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Plugo - EV Charging Station Locator

Rameshwar Bhumbar[1], Kshitij Borse[2], Yash Zagare[3], Vivek Visave[4]
*1,2,3,4, Department of Computer Engineering, Pune Vidyarthi Griha's College of Engineering & S. S. Dhamankar Institute of Management, Nashik
Email : ram26.bhumbar@gmail.com , borsekshitij046@gmail.com , vivekvisave08@gmail.com ,yashzagare2004@gmail.com

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Abstract:

The sudden uptake of Electric Vehicles (EVs) has raised the need for effective and affordable charging infrastructure. This EV Charging Station Locator project seeks to offer EV users an uncomplicated platform to find, reserve, and pay for charging services. The system incorporates GPS location technology to determine the nearest accessible charging stations in real-time. Users are able to access station information like chargers type, availability, price, and estimated charging time. An inbuilt booking capability allows users to book charging slots prior to charging, minimizing waiting time and ensuring convenience. The inbuilt secure payment portal facilitates various payment modes, enabling rapid and cashless transactions. By combining location-based search, booking management, and electronic payments within a single app, the project improves user experience, encourages efficient usage of charging infrastructure, and supports supports growth in sustainable transportation.

Keywords — **Electric Vehicle (EV), Charging Station Locator, GPS Navigation,Slot ,Booking Payment Gateway , Location-Based Services , Renewable Energy, Sustainable Transportation , Real-Time Availability, Mobile Application**

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I. INTRODUCTION

India's electric vehicle (EV) sector is rapidly growing due to rising environmental awareness, government initiatives like the FAME scheme and PM E-Drive program, and advances in battery technology. Although India now has over 12,000 public charging stations and more than 40 charge point operators, the charging infrastructure is still insufficient compared to the increasing number of EVs, leading to challenges such as range anxiety, uneven distribution of charging stations, high setup costs, grid limitations, and network fragmentation. To address these issues, intelligent EV charging station locator systems are needed that provide real-time station availability, booking, secure payments, route optimization, offline support, and integration with navigation services. The proposed Plugo EV Charging Station Locator aims to offer a unified and user-friendly platform that improves charging accessibility, reduces user anxiety, and supports India's vision of a sustainable transportation ecosystem with widespread EV adoption by 2030.

II. LITERATURE SURVEY

[1] Chokkalingam, Padmanaban, and Siano focused their research on real-time forecasting models for scheduling EV charging stations within smart energy systems. Their work aimed to optimize energy usage from the grid by predicting charging demand patterns and managing charging loads according to vehicle

usage behavior. This approach helped reduce congestion during peak hours and improved energy distribution efficiency. However, the proposed system mainly concentrated on backend energy management and did not provide a user-friendly platform for locating charging stations or booking charging slots. Plugo EV Charging Station Locator builds upon this concept by integrating intelligent forecasting with a real-time mobile and web application. The system not only improves charging efficiency but also provides live station discovery, slot booking, and user interaction features that enhance overall convenience and accessibility for EV users.

[2] Weijia Zhang, Hao Liu, and Fan Wang proposed a multi-agent reinforcement learning framework for recommending optimal EV charging stations based on system conditions and user demand. In their framework, each charging station acted as an independent intelligent agent that continuously learned from traffic patterns, waiting times, and user feedback to improve significantly reduced waiting times and improved user satisfaction. However, the framework remained largely theoretical and lacked real-time user interaction, GPS navigation, and booking facilities. Plugo EV Charging Station Locator extends this research by integrating AI-driven recommendation mechanisms into a practical application environment. The system provides intelligent charging station suggestions based on user routes, charger availability, and traffic conditions while also offering live navigation and reservation services for better user experience.

