80
```

Behind the scenes, Kubernetes will periodically (by default, every 30 seconds) collect CPU utilization and determine the number of pods needed.

You can see the current status of the autoscaler by using the describe command:

```
$ kubectl describe hpa helloworld-service
Name:                           helloworldservice
Namespace:                      default
Labels:                         <none>
Annotations:                    <none>
CreationTimestamp:              Tue, 19 Apr 2016 03:02:18 +0200
Reference:                      Deployment/helloworldservice/scale
Target CPU utilization:         80%
Current CPU utilization:        21%
Min replicas:                   2
Max replicas:                   10
```

It's going to be a little difficult to generate the load needed to kick off the autoscaler. If you are interested, try to install and use Apache HTTP server benchmarking tool `ab`. We won't do that during the lab.

Learn more about Horizontal Pod Autoscaling in the guide.

Running Daemons on Every Machine (Optional)

Duration: 5:00

When running pods using Replication Controllers, Replica Set, or Deployments, the pods can be scheduled to run on any machines in the Kubernetes cluster, and sometimes, the more than 1 of pod of the same application could be running on the same machine. This is not a behavior you'd want if you want to have exactly one instance of the pod on each of the machines in the Kubernetes clusters.

A Daemon Set ensures that all (or some) nodes run a an instance of the pod. As nodes are added to the cluster, pods are added to them. As nodes are removed from the cluster, those pods are garbage collected. This is great for running per-machine daemons, such as:

- cluster storage daemon on every node, such as `glusterd`, `ceph`, etc.
- logs collection daemon on every node, such as `fluentd` or `logstash`, etc.
- monitoring daemon on every node, such as Prometheus Node Exporter, `collectd`, etc.

For this lab, we'll deploy a Cassandra cluster as a Daemon Set because we want to ensure exactly one Cassandra node is running on every machine. Luckily, there is an example of this on GitHub:

https://raw.githubusercontent.com/kubernetes/kubernetes/master/examples/storage/cassandra/cassandra-daemonset.yaml. Examine the file carefully - it's almost the same as a Deployment descriptor, but with the kind as DaemonSet.

You can actually deploy this Daemon Set descriptor from GitHub directly:

```
$ kubectl create -f  \
https://raw.githubusercontent.com/kubernetes/kubernetes/master/examples/storage/cassand
ra/cassandra-daemonset.yaml
```

The take way from this YAML file is that the kind is a `DaemonSet` rather than a Deployment.

Since we started with 1-CPU VM instances, it's very likely that we don't have .enough physical resource to run a Cassandra instance on every node. The configuration requests for 500m CPU cores.

```
$ kubectl describe ds cassandra
…
 FirstSeen     LastSeen        Count   From                    SubObjectPath   Type
Reason          Message
  ---------     --------        -----   ----                    -------------
--------        ------          -------
  15s           15s             4       daemonset-controller                    Normal
FailedPlacement failed to place pod on "gke-guestboo
k-default-pool-38a0d458-r8hn": Node didn't have enough resource: cpu, requested: 500,
used: 800, capacity: 1000
  15s           15s             4       daemonset-controller                    Normal
FailedPlacement failed to place pod on "gke-guestboo
k-default-pool-38a0d458-0gjw": Node didn't have enough resource: cpu, requested: 500,
used: 958, capacity: 1000
  15s           15s             4       daemonset-controller                    Normal
FailedPlacement failed to place pod on "gke-guestboo
k-default-pool-38a0d458-bc5l": Node didn't have enough resource: cpu, requested: 500,
used: 870, capacity: 1000
  15s           15s             4       daemonset-controller                    Normal
FailedPlacement failed to place pod on "gke-guestboo
k-default-pool-38a0d458-6rzx": Node didn't have enough resource: cpu, requested: 500,
used: 760, capacity: 1000
  15s           15s             4       daemonset-controller                    Normal
FailedPlacement failed to place pod on "gke-guestboo
k-default-pool-38a0d458-42s7": Node didn't have enough resource: cpu, requested: 500,
used: 800, capacity: 1000
```

Let's increase the size of the nodes! First, create a new node pool with larger machines:

```
$ gcloud container node-pools create larger-vm-pool \
  --cluster guestbook \
  --machine-type n1-standard-2 \
  --num-nodes 3 \
  --scopes cloud-platform
```

This will create 3 more VMs of larger size and join the existing cluster. You can use this technique to add nodes of different configuration (machine types, disks, scopes) into an existing cluster.

Check the new nodes joined the cluster:

```
$ kubectl get nodes
NAME                                         STATUS    AGE       VERSION
gke-guestbook-default-pool-38a0d458-0gjw     Ready     1h        v1.6.4
gke-guestbook-default-pool-38a0d458-42s7     Ready     51m       v1.6.4
gke-guestbook-default-pool-38a0d458-6rzx     Ready     1h        v1.6.4
gke-guestbook-default-pool-38a0d458-bc5l     Ready     1h        v1.6.4
gke-guestbook-default-pool-38a0d458-r8hn     Ready     1h        v1.6.4
gke-guestbook-larger-vm-pool-0547e557-066h   Ready     45s       v1.6.4
gke-guestbook-larger-vm-pool-0547e557-fzbv   Ready     1m        v1.6.4
gke-guestbook-larger-vm-pool-0547e557-g8n5   Ready     1m        v1.6.4
```

Once new nodes are created, delete the old pool:

```
$ gcloud container node-pools delete default-pool --cluster guestbook
```

You may need to delete a few existing deployments, or resize the cluster, before the the node has capacity to run this. You can verify that there is one instance running on every machine:

```
$ kubectl get pods -owide
NAME                               READY     STATUS    RESTARTS   AGE       NODE
cassandra-0oy09                    1/1       Running   0          4m
gke-guestbook-default-pool-622f144b-6rrv
cassandra-7nrcq                    1/1       Running   0          4m
gke-guestbook-default-pool-622f144b-be8d
cassandra-kw2kc                    1/1       Running   0          4m
gke-guestbook-default-pool-622f144b-56tt
cassandra-sfoep                    1/1       Running   0          4m
gke-guestbook-default-pool-622f144b-bpfa
```

You can expose all of these Pods via a Service exactly the same way that you expose pods with Replication Controllers, Replica Set, or Deployments. At the end of the day, Service will route traffic based on label selectors, so it doesn't matter how a Pod was initially created.

There is a Service descriptor on GitHub you can deploy as well:
https://raw.githubusercontent.com/kubernetes/kubernetes/master/examples/storage/cassandra/cassandra-service.yaml
(hint: use `kubectl create -f <url to the raw file>`).

You can delete all of the pod instances by deleting the Daemon Set:

```
$ kubectl delete daemonset cassandra
```

Managing Batched / Run-Once Jobs

Duration: 15:00

So far, the lab has been showing how to run long running serving processes. What if you need to run a one-time job, such as a batch process, or simply leveraging the cluster to compute a result (like computing digits of Pi)? You shouldn't use Replication Controllers, Replica Set, or Deployments to run a job that is expected exit once it completes the computation (otherwise, upon exit, it'll be restarted again!).

Kubernetes supports running these run-once jobs, which it'll create one or more pods and ensures that a specified number of them successfully terminate. When a specified number of successful completions is reached, the job itself is complete. In many cases, you'll have run a job that only need to complete once.

For this lab, we'll run a job that uses Google DeepDream to produce a dreamy picture. The job will retrieve an image from the web, processes it with Google DeepDream, and then output the processed image into a Google Cloud Storage bucket, like this:

First, create a Google Cloud Storage bucket that will be used to store the image. Bucket names are globally unique. Use the Project ID as the bucket name to minimize conflicts with other bucket names:

```
$ export PROJECT_ID=$(gcloud config get-value core/project)
$ gsutil mb gs://${PROJECT_ID}
```

Next, find an interesting image to process. Since the processing time will increase with the size of the image, please find a JPG image that's no larger than 640px by 480px large. Make sure you grab the public URL to the image, e.g., this one: https://farm2.staticflickr.com/1483/25947843790_7cf8d5e59c_z_d.jpg

Then, you can launch a job directly from the command line using `kubectl run` with the `--restart=Never` argument. This tells Kubernetes that this is a Run Once job:

