# Autonomous Vehicle Rental

CMPE-281 –Cloud Technologies
Dr. Jerry Gao


**Group 6**

**Team Members:**

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# Agenda

- Introduction
- Purpose of the System
- Advantages and Disadvantages of AV
- Functional Services
- Architecture Diagram and Cloud System Design
- Auto Scaling and System Load Balance Design
- Team and their work
- Individual component implementation

# Introduction

An autonomous vehicle is one that can drive itself from a starting point to a predetermined destination in autopilot mode using various in-vehicle technologies and sensors.

It is a vehicle, capable of sensing its environment and moving safely with little or no human input.

Autonomous driving technologies have become one of the promising applications because of their potentials to enhance transportation efficiency, such as, automated guided vehicles (AGV) for goods delivery in warehouses, and self-driving cars sharing the loads for drivers.

# Purpose of the system

- The purpose of our system is:
  - To provide an autonomous vehicle booking system for customers using real time data from CARLA Simulator.
  - To design an efficient cloud-based car booking system to ensure that end users can seamlessly access the application

# Advantages of Autonomous Vehicles

- **360° vision:** Autonomous vehicles possess the ability to view the environment in a 360° range, twice as much as humans, who have a viewing angle of only 180° horizontally.

- **Reduced accidents:** Thanks to 360° vision and vehicles being interconnected with each other and in constant communication, accidents will be significantly reduced. Although (at least initially) accidents will not be reduced to zero, they will be much less than accidents caused by human driving.

# Advantages of Autonomous Vehicles

- **Higher traffic efficiency:** Although it is estimated that their speed in big cities will be lower, their traffic efficiency will be higher.
- **Access to the disabled and people with reduced mobility:** Thanks to the fact that the automobile will be autonomous and will require practically no human interaction for its operation, even people with visual or hearing disabilities will be able to have one, i.e., they will become inclusive.
- **Sustainable vehicles:** It is expected that these vehicles will operate based on clean energy, so carbon and greenhouse gas emissions will be practically zero.

# Disadvantages of Autonomous Vehicles

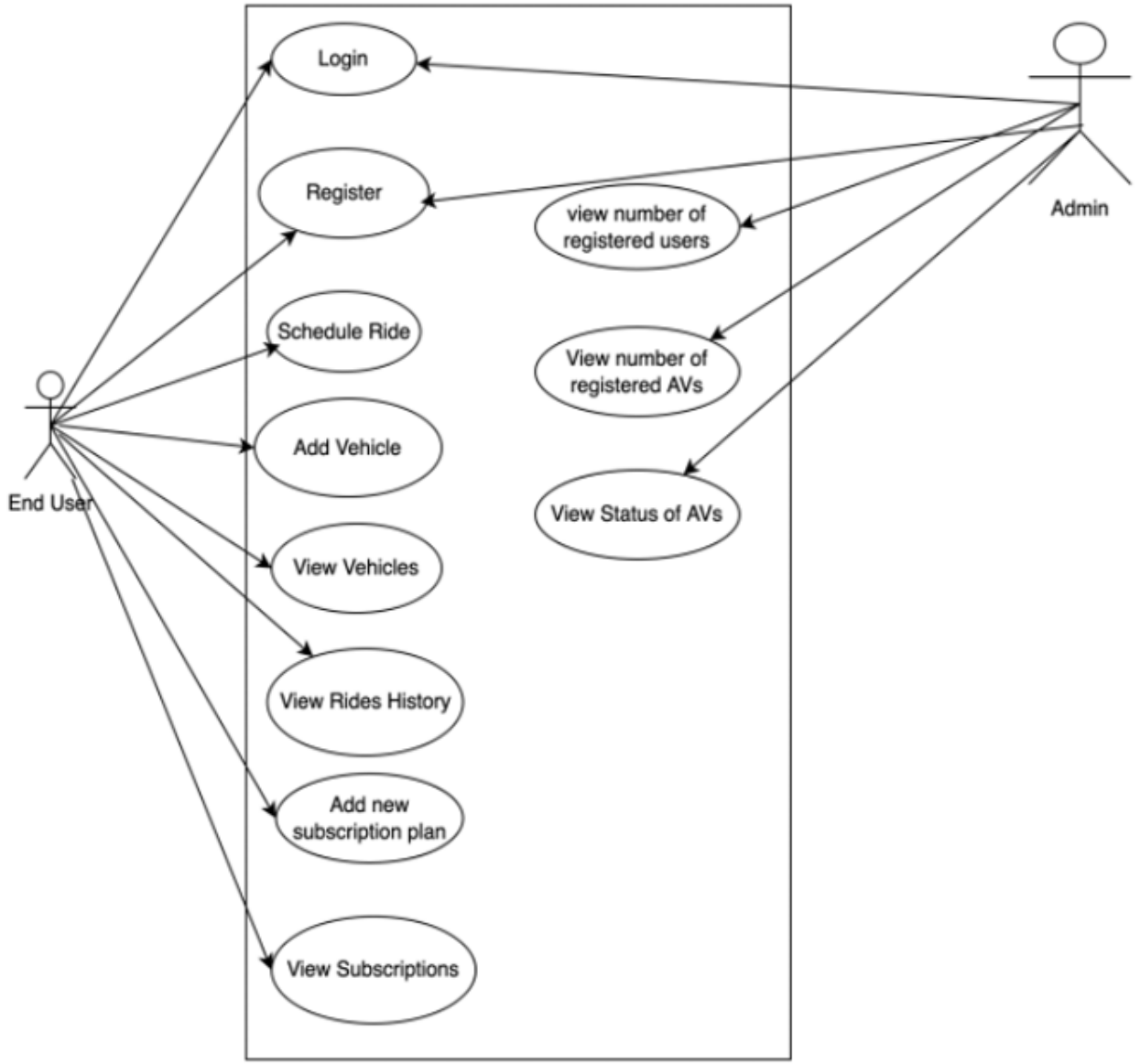
- **Data protection issues.** The first problem that arises, is in that, being connected all the time with the whole environment, it can become a cyber problem of data protection. Even the correct handling of road networks can be compromised.

- **High cost of implementation.** Autonomous vehicle infrastructure revolves around 5G network coverage, which is still expensive, so it may take governments considerable time to invest in sufficient infrastructure for optimal performance of autonomous vehicles.

- **High cost of vehicles.** Although significant progress has been made in reducing the cost of producing their implements, these cuts are not low enough to make them a financially viable alternative for the average family. It will be some years before they become an everyday reality within the reach of the middle class.

# Functional Services

- Our System comprises of two types actors - Admin and End Users.
- Use case diagram:



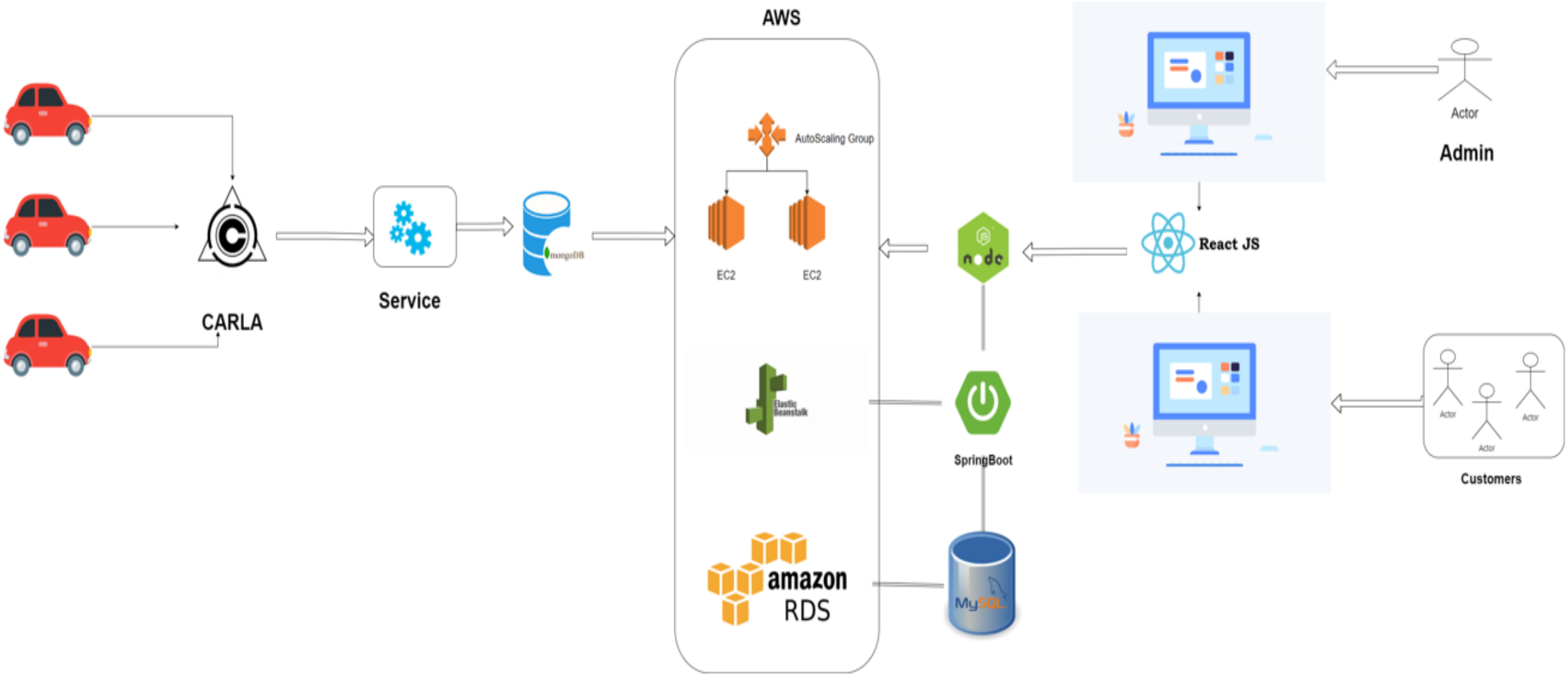
# Admin User Responsibilities

| Function | Description |
| --- | --- |
| Register | Register to the application by giving Name,Username,Password |
| Login | Login to the applicatio by giving username,password |
| Admin Dashboard | To view status of AVs, To view number of registered users, To view number of registered vehicles |

# End User Responsibilities

| Function | Description |
|---|---|
| Register | Register to the application by giving Name,username,password |
| Login | Login to the application by giving Username,Password |
| Add Vehicle | End user can add vehicle by giving vehicleid, vehicle color, vehicle model, vehicle mileage, passenger space |
| My Vehilces | End user can able to view all the vehciles added by him |
| Schedule a ride | End user can schedule a ride by entering pickup and drop off locations |
| Rides history | End user can view the rides history |
| Add plan | End user can add subscription plan |

# Architecture Diagram



# Components of System Architecture

- **CARLA Simulator:**

It is an open-source simulator for Autonomous vehicle driving research. It provides different API's that allows us to retrieve data from the Autonomous Vehicle surroundings.

- **User Interface:**

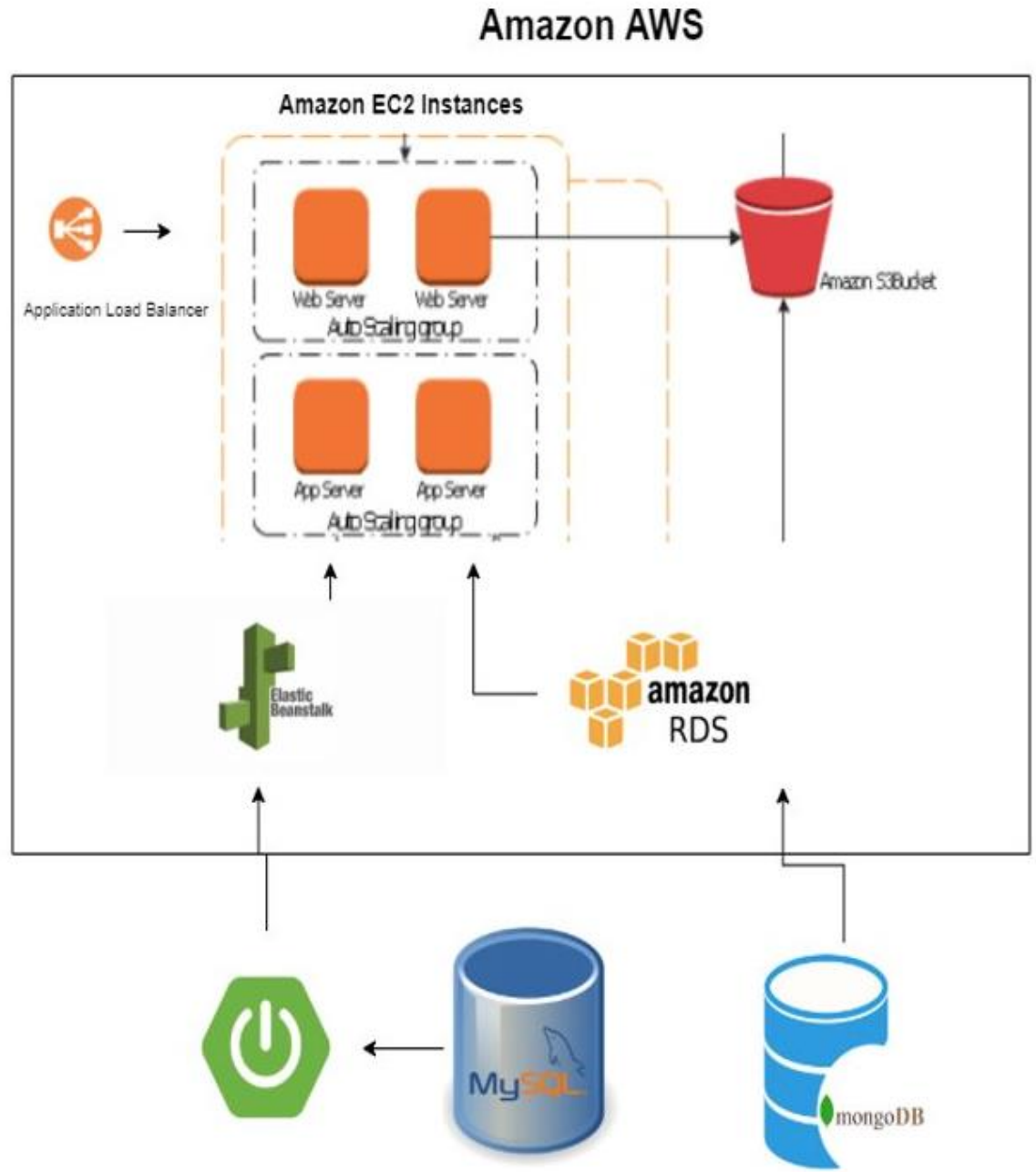
We are using **ReactJS** for the frontend of the application and **NodeJS** for the backend of the application. Customers can register, login, add membership plan, add vehicles, book a ride and track the car from the User Interface and Admins can monitor the Registered Av vehicles data and information.

