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Slot: G2+TG2

Software Engineering Theory DA

1. Setup Kubernetes Cluster

- Use Minikube (for local deployment) or Google Kubernetes Engine (GKE), Amazon EKS, or Azure AKS for cloud-based deployment.
- Ensure the cluster is up and running with at least two worker nodes

Command:- minikube start --driver=docker --nodes=2

Output:-

```
C:\Users\Samyak Shah>minikube start --driver=docker --nodes=2
* minikube v1.35.0 on Microsoft Windows 11 Home Single Language 10.0.26100.3476 Build 26100.3476
* Using the docker driver based on user configuration
* Using Docker Desktop driver with root privileges
* Starting "minikube" primary control-plane node in "minikube" cluster
* Pulling base image v0.0.46 ...
* Downloading Kubernetes v1.32.0 preload ...
  > gcr.io/k8s-minikube/kicbase...: 500.31 MiB / 500.31 MiB 100.00% 1002.98
  > preloaded-images-k8s-v18-v1...: 333.57 MiB / 333.57 MiB 100.00% 478.20
* Creating docker container (CPUs=2, Memory=2200MB) ...
! Failing to connect to https://registry.k8s.io/ from both inside the minikube container and host machine
* To pull new external images, you may need to configure a proxy: https://minikube.sigs.k8s.io/docs/reference/networking/proxy
* Preparing Kubernetes v1.32.0 on Docker 27.4.1 ...
  - Generating certificates and keys ...
  - Booting up control plane ...
  - Configuring RBAC rules ...
* Configuring CNI (Container Networking Interface) ...
* Verifying Kubernetes components...
  - Using image gcr.io/k8s-minikube/storage-provisioner:v5
* Enabled addons: storage-provisioner, default-storageclass

* Starting "minikube-m02" worker node in "minikube" cluster
* Pulling base image v0.0.46 ...
* Creating docker container (CPUs=2, Memory=2200MB) ...
* Found network options:
  - NO_PROXY=192.168.49.2
  - NO_PROXY=192.168.49.2
! Failing to connect to https://registry.k8s.io/ from inside the minikube container
* To pull new external images, you may need to configure a proxy: https://minikube.sigs.k8s.io/docs/reference/networking/proxy
* Preparing Kubernetes v1.32.0 on Docker 27.4.1 ...
  - env NO_PROXY=192.168.49.2
* Verifying Kubernetes components...
* kubectl not found. If you need it, try: 'minikube kubectl -- get pods -A'
* Done! kubectl is now configured to use "minikube" cluster and "default" namespace by default
```

```
C:\Users\Samyak Shah>kubectl get nodes
NAME      STATUS   ROLES      AGE      VERSION
minikube  Ready    control-plane   73s      v1.32.0
minikube-m02  Ready    <none>       44s      v1.32.0
```

```
C:\Users\Samyak Shah>
```

2. Deploy a Web Application

- Use a simple Node.js or Python Flask-based application (or any web app of your choice).
- Containerize the application using Docker.
- Push the container image to Docker Hub or a private container registry

