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Strategic Decision Making in Consortium Blockchains through Modified Proof of Work

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Abstract: Blockchain technology offers a solution to the challenge of transaction storage within consortia, yet it seldom addresses issues concerning strategic decision-making within these groups. In practical scenarios, consortia consist of multiple companies or enterprises engaged in business relationships, inevitably encountering pressing problems that demand resolution. To address the issue of centralized decision-making authority, this paper introduces a strategic decision-making consensus mechanism, refined from the proof of work model to tackle a real-world problem. This mechanism incorporates a voting system to select the most optimal strategy. Initially, the strategy proposer presents viable strategies based on the issues identified by the system. Simultaneously, the system randomly selects Nb bookkeepers from the pool of accounting candidates. These Nb bookkeepers then evaluate the received strategies based on their satisfaction levels. Bookkeeper i documents the calculation process of the strategy satisfaction and the optimal strategy within the blockchain. By analyzing security performance, as well as fair and reliable performance, this improved consensus algorithm ensures the optimal policy is tamper-proof. Experimental verification demonstrates that the enhanced consensus mechanism can achieve transaction authentication at the level of seconds.

Keywords: Blockchain, Alliance Blockchain, Consensus Mechanism, Optimal Strategy.

1. Introduction

With the successful application of Bitcoin, blockchain technology has attracted widespread attention in the industry, and has become the darling of next-generation computer technology. The Bitcoin blockchain system is essentially a public chain. All nodes in the public network can freely access and withdraw, and can voluntarily mine for bitcoin rewards and even accounting rights. But in fact, the PoW consensus mechanism such as Bitcoin has few applications on the public network and the Bitcoin system will cause a huge waste of power. However, the PoW consensus mechanism is the consensus algorithm that can best guarantee the status of each node. Competing for the block's right to book, all nodes work together to solve a random number problem, and the node that finally obtains this random number can generate a block for verification.

Blockchain can be divided into three types of chains based on the nature of the nodes, public chain, private chain and alliance chain. All nodes in the public chain are completely decentralized, such as the Bitcoin and Ethereum systems; the private chain refers to the blockchain used within the enterprise to record the company's own information, then in the private chain, the nodes have permissions It is necessary to follow the internal standards of theenterprise. The existing private chain applications include Eris Industries and Coin Science; and the nodes of the alliance chain refer to the nodes in the alliance, which can ensure that all components in the alliance (including all companies Enterprise) status is equal. Blockchain alliance R3, ants and Hyperledger are important alliance chain applications.

The consensus mechanism is one of the important innovative technologies of the blockchain. Inorder for the blockchain to exert its advantages in different scenarios, researchers are committed to the research of consensus mechanisms, and there have been peer-to-peer [1] using the PoS (Proof of Stake) consensus mechanism, DPoS (authorized shares) pioneered by Bitcoin Proof mechanism) [2], the consensus mechanism such as PBFT (Practical Byzantine Fault Tolerance) consensus mechanism adopted by Hyperleger, Little Ant Consensus Mechanism, POET (Time Disappearance Proof). Different consensus mechanisms have differentcharacteristics and corresponding application scenarios. Although the above consensus mechanisms have more or less shortcomings, they all play a very important role in their application scenarios. To sum up, in addition to the small ant consensus protocol, most of the existing researches on the consensus mechanism are aimed at improving performance by changing the competition rules of accounting rights, and avoiding problems such as low transaction throughput and high transaction delay in PoW. However, it ignores the fact that even if the PoW consensus mechanism causes a waste of computing power, it still has the advantage of being able to solve the problem. Now consider setting its workload to be a practical, meaningful problem to be solved. In an alliance formed by several companies or companies, there are often a large number of strategic issues to be resolved, and each alliance entity is unwilling to give up strategic decision-making power to other entities. In order to ensure fairness and meet the expectations of the alliance entities For the optimal decision, you can consider recording the decision-making election process in the blockchain, and the bookkeeping rights owner will generate the alliance strategy block.

