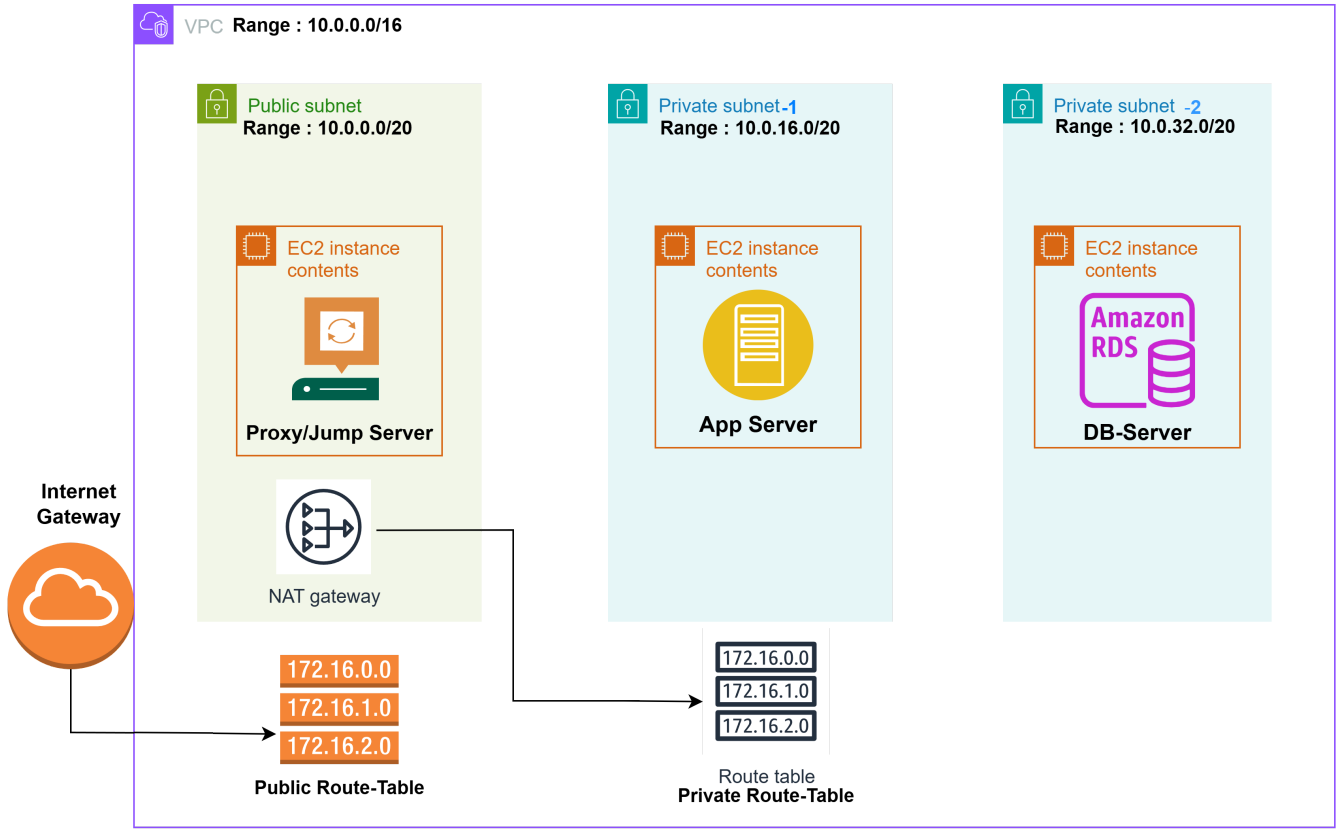
Three-Tier Project Deployment on AWS (Student Registration Form)

Overview

I deployed a **3-Tier Student Registration Web Application** on AWS using a complete **VPC** setup with **NGINX** as a reverse proxy, **Tomcat** as the application server, and **MariaDB on RDS** as the database layer.

- The architecture is divided into three layers:
  1. **Presentation Layer** – Proxy Server (Public Subnet)
  2. **Application Layer** – App Server (Private Subnet-1)
  3. **Database Layer** – RDS & DB Server (Private Subnet-2)
- It ensures **high availability**, **security**, and **scalability** by distributing components across multiple availability zones and using appropriate networking configurations.

Three-Tier Architecture



- The **public subnet** only hosts the proxy (exposed to the internet).
- The **app and DB subnets** remain private for security.
- A **NAT Gateway** allows private EC2s to download updates without public exposure.

1. Presentation Tier (Proxy Layer)

- Hosted in a public subnet

- Uses NGINX as a reverse proxy
- Handles all incoming HTTP traffic
- Also works as a Jump Server (Bastion Host) to connect securely to private instances

2. Application Tier (Private Subnet)

- Runs Apache Tomcat
- Hosts the Java-based Student Registration Web Application
- Connects to the database through JDBC

