Research on Blockchain-Based Interactive Operation and Transaction Service Technology of Customer-side Flexible Resources

Chen Songsong[1]; Gong Taorong[1]; Yuan Jindou[1]； Chen Ke[1]； Gong Feixiang[1]
(China Electric Power Research Institute Co., Ltd., Beijing Key Laboratory of Demand Side Multi-Energy Carriers Optimization and Interaction Technique, Beijing 100192, China)

Abstract

The traditional generation right transaction ledger has disadvantages such as high operation and maintenance costs, non-public transactions, and insecure information storage, as well as long subsidy accounting cycle and low subsidy issuing efficiency, which is not conducive to users' simultaneous distributed energy transactions and demand response operations. Blockchain technology has the characteristics of decentralization, strong traceability and high transaction transparency. Using Blockchain technology can reduce the pressure of audit, supervision, data maintenance and other aspects of energy transactions. Traditional single consensus chain is not enough to support complex transactions of multi-business energy block chain. Therefore, this paper proposes the application of combined block chain to improve and innovate user transaction mode, so as to fit the transaction scenario of client-side distributed energy.

Introduction

With the deepening of researches on the interactive operation and trading mechanism of customer-side adjustable resources, a trading platform that can provide flexible load resources to participate in the interaction of power grid is urgently needed, so as to ensure that the interactive operation and trading service of customer-side flexible resources enter the practical stage.

Western provinces such as Jiangsu, Gansu and Xinjiang began to implement renewable energy power generation right substitution transactions to increase the consumption of clean energy, with an annual transaction scale of about 460 million kWh. On March 30, 2021, the National Energy Administration for the first time put forward the "14th Five-Year" target of transforming renewable energy into the incremental main body of energy and electricity consumption. The absorption of distributed energy has been paid more and more attention[7], so it is necessary to conduct innovative research on the absorption mode and mechanism.

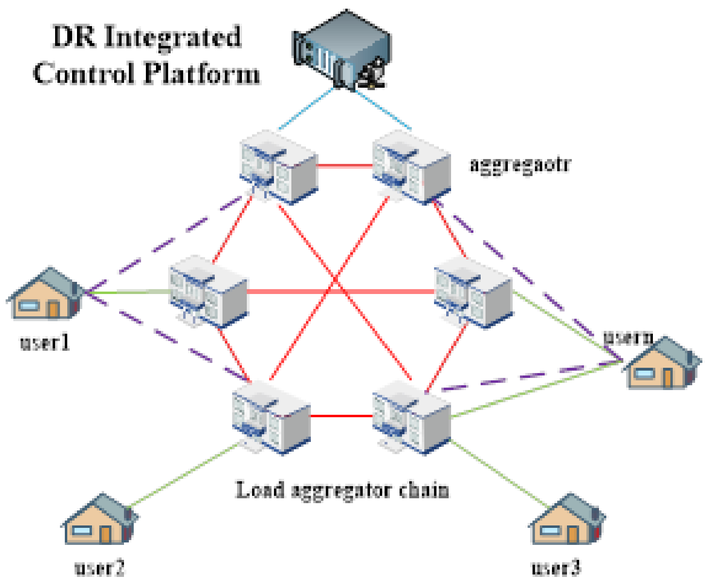

Figure 1. DR Integrated control platform based on blockchain

Methods and Materials

Using block chain technology to build a decentralized demand response (DR) system, can effectively prevent DR data tampering, solve the DR interoperability in the process of the interaction between the user and the load aggregators trust issues. As shown in Fig. 1.

The transaction tree indicates that the distributed energy transaction is contained within a specific block. To create the distributed energy blockchain transaction tree, first judge whether the current verified transaction list is empty. If it is empty, then the root hash of the current block N transaction tree is Null. If it is not empty, then the root hash value of the transaction tree is gradually generated by the verified transactions A1, B1, C1, D1, etc. in the trade list, as shown in the figure 2.

In order to maximize The transaction efficiency of The market, The first price sealed auction (FPSA) is designed. Based on the mode of quotation, namely transaction price, in the first price sealed auction rule, a bidding strategy suitable for fair auction is proposed. As shown in Fig. 3 .

This paper proposes to establish a descending ranking list of node credit value , and nodes can choose transaction partners according to the matching range of . If the node fails to match by the end of the trading cycle, the platform may determine that the node is inactive during the current period and deduct the appropriate credit value as a penalty. Through the list of credit value, the system can not only reward the nodes with good reputation to stimulate the market credit transaction, but also cancel the quota of the accounting right competition of the inactive nodes or malicious nodes to ensure the normal operation of the distributed energy trading system.

