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Research Article

Application of the Blockchain Technology in the Vertical Value Chain Management of Enterprises

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This paper studies how the blockchain technology applies the enterprise's vertical value chain management and specifically studies how the blockchain technology is applied to the management of various transaction information involved in the enterprise's vertical value chain management. This paper first analyzes the basic needs of the enterprise vertical value chain management, analyzes the decentralization, integrity, and authenticity of relevant transaction information in management, and designs and implements enterprise value chain management solution based on the blockchain technology, including the design and implementation of organizations, consensus mechanisms, data structures, and business processes. The simulation data is used for testing, and finally, the solution is evaluated in terms of security, transparency, efficiency, and scalability. The research in this paper shows that the blockchain technology can be applied to the enterprise's vertical value chain management, which can ensure the authenticity, transparency, tamper resistance, and security of various transaction information of enterprises, thus improving the quality and reliability of the vertical value chain management of enterprises.

1. Introduction

On November 1, 2008, Satoshi Nakamoto first proposed the concept of blockchain in *Bitcoin: A Peer-to-Peer Electronic Cash System*, which attracted wide attention from the general public. Blockchain technology attracts investors with its decentralized characteristics and is considered to be a potential technology that will bring about major changes to human society in the future.

In *Bitcoin: A Peer-to-Peer Electronic Cash System* published by Satoshi Nakamoto in 2008, it is pointed out that blockchains are data structures used to record the history of bitcoin transactions. In addition, Wikipedia likens blockchain technology to a distributed database technology, which can maintain a continuously growing and tamper-resistant data record by maintaining the chain structure of data blocks [1].

The concept of a value chain was first proposed by Michael Porter in his book *Competitive Advantage* in 1985 [2], who held that an enterprise is a collection of interrelated but separated activities, all of which constitute the value creation of an enterprise, and that formation and change of the value chain are caused by the market demand [3]. The competitiveness of an enterprise is reflected on all the activities in the value chain, but not all links of the value chain can produce value; only a few specific links can [4]. Porter classified the value chain into two categories: basic activities, which include the activities of internal logistics, production, marketing external logistics, and service, and ancillary activities, which include enterprise infrastructure, technology development, procurement, and human resources. These separate and interrelated activities constitute the dynamic process of corporate value creation, which is called the value chain [5]. Value chain analysis methods can be divided into three types: vertical value chain analysis, horizontal value chain analysis, and internal value chain analysis [6].

Unlike Porter's emphasis on internal value chains, vertical value chains are defined as a chain of value creation and value transfer between suppliers, businesses, and buyers, each providing a variety of activity links that form a chain [7], ranging from the initial supplier of raw materials to the final buyer of final products. For an enterprise, its vertical value chain is represented by the relationship between the enterprise and upstream suppliers and downstream buyers or consumers [8]. The vertical value chain and the internal value chain of

an enterprise are interrelated and interdependent, which form an organic whole and serve the strategic objectives of the enterprise together [9].

Since the information related to the transaction is held by each transaction participant separately, there is a technical single point of risk in the traditional vertical value chain management. Transaction information is low in transparency, easy to be tampered with, and difficult to be traced and has a low degree of trust. This paper designs a solution for enterprise value chain management based on blockchain technology by using the characteristics of blockchain's decentralization, immutability, and untrustworthiness. This solution can not only fundamentally solve the technical single-point risk in traditional vertical value chain management but also help improve the quality and reliability of enterprise vertical value chain management.

2. Design of Solutions to Enterprise Vertical Value Chain Management Based on the Blockchain Technology

2.1. Demand Analysis of Enterprise Vertical Value Chain Management Based on the Blockchain Technology. In the demand analysis of vertical value chain management, the enterprise is regarded as a link in the value production process of the whole industry to analyze the relationship between the upstream and downstream enterprises, to discover the demand in optimizing the relationship with them.

Vertical value chain management involves the management of various transactions, including the management of its procurement, sales, logistics, and funds. Purchasing management and sales management are the core content of vertical value chain management, and the vertical value chain of an enterprise can be optimized based on them.

In the traditional transaction model, the accounting process of the enterprise transaction involved in the vertical value chain management is independently completed by transaction participants, so that it is difficult to discover the omission of transaction information and multiple recorded errors among transaction participants in time. They are often discovered when the transaction information is found inconsistent with the actual books or the auditing is performed. Therefore, the independent custody of transaction information by all parties is a risk that the traditional transaction model cannot solve.

Longitudinal value chain management is applied to blockchain technology, which allows a set of ledgers to be maintained by both parties involved in purchasing management and sales management. Moreover, all relevant transaction information, including purchasing, sales, logistics, and cash flow, can only be written into the blockchain ledger with the unanimous consent of the relevant parties. Trading participants can query related transactions at any time without restrictions from other parties, including historical transaction information, historical update information, and historical deletion of transaction information. For transaction participants, the blockchain ledger is a transparent, tamperproof, traceable, and trustworthy shared ledger endorsed, thus ensuring the consistency, tamper resistance, and transparency of transaction information between related parties in the vertical value chain from the source and eliminating the risk of inconsistency and tampering of ledgers caused by traditional independent accounting.

As the information in the blockchain ledger is shared and trustworthy, there is no need to reconcile between the relevant parties when entering relevant transaction information, thus improving transaction efficiency.

In addition, enterprises can use programmable smart contracts to implement their business logic in the blockchain platform. Because the programming language of smart contracts is Turing complete and can access the various resources of the enterprise as needed, which enables them to implement various complex business logic and automatically execute smart contract codes written in advance and related businesses, including procurement, sales, logistics, cash settlement, and other businesses, as well as high-level businesses such as data analysis, statistics, and early warning, it can ensure business security while greatly providing business efficiency. Improving the level of vertical value chain management.

