EV Charging Reservation and Tracker using OCPP

Aadarsh Pandey,Alokkumar Jha,Vivek Pandey and Prof. Anas Dange

Department of Artificial Intelligence and Machine Learning, Universal College of Engineering Mumbai, India

alokkumar.jha@universal.edu.in

vivek_h.pandey@universal.edu.in

aadarsh.pandey@universal.edu.in

anas.dange@universal.edu.in

***Abstract*— The EV Slot Booking app is an innovative solution designed to streamline the process of locating and reserving electric vehicle (EV) charging stations. Developed as an Android application, it leverages modern technologies such as Firebase, Google Maps API, and OpenChargeMap API to provide users with real-time access to nearby charging points. The app's core feature is its integration with the Open Charge Point Protocol (OCPP), enabling seamless communication with charging stations for booking and charging management.Users can authenticate using Firebase's secure login methods and utilize the app to search for stations, track routes, and make reservations. The booking process is completed through an intuitive interface, supported by a payment gateway integration with platforms like Razorpay and PayPal for secure transactions. Once a booking is confirmed, the app generates a QR code that users can scan at the station for validation. This EV Slot Booking app addresses the growing need for efficient charging station management in the expanding electric vehicle ecosystem. It offers a convenient and user-friendly platform for EV owners to ensure access to charging infrastructure while providing station operators with an OCPP-compliant system for handling reservations and usage. Ethical considerations, such as ensuring user data privacy and secure payment processing, are integrated into the app's design to maintain trust and security.**

***Keywords*— EV slot booking, Open Charge Point Protocol (OCPP), Firebase, Google Maps API, OpenChargeMap API, Android app, Razorpay, PayPal, electric vehicle charging stations, real-time booking.**

I. INTRODUCTION

The EV Slot Booking app is a mobile application meticulously crafted to streamline the entire experience of locating, reserving, and paying for electric vehicle (EV) charging stations, addressing a critical need in the rapidly evolving landscape of sustainable transportation. As electric vehicles surge in popularity, driven by growing environmental awareness and advancements in battery technology, the demand for an efficient, reliable, and user-friendly system to manage the expanding network of charging infrastructure has become more pressing than ever [3]. This innovative app is designed to empower EV owners by delivering real-time, location-based information about nearby charging stations, enabling them to effortlessly book available charging slots in advance, and offering secure, hassle-free payment options through trusted gateways such as Razorpay and PayPal. By integrating the Open Charge Point Protocol (OCPP), an industry-standard framework for communication between charging stations and management systems, the app ensures

compatibility and interoperability with a wide range of charging hardware [1]. Additionally, it leverages cutting-edge cloud technologies like Firebase to facilitate seamless data synchronization, real-time updates, and robust scalability, creating a smooth and responsive experience for both users and charging station operators [4]. Beyond convenience, the app also provides features such as charging station status updates, estimated wait times, and personalized user profiles, enhancing accessibility and efficiency. For operators, it offers tools to manage availability, monitor usage patterns, and optimize station performance, fostering a cohesive ecosystem that supports the growing adoption of electric vehicles. With its intuitive interface and forward-thinking design, the EV Slot Booking app stands as a pivotal solution in bridging the gap between EV drivers and the infrastructure they rely on, paving the way for a more sustainable and connected future.

II. LITERATURE REVIEW

We have thoroughly examined a diverse range of research papers within the domain of EV slot booking for our project, aiming to gain a deeper understanding of the intricacies and insights offered by the extensive studies conducted in the field of EV tracking and slot booking systems. This exploration has allowed us to analyze cutting-edge methodologies, identify prevailing trends, and uncover innovative approaches that address the challenges of managing electric vehicle charging infrastructure, ensuring our project is informed by the latest advancements and best practices in this rapidly evolving area.

