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RESEARCH ARTICLE

An Intelligent Optimization Control Method for Enterprise Cost Under Blockchain Environment

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ABSTRACT This paper uses blockchain technology to conduct in-depth research and analysis on enterprise cost optimization control. Based on the analysis of the cost control status in enterprises, the concept of target cost optimization control and specific control ideas are proposed. And the study of optimization control under target cost based on genetic algorithm is carried out in combination with the current three major controls of quality, schedule, and cost. It provides the technical basis for the realization of the target profit of the enterprise. The Optimized Scalable Byzantine Fault Tolerance (OSBFT) algorithm, which is suitable for spectrum sharing, is proposed based on PBFT (Practical Byzantine Fault Tolerance) algorithm. So, in this paper, an improved consensus algorithm OSBFT (Optimized Scalable Byzantine Fault Tolerance) is proposed based on it. The improved genetic algorithm is used to solve the objective function and verify the validity, reasonableness and applicability of the model and algorithm. It is shown that the introduction of delay cost in the multilevel inventory model reduces the total cost of the optimized model by 16.87% compared to previous studies. The algorithm reduces the consensus steps, incorporates a data synchronization mechanism, and enables nodes to join and exit consensus.

INDEX TERMS Intelligent optimization control, blockchain, enterprise cost, information security, machine learning.

I. INTRODUCTION

Blockchain is a decentralized ledger or database made of a combination of distributed peer-to-peer networks, data encryption technology, consensus algorithms and other technologies [1]. Blockchain uses technology to provide trust to users so that they can complete transactions without a basis of trust between them, and its decentralized storage with consensus mechanisms makes the records of transactions unamenable [2]. Blockchain was originally born in Bitcoin as the underlying architecture for servicing transactions, and was subsequently extended to a wide variety of digital currencies and even financial businesses [3]. Subsequently, the federated chain with certain changes to the architecture and consensus mechanism was considered to go beyond finance and be used in commercialized fields such as digital asset authentication and supply chain traceability [4]. In the face of modern Internet servers' pursuit of response speed, security, disaster tolerance, etc., increased network structures are gradually shifting from centralized to distributed [5]. And blockchain, as a new distributed network structure, has been a hot spot of attention and research for research institutions and many scholars in recent years [6].

However, in practical applications, blockchain networks are widely used in applications such as virtual currency, and less attention has been paid to application areas such as Internet of Things [7], transportation networks, and energy networks [8]. In this paper, we focus on the specific framework and security protocols of blockchain in data transmission application field as the research focus, and study the secure and trustworthy general data transmission model and transmission protocols, and propose different protocol contents according to different application requirements. With the continuous progress of science and technology and economic development, the formation of a globalized market and the acceleration of technological change, the competition in

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the product market has become increasingly fierce, and the external macro environment and internal micro environment in which enterprises are located have undergone fundamental changes, and modern enterprises are faced with numerous challenges [9]. At the same time, all enterprises can break the limitation of geographical resources, use global manufacturing resources, and proactively seek market opportunities; the development of information technology makes the core technology of superior products of enterprises be quickly imitated and acquisition, thus losing market opportunities and advantages [10].

Therefore, it is impossible for enterprises to take advantage of the geographical resource limitation and traditional leading products to dominate the market all the time, and the competition among enterprises is more intense. With the intensification of competition and the strengthening of specialized division of labor, increased enterprises choose to outsource their coordination needs, while with the rapid development of e-commerce, as well as the combined effect of other favorable factors, the development of the coordination industry has been greatly accelerated. The rapid development of the coordination industry has accelerated the speed of distribution of goods and enhanced the flow of coordination and capital flow, further promoting the rapid development of the economy. It can be said that the coordination industry plays an increasingly important role in the whole process of economic development, and is a necessary component of the healthy operation of the economy. To promote the healthy and rapid development of China's coordination industry, several encouraging policies and measures have been introduced at the national level.

With the increase in technological complexity, rising innovation risks and increasing difficulties in R&D, enterprises gradually tend to join other enterprises to form a group development. Inter-firm cooperation has become a key way for enterprises to integrate external resources to achieve complementary advantages and obtain sustainable competitiveness, as well as an important mode to promote technological progress and strengthen enterprises' competitive advantages. However, although enterprises can obtain more effective resources and improve innovation performance through cooperation, they also face the possibility that the resources owned by enterprises may cause outflow due to cooperation and affect the development of enterprises [11]. Along with the fourth wave of industrial revolution, global informatization has entered a new stage of comprehensive penetration, cross-border integration, accelerated innovation and leading development, and the technology, concept, and application of blockchain have rapidly developed into the hottest concept in the world.

