DevOps Project BankApp Terraform upgrade to Opentofu with secure kubernetes Cluster (EKS, AKS and GKE)

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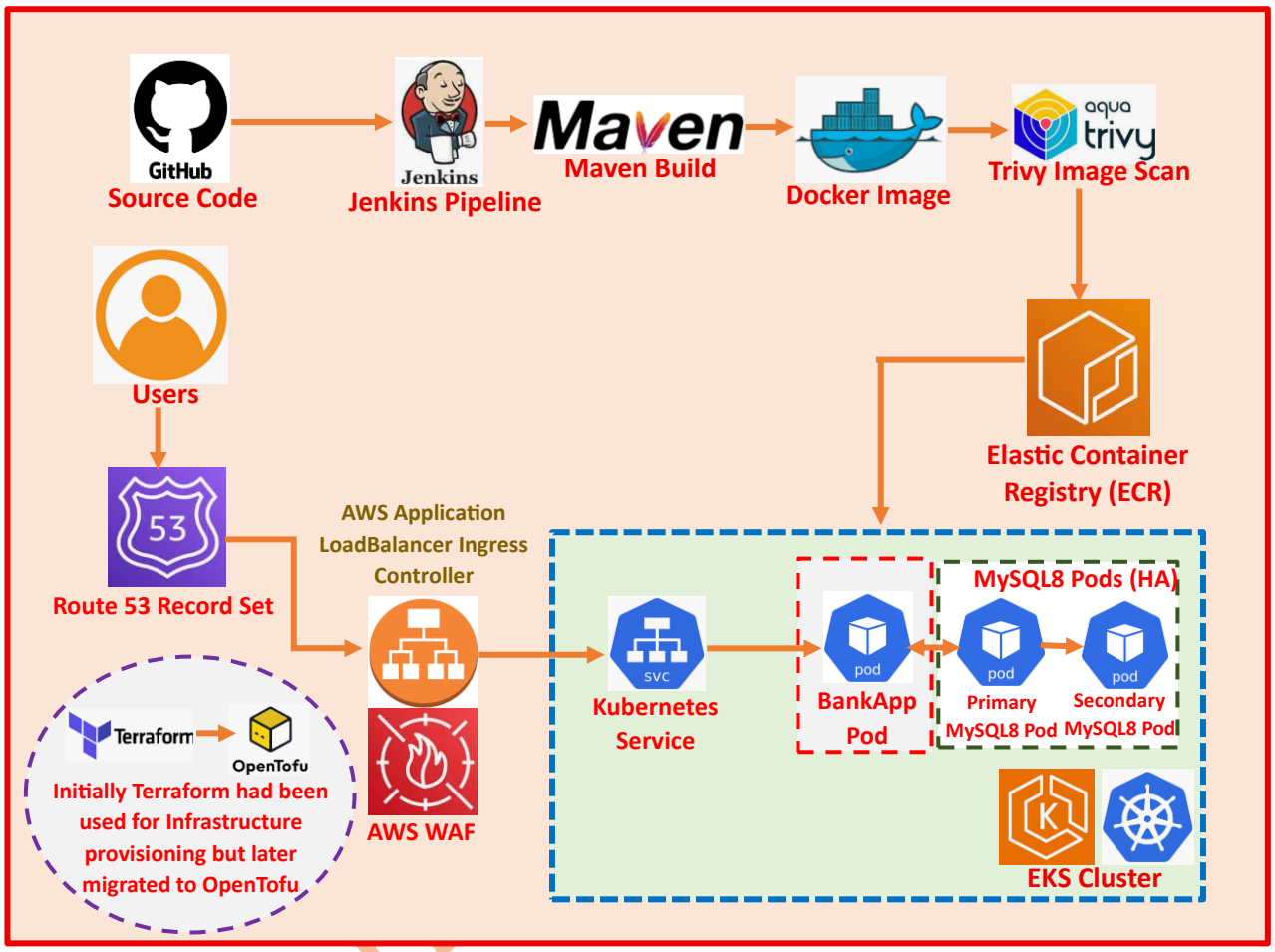
या कुन्देन्दुतुषारहारधवला या शुभ्रवस्त्रावृता
या वीणावरदण्डमण्डितकरा या श्वेतपद्मासना।
या ब्रह्माच्युत शंकरप्रभृतिभिर्देवैः सदा वन्दिता
सा मां पातु सरस्वती भगवती निःशेषजाड्यापहा ॥

DevOps Project BankApp Terraform upgrade to Opentofu with Secure EKS Cluster

Module-1



Till now I used Terraform to provision the infrastructure but Hashicorp license changes due to which Terraform will introduce restrictions for commercial use, due to this reason many organisations are migrating from Terraform to OpenTofu. However, I would like to mention here that DevOps Team who used it as a tool to provision the infrastructure will not be affected but those who provides it as a Service will be affected. You already aware that Terraform state file was kept locally or in the S3 Bucket / Azure Storage Account Container / GCP Bucket. The problem was its state file was not encrypted, so anyone who had the access of Terraform Server (when state file was kept locally) or Bucket or Storage Account Container can easily see its state file. But if you use OpenTofu, you will not face such an issue. OpenTofu is an Open Source, community-driven Infrastructure as Code (IaC) tool, it is a fork of Hashicorp Terraform. I will migrate from Terraform to OpenTofu at the end of Module-1.

This DevOps project deals will creation of infrastructure using Terraform, GitHub was used to keep the source Code and Jenkins had been used as CI/CD Tool. The build tool used in this project was Maven and Docker Image was pushed to the Elastic Container Registry (ECR) which was finally deployed to the Elastic Kubernetes Services (EKS). The Bank Application Pods was accessed using Application LoadBalancer Ingress Controller and hence using the kubernetes service as shown in the screenshot attached above. I applied WAF Policy (to Limit the Rate) to the Bank Application URL and

to prevent from SQL Injection. As this Bank Application was open to entire world so rate limit and SQL Injection was applied through WAF Policy so that non-of-the IP Address can access the Bank Application more than 40 times in one minute. There may be the possibility that the Bank Application URL accessed using the Bot (by the Hackers) so that its speed becomes slow or this website hangs to refrain from such a situation WAF Policy Rate Limit was applied. Finally, I migrated from Terraform to OpenTofu. For EKS Cluster I used cilium in chain mode with VPC CNI the reason to implement this was secure (encrypted with WireGuard) Node-to-Node Communication. I implemented Istio for encrypted Pod-to-Pod Communication and implemented **OPA** (Open Policy Agent) and **Falco** to Secure the EKS Cluster. I had used Aqua Security Trivy image scan for vulnerability scanning during CI/CD Pipeline as shown in the end-to-end architecture diagram of the project drawn above. I used Guard Duty to add extra layer of security to the EKS Cluster. In EKS Cluster with version 1.28 and more envelope encryption is by default implemented, if you do not use AWS Customer Managed Key then using AWS Managed Key envelope encryption gets implemented. The AWS Customer Managed Key enables you to rotate it as per the standard followed by your organisation. Usually after 90 days the AWS Customer Managed Key should be rotated but you can rotate it as per your organisation need. If you use Amazon Managed Key then it will be rotated after 1 year (365 days) by the AWS. In this project I used AWS Customer Managed Key for envelope encryption and to encrypt the all the EBS Volumes used in this project.

In EKS however it is possible to encrypt all the volumes either by Amazon Managed Key or AWS Customer Managed Key but envelope encryption provides extra layer of security by encrypting the etcd.

Terraform script to create the infrastructure is present at the path **terraform-route53-hosted-zone-with-acm-certificate** (this terraform script is handy for you to create the Route53 hosted-zone and AWS Certificate Manager SSL Certificate) in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. Commands as written below had been used to create infrastructure using Terraform.

terraform init -------> initializes a working directory containing configuration files and installs plugins for required providers.

terraform validate --------> verify that terraform configuration file is correct or not

terraform plan ---------> Check which resources are going to be created.

Then you can run the command **terraform apply -auto-approve** -----> Finally, Create the resources.

At this point after executing the command **terraform apply -auto-approve** make sure you do the entry for Nameservers of the Route53 created Hosted Zone in your domain name service provider's Nameserver. After doing such an entry the terraform script will give the output as written below.

```
module.route53_hosted_zone.aws_acm_certificate.acm_cert: Creating...
module.route53_hosted_zone.aws_acm_certificate.acm_cert: Creation complete after 5s [id=arn:aws:acm:us-east-2:02[redacted]6:certificate/[redacted]
[redacted]]
module.route53_hosted_zone.aws_route53_zone.hosted_zone: Still creating... [00m10s elapsed]
module.route53_hosted_zone.aws_route53_zone.hosted_zone: Still creating... [00m20s elapsed]
module.route53_hosted_zone.aws_route53_zone.hosted_zone: Still creating... [00m30s elapsed]
module.route53_hosted_zone.aws_route53_zone.hosted_zone: Creation complete after 31s [[redacted]]
module.route53_hosted_zone.aws_route53_record.record_cert_validation: Creating...
module.route53_hosted_zone.aws_route53_record.record_cert_validation: Still creating... [00m10s elapsed]
module.route53_hosted_zone.aws_route53_record.record_cert_validation: Still creating... [00m20s elapsed]
module.route53_hosted_zone.aws_route53_record.record_cert_validation: Still creating... [00m30s elapsed]
module.route53_hosted_zone.aws_route53_record.record_cert_validation: Creation complete after 31s [[redacted].s
inghritesh85.com._CNAME]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Creating...
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m10s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m20s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m30s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m40s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m50s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m00s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m10s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m20s elapsed]
module.route53_hosted_zone.aws_acm_certificate_validation.acm_certificate_validation: Creation complete after 1m23s [id=[redacted] UTC]

Apply complete! Resources: 4 added, 0 changed, 0 destroyed.

Outputs:

route53_hosted_zone_details = {
  "certificate_arn" = "arn:aws:acm:us-east-2:02[redacted]6:certificate/[redacted]"
  "hosted_zone_id" = "[redacted]"
  "hosted_zone_name_servers" = tolist([
    "[redacted]",
    "[redacted]",
    "[redacted]",
    "[redacted]",
  ])
}
```

Now the Route53 Hosted Zone and AWS Certificate Manager SSL Certificate became ready. Then I created the other AWS Resources using the terraform script present at the path **terraform-eks-cluster-waf-with-velero-backup-with-cmk** in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git.

```
module.eks_cluster.aws_eks_addon.core_dns: Still creating... [00m10s elapsed]
module.eks_cluster.aws_eks_addon.core_dns: Creation complete after 14s [id=eks-demo-cluster-dev:coredns]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Still creating... [00m20s elapsed]
module.eks_cluster.aws_eks_addon.csi_snapshot_controller: Still creating... [00m20s elapsed]
module.eks_cluster.aws_eks_addon.ebs_csi_driver: Still creating... [00m20s elapsed]
module.eks_cluster.aws_eks_addon.metrics_server: Still creating... [00m20s elapsed]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Still creating... [00m30s elapsed]
module.eks_cluster.aws_eks_addon.csi_snapshot_controller: Still creating... [00m30s elapsed]
module.eks_cluster.aws_eks_addon.metrics_server: Still creating... [00m30s elapsed]
module.eks_cluster.aws_eks_addon.ebs_csi_driver: Still creating... [00m30s elapsed]
module.eks_cluster.aws_eks_addon.csi_snapshot_controller: Creation complete after 34s [id=eks-demo-cluster-dev:snapshot-controller]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Creation complete after 35s [id=eks-demo-cluster-dev:amazon-cloudwatch-observability]
module.eks_cluster.aws_eks_addon.ebs_csi_driver: Still creating... [00m40s elapsed]
module.eks_cluster.aws_eks_addon.metrics_server: Still creating... [00m40s elapsed]
module.eks_cluster.aws_eks_addon.ebs_csi_driver: Creation complete after 44s [id=eks-demo-cluster-dev:aws-ebs-csi-driver]
module.eks_cluster.aws_eks_addon.metrics_server: Creation complete after 44s [id=eks-demo-cluster-dev:metrics-server]

Apply complete! Resources: 104 added, 0 changed, 0 destroyed.

Outputs:

ecr_ec2_private_ip_eks_details = {
  "alb_dns_name" = "jenkins-ms-[redacted].us-east-2.elb.amazonaws.com"
  "alb_ingress_controller_role_arn" = "arn:aws:iam::02[redacted]6:role/aws-alb-ingress-controller-role"
  "aws_wafv2_web_acl_arn" = "arn:aws:wafv2:us-east-2:0[redacted]6:regional/webacl/aws-wafv2-rate-limit/[redacted]"
  "eks_cluster_endpoint" = "https://[redacted].us-east-2.eks.amazonaws.com"
  "eks_cluster_name" = "eks-demo-cluster-dev"
  "jenkins_master_instance_id" = "i-[redacted]"
  "jenkins_master_private_ip" = "10.[redacted]"
  "jenkins_slave_instance_id" = "i-[redacted]"
  "jenkins_slave_private_ip" = "10.[redacted]"
  "karpenter_node_spun_iam_role_arn" = "arn:aws:iam::02[redacted]6:role/karpenter-eks-noderole"
  "registry_id" = "02[redacted]6"
  "repository_url" = "02[redacted]6.dkr.ecr.us-east-2.amazonaws.com/bankapp"
  "velero_backup_iam_role_arn" = "arn:aws:iam::02[redacted]6:role/eks-velero-backup-role"
  "velero_backup_s3_bucket_name" = "dexter-velero-backup"
}
```

To install karpenter I edited the configmap **aws-auth** in the namespace **kube-system** as shown in the screenshot present below.

```
[root@[redacted] ~]# kubectl edit cm aws-auth -n kube-system
```

```
# Please edit the object below. Lines beginning with a '#' will be ignored,
# and an empty file will abort the edit. If an error occurs while saving this file will be
# reopened with the relevant failures.
#
apiVersion: v1
data:
  mapRoles: |
    - rolearn: arn:aws:iam::02          5:role/eks-nodegroup-role-dev
      groups:
      - system:bootstrappers
      - system:nodes
      username: system:node:{{EC2PrivateDNSName}}
    - rolearn: arn:aws:iam::02          6:role/karpenter-eks-noderole
      groups:
      - system:bootstrappers
      - system:nodes
      username: system:node:{{EC2PrivateDNSName}}
kind: ConfigMap
metadata:
  creationTimestamp: "2025                "
  name: aws-auth
  namespace: kube-system
  resourceVersion: "      "
  uid:                                    
~
~
~
~
~
~
~
~
~
~
~
~
~
~
```

I installed the karpenter controller using helm as shown in the screenshot attached below.

helm upgrade --install karpenter oci://public.ecr.aws/karpenter/karpenter --version "1.6.2" --namespace "karpenter" --create-namespace --set "settings.clusterName=eks-demo-cluster-dev" --set "serviceAccount.annotations.eks\.amazonaws\.com/role-arn=arn:aws:iam::02XXXXXXXXX6:role/karpenter-controller-role" --set controller.resources.requests.cpu=1 --set controller.resources.requests.memory=1Gi --set controller.resources.limits.cpu=1 --set controller.resources.limits.memory=1Gi

```
[root@           ~]# helm upgrade --install karpenter oci://public.ecr.aws/karpenter/karpenter --version "1.6.2" --namespace "karpenter" --create-namespace
 --set "settings.clusterName=eks-demo-cluster-dev" --set "serviceAccount.annotations.eks\.amazonaws\.com/role-arn=arn:aws:iam::02          6:role/karpenter-con
troller-role" --set controller.resources.requests.cpu=1 --set controller.resources.requests.memory=1Gi --set controller.resources.limits.cpu=1 --set controlle
r.resources.limits.memory=1Gi
```

Then ran the kubernetes Manifests file **karpenter.yaml** present at the path **terraform-eks-cluster-waf-with-velero-backup-with-cmk** in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. For your reference **karpenter.yaml** I had also provided below.

```
[root@                ~]# kubectl apply -f karpenter.yaml
nodepool.karpenter.sh/general-purpose created
ec2nodeclass.karpenter.k8s.aws/default created
```

karpenter.yaml

```
# This example NodePool will provision general purpose instances
---
apiVersion: karpenter.sh/v1
kind: NodePool
metadata:
  name: general-purpose
  annotations:
    kubernetes.io/description: "General purpose NodePool for generic workloads"
spec:
  template:
    spec:
      requirements:
        - key: kubernetes.io/arch
          operator: In
          values: ["amd64"]
        - key: kubernetes.io/os
          operator: In
          values: ["linux"]
        - key: karpenter.sh/capacity-type
          operator: In
          values: ["on-demand"]    #["spot"] ### You can select on-demand or spot instance depending on your requirement.
        - key: karpenter.k8s.aws/instance-category
          operator: In
          values: ["t"]   # Interested to launch t series instance          #["c", "m", "r"]
        - key: karpenter.k8s.aws/instance-generation
          operator: Gt
          values: ["1"]   # Instances launched will be greated than 1    ###["2"]   # Instances launched will be greated than 2
      nodeClassRef:
        group: karpenter.k8s.aws
```

```
    kind: EC2NodeClass
    name: default
---
apiVersion: karpenter.k8s.aws/v1
kind: EC2NodeClass
metadata:
  name: default
  annotations:
    kubernetes.io/description: "General purpose EC2NodeClass for running Amazon Linux 2023 nodes"
spec:
  role: "karpenter-eks-noderole" # replace with your karpenter noderole
  subnetSelectorTerms:
    - tags:
      karpenter.sh/discovery: "eks-demo-cluster-dev" # replace with your cluster name
  securityGroupSelectorTerms:
    - tags:
      karpenter.sh/discovery: "eks-demo-cluster-dev" # replace with your cluster name
  amiSelectorTerms:
    - alias: al2023@latest # Amazon Linux 2023
```

```
[root@                ~]# kubectl get pods -n karpenter
NAME                         READY   STATUS    RESTARTS   AGE
karpenter-                   1/1     Running   0          5m16s
karpenter-                   1/1     Running   0          5m16s
```

To install velero using helm I used the commands as written below.

helm repo add vmware-tanzu https://vmware-tanzu.github.io/helm-charts/

helm repo update

helm install velero vmware-tanzu/velero --namespace velero --create-namespace --set configuration.backupStorageLocation[0].provider=aws --set configuration.backupStorageLocation[0].bucket=dexter-velero-backup --set configuration.volumeSnapshotLocation[0].config.region=us-east-2 --set configuration.volumeSnapshotLocation[0].provider=aws --set serviceAccount.create=true --set serviceAccount.name=velero-server --set serviceAccount.server.annotations."eks\.amazonaws\.com/role-arn"="arn:aws:iam::02XXXXXXXXX6:role/eks-velero-backup-role" --set initContainers[0].name=velero-plugin-for-aws --set initContainers[0].image="velero/velero-plugin-for-aws:v1.12.2" --set initContainers[0].volumeMounts[0].mountPath="/target" --set initContainers[0].volumeMounts[0].name="plugins" --version=10.1.0 --set credentials.useSecret=false

```
[root@                ~]# helm repo add vmware-tanzu https://vmware-tanzu.github.io/helm-charts/
"vmware-tanzu" has been added to your repositories
[root@                ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "vmware-tanzu" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@                ~]# helm install velero vmware-tanzu/velero --namespace velero --create-namespace --set configuration.backupStorageLocation[0].provider=aw
s --set configuration.backupStorageLocation[0].bucket=dexter-velero-backup --set configuration.volumeSnapshotLocation[0].config.region=us-east-2 --set configu
ration.volumeSnapshotLocation[0].provider=aws --set serviceAccount.create=true --set serviceAccount.name=velero-server --set serviceAccount.server.annotations
."eks\.amazonaws\.com/role-arn"="arn:aws:iam::02          5:role/eks-velero-backup-role" --set initContainers[0].name=velero-plugin-for-aws --set initContainer
s[0].image="velero/velero-plugin-for-aws:v1.12.2" --set initContainers[0].volumeMounts[0].mountPath="/target" --set initContainers[0].volumeMounts[0].name="pl
ugins" --version=10.1.0 --set credentials.useSecret=false
NAME: velero
LAST DEPLOYED: Fri Sep 12 09:36:32 2025
NAMESPACE: velero
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Check that the velero is up and running:

    kubectl get deployment/velero -n velero

Check that the secret has been created:

    kubectl get secret/velero -n velero

Once velero server is up and running you need the client before you can use it
1. wget https://github.com/vmware-tanzu/velero/releases/download/v1.16.2/velero-v1.16.2-darwin-amd64.tar.gz
2. tar -xvf velero-v1.16.2-darwin-amd64.tar.gz -C velero-client

More info on the official site: https://velero.io/docs
```

```
[root@                ~]# kubectl get pods -n velero
NAME                      READY   STATUS    RESTARTS   AGE
velero-                   1/1     Running   0          97s
```

To install AWS Application LoadBalancer Ingress Controller using helm I used the command as written below.

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

helm repo update

helm install aws-load-balancer-controller eks/aws-load-balancer-controller -n kube-system --set clusterName=eks-demo-cluster-dev --set serviceAccount.create=true --set region=us-east-2 --set vpcId=vpc-0XXXXXXXXXXXXXXX2 --set serviceAccount.name=aws-load-balancer-controller --set serviceAccount.annotations."eks\.amazonaws\.com/role-arn"="arn:aws:iam::02XXXXXXXXX6:role/aws-alb-ingress-controller-role" --set enableWafv2=true

```
[root@ ~]# helm repo add eks https://aws.github.io/eks-charts
"eks" has been added to your repositories
[root@ ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "vmware-tanzu" chart repository
...Successfully got an update from the "eks" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@ ~]# helm install aws-load-balancer-controller eks/aws-load-balancer-controller -n kube-system --set clusterName=eks-demo-cluster-dev --set
 serviceAccount.create=true --set region=us-east-2 --set vpcId=vpc- --set serviceAccount.name=aws-load-balancer-controller --set serviceAccou
nt.annotations."eks\.amazonaws\.com/role-arn"="arn:aws:iam::02 6:role/aws-alb-ingress-controller-role" --set enableWafv2=true
NAME: aws-load-balancer-controller
LAST DEPLOYED: Fri Sep 12 09:42:17 2025
NAMESPACE: kube-system
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
AWS Load Balancer controller installed!
```

```
[root@ ~]# kubectl get pods -n kube-system|grep -i "aws-load-balancer-controller"
aws-load-balancer-controller-  1/1     Running   0          2m
aws-load-balancer-controller-  1/1     Running   0          2m
```

Then I installed ArgoCD and ArgoCD CLI. To install ArgoCD CLI run the commands as written below.

curl -sSL -o argocd-linux-amd64 https://github.com/argoproj/argo-cd/releases/latest/download/argocd-linux-amd64

sudo install -m 555 argocd-linux-amd64 /usr/local/bin/argocd

rm argocd-linux-amd64

```
[jenkins@jenkins-slave ~]$ curl -sSL -o argocd-linux-amd64 https://github.com/argoproj/argo-cd/releases/latest/download/argocd-linux-amd64
[jenkins@jenkins-slave ~]$ sudo install -m 555 argocd-linux-amd64 /usr/local/bin/argocd
[jenkins@jenkins-slave ~]$ rm argocd-linux-amd64
```

Following steps I used to install the ArgoCD.

kubectl create namespace argocd

kubectl apply -n argocd -f https://raw.githubusercontent.com/argoproj/argo-cd/stable/manifests/install.yaml

To the default password of Admin user run the command as written below.

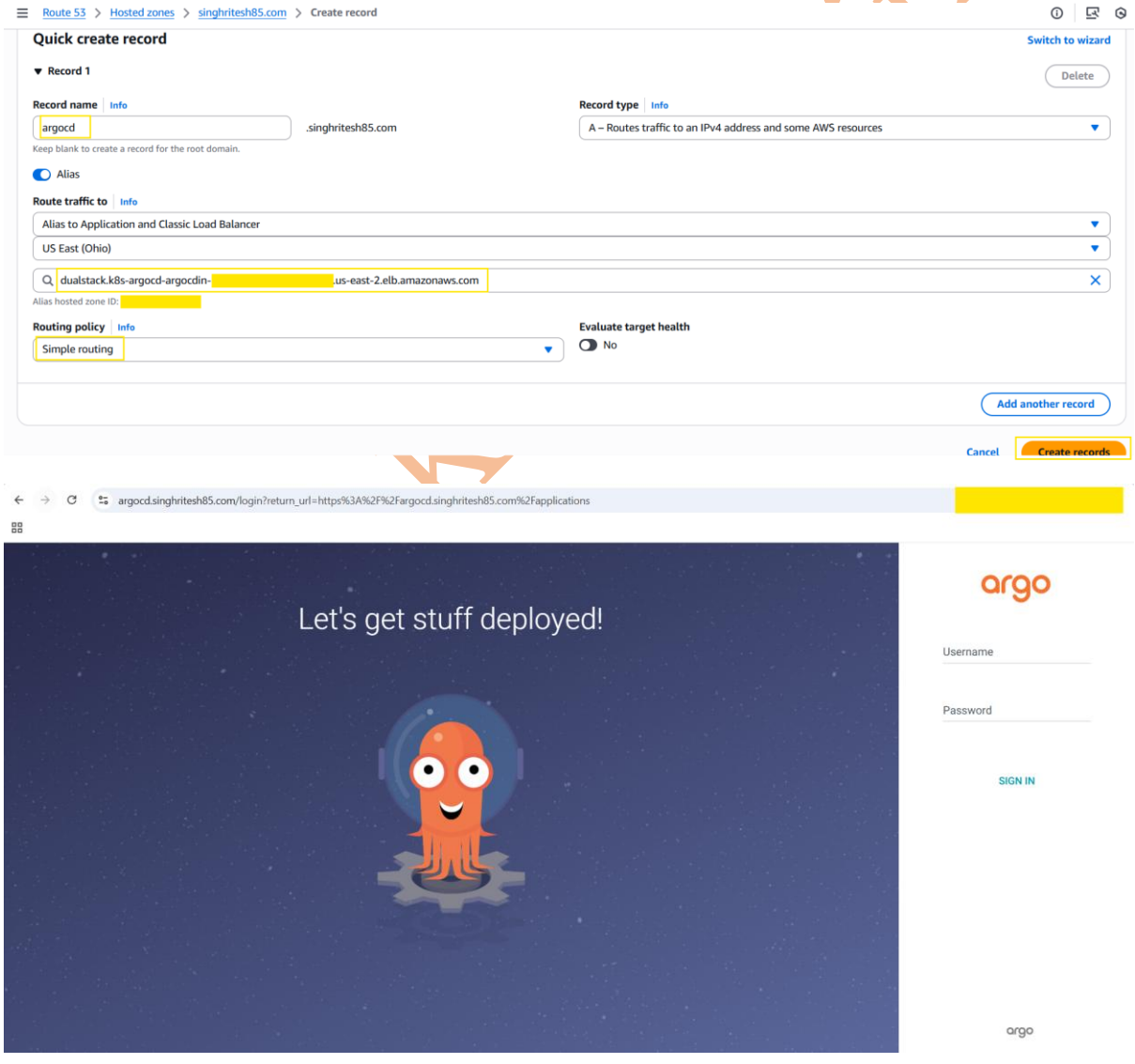
kubectl -n argocd get secret argocd-initial-admin-secret -o jsonpath='{.data.password}' | base64 -d

```
[root@ ~]# kubectl create namespace argocd
namespace/argocd created
[root@ ~]# kubectl apply -n argocd -f https://raw.githubusercontent.com/argoproj/argo-cd/stable/manifests/install.yaml
```

```
[root@ ~]# kubectl -n argocd get secret argocd-initial-admin-secret -o jsonpath='{.data.password}' | base64 -d
w e[root@ ~]#
```

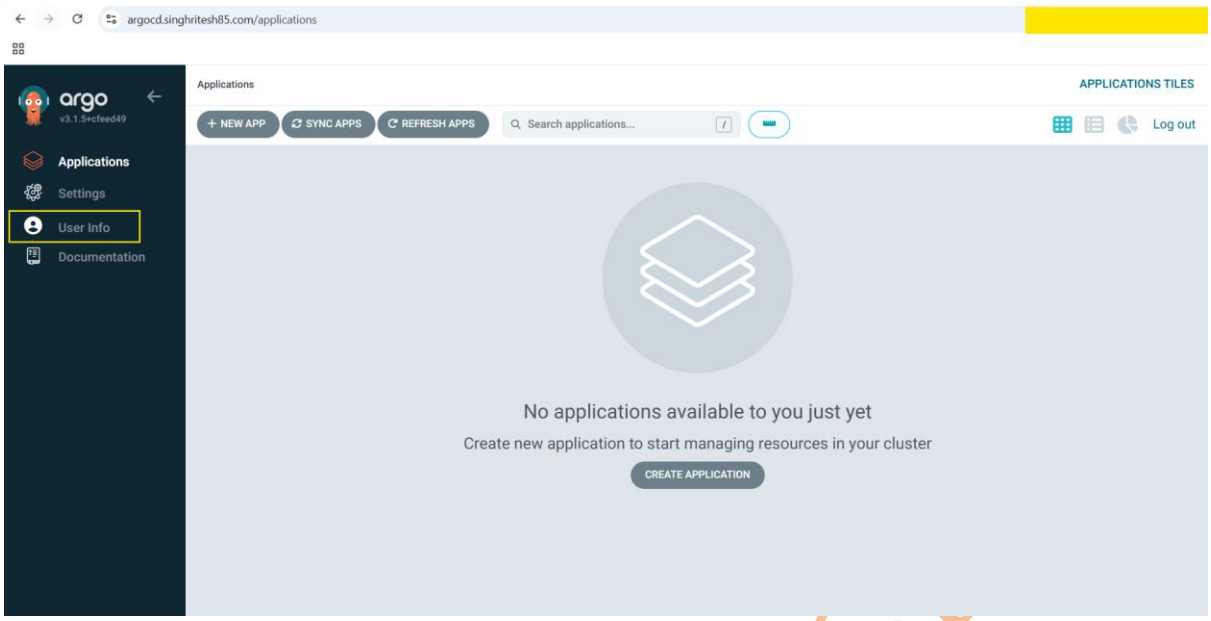
To access ArgoCD I used the Ingress Rule as written below. It will create an AWS Application LoadBalancer which entry I will do in the Route53 to create the Record Set of A-Type as shown in the screenshot attached below. Finally using that URL it is possible to access the ArgoCD as shown below.

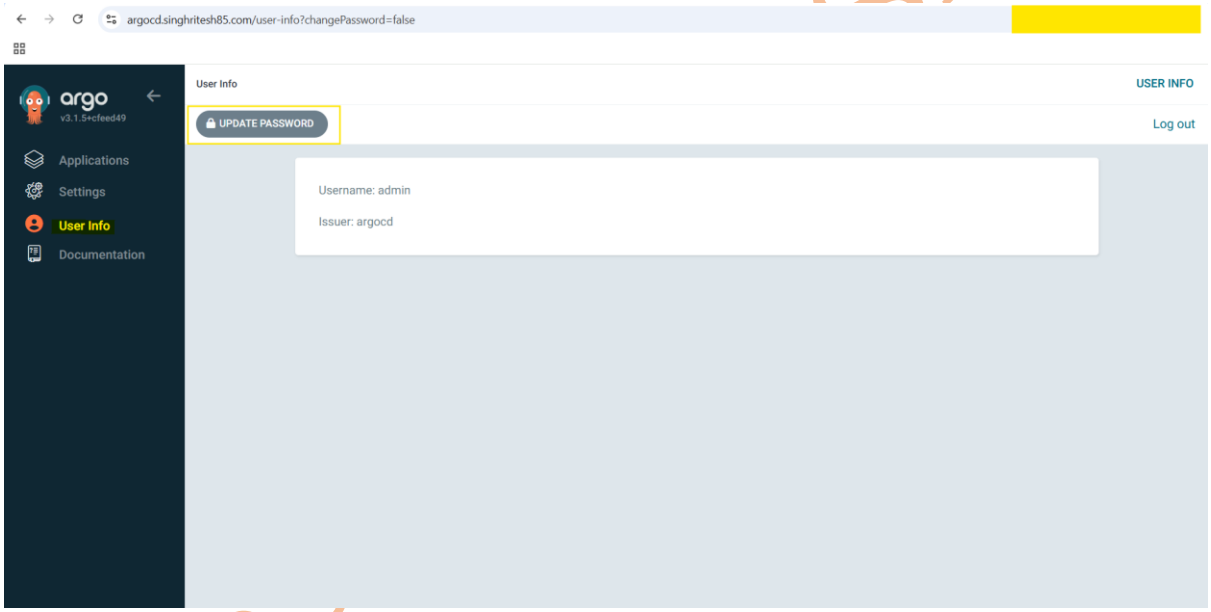
```
[root@                ~]# cat argocd-ingress-rule.yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: argocd-ingress
  namespace: argocd
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/backend-protocol: HTTPS
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02        6:certificate/
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
spec:
  ingressClassName: alb
  rules:
    - host: argocd.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: argocd-server
                port:
                  number: 443

[root@                ~]# kubectl apply -f argocd-ingress-rule.yaml
ingress.networking.k8s.io/argocd-ingress created
[root@                ~]# kubectl get ing -A --watch
NAMESPACE   NAME            CLASS   HOSTS                    ADDRESS                                                          PORTS   AGE
argocd      argocd-ingress  alb     argocd.singhritesh85.com  k8s-argocd-argocdin-                    .us-east-2.elb.amazonaws.com   80      9s
```

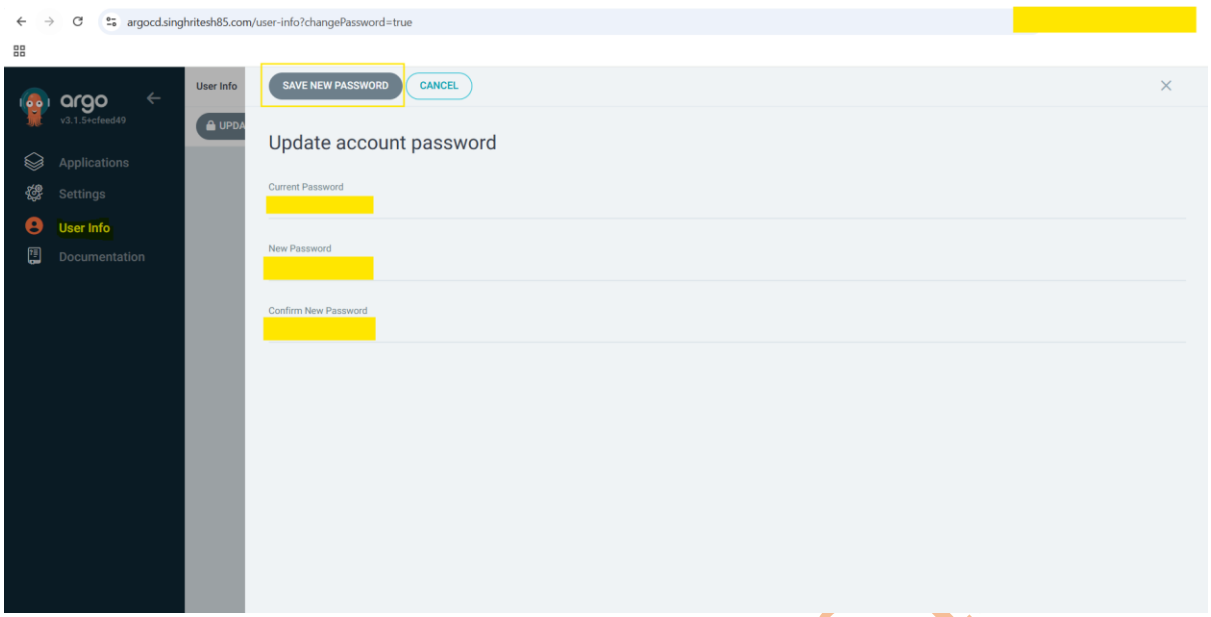


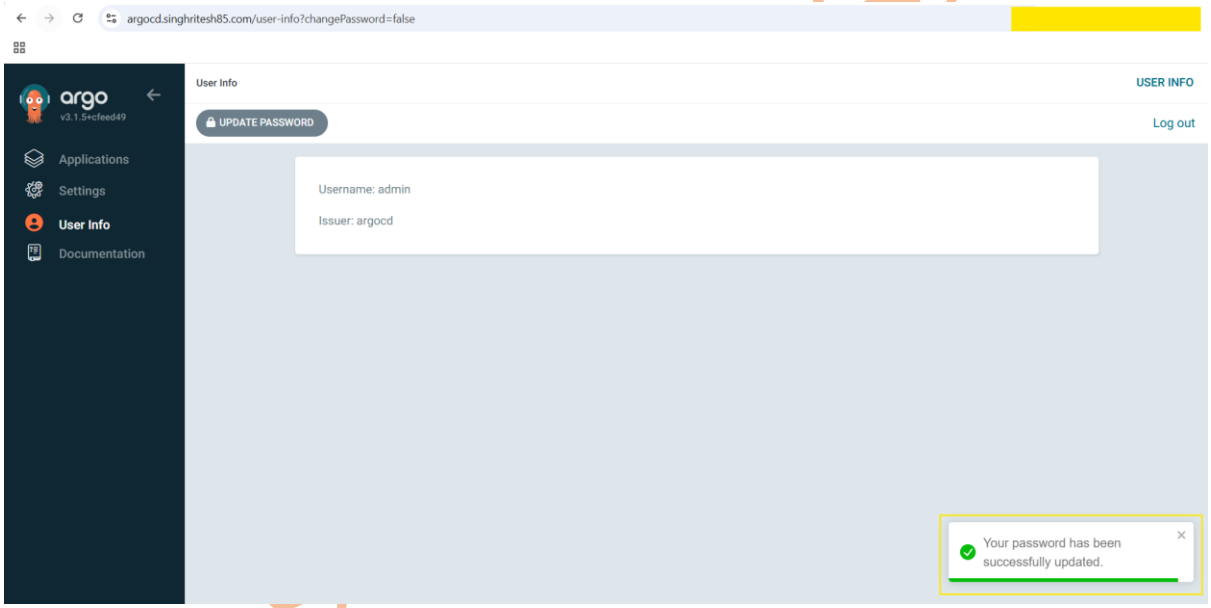
```
cat argocd-ingress-rule.yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: argocd-ingress
  namespace: argocd
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/backend-protocol: HTTPS
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-
2:02XXXXXXXXX6:certificate/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
spec:
  ingressClassName: alb
  rules:
    - host: argocd.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: argocd-server
                port:
                  number: 443
```

To Login for the first time, I used admin user and its default password, after first Login I changed the default password of admin user as shown in the screenshot attached below.

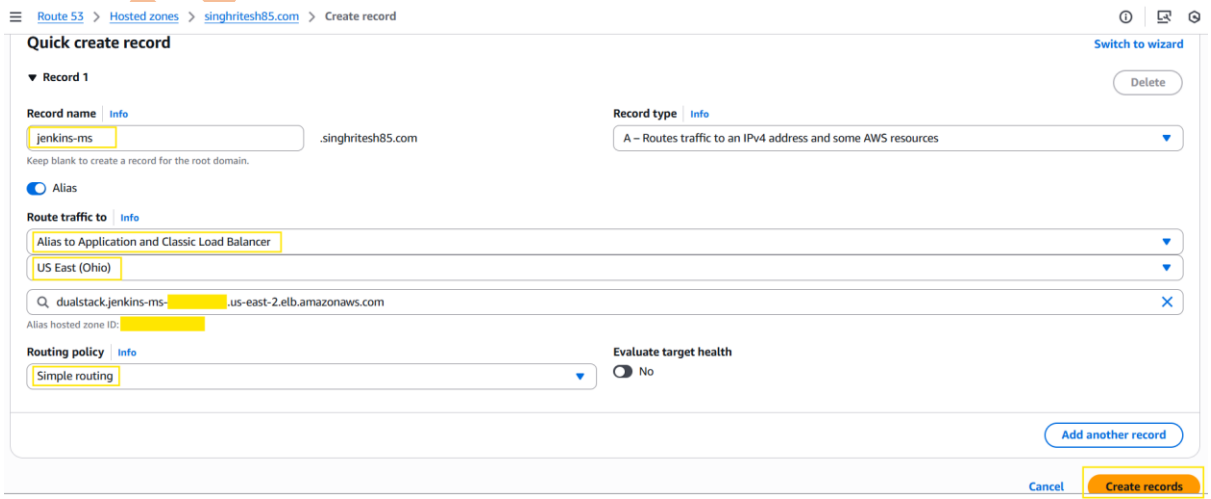

argocd.singhritesh85.com/applications
argo
v3.1.5+cfeed49
Applications
Settings
User Info
Documentation
Applications
APPLICATIONS TILES
+ NEW APP
SYNC APPS
REFRESH APPS
Search applications...
Log out
No applications available to you just yet
Create new application to start managing resources in your cluster
CREATE APPLICATION


argocd.singhritesh85.com/user-info?changePassword=false
argo
v3.1.5+cfeed49
Applications
Settings
User Info
Documentation
User Info
USER INFO
UPDATE PASSWORD
Log out
Username: admin
Issuer: argocd



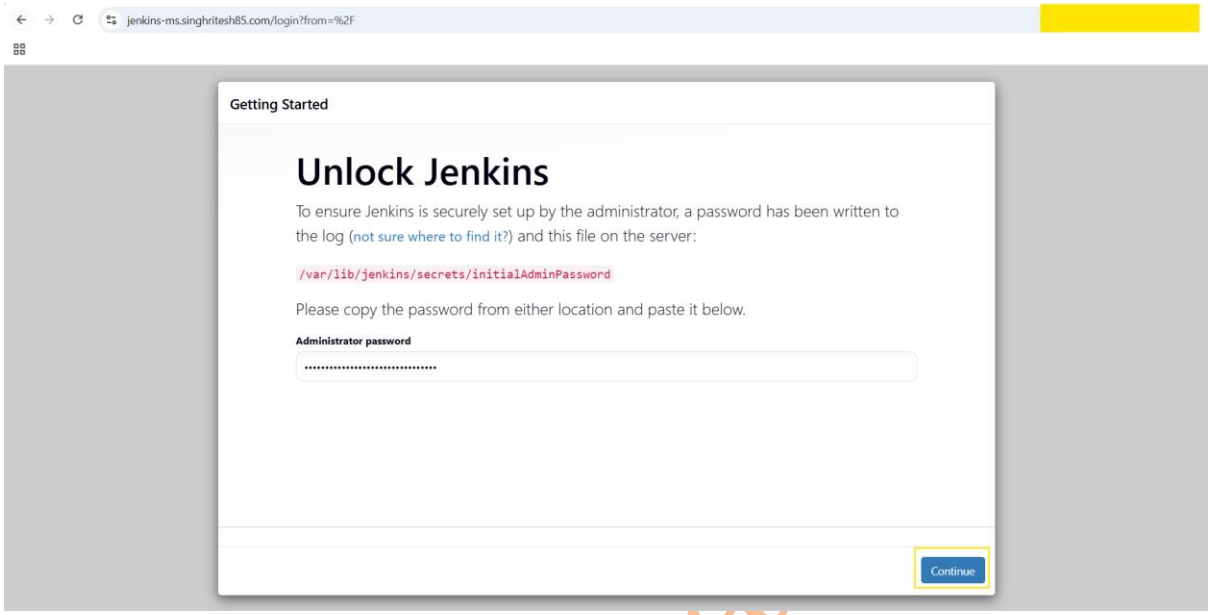


To create the URL for accessing Jenkins I did the entry for Jenkins LoadBalancer DNS Name in Route53 to create the record set of A-Type as shown in the screenshot attached below.

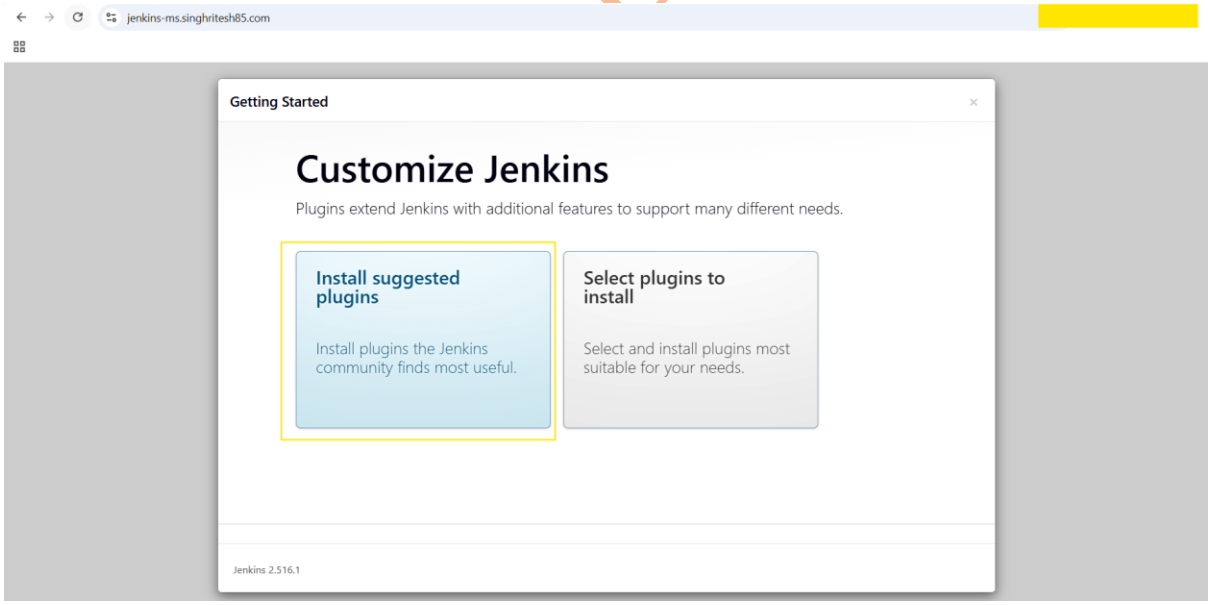


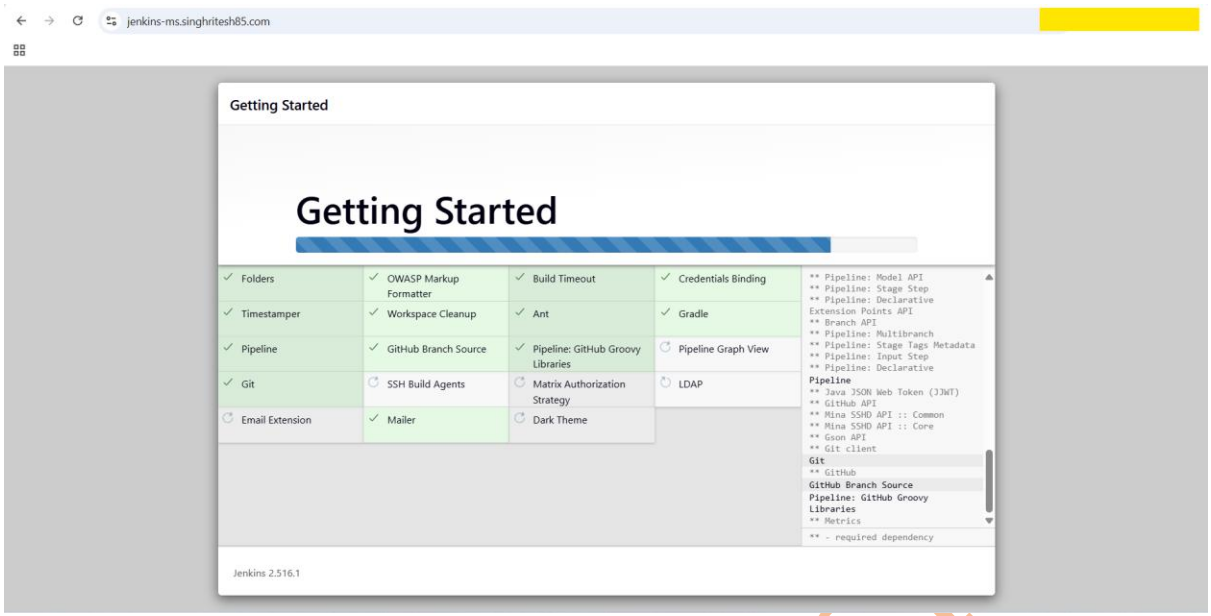
For first access to Jenkins, it required initial admin password which was present on Jenkins-Server at the path **/var/lib/jenkins/secrets/initialAdminPassword**.

```
[root@jenkins-master ~]# cat /var/lib/jenkins/secrets/initialAdminPassword
2                                                                        5
```

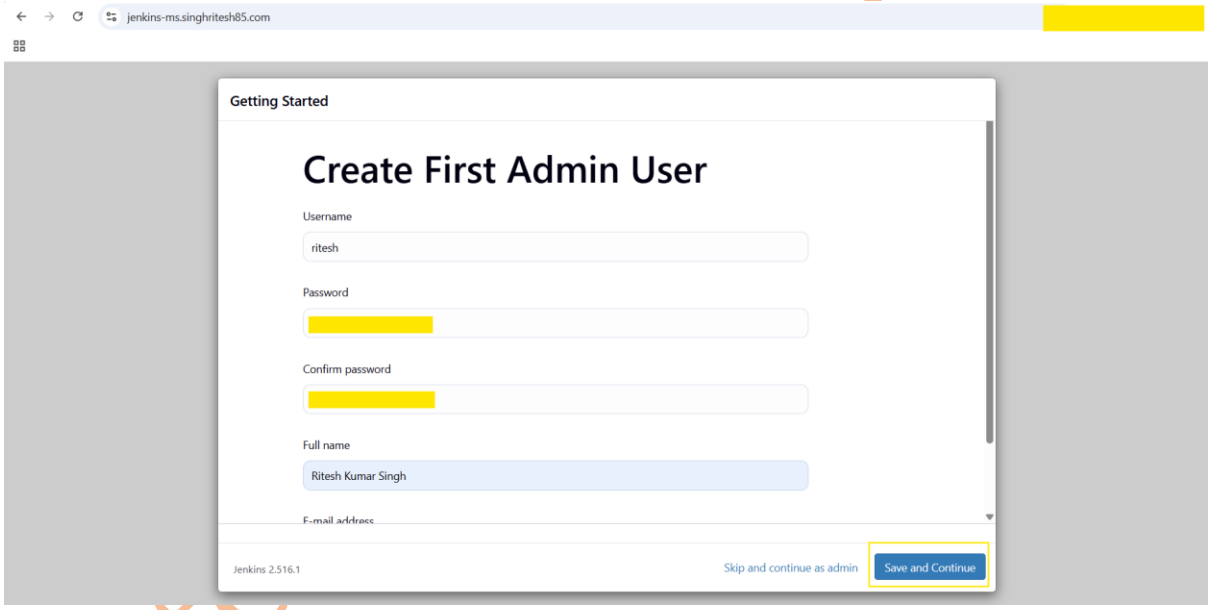


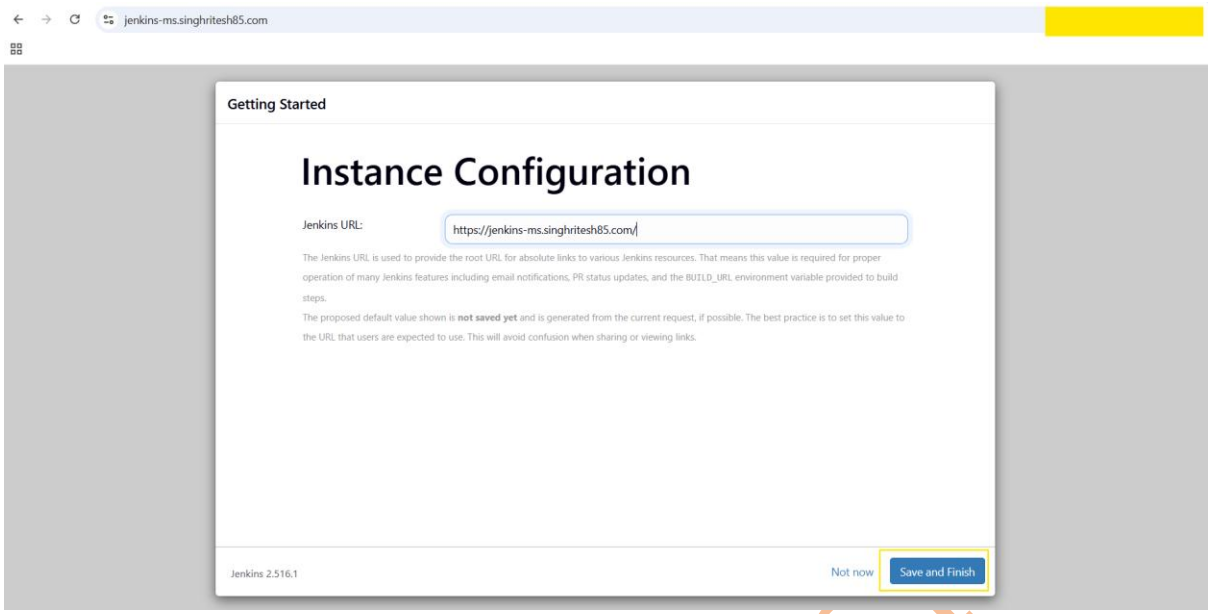
Then it will ask to install the plugins, I went with the option of suggested plugins and install then as shown in the screenshot attached below.

