Research on Risk Assessment Method of Enterprise's Arrears Based on Block-Chain Credit Consensus

Qian Zhang
North China Electric Power University
Sujie Xing (1007101848@qq.com)
North China Electric Power University https://orcid.org/0000-0002-7757-6687

Original article

Keywords: Blockchain, Enterprise arrears, Risk assessment, Electricity charge recovery

Posted Date: June 15th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-564765/v1

Abstract

Background: At present, the power supply market has always acquiesced to the rule of ‘use electricity first, pay later’,some electricity users may delay payment or even default on electricity bills due to various reasons, causing problems such as a long recovery period for electricity bills and difficulty in debt settlement. In order to reduce this kind of phenomenon, the power supply company must understand the user's historical electricity consumption data, capital status, credit status and other information, but the establishment of such a database requires a lot of time and human resource costs.

Methods: Based on the distributed storage technology of blockchain, this paper abstracts power supply companies, power users, banking financial institutions, government regulatory agencies, etc. into nodes on the alliance chain.After that,this paper introduces a credit scoring model to judge the credit rating of user information based on characteristic indicators, and select the corresponding electricity fee recovery policy after the result is obtained, so as to reduce the operating risk of the power supply company.

Results: This article combines the power and energy market with blockchain technology to establish a secure and distributed credit data blockchain, and at the same time establish a credit scoring model based on expert review questionnaire data. The analysis results show that this mechanism is suitable for credit data storage and sharing in energy transactions.

Conclusions: Research and analysis indicate that the credit risk assessment method of electricity transaction data proposed in this article provides a theoretical basis for the combination of electricity transaction credit risk assessment and blockchain technology,which will help improve the company's ability to assess the risk of arrears and reduce the operating risk of power supply companies.

Introduction

In the current market competition, companies are under greater operating pressure, and many companies are facing closure and bankruptcy. For a long time, power supply companies have been adopting the market rule of "use electricity first, pay later", so there are hidden dangers such as long recovery period of electricity bills and difficulty in reminders. Due to the existence of high-risk consumers, it is very difficult to collect electricity bills, which has a huge impact on the normal operation and development of the company[1]. Once customers have repeatedly delayed or even failed to pay their electricity bills for some reason, and local administrative intervention, short-term receivables of power companies will become mid-term receivables, long-term receivables, and even bad debts. This type of operation of consuming first and paying bills inherently has certain operating risks. Some customers owe large amounts of electricity bills during the operation of the power system, which seriously hinders the healthy development of the power industry[2]. Based on all responsibility to customers, collection of electricity bills has always been a major problem that plagued power supply companies. Coupled with the impact of the market economy, some poorly managed companies went bankrupt, and some unscrupulous companies passed their own losses to the power supply company in order to reduce losses, and maliciously defaulted on electricity bills, which made it more difficult to recover electricity bills. However, the power supply company lacks effective penalties for such problems and can only restrict it by cutting off the power and charging a small amount of liquidated damages. These methods are low in binding force, leading to frequent arrears of electricity bills, affecting the daily operation and development of power supply companies, which makes the recovery of electricity bills increasingly a major problem that plagues power companies. In order to avoid this situation as much as possible, it is necessary for power supply companies to understand the historical power usage information data, capital status, and credit status of the company before power transactions to formulate a reasonable electricity fee recovery policy and conclude a complete power supply contract. Use this method to determine a reasonable electricity bill settlement method, do a good job of credit analysis, and actively master information and business market conditions.

Since the power company cannot accurately discover the user's arrears, resulting in a shortage of power transaction data [3]. This enables power supply companies to spend a lot of manpower and material resources to store and manage corporate power consumption data while completing normal production and operation, which greatly increases the burden on power supply companies. The electricity consumption information of an enterprise is complex and diverse, and its storage requires a special database and management by professionals. But this does not guarantee that power supply companies can easily and accurately obtain the information they need. The fundamental reason is that there are many problems with centralized storage.1. Higher cost. 2. The data transmission speed is slow. 3. Low security. 4. Privacy leakage.

In the current power system, distributed energy makes it possible for high-consumption customers to significantly reduce the share of the remaining costs they pay, leaving the deficit to the power supply company[4]. In order to reduce the operating pressure of power companies, various power companies have proposed various administrative and technical means, trying to establish user-oriented power recovery risk assessment strategies. However, due to the insufficient ability of power grid companies to predict the risk of arrears of power users, they cannot take targeted preventive measures in advance according to the risk level of customer arrears, which is a major problem facing the prevention of the risk of electricity fee recovery. In order to effectively improve the risk prevention and control capabilities of power companies and reduce business risks, efficient and accurate arrears risk prediction is particularly important.

With the development of information technology in the new era, distributed storage technology based on blockchain can effectively liberate the above problems. Distributed storage of data is not stored on a single company's server, but is encrypted and distributed through a decentralized network. It has higher reliability, availability and lower cost.

This paper uses the DPOS consensus system in the blockchain to establish a distributed and decentralized credit data processing method. The information database is jointly maintained by all members of the chain, and the cost is low. All enterprise electricity information data is encrypted and stored on the blockchain, which can not only ensure the privacy of the enterprise, but also realize that each transaction of the enterprise account can be traced on the chain for easy query.This blockchain-based decentralized structure avoids the possibility of a node tampering with information privately and increases the security of the system. In this way, the power supply company can inquire about the basic data, electricity bill information, historical payment records and other data of the electricity user, and can conduct risk assessment and analysis on the user's historical data. As a result, a credit evaluation method for power users is established, user risk levels are refined, and flexible electricity bill settlement methods are adopted according to user arrears risk levels to optimize the electricity bill recovery process and reduce business risks.

Literature Review

For a long time, due to its traditional monopoly, Chinese power industry has faced increasing pressure from peer competition and technological shocks with the advancement of the market system. As the last link in the management of power supply enterprises, electricity fee recovery management has always been the focus of power supply enterprises [6], and effective electricity fee recovery management is inseparable from effective data management and data analysis.

With the development of economy and technology, data mining and big data analysis techniques are often used in China to analyze users' electricity consumption characteristics, so as to find out the relationship between electricity consumption characteristics and the risk of arrears. Li Jianbin et al. [5] used the big data analysis method to extract and transform data, and established the risk identification model of customer electricity bill by machine learning. While performing big data mining on user data, Zhao Yadi et al. [6] introduced logistic regression and scoring card function methods to screen and transform index data. Zhao Yongliang et al. [7] also took big data analysis and logistic regression model as the design connotation, and proved the validity of the risk prediction model through example analysis. Chen Peili et al. [8] formed a user payment data release model based on data mining and analysis of user payment methods, payment frequency, payment time, electricity consumption changes, and electricity business changes to carry out electricity tariff risk level assessment.

In addition to big data analysis, Xie Lefeng et al. [9], facing the risk of electricity charge recovery, proposed to make early warning of customers' electricity charge recovery risk based on the long and short term memory network algorithm in deep learning, and used entropy method and correlation to analyze key indicators of electricity charge recovery risk, and achieved remarkable results. Wu Haiguang et al. [15] proposed a comprehensive learning method – gradient enhanced decision tree – random forest – Adaboost logistic regression (GRAL), and established a risk prediction model for electricity price recovery. Experiments show that this method can effectively evaluate the payment behavior of power users.

