Intelligent Connected Vehicle Distributed Charging Pile Platform Architecture Design

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Abstract—The intelligent connected vehicle distributed charging pile platform is the fusion of charging pile, electric automobile, charging network, parking network, communication technology, information technology, digital technology, intelligent network-connected technology, etc. It is the organic combination of traditional industry and modern technology. As an IoT sensing terminal, the development of charging pile information interaction, building and perfecting the distributed charging pile platform for intelligent networked vehicles, building a data service chain for travel and life services, and giving a new development and imagination space to the upstream and downstream of the new energy automobile industry chain.

Keywords—New energy automobile; Distributed; Charging Pile; Architecture

1. Introduction

The vigorous emission of automobile exhaust has led to climate warming and frequent extreme climate events. The automobile industry urgently needs to transform to energy-saving, environmentally friendly and clean consumption methods as the main development direction, and new energy automobiles are bred in this context. Compared with traditional fuel cars, new energy automobiles far exceed fuel cars in energy utilization, and their pollutant emissions are almost negligible. Thus, it plays an important role in the global energy crisis and environmental pollution problems to improve the popularity of new energy automobiles.

2. Problems with electric automobiles

There are four main types of new energy automobiles: pure electric automobiles, extended program electric automobiles, plug-in hybrid automobiles and ordinary hybrid automobiles, of which pure electric automobiles are the most mainstream models. Electric automobiles are almost "zero-pollution" to the environment, and they are driven by power battery packs and electric motors, which do not produce exhaust gas during the driving process and have no tailpipe pollution problems. At present, the longest electric automobile range is more than 500 kilometers, which is comparable to the range of a full tank of fuel, but the popularity of charging piles and charging stations is less than that of gas stations, and the most conventional charging method for electric automobiles is AC charging, which generally takes 5-10 hours to charge, even with the high-power DC fast charging mode, it takes 30 minutes to charge to 80% of the battery capacity under the existing battery technology. When the battery power

BDEIM 2022, December 02-03, Zhengzhou, People's Republic of China

DOI 10.4108/eai.2-12-2022.2328772

reaches 80%, it must reduce the charging current to protect the safety of the battery, so the charging time to 100% power is much longer than the fuel car to fill a tank of gas. Insufficient number of charging piles, slow charging speed and time consuming, difficult to find piles and other problems have to a certain extent affected the user experience of electric automobiles and become a constraint to the development of new energy automobiles.

In recent years, Chinese scholars have made certain achievements and breakthroughs in the field of charging pile research. Luan Hao and Sun Yixing (2015) Exploring the business model of charging pile designed the O2O closed-loop business model of online APP + charging network + offline charging equipment; Wu Fuping et al. (2020) Research on the remote control method of electric automobile charging pile based on Internet of Things proposed the remote control method of electric automobile charging pile based on Internet of Things and designed the constraint parameter model of electric automobile charging pile; Yang Qian et al. (2021) Research on Smart Management System of EV Charging Piles in the Context of Big Data proposed to use mobile internet technology to build an EV user information platform in the context of big data to understand the charging needs of EV users in a timely manner. However, further comprehensive research is still needed in the aspects of charging facility netlink management, charging time slots, demand response, operation service and profit approach.

3. Intelligent connected vehicle distributed charging pile platform architecture

The charging process of electric automobiles is a combination of automobile and communication technology, digital technology, including intelligent network connection technology, and charging is also a process of information interaction. Through the organic integration of charging pile and new infrastructure such as 5G, ultra-high voltage, big data center, artificial intelligence and industrial internet, a distributed charging pile platform for intelligent connected vehicles can be built, which can realize effective links among new energy automobile industry, energy industry and internet industry. The intelligent connected vehicle distributed charging pile platform is mainly composed of sensing terminal layer, network transmission layer and application layer.