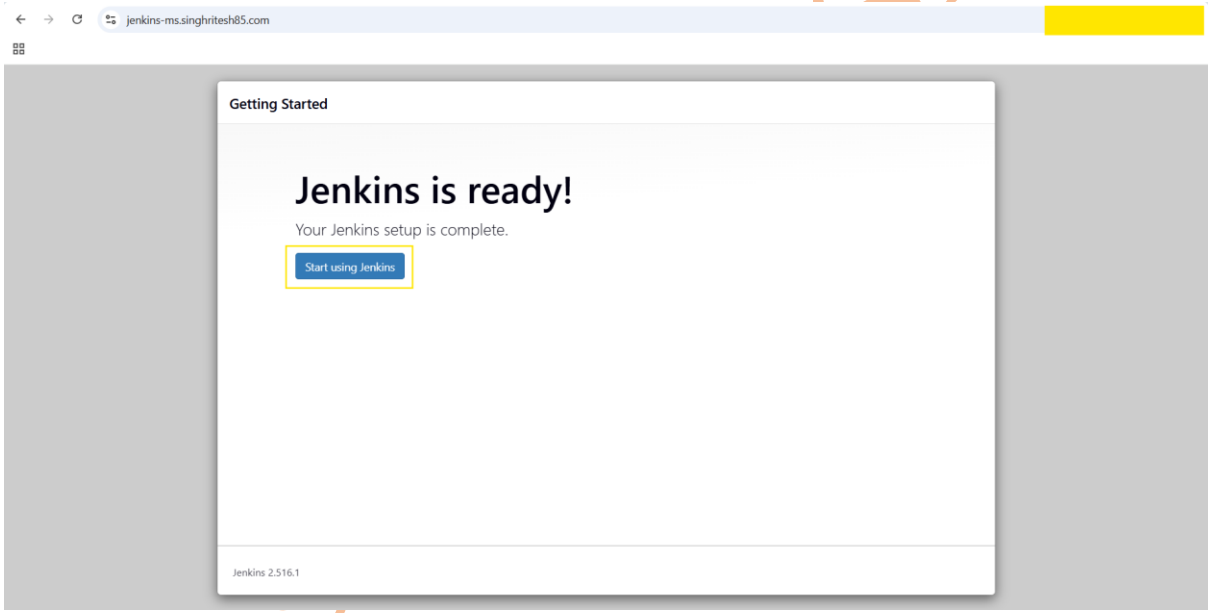




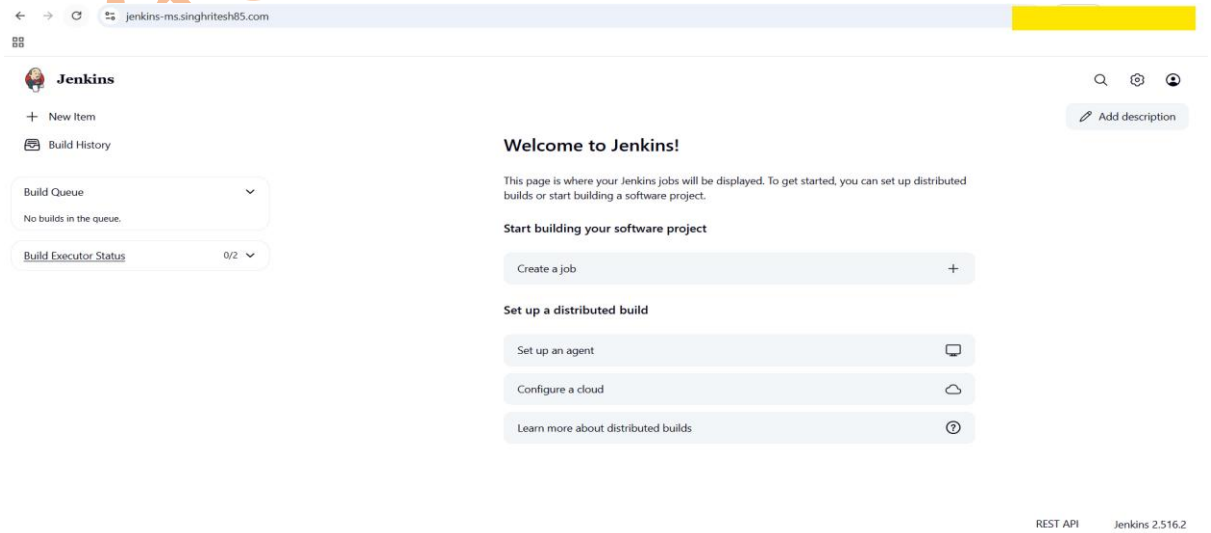
Provided username and password of Admin user as shown in the screenshot attached below.



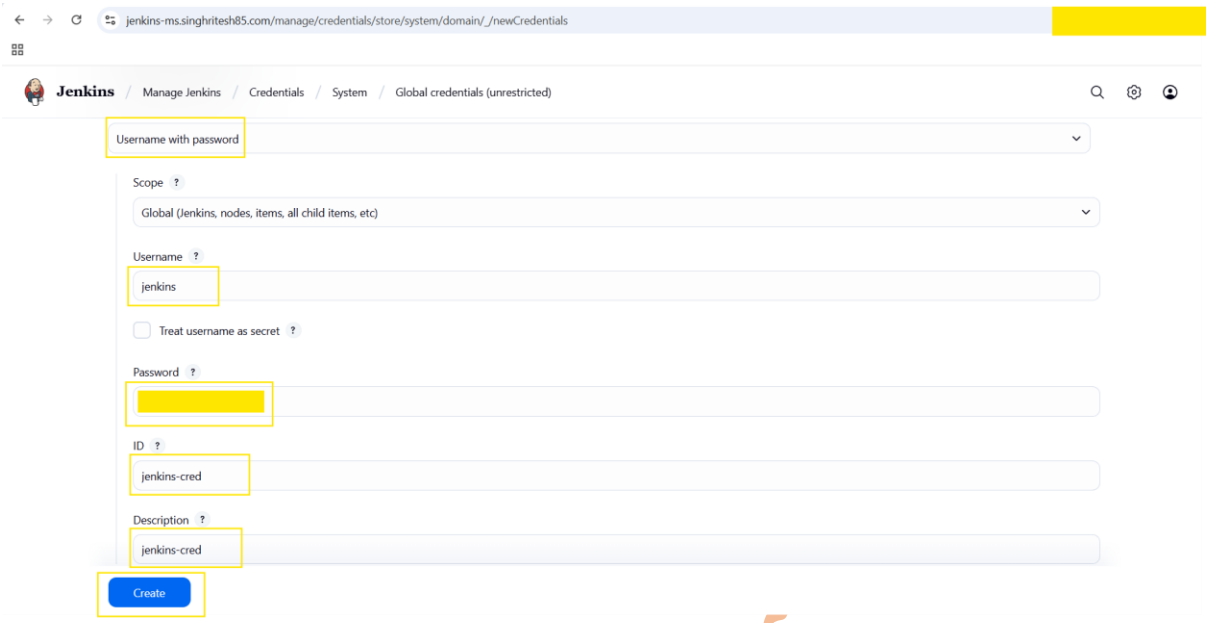


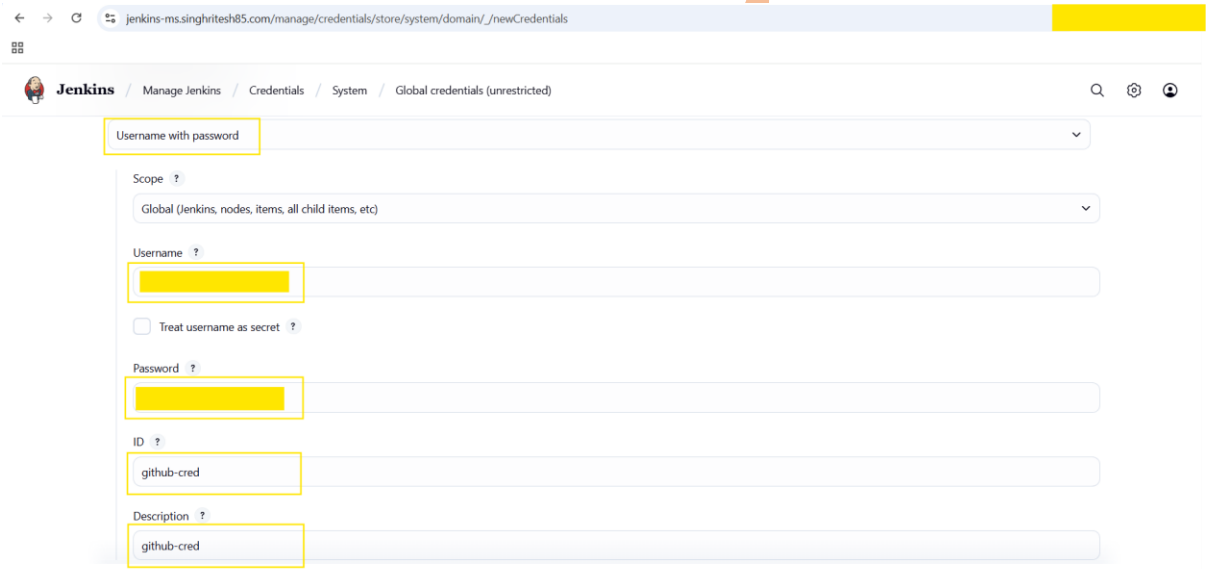


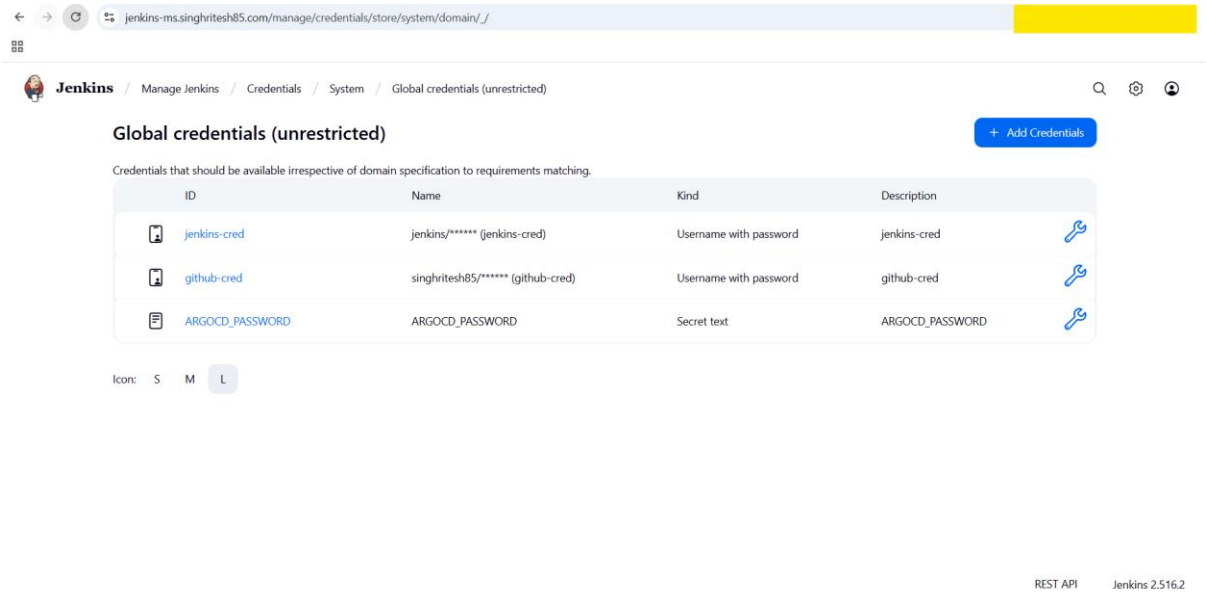
Finally, I was able to access Jenkins as shown in the screenshot attached below.



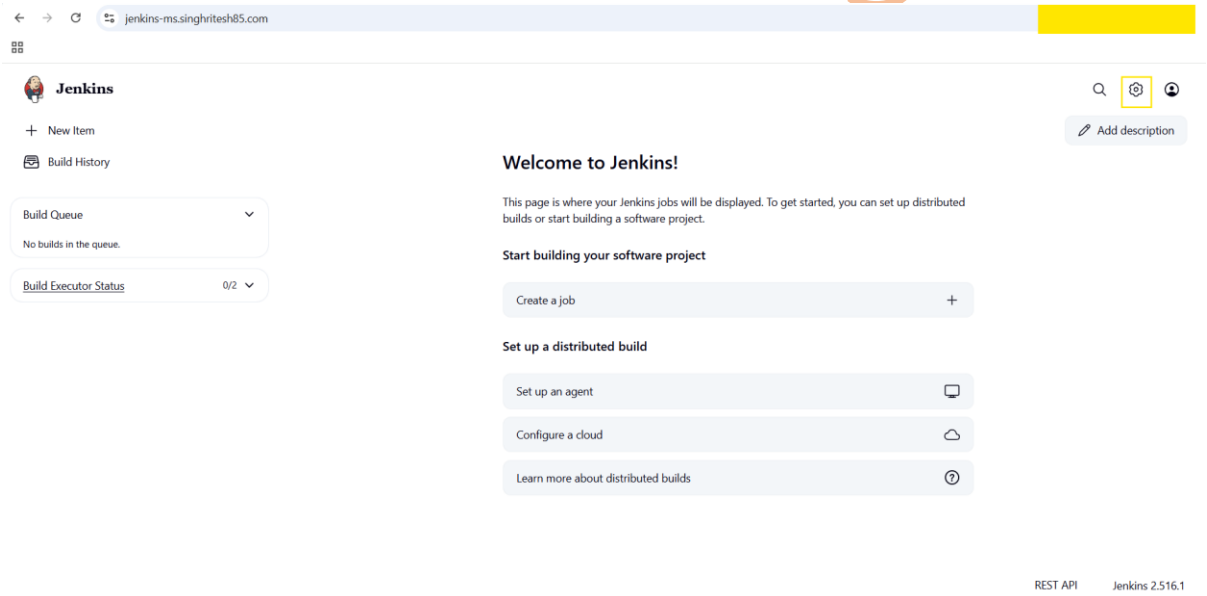
After Login into Jenkins, I created the Jenkins Credentials jenkins-cred, github-cred of **kind Username with Password** and **ARGOCD_PASSWORD** of kind secret text.

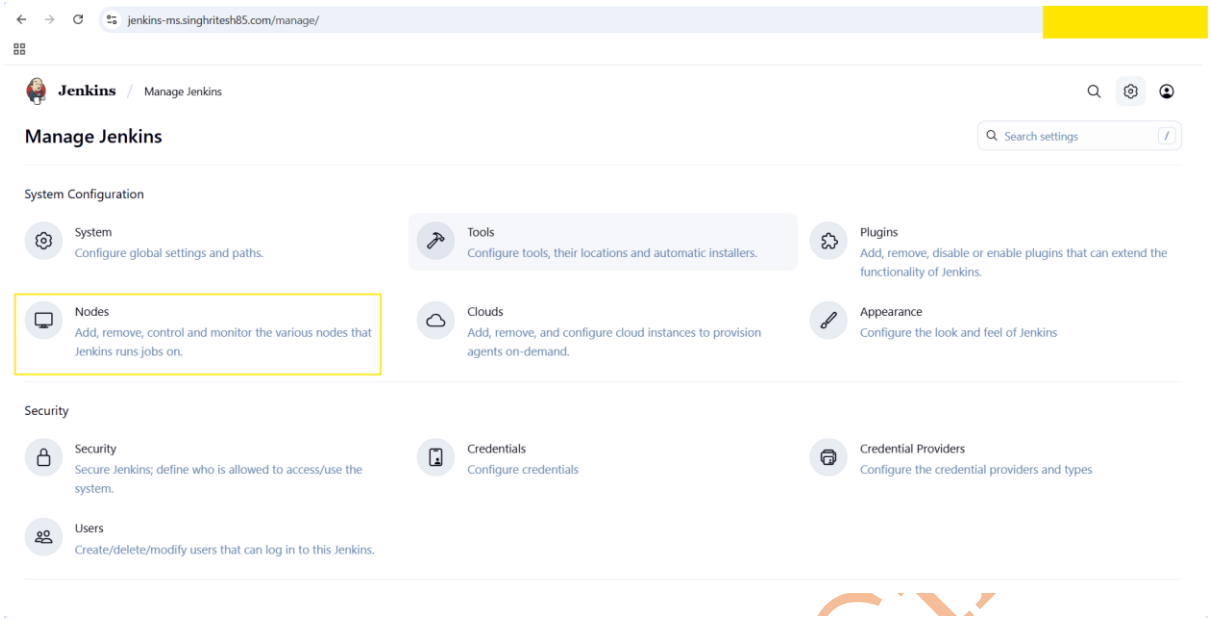


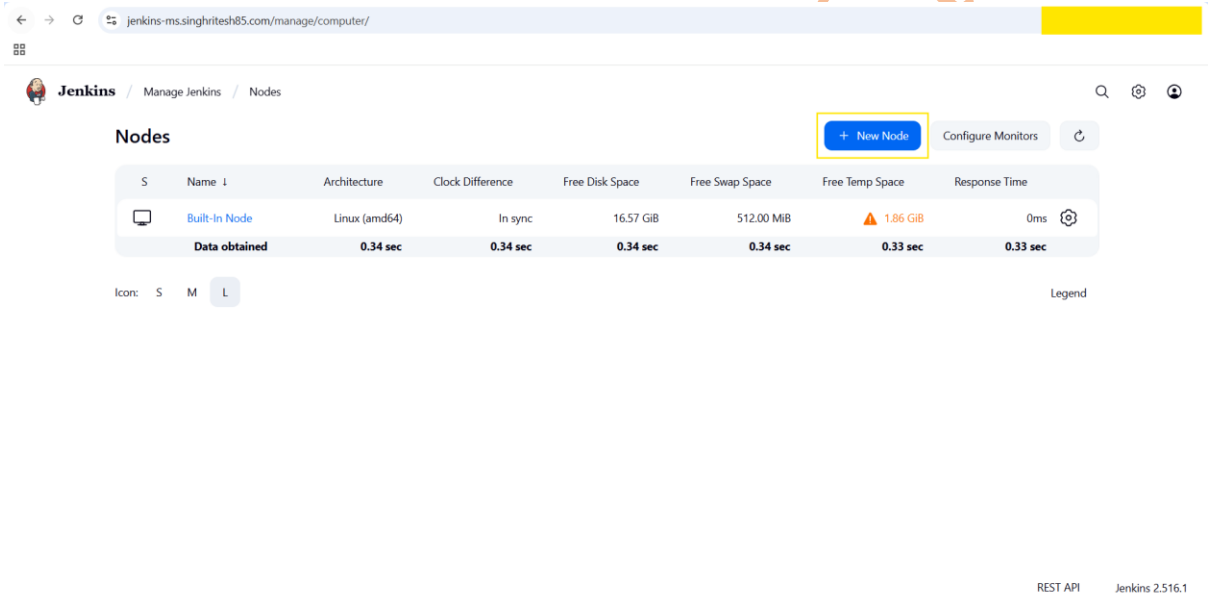


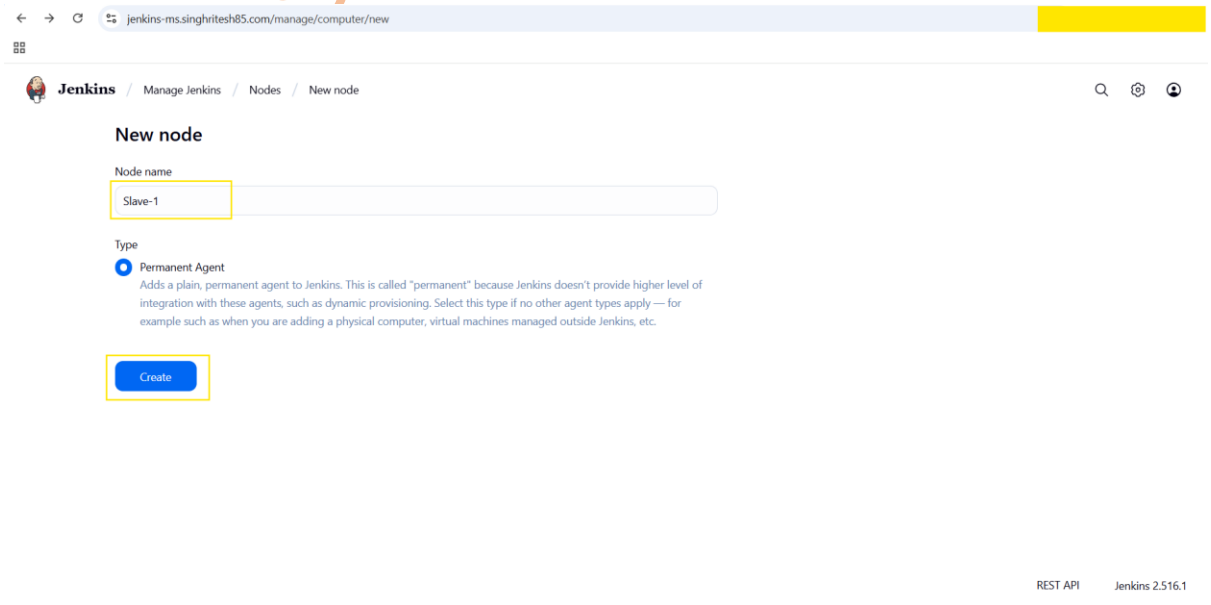


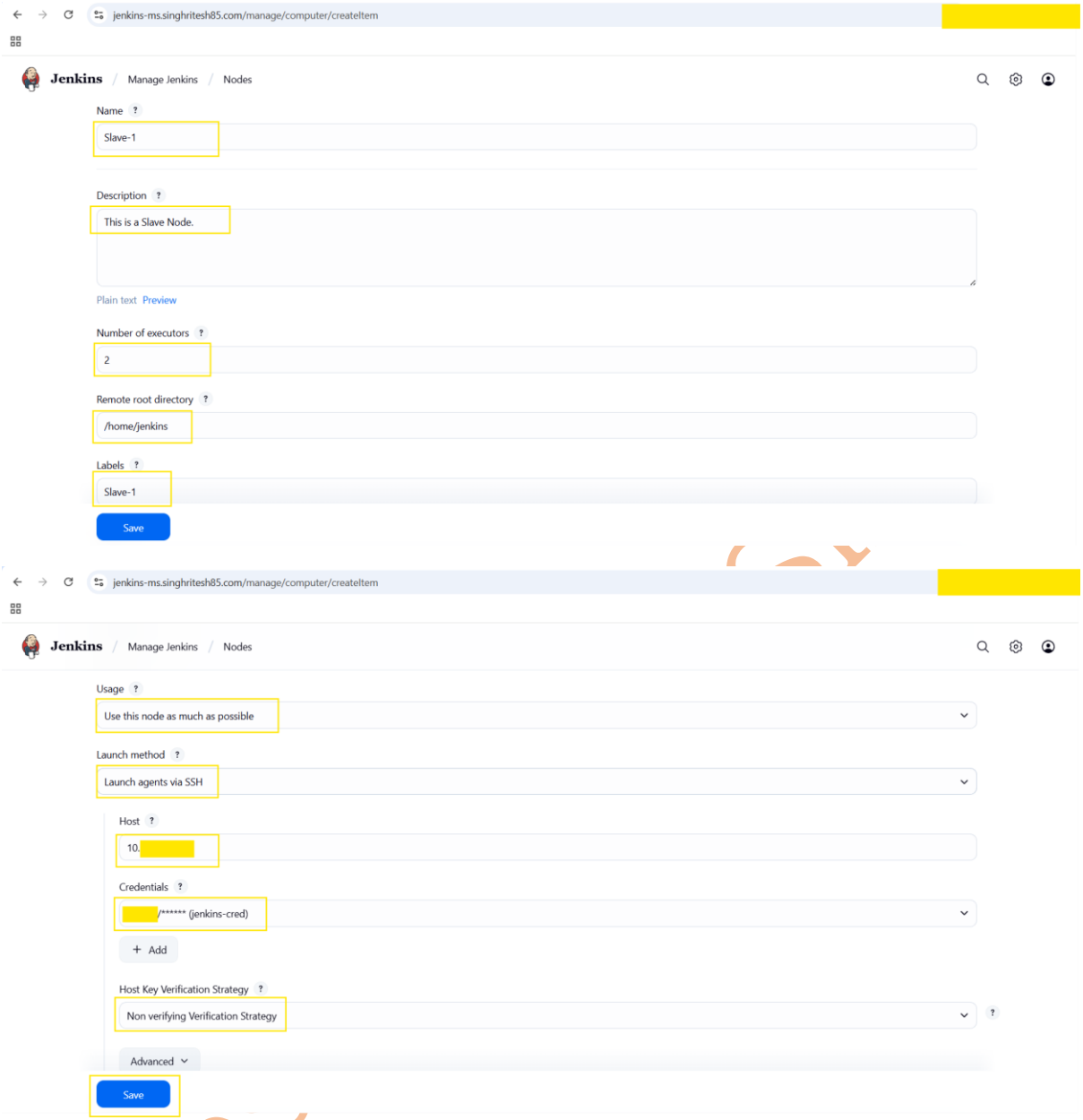
Then I added the Jenkins-Slave to the Jenkins-Master as shown in the screenshot attached below.




jenkins-ms.singhritesh85.com/manage/
Jenkins / Manage Jenkins
Manage Jenkins
Search settings
System Configuration
System
Configure global settings and paths.
Tools
Configure tools, their locations and automatic installers.
Plugins
Add, remove, disable or enable plugins that can extend the functionality of Jenkins.
Nodes
Add, remove, control and monitor the various nodes that Jenkins runs jobs on.
Clouds
Add, remove, and configure cloud instances to provision agents on-demand.
Appearance
Configure the look and feel of Jenkins
Security
Security
Secure Jenkins; define who is allowed to access/use the system.
Credentials
Configure credentials
Credential Providers
Configure the credential providers and types
Users
Create/delete/modify users that can log in to this Jenkins.

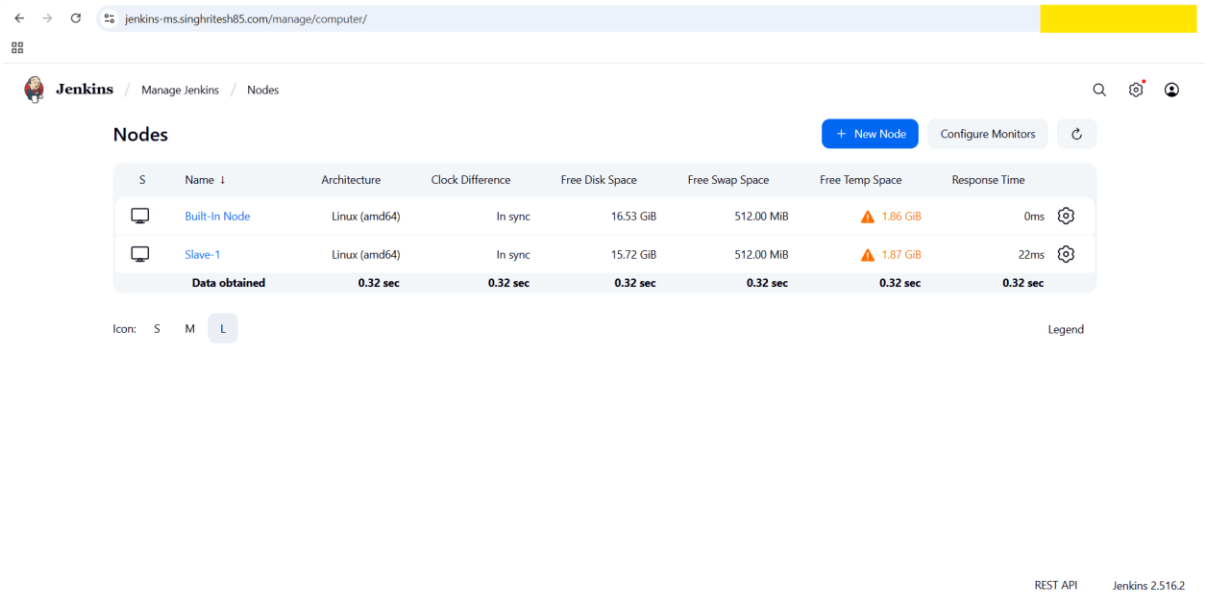

jenkins-ms.singhritesh85.com/manage/computer/
Jenkins / Manage Jenkins / Nodes
Nodes
New Node
Configure Monitors
S
Name ↓
Architecture
Clock Difference
Free Disk Space
Free Swap Space
Free Temp Space
Response Time
Built-In Node
Linux (amd64)
In sync
16.57 GiB
512.00 MiB
1.86 GiB
0ms
Data obtained
0.34 sec
0.34 sec
0.34 sec
0.34 sec
0.33 sec
0.33 sec
Icon: S M L
Legend
REST API
Jenkins 2.516.1


jenkins-ms.singhritesh85.com/manage/computer/new
Jenkins / Manage Jenkins / Nodes / New node
New node
Node name
Slave-1
Type
Permanent Agent
Adds a plain, permanent agent to Jenkins. This is called "permanent" because Jenkins doesn't provide higher level of integration with these agents, such as dynamic provisioning. Select this type if no other agent types apply — for example such as when you are adding a physical computer, virtual machines managed outside Jenkins, etc.
Create
REST API
Jenkins 2.516.1



Below commands I executed on Jenkins-Master and Jenkins-Slave to add swap space of 512 MiB.

```
[root@jenkins-slave ~]# fallocate -l 512M /swapfile
[root@jenkins-slave ~]# chmod 600 /swapfile
[root@jenkins-slave ~]# mkswap /swapfile
Setting up swapspace version 1, size = 512 MiB (536866816 bytes)
no label, UUID=
[root@jenkins-slave ~]# vim /etc/fstab
[root@jenkins-slave ~]# swapon -a
[root@jenkins-slave ~]# free -mh
              total        used        free      shared  buff/cache   available
Mem:          3.7Gi       454Mi       850Mi       0.0Ki       2.5Gi       3.0Gi
Swap:         511Mi          0B       511Mi
[root@jenkins-slave ~]# cat /etc/fstab
#
UUID=                                     /           xfs    defaults,noatime  1   1
UUID=                 /boot/efi       vfat    defaults,noatime,uid=0,gid=0,umask=0077,shortname=winnt,x-systemd.automount 0 2

/swapfile swap swap defaults 0 0
```



For this project I have not configured SonarQube and Nexus if you require to use it during the pipeline in your project you can refer the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApplication-Multibranch-MultiCloud.git.

For this project to refrain from higher cloud cost I used **t3.medium** instance type for Jenkins-Master and Jenkins-Slave.

Create the storage class named as dexter, this storage class will provision the EBS volume (and encrypt the EBS volume using AWS Customer Managed Key) dynamically using the EBS CSI driver deployed as an Add Ons in the EKS Cluster.

```
[root@                ~]# cat storage-class.yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: dexter
provisioner: ebs.csi.aws.com    #ebs.csi.eks.amazonaws.com
volumeBindingMode: WaitForFirstConsumer
parameters:
  type: gp3
  encrypted: "true"
  kmsKeyId: arn:aws:kms:us-east-2:0          6:key/
[root@                ~]# kubectl apply -f storage-class.yaml
storageclass.storage.k8s.io/dexter created
[root@                ~]# kubectl get sc
NAME      PROVISIONER             RECLAIMPOLICY   VOLUMEBINDINGMODE      ALLOWVOLUMEEXPANSION   AGE
dexter    ebs.csi.aws.com         Delete          WaitForFirstConsumer   false
gp2       kubernetes.io/aws-ebs   Delete          WaitForFirstConsumer   false
```

The storage class named as **dexter** will be used during the deployment of MySQL8 Pods.

cat storage-class.yaml

apiVersion: storage.k8s.io/v1

kind: StorageClass

metadata:

name: dexter

provisioner: ebs.csi.aws.com

volumeBindingMode: WaitForFirstConsumer

parameters:

type: gp3

encrypted: "true"

kmsKeyId: arn:aws:kms:us-east-2:02XXXXXXXXX6:key/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX

Installation of Istio in Amazon EKS Cluster

To install Istio Service mesh using helm chart use the command as written below.

helm repo add istio https://istio-release.storage.googleapis.com/charts

helm repo update

kubectl create ns istio-system

helm install istio-base istio/base -n istio-system

helm install istiod istio/istiod -n istio-system

helm install istio-ingressgateway istio/gateway --set service.type=ClusterIP -n istio-system

helm install istio-egressgateway istio/gateway --set service.type=ClusterIP -n istio-system

cat server.crt intermediate1.crt intermediate2.crt root.crt > tls.crt

kubectl create secret generic cacerts -n istio-system --from-file=server.crt --from-file=tls.key --from-file=root.crt --from-file=tls.crt

```
[root@ ~]# helm repo add istio https://istio-release.storage.googleapis.com/charts
"istio" has been added to your repositories
```

```
[root@ ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "vmware-tanzu" chart repository
...Successfully got an update from the "eks" chart repository
...Successfully got an update from the "istio" chart repository
Update Complete. ⎈Happy Helming!⎈
```

```
[root@ ~]# kubectl create ns istio-system
namespace/istio-system created
[root@ ~]# helm install istio-base istio/base -n istio-system
```

```
[root@ ~]# helm install istiod istio/istiod -n istio-system
[root@ ~]# helm install istio-ingressgateway istio/gateway --set service.type=ClusterIP -n istio-system
[root@ ~]# helm install istio-egressgateway istio/gateway --set service.type=ClusterIP -n istio-system
[root@ ~]# cat server.crt intermediate1.crt intermediate2.crt root.crt > tls.crt
[root@ ~]# kubectl create secret generic cacerts -n istio-system --from-file=server.crt --from-file=tls.key --from-file=root.crt --from-file=tls.
crt
secret/cacerts created
```

I had installed Kiali, Prometheus and Grafana as shown in the screenshot attached below.

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/kiali.yaml

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/prometheus.yaml

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/grafana.yaml

```
[root@ ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/kiali.yaml
serviceaccount/kiali created
configmap/kiali created
clusterrole.rbac.authorization.k8s.io/kiali created
clusterrolebinding.rbac.authorization.k8s.io/kiali created
service/kiali created
deployment.apps/kiali created
[root@ ~]# kubectl get pods -n istio-system --watch
NAME                                    READY   STATUS    RESTARTS   AGE
istio-egressgateway-                    1/1     Running   0          21m
istio-ingressgateway-                   1/1     Running   0          26m
istiod-                                 1/1     Running   0          27m
kiali-                                  1/1     Running   0          48s

[root@ ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/prometheus.yaml
serviceaccount/prometheus created
configmap/prometheus created
clusterrole.rbac.authorization.k8s.io/prometheus created
clusterrolebinding.rbac.authorization.k8s.io/prometheus created
service/prometheus created
deployment.apps/prometheus created
[root@ ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/grafana.yaml
serviceaccount/grafana created
configmap/grafana created
service/grafana created
deployment.apps/grafana created
configmap/istio-grafana-dashboards created
configmap/istio-services-grafana-dashboards created
```

```
[root@ ~]# kubectl get pods -n istio-system
NAME                                    READY   STATUS    RESTARTS   AGE
grafana-                                1/1     Running   0          s
istio-egressgateway-                    1/1     Running   0
istio-ingressgateway-                   1/1     Running   0
istiod-                                 1/1     Running   0          m
kiali-                                  1/1     Running   0
prometheus-                             2/2     Running   0          s
```

```
[root@ ~]# kubectl get virtualservice -n istio-system
NAME                                GATEWAYS                        HOSTS                          AGE
telemetry-kiali-virtual-service     ["istio-telemetry-gateway"]     ["kiali.singhritesh85.com"]    30m
```

To enable peer-to-peer authentication (mTLS) in Istio Service mesh I used the STRICT mode and the manifests file as shown below. If you use mode as PERMISSIVE mode then it accepts both http (plain text) and https (Mutual TLS) based communication. I created a kubernetes secrets named as cacerts as shown in the screenshot attached above. I will use this kubernetes secret for the creation of gateway.

I created the record set in Route53 for kiali corresponding to DNS Name of the LoadBalancer for the kiali service as shown in the screenshot attached below.

```
[root@ ~]# cat kiali-ingress.yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: kiali-ingress
  namespace: istio-system # Or the namespace where Kiali is deployed
  annotations:
    kubernetes.io/ingress.class: alb
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip # Or 'instance'
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS":443}]' # If using HTTPS
    ingress.kubernetes.io/backend-protocol: HTTPS
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02      6:certificate/
spec:
  rules:
  - host: kiali.singhritesh85.com # Replace with your desired hostname
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: kiali # Name of the Kiali service created by the operator
            port:
              number: 20001 # Kiali's default port
[root@ ~]# kubectl get ing -n istio-system
NAME            CLASS    HOSTS                  ADDRESS                                                          PORTS   AGE
kiali-ingress   <none>   kiali.singhritesh85.com   k8s-istiosys-kialiing-                .us-east-2.elb.amazonaws.com   80      48m
```

cat kiali-ingress.yaml

apiVersion: networking.k8s.io/v1

kind: Ingress

metadata:

name: kiali-ingress

namespace: istio-system

annotations:

alb.ingress.kubernetes.io/scheme: internet-facing

alb.ingress.kubernetes.io/target-type: ip

alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS":443}]'

ingress.kubernetes.io/backend-protocol: HTTPS

alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02XXXXXXXXX6:certificate/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX

spec:

ingressClassName: alb

rules:

- host: kiali.singhritesh85.com

http:

paths:

- path: /

pathType: Prefix

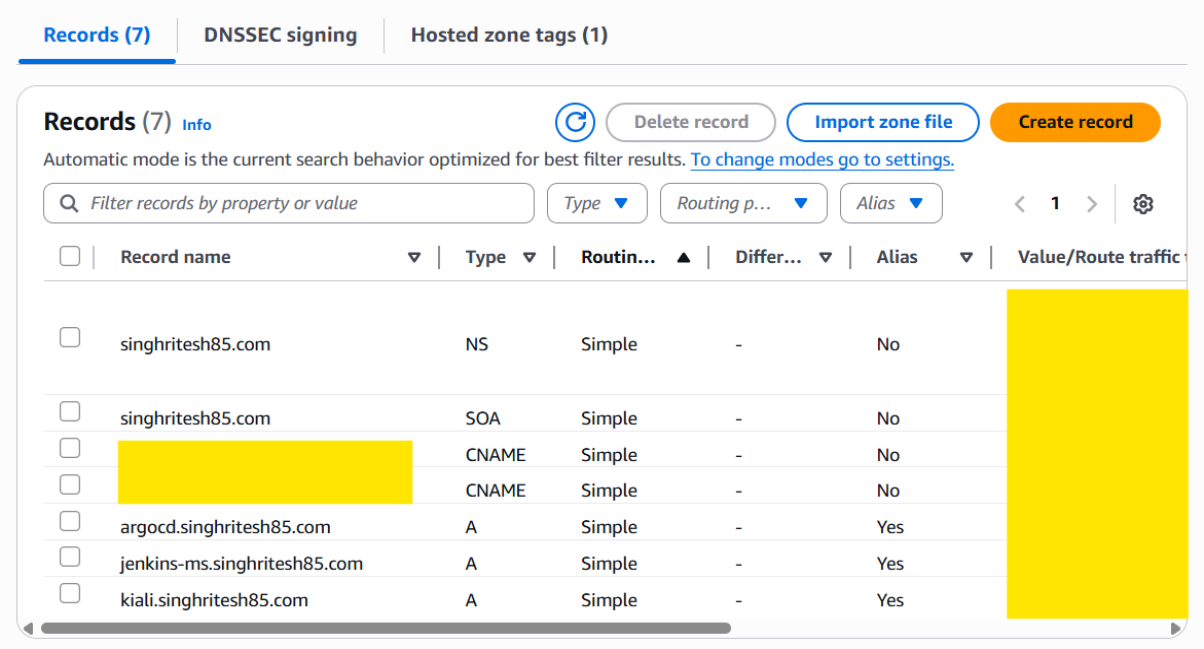
backend:

service:

name: kiali

port:

number: 20001




```
[root@ ~]# cat peerauthentication.yaml
apiVersion: security.istio.io/v1
kind: PeerAuthentication
metadata:
  name: "default"
  namespace: istio-system
spec:
  mtls:
    mode: STRICT
```

cat peerauthentication.yaml

apiVersion: security.istio.io/v1

kind: PeerAuthentication

metadata:

name: "default"

namespace: istio-system

spec:

mtls:

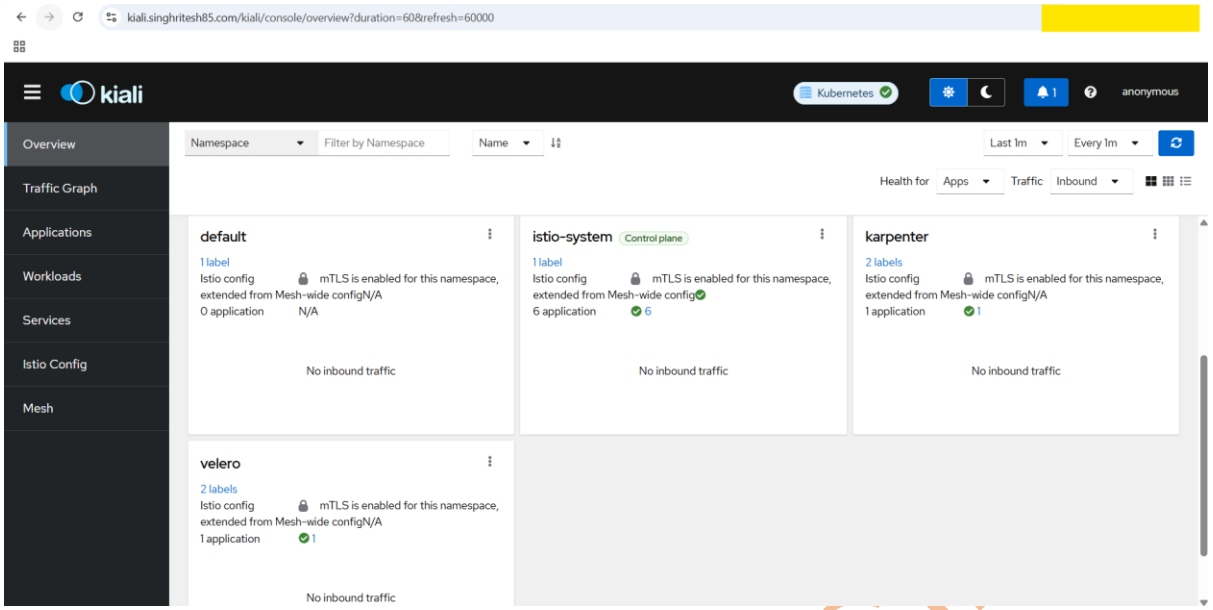
mode: STRICT

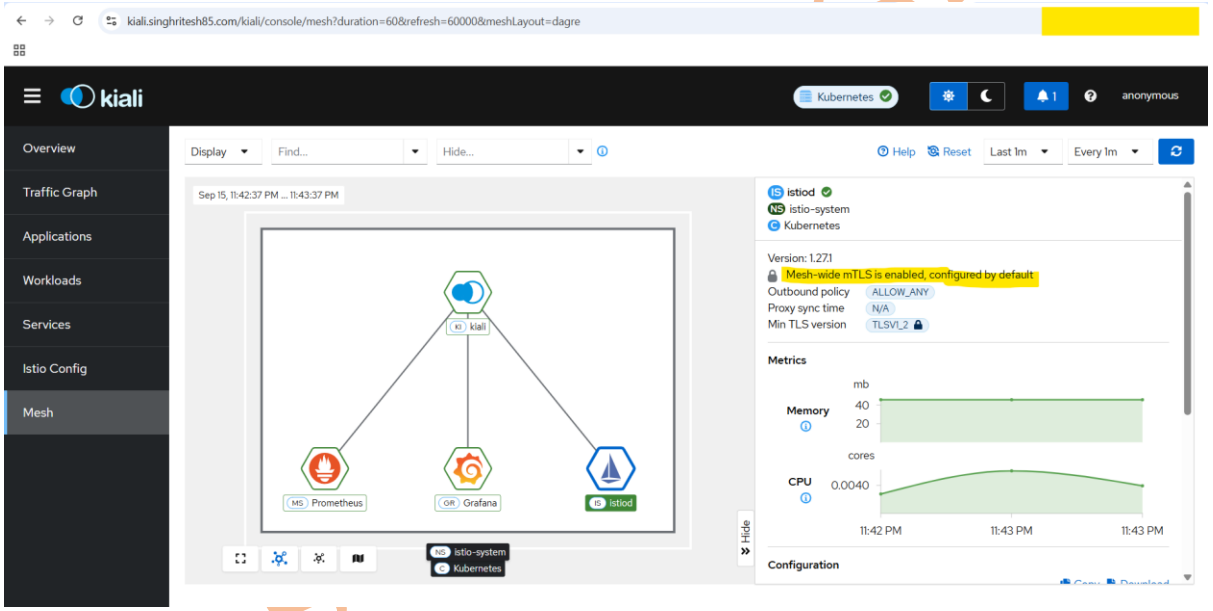
```
[root@ ~]# kubectl get virtualservice -n istio-system
NAME                            GATEWAYS                        HOSTS                          AGE
telemetry-kiali-virtual-service   ["istio-telemetry-gateway"]   ["kiali.singhritesh85.com"]   45m
[root@ ~]# kubectl get destinationrule -n istio-system
NAME     HOST                                    AGE
kiali    kiali.istio-system.svc.cluster.local    45m
```

```
cat gtw-vsc-destrule-kiali.yaml
---
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: istio-telemetry-gateway
  namespace: istio-system
spec:
  selector:
    istio: ingressgateway
  servers:
  - port:
      number: 80
      name: http
      protocol: HTTP
    hosts:
    - "kiali.singhritesh85.com"
    tls:
      httpsRedirect: true
  - port:
      number: 443
      name: https
      protocol: HTTPS
    hosts:
    - "kiali.singhritesh85.com"
    tls:
      mode: SIMPLE
      credentialName: cacerts
---
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
```

```
  name: telemetry-kiali-virtual-service
  namespace: istio-system
spec:
  hosts:
  - "kiali.singhritesh85.com"
  gateways:
  - istio-telemetry-gateway
  http:
   - route:
     - destination:
       host: kiali.istio-system.svc.cluster.local
       port:
         number: 20001
---
apiVersion: networking.istio.io/v1alpha3
kind: DestinationRule
metadata:
  name: kiali
  namespace: istio-system
spec:
  host: kiali.istio-system.svc.cluster.local
  trafficPolicy:
    tls:
     mode: DISABLE
```

Kiali dashboard is as shown in the screenshot attached below which confirms mesh-wide mTLS had been enabled.