```
$ kubectl run deepdream-1 --restart=OnFailure \
      --image=saturnism/deepdream-cli-gcs -- \
      -i 1 --source=<an image url> \
      --bucket=${PROJECT_ID} --dest=output.jpg
```

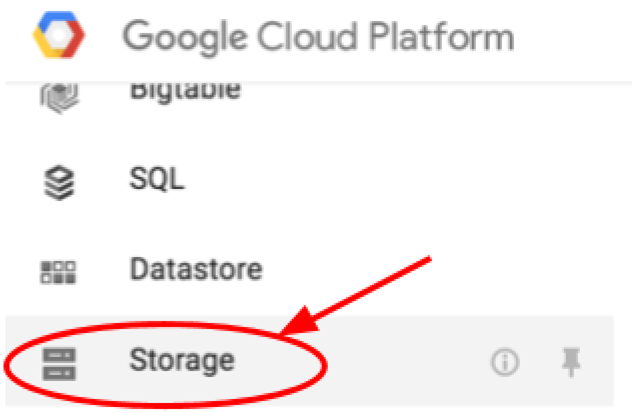
Note: You can also create a Job descriptor as well. Read the Kubernetes Jobs Guide to learn how you can write a YAML file to schedule a job.

This job should finish relatively quickly. You'll be able to see the status of the job via the command line:

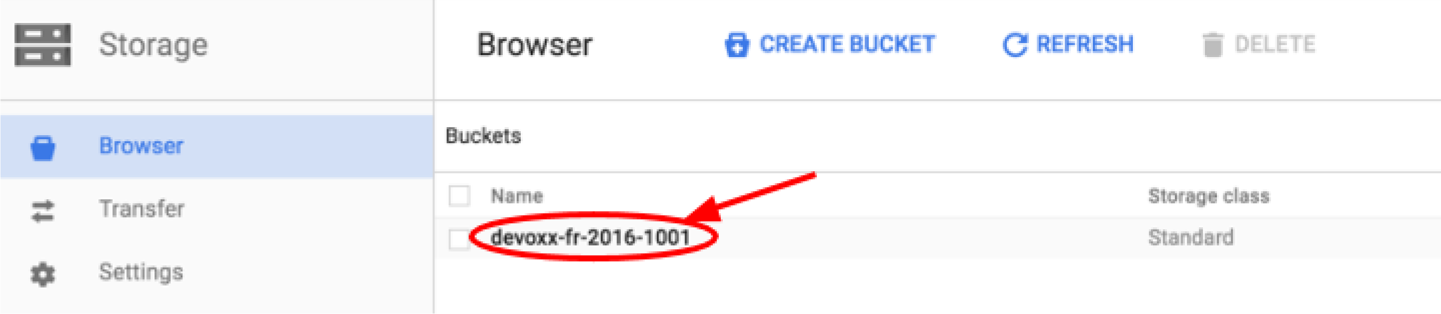
```
$ kubectl get jobs
NAME              DESIRED    SUCCESSFUL    AGE
deepdream-1       1          0             13m
```

Wait until the successful count is 1. Once the job finishes, browse to your Google Cloud Storage bucket and check the output.

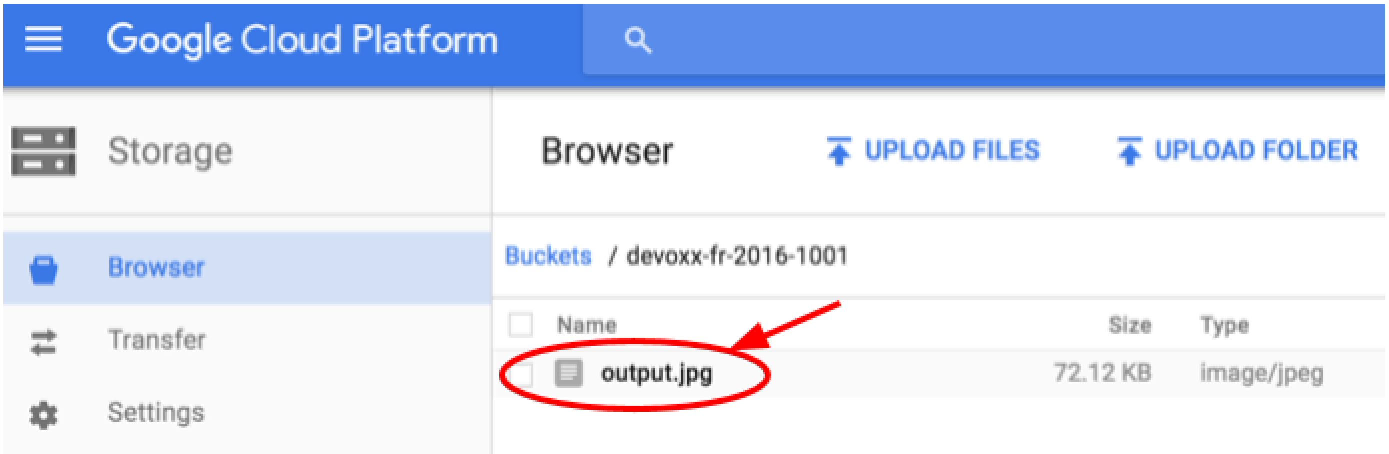
First, navigate to **Storage** > **Browser**:



Then, navigate to the bucket (your Project ID is the bucket name):



You should see the `output.jpg`, click on it and see the output.



This first iteration is probably not very impressive due to the configuration parameter we used.

Now that we know this job works, let's run a longer job:

```
$ kubectl run deepdream-2 --restart=OnFailure \
      --image=saturnism/deepdream-cli-gcs -- \
      -o 6 -l conv2/3x3 --source=<an image url> \
      --bucket=${PROJECT_ID} --dest=output-2.jpg
```

This job will take a couple of minutes to complete. While it's running, you can see the pod that was started, and also tail its logs (recall how you can do that via the command line).

Regardless of whether the job is running or already finished, you can retrieve the job output by first, getting the Pod name associated with the job:

```
$ kubectl get pods --selector=job-name=deepdream-2 --show-all
NAME                    READY     STATUS       RESTARTS    AGE
deepdream-2-...         0/1       Completed    0           1m
```

Then, you can use `kubectl logs` to retrieve the job output:

```
$ kubectl logs deepdream-2-czsrk
libdc1394 error: Failed to initialize libdc1394
WARNING: Logging before InitGoogleLogging() is written to STDERR
I1108 00:06:20.109063     1 net.cpp:42] Initializing net from parameters:
name: "GoogleNet"
input: "data"
input_dim: 10
input_dim: 3
input_dim: 224
input_dim: 224
force_backward: true
...
```

Try calculating Pi to the 2,000 place in a Job and use the above technique to find its value!

```
$ kubectl run pi --image=perl --restart=OnFailure -- perl -Mbignum=bpi -wle 'print
bpi(2000)'
```

Last, but not least, even though we launched the jobs from the command lines, you can always write a Job descriptor as a YAML or JSON file and submit those descriptors as well.

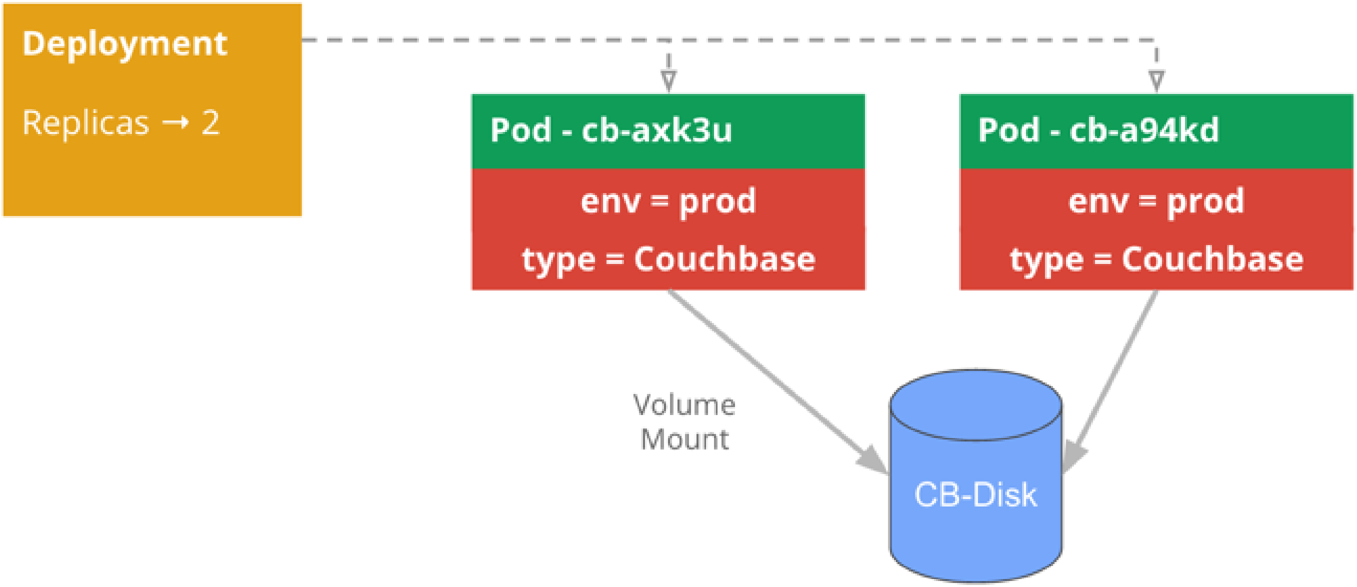
Note: Kubernetes 1.4 has Alpha support for Scheduled Jobs. Thinks of it as a distributed crontab. You can learn more in Kubernetes Scheduled Job Guide.

StatefulSets

In this section, we'll deploy Couchbase to Kubernetes using Arun Gupta's couchbase example that Ray Tsang collaborated on. The example is here: https://github.com/arun-gupta/couchbase-kubernetes, but you don't need to clone this repository.

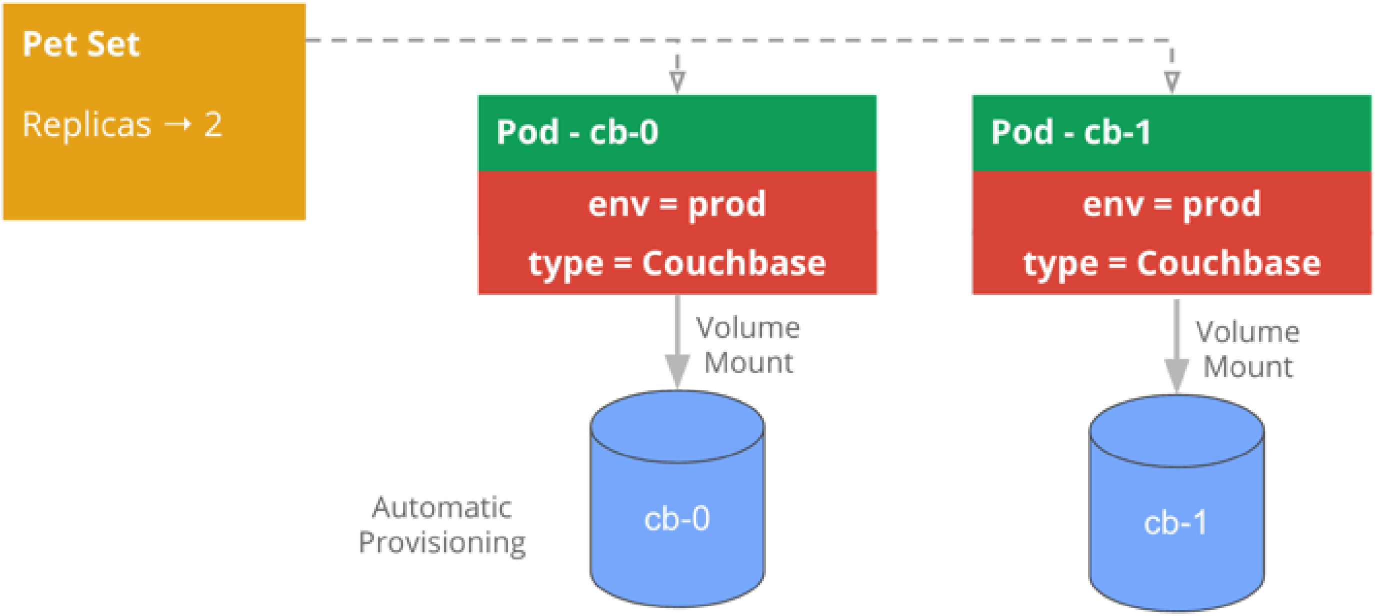
If each of your application instance is stateful (i.e., stores instance-specific data), you'll run into issues quickly if you use a normal Kubernetes Deployment, because each of the replica will be pointing to exactly the same persistent volume for storage - and it may not work.

Take Couchbase for example - each Couchbase node will need to store its own sharded data. If you used a regular Deployment, it'll look like this:



Not only that, each Pod will have a ephemeral Pod name, making it impossible to tell which Pod is the primary/master/first.

With StatefulSet, each Pod can have its own persistent volumes - and the names become stable, i.e., the first instance of the StatefulSet will have the ID of 0, and second instance will have ID of 1:



StatefulSet is a beta a feature in Kubernetes 1.5, which is automatically enabled in Google Kubernetes Engine 1.5.x.

Using a headless service is important in StatefulSet. It will provide stable DNS names such as `couchbase-0` for the first instance, and `couchbase-1` for the second instance. Instance name is important in this example deployment, because all `couchbase-0` will act as the master instance. Let's provision the service:

```
$ kubectl apply -f \
https://raw.githubusercontent.com/arun-gupta/couchbase-kubernetes/master/cluster-statef
ulset/couchbase-service.yml
```

In this YAML file, notice of a couple of important details:

- The first service has a `ClusterIP` attribute to to `None`. This creates a headless service. Unlike the regular service which provides a stable IP address acting as a network load balancer, a headless service doesn't create a stable IP address. Instead, in this case, it allows the creation of stable Pod hostnames, such as `couchbase-0`, `couchbase-1`, and so on.
- The second service has a `sessionAffinity` attribute set to `ClientIP`. This make sure your browser is connection is pinned to one of the many instances based on your IP address.

Finally, we can deploy Couchbase as a StatefulSet:

```
$ kubectl apply -f \
https://raw.githubusercontent.com/arun-gupta/couchbase-kubernetes/master/cluster-statef
ulset/couchbase-statefulset.yml
```

In this YAML file, notice of a couple of important details:

- The kind is a StatefulSet rather than a Deployment or ReplicaSet
- You can depend on `couchbase-0` being provisioned before `couchbase-1`. Provision of the instances sequential, from the first instance to to the number of replicas you need.

- `volumeClaimTemplates` is used to automatically generate a new Persistent Volume Claim, and subsequently, this will automatically provision a disk in Google Cloud Platform with the specified capacity. We didn't need to create a Google Compute Engine disk manually.

Validate that all the pods were started successfully. Once started, you can login into the Couchbase UI by first finding the `couchbase-ui` external IP address:

```
$ kubectl get svc
NAME           CLUSTER-IP    EXTERNAL-IP     PORT(S)    AGE
couchbase      None          <none>          8091/TCP   12m
couchbase-ui   10.3.250.7    IP_ADDRESS      8091/TCP   12m
kubernetes     10.3.240.1    <none>          443/TCP    13m
```

Then, open the browser and navigate to `http://MY_IP_ADDRESS:8091`
The username is `Administrator` and password is `password`.

You can scale the Statefulset Set just like a Deployment:

```
$ kubectl scale statefulset couchbase --replicas=3
```

This will create the a Pod with stable name of `couchbase-2`, and also automatically provision a new disk. You can see all of the disks that were automatically created:

```
$ kubectl get pv
NAME      CAPACITY   ACCESSMODES   RECLAIMPOLICY   STATUS    CLAIM
REASON    AGE
pvc-...   1Gi        RWO           Delete          Bound
default/couchbase-data-couchbase-0                10m
pvc-...   1Gi        RWO           Delete          Bound
default/couchbase-data-couchbase-1                10m
pvc-...   1Gi        RWO           Delete          Bound
default/couchbase-data-couchbase-2                38s
```

You can delete all of the Pod instances as well as all the storage simply by deleting the StatefulSet:

```
$ kubectl delete statefulset couchbase
```

Lastly, delete the services too!

```
$ kubectl delete svc couchbase couchbase-ui
```

Note: If you are interested in deploying Akka in Kubernetes, you can read Clustering Akka in Kubernetes with Statefulset and Deployment blog - it utilizes both Deployment and StatefulSet.

Deploy Whatever You Want

Deploy a Monolith - Pet Clinic

The best way validate what you've learned is to put them into practice, from scratch! Here is a challenge - configure and deploy Spring Pet Clinic in Kubernetes.

There is a good Spring Pet Clinic Docker container on Docker Hub: anthonydahanne/spring-petclinic, I recommend start from there.

You should create the necessary resource YAML files (hint, look at files in `~/spring-boot-docker/examples/kubernetes-1.6`):

For MySQL:

- mysql-deployment.yaml
- mysql-pvc.yaml
- mysql-service.yaml

For the Application:

- petclinic-deployment.yaml
- petclinic-service.yaml

Other Goodies

There are many more features that are not covered in this lab. It's good to know those features exists though. For example:

- Ingress - Provision HTTP/HTTPs Load Balancer.
- Namespaces - Create virtual clusters, so that you can host multiple teams, projects, or environments.
- StatefulSet - Provision stateful applications that require stable names and instance-specific storage (e.g., running Couchbase, Zookeeper, etc). Storage can be dynamically provisioned.
- Third-party Resource - You can create your own resource descriptors and provision your own controllers!
- Federation - You can federate multiple clusters together and control it through a single control plane.
- Helm - A package manager for Kubernetes. There are many pre-packaged deployments you can easily provision into a Kubernetes cluster.
- Security features: Role-Based Access Control, Network Policy and Pod Security Policy

Remove Existing Clusters

Your account has a default quota of 24 CPU cores, and 8 IP addresses by default. To do the next portion of the lab, you'll need to remove the existing resources first in order to ensure you don't exceed the quota.

First, let's undeploy everything from the guestbook cluster:

```
$ cd ~/spring-boot-docker/examples/kubernetes-1.2
$ kubectl delete -f .
```

Next, delete the cluster altogether:

```
$ gcloud container clusters delete guestbook
The following clusters will be deleted.
 - [guestbook] in [us-central1-c]
Do you want to continue (Y/n)?  Y
Deleting cluster guestbook...done.
```

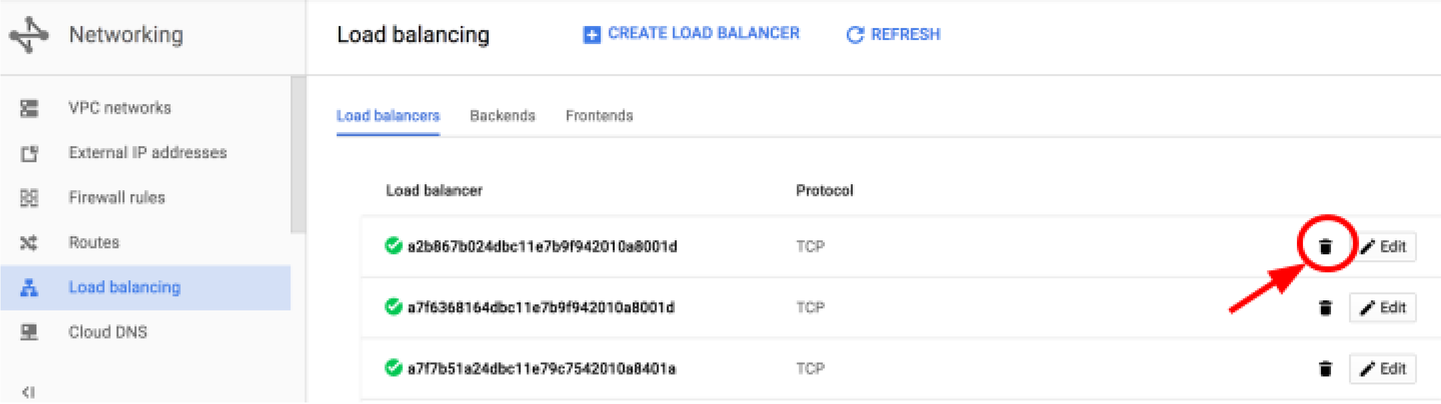
```
Deleted [https://container.googleapis.com/v1/projects/.../guestbook].

$ gcloud compute disks delete mysql-disk

$ gsutil rm -r gs://artifacts.${PROJECT_ID}.appspot.com/
Removing gs://artifacts.<PROJECT_ID>.appspot.com/...

$ gsutil rm -r gs://${PROJECT_ID}/
Removing gs://<PROJECT_ID>/...
```

Just to be sure, also navigate to **Networking** → **Load Balancing** and *delete every load balancer*.



Load balancer	Protocol
a2b867b024dbc11e7b9f942010a8001d	TCP
a7f6368164dbc11e7b9f942010a8001d	TCP
a7f7b51a24dbc11e79c7542010a8401a	TCP

Cluster Federation

Create Multiple Clusters

For this lab, we'll create a small 3-node Kubernetes cluster in US Central and in Europe West regions:

```
$ gcloud container clusters create us-central-cluster \
  --cluster-version 1.7.8-gke.0 \
  --machine-type n1-standard-2 \
  --zone us-central1-c --scopes cloud-platform

# You can open another Cloud Shell tab to provision the second cluster in parallel
$ gcloud container clusters create eu-west-cluster \
  --cluster-version 1.7.8-gke.0 \
  --machine-type n1-standard-2 \
  --zone europe-west1-c --scopes cloud-platform
```

Note: This will take a while!

Use Certificate Credentials

In Google Kubernetes Engine the cluster credential is fetched and stored upon cluster creation.However, by default,it only stores a temporary access token. This access token will expire - hence you'll need to re-authenticate periodically. However, for cluster federation, a federation control plane will need access to the clusters, without the ability to re-authenticate to fetch a new access token every time. Because of this, we'll need to make sure we use certificate authentication:

```
$ gcloud config set container/use_client_certificate True
```

Then, re-fetch the credentials:

```
$ gcloud container clusters get-credentials us-central-cluster --zone us-central1-c
$ gcloud container clusters get-credentials eu-west-cluster --zone europe-west1-c
```

Understanding Context

Every time you created a new cluster, credentials were automatically added to the Kubernetes configuration file in `~/.kube/config`. It's a YAML file consisting of 3 components: `contexts`, `clusters`, and `users`.

A `cluster` entry is composed of a name, a server endpoint, and optionally, a certificate for establishing SSL connections.

A `user` entry contains the credential to connect to a cluster, it can be username/password pair, a client certificate, an OAuth access token, etc.

A `context` is composed of a `cluster` and a `user`. I.e., a context specifically designates which user to access which cluster.

Every time you created a new cluster, its user entry, cluster entry, and context entry are automatically created.

You can list all of the contexts, and see which cluster and user are associated w/ the context:

```
$ kubectl config get-contexts
CURRENT   NAME                     CLUSTER                  AUTHINFO
   gke_...us-central-cluster   gke_...us-central-cluster   gke_...us-central-cluster
*  gke_...eu-west-cluster      gke_...eu-west-cluster      gke_...eu-west-cluster
```

Since we have multiple clusters, we have multiple contexts. There are multiple ways to desginate which context to use when you use kubectl commands.

If you want to set the default context whenever you use kubectl:

```
$ kubectl config use-context gke_...us-central-cluster
```

You can see which context is currently the default context:

```
$ kubectl config current-context
```

This is not ideal for some use cases though. For example, if you have a CI/CD system that automatically deploys new versions of different applications to different clusters (e.g., a development cluster vs a staging cluster), setting this default context is not ideal. E.g., if you have a job that is deploying to Staging, so you switched context to the staging context - but another job deploys to the QA context. You could potentially overwrite the default setting and cause conflicts during parallel deployments.

Luckily, you can specify a context that's scoped to every command run, by using `--context` parameter:

```
$ kubectl --context=gke_...us-central-cluster get pods
```

This is important to remember as we are working with multiple clusters now.

Creating Shorter Context Names

By default, Google Kubernetes Engine cluster context names are very long. We can shorten it. Ideally, there would be a `kubectl config rename-context` command of some sort - but there isn't one :(

One way is to directly rename the context in `~/.kube/config` YAML file. But this can be error prone. For this exercise, you can simply create a new context pointing to existing cluster and user pairs.

First, list the existing contexts:

```
$ kubectl config get-contexts
```

You should be able to see contexts corresponding to the clusters in the US and Europe. For each of them, you can see the associated cluster and users.

You can create a new context for each of them, with a shorter name:

```
$ kubectl config set-context us-central \
  --cluster=gke_…_us-central1-c… --user=gke_…_us-central1-c…

$ kubectl config set-context eu-west \
  --cluster=gke_…_europe-west1-c… --user=gke_…_europe-west1-c…
```

Validate both new contexts work:

```
$ kubectl --context=us-central cluster-info
Kubernetes master is running at https://...
...
$ kubectl --context=eu-west cluster-info
Kubernetes master is running at https://...
```

They should print different Kubernetes masters IP addresses!

Creating DNS Zone

Kubernetes Federation requires a DNS zone to operate against. It can operate against different cloud DNS services - this lab will use Google Cloud DNS. When you deploy new federated services, each load balanced service from each cluster will automatically register in the DNS zone. DNS is also used for cross-cluster service discovery. We'll look into these use cases in more detail later - but first, let's create the zone.

Warning: The DNS Zone has to be a *real* DNS - using a non-existing DNS or someone else's DNS won't work when it comes to cross-cluster service discovery!

Luckily, the instructor has a DNS domain to use: `kubefed.world`

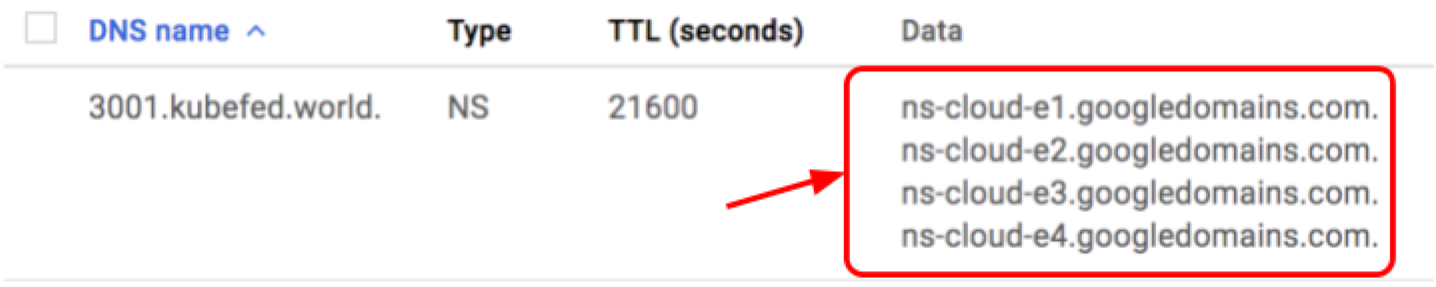
The instructor can delegate a subdomain to your DNS zone. This way, you don't have to purchase a new domain just for this lab, and everything should still work.

When you are logged in as the lab account user, open Kubernetes Federation Lab Accounts sheet. Add your lab account username to left column in a new row:

1. Add your username in the **Username** cell
2. Add a comment with your First name in the **Used By** cell
3. Note the **DNS Zone** cell. That value will be used in the rest of the lab subdomain. E.g., `1234.kubefed.world` as your DNS zone. Add your DNS zone to the spreadsheet next to your login E-Mail.

```
$ export DNS_ZONE="YOUR_DNS_ZONE_FROM_SHEET"
$ gcloud dns managed-zones create kubefed-world \
  --description "Kubernetes Federation Zone" \
  --dns-name ${DNS_ZONE}
API [dns.googleapis.com] not enabled on project [...]. Would
you like to enable and retry?  (Y/n)? Y
Enabling service dns.googleapis.com on project ...
Waiting for async operation ... to complete...
Operation finished successfully. The following command can describe the Operation
details:
 gcloud service-management operations describe ...
Created [https://www.googleapis.com/dns/v1/projects/...].
```

Once this is created, browse to **Network Services** → **Cloud DNS** → **kubefed-world**, and copy the data of the NS record, and paste it into a new comment in spreadsheet's corresponding **Zone Data** cell.



□	DNS name ^	Type	TTL (seconds)	Data
	3001.kubefed.world.	NS	21600	ns-cloud-e1.googledomains.com. ns-cloud-e2.googledomains.com. ns-cloud-e3.googledomains.com. ns-cloud-e4.googledomains.com.

This is needed so that the instructor can delegate the subdomain to your Cloud DNS zone.

Download Kubefed

We'll use `kubefed` command line utility to create federate our clusters. But first, we need to download it:

```
$ cd ~/
$ curl -LO
https://storage.googleapis.com/kubernetes-release/release/v1.7.8/kubernetes-client-linu
x-amd64.tar.gz
$ tar -xzvf kubernetes-client-linux-amd64.tar.gz
$ sudo cp kubernetes/client/bin/kubefed /usr/local/bin
$ sudo chmod +x /usr/local/bin/kubefed
```

Validate you can run `kubefed`:

```
$ kubefed version
Client Version: version.Info{...}
Server Version: version.Info{...}
```

Deploy Federation Control Plane

The federation control plane must be deployed into one of the clusters. Let's use the US cluster as the control plane cluster:

Important: The ending period/dot in the end of the `dns-zone-name` is *IMPORTANT*! Don't miss it!

```
$ kubefed init federation \
  --host-cluster-context=us-central \
  --dns-provider=google-clouddns \
  --dns-zone-name=${DNS_ZONE}.      # The "." in the end is very important!

Federation API server is running at: X.X.X.X
```

This will deploy a Ffederation Controller and a Federation API server into the US cluster, under the `federation-system` namespace. Check to see that deployment is complete and that the pods are all up and running:

```
$ kubectl --context=us-central --namespace=federation-system get pods
```

Lastly, `` `kubefed init` `` will automatically configure the context/cluster/user for you as well. Because we named the federation `federation`, the a context of the same name would be created. Validate it:

```
$ kubectl config get-contexts
```

Join the Federation

Once the federation control plane is up and running, you can now register existing clusters into the federation:

```
$ kubefed --context=federation join us-central-cluster \
  --cluster-context=us-central \
  --host-cluster-context=us-central

cluster "us-central-cluster" created

$ kubefed --context=federation join eu-west-cluster \
  --cluster-context=eu-west \
  --host-cluster-context=us-central

cluster "eu-west-cluster" created
```

Validate that the clusters have been registered:

```
$ kubectl --context=federation get clusters
NAME                 STATUS    AGE
eu-west-cluster      Ready     1m
us-central-cluster   Ready     1m
```

Note: It takes a minute or two for all the clusters to register. Wait until both clusters are ready.

Create Federated Namespaces

```
$ kubectl --context=federation create ns default
```

This will ensure that the Federation controllers understand that there is a `default` namespaces that can be used.

Kube DNS Configuration

When we used `kubefed` to register a cluster into the federation, it also automatically updated the Kube DNS configuration with federation's DNS zone.

You can see it in each cluster:

```
$ kubectl --context=us-central --namespace=kube-system get configmap kube-dns
$ kubectl --context=eu-west --namespace=kube-system get configmap kube-dns
```

Take a look at the configuration itself, and notice the `federations` section, which is important for cross-cluster service discovery (we'll get back to that in more detail later):

```
$ kubectl --context=us-central --namespace=kube-system get configmap kube-dns -oyaml
apiVersion: v1
data:
  federations: federation=YOUR_DNS_ZONE
```

```
kind: ConfigMap
metadata:
  ...
```

Deploy Federated Service

First, let's deploy all of the services (network load balancers) into the federation:

```
$ cd ~/spring-boot-docker/examples/kubernetes-federation
$ kubectl --context=federation apply -f federated-service/
```

This will create a corresponding service in each of the clusters. For example:

```
$ kubectl --context=us-central get svc
guestbook-service    10.15.247.249   35.184.43.99   8080:32481/TCP   2m
helloworld-service   10.15.250.232   x.x.x.x        8080/TCP         2m
helloworld-ui        10.15.249.82    <nodes>        80:30080/TCP     2m
kubernetes           10.15.240.1     <none>         443/TCP          20m
redis                10.15.248.216   y.y.y.y        6379/TCP         2m

$ kubectl --context=eu-west get svc
NAME                 CLUSTER-IP      EXTERNAL-IP      PORT(S)          AGE
guestbook-service    10.27.247.175   35.187.185.224   8080:32121/TCP   2m
helloworld-service   10.27.242.131   a.a.a.a          8080/TCP         2m
helloworld-ui        10.27.244.140   <nodes>          80:30080/TCP     2m
kubernetes           10.27.240.1     <none>           443/TCP          17m
redis                10.27.251.61    b.b.b.b          6379/TCP         2m
```

Important: Make sure the external IP addresses of `guestbook-service`, `hellworld-service`, and `redis` are all provisioned before moving on. I.e., there shouldn't be any EXTERNAL-IP in the `<pending>` state.

Once each cluster's services gets assigned an external IP, the federated service will also reflect those IPs:

```
$ kubectl --context=federation get svc
NAME                 CLUSTER-IP   EXTERNAL-IP        PORT(S)        AGE
guestbook-service                 104.198.61.16...   8080/TCP       3m
helloworld-service                104.154.31.16...   8080/TCP       3m
helloworld-ui                     <nodes>            80:30080/TCP   3m
redis                             146.148.35.35...   6379/TCP       3m
```

Deploy MySQL and Guestbook Service

MySQL and Guestbook must be deployed into just a single cluster. This is because MySQL doesn't span across multiple regions. Thus, we'll keep a zone locality for the Guestbook microservices as well. However, we'll make Guestbook microservice publicly accessible for now, so that we can use cross-cluster service discovery.

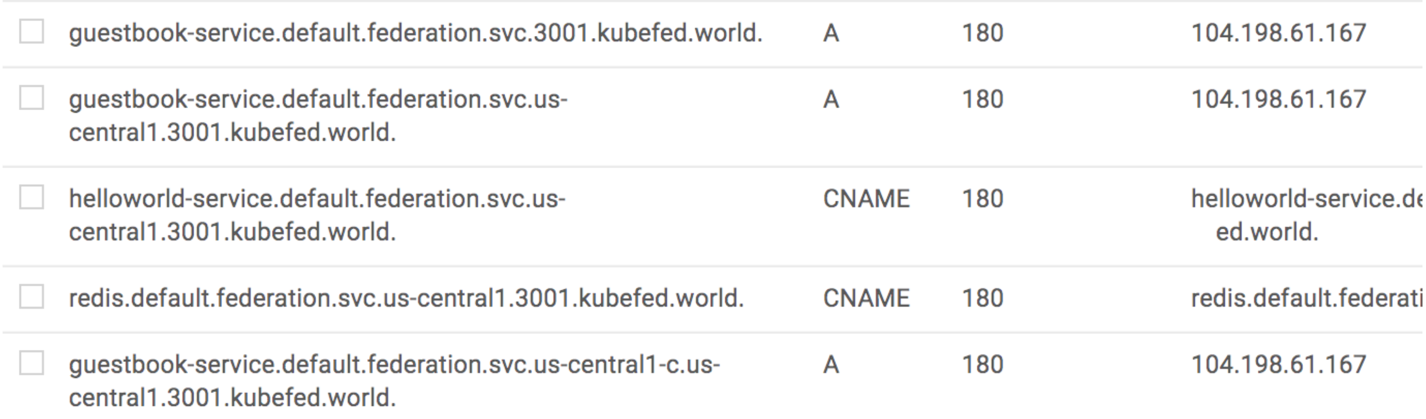
Nice to know: Data is always the most difficult bottleneck to deal with in a multi-region deployment. If you do want a globally distributed relational database, you can use Google Cloud Platform's Cloud Spanner. With Spanner, you can fully scale out multi-region stateful microservices.

Let's deploy MySQL and Guestbook microservices into the US cluster:

```
$ kubectl --context=us-central apply -f single-cluster/
```

Wait for everything to deploy before continuing (Use `kubectl --context=us-central get pods` to validate).

Wait a couple of minutes, the federation service will also sync up, Navigate to **Networking** → **Cloud DNS** → **kubefed-world** zone:



□	guestbook-service.default.federation.svc.3001.kubefed.world.	A	180	104.198.61.167
□	guestbook-service.default.federation.svc.us-central1.3001.kubefed.world.	A	180	104.198.61.167
□	helloworld-service.default.federation.svc.us-central1.3001.kubefed.world.	CNAME	180	helloworld-service.de ed.world.
□	redis.default.federation.svc.us-central1.3001.kubefed.world.	CNAME	180	redis.default.federati
□	guestbook-service.default.federation.svc.us-central1-c.us-central1.3001.kubefed.world.	A	180	104.198.61.167

You should see that the DNS records are updated with the IP address of the service load balancer. There is only one IP, because only one of the two clusters (the US cluster) have the actual Guestbook microservices deployed.

Deploy Federated Deployment

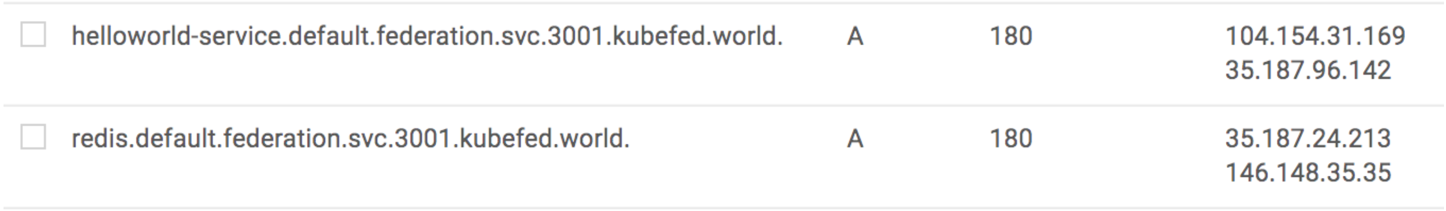
The Guestbook microservice has state, so it had to be deployed into the same cluster that is running MySQL. The other microservices are stateless, so it can be deployed in all clusters. First, deploy Helloworld microservice and Redis:

```
$ kubectl --context=federation apply \
  -f federated-deployment/redis-deployment.yaml

$ kubectl --context=federation apply \
  -f federated-deployment/helloworldservice-deployment-v1.yaml
```

Check each of the clusters to see that the deployments have propagated and that the pods started.

Once deployed, validate that the Federated Service are synchronized, and the DNS entry has been updated:



□	helloworld-service.default.federation.svc.3001.kubefed.world.	A	180	104.154.31.169 35.187.96.142
□	redis.default.federation.svc.3001.kubefed.world.	A	180	35.187.24.213 146.148.35.35

Now all serives are ready for cross-cluster service discovery!

Cross-cluster Service Discovery

Let's talk a bit more about cross-clusster service discovery.

Typically, when you use DNS service discovery, you can use the service name directly, e.g., `http://helloworld-service:8080`.

This will eventually resolve the service name to its FQN:
`[service name].[namespace].svc.cluster.local`

For example, `helloworld-service` → `helloworld-service.default.svc.cluster.local`.

Similarily, you can address a service in a different namespace, by using the DNS name:
`[service name].[namespace]` that will then resolve to the FQN as well.

When using cross-cluster service discovery, you would want to use a different DNS name, of the form:
`[service name].[namespace].[federation name]`.

For example, when you want to use a federated helloworld-service in this lab, you can address it like:
`http://helloworld-service.default.federation`

If there is a local deployment of Helloworld microservice that can respond to requests, then this DNS name will resolve to the IP within the cluster. Otherwise, this DNS name will be expanded to a FQN of the form:
`[service name].[namespace].[federation name].svc.[zone].[dns zone]`.

So, in our Helloworld example, `helloworld-service.default.federation` →
`helloworld-service.default.federation.svc.us-central1-c.YOUR_DNS_ZONE`

If you check the Helloworld UI's deployment file, note that it's now configured to connect via cross-cluster service discovery DNS names (e.g., `helloworld-service.default.federation`, etc.).

Deploy the UI frontend:

```
$ kubectl --context=federation apply \
  -f federated-deployment/helloworldui-deployment-v1.yaml
```

Wait for everything to finish deploying.

Important: Because we ultimately want to expose the UI via an Ingress, the service is now exposed as of the type `NodePort` rather than of the type `LoadBalancer`.

Federated Ingress

Traditionally, when you have a web application deployed to multiple regions, you would expose the application from an IP from each of the regions. To route the traffic to the nearest region, you would use Geo DNS entries, so that users in Europe will look up the DNS entry and get the IP address in Europe.

Google Cloud Platform can provision a single global IP address and a global HTTP(s) load balancer that can automatically route the user to the nearest region. This is the same global load balancer technology that Google uses for all of its services!

From Kubernetes Federation, you can create a Federated Ingress that automatically takes advantage of this global load balancer.

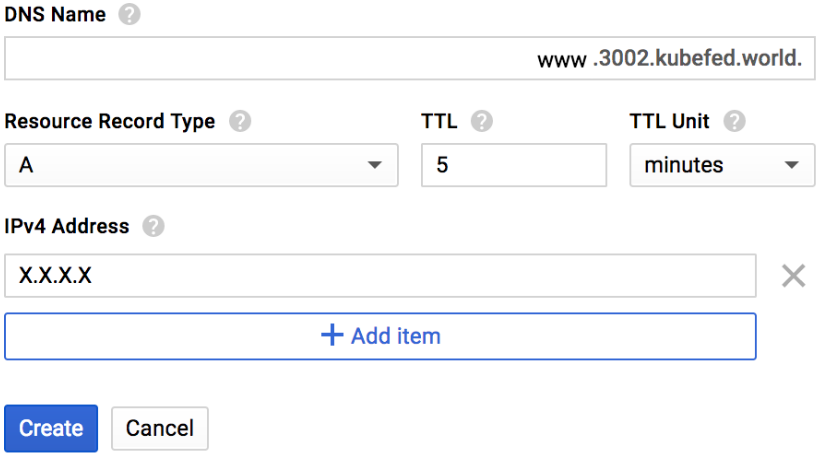
First, open up the firewall so that the global load balancer can connect to the cluster ports:

```
$ gcloud compute firewall-rules create allow-lb \
  --source-ranges 130.211.0.0/22,35.191.0.0/16 \
  --allow tcp:30000-65535
```

Then, create a global IP address that will be used by the Load Balancer:

```
$ gcloud compute addresses create guestbook-ingress --global
Created [https://www.googleapis.com/compute/v1/...].
---
address: X.X.X.X              ← Note down this IP Address!
...
status: RESERVED
```

Navigate to **Networking** → **Cloud DNS** → **kubefed-world**, click **Add Record Set** to add a new `www` A record to point to this IP address, and click **Create**.



DNS Name: www .3002.kubefed.world.

Resource Record Type: A

TTL: 5

TTL Unit: minutes

IPv4 Address: X.X.X.X

Finally, deploy the Federated Ingress:

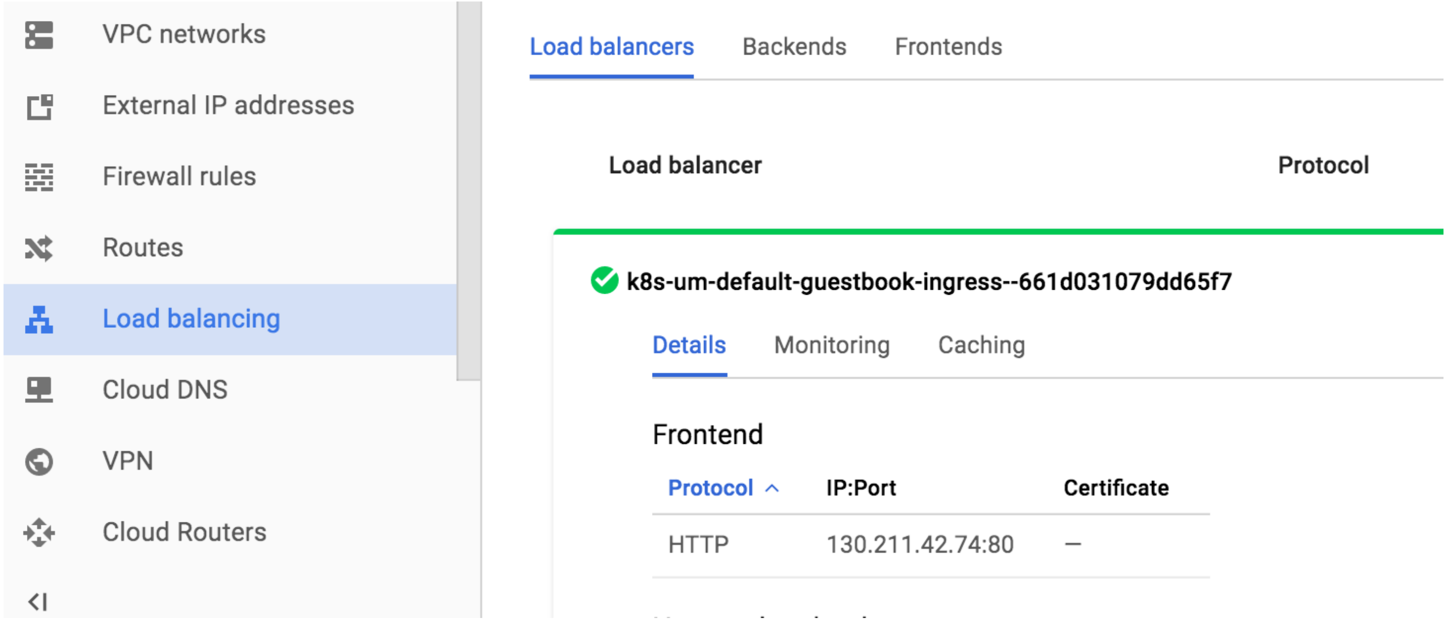
```
$ kubectl --context=federation apply -f federated-ingress/guestbook-ingress.yaml
```

Note: In the Ingress YAML file, there is an annotation that references the `guestbook-ingress` global IP address that you created earlier.

Federated ingress will take several minutes to initialize as its configuration is propagated globally. It also need to perform necessary health checks against the VMs themselves prior to routing the traffic. You can check the status of the ingress provisioning:

```
$ kubectl --context=federation describe ingress guestbook-ingress
Name:                   guestbook-ingress
Namespace:              default
Address:                X.X.X.X
Default backend:        default-http-backend:80 (<none>)
Rules:
  Host  Path    Backends
  ----  ----    --------
  *
                helloworld-ui:80 (<none>)
…
```

You can also visit the console **Networking** > **Load Balancer** > … to find the Ingress load balancer where you can find the current status.

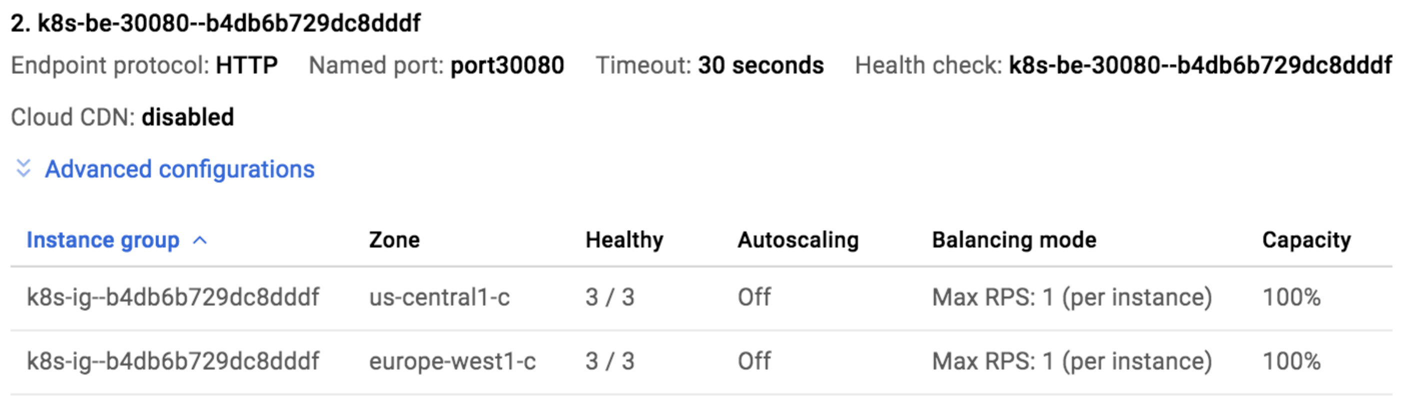


✓ k8s-um-default-guestbook-ingress--661d031079dd65f7

Frontend

Protocol ^	IP:Port	Certificate
HTTP	130.211.42.74:80	—

When ready, **backend services** section should reflect that all instances from all clusters are healthy.



2. k8s-be-30080--b4db6b729dc8dddf

Endpoint protocol: **HTTP** Named port: **port30080** Timeout: **30 seconds** Health check: **k8s-be-30080--b4db6b729dc8dddf**

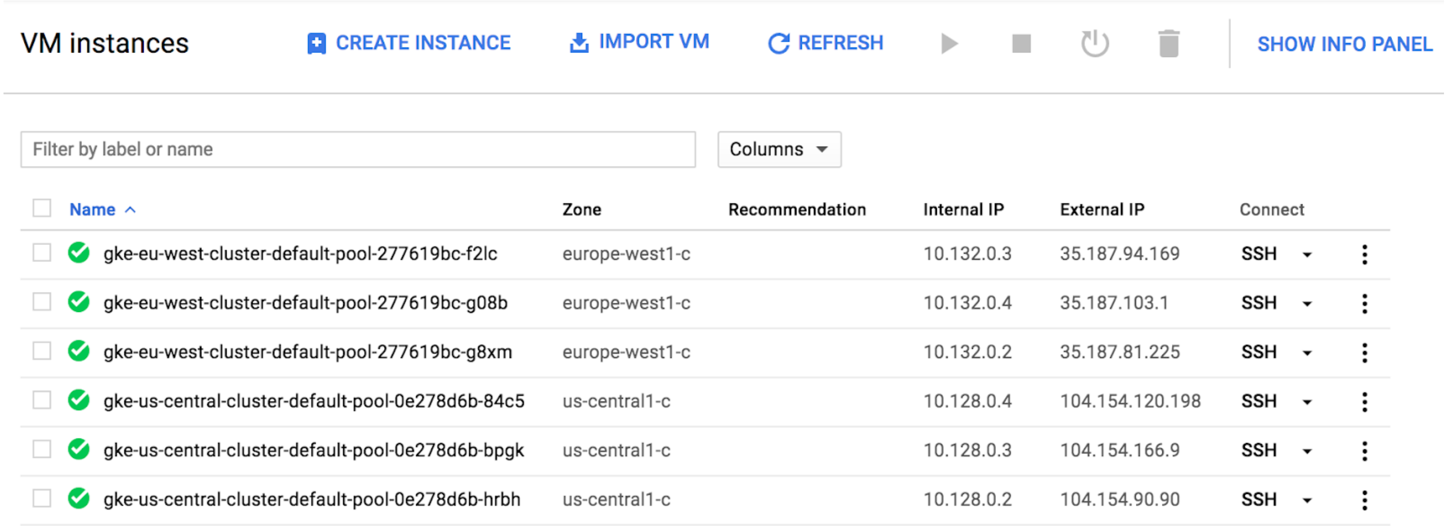
Cloud CDN: **disabled**

Instance group	Zone	Healthy	Autoscaling	Balancing mode	Capacity
k8s-ig--b4db6b729dc8dddf	us-central1-c	3 / 3	Off	Max RPS: 1 (per instance)	100%
k8s-ig--b4db6b729dc8dddf	europe-west1-c	3 / 3	Off	Max RPS: 1 (per instance)	100%

Once it's ready, grab the IP address and take a look!

Simulating Traffic from Another Region

Now that we have VMs in both US and Europe, you simulate traffic from different regions, and see where the traffic went. Navigate to **Compute Engine** → **VM instances**



VM instances

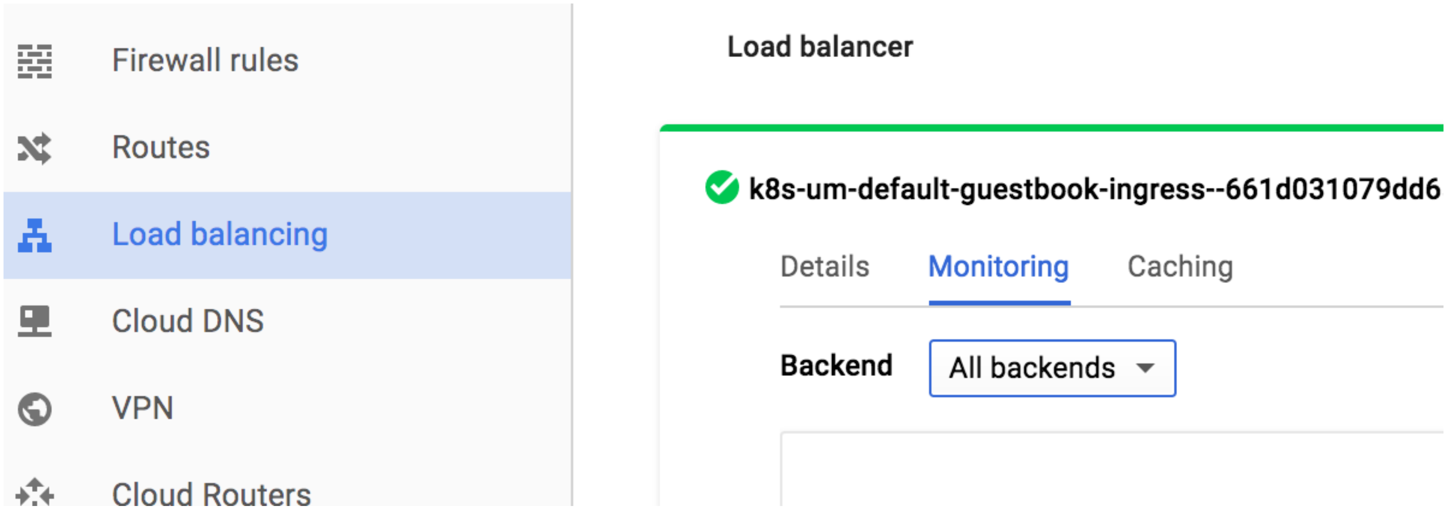
Name	Zone	Recommendation	Internal IP	External IP	Connect
gke-eu-west-cluster-default-pool-277619bc-f2lc	europe-west1-c		10.132.0.3	35.187.94.169	SSH
gke-eu-west-cluster-default-pool-277619bc-g08b	europe-west1-c		10.132.0.4	35.187.103.1	SSH
gke-eu-west-cluster-default-pool-277619bc-g8xm	europe-west1-c		10.132.0.2	35.187.81.225	SSH
gke-us-central-cluster-default-pool-0e278d6b-84c5	us-central1-c		10.128.0.4	104.154.120.198	SSH
gke-us-central-cluster-default-pool-0e278d6b-bpgk	us-central1-c		10.128.0.3	104.154.166.9	SSH
gke-us-central-cluster-default-pool-0e278d6b-hrbh	us-central1-c		10.128.0.2	104.154.90.90	SSH

Pick a machine from each of the zones to SSH into, click on **SSH**. These VMs runs Container Optimized OS by default (COS). COS doesn't have a package manager, but you can run Docker containers. We can simulate load by using a container that contains Apache Bench.

