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A Flutter-Based Mobile App for Finding, Booking and Managing Charging Stations

Prof. Punam V. Chavan¹, Trupti Panhale², Pragati Kale³, Akeshrain Gedam⁴, Vinod Kumar⁵

Assistant Professor, Department of Information Technology, Zeal College of Engineering and Research, Pune,

Maharashtra, India¹

Students, Department of Information Technology, Zeal College of Engineering and Research, Pune,

Maharashtra, India^{2,3,4,5}

ABSTRACT-In this research, we introduce a novel solution to tackle one of the primary concerns faced by electric vehicle (EV) owners, which is the limited accessibility and availability of charging stations. To address this challenge, we have developed and implemented an EV charging station locator application using the Flutter framework. Our application leverages the powerful Google Maps API to visualize the locations of nearby charging stations, while also providing comprehensive details such as connector types, availability status, and pricing information. To assess the usability and effectiveness of our app, we conducted thorough user testing sessions. The results indicated that the application is user-friendly, offering a hassle-free experience, and provides reliable and up-to-date information on charging stations. By implementing our app, we aim to alleviate the challenges surrounding charging station availability and enhance the overall EV ownership experience.

KEYWORDS:Flutter Framework, Google Maps API, EV Charging Station, Firebase

I. INTRODUCTION

In India, the sales of Electric Vehicles (EVs) are on the rise, reflecting the emergence of new industries. The chart below showcases the increasing popularity of EVs, with companies such as Tata Motors and Hyundai playing a significant role in this growth.

| ELECTRIC CAR SALES RECORD 268% YoY INCREASE IN FIRST-HALF OF FY2023 | | | | | | | |
|---|--------------|--------------|--------------|--------------|--------------|--------------|---------------|
| ELECTRIC CARMAKERS | April '22 | May '22 | June '22 | July '22 | Aug '22 | Sep '22 | Total |
| Tata Motors | 1,812 | 2,495 | 2,724 | 2,891 | 2,765 | 2,831 | 15,518 |
| MG Motor India | 245 | 247 | 235 | 268 | 316 | 280 | 1,591 |
| Hyundai Motor India | 23 | 27 | 51 | 61 | 73 | 74 | 309 |
| BYD India | 21 | 42 | 49 | 44 | 45 | 63 | 264 |
| Mahindra & Mahindra | 13 | 9 | 19 | 26 | 17 | 112 | 196 |
| BMW India | 17 | 9 | 5 | 5 | 25 | 27 | 88 |
| Audi | 8 | 8 | 14 | 8 | 14 | 10 | 62 |
| Porsche | 4 | 5 | 4 | 7 | 7 | 13 | 40 |
| Mercedes-Benz | 11 | 5 | 3 | 2 | 4 | 7 | 32 |
| Jaguar Land Rover India | 3 | 7 | | | 0 | 1 | 11 |
| Others | 4 | 1 | 7 | 17 | 1 | 1 | 31 |
| Total | 2,161 | 2,855 | 3,111 | 3,329 | 3,267 | 3,419 | 18,142 |

Fig -1:India Electric Vehicle Market

The availability of electric charging stations in India is currently limited, causing inconvenience for EV owners who struggle to find suitable stations, resulting in wasted time and increased expenses. This issue is further compounded by the lengthy charging process required for EVs. To address these challenges, a slot booking system is essential to streamline the charging experience. As the electric vehicle industry in India expands and new charging stations are registered, their growing numbers are not adequately reflected on virtual maps. This makes it difficult for users to locate charging stations virtually, leading to further inconveniences. To alleviate these problems, an Electric Vehicle (EV) charging station app has been developed to assist EV owners in locating and managing charging station services. The app provides crucial information such as charging station availability, locations, charging speeds, and

costs. Users can conveniently navigate to the nearest charging station using the app's built-in navigation feature. Furthermore, the app offers the convenience of in-app payments, eliminating the need for cash or card transactions at the charging station. It may also track the charging history of the user's vehicle, enabling them to monitor their usage and expenses effectively. The primary objective of the EV charging station app is to enhance the convenience and efficiency of the charging process for EV owners. This article primarily focuses on the fundamental idea of the project we are developing. The subsequent chapters will present a literature survey, encompassing relevant documents, manuals, and analysis papers that align with our project's objectives. The methodology employed during the implementation of the project will be discussed in the following chapter. Additionally, the technology stack we plan to utilize will be outlined. A detailed discussion will follow, outlining the specific approach we will undertake for the project. Finally, we will explore future work and conclude by outlining our plan to make the project readily available for public use. Our project aims to design and develop an app that locates nearby charging stations based on the user's locality. The app will display all available electric vehicle charging stations in proximity, allowing users to navigate directly to them. Moreover, the app will offer a slot booking feature that enables users to reserve charging slots according to their vehicle type and charging port, facilitating charging at their preferred time slots. This app has the potential to significantly reduce the time spent by electric vehicle owners in search of suitable charging stations.