Installation of Cilium in Chain Mode with VPC CNI in Amazon EKS Cluster

To **enable Node-to-Node encryption with wireguard** install **cilium** in chain mode with VPC-CNI follow the steps as written below.

helm repo add cilium https://helm.cilium.io/

helm repo update

helm upgrade --install cilium cilium/cilium --version 1.18.1 --namespace kube-system --set cni.chainingMode=aws-cni --set kubeProxyReplacement=false --set cni.exclusive=false --set enableIPv4Masquerade=false --set endpointRoutes.enabled=true --set encryption.enabled=true --set encryption.nodeEncryption=true --set encryption.type=wireguard --set l7Proxy=false

kubectl get pods -n kube-system --watch| grep -i "cilium"

kubectl -n kube-system exec -it ds/cilium -- cilium status | grep Encryption

```
[root@                ~]# helm repo add cilium https://helm.cilium.io/
"cilium" has been added to your repositories
[root@                ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "vmware-tanzu" chart repository
...Successfully got an update from the "eks" chart repository
...Successfully got an update from the "cilium" chart repository
...Successfully got an update from the "istio" chart repository
Update Complete. ⎈Happy Helming!⎈
```

```
[root@          ~]# helm upgrade --install cilium cilium/cilium --version 1.18.1 --namespace kube-system --set cni.chainingMode=aws-cni --set kubeProxyRep
lacement=false --set cni.exclusive=false --set enableIPv4Masquerade=false --set endpointRoutes.enabled=true --set encryption.enabled=true --set encryption.nod
eEncryption=true --set encryption.type=wireguard --set l7Proxy=false
```

```
[root@                ~]# kubectl get pods -n kube-system --watch| grep -i "cilium"
cilium-                                          1/1     Running   0          113s
cilium-                                          1/1     Running   0          113s
cilium-                                          1/1     Running   0          113s
cilium-operator-                                 1/1     Running   0          113s
cilium-operator-                                 1/1     Running   0          113s
cilium-                                          1/1     Running   0          87s
cilium-                                          1/1     Running   0          63s
```

To get confirmation regarding Node-to-Node encryption run the below command.

kubectl -n kube-system exec -it ds/cilium -- cilium status | grep Encryption

```
[root@jenkins-slave ~]# kubectl -n kube-system exec -it ds/cilium -- cilium status | grep Encryption
Encryption:             Wireguard   [NodeEncryption: Enabled, cilium_wg0 (Pubkey:                                , Port: 51871, Peers: 4)]
```

As shown in the screenshot attached above Node-to-Node Encryption in EKS had been Enabled.

Installation of Open Policy Agent (OPA) Gatekeeper in Amazon EKS Cluster

To install OPA using Helm follow the steps as written below.

helm repo add gatekeeper https://open-policy-agent.github.io/gatekeeper/charts

helm repo update

helm install gatekeeper gatekeeper/gatekeeper --namespace gatekeeper-system --create-namespace

kubectl get pods -n gatekeeper-system --watch

```
[root@                ~]# helm repo add gatekeeper https://open-policy-agent.github.io/gatekeeper/charts
"gatekeeper" has been added to your repositories
[root@                ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "gatekeeper" chart repository
...Successfully got an update from the "vmware-tanzu" chart repository
...Successfully got an update from the "eks" chart repository
...Successfully got an update from the "cilium" chart repository
...Successfully got an update from the "istio" chart repository
Update Complete. ⎈Happy Helming!⎈
```

```
[root@                ~]# helm install gatekeeper gatekeeper/gatekeeper --namespace gatekeeper-system --create-namespace
```

```
[root@                ~]# kubectl get pods -n gatekeeper-system --watch
NAME                                             READY   STATUS    RESTARTS   AGE
gatekeeper-audit-                                1/1     Running   0          90s
gatekeeper-controller-manager-                   1/1     Running   0          90s
gatekeeper-controller-manager-                   1/1     Running   0          90s
gatekeeper-controller-manager-                   1/1     Running   0          90s
```

You can check the logs for OPA using the command as shown in the screenshot attached below.

kubectl logs -l control-plane=audit-controller -n gatekeeper-system

```
[root@          ~]# kubectl logs -l control-plane=audit-controller -n gatekeeper-system
{"level":"info","ts":1758008534.146585,"msg":"Starting workers","controller":"syncset-controller","worker count":1}
{"level":"info","ts":1758008593.6449754,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-16T07:43:13Z",
"event_type":"audit_started"}
{"level":"info","ts":1758008593.674333,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-16T07:43:13Z
","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758008593.6743734,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-16T07:43:13Z","event_type":"a
udit_finished","duration":"29.429417ms"}
{"level":"info","ts":1758008653.6453779,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-16T07:44:13Z",
"event_type":"audit_started"}
{"level":"info","ts":1758008653.6742582,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-16T07:44:13
Z","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758008653.6745305,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-16T07:44:13Z","event_type":"a
udit_finished","duration":"29.16974ms"}
{"level":"info","ts":1758008713.6448324,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-16T07:45:13Z",
"event_type":"audit_started"}
{"level":"info","ts":1758008713.6736693,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-16T07:45:13
Z","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758008713.6737137,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-16T07:45:13Z","event_type":"a
udit_finished","duration":"28.910995ms"}
```

Here, I created OPA Policy (Constraint Template and Constraint) which will disallow the creation of pod with container had the capability of host machine (Privileged = true) and elevated privileges (allowPrivilegeEscalation = true) in the namespace bankapp and mysql, and no one can create the LoadBalancer Service in the namespace bankapp and mysql. If any one wants to create the service, then create the ClusterIP service and expose the pods using Ingress Rule through the created ClusterIP service. It will also not allow anyone to use the Image with latest tag and do not allow to create the Resources Pod, Deployment, Statefulset or Daemonset in the namespace mysql and bankapp if require resource requests and limits per Pod is not mentioned.

```
[root@              ~]# kubectl apply -f constrainttemplate.yaml
constrainttemplate.templates.gatekeeper.sh/k8sdisallowprivileged created
constrainttemplate.templates.gatekeeper.sh/loadbalancerconstraint created
constrainttemplate.templates.gatekeeper.sh/k8scontainerresourcerequirements created
constrainttemplate.templates.gatekeeper.sh/k8sdisallowedtags created
[root@              ~]# kubectl apply -f constraint.yaml
k8sdisallowprivileged.constraints.gatekeeper.sh/psp-privileged-container created
loadbalancerconstraint.constraints.gatekeeper.sh/loadbalancerconstraint created
k8scontainerresourcerequirements.constraints.gatekeeper.sh/pod-resource-requirements created
k8sdisallowedtags.constraints.gatekeeper.sh/container-image-must-not-have-latest-tag created
```

You can list the constraint template and constraint currently deployed and used in the cluster using the command **kubectl get constrainttemplate** and **kubectl get constraints** respectively.

```
cat constrainttemplate.yaml
---
apiVersion: templates.gatekeeper.sh/v1beta1
kind: ConstraintTemplate
metadata:
 name: k8sdisallowprivileged
spec:
 crd:
  spec:
   names:
    kind: K8sDisallowPrivileged
 targets:
  - target: admission.k8s.gatekeeper.sh
   rego: |
    package k8sdisallowprivileged

    violation[{"msg": msg}] {
     container := input.review.object.spec.containers[_]
     container.securityContext.privileged == true
     msg := sprintf("Privileged container %v is not allowed", [container.name])
    }

    violation[{"msg": msg}] {
     initContainer := input.review.object.spec.initContainers[_]
     initContainer.securityContext.privileged == true
     msg := sprintf("Privileged init container %v is not allowed", [initContainer.name])
    }

    violation[{"msg": msg}] {
     container := input.review.object.spec.containers[_]
     container.securityContext.allowPrivilegeEscalation == true
```

```
        msg := sprintf("allowPrivilegeEscalation container %v is not allowed", [container.name])
      }
      violation[{"msg": msg}] {
        initContainer := input.review.object.spec.initContainers[_]
        initContainer.securityContext.allowPrivilegeEscalation == true
        msg := sprintf("allowPrivilegeEscalation init container %v is not allowed", [initContainer.name])
}
---
apiVersion: templates.gatekeeper.sh/v1beta1
kind: ConstraintTemplate
metadata:
 name: loadbalancerconstraint
spec:
 crd:
   spec:
     names:
       kind: LoadBalancerConstraint
 targets:
   - target: admission.k8s.gatekeeper.sh
     rego: |
       package insomniacoder.constraint
       violation[{"msg": msg}] {
         input.review.kind.kind = "Service"
         input.review.operation = "CREATE"
         input.review.object.spec.type = "LoadBalancer"
         msg := "Service type LoadBalancer are restricted"
       }
---
apiVersion: templates.gatekeeper.sh/v1beta1
kind: ConstraintTemplate
metadata:
 name: k8scontainerresourcerequirements
```

```
spec:
  crd:
    spec:
      names:
        kind: K8sContainerResourceRequirements
      validation:
        openAPIV3Schema:
          type: object
          properties:
            spec:
              type: object
  targets:
    - target: admission.k8s.gatekeeper.sh
      rego: |
        package k8scontainerresourcerequirements

        violation[{"msg": msg}] {
          container := input.review.object.spec.containers[_]
          not container.resources.requests.cpu
          msg := sprintf("Container '%v' must have CPU requests defined", [container.name])
        }

        violation[{"msg": msg}] {
          container := input.review.object.spec.containers[_]
          not container.resources.requests.memory
          msg := sprintf("Container '%v' must have memory requests defined", [container.name])
        }

        violation[{"msg": msg}] {
          container := input.review.object.spec.containers[_]
          not container.resources.limits.cpu
          msg := sprintf("Container '%v' must have CPU limits defined", [container.name])
```

```
    }

    violation[{"msg": msg}] {
      container := input.review.object.spec.containers[_]
      not container.resources.limits.memory
      msg := sprintf("Container '%v' must have memory limits defined", [container.name])
    }
---
apiVersion: templates.gatekeeper.sh/v1
kind: ConstraintTemplate
metadata:
  name: k8sdisallowedtags
spec:
  crd:
    spec:
      names:
        kind: K8sDisallowedTags
      validation:
        openAPIV3Schema:
          type: object
          properties:
            tags:
              type: array
              description: Disallowed container image tags.
              items:
                type: string
  targets:
    - target: admission.k8s.gatekeeper.sh
      rego: |
        package k8sdisallowedtags
        violation[{"msg": msg}] {
          container := input_containers[_]
```

```
        tags := [tag_with_prefix | tag := input.parameters.tags[_]; tag_with_prefix := concat(":", ["", tag])]

        strings.any_suffix_match(container.image, tags)

        msg := sprintf("container <%v> uses a disallowed tag <%v>; disallowed tags are %v", [container.name, container.image, input.parameters.tags])

    }


    violation[{"msg": msg}] {

        container := input_containers[_]

        not contains(container.image, ":")

        msg := sprintf("container <%v> didn't specify an image tag <%v>", [container.name, container.image])

    }


    input_containers[c] {

        c := input.review.object.spec.containers[_]

    }

    input_containers[c] {

        c := input.review.object.spec.initContainers[_]

    }
```

```
cat constraint.yaml
apiVersion: constraints.gatekeeper.sh/v1beta1
kind: K8sDisallowPrivileged
metadata:
  name: psp-privileged-container
spec:
  match:
    kinds:
      - apiGroups: [""]
        kinds: ["Pod"]
    namespaces:
      - "bankapp"
      - "mysql"
---
apiVersion: constraints.gatekeeper.sh/v1beta1
kind: LoadBalancerConstraint
metadata:
  name: loadbalancerconstraint
spec:
  match:
    kinds:
      - apiGroups: [""]
        kinds: ["Service"]
    namespaces:
      - "bankapp"
      - "mysql"
---
apiVersion: constraints.gatekeeper.sh/v1beta1
kind: K8sContainerResourceRequirements
metadata:
  name: pod-resource-requirements
```

```
spec:
  match:
    kinds:
      - apiGroups: [""]
        kinds: ["Pod"]
      - apiGroups: ["apps"]
        kinds: ["Deployment", "StatefulSet", "DaemonSet"]
    namespaces:
      - "bankapp"
      - "mysql"
---
apiVersion: constraints.gatekeeper.sh/v1beta1
kind: K8sDisallowedTags
metadata:
  name: container-image-must-not-have-latest-tag
spec:
  match:
    kinds:
      - apiGroups: [""]
        kinds: ["Pod"]
      - apiGroups: ["apps"]
        kinds: ["Deployment", "StatefulSet", "DaemonSet"]
    namespaces:
      - "bankapp"
      - "mysql"
  parameters:
    tags: ["latest"]
```

Installation of Falco in Amazon EKS Cluster

To install Falco in Amazon EKS Cluster, follow the steps as written below.

helm repo add falcosecurity https://falcosecurity.github.io/charts

helm repo update

helm install falco falcosecurity/falco --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false

kubectl get pods -n falco --watch

```
[root@                ~]# helm install falco falcosecurity/falco --namespace falco --create-namespace
```

```
[root@                ~]# helm repo update
```

```
[root@                ~]# helm install falco falcosecurity/falco --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui
.enabled=true -set falcosidekick.webui.redis.storageEnabled=false
Error: INSTALLATION FAILED: expected at most two arguments, unexpected arguments: -set, falcosidekick.webui.redis.storageEnabled=false
[root@                ~]# helm install falco falcosecurity/falco --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui
.enabled=true --set falcosidekick.webui.redis.storageEnabled=false
NAME: falco
LAST DEPLOYED:                  2025
NAMESPACE: falco
STATUS: deployed
REVISION: 1
NOTES:
Falco agents are spinning up on each node in your cluster. After a few
seconds, they are going to start monitoring your containers looking for
security issues.


No further action should be required.



NOTICE:
It seems you are loading the following plugins [container], please make sure to install them by specifying the correct reference to falcoctl.config.artifact.i
nstall.refs: [falco-rules:4 ghcr.io/falcosecurity/plugins/plugin/container:0.3.6]Ignore this notice if the value of falcoctl.config.artifact.install.refs is c
orrect already.
```

I had applied a custom falco rule, if anyone will try to access the **/etc** directory to write in a file then it will be notified through Falco as shown in the screenshot attached below.

```
[root@                ~]# cat dexter-falco-rule.yaml
customRules:
  custom-rules.yaml: |-
    - rule: Write below etc
      desc: An attempt to write to /etc directory
      condition: >
        (evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)
        and fd.name startswith /etc
      output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname
[4] evt_type=%evt.type user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name proc_exepath=%proc.exepath parent=%proc.pname comman
d=%proc.cmdline terminal=%proc.tty"
      priority: WARNING
      tags: [filesystem, mitre_persistence]
```

helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false

```
[root@                ~]# helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosidekick.en
abled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false
```

cat dexter-falco-rule.yaml

customRules:

custom-rules.yaml: |-

- rule: Write below etc

desc: An attempt to write to /etc directory

condition: >

(evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)

and fd.name startswith /etc

output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname[4] evt_type=%evt.type user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name proc_exepath=%proc.exepath parent=%proc.pname command=%proc.cmdline terminal=%proc.tty"

priority: WARNING

tags: [filesystem, mitre_persistence]

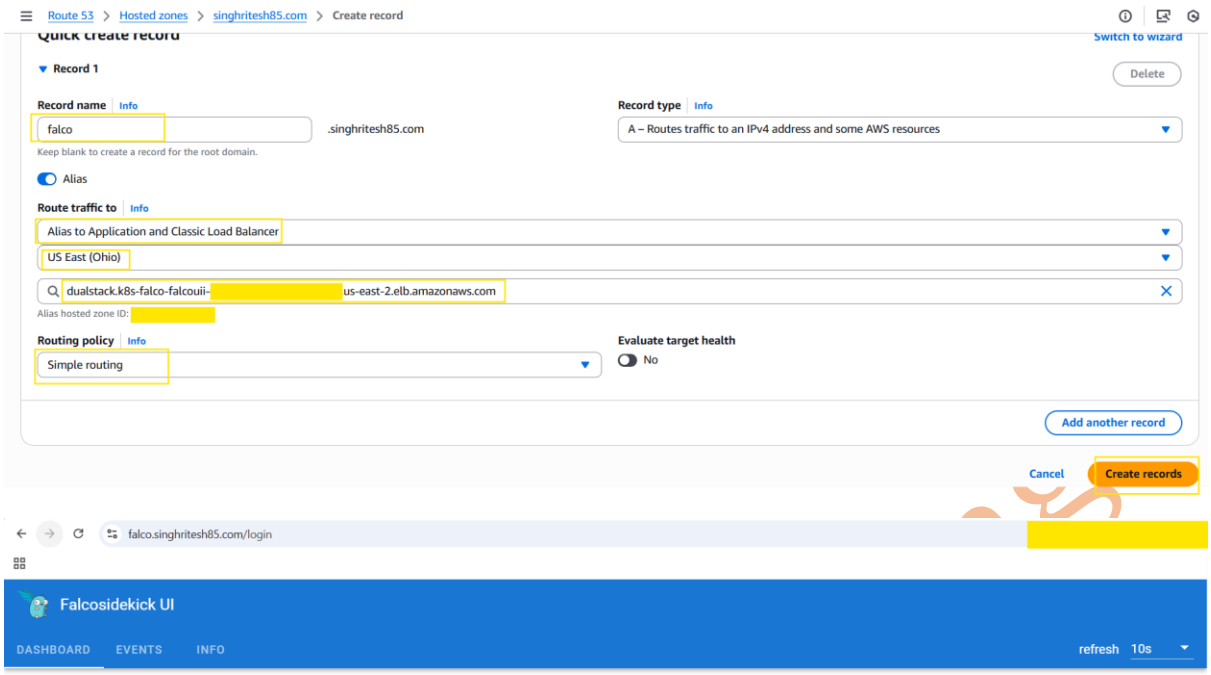
Created Ingress Rule to access Falco ui as shown in the screenshot attached below.

```
[root@ ~]# cat falco-ingress-rule.yaml
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02 6:certificate/
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
    alb.ingress.kubernetes.io/ssl-redirect: '443'
spec:
  ingressClassName: alb
  rules:
    - host: falco.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: falco-falcosidekick-ui
                port:
                  number: 2802
```

```
[root@ ~]# kubectl apply -f falco-ingress-rule.yaml
ingress.networking.k8s.io/falco-ui-ingress created
[root@ ~]# kubectl get ing -A
NAMESPACE      NAME              CLASS   HOSTS                    ADDRESS                                                          PORTS   AGE
argocd         argocd-ingress    alb     argocd.singhritesh85.com k8s-argocd-argocdin- .us-east-2.elb.amazonaws.com                80
falco          falco-ui-ingress  alb     falco.singhritesh85.com  k8s-falco-falcouii- .us-east-2.elb.amazonaws.com                 80
istio-system   kiali-ingress     alb     kiali.singhritesh85.com  k8s-istiosys-kialiing- .us-east-2.elb.amazonaws.com              80
```

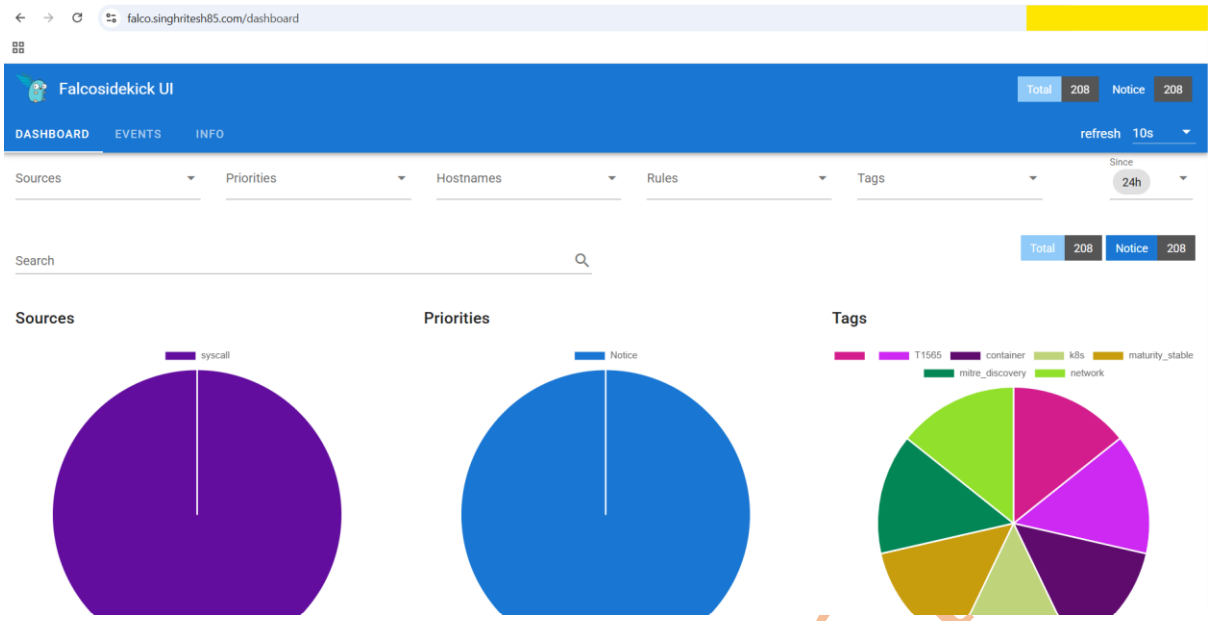
```
cat falco-ingress-rule.yaml
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-
2:02XXXXXXXXX6:certificate/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
    alb.ingress.kubernetes.io/ssl-redirect: '443'
spec:
  ingressClassName: alb
  rules:
    - host: falco.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: falco-falcosidekick-ui
                port:
                  number: 2802
```

I had created the entry for falco HOST resulted from ingress rule as shown in the screenshot attached above in Route53 to create the Record Set of A-Type as shown in the screenshot attached below.



Use the username/password as admin/admin and logged-in into the Falco ui as shown in the screenshot attached below. It is also possible to check falco logs using the command

kubectl logs -l "app.kubernetes.io/instance=falco" -n falco



Application Deployment using ArgoCD and Karpenter

To deploy Application using ArgoCD and Karpenter through Jenkins I followed the steps as written below.

First deploy MySQL 8 Pods, for that I created the Jenkins Job as shown in the screenshot attached below.

```
[root@                ~]# kubectl get pvc -n mysql
NAME                                STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS   VOLUMEATTRIBUTESCLASS   AGE
mysql-persistent-storage-mysql-0    Bound    pvc-                                       1Gi        RWO            dexter         <unset>                 9m14s
mysql-persistent-storage-mysql-1    Bound    pvc-                                       1Gi        RWO            dexter         <unset>                 2m36s
mysql-persistent-storage-mysql-2    Bound    pvc-                                       1Gi        RWO            dexter         <unset>                 2m9s
[root@                ~]# kubectl get pods -n mysql
NAME      READY   STATUS    RESTARTS   AGE
mysql-0   1/1     Running   0          9m24s
mysql-1   1/1     Running   0          2m46s
mysql-2   1/1     Running   0          2m19s
```

The Jenkinsfile to deploy MySQL 8 Pods is provided for your reference blow.

Jenkinsfile-MySQL 8

```
pipeline{
   agent{
       node{
          label "Slave-1"
          customWorkspace "/home/jenkins/mysql"
       }
   }
   environment{
      JAVA_HOME="/usr/lib/jvm/java-17-amazon-corretto.x86_64"
      PATH="$PATH:$JAVA_HOME/bin:/opt/apache-maven/bin:/opt/node-v16.0.0/bin:/usr/local/bin"
      ARGOCD_PASSWORD=credentials('ARGOCD_PASSWORD')
   }
   stages{
      stage("MySQL-Deployment"){
         steps{
            //MySQL
            sh 'argocd login argocd.singhritesh85.com --username admin --password
$ARGOCD_PASSWORD --skip-test-tls  --grpc-web'
            sh 'argocd app create mysql --project default --repo
https://github.com/singhritesh85/kustomize-bankapp.git --path ./overlay/mysql --revision main --
dest-namespace mysql --sync-option CreateNamespace=true --dest-server
https://kubernetes.default.svc --upsert'
            sh 'argocd app sync mysql'
         }
      }
   }
}
```

Then I created the Jenkins Job to deploy bankapp pods as shown in the screenshot attached below.

```
[root@                ~]# kubectl get pods -n bankapp --watch
NAME                         READY   STATUS    RESTARTS   AGE
bankapp-6fcb47f9dd-km4k2     1/1     Running   0          2m47s
```

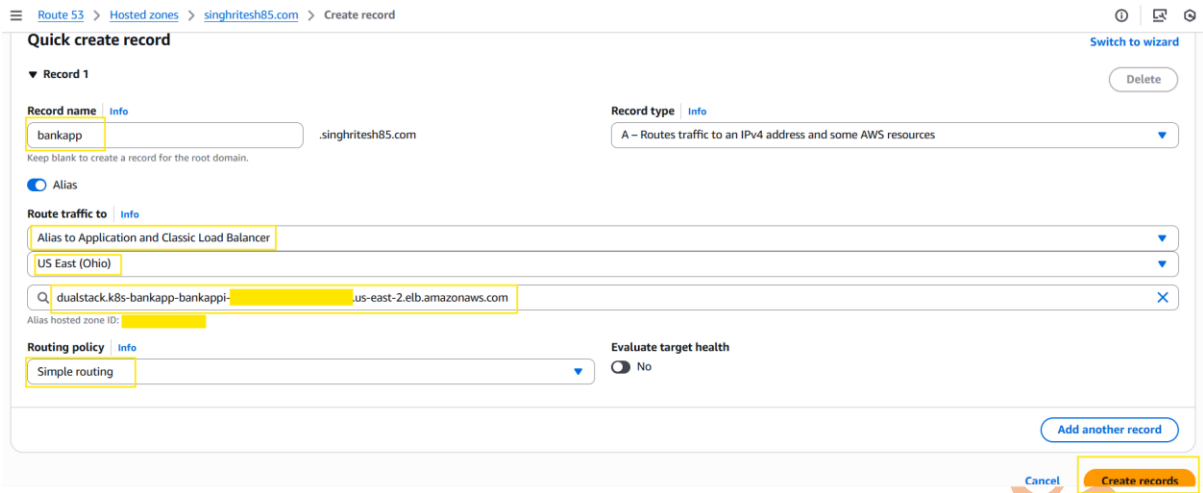
Jenkinsfile-Bankapp

```
pipeline{
   agent{
       node{
          label "Slave-1"
          customWorkspace "/home/jenkins/bankapp"
       }
   }
   environment{
      JAVA_HOME="/usr/lib/jvm/java-17-amazon-corretto.x86_64"
      PATH="$PATH:$JAVA_HOME/bin:/opt/apache-maven/bin:/opt/node-v16.0.0/bin:/usr/local/bin"
      ARGOCD_PASSWORD=credentials('ARGOCD_PASSWORD')
   }
   stages{
      stage("Clone-Code"){
         steps{
            cleanWs()
            checkout scmGit(branches: [[name: 'main']], extensions: [], userRemoteConfigs:
[[credentialsId: 'github-cred', url: 'https://github.com/singhritesh85/Bank-App-Kustomize.git']])
         }
      }
      stage("Build"){
         steps{
            sh 'mvn clean install'
         }
      }
      stage("Docker Build"){
         steps{
            sh 'docker system prune -f --all'
            sh 'docker build -t 027330342406.dkr.ecr.us-east-2.amazonaws.com/bankapp:1.0.1 -f
Dockerfile-Project-1 .'
           sh 'trivy image --exit-code 0 --severity MEDIUM,HIGH 027330342406.dkr.ecr.us-east-
2.amazonaws.com/bankapp:1.0.1'
```

```
            sh 'trivy image --exit-code 1 --severity CRITICAL 027330342406.dkr.ecr.us-east-2.amazonaws.com/bankapp:1.0.1'

            sh 'aws ecr get-login-password --region us-east-2 | docker login --username AWS --password-stdin 027330342406.dkr.ecr.us-east-2.amazonaws.com'

            sh 'docker push 027330342406.dkr.ecr.us-east-2.amazonaws.com/bankapp:1.0.1'

        }

      }

      stage("Deployment"){

        steps{

            sh 'argocd login argocd.singhritesh85.com --username admin --password $ARGOCD_PASSWORD --skip-test-tls  --grpc-web'

            sh 'argocd app create bankapp --project default --repo https://github.com/singhritesh85/kustomize-bankapp.git --path ./overlay/bankapp --revision main --dest-namespace bankapp --sync-option CreateNamespace=true --dest-server https://kubernetes.default.svc --upsert'

            sh 'argocd app sync bankapp'

        }

      }

   }

}
```

I created the Ingress Rule for BankApp and did the entry in Route53 to create the A-Type Record Set with HOST and DNS Name od the LoadBalancer as shown in the screenshot attached below.

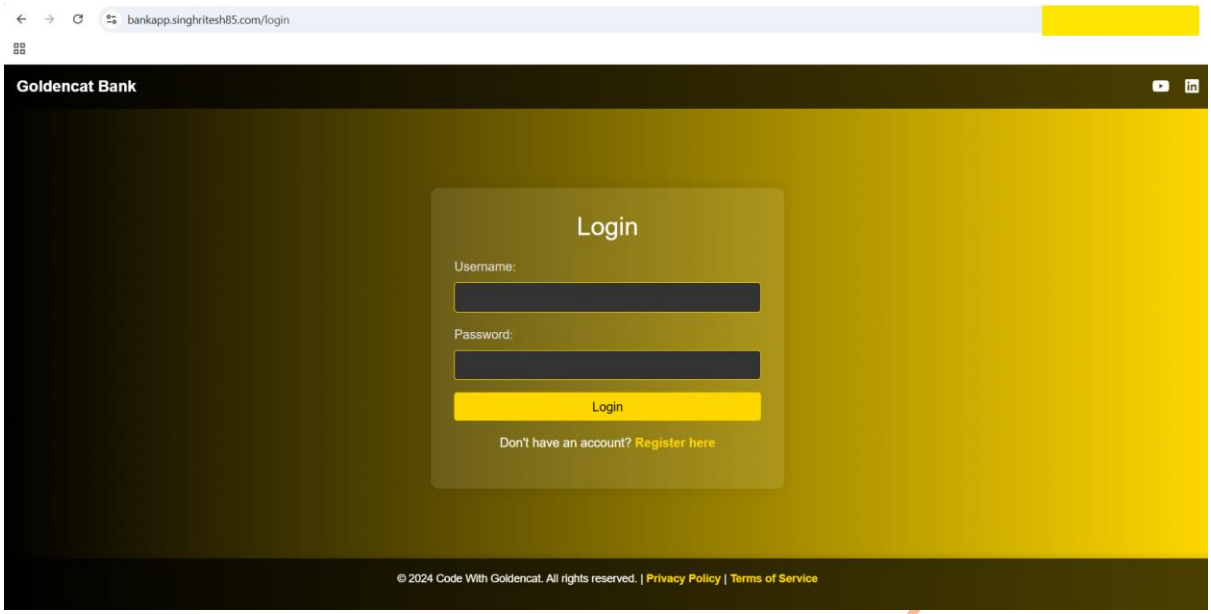
```
[root@                ~]# kubectl get svc -n bankapp
NAME              TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
bankapp-service   ClusterIP   172.      .79   <none>        80/TCP    23m
[root@                ~]# cat ingress-rule.yaml
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: bankapp-ingress
  namespace: bankapp
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02        6:certificate/
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
    alb.ingress.kubernetes.io/ssl-redirect: '443'
    alb.ingress.kubernetes.io/wafv2-acl-arn: arn:aws:wafv2:us-east-2:02        6:regional/webacl/aws-wafv2-rate-limit/
spec:
  ingressClassName: alb
  rules:
    - host: bankapp.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: bankapp-service
                port:
                  number: 80
[root@                ~]# kubectl apply -f ingress-rule.yaml
ingress.networking.k8s.io/bankapp-ingress created
[root@                ~]# kubectl get ing -n bankapp
NAME              CLASS   HOSTS                    ADDRESS                                                          PORTS   AGE
bankapp-ingress   alb     bankapp.singhritesh85.com   k8s-bankapp-bankappi-                .us-east-2.elb.amazonaws.com   80      9s
```

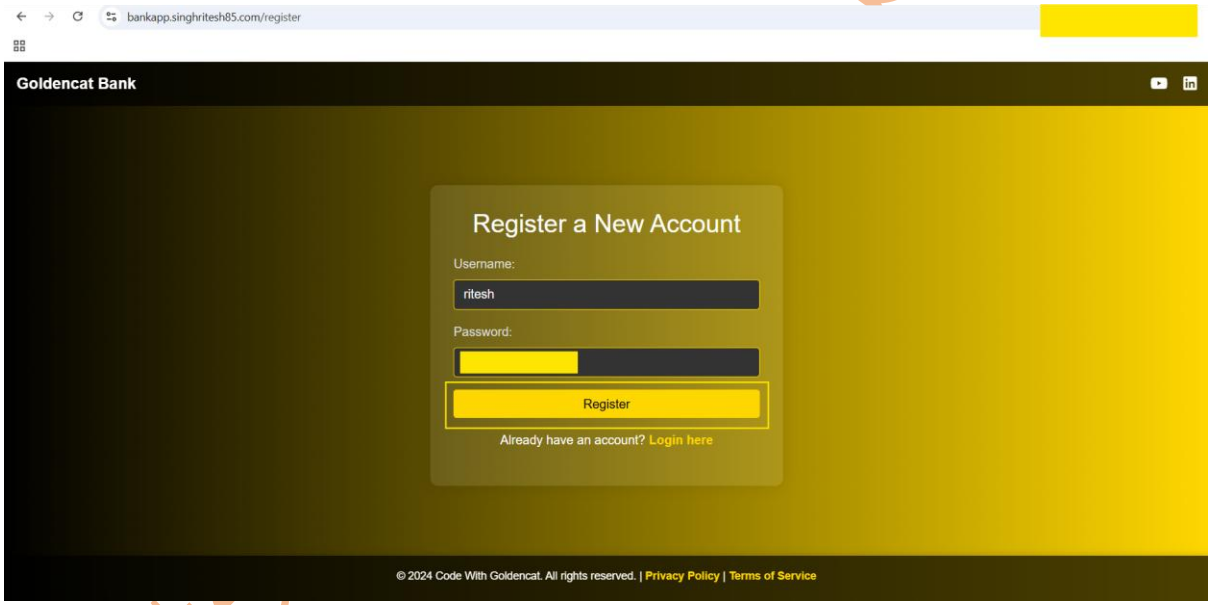


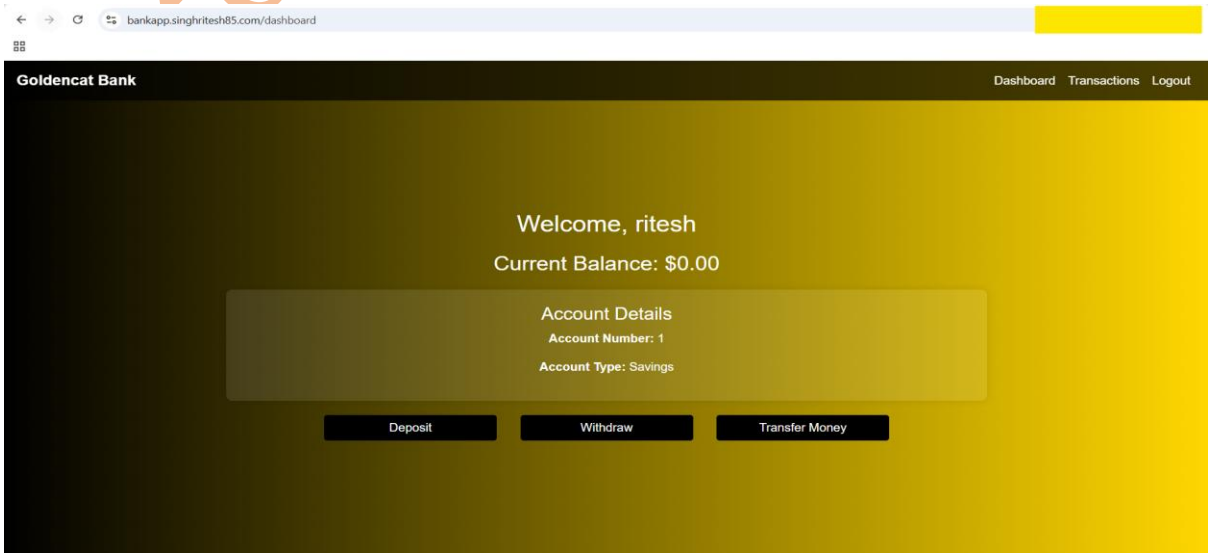
cat ingress-rule.yaml

```
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: bankapp-ingress
  namespace: bankapp
  annotations:
    alb.ingress.kubernetes.io/scheme: internet-facing
    alb.ingress.kubernetes.io/target-type: ip
    alb.ingress.kubernetes.io/certificate-arn: arn:aws:acm:us-east-2:02XXXXXXXX6:certificate/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX
    alb.ingress.kubernetes.io/listen-ports: '[{"HTTP": 80}, {"HTTPS": 443}]'
    alb-ingress.kubernetes.io/ssl-redirect: '443'
    alb.ingress.kubernetes.io/wafv2-acl-arn: arn:aws:wafv2:us-east-2:02XXXXXXXX6:regional/webacl/aws-wafv2-rate-limit/XXXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX
spec:
  ingressClassName: alb
  rules:
    - host: bankapp.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: bankapp-service
                port:
                  number: 80
```

Finally, I was able to access the BankApp as shown in the screenshot attached below.







Migrate from Terraform to Opentofu

To Migrate from Terraform to Opentofu make sure about below mentioned points.

1. Take the backup of state file
2. Take the backup of existing Terraform Script.

For backing up terraform state file I created a new s3 bucket and copied the existing state file to the new bucket

```
[root@ ~]# aws s3 mb s3://dexter-backup-statefile --region=us-east-2
make_bucket: dexter-backup-statefile
```

```
[root@ ~]# aws s3 ls --region=us-east-2
2025- dexter-backup-statefile
2025- dexter-velero-backup
2025- dolo-dempo
2025- s3bucketcapturealblogjenkins
```

```
[root@ ~]# aws s3 sync s3://dolo-dempo/ s3://dexter-backup-statefile/
copy: s3://dolo-dempo/state/route53/terraform.tfstate to s3://dexter-backup-statefile/state/route53/terraform.tfstate
copy: s3://dolo-dempo/state/dev/terraform.tfstate to s3://dexter-backup-statefile/state/dev/terraform.tfstate
```

For terraform script I have new set of script present in the directory **opentofu-eks-cluster-waf-with-velero-backup-with-cmk** and **opentofu-route53-hosted-zone-with-acm-certificate** as shown in the screenshot attached below.

```
[root@ ~]# ls
opentofu-eks-cluster-waf-with-velero-backup-with-cmk  terraform-eks-cluster-waf-with-velero-backup-with-cmk
opentofu-route53-hosted-zone-with-acm-certificate     terraform-route53-hosted-zone-with-acm-certificate
```

The only difference between the Terraform and Opentofu codebase is backend.tf file because in Opentofu I am going to encrypt the state file.

Below is the backend.tf for Terraform.

```
[root@ ~]# cat terraform-route53-hosted-zone-with-acm-certificate/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/route53/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
}
```

```
[root@ ~]# cat terraform-eks-cluster-waf-with-velero-backup-with-cmk/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/dev/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
}
```

Below is the backend.tf for Opentofu before migration.

```
[root@                    ~]# cat opentofu-route53-hosted-zone-with-acm-certificate/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/route53/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
   encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

```
[root@                    ~]# cat opentofu-eks-cluster-waf-with-velero-backup-with-cmk/main/backend.tf
terraform {
  backend "s3" {
    bucket         = "dolo-dempo"
    key            = "state/dev/terraform.tfstate"
    region         = "us-east-2"
    encrypt        = true
    use_lockfile   = true   ###dynamodb_table = "terraform-state"
  }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }
  }
}
```

Below is the backend.tf for Opentofu after migration.

```
[root@                ~]# cat opentofu-route53-hosted-zone-with-acm-certificate/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/route53/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
   encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@               3 ~]# cat opentofu-eks-cluster-waf-with-velero-backup-with-cmk/main/backend.tf
terraform {
  backend "s3" {
    bucket         = "dolo-dempo"
    key            = "state/dev/terraform.tfstate"
    region         = "us-east-2"
    encrypt        = true
    use_lockfile   = true   ###dynamodb_table = "terraform-state"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }
  }
}
```

I changed in backend.tf because the state file of terraform is not encrypted and you already created the resources using terraform which resources might be utilized in some project so you cannot delete the existing resources created using terraform and the create the new one and terraform state file was unencrypted.

You can follow below steps to install Opentofu.

cd /opt/

curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh

chmod +x install-opentofu.sh

./install-opentofu.sh --install-method rpm

rm -f install-opentofu.sh

```
[root@            ~]# cd /opt/
[root@            opt]# curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh
[root@            opt]# chmod +x install-opentofu.sh
[root@            opt]# ./install-opentofu.sh --install-method rpm
```

```
[root@                    opt]# rm -f install-opentofu.sh
```

```
[root@                    ~]# tofu --version
OpenTofu v1.10.6
on linux_amd64
```

Below commands you should run for migration.

tofu init -reconfigure

tofu validate

tofu plan

tofu apply -auto-approve

```
[root@            ~]# cd opentofu-route53-hosted-zone-with-acm-certificate/main/
[root@            main]# tofu init -reconfigure
```

```
[root@                    main]# tofu validate
Success! The configuration is valid.
```

```
[root@                    main]# tofu plan
```

```
No changes. Your infrastructure matches the configuration.

OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.
```

```
[root@                    main]# tofu apply -auto-approve
```

```
OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

route53_hosted_zone_details = {
  "certificate_arn" = "arn:aws:acm:us-east-2:02        6:certificate/                                    "
  "hosted_zone_id" = "                    "
  "hosted_zone_name_servers" = tolist([
    "
    "                    ",
    "
    "
  ])
}
```

Migration had been done, below is the backend.tf after Migration.

```
[root@                ~]# cat opentofu-route53-hosted-zone-with-acm-certificate/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/route53/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
   encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@                ~]# cd opentofu-eks-cluster-waf-with-velero-backup-with-cmk/main/
[root@                main]# tofu init -reconfigure
```

```
[root@                main]# tofu validate
Success! The configuration is valid.
```

```
[root@                main]# tofu plan
```

```
Plan: 0 to add, 5 to change, 0 to destroy.

Note: You didn't use the -out option to save this plan, so OpenTofu can't guarantee to take exactly these actions if you run "tofu apply" now.
```

```
[root@                main]# tofu apply -auto-approve
```

```
Plan: 0 to add, 5 to change, 0 to destroy.
module.eks_cluster.aws_route_table.private_route_table_3: Modifying... [id=                    ]
module.eks_cluster.aws_route_table.private_route_table_2: Modifying... [id=                    ]
module.eks_cluster.aws_route_table.private_route_table_1: Modifying... [id=                    ]
module.eks_cluster.aws_route_table.private_route_table_2: Modifications complete after 0s [id=                    ]
module.eks_cluster.aws_route_table.private_route_table_3: Modifications complete after 0s [id=                    ]
module.eks_cluster.aws_route_table.private_route_table_1: Modifications complete after 0s [id=                    ]
module.eks_cluster.aws_eks_node_group.eksnode: Modifying... [id=eks-demo-cluster-dev:eks-nodegroup-dev]
module.eks_cluster.aws_eks_node_group.eksnode: Modifications complete after 8s [id=eks-demo-cluster-dev:eks-nodegroup-dev]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Modifying... [id=eks-demo-cluster-dev:amazon-cloudwatch-observability]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Still modifying... [id=eks-demo-cluster-dev:amazon-cloudwatch-observability, 10s elapsed]
module.eks_cluster.aws_eks_addon.amazon_cloudwatch_observability: Modifications complete after 14s [id=eks-demo-cluster-dev:amazon-cloudwatch-observability]

Apply complete! Resources: 0 added, 5 changed, 0 destroyed.

Outputs:

ecr_ec2_private_ip_eks_details = {
  "alb_dns_name" = "jenkins-ms-          .us-east-2.elb.amazonaws.com"
  "alb_ingress_controller_role_arn" = "arn:aws:iam::02        6:role/aws-alb-ingress-controller-role"
  "aws_wafv2_web_acl_arn" = "arn:aws:wafv2:us-east-2:02        6:regional/webacl/aws-wafv2-rate-limit/                                    "
  "eks_cluster_endpoint" = "https://                                    .us-east-2.eks.amazonaws.com"
  "eks_cluster_name" = "eks-demo-cluster-dev"
  "jenkins_master_instance_id" = "i-                    "
  "jenkins_master_private_ip" = "10.        "
  "jenkins_slave_instance_id" = "i-                    "
  "jenkins_slave_private_ip" = "10.        "
  "karpenter_node_spun_iam_role_arn" = "arn:aws:iam::02        5:role/karpenter-eks-noderole"
  "registry_id" = "02        5"
  "repository_url" = "02        6.dkr.ecr.us-east-2.amazonaws.com/bankapp"
  "velero_backup_iam_role_arn" = "arn:aws:iam::02        6:role/eks-velero-backup-role"
  "velero_backup_s3_bucket_name" = "dexter-velero-backup"
}
```

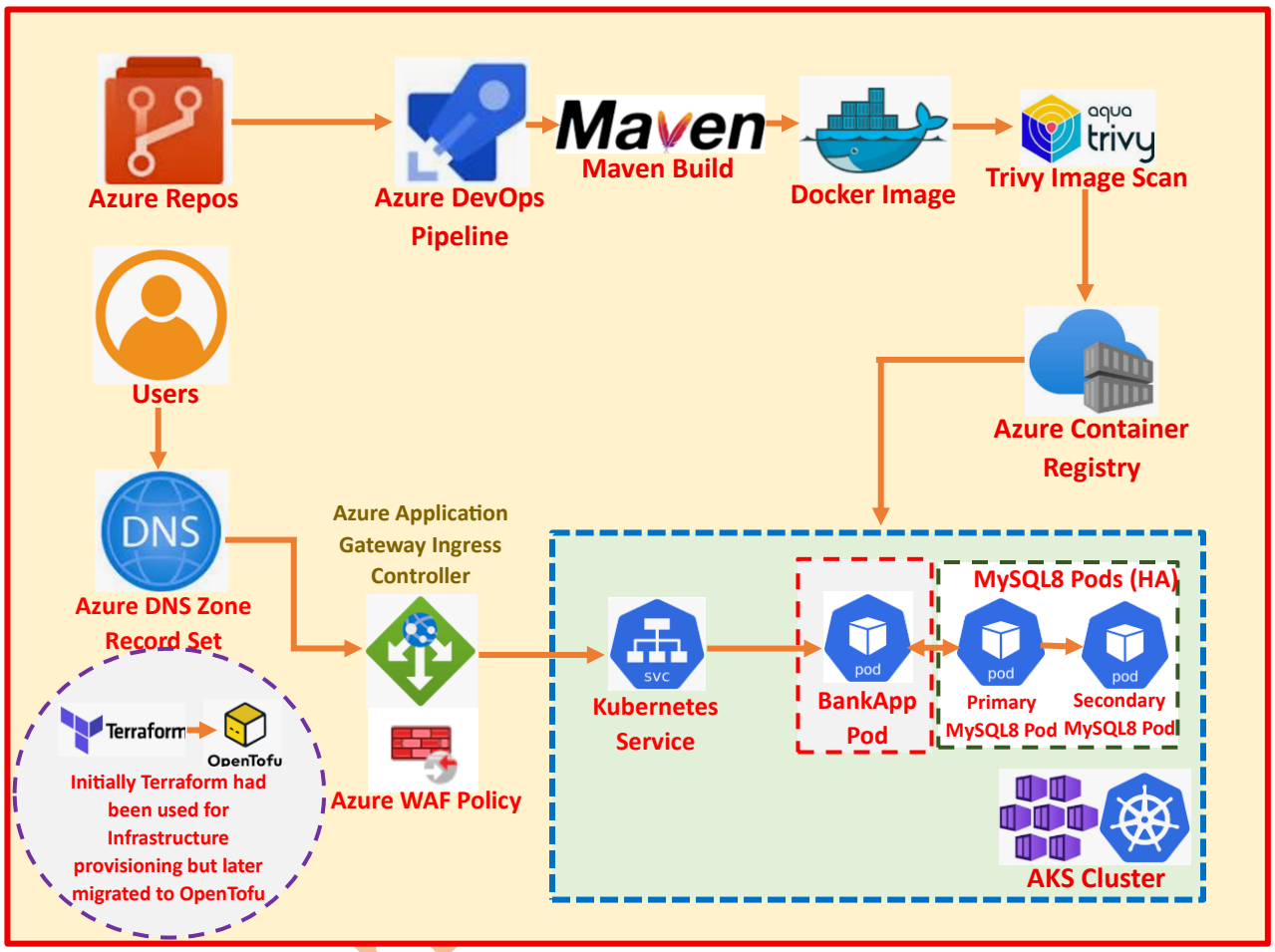
Migration had been done, below is the backend.tf after Migration.