Blockchain, as a disruptive information technology with great potential for development, is characterized by decentralization, collective maintenance, immutability and traceability, which can fundamentally solve the free-riding behavior in the process of value exchange and transfer, reduce transaction costs and transaction risks, achieve supervision and accountability of partners through tracking and tracing technology, establish a ''trust'' network using decentralized consensus mechanism and smart contract technology, and alleviate the risk of ''trust'' [12]. The decentralized consensus mechanism and smart contract technology can be used to establish ''trust'' network and alleviate the problem of information asymmetry to ensure that the members of the cooperative network share information, cooperate deeply and improve the innovation performance of enterprises. Therefore, the integration of blockchain and enterprise network becomes a new way for the sustainable and healthy development of enterprise network, and its integration level measurement, integration performance measurement and the relationship between them become important topics worthy of in-depth research and exploration. In the digital age, the innovative development of blockchain technology in the field of supply chain management has played a disruptive effect. Therefore, it is of great practical significance to study how to reduce inventory cost, restrain time lag of supply chain and improve customer service level.

Main contributions of this paper are summarized as following three points:

- The significance of integration of blockchain into enterprise management is deeply discussed and recognized, which is the main motivation of this work.
- This paper develops an intelligent optimization control model for enterprise cost under blockchain context, which is the main proposal of this work.
- Some simulative experiments are conducted to verify efficiency and reliability of the proposed OSBFT method, which is the main conclusion of this work.

II. RELATED WORK

Since the 1980s, the impact of biotechnology and information technology has increased the complexity of technology, made R&D more difficult, increased the complexity and risk of innovation, and shortened the iteration cycle of technology and market. As a result, enterprises need more resources to support their innovation and a stronger ability to take risks and uncertainties at a later stage, and they are gradually moving from fighting alone to joining with other enterprises to form a group [13]. The phenomenon of information silos in the supply chain has increased the backlog of inventory and the difficulty of supply chain system management. In the face of increased randomness of customer demand, reduced delivery lead time, competitive pressure on customer service level, demand for high quality products and increased efficiency of product supply, supply chains urgently need to adopt rapid response mechanisms to achieve the purpose of reducing enterprise costs and increasing economic benefits [14].

At the same time, scholars have found that increasing the degree of information sharing among supply chains can effectively suppress the amplification of demand information, i.e., the bullwhip effect. By constructing a mathematical model, Khan et al. investigated the impact of three

information sharing scenarios among supply chain members, i.e., no information sharing, partial information sharing, and complete information sharing on cost-benefit, and obtained that complete information sharing can reduce the total inventory cost and improve the overall efficiency of the supply chain system [15]. Orszag et al. considered a three-level supply chain system model with stochastic demand and delivery time, and simulated the effect of the degree and type of information sharing on the bullwhip effect through Visual Slam simulation, and concluded that a supply chain system under information sharing can weaken the negative effects of the bullwhip effect [16]. Many enterprises use information network technologies such as OA systems and ERP systems to solve the problems of low information transparency, slow interaction speed and poor information reliability in supply chains, however, due to the limitation of technical architecture, the data of information systems of all parties cannot be effectively and credibly synchronized.

In recent years, national product warranty research has just started, and there are still few relevant research results and scattered research areas. Although some scholars have discussed the prediction and optimization of product warranty cost and product warranty responsibility, most of the research has focused on the product after-sales service stage, such as improving the product after-sales warranty cost model for preventive maintenance, and establishing product warranty cost models for the specific problems of product after-sales warranty period and non-after-sales warranty period respectively, so as to provide enterprises with the best product warranty policy Provide a basis for decision making [17]. The problem of product after-sales warranty strategy is studied from the cost/benefit perspective, and the process of forming a warranty policy based on product warranty cost is discussed, and a warranty optimization strategy for color TVs in China is proposed. The literature discusses various types of warranty strategies, based on which a warranty cost model is established. Finally, the optimal warranty period problem in the warranty strategy is analyzed, and the optimization method of the warranty period under different product failure distribution is given. Batwa A. and Norrman A. pointed out that inter-firm cooperation has become a key way for firms to integrate external resources to achieve complementary advantages and obtain sustainable competitiveness, and an important mode to promote technological progress and strengthen firms' competitive advantages [18]. Shardeo et al. proposed that the establishment of a firm network can help firms to bring into play their comparative advantages, better access to external resources, bring about cross-institutional learning effects, reduce uncertainty, greater [19]. The establishment of an enterprise network can help enterprises to exploit their comparative advantages, gain better access to external resources, bring about cross-institutional learning effects, reduce uncertainty, reduce innovation risks to a greater extent, save innovation costs, and achieve economies of scale and scope. The era of fighting alone has passed. It is not your peers but technology that defeats you. Based on this, companies gradually tend to form a group development with other companies.

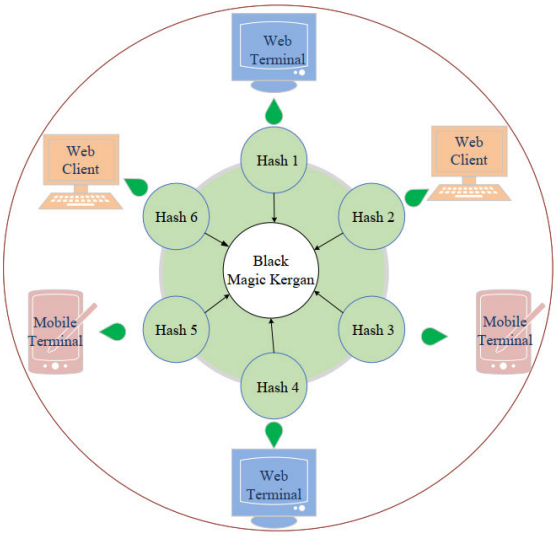

FIGURE 1. Sketch map of the designed blockchain structure.

