Containerized Full-Stack Application on AWS

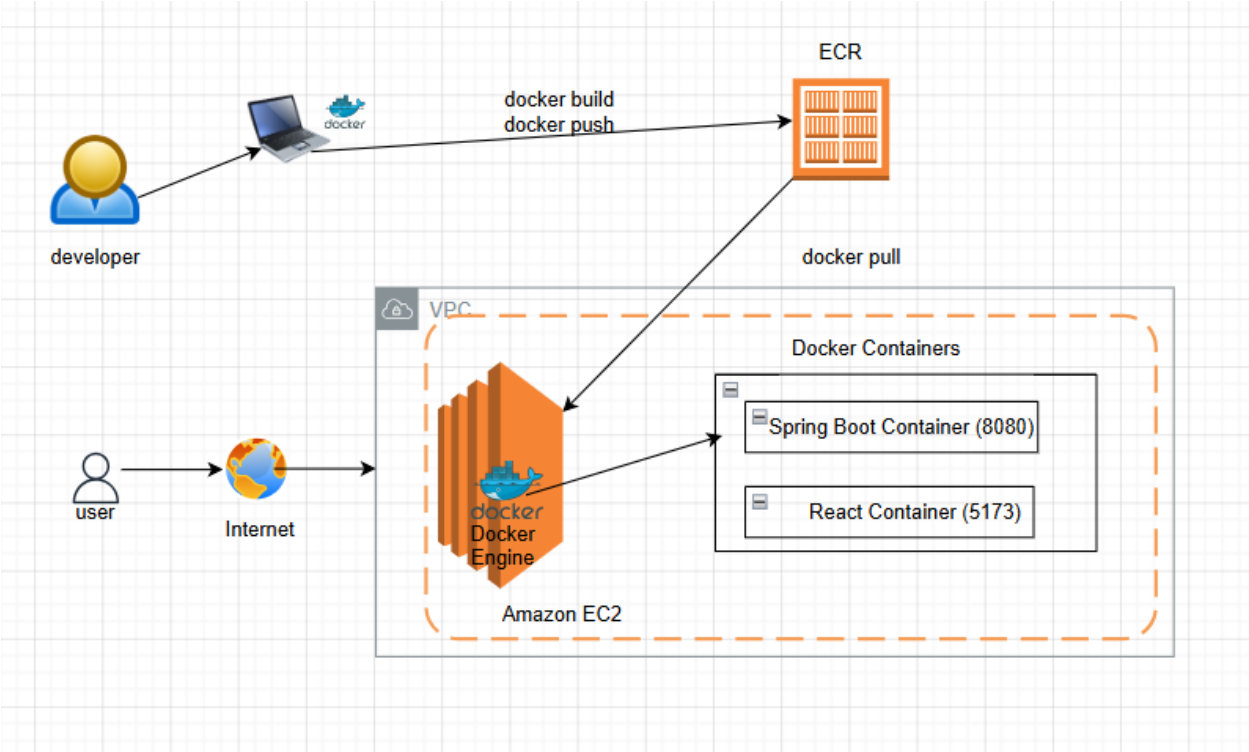
Project Overview:

Designed and implemented a containerized full-stack web application that recommends AWS architecture solutions based on application requirements. The solution was developed using Spring Boot for the backend and React for the frontend, containerized using Docker, stored in Amazon ECR, and deployed on Amazon EC2. This project demonstrates end-to-end application development, containerization, and cloud deployment on AWS.

1. Technology Stack Table:

Layer	Technology
Frontend	React + Vite
Backend	Spring Boot
Containerization	Docker
Orchestration	Docker Compose
Image Repository	Amazon ECR
Compute	Amazon EC2
OS	Amazon Linux 2023

2. Architectural Diagram



3. Spring Boot Backend Set-up:

3.1 Installation:

Install VSCode with the following extension packs:

- Extension Pack for Java
- Spring Boot Extension Pack
- Maven for Java
- Docker
- Language Support for Java
- Test Runner for Java

Install JDK 21 from: Eclipse Adoptium Downloads

3.2 Create Spring-Boot application using VS Code:

3.2.1 Using Ctrl + Shift + P, create a new project

3.2.2 Search Spring Initializr: Create a Maven Project:

3.2.3 Spring Boot 3.x

3.2.4 Java

Group Id: com.dipti

Artifact Id: architecture-engine

Packaging: Jar

Java Version: 21

3.2.5 Add dependency: Spring Web

3.2.6 Choose a folder to save the project

3.2.7 Open project – folder - architecture-engine

3.2.7.1 Run the application using the following command in the VSCode terminal `.\mvnw.cmd spring-boot:run`

This file was generated automatically by Spring Initializr. It's called by Maven Wrapper, which is a mini bootstrap program that downloads and runs Maven without installing Maven. It reads POM and downloads all the dependencies needed by the application and converts java file to class files and store it under target/classes.

3.2.8 Once it starts, open: http://localhost:8080 If you can open the default page, it means the installation and the project were successful.

