Smart contract transaction model of blockchain for multi-source and heterogeneous distribution network

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ABSTRACT

Aiming at the transaction problem of multi-source heterogeneous distribution network, a P2P intelligent contract based on blockchain technology is proposed. Firstly, a multi-source heterogeneous distribution network model based on Intelligent contract is established. Secondly, a multi-source heterogeneous distribution network market transaction mechanism is proposed. The mechanism designs different kinds of transaction members, frameworks and processes. Transaction members can participate in the market quotation and determine the transaction unit price according to their own power surplus and shortage state. Finally, a smart contract solution with blind beat mechanism is designed for the proposed transaction mechanism. The effectiveness of the transaction mechanism is verified by an example and deployed on the Ethereum private chain. The effectiveness of the transaction mechanism is verified by an example and deployed on the Ethereum private chain. Through the simulation transaction analysis, it can be seen that the above transaction mechanism effectively improves the economic benefits of trading members and effectively ensures the market security and free competition.

Keywords: Distribution network, blockchain, smart contract, Ethereum, distributed transaction

1. INTRODUCTION

At present, the use of traditional power energy has caused serious damage and pollution to the human ecological environment. How to use low-carbon power energy has become the direction of power development in the future[1, 2]. In order to penetrate more and more distributed clean power generation into the distribution system, ubiquitous power Internet of things and smart grid will gradually become the core components of power and energy Internet[3]. Intelligent distribution network is one of the key links of ubiquitous power Internet of things and smart grid. The basic condition for its implementation is intelligent distribution communication network. The business types of intelligent distribution communication are complex and diverse, the distribution communication nodes are scattered, the types of distribution network equipment are complex, and the communication needs between each node are different[4, 5].

In order to fully optimize and dispatch the power supply of distributed heterogeneous distribution network, the blockchain technology is adopted for the transaction of heterogeneous distribution network, which can effectively remove the centralization and ensure the security of transaction data[6, 7]. Blockchain technology, also known as “Distributed Ledger” technology, was proposed in the foundation paper bitcoin: a point-to-point e-cash system published by Satoshi Nakamoto in 2008[8]. Blockchain is a data storage technology based on the bottom layer of the Internet, which collectively maintains a reliable distributed data storage mechanism through decentralization and distrust. Reference[9] proposes a smart contract model based on blockchain, which applies blockchain technology to tea trading. Reference[10] proposed a method of automatic demand response, which applies blockchain technology to the field of energy. Reference[11] proposed a medical data sharing model based on blockchain to solve the problem of data sharing in various medical institutions. Reference[12] proposed a logical framework of blockchain model applied to the supply chain of agricultural products. Reference[13] proposes a privacy protection technology based on blockchain and interplanetary file system to solve the problem of information encryption and storage in the food supply system. Reference[14] respectively constructed a blockchain system architecture based on food traceability to solve the problem of improving the efficiency and transparency of the food supply chain. Reference[15] proposed using blockchain technology to solve the supervision of financial institutions. Reference[16] proposes to use the dual technology of blockchain and face recognition to solve the problem of authentication. In the application of distribution network, Reference[17] proposed a blockchain model for

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distribution network market transaction mechanism to solve the problem of market equilibrium and restrain cost information asymmetry. Reference[18] proposed a blockchain based and continuous two-way auction mechanism to solve the problem of direct transaction between microgrid distributed generation and user electricity.

In the distribution network with multi-source and heterogeneous forms, how to make the direct transaction between different types of nodes and ensure the transparency and credibility of the transaction is an important research topic in the field of power industry. Aiming at this problem, combined with blockchain technology, this paper proposes an intelligent contract model to meet the transaction of multi-source heterogeneous distribution network.

2. SMART CONTRACT MECHANISM AND BASIC MODEL

2.1 Basic structure of blockchain

As shown in Figure 1, its overall architecture model is divided into six layers[19].

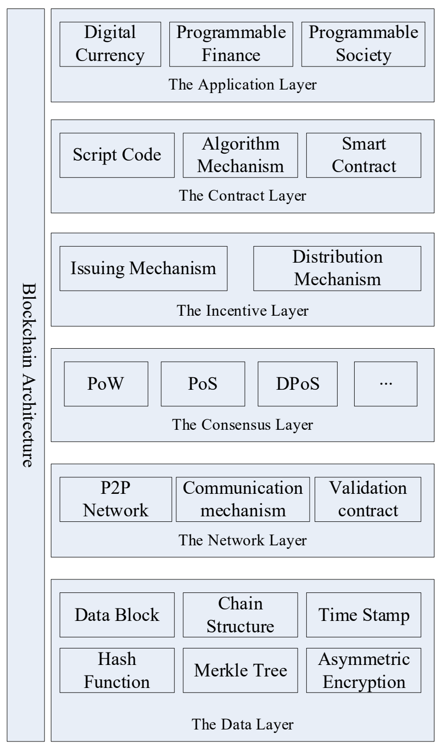

Figure 1. Blockchain system base architecture.

