Charging reservation service for electric vehicles using automatic notification

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Abstract: Since technology of electro mobility is rapidly getting mature and attracts attention of consumers year after year, the management of charging demand and processes has more and more relevance. Nowadays, companies already test novel charging technologies with advanced information services. Therefore, the research question was how to decrease idle time on the charging points and make it predictable as well as to increase capacity utilization of charging facilities. In this paper, we elaborated a new method of automatic reservation process requiring notification of the user. The method uses real-time information about the vehicle status and position. We simulated the application of the method, and the results are presented in detail. This new information service based on the method can be applied in smart cities and along the highways too.

Keywords: electric vehicles, charging infrastructure, reservation, automatic notification

Introduction

There are three basic ways to charge an electric vehicle (EV): plug-in charging, battery swapping or wireless charging.

Plug-in charging is used by the majority of current battery electric vehicles and plug-in hybrid electric vehicles in Europe. Vehicles are physically connected to a charging point using a cable and a plug. Plug-in charging can occur wherever charging stations are located: at homes, in public streets or on commercial or private premises. Electric vehicles can be charged at home, but this is slow because the charging capacity is low. Therefore, it may take approximately eight hours for a typical charge. However, this can be quite suitable for overnight charging. Faster plug-in charging requires higher capacity and specialized infrastructure. To date, most public plug-in stations established at a city, regional or national level offer mostly normal-speed charging (European Alternative Fuels Observatory, 2016), but more and more fast and superfast chargers have been launched in the last months.

Battery swapping involves replacing a used battery with a fully charged one at a special swapping station. This offers a rapid way of quickly 'recharging' a vehicle. At present, no major providers in Europe offer battery swapping. A number of barriers have set back battery-swapping technology from becoming widespread, including the lack of electric vehicle models that support battery swapping, no standard type or size of battery, and the high cost of developing the associated charging and swapping infrastructure.

Wireless charging, which is also known as induction charging, does not require a fixed physical connection between the charging facility and the vehicle. Instead, the system creates a localized electromagnetic field around a charging pad, which is activated when an electric vehicle with a corresponding pad is positioned above it. The wireless method currently operates at only a few pilot locations and is yet to be used commercially. Examples of inductive charging pilot projects include wireless charging for buses at bus stations in Belgium, Germany, the Netherlands and the United Kingdom, as well as some pilot testing for users of electric cars in Sweden.

The limited driving range of many electric vehicles means that the type of technology used to charge them, and the time it takes, are very important to consumers [1]. However, we have to notice that not only elaboration of novel technologies can economize costumer's time, but also a new operational method which can be applied to these technologies.

Since technology of electro mobility is getting mature and amount of EVs is rapidly growing year by year, it is reasonable to state that in the future people can face the problem when vehicle waits at a queue for a charging outlet to become available (queuing time).

The rest of the paper is organized as follows. In Section 1, the situation analysis is provided by review of the existing services. The basic concept of the new charging reservation service is described in Section 2. In Section 3, the implementation technologies of the reservation service are presented. The paper is completed by the concluding remarks, including further research directions. This paper does not provide a programming-based data as well as deeper technical or electricity issues were also out of scope. The objective of the article is to elaborate the principle of the new service in order to minimize EVs charging time and satisfy traveler's expectations.

1. State of the art

There are a lot of solutions proposed by different researchers with the aim of decreasing user's waiting time. Of course most of them focused on future and trying to facilitate rapidly growing market of electro mobility. There are some approaches which are uses communication technologies:

1. V-Charge proposes a solution for charging autonomous EVs in parking places and efficiently using scarce charging resources, thus simplifying the life of the customer and increasing the feasibility of EVs. For the management of parking lots and charging resources, V-Charge provides a server back end and a communication infrastructure. The combination of an autonomous parking system with automatic recharging capabilities offers great convenience to EV drivers. It also addresses major challenges to the wide-scale deployment of EVs: the time it takes to charge the battery and the narrow range due to limited battery capacity. The V-Charge system proposes new concepts for an optimal combination of public and individual transportation and for coordinated recharging strategies. Hence, the customer acceptance of EVs is increased by satisfying the customer's needs [2].

2. The proposed scheme makes it possible for a customer to reduce the charge cost and waiting time, while a station can extend the number of clients to be served. A linear rank function is defined based on estimated arrival time, waiting time bound, and the amount of needed power, reducing the scheduling complexity. Receiving the requests from the clients, the power station decides the charge order by the rank function and then replies to the requesters with the waiting time and cost it can guarantee. Each requester can decide whether to charge at that station or try another station. This scheduler can evolve to integrate a new pricing policy and services, enriching the electric vehicle transport system [3].

