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EVPowerStop EV Charging Station Finder with Dynamic Availability and Slot Booking

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***Abstract*—Electric Vehicle (EV) adoption is growing rapidly, but drivers continue to face difficulty locating charging stations with actual slot availability, often resulting in wasted travel time, range anxiety, and inefficient use of existing charging infrastructure. Most current applications provide only station location through mapping services, without Realtime, slot level visibility into whether a charger is actually free. This project proposes EVPowerStop, a webbased Electric Vehicle Station Finder and Slot Scheduler developed using the MERN (MongoDB, Express.js, React.js, Node.js) stack, integrated with mapping APIs for geolocation and navigation. The system enables users to register, search for nearby charging stations, view Realtime slot availability, book or modify/cancel a reservation, complete a simulated payment, and receive basic notifications on their booking status. Availability is determined dynamically using a rule-based approach calculated from the number of slots already booked against the total slots remaining at a station rather than through machine learning based prediction models. This keeps the system computationally lightweight, transparent, and easy to maintain, while still delivering accurate, real-time information to users. The proposed platform aims to reduce station search time, prevent double booking through slot locking, and improve the overall EV charging experience through a unified full stack solution.**

I. INTRODUCTION

The global push towards sustainable transportation has driven a sharp rise in Electric Vehicle (EV) adoption, supported by government incentives and increasing environmental awareness. However, this growth has not been matched by an equally rapid expansion of accessible and well managed charging infrastructure. Unlike conventional fuel stations, EV charging points are limited in number, unevenly distributed, and frequently experience high demand during peak hours, resulting in long wait times at some locations and underused capacity at others. A key reason for this inefficiency is the lack of Realtime, slot level visibility most existing navigation and station locator applications show only the physical location of a station, not whether a charging slot is actually free at that moment. This forces drivers to travel to a station without any certainty of finding an

available charger, contributing to wasted time and heightened range anxiety, which remains a significant barrier to wider EV adoption.

To address this gap, this project proposes EVPowerStop, an integrated Electric Vehicle Station Finder and Slot Scheduler built on the MERN (MongoDB, Express.js, React.js, Node.js) technology stack, combined with mapping APIs for geolocation and route navigation. The system connecting allows users to locate nearby charging stations, view real time slot availability, book, modify, or cancel a charging slot, complete a simulated payment transaction, and receive basic notifications regarding their bookings. Rather than relying on machine learning based prediction models that require extensive historical data vulnerability discovery with secure and verifiable code remediation.

The system computes availability dynamically and deterministically from the ratio of booked to remaining slots at each station, ensuring accuracy, transparency, and ease of maintenance.

II. RELATED WORK

The development of electric vehicles (EVs) has increased the need for reliable and accessible charging infrastructure. Existing research and applications have focused on locating charging stations, providing station information, and improving the utilization of available charging facilities. However, users may still face difficulties in identifying stations with available charging capacity and planning their charging sessions efficiently.

A. Electric Vehicle Charging Infrastructure

The International Energy Agency (IEA), in its Global EV Outlook 2025, discusses the continued expansion of public electric vehicle charging infrastructure worldwide. The increasing number of public charging points highlights the importance of digital platforms that help EV users locate suitable charging facilities. Our proposed system uses this motivation to provide a centralized interface for station discovery and charging-slot management.

B. Location-Based Charging Station Finder

Location-based services and mapping APIs can help users identify charging stations according to their current location or a specified destination. Alternative Fuel Stations APIs, such as those documented by the National Laboratory of the Rockies (NLR), provide station-location and search capabilities. Such services can support the station-discovery module of our project. However, station-location information alone does not necessarily indicate whether a charger is currently available, so additional availability data is required.

C. Charging Station Availability and Prediction

Charging-station availability can change over time because of variations in user demand, charging duration, and booking activity. A system that displays only current availability may not help users anticipate future congestion. Historical booking and usage data can potentially be used to estimate

future slot availability. In the proposed system, this prediction component can be implemented using Python and machine-learning models, provided that sufficient historical data is available. Predicted availability is treated as an estimate rather than a guarantee of a free charging slot.

D. Online Booking and Charging Management

Online reservation systems can improve the organization of charging sessions by allowing users to select, book, modify, or cancel charging slots. A booking platform must also prevent two users from reserving the same available capacity. The proposed system addresses this requirement by rechecking availability during booking and updating the booking records securely. Payment simulation and notifications can further demonstrate the complete reservation workflow.

III. SYSTEM ARCHITECTURE

A. Overview

EV-PowerStop follows a three-tier client-server architecture:

• Presentation Layer (Frontend): Built using React.js, this layer provides the user interface for registration/login, station search, slot booking, and notification display. It communicates with the backend via RESTful API calls.

• Application Layer (Backend): Built using Node.js and Express.js, this layer contains the core business logic authentication, station and slot management, the rule-based availability engine, booking/cancellation handling, and simulated payment processing. It also integrates with the Google Maps API for geolocation and route data.

• Data Layer (Database): MongoDB stores structured collections for users, stations, slots, bookings, and payment records, enabling efficient querying and real-time updates to slot status.

Data Flow: User request → React frontend → Express.js API layer → MongoDB (read/write) → Response returned to frontend, with the Google Maps API queried in parallel for location-based data whenever a station search or navigation request is made.