• The data layer mainly encapsulates the underlying data blocks and related basic data and basic algorithms such as data encryption and timestamp.

• The network layer mainly realizes the communication between network nodes, often uses peer-to-peer (P2P) communication mechanism for distributed networking, and gives the encapsulation of network data dissemination mechanism and verification mechanism.

• The consensus layer mainly realizes the record consistency of data and transaction information between all nodes, can prevent consensus attacks, and gives the encapsulation of consensus mechanism algorithm.

• The incentive layer mainly realizes the distribution of economic factors of the blockchain system, often adopts a game mechanism to encourage nodes that abide by the rules, and encapsulates the issuance mechanism and the distribution mechanism.

• The contract layer mainly provides the encapsulation of various scripts, algorithms and smart contracts, and can realize the programmability of the account book.

• The application layer mainly gives the encapsulation of various 11 application scenarios and cases of the blockchain system, as well as the further development environment and interface of the blockchain.

In the blockchain system, the nodes of data are connected one by one. Each block can be regarded as an independent bill, and its structure is shown in Figure 2.

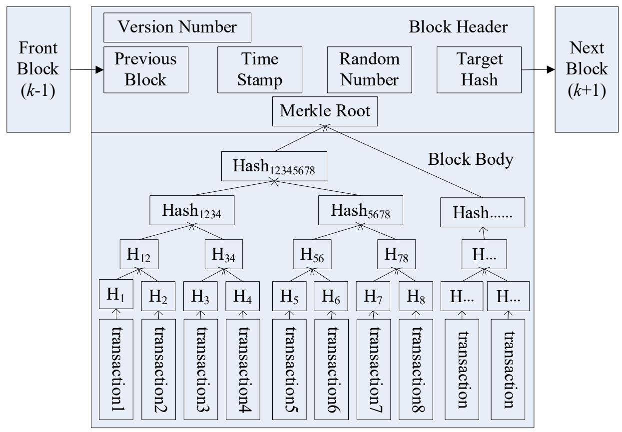

Figure 2. Block structure.

Each block is mainly composed of block header and block body, and its data structure information is shown in Table 1.

The block header includes three groups of block elements, namely: reference pre block hash value data information, metadata information and Merkle tree root data information. Its data structure information is shown in Table 2.

Table 1. Block data structure.

Serial Number	Field	Size	Field description
1	Block size	4 byte	The storage space size of the block is expressed in bytes
2	Block header	80 byte	Component block header element information
3	Transaction counter	1-9 (variable integer)	Record transaction quantity
4	Block body	Variable	Record the transaction information within the block

Table 2. Block header data structure.

Serial Number	Field	Size	Field description
1	Edition	4 byte	Version number for tracking system updates
2	Previous block	32 byte	The hash value of the preceding block that references the block
3	Merkle root	32 byte	The hash value of the Merkle tree root of the block
4	Time stamp	4 byte	The time the block was written
5	Target hash	4 byte	The block workload proves the target hash value of the algorithm
6	Random number	4 byte	Counter for workload proof algorithm

The timestamp, random number and target hash in the block header are mainly used in the mining process. The block body mainly records the hash value information of the Merkle tree of the transaction.

2.2 Smart contract mechanism

The concept of smart contract was first proposed by Nick Szabo in 1995. It is mainly to formulate a series of commitments in digital form, including the agreement of all parties to fulfil these commitments[20].

The blockchain based smart contract mechanism includes three parts: smart contract transaction processing, smart contract storage and smart contract state machine[21].

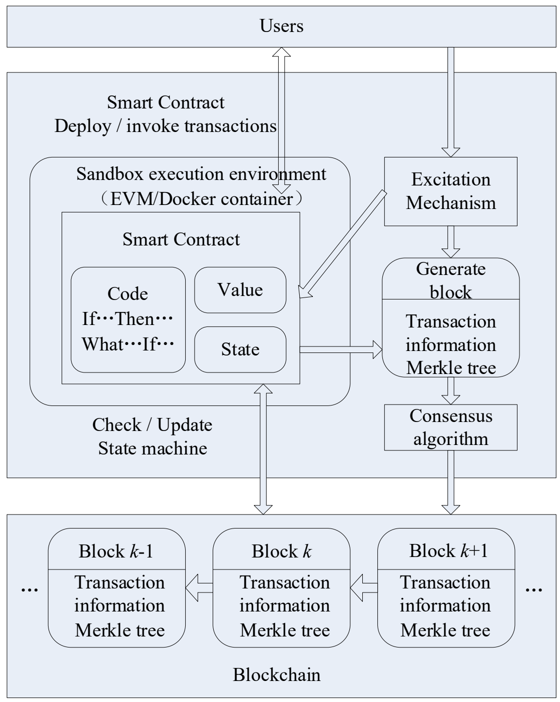

Figure 3. Basic structure of smart contract.

The basic structure of the smart contract is shown in Figure 3. The smart contract includes two attributes: value and state, and the trigger conditions and event corresponding rules of the smart contract are set with if then and what if statements[22]. After reaching the agreement consensus, the smart contract can be initiated by any user, spread through P2P network, and then stored in the block of the specified blockchain after being verified by the miner node.