The demand for vertical value chain management of enterprises based on blockchain technology analyzed in this paper includes the following contents:

2.1.1. Decentralization of Transaction Information. In the traditional transaction mode, the accounting process of transactions is carried out by two or more parties of the buyer and the supplier, each of which has an independent set of ledgers. The transaction participants each have a set of independent ledgers, and they only maintain their own ledgers.

Blockchain technology, such as consortium blockchain, enables buyers and suppliers to distribute their own nodes in the consortium blockchain network, which can be freely connected to exchange transaction data, information, and assets, to maintain a set of ledgers together. Transaction information recorded in the ledgers is endorsed by relevant parties and recorded in each node of the consortium blockchain to achieve true decentralization.

2.1.2. Integrity of Transaction Information. Enterprises need to manage and maintain all necessary information with suppliers, sellers, transporters, and banks, including purchase and sale transaction information, logistics information, cash flow information, and related contracts.

Ensuring the integrity of transaction information is an important responsibility for an enterprise to safeguard the security of transactions and the legal rights and interests of the enterprise.

2.1.3. Authenticity of Transaction Information. The authenticity of transaction information, including the authenticity of transaction information content. The correctness of transaction data and the trustworthiness of transaction data are an important basis for enterprise accounting, enterprise decision-making, and management and an objective basic requirement for the quality of enterprise accounting information.

2.1.4. Tamper Resistance of Transaction Information. The immutability of transaction information means that the relevant participants cannot hide or individually modify the transaction information that has occurred. The transaction information queried by each participant is the same information that was originally recorded.

2.1.5. Traceability of Transaction Information. Trading information traceability refers to the ability of trading participants to trace the relevant transaction history information and to query and obtain the transaction history information without restriction by others.

2.1.6. Transparency of Transaction Information. Transparency of transaction information means that the transaction information is open, transparent, and accessible to the participants and the participants are not restricted by other parties to obtain transaction information.

2.1.7. Efficiency of Transaction Information. Transaction efficiency refers to the comparison of the cost and time to complete an exchange with the results achieved. The transaction system can realize the basic functions of the transaction procedure and has low cost of learning and maintenance.

2.1.8. Application of Transaction Information. The application of transaction information refers to providing support for further decision-making, improving the efficiency and level of enterprise management and further enhancing the enterprise value through data analysis and information discovery based on various transaction information recorded in the course of the transaction.

2.2. Enterprise Vertical Value Chain Management Solution Based on the Blockchain Technology. Based on the basic needs of enterprise vertical value chain management, this paper designs and implements an enterprise value chain management solution based on the blockchain technology, including the design and implementation of transaction organization, consensus mechanism, data structure, and business process. The application of the blockchain technology to the management of the enterprise's vertical value chain can ensure the transparency, traceability, immutability, and authenticity of various transaction information of the enterprise, thereby improving the quality and reliability of the enterprise's vertical value chain management.

2.2.1. Design of the Organizational Structure. The organization referred to in this paper refers to a consortium of some nodes with transaction, accounting, and endorsement functions in the vertical value chain, where "node" usually represents one or more servers with transaction, accounting, or endorsement functions and usually jointly assumes the corresponding functions of an enterprise or a department in an enterprise, such as purchasing and sales.

Enterprises in the vertical value chain are interrelated by purchasing and selling activities. Therefore, the vertical value chain management involves buyers, suppliers, transporters, and banks. The typical transactions involved in the vertical value chain management cannot be separated from the participation of these four parties. According to the different functions of participants in the transaction, four organizations are set up in this paper: buyer organization, supplier organization, transporter organization, and banking organization. These four organizations participate in the consensus and maintenance of the blockchain ledgers.

2.2.2. Design of the Consensus Mechanism. As the block chain studied in this paper is a coalition block chain, consensus mechanism is reached between alliance participants. Every transaction can be recorded in the blockchain ledger after the alliance participants reach consensus.

When wanting to reach a consensus on a certain transaction, each participant first writes the information related to the transaction into their own temporary ledgers. As a consensus initiator, one of the participants first sends relevant information and endorsement request to its endorsement node, and then the endorsement node sends it to the endorsement node of others. Next, the endorsement nodes of other participants will verify the information with the information in their own temporary ledgers. Finally, after the endorsement node of the consensus initiator collects all the information with the signatures of the participants, it is included in the blockchain ledger. The specific process is shown in Figure 1.

2.2.3. Design of the Data Structure. The following data structure is designed in this paper according to the participants and related transactions involved in vertical value chain management:

The structure of transaction data, a common standard for the records of the transaction between the buyer and the supplier, is mainly used to record the format of the transaction information that is convenient for the exchange of the transaction information between the buyer and the supplier. The transaction data includes the transaction number, transaction creation time, logistics number, cash flow number, transaction status and remarks, and other transaction information.

The structure of logistics data, a common standard for the records of the logistics among the buyer, the transport enterprise, and the supplier, is mainly used to record the logistics information in a form that is convenient for the exchange of the logistics information among the buyer, the transport enterprise, and the supplier. The logistics data includes the logistics number, logistics creation time, cash flow number, logistics status and remarks, and other logistics information.

The structure of cash flow data, a common standard for the records of the cash flow among the buyer, the bank, and the supplier, is mainly used to record the cash flow information in a form that is convenient for the exchange of the cash flow information among the buyer, the bank, and the supplier. The cash flow data includes the cash flow number, cash flow creation time, bank statement number, cash flow status and remarks, and other cash flow information.

