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VoltSpot: EV Dock Locator and Power Reservations

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Abstract
The widespread adoption of electro mobility constitutes one of the measures designed to reduce air pollution caused by traditional fossil fuels. However, several factors are currently impeding this process, ranging from insufficient charging infrastructure, battery capacity, and long queueing, and charging times, to psychological factors. On top of range anxiety, the frustration of the EV drivers is further fueled by the uncertainty of finding an available charging point on their route. To address this issue, we propose a solution that enables EV drivers to make charging reservations for the upcoming days, especially when planning a longer trip. Our algorithm Utilizes geolocation technology to track customer locations, enabling predictive analytics to optimize charging station placement. The system also provides real-time information on the availability of charging slots at each station, allowing users to check slot availability and book a slot in advance. By empowering EV users with the ability to conveniently find nearby charging stations and reserve charging slots tailored to their vehicle's requirements, this solution aims to promote the adoption of electric vehicles alleviate range anxiety among EV drivers.

Keywords *- Electric Vehicles, Charging Infrastructure, Slot Booking System, Haversine Algorithm, Range Anxiety.*

1. Introduction

In our rapidly advancing world, technological innovations permeate every facet of life, revolutionizing industries and reshaping societal norms. In the realm of transportation, electric vehicles (EVs) have emerged as a pivotal solution to mitigate environmental impact and foster sustainable mobility. Their energy-efficient operation and minimal carbon footprint have garnered increasing adoption among conscientious consumers seeking eco-friendly alternatives. However, despite their environmental benefits, the widespread adoption of EVs faces a significant hurdle: the time-consuming nature of charging these vehicles, especially in scenarios of high demand. This challenge has prompted the development of innovative solutions to streamline the charging process and alleviate user discomfort. One such solution is the implementation of a slot booking system for EV charging, aimed at providing users with the convenience and assurance of scheduled charging sessions. By enabling individuals to reserve charging slots in advance, this system seeks to alleviate the uncertainty and stress associated with EV charging, ultimately fostering greater acceptance and utilization of electric vehicles. In this paper, we propose a comprehensive examination of the proposed system's potential to enhance the accessibility and convenience of EV charging, thereby catalyzing the transition towards a more sustainable transportation ecosystem. Below figure 1. Shows India electric vehicle market statistics with 2022 year.

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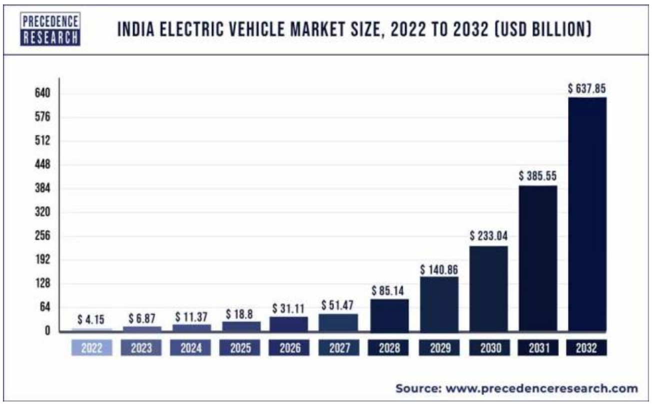

Figure 1 Electric Vehicle Statistics

In our rapidly advancing world, technological innovations permeate every facet of life, revolutionizing industries and reshaping societal norms. In the realm of transportation, electric vehicles (EVs) have emerged as a pivotal solution to mitigate environmental impact and foster sustainable mobility. Their energy-efficient operation and minimal carbon footprint have garnered increasing adoption among conscientious consumers seeking eco-friendly alternatives. However, despite their environmental benefits, the widespread adoption of EVs faces a significant hurdle: the time-consuming nature of charging these vehicles, especially in scenarios of high demand. This challenge has prompted the development of innovative solutions to streamline the charging process and alleviate user discomfort. One such solution is the implementation of a slot booking system for EV charging, aimed at providing users with the convenience and assurance of scheduled charging sessions. By enabling individuals to reserve charging slots in advance, this system seeks to alleviate the uncertainty and stress associated with EV charging, ultimately fostering greater acceptance and utilization of electric vehicles. In this paper, we propose a comprehensive examination of the proposed system's potential to enhance the accessibility and convenience of EV charging, thereby catalyzing the transition towards a more sustainable transportation ecosystem.

