VIVEKANAND EDUCATION SOCIETY'S
INSTITUTE OF TECHNOLOGY

Department of Computer Engineering

Project Report
on

EVolve Chargemates: Decentralising EV Station Networks

In partial fulfillment of the Fourth Year (Semester–VII), Bachelor of Engineering (B.E.) Degree in Computer Engineering at the University of Mumbai Academic Year 2024-2025

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CERTIFICATE of Approval

This is to certify that ***Vedant Tawade D17C/65, Soham Tawade D17C/64, Nikhil Singh D17C/60, Vedant Pawar D17C/52*** of Fourth Year Computer Engineering studying under the University of Mumbai has satisfactorily presented the project on "***EVolve Chargemates: Decentralizing EV Stations***" as a part of the coursework of PROJECT-I for Semester-VII under the guidance of ***Mrs. Lifna CS*** in the year 2024-2025.

Date

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We wish to express our profound thanks to all those who helped us in gathering information about the project. Our families too have provided moral support and encouragement several times.

Computer Engineering Department

COURSE OUTCOMES FOR B.E PROJECT

Learners will be to:-

Course Outcome	Description of the Course Outcome
CO 1	Do literature survey/industrial visit and identify the problem of the selected project topic.
CO2	Apply basic engineering fundamental in the domain of practical applications FORproblem identification, formulation and solution
CO 3	Attempt & Design a problem solution in a right approach to complex problems
CO 4	Cultivate the habit of working in a team
CO 5	Correlate the theoretical and experimental/simulations results and draw the proper inferences
CO 6	Demonstrate the knowledge, skills and attitudes of a professional engineer & Prepare report as per the standard guidelines.

Abstract of our Project

The increasing adoption of electric vehicles (EVs) requires the development of more accessible and efficient charging infrastructures. The "EVolve Chargemates" app leverages modern technology to create a decentralized EV charging network by allowing homeowners to register their residences as EV charging stations. This app integrates real-time data, smart filters, and navigation to connect EV owners with the nearest available charging station. By utilizing advanced routing algorithms and location-based services, EVolve Chargemates helps optimize the search for charging points and streamlines the entire charging process. The app also empowers homeowners, especially those with solar panels, to monetize their excess energy by becoming EV stations without the need for additional infrastructure. Through this innovative approach, EVolve Chargemates not only addresses the shortage of public EV charging infrastructure but also encourages community participation in sustainable transport solutions. This project sets a new standard in the EV charging landscape, fostering a collaborative and eco-friendly future for urban and residential mobility.

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Chapter 1: Introduction

1.1 Introduction

The rapid growth of electric vehicle (EV) adoption and increasing strain on conventional charging infrastructure pose significant challenges for urban mobility and sustainability. Traditional EV charging networks often face issues such as limited charging stations, long wait times, and inefficient resource management, especially in densely populated areas. This scarcity of charging points can hinder the wider adoption of EVs, slowing down the transition to eco-friendly transportation.

To address these challenges, *EVolve Chargemates* offers a community-driven solution that empowers homeowners to register their properties as EV charging stations. By creating a decentralized network, the app integrates real-time data, smart filters, and navigation features to help EV owners locate and connect with the nearest available charging station. The app also allows homeowners, especially those with solar panels, to monetize their excess energy without requiring additional infrastructure. *EVolve Chargemates* revolutionizes the EV charging landscape by enabling smarter resource allocation, reducing wait times, and fostering a collaborative approach to sustainable transportation.

1.2 Motivation

The rising demand for electric vehicles (EVs), driven by environmental concerns and government incentives, has exposed the limitations of existing EV charging infrastructure. With a growing number of EVs on the road, urban areas are struggling to provide sufficient charging points, leading to long wait times and limited access, especially in residential areas. This shortage hampers the widespread adoption of EVs, which is critical for reducing carbon emissions and promoting sustainable transport.

The motivation behind *EVolve Chargemates* is to address these infrastructure challenges by empowering homeowners to contribute to the EV charging network. By enabling homeowners to register their properties as charging stations, the app aims to decentralize the charging system, reducing pressure on existing infrastructure. This approach not only accelerates the adoption of EVs but also offers homeowners, especially those with solar panels, an opportunity to monetize their resources withou+t requiring additional investments. The drive to support a sustainable, collaborative, and efficient charging solution forms the core motivation for this project.

1.3 Problem Statement and Objectives

The current EV charging infrastructure in urban areas is under strain due to the rising number of electric vehicles (EVs), leading to limited access to charging stations, long wait times, and inefficiencies in resource allocation. These challenges are particularly acute in residential areas, where charging options are scarce, limiting the convenience and widespread adoption of EVs. Additionally, the absence of decentralized and easily accessible charging solutions hinders the growth of a sustainable EV ecosystem.

The growing demand for EVs, coupled with the urgent need to reduce carbon emissions, highlights the critical need for a more robust and scalable charging network. The objective of EVolve Chargemates is to create a decentralized platform where homeowners can register their EV charging points, offering a solution to the infrastructure gap. By incorporating real-time data, smart filters, and station management capabilities, the app aims to streamline the charging process for EV owners while empowering homeowners to become part of the charging ecosystem. This approach not only supports the transition to electric mobility but also fosters community-driven solutions to sustainability challenges.

1.4 Relevance of the Project

The EVolve Chargemates app addresses the increasing demand for electric vehicle (EV) infrastructure, driven by the rapid growth of EV adoption and the transition toward sustainable urban transportation. Traditional EV charging networks are limited, often concentrated in specific areas, leaving many regions underserved. This lack of infrastructure leads to "range anxiety" among EV users, limiting the widespread adoption of electric vehicles.

EVolve Chargemates solves this issue by creating a decentralized network of EV charging stations. By empowering homeowners to register their homes as charging points and providing EV owners with real-time access to these locations, the app significantly expands the availability of charging stations. Additionally, the app supports users with features such as location-based station search, smart filters, and journey planning, making EV ownership more convenient and accessible.

The relevance of this project lies in its potential to bolster the EV infrastructure, promote sustainability, and accelerate the shift to clean energy by enabling everyday homeowners to contribute to the charging network, without requiring extensive additional infrastructure. This creates an efficient, scalable solution to reduce pressure on existing transport networks and urban resources.

1.5 Methodology Used

1. **Requirement Analysis and System Design:**
    - **Requirement Gathering:** Identify user needs, including EV owners and station hosts, by understanding the charging infrastructure gaps.
    - **System Design:** Design the app architecture, focusing on user registration, station search, and route planning with user interaction flow.
2. **User and Station Registration:**
    - **User Authentication:** Implement secure user authentication for EV owners and station hosts using Firebase Auth.
    - **Station Registration:** Allow homeowners to register their homes as EV charging stations by integrating form inputs and map markers.
3. **Map Integration and Station Search:**
    - **Map API:** Integrate OpenStreetMap for displaying charging stations on the map.
    - **Search and Filters:** Enable real-time station search with user-defined filters (distance, availability, speed, and ratings).
4. **Real-Time Data Processing:**
    - **Station Availability:** Develop logic for hosts to update station availability in real-time.
    - **Navigation:** Incorporate map-based navigation to guide users to the selected charging station.
5. **Journey Planning and Route Optimization:**
    - **Route Planning:** Implement journey planning that suggests optimal charging stations along the user's route.
    - **Smart Filters:** Integrate smart filters for route-based station selection based on user preferences.
6. **Solar Energy Monetization:**
    - **Solar Integration:** Promote solar panel owners to register as EV stations and monetize excess energy.
7. **Sustainability and Scalability:**
    - **Sustainability Focus:** Emphasize environmental benefits and support for sustainable EV growth.
    - **Scalability:** Design the app for scalability, enabling expansion to new regions and user bases.