- **Databases:**

**MongoDB:** The CARLA Simulator sends massive amounts of data, so we are using a NoSQL database to handle all the sensor data that is sent by the simulator.

**MySQL:** We are using MySQL- a Relational database to store the user's data, rides history and the membership plan information.

# Cloud System Design




# Components of Cloud System Design

- **Amazon Remote Database Service:** To access the database from anywhere, we have deployed the database on AWS-RDS which is web service running on cloud designed to simplify the setup and operation. To connect the node application to MySQL database, MySQL middleware is used.
- **Amazon Elastic BeanStalk:** We have used SpringBoot application to configure restful api's to fetch data from MySQL database. To access the java application remotely we have deployed the jar file onto Elastic BeanStalk.
- **Amazon EC2:** We have used Amazon EC2 instance to deploy NodeJS and react application. We cloned the application and installed the dependencies on EC2 instance by running npm install command. Once the application cloned, we start both frontend and backend servers. The application will be deployed on the generated publicIP and can be accessed usingthe same.
- **Amazon Cloud Watch:** CloudWatch collects monitoring and operational data in the form of logs, metrics, and events, and visualizes it using automated dashboards so you can get a unified view of your AWS resources, applications, and services that run on AWS and on premises.It helps us to montior the AWS applications that are deployed on cloud.

# Auto Scaling

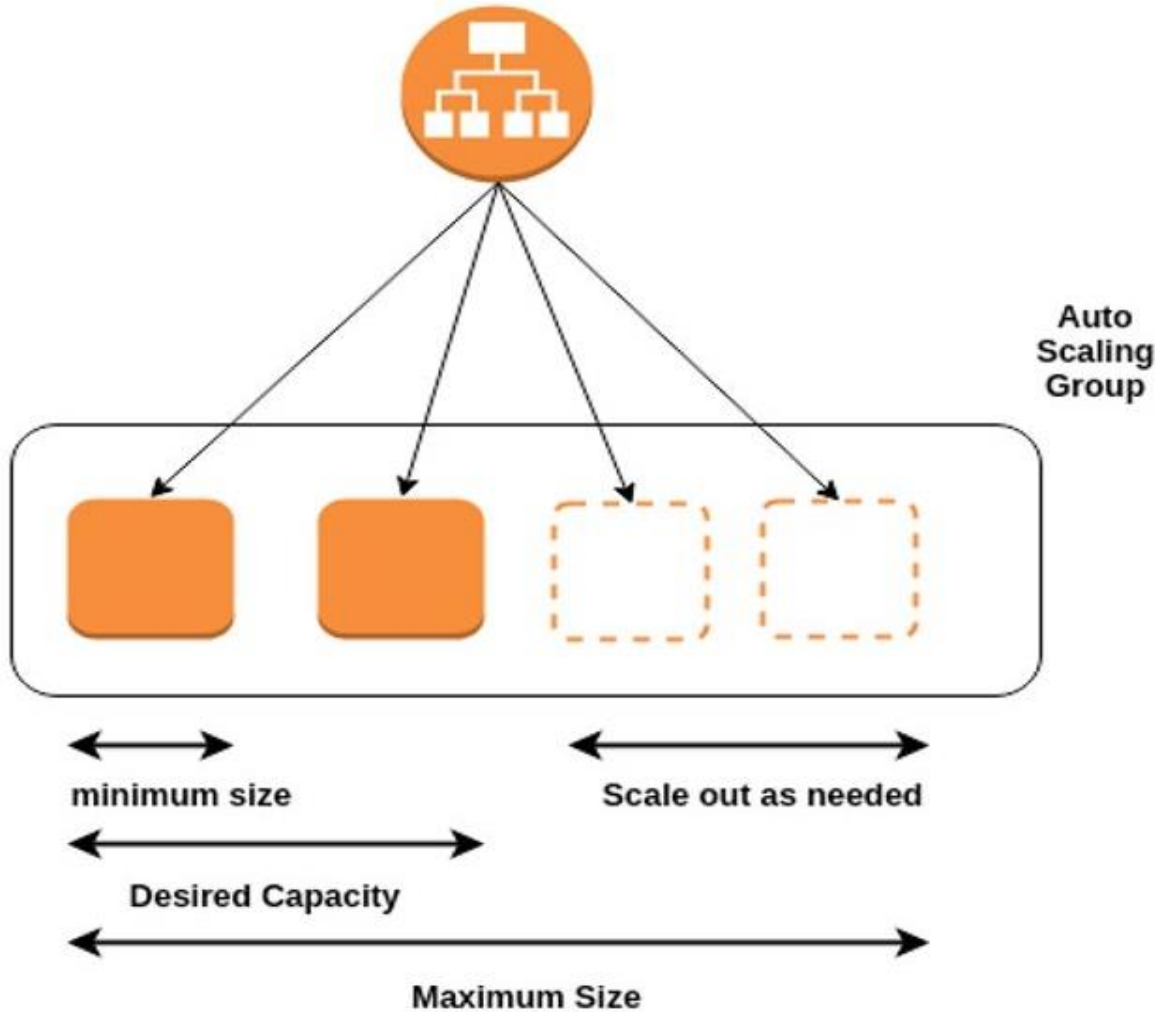
Auto Scaling monitors applications and automatically adjusts capacity to maintain steady, predictable performance at the lowest possible cost.

Using AWS Auto Scaling, it's easy to setup application scaling for multiple resources across multiple services in minutes.

AWS Auto Scaling makes scaling simple with recommendations that allows us to optimize performance, costs, or balance between them.

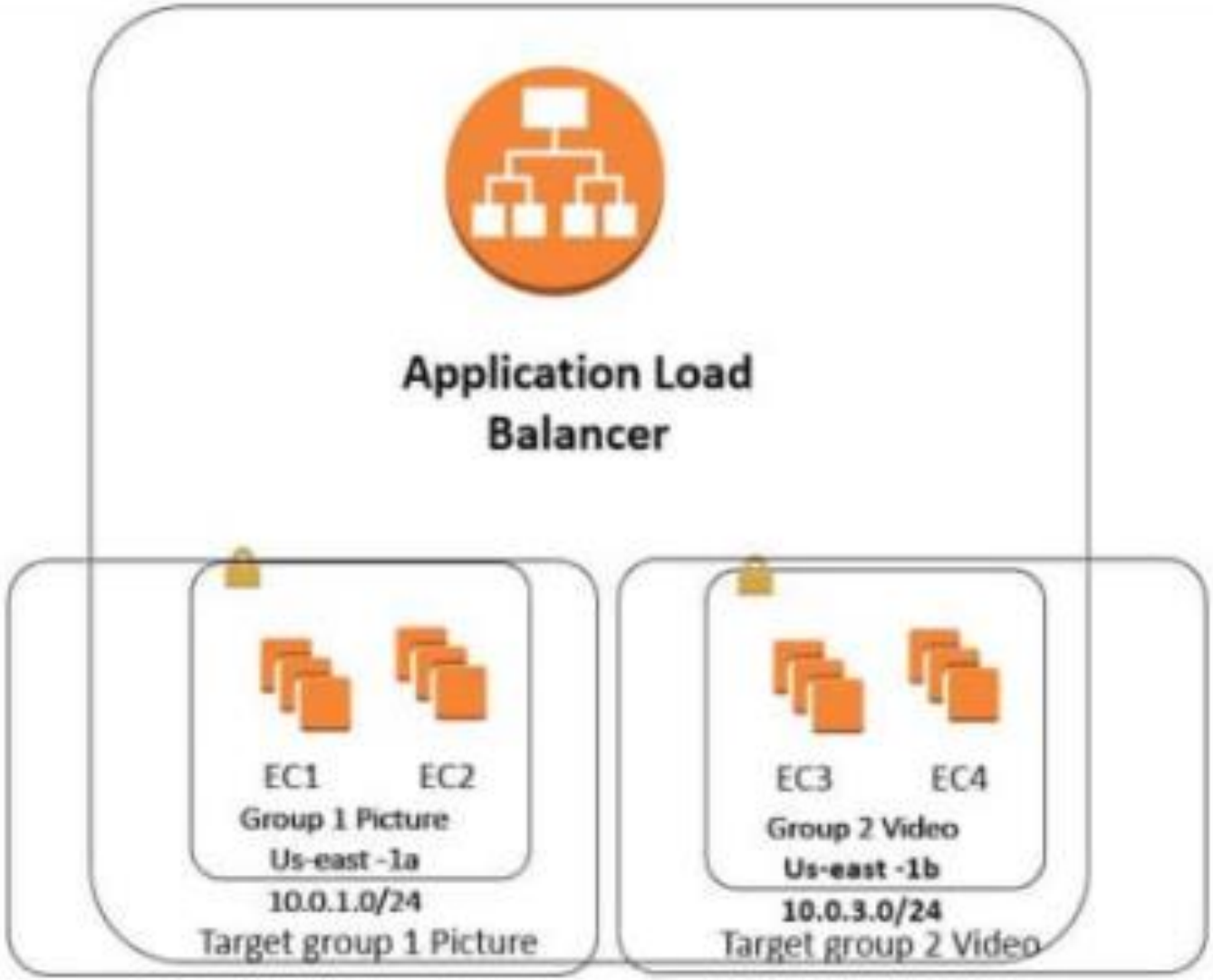
With AWS Auto Scaling, applications always have the right resources at the right time.

# Amazon Auto Scaling



# System Load Balance Design

We have used Application Load balancer (ALB) service provided by AWS in front of our web and application servers. This is responsible for maintaining load among different availability zones our servers are set in. Whenever a request comes in at Application Load Balancer, it analyzes the rules provided by the listener and directs it accordingly to a target group. The targets can be registered by IP address of the EC2 instance auto scaling groups.