The structure of organization information data is a format used to record organization information, which facilitates the identification and maintenance of identity information

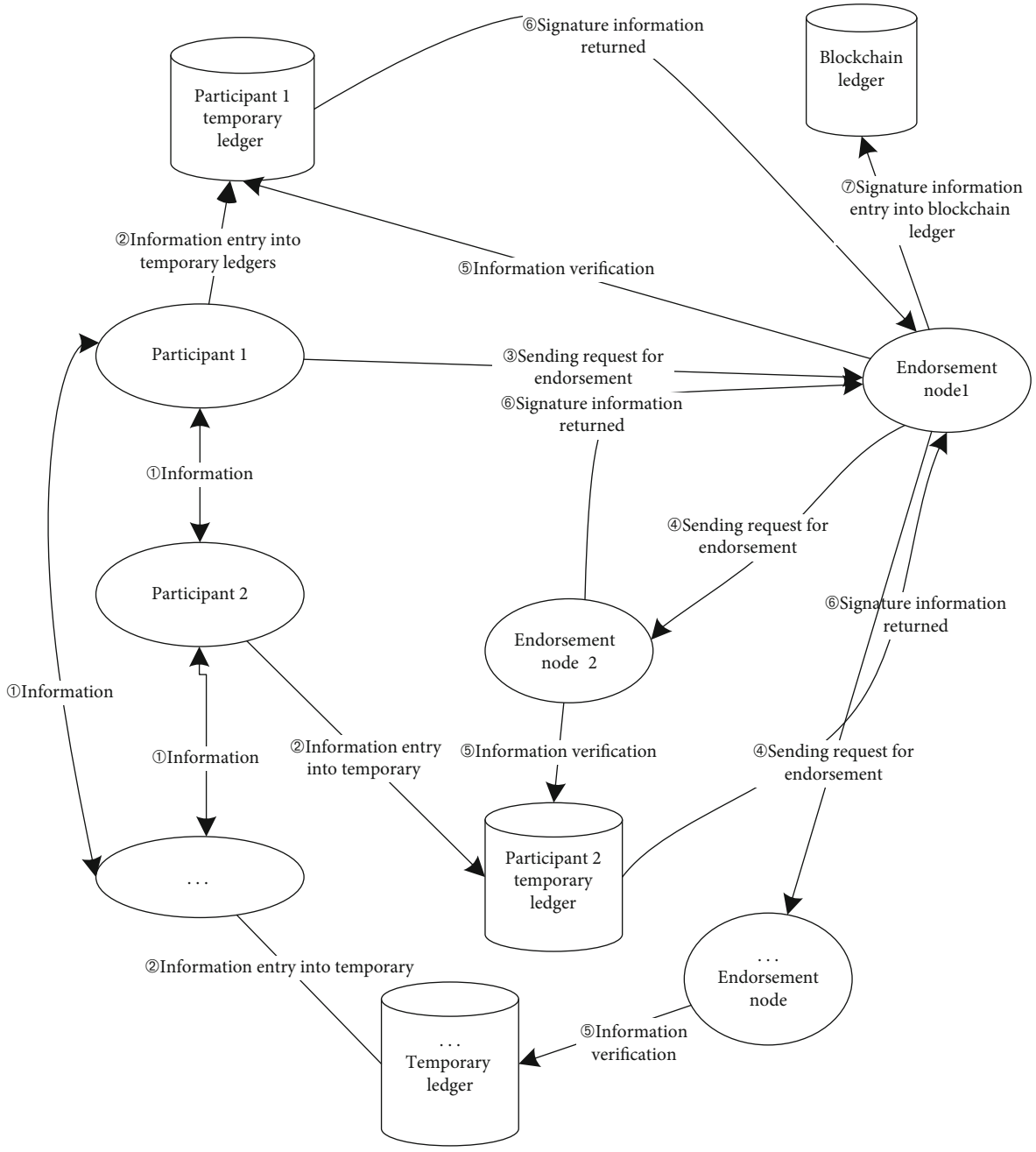

Figure 1: Information consensus process based on the blockchain technology.

between the buyer, the supplier, the transporter, and the bank. The organization information data mainly includes the organization number, organization name, organization domain name, organization address, organization creation time, organization modification time, organization status, and other organization information.

Taking the transaction data structure as an example, the implementation code is

2.2.4. Design of the Business Process. The vertical value chain management process in this paper involves four main bodies: the supplier, buyer, transporter, and bank. In a typical vertical value chain, the enterprise is both the supplier and the buyer. Therefore, this paper mainly studies the content of related processes that the enterprise as a supplier involves upstream vertical value chain management and as a buyer involves downstream vertical value chain management.

In this paper, the business involved in enterprise vertical value chain management based on the blockchain technology is divided into three tiers; the upper tier is based on its lower tier, and the next tier provides services for its upper tier. At the bottom is the business related to the reading and writing of blockchain ledgers, at the middle is the business related to basic transactions, and at the top is the business related to purchasing

```
// Transaction information structure
type Transaction struct {
Transaction ID string //Transaction ID e.g. tx0001
Logistics ID string //Logistics ID e.g. pd0001
Cash Flow ID string //Cash Flow ID e.g. fd0001
Create Time int64 //Transaction creation time Unix time
Change Time int64 //Transaction modification time Unix time
State string //Transaction status
Type string //Transaction type
Mode string //Transaction method
Remark string //Transaction Remarks
Product ID string //Product ID
Product Name string //Product Name
Unit string //Unit
Count int //Quantity
Price int //Unit price
Total int //Total price
Attrs map[string]string //Other attributes
}
```

Code 1 .