The decentralized consensus mechanism and smart contract technology can be used to establish ''trust'' network and alleviate information asymmetry, ensure information sharing and deep cooperation among cooperative network members, and improve the innovation performance of enterprises. Therefore, blockchain technology is a powerful means to solve the problem of enterprise cooperation [20]. At present, blockchain technology is in a rapid development stage and is widely used in various industries. For example, Provenance Software in the UK uses the traceability of blockchain technology to ensure the authenticity and reliability of data such as the production date of ingredients; IBM is working to make networked devices self-manageable based on blockchain technology, without manual maintenance [21].

III. MAIN METHODOLOGY

A. BLOCKCHAIN STRUCTURE DESIGN

Blockchain mainly contains several parts: application layer, incentive layer, consensus layer, network layer and data layer [22]. Before the design of fundamental blockchain environment in this paper, two aspects are majorly considered for practice [23]. The first aspect is a chain composed of blocks one by one in chronological order. There is only one chain in the Bitcoin system, and future systems may allow for multiple chains. The other aspect is the various types of nodes running in the background, including storage nodes, consensus nodes, etc. The structure of a block can be divided into two parts, the block header, and the block body, as shown in Figure 1. The block header encapsulates the version number of the current block, the address of the previous block, the timestamp, the random number, the target hash of the current block, and a unique Merkle root of all transactions in the block. The number of transactions contained in the

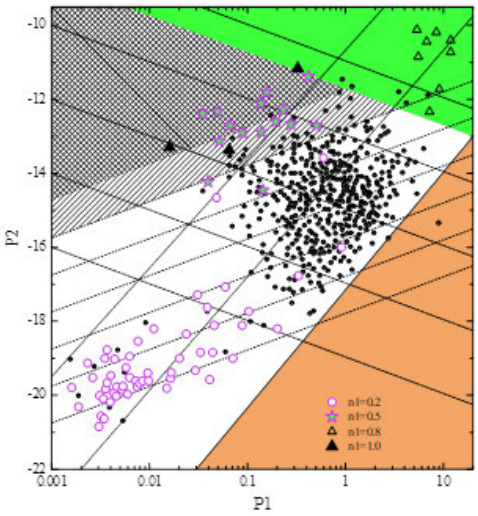

FIGURE 2. Nash equilibrium in the asymmetric case.

block and the details of each transaction are recorded in the block body. The Merkle tree and the hash function are both cryptographic techniques. A hash function is an encryption method that converts input data into a fixed-length hash, such as SHA256, which converts data into a 256-bit hash. The data processed by the hash function is unidirectional and it is basically impossible to reverse the input data from the output result. Blockchain uses double SHA256 encryption, that is, the data is converted into a binary number of 256 bits in length after two SHA256 hashing operations to unify the identification.

A blockchain can be thought of as a network, and a network consists of many nodes. And Bitcoin is a P2P (peer-to-peer) network, i.e., a peer-to-peer network. All nodes in this network are equal and assume the same functions, without any special or central nodes, which is the embodiment of the distributed architecture that blockchain has been talking about. Bitcoin is a fully P2P network, with all nodes equally undertaking functions such as data storage, consensus verification, and broadcasting. However, this approach can lead to low efficiency and lack of scalability, so the architecture of blockchain 2.0 started to be divided into specialized consensus nodes, storage nodes, etc., but each type of node still constitutes a P2P network. Because the blocks of the Bitcoin blockchain store transaction information, the blockchain is seen as a distributed ledger. From the above introduction, we can see that the blockchain stores not only transaction information but also various categories of data after the application scenario is extended, so more strictly speaking, the blockchain should be a distributed database.

B. DESCRIPTION OF CONSENSUS MECHANISM

For Class I operators, their strategy space is denoted by S_i and their utility function is denoted by U_i. The strategy space of the first-class operator is its offer to the second-class operator for leasing spectrum p_i and the utility function is the difference between the benefit and the cost of sharing the spectrum. The cost is mainly reflected in the degradation of the quality of service provided to its own end users after leasing part of the spectrum. Denoting the amount of shared spectrum by b_i. This following formulas can be deduced:

$$C_i(b_i) = K_i^p \frac{W_i + b^2}{M_i} \tag{1}$$

$$K_i^p = {}^{W_i}/_{M_i} \tag{2}$$

Like constructing block trust values, to improve consensus efficiency, it should be ensured that all nodes participating in consensus verification make correct verifications as much as possible. When a node frequently makes incorrect validation, the probability of that node participating in consensus validation should be reduced. The parameter pair (w_i, c_i) is used to denote the number of incorrect validations made by node i and the number of correct validations, respectively. When the verification made by node i results in incorrect verification, the value of w_i is summed to 1, and vice versa the value of c_i is summed to 1. The trust value of the verification block for node i as a block verifier is calculated as:

$$VT_i = \begin{cases} w_i < c_i, & 1 \\ w_i \geq c_i, & 0 \\ c_i + w_i = 1 \end{cases} \tag{3}$$

$$\varepsilon_i^2 = \begin{cases} 0, & w_i \geq 0 \\ 1, & w_i < 0 \end{cases} \tag{4}$$

