Application of identity resolution and blockchain technology in the whole industrial chain management of electrical equipment

Jianye Cui¹, Huanjuan Wang²,³,⁴,⁵, Wenhao Xue²,³,⁴,⁵* and Bin Wang¹

¹ State Grid Jinhua Electric Power Company, State Grid Zhejiang Electric Power Company, Jinhua, Zhejiang, 321000, China
² State Grid Blockchain Technology (Beijing) Co., Ltd, State Grid Corporation of China, Beijing, 100053, China
³ State Grid E-Commerce Co., Ltd., State Grid Corporation of China, Beijing, 100053, China
⁴ State Grid Xiongan Financial Technology Company, State Grid Corporation of China, Xiongan, Hebei, 071700, China
⁵ State Grid Blockchain Technology Laboratory, State Grid Corporation of China, Beijing, 100053, China

*Corresponding author’s e-mail: xuewenhao@sgec.sgcc.com.cn (ORCID: 0000-0003-2337-6513)

Abstract. As the proportion of electric energy in the world energy consumption increases year by year, the demand and usage of electrical equipment also increase. For a lot of electrical equipment management, the traditional management method is unable to get through data barriers that exist in the industrial chain; the information interaction between each link is more and more untimely, leading to a great increase of each link’s error rate. Not only reduces the safety of electrical equipment, but affects the response efficiency of other links when one link sends a request, lowers the quality of service. To solve this problem, this paper proposes the method of integrating the identity resolution system with blockchain technology to standardize the management of the whole industrial chain of electrical equipment. The data barriers between links are broken through the identity resolution system, and the blockchain technology is used to speed up the response of each link, and the key information is stored on the blockchain. This method carries out comprehensive management on the whole life cycle chain, conducts better standardized management on the field of electrical equipment in terms of intelligent trading, intelligent operation and maintenance, etc., and puts forward efficient management mode for the management of electrical equipment.

1. Introduction

With the development of the social economy, electric power energy gradually replaces the traditional fossil energy in production and life, and takes an increasing proportion in the energy field[1]. The demand for electrical energy has grown exponentially, and a large number of new power plants have been built. In addition, many individual new energy users have also expanded their power generation
businesses. The monitoring of electrical equipment is an important measure to ensure the safety of electric power production. The widely distributed and large-scale electrical equipment brings new challenges to the traditional equipment management system. Due to the complexity and diversity of electrical equipment, the equipment has different identification code systems in different manufacturers and life cycle stages. There are serious data barriers among each link and manufacturer[2]. Traditional equipment management system cannot carry out unified control of the equipment. Different identification systems also lead to different identification codes for the same data in different links, which greatly increases the number of repetitive identification codes. The key information retention lacks security guarantee, and the data transmission delay of each link is relatively large. In view of these problems, this paper proposed the method which combines the identification analysis system and blockchain technology to establish the electrical equipment industrial cloud network. To carry out unified standardized management of the whole industrial chain of electrical equipment, the safety management of electrical equipment should be enhanced; the information communication between each link and the quality of electrical equipment should be improved.

As the foundation of the development of the Internet of Things (IOT) industry, the technology and services related to the Identity Resolution of the IOT are the core support for the rapid and large-scale development of the IOT industry[3]. Identity solutions not only provide domain names, similar to Internet functions, but also regulate IOT management information. More importantly, the system is a fast, effective and secure data connection, which can solve the problem of data island. There are many kinds of identification systems around the world, including EPC code, UCODE code, Ecode code and OID code proposed in China, which have been applied to some extent, but these identification systems are not compatible with other systems[4]. In 1994, handle system was put forward. In 2014, non-profit organizations DONA established maintenance and operating system, which accelerated the development of handle recognition system. Handle system established 10 servers in the United States, China, Germany, the United Kingdom and other countries.[5]. Chinese State Department also identifies the system construction as an important goal. The global root node and the auxiliary root node of Handle identity resolution has completed preliminary layout, then, the nation's top node and the industry node has been launched. This article uses the identity resolution system of Handle as the main body, realize the compatibility and interoperability of the ecosystem, EPC and other mainstream identification systems, complete the authorization and trust of nodes in the field of electrical equipment, and solve the problem of data interoperability in the field of electrical equipment.

