Trustworthiness Optimization of Industrial Cluster Network Platform Based on Blockchain

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***Abstract*—Industrial cluster is an important organization form and carrier of development of small and medium-sized enterprises, and information service platform is an important facility of industrial cluster. Improving the credibility of the network platform is conducive to eliminate the adverse effects of distrust and information asymmetry on industrial clusters. The decentralization, transparency, openness, and intangibility of block chain technology make it an inevitable choice for trustworthiness optimization of industrial cluster network platform. This paper first studied on trusted standard of industry cluster network platform and construct a new trusted framework of industry cluster network platform. Then the paper focus on trustworthiness optimization of data layer and application layer of the platform. The purpose of this paper is to build an industrial cluster network platform with data access, information trustworthiness, function availability, high-speed and low consumption, and promote the sustainable and efficient development of industrial cluster.**

Keywords—blockchain, industrial cluster, trustworthiness optimization, network platform

I. INTRODUCTION

SMEs (Small and medium-sized enterprises) have become an important force in the Chinese economy. Their development also plays a crucial role in the future of China's economy. At the end of 2017, there were 98.148 million market entities in the country, of which SMEs accounted for 99%, and created 50% of national tax revenue and 60% of GDP, 70% of invention patents, and 80% of jobs [1]. Due to low operating costs and flexible organization, SMEs play a key role in stabilizing regional economic growth, alleviating employment pressure, stimulating private investment, optimizing economic structure, promoting market competition, promoting technological innovation, and maintaining social stability. Invigorating small and medium-sized enterprises has become the main responsibility of local government departments.

Industrial clusters are important organizational forms and vehicles for the development of small and medium-sized enterprises that have been proved by the developed countries. However, the organizational structure of industrial clusters is relatively loose, and there is still a certain distance between the member distribution space. Therefore, strengthening the collaborative management of industrial clusters is inseparable from the support of information systems. The advanced network clustering platform can not only realize the vertical and horizontal information of the enterprises in the cluster. Exchange and sharing can improve the efficiency of collaboration between companies and reduce the cost of collaboration. It can also provide integrated, systematic and customized information resources as an information platform for realizing the macro strategy of industrial clusters, and promote the overall development of industrial clusters.

2017 was a year of digital currency eruption. Bitcoin's fiery explosion also triggered Blockchain technology. Blockchain is an innovative Internet technology that integrates cryptography, distributed network and data storage, and consensus algorithms. It has the advantages of decentralized distribution, system without centralized trust, irreconcilable and encrypted security. The chain itself is a new credit mechanism based on the decentralization of the bottom layer. Compared with the trust-based operating mechanism endorsed by the central organization, the Blockchain is a low-cost credit mechanism guaranteed by design mechanism, and the longer its running time, the higher the difficulty of tampering, which means that the longer Blockchain system runs, the more secure it is. Blockchain technology is applicable to any field that lacks trust. It can increase the speed of mutual trust, reduce the cost of establishing trust, and improve the execution efficiency of the entire event. Therefore, using Blockchain technology to optimize the industrial cluster network platform and build a reliable industrial cluster network platform is entirely feasible.

This article studies the industrial cluster network platform from the perspective of security and reliability, combines the industrial cluster management requirements, reconstructs the credible industrial cluster network platform framework, and uses block chain technology to implement the data layer and application layer of the industrial cluster network platform. The letter optimization will provide a safe and credible support platform for the development of industrial clusters from a technical perspective, which will

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help eliminate the impact on information asymmetry on the development of industrial clusters, and increase the trust and synergy of the entire industrial clusters, and make the industrial cluster to maximize synergies.

II. Research Status of Industrial Cluster Network Platform

At present, the research of industrial cluster network platform mainly focuses on three aspects: platform architecture, platform operation mode, and cloud manufacturing platform. In terms of platform architecture, Luo et al. conducted a research on the common key technology systems of SME cloud manufacturing service platforms [2]. Xiao et al. analyze the characteristics of multi-tenant business association and data storage characteristics of enterprise alliances, and combine the database with a shared database to analyze the security and encryption configuration requirements of multi-tenant service data [3]. In the operating mode of the platform, Liu concluded that there are three major models of the industrial cluster network platform: government, industry associations, and enterprise operations [4]. Shuiyong et al. conducted research on the application of the integrated information and communication platform, and pointed out that government and industry associations participating in the network platform to provide corresponding public services can promote the continuous growth of industrial clusters [5]. Yang and Xiao conducted a research on the construction and operation of a scientific and technological financial service information cooperation platform [6]. In terms of cloud manufacturing platforms, Yang et al. studied the collaboration of large-scale equipment in the cloud manufacturing model for the cooperation problem in the cloud manufacturing model [7]. Moghaddam and Nof studied the problem of collaborative service component integration in cloud manufacturing [8].