```
eu$ docker run --rm jordi/ab ab -q -c 1 -n 1000 http://YOUR_INGRESS_IP/
```

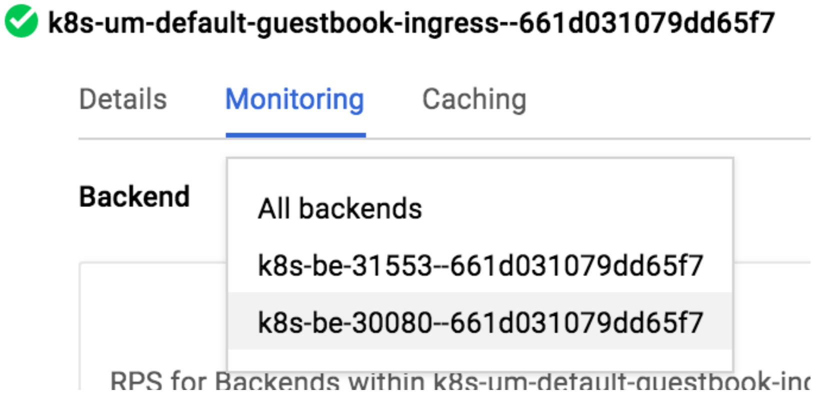
```
us$ docker run --rm jordi/ab ab -q -c 1 -n 1000 http://YOUR_INGRESS_IP/
```

Let it run for a couple of minutes. This should generate enough traffic for us to visualize on the Load Balancer monitoring page. Navigate to **Networking** → **Load balancing** → **the ingress LB** → **Monitoring**

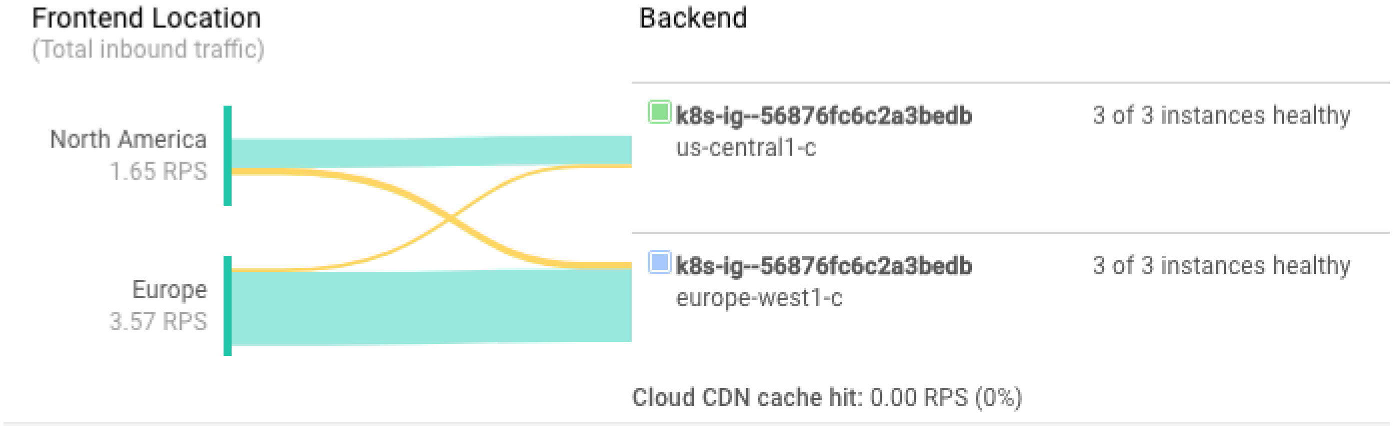


Backend: All backends

In **Backend** dropdown, select the item starting with **k8s-be-30080**…


k8s-um-default-guestbook-ingress--661d031079dd65f7
Details
Monitoring
Caching
Backend
All backends
k8s-be-31553--661d031079dd65f7
k8s-be-30080--661d031079dd65f7
RPS for Backends within k8s-um-default-guestbook-inc

Depending on how much load you put, you should see that different request origins are routed to the closest cluster:

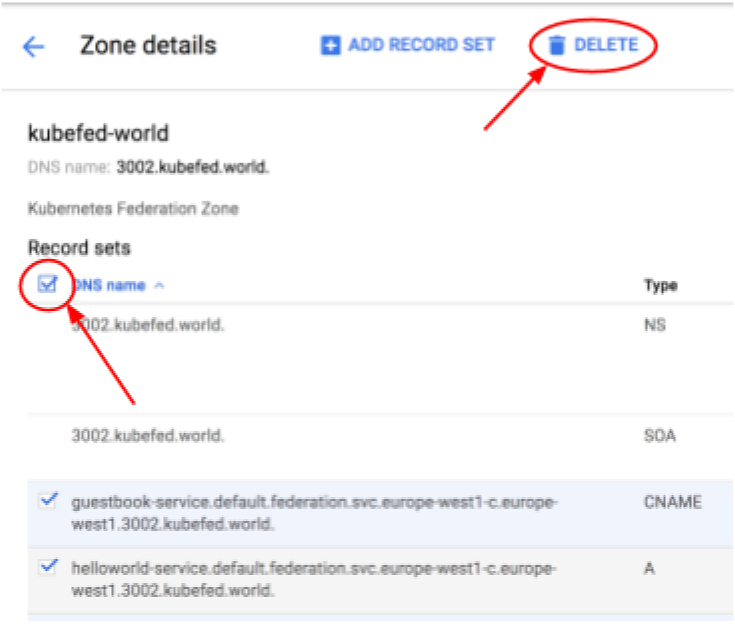


Clean up

Please shut down all clusters!