II. LITERATURE REVIEW

Mobile application development gained special interest from researchers in the last years. Many people have a smartphone and use mobile applications for various purposes such as transport, travel, shopping, medical services, etc. These applications proved their importance also in the tourism domain. Various applications were developed to facilitate the access of the tourists to accommodation options, must-see locations suggestions, restaurants etc., but the main drawback is that many of these are separate applications. For this reason, the users shall switch between all these applications. This paper intends to improve the users' experience by providing all the before mentioned functionalities in just one application. Current research highlights the development process of an all-in-one touristic mobile app for Timișoara (Romania) by employing recent technologies such as Firebase and Flutter. [1] The system proposed in this paper is new framework that can be utilized by any application programmer to use it for control mobile Application by using FCM technology Stand for (Firebase Cloud Messaging), which is supported by Google. It is a very powerful technology in sending Notifications to Mobile applications through data messages that can be used to change the behavior of mobile applications that installed on the smart phones. The system is designed to deal with more than one Firebase application at the same time and send data messages that designed by the programmer either by creating these data manually or to get this data from another environment. This system was designed to save the information of the applications that need to get control and data Message information can be store inside the local system database. The proposed system is working as Rest Clint to send information that containing JSON Format with key-value pairs, which is created inside the system itself or by using existing Data message from the Database, this messages can be send to specific application and it is possible to send this data Messages and information to a specific user or specific group of users in the same group using (subscribe topic) or all users of the Mobile App The system is designed using technology of Dot Net, Web Service, Firebase Cloud Messaging and SQL server database that use to manage the Data and firebase applications. this Data Messages Can be sent to specific Mobile Application or Group of Mobile Applications using same Data message, the proposed system is solved the main problem of this paper that difficult to manage the orientation of the functions within the applications to make it easy and fast as much as possible. [2] Government of India is ramping up efforts to increase the use of electric vehicles in the country, by formally announcing higher Electric Vehicle (EV) incentives and on-going discussions on regulating the sale of conventional 2 and 3-wheelers by 2025. National standards for charging infrastructure are expected to be finalized soon, allowing both public and private sector to deploy their charging fleet to cater the EV charging demands. Centralized strategic planning and optimization in charging station location selection is proven to drastically reduce the initial cost required to serve the EV charging demand and reduce range anxiety. This review focuses on the most significant parameters considered in charging station location planning by various researches, its relevance and pitfalls. [3] Under the background that the country advocates green travel and vigorously promotes the development of new energy industry, electric vehicles are bound to be gradually popularized in China, and the demand of electric vehicle users for charging service is also increasing. In order to let electric vehicle user know the location and availability of the charging pile station nearby in real time, it is a feasible scheme to build an intelligent pile station management platform by applying the rapid development of cloud computing technology and mobile app based on map navigation function. However, with the increase of the number of charging piles and charging stations, it is bound to put forward higher requirements for the performance of the management platform. This paper proposes an optimization scheme based on LBS cloud retrieval technology to update the available status of a large number of piles. [4] With recent years' fast growing penetration of Plug-in Electric Vehicles (PEV), the energy source under

demand is gradually transferring from gasoline to electricity. It would be of significant interest to the utility and energy service community to predict charging demand on users' side. In this paper, we find and propose a practical PEV user demand prediction algorithm through user-based charging session data. The analysis is completed with the data collected from the charging stations installed on campus of University of California, Los Angeles (UCLA). We also present a mobile interface for PEV users to interact with the charging system. Initial investigations recommend to use the median value of each individual user's charging history as a personal energy demand value. The SMAPE accuracy of this approach is 0.55 for users with small and large sample sizes. [5] Mobile data visualisation solutions for electric vehicles will help both drivers extremely helpful in providing considerable support for maintenance and monitoring operations since users will need to be advised of the vehicle's present state of health. The project's scope and tasks has been accomplished in accordance with the timeframes specified for delivering the components, which is following the agile approach that are being used. [6] In order to meet the trend of increasing scale and more complexly layout of electric vehicle (EV) fast charging station (FCS), as well as the development of urban intelligent city, this paper studied on use mobile Internet and mobile terminal to realize the intelligent billing and settlement system of EV FCS, which provided a integrated charging billing model based on time-of-use price, proposed a solution to achieve system that can scan identification through vehicle QR code, guide the charging vehicle orderly parking by APP, start charging process, and realized no card payment by the mobile terminal. At last, this paper gave experimental result to verify time-of-use price is the and customers that have interest in electric vehicles technology. The Data Visualization mobile application help to collect, process, and analyse the data of an electric vehicle prototype via the Power BI features that will be combined with the Data Visualization mobile app. Poor data display on the system status is a common issue that users have reported. The insights that have been produced in the form of data dashboard that is compact with visualization is simple to grasp since it employs colourvisualisation and is presented in a basic manner. The electric vehicle maintenance and administration will be simplified; examples of data that will be visualised include mileage, duration, battery state and battery temperature. It is intelligent and integrated as it will become more easily accessible for remote support when it is important influence factor to integrated charging fee, and the billing model which adopted optimized peak-valley segmentation method can instruct the customer to charge economically, a lot of users can save the cost of travel. The system can enhance the customer satisfaction and will help to improve the operational efficiency and service capability of EV FCS. [7]

