Research and Application of Adjustable Load Measurement Technology Based on Blockchain

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Abstract: In order to promote the synergistic interaction between source network and storage, and enhance the load control capability, the adjustable load measurement technology based on blockchain has become the focus of research at home and abroad. This paper reviews the current research status of block chain technology and its application in declaration and issuance, market supervision, market settlement, load measurement, enhancing mutual trust of market transactions and information security. Distributed ledger from block chain under containerized edge service engine, improved directed and acyclic chart distributed ledger structure and adjustable load execution score three based on distributed ledger data. In this respect, the key and difficult points of technology are summarized. Combined with the current situation of power development demand, power market, electricity price mode, demand response, the possible problems and development trend of adjustable load measurement technology based on block chain are discussed in detail.

1. Introduction

According to the construction requirements of the large-scale source network load-storage friendly interactive system in Zhejiang, initially achieving the second-level accurate load control of 1000MW through relying on the Internet of Things technology, innovating the market mechanism, building the province-wide interruptible load resource pool. In order to meet the need of further deepening the development of the marketization of the load and storage transactions in Zhejiang electric power source network, guide and cooperate with the government to promote the construction of a transparent, efficient and shared power market, data intertrust, data sharing, data traceability and data can be achieved by applying technologies such as block chain distributed accounts, consensus mechanism and smart contracts in the process of the market transaction of the load and storage in the source network[1].Tamper-proof, and build a safe, reliable, transparent and trusted market-oriented trading environment for source network dump storage[2].Block chain technology can be applied to declaration and issuance, market supervision, market settlement, load measurement to enhance mutual trust in market transactions and information security, in which the adjustable load measurement data is recorded through the block chain distributed accounts, to achieve reliable storage of data, as a voucher for electricity billing, and to realize the mutual trust basis for block chain-based source network load storage and transaction behavior[3-4].However, there are few large-scale Internet of Things data recording applications based on block chain Distributed Accounting technology[5].

2. Research Content and Purpose

In the notice on key tasks of the company in 2020 issued by State Grid ,it is clearly proposed to promote the construction of “platform + ecology”, among which “promoting the coordinated interaction of source network and load storage and improving the load regulation ability” is one of its sub tasks. According to this, the user adjustable load can also participate in power grid regulation

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and control to build power transaction blockchain(Figure 1), which puts forward higher requirements for traceability and safety of measurement data. The purpose of this project is to study the following three aspects:

1) The blockchain distributed ledger migration runs on the adjustable load node equipment, so that the adjustable load measurement data can be quickly and accurately linked on the equipment side[6-7].

2) The conventional blockchain can only complete several transactions per second, and the establishment of consensus mechanism needs hours[8], while the friendly interaction construction of source network load storage makes it clear that the regulation time of adjustable load is seconds, and at the same time, in order to complete the power regulation of the whole network, all adjustable load nodes of the whole network can participate in the regulation to generate transaction data[9], so it needs to be designed and established in seconds A consensus mechanism is established on the time scale, and the ledger structure of high concurrent data transactions is supported.

3)In the process of load adjustment transaction, the behavior of node's doing evil and attacking account book, node's false declaration and malicious competition will lead to invalid transaction[10-11]. Through the classification and chain storage of such nodes and data, advanced applications based on distributed account book data (such as credit rating of adjustable load users, user profile of adjustable load users, optimal load selection in emergency regulation and control) Select and so on), different weights will be selected for calculation according to different data levels.