When ε_i^2 satisfies $\varepsilon_i^2 = \begin{cases} w_i \geq 0, 0 \\ w_i < 0, 1 \end{cases}$, the initial value of VT_i equals to 1. When $w_i \geq 1$, the higher the number of incorrect verifications made by node i, the lower the verification block trust value will be until $w_i \geq c_i$, and the verification block trust value of node equals to 0. When w_i is certain, the higher the value of c_i is, the higher the value of the verification block trust value VT_i will be. Therefore, to obtain a larger validation block trust value, as many correct validations as possible should be made while avoiding incorrect ones. Hash algorithm and digital signature protection function can ensure that transaction data cannot be easily tampered with, thereby preventing anyone from changing data and transaction information.

The intersection of the two lines of the same color is the equilibrium price at the current value of v. As v increases, the preference becomes less obvious, the substitutability of the second-class operators is higher, and the competition is more intense, so the first-class operators can only attract more second-class operators to buy their spectrum by lowering the price. In addition, since the first-class operators X1 and X2 are symmetric at this time and their spectrum occupancy rates are both 0.5, their relationship curves are symmetric about y=x, and their equilibrium prices are the same when Nash equilibrium is reached. As shown in Figure 2, the relationship between the optimal price of a first-class operator and the bid of another first-class operator in the asymmetric case is

shown. There are two sets of six lines in the figure, the solid line is the curve of p_1 with p_2 and the dashed line is the curve of p_1 with p_2. The value of v is the same between each set of curves and is equal to 0.4. We fix the spectrum occupancy of X_2 to 0.5 and change the spectrum occupancy of X_1 to 0.2, 0.5 and 0.8. The intersection of each of the two lines of the same color is the equilibrium price at the current η. From the results, p_1 and p_2 are still positively correlated, but the equilibrium prices of X_1 and X_2 are equal only when the spectrum occupancy ofare equal only when the spectrum occupancy of X_1 is also 0.5. As η_1 increases, the equilibrium price of $X_1 \cdot P_1^*$ will become smaller and the equilibrium price of $X_1 \cdot P_1^*$ will become larger.

We assume that the spectrum occupancy is the same for both Class 1 operators. The blue line in the figure is the initial spectrum utilization of the operator at the time of accessing the blockchain system, and its value is the same as the spectrum occupancy rate. The red line is the spectrum utilization after completing one transaction, and the green line is the spectrum utilization after completing five transactions. From this, we can see that the whole system can improve the spectrum utilization of operators by spectrum trading, and the freer spectrum they have, the more the spectrum utilization will be improved.

C. OPTIMIZATION CONTROL MODEL FOR ENTERPRISE COST

In the procurement process, it is impossible to use scientific and reasonable procurement cost concepts or methods to carry out cost measurement control. As a result, the control standards for the procurement of different materials are inconsistent, which makes it difficult for enterprises to calculate the cost of procurement, and the cost of procurement is obvious. increase, thereby increasing the cost of the enterprise. Key technologies such as blockchain distributed ledger, asymmetric encryption, timestamp, consensus mechanism and smart contract make it decentralized, de-trusted, tamper-evident, and traceable, which can achieve optimal resource allocation, reduce opportunistic behavior, and enhance data security protection. The characteristics of blockchain technology are in line with the risk control objectives of traditional enterprise networks [24].

The consensus mechanism and asymmetric cryptography principle of blockchain technology can permanently mark the time of transactions and store the value, and the hash algorithm and digital signature protection ensure that the transaction data cannot be easily tampered with, thus preventing anyone from changing the data and transaction information. The information on the blockchain is highly transparent and open, and the data on the chain is open to each participating node, and personal information is realized through the technical method of asymmetric encryption and authorization.The information on the blockchain is highly transparent and open, and the data on the chain is open to the nodes of each participant, and personal information can be accessed only with the authorization of the data owner through asymmetric encryption and authorization technology, which ensures data security and personal privacy and enhances imitation barriers.

