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Charging Slot Prediction and Automation System for Electric Vehicle Charging Station

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ABSTRACT

With ever-increasing pollution levels and its impact on the environment, governments are looking for alternate energy options for transportation services. Rapidly depleting global oil reserves and rising oil import bills of governments are also driving the need for alternate energy sources for the transport vehicles. Transportation as a whole is undoing a transformational change worldwide and Electric vehicle are the best solution to address both pollution and oil import bills. Electric vehicles are becoming more and more common these days. With the growing demand for Electric vehicles, the charging infrastructure is critical for sustaining the E-Mobility services. As EVs become more commercial, there will be a need to create an efficient slot booking system as the charging process can be time consuming and the need for more stations will be demanding. Developed the Framework and Architecture of the Next-Generation Communication based Online EV's Charging Slot Booking at Charging Station. We built the stochastic queuing model for EVs in the charging station. We formulated the objective function of EV's charging at charging points in charging stations to determine the optimal charging time, minimal charging cost, least distance, minimal queuing delay and optimal duration for particular charging slots. The proposed model of the booking system is designed to create a cost effective and efficient system. Our Cloud based Charging Station Management platform is developed to network and manage multiple charging stations. The proposed server-based real-time forecast charging infrastructure avoids waiting times and its scheduling management efficiently prevents the EV from halting on the road due to battery drain out.

1 Introduction

An electric vehicle (EV) is a vehicle that runs on an electric motor powered by rechargeable batteries instead of using internal combustion engines that run on fossil fuels. EVs are becoming increasingly popular due to their low environmental impact, improved performance, and reduced operational costs. The batteries that power EVs can be recharged by plugging the vehicle into an electric power source, such as a charging station, or by regenerative braking, which captures the kinetic energy of the vehicle during braking and converts it into electrical energy to recharge the batteries. EVs are available in a range of types, including all-electric vehicles, plug-in hybrid electric vehicles, and hybrid electric vehicles. 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



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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. Electric Vehicle Charging Station: 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.

Web Design and Development: Web development on the other hand refers to the process involving building and maintenance of websites. The process is mainly concerned with what happens behind the scenes to make a website look great, work fast, and perform well with seamless user experience. Web developers often do this by using a variety of coding languages. Viral Grow, a website development company in Delhi more often than not chooses to also break down such a wide-ranging term into smaller tasks, skills, and disciplines and compartmentalize them as web engineering, web development, web content writing, server-side scripting, client liaison, web server and security configuration, e-commerce development and many more.

The specific objectives of developing an EV charging station finder website may include:

- Improving convenience for EV drivers
- Reducing range anxiety
- Encouraging EV adoption
- Supporting sustainable transportation
- Providing valuable data insights

Thus, the objective of developing an EV charging station finder website is to support the growth and adoption of EVs by providing a reliable and user-friendly resource for EV drivers to find charging stations easily and efficiently.

2 Recent Works

Sugii et al. proposed a genetic algorithm-based scheduling method of charging electric vehicles. It manages to determine a sub-optimal charging timetable which satisfies the given electric load curve under the structural constraints of their system. The charging facility consists of several charging bays which offer multiple connectors to vehicles, but of which only one can be actively charging at a time. An ideal load curve is defined as a step function in order to make use



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of the late-night off-peak electricity prices. Problem is split into two: (i) connecting problem (selecting a charger to which the EV should connect) and (ii) scheduling problem (determine the starting time of charging). The genetic algorithm is applied to the latter, with the goal of fitting the total charging load curve to the ideal load curve.

Hutson et al. proposed an intelligent binary particle swarm optimization (BPSO) based approach to schedule the usage of available energy storage capacity from EVs. Next to the vehicles being able to take power from the grid and charge the batteries, they introduce an idea of also providing power to the grid when parked, so called vehicle-to-grid (V2G) concept. A scalable parking lot model, with the objective of maximizing profit for the operator, is developed. BPSO is applied to schedule whether each vehicle should buy, sell, or hold at every time step it is parked. Two case studies have been conducted. The first one takes the price curve and determines the best (maximum) selling and best (minimum) buying price — this way only one transaction occurs for each vehicle. This results in lower profit potential but the schedule is easy to determine. The second case study considers multiple transactions throughout the parking duration. This allows for higher profits but greatly increases the scheduling difficulty. However, the problem is separable, since there are no common constraints and the solution can be found for each vehicle individually, which greatly reduces its dimensionality. The results show that multiple transactions result not only in significantly higher profits, but also reduce the net power out to the grid.