Chapter 2: Literature Survey

Performing a literature survey in a research paper is a fundamental step that serves multiple crucial purposes. Firstly, it provides context and background information, allowing readers to comprehend the problem's significance and what has previously been investigated in the field. By thoroughly reviewing existing literature, researchers can pinpoint gaps, inconsistencies, or areas where additional research is required, helping to define their research question and scope. This process also enables researchers to build upon the work of others, advancing the field and demonstrating that their research is a meaningful contribution to an ongoing scholarly conversation. Moreover, it aids in the avoidance of duplicating studies that have already been conducted, emphasizing originality.

2.1 Survey of Existing System

Sr. No	Name of the Paper /Article	Author	Year of Publication	Description
1.	Charging of Electric Vehicles	India Energy Storage Alliance	7th Sep 2022	Electric vehicle charging is divided into AC, using an onboard converter, and faster DC, supplying power directly to the battery, with speed influenced by charger power ratings, battery C-rates, and varying global standards and connectors.
2.	Charging infrastructure planning for electric vehicle in India: Present status and future challenges	Sulabh Sachan,Praveen Prakash Singh	29 November 2022	The lack of studies linking EV impacts on power systems, like network congestion and power distribution, leads to inaccurate emissions and cost estimates, affecting policy-making and planning, with varying state policies complicating a unified approach.
3.	A Review of Techniques for Optimal Placement and Sizing of	Md. Mainul ISLAM1 , Hussain SHAREEF2 , Azah	2020	This study reviews optimization techniques from the past decade to address the challenge of strategically placing and sizing EV

	Electric Vehicle Charging Stations	MOHAMED1		charging stations for efficient battery recharging within users' driving ranges.
4.	Research on the performance of dynamic routing algorithm	Ming-Xin Yang; Bing-Tong Wang; WQen-Dong Guo	25 August 2009	compares static and dynamic routing,Dijkstra's being best for single-source paths and Floyd's ideal for all-pairs shortest paths in networks.
5.	A Comparative Study of Vehicles' Routing Algorithms for Route Planning in Smart Cities.	Soufiene Djahel, John Murphy, Vi Tran Ngoc Nha	Nov 2012	explores vehicle routing problems, comparing route planning algorithms like Dijkstra's in real-time traffic simulations to optimize road navigation.

table 1. Literature Survey

2.2 Existing system

Current electric vehicle (EV) charging station systems, such as PlugShare, EZ Charge, and Ather Grid, have made strides in facilitating EV adoption and providing essential charging infrastructure. However, these platforms face several limitations that hinder their effectiveness in offering a seamless user experience and optimal charging solutions.

PlugShare:
PlugShare is a widely recognized platform that enables EV drivers to locate charging stations through its interactive map. While it offers a comprehensive database of charging locations and user-generated reviews, its reliance on user inputs for station availability can lead to inconsistencies. Furthermore, PlugShare lacks real-time updates and often provides limited information regarding the operational status of charging stations, resulting in potential frustration for users who find stations unavailable upon arrival.

EZ Charge:

EZ Charge aims to simplify the charging process by providing a network of charging stations with a focus on user-friendly payment options. However, its effectiveness is often hampered by inadequate coverage in certain regions, limiting access for EV drivers in less populated areas. Additionally, EZ Charge’s integration with other navigation systems is not seamless, which can complicate the planning of charging stops during longer trips.

Ather Grid:
Ather Grid is known for its focus on fast-charging solutions in urban areas, catering primarily to Ather electric scooters. While it offers a network of fast-charging stations with advanced features like mobile app integration, its geographical limitations restrict its utility for a broader range of EV users. The platform also faces challenges in expanding its network to accommodate a wider variety of EV models, leading to concerns about compatibility and accessibility.

2.3 Lacuna in Existing System

Application	USP	Success	Failures
PlugShare	1)Extensive network. 2)User-generated reviews 3)Real-time updates.	1)Community-driven insights. 2)Free to use.	1)Inconsistencies in real-time updates. 2)Unorganized data.
TATA POWER EZ CHARGE EZ Charge	1)Integration with Tata Power's extensive charging infrastructure.	1) Reliable Network. 2)Integration with Tata's ecosystem. 3)Secure and Multiple payment options.	1) Only focused on Tata's stations , other stations not visible.
Ather Grid	1)Dedicated for Ather Energy scooters but usable by others.	1) Reliable for Ather users.	1)Only limited to urban areas. 2) Unreliable Payment options.

table 2. Lacuna in Existing System

Despite advancements in EV charging infrastructure and management systems, significant gaps persist that hinder their overall effectiveness and scalability. These deficiencies underscore the necessity for a more integrated and comprehensive approach, such as EVolve Chargemates. Key gaps in current EV charging solutions include:

Limited Access to Charging Infrastructure:
Many existing solutions predominantly focus on commercial charging stations, leaving gaps in residential areas. Homeowners who wish to offer their charging facilities face barriers in accessing platforms to register their stations, limiting the available charging options for EV owners. This results in inadequate coverage, particularly in neighborhoods where EV adoption is growing but charging infrastructure remains scarce.

Inefficient Resource Allocation:
Current applications for locating charging stations often lack real-time data on station availability, leading to inefficient routing for users. As seen with applications like ChargePoint, users frequently encounter charging stations that are either occupied or out of service, which can prolong charging times and deter potential EV owners.

Inconsistent User Experience:
Most existing systems do not provide comprehensive user feedback mechanisms, making it challenging for users to evaluate charging stations before arriving. While apps like PlugShare allow users to leave reviews, they often do not enable a holistic view of the user experience, such as pricing, accessibility, and average wait times, which are crucial for informed decision-making.

Lack of Integration of Home Charging Solutions:
Many platforms do not integrate home charging options into their maps, neglecting the potential for homeowners to participate in the EV ecosystem by offering their charging stations. This oversight limits the development of a decentralized network that could effectively meet local demand.

Scalability Across Regions:
Existing solutions typically struggle to adapt to varying regional needs and regulatory frameworks. Systems designed for urban areas may not adequately address the requirements of rural communities or regions with different energy policies, resulting in uneven access to charging infrastructure.

These limitations highlight the urgent need for a comprehensive, user-friendly, and real-time EV charging management system like EVolve Chargemates. By integrating homeowner-registered charging stations and providing real-time availability, the system aims to enhance the overall EV charging experience, ensuring efficient resource utilization and improved access for all EV owners.

2.4 Comparison of existing systems and proposed area of work

While current EV charging station systems, such as PlugShare, EZ Charge, and Ather Grid, have made notable contributions to enhancing EV infrastructure, they still exhibit significant limitations. The **EVolve Chargemates** app proposes to address these challenges by providing a more comprehensive and user-friendly solution. Below is a detailed comparison between existing systems and the proposed work:

Data Integration:

- **Existing Systems**: Platforms like PlugShare and EZ Charge primarily rely on user-generated data and limited charging network information. This can lead to gaps in situational awareness, particularly when stations are offline or unavailable.
- **Proposed System**: **EVolve Chargemates** integrates a diverse range of data sources, including real-time charging station statuses, IoT sensor data, user feedback, and crowdsourced reports. This multi-source approach ensures comprehensive visibility and accurate information for EV drivers.

