Research on the Charging Method for Electric Vehicles Based on the Interaction between Charging Piles and Intelligent Terminals

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Abstract. This thesis proposes an online payment method for charging services based on the interaction between intelligent terminals and charging piles. Applying the intelligent mobile terminal as a tie binding users, charging piles, vehicles and network services together, this method realizes the remote control over charging, billing and settlement. Having improved the intelligence of charging piles and simplified operating procedures, this method is convenient in paying charging services of electric vehicles in the mobile age.

Introduction

Under the strategic environment where the international community advocate low-carbon economy, energy conservation and emission reduction, the development of electric vehicles has held an important position in China’s low-carbon economy and new energy consumption. Starting at the beginning of the 21st century, China’s electric vehicle industry has been included into the strategic emerging industries since 2010 and enjoyed more support. According to the National Outline of Scientific and Technological Development During the “Twelfth Five-Year Plan” Period, the “Twelfth Five-year” Plan Specialized in the Development of Electric Vehicle Technologies formulated by the Ministry of Science and Technology for the 12th five-year development strategies and the Energy-saving and New Energy Automobile Industry Development Plan (2012-2020) issued by the State Council, the State Grid Group has made a plan to apply electric vehicles and build charging facilities, promoting the development of electric vehicle industry. In 2013, the Ministry of Industry and Information Technology, the Ministry of Finance, the Ministry of Science and Technology and the National Development and Reform Commission jointly issued the Notice on Continuing the Promotion and Application of New Energy Automobiles \cite{1}. It states that the central finance will allocate subsidies for new energy auto manufacturers and the money should be allocated before the next quarter begins and be cleared at the end of the year. This will expand the sales of new energy automobiles and further reduce the costs. In 2014, the municipal governments of Beijing, Shanghai, Hangzhou and Hefei introduced a wide range of preferential policies, sparing efforts to promote the development of private electric vehicles to a large scale \cite{2}. In 2015, the General Office of the State Council printed and distributed the Opinions on Accelerating the Deployment of Electric Vehicle Charging Infrastructure \cite{3}. It states that by 2020, China will basically finish building the charging infrastructure system that is both intelligent and efficient in moderate advance and ensure “one vehicle, one pile”. This will meet the charging demands of over five million electric vehicles. Currently, policies about new energy automobiles have been introduced vigorously. But the fact that the charging infrastructure, such as charging stations and charging piles, is not matched and inconvenient, to some extent, has exerted a negative impact on user experiences. The charging facilities are in the need of expansion while the current charging station network is not sound, the payment system of charging piles is not mature and the payment methods are not convenient. These contradictions have been more prominent, restricting the popularization and application of new energy automobiles.
Existing Problems

Nowadays, the number of public charging facilities is increasing rapidly. So do users’ demands. This has set a higher requirement on the intelligence of charging piles and the services of charging, billing, settlement, payment and intelligent control so as to support the services targeted at the large quantity of users.

The computer technology and mobile technology have been combined more closely and the number of mobile phone users is increasing consistently. Also, the mobile phone terminals have replaced the PC terminals at a high speed. These circumstances have driven the e-commerce to be mobile and the mobile e-commerce and mobile banking service will take on a fast-growing trend.

Since the charging service for electric vehicles is closely related to individual activities, its payment methods will certainly be more flexible. But the current services of charging piles are paid by swiping traditional intelligent cards, requiring the users to have such a card in hand. It’s inconvenient to carry the cards around and if users want to apply for such a card and open an account, they have to go to the business halls of electric power companies and go through complicated procedures. This thesis proposes a method that enables the interaction between intelligent terminals and charging piles to pay for the charging services. This method applies the intelligent mobile terminals as a tie binding users, charging piles, vehicles and network services together, realizing the long distance control over charging, billing and payment.

Overall Design

Methods and Principles

This thesis proposes a method for electric vehicle users to pay for charging services. The method is about to charge vehicles first and then pay for the electricity bills. It enables users to pay for the electricity bills by apps instantly. After charging, through the metering and billing module on the charging pile and the quick response code (QR code) generating module, a QR code can be generated containing the information of the quantity of electric charge, spending amount and the serial number of the charging pile. Then the user can use the app on mobile terminals to scan and decode the payment QR code. By invoking the background server of the smart interactive platform, this method can realize the instant payment of charging services. It can also control the charging piles to start or stop and lock or unlock them a long distance away.

This method mainly involves charging piles, mobile intelligent terminals and background servers (the smart interactive platform of electric vehicles). The mobile terminals are connected to the charging piles and interactive platform by wireless networks. The interactive platform and the front-end processor are connected by Ethernet and the front-end processor and the charging piles communicate via IP addresses. The principle diagram refers to Figure 1.

![Principle Diagram of the Method](Figure 1)
The smart interactive platform, managing the information of all charging piles, can issue control instructions through the front-end processor. The functions of this platform include but are not limited to background services. In this thesis, the smart interactive platform, performing as the background server, provides various services and interact with the intelligent terminals and charging piles. These processes are invisible to the external, so it seems that the intelligent terminals are interacting with the charging piles directly. The services provided by this platform include registration service, authentication service, control service and payment service. Services are invoked through http://ip/ecarService/chargeManagement/AndroidChargeControl.action. The IP address refers to the IP address of the smart interactive platform. The return parameters are in the form of JavaScript Object Notation (JSON): {"result": "Y"}. “Y” (yes) means setup completed and “N” (no) means setup failed.