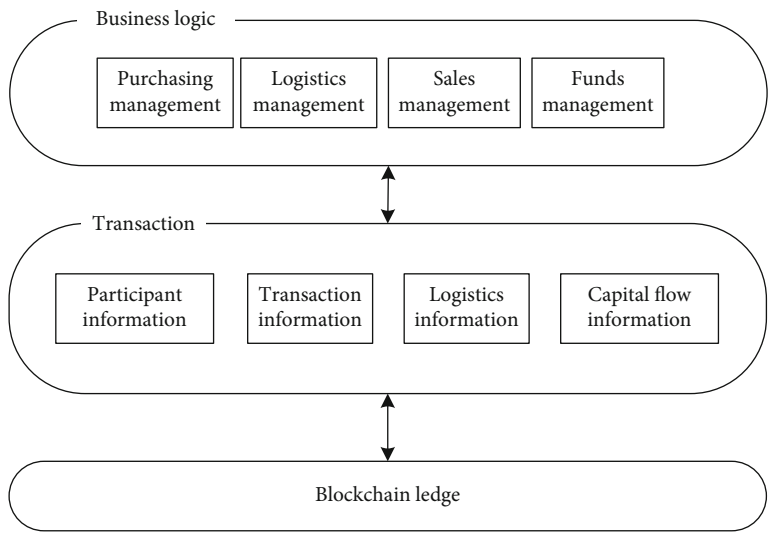

Figure 2: The three-tier structure of the business processes.

management, logistics management, sales management, and fund management. The three-tier structure is shown in Figure 2.

2.2.5. Design of the Transaction Process. In traditional transactions, the buyer-seller transaction generally involves the supplier, the buyer, the transporter, and the bank. The transaction request can be initiated by the buyer or the supplier, mostly by the buyer, which is also the case in this paper. After the purchaser generates the product demand, it sends the product demand information to the supplier and initiates the transaction request. After negotiation, the supplier signs a sales contract with the buyer to conclude the transaction and entrusts the transportation enterprise to transport the products. The transportation enterprise delivers the products to the buyer who entrusts the bank to pay, and the bank pays to the supplier, in which the supplier delivers the goods first or the buyer pays first depending on the contract between the two parties. For the convenience of research, this paper considers the case that the supplier delivers goods first. The transaction process is shown in Figure 3.

In the traditional transaction model, the accounting process of the transaction is completed by the buyer and seller separately. So the both parties are prone to errors, omissions, and multiple records of the transaction information, which are difficult to be discovered by both parties to the transaction until the account books are unbalanced or audited. Once errors are found, not only a large number of manpower, financial, and material resources are needed but also problems such as inconsistent accounting of transaction information may be difficult to be traced and dealt with. Therefore, the transaction information is kept independently

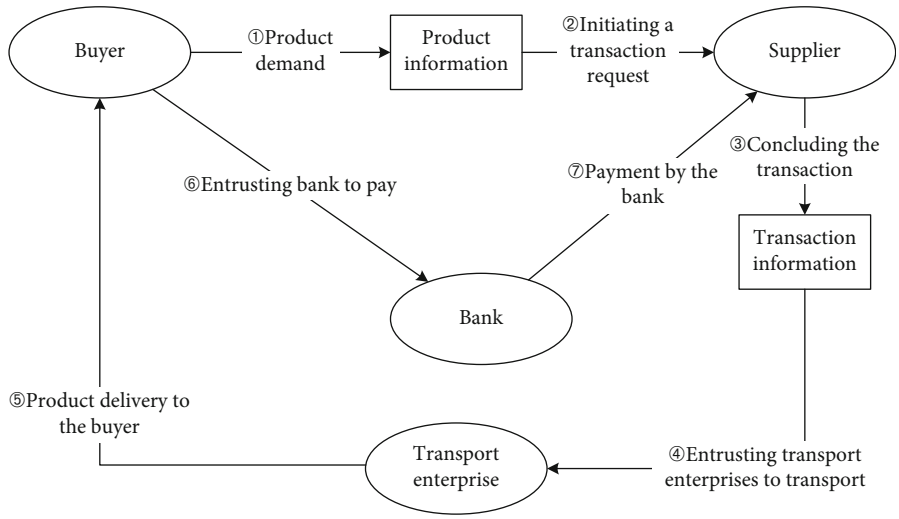

Figure 3: Traditional transaction process.

by all parties, which makes it difficult for the traditional transaction mode to solve the technical single-point risk.

Longitudinal value chain management is applied to blockchain technology, which allows a set of ledgers to be maintained by both or many parties involved in purchasing management and sales management. Moreover, all relevant transaction information, including purchasing, sales, logistics, and cash flow, must be unanimously approved by the relevant parties before it can be written into and updated to the blockchain ledger. Trading participants can query related transactions at any time without restrictions from other parties. For transaction participants, the blockchain ledger is a transparent, tamperproof, traceable, and trustworthy shared ledger endorsed, thus ensuring the consistency, tamper resistance, and transparency of transaction information between related parties in the vertical value chain from the source and eliminating the risk of inconsistency and tampering of ledgers caused by traditional independent accounting. As the information in the blockchain ledger is shared and trustworthy, there is no need to reconcile between the relevant parties when entering relevant transaction information, thus improving transaction efficiency.

In the transaction process of vertical value chain management based on the blockchain technology, the buyer, the transporter, and the supplier jointly maintain the ledgers related to logistics in the transaction. The transaction information included in the logistics ledgers is signed by the buyer, the transporter, and the supplier and cannot be tampered with by any single party and is transparent and traceable to any of them.

The buyer, the bank, and the supplier jointly maintain the ledgers related to the transactional capital in the transaction. The transaction information included in the capital ledgers is signed by the buyer, the transporter, and the supplier and cannot be tampered with by any single party and is transparent and traceable to any of them.