Real-Time Predictive Capabilities:

- **Existing Systems**: While systems like Ather Grid provide location information for fast chargers, they often struggle with real-time updates regarding station availability, leading to potential delays in finding functional charging points.
- **Proposed System**: **EVolve Chargemates** emphasizes real-time data collection and predictive analytics to provide users with live updates on station availability and charging times, ensuring efficient route planning and minimizing downtime.

Handling of Noisy Data:

- **Existing Systems**: Current platforms may face challenges related to data accuracy due to user-reported information, which can be inconsistent or outdated, especially in busy urban environments.
- **Proposed System**: **EVolve Chargemates** employs advanced algorithms and noise-reduction techniques to validate user inputs and automatically update station information, improving accuracy and reliability in both urban and rural settings.

Scalability:

- **Existing Systems**: Existing solutions like EZ Charge may be limited in geographic reach and often cater to specific EV models, restricting their applicability to a wider audience.
- **Proposed System**: **EVolve Chargemates** is designed to be scalable across various regions and adaptable to multiple EV models, ensuring broad accessibility and support for a diverse range of users.

Coordination and Communication:

- **Existing Systems**: While some platforms like PlugShare offer user interaction features, they often lack integrated communication tools that facilitate coordination among EV drivers, station operators, and local authorities.
- **Proposed System**: **EVolve Chargemates** incorporates a robust communication platform that allows seamless interaction between EV owners, charging station operators, and community stakeholders. This feature enables efficient information sharing and fosters a supportive EV ecosystem.

In conclusion, **EVolve Chargemates** offers a more integrated, real-time, and user-friendly approach to managing EV charging infrastructure compared to existing systems like PlugShare, EZ Charge, and Ather Grid. By addressing key challenges such as data integration, real-time updates, and scalability, **EVolve Chargemates** significantly enhances the overall EV charging experience, promoting greater adoption of electric vehicles and contributing to a sustainable future.

2.5 Focus Area

The primary focus of **EVolve Chargemates** is to utilize advanced technology to enhance the accessibility and efficiency of electric vehicle (EV) charging solutions. The system aims to integrate real-time data from various sources, including user-generated inputs, charging station availability, and geographical information, to provide timely and accurate information to EV owners seeking charging options.

By employing intelligent algorithms, the platform focuses on optimizing charging station locations and availability, allowing users to quickly identify the nearest and most suitable charging stations based on their current location and route.

A significant area of focus is enhancing user experience through intuitive design and streamlined navigation, which ensures that users can easily find charging stations that meet their needs. Additionally, **EVolve Chargemates** aims to foster communication and coordination among EV owners and station operators, facilitating a more connected and efficient ecosystem.

This project also emphasizes scalability and adaptability, ensuring that the platform can cater to a growing number of users and charging stations while maintaining high performance and reliability across various geographic regions. This approach addresses existing gaps in EV charging solutions and enhances the overall EV experience.

Chapter 3: Requirements of Proposed System

The proposed system, **EVolve Chargemates**, necessitates a comprehensive set of technical and functional requirements to ensure its successful development and deployment. These requirements are driven by the system's goal to provide real-time access to electric vehicle (EV) charging stations, enhance user experience, and facilitate efficient resource management.

This chapter outlines the detailed functional, non-functional, hardware, and software requirements essential for the successful execution of the **EVolve Chargemates** system. These requirements ensure that all necessary components are in place to achieve the desired outcomes in EV charging accessibility and user engagement.

3.1 Functional Requirements

1. **Data Collection and Integration**:
   The system must continuously gather and integrate data from multiple sources, including:
   - **Charging Station Data**: Real-time availability and status of EV charging stations.
   - **User Data**: Information from EV owners and station owners, including preferences and usage patterns.
   - **Location Data**: Geographic data to facilitate navigation and find nearby charging stations.
2. **Data Pre-Processing**:
   The system must pre-process incoming data by:
   - Cleaning and normalizing data to ensure compatibility with the application.
   - Removing irrelevant or noisy data and handling missing values.
   - Normalizing formats for consistent data representation.
3. **AI-based Charging Station Detection and Prediction**:
   The system must use AI models to analyze pre-processed data to:
   - Detects available charging stations based on user queries.
   - Predict optimal charging station locations based on user trends and historical data.
4. **Real-Time Response Generation**:
   The system must generate real-time responses based on user requests, including:
   - Alerts for nearby charging station availability.
   - Recommendations for charging routes and nearby amenities.
5. **Evaluation and Feedback Mechanism**:
   The system must include an evaluation module to assess the accuracy and effectiveness of the responses, providing:
   - Feedback based on user interactions.
   - Continuous improvement through updates and training with new user data.

3.3.Non-Functional Requirements

1. **Performance and Scalability**:
   The system must efficiently handle large-scale data processing, ensuring:
   - Seamless scalability to accommodate increased data input during peak usage times.
   - Minimal performance degradation, especially during high-demand periods.
2. **Reliability and Availability**:
   The system must be highly reliable and available 24/7 to:
   - Ensure continuous monitoring of charging station statuses and user requests.
   - Include fault tolerance and automatic recovery mechanisms to avoid downtime.
3. **Security and Data Privacy**:
   The system must ensure the security of sensitive user data, including:
   - Implementation of encryption and secure access controls.
   - Compliance with relevant data privacy regulations (e.g., GDPR, CCPA) to protect user information.
4. **Usability and Accessibility**:
   The system must be user-friendly and accessible to all users, including:
   - Intuitive interfaces for easy navigation and interaction.
   - Real-time access to critical information, alerts, and recommendations.
5. **Accuracy and Precision**:
   The AI models used in the system must provide high accuracy in:
   - Detecting charging station availability and user needs.
   - Minimizing false positives and negatives to ensure precise and reliable responses.

3.4.Hardware & Software Requirements

Hardware Requirements:

Minimum Requirements:

- **Operating System**:
  - Android: Version 8.0 (Oreo) or higher
  - iOS: Version 12.0 or higher
- **Processor**: Quad-core processor (e.g., Snapdragon 450 or equivalent)
- **RAM**: Minimum 4 GB
- **Storage**: Minimum 64 GB of internal storage
- **Display**: 5.5 inches or larger, HD (1280 x 720) resolution
- **Network**: 4G LTE support for reliable connectivity
- **Battery**: Minimum 3000 mAh for adequate usage time

Recommended Requirements:

- **Operating System**:
    - Android: Version 11.0 (R) or higher
    - iOS: Version 14.0 or higher
- **Processor**: Octa-core processor (e.g., Snapdragon 660 or equivalent)
- **RAM**: 4 GB or higher
- **Storage**: 150 MB of storage
- **Display**: 6.0 inches or larger, Full HD (1920 x 1080) resolution
- **Network**: 5G support for faster data access and real-time features
- **Battery**: Minimum 4000 mAh with fast charging capability

Software Requirements:

Here's a detailed system requirements section tailored for your EVolve Chargemates mobile app, incorporating the specified tech stack:

Development Environment:

- **Flutter SDK** (version 3.7.0 or higher): Core framework for building cross-platform mobile applications.
- **Dart SDK** (version 2.19.0 or higher): Programming language used for Flutter development.
- **Firebase**: Backend as a Service (BaaS) for real-time database, user authentication, cloud storage, and hosting.
    - Firebase Authentication: For managing user accounts and login sessions.
    - Cloud Firestore: For storing user data and app state.
    - Firebase Cloud Messaging: For push notifications and real-time alerts.

