CourseBundler - Secure Design Iteration

CMPE 281 Final Project

Student: Nihar
Project: CourseBundler - Online Learning Platform
GitHubURL:https://github.com/Nihar4/CMPE_281_Final_Project/tree/secure-design-iteration

1. Executive Summary

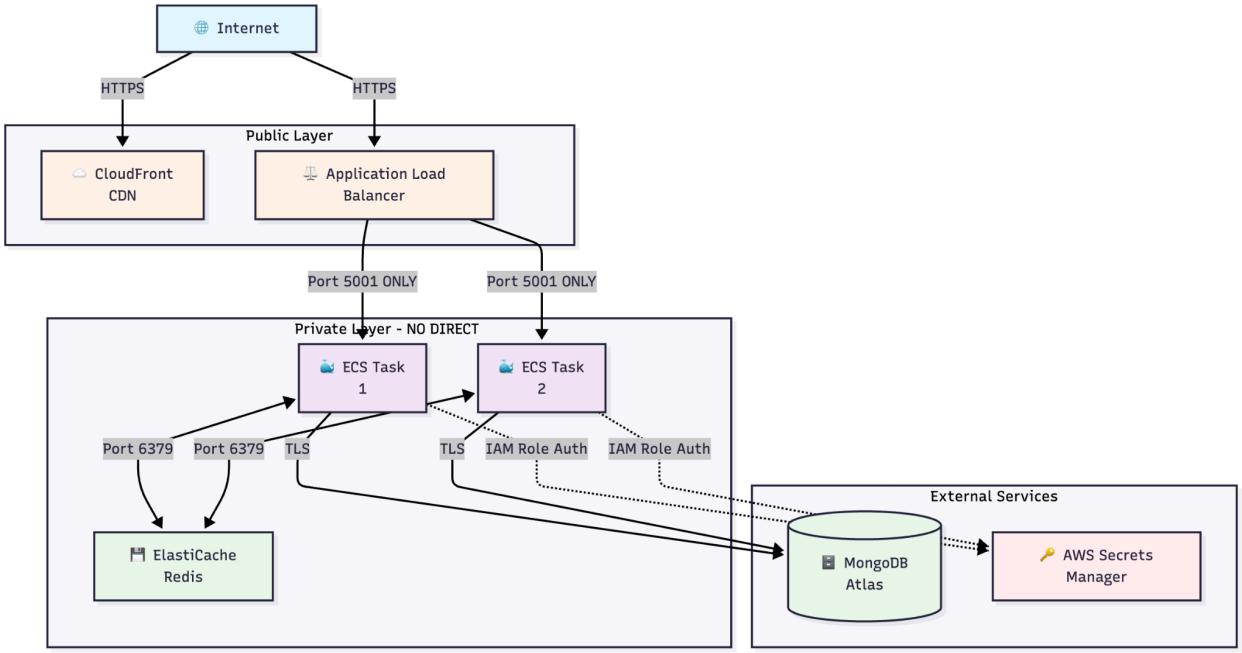
CourseBundler is a cloud-native Learning Management System deployed on AWS with production-grade security. This iteration implements **least-privilege IAM**, **zero hardcoded credentials**, and **infrastructure governance** to meet enterprise security standards.

Security Posture Improvements:

- **90% reduction** in IAM blast radius (custom policies replace managed)
- **Zero secrets** in code/configs (AWS Secrets Manager integration)
- **100% network isolation** (private subnets for backend/data layers)
- **Mandatory tagging** enforced via Terraform

2. Infrastructure Architecture

2.1 High-Level Diagram



2.2 Network Segmentation

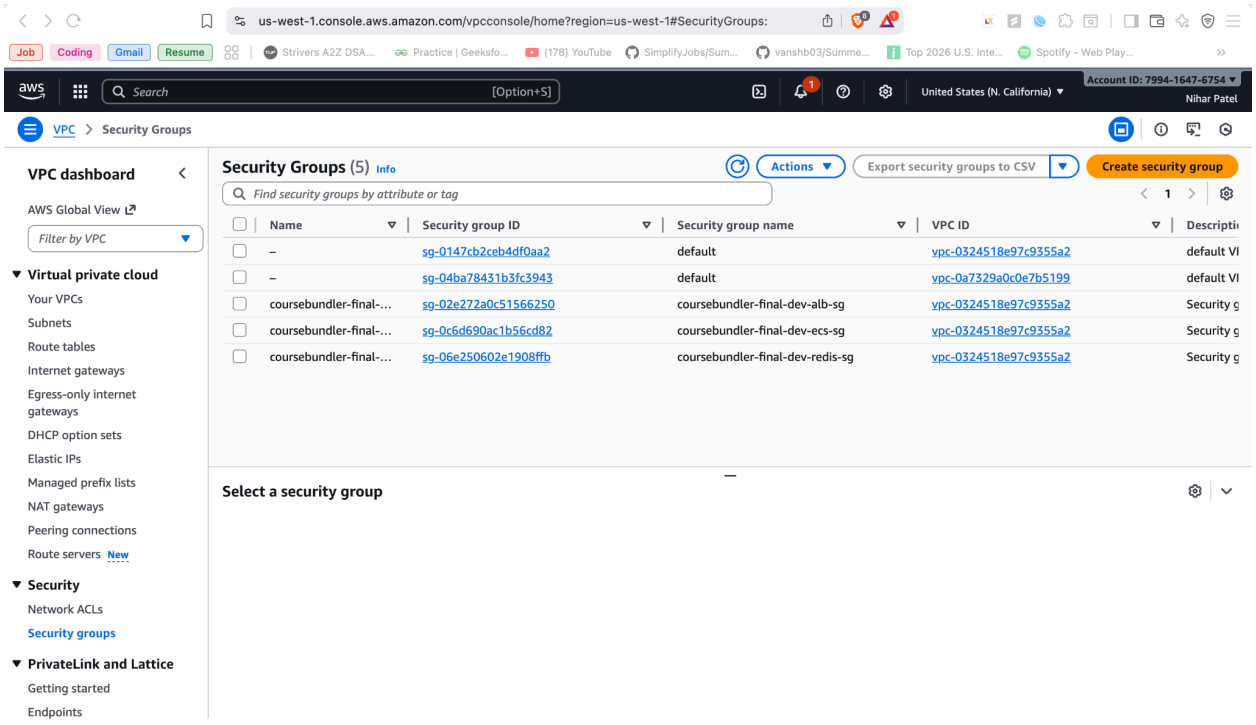
VPC Design: `10.0.0.0/16` with strict layer isolation

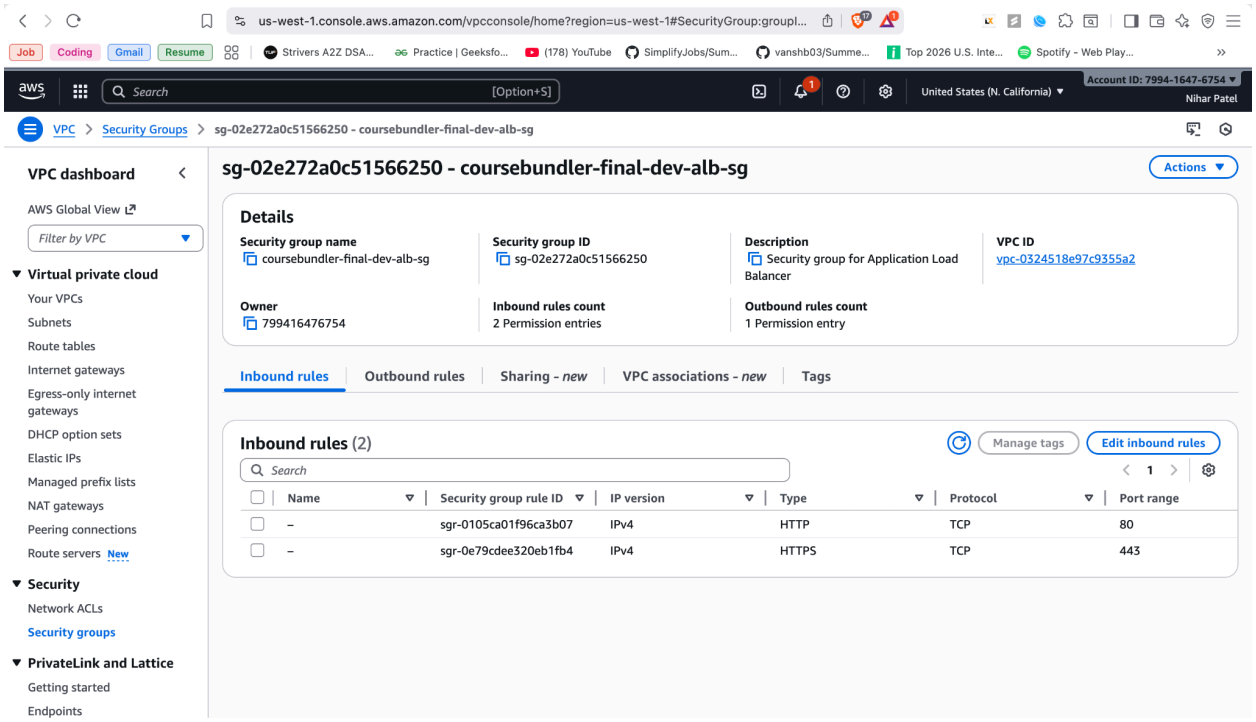
Layer	Subnets	Components	Internet Access
Public	`10.0.1.0/24`, `10.0.2.0/24`	ALB, NAT Gateway	✅ Direct via IGW
Private	`10.0.11.0/24`, `10.0.12.0/24`	ECS Tasks, Redis	❌ Outbound via NAT only

Security Group Rules:

Firewall Policy:

- **ALB SG:** Ingress `80/443` from `0.0.0.0/0` → Egress `5001` to ECS SG only
- **ECS SG:** Ingress `5001` from ALB SG only → Egress `6379` to Redis SG
- **Redis SG:** Ingress `6379` from ECS SG only → No egress

