

Design and Implementation of Traceability System Based on Blockchain

Xinlong Dai^{1,2}, Qin Li¹, Xuzheng Li¹, Zhengmao Yan¹, Xiaobo Jiang¹

¹Hunan University of Humanities, Science and Technology, Hunan, China

²LouDi XiaoXiang Vocational College, Hunan, China

* Corresponding author: Hao Liu (Email: lhkd0407@126.com)

Abstract: The fifth Plenary Session of the 19th CPC Central Committee included poverty alleviation and rural revitalization as the main goals of economic and social development during the 14th Five-Year Plan period. Moreover, it has created a new situation of digital sales of poverty alleviation and helps agricultural products such as "agriculture + e-commerce" and "agriculture + live streaming", and the traceability of agricultural products has attracted much attention. Combining the current social environment background and the investigation and understanding of the existing agricultural product sales mode of poverty alleviation, we found that the existing sales model chain and the traditional traceability system model have many shortcomings, such as unclear information sources and easy tampering. Based on this design, the idea of constructing a traceability system based on blockchain is proposed, and the required technical and economic feasibility is analyzed to confirm the realization of the idea. It is intended to meet the needs of agricultural product information management, poverty alleviation farmer information management, product traceability, etc. And through the web page and mobile terminal information interaction, the realization of agricultural products at any time, mobile, portable query. The final system test can ensure the normal operation of functions and the security, credibility, and transparency of information, provide new ideas and solutions for the field of targeted poverty alleviation, and help rural revitalization.

Keywords: Blockchain, Agricultural products traceability, Poverty alleviation and agriculture.

1. Foreword

With the steady development of society, people's awareness of the safety of agricultural products is also increasing. However, the complex procedures involved in the agricultural supply chain of agricultural products make it difficult for consumers to intuitively judge whether there are safety problems in the poverty alleviation of agricultural products, let alone determine which link of the problems appears. In order to protect people's health, and improve public confidence in agricultural products, using blockchain technology to establish safe and credible agricultural products traceability system for poverty alleviation, which improves the information transparency of agricultural products in the supply chain, effectively solves the current poverty alleviation agricultural traceability problems, and meet agricultural information management, farmers information management, product traceability, and other needs. The technical characteristics of blockchain give it a natural advantage in the field of traceability. From the perspective of decentralization: participants can automatically execute transactions through smart contracts and need to reach a consensus from multiple parties, transaction autonomy, and a High degree of decentralization; In terms of tamper-proof information: all transaction information is stored in the block, Multiple participating nodes need to confirm together and each block has a copy of the transaction information. In terms of data security: the data is processed using asymmetric encryption technology, and only with the corresponding private key can you decrypt, High data security; In terms of regulatory accountability: all the information on the blockchain can be found, When a product has a quality problem, The regulatory department can locate the responsible person in time, Precise accountability. Therefore,

the application of blockchain to the traceability of agricultural products is helpful to establish a traceability system of agricultural products that can be traced, so as to build a solid bottom line for agricultural products safety.

2. Blockchain Technology

2.1. Blockchain-related overview

As an emerging distributed database technology, the transactions occurring on the chain will produce a time stamp. It records the time at which the transaction took place, and the hash values generated by a certain hash algorithm are concatenated with the previous and subsequent blocks so that the transaction can be traced.

Blockchain technology is a new paradigm that is different from traditional network architectures. The unique decentralized mode of blockchain can avoid the shortcomings brought by the centralized network, and build a trusted autonomous operation network mode[1-2]. By type, blockchains can be divided into public, federated (industrial), and private blockchains. Public blockchain (public blockchains) refers to the consensus process in which any user or group in the world can send a transaction, and the transaction can be confirmed by the blockchain, and anyone can participate in the transaction. Joint blockchain (consortium blockchains) refers to the internal designation of multiple nodes as bookkeeping nodes, the generation of each block is determined by all the preset nodes, other nodes can participate in the transaction, but have no bookkeeping authority, anyone can query through the blockchain[3]. Private blockchain (private blockchains) refers to using the bookkeeping technology of the blockchain only, either as an enterprise, a company, or an individual, with the written permission of the private blockchain.