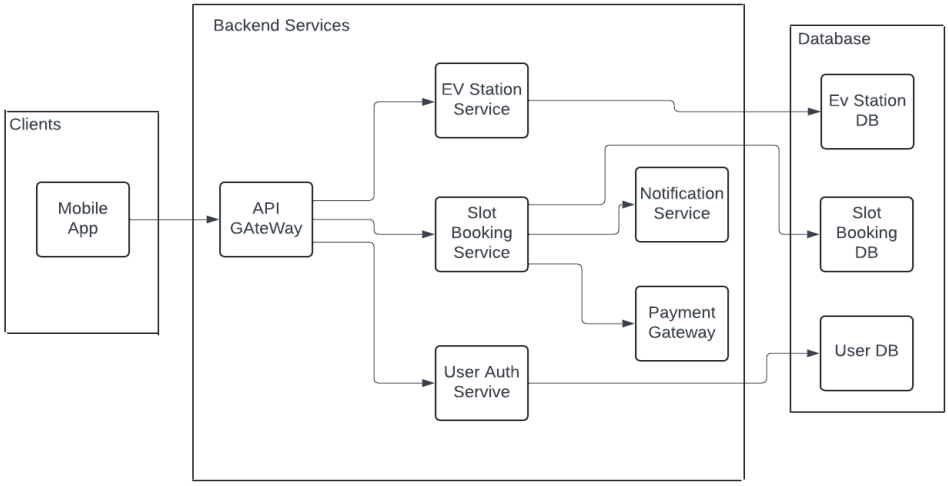

Fig. 1. System architecture of the EVPowerStop

Explanation of components

1. React.js frontend: Provides the user interface for registration, login, searching nearby charging stations, viewing availability, booking slots, and managing reservations.
2. Node.js and Express.js backend: Processes requests from the frontend and provides REST APIs for the system's core functionality.
3. Authentication module: Handles user registration, login, and role-based access for users and administrators.
4. Station management module: Retrieves station details and location information through external APIs and displays relevant charging stations.
5. Booking management module: Allows users to select, book, modify, and cancel slots. It checks availability again before confirming a reservation to prevent conflicting bookings.
6. MongoDB database: Stores user accounts, station details, booking records, payment-simulation records, and historical usage data.
7. Optional Python ML module: Uses historical booking and usage information to predict future slot availability. The predicted result is an estimate, while actual booking confirmation depends on current availability.
8. Payment and notification modules: Demonstrate a dummy payment workflow and provide booking confirmations, cancellation messages, and other relevant updates.

IV. DETECTION METHODOLOGY

The detection methodology of EVPowerStop focuses on identifying nearby electric vehicle (EV) charging stations and determining the real-time availability of charging slots. The system uses location-based services and a rule-based

When a user selects a charging slot, the system checks whether that slot is available before confirming the reservation. Slot-locking logic prevents multiple users from booking the same slot simultaneously.

The system uses geolocation services or a manually entered location to identify the user's current area. Mapping APIs, such as Google Maps API, help locate nearby EV charging stations and display their locations on the map.

After obtaining the user's location, the system searches the database for nearby charging stations. It retrieves stat details such as address, connector type, charging speed, total slots, and current availability.

When a user selects a charging slot, the system checks whether that slot is available before confirming the reservation. Slot-locking logic prevents multiple users from booking the same slot simultaneously.

The system checks the booking status to identify whether a reservation is active, modified, or cancelled. When a booking is cancelled, the corresponding slot becomes available again, and the availability count is updated.

V. IMPLEMENTATION

EVPowerStop is implemented using the MERN stack (MongoDB, Express.js, React.js, and Node.js). React.js provides the user interface, while Node.js and Express.js handle station search,

slot booking, and availability calculations. MongoDB stores user, station, booking, and payment details. Google Maps API helps locate nearby charging stations. The system also includes slot-locking to prevent double-booking, simulated payment processing, and booking notifications.

VI. EXPERIMENTAL EVALUATION

EVPowerStop is developed and evaluated in phases. Initially, the system is tested for user registration and login, followed by nearby charging station detection using Google Maps API. Next, slot availability calculation and booking functionality are tested to ensure accurate updates and prevent double-booking. Finally, simulated payment, booking cancellation, and notifications are evaluated to verify the overall system functionality, reliability, and usability.

VII. DISCUSSION AND LIMITATIONS

EVPowerStop helps electric vehicle users find nearby charging stations, check available slots, and book charging slots in advance. It uses Google Maps API to display station locations and a rule-based method to calculate available slots. Users can book, modify, or cancel their reservations. The system also provides simulated payment and basic notifications for booking updates. Overall, it makes the EV charging process easier and helps users save time by checking slot availability before visiting a station.

EVPowerStop has some limitations. It does not directly connect to charging station hardware, so it cannot automatically detect the actual status of a charger. It uses a rule-based method and cannot predict future slot availability or charging demand. The payment system is simulated and does not support real transactions. The system also depends on updated station information and a stable internet connection. Additionally, advanced notifications and real-time hardware monitoring are not included in the current version.

VIII. CONCLUSION AND FUTURE WORK

EVPowerStop provides a simple and user-friendly platform for finding nearby EV charging stations, checking slot availability, and booking charging slots in advance. It uses the MERN stack, Google Maps API, and rule-based availability calculation to make the charging process easier and more convenient. The system also includes booking management, simulated payments, and notifications. Overall, it helps reduce uncertainty, saves users' time, and improves the EV charging experience.

In the future, EVPowerStop can be improved by integrating IoT sensors to detect the actual status of charging stations in real time. Machine learning can be added to predict charging demand and future slot availability. Real payment gateways, SMS alerts, and push notifications can also be introduced. Additionally, a mobile application can be developed to make the system more accessible. These improvements can make EVPowerStop more reliable, efficient, and suitable for real-world use.

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