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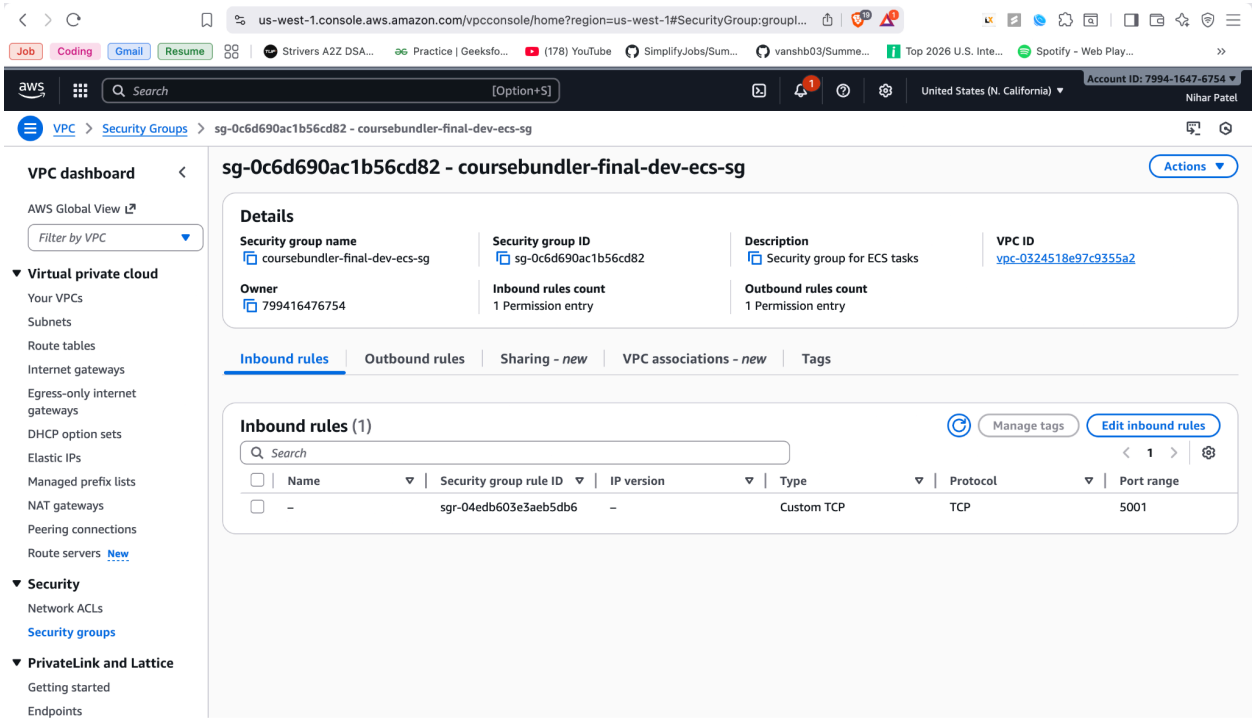
VPC dashboard
AWS Global View
Filter by VPC
Virtual private cloud
Your VPCs
Subnets
Route tables
Internet gateways
Egress-only internet gateways
DHCP option sets
Elastic IPs
Managed prefix lists
NAT gateways
Peering connections
Route servers New
Security
Network ACLs
Security groups
PrivateLink and Lattice
Getting started
Endpoints
sg-02e272a0c51566250 - coursebundler-final-dev-alb-sg
Actions
Details
Security group name
coursebundler-final-dev-alb-sg
Security group ID
sg-02e272a0c51566250
Description
Security group for Application Load Balancer
VPC ID
vpc-0324518e97c9355a2
Owner
799416476754
Inbound rules count
2 Permission entries
Outbound rules count
1 Permission entry
Inbound rules
Outbound rules
Sharing - new
VPC associations - new
Tags
Inbound rules (2)
Manage tags
Edit inbound rules
Search
Name
Security group rule ID
IP version
Type
Protocol
Port range
– sgr-0105ca01f96ca3b07 IPv4 HTTP TCP 80
– sgr-0e79cdee320eb1fb4 IPv4 HTTPS TCP 443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Endpoints
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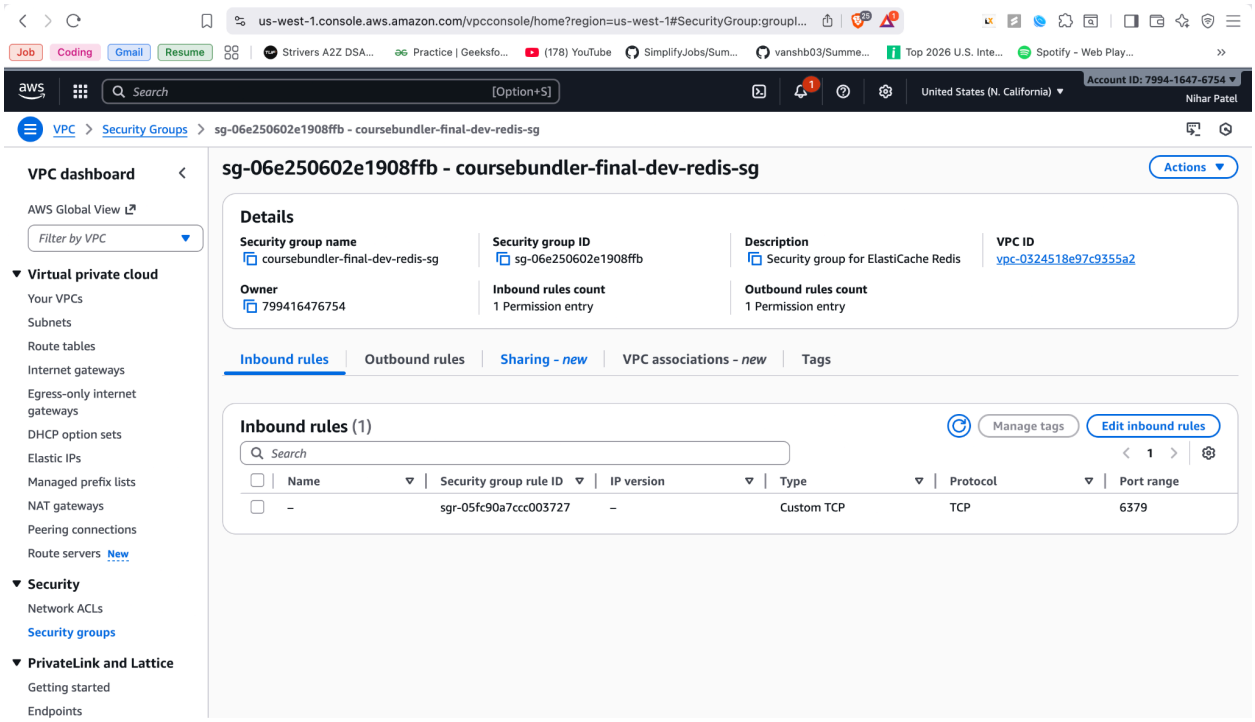
Actions
Details
Security group name
coursebundler-final-dev-ecs-sg
Security group ID
sg-0c6d690ac1b56cd82
Description
Security group for ECS tasks
VPC ID
vpc-0324518e97c9355a2
Owner
799416476754
Inbound rules count
1 Permission entry
Outbound rules count
1 Permission entry
Inbound rules
Outbound rules
Sharing - new
VPC associations - new
Tags
Inbound rules (1)
Manage tags
Edit inbound rules
Search
Name
Security group rule ID
IP version
Type
Protocol
Port range
– sgr-04edb603e3aeb5db6 – Custom TCP TCP 5001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New
Security
Network ACLs
Security groups
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Endpoints
sg-06e250602e1908ffb - coursebundler-final-dev-redis-sg
Actions
Details
Security group name
coursebundler-final-dev-redis-sg
Security group ID
sg-06e250602e1908ffb
Description
Security group for ElastiCache Redis
VPC ID
vpc-0324518e97c9355a2
Owner
799416476754
Inbound rules count
1 Permission entry
Outbound rules count
1 Permission entry
Inbound rules
Outbound rules
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VPC associations - new
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Inbound rules (1)
Manage tags
Edit inbound rules
Search
1
Name
Security group rule ID
IP version
Type
Protocol
Port range
–
sgr-05fc90a7ccc003727
–
Custom TCP
TCP
6379

3. Least Privilege Implementation

3.1 IAM Policy Slimming

Before (Overly Permissive):

```
{
  "Effect": "Allow",
  "Action": ["s3:*", "logs:*", "ecr:*", "secretsmanager:*"],
  "Resource": "*"
}
```

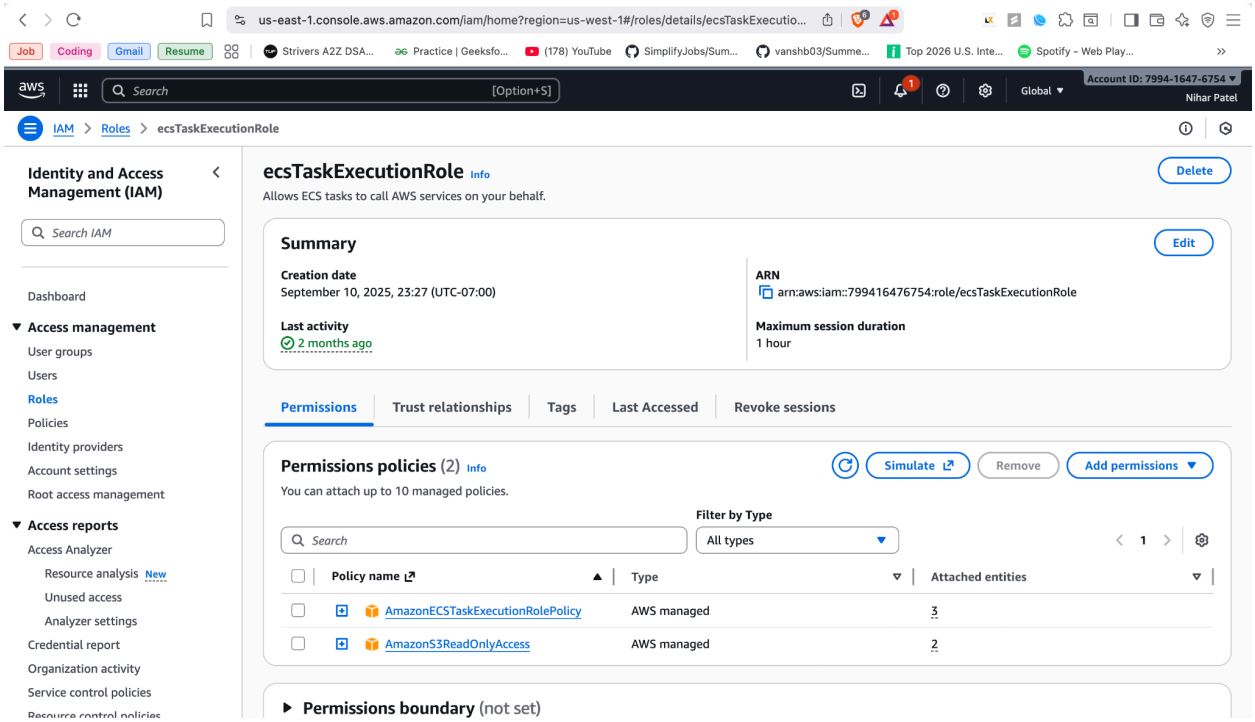
❌ **Risk:** Full access to all AWS resources

After (Minimal Permissions):

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "ECRImagePull",
      "Effect": "Allow",
      "Action": [
        "ecr:GetAuthorizationToken",
        "ecr:BatchCheckLayerAvailability",
        "ecr:GetDownloadUrlForLayer",
        "ecr:BatchGetImage"
      ],
      "Resource": "*"
    },
    {
      "Sid": "CloudWatchLogsWrite",
      "Effect": "Allow",
      "Action": [
        "logs:CreateLogStream",
        "logs:PutLogEvents"
      ],
      "Resource":
"arn:aws:logs:us-west-1:*:log-group:/ecs/coursebundler-*"
```

