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The Adoption of Blockchain Technologies in Data Sharing: A State of the Art Survey

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Abstract: In the big data era, it is a significant need for data sharing in various industries. However, there are many weaknesses in the traditional centralized way of data sharing. It is easy to attack the centralized data storage center. As the process of data asset transactions is not transparent, there is a lack of trust in the percipients of data sharing. Blockchain technology offers a possibility to solve these problems in data sharing, as the blockchain can provide a decentralized, programmable, tamperproof, and anonymous data sharing environment. In this paper, we compare the blockchain-based data sharing with the traditional ways of data sharing, and analyze the scenarios in major industry applications. We survey the state of the art of the adoption of blockchain technologies in data sharing, and provide a summary about their technical frameworks and schemes.

Keywords: Data sharing, Blockchain, Distributed ledger, Review

1. INTRODUCTION

In the era of big data, every industry that takes advantage of data possess the demand for data sharing, especially the data-based companies, such as Amazon, Facebook, Alibaba and so on. They are now increasingly faced with the "data island" problem and in result pursuing effective solutions to establish a reasonable and efficient data sharing model. In present market environment, open data and data transaction are two common data sharing method [1]. However, more and more stringent requirements for data security, integrity and privacy protection of user data not only see the traditional data sharing methods to be not effective enough, but data transactions are faced with essential ethical and legal risks.

Since Satoshi Nakamoto designed and implemented the Bitcoin system[2], blockchain, serving as its core supporting technology, has gained more and more attention. Designed as a distributed ledger technology, Blockchain combines time series data into a chained data setting in a front-to-back manner and uses cryptography to promise a transparent, tamper-proof and secure system. The main features of blockchain include decentralization, programmability, non-tampering, unforgeability, peer-to-peer transmission, and anonymity. And this technology can also be viewed as a trust mechanism, open ledger, or database.

It is noticed that many scholars have gradually realized that blockchain technology may play a huge role in solving data sharing problems: on the one hand, the transformation of traditional data storage methods based on blockchain technology can significantly improve the security of data storage and the controllability of data sharing progress. On the other hand, the use of blockchain technology to determine the ownership of data assets makes data transactions more transparent and credible.

However, compared with its potential usage, although domestic and foreign scholars have made some explorations about how to apply blockchain in data sharing, there's still a lack of systematic research and application about it. Hence, we collect relevant papers, including technical literature on the use of blockchain technology to improve data sharing schemes domestic and overseas and specific data sharing applications (or application feasibility) of blockchain in some industries. In this paper, we mainly focus on blockchain solutions

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for data sharing and inform the state-of-the-art by systematically reviewing the literature and current business cases.

2. COMPARISON OF DATA SHARING APPROACHES

2.1 Disadvantages of traditional data sharing

There are some problems in the traditional data sharing method. On the one hand, traditional ways of data sharing rely on traditional databases for data storage, and the limitation of databases can lead to the defect of data sharing. On the other hand, the traditional data sharing model also has many weaknesses, which makes the data sharing model have many failures.

For the first part, we find that traditional database has several limitations: (1) The storage space of the traditional database is difficult to meet large data volume (2)Traditional database operation has little transparency, so that it is difficult to realize the sharing and circulation of data resources (3) Data can be tampered with unilaterally (4)Access to data needs a central organization which relies on human management.

And for the second concern, we can see that traditional data sharing and analyzing model has some problems: (1)Data is aggregated and stored in a third-party platform and the analysis or use of data is out of the data provider's control, which affects the transparency, credibility, and controllability of the data use process. Sexuality, value-added and other requirements (2)The description of the data set is limited to the basic information level of the data, such as data set name, data format, data set size, etc., lacking data usage history and data analysis tools. At the same time, the keyword-based indexing method only considers the occurrence frequency of a given keywords in the document (i.e. TF-IDF), ignoring the connectivity between documents (3)Data owners and data demanders cannot query the use of data sets and data set expansion is not convenient to use (4)Data update isn't timely so that most of the data is outdated, and user participation is at a quite low level.

2.2 Advantages of blockchain-enabled data sharing

2.2.1Data storage is security and transparent

Blockchain is a decentralized distributed database storage technology. Based on the chain structure, the data can be stored in order, and the node with the highest calculation level will be rewarded by the workload proof mechanism. As the number of participating nodes increases, the network scale becomes larger and the complexity of tampering data increases. All blockchain data participates in the calculation and recording by nodes in the network, and mutually verify the validity of the information. Therefore, blockchain has the characteristics of non-tampering and strong endorsement. Once the data is stored in the blockchain block, it will be quite hard to be modified, which ensures the persistence of the data.

