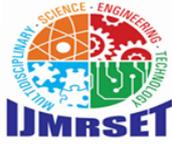# International Journal of Multidisciplinary
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EV Charging Station and Slot Booking Application

Keerthana J, Prof. Gunasekaran K

Student, Department of MCA, AMC Engineering College, Bengaluru, India

Assistant Professor, Department of MCA, AMC Engineering College, Bengaluru, India

ABSTRACT: The increasing adoption of electric vehicles (EVs) has emphasized the need for intelligent charging infrastructure capable of efficiently managing charging demand and reducing user inconvenience. Conventional EV charging systems often lack real-time monitoring, prior slot reservation facilities, and centralized management, leading to long waiting times, underutilization of resources, and poor user experience. This paper proposes an **Electric Vehicle Charging Station Locator and Slot Booking Application** designed to provide a smart, user-centric solution for EV charging management. The proposed system allows users to identify nearby charging stations using **location-based services**, check real-time slot availability, and book charging slots in advance through a mobile application.

The application is developed using the **Android platform with Kotlin/WEB**, while **Firebase Cloud Services** are employed to handle user authentication, data storage, and real-time synchronization of booking information. An administrative module enables charging station operators to manage station details, charging slots, and user bookings effectively. The system architecture ensures scalability, data consistency, and secure access control. Performance evaluation of the implemented system indicates a significant reduction in charging wait times, improved utilization of charging stations, and enhanced operational efficiency compared to traditional walk-in charging models. The proposed solution supports the advancement of smart transportation systems and contributes toward the development of sustainable and intelligent urban mobility infrastructure.

I. INTRODUCTION

The global transition from conventional fossil fuel–based transportation to electric vehicles (EVs) has gained significant momentum due to increasing environmental concerns, rising fuel costs, and supportive government policies. Electric vehicles offer a sustainable alternative by reducing greenhouse gas emissions and dependence on non-renewable energy resources. As a result, the adoption of EVs has increased rapidly, particularly in urban regions, creating a growing demand for efficient and reliable EV charging infrastructure.

Despite advancements in EV technology, charging infrastructure management remains a critical challenge. Limited availability of charging stations, uneven geographical distribution, lack of real-time information, and long waiting times are common issues faced by EV users. In many existing systems, users must physically visit charging stations without prior knowledge of slot availability, often resulting in congestion, inefficient utilization of resources, and user dissatisfaction. These challenges highlight the necessity for intelligent systems that can streamline the charging process and improve user experience.

With the widespread use of smartphones and advancements in mobile application development, digital solutions have emerged as an effective approach to address infrastructure management problems. Mobile-based EV charging applications can provide real-time station information, navigation assistance, and remote booking facilities, enabling users to plan charging activities efficiently. Integrating cloud computing and real-time databases further enhances system scalability, data reliability, and accessibility.

This paper presents an **Electric Vehicle Charging Station Locator and Slot Booking Application** designed to overcome the limitations of traditional charging systems. The proposed application enables users to locate nearby charging stations using location-based services, view real-time charging slot availability, and reserve slots in advance through a user-friendly mobile interface. The system is developed on the **Android platform using Kotlin**, with **Firebase** serving as the backend for authentication, data storage, and real-time synchronization. Additionally, an admin
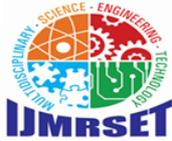
module is incorporated to allow charging station operators to manage station details, monitor bookings, and dynamically update slot availability.

The proposed system aims to reduce waiting time at charging stations, optimize resource utilization, and enhance operational efficiency. By providing a structured and automated booking mechanism, the application contributes to the development of smart transportation systems and supports sustainable urban mobility. The implementation and evaluation of the system demonstrate its potential to improve the overall EV charging experience for both users and service providers.