The transporter, the bank, and the supplier jointly maintain the ledgers related to the capital for the transport transaction in the transaction. The transaction information included in the transport capital ledgers is signed by the transporter, the bank, and the supplier and cannot be tampered with by any single party and is transparent and traceable to any of them.

2.2.6. Design of the Organization Information Maintenance Process. The buyer sends the latest information after the initialization, updating, and deletion of organization information to the supplier for endorsement confirmation. Each party will write the latest buyer organization information to the temporary ledgers. Upon confirmation of endorsement by the supplier and the buyer, the latest buyer organization information will be recorded in the blockchain ledger.

The supplier sends the latest information after the initialization, updating, and deletion of organization information to the supplier for endorsement confirmation. Each party will write the latest supplier organization information to the temporary ledgers. Upon confirmation of endorsement by the supplier and the buyer, the latest supplier organization information will be recorded in the blockchain ledger.

The transporter sends the latest information after the initialization, updating, and deletion of organization information to the buyer and supplier for endorsement confirmation. Each party will write the latest transporter organization information to the temporary ledgers. Upon confirmation of endorsement by the supplier, the buyer, and the transporter, the latest transporter organization information will be recorded in the blockchain ledger.

The bank sends the latest information after the initialization, updating, and deletion of organization information to the buyer and supplier for endorsement confirmation. Each party will write the latest bank organization information to the temporary ledgers. Upon confirmation of endorsement by the supplier, the buyer, and the bank, the latest bank organization information will be recorded in the blockchain ledger.

The transaction process using the blockchain technology is shown in Figure 4.

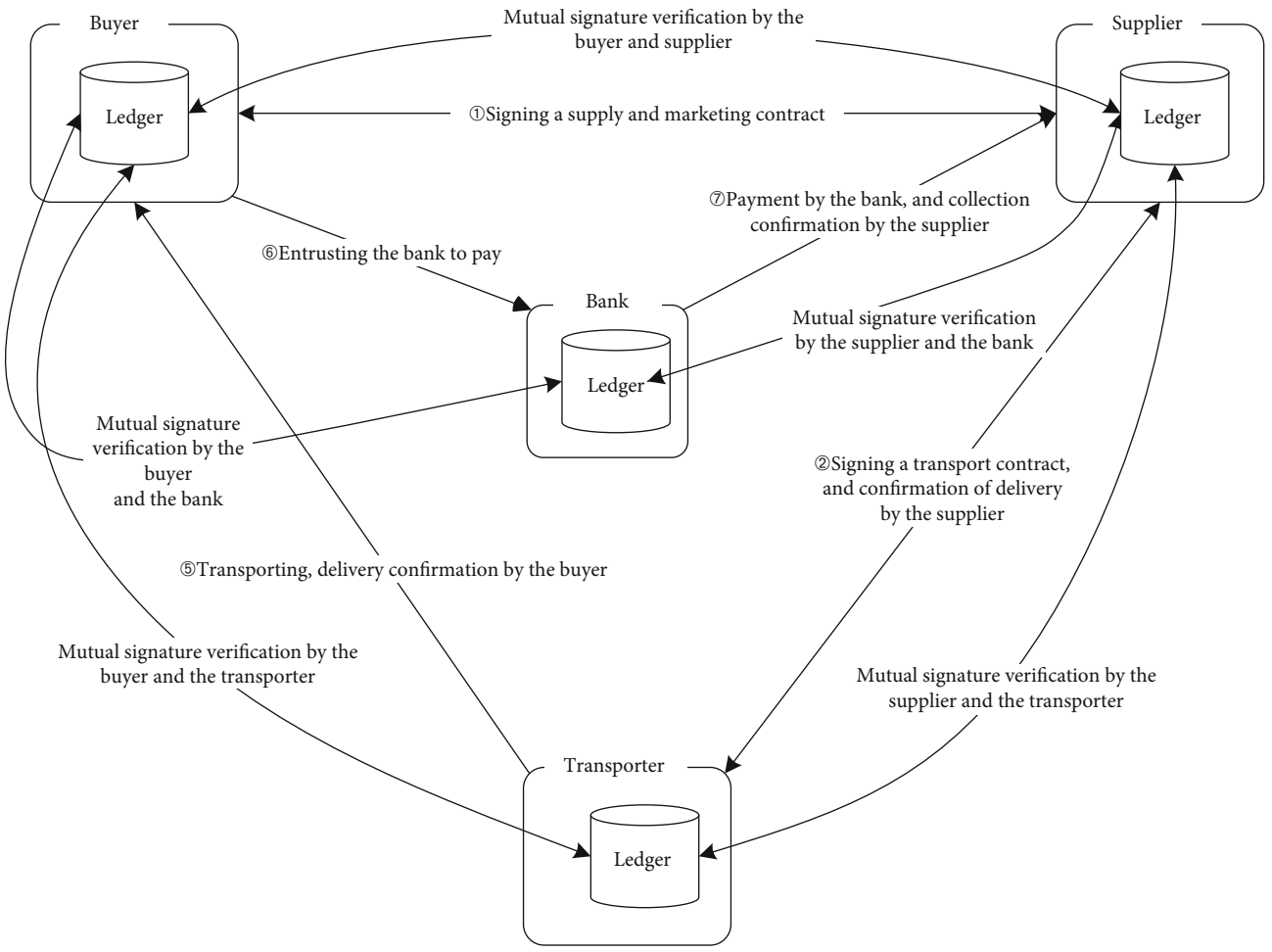

Figure 4: Transaction process using the blockchain technology.