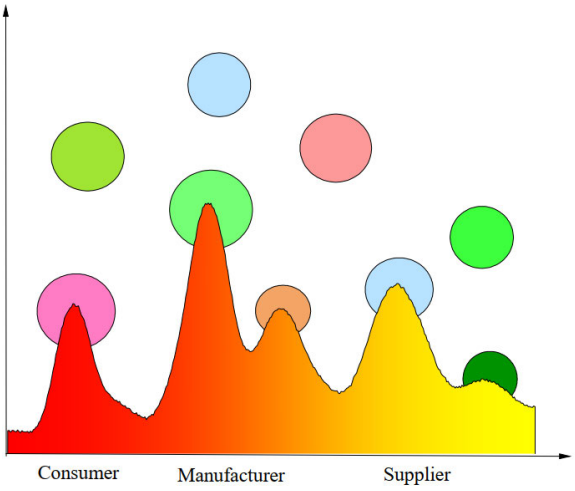

FIGURE 3. The formation process of corporate bullwhip effect.

$$t_i + t_y - d^2 \geq 0 \tag{5}$$

Forrester proposed in Harvard Business Review in 1958 that the bullwhip effect refers to the phenomenon that customer demand information fluctuates and amplifies with upstream and downstream companies in the supply chain. Lee attributed the bullwhip effect to lead time changes, demand forecasting, volume ordering, price changes, and gaming [25]. As shown in Figure 3, the bullwhip effect in the supply chain causes lower demand forecast accuracy in upstream companies, which leads to excess inventory and higher inventory storage costs on the one hand, and may lead to insufficient inventory and increase the cost of out-of-stock losses on the other. These all result in negative impacts such as lower service levels, lagging supply chain responsiveness, high inventory costs, and reduced firm competitiveness. The bullwhip effect refers to a phenomenon of demand variation amplification in the supply chain. When the information flow is transmitted from the final client to the original supplier, the information cannot be effectively shared, and the information is distorted and amplified step by step, resulting in the emergence of demand information. increasing volatility.

In modern business management, it has not yet formed a comprehensive and systematic cost management, using the awareness of scientific cost management to guide the development of structured cost control. In the business development of modern enterprises, there is a lack of comprehensive cost management concept. The cost management concept is not carried out in the whole modern enterprise management process [26]. Taking the procurement activities of enterprises as an example, the procurement of various materials of enterprises is an important part of the cost expenditure of enterprises, and the awareness of procurement cost control of some enterprises is weak at present. In the procurement

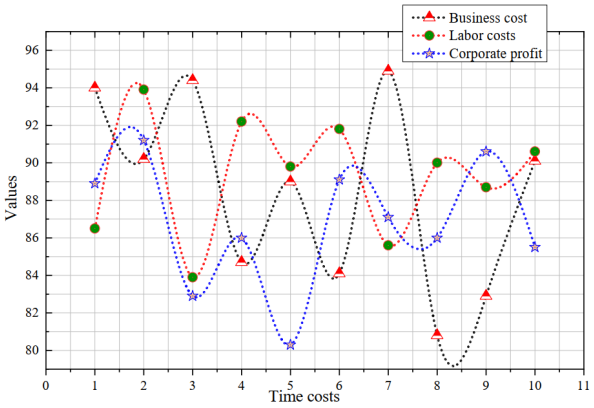

FIGURE 4. The relationship between revenue and cost.

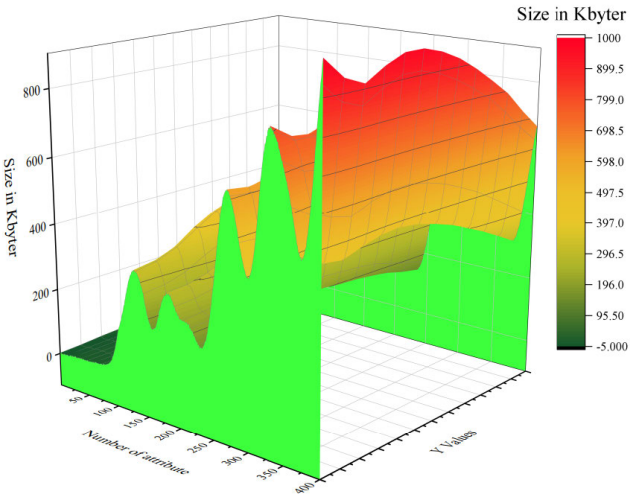

FIGURE 5. Correspondence between the number of attributes and text size.

process, it is impossible to use the scientific and reasonable procurement cost concept or the way to start the cost measurement and control, so the control standard of different material procurement is not consistent, which makes it difficult for the enterprise to account for the cost of procurement, and the procurement cost expense increases significantly, thus increasing the cost expense of the enterprise.

The classification of quality costs from different perspectives is conducive to scientific and reasonable control and analysis of quality costs with different characteristics. For example, the scope of expenditure of quality costs can be combined with the system of hierarchical management, and the decomposition of indicators can be implemented. The cost control tasks are specifically implemented to the department, workshop, team or even individual; another example is to appropriately improve the controllable costs (prevention costs and inspection costs), to reduce the resultant costs (loss costs); especially in the enterprise marketing management should not only strengthen the control of the visible costs, but also strengthen the control of the hidden costs.

