Exercise 14b

Create a Kubernetes Cluster in DigitalOcean and Deploy Cassandra

Prior Knowledge
Unix Command Line Shell
YAML
Completion of Ex 14a

Learning Objectives
See how Cassandra replicates
Introduction to Kubernetes

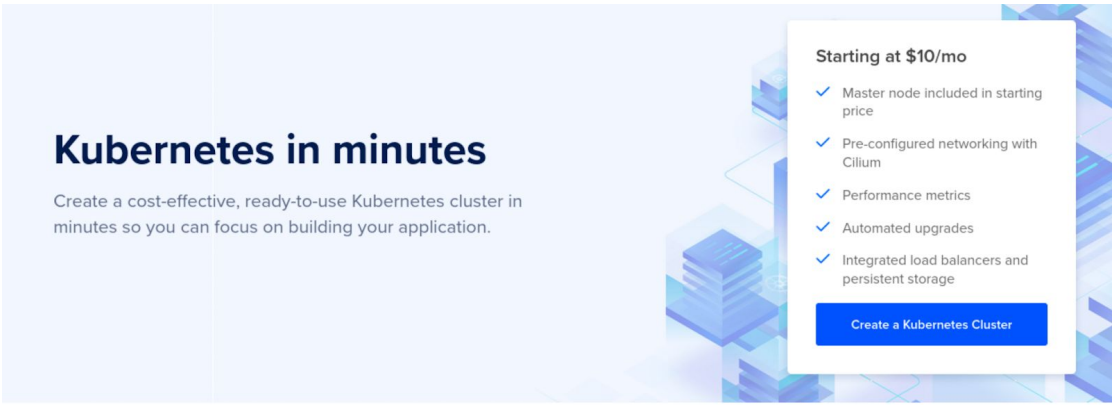
Software Requirements
Browser
kubectl

Overview

In this exercise we are going to instantiate a Kubernetes cluster in DO, then install a Cassandra ring onto the kubernetes cluster. Finally we will do some load-testing.

1. If you have left the cluster running from Ex14a, go straight to **step 2**

    a. Otherwise redo the steps to create a cluster:



    b. Make sure you install the monitoring 1-click app.

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d. Download the config file, then:
```
mv ~/Downloads/k8s-cass-kubeconfig.yaml ~/.kube/
```

In your terminal window:
```
export KUBECONFIG=~/.kube/k8s-cass-kubeconfig.yaml
```

(There are also other things we can do, but this works fine)

e. Check it works:

```
kubectl get all
```

You should see something like:

```
NAME                 TYPE        CLUSTER-IP    EXTERNAL-IP   PORT(S)   AGE
service/kubernetes   ClusterIP   10.245.0.1    <none>        443/TCP   45m
```

2. Now let's make a directory for our Cassandra YAMLs:

```
mkdir ~/cassandra
```

3. There are only two small YAML files required to get Cassandra running. They come from this webpage:
https://kubernetes.io/docs/tutorials/stateful-application/cassandra/

Because we need to modify one of them, let's download them:

```
cd ~/cassandra
wget https://k8s.io/examples/application/cassandra/cassandra-service.yaml
wget https://k8s.io/examples/application/cassandra/cassandra-statefulset.yaml
```

4. Take a look at the cassandra-service.yaml:

It is really simple (for YAML!):

```yaml
apiVersion: v1
kind: Service
metadata:
  labels:
    app: cassandra
  name: cassandra
spec:
  clusterIP: None
  ports:
  - port: 9042
  selector:
    app: cassandra
```

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5. This is "kind of" the equivalent of EXPOSE in Docker. You could compare this to the one in the "hello-kubernetes" app if you like.

6. Let's deploy this:
```
kubectl apply -f cassandra-service.yaml

service/cassandra created
```

7. Check if it is happy:
```
kubectl get svc

NAME         TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
cassandra    ClusterIP   None         <none>        9042/TCP   29s
kubernetes   ClusterIP   10.245.0.1   <none>        443/TCP    28m
```

8. You should see the cassandra service running alongside the kubernetes master. We need this to be in place **before** we start the next part because the different pods need to be able to access each other via port 9042 for the cluster to form.

9. The second file is more complex. It basically defines three things:
    a. The cassandra images and config to start a cassandra container

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: cassandra
  labels:
    app: cassandra
spec:
  serviceName: cassandra
  replicas: 3
  selector:
    matchLabels:
      app: cassandra
  template:
    metadata:
      labels:
        app: cassandra
```

(That is just the start of that bit)

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b. Defines the storage that will be needed by these servers in a StatefulSet (https://cloud.google.com/kubernetes-engine/docs/concepts/statefulset)

```
volumeClaimTemplates:
  - metadata:
      name: cassandra-data
    spec:
      accessModes: [ "ReadWriteOnce" ]
      storageClassName: fast
      resources:
        requests:
          storage: 1Gi
```

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c. Defines a StorageClass for deploying into Minikube (a kubernetes distro designed to run on developers' machines).

