

EV Charging Station Finder and Slot Booking Application

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Abstract - The EV Station Finder and Slot Booking System is a mobile application developed to assist electric vehicle users in locating nearby charging stations and booking charging slots in advance. With the rapid growth of electric vehicles, finding available charging stations and waiting in queues has become a common challenge. The proposed application provides a centralized platform where users can search for nearby EV charging stations based on location, view real-time availability, and reserve charging slots conveniently. Station owners or administrators can manage slot availability, monitor usage, and update station details. The system ensures efficient utilization of charging infrastructure through real-time updates and automated booking management. By integrating location tracking, slot reservation, and user notifications into a single mobile platform, the application reduces waiting time, improves accessibility, enhances user convenience, and supports the adoption of electric vehicles.

Keywords Electric Vehicle, EV Charging Station, Slot Booking, Mobile Application, Location Tracking, Smart Transportation, Real-time Availability

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has created a significant demand for efficient and accessible charging infrastructure. However, EV users often face challenges such as difficulty in locating nearby charging stations, lack of real-time availability information, long waiting times, and range anxiety due to limited battery capacity. These issues highlight the need for a smart and reliable system to manage EV charging efficiently.

To overcome these challenges, the proposed EV Station Finder and Slot Booking System is developed as a mobile application that provides a user-friendly and efficient solution. The application uses GPS and location-based services to help users find nearby charging stations and view real-time slot availability. Users can also book charging slots in advance, reducing waiting time and improving travel planning.

The system also enables station administrators to manage

charging slots, monitor usage, and update station details through a centralized platform. By integrating real-time database management, location tracking, and automated booking features, the application ensures efficient utilization of charging infrastructure.

The main objective of this system is to reduce waiting time, improve accessibility of charging stations, and enhance user convenience. Furthermore, it supports the development of smart transportation systems and promotes the adoption of eco-friendly electric vehicles.

II. METHODOLOGY

The proposed EV Station Finder and Slot Booking System is designed as a centralized mobile application to simplify the process of locating electric vehicle charging stations and managing slot reservations. The workflow begins with user authentication, followed by location-based station search, real-time slot availability checking, and slot booking. The system also includes payment processing (if applicable), booking confirmation, and notification services, forming a complete end-to-end EV charging management system.

The application utilizes GPS and location-based services to identify nearby charging stations and display them to users. Real-time database integration ensures that slot availability is updated dynamically, allowing users to make accurate booking decisions. Once a slot is selected, the system processes the booking and updates the availability status immediately.

Additionally, the system provides an administrative module where station owners can manage charging slots, monitor usage, and update station information. Notifications and alerts are sent to users regarding booking status, reminders, and cancellations, improving overall user experience.

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A. Requirement Analysis and System Design

The initial phase of the system development focuses on identifying the core functional requirements of the EV Station Finder and Slot Booking System. The application is designed to provide an efficient solution for locating EV charging stations and managing slot reservations.

The primary modules of the system include EV station search, real-time slot availability tracking, slot booking, user notifications, and administrative management. These modules work together to ensure a smooth and seamless user experience.

The system defines two main user roles: User (EV owner) and Administrator (station owner). The user is responsible for searching nearby charging stations, checking slot availability, and booking slots. The administrator manages station details, updates slot availability, and monitors overall system usage. A role-based access control mechanism is implemented to ensure secure and restricted access to system functionalities.

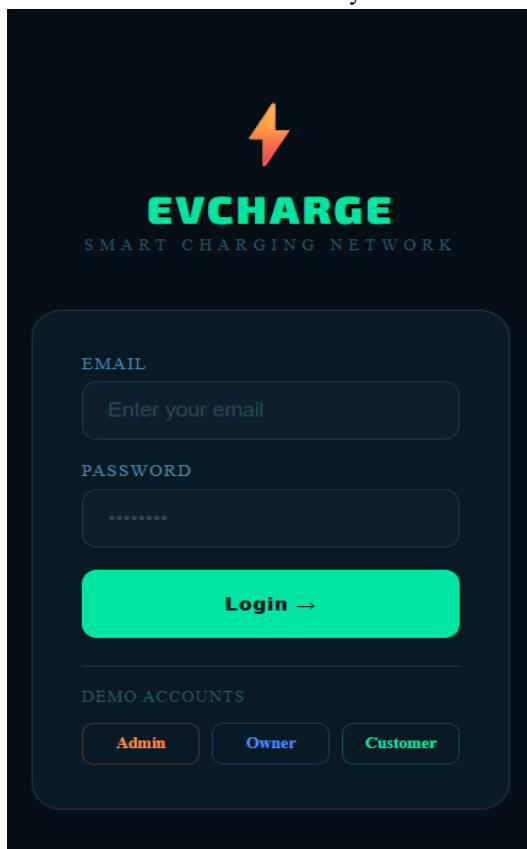


Figure 1: User Authentication Interface of the EV Charging Finder and Slot booking

