Kubernetes Project

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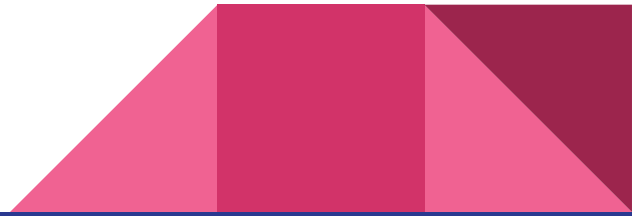
Introduction

- The platform for this project is Google Cloud Platform
- The technology used are
  - Google Kubernetes Engine (GKE)
  - MongoDB
  - Python flask web framework
  - REST API
- GKE techniques used are
  - Pod
  - Service
  - Persistent volume
  - Ingress
  - ConfigMaps

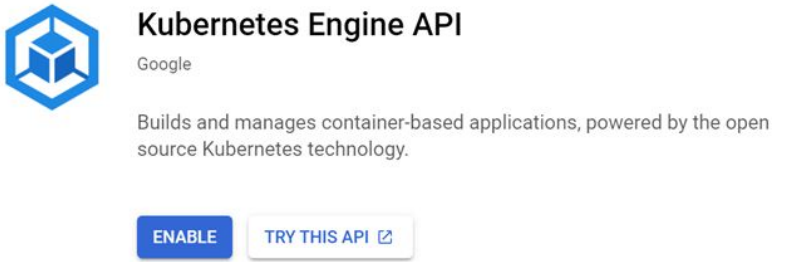


Design

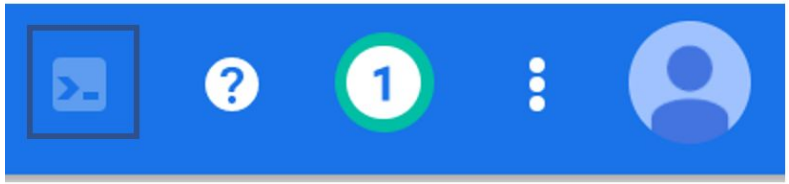
- Kubernetes has the ability to flexibly run on distributed systems
  - Service discovery and load balancing
  - Storage orchestration
  - Automated rollouts and rollbacks
  - Automatic bin packing
  - Self-healing
  - Secret and configuration management
- MongoDB is fast, it supports JSON query language, and supports dynamic queries which is necessary in cloud computing
- Flask is easy to understand, fast and flexible like Kubernetes with the ability to scale up
- REST API is flexible because it can handle multiple calls and return various data formats

Implementation

1. If starting from a new project, enable GKE



2. Activate Cloud Shell and create a cluster



Implementation

3. `gcloud container clusters create kubia --num-nodes=1 --machine-type=e2-micro --region=us-west1`

```
NAME   LOCATION   MASTER_VERSION   MASTER_IP        MACHINE_TYPE   NODE_VERSION      NUM_NODES   STATUS
kubia  us-west1   1.18.16-gke.502  104.196.236.204  e2-micro       1.18.16-gke.502   3           RUNNING
```

4. Create a persistent volume

   `gcloud compute disks create --size=10GiB --zone=us-west1-a mongodb`

```
NAME     ZONE        SIZE_GB  TYPE          STATUS
mongodb  us-west1-a  10       pd-standard   READY
```

Implementation

5. Create a yaml file named mongodb-deployment.yaml

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
    name: mongodb-deployment
spec:
    selector:
        matchLabels:
            app: mongodb
    strategy:
        type: Recreate
    template:
        metadata:
            labels:
                app: mongodb
        spec:
            containers:
                # by default, the image is pulled from docker hub
                - image: mongo
                  name: mongo
                  ports:
                    - containerPort: 27017
                  volumeMounts:
                    - name: mongodb-data
                      mountPath: /data/db
            volumes:
                - name: mongodb-data
                  gcePersistentDisk:
                    pdName: mongodb
                    fsType: ext4
```

Implementation

6. Create a MongoDB deployment pod:

```
kubectl apply -f mongodb-deployment.yaml
```

```
montaos19518@cloudshell:~ (cs571-new)$ kubectl apply -f mongodb-deployment.yaml
deployment.apps/mongodb-deployment created
```

7. Check if the pod is running: kubectl get pods

```
montaos19518@cloudshell:~ (cs571-new)$ kubectl get pods
NAME                                 READY   STATUS    RESTARTS   AGE
mongodb-deployment-554cbb9965-lh569  1/1     Running   0          57s
```

8. Create a yaml file named mongodb-service.yaml to create a service to access from the outside

Implementation

```
apiVersion: v1
kind: Service
metadata:
    name: mongodb-service
spec:
    type: LoadBalancer
    ports:
        # service port in cluster
        - port: 27017
        # port to contact inside container
          targetPort: 27017
    selector:
        app: mongodb
```

9. Create a service for MongoDB: `kubectl apply -f mongodb-service.yaml`

