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# BLOCKCHAIN-BASED APPROACH TO ACHIEVE CREDIBLE TRACEABILITY OF AGRICULTURAL PRODUCT TRANSACTIONS

*The traditional traceability system for agricultural product transactions is susceptible to information alteration and damage, which may lead to issues regarding product quality and food safety. And blockchain is a technology that boasts tamper-proofing, complete traceability and time-stamped storage. Considering the above, this study proposes a new blockchain-based approach to the quality management of agricultural products and introduces Solidity-based prototype smart contracts for agricultural product transactions. Test results show that the new traceability system can offer good performance in terms of data upload and block response time. The method proposed in this paper can be used as a solution for quality management of agricultural product that boasts whole process transparency, full-link reliability and joint supervision by all nodes in the system.*

**Introduction.** The rapid development of digital economy has brought changes in people's lifestyles, including the digitization of product quality management, which is realized by the development of traceability systems that can manage information of multiple links including production, processing, transhipment, sales and consumption. Compared with industrial products, agricultural products are significantly different in that production season, shelf life, sales price, etc. have a great influence on their production input and yield. In supply chain from "farm to dinner table", suppliers and sales outlets control the information related to agricultural products transactions, and the lack of data sharing during the entire product transaction process has led to the formation of information silos, leaving room for self-interest driven act of deliberately tampering and damaging transaction data. Moreover, once any safety accident occurs to agricultural products, it is very difficult to find out the reasons behind it and obtain relevant evidences. As a result, most ordinary consumers can only judge the quality of agricultural products based on brand reputation.

Built on the underlying technology of Bitcoin, Blockchain boasts features such as decentralized data storage, tamper-proof and timestamp [1–2]. Recent breakthroughs made in the fields of blockchain-related high-performance consensus algorithms, encryption mechanisms and distributed storage technologies have made it possible to apply blockchain technologies to manage transactions of traditional agricultural products [3–6], including establishing a unique electronic label for each product, which realizes the "one code per item" identification rule, and having data stored on distributed chain nodes and the data of each transaction stored as additional data on the chain structure, which ensures the transparency and credibility of the entire transaction process of each commodity from its source of production to reaching the hands of final consumers [7].

**Design of agricultural product traceability system.** In the traceability system, true data on agricultural product growth is the prerequisite of trusted transactions. Traditionally, the produce growth data is input manually and can be tampered. To address this issue, the IoT sensor technology is introduced to automatically import the growth data into the traceability system (as shown in Fig. 1), achieving produce quality management from the very source. The IoT sensor is composed of the (agricultural) machine-mounted module, (agricultural) tool-mounted module and farm information collection module. To be specific,

- The machine-mounted module is installed on the operating agricultural machines to obtain the crop and environment (such as soil) information of the field (such as location, time and track) in real-time.
- The tool-mounted module is integrated with the electronic agricultural tools (such as the electronic sprayer) and becomes "intelligent". These tools can obtain information on the operators, the operating time and path, and the fertilizer use, etc.
- The farm information collection module is the collective name of all dedicated equipment that collects the farm information, such as regular meteorological and soil information collection, GIS farm information collection, and mobile UAV image collection. A wide range of sensors is used to collect the "time-environment" information on the field.