A. Frontend Development Using React JS

The frontend of the EV Station Finder and Slot Booking System is developed using React JS to provide a dynamic, responsive, and user-friendly interface. React JS enables the creation of reusable components and ensures efficient rendering, which enhances overall application performance and user experience.

Separate dashboards are designed for Users (EV owners) and Administrators (station owners). The user interface allows EV owners to search for nearby charging stations, view real-time slot availability, and book charging slots easily. The administrator interface enables station owners to manage station details, update slot availability, and monitor booking activities.

React components and state management techniques are used to ensure smooth navigation and seamless interaction between different modules. Additionally, APIs are integrated to fetch real-time data from the backend, ensuring that users receive up-to-date information about station availability and bookings.

The responsive design ensures that the application works efficiently across different devices, providing accessibility and convenience to users.

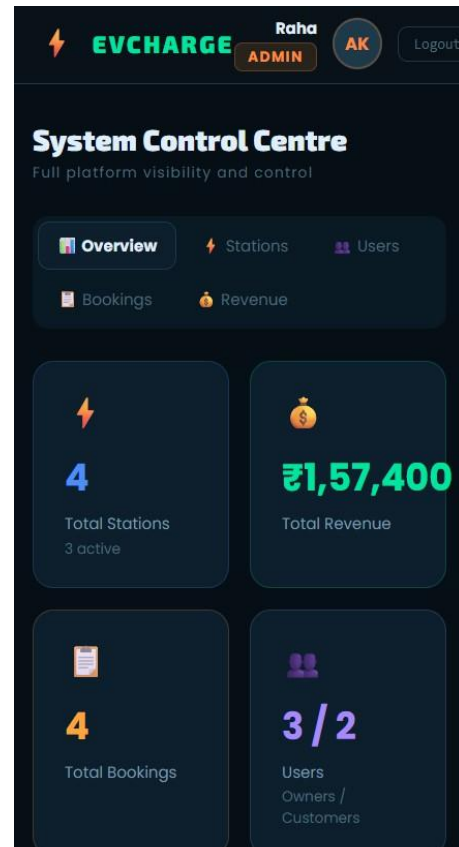


Figure 2: Admin Dashboard

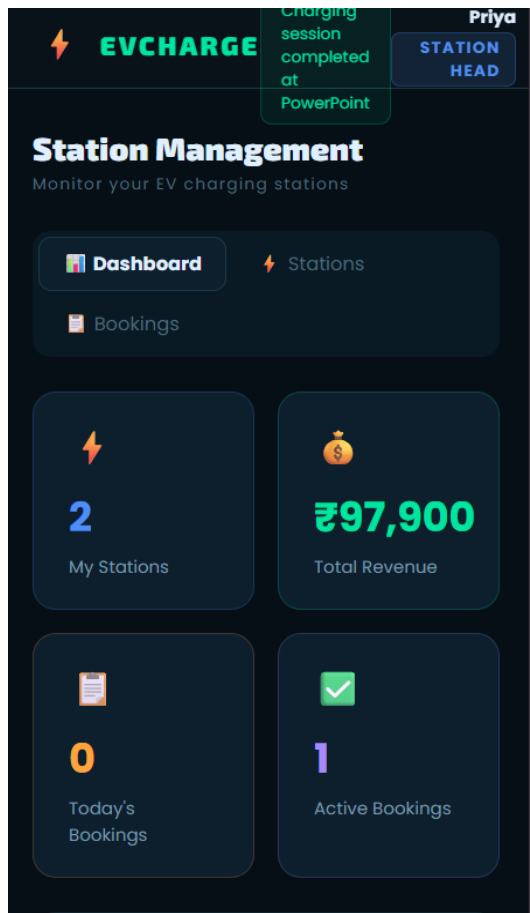


Figure 3: Resident Dashboard

C. Backend Integration with MongoDB

The backend of the EV Station Finder and Slot Booking System is implemented using MongoDB as the primary database for data storage and management. MongoDB, a NoSQL database, is used to efficiently store and handle large volumes of data such as user information, EV station details, slot availability, and booking records.

