Research on the Application of Smart Rural Governance Platform Based on Blockchain Technology in Rural Sustainable Development

Zhou Yangang [1], Duan Zhiyi [2] *

Abstract

After the 21st century, urban development is an important support and main symbol of national economic development, but various sharp problems emerge one after another in the process of rapid urban development, and the time period from brewing to worsening is getting shorter and shorter. With the acceleration of urbanization, the development of smart cities has begun to take shape, and the rapid development of new technologies such as mobile Internet also brings new opportunities for the construction of smart villages. Blockchain thinking is very suitable for rural governance, which is of great significance for rural revitalization. However, there are many problems in the process of applying blockchain to help rural governance innovation. Therefore, we must strengthen the construction of rural governance subject, unite the consensus of rural governance, innovate the rural governance mechanism, give full play to the role of rural governance subject, develop rural industry and realize the innovation of rural governance mode. For the evaluation of smart villages, it is necessary to comprehensively consider the development status and future trends, not only to evaluate the application results achieved, but also to pay attention to the future development ability. In order to promote the modernization of rural economic management and ensure the sustainable development of rural economy.

Keywords: Blockchain; Smart country; Rural areas; Sustainable development

1 Introduction

Today is an era when information technology is taking off. All industries and fields have achieved a high degree of integration with information technology, and with the help of the advantages of information technology, the innovative development of industries and fields has been realized. Since IBM put forward "Smart Earth" in 2008, how to make our society more "smart" has become a global concern [1]. Innovating the rural governance model and realizing effective governance are the key to implementing the rural revitalization strategy, and the guarantee for realizing the goal of rural agricultural modernization, implementing the new development concept and

liberating and developing rural productive forces. Apart from the well-known simple applications such as virtual currency, blockchain is a new technology with broader concept, wider application and infinite potential. Embodying the concept of decentralization of blockchain, rural revitalization needs to play the role of each type of subject, which is a higher-level self-organization [2].

Smart villages deeply integrate emerging technologies such as Internet of Things infrastructure, cloud computing, big data, Internet of Things, mobile internet and artificial intelligence with urban planning, construction, management and operation, and implement the development concept of innovation, coordination, green, openness and sharing to promote the healthy development of cities. Research on supply chain governance is gradually rising, in order to better solve the problem of "rip-off" and corresponding renegotiation and benefit distribution [3-4]. It can be said that blockchain technology is a

1. School of Fine Arts and Art Design of Kunming University, Yunnan, Kunming City,China,650000
2. School of Fine Arts and Art Design of Kunming University, Yunnan, Kunming City,China,650000
*Corresponding Author Email:lookstone@163.com

technical tool, and its application can realize interaction, mutual assistance and economies of scale in the process of rural governance, and can eliminate some drawbacks of traditional rural governance [5]. For example, environmental degradation, traffic congestion, irrational allocation of resources, and intensified social contradictions have brought great challenges to people's happy life, stable economic development and safe operation of cities. Rural revitalization should also establish a mechanism that can resist the externalities of economic interaction and maintain a good rural environment in the process of development. If the application of information means can not bring rich economic benefits to rural residents in time, or help them solve their economic difficulties quickly, it will make the propaganda of information means meaningless and hinder the application process of rural economic information means to a certain extent.

The so-called blockchain is a technical scheme to collectively maintain a reliable database through distributed data storage, point-to-point transmission, consensus mechanism, encryption algorithm and other computer technologies in a decentralized and distrustful way [6]. Blockchain, as a frontier technology and social hotspot, has no reason not to bring it into the research field of vision. Combining it with the study of rural development, blockchain can promote the continuous development of rural areas at the technical level, and may also impact the inherent market structure. The data records of blockchain system are open and transparent, and cannot be tampered with, which is very suitable for collective maintenance and supervision. This "decentralization" thinking of blockchain is very suitable for rural governance, which is of great significance for rural revitalization. Based on this, this study establishes a smart village governance platform based on blockchain technology wisdom, with a view to deepening the analysis and research of smart villages and providing reference for the sustainable development of smart villages in China.