Data Collection and Integration:

- **OpenStreetMap API**: For accessing mapping data and integrating location-based services within the app.
- **HTTP Library**: For making network requests and handling API calls (e.g., Dio or http package in Flutter).

Testing and Debugging Tools:

- **Flutter DevTools**: For debugging and performance profiling.
- **Firebase Test Lab**: For testing the app across a variety of devices and configurations.

Development Tools:

- **IDE**: Visual Studio Code or Android Studio with Flutter and Dart plugins installed for a better development experience.

This comprehensive overview covers the essential hardware and software requirements necessary for developing, deploying, and running the EVolve Chargemates mobile application effectively.

3.5.Technology and Tools utilized

1. **OpenStreetMap API**: We utilize the OpenStreetMap API for accessing detailed mapping and geolocation data. This allows us to display nearby EV charging stations on the app, enabling users to find available charging points based on their current location and preferences.
2. **Flutter**: Flutter serves as the core framework for building the EVolve Chargemates app. It enables us to create a seamless cross-platform application that operates efficiently on both Android and iOS devices. With Flutter, we can design a user-friendly and visually appealing interface that enhances the user experience during navigation and interaction with charging stations.
3. **Firebase**: Firebase provides the backend infrastructure for the EVolve Chargemates app. We leverage its services for user authentication, real-time database functionality, and cloud storage. For instance, when users register their households as EV charging stations, their data is securely stored in Firebase, allowing for quick access and updates to charging availability.
4. **Google Maps API**: We integrate the Google Maps API to enhance location-based features within the app. This allows users to visualize charging stations on an interactive map, view navigation routes, and receive directions to their selected charging points.
5. **Dart**: Dart is the programming language used with Flutter, allowing us to develop efficient, high-performance applications. Its asynchronous programming capabilities help manage tasks like network requests and real-time data updates effectively.
6. **Cloud Functions**: We implement Firebase Cloud Functions to handle server-side logic, such as processing user requests, sending notifications, and managing data updates in real-time. This serverless architecture enables us to scale our app efficiently as user demand grows.
7. **RESTful API**: We utilize a RESTful API to facilitate communication between the mobile app and the backend services. This approach allows for efficient data exchange, enabling features such as searching for nearby charging stations and retrieving user-related information.
8. **Analytics Tools**: We incorporate analytics tools (like Firebase Analytics) to monitor user interactions within the app. This data helps us understand user behavior, optimize features, and enhance the overall user experience.
9. **Testing Frameworks**: We use testing frameworks, such as Flutter's built-in testing tools, to ensure the app is bug-free and performs well across different devices and operating systems. This includes unit testing, widget testing, and integration testing to maintain high-quality standards.

This tech stack enables the EVolve Chargemates app to deliver a robust and user-friendly experience for both EV station owners and users looking for charging solutions.

3.6.Constraints of working

1. **Data Availability and Quality**:

- The availability of real-time data from EV charging stations and user submissions may fluctuate, potentially affecting the app's ability to provide accurate information on station availability.
- Low-quality or inconsistent data submitted by users can impact the app's performance and reliability, leading to potential user dissatisfaction.

2. **Computational Resources**:
    - Although Flutter allows for efficient app performance, certain features (like real-time location tracking and data processing) may require significant computational resources, which could limit functionality on older mobile devices.
    - High demand during peak hours (e.g., when many users are searching for charging stations) may lead to performance degradation if the backend infrastructure is not adequately provisioned.
3. **Scalability**:
    - As the user base grows, the system must scale to handle increased data volume, especially with more EV station registrations and user interactions. This scalability may necessitate additional cloud infrastructure or services, complicating deployment and increasing costs.
    - Ensuring a seamless user experience during times of high demand, such as major events or holidays, will require careful planning and resource allocation.
4. **Real-time Processing**:
    - Achieving real-time data processing for features like dynamic mapping and user notifications can be challenging, particularly during peak usage when multiple users are accessing the app simultaneously.
    - Delays in data updates from the backend (such as availability changes in charging stations) may hinder the app's ability to provide timely and accurate information to users, potentially affecting their experience and trust in the service.

These constraints highlight the challenges associated with developing and maintaining the **EVolve Chargemates** app, emphasizing the need for robust design and efficient resource management to deliver a reliable user experience.

Chapter 4: Proposed Design

4.1 Block diagram representation of the proposed system

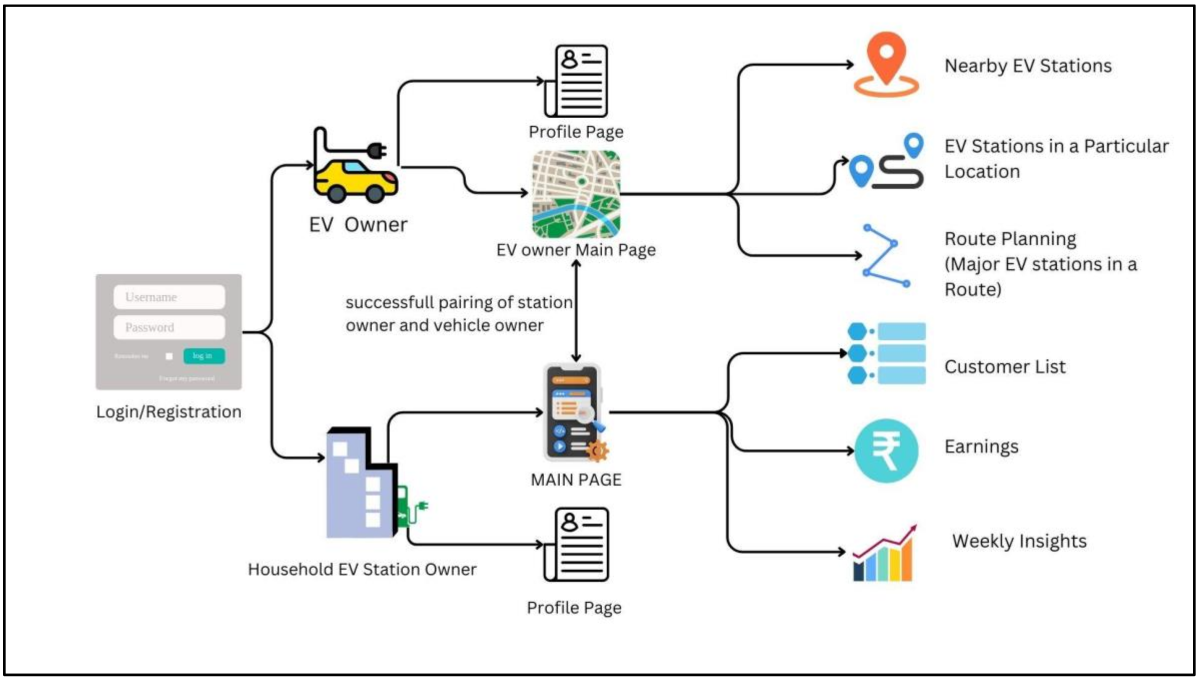

Fig 1: Block Diagram

Input Parameters:

1. **User Registration Data**: Users submit personal information, vehicle details, and charging preferences, enabling personalized services and notifications.
2. **Location Data**: GPS data from users' devices is utilized to identify nearby charging stations and provide navigation support.
3. **Charging Station Availability**: Station owners input real-time availability data, including the number of chargers in use, maintenance status, and operational hours.