Application Load Balancer
EC1
EC2
Group 1 Picture
Us-east -1a
10.0.1.0/24
Target group 1 Picture
EC3
EC4
Group 2 Video
Us-east -1b
10.0.3.0/24
Target group 2 Video

# Team and their Work

Guruvardhan Reddy Rajanala:
Component #0 – Edge-based (or simulated) autonomous vehicles (Carla-based simulator)

Vineeth Reddy Govind : Component #1 – AV-based database management component(s)

Monica Lakshmi Mandapati : Component #2 – Remote online AV tracking and controlling

Annapurna Ananya Annadatha : Component #3 – AV service connectivity supporting rental AVs on a cloud

Indhu Priya Reddem: Component #4 – User service management

Component #0 : Edge based(Or Simulated) Autonomous Vehicles (CARLA-based Simulator)

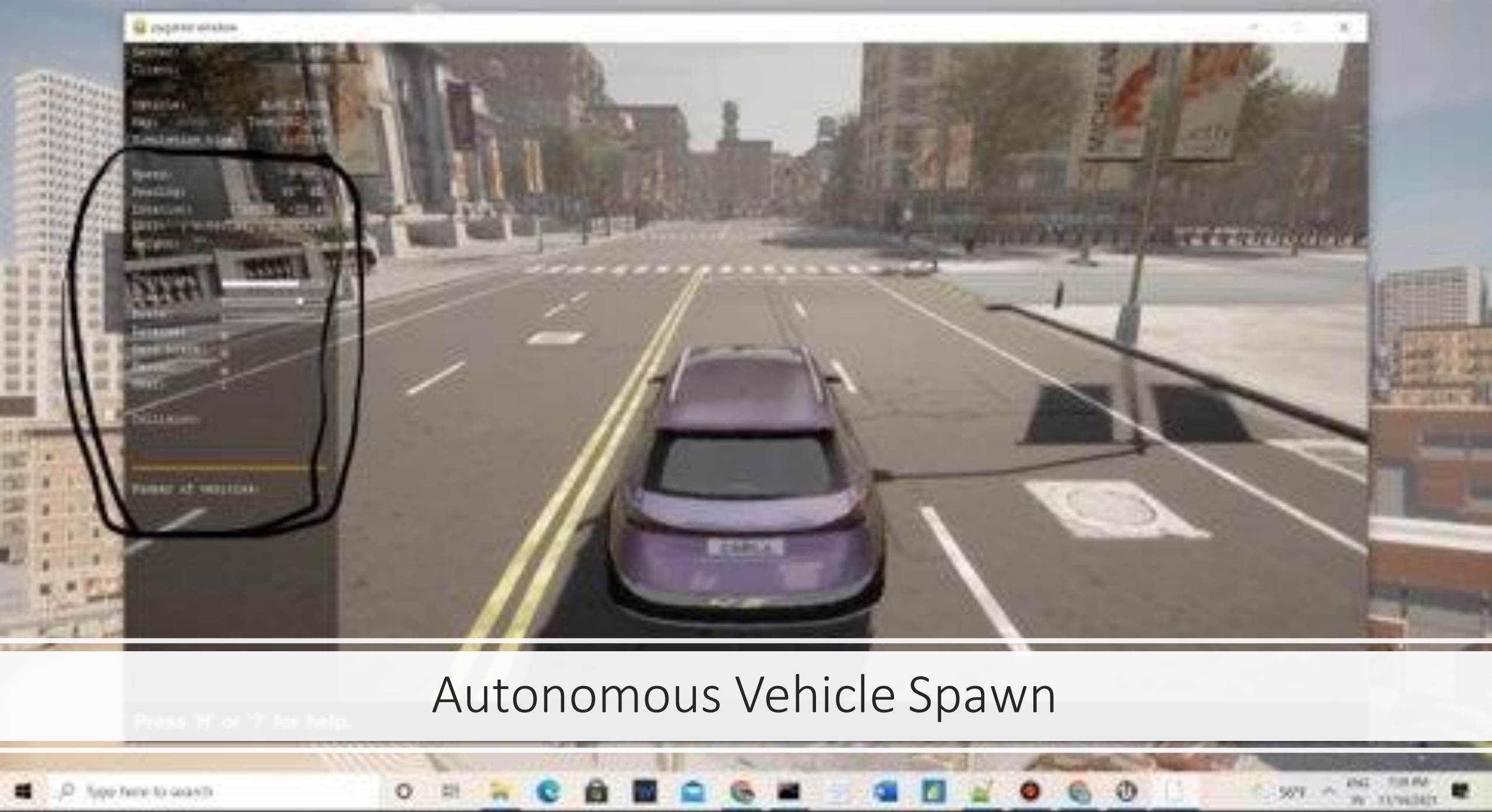
## Functions Of CARLA

Our Edge-based simple autonomous vehicles will use the following components:

Data from sensors is pushed into MongoDB, supporting the following:

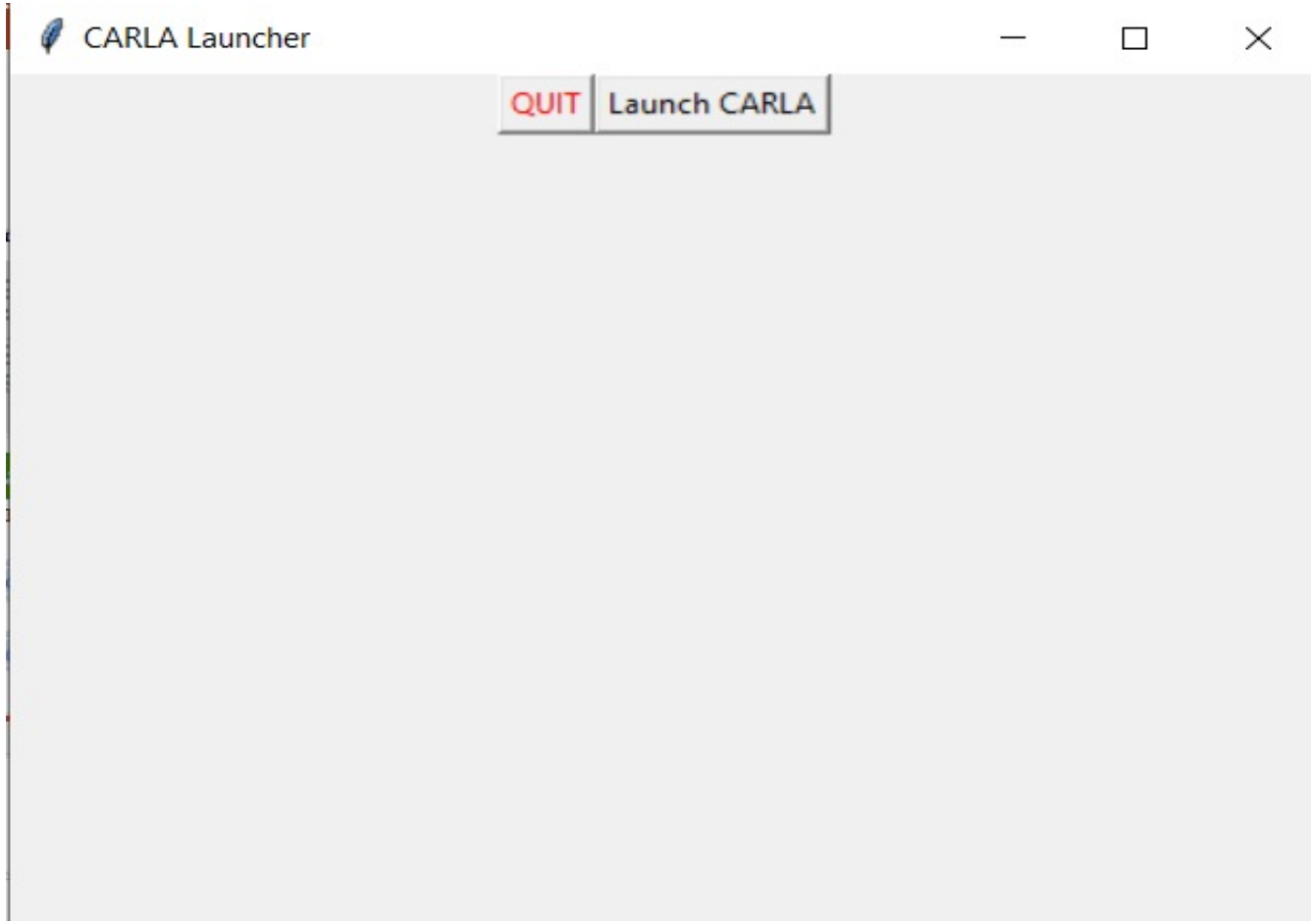
- In the dashboard, show the user statistics about the AV.
- Display AV Sensor Data

# CARLA Simulator Interface



# Autonomous Vehicle Spawn

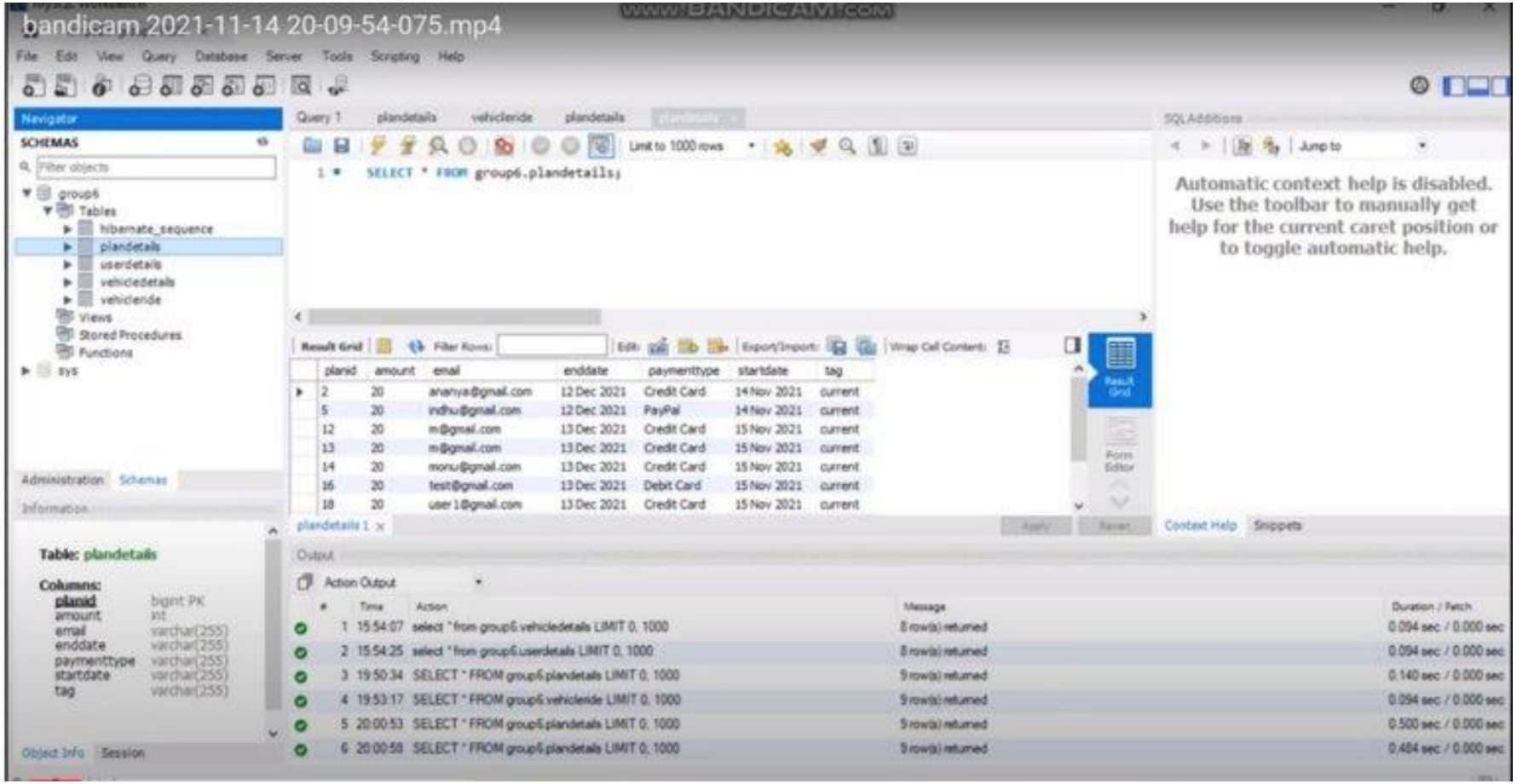
# Button to interact from UI to CARLA



# Component #1 – AV-based database management component(s)

- Database 1: RDMS SQL database
- RDBMS SQL database is being used to store the user information, ride information, payment information and booking information.
- Following are the tables:
- 1. user_data,
- 2. rides_data,
- 3. payment_info,
- 4. booking_info,
- 5. vehicle_info