2. Related Work

According to Ruzmetov et al. [1], is the EV driver's lack of certainty that there will be an available charging point once they reach the charging station on their route. The authors present a platform designed to ensure continuous cooperation among the various entities involved: energy suppliers, charging stations, EVs, and EV users, proposing an optimization of EV scheduling and allocation to charging stations. When proposing a charging station, the driver's destination and the battery level are considered to ensure that they are not diverted from the route. One of the major impediments to widespread EV adoption is the scarcity of fast chargers, ranking third, after price and driving range, according to a survey conducted by the McKinsey Center for Future Mobility. However, with the EV purchasing costs declining and ranges steadily increasing, charging may soon become the most significant barrier to the adoption of electromobility [2]. Bernal et al. [3] provide a model to optimize charging station management with the use of reservations made in advance, while also calculating the ideal pricing and management strategy, to handle the issue of uncertainty associated with connector availability. Kumar et al. [4] created a distributed system that, based on the battery level, road conditions, the spatial distribution of charging stations, and their available resources and occupancy levels, plans an energy-efficient route, while employing an agile charging slot reservation approach. Wang et al. [5], underline the importance of a scheduling strategy to fill the gap between EV charging requirements and the resources provided by the charging stations and to ensure a positive user experience that would encourage EV adoption. In the same line, Hye-Jin et al. [6] propose a scheduling system relying on reservations made by the users, with the main goal of increasing EV user satisfaction by reducing both costs and queuing times, while maximizing charging station utilization. A linear ranking function is constructed around several factors such as estimated time of arrival of the EVs, waiting time, and the energy requirements, in order to facilitate the scheduling process. In this paper, we present a comprehensive review and analysis of the existing works presented in the literature on commercial vehicle charging. [7] During this process, the deployment can be quite costly, relating to labor and material expenses [8]. There are also studies looking at the optimal number of FCSs to be deployed [9]. As for FCS operational aspect, the

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major concern is the fact that there are too many EVs with charging demand, compared with insufficient FCSs installed. Most existing researches mainly focus on the issue of where to charge .An optimal FCS is selected with charging decision-making [10-12], through constant interaction between EVs and other participants, such as FCSs. Game theoretic models are extensively employed for modeling charging interactions [13-15].

3. Proposed Methodology

The architectural design for our system show in figure 2 encompasses a cohesive framework that seamlessly integrates various components to facilitate efficient interaction between application users, electric vehicle (EV) owners, charging station management systems, and charging stations. At the core of the architecture lies the database, serving as the central repository for storing critical information related to charging stations, user profiles, bookings, and system configurations. The application user interface provides a user-friendly platform for users to access the system, search for nearby charging stations, and book charging slots according to their preferences.

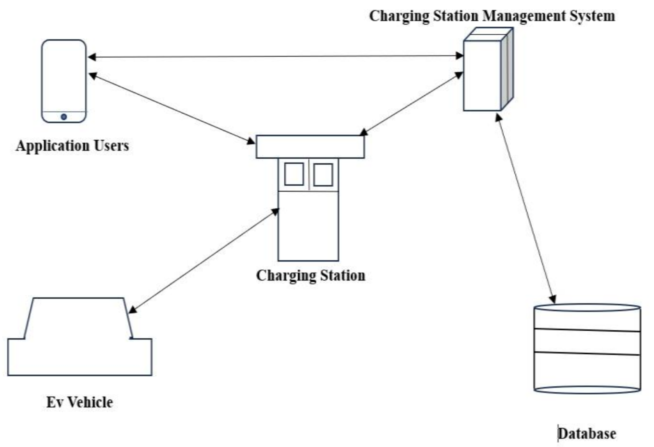

Figure 2 Proposed System

The EV vehicle interface enables communication between EVs and the system, allowing vehicles to interact with charging stations and initiate charging sessions. The charging station management system acts as an intermediary layer, orchestrating communication between the database, charging stations, and application users. It facilitates real-time monitoring of charging station availability, updates charging station statuses, and manages charging slot reservations. Charging stations, equipped with various charging infrastructure, serve as the physical endpoints where EVs can recharge their batteries. Together, these architectural components form a robust and scalable system that streamlines the EV charging process, enhances user experience, and promotes the adoption of electric vehicles in our sustainable transportation ecosystem.