Preprocessing:

- Incoming data is standardized and cleaned to ensure uniformity. This includes filtering out outdated or incorrect station information and aligning user preferences with available charging stations.

Station Search and Filtering:

- Users can search for nearby charging stations based on various criteria (e.g., availability, charger type, and distance). This functionality includes implementing filters to refine search results according to user preferences.

User Interface:

- The app provides an intuitive interface that displays nearby charging stations on a map, highlighting their availability, distance, and user ratings. Users can easily select a station for navigation or additional details.

Charging Station Selection:

- Users select a charging station based on their preferences and the displayed information. This step is crucial for ensuring that users can find the most suitable charging options for their needs.

Navigation and Route Planning:

- Once a station is selected, the app generates navigation directions using OpenStreetMap API, guiding users to the charging station. The route planning feature considers traffic conditions and the best possible path.

Real-Time Updates:

- The system provides real-time updates on charging station availability, user notifications for nearby stations, and alerts for any changes in operational status. This ensures that users receive accurate and timely information during their charging journey.

Feedback Mechanism:

- Users can provide feedback on their charging experience, which is collected and analyzed to improve the service and user satisfaction. This feedback loop allows for continuous improvement of the app's functionality and user interface.

Data Analysis and Optimization:

- Collected data from users and charging stations is analyzed to optimize station recommendations and enhance resource allocation for station owners. Insights from this analysis support decision-making for future infrastructure developments.

4.2. Modular diagram representation of the proposed system

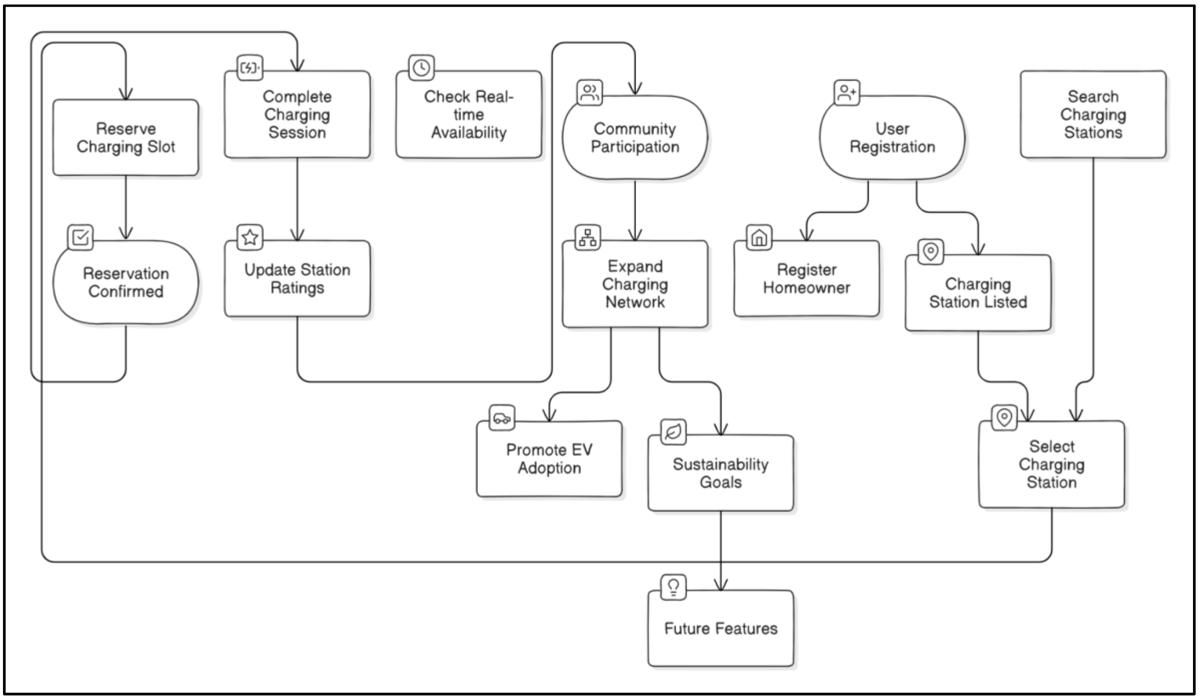

Fig 2: Modular Diagram

The modular diagram of **EVolve Chargemates** outlines a systematic approach to enhancing electric vehicle (EV) charging accessibility through community engagement and real-time data integration. The system begins with homeowners registering on the app to list their residences as EV charging stations, capturing essential data such as charger type, availability, and pricing. EV owners utilize the app's search functionality to find nearby charging stations based on various filters, ensuring quick access to suitable options. Real-time availability updates allow users to reserve slots at charging stations, managing the flow of EVs and reducing wait times. A user feedback and rating system fosters community-driven improvements, as feedback is collected and analyzed to maintain service quality and encourage high standards among station owners. Additionally, an analytics dashboard provides insights into user behavior and charging patterns, enabling the system to assess its effectiveness and refine features based on user needs. This modular flow ensures efficient data management, enhances user experience, and promotes timely access to charging infrastructure, contributing to the overall goal of sustainable transportation through electric vehicles.

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4.3 Design of the proposed system with proper explanation of each :

a. Data Flow Diagrams

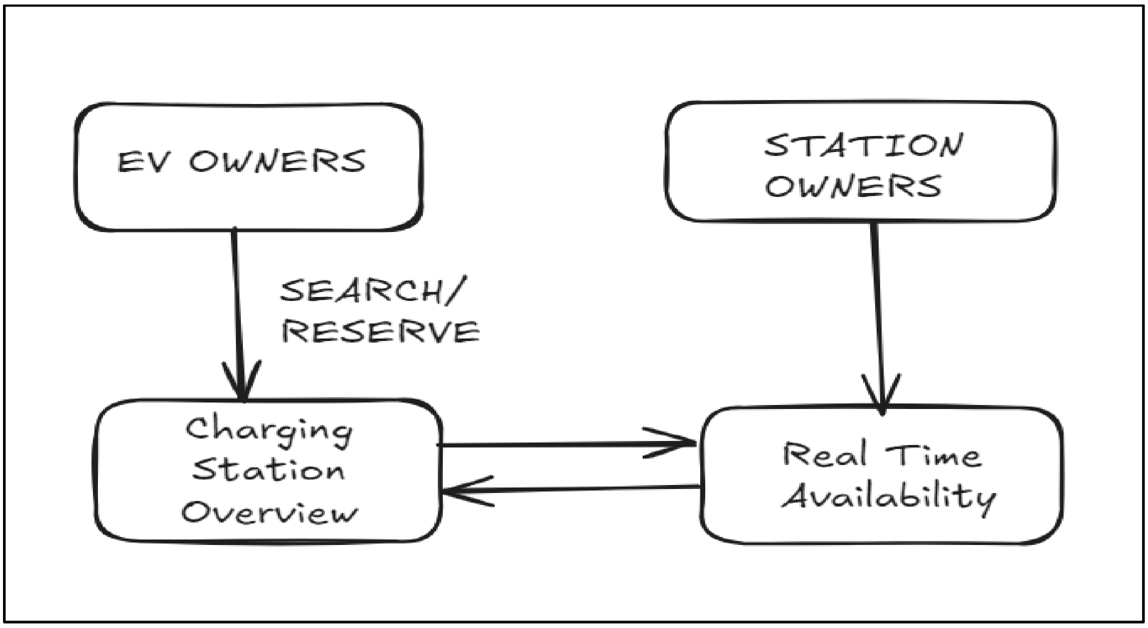


Fig 3. Level 0 - DFD Diagram

The **Level 0 Context Diagram** illustrates the overall interaction of the **EVolve Chargemates** electric vehicle charging platform with its external entities. The system receives inputs from **EV Owners**, who search for and reserve nearby charging stations, and from **Charging Station Providers**, who list their household or business charging stations, specifying details such as location, availability, charging speed, and pricing.