3. Database Tier (Private Subnet)

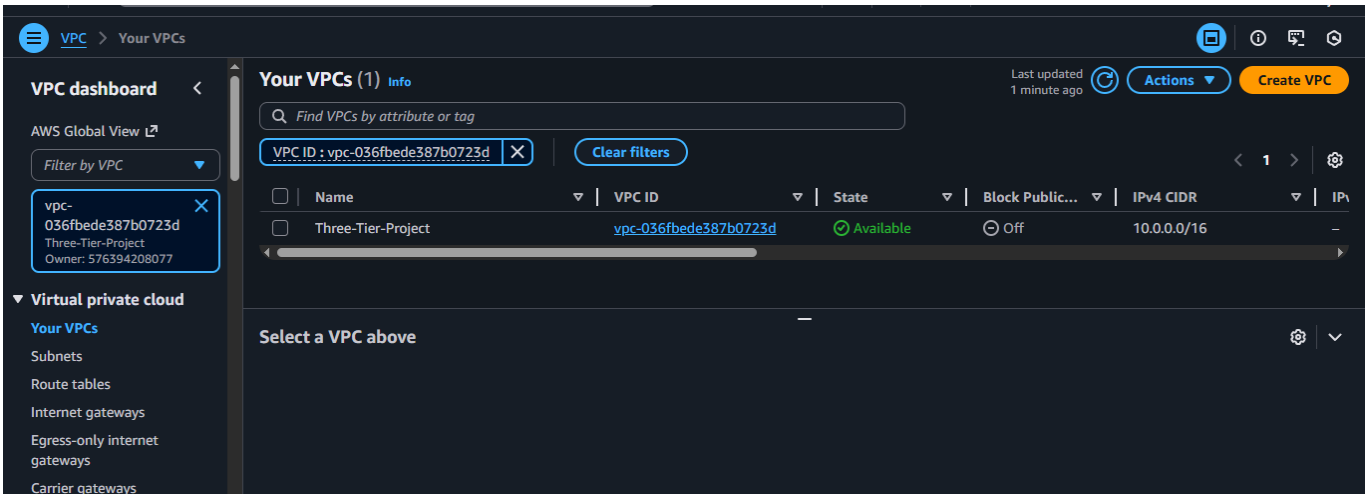
- Uses Amazon RDS (MariaDB)
- Stores student registration data
- Only accessible from the Application Tier (port 3306)”

Steps to deploy the Student Application Form :

1. Create the VPC

1. Create VPC:
    - Name: **three-tier-VPC**
    - CIDR: `10.0.0.0/16`

```
# The VPC defines your isolated network in AWS.
# The `/16` block provides enough IPs to subdivide into multiple subnets.
# (Optional) Tag the VPC so you can filter easily in the console.
```



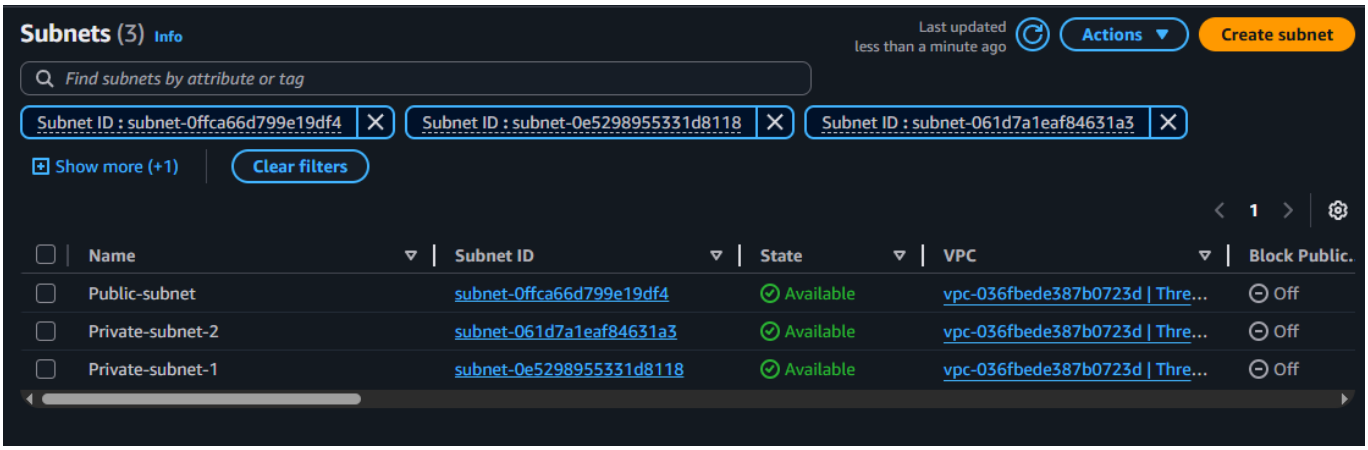
2. Create subnets (different AZs for High Availability)

1. **public-subnet**
    - CIDR: `10.0.0.0/20`

- AZ: **us-east-1a**
- Enable auto-assign public IPv4 if you want EC2 with public IP.

2. **private-subnet-1**
   - CIDR: `10.0.16.0/20`
   - AZ: **us-east-1b**
3. **private-subnet-2**
   - CIDR: `10.0.32.0/20`
   - AZ: **us-east-1c**

```
#  Public subnet : hosts internet-facing resources (proxy, NAT).
# Private subnets : isolate app and DB tiers for security and compliance.
```