```
---
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: fast
provisioner: k8s.io/minikube-hostpath
parameters:
  type: pd-ssd
```

10. This YAML will **not work** as is. That is because we need the Kubernetes cluster to request disk from DigitalOcean specifically, not from minikube.

11. Let's see what StorageClass is available in our DO cluster:

```
kubectl get storageclass
```

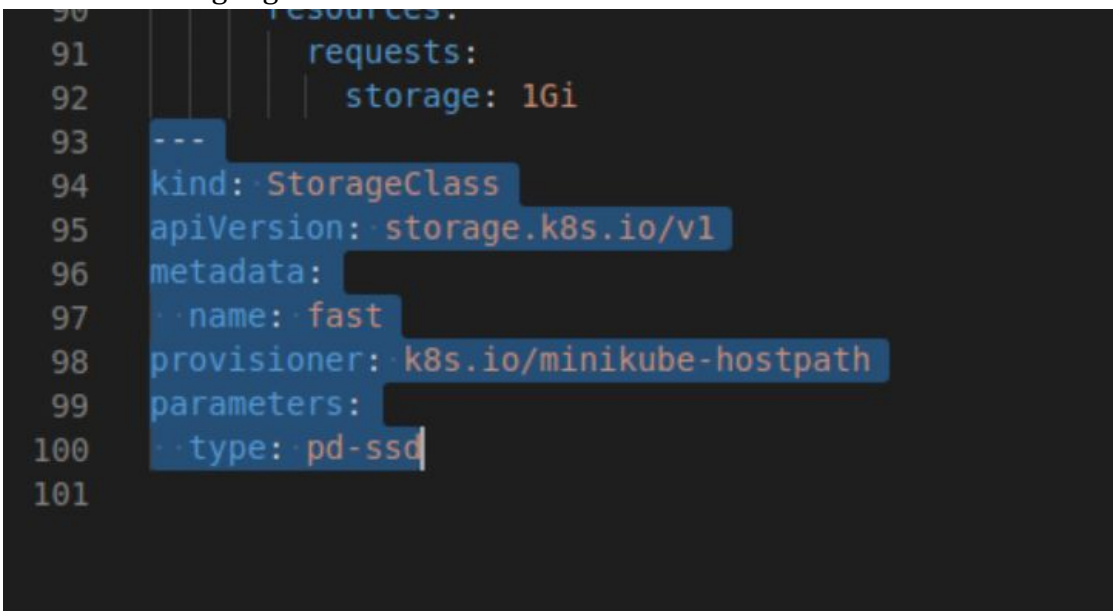
```
NAME                         PROVISIONER                 RECLAIMPOLICY   VOLUMEBINDINGMODE   ALLOWVOLUMEEXPANSION   AGE
do-block-storage (default)   dobs.csi.digitalocean.com   Delete          Immediate           true                   5h26m
```

This is a pre-configured storage class for DO called `do-block-storage`

12. We need to edit the YAML file:

```
code ~/cassandra/cassandra-statefulset.yaml
```

13. Firstly, lets delete the StorageClass section:
Delete all the highlighted lines:



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14. Secondly, change the storageClassName from **fast** to **do-block-storage** (which we just identified above).

```
80            mountPath: /cassandra_data
81      # These are converted to volume claims by the controller
82      # and mounted at the paths mentioned above.
83      # do not use these in production until ssd GCEPersistentDisk or
84      volumeClaimTemplates:
85      - metadata:
86          name: cassandra-data
87        spec:
88          accessModes: [ "ReadWriteOnce" ]
89          storageClassName: do-block-storage
90          resources:
91            requests:
92              storage: 1Gi
93
94
```

15. Save the file

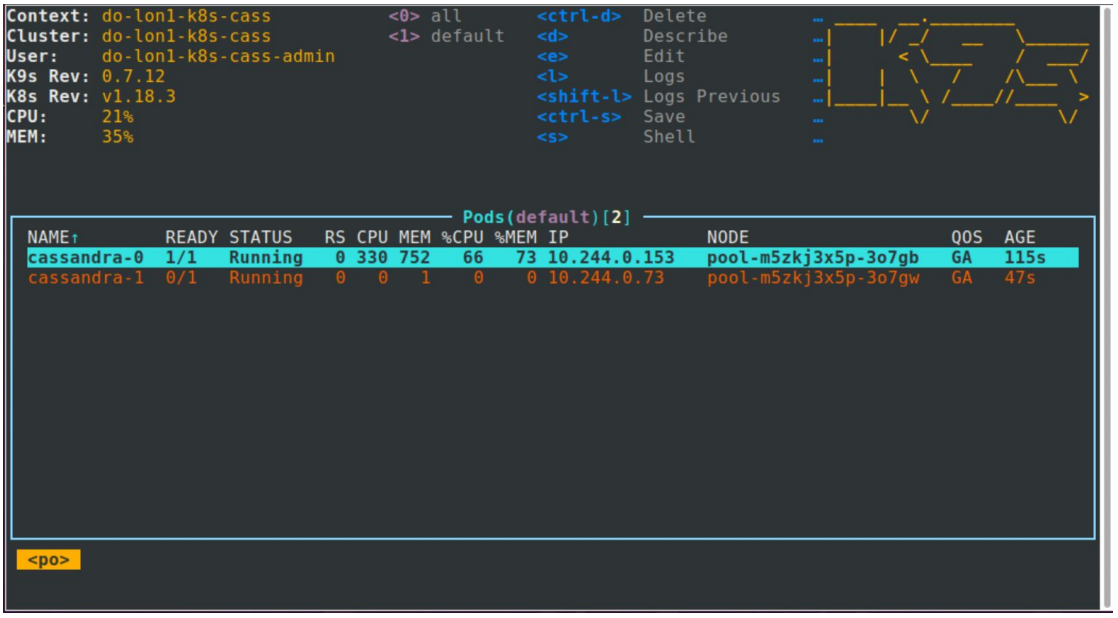
16. Let's deploy this now:

```
kubectl apply -f cassandra-statefulset.yaml

statefulset.apps/cassandra created
```

17. We need to wait a bit for this to start. Basically the system is making API requests to DigitalOcean to provision disks.

    If you go to k9s, you should see the containers appearing and starting up:



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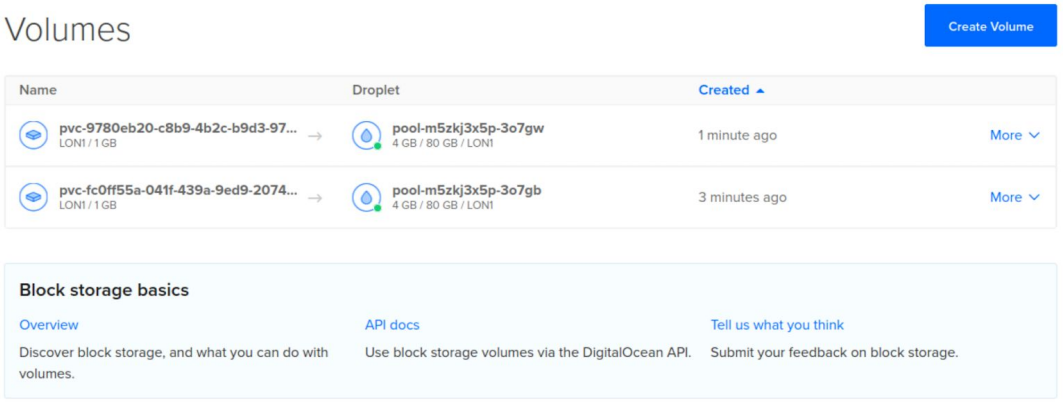
19. If you go to the DigitalOcean control panel you will see **Volumes** being created:



20. After about 5 minutes the cluster should be up and running:

```
kubectl get all
```

```
NAME              READY   STATUS    RESTARTS   AGE
pod/cassandra-0   1/1     Running   0          10m
pod/cassandra-1   1/1     Running   0          9m21s
pod/cassandra-2   1/1     Running   0          7m37s

NAME                 TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
service/cassandra    ClusterIP   None         <none>        9042/TCP   5h14m
service/kubernetes   ClusterIP   10.245.0.1   <none>        443/TCP    5h42m

NAME                           READY   AGE
statefulset.apps/cassandra     3/3     10m
```

21. We can now execute commands in the cassandra cluster.
"kubectl exec -ti" is a bit like docker exec. This executes the command that follows -- on the cassandra-0 container instance.