User authentication and authorization are managed through secure APIs, ensuring role-based access for Users (EV owners) and Administrators (station owners). The backend is developed using Node.js and Express, which handle client requests, process booking operations, and communicate with the MongoDB database.

MongoDB collections are structured to store user profiles, charging station data, slot schedules, and booking history. Real-time updates are managed through API calls, ensuring that slot availability and booking status are accurately reflected across the system.

The integration of MongoDB with the backend ensures scalability, flexibility, and efficient data management. It

also supports fast query processing,

enabling users to quickly search for nearby charging stations and make bookings without delay.

D. Slot Booking and Payment Processing

The EV Station Finder and Slot Booking System provides an automated mechanism for managing charging slot reservations and payments. Users can view real-time slot availability and book preferred slots through the application. The system calculates the charging cost based on predefined tariff rates and displays the total amount before confirmation. A secure payment gateway is integrated to enable online transactions. Upon successful payment, booking details are stored in the database, and slot availability is updated instantly to avoid conflicts. Notifications are also sent to users regarding booking and payment status.



Figure 4: Customer slot booking

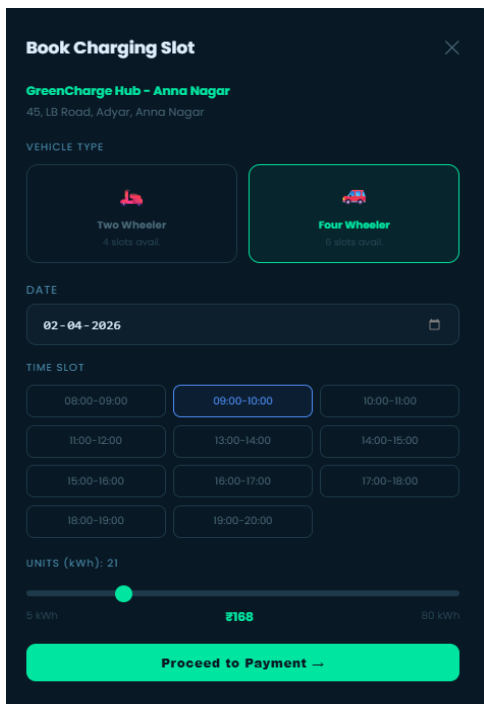


Figure 5: Slot Finding and booking

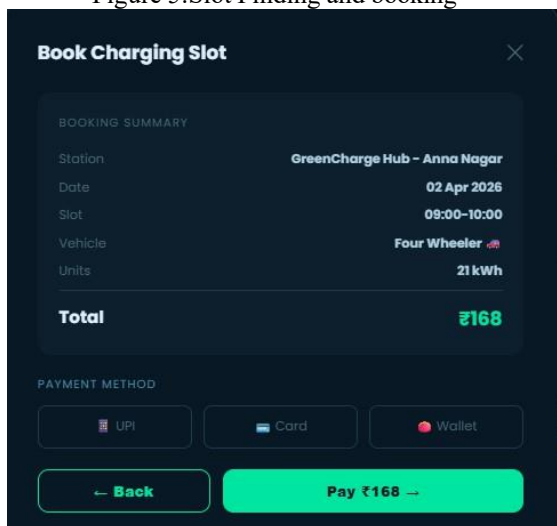


Figure 6: Bill Payment Interface Showing Charges and Successful Transaction Status of the Owner

E. Booking Management

The system includes a booking and feedback management module where users can view their booking history and provide feedback regarding charging stations and services. Each booking and feedback entry is stored in the database with relevant details such as time, status, and user input. Administrators can monitor bookings, review user feedback, and take necessary actions to improve service quality. This module ensures better user interaction, service optimization, and efficient management of charging station operations.