The characteristics of blockchain also include decentralization, openness, independence, security, and anonymity. (1) Decentralization of power. Blockchain does not rely on a third manager or hardware, nor does it have a central server. Each node implements self-verification of data, transmission, and management through distributed computing and storage. (2) Open-minded. Blockchain technology is open source. In addition to the private information kept confidential, the data within the blockchain is open to everyone, and everyone can enter the blockchain through an open interface for query and development[4]. (3) Security. As long as 51% of all the nodes are not mastered, the data can not be casually tampered with, which makes the blockchain avoid artificial malicious tampering[4]. (4) Anonymous nature. The identity information of any node does not need to be disclosed and verified, and the data transfer can be sent anonymously[5]. (5) Traceability. The information is uploaded to each block in the blockchain. Each block has the hash value of the previous block. Only by identifying the correct hash block can you get the chain connected (Figure 1), which ensures the traceability of the information use.

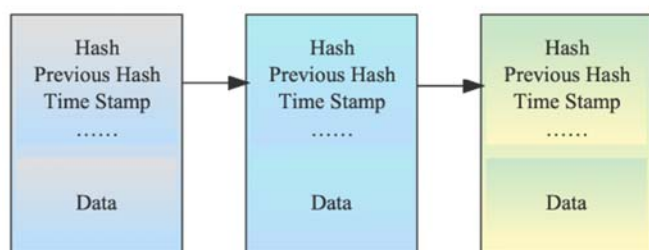


Figure 1. Block chain schematic diagram

2.2. Blockchain Development Platform

Currently, blockchain technology has been applied in various fields and many decentralized applications and blockchain platforms have emerged, but at present, there are mainly three mature blockchain platforms: Bitcoin, Ethereum, and Hyperledger Fabric. Scale, activity, stability, and difficulty of node deployment should be considered as much as possible. In order to avoid the occurrence of platform software vulnerabilities, and also to avoid technical problems in the development process of the blockchain platform, you can communicate with other developers to solve the problems. Ethereum is a blockchain development platform with programming capabilities that enable any business logic through smart contracts. It currently supports a variety of programming languages, but its official promotion is the Turing complete Solidity programming language, which can be better run in EVM (Ethereum Virtual Machine). At the same time, the Gas mechanism is used to charge, to effectively reduce the generation of useless transactions, or to prevent some malicious and continuous transfer of extremely minor accounts resulting in network paralysis. In addition, Ethereum has a large number of users and developers and has open source code and rich platform interfaces.

3. Agricultural Products Traceability

3.1. Traceability of traditional agricultural products

References The agricultural products traceability system refers to the system that tracks agricultural products (including food, means of production, etc.) into each stage of

the market (from the whole process of production to circulation), and involves multiple links such as the origin, processing, transportation, wholesale and sales of agricultural products, which is conducive to quality control and product recall when necessary. The adoption of the agricultural products traceability system can realize the traceability of the product source to the processing and circulation process, ensure that the end users can buy the assured products, and prevent fake and shoddy agricultural products from entering the market [4].

Throughout the agricultural supply chain, each level of participation can be classified as producer, processor, carrier, regional seller, and retailer. At present, the mainstream agricultural product traceability system is mainly double-layer traceability combining internal traceability and external traceability (Figure 2). This traditional way of traceability has exposed a variety of problems, such as (1) information is easy to be tampered with, lost, regional agricultural information sharing is difficult, low data transmission efficiency, the first level of agricultural products (crops) traceability difficulty; (2) complex system, regulatory information overlap or contradiction, regulatory pressure; (3) users at all levels are difficult to trust the authenticity of the data [6].

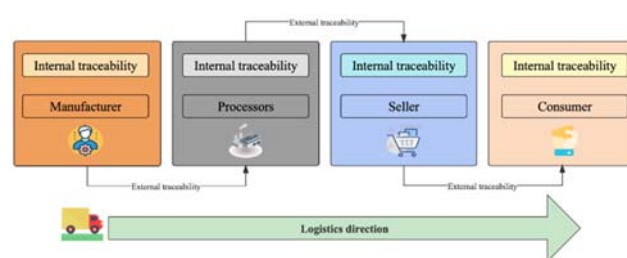


Figure 2. Traceability of traditional agricultural products

3.2. The Origin of agricultural product tide source system

The earliest agricultural product traceability system originated in Europe in the 1970s, when a severe mad cow disease began in Europe, and European countries began to trace the sources of livestock agricultural products such as cattle and mutton [7]. After the re-emergence of BSE in 1997, the EU set up a traceability system for cattle and beef products, with ears tagged and animal passports issued, allowing consumers to trace the entire process from breeding to slaughter to processing and marketing. At present, the EU has established a traceability system for livestock and poultry animals and their meat products, transgenic products, and feed [8].