Sundstrom and Binding compare two different approaches to optimize EV battery charging behavior with the goal of minimizing charging costs, achieving satisfactory state-of charge (SoC) levels and optimal power balancing. The first one is based on a linear approximation, whereas the second one uses a quadratic approximation. The battery's non-linear and state-dependent model is used to evaluate the obtained solutions. They do mention the V2G concept, but do not apply it in their setting. The difference between the two methods turn to be minor and they conclude that a linear approximation is sufficient, as the resulting violations of the battery boundaries are less than 2% (however, in a perfect, deterministic setting). They continue their work by proposing a method of planning the individual charging schedules of a large EV fleet while respecting the constrained low-voltage distribution grid. It has been tested in a simulation environment in which the movement and charging of individual EVs are simulated simultaneously. Here, the planning period is represented by 96 slots of 15 minutes and the charging spots are rated at 16 kW. A centralized fleet operator is assumed, which handles data storage, trip forecasting (here assumed perfect), optimization, customer relationship and billing information, and communication. Three different charging schemes are compared:

- (i) Eager charging (connect and charge)
- (ii) Price-based charging (unconstrained grid, minimizing only the total cost of electricity used for the fleet)
- (iii) Grid aware price-based charging (respecting the grid capacity as well).

Results show that both for eager and pure price-based charging, the grid is significantly



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overloaded. Including the grid constraints reduces the overload (however, with still present peaks), but slightly increases the total cost.

Sánchez-Martin and Sánchez focus on the electric power management at parking garages, as new potential high concentrated electric consumption nodes. By exploring the benefits of implementing a consumption management control (CMC) in a 50 plug-in vehicles case study, they analyze power capacity requirements and costs, savings on energy consumption and penalties for non-supplied energy. The vehicles are modeled as EV and PHEV entities with specific attributes, such as maximum battery charge (23 kWh and 7.2 kWh), charging rate (3.8 kW and 2.2 kW), arrival time, stay duration, and initial and final SoC. At the parking garage, power capacity is considered an actual parking resource, next to the several parking zones managing different charging status of the vehicles: waiting, charging and resting (FIFO queues). Vehicle arrivals are modeled as a Poisson process with a different arrival rate for each hour of the day. The CMC attempts to avoid excesses over the total power capacity and to minimize the total energy cost, based on three charging time frames: two valleys (0:00 – 3:00; 3:00 – 6:00) and off-valley (6:00 – 0:00). Simulations show that implementing the CMC:

- (i) Delays a significant percentage of the supply energy to a period of lower energy prices
- (ii) Avoids overcoming the power capacity
- (iii) Reduces the contracted power capacity
- (iv) Reduces the non-supplied energy levels. Total cost savings are rated at 34% to 50% when CMC is employed.

Disadvantages of existing system are:

- 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, Limited efficiency (max. 90% today)
- Today, charging stations and cars may not yet be equipped for smart charging.

3 Proposed Work

Stochastic Queuing Simulation (SQS) is a methodology for characterizing and simulating large-scale workloads (e.g. to evaluate new server configurations, scheduling policies, etc.). While pieces of these methods may be well known to queuing theorists or statisticians, they have not been presented in a cohesive manner, or widely adopted by the systems community. A queuing model is composed of a collection of “slots” which process charge. We model each charging station as a single queuing system; this queuing system may have multiple “slots” which correspond to individual CS in a multicore CS. car arrive into the system according to an inter arrival time distribution and their size (measured in time) is distributed according to a service time distribution. A queuing discipline must be chosen to determine how queued jobs are scheduled and processed;

Web and mobile application the innovative advantages over other charging stations are the web



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and mobile application. When a user registers, all the functions of the system can be managed through the application. With the application, charging of EV becomes reliable, and the trip less stressful, as the application allows the user:

- Find the nearest charging station,
- Reserve charging time,
- Navigation to the location,
- Easy charging activation,
- Charging limit setup (amount of energy, amount, time),
- Flexible payment system (payment cards, PayPal system...);
- Live monitoring of charging during other activities (meeting, shopping, viewing the show...)

