E-commerce Credit Evaluation Model Based on Blockchain

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Abstract : As an emerging technology, blockchain is gradually integrating with various application scenarios. In view of the situation that the credit status is not true in the scenario of C2C e-commerce, according to the existing problems, a blockchain-based game theory and smart contract credit evaluation model are constructed. In the evaluation model, through the design of the payment function, the raters are encouraged, and the honest raters will be guaranteed to obtain benefits. The principle of equilibrium in game theory is adopted to ensure the honesty of the scorer. In addition, a random sorting algorithm is proposed to make the selection of scorers as random and credible as possible to avoid collusion in advance. Finally, an audit mechanism is introduced to detect malicious scorers.

Keywords : Blockchain, Smart contract, Nash equilibrium

1 Introduction

Blockchain is a distributed data ledger, which is characterized by decentralization, immutability, difficulty in forgery and traceability [1,2]. Applying these characteristics to the traditional evaluation model can effectively improve the credibility and security of the evaluation model. Smart contract (SC) was originally defined as a set of commitments defined in digital form, including contract participants' implementation of commitment agreements on smart contracts. This allows both parties to conduct trusted transactions without a third party and solves the trust problem of intermediaries [3].SC can be applied in many scenarios, such as finance, insurance, identity verification, and medical care. The decentralization and the tamper-proof of data of the blockchain determine that smart contracts are more suitable for implementation on the blockchain. Applying this feature to the blockchain-based evaluation model can reduce the human impact on the evaluation model and trace back malicious evaluations [4].

The credit evaluation of C2C e-commerce sellers has the following two characteristics [5,6]. First, the opacity of C2C e-commerce sellers' personal information; Second, the credit evaluation of C2C e-commerce sellers can neither be the same as personal credit, which uses personal information as the evaluation benchmark nor can the credit score be evaluated through a large number of financial data.

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The article [7] proposed a blockchain-based online rating system to rate the products and services provided by users, manage the raters by controlling access procedures, and only qualified raters can rate. The article [8] proposed a relatively comprehensive decentralized e-commerce system, and provides corresponding credit calculation methods and incentive mechanisms. The article [9] proposed an e-commerce reputation system, which uses the advantages of Ethereum blockchain, IPFS and smart contracts to store product information and evaluate users' reputation in online shopping. Our work is closer to the latter two methods, but we are closer to the improvement of smart contracts. In particular, we borrowed the methods of game theory to apply it to smart contracts, effectively improving the credibility of credibility.

2 Credit evaluation model

2.1 Scorer's Design

In the traditional C2C e-commerce evaluation model, there are two kinds of credit loopholes [10]. On the one hand, buyers do not rate sellers and products after completing the purchase; on the other hand, there will be some collusion in advance, maliciously giving a seller a low rating. The evaluation model designed takes into account the above two loopholes, reducing dishonesty behavior The possibility of fully mobilizing the enthusiasm of buyers' evaluation.

To make the evaluation behavior more real and effective, the rating screening process is introduced into the traditional evaluation model. In order to customers who do not want to participate in the scoring activities will not become scoring candidates, and the player candidates who voluntarily participate in the scoring can pass the honest supervision and evaluation services. For make the scoring data traceable, a scoring pool is selected to participate in a set of scoring activities. They will jointly rate the seller's behavior, report the seller's dishonest behavior, and receive a reward fee from the seller as a reward.

This paper makes a basic assumption about the roles involved in scoring, that is, they are always selfish and aim to maximize their benefits.

2.2 Overall system architecture

The Figure 1 shows the overall framework of the evaluation model. The system is based on blockchain and consists of three types of smart contracts: one is the scoring pool smart contract, which is the basic smart contract of the system; the other is the safe purchase smart contract, which is the premise of evaluating smart contracts, and finally the specific evaluation smart contract. The smart contract is initiated by the seller. It randomly selects the appropriate buyer as the rater through screening, and asks the buyer whether to conduct scoring activities. The buyer who accepts the scoring activity will form a scoring committee and score within the time specified in the contract. Finally, the smart contract will calculate the collected scores and upload them to the blockchain to update the reputation value of the sellers. In this system, the incentive for the scorers is to earn profits. And the more members participating in the scoring, the more reliable and credible the system will be.