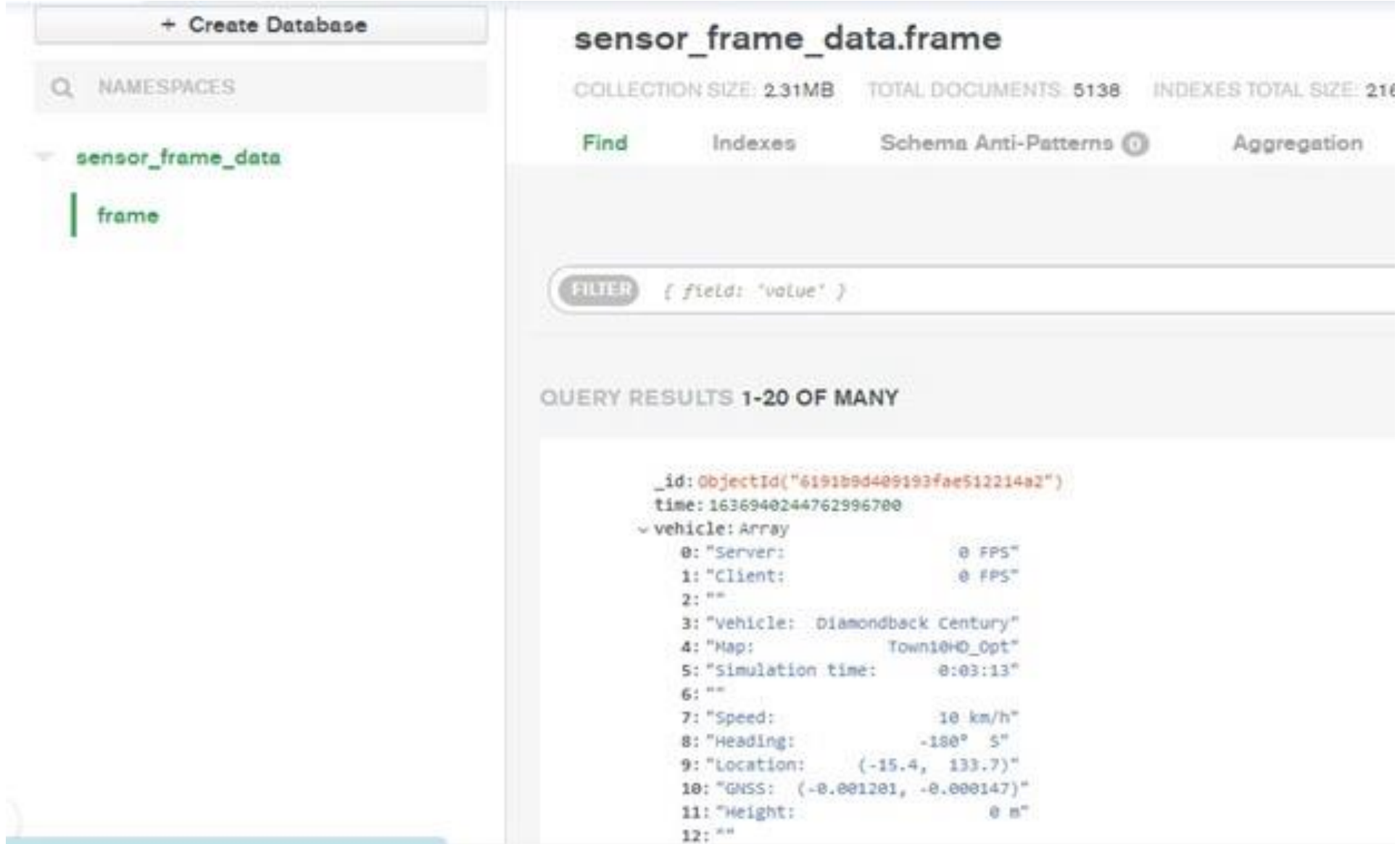
# MySQL Database



# MongoDB

MongoDB is a NoSQL database i.e information is stored in the form of documents.
This database is used to store all the information from vehicle sensors.
Following is the information that is stored in this database

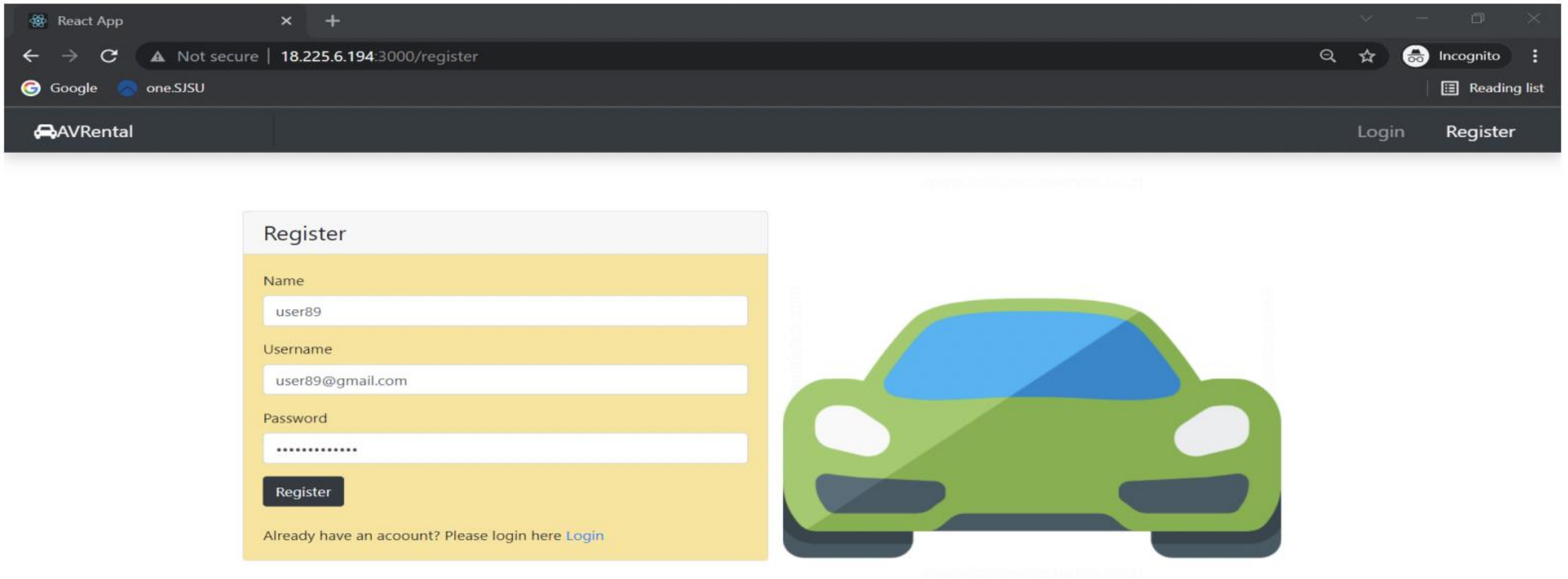
1. Frame data
2. Timestamp
3. Vehicle speed
4. Vehicle direction
5. Vehicle name
6. Ride destina`tion
7. Vehicle location
8. Vehicle GNSS data
9. Vehicle state


+ Create Database
NAMESPACES
sensor_frame_data
frame
sensor_frame_data.frame
COLLECTION SIZE: 2.31MB
TOTAL DOCUMENTS: 5138
INDEXES TOTAL SIZE: 216
Find
Indexes
Schema Anti-Patterns
Aggregation
FILTER
{ field: 'value' }
QUERY RESULTS 1-20 OF MANY
_id: ObjectId("6191b9d409193fae512214a2")
time: 1636940244762996700
vehicle: Array
0: "Server: 0 FPS"
1: "Client: 0 FPS"
2: ""
3: "Vehicle: Diamondback Century"
4: "Map: Town10HD_Opt"
5: "Simulation time: 0:03:13"
6: ""
7: "Speed: 10 km/h"
8: "Heading: -180° S"
9: "Location: (-15.4, 133.7)"
10: "GNSS: (-0.001201, -0.000147)"
11: "Height: 0 m"
12: ""

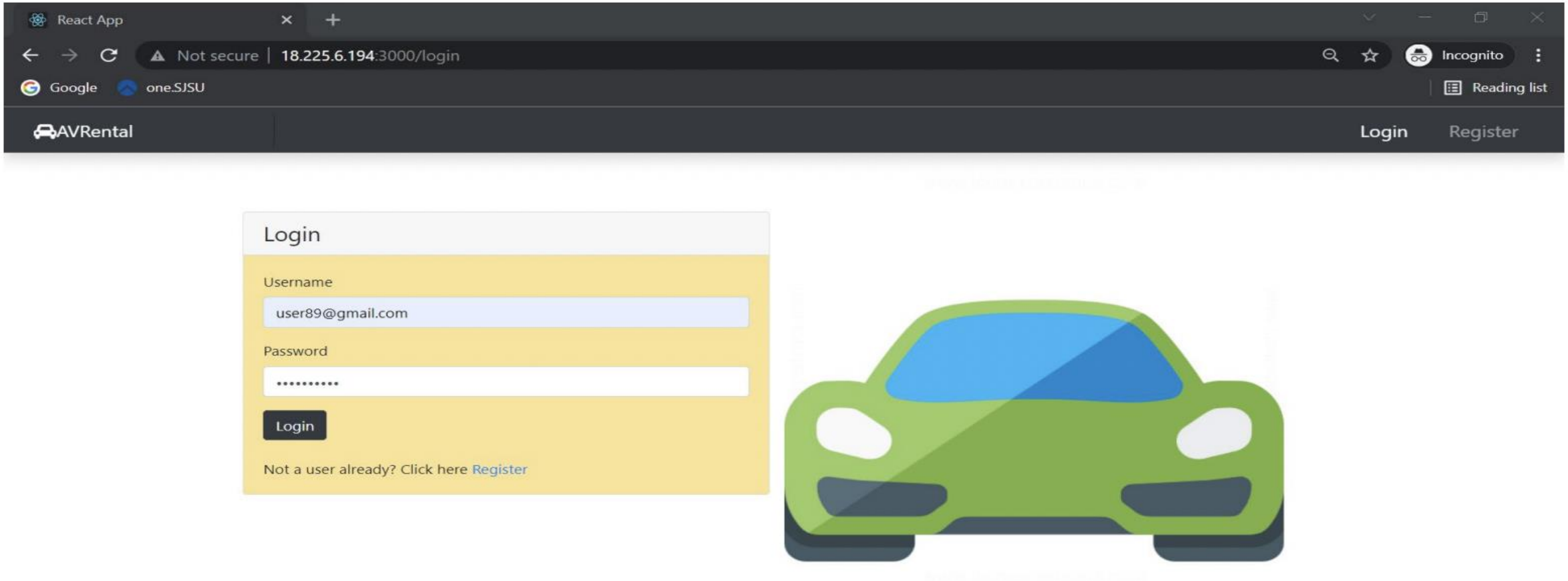
# Component #4- User Service Management

- The graphical user interface (GUI) is utilized by the user or AV owner to operate the service, track status, charge, and perform basic taxi services. The data from the sensors is extracted with ROS, saved in a database, and then shown on the dashboard for users.
- This component provides GUI for the Users to Login, Register, Manage their profile, Books a ride, View Payment Details, Manage AV Sensor Data.
- Components also include User Accounts, AV Sensor Accounts. User Accounts for Manage and provide access to the user information. AV Sensor Accounts for manage and provide AV information to the admin

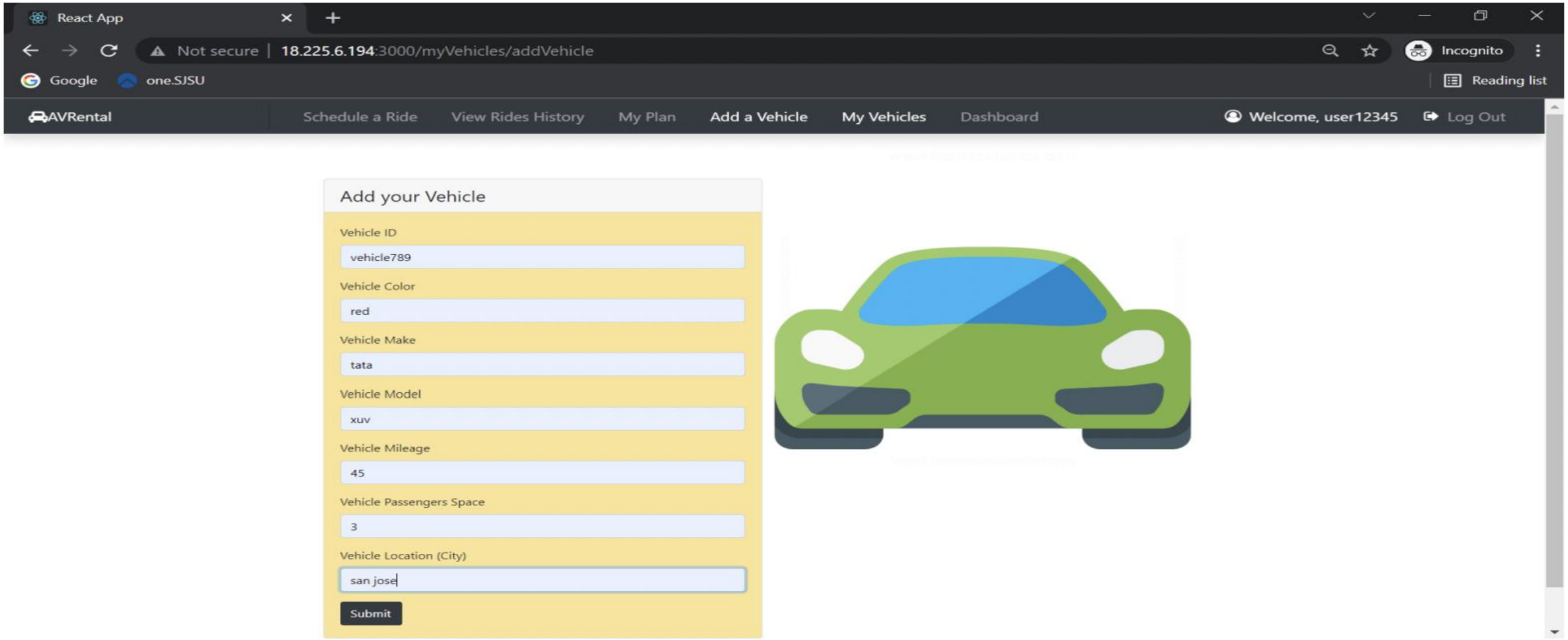
# Register


React App
Not secure | 18.225.6.194:3000/register
Incognito
Google
one.SJSU
Reading list
AVRental
Login
Register
Register
Name
user89
Username
user89@gmail.com
Password
Register
Already have an acoount? Please login here Login