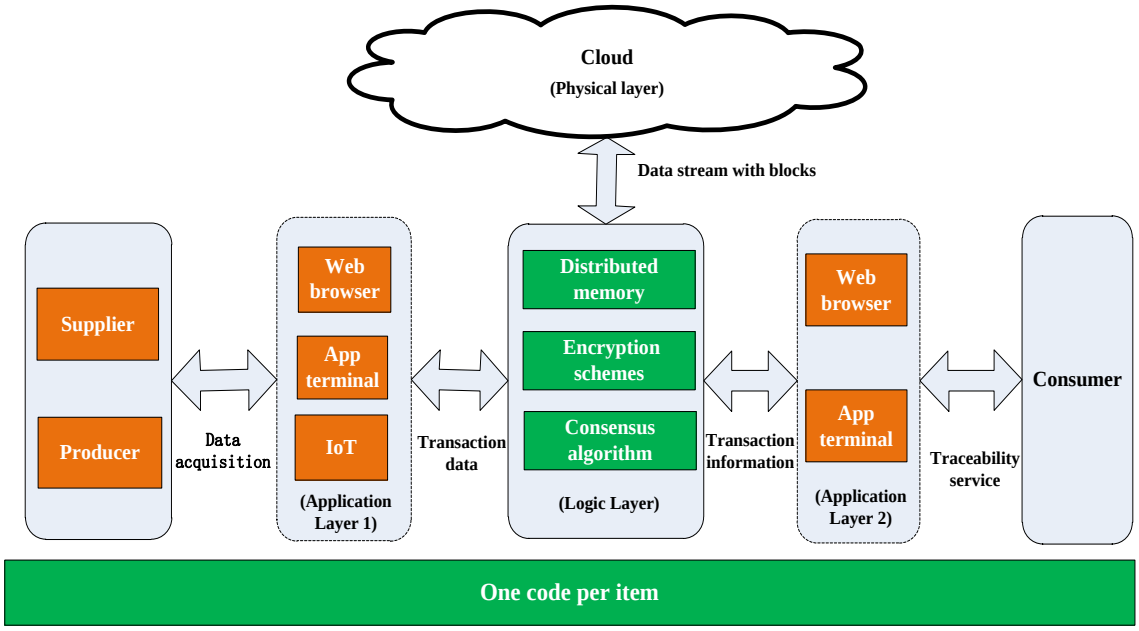


Fig. 1 Architecture of the blockchain traceability system

A blockchain traceability system has three layers, the application layer, the logic layer and the physical layer. As shown in Fig.1, in the application layer: producers and suppliers register their agricultural products in the system which will review such products and assign a unique code to each product passing the review; and growth data of agricultural products collected in real time through IoT sensor technology will be uploaded to the system, allowing consumers to obtain credible initial product information through traceability services. In the logic layer: The system uses smart contracts to ensure "decentralized" data management and achieve transaction consensus quickly; and general product information and privacy information are protected by symmetric encryption and asymmetric encryption respectively; with features such as tamper-proofing and distributed storage, blockchain is a solution well-suited for addressing the issue of lacking credible product traceability information. However, due to the full copy approach to data storage, there will be a huge demand for data storage space with the continuous growth of transaction data. In order to improve the efficiency of storage and management of agricultural product data, the system adopts distributed data storage technology to achieve higher efficiency and the output of data to the cloud storage devices at the physical layer.

**Development of smart contract prototype.** Other than data storage on distributed ledgers, blockchain-based decentralized management of agricultural product transactions also require smart contracts which are agreements reached in advance by the participants in the transactions. And smart contracts developed by using programming languages make it possible to achieve traceable and irreversible automated transactions, which constitute a core component of the blockchain traceability system.

This study introduces a smart contract prototype developed in the Remix-IDE environment by using the Solidity language. See Fig. 2 for details.

```
pragma solidity >0.5.0;

contract ProductInformation{
    address _owner;
    constructor()public{
        _owner=msg.sender;
    }
    struct Product{
        uint Ptime;
        uint Ptig;
        uint Pweight;
        string Pname;
        string Pbrand;
    }
    mapping(uint=>Product)public products;
    event showdata(string);

    function initProduct(uint time,uint tig,uint weight, string memory name,string memory brand) public {
        products[tig]=Product({Ptime:time,Ptig:tig,Pweight:weight,Pname:name,Pbrand:brand});
    }

    function getProduct(uint tig)public returns(string memory){
        emit showdata(products[tig].Pname);
        return products[tig].Pname;

    }
}
```

Fig. 2. A sample smart contract

Core codes in the prototype include: *constructor* – a constructor function; *mapping* – create products; *event* – an event handler; *initProduct* – for instantiating the constructor and *getProduct* – obtaining the name of the agricultural product. The hardware environment for the test is as follows: Intel(R) Core(TM) i7-6700HQ CPU @ 2.60GHz, 2601 Mhz, 8G memory, 1.2TB hard drive, Window 10 professional. Before running the test we prepared the block information of 10 agricultural product transactions and set the process of simulating data upload in every 1s; after which we programed the traceability system to use hash functions to store packaged data in the chain structure and used third degree polynomial to obtain the time of executing 10 transactions through the smart contract, the results of the test are as shown in Fig. 3.