3. MULTI-SOURCE HETEROGENEOUS DISTRIBUTION NETWORK MODEL BASED ON SMART CONTRACT

3.1 Multi-source heterogeneous structure of power internet of things

At present, in the power Internet of things, the information of power equipment has obvious heterogeneous characteristics. Power distributed energy information includes photovoltaic power information, wind power information and hydropower. User side information mainly includes smart meter information and smart load information. Under the multi-source heterogeneous power Internet of things, the overall architecture of distribution network is shown in Figure 4.

The sensing layer collects different power sources such as photovoltaic, wind power and energy storage through on-site acquisition components such as micro power inverter, collects end-user data through user smart meter, and carries out communication access of edge Internet of things through various sensors. The data aggregation layer arranges the data collected by the sensing layer through the aggregation node, accesses to the service layer through the network layer, and provides data for users of the application layer.

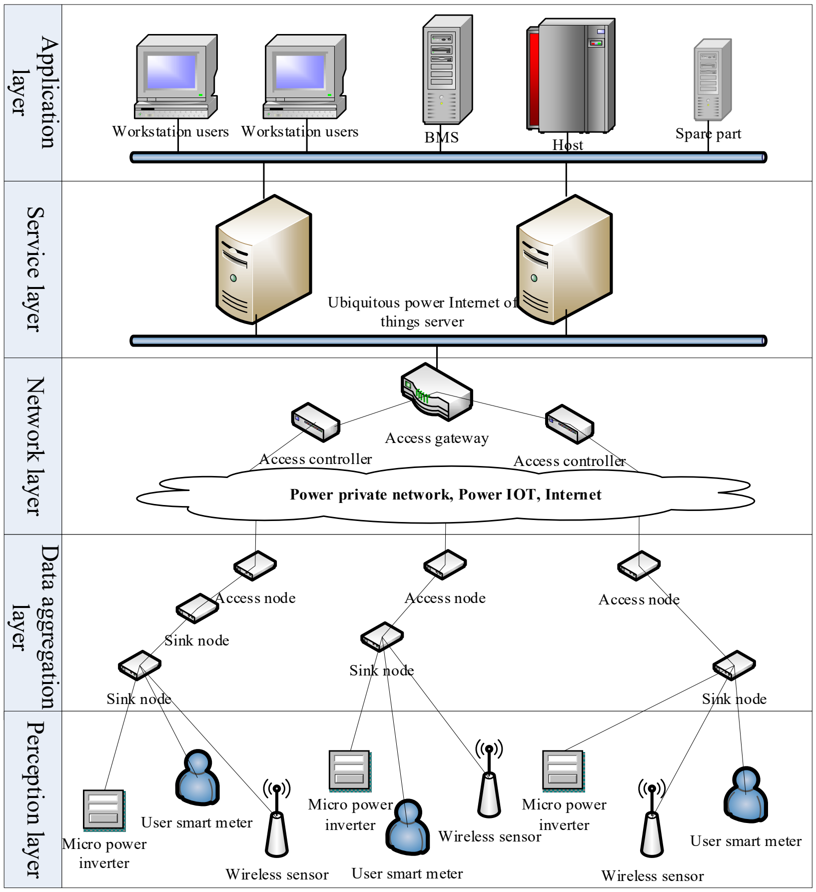

Figure 4. Framework of multi-source and heterogeneous power distribution network.

3.2 Power system model based on smart contract

In the distribution network power transaction of ubiquitous electric Internet of things, the user end members mainly include power users and power selling users. The power selling users are mainly microgrid users (MG users) and retail supplier users (RES users), and the power users are mainly load aggregator users (LA users). Compared with the previous centralized distribution system models, the distribution system based on blockchain technology will weaken the centralized operation mechanism of distribution system operator (DSO) in the whole distribution process, and use the protocol technology of intelligent contract to support the automatic execution of transactions through the pre agreed business requirements. Its model is shown in Figure 5.

MG users, LA users and RES users establish corresponding blocks respectively, and form a blockchain through the interconnection of the original sensing layer access node and sink node row. Blockchain is responsible for managing user terminals and transactions, forwarding distribution transactions initiated by terminals, verifying the legitimacy of new distribution transactions through the public key of distribution transaction information, maintaining a unified ledger, and each node finally forms a distributed ledger.