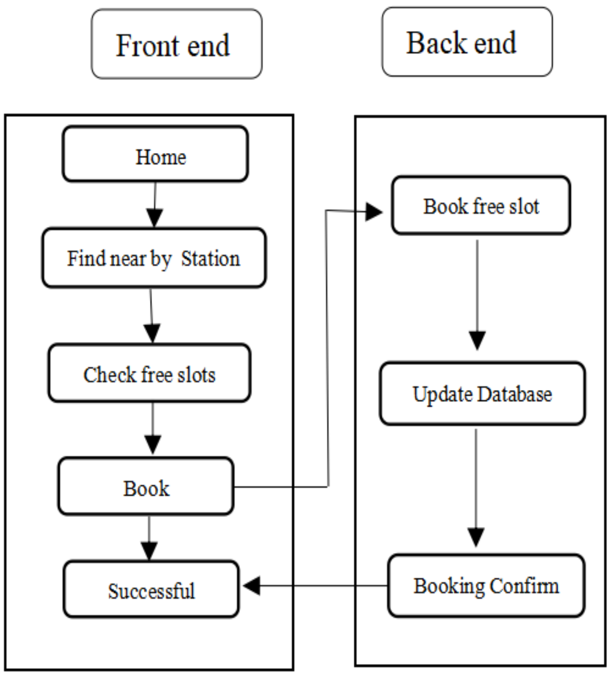

Figure 3 Interface Design of EV Charging Station

In the realm of electric vehicle (EV) charging services, a seamless interaction between the frontend and backend systems is imperative for ensuring a user-friendly experience show in figure 3. On the frontend, users can easily navigate through the platform's interface, accessing features like "Find Nearby Station" to locate convenient charging points. With the ability to "Check Free Slots," users can swiftly identify available charging slots, enhancing their charging experience. Upon selecting a suitable slot, users can proceed to "Book Free Slot," initiating the booking process seamlessly integrated into the

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frontend design. Meanwhile, on the backend, the system springs into action, updating the database in real-time to reflect the reserved slot. As users confirm their bookings, the backend processes the requests swiftly and efficiently, ensuring that each "Booking Confirm" is met with success. Through this harmonious collaboration between the frontend and backend components, the platform delivers a cohesive and efficient service, empowering users to charge their EVs with ease and confidence.

4. Modules Description

The system encompasses two primary modules:

- The Dock Locator Module
- The Power Reservations Module.

The Dock Locator Module utilizes geolocation technology to pinpoint available charging docks in real-time. It employs algorithms to analyze data from charging stations, providing users with accurate information on dock availability and facilitating seamless navigation to the nearest charging point.

4.1 Implementation Details

we have considered various algorithms to calculate the distance between nearby charging station and user. Like Bellman-ford algorithm, Floyd-Warshall, Dijkstra's Algorithm and haversine Algorithm. In that we have choosen haversine algorithm for it's extra feature (calculate distance considering arc length) and time complexity. The Haversine formula is a mathematical formula used to calculate the shortest distance between two points on the surface of a sphere, such as the Earth. It is commonly employed in navigation, geolocation applications, and other fields that require distance calculations between coordinates. An Haversine formula demonstration is show in figure 4.

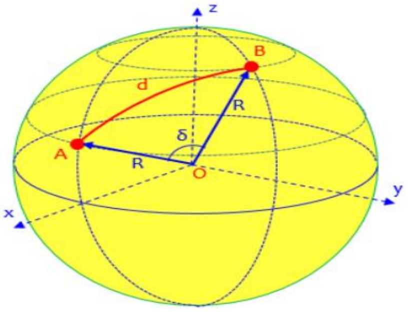

Figure 4 Haversine Formula Demonstration

4.2 Haversine Algorithm

Input: points refer to user and station location.

