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Blockchain Technology-based Construction Project Management System -- A Case from Xiong'an construction funds management blockchain system

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Abstract: Due to the large amount of funds involved, the large number of participants, and the complicated projects in the construction industry, it is difficult to improve work efficiency. The block chain technology, by which the data cannot be tampered, is decentralized, and intelligence contracts can be applied, so it provides a new way for the construction project management. This article analyzes the current situation of construction project management, points out the current problems, and discusses the application of blockchain technology in the management of construction projects. Finally, it takes the construction fund management blockchain system of Xiong'an New Area in China as an example, to discuss the application prospect of block chain technology in construction project management and the problems that remain to be solved.

Keywords: Blockchain, construction management system, transparency.

1. Introduction

The construction industry, as a pillar industry of the national economy, has an important position and role in modernization. However, the construction industry is highly complex, involving various regulations and standards. In the traditional construction industry, problems such as cumbersome and long-term project approval, weak building asset management, and "information isolated island" always affect the efficiency of the industry.

Blockchain, as an open, trustworthy, traceable, and collectively-maintained distributed data storage technology, ensures all historical data recorded in strict chronological order through the hash function. Its immutability and traceability can significantly improve the trust issues of all parties involved in the current construction projects. Also, the characteristics of collective maintenance and data sharing of the blockchain can also ensure the timely exchange of information for the upstream and downstream of the construction material supply chain, which can effectively solve several pain points in the traditional construction industry.

Therefore, this article studies the application of construction project management based on blockchain technology. First of all, this article puts forward problems existing in traditional construction project management, and then introduces the basic principles and advantages of blockchain and the specific implementation of blockchain in construction project management. Finally, it

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takes the Xiong'an construction fund blockchain management system as an example to introduce the application prospects and the problems that still need to be resolved.

2. Problems existing in traditional construction project management

2.1 Cumbersome approval of construction projects

In traditional construction project management, low efficiency is always a big problem. Only in preliminary approval, participants need to submit more than 40 kinds of documents, and participate in preliminary work letter approval, feasibility study report approval, planning and design plan approval, etc. And depending on different projects, there will be some differences in the documents and the process of preliminary approval will also not be the same. This has led to a lot of problems, such as, repeated application, stamps, and approvals during the approval of construction projects. Moreover, in the traditional situation, due to the lack of information management, relevant departments often need to consume a lot of human resource and time to sort out data and information, which makes it difficult to effectively reduce the approval time.

2.2 Weak management of the construction material

Theoretically speaking, construction materials and large-scale equipment should be arranged as the preliminary engineering design and the material procurement plan. However, in practice, many construction companies pay insufficient attention to project control and the management process is chaotic, so there are often temporary changes in demand planning and temporary material allocation. Due to time constraints, it is often difficult to follow the bidding procedures to maximize economic effectiveness. And because the material accounting needs relevant staff when the project is in progress, it is difficult to achieve timely and accurate accounting. The lag in accounting will result in the lack of an effective reward and punishment mechanism, which will lead to serious waste of materials in actual use. The fundamental reason lies in the excessive human capital required for construction material management and the lack of timely information transmission.

2.3 The information is opaque and it is difficult to guarantee the authenticity

Although information platforms such as BIM management platforms and smart construction management platforms have been used in many construction companies, most of the platforms are currently only used within a single enterprise and only realize the informatization of a project or an enterprise. Because various enterprises and approval departments use different information systems, it is still difficult to realize the rapid circulation of information and the transparency of key information. This has resulted in the isolated information, without truly taking the convenience brought by informatization.

Moreover, due to opaque information, all parties involved in the construction project hope to maximize their own interests, which may lead to misappropriation of construction funds, malicious arrears of wages, difficulty in guaranteeing the quality of raw materials, etc. Finally, it will affect the normal development of the entire industry.

3. The advantages of blockchain used in construction project fund management

3.1 The history of blockchain

The concept of blockchain originated from the article "Bitcoin: A Peer-to-Peer Electronic Cash System" published by Satoshi Nakamoto on the Bitcoin Forum in 2008. In 2013, Vitalik Buterin conceptualized Ethereum, realized smart contracts for the first time, and successfully brought the

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blockchain into the 2.0 era. By creating new units of value, assets, digital identities and private records can be moved into the blockchain system to save and transfer transactions, so as to establish a decentralized market based on the blockchain [1].