Foreign countries have also studied the issue of electricity fee recovery. Tim Schittekatte's team [11] studied the problem of electricity charge recovery from the perspective of electricity price design, described the problem of power grid cost recovery of distribution system as a non-cooperative game between consumers, and focused on the limitation of capacity-based charging, which will provide challenges for power grid cost recovery. Batlle et al. [12] also studied cost recovery from the perspective of residual cost distribution of electricity price. They analyzed the problem according to the rate setting theory, reviewed the different allocation methods currently considered, and proposed a solution based on unbalanced fixed fees to achieve efficiency, fairness and cost recovery of modern electricity price. However, the problem of electricity bill collection does not stop there. More importantly, it is based on the judgment of user credit. Abdulrahman [13] and others took KWIQPLUS loans as an example, using the fuzzy logic method of Ghana's microfinance credit scoring to complete the evaluation of user credit. Based on Turkish credit card data, Akkoc and Soner [14] compared traditional technology, neural network, and three-stage hybrid adaptive neuro-fuzzy inference system (ANFIS) credit scoring analysis model,and showed that the model is superior to traditional data analysis methods in terms of the average correct classification rate and the estimated cost of misclassification, which is a good reference for the credit evaluation of users in the power industry.

So far this paper have come to the conclusion that in order to effectively establish user risk assessment models, reasonable data analysis and data sharing technologies are indispensable.With the advent of the information age, while big data reduces the cost of credit, it also brings about the problems of big data monopoly and misplaced information ownership [10]. Facing the problems of information asymmetry and lack of credit between power supply companies and users, the current research methods are mostly based on data storage and data sharing based on blockchain technology. In addition, the blockchain credit consensus mechanism can better solve the credit problem between power supply companies and power users. In the existing domestic literature, there are many articles on the blockchain consensus model. Yang Man [16] introduced blockchain into the existing Internet group collaboration, and constructed a group collaboration model based on blockchain trust consensus technology, which can be widely used in enterprises. In power supply companies, it is precisely due to the lack of mutual trust and consensus mechanism that transaction information is not shared, which leads to the risk of recovery of power supply companies. In the current Internet environment of information asymmetry,Li Shuai [17]created a new operation mode through the innovative information consensus mechanism and trust mechanism of block chain. The research focus is on how to transmit and maintain information data in the chain, which has certain enlighten effect on the research of this paper. The management and sharing of information and data in the construction field by the blockchain credit consensus mechanism is also related to the power industry.Taking this as the research object, Li Meng et al. [18] used the unique function of block recording data to trade building materials into a complete information trading chain.Cao Yang et al. [19] built a construction supply chain information sharing management blockchain to provide a new model for information sharing in the construction supply chain to promote information sharing among project participants in the supply chain.

In foreign countries, the research on blockchain and reputation privacy is more extensive. Keke Gai et al. [20] proposed a block chain edge model suitable for smart grid in order to protect user privacy of smart grid, and ensured the security of energy transactions by using smart contracts. Nir Kshetri[21] emphasized the superiority of blockchain for user privacy and transaction security in the field of Internet of Things. Also in the field of the Internet of Things, Seong-Kyu Kim et al. [22] proposed a blockchain-based ecosystem to improve efficiency and stability in view of the multi-platform security vulnerabilities of the Internet of Things. Seong-Kyu Kim and Jun-Ho Huh[24] used block chain technology to measure carbon emission rights and proposed a carbon emission right verification system based on block chain. It also discusses the verification encryption algorithm required by the blockchain engine.

This idea is also applicable to the power industry. At present, distributed energy is a global hot issue. Wayes Tushar et al. [23] tried to study P2P distributed energy networks through game theory, and used auction theory models to simulate the actions of participants in the grid for effective energy management. Italo Atzeni et al. [25] proposed a new algorithm of distributed intelligent instrument, which not only protects privacy, but also provides an optimal production and storage strategy, and is directly applicable to small enterprises and home end users.

Nowadays, the combination of blockchain technology and distributed energy trading is the general trend. Merlinda Anonia and Valentin Robu[26] studied more than 140 block chain research projects and startups based on the system architecture of block chain technology, and concluded the potential and feasibility of building block chain for energy application. Among them, the blockchain consensus issue is the top priority.In order to study the credit consensus mechanism of blockchain, Yuhao Wang et al. [27] proposed a trust-type Byzantine fault-tolerant protocol and a consistency and checkpoint protocol based on PBFT, which can improve the efficiency and stability of the system through simulation results. Junqin Huang et al. [28] made use of the elasticity and security of blockchain to propose a work proof mechanism of blockchain IoT devices based on credit consensus mechanism, and proved the effectiveness of the system through examples. Similarly, Yinqiu Liu et al. [29] combined the Internet of things with block chain technology and proposed a green consensus mechanism of collaborative multiple verification and Lightblock lightweight data structure to save storage space. In the field of energy, Wenjun Cai et al. [30] studied the dynamic consensus mechanism based on reputation and applied it to real-time energy transactions to solve problems such as low transaction throughput and long delay time.

In addition, in terms of data processing and data sharing, blockchain technology can also be used to great advantage.Jiawen Kang et al. [31] put forward a reputation-based data sharing scheme in the vehicle edge network system by using Alliance blockchain and smart contract technology to ensure high-quality data sharing of vehicles. Jian Shen et al. [32] also studied data sharing, proposed to provide high security and high efficiency data sharing and data storage for the same group in the cloud in an anonymous way, and established a new data sharing scheme of traceable group to support anonymous multiple users in the public cloud.

From the above point of view, blockchain can be applied to a variety of social fields due to its characteristics of decentralization, immutability of information, openness and independence, which will provide a good reference for it in the field of power trading.In this paper, based on the alliance chain technology in the blockchain, the nodes jointly record the transaction credit data through the on-chain transaction, and pack it into blocks through the encryption algorithm, so as to achieve the data's immutability and traceability.

The main contributions of this paper are as follows:

1. This paper proposes to build a secure and distributed credit data blockchain using the Alliance Blockchain technology for credit data storage and data sharing in energy transactions;
2. In the blockchain, the DPOS consensus mechanism is used to select authorized nodes to achieve efficient storage of energy data and data sharing between the two parties in the transaction, and at the same time protect the privacy of users with an asymmetric encryption algorithm;
3. This paper deploys energy transaction smart contracts in the blockchain, which can realize the automatic execution of the transaction when they are determined, and the transaction data will also be packaged on the chain;
4. Analytic Hierarchy Process (AHP) model is introduced to evaluate user credit rating at volunteer nodes to help power supply companies choose appropriate power recovery policies.

The rest of this article is arranged as follows. The first part of the third section introduces the application architecture of alliance chain based on P2P technology. The second part of the third section describes the steps of information and data storage and data sharing for each component node of the transaction blockchain. The third part introduces the credit evaluation model, the model uses the analysis method to screen the sample indicators, and then uses the analytic hierarchy process to calculate the weight of the model, so as to score the information provided by the user and judge the user's credit rating and choose the appropriate electricity fee recovery method. The fourth section summarizes the conclusion of this paper.

Methods

In recent years, blockchain technology has developed rapidly. It is known from the above-mentioned literature that it is widely used in various industries. In this paper, blockchain technology is introduced into the field of power transactions, and the value of blockchain is extended to a wide range of services ranging from pure data storage (such as device configuration and governance, sensor data storage and management, and multi-access payment) [27]. In the field of power recycling transactions, this paper studies new transaction models based on blockchain credit consensus, and builds a distributed information storage method based on digital encryption and verification technology to provide power users with non-tampering and traceability for historical credit data. At the same time, this paper designs the application of user credit query method based on alliance blockchain, and elaborates on application architecture, information storage, credit query logic and so on.Firstly, combining with the technical characteristics of blockchain, the storage and query mechanism of information on the chain is described. Finally, according to the user's information on the chain, the risk assessment and analysis are carried out to determine the risk level, so as to implement the corresponding electricity bill settlement method.

