International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Next-Generation Online EV Charging Slot Management Framework

SHILPA A, Prof. K. Rajeswari
DEPARTMENT OF COMPUTER APPLICATION,
ADHIYAMAAN COLLEGE OF ENGINEERING,HOSUR
EMAIL ID:Shilpa.a.mca2023@adhiyamaan.in

Abstract

With the rapid adoption of Electric Vehicles (EVs), the need for an efficient and robust charging infrastructure has become essential to support the growing demand for E-Mobility services. However, the current EV charging stations face several challenges, including long waiting times, charging delays, uneven charge scheduling, and an unequal distribution of charging stations. These issues are particularly prevalent during peak hours, leading to increased queues and extended waiting times for EVs. To address these challenges, this project aims to design a comprehensive framework for an advanced online EV charging slot booking system. The proposed system leverages a stochastic queuing model to optimize the charging process at stations. By formulating an objective function that considers charging time, cost, queuing delay, and distance, the system aims to minimize these inefficiencies while maximizing the overall user experience. Additionally, the project introduces a cloud-based Charging Station Management platform that will network and manage multiple charging stations, facilitating real-time charging forecasts and efficient scheduling. This server-based approach will reduce waiting times, improve resource allocation, and help prevent EVs from running out of battery on the road. Ultimately, the proposed system aims to provide a cost-effective, scalable, and user-friendly solution for optimizing EV charging infrastructure.

KEYWORD:

The Next-Generation Online EV Charging Slot Management Framework integrates key technologies like real-time availability tracking, dynamic pricing, and predictive demand modeling to optimize the user experience and enhance station efficiency. With AI-driven optimization algorithms, it ensures efficient allocation of resources, balancing energy load across the grid and integrating renewable energy sources for greener charging options

INTRODUCTION

EVs offer several advantages over traditional gasoline-powered vehicles. First, they produce zero emissions while driving, making them a more environmentally friendly transportation option. Second, they are often more efficient than gasoline-powered vehicles, meaning they require less energy to travel the same distance. Finally, EVs can save drivers money in the long run by requiring less maintenance and offering lower operational costs due to the lower cost of electricity compared to gasoline. Despite these advantages, EVs also face some challenges, including limited driving range and the need for widespread charging infrastructure to support their use. However, ongoing developments in battery technology and charging infrastructure are helping to address these challenges and make EVs a more viable transportation option for drivers around the world.

An electric vehicle (EV) charging station, also known as an EV charging point or EVSE (Electric Vehicle Supply Equipment), is a device that provides an electric charge to recharge the batteries of electric vehicles. Charging stations can be found in public places such as parking lots, shopping malls, and rest areas, as well as in private residences and workplaces. There are several types of EV charging stations, including Level 1, Level 2, and Level 3 charging stations. Level 1 charging stations provide a low level of power and can typically charge a vehicle in 8-12 hours, using a standard household electrical outlet. Level 2 charging stations provide a higher level of power and can charge a vehicle in 3-8 hours, using a 240-volt power supply. Level 3 charging stations, also known as DC fast charging stations, provide the highest level of power and can charge a vehicle in as little as 20-30 minutes, using a 480-volt power supply.

OBJECTIVE

The **Next-Generation Online EV Charging Slot Management Framework** is to develop a smart, efficient, and user-centric system that optimizes the management of electric vehicle (EV) charging stations. By leveraging **real-time data**, **AI-driven optimization**, and **dynamic pricing**, the framework aims to enhance the charging experience for users, reduce waiting times, and ensure the efficient allocation of resources. It strives to integrate **renewable energy sources**, balance **grid load**, and promote **sustainability** through features like **carbon offset tracking** and **energy consumption insights**. Additionally, the framework seeks to provide **seamless interoperability** across various charging networks and **secure payment solutions**, ensuring that users have access to reliable and efficient charging options. By offering tools for **fleet management** and **maintenance alerts**, the framework also supports businesses and charging station operators in optimizing operations, reducing downtime, and improving profitability. Ultimately, the objective is to contribute to the transition toward a **greener, smarter, and more connected EV ecosystem**, enhancing the overall EV adoption experience.