3.3 Code

3.3.1 Create

- Controller receives API requests
- Service contains business logic
- Model represents data objects

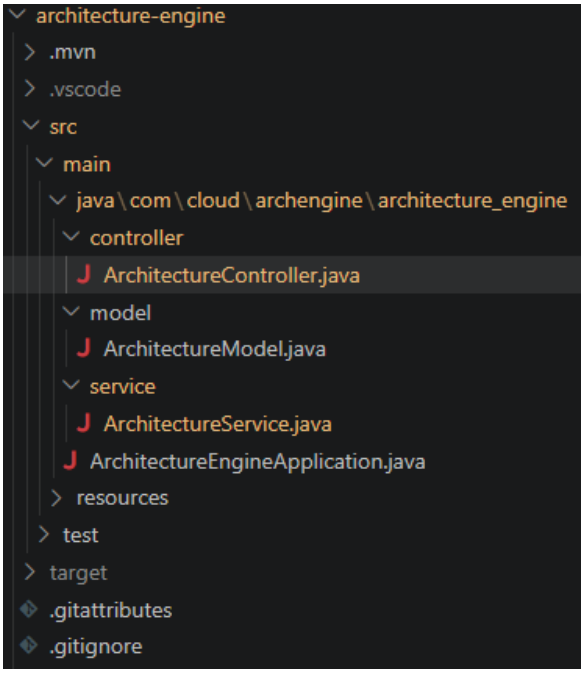


Figure 1. Springboot Project Structure

3.3.2 Code uploaded to my git repository at: https://github.com/uppaldipti/aws-architecture-recommendation-engine/tree/main/architecture-engine

```java
import com.cloud.archengine.architecture_engine.service.ArchitectureService;
import com.fasterxml.jackson.databind.JsonNode;
import com.fasterxml.jackson.databind.ObjectMapper;

@CrossOrigin
@RestController
public class ArchitectureController {
    @Autowired
    ArchitectureService archService;

        @Autowired
    private ObjectMapper objectMapper; // Spring Boot automatically injects thi

    @GetMapping("/getarhitecture")
    public JsonNode getArchitecture(String appType){

        try {
            //call the method from service class
        JsonNode jsonNode =archService.getArchDetailsJson(appType);
            return jsonNode;
        } catch (Exception e) {
            System.out.println("Exception -> " + e.getMessage());
            e.printStackTrace();
        }
        return null;
    }
}
```

Figure 2: Spring Boot REST controller endpoint.

3.4 Local Testing:

3.4.1 Start and run the server using .\mvnw.cmd spring-boot:run

3.4.2 Call the API with the parameter in Postman.

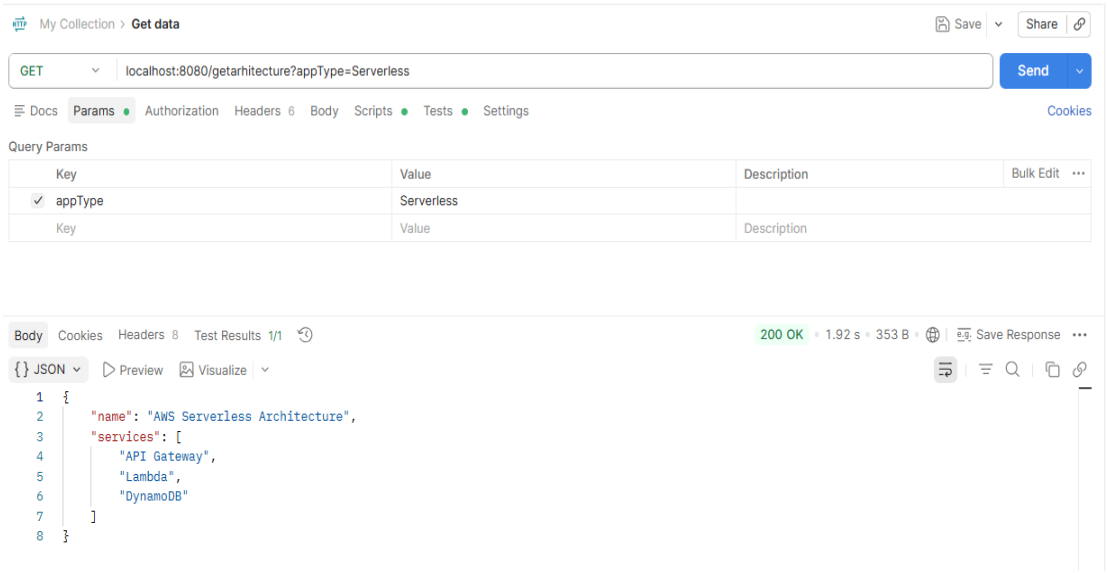


Figure 3: Testing endpoint.