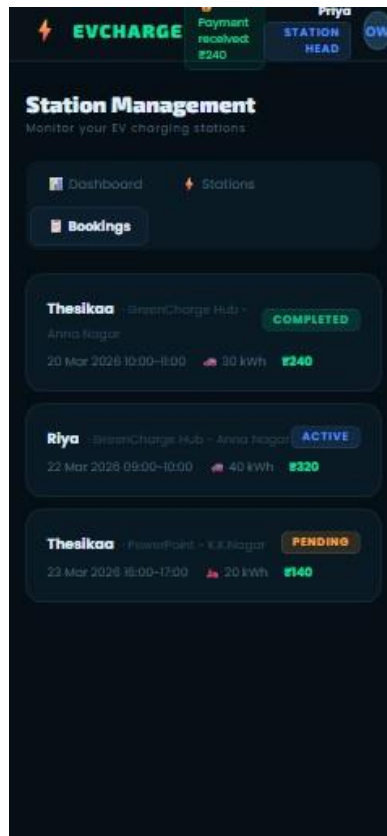


Figure 7: Admin Service Booking Management Screens

F. Testing and Deployment

Functional testing was conducted to verify user authentication, slot booking accuracy, payment processing reliability, and database consistency. Real-time slot availability updates and error handling mechanisms were tested under simulated user conditions to ensure system reliability. After successful validation, the application was deployed for operational use, ensuring stable performance and scalability in real-world EV charging environments.

III. SYSTEM ARCHITECTURE

The EV Station Finder and Slot Booking System follows a client-server architecture designed to ensure scalability, real-time data processing, and secure communication. The system consists of three primary components: the frontend application (developed using React JS), the backend server (implemented using Node.js and Express), and the MongoDB database for data storage and management. These components interact to provide a seamless end-to-end EV charging and booking solution.

The frontend application acts as the user interface, allowing users to search for nearby charging stations, view slot availability, and book charging.

slots. The backend server processes user requests, handles business logic, and communicates with the MongoDB database to store and retrieve data such as user details, station information, and booking records.

Additionally, a secure payment gateway is integrated into the system to facilitate online transactions. Real-time updates are managed through API communication, ensuring accurate slot availability and preventing booking conflicts. This architecture ensures efficient system performance, data consistency, and a reliable user experience.

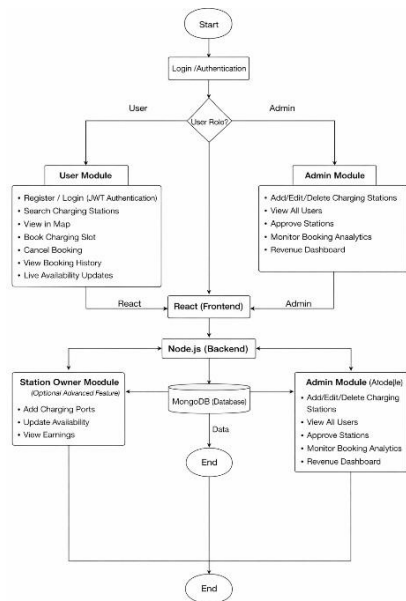


Figure 8: Overall System Architecture and Process Flow

A. Client Layer – Mobile Application

The client layer is developed using React JS, providing a responsive and dynamic user interface for both web and mobile platforms. The application offers separate dashboards for Users (EV owners) and Administrators (station owners) based on role-based authentication. Users interact with the system to perform operations such as searching nearby EV charging stations, checking real-time slot availability, booking charging slots, and making payments. The frontend communicates with the backend server through secure API calls. All user actions, such as slot booking or payment confirmation, trigger corresponding updates in the database.

B. Backend Layer – Node JS and MongoDB

- The backend layer is implemented using Node.js and Express, which handle application logic, API requests, and communication with the database. MongoDB serves as the primary NoSQL database for storing user profiles, EV station details, slot

availability, and booking records.

- User authentication and role-based access control are managed through secure backend services.
- MongoDB stores and manages all system data in a structured and scalable manner.
- API-based communication ensures smooth interaction between the frontend and backend.
- Real-time updates are handled through efficient data fetching mechanisms to reflect accurate slot availability and booking status.

This backend architecture provides flexibility, scalability, and efficient data management, eliminating complexity while ensuring reliable system performance.

C. Payment Integration – Razorpay Gateway

To facilitate secure online transactions, the EV Station Finder and Slot Booking System integrates the Razorpay payment gateway. When a user initiates a slot booking, the application securely redirects the transaction to the Razorpay payment interface. Upon successful payment, a confirmation response is generated and recorded in the MongoDB database.