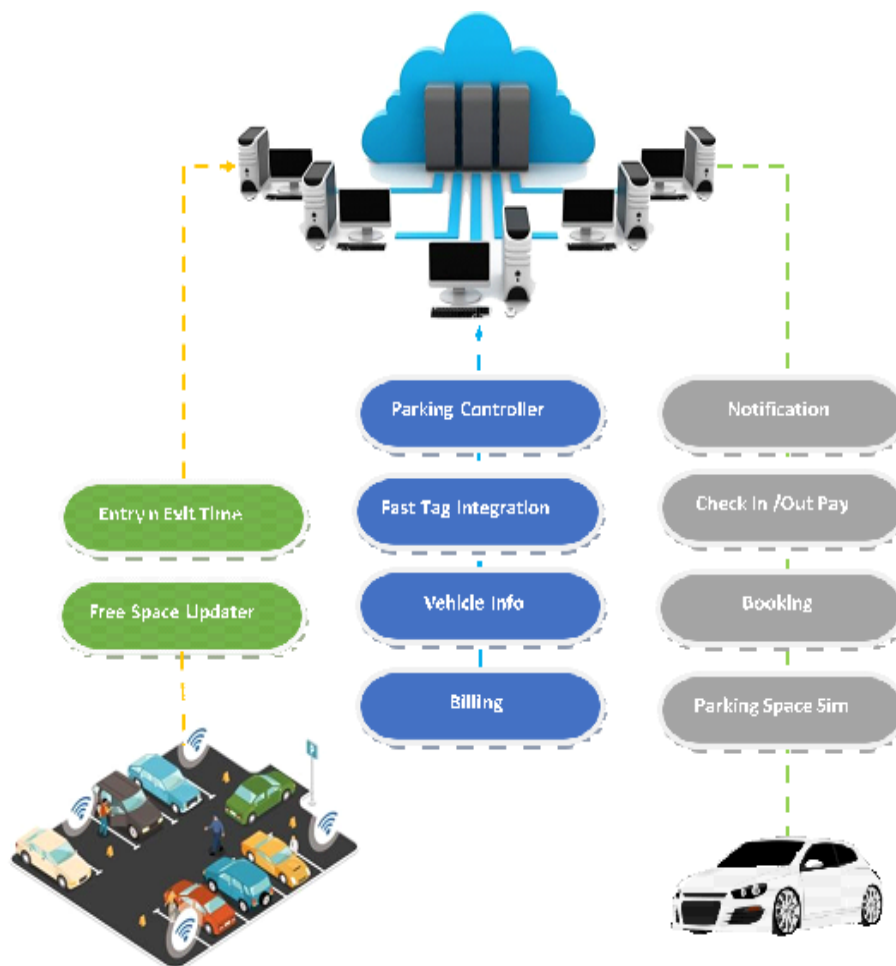


Figure 1: Proposed system's diagram

Modules of the proposed system includes:



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Web-based Control Panel: Manage all aspects of your charging infrastructure, customer & partner relations, billing and payments, view stats and reports. Accessible online with comprehensive access control. It also provides to the platform users a complementary user interfaces that, although supporting only a reduced set of the operations available on the native mobile app, allows the users to interact with the platform using browser-only technologies, available in a wide. This possess End user/Admin Module.

CRM: Manage user accounts, define access rules and monitor usage. Set access rules and manage user groups to better control access and terms of usage for your users.

Parking Lot Controller: The parking lot control center (PLCC) plays a major role in collecting all available offer/demand information among parked electric vehicles.

Parking Slot: This module creates and configures parking lots, sometimes referred to as parking orbits, Real-time monitoring of parking space availability by facility, level, and single space. Monitors the occupancy of parking lots and parking garages.