In summary, consider changing the random number problem that needs to be solved in PoW to a strategic problem to be solved, and a feasible strategic decision made by a capable node. This can solve the waste of computing power in the PoW consensus algorithm to a certain extent. Problem; in order to ensure that the optimal strategy meets the expectations of all alliance nodes, a fuzzy mathematical comprehensive evaluation voting mechanism is added to prevent private alliance monopolies; in order to ensure the fairness of decision-making within the alliance, it is proposed to separate the competition bookkeeping rights holder from the strategy proposer Make bookkeepers have supervisory and evaluation rights, supervise strategy proposers, and evaluate proposed strategies; in order to ensure the equality of the status of allnodes in the consortium, set up reward mechanisms to reward strategy proposers without It has a higher equity; at the same time, the selection process of strategic decisions for each time period is performed by only one bookkeeper, which can avoid the problem of chain fork in the Bitcoin blockchain and avoid block verification delays. High problem.

2. PoW Consensus Mechanism

2.1. Precedure of PoW Consensus Mechanism

The PoW consensus mechanism (Proof of Work) is based on the proof-of-work mechanism, which perfectly integrates the functions of currency issuance, transaction payment, and verification of the Bitcoin system [3]. The implementation process of this algorithm is shown in Figure 1. The competition accounting miners and all nodes are the main bodies. The specific description is as follows:

(1) All nodes in the entire network place the completed transaction information in the transaction pool;

(2) Miners participating in the competition for bookkeeping rights encapsulate the transactions in the transaction pool within a block interval period (through the hash function and Merkle tree) to generate a Merkle root;

(3) Miners rely on computing power to obtain accounting rights by solving a random number; A:

The blockchain system gives a global threshold (target hash)

B: Miners hash the random numbers

C: If the hash value of the random number is greater than the global threshold, add 1 to the random number and skip to B

D: If the hash value of the random number is less than the global threshold, it means that theminer successfully searched for the random number, that is, obtained the right of accounting

(4) The miners who have obtained the right to book accounts complete the block header information, form a block b, and propagate block b to the entire network through the blockchain network;

(5) After receiving the block b, all nodes in the entire network verify the hash value to determine whether the block is valid;

(6) If block b is valid, the node will link it to the main chain;

(7) If block b is invalid, discard it.

2.2. The Problems of Pow Consensus Mechanism

The PoW consensus mechanism relies on computing power to ensure the decentralization of all nodes in the public network. However, the problem of unresolved random numbers has caused a huge waste of computing power. Some studies have shown that bitcoin consumed in 2013 The amount of electricity is equivalent to one year's electricity consumption in Ireland [4], and the random number problem has no practical significance. All nodes in the public network can enter and exit the system freely, and have a fair opportunity to compete for accounting rights. However, if several nodes simultaneously solve the problem of random numbers, these nodes will obtain accounting rights at the same time. It will cause the block fork problem. In later applications, researchers will solve the block fork problem in different ways. The research in [5] shows that under the premise of guaranteeing the same security, in order to solve the block fork problem in the Bitcoin system, a link of 6 consecutive blocks is specifiedto determine a valid block, but this leads to 1h Block confirmation delay time (the block intervalof the Bitcoin system is 10min); the Ethereum system uses the Ghost protocol to solve the block fork problem [6], which requires about 37 block confirmation times (the Ethereum system 's Block interval is about 25s). In addition, Litecoin and Dogecoin have added the scrypt encryption algorithm on the basis of proof of work, in order to reduce the mining difficulty of miners and shorten the block interval time. In the case of comparable security performance, Litecoin requires 28 block confirmation times (block interval of 2.5min), and Dogecoin requires47 block confirmation times (block interval of 1min).

The above data shows that the block verification delay is mainly caused by the problem of solving the block fork problem under the premise of ensuring security.

