VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590018

Project Report on

" SMART CHARGING AND CNG BOOKING SYSTEM FOR SUSTAINABLE TRANSPORTATION "

Submitted in partial fulfillment of the requirement for the award of

Bachelor of Engineering

in

Computer Science and Engineering

Submitted by

ANURAG GUNDAPI	2JI20CS011
PRATHAMESH BAMANE	2JI20CS034
VAISHNAVI KULKARNI	2JI20CS053
ANEESH PHAPE	2JI20CS060

Under the guidance of
Prof. Nalinakshi B G

Department of Computer Science and Engineering

(Accredited by NBA)

Sri Bhagawan Mahaveer Jain Educational & Cultural Trust's

JAIN COLLEGE OF ENGINEERING

Belagavi-590014

Academic Year 2023-24

Sri Bhagawan Mahaveer Jain Educational & Cultural Trust's

JAIN COLLEGE OF ENGINEERING

Belagavi – 590014

Department of Computer Science and Engineering

(Accredited by NBA)

Certificate

This is to certify that Project Phase-2 entitled **"Smart Charging and CNG Booking System for Sustainable Transportation"** is carried out by **Anurag Gundapi 2JI20CS011, Prathamesh Bamane 2JI20CS034, Vaishnavi Kulkarni 2JI20CS053, Aneesh Phape 2JI21CS060,** bonafied student of Jain College Of Engineering, Belagavi, in partial fulfilment for the Award of Bachelor Of Engineering in Computer Science And Engineering from Visvesvaraya Technological University, Belagavi, during the academic year 2023-24. It is certified that all corrections /suggestions indicated for internal Assessment have been incorporated in the report. The Project Phase-2 report has been approved as it's satisfied the academic requirements in respect of Project Phase-2 work prescribed for the said degree.

Prof. Nalinakshi B G	**Dr. Uttam Patil**	**Dr. J. Shivakumar**
Guide	**HOD, CSE**	**Principal**

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned the efforts with success.

We would like to profoundly thank management of **Jain College of Engineering, Belagavi** for providing such a healthy environment for the successful completion of project work.

We would like to express my thanks to the Director and Principal **Dr. J Shivakumar** for his encouragement that motivated me for the successful completion of project work.

It gives us immense pleasure to thank **Dr. Uttam Patil**, Head of Department for his constant support and encouragement.

Also, We would like to express our deepest sense of gratitude to our project guide **Prof. Nalinakshi B G ,** Assistant Professor, Department of Computer Science & Engineering for his constant support and guidance throughout the project work.

We would also like to thank the Project Coordinator **Prof. Nalinakshi B G ,**Assistant Professor, Department of Computer Science & Engineering and all other teaching and non-teaching staff of Computer Science Department who has directly or indirectly helped us in the completion of the project work.

Last, but not the least, We would hereby acknowledge and thank our parents who have been a source of inspiration and also instrumental in the successful completion of the project work.

DECLARATION

We hereby declare that the entire work embodied in this report entitled **"Smart Charging and CNG Booking System for Sustainable Transportation"**, has been carried out by us at Department of Computer Science and Engineering, Jain College Of Engineering, Belagavi under the supervision of **PROF. NALINAKSHI B G**. The report has not been submitted in part or full for the award of any degree of this or any other University.

ANURAG GUNDAPI (2JI20CS011)

PRATHAMESH BAMANE (2JI20CS034)

VAISHNAVI KULKARNI (2JI20CS053)

ANEESH PHAPE (2JI20CS060)

Date :

Place : Belagavi

JAIN COLLEGE OF ENGINEERING

(Approved by AICTE, New Delhi & Affiliated to VTU, Belagavi)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Accredited by NBA)

VISION

"*To create a centre of excellence in teaching, learning and professional environment in the discipline of Computer Science and Engineering addressing emerging and existing challenges striving to meet the requirement of both industry and society*."

MISSION

- To provide value-based quality technical education and training with continuous improvement in the discipline of Computer Science and Engineering.
- To develop professionals to meet the requirements of industry and society.
- To promote innovation, dedication, and hard work with ethically and professionally responsible behavior

Program Educational Objectives (PEO's)

- Graduates will be able to solve real-world problems and engineering problems by applying fundamentals and recent technologies in the discipline of Computer Science and Engineering.
- Graduates will be able to perform well in design and development of software product formulating necessary requirements through effective communication.
- Graduates will be able to take up higher studies and innovative projects.
- Graduates will behave in an ethically and professionally responsible manner.

Program Specific Outcomes (PSO's)

. Engineering Graduates will be able to:

- Identify the problem, analyze, design, develop, test and implement solution using appropriate tools and technologies.
- Apply the knowledge to carry out innovative projects and transform ideas into working modules following the professional ethics and engineering principles.
- Exhibit good communication and teamwork skills for their lifelong learning.

ABSTRACT

The project focuses on the diverse charging infrastructure for electric vehicles (EVs), considering location-specific requirements. Electric vehicle supply equipment (EVSE), serving as the fundamental unit of EV charging infrastructure, varies globally based on specifications, standards, and the characteristics of the electricity grid. With specifications adapting to the available EV models and grid features, EVSE control systems play a crucial role, facilitating functions like user authentication, authorization, information exchange, and ensuring data privacy and security. The prevalent conductive charging technology, involving wired connections, dominates the charging landscape. Additionally, the project introduces an innovative Online Appointment Booking System for CNG Pump, leveraging technologies such as GPS data. The system aims to enhance the efficiency of CNG refueling processes by allowing users to book appointments through a web-based application, enabling real-time monitoring, online payments, and notifications.

TABLE OF CONTENT

List of Figures

List of Tables

CHAPTER 1

INTRODUCTION

The project focuses on electric vehicles (EVs) and smart EV charging systems. An electric vehicle uses electric motors for propulsion and can be powered by an external collector system or autonomously by a battery. Smart EV charging involves a data connection between the EV, charging device, and charging operator. Additionally, the project addresses the growing demand for Compressed Natural Gas (CNG) as an alternative fuel due to its environmental and cost benefits. However, the project aims to tackle the challenge of long waiting times at CNG pumps, aiming to reduce inconvenience and time wastage for CNG users.

In the ever-evolving landscape of transportation, the quest for sustainability has become a paramount concern. As the global community grapples with the challenges posed by climate change and environmental degradation, the need for innovative solutions has never been more urgent. In the context, the integration of Smart Charging and Compressed Natural Gas (CNG) Booking System emerges as a pivotal advancement in the pursuit of sustainable transportation.

Smart Charging and CNG Booking System represent a dynamic and interconnected approach to address the ecological footprint of traditional transportation methods. The system seamlessly combines intelligent charging infrastructure for electric vehicles (EVs) with a streamlined booking process for CNG-powered vehicles. The integration fosters a more sustainable and eco-friendly mode of transportation, significantly reducing the reliance on fossil fuels and mitigating harmful emissions.

The smart charging component of the system leverages cutting-edge technologies, such as Internet of Things (IoT) devices and advanced data analytics, to optimize the charging process for electric vehicles. It enables real-time monitoring, efficient energy management, and predictive maintenance, thereby maximizing the utilization of renewable energy sources and minimizing the environmental impact.

Simultaneously, the CNG booking system introduces a user-friendly platform that simplifies the reservation and allocation of CNG for vehicles. The ensures a smooth transition to cleaner fuel alternatives, promoting the use of compressed natural gas—a low-emission and cost-effective alternative to traditional gasoline and diesel.

The amalgamation of these two systems not only addresses the pressing environmental concerns but also contributes to the broader goals of sustainable urban planning and smart city initiatives. By fostering the adoption of cleaner energy sources and optimizing the usage of available resources, Smart Charging and CNG Booking System pave the way for a more resilient, efficient, and environmentally conscious transportation ecosystem.

CHAPTER 2

LITERATURE SURVEY

[1] Smart Electric Vehicle Charging System: : João C. Ferreira, Vítor Monteiro, João L. Afonso, Alberto Silva Member, IEEE (2021).

In the work is proposed the design of a system to create and handle Electric Vehicles (EV) charging procedures, based on intelligent process. Due to the electrical power distribution network limitation and absence of smart meter devices, Electric Vehicles charging should be performed in a balanced way, taking into account past experience, weather information based on data mining, and simulation approaches. In order to allow information exchange and to help user mobility, it was also created a mobile application to assist the EV driver on these processes. The proposed Smart Electric Vehicle Charging System uses Vehicle-to-Grid (V2G) technology, in order to connect Electric Vehicles and also renewable energy sources to Smart Grids (SG). The system also explores the new paradigm of Electrical Markets (EM), with deregulation of electricity production and use, in order to obtain the best conditions for commercializing electrical energy.

[2] An in-depth analysis of electric vehicle charging station infrastructure: Muhammad Shahid Mastoi a , Shenxian Zhuang a , Hafiz Mudassir Munir b , Malik Haris c , Mannan Hassan a , Muhammad Usman a , Syed Sabir Hussain Bukhari b , Jong-Suk Ro,Energy reports (2022).

A significant transformation occurs globally as transportation switches from fossil fuel-powered to zero and ultra-low tailpipe emissions vehicles. The transition to the electric vehicle requires an infrastructure of charging stations (CSs) with information technology, ingenious, distributed energy generation units, and favorable government policies. The paper discusses the key factors when planning electric vehicle charging infrastructure. The paper provides information about planning and technological developments that can be used to improve the design and implementation of charging

station infrastructure. A comprehensive review of the current electric vehicle scenario, the impact of EVs on grid integration, and Electric Vehicle optimal allocation provisioning are presented. In particular, the paper analyzes research and developments related to charging station infrastructure, challenges, and efforts to standardize the infrastructure to enhance future research work. In addition, the optimal placement of rapid charging stations is based on economic benefits and grid impacts. It also describes the challenges of adoption. On the other hand, future trends in the field, such as energy procurement from renewable sources and cars' benefits to grid technology, are also presented and discussed.

[3] Electric Vehicle Charging Station: 1Avinash V. Shrivastav, 1Sajidhussain S. Khan, 1Rahul K. Gupta, 1Prajkta R. Ekshinge, 2 Parmeshwar Suryawanshi, Journal of emerging technologies and innovative research(JETIR) vol 7, (2020).

