📖 Simple 3-Tier Web Application

This project is a simple 3-tier web application with a static frontend and a Node.js backend. The frontend is served by Nginx, while the backend is built with Express.js.

🗁 Project Structure

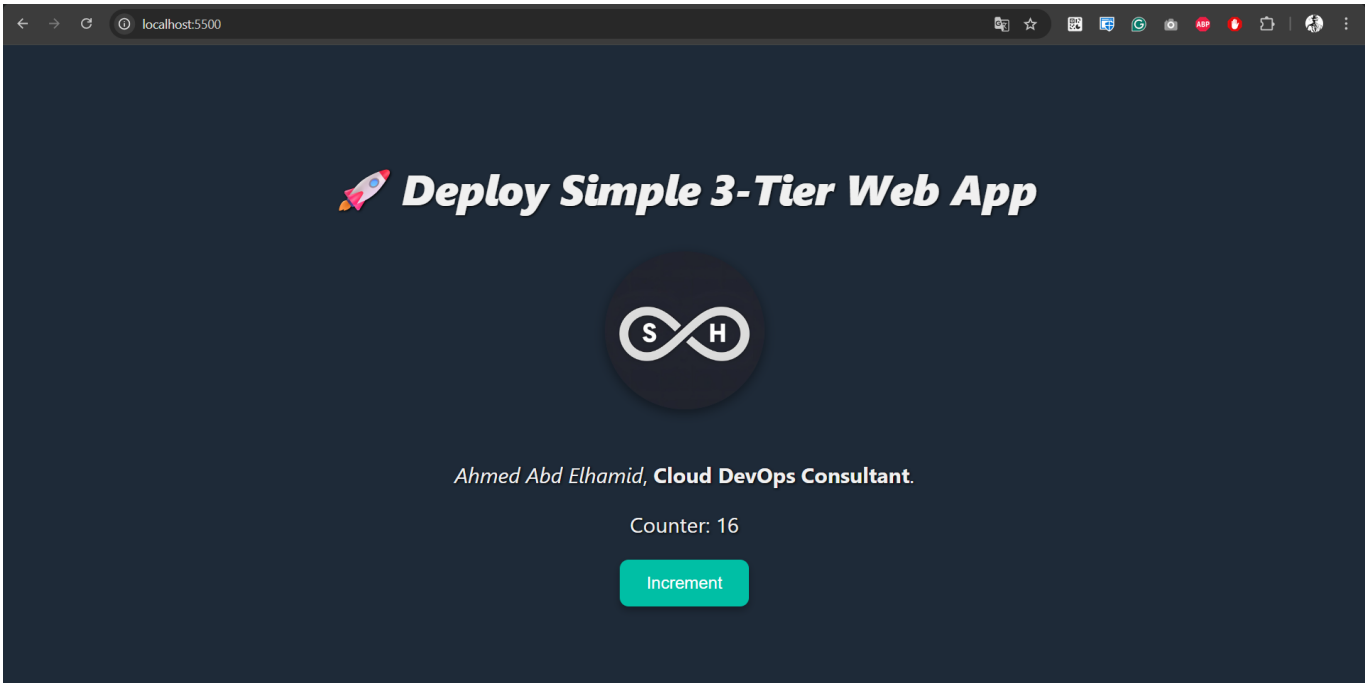
```
simple-3-tier-app/
├── assets/            # Contains project images
├── Backend/           # Node.js (Express) API
├── FrontEnd/          # Static HTML served by Nginx
├── K8s-Local/         # Deploy K8s through minikube
├── K8s-EKS-Region/    # Deploy k8s manifests through Amazon EKS
├── docker-compose.yml
└── README.md
```

💻 Test Local firstly

to test locally

```
Deploy simple-3-tier-app locally
│
├── Backend/
│   │
│   ├── .env
│   │     PORT=3000
│   │     // MONGO_URI=mongodb://mongo-service:27017/counterdb   # EKS
│   │     MONGO_URI=mongodb://localhost:27017/counterdb          # Local
│   │
│   ├── app.js
│   ├── npm install express cors mongoose dotenv
│   │    │
│   │    ├── node_modules/
│   │    └── package.json
│   │
│   # Run MongoDB locally using Docker
│   └─── docker run -d -p 27017:27017 --name mongo mongo
│   │
│   # Run Backend API
│   └─── node app.js
│
│
├── FrontEnd/
│   │
│   ├── index.html
│   │     // const backendUrl = "/api/increment";                  # EKS /
Ingress
```

```
│   │     const backendUrl = "http://localhost:3000/api/increment";  # Local
testing
│   │
│   # Run Frontend server
│   └── python -m http.server 5500
```



Prepare Dockerfile

Backend Structure

```
Backend/
├── app.js
├── package.json
├── package-lock.json  (.gitignore)
├── node_modules       (.gitignore)
├── .env
└── Dockerfile
```

Dockerfile

```
FROM node:20.11.1-alpine3.19
WORKDIR /app
COPY package*.json ./
RUN npm install --only=production
COPY . .
# Expose backend port
EXPOSE 3000
CMD ["node", "app.js"]
```

```
docker build -t backend-app .
```

Frontend Structure

```
FrontEnd/
├── index.html
├── Dockerfile
└── nginx.conf   (import for Ingress/api to work well)
```

nginx.conf

```
server {
    listen 80;

    location / {
        root /usr/share/nginx/html;
        index index.html;
        try_files $uri /index.html;
    }

    location /api/ {
        #(backend:3000) → Name of Backend Service in "Kubernetes"
        proxy_pass http://backend:3000;
        proxy_set_header Host $host;
        proxy_set_header X-Real-IP $remote_addr;
    }
}
```

