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Cloud-Based Ev Charging Station Locator And Booking System

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Abstract

The rapid growth of electric vehicles (EVs) has significantly increased the demand for efficient and intelligent The rapid growth of electric vehicles (EVs) has increased the demand for efficient and intelligent charging infrastructure, yet existing systems often lack real-time availability information and reservation capabilities, leading to long waiting times and inefficient utilization of charging stations. This paper presents the design and implementation of a cloud-based EV charging station locator and booking system that enables users to find nearby charging stations, check real-time slot availability, and reserve charging slots in advance through a web-based platform. The proposed system integrates location-based services, cloud computing, and a scheduling mechanism to optimize charging station selection based on distance and availability. It also provides additional features such as reminder notifications before the scheduled charging time and navigation support to guide users to the selected station. An admin panel is included to manage users, monitor bookings, and dynamically control slot availability. The system demonstrates improved performance in terms of reduced waiting time, enhanced user convenience, and better utilization of charging infrastructure, making it a practical and scalable solution for modern EV charging systems.

Keywords: *Electric Vehicles (EV), EV Charging Station, Cloud Computing, Reservation System, Real-Time Scheduling*

1. Introduction

The rapid growth of electric vehicles (EVs) has transformed modern transportation systems, driven by environmental concerns, government incentives, and advancements in battery technologies. As EV adoption increases globally, the demand for efficient and accessible charging infrastructure has become a critical challenge. Existing charging systems often suffer from limited availability, uneven distribution of stations, and lack of real-time information, which leads to increased waiting time and user inconvenience. Studies have highlighted that inefficient charging infrastructure management results in congestion, poor utilization of resources, and reduced user satisfaction [1]. To address these challenges, significant research has been conducted in the areas of EV charging station placement and optimization. Several works have proposed mathematical models and optimization techniques, such as mixed-integer programming and metaheuristic algorithms, to determine optimal locations and capacities of charging stations [2], [3]. These approaches focus on minimizing travel distance and infrastructure cost; however, they are primarily static in nature and do not consider real-time user interaction or dynamic demand patterns. As a result, their practical applicability in real-world scenarios remains limited. In addition to infrastructure planning, EV charging scheduling has been widely studied to reduce waiting time and improve system efficiency. Techniques such as mobile edge computing and cloud-assisted scheduling have been introduced to enable real-time decision-making and reduce computational latency [4], [5]. Furthermore, blockchain-based solutions have been explored to ensure secure and transparent transactions in EV charging systems [6]. Although

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these approaches enhance system performance and security, they often lack user-oriented features such as booking systems, navigation, and real-time slot visibility. Recent advancements have also introduced digital twin technologies and Internet of Things (IoT)-based frameworks for monitoring and managing charging infrastructure [7], [8]. These systems provide real-time data analysis and predictive capabilities, improving operational efficiency. However, they primarily focus on infrastructure management rather than user convenience. Similarly, location-based services have been used to help users find nearby charging stations using GPS and cloud platforms [9], but they do not provide booking or reservation capabilities, which are essential for reducing congestion and improving accessibility. Despite these developments, a significant gap still exists in integrating real-time user interaction with charging infrastructure. Most existing systems lack features such as slot reservation, notification alerts, navigation assistance, and centralized management. Additionally, many solutions are simulation-based and do not provide practical implementation for real-world deployment [10]–[12]. Cloud computing has emerged as a promising solution to overcome these limitations by enabling scalable, real-time, and centralized system management [13], [14]. It allows seamless communication between users and charging stations while supporting data analytics and dynamic resource allocation. In this context, this paper proposes a cloud-based EV charging station locator and booking system that integrates real-time slot availability, reservation functionality, and user-friendly interaction into a unified platform[15]. The proposed system allows users to search for nearby charging stations, check available slots, and reserve charging sessions in advance[16]. It also provides navigation support and reminder notifications to enhance user convenience. An admin panel is implemented to manage user data, monitor bookings, and dynamically control slot availability. By combining cloud computing, location-based services, and scheduling algorithms, the proposed system improves efficiency, reduces waiting time, and enhances the overall user experience Figure 2. The remainder of this paper is organized as follows[17]. Section 2 presents the literature survey, Section 3 describes the methodology, Section 4 discusses the results, and Section 5 concludes the paper Table 1.