In the study of trusted networks, Prof David Patterson of the American Academy of Engineering pointed out that high-trust network services have become one of the important standards for measuring network applications. Yang compared and analyzed the six trust models of the Beth trust model, the trust model based on fuzzy set theory, the trust model based on weight, the trust model based on the semi-ring theory, the trust model based on information theory, and the trust model based on evidence theory. The advantages and disadvantages of each model are discussed, and the limitations of each model are discussed. It is proposed that a corresponding trust model should be selected according to different network environments [9]. Li and Cheng established an analytical model for the construction of a trusted network based on data source dependencies so that the more data sources provided by the data source, the more accurate the analysis of the credibility of data can be provided to meet the information security requirements [10].

The current research on industrial cluster network platforms focus more on the management and operating models of the platform, information flow and sharing between different companies, and there is not much research on how to achieve business collaboration and information security, especially on the technical level. The current research on trusted networks are more about how to ensure information security on network platforms and avoid artificial or inhuman errors in the storage and transmission of data. However, this does not completely eliminate the mistrust between enterprise members of industrial clusters. Therefore, the research on the trusted optimization of industrial cluster information network platform should further to solve the trust problem based on the trusted network.

III. Blockchain Research Status

The concept of blockchain first appeared at the end of 2008 in a controversial paper by Bitcoin: A Peer-to-Peer Electronic Cash System. At present, the research on blockchain mainly focuses on the following four aspects: the connotation and characteristics of blockchain, blockchain architecture, blockchain mechanism, and the application of blockchain.

In terms of the connotation and characteristics of the blockchain, Satoshi Nakamoto defines the blockchain as a distributed database designed for decentralization, using a time stamp, Merkle tree structure, asymmetric key encryption algorithm, and consensus algorithm. The reward mechanism uses the peer-to-peer network to implement decentralized credit transactions, and proposes a new computing paradigm for solving the problems of poor reliability and inefficiency in the centralized model. Blockchain technology is a decentralized, high-confidence, distributed database ledger technology with traceability and information that cannot be tampered with. In the area of blockchain architecture, Yuan Yong discusses the blockchain six-tier infrastructure model [11]. The six layers include the data layer, network layer, consensus layer, incentive layer, contract layer, and application layer. The People's Bank of China Hefei Center Branch speaks from a functional point of view that the blockchain hierarchy is divided into four layers: shared data layer, shared protocol layer, application programming interfaces (APIs) and applications (Apps) [12]. In the blockchain mechanism, the consensus mechanism is considered to be the core of the blockchain system and is the key to solving the problems of blockchain security, scalability, performance efficiency, and energy cost. In a P2P network, the mutual trust in nodes to achieve the consistency of the data by following a preset mechanism is known as consensus (Satoshi Satoshi 2008), and the typical consensus mechanism supported in blockchain technology is pow (Proof of Work) and pos (Prof of Stake), Byzantine Agreement, and other mechanisms also include the integration of different mechanisms. The blockchain knowledge graph is shown in Fig. 1. Smart contracts are the basis of the flexible programming and manipulation of data in blockchain systems. The smart contract was first proposed by cryptographer Nick Szabo in 1994. It is a program code that implements the terms of the contract. Instead of the traditional paper contract, it can greatly reduce the contract formulation, control agreement and execution efficiency. Labor costs and computational costs. But until the emergence of blockchain technology, smart contracts became a trusted system. It was no longer limited to the functions of the database, but also became a distributed computer that could execute code and record asset ownership. At present, most blockchain projects, such as the open source projects Ethereum, Codius, and Hyperledger, combine blockchain and smart contract technology to implement smart contracts with programmable contract languages and executable infrastructure [13]. In the application of blockchain, Andreas and Antonopoulos described in detail the local ecosystem formed in bitcoin applications, including distribution, verification, circulation,

