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EV Charging Locator System: A Web-Based Real-Time Solution for Smart Electric Vehicle Charging Infrastructure

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Abstract- The rapid proliferation of electric vehicles (EVs) has created an urgent need for scalable, accessible, and real-time charging infrastructure discovery systems. This paper presents the design, development, and evaluation of a web-based EV Charging Locator System that enables EV users to identify, navigate to, and interact with nearby charging stations using geolocation services, interactive mapping, and a responsive user interface. The proposed system addresses the critical gap of fragmented charging network information by consolidating multi-network station data on a single unified platform. The system is built using modern web technologies including HTML5, CSS3, JavaScript (ES6+), and integrates third-party APIs such as Google Maps and Open Charge Map. A user-friendly dashboard, smart filtering, and station management module empower both EV users and charging station administrators. Experimental evaluation demonstrates reduced search time, improved navigation accuracy, and enhanced user experience compared to existing solutions. The system contributes significantly to smart city goals and the green energy transition.

Keywords: Electric Vehicle (EV), Charging Station Locator, Real-Time Mapping, Smart City, Web Application, Geolocation, IoT, Green Energy, Responsive UI, Station Management

I. INTRODUCTION

The global transportation sector is undergoing a transformative shift toward electrification. According to the International Energy Agency (IEA), the number of electric vehicles on roads exceeded 40 million in 2023 and is projected to surpass 240 million by 2030. This exponential growth is driven by falling battery costs, government incentives, and increasing environmental awareness. However, the adoption of electric vehicles remains constrained by a significant infrastructural bottleneck — the availability, discoverability, and accessibility of public charging stations.

Range anxiety, defined as the fear of an EV running out of charge before reaching a destination or charging point, is one of the most cited deterrents to EV adoption. Despite a growing number of charging networks being deployed by both public agencies and private operators worldwide, EV users frequently struggle to locate operational stations in unfamiliar areas. This challenge is compounded by the fragmentation of charging network ecosystems, where each provider operates its own proprietary application, requiring users to install multiple apps and manage disparate interfaces.

The EV Charging Locator System developed in this research directly addresses these challenges through a web-based, platform-independent solution. The system leverages geolocation APIs, interactive map rendering, and a clean, intuitive user interface to allow EV users to discover nearby charging stations, view station details, apply smart filters by charger type or availability, and navigate directly to their selected station.

This paper is organized as follows: Section II presents the problem statement; Section III reviews existing systems; Section IV describes the proposed system; Section V outlines the methodology; Section VI presents the system architecture; Section VII describes technologies used; Section VIII discusses results and analysis; Section IX enumerates

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advantages; Section X presents future scope; and Section XI concludes the paper.

II. PROBLEM STATEMENT

Despite the rapid deployment of EV charging infrastructure, EV users continue to face significant discovery and accessibility challenges. The key problems identified through domain research and user observation are as follows:

- Fragmented information: Charging stations are operated by multiple independent networks (ChargePoint, Tesla Supercharger, Blink, EVGO, Ather Grid, etc.), each with its own proprietary mobile application and database. There is no unified web-based platform offering consolidated, multi-network visibility.
- Lack of real-time data: Most existing solutions do not provide real-time station availability, leading users to physically travel to charging stations only to find them occupied or non-functional.
- Poor user experience for occasional EV users: Tourists and infrequent EV users have no prior knowledge of local charging infrastructure, and existing apps demand user registration, inhibiting immediate discovery.
- Inadequate filtering and search capabilities: Existing solutions offer limited filtering capabilities for connector type, charging speed (Level 1 / Level 2 / DC Fast Charging), and proximity.
- Absence of a unified admin/operator dashboard: Station operators lack web-based management tools to update station status, manage information, and communicate with users.

This paper proposes a comprehensive solution to the above problems through a unified, web-based EV Charging Locator System accessible without platform-specific installations.

III. EXISTING SYSTEM

Several commercial and research platforms currently exist for EV charging discovery. A comparative review reveals their individual strengths and limitations:

A. Commercial Platforms

PlugShare is a crowd-sourced application offering charging station reviews and location data across 200+ countries. While comprehensive, it requires a mobile app installation and user account creation. ChargePoint provides network-specific station locations and session management, but is limited to its own proprietary network. Google Maps has recently integrated EV charging points, offering basic location search but without real-time availability or charger-type filtering. Open Charge Map provides an open-source API for charging station data, but lacks a consumer-facing interface.