```
kubectl exec -ti cassandra-0 -- nodetool status
```

```
Datacenter: DC1-K8Demo
======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address       Load       Tokens       Owns (effective)  Host ID                               Rack
UN  10.244.1.109  89.9 KiB   32           52.6%             70e6195b-3629-4d66-a10c-f345015cf68c  Rack1-K8Demo
UN  10.244.0.153  104.55 KiB  32           73.9%             5690399f-6052-439d-b23d-e76e6c152758  Rack1-K8Demo
UN  10.244.0.73   65.81 KiB  32           73.5%             c5a95d05-6891-4586-b416-db5b828b3ccf  Rack1-K8Demo
```

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22. Now let's stress test the server. We can do it over the network between our machine and the DO cluster, but be warned this isn't terribly efficient.

    First, let's forward the cluster port 9042 to local port 9040. We are choosing 9040 locally because we might still be running cassandra locally on 9042 and we want to be sure we are talking to the remote cluster:

    ```
    kubectl port-forward pods/cassandra-0  9040:9042
    ```

    You should see:

    ```
    Forwarding from 127.0.0.1:9040 -> 9042
    Forwarding from [::1]:9040 -> 9042
    ```

    Leave that window and ***start a new terminal window.***

23. Now let's to a stress test on port 9040:

    ```
    cassandra-stress write n=100000 -port native=9040 -rate threads=1000
    ```

    You may see some Java exceptions in the logs (due to networking challenges). Eventually it should finish with something like:

    ```
    Results:
    Op rate                   :    1,745 op/s  [WRITE: 1,745 op/s]
    Partition rate            :    1,745 pk/s  [WRITE: 1,745 pk/s]
    Row rate                  :    1,745 row/s [WRITE: 1,745 row/s]
    Latency mean              :  562.7 ms [WRITE: 562.7 ms]
    Latency median            :  504.9 ms [WRITE: 504.9 ms]
    Latency 95th percentile   :  995.1 ms [WRITE: 995.1 ms]
    Latency 99th percentile   : 1297.1 ms [WRITE: 1,297.1 ms]
    Latency 99.9th percentile : 1903.2 ms [WRITE: 1,903.2 ms]
    Latency max               : 2493.5 ms [WRITE: 2,493.5 ms]
    Total partitions          :    100,000 [WRITE: 100,000]
    Total errors              :          0 [WRITE: 0]
    Total GC count            : 0
    Total GC memory           : 0.000 KiB
    Total GC time             :    0.0 seconds
    Avg GC time               :    NaN ms
    StdDev GC time            :    0.0 ms
    Total operation time      : 00:00:57

    END
    ```

24. Kill the port forwarding process (Ctrl-C).

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26. Let's now do the same test from within the cluster. Use the same window you've been using for kubectl before
(i.e. the one where you did `export KUBECONFIG=`)
To do this, we can start a new pod and get shell access:

```
kubectl apply -f https://raw.githubusercontent.com/pzfreo/ox-clo/master/code/cass-tools/shell.yaml
```

You should see:
`root@pool-gdbxlmdop-3oyjy:/#`

27. This is just an Ubuntu container with cassandra tools installed.

Start another window and do

```
export KUBECONFIG=~/.kube/k8s-cass-kubeconfig.yaml
```

Let's check it started:

```
kubectl get all
```

```
NAME              READY   STATUS    RESTARTS   AGE
pod/cassandra-0   1/1     Running   0          4h27m
pod/cassandra-1   1/1     Running   0          4h26m
pod/cassandra-2   1/1     Running   0          4h24m
pod/casstool      1/1     Running   0          23m

NAME                 TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)
AGE
service/cassandra    ClusterIP   None         <none>        9042/TCP
9h
service/kubernetes   ClusterIP   10.245.0.1   <none>        443/TCP
9h

NAME                           READY   AGE
statefulset.apps/cassandra     3/3     4h27m
```

28. Inside kubernetes, the networking is different to the real world. We need to know a host IP to contact the pods on:

```
kubectl describe svc/cassandra

Name:              cassandra
Namespace:         default
Labels:            app=cassandra
Annotations:       Selector:  app=cassandra
Type:              ClusterIP
IP:                None
Port:              <unset>  9042/TCP
TargetPort:        9042/TCP
Endpoints:         10.244.0.153:9042,10.244.0.73:9042,10.244.1.109:9042
Session Affinity:  None
Events:            <none>
```

Choose one of the IP addresses listed as an endpoint. Make a note
(in my case 10.244.0.153)

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29. We can now get a command-line in that container:

```
kubectl exec -it casstool -- bash
```

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30. Now let's redo that test from within the cluster (with your IP address)