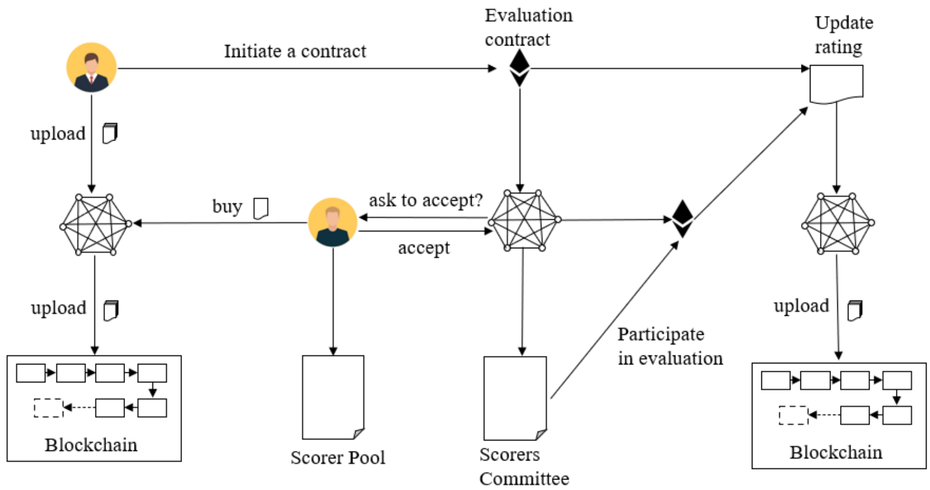


Figure 1 Evaluation model framework diagram

3 Key technology

In this section, the key techniques employed in the trust assessment model will be described in detail. The model supports automatic scoring of this transaction, and the scoring results can convince both sellers and customers.

3.1 Screening algorithm

In the trust evaluation model, the most important point is that the selected scorers are required to be unbiased, that is, in the selection of scorers, neither the seller nor the customer can have an advantage. In this paper, a screening method is proposed to screen the scorer group, as shown in Figure 2. The algorithm is also implemented in a smart contract to ensure the automatic operation of the contract.

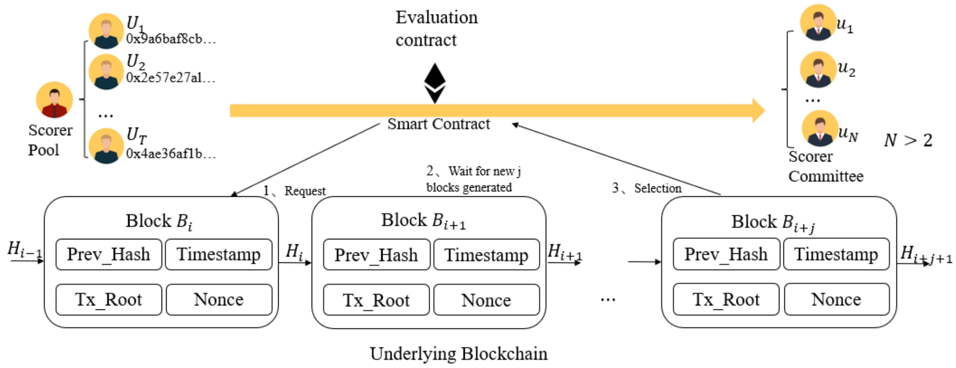


Figure 2: Screening algorithm flowchart

3.2 Payoff function and Nash equilibrium

The purpose of game theory is to make mathematical predictions and obtain strategies in a situation, not to obtain solutions, namely each player's payoff depends on his strategy and others' strategies [11]. Currently, it has a wide range of applications in economics, evolutionary biology, computer science, political science, and philosophy [12].

3.2.1N-person game

The matrix form is commonly used in the N-player game. This matrix defines a set of actors, a set of strategies for a set of actors, and a payoff function for a set of actors. Based on the complete definition in game theory, we define the scoring game behavior as:

$SS = \{S_1, S_2, \cdots, S_n\}$ is the set of n participants. Each participant is a chosen rater, and they form rater groups.