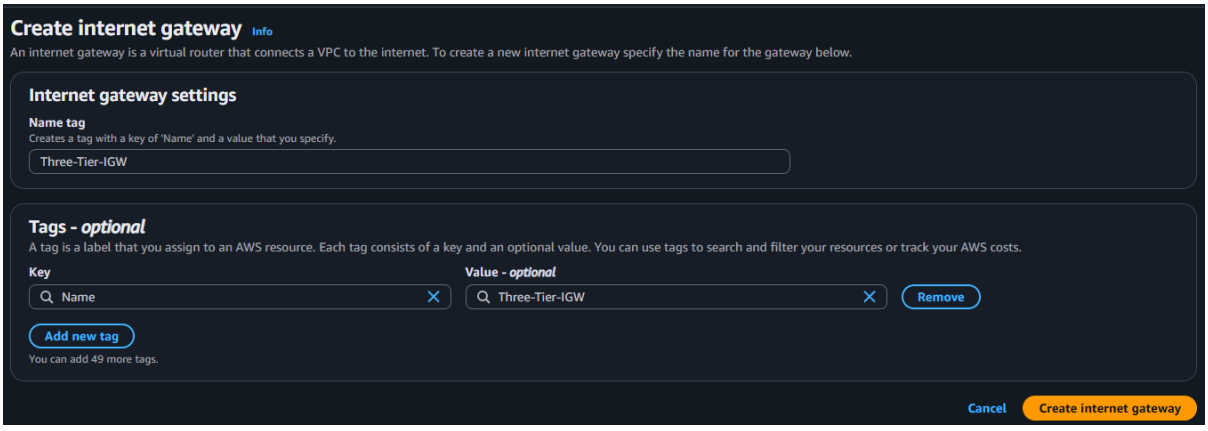


- Ensure different AZs are used for high availability.
- Ensure each private subnet is associated with the private route table later.

---

3. Internet Gateway (IGW) + Public Route Table

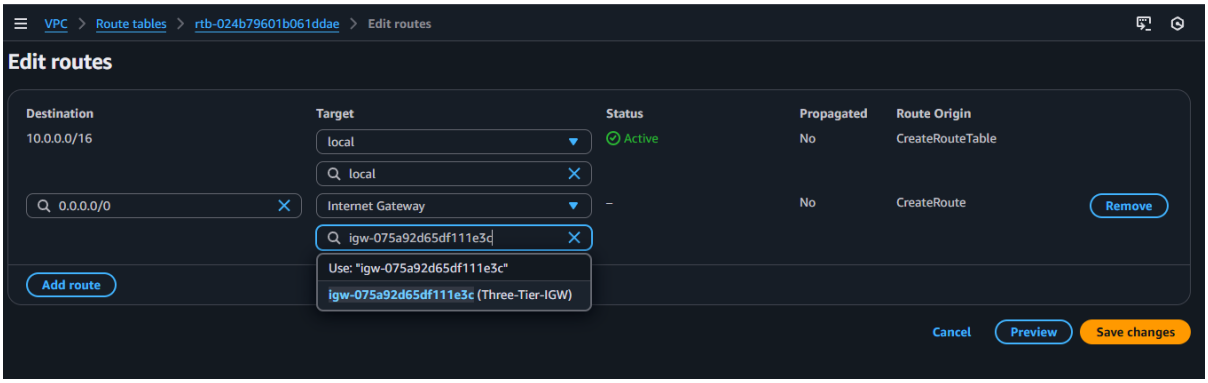
1. Create an Internet Gateway:
   - Name: **three-tier-IGW**



   - Attach it to **three-tier-VPC**.

```
# Enables public subnets to access the Internet.
```

2. Create / or edit Route Table for public traffic:
    - Rename route table to **public-RT** (or create new).
    - Edit routes: add `0.0.0.0/0` → target **three-tier-IGW**.



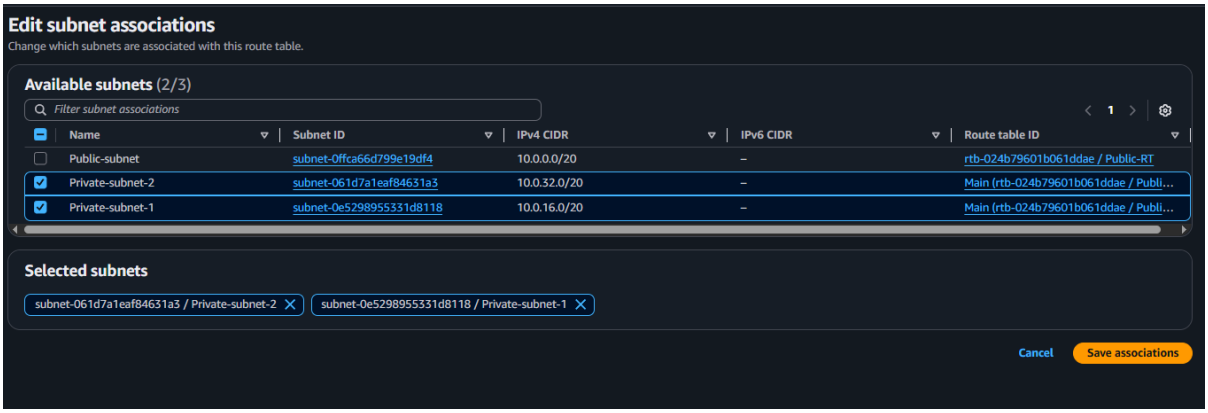
    - **(Optional)** Subnet association: associate **public-RT** with **public-subnet**.

```
# Public-RT → route `0.0.0.0/0` → IGW → associate with `public-subnet`.
```