1. Consortium chain application architecture

Blockchain technology was proposed by Satoshi Nakamoto in 2008. After continuous iterative evolution, it has formed five major technical features: distributed, trustless, time stamping, asymmetric encryption and smart contracts. Compared with the operating space and efficiency of the private chain, the value of the alliance chain is greater. Compared with the uncontrollable and privacy security issues of the complete decentralization of the public chain, the alliance chain is more flexible and more maneuverable.According to the transaction characteristics of electricity companies, power supply companies and financial institutions, this paper abstracts the regulatory agencies such as companies and financial institutions as nodes on the alliance chain for research.

Blockchain data is timestamped, so it can be used as a reliable tool for data traceability of power and energy transactions. Based on blockchain technology, this paper establishes a distributed and decentralized credit data storage mechanism, and obtains the consensus of banks and financial institutions, government regulatory agencies, large power supply and sales companies, and power users, and forms a joint management by the three parties. The blockchain data architecture is mainly divided into six levels: data layer, network layer, consensus layer, incentive layer, contract layer, and application layer, which jointly complete transaction verification, judgment, storage, and backup [9].

2. Risk assessment of arrears based on alliance chain technology

Alliance chain is a relatively new way to apply blockchain to enterprises, which can be applied to collaborative services between various enterprises. In the alliance, a number of nodes are pre-designated for accounting, and the nodes that join later need to apply and verify, and join the alliance chain after approval. This paper introduces volunteer nodes [19] as the lower-level virtual members of power supply enterprise nodes in the blockchain to help power supply companies complete data analysis and risk assessment.

The form of alliance chain is used for the traceability and sharing of power consumption data information of power companies, which can ensure that all parties to the transaction share information with each other. At the same time, the non-fully decentralized structure guarantees the relative leadership of power supply companies, bank governments and other regulatory agencies in the entire organization, and the transaction speed of the alliance chain can also handle various transaction information data generated during the transaction process[20].

(1) Division and role of institutions on the alliance chain

In the entire alliance node, the institutions and functions are as follows:

Power supply enterprise node

Containing institutions a supply node that receives transaction requests and provides electricity and energy services.

Information data：The information provided includes power energy quality, stock quantity, energy production time, power plant location, energy transportation routes, power energy purchase and transportation price and other basic energy information.

User Enterprise Node

Containing institutions：The demand-side unit composition of electric energy includes high-voltage non-resident users and low-voltage non-resident users.

Information data：The information provided includes basic information such as the number of electricity transactions, expected prices, and historical payment records.

Bank financial node

Containing institutions：The composition of banking institutions undertaking corresponding financial transfer tasks.

Information data：The information provided includes basic information such as user company registered capital, financial loan status, other energy transaction status (such as water charges), historical electricity payment records, etc.

Government regulator node

Containing institutions：Unit nodes responsible for power energy operations and trading tasks.

Information data：Provides energy policy updates and access to information about the energy trading process.

Volunteer node

Containing institutions：The nodes included in the power supply company’s subordinates are used to calculate and evaluate the risk level of power users, and assist in completing calculations and transmitting information.

Information data：This node is a virtual node, which does not need a secret key. It is only used to receive the information transmitted by the power supply node, perform the corresponding calculation, and then pass the calculation result to the power supply node.

The energy and power information database is jointly maintained and operated by all nodes, and each node has equal rights to exchange and store information. At the same time, data is uploaded through consensus mechanism and P2P network diffusion, and a traceable and tamper-free block is formed by relying on hash algorithm and linked to form a block chain in turn.

(2) Blockchain information storage and sharing

According to the different participants in the transaction alliance chain, the alliance node in the blockchain can be divided into banking and financial node, power supply enterprise node, user node, government regulator, volunteer node and other auxiliary nodes. After each node is verified, it will get the corresponding ID IP of its own node.In order to protect the privacy of corporate information and data of power users, this paper adopts asymmetric encryption method, and the public key and private key of each node are generated by the elliptic curve algorithm. Public and private keys appear in pairs, which can not only protect the basic information privacy of electricity users, but also complete the storage and sharing of information and data. After the public and private keys are generated, they broadcast their own information and public keys to the entire network, and obtain and save information from other nodes to form an alliance transaction chain.

Analogous to the blockchain data storage and sharing scheme adopted by Kang in the field of vehicle interaction [21], in the power information sharing blockchain, the steps of generating and storing the user's original information in the blockchain are as follows:

1: Both parties of power supply and demand, as well as banks and governments, jointly form alliance nodes. The identity of enterprise nodes needs to be verified by government regulatory agencies.Each node uses elliptic curve algorithm and asymmetric cryptographic algorithm to obtain public key K and private key k as identity IP identification, and generates its own digital signature sig, and at the same time confirms the authority of each node;

2: Each node uses the DPOS consensus mechanism to vote for the authorized node, which is generally voted by all enterprises on the alliance chain. Each unit uploads its own information through the P2P network, which is packaged and uploaded to the block chain by the authorized node to store the original data of information;

3: When the user company needs to purchase energy, the node Xi sends the transaction request to the authorized node with the time stamp and digital signature sig, and the node verifies its identity and then feeds back Xi. After that the node Xi will send the transaction history information data of the most recent year (Such as: current default situation, historical payment information, corporate credit, etc.)to the authorized node with public key Ki , that is

Vi→AN□request □sig□

Message□data|Ki|sig|timestamp□

Block

4: The authorized node broadcasts the ciphertext information M to other ordinary nodes for review and verification.After confirming its authenticity, the information will be packaged and added to the block chain for permanent storage.

Credit information mainly includes two parts:

1. Normal performance (average monthly electricity consumption, frequency of electricity purchase, etc.)

2. Information on breach of contract (number of breaches, amount of breach, delay in payment of penalties, etc.)

Therefore, the encrypted information of historical data verified by users is stored in the alliance chain, which has the characteristics of non-tampering and traceability. In order to simplify the storage space, the recording adopts the method of data indexing. The other nodes of the blockchain can only store the hash value of the data.

After the authorized node verifies the information submitted by the user,it sends its transaction request to the power supply node Yj, Yj queries the user's information data based the blockchain before the transaction, and the volunteer node calculates the risk level according to the index.(The credit index evaluation will be explained in detail in 3 Part).The corresponding electricity fee recovery method will be adopted. The P2P data sharing query steps are as follows:

1: The power supply node Yj sends the identity ip and digital signature to the authorized node when receiving the transaction request. After receiving the response, it queries the data block about Xi according to the information index in the blockchain, and sends a data access request to Xi including its own number signature

Yj → Xi   request □sig|timestamp□

2: After receiving it, Xi verifies the identity of YJ according to the digital signature. The permission opening authorization is sent to the authorized node, and the private key of the queryer and the public key of the queryer Yj are attached for query.

Xi → AN message □authority|ki|Kj|timestamp□

3: Upon receiving the information, the authorized node has the right to open query to Yj .Yj queries Xi's historical transaction and financial record raw data according to the bank node data pool and the information index in the blockchain, and sends it to volunteer nodes for data analysis after verification to determine the user's credit rating (detailed in the next section), so that the corresponding electricity fee transaction measures can be implemented under the control of the government supervision node.