2. Literature Review

2.1. Robust Placement and Sizing of EV Charging Stations

- **Focus:** Optimization of charging station placement and capacity planning
- **Limitation:** Does not provide real-time user interaction or booking system
- **Our Contribution:** We implement a real-time booking platform with slot availability and reservation system Figure 1

2.2. Mobile Edge Computing-Based EV Charging Scheduling

- **Focus:** Reducing computation delay using edge computing
- **Limitation:** No user interface for booking or slot selection
- **Our Contribution:** We provide a user-friendly web system with booking and scheduling

2.3. Blockchain-Based EV Charging Management System

- **Focus:** Security and decentralized energy transactions
- **Limitation:** No real-time slot booking or user interaction
- **Our Contribution:** We provide simple and practical booking with real-time availability

2.4. Optimization of EV Charging Station Allocation Using Metaheuristics

- **Focus:** Placing stations using smart algorithms to find the best spots
- **Limitation:** We only did testing in a simulated environment, not real-world setup
- **Our Contribution:** We built a real system with a user-friendly interface for interaction

2.5. Digital Twin-Based EV Charging Infrastructure

- **Focus:** Creating a virtual simulation of charging stations
- **Limitation:** Users can't interact or book directly in the simulation
- **Our Contribution:** We offer a real-time booking and navigation system.

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Table 1 Comparison of Existing Work and Proposed System

No.	Paper Title	What They Do	Limitation (What They Don't Do)	What Our System Does
1	Robust Placement and Sizing of EV Charging Stations	Optimizes station placement	No real-time booking system	Provides real-time booking with slot availability
2	Mobile Edge Computing-Based EV Charging Scheduling	Reduces computation delay	No user interface or booking	Provides user-friendly booking platform
3	Blockchain-Based EV Charging System	Ensures secure transactions	No slot reservation system	Enables real-time reservation and booking
4	Optimization of EV Charging Station Allocation	Uses optimization algorithms	Simulation only, no real system	Implements real working system
5	Digital Twin-Based EV Charging Infrastructure	Virtual monitoring system	No user interaction	Provides real-time booking + navigation
6	Privacy-Preserving EV Charging Query	Protects user data	No booking feature	Full booking + scheduling system
7	EV Charging Scheduling Using Game Theory	Optimizes scheduling	No real-time user system	Provides real-time scheduling + booking
8	Wireless EV Charging System	Focus on hardware charging	No software system	Develops software platform for booking
9	Smart Grid-Based EV Charging	Grid load management	No user-side interaction	Provides user-based station selection
10	Cloud-Based EV Charging Monitoring	Monitors stations	No reservation system	Adds booking + slot management
11	EV Charging Load Optimization	Optimizes energy usage	Ignores user convenience	Focuses on user experience
12	Intelligent EV Charging Station Selection	Selects best station	No booking system	Selection + booking integration
13	IoT-Based EV Charging System	Sensor-based monitoring	No cloud booking system	Cloud-based booking system
14	EV Charging Station Finder Using GPS	Finds nearest station	No slot availability	Provides availability + booking
15	EV Charging Reservation System	Basic reservation	No admin control	Admin panel + dynamic slots
16	Energy-Efficient EV Charging Scheduling	Focus on energy saving	No user interface	Provides real-time user system
17	Cloud-Based Smart EV Charging System	Uses cloud infrastructure	No complete workflow	Full system (locator + booking + notification + navigation)

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2.6. Privacy-Preserving EV Charging Query System

- **Focus:** Protecting user location privacy
- **Limitation:** Does not include booking or slot reservation
- **Our Contribution:** We provide complete locator + booking + scheduling system Figure 3.

2.7. EV Charging Scheduling Using Game Theory

- **Focus:** Optimal charging strategies
- **Limitation:** No real-time system or user-level interaction
- **Our Contribution:** We provide practical booking system with scheduling

2.8. Wireless EV Charging Infrastructure Study

- **Focus:** Charging technology (hardware level)
- **Limitation:** Does not address software system or booking
- **Our Contribution:** We develop software platform for charging management

2.9. Smart Grid-Based EV Charging Management

- **Focus:** Balancing the electricity load on the grid
- **Limitation:** There is no way for users to interact or book charging times
- **Our Contribution:** We let users choose and reserve charging times themselves

2.10. Cloud-Based EV Charging Station Monitoring System

- **Focus:** Keeping track of charging stations
- **Limitation:** Users can't book a spot in advance
- **Our Contribution:** We implement booking + notification and slot handling

2.11. EV Charging Load Optimization Model

- **Focus:** Reducing grid load
- **Limitation:** Ignores user convenience and booking
- **Our Contribution:** We focus on user experience with real-time booking

