Electric Vehicle Charging Point Navigator

*Prabal P. Nair[1], Shashank S. Karkera[2], Pratik H. Shinde[3], Shraddha S. More[4]

[1,2,3,4] Department of Information Technology
[1,2,3,4] St. John College of Engineering and Management, Palghar, India

[1*]prabalnair10@gmail.com, [2]shashankkarkera.64@gmail.com,
[3]shindepratik9495@gmail.com, [4]shraddham@sjcem.edu.in

Abstract. Electric vehicles are a growing industry in India. Currently, there are over 13,92,200 electric vehicles and over 1700 public charging stations. This gives us a ratio of 135 EVs per charging station in India. Compared to other nations like the USA and China, the ratio is 16 EVs per charging station and 6 EVs per charging station, respectively. The International Energy Association (IEA) recommends an EV to charging station ratio of 10 EVs per charging station. This puts India in a low position with regards to the development of EV charging infrastructure. Even though the EV industry is growing rapidly, it will take a lot of time and money to create a robust charging infrastructure that meets the desired standards. Electric Vehicle Charging Point Navigator is a mobile application that will allow EV users to navigate to the nearest public and private charging stations to charge their vehicle. The public stations are already available in different areas, but private charging stations owned by individuals are not publicly available. This application will allow users with in-home charging points to provide charging services to other EV users. The users who are willing to do the same have to register through the app and allow their location to be an active EV charging point. The use of private charging publicly will contribute to the growth of the overall EV charging infrastructure. This will also encourage users to use their EVs for longer distances without any concern for charging stations.

Keywords: Electric Vehicles, Charging Point, Infrastructure, Mobile Application

1 Introduction

Electric vehicles (EVs) are the future of automobile transportation. Not only are they eco-friendly, but they are also easy to recharge and run on a renewable source of energy, i.e., electricity. As the demand for EVs increases in the market, the demand for a robust charging infrastructure will also increase. Currently in India, there are very few publicly available charging stations for EV users, which also indirectly plays a role in the slow growth of EVs in India. To establish a robust charging infrastructure, it would not only take time but also a lot of money. Electric Vehicle

Charging Point Navigator is a mobile application that would allow EV users to not only use public charging stations but also private charging points, i.e., charging points owned by different EV users at their homes. This app will allow EV users who have charging points in their homes to provide the charging facility to other EV users in their area at a particular price. This utilization of existing private charging points will allow the EV charging infrastructure to grow without much investment or time.

2 Literature Review

In 2019, Md Umar Hashmi, et al. [1] proposed a business model, WEcharge, which could allow privately owned EV charging infrastructure to share their resource. This will reduce congestion and waiting time for company and publicly owned charging infrastructure. WEcharge will also assist in mapping incoming EVs to their best suited EV charging infrastructure.

In 2017, Zeinab Moghaddam, et al. [2] proposed a smart charging strategy for PEV networks that offered multiple charging options at different prices and capacities. They used a multi-objective optimization model and queuing theory to minimize charging time, travel time, and cost. They introduced partial charging to reduce waiting times and used pricing to encourage its use.

In 2018, Florian Plentera, et al.[3] proposed an IT-enabled P2P sharing and collaborative consumption transportation service for private charging infrastructure. They used New Service Development (NSD) and provider assessment to develop the service and showed how a survey assessing potential peer-providers aided in its development.

In 2022, Sarah LaMonaca, et al. [4] conducted a study and found that customers needed greater transparency to fully understand the costs assocated with commercial charging services. The different pricing structures offered by charging service providers, such as per-minute, per-hour, per-kWh or subscription services, made it difficcult for customers to compare the prices of different operators and home charging. To address this issue, they recommended the implementation of standardized labelling or consumer protection laws to enhance the cutomer experience when searching for charging services.