```
montaos19518@cloudshell:~ (cs571-new)$ kubectl apply -f mongodb-service.yaml
service/mongodb-service created
```

Implementation

10. Check if the service is running: `kubectl get svc`

```
montaos19518@cloudshell:~ (cs571-new)$ kubectl get svc
NAME              TYPE           CLUSTER-IP     EXTERNAL-IP      PORT(S)           AGE
kubernetes        ClusterIP      10.3.240.1     <none>           443/TCP           22m
mongodb-service   LoadBalancer   10.3.245.57    35.230.71.134    27017:32306/TCP   48s
```

11. Check if MongoDB connection with external IP is working

    `kubectl exec -it <mongo-db-deployment pod name> -- bash`

```
montaos19518@cloudshell:~ (cs571-new)$ kubectl exec -it mongodb-deployment-554cbb9965-lh569 -- bash
root@mongodb-deployment-554cbb9965-lh569:/#
```

12. `mongo <external-ip>`

    Output should display info about MongoDB and its connection

13. `exit`
14. Install mongoose: `npm install mongoose`

Implementation

15. Insert records in MongoDB: `node`

```
montaos19518@cloudshell:~ (cs571-306821)$ node
Welcome to Node.js v12.14.1.
Type ".help" for more information.
>
```

Implementation

16.

```
> var MongoClient = require('mongodb').MongoClient;
undefined
> var url = "mongodb://35.230.71.134/mydb"
undefined
> // Connect to db
undefined
>
> MongoClient.connect(url, { useNewUrlParser: true, useUnifiedTopology: true },
... function(err, client) {
.....   if(err)
.....       throw err;
.....
.....           // create a document to be inserted
.....           var db = client.db("studentdb");
.....           const docs = [
.....       { student_id: 11111, student_name: "Bruce Lee", grade: 84 },
.....       { student_id: 22222, student_name: "Jackie Chen", grade: 93 },
.....       { student_id: 33333, student_name: "Jet Li", grade: 88 }
.....     ]
.....     db.collection("students").insertMany(docs, function(err, res) {
.......       if(err) throw err;
.......       console.log(res.insertedCount);
.......       client.close();
.......     });
.....           db.collection("students").findOne({"student_id": 11111},
.......     function(err, result) {
.........       console.log(result);
.........     });
..... });
undefined
> null
3
```

Implementation

17. Create studentServer.js
18. Create Dockerfile

```
montaos19518@cloudshell:~ (cs571-new)$ vi Dockerfile
montaos19518@cloudshell:~ (cs571-new)$ cat Dockerfile
FROM node:7
ADD studentServer.js /studentServer.js
ENTRYPOINT ["node", "studentServer.js"]
RUN npm install mongodb
```

19. Build the studentServer docker image

`docker build -t <Docker Hub ID>/studentserver .`

```
Successfully built ef8c751ff90d
Successfully tagged mva456/studentserver:latest
```

Implementation

20. Push the docker image: `docker push <Docker Hub ID>/studentserver`

21. Create bookshelf.py which contains flask server and API responses
22. Create requirements.txt to include which files to install for the flask server to work

Implementation

```
montaos19518@cloudshell:~ (cs571-306821)$ cat requirements.txt
Flask>=1.1.1,<1.2
flask-restplus>=0.13,<0.14
Flask-SSLify>=0.1.5,<0.2
Flask-Admin>=1.5.3,<1.6
gunicorn>=19,<20
Flask-PyMongo
```

23. Create a Dockerfile

```
montaos19518@cloudshell:~ (cs571-306821)$ cat Dockerfile
FROM python:alpine3.7
COPY . /app
WORKDIR /app
RUN pip install -r requirements.txt
ENV PORT 5000
EXPOSE 5000
ENTRYPOINT ["python3.7"]
CMD ["bookshelf.py"]
```

Implementation

24. Build the bookshelf app into a docker image

    `docker build -t <Docker Hub ID>/bookshelf .`

```
Successfully built f55034334358
Successfully tagged mva456/bookshelf:latest
```

25. Push the docker image to Docker Hub: `docker push <Docker Hub ID>/bookshelf`

```
montaos19518@cloudshell:~ (cs571-new)$ docker push mva456/bookshelf
Using default tag: latest
The push refers to repository [docker.io/mva456/bookshelf]
74a40ac8f6a8: Pushed
43175facf1b0: Pushed
66b6213aba6c: Pushed
5fa31f02caa8: Mounted from library/python
88e61e328a3c: Mounted from library/python
9b77965e1d3f: Mounted from library/python
50f8b07e9421: Mounted from library/python
629164d914fc: Mounted from library/python
latest: digest: sha256:d70b83c78659d13e55792c7f66f5081087750a32fa9f05ff24afd469f5d6c232 size: 2000
```

Implementation