II. ARCHITECTURE IN WEBSITE

The proposed EV Charging Station and Slot Booking system employs a cloud-based, multi-layer web architecture designed to support real-time charging management, secure access, and scalable deployment. The architecture consists of a presentation layer, application layer, and data layer working cohesively to deliver seamless system functionality. The presentation layer is developed using responsive web technologies such as HTML, CSS, and JavaScript, providing role-based interfaces for EV users and administrators to access station information, real-time slot availability, and booking services. The application layer handles core business logic including station discovery, slot allocation, booking validation, and conflict prevention, while also integrating location-based services for navigation. Backend services are implemented using Firebase cloud infrastructure to provide authentication, authorization, and real-time event handling for booking updates. The data layer utilizes a cloud-hosted NoSQL database to store user profiles, charging station details, slot schedules, and booking records, ensuring consistency and high availability. This architecture enables efficient utilization of charging resources, minimizes waiting time, supports concurrent users, and provides centralized monitoring and management of EV charging operations.

III. RELATED WORK

Recent research on electric vehicle charging infrastructure highlights the growing need for intelligent systems that can manage charging demand, reduce waiting time, and improve user experience. Early studies on EV charging primarily focused on static station locators and manual queue-based charging mechanisms, which lacked real-time availability updates and advance reservation capabilities. Subsequent works introduced mobile and web-based applications that integrated map services to locate nearby charging stations; however, many of these systems provided limited functionality and did not address slot conflict management or backend scalability. With the advancement of cloud computing, several studies proposed centralized platforms using cloud databases to monitor charging station status and user activity, improving data accessibility and system reliability. More recent research has explored real-time slot booking, IoT-enabled chargers, and smart grid integration to optimize energy distribution and charging efficiency. Despite these advancements, existing solutions often suffer from challenges such as poor scalability, lack of role-based management, and limited administrative control over station operations. Furthermore, many commercial solutions remain proprietary, with minimal academic exploration of customizable, cloud-native architectures for EV charging systems. The proposed system addresses these gaps by providing a scalable, real-time, and role-based web application that integrates charging station discovery, slot booking, and centralized administration within a unified platform.

IV. METHODOLOGY

The development of the EV Charging Station and Slot Booking Application follows a systematic, design-oriented methodology aimed at solving real-world challenges associated with EV charging management. The process begins with problem identification through the analysis of existing EV charging practices, highlighting issues such as lack of real-time slot visibility, inefficient manual booking, and poor utilization of charging resources. Functional and non-functional requirements are then gathered to define system objectives, including scalability, real-time data synchronization, and secure access. Based on these requirements, a web-based system architecture is designed using a multi-layer cloud model, integrating a responsive user interface, centralized business logic, and a cloud-hosted database. The system is implemented using modern web technologies and cloud services to enable real-time station discovery, slot reservation, and administrative management. Finally, the developed application is tested and evaluated for functionality, performance, and reliability to ensure accurate slot allocation, reduced waiting time, and improved operational efficiency, thereby validating the effectiveness of the proposed approach.
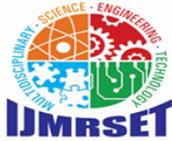
Figure 1: Flow Diagram of Architecture.
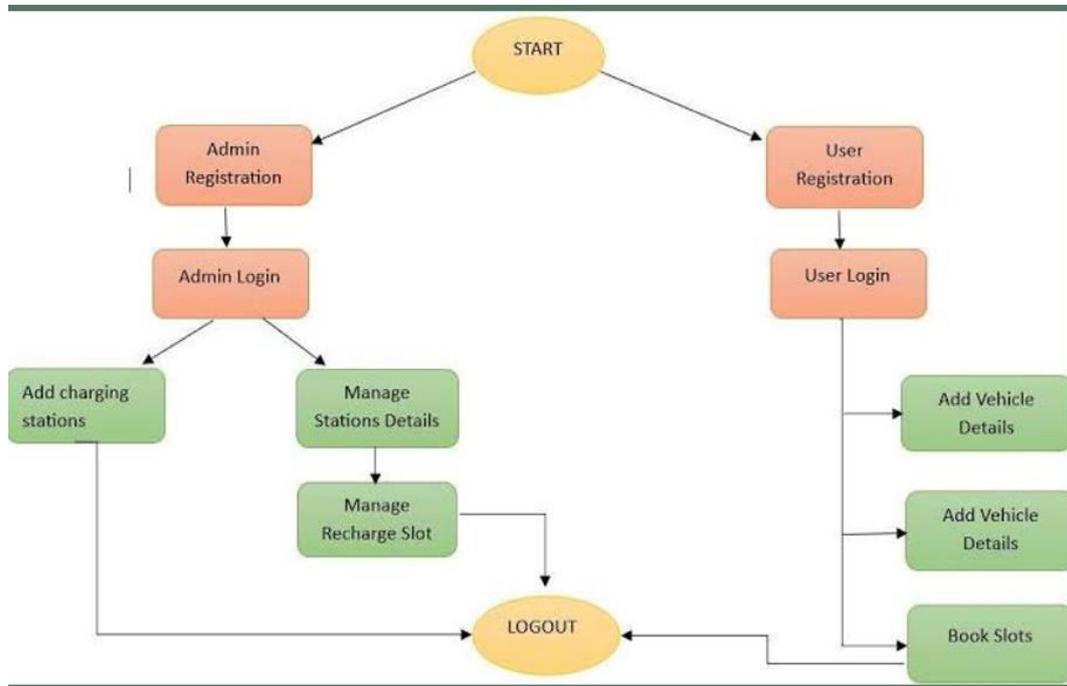
IV.1. Problem Identification & Requirements Analysis: The initial phase of this work focuses on identifying the key challenges associated with existing electric vehicle charging systems and defining the requirements for an improved solution. A review of current EV charging practices reveals several limitations, including the absence of real-time slot availability information, reliance on walk-in charging methods, inefficient utilization of charging infrastructure, and lack of centralized management for station operators. These issues often lead to increased waiting times, user inconvenience, and operational inefficiencies. To address these challenges, functional requirements such as user registration, location-based charging station discovery, real-time slot availability display, advance slot booking, booking cancellation, and administrative control over station and slot management are identified. Additionally, non-functional requirements including system scalability, data consistency, security, real-time synchronization, and high availability are considered essential to support concurrent users and growing charging demand. This requirements analysis provides a structured foundation for designing a robust, cloud-based EV charging station and slot booking system that effectively improves user experience and optimizes charging resource utilization.