Step 1. Latitude and longitude of two points (lat1, lon1, lat2, lon2).

Step 2. Set the radius of the Earth (R) to 6371 kilometers.

Step 3. Calculate the difference in latitude (dLat) by converting the

Step 4. latitude difference to radians using the deg2rad function.

Step 5. Calculate the difference in longitude (dLon) by converting the longitude difference to radians using the deg2rad function.(Degree value (deg). Convert degrees to radians by multiplying deg with (Math.PI / 180)).

Step 6. Calculate the intermediate result (a) using the Haversine formula.

$$a = \sin^2(\Delta\varphi/2) + \cos(\varphi 1) * \cos(\varphi 2) * \sin^2(\Delta\lambda/2)$$

Step 7. Calculate the central angle (c) using the arctangent function.

$$c = 2 * \operatorname{atan2}(\operatorname{sqrt}(a), \operatorname{sqrt}(1-a)) - \operatorname{sqrt}(a)$$

Step 8. Calculate the distance between the two points using the formula:

$$\text{Distance} = R * c.$$

Step 9. Return the calculated distance

In addition, optimal pricing is achieved through the maximization of individual utility functions through Nash equilibrium evaluations [15]. Regardless of the efforts put forth into charging scheduling, driver etiquette directly affects the true utilization of charging stations. Once the EV is fully charged, people often simply forget to move the vehicle, which intensifies the imbalance between supply and demand.

5. Results and Discussion

The proposed reservation-based mobile charging solution with minimum charging cost value (R-COST) is compared with two other relative schemes, the shortest distance-based MPU selection (DIST) and the earliest available-time MPU selection based on Algorithm 1 (AVAIL), both with reservation

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concerns as well. Note that the two solutions (DIST and AVAIL) are not capable of providing estimations on charging status at MPUs of any future events. And we are interested in the following performance metrics for evaluation show in figure 5 & 6.

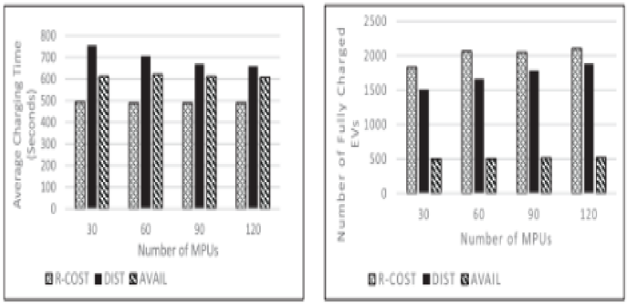
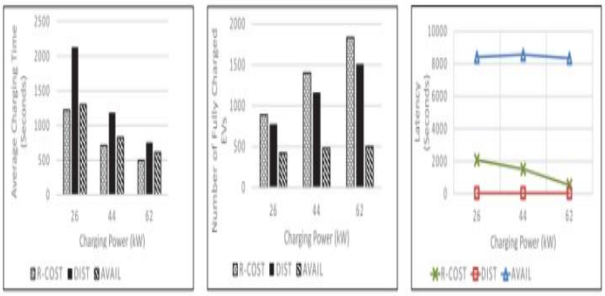


Figure 5 **Impact of Charging Capacity**

Latency: The time taken from when the EV makes its charging reservation to the time the selected MPU arrives.



(a) (b) (c)

Figure 6 **Impact of MPU Charging Power**

The Voltspot home screen as in figure 7(a-i), is the first page you encounter when accessing the Voltspot platform.