Command:- docker build -t samyakshah1/my-app:latest .

```
docker push samyakshah1/my-app:latest
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>docker build -t samyakshah1/my-app:latest .
[+] Building 241.3s (5/9)
=> [internal] load build definition from Dockerfile
=> => transferring dockerfile: 284B
=> [internal] load metadata for docker.io/library/python:3.9
=> [auth] library/python:pull token for registry-1.docker.io
=> [internal] load .dockercfg
=> => transferring context: 2B
=> [1/4] FROM docker.io/library/python:3.9@sha256:bc2e05bca883473050fc3b7c134c28ab822be73126ba1ce29517d9e8b7f3  237.2s
=> => resolve docker.io/library/python:3.9@sha256:bc2e05bca883473050fc3b7c134c28ab822be73126ba1ce29517d9e8b7f370  0.0s
=> => sha256:7cd785773db44407e20a679ce5439222e505475eed5b9f1910eb2cda51729ab 48.47MB / 48.47MB  132.0s
=> => sha256:859d4a0f1fd8b03e685b4f3b6f0abfeeb84cca3047f9b87d0a8c8f3c90764365 6.17kB / 6.17kB  0.0s
=> => sha256:091eb8249475f42de217265c501e0186f0a3ea7490ef7f51458c30db91fb3cac 24.01MB / 24.01MB  92.2s
=> => sha256:255774e0027b72d2327719e78dbad5ad8c9cf446d055e45be7fc149418470bae 64.40MB / 64.40MB  188.0s
=> => sha256:bc2e05bca883473050fc3b7c134c28ab822be73126ba1ce29517d9e8b7f3703b 10.35kB / 10.35kB  0.0s
=> => sha256:3db46eeb095dbddf83794896233f9ed627746b394587600bf4e8e4c68303a915 2.32kB / 2.32kB  0.0s
=> => sha256:353e14e5cc47664fba714a7da288001d90427c705494847ac773f5cc08199451 103.81MB / 211.35MB  237.2s
=> => extracting sha256:7cd785773db44407e20a679ce5439222e505475eed5b99f1910eb2cda51729ab 1.9s
=> => sha256:f6d72b0ae7cbea513baa839d4f1bcebb51c434df9602410dfd34bc71e233c8e 6.16MB / 6.16MB  148.2s
=> => extracting sha256:091eb8249475f42de217265c501e0186f0a3ea7490ef7f51458c30db91fb3cac 0.5s
=> => sha256:6e02a90e58aec58d3d8f4549cb6a82a2ccc1db075b8a26a48fe1d0f065b52d86 19.85MB / 19.85MB  191.4s
=> => extracting sha256:255774e0027b72d2327719e78dbad5ad8c9cf446d055e45be7fc149418470bae 2.7s
=> => sha256:f299e06712452fd49405fe52fb66dc0bbdd14cc8d8342baa8b2741df89dd465d 250B / 250B  188.9s
=> [internal] load build context
=> => transferring context: 2.29kB  0.0s
|
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>docker push samyakshah1/my-app:latest
The push refers to repository [docker.io/samyakshah1/my-app]
7352f1e02a95: Pushed
3daaa0e1dbdf8: Pushed
ad54e311740c: Pushed
7c6f47952aec: Mounted from library/python
bb8db7b74260: Mounted from library/python
c0102644065e: Mounted from library/python
4c13ea2c0b02: Mounted from library/python
2ed6a19677f5: Mounted from library/python
d2f7abddd607: Mounted from library/python
53babef930602: Mounted from library/python
latest: digest: sha256:78532f4089db067bdeb4dd97171ee0b652ed1564f048a708a94f527d5b7c1a30 size: 2421
```

3. Create Kubernetes Resources

- Deployments: Deploy the web application using a Kubernetes Deployment with at least 3 replicas.

- Services: Create a Service (NodePort or LoadBalancer) to expose the application.
- ConfigMaps & Secrets: Store environment variables (e.g., database connection string) securely using ConfigMaps and Secrets.

Command:-

```
kubectl apply -f configmap.yaml
```

```
kubectl apply -f secret.yaml
```

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

```
kubectl get pods
```

```
kubectl apply -f service.yaml
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f configmap.yaml
configmap/my-app-config created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f secret.yaml
secret/my-app-secret created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get configmaps
NAME          DATA   AGE
kube-root-ca.crt    1      10m
my-app-config      2      40s
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get secrets
NAME          TYPE    DATA   AGE
my-app-secret  Opaque  1      50s
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f deployment.yaml
deployment.apps/my-app created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pods -w
NAME           READY   STATUS    RESTARTS   AGE
my-app-5ff84795dc-2pkkc  1/1     Running   0          43s
my-app-5ff84795dc-fw2bk  1/1     Running   0          43s
my-app-5ff84795dc-zfj5c  1/1     Running   0          43s
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f service.yaml
service/my-app-service created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get services
NAME           TYPE      CLUSTER-IP   EXTERNAL-IP  PORT(S)        AGE
kubernetes     ClusterIP  10.96.0.1    <none>       443/TCP       13m
my-app-service NodePort   10.102.74.193 <none>       80:30007/TCP  25s
```