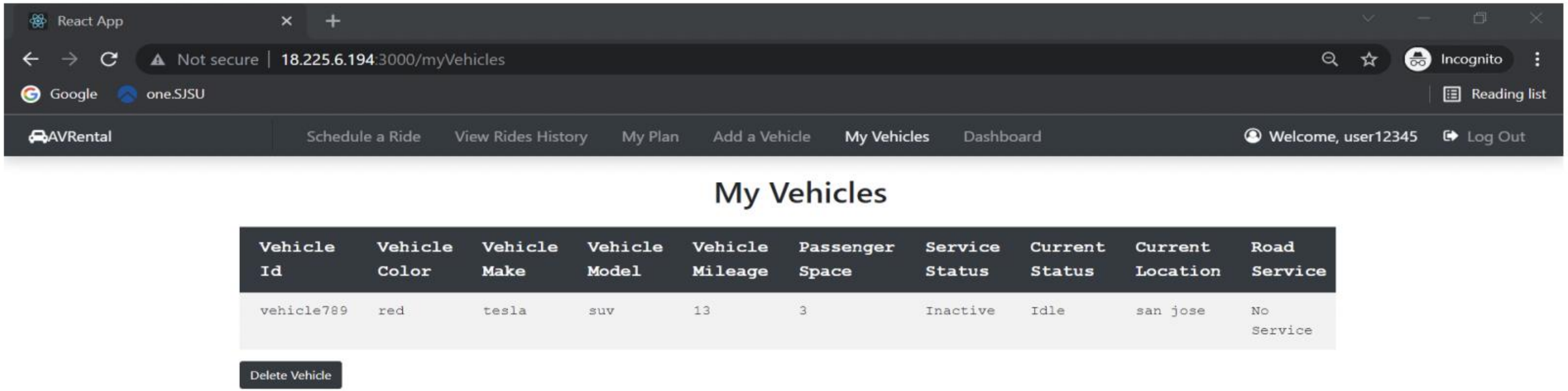
# Login


React App
Not secure | 18.225.6.194:3000/login
Incognito
Google
one.SJSU
Reading list
AVRental
Login
Register
Login
Username
user89@gmail.com
Password
Login
Not a user already? Click here Register

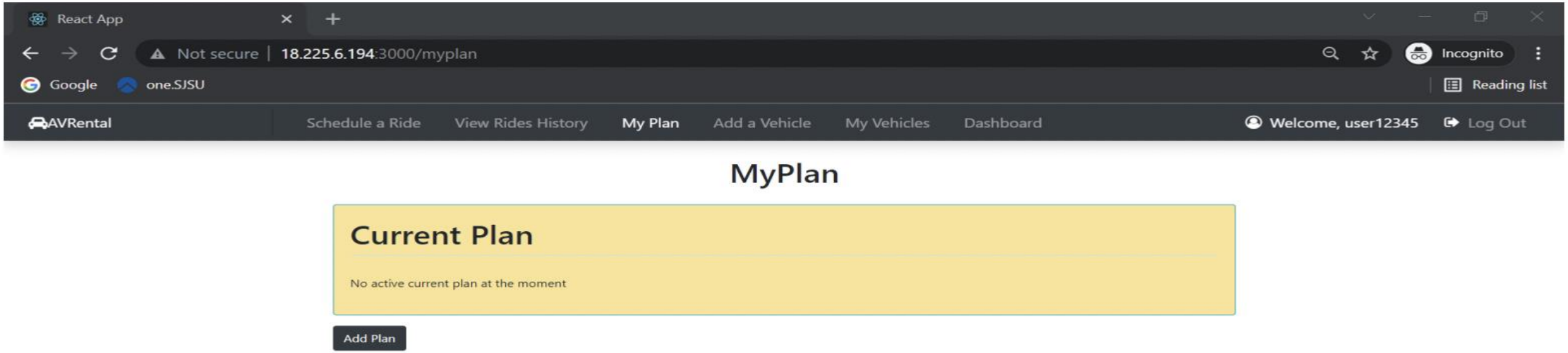
# Add Vehicle


React App
Not secure | 18.225.6.194:3000/myVehicles/addVehicle
Incognito
Google
one.SJSU
Reading list
AVRental
Schedule a Ride
View Rides History
My Plan
Add a Vehicle
My Vehicles
Dashboard
Welcome, user12345
Log Out
Add your Vehicle
Vehicle ID
vehicle789
Vehicle Color
red
Vehicle Make
tata
Vehicle Model
xuv
Vehicle Mileage
45
Vehicle Passengers Space
3
Vehicle Location (City)
san jose
Submit

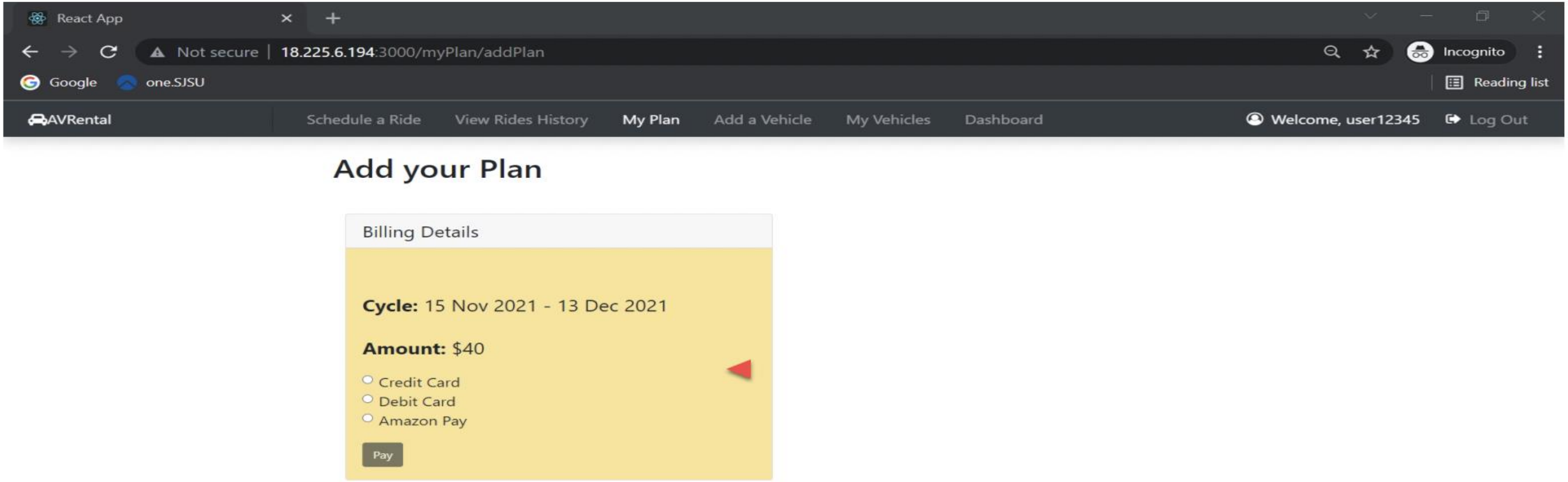
# My Vehicles


React App
Not secure | 18.225.6.194:3000/myVehicles
Incognito
Google
one.SJSU
Reading list
AVRental
Schedule a Ride
View Rides History
My Plan
Add a Vehicle
My Vehicles
Dashboard
Welcome, user12345
Log Out
My Vehicles
Vehicle Id
Vehicle Color
Vehicle Make
Vehicle Model
Vehicle Mileage
Passenger Space
Service Status
Current Status
Current Location
Road Service
vehicle789
red
tesla
suv
13
3
Inactive
Idle
san jose
No Service
Delete Vehicle

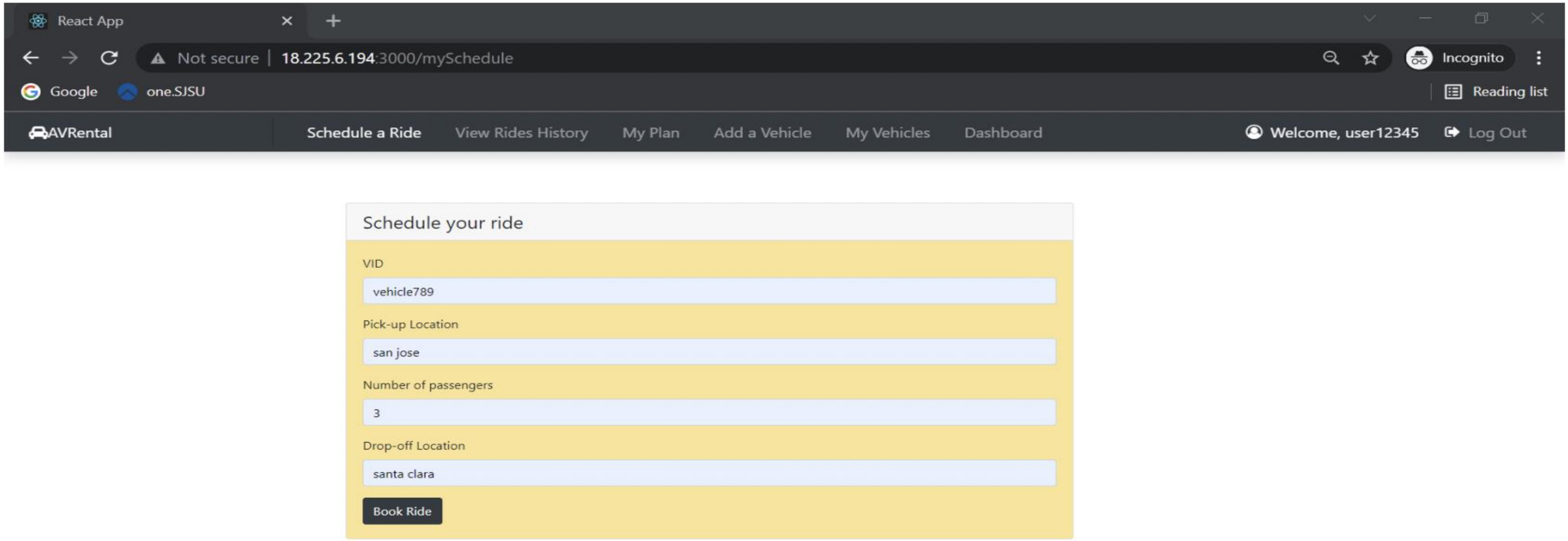
# My Plan


React App
Not secure | 18.225.6.194:3000/myplan
Incognito
Google
one.SJSU
Reading list
AVRental
Schedule a Ride
View Rides History
My Plan
Add a Vehicle
My Vehicles
Dashboard
Welcome, user12345
Log Out
MyPlan
Current Plan
No active current plan at the moment
Add Plan

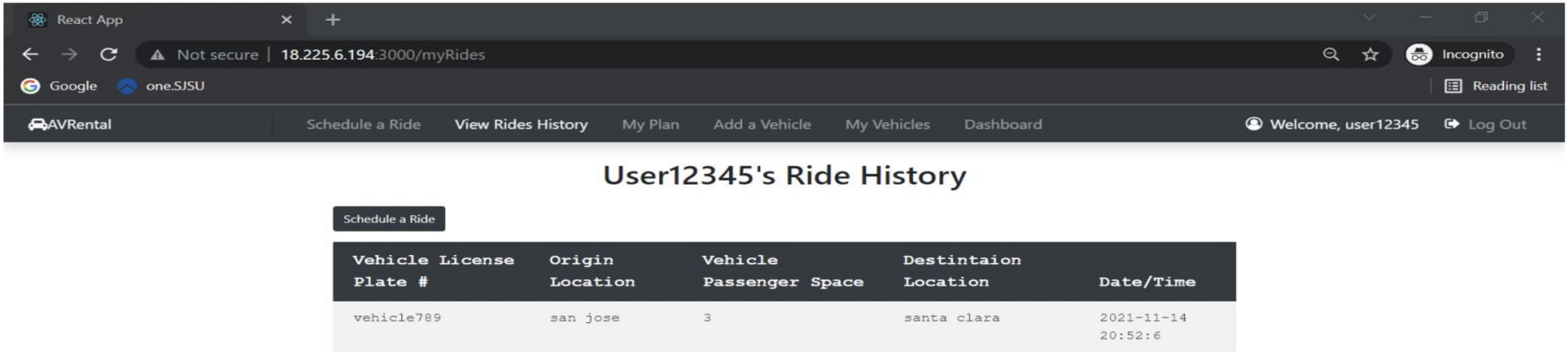
# Add Plan


React App
Not secure | 18.225.6.194:3000/myPlan/addPlan
Incognito
Google
one.SJSU
Reading list
AVRental
Schedule a Ride
View Rides History
My Plan
Add a Vehicle
My Vehicles
Dashboard
Welcome, user12345
Log Out
Add your Plan
Billing Details
Cycle: 15 Nov 2021 - 13 Dec 2021
Amount: $40
Credit Card
Debit Card
Amazon Pay
Pay

