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Electric Vehicle Smart Charging with Advance Reservation Extension

Dr. Harish B.G[1], Swarnashree M S[2]

Assistant Professor, Dept. of Master Applications, University B. D. T College of Engineering, Davanagere, India[1]

PG Student Dept. of Master Applications, University B. D. T College of Engineering, Davanagere, India[2]

ABSTRACT: The accurate management of interactions between the end user, electric vehicle, and charging station during recharge is critical for the spread of electric mobility. The paper proposes an extension to the Open Charge Point Protocol standard to involve the user in the charging optimization process. The user negotiates a recharge reservation with the central station, indicating his or her preference and flexibility. The charging station management system offers a variety of solutions based on the user's flexibility. This negotiation enables the optimization of power grid management while taking into account user requests and constraints. The entire architecture has been designed, implemented on a web server, and tested on a smartphone app. This paper reports on the findings.

KEYWORDS: Electric, open charge point, FEV.

I.INTRODUCTION

Full electric vehicles (FEV) are becoming more popular, and market penetration can grow and sustain itself, lowering FEV costs. Despite widespread electrical infrastructure, one of the most serious barriers to FEV adoption is the lack of a widespread FEV charging infrastructure. This infrastructure will necessitate both private and public sector investment. Although the cost of FEVs is expected to fall as they become more widely available, buyers continue to perceive limited car autonomy and long battery charging times, which are significantly longer when compared to refuelling internal combustion vehicles [1], as significant barriers to purchase [2,3].

The capacity of the grid connection is the primary constraint on battery charging time. While plug-in recharging can be done at home overnight, a faster charging solution, requiring a high power to the electrical grid, can be made in recharging stations, commercial or public parking lots, shopping centres, and along streets or workplaces.

With the widespread adoption of FEVs, battery charges will have a significant impact on the configuration and operation of smart grids, given the high power required for a fast charge (e.g., 150 kW required to charge a Tesla model S from 20 percent to 80 percent in 30 min). Overloading issues can occur when multiple vehicles in the same neighbourhood recharge at the same time or during normal peak loads [4,5,6,7,8,9]. The impact of electric vehicle (EV) charging on a smart grid can be significant. [10] presents a pooling strategy of multiple charge points that could improve grid stability in the event of high fluctuation of renewable energy resources.

The lack of publicly available charging stations contributes to EV sales continues to be low. A review of studies facing the relation among parking spaces and chargers and the cost of charging for EVs on EV sales is reported in [11].

The transition to electric mobility is aided by software services and applications. [2,3] presented a smartphone app with battery monitoring, dynamic range prediction, route planning, and station reservation based on the Internet-of-Energy (IoE) project [4] toward interoperable services for large-scale EV mobility. According to current standards, charging station reservations are permitted from the time of reservation for a set period of time. It is not possible to make a reservation in advance that specifies the start time of the charge reservation. As a result, the authors present in [2] a complex system of continuous reservation throughout the journey, calculating the expected time of arrival at the charging station.

Extensions to the Open Charge Point Protocol (OCPP) are proposed in [12,13]. The extension in both papers is primarily the integration of the smartphone into the system and the development of an application to monitor vehicle charging in real time. The recharge reservation is not taken into consideration.

The security of the OCPP protocol is addressed in [14], where the authors, focusing on the protocol's 1.6 version, analyse some threat scenarios that can be configured in the protocol's use. It is argued that possible protocol subversion or malicious endpoints can also lead to power network destabilisation. The attack could be the result of a man in the

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middle, energy theft, or fraud. Countermeasures have recently been proposed in [15], specifically for Man-in-the-Middle attacks between a charge point and the central server, which may expose sensitive data of particular interest to the various stakeholders involved in this context.

The OCPP security issue is also addressed in [16] where the problem of network traffic analysis to detect malicious transaction is faced with the use of back-propagation artificial neural network.
[17] recently addressed the problem of implementing grid-aware electric vehicle charging systems with local load control. Changes to the US National Electric Code (NEC) now allow for the 'over subscription' of more EV charging stations than can be continuously supported if the total load at any time remains within the supply system safety limit. Local load control from grid to vehicle in a small system is proposed using compact submeters with locally hosted control algorithms and direct communication to the managed EV supply equipment.
The application will enable advance remote booking of charging slots by electric vehicle owners.
The application will also provide information regarding location, types and number of chargers installed and available during a given time period," said the official, who did not wish to be identified.
In the current system, electric vehicle owners must visit the charging station to obtain information. Furthermore, they have no knowledge of the availability of charging slots for vehicles. If all available slots are full, electric vehicle owners will have to wait a long time to recharge their vehicle. The manual system is the current system. It must be converted into an automated system. In the current system, people must push their vehicles or seek assistance to reach the nearest electric recharge station to check the availability of charging slots. The above method requires time and manual labour from vehicle owners. For some aged people or medically ill people it will get even hard. To get electric to fill generators people need to go to an electric recharge bunk station.