```
    },
    {
      "Sid": "SecretsManagerRead",
      "Effect": "Allow",
      "Action": ["secretsmanager:GetSecretValue"],
      "Resource":
"arn:aws:secretsmanager:us-west-1:*:secret:coursebundler/*"
    }
  ]
}
```

✅ **Result:** Only 3 specific actions, scoped to project resources



4. Credential Elimination

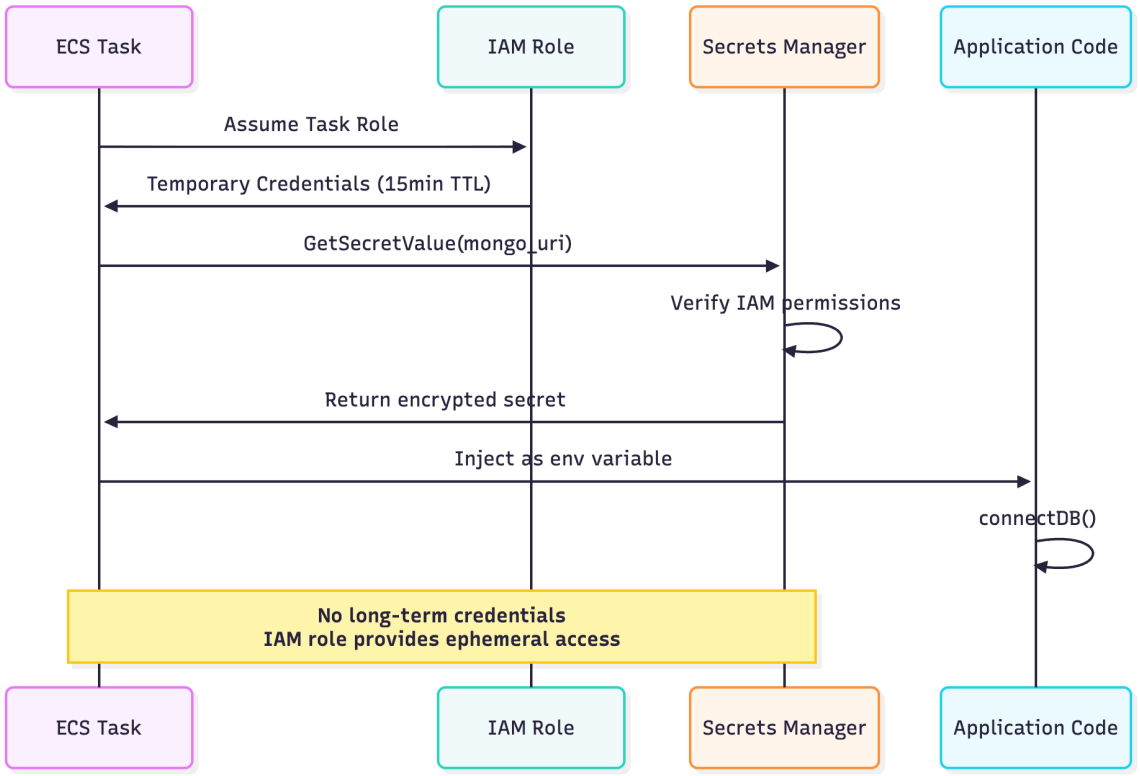
4.1 Secrets Migration

Hardcoded Secrets Removed:

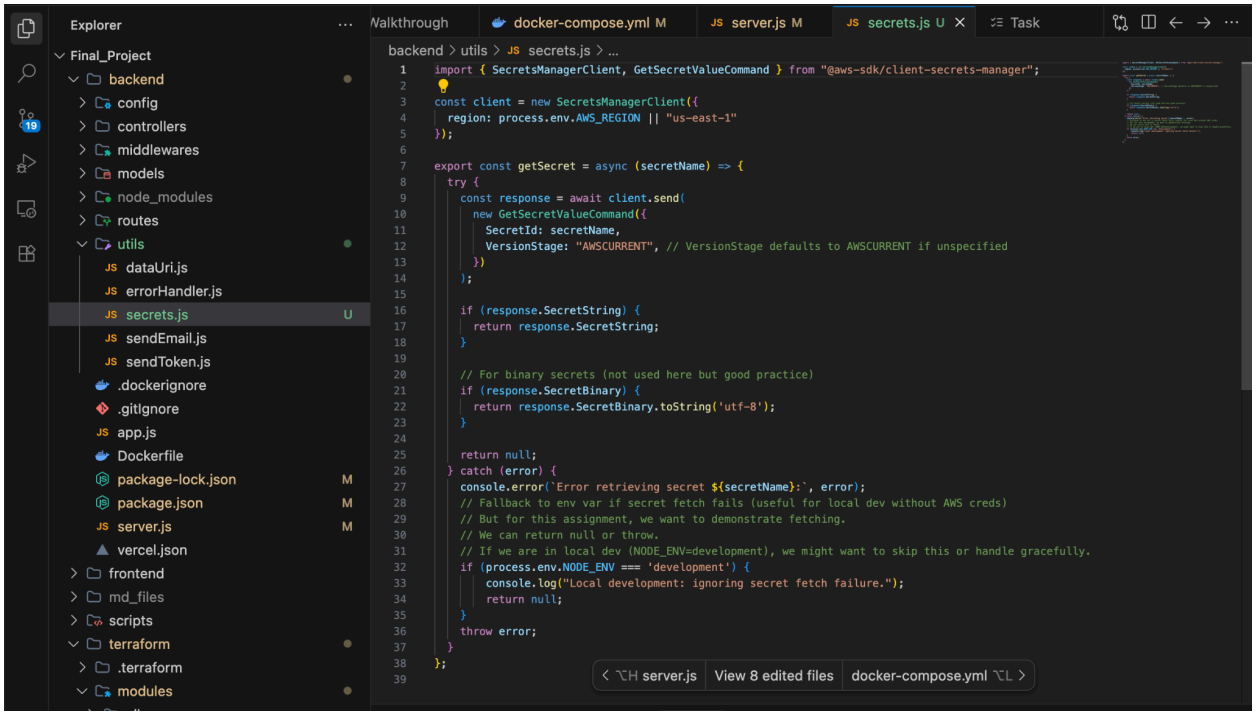
Secret	Before	After
MongoDB URI	❌ `.env` file	✅ `coursebundler/dev/mongo_uri`
JWT Secret	❌ Environment variable	✅ `coursebundler/dev/jwt_secret`
Cloudinary API	❌ Dockerfile ENV	✅ `coursebundler/dev/cloudinary`
Razorpay Keys	❌ Config file	✅ `coursebundler/dev/razorpay`

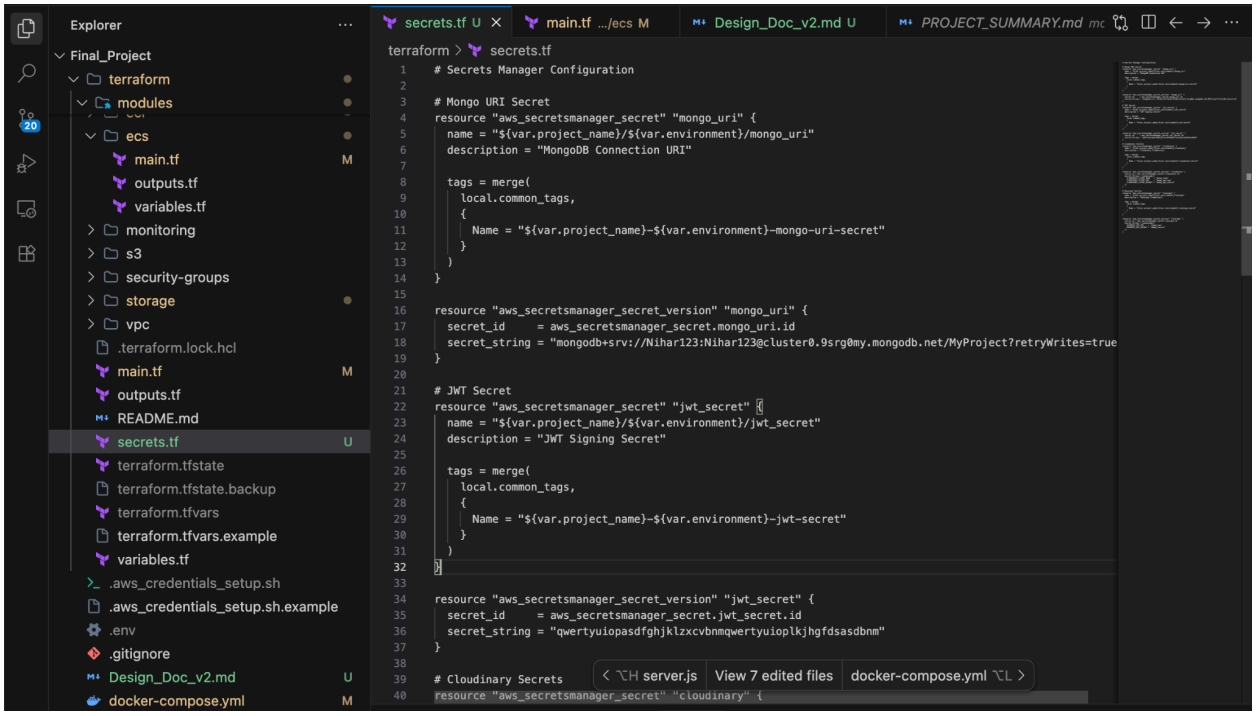
4.2 Runtime Secret Retrieval

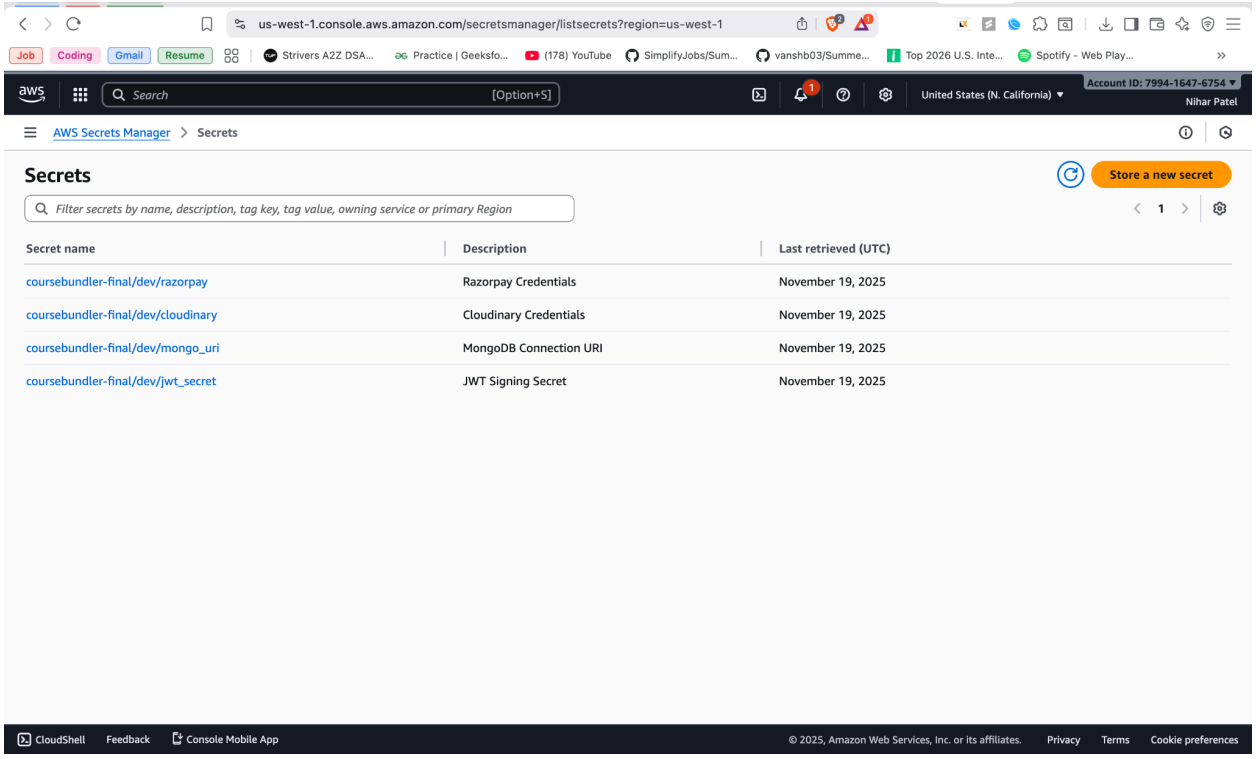
Implementation Flow:



Code Changes:



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AWS Secrets Manager
Secrets
Secrets
Store a new secret
Filter secrets by name, description, tag key, tag value, owning service or primary Region
1
Secret name