# Schedule Ride



# Ride History



# Component #2 – Remote online AV tracking and controlling

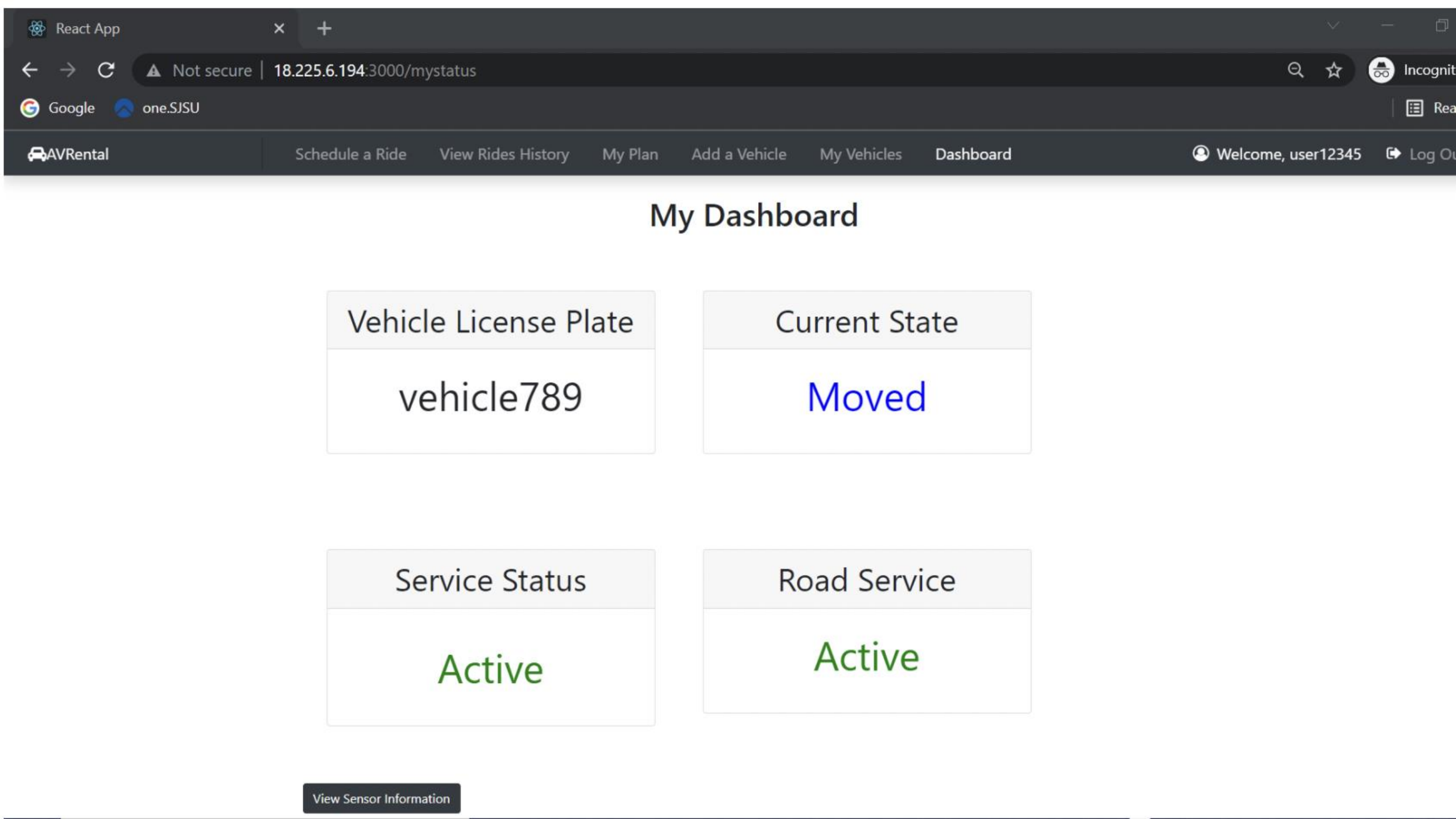
This component provides the Graphical User interface for tracking and controlling of the Autonomous Vehicle.

The purpose of this component is to track and monitor the moving status, service states, location information, road service records and sensor states of the Autonomous Vehicle. The sensor data which is generated by the CARLA is stored in a NoSQL database – MongoDB and is transmitted onto the cloud. The user can view the moving status, service status and road service status of the booked vehicle on the User Dashboard. The user can also view the Additional sensor data of his vehicle.

The admin user will have the access to view the details of the AV vehicles and also can log into to MongoDB to view the detailed sensor information.

# User Dashboard

- The User Dashboard consists of information about the active and registered cars along with the registered user's information.
- Moving state of the car – idle/Moving/Moved
- Service state of the car – active, Inactive
- Road Service – In Service/ No Service
- Location details – Latitude and Longitude
- GNSS details,
- Heading Towards
- Speed/Velocity
- Simulated Time of the AV

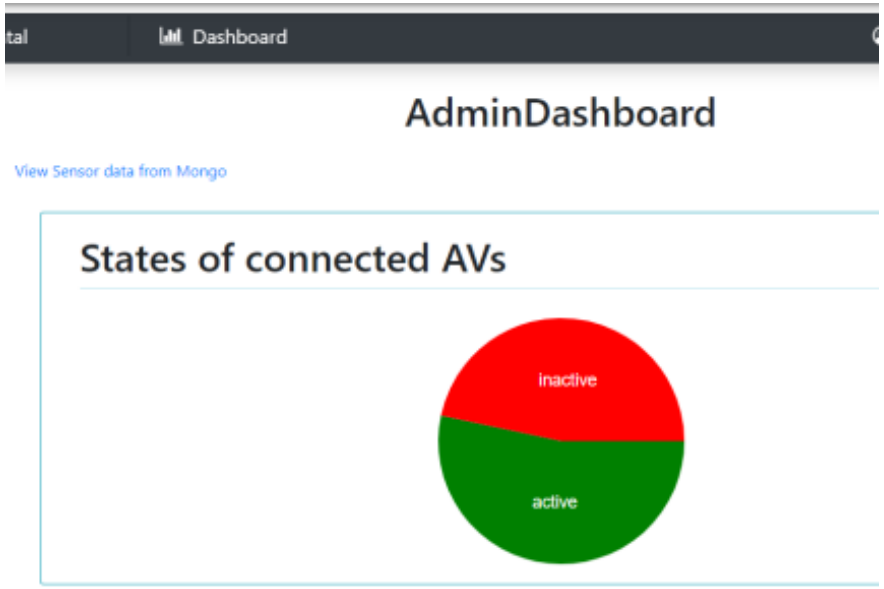

React App
Not secure | 18.225.6.194:3000/mystatus
Incognit
Google
one.SJSU
AVRental
Schedule a Ride
View Rides History
My Plan
Add a Vehicle
My Vehicles
Dashboard
Welcome, user12345
Log Ou
My Dashboard
Vehicle License Plate
vehicle789
Current State
Moved
Service Status
Active
Road Service
Active
View Sensor Information

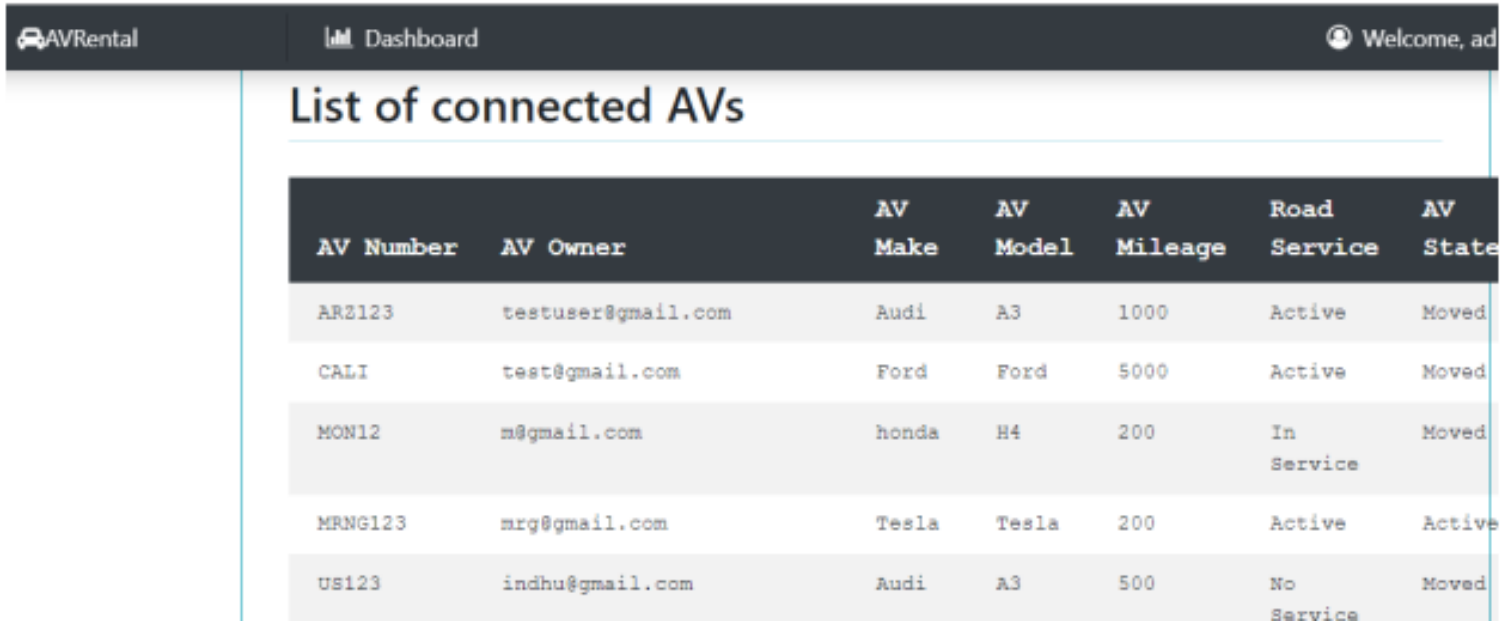
- The different sensors that are used to fetch the sensor data are
- **Camera sensors:** which fetches the heading towards parameter details.
- **GNSS sensors:** which fetches the geolocation, latitude and longitude of the vehicle.
- **RADAR Sensors:** which fetches velocity, acceleration of the vehicle.

**IMU Sensors:** which fetches the Simulation time of the AV.

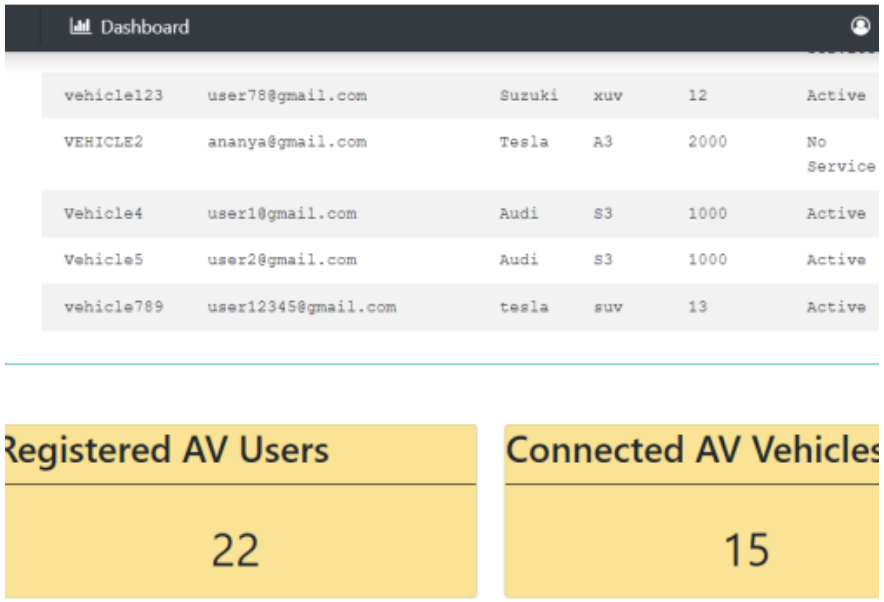
# Admin Dashboard

- The Admin Dashboard consists of information about the active and registered cars along with the registered user's information. It comprises of the following data about the Autonomous vehicle:
- Chart which represent Active and Inactive Vehicles.
- The Admin Dashboard also has a button to navigate to MongoDB




| AV Number | AV Owner | AV Make | AV Model | AV Mileage | Road Service | AV State |
|---|---|---|---|---|---|---|
| ARZ123 | testuser@gmail.com | Audi | A3 | 1000 | Active | Moved |
| CALI | test@gmail.com | Ford | Ford | 5000 | Active | Moved |
| MON12 | m@gmail.com | honda | H4 | 200 | In Service | Moved |
| MRNG123 | mrg@gmail.com | Tesla | Tesla | 200 | Active | Active |
| US123 | indhu@gmail.com | Audi | A3 | 500 | No Service | Moved |



