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Improvement of Market Economy Management Measures for Innovative Enterprises under Block Chain Technology

(Full Paper)

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ABSTRACT

In order to solve the financing difficulties of innovative Small and Medium Enterprise (SMEs) in the financial and economic field, this research proposes a market economy management measure for innovative enterprises, namely the enterprise credit information sharing model based on block chain technology. Firstly, the problems existing in the sharing model based on block chain technology are analyzed, and the basic model framework of block chain is adopted to improve the sharing model. Secondly, according to the improved Practical Byzantine Fault Tolerance (PBFT) consensus mechanism, the simulation experiment design of the credit information sharing model of enterprise market economy management measures is carried out. Finally, the improved sharing model proposed in this research is evaluated in terms of fault tolerance and throughput. The results show that the improved market economy management measures based on block chain technology in this research can meet certain fault tolerance rate, and the throughput is relatively stable. To some extent, it can meet the needs of credit information trading and sharing, and solve the difficulties of enterprise information sharing and low efficiency of data exchange.

Keywords: Block chain Technology, Improve Finance for Enterprise, PBFT, Credit Reporting

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INTRODUCTION

With the continuous development of credit economy, China's innovative SMEs not only have the problem of financing difficulties, but also often don't enjoy the financial services provided by Banks or other financial institutions. Nowadays, the market demand for credit information sharing is very large. As a very important link in China's financial economy, the problem of credit information sharing has not been fully solved (Saberi *et al.*, 2019). In addition, the information of innovative SMEs is not transparent, the financial management system is not clear, leading to the enterprise credit information access more difficult. Although China has established a large scale, wide coverage and the most comprehensive credit investigation system (Navadkar *et al.*, 2018), in the innovative Internet field, there are a large number of debt personnel outside of licensed financial institutions whose debt information is not included (Peck, 2017). Therefore, only when the credit information sharing mechanism is perfect, innovative SMEs can conduct credit evaluation on their own enterprises, help enterprises to obtain financing, and realize the steady improvement and development of market economy management (Liu *et al.*, 2011).

In recent years, with the continuous innovation and development of blockchain technology, as a decentralized distributed database, the application scope of blockchain is expanding, involving enterprise supply chain management, government public management and social security, financial market, digital asset transaction, etc. (Zhang *et al.*, 2017). Block chain technology is a kind of chained data structure combining data blocks in chronological order, and ensuring that they are not tampered or forged by means of encryption (Visvizi *et al.*, 2018). Blockchain technology has successfully affected the economic strategic plans of enterprises, but has not completely solved the difficulty of providing credit information for enterprises to share (Puthal *et al.*, 2018). From the perspective of the use of corporate credit data, the secondary use of data is likely to cause corporate privacy leakage or resale. In the era of big data, data privacy protection has become a new challenge (La Monaca *et al.*, 2010). From the perspective of data management, user data may be tampered with or deleted, resulting in the unguaranteed ownership of user data in the enterprise. However, blockchain technology has the advantages of being trustworthy and not tampered with, so the birth of blockchain technology provides solutions and directions for information sharing (Mengelkamp *et al.*, 2018). Most of the existing block chain models are designed for the public chain, because the public chain mechanism requires mining, resulting in a large amount of resource waste and throughput is difficult to meet the needs of credit information trading and sharing. Although the Byzantine algorithm has certain consensus efficiency, due to the limitations of the algorithm itself, it can't be directly applied to the block chain model.

To sum up, this research designs an improved information sharing model based on block chain technology. By combining with the Shared environment, the block chain framework model is improved. It is beneficial to solve the problem of quantity and quality of data information in the management measures of market economy of enterprises, serve for the improvement and enrichment of credit investigation products of enterprises and individuals, and further promote the sustainable development of national economy and the rationalization construction of social credit system.

METHODS

Analysis of sharing model based on block chain technology

Enterprise economic management activities will produce a variety of credit records, the effective information sharing mechanism is currently facing great challenges. Part of the block chain design can't be fully applied to the enterprise credit information sharing model, the main reasons include the following: I: As the underlying technology of bitcoin, blockchain is essentially a decentralized distributed database (Taleb, 2019). Most of the models composed of block chain technology adopt the architecture of public chain, which requires a large number of nodes to ensure its normal operation (Lewis *et al.*, 2017). In addition, the way the public chain architecture maintains the blockchain is proved by the workload, which causes a great waste of resources. A large number of nodes will not participate in the block chain model of credit information sharing. Only some enterprises requiring credit investigation will supervise and maintain the block chain of information investigation. II: The block chain technology is open to the public, and the data on it is open and transparent. All members can query the data and relevant development information on the block chain through the open interface. However, the confidentiality of information should be guaranteed during the sharing of credit data. As the credit investigation data is very large, it can't be transmitted directly through block transactions, but only through the chain (Crosby *et al.*, 2016). Therefore, the current problem for enterprise credit investigation agencies is how to use new technology to manage and maintain the shared data.