Electric vehicle charging point: Add and manage charging stations and locations. Set access rules and visibility (private/public), monitor usage and consumption.

Tariff Management: Tariffs could be setup based on power consumption or time elapsed or combination of both. Different fees could be applied during charging and for parking after charging is complete.

- Level 1 Charging: Up to 2 miles, 30 minutes
- Level 2 Charging: Up to 10 miles, 30 minutes
- DC Fast Charging: Up to 90 miles, 30 minutes

Charging On-the-Go: On forecourts electric fast charging services are developed for drivers who need to recharge their vehicle during their journeys. High-powered fast or super-fast chargers (50kW to 350kW) can charge an electric vehicle in between 10 and 30 minutes, depending on the size of the battery.

Charging Station Payment: Accept payments from customers, generate receipts and reports. PayPal, credit & debit card and voucher payments are supported out-of-the-box with further payment options to be added upon request.

Schedule your charging: Easy booking via web or mobile application, Authentication with a telephone call or mobile application allows the ad hoc use of unregistered users (no need to build roaming systems for users). EV drivers will be able to locate EV charging stations, get step by-step directions, determine the charger type (Single or Dual Level Port), and view real-time station status (available, in use, etc.) in our new Advanced dashboards.

Charging history: View usage statistics and generate and export usage reports. Monitor network activity in real time and export historical data.

Geo-based Ads: An integrated ads delivery module allows for publishing of geo-specific promotional offers per location/charging station, thus providing an additional monetization model.

Notification Service: This module provides all the notification related services to the platform,



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routing the system-generated notifications to users that had subscribed to that notification (i.e., vehicle charged, abnormal charge pattern, etc)

Parking Simulator: The parking simulator takes, as input, a lot physical layout file, a schedule file of incoming EVs and normal cars, and a set of parking behavior rules. In order of arrival in the schedule file, the parking simulator applies the following steps to determining the placement of the EV or normal car:

Parking Incentives: Free parking for EVs citywide, downtown, or in select sectors of the city. Free parking while charging, Parking for EVs allowed in otherwise restricted areas, Parking spaces reserved for EVs only reduced parking fees for EVs in public lots.

Rescheduling Reservation: Push/Pull Mode communication framework to support basic EV charging service as well as the Advanced Pull Mode to support reservation-based service are fully compatible with these two standards. Note that our proposed communication framework can also support a reservation updating operation. Specifically, an EV may publish an update about its reservation, if it cannot arrive at the selected CS on time due to traffic congestion, such that its original reservation can be rescheduled. Upon receiving reservation updates due to experienced traffic uncertainties on the EV side, a CS may publish this information periodically to EVs through RSUs.

4 Results

An electric vehicle (EV) charging station finder website is to provide accurate, up-to-date information about the location, availability, and compatibility of charging stations to help EV drivers find a station when they need it. The website should aim to address the issues that EV drivers face in finding charging stations, such as insufficient charging station locations, inconsistent charging station information, and confusing payment methods.

The above figure 2. describes the user registration process. User/Admin register the information like a user name, mobile number, mail id, etc. User/Admin was registered into this website after that they receive the notification via SMS/email id. The user/admin can login in this page. It checks whether the username and password are correct, if correct allows the user/administrator to update or view the details else displays the error message.



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The screenshot shows a 'User Registration' form. On the left, there is a sidebar with a logo and contact information: 'EV Charging Station', 'Phone: +1235 2355 98', and 'Email: evcharge@info.com'. The main form area contains the following fields: 'Name' (filled with 'Rahul'), 'Surname' (filled with 'Salem'), 'Phone' (filled with '9674283074'), 'Email' (filled with 'rahul@gmail.com'), 'Sex' (a dropdown menu), 'Age' (filled with '2200774433'), 'Address' (filled with '270600042828'), 'Username', 'Password', and 'Re-type Password'. A blue 'Register' button is at the bottom.

Figure 2: User Registration Page

The screenshot shows a 'Parking Station: evstation' page. On the left, there is a sidebar with a logo and contact information: 'EV Charging Station', 'Phone: +1235 2355 98', and 'Email: evcharge@info.com'. The main form area contains the following fields: 'Energy Station' (filled with 'evstation'), 'Area' (filled with 'SS Nagar'), 'City' (filled with 'Salem'), and 'Location' (with a 'View Map' link). A blue 'Book' button is at the bottom.