4. React Frontend Set-up:

4.1 Installation: Install VSCode

4.2 Create React application using VSCode:

4.2.1 Open VS Terminal and go to the folder you want to create React app and run

```
npm create vite@latest architecture-ui
```

4.2.2 Select the Framework -> React, Varient-> Javascript

4.2.3 cd to the folder and run

```
npm install
```

```
npm run dev
```

4.2.4 You should see : http://localhost:5173/ - It means the server is started

4.3 Code:

4.3.1 Project Structure in React will look like this

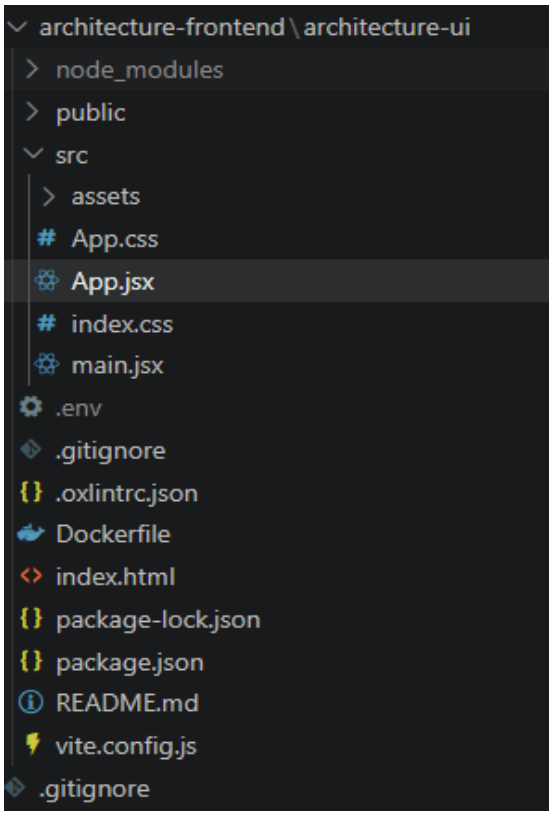


Figure 4: React Project Structure

4.3.2 Edit App.jsx file with the code that can be found in my repo at https://github.com/uppaldipti/aws-architecture-recommendation-engine/tree/main/architecture-frontend/architecture-ui

4.3.3 fetch() is used to invoke the Spring Boot REST API endpoint and retrieve the architecture recommendation as a JSON response.

```
const getRecommendation = async () => {
  const response = await fetch(
    `${API_URL}/getarhitecture?appType=${appType}`
  )
```

Figure 5: React endpoint to consume the api request

4.4 Local Testing:

4.4.1 Run `npm run dev`

4.4.2 You should see:

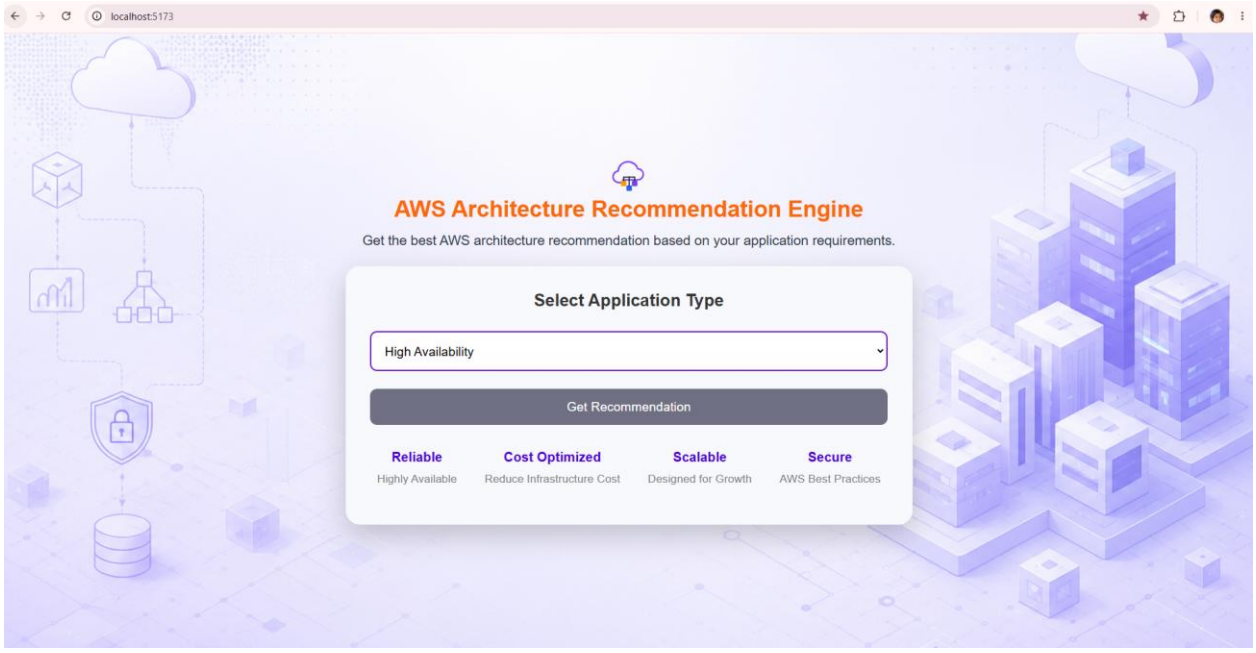


Figure 6: Testing application.