4. Implement Auto-scaling

- Configure Horizontal Pod Autoscaler (HPA) to scale pods based on CPU utilization.
- Set minimum 2 pods and maximum 5 pods, scaling up when CPU usage exceeds 50%

Command:-

```
kubectl apply -f hpa.yaml
```

```
kubectl get hpa
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f hpa.yaml
horizontalpodautoscaler.autoscaling/my-app-hpa created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get hpa
NAME          REFERENCE          TARGETS          MINPODS   MAXPODS   REPLICAS   AGE
my-app-hpa   Deployment/my-app  cpu: <unknown>/50%  2          5          3          19s
```

5. Implement Persistent Storage (Optional)

- If the application stores data, use Persistent Volume (PV) and Persistent Volume Claim (PVC).
- Mount the volume in the pod for persistent storage.

Command:-

```
kubectl apply -f persistent-volume.yaml
```

```
kubectl apply -f persistent-volume-claim.yaml
```

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

```
kubectl get pods
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f persistent-volume.yaml
persistentvolume/my-pv created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f persistent-volume-claim.yaml
persistentvolumeclaim/my-pvc created
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl apply -f deployment.yaml
deployment.apps/my-app configured
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pv
NAME      CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS     CLAIM      STORAGECLASS
GECCLASS VOLUMEATTRIBUTESCLASS   REASON   AGE
my-pv      1Gi        RWO          Retain       Available
           <unset>    84s
pvc-7b3f5890-be6b-41d9-8e41-bcfb18132e19 500Mi      RWO          Delete      Bound      default/my-pvc  standard
ard       <unset>    47s
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pvc
NAME      STATUS    VOLUME      CAPACITY   ACCESS MODES   STORAGECLASS   VOLUMEATTRIBUTESCL
ASS   AGE
my-pvc   Bound    pvc-7b3f5890-be6b-41d9-8e41-bcfb18132e19 500Mi      RWO          standard      <unset>
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pods -w
NAME      READY   STATUS    RESTARTS   AGE
my-app-5ff84795dc-2pkkc 1/1     Running   0          43s
my-app-5ff84795dc-fw2bk 1/1     Running   0          43s
my-app-5ff84795dc-zfj5c 1/1     Running   0          43s
```

6. Rolling Updates & Rollbacks

- Simulate a rolling update by deploying a new version of the application.
- Perform a rollback in case of a failure.

Command:-

kubectl rollout history deployment my-app

kubectl set image deployment/my-app my-app=samyakshah1/my-app:v2

kubectl get pods

kubectl rollout undo deployment my-app

kubectl rollout status deployment my-app

kubectl get pods

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl rollout history deployment my-app
deployment.apps/my-app
REVISION  CHANGE-CAUSE
1          <none>
2          <none>
3          <none>
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl set image deployment/my-app my-app=samyakshah1/my-app:v2
deployment.apps/my-app image updated
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pods
NAME          READY   STATUS    RESTARTS   AGE
my-app-5ff84795dc-2pkkc  1/1     Running   0          5m57s
my-app-5ff84795dc-fw2bk  1/1     Running   0          5m57s
my-app-5ff84795dc-zfj5c  1/1     Running   0          5m57s
my-app-6f4865bcf4-nfs9d  0/1     ErrImageNeverPull  0          18s
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl rollout undo deployment my-app
deployment.apps/my-app rolled back
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl rollout status deployment my-app
deployment "my-app" successfully rolled out
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pods
NAME          READY   STATUS    RESTARTS   AGE
my-app-5ff84795dc-2pkkc  1/1     Running   0          7m4s
my-app-5ff84795dc-fw2bk  1/1     Running   0          7m4s
my-app-5ff84795dc-zfj5c  1/1     Running   0          7m4s
```

7. Logging • Use kubectl logs to view application logs.

Command:-