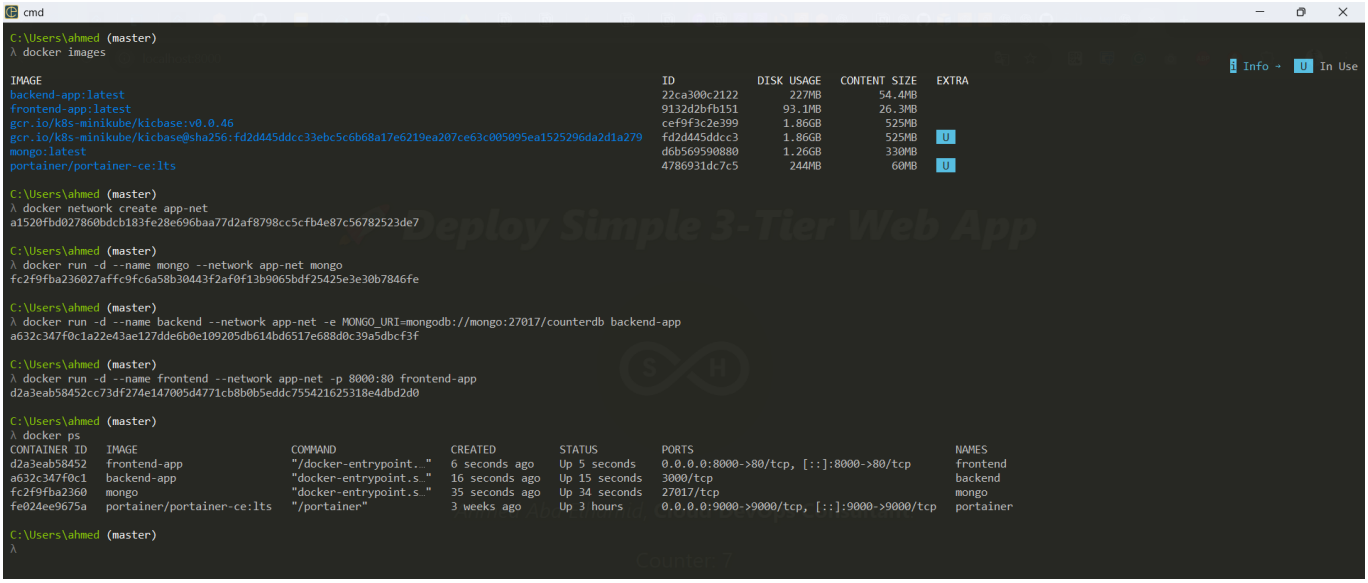
Dockerfile

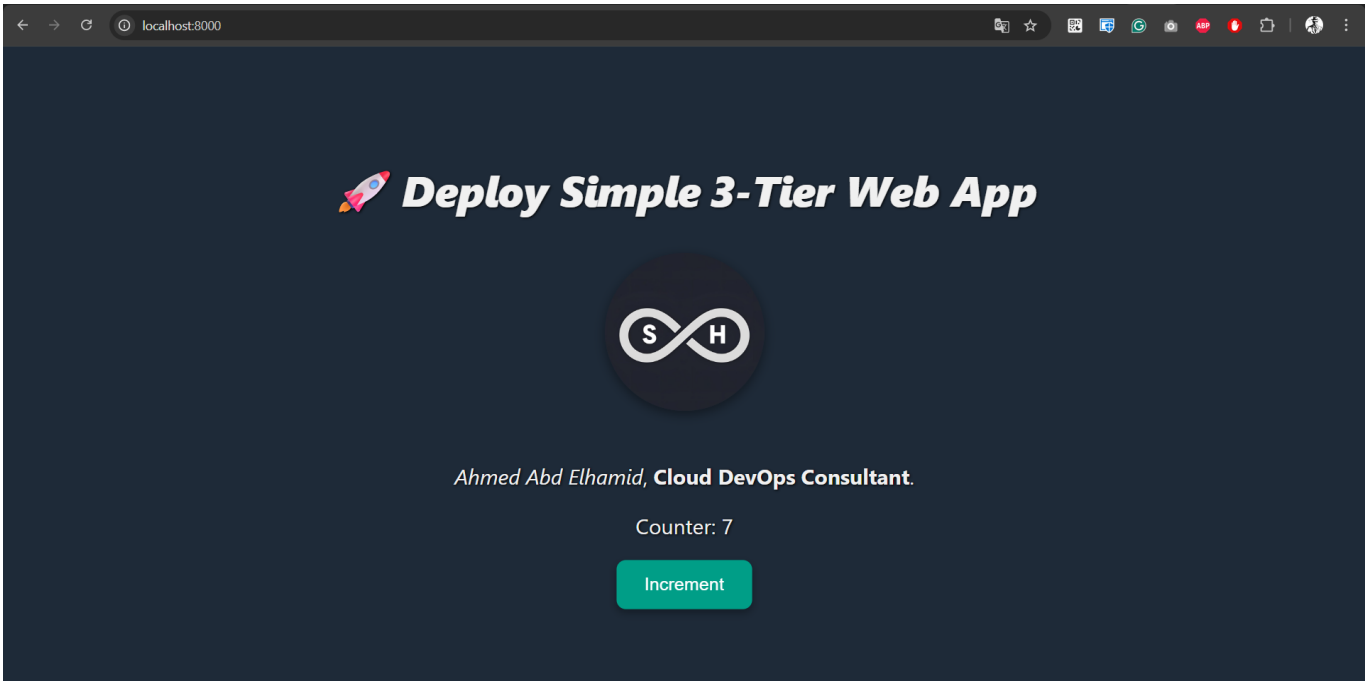
```
FROM nginx:alpine

# Remove default config
RUN rm /etc/nginx/conf.d/default.conf

# Copy custom nginx config
COPY nginx.conf /etc/nginx/conf.d/default.conf

COPY index.html /usr/share/nginx/html/index.html

EXPOSE 80
```

```
docker build -t frontend-app .
```

Test locally through "Docker"