Improved design of sharing model based on block chain technology

The credit status of enterprises is usually reflected by the basic information and credit information of enterprises, which usually comes from government departments, commercial Banks, trust companies, and leasing companies. In addition, more and more non-traditional data are also gradually collected and used as credit information, such as public information of government departments, electricity, communication and water charges, and even e-commerce transaction data and social data (Kwok *et al.*, 2019). However, these huge credit data resources are relatively dispersed, and new market economy management measures need to be developed and applied urgently. This paper takes the enterprise credit investigation agency as the demand side of the enterprise confidence sharing platform. When it is necessary to collect personal credit investigation information, the enterprise credit investigation agency needs to ensure the authenticity of the information. As shown in Figure 1, the model designs the roles of the information subject, including the information subject, credit reference agency, credit information provider, cloud service provider, and regulatory agency.

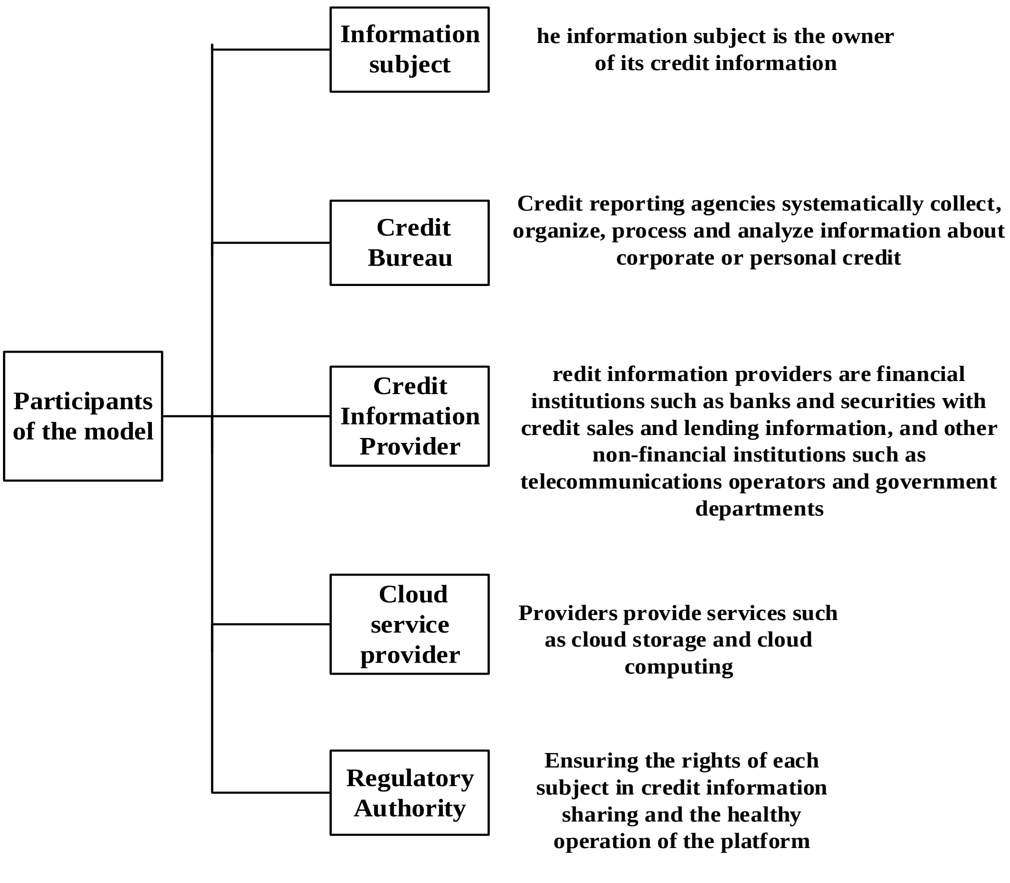

Figure 1: Role classification of information subject in model design

The design of the model framework adopts the basic framework of the block chain model, as shown in Figure 2, including P2P network, message transmission mechanism, block data structure and the new basic framework (Hong, 2020). These new basic frameworks include: the interaction between enterprise credit bureaus and principals, between cloud servers, and between supervisory agencies.