2 Related work

The development prospect of blockchain technology was studied earlier by foreign researchers. First of all, some scholars believe that from the perspective of commercial banks, if these banks actively and reasonably apply blockchain technology, they will certainly benefit from it. The value chain will further extend to the service end, providing high-quality and rich services and solutions will be an important source of income for the manufacturing industry, and products will gradually be transformed into carriers for manufacturers to provide services; Zhang et al. [7] think that blockchain itself has some shortcomings, such as the insecurity and difficulty in supervision of public chain, so the market is more willing to study private chain with smaller scope of application, fewer participants and lower advantages, which is contrary to the original intention of developing blockchain. For example, Wei Houkai [8] thinks that although a large amount of funds flow into the fund pool of blockchain research, blockchain application itself is only slowly and cautiously out of the laboratory. Wang Yong [9] emphasized that blockchain technology is a virtual technology after all, and it is difficult to assume the responsibility of international currency. Song Xianfeng [10] believes that the application of blockchain technology in virtual currency and other fields will help strengthen the control of currency and promote the development of the real economy. Kshetri[11] pointed out that banks are industries with high-strength trust, and the existence of blockchain just meets this point, so it has broad development prospects. Therefore, only by fully evaluating the risks, benefits and objectives of blockchain technology in rural governance, can it be applied to future rural governance and become the best choice for interaction between the state and citizens.

3 Method

If we compare the operation of blockchain system to the activity of beading, then blockchain is a continuously extended bead chain. Blocks are beads with their own names and previous bead names. The working node is not only the beader, but also the bead maker. It's just that people with keys can check it. This means that any authorized person can see the records of the whole data chain at any node, so that the audit department and the supervision department will celebrate the first time. Individualization will become the basic attribute of many products, which also provides new ideas for solving the competitive dilemma of enterprise homogenization; Anyone with appropriate encryption rights (consumers, auditors or regulators) can access a copy of the classification chain and verify past transactions without having to trust the participants' original transactions. Blockchain first exerts its strength in point-to-point value exchange, and if it is extended to the society, a new type of fully automatic intelligent contract society can be formed [12-13]. Using distributed

network management and data opening can improve the openness of government's handling affairs according to law. Data analysis and big data technology also play a positive role in government management and decision-making, which can avoid many problems of doing things by experience.

With the rapid development of blockchain technology, its technology platform also presents a diversified development trend. Choosing the appropriate blockchain technology platform can often make the developed application system safer and more efficient. Considering the running stability of the system, this paper only chooses Bitcoin, Ethereum and Hyperledger Fabric as the mainstream open source blockchain platforms for analysis [14]. By comparing the architecture model, consensus mechanism and applicable scenarios of the three, the blockchain basic platform suitable for the digital asset trading system is selected. The characteristics of the three types of blockchain platforms are shown in Table 1:

Table 1 Comparison table of mainstream blockchain platforms

Frame type	Do you need tokens	Do you support smart contracts	Consensus mechanism	Running environment	Applicable scenarios
Bitcoin	Yes	Yes	POW	Built-in script engine	Public chain
Ethereum	Yes	Yes	POW/POS	EVM	Public chain/alliance chain
Fabric	No	Yes	PBFT/KAFKA	Docker	Alliance chain

Because bitcoin platform does not support smart contracts, it is difficult to realize complex digital asset trading business, so it is impossible to develop and design a digital asset trading system based on Bitcoin platform. Ethereum platform provides intelligent contract support, but it can only achieve the throughput of about 25 transactions per second [15]. Fabric platform is a kind of alliance chain architecture, which supports intelligent contract technology. The operation of the system does not depend on tokens, and can support the throughput of about 100 transactions per second, which basically meets the needs of cross-institutional transactions of digital assets between alliance institutions.

Blockchain is a reliable system established under the condition that each node does not trust each other. In terms of its function, it provides users with reliable data. In terms of content, its data has a copy at each node, which can be regarded as a distributed database. This database only allows data modification and insertion by adding, and does not allow deletion [16].