3.2.1 Regional Economic Optimization Model. In the decentralized transaction of distribution network, a multilateral transaction mechanism is adopted to enable flexible transactions between various producers and sellers in the blockchain network and reduce the deviation between the actual output (load) and power generation and consumption plan caused by transaction transmission. And through the regional economic optimization model to determine its own surplus and deficit state in the next period of time. Among them, the regional economic model of MG, LA and RES users is:

$$\min_{ID=i} C_{EMS,i} = C_{use,i} + C_{sell,i} + C_{pcc,i} \tag{1}$$

$$P_{t,i}^{pcc} + P_{t,i}^{CMS} + P_{t,i}^{DG} = P_{t,i}^{load} + P_{t,i}^{cl} \tag{2}$$

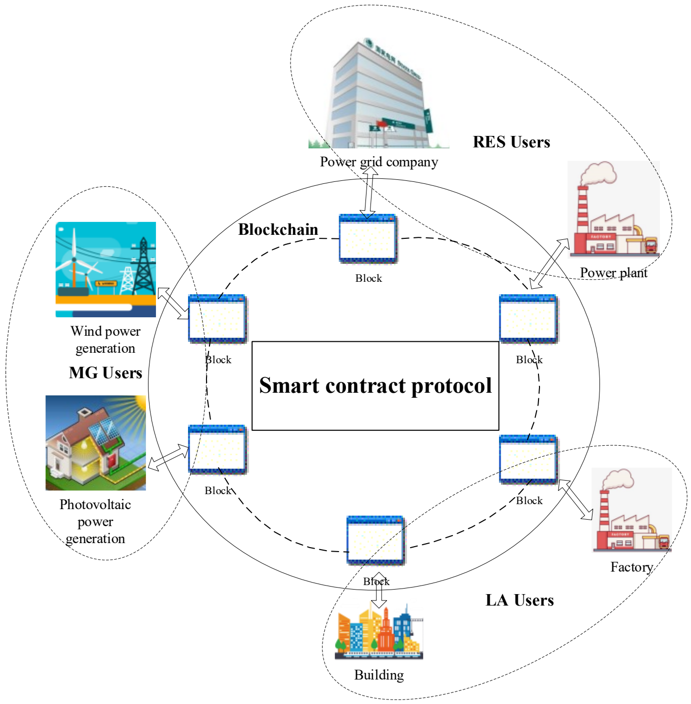

Figure 5. Framework of multi-source and heterogeneous power distribution network.

where $C_{EMS,i}$ is the operating cost of user I; $C_{use,i}$ is the operation cost of power consumption unit; $C_{sell,i}$ is the operating cost of power selling unit; $C_{pcc,i}$ is the operation cost of voltage conversion unit between users. $P_{t,i}^{pcc}$ is the power of tie line between users; $P_{t,i}^{CMS}$ is the output of controllable micro source; $P_{t,i}^{DG}$ is the output of uncontrollable micro source; $P_{t,i}^{load}$ is the power demand of uncontrollable load at time t; $P_{t,i}^{cl}$ is the power demand of controllable load.

3.2.2 Regional Trading Volume Model. When the market is open, the transaction share of each LA user can be determined through the regional transaction volume model, and the transaction unit price can be further determined through the auction contract. Among them, the smart contract layer model will be introduced in detail in Section 3.3. The LA regional transaction volume model is:

$$P_{t,i}^{EV} = \frac{\sum_{d=1}^{n} P_{\mathrm{n},t,i}^{DV}}{n} \alpha_i \tag{3}$$

where $P_{t,i}^{EV}$ is the expected transaction value of LA user i at time t, n is the number of days of data history, $P_{t,i}^{DV}$ is the demand value of LA user i at time t on the nth day, α_i is the energy saving coefficient set to prevent energy waste.

In addition, the transaction share of each user shall meet the following power balance constraints:

$$P_{i,t}^{sell} + P_{i,t}^{load} = P_{i,t}^{buyGrid} + P_{i,t}^{buyProsumer} + P_{i,t}^{MV} \tag{4}$$

where $P_{i,t}^{sell}$ is the selling power value of user i at time t, $P_{i,t}^{load}$ is the load power value, $P_{i,t}^{buyGrid}$ is the power value purchased from RES users, $P_{i,t}^{buyProsumer}$ is the power value purchased from MG users, $P_{i,t}^{MV}$ is the wind power value of MG user.

3.2.3 Regional Bidding Model. When the MG user determines the transaction with other users, the unit price quotation of transaction power auction of each La user can be determined through the regional bidding model. The following is a regional bidding model for LA users.

$$C_{\mathrm{at,i}} = (e^{\frac{P_{t,i}^{EV}}{S_t}\ln 2} - 1) \cdot (C^{buyGrid} - C^{sellGrid}) + C^{sellGrid} \tag{5}$$

where $C_{\mathrm{at,i}}$ is the bidding unit price of LA user i at time t, S_t is the total shortfall power value of all LA users at time t, $C^{buyGrid}$ is the multistep electricity unit price of RES users in different periods, $C^{sellGrid}$ is the unit price of on grid electricity price of MG users.

3.3 Smart contract layer constraint model

3.3.1 Auction Contract Introduction. The auction contract adopts the "blind auction" mechanism, while the LA user i is conducting the unit price auction, the quotation will not be seen by other users, but will be published as a false quotation. When the auction is over and the price is made public, the LA user will record the unit price quotation from high to low and count it into the clearing queue.