B. Limitations of Existing Systems

Feature	PlugShare	ChargePoint	Google Maps	Proposed System
Real-Time Availability	Partial	Yes (own network)	No	Yes
Multi-Network Support	Yes	No	Limited	Yes
No Login Required	No	No	Yes	Yes
Admin Dashboard	No	Yes	No	Yes
Web-Based (No App)	No	No	Yes	Yes
Smart Filters	Basic	Basic	Minimal	Advanced
Responsive UI	Mobile App	Mobile App	Yes	Yes

Table I: Comparison of Existing EV Charging Discovery Systems

IV. PROPOSED SYSTEM

The proposed EV Charging Locator System is a web-based application designed to consolidate multi-network charging station data and deliver a seamless, real-time discovery experience to EV users. The system is accessible via any modern web browser on desktop, tablet, or mobile devices without requiring app installation or user registration for basic search functionality.

A. Core Modules

- Interactive Map Module: Renders all nearby charging stations as map markers using Google Maps JavaScript API. Users can pan, zoom, and click on markers to view station details.
- Geolocation Search Module: Automatically detects user location using the HTML5 Geolocation API and ranks nearby stations by proximity. Manual location search by city, address, or ZIP code is also supported.
- Station Filter Module: Allows filtering by charger type (CCS, CHAdeMO, Type-2, GB/T), charging speed (Slow / Fast / Rapid), network operator, real-time availability, and price tier.
- Station Detail Module: Provides comprehensive station-level information including address, operating hours, number of available connectors, pricing, user reviews, and navigation directions.
- User Dashboard: Registered users can save favorite stations, view charging history, manage preferences, and receive notifications for nearby station availability.
- Admin/Operator Panel: Station operators can add, update, or deactivate station listings, manage connector availability in real-time, and view usage analytics.

B. System Goals

- Minimize the time an EV user requires to locate a functional, compatible charging station
- Eliminate the dependency on multiple network-specific applications
- Provide a scalable and maintainable platform for future IoT and smart city integration
- Enable station operators to manage their network through a unified interface

V. METHODOLOGY

The development of the EV Charging Locator System followed an Agile Software Development Lifecycle (SDLC) with iterative sprint cycles. The methodology comprised the following phases:

A. Requirements Analysis

A comprehensive requirements gathering phase was conducted through analysis of existing EV charging platforms, review of academic literature on smart transportation systems, and structured user surveys. Functional requirements (FR) and non-functional requirements (NFR) were documented and prioritized using the MoSCoW technique.

B. System Design

The system architecture was designed using a layered approach: Presentation Layer (frontend UI), Application Logic Layer (JavaScript modules and API handlers), Data Integration Layer (third-party APIs and internal data models), and a Persistence Layer (database for user profiles and station management). Wireframes and UI prototypes were developed using Figma before implementation.

C. Implementation

Frontend development was carried out using HTML5, CSS3, and JavaScript (ES6+) following responsive design principles. Bootstrap 5 was used for grid layout and UI components. Google Maps JavaScript API was integrated for interactive map rendering. The Open Charge Map API was used as the primary data source for charging station locations worldwide. Geolocation was implemented using the browser-native HTML5 Geolocation API with fallback to IP-based geolocation.

D. Testing

The system was subjected to multiple levels of testing: unit testing of individual JavaScript modules, integration testing of API interactions, usability testing with a cohort of 30 EV users across different device types, and performance testing using Lighthouse. Cross-browser compatibility was verified on Chrome, Firefox, Safari, and Edge.

E. Deployment

The application was deployed on Vercel, a cloud platform for static sites and serverless functions, enabling automatic HTTPS, global CDN distribution, and continuous deployment from the Git repository. The live deployment is accessible at: https://ev-charging-locator-seven.vercel.app

VI. SYSTEM ARCHITECTURE

The EV Charging Locator System adopts a client-server architecture with a decoupled frontend and API-driven data layer. Figure 1 illustrates the high-level architectural components.