We take Bitcoin as an example to introduce the blockchain structure. In the blockchain system, each user has his own public key address and private key. Blockchain is a chain data structure composed of blocks. The structure of each block is shown in Figure 1. The structure of each block contains the hash value of the previous block, thus forming a chain structure. Transaction records are organized in the form of Merkle Tree.
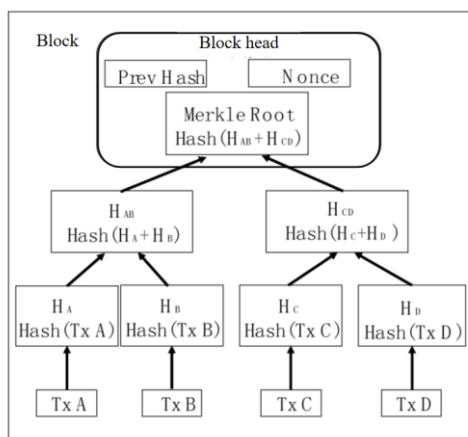

Figure 1 Common blockchain structure

Time stamp technology is widely used in business application of blockchain, that is, time values

collected on authoritative timing platform are written into blocks, time marks are added to data blocks, and "data+time" is broadcast to the whole network to synchronize the whole network. The data block records the hash value of the previous block through the block header along the time axis, so that all blocks are connected in series, which can not be tampered with. As shown in figure 2.

Figure 2 Timestamp server of Bitcoin chain

Another key point of algorithmic rationality is "timeline", which makes use of the unidirectional and irreversible characteristics of time to ensure that there is no duplicate record of transactions. Therefore, there is no duplicate and original in the blockchain, and all files are the only original, because time cannot appear twice.

"Smart Village" is a higher demand and standard for the construction of beautiful countryside. To build a "smart village" is not only to build a new countryside with "productive development, affluent life, clean village, civilized rural style and democratic management", but also to further break the current dual structure between urban and rural areas and release the potential and vitality of rural development. We can think of blockchain as a pearl necklace, each pearl is a block (data block), and the chain connecting pearls is a variety of relationships and mechanisms. However, the constructed rural informatization network and facilities can not be optimized and upgraded in time, resulting in poor application effect of informatization means in rural economic management [17]. Therefore, the construction emphasis of smart villages will be different from that of smart villages. The European Commission believes that smart villages tend to pay more attention to big data and change the way cities operate through interrelated digital technologies; Smart countryside is not only an extension of these principles in scattered areas, but also a place that holds its own future in its own hands with the help of digital technology [18].

There are incentives in the system to encourage users to gain benefits by maintaining the blockchain system. Users participating in the consensus process collect the newly generated transaction record construction blocks, and try to modify the Nonce value in the blocks until the hash value of the blocks is smaller than the hash value with specific difficulty, and then they can broadcast the blocks to the outside world.

Algorithm 1: Pow proof mechanism
Input:preHash, txs, D
Output:Block
1:nonce $\leftarrow$ 1
2:while(H(nonce, txs, preHash) $>$ = D):
3: nonce $\leftarrow$ nonce +1
4:Broadcast($<$ nonce, txs, preHash $>$)
5:end

If most computing resources are controlled by honest nodes, the bitcoin ledger will be maintained normally.

Algorithm 2: Peercoin proof mechanism algorithm
Input:preHash, txs, D,
Account Balance, lash Transaction Time
Output:Block
1:nonce $\leftarrow$ 1
2:coins $\leftarrow$ account Balance
3:age $\leftarrow$ current Time-lash Transaction Time
4:while(H(nonce, txs, preHash) $>$ = coins·age·D):
5: nonce $\leftarrow$ nonce +1
6:Broadcast($<$ nonce, txs, preBlockHash $>$)
7:end

Although POS (Proof of Stake) algorithm can alleviate the competition of computing resources brought by POW to a certain extent, it still has problems. For example, a user owns a lot of blockchain assets, or holds them for a long time, or even holds blockchain assets from ICO, which can cause serious inequality between the rich and the poor, and is not friendly to new nodes in the network.

Merkle Tree [19] is a generalization of Hash List, which is also commonly called hash tree. the structure

of merkletree is shown in figure 3. The hash value of the transaction is taken as the leaf node of MerkleTree, which is merged in pairs to obtain the upper node and finally the root node. The root node is stored in the head of the blockchain. Merkle Tree has the function of error detection, and the inconsistency of any node will lead to the inconsistency of the final root result.
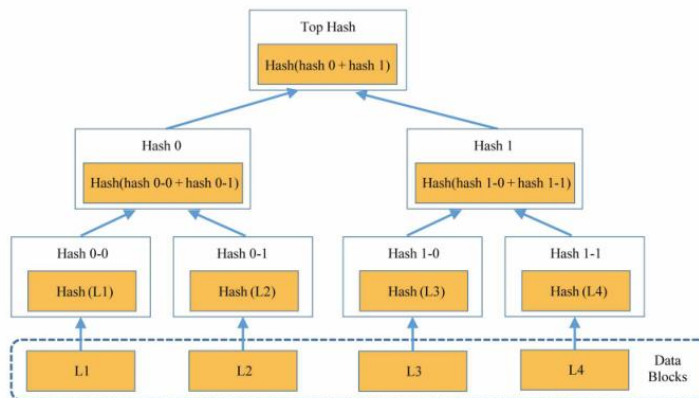

