Blockchain-based traceability system for trading pre-made food products

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***Abstract* —The prepared vegetable traceability system will be based on blockchain technology in order to guarantee the quality and safety of pre-made food, improve the traceability effect, and build a good trust bridge. Data is partitioned. and dynamic traceability is used to give the system the ability to adapt to various application scenarios. The super ledger blockchain implementation method, smart contracts for actual transaction accomplishment, and the HyperLedger Fabric framework are all used to create the pre-made food product traceability system. The method ensures the security and authenticity of the information on the quality of pre-made food products and alleviates the tough problems with the trade circulation of these items.**

Keywords-component; blockchain; pre-made food; traceability; distributed storage

I. INTRODUCTION

Cases involving poor food quality and safety have been more frequent in recent years, endangering not only the lives and health of people but also having a negative impact on the growth of the food business. The data of pre-made food are essential in the trading process, not only as a foundation for consumers to trace the quality of products, but also as an important tool for government entities to monitor the quality and safety of food, and can bring greater economic benefits to the business owners of pre-made food products. The conventionally produced traceability system, on the other hand, is based on a central database, which is susceptible to hacking during transmission, easy data loss, low trust of traceability results, poor flexibility, and other problems, and faces several security challenges [1]. The problem of the traceability of pre-made food goods has a new answer due to the advancement of blockchain technology. Blockchain is a unique distributed database that implements technology specific to multi-party consensus, decentralization, distribution, and tamper-evident, and has an inherent fit with food traceability. By addressing the issues of centralization and trust crisis of traditional traceability systems, as well as boosting the reliability and security of traceability systems, blockchain can solve the problems with traditional traceability systems [2].

This article examined the traditional traceability system and starts building a blockchain-based traceability model and traceability system architecture for pre-made food products based on the issues with the traceability system. To address the problem of traceability information security, the paper stores the traceability information of pre-made food products on each node. The blockchain-based pre-made food traceability system is then put in place using the Hyperledger Fabric framework[3-5].

II. RELATED BACKGROUND

The State Council published the "13th Five-Year" National Informatization Plan and other documents in 2016, which made planning and deployment for the development direction of blockchain technology and its applications; the "Digital Agriculture Rural Development Plan (2019)" was yet another document issued in 2016. - In March 2022, Guangdong Province published "Ten Measures on Accelerating the High-Quality Development of Guangdong Prepared Vegetables Industry," which for the first time proposed building a joint R&D platform for ready meals and strengthening quality and safety supervision.The Guangdong Provincial People's Report includes "Implementation Opinions on the Key Work of Comprehensive Promotion of Rural Revitalization in 2022" in June of the same year, placing special emphasis on the growth of the pre-prepared vegetable industry and the encouragement of the formation of contemporary agricultural industrial parks. China's information construction in the food circulation field has begun to pay off with the gradual entry of technologies such as the Internet of Things, artificial intelligence, and blockchain into the food field. With the support of policies and technologies, China will further guide the arrival of the technological revolution in the food circulation field[6]. The desire for traceability of pre-prepared vegetable products and the technological capabilities of blockchain are linked, and this relationship can be used to address the issue of traceability in the distribution of pre-made food products.

III. APPLICATION KEY TECHNOLOGIES

A. *Distributed* Storage

Figure 1 depicts the blockchain's distributed storage process, which can be broken down into the following six steps: (1) create data slice; (2) encrypt each slice; (3) generate hash for each slice; (4) replicate each slice (5) distribute the replicated slice; (6) record transactions to the ledger[7]. For the purpose of data-to-data circulation, each block should contain the hash of the preceding block to create a complete blockchain L, i.e.

$H_0 = SHA256(0, N_0, T_0, R_0)$, and

$H_1 = SHA256(H_0, N_1, T_1, R_1)$, $H_1 = SHA256(H_0, N_1, T_1, R_1)$, and

$H_2 = SHA256(H_1, N_2, T_2, R_2)$, $H_2 = SHA256(H_1, N_2, T_2, R_2)$.

......

$H_i = SHA256(H_{i-1}, N_i, T_i, R_i)$

where: Hi- block's hash value; Ni- a block-specific random number with a value between 1 and 232 (or higher); timestamp of the associated block, indicating when the JSON value was produced; a transaction record in ri; zero genesis block; Secure Hash Algorithm's one-way hash algorithm is SHA256 (SHA256) [8]. Since each node maintains a complete copy of the information, distributed storage on the blockchain eliminates the centralized data storage problem that plagues traditional traceability systems. As a result, the information on the chain is transparent and verifiable to all participating members. The sector of agricultural traceability benefits from its decentralized, transparent, recoverable, and tamper-proof characteristics.