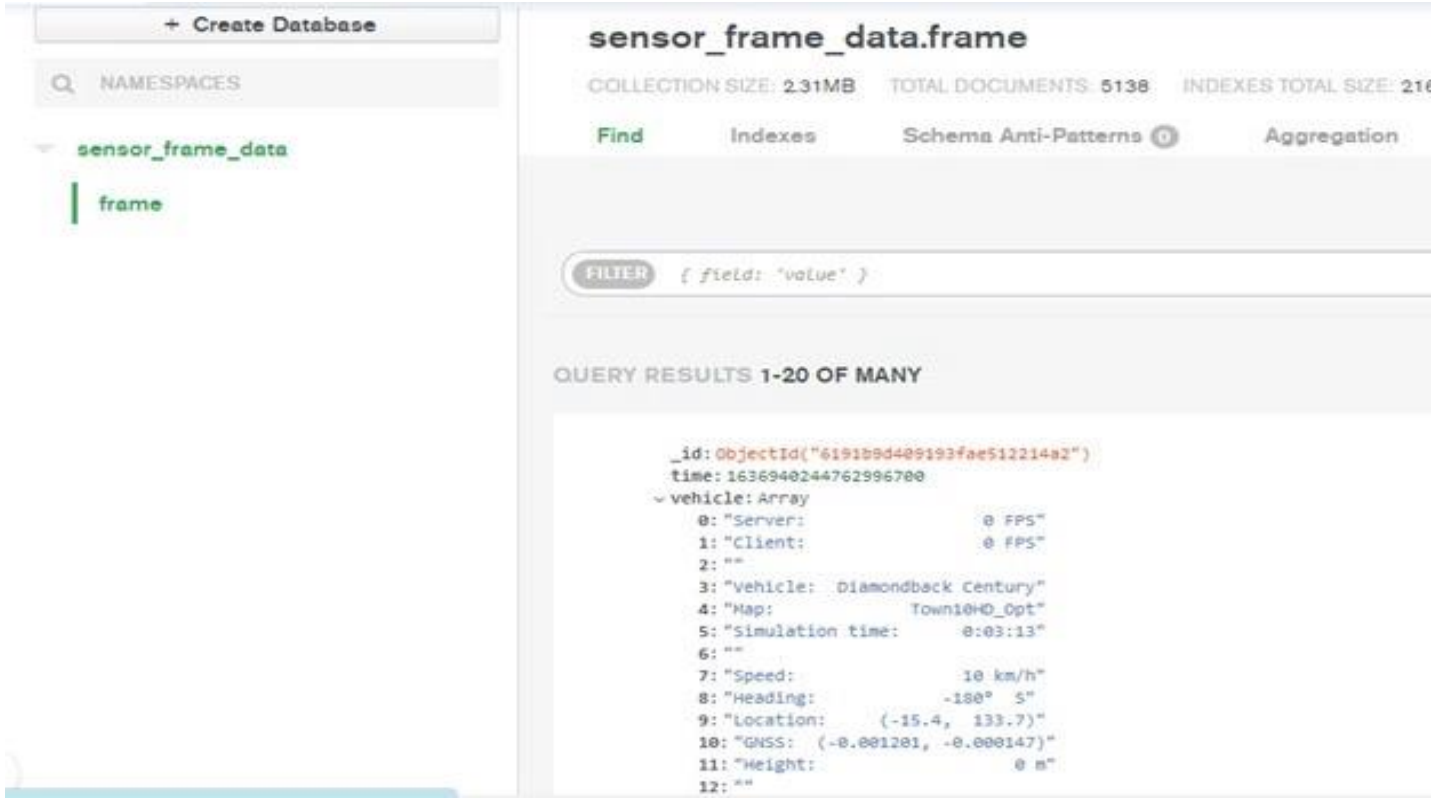

# Admin Dashboard

# Component #3: AV service connectivity supporting rental AVs on a cloud

- The purpose of the component#3 AV service connectivity supporting rental AVs on a cloud is to provide connectivity between different components of the rental AVs on the cloud - CARLA simulator, cloud DB, and GUI of the autonomous vehicle cloud.
- This component aims to achieve the following types of communication between the components.
    1. AV cloud management connectivity protocol.
    2. AV service management connectivity protocol.

# Implementation of the component

1) MongoDB implementation
2) MySQL and Remote Database Service
3) Amazon Elastic Bean Stalk
4) Amazon EC2
5) Amazon CloudWatch

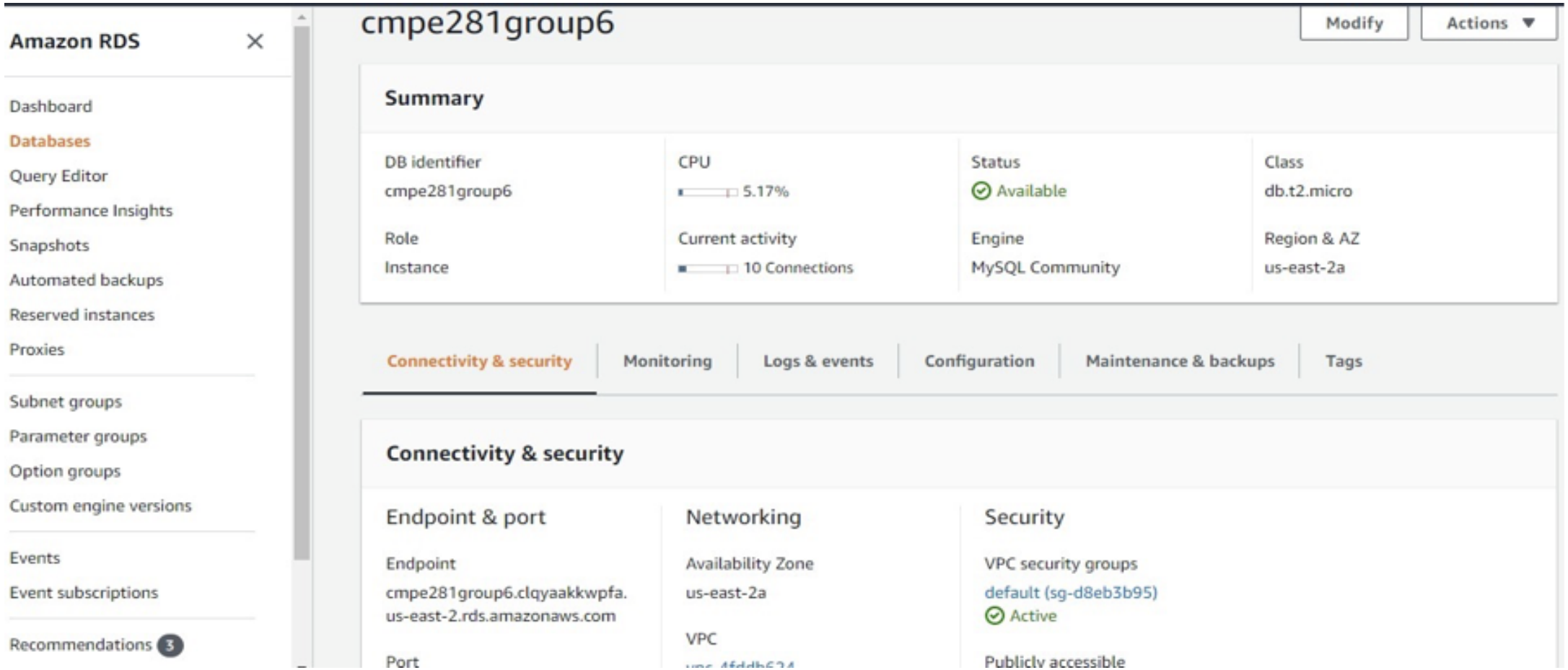



## MongoDB sensor data

## MongoDB connection from NodeJS

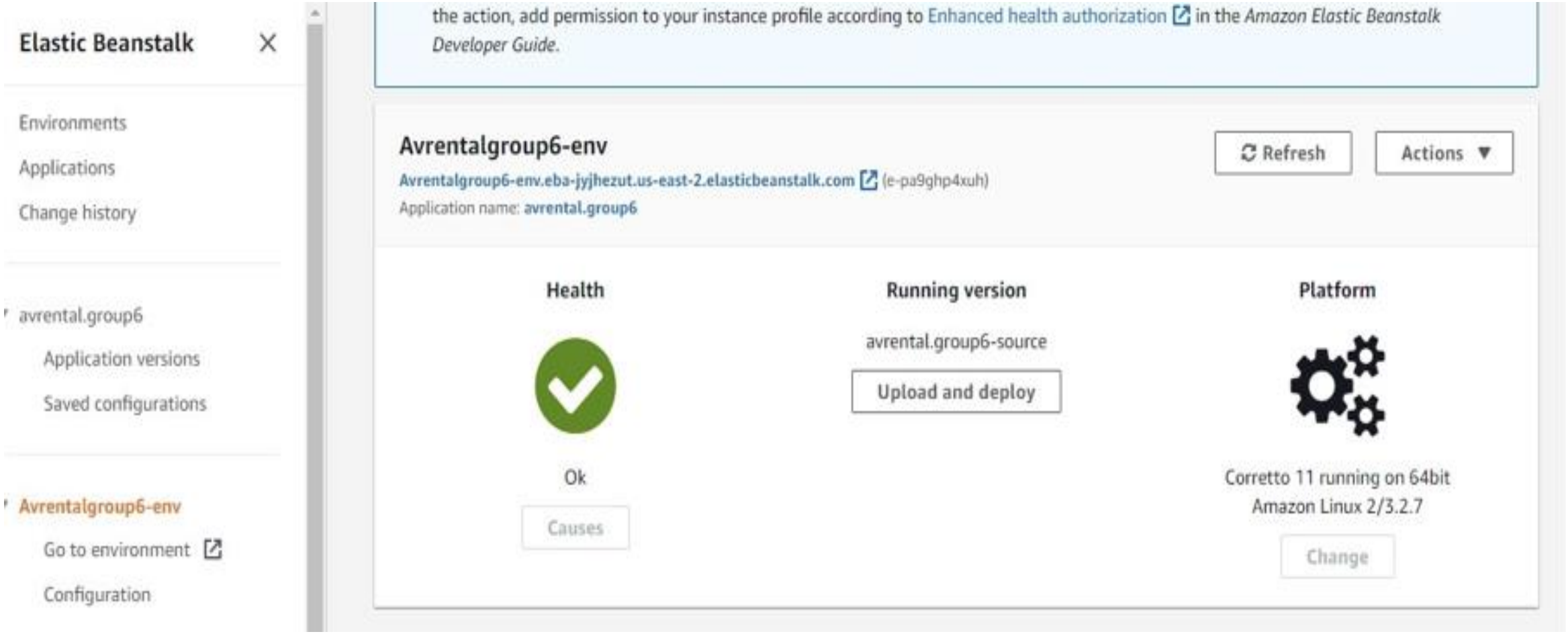
```
const mongoose = require("mongoose");

mongoose
  .connect("mongodb+srv://root:mongoPassword@cluster0.a5yk3.mongodb.net/sensor_frame_data?retryWrites=true&w=majority" , {
    // retry to connect
    reconnectTries: 1,
    // wait 5 seconds before retryMon
    reconnectInterval: 5000,
  })
  .then(() => console.log("Connected to MongoDatabase"))
  .catch((err) => console.log("Failed to connect to Database"));
```