---

4. NAT Gateway + Private Route Table

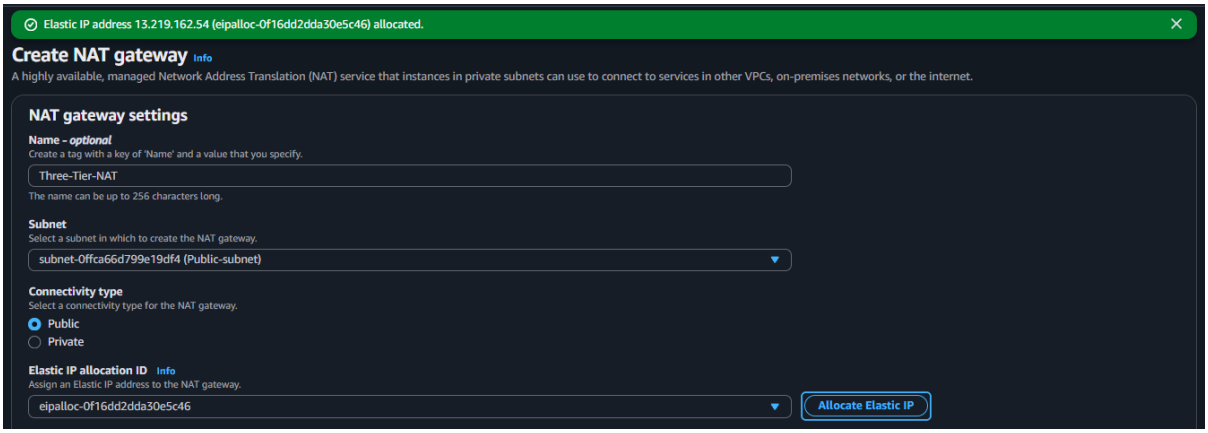
1. Create a private route table:
    - Name: **private-RT**
    - Associate **private-RT** with **private-subnet-1** and **private-subnet-2**.




```
# Private-RT → route `0.0.0.0/0` → NAT Gateway → associate with private subnets.
```

2. Create NAT Gateway:
    - Name: **three-tier-NAT**
    - Subnet: **public-subnet**

- Allocate an **Elastic IP** for it.




```
# Lets private EC2s download updates or dependencies from the internet securely.
```

3. Edit **private-RT** routes:
   - Add `0.0.0.0/0` → target **three-tier-NAT**.

```
# This allows instances in private subnets to access the Internet for
updates/patches without public IPs.
```

---

5. Security Group (three-tier-SG)

- **Name:** `three-tier-SG`
- **Description:** Allow SSH, HTTP, MySQL, and custom TCP (8080)
- **VPC:** `three-tier-VPC`
- **Inbound Rules:**
  - SSH: Anywhere (IPv4)
  - HTTP: Anywhere (IPv4)
  - MySQL/Aurora: Custom TCP 3306
  - Custom TCP: 8080

```
# Security groups act as  firewalls controlling inbound/outbound traffic.
```

---

6. Launch Instances

6.1 Proxy Server (public)

- **Name:** Proxy Server
- **AMI:** Amazon Linux 2 (A1)

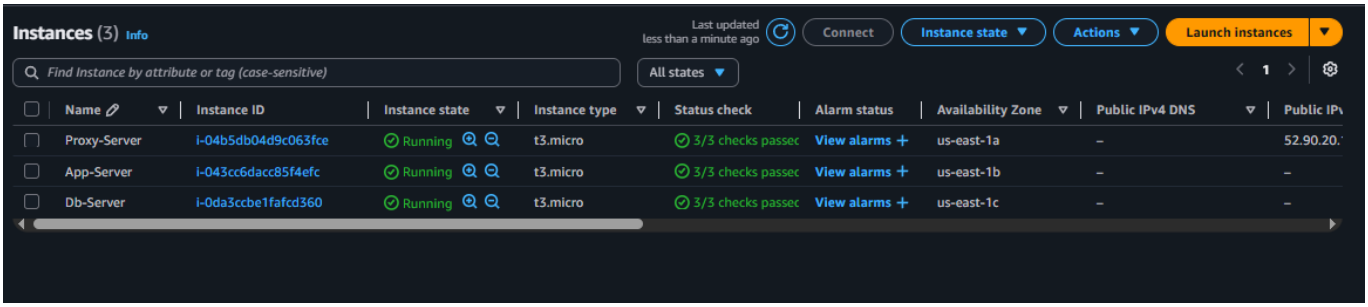
- **VPC:** three-tier-VPC
- **Subnet:** public-subnet
- **SG:** three-tier-SG

6.2 App Server (private)

- **Name:** App Server
- **AMI:** Amazon Linux 2 (A1)
- **VPC:** three-tier-VPC
- **Subnet:** private-subnet-1
- **SG:** three-tier-SG

6.3 DB Server (private)

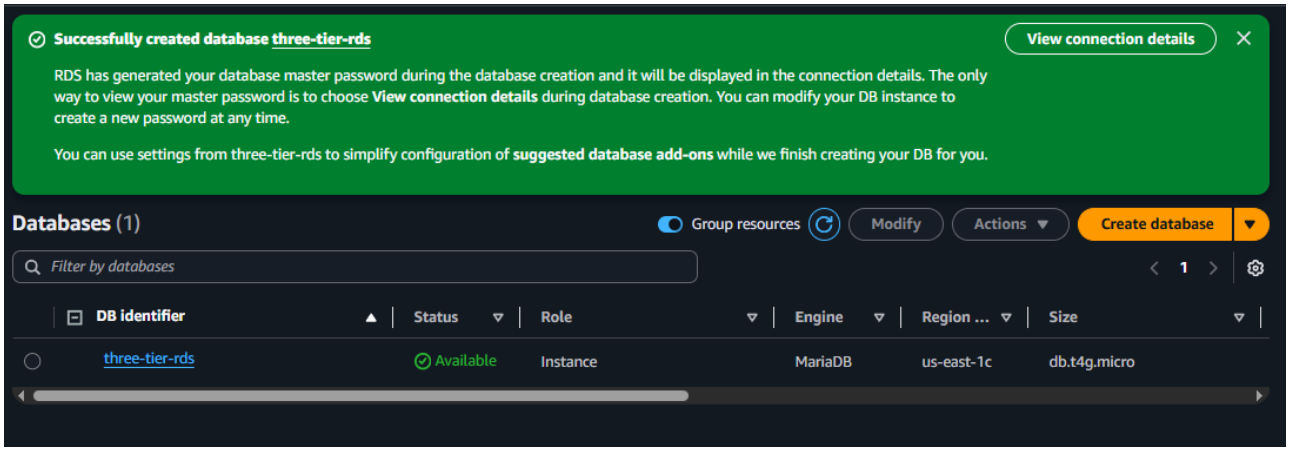
- **Name:** DB Server
- **AMI:** Amazon Linux 2 (A1)
- **VPC:** three-tier-VPC
- **Subnet:** private-subnet-2
- **SG:** three-tier-SG