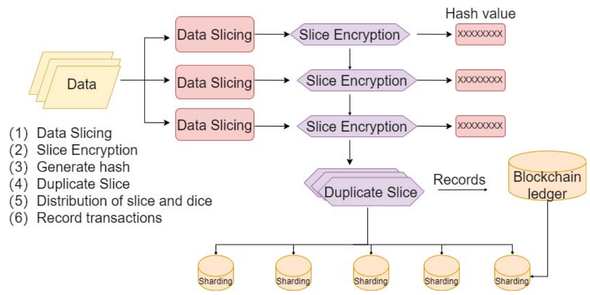

Figure 1 Blockchain distributed stored procedure

B. *Smart Contracts*

Smart contracts, also known as smart contracts, are multi-party, event-driven, stateful contracts that can automatically handle assets in accordance with preset circumstances. They operate on the blockchain. The primary benefit of smart contracts is that contract execution and arbitration are replaced by algorithms. They provide continuous real-time delivery and tracking of information, address the issues with uneven standards and poor distribution of conventional agricultural traceability systems, and further the decentralization of the system. Right present, smart contracts are successfully used in situations like elections, supply chain optimization, and shopping online. Figure 2 shows an example of the method for proactively detecting and recording pesticide residues in ready meals.

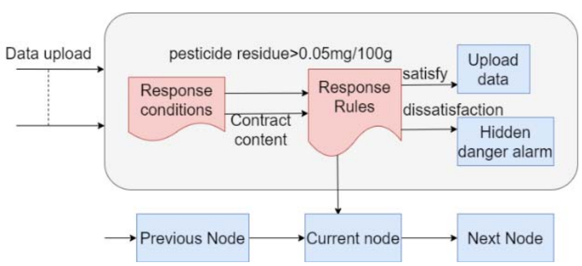

Figure 2 Smart Contracts

Algorithm 1 pre-made food product transaction operation in smart contract

The node number is u_id, the node role is u_name, the transaction number is t_id, the timestamp is t_stamp, and the product information is p_information.

/ / Register user and generate private key
user.id = u_id, user.name = u_name,
; newKeyPair( ) (u_id, [ ] byte) ;
/ / for product information entry and block generation
protected List < p_information > inputs;
pro_hash = sha256(p_information) , pro_time = t_stamp; generateBlock(p_information) ;
/ / node validation
if proving(u_id) . equal = = 0 then
return false;
/ / block broadcast and validation
else public boolean broadcast(Block p_information) ; isBlockValid(Block p_information) ;
AddBlockchain( ) ;
return ture;

Algorithm 2 Prepared dish product information query in smart contract

The node number is u_id, the node role is u_name, the timestamp is t_stamp, and the product information is p_information.

/ / node validation
if proving(u_id). equal = = 0 then
return false;
/ / traverse the block
Else
mineTxList = blockStoreProvider. loadRelatedTransactions( ) ; for
(TransactionStore. getTransactionStore: mineTxList)
If
(TransactionStore. getTransaction ( ). getHash. equals (prohash))
List < TransactionOutput > outputs = TransactionStore. getOut-puts( ) ;
/ / Iterate through the query outputs
For(int i = 0; i < outputs. size( ) ; i + +) { TransactionOutput output = outputs. get(i) ; Break;
return output;
if proving(u_id). equal = = 0 then
return false;
/ / traverse the block
Else
mineTxList = blockStoreProvider. loadRelatedTransactions( ) ; for
(TransactionStore. getTransactionStore: mineTxList)
If
(TransactionStore. getTransaction ( ). getHash. equals (prohash))
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/ / Iterate through the query outputs
For(int i = 0; i < outputs. size( ) ; i + +) { TransactionOutput output = outputs. get(i) ; Break;
return output;

IV. System Design

A. *System a rchitecture design*

Figure 3 depicts the general architecture of the blockchain-based pre-made food traceability system that is suggested in this paper. This design is composed of three layers: data access layer, data service layer, and user application layer. The traceability system for prepared vegetable products uses the sensor front-end network primarily to realize data collection and uploading, and the production process APP communicates with the blockchain backend to ensure data uploading to the blockchain. The data access layer and the data service layer finish off the data recording and storage functions of the traceability system. Here, agricultural products' information is carried by a product traceability QR code that is indexed and logged along all important production, picking, processing, and sales links. The interface between the blockchain system and users is then primarily realized using the user application layer. To provide effective and trustworthy product interaction and traceability, the layers are interconnected.