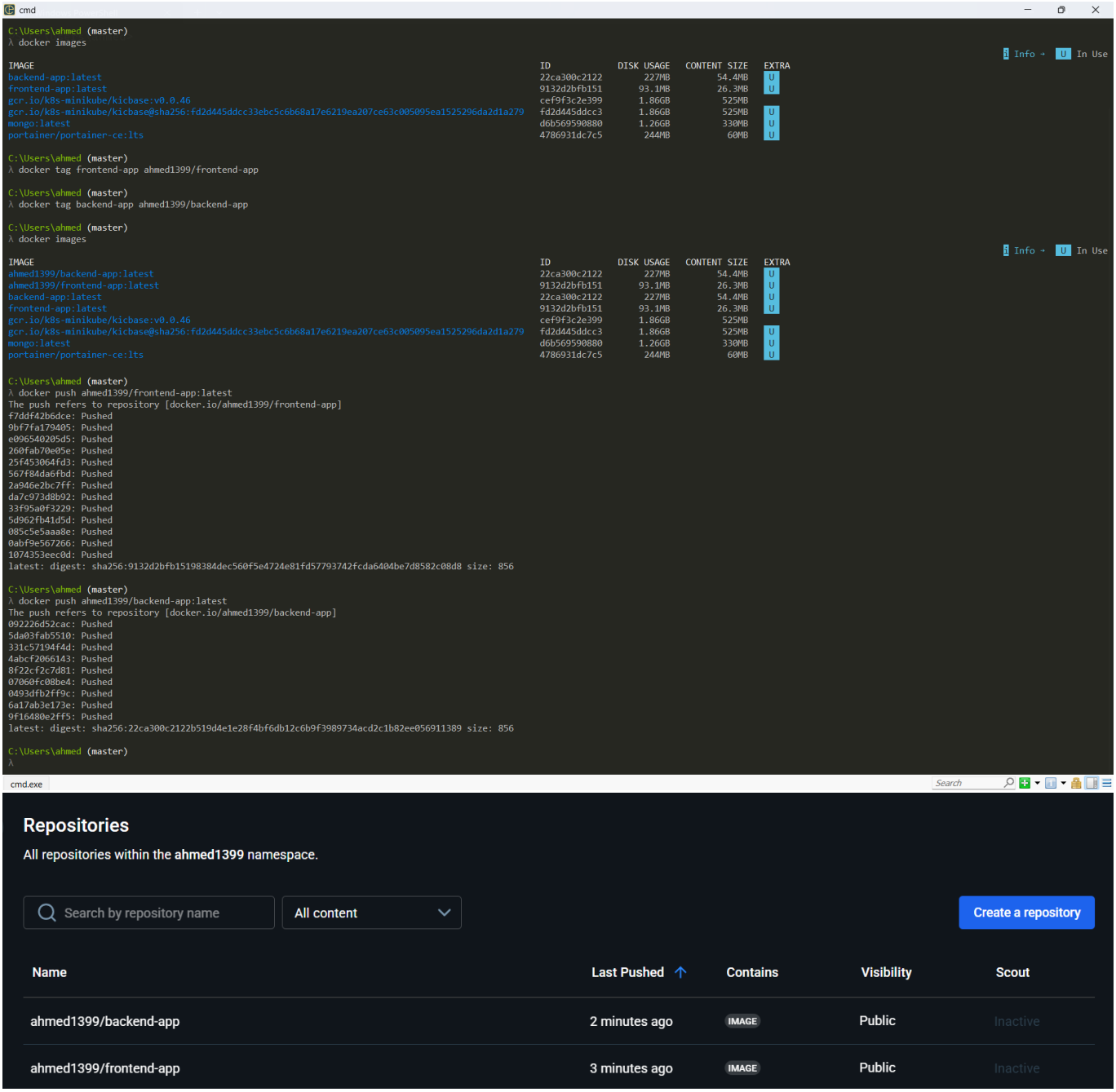
```
# Create Network
docker network create app-net

docker run -d --name mongo --network app-net mongo

// Container Name of "backend-app" image must be the same name in "nginx.conf" -> http://backend:3000
docker run -d --name backend --network app-net -e MONGO_URI=mongodb://mongo:27017/counterdb backend-app

docker run -d --name frontend --network app-net -p 8000:80 frontend-app
```





🏷️🚀 Tag & Push image

```
# Tag Image
docker tag <Image-Name> <Docker_Hub-User>/<Image-Name>
# Push Image
docker push <Docker_Hub-User>/<Image-Name>
```



Prepare Kubernetes manifest files

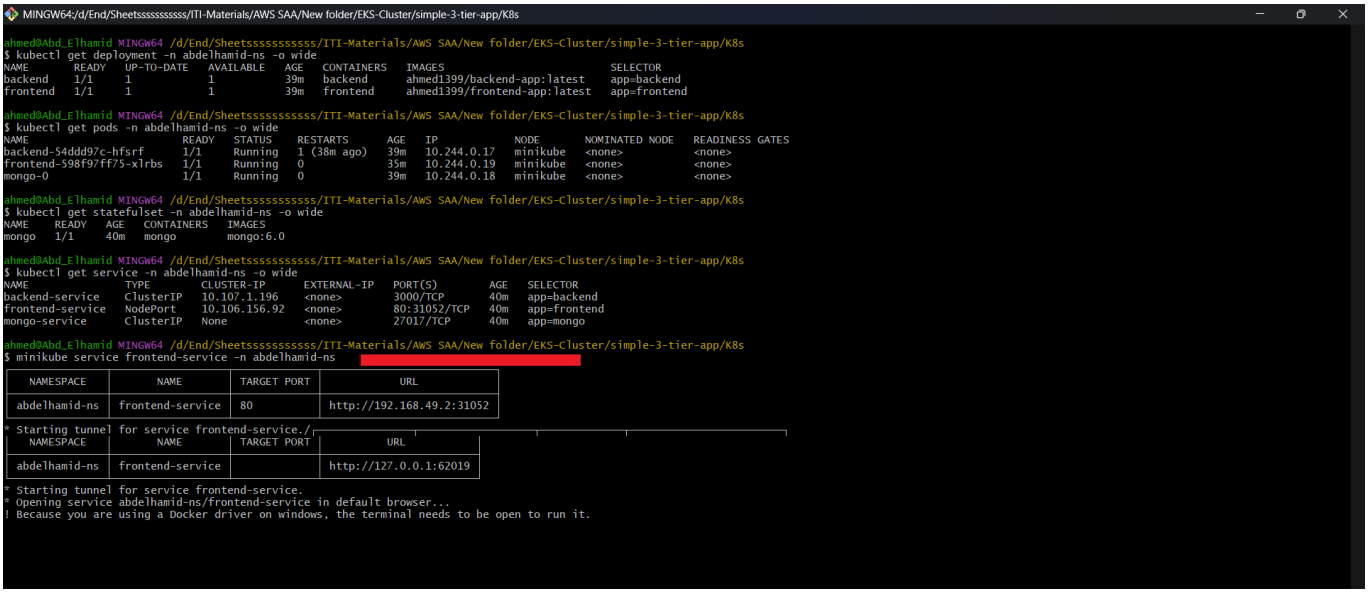
You can check (K8s manifest files) from here EKS Files