[3] Philipp Hummler, Christof Naumzik, and Stefan Feuerriegel developed a web mining-based methodology for identifying optimal EV charging station locations using Points of Interest (POIs) such as malls, offices, and restaurants. Their work greatly supported infrastructure planning by identifying regions with high EV activity and charging demand. However, the proposed model focused mainly on infrastructure distribution and lacked real-time operational features such as dynamic navigation and user interaction. Plugo EV Charging Station Locator builds upon this concept by dynamically displaying nearby charging stations using geospatial mapping and GPS technology.

[4] Researchers working on IoT-based EV charging infrastructure proposed systems capable of monitoring charger status, energy flow, and charging activity in real time through connected sensors and smart devices. Their work improved operational transparency and enabled automated monitoring of charging stations. However, most IoT-based systems focused primarily on hardware-level communication and lacked user-centric features such as intelligent recommendations, payment integration, and reservation management. Plugo EV Charging Station Locator extends these concepts by integrating real-time monitoring with user-friendly software services. The proposed system can support future IoT integration for live charger availability tracking, automated slot updates, and accurate charging status notifications, thereby improving infrastructure reliability and user convenience.

[5] Several mobile-based EV charging applications developed by private charging providers focused on helping users locate nearby charging stations and complete digital payments. These applications provided basic features such as charger maps and station information. However, most existing platforms are limited to specific charging networks and suffer from fragmented services, poor interoperability, and limited offline functionality. Plugo EV Charging Station Locator addresses these limitations by creating a unified platform that integrates multiple charging networks within a single application. The system supports real-time availability updates, secure payments, route optimization, and offline data caching, allowing

users to access essential charging information even in areas with poor internet connectivity.

[6] Researchers studying smart city transportation systems emphasized the importance of integrating EV charging infrastructure with sustainable urban mobility solutions. Their studies highlighted the role of intelligent transportation systems, renewable energy integration, and digital infrastructure in supporting future EV ecosystems. However, many of these studies remained conceptual and lacked practical implementations focused on user engagement and charging accessibility. Plugo EV Charging Station Locator bridges this gap by combining sustainable mobility concepts with practical real-world functionalities such as GPS navigation, intelligent recommendations, and efficient slot management. The platform contributes toward smarter transportation infrastructure while promoting cleaner and greener mobility solutions.

[7] Studies related to grid integration and EV charging demand management focused on minimizing the impact of large-scale EV charging on electrical grids. These works proposed load balancing techniques, peak demand reduction strategies, and renewable energy utilization methods to improve grid stability. Although effective from an energy management perspective, these studies provided limited attention to end-user interaction and charging convenience. Plugo EV Charging Station Locator complements these approaches by integrating user-level charging management with intelligent infrastructure utilization. The system can support future energy optimization mechanisms while ensuring a seamless charging experience for EV users.

[8] Research on geospatial analytics and route optimization for EVs highlighted the importance of accurate distance calculations, route planning, and traffic-aware navigation systems. Many proposed solutions improved travel efficiency and reduced energy consumption during EV journeys. However, several systems lacked integration with charging station booking and real-time availability monitoring. Plugo EV Charging Station Locator enhances these ideas by combining geospatial analysis with live charging station information, booking services, and dynamic route recommendations. This integration helps users identify the most suitable charging station quickly while minimizing travel delays and charging uncertainty.

[9] Recent studies on EV ecosystem development emphasized the growing importance of digital platforms capable of integrating AI, IoT, navigation services, and cloud-based infrastructure management into a unified charging environment. These studies identified challenges such as fragmented charging networks, inconsistent data availability, and poor interoperability among providers. Plugo EV Charging Station Locator directly addresses these challenges by providing an intelligent and scalable ecosystem that combines real-time data handling, contextual AI, booking management, and navigation services within a single platform. The system improves accessibility, reliability, and user satisfaction while supporting the long-term vision of sustainable electric mobility in India.