To solve the existing problem, I created an online framework where all data about charging stations and charging slots can be accessed. Electric vehicles can use their fingertips to find the nearest electric charging stations and available charging slots. The proposed Android app will allow users to reserve charging slots at charging stations. Because the framework will be online, an electric vehicle owner will be able to book slots whenever and wherever they want.

III. SYSTEM ARCHITECTURE

WebSocket is used as a communication protocol between the individual charging stations and the central system in this protocol. Data sent over WebSocket can be formatted in a variety of ways, including the Simple Object Access Protocol (SOAP) or JSON (JavaScript Object Notation).
We used the JSON implementation, which is a widely used format in many fields and lends itself to interacting with Web Applications written in the ASP.Net language and Android applications. Figure 1 depicts the developed system, which consists of the Charging Station Management System, the Database storing the data, the Charging Station, the Electric Vehicle (EV), and the EV driver via a smartphone app.
Electric Vehicle. The EV creates a communication with the charging station through powerli using ISO/IEC 15118 standard. They exchange information on the capacity of the battery, maximum power allowed, etc.
Driver of an EV. The driver defines the recharge parameters and performs the recharge reservation using an interface on the charge spot, a smartphone, or a wifi range wireless protocol already present in the EV.
Station for charging: It enables interoperability with all types of electrical vehicles, provides users with information on the cost, maximum available power directly when the driver performs a recharge without reservation or through the central system during the reservation, and exchanges information with the database via the central system.

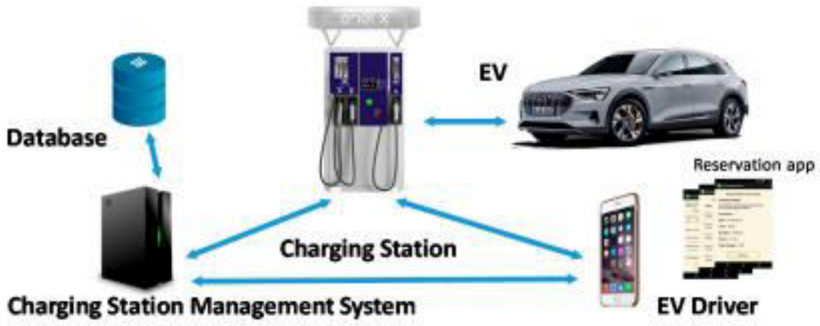

Figure 1. System Architecture proposed.

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- User login
- Creating a reservation for a certain time.
- Cancellation of bookings made by the user.

- The charging operation is performed in advance in order to perform and advance reservation of a connector of the Charging station. The core of the proposed system is to provide the user with a set of possible solutions based on the user's flexibility, rather than just whether it is possible to reserve the specific request and the cost of the recharge.

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It is reported the typical sequence of messages with a specified format exchanged by agents during a reservation.

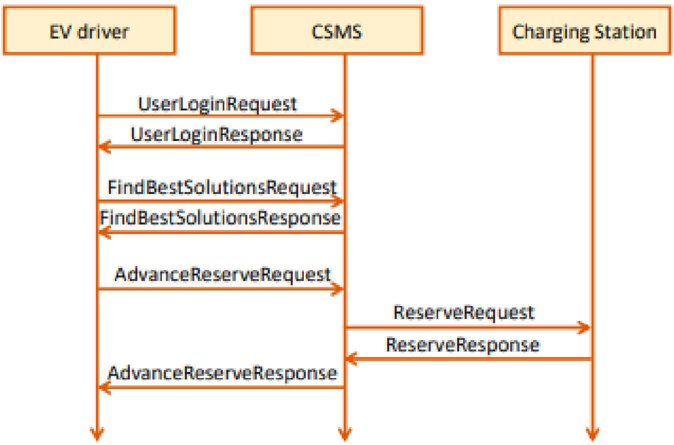

Figure 2: Exchange of data during the reservation

IV.CONCLUSION

The spread of EV necessitates the establishment of a widespread charging station network, the development of standards, and the development of strategies to integrate EV recharge requests with power grid specifications. To accomplish this, we propose extending the OCPP protocol to the reservation phase.

The user negotiates a recharge reservation with the central station, indicating his or her preference and flexibility. The central station offers various solutions based on the user's flexibility. This negotiation enables optimization of power grid management as well as user requests and constraints.

To interact with the reservation system, an app for an Android smartphone has been developed.

The system was tested under various conditions, simulating the reservations of multiple users at the same charging station: different capacity, power, initial and final charge, reservation time, and flexibility on time, duration, price, and final charge.

The framework enables testing the effect of charging station flexibility on recharging system performance. Furthermore, the effect of different user behaviours and preferences on the charging system can be verified.

Finally, the efficiency of the recharge system is obtained by developing a flexible reservation system that is available to the user's needs, and when the user does not have strong constraints, particularly in terms of cost. To achieve the first goal, we proposed modifying the OCPP standard; to achieve the second goal, we believe that a culture of green economy and energy conservation must be spread. The availability of a flexible recharge system could aid in the spread of green economy culture.

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