```
kubectl logs my-app-5ff84795dc-2pkkc
```

```
kubectl logs -f my-app-5ff84795dc-2pkkc
```

```
kubectl logs -l app=my-app --tail=100
```

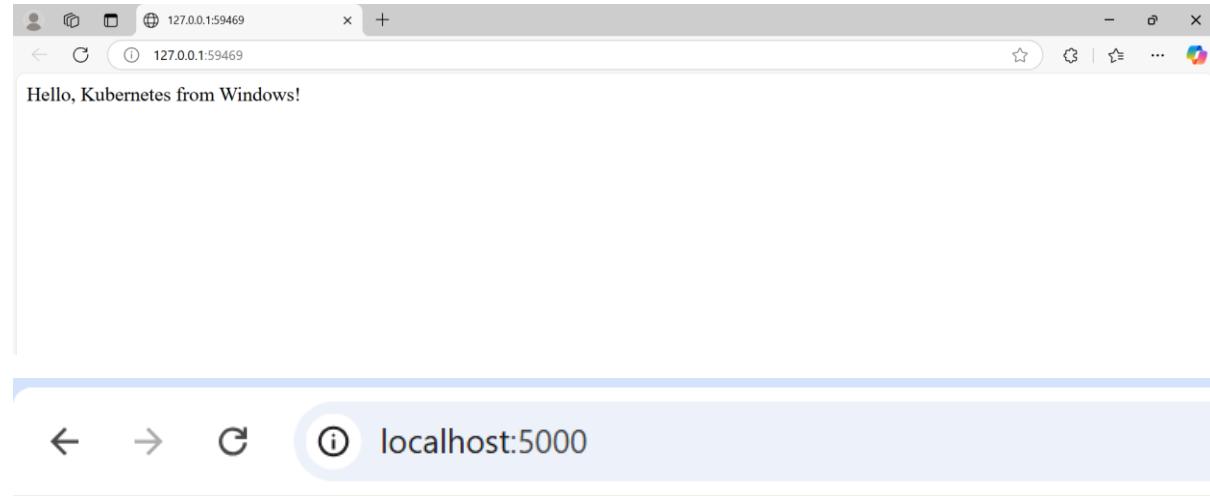
Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl logs my-app-5ff84795dc-2pkkc
* Serving Flask app 'app'
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:5000
* Running on http://10.244.1.14:5000
Press CTRL+C to quit
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl logs -f my-app-5ff84795dc-2pkkc
* Serving Flask app 'app'
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:5000
* Running on http://10.244.1.14:5000
Press CTRL+C to quit
```

```
kubectl expose deployment my-app --type=NodePort --port=5000
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl expose deployment my-app --type=NodePort  
service/my-app exposed  
  
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get svc  
NAME      TYPE      CLUSTER-IP      EXTERNAL-IP      PORT(S)      AGE  
kubernetes   ClusterIP   10.96.0.1    <none>        443/TCP     52m  
my-app       NodePort    10.98.128.29  <none>        5000:32387/TCP 24s  
my-app-service  NodePort    10.102.74.193  <none>        80:30007/TCP  39m  
  
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>minikube ip  
192.168.49.2
```



TESTING PHASE:-

- 1. Application Availability Tests ✓ Test: Check if the application is accessible via the Kubernetes service.**

Command:- kubectl get services

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get services
NAME            TYPE      CLUSTER-IP   EXTERNAL-IP   PORT(S)        AGE
kubernetes      ClusterIP  10.96.0.1    <none>       443/TCP       64m
my-app          NodePort   10.98.128.29 <none>       5000:32387/TCP 12m
my-app-service  NodePort   10.102.74.193  <none>       80:30007/TCP  51m
```

Hello, Kubernetes from Windows!

2. Scaling Tests  **Test:** Trigger high CPU usage to see if the Horizontal Pod Autoscaler (HPA) scales up pods

Command:-

kubectl get hpa