Japan began to promote the "food traceability system" in 2001. Most supermarkets have installed product traceability terminals, which basically realize the traceability of the food retail business. In 2003, Japan began tracking beef products; in 2005, Japan Agricultural Cooperation (CA) required that the agricultural products listed through the CA must be traced [9-10]; in 2008, Japan announced plans for a traceability system for rice [11].

In the early 2000s, the United States began to build a traceability system from the level of national strategy and established the American National Animal Identification System (NAIS). Australia has also built a National Livestock Certification System (NLIS), which issues a unique "ID card" to each cow through RFID technology to realize the whole

process of data collection of breeding. India has established GrapeNet, a traceability platform, to ensure the safety and quality of exported grapes.

China has been late to the party on the traceability of agricultural products, but it has also been making progress. In 2004, the former Ministry of Agriculture took the lead in starting the pilot traceability system in Beijing and Hebei and implementing the "pilot project of vegetable product quality traceability system in Beijing"[12]. In 2008, the state proposed establishing and improving the labeling of agricultural products and establishing and implementing traceability of agricultural product safety systems. In addition, the national vegetable quality and safety traceability system and other traceability systems are also under construction and piloted. In 2017, the National Agricultural product quality and safety traceability management information platform was officially launched, first launched in Sichuan, Guangdong, Shandong, and other places to pilot[13].

4. The Application of Blockchain in Agricultural Product Traceability

The quality and safety of agricultural products is the fundamental guarantee of people's healthy life. The traceability system of the agricultural products supply chain

is an important means to guarantee the quality of agricultural products. The traditional agricultural supply chain traceability system is highly dependent on the centralized server. Once the server operation fails, the stored data will be lost. In addition, in the process of agricultural product industry chain circulation, data sharing is not timely, which easily leads to the updating speed of traceability information can not keep up with the speed of data query. As a result, traditional agricultural supply chain traceability systems need to seek new technological solutions to address the aforementioned issues.

Because of its own characteristics, blockchain has great advantages over traditional traceability methods (such as Table 1). Compared with the traditional traceability method, the data collection work at the front end of the traceability method based on blockchain technology is not very different from the traditional method, and the huge difference lies in the back end. Blockchain technology can provide new traceability tools that make it easy for consumers to query agricultural product safety information. In addition, the blockchain has the characteristics of decentralization, so that each node can share data in real-time through the chain, and all nodes must also fulfill the obligation of jointly maintaining data reliability [21-24].

Table 1. Differences between blockchain and traditional ways

| Difference | Traditional way | Blockchain technology |
|-----------------------|---|---|
| Front end | Use various sensors, information acquisition terminals and other equipment to complete data acquisition | It is not very different from the traditional way |
| Back-end | The source is traced according to the anti-counterfeiting code made by the merchant, which is easy to be copied | Blockchain provides a new tool for traceability business, which can query information through RFID chip, QR code, barcode, etc |
| Information tampering | Centralized storage mode, data is easy to be tampered with by authorized parties | Digital input to reduce manual participation and protect data from tampering |
| Security | Centralized storage mode, data vulnerable | In the decentralized storage mode, any node damage will not affect the normal operation of the entire system |
| Transparency | Only the results, not the process, and the data is not transparent and real enough | Data will be automatically recorded from entry, modification to final confirmation, ensuring high transparency and authenticity of data |
| Autonomy | Highly dependent on central institutions, poor autonomy | Adopt the algorithm created based on consensus mechanism to remove the interference of human factors and achieve high autonomy |

Therefore, in view of the problems existing in the current poverty alleviation system, such as excessive power, lack of mutual trust, and insufficient sales of agricultural products, this paper proposes a traceability system for poverty alleviation agricultural products based on blockchain technology. In order to solve the storage problem of large text data, this paper proposes a way to combine blockchain with the interstellar Archival System (IPFS) to realize the retrieval and storage of large text data.

Through the construction of a traceability system for poverty alleviation agricultural products based on blockchain technology, the poverty problem in the current poverty-stricken areas is analyzed and the overall plan is implemented. In this article, we address the need for a blockchain-based agri-product traceability system for poverty alleviation from the point of view of system account management, poverty alleviation management and agri-product traceability. Based on this approach, a traceability system for poverty alleviation agricultural products based on blockchain technology ensures decentralized storage, anti-counterfeiting, and traceability of data, thus effectively improving the security of system data

and providing a new idea and approach for the implementation of targeted poverty alleviation efforts.