```
montaos19518@cloudshell:~ (cs571-new)$ vi studentserver-configmap.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat studentserver-configmap.yaml
apiVersion: v1
kind: ConfigMap
metadata:
    name: studentserver-config
data:
    MONGO_URL: 35.230.71.134
    MONGO_DATABASE: mydb
```

```
montaos19518@cloudshell:~ (cs571-new)$ vi bookshelf-configmap.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat bookshelf-configmap.yaml
apiVersion: v1
kind: ConfigMap
metadata:
    name: bookshelf-config
data:
    # SERVICE_NAME.NAMESPACE.svc.cluster.local:SERVICE_PORT
    MONGO_URL: 35.230.71.134
    MONGO_DATABASE: mydb
```

Implementation

```
montaos19518@cloudshell:~ (cs571-new)$ vi studentserver-deployment.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat studentserver-deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
    name: web
    labels:
        app: studentserver-deploy
spec:
    replicas: 1
    selector:
        matchLabels:
            app: web
    template:
        metadata:
            labels:
                app: web
        spec:
            containers:
                - image: mva456/studentserver
                  imagePullPolicy: Always
                  name: web
                  ports:
                    - containerPort: 8080
                  env:
                    - name: MONGO_URL
                      valueFrom:
                        configMapKeyRef:
                            name: studentserver-config
                            key: MONGO_URL
                    - name: MONGO_DATABASE
                      valueFrom:
                        configMapKeyRef:
                            name: studentserver-config
                            key: MONGO_DATABASE
```

Implementation

```
montaos19518@cloudshell:~ (cs571-new)$ vi bookshelf-deployment.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat bookshelf-deployment.yaml
apiVersion: apps/v1
kind: Deployment
metadata:
    name: bookshelf-deployment
    labels:
        app: bookshelf-deployment
spec:
    replicas: 1
    selector:
        matchLabels:
            app: bookshelf-deployment
    template:
        metadata:
            labels:
                app: bookshelf-deployment
        spec:
            containers:
                - image: mva456/bookshelf
                  imagePullPolicy: Always
                  name: bookshelf-deployment
                  ports:
                    - containerPort: 5000
                  env:
                    - name: MONGO_URL
                      valueFrom:
                        configMapKeyRef:
                            name: bookshelf-config
                            key: MONGO_URL
                    - name: MONGO_DATABASE
                      valueFrom:
                        configMapKeyRef:
                            name: bookshelf-config
                            key: MONGO_DATABASE
```

Implementation

```
montaos19518@cloudshell:~ (cs571-new)$ vi studentserver-service.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat studentserver-service.yaml
apiVersion: v1
kind: Service
metadata:
    name: web
spec:
    type: LoadBalancer
    ports:
        # service port in cluster
        - port: 8080
          # port to contact inside container
          targetPort: 8080
    selector:
        app: web
```

```
montaos19518@cloudshell:~ (cs571-new)$ vi bookshelf-service.yaml
montaos19518@cloudshell:~ (cs571-new)$ cat bookshelf-service.yaml
apiVersion: v1
kind: Service
metadata:
    name: bookshelf-service
spec:
    type: LoadBalancer
    ports:
        # service port in cluster
        - port: 5000
          # port to contact inside container
          targetPort: 5000
    selector:
        app: bookshelf-deployment
```

Implementation

26. Start minikube: `minikube start`
27. Start ingress: `minikube addons enable ingress`

```
montaos19518@cloudshell:~ (cs571-new)$ minikube addons enable ingress
  - Using image us.gcr.io/k8s-artifacts-prod/ingress-nginx/controller:v0.40.2
  - Using image jettech/kube-webhook-certgen:v1.2.2
  - Using image jettech/kube-webhook-certgen:v1.3.0
* Verifying ingress addon...
* The 'ingress' addon is enabled
```

28. Create studentserver pods and service using previously created YAML files

```
kubectl apply -f studentserver-deployment.yaml
kubectl apply -f studentserver-configmap.yaml
kubectl apply -f studentserver-service.yaml
```

Implementation

29. Create bookshelf pods and service using previously create YAML files

```
kubectl apply -f bookshelf-deployment.yaml
kubectl apply -f bookshelf-configmap.yaml
kubectl apply -f bookshelf-service.yaml
```

30. Check if the pods are running: `kubectl get pods`

```
montaos19518@cloudshell:~ (cs571-306821)$ kubectl get pods
NAME                                    READY   STATUS    RESTARTS   AGE
bookshelf-deployment-7bcfdfc44b-xl7kl   1/1     Running   7          8m17s
web-7cc57c5b74-4n4kd                    1/1     Running   6          120m
```

Implementation