5. End-to-End Architecture Flow:

5.1 Architecture Flow Description: The React frontend captures the user-selected application type, invokes the Spring Boot REST API, and dynamically renders the recommended AWS architecture based on the JSON response returned by the service layer.

```
User Selection
      ↓
React Frontend
      ↓
Spring Boot REST API
      ↓
Architecture Service
      ↓
JSON Response
      ↓
Dynamic UI Rendering
```

Figure 7: End-To-End Flow Diagram

5.2 React-to-Spring Boot API Communication: Figure 8 demonstrates the successful communication between the React frontend and the Spring Boot REST API. The browser Network tab confirms that the selected application type is passed to the backend endpoint and a JSON response is returned successfully.

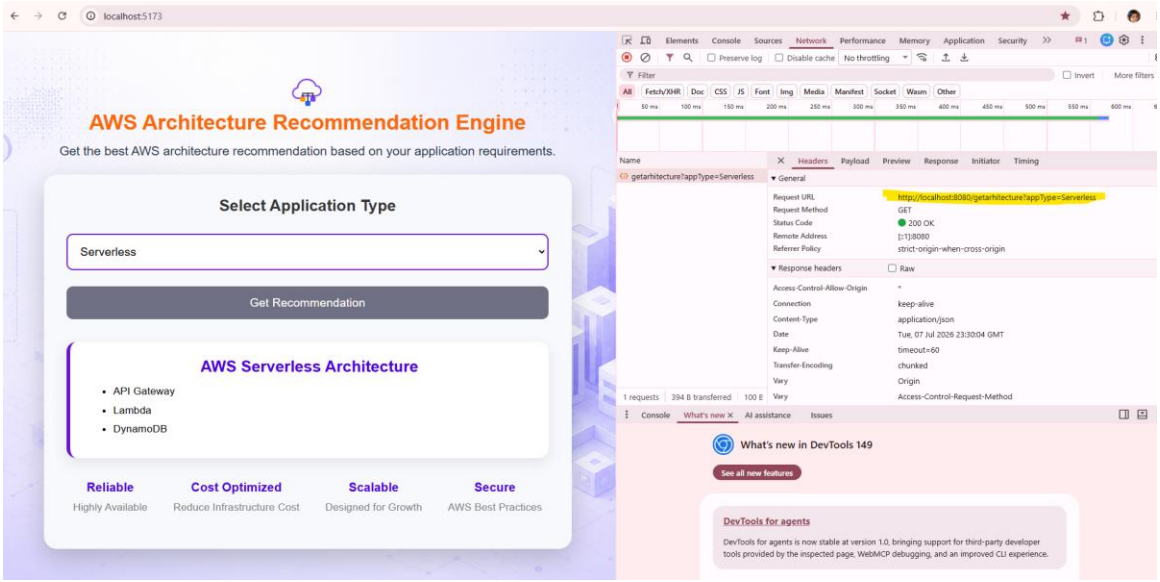


Figure 8: React Frontend Invoking Spring Boot REST API

6. Containerization using Docker:

6.1 Why Docker? Docker is used to package an application and its dependencies into a portable container that can run consistently across different environments.

6.2 Dockerfile Overview: This file is added to the project with the instructions that are required by Docker to build the Docker Image. This Image can be used to run 1 or more containers.

6.3 Installation: Use powershell or command prompt

Install Docker Desktop
Verify Docker Installation
Install WSL (Windows Subsystem for Linux)
docker --version
docker ps

6.4 Flow / Code / Build / Run:

<table>
<tr>
<td>

- Dockerize React

React Code
↓
Dockerfile
↓
Docker Image
↓
Docker Container

//Code in Dockerfile

```
FROM node:20-alpine
WORKDIR /app
COPY package*.json ./
RUN npm install
COPY . .
EXPOSE 5173
CMD ["npm", "run", "dev", "--", "--host", "0.0.0.0"]
```

//Build Docker Image
docker build -t aws-react-ui .

//Run Docker Image
docker run -d -p 3000:3000 --name react-ui aws-react-ui

</td>
<td>

- Dockerize Spring Boot

Springboot Code
↓
Dockerfile
↓
Docker Image
↓
Docker Container

//Code in Dockerfile

```
FROM eclipse-temurin:21-jdk
WORKDIR /app
COPY target/*.jar app.jar
EXPOSE 8080
ENTRYPOINT ["java", "-jar", "app.jar"]
```

//Build Docker Image
docker build -t architecture-engine-backend .

//Run Docker Image
docker run -p 8080:8080 architecture-engine-backend

</td>
</tr>
</table>

6.5 After updating both the applications and running the commands, we can now see that the applications are running in their own containers**.**