Blockchain is a distributed database, which is realized by consensus mechanism and "decentralization" [6]. Every system.node has equal rights and responsibilities, and there is no central node. Many nodes achieve data consistency and chain consistency. Through the consistency mechanism, most agreed data can be saved in the blockchain[7]. Data records are in a common chain. All nodes can query the existing data. Data records can not be tampered, which also ensures the security and traceability of data.[8]. The application of chain operation in various industries has always been the focus of research, starting from Bitcoin, developing to Ethereum and intelligent contract, gradually emerging private chain and consortium chain[9]. The scholars also studied the application of distributed transaction blockchain technology in smart grid, automobile, network, smart home and industrial IOT.[10]. Based on the characteristics of the field of electrical equipment, in order to improve the production efficiency and product quality of the whole industrial chain of electrical equipment, this paper proposes a method combining blockchain technology and identity resolution to optimize the process of the establishment of the electrical equipment life cycle, intelligent transactions, and intelligent operation and maintenance.

2. Whole electrical equipment life cycle based on blockchain
As an important part of power system operation, Due to its multiple production links, different manufacturers have different codes between each link and within the same link. The origin of current tracking electrical equipment is limited by step-by-step evaluation of design, production, sales,
maintenance, etc., by manual means. Although there are some equipment management platforms, the integration of each part of the system is low, and the platform can’t bear the upload of large quantities of data. Usually, the fault is tracked, and there is no comprehensive management of electrical equipment to enhance the availability of electrical equipment and improve the quality assurance of equipment, this chapter uses the identity resolution to establish a full life cycle chain for electrical equipment and uses blockchain technology to record it, to increase its non-repudiation. Important data can be inquired when necessary, and the source can also be timely traced after quality problems occur.

**Figure 1. Life cycle management process**

This paper introduces how to establish the resolution of equipment life cycle. All operations and data are included in several stages of materials, power supply, equipment, production, logistics and transportation, electrical equipment, transaction management, equipment operation and maintenance, equipment asset management shall be uniformly identified. The existing identification codes of previous links should be transformed into the electrical equipment identification system, and the data not previously identified are identified using the electrical equipment identity resolution. Break the barriers between production equipment and management system, establish a complete life cycle of electrical equipment, can record and query the production of equipment and components., equipment construction planning records, electrical equipment transportation, sales records and recycling[11]. Compared with the previous independent identification of each link, the electrical identity resolution uses the same code to identify each link in the life cycle chain, and any code of any link can be informed by all nodes. The establishment of a unified full life cycle chain has the following advantages. First of all, the identification should be standardized to prevent the identification duplication caused by the same equipment having different identification codes in different links. This reduces the repeated identification and enhances the efficiency of information interaction. Secondly, the whole life cycle chain constructed by the standard identification system also reduces the repeated coding steps of different links. Each link only needs to code the products or operations of its links. At the same time, the product information of previous links can be fast read through identification code analysis, which facilitates the efficient use of information. The unified identification code also reduces the information transmission errors caused by improper communication in different links[12]. These improvements significantly solve the problems such as logistics can’t be processed in time, information reading waste time, more manual processing errors.

The unique resolution of the system can not achieve the tracking of the whole life cycle of the device, It also can be used to realize convenient information interconnection between enterprises and institutions, and share the production, equipment manufacturing and operation data. In each link of the whole life cycle of the product chain, the information of the product life cycle can also be read, making each link more transparent. The data of each link can also be connected through the identification system to break the data barriers between links, Including research and design, production and manufacturing, acceptance and testing, storage and distribution, installation,
disassembly and scrap and other links can be widely connected. Post identification and coding data can be shared through every link, quality evaluation, electrical and so on. Equipment can use each link data in the whole life cycle to mine and extract key process data, study the impact of these product performance data and product quality on international relations, and form a typical identification model of electrical equipment quality evaluation. The quality optimization of production process is analyzed and evaluated.

After the complete construction of the full life cycle chain of electrical equipment, the full life cycle chain of valuable equipment and important equipment is uploaded to the blockchain for recording. In case of unstable working conditions or failure of electrical equipment, hold relevant manufacturers accountable. The record of blockchain can effectively prevent any link from malicious repudiation[13]. In addition, it is difficult to find the information on electrical equipment that has been reimbursed and destroyed. Through the records of blockchain technology, relevant information can be traced, so as to restore the full life cycle chain of such products through the query result identification code.