In 2019, Lizi Luo, et al. [5] put forward a method and model in 2019 that effectively addresses the joint planning issues of Electric Vehicle Charging Stations (EVCSs) and Distributed Generators (DGs) while considering the real-time charging naviagation. This approach can determine the optimal locations and sizes of both

DGs and EVCSs during the planning phase. By considering electric vehicle charging demands as spatially dispatchable resources, the total installation capacity and quantity of EVCSs and DGs can be reduced along with some operation related costs. Therefore, the propsed model and approach can yield significant economic advantages by allocating DGs and EVCSs

In 2022, Fareed Ahmad, et al. [6] analyzed and researched on optimal locations for charging stations, considering three approaches: distribution network operator, charging station owner, and electric vehicle user. The article discussed the problem formulation, objective functions, and constraints for determining the best location, as well as EV load modeling, uncertainty handling, renewable energy integration, charging level, and V2G strategy. Optimization strategies were explored, and metaheuristics algorithms were suggested to provide better results. Additionally, the article addressed the impact of charging station load on the distribution network.

3 Proposed System

The electric vehicle (EV) industry in today's world is still in a developing phase. Even though EVs have seen some substantial growth in many places, there aren't many areas where the charging infrastructure is sufficient to support the current demand for EVs. Compared to the number of gasoline pumps in an area, charging stations are way less than the desired amount. Developed countries like the USA and England do have developed charging infrastructure, but there isn't a dedicated platform for the users to navigate to an optimal charging point. Most of the navigation is done through online mapping services like Google Maps, where the users have to find charging stations by scrolling through different locations, and even after finding one, there is no way to know whether the station is occupied or whether the charging socket is compatible with the user's EV. Therefore, there is a need for a system that could address and solve these problems and help in building a robust charging infrastructure for EVs.

This proposed system is an effort to solve the current problems in the EV charging infrastructure and create a dedicated platform for EV users to navigate to different charging locations. One of the main aims of this system is to allow public access to the private charging points owned by individual EV users in their residential areas. Before we get into the details of the proposed system, there are some EV charging technologies that need to be explored. These technologies will help us better understand the proposed system. In an EV charging infrastructure, there are many types of chargers that are used to charge EVs. Different chargers have their own characteristics. Here, we have considered three types of EV chargers that are currently in use.

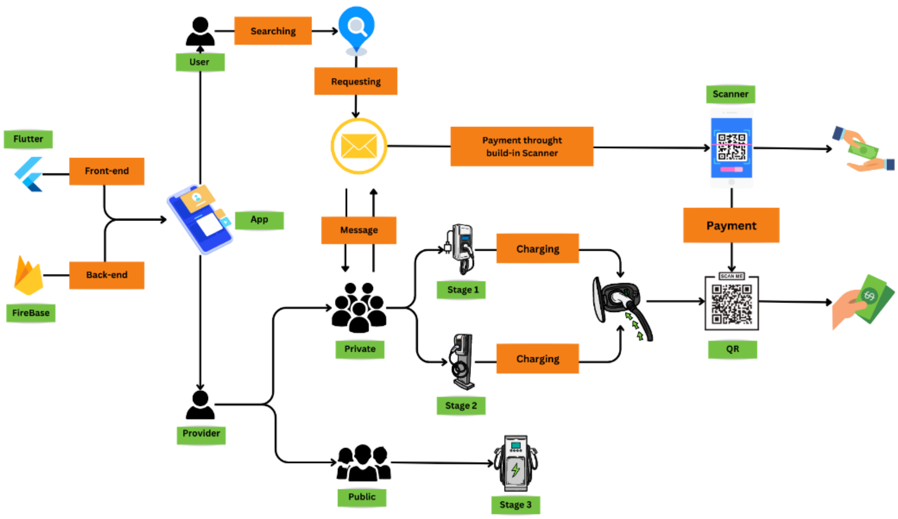

Fig. 1. Proposed System Architecture.

- **Stage 1:** A stage 1 charger is a 120-volt outlet, which typically takes 11–20 hours to fully charge an EV. Each hour adds 2–5 miles of driving range.
- **Stage 2:** A stage 2 charger is a 240-volt outlet that takes around 3–8 hours to fully charge an EV. Each hour adds approximately 20 miles of driving range.
- **Stage 3:** Stage 3 chargers charge some EVs up to 80% in as few as 20–30 minutes. Each hour adds approximately 100 miles of driving range.