10] Research on battery swapping technology for electric vehicles highlighted its importance in reducing charging time and minimizing range anxiety, especially for two-wheelers and three-wheelers commonly used in urban transportation. Several researchers proposed automated battery swapping systems that allow users to replace discharged batteries with fully charged ones within minutes. These systems significantly improve operational efficiency and reduce waiting times when compared to traditional charging methods. However, many battery swapping solutions lack integrated digital

platforms for locating nearby swapping stations, monitoring

battery availability, and handling reservations. Plugo EV Charging Station Locator can be extended to support battery swapping infrastructure by integrating swapping station discovery, live battery availability tracking, and navigation assistance into a single user-friendly platform, thereby improving accessibility and convenience for EV users.

[11] Researchers working on cloud-based EV charging management systems proposed centralized platforms capable of collecting, storing, and analyzing charging data from multiple charging stations. These systems enabled operators to monitor charging activities, energy consumption, and station utilization efficiently. Cloud integration also improved scalability and real-time data synchronization across different charging networks. However, several proposed systems focused mainly on infrastructure management and provided limited functionality for end users such as personalized recommendations, offline access, and intelligent route planning. Plugo EV Charging Station Locator extends these cloud-based concepts by combining centralized data management with user-centric services including live station discovery, slot booking, payment integration, and AI-based charging recommendations, thereby creating a more complete and interactive EV charging ecosystem.

[12] Studies related to renewable energy integration in EV charging infrastructure emphasized the importance of sustainable charging solutions powered by solar and wind energy sources. Researchers proposed hybrid charging stations capable of storing renewable energy and supplying clean electricity for EV charging. These approaches help reduce carbon emissions and minimize dependence on conventional power grids. Despite their environmental benefits, many renewable-energy-based charging systems face challenges related to real-time energy management and user accessibility. Plugo EV Charging Station Locator complements these efforts by supporting intelligent energy-aware charging recommendations and can be integrated in the future with renewable-powered charging networks to promote environmentally sustainable transportation systems.

[13] Researchers focusing on smart parking and EV availability, charging speed, pricing, and provider network preferences selected by the user.The application retrieves real-time charging station status through APIs and IoT-enabled station monitoring systems. Users can view available charging ports, waiting times, charging tariffs, and station ratings directly on the map interface. When a charging station is selected, the application calculates the optimal route using shortest path algorithms integrated with Google Maps APIs. The user can then reserve a charging slot through the booking module. The backend validates slot availability using queue management algorithms to prevent conflicts and double-booking. After successful booking confirmation, the user completes the payment using integrated digital payment gateways such as Razorpay or Paytm.

[14] Several studies on user behavior analysis in EV charging systems highlighted the importance of understanding charging preferences, travel patterns, and peak charging times to improve infrastructure planning and service quality. Machine learning algorithms were used to predict user demand and recommend efficient charging schedules. Although these studies improved demand forecasting accuracy, many lacked direct interaction with users through practical mobile applications. Plugo EV Charging Station Locator incorporates user behavior analysis into its recommendation engine by providing personalized charging suggestions based on travel history, preferred charging times, and nearby station availability. This helps improve

both charging efficiency and customer satisfaction.

III. METHODOLOGY

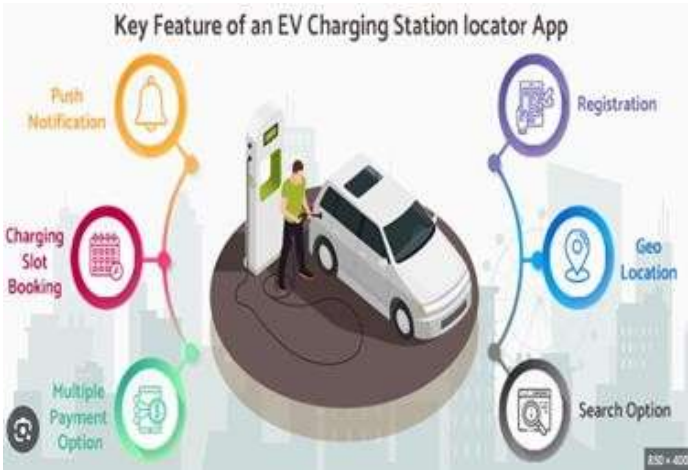
A.FLOWCHART EXPLANATION

The system workflow begins when the user opens the Plugo EV Charging Station Locator application and enables location access on the mobile device. The application retrieves the user's live GPS coordinates using the device's built-in location services and sends the coordinates to the backend server through secure API communication. The backend processes the request and fetches nearby charging stations from the central database.