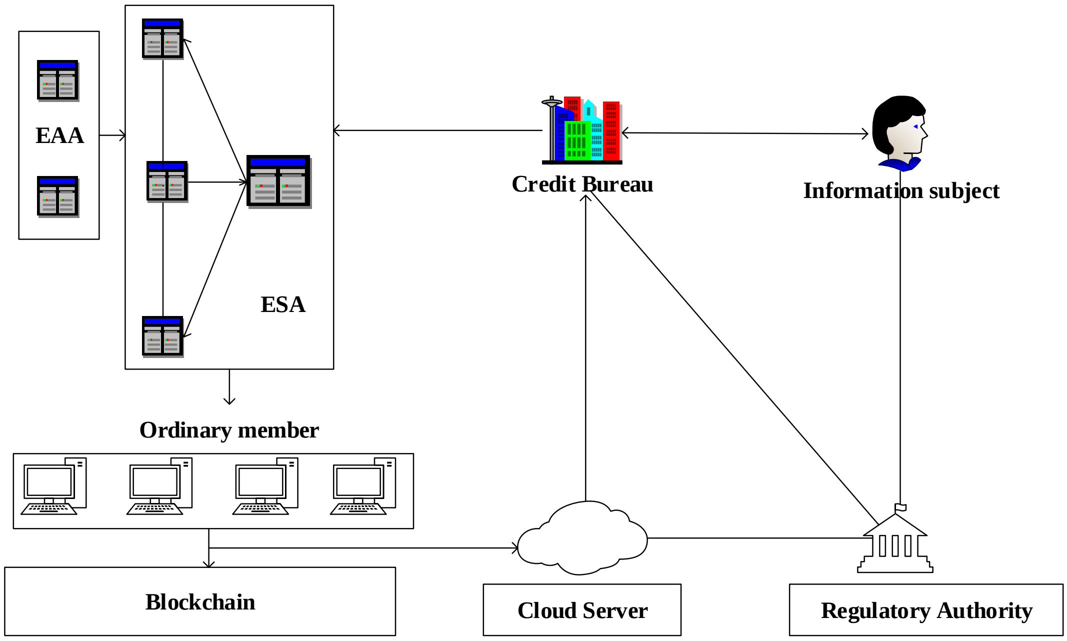

Figure 2: Block chain technology based on the enterprise credit agency information sharing model framework

Among them, the realization of the interaction between the enterprise credit investigation agency and the information subject requires the authorization of the user for the requested data. Then, the enterprise credit investigation agency uses the authorization information signed by the information subject to initiate a request to the credit information provider to obtain the corresponding data (Lemieux, 2016). The interaction between the enterprise credit investigation agency and the cloud server requires the credit information provider to encrypt and upload relevant data to the cloud server according to certain data format requirements after receiving the request. In order to protect the rights and interests of the credit information provider, the credit information provider initiates the transaction containing the summary of uploaded data, the request object, metadata and other information to the block chain node to obtain the upload certificate (Niranjanamurthy *et al.*, 2019). The request records of user authorization and credit information agencies, as well as data uploaded by credit information providers, are recorded on the block chain, providing a fair and credible credit information sharing environment. The interaction between enterprise credit investigation agencies and regulatory agencies is to solve some disputes in the sharing of credit investigation information. The establishment of regulatory agencies in this model protects the rights and interests of each participant.

The design of the consensus mechanism in market economy management measures of enterprises adopts improved PBFT algorithm (Gao *et al.*, 2019). The complexity of the original PBFT algorithm is reduced from exponential to polynomial, which solves the low efficiency of the original Byzantine fault-tolerant algorithm (Yeoh *et al.*, 2017). However, this algorithm is proposed based on C/S architecture, while block chain is proposed based on P2P network architecture. Due to the obvious difference between the two, there are many problems if the original PBFT algorithm is directly applied to the block chain model. Therefore, the original PBFT algorithm and algorithm protocol need to be improved appropriately, and the roles of the client and server of the original PBFT algorithm should be changed accordingly. Based on this, an improved PBFT consensus mechanism is designed. The improvement idea is to limit the transfer nodes and redefine the number of participating consensus nodes in the block chain network, so as to avoid the network channel blockage caused by too many nodes. Furthermore, on the basis of the improved PBFT algorithm, the verification function of the primary node is separated from other functions to reduce the task load of the primary node and improve the performance of the improved model. The main operating process of the improved consensus mechanism is shown in Figure 3.