The report discusses about the potential need for electric vehicles (EV), charging station (CS) infrastructure and its challenges for the Indian scenario. With increase in liberalization, privatization and expansion of distributed and renewable power generation of Indian electricity market, transmission and distribution, as well as market processes related to the allocation of energy and energy mix are undergoing an evolutionary development with improved efficiency and reliability.

[4] Review Paper on Charging of Electrical Vehicle: Aishwarya Gajanan Billea , Yashashri Rajaram Patila , Vikram B Patil b, International journal of research publication and reviews (2021).

The paper discuss about electrical vehicle battery and it's charging stations. Most of Electric vehicles (EVs) use electric motors powered by electrical energy stored in a battery for propulsion. The type vehicles are available in a variety of models with varying ranges and capabilities and are plugged in to a source of electrical power to recharge. Now in market two major battery technologies used in EVs are nickel metal hydride (NiMH) and lithium ion (Liion).The paper also evaluates the batteries and challenge of deploying an expanded network of EV charging system.

[5] Electric Vehicles Charging Technology Review and Optimal SizEstimation: Morris Brenna1 · Federica Foiadelli1 · Carola Leone1 · Michela Longo Journal of Electrical Engineering & Technology , vol 15 (2022).

The different types of electric vehicle (EV) charging technologies are described in literature and implemented in practical applications. The paper presents an overview of the existing and proposed EV charging technologies in terms of converter topologies, power levels, power flow directions and charging control strategies. An overview of the main charging methods is presented as well, particularly the goal is to highlight an effective and fast charging technique for lithium ions batteries concerning prolonging cell cycle life and retaining high charging efficiency.

[6] Online Booking System for CNG Pump: by Vaishnavi Shinde, Saloni Pawar,Purva Patel, Sakshi Ghorpade, Nilesh Wankhede, International Journal for Scientific Research & Development| Vol. 11, Issue 3, 2023.

The paper presents an innovative Online Appointment Booking System for CNG Pump, aimed at reducing waiting times and improving the efficiency of CNG refuelling processes. The system allows users to book appointments for CNG refuelling through a web- based application, providing convenience and time savings. Utilizing technologies such as GPS and real-time data, users can locate nearby CNG pumps, view availability, book appointments, make online payments, and receive notifications.

CHAPTER 3

PROBLEM STATEMENT

The existing system grapples with significant challenges related to electric vehicle (EV) charging. One major issue is the difficulty drivers face in locating charging stations, highlighting the pressing need for an implementation of a smart charging infrastructure network. The selection of appropriate locations for installing EV charging stations is crucial to ensure widespread EV adoption. Additionally, the system falls short in addressing various inherent risks, including concerns about battery cost and degradation, economic risks, insufficient charging infrastructure, risky maintenance practices for EVs, integration challenges with smart grids, range anxiety, auxiliary loads, and motorist attitudes. To enhance the efficiency and effectiveness of the current system, comprehensive solutions are required to tackle these multifaceted issues associated with the charging infrastructure for electric vehicles.The current CNG filling stations are time-consuming. Cars must wait in queues, leading to a lengthy and hectic process. Additionally, not all CNG pumps are online, risking potential time wastage if a station runs out before users can fill gas.

Disadvantages of Existing System:

- Difficulty in finding electric vehicle charging stations easily.
- Lack of a smart network to optimize charging station locations.
- Challenges associated with expensive batteries in electric vehicles.
- Insufficient availability of charging spots.
- Concerns about the longevity of electric cars.
- Time-consuming process at current CNG filling stations.
- Lengthy and hectic queues at CNG stations.
- Risk of wasted time if a CNG station runs out of gas before users can fill up.

3.2 PROBLEM DEFINATION AND OBJECTIVES OF PROJECT WORK

As the rising use of electric vehicles, we need better charging systems. Current infrastructure problems make it hard to smoothly include electric vehicles in everyday transportation. There's no organized appointment system, leading to unpredictable wait times and a less-than-ideal user experience. We need a solution that lets users pre-book CNG refuelling appointments to reduce waits and make the process more efficient.

Objectives

- To enable faster adoption of electric vehicles by ensuring safe, reliable, accessible and affordable charging infrastructure and eco-system.
- To promote affordable tariff chargeable from EV owners and charging station operators.
- To proactively support creation of EV charging infrastructure in the initial phase and eventually create a market for EV charging business.
- To encourage preparedness of electrical distribution system to adopt EV charging infrastructure.
- The user can locate nearby CNG pump and can book a appointment by maintaining virtual queue for each pump which is simple and easy to use .
- To enable users to book appointments for CNG refuelling at their preferred pump stations, to provide a user-friendly interface for easy registration and login, to allow users to select appointment slots based on availability and to facilitate online payment for seamless and secure transactions.

CHAPTER 4

METHODOLOGY

The project aims to revolutionize the transportation sector by integrating cutting-edge technologies to promote environmental sustainability and enhance user convenience. The methodology outlines a systematic approach to successfully plan, develop, and implement a comprehensive system that seamlessly integrates smart charging infrastructure for electric vehicles and an efficient booking system for Compressed Natural Gas (CNG) vehicles.

4.1 Proposed Method

The project addresses the problem by introducing an affordable electric vehicle charging model. The Project will be implemented using cost-efficient and readily available components for the prototype. The system utilizes a codebase comprising Python, Embedded Javascript (EJS). Embedded JS contribute to the user interface (front-end), while Python facilitates the connection between Hardware Components. Node.js is used as runtime environment that allows to run Javascript code outside web browser and MongoDB is used to store data and is a popular Database system which is flexible and scalable. The integrated approach ensures an efficient and cost-effective electric vehicle charging solution. The main aim of the proposed system is to avoid customer spending time in queue. It is done by maintaining a virtual queue for each pump. Each pump will have queue of customized slots each of 5 to 10 minutes which user can view whichever user want can book it but before booking user must do login. In the we have a page Pump Queue were user can view the queue of each pump and accordingly make a appointment with pumps having lesser queue.

- **Register:**
  - Users provide their details such as username, email, and password.
  - The system validates the information and creates a new user account.
- **Login:**
  - Registered users enter their credentials (username/email and password).
  - The system verifies the credentials against the stored user data.
  - Upon successful verification, the user is authenticated and granted access to their account.
- **Locating Nearby Stations with Free Slot:**
  - The system determines the user's current location using geolocation services or manually entered address.
  - It queries a database or external API to find nearby charging stations, CNG (Compressed Natural Gas) refueling stations.
  - Stations with available slots or pumps are filtered and displayed to the user.
- **Display of Charging, CNG Refueling:**
  - Charging plans for electric vehicles, refueling plans for CNG vehicles are retrieved from a database or backend service.
  - These plans include details such as pricing, charging speed (for EVs), refill cost (for CNG),Plans are presented to the user for selection.
- **Selecting Plan and Making Payment:**
  - Users choose a charging plan for electric vehicles, a refueling plan for CNG vehicles based on their requirements.
  - They proceed to the payment step where they enter their payment details.
  - The system securely processes the payment using a payment gateway.
  - Upon successful payment, the user's account is updated to reflect the chosen plan.
- **Tracking Location to Destination:**
  - Users input their destination or select it from a list of options.The system calculates the route from the user's current location to the destination using mapping services.
  - Updates on the user's location and progress along the route are provided.

- **Connecting Vehicle to Charging Station (EV), CNG Refueling Station:**
  - Users drive their vehicle to the selected station based on their chosen plan.
  - For EV charging, users connect their electric vehicle to the charging station hardware.
  - For CNG refueling, users follow instructions to connect the refueling nozzle to their vehicle's inlet.
  - The system provides feedback on the connection status and initiates the charging or refueling process accordingly.
- **Checking the Status of Charging or Refueling Progress:**
  - The system continuously monitors the charging or refueling process.
  - Users can view updates on the progress, including current battery level (for EVs) or amount of gas dispensed (for CNG).
- **Charging or Refueling Process Completion:**
  - Once the charging or refueling process is complete, the system notifies the user.
  - Users receive instructions for safely disconnecting their vehicle from the station.
  - The system updates the user's account and charging/refueling history to reflect the completed session.
  - By integrating CNG refueling booking into the existing methodology, the system provides users with a comprehensive solution for their energy needs, catering to a wider range of vehicles and fuel preferences.