As we all know, the security problem is the most difficult to guarantee in the distributed system,so is the blockchain technology, especially the pow consensus mechanism, which is one of the core technologies to realize the complete decentralization of each node. Literature [7] specifically analyzes the block interception attack in the blockchain system based on workload proof, which shows that rogue nodes can maximize their own benefits by attacking other nodes,and puts forward two schemes: general scheme of encryption commitment and improvement of hash function, which make miners unable to prove the division of work and full workload, so as to prevent the block interception attack.

In reference [8], the game dilemma of miners is proposed for block interception, and zero determinant strategy (ZD strategy) is proposed to optimize the game, so as to maximize the system revenue. Literature [3] studies the impact of block size, block interval and other issues on the security performance of blockchain system, and uses MDP model to quantify the selfish mining and double blossom problems, which shows that selfish mining is not always the most rational strategy, but also shows that changing block size and block interval has little impact on the security performance. In addition, literature [9] proposes a multi-center dynamic consensus mechanism based on the license chain, designs a two-tier blockchain structure, and constructs a master-slave dual chain, so as to achieve the global consistency of digital assets. Tosum up, the existing literature does not focus on the advantages of pow. In this paper, we consider setting practical problems that can be solved to realize workload proof and make it applied to the alliance chain with node permission.

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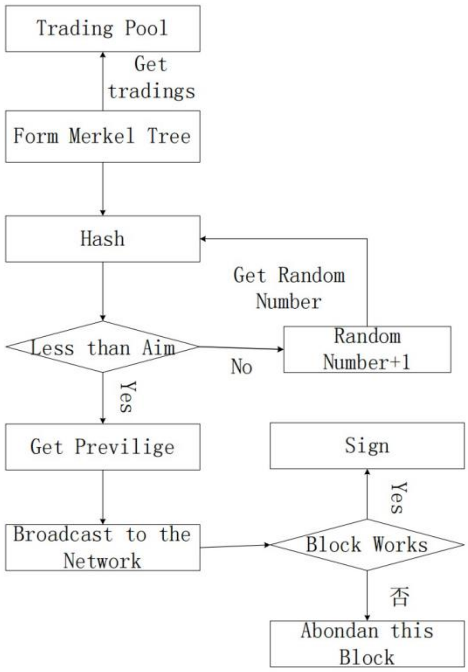

Figure 1. Process of PoW Consensus Mechanism

3. Approved PoW Consensus Algorithm

Assuming that some companies form alliances due to development needs, there must be a large number of business contacts and problems to be solved within the system. In order to ensure the decision fairness of all companies in the system, it is considered to use blockchain technology to record and select the optimal strategic decision that meets the system expectations. In the improved workload proof consensus algorithm, the problems to be solved are put into the system, and the representatives of the companies with the ability put forward feasible strategies for the problems into the strategic pool (equivalent to the transaction pool);the right representatives vote and evaluate all the strategies received from multiple factors; finally, the bookkeeping right representatives record the whole process into the blockchain. In this algorithm, the right representative has the right of policy supervision and decision-making voting. The right representative of bookkeeping is selected randomly from the right representative and has the right of bookkeeping. In the following sections, the right representatives and the bookkeeping right representatives collectively refer to the bookkeeper.

3.1. Defination of Algorithm

In this algorithm, we define five identities: ordinary user, member user, bookkeeping candidate, bookkeeper, policy proposer.

Definition 1: member users. A number of companies and enterprises form an alliance in which member users are members, and the alliance must ensure that its members are legal. Member users have the right to recommend themselves as bookkeeping candidates; they have the right to evaluate bookkeepers, score Bookkeepers who fail to generate blocks, and deprive them of their bookkeeping rights; they have the right and obligation to solve problems. Some member users need to put forward strategies that meet the conditions for the problems raised, and member users also have the obligation to verify the blocks. After the blocks are generated, theywill Sent to all member users, when the bookkeeper receives 51% approval, the block will be considered valid, and this vote represents the wishes of all member users.