7. RDS MariaDB (managed DB)

1. Create DB instance:
    - **Type:** Standard Create
    - **Engine:** MariaDB
    - **DB Identifier:** `three-tier-RDS`
    - **Authentication:** Auto-generate password (store securely)
    - **VPC:** `three-tier-VPC`
    - **Security Group:** `three-tier-SG`
    - **Availability Zone:** `us-east-1c` (or use Multi-AZ for higher availability)

2. Note the **RDS endpoint and saved password** — you'll use this in the app **DB config**.




```
# RDS can replace the DB EC2 instance for managed performance and backups.
```

---

8. SSH & Setup Proxy Server (nginx)

- SSH in (from your workstation)

```
ssh -i <key.pem> ec2-user@<proxy-public-ip>
sudo  hostnamectl hostname proxy
exit

# SSH :Connect to the public EC2 using your SSH key.
# hostnamectl : sets a logical name for the host.
```

```
sadguru@DESKTOP-8JENEDM MINGW64 /c/Poonam AWS/SSh-key
$ ssh -i "north-v-key2.pem" ec2-user@52.90.20.169
The authenticity of host '52.90.20.169 (52.90.20.169)' can't be established.
ED25519 key fingerprint is SHA256:RXXihhzKFlWfByVTnk7vOGB4bCvjO2dNLtBA+8lKnQE.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '52.90.20.169' (ED25519) to the list of known hosts.
   ,     #_
   ~\_  ####_        Amazon Linux 2023
  ~~  \_#####\
  ~~     \###|
  ~~       \#/ ___   https://aws.amazon.com/linux/amazon-linux-2023
   ~~       V~' '->
    ~~~         /
      ~~._.   _/
         _/ _/
       _/m/'
[ec2-user@ip-10-0-3-114 ~]$ sudo hostnamectl hostname proxy-server
[ec2-user@ip-10-0-3-114 ~]$ exit
logout
Connection to 52.90.20.169 closed.

sadguru@DESKTOP-8JENEDM MINGW64 /c/Poonam AWS/SSh-key
$ ssh -i "north-v-key2.pem" ec2-user@52.90.20.169
   ,     #_
   ~\_  ####_        Amazon Linux 2023
  ~~  \_#####\
  ~~     \###|
  ~~       \#/ ___   https://aws.amazon.com/linux/amazon-linux-2023
   ~~       V~' '->
    ~~~         /
      ~~._.   _/
         _/ _/
       _/m/'
Last login: Wed Oct 29 14:55:41 2025 from 157.32.139.245
[ec2-user@proxy-server ~]$
```

- Update and Install Nginx:

```
sudo yum update
sudo yum install nginx -y
sudo systemctl start nginx
sudo systemctl enable nginx

# yum update : ensures system packages are current.
# systemctl : starts and auto-enables NGINX at boot.
```

- Edit nginx config to proxy to app server
  - Open the nginx config (or site conf):

```
cd /etc/nginx/
sudo vim nginx.conf
```

- Add inside server block:

```
        location / {
        proxy_pass http://<app-server-private-ip>:8080/student/;
        }
 # NGINX forwards external HTTP traffic to the private app server’s internal IP on
port 8080.
```

```
    include /etc/nginx/conf.d/*.conf;

    server {
        listen       80;
        listen       [::]:80;
        server_name  _;
        root         /usr/share/nginx/html;

        # Load configuration files for the default server block.
        include /etc/nginx/default.d/*.conf;

        error_page 404 /404.html;
        location = /404.html {
        }

        error_page 500 502 503 504 /50x.html;
        location = /50x.html {
        }
        location /{
        proxy_pass http://10.0.21.19:8080/student/;
        }
    }
```

- Restart Nginx:

```
        sudo systemctl restart nginx
```

---

9. Transfer private key to proxy (if you plan to SSH into app via proxy)

- From your local machine:

```
   scp -i <key.pem> <key.pem> ec2-user@<proxy-public-ip>:/home/ec2-user/
 # Transfers key to proxy for secure access into private EC2 via bastion model.
```

```
sadguru@DESKTOP-8JENEDM MINGW64 /c/Poonam AWS/SSh-key
$ scp -i north-v-key2.pem north-v-key2.pem ec2-user@52.90.20.169:/home/ec2-user/
north-v-key2.pem                                              100% 1678     4.9KB/s   0

sadguru@DESKTOP-8JENEDM MINGW64 /c/Poonam AWS/SSh-key
$
```

10. SSH to App Server (via proxy or using SSM)

- From proxy (if using private key on proxy):

```
sudo ssh -i <key.pem> ec2-user@<app-server-private-ip>
sudo hostnamectl hostname app-server
exit
```