Figure 3 Merkle Tree structure

The structure of MPT tree nodes is shown in Figure 4. There are four kinds of nodes: empty nodes, leaf nodes, extended nodes and branch nodes.
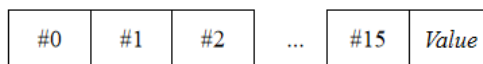

Figure 4 MPT tree node

Empty nodes are simply represented as empty, and leaf nodes are represented as a list of (key,value), where key is a special hexadecimal code of key and value is RLP code of value.

The extended node is also a list of (key,value), but the value here is the hash of other nodes, which can be used to query the nodes in the database, that is, to link to other nodes through hash.

Rural industry revitalization can not be separated from efficient rural governance, and the innovation of rural governance system with the idea and method of blockchain is beneficial to rural industry revitalization. Blockchain technology breaks through the limitation of traditional centralized data technology, and has the advantages of decentralization, security, openness, and unchangeable data. Its "distribution" is not only reflected in the distribution of data records, but also in the distribution of data backup and storage. In the working process of blockchain, its distribution characteristics just correspond to the industrial revitalization in rural revitalization, and the interaction, mutual connection and vertical development among various nodes reflect the mutual cooperation and development role among various subjects of industrial revitalization. Enhance traditional and new networks through digital communication technology, innovation and better use of knowledge, so as to benefit rural areas and society. The data layer is the basic data recorded by algorithm, such as data block, data encryption and time stamp. The network layer includes the rules of distributed network organization, data dissemination and verification. A large amount of information from rural planning, design and construction can be brought into the operation and maintenance stage, so BIM technology will also be applied to the operation and maintenance stage in beautiful countryside.

4 Result analysis

In this era of data explosion, how to deal with all kinds of data problems has naturally become the top priority of the government. The integration of blockchain and supply chain governance on the network by means of information system integration includes digital supply chain [20], dynamic multi-center collaborative certification of supply chain [20] and intelligent contract program development to promote multi-party business cooperation [21]. The advantage of blockchain is that it does not need a trusted third party (e.g. notary), but only needs to

execute instructions through an encrypted code, so that all participants are protected from fraud risks, and at the same time, it can reduce management costs. Because the production line will organize production according to orders, which come from customers, designers or next-level manufacturing links, but they must be authentic and effective, which can also be guaranteed by recording orders in the blockchain distributed whole-course bookkeeping mode [23]. This ensures the security of the data on the chain. Third, if the laws and blockchain rules are set in place, it will save manpower input and subjective judgment, so that intelligent procedures will make transactions and other applications more fair and reliable.

In order to improve the anti ASIC ability of blockchain consensus algorithm and ensure the security of the algorithm, this paper proposes a random parallel consensus algorithm rpca16 (random parallel consensus algorithm 16). The main idea of rpca16 algorithm is to construct a hash algorithm pool, and then randomly select the algorithm from the algorithm pool for parallel calculation, so as to obtain the random number (none value) of the block that meets the difficulty conditions [24].

To build RPCA16 random algorithm, hash algorithm pool should be built first [25]. Hash algorithm pool is an ordered set containing 16 hash algorithms, and its elements are shown in Table 2, in which the serial numbers are expressed in hexadecimal numbers. The selected hash algorithms include 15 standard hash algorithms in X15 algorithm, plus SHA512 algorithm.