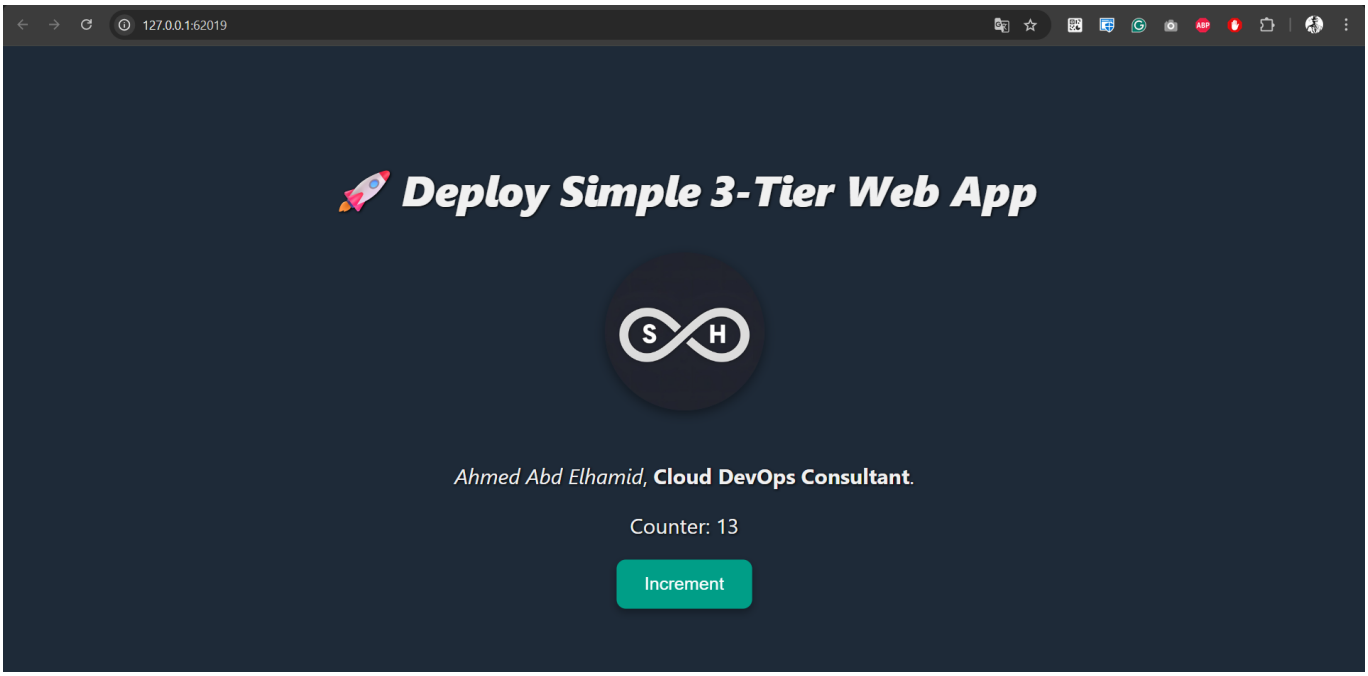
🚀❌ Deploy or Remove using:

```
#!/bin/bash

kubectl apply -f namespace.yaml
kubectl apply -f mongodb.yaml
kubectl apply -f backend.yaml
kubectl apply -f frontend-configmap.yaml
kubectl apply -f frontend.yaml

# kubectl delete -f mongodb.yaml
# kubectl delete -f backend.yaml
```

```
# kubectl delete -f frontend-configmap.yaml
# kubectl delete -f frontend.yaml
# kubectl delete -f namespace.yaml
```

```
minikube service frontend-service -n abdelhamid-ns
```

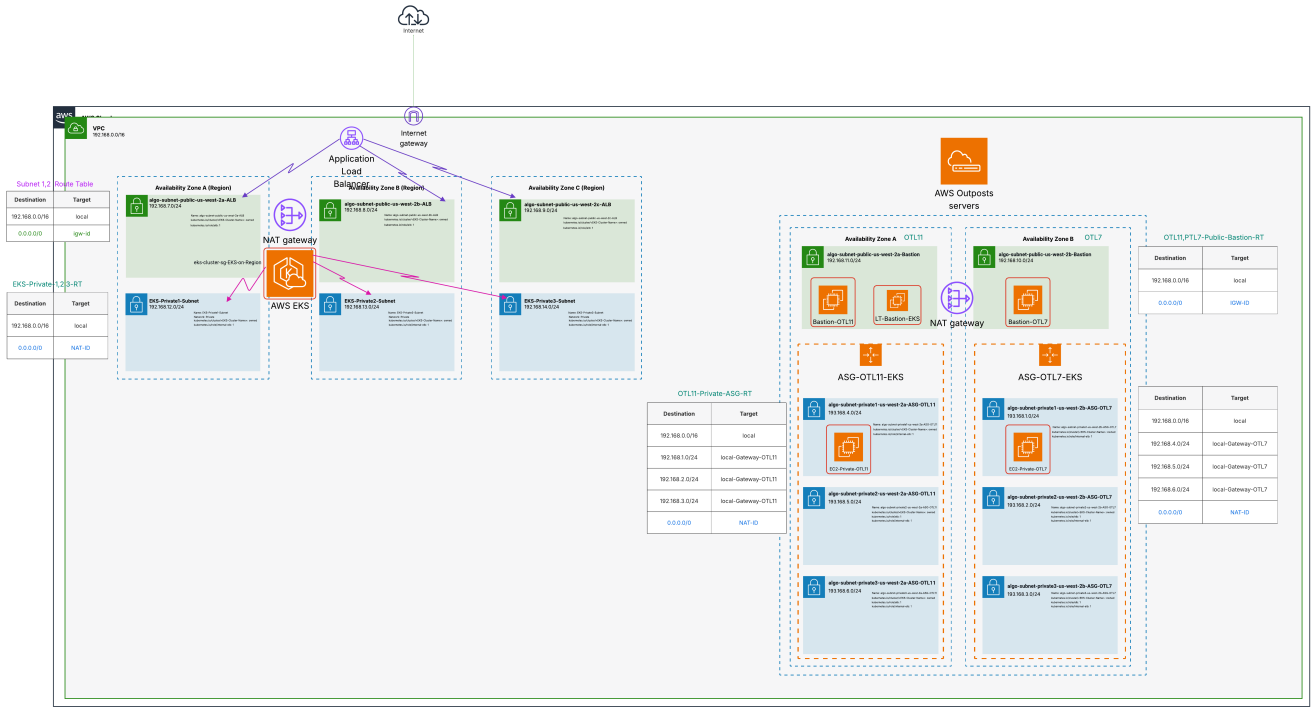




```
cmd
D:\End\Sheetsssssssssss\ITI-Materials\AWS SAA\New folder\EKS-Cluster\simple-3-tier-app\K8s
λ kubectl get all -n abdelhamid-ns
NAME                           READY   STATUS    RESTARTS      AGE
pod/backend-54ddd97c-hfsrf     1/1     Running   1 (83m ago)   84m
pod/frontend-598f97ff75-xlrbs  1/1     Running   0             80m
pod/mongo-0                    1/1     Running   0             84m

NAME                       TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)        AGE
service/backend-service    ClusterIP   10.107.1.196    <none>        3000/TCP       84m
service/frontend-service   NodePort    10.106.156.92   <none>        80:31052/TCP   84m
service/mongo-service      ClusterIP   None            <none>        27017/TCP      84m

NAME                       READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/backend    1/1     1            1           84m
deployment.apps/frontend   1/1     1            1           84m

NAME                                 DESIRED   CURRENT   READY   AGE
replicaset.apps/backend-54ddd97c     1         1         1       84m
replicaset.apps/frontend-598f97ff75  1         1         1       80m
replicaset.apps/frontend-77b67f4979  0         0         0       84m

NAME                     READY   AGE
statefulset.apps/mongo   1/1     84m

D:\End\Sheetsssssssssss\ITI-Materials\AWS SAA\New folder\EKS-Cluster\simple-3-tier-app\K8s
λ kubectl get ingress -n abdelhamid-ns
NAME          CLASS   HOSTS       ADDRESS         PORTS   AGE
app-ingress   nginx   app.local   192.168.49.2    80      18m

D:\End\Sheetsssssssssss\ITI-Materials\AWS SAA\New folder\EKS-Cluster\simple-3-tier-app\K8s
λ
```