2.2.2Data transmission is secure and controllable

The blockchain is desensitized by encryption algorithms such as hash processing and smart contract to ensure the privacy of the data, and the decentralized data storage method can effectively ensure the security of the data. The block-based data desensitization method and the smart contract built on the blockchain can ensure multi-source data fusion analysis under the condition of metadata security, effectively improving the information security matter in the existing data sharing process.

2.2.3Data transactions can be uniquely determined

The data on the blockchain is unique. Once written into the block, the data cannot be tampered with, preventing the data from being copied indefinitely. In addition, any transaction information about the data can be written onto the blockchain, which is conducive to the establishment of a trusted data asset trading environment. Data assets, different from other tangible assets, possessing one vital factor that ownership is

unclear and cannot be traced back to the owner of the data. The distributed accounting function of the blockchain can solve the problem concerning sharing, exchange, and transaction in data. It protects the legitimate rights and interests of data owners to improve the circulation of data in various industries. Owners of high-value data can monetize data through data transactions. Secure and confidential data transactions not only break the data island phenomenon that has long plagued the entire industry but also generate many new business models and opportunities. Taking the credit industry as an example, secure data transactions promote the circulation of data within the credit reporting industry. Furthermore, the integration of multi-source data can provide strong support for credit bureaus to comprehensively assess the credit level of individuals or enterprises.

2.2.4Data can be traceable

Data traceability refers to the traceability of data in the process of data transaction and circulation. The blockchain network nodes participating in the calculation and recording ensure that the data is true, effective and traceable through mutual verification. The whole process of data transaction and circulation can be accurately recorded. If there is any doubt about the data stored in a certain block, it is convenient to backtrack the historical transaction record by using the blockchain technique to judge the authenticity of the data. Data traceability makes it difficult to tamper with, which in a way guarantees the authenticity of the data during credit evaluation and is of great significance for constructing an accurate credit evaluation model.

3. BLOCKCHAIN-ENABLED DATA SHARING IN DIFFERENT INDUSTRIES

3.1Blockchain-enable data sharing in government

The share of government information resources is the main content of e-government construction. Government information includes population, legal person, geospatial, macroeconomic, social credit, natural environment and other content, which can be divided mainly into two categories, i.e. basic information and extended information. Basic information reflects the descriptive information on the basic situation of the object required by all government departments while extended information focuses on business-specific information corresponding to the interaction activities of citizens, enterprises and government departments.

Gao et al.[3] believed that data sharing in the field of government service still has problems with real-time and consistency of information sharing and non-trust, especially involving cross-level, cross-department, cross-platform, cross-system business collaborative information exchange and sharing. For example, some personal basic data of the public will not be shared with other departments after collected and stored in a certain department, or other departments may not update the storage collected from other departments in time, which requires the public to undertake the responsibility of “proving themselves” when they have to conduct business in one department or other. Furthermore, the division of government departments and the repeated construction of the system lead to difficulty and possibility in the connection of information sharing channels because due to a lack of trust, many departments are unwilling to share and due to the hidden dangers of information sharing security issues, many departments, fear of taking responsibility, do not dare to share.

Blockchain technology provides a secure and trusted environment for cross-level, cross-departmental data connectivity. The blockchain allows government departments to independently authorize accessors and data access, record data call behaviors, and accurately track data breaches, significantly reducing the security risks of e-government data sharing and improving law enforcement efficiency.

In this field, several cities have already taken the first step. By applying blockchain technology to government services, the Zhuzhou Municipal government of Hunan Province has established a blockchain sensitive data auditing platform, using blockchain technology to record sensitive data operations, forming a strong auditing business log, which can trace the operational history behavior[4]. Chancheng District, Foshan

City, Guangdong Province succeeded in transforming of “city data” to “city block data” and accomplished data sharing across platforms, departments and regions[5]. Shanxi Province uses blockchain technology to create a "Shanxi Digital Communication" government data sharing system, making attempts to a smooth exchange of government data, compliance sharing, and succeeding in conducting a new model of government service with clear responsibility, credibility and, security.

3.2 Blockchain-enable data sharing in energy

Energy data sharing has a wide range of application scenarios, which can be divided specifically into energy production and regulatory data sharing and energy transaction data sharing.

In the application scenario of energy production and regulatory data sharing, Wu et al.[6], taking the management of smart grid as an example, pointed out that in the traditional smart grid, the wireless sensor node monitors the operation of the grid equipment in real time and periodically uploads the grid data collected through the neighboring data acquisition base station to a trusted central node for storage and sharing. This centralized data storage method faces a series of information security issues like centralized malicious attacks, single-point failure of central nodes and malicious tampering of data stored in data centers.