Table 2 RPCA16 algorithm pool

Serial number	Algorithm	Serial number	Algorithm	Serial number	Algorithm	Serial number	Algorithm
0	blake	4	keccak	8	shavite	C	fugue
1	bmw	5	skein	9	simd	D	shabal
2	groestl	6	luffa	A	echo	E	whirlpool
3	jh	7	cubehash	B	hamsi	F	sha512

For example, assuming that the last four bits of H1 are 9d2a, these four numbers are sorted from small to large, with the sorting number of 9 being 1, the sorting number of D being 3, the sorting number of 2 being 0 and the sorting number of A being 2, then each bit in 9d2a is replaced by the sorting number, and 1302 is obtained. Taking each bit in 1302 as the serial number, the algorithm is selected from the ordered set A in turn, and a new ordered set A1 is obtained, as shown in Table 3.

Table 3 Ordered set A1

| Serial number	Algorithm	Serial number	Algorithm	Serial number	Algorithm	Serial number	Algorithm
0	whirlpool	0	fugue	2	jh	3	groestl

The block header data D of the current block is sequentially calculated by four hash algorithms in the ordered set A1 to obtain hash values h1, h2, h3 and h4. That is,

$h1 = whirlpool(A1)$
$h2 = fugue(h1)$
$h3 = jh(h2)$
$h4 = groestl(h3)$

Take the first 64 bits (binary bits) of each hash value of h1, h2, h3 and h4 to obtain p1, p2, p3 and p4. Divide each number into front and back sections according to the length of 32 bits (binary bits), and get p1a, p1b, p2a, p2b, p3a, p3b, p4a and p4b. The eight numbers are confusingly arranged in the following order: p1a, p2a, p3a, p4a, p1b, p2b, p3b and p4b, and the final block header hash value L is obtained. See fig. 5 for the specific arrangement method.

Smart contract was first proposed by Dr. Nick Szabo, and it is considered as a contract defined in digital form, which can automatically execute terms. Intelligent contract was originally designed to create flexible and controllable intelligent assets, but it has not been widely used due to the limitations of technology development and lack of practical application scenarios [26]. The emergence of blockchain has greatly enriched and developed smart contract technology. Blockchain smart contract is defined as a computer program, which can be automatically executed once successfully deployed, so that blockchain system can flexibly program and

$whirlpool(a1) \rightarrow p1$ $fugue(h1) \rightarrow p2$

$ih(h2) \rightarrow p1$ $groestl(h3) \rightarrow p4$
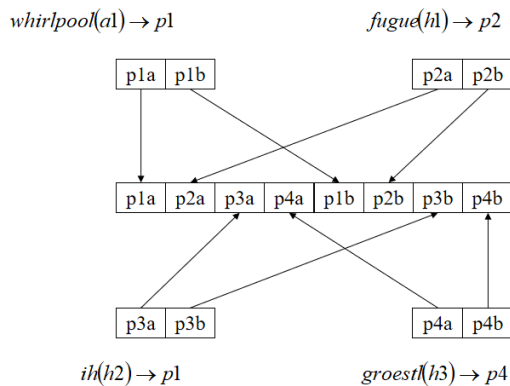
operate data.

Figure 5 The hash value L of block header is obtained by confusing arrangement

Blockchain smart contracts are programmable, which makes it possible for all participants to add complex business terms if they reach a consensus. In the alliance chain system, the intelligent contract is deployed to the blockchain system by authorized members and executed through preset conditions or API interface calls. The common operation mechanism of the intelligent contract is shown in Figure 6 [27]:
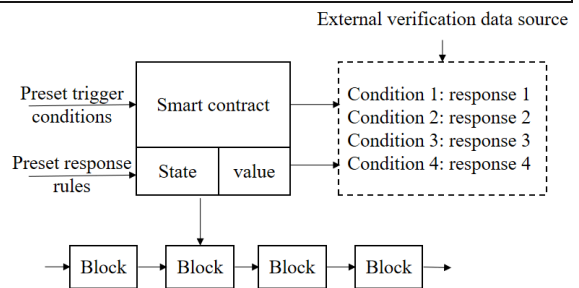
Figure 6 Operation mechanism of intelligent contract