In recent years, China has attached great importance to the research and application of blockchain technology in related fields. In 2016, the Chinese 13th Five-Year National Plan of Information clearly pointed out that the blockchain technology will be used as an emerging technology and a frontier technology in key areas for innovative development and practical application [2]. In March 2018, the Ministry of Industry and Information Technology announced the preparation of the "National Blockchain and Distributed Accounting Technology Standardization Committee", which marked a new level in the development of China's blockchain technology [3]. In 2019, on the 18the collective learning of the Central Political Bureau, General Secretary Xi Jinping stressed that the block chain technology innovation was the core of an important breakthrough, and that we should accelerate the development of block chain technology and industrial innovation. In April 2020, the National Development and Reform Commission formally incorporated the block chain into "new infrastructure" on the regular news conference. In 2021, the National Blockchain and Distributed Billing Technology Standardization Committee (SAC/TC590) was approved to be established, marking that the Chinese block chain industry had entered the era of standardization.

3.2 Advantages of Blockchain

3.2.1 Information is transparent and traceable, breaking information barriers.

Latham has written the "The Latham report" [4]. This highly influential report pointed out that the construction industry relies heavily on bidding and confrontation, and the credit level is low, so a lot of additional costs have been added. The main feature of blockchain is decentralization and transparency. Each block in the blockchain system contains the data of the previous block and the transaction data with timestamp [5]. Whenever a new transaction is made or a new contract is signed, the relevant information will be re-verified and the block can be successfully established only when all nodes agree to the transaction in the data block, and a single participant cannot change or delete these data in the block [6]. This ensures that all information is credible, transparent, and traceable, and facilitates the supervision and the efficient circulation of supply chain information during the project.

3.2.2 Use smart contracts to realize low-cost and timely payment.

Another big advantage of blockchain is that it can run smart contracts. A smart contract is a special type of contract that runs in a digital environment. Its uniqueness lies in the ability to create algorithms and programs that can partially or fully execute the content of the contract when the conditions agreed and preset by both parties are triggered and notify (or update data of) all participants through the contract. So, we can use computer technology to replace complicated and troublesome human interaction [7].. In the traditional construction industry, low examination and approval efficiency and slow payment speed are the main problems that affect the progress of the project and cause various disputes. Through smart contracts, funds can be directly embedded in the contract to prevent delayed payments and protect general contractors, subcontractors, and suppliers, which will also greatly reduce the credit cost of all parties involved in the project.

On the other hand, smart contracts are clear codes that are traceable and predictable compared with traditional contracts. Therefore, a lot of time can be saved in contract registration and monitoring, and its automation can update data and avoid data tampering, so it can improve the efficiency of approval and reduce the cost of supervision.

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4. Realization of construction project control based on blockchain

The highest stage of blockchain application is to achieve all relevant information on the blockchain, and every transaction can be guaranteed.

It is traceable, and all contracts are automatically executed when the conditions are met. This is not only very challenging for the blockchain technology itself, but also has higher requirements for the construction of urban high-tech infrastructure. Then the overall structure diagram of the construction project fund management system using blockchain technology in this article is shown in Figure 1:

4.1 Principle of operation

As can be seen from the figure, the entire system is divided into three layers:

The first layer is the environment layer. It is necessary to build a CIM platform, an IOT platform, a big data platform, and a three-in-one computing center for edge computing, cloud computing, and supercomputing, as the data base of the blockchain system. It ensures that the data entering the blockchain system is authentic and can be circulated, exchanged, and shared with real-life data.