```
[root@                3 ~]# cat opentofu-eks-cluster-waf-with-velero-backup-with-cmk/main/backend.tf
terraform {
  backend "s3" {
    bucket         = "dolo-dempo"
    key            = "state/dev/terraform.tfstate"
    region         = "us-east-2"
    encrypt        = true
    use_lockfile   = true   ###dynamodb_table = "terraform-state"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }
  }
}
```

Now check state file in s3 bucket you will find it is encrypted. However, if you run **tofu show**, you can see the state file but in S3 Bucket it is encrypted.

DevOps Project BankApp Terraform upgrade to Opentofu with Secure AKS Cluster

Module-2



Till now I used Terraform to provision the infrastructure but Hashicorp license changes due to which Terraform will introduce restrictions for commercial use, due to this reason many organisations are migrating from Terraform to OpenTofu. However, I would like to mention here that DevOps Team who used it as a tool to provision the infrastructure will not be affected but those who provides it as a Service will be affected. You already aware that Terraform state file was kept locally or in the S3 Bucket / Azure Storage Account Container / GCP Bucket. The problem was its state file was not encrypted, so anyone who had the access of Terraform Server (when state file was kept locally) or Bucket or Storage Account Container can easily see its state file. But if you use OpenTofu, you will not face such an issue. OpenTofu is an Open Source, community-driven Infrastructure as Code (IaC) tool, it is a fork of Hashicorp Terraform. I will migrate from Terraform to OpenTofu at the end of Module-2.

This DevOps project deals will creation of infrastructure using Terraform, GitHub was used to keep the source Code and Azure DevOps had been used as CI/CD Tool. The build tool used in this project was Maven and Docker Image was pushed to the Azure Container Registry (ACR) which was finally deployed to the Azure Kubernetes Services (AKS). The Bank Application Pods was accessed using Application Gateway Ingress Controller (AGIC) and hence using the kubernetes service as shown in the screenshot attached above. I applied WAF Policy (to Limit the Rate) to the Bank Application URL and to prevent from SQL Injection. As this Bank Application was open to entire world so rate limit

and SQL Injection was applied through WAF Policy so that non-of-the IP Address can access the Bank Application more than 40 times in one minute. There may be the possibility that the Bank Application URL accessed using the Bot (by the Hackers) so that its speed becomes slow or this website hangs to refrain from such a situation WAF Policy Rate Limit was applied. Finally, I migrated from Terraform to OpenTofu. For AKS Cluster Node-to-Node encryption (at rest) is enabled by setting **host_encryption_enabled = true** using Terraform and Node-to-Node encryption (in transit) is enabled by running the command **kubectl patch felixconfiguration default --type='merge' -p '{"spec":{"wireguardEnabled":true}}'** after creation of the AKS cluster as shown in the screenshot attached below. In AKS cluster nodes kernel has WireGuard installed already, so there is no manual installation required.

I implemented Istio for encrypted Pod-to-Pod Communication and implemented **Kyverno** (Open-Source Policy Engine) and **Falco** to Secure the AKS Cluster. Kyverno was developed by Nirmata and donated to CNCF. It comes under CNCF Incubating Project and used by Organisation like Adidas, Wayfair, US Department of Defence, Spotify, Bloomberg, Robinhood and Razorpay. Like OPA Gatekeeper, Kyverno is a **dynamic admission controller.** I had used Aqua Security Trivy image scan for vulnerability scanning during CI/CD Pipeline as shown in the end-to-end architecture diagram of the project drawn above. In AKS Cluster to enable envelope encryption I used **key_management_service** in Terraform Script. The Azure Key-Vault Key enables you to rotate it as per the standard followed by your organisation. Usually after 90 days the Azure Key-Vault Key should be rotated but you can rotate it as per your organisation need. If you use Azure Platform Managed Key then it will be rotated by Azure, however Azure did not announce it publicly that after specific number of days it will be rotated by Azure. In this project I used Azure Key-Vault Key for envelope encryption and to encrypt the all the disks used in this project.

In AKS however it is possible to encrypt all the disks either by Azure Platform Managed Key or Azure Key-Vault Key but envelope encryption provides extra layer of security by encrypting the etcd.

Terraform script to create the infrastructure is present at the path **terraform-azure-dns-zone** (this terraform script is handy for you to create the Azure DNS Zone) in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. Commands as written below had been used to create infrastructure using Terraform.

terraform init -------> initializes a working directory containing configuration files and installs plugins for required providers.

terraform validate --------> verify that terraform configuration file is correct or not

terraform plan ---------> Check which resources are going to be created.

Then you can run the command **terraform apply -auto-approve** -----> Finally, Create the resources.

After successful execution of the command **terraform apply -auto-approve** make sure you do the entry for Nameservers of the Azure DNS Zone in your domain name service provider's Nameserver.

```
      + soa_record (known after apply)
    }

  # module.dns.azurerm_resource_group.dns_rg will be created
  + resource "azurerm_resource_group" "dns_rg" {
      + id       = (known after apply)
      + location = "eastus"
      + name     = "dns-rosource-group"
    }

Plan: 2 to add, 0 to change, 0 to destroy.

Changes to Outputs:
  + azure_dns_zone_name_and_nameserver = {
      + dns_zone_name = "singhritesh85.com"
      + name_servers  = (known after apply)
    }
module.dns.azurerm_resource_group.dns_rg: Creating...
module.dns.azurerm_resource_group.dns_rg: Still creating... [00m10s elapsed]
module.dns.azurerm_resource_group.dns_rg: Creation complete after 11s [id=/subscriptions/[redacted]/resourceGroups/dns-rosource-grou
p]
module.dns.azurerm_dns_zone.dns_zone: Creating...
module.dns.azurerm_dns_zone.dns_zone: Creation complete after 5s [id=/subscriptions/[redacted]/resourceGroups/dns-rosource-group/pro
viders/Microsoft.Network/dnsZones/singhritesh85.com]

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.

Outputs:

azure_dns_zone_name_and_nameserver = {
  "dns_zone_name" = "singhritesh85.com"
  "name_servers" = toset([
    "[redacted]",
    "[redacted]",
    "[redacted]",
    "[redacted]",
  ])
}
```

Finally, the Azure DNS Zone had been created. Then I created the other Azure Resources using the terraform script present at the path **terraform-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault** in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git.

```
nkapp-rg/providers/Microsoft.RecoveryServices/vaults/bankapp-recovery-vault/backupFabrics/Azure/protectionContainers/iaasvmcontainer;iaasvmcontainerv2;bankapp
-rg;devopsagent-vm/protectedItems/VM;iaasvmcontainerv2;bankapp-rg;devopsagent-vm]
module.aks.azurerm_kubernetes_cluster_extension.aks_cluster_extension: Still creating... [03m30s elapsed]
module.aks.azurerm_kubernetes_cluster_extension.aks_cluster_extension: Still creating... [03m40s elapsed]
module.aks.azurerm_kubernetes_cluster_extension.aks_cluster_extension: Still creating... [03m50s elapsed]
module.aks.azurerm_kubernetes_cluster_extension.aks_cluster_extension: Still creating... [04m00s elapsed]
module.aks.azurerm_kubernetes_cluster_extension.aks_cluster_extension: Creation complete after 4m2s [id=/subscriptions/[redacted]/re
sourceGroups/bankapp-rg/providers/Microsoft.ContainerService/managedClusters/bankapp-cluster/providers/Microsoft.KubernetesConfiguration/extensions/bankapp-ex
tension]
module.aks.azurerm_role_assignment.backup_extension_and_storage_account_permission: Creating...
module.aks.azurerm_role_assignment.backup_vault_data_contributor_on_storage: Creating...
module.aks.azurerm_role_assignment.backup_vault_data_contributor_on_storage: Still creating... [00m10s elapsed]
module.aks.azurerm_role_assignment.backup_extension_and_storage_account_permission: Still creating... [00m10s elapsed]
module.aks.azurerm_role_assignment.backup_extension_and_storage_account_permission: Still creating... [00m20s elapsed]
module.aks.azurerm_role_assignment.backup_vault_data_contributor_on_storage: Still creating... [00m20s elapsed]
module.aks.azurerm_role_assignment.backup_vault_data_contributor_on_storage: Creation complete after 28s [id=/subscriptions/[redacted]
/resourceGroups/bankapp-rg/providers/Microsoft.Storage/storageAccounts/bankappbackupsa2025/providers/Microsoft.Authorization/roleAssignments/[redacted]]
module.aks.azurerm_role_assignment.backup_extension_and_storage_account_permission: Creation complete after 29s [id=/subscriptions/[redacted]
/resourceGroups/bankapp-rg/providers/Microsoft.Storage/storageAccounts/bankappbackupsa2025/providers/Microsoft.Authorization/roleAssignments/[redacted]]
module.aks.azurerm_data_protection_backup_instance_kubernetes_cluster.aks_backup_instance: Creating...
module.aks.azurerm_data_protection_backup_instance_kubernetes_cluster.aks_backup_instance: Still creating... [00m10s elapsed]
module.aks.azurerm_data_protection_backup_instance_kubernetes_cluster.aks_backup_instance: Creation complete after 17s [id=/subscriptions/[redacted]
/resourceGroups/bankapp-rg/providers/Microsoft.DataProtection/backupVaults/bankapp-backup-vault/backupInstances/bankapp-backup-instance]

Apply complete! Resources: 62 added, 0 changed, 0 destroyed.

Outputs:

acr_azurevm_private_ip_and_aks_details_waf_policy_name_and_application_gateway_name = {
  "acr_login_server" = "bankappcontainer24registry.azurecr.io"
  "aks_id" = "/subscriptions/[redacted]/resourceGroups/bankapp-rg/providers/Microsoft.ContainerService/managedClusters/bankapp-clust
er"
  "aks_name" = "bankapp-cluster"
  "application_gateway_name" = "app-gtw-ingress-controller"
  "azurevm_devopsagent_privateip" = "10.[redacted]"
  "web_application_firewall_policy_name" = "bankapp-wafpolicy"
}
```

```
[root@[redacted] ~]# kubectl patch felixconfiguration default --type='merge' -p '{"spec":{"wireguardEnabled":true}}'
felixconfiguration.crd.projectcalico.org/default patched
```

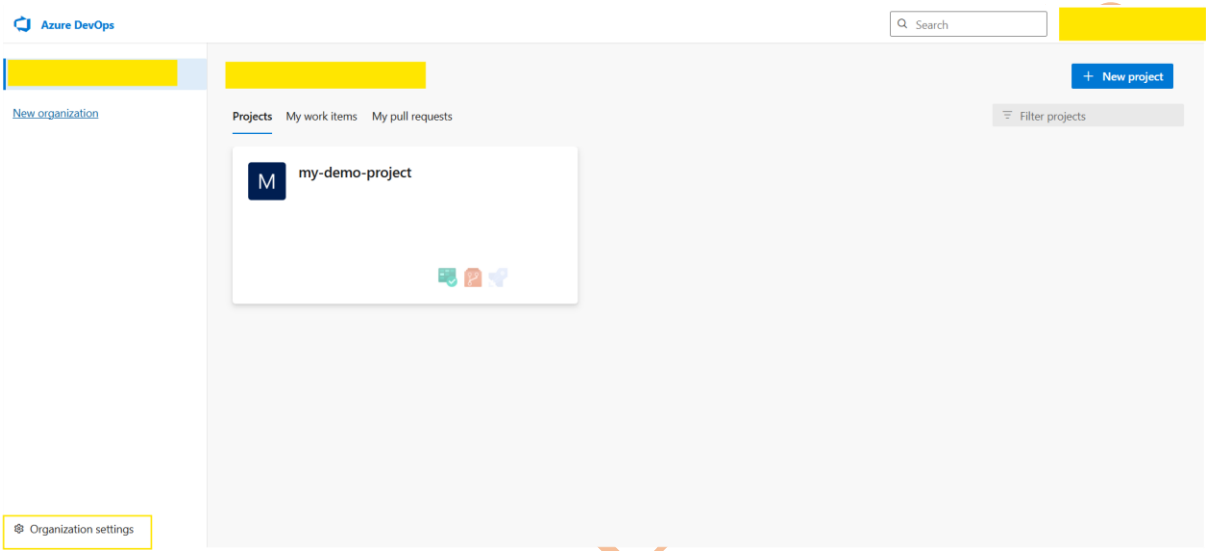
After enabling wireguard encryption in AKS Cluster I checked felixconfiguration resource to see if WireGuard is enabled or not and found **spec.wireguardEnabled: true** as shown below.

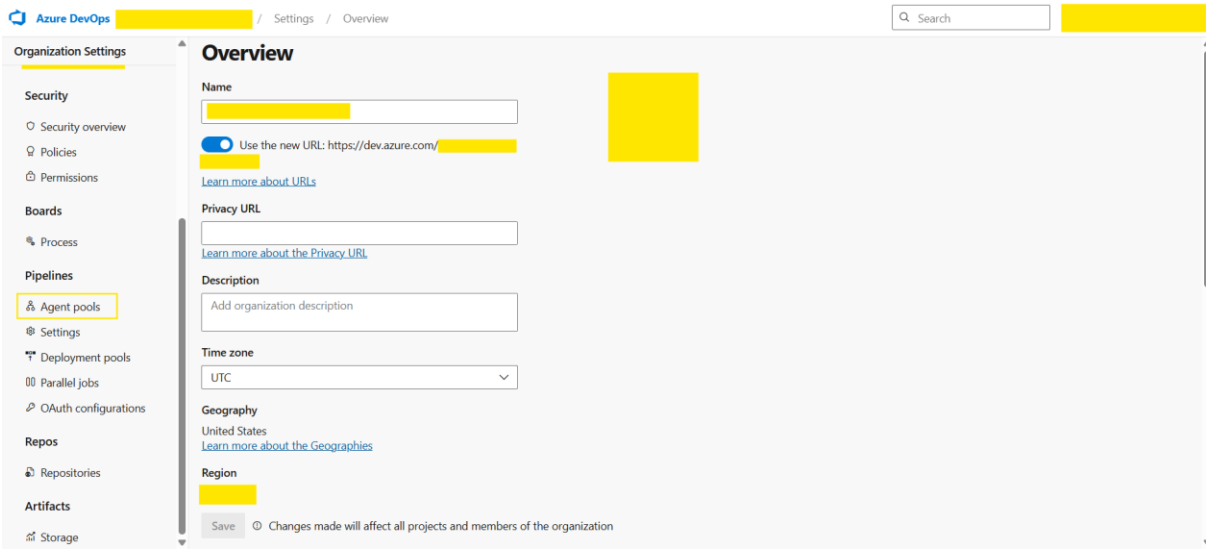
```
[root@[redacted] ~]# kubectl get felixconfiguration default -o yaml
spec:
  wireguardEnabled: true
```

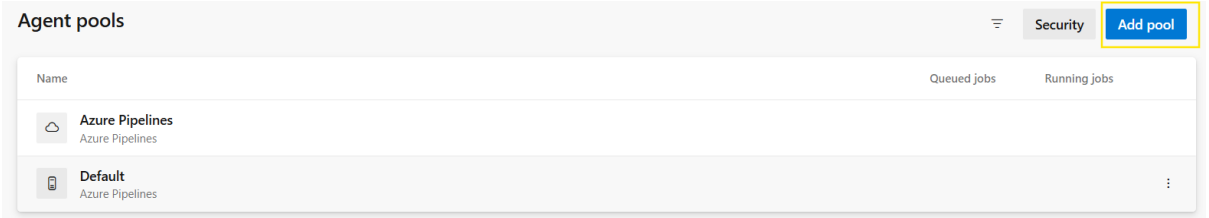
In the installed AKS Cluster OPA Gatekeeper is already installed in the namespace **gatekeeper-system** and I explained it in Module-1, so in Module-2 I will install Kyverno Policy Agent using Helm and achieve the same goal which I explained in Module-1 with OPA Gatekeeper. If you want to go with OPA Gatekeeper then create the OPA Policy (Constraint Template and Constraint) and directly apply them to use here.

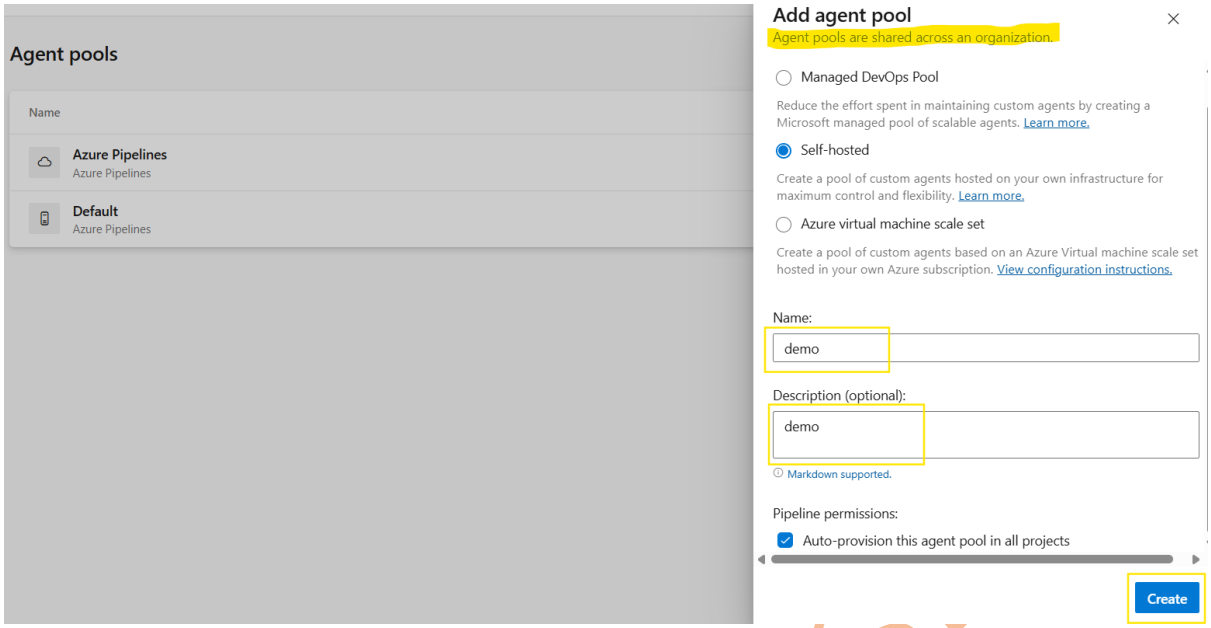
Installation of Azure DevOps Agent

To install the self-hosted agent for Azure DevOps pipeline first I opened the Azure DevOps UI and went to Organisations Settings > Agent Pools > Add Pool.

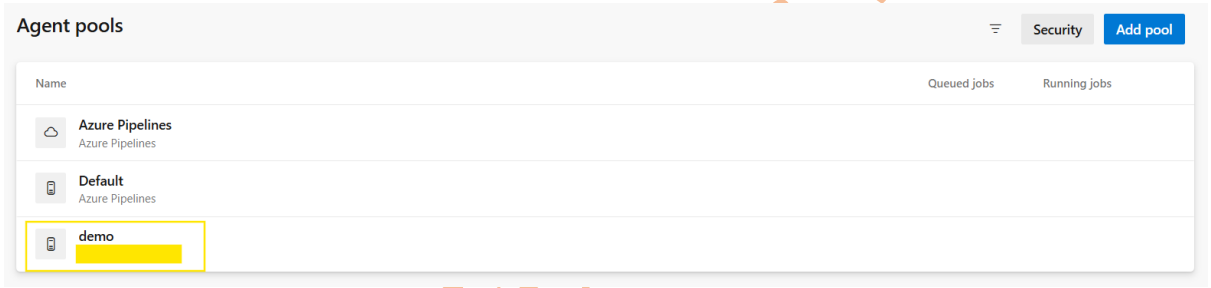




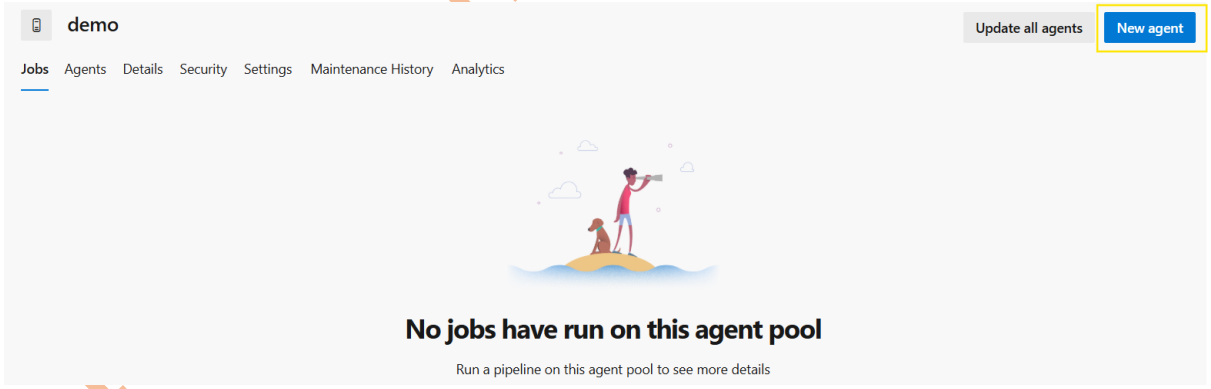




New Agent Pool had been added as shown in the scrrenshot attached below.



Then added the agent as shown in the screenshot attached below.



For Azure DevOps Pipeline I had used Self-hosted-Agent and followed the below procedure to install it.

```
[root@devopsagent-vm ~]# cd /opt && mkdir myagent && cd myagent

[root@devopsagent-vm myagent]# wget https://vstsagentpackage.azureedge.net/agent/[redacted]/vsts-agent-linux-x64-[redacted].tar.gz

[root@devopsagent-vm myagent]# tar -xvf vsts-agent-linux-x64-[redacted].tar.gz

[root@devopsagent-vm myagent]# rm -f vsts-agent-linux-x64-[redacted].tar.gz

[root@devopsagent-vm myagent]# ./bin/installdependencies.sh
```

```
[demo@devopsagent-vm myagent]$ sudo chown -R demo:demo /opt/myagent/
```

```
[demo@devopsagent-vm myagent]$ ./config.sh
```

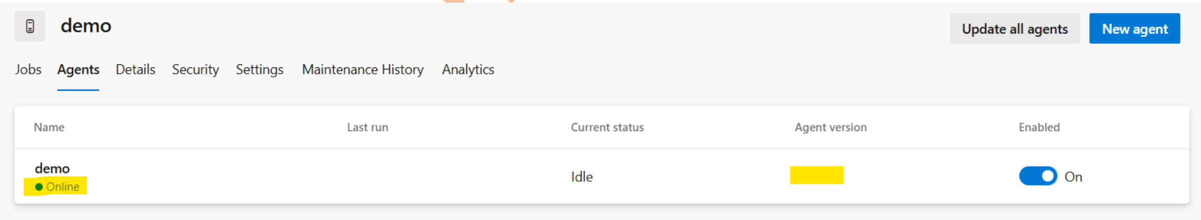
```
>> End User License Agreements:

Building sources from a TFVC repository requires accepting the Team Explorer Everywhere End User License Agreement. This step is not required for building sou
rces from Git repositories.

A copy of the Team Explorer Everywhere license agreement can be found at:
  /opt/myagent/license.html

Enter (Y/N) Accept the Team Explorer Everywhere license agreement now? (press enter for N) > Y

>> Connect:

Enter server URL >
Enter authentication type (press enter for PAT) >
Enter personal access token >
Connecting to server ...

>> Register Agent:

Enter agent pool (press enter for default) > demo
Enter agent name (press enter for devopsagent-vm) > demo
Scanning for tool capabilities.
Connecting to the server.
Successfully added the agent
Testing agent connection.
Enter work folder (press enter for _work) >
2025 : Settings Saved.
```

```
[demo@devopsagent-vm myagent]$ ./env.sh
[demo@devopsagent-vm myagent]$
[demo@devopsagent-vm myagent]$ echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/bin:/opt/sonar-scanner/bin:/opt/apache-maven/bin:/opt/node-v16.0.0/bin:/opt/dependency-check/bin:/usr/local
/bin
```

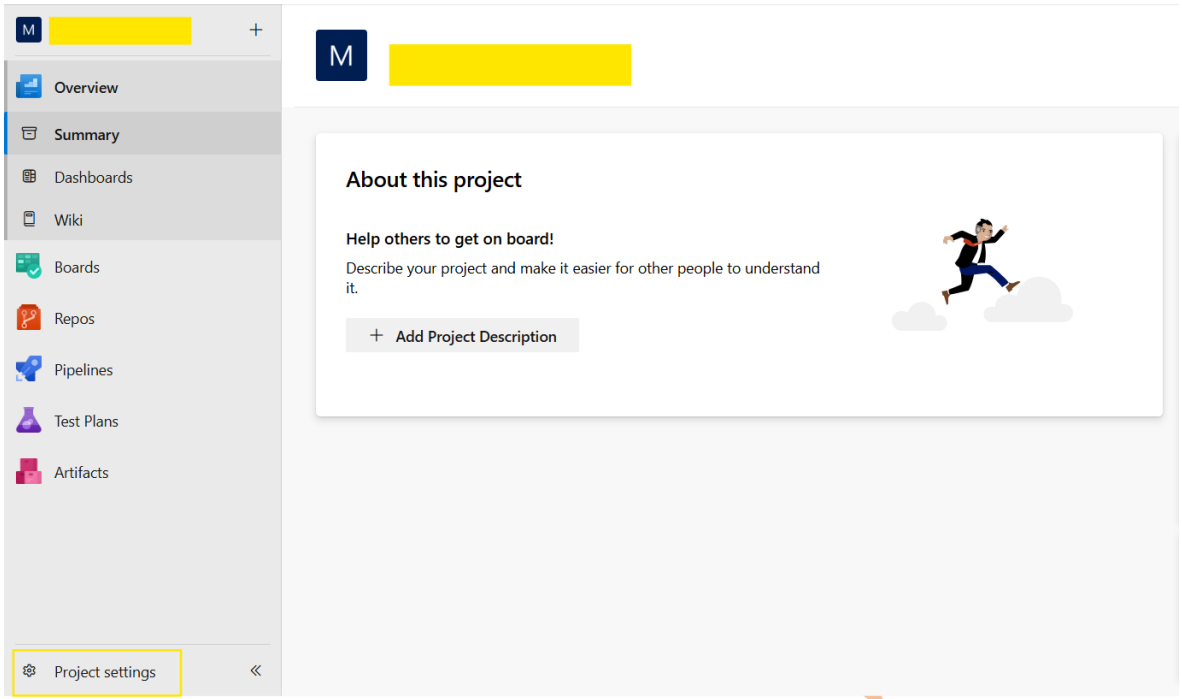
```
[demo@devopsagent-vm myagent]$ sudo ./svc.sh install
```

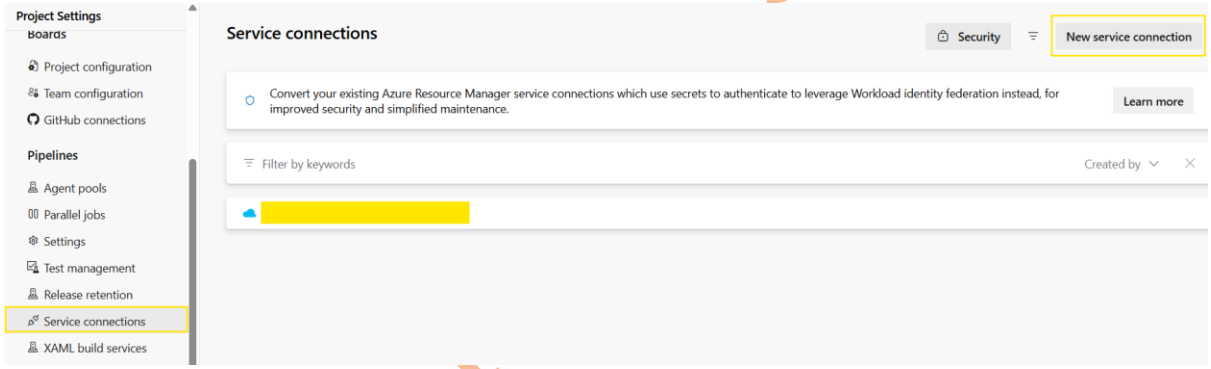
```
[demo@devopsagent-vm myagent]$ sudo ./svc.sh start
```

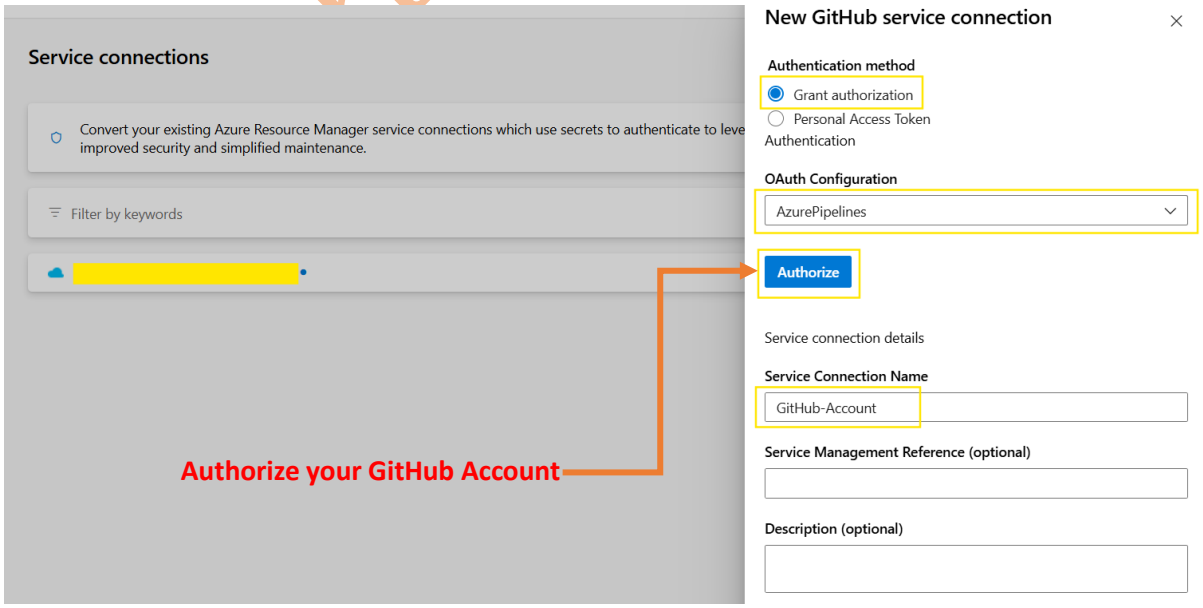
Now the Agent came in online state as shown in the screenshot attached below.

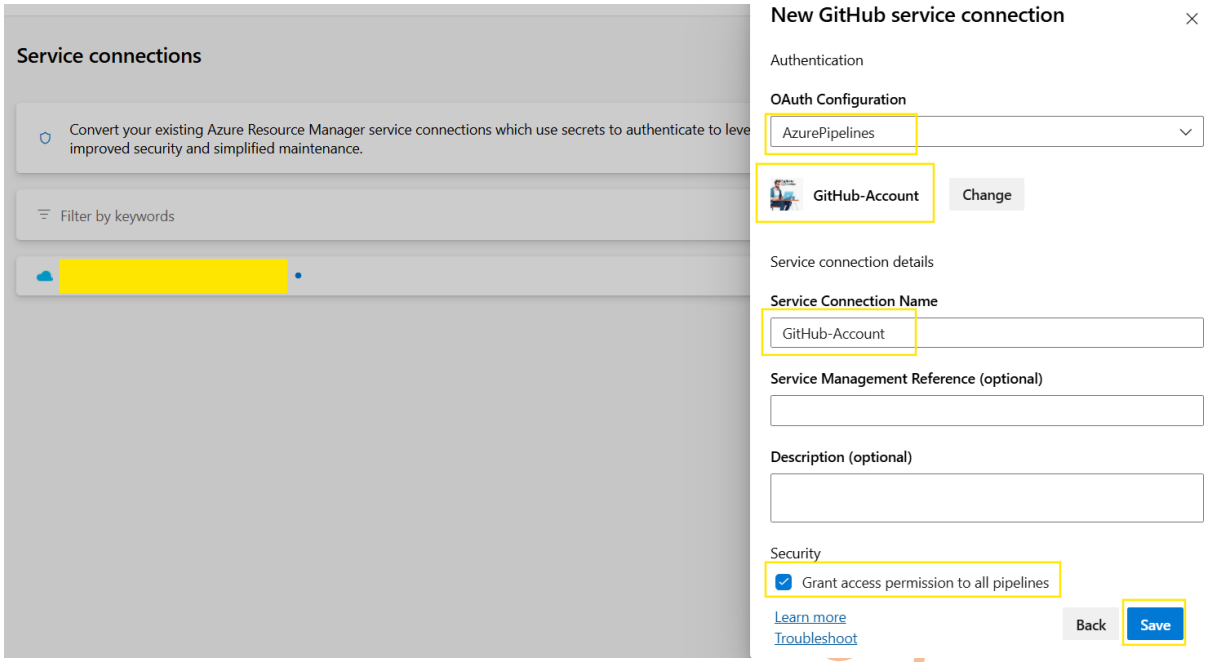


Then I went into the **Azure DevOps project > Project Settings** and created the **Service connections** for GitHub Account, Docker Registry as shown in the screenshot attached blow.


Overview
Summary
Dashboards
Wiki
Boards
Repos
Pipelines
Test Plans
Artifacts
Project settings
About this project
Help others to get on board!
Describe your project and make it easier for other people to understand it.
Add Project Description

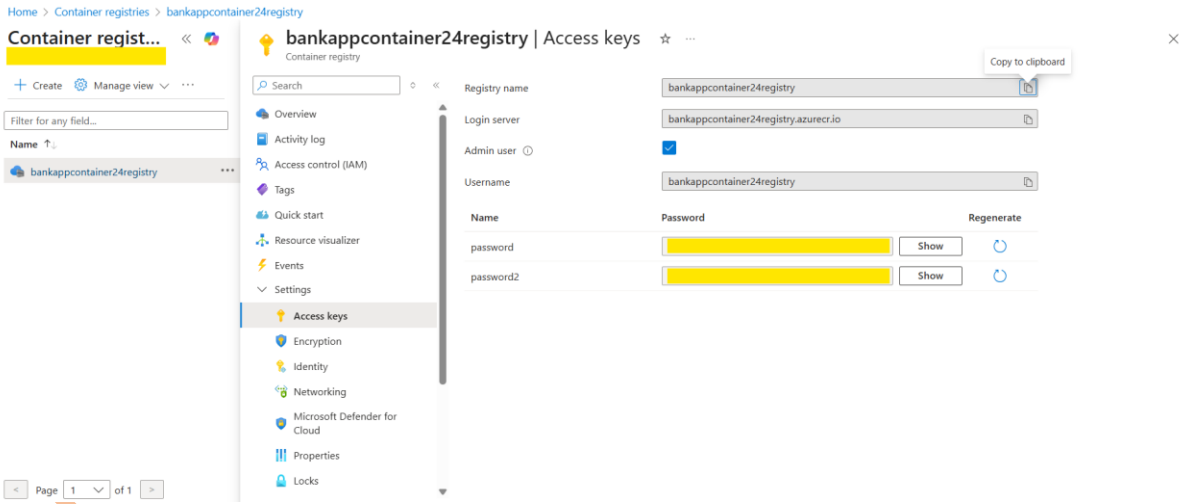

Project Settings
Boards
Project configuration
Team configuration
GitHub connections
Pipelines
Agent pools
Parallel jobs
Settings
Test management
Release retention
Service connections
XAML build services
Service connections
Security
New service connection
Convert your existing Azure Resource Manager service connections which use secrets to authenticate to leverage Workload identity federation instead, for improved security and simplified maintenance.
Learn more
Filter by keywords
Created by

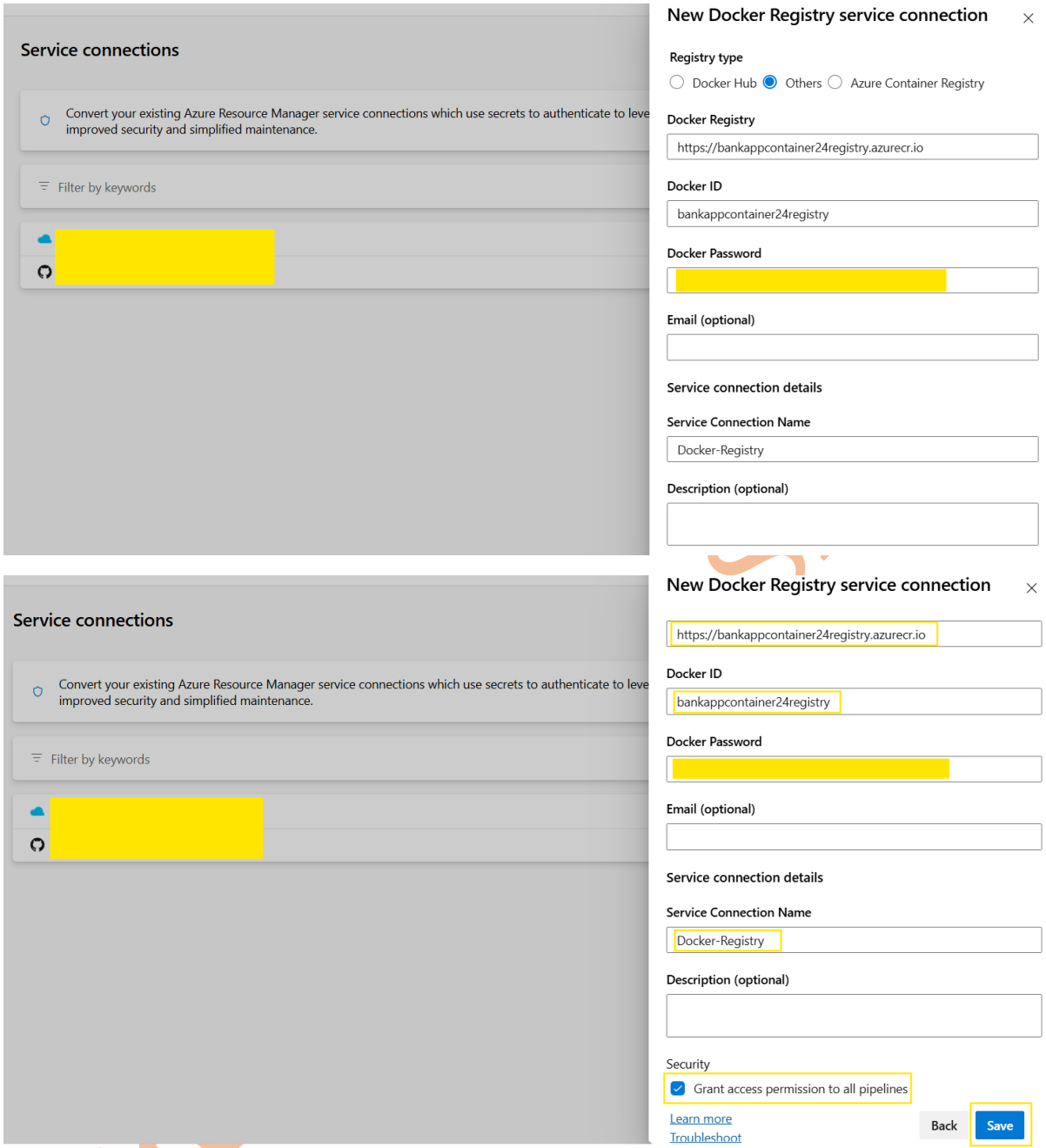

Service connections
Convert your existing Azure Resource Manager service connections which use secrets to authenticate to leve
improved security and simplified maintenance.
Filter by keywords
Authorize your GitHub Account
New GitHub service connection
Authentication method
Grant authorization
Personal Access Token
Authentication
OAuth Configuration
AzurePipelines
Authorize
Service connection details
Service Connection Name
GitHub-Account
Service Management Reference (optional)
Description (optional)



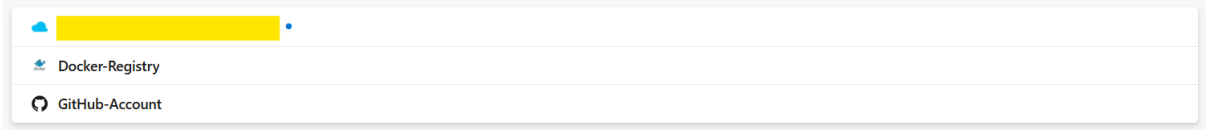
The Azure Container Registry which I had created for this project is as shown in the screenshot attached below.

Then I had created the Service Connection for Docker Registry as shown in the screenshot attached below.





Finaly the service connections had been created as shown in the screenshot attached below.



Installation of Kyverno Policy Engine

To install Kyverno Policy Engine follow the steps as written below.

helm repo add kyverno https://kyverno.github.io/kyverno/

helm repo update

helm install kyverno kyverno/kyverno --set admissionController.replicas=3 --set enablePolicyException=true --set backgroundController.replicas=2 --set cleanupController.replicas=2 --set reportsController.replicas=2 --namespace kyverno --create-namespace

kubectl get pods -n kyverno

```
[root@ ~]# helm repo add kyverno https://kyverno.github.io/kyverno/
"kyverno" has been added to your repositories
[root@ ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "kyverno" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@ ~]# helm install kyverno kyverno/kyverno --set admissionController.replicas=3 --set enablePolicyException=true --set backgroundController
.replicas=2 --set cleanupController.replicas=2 --set reportsController.replicas=2 --namespace kyverno --create-namespace
```

```
[root@ ~]# kubectl get pods -n kyverno
NAME                                             READY   STATUS    RESTARTS   AGE
kyverno-admission-controller-                    1/1     Running   0
kyverno-admission-controller-                    1/1     Running   0
kyverno-admission-controller-                    1/1     Running   0
kyverno-background-controller-                   1/1     Running   0
kyverno-background-controller-                   1/1     Running   0
kyverno-cleanup-controller-                      1/1     Running   0
kyverno-cleanup-controller-                      1/1     Running   0
kyverno-reports-controller-                      1/1     Running   0
kyverno-reports-controller-                      1/1     Running   0
```

I had applied the Kyverno policy as shown in the screenshot attached below.