Most of the private charging stations owned by individual EV users are either stage 1 or stage 2 chargers since these chargers use less voltage for charging, because of which the charging time also increases. Most of the public charging stations use stage 3 chargers since these chargers use a lot of electricity for charging but also charge EVs much faster than stage 1 and stage 2 chargers.

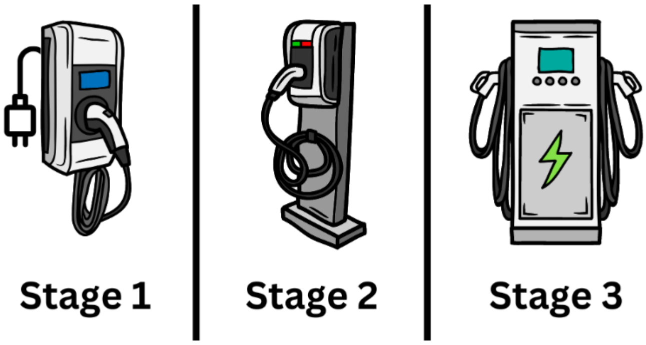

Fig. 2. Different Charging Stations

The basic idea of the proposed system is to allow private charging stations owned by individual EV users to be accessed publicly by other EV users on the basis of availability. Similarly, users can access publicly available charging stations through this system. The next objective is to allow EV users to choose or get recommended an optimal charging station with respect to their location and navigate to the location of the same easily and without much problem. Finally, the last objective is to allow secure financial transactions between an EV user and the charging provider.

Following is a detailed explanation of each component in the

Block diagram:

EV Charging Point Navigator Application: This is a mobile application and a core component of the proposed system that allows users to use different services, like navigating charging stations, providing charging services, using a secure payment interface, etc. The application runs on technologies **.**

Flutter: Flutter is a mobile application development framework built on the Dart programming language developed by Google. This framework allows us to create interactive user interfaces (UI) for mobile applications and provides methods to interact with the backend of the application.

Firebase: Firebase is a cloud platform built by Google. It provides services like application hosting, real-time database access, user authentication, and other back-end services that make it a perfect tool to be used for the back-end of any application.

User: The user would use the app to find and navigate to the nearest charging station available. Once the user selects a charging station, if it’s a private charging station, a message will be sent to the owner of the charging station requesting charging service. If the private owner accepts the request, then the user would navigate to the location of the charging station and charge his or her vehicle.

Fig. 3. Navigation Of Charging Stations

Provider: The providers are the ones who provide the charging service to other EV users. The providers are of two types: public and private. Private providers are the ones who provide their personally owned charging points to other EV users. Public providers are private companies or government organizations that provide charging facilities publicly.

Payment: Once the charging is complete, the EV user would pay the provider using the built-in payment interface, i.e., a QR code. The QR code will be displayed on the provider's mobile application, and the user just has to scan the code and pay the amount of charging.

4 Implementation

The whole system is a mobile application built on the Flutter framework for the front-end and Firebase for the back-end services. The Flutter framework gives various ways of coding an attractive and interactive user interface, along with backend connection services for mobile applications. One of the most important features of Flutter is that it is a cross-platform framework, i.e., the same code base is compatible with both Android and iOS mobile operating systems. It can also be used to develop web and desktop applications. Firebase is a cloud hosting platform that provides multiple back-end services for mobile application development. It has a firestore database that allows us to store data on the cloud and modify it in real time. Another service used in this system is user authentication. Firebase provides a way to authenticate users through email, contact numbers, etc. This feature makes sure that the user on the app is legitimate.

