Research on the Application of Data Collaboration Platform for Metrology Instruments Based on the Blockchain

Angang Zheng[1], Huaiying Shang[1(✉)], Yubo Yang[1], Qiongqiong Yao[2], and Yang Jin[3]

[1] China Electric Power Research Institute, Beijing 100192, China
zhengangang@epri.sgcc.com.cn, shanghuaiyingip@163.com
[2] State Grid Henan Marketing Service Center, Zhengzhou 450052, China
yaoqiongqiong@ha.sgcc.com.cn
[3] State Grid Beijing Electric Power Research Institute, Beijing 100162, China
jinyanga@bj.sgcc.com.cn

Abstract. Electric energy Metrology business belongs to the category of legal Metrology. The public pays attention to the accuracy of equipment and the justice and fairness of the verification process. However, due to the long process of equipment production verification, involving many enterprises and links, the current government's supervision and equipment data traceability mainly rely on offline statistics and reporting, and the lack of online collaboration mechanism with manufacturers. The characteristics of multi-governance, openness and transparency of blockchain technology can effectively promote the transformation and upgrading of the traditional metering business model. This paper proposes a data collaboration platform for metering instruments based on blockchain. By creating the "blockchain +" of the Metrology standard system, the accuracy of data, the standardization of business and the legitimacy of the system can be achieved. It also supports the traceability of the whole process of electricity meters, which can provide residents with reliable verification of the accuracy and compliance of electricity meters, and comprehensively improve the credibility of energy metering business.

Keywords: Verification of Metrology · Blockchain · Data collaboration

1   Background Introduction

Metrology as the key link of national quality basis, influencing the country's stable, high-speed development and people's livelihood level. In documents such as the Metrological Development Plan (2021–2035) released in 2021, it is clear the empowerment and upgrading of metrological equipment should be realized based on blockchain technology, and the social co-governance service platform of integrity metrological based on blockchain should be created. Electric energy Metrology is an important field closely related to the people, and the accuracy of the Metrology results affects the accuracy of the user's electricity charge settlement. In order to ensure the stability and reliability of

the Metrology equipment, Before electricity meters are put into use, the state adopts the multi-link and multi-process verification mode of the government, Metrology institute, power grid company, third-party testing institution and production enterprise. Due to the long verification process and obvious data barriers in each link at the present stage, the communication efficiency of data in the verification process is low, which leads to the complex and time-consuming data sharing of metrological verification [1]. At the same time, the lack of public information cause energy users sometimes question the qualification rate of electricity meters, and put forward false statements such as "running fast" and "turning fast". Frequent application for re-verification increases the workload of grid enterprises, and is not good for the improvement of residents' happiness.

This paper innovatively proposes a blockchain collaborative platform for Metrology business. By constructing a blockchain covering upstream and downstream units in the Metrology field [2]. The whole life cycle data of Metrology equipment production, component testing, factory testing, receiving testing, government sampling inspection, third-party testing and other data are trusted endorsed and transferred through the blockchain, so as to open up the data barriers between various business systems, realize the convenient circulation of verification data and the credible supervision of the testing process [3, 4]. Realize the whole process traceability of each Metrology equipment relying on the upstream and downstream whole process data. The blockchain certificate for the full-cycle verification results of Metrology is formed to provide verifiable equipment verification endorsement for the metering equipment of power users, further reduce the cost of explanation and communication at all levels, and reduce the investment in dealing with negative and bad public opinion.

2 Electronic License Multi-chain Sharing Architecture

This paper proposes a Metrology blockchain architecture covering upstream and downstream metering enterprises, covering state grid headquarters, provincial company nodes, and completing docking with external government supervision nodes, production enterprises production nodes, and social public inspection service nodes. Form a professional blockchain network covering the whole country in the field of quality Metrology with the government, regulatory agencies, Metrology institutions, production enterprises, electricity customers and power grid companies as the main body, realize the trusted sharing of Metrology business data, provide public trust inquiry and inspection for the public, provide effective supervision ways for government departments, and enhance the credibility of electric energy Metrology [5, 6]. The main body architecture is shown in Fig. 1.

In order to meet the business needs of metrological professionals, the underlying management service of blockchain adopted in this model is improved and optimized from three aspects of service capabilities: node, function and business.