1. The architecture consists of user module, access control strategy module, data analysis module,and transaction module.

2. Electricity supply and use companies obtain their own public and private keys through key handling.

3. Electricity companies set access policies, power supply nodes verify their identities, and obtain permissions

4. If the identity of the power supply node matches the access control policy set by the power user, the encrypted shared data can be obtained through the blockchain and the bank data node, and the data will be sent back to the power supply company after being processed by the key center

5. The volunteer nodes subordinate to the power supply company judge the credit rating of the power supply company according to the data sent back. The power company then transacts power with customers through smart contracts under the supervision of government nodes and uploads it to the blockchain.

(4) Analysis of the alliance chain transaction and verification process

The power transaction alliance chain established in this article is developed around the historical information and data of user companies. It is a tool for the power supply company to verify transactions. Combined with the blockchain system, it can further increase the ability of tamper-proof, transparent transaction processing and privacy protection[27] .

Among them, the power transaction smart contract is formulated by the nodes in the alliance chain. The power supply company, the bank supervisory agency and the power user respectively make transaction guarantees. This commitment stipulates the rights and obligations of the parties to the transaction, and is generated after both parties' private keys are signed.

The contract is translated into the corresponding code, broadcast to the entire chain via the P2P network, and after verification by all parties, it is transmitted to the blockchain by the authorized node to form an energy transaction smart contract.During the execution of the smart contract, the status information always records the energy status of the power supply company. After the transaction is completed, the grid unit, bank and supervisory unit verify the transaction completion data information.After the verification is passed, the authorized node on the chain temporarily stores the information in the transaction database and disseminates it to the entire chain. After the entire chain is verified, the transaction information can be packaged on the chain (the process is similar to the second part: data storage on the chain) to ensure the authenticity and traceability of transaction information.

Before the transaction, the electricity user first verifies the identity through the "registered account" of the alliance chain node.Relying on the alliance chain technology platform, the node initiates a transaction request in the blockchain, stamps a time stamp and digital signature, forms the transaction cipher text through the hash function and publishes it to the entire network. After receiving the transaction request, the authorized node determines the user's identity information and receives the original data uploaded by the user by checking the digital signature in the transaction request. At the same time, the power supply company packages its own identity and credit information and sends it to the corresponding authorized node, and broadcasts it to all chain.and with the help of authorized nodes, query the user's basic data, electricity bill information, historical payment records and other historical data and current financial conditions, and send them to the entire network for verification.

In the transaction process, both parties of the transaction trigger the power and energy transaction smart contract deployed on the chain by setting the transaction quantity, transaction price and other data.The specific terms of the transaction contract and the incentive reward sharing for authorized nodes are pre-set in the smart contract. After the smart contract is over, the transaction information is stamped with time stamp and the digital signature of both parties to the transaction is packaged into the block, and the entire transaction is declared complete .

Grid companies can make detailed explanations on the quality and inventory of electric energy and set prices on their own, and they have the right to change the pricing. Through the deployment of smart contracts, users can initiate transactions with power companies and pay a certain fee, which can achieve the purpose of as-used as needed. The grid company will immediately carry out energy transmission, which reduces the risk of energy users in arrears to a certain extent.

3. Information extraction and risk level assessment

This paper adopts the analytic hierarchy process model to analyze and score the indicators. This model is a mature forecasting method. First, the analysis method is used to construct the indicator system, and then the indicator weight is calculated through the expert scoring system, thereby establishing an evaluation model for power customers in arrears. [24]

1. Use analytical methods to build an index system

Table 1. Index table

Total target layer	Sub-goal layer	Criterion layer
Credit Evaluation Rating Model	Business ability	Business structure
		Scale efficiency
		Equipment level
		technical skills
	Management ability	Management quality
		Net asset profit margin
		Roe
	Financial strength	Net sales profit margin
		Assets and liabilities
		sales growth rate
	Integrity record	Number of breaches
		Default amount
		Credit repayment history
		Electricity contribution rate

2. Calculate the weights through the pairwise comparison matrix indicators

The matrix form is

$$A\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix}$$

The matrix satisfies the conditions:

$$x_{ii}=1,\ x_{ij}=\frac{1}{x_{ji}}\ ,\ x_{ij}>0$$

According to the ratio scale of the judgment matrix, the experts score to determine the mutual importance of different indicators, and the survey opinion form will be statistically analyzed

$$M_{ij}=\frac{1}{n}\sum_{i=1}^{n} S_{ij}$$

(Among them: M_{ij} is the arithmetic square root of the importance score of the i-th index and the j-th index, s_{ij} is the sum of the scores, and n represents the number of experts)

After completing this judgment matrix, perform a random consistency test and calculate the weights

The random consistency test formula is: $CR = \frac{\mathrm{CI}}{\mathrm{RI}}, \mathrm{CI} = \frac{\lambda_{\max} - n}{\mathrm{n}-1}$

In the analytic hierarchy process, it is generally believed that when CR<0.1, the judgment matrix has acceptable consistency; when the CR is smaller, the judgment matrix is close to complete consistency, otherwise, the degree of deviation is greater.

RI is a random consistency index, this paper directly borrows from Xu Shubo's RI value of the first 1-8 steps obtained by repeating the RI of 1-15 steps:

N steps	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41

After the expert opinions are collected, the score matrices of the sub-target layer and each criterion layer are constructed through statistical analysis. Then, the consistency test is carried out, and the weight value is calculated after the consistency test. The weight value is the proportion in the evaluation system.The calculation method is as follows:

G	P_1	P_2	...	P_n	C_n	W_n
P_1	x_{11}	x_{12}	...	x_{1n}	$C_1=\sqrt[n]{x_{11}x_{12}..x_{1n}}$	$W_1=\frac{C_1}{\sum_{i=1}^{n} C_i}$
...	...	...	...	...	...	...
P_n	x_{n1}	x_{n2}	...	x_{nn}	$C_n=\sqrt[n]{x_{n1}x_{n2}..x_{nn}}$	$W_n=\frac{C_n}{\sum_{i=1}^{n} C_i}$

At the same time, the eig function in MATLAB was used to calculate the value of the matrix, and then the consistency test was carried out. This time, a total of 30 questionnaires and 30 valid questionnaires were issued.

Through investigation and statistics, this paper obtains the weight distribution of the total target and sub-targets

Table2. Total target level index weight table

	P_1	P_2	P_3	P_4	C_n	W_n	λ_{max}	CR
P_1	1.000	1.039	0.344	0.222	0.531	0.103	4.1827	0.068
P_2	0.672	1.000	0.417	0.366	0.564	0.110		
P_3	3.233	2.433	1.000	0.332	1.284	0.250		
P_4	4.567	4.033	3.167	1.000	2.764	0.537		

According to the table 2 , the CR value of the total target and the sub-target is 0.068, and the result is less than 0.1, which passes the consistency test.

According to the table 3-6 , the CR value of the total target and the sub-target is 0.068, and the result is less than 0.1, which passes the consistency test.

Through statistical analysis of the questionnaire, the weight distribution of the following sub-target items and various criteria is obtained.

