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# Research on Power Data Management Based on Sovereign Blockchain Technology

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**Abstract.** The development of smart grid technology has improved the way in which grid companies interact with power users, but there are data breaches when data falls into the hands of malicious attackers. This paper implements a multi-blockchain system based on sovereign blockchain technology for the main body of the power trading market, and designs the data transmission mechanism and system architecture. Through the power data classification index, the effective mining and utilization of intelligent power data is realized. Incorporating national sovereignty constraints into smart contracts ensures that smart grids provide a system of trusted, nationally compliant systems for power users' electricity transactions. Finally, the advantages of the power data management scheme proposed in this paper are analysed by comparing with the traditional power data management methods.

## 1. Introduction

There are a large number of power data in smart grid [1]. On the one hand, these data have great extensibility, which is conducive to better integration of new energy technologies such as wind and solar power generation [2,3]. At the same time, these data are conducive to the efficient management of power data by relevant institutions [4,5] and various related research [6,7]. On the other hand, from power data recordings, Internet transmissions in smart grid, to the processing and storage processes in the database, the power data is at risk of being vulnerable to attack and privacy exposure.

At present, scholars have proposed solutions to the hidden dangers of the application of a large amount of power data in smart grids. Literature [8] combines smart grid with communication technology to solve the problems of lack of automatic analysis, poor visibility and lack of situational awareness in today's power distribution system. Literature [9] proposes a cloud computing model for managing real-time flow of smart grid data, enabling collaboration and information exchange between users, retailers, virtual power plant operators with highly distributed generation, and network operators.

Blockchain technology has weak centralization, distributed data storage, traceability, and consensus mechanisms. These features are expected to solve the problem of smart grid power data privacy exposure and improve power data security. Literature [10] proposed a blockchain model for smart grids as an intermediary for power consumers and power producers. The model uses blockchain technology and smart contracts to help reduce costs, increase transaction speed, and enhance transaction data security. For user privacy exposure problems during the smart grid production



planning and scheduling process, a dual-blockchain architecture power consumption information storage method is established in [11] for storing power consumption data and users' power billing.

Sovereign blockchain [12] brings new regulations to cyberspace governance. Under the premise of upholding the principle of national sovereignty, sovereign blockchain carries out further legal supervision of the blockchain, improves the credibility and supervisability of the data channel, and forms a unified body of consensus, co-governance and sharing. At present, scholars have applied sovereign blockchain technology to tax credit management [13], tax collection and management [14] and other fields. In fact, with the continuous construction of the smart grid, new relationships and new problems between different market players will be brought about in the process of electric energy production, transmission, use and sales. A corresponding legal system is needed to consolidate and regulate the orderly operation of the power trading order [15].

The contributions of this paper lie in: Based on the consideration of the efficiency and security performance of blockchain, this paper proposes a multi-blockchain power transaction data management structure based on sovereign blockchain. The data management structure distributes power transaction data and improves power data management efficiency. Grid data is protected based on sovereign blockchain technology and intelligent contract tamper-proof systems. At the same time, the algorithm implementation of the power market main contract terms is introduced in the smart contract to prevent any market entities from violating the rules.

## **2. Adaptability Analysis of Secure Power Trading under Sovereign Blockchain Framework**

### *2.1. Technology Integration of Blockchain Technology and Smart Grid*

Blockchain, as the core technology of Bitcoin, has been successfully applied in Bitcoin by virtue of its decentralization, trustworthiness, traceability, and non-tamperability. However, in fact, the essence of blockchain technology is not "decentralization". According to the definition of China's Ministry of Industry and Information Technology in the "White Paper on China's Blockchain Technology and Application Development" in 2016, blockchain technology is an innovative application mode of computer technology such as distributed data storage, point-to-point transmission, consensus mechanism and encryption algorithm in the Internet age. In other words, the essence of blockchain technology is a large distributed shared database built and maintained based on a consensus mechanism.