For example, the smart contract is used to write the consensus clean energy power generation information into the blockchain in the form of "power generation information of a certain equipment at a certain time"; Each electricity customer (such as a factory, etc.) sends its own electricity demand information for a certain period of time to the intelligent contract equipment. The results of the transaction are recorded in the blockchain and drive the power system to automatically execute. When there is excess energy, energy storage equipment is used to store excess energy; On the basis of considering energy storage period and cost, energy storage resources should be reasonably scheduled to avoid waste of resources.
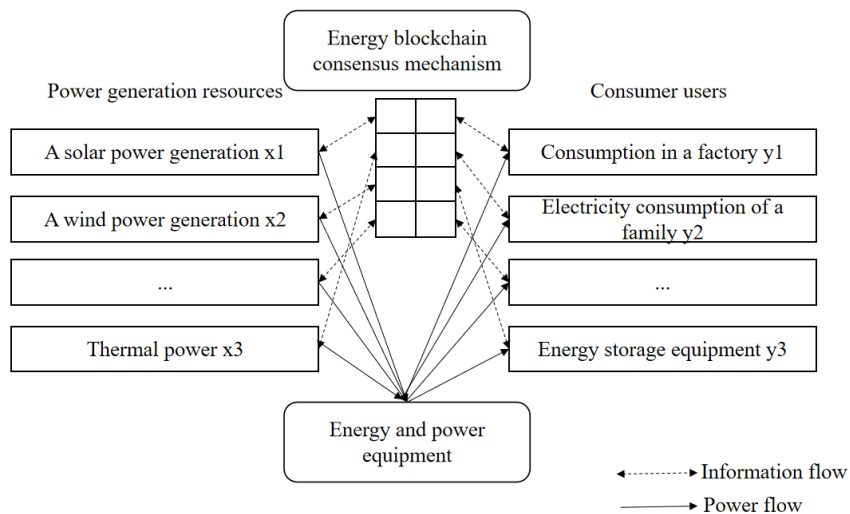
Figure 7 Transaction schematic diagram

As shown in Figure 7, the distributed transaction diagram based on the energy blockchain uses the collected accurate supply and demand information to establish the best match between supply and demand and realize the point-to-point transaction of energy; On the basis of transaction, energy and power equipment complete transmission and conversion.

With the continuous extension of each bead chain, the length gap between the long and short bead chains will eventually be opened and will become larger and larger; The extension speed of shorter bead chains will be slower and slower, and the extension speed of longer bead chains will be faster and faster. This accounting mode can achieve a desire

for interconnection between points, so as to meet the needs of the market. Give the supplier strong confidence and determination, and select the best combination of production lines and logistics by searching the qualified certificates in the blockchain, so that the production factors can be scientifically met and matched in the shortest time. Therefore, some scholars believe that the application of blockchain technology can replace some traditional national functions, so that civil society can protect itself through self-organization in order to seek its own interests as much as possible. In a word, blockchain has laid a new Internet foundation for supply chain governance and provided a new development direction for integrating use value and exchange value.

The development of blockchain cooperation mechanism based on value flow management of enterprise product service system can be organically related to the value structure caused by transaction; If the contract mechanism of blockchain intelligent contract is further combined, the research on intelligent contract coordination mechanism at the objective operation level of integrated supply chain management can be developed. Secondly, taking the intelligent coordination optimization model with two levels and three perspectives for sustainable development as an example, refer to Formula (1) to Formula (4) to clarify the corresponding intelligent contract coordination mechanism.

$$F(W) = \{F_1(W), F_2(W), F_3(W)\} \tag{1}$$

$$\max F_1(W) = \sum_{j=1}^{n} f_{j1}(W_j) = \max \sum_{j=1}^{n} f_{j1}(\alpha W_{j1} + \beta W_{j2} + \cdots + \lambda_j W_{jk}) \tag{2}$$

$$\max F_2(W) = n \cdot \left(\prod_{j=1}^{n} F_{j2}(W_j)\right)^{1/n} \tag{3}$$

$$\max F_3(W) = \sum_{j=1}^{n} f_{j3}(W_j) = \sum_{j=1}^{n} R_j \leq R_0 \tag{4}$$

Among them, $F(W)$ is the first-level objective function, which involves three sub-objectives of economic, social and ecological environmental benefits (efficiency, fairness and sustainable scale/structure); $F_1(W)$ is the overall economic benefit of the supply chain, which is summarized from the k economic benefits of n enterprises in the chain and strives to maximize it; $F_2(W)$ is the overall social benefit of the supply chain, aiming at maximizing the coupling coordination degree among enterprises in the chain. On the right side of formula (3) is the coupling coordination degree calculation model of multiple subsystems; $F_3(W)$ is the overall

ecological and environmental benefit of the supply chain, and the purpose is to control the overall maximum consumption $\leq R_0$; The $f_{j3}(W_j)$ represents the maximum allowable usage R_j of the jth enterprise in the chain.