- SSH again to app-server :

---

11. Install Java and Tomcat on App Server

- Install Java

```
sudo yum update -y
sudo yum install java -y
java -version
# `yum install java` installs the JRE runtime for Tomcat.
```

- Download and extract Tomcat (example using curl)
  1. On Tomcat website pick the `apache-tomcat-9.x` core tar.gz and copy its link.
  2. On the app server:

```
cd /opt
sudo wget <tomcat-core-tar.gz-link>
sudo tar -xvzf apache-tomcat-9.x.xx.tar.gz -C /opt/
# `curl` downloads the Tomcat package.
```

```
[ec2-user@app-server ~]$ sudo wget https://dlcdn.apache.org/tomcat/tomcat-9/v9.0.111/bin/apache-tomcat-9.0.111.tar.gz
--2025-10-29 15:14:42--  https://dlcdn.apache.org/tomcat/tomcat-9/v9.0.111/bin/apache-tomcat-9.0.111.tar.gz
Resolving dlcdn.apache.org (dlcdn.apache.org)... 151.101.2.132, 2a04:4e42::644
Connecting to dlcdn.apache.org (dlcdn.apache.org)|151.101.2.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 13037002 (12M) [application/x-gzip]
Saving to: 'apache-tomcat-9.0.111.tar.gz'

apache-tomcat-9.0.111.tar 100%[=====================================>]  12.43M  --.-KB/s    in 0.1s

2025-10-29 15:14:43 (118 MB/s) - 'apache-tomcat-9.0.111.tar.gz' saved [13037002/13037002]

[ec2-user@app-server ~]$ ls
apache-tomcat-9.0.111.tar.gz
```

- Start Tomcat

```
cd /opt/<apache-tomcat-folder>/bin
./catalina.sh start
# `catalina.sh start` launches the Tomcat service.
```

---

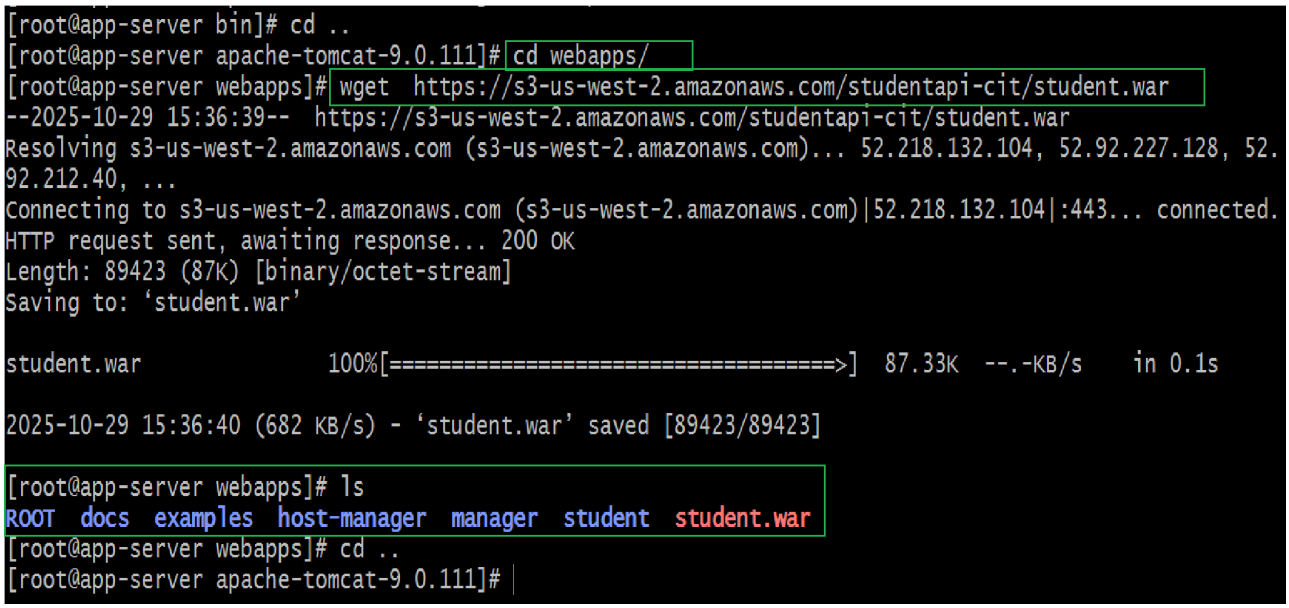
12. Deploy Student Application

- On the app server:

```
cd /opt/<apache-tomcat-folder>/webapps/
```

- **download the WAR provided by your source (e.g., from a PDF link or artifact storage)**

```
wget <link-to-studentapp.war>
```



- restart Tomcat to pick up the WAR

```
cd ../bin/
./catalina.sh stop
./catalina.sh start
```

- After Tomcat starts, app should be available on port `8080` (internally).
- Restart Nginx:

```
sudo systemctl restart nginx
```

Paste the public ip of proxy-server on the Google

13.Database Setup

- SSH to DB Server and change the hostname:

```
sudo ssh -i <key.pem> ec2-user@<private-IP of db-server>
sudo hostnamectl hostname db
exit
```

- Login again to db-server:

```
sudo yum update -y
sudo yum install mariadb105-server -y
sudo systemctl start mariadb
# Installs and starts MariaDB locally, or connects to RDS via client.
```