3. Intelligent transaction of electrical equipment based on blockchain

The same types of electrical equipment in different applications have small differences in requirements, it is usually necessary to adjust the parameters of equipment parts to solve this problem. After the buyer puts forward specific requirements, the traditional procurement method requires the equipment manufacturer to put forward requirements for each component manufacturer, and the component manufacturer then puts forward requirements for the sub-component manufacturer or raw material manufacturer. This complicated requirement transmission process greatly lengthens the response time of electrical equipment production and increases the error rate of transmission process. In addition, in the case of a large number of parts in demand, hoarding of parts and waste of materials are also one of the problems that need to be solved, so the number of required parts needs to be accurately controlled to avoid the manufacture of redundant parts[14].

This chapter uses the identification resolution system and blockchain technology to solve this problem. First of all, a complete part identification code base is established for parts of various specifications, and corresponding identification codes are established for parts of various parameter types. After the customer presents the requirement, the requirement is identified and registered. Through identity codes, people can get the parts identification codes related to the equipment, and then upload the requirements identification codes to the blockchain. Through the analysis of demand code, each manufacturer can combine their production conditions for customer demand bidding. Finally, after the customer receives the quotation, the manufacturer will be selected for cooperation, and the online electronic contract signing business can be completed with the help of blockchain technology. Due to the registration of the identity resolution system, the data barriers between all links are broken. The same identity code can be read and analyzed by all nodes on the chain, realizing the sharing of data. Blockchain technology also saves the process of information transmission, and manufacturers only
need to pay attention to whether the information on the blockchain contains the required information. After reading the relevant identification code, each manufacturer will analyze it separately. The parts manufacturer of the equipment gets the identification code of the parts to be produced. After the parts identification code is identified by the factory's processing line, the customized assembly line does not need to be adjusted manually, which also ensures the accuracy of parts production and reduces the errors caused by human factors to some extent. At the same time, the demand code also includes the number of parts required by the customer. Reading the identification code on the blockchain, the manufacturer determines the number of parts to be produced, so as to carry out quantitative production of parts and avoid the hoarding of parts and waste of resources caused by excessive production. After the order is placed, both parties can sign the online contract with the electronic signature through the blockchain, eliminating the need to go through the offline procedures. The signed contract also has legal effect. After the electronic contract is uploaded to the blockchain, the contract can be traced in case of later problems. After the transaction is completed, the transaction certificate is also uploaded to the blockchain, so that the transaction can be traced, with stronger reliability and non-repudiation[15]. By combining the Identification resolution system with the blockchain technology to solve the trading problem of electrical equipment, intermediate steps can be reduced. The component manufacturers at all levels can understand the needs of customers through the identification codes on the blockchain. In this way, the design and manufacturing of required parts can be carried out more accurately, which can reduce errors caused by intermediate communication, shorten the communication and manufacturing response time of manufacturers, and also avoid hoarding of parts and wasting of materials. In addition, the use of blockchain for trading can ensure the security and credibility of transactions.

4. Intelligent operation and maintenance of electrical equipment based on blockchain

After the electrical equipment is put into operation and production, equipment failure is inevitable. The traditional method usually asks professional maintenance personnel for inspection, evaluation and repair after the failure and shutdown. The complicated maintenance process wastes a long waiting time and reduces the working efficiency of the equipment. Improving the operability monitoring of electrical equipment is the basis for equipment manufacturers to provide high quality and intelligent products and services. In this chapter, a new approach to equipment operation and maintenance is proposed by combining the Identification resolution system with blockchain technology.

First of all, the electrical equipment and the whole life cycle chain should be identified and registered, and then the key data of each equipment should be encrypted and uploaded to the shared chain block. The relevant manufacturers have the ability to crack the password chain. They can get the operation data of the user's equipment through system analysis, so as to monitor the status of the operating equipment in real-time. Combined with the historical equipment monitoring records, they can establish a comprehensive evaluation model for comprehensive inspection and analysis. In this regard, big data, artificial intelligence and other technologies are used to extract, classify and summarize error types.

![Figure 3. Intelligent operation and maintenance process](image)

The equipment fault model library is established, the multi-dimensional analysis and state comparison are carried out, the accurate fault diagnosis, early warning and recovery system is established, and the fault alarm of the electrical equipment manufacturer is responded in time. If there is a simple fault, the MA If there is a complex problem, the power plant will directly send special personnel to replace and repair the equipment, so as to reduce the response time and maintenance time. The method provides users, operation and maintenance, with accurate and efficient equipment, health diagnosis service, reduces customer losses due to accidents, and provides high quality after-sales service to support manufacturers.