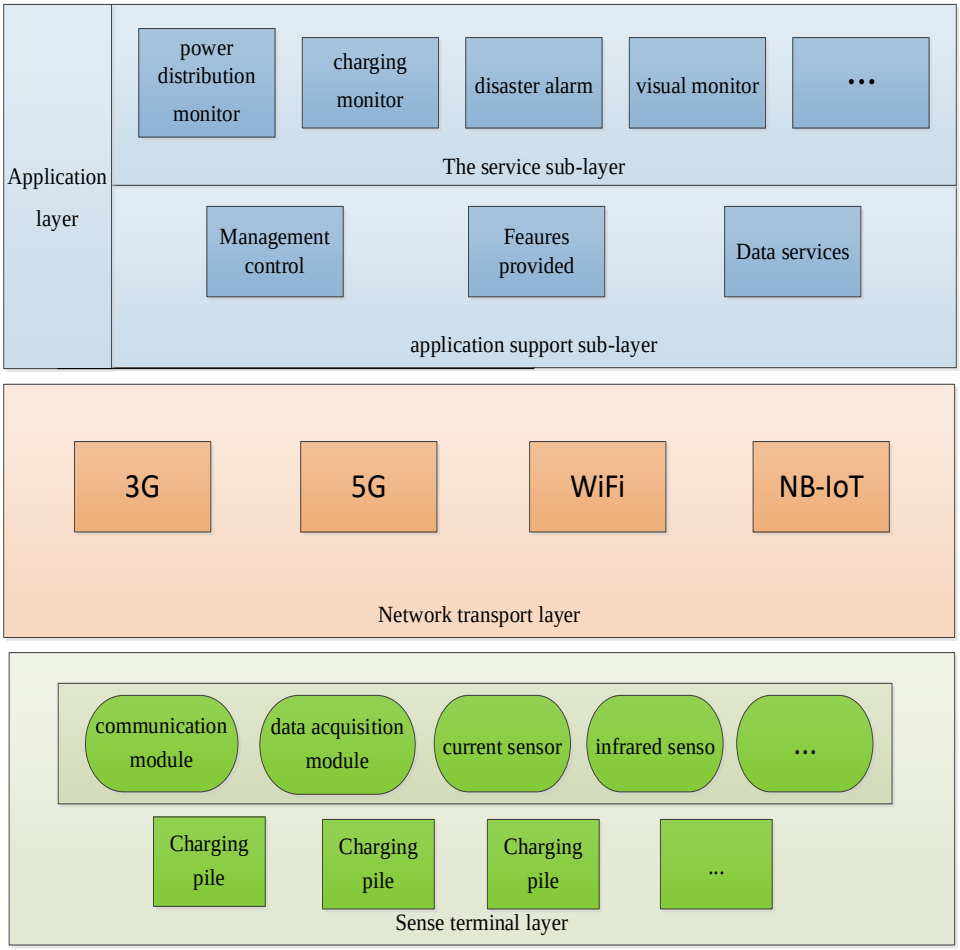

Figure 1 Architecture design diagram of intelligent networked vehicle distributed charging pile platform

(1) Sensing terminal layer

The charging pile is one of the most important terminals with power supply module, input module, display module, intelligent control module, communication module and other components. It can grasp the charging voltage and current, statistical power, reservation of charging hours and other real-time conditions to achieve intelligent management and maintenance of the charging pile. It combined with NFC technology, zigbee (LoRa), 5G and other technologies and covers charging pile, charging network, users, enterprise operation and management and other terminal equipment facilities and environment through communication module, data acquisition module, GPS positioning module, current sensor, voltage sensor, displacement sensor, infrared sensor, camera, mobile intelligent terminal and other network connected devices. When charging, the charging pile is connected to the electric automobile battery management system through CAN bus, which can sense the charging current and voltage of the charging pile, charging volume, charging duration, electric automobile battery consumption, electric automobile battery management system operation, etc., and realize the functions of

positioning of charging facilities and parking spaces, real-time status monitoring of charging piles and parking spaces, network connection and co-management of charging facilities and parking spaces, and real-time status monitoring of electric automobile charging. It fully integrates IOT and mobile Internet technologies, embeds 5G modules and WIFI modules into charging piles, realizes full network coverage of charging piles and the surrounding environment, and instantly transmits charging pile sensing data and information. In addition, to further strengthen the management and operation and maintenance of busy lots and remote charging piles, video data integration collection systems and equipment can be installed in the charging pile equipment to visualize and monitor the charging pile infrastructure and the surrounding environment of the charging pile in real time.

(2) Network transmission layer

The network transmission layer is the hub between the sensing terminal layer and the application layer. It transmits the data acquired by the sensing terminal layer to the application layer securely, accurately and reliably through the transmission forms of Internet, mobile network, wired and wireless communication networks. And it organizes and calculates the collected data information and other processing according to different scenarios and application requirements. The mobile Internet has the advantages of stable signal, not limited by time and space, wide coverage and various network types, which fits the characteristics of geographically dispersed, widely distributed and increasing number of charging piles. When charging, the charging pile senses the connection and operation of electric automobiles, parking spaces and other facilities and equipment internally and externally, generates corresponding status messages according to TCP/IP protocol. And the messages are transmitted by network through the IoT card, processed by the background processor and cloud computing in turn, and finally forms the big data of electric automobile intelligent network connection charging pile to realize automobile network, charging pile network, parking network, power network, information interconnection and database sharing. At present, the charging pile network connection mainly adopts the way of mobile Internet for network connection and data transmission to monitor and manage.

Due to the high usage rate of large charging piles, generating massive data and high requirements for data security and transmission rate, wireless routers can be used. With the development of narrowband IoT technology, IoT continues to penetrate and integrate into all walks of life. Narrowband IoT technology, also known as NB-IoT, has the characteristics of supporting massive connections, wide coverage, low power consumption, low cost, etc. It can provide effective coverage of IoT in indoor scenes. With the same frequency band, compared with the current network, narrowband IoT gains 20dB, regional coverage is enhanced by 100 times, and a single sector can support 100,000 connections. It also have the advantages of low power consumption, terminal module standby time up to 10 years, and low module cost and become a breakthrough technology to realize the Internet of Everything. At present, major domestic communication operators have deployed NB-IoT experimental networks in some areas. With the gradual and large-scale popularization of NB-IoT networks, more and more charging piles will be connected in the future.