IV.2. Architectural Design -(The Proposed Artifact) : The proposed artifact is designed as a cloud-native, multi-tier web-based architecture that enables efficient management of electric vehicle charging stations and real-time slot booking. The architecture adopts a layered design comprising a responsive presentation layer for user and administrator interaction, an application layer responsible for implementing core business logic such as station discovery, slot allocation, booking validation, and conflict resolution, and a data layer that ensures reliable and scalable storage of system data. Location-based services are integrated into the application layer to support interactive map-based station visualization and navigation. Cloud services are employed to handle authentication, authorization, and real-time event processing, enabling instant updates of slot availability across all connected users. A centralized administrative interface allows operators to manage charging stations, configure slots, and monitor system usage. This architectural design ensures scalability, real-time responsiveness, secure role-based access, and efficient utilization of charging infrastructure, making it suitable for large-scale deployment in urban environments.

IV.3. Technology Stack & Development Environment: The proposed EV Charging Station and Slot Booking system is developed using a modern, cloud-oriented technology stack to ensure scalability, reliability, and real-time performance. The web interface is built using standard front-end technologies such as HTML, CSS, and JavaScript, providing a responsive and user-friendly experience across devices. The backend services are implemented using

Firebase Cloud Services, which handle user authentication, role-based access control, and real-time data synchronization. Firebase Firestore, a NoSQL cloud database, is used to store charging station details, slot schedules, user profiles, and booking records, enabling concurrent access with high availability. Location-based functionality is supported through map service integration for station visualization and navigation. The development environment utilizes modular coding practices and cloud-hosted infrastructure to simplify deployment and maintenance. This technology stack enables rapid development, seamless integration between system components, and efficient management of EV charging operations in a real-world setting.