```
[root@ ~]# kubectl apply -f kyverno-policy.yaml
clusterpolicy.kyverno.io/no-loadbalancer-service created
clusterpolicy.kyverno.io/disallow-latest-tag created
clusterpolicy.kyverno.io/disallow-privileged-and-escalation created
clusterpolicy.kyverno.io/require-requests-limits created
[root@ ~]# kubectl get clusterpolicy
NAME                                ADMISSION   BACKGROUND   READY   AGE     MESSAGE
disallow-latest-tag                 true        true         True    6m56s   Ready
disallow-privileged-and-escalation  true        true         True    6m55s   Ready
no-loadbalancer-service             true        true         True    6m56s   Ready
require-requests-limits             true        true         True    6m55s   Ready
```

```
---
### This policy restricts use of the Service type LoadBalancer ###
apiVersion: kyverno.io/v1
kind: ClusterPolicy
metadata:
  name: no-loadbalancer-service
  annotations:
    policies.kyverno.io/title: Disallow Service Type LoadBalancer
    policies.kyverno.io/category: Sample
    policies.kyverno.io/severity: medium
    policies.kyverno.io/subject: Service
    policies.kyverno.io/minversion: 1.6.0
    policies.kyverno.io/description: >-
      Especially in cloud provider environments, a Service having type LoadBalancer will cause the
      provider to respond by creating a load balancer somewhere in the customer account. This adds
      cost and complexity to a deployment. Without restricting this ability, users may easily
      overrun established budgets and security practices set by the organization. This policy restricts
      use of the Service type LoadBalancer.
spec:
  validationFailureAction: Enforce  ### Block the resource creation if the policy is violated
  background: true
  rules:
  - name: no-LoadBalancer
    match:
      any:
      - resources:
          kinds:
          - Service
          namespaces:
          - bankapp
          - mysql
```

```
  validate:
    message: "Service of type LoadBalancer is not allowed."
    pattern:
      spec:
        type: "!LoadBalancer"
---
### This policy validates that the image specifies a tag and that it is not called latest ###
apiVersion: kyverno.io/v1
kind: ClusterPolicy
metadata:
 name: disallow-latest-tag
 annotations:
   policies.kyverno.io/title: Disallow Latest Tag
   policies.kyverno.io/category: Best Practices
   policies.kyverno.io/minversion: 1.6.0
   policies.kyverno.io/severity: medium
   policies.kyverno.io/subject: Pod
   policies.kyverno.io/description: >-
     The ':latest' tag is mutable and can lead to unexpected errors if the
     image changes. A best practice is to use an immutable tag that maps to
     a specific version of an application Pod. This policy validates that the image
     specifies a tag and that it is not called `latest`.
spec:
 validationFailureAction: Enforce   ### Block the resource creation if the policy is violated
 background: true
 rules:
 - name: require-image-tag
   match:
     any:
     - resources:
         kinds:
```

```
      - Pod
      namespaces:
      - bankapp
      - mysql
  validate:
    message: "An image tag is required."
    foreach:
     - list: "request.object.spec.containers"
       pattern:
         image: "*:*"
     - list: "request.object.spec.initContainers"
       pattern:
         image: "*:*"
     - list: "request.object.spec.ephemeralContainers"
       pattern:
         image: "*:*"
- name: validate-image-tag
  match:
    any:
    - resources:
       kinds:
       - Pod
       namespaces:
       - bankapp
       - mysql
  validate:
    message: "Using a mutable image tag e.g. 'latest' is not allowed."
    foreach:
     - list: "request.object.spec.containers"
       pattern:
         image: "!*:latest"
```

```
      - list: "request.object.spec.initContainers"
        pattern:
          image: "!*:latest"
      - list: "request.object.spec.ephemeralContainers"
        pattern:
          image: "!*:latest"
---
apiVersion: kyverno.io/v1
kind: ClusterPolicy
metadata:
  name: disallow-privileged-and-escalation
  annotations:
    policies.kyverno.io/title: Disallow Privileged and Privilege Escalation
    policies.kyverno.io/category: Pod Security Standards (Restricted)
    policies.kyverno.io/severity: medium
    policies.kyverno.io/subject: Pod
    policies.kyverno.io/description: >-
      Privileged mode disables most security mechanisms. Privilege escalation,
      such as via set-user-ID or set-group-ID file mode, should not be allowed.
      This policy ensures Pods do not request privileged mode and that
      allowPrivilegeEscalation is set to false.
spec:
  validationFailureAction: Enforce
  background: true
  rules:
    - name: disallow-privileged-containers
      match:
        any:
          - resources:
              kinds:
                - Pod
```

```
        namespaces:
        - bankapp
        - mysql
    validate:
      message: "Privileged containers are disallowed."
      pattern:
        spec:
          =(initContainers):
            - =(securityContext):
                =(Privileged): "false"
          containers:
            - =(securityContext):
                =(Privileged): "false"
  - name: disallow-privilege-escalation
    match:
      any:
        - resources:
            kinds:
              - Pod
            namespaces:
            - bankapp
            - mysql
    validate:
      message: "Privilege escalation is disallowed."
      pattern:
        spec:
          =(initContainers):
            - =(securityContext):
                =(allowPrivilegeEscalation): "false"
          containers:
            - =(securityContext):
                =(allowPrivilegeEscalation): "false"
```

```
---
### This policy validates that all containers have something specified for memory and CPU requests and memory limits ###
apiVersion: kyverno.io/v1
kind: ClusterPolicy
metadata:
  name: require-requests-limits
  annotations:
    policies.kyverno.io/title: Require Limits and Requests
    policies.kyverno.io/category: Best Practices, EKS Best Practices
    policies.kyverno.io/severity: medium
    policies.kyverno.io/subject: Pod
    policies.kyverno.io/minversion: 1.6.0
    policies.kyverno.io/description: >-
      As application workloads share cluster resources, it is important to limit resources
      requested and consumed by each Pod. It is recommended to require resource requests and
      limits per Pod, especially for memory and CPU. If a Namespace level request or limit is specified,
      defaults will automatically be applied to each Pod based on the LimitRange configuration.
      This policy validates that all containers have something specified for memory and CPU
      requests and memory limits.
spec:
  validationFailureAction: Audit
  background: true
  rules:
  - name: validate-resources
    match:
      any:
      - resources:
          kinds:
          - Pod
```

```
    - Deployment
    - StatefulSet
    - DaemonSet
    namespaces:
    - bankapp
    - mysql
  validate:
   message: "CPU and memory resource requests and memory limits are required for containers."
   pattern:
    spec:
     containers:
     - resources:
        requests:
         memory: "?*"
         cpu: "?*"
        limits:
         memory: "?*"
     =(initContainers):
     - resources:
        requests:
         memory: "?*"
         cpu: "?*"
        limits:
         memory: "?*"
     =(ephemeralContainers):
     - resources:
        requests:
         memory: "?*"
         cpu: "?*"
        limits:
         memory: "?*"
```

Installation of Falco in AKS Cluster

Falco is a tool that captures and analyses logs within a runtime environment to detect suspicious and malicious activity. I had installed here Falco with the custom rule that if anyone will try to access the **/etc** directory to write in a file then its logs will be captured by the Falco.

cat dexter-falco-rule.yaml

customRules:

custom-rules.yaml: |-

- rule: Write below etc

desc: An attempt to write to /etc directory

condition: >

(evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)

and fd.name startswith /etc

output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname[4] evt_type=%evt.type user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name proc_exepath=%proc.exepath parent=%proc.pname command=%proc.cmdline terminal=%proc.tty"

priority: WARNING

tags: [filesystem, mitre_persistence]

helm repo add falcosecurity https://falcosecurity.github.io/charts

helm repo update

helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false

kubectl get pods -n falco --watch

```
[root@ ~]# cat dexter-falco-rule.yaml
customRules:
  custom-rules.yaml: |-
    - rule: Write below etc
      desc: An attempt to write to /etc directory
      condition: >
        (evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)
        and fd.name startswith /etc
      output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname
[4] evt_type=%evt.type user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name proc_exepath=%proc.exepath parent=%proc.pname comman
d=%proc.cmdline terminal=%proc.tty"
      priority: WARNING
      tags: [filesystem, mitre_persistence]
[root@ ~]# helm repo add falcosecurity https://falcosecurity.github.io/charts
"falcosecurity" has been added to your repositories
[root@ ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "kyverno" chart repository
...Successfully got an update from the "falcosecurity" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@ ~]# helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosidekick.e
nabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false
```

```
[root@                ~]# kubectl get pods -n falco --watch
NAME                                        READY   STATUS    RESTARTS   AGE
falco-falcosidekick-                        1/1     Running   0          92s
falco-falcosidekick-                        1/1     Running   0          92s
falco-falcosidekick-                        1/1     Running   0          92s
falco-falcosidekick-                        1/1     Running   0          92s
falco-falcosidekick-                        1/1     Running   0          92s
falco-                                      2/2     Running   0          92s
falco-                                      2/2     Running   0          92s
```

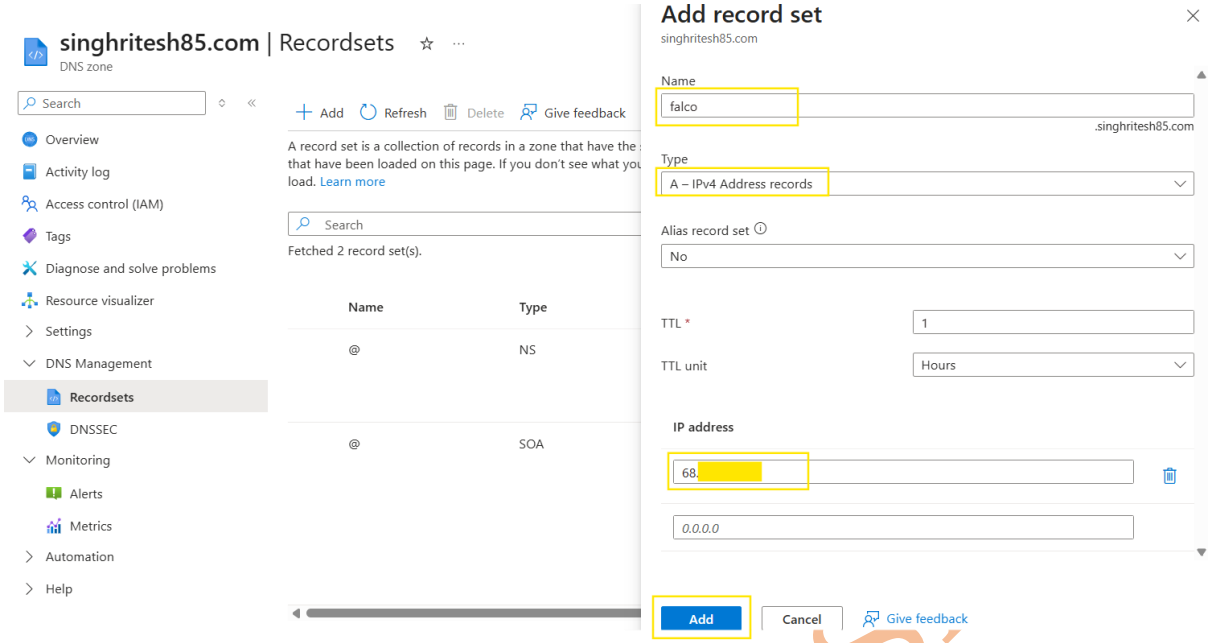
I had created Ingress Rule for Falco as shown in the screenshot attached below.

```
[root@                ~]# cat falco-ingress-rule.yaml
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
    - host: falco.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: falco-falcosidekick-ui
                port:
                  number: 2802
[root@                ~]# kubectl apply -f falco-ingress-rule.yaml
ingress.networking.k8s.io/falco-ui-ingress created
[root@                ~]# kubectl get ing -n falco
NAME               CLASS                       HOSTS                     ADDRESS          PORTS     AGE
falco-ui-ingress   azure-application-gateway   falco.singhritesh85.com   68.              80, 443   9s
```

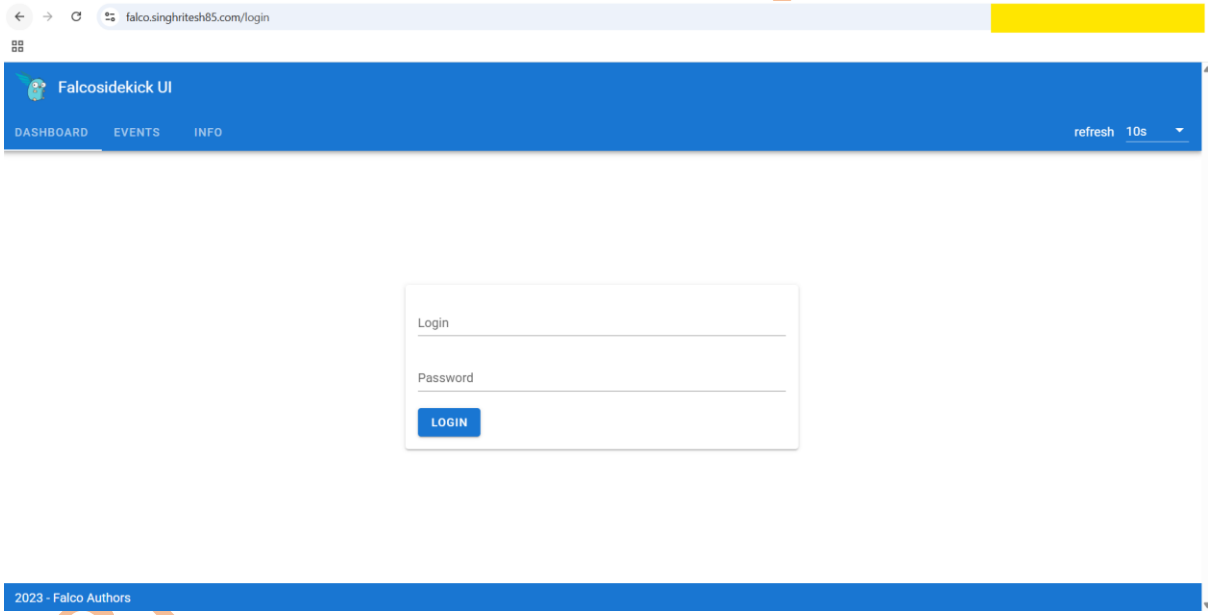
Created the kubernetes secrets as shown in the screenshot attached below.

```
[root@                ~]# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n falco
secret/ingress-secret created
```

I did the entry for Ingress HOST with External IP Address in Azure DNS Zone to create the Record Set of A-Type as shown in the screenshot attached below.



Finally, I was able to access Falco UI as shown in the screenshot attached below. You can login with username and password admin and admin respectively.



It is also possible to check falco logs using the command

kubectl logs -l "app.kubernetes.io/instance=falco" -n falco

```
cat falco-ingress-rule.yaml
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
    - host: falco.singhritesh85.com
      http:
        paths:
          - path: /
            pathType: Prefix
            backend:
              service:
                name: falco-falcosidekick-ui
                port:
                number: 2802
```

Installation of Istio in AKS Cluster using Helm

To install Istio Service mesh using helm chart use the command as written below.

helm repo add istio https://istio-release.storage.googleapis.com/charts

helm repo update

kubectl create ns istio-system

helm install istio-base istio/base -n istio-system

helm install istiod istio/istiod -n istio-system

```
[root@                ~]# helm repo add istio https://istio-release.storage.googleapis.com/charts
"istio" has been added to your repositories
[root@                ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "falcosecurity" chart repository
...Successfully got an update from the "istio" chart repository
...Successfully got an update from the "kyverno" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@                ~]# kubectl create ns istio-system
namespace/istio-system created
```

```
[root@                ~]# helm install istio-base istio/base -n istio-system
```

```
[root@                ~]# helm install istiod istio/istiod -n istio-system
```

Then I had installed Kiali, Prometheus and Grafana as shown in the screenshot attached below.

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/kiali.yaml

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/prometheus.yaml

kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/grafana.yaml

```
[root@                ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/kiali.yaml
serviceaccount/kiali created
configmap/kiali created
clusterrole.rbac.authorization.k8s.io/kiali created
clusterrolebinding.rbac.authorization.k8s.io/kiali created
service/kiali created
deployment.apps/kiali created
[root@                ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/prometheus.yaml
serviceaccount/prometheus created
configmap/prometheus created
clusterrole.rbac.authorization.k8s.io/prometheus created
clusterrolebinding.rbac.authorization.k8s.io/prometheus created
service/prometheus created
deployment.apps/prometheus created
[root@                ~]# kubectl apply -f https://raw.githubusercontent.com/istio/istio/release-1.27/samples/addons/grafana.yaml
serviceaccount/grafana created
configmap/grafana created
service/grafana created
deployment.apps/grafana created
configmap/istio-grafana-dashboards created
configmap/istio-services-grafana-dashboards created
```

```
[root@                ~]# kubectl get pods -n istio-system --watch
NAME                          READY   STATUS    RESTARTS   AGE
grafana-cdb9db549-5652h       1/1     Running   0          57s
istiod-589d764-xbx7c          1/1     Running   0          5m7s
kiali-56f54f58f9-57klh        1/1     Running   0          77s
prometheus-7bf56b6bc-xv66q    2/2     Running   0          66s
```

To establish mesh-wide mTLS I created the peer authentication as shown in the screenshot attached below.

cat peerauthentication.yaml

apiVersion: security.istio.io/v1

kind: PeerAuthentication

metadata:

name: "default"

namespace: istio-system

spec:

mtls:

mode: STRICT

```
[root@                ~]# cat peerauthentication.yaml
apiVersion: security.istio.io/v1
kind: PeerAuthentication
metadata:
  name: "default"
  namespace: istio-system
spec:
  mtls:
    mode: STRICT
[root@                ~]# kubectl apply -f peerauthentication.yaml
peerauthentication.security.istio.io/default created
```

```
[root@                ~]# kubectl get peerauthentication -n istio-system
NAME      MODE     AGE
default   STRICT   38s
```

cat kiali-ingress-rule.yaml

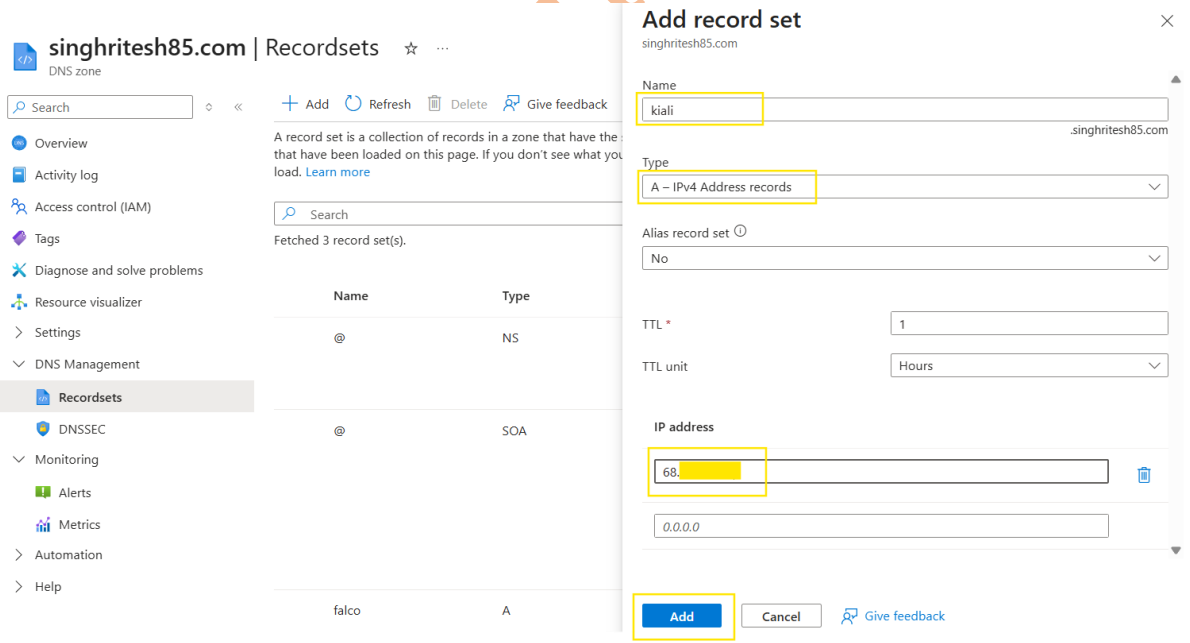
```
# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n istio-system
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: kiali-ingress
  namespace: istio-system
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
  - host: kiali.singhritesh85.com
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: kiali
            port:
              number: 20001
```

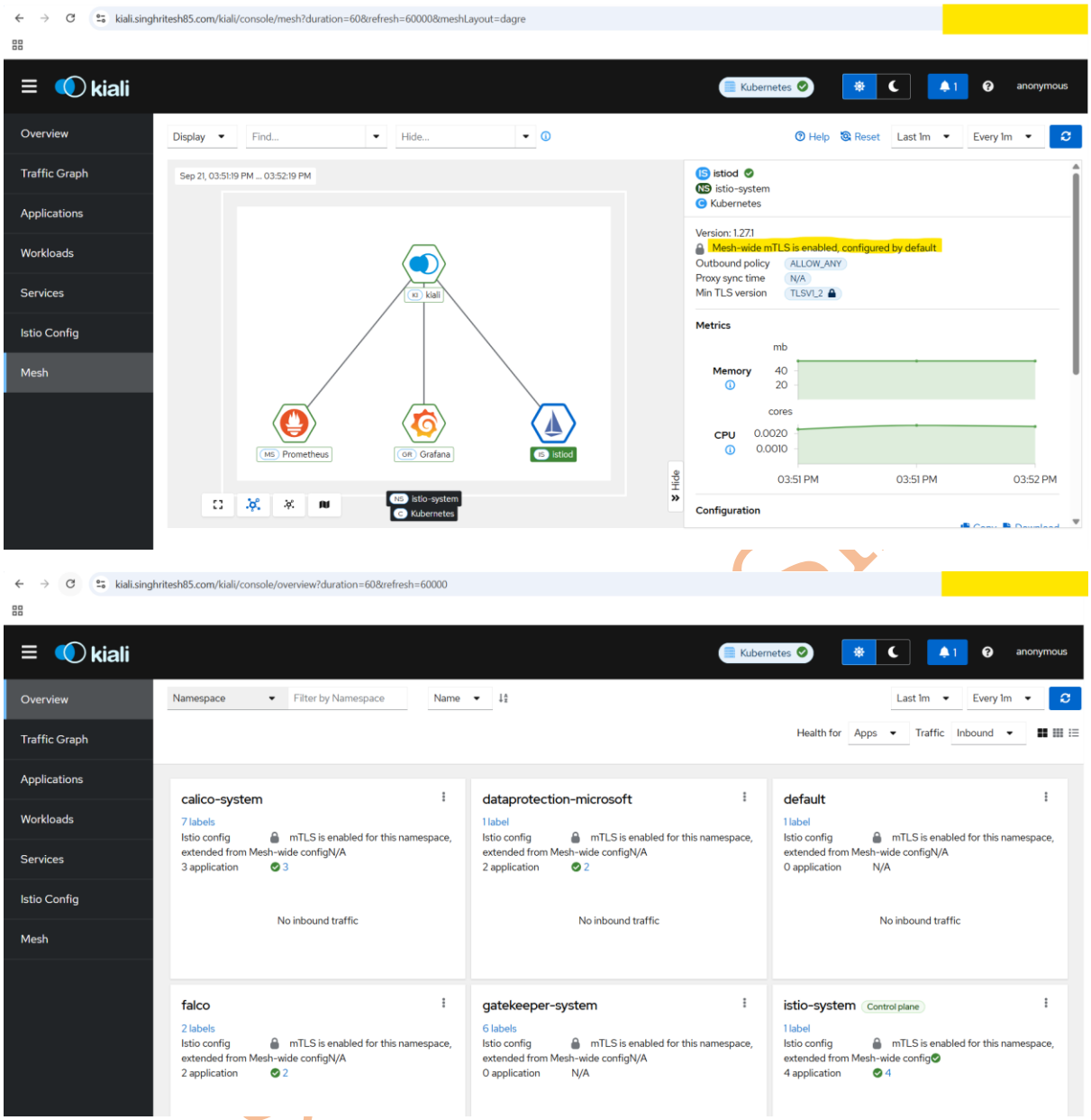
I created the Ingress Rule to access Kiali as shown in the screenshot attached below.

kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n istio-system command had been used to create the kubernetes tls secrets as shown in the screenshot attached below.

```
[root@                ~]# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n istio-system
secret/ingress-secret created
[root@                ~]# cat kiali-ingress-rule.yaml
# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n istio-system
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: kiali-ingress
  namespace: istio-system
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
  - host: kiali.singhritesh85.com
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: kiali
            port:
              number: 20001
[root@                ~]# kubectl apply -f kiali-ingress-rule.yaml
ingress.networking.k8s.io/kiali-ingress created
[root@                ~]# kubectl get ing -n istio-system
NAME            CLASS                    HOSTS                   ADDRESS         PORTS     AGE
kiali-ingress   azure-application-gateway   kiali.singhritesh85.com   68.             80, 443   8s
```

I did the entry for HOST resulted from Kiali Ingress Rule and External IP in Azure DNS Zone to create the Record Set of A-Type as shown in the screenshot attached below.





Creation of Azure DevOps Pipeline

Before creation of Azure DevOps Pipeline create the storage class named as **dexter** as shown in screenshot attached below. Then created namespaces mysql, bankapp and Kubernetes Secrets for Azure Container Registry as mentioned below.

kubectl create ns bankapp

kubectl create ns mysql

kubectl create secret docker-registry bankapp-auth --docker-server=https://bankappcontainer24registry.azurecr.io --docker-username=bankappcontainer24registry --docker-password=XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX -n bankapp

```
[root@                ~]# kubectl create ns bankapp
namespace/bankapp created
[root@                ~]# kubectl create ns mysql
namespace/mysql created
[root@                ~]# kubectl create secret docker-registry bankapp-auth --docker-server=https://bankappcontainer24registry.azurecr.io --docker-username=ba
nkappcontainer24registry --docker-password=                                        -n bankapp
secret/bankapp-auth created
[root@                ~]# kubectl get secrets -n bankapp
NAME           TYPE                             DATA   AGE
bankapp-auth   kubernetes.io/dockerconfigjson   1      10s
```

cat storage-class.yaml

kind: StorageClass

apiVersion: storage.k8s.io/v1

metadata:

name: dexter

provisioner: disk.csi.azure.com

parameters:

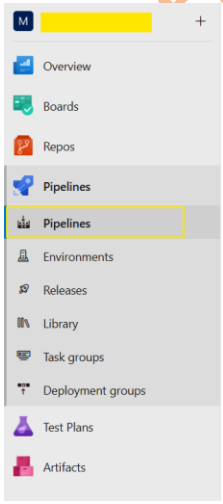
skuname: StandardSSD_LRS

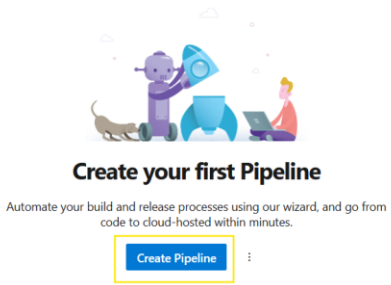
kind: managed

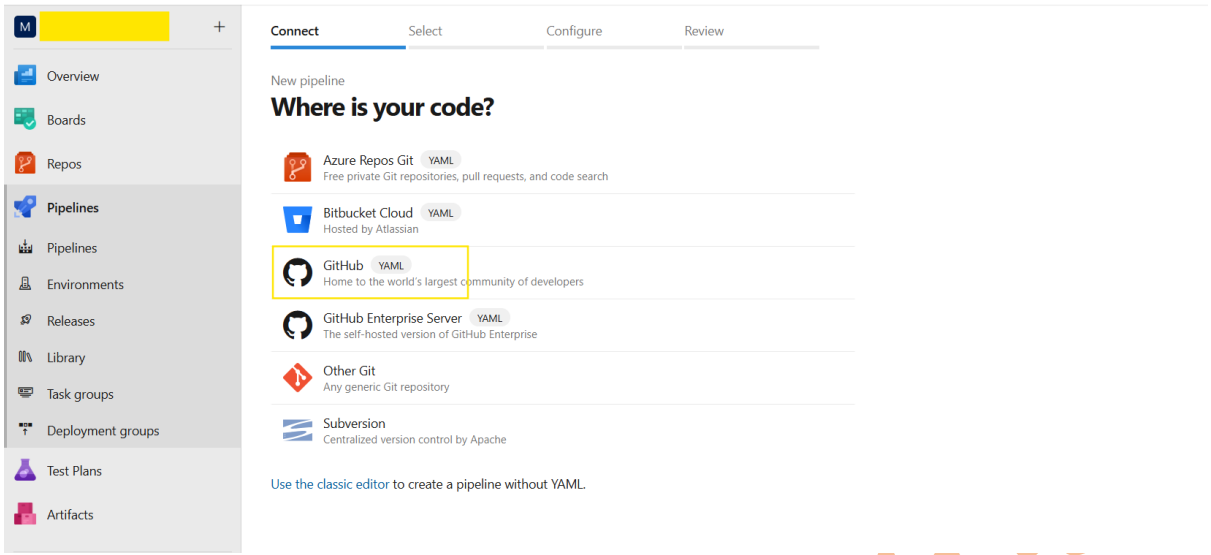
diskEncryptionSetID: "/subscriptions/5XXXXXXX-XXXX-XXXX-XXXX-XXXXXXXXXXXX/resourceGroups/bankapp-rg/providers/Microsoft.Compute/diskEncryptionSets/bankapp-aks-des" ### Resource ID of Disk Encryption Set

```
[root@                ~]# cat storage-class.yaml
kind: StorageClass
apiVersion: storage.k8s.io/v1
metadata:
  name: dexter
provisioner: disk.csi.azure.com
parameters:
  skuname: StandardSSD_LRS
  kind: managed
  diskEncryptionSetID: "/subscriptions/                                /resourceGroups/bankapp-rg/providers/Microsoft.Compute/diskEncryptionSets/bankapp-a
ks-des" ### Resource ID of Disk Encryption Set

[root@                ~]# kubectl apply -f storage-class.yaml
storageclass.storage.k8s.io/dexter created
```

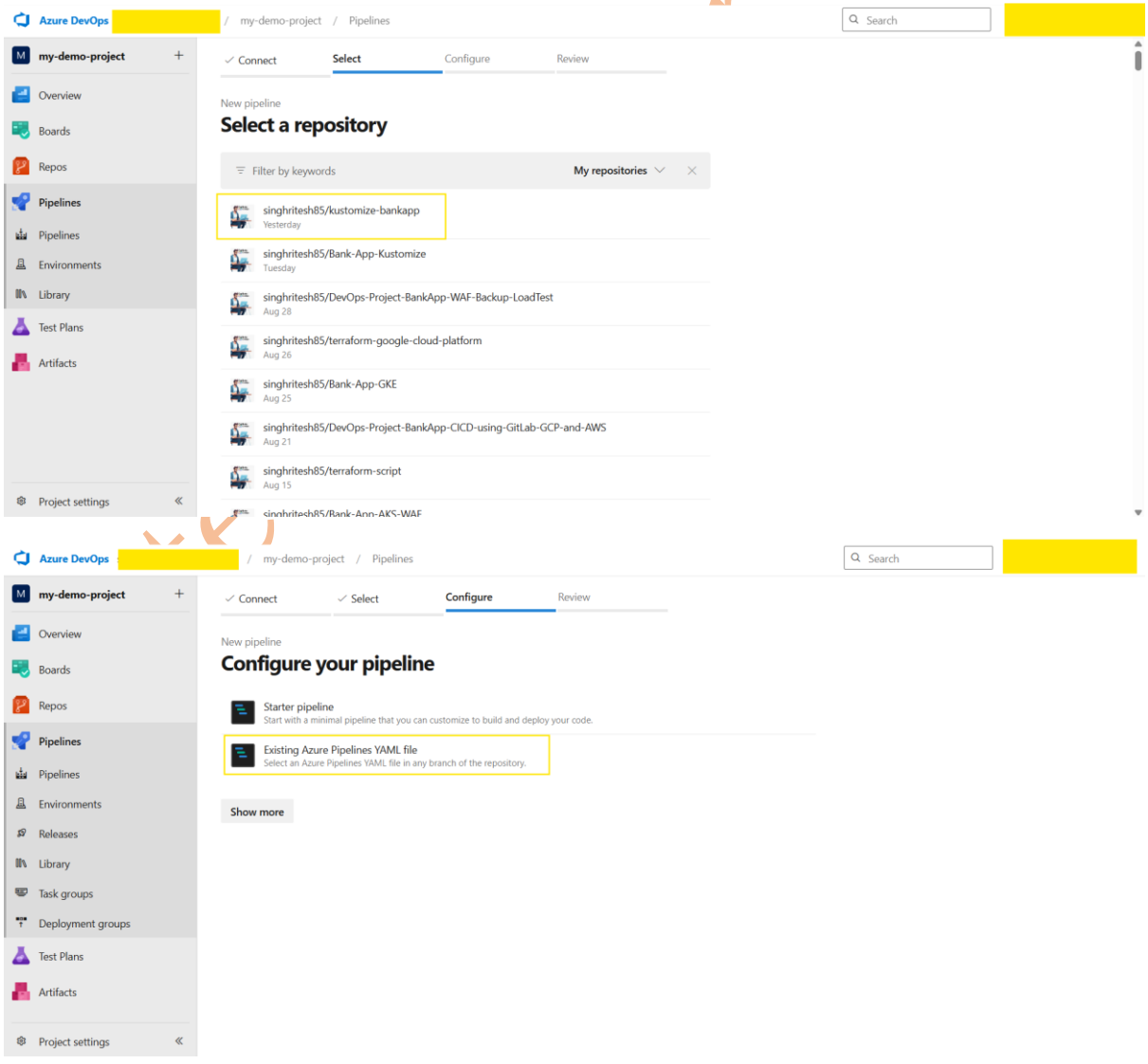
Then I created the Azure DevOps CI/CD pipeline as shown in the screenshot attached below. First, I created the CI/CD Pipeline to deploy MySQL Pods and after successfully running the MySQL 8 Pods I created the CI/CD Pipeline to deploy bankapp pods.

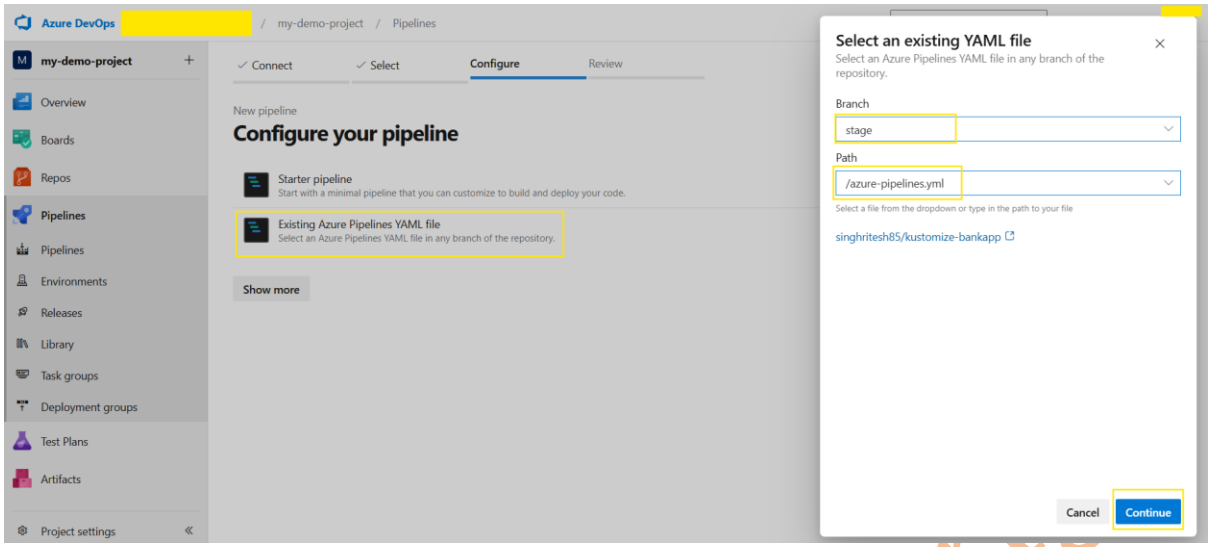






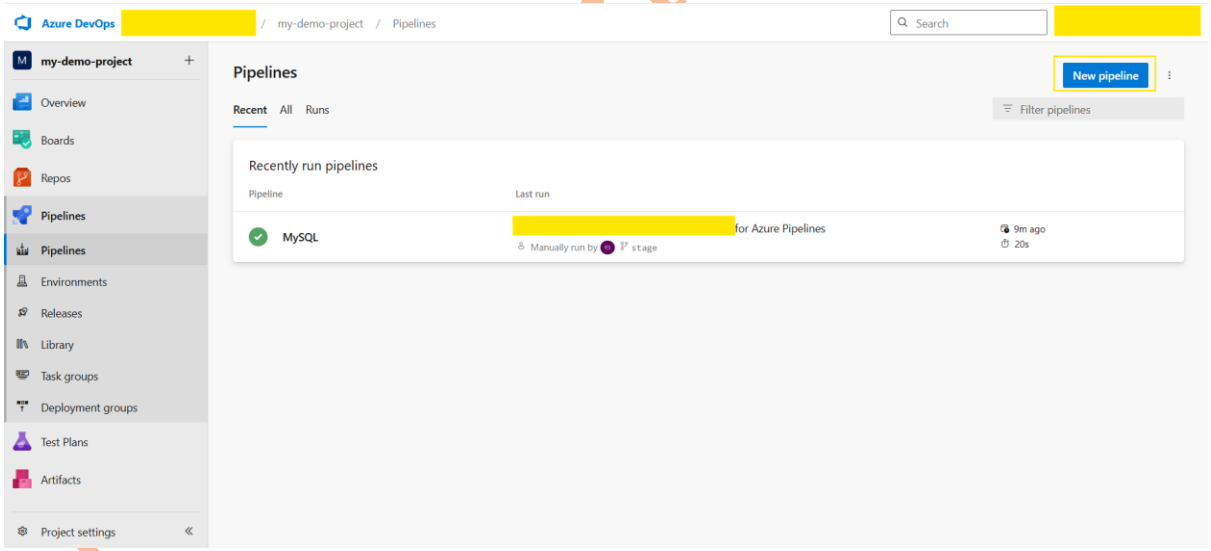
At this stage it will ask to authorize your GitHub Account and after authorizing your GitHub Account select the desired GitHub Repo as shown in the screenshot attached below.

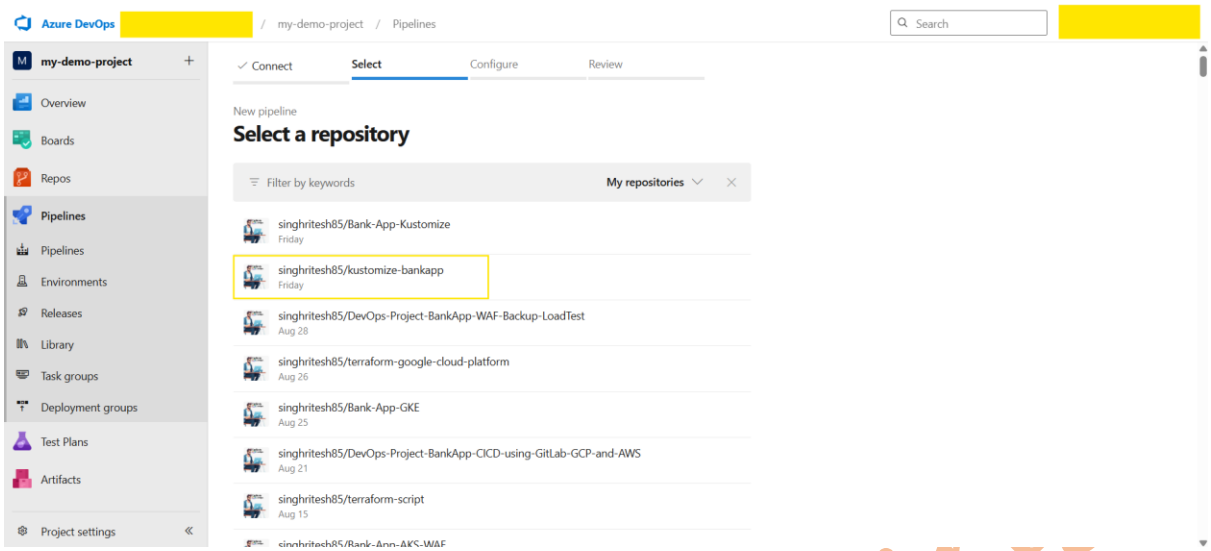


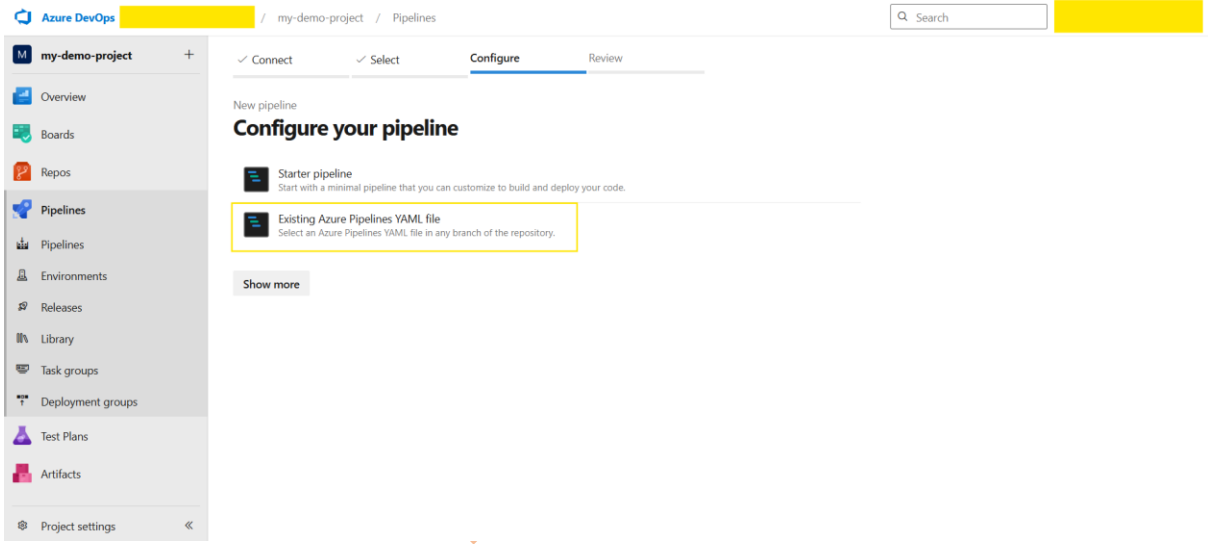


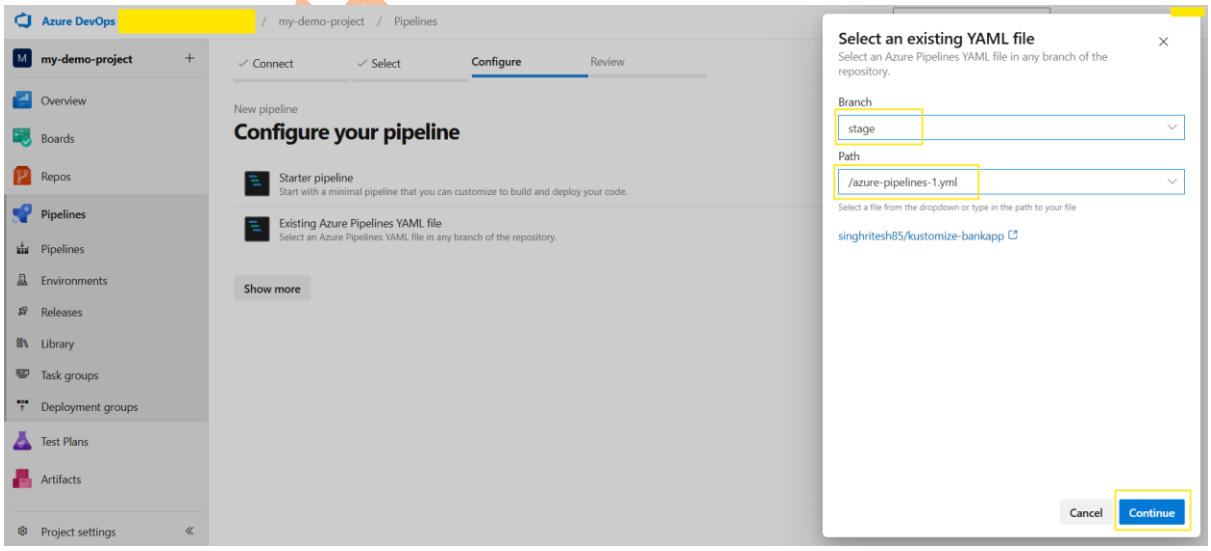

```
[demo@devopsagent-vm ~]$ kubectl get pods -n mysql --watch
NAME      READY   STATUS    RESTARTS   AGE
mysql-0   1/1     Running   0          2m35s
mysql-1   1/1     Running   0          119s
mysql-2   1/1     Running   0          77s
^C[demo@devopsagent-vm ~]$
[demo@devopsagent-vm ~]$ kubectl get pvc -n mysql --watch
NAME                                STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS   VOLUMEATTRIBUTESCLASS   AGE
mysql-persistent-storage-mysql-0    Bound    pvc-[redacted]                             1Gi        RWO            dexter         <unset>                 2m46s
mysql-persistent-storage-mysql-1    Bound    pvc-                                       1Gi        RWO            dexter         <unset>                 2m10s
mysql-persistent-storage-mysql-2    Bound    pvc-                                       1Gi        RWO            dexter         <unset>                 88s
```

As shown in the screenshot attached above PVC and MySQL 8 Pods had been created successfully. Then I created the CI/CD Pipeline to deploy BankApp Pods as shown in the screenshot attached below.

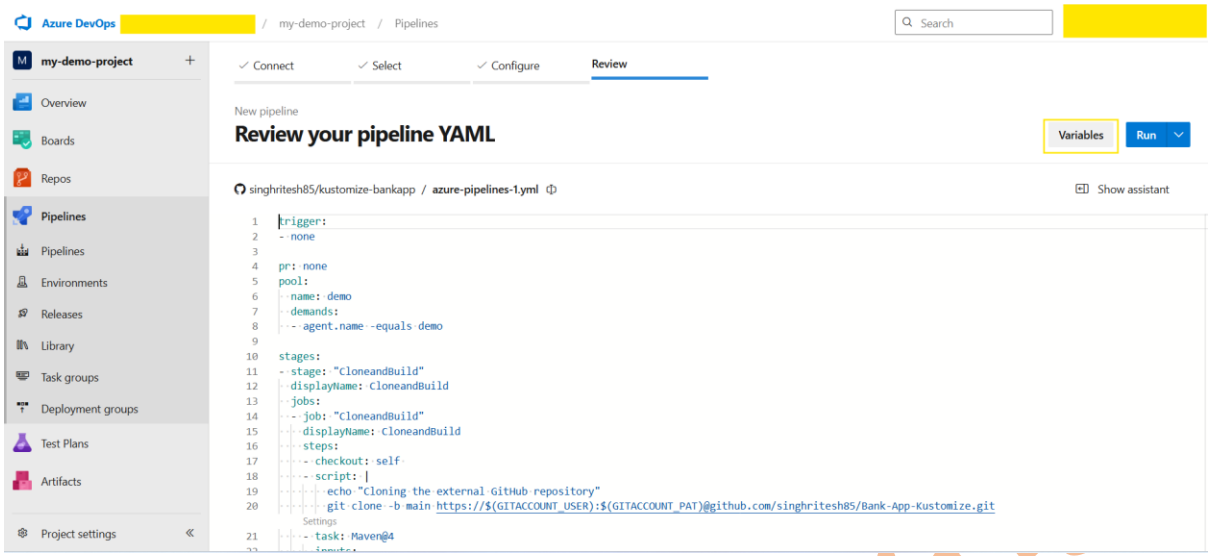


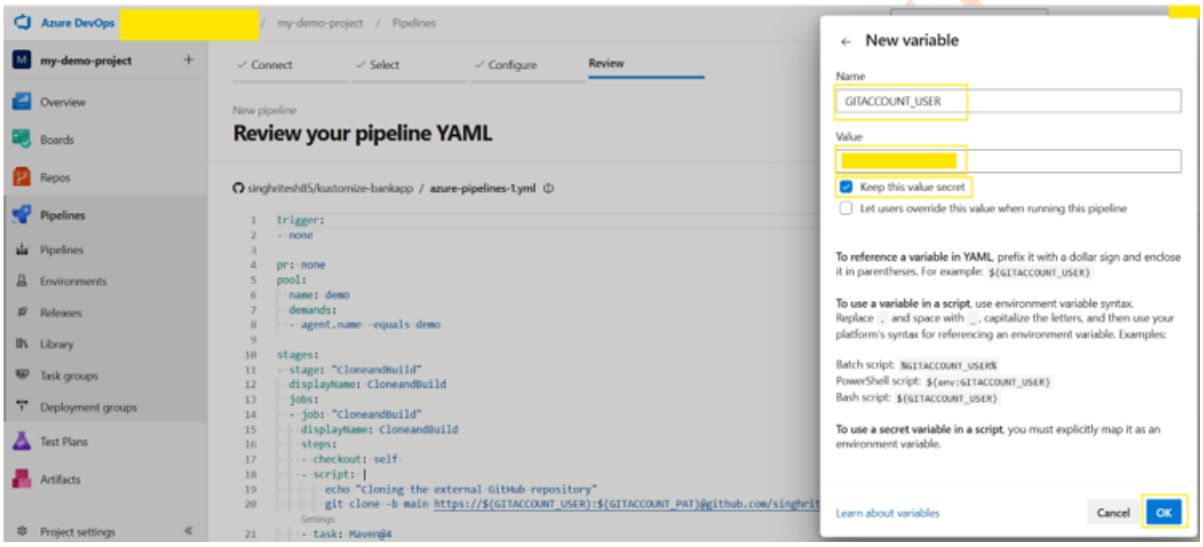


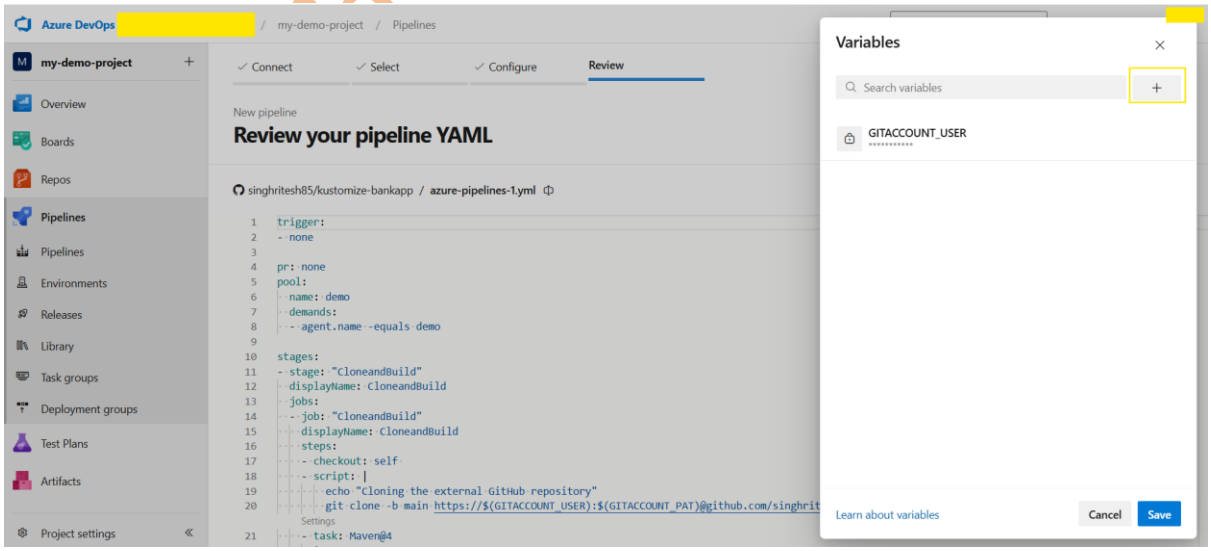


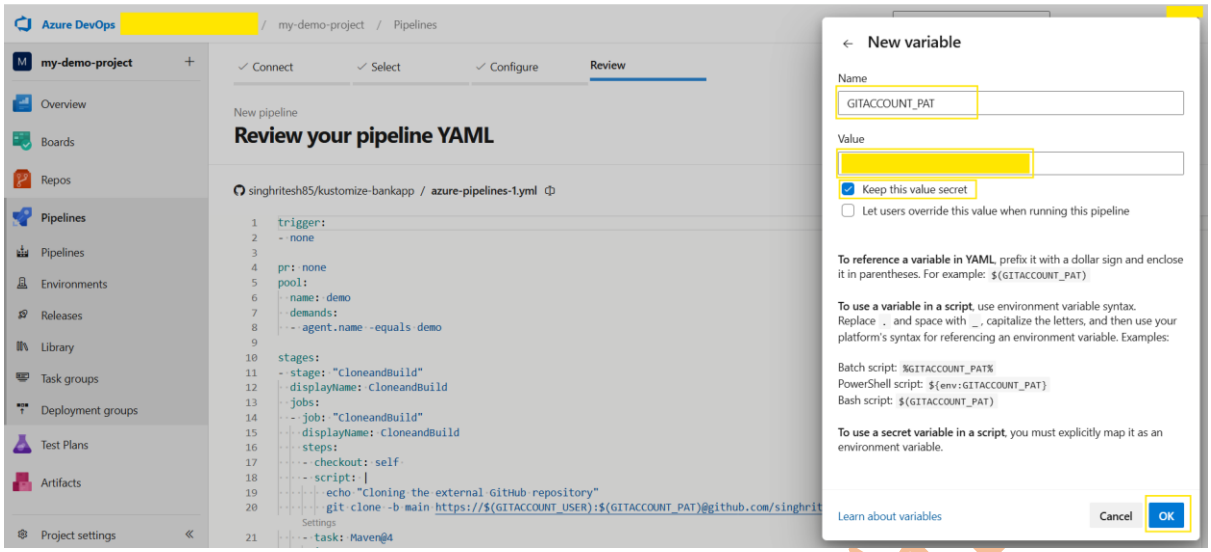


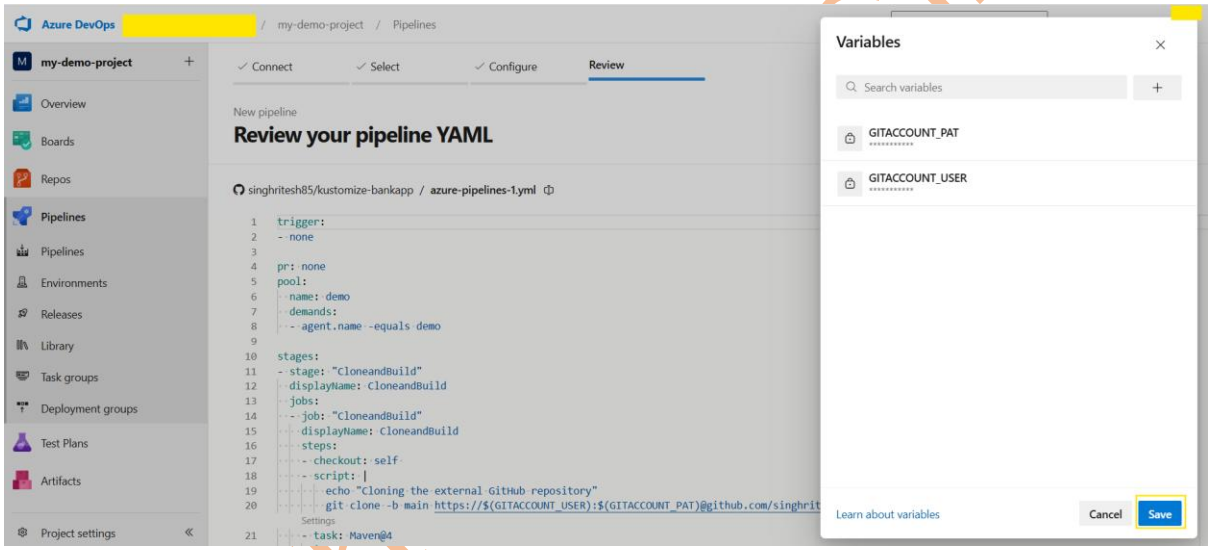
Added the two variables GITACCOUNT_USER and GITACCOUNT_PAT as shown in the screenshot attached below.


Azure DevOps
my-demo-project / Pipelines
Search
my-demo-project
Overview
Boards
Repos
Pipelines
Pipelines
Environments
Releases
Library
Task groups
Deployment groups
Test Plans
Artifacts
Project settings
Connect
Select
Configure
Review
New pipeline
Review your pipeline YAML
Variables
Run
singhritesh85/kustomize-bankapp / azure-pipelines-1.yml
Show assistant
trigger:
- none
pr: none
pool:
name: demo
demands:
- agent.name -equals demo
stages:
- stage: "CloneandBuild"
displayName: CloneandBuild
jobs:
- job: "CloneandBuild"
displayName: CloneandBuild
steps:
- checkout: self
- script: |
echo "Cloning the external GitHub repository"
git clone -b main https://$(GITACCOUNT_USER):$(GITACCOUNT_PAT)@github.com/singhritesh85/Bank-App-Kustomize.git
Settings
- task: Maven@4


New variable
Name
GITACCOUNT_USER
Value
Keep this value secret
Let users override this value when running this pipeline
To reference a variable in YAML, prefix it with a dollar sign and enclose it in parentheses. For example: $(GITACCOUNT_USER)
To use a variable in a script, use environment variable syntax. Replace . and space with _, capitalize the letters, and then use your platform's syntax for referencing an environment variable. Examples:
Batch script: %GITACCOUNT_USER%
PowerShell script: $(env:GITACCOUNT_USER)
Bash script: $(GITACCOUNT_USER)
To use a secret variable in a script, you must explicitly map it as an environment variable.
Learn about variables
Cancel
OK


Variables
Search variables
GITACCOUNT_USER
Learn about variables
Cancel
Save





After Running the pipeline, I found Pods had been created successfully as shown in the screenshot attached below.