Definition 2: Bookkeeping candidates. The number of bookkeeping candidates is limited. To become a bookkeeping candidate, you need to pay a deposit to the system and have the right to be selected as Bookkeeper. Bookkeeper is randomly selected from bookkeeper candidates. If the bookkeeper candidate does not become bookkeeper, he can choose to continue waiting for the next round of random selection, or he can choose to exit at any time.

Definition 3: bookkeeper. Bookkeeper is selected randomly from the candidates for bookkeeping, and the number of bookkeepers is certain, less than the candidates for bookkeeping. The bookkeeper has the right to vote on the evaluation strategy. The strategy with the highest evaluation will be considered as the optimal strategy. The bookkeeper will send the voting evaluation process and the generated block of the optimal strategy to the whole network. The bookkeeper shall not withdraw during his term of office.

Definition 4: Policy proposer. The strategy proposer is mainly to solve the problems in the alliance. The competent member users will actively give the strategy to solve the problems, and then put the strategy into the strategy pool. The bookkeeper will vote and evaluate all strategies in the strategy pool for a period of time, and the proponent of the highest evaluated strategy will be rewarded accordingly. The policy proposer can withdraw at any time after proposing the policy and submitting it.

Definition 5: ordinary user. Ordinary users become member users through identity authentication. Ordinary users do not have any rights to view the account books. Since ordinary users only have the "readable" qualification, they can exit the alliance system at any time.

3.2. Process of Achieving Consensus

Suppose the number of member users is nm, the number of accounting candidates is NBC, the number of bookkeepers is Nb, the number of policy proponents is ns, and the number of ordinary members is No. Set the tenure of bookkeeper as TW, and number all bookkeepers within the tenure of bookkeeper. Starting from 0, the number of each bookkeeper is 0,1,2... NB-1 in sequence. BW + 1 blocks will be generated in each term, and the last block will record the number and list of bookkeepers for the next term. The bookkeeper is required to generate a block within a block interval TB.

The generation process of an effective block is the process of nodes realizing a consensus. After each consensus, the bookkeeper will generate a random number r from 0 to NB-1 by calling the function() function. Then the bookkeeper with the number R is considered as the bookkeeper of the next period TB. According to the algorithm, a block must receive at least nm / 2 + 1 consent signals from different member users to become an effective block; if there is no effective block generated in TB, the bookkeeper numbered R + 1 regenerates the block; if R + 1 > Nb, r = 0 is defined, that is, rotation starts from 0. Because there is only one block generated in TB, and only one block needs to be verified and finally becomes an effective block, the blockchain will not generate forks, and there will be no verification delay.

3.3. Block Generating Process

Suppose the number of member users is nm, the number of accounting candidates is NBC, the number of bookkeepers is Nb, the number of policy proponents is ns, and the number of ordinary members is No. Set the tenure of bookkeeper as TW, and number all bookkeepers within the tenure of bookkeeper. Starting from 0, the number of each bookkeeper is 0,1,2... NB-1 in sequence. BW + 1 blocks will be generated in each term, and the last block will record the number and list of bookkeepers for the next term. The bookkeeper is required to generate a block within a block interval TB.

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3.4. Voting Process

In this algorithm, one consensus has two voting processes. The first is that all bookkeepers vote for all strategies, and the second is that member users vote for the generation of effective blocks. Select the optimal strategy to vote: NB bookkeepers receive the strategies proposed by different strategy proponents and verify their effectiveness within the time of TB. Bookkeeper I sends a strategy voting evaluation request to all bookkeepers. By calculating each bookkeeper's satisfaction with the strategy, the strategy with the highest satisfaction is selected as the optimal strategy. Bookkeeper I records the voting evaluation results and the optimal strategy to the area Block, and then send it to all member users to verify the effectiveness of the block;

Vote for the generation of effective block: bookkeeper J generates the block and sends it to all member users. If member users approve the block information, they sign on the block head and send it to bookkeeper J for consent. If bookkeeper J receives at least nm / 2 + 1 consent signal within the specified time, it proves that the block is effective. Otherwise, the block is considered invalid and needs to be regenerated by the bookkeeper j + 1.