$\Sigma = \Sigma_1 \times \Sigma_2 \times \cdots \times \Sigma_n$ is the policy set of a group of participants, where Σ_k is a set of actions of the participant S_k, that is, $S_k$can choose any set of actions $\sigma_k \in \Sigma_n$ in the policy Σ_n set. The strategy choice is a vector, $\sigma^* = \{\sigma^*{}_1, \sigma^*{}_2, \cdots, \sigma^*{}_n\}$, where $\sigma^*{}_k$ is a specific action in $\Sigma_k (k = 1,2, \cdots, n)$.

$\Pi = \{\Pi_1, \Pi_2, \cdots, \Pi_n\}$ is a set of payoff functions, where $\pi_k: \Sigma \rightarrow \mathrm{R}$, $(k = 1,2, \cdots, n)$ is the payoff function that determines the scorer S_k under a certain strategy, R is the corresponding income.

$\sigma_{-k} = \{\sigma_1, \sigma_2, \cdots, \sigma_{k-1}, \sigma_{k+1}, \cdots, \sigma_n\}$ is the strategy for the action without the participants. There are only two options in the credit evaluation, namely $\Sigma_k = \left\{\sigma_k^{(r)}, \sigma_k^{(s)}\right\}$, $\sigma_k^{(r)}$ means reporting the seller's default to the smart contract, $\sigma_k^{(s)}$ means not reporting and keeping silent. In this n-player game, the set of choosing to report behavior is defined as $S_{report}, \forall S_k \in S_{report}$, $\sigma^*{}_k = \sigma_k^{(r)}$, and the set of choosing not to report behavior is defined as$S_{silence}, \forall S_k \in S_{silence}, \sigma^*{}_k = \sigma_k^{(s)}$. These operations determine whether the seller's status is violated. If $state = Violated$, it means that the seller has untrustworthy behavior. If $state = Completed$, it means that the purchase has been completed and there is no untrustworthy behavior.

Determine whether the seller's behavior violates the rules according to the strategy set. In a set of strategy sets, if the person who reports is M, and $1 < N / 2 < M < N$, it means that the seller has untrustworthy behavior, which is the seller's violation. On the contrary, if the seller behaves in good faith, the informant must be less than M. It is important to mention that the number of people participating in the scoring is defined here $N > 2$, and $M < N$. Therefore, if the scorer reports untrustworthy, but the behavior is not confirmed, the scorer will not be able to recover its fees as punishment. According to the above definition and analysis, the detailed payoff function design is presented in the following section.

3.2.2 Payoff function

The payoff function of this contract is designed as follows:

When $state = Violated$:

$$\forall S_k \in S_{report}, \pi_k\left(\sigma_k^{(r)}, \sigma_{-k}\right) = 10, \quad (1)$$

$$\forall S_k \in S_{silence}, \pi_k\left(\sigma_k^{(s)}, \sigma_{-k}\right) = 0, \quad (2)$$

When $state = Completed$:

$$\forall S_k \in S_{report}, \pi_k\left(\sigma_k^{(r)}, \sigma_{-k}\right) = -1, \quad (3)$$

$$\forall S_k \in S_{silence}, \pi_k\left(\sigma_k^{(s)}, \sigma_{-k}\right) = 1, \quad (4)$$

As shown in formula (1)-(4), in the N-person game, when it is finally determined that the seller violates the rules, the scorers who participate in the scoring will be rewarded. Raters who choose to report will be rewarded 10 times the predetermined incentive, while silent raters will not receive any incentives. Conversely, if there is no violation of the seller's behavior, the rater who chooses to be silent at this time will receive a predetermined bonus, while the rater who chooses to report will be fined.

3.2.3Nash Equilibrium

In the n-player game, in order to maximize his interests, a person will choose the best strategy under the combination of strategies adopted by all the other parties. This is called a Nash equilibrium.

As shown in Formula (5)(6), in this game, there are only the following two Nash equilibrium points:

$$\sigma^* = \{\sigma^*{}_1, \sigma^*{}_2, \cdots, \sigma^*{}_n\}, \text{ where } \forall S_k \in SS, \sigma^*{}_k = \sigma_k^{(r)}, \quad (5)$$

$$\sigma^* = \{\sigma^*{}_1, \sigma^*{}_2, \cdots, \sigma^*{}_n\}, \text{ where } \forall S_k \in SS, \sigma^*{}_k = \sigma_k^{(s)}, \quad (6)$$

At this time, the scorers were $N \geq 3$, $N / 2 < M < N - 1$, and $M \geq 2$.