Figure 3: Booking of Parking station

Figure 3 shows that the parking slot control center collecting all available offer/demand information among parked electric vehicles. After that it will create and configures parking slots, monitor the parking space availability and the occupancy of parking slots and parking



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garages.

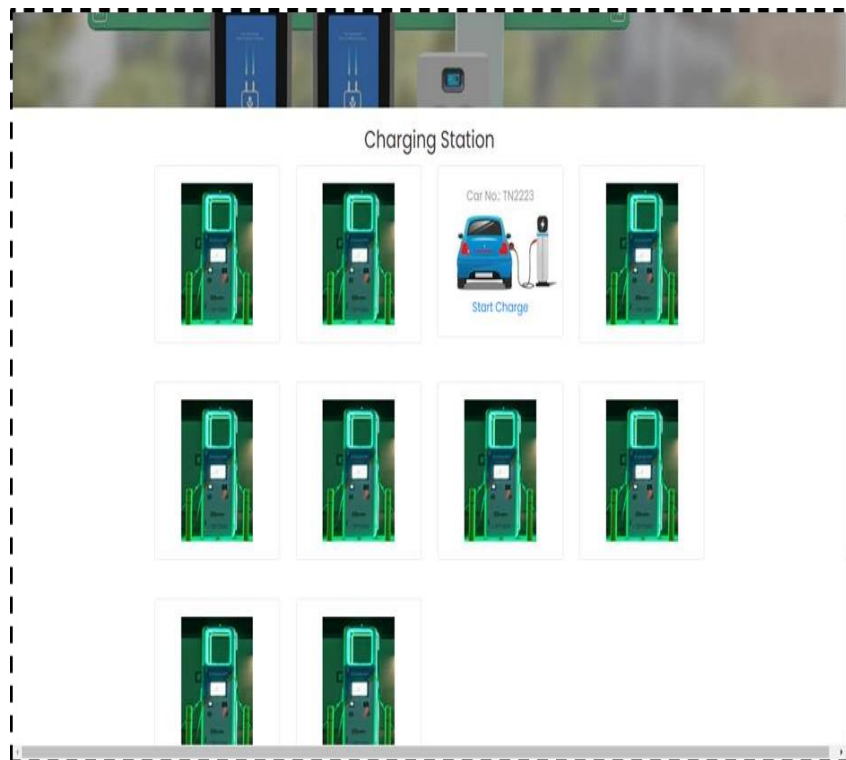


Figure 4: Charging station

Figure 4 depicts the electric fast charging services are developed for drivers who need to recharge their vehicle during their journeys. High-powered fast or super-fast chargers (50kW to 350kW) can charge an electric vehicle in between 10 and 30 minutes, depending on the size of the battery. It is also possible to view usage statistics and generate and export usage reports. Payments are accepted from the customer and accordingly generates the receipts. Notification services are provided by the system to the users.

5 Conclusion

We have implemented a complete system to supervise the charging of EVs in car parks, using small and cheap is connected to the Internet wirelessly. The proposed system allows a user to access the information associated with the charging process (cost, effective elapsed time, estimated time to full charge, etc.), and a supervisor to manage different aspects of the process such as billing of consumed energy, charging priorities, etc. The use of a Wi-Fi connection dramatically reduces the wiring and the complexity of the installation, and simplifies the interaction with the users of the system. The main idea behind this is the fact that every single parking space will need to be adapted to serve as a charging point, and given the shared ownership nature of these garages, we need a way to measure and manage the power consumed



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by the vehicle recharge. Electric mobility is developing rapidly - both in demand and supply. The demand for (better) charging infrastructure is bigger than ever. This is why we've installed charging facilities for electric vehicles in all of our parking locations. Charging stations, charging management, and support services. All-in-one. We're here to save you from the hours of administration, by taking care of the installation of our charging stations, the monitoring and balancing of their power consumption, the pricing and invoicing of all charging sessions, and technical support altogether.

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