- **Admission and management of nodes.** When a new node is allowed to join the metering alliance chain, firstly, a TLS certificate based on CA is issued to the new access user to determine the legitimacy of the node [7, 8]. It is not only the existence proof of the blockchain, but also provides data signature services when nodes upload data;
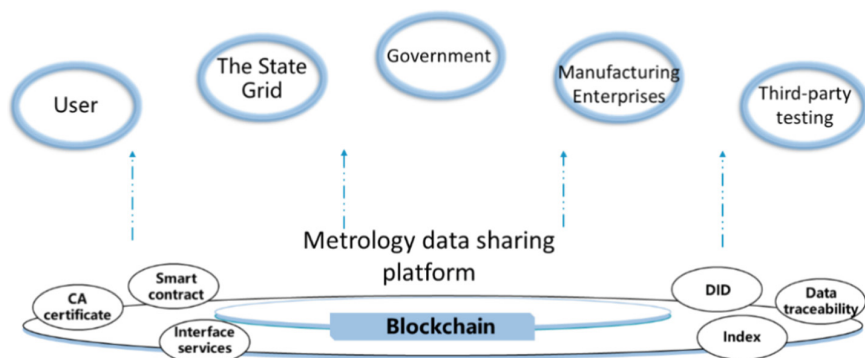
Fig. 1. The chain structure of Metrology alliance for upstream and downstream enterprises

- **Editable porting of smart contracts.** The blockchain platform supports online editing and porting of smart contracts, supports uploading smart contracts by any node. The smart contract call API for typical metering business systems is designed to ensure the chain code compatibility of the underlying system of the alliance chain;
- **Flexible adaptation of services.** According to the needs of the business system, the transformation and integration of customized interfaces are performed to adapt to the access of various business applications and support the efficient interoperability of on-chain and off-chain data;

3 Multi-level Data Sharing and Coordination

The main function of the Metrology chain architecture proposed in this paper is to trace the whole process of verification data through the blockchain. Each node on the blockchain can independently upload relevant data, and node members process data in accordance with normative standards to form pre-chain data. Secondly, the integrity, compliance and logical compliance of the data were verified based on the smart contract, and the verified data were stored on the blockchain. Finally, the device number DID was used as the only index of the uplink data, and the whole process data of the asset was traced to the source, forming a traceability scheme for Metrology equipment.

3.1 Smart Contract Application for Whole Process Traceability

Firstly, the various types of users involved and their uploaded data information are sorted out, and the data standards for linking are formulated to guide the data providers to process the verification data of electricity meters. It mainly includes specific technical parameters such as data format and data length of each link. The data standards of each link are formulated and published by the data source department. Specification of the subject definition, information items, standard code and other parts of the data on the chain. This experiment proposes a universal uplink port of blockchain data for all kinds of subjects. After all kinds of business systems upload data, the blockchain smart contract performs the uplink inspection and data right confirmation verification.
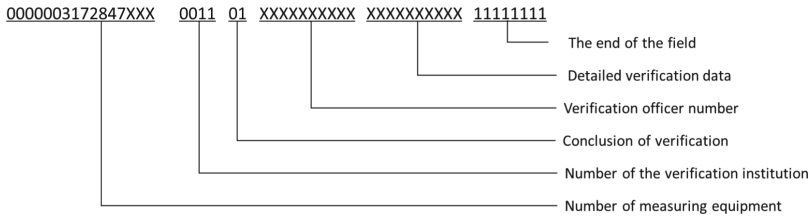
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                                                        └──  The end of the field
                                                   └───────  Detailed verification data
                                        └────────────────  Verification officer number
                                   └─────────────────────  Conclusion of verification
                            └──────────────────────────  Number of the verification institution
             └─────────────────────────────────────────  Number of measuring equipment
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Fig. 2. Diagram of the uplink data structure

Since the data cannot be tampered with or deleted after being stored on the blockchain node, in order to prevent harmful or unqualified data from being added to the chain, a data verification module based on smart contract is developed according to the data standards of each link of the device. After the verification is passed, the data is stored on the chain. The verification process is as follows:

- Verify the legitimacy of the user certificate: The smart contract will compare the node certificate of the uploaded data with the user information and user certificate recorded in the metering blockchain, and the node that verifies the existence of the node through the comparison will pass this round of verification.
- Verify the legitimacy of the data format: due to the different business links, the information on the chain of each node of the Metrology data is very different. For example, the chain field of the production mainly includes the part number and the factory test, etc. The verification link chain field mainly includes the test link number, the test subject number, etc. The identity token of the chain node is associated to verify the overall data format, and the data that passes the legitimacy verification is used for the next verification.
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3.2   Data Right Confirmation and Traceability