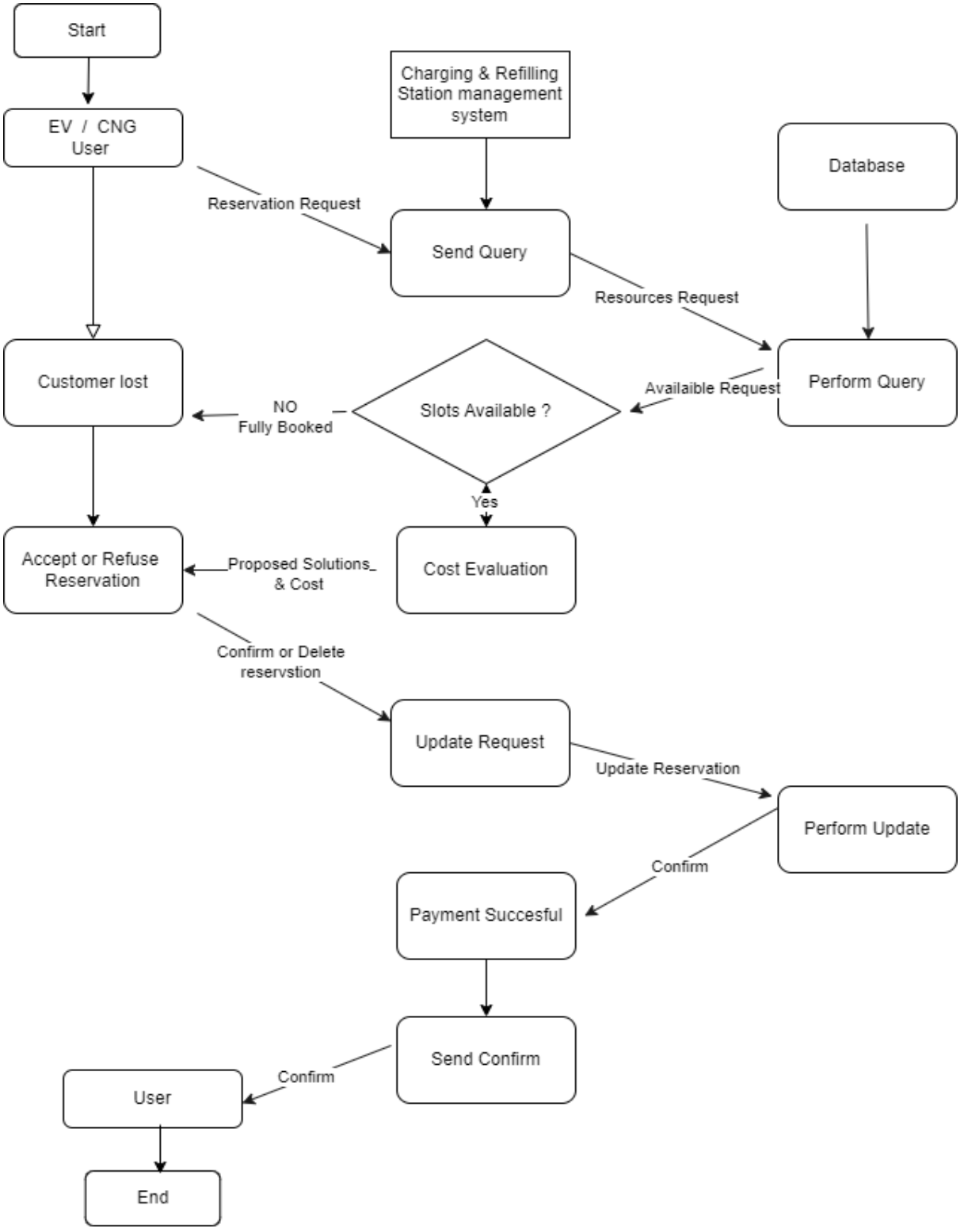

Figure 4.1: Work Flow Diagram

CHAPTER 5

REQIREMENTS SPECIFICATION

5.1 Hardware requirements:

- NodeMCU
- LCD display
- Relay

5.1.1 NodeMCU

NodeMCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espreffic Systems, and hardware which was based on the ESP- 12 module. Later, support for the ESP32 32-bit MCU was added.

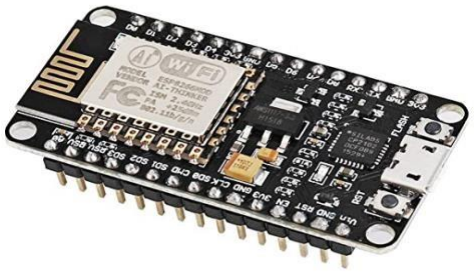

Figure 5.1: NodeMCU

NodeMCU ESP8266 Specifications & Features

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1

- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

5.1.2 Relay

A **relay** is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms such as make contacts, break contacts, or combinations thereof.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal.

Figure 5.2: Relay

Dual-Channel Relay Module Specifications

- Supply voltage – 3.75V to 6V
- Trigger current – 5mA
- Current when relay is active - ~70mA (single), ~140mA (both)
- Relay maximum contact voltage – 250VAC, 30VDC
- Relay maximum current – 10A

5.1.3 LCD Display

A **liquid-crystal display** (**LCD**) is a flat-panel display or other electronically modulated optical devices that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden.

Figure 5.3: LCD Display

Specifications of LCD 16X2

- The operating voltage of the display ranges from 4.7V to 5.3V
- The display bezel is 72 x 25mm
- The operating current is 1mA without a backlight
- PCB size of the module is 80L x 36W x 10H mm
- HD47780 controller
- LED colour for backlight is green or blue
- Number of columns – 16
- Number of rows – 2
- Number of LCD pins – 16
- Characters – 32
- It works in 4-bit and 8-bit modes
- Pixel box of each character is 5×8 pixel
- Font size of character is 0.125Width x 0.200height

5.2 Software requirements:

- IoT cloud(ThingSpeak)
- Python
- Embedded Javascript
- Node.js
- MongoDB

ThinkSpeak cloud:

ThingSpeak is a cloud-based IoT platform by MathWorks. It allows users to collect, store, analyze, and visualize data from IoT devices. Users can send data, view visualizations, analyze data with MATLAB, set alerts, and share channels. It's widely used for various IoT applications due to its flexibility and ease of integration.

Embedded JS(EJS):

EJS is a templating language that allows to generate HTML markup with plain JavaScript. It is typically used in web development alongside JavaScript and Node.js to dynamically generate HTML content on the server side.EJS allows to embed JavaScript code within HTML markup, making it easier to generate dynamic content based on data or conditions.

Node.js:

Node.js provides a runtime environment for executing JavaScript code outside of a web browser, allowing developers to build scalable and high-performance server-side applications. It includes a set of built-in modules that provide functionality for handling network requests, accessing the file system, working with streams, and more.

MongoDB:

MongoDB is a popular database system that stores data in a flexible and scalable way. It uses a document-oriented model, similar to storing data in JSON files. MongoDB is great for handling large amounts of data and is used in many different applications, from websites to analytics tools. It's known for its easy-to-use interface and powerful features, like fast querying and high availability.

Express JS:

Express.js is a minimalist web application framework for Node.js, designed to make building web applications and APIs easier and faster. It provides a robust set of features for web and mobile applications, allowing developers to quickly set up routes to handle HTTP requests and define middleware functions to execute during the request-response cycle. With its simplicity and flexibility, Express.js enables developers to focus on writing clean, efficient code while providing powerful tools for building scalable and maintainable web applications. Its extensive ecosystem of plugins and middleware further extends its capabilities, making it a popular choice for both beginners and experienced developers alike.

5.3 Programming languages:

- Python
- Javascript

Python:

Python is a high-level, interpreted programming language that is known for its simplicity, readability, and versatility. Python supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is used for connecting the Node MCU and the ThinkSpeak cloud.

Javascript:

JavaScript is a programming language used to make websites interactive. It adds functionality like dynamic content and user interfaces, running in web browsers to create engaging web experiences.

5.4 Integrated Development Environment's (IDE's):

Visual Studio Code:

Visual Studio Code (VS Code) is a lightweight yet powerful code editor developed by Microsoft. It's popular among developers for its customizable interface, extensive language support, and rich ecosystem of extensions. Essentially, it's a tool that helps programmers write and edit code more efficiently, with features like syntax highlighting, debugging support, and version control integration. It's free, open-source, and available on multiple platforms, making it widely accessible to developers worldwide.

Arduino IDE:

The Arduino IDE, or Integrated Development Environment, is a software tool used to write and upload code to Arduino microcontroller boards. It provides a simple interface for writing, compiling, and uploading code to control electronic projects with a set of libraries for interacting with hardware components such as sensors, actuators, and displays. With features like syntax highlighting, code completion, and serial monitor for debugging, the Arduino IDE simplifies the process of creating embedded projects and prototypes.

5.5 Functional Requirements:

1. **User Registration and Login:** The registration process includes robust authentication mechanisms and secure storage of user credentials. Upon successful registration, users can log in securely using their credentials. Additionally, password reset and account recovery functionalities are provided for user convenience and security enhancement.

2. Selecting between EV station and CNG refill station: The system provides a clear interface for users to indicate their vehicle type and preferences, ensuring they are directed to the appropriate charging or refilling stations. Moreover, users can save their vehicle preferences for future sessions, streamlining the station selection process.

3. Locating Nearby Stations: Utilizing geolocation services, users can effortlessly discover nearby recharge and refill stations, either by their current GPS coordinates or by entering a specific destination. The system presents station details such as distance, availability, and amenities, and users can filter stations based on additional criteria like station ratings or available charging/refilling speeds.

4. Selecting Plan and Making Payment: Users are presented with various charging or refilling plans, along with transparent pricing details. Payment options are securely integrated, supporting multiple payment methods for user convenience. Furthermore, users can review their payment history and manage their payment methods within their account settings.

5. Mapping Route: Integrating with mapping APIs, the system generates optimal routes from the user's current location to the selected station, considering factors like traffic conditions and road closures. Users can view step-by-step directions for seamless navigation. Additionally, alternative routes and estimated arrival times are provided to accommodate user preferences and real-time traffic updates.

6. Progress and Status Updates: Users receive notifications and status updates on their device or through the web interface, keeping them informed about the charging or refilling process, including estimated time remaining and any potential issues. Users can also opt-in for SMS or

email notifications for critical updates, ensuring they stay informed even when not actively using the application.

7. Process Completion Alert: Upon successful completion of the recharging or refilling process, users receive prompt notifications, allowing them to proceed with their journey confidently. Moreover, users can rate their charging/refilling experience and provide feedback, contributing to the continuous improvement of station services and overall user satisfaction.

8. Hardware Prototype Integration: The web application seamlessly interfaces with the hardware prototype, providing users with a visual representation or simulation of the EV charging process, enhancing their understanding and experience. Additionally, users can access instructional videos or FAQs to troubleshoot common issues or queries related to hardware usage.

5.6 Non-Functional Requirements:

1. Performance: The system is optimized for speed and responsiveness, ensuring rapid loading times and smooth user interactions even during peak usage periods. Load testing is conducted to maintain performance standards under various traffic conditions, and performance metrics are monitored regularly to identify and address potential bottlenecks proactively.

2. Reliability: Continuous monitoring and fault-tolerant mechanisms are in place to minimize service disruptions. Regular backups and failover systems ensure data integrity and availability in the event of hardware or software failures. Moreover, automated alerts and escalation procedures are implemented to expedite issue resolution and minimize downtime impact on users.

3. Security: User data is encrypted both in transit and at rest, utilizing industry-standard encryption algorithms. Access controls and auditing mechanisms safeguard against unauthorized access, and regular security audits are conducted to identify and mitigate vulnerabilities.

4. Scalability: The system architecture is designed for horizontal scalability, allowing it to expand seamlessly as user and station numbers grow. Scalability testing is performed regularly to assess performance under increased loads and to optimize resource allocation.