Table 1 Scorer's Earnings Function

S_1	S_3			
	$\sigma_3^{(r)}$:Report		$\sigma_3^{(s)}$:Silence	
	S_2		S_2	
	$\sigma_2^{(r)}$:Report	$\sigma_3^{(s)}$:Silence	$\sigma_2^{(r)}$:Report	$\sigma_2^{(s)}$:Silence
$\sigma_1^{(r)}$:Report	(10,10,10)	(10,0,10)	(10,10,0)	(−1,1,1)
$\sigma_1^{(s)}$:Silence	(0,10,10)	(1,1,−1)	(1,−1,1)	(1,1,1)

Based on the above analysis, a scorer, participate in this scoring game to maximize their income. As shown in Table 1, in the game, his behavior is fixed, that is, he will choose the most beneficial strategy for himself. If he knows that there are violations, other raters are also trying to maximize their interests like him. Then he knows that most of them choose to report, and he will also choose to report. On the contrary, if there is no violation, although the scorer wants to obtain the highest profit, under the circumstance that he knows that most people will choose to remain silent if he chooses to report, he will be punished for his fraudulent behavior, which requires taking a big risk. Hence, when there is no untrustworthy situation, all choices are to maximize their interests.

Therefore, only scoring honestly will maximize personal benefits.

3.3 Scorer Audit Algorithm

The screening algorithm ensures that the scorers are independent to a large extent, and the payment function will stimulate the scorers to score honestly [13]. However, an audit mechanism is still needed to block the scorers with malicious behavior so that they no longer have the scoring authority. Since all interactions of smart contracts are open and transparent [14,15], historical behaviors are traceable, and the contract will audit scorers through their historical behavior pairs. Two types of raters are analyzed below: those who do not rate and those who rate too quickly.

No Scorekeeper: Selected as a scorer, but did not score until the end of the time.

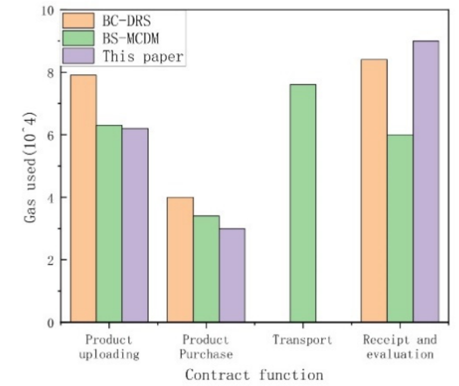
Scoring too fast: With each game, the scoring moves are so fast that players in the back can make judgments based on their choices.

To audit the actions of the scorer, the scorer's reputation is combined with the scoring action. For example, when the seller does have violations, the scorer who chooses to remain silent will have his reputation points reduced at the end of the contract; when it is finally determined that the seller does not violate the law, the scorer who chooses to report will not only reduce the reputation points but also pay a certain amount. When the reputation points of all scorers are reduced to 0, they will be blocked by the blockchain network and cannot participate in scoring activities. It is also worth mentioning that these audit mechanisms are also implemented in smart contracts to avoid the dominant judgment of third-party centralization.

4 Experiment

In this study, smart contracts are arranged on Remix to predict gas cost and time cost, and compared with BC-DRS and BS-MCDM.. The results are shown in Figure 3.

1. It can be seen from the left of Figure 3 that in terms of purchase and upload, BC-DRS, BS-MCDM and our work are not much different, but in terms of purchase contracts, our contracts make sure that the purchase of gas consumed is minimal through optimization functions.
2. For smart contracts, uploading large amounts of data consumes more gas cost than simply signing a transaction. Our contract has the largest gas volume in the evaluation model, because our evaluation contract has an incentive system, and the data of the payoff function needs to be uploaded to the blockchain, so the gas volume is the largest. However, the overall gas cost is also acceptable.