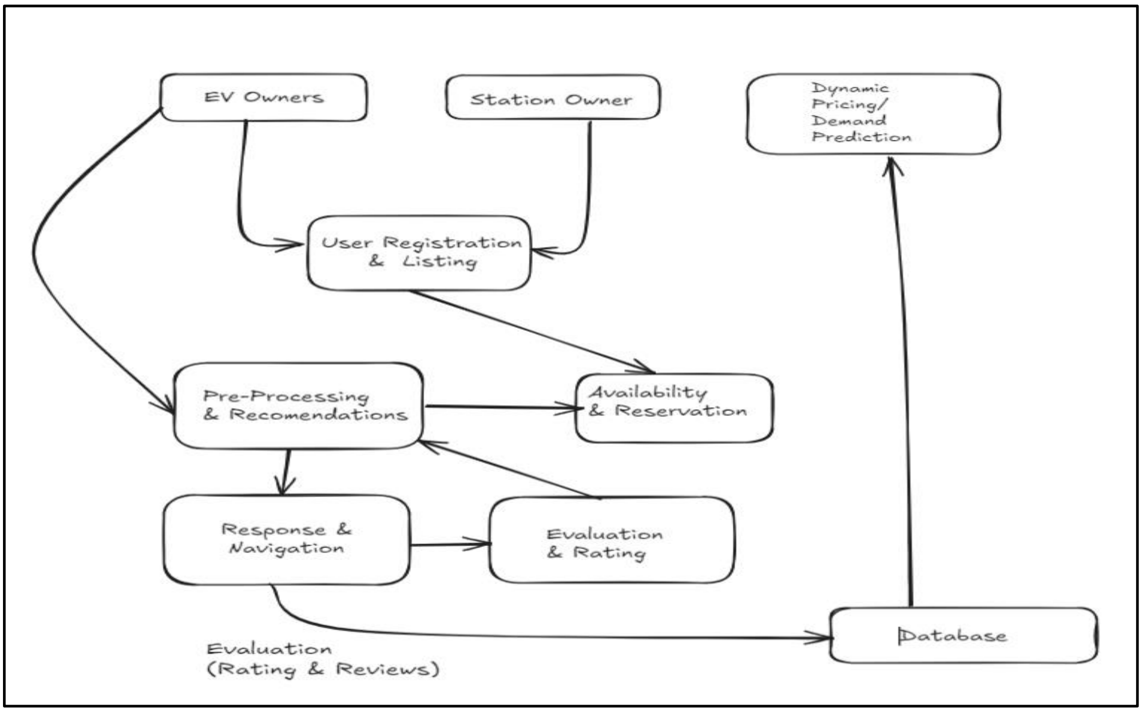
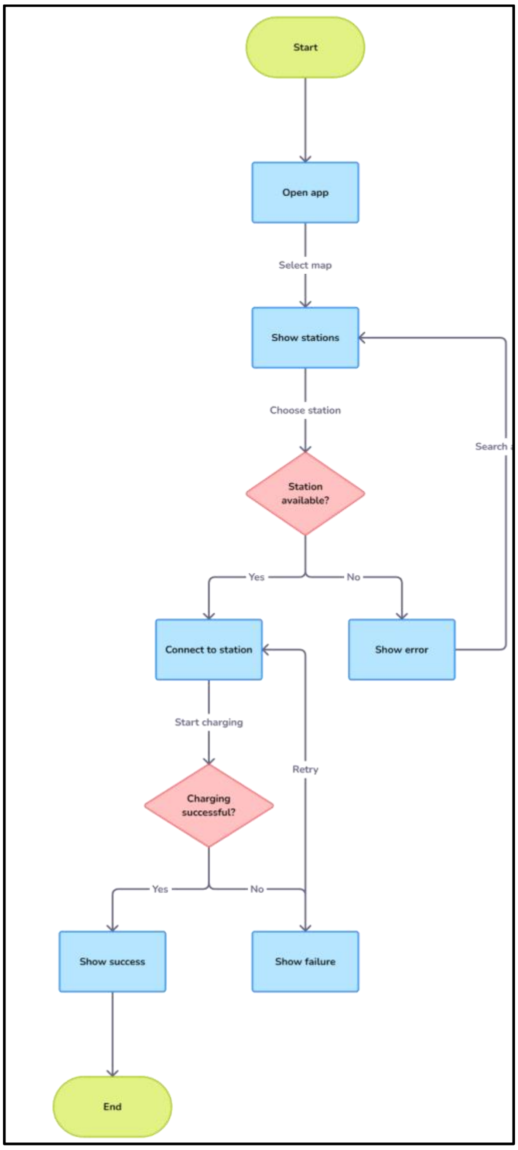


Fig 4. Level 1 - DFD Diagram

The **Level 1 Data Flow Diagram (DFD)** for the **EVolve Chargemates** app outlines the internal processes and data flow involved in connecting EV owners to available charging stations. The process begins with **EV Owners** searching for charging stations based on specific criteria such as distance, charging speed, and availability. These preferences are sent to the system's filtering and recommendation engine, which processes real-time data on charging station availability, user ratings, and pricing.

b. Activity Diagram



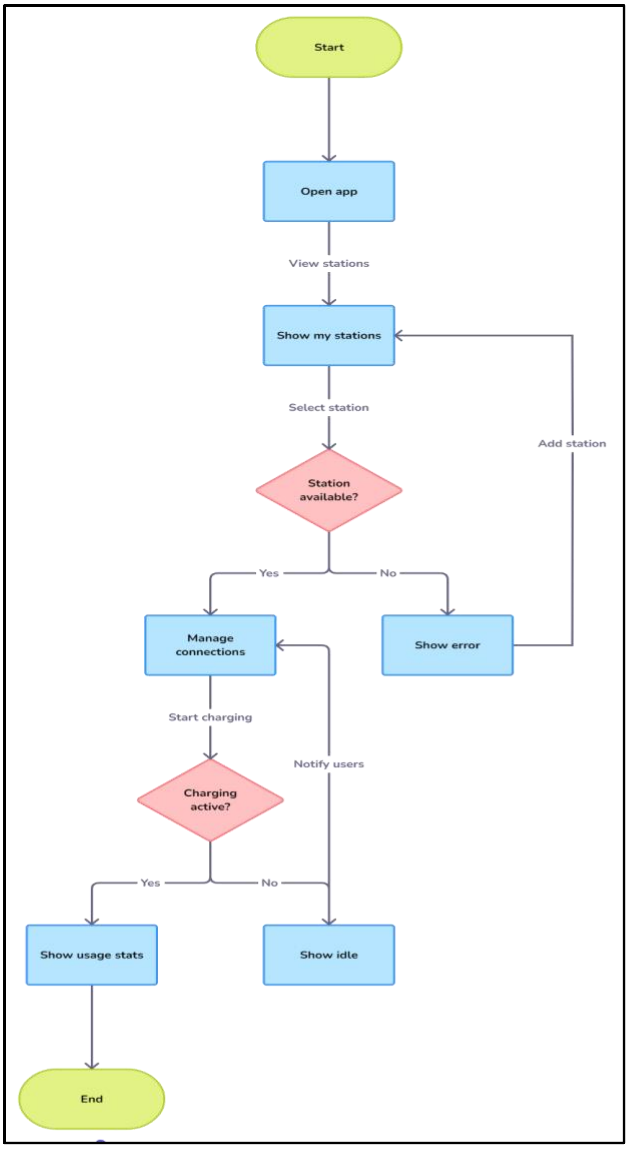
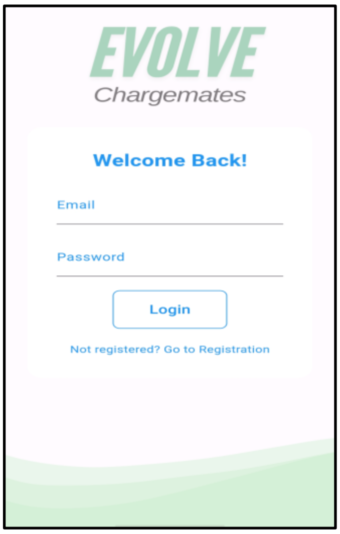