The mobile phone terminals provide the following functions: registration, logging in, starting charging, identifying and analyzing QR codes, payment and long distance control.

The charging piles provide the following functions: starting, locking, charging, metering, billing, generating settlement QR codes and unlocking.

The users can register to link their phone numbers to the information of the vehicles and vehicle owners, including the plate numbers, models, the owners’ contact information and credit cards.

Applying this method, the users can not only start or stop the charging piles manually, but also control them by using mobile terminals and stop charging at any time.

Network Connections

The mobile intelligent terminals are connected to the background server by mobile telecommunications technology (e.g. GPRS, 3G) or WIFI. And the charging piles are linked to the server by two methods. The first one is targeted at centralized charging piles which are usually available at charging stations. They are connected to the background server by exclusive fiber-optic channels. The second method is mainly for the dispersed charging piles which are usually installed in residential districts, shopping malls or by the roadsides. The radio frequency module of these charging piles is equipped with a SIM card which can connect the piles to the front-end processor through mobile networks, such as GPRS, CDMA and 3G.

Interaction Services

Registration service: To save the information of the registered vehicle and the owner, including the plate number, the model, the contact info of the owner and the credit card, into the database of the smart interactive platform.

Authentication service: To acquire the user’s account info and verify it on the smart interactive platform.

Remote control service: To search for the IP address of the charging pile via the front-end processor and send control instructions to it.

Payment service: After receiving the serial number of the charging pile and correct account info, the platform will verify if the charging pile belongs to its management scope. If so, the payment interface will be used to help finish the payment and the information of whether the payment is finished will be sent back. If it is completed successfully, information of the quantity of electric charge, spending amount and the serial number of the charging pile will be saved in the interactive platform. Also, whether the payment is completed successfully or not, this information will be sent to the mobile terminal.

Interaction Process

After the electric vehicle arrives around the charging pile and a charger is in place, the charging pile begins to operate. The process refers to Figure 2.

1. The owner of the electric vehicle should register on the app of the mobile terminal. The app will invoke the registration service of the smart interactive platform.
2. The owner then logs in the app on the mobile terminal and the authentication service of the smart interactive platform will be requested to verify the user’s identity. If it is verified
If the user successfully logs in, the user will enter the system. If not, the user will log out.

(3) The user taps the “Start Charging” button on the app. The app will then activate the long distance control of the platform. The platform will search for the IP address of the charging pile through the front-end processor and send a locking instruction to the pile.

(4) The billing module in the charging pile will generate a settlement QR code containing information of the spending amount, the serial number of the pile and the user account. This code will be displayed on the screen.

(5) The user scans the settlement QR code using the mobile terminal to acquire information of the spending amount, the serial number and the quantity of electric charge. The user then checks this information and after confirming it, the user taps the payment button or recharges his card. This will invoke the payment service of the smart interactive platform. Also, whether the payment is finished successfully or not, the payment information will be sent to the mobile terminal.

(6) The mobile terminal will display the payment information. If it fails, the user can scan the QR code again and choose to recharge his card or to pay the bill by other means.

Figure 2. Flow Chart of Paying the Electricity Bills for Electric Vehicles.

**The Charging Piles and the Smart Interactive Platform**

The charging piles communicate with the smart interactive platform via the front-end processor to regularly update their states. When the charger is in place, a charging pile will acquire the plate number of the charging electric vehicle and send its updated state, the plate number and other information to the smart interactive platform. Then the charging pile will switch to busy state. The platform afterwards will search for the corresponding user account, the owner information and cell phone number. After the user logs in and taps the charging button, the platform can automatically search for the plate number bound to the mobile phone and the serial number of the operating charging pile.

**The Charging Pile and the Vehicle**

The charging pile and the vehicle, in fact, are connected by the battery management system (BMS) of the vehicle. According to the GB/T 27930 Communication Protocols, if BMS establishes physical connections to the charging pile and the vehicle gets electrified, the messages provided in
the handshaking between the charging pile and BMS will contain the vehicle identification information so the plate number could be sent to the charging pile.

Summary

The method proposed in this thesis is to connect the intelligent terminal with the charging pile to pay for the charging services. This method enables users to acquire the metering and billing information and pay for bills from offline to online. It also realizes the card-not-present payment in this field. The service can be automatically billed on the background server without the users doing anything and users can pay for the bill without leaving the charging pile. So this method is convenient, fast and easy-to-use. Besides, applying the background server invisible to the external, this method also enables the intelligent terminals to control the charging process a long distance away. Having simplified the payment process, this method complies with the international trend and is new in improving the intelligence of charging piles. Applying this method, the users do not need to apply for a card in the business halls. Also, catering for people’s habits in the mobile age, the cash-not-present payment turns to be new and promising in the charging and billing of electric vehicles.

References