IV.4. Prototype development & module implementation: The prototype of the EV Charging Station and Slot Booking Application was developed as a functional web-based system to validate the proposed architecture and demonstrate key system capabilities. The implementation focused on core modules, including user authentication, charging station management, real-time slot availability, and booking processing. The user module enables EV owners to register, log in, search for nearby charging stations, view available slots, and reserve or cancel charging sessions. The admin module provides functionality to add and manage charging stations, configure charging slots, and monitor booking activity. Real-time data synchronization ensures that slot availability is instantly updated upon booking confirmation or cancellation, preventing conflicts and duplicate reservations. The prototype was developed incrementally, allowing continuous testing and refinement of individual modules, thereby demonstrating the feasibility, usability, and effectiveness of the proposed system in managing EV charging operations.

IV.5. System Integration & API Testing: System integration was carried out to ensure seamless interaction between the user interface, application logic, and cloud-based backend services of the EV Charging Station and Slot Booking system. All system components communicate through well-defined APIs that manage user authentication, charging station data retrieval, slot availability updates, and booking transactions. Integration testing was performed to verify correct data flow between modules, ensuring that booking requests, confirmations, and cancellations were accurately reflected in real time across the system. API testing validated request handling, response accuracy, and error management under various scenarios, confirming consistent behavior during concurrent user access. This phase ensured reliable interoperability between system components and maintained data consistency throughout the application.

IV.6. Performance & Load Evaluation: Performance and load evaluation were conducted to assess the system's responsiveness, scalability, and reliability under varying usage conditions. Simulated user interactions were used to evaluate key performance metrics such as response time, booking confirmation latency, and system stability during peak usage. The cloud-based backend and real-time database effectively handled multiple concurrent users accessing station data and booking slots without significant performance degradation. The evaluation demonstrated that the system could scale dynamically to accommodate increased demand, maintaining acceptable response times and ensuring uninterrupted access to charging services, making it suitable for real-world deployment in urban environments.

IV.7. Security & Validation Framework: Security and validation were integrated at multiple levels of the EV charging system to protect user data and ensure authorized access. Secure authentication mechanisms were implemented to verify user identities, while role-based access control restricted system operations based on user roles such as EV user and administrator. Data validation checks were applied during booking transactions to prevent invalid or conflicting requests. Additionally, security testing was conducted to identify potential vulnerabilities related to unauthorized access and data manipulation. The validation framework confirmed that the system adhered to essential security requirements, ensuring data integrity, confidentiality, and reliable operation of the EV Charging Station and Slot Booking Application.

V. DETAILED OVERVIEW OF PAGES IN College ERP SYSTEM

1. Login Page:
The Login Page provides secure access to the EV Charging Station and Slot Booking Application through user authentication. Registered users can log in using their email and password, while new users are directed to the registration page for account creation. Upon successful authentication, users are redirected to their respective dashboards to access charging station informaton and booking features. This page ensures secure and controlled access to the system.

Figure 2: Login page
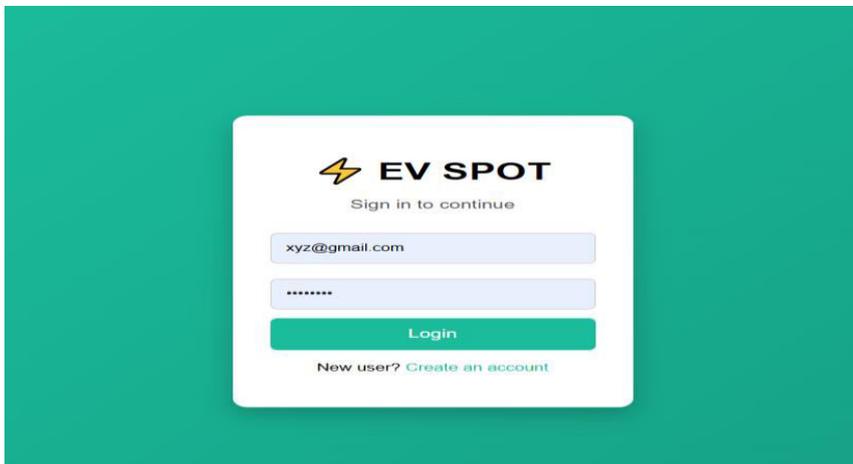
2. Register Page:

The Registration Page enables new users to create an account in the EV Charging Station and Slot Booking Application. Users are required to provide basic details such as name, email address, and password to complete the registration process. Upon successful account creation, users can log in and access system features including charging station search and slot booking. This page supports secure onboarding and ensures authorized user participation in the system.