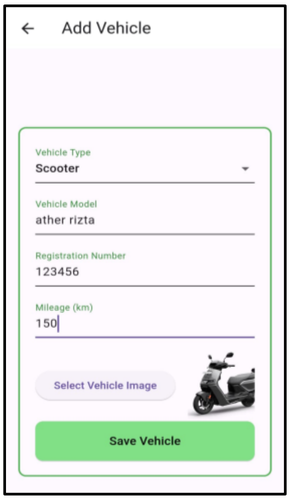
Fig 5. EV OWNER

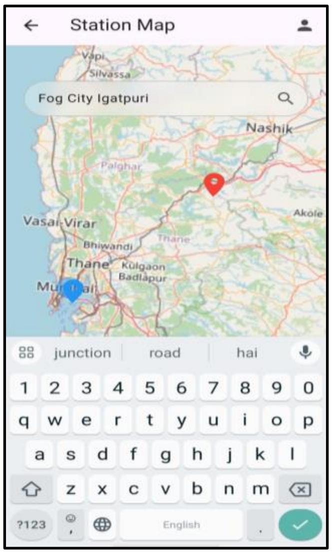
Fig 6. STATION OWNER

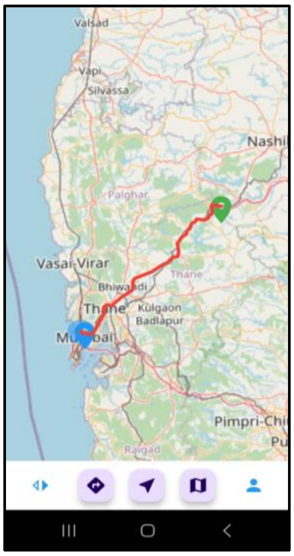
- The activity diagram depicts the high-level process of the EVolve Chargemates system. It begins with users registering on the app to list their homes as EV charging stations, which then flows into two main components: charging station listings management and user search functionality. Homeowners input details about their charging stations, such as charger type, availability, and pricing, while EV owners search for nearby charging stations using filters like distance and charging speed. Once both components are operational, the system checks the availability of charging stations. If a station is available, the user can reserve a slot, confirming their booking. If no stations are available, the system continues searching for options, creating a continuous feedback loop that ensures users receive timely updates on charging station availability.

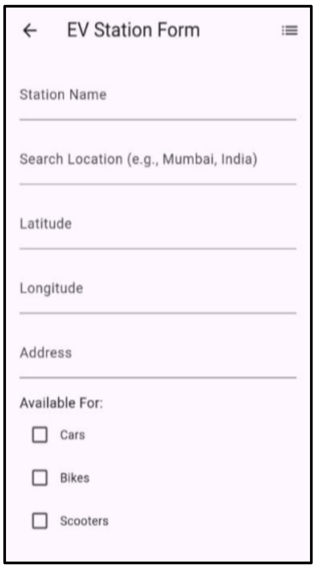
c. Screenshot of implementation

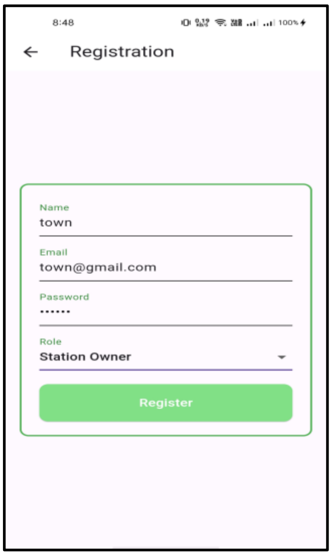


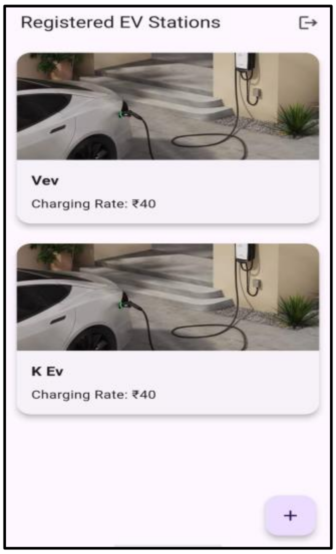












4.4 Algorithms utilized in the system

- **Dijkstra's Algorithm:** Dijkstra's algorithm is a graph search algorithm that finds the shortest path between nodes in a weighted graph. It works by maintaining a set of nodes whose shortest distance from the source is known and iteratively selecting the node with the smallest known distance to explore its neighbors. This algorithm is particularly useful for calculating the shortest route in a network of charging stations.
- *A Search Algorithm:** The A* search algorithm is an extension of Dijkstra's algorithm that uses heuristics to improve efficiency. It combines the actual cost to reach a node from the starting point with an estimated cost to reach the goal (the heuristic). This helps A* to prioritize paths that are likely to lead to the goal faster, making it ideal for real-time navigation and route optimization in applications like EVolve Chargemates.
- **Bellman-Ford Algorithm:** The Bellman-Ford algorithm is another shortest path algorithm that is capable of handling graphs with negative edge weights. It iteratively relaxes the edges of the graph to find the shortest paths from a single source to all other nodes. This algorithm is useful in scenarios where charging stations might have varying costs or availability based on specific conditions.
- **Floyd-Warshall Algorithm:** The Floyd-Warshall algorithm is a dynamic programming algorithm used to find the shortest paths between all pairs of nodes in a weighted graph. It iteratively updates the distances between every pair of nodes, making it particularly useful for dense graphs where many nodes are interconnected, such as a network of charging stations.
- **Geohashing:** Geohashing is a method of encoding geographic coordinates (latitude and longitude) into a short string of letters and digits. It helps in efficiently indexing and searching spatial data, enabling quick location-based queries in applications like EVolve Chargemates. Geohashing can simplify spatial queries by dividing the area into grid cells, facilitating the search for nearby charging stations.
- **K-Means Clustering:** K-means clustering is an unsupervised machine learning algorithm used to group a set of data points into clusters based on similarity. In the context of EVolve Chargemates, it can be used to analyze user behavior and charging

patterns, helping to identify high-demand areas for charging stations and optimize their placement.