III. RESULTS

Developed and implemented using the versatile Flutter framework, the app leverages the power of the Google Maps API to present users with a visually appealing interface that displays the location of nearby charging stations. By providing essential information such as the type of connector, availability, and pricing, the app empowers EV owners to make informed decisions about where to charge their vehicles. Furthermore, the app's ability to allow users to filter charging stations based on their preferences and report inaccuracies or out-of-service stations enhances its utility and ensures the information remains accurate and up-to-date. The results of user testing indicate that the app excelled in usability, offering an intuitive and seamless experience. With its successful implementation, this app holds great potential to improve the overall EV ownership experience by alleviating concerns related to charging station availability and fostering sustainable transportation practices.

| Module: Registration | | | | | | | | |
|----------------------|--------------|--|---|-----------------------------------|-------------------|--|---------------------------------|------------|
| Sr no | Test Case ID | Test Scenario | Test Steps | Test Data | Test Type | Expected Results | Actual Results | Pass /Fail |
| 1 | R1 | Signing into application as an Individual. | <ol style="list-style-type: none"> 1. Open the application. 2. Click on Sign up. 3. Fill in the required Test Data. 4. Click on Sign Up button. | Full name: Email: Password: | Black Box Testing | User must be redirected to login screen. | User redirected to login screen | Pass |

Fig -2: Test Module for User Registration.

| Module: Login | | | | | | | | |
|---------------|--------------|-------------------------------|---|-------------------------|-------------------|--|--|------------|
| Sr no | Test Case ID | Test Scenario | Test Steps | Test Data | Test Type | Expected Results | Actual Results | Pass /Fail |
| 1 | L1 | Check login with valid data | <ol style="list-style-type: none"> 1. Open the application. 2. Fill in the required Test Data under Login section. 3. Click on login button. | Email: Password: | Black Box Testing | User must be redirected to its Dashboard | User redirected to dashboard | Pass |
| 2 | L2 | Check login with invalid data | <ol style="list-style-type: none"> 1. Open the application. 2. Fill in the required Test Data under Login section. 3. Click on login button. | Email: Password: | Black Box Testing | There must be an error message | Error message generated | Pass |
| 3 | L3 | Roadmap | <ol style="list-style-type: none"> 1. Select source and destination. 2. Get All Stations on the way 3. Destination | Source: Destination: | Black Box Testing | Display all station on map | All stations displayed on map Marked nearest station | Pass |

Fig -3: Test Module for User Registration.