```
[demo@devopsagent-vm ~]$ kubectl get pods -n bankapp --watch
NAME                          READY   STATUS    RESTARTS   AGE
bankapp-                      1/1     Running   0          11s
```

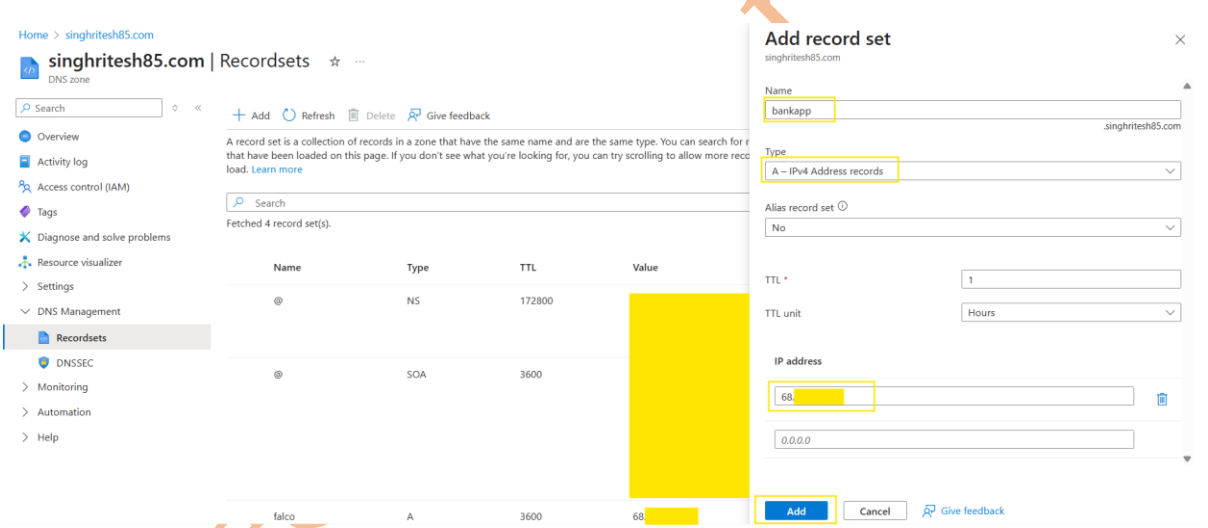
```
[demo@devopsagent-vm ~]$ kubectl get svc -n bankapp
NAME              TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
bankapp-service   ClusterIP   10.             <none>        80/TCP    38s
```

Created the Ingress Rule as shown in the screenshot attached below.

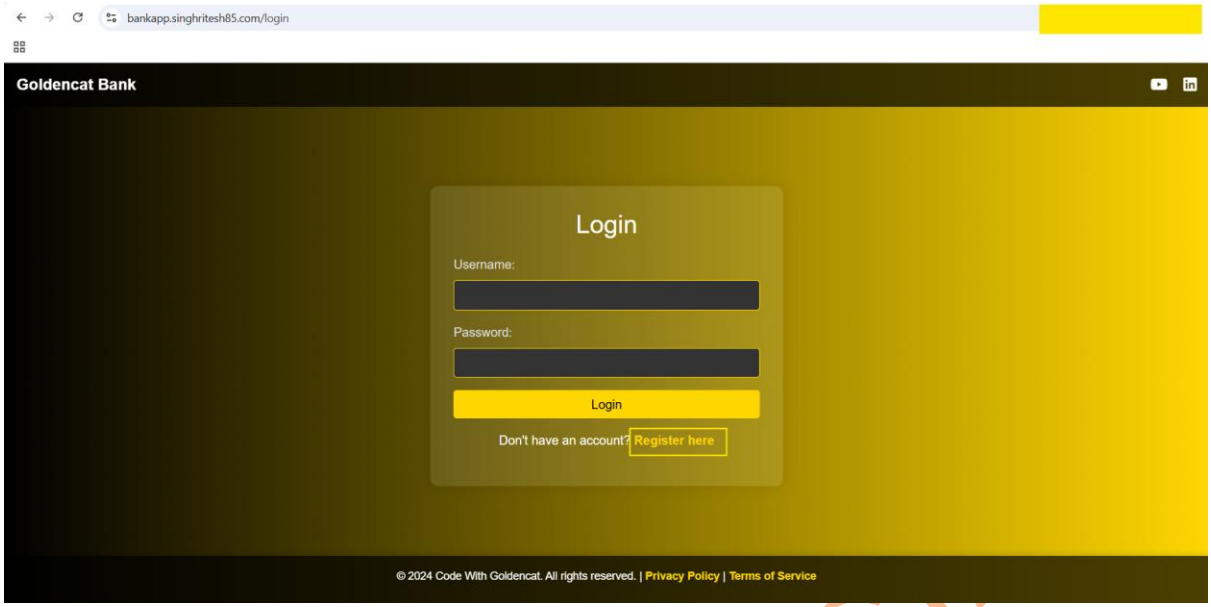
cat ingress-rule.yaml

```
# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n bankapp
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: bankapp-ingress
  namespace: bankapp
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
  - host: bankapp.singhritesh85.com
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: bankapp-service
            port:
              number: 80
```

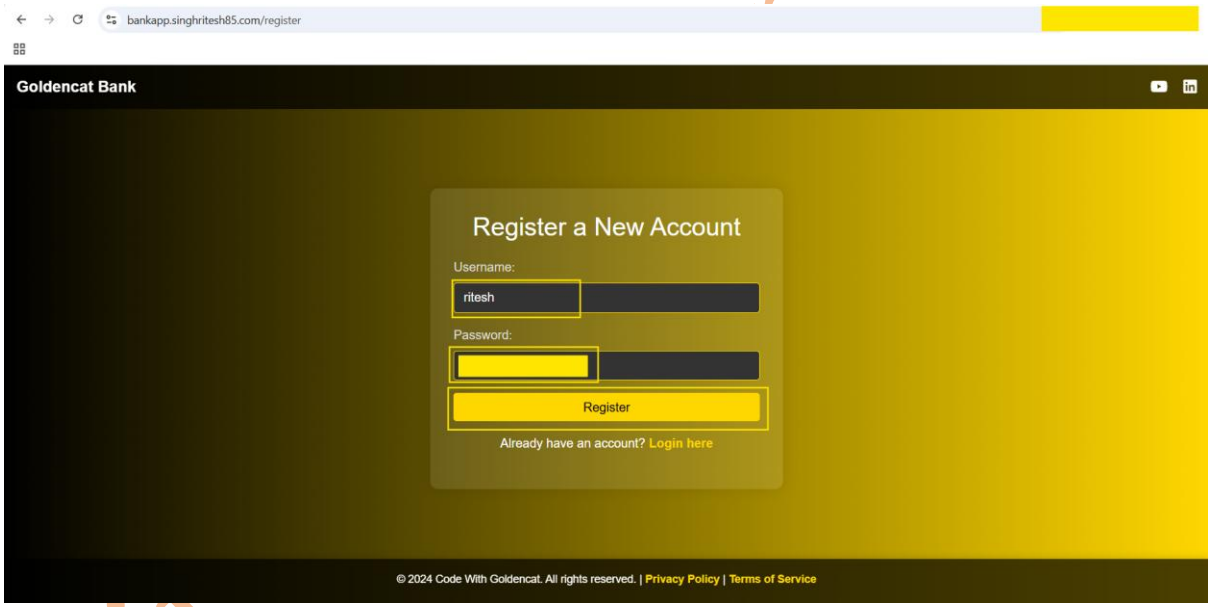
```
[demo@devopsagent-vm ~]$ cat ingress-rule.yaml
# kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n bankapp
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: bankapp-ingress
  namespace: bankapp
  annotations:
    appgw.ingress.kubernetes.io/ssl-redirect: "true"
spec:
  ingressClassName: azure-application-gateway
  tls:
  - secretName: ingress-secret
  rules:
  - host: bankapp.singhritesh85.com
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: bankapp-service
            port:
              number: 80

[demo@devopsagent-vm ~]$ kubectl create secret tls ingress-secret --key mykey.key --cert STAR_singhritesh85_com.crt -n bankapp
secret/ingress-secret created
[demo@devopsagent-vm ~]$ kubectl apply -f ingress-rule.yaml
ingress.networking.k8s.io/bankapp-ingress created
[demo@devopsagent-vm ~]$ kubectl get ing -n bankapp
NAME              CLASS                       HOSTS                       ADDRESS         PORTS     AGE
bankapp-ingress   azure-application-gateway   bankapp.singhritesh85.com   68.[redacted]   80, 443   8s
[demo@devopsagent-vm ~]$ kubectl get secrets -n bankapp
NAME             TYPE                                  DATA   AGE
bankapp-auth     kubernetes.io/dockerconfigjson        1      75m
ingress-secret   kubernetes.io/tls                     2      29s
```

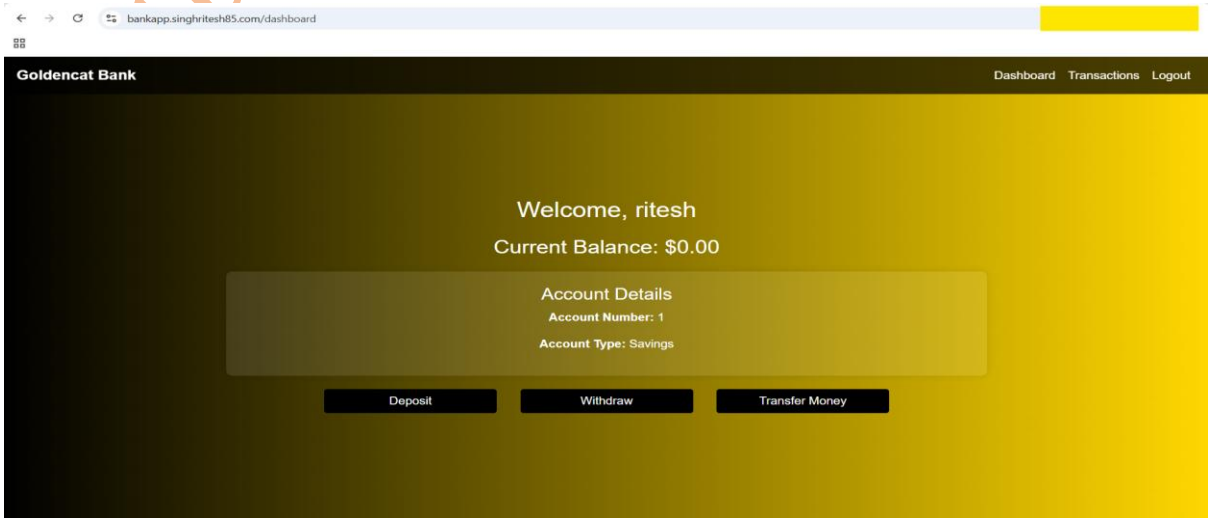


Finally, I was able to access the Bank Application as shown in the screenshot attached below.



I registered with a user and logged-in with the same user and found that I was able to login with the newly created user successfully as shown in the screenshot attached below.





Migration from Terraform to OpenTofu

To Migrate from Terraform to Opentofu make sure about below mentioned points.

1. Take the backup of state file
2. Take the backup of existing Terraform Script.

For backing up terraform state file I created a new Azure Storage Account and container then

copied the existing state file to the new bucket

```
[root@ ~]# az storage account create --name dexter202509 --resource-group bankapp-rg --location "East US 2" --sku Standard_LRS

[root@Terraform-Server ~]# az storage container create --name terraform-state --account-name dexter202509 --account-key
{
  "created": true
}

[root@ ~]# az storage account list --query "[].name" --output tsv
terraformstate08022024
bankappbackupsa2025
dexter202509

[root@Terraform-Server ~]# az storage container generate-sas --name terraform-state --account-name terraformstate08022024 --expiry 2025-09-21T23:00Z --permiss
ions acdlrw --account-key=
"se=2025-09-
[root@Terraform-Server ~]# az storage container generate-sas --name terraform-state --account-name dexter202509 --expiry 2025-09-21T23:00Z --permissions acdlr
w --account-key=
"se=2025-09-
```

Installed azcopy as shown in the screenshot attached below.

```
[root@Terraform-Server ~]# wget https://aka.ms/downloadazcopy-v10-linux

[root@Terraform-Server ~]# tar -xvf downloadazcopy-v10-linux --strip-components=1

[root@Terraform-Server ~]# sudo mv azcopy /usr/local/bin/

[root@Terraform-Server ~]# chmod +x /usr/local/bin/azcopy
```

```
[root@Terraform-Server ~]# azcopy copy 'https://terraformstate08022024.blob.core.windows.net/terraform-state?se=2025-09
'https://dexter202509.blob.core.windows.net/terraform-state/?se=2025-09
--recursive
INFO: Scanning...
INFO: Any empty folders will not be processed, because source and/or destination doesn't have full folder support

Job has started
Log file is located at: /root/.azcopy/.log

100.0 %, 2 Done, 0 Failed, 0 Pending, 0 Skipped, 2 Total, 2-sec Throughput (Mb/s): 0.8656


Job summary
Elapsed Time (Minutes): 0.0334
Number of File Transfers: 2
Number of Folder Property Transfers: 0
Number of Symlink Transfers: 0
Total Number of Transfers: 2
Number of File Transfers Completed: 2
Number of Folder Transfers Completed: 0
Number of File Transfers Failed: 0
Number of Folder Transfers Failed: 0
Number of File Transfers Skipped: 0
Number of Folder Transfers Skipped: 0
Number of Symbolic Links Skipped: 0
Number of Hardlinks Converted: 0
Number of Special Files Skipped: 0
Total Number of Bytes Transferred: 216839
Final Job Status: Completed
```

For terraform script I have new set of script present in the directory **opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault** and **opentofu-azure-dns-zone** as shown in the screenshot attached below.

```
[root@ ~]# ls
opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault  terraform-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault
opentofu-azure-dns-zone                                                  terraform-azure-dns-zone
```

The only difference between the Terraform and Opentofu codebase is backend.tf file because in Opentofu I am going to encrypt the state file.

Below is the backend.tf for Terraform.

```
[root@                ~]# cat terraform-azure-dns-zone/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "dns-zone/terraform.tfstate"
    subscription_id      = "5                                  "  ### Provide Subscription ID of your Azure Account.
  }
}

[root@                ~]# cat terraform-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "state/terraform.tfstate"
    subscription_id      = "5                                  "  ### Provide Subscription ID of your Azure Account.
  }
}
```

Below is the backend.tf for Opentofu before migration.

```
[root@                ~]# cat opentofu-azure-dns-zone/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "dns-zone/terraform.tfstate"
    subscription_id      = "5                                  "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

```
[root@                ~]# cat opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "state/terraform.tfstate"
    subscription_id      = "5                                    "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

Below is the backend.tf for Opentofu after migration.

```
[root@                ~]# cat opentofu-azure-dns-zone/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "dns-zone/terraform.tfstate"
    subscription_id      = "5                                    "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@ ~]# cat opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "state/terraform.tfstate"
    subscription_id      = "5                                    "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

I changed in backend.tf because the state file of terraform is not encrypted and you already created the resources using terraform which resources might be utilized in some project so you cannot delete the existing resources created using terraform and the create the new one and terraform state file was unencrypted.

You can follow below steps to install Opentofu.

cd /opt/

curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh

chmod +x install-opentofu.sh

./install-opentofu.sh --install-method rpm

rm -f install-opentofu.sh

```
[root@ ~]# cd /opt/
[root@ opt]# curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh
[root@ opt]# chmod +x install-opentofu.sh
[root@ opt]# ./install-opentofu.sh --install-method rpm
```

```
[root@ opt]# rm -f install-opentofu.sh
```

```
[root@ ~]# tofu --version
OpenTofu v1.10.6
on linux_amd64
```

Below commands you should run for migration.

tofu init -reconfigure

tofu validate

tofu plan

tofu apply -auto-approve

```
[root@                    ~]# cd opentofu-azure-dns-zone/main/
[root@                    main]# tofu init -reconfigure
```

```
[root@                    main]# tofu validate
Success! The configuration is valid.
```

```
[root@                    main]# tofu plan
```

```
No changes. Your infrastructure matches the configuration.

OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.
```

```
[root@                    main]# tofu apply -auto-approve
```

```
No changes. Your infrastructure matches the configuration.

OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

azure_dns_zone_name_and_nameserver = {
  "dns_zone_name" = "singhritesh85.com"
  "name_servers" = toset([
    "                    ",
    "                    ",
    "                    ",
    "                    ",
  ])
}
```

Migration had been done, below is the backend.tf after Migration.

```
[root@                    ]# cat opentofu-azure-dns-zone/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "dns-zone/terraform.tfstate"
    subscription_id      = "5                                    "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@                    ~]# cd opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault/main/
[root@                    main]# tofu init -reconfigure
```

```
[root@ main]# tofu validate
Success! The configuration is valid.

[root@ main]# tofu plan

Plan: 0 to add, 4 to change, 0 to destroy.

Note: You didn't use the -out option to save this plan, so OpenTofu can't guarantee to take exactly these actions if you run "tofu apply" now.

[root@ main]# tofu apply -auto-approve

module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 20s el
apsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 30s el
apsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 40s el
apsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 50s el
apsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 1m0s e
lapsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 1m10s
elapsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 1m20s
elapsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 1m30s
elapsed]
module.aks.azurerm_application_gateway.appgtw: Still modifying... [id=/subscriptions/ -...ionGateways/app-gtw-ingress-controller, 1m40s
elapsed]
module.aks.azurerm_application_gateway.appgtw: Modifications complete after 1m42s [id=/subscriptions/ /resourceGroups/banka
pp-rg/providers/Microsoft.Network/applicationGateways/app-gtw-ingress-controller]
module.aks.azurerm_kubernetes_cluster.aks_cluster: Modifying... [id=/subscriptions/ /resourceGroups/bankapp-rg/providers/Mi
crosoft.ContainerService/managedClusters/bankapp-cluster]
module.aks.azurerm_kubernetes_cluster.aks_cluster: Modifications complete after 8s [id=/subscriptions/ /resourceGroups/bank
app-rg/providers/Microsoft.ContainerService/managedClusters/bankapp-cluster]

Apply complete! Resources: 0 added, 4 changed, 0 destroyed.

Outputs:

acr_azurevm_private_ip_and_aks_details_waf_policy_name_and_application_gateway_name = {
  "acr_login_server" = "bankappcontainer24registry.azurecr.io"
  "aks_id" = "/subscriptions/ /resourceGroups/bankapp-rg/providers/Microsoft.ContainerService/managedClusters/bankapp-clust
er"
  "aks_name" = "bankapp-cluster"
  "application_gateway_name" = "app-gtw-ingress-controller"
  "azurevm_devopsagent_privateip" = "10. "
  "web_application_firewall_policy_name" = "bankapp-wafpolicy"
}
```

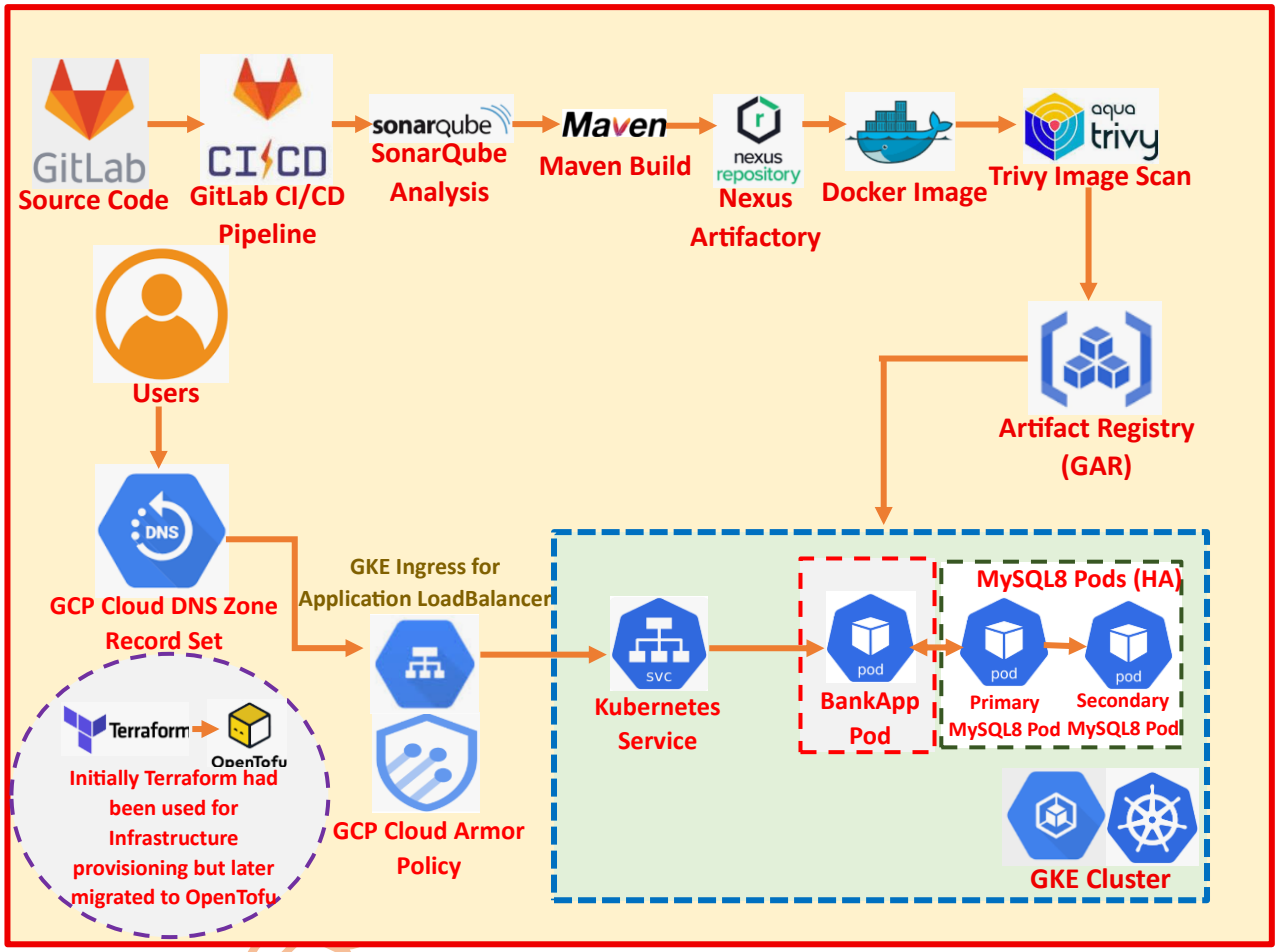
Migration had been done, below is the backend.tf after Migration.

```
[root@ ~]# cat opentofu-aks-cluster-waf-with-backup-envelope-encryption-azure-keyvault/main/backend.tf
terraform {
  backend "azurerm" {
    resource_group_name  = "ritesh"
    storage_account_name = "terraformstate08022024"
    container_name       = "terraform-state"
    key                  = "state/terraform.tfstate"
    subscription_id      = "5 "  ### Provide Subscription ID of your Azure Account.
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

Now check state file in Azure Storage Account Container you will find it is encrypted. However, if you run **tofu show**, you can see the state file but in Azure Storage Account Container it is encrypted.

DevOps Project BankApp Terraform upgrade to Opentofu with Secure GKE Standard Cluster

Module-3



Till now I used Terraform to provision the infrastructure but Hashicorp license changes due to which Terraform will introduce restrictions for commercial use, due to this reason many organisations are migrating from Terraform to OpenTofu. However, I would like to mention here that DevOps Team who used it as a tool to provision the infrastructure will not be affected but those who provides it as a Service will be affected. You already aware that Terraform state file was kept locally or in the S3 Bucket / Azure Storage Account Container / GCP Bucket. The problem was its state file was not encrypted, so anyone who had the access of Terraform Server (when state file was kept locally) or Bucket or Storage Account Container can easily see its state file. But if you use OpenTofu, you will not face such an issue. OpenTofu is an Open Source, community-driven Infrastructure as Code (IaC) tool, it is a fork of Hashicorp Terraform. I will migrate from Terraform to OpenTofu at the end of Module-3.

This DevOps project deals will creation of infrastructure using Terraform, GitLab was used to keep the source Code and GitLab CI/CD had been used as CI/CD Tool. For Code Analysis SonarQube had been used, the build tool used in this project was Maven, Sonatype Nexus3 was used to keep the Artifacts and Docker Image was pushed to the GCP Artifact Registry (GAR) which was finally deployed to the

Google Kubernetes Engine (GKE) Standard Cluster. The Bank Application Pods was accessed using GKE Ingress for Application Load Balancer and hence using the kubernetes service as shown in the screenshot attached above. I applied GCP Cloud Armor Policy (to Limit the Rate) to the Bank Application URL and to prevent from SQL Injection. As this Bank Application was open to entire world so rate limit and SQL Injection was applied through GCP Cloud Armor Policy so that non-of-the IP Address can access the Bank Application more than 40 times in one minute. There may be the possibility that the Bank Application URL accessed using the Bot (by the Hackers) so that its speed becomes slow or this website hangs to refrain from such a situation GCP Cloud Armor Policy Rate Limit was applied. Finally, I migrated from Terraform to OpenTofu. For GKE Standard Cluster Node-to-Node encryption (in transit) was enabled by setting **in_transit_encryption_config = "IN_TRANSIT_ENCRYPTION_INTER_NODE_TRANSPARENT"** using Terraform.

I implemented Istio for encrypted Pod-to-Pod Communication and implemented **Open Policy Agent Gateway** (Open-Source Policy Engine) and **Falco** to Secure the GKE Standard Cluster. It comes under CNCF Graduated Project and used by Organisation like Allstate, Bloomberg, BNY, CapitalOne, Cisco, Intuit, and Marsh McLennan. The OPA Gatekeeper is a **dynamic admission controller.** I had used Aqua Security Trivy image scan for vulnerability scanning during CI/CD Pipeline as shown in the end-to-end architecture diagram of the project drawn above. In GKE Standard Cluster to enable envelope encryption I used **database_encryption** in Terraform Script. The GCP Customer Managed Encryption Key (CMEK) enables you to rotate it as per the standard followed by your organisation. Usually after 90 days the GCP CMEK Key should be rotated but you can rotate it as per your organisation need. If you use Google Managed Encryption Keys (GMEK) then it will be rotated by Google, however there is no specific number of days after which Google rotates it. In this project I used GCP CMEK for envelope encryption and to encrypt the all the disks used in this project.

In GKE Standard Cluster, however it is possible to encrypt all the disks either by Google Managed Encryption Key (GMEK) or Customer Managed Encryption Key (CMEK) but envelope encryption provides extra layer of security by encrypting the etcd.

For Authentication and Authorization of AWS Account, I installed **aws cli** on GCP VM instance and created an IAM user in AWS account and used its access key and secret key as shown in the screenshot attached below.

```
[root@terraform-server ~]# cat /etc/os-release
NAME="Rocky Linux"
VERSION="8.10 (Green Obsidian)"
ID="rocky"
ID_LIKE="rhel centos fedora"
VERSION_ID="8.10"
PLATFORM_ID="platform:el8"
PRETTY_NAME="Rocky Linux 8.10 (Green Obsidian)"
ANSI_COLOR="0;32"
LOGO="fedora-logo-icon"
CPE_NAME="cpe:/o:rocky:rocky:8:GA"
HOME_URL="https://rockylinux.org/"
BUG_REPORT_URL="https://bugs.rockylinux.org/"
SUPPORT_END="2029-05-31"
ROCKY_SUPPORT_PRODUCT="Rocky-Linux-8"
ROCKY_SUPPORT_PRODUCT_VERSION="8.10"
REDHAT_SUPPORT_PRODUCT="Rocky Linux"
REDHAT_SUPPORT_PRODUCT_VERSION="8.10"
```

Then installed aws-cli using the commands as shown below.

```
curl "https://awscli.amazonaws.com/awscli-exe-linux-x86_64.zip" -o "awscliv2.zip"

unzip awscliv2.zip

sudo ./aws/install
```

```
[root@terraform-server ~]# vim ~/.bashrc
[root@terraform-server ~]# logout
[ritesh@terraform-server ~]$ sudo -i
[root@terraform-server ~]# cat ~/.bashrc
# .bashrc

# User specific aliases and functions

alias rm='rm -i'
alias cp='cp -i'
alias mv='mv -i'

# Source global definitions
if [ -f /etc/bashrc ]; then
        . /etc/bashrc
fi

PATH="$PATH:/usr/local/bin"
[root@terraform-server ~]# echo $PATH
/usr/local/sbin:/sbin:/bin:/usr/sbin:/usr/bin:/usr/local/bin:/root/bin
[root@terraform-server ~]# aws --version
aws-cli/2.30.7 Python/3.13.7 Linux/4.18.0-553.72.1.el8_10.x86_64 exe/x86_64.rocky.8
```

```
[root@terraform-server main]# aws configure
AWS Access Key ID [None]:
AWS Secret Access Key [None]:
Default region name [None]: us-east-2
Default output format [None]: text
```

Terraform script to create the infrastructure is present at the path **terraform-gcp-cloud-dns-aws-acm-certificate** (this terraform script is handy for you to create the GCP Cloud DNS Zone and AWS Certificate Manager SSL Certificate) in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. Commands as written below had been used to create infrastructure using Terraform.

terraform init -------> initializes a working directory containing configuration files and installs plugins for required providers.

terraform validate --------> verify that terraform configuration file is correct or not

terraform plan ---------> Check which resources are going to be created.

Then you can run the command **terraform apply -auto-approve** -----> Finally, Create the resources.

At this point after executing the command **terraform apply -auto-approve** make sure you do the entry for Nameservers of the created GCP Cloud DNS Zone in your domain name service provider's Nameserver. After doing such an entry the terraform script will give the output as written below.

```
      + cloud_dns_zone_id              = (known after apply)
      + gcp_cloud_dns_zone_name_servers = (known after apply)
    }
module.gcp_cloud_dns_zone_aws_certificate.google_dns_managed_zone.dexter_public_zone: Creating...
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate.acm_cert: Creating...
module.gcp_cloud_dns_zone_aws_certificate.google_dns_managed_zone.dexter_public_zone: Creation complete after 0s [id=projects/[redacted]/managedZones
/bankapp-public-zone]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate.acm_cert: Creation complete after 6s [id=arn:aws:acm:us-east-2:02[redacted]6:certificate/[redacted]
]
module.gcp_cloud_dns_zone_aws_certificate.google_dns_record_set.record_cert_validation: Creating...
module.gcp_cloud_dns_zone_aws_certificate.google_dns_record_set.record_cert_validation: Creation complete after 2s [id=projects/[redacted]/managedZon
es/bankapp-public-zone/rrsets/[redacted].singhritesh85.com./CNAME]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Creating...
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m10s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m20s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m30s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m40s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [00m50s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m00s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m10s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Still creating... [01m20s elapsed]
module.gcp_cloud_dns_zone_aws_certificate.aws_acm_certificate_validation.acm_certificate_validation: Creation complete after 1m24s [id=[redacted]
UTC]

Apply complete! Resources: 4 added, 0 changed, 0 destroyed.

Outputs:

gcp_cloud_dns_zone_and_aws_cerificate_arn_details = {
  "certificate_arn" = "arn:aws:acm:us-east-2:02[redacted]6:certificate/[redacted]"
  "cloud_dns_zone_id" = "projects/[redacted]/managedZones/bankapp-public-zone"
  "gcp_cloud_dns_zone_name_servers" = tolist([
    "[redacted]",
    "[redacted]",
    "[redacted]",
    "[redacted]",
  ])
}
```

Now the GCP Cloud DNS Zone and AWS Certificate Manager SSL Certificate became ready. Then I created the GitLab Server using the terraform script **terraform-gitlab-server** present in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. I had created the snapshots of EBS Volume attached to the GitLab Server using the Lifecycle Manager Policy and created the snapshots at 11:00 AM and 11:00 PM UTC (twice a day). The below steps and screenshot show how I had executed the terraform script.

terraform init -------> initializes a working directory containing configuration files and installs plugins for required providers.

terraform validate --------> verify that terraform configuration file is correct or not

terraform plan ---------> Check which resources are going to be created.

Then you can run the command **terraform apply -auto-approve** -----> Finally, Create the resources

```
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: gitlab-kas: (pid 31152) 279s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: gitlab-workhorse: (pid 31913) 20s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: logrotate: (pid 30724) 313s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: nginx: (pid 31923) 19s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: node-exporter: (pid 31934) 19s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: postgres-exporter: (pid 31981) 14s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: postgresql: (pid 30904) 290s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: prometheus: (pid 31958) 17s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: puma: (pid 31344) 148s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: redis: (pid 30770) 307s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: redis-exporter: (pid 31950) 18s
module.gitlab.null_resource.gitlab_server (remote-exec): ok: run: sidekiq: (pid 31845) 36s
module.gitlab.null_resource.gitlab_server (remote-exec): run: alertmanager: (pid 31973) 17s; run: log: (pid 31701) 100s
module.gitlab.null_resource.gitlab_server (remote-exec): run: gitaly: (pid 31939) 20s; run: log: (pid 30838) 300s
module.gitlab.null_resource.gitlab_server (remote-exec): run: gitlab-exporter: (pid 31948) 20s; run: log: (pid 31588) 118s
module.gitlab.null_resource.gitlab_server (remote-exec): run: gitlab-kas: (pid 31152) 281s; run: log: (pid 31162) 280s
module.gitlab.null_resource.gitlab_server (remote-exec): run: gitlab-workhorse: (pid 31913) 22s; run: log: (pid 31443) 136s
module.gitlab.null_resource.gitlab_server (remote-exec): run: logrotate: (pid 30724) 315s; run: log: (pid 30732) 314s
module.gitlab.null_resource.gitlab_server (remote-exec): run: nginx: (pid 31923) 21s; run: log: (pid 31496) 128s
module.gitlab.null_resource.gitlab_server (remote-exec): run: node-exporter: (pid 31934) 21s; run: log: (pid 31553) 122s
module.gitlab.null_resource.gitlab_server (remote-exec): run: postgres-exporter: (pid 31981) 16s; run: log: (pid 31738) 94s
module.gitlab.null_resource.gitlab_server (remote-exec): run: postgresql: (pid 30904) 292s; run: log: (pid 30928) 289s
module.gitlab.null_resource.gitlab_server (remote-exec): run: prometheus: (pid 31958) 19s; run: log: (pid 31663) 104s
module.gitlab.null_resource.gitlab_server (remote-exec): run: puma: (pid 31344) 150s; run: log: (pid 31357) 147s
module.gitlab.null_resource.gitlab_server (remote-exec): run: redis: (pid 30770) 309s; run: log: (pid 30779) 308s
module.gitlab.null_resource.gitlab_server (remote-exec): run: redis-exporter: (pid 31950) 20s; run: log: (pid 31619) 112s
module.gitlab.null_resource.gitlab_server (remote-exec): run: sidekiq: (pid 31845) 38s; run: log: (pid 31386) 141s
module.gitlab.null_resource.gitlab_server: Creation complete after 12m38s [id=[redacted]]

Apply complete! Resources: 39 added, 0 changed, 0 destroyed.

Outputs:

ec2_private_ip_alb_dns = {
  "EC2_Instance_GitLab_Server_Private_IP_Address" = "10.[redacted]"
  "GitLab_ALB_DNS_Name" = "gitlab-[redacted].us-east-2.elb.amazonaws.com"
}
```

Then I created the other GCP Resources using the terraform script present at the path **terraform-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek** in the GitHub Repo https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git. As a part of disaster recovery, I created the Lifecycle Policy to create the EBS backed AMI periodically 11:00 AM and 11:00 PM UTC (twice daily) for SonarQube and Nexus Server, snapshot schedule for gitlab-runner and GKE backup plan to take the backup daily twice a day (11:00 AM UTC and 11:00 PM UTC).

terraform init -------> initializes a working directory containing configuration files and installs plugins for required providers.

terraform validate --------> verify that terraform configuration file is correct or not

terraform plan ---------> Check which resources are going to be created.

Then you can run the command **terraform apply -auto-approve** -----> Finally, Create the resources.

The final GKE Cluster is as shown in the screenshot attached below.

```
[root@                    ~]# gcloud --version
Google Cloud SDK 526.0.0
alpha 2025.06.06
beta 2025.06.06
bq 2.1.18
bundled-python3-unix 3.12.9
core 2025.06.06
gcloud-crc32c 1.0.0
gke-gcloud-auth-plugin 0.5.10
gsutil 5.34
kubectl 1.33.4
```

```
[root@                    ~]# gcloud auth login

You are running on a Google Compute Engine virtual machine.
It is recommended that you use service accounts for authentication.

You can run:

  $ gcloud config set account `ACCOUNT`

to switch accounts if necessary.

Your credentials may be visible to others with access to this
virtual machine. Are you sure you want to authenticate with
your personal account?

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

Go to the following link in your browser, and complete the sign-in prompts:

                                                                                

Once finished, enter the verification code provided in your browser:

You are now logged in as [                ].
Your current project is [                ].  You can change this setting by running:
  $ gcloud config set project PROJECT_ID
[root@                    ~]# gcloud container clusters get-credentials bankapp-gke-cluster --region us-central1 --project                
Fetching cluster endpoint and auth data.
kubeconfig entry generated for bankapp-gke-cluster.
```

Status	Name ↑	Location	Number of nodes	Total vCPUs	Total memory	Notifications	Labels
✓	bankapp-gke-cluster	us-central1	2	4	8 GB		goog-terra... : true

```
[root@                    ~]# kubectl get nodes
NAME                                                  STATUS   ROLES    AGE     VERSION
gke-bankapp-gke-clus-bankapp-linux-no-                Ready    <none>   7m51s   v1.33.4-gke.1172000
gke-bankapp-gke-clus-bankapp-linux-no-                Ready    <none>   7m56s   v1.33.4-gke.1172000
```

Installation of OPA Gateway Policy Engine

I had installed OPA Gateway as shown in the screenshot attached below.

helm repo add gatekeeper https://open-policy-agent.github.io/gatekeeper/charts

helm repo update

helm install gatekeeper/gatekeeper --name-template=gatekeeper --namespace gatekeeper-system --create-namespace

kubectl get pods -n gatekeeper-system

```
[root@                    ~]# helm repo add gatekeeper https://open-policy-agent.github.io/gatekeeper/charts
"gatekeeper" has been added to your repositories
[root@                    ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "gatekeeper" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@                    ~]# helm install gatekeeper/gatekeeper --name-template=gatekeeper --namespace gatekeeper-system --create-namespace
NAME: gatekeeper
LAST DEPLOYED:                    2025
NAMESPACE: gatekeeper-system
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

```
[root@                    ~]# kubectl get pods -n gatekeeper-system
NAME                                             READY   STATUS    RESTARTS   AGE
gatekeeper-audit-                                1/1     Running   0          89s
gatekeeper-controller-manager-                   1/1     Running   0          88s
gatekeeper-controller-manager-                   1/1     Running   0          89s
gatekeeper-controller-manager-                   1/1     Running   0          88s
```

You can check the logs for OPA using the command as shown in the screenshot attached below.

kubectl logs -l control-plane=audit-controller -n gatekeeper-system

```
[root@                    ~]# kubectl logs -l control-plane=audit-controller -n gatekeeper-system
{"level":"info","ts":1758704970.2340465,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-24T09:09:30Z","event_type":"audit_finished","duration":"29.946014ms"}
{"level":"info","ts":1758705030.2034974,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-24T09:10:30Z","event_type":"audit_started"}
{"level":"info","ts":1758705030.2696376,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-24T09:10:30Z","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758705030.2696836,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-24T09:10:30Z","event_type":"audit_finished","duration":"66.219891ms"}
{"level":"info","ts":1758705090.204344,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-24T09:11:30Z","event_type":"audit_started"}
{"level":"info","ts":1758705090.2350106,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-24T09:11:30Z","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758705090.235044,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-24T09:11:30Z","event_type":"audit_finished","duration":"30.736843ms"}
{"level":"info","ts":1758705150.2046235,"logger":"controller","msg":"auditing constraints and violations","process":"audit","audit_id":"2025-09-24T09:12:30Z","event_type":"audit_started"}
{"level":"info","ts":1758705150.2507365,"logger":"controller","msg":"no constraint is found with apiversion","process":"audit","audit_id":"2025-09-24T09:12:30Z","constraint apiversion":"constraints.gatekeeper.sh/v1beta1"}
{"level":"info","ts":1758705150.2507737,"logger":"controller","msg":"auditing is complete","process":"audit","audit_id":"2025-09-24T09:12:30Z","event_type":"audit_finished","duration":"46.185006ms"}
```

Here, I created OPA Policy (Constraint Template and Constraint) which will disallow the creation of pod with container had the capability of host machine (Privileged = true) and elevated privileges (allowPrivilegeEscalation = true) in the namespace bankapp and mysql, and no one can create the LoadBalancer Service in the namespace bankapp and mysql. If anyone wants to create the service, then create the ClusterIP service and expose the pods using Ingress Rule through the created ClusterIP service. It will also not allow anyone to use the Image with latest tag and do not allow to create the Resources Pod, Deployment, Statefulset or Daemonset in the namespace mysql and bankapp if require resource requests and limits per Pod is not mentioned.

```
[root@                    ~]# kubectl apply -f constrainttemplate.yaml
constrainttemplate.templates.gatekeeper.sh/k8sdisallowprivileged created
constrainttemplate.templates.gatekeeper.sh/loadbalancerconstraint created
constrainttemplate.templates.gatekeeper.sh/k8scontainerresourcerequirements created
constrainttemplate.templates.gatekeeper.sh/k8sdisallowedtags created
[root@                    ~]# kubectl apply -f constraint.yaml
k8sdisallowprivileged.constraints.gatekeeper.sh/psp-privileged-container created
loadbalancerconstraint.constraints.gatekeeper.sh/loadbalancerconstraint created
k8scontainerresourcerequirements.constraints.gatekeeper.sh/pod-resource-requirements created
k8sdisallowedtags.constraints.gatekeeper.sh/container-image-must-not-have-latest-tag created
```

You can list the constraint template and constraint currently deployed and used in the cluster using the command **kubectl get constrainttemplate** and **kubectl get constraints** respectively.

```
[root@                    ~]# kubectl get constrainttemplate
NAME                              AGE
k8scontainerresourcerequirements   2m6s
k8sdisallowedtags                  2m5s
k8sdisallowprivileged              2m6s
loadbalancerconstraint             2m6s
[root@                    ~]# kubectl get constraint
NAME                                                                    ENFORCEMENT-ACTION   TOTAL-VIOLATIONS
k8scontainerresourcerequirements.constraints.gatekeeper.sh/pod-resource-requirements   deny                 0

NAME                                                                    ENFORCEMENT-ACTION   TOTAL-VIOLATIONS
k8sdisallowedtags.constraints.gatekeeper.sh/container-image-must-not-have-latest-tag   deny                 0

NAME                                                                ENFORCEMENT-ACTION   TOTAL-VIOLATIONS
k8sdisallowprivileged.constraints.gatekeeper.sh/psp-privileged-container   deny                 0

NAME                                                                ENFORCEMENT-ACTION   TOTAL-VIOLATIONS
loadbalancerconstraint.constraints.gatekeeper.sh/loadbalancerconstraint   deny                 0
```

The constrainttemplate.yaml and constraint.yaml files used are same as that was used and provided in **Module-1**.