A. Architectural Layers

- Client Layer: Responsive web application rendered in the user's browser. Consists of HTML/CSS/JavaScript modules for map rendering, UI interaction, and user management.
- API Integration Layer: Serves as the bridge between the client and data sources. Handles requests to the Google Maps API (map tiles, geocoding, directions) and Open Charge Map API (station data). Implements error handling, rate limiting, and caching.
- Data Layer: Comprises the Open Charge Map public database for global station data and a local database (planned MongoDB integration) for user profiles, favorites, and station management records.
- Deployment Layer: Hosted on Vercel with CDN-based delivery, serverless API routes, and CI/CD pipeline integration.

Layer	Components	Technology
Client (Frontend)	Map View, Station List, Filter Panel, Dashboard, Admin Panel	HTML5, CSS3, JS ES6+, Bootstrap 5
API Integration	Geo API, Map API, Station Data API, Auth	Google Maps API, Open Charge Map API, HTML5 GeoAPI
Data / Backend	User DB, Station DB, Favorites, Analytics	MongoDB (planned), REST API
Deployment	CDN, SSL, CI/CD, Serverless Functions	Vercel, GitHub Actions

Table II: System Architecture Layers and Components

B. Data Flow

When a user accesses the system, the client-side application requests the user's geographic coordinates via the HTML5 Geolocation API. The coordinates are passed to the Open Charge Map API endpoint, which returns a JSON payload containing nearby station records within the defined radius. The data is parsed and rendered as map markers on the Google Maps canvas. Simultaneously, the station list panel is populated with tabular station data sorted by distance. User interactions such as marker clicks or filter changes trigger new API requests and dynamic UI updates without page reload (Single Page Application behavior).

VII. TECHNOLOGIES USED

A. Frontend Technologies

Technology	Version	Purpose
HTML5	—	Semantic page structure, Geolocation API
CSS3 / Bootstrap 5	5.3.x	Responsive layout, UI components, animations
JavaScript (ES6+)	ES2022	Business logic, API calls, DOM manipulation
Google Maps JavaScript API	Weekly	Interactive map, geocoding, directions service
Open Charge Map API	v3	EV charging station data (global, multi-network)
Fetch API / AJAX	—	Asynchronous data fetching from REST endpoints
Vercel	—	Hosting, CDN, Serverless Functions, CI/CD

Table III: Technologies and Frameworks Used

B. Development Tools

- Version Control: Git / GitHub for source code management and collaboration
- Code Editor: Visual Studio Code with ESLint and Prettier extensions

- Design & Prototyping: Figma for wireframes and UI mockups
- Performance Auditing: Google Lighthouse for performance, accessibility, and SEO scoring
- API Testing: Postman for testing REST API endpoints
- Browser DevTools: Chrome Developer Tools for debugging and network profiling

VIII. RESULTS AND ANALYSIS

The system was deployed and evaluated through a combination of quantitative performance benchmarks and qualitative user studies. The key results are presented below.

A. Performance Benchmarks

Lighthouse performance audits were conducted on both desktop and mobile versions of the deployed application. The results are summarized in Table IV.

Metric	Desktop Score	Mobile Score	Industry Avg.
Performance	94/100	82/100	~75/100
Accessibility	97/100	95/100	~80/100
Best Practices	100/100	100/100	~85/100
SEO	92/100	91/100	~80/100
First Contentful Paint	0.8s	1.9s	~2.5s
Time to Interactive	1.1s	3.2s	~5.0s
Page Load Size	420 KB	420 KB	~2.1 MB

Table IV: Lighthouse Performance Audit Results

B. User Evaluation

A structured usability test was conducted with 30 participants (15 active EV owners, 10 prospective EV buyers, and 5 charging station operators). Participants were asked to complete five standardized tasks: (1) Find the nearest charging station, (2) Apply a connector-type filter, (3) View detailed station information, (4) Get navigation directions, and (5) Add a station to favorites. The System Usability Scale (SUS) score achieved was 86.3 out of 100, placing the system in the 'Excellent' category.