(3) Application layer

It is the top layer of the platform, and is the core layer of the platform together with the terminal sensing layer. And it consists of servers, software and related auxiliary facilities, whose

main function is to process and use data information and provide diversified value-added services. In other words, the application layer needs to effectively and accurately process and manage the massive data received in real time, and be ready to be called at all times; at the same time, it precisely fits the data with various services and closely connects the data content with specific matters to realize the connection between data and business applications. Through the accurate, reasonable and effective use of terminal data and the collection of hardware terminals such as electronic terminals and sensors of the intelligent network link platform, feedback is managed, and multi-level input and output control is carried out to realize the information interaction of terminals in the process of electric automobile charging to form a complete loop of people, vehicles, things and environment.

The application layer is composed of application support sub-layer and service sub-layer. The main function of application support sub-layer is to provide business capability and business control capability, where business capability is the core function of application support sub-layer, covering access to business capability, policy control, etc. In addition, application support sub-layer also has business control capability, covering monitoring and management of terminals and application management. It also possess the functions of data statistics and mining. The application support sub-layer can provide APP basic application and basic data, and charging pile manufacturers, charging pile operation and maintenance managers. And software developers can develop various APPs through the external API interface provided by the application support sub-layer.

The service sub-layer is on top of the application support sub-layer and it can realize monitoring and management of the charging piles of Netlink by equipping hardware such as distribution monitor, charging monitor, disaster alarm, visual monitor, billing server and database server, and software such as operating system, communication protocol software, human-computer interaction system and database software in real time. In the service sub-layer, diversified APP applications can be developed according to the actual needs of manufacturers, operation management departments, power management departments and users, such as providing multi-dimensional and all-round value-added services such as querying the location of charging piles, booking charging, implementing charging status feedback, dynamic charging plan prompting, online payment and parking space query.

As the increasing usage of electric automobiles and charging piles, the charging piles will generate massive data in the process of usage, covering charging pile distribution data, charging pile real-time charging data, charging pile operation, management data, regular maintenance, overhaul data, charging pile fault, repair data, charging transaction data, users' daily charging path, users' charging habits, users' personalized portrait and so on. Through the statistics, screening and processing of massive data, it provides important reference for charging pile infrastructure construction, urban planning, charging pile management and user differentiated personalized services.

The overall design of the platform adopts distributed architecture, data information is stored in each node, and each node is combined with cluster deployment. It can be with strong scalability and flexibility, effectively avoiding the risk of single point failure and data information leakage due to single point failure. And it can support service level expansion under the premise of fully considering the maximum load bearing capacity of different nodes. The platform is composed of multiple levels, and the hardware and quantity can be selected according to the

operational requirements of each node. It can be selected the appropriate hardware and quantity according to the operational requirements of each node. The platform is composed of multiple levels and belongs to microservice architecture. Each service has a single specific business scope, which eliminates the problems of large engineering volume and complicated operation and maintenance of the traditional platform structure. The platform adopts restful for external application service interface, with friendly protocol and simple operation. And the platform nodes do not make uniform restrictions and requirements on platform intelligent networked vehicle distributed charging pile platform and development language. It can also communicate across platforms. In addition, the communication service is highly available, and the information transmission between platform communication and business service is realized in the form of distributed concatenation, and the data information is transmitted and processed asynchronously to ensure two-way asynchronous communication.

4. Summary and Outlook

Driven by a new round of technological and industrial changes, the function of automobiles has been further expanded and extended from traditional transportation, and new energy automobiles have become machines and carriers for the manufacture and transmission of massive amounts of data. And they are important communication products and portals for life. The world is continuing to change rapidly and will become a truly metaphysical automotive industry. Charging pile facilities have evolved from traditional basic physical facilities to the hub and port of the digital world. Whether the construction of charging pile infrastructure can resonate with the development of new energy vehicle industry has become an important factor limiting the development of new energy automobile industry. In view of the current problems of insufficient charging pile infrastructure, uneven distribution, lack of unified operation and maintenance and management of charging piles, and difficulties in charging, the distributed charging pile platform for intelligent connected vehicles is built with the help of artificial intelligence, Internet, mobile Internet, Internet of Things, big data, cloud computing and other technologies, and distributed charging piles are interconnected through a unified charging pile network to break the original single isolated charging mode and improve the intelligence of charging piles. Through the platform, the distributed charging facilities are gathered and the remote monitoring and management of the distributed charging piles are realized; through the integration of resources and complementary advantages, the distributed charging piles are planned and managed in a unified manner, and the functions of realistic monitoring of distributed electric piles, pile fault tracking and data collection are realized. After the data integration of vehicle, pile and network, through the massive data mining and sorting of the intelligent network connected car distributed charging pile platform, the intelligent network connected car distributed charging pile platform can provide more personalized services for charging pile operators and users through big data analysis of charging, electricity consumption and driving.

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