5. Summary Design of the Traceability System

5.1. System design ideas

The system adopts the construction mode of front-rear-end separation and back-end three-layer architecture. The Web main interface sets multiple functional modules such as agricultural products management, poverty alleviation farmer management, file management, and traceability coding query to realize accurate data query and management, and realizes the portable query of small programs through data interaction with the client. The back end realizes on-chain data management, file upload management, data interaction, and other functions through the three-tier architecture mode of blockchain technology, IPFS, and MySQL, as shown in Figure 3.

5.2.3. Database technology

Use the relational database MySQL to provide the storage of basic information, maintain various kinds of data generated during the management and operation of the system, and provide data support for traceability query.

5.3. System function design

According to the functional requirements of the system, the main modules of the system are the agricultural product management module, document management module, poverty alleviation farmers management module, traceability code data tracking, query module, etc. The functions of the main modules are introduced below.

5.3.1. Agricultural Products Management Module

Agricultural product management is an important module of the system. According to the database design, agricultural

products are dependent on most of the data tables of the system, and the data on the blockchain is the relevant information from the agricultural products. Therefore, agricultural product management is the key and difficult point of the agricultural products traceability system for poverty alleviation. The poverty alleviation agricultural products traceability system uses Web3J to operate Ethereum smart contracts. Web3J enables Java to operate our deployed Ethereum private chain and call the smart contract deployed above in the form of RPC communication. After the administrator links the information related to agricultural products, he returns the block hash corresponding to the agricultural product information, and then the system will generate the corresponding traceability QR code and traceability code of the agricultural product according to the hash (see Figure 6).

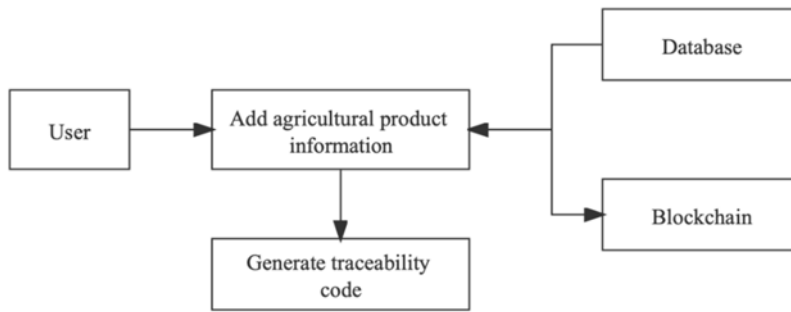


Figure 6. Overall architecture diagram

5.3.2. File management module

The File management module provides the upload files, modify file information and delete file information function, upload files and add agricultural products generated traceability QR code will be saved in IPFS. IPFS is a peer-distributed file system and has a permanent, decentralized save and sharing files, point-to-point super media, and content

addressing features, every time upload a file, it will generate a unique hash. The corresponding files can be viewed and downloaded on the IPFS through the hash. The traceable two-dimensional code is stored on the IPFS, ensuring that the poverty-alleviation agricultural products are "one thing, one code, anti-counterfeiting, and true authentication" (as shown in Figure 7).

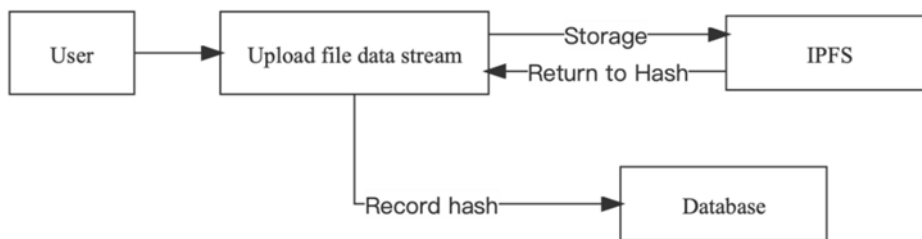


Figure 7. File upload structure diagram

5.3.3. Management module for poverty alleviation farmers

The peasant household module registers the information of the poor farmers so that relevant information about the farmers can be obtained when tracing the source of the agricultural products. Whether the farmers meet the standard

of poverty alleviation needs the administrator to evaluate according to their materials and documents and upload the peasant household information. Administrators can also distribute funds to poor households, which will be distributed to the farmers' Ethereum accounts. Figure 8 fund distribution transaction, Figure 9 Ethereum account balance for poor households.

```
> eth.getBalance('0x3a0b7cd0eb850022fb20c936e6783899b5938cc8')
2000
>
```