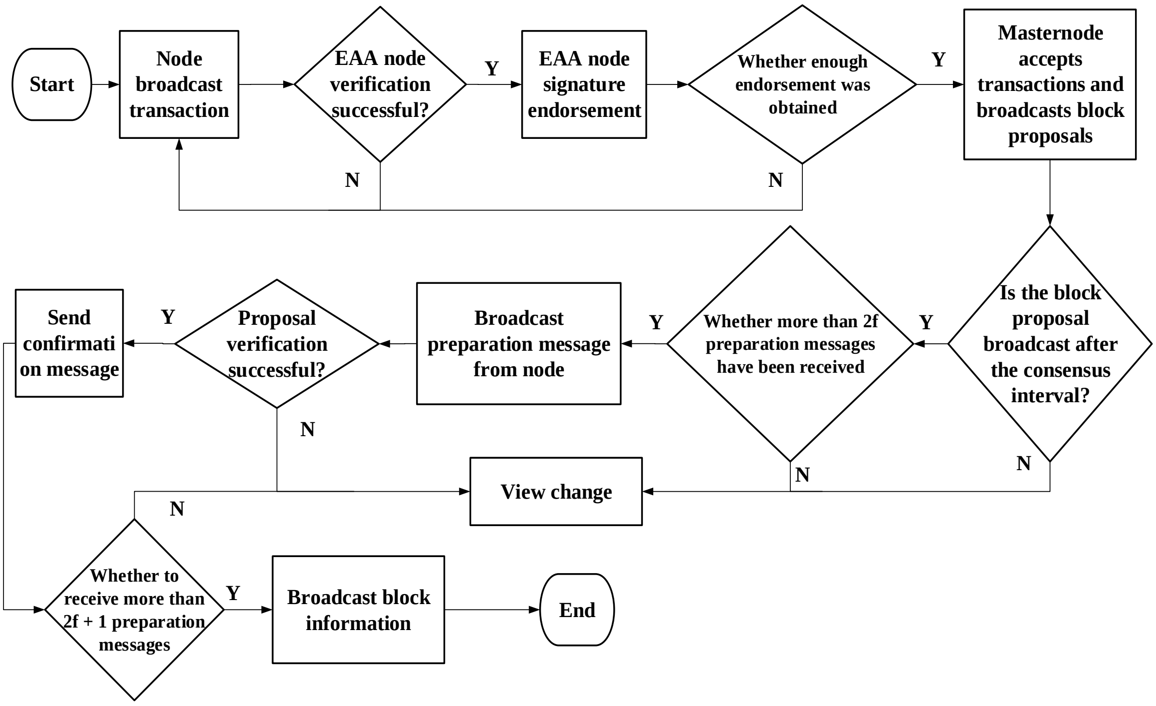

Figure 3: The improved consensus mechanism flowchart

The basic process design of the consensus mechanism in the improved market economy management measures is mainly composed of three parts. The user authorization, publish requests, and upload information are obtained. The agency needs authorization from the information body to issue the relevant task request. In this process, the enterprise needs to release the data source (Company Name), main content (Resource), Purpose (Purpose), Scope (Scope) and Public Key (Public Key) to the information body. The purpose is to explain the information collected and its purpose. After authorization, the information subject returns SIGSI (hash(m)) of its signed authorization information to the enterprise credit investigation agency. Corporate credit bureaus issue sharing requests to the network through clients. These include request type V and request time T, lock time T, get user authorization phase message m, and authorization letter. After verifying the signature of the information subject, the client outputs the signature result Veried-m and publishes the Request.

C→S: m, among them, m= (Company Name, Resource, Purpose, Scope, Public Key)
S→C: SIGSI (hash(m))
Request= (V, T, t, Public Key, input (), output ())
Among them, input= (m, SIGSI (hash(m)), SIGCB (hash(m))), output=(Veried-m)

According to the sharing request, the provider of credit information needs to upload the data to the block chain network in a certain format or upload the encrypted data to the cloud server, so that the data summary, metadata and other credit information can be broadcast to the block chain network through transactions. The specific block chain model workflow is shown in Figure 4. After obtaining user authorization, publishing the SHARED request, and broadcasting the transaction, the EAA (Enterprise Audit Alliance) node is used to verify whether the transaction information is uploaded and whether the data transaction format is correct. If the verification passes, then the EAA node signature endorsement is carried out. Only when the EAA node signature is endorsed by a sufficient number of rows can it be considered as a legitimate transaction, so as to carry out the master node packaging link of ESA (Enterprise Service Alliance) node and enter the three-stage consensus link. After the completion of the task, each node adds the block to the ledger maintained by itself. When the transaction appears on the block chain, it means that the requested task has been uploaded and completed. At this point, the enterprise credit investigation agency can access the Shared data through the key.