The technical characteristics of blockchain and the mining and scheduling of distributed data in smart grids have coupling characteristics in terms of technology requirements and structure. And these coupling characteristics contribute to the efficient mining of power data and promote the security and stability of the power grid.

### *2.2. The Trend of Legalization of Power Industry Management under Sovereignty Framework*

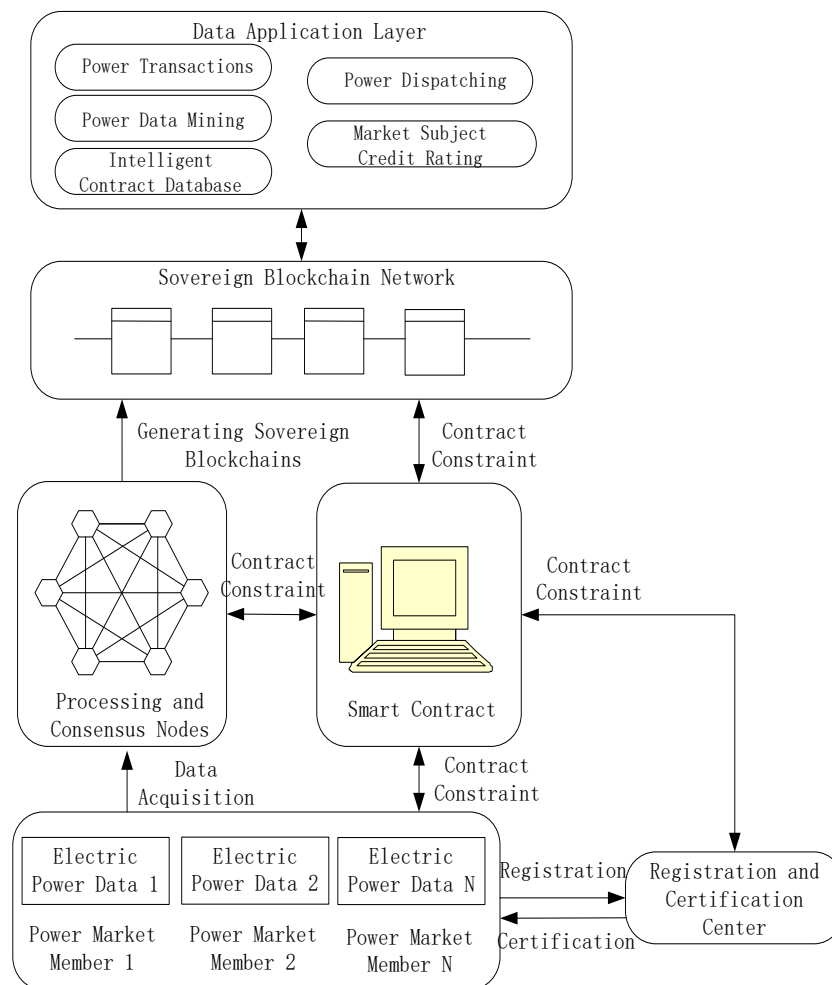
Blockchain technology provides effective technical support for power transaction data management. At the same time, the power trading process is inseparable from the supervision of the power grid enterprises, which means that the power data cannot be decentralized by the power grid company. In order to effectively regulate the smart grid network environment and make it operate in a healthy and orderly manner, it is necessary to put power transaction regulation into the legal track [16].

Participants in the power trading market are placed under the supervision of a sovereign blockchain network. The authority of the grid company can be retained by relying on the node permission setting method of the alliance blockchain technology. In this way, the grid company's controllability requirements for the identity information and power distribution information of the main body of the power transaction are met, and the security risks caused by decentralized power transactions can be avoided. Sovereign blockchain smart contracts can automatically analyze and identify power trading information in the electricity market to ensure the identification and record of default status in the power trading process. In addition, the blockchain technology characteristics can be combined with the credit score of the power transaction entity to reduce the loss of power transaction related parties

due to information asymmetry. It is also possible to maintain the security and stability of smart grid power transactions by establishing a reward mechanism for trustworthy power trading participants, and to help build a credit system for the electricity market.