3.3.2 Contract Layer Constraint Model. While carrying out the auction contract, LA users need to abide by the following constraint model. The following is the wind power generation cost model of MG user.

$$C_t^{mv} = \frac{C_{EC}}{P_{GE} \cdot T_{LS}} \tag{6}$$

where C_t^{mv} is the unit price of wind power generation cost of Mg users in period t, C_{EC} is the cost of wind power generation equipment for MG users, P_{GE} is the average annual power generation of wind power generation equipment, T_{LS} is the service life of wind power generation equipment.

The following is the unit price constraint model of LA user bidding.

$$C_t^{mv} \le C_{at} \le C_t^{buyGrid} \tag{7}$$

where C_{at} is the unit price that LA users can bid at time t.

MG tradable unit price constraint model:

$$C_t^{sellGrid} \le C_{dt} \tag{8}$$

where C_{dt} is the unit price available for MG users at time t.

3.4 Market transaction framework and process

3.4.1 Transaction Framework. According to the analysis of trading framework in Figure 6, the market transaction process is mainly divided into three stages: task release stage, market clearing stage and transaction execution stage. Users conduct electricity unit price bidding at the market clearing stage through smart contracts. Finally, in the transaction execution stage, through "Web3.eth.sendtransaction" command executes an on-chain transaction.

3.4.2 Process of Each Transaction Stage. In the task release stage, firstly, the expected transaction power of each LA user the next day is determined through the economic optimization model and regional transaction volume model. After that, each LA user publicizes the expected transaction volume by executing the online access contract from 16:00 to 17:00 every day. Finally, the expected transaction power is stored on the private chain and reported to the market.

In the market clearing stage, each LA user first carries out market bidding with the auction contract through the regional bidding model 15 minutes before each time period on the premise of ensuring that the bidding and transaction unit price comply with the constraint model of each contract layer, and the one with low bidding first enters the clearing queue. Finally, the MG user determines the total transaction share according to the clearing queue order and the expected transaction volume reported by each LA user.

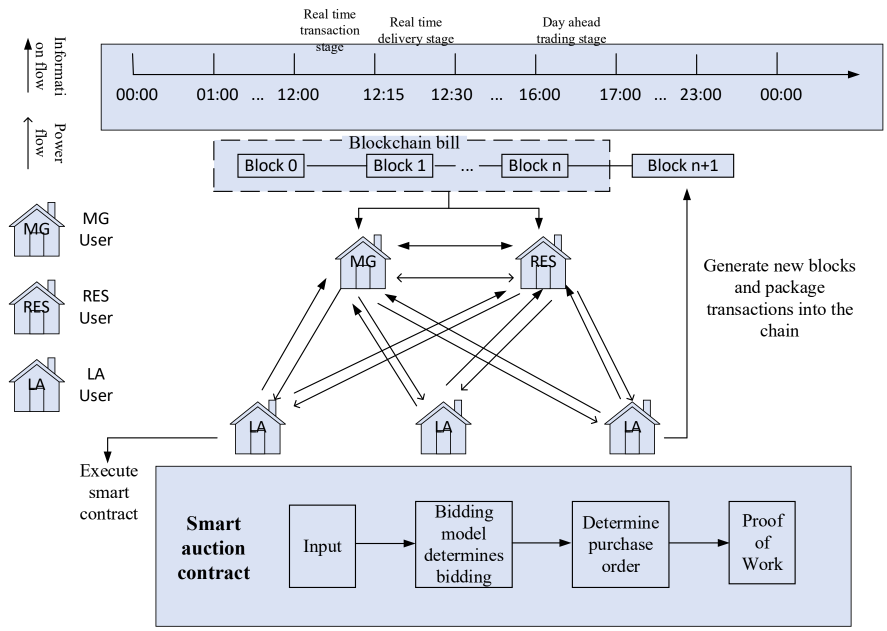

Figure 6. Transaction framework of multi-source and heterogeneous power distribution network.

In the transaction execution stage, according to the total transaction share determined by the MG user, execute the on-chain transaction according to the clearing queue determined by the LA user within 15 minutes of each time period. When the power is in the unbalanced state, the RES user will automatically balance the power surplus and deficit state of each user.

4. EXPERIMENTAL DESIGN

4.1 Experimental platform and construction

The experimental work of this paper uses a computer (Intel® Core ™ i5-10200H CPU，RAM 16G) in the environment of Ubuntu 16 geth1.10.1 and go1.16. It is completed jointly in the two platforms. The private blockchain adopts the Proof-of-Work (POW), and its private blockchain ID is 980429.

This paper sets up an experimental analysis for a multi-source heterogeneous distribution network composed of three LA users, one MG user and one RES user. The specific parameter settings are shown in Table 3.

Table 3. Parameters configuration.

Parameters and units	Value
α_i	0.33
$C^{buyGird}$/RMB	0.425 (peak load time)
	0.725 (normal load time)
	1.025 (valley load time)
$C^{sellGird}$ /RMB	0.38

This paper focuses on the smart contract model supported by blockchain technology, so the conversion relationship between digital currency and real electricity price when generating blockchain bills is not considered. This paper assumes that the conversion relationship between digital currency and RMB used in the blockchain is 1eth to RMB 1. In the initial state, the balance of each LA user account is 1500eth, and the balance of RES user account is 1000eth. Since MG only sells power, it does not need the basic fund to purchase power, and its balance is set to 0.