```
montaos19518@cloudshell:~ (cs571-306821)$ vi studentServerMongoIngress.yaml
montaos19518@cloudshell:~ (cs571-306821)$ cat studentServerMongoIngress.yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
    name: server
    annotations:
        nginx.ingress.kubernetes.io/rewrite-target: /$2
spec:
    rules:
        - host: cs571.project.com
          http:
            paths:
                - path: /studentserver(/|$)(.*)
                  pathType: Prefix
                  backend:
                    service:
                        name: web
                        port:
                            number: 8080
                - path: /bookshelf(/|$)(.*)
                  pathType: Prefix
                  backend:
                    service:
                        name: bookshelf-service
                        port:
                            number: 5000
```

Implementation

31. Create an ingress service:

    `kubectl apply -f studentServerMongoIngress.yaml`

```
montaos19518@cloudshell:~ (cs571-306821)$ kubectl apply -f studentServerMongoIngress.yaml
ingress.networking.k8s.io/server created
```

32. Get the ingress' address: `kubectl get ingress`

```
montaos19518@cloudshell:~ (cs571-306821)$ kubectl get ingress
NAME     CLASS    HOSTS              ADDRESS        PORTS   AGE
server   <none>   cs571.project.com  192.168.49.2   80      45s
```

33. Enter the command `sudo vi /etc/hosts`
34. In the last line, add `<address> cs571.project.com`

Implementation

```
montaos19518@cloudshell:~ (cs571-306821)$ cat /etc/hosts
# Kubernetes-managed hosts file.
127.0.0.1       localhost
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
fe00::0 ip6-mcastprefix
fe00::1 ip6-allnodes
fe00::2 ip6-allrouters
172.17.0.4      cs-824671623995-default-boost-2mvvh
192.168.49.2 cs571.project.com
```

Test

Display student's score

```
curl cs571.project.com/studentserver/api/score?student_id=11111
```

```
montaos19518@cloudshell:~ (cs571-306821)$ curl cs571.project.com/studentserver/api/score?student_id=11111
{"_id":"6074b903888c4370acfc8890","student_id":11111,"student_name":"Bruce Lee","grade":84}
```

Display books: `curl cs571.project.com/bookshelf/books`

```
montaos19518@cloudshell:~ (cs571-306821)$ curl cs571.project.com/bookshelf/books
[]
```

Add book

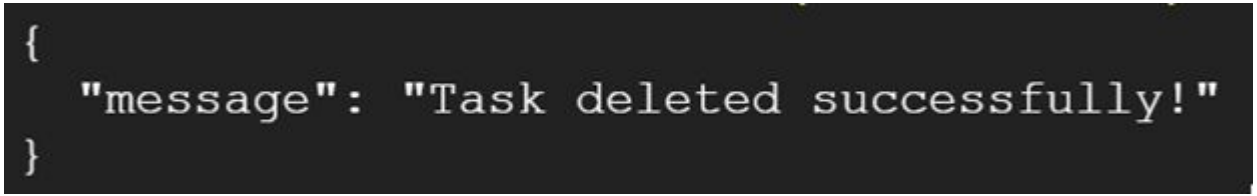
```
curl -X POST -d "{\"book_name\": \"cloud computing\",\"book_author\":
\"unkown\", \"isbn\": \"123456\" }"
http://cs571.project.com/bookshelf/book
```

```
{
  "message": "Task saved successfully!"
}
```

Test

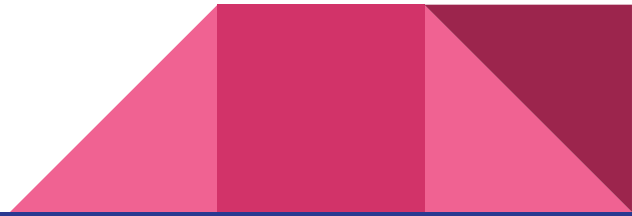
Delete book

```
curl -X DELETE cs571.project.com/bookshelf/book/<id>
```



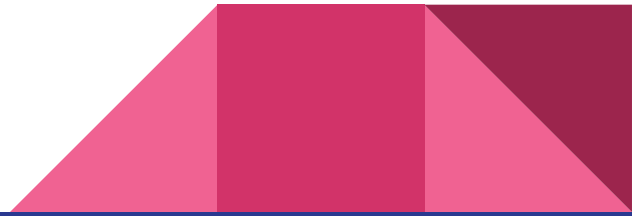
Enhancement ideas

- Implement different apps in GKE
  - Recipe collection
  - To-do list



Conclusion

- It is important to use technologies that are easy to scale for business using cloud computing
- Kubernetes makes a lot of things automated and it eliminated the need to do it manually
- Kubernetes is like an operating system in the cloud



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