Installation of Falco in GKE Standard Cluster

Falco is a tool that captures and analyses logs within a runtime environment to detect suspicious and malicious activity. I had installed here Falco with the custom rule that if anyone will try to access the **/etc** directory to write in a file then its logs will be captured by the Falco.

cat dexter-falco-rule.yaml

```
customRules:
  custom-rules.yaml: |-
    - rule: Write below etc
      desc: An attempt to write to /etc directory
      condition: >
        (evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)
        and fd.name startswith /etc
      output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline
gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname[4] evt_type=%evt.type
user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name
proc_exepath=%proc.exepath parent=%proc.pname command=%proc.cmdline terminal=%proc.tty"
      priority: WARNING
      tags: [filesystem, mitre_persistence]
```

helm repo add falcosecurity https://falcosecurity.github.io/charts

helm repo update

helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosidekick.enabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false

kubectl get pods -n falco --watch

```
[root@                    ~]# helm repo add falcosecurity https://falcosecurity.github.io/charts
"falcosecurity" has been added to your repositories
[root@                    ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "gatekeeper" chart repository
...Successfully got an update from the "falcosecurity" chart repository
Update Complete. ⎈Happy Helming!⎈
```

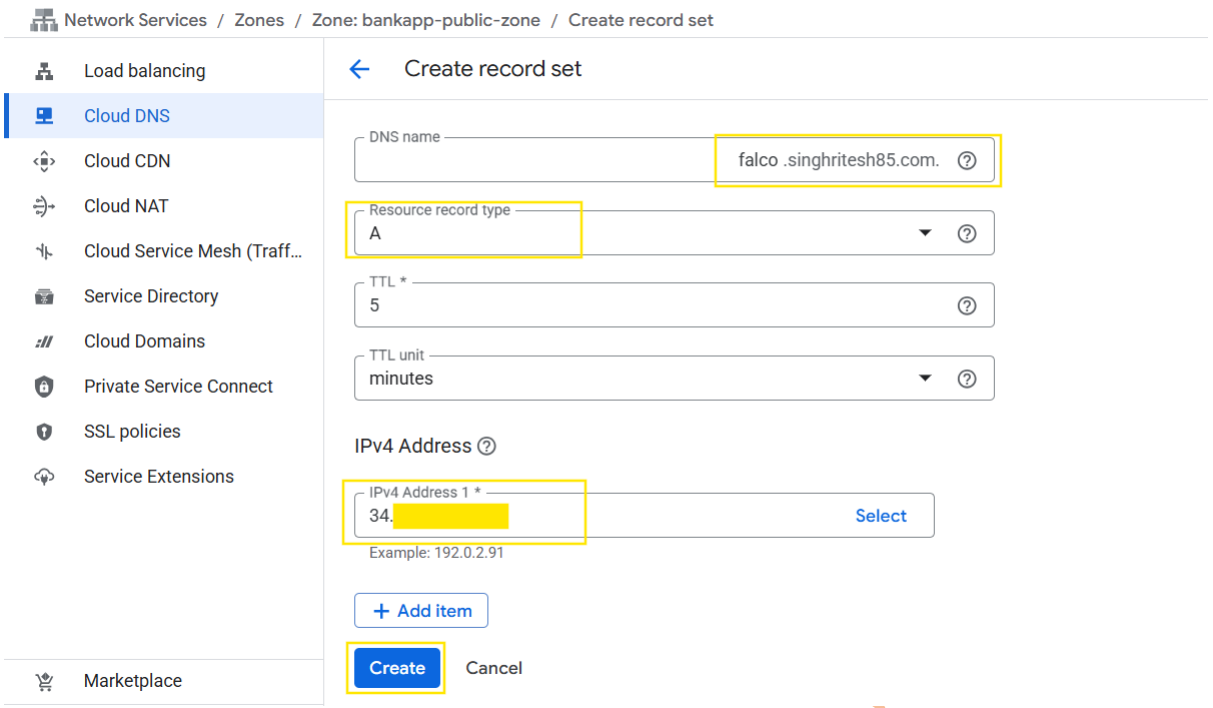
```
[root@                    ~]# cat dexter-falco-rule.yaml
customRules:
  custom-rules.yaml: |-
    - rule: Write below etc
      desc: An attempt to write to /etc directory
      condition: >
        (evt.type in (open,openat,openat2) and evt.is_open_write=true and fd.typechar='f' and fd.num>=0)
        and fd.name startswith /etc
      output: "File below /etc opened for writing | file=%fd.name pcmdline=%proc.pcmdline gparent=%proc.aname[2] ggparent=%proc.aname[3] gggparent=%proc.aname
[4] evt_type=%evt.type user=%user.name user_uid=%user.uid user_loginuid=%user.loginuid process=%proc.name proc_exepath=%proc.exepath parent=%proc.pname comman
d=%proc.cmdline terminal=%proc.tty"
      priority: WARNING
      tags: [filesystem, mitre_persistence]

[root@                    ~]# helm upgrade --install falco falcosecurity/falco -f dexter-falco-rule.yaml --namespace falco --create-namespace --set falcosid
ekick.enabled=true --set falcosidekick.webui.enabled=true --set falcosidekick.webui.redis.storageEnabled=false
```

I had created Ingress Rule for Falco as shown in the screenshot attached below.

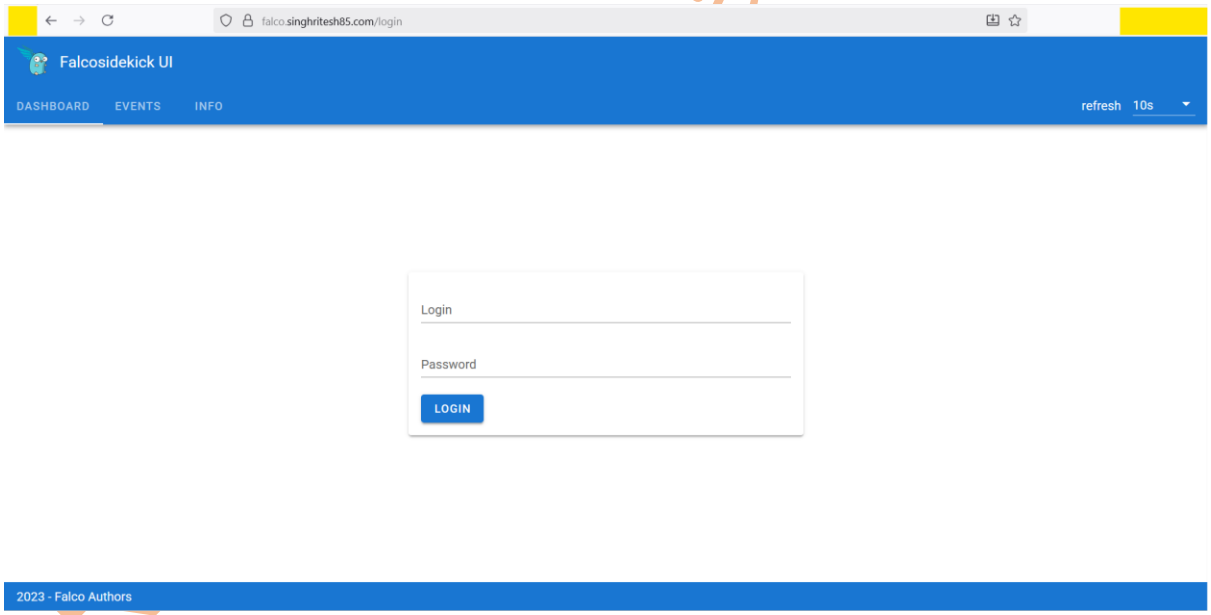
```
[root@                    ~]# kubectl create secret tls ingress-secret --key server.key --cert f                a.crt -n falco
secret/ingress-secret created
[root@                    ~]# cat falco-ingress-rule.yaml
# kubectl create secret tls ingress-secret --key server.key --cert f                a.crt -n falco
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    kubernetes.io/ingress.class: "gce" ### Specify the Ingress class
    kubernetes.io/ingress.allow-http: "false"
spec:
  ingressClassName: "gce"
  tls:
  - hosts:
    - falco.singhritesh85.com
    secretName: ingress-tls
  rules:
  - host: "falco.singhritesh85.com"
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: falco-falcosidekick-ui
            port:
              number: 2802
[root@                    ~]# kubectl apply -f falco-ingress-rule.yaml
ingress.networking.k8s.io/falco-ui-ingress created
```

```
[root@                    ~]# kubectl get ing -A
NAMESPACE   NAME               CLASS   HOSTS                   ADDRESS          PORTS     AGE
falco       falco-ui-ingress   gce     falco.singhritesh85.com   34.              80, 443   2m58s
```

I did the entry for Ingress HOSTS with External IP Address in GCP Cloud DNS Zone to create the Record Set of A-Type as shown in the screenshot attached below.



Finally, I was able to access Falco UI as shown in the screenshot attached below. You can login with username and password admin and admin respectively.



It is also possible to check falco logs using the command

kubectl logs -l "app.kubernetes.io/instance=falco" -n falco

```
cat falco-ingress-rule.yaml
# kubectl create secret tls ingress-tls --key server.key --cert XXXXXXXXXXXXXXXX.crt -n falco
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: falco-ui-ingress
  namespace: falco
  annotations:
    kubernetes.io/ingress.class: "gce" ### Specify the Ingress class
    kubernetes.io/ingress.allow-http: "false"
spec:
  ingressClassName: "gce"
  tls:
  - hosts:
    - falco.singhritesh85.com
    secretName: ingress-tls
  rules:
  - host: "falco.singhritesh85.com"
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: falco-falcosidekick-ui
            port:
              number: 2802
```

Installation of Istio in GKE Standard Cluster using Helm

To install Istio Service mesh using helm chart use the command as written below.

helm repo add istio https://istio-release.storage.googleapis.com/charts

helm repo update

kubectl create ns istio-system

helm install istio-base istio/base -n istio-system

helm install istiod istio/istiod -n istio-system

```
[root@                ~]# helm repo add istio https://istio-release.storage.googleapis.com/charts
"istio" has been added to your repositories
[root@                ~]# helm repo update
Hang tight while we grab the latest from your chart repositories...
...Successfully got an update from the "falcosecurity" chart repository
...Successfully got an update from the "istio" chart repository
...Successfully got an update from the "kyverno" chart repository
Update Complete. ⎈Happy Helming!⎈
[root@                ~]# kubectl create ns istio-system
namespace/istio-system created
```

```
[root@                ~]# helm install istio-base istio/base -n istio-system
```

```
[root@                ~]# helm install istiod istio/istiod -n istio-system
```

To establish mesh-wide mTLS I created the peer authentication as shown in the screenshot attached below.

cat peerauthentication.yaml

apiVersion: security.istio.io/v1

kind: PeerAuthentication

metadata:

  name: "default"

  namespace: istio-system

spec:

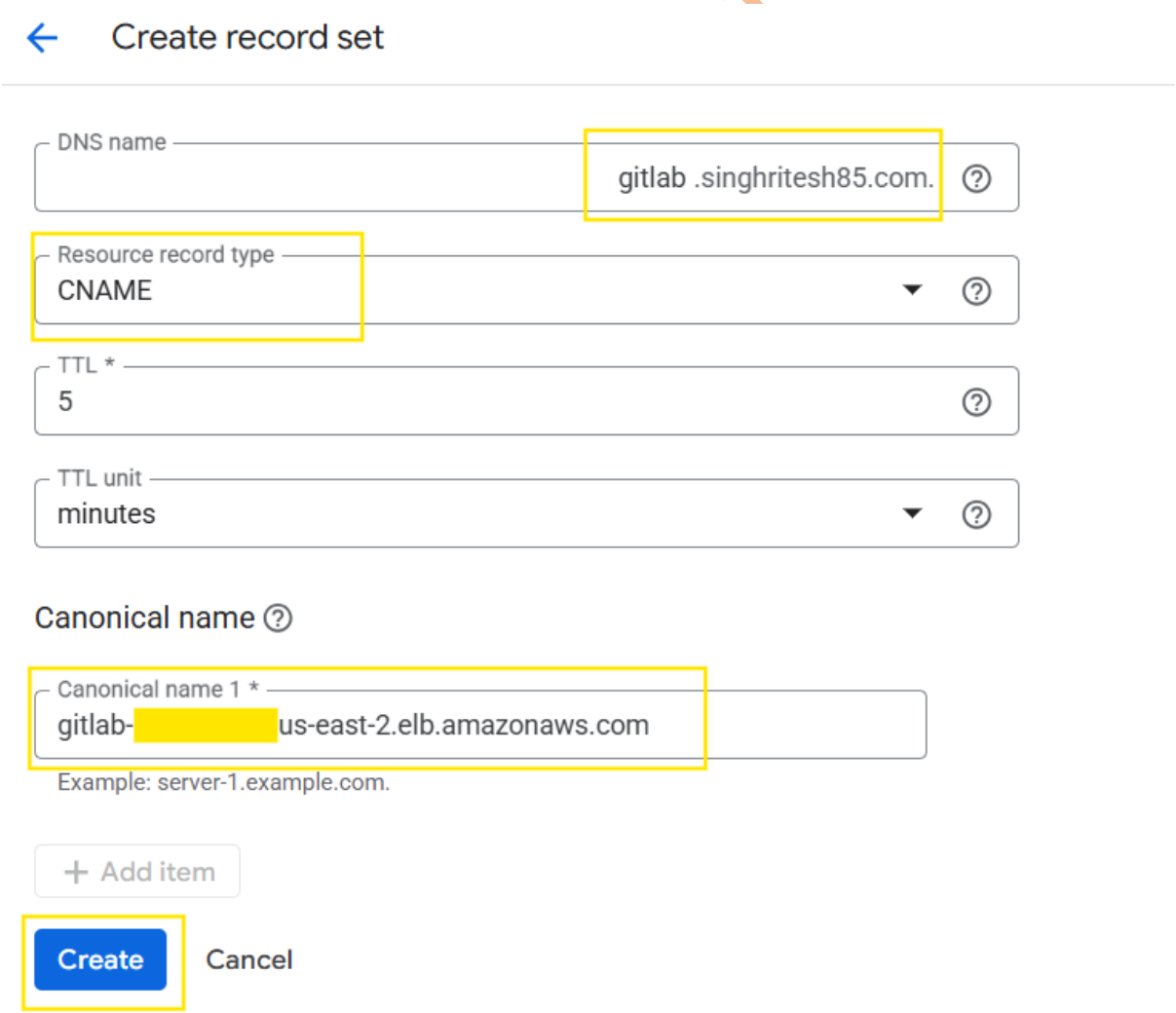
  mtls:

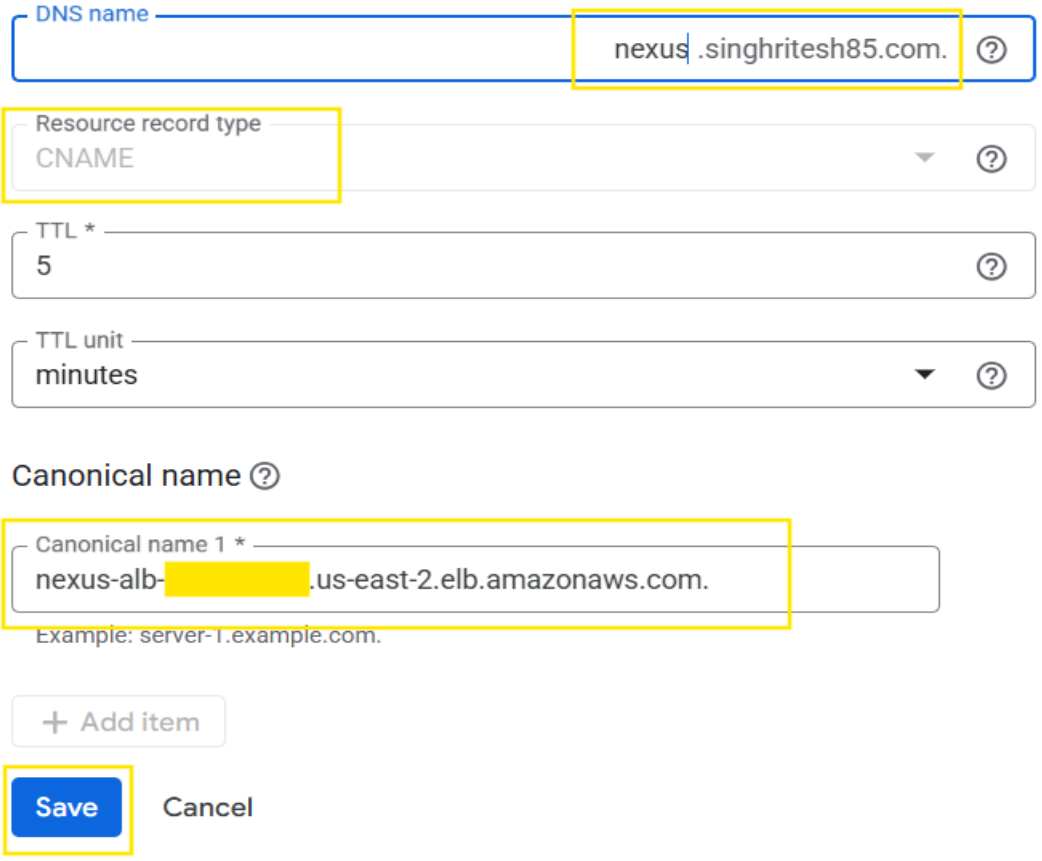
    mode: STRICT

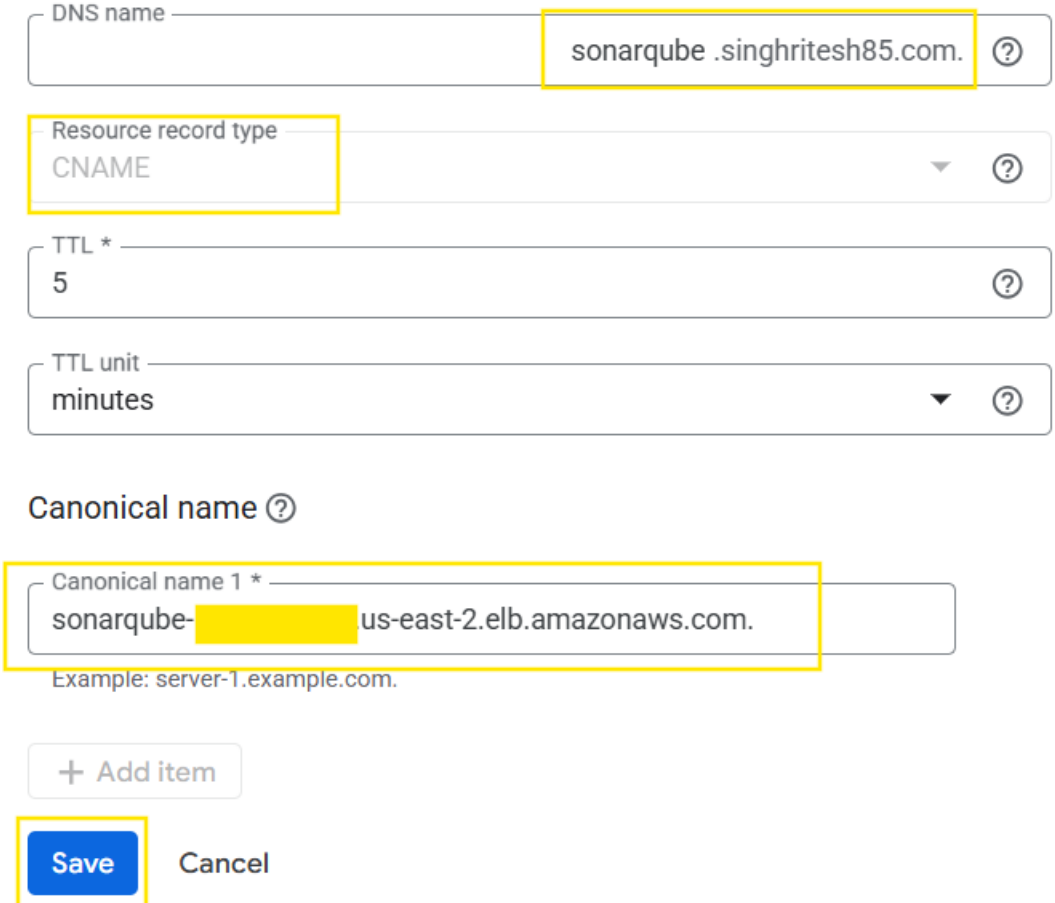
```
[root@                ~]# cat peerauthentication.yaml
apiVersion: security.istio.io/v1
kind: PeerAuthentication
metadata:
  name: "default"
  namespace: istio-system
spec:
  mtls:
    mode: STRICT
[root@                ~]# kubectl apply -f peerauthentication.yaml
peerauthentication.security.istio.io/default created
```

```
[root@                ~]# kubectl get peerauthentication -n istio-system
NAME      MODE     AGE
default   STRICT   38s
```

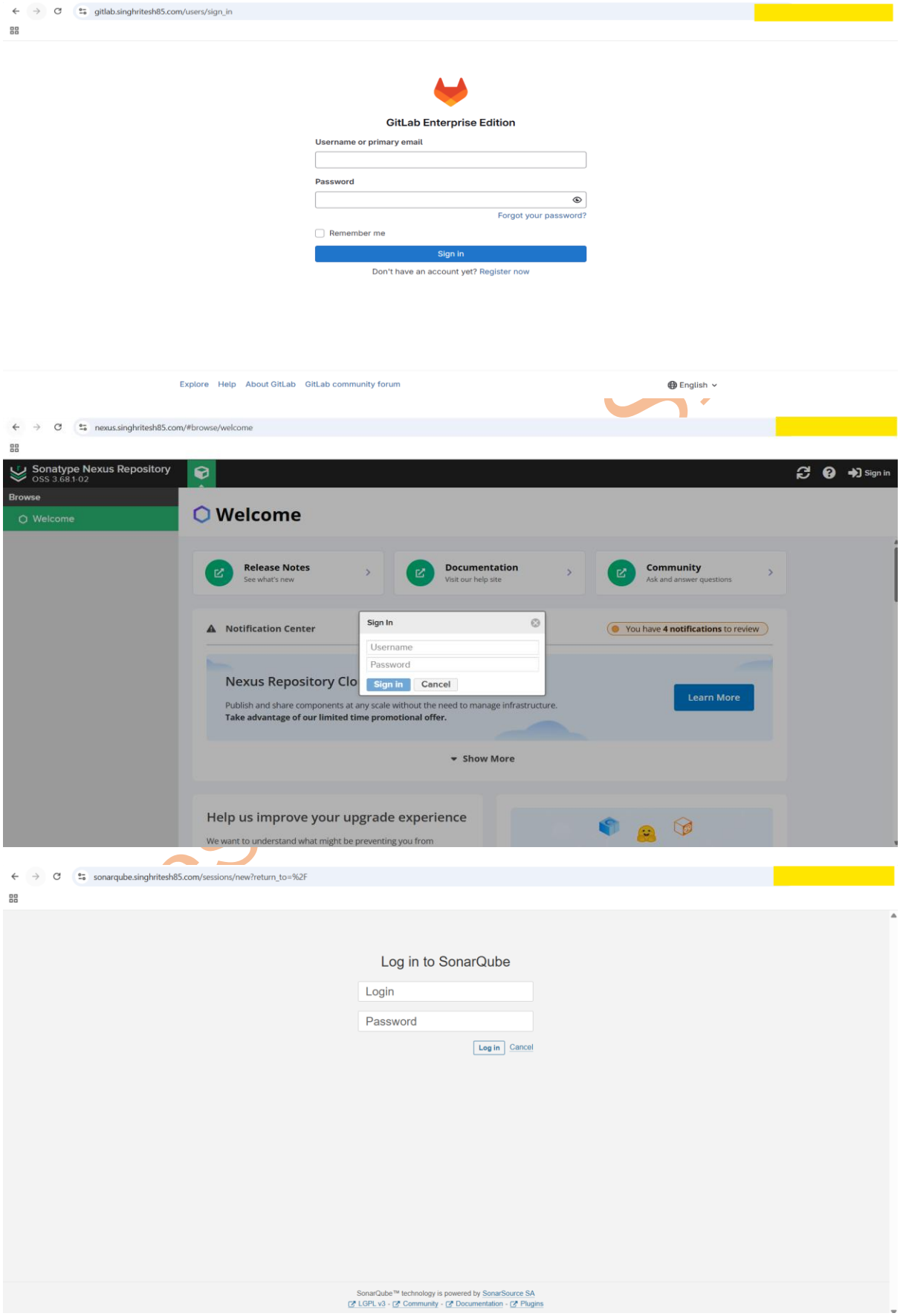
At this stage GKE Standard Cluster is Ready, Now I will do the entry for GitLab LoadBalancer DNS Name, Sonatype Nexus LoadBalancer DNS Name and SonarQube LoadBalancer DNS Name in the GCP Cloud DNS Zone to create the three Record Set of CNAME Type as shown in the screenshot attached below.



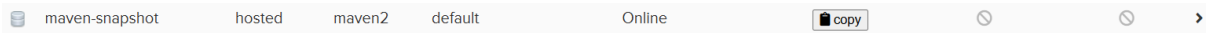

DNS name
nexus .singhritesh85.com.
Resource record type
CNAME
TTL *
5
TTL unit
minutes
Canonical name
Canonical name 1 *
nexus-alb- .us-east-2.elb.amazonaws.com.
Example: server-1.example.com.
Add item
Save
Cancel


DNS name
sonarqube .singhritesh85.com.
Resource record type
CNAME
TTL *
5
TTL unit
minutes
Canonical name
Canonical name 1 *
sonarqube- us-east-2.elb.amazonaws.com.
Example: server-1.example.com.
Add item
Save
Cancel

After creating CNAME Type Record Set in GCP Cloud DNS Zone I was able to access GitLab, Nexus Artifactory and SonarQube as shown in the screenshot attached below.



I had created a Repository in Sonatype Nexus with the name **maven-snapshot** as shown in the screenshot attached below.



For first time login-into the GitLab UI you need root password which was present at the path **/etc/gitlab/initial_root_password** on the GitLab Server (EC2 Instance) as shown in the screenshot attached below.

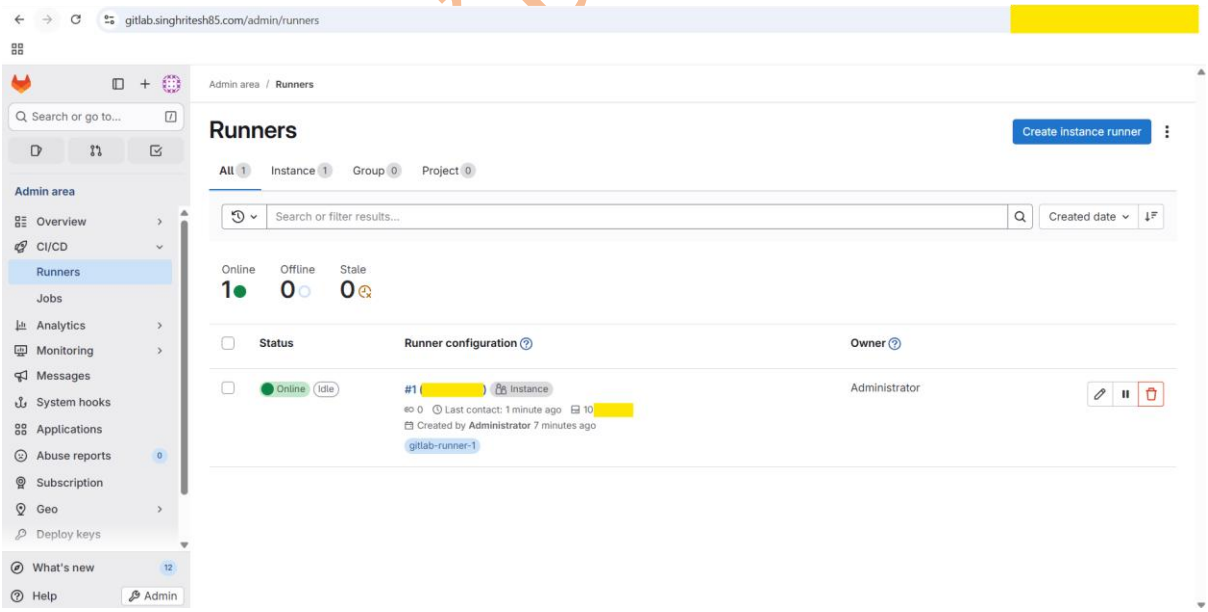
```
[root@gitlab-server ~]# cat /etc/gitlab/initial_root_password
# WARNING: This value is valid only in the following conditions
#          1. If provided manually (either via `GITLAB_ROOT_PASSWORD` environment variable or via `gitlab_rails['initial_root_password']` setting in `gitlab.r
b`, it was provided before database was seeded for the first time (usually, the first reconfigure run).
#          2. Password hasn't been changed manually, either via UI or via command line.
#
#          If the password shown here doesn't work, you must reset the admin password following https://docs.gitlab.com/ee/security/reset_user_password.html#r
eset-your-root-password.

Password: [redacted]

# NOTE: This file will be automatically deleted in the first reconfigure run after 24 hours.
```

After login for the first time, I changed the admin password.

Configure GitLab Runner as shown in the screenshot attached below.

```
[root@bankapp-gitlab-runner ~]# gitlab-runner register
Runtime platform                                    arch=amd64 os=linux pid=[redacted] revision=[redacted] version=18.4.0
Running in system-mode.

Enter the GitLab instance URL (for example, https://gitlab.com/):
https://gitlab.singhritesh85.com
Enter the registration token:
[redacted]
Verifying runner... is valid                        correlation_id=[redacted] runner=[redacted]
Enter a name for the runner. This is stored only in the local config.toml file:
[bankapp-gitlab-runner]: gitlab-runner-1
Enter an executor: custom, shell, ssh, virtualbox, docker-windows, docker+machine, kubernetes, docker-autoscaler, parallels, docker, instance:
shell
Runner registered successfully. Feel free to start it, but if it's running already the config should be automatically reloaded!

Configuration (with the authentication token) was saved in "/etc/gitlab-runner/config.toml"
```

Now you can see Runner had been configured as shown in the screenshot attached below.



Then open the file **/etc/gitlab-runner/config.toml** and configured clone_url = "https://gitlab.singhritesh85.com" as shown in the screenshot attached below.

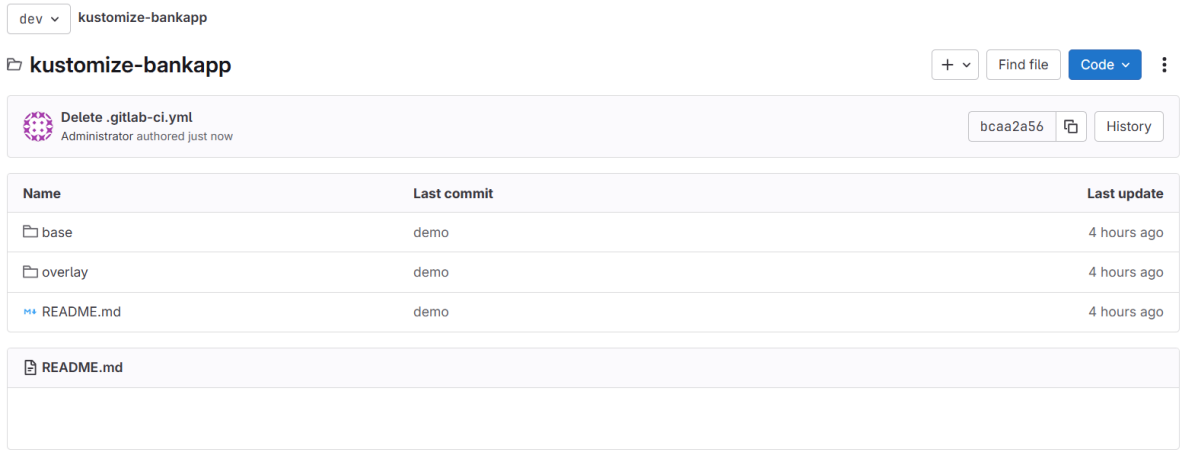
```
[root@bankapp-gitlab-runner ~]# vim /etc/gitlab-runner/config.toml
```

```
concurrent = 1
check_interval = 0
connection_max_age = "15m0s"
shutdown_timeout = 0

[session_server]
  session_timeout = 1800

[[runners]]
  name = "gitlab-runner-1"
  url = "https://gitlab.singhritesh85.com"
  clone_url = "https://gitlab.singhritesh85.com"
  id = 1
  token = "                                                                    "
  token_obtained_at = 2025
  token_expires_at =
  executor = "shell"
  [runners.cache]
    MaxUploadedArchiveSize = 0
    [runners.cache.s3]
    [runners.cache.gcs]
    [runners.cache.azure]
```

I created two Repository in GitLab named as **kustomize-bankapp** and then pushed the source code and Kustomize Manifests Yaml files to the GitLab Repository as shown in the screenshot attached below.

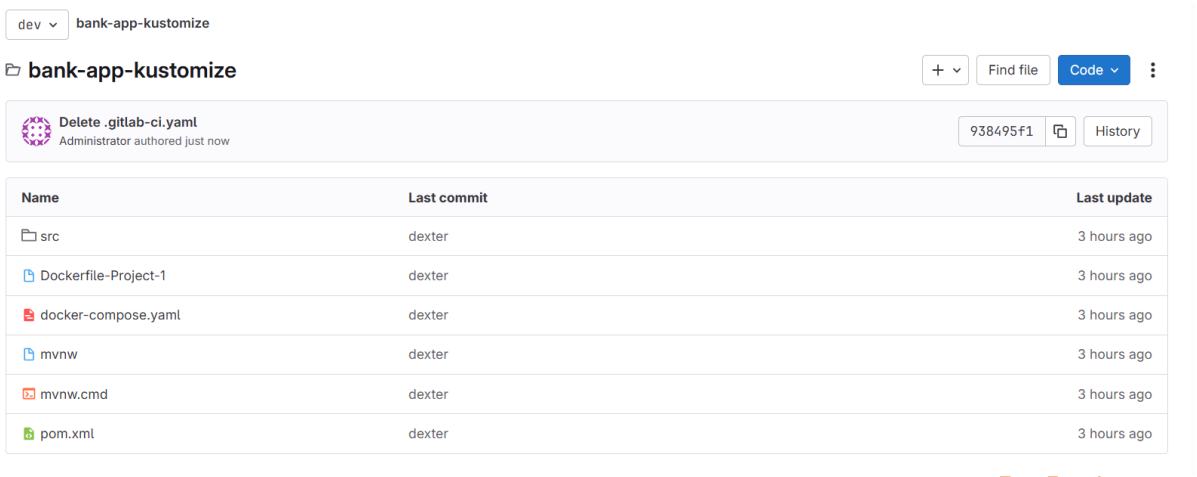
```
[root@                    ~]# cd demo/
[root@                    demo]# git init
hint: Using 'master' as the name for the initial branch. This default branch name
hint: is subject to change. To configure the initial branch name to use in all
hint: of your new repositories, which will suppress this warning, call:
hint:
hint:   git config --global init.defaultBranch <name>
hint:
hint: Names commonly chosen instead of 'master' are 'main', 'trunk' and
hint: 'development'. The just-created branch can be renamed via this command:
hint:
hint:   git branch -m <name>
Initialized empty Git repository in /root/demo/.git/
[root@                    demo]# git config --local user.name "Administrator"
[root@                    demo]# git config --local user.email "          @gmail.com"
[root@                    demo]# git remote add origin https://          @gitlab.singhritesh85.com/dexter/kustomize-bankapp.git
[root@                    demo]# cd
[root@                    ~]# git clone --branch dev https://github.com/singhritesh85/kustomize-bankapp.git
Cloning into 'kustomize-bankapp'...
remote: Enumerating objects: 199, done.
remote: Counting objects: 100% (6/6), done.
remote: Compressing objects: 100% (6/6), done.
remote: Total 199 (delta 2), reused 0 (delta 0), pack-reused 193 (from 1)
Receiving objects: 100% (199/199), 44.83 KiB | 882.00 KiB/s, done.
Resolving deltas: 100% (73/73), done.
[root@                    ~]# cp -r kustomize-bankapp/* demo/
[root@                    ~]# cd demo/
[root@                    demo]# git checkout -b dev
Switched to a new branch 'dev'
[root@                    demo]# git add .
[root@                    demo]# git commit -m "demo"
[dev (root-commit) 0      8] demo
 10 files changed, 149 insertions(+)
 create mode 1     4 README.md
```

```
[root@                          demo]# git push origin dev
Enumerating objects: 18, done.
Counting objects: 100% (18/18), done.
Delta compression using up to 2 threads
Compressing objects: 100% (15/15), done.
Writing objects: 100% (18/18), 2.58 KiB | 880.00 KiB/s, done.
Total 18 (delta 1), reused 0 (delta 0), pack-reused 0
To https://gitlab.singhritesh85.com/dexter/kustomize-bankapp.git
```

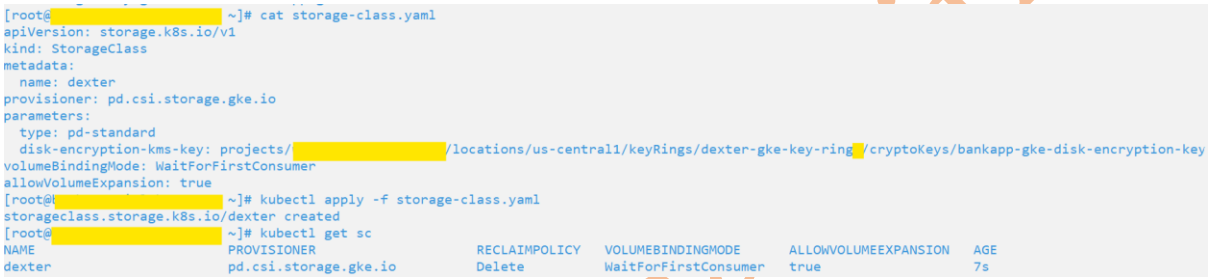



```
[root@                    ~]# mkdir bolo
[root@                    ~]# cd bolo/
[root@                    bolo]# git init
hint: Using 'master' as the name for the initial branch. This default branch name
hint: is subject to change. To configure the initial branch name to use in all
hint: of your new repositories, which will suppress this warning, call:
hint:
hint:   git config --global init.defaultBranch <name>
hint:
hint: Names commonly chosen instead of 'master' are 'main', 'trunk' and
hint: 'development'. The just-created branch can be renamed via this command:
hint:
hint:   git branch -m <name>
Initialized empty Git repository in /root/bolo/.git/
[root@                    bolo]# git config --local user.name "Administrator"
[root@                    bolo]# git config --local user.email "              @gmail.com"
[root@                    bolo]# git remote add origin https://              @gitlab.singhritesh85.com/dexter/bank-app-kustomize.git
[root@                    bolo]# cd
[root@                    ~]# git clone --branch main https://github.com/singhritesh85/Bank-App-Kustomize.git
Cloning into 'Bank-App-Kustomize'...
remote: Enumerating objects: 51, done.
remote: Counting objects: 100% (51/51), done.
remote: Compressing objects: 100% (38/38), done.
remote: Total 51 (delta 5), reused 0 (delta 0), pack-reused 0 (from 0)
Receiving objects: 100% (51/51), 21.62 KiB | 3.09 MiB/s, done.
Resolving deltas: 100% (5/5), done.
[root@                    ~]# cp -r Bank-App-Kustomize/* bolo/
[root@                    ~]# cd bolo/
[root@                    bolo]# git checkout -b dev
Switched to a new branch 'dev'
[root@                    bolo]# git add .
[root@                    bolo]# git commit -m "dexter"
```

```
[root@                              bolo]# git push origin dev
Enumerating objects: 42, done.
Counting objects: 100% (42/42), done.
Delta compression using up to 2 threads
Compressing objects: 100% (29/29), done.
Writing objects: 100% (42/42), 18.13 KiB | 2.01 MiB/s, done.
Total 42 (delta 2), reused 0 (delta 0), pack-reused 0
To https://gitlab.singhritesh85.com/dexter/bank-app-kustomize.git
 * [new branch]      dev -> dev
```



Then I created the storage class as shown in the screenshot attached below.



cat storage-class.yaml

apiVersion: storage.k8s.io/v1

kind: StorageClass

metadata:

name: dexter

provisioner: pd.csi.storage.gke.io

parameters:

type: pd-standard

disk-encryption-kms-key: projects/XXXX-XXXXXXX-XXXXXX/locations/us-central1/keyRings/dexter-gke-key-ring/cryptoKeys/bankapp-gke-disk-encryption-key

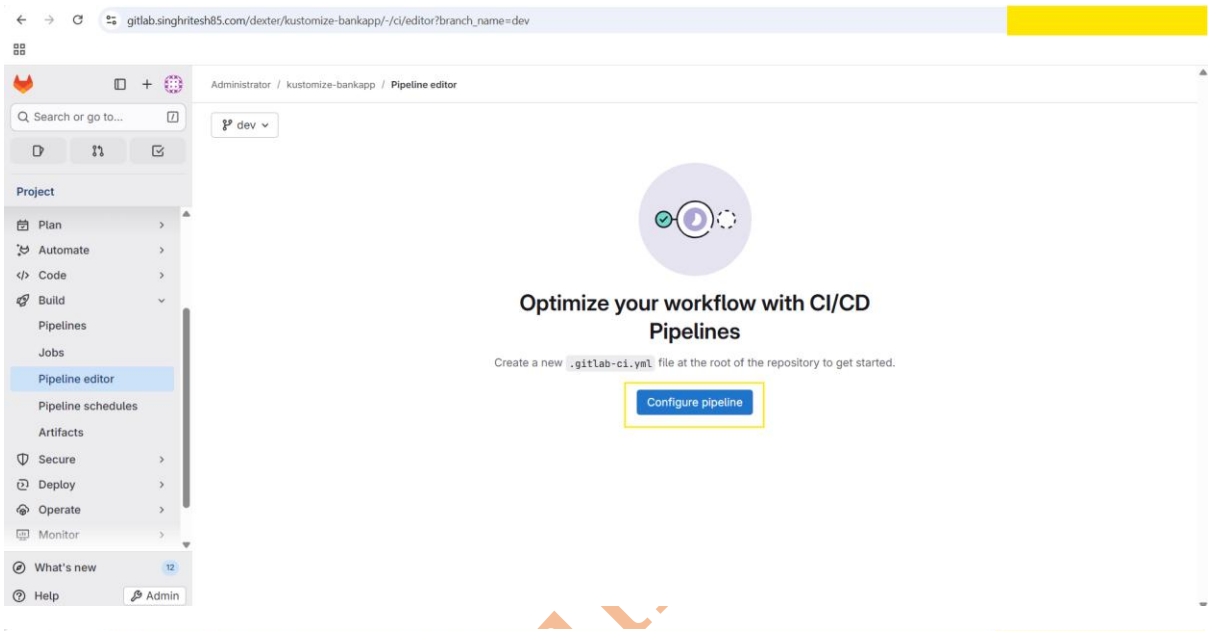
volumeBindingMode: WaitForFirstConsumer

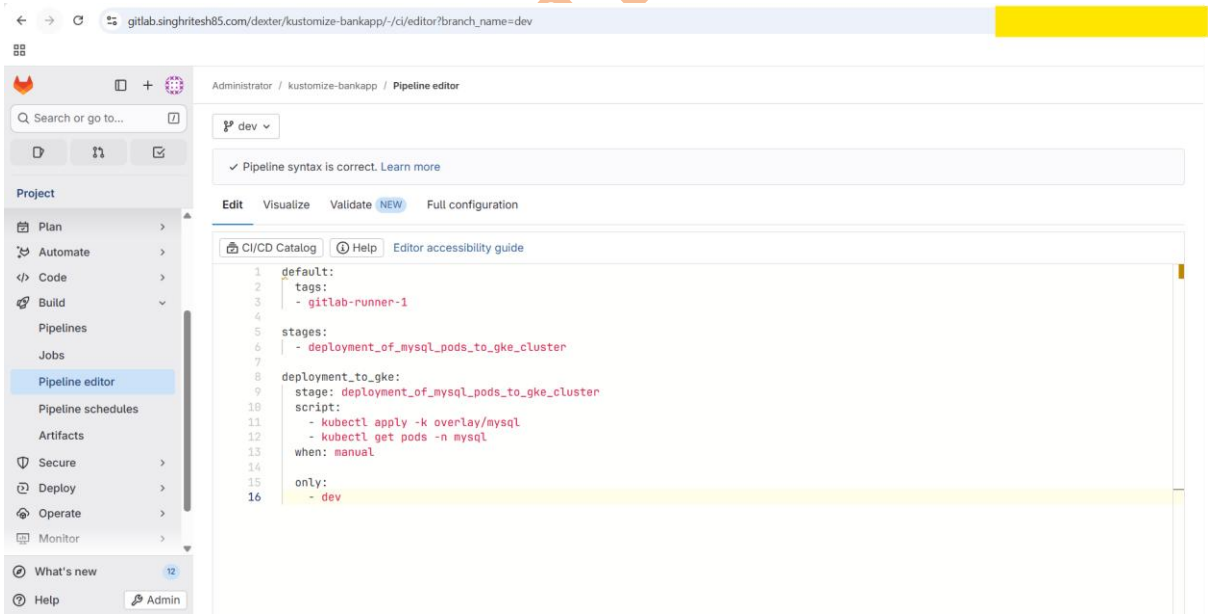
allowVolumeExpansion: true

After Creation of Storage Class, I had created the two namespaces **mysql** and **bankapp** then I had created the first GitLab CI/CD Pipeline to deploy MySQL 8 Pods as shown in the screenshot attached below.

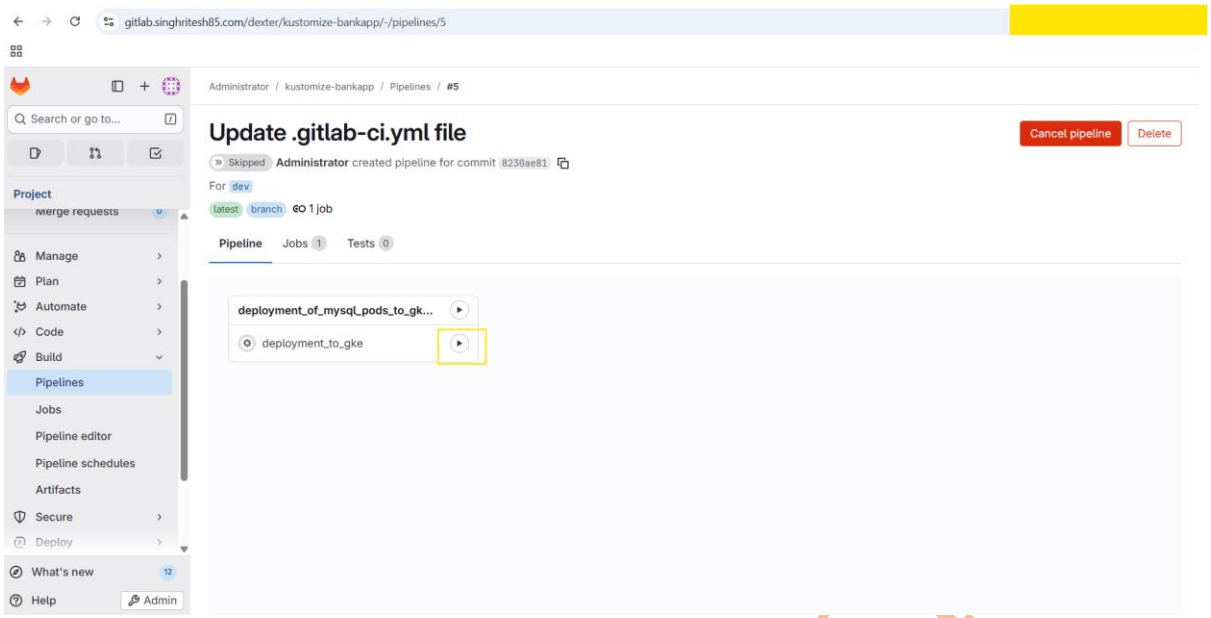
```
[root@                    ~]# kubectl create ns mysql
namespace/mysql created
[root@                    ~]# kubectl create ns bankapp
namespace/bankapp created
```

Go to the GitLab Repository kustomize-bankapp > Build > Pipeline editor > Configure Pipeline and provide the details to create .gitlab-ci.yml. For your reference this file present in GitHub Repo https://github.com/singhritesh85/kustomize-bankapp.git (**dev branch**).





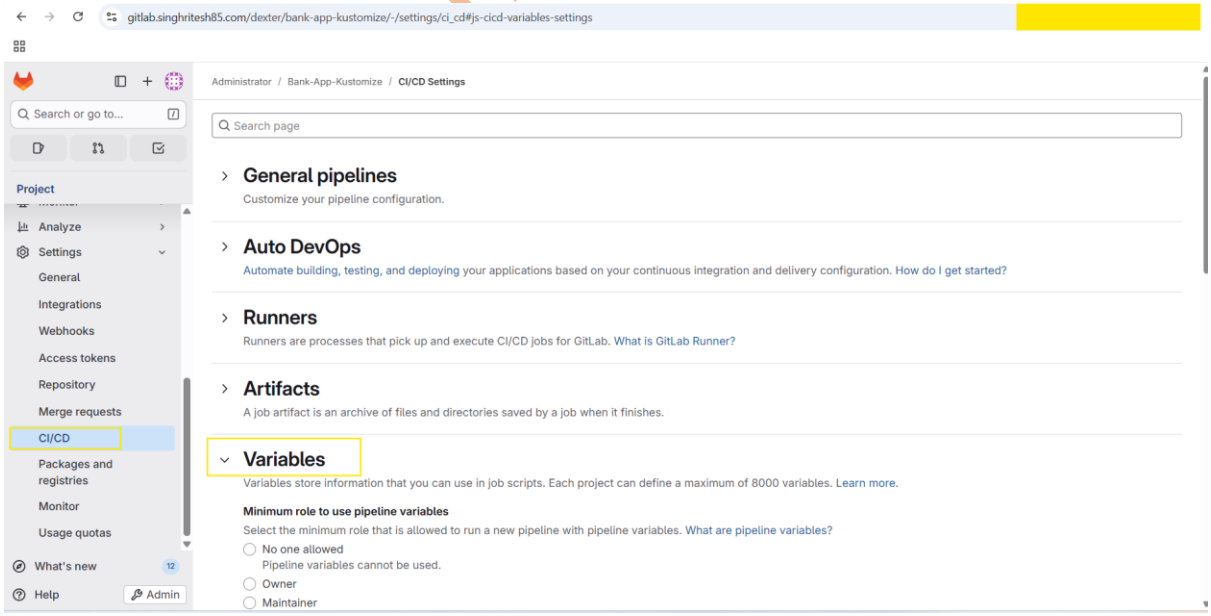
Then Go to the Pipelines and Run the Pipeline as shown in the screenshot attached below.