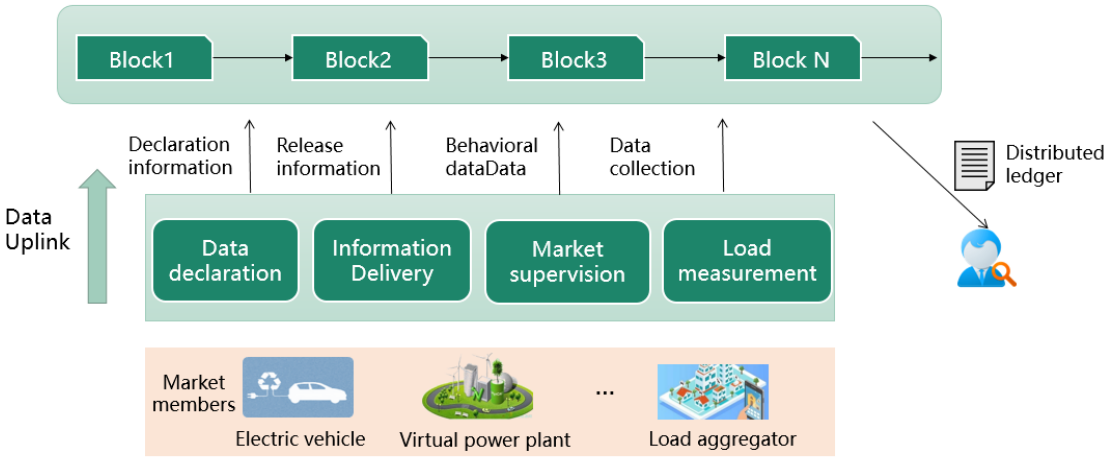

Fig.1 Power Transaction Blockchain

3. Overview of Research Level At Home and Abroad

In this paper, In recent years, block chain technology has received wide attention, and China has upgraded block chain technology to a national development technology strategy[12].Distributed frameworks in block chains, together with their edge Intelligent Computing and intelligent contract management mechanisms, provide a powerful means for access and transaction management of large controllable loads [13-15].The construction of demand response business requires the participation of power grid enterprises, load integrators, service providers, etc. [16] under the premise of ensuring power system security and promoting power transaction measurement. Based on the development experience of foreign countries, the current transaction and measurement methods can adopt cost compensation system, value accounting system, bilateral contracts, bidding market or real-time bidding[17], which involves a large amount of information flow, capital flow operation. The distributed architecture of block chains provides an efficient means for recording large amounts of adjustable load information[18].

The Transactive Grid project in the Brooklyn Community, New York, USA, is the world's first energy block chain project to be put into practice. The whole project uses P2P direct energy trading without going through third-party power operators. The bottom application of smart meter integrates the function of intelligent contract based on the block chain of Taifang, which can collect

information such as power generation, power consumption and transaction power of users, and synchronously upload the data to the public block chain network platform. The Share & Charge project in Germany is one of the projects that applies block chain technology to the field of shared charging stakes [19].The basic working principle of this project is to make the billing transparent and enhance the trust of both parties through the distributed accounting of block chain technology.

Although many foreign countries have acquired rich practical experience in demand response and have gradually matured in technology and market mechanism, they lack the ability of uniform allocation of power side and power side resources, and are not able to respond quickly to serious failures [22].For example, in 2003, the northeastern United States and southeastern Canada power grid, equipment overload caused a chain reaction leading to a large area of power outage. The major reason for the accident occurred was that the United States carried out power market reform at that time, lacked the coordinated control mechanism, the power grid was prone to line overload during peak power use, and it was difficult to take appropriate emergency measures when the accident occurred, and the lack of dispatch and operation departments on the load. Direct fast control, inadequate ability to cope with sudden failures[20].

4. Practice and Theoretical Basis

The characteristics and advantages of blockchain can help energy companies to solve the above problems innovatively on the basis of security and promote the reconstruction of energy value chain. Table 1 shows the application of blockchain in three scenarios to describe new opportunities for energy value innovation.

Table 1 .Three Application Scenarios of Blockchain Technology

				content			location				
Native scene				Digital currency			The original value of blockchain				
				Intelligent contract							
				Value transfer							
Derived Scene				Corporate governance			Integration with traditional energy industry				
				Intelligent service							
				Supply chain management							
				Asset management							
				User experience							
Innovation Scene				Sharing experience			Integration with the Internet				
				Distributed energy management							
				Energy capital market							
				Integration with the Internet							

4.1 Native Scene

The application of native scene is the original value of blockchain realized by the characteristics of blockchain itself. The application in the original scenario has little relevance to the characteristics of the energy industry, but it can still be used as the underlying application of the energy industry.

4.2 Derived Scene

When the blockchain technology is combined with the traditional business and governance framework of the energy industry, more rich applications can be derived to help the power industry create new revenue and reduce operating costs. For example, the built-in security and consensus foundation of blockchain can improve the ability of enterprise risk management and capital management [21].

4.3 Innovation Scene

Energy companies are facing more risks and management challenges. Blockchain technology can help the energy Internet to achieve new functions and modes, such as trusted measurement, efficient collaboration, distributed and equal decision-making, and automatic transaction anytime

and anywhere. At the same time, the blockchain's distributed mesh structure is just in line with the market-oriented structure of distributed renewable energy, which can be used to synchronize the real-time price and real-time phasor control system of grid services, so as to balance grid operation, distributed generation system access and wholesale market operation[22]. Figure 2 shows the specific application of blockchain technology in power system measurement.