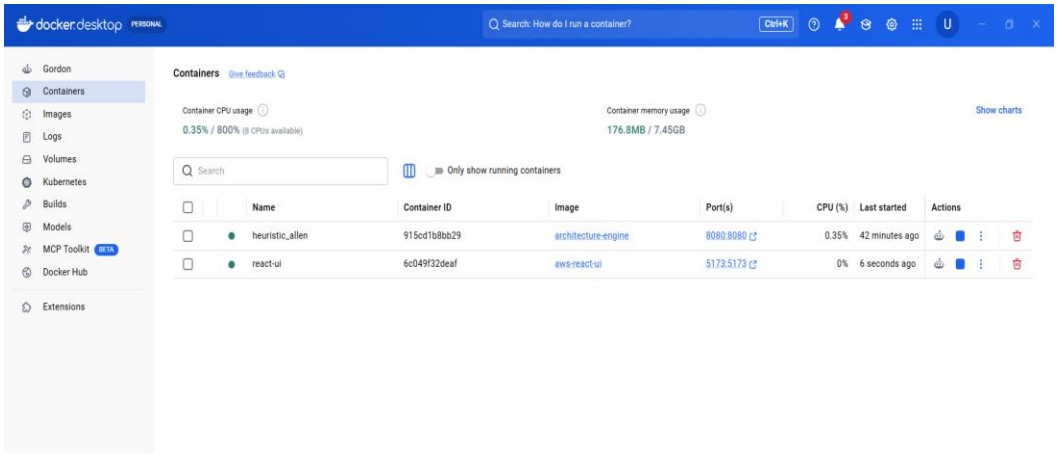


Figure 9: React and Spring containers

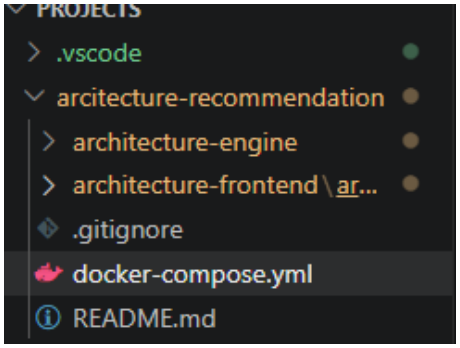
6.6 In real-world applications, multiple services often need to run together. Managing each container separately can become difficult as the application grows. Docker Compose helps define and manage multiple containers as a single application stack using a single **docker-compose.yml** file, making deployment and maintenance much easier.

6.7 What is docker-compose doing?

- Creates a private Docker network
- Connects containers together
- Handles startup order
- Starts everything with one command

6.8 docker-compose.yml: This file is created in the root folder of the project.

NOTE: Stop the existing containers.



6.9 Flow / Code / Build / Run:

//docker-compose.yml

```
services:
  Run Service
  backend:
    build:
      context: ./architecture-engine
    image: architecture-engine
    container_name: architecture-backend
    ports:
      - "8080:8080"

  Run Service
  frontend:
    build:
      context: ./architecture-frontend
    image: aws-react-ui
    container_name: architecture-frontend
    ports:
      - "5173:5173"
    depends_on:
      - backend
```

//Build Docker Image
docker compose build

//run Docker Image
docker compose up -d
(-d runs in background)

//Verify
http://localhost:5173
Application webpage will be shown as seen in Figure 8

6.10 Figure 10 shows both frontend and backend containers running separately. Figure 11 shows Docker Compose managing both containers together under one application stack.