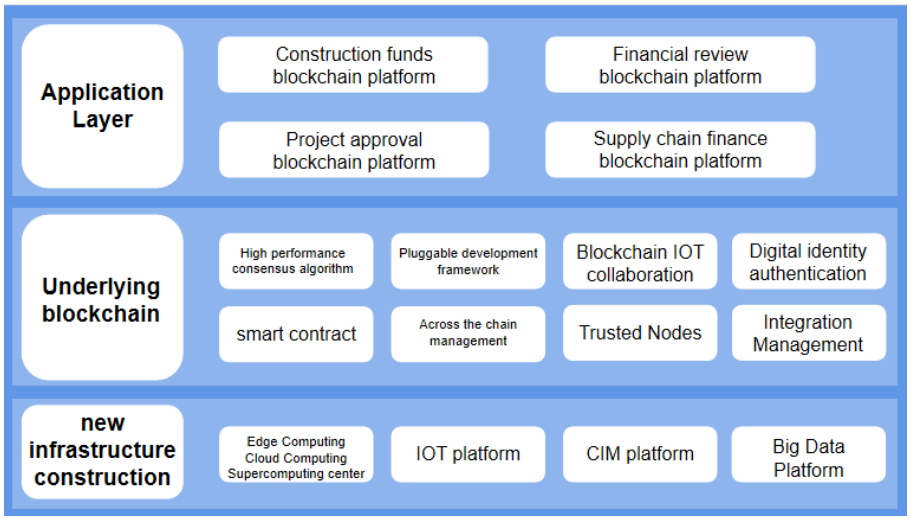

Figure 1: General framework of the construction project fund management system.

The second layer is the underlying blockchain technology, which uses a large amount of trusted data provided by the environment layer to achieve efficient IOT and blockchain collaboration and cross-chain management through high-performance consensus algorithms to identify digital identities. It uses a variety of security mechanisms to ensure that each node is credible and controllable and realize smart contracts. Through the pluggable development framework, the underlying blockchain technology can be quickly developed according to the different needs of the actual application layer.

The third layer is the application layer. The construction fund payment blockchain platform, the financial approval blockchain platform, the project approval blockchain platform, the supply chain finance blockchain platform, and other systems are all developed through the underlying system of the block to solve the pain points and difficulties of traditional construction project management.

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4.2 Application scenario analysis

4.2.1 The construction fund payment blockchain platform.

In traditional construction projects, the general subcontracting model is generally adopted for large and medium-sized projects. However, due to the excessive number of projects involved, illegal subcontracting and layered subcontracting often occur, which usually induces the quality of the project to fail to meet the standards. A series of problems such as wage arrears of migrant workers will also occur. By building a blockchain platform for payment of construction funds, with the help of methods such as smart contracts, process management, and payment on the chain, the project can be managed through the entire life cycle. When the contract is on the chain, the information related to the contract is also recorded on the chain and cannot be changed at will. The appropriation of funds and the mutual verification of the contract can greatly alleviate the problems of illegal subcontracting, construction without a contract, and delayed wages.

For example, penetrating payment can be used to solve the problem of wage arrears of migrant workers, which is difficult to monitor in the traditional situation. During the traditional construction projects, most salary arrears occur in the intermediate links, and the intermediate links are the most complicated part and difficult to monitor. To pay through the blockchain platform, the subcontractor needs to submit an application for salary payment on the platform, and upload the worker's bank account, payment amount, and other salary information to the chain. The bank will pay the wage directly from subcontractors' accounts to workers' accounts in batches, thereby realizing the "penetrating" payment of builders' wages, which greatly simplifies the intermediate payment process. The employment records and wage payment are all on the blockchain, so the government and participants of the project can clearly and quickly understand whether migrant workers receive their wages in a timely manner. When a subcontractor fails to pay wages on time, the government will promptly intervene to replace the subcontractor to pay the migrant workers' wages, and the subcontractor will bear the corresponding capital costs and fines. January 20, 2020, Xiong'an construction funds block chain management information system officially launched. The first wage payments, after the completion of all of the information on the chain, through the company accounts, the subcontractor accounts, and the builder's wage account, were a success. Via cross-bank penetrating payment, within 10 minutes, 360,000-yuan wages are issued to the wage cards of 29 builders. The development of the construction fund blockchain payment platform will greatly promote the efficient circulation of funds and promote the healthy development of the construction industry.