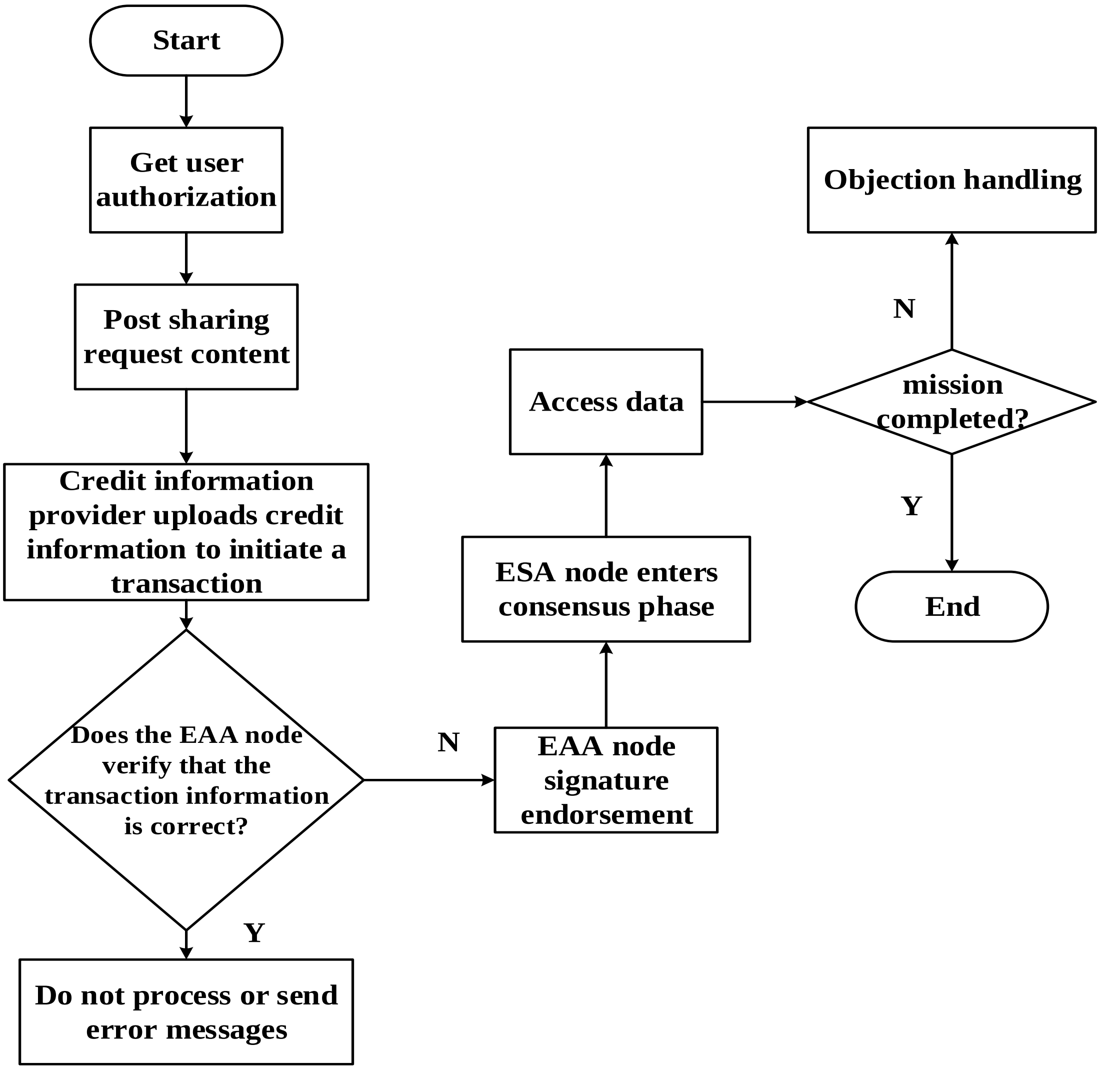

Figure 4: Block chain simulation basic workflow flowchart

In order to achieve the control of access to credit data, but also prevent information providers to upload the same data encryption information with the increase of data demand, the block chain data sharing scheme based on proxy re-encryption is used to share the data of the cloud server. A protocol scheme is provided for proxy re-encryption, in which the primary node acts as the proxy for the re-encryption operation. The specific protocol is divided into the following steps: step 1: the key is generated: KeyGen(1k) → (pki, ski). A pair of public and private keys (pki, ski) of user i is output according to the security parameter 1k. Step 2: the re-encryption key is generated: ReKeyGen(pkA, skA, pkB, skB) → rA →B. According to the public key and private key of information provider A and the public key of enterprise credit investigation agency B, the proxy re-encryption key is output. Step 3: based on the public key and credit information, the information provider outputs the ciphertext of the credit information and then transmits it to the cloud server: Encrypt(pkA,m) →CA. Step 4: ReEncrypt(rkA→ B, cA) →rA →B credit information provider transmits the re-encryption key rA →B of its agent to the block chain by means of transaction. The consensus node verifies the transaction, and the master node performs the re-encryption operation. According to the agent re-encryption key rkA→ B and cA of A, the heavy encrypted ciphertext cB is output for B. Step 5: Decrypt(skB,cB) →m is decoded. Enterprise credit machine uses its private key skB and ciphertext cB to output original plaintext m.

The simulation experiment design of the improved information sharing model

The simulation experiment in this paper is to simulate the credit investigation process of an enterprise in a stand-alone environment, including four processes: enterprise registration, Shared data item design and upload, transaction transmission, and consensus realization. Enterprise registration starts the process through ports from 5000 to 5005, and 5 blockchains are constructed through Flask framework to simulate 5 registered enterprises. Sharing credit investigation enterprises can encrypt relevant information and upload it to the cloud server, and then upload the summary and metadata of the encrypted credit investigation data to the block chain network through transactions. Due to the different purposes of credit investigation, the collected data are not the same. Five enterprises in the simulation experiment upload the data to be shared to the cloud server using aes-128 encryption and initiate the transaction through the block chain network.

Five companies in the simulation upload their own credit data and then initiate five transactions. Firstly, the transaction passes through the EAA node, which verifies the accuracy of the transaction structure and uploaded data. After successful verification, the transaction signature is carried out, and the transaction data is encapsulated and broadcast to the master node in ESA. Figure 5 shows the specific transaction validation process for the EAA node. The master node in ESA collects the transaction after the signature of the previous section and verifies it, and the transaction is legal when the verification passes. Finally, the block is packaged and generated, and the consensus process is conducted through ESA, as shown in Figure 6.