Figure 8. Fund issuance and transaction

```
INFO [09-10]20:53:35.072] Regenerated local transaction journal transactions=0 accounts=0
INFO [09-10]20:53:53.854] Submitted transaction fullhash=8a0f0a13d85070e4498b050cb842a0247a205cf151c477f0bb171a55952a recipient=0x5018059706b3c2560f957701060c19980755561
INFO [09-10]20:53:53.854] Commit new mining work number=52 sealhash="24523c_b05711" uncles=0 txs=1 gas=21989 fees=1.47e-09 elapsed="283.243us"
INFO [09-10]20:53:53.855] Successfully sealed new block number=52 sealhash="24523c_b05711" hash="0b0ffa_5c0886" elapsed="735.499us"
INFO [09-10]20:53:53.855] block reached canonical chain number=52 hash="0b0ffa_5c0886"
INFO [09-10]20:53:53.855] mined potential block number=52 hash="0b0ffa_5c0886"
INFO [09-10]20:53:53.856] Commit new mining work number=53 sealhash="744fd_c59b98" uncles=0 txs=0 gas=0 fees=0 elapsed="469.613us"
INFO [09-10]20:53:53.856] Sealing paused, waiting for transactions
```

Figure 9. Poor Ethereum account balance

5.3.4. Traceability module

The traceability module mainly includes two aspects, namely the generation of traceability code and traceability QR code. Traceability coding adopts the idea of 8-bit UUID, which refers to the generation method of a microblog short domain name. However, the repetition probability is too high, and four codes are generated each time, and one code needs to be randomly selected. The method uses 62 printable

characters to randomly produce a 32-bit UUID. The UUID is a 16-decimal number, which is divided into 8 groups of 4 each, and the number of repetitions is greatly reduced by using module 62 to remove characters as indices.

The trace QR codes were generated using the ZXing API, the implementation principle of this QR code is relatively simple, according to the height and width of the QR code, and then according to the algorithm in the ZXing, divide it into one pixel, and fill them with black and white (see Figure 10).

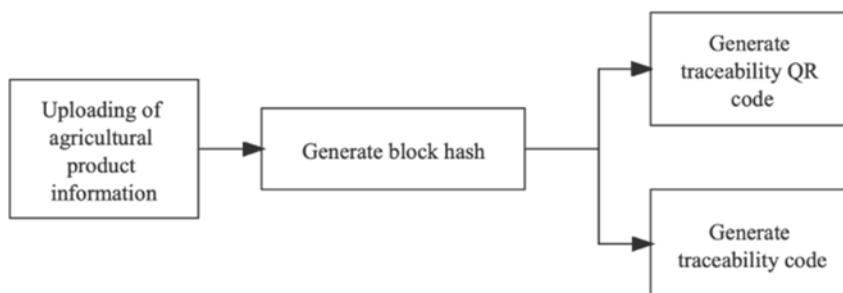


Figure 10. Tracing and encoding, QR code generation structure diagram

The traceability coding query module obtains the associated block Hash through the traceability coding, and through the block Hash obtains the agricultural products

information stored on the blockchain, so as to achieve the function of the traceability of agricultural products (as shown in Figure 11).

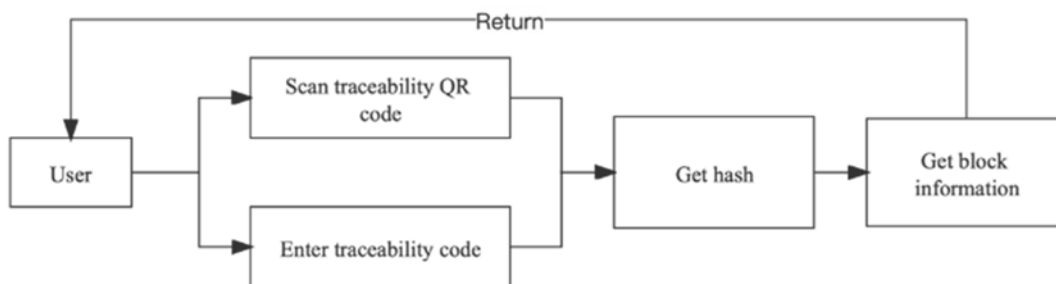


Figure 11. Tracing and encoding query structure diagram

6. System test

6.1. Traceability encoding query module test

The page queries the corresponding hash by entering a

traceability code and then queries the information stored in the blockchain by entering the hash. According to the information displayed, the goods can be traced and anti-counterfeiting.