4. Experiment Analysis

The number of proposed strategies (SN) in TB time is determined by the difficulty of the proposed problems in the coalition. When the bookkeeper NB is greater than Sn, in the optimal state, a certain strategy wins the favor of most bookkeepers, then this strategy is selected as the optimal strategy. But there may be the same vote situation. At this time, it is necessary to vote again until the optimal strategy is put forward. When the number of Nb of bookkeeper is far less than the number of Sn proposed by the policy, in order to select an optimal policy, an bookkeeper will have a K ticket, but the value of Sn cannot be predicted, estimated, and belongs to a random variable, so the corresponding K value cannot be defined. In view of the above problems, a fuzzy comprehensive evaluation method is proposed to calculate the satisfaction of Nb bookkeepers with all proposed strategies, and select a strategy with the highest satisfaction without considering SN.

In the selection of bookkeeper, random algorithm is used, which is equivalent to random sampling. The probability of each bookkeeper being selected is equal to 1 / NBC. There is no subjective factor in the process of random sampling, so the satisfaction of bookkeeper is very representative.

Assuming NB = 10, the number of samples is 10. Take Sn = 8,10,20 respectively. Evaluation factor set = {U1, U2, U3, U4}, evaluation grade set V = {very satisfied, satisfied, general, unsatisfied, very unsatisfied}, corresponding score set VW = {95,80,60,40,15} weight set w = {0.4,0.1,0.2,0.3}, fuzzy synthesis operator selects weighted average type, which can take into account the influence of all factors. Reference [12].

Select the required membership matrix randomly, input the set of scores and weights in Matlab environment, and get the results as shown in Figure 4, figure 5 and Figure 6. In the result shown in Figure 4, Sn = 8, and the main factor determining type, the main factor highlighting type and the weighted average type of fuzzy synthesis operators are respectively selected for comparison. It is concluded that the weighted average type of fuzzy synthesis operator is more comprehensive and the possibility of repeated results is very small. Therefore, select this operator to make the results of policy satisfaction analysis with Sn values of 10 and 20 as shown in Fig. 5 and Fig. 6. It is found that a policy with the highest satisfaction can always be found.