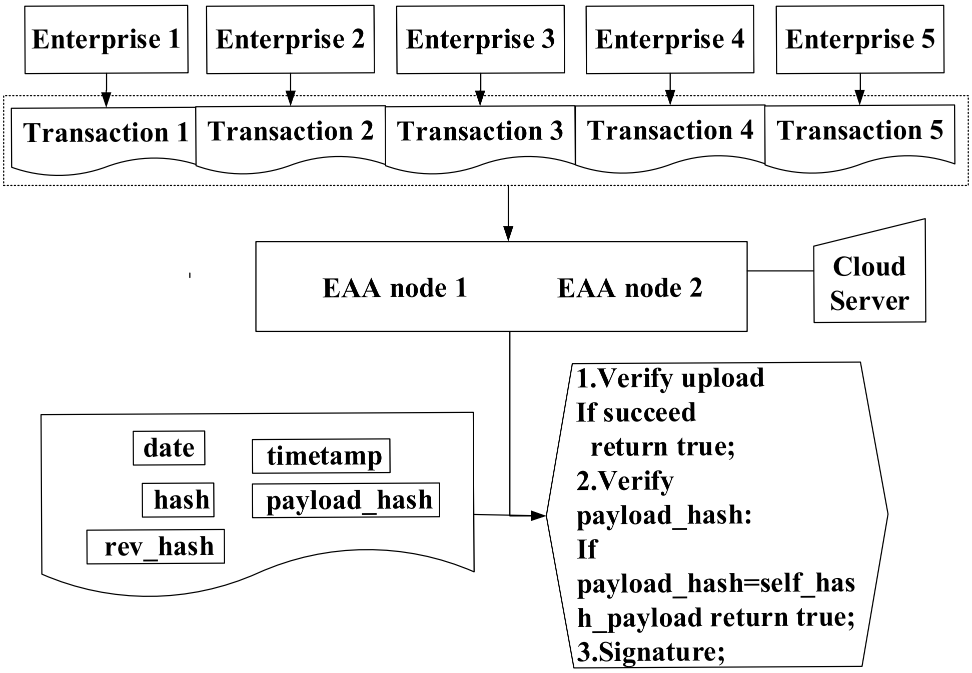

Figure 5: Transaction verification process

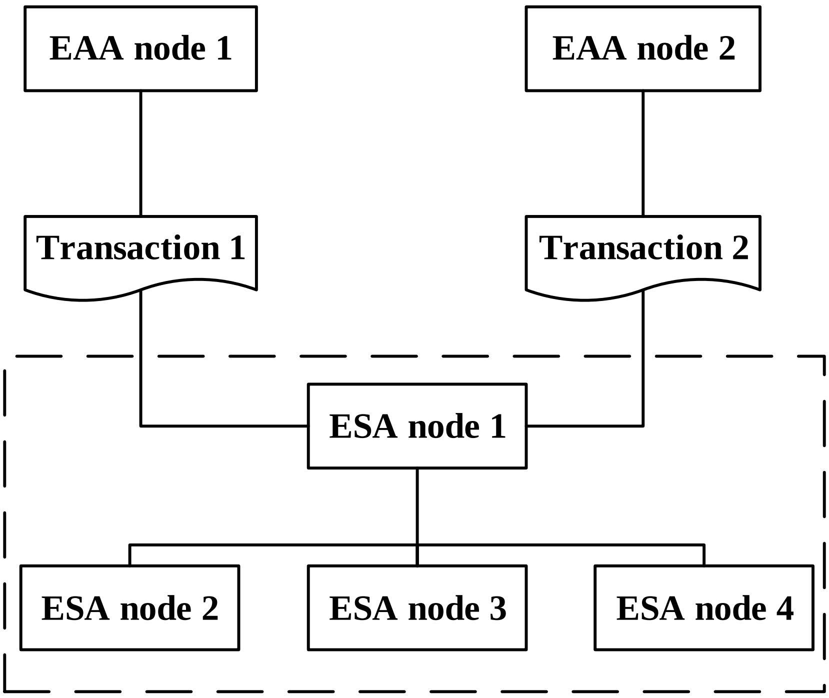

Figure 6: Block generation and consensus process

RESULTS

Analysis of the advantages of the improved sharing model

Based on the market economy management measures designed based on the combination of block chain technology and enterprise credit information sharing scenario, the improved PBFT consensus algorithm is adopted. Through the design of EAA nodes and ESA nodes, the number of consensus nodes and the communication between nodes can be reduced to improve the consensus efficiency. The functional advantages of its model are shown in Table 1.

Table 1: The advantages of credit information sharing model

Advantages	Specific manifestations
Protecting the ownership and rights of user data	Authorizing all actual actions and information before collecting credit information related to the user. In the sharing process, objection records on the block chain are processed by regulators.
Solving the problem of data abuse and low exchange efficiency	The sharing model established through the block chain technology completely records the transaction information. And the transaction data can't be tampered with, and any participant in the sharing can't deny its actions. The transaction information is uploaded to the cloud database through encryption to ensure the authenticity of the Shared data.
Solving the problem of information sharing difficulty and data forming island	By sharing information on a trusted credit information sharing platform, the willingness of credit information providers to share can be promoted.

Performance analysis of experimental results of the improved Shared model

The maximum number of node errors that can be tolerated by the improved PBFT algorithm is:

$$f = \lfloor (n-1)/3 \rfloor \tag{1}$$