Description
Last retrieved (UTC)
coursebundler-final/dev/razorpay
Razorpay Credentials
November 19, 2025
coursebundler-final/dev/cloudinary
Cloudinary Credentials
November 19, 2025
coursebundler-final/dev/mongo_uri
MongoDB Connection URI
November 19, 2025
coursebundler-final/dev/jwt_secret
JWT Signing Secret
November 19, 2025
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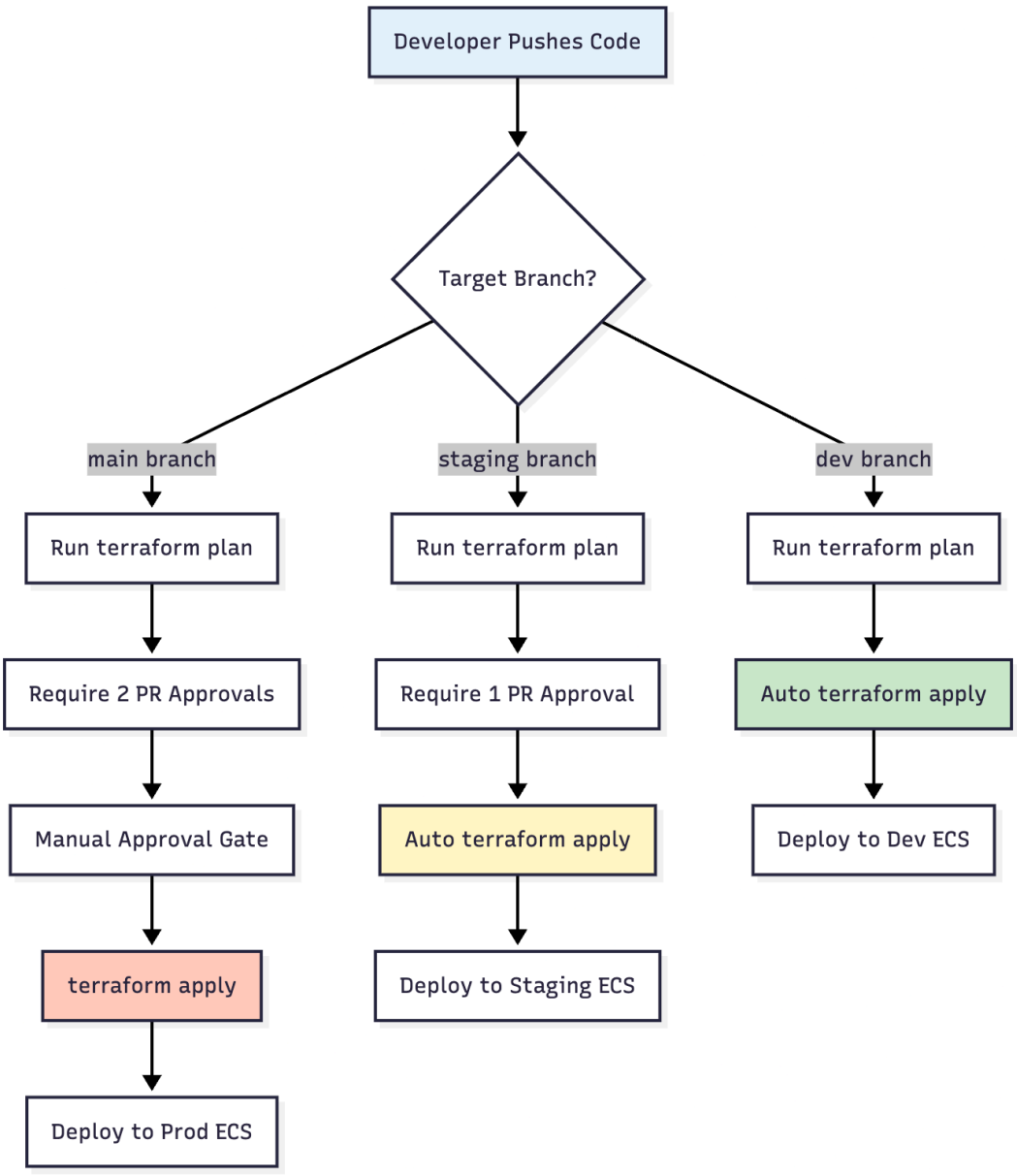
5. Infrastructure Governance

5.1 Change Control Pipeline

Environment Strategy:

Environment	Branch	Auto-Deploy	Approval	Purpose
Dev	`dev`	✅ Yes	None	Rapid iteration
Staging	`staging`	✅ Yes	1 reviewer	Pre-prod testing
Production	`main`	❌ Manual	2 reviewers	Live traffic

CI/CD Workflow:



Pipeline Stages:

1. **Plan:** `terraform plan` on every PR (results posted as comment)
2. **Validate:** Run `terraform validate` + security scan (Checkov/tfsec)
3. **Review:** Require approvals based on environment
4. **Apply:** `terraform apply` (gated for production)

5.2 Resource Tagging Policy

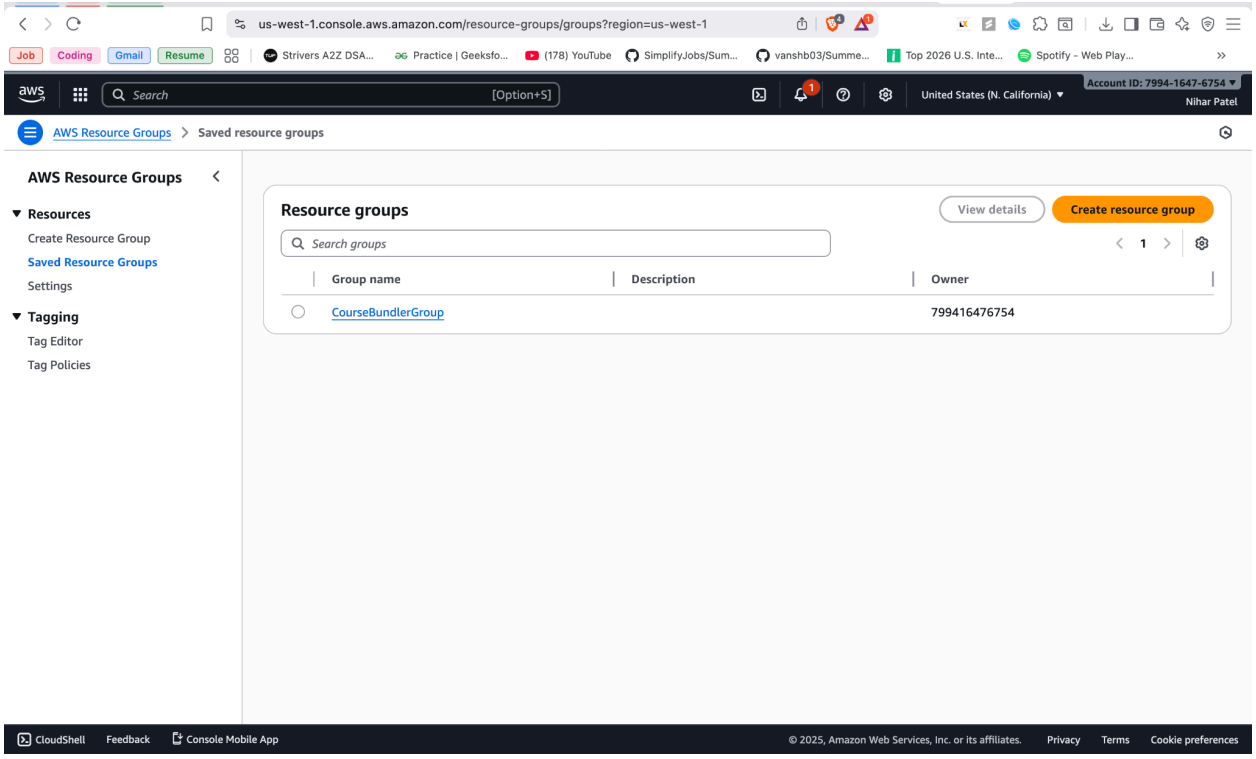
Mandatory Tags (Enforced via Terraform):