Table 2. Tractable encoding query test table

| test function | Test description | test result |
|---------------------|---|--------------|
| Source coding query | Enter the correct traceability encoding query to return the correct query result (use case: backtracking Source code: GKgMsUZg.) | pass through |
| | Enter the incorrect traceability code to give the incorrect response prompt | pass through |

6.2. Test of agricultural product management module

This module contains a list of poverty alleviation products and new poverty alleviation products. This page can view detailed information on poverty alleviation products, such as

a breeding address, processing plants, etc. The block hash, traceability QR code, and traceability code of each poverty alleviation product are displayed on this page. When the administrator adds a poverty alleviation product, the system will chain the information of the poverty alleviation product, and generate the traceability QR code and traceability code.

Table 3. Agricultural Product Management Function Test Table

| test function | Test description | test result |
|----------------------------------|--|--------------|
| Agricultural products management | Enter the agricultural product management page, can normally add and delete agricultural products and link the information of agricultural products chain (use case: type: meat, farmer name: Zhang San, farmer address: Kunming, Yunnan, processing factory: Hubei Huafeng Food Processing Plant, Product No.: 123456789) | pass through |
| | Select agricultural products to generate a relative traceability QR code and traceability code | pass through |

6.3. Test of the management module of farmers and processing plants

The farmer management module includes the management of poverty alleviation farmers, the display of detailed information, and the uploading of related poverty alleviation

information of farmers. Farmers' information is processed on the chain when added, and farmers' information is stored in the blockchain. Relevant poverty alleviation materials are uploaded and stored in the IPFS. The processing factory module is the management module of the processing factory in the traceability information of poverty alleviation products.

Table 4. Management Test Table for Farmers and Processing Plants

| test function | Test description | test result |
|-----------------------------|---|--------------|
| Farmers management | Enter the farmer management page, and can normally view, add, modify and delete the farmer information (use case: Wang Lao Han, home address: the fifth Ring Road of Beijing Municipal District ID Number: 12111111111111:17778511323) | pass through |
| Processing plant management | Enter the processing plant management page, and you can normally view, add, modify and delete the processing plant information (use case: Hubei Huafeng food processing plant, factory site Address: Wuhan, Lot No.: 123456789) | pass through |

6.4. Document management module test

This module is the centralized management of the documents required by the whole system, such as the QR code of poverty alleviation products, block hash, farmer poverty alleviation materials, etc. The module also records the system's operation log and related files uploaded to the IPFS.

given. Next, test the user interface. Through testing, after many attempts to modify, and finally, to make the system achieve the best efficiency.

The test results confirm that the system basically meets the original design requirements, and the software has full functionality and a good user interface. The interface basically realizes multiple functional modules, including traceability coding and query module, poverty alleviation product management module, file management module, peasant household management module, and so on. The system realizes the registration and management of the name, type, planting (breeding) address, and other information about agricultural products, and the function of adding and deleting the types of agricultural products. It has realized the information registration management of poverty alleviation farmers and the flow direction management of poverty alleviation funds.

Table 5. File Management Test Table

| test function | Test description | test result |
|-----------------|---|--------------|
| file management | Enter the file management page, can normally upload the file to the IPFS, and generate The file Hash is recorded, and it can view its contents online | pass through |

6.5. Test results

According to the test requirements, the relevant test cases are designed, and the problems in the system are analyzed and tested. First, from the perspective of function, the functions of each module are tested in detail, and specific test cases are

7. System test

This project by analyzing the current poverty alleviation agricultural products sales chain, fund distribution mechanism, reference to the traditional product traceability

system and information management system, found that the existing product traceability system and based on traditional software development technology "centralized" information management system has some personnel can tamper with poverty alleviation data, agricultural information is difficult to verify the root cause, poor fraud, poverty alleviation funds is not transparent, in order to solve the above problems, puts forward the chain based on blocks. Based on blockchain and interstellar file system (IPFS) technology of agricultural products traceability system for demand analysis, mainly including agricultural products management, poverty alleviation, poor information management, system file management four modules, and the overall design of the whole system, user interface design, smart contract design, and the design of the core class. Based on the demand analysis, the development environment required for the poverty alleviation product traceability system, including the operating environment and Ethereum platform, a complete poverty alleviation system has been constructed, tested, and analyzed to ensure the complete operation of various functions. I believe that the future and prospects of this project are also worth looking forward to.

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