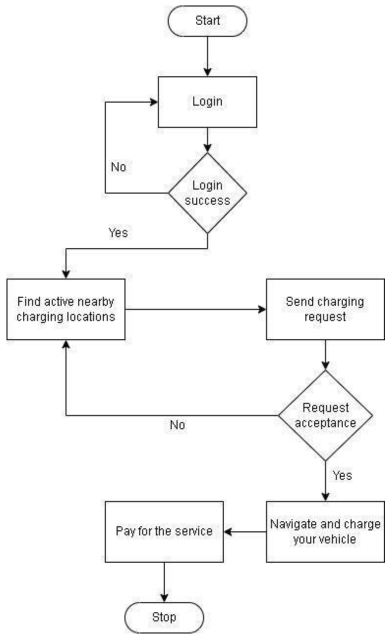

Fig. 4. Basic Flow of Application

The above diagram shows the basic workings and flow of the application. The application starts with a login page where the users have to login if they haven't already registered with the app. If the user isn’t registered, then the user must go to the registration page and enter their details according to the requirements. Once registered, the user can login to access the user dashboard.

Fig. 5. Login Interface for Users and Providers

Once the users have successfully logged in, they will be given the option of choosing whether to enter the provider dashboard or the user dashboard. In the user dashboard, the user will be able to view the closest public and private charging stations.

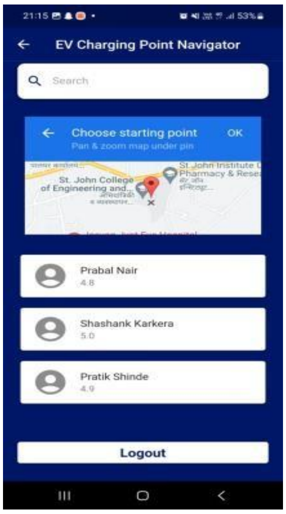

Fig. 6. User Dashboard

These locations will be displayed on a map, and the user can choose the most optimal charging point accordingly. Once chosen, the provider will be sent a notification to either accept the charging request or deny it. If the charging request is accepted, the user will be navigated to the appropriate charging point and will be able to charge their electric vehicle. Once charged, the user has to pay the provider through the app using a payment interface. After a successful payment for the service, the process ends.

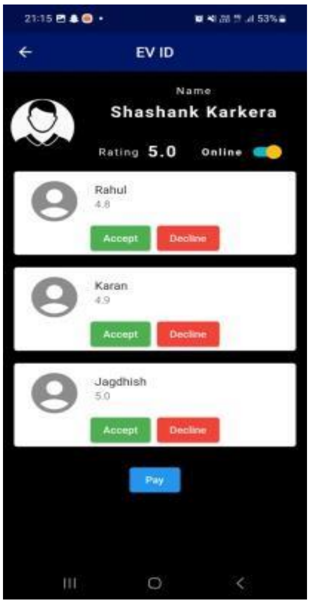

Fig. 7. Provider Dashboard

In the provider dashboard, the provider will be able to either activate or deactivate their charging location. If the charging location is set to active, then the provider will start receiving requests from different EV users according to their location. The provider has the authority to either reject or accept the request. If the charging request is accepted, the EV user will be navigated to the provider's location.

The users will also be able to view public charging stations provided by private companies or government authorities. The same charging process is carried out with regards to the public charging station.

Fig. 8. Provider QR Code

Once the charging service is completed, the providers could open the QR code scanner in their app so that the EV user could scan the QR code to make the payment for the charging service. After a successful payment, the whole process of EV charging ends.

5 Result and Discussions

The EV industry will grow exponentially in the coming years and reduce our dependency on traditional ICE vehicles. With this growth, the demand for EVs will increase, along with the demand for a robust charging infrastructure. To meet these demands, the Electric Vehicle Charging Point Navigator would be able to contribute towards the growth of EV charging infrastructure by enabling private charging points to be accessed publicly by any EV user. Also, it will give precise recommendations and navigation of charging stations to the user. This application will make it easy for EV users to navigate and charge their vehicles anywhere without any problems.

6 Conclusion and Future Scope

In conclusion, Electric Vehicle Charging Point Navigator is a mobile application that will allow easy access and navigation to the nearest charging points for the user. Since this application is still in its initial development phase, many features will be added to the app. A secure payment interface would be added to the application for the users to manage all their financial transactions regarding the charging services. Also, a complete business model will be integrated into this app so that the EV charging providers will be able to earn money by providing the charging service to the EV users.

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