Blockchain Enabled Secure Energy Trading based on Smart Contract Design

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三等奖

Abstract

Blockchain technology has become an efficient way to solve distributed clearing problems, but it still has many defects nowadays like the difficulty lies in contract settlement and management. In this paper, a blockchain enabled energy trading method including the design of smart contract and excitation mechanism is proposed to deal with the inefficient and incomplete present energy trading situation. Credit points are included into the design of smart contract used in the process of energy trading. A strategy to estimate the credit points of each node and to describe the excitation mechanism is illustrated. We establish the connection between the credit points and the probability that each node would be accepted during the energy trading and reach the conclusion that the higher the credit points they have, the more trading initiative they would have during energy transaction and transmission. The smart contract design and excitation mechanism proposed in this paper would reward the nodes that perform well and punish the beguiling nodes to regulate the trading process and maximize the profit.

Proposed method

1. Frame of energy trading

The specific process of energy trading based on excitation mechanism designed in this paper is shown in Fig. 1. The process is divided into six parts: user registration, requirements publishing, qualification auditing, transaction confirmation, transaction execution and transaction settlement.

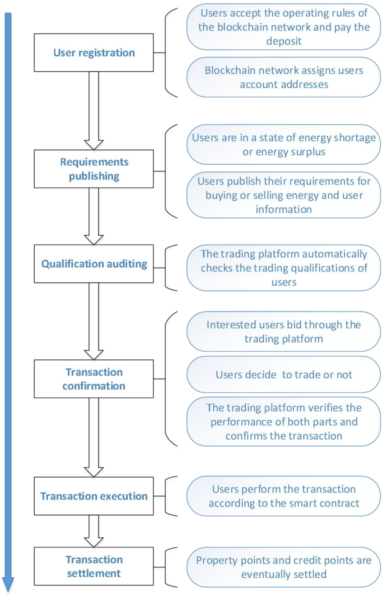

Figure 1.Process of energy trading.

2. Realization process

① The difference between the actual turnover and the ideal turnover:

$$Q = 1 - \frac{|E_{real} - E_{plan}|}{E_{plan}}$$

where E_{real} represents the actual turnover and E_{plan} represents the ideal turnover.

② Contribution of energy transmission:

$$T = Q_x / n$$

where Q_x represents evaluation of transaction quality in the x transaction and n represents the number intermediate nodes in the transmission.

③ Credit points:

$$C = \alpha \frac{\sum_{x=1}^{A} T}{A} + \beta \frac{\sum_{y=1}^{B} Q_y}{B}$$

where T represents the contribution of node transmission, A and B represent the total number of times the node participated in transmission and transaction, α and β are weight factors.

④ The probability P of node j responding to node i :

$$P = \begin{cases} 1, & C \geq c_j \\ \frac{f(\mathrm{C})}{f(c_j)}, & c_{min} \leq C < c_j \\ 0, & C < c_{min} \end{cases}$$

where C is the credit points of node i, and c_j is the credit points of node j. $f(x)$ is a monotonically increasing function with credit points x. There are many such functions, one of the classical $f(x)$ constructors is given here, specifically $f(x) = \ln \frac{1 - c_{min}}{1 - x}$.

⑤ The credit points of one transaction:

$$C_1 = \alpha T + \beta Q_y$$

Simulations

1. Data description

In this paper, the default values of α and β are 0.5, so the range of credit value is [0,1). By taking the derivative of (4) we can find that the differential coefficient of (4) is always greater than zero, so probability P increases monotonically on [0,1). Next, we will randomly initialize the values of and, and show the performance with Matlab. The initial values of the parameters are shown in Table 1.

Table 1. The initial values of the parameters.

Parameter	Initial value
c_{min}	0.2
c_j	0.6

2. Simulation results

Based on the analysis above, we design a trading platform that would encourage each node to actively participate in energy trading. Under the action of excitation mechanism, each node cooperates actively and effectively. It also improves the quality of transactions and transmissions. We prove that the excitation mechanism can encourage transactions among nodes through the probability that node i would be accepted by node j. The graph of probability P is shown in Fig. 2. It can be seen from the graph that probability P is a monotone increasing function. When the credit points of node i is higher, the probability of node i being responded to is higher.

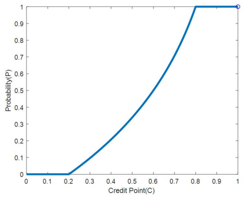

Figure 2. The probability P when the quantity of credit points C varies.

The simulation result shows that the higher the credit points of the user, the more opportunities they have to trade. It also shows the user who has high credit points has the right to trade with the excellent user with high level in energy trading. These advantages can not only promote users to actively participate in the transaction, but also urge users to improve the transaction quality and abide by the transaction rules. In conclusion, the excitation mechanism in the energy trading is effective and significant.

Conclusion

In conclusion, this paper illustrates a design for smart contract based on the excitation mechanism. At the beginning of this paper, the energy trading system architecture is exhibited, followed by the parameter and rules included in the design of smart contract, and the energy trading process with flow chart goes next. In the end, the simulation to prove the efficiency of the excitation layer is posted. To be specific, the result shows that after trading for several times, the trading behavior and transmission behavior of each node can be shown via credit points. While using blockchain technology to conduct direct transactions, users with higher credit points are more likely to complete their idealized transactions, for example, the price they can obtain is more satisfactory.

Main references

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