Fault tolerance represents the important performance of the distributed system implementation, that is, when the node fails, it can recover itself without affecting the overall performance of the system. When f is 0, 1, 2, 3, 4, the maximum node fault-tolerant test results are shown in Table 2.

Table 2: Fault tolerance test results

Fault tolerance	Test results	Failure node
0	Success	None
1	Success	Primary node, slave node 1,2,3
2	Success	Master node + slave node 1, slave node 1+ slave node 2
3	Failure	Any node other than the master node, except one slave node
4	Failure	Any node other than the master node, except one slave node

When the improved PBFT algorithm performs view replacement, it indicates that the primary node is invalid, and the new primary node is selected to continue the consensus operation. It can be concluded from the experimental results that when the number of consensus nodes is 4, the number of failed nodes is only one. No matter which node fails, the final agreement can be reached. When the failure node is 2, the consensus result cannot be reached. Therefore, the improved PBFT algorithm designed in this paper meets certain fault-tolerant performance.

Whether the improved PBFT algorithm can efficiently process transaction requests per unit time is calculated as follows:

$$TPS_{\Delta t} = \frac{Transactions_{\Delta t}}{\Delta t} \qquad (2)$$

In Eq. 2, is the time interval between the start of the transaction and the block confirmation. is the total volume of transactions in a block. The JMeter performance testing tool simulates that 60 users simultaneously send simulated corporate credit information to a transaction process in a single machine. When the time interval between the start of the transaction and the end of the confirmation block is 10s, 20s, 30s, 40s, 50s and 60s, each transaction volume is repeated for 25 times, and the measurement results are shown in Figure 7.