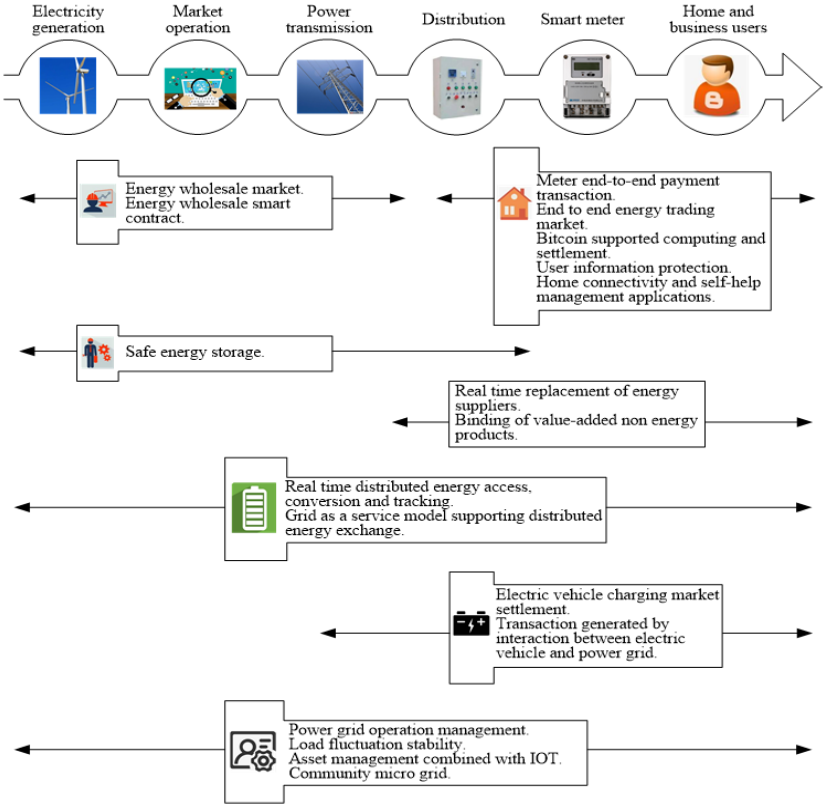

Fig.2 Overview of Application of Blockchain Technology in Power System Measurement

5. Numerical Simulation Analysis

This ariticle studies key issues and difficulties from three aspects. Content 3 is based on the research of content 1 and content 2 to carry out specific data analysis and application case design research. From the perspective of vertical (time) and horizontal (each adjustable load node) data comparison, this paper studies the adjustable load execution scoring system based on distributed ledger data, and gives suggestions for subsequent advanced applications.

5.1 Blockchain Distributed Ledger under Container Edge Service Engine

Although the blockchain technology has been developed in the financial field, the scale, business logic and application scenarios of the blockchain of the adjustable load node equipment are different from those of the financial network, with the characteristics of large scale, scattered nodes and strong autonomy. The mutual trust of electricity tariff measurement data can be enhanced by storing measurement data and transaction data in adjustable load node equipment in the form of distributed ledger. However, most of the adjustable load node devices are edge side light-weight devices, which inevitably need to use various applications such as device resource management, cloud edge data collaboration, data encryption storage and transmission when storing the distributed ledger data.

The key point of this technology is to embed the blockchain distributed ledger storage into the existing ones through the containerized edge service engine In the equipment container of load control node, the blockchain distributed ledger storage of edge equipment data is realized, and through the edge service engine, it is easy to deploy and implement, the edge cloud collaboration of distributed ledger (to solve the problem of data expansion), the edge equipment resource

management (the storage amount of distributed ledger and the early warning and management of computing resources), the enterprise level security of edge equipment, etc.

5.2 Improved Distributed Ledger Structure of Directed Acyclic Graph

The consensus mechanism of the blockchain solves the problem of how the blockchain can achieve consistency in distributed scenarios. It is not suitable for the application scene of adjustable load measurement distributed storage. A new distributed ledger structure needs to be designed to address the following issues:

1) Support large-scale network concurrent processing.
2) Quickly reach consensus among nodes.
3) Effectively prevent nodes from doing evil and attacking.

The key point of this study is to design a compact directed acyclic graph based ledger structure, ensure the rapidity of confirmation time on the basis of distributed ledger data storage, and improve the convergence speed and security of DAG protocol by designing a node consensus mechanism based on connectivity and analyzing its anti attack characteristics.

5.3 Performance Rating of Adjustable Load Based on Distributed Ledger Data

Although the “machine trust” mechanism of blockchain can enable the network to automatically verify the ownership of resources and the authenticity of transactions, it does not prevent selfish nodes from disrupting the market for the purpose of maximizing their own interests, such as false offers, malicious competition, etc. By designing fair and just transaction algorithm, the rights and interests of all participants can be protected. However, it is inevitable that invalid data will enter the distributed ledger, and the data validity of different execution effects will be different. The key point of this research technology is that through the difference between the adjustable load nodes participating in the adjustment quota and the declared (published) adjustment quota, combined with the performance of other nodes in this adjustment, quantitative scoring is carried out, and synchronously stored in the adjustable load measurement blockchain distributed ledger of this node, laying a good foundation for the advanced application based on the adjustable load measurement data in the future.

6. Conclusion

This article summarizes the research status of blockchain technology, its value and significance in application and release, market supervision, market settlement, load measurement, enhancing mutual trust in market transactions and information security; from the blockchain distributed ledger under the container edge service engine, the improved directed acyclic graph distributed ledger structure and the adjustable load execution score based on distributed ledger data This paper sums up the key and difficult points of technology, and discusses the problems and development trend of adjustable load measurement technology based on blockchain in depth, combining the current situation of power development demand, power market, electricity price mode, demand response and so on. At present, there are few large-scale IOT network data recording applications based on blockchain distributed ledger technology. Whether the blockchain distributed ledger technology can be reasonably combined with the Internet of things to design the practical application of the distributed ledger adjustable load measurement data record under the real network conditions is the primary problem to be solved.

Acknowledgments

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