4.2 Experimental data

The experimental data of LA users in this paper are taken from the real power consumption data of different enterprises in a certain area. The experimental data of MG users are taken from the onshore wind power output data set of a certain area. RES user data is based on China's wind power grid price and industrial power flow price in 2020. The power flow period is divided into peak load time (8:00-11:00,18:00-23:00), normal load time (7:00-8:00,11:00-18:00) and valley load time (23:00-7:00).

4.3 Experimental result

4.3.1 Result Analysis of Task Release Stage. The data of different enterprises are analyzed through LA regional transaction volume model, and compared with the real power required on that day. On the premise of setting the energy-saving coefficient, it is ensured that the expected transaction power is lower than the real required power, and the rest of the required power is balanced by res users in the transaction execution stage. The transaction power and real demand of each La user are shown in Figures 7 and 8.

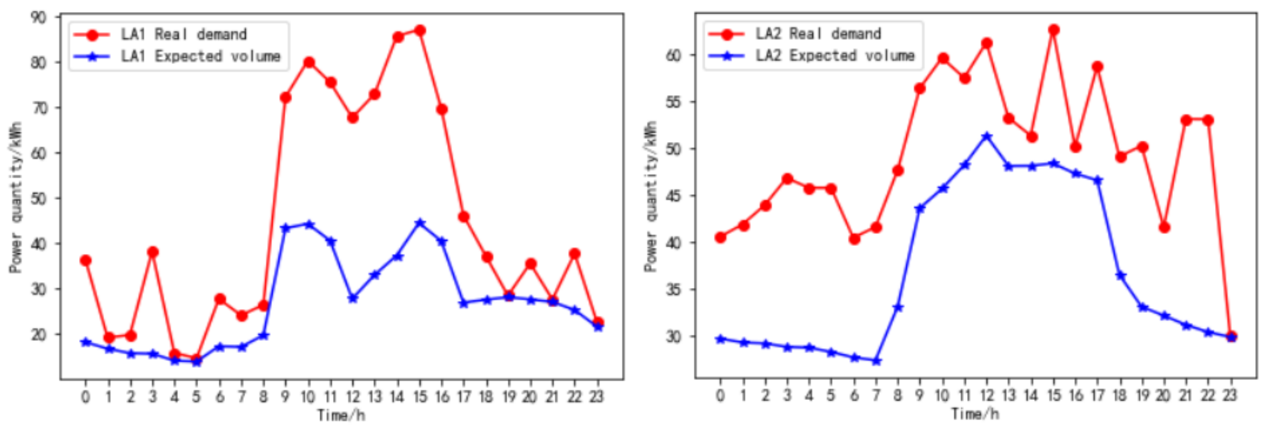

Figure 7. Comparison between expect transaction power and real demand of LA users1 & 2.

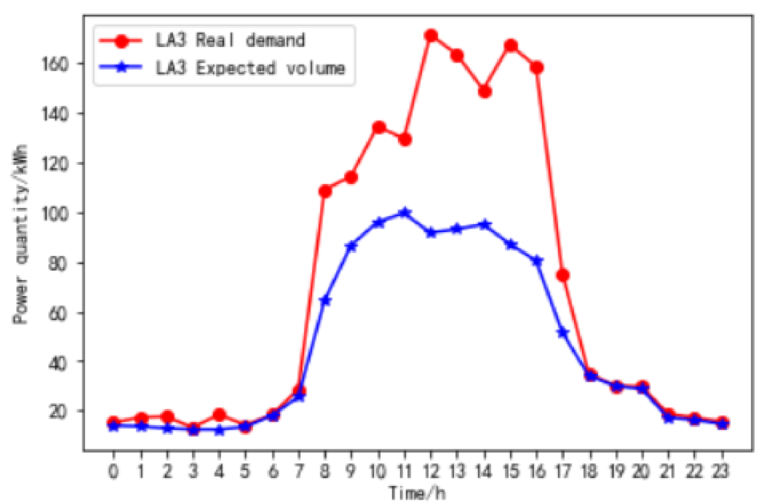

Figure 8. Comparison between expect transaction power and real demand of LA user 3.

Through the La regional trading volume model, the market vacancy status reported by La users under the premise of the same energy-saving coefficient can be determined, so as to determine the expected trading share.

4.3.2 Result Analysis of Market Clearing Stage. The system determines the power bidding unit price according to the regional bidding model of La users and compares the bidding of different La users. After that, each La users enter the transaction queue according to the unit price.