Production (EKS)

You can check (K8s manifest files) from here: EKS Files



Deployment, Service, Ingress

Workflows

ALB Workflow **3-Tier Application Workflow**

ALB Workflow **3-Tier Application Workflow**

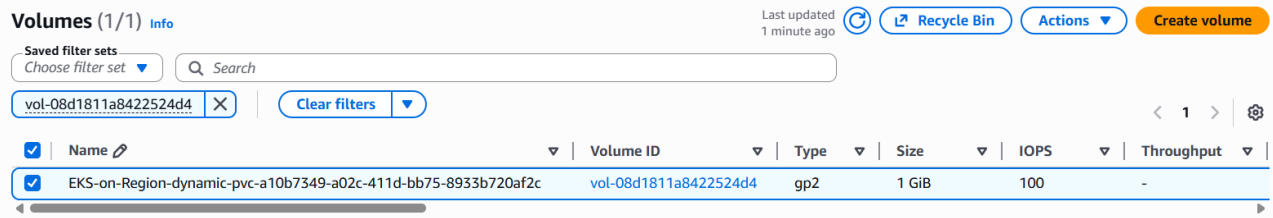
```
Internet
   |
ALB (Region VPC public subnets)
   |
EKS Control Plane (Region)
   |
Ingress Controller
   |
Pods (Outposts – private subnets)
```

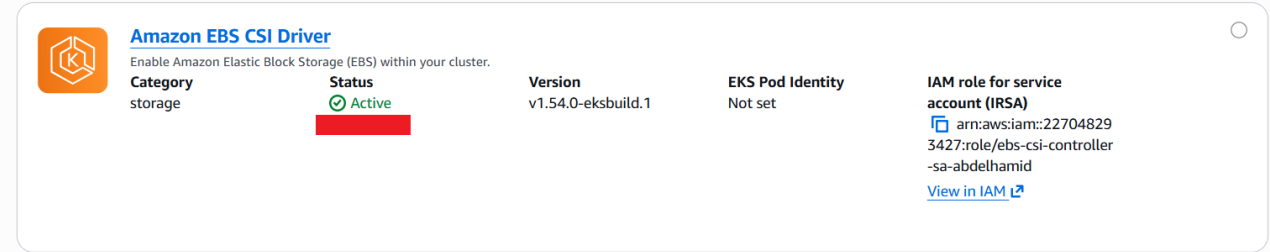
```
Client (Browser)
   |
Ingress / LoadBalancer
   |
Frontend (UI)
   |
Backend (API)
   |
MongoDB (Database)
```

- from within **Bastion Host**
  - Firstly, create a **namespace**
  - Create **Deployment & Service**
  - Create **Ingress**
    - `namespace.yaml`
    - `mongodb.yaml`
      - **To save data in MongoDB persistently**, we will use the **Amazon EBS CSI Driver**
      - Some problems will face you, so to solve them. Check the steps to solve the problem with the **Amazon EBS CSI Driver** (**Deprecated**).
    - `backend.yaml`
    - `frontend-configmap.yaml`, `frontend.yaml`
    - `ingress.yaml`
  - **Amazon EBS CSI Driver** `CrashLoopBackOff` (**mongodb**) (**Deprecated**)
    - `ebs-csi-controller-sa`

```
# The problem that will face you
kubectl get pods -n kube-system | grep ebs   # **CrashLoopBackOff**

# **Create IAM Role** & attach it with Service Account to talk with EBS &
create volume
eksctl create iamserviceaccount \
  --cluster <EKS-Cluster-Name> \
  --namespace kube-system \
  --name **ebs-csi-controller-sa** \
  --role-name ebs-csi-controller-sa-abdelhamid \
  --attach-policy-arn arn:aws:iam::aws:policy/service-
role/AmazonEBSCSIDriverPolicy \
```

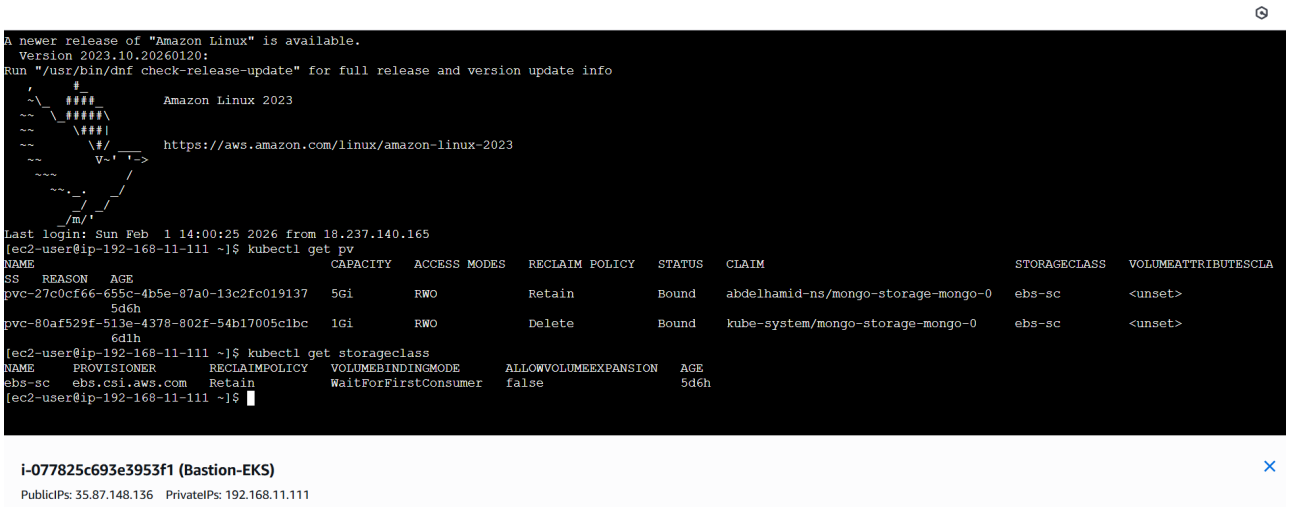
```
  --region <Region> \
  --approve \
  --override-existing-serviceaccounts

# Ensure that **Service Account** exist
kubectl get sa **ebs-csi-controller-sa** -n kube-system

# Display **Role ARN**
role_arn=$(aws iam get-role --role-name ebs-csi-controller-sa-abdelhamid --
query 'Role.Arn' --output text)
# Update add-ons with **new Role**
aws eks update-addon \
  --cluster-name <EKS-Cluster-Name> \
  --addon-name ***aws-ebs-csi-driver*** \
  --service-account-role-arn $role_arn \
  --region <Region>

# Ensure that **Add-ons active**
aws eks describe-addon --cluster-name <EKS-Cluster-Name> --addon-name
***aws-ebs-csi-driver*** --region <Region> --query "addon.status"

# to accelerate the process
kubectl delete pod -n kube-system -l app.kubernetes.io/name=aws-ebs-csi-
driver

# Ensure that **pod of ebs** **run**
# ebs-csi-controller, ebs-csi-node (**Run**)
kubectl get pods -n kube-system | grep ebs

# persistentVolume(PV) will be created automatically
kubectl get pv
# Bound
kubectl get pvc -n <namespace-name>
kubectl get storageclass
```