### 3. Development of data transmission mechanism

This paper develops a secure transmission mechanism for grid transaction data based on the architecture of a sovereign blockchain, which is used to improve the security and transparency of power transaction data between consumers and generators. Figure 1 shows the power transaction data transmission mechanism in a sovereign blockchain.



**Figure 1.** System data transmission mechanism

#### 3.1. Data Acquisition Layer

The data acquisition object is the participants of the power market, and the transmission of related data such as power generation, transmission and distribution, and electricity sales through wireless communication technology [17]. The data collection layer is directly connected to the registration and certification authority on the smart grid network. The registration and certification center can be undertaken by the grid enterprise management organization. Its main function is to issue a unique ID to the user registered in the system, which can uniquely identify the corresponding users. The users register and provide the necessary information on the system by accessing the registration and certification center. In this system, the power data is reported to the processing and consensus layer through the smart meter.

### 3.2. Data Processing and Consensus Layer

The main task of the data processing and consensus layer is to realize the transmission verification of the grid data information by processing and consensus nodes. The processing and consensus nodes collect data and process requests and accesses of users who have registered authentication, and agree on the consistency of the generated block information. Data processing between processing and consensus nodes is critical to secure and accurate transactions between untrusted participants. The high integrity of power data must be maintained, the heterogeneity of data must be eliminated and the confidentiality of confidential data must be ensured to ensure the reliability of the data in processing and consensus.

This layer distributes the power data of the power market participants, and the calling interface of the smart contract provides the service type and ID number for the layer. In this paper, the node that first receives the data is defined as the original processing and consensus node. And the node desensitizes the power data such as power user identity information and commercial confidential information to generate a temporary block. When the block is validated and accepted by most other processing and consensus nodes, the data validation successful response is sent back to the original node. The Smart Contract Center generates a smart contract script of this data and transmits it to the node. The processing and consensus nodes attach the script and timestamp to the block and store the block in the sovereign blockchain.

For aggregated power data, the processing and consensus nodes add two parameters: the service type and the service type ID number. The business types include: power trading business, user credit rating business, power dispatching center security check business, power data mining business, smart contract database, etc.

### 3.3. Smart Contract Layer

Smart contract layer is responsible for verifying the standard determination of whether the operation and data access requests in the system are breached. Once there is any illegal action in the system, the action of denying data access will be automatically reported and triggered, and the illegal operation report with the corresponding user ID will be recorded in the smart contract database and broadcasted to the smart grid network. Smart contracts are not interfered by human participation and external factors. This improves the efficiency of grid data processing and improves the reliability of the monitoring environment of power data under the premise of ensuring the fairness of the contract level.

### 3.4. Power Data Application Layer

The power data application layer directly interfaces with the data monitoring layer and receives the supervision of the data monitoring layer at all times. The specific application services of power data include functions such as power transaction business, user credit rating service, power dispatch center security check service, power data mining service, and intelligent contract database storage.

a) The power trading business is responsible for reliable energy trading in the main body of the electricity market;

b) The user credit rating service reduces the loss of power transaction related parties caused by information asymmetry through the credit rating of power users and the reward of trustworthy users [18];

c) The power dispatching center of the power dispatching center conducts a safety check on the results of the power trading, and supervises the generation of the power transmission contract of the entrusted power grid enterprise;

d) The power data mining chain helps to improve the lean level of grid operation and management through the mining of power data, and enhance the experience of smart grid construction.

e) The smart contracts database records violation reports for violations of smart contracts on the Sovereign Blockchain Network.