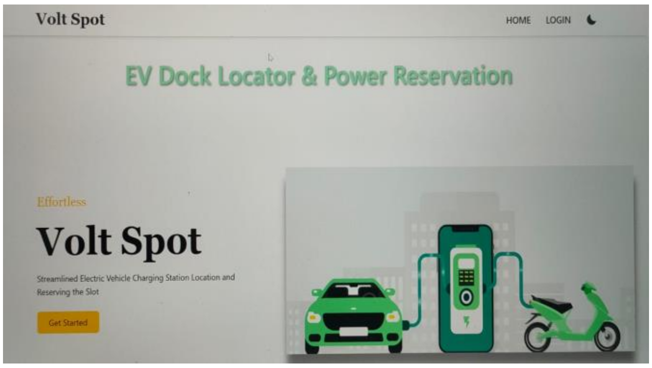


Figure 7a **Home Screen of Voltspot**

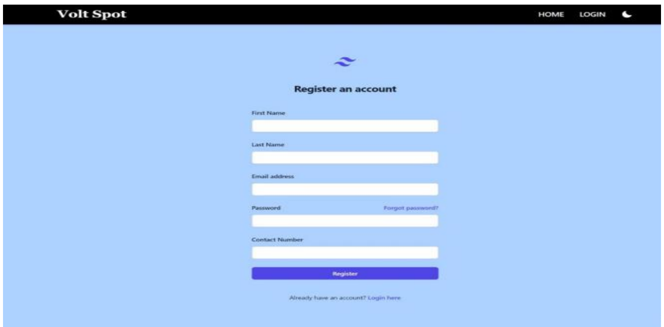


Figure 7b **User Registration Page**

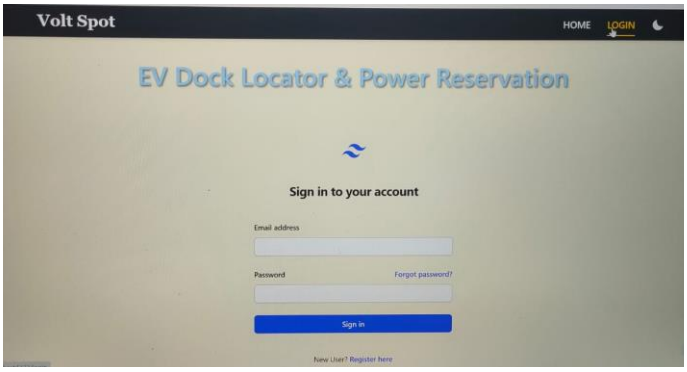


Figure 7c **Login Page**

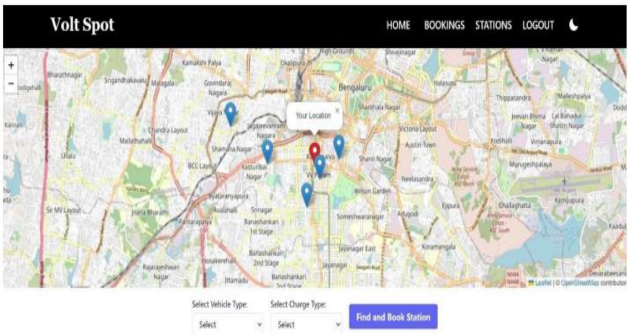


Figure 7d **Bookings and Charging Stations Display**

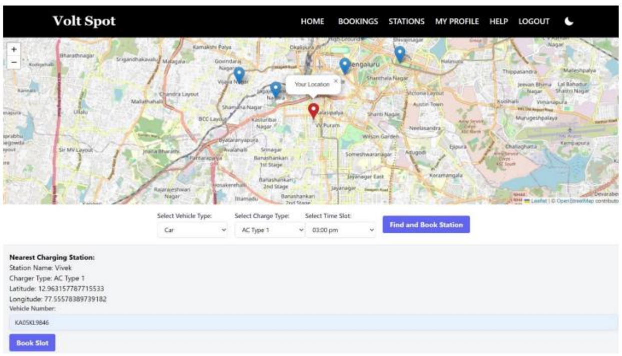


Figure 7e **Nearest Charging Station Displayed**

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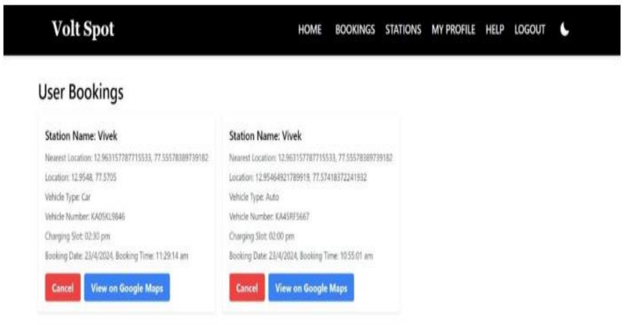