```
cassandra-stress write n=100000 -rate threads=1000 -node 10.244.0.153
```

Unless you have a massively fast connection from your machine to the DO datacentre, you should see much better performance now:

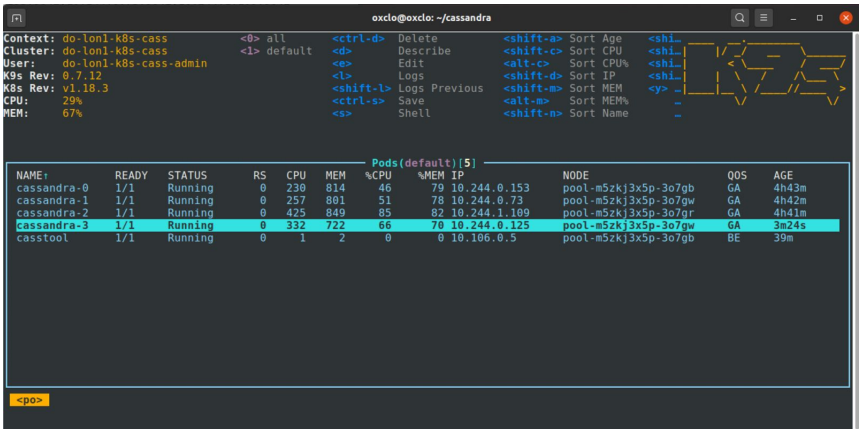
```
Results:
Op rate                   :    7,527 op/s  [WRITE: 7,527 op/s]
Partition rate            :    7,527 pk/s  [WRITE: 7,527 pk/s]
Row rate                  :    7,527 row/s [WRITE: 7,527 row/s]
Latency mean              :  123.7 ms [WRITE: 123.7 ms]
Latency median            :   87.9 ms [WRITE: 87.9 ms]
Latency 95th percentile   :  419.7 ms [WRITE: 419.7 ms]
Latency 99th percentile   :  649.6 ms [WRITE: 649.6 ms]
Latency 99.9th percentile : 1015.0 ms [WRITE: 1,015.0 ms]
Latency max               : 1106.2 ms [WRITE: 1,106.2 ms]
Total partitions          :    100,000 [WRITE: 100,000]
Total errors              :          0 [WRITE: 0]
Total GC count            : 0
Total GC memory           : 0.000 KiB
Total GC time             :    0.0 seconds
Avg GC time               :    NaN ms
StdDev GC time            :    0.0 ms
Total operation time      : 00:00:13

END
```

31. Now let's add another node into the cluster.

Quit that container shell (Ctrl-D) and execute this command:

```
kubectl scale --replicas 4 statefulset/cassandra
```

Wait for the new instance to be live:



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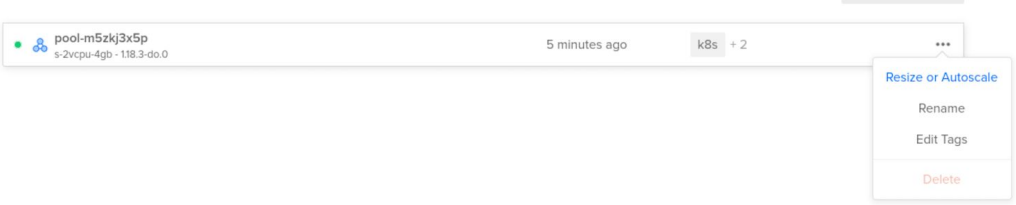
33. Now lets ask the status from Cassandra:

```
oxclo@oxclo: ~/cassandra
oxclo@oxclo:~/cassandra$ kubectl exec -ti cassandra-0 -- nodetool status
Datacenter: DC1-K8Demo
======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address       Load       Tokens       Owns (effective)  Host ID                               Rack
UN  10.244.0.125  11.04 MiB  32           34.2%             bedbd45a-1cba-4e51-ad2e-d32aadc43773  Rack1-K8Demo
UN  10.244.1.109  22.65 MiB  32           20.2%             70e6195b-3629-4d66-a10c-f345015cf68c  Rack1-K8Demo
UN  10.244.0.153  27.48 MiB  32           23.8%             5690399f-6052-439d-b23d-e76e6c152758  Rack1-K8Demo
UN  10.244.0.73   10.19 MiB  32           21.9%             c5a95d05-6891-4586-b416-db5b828b3ccf  Rack1-K8Demo
```

34. Rerun the stress test (Steps 29 and 30).
    Unfortunately, we may not be any faster - because now at least 2 pods are on one node (4 pods, 3 nodes).