$$TS_{t,n} = F_{t,n} + \sum_{k=1} (L_k - C_k) \tag{6}$$

The cost curve does not start at the origin, which is caused by the fixed costs associated with activities such as receiving and shipping during the transportation process. The cost curve tends to flatten out as the distance of transportation increases. This phenomenon is often referred to as the principle of decreasing distance. The relationship between the load weight and the transportation cost per unit of cargo is described. As shown in Figure 4, there is an inverse variation between load weight and transportation cost, which is since economies of scale exist in most transportation activities, and the transportation cost per unit weight of cargo decreases with the increase in load weight, and the cost curve tends to decrease [27]. Therefore, this is the rationale behind the proposed consolidation of cargoes, which is based on the idea of minimizing the cost per unit of cargo and maximizing the economies of scale by combining small-scale cargoes to form a large-scale cargo volume. Other factors also have a certain influence on transportation costs, and only two important ones are explained in detail here. Enterprises in the supply chain have their own independent performance indicators, lack of key performance indicators (KPIs) that can measure the overall supply chain, and cannot make overall and coordinated planning for enterprises in the supply chain.

There is a non-linear relationship between cost and customer service level, that is, the improvement of coordination service level will lead to the increase of business volume and revenue, and of course, the cost of the enterprise will also increase, which is a perfect embodiment of the theory of benefit-reversal. Moreover, when considering the relationship between the two, it is also necessary to consider from the perspective of the whole supply chain, not only the local coordination operation process, to achieve the optimal level of coordination services and cost effectiveness of the whole supply chain. Enterprises in the control of costs, the choice of measures strategy, to consider the cost control and coordination service level, not only to minimize the cost of enterprises, but also to ensure that the provision of coordination services to meet the requirements of customers, give up either one of them, is not conducive to the long-term development of coordination enterprises.

IV. RESULTS AND ANALYSIS

A. TESTING OF THE BLOCKCHAIN STRUCTURE

If the database is compared to a large ledger, reading, and writing the database is equivalent to the act of bookkeeping. Everyone can book on the ledger. Through the competitive bookkeeping mechanism, the person who remembers the best bookkeeping will be selected and the bookkeeping power will be obtained once. And synchronize the new ledger information to others. The Identification Contract (IC) in this solution is executed at the stage when the user registers with the system. When a user registers with the system for the first time, the system determines the user's subordinate status

based on the user's predefined attributes, and in this scheme, the user status can be divided into: data owner, data acquirer and third-party organization. When the user enters the system, the system will be based on the user ID and agent license as the identity authentication, and the return result is whether it is a legitimate identity or a legitimate unique identity [28]. Users can be divided into three categories after executing the identity contract IC, for each storage there exists data index, before accessing the data index you must run the access control contract APC. each data index comes with its own permission list to control the user's read or write permissions, the main function of the contract is to identify illegal access behavior of malicious users. The access track tracking process requires multiple contracts to work together. First, the status of data access records is queried through the REC contract, and second, the CPC contract is executed to verify whether the contract has formed a data sharing relationship with the data. Then, the ARC contract is executed to detect the address of the contract that sends and receives the data, and after verifying the address, the ARC contract is used to query the data access records.

The hardward running environment for simulation is a working PC with a CPU of "Core i7-12700F", a Graphics board of "NVIDEA RTX3050", and a RAM of 16GB. For simulation platform, the most common simulation software "MATLAB" is selected for this purpose. It is known that a block is actually a data structure. Hence, a programming class is used to represent a block in programming. In definition of a block class, attributes include block number, transaction data, the Hash value of the block itself, the Hash value of the previous block, and a random value. For smart contact coding management, it is also defined in similar way with the MATLAB platform. The proxy re-encryption scheme of this solution not only has access anonymity but also fine-grained access control. IC smart contracts can pre-filter unauthorized users to ensure that only authorized users can perform data sharing. In addition, the REC smart contract can revoke access credentials in case of malicious behavior of honest nodes. C, CPC, ARC and REC smart contracts work together to protect users' identity against tampering. That is only users who are authenticated by the REC contract can enable data sharing or data reception. In addition, (pk, sk) is updated in real time during data sharing, and the new (pk, sk) key pair is chained chronologically after the previous (pk, sk) key pair, so that if the key is lost, the new key can replace the old one to complete the process.

B. SIMULATION OF THE BLOCKCHAIN STRUCTURE

The encryption and decryption time increases linearly with the number of attributes in the range $S \in (0, 50)$ of this scheme (Figure 5). The encryption time is about 500 ms at most for the attribute 100. On the other hand, in the range of attributes $N \in (60, 100)$, the average encryption time is reduced by 150 ms compared to the decryption process. The simulation experiments also consider the running time for

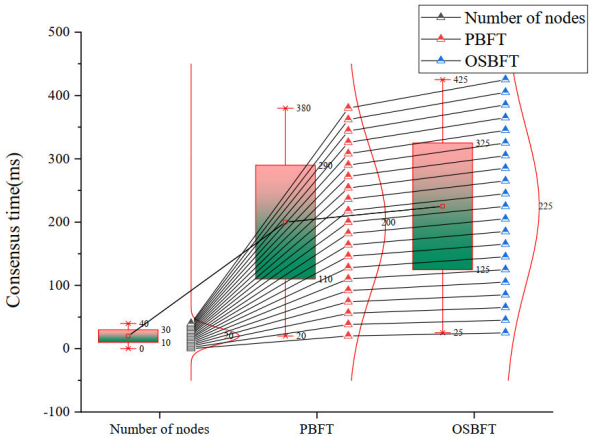

FIGURE 6. Error-free node consensus time.

file blocks with different sizes, as shown in Figure 5. In the test text size interval of (16,128), i.e., $M \in (16, 128)$, the time scheme increases from 400 ms to 660 ms. It is worth noting that having the cipher text sliced to 32 bytes ensures the maximum efficiency and stability of the system. As the ciphertext size increases from 16 to 128 bytes, the time cost of the whole process increases by about 10 ms and we can conclude that the overall and partial processing time cost is at a reasonable level.