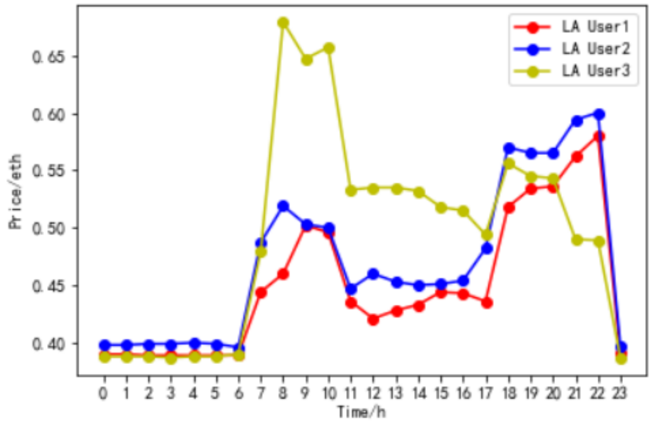

Figure 9. Bidding curve of users LA.

As shown in Figure 9, during 00:00-06:00, the expected transaction power value of each La user is small and the quotation is basically similar. Since 6:00, the power consumption gap of enterprises began to appear. At this time, the quotation span is quite different. The higher the quotation of users with high demand, the lower the power purchased from res users, so as to improve economic benefits.

4.3.3 Current Day Block Bill and Execution Results. The parent hash value of the blockchain built in this paper can trace the transaction information of the previous block, so as to realize the billing function of the blockchain and ensure the transparency and accessibility of the transaction. Moreover, the blockchain has a timestamp mechanism, which can be used to define the transaction time and prevent the possibility of malicious tampering. This paper determines the transaction flow and capital flow through the block transaction hash, and further shows the change of each account balance. The block bill is shown in Figures 10-12.

Figure 10. Genesis block.

Bolck0 is the creation block, which is responsible for recording the original information. Its parent hash value and timestamp are null.

```
{
  blockHash: "0xb02a5cad5134fe8bb48f905da7267d1f4c34d4cb1921c8e0f8d5cef28d2fcf97",
  blockNumber: 95,
  from: "0xbf9a98e415d907cb9771437ca52bf9d03ab7fff4",
  gas: 42461,
  gasPrice: 1000000000,
  hash: "0xa4fb43d1733b7d6ba7db82f5b599ec600bd0d8184b1dddd0b778fdc78c3a0651",
  input: "0xcbb053a800000000000000000000000000000000000000000000000000000000000002b",
  nonce: 23,
  r: "0x7ab5c82828e2183aacfaa285243f9de0c3693d59194d8eecb03860899a2a006d",
  s: "0x55ff49acb6dc5316bd353640d10d7c0c3fd215a4bfe0fed79f6e467514f602a0",
  to: "0x10d408c99257e9d2f7690dfc04a74d28f75bde54",
  transactionIndex: 0,
  type: "0x0",
  v: "0x1debbd",
  value: 0
}
```


Figure 11. The bill blockchain of publishing task.

The task release block bill records the expected transaction power confirmed by each LA user in this stage. Each LA user executes the contract 24 times before the day, and records the expected transaction power in 24 periods of the next day. The figure above shows the expected trading power of a certain period published by LA user 1. According to the input, the expected trading power of this user in this period is 43kwh.


```
blockHash: "0x0f9f005ee1876ff76fb9261649d9852e48d2f095c771adc4331febc8e1108023",
blockNumber: 645,
from: "0x9b2371daf6f578d854cd0f9469f1a2b76385bb05",
gas: 21000,
gasPrice: 1000000000,
hash: "0x61757abd83a306e0e13e46714422320ca334ded106eaf91e52017ff04faacc67",
input: "0x",
nonce: 0,
r: "0xb1ae1bad6c84b20222aa8f7db6c8a8061f34f3d50f1257a44a65b8c8bd0df926",
s: "0x35cd36738f9295c76719283c520a8f0b9eadb7ba1f972c7fdb47e53efc88eb2f",
to: "0xe97e2c4abff96bfeb289f5ba9f15180a189af1ce",
transactionIndex: 0,
type: "0x0",
v: "0x1debbd",
value: 12920000000000000000
blockHash: "0x8dc78987b24d5d5b33dfd2347e553592d3be4b34035d0ec73a679cc944b0c07e",
blockNumber: 648,
from: "0x9b2371daf6f578d854cd0f9469f1a2b76385bb05",
gas: 21000,
gasPrice: 1000000000,
hash: "0x4168c3820db77ca832f38601d1139c66a37c7ba9cda87d46c5460df7e79b82b9",
input: "0x",
nonce: 1,
r: "0xf6e3775260f5e7204ace8013e031964eefd3a0a10082e1320a232d1a9a4a1467",
s: "0x3e068f41c5f06d8f9d55c44d019c19db86d3547d2a630b08ce588cca625987d7",
to: "0x6b192c5b79bc758629f3aed8b6c10ceb6f659eb9",
transactionIndex: 0,
type: "0x0",
v: "0x1debbd",
value: 23150000000000000000
```


Figure 12. The bill blockchain of executing transaction.

Figure 12 shows the block bill in the transaction execution stage. At this stage, the bill records the details of the clearing results of each LA user, and the capital flow and transaction amount can be determined according to the sender/receiver and value.

After the transaction is completed, the detailed quotation, bidding and transaction completion information of each user in each period of the day determined according to the bill balance of each user are shown in Table 4.

Table 4. Detailed transaction volume.