and so on [14]. Blockchain is now not only limited to tokens, but also covers to finance, healthcare, education, networking, security, privacy, cloud storage, big data, and artificial intelligence. Radu analyzed that how the blockchain works to establish trust mechanisms in the absence of trust [15]. Kshetri evaluated the role of blockchain in enhancing cybersecurity and protecting privacy [16]. Liu pointed out that industrial clusters can use the characteristics of blockchain decentralization and detrusting, and consciously establish a cluster financing to trust mechanism; they can use the irreversible and untraceable characteristics of blockchain data to perform trustworthy behavior and strengthen risk control. Guarantee cluster trust mechanism [17]. The introduction to blockchain into the supply chain logistics information ecosystem construction will help us master the laws of supply chain logistics information resource flow, optimize the management of supply chain logistics information resources, improve the supply chain logistics information ecological environment, and realize industrial cluster innovation and development [18]-[19]. Chen studied on the Development Strategy of Small and Medium-sized Enterprises' Industrial Clusters [20]. Meng put forward more reasonable suggestions for the development of regional circulation industrial clusters, so as to provide a useful reference to promoting regional economic development [21].

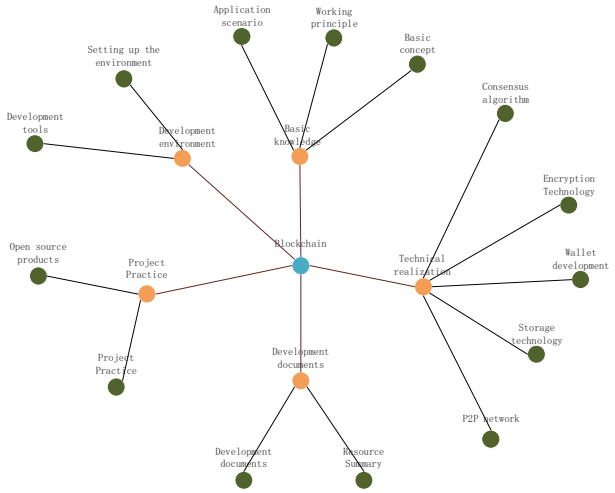

Fig. 1. Blockchain knowledge graph

Blockchain has transitioned from the initial pure digital currency to the broader financial industry, and has penetrated into many fields in society, such as authentication, cross-border payment, file storage, and internet of things, among which the financial sector is currently the most mature and the most widely used field. However, there is no inter-enterprise, cross-platform, and large-scale application scenario for blockchain at present. Therefore, the industrial cluster network platform system based on blockchain technology has great practical significance of the promotion of blockchain technology.

In addition, the existing blockchain technology has several defects:

- The service interface of the blockchain system and the platform is usually procedural, requiring users to write complex smart contracts, which easily leads to errors and loopholes;
- Most of the blockchain systems do not support complex mode data management and cannot provide general data modeling and mode management functions. This results in high system and platform coupling with applications and difficulty in application development.
- Partial blockchain platforms (especially It is a public chain system. In order to ensure the scalability of the system, the PoW consensus mechanism is used. Compared with traditional trusted data management systems, the delay and throughput rates cannot meet the needs of most mission-critical applications.
- Language and solution design, interoperability and verification across smart contracts are yet to be further verified. Therefore, the research in this paper is also a useful supplement to the development of blockchain technology.

IV. Research on the Credibility of Industrial Cluster Network Platform

A. Industry Cluster Network Platform Trust Architecture

From the previous research status of the industrial cluster network platform, it can be known that the existing network cluster platform has great defects in platform trust.

In this part of the consensus algorithm, we will mention the aforementioned pow consensus mechanism. Here is a brief introduction. Pow stands for that Proof of Work, and the format of block B submitted by the node is $H(B) \leq target$, where H is a certain hash algorithm and target is a fixed number. Assuming that the maximum value of the hash value is: $HASH_{max}$, the probability p for each attempt to find a valid block is:

$$p = \frac{target}{HASH_{\max}} \tag{1}$$

Every 2016 block (two weeks) adjusts the value of target and adjusts to the following formula:

$$target_{new} = \frac{t_{2016}}{2weeks} * target \tag{2}$$

t_{2016} represents the time which it takes to generate the first 2016 blocks. The shorter the time spent, the smaller the final target value. The difficulty level of the generated block can also be obtained by the following formula:

$$difficulty = \frac{target_1}{current_{target}} \tag{3}$$

Based on the analysis of the existing different types of industrial cluster network platforms, this study combines the future trends of collaborative development of industrial clusters, studies the credible requirements of industrial cluster network platforms, and determines the trusted standards of industrial cluster network platforms. Trusted network and blockchain related theories and technologies to build a credible framework for the industrial cluster network platform, and perform trusted optimization on all aspects of the traditional industrial cluster network platform. The optimized enterprise cluster network platform's trusted framework is shown in Fig. 2. This paper focuses on

optimizing the application layer and data layer of the platform, adopting mechanisms such as smart contracts and consensus algorithms, and optimizing the application layer based on credit evaluation, using blockchain technology to store data, and constructing a reliable data storage layer.