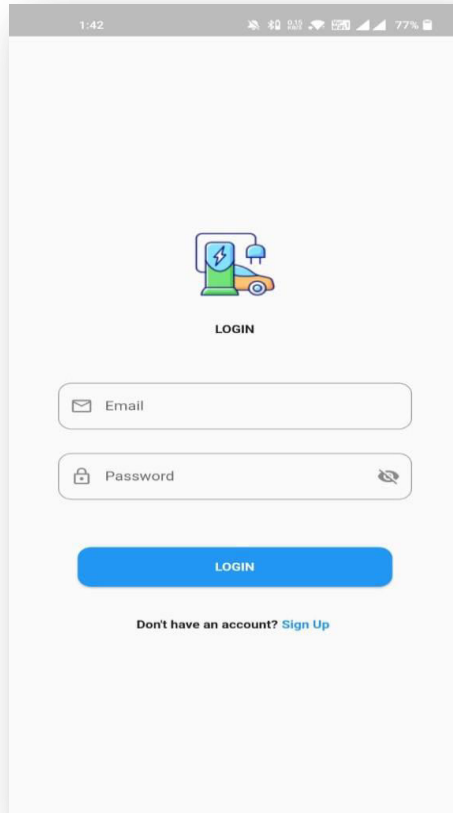


Fig -4: Login screen for User

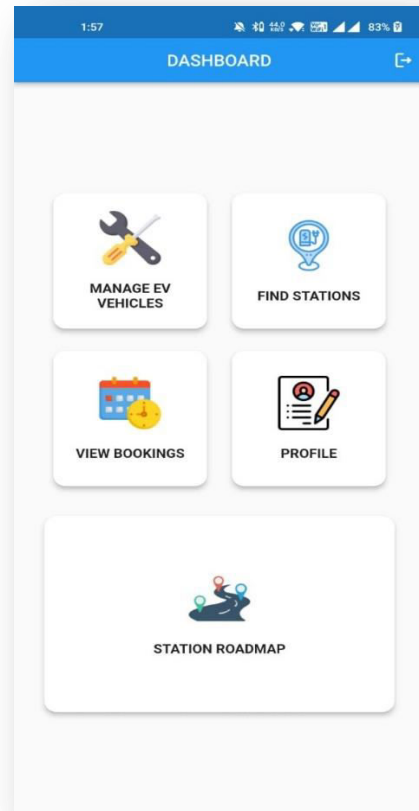


Fig -5: Dashboard for User

IV. TECHNOLOGY STACK

Dart: Dart is a programming language developed by Google, primarily used for building mobile, web, and desktop applications. It is the language of choice for developing applications using the Flutter framework.

Virtual Studio Code: Virtual Studio Code (VS Code) is a lightweight and versatile source code editor developed by Microsoft. It provides a comprehensive set of features for software development, including support for various programming languages, code debugging, version control integration, and customizable user interfaces.

Xcode: Xcode is an integrated development environment (IDE) created by Apple for developing software on MacOS, iOS, pads, watches, and TVs. It is the primary tool used by developers to build applications for the Apple ecosystem. Xcode provides a complete suite of tools for software development, including a source code editor, a graphical user interface builder, testing tools, and a powerful debugger. Xcode makes it easy for developers to create high-quality, native apps for Apple's platforms.

Firebase: Google Firebase is software that is used for the application development of iOS, Android, and web apps. It is a google-backed application development software. Firebase provides services tools and support for real-time tracking systems, fixing of app crashes, product experiments, and reporting of app crashes.

Firebase Authentication: Firebase Authentication provides backend services for the authentication of users of the app. It provides service authentication in different formats such as password authentication, phone number authentication using OTP, and Organization identity providers like Facebook, Twitter, Google, and more. It provides easy SDKs to use and already Ui libraries also.

Cloud Firestore: Cloud Firestore is a NoSQL document database provided by Google Cloud Platform. It is designed to store and synchronize data in real-time across multiple devices and platforms. Firestore offers a flexible and scalable solution for building web and mobile applications that require real-time data updates and offline capabilities.

Google Play Services: Google Play services provide a large set of SDKs on android to help us to build our app, increase privacy and security, engagement of the users, and grow your apps. These SDKs are unique. These libraries require a thin client library to be included in our app. At runtime, the client library communicates with the packages of the SDK's implementation and footprint in Google Play services.

Google Maps API: It is a set of APIs (application programming interfaces) that provide the communication bridge to Google's various services. It will help us to build simple android, iOS, and apps to very complex apps which are based on real-time location for Android, web, and iOS.

Google Place API: The Places API (application programming interface) is a service that provides information about places using HTTP requests. Prominent points of interest like establishments or geographic locations are referred to as places in these APIs.

Google Direction API: It is a set of APIs (application programming interfaces) that provide the communication bridge to Google's various services. It provides to navigate to the destination from the source. It will help us to build simple android, and iOS apps to very complex apps which are based on real-time location for Android, web, and iOS.

V. DISCUSSION

We will employ interactive and user-friendly concepts and methodologies in our app, enabling seamless interaction for both EV owners and charging station owners. The app will be highly reliable and easy to use, providing a convenient experience for all users. Our architecture will encompass various services, including real-time location finding, integration with Google Maps, navigation assistance, slot booking and management, and efficient profile management. By deploying these features, we aim to create an app that offers comprehensive functionality while ensuring a unique and satisfying user experience.

VI. CONCLUSION

The primary objective of this project is to create a highly convenient and practical solution for EV users. The app will not only serve the users but also function as an interactive system for the administrators. Additionally, it has the potential to generate valuable data regarding EV owners and charging station operators. With its ability to locate and navigate to charging stations, the app aims to provide comprehensive assistance. Furthermore, there are plans to expand the app into a commercial product in the future, offering additional features and subscription packages. These enhancements, such as the "charge and chill" feature, have the potential to generate increased revenue for the app.

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