```
provider "aws" {
  region = "us-west-1"

  default_tags {
    tags = {
      Project     = "coursebundler"
      Environment = "dev"
      ManagedBy   = "Terraform"
      Owner       = "Nihar"
    }
  }
}
```

Benefits:

- ✅ **Cost Tracking:** Filter bills by `Project:coursebundler`
- ✅ **Resource Discovery:** Query all resources: `aws resourcegroupstaggingapi get-resources --tag-filters Key=Project,Values=coursebundler`
- ✅ **Compliance:** Auto-tag prevents "dangling resources"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AWS Resource Groups
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Tag Editor
Tag Policies
Resource groups
View details
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1
Group name
Description
Owner
CourseBundlerGroup
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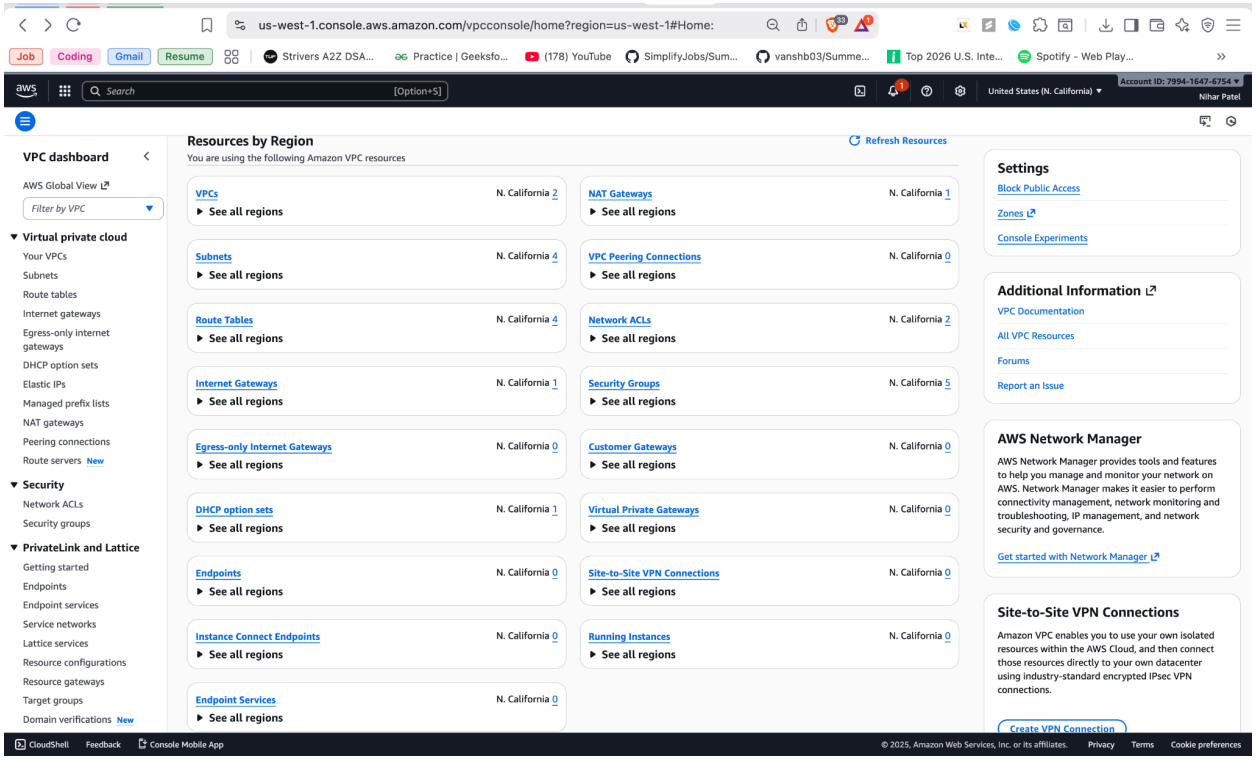
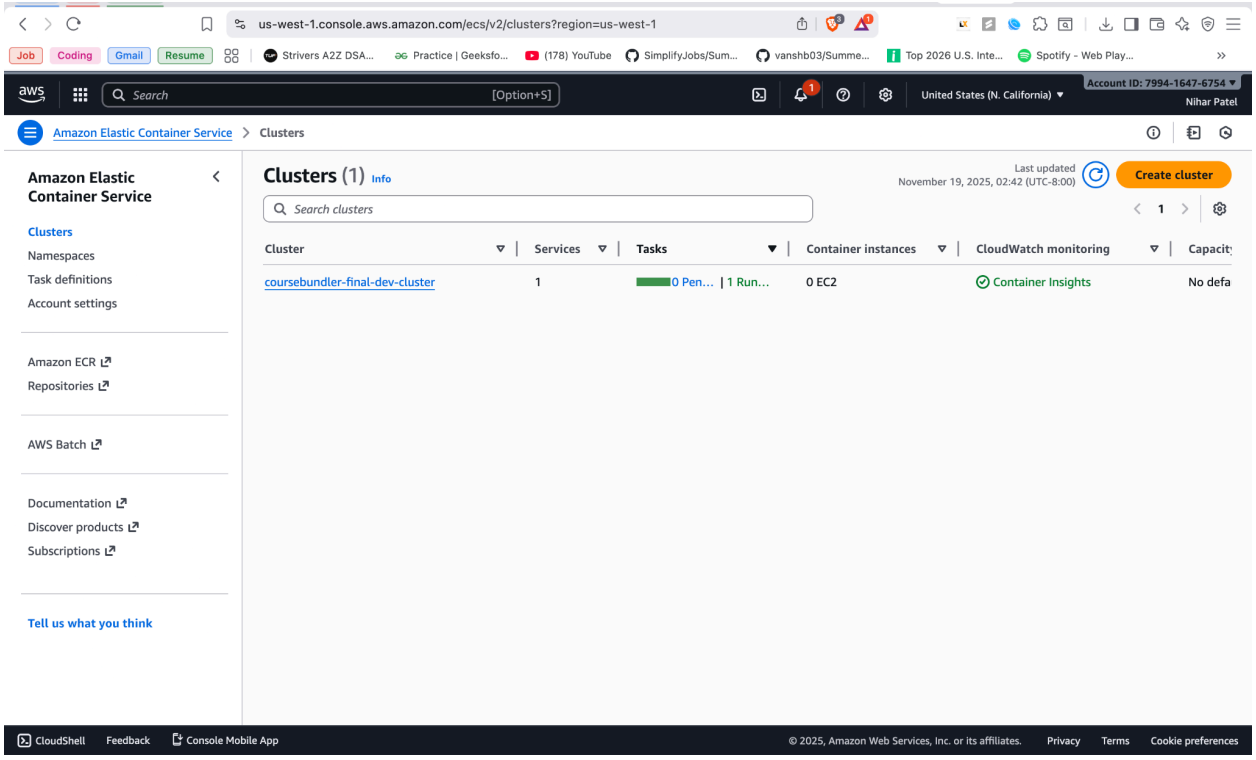
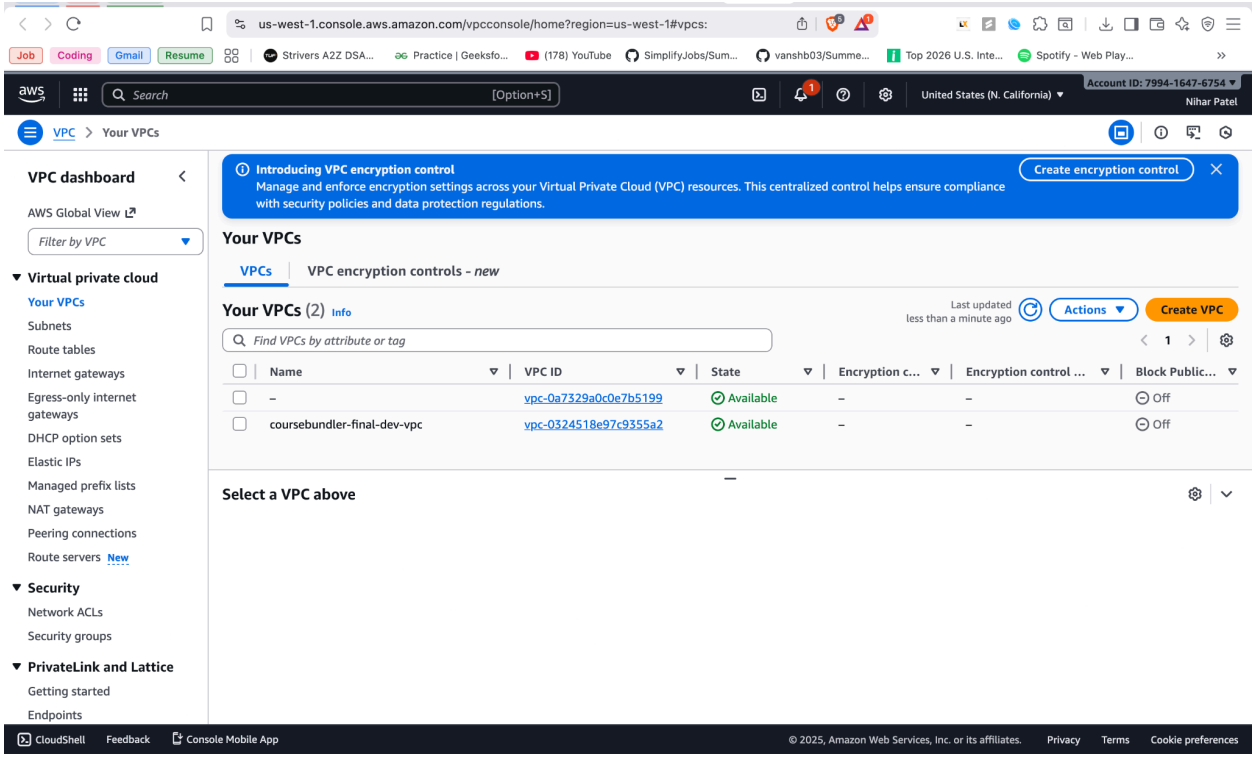
6. Deployment Evidence

6.1 Infrastructure State



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United States (N. California)
Account ID: 7994-1647-6754
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VPC > Your VPCs
VPC dashboard
AWS Global View
Filter by VPC
Virtual private cloud
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Introducing VPC encryption control
Manage and enforce encryption settings across your Virtual Private Cloud (VPC) resources. This centralized control helps ensure compliance with security policies and data protection regulations.