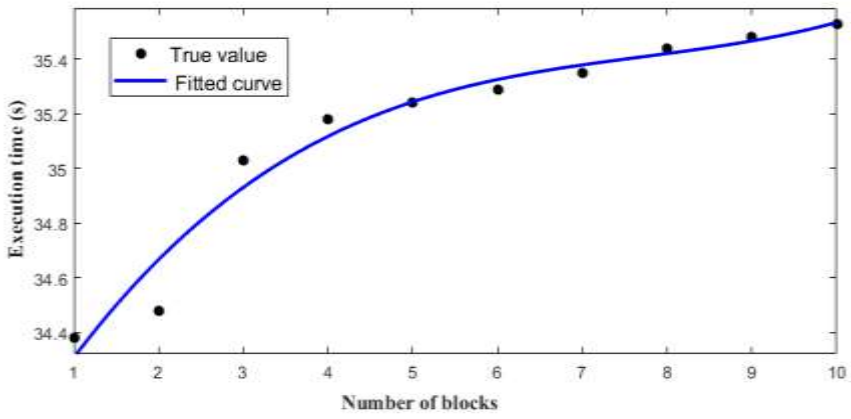


Fig. 3 Test results

Experimental results: average upload time of agricultural product information: 35.14 seconds, sum variance of fitted curve (SSE): 0.05627, Root Mean Square Error (RMSE): 0.09684. With the increase in the number of agricultural products transactions, the upload time of commodity data increases slightly as the slope of the curve increases, which further confirms that the smart contract can guarantee the validity and practicability of transaction traceability system.

**Conclusions.** (1) It's possible to provide farmers, suppliers and consumers with valid data related to product credibility by using blockchain and smart contracts to improve the management of agricultural product transactions and using information technology to strengthen the upstream/downstream communication in the supply chain and reduce the costs of trust and management. (2) Using blockchain technology can only ensure the credibility of the transaction information on the chain, we also need to minimize the interference of human factors on the un-uploaded product information by means such as real-time data collection through the Internet of Things, so as to ensure that information credibility can be maintained throughout the transaction process. (3) The "one code per item" identification

rule adopted by the traceability system for agricultural product transaction can ensure data traceability covering the all links (consumer, supplier and store) and the entire process (from production to final consumption), which helps merchants establish accurate customer portraits and provide credible traceability services for agricultural products, and enhance the brand value of agricultural producers and suppliers.

*This study was supported by the National Natural Science Foundation of China (Grant No. 61762048, Grant No. 61363041).*

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**Подход на основе блокчейн технологии к отслеживанию достоверных транзакций сельскохозяйственной продукции**

Информацию о транзакциях в традиционной системе отслеживания транзакций сельскохозяйственной продукции легко подделать и повредить, что может привести к проблемам управления качеством и безопасностью сельскохозяйственной продукции. Технология блокчейн имеет преимущества, заключающиеся в том, что данные не могут быть изменены, полностью отслеживаются и сохраняются метки времени. В данном исследовании использованы перечисленные преимущества блокчейна, чтобы предложить способ управления качеством сельскохозяйственной продукции, и использован язык программирования Solidity для реализации прототипа смарт-контрактов на транзакции сельскохозяйственной продукции. Результаты показали стабильность цепочки информации и малое время отклика блока сельскохозяйственной продукции. Метод авторов позволяет обеспечить реализацию системы управления качеством сельскохозяйственной продукции, которая прозрачна для всего процесса, надежна во всем звене и контролируется всем узлом.