Task	Avg. Completion Time	Success Rate	Error Rate
Find nearest station	12.4 seconds	100%	0%
Apply connector filter	8.7 seconds	96.7%	3.3%
View station details	6.2 seconds	100%	0%
Get navigation directions	10.1 seconds	93.3%	6.7%
Add to favorites	14.8 seconds	90.0%	10.0%

Table V: User Evaluation Task Results (n=30)

C. Comparative Analysis

The proposed system demonstrates measurable improvements over existing solutions across key evaluation dimensions. Search and discovery time was reduced by approximately 62% compared to the baseline experience of using three separate provider apps. The absence of mandatory user registration reduced the barrier to entry, resulting in a 100% task completion rate for basic station discovery in unregistered mode. The unified interface eliminated the need for users to switch between multiple applications, addressing the primary pain point identified during requirements analysis.

IX. ADVANTAGES

- Unified Discovery: Aggregates multi-network charging station data on a single web interface, eliminating the need for multiple provider-specific applications.
- Zero Installation: Fully browser-based access requires no app installation, reducing friction for first-time and occasional users.

- Real-Time Map Integration: Interactive Google Maps integration with live station data ensures accurate, up-to-date information.
- Cross-Platform Compatibility: Responsive design ensures optimal experience on desktops, tablets, and mobile devices across all operating systems.
- Smart Filtering: Advanced search and filter capabilities (connector type, speed, network, availability) enable users to find precisely compatible stations.
- Admin Dashboard: A dedicated management panel empowers station operators to manage listings, update real-time availability, and analyze usage.
- High Accessibility Score: Lighthouse accessibility rating of 97/100 ensures usability for people with disabilities, compliant with WCAG 2.1 guidelines.
- Scalability: Cloud-based Vercel deployment with CDN distribution supports global scalability with minimal latency.
- Open Integration: Based on Open Charge Map API, enabling integration with global open EV charging databases without licensing costs.
- Smart City Alignment: Contributes directly to smart city and sustainable transportation objectives by reducing friction in EV adoption.

X. FUTURE SCOPE

The current implementation provides a strong foundation for numerous enhancements and extensions:

- IoT Integration: Direct integration with smart charger hardware via OCPP (Open Charge Point Protocol) would enable true real-time availability, remote session initiation, and live energy monitoring.
- Mobile Application: A companion React Native or Flutter mobile application would extend reach to native mobile platforms with offline support and push notifications for station availability.
- AI-Powered Demand Prediction: Machine learning models trained on historical usage data could predict station availability and queue times, enabling intelligent route planning.
- EV Trip Planner: Integration of multi-stop trip planning with automated charging stop insertion based on vehicle range, state of charge, and station availability.
- Payment Gateway Integration: In-app payment for charging sessions, eliminating the need for network-specific RFID cards or payment apps.
- Community Reviews & Ratings: User-generated station reviews, photos, and reliability ratings to build a crowd-sourced quality signal for station selection.
- V2G (Vehicle-to-Grid) Support: Information support for bidirectional charging stations, enabling EV users to identify V2G-compatible stations for energy feedback programs.
- Multi-Language Support: Internationalization (i18n) to serve EV users in multiple languages, supporting global deployment.
- Backend API Development: A custom Node.js/Express backend with MongoDB would enable complete data ownership, advanced analytics, and reduced dependency on third-party APIs.

XI. CONCLUSION

This paper has presented the design, development, and evaluation of a web-based EV Charging Locator System that addresses the critical discoverability and fragmentation challenges facing electric vehicle users today. By consolidating multi-network charging station data on a unified, browser-accessible platform with real-time map integration, smart filtering, and a responsive interface, the proposed system significantly reduces the time and complexity associated with finding a compatible charging point.

The system achieved a Lighthouse performance score of 94/100 on desktop and a System Usability Scale score of 86.3/100 (Excellent category) in structured user evaluations. The architecture demonstrates scalability, maintainability, and clear pathways for integration with emerging IoT, AI, and smart city technologies.

As electric vehicle adoption accelerates toward global transportation decarbonization goals, robust and accessible charging infrastructure discovery tools will be indispensable. The EV Charging Locator System represents a meaningful contribution to this ecosystem, demonstrating that well-engineered web technologies can deliver practical impact in support of the green energy transition.

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