Table 3.Weight Table of Business Ability Index

P	x_1	x_2	x_3	x_4	C_n	W_n	Consistency check	
							λ_{max}	CR
x_1	1.000	0.279	0.38	0.424	0.460	0.103	4.1603	0.06
x_2	3.867	1.000	1.344	1.111	1.550	0.347		
x_3	2.733	0.852	1.000	0.422	0.996	0.222		
x_4	2.600	0.722	2.467	1.000	1.467	0.328		

Table 4.Management Ability Index Weight Table

P	x_1	x_2	x_3	C_n	W_n	Consistency check	
						λ_{max}	CR
x_1	1.000	0.396	0.367	0.526	0.141	2.8815	-0.11
x_2	3.767	1.000	0.402	1.148	0.309		
x_3	3.133	2.733	1.000	2.046	0.550		

Table 5.Financial Strength Index Weight Table

P	x_1	x_2	x_3	C_n	W_n	Consistency check	
						λ_{max}	CR
x_1	1.000	0.258	1.760	0.769	0.228	3.0927	0.089
x_2	3.860	1.000	1.822	1.916	0.569		
x_3	0.580	0.546	1.000	0.682	0.202		

Table 6.Integrity record index weight table

P	x_1	x_2	x_3	x_4	C_n	W_n	Consistency check	
							λ_{max}	CR
x_1	1.000	0.644	0.480	0.226	0.514	0.104	4.1503	0.056
x_2	1.652	1.000	0.417	0.304	0.676	0.137		
x_3	2.283	2.533	1.000	0.556	1.339	0.271		
x_4	4.524	3.400	2.167	1.000	2.403	0.487		

From the above table, It can be knowed that the above CR values have passed the consistency test, and then summarize the above matrix to obtain the weight table of each indicator of the credit evaluation model

Table 7.Credit Evaluation Model Index Weight Table

Target layer	Weights	Criterion layer	Weights
Business ability	0.103	Business structure	0.103
		Scale efficiency	0.347
		Equipment level	0.222
		technical skills	0.328
Management ability	0.110	Management quality	0.141
		Net asset profit margin	0.309
		Roe	0.550
Financial strength	0.250	Net sales profit margin	0.228
		Assets and liabilities	0.569
		sales growth rate	0.202
Integrity record	0.537	Number of breaches	0.104
		Default amount	0.137
		Credit repayment history	0.271
		Electricity contribution rate	0.487

After determining the final weight, it is to assign the score of each index, define each index, define and score the index according to the percentage system after determining the scoring principle

Table 8.Credit Evaluation Model Index Assignment Table

	Reference value	Limit value	Full score	Grading
Business structure			1	1 point for the complete and complex business structure of the enterprise, 0 point otherwise
Scale efficiency			4	Score 0-4 points according to enterprise scale and production efficiency
Equipment level			2	2 points for more advanced equipment 1 point for holding 0 points for basically no equipment
technical skills			3	Divided into 0-3 points according to the advanced level of the company's technological capabilities
Management quality			2	Rich management experience, 2 points for significant performance, 1 point otherwise
Net asset profit margin	≥5%	□1%	3	Actual value/reference value*full score
Roe	≥12%	□ 1.5%	6	Actual value/reference value*full score
Net sales profit margin	≥8%	□1%	6	Actual value/reference value*full score
Assets and liabilities	≤50%	□80%	15	[1-(Actual value-reference value)/(reference value-limit value)]*Full score
sales growth rate	≥10%	□3%	5	Actual value/reference value*full score
Number of breaches			6	The number of defaults is 0, 6 points are awarded 5 points for 1-2 times 4 points for 3-4 times And so on until the deduction is over
Default amount			7	3 points deducted for the monthly default amount greater than 50,000 yuan, until the deduction is complete
Credit repayment history			14	3 points will be deducted for each outstanding interest over 5 days until the deduction is complete
Electricity contribution rate	≤50	□70	26	[1-(Actual value-reference value)/(reference value-limit value)]*Full score

Divide the scoring results into five levels

Points	grade
81-100	A
61-80	B
41-60	C
21-40	D
0-20	E

1. Excellent and trustworthy A-level users are regarded as the preferred users of the power supply company. The power company shall provide preferential services in terms of electricity charge policies, power dispatching, equipment calibration and other aspects, and may also reward them based on power consumption;
2. Class B and C are generally trustworthy users with good credit awareness, good financial status and few times of arrears. Electric power companies should actively cooperate with them, give appropriate preferential policies, pay attention to their operation level and strive to cultivate high-quality customers
3. Electric power users of grade D and E are listed as trust-breaking users of the power supply company. Such users have a high risk of arrears and are not suitable for subsequent development and training. Power supply companies should carry out certain constraints on management, when necessary, to take a special policy of charge recovery of pay first and then use electricity, and cautiously sign electricity purchase contracts.

In this section, based on the principles of system, science, and stratification, the arrears of electricity users are divided into three levels , and then different electricity charge management strategies are formulated for the three levels of customers. While actively maintaining users with good risk levels, targeted measures should be taken to recover electricity charges for users with poor risk levels, so as to avoid operational risks of electric power enterprises, and improve the risk prevention ability of electricity charges recovery in time.

Conclusion

As we all know, the primary characteristics of the blockchain are non-tamperability and openness and transparency. Most scenarios require this technology, but not all companies are willing to make all their information open and transparent.The alliance chain is jointly managed by several institutions or enterprises, and each institution or enterprise runs its own node. The transaction data is only allowed to be recorded by the nodes on the chain. Only the data authorized by the node can be broadcast on the chain. This mechanism well solves the problem of data privacy and the security of all parties. Therefore, alliance chain is the most valuable branch of blockchain at present..

Since the beginning, how to carry out effective risk assessment for power users has been an important work at present[26].It is necessary to find a specialized database and carry out professional management, but it still cannot solve the problem that the power supply company does not have a comprehensive understanding of user information, which is the disadvantage of central management. Distributed storage using blockchain technology can effectively solve the current central storage of high cost, slow data transmission speed, low security, privacy leakage and other issues.

This article abstracts banking financial institutions, government regulators, power supply enterprises, and users into alliance chain nodes, expounds the application architecture, information storage and processing, and transaction execution logic of the blockchain credit consensus mechanism, and establishes a power transaction alliance chain model,and gives a credit risk assessment method for electricity transaction data, which provides a theoretical basis for the combination of electricity transaction credit risk assessment and blockchain technology, and helps power supply companies quickly obtain basic user information, electricity preferences, credit risks, etc., which can effectively improve the enterprise's ability to assess the risk of arrears, effectively manage user credit, so as to reduce the operating risk of the power supply company.

Shortcomings of current research in this paper:

1. Chinese energy-related blockchain projects are still in the development and exploration stage, many application scenarios have just landed, and there are still many problems that have not been resolved;
2. This article only considers the research of theoretical methods, and gives theoretical solutions to the risk of enterprise arrears. The specific practical application needs to improve the mechanism to complete;
3. The arrears risk assessment method of power supply enterprises after information data collection still needs to be improved, the indicators can be clearer and more complete, the application of the model needs more samples to ensure the effectiveness of the prediction, and intelligent assessment is needed when necessary.
4. Development cost issues: Blockchain technology applications require huge costs to be developed and put into use. The cost recovery can only rely on the manpower saved in the transaction process, the time and the on-time recovery of electricity bills, and the phase of capital return is relatively long.

The transaction application efficiency of blockchain technology in the field of power and energy still needs further research. This paper theoretically provides the possibility of traceability and tamper-proof function of data on the chain for transaction data. It provides research basis and construction reference for the application scenario of block chain technology and the construction of energy market in China. What is certain is that the consortium chain technology has more research value than traditional blockchain in terms of high performance, availability, programmable, and privacy protection. In addition, future research work can consider the issue of access rights management of transaction data. In distributed storage, using blockchain technology to design on-chain data access rights can further ensure the security of data.