2.2.7. Design of the Business Logic. Business logic is based on transactions between buyers and suppliers. On the basis of the data generated by transactions, business logic of enterprises provides a higher level of application, including purchasing management, supply management, logistics management, and fund management. Due to the need for research purposes and limited space, this paper only lists some basic business logic as follows:

(I) The business logic content of purchasing management

(1) Query for purchase: enter the transaction number to query the purchase of certain goods or the time period parameter to query good purchase in a certain time period

(2) Query for exchange: enter the transaction number to query the exchange of certain goods or the time period parameter to query good exchange in a certain time period

(3) Query for return: enter the transaction number to query the return of certain goods or the time period parameter to query good return in a certain time period

(4) Query for purchasing logistics: enter the transaction number to query the purchasing logistics of certain goods or the time period parameter to query purchasing logistics in a certain time period.

(5) Query for the payment for purchasing: enter the transaction number to query the payment of certain goods or the time period parameter to query the payment for goods in a certain time period

(6) Purchasing statistics: query the purchasing information of certain goods in a certain time period according to the commodity information

(7) Query purchase per day: count the purchase of goods on a certain day

(II) The business logic content of sales management

(1) Sales query: enter the transaction number to query the sales of certain goods or the time period

parameter to query commodity sales in a certain time period

(2) Query for exchange: enter the transaction number to query the exchange of certain goods or the time period parameter to query good exchange in a certain time period

(3) Query for return: enter the transaction number to query the return of certain goods or the time period parameter to query good return in a certain time period

(4) Query for distribution logistics: enter the transaction number to query the distribution logistics of certain goods or the time period parameter to query distribution logistics in a certain time period

(5) Query for the payment for sales: enter the transaction number to query the payment of certain goods or the time period parameter to query the payment for goods in a certain time period

(6) Sales statistics: to query the sales information of certain goods in a certain time period according to the commodity information

(7) Query sales per day: count the sales of goods on a certain day

(III) The business logic content of logistics management

(1) Query for logistics: enter the logistics number to query the logistics of certain goods or the time period parameter to query logistics in a certain time period

(2) Logistics expenses statistics: count the logistics cost in a certain time period

(3) Logistics time inquiry: enter the logistics number to query logistics updating of specific goods

(4) Logistics time statistics: count the logistics time in a certain time period

(IV) The business logic content of cash management

(1) Query for cash flow: enter the cash flow number to query the cash flow of certain goods or the time period parameter to query cash flow in a certain time period

(2) Statistics of cash flow expenses: count the cash flow expenses in a certain period of time

(3) Cash flow time inquiry: enter the cash flow number to query the cash flow updating of certain goods

(4) Statistics of cash flow time: count the time consumption of the cash flow in a certain period of time

(V) The business logic content of organizational information management

(1) Query for organizational information: enter the organizational number to query the current information of a certain organization

(2) Statistics of organizational information: count the change in organizational information in a certain period of time

(3) Query for historical organizational information: enter the organizational number to query all the historical information of a certain organization

3. Realization of Solutions to the Vertical Value Chain Management of Enterprises Based on the Blockchain Technology

The Hyperledger Fabric platform is set up in the Ubuntu system by using Docker environment, in which the version is v1.3.0.

(1) Organizational structure configuration which includes the ordering organization, bank organization, shipper organization, buyer organization, and seller organization is set up. There are three consortiums configured under the consortium node. The first is the Transaction Consortium, which consists of two organizations, the supplier and buyer. The second is the Logistics Consortium, which consists of three organizations, the shipper, seller, and buyer. The third is the Cash Flow Consortium, which consists of three organizations, the bank, seller, and buyer

(2) The application channel configuration template contains three channels, which enable specific peer nodes and applications in the blockchain network to interact. The first application channel is the Transaction Orgs Channel, in which a transaction consortium is configured, including two organizations, the supplier and the buyer. The second application channel is the logistics channel, in which a logistics alliance is configured, including the transporter, the supplier, and the buyer. The third application channel is the capital flow channel, in which the capital flow alliance is configured, including the bank (bank), the supplier (seller), and the buyer (buyer). Default parameters are configured in the three application channels

(3) In Docker, the mirrors and containers required by the Hyperledger Fabric environment are defined by docker-compose.yaml. Docker can use docker-Compose.yaml to start containers required by multiple

Hyperledger Fabric environments. Docker Compose.yaml mainly consists of two parts, networks and services

(4) In this paper, the function of the Hyperledger Fabric client is realized through fabric-sdk-go, by firstly installing the package related to fabric-sdk-go so that fabric-sdk-go is installed via go get—u http://github.com/hyperledger/fabric-sdk-go, secondly encapsulating the relevant API of fabric-sdk-go for client use, and finally initializing fabric-sdk by writing config.yaml

(5) Chaincode is a program written in Go, node.js, or Java that implements a specified interface and runs in a secure Docker container isolated from supporting peer-to-peer processes, which initializes and manages the ledger status through transactions submitted by the application

In this paper, the chaincode of basic business logic required in this paper is mainly implemented in Go language and the transaction information structure is implemented in the datastruct folder; the transaction process is implemented in each folder under chaincode/transaction; the logistics process is implemented in each folder under chaincode/logistics; the cash flow process is implemented in each folder under chaincode/capitalflow; the information maintenance process is implemented in files ending Invoke.go in various folders under chaincode (Table 1).

4. Testing and Evaluation on Solutions to Enterprise Vertical Value Chain Management Based on the Blockchain Technology

4.1. Testing on Solutions to Enterprise Vertical Value Chain Management Based on the Blockchain Technology. Due to the nonforeseeability of the formal system and the limitation of the code language, there are some flaws in the software [10]. Software testing, as an important part of the whole software development process [11], is to find out the defects and errors in the design and operation process of the software through various tests of the software, analyze and sort out the test results specifically, to evaluate the software, and provide evidence for the reliability of the system [12], with a view to ensure the high quality and reliability of software.