While in the application scenario of energy transaction data sharing, Wang et al.[7] took the residual electricity trading of household photovoltaic power plants as an example. He pointed out that the current energy trading mode, usually using centralized management and control institutions, puts a heavy burden on the centralized management agencies, which, as a result, making it even less efficient than decentralized methods in some cases. Yang et al.[8] believed that there exists other defects in this type of centralized management and control methods, such as (1) Privacy and security of user data is difficult to be guaranteed, too much interaction information is required and there is difficulty in finding solutions. (2) Information security problems exist. (3) Basing mostly on a certain statistical probability, it is difficult to achieve real-time control of schedulable resources. She et al.[9] pointed out that most of the current distributed energy trading systems use centralized data storage to centrally store all the transaction details, threatening the security and stability of energy transactions. Once the system is compromised, it may cause irreparable damage. In addition, there are mismatches and inconsistencies among energy transactions, energy circulation on physical networks, and capacity programs of each unit.

The above scholars propose a class of distributed energy transaction authentication model based on alliance chain, which optimizes the traditional energy transaction mode through blockchain equity proof, data encryption, time stamp, and distributed consensus, solves the problem of data being too centralized by using distributed shared ledger, and protects the private data of the parties to a certain extent with the data separation method, improving information transparency and automatic certification level of distributed energy transactions.

3.3 Blockchain-enable data sharing in finance

Financial reference is a major application scenario of financial data sharing. Credit, serving as the base of internet finance, plays a huge role in individual lending and investment. Through the multi-party sharing of credit data, the user's holographic image data is obtained to make a comprehensive analysis of the user's credit, which can eliminate the asymmetry of the information and conduct the user's credit evaluation more completely and comprehensively.

Ju et al.[10] think that the Internet is full of false, repeated and low-quality data， and the data of enterprises, governments, and departments are stored in their respective central databases，causing a prominent data isolation problem. In addition, there are risks such as data being leaked, tampered with and abused. These problems invisibly increase the credit cost between people, between industries, and as well between people and industries.

They summarized the traditional credit information system and believed that the existing credit information system exists defects such as non-uniformity of credit evaluation standard and poor portability of credit evaluation results.

In February 2018, Suning Finance launched the financial industry blockchain-based blacklist sharing platform system and encrypted the blacklist data of financial institutions in the blockchain so that financial institutions can access the alliance chain through independent deployment nodes and develop blockchains-based blacklist data uploading and querying services. Through the blockchain technology, the platform realizes the decentralized blacklist sharing mode without operating agencies and solves the pain points of the industry, such as undisclosed blacklist data, unfocused data, and difficulty in data obtaining. Furthermore, its low cost effectively reduces financial institutions, thus protects the privacy of customers and the interests of financial institutions.

Another application scenario for financial data sharing is point information sharing. The points system refers to providing a mature member point system and a rich membership card system service for banks/enterprises, also providing member stored value system application and member point card marketing solutions. Consumers will encounter different points systems such as banks, businesses, and institutions in the process of consumption. These credit systems are closed in their own organizations and cannot be used universally, resulting in difficulty in integrating points and low utilization rate. In addition, each organization has its own user database, which can be used to know the user's personal identity information, having risks in protecting the user's privacy. Also, the point data has risks of being tampered with, and cannot guarantee information security. The integral system of each institution is complicated, and it is impossible to accurately formulate a balanced exchange ratio.

Based on the blockchain technology, Zhong'an Technology's polar line platform realizes the use of more points in the process without revealing the user information. Through the public security link, the technology and other chain points are used for cross-chain management, thus forming a Points Alliance. Based on blockchain technology, Zhong'an Technology turns the two account books of the original merchants and suppliers into the same account books, which are shared by the same blockchain. The mutual trust of data and synchronization of information flow and capital flow between the two sides can realize the free reconciliation between the merchants and suppliers and the real-time allocation of settlement funds. Zhong'an Technology's polar line platform provides a set of points distribution and point consumption tools for users with business operations, helping merchants to build their own points malls quickly and at low cost, so that to make it simple, convenient and low-cost for small and micro enterprises to use the points to operate users.

3.4 Blockchain-enable data sharing in IoT

As an extended network based on the Internet, the Internet of Things (IoT) can realize information exchange and communication by applying computer technologies such as intelligent sensing, identification technology, and pervasive computing. Similarly，it can meet the requirements of the deployment and operation of blockchain systems. In addition, since the blockchain system network is a typical P2P network with distributed heterogeneous features, the Internet of Things naturally has distributed features. Each device in the network can manage its roles, behaviors, and rules in interaction, strongly supporting the establishment of a consensus mechanism for blockchain systems.