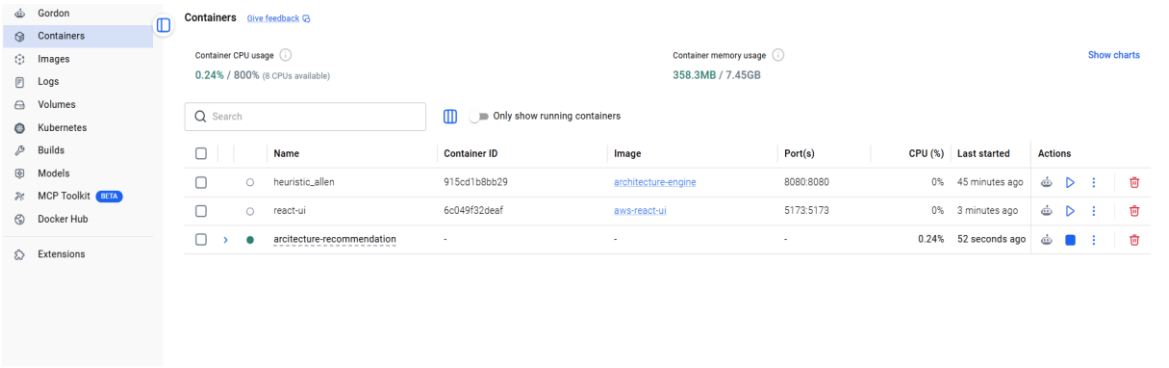


Figure 10: Single container running

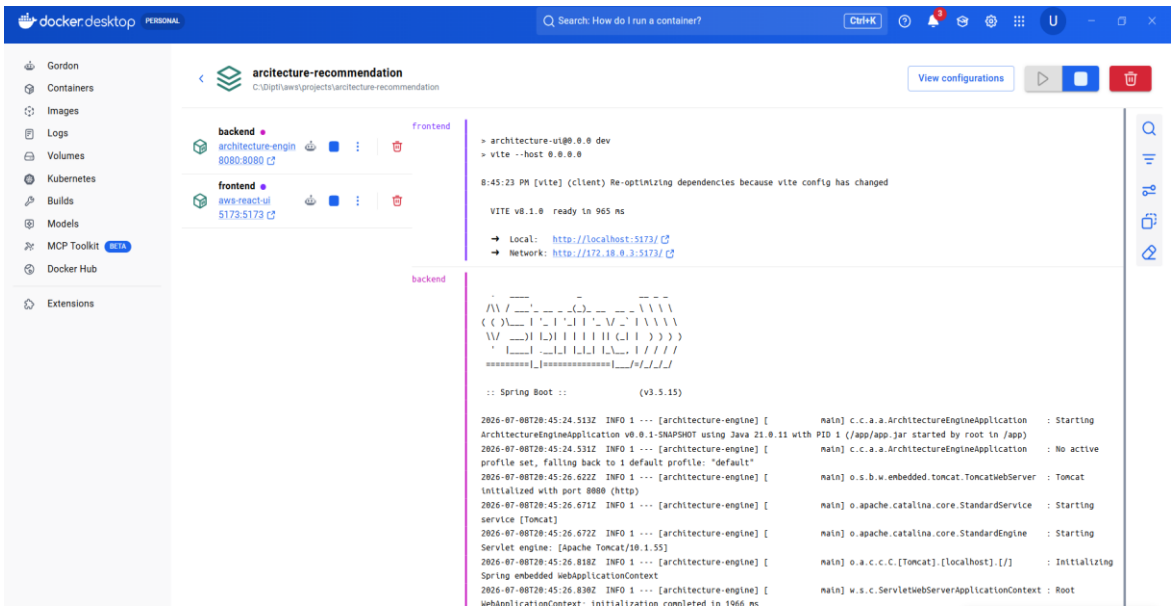


Figure 11: Docker Compose project running both frontend and backend containers as one application stack.

Now that the application is working locally, the next step is to make it cloud-ready by pushing the Docker images to Amazon ECR, launching an EC2 instance, installing Docker on EC2, pulling the images from ECR, and running the application on AWS.

7. Amazon Elastic Container Registry (ECR):

7.1 Login to your AWS account. ECR – Create Repository.

Settings:

Repository Name: aws-architecture-recommendation-engine
Visibility: Private
Tag Immutability: Disabled (default)
Encryption: AES-256 (default)
Click **Create Repository**.

7.2 Install AWS CLI & Configure the AWS credentials using command prompt or powershell.

7.3 In the same window - **Login to ECR** from your local machine using:

```
aws ecr get-login-password --region us-east-1 docker login --username AWS --password-stdin <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com
```

OR

```
$ECR_PASSWORD = aws ecr get-login-password --region us-east-1

docker login --username AWS --password $ECR_PASSWORD <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com
```

7.4 Tag Images: Docker image tags uniquely identify image versions and destinations. Before pushing to ECR, we tag the local image with the ECR registry URL, repository name, and version tag so Docker knows where to store the image. Tags also help manage multiple versions such as development, testing, and production releases. **We are essentially giving Docker the full address of where the image should live in ECR.**

React:

```
docker tag aws-react-ui:latest <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-recommendation-engine:frontend
```

Spring Boot:

```
docker tag architecture-engine:latest <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-recommendation-engine:backend
```

7.5 Push Images: Pushing the image to the mentioned path

React

docker push <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-recommendation-engine:frontend

Springboot

docker push <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-recommendation-engine:backend