2.12. Intelligent EV Charging Station Selection System

- **Focus:** Choosing best charging station
- **Limitation:** No way to reserve a spot
- **Our Contribution:** We offer selection, booking and scheduling all in one

2.13. IoT-Based EV Charging System

- **Focus:** Sensor-based monitoring
- **Limitation:** No cloud-based booking system
- **Our Contribution:** We provide cloud-integrated booking system

2.14. EV Charging Station Finder Using GPS

- **Focus:** Finding the closest station
- **Limitation:** Only shows location, not whether a slot is available or if you can book one
- **Our Contribution:** We provide location , availability and the ability to book

2.15. EV Charging Reservation System (Basic Model)

- **Focus:** Easy booking system
- **Limitation:** Can't manage time slots live or control them from an admin area
- **Our Contribution:** We offer an admin panel and the ability to control time slots dynamically

2.16. Energy-Efficient EV Charging Scheduling

- **Focus:** Making energy use more efficient
- **Limitation:** No user involvement or real system setup
- **Our Contribution:** We offer a system that works in real time and allows user interaction

2.17. Cloud-Based Smart EV Charging System

- **Focus:** Cloud infrastructure
- **Limitation:** Lacks complete booking workflow
- **Our Contribution:** We provide complete end-to-end system (locator + booking + notification + navigation)

3. Methodology

The system proposed is a web-based tool that helps find and book electric vehicle charging stations. It shows available charging spots in real time, lets users reserve a spot, and manages the charging stations efficiently Figure 4. The approach covers designing the system, how it works, creating the necessary algorithms, and setting up the framework for building it.

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- System Overview

The system is designed as a web-based application integrated with cloud services, enabling users to locate nearby EV charging stations and reserve charging slots in advance. The system operates in two main modules:

3.1.User Module

The user module allows EV users to:

- Enter their current location
- Search for nearby charging stations
- View real-time slot availability
- Select and book available slots
- Schedule charging time
- Receive reminder notifications
- Navigate to the charging station

3.2.Admin Module

The admin module provides control over the system, including:

- Monitoring user bookings
- Managing charging station data
- Controlling slot availability (online/offline)
- Updating station information
- This dual-module design ensures both user convenience and efficient system management.