- If you face a problem during activation `Amazon EBS CSI Driver` install **Amazon EBS CSI Driver** through **Manual manifest files (for full control)**

```
# ----------> Install EBS-CSI-Driver through **manifest**

# **Create IAM Role** & attach it with Service Account to talk with EBS &
create volume
eksctl create iamserviceaccount \
  --cluster <EKS-Cluster-Name> \
  --namespace kube-system \
  --name **ebs-csi-controller-sa** \
  --role-name *My-EBS-CSI-Role* \
  --attach-policy-arn arn:aws:iam::aws:policy/service-
role/AmazonEBSCSIDriverPolicy \
  --region <Region> \
  --approve \
  --override-existing-serviceaccounts

# Install the **Driver** "**ebs-csi-controller-sa**" automatically
kubectl apply -k "github.com/kubernetes-sigs/aws-ebs-csi-
driver/deploy/kubernetes/overlays/stable/?ref=release-1.34" --server-side

----------
# **Regional STS**
# Solve the problem of **STS** → **Driver** can't talk with **Global STS
endpoint**
# **5 Sidecars containers** (ebs-plugin, csi-provisioner, csi-attacher, csi-
snapshotter, csi-resizer)
****# Important for remote region
for container in **ebs-plugin** **csi-provisioner** **csi-attacher** **csi-
snapshotter** **csi-resizer**; do
  kubectl set env deployment/ebs-csi-controller \
    -n kube-system \
    -c $container \
    AWS_STS_REGIONAL_ENDPOINTS=regional
done
----------

# Rerun pods
kubectl rollout restart deployment ebs-csi-controller -n kube-system

# If still pending "IAM Role has problem in **Trust Policy**"
# must contain → **OIDC Provider**, **Name of** '**Service Account**'
aws iam get-role --role-name *My-EBS-CSI-Role* --query
'Role.AssumeRolePolicyDocument'

# Ensure that **pod of ebs** **run**
# ebs-csi-controller, ebs-csi-node (**Run**)
kubectl get pods -n kube-system | grep ebs

# persistentVolume(PV) will be created automatically
kubectl get pv
# Bound
kubectl get pvc -n <namespace-name>
kubectl get storageclass
```



📌 Install ALB Ingress Controller on EKS

- Create **Ingress** → `ingress.yaml`
  - **Ingress annotations**

Steps to install Ingress Controller from here

- **install** `eksctl`
  - `eksctl version`
- 🔓 **Enable OIDC Provider (Allow Kubernetes to talk with IAM)**

```
eksctl utils associate-iam-oidc-provider \
  --region <Region> \
  --cluster <EKS-Cluster-Name> \
  --approve

# Ensure that **OIDC** Added
aws iam list-open-id-connect-providers

# if you want to delete **OIDC**
aws iam delete-open-id-connect-provider \
  --open-id-connect-provider-arn <**OIDC-ARN**>
```

- **Create an IAM Role & Service Account for each other using `eksctl` (Step1)**
  - Will not be installed until you **add admin access**, then **remove admin access**

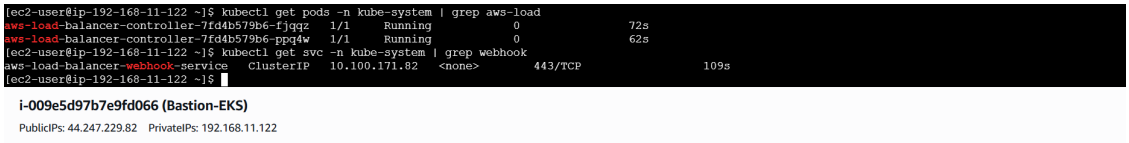
```
# Download IAM Policy (Change Version according to document)
curl -O https://raw.githubusercontent.com/kubernetes-sigs/aws-load-balancer-controller/v2.14.1/docs/install/iam_policy.json

# Create IAM Policy
```

```
aws iam create-policy \
    --policy-name AWSLoadBalancerControllerIAMPolicy \
    --policy-document file://iam_policy.json

eksctl create iamserviceaccount \
  --cluster=<EKS-Cluster-Name> \
  --namespace=kube-system \
  --name=**aws-load-balancer-controller** \
  --role-name AmazonEKSLoadBalancerControllerRole \
  --attach-policy-arn=arn:aws:iam::<Account-
ID>:policy/AWSLoadBalancerControllerIAMPolicy \
  --approve \
  --region=<Region> \
  --override-existing-serviceaccounts
```

- **Install AWS Load Balancer Controller (Step2)**
  - **Install** `Helm` from the script

```
helm repo add eks https://aws.github.io/eks-charts
helm repo update

# Display VPC_ID
aws eks describe-cluster --name <EKS-Cluster-Name> --query
"cluster.resourcesVpcConfig.vpcId" --output text

helm upgrade --install aws-load-balancer-controller eks/aws-load-balancer-
controller \
  -n kube-system \
  --set clusterName=<EKS-Cluster-Name> \
  --set serviceAccount.create=false \
  --set serviceAccount.name=**aws-load-balancer-controller** \
  --set region=<Region> \
  --set vpcId=<VPC-ID> \
  --set enableShield=false \
  --set enableWaf=false \
  --rollback-on-failure
```

  - Ensure that the **Webhook** works well
    - `kubectl get pods -n kube-system | grep aws-load kubectl get svc -n kube-system | grep webhook`



  - **Verify that the controller is installed (Step3)**
    - `kubectl get deployment -n kube-system aws-load-balancer-controller`