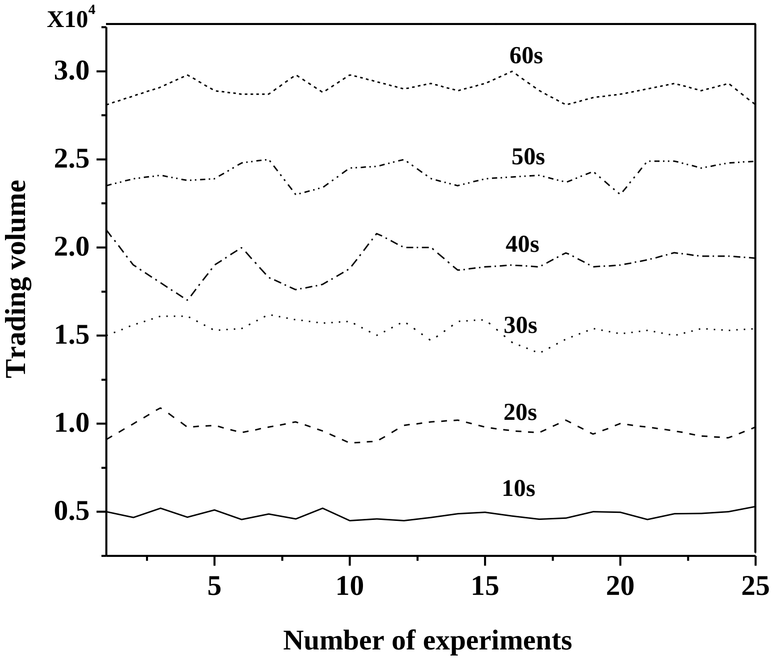

Figure 7: Trading volume test results at different time intervals

It can be concluded from the test results that the improved PBFT algorithm has stable throughput at each time interval and can meet commercial applications to a certain extent.

DISCUSSION

Due to its advantages of decentralization and tamper-proof, blockchain technology has become the focus of more and more researchers, and its potential has been highly valued by the government, especially financial regulators. Some researchers in China have realized the availability of block chain technology in the sharing of enterprise credit information and proposed to apply the block chain technology to the construction of enterprise credit system. Sun *et al.* (2018) proposed a data trading model at the regulatory level based on the block chain technology. Morkunas *et al.* (2019) proposed the application of block chain technology to the data trading market framework of credit investigation industry based on the core data problem of credit investigation innovation in Europe. Suggestions and ideas are provided for the establishment of this model, but its feasibility needs to be further analyzed. In this study, block chain technology is applied to the establishment of enterprise credit sharing model by referring to its data trading ideas, and an improved PBFT consensus algorithm is added on the basis of the optimized sharing model to further integrate block chain technology and information sharing mechanism. Wang *et al.* (2019) upgraded the block chain technology to a "decentralized + centralized" "two-channel" credit investigation technology based on big data, providing effective solutions for Internet economic management, but problems in risk control need to be solved urgently. In this study, the block chain model and information sharing are perfectly integrated through the improved Byzantine algorithm, and data sharing and information management are realized at the same time. Compared with the "double channel" credit investigation technology, it effectively solves the problem of large credit investigation data and complicated Shared data management during the transmission. In addition, the cloud server is used to store the Shared data, and the scheme of privacy protection and Shared access is also designed to solve the risk control problem of the credit investigation platform proposed by other scholars to ensure credit information provider uploads data successfully and credit enterprises successfully receive the corresponding credit information (Kuo *et al.*, 2020).

CONCLUSION

In order to solve the problem that PBFT consensus mechanism of credit information in enterprise market economy management measures is difficult to be directly applied to block chain model, based on the block chain technology, the PBFT consensus algorithm is improved, and the EAA node and ESA node as well as the sharing model to reduce the number of consensus nodes are designed. Through comparative analysis with the original model, it is found that the improved model can guarantee the ownership of user data and has the advantage of high data exchange efficiency. Through the evaluation of the improved model, it is found that when the improved PBFT algorithm changes the view, the failure of single node won't lead to the model error. Moreover, it can be tried to start the switching protocol and reach a consensus again, which indicates that the model can meet a certain fault tolerance rate. It can be concluded from the measurement results of transactions at various time intervals that the transaction curve trend is relatively stable, which proves that the throughput of this model is relatively stable. Therefore, the improved model proposed in this research gives full play to the feasibility of market economy management measures and can meet certain commercial applications.

However, the enterprise credit information sharing model proposed in this research based on the block chain technology is not enough to completely protect the enterprise privacy. Therefore, on the premise of realizing credit information sharing, it is necessary to improve and further study the security and privacy protection of user data.

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