5. Usability: The user interface is designed with a focus on simplicity and intuitiveness, incorporating user feedback and usability testing to ensure easy navigation and task completion for users of all skill levels.

6. Compatibility: The web application is tested across a range of devices and browsers, ensuring consistent functionality and user experience regardless of the platform used. Responsive design techniques are employed to adapt to various screen sizes and resolutions.

7. Integration: The system seamlessly integrates with external APIs for mapping services, payment gateways, and hardware communication protocols, ensuring interoperability and smooth data exchange between different components of the ecosystem. Regular compatibility checks and API versioning strategies are employed to mitigate integration risks.

CHAPTER 6

SYSTEM DESIGN

6.1 System Architecture:

The architecture of the system consists of a Web Application provides a user-friendly interface accessible via web browser and the User Account Management Handles user registration, authentication, and profile management. The Dashboard displays real-time information on available charging and refueling stations. The maps Integration Integrates with mapping services to show nearby stations and navigation. The Booking Interface allows users to book charging or refueling slots and make payments online.

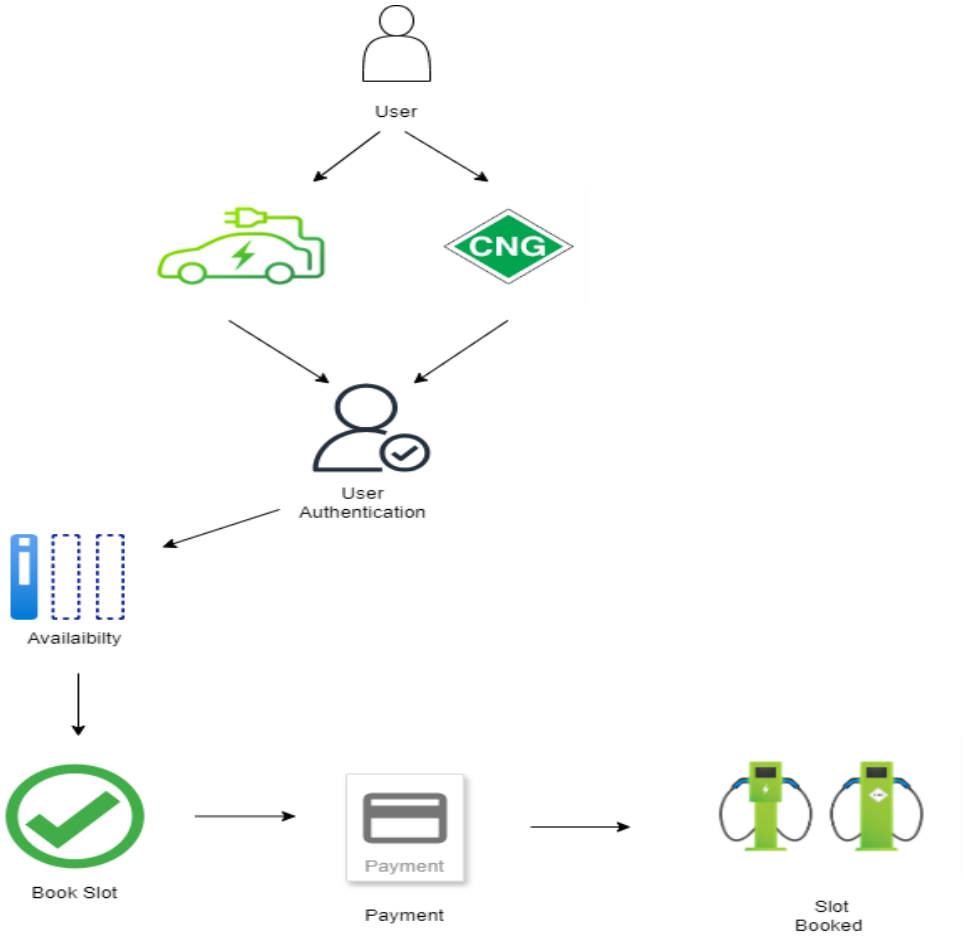

Fig 6.1: System Architecture

6.2 DATA FLOW:

The Data Flow Diagram showcases how data moves through our website application for our Project. It outlines the various processes, data sources, destinations, and data flows within the system. From user interactions to backend operations, the DFD visually depicts the journey of data as users book CNG services, reserve charging slots, make payments, and receive confirmations. It provides a clear understanding of how information flows within the system, aiding in the analysis, design, and optimization of your website application for sustainable transportation solutions.

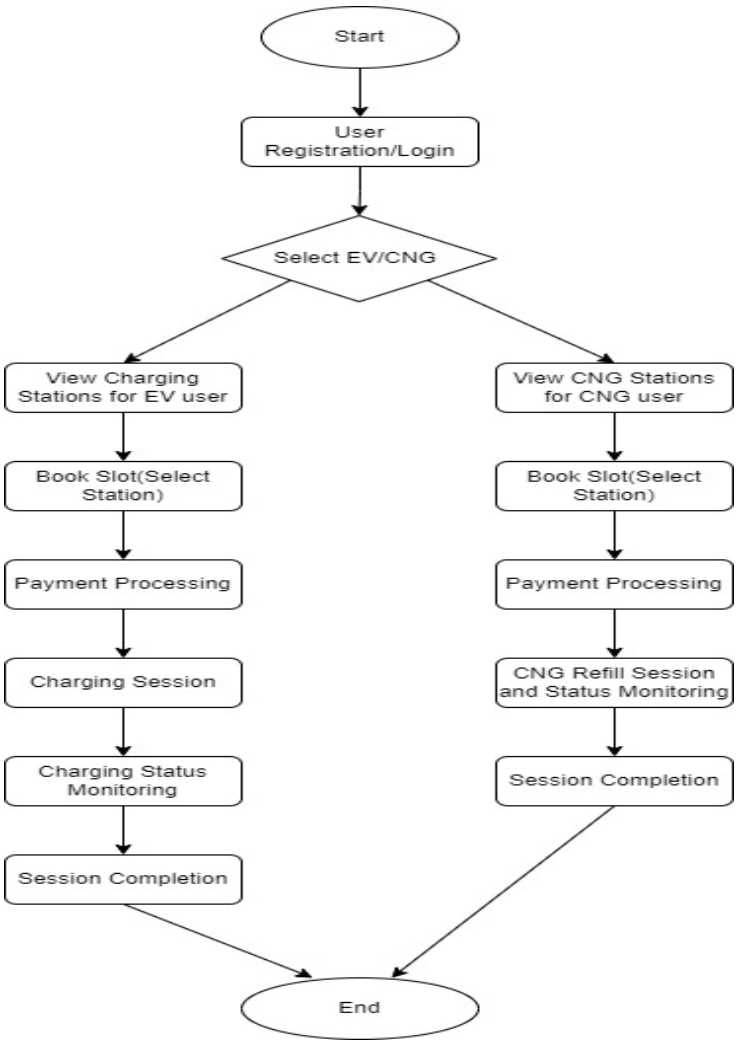

Fig 6.2: Data Flow Diagram

6.3 CLASS DIAGRAM:

The class diagram depicts the structure of the website application designed to facilitate smart charging and CNG (Compressed Natural Gas) booking for sustainable transportation. It illustrates the main classes and their relationships, focusing on the key components necessary for the system's functionality. Classes such as User, Charging Station, CNG Station, Booking, Payment Info, and possibly others are included, along with their attributes and methods. Relationships between classes represent interactions such as user bookings, payments, and the association between users and charging/CNG stations.

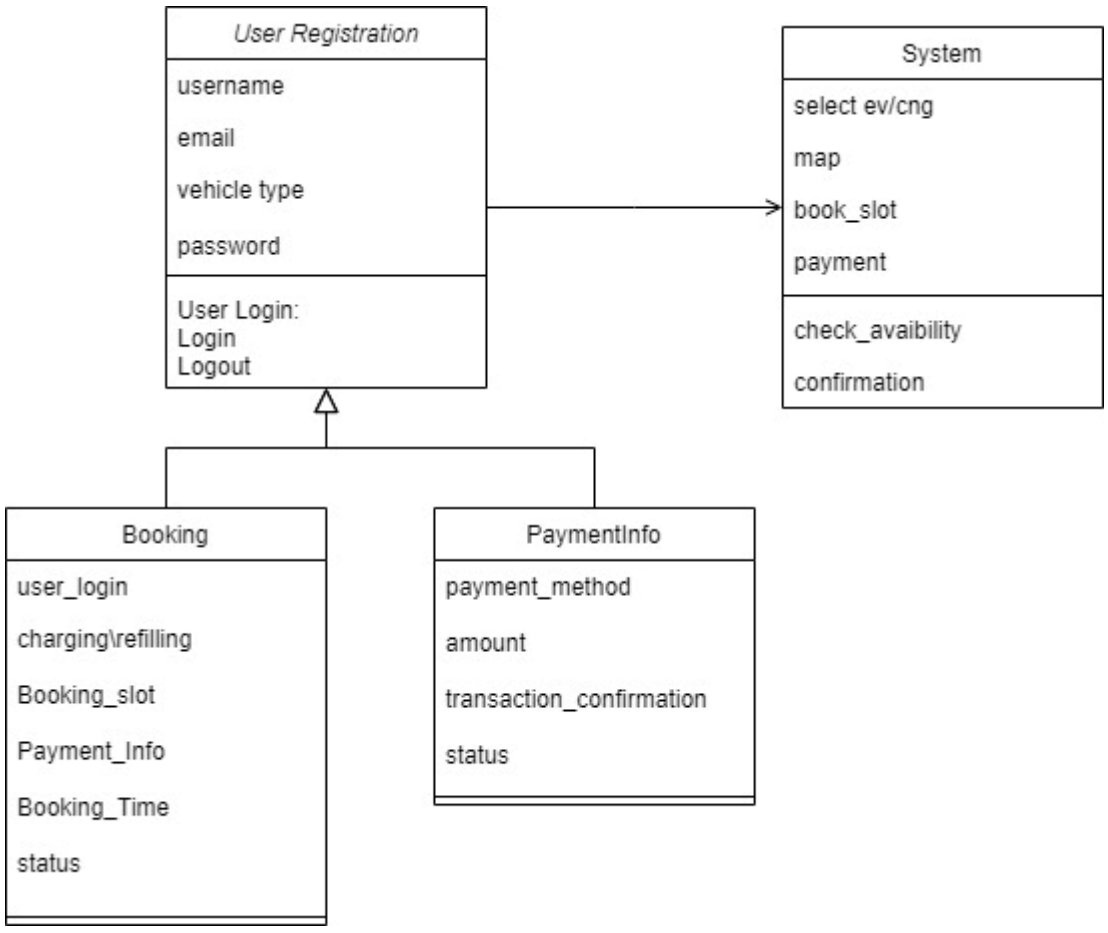

Fig 6.3: Class Diagram

6.4 IMPLEMENTATION

- **Web Application Implementation:**

1. Frontend Development:

- Use HTML, CSS, and Embedded JS for the user interface.