The test in this paper is designed to verify whether the solution achieves the functions described above and meets the requirements of enterprise vertical value chain management described above.

(1) Testing environment

The hardware environment for testing in this paper is as follows: CPU: Intel core i5-3,210 M; memory: 8 G; and hard disk: 1 T. The software environment is as follows: operating system: Ubuntu 18.04.1 LTS, Docker version 18.06.1-ce, build e68fc7a, Go language version: go1.10.4 Linux/AMD64, Hyperledger Fabric version: v1.3.0.

(2) Testing process

Testing processes are as follows:

(a) Start the completed Hyperledger Fabric environment platform

(b) Run channel creation and chaincode installation client

(c) Generate simulated transaction data

(d) Run data test client

(3) Test case

In this paper, the transaction process between the buyer and the supplier is divided into three main categories: payment before delivery, delivery before payment, prepayment before delivery, and final payment. According to the completion of the transaction, each of the three categories can be further divided into 4 types: normal completion, return, exchange, and cancellation, totaling 12 types of transaction processes. For each of these twelve scenarios, transaction data generated randomly and six products, namely, A, B, C, D, E, and F, are prepared for each transaction (Table 2).

Transaction test data, logistics test data, cash flow test data, and organizational information maintenance test data are generated based on the above product data simulation. Take transaction test data as an example (Table 3).

The transaction data of the tamperproof test for related transactions are carried out by selecting data modified unilaterally by one party. If the data can not complete the relevant transaction, the tamperproof test is successful, whereas the tamperproof test fails. In this paper, the transaction data is tampered with by prefixing the product name with "tamper." The new transaction tamperproof test data, logistics tamperproof test data, cash flow tamperproof test data, and organization information tamperproof test data are generated. Take transaction tamperproof test data as another example (Table 4).

(4) Test result

Chaincode test results are as follows, taking transaction chaincode test results as an example (Table 5).

In Table 5, the consensus and writing test results are passed, indicating that any transaction information has passed the consensus of the transaction participants and been successfully written into the blockchain ledger. The passing of the tamperproof modification test indicates that any party to the transaction cannot unilaterally tamper with the transaction information. The pass of the transparency test indicates that any party to the transaction can query transaction information. The traceability test result passed, indicating that any party to the transaction can query historical transaction information.

The test results of the business layer are as follows, taking the test results of the purchasing management business as an example (Table 6).

Table 1: Information structure implementation.

Items	Structure	Files
Structure of transaction information	Transaction	TransactionStruct.go
Structure of cash flow information	CapitalFlow	CapitalFlowStruct.go
Structure of logistics information	Logistics	LogisticsStruct.go
Structure of organization information	Organization	OrganizationStruct.go

Table 2: Product test data.

Product no.	Product name	Unit price (Yuan)	Freight (Yuan/piece)	Number of transaction (piece/time)
pd001	Product A	80–120	0.1–0.3	100–300
pd002	Product B	200–300	0.2–0.5	50–500
pd003	Product C	180–250	0.1–0.3	200–600
pd004	Product D	300–400	0.3–0.6	100–200
pd005	Product E	500–800	0.3–0.5	30–300
pd006	Product F	20–40	0.1–0.5	500–1000

The test results show that the enterprise vertical value chain management solution based on the blockchain technology achieves the expected goals using Go language based on the Hyperledger Fabric platform.

4.2. Evaluation on Solutions to Enterprise Vertical Value Chain Management Based on the Blockchain Technology

(1) In terms of security, the blockchain ledger uses distributed storage and relies on a consensus mechanism to ensure consistency between nodes. Each piece of transaction information that is entered in the blockchain ledgers cannot be tampered with without the consent of all nodes, thus ensuring the reliability and security of the transaction information stored in the distributed ledgers

(2) In terms of transparency and traceability, the data information of each transaction is entered in the blockchain ledger in the order of transaction time. The latter purchase transaction will record the previous hash value, so that the purchase transaction data entered into the blockchain ledger is continuous, accurate, and unique and cannot be tampered with. Therefore, every purchase transaction data information entered in the blockchain ledger can be retrospectively queried to facilitate the management of participants

(3) In terms of efficiency, each transaction data entered in the blockchain ledger is shared and trusted by the transaction participants through the consensus and endorsement of the transaction participants. So, they do not need to check the transaction data in the later stage, saving a lot of time and human, material, and financial resources of the enterprise

(4) In terms of expandability, enterprises can use the blockchain technology to record various transaction information and organization information in the blockchain ledger, which can be used as a basis to expand the related applications, for example, data analysis, customer management, and vendor management to support purchasing and sales decisions of enterprises and to expand the related applications of vertical value chain management

5. Research Conclusions and Suggestions

5.1. Research Conclusions. Through the above research, the following conclusions are drawn:

(1) The application of the blockchain technology in vertical value chain management of enterprises can solve the problem of inconsistency and opacity between transaction information in vertical value chain management and one party. Each piece of transaction information must be unanimously approved by all the parties and endorsed by their signatures before it can be entered in the blockchain ledger, eliminating the technical single-point risk in the vertical value chain management of the enterprise

(2) The blockchain technology can ensure the authenticity, transparency, tamper resistance, and security of enterprise purchase transaction information, sales transaction, logistics information, and cash flow information, thus improving the quality and reliability of vertical value chain management

(3) The application of blockchain in enterprise vertical value chain management enables core enterprises to share a set of trustworthy and transparent blockchain ledgers with upstream and downstream enterprises, so that they can connect more closely, optimize the transaction process between them, enhance mutual trust and transaction security, and reduce enterprise costs

Table 3: Transaction test data.