A. Literature Survey

The existing systems for managing EV charging stations have been extensively explored in recent research, focusing on enhancing user experience, energy efficiency, and operational effectiveness. The study titled *"An OCPP-Based Approach for Electric Vehicle Charging Management"* [1] presents the integration of the Open Charge Point Protocol (OCPP) with photovoltaic (PV) energy optimization, demonstrating improved charging reservations and energy efficiency. The authors emphasize the benefits of combining renewable energy with standardized protocols to create a sustainable infrastructure. However, the study lacks detailed coverage of remote control methods for smart charging, which are critical for centralized monitoring, load balancing, and emergency management in advanced EV systems.

Similarly, the paper *"Electric Vehicles Charging Reservation Based on OCPP"* [2] explores how OCPP facilitates improved customer satisfaction and energy optimization. It highlights the advantages of smart scheduling and reduced waiting times, ultimately improving the user experience and boosting station efficiency. However, the paper identifies a key limitation in its pricing approach during peak hours. High pricing intended to manage congestion may deter users from making reservations, which can lead to dissatisfaction. This indicates the need for adaptive, user-focused pricing strategies that encourage usage even during high-demand periods.

The study *"Charger Reservation Web Application"* [3] introduces a user-centric, web-based platform designed to streamline the reservation of EV charging slots while promoting grid stability and clean energy integration. The system supports scheduled charging to reduce peak-time congestion and operational costs. Despite its strengths, the absence of a monetized payment gateway and dynamic pricing mechanisms restricts the platform's ability to function in real-time market environments. These limitations reduce its flexibility and commercial viability, underscoring the importance of integrating payment solutions and pricing models into future versions.

On the other hand, *"PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions"* [4] focuses on the use of solar energy to power EV charging stations. The paper outlines technical and economic prerequisites, showing that PV systems can reduce reliance on the grid, lower emissions, and cut costs, especially in rural or remote areas. However, fast charging under high demand remains a challenge due to PV's limited instant generation capability, especially during cloudy weather or at night. The intermittent nature of solar power

necessitates the use of energy storage systems, which can be expensive and space-consuming, limiting scalability. Lastly, the paper *"Real-Time Power Management Including an Optimization Problem for PV-Powered Electric Vehicle Charging Stations"* [5] offers a solution by proposing an optimization-based real-time energy management system. This system dynamically balances energy allocation based on PV availability and demand, outperforming static methods in reducing grid dependency and operational costs. It takes into account factors such as solar irradiance and pricing, making it highly suitable for smart city applications where energy efficiency is a priority. Collectively, these studies highlight the progress and challenges in EV charging infrastructure. While OCPP and PV integration offer significant improvements in efficiency and sustainability, real-world implementation still requires advances in remote control, dynamic pricing, and economic integration to ensure scalable, user-friendly, and financially viable systems.

TABLE 1: LITERATURE REVIEW

Paper no.	Paper Title	Year	Advantages	Disadvantages	Refs
1	Charger Reservation Web Application	2023	Web Application boosts grid stability, cuts costs, supports clean energy.	The software lacks a monetized payment system and dynamic pricing, with these features planned.	[10]
2	Electric vehicles charging reservation based on OCPP	2022	The optimization minimizes energy costs and maximizes PV use for EV charging, outperforming traditional storage strategies.	High PV power fluctuations may lead to suboptimal EV charging energy distribution.	[1]
3	Real-Time Power Management Including an Optimization Problem for PV-Powered Electric Vehicle	2022	The optimization minimizes energy costs and maximizes PV use for EV charging, outperforming traditional storage	High PV power fluctuations may lead to suboptimal EV charging energy distribution.	[5]

	Charging Stations		strategies.		
4	PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions	2021	Increases EV charging from PV energy and reduces grid dependency, boosting sustainability and cutting costs.	Fast charging can reduce efficiency for other EVs and increase grid dependency.	[11]
5	PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions	2021	Increases EV charging from PV energy and reduces grid dependency, boosting sustainability and cutting costs.	Fast charging can reduce efficiency for other EVs and increase grid dependency.	[7]