Create encryption control
Your VPCs
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Your VPCs (2) Info
Last updated less than a minute ago
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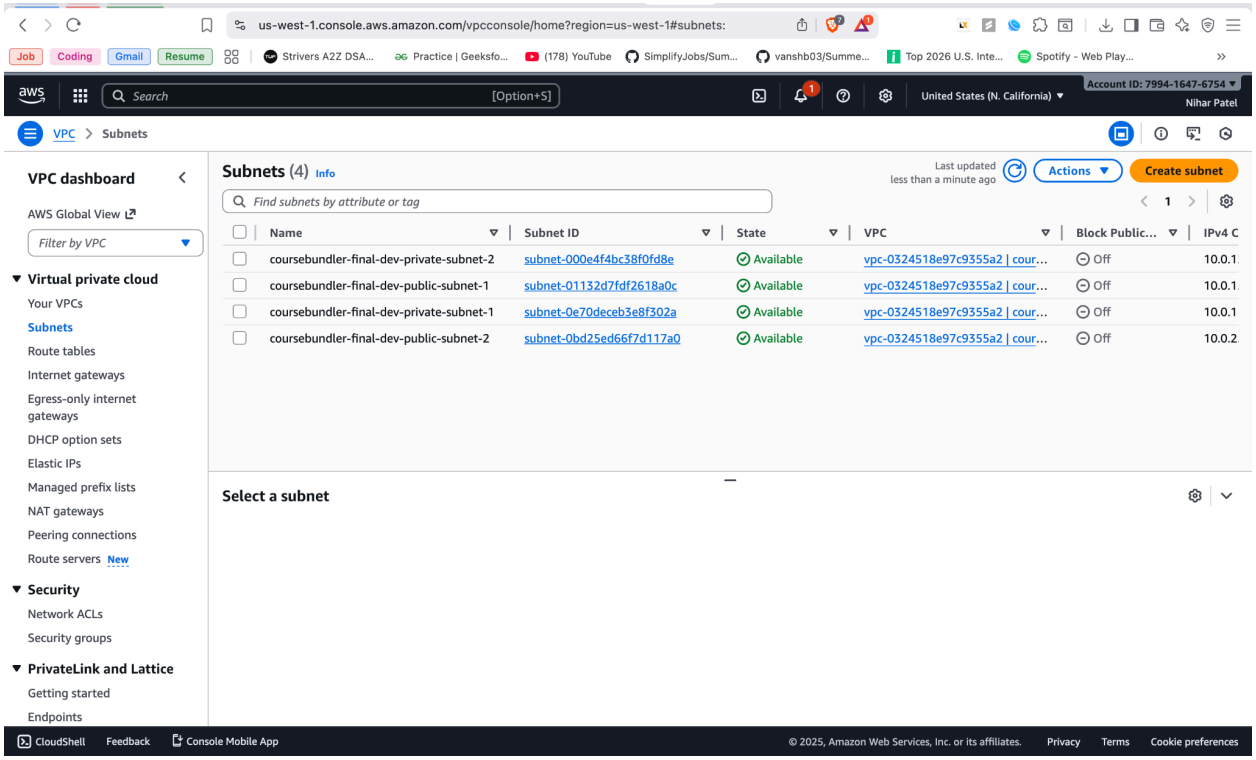
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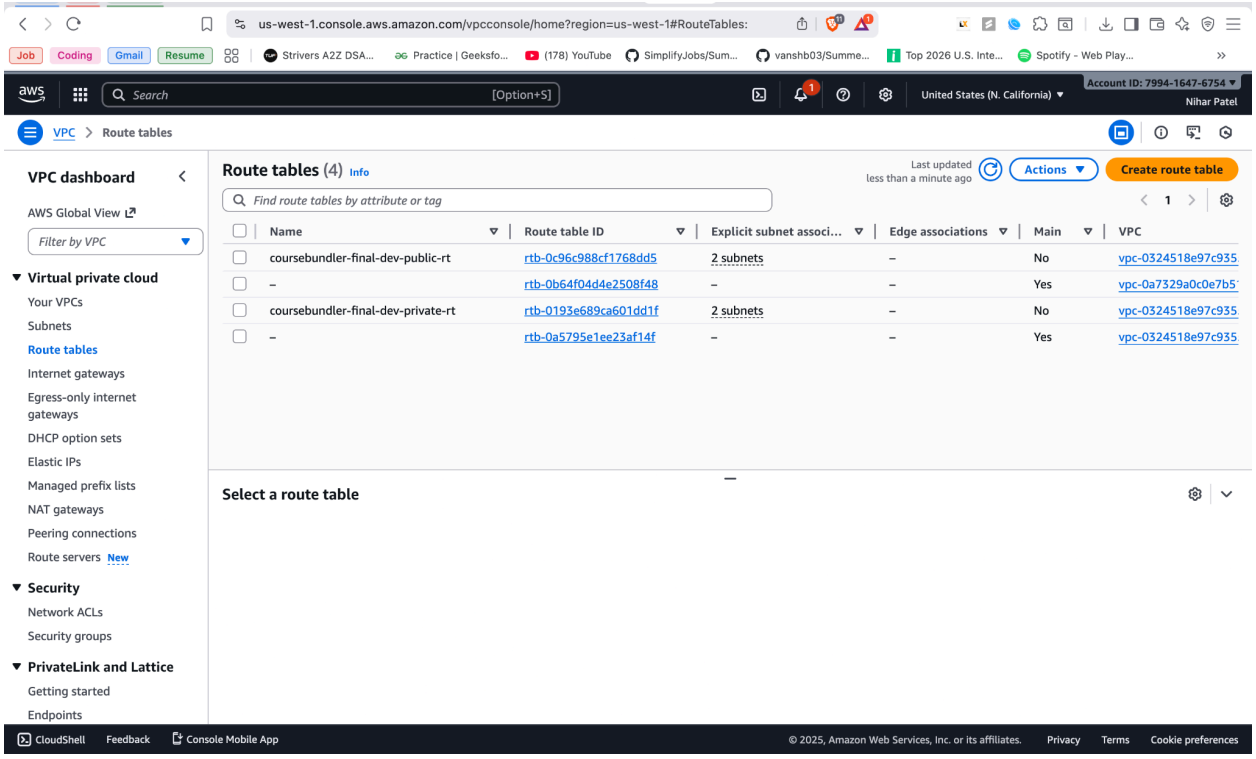
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Main
VPC
coursebundler-final-dev-public-rt
rtb-0c96c988cf1768dd5
2 subnets
–
No
vpc-0324518e97c935
–
rtb-0b64f04d4e2508f48
–
–
Yes
vpc-0a7329a0c0e7b5
coursebundler-final-dev-private-rt
rtb-0193e689ca601dd1f
2 subnets
–
No
vpc-0324518e97c935
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rtb-0a5795e1ee23af14f
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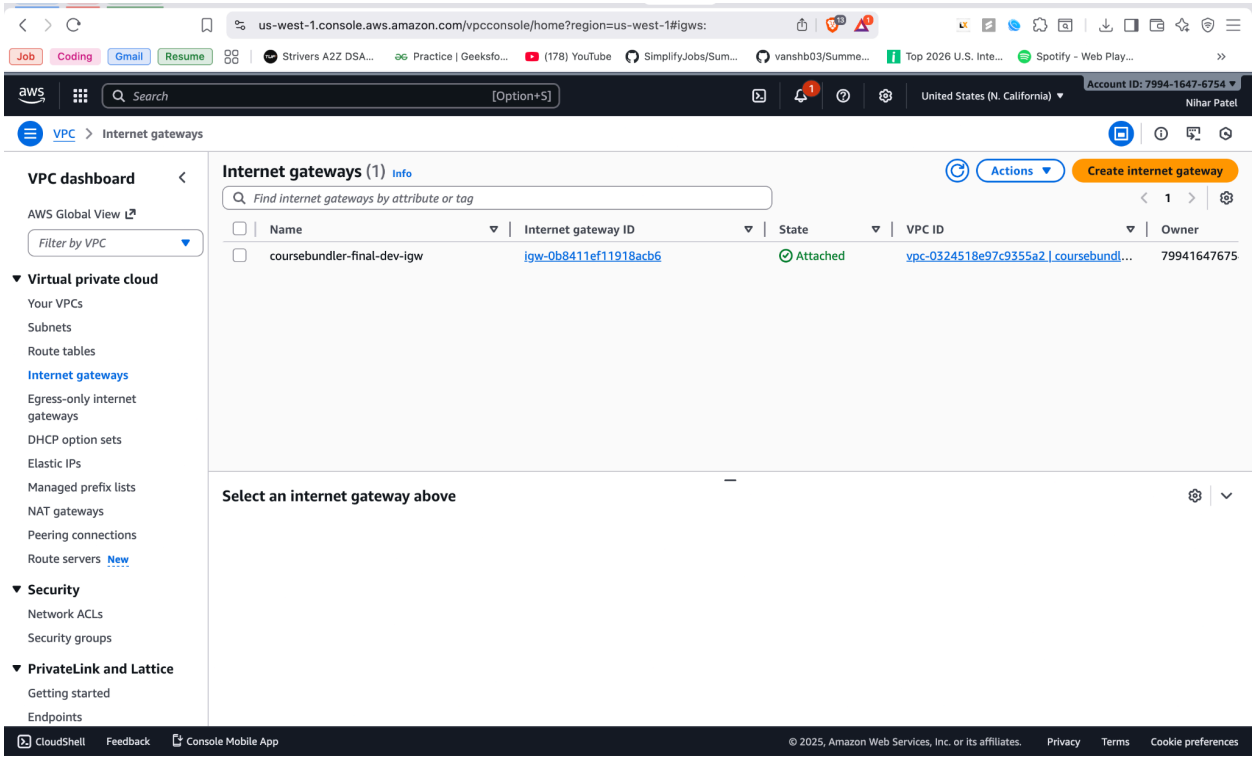
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Internet gateways (1) Info
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Create internet gateway
Find internet gateways by attribute or tag
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Internet gateway ID
State
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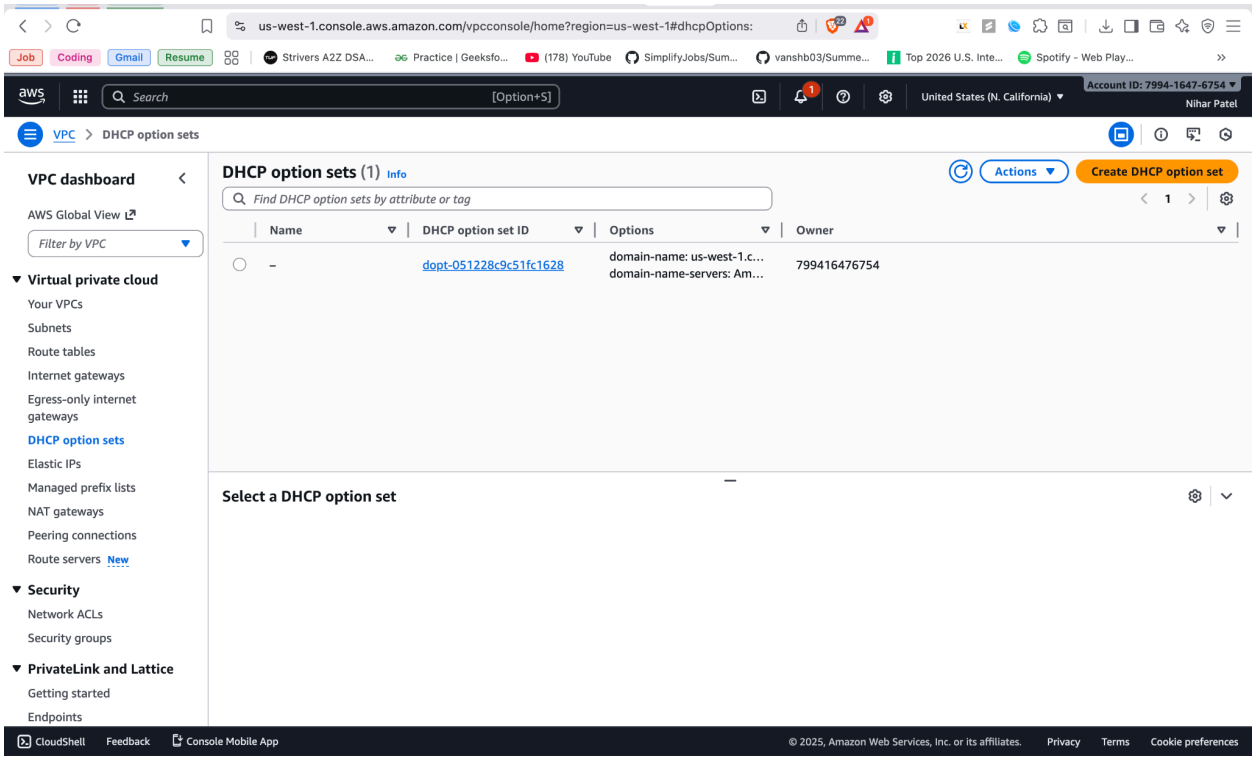
us-west-1.console.aws.amazon.com/vpcconsole/home?region=us-west-1#dhcpOptions:
Search [Option+S]
United States (N. California)
Account ID: 7994-1647-6754
Nihar Patel
VPC > DHCP option sets
VPC dashboard
AWS Global View
Filter by VPC
Virtual private cloud
Your VPCs
Subnets
Route tables