---

14. Configure DB (if using RDS)

- From the **DB server** (or from an EC2 in same VPC with mysql client):

```
# if you installed mariadb client
mysql -h <RDS-endpoint> -u admin -p
# enter RDS password when prompted
```

- SQL to create DB and table:

```
CREATE DATABASE studentapp;
USE studentapp;

CREATE TABLE IF NOT EXISTS students (
    student_id INT NOT NULL AUTO_INCREMENT,
    student_name VARCHAR(100) NOT NULL,
    student_addr VARCHAR(100) NOT NULL,
    student_age VARCHAR(3) NOT NULL,
    student_qual VARCHAR(20) NOT NULL,
    student_percent VARCHAR(10) NOT NULL,
    student_year_passed VARCHAR(10) NOT NULL,
    PRIMARY KEY (student_id)
);

SHOW TABLES;
SELECT * FROM students;
exit
```

```
MariaDB [(none)]> create database studentapp;
Query OK, 1 row affected (0.006 sec)

MariaDB [(none)]> use studentapp;
Database changed
MariaDB [studentapp]> CREATE TABLE students (
    ->  student_id INT NOT NULL AUTO_INCREMENT,
    ->  student_name VARCHAR(100) NOT NULL,
    ->  student_addr VARCHAR(100) NOT NULL,
    ->  student_age VARCHAR(3) NOT NULL,
    ->  student_qual VARCHAR(20) NOT NULL,
    ->  student_percent VARCHAR(10) NOT NULL,
    ->  student_year_passed VARCHAR(10) NOT NULL,
    ->  PRIMARY KEY (student_id)
    -> );
Query OK, 0 rows affected (0.016 sec)

MariaDB [studentapp]> show tables;
+----------------------+
| Tables_in_studentapp |
+----------------------+
| students             |
+----------------------+
1 row in set (0.001 sec)

MariaDB [studentapp]> select * from students;
Empty set (0.001 sec)

MariaDB [studentapp]> exit
Bye
```

```
# Initializes schema for the web app to store student records
```

---

15. Add MySQL connector to Tomcat (app → RDS)

- On app server:

```
sudo -i
cd /opt/<apache-tomcat-folder>/lib/
ls

# download connector
curl -O <mysql-connector-link>
ls
# The connector JAR provides JDBC connectivity, and the datasource config enables
Tomcat to pool DB connections securely.
```

- Edit Tomcat `context.xml` to add resource:

```
# /opt/<apache-tomcat-folder>/conf/context.xml
<Context>
  ...
            <Resource name="jdbc/TestDB" auth="Container"
type="javax.sql.DataSource"
                      maxTotal="500" maxIdle="30" maxWaitMillis="1000"
                      username="admin" password="<your-rds-password>"
                      driverClassName="com.mysql.jdbc.Driver"
                      url="jdbc:mysql://<RDS-ENDPOINT>:3306/studentapp?useUnicode
                      =yes&amp;characterEncoding=utf8"/>
  ...
</Context>
```

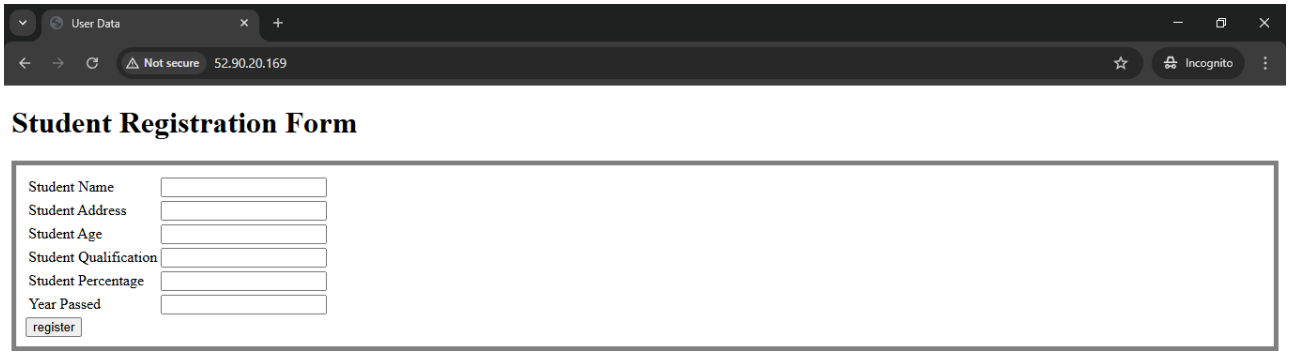
```
<Context>

    <!-- Default set of monitored resources. If one of these changes, the    -->
    <!-- web application will be reloaded.                                   -->
    <WatchedResource>WEB-INF/web.xml</WatchedResource>
    <WatchedResource>WEB-INF/tomcat-web.xml</WatchedResource>
    <WatchedResource>${catalina.base}/conf/web.xml</WatchedResource>

    <!-- Uncomment this to disable session persistence across Tomcat restarts -->
    <!--
    <Manager pathname="" />
    -->
    <Resource name="jdbc/TestDB" auth="Container" type="javax.sql.DataSource"
     maxTotal="500" maxIdle="30" maxWaitMillis="1000"
     username="admin" password="Oaas3BlTsrebtGnXKRyf" driverClassName="com.mysql.jdbc.Driver"
     url="jdbc:mysql://three-tier-rds.cirk6si6wi85.us-east-1.rds.amazonaws.com:3306/studentapp?useUnico
     de=yes&amp;characterEncoding=utf8"/>
```

- Restart Tomcat:

```
cd /opt/<apache-tomcat-folder>/bin/
./catalina.sh stop
./catalina.sh start
```