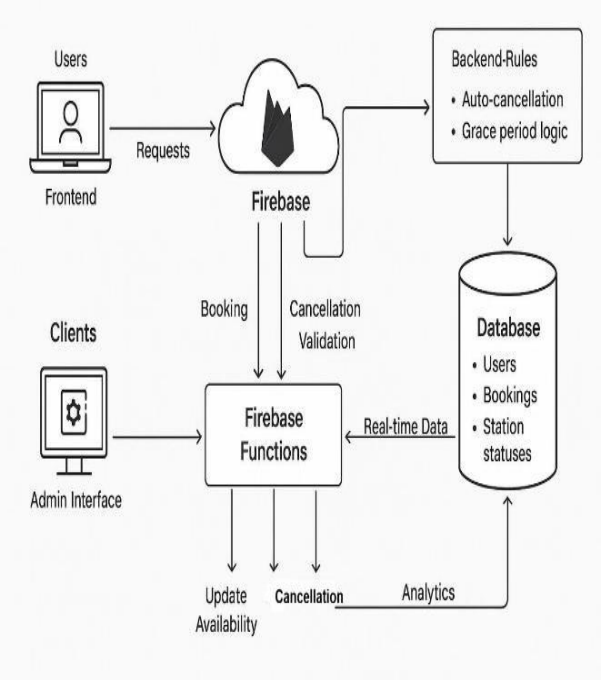

Figure 1 Architecture Diagram

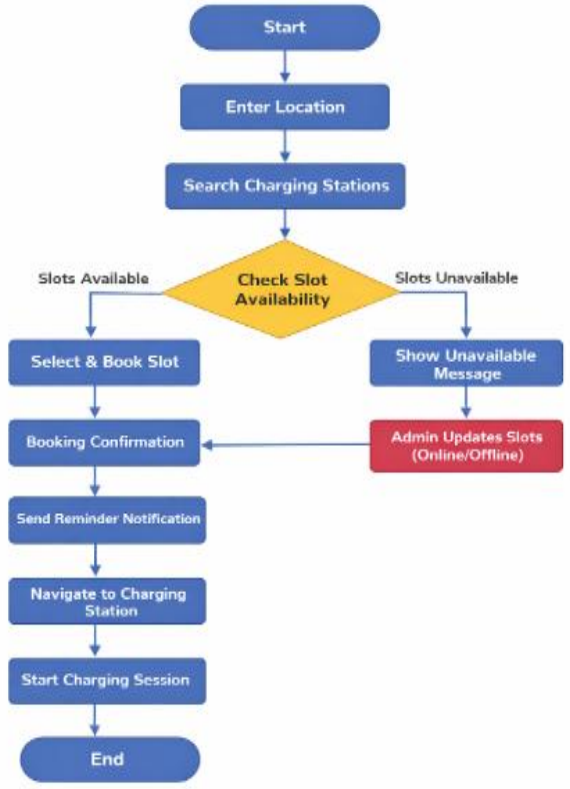

Figure 2 Architecture Flow

3.3.System Architecture

The architecture follows a client-server model using cloud computing to enable scalability and real-time data synchronization.

Components

- **Frontend (Web Interface):** Provides user interaction for location input, station selection, and booking.
- **Backend (Cloud Server):** Handles request processing, booking logic, and communication between modules.
- **Database:** Stores user data, booking details, and slot availability.
- **Charging Station Module:** Represents physical stations with available slots.
- **Map & Navigation Service:** Provides route guidance to selected stations.
- **Notification System:** Sends alerts before booking time.

The use of cloud computing ensures real-time updates, scalability, and reliability Figure 5.

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3.4.Working Process

The system follows a structured workflow for booking EV charging slots:

- User enters current location
- System retrieves nearby charging stations
- Available slots are displayed (online/offline)
- User selects preferred station
- User enters booking details (time, duration)
- System checks slot availability
- Booking is confirmed
- User receives confirmation message
- Reminder notification is sent 30 minutes before schedule
- Navigation route is displayed

This process ensures efficient booking and reduced waiting time Figure 6.

3.5.Slot Management Mechanism

- Each charging station has a predefined number of slots.

Example:

Total slots = 5
Online slots = 2
Offline slots = 3

Only online slots are available for booking, while offline slots can be controlled by the admin.

Features

- Dynamic slot activation/deactivation
- Real-time availability updates
- Prevention of double booking

This mechanism improves resource utilization and system control.

3.6.Algorithm for Station Selection and Booking

The system uses a distance and availability-based selection algorithm.

Steps

- Input user location (x, y)
- Retrieve list of charging stations
- Calculate distance using Euclidean formula:
  Distance√(x_2-x_1)^(2)+ (y_2-y_1)^(2)
- Check available slots for each station
- Estimate waiting time:
  Waiting Time =Queue/Capacity
- Calculate score:
  Score=Distance + Waiting Time
- Select station with minimum score
- Allocate available slot
- Confirm booking

This algorithm ensures optimal station selection with minimum delay.

This algorithm ensures **optimal station selection with minimum delay**.

3.7.Mathematical Model

The system is formulated as an optimization problem:

$$min \sum_i (C_i^{open} x_i + C_i^{cap} S_i) + \sum_j \sum_i C_{i,j}^{dist} D_j Y_{i,j}$$

Where

- X_i : Station selection (0/1)
- S_i : Station capacity
- $Y_{i,j}$: Assignment of user to station
- D_j : Demand
- $C_{i,j}^{Dist}$ :: Distance cost

Objective

Minimize

- Travel distance
- Waiting time
- Operational cost
- Implementation Framework

The system is implemented using modern web and cloud technologies:

Frontend

- HTML, CSS, JavaScript
- User interface for booking

Backend

- Node.js
- Handles logic and API requests

Database

- MySQL
- Stores users and booking data

Cloud Platform

- Firebase
- Enables real-time communication

Map Integration

- Google Maps API
- Provides location and navigation

Notification System

- SMS / Email API
- Sends reminders
- Key Features of the Proposed System
- Real-time charging station locator
- Slot availability visualization

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- Booking and scheduling system
- Reminder notification system
- Navigation support
- Admin control panel
- Advantages of the Proposed Methodology
- Reduces waiting time
- Improves user convenience
- Enables real-time booking
- Enhances resource utilization
- Scalable cloud-based system