B. Proposed System

The proposed EV Slot Booking App is a mobile-first solution developed using Android Studio with Kotlin, replacing web-based interfaces. It enables user registration and profile creation, capturing vehicle details and charging preferences, while station operators can list stations with location, charger availability, power types, and pricing. NLP techniques analyze user profiles and station descriptions, and machine learning models predict user-station compatibility [12]. A hybrid recommendation system employing collabora- tive and content-based filtering suggests optimal stations, while AI-driven search via Elasticsearch enhances query retrieval. Sentiment analysis as- sesses feedback, and chatbots manage inquiries and bookings. Reinforcement learning improves recommendations dynamically based on real-time interac- tions [12]. To ensure data security, the system follows GDPR compliance with encryption and anonymization measures. Performance is maintained through continuous monitoring and model retraining [13]. For system im- plementation, minimum hardware requirements include an Intel i3/i5 pro- cessor, 8GB RAM, and a 256GB SSD. The software stack includes Google Maps API for location tracking, replacing Mapbox, and Retrofit or Volley for API interactions. Push notifications via Firebase Cloud Messaging (FCM) provide real-time alerts, and WebSocket communication is facilitated using Socket.IO, with Firebase Realtime Database or Firestore as an alternative for real-time synchronization. MongoDB stores user and station data, while an OCPP server manages stations, with potential API extensions for mobile- based control. The Node.js backend remains unchanged but is optimized for mobile-friendly REST APIs with JSON responses. This architecture ensures a seamless, efficient, and real-time user experience in EV slot booking.

III. METHEDOLOGY

The EV Slot Booking App adopts a structured methodology to ensure efficient operations and an intuitive user experience. It incorporates well-defined data management techniques, intuitive user interaction flows, and seamless backend integration. Data related to users, reservations, and charging stations is managed using a relational database system,

allowing quick and accurate access for real-time slot availability and booking. The user flow is designed to be simple and responsive, enabling users to locate stations on a map, check availability, and reserve slots with real-time confirmation and feedback. The app is integrated with external systems such as an OCPP server for managing charging sessions and processing payments. This integration enables real-time status updates and smooth communication between the app and charging stations. The system architecture is divided into several modules to streamline functionality: User Management handles registration, login, and profile updates; Reservation Management enables slot search and booking; Charging Station Management allows providers to update availability; and Payment Processing ensures secure and efficient transactions. Additional modules include OCPP Integration for managing charging sessions and a Reporting & Analytics module that provides insights into usage trends and system performance. Together, these methodologies and modular components provide a reliable, user-friendly platform that supports real-time EV charging slot reservations while ensuring scalability and operational efficiency.

A. System Architecture

The homepage of the EV Charging Station Reservation Web Application is designed to be both functional and visually engaging, providing users with a seamless experience from the moment they land on the site. At the top of the page, a prominent header features the application's logo, a clean navigation menu, and accessible login/registration options for users and charging station owners. Directly beneath the header, a smart search bar allows users to quickly locate nearby EV charging stations, with autocomplete functionality for improved efficiency and accuracy. The introductory section of the homepage serves as a visual highlight of the application's purpose and key features. This segment includes a brief, compelling description of the app's benefits—such as ease of use, real-time availability, and energy-efficient solutions—accompanied by a call-to-action button prompting users and providers to register or log in. The design ensures that visitors immediately understand the platform's value and are encouraged to take the next step.

Below the introductory section, users are presented with a curated list of available charging stations, displayed in an aesthetically appealing and informative layout. Each station appears as an interactive card that displays essential details including the station name, location, real-time availability, and type of charger. Users can filter these listings based on parameters such as location, availability status, and charging type, allowing for a personalized and efficient browsing experience. When a user clicks on the "View Details" button on any station card, they are taken to a dedicated page containing comprehensive information about that particular station. This includes address, operational hours, pricing details, services offered (e.g., fast charging or solar-powered units), and station-specific features. This deeper insight enables users to make informed decisions about where to charge their vehicles.

To encourage action, each station card and detail page prominently features a "Reserve Now" button, which initiates the reservation process. This button leads users through a smooth reservation flow where they can choose time slots and confirm bookings. The platform ensures secure handling of user data and transactions through backend authentication and integration with payment gateways. Finally, the homepage also includes a "Related Stations" section that intelligently suggests alternative charging stations based on the user's browsing behavior or selected station. This feature enhances user engagement by offering more options and encouraging users to explore different locations, ultimately improving the chances of successful and convenient reservations. The overall layout and functionality are crafted to support a user-friendly, responsive experience that caters to both regular EV users and station operators.