```
Results:
Op rate                   :    5,695 op/s  [WRITE: 5,695 op/s]
Partition rate            :    5,695 pk/s  [WRITE: 5,695 pk/s]
Row rate                  :    5,695 row/s [WRITE: 5,695 row/s]
Latency mean              :  164.1 ms [WRITE: 164.1 ms]
Latency median            :   72.7 ms [WRITE: 72.7 ms]
Latency 95th percentile   :  590.3 ms [WRITE: 590.3 ms]
Latency 99th percentile   :  788.0 ms [WRITE: 788.0 ms]
Latency 99.9th percentile :  976.2 ms [WRITE: 976.2 ms]
Latency max               : 1406.1 ms [WRITE: 1,406.1 ms]
Total partitions          :    100,000 [WRITE: 100,000]
Total errors              :          0 [WRITE: 0]
Total GC count            : 0
Total GC memory           : 0.000 KiB
Total GC time             :    0.0 seconds
Avg GC time               :    NaN ms
StdDev GC time            :    0.0 ms
Total operation time      : 00:00:17
```

35. Let's fix that:
    Go to the Digital Ocean **Kubernetes**-> **k8s-cass**-> **Nodes**. Click on the Node Pool …



Now choose **Resize or Autoscale**

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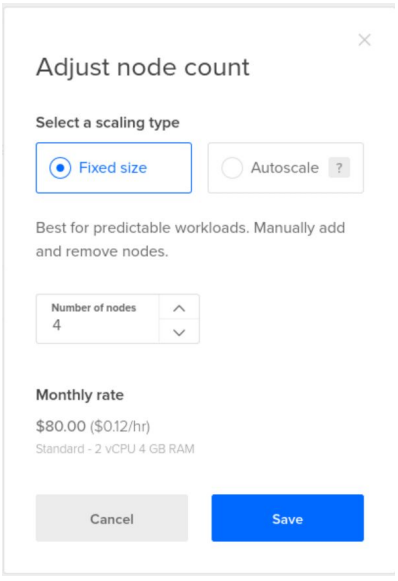
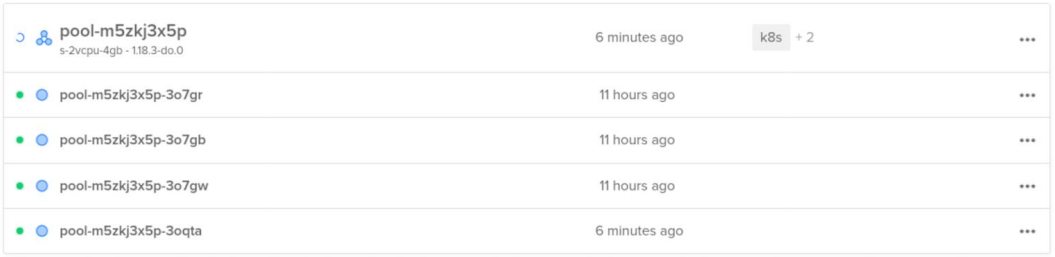
Add an extra node:



36. Wait until the new node is in place:



37. Quit the casstool shell (Ctrl-D)

38. Check from kubectl that the new node is active:

```
kubectl get nodes

NAME                    STATUS   ROLES    AGE     VERSION
pool-m5zkj3x5p-3o7gb    Ready    <none>   11h     v1.18.3
pool-m5zkj3x5p-3o7gr    Ready    <none>   11h     v1.18.3
pool-m5zkj3x5p-3o7gw    Ready    <none>   11h     v1.18.3
pool-m5zkj3x5p-3oqta    Ready    <none>   5m57s   v1.18.3
```

39. Use either the Kubernetes Dashboard or k9s or kubectl to see how the pods are assigned to nodes. Unfortunately we are unbalanced, because Kubernetes hasn't had any impetus to move the extra pod to the new node.

40. Rerun the stress test and see what the performance is like. Why isn't it better?!

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41. We have two options. We could just create a few more Cassandra nodes to more evenly use the nodes. However, there is another option using a cool tool called the Kubernetes Descheduler:

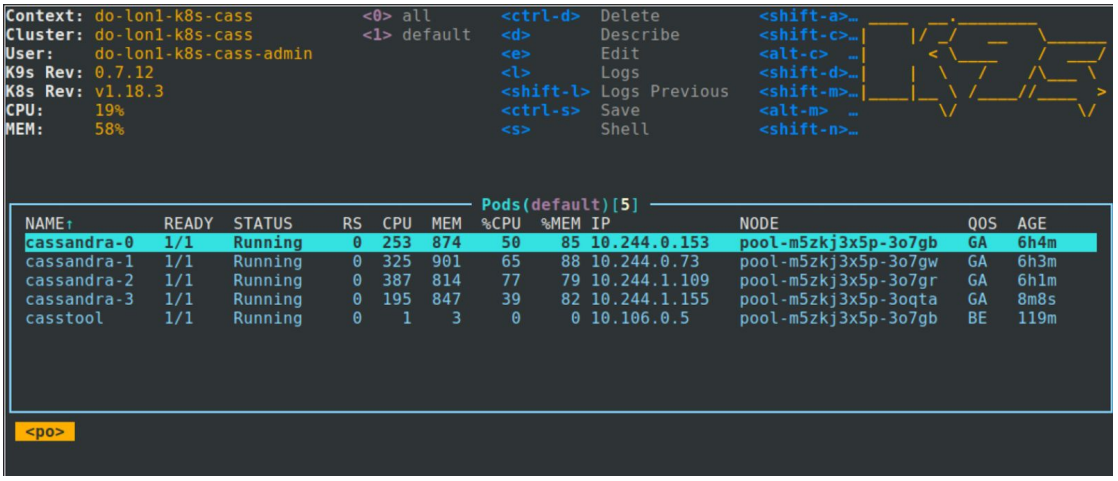
    https://github.com/kubernetes-sigs/descheduler

42. In a window do this:

```
export KUBECONFIG=~/.kube/k8s-cass-kubeconfig.yaml
git clone
https://github.com/kubernetes-sigs/descheduler.git
cd descheduler
kubectl create -f kubernetes/rbac.yaml
kubectl create -f kubernetes/configmap.yaml
kubectl create -f kubernetes/job.yaml
```

43. Watch what happens using k9s

44. Once the pod has moved, all the cassandra pods should be on different nodes:



45. Now rerun the stress test one more time:
    You can see my results were considerably better:

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```
Results:
Op rate                   :    9,650 op/s  [WRITE: 9,650 op/s]
Partition rate            :    9,650 pk/s  [WRITE: 9,650 pk/s]
Row rate                  :    9,650 row/s [WRITE: 9,650 row/s]
Latency mean              :   98.2 ms [WRITE: 98.2 ms]
Latency median            :   81.1 ms [WRITE: 81.1 ms]
Latency 95th percentile   :  299.9 ms [WRITE: 299.9 ms]
Latency 99th percentile   :  464.0 ms [WRITE: 464.0 ms]
Latency 99.9th percentile :  724.6 ms [WRITE: 724.6 ms]
Latency max               :  801.6 ms [WRITE: 801.6 ms]
Total partitions          :    100,000 [WRITE: 100,000]
Total errors              :          0 [WRITE: 0]
Total GC count            : 0
Total GC memory           : 0.000 KiB
Total GC time             :    0.0 seconds
Avg GC time               :    NaN ms
StdDev GC time            :    0.0 ms
Total operation time      : 00:00:10
```

46. Congratulations - we have deployed cassandra, scaled it, tested it and increased performance all in a kubernetes cluster.

47. Let's clean up.

48. Firstly, let's delete our cassandra cluster.

```
cd ~/cassandra
kubectl delete -f cassandra-statefulset.yaml
```

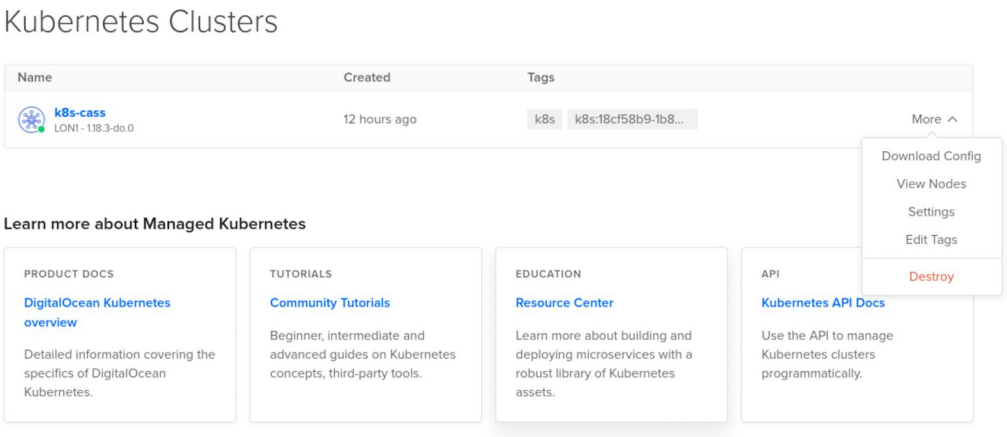
49. Delete our casstool pod:

```
kubectl delete pod/casstool
```

50. Delete the volumes / volume claims:

```
kubectl delete persistentvolumeclaim -l app=cassandra
```

51. Delete the kubernetes cluster (from the DO web panel):



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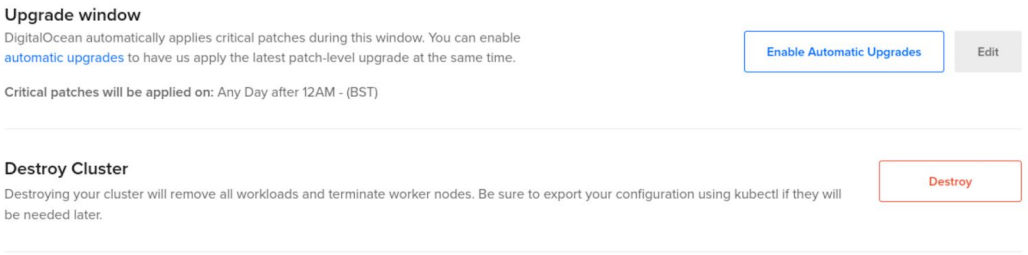
Click **Destroy**



Then **Destroy** again.