5. Conclusion
The traditional management method of electrical equipment could result in unnecessary mistakes due to the excessive information of relatively independent management of each link and the complexity of the process of communication. In order to solve the existing problems at the present stage, this paper uses the identity resolution system to carry out unified identification and management on the production, sales, transportation, scrap recycling and other aspects of electrical equipment, establish the full life cycle chain of equipment, use the blockchain technology to realize the information preservation of the full life cycle chain of equipment, and improve the non-repudiation of transactions. In addition, the combination of this technology also has applications in the field of equipment intelligent trading. By sharing the user's demand identification code through the blockchain, the component manufacturers could confirm the parameters and number of the spare parts through the analysis of the identification code, which reduces the waste of spare parts manufacturing and reduces the mistakes in setting parameters and conveying process. Finally, through the openness of blockchain technology, the data sharing of electrical equipment can be realized. Through identification code, the working data monitoring identification code by component manufacturers can be realized, consequently, the problem of equipment failure could be solved in-time and the intelligent operation and maintenance of equipment could be accomplished. This paper uses the method of combining identity resolution system and blockchain technology to solve the complex problems in the management of electrical equipment, which could break through the data barriers between businesses, improve business efficiency, reduce unnecessary waste, and open up new ideas for promoting the systematic management of electrical equipment.

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References
[1] Boqiang Lin.(2009) The idea of electric power development under low carbon economy[J]. Chinese Electric Power Enterprise Management, (31):13-16.
[2] Jian Jiang.(2016) Research on Business Model Innovation of Electrical Equipment Enterprises directly under State Grid [D].
[3] Frederic P. Miller, Agnes F. Vandome, John McBrewster, et al.(2010) Identity resolution[M]. Alphascript Publishing.
[4] Zhen Yang, Dong Zhang, Jie Li, et al.(2017) Identification resolution technology in industrial Internet [J]. Telecommunication Science, 33(11):134-140.
[5] Wei Mao, Xun Sun, Feng Wang.(2004) The technology of Internet resource marking and addressing: Handle System [J]. Computer application research, (05):252-254.
[6] Zhang Ning, Yi Wang, Chongqing Kang, et al.(2016) Blockchain technique in the energy internet: preliminary research framework and typical applications[J]. Proceedings of The Chinese Society for Electrical Engineering, 36(15): 4011-4022
[7] Zhetao Li, Jiawen Kang, Rong Yu, et al. (2017) Consortium Blockchain for Secure Energy Trading in Industrial Internet of Things[J]. IEEE Transactions on Industrial Informatics.

[8] Mattila J, Seppl T, Naucler C, et al. (2016) Industrial Blockchain Platforms: An Exercise in Use Case Development in the Energy Industry[J]. ETLA Working Papers.

[9] Zhang J, Gao W Z, Zhang Y C, et al. (2017) Blockchain Based Intelligent Distributed Electrical Energy Systems: Needs, Concepts, Approaches and Vision[J]. Zidonghua Xuebao/acta Automatica Sinica, 43(9):1544-1554.

[10] Zheng Z, Xie S, Dai H, et al. (2017) An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends[C]// 2017 IEEE International Congress on Big Data (Big Data Congress). IEEE.

[11] Ge-Fen Z, Xiao X. (2013) Pattern of whole industrial chain: The important choice of regional rural tourism in China[J]. Guangdong Agricultural Sciences, 40(3):234-236.

[12] Hunt B L, Mezofenyi M M. (2013) Tracking entities during identity resolution[J].

[13] Imbault F, Swiatek M, Beaufort R D, et al. (2017) The green blockchain: Managing decentralized energy production and consumption[C]// IEEE International Conference on Environment & Electrical Engineering & IEEE Industrial & Commercial Power Systems Europe. IEEE.

[14] P.A. Wäger and R. Hischier and M. Eugster. (2011) Environmental impacts of the Swiss collection and recovery systems for Waste Electrical and Electronic Equipment (WEEE): A follow-up[J]. Science of the Total Environment.

[15] Droriano L, Mastandrea G, Rana G, et al. (2018) Decentralized blockchain flexibility system for Smart Grids: Requirements engineering and use cases[C]// 2018 International IEEE Conference and Clean Energy, 6(05):118-127.