This integration ensures encrypted transaction processing, secure payment handling, and automatic updating of booking and payment status within the system. It enhances reliability, transparency, and user trust in the overall EV charging and booking process.

D. Data Flow Overview

The system workflow begins with user authentication, after which users access their respective dashboards based on roles. Users can search for nearby EV charging stations, view real-time slot availability, and initiate slot booking. The booking details are processed by the backend server and stored in the MongoDB database.

When a user proceeds with payment, the transaction is handled through the Razorpay payment gateway. Upon successful payment, the booking and transaction details are automatically updated in the database. Administrators can manage station details, monitor bookings, and update slot availability, with all changes reflected in real time.

This structured data flow ensures efficient communication between the frontend, backend, and database components. It enables accurate data management, prevents booking conflicts, and ensures reliable and seamless service delivery for EV users.

IV. RESULT AND DISCUSSION

The EV Station Finder and Slot Booking System was successfully developed and tested using React JS as the frontend framework, Node.js and Express for backend processing, MongoDB for database management, and Razorpay for secure payment integration. The system was evaluated based on functionality, performance, usability, and reliability under real-time conditions.

A. Functional Testing Results

All core modules of the application were tested to ensure proper functionality. The authentication module successfully provided secure login and role-based access for users and administrators.

Users were able to search nearby EV charging stations, view real-time slot availability, and book slots without errors.

The booking module accurately stored booking details in the MongoDB database and updated slot availability instantly to prevent double booking. The payment module was tested under different scenarios such as successful, failed, and cancelled transactions. In successful cases, booking and payment details were automatically updated in the database, ensuring reliable system performance.

B. Performance Evaluation

The system demonstrated efficient performance during real-time usage. Data retrieval and updates through MongoDB were performed with minimal delay. The backend handled multiple user requests effectively, ensuring smooth operation even during concurrent bookings.

React JS provided a responsive and dynamic user interface, enabling smooth navigation across different devices. The average response time for key operations such as station search and slot booking remained within acceptable limits.

C. Usability Analysis

The application interface was designed to be simple and user-friendly. Users could easily navigate through features such as station search, booking, and payment using a well-structured dashboard.

Testing results showed that users were able to complete booking and payment processes without

technical assistance, indicating high usability. Role-based dashboards ensured that users and administrators accessed only relevant features, reducing complexity.

D. System Reliability and Security

The system ensures secure access through authentication mechanisms and encrypted API communication. Razorpay integration provides secure payment processing, protecting financial transactions.

MongoDB ensures reliable data storage, while backend validation prevents incorrect or duplicate bookings. The system maintains consistency in booking and payment records, ensuring dependable operation in real-world scenarios.

V. PERFORMANCE ENHANCEMENT

The performance of the EV Station Finder and Slot Booking System is enhanced through the use of modern web

technologies such as React JS, Node.js, MongoDB, and Razorpay. React JS ensures fast rendering and a responsive user interface, improving overall user experience.

The use of MongoDB enables efficient data storage and quick retrieval, while Node.js supports scalable backend processing and handles multiple user requests simultaneously. Real-time updates in slot availability reduce waiting time and prevent booking conflicts.

Integration of Razorpay provides secure and fast online payment processing, ensuring smooth transaction flow. Automated booking management and real-time data handling reduce manual effort and improve system efficiency.

Overall, the system enhances operational speed, improves resource utilization, and provides a reliable solution for EV charging management compared to traditional methods.

VII. CONCLUSION

The EV Station Finder and Slot Booking System successfully demonstrates how digital technology can improve the efficiency and accessibility of electric vehicle charging infrastructure through a centralized application platform.

The developed system eliminates the difficulties associated with manually locating charging stations and waiting for slot availability. By providing real-time information on nearby stations and enabling advance slot booking, the system reduces waiting time and enhances user convenience. The integration of secure authentication and online payment processing further ensures reliable and safe transactions.

Real-time data management and automated booking updates improve transparency and prevent conflicts such as double booking. The use of a scalable architecture with modern technologies ensures that the system can handle increasing numbers of users and charging stations effectively.

In conclusion, the proposed system provides an efficient, reliable, and user-friendly solution for EV charging management. It supports the growth of electric vehicle adoption by improving infrastructure accessibility, optimizing resource utilization, and enhancing overall user experience.

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