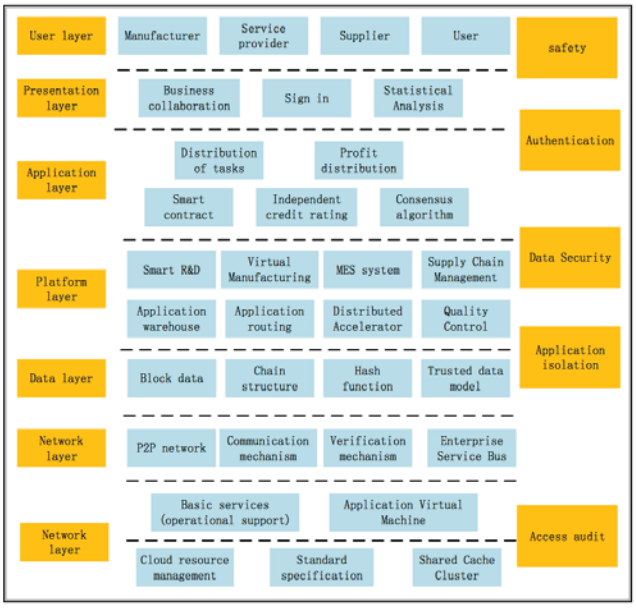

Fig. 2. The trustworthiness framework of industrial cluster network platform

B. *The Credibility of Data Storage in Industrial Cluster Network Platforms*

The metadata of the traditional data model is usually stored in the central node, which is easy to produce single point of failure, and it is vulnerable to malicious tampering. To overcome this shortcoming, blockchain technology and distributed identity authentication technology can be applied to the data storage of industrial cluster network platform. The data is used as an asset for uniform identification, and the data is distributed and stored using the blockchain. By introducing multiple nodes to participate in the recording, the integrity of the data is ensured and the credibility of the data storage is improved.

Trusted data storage can be further decomposed into a storage layer, a verification layer, and a block chain layer from the bottom of (as shown in Fig. 3).

The specific workflow includes:

- Based on the industry cluster data specification and the uniform resource identifier specification, form the industry cluster data index naming rules, and uniformly name the data that needs to be stored.
- Save the user's signed data onto the storage node, and send the user's signature set and replica location information to all verification nodes, where the replica location information can be obtained by the central node of the distributed storage system.
- Each verification node verifies the signature information on all users.
- When all the signature information passes verification, the metadata and metadata blocks are constructed using the user signature and the corresponding user data copy location information, and the metadata block chain is updated.

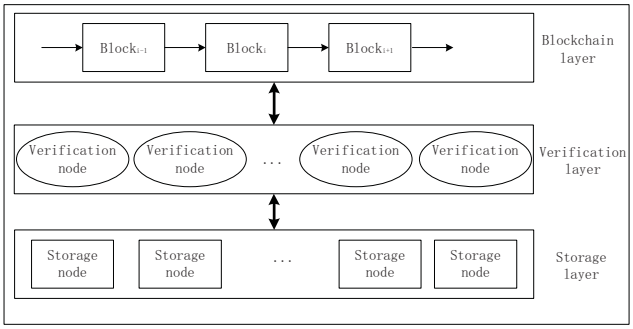

Fig. 3. Trustworthiness data storage model

C. *Industry Cluster Network Platform Task Distribution System Trusted Optimization*

Traditional task distribution of industrial clusters often requires the intervention in a third party. While it consumes a large amount of manpower and material resources, it cannot prevent the production and dissemination of fraudulent or false information. It is difficult to achieve effective and credible distribution of orders for cluster enterprises. Based on the enterprise's trustworthy credit rating of the industrial cluster's independent credit rating system, it can design and implement the task distribution algorithm of industrial clusters based on the consensus algorithm and smart contracts, and quickly complete the order-based partner selection and order assignment.

According to the characteristics of the collaborative production of industrial clusters, the improved shuffled frog leaping algorithm was used to optimize the task distribution algorithm, and the intelligent task distribution method was developed from the task level. The algorithm framework of distributing smart contracts for tasks is shown in Fig. 4.