- Design user-friendly pages for registration, login, selecting options, making payments, booking slots, viewing progress/status, etc.

- Implement interactive features such as maps for route navigation and displaying nearby stations.

2. Backend Development:

- Utilize Node.js and JavaScript for backend logic.

- Set up RESTful APIs for communication between frontend and backend.

- Implement user authentication and authorization for secure access.

- Integrate MongoDB for storing user credentials, transaction details, and other necessary data.

3. Payment Gateway Integration:

- Integrate a payment gateway (e.g., Stripe, PayPal) for handling transactions securely.

4. Route Mapping:

- Utilize APIs like Google Maps to implement route mapping functionality.

- **Hardware Component Integration:**

1. NodeMCU Setup:

- Use Arduino IDE for programming NodeMCU.

- Write firmware in Python for connecting hardware components to the web application.

2. Relay and Power Supply Module:

- Use the relay to control power supply to the charging station.

- Ensure proper voltage regulation and safety measures with the power supply module.

3. LED Display:

- Integrate the LED display to show status updates and process completion alerts.

4. ThinkSpeak Integration:

- Configure NodeMCU to send hardware component data to ThingSpeak server for storage and monitoring.

- **Integrated Development Environment (IDE):**

1. Arduino IDE:

- Use Arduino IDE for programming NodeMCU and interacting with hardware components.

2. Visual Studio:

- Utilize Visual Studio for backend development, providing a robust development environment.

- **Features Implementation:**

1. User Registration and Login:

- Implement forms for user registration and login with validation checks.

2. Station Selection and Booking:

- Allow users to select between EV charging stations and CNG refill stations.

- Enable users to book slots based on availability.

3. Nearby Station Locator:

- Integrate APIs for locating nearby recharge and refill stations based on the user's current location.

4. Payment and Plan Selection:

- Implement payment processing and allow users to select from different plans/packages.

5. Route Mapping and Navigation:

- Integrate maps for displaying routes from the current location to the destination station

6. Progress and Status Updates:

- Provide real-time updates on the progress of recharging and refilling processes.

- Send alerts upon completion of processes.

- **Hardware Prototype Demonstration:**

1. Demonstration Setup:

- Set up a hardware prototype to demonstrate the EV charging process.

- Ensure all components are properly connected and functional.

2. User Interaction:

- Allow users to interact with the hardware prototype during demonstrations.

- Display relevant information on the LED display to simulate real-world scenarios.

3. Testing and Debugging:

- Conduct thorough testing of the entire system to identify and resolve any issues.

- Debug hardware and software components as needed.

Code Snippet:

```
#include <ESP8266WiFi.h>

#include <WiFiClient.h>

#include <LiquidCrystal_I2C.h>


LiquidCrystal_I2C lcd(0x27,16,2);

const char* ssid = "Swaps";

const char* password = "12345678";

int RELAY_PIN = 13;

const char* server = "api.thingspeak.com";

const String resource =
"/channels/2440083/feeds.json?api_key=YPYKOVNSWLUUSB3X&results=1";

int latest_entry_id = -1;

int latest_field1 = -1;

void setup() {

  Serial.begin(115200); // Initialize serial communication

  pinMode(RELAY_PIN, OUTPUT); // Set the relay pin as output

  digitalWrite(RELAY_PIN, LOW); // Turn off the relay initially

  lcd.init();

  lcd.clear();

  lcd.backlight();      // Make sure backlight is on
```

```
// Print a message on both lines of the LCD.
lcd.setCursor(0,0);   //Set cursor to character 2 on line 0
Serial.begin(115200);
delay(10);
WiFi.begin(ssid, password);
Serial.println();
Serial.print("Connecting to ");
Serial.println(ssid);
// lcd
lcd.setCursor(0,0);   //Set cursor to character 2 on line 0
lcd.print("Connecting to");
lcd.setCursor(0,1);
lcd.print(ssid);
while (WiFi.status() != WL_CONNECTED) {
  delay(500);
  Serial.print(".");
}
lcd.clear();
Serial.println("")
Serial.println("WiFi connected");
lcd.setCursor(0,0);
```

```
lcd.print("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());
lcd.setCursor(0,1);
lcd.print(WiFi.localIP());
// Fetch initial values
String json = fetchJSON();
if (json.length() > 0) {
  int entry_id = getEntryID(json);
  int field1 = getField1Value(json);
  latest_entry_id = entry_id;
  latest_field1 = field1;
  Serial.print("Initial Latest Entry ID: ");
  Serial.println(latest_entry_id);
  Serial.print("Initial Latest Field1 Value: ");
  Serial.println(latest_field1);
} else {
  Serial.println("Error fetching JSON data");
}
lcd.clear();
lcd.setCursor(0, 0);
```

```
  lcd.print("wlcome to");
  lcd.setCursor(0, 1);
  lcd.print("Pay Charge");
  delay(500);
}
void loop() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Scan the QR code");
  lcd.setCursor(0, 1);
  lcd.print("Choose plan");
  delay(500);
  if (WiFi.status() == WL_CONNECTED) {
    String json = fetchJSON();
    if (json.length() > 0) {
      int entry_id = getEntryID(json);
      int field1 = getField1Value(json);
      if (entry_id != latest_entry_id) {
        latest_entry_id = entry_id;
        latest_field1 = field1;
```

```
Serial.print("Latest Entry ID: ");
Serial.println(latest_entry_id);
Serial.print("Latest Field1 Value: ");
Serial.println(latest_field1);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("payment recived");
lcd.setCursor(0, 1);
lcd.print("charging ");
lcd.print(latest_field1);
lcd.print(" Min");
int remaining_time = latest_field1 * 60;
digitalWrite(RELAY_PIN, HIGH);
delay(1000);
// Count down the remaining time and update the LCD screen
for (int i = remaining_time; i > 0; i--) {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Charging for");
  lcd.setCursor(0, 1);
  lcd.print(i / 60);
```

```
  lcd.print(":");
  lcd.print(i % 60);
  delay(1000);
}
// Turn off the relay on pin 13
digitalWrite(RELAY_PIN, LOW);
// Reset the latest field 1 value to 0
latest_field1 = 0;
lcd.clear();
lcd.setCursor(2, 0);
lcd.print("Charging");
lcd.setCursor(2, 1);
lcd.print("Sucessful");
delay(3000);
lcd.clear();
lcd.setCursor(2, 0);
lcd.print("Visit");
lcd.setCursor(2, 1);
lcd.print("Again");
delay(3000);
```

```
    }
   } else {
    Serial.println("Error fetching JSON data");
   }
  } else {
   Serial.println("WiFi Disconnected");
  }

  delay(10000);
}
String fetchJSON() {
  WiFiClient client;
  if (client.connect(server, 80)) {
   client.print(String("GET ") + resource + " HTTP/1.1\r\n" +9
          "Host: " + server + "\r\n" +
          "Connection: close\r\n\r\n");
   delay(500);
   String response = "";
   while (client.available()) {
    char c = client.read();
 response += c;
```

```
    }
    int start = response.indexOf("[{");
    int end = response.lastIndexOf("}]") + 2;
    String json = response.substring(start, end);
    return json;
  } else {
    return "";
  }
}
int getEntryID(String json) {
  int start_entry_id = json.indexOf("entry_id\":") + 10;
  int end_entry_id = json.indexOf(",", start_entry_id);
  int entry_id = json.substring(start_entry_id, end_entry_id).toInt();
  return entry_id;
}
int getField1Value(String json) {
  int start_field1 = json.indexOf("field1\":\"") + 9;
  int end_field1 = json.indexOf("\"", start_field1);
  int field1 = json.substring(start_field1, end_field1).toInt();
  return field1;
}
```

CHAPTER 7

TESTING

In our Smart EV Charging and CNG Booking System, we've set up several tests to ensure everything works smoothly. First, we're checking if users can register and log in without any issues. Then, we're making sure they can easily choose between EV charging and CNG refill options and find nearby stations. Users should be able to pick their preferred plan, make payments securely, and see the route to their destination on a map. We're also testing to ensure that progress updates and completion alerts work properly. Lastly, we're demonstrating the EV charging process with our hardware prototype to ensure it performs as expected.

7.1 Unit Testing:

Test Case No.	Activity	Test Case	Excepted Output	Actual Output
1.	User Registration and Login	Enter Valid Details	Successful Registration.	Successful Registration.
		Enter Invalid or Incomplete Details	Registration Unsuccessful.	Registration Unsuccessful.
		User Login With Correct Credentials	Success Login.	Success Login.
		User Login With Wrong or Incorrect Credentials	Invalid Credentials.	Invalid Credentials.
2.	Selecting EV Recharge Station option	Redirecting to EV station Selected Page	Redirected to EV station page.	Redirected to EV station page.
		Locating Nearby Recharging Station	Map Displaying Nearby	Map Displaying

			Recharge stations.	Nearby Recharge stations.
		Making Payment for the Selected Plan	Payment Successful.	Payment Successful.
		Book a slot	User should be able to book a slot.	Slot Booked.
		Mapping Route from current Location to Destination	Correct route display.	Correct route display.
		Tracking Progress of Recharging	Real-time Progress Updates.	Real-time Progress Updates.
		Status alert for process completion	Completion alert displayed.	Completion alert displayed.
		Demonstrating EV charging process with hardware prototype	Successful Demonstration of EV charging process.	Successful Demonstration of EV charging process.
3.	Selecting CNG Refill Station option	Redirecting toCNG Refill station Selected Page	Redirected to CNG station page.	Redirected to CNG station page.
		Locating Nearby CNG Refill Stations	Map Displaying Nearby CNG Refill stations.	Map Displaying Nearby CNG Refill stations.