7.6 Verify the Images are stored in ECR Repository as shown.

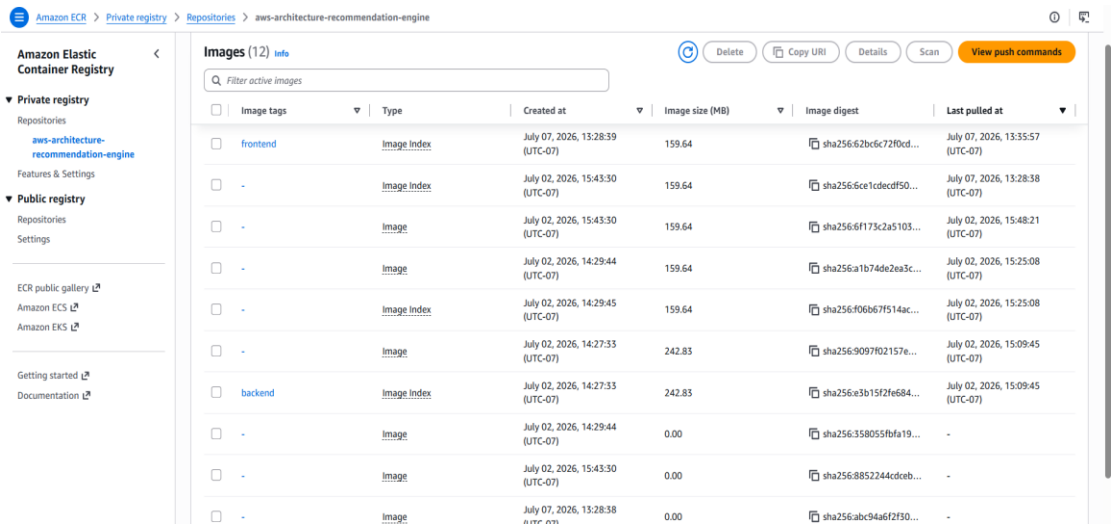


Figure 12: ECR Repository

8. Preparing EC2 for Deployment

8.1 IAM role: Will be created so the EC2 instance will have the authority to pull the image from the ECR Repository

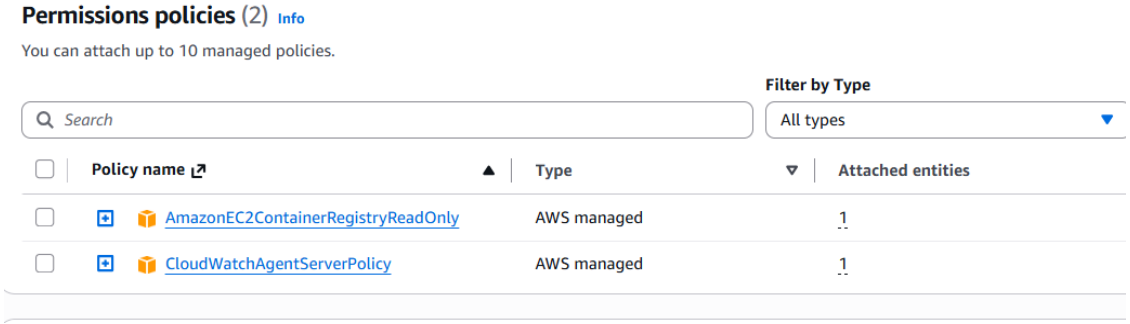


Figure 13: IAM Roles

8.2 Security group:

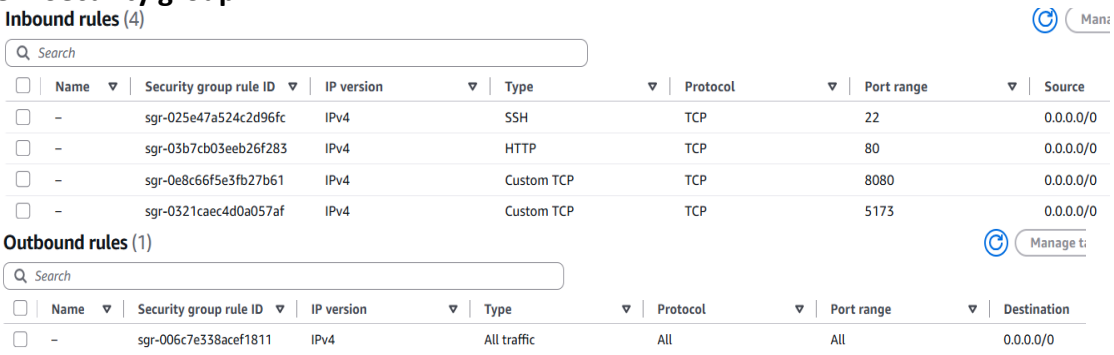


Figure 14: Security Rules

8.3 Launch EC2 instance: Launch an EC2 Instance with the IAM Role, Security group and accept all the default settings. Connect to EC2 by "connect using public IP". Login and install Docker.

- sudo dnf update -y
- sudo dnf install docker -y
- sudo systemctl start docker
- sudo systemctl enable docker
-
- sudo usermod -aG docker ec2-user

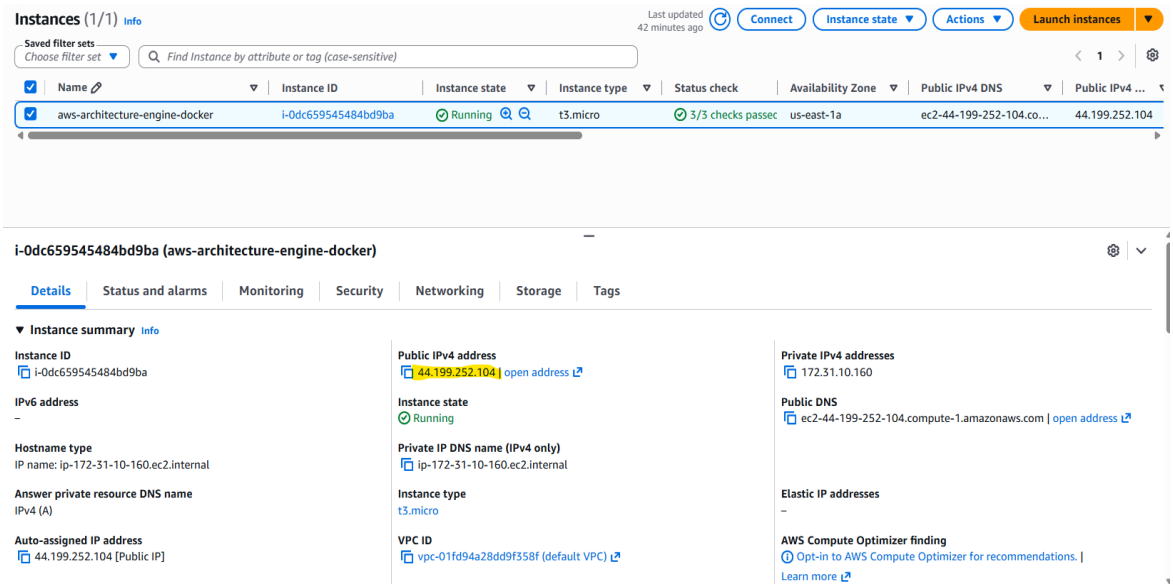


Figure 15: Launched EC2.