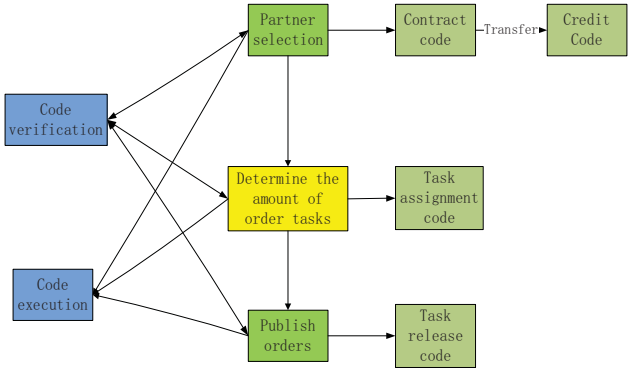

Fig. 4. Task distribution smart contract algorithm

In task distribution smart contracts, task contracts are used to generate contracts and modify task status. The credit code is used to obtain the corporate credit rating, the contract code calls the credit code, and the partner selection is performed. The task assignment code is used to determine the quantity of the order task. After the order is generated, the task release codes to publish the enterprise-signed order for the block chain to generate a formal transaction block.

Code verification uses formal methods to reduce contract design errors and verify code and text consistency. Code execution refers to reading a code from a blockchain when the block link receives a triggered transaction of the code,

and then executing the code based on the content of the transaction, the contract status and external information, and querying the block through the smart contract interface provided by the blockchain Chain information and return execution results of the blockchain.

D. Industry Cluster Network Platform Profit Distribution System Trusted Optimization

The scientific and reasonable interest distribution mechanism is the key to the stable operation and sustainable development of industrial clusters. At present, the basic modes of interest distribution of industrial clusters are output sharing mode, fixed payment mode, and hybrid mode, in which output sharing mode is the most commonly used. However, due to asymmetric information, the quantity, quality, delivery schedule, and customer satisfaction of each company's output cannot be accurately determined. Therefore, in the distribution of benefits, there are often cases where companies do not recognize the workload among themselves. At present, the common method adopted by enterprises is to introduce third-party arbitration institutions, or to complete distribution of interests through multiple rounds of negotiation and negotiations, but this greatly increase the operating costs of the entire cluster.

Therefore, it is possible to optimize based on the traditional PBFT (Practical Byzantine Fault Tolerance) consensus mechanism and design the cluster enterprise task completion degree verification algorithm PoTC to achieve a credible proof of the completion degree of each enterprise task. The specific process of verifying the completion of tasks is:

- Using the dynamic authorization mechanism, each enterprise in the industrial cluster will vote for the "consensus accounting representative" node according to the ratio of output value.
- Introduce the "Rise and Fall" rules, and dynamically update the "consensus accounting node" with low rating according to the credit information about the automatic credit rating system.
- Through the cluster enterprise tasks completion degree verification algorithm PoTC, the task completion degree data submitted by the enterprise is verified after passing more than half of the nodes in the other consensus participating node sets, and this data is stored in the task block.
- The information about the degree of completion of the proved enterprise mission is stored in the company's credit block, and the company's credit rating is automatically updated.

Through the dynamic authorization mechanism and the “remove-level” representative retention mechanism, under the premise of ensuring fairness, reciprocity, and credibility, the speed of reaching consensus in the block is greatly increased, making the task efficiency of the cluster enterprises more efficient in verifying the efficiency of the algorithm.

V. CONCLUSIONS

This article studies the industrial cluster network platform from the perspective of security and credibility, combines the industrial cluster management requirements, reconstructs the credible industrial cluster network platform framework, and uses Blockchain technology to implement the data layer and application layer of the industrial cluster network platform. The letter optimization will provide a safe and credible support platform for the development of industrial clusters from a technical point of view, which will help eliminate the impact on information asymmetry on the development of industrial clusters, increase the trust and synergy of the entire industrial clusters, and maximize the industrial clusters.

Furthermore, this article combines the requirements of blockchain technology and enterprise cluster network platform, optimizes and improves the traditional network platform of some industrial clusters, that is, utilizing the characteristics of blockchain decentralization to study the trust issues enterprise clusters faced. Using blockchain smart contract technology to study the order allocation problem of enterprise cluster trusted platform, designing reliable and effective smart contract algorithm; using the optimization theory and consensus algorithm to study the partner selection based on orders; using sidechain technology to study The function expansion of the platform and personalized customization issues, in order to build an industrial cluster network platform with data availability, information credibility, features available, high-speed and low-cost, and then promote the sustainable and efficient development of industrial clusters.

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