		Making Payment for the Selected Plan	Payment Successful.	Payment Successful.
		Book a slot	User should be able to book a slot.	Slot Booked.
		Mapping Route from current Location to Destination	Correct route display.	Correct route display.
		Tracking Progress of Refill	Real-time Progress Updates.	Real-time Progress Updates.
		Status alert for process completion	Completion alert displayed.	Completion alert displayed.
		RefillProcess Completion	Success Refill.	Success Refill.

7.2 INTEGRATION TESTING:

Integration testing ensures that individual hardware components and software modules work together seamlessly within a system. It verifies that various parts of the system, such as Node MCU, relay, power supply module, LED display, and web application features like user registration, station selection, payment processing, and route mapping, integrate correctly and function as intended. Integration testing thus validates the interoperability and interaction between different elements of the system, verifying that they collectively deliver the intended functionality and user experience.

Test case No.	Test case Description	Test Steps	Expected Result
1.	Node MCU connection	1.Ensure Node MCU is properly Connected.	NodeMCU successfully communicates with the server.
		2.send test data from Node MCU to the server.	Data is received and processsed by the server.
2.	Relay Functionality	Activate relay to simulate switching power supply.	Power supply output is toggled accordingly.
3.	LED Display Output	Display Different messages on the LED Display.	Messages are diaplayed correctly on the LED.
5.	Ensure MongoDB integration with the Web Application for user	User can register and login successfully using MongoDB	User data storedsuccessfully in Database

CHAPTER 8

RESULTS

The below snapshot represents dashboard of the web page which consists options for Login, Register & Contact us.

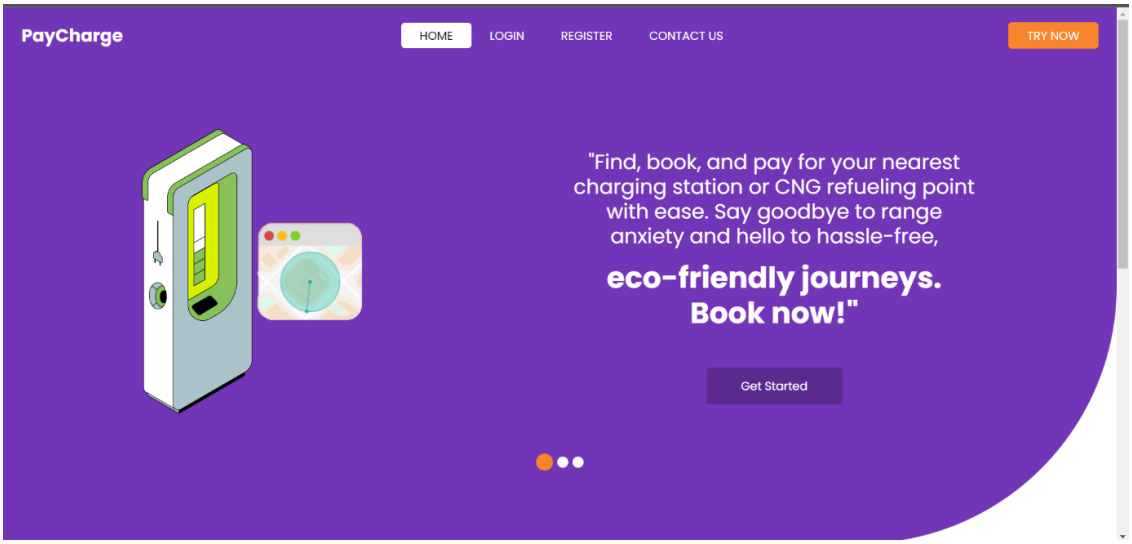

Fig 8.1:Front Web Page

The following snapshot contains booking option related to EV charging station.

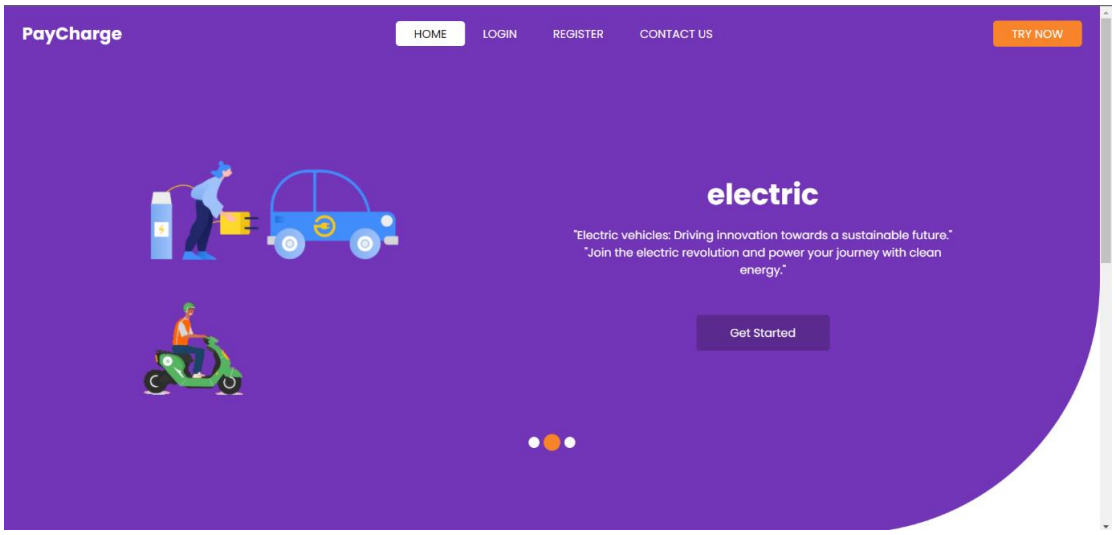

Fig 8.2: Front Web Page to get started with with EV

The following snapshot contains booking option related to CNG refueling station.

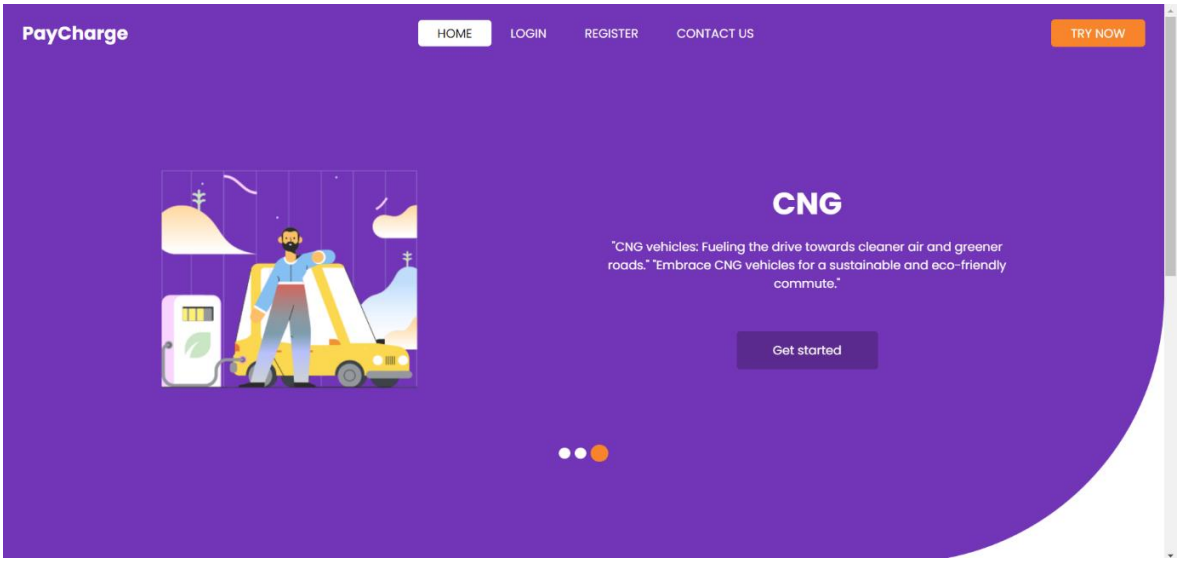

Fig 8.3: Front Web Page to get started with with CNG

The following snapshot represents the user registration page where they can enter their credentials.

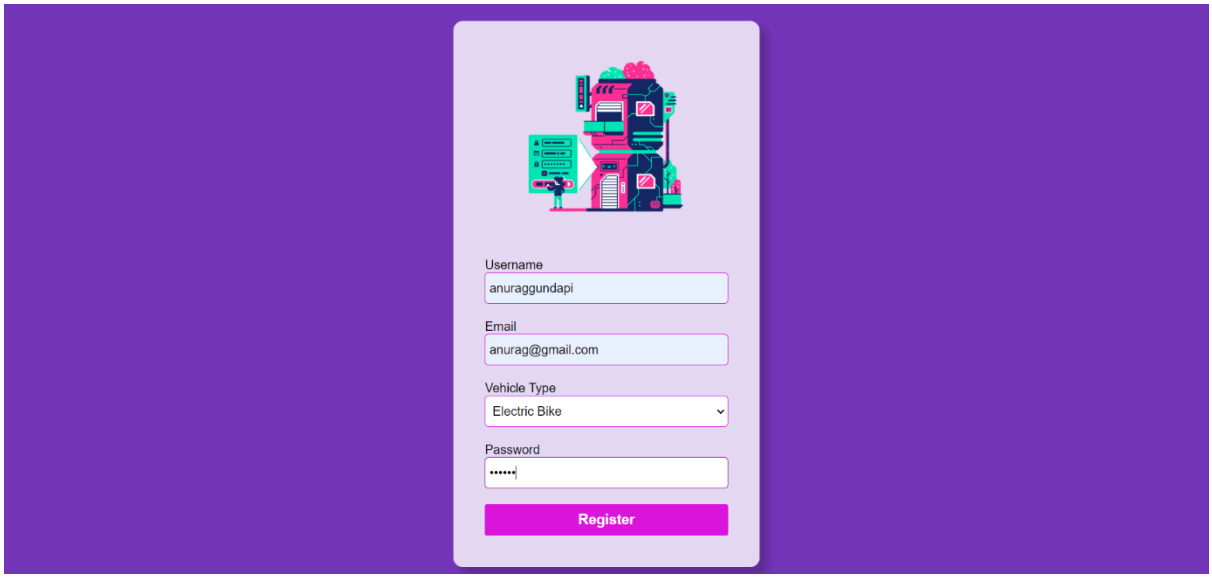

Fig 8.4: User Registration page

The following snapshot represents user login page where the users can login using their username and password.