Abbreviations

There are no abbreviations in this paper

Declarations

Acknowledgements

The authors is grateful for the expert data provided by China Southern Power Grid Corporation.

We are also sincerely thank the editor and reviewers for their very valuable and professional comments.

Author Contributions

Conceptualization: Qian Zhang; Formal analysis, Methodology, Writing–review and editing: Sujie Xing. All authors have read and agreed to the published version of the manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials

The data sets supporting the results of this article are included within the article and its additional files

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

1 North China Electric Power University（Baoding Campus）, Baoding 071000, China.

2 North China Electric Power University（Baoding Campus）, Baoding 071000, China.

References

1. Design and Implementation of Electric Charge Arrears Prediction System By: Guo, Wenzhong; Hong, Wei; Li, Wanhua; . 2015 12TH WEB INFORMATION SYSTEM AND APPLICATION CONFERENCE (WISA) Pages: 309-313 Published: 2015
2. Research of Evaluating Credit-Risk in Power Enterprise Based on SVM and VIKOR Method By: Huang, Yuansheng; Yan, Ying IEEM: 2008 INTERNATIONAL CONFERENCE ON INDUSTRIAL ENGINEERING AND ENGINEERING MANAGEMENT, VOLS 1-3 book: International Conference on Industrial Engineering and Engineering Management IEEM Pages: 1596-1599 Published: 2008
3. Arrears Prediction For Electricity Customer Through Wgan-Gp By: Fu, Weiwei; Li, Jianyuan; Zhang, Dezheng; PROCEEDINGS OF 2017 IEEE 2ND INFORMATION TECHNOLOGY, NETWORKING, ELECTRONIC AND AUTOMATION CONTROL CONFERENCE (ITNEC) Pages: 1667-1670 Published: 2017
4. Redesigning residual cost allocation in electricity tariffs: A proposal to balance efficiency, equity and cost recovery By: Batlle, Carlos; Mastropietro, Paolo; Rodilla, Pablo RENEWABLE ENERGY Volume: 155 Issue: 257-266 Published: AUG 2020
5. .Eurostat static explained group collaboration trust model based on blockchain technology [J]. Jiangsu Science and technology information□in Chinese□By□yang,man Jiangsu Science & Technology Information Volume: 36 Issue□27 Pages□35-41 September□2019
6. Study of Blockchains's Consensus Mechanism Based on Credit By: Wang, Yuhao; Cai, Shaobin; Lin, Changlong; et al. IEEE ACCESS Volume: 7 Pages: 10224-10231 Published: 2019
7. Regulation of decision algorithm in the information asymmetry environment of sharing economy□in Chinese□By□li□shuai Law and Economy Issue□02 Pages□17-28 Mar 2019
8. Key technologies of distributed energy trading based on blockchain□in Chinese□By□wangbeibei□liyachao□zhaoshengnan□chenhao Automation of Electric Power Systems Volume: 43 Issue□14 Pages□53-64 APR 2019
9. Research on the architecture of building material information technology under blockchain Technology□in Chinese□By□limeng□luman□yuhongliang□Construction Economy Volume: 40 Issue: 10 Pages: 103-107 OCT2019
10. Agricultural product information blockchain technology architecture design and application prospect □in Chinese□By□lianghao□liusichen□zhangyinuo□lvke Smart Agriculture Volume: 1 Issue: 01 Pages: 67-75 JAN2019
11. Blockchain's roles in strengthening cybersecurity and protecting privacy By: Kshetri, Nir TELECOMMUNICATIONS POLICY Volume: 41 Issue: 10 Special Issue: SI Pages: 1027-1038 Published: NOV 2017
12. Blockchain of Carbon Trading for UN Sustainable Development Goals By: Kim, Seong-Kyu; Huh, Jun-Ho SUSTAINABILITY Volume: 12 Issue: 10 Published: MAY 2020

13. LightChain: A Lightweight Blockchain System for Industrial Internet of Things By: Liu, Yinqiu; Wang, Kun; Lin, Yun; IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS Volume: 15 Issue: 6 Pages: 3571-3581 Published: JUN 2019
14. Trust-Enhanced Content Delivery in Blockchain-Based Information-Centric Networking By: Li, Huining; Wang, Kun; Miyazaki, Toshiaki; IEEE NETWORK Volume: 33 Issue: 5 Pages: 183-189 Published: SEP-OCT 2019
15. A Study on Improvement of Blockchain Application to Overcome Vulnerability of IoT Multiplatform Security By: Kim, Seong-Kyu; Kim, Ung-Mo; Huh, Jun-Ho ENERGIES Volume: 12 Issue: 3 Document number: 402 Published: FEB 1 2019
16. Blockchain technology in the energy sector: A systematic review of challenges and opportunities By: Andoni, Merlinda; Robu, Valentin; Flynn, David; RENEWABLE & SUSTAINABLE ENERGY REVIEWS Volume: 100 Pages: 143-174 Published: FEB 2019
17. Towards Secure Industrial IoT: Blockchain System With Credit-Based Consensus Mechanism By: Huang, Junqin; Kong, Linghe; Chen, Guihai; et al. IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS Volume: 15 Issue: 6 Pages: 3680-3689 Published: JUN 2019
18. Dynamic reputation-based consensus mechanism: Real-time transactions for energy blockchain By: Cai, Wenjun; Jiang, Wei; Xie, Ke; et al. INTERNATIONAL JOURNAL OF DISTRIBUTED SENSOR NETWORKS Volume: 16 Issue: 3 Article Number: 1550147720907335 Published: MAR 2020
19. Anonymous and Traceable Group Data Sharing in Cloud Computing By: Shen, Jian; Zhou, Tianqi; Chen, Xiaofeng; IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY Volume: 13 Issue: 4 Pages: 912-925 Published: APR 2018
20. Research on information sharing management system architecture of construction supply chain based on blockchain（in Chinese）By：caoyang suzhenmin lina Construction economy Volume: 40 Issue: 05 Pages: 69-74 Published MAY2019
21. Blockchain for Secure and Efficient Data Sharing in Vehicular Edge Computing and Networks By: Kang, Jiawen; Yu, Rong; Huang, Xumin; IEEE INTERNET OF THINGS JOURNAL Volume: 6 Issue: 3 Pages: 4660-4670 Published: JUN 2019
22. A logistic regression model for consumer default risk By: Costa e Silva, Eliana; Lopes, Isabel Cristina; Correia, Aldina; et al. JOURNAL OF APPLIED STATISTICS Volume: 47 Issue: 13-15 Special Issue: SI Pages: 2879-2894 Published: NOV 17 2020 Early Access: MAY 2020
23. Research on personal credit evaluation based on machine learning method（in Chinese）By：zhouyuping，chenguanyu Financial Theory & Practice Issue: 12 Pages: 1-8 DEC2019
24. Prediction of Default Probability of Clients' Electricity Charge Arrears By: Zhou, Hui; Wang, Yi; Wang, Wei; conference: IEEE International Conference on Service Operations and Logistics and Informatics site: Beijing Jiaoton Univ, Beijing, PEOPLES R CHINA date: OCT 12-15, 2008
Conference sponsor: IEEE; IEEE Intelligent Transportat Syst Soc; Inst Operat Res & Management Sci, Serv Sci; Natl Sci Fdn China; K C Wong Educ Fdn; IBM; Chinese Acad Sci, Inst Automat