In the simulation experiments, processes that require high performance computing, such as key generation, re-encryption, etc., are performed on the off-chain operating system. Trusted key distribution processes (e.g., key distribution, time-based dynamic key update) are done on smart contracts in Ether. In this scenario, to verify that the number of attribute sets in decryption and decryption is linearly related to time, attribute generation is divided into ciphertext attributes of different group sizes in the form of $\{A_1, A_2, \ldots, A_n\}$, where A_i is an attribute that encrypts sk. To make the experiment generalizable, in this paper, 100 different attributes are randomly generated with numbers from 1 to 100, and then, the relationship between time and attribute number N is counted. Nowadays, the globalized market has been formed, and the competition of enterprises has broken through the boundaries of regions and countries. Enterprises must not only compete with domestic enterprises of the same type, but also withstand the impact of foreign enterprises.

In this section, the performance of the proposed optimized scalable consensus algorithm is analyzed and compared with the PBFT algorithm [29]. It is assumed that both the number of transactions arriving at the expert node and the node processing time of the message are exponentially distributed with a mean value of about 1.1 ms and a variance of about 1.23 ms. The message transmission time in the link is related to the size of the data contained in the message, and there may be additional delay. In this paper, we take the number of nodes of 4, 7, 10, 13, 19, 25, 31 and 40 and study the performance of the algorithm with these number of nodes. The consensus

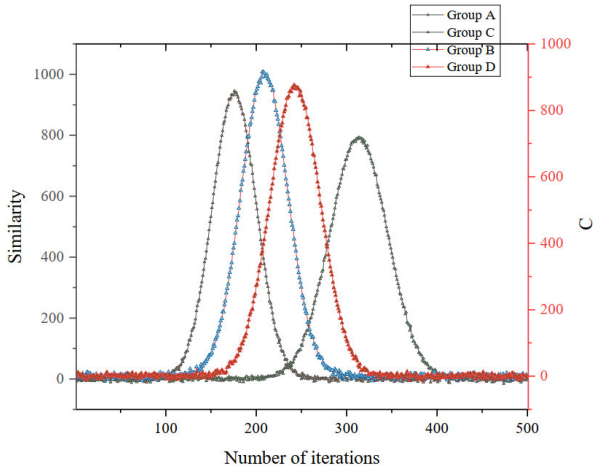

FIGURE 7. Similarity change of simulated annealing algorithm.

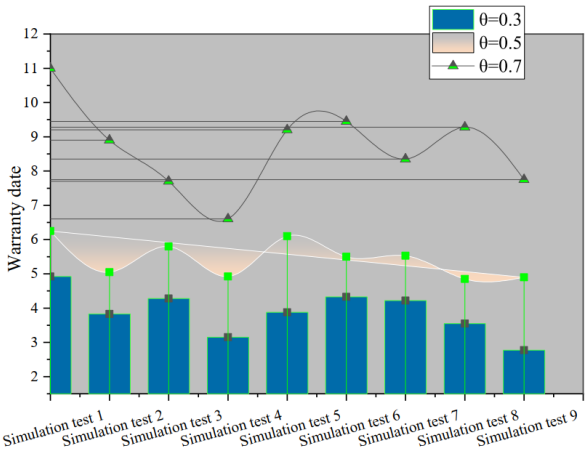

FIGURE 8. Effect of cost structure on optimal solution.

time of the improved algorithm in the absence of erroneous nodes is plotted against the PBFT algorithm. As shown in Figure 6, the consensus time of both algorithms increases with the number of nodes and the rate of increase is getting faster. This is because the more the number of nodes, the more messages need to be sent to confirm a transaction, which is naturally more time consuming. When the number of nodes is small, the consensus completion time of both algorithms is not much different, but when the number of nodes gradually increases, especially after more than 20 nodes, the consensus time of OSBFT decreases significantly compared to PBFT, which proves that the improved algorithm with fewer consensus steps achieves the desired effect.

The improved OSBFT algorithm has the same latency as in the absence of error nodes, and both outperform the original PBFT algorithm, but both algorithms have higher consensus completion times than in the absence of error nodes [30]. This is because error nodes may delay sending messages resulting in longer node communication time or send error messages increasing node processing time, which leads to slower transaction confirmation. The more error-free nodes there are, the higher the message validity and the higher the message utilization. With 40 consensus nodes in the system, OSBFT can reduce the time for single transaction confirmation by about 80ms compared to PBFT, which means that faster transaction arrival is supported by OSBFT, i.e., more transactions can be accommodated per unit time, thus increasing the throughput of the whole system. In addition, faster consensus also means that transactions can be recorded faster, which is in line with the requirements of this paper's scenario (Figure 6).