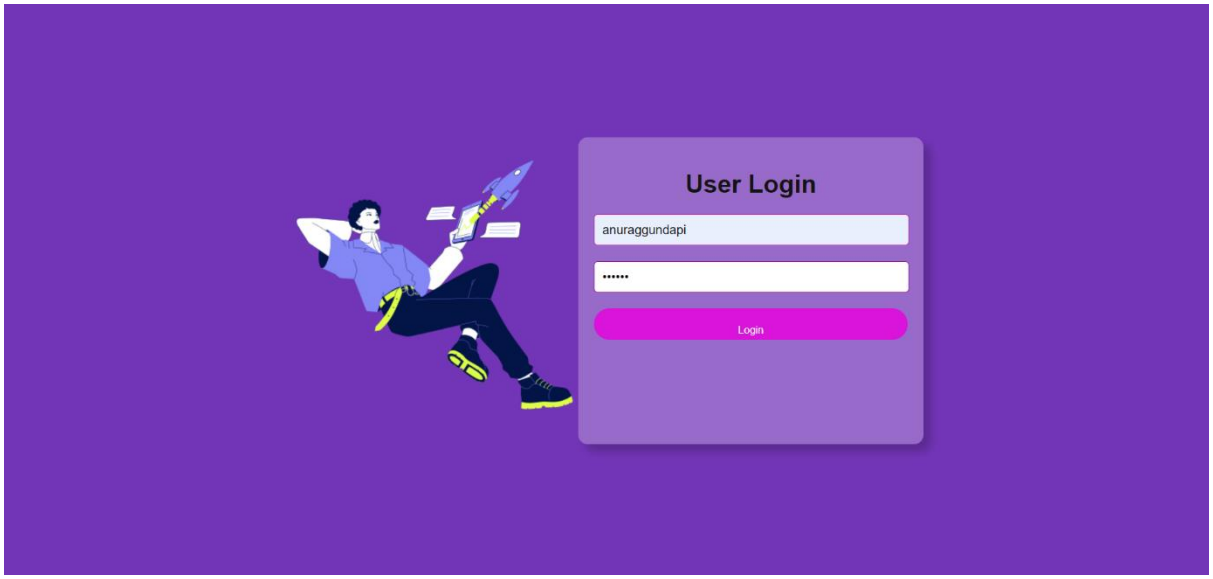

Fig 8.5:User Login Page

The following snapshot represents option for the user where they can choose between EV and CNG.

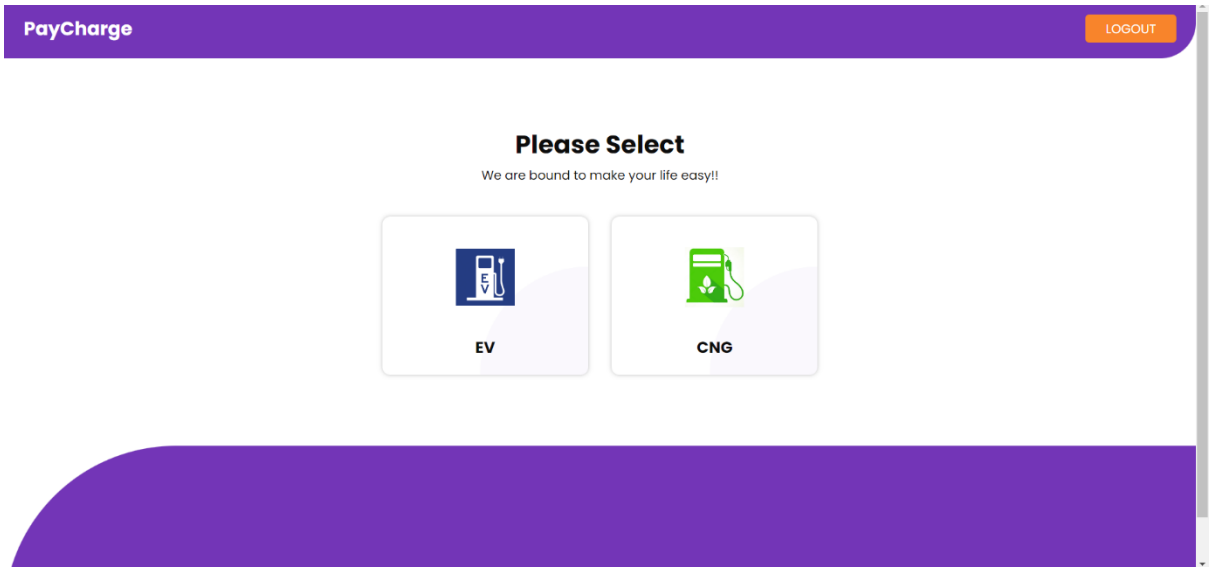

Fig 8.6:EV or CNG Booking Selection page

The following snapshot represents the nearby EV stations which are available.

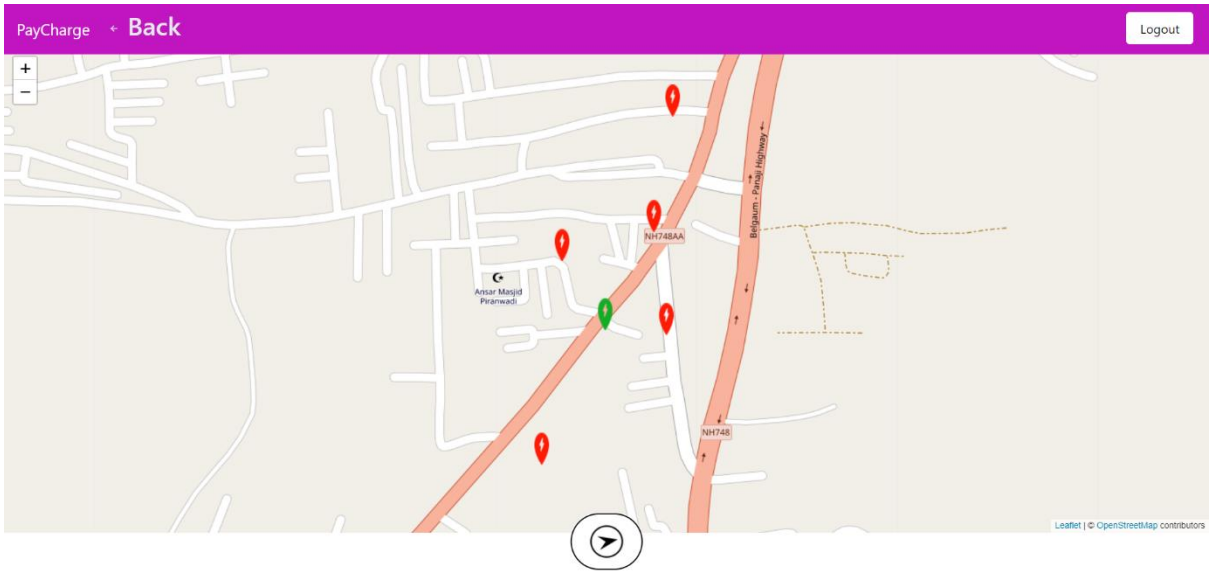

Fig 8.7:Demonstration of EV Engaged stations and available stations nearby to the user

The following snapshot represents the details related to charging station such as time & price of the selected plan.

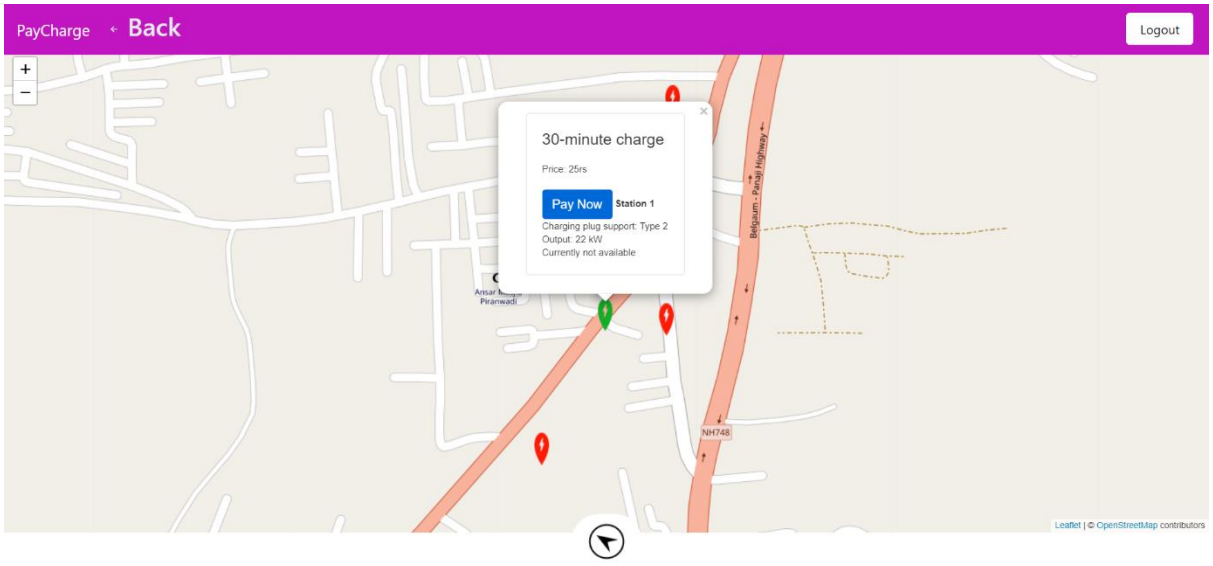

Fig 8.8:Display and Selection of plan to book a slot and make payment

The following snapshot represents the modes of payment options available for users.