## 4. Sovereign Blockchain Architecture

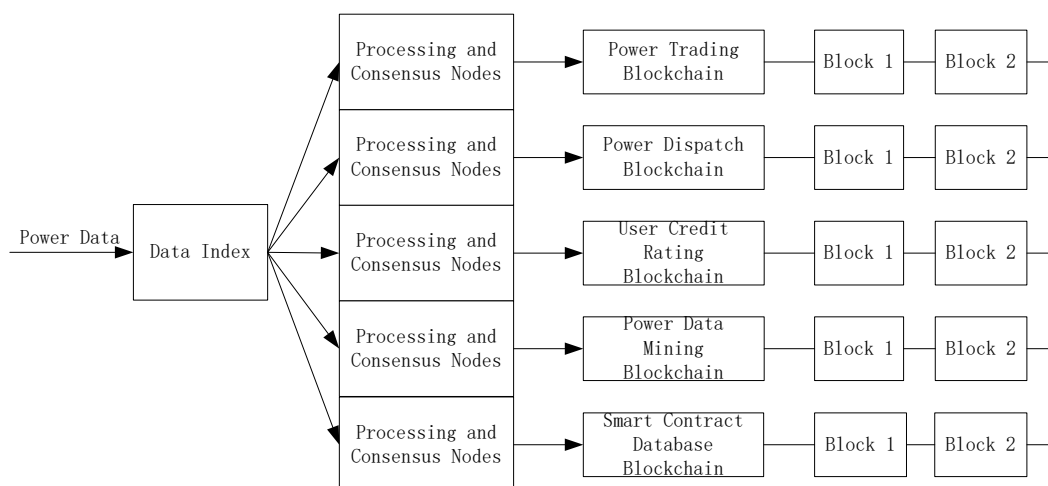
### 4.1. Multi-Blockchain Structure

Traditional blockchain technology uses distributed billing and storage technology. All data is completely shared by each node, ensuring that data is not tampered with, but the pattern of node storage blockchain accounts will also result in wasted storage space. In addition, due to the different business data volume, data processing time and sequence synchronization in the smart grid, it may lead to inconsistent records between network nodes [19].

Based on this, this paper constructs a multi-chain structure of sovereign blockchain and distributes the data information of members of the electricity market. Multi-blockchains of different service types are shared by the corresponding nodes by a corresponding number of processes. Although the processing and consensus nodes of each blockchain in the structure do not have all the power data information, the logical interconnection between all the chains of the sovereign blockchain can be realized. On the one hand, this distributed storage method can solve the problem of limited data storage space. On the other hand, the classification management of power data can be effectively implemented [20], and the consensus results between multiple blockchains can be recognized and received.

The multi-chain architecture of the sovereign blockchain is shown in Figure 2. The power transaction subject is uniquely identified by the identity ID of the registration and authentication center in the blockchain of different service types. The power data is divided into different blockchains for service processing and storage according to the service type ID. The specific service type is as described in Section 3.2. The power data processing process of different service types is logically parallel, not serial [21].

After the power data is indexed, the processing and consensus nodes in different service blockchains process the corresponding power data and generate blocks, and the blocks are recorded into the sovereign blockchain through the block consensus. Multi-blockchains in sovereign blockchain networks are used to maintain event records for different service types [22]. Any event that changes will generate a new block in the sovereign blockchain network and broadcast the block to the sovereign blockchain network.



**Figure 2.** Sovereign blockchain multi-chain architecture

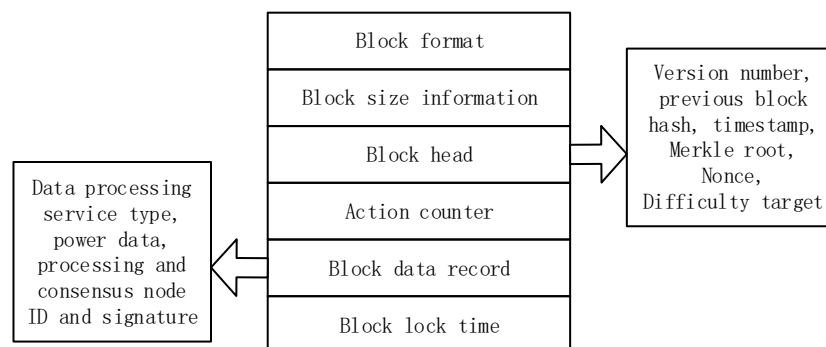
In the sovereign blockchain network, the number of power market participants can be dynamically increased or decreased according to actual conditions, and the number of market entities is not directly related to the total number of blockchains in the sovereign blockchain network. This paper proposes a smart grid network based on the multi-blockchain architecture of the sovereign blockchain. Power data is indexed and recorded to multi-block chains of different service types, and new blocks can be generated when power data changes.