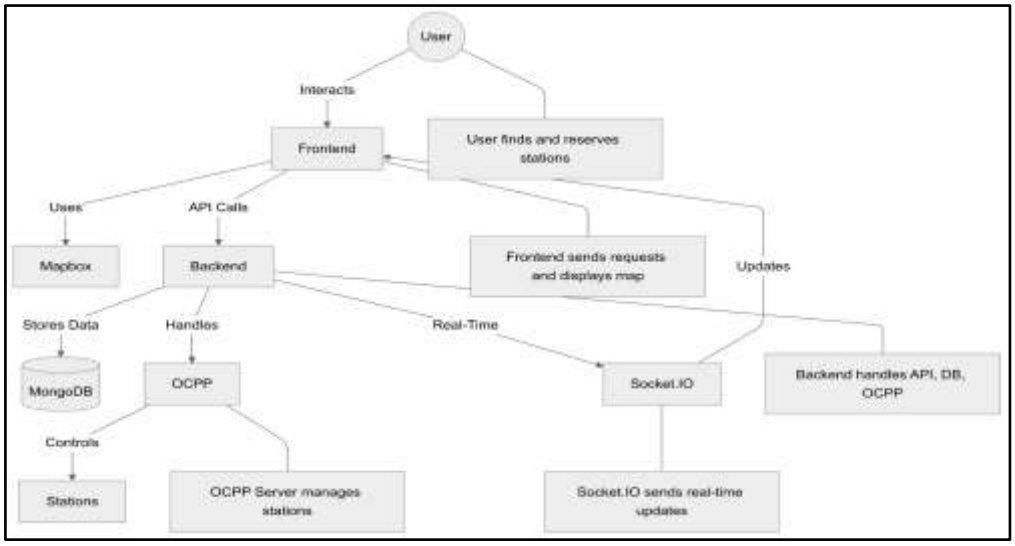

Figure 1 – System Architecture

IV. RESULTS

The registration page allows users to create an account by entering their full name and car name, email address, and password. As shown in Figure 4.1, this page is designed to provide a simple and user-friendly experience for car registering on the platform. Users are required to input their car name / username and a valid email address, which will be used for login and communication purposes. A strong password must also be set to ensure account security. Once registered, users will gain access to the app, where they can explore its features, such as booking EV charging slots or managing station profiles for station managers.

Figure 4.1 – Car Registration Page

The user login page allows registered users to access their accounts by entering their email address and password. As displayed in Figure 4.2, the login page is designed to provide a quick and secure way for users to sign in to the platform. Users need to input their registered email address and corresponding password to authenticate their identity. After successful login, users can access the app's features, such as booking EV charging slots or managing charging station profiles for station managers. The page also includes options for password recovery and creating a new account if the user has not yet registered.

Figure 4.2 User Login section

Figure 4.3 displays the map section, where users can find the location of nearby EV charging stations, track their current position, and get directions to their chosen station. The map provides real-time updates and is integrated with navigation features, allowing users to easily plan their route from their current location to the selected charging station. This functionality helps users find the most convenient charging points and ensures a smooth journey by providing step-by-step directions.