8.4 Once we get the Public IP for the EC2 instance, update the address in:
react project-> .env file->

NOTE: We have to build, tag & push this image again to ECR again

Figure 16: Updating IP for backend Service.

9. Pulling Images from ECR to EC2

9.1 Connect to EC2.

9.2 Login to ECR from EC2 using

```
aws ecr get-login-password --region us-east-1 docker login --username AWS
--password-stdin <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com
```

You should see: Login Succeeded

9.3 Pull and Run the **SPRINGBOOT** Image using

```
docker pull <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-
recommendation-engine:backend
```

```
docker run -d -p 8080:8080 --name architecture-engine-backend
062541600148.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-
recommendation-engine:backend
```

9.4 Pull and Run the **REACT** Image using

```
docker pull <ACCOUNT_ID>.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-
recommendation-engine:frontend
```

```
docker run -d -p 5173:5173 --name achitecture-engine-frontend
062541600148.dkr.ecr.us-east-1.amazonaws.com/aws-architecture-
recommendation-engine:frontend
```

9. 5 Check container using:

```
docker ps -a

docker images
docker logs architecture-engine-backend
```

10. Test the application in Browser

```
Frontend - http://<EC2-PUBLIC-IP>:5173

Backend- http://<EC2-PUBLIC-IP>:/getarhitecture?appType=Serverless
```

11.End-to-End Application running on Cloud

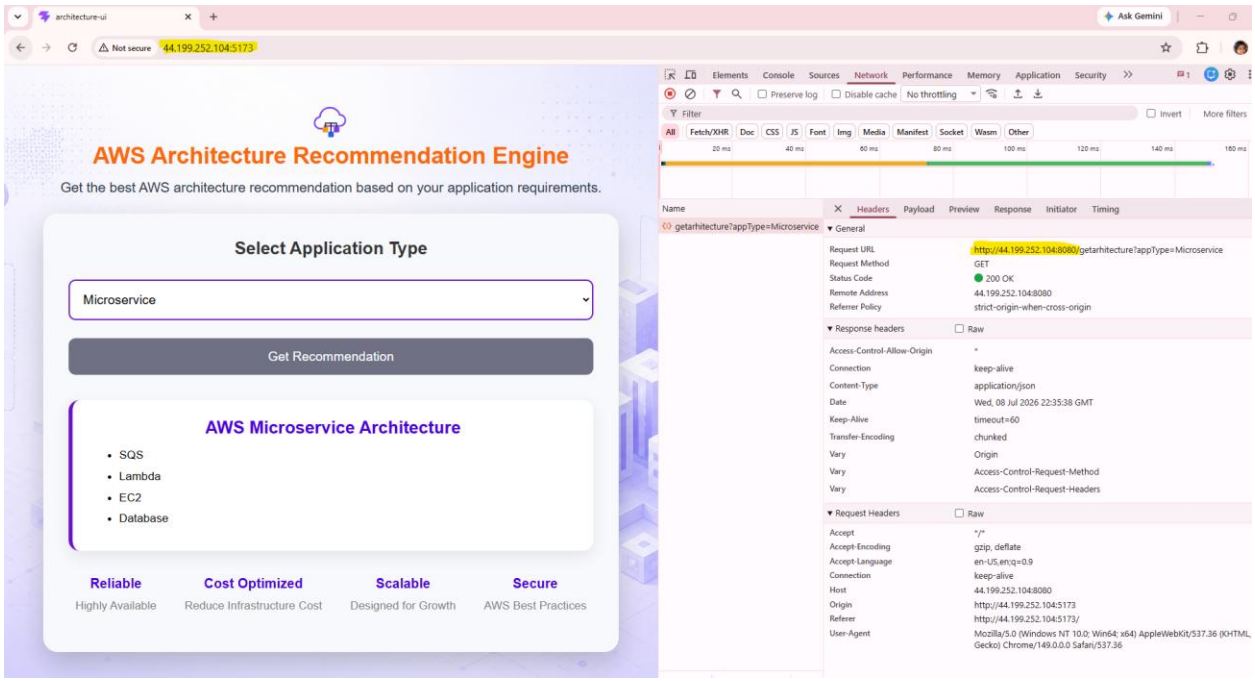


Figure 17: Containerize Cloud native Application

12. Challenges & Resolutions:

Challenge	Resolution
Docker Desktop WSL issue	Enabled WSL Integration
React container not reachable	Updated Vite configuration
EC2 security group issue	Opened port 5173
Public IP changed after restart	Updated frontend API URL
Docker login to ECR failed	Configured IAM user and AWS CLI

13. Conclusion:

Docker → ECR → EC2 → Container Running

This project successfully demonstrated the complete lifecycle of a cloud-native application, from development and local testing to containerization, image management, and deployment on AWS. The application was built using React and Spring Boot, containerized with Docker, stored in Amazon ECR, and deployed on Amazon EC2, providing hands-on experience with modern cloud deployment practices.