Internet gateways
Egress-only internet gateways
DHCP option sets
Elastic IPs
Managed prefix lists
NAT gateways
Peering connections
Route servers New
Security
Network ACLs
Security groups
PrivateLink and Lattice
Getting started
Endpoints
DHCP option sets (1) Info
Find DHCP option sets by attribute or tag
Actions
Create DHCP option set
Name
DHCP option set ID
Options
Owner
dopt-051228c9c51fc1628
domain-name: us-west-1.c...
domain-name-servers: Am...
799416476754
Select a DHCP option set
CloudShell
Feedback
Console Mobile App
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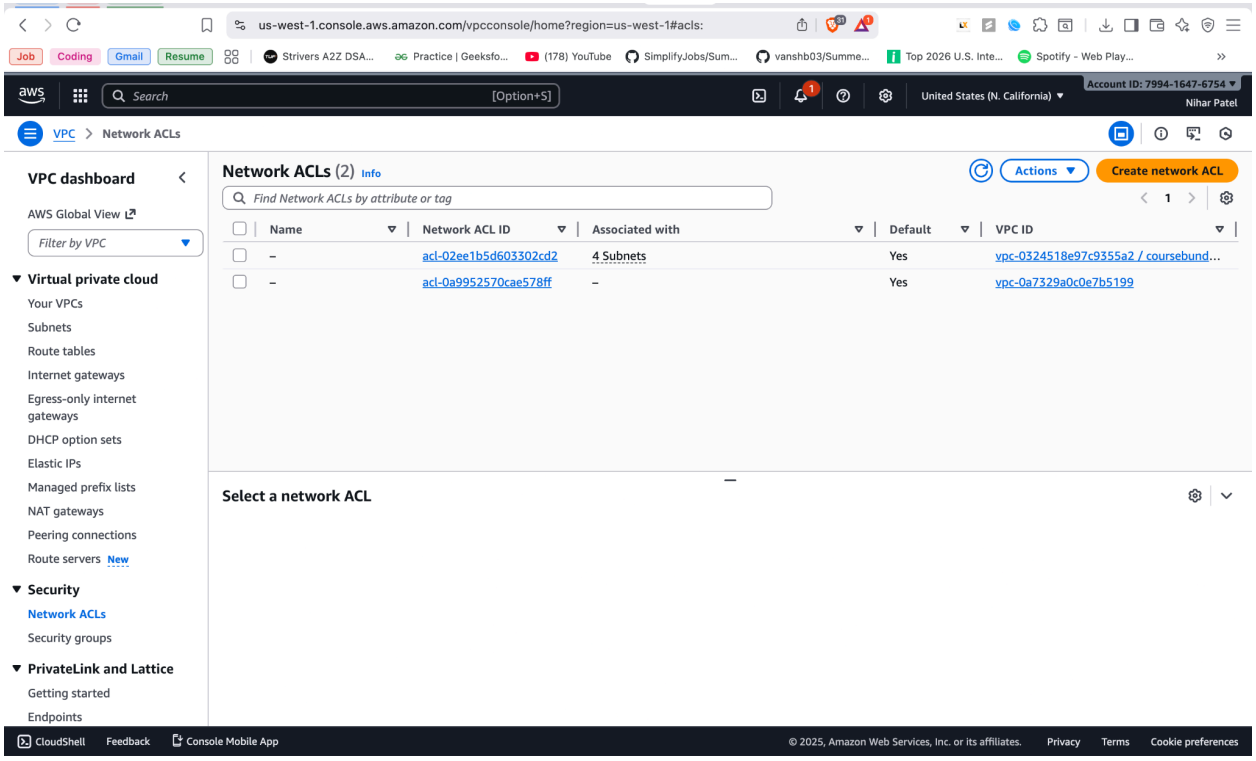
us-west-1.console.aws.amazon.com/vpcconsole/home?region=us-west-1#acls:
Search [Option+S]
United States (N. California)
Account ID: 7994-1647-6754
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VPC > Network ACLs
VPC dashboard
AWS Global View
Filter by VPC
Virtual private cloud
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Endpoints
Network ACLs (2) Info
Find Network ACLs by attribute or tag
Actions
Create network ACL
Name
Network ACL ID
Associated with
Default
VPC ID
acl-02ee1b5d603302cd2
4 Subnets
Yes
vpc-0324518e97c9355a2 / coursebund...
acl-0a9952570cae578ff
Yes
vpc-0a7329a0c0e7b5199
Select a network ACL
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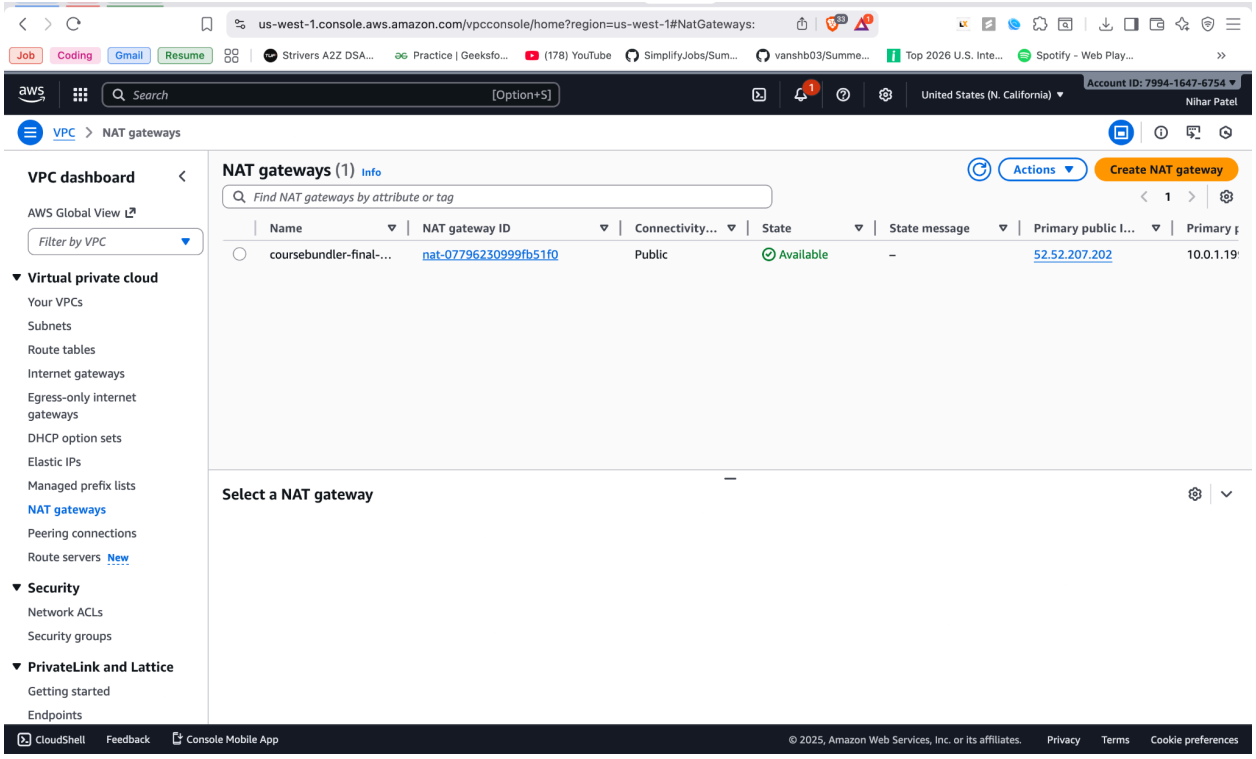
us-west-1.console.aws.amazon.com/vpcconsole/home?region=us-west-1#NatGateways:
Job
Coding
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Resume