IEEE/SOLI'2008: PROCEEDINGS OF 2008 IEEE INTERNATIONAL CONFERENCE ON SERVICE OPERATIONS AND LOGISTICS, AND INFORMATICS, VOLS 1 AND 2 Pages: 2582 -+ Published: 2008

25. An empirical comparison of conventional techniques, neural networks and the three stage hybrid Adaptive Neuro Fuzzy Inference System (ANFIS) model for credit scoring analysis: The case of Turkish credit card data By: Akkoc, Soner EUROPEAN JOURNAL OF OPERATIONAL RESEARCH Volume: 222 Issue: 1 Pages: 168-178 Published: OCT 1 2012
26. Application of an Ensemble Learning Method in the Risk Prediction of Electricity Tariff Recovery By: Wu Huaiguang;Zhang Mingxing;Jin Baohua Journal of Physics: Conference Series Volume 1549, period: 5 JUN2020
27. Permissioned Blockchain and Edge Computing Empowered Privacy-Preserving Smart Grid Networks By: Gai, Keke; Wu, Yulu; Zhu, Liehuang; et al. IEEE INTERNET OF THINGS JOURNAL Volume: 6 Issue: 5 Special Issue: SI Pages: 7992-8004 Published: OCT 2019

Figures

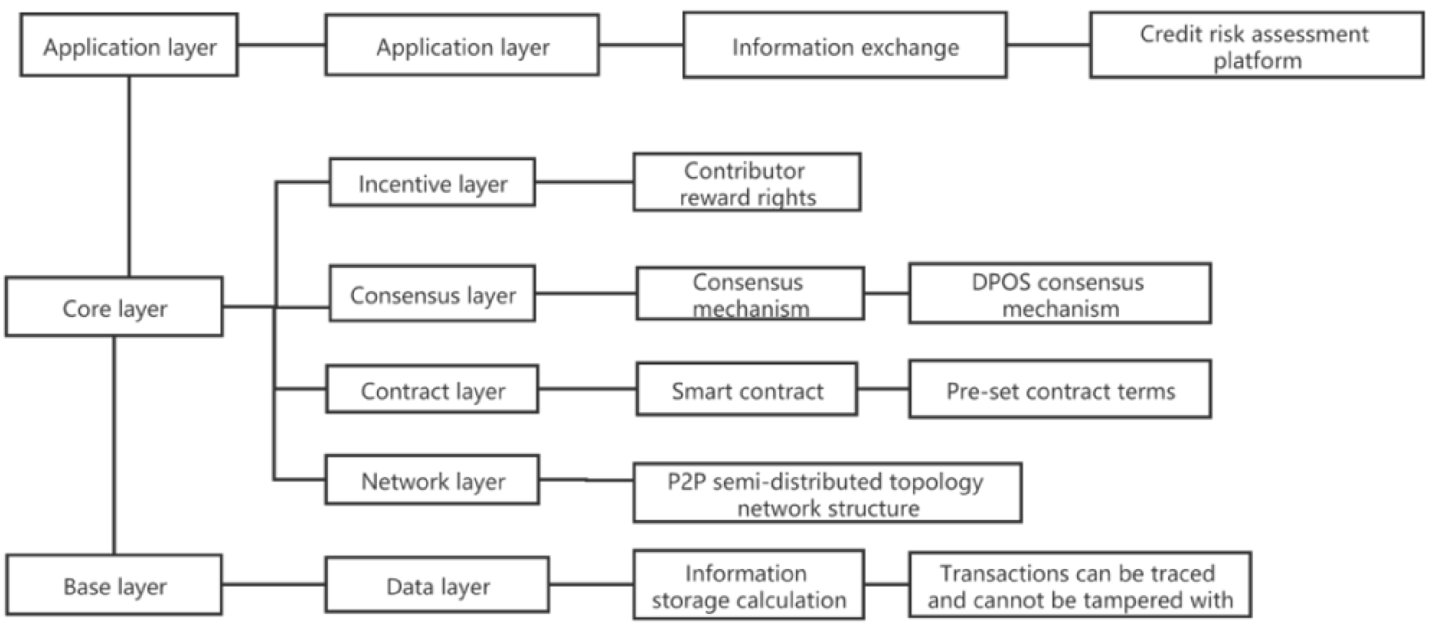

Figure 1

Blockchain data architecture diagram

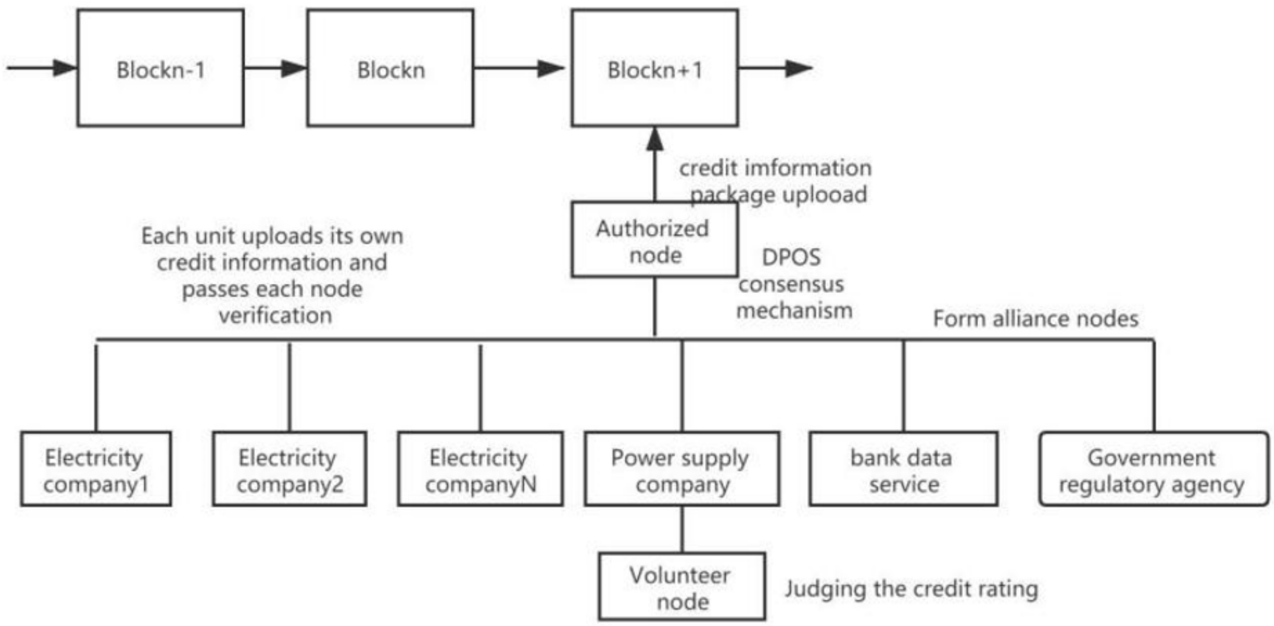

Figure 2

Blockchain data upload process

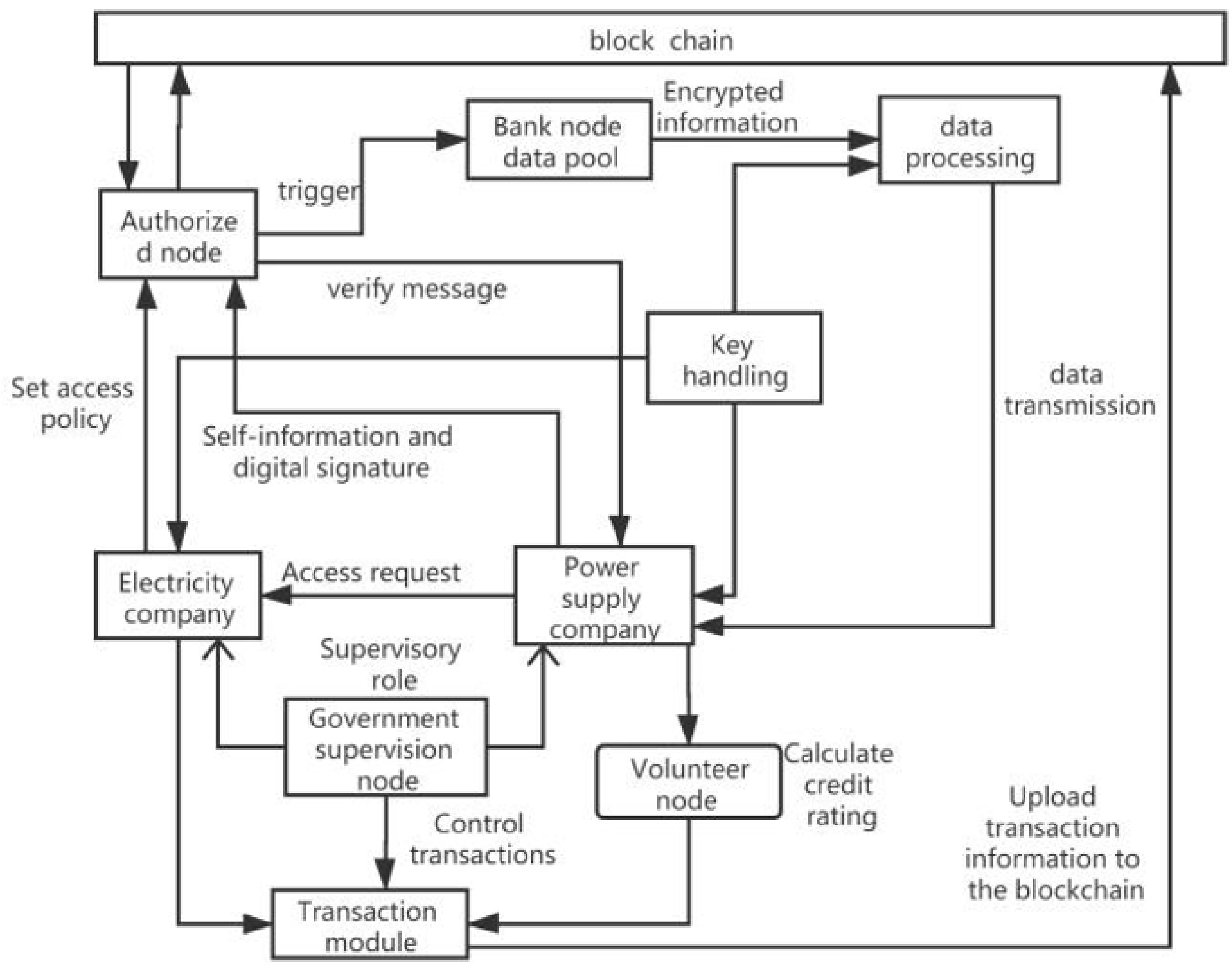

Figure 3

Blockchain data transmission

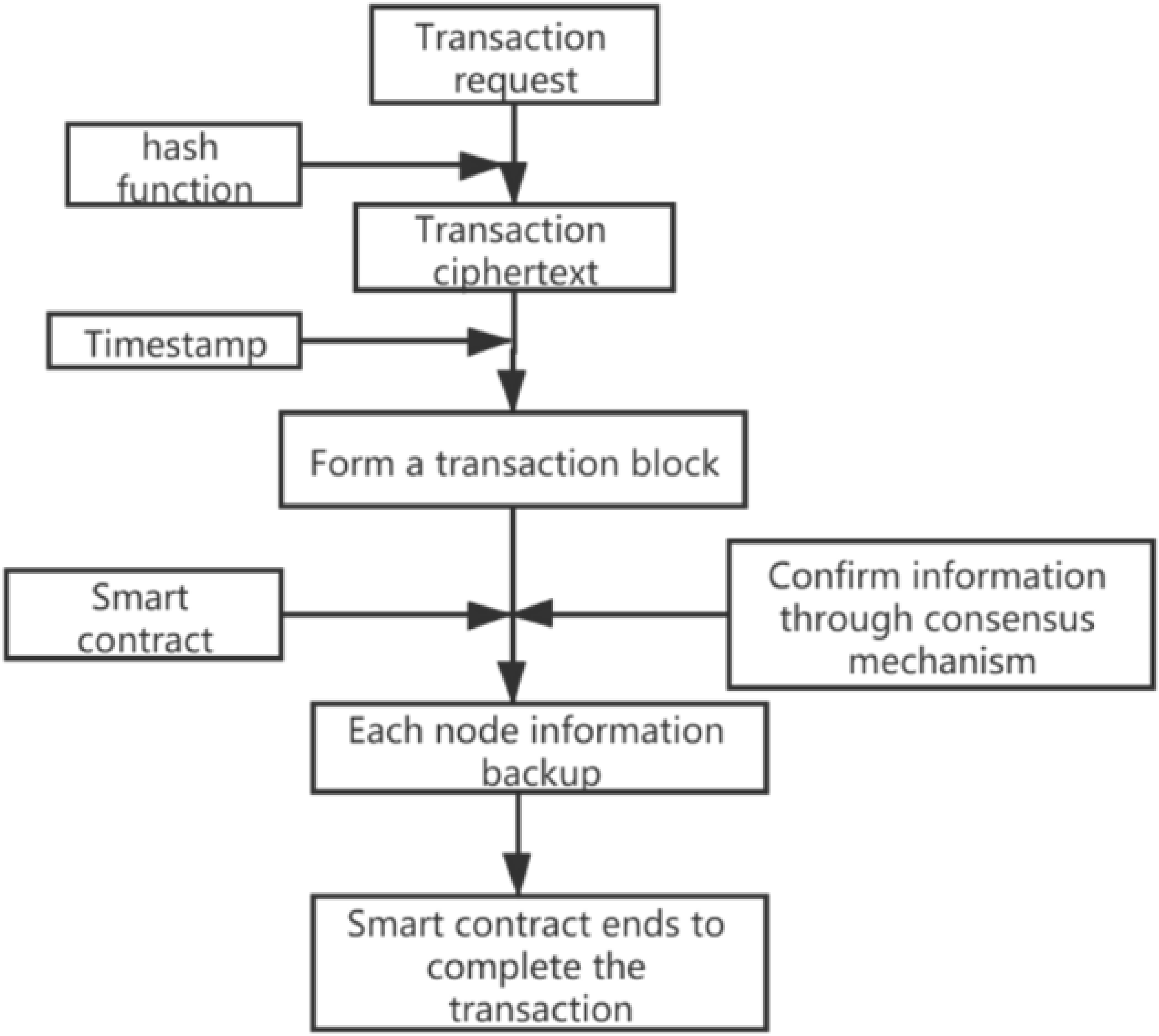

Figure 4

Blockchain transaction process