Figure 7f Bookings History

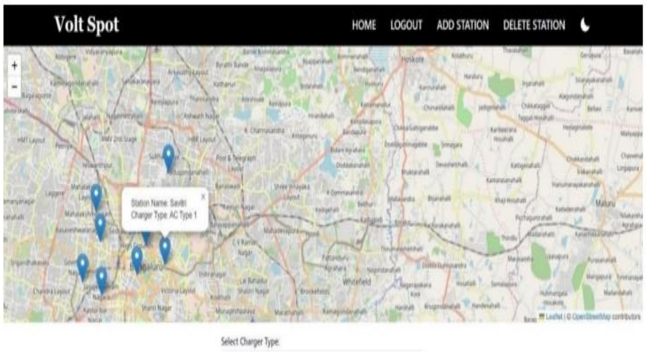

Figure 7g Admin Map

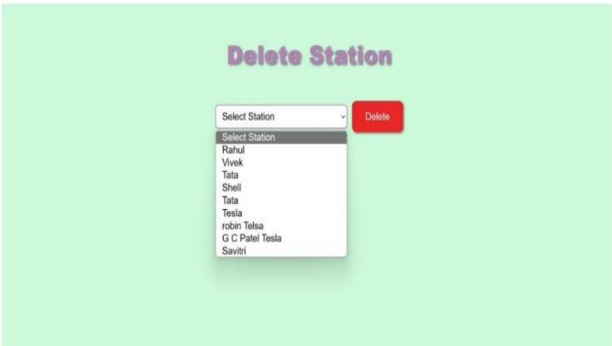

Figure 7h Delete Station

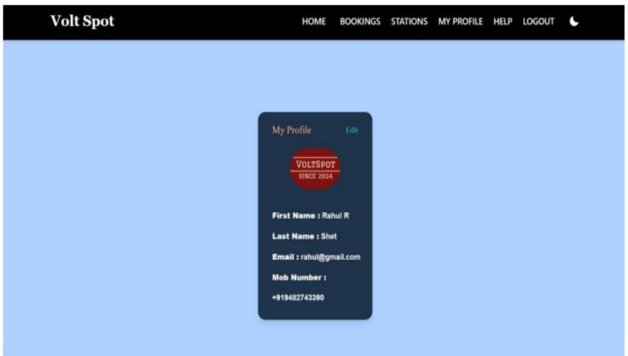

Figure 7i My Profile Page

Conclusion

We proposed a solution for the challenge of electric vehicle reservations. It efficiently identifies and displays nearby charging stations, enhancing accessibility and convenience for electric vehicle owners. With a user-friendly interface, the system enables seamless booking of available slots, ensuring users can plan their charging sessions in advance. Instant booking confirmations provide users with peace of mind, assuring them of their reserved slot and minimizing uncertainty in their charging plans. When the user books a slot on the instant his location is accessed to verify the user movement. If the location is idle for prescribed time user is presented with two choices upon either confirm their arrival to retain the reservation or cancel to release the slot, providing flexibility and accommodating unexpected changes in plans. Through an innovative idle detection mechanism, the system automatically cancels bookings if the user's location idle after reserving a slot, optimizing resource allocation and minimizing inconvenience. By promoting mobile charging services enhanced with mobile charger-selection intelligence, EV drivers range anxiety and charging load over the power grid could be greatly alleviated. This article considers the scenario where EV charging demand is served by MPUs and charging stations.

Future Enhancement

To further expand the functionalities of the reservation module, we plan to add a new option where users can select a time span, and the application returns the closest charging points that are available at that moment. If the closest station has no free slots then it should be displayed next closest station for the same time slot.

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