Traditional IoT devices are extremely vulnerable, data is vulnerable to loss and maintenance costs are high. Typical information security risk issues for IoT devices include low firmware versions, lack of security patches, privilege vulnerabilities, excessive network ports on devices, unencrypted information transfers and so on. Blockchain, with the consensus mechanism for network-wide node verification, asymmetric encryption

technology, and distributed data storage, can greatly reduce the risk of hacker attacks. So the use of blockchain technology in sharing IoT data can greatly improve the level of security.

3.5 Blockchain-enable data sharing in healthcare

The verification, preservation, and synchronization of medical records have always been a difficult point in the healthcare industry. There are strict restrictions when patients and doctors access and share medical data, which require a lot of resources and time for permission review and data verification. Users have to struggle for obtaining medical data, and they need to submit an application to an organization like the Health Information Exchange (HIE) and the Total Population Database (APCD) every time they want it. What's worse, there are many problems in the entire response process such as slow response, data tampering and insecure data transmission. And all of these have seriously hindered the development of smart medical and medical big data.

Luckily, the birth of blockchain technology has steadily changed the traditional way of centrally storing medical data in the medical industry. At present, there are many decentralized medical data sharing platforms in foreign countries, such as Encrypgen, Health Nexus, Luna Coin, MedRec, Nebula Genomics, Opal/Enigma, Shivom, Zenome.io and so on[11].

3.6 Blockchain-enable data sharing in machine learning

In big data era, the problem is not a lack of data, but how to find value and mine value from massive data and machine learning is currently a very popular answer for this question. And the quality of the machine learning model is closely related to the dimensions, quantity, and quality of the data. For data companies such as Facebook, Google, Amazon, Didi, Taobao, etc., on the one hand, their data mining algorithms have a very urgent need for large and multi-dimensional data, however on the other hand, because of the restrictions of data transactions, the risk of violation of direct data transactions is very high, considering privacy protection of user data. Especially in recent years, the European GDPR (General Data Protection Regulations) has been introduced, and the requirements for data privacy protection have become more stringent. Under these circumstances, data merging and data sharing have become a viable solution as data cannot be directly exchanged and data companies want data from other companies to analyze and commercialize.

At present, some scholars have proposed a data sharing improvement scheme based on federated learning. The method of federated learning indicates that users learn through a joint machine learning model to avoid getting data directly from the data owner[12]-[14]. For the distrust of data exchange, some scholars proposed a data sharing improvement scheme integrated blockchain technology depend on the base talked above. To guarantee the credibility of their identity, it restricts the identity of participants by introducing smart contracts on the blockchain[15].

4. TECHNICAL ARCHITECTURE AND PROPOSAL OF DATA SHARING BASED ON BLOCKCHAIN

In this section, we summarized schemes and models of data sharing based on blockchain in several industries above[16]-[20]. It is found that blockchain-based data sharing mostly takes the form of alliance chain, following a private chain and public chain scheme. The potential reason for this kind of pattern might be the concern to ensure the security of data sharing. In the alliance chain, multiple industry units form an alliance and then, the members of the alliance can maintain blockchain data while other unauthorized nodes cannot contact them. And in the private chain, only internal users can maintain blockchain data[21]. Therefore, compared with the public chain, the alliance chain, and the private chain is easier to control, whether in security factor or other. The form of blockchain-based data sharing is essential because adopting an appropriate access control strategy

to prevent malicious nodes from accessing and monitoring the network can fundamentally enhance the protection capability of the network layer.

5. CONCLUSIONS

To conclude, despite the very need for data sharing, there are still many problems remaining in traditional data sharing approaches, e.g. the monotony of data storage easily leading to attacks, lack of trust between data sharing entities and opacity of data asset transactions. Blockchain technology can solve some problems of industry data sharing in the big data environment due to its characteristics of decentralization, trustless, collective maintenance, programmability, data non-tampering, unforgeability, peer-to-peer transmission, and anonymity.

In this paper, we summarized the current cases of using blockchain technology for data sharing domestic and overseas, and outlined the main industries and application scenarios of blockchain-based data sharing:(1) medical data sharing (2) government data sharing (3) energy data Sharing (4) financial data sharing (5) IoT data sharing and (6) machine learning data sharing. We also compared data sharing based on traditional way and blockchain technology, analyzed the shortcomings of data sharing in the traditional way from aspects such as data storage and data analysis, and outlined the four advantages of blockchain-based data sharing. Moreover, we summarized the current technical architecture and proposal of blockchain-based data sharing globally. It is found that the architecture of the alliance chain is the most mainstream in blockchain-based data sharing.

The shortcoming of this paper is that the accumulation of relevant research abroad is still insufficient. The lack of comparison of technical solutions in the same field around the world is also a limitation of the research at present.

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