Figure 4.3 Map section

V. DISCUSSION

The development of the EV Charging Station Reservation Web Application highlights the increasing importance of intelligent, user-centric systems in addressing modern mobility challenges. By integrating features such as real-time slot booking, charging station filtering, and OCPP-based communication, the application significantly enhances the convenience and efficiency of EV charging for users. The system promotes sustainable transportation by streamlining access to charging infrastructure, encouraging more users to transition to electric vehicles. Despite its strengths, the application also presents certain challenges. These include ensuring the accuracy of real-time availability data, managing a scalable backend capable of handling growing user demands, and maintaining a secure authentication process for user data. Furthermore, integrating various modules—such as payment processing, OCPP communication, and station management—requires robust coordination to avoid service disruptions and ensure a seamless user experience. The integration of OCPP proves to be a pivotal component, allowing smooth interaction between the application and physical charging stations. This feature supports live monitoring of charging sessions, remote control, and status updates—features that are essential for modern EV infrastructure. As EV adoption increases, future improvements should aim to incorporate advanced analytics, predictive maintenance, and machine learning algorithms to forecast usage patterns and improve energy efficiency. Ultimately, the project demonstrates how web applications can contribute to solving real-world environmental and infrastructural challenges. It reflects a shift towards digitization in the electric mobility sector, offering a scalable, adaptable, and user-friendly platform that can evolve with the growing needs of users and charging station providers alike.

VI. CONCLUSION

In conclusion, the EV Slot Booking App project represents a significant advancement in the convenience and efficiency of electric vehicle charging so- lutions. By integrating user-friendly interfaces, real-time data management, and seamless connectivity with charging infrastructure, the app addresses the growing need for accessible charging options in a rapidly expanding elec- tric vehicle market. Through meticulous planning, comprehensive module design, and robust backend systems, the project successfully meets user de- mands while optimizing resource management for charging station operators. As we move forward, this application not only promotes sustainable trans- portation but also paves the way for future innovations in the realm of electric mobility, ultimately contributing to a greener and more efficient future.

ACKOWLEDGEMENT

I would like to express my sincere gratitude to my project guide and faculty members for their valuable support, technical guidance, and continuous encouragement throughout the development of this project. Their expertise and feedback played a significant role in shaping the direction and quality of this work. I am also thankful to my peers and collaborators for their insightful discussions, teamwork, and help during the design, coding, and testing phases. Their input and cooperation made the development process more efficient and enriching. A special thanks goes to the developers and contributors of open-source tools and libraries that were instrumental in building the web application, including the OCPP protocol, React framework, and other technologies that made the project possible. Lastly, I extend heartfelt thanks to my family and friends for their unwavering support, motivation, and understanding during the course of this project. Their belief in me served as a constant source of inspiration and strength.

REFERENCES

[1] Hsaini, S.; Ghogho, M.; Charaf, M.E.H. An OCPP-Based Approach for Electric Vehicle Charging Management. Energies 2022, 15, 6735. https://doi.org/10.3390/ en15186735

[2] Clemente, M., Fanti, M.P., & Ukovich, W. (2014). Smart Management of Electric Vehicles Charging Operations: the Vehicle-to-Charging Station Assignment Problem. *IFAC Proceedings Volumes, 47*, 918-923.

[3] Bernal, R.; Olivares, D.; Negrete-Pincetic, M.; Lorca, Á. Management of EV charging stations under advance reservations schemes in electricity markets. Sustain. Energy Grids Netw. 2020, 24, 100388.

[4] Bedogni, L.; Bononi, L.; D'Elia, A.; Di Felice, M.; Rondelli, S.; Cinotti, T.S. A mobile application to assist electric vehicles' drivers with charging services. In Proceedings of the 2014 8th International Conference on Next Generation Mobile Applications, Services and Technologies, NGMAST 2014, Washington, DC, USA, 10–12 September 2014; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2014, pp. 78–83.

[5] Cheikh-Mohamad, S.; Sechilariu, M.; Locment, F. Real-Time Power Management Including an Optimization Problem for PV-Powered Electric Vehicle Charging Stations. Appl. Sci. 2022, 12, 4323.

[6]Cheikh-Mohamad, S.; Sechilariu, M.; Locment, F.; Krim, Y. Pv-powered electric vehicle charging stations: Preliminary require ments and feasibility conditions. Appl. Sci. 2021, 11, 1770.

[7] Clemente, M.; Fanti, M.P.; Ukovich, W. Smart management of electric vehicles charging operations: The vehicle-to-charging station assignment problem. In Proceedings of the IFAC, Cape Town, South Africa, 24–29 August 2014; Volume 19.