3. A method for reserving a vehicle charging station includes receiving a desired destination, and automatically verifying the availability of a designated station at an expected arrival time. The method further includes reserving the designated station when the designated station is available at the expected arrival time and transmitting an electronic token to the client device. The token confirms the reservation and uniquely identifies the vehicle. A system for reserving the station includes a server in communication with the station, and with a client device configured for communicating a desired destination to the server. The server automatically verifies the availability of the designated charging station at an expected arrival time at the desired destination, reserves the designated station when it is available at the expected arrival time, and then generates and transmits the token to the client device [4].

Despite the variety of research proposals, the topic of operational methods for charging technologies is not fully discovered. Therefore, we propose a new charging reservation service for electric vehicles using automatic notification. Our study is focused only on public charging stations which are not connected through the internet with each other. Each charging point represents as a separate server.

2. Reservation service description

Our proposed method based on intelligent communication between public charging stations and electric vehicles. Each charging point serves as an operational center (server) and has particular radius of communication distance (e.g. r = X m.). Thus, each station creates a zone of influence on electro mobiles. When electric vehicle drives into a zone, charging point automatically identifies a vehicle's position and battery level. If battery level is low, then the system sends automatic notification with proposal to make the recharge. It means that vehicle receives a message to the onboard display with the following information:

- Battery level.
- Range reserve.
- Point-to-point direction on a map.
- Proposal of recharge.

Driver can accept or dismiss notification. In case of driver's positive answer, system automatically assigns time of recharge according to availability of charging socket and duration according to current battery level and charging power. Thus, driver knows the exact time when he or she must arrive to the charging point. There is no necessary to wait at a queue and driver can spend his waiting time according to his/her preferences or interests. It is a reservation of charging with 'one touch' on the screen.

There is a potential situation when driver with middle or high level of battery, nevertheless, decide to charge its car, but after arriving to station faces the problem of lack of available sockets. To overcome conflict situation the service works in a reverse. Driver can make an online registration through the onboard device and choose an available charging time.

Server is tracking a movement of all reserved vehicles and if one of them delays on path to the charging point, it sends confirmation notification and asks driver whether to decline or postpone the charging. If driver ignore the notification, then reservation automatically canceled. The schedule is updated in favor of the next vehicle in the list with the appropriate notice of changing reservation time. Thus, reservations are dynamically changeable, so that the charging schedule can result in the minimum waiting time for the EV. The concept of service is shown on Figure 1.