Transaction no.	Logistics no.	Cash flow no.	Product no.	Product name	Unit	Quantity	Unit price
tx00001	lg00001	cf00001	pd003	Product C	kg	355	180
tx00002	lg00002	cf00002	pd001	Product A	kg	273	90
tx00003	lg00003	cf00003	pd004	Product D	kg	149	395
tx00004	lg00004	cf00004	pd006	Product F	kg	741	33
tx00005	lg00005	cf00005	pd005	Product E	kg	91	663
tx00006	lg00006	cf00006	pd003	Product C	kg	434	235
tx00007	lg00007	cf00007	pd006	Product F	kg	942	31
tx00008	lg00008	cf00008	pd003	Product C	kg	557	221
tx00009	lg00009	cf00009	pd005	Product E	kg	99	762
tx00010	lg00010	cf00010	pd004	Product D	kg	101	318
tx00011	lg00011	cf00011	pd003	Product C	kg	454	229
tx00012	lg00012	cf00012	pd001	Product A	kg	102	100

Table 4: Transaction tamperproof test data.

Transaction no.	Logistics no.	Cash flow no.	Product no.	Product name	Name of tampered product	Unit	Quantity	Unit price
newtx00001	lg00001	cf00001	pd003	Product C	tamper-Product C	kg	355	180
newtx00002	lg00002	cf00002	pd001	Product A	tamper-Product A	kg	273	90
newtx00003	lg00003	cf00003	pd004	Product D	tamper-Product D	kg	149	395
newtx00004	lg00004	cf00004	pd006	Product F	tamper-Product F	kg	741	33
newtx00005	lg00005	cf00005	pd005	Product E	tamper-Product E	kg	91	663
newtx00006	lg00006	cf00006	pd003	Product C	tamper-Product C	kg	434	235
newtx00007	lg00007	cf00007	pd006	Product F	tamper-Product F	kg	942	31
newtx00008	lg00008	cf00008	pd003	Product C	tamper-Product C	kg	557	221
newtx00009	lg00009	cf00009	pd005	Product E	tamper-Product E	kg	99	762
newtx00010	lg00010	cf00010	pd004	Product D	tamper-Product D	kg	101	318
newtx00011	lg00011	cf00011	pd003	Product C	tamper-Product C	kg	454	229
newtx00012	lg00012	cf00012	pd001	Product A	tamper-Product A	kg	102	100

Table 5: Transaction chaincode test results.

Type of test	Test items	Test methods	Number of passes	Number of failures	Test result	Time per request (msec)
Consensus and writing	Initializing transaction information	Init transaction	12	0	Pass	2443
Tamperproofness	Initializing transaction information	Init transaction	12	0	Pass	18
Consensus and writing	Updating transaction information	Update transaction	25	0	Pass	2458
Tamperproofness	Updating transaction information	Update transaction	25	0	Pass	18
Transparency	Querying updating transaction information	Query transaction	74	0	Pass	15
Transparency	Rich query of updating transaction information	Rich query transactions	25	0	Pass	18
Traceability	Query of historical information	Query transaction history	25	0	Pass	11

Table 6: Purchasing management business test results.

Test items	Number of passes	Number of failures	Test result	Time per request (msec)
Query purchase by transaction ID	1	0	Pass	147
Query purchase by time range	1	0	Pass	23
Query purchase exchange by transaction ID	1	0	Pass	20
Query purchase exchange by time range	1	0	Pass	17
Query buyer, return by transaction ID	1	0	Pass	16
Query buyer return by time range	1	0	Pass	16
Query purchase logistics by transaction ID	1	0	Pass	41
Query purchase cash flow by transaction ID	1	0	Pass	37
Query purchase product by time range	1	0	Pass	16
Query purchase daily	1	0	Pass	22

5.2. Suggestions. When applying blockchain technology, enterprises should pay attention to distinguish the application scenarios of different blockchain types, determine the type of blockchain that they should use according to their own actual needs, and select a suitable blockchain platform.

Before and after applying blockchain technology in vertical value chain management, enterprises should communicate with upstream and downstream enterprises to improve their cooperation ability and jointly develop and maintain the blockchain.

Enterprises should realize that while improving the security and transparency of transactions, blockchain also has disadvantages such as slow transaction speed and high requirements for enterprise computer hardware and network configuration.

When using the Hyperledger Fabric platform, enterprises should plan the channel design, isolate unrelated nodes, prevent data leakage, and design endorsement strategy to ensure effective transactions. They should also set up and configure peer-to-peer nodes and sorting nodes reasonably to ensure business security and improve efficiency.

Due to the research purpose and space limitation, this paper only analyzes and realizes some basic requirements involved in the process of enterprise vertical value chain management based on blockchain technology and other specific, special, or complex needs should be analyzed and realized by readers themselves.

In this paper, the implementation of solutions to enterprise vertical value chain management based on the blockchain technology is only applicable to the relevant software and hardware environments used herein. Please pay attention to the relevant software and hardware versions when inspecting and using.

The test results in this paper may vary depending on the software and hardware environments tested.

6. Prospect

According to the research of the blockchain technology in the enterprise's vertical value chain management in this paper, it only includes the value transmission activities between the enterprise and the upstream and downstream and does not include the internal value creation and transmission process of the enterprise. In the next step of research, we will combine internal and external value chain activities to conduct research on full value chain management and explore how the blockchain technology can be used in full value chain management and how to use the blockchain technology to improve the value of the entire chain. Doing these helps companies improve their management and decision-making capabilities.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

It is declared by the authors that this article is free of conflict of interest.

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