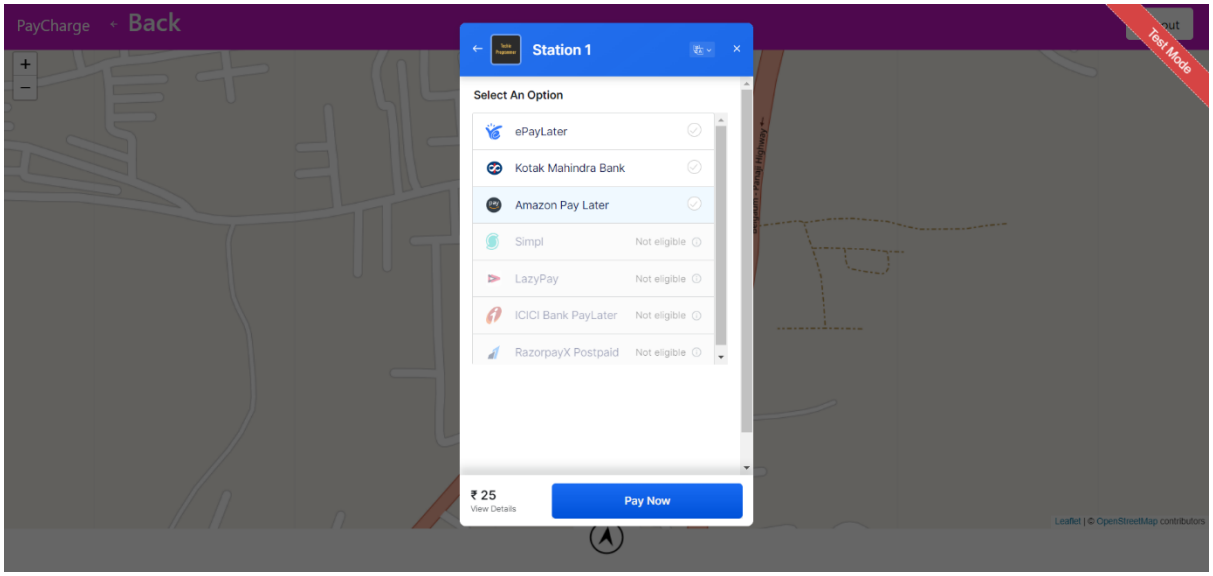

Fig 8.9: Payment options

The following snapshot represents the payment successful confirmation for the user.

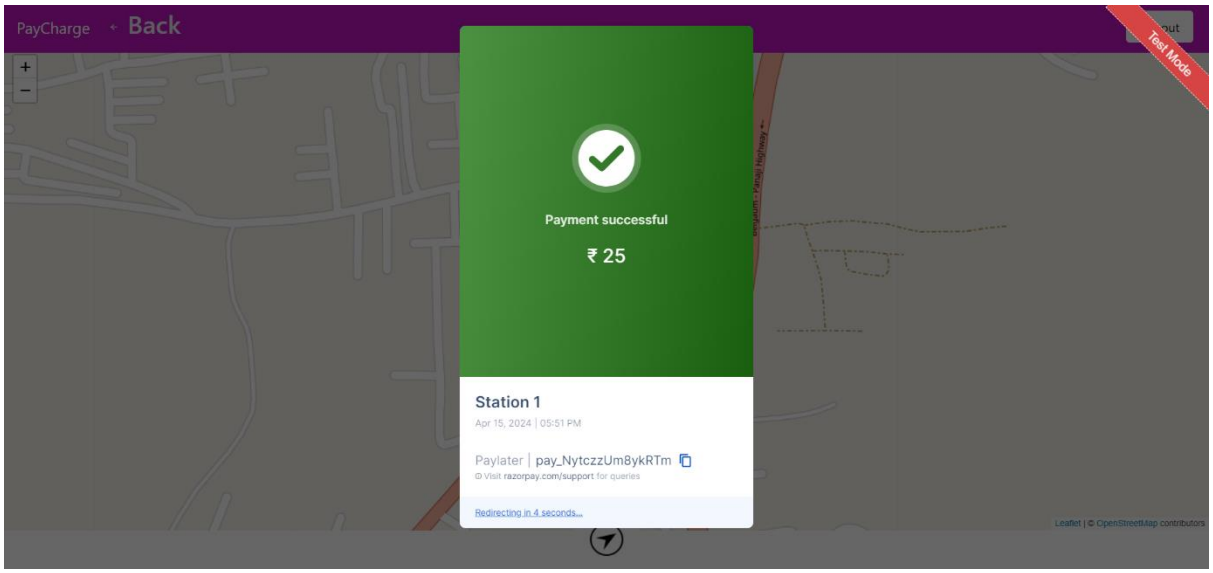

Fig 8.10: Payment Successful and confirmation

The following snapshot represents the booking confirmation of the EV station.

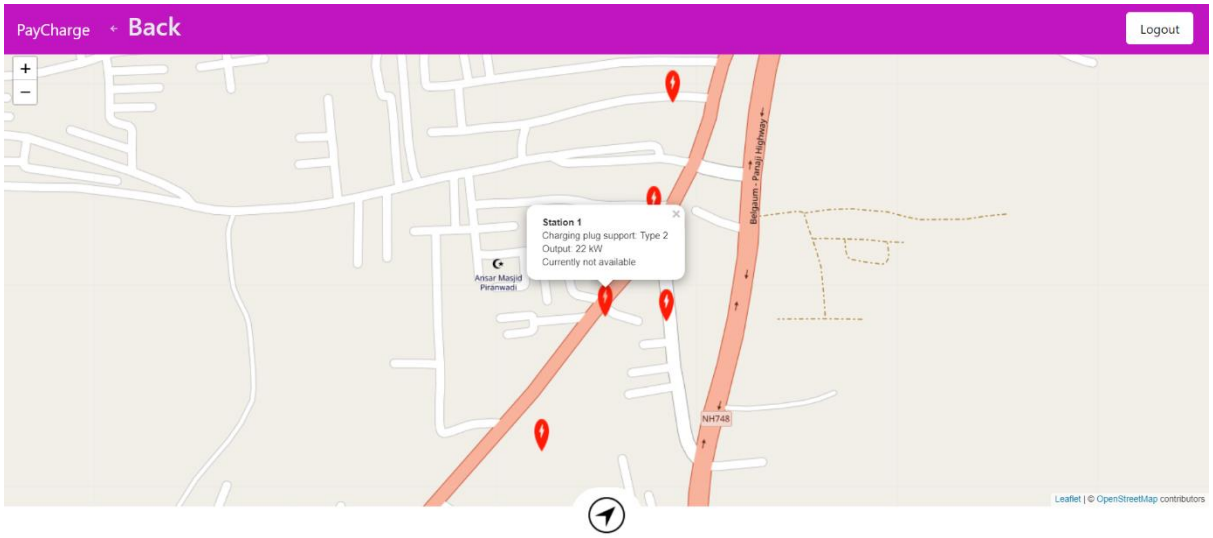

Fig 8.11: Display of Booked slot for EV station

CONCLUSION

In conclusion, the "Smart Charging and CNG Booking System for Sustainable Transportation" advances eco-friendly mobility by integrating user-friendly web applications with a demonstrative hardware prototype. This comprehensive platform facilitates the transition to sustainable transportation by allowing seamless registration, login, and navigation between EV and CNG options. Features like locating nearby stations, selecting plans, making payments, and real-time progress updates ensure a smooth user experience. The map route feature optimizes travel routes, promoting efficient resource use. Progress tracking and completion alerts enhance transparency and reliability, fostering user trust. The hardware prototype for EV charging demonstrates practical application, educating and inspiring individuals towards sustainable transportation. As environmental awareness grows, such initiatives are crucial for driving positive change towards a greener transportation future.

FUTURE SCOPE

Electric vehicles are the future not only of transport but of our planet. These vehicles are plugged into a charging station at a minimal voltage; therefore, no emissions are released which are harmful to our environment. Electric vehicles are contributing a lot in reducing the carbon footprints and will also lower the oil imports to the country, where in increasing the Gross domestic product (GDP) of our country. This is however only the first step in a potential journey which will see charge banks and other industrial areas as well as homes and cities. India has the largest market of EV in the world. With the development of infrastructure, technology and power source there will be a complete shift towards EVs in the coming years. As the number of EVs in the future will be maximum, efficiency in the charging of the vehicles is a challenge. Our prototype is one of the best solutions in the betterment of electric vehicles charging. We know that such vehicles can provide us great flexibility and we will soon see the potential. The future scope of electric vehicles is therefore massive.

REFERENCES

[1] Smart Electric Vehicle Charging System: João C. Ferreira, Vítor Monteiro, João L. Afonso, Alberto Silva Member, IEEE (2021)

[2] An in-depth analysis of electric vehicle charging station infrastructure: Muhammad Shahid Mastoi a , Shenxian Zhuang a , Hafiz Mudassir Munir b , Malik Haris c , Mannan Hassan a , Muhammad Usman a , Syed Sabir Hussain Bukhari b , Jong-Suk Ro (2022)

[3] ELECTRIC VEHICLE CHARGING STATION: 1Avinash V. Shrivastav, 1Sajidhussain S. Khan, 1Rahul K. Gupta, 1Prajkta R. Ekshinge, 2 Parmeshwar Suryawanshi (2020)

[4] Review Paper on Charging of Electrical Vehicle: Aishwarya Gajanan Billea , Yashashri Rajaram Patila , Vikram B Patil b (2021)

[5] Electric Vehicles Charging Technology Review and Optimal Size Estimation:V Morris Brenna1 · Federica Foiadelli1 · Carola Leone1 · Michela Longo (2020)

[6] Online Booking System for CNG Pump: by Vaishnavi Shinde, Saloni Pawar,Purva Patel, Sakshi Ghorpade, Nilesh Wankhede, International Journal for Scientific Research & Development| Vol. 11, Issue 3, 2023.