[8] Ravindran, S.; Amal, S.; Bhavya, Y.V.; Chandrasekar, V. OCPP based Electric Vehicle Supply Equipment and its user interface for ACcharging in Indian scenario. In Proceedings of the 2020 IEEE 17th India Council International Conference (INDICON), New Delhi, India, 10–13 December 2020; pp. 1–6.

[9] Bedogni, L.; Bononi, L.; D'Elia, A.; Di Felice, M.; Rondelli, S.; Cinotti, T.S. A mobile application to assist electric vehicles' drivers with charging services. In Proceedings of the 2014 8th International Conference on Next Generation Mobile Applications, Services and Technologies, NGMAST 2014, Washington, DC, USA, 10–12 September 2014; Institute of Electrical and Electronics Engineers Inc.: Piscataway, NJ, USA, 2014, pp. 78–83.

[10] Anderson, R., Anderson, J., Anderson, T., & Harper, M. (2023). Charger reservation web application. *Software Impacts*, *18*, 100589. https://doi.org/10.1016/j.simpa.2023.100589

[11] Cheikh-Mohamad, S., Sechilariu, M., Locment, F., & Krim, Y. (2021). PV-Powered Electric Vehicle charging Stations: Preliminary requirements and feasibility conditions. *Applied Sciences*, *11*(4), 1770. https://doi.org/10.3390/app11041770

The existing systems for managing EV charging stations have been extensively explored in recent research, focusing on enhancing user experience, energy efficiency, and operational effectiveness. The study titled *"An OCPP-Based Approach for Electric Vehicle Charging Management"* [1] presents the integration of the Open Charge Point Protocol (OCPP) with photovoltaic (PV) energy optimization, demonstrating improved charging reservations and energy efficiency. The authors emphasize the benefits of combining renewable energy with standardized protocols to create a sustainable infrastructure.

However, the study lacks detailed coverage of remote control methods for smart charging, which are critical for centralized monitoring, load balancing, and emergency management in advanced EV systems.

Similarly, the paper *"Electric Vehicles Charging Reservation Based on OCPP"* [2] explores how OCPP facilitates improved customer satisfaction and energy optimization. It highlights the advantages of smart scheduling and reduced waiting times, ultimately improving the user experience and boosting station efficiency. However, the paper identifies a key limitation in its pricing approach during peak hours. High pricing intended to manage congestion may deter users from making reservations, which can lead to dissatisfaction. This indicates the need for adaptive, user-focused pricing strategies that encourage usage even during high-demand periods.

The study *"Charger Reservation Web Application"* [3] introduces a user-centric, web-based platform designed to streamline the reservation of EV charging slots while promoting grid stability and clean energy integration. The system supports scheduled charging to reduce peak-time congestion and operational costs. Despite its strengths, the absence of a monetized payment gateway and dynamic pricing mechanisms restricts the platform's ability to function in real-time market environments. These limitations reduce its flexibility and commercial viability, underscoring the importance of integrating payment solutions and pricing models into future versions.

On the other hand, *"PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions"* [4] focuses on the use of solar energy to power EV charging stations. The paper outlines technical and economic prerequisites, showing that PV systems can reduce reliance on the grid, lower emissions, and cut costs, especially in rural or remote areas. However, fast charging under high demand remains a challenge due to PV's limited instant generation capability, especially during cloudy weather or at night. The intermittent nature of solar power necessitates the use of energy storage systems, which can be expensive and space-consuming, limiting scalability.

Lastly, the paper *"Real-Time Power Management Including an Optimization Problem for PV-Powered Electric Vehicle Charging Stations"* [5] offers a solution by proposing an optimization-based real-time energy management system. This system dynamically balances energy allocation based on PV availability and demand, outperforming static methods in reducing grid dependency and operational costs. It takes into account factors such as solar irradiance and pricing, making it highly suitable for smart city applications where energy efficiency is a priority.

Collectively, these studies highlight the progress and challenges in EV charging infrastructure. While OCPP and PV integration offer significant improvements in efficiency and sustainability, real-world implementation still requires advances in remote control, dynamic pricing, and economic integration to ensure scalable, user-friendly, and financially viable systems.