The system then filters stations based on charger type, availability, charging speed, pricing, and provider network preferences selected by the user.The application retrieves real-time charging station status through APIs and IoT-enabled station monitoring systems. Users can view available charging ports, waiting times, charging tariffs, and station ratings directly on the map interface. When a charging station is selected, the application calculates the optimal route using shortest path algorithms integrated with Google Maps APIs.

The user can then reserve a charging slot through the booking module. The backend validates slot availability using queue management algorithms to prevent conflicts and double-booking. After successful booking confirmation, the user completes the payment using integrated digital payment gateways such as Razorpay or Paytm. Finally, the booking details, navigation route, and digital receipt are displayed within the application dashboard.

If internet connectivity becomes unavailable, the system still provides offline access to cached station data and previously downloaded maps, ensuring uninterrupted usability. usability.



B. SYSTEM ARCHITECTURE

The proposed Plugo EV Charging Station Locator system architecture consists of four major layers: the User Interface Layer, the Application Processing Layer, the Real-Time Data Management Layer, and the Database & Integration Layer.

The User Interface Layer is developed as a mobile-first application that allows EV users to search charging stations, view live maps, reserve charging slots, make payments, and provide reviews. The interface is designed to be responsive, intuitive, and accessible across different mobile devices.The Application Processing Layer handles the core functionality of the system. It processes GPS coordinates, performs station filtering, manages slot bookings, handles route optimization, and communicates with external APIs such as Google Maps and payment gateways. This layer also implements queue scheduling algorithms and recommendation logic for suggesting suitable charging stations.The Real-Time Data Management Layer continuously retrieves live charging station data from connected charging operators and IoT-enabled chargers. This

layer monitors charger availability, charging status, estimated waiting time, and operational conditions in real time. It ensures that users receive accurate and updated station information before starting navigation or booking sessions.

C. STEP-BY-STEP METHODOLOGY

Step 1: User Geolocation Detection

The system starts by detecting the user's current location using GPS services available on the mobile device. The latitude and longitude coordinates are fetched in real time and mapped using Google Maps APIs.

Step 2: Charging Station Search

The application sends the user location to the backend server, which searches the charging station database for nearby stations. The search results include station name, charger type, charging speed, operational status, pricing, and distance from the user.

Step 3: Filtering and Recommendation

Users can filter charging stations according to their preferences such as nearest station, lowest charging cost, fastest charger, or preferred provider network. The recommendation engine analyzes station conditions and suggests the most suitable charging options.

Step 4: Real-Time Data Retrieval

The system retrieves live station information using APIs and IoT-enabled monitoring systems. Real-time details such as charger availability, estimated waiting time, active charging sessions, and maintenance status are displayed to users.

Step 5 : Route Optimization and Navigation

Once the user selects a charging station, the system calculates the shortest and most efficient route using graph-based algorithms such as Dijkstra's Algorithm and GPS navigation
The system accurately retrieved live station information, including

services.Shortest Path using Dijkstra's Algorithm
The navigation module minimizes travel distance, reduces energy consumption, andimproves travel efficiency.

Slot Booking and Reservation

The application allows users to reserve charging slots in advance. The backend validates slot availability using First-Come-First-Serve (FCFS) and queue management algorithms to prevent booking conflicts and overcrowding.

Step 7: Secure Payment Integration

Users complete charging payments using integrated digital payment systems such as UPI, debit cards, credit cards, net banking, and mobile wallets. Secure payment APIs ensure fast and protected transactions.