# AWS Remote Database Services



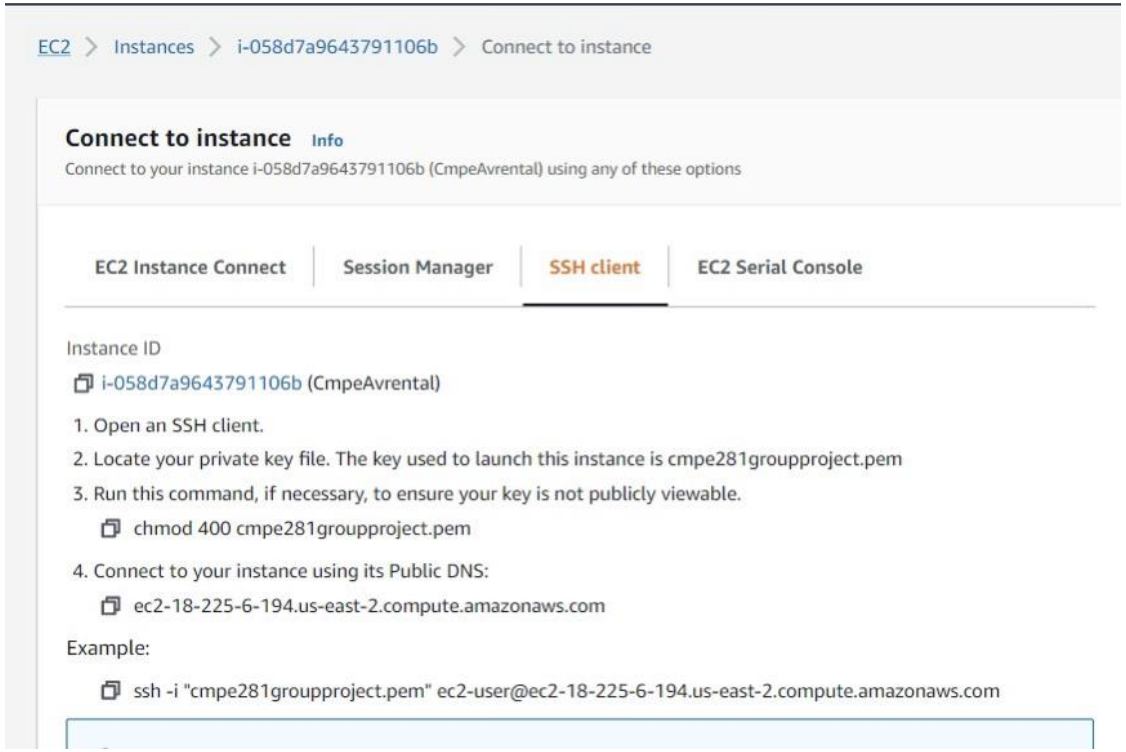
Connection to RDS from NodeJS app

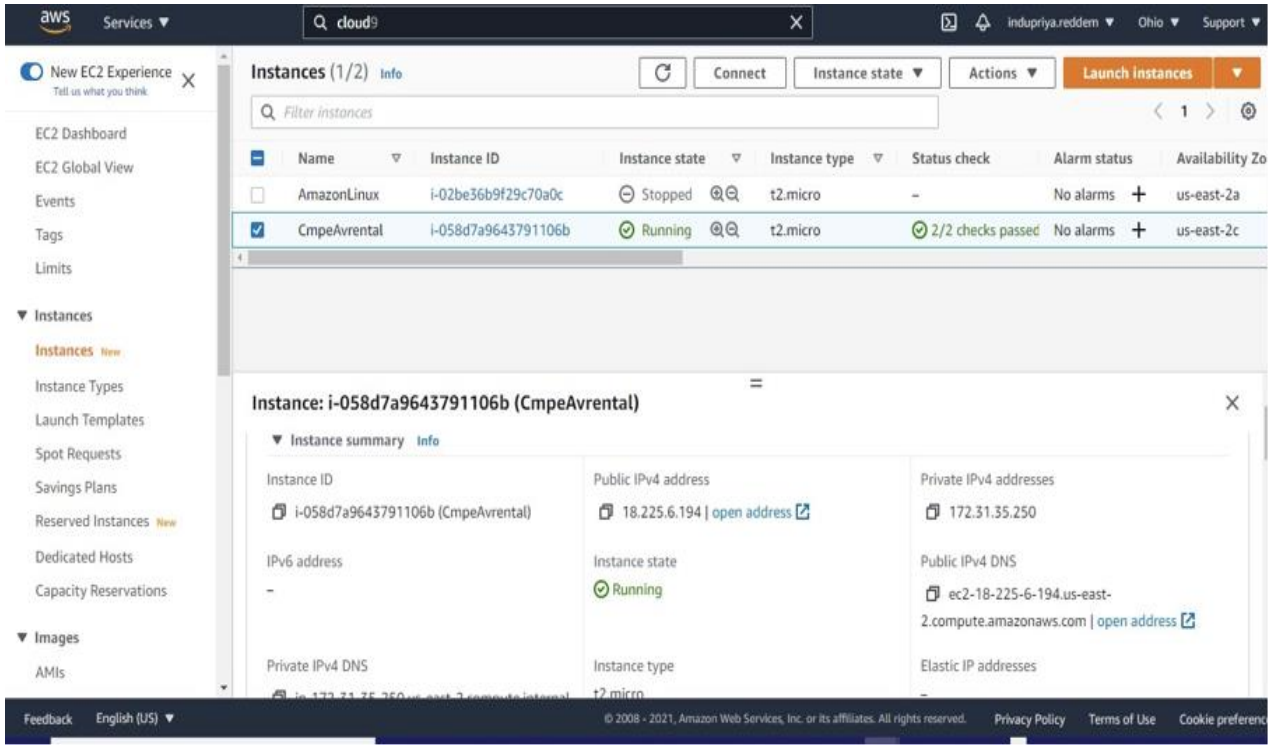
```
const pool = mysql.createConnection({
  host: 'cmpe281group6.clqyaakkwpfa.us-east-2.rds.amazonaws.com',
  user: 'root',
  port: 3306,
  password: 'Password12345',
  database: 'group6'
});

pool.connect((err) => {
  if(err){
   console.log("failed to connect"+err);
  }
  if(!err){
      console.log("connected to mysql database");
  }
});

if (!config.get("jwtPrivateKey")) {
  console.log("FATAL ERROR: jwtPrivateKey is not defined");
  process.exit(1);
}
```



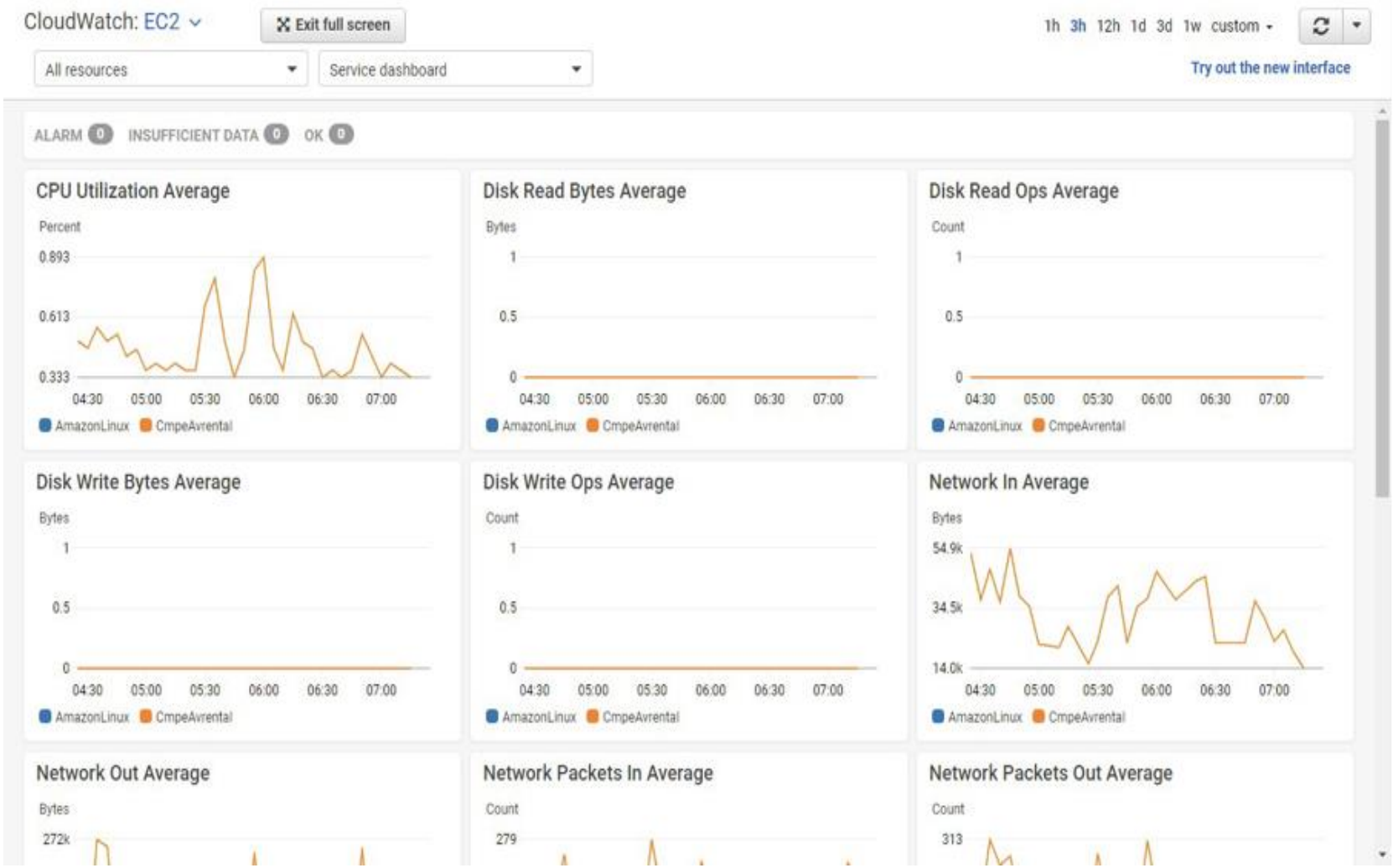

AWS Elastic Bean Stalk interface

# AWS EC2 Connection Details

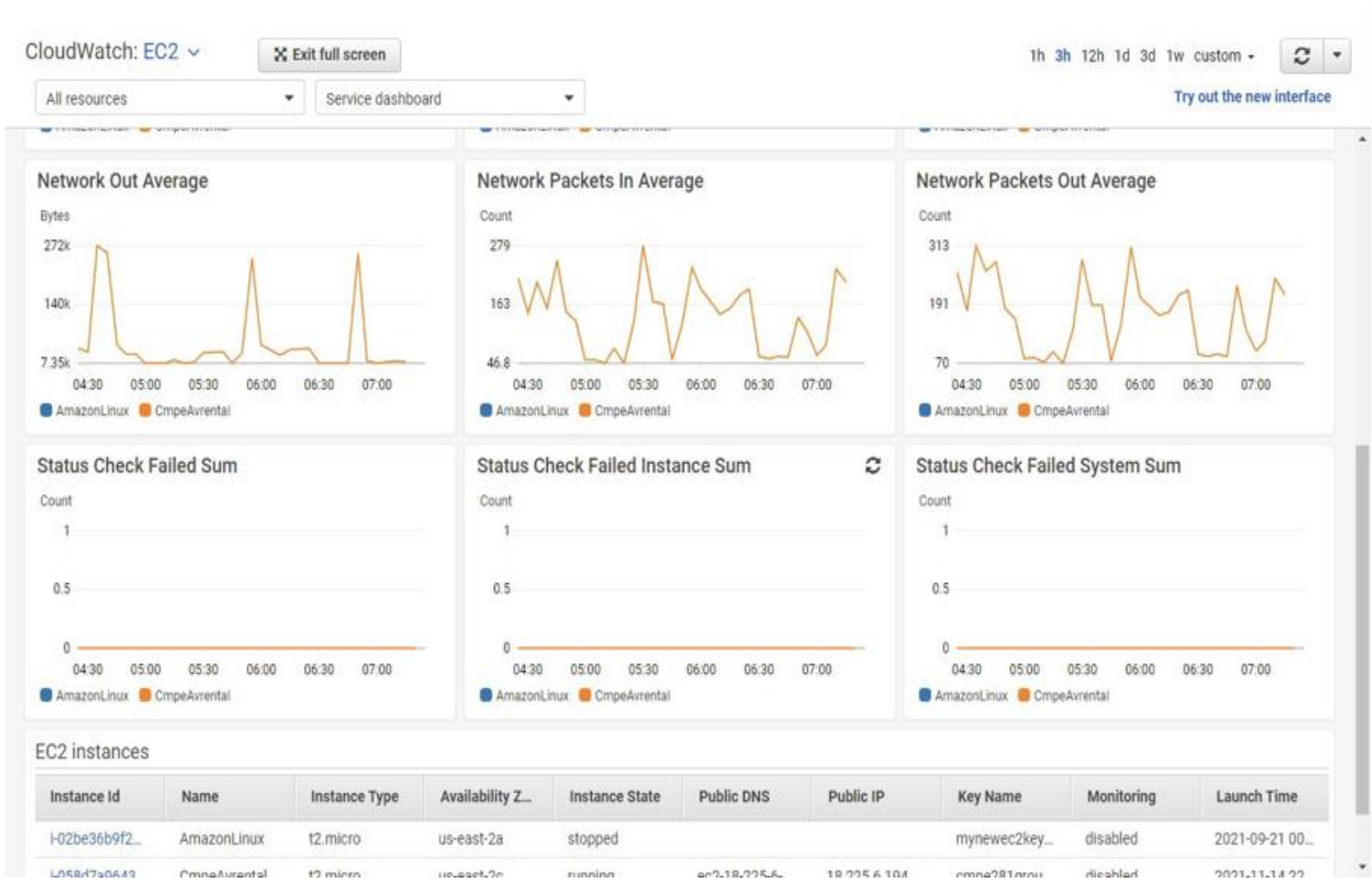


- AWS Cloud. Watch Graphs



- AWS Cloud Watch Graphs



# Extra Features

- Added an interaction from UI (Button) to simulate CARLA.
- Fetching additional data like Simulation time, Speed, Location and GNSS

# THANK YOU