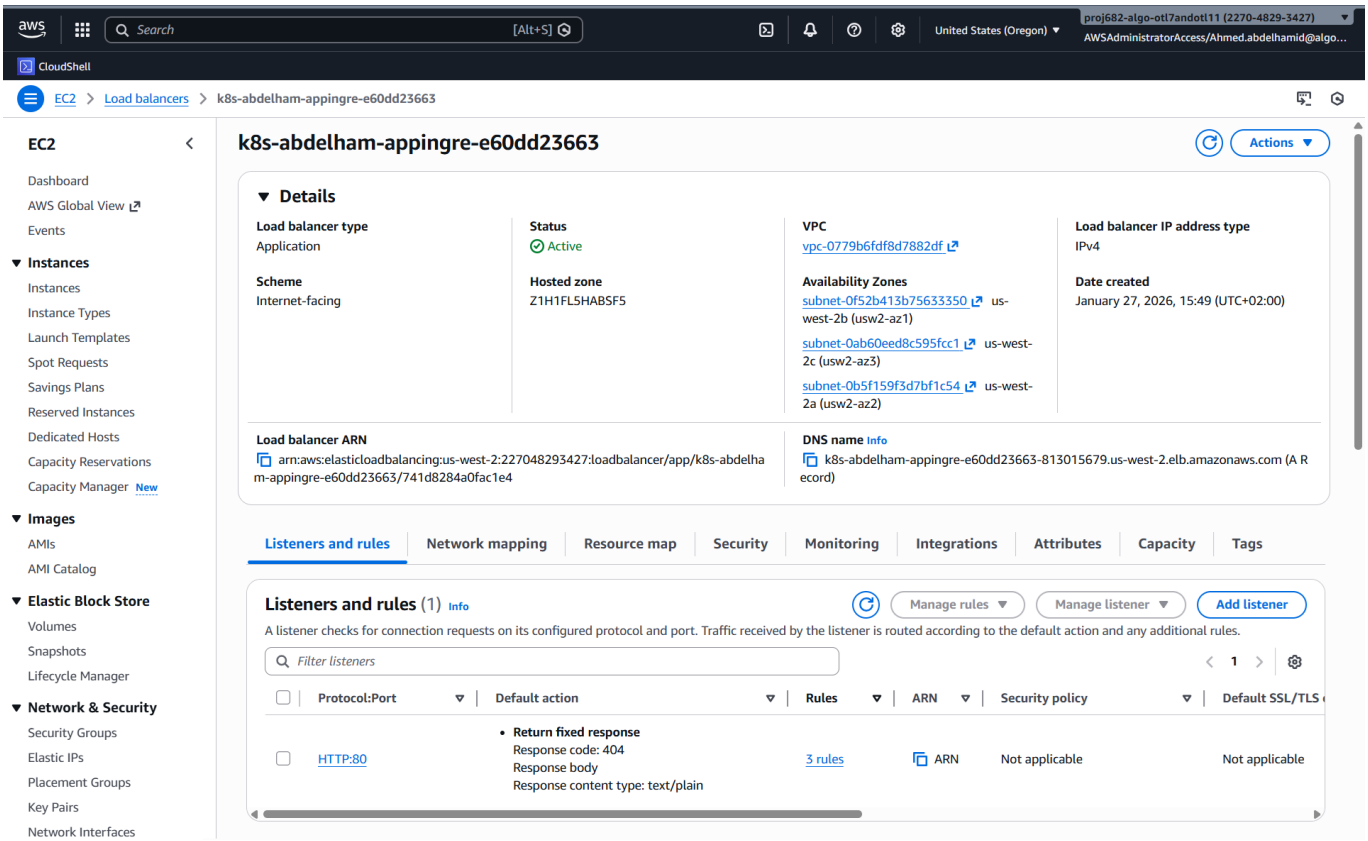
```
[ec2-user@ip-192-168-11-122 ~]$  kubectl get deployment -n kube-system aws-load-balancer-controller
NAME                           READY   UP-TO-DATE   AVAILABLE   AGE
aws-load-balancer-controller   2/2     2            2           90s
[ec2-user@ip-192-168-11-122 ~]$
```

i-009e5d97b7e9fd066 (Bastion-EKS)

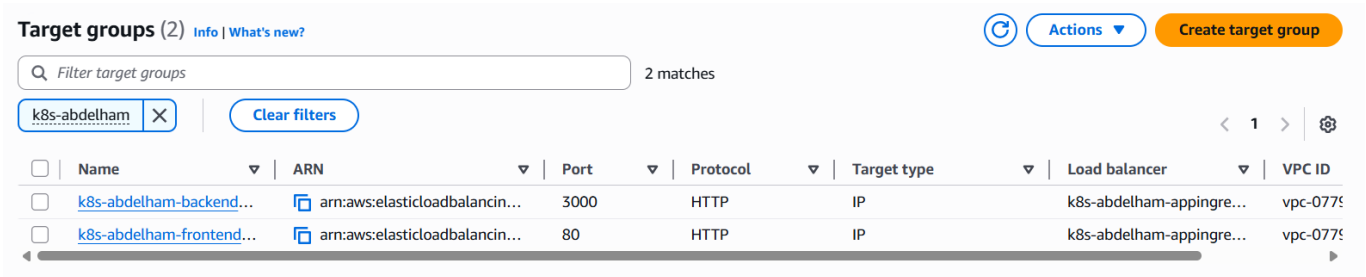
PublicIPs: 44.247.229.82 PrivateIPs: 192.168.11.122