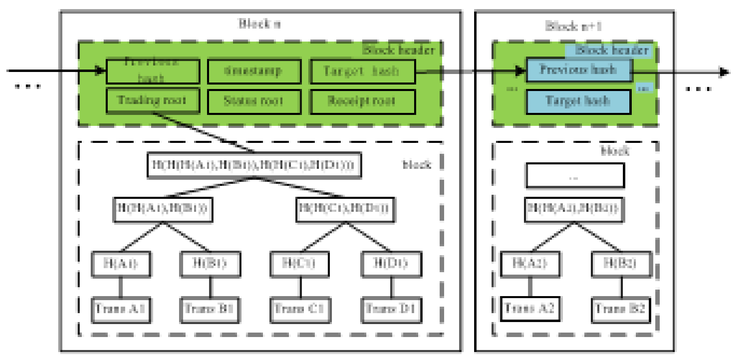

Figure 2. Distributed energy blockchain transaction tree

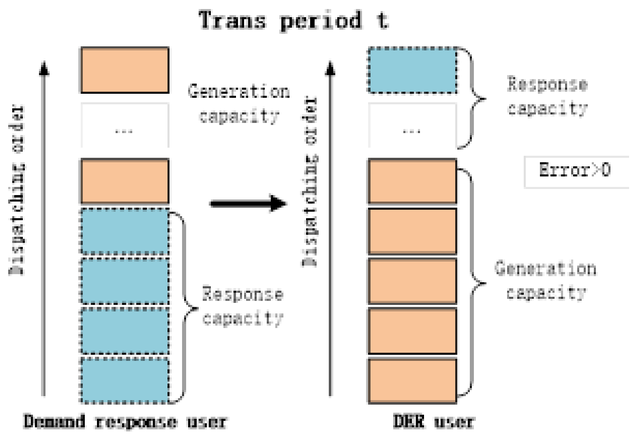

Figure 3. Transactive energy dispatching orders for demand response users and DER users

Results

This article simulates 25 user nodes and four load aggregator nodes, which contains reputations node of users and load aggregators with 1000 DR interop iterations. Fig.4 present the changes in the reputation of load aggregator nodes, and the final ranking of the aggregator's reputation from high to low is aggregator 3, aggregator 2, aggregator 1 and aggregator 4. The user and the aggregator confirm their registration relationship by querying the blockchain to achieve two-way selection based on each other's reputation.

It can be seen in fig 5 that, the method based on reputation block chain, in the process of distributed business interactive demand response, compared to the traditional method, have a higher completion rate response and response, according to the requirements of different rounds of the statistics found that the method based on reputation is about 96%, the average completion rate and demand response to the traditional way of completion rate of about 88.5% on average.

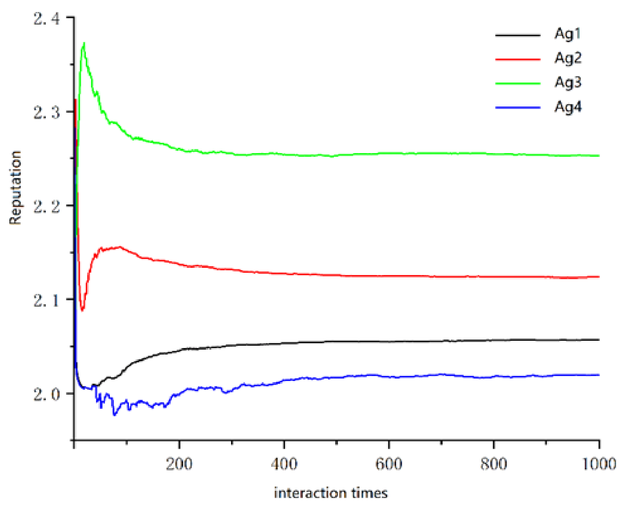

Figure 4. Reputation values for different aggregators during interaction times

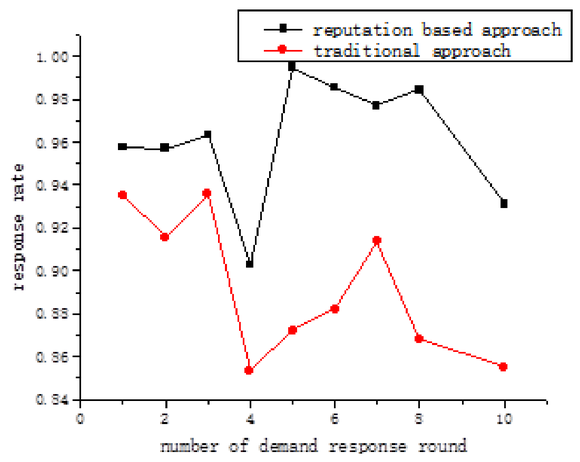

Figure 5. comparisons between reputation-based approach and traditional approach

Conclusions

This paper first analysis of the advantages of demand response for distributed energy given second research photovoltaic, temperature control, energy storage, electric cars, three trading pattern of distributed energy, based on the competitive equilibrium price, the master-slave game model, the continuous bilateral auction mechanism design bidding strategy based on node reputation, we finally design reputation block chain interoperability strategy improvement and example analysis. The results of the calculation examples show that compared with the traditional demand response interoperability and blockchain interoperability strategies, the blockchain interoperability strategy with improved credibility has a higher DR success rate and user incentive benefits, and is more suitable for frequent interoperability scenarios of customer side distributed energy users.

Contact

<name> Gong Taorong

<organization>China Electric Power Research Institute Co., Ltd., Beijing Key Laboratory of Demand Side Multi-Energy Carriers Optimization and Interaction Technique

Email:gongtr@163.com