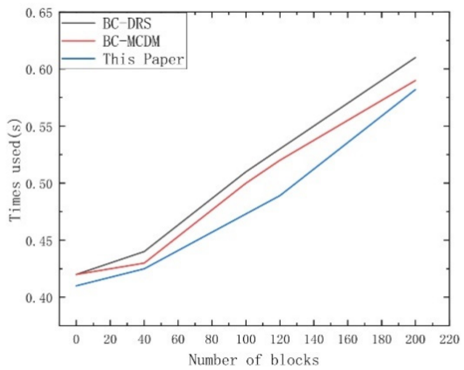


Figure 3: Gas cost comparison chart and time cost comparison chart

3. As the number of blocks in the blockchain increases, the time cost of all four processes increases slightly. The time cost is divided into the time cost of accessing and storing information in the blockchain and the time cost of realizing functions in smart contracts. As the number of blocks increases, the time cost of accessing and storing information increases slightly.

4. The right of Figure 3 shows the time cost of the evaluation process. The time cost of the evaluation process is slightly high. The main reason is that in the evaluation process, the rating data of users need to be calculated and updated, and the reputation value of merchants needs to be updated. Compared with BC-DRS and BS-MCDM, our work has relatively small time cost and greater feasibility.

Finally, these gas consumption values were obtained through experiments based on current implementations. It is still possible to further optimize the interface implementation to reduce gas consumption.

5 Conclusion

In this paper, we propose a blockchain-based smart contract credit evaluation solution. Our framework uses Ethereum smart contracts to automate functions without intermediaries. The solution based on smart contract ensures that the buyer's credit evaluation follows a transparent credit evaluation process and the submitted credit is true. Compared with centralized e-commerce credit rating, our solution ensures transparency, traceability and security due to the inherent attributes of blockchain. The system architecture, sequence diagrams, algorithms, implementation and test details can be appropriately modified to adapt to various e-commerce assessments.

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References

[1] Qiao Y, Lan Q, Zhou Z, et al. Privacy-preserving credit evaluation system based on blockchain[J]. Expert Systems with Applications, 2022, 188: 115989.
[2] Vranken H. Sustainability of bitcoin and blockchains[J]. Current opinion in environmental sustainability, 2017, 28: 1-9.
[3] Zheng Z, Xie S, Dai H N, et al. Blockchain challenges and opportunities: A survey[J]. International journal of web and grid services, 2018, 14(4): 352-375.
[4] Nadarajah S, Chu J. On the inefficiency of Bitcoin[J]. Economics Letters, 2017, 150: 6-9.
[5] Davidson S, De Filippi P, Potts J. Economics of blockchain[J]. Available at SSRN 2744751, 2016.
[6] Patel S B, Bhattacharya P, Tanwar S, et al. KiRTi: A blockchain-based credit recommender system for financial institutions[J]. IEEE Transactions on Network Science and Engineering, 2020, 8(2): 1044-1054.
[7] Ma Q, Yang H, Wang D, et al. Supply Chain Credit Evaluation Mechanism Integrating Federated Learning and Blockchain[C]//Proceedings of the 11th International Conference on Computer Engineering and Networks. Springer, Singapore, 2022: 1471-1480.
[8] Xiao Y, Zhou C, Guo X, et al. A Novel Decentralized E-Commerce Transaction System Based on Blockchain[J]. Applied Sciences, 2022, 12(12): 5770.
[9] Zhou Z, Wang M, Yang C N, et al. Blockchain-based decentralized reputation system in E-commerce environment[J]. Future Generation Computer Systems, 2021, 124: 155-167.
[10] Yaga D, Mell P, Roby N, et al. Blockchain technology overview[J]. arXiv preprint arXiv:1906.11078, 2019.
[11] Zhou H, Ouyang X, Ren Z, et al. A blockchain based witness model for trustworthy cloud service level agreement enforcement[C]//IEEE INFOCOM 2019-IEEE conference on computer Communications. IEEE, 2019: 1567-1575.
[12] K. Binmore, Game theory: a very short introduction. Oxford University Press, 2007, vol. 173.
[13] Hsieh Y G, Antonakopoulos K, Mertikopoulos P. Adaptive learning in continuous games: Optimal regret bounds and convergence to Nash equilibrium[C]//Conference on Learning Theory. PMLR, 2021: 2388-2422.

[14] Ye M, Hu G, Xie L, et al. Differentially private distributed Nash equilibrium seeking for aggregative games[J]. IEEE Transactions on Automatic Control, 2021, 67(5): 2451-2458.
[15] Tan S, Wang Y. A payoff-based learning approach for Nash equilibrium seeking in continuous potential games[J]. Neurocomputing, 2022, 468: 431-440.