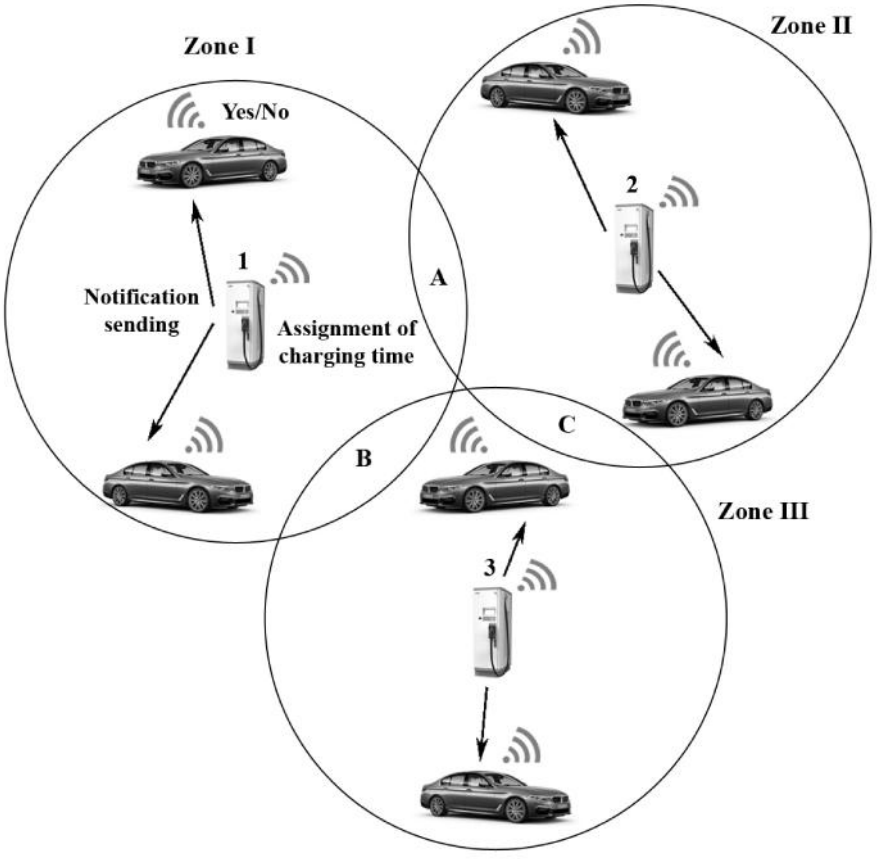

Figure 1. Concept of service

There are some specific situations when vehicle may locate in the intersection of two or more zones. In that case, a car receives notification from several charging points and chooses an appropriate (closest) one. However, stations can be also situated at a long distance from each other, so that it is not common area. It is a charging stations infrastructure question and depends on provider decision.

3. Technology implementation for the reservation service

The implementation of the service is possible thanks to the following technologies:

Geolocation

1) Identifying a vehicle location. To locate vehicle's onboard device CoreLocation framework or Google's Location APIs can be used. The CoreLocation framework provides classes and protocols to configure and schedule location delivery and send location events to the server. The CoreLocation framework also allows define geographic regions and monitor a device's movements as it crosses defined boundaries. Google's Location APIs can intelligently manage underlying location technology while meeting various development needs when implementing location-based features.

Probably, these are the most popular technologies nowadays; however, this does not exclude the fact that many companies and developers around the world permanently trying to propose new solutions.

2) Providing driving directions. To display route plan and navigation on a map MapKit or Google Maps API can be used.

3) Integrating with mapping software. The integration is possible due to Google Maps or other mapping technology.

Notification

To implement notifications services of telecommunications providers can be used.

It is also necessary to create a protocol which may be implemented by specialists. Communication protocol is a system of rules that allows two or more entities of a communications system to transmit information via any kind of variation of a physical quantity. The protocol defines the rules syntax, semantics and synchronization of communication and possible error recovery methods. Protocols may be implemented by hardware, software, or a combination of both.

All charging stations are equipped with wireless communication devices (e.g., WI-FI, 3G), which allow them to communicate with nearby EVs that are also equipped with wireless devices [5]. Figure 2 illustrates the operational model of service.

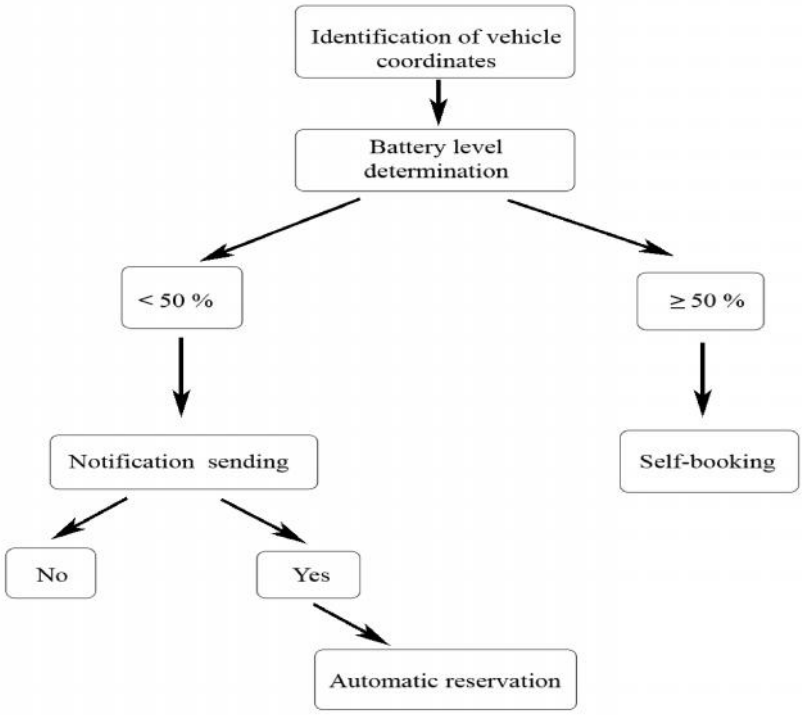

Figure 2. Process diagram of service

Conclusions

Planning and operation of future charging infrastructure will be much more complex than before. Therefore, new analysis and operational methods should be elaborated and applied in order to facilitate the rapidly growing electro mobility market.

Among the main contribution of the paper we highlight the opportunity of decreasing of the waiting time for EV charging using charging reservation service with automatic notification.

Our results may have high relevance for innovation and development. In the future, we plan to extend our work in several directions through studying the problems such as (1) how to navigate EVs for minimal waiting time and travel time, and (2) how to allocate charging points to create an optimal service for potentially huge amount of EVs.

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