Figure 3: Register page
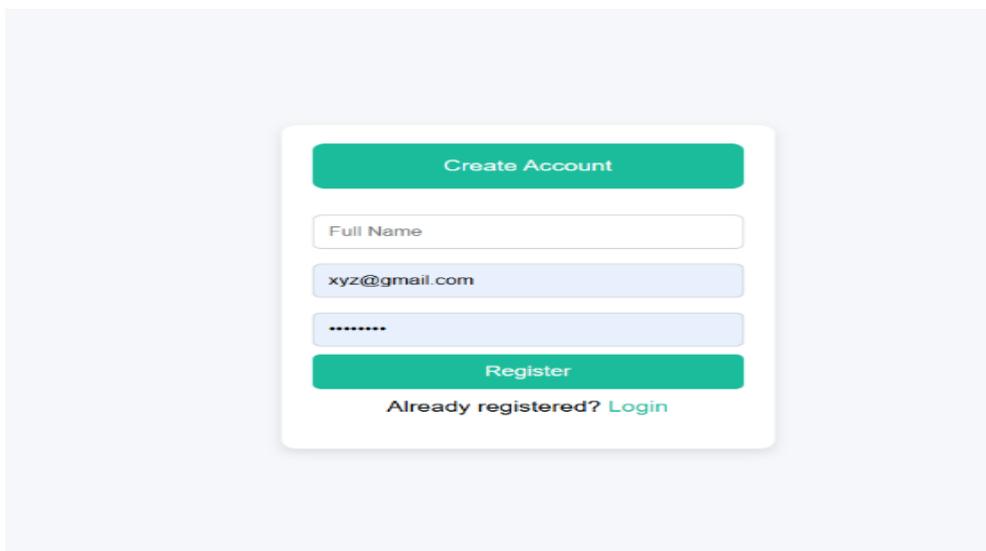
3.Dashboard page:

The User Dashboard Page acts as the central interface for authenticated users of the EV Charging Station and Slot Booking Application. It displays the logged-in user details and provides quick access to core functionalities such as viewing available charging stations and managing sessions. The dashboard also includes a logout option to ensure secure session handling. This page improves usability by offering a centralized and organized entry point for user operations.

Figure 4: dashboard page
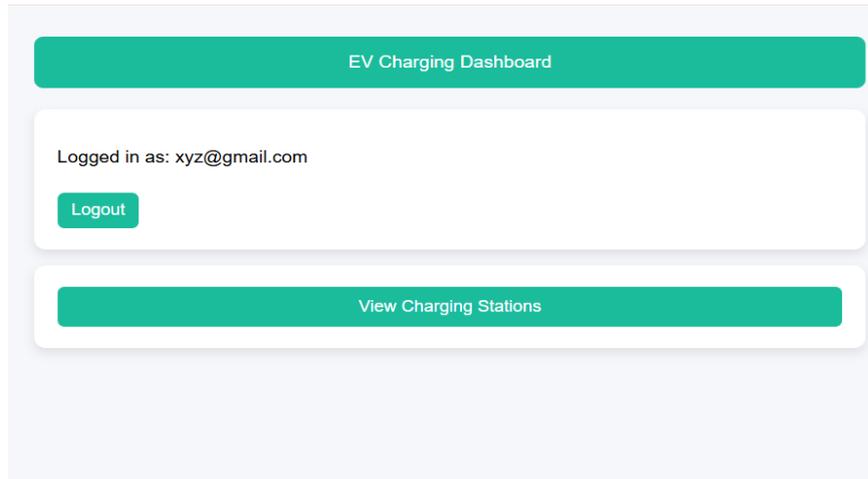
4. Charging Station page:

 The Charging Stations Page displays a list of available EV charging stations along with their geographic locations using an interactive map. Users can view station details such as location, number of available slots, and charging price. The page also provides options for navigation and slot booking, enabling users to easily select a preferred charging station. This page enhances user convenience by combining location-based visualization with real-time charging information.