Step 8: Offline Data Access

To support users in low-network regions, the system caches station information and map data locally on the device. Users can still access station locations and navigation support even without active internet connectivity.

Step 9: Feedback and Review System

After charging completion, users can submit ratings and reviews based on station quality, charger performance, cleanliness, and service experience. These reviews help improve transparency and support future user decisions.

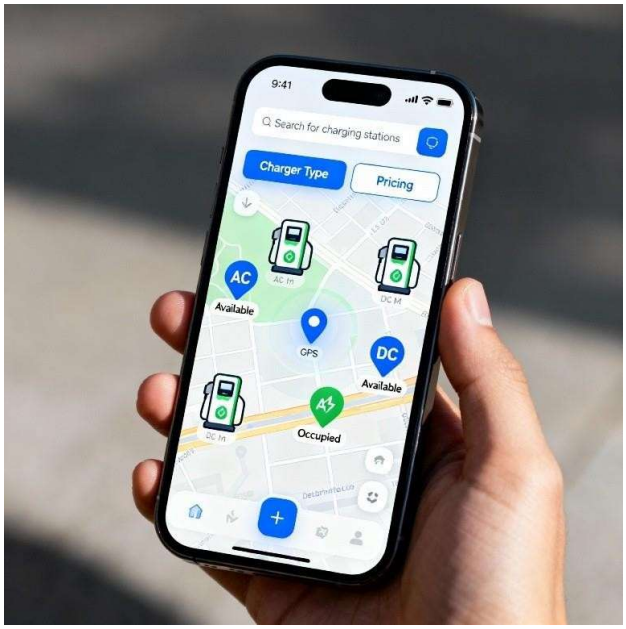
IV. RESULTS AND DISCUSSION

The proposed Plugo EV Charging Station Locator system was evaluated to analyze its effectiveness in locating EV charging stations, providing real-time updates, and improving user convenience. The application successfully detected user locations using GPS technology and displayed nearby charging stations dynamically on the
charger availability, waiting time, charging speed.

The slot booking module effectively prevented double-booking conflicts and managed charging

reservations using queue management techniques. Route optimization through Google Maps integration and shortest path algorithms reduced unnecessary travel distance and minimized user waiting time. Offline caching functionality also improved accessibility in low-network areas, particularly in Tier-2 and rural regions.

The secure payment gateway integration enabled smooth digital transactions using multiple payment methods. User feedback and review features helped improve trust and transparency across the charging network. Overall, the results demonstrate that Plugo provides a reliable, scalable, and intelligent EV charging solution capable of improving charging accessibility, reducing range anxiety, and enhancing user experience within India's growing electric mobility ecosystem.



V. CONCLUSION AND FUTURE SCOPE

The Plugo EV Charging Station Locator system provides an intelligent and user-friendly platform designed to improve the accessibility, reliability, and efficiency of EV charging infrastructure. By integrating GPS navigation, real-time station monitoring, slot booking, digital payments, and offline support within a single application, the system effectively addresses major challenges faced by EV users such as range anxiety, charging delays, and fragmented charging networks. The proposed platform enhances both infrastructure utilization and customer convenience through real-time data processing, route optimization, and smart recommendation mechanisms. Its scalable architecture supports integration with multiple charging providers, renewable energy systems, and future IoT-enabled charging technologies.

In the future, the system can be enhanced using Artificial Intelligence and Machine Learning algorithms for predictive charging recommendations based on user behavior, battery conditions, and traffic analysis. Integration with IoT sensors can further improve live charger monitoring and automated maintenance detection. Future versions may also include vehicle-to-grid (V2G) communication, renewable energy optimization, blockchain-based payment security, and support for international charging standards. These advancements will help Plugo contribute significantly toward building a smarter, greener, and more sustainable electric mobility ecosystemEmail address is compulsory for the corresponding author.

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