```
$ gcloud container clusters delete us-central-cluster --zone us-central1-c
$ gcloud container clusters delete eu-west-cluster --zone europe-west1-c
```

Then, **Select all** DNS records, and click **Delete**:



kubefed-world

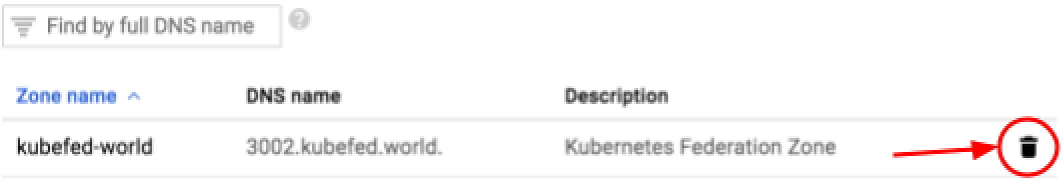
DNS name: 3002.kubefed.world.

Kubernetes Federation Zone

Record sets

☑	DNS name ^	Type
	3002.kubefed.world.	NS
	3002.kubefed.world.	SOA
✓	guestbook-service.default.federation.svc.europe-west1-c.europe-west1.3002.kubefed.world.	CNAME
✓	helloworld-service.default.federation.svc.europe-west1-c.europe-west1.3002.kubefed.world.	A

Finally, delete the DNS Zone:



Zone name ^	DNS name	Description
kubefed-world	3002.kubefed.world.	Kubernetes Federation Zone

Cleanup : Shut down your clusters!!!!

Duration: 5:00

If you are using your own account, don't forget to shut down your cluster, otherwise they'll keep running and accruing costs. The following commands will delete the persistent disk, the GKE cluster, and also the contents of the private repository.

Of course, you can also delete the entire project but note that you must first disable billing on the project. Additionally, deleting a project will only happen after the current billing cycle ends.

Extra Credit

Duration: 10:00

Here are some ideas for next steps.

Run Kubernetes Locally with Minikube

You can run Kubernetes locally with Minikube. See https://github.com/kubernetes/minikube for instructions.

Install Cloud SDK Command Line tool locally

To use `gcloud` command line locally, you'll need to install Cloud SDK. Follow the Cloud SDK installation guide for your platform.

Create a Docker Machine on Google Compute Engine

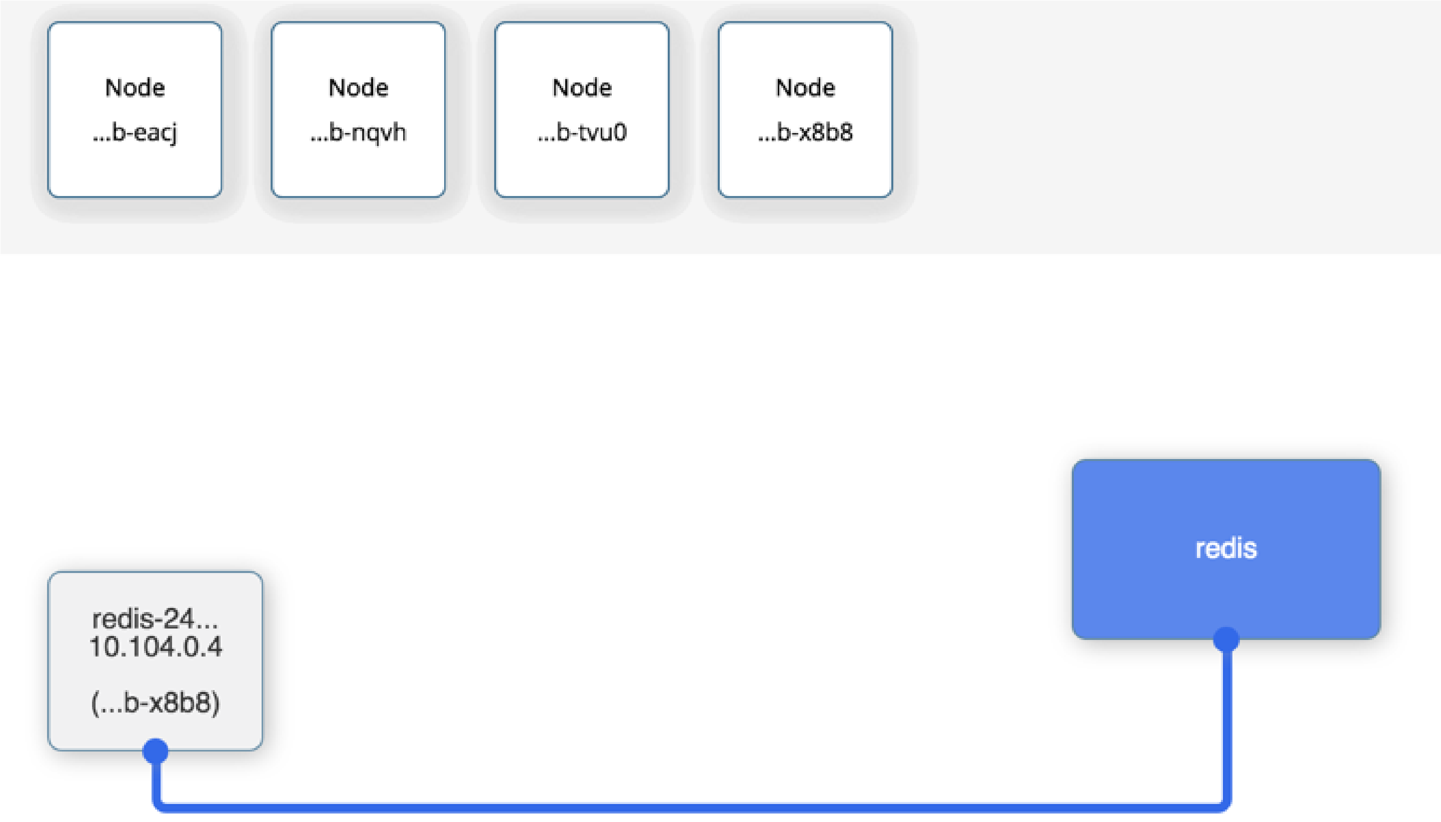
You can create a Docker Machine on Google Compute Engine rather than Virtualbox. You can see some of neat tips and tricks on Ray's blog on My Slow Internet vs Docker.

DIY Kubernetes cluster on Compute Engine

Download the open source version, build it and deploy a cluster yourself with the kubernetes tools.
Check out the Kubernetes Getting Started documentation. This can be as simple as running: '`curl -sS https://get.k8s.io | bash`'

Deploy a Visualizer

There is a nice visualizer tool that was originally created by Brendan Burns, a Kubernetes engineer. There is a fork of the visualizer that can display nodes and more under the GitHub repository: https://github.com/saturnism/gcp-live-k8s-visualizer that looks like this:



Warning: The visualizer will continuously poll the current states via the proxy. It will increase internet usage, decrease laptop battery life, and in some cases, increase CPU usage.

If you find the browser to slow down, refresh the visualizer page, or close it :)

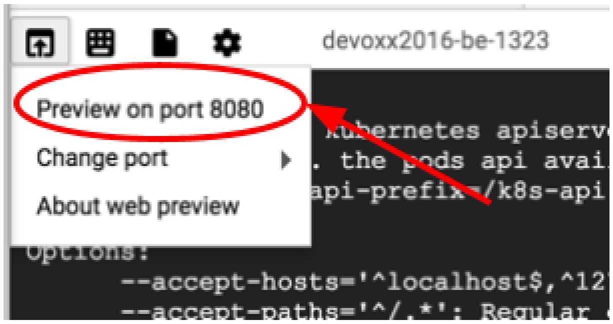
You can install the visualizer for this lab if you like - but it'll take a little time and extra steps. First, clone the GitHub repository, and let's go into it:

```
$ git clone https://github.com/saturnism/gcp-live-k8s-visualizer
$ cd gcp-live-k8s-visualizer
$ git checkout kubernetes-1.2
```

You can then start a local Kubernetes proxy that will forward requests from the proxy to the Kubernetes server via a secure proxy. It's important to know that you can issue any Kubernetes API calls to the proxy without additional authentication:

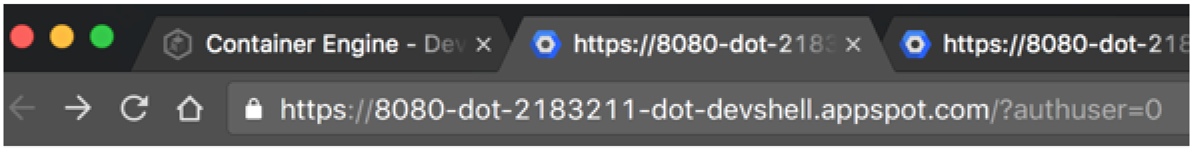
```
$ kubectl proxy --address=0.0.0.0 -w . -p 8080
Starting to serve on [::]:8080
```

Finally, use Web Preview to see the visualizer from the Cloud Shell environment:



```
 Kubernetes apiserv
. the pods api avai
api-prefix=/k8s-api
Options:
      --accept-hosts='^localhost$,^12
      --accept-paths='^/.*': Regular
```

You will first see an Unauthorized error message:

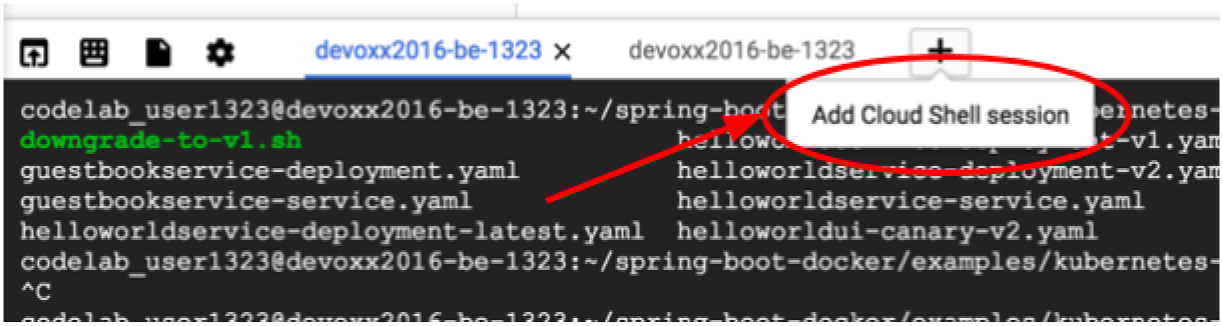


```
<h3>Unauthorized</h3>
```

In the URL, remove the query parameter `?authuser=0` and append the path `static/` so that your URL looks like: `https://8080-dot-.....-devshell.appspot.com/static`

That should be it! For the rest of the lab, you'll be able to visualize the changes you are making.

To do the rest of the lab, please open a new Cloud Shell tab by clicking on **+**:



```
codelab_user1323@devoxx2016-be-1323:~/spring-boot                    ernetes-
downgrade-to-v1.sh                         hellowo                       t-v1.yam
guestbookservice-deployment.yaml           helloworldse                ployment-v2.yam
guestbookservice-service.yaml              helloworldservice-service.yaml
helloworldservice-deployment-latest.yaml   helloworldui-canary-v2.yaml
codelab_user1323@devoxx2016-be-1323:~/spring-boot-docker/examples/kubernetes-
^C
```

In the newly opened shell, set the default zone and region again:

```
$ gcloud config set compute/zone europe-west1-c
$ gcloud config set compute/region europe-west1
```

What's next?

Duration: 5:00

Codelab feedback

- The codelab was easy and useful
- The codelab was too complicated
- The codelab didn't go far enough
- I had some technical difficulties (please share details using the feedback link)

Kubernetes

- http://kubernetes.io
- https://github.com/googlecloudplatform/kubernetes
- mailing list: google-containers
- twitter: @kubernetesio
- IRC: #google-containers on freenode

Minikube

- https://github.com/kubernetes/minikube

Google Kubernetes Engine

- https://cloud.google.com/kubernetes-engine/

Google Compute Engine

- https://cloud.google.com/compute-engine/

Other Adaptations

Following are a few labs that are created based on this lab:

- Google Compute Engine and Kubernetes Engine Lab
- RedHat Developer Kubernetes Lab

Run a Container

Duration: 10:00

We'll start off with something straight forward. What if you already have a container built and ready to be used? You can deploy a container image into a cluster of machines, and scale them, easily with Kubernetes.

For example, to run a container image you built:

```
$ kubectl run myapp --image=YOUR_DOCKER_IMAGE
// Example with NGINX:
// kubectl run myapp --image=nginx
```

You can scale the number of instances of your application:

```
$ kubectl scale deployment myapp --replicas=2
```

Check the status of all of the instances and make sure all instances are in the RUNNING status:

```
$ kubectl get pods
```

To make this application accessible from the public Internet, you can provision a load balancer:

```
$ kubectl expose deployment myapp \
    --type=LoadBalancer --port=80 --target-port=YOUR_APP_PORT
// Example with NGINX:
// kubectl expose deployment myapp --type=LoadBalancer --port=80 --target-port=80
```

You can retrieve the public IP address by checking the External IP of the service. It will take a few minutes to provision the public IP. If you see the External IP as Pending, check again in a minute or two:

```
$ kubectl get svc myapp
NAME      CLUSTER-IP      EXTERNAL-IP         PORT(S)        AGE
myapp     10.15.253.160   XXX.XXX.XXX.XXX     80:30735/TCP   29s
```

Use the browser to browse to the newly provisioned IP address and you should see the application running.

Finally, you can un-deploy both the app and the load balancer:

```
$ kubectl delete deployment/myapp svc/myapp
```

What just happened?! Let's go through this in detail in the rest of the lab with deploying something more complex.