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Chapter 5: Plan of action for the next semester

5.1. Work done till date

1. **Frontend Development Implementation**
   The implementation of the front-end interface has been successfully completed. The user interface is designed to facilitate seamless interaction with the app, allowing users to search for charging stations, make reservations, and view real-time availability. Emphasis has been placed on usability and accessibility to ensure that both EV owners and homeowners can easily navigate and utilize the app's features.
2. **Map Integration with OpenStreetMap**
   Integration with OpenStreetMap has been successfully achieved, enhancing the app's ability to display nearby charging stations accurately. This feature allows users to visualize their surroundings and locate available charging points efficiently. The integration supports dynamic updates, ensuring that the map reflects real-time changes in charging station availability and location.
3. **Feedback and Review System Development**
   A feedback and review system has been developed to allow users to rate their charging experiences and provide comments. This feature promotes accountability among charging station providers and helps maintain high standards within the network. Initial user feedback has been positive, indicating that the system encourages user engagement and fosters trust in the community.
4. **Dashboard Creation for Analytics**
   The development of a dashboard for analytics has been completed. This dashboard provides valuable insights into user behavior, charging station usage, and overall network performance. It enables homeowners and administrators to track key metrics, facilitating informed decisions regarding charging station management and improvements.
5. **Initial Testing and User Feedback**
   Preliminary testing of the app's features has been conducted, focusing on the functionality of the charging station search, reservation system, and feedback module. Early user feedback has been collected, indicating areas for improvement and potential enhancements. This feedback will guide future iterations of the app to better meet user needs.

The progress made so far has established a robust foundation for EVolve Chargemates, with a fully functional front end, effective map integration, user engagement features, and analytical dashboards. This sets the stage for further developments and refinements in the upcoming phases of the project.

5.2. Plan of action for project II

1. **Transition to Google Maps Integration**
   As part of our commitment to enhancing user experience, we plan to transition from OpenStreetMap to Google Maps integration. This switch will allow for more accurate location data, improved route planning, and access to advanced features such as real-time traffic updates. The integration will also provide users with a more familiar interface, ensuring seamless navigation to charging stations.
2. **Enhanced User Features and Personalization**
   Future updates will focus on adding personalized features for users, such as tailored charging recommendations based on individual driving habits and preferences. By utilizing machine learning algorithms, the app will be able to suggest optimal charging times and locations, improving the overall efficiency of the charging process.
3. **Dynamic Pricing and Availability Notifications**
   We aim to implement a dynamic pricing model that adjusts charging costs based on demand and time of day. Additionally, users will receive real-time notifications about charging station availability and price changes, ensuring they are well-informed and can make timely decisions regarding their charging needs.
4. **Expansion of the Charging Network**
   Efforts will be made to expand the charging network by partnering with local businesses, municipalities, and other organizations. By encouraging more homeowners to list their properties as charging stations, we aim to increase the availability of charging options and support the growing electric vehicle community.
5. **Advanced Analytics Dashboard for Users**
   An enhanced analytics dashboard will be developed to provide users with insights into their charging patterns, costs, and overall energy consumption. This feature will empower users to make informed decisions about their electric vehicle usage and contribute to a more sustainable lifestyle.
6. **Integration of Renewable Energy Sources**
   Future versions of the app will explore partnerships with renewable energy providers to facilitate the integration of green energy sources into the charging network. This will not only promote sustainability but also offer users the option to charge their vehicles using clean energy.
7. **Community Engagement and Gamification**
   To foster a sense of community among users, we plan to introduce gamification elements such as rewards for frequent users and participation in community initiatives. This will encourage more users to engage with the app and contribute to the growth of the EVolve Chargemates network.

These future plans aim to create a more robust and user-friendly platform, positioning EVolve Chargemates as a leader in the electric vehicle charging ecosystem. By continuously innovating and responding to user feedback, we aspire to enhance the accessibility and convenience of EV charging for all users.

Chapter 6: Conclusions

EVolve Chargemates represents a significant advancement in the realm of electric vehicle (EV) charging by leveraging technology to create a decentralized network of charging stations within communities. The app empowers homeowners to register their residences as charging points, thereby increasing the availability of charging infrastructure and promoting the adoption of electric vehicles. By integrating real-time data collection and mapping capabilities, EVolve Chargemates allows EV owners to locate nearby charging stations effortlessly, ensuring a seamless and efficient charging experience.

The user-friendly interface, coupled with features like reservation systems and feedback mechanisms, fosters engagement and trust within the community. By facilitating direct communication between charging station providers and EV owners, the app enhances collaboration and efficiency in managing the charging network. This connectivity not only improves user satisfaction but also encourages more homeowners to participate in the initiative, further expanding the network.

In addition to improving immediate access to charging stations, EVolve Chargemates aims to contribute to long-term sustainability by promoting the use of electric vehicles and reducing carbon emissions. The app's scalability and adaptability make it suitable for various urban and rural settings, addressing the diverse needs of users across different geographical regions. Ultimately, EVolve Chargemates sets a new benchmark for electric vehicle infrastructure, providing a powerful tool to enhance the accessibility and convenience of EV charging, thereby fostering a more sustainable future for transportation.

Chapter 7: References

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Chapter 8: Appendix

8.1.List Of Figures

8.2.List Of Tables

Chapter 9: Review Sheets

9.1. Review - 1 score sheet:

Industry/Inhouse: **Project Evaluation Sheet 2024-25** 32 **Class: D17** C

Title of Project(Group no): EVolve Chargemates (Grp No - 32)

Group Members: Vedant Tawade (65), Vedant Pawar(52), Soham Tawade (64), Nikhil Singh(60) D17C D17C D17C D17C

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	4	4	4	2	4	0	2	2	2	3	3	3	4	5	42

Comments: - Every aspect of problem specially wrt houshold charging owner need to be consider (benefit to owner)
- Dataset need to present next Review
→ All Security measure need tobe considel for Installing charging station what are the prequisite for the same give clarity on that

Yugchhaya Galphat

Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	4	4	4	2	5	2	2	2	2	3	3	3	4	5	45

Comments: ⊛ Focus on prototype. and pitch the idea

Date: 23rd August, 2024

Lifna CS 23/8/24

Name & Signature Reviewer2

9.2. Review- 2 score sheet:

Industry/Inhouse: Project Evaluation Sheet 2024-25 32 Class: D17 C

Title of Project(Group no): Evolve Chargemates (32)

Group Members: Vedant Pawar (52) Vedant Tawade (65) Nikhil Singh (60) Soham Tawade (64) D17C D17C D17C D17C D17C

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	4	4	5	3	4	2	2	2	2	2	2	2	4	4	42

Comments: Business model can be prepared - detailed comparison study considering different factors

(Priya R. L)

Name & Signature Reviewer1

	Engineering Concepts & Knowledge (5)	Interpretation of Problem & Analysis (5)	Design / Prototype (5)	Interpretation of Data & Dataset (3)	Modern Tool Usage (5)	Societal Benefit, Safety Consideration (2)	Environment Friendly (2)	Ethics (2)	Team work (2)	Presentation Skills (3)	Applied Engg &Mgmt principles (3)	Life - long learning (3)	Professional Skills (5)	Innovative Approach (5)	Total Marks (50)
Review of Project Stage 1	4	4	4	3	4	2	2	2	2	2	2	2	4	4	41

Comments: ⊛ Complete the implementation c̄ integration c̄ API's
⊛ Get ready c̄ Prototype before Project Viva

Date: 26th September, 2024

Lifna CS 26/9/24

Name & Signature Reviewer2