```
kubectl run --rm -it --image=busybox stress-test -- /bin/sh
```

```
while true; do wget -q -O- http://192.168.49.2:32387; done
```

```
kubectl get pods -w
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get hpa
NAME      REFERENCE          TARGETS      MINPODS   MAXPODS   REPLICAS   AGE
my-app-hpa  Deployment/my-app  cpu: <unknown>/50%  2          5          3          54m
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get pods -w
NAME           READY   STATUS    RESTARTS   AGE
my-app-5ff84795dc-2pkkc  1/1     Running   0          32m
my-app-5ff84795dc-fw2bk  1/1     Running   0          32m
my-app-5ff84795dc-zfj5c  1/1     Running   0          32m
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl get hpa
NAME      REFERENCE      TARGETS      MINPODS   MAXPODS   REPLICAS   AGE
my-app    Deployment/my-app  cpu: <unknown>/50%  1         5          3          45s
my-app-hpa Deployment/my-app  cpu: <unknown>/50%  2         5          3          64m
```

3. Rolling Update & Rollback Test ✓ Test: Perform a rolling update and verify zero downtime.

Command:- kubectl set image deployment/my-app my-app=samyakshah1/my-app:v2

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl set image deployment/my-app my-app=samyakshah1/my-app:v2
deployment.apps/my-app image updated
```

✓ Test: Rollback to the previous version in case of failure.

Command:- kubectl rollout undo deployment/my-app

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl rollout undo deployment/my-app
deployment.apps/my-app rolled back
```

4. Pod Failure and Self-Healing Test ✓ Test: Manually delete a pod and check if Kubernetes automatically recreates it.

Command:-

kubectl get pods

kubectl delete pod <POD_NAME>

kubectl get pods -w

Output:-

```
my-app-5ff84795dc-2pkkc  1/1     Running   0          49m
my-app-5ff84795dc-fw2bk  1/1     Running   0          49m
my-app-5ff84795dc-zfj5c  1/1     Running   0          49m
```

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl delete pod my-app-5ff84795dc-fw2bk
pod "my-app-5ff84795dc-fw2bk" deleted
```

my-app-5ff84795dc-2pkkc	1/1	Running	0	51m
my-app-5ff84795dc-wnc7c	1/1	Running	0	44s
my-app-5ff84795dc-zfj5c	1/1	Running	0	51m

5. Persistent Storage Test (If Implemented) ✓ Test: Verify if data persists after pod restart.

Command:-

```
kubectl delete pod <POD_NAME>
```

```
kubectl get pods -w
```

Output:-

Old pod data:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl exec -it my-app-5ff84795dc-2pkkc -- /bin/sh
# cd /app/data
# echo "Persistent Storage Test - Kubernetes" > testfile.txt
# cat testfile.txt
Persistent Storage Test - Kubernetes
# exit
```

Pod deleted:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl delete pod my-app-5ff84795dc-2pkkc
pod "my-app-5ff84795dc-2pkkc" deleted
```

Newly created pod:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl exec -it my-app-5ff84795dc-sqbfx -- /bin/sh
# cd /app/data
# ls
testfile.txt
# cat testfile.txt
Persistent Storage Test - Kubernetes
``
```

6. Logging Test ✓ Test: Check if application logs are available.

Command:-

```
kubectl logs my-app-5ff84795dc-sqbfx
```

Output:-

```
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>kubectl logs my-app-5ff84795dc-sqbfx
* Serving Flask app 'app'
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on all addresses (0.0.0.0)
* Running on http://127.0.0.1:5000
* Running on http://10.244.1.24:5000
Press CTRL+C to quit
C:\Users\Samyak Shah\OneDrive\Desktop\kubernetes_app>
```