C. SIMULATION OF THE OPTIMIZATION CONTROL MODEL

The examples retrieved are usually different from the current problem, so they should be evaluated and modified. The following strategy should be adopted for example rewriting based on FMEA knowledge model. If the similarity between the problem example and the old example in the example database is 90%-100%, the feature factors of the two examples are very similar and the guaranteed cost of the problem example is the same as the guaranteed cost of the old example. If the similarity between the problem example and the old example in the example database is less than 90%, the guaranteed cost of the problem example can be solved by using the relevant data of the old example and the proposed formula. According to the guaranteed cost prediction method proposed in this paper, a test case is given for a certain model of relay as an example. After detailed search, the similarity between the problem example and the retrieved example 9 is over 90%, and the similarity is optimized with the number of iterations. Therefore, the guaranteed cost of retrieval example 9 can be directly applied as the guaranteed cost of the problem example (Figure 7). Therefore, the guaranteed cost of retrieval example 9 can be directly applied as the guaranteed cost of the problem example.

Production cost is influenced by product quality and guarantee period, therefore, whether the cost structure is reasonable also affects the change of the optimal solution of product quality and guarantee period. The trajectory of the optimal product warranty period under different θ values, as shown in Figure 8, although the warranty period is increasing during the product life cycle, the larger the θ value, the shorter the product warranty period. In the actual operation of the enterprise, the cost curve does not start from the origin, because even if the production output of the enterprise is 0, other fixed expenditure costs such as labor and other fixed costs have already occurred. Because according to the reliability theory, the larger the θ value the worse the product reliability, the more reworked products, and the larger the warranty cost incurred during the same warranty period, so the enterprise must set a shorter warranty period to reduce the warranty cost. The optimal product quality trajectory with different B values, and it can be seen from the Figure that the larger B is, the higher the product quality level is. Since B is the variable cost associated with product quality, a larger B indicates that

the larger the cost that the firm invests in improving product quality, and therefore, the higher the level of product quality. In addition, the numerical calculation shows that the larger the B, the higher the price of the product. This requires that enterprises must optimize the cost structure of their products and reduce production costs as much as possible to achieve the goal of profit maximization while formulating reasonable competitive strategies and increasing the sales volume of their products.

Robustness tests are usually used to evaluate the robustness of the explanatory power of methods and indicators. Rasey RESET test and White test were conducted for the main model M2-M9 in this paper, and the P-values of Rasey RESET test for the main model were greater than 0.1, and the P-values of White test were less than 0.1, which indicated that the model did not omit key variables and there was no heteroskedasticity problem, so the model did not have setting error and the model test results were sound and credible. The effect regression method was used to re-examine the above data empirically, and the test results were consistent with the results of this paper. The empirical results found that Sample I and Sample II are still consistent with the above empirical results. Multiple tests should prove that the empirical evidence in this paper meets the robustness requirements.

Based on the test, the theoretical model of the integration and convergence performance of blockchain and enterprise network in technology, organization, business and market constructed in the previous paper is empirically tested to verify the degree of influence of technology convergence, organization convergence, business convergence and market convergence on rapid response capability, learning and innovation capability, information communication capability and coordination and integration capability. The degree of influence of technology convergence, organization convergence, business convergence and market convergence the degree of influence of technology integration, organizational integration, business integration and market integration on outcome performance. The degree of influence of rapid response capability, learning innovation capability, information communication capability and coordination and integration capability on outcome performance and the mediating role of rapid response capability, learning innovation capability, information communication capability and coordination and integration capability.

V. CONCLUSION

In view of the advantages of blockchain, this paper builds a blockchain-based enterprise cost optimization control model. The paper proposes an improved OSBFT algorithm suitable for spectrum sharing based on PBFT algorithm, and finally builds a private chain based on Ether. For the data transmission problem in blockchain network, this paper constructs a generic framework construction, proposes a data sharing protocol, designs an identity verification protocol, and solves different problems mainly in different contexts.Total cost function is encoded with real numbers to improve algorithm accuracy, convergence speed and good stability, and also improves the crossover operator in genetic algorithm to select the optimal and suboptimal two individuals into the next generation to achieve the population to the region with high fitness value to accelerate convergence.

The empirical results show that the technical integration, business integration and organizational integration of blockchain and enterprise network have a facilitating effect on the outcome performance, i.e., there is a significant positive correlation between technical integration, business integration and organizational integration and convergence performance, and the higher the degree of integration of technical integration, business integration and organizational integration, the better the improvement of enterprise outcome performance; and the opposite is worse. Although this study has achieved some achievements, there are still some limitations in variable design and sample selection. More capability and performance variables can be considered in the future to compare the results with those of this study.

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