The sovereign blockchain multi-chain architecture in Figure 2 is not limited to the data storage structures of the five service types described in the text. In practical applications, there can be far more complex data services than in Figure 2. However, the data storage mechanism in the figure has the same guiding significance for the storage of complex power service data.

#### 4.2. Block structure

Figure 3 depicts the original index block structure, specifically containing six parts. The first part is a block format with unique identity. The second part is the block size information, and the size information of the block is recorded. The third part is the block header, which includes the version number, the previous block hash value, the timestamp, the Merkle root value, the nonce, and the difficulty target. The block header is hashed using the SHA-256 secure hash algorithm. When an attacker wants to modify the block header, in order to falsify the block record, the attacker should modify all the block headers starting from the most primitive block. This approach helps ensure a higher level of security on the network, as this task is largely unachievable.

The fourth part is the action counter, which records the total number of violations in the blockchain. The fifth part is the block data record, which includes the blockchain data processing service type and data, and all the processing and consensus node IDs and signature summaries in the chain. The sixth part is the block lock time, which is the creation time of the block in the sovereign blockchain.



**Figure 3.** Block structure

### 5. Comparative Analysis

This section compares the traditional power transaction data management method with the sovereign blockchain multi-chain data management architecture proposed in this paper. The comparison results of the two are shown in Table 1, and the following indicators are specifically considered:

a) Data security: Traditional power transaction data relies on the storage of third-party central organizations. Once a third-party organization is attacked, it will cause huge security risks. The data distributed storage and consensus mechanism in the sovereign blockchain multi-chain architecture greatly enhances data security.

b) Information sharing: This indicator refers to the ability of data stakeholders to provide information to third-party research institutions. The data management method proposed in this paper provides a good opportunity for further data mining by third-party organizations.

c) Efficient management of data: The amount of power data in today's power grids has increased dramatically, and data types have become more complex. Under traditional data management methods, data interaction between different systems is more difficult [23]. The multi-blockchain architecture of data classification, storage and management proposed in this paper improves the efficiency of data management and provides a stable and reliable data channel for the logical interconnection of different power services [24, 25].

d) Data Unchangeability: In the blockchain, unauthorized external attackers cannot access tamper data, which improves the reliability of the power data application process.

e) Data confidentiality: blockchain technology data desensitization, encryption technology and other technical means to ensure that the power data has a strong confidentiality.

**Table 1.** Comparison between traditional power data management and power data management in this paper

| Index                     | Traditional data management       | The data management in this paper                          |
|---------------------------|-----------------------------------|------------------------------------------------------------|
| Data security             | Relying on third-party agencies   | Data storage and consensus mechanisms ensure data security |
| Information sharing       | Weak                              | Stable information sharing platform                        |
| Efficient data management | Weak                              | Strong                                                     |
| Data non-changeability    | Depending on third-party agencies | Unable to change                                           |
| Data confidentiality      | Weak                              | Strong                                                     |

## 6. Conclusion

This paper implements a multi-blockchain system based on sovereign blockchain technology for the players in the power trading market, and designs the data transmission mechanism and system architecture. This paper improves the efficiency of power data processing by means of power data classification and indexing. The multi-blockchain data storage structure solves the hidden danger of inconsistent information recording between power transaction entities. Incorporate national sovereignty constraints into blockchain smart contracts to provide power users with a system that is trusted to comply with national regulations. Finally, the power data is ultimately ensured to be transparent, traceable and non-destructive.

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