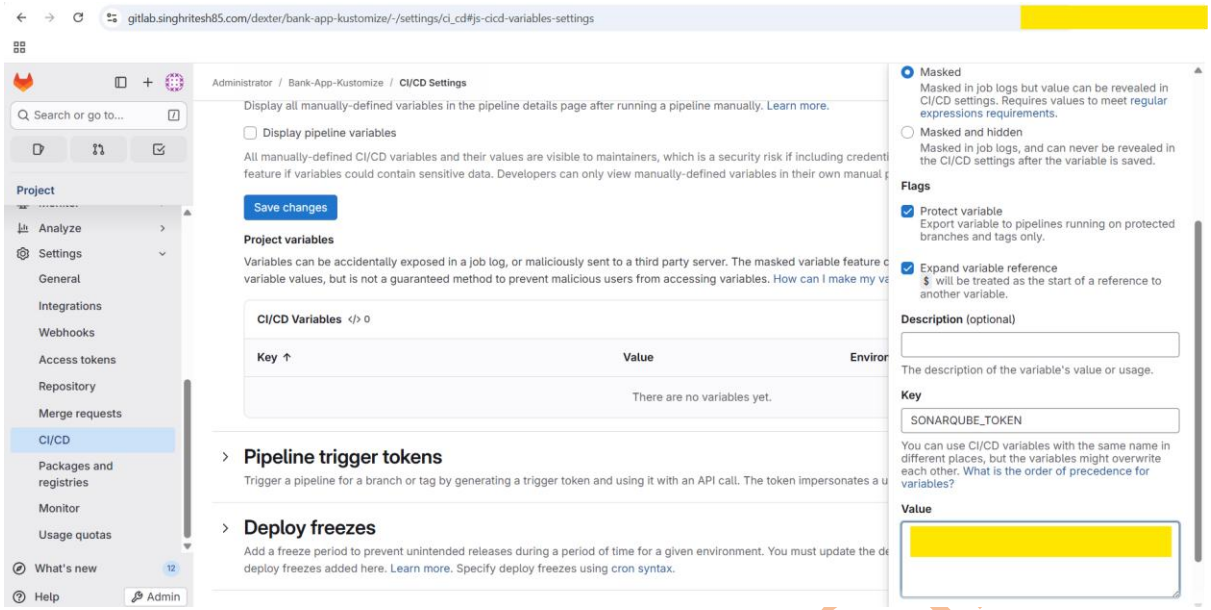


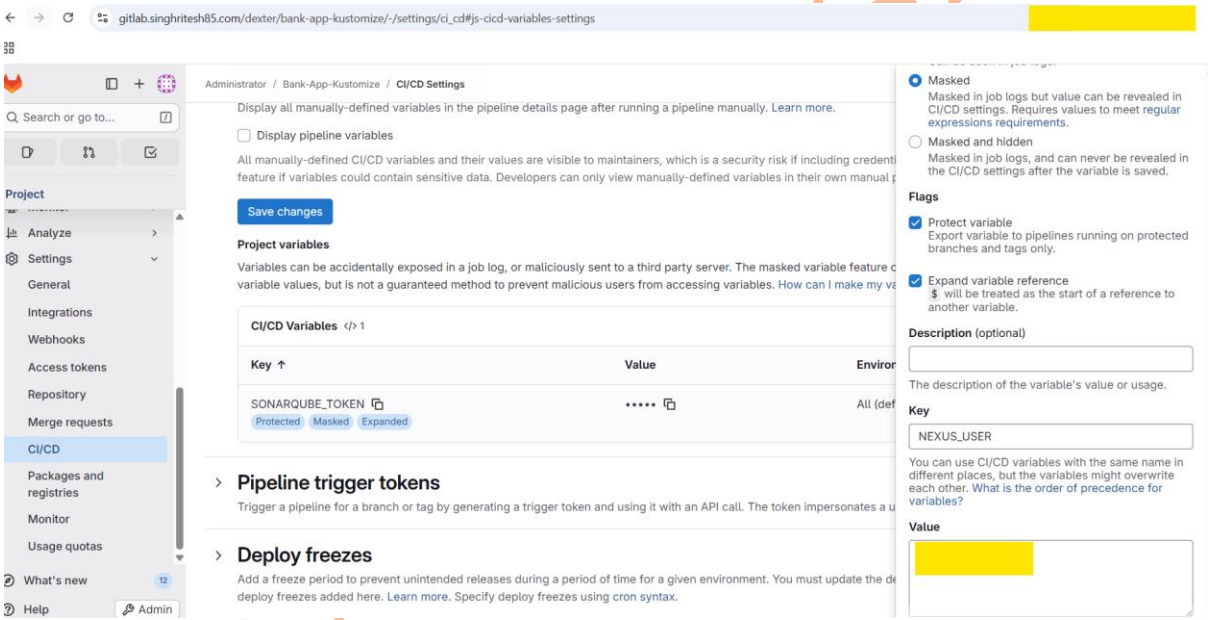

```
[gitlab-runner@bankapp-gitlab-runner ~]$ kubectl get pods -n mysql --watch
NAME      READY   STATUS    RESTARTS   AGE
mysql-0   1/1     Running   0          77s
mysql-1   1/1     Running   0          63s
mysql-2   1/1     Running   0          48s
```

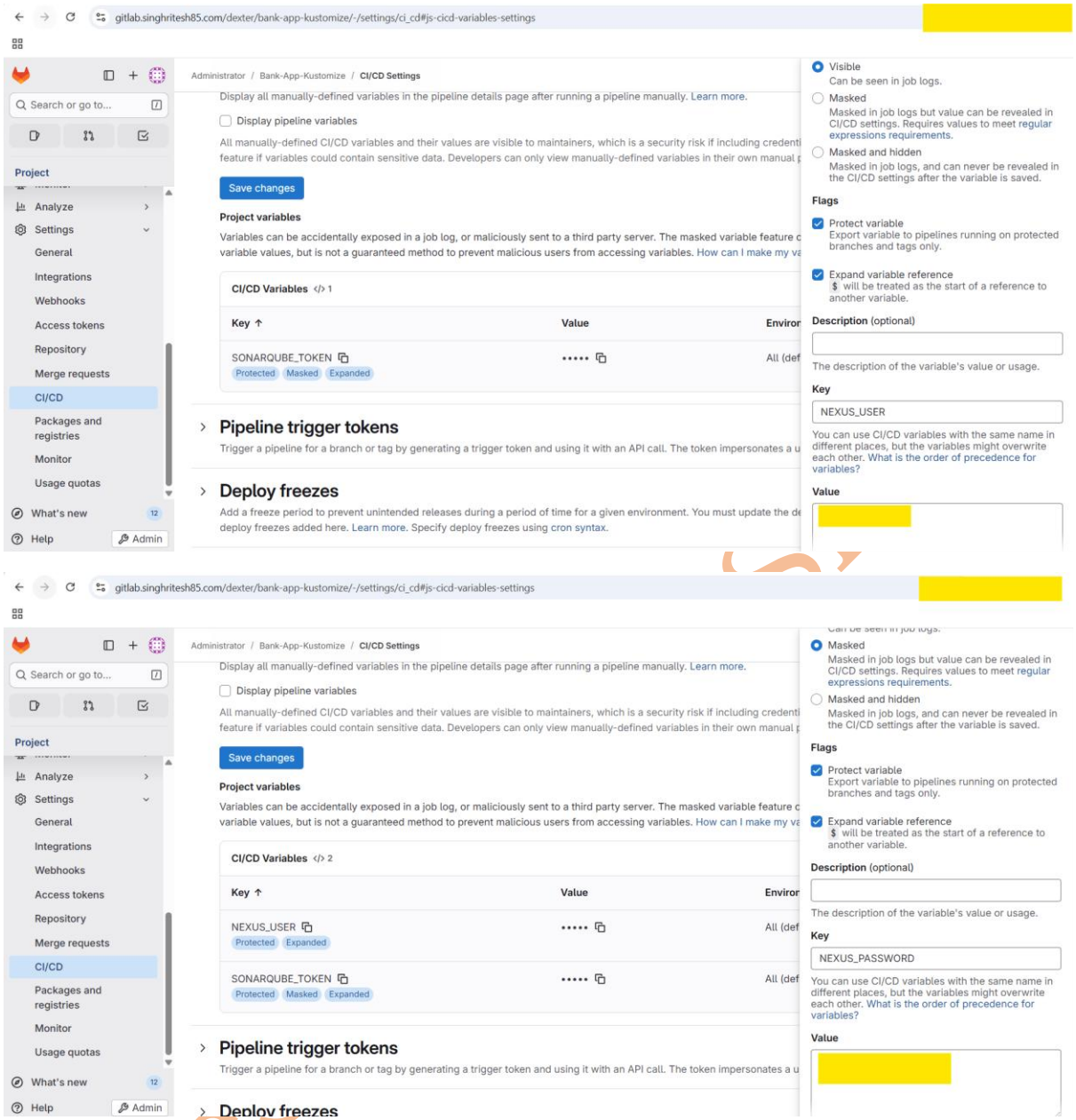
After successful deployment of all the MySQL 8 Pods, I created the GitLab CI/CD Pipeline to deploy Bank Application Pods as shown below, but before that I create three variables named as SONARQUBE_TOKEN, GITLAB_USER, GITLAB_PASSWORD and HELM_REPO_FOR_GKE_ACCESS_TOKEN as shown in the screenshot attached below.

Go to GitLab Repo bank-app-kustomize > Settings > CICD > Variables as show below.

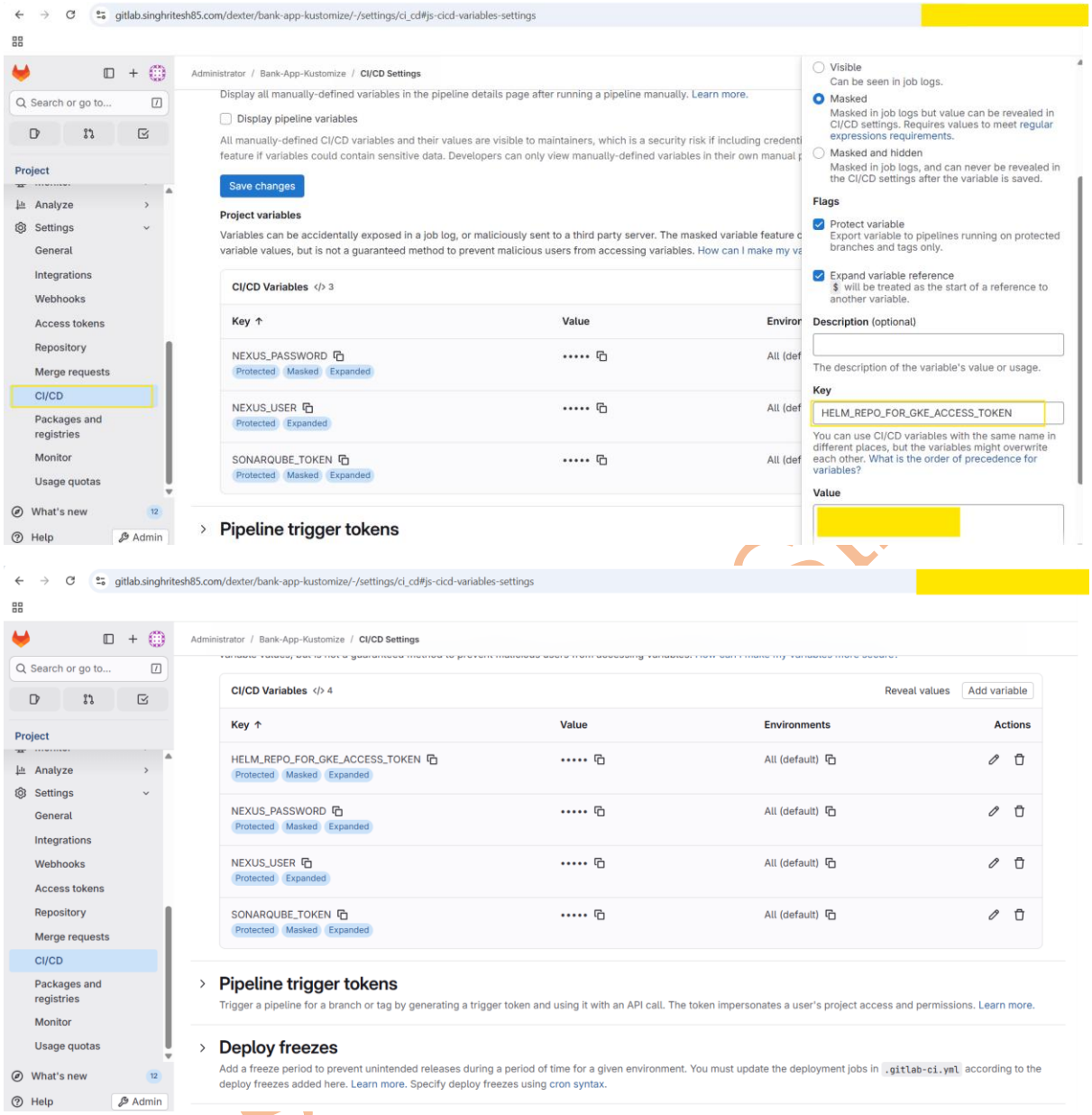



gitlab.singhritesh85.com/dexter/bank-app-kustomize/-/settings/ci_cd#js-cicd-variables-settings
Administrator / Bank-App-Kustomize / CI/CD Settings
Search or go to...
Project
Analyze
Settings
General
Integrations
Webhooks
Access tokens
Repository
Merge requests
CI/CD
Packages and registries
Monitor
Usage quotas
What's new
Help
Admin
Display all manually-defined variables in the pipeline details page after running a pipeline manually. Learn more.
Display pipeline variables
All manually-defined CI/CD variables and their values are visible to maintainers, which is a security risk if including credenti
feature if variables could contain sensitive data. Developers can only view manually-defined variables in their own manual p
Save changes
Project variables
Variables can be accidentally exposed in a job log, or maliciously sent to a third party server. The masked variable feature c
variable values, but is not a guaranteed method to prevent malicious users from accessing variables. How can I make my va
CI/CD Variables 0
Key
Value
Environ
There are no variables yet.
Pipeline trigger tokens
Trigger a pipeline for a branch or tag by generating a trigger token and using it with an API call. The token impersonates a u
Deploy freezes
Add a freeze period to prevent unintended releases during a period of time for a given environment. You must update the de
deploy freezes added here. Learn more. Specify deploy freezes using cron syntax.
Masked
Masked in job logs but value can be revealed in CI/CD settings. Requires values to meet regular expressions requirements.
Masked and hidden
Masked in job logs, and can never be revealed in the CI/CD settings after the variable is saved.
Flags
Protect variable
Export variable to pipelines running on protected branches and tags only.
Expand variable reference
$ will be treated as the start of a reference to another variable.
Description (optional)
The description of the variable's value or usage.
Key
SONARQUBE_TOKEN
You can use CI/CD variables with the same name in different places, but the variables might overwrite each other. What is the order of precedence for variables?
Value


gitlab.singhritesh85.com/dexter/bank-app-kustomize/-/settings/ci_cd#js-cicd-variables-settings
Administrator / Bank-App-Kustomize / CI/CD Settings
Search or go to...
Project
Analyze
Settings
General
Integrations
Webhooks
Access tokens
Repository
Merge requests
CI/CD
Packages and registries
Monitor
Usage quotas
What's new
Help
Admin
Display all manually-defined variables in the pipeline details page after running a pipeline manually. Learn more.
Display pipeline variables
All manually-defined CI/CD variables and their values are visible to maintainers, which is a security risk if including credenti
feature if variables could contain sensitive data. Developers can only view manually-defined variables in their own manual p
Save changes
Project variables
Variables can be accidentally exposed in a job log, or maliciously sent to a third party server. The masked variable feature c
variable values, but is not a guaranteed method to prevent malicious users from accessing variables. How can I make my va
CI/CD Variables 1
Key
Value
Environ
SONARQUBE_TOKEN
Protected
Masked
Expanded
Pipeline trigger tokens
Trigger a pipeline for a branch or tag by generating a trigger token and using it with an API call. The token impersonates a u
Deploy freezes
Add a freeze period to prevent unintended releases during a period of time for a given environment. You must update the de
deploy freezes added here. Learn more. Specify deploy freezes using cron syntax.
Masked
Masked in job logs but value can be revealed in CI/CD settings. Requires values to meet regular expressions requirements.
Masked and hidden
Masked in job logs, and can never be revealed in the CI/CD settings after the variable is saved.
Flags
Protect variable
Export variable to pipelines running on protected branches and tags only.
Expand variable reference
$ will be treated as the start of a reference to another variable.
Description (optional)
The description of the variable's value or usage.
Key
NEXUS_USER
You can use CI/CD variables with the same name in different places, but the variables might overwrite each other. What is the order of precedence for variables?
Value


gitlab.singhritesh85.com/dexter/bank-app-kustomize/-/settings/ci_cd#js-cicd-variables-settings
Administrator / Bank-App-Kustomize / CI/CD Settings
Display all manually-defined variables in the pipeline details page after running a pipeline manually. Learn more.
Display pipeline variables
Save changes
Project variables
CI/CD Variables 1
Key
Value
SONARQUBE_TOKEN
Protected Masked Expanded
Pipeline trigger tokens
Trigger a pipeline for a branch or tag by generating a trigger token and using it with an API call. The token impersonates a u
Deploy freezes
Add a freeze period to prevent unintended releases during a period of time for a given environment. You must update the de
deploy freezes added here. Learn more. Specify deploy freezes using cron syntax.
Visible
Can be seen in job logs.
Masked
Masked in job logs but value can be revealed in CI/CD settings. Requires values to meet regular expressions requirements.
Masked and hidden
Masked in job logs, and can never be revealed in the CI/CD settings after the variable is saved.
Flags
Protect variable
Export variable to pipelines running on protected branches and tags only.
Expand variable reference
$ will be treated as the start of a reference to another variable.
Description (optional)
The description of the variable's value or usage.
Key
NEXUS_USER
You can use CI/CD variables with the same name in different places, but the variables might overwrite each other. What is the order of precedence for variables?
Value
Project
Analyze
Settings
General
Integrations
Webhooks
Access tokens
Repository
Merge requests
CI/CD
Packages and registries
Monitor
Usage quotas
What's new
Help
Admin

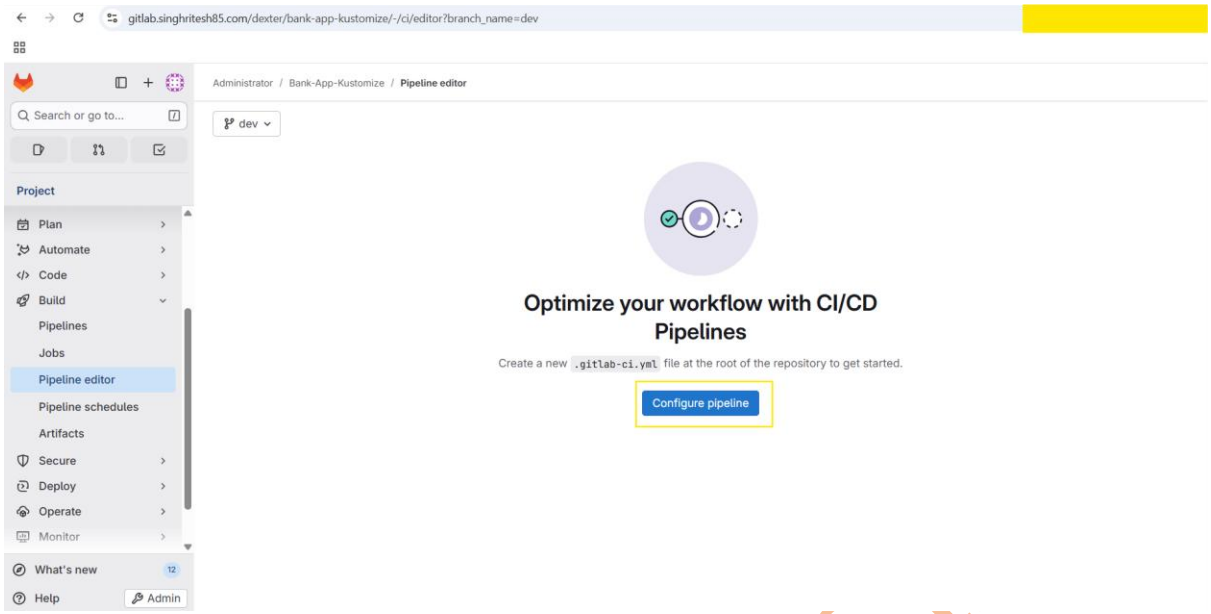
gitlab.singhritesh85.com/dexter/bank-app-kustomize/-/settings/ci_cd#js-cicd-variables-settings
Administrator / Bank-App-Kustomize / CI/CD Settings
Display all manually-defined variables in the pipeline details page after running a pipeline manually. Learn more.
Display pipeline variables
Save changes
Project variables
CI/CD Variables 2
Key
Value
NEXUS_USER
Protected Expanded
SONARQUBE_TOKEN
Protected Masked Expanded
Pipeline trigger tokens
Trigger a pipeline for a branch or tag by generating a trigger token and using it with an API call. The token impersonates a u
Masked
Masked in job logs but value can be revealed in CI/CD settings. Requires values to meet regular expressions requirements.
Masked and hidden
Masked in job logs, and can never be revealed in the CI/CD settings after the variable is saved.
Flags
Protect variable
Export variable to pipelines running on protected branches and tags only.
Expand variable reference
$ will be treated as the start of a reference to another variable.
Description (optional)
The description of the variable's value or usage.
Key
NEXUS_PASSWORD
You can use CI/CD variables with the same name in different places, but the variables might overwrite each other. What is the order of precedence for variables?
Value
Project
Analyze
Settings
General
Integrations
Webhooks
Access tokens
Repository
Merge requests
CI/CD
Packages and registries
Monitor
Usage quotas
What's new
Help
Admin

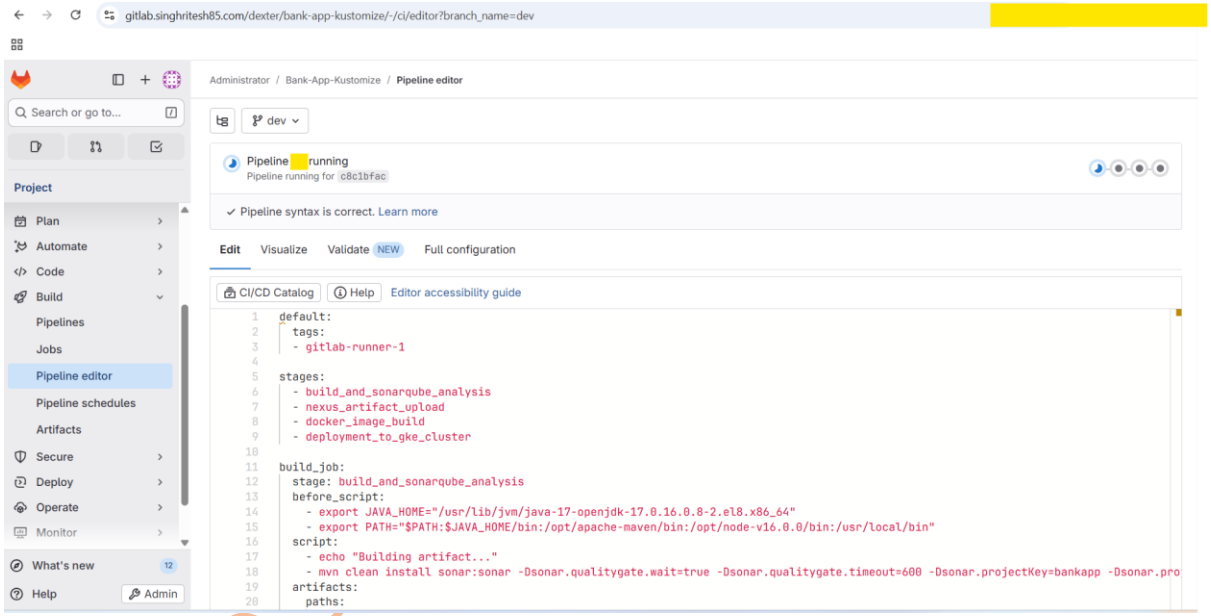


Then Authenticate GAR (GCP Artifact Registry) as shown in the screenshot attached below.

```
[gitlab-runner@bankapp-gitlab-runner ~]$ gcloud auth configure-docker us-central1-docker.pkg.dev
Adding credentials for: us-central1-docker.pkg.dev
After update, the following will be written to your Docker config file located at [/home/gitlab-runner/.docker/config.json]:
 {
  "credHelpers": {
    "us-central1-docker.pkg.dev": "gcloud"
  }
}

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

Docker configuration file updated.
```

Go to the GitLab Repository **bank-app-kustomize** > Build > Pipeline editor > Configure Pipeline and provide the details to create .gitlab-ci.yml. For your reference this file present in GitHub Repo https://github.com/singhritesh85/Bank-App-Kustomize.git (**main branch**).






```
[gitlab-runner@                                ~]$ kubectl get pods -n bankapp
NAME                          READY   STATUS    RESTARTS   AGE
bankapp-                      1/1     Running   0          10m
```

Created Kubernetes Secret ingress-tls and Ingress Rule as shown in the screenshot attached below.

kubectl create secret tls ingress-tls --key server.key --cert 1XXXXXXXXXXXXXXX.crt --namespace bankapp

```
[gitlab-runner@bankapp-gitlab-runner ~]$ kubectl create secret tls ingress-tls --key server.key --cert              .crt --namespace bankapp
secret/ingress-tls created
```

To create Ingress Rule with Cloud Armor Policy, use the procedure as written below.

cat backendconfig-bankapp.yaml

```
apiVersion: cloud.google.com/v1
kind: BackendConfig
metadata:
     namespace: bankapp
     name: bankapp-backendconfig
spec:
    securityPolicy:
    name: bankapp-gke-cloud-armor-policy
```

kubectl get backendconfig -n bankapp

```
[gitlab-runner@                              ~]$ kubectl edit svc bankapp-service -n bankapp
# Please edit the object below. Lines beginning with a '#' will be ignored,
# and an empty file will abort the edit. If an error occurs while saving this file will be
# reopened with the relevant failures.
#
apiVersion: v1
kind: Service
metadata:
  annotations:
    cloud.google.com/neg: '{"ingress":true}'
    cloud.google.com/neg-status: '{"network_endpoint_groups":{"80":"                                        "},"zones":["us-central1-a","us-central1-
c"]}'
    cloud.google.com/backend-config: '{"default": "bankapp-gke-cloud-armor-policy"}'
    kubectl.kubernetes.io/last-applied-configuration: |
      {"apiVersion":"v1","kind":"Service","metadata":{"annotations":{},"name":"bankapp-service","namespace":"bankapp"},"spec":{"ports":[{"port":80,"targetPort
":8080}],"selector":{"app":"bankapp"},"type":"ClusterIP"}}
  creationTimestamp: "2025              "
  name: bankapp-service
  namespace: bankapp
  resourceVersion: "                "
  uid:
spec:
  clusterIP:
  clusterIPs:
  -
  internalTrafficPolicy: Cluster
  ipFamilies:
  - IPv4
  ipFamilyPolicy: SingleStack
  ports:
  - port: 80
    protocol: TCP
    targetPort: 8080
  selector:
    app: bankapp
  sessionAffinity: None
  type: ClusterIP
status:
  loadBalancer: {}
```

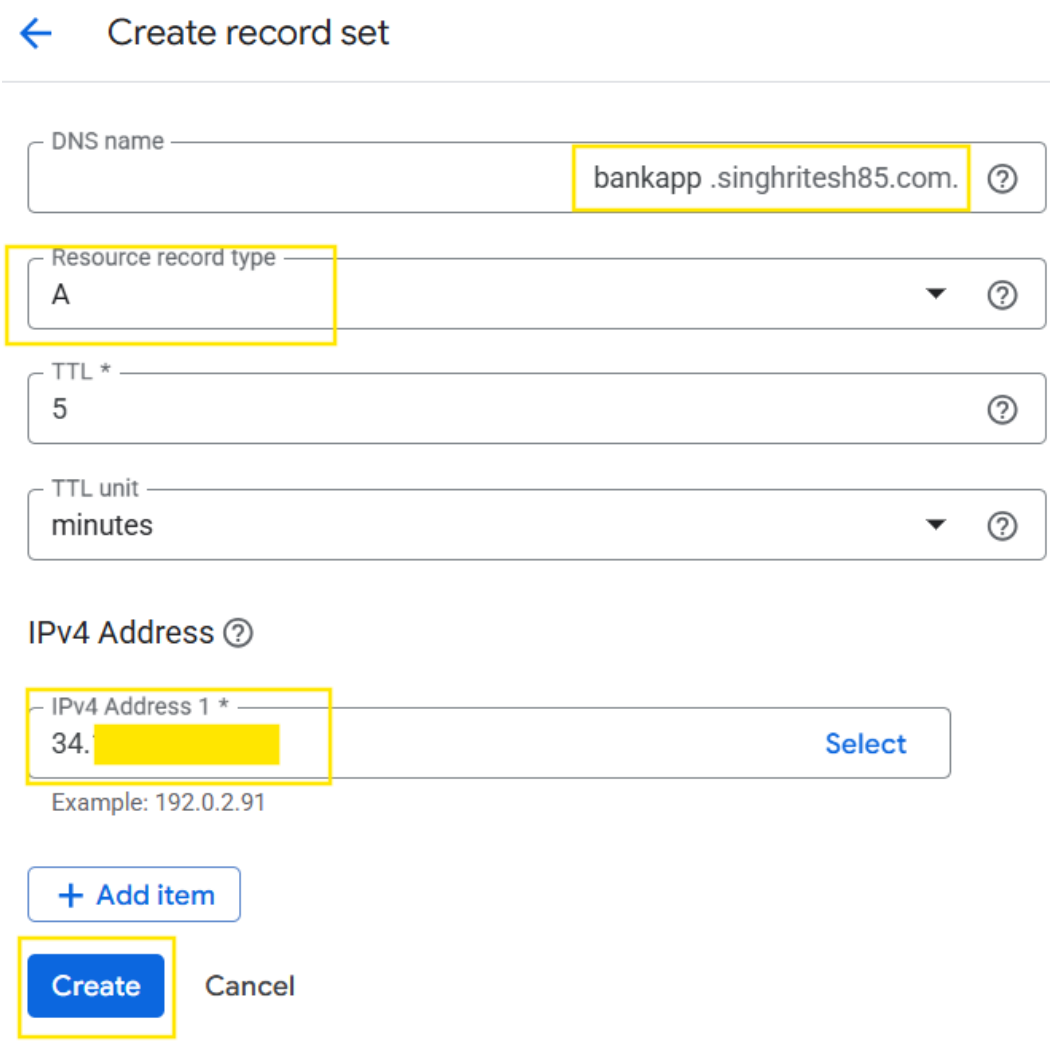
```
[gitlab-runner@bankapp-gitlab-runner ~]$ cat ingress-rule.yaml
# kubectl create secret tls ingress-tls --key server.key --cert 1XXXXXXXXXXXXXXX.crt --namespace bankapp
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: dexter-ingress
  namespace: bankapp
  annotations:
    kubernetes.io/ingress.class: "gce" # Specify the Ingress class
    kubernetes.io/ingress.allow-http: "false"
#    cloud.google.com/backend-config: '{"default": "bankapp-backendconfig"}'
spec:
  ingressClassName: "gce"
  tls:
  - hosts:
    - bankapp.singhritesh85.com
    secretName: ingress-tls
  rules:
  - host: "bankapp.singhritesh85.com"
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: bankapp-service
            port:
              number: 80
```

```
[gitlab-runner@bankapp-gitlab-runner ~]$ kubectl apply -f ingress-rule.yaml
ingress.networking.k8s.io/dexter-ingress created
```

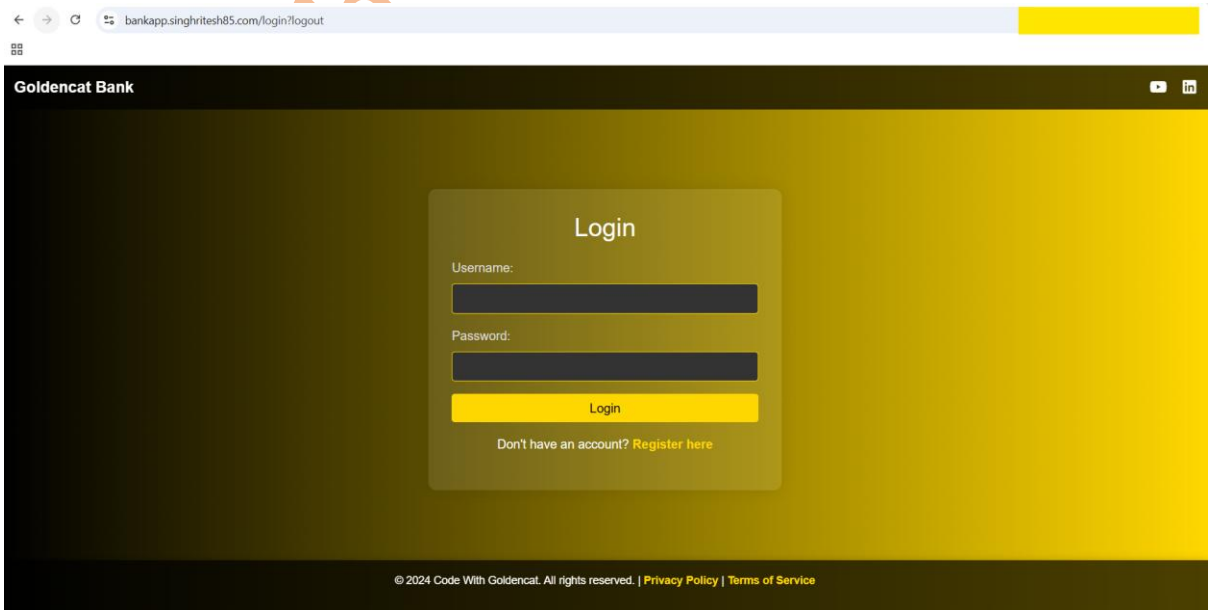
```
[gitlab-runner@bankapp-gitlab-runner ~]$ kubectl get ing -n bankapp --watch
NAME             CLASS   HOSTS                      ADDRESS          PORTS     AGE
dexter-ingress   gce     bankapp.singhritesh85.com   34.[redacted]   80, 443   5m47s
```

```
cat ingress-rule.yaml

# kubectl create secret tls ingress-tls --key server.key --cert 1XXXXXXXXXXXXXXX.crt --namespace bankapp

---

apiVersion: networking.k8s.io/v1

kind: Ingress

metadata:

 name: dexter-ingress

 namespace: bankapp

 annotations:

  kubernetes.io/ingress.class: "gce" # Specify the Ingress class

  kubernetes.io/ingress.allow-http: "false"

#   cloud.google.com/backend-config: '{"default": "bankapp-backendconfig"}'

spec:

 ingressClassName: "gce"

 tls:

 - hosts:

  - bankapp.singhritesh85.com

  secretName: ingress-tls

 rules:

 - host: "bankapp.singhritesh85.com"

  http:

   paths:

   - path: /

    pathType: Prefix

    backend:

     service:

      name: bankapp-service

      port:

       number: 80
```

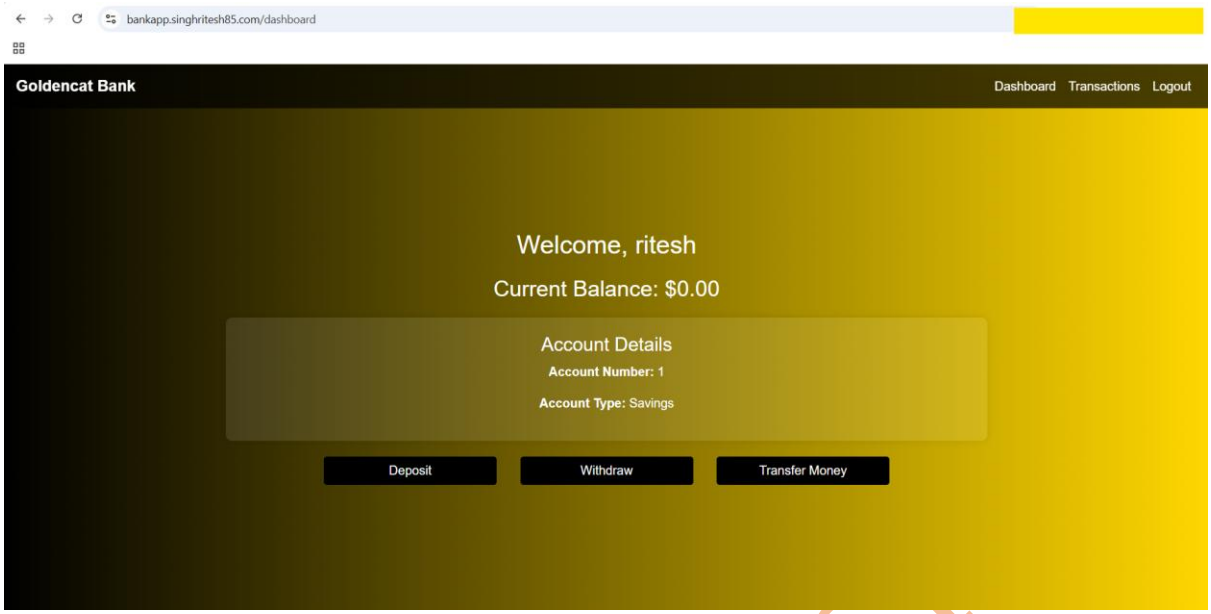
I had done the entry of HOSTS and EXTERNAL IP Address in the GCP Cloud DNS Zone to create the Record Set of A-Type as shown in the screenshot attached below.



Finally, I was able to access the Bank Application as shown in the screenshot attached below.



I registered with a user and I was able to login successfully with same registered user as shown in the screenshot attached below.



Migration from Terraform to Opentofu

As mentioned at the starting of the project that lastly, I will migrate from Terraform to Opentofu. So, in this section I am explaining how to migrate from Terraform to Opentofu.

To Migrate from Terraform to Opentofu make sure about below mentioned points.

1. Take the backup of state file
2. Take the backup of existing Terraform Script.

For backing up terraform state file I created a new GCP bucket and copied the existing state file to the new bucket

```
[root@                    ~]# gsutil mb -l US-CENTRAL1 gs://dexter-therema
Creating gs://dexter-therema/...
```

```
[root@terraform-server ~]# gcloud storage ls
gs://dexter-therema/
gs://dolo-dempo/
```

```
[root@terraform-server ~]# gcloud storage cp --recursive gs://dolo-dempo/* gs://dexter-therema/
Copying gs://dolo-dempo/state/cloud-dns/default.tfstate to gs://dexter-therema/state/cloud-dns/default.tfstate
Copying gs://dolo-dempo/state/gke-standard/terraform.tfstate/default.tfstate to gs://dexter-therema/state/gke-standard/terraform.tfstate/default.tfstate
  Completed files 2/2 | 222.1kiB/222.1kiB

Average throughput: 14.9MiB/s
```

```
[root@                    ~]# gcloud storage ls gs://dexter-therema/
gs://dexter-therema/state/
[root@                    ~]# gcloud storage ls gs://dexter-therema/state/
gs://dexter-therema/state/cloud-dns/
gs://dexter-therema/state/gke-standard/
```

For backing up terraform state file (present is s3 Bucket, for creation of GitLab Server) I created a new s3 bucket and copied the existing state file to the new bucket

```
[root@                ~]# aws s3 mb s3://dexter-backup-statefile --region=us-east-2
make_bucket: dexter-backup-statefile
```

```
[root@                ~]# aws s3 ls --region=us-east-2
2025-                 dexter-backup-statefile
2025-                 dexter-velero-backup
2025-                 dolo-dempo
2025-                 s3bucketcapturealblogjenkins
```

```
[root@                ~]# aws s3 sync s3://dolo-dempo/ s3://dexter-backup-statefile/
```

For terraform script I have new set of script present in the directory **opentofu-gcp-cloud-dns-aws-acm-certificate**, **opentofu-gitlab-server** and **opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek** as shown in the screenshot attached below.

```
[root@terraform-server ~]# ls
opentofu-gcp-cloud-dns-aws-acm-certificate                          terraform-gcp-cloud-dns-aws-acm-certificate
opentofu-gitlab-server                                              terraform-gitlab-server
opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek  terraform-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek
```

The only difference between the Terraform and Opentofu codebase is backend.tf file because in Opentofu I am going to encrypt the state file.

Below is the backend.tf for Terraform.

```
[root@terraform-server ~]# cat terraform-gcp-cloud-dns-aws-acm-certificate/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/cloud-dns"
  }
}
[root@terraform-server ~]# cat terraform-gitlab-server/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/gitlab/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
}
[root@terraform-server ~]# cat terraform-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/gke-standard"
  }
}
```

Below is the backend.tf for Opentofu before migration.

```
[root@terraform-server ~]# cat opentofu-gcp-cloud-dns-aws-acm-certificate/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/cloud-dns"
  }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

```
[root@terraform-server ~]# cat opentofu-gitlab-server/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/gitlab/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

```
[root@terraform-server ~]# cat opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/gke-standard"
  }
  encryption {
    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

    plan {
      method = method.aes_gcm.passphrase
      fallback {
        method = method.unencrypted.read_unencrypted_state
      }
    }

  }
}
```

Below is the backend.tf for Opentofu after migration.

```
[root@terraform-server ~]# cat opentofu-gcp-cloud-dns-aws-acm-certificate/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/cloud-dns"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@terraform-server ~]# cat opentofu-gitlab-server/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/gitlab/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@terraform-server ~]# cat opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/gke-standard"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

I changed in backend.tf because the state file of terraform is not encrypted and you already created the resources using terraform which resources might be utilized in some project so you cannot delete the existing resources created using terraform and create the new one and terraform state file was unencrypted.

You can follow below steps to install Opentofu.

cd /opt/

curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh

chmod +x install-opentofu.sh

./install-opentofu.sh --install-method rpm

rm -f install-opentofu.sh

```
[root@                ~]# cd /opt/
[root@                opt]# curl --proto '=https' --tlsv1.2 -fsSL https://get.opentofu.org/install-opentofu.sh -o install-opentofu.sh
[root@                opt]# chmod +x install-opentofu.sh
[root@                opt]# ./install-opentofu.sh --install-method rpm
```

```
[root@                opt]# rm -f install-opentofu.sh
```

```
[root@                ~]# tofu --version
OpenTofu v1.10.6
on linux_amd64
```

Below commands you should run for migration.

tofu init -reconfigure

tofu validate

tofu plan

tofu apply -auto-approve

```
[root@terraform-server ~]# cd opentofu-gcp-cloud-dns-aws-acm-certificate/main/
[root@terraform-server main]# tofu init -reconfigure
```

```
[root@terraform-server main]# tofu validate
Success! The configuration is valid.
```

```
[root@ main]# tofu plan
```

```
No changes. Your infrastructure matches the configuration.

OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.
```

```
[root@ main]# tofu apply -auto-approve
```

```
No changes. Your infrastructure matches the configuration.

OpenTofu has compared your real infrastructure against your configuration and found no differences, so no changes are needed.

Apply complete! Resources: 0 added, 0 changed, 0 destroyed.

Outputs:

gcp_cloud_dns_zone_and_aws_cerificate_arn_details = {
  "certificate_arn" = "arn:aws:acm:us-east-2:02      6:certificate/                                  "
  "cloud_dns_zone_id" = "projects/                  /managedZones/bankapp-public-zone"
  "gcp_cloud_dns_zone_name_servers" = tolist([
    "                                ",
    "                                ",
    "                                ",
    "                                ",
  ])
}
```

Migration had been done, below is the backend.tf after Migration.

```
[root@terraform-server ~]# cat opentofu-gcp-cloud-dns-aws-acm-certificate/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/cloud-dns"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@terraform-server ~]# cd opentofu-gitlab-server/main/
[root@terraform-server main]# tofu init -reconfigure
```

```
[root@                    main]# tofu validate
Success! The configuration is valid.
```

```
[root@                    main]# tofu plan
```

```
Plan: 0 to add, 3 to change, 0 to destroy.

Note: You didn't use the -out option to save this plan, so OpenTofu can't guarantee to take exactly these actions if you run "tofu apply" now.
```

```
[root@                    main]# tofu apply -auto-approve
```

```
Plan: 0 to add, 3 to change, 0 to destroy.
module.gitlab.aws_route_table.private_route_table_3: Modifying... [id=rtb-                ]
module.gitlab.aws_route_table.private_route_table_1: Modifying... [id=rtb-                ]
module.gitlab.aws_route_table.private_route_table_2: Modifying... [id=rtb-                ]
module.gitlab.aws_route_table.private_route_table_3: Modifications complete after 0s [id=rtb-                ]
module.gitlab.aws_route_table.private_route_table_2: Modifications complete after 0s [id=rtb-                ]
module.gitlab.aws_route_table.private_route_table_1: Modifications complete after 0s [id=rtb-                ]

Apply complete! Resources: 0 added, 3 changed, 0 destroyed.

Outputs:

ec2_private_ip_alb_dns = {
  "EC2_Instance_GitLab_Server_Private_IP_Address" = "10.        "
  "GitLab_ALB_DNS_Name" = "gitlab-          .us-east-2.elb.amazonaws.com"
}
```

Migration had been done, below is the backend.tf after Migration.

```
[root@terraform-server ~]# cat opentofu-gitlab-server/main/backend.tf
terraform {
 backend "s3" {
   bucket         = "dolo-dempo"
   key            = "state/gitlab/terraform.tfstate"
   region         = "us-east-2"
   encrypt        = true
   use_lockfile   = true   ###dynamodb_table = "terraform-state"
 }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

```
[root@terraform-server ~]# cd opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek/main/
[root@terraform-server main]# tofu init -reconfigure
```

```
[root@                    main]# tofu validate
Success! The configuration is valid.
```

```
[root@                    main]# tofu plan
```

```
Plan: 0 to add, 4 to change, 0 to destroy.

Note: You didn't use the -out option to save this plan, so OpenTofu can't guarantee to take exactly these actions if you run "tofu apply" now.
```

```
[root@                    main]# tofu apply -auto-approve
```

Migration had been done, below is the backend.tf after Migration.

```
[root@terraform-server ~]# cat opentofu-gke-cluster-cloudarmor-with-backup-envelope-encryption-kms-cmek/main/backend.tf
terraform {
  backend "gcs" {
    bucket  = "dolo-dempo"
    prefix  = "state/gke-standard"
  }
  encryption {
#    method "unencrypted" "read_unencrypted_state" {} ### To read unencrypted state file

    key_provider "pbkdf2" "statefile_encryption_password" {
      passphrase = var.encryption_passphrase
    }

    method "aes_gcm" "passphrase" {
      keys = key_provider.pbkdf2.statefile_encryption_password
    }

    state {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

    plan {
      method = method.aes_gcm.passphrase
#      fallback {
#        method = method.unencrypted.read_unencrypted_state
#      }
    }

  }
}
```

Now check state file in GCP Bucket (For GCP Cloud DNS Zone and GKE Creation) and S3 Bucket (For GitLab Server Creation) you will find it is encrypted. However, if you run **tofu show**, you can see the state file but in GCP Bucket and S3 Bucket it is encrypted.

Source Code: https://github.com/singhritesh85/Bank-App-Kustomize.git

GitHub Repo: https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git

Kustomize Manifests Repo: https://github.com/singhritesh85/kustomize-bankapp.git

dev branch: - GKE

stage branch: - AKS

main branch: - EKS

Terraform Script: https://github.com/singhritesh85/DevOps-Project-BankApp-terraform-upgrade-to-opentofu-secure-kubernetes-clusters.git

References: https://github.com/Goldencat98/Bank-App.git

https://open-policy-agent.github.io/gatekeeper/website/

https://kyverno.io/docs/

https://falco.org/docs/

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