Figure5: charging station pages
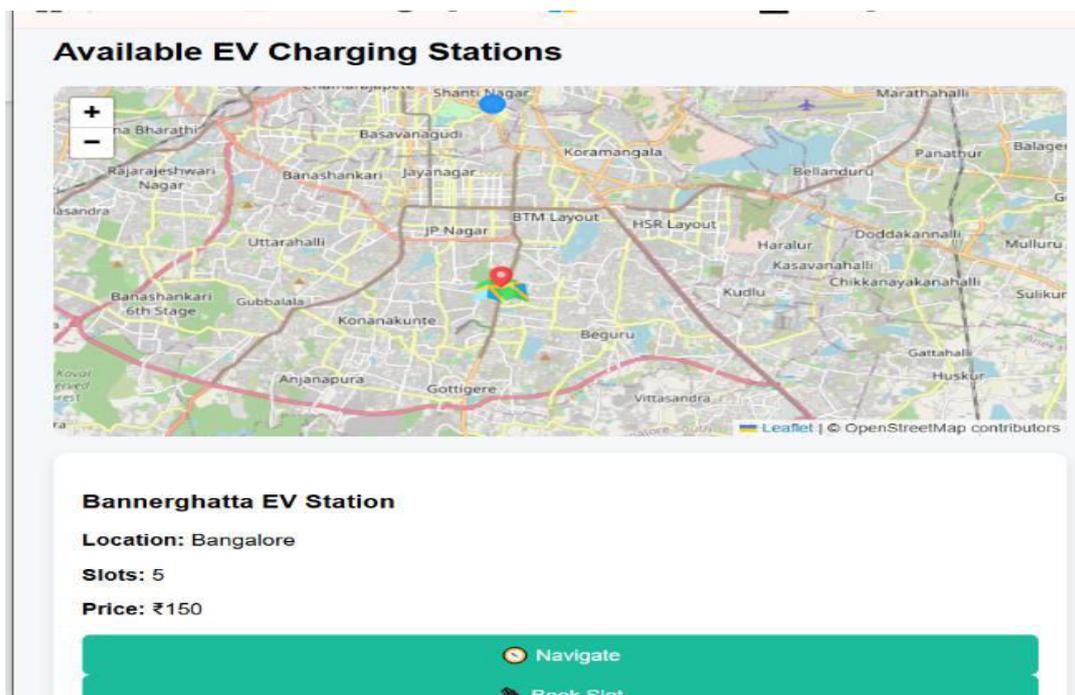
5. Slot Booking Page:

The Slot Booking Page allows users to reserve an EV charging slot at a selected charging station. It displays station details such as location and pricing, and enables users to choose a preferred date and time for charging. Upon confirmation, the booking is processed and stored in the system. This page ensures efficient scheduling and helps reduce waiting time at charging stations.

Figure 6: Slot booking page

6. Amin dashboard Page:

The Admin Dashboard Page provides centralized control and monitoring of the EV Charging Station and Slot Booking Application. It displays registered user details, charging station information, and booking records in a structured format. Administrators can monitor slot usage, booking status, and station details to ensure smooth system operation. This page supports effective management and oversight of the EV charging infrastructure.

Figure 7: Admin Dashboard

VI. FUTURE UPDATES

Future enhancements of the EV Charging Station and Slot Booking Application will focus on improving intelligence, scalability, and user experience. Planned updates include the integration of real-time IoT-enabled charging stations for automatic status monitoring, AI-based demand prediction for optimized slot allocation, and support for online payment gateways. The system can be extended with a mobile application, smart grid integration for energy management, and notification services for booking reminders. These enhancements aim to make the system more efficient, intelligent, and suitable for large-scale smart city deployments.

VII. CONCLUSION

This paper presented the design and implementation of an EV Charging Station and Slot Booking Application aimed at improving the efficiency and accessibility of EV charging infrastructure. The proposed system provides real-time charging station information, advance slot booking, and centralized administrative control through a cloud-based web platform. By reducing waiting time and optimizing charging resource utilization, the application enhances user convenience and operational efficiency. The system demonstrates the practical feasibility of integrating location-based services and real-time data management to support sustainable and smart transportation solutions.

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