Time	Bidding per LA user/eth			Expected transaction volume per LA user/kWh			Actual demand per LA user /kWh			MG user's residual power/kWh
	LA1	LA2	LA3	LA1	LA2	LA3	LA1	LA2	LA3	
00:00-01:00	0.390	0.398	0.388	18.21	29.71	14.05	36.36	40.58	15.10	160.5
01:00-02:00	0.390	0.398	0.388	16.76	29.30	13.65	19.20	41.87	17.30	165.8
02:00-03:00	0.389	0.399	0.388	15.79	29.20	12.92	19.80	43.92	17.60	159.2
03:00-04:00	0.389	0.399	0.387	15.67	28.83	12.44	38.16	46.84	13.20	145.5
04:00-05:00	0.389	0.400	0.388	14.14	28.75	12.43	15.84	45.78	18.40	148.9
05:00-06:00	0.389	0.399	0.388	13.96	28.29	13.46	14.68	45.77	14.20	147.1
06:00-07:00	0.389	0.396	0.390	17.32	27.71	17.99	27.72	40.46	18.30	141.8
07:00-08:00	0.444	0.487	0.479	17.17	27.40	25.51	24.12	41.60	28.60	128.6
08:00-09:00	0.460	0.519	0.679	19.70	33.10	64.40	26.40	47.66	108.90	111.7
09:00-10:00	0.502	0.503	0.647	43.25	43.61	86.52	72.12	56.39	114.40	97.3
10:00-11:00	0.496	0.500	0.657	44.21	45.68	95.87	80.04	59.63	134.40	89.1
11:00-12:00	0.436	0.447	0.533	40.54	48.19	99.46	75.36	57.50	129.50	76.4
12:00-13:00	0.421	0.460	0.535	27.75	51.35	91.61	67.56	61.26	171.30	69.7
13:00-14:00	0.428	0.453	0.535	32.97	48.11	92.99	72.72	53.24	163.40	60.4
14:00-15:00	0.433	0.450	0.532	37.27	48.13	94.98	85.44	51.35	149.20	58.4
15:00-16:00	0.444	0.451	0.518	44.41	48.39	87.15	86.88	62.70	167.30	61.7
16:00-17:00	0.443	0.454	0.515	40.45	47.30	80.33	69.60	50.16	158.60	67.3
17:00-18:00	0.436	0.482	0.494	26.90	46.58	51.35	46.08	58.73	75.00	77.8
18:00-19:00	0.518	0.570	0.556	27.54	36.52	34.08	37.20	49.11	34.90	92.4
19:00-20:00	0.534	0.565	0.545	28.08	33.11	29.93	28.44	50.27	30.00	109.2
20:00-21:00	0.536	0.565	0.543	27.62	32.16	28.71	35.52	41.58	29.70	119.8
21:00-22:00	0.562	0.594	0.490	27.05	31.17	17.19	27.60	53.12	18.70	124
22:00-23:00	0.580	0.600	0.489	25.28	30.40	16.25	37.68	53.10	17.20	132.1
23:00-24:00	0.391	0.397	0.387	21.63	29.88	14.70	22.68	30.03	15.60	139.8

According to the execution results, compared with the traditional main network supply mode, users LA1, LA2 and LA3 save 9.22%, 12.96% and 20.31% respectively. For MG users, compared with the traditional clearing method of the main network, the economic benefit is increased by 20.2%. The improvement of users' own economy means that their dependence on the main network has decreased, and the loss of transformer equipment during peak power consumption has also been reduced.

5. CONCLUSION

With the development of low-carbon power, the proportion of microgrid users participating in the market is increasing.

In order to improve the economic benefits of distribution network users, this paper proposes an intelligent contract model of multi-source heterogeneous distribution network blockchain. Firstly, a power system model based on smart contract is proposed. Secondly, the market transaction process is described. Third, according to the contract model, the application scheme of intelligent contract for multi-source heterogeneous distribution network is designed and verified on Ethereum platform. Finally, according to a real power consumption data and an onshore wind power load output data, the simulation transaction analysis is carried out on the Ethereum private chain, and the following conclusions are obtained.

The intelligent contract model of multi-source heterogeneous distribution network blockchain proposed in this paper is compared with the traditional clearing method of the main network. Each user can dynamically adjust the quotation and independently select the transaction unit price according to the real-time market information, instead of trading with the main network alone. Moreover, the economic benefits of all users have been improved to a certain extent, and the win-win situation among users has been realized.

For the whole distribution network, by setting energy-saving coefficient and constraint model, the energy utilization rate is improved and the waste of resources is avoided to a certain extent.

For all users, the blind auction mechanism smart contract proposed in this paper prevents malicious bidding to a certain extent and ensures the free competition of the market.

Using blockchain technology and smart contract as technical support can ensure the openness, transparency and automatic execution of transactions, and make the bills in each period traceable and ensure the security of transactions.

The prediction accuracy is improved when establishing the regional volume trading model and considering the rules of market economy when establishing the bidding model, so as to further improve the economic benefits of each user will be the main research direction in the next step.

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