Proof of Work is highly dependent on computers at each point in the distributed system. The higher the performance of computers, the higher the performance of POW. Compared with other consensus algorithms, the cost of Proof of Work is higher, but the efficiency of block generation is lower. Its performance is shown in Table 4.

Table 4 Advantages and disadvantages of POW

Advantages	Disadvantage
The working principle is simple and easy to realize	Easy to waste computing power
The network communication protocol between system nodes is simple	The cycle of generating new blocks is longer
Good security and difficult attack	Bifurcation is easy to occur and requires extra safety treatment

Although the Proof of Rights (POS) algorithm can reduce the huge waste caused by the Proof of Workload (POW) algorithm to a certain extent and avoid the competition of computing resources, it still

has some problems.

In the blockchain based on proof of workload (POW), the algorithm encourages participating blocks to solve password problems, so as to verify the

success of transactions and create new blocks-mining for short. In the public block chain based on POS, verifiers put forward to vote and vote in the next block, and the voting weight of each verifier depends on the size of the verifier's deposit-equity.

It can be found from Table 5 that the POW algorithm takes the longest time, but consumes the highest resources, but it still has important significance in research and commercial fields. Although DPOS (Delegated Proof of stake) algorithm has the advantages of high efficiency and energy saving, it is not as effective as POW algorithm in dealing with Byzantine fault-tolerant nodes. The following is a comparison of four commonly used consensus algorithms.

Table 5 Performance comparison of consensus algorithms

Algorithm	POW	POS	DPOS
Block generation speed	4	3	4
Computational power demand	3	3	2
Throughput	1	1	1
Byzantine fault tolerance	4	4	3
Bandwidth requirements	1	2	1

Note: 1: Low; 2: high; 3: slow; 4: Yes; 5: fast.

Data asset is one of the core assets of the government, which has become a broad consensus of all sectors of society. Relying on the strong leading ability of the government, taking government data as the core subject, collecting and utilizing data resources from all sectors of society, building a smart rural big data platform, and realizing the interconnection and exchange of data. On the premise of not increasing rural financial burden, the service mode combines physical stores such as China Telecom, China Mobile agency, village Committee, supply and marketing cooperatives, cooperative medical clinics, grocery stores and tea shops with network service platform. The incentive layer stipulates the economic incentive mode in the blockchain; The contract layer integrates various algorithms and scripts for writing blocks; The application layer can be regarded as various application scenarios of blockchain. The management and operation system was established, in which the villagers in the demonstration village formed the operation committee, and the information guidance personnel and the information center management personnel participated in the operation. In addition, the project also trains villagers on computer use and internet access, and trains rural informatization backbone and management personnel. In addition, improve and construct the rural modern information dissemination channels and platforms, and timely release and transmit the latest information on economic development, innovative technologies and innovative achievements to the broad masses of residents, so as to help them obtain more economic benefits and make information technology deeply rooted in the hearts of the people.

5 Conclusion and prospect

Compared with cities, rural areas are more regional and heterogeneous. Under different time and space conditions, the main functions of rural areas are quite different, and the key problems restricting their development are also inconsistent. Rural culture revitalization needs the guarantee function of rural governance. Innovating the rural governance system with the idea and method of blockchain is conducive to the prosperity and progress of rural culture and the realization of rural culture revitalization. There are great differences in the practice of smart villages in different regions due to their differences in nature, history and culture. The process of building a smart village is also a process of exploring the establishment of a new urban-rural relationship with urban-rural integration and complementary functions, but it is necessary to further explore the establishment of a sustainable development mechanism for smart villages. In the information age, promoting the high integration of information means and management can improve the level and efficiency of rural economic management, and better guide farmers to get rich.

Building a smart village with blockchain technology as the infrastructure enables participants to better serve the society, create greater benefits and give people more choices. Although blockchain has laid a new network foundation and integration direction for supply chain governance, the related integration research needs to be deepened urgently for two reasons. In terms of blockchain, the existing

research pays too much attention to Internet technology and neglects other sciences, such as whether it is appropriate to pay too much attention to the trust of blockchain algorithm. On this premise, in the future rural governance, the breakthrough of blockchain technology may be the best choice for the interaction between the state and citizens.

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