Data provenance involves many participants. The management mechanism of the consortium blockchain will register a CA digital certificate for each user, containing a public/private key pair [9]. The public key is used to identify the identity of the user in the system, and the private key is used for digital signature to ensure the authenticity of the user's identity. When user node A needs to transfer data M to the blockchain network, A's on-chain data is first audited by the smart contract. After the basic format of the data is verified, the data are sent to the blockchain certificate management server. The blockchain certificate management server verifies the correctness of the signature by
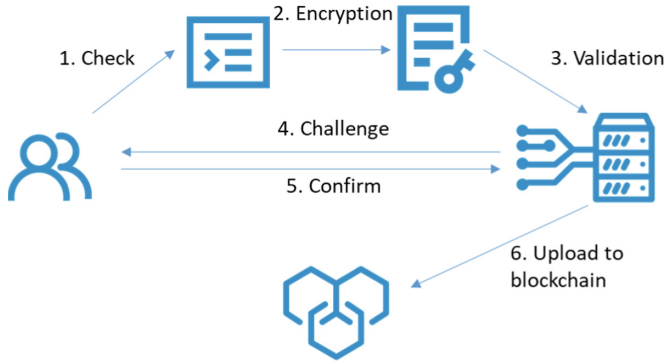
Fig. 3. Flow chart of data right confirmation

using the public key. Finally, after receiving the verification, the certificate management server used the bilinear property of the bilinear pairing to verify whether the equation was true. If it was true, the certificate server completed the data origin authentication. The blockchain encapsulates the verification evidence, relevant right confirmation information and relevant meta information into a transaction in JSON format and sends it to the data source that can provide the signature. Then it will be sent to the blockchain to complete the registration. After receiving the information, other nodes on the chain use A's public key to decrypt the signature and obtain the provided original data, which can complete the verification and right confirmation of the target data source (Fig. 3).

In order to realize the efficient traceability of data, this paper proposes a data traceability system based on DID coding. BID are used to make the metering equipment have the digital unique identification. Each device can form an exclusive associated code table, and rely on smart contracts to quickly retrieve and call the data of each link of the device to form a equipment data chain, so as to realize the trusted traceability of the whole life cycle chain of Metrology equipment. Make all aspects of equipment more transparent, break the data barriers between links. It can not only provide users with equipment traceability information through production and verification data, but also support manufacturers to further mine and refine key process data through operation and quality evaluation data, and study the internal relationship between product performance and product quality by data results, so as to optimize their own production links.

4 Blockchain Verification Certificate Issued

Global e-certificate number generation: Generate a unified, global and unique certificate number for the verification certificate and calibration certificate of metering equipment involved in the verification data of electric energy meters [10]. The data format on the blockchain and the electronic verification certificate issued are shown in Fig. 4.

In order to verify the theoretical correctness of this paper, a batch of equipment data is linked, which mainly involves important data in the production and verification process, including metering equipment number, manufacturer data, production specification data, verification organization information, various verification conclusions,
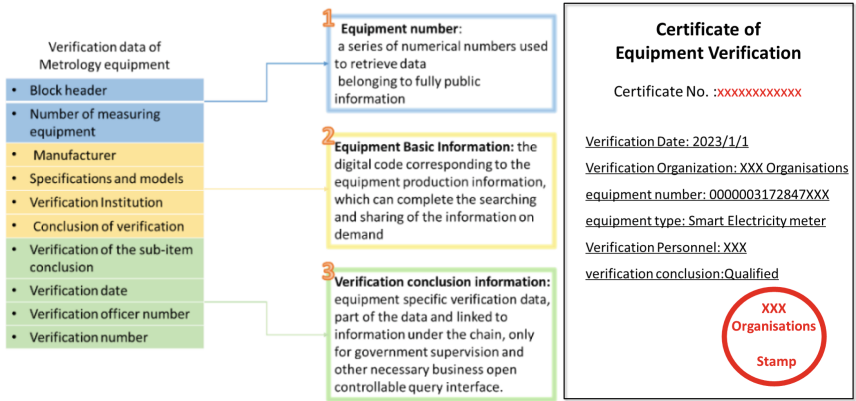
Fig. 4. Display of equipment traceability data and the certificate example

verification general conclusions, verification date, verification number and other key data. Relying on the blockchain smart contract to trace and bind all kinds of data of the whole chain, and according to the DID code, the unique metering equipment verification certificate number of the whole network is formed for the device. When the user consults the wechat public account according to the code marked on the meter equipment, the blockchain collects all the associated information and stamps the electronic seal of the issuing unit, so as to provide users with a visual and verifiable metering equipment verification certificate.

5   Summary and Prospect

Relying on the professional blockchain of Metrology constructed in this paper, the practice and implementation of blockchain in power Metrology business are realized. The government's transparent supervision of power Metrology business is fully supported. Provide public trust query and inspection for the public to improve credibility, help eliminate data barriers between testing institutions at all levels, and realize the trusted sharing of Metrology business data. Through the "blockchain +" of the Metrology standard system, the accuracy of data, the standardization of business and the legitimacy of the system are realized. The ability of electric energy Metrology and detection is strengthened, and the management level of Metrology verification and detection is improved. With the sharing and integration of verification data between government and enterprise, improve the collaboration and management efficiency of government and enterprise, enterprise and enterprise. We will fully support the digital transformation of Metrology, promote the construction of a social equity and public trust system, and improve the construction of a transparent and fair electricity business environment.

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