EXISTING SYSTEM

The existing system for electric vehicle (EV) charging typically involves manual processes and lacks advanced features for optimizing charging slot allocation and enhancing user experience. Some key characteristics of the existing system include:

- **Manual Booking Process**

EV users typically rely on manual methods to find and book charging slots at charging stations. This may involve searching for available stations online, contacting station operators, and manually reserving slots, which can be time-consuming and inefficient.

- **Queueing Theory**

Queueing theory models, such as M/M/1 and M/M/c queues, can be used to analyze and optimize charging station queues. These models characterize the behavior of users waiting for charging slots, helping to minimize queue lengths, waiting times, and system congestion.

- **Rule-based Algorithms**

These algorithms rely on predefined rules and heuristics to allocate charging slots. For example, a simple first-come-first-served (FCFS) approach may be used, where charging slots are allocated to users on a first-come, first-served basis. While straightforward, rule-based algorithms may not account for dynamic factors such as user

- **Dynamic Programming**

Dynamic programming techniques, such as the knapsack problem or shortest path algorithms, can be applied to optimize charging station utilization and slot allocation. These algorithms consider multiple charging sessions and constraints to determine the most efficient allocation of resources.

- **Machine Learning Algorithms**

Various machine learning techniques, such as regression, classification, and clustering, can be applied to predict charging slot availability and demand patterns. These algorithms analyze historical data on charging station usage, user behavior, and environmental factors to make predictions. Support Vector Machines (SVM), Decision Trees, and Random Forests are examples of machine learning algorithms used for prediction tasks.

DISADVANTAGES

- Charging an EV could be very time-consuming,
- So reaching a CS and all of the connectors are being used could be frustrating and make us wait in line.
- The number of stations providing full recharge of batteries is quite rare

  Decentralized.
- Today, charging stations and cars may not yet be equipped for smart charging.
- Limited efficiency (max. 90% today)
- Need for infrastructure build-out
- Manual booking process leads to inefficiencies and inconvenience for users.

- Limited visibility hampers effective planning of charging sessions.
- Fixed pricing models may not align with dynamic factors such as grid demand.
- Manual payment processing is cumbersome and inefficient.
- Lack of feedback mechanisms makes it challenging to assess user satisfaction.
- Inefficient resource allocation may lead to underutilized or overbooked charging slots.
- Limited scalability hinders the accommodation of growing demand for EV charging infrastructure.

PROPOSED SYSTEM

The proposed system aims to transform the electric vehicle charging experience by leveraging advanced technologies like reinforcement learning, particularly Q-learning. Through real-time slot prediction and automated booking processes, the system optimizes slot allocation, ensuring efficient resource utilization and enhancing user satisfaction. By integrating with external data sources and maintaining robust security measures, it promises scalability, reliability, and user privacy. The system will optimize charging slot allocation, enhance user experience, and improve overall operational efficiency of charging stations. Key components of the proposed system include:

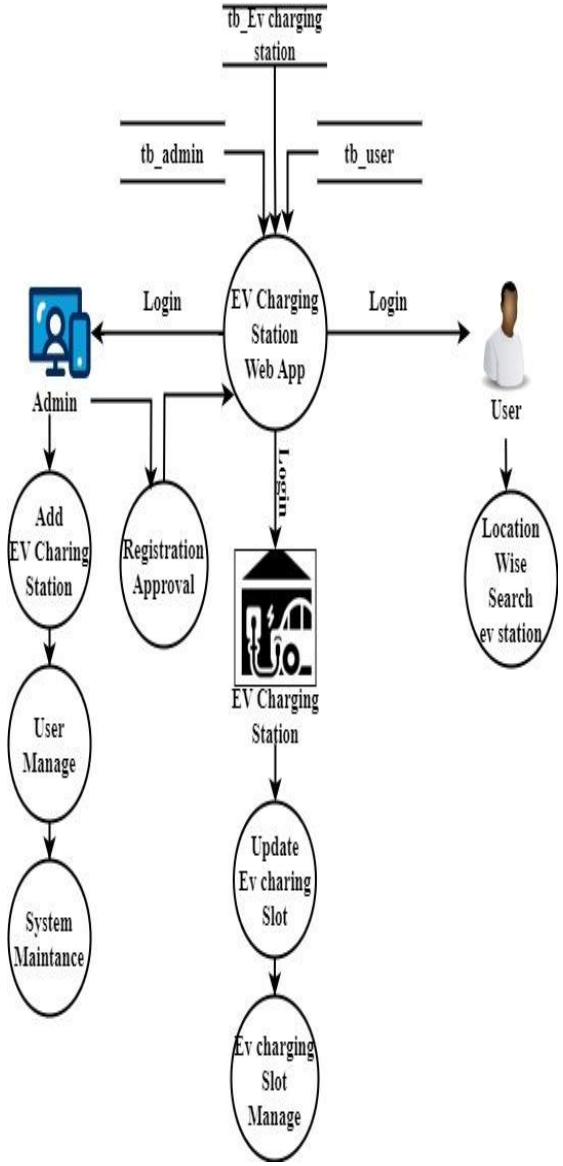
- **Slot Prediction Module:** Implement reinforcement learning techniques, such as Q-learning, to predict charging slot availability in real-time. The module will analyze historical data, user behavior, and external factors to anticipate future demand and optimize slot allocation.
- **Booking and Reservation System:** Develop an automated booking system that allows EV users to easily find and reserve charging slots. The system will provide a user-friendly interface for browsing available slots, making reservations, and managing charging sessions.
- **Payment Processing Integration:** Integrate payment processing functionality to facilitate seamless transactions for charging sessions. Users will be able to make payments securely through the platform using various payment methods.
- **Notification System:** Implement a notification system to provide users with real-time updates on booking confirmations, charging session reminders, and payment notifications. Notifications will be sent via email, SMS, or through the mobile app.
- **Charging Slot Visualizer:** Develop a visual interface that displays real-time information about charging slot availability, occupancy status, and predicted demand. The visualizer will help users locate available slots and make informed decisions about charging their vehicles.

- **Admin Dashboard:** Provide an administrative dashboard for charging station operators to manage slot allocation, view booking details, monitor system performance, and generate reports. The dashboard will offer insights into station utilization and revenue generation.

ADVANTAGES

- Automatic EV authentication at DC charging stations through communications protocols which provide plug & charge principles of use
- notification of start and end of charging via SMS messages
- the possibility of determining the amount of energy or charging cost with possibility of automatic interruption
- control of the parking space intended for filling
- A flexible payment system allows charging in a way that promotes optimum use of the infrastructure
- Wi-Fi point for users
- Platform to manage the charging stations
- Interoperable with multiple vendor's charging station
- Innovation with open standard

- Locating and Reserving Charging stations with a Mobile App
- Billing & Access Control
- Location based search to find you the most appropriate charger for your EV.



Find all the details about the charger including customer reviews, recent rating trends

WEB REFERENCE

1. Flask documentation: https://flask.palletsprojects.com/en/2.0.x/
2. OpenCV documentation: https://docs.opencv.org/master/
3. MySQL documentation: https://dev.mysql.com/doc/
4. Brute force attack definition: https://en.wikipedia.org/wiki/Brute-force_attack
5. Python MySQL Connector documentation: https://dev.mysql.com/doc/connector-python/en/
6. Flask-MySQL documentation: https://flask-mysql.readthedocs.io/en/latest/
7. OpenCV Face Recognition tutorial: https://docs.opencv.org/3.4/db/d7c/tutorial_table_of_content_face.html
8. OpenCV Face Detection tutorial: https://docs.opencv.org/3.4/d2/d99/tutorial_js_face_detection.html
9. Flask OpenCV integration tutorial: https://www.pyimagesearch.com/2018/09/17/opencv-ocr-and-text-recognition-with-tesseract/
10. Flask login extension documentation: https://flask-login.readthedocs.io/en/latest/