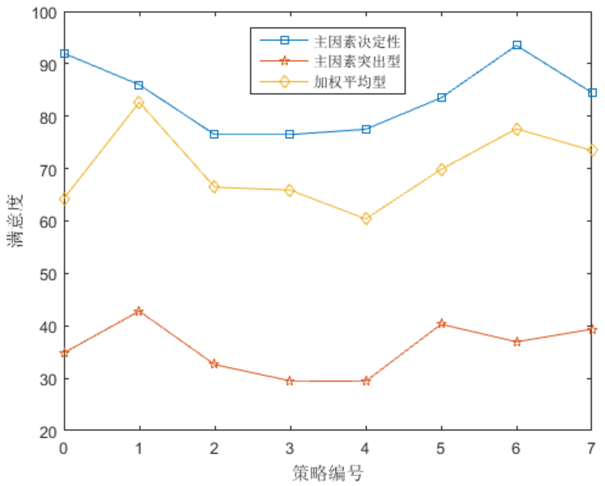

Fig 2. Fuzzy results of different fuzzy composition operators

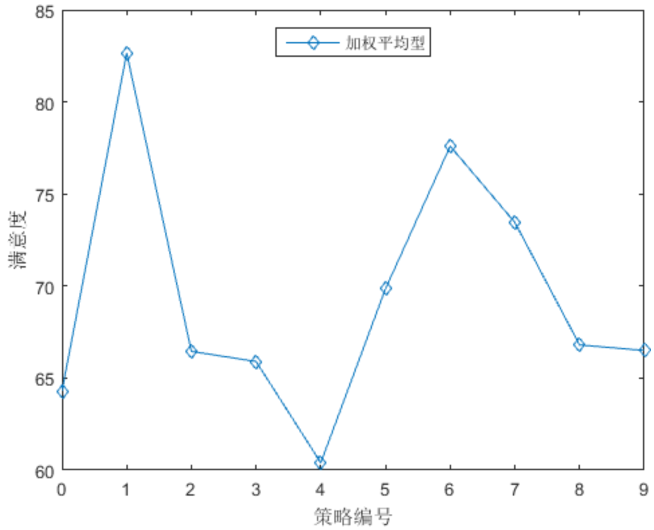

Figure 3. Strategy satisfaction with Sn = 10

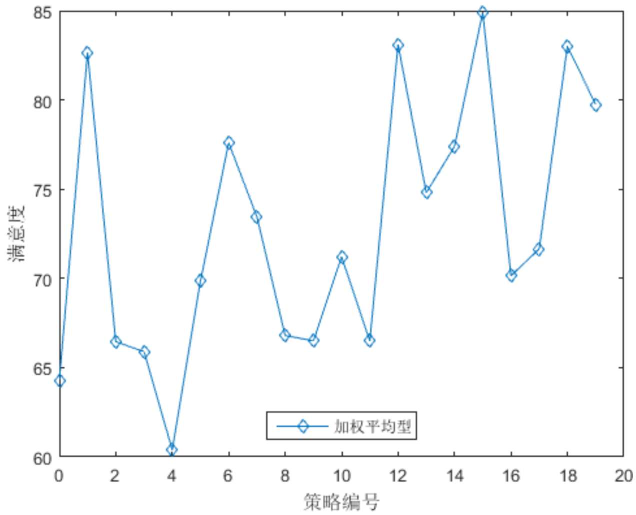

Figure 4. Satisfaction graph of strategy with Sn = 20

In addition, the choice of weight, the number of evaluation factors and the choice of fuzzy synthesis operator all affect the satisfaction results. When the weight and the number of evaluation factors are fixed, if there are two optimal strategies with the same score (the probability of occurrence is very small), we can choose to replace the fuzzy synthesis operator to choose the strategy with the highest satisfaction, that is, the optimal strategy.

The process of the bookkeeper voting for the optimal strategy is as follows:

(1) the bookkeeper expresses satisfaction with each factor of each strategy;

(2) the system calculates the satisfaction value of each strategy by changing the weight distribution;

(3) the strategy with the highest score is considered as the optimal strategy.

In this process, because the bookkeeper can not predict the weight distribution, the possibility of tampering with the voting data to affect the results is very small, which guarantees the reliability to a certain extent.

Theorem 4: the alliance blockchain will not be bifurcated

Analysis 1: in this algorithm, there is only one bookkeeper to generate blocks each time the consensus is completed. When the bookkeeper I fails to generate a valid block, the block will be regenerated by the bookkeeper I + 1.

Analysis 2: if the network partition occurs in this algorithm, assuming that the number of member users is divided into two zones, i.e. zone 1 with more than nm / 2 + 1 and zone 2 with less than nm / 2 + 1, then effective blocks can be generated in zone 1, and no effective blocks can be generated in zone 2, which ensures that there will be no block bifurcation in the alliance chain.

Theorem 5: the algorithm can realize the second level verification of blockchain.

The purpose of the improved POW consensus algorithm is to generate and select the optimal policy block, and control the block generation speed by controlling TB. The improved algorithm specifies that the generation time of each effective block is TB. If bookkeeper I does not generate, bookkeeper I + 1 will regenerate. In the time of TB, the bookkeeper should not only complete the block generation process, but also the block verification process.

5. Summary

Blockchain technology can solve the problem of transaction storage in the alliance, but it rarely involves the problem of strategic decision-making in the alliance. In real life, alliance is composed of several companies or enterprises with business contacts, which inevitably has problems to be solved. In order to solve the problem of centralization of decision-making power, this paper proposes a consensus mechanism for strategic decision-making, which is improved on the basis of workload proof. Through experimental verification, the improved consensus mechanism can achieve second level transaction authentication.

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