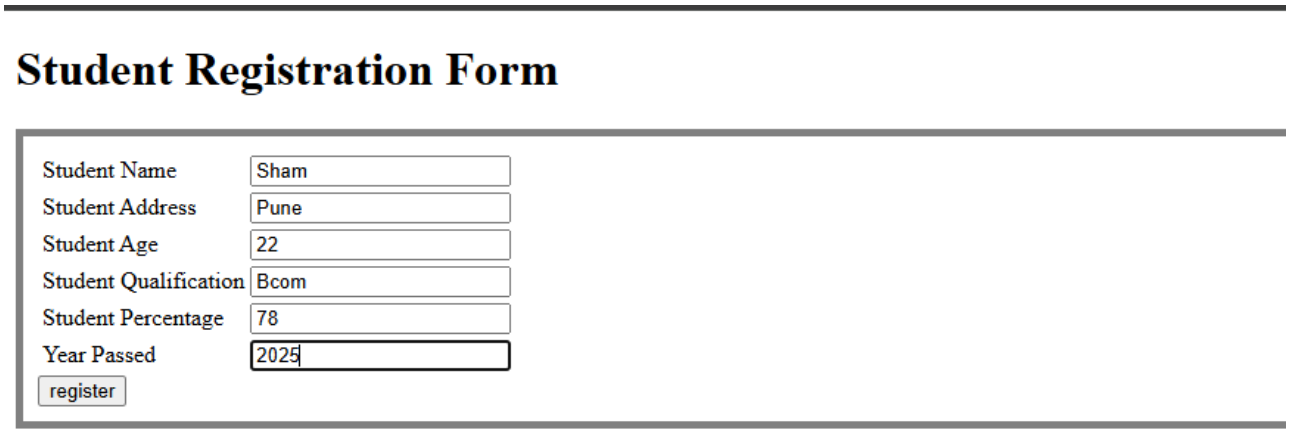
Verification

1. Visit the **Proxy Public IP** in a browser: `http://<proxy-public-ip>/`

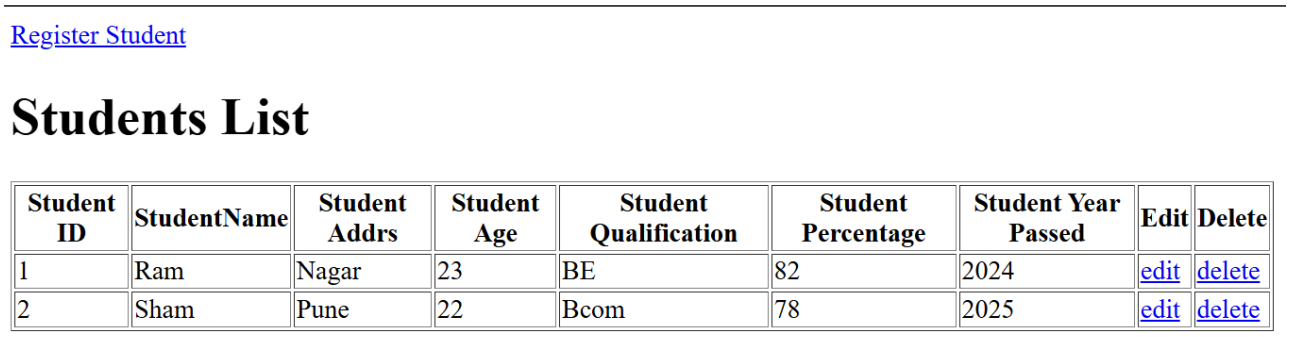


   - Nginx proxies requests to `http://<app-private-ip>:8080/student`

2. Fill in the student data form.



3. Verify data is saved successfully.



4. Connect to RDS or DB Server:

```
USE studentapp;
SELECT * FROM students;
```

- You should see the inserted records.

```
[ec2-user@db-server ~]$ sudo mysql -h three-tier-rds.cirk6si6wi85.us-east-1.rds.amazonaws.com -u admin
-p
Enter password:
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 171
Server version: 11.4.8-MariaDB-log managed by https://aws.amazon.com/rds/

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MariaDB [(none)]> use studentapp;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
MariaDB [studentapp]> select * from students;
+------------+--------------+--------------+-------------+--------------+-----------------+------------
---------+
| student_id | student_name | student_addr | student_age | student_qual | student_percent | student_yea
r_passed |
+------------+--------------+--------------+-------------+--------------+-----------------+------------
---------+
|          1 | Ram          | Nagar        | 23          | BE           | 82              | 2024
         |
|          2 | Sham         | Pune         | 22          | Bcom         | 78              | 2025
         |
+------------+--------------+--------------+-------------+--------------+-----------------+------------
---------+
2 rows in set (0.001 sec)
```

Troubleshooting tips

- If the app is not reachable, check:
  - Security group inbound rules (ports open correctly).
  - NACLs on subnets (should allow traffic).
  - Route tables (public subnet routes to IGW, private to NAT).
  - Tomcat status and logs (`catalina.out`).
  - Nginx error logs (`/var/log/nginx/error.log`).
  - RDS inbound rule allows app SG to connect on 3306.

Conclusion

- This project successfully sets up a Three-Tier Web Application on AWS, complete with:
  - Secure networking (VPC, subnets, routing)
  - Scalable compute (EC2)
  - Managed database (RDS)
  - Load separation (proxy → app → DB)
- It demonstrates fundamental AWS networking, EC2 configuration, and integration between compute and database layers in a real-world architecture.