4.2.2 Financial review blockchain system and project approval blockchain system.

At present, for government-participated construction projects, the examination and approval work has been relatively independent, and the efficiency is low due to offline circulation. The review results are simply archived, but a large amount of construction data is not effectively used, and the degree of data utilization is very low. After the processes of the financial review process including preliminary project approval, feasibility study review, budget review, bidding review, contract review, process review, settlement review, and other financial review are all put on the blockchain, the review process can be standardized, digitized, and informatized, and also data visualization can be realized. Finally, through the accumulation of big data, a highly accurate risk decision model can be trained to achieve a more accurate pre-review by AI. At present, several project approval systems have appeared in the market, such as the online business review management system of the Financial Review Center of Mianyang, Sichuan Province, which provides the online project submission function for the construction project participants. The system will automatically check the completeness of the data to improve the efficiency of project submission and save time for approval.

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However, because the project materials still need to be reviewed by human throughout the process, it only saves the time for materials to transport between departments and does not really solve the essential problem of slow review and approval. At present, the project approval blockchain system of Xiong'an has completed the digitization of project and ensure that the data is highly structured. Driven by the data, through the blockchain, the cross-departmental approval is transformed into multi-departmental approval, realizing fast and transparent approval without a face-to-face meeting. In addition, the data of the blockchain can be used for cross-validation to ensure the credibility of the materials and save review time.

4.2.3 Supply chain finance blockchain platform

Compared with other industrial enterprises, due to the particularity of products in the construction industry, their production, sales, and payment recovery models have a longer cycle. They are usually paid after the projects are completed, so they often face more serious cash-flow problems. The traditional construction industry has increased market risks due to non-transparent information and weakened the willingness of financial institutions to offer funds. The blockchain platform can well solve the problem of information transparency, and the coordination of the blockchain information system of other construction projects through the blockchain system will greatly reduce the difficulty of information collection. So, without the receivables, they can also be financed using the order information. That greatly revitalize the funds and help the small and micro enterprises.

4.3 Challenges

4.3.1 Regulatory regulations need to be improved

Blockchain is still an emerging technology, and various countries are still exploring the supervision of blockchain. In August 2020, the Chinese Community Standard Information Platform released 32 blockchain standards. However, there are currently no clear legal regulations when the standards must be observed and what penalties are for violations. For example, in 2019, the "Regulations on the Management of Blockchain Information Services" issued by China on the use of blockchain technology only mentioned that the technical solutions must comply with the relevant national standards and regulations, but the relevant standards and regulations are not clear, and other countries are also in this way. It can be seen that the regulatory system of the blockchain has not been fully established. The construction industry is closely related to people's livelihood. The combination of blockchain and the construction industry will involve a large amount of corporate, personal, social information, and even important data related to the government and the military. If these information data are used carelessly, it will cause great security hidden danger. Therefore, the large-scale application of blockchain technology to the field of construction requires further improvement of the regulatory system.

4.3.2 Technology needs a breakthrough

Blockchain technology is a data storage technology that the data can only be added but cannot be deleted. This technology not only ensures that the data can be traced, but also means that as time goes by, the storage space required by the blockchain will increase. The huge amount of data required by the consensus mechanism will cause the lag effect of blockchain processing, which means that as more and more data exist in the blockchain system of construction, more and more intelligent AI implemented, and its processing speed becomes more and more slow, which is contrary to the original intention of using the blockchain system, the performance problem still needs a breakthrough.

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On the other hand, because the blockchain involves a huge amount of information, in order to protect the privacy of enterprises, individuals, and society, access restrictions should be set for some information. The current mainstream method is zero-knowledge proof, which is to ensure that the transaction is valid while hiding the sender, receiver, and transaction amount and other details. But zero-knowledge proof itself is not a mature technology. It involves the implementation of a large number of cryptographic algorithms and high demand of the art of computer programming. It is easy to have logic vulnerabilities, which can be exploited by attackers and lead to privacy leakage. Therefore, further technical development is still needed.

5. Prospects and future development

The combination of blockchain and construction project management can effectively improve the data credibility of all participants in the construction industry, reduce the difficulty of supervision, improve capital liquidity, and improve the efficiency of the entire project. At present, the management based on blockchain of construction projects is slowly starting, but with the development of the IOT, the breakthrough of blockchain technology in the future, and the continuous improvement of the informatization level of construction industry, blockchain will become the best booster, through reducing production costs, improving market transparency, and promoting the healthy development of the construction industry.

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