4. Results

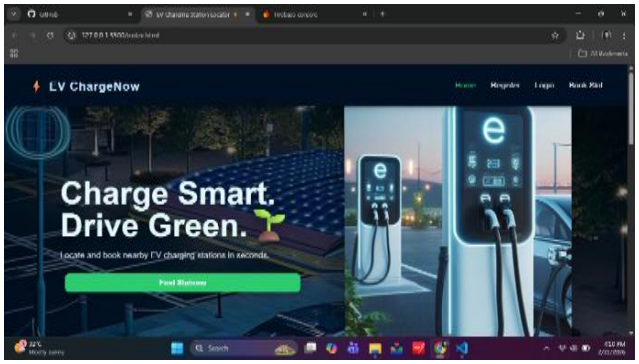

Figure 3 Homepage of Web-Application

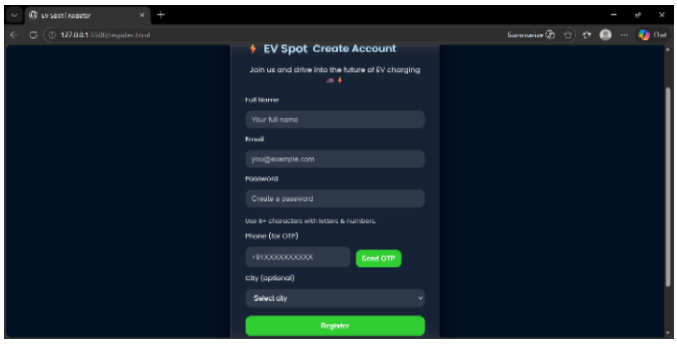

Figure 4 Registration Process

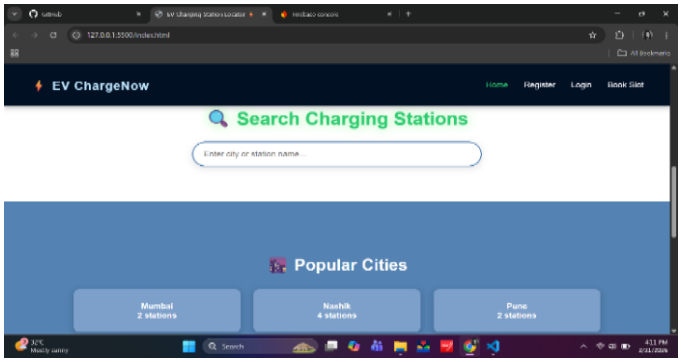

Figure 5 Searching Charging Stations

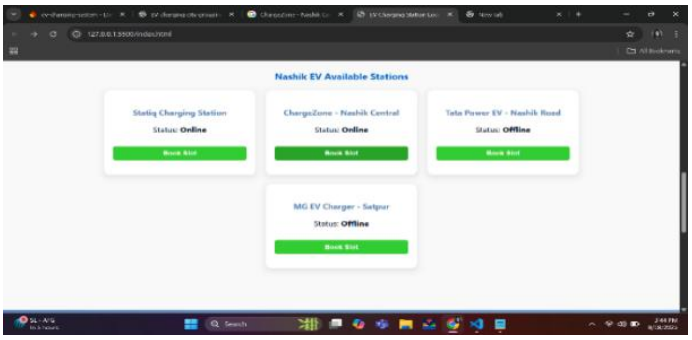

Figure 6 Selection of city and booking slot

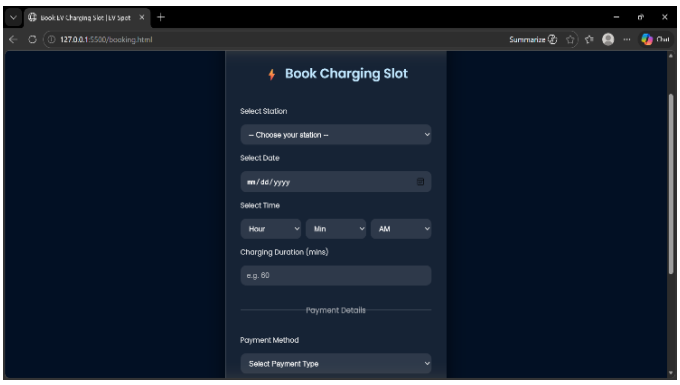

Figure 7 Slot booking and Authentication

Conclusion

This paper presented the design and implementation of a cloud-based EV charging station locator and booking system aimed at improving the efficiency and usability of EV charging infrastructure. The proposed system enables users to locate nearby charging stations, check real-time slot availability, and reserve charging slots in advance through a user-friendly web interface Figure 7. By integrating cloud computing, location-based services, and a scheduling mechanism, the system effectively reduces waiting time, enhances charging station utilization, and improves overall user experience. The inclusion of features such as reminder notifications, navigation support, and an admin panel for slot management further strengthens the practicality of the system. The results demonstrate that the proposed approach outperforms traditional methods in terms of efficiency and convenience, making it a scalable and effective solution for modern EV charging systems.

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