☑ Check

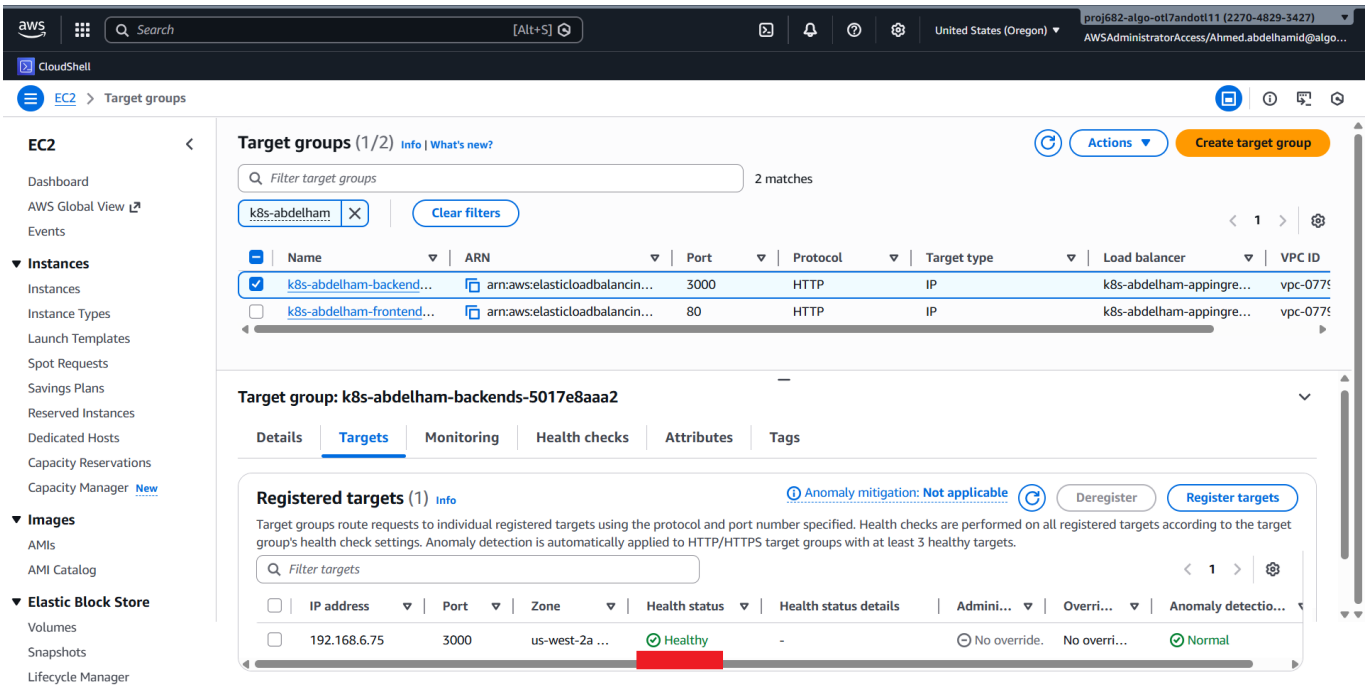
Application Load Balancer



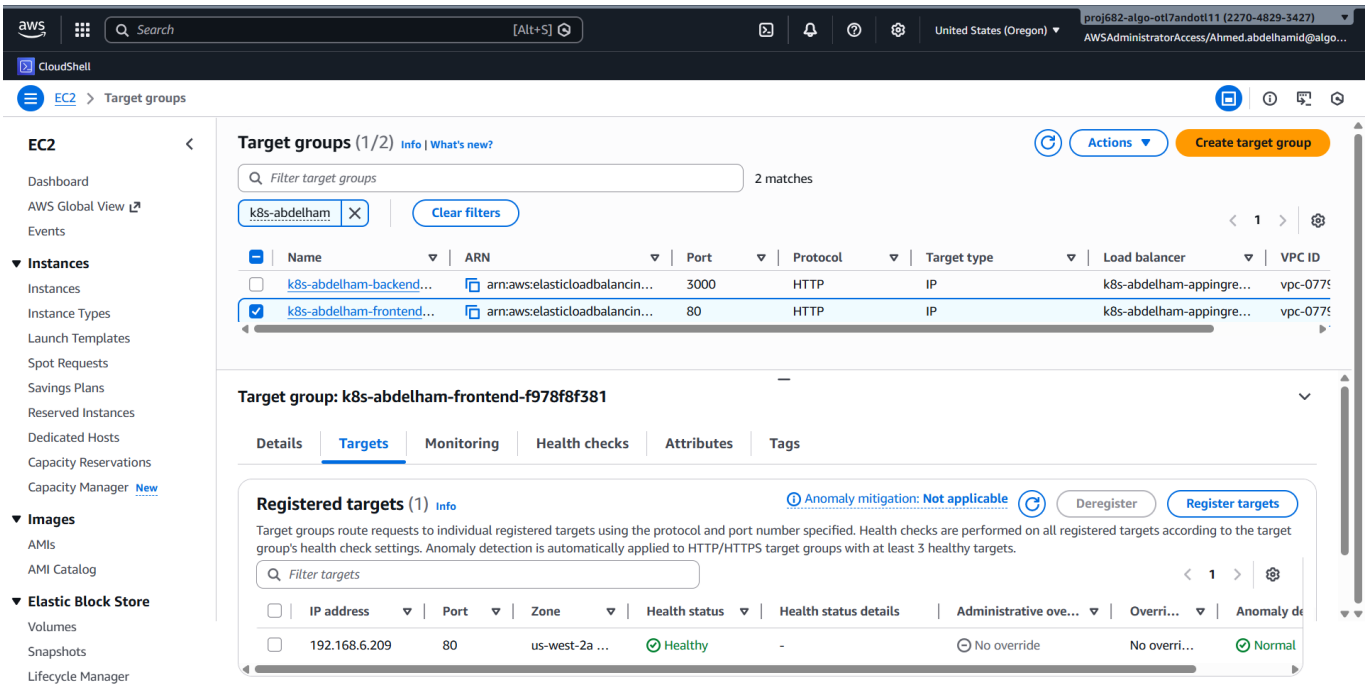
Target Group



Backend Target Group



Frontend Target Group



Deployment, Service, Ingress

```
[ec2-user@ip-192-168-11-111 ~]$ kubectl get all -n abdelhamid-ns
NAME                           READY   STATUS    RESTARTS   AGE
pod/backend-5ccf4f44f6-xmb5f   1/1     Running   0          5d8h
pod/frontend-5d9cc9f7c5-nv5x9  1/1     Running   0          4d
pod/mongo-0                    1/1     Running   0          5d14h

NAME                       TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)        AGE
service/backend-service    ClusterIP   10.100.6.179    <none>        3000/TCP       5d8h
service/frontend-service   NodePort    10.100.42.192   <none>        80:32567/TCP   5d14h
service/mongo-service      ClusterIP   None            <none>        27017/TCP      5d14h

NAME                       READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/backend    1/1     1            1           5d8h
deployment.apps/frontend   1/1     1            1           5d14h

NAME                                 DESIRED   CURRENT   READY   AGE
replicaset.apps/backend-5ccf4f44f6   1         1         1       5d8h
replicaset.apps/frontend-5d9cc9f7c5  1         1         1       4d

NAME                     READY   AGE
statefulset.apps/mongo   1/1     5d14h
[ec2-user@ip-192-168-11-111 ~]$
[ec2-user@ip-192-168-11-111 ~]$
[ec2-user@ip-192-168-11-111 ~]$ kubectl get ingress -n abdelhamid-ns
NAME          CLASS   HOSTS   ADDRESS                                                                  PORTS   AGE
app-ingress   alb     *       k8s-abdelham-appingre-e60dd23663-813015679.us-west-2.elb.amazonaws.com   80      5d8h
[ec2-user@ip-192-168-11-111 ~]$
```

i-077825c693e3953f1 (Bastion-EKS)

PublicIPs: 35.87.148.136 PrivateIPs: 192.168.11.111

Output