Strivers A2Z DSA...
Practice | Geeksfo...
(178) YouTube
SimplifyJobs/Sum...
vanshb03/Summe...
Top 2026 U.S. Inte...
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VPC
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NAT gateways (1) Info
Find NAT gateways by attribute or tag
Actions
Create NAT gateway
Name
NAT gateway ID
Connectivity...
State
State message
Primary public I...
Primary
coursebundler-final-...
nat-07796230999fb51f0
Public
Available
–
52.52.207.202
10.0.1.19
Select a NAT gateway
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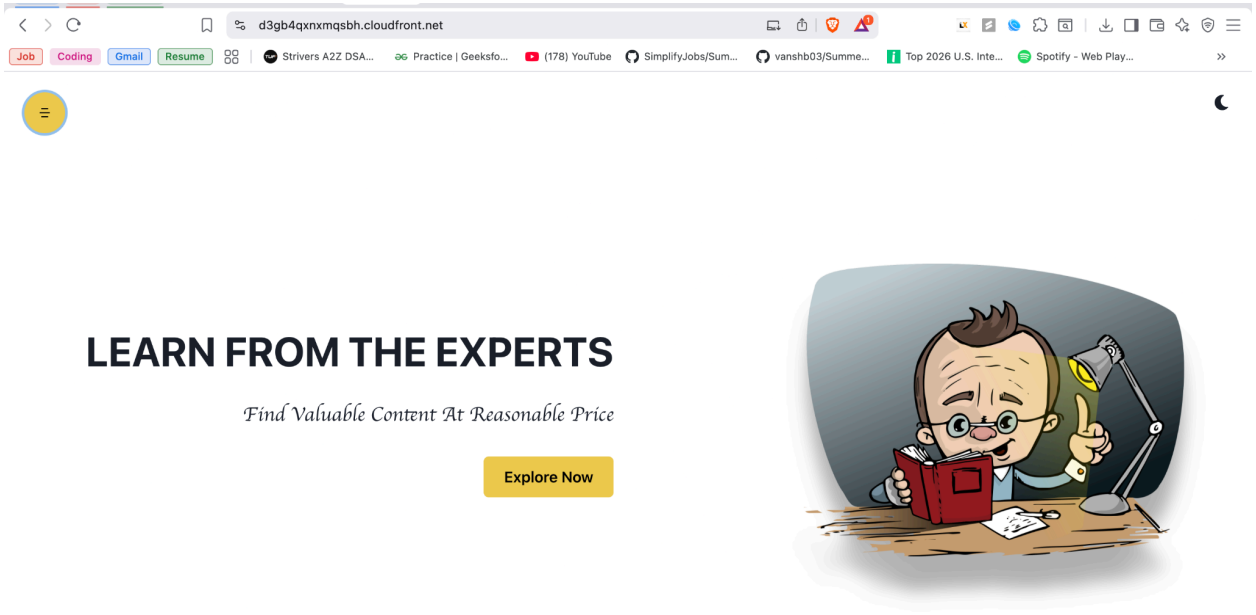
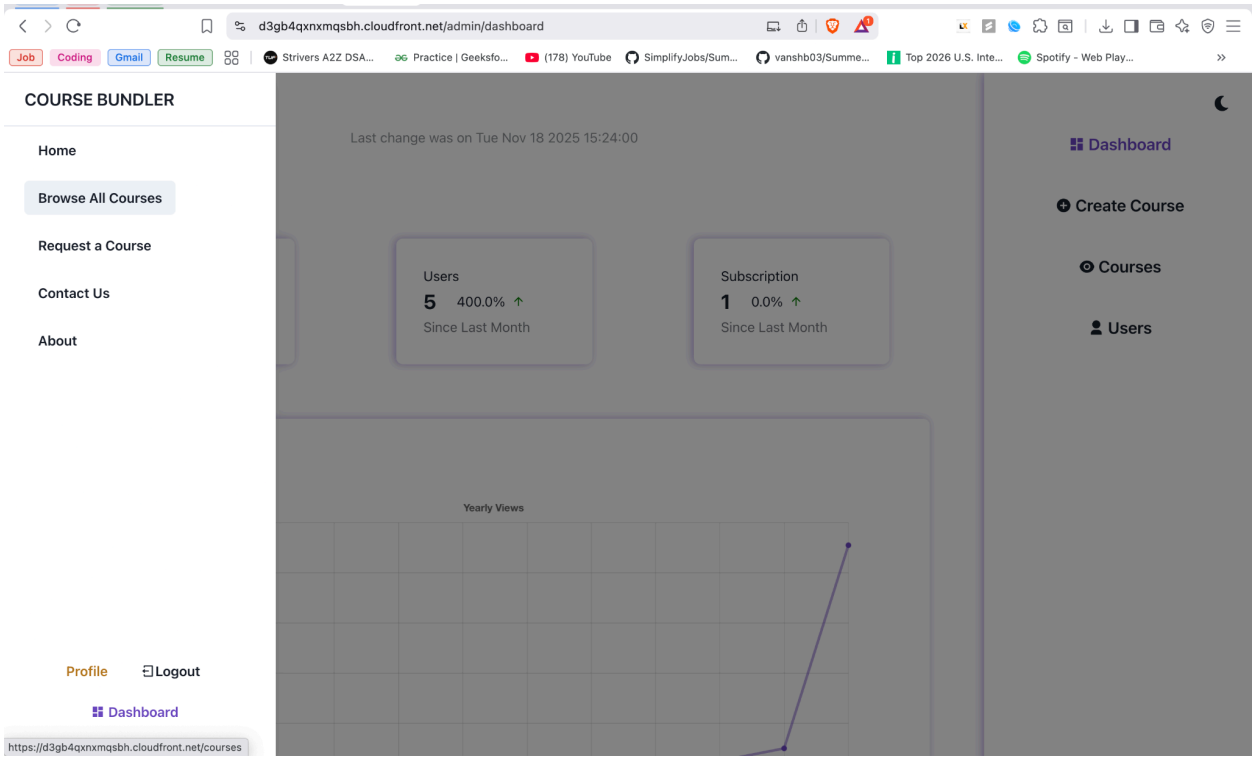
6.2 Application Screenshots

Live Application: https://d3gb4qxnxmqsbh.cloudfront.net

> **Note:** The application may not be currently accessible as the AWS services have been temporarily stopped to avoid ongoing charges. However, the screenshots below serve as proof that the deployment was completed successfully and the website was fully functional at the provided link.

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Since Last Month
Subscription
1 0.0%
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Courses
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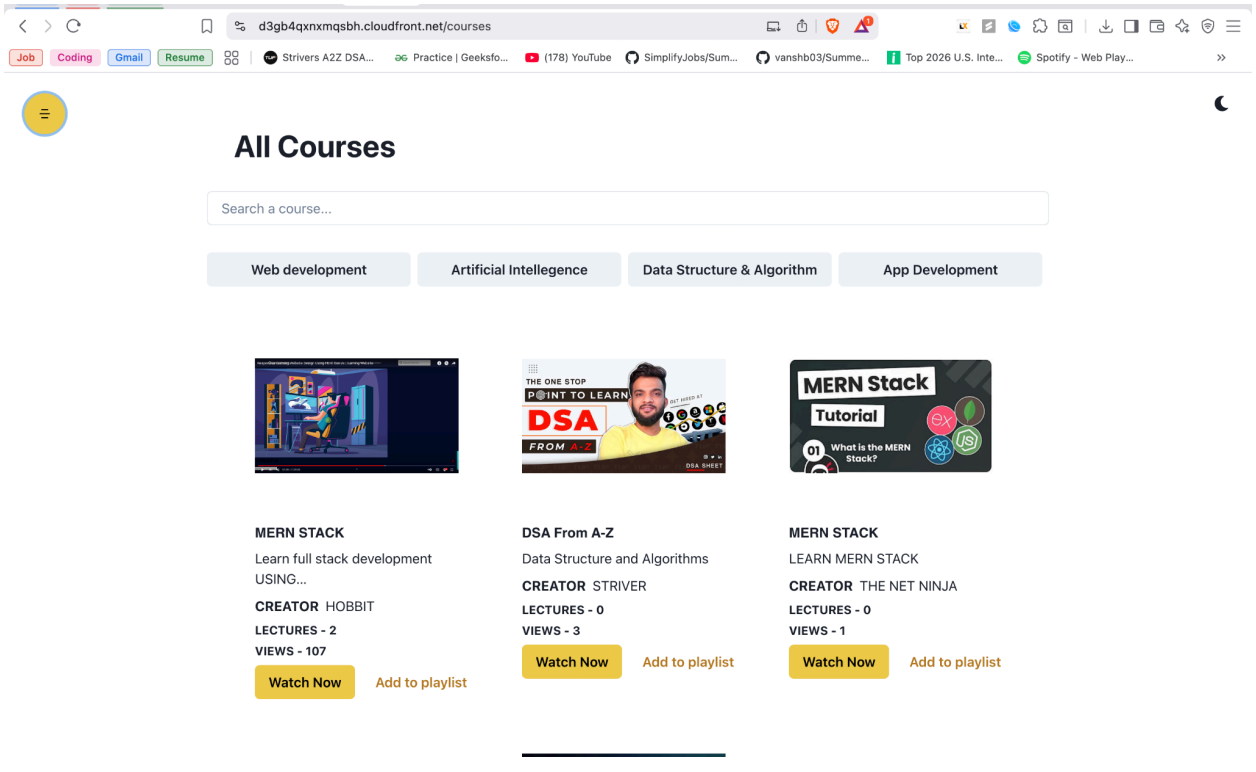
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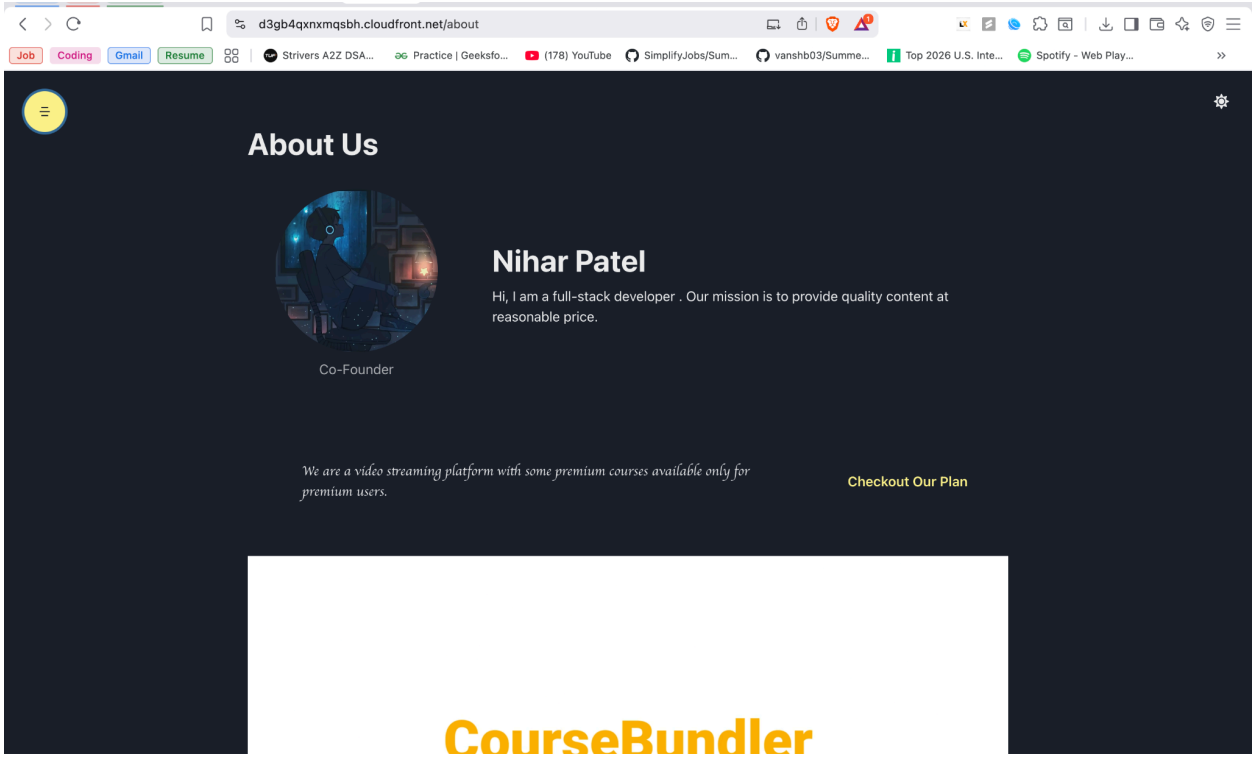
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Nihar Patel
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