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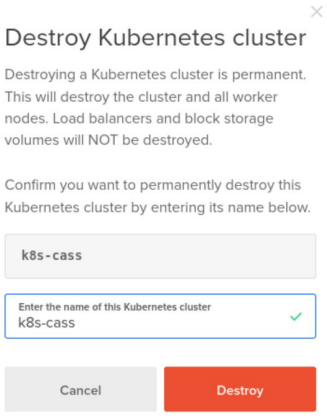
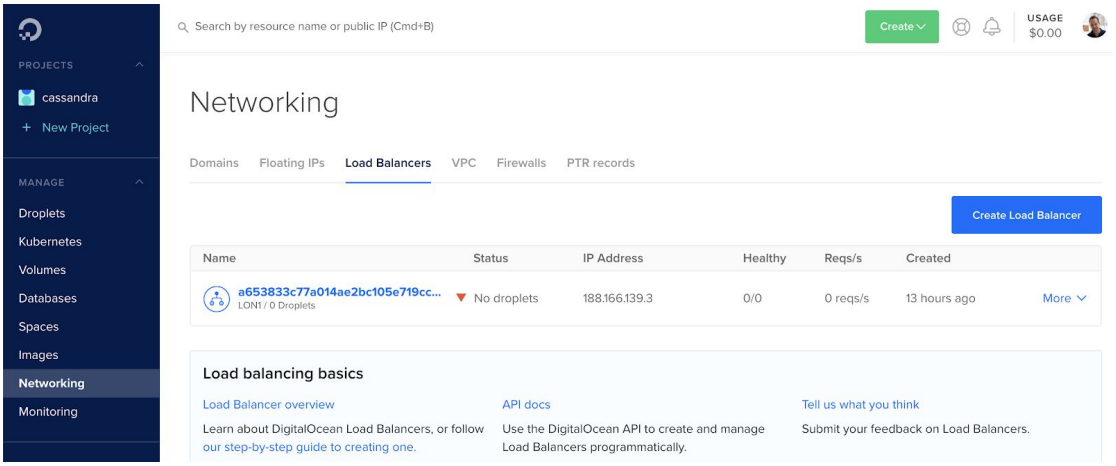
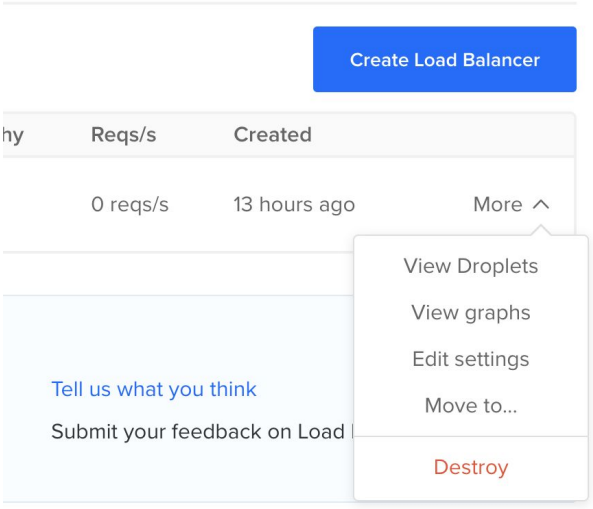
Then enter the cluster name (k8s-cass) and actually finally **Destroy**



51. If you came straight to this lab from the last one, you will also have one last remaining load balancer running.

DigitalOcean will also have created a load-balancer to handle the incoming traffic for your service. Go to **Networking -> Load Balancers**





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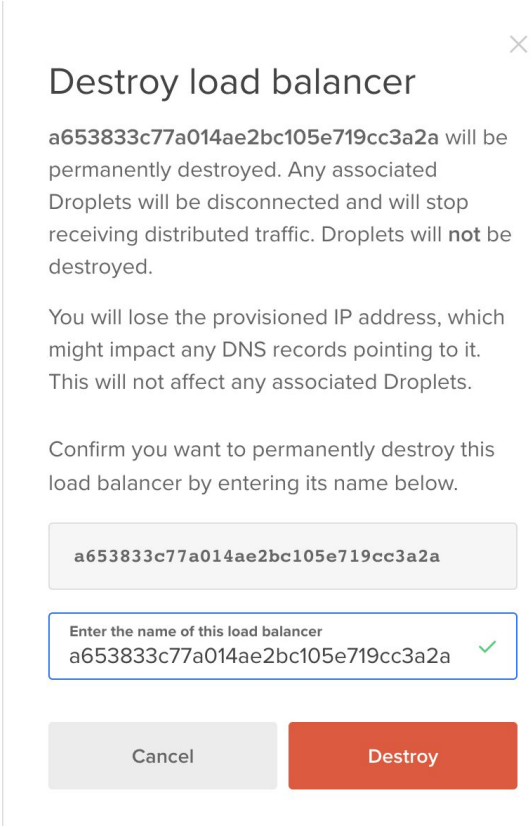
52. Click on **Destroy** and once again enter the name (copy and paste!)



53. Have a hunt round all the resources in DigitalOcean and just check you haven't left anything running!

54. This lab is done! Congratulations.

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