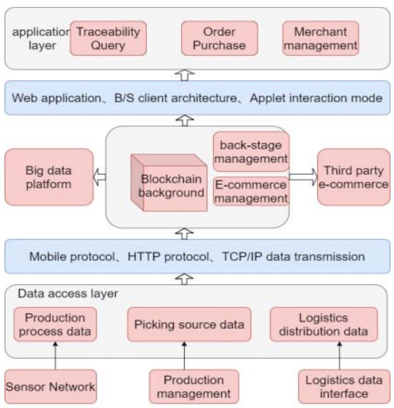

Figure 3 Overall architecture of the blockchain traceability system for pre-made vegetables

B. System Business Process Design

Figure 4 depicts the traceability system's business operating process. The following describes the system's business operating process.

1) The stage of production for ready vegetables

The database's user table is used to store the producer's (farmer) basic information, such as the farm's production species, the kind of fry produced, the number of different types of fish ponds produced, and the features of product attributes, among other things. The information is inputted into the back-end management system by the producer (farmer).

2) The stage of processing and transportation

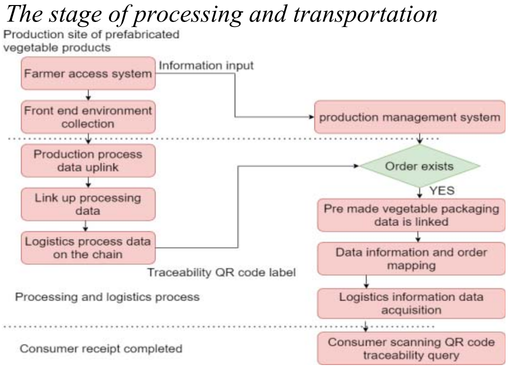

Figure 4 System business process

C. System coding design

As an illustration, the supply chain for the prepared food "pineapple grilled fish" is broken down into four primary database coding links: breeding (seed), processing, transportation, and sales. The corresponding database is built as an E-R graphic. Figure 5 displays the information that has to be gathered.

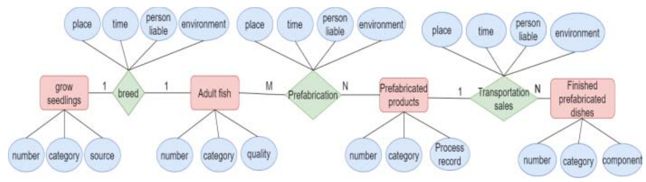

Figure 5 Collecting information

non-tearable QR codes, and the batch information (including types, photographs, proof of purchase, etc.) is recorded to create a chain of evidence that can be validated to assure the unity of the goods and evidence. If the QR code is forcibly replaced, it will harm pre-made vegetable items irreparably and guarantee the consistency of its QR code coding procedure in the supply chain of, for instance, "pineapple grilled fish." The whole process is hierarchical, the first layer, the main node of the supply chain (N_p), such as live fish (N_1); the second layer for the first layer of branch points (N_{pq}), such as fish fry (N_{11}), ponds (N_{12}); the third layer for the second layer of branch points (N_{pql}), in the case of fish fry, the third layer of branch points can be feeding (N_{111}), disease control (N_{112}) and so on. Each new level's node information is made up of the information from all preceding nodes, or the entire supply chain information.

$$\begin{aligned} N &= \sum N_p, p = 1,2,3,\ldots \\ N_p &= N_p + \sum N_{pq}, q = 1,2,3,\ldots \\ N_{pq} &= N_{pq} + \sum N_{pql}, l = 1,2,3,\ldots \end{aligned} \quad (1)$$

Where: N-Total node information; N_p-Some primary node information, or some first-level node information; N_{pq}-Some branch node information, or some second-level node information; N_{pql}-Some secondary branch point information, or some third-level node information.

V. SYSTEM TESTING AND IMPLEMENTATION

A. Environment Deployment: The environment of the prefabricated product

The transaction traceability system is created in a VMware virtual machine running Ubuntu Linux. The blockchain backend environment is deployed using the Go language through the GoLand compiler with the Hyperledger Fabric underlying architecture, and the virtual machine is set up with 4 GB of memory and 80 GB of hard disk.

B. Functional implementation.

Based on the aforementioned architecture and model, a blockchain-based traceability system for pre-made food transactions is designed and implemented. It has two components, the front and the back, and it is a reliable quality control traceability system for customers, producers, and market managers of pre-prepared vegetables. After entering the traceability code or scanning the QR code on the product package, customers can access the system's product information traceability interface to get details about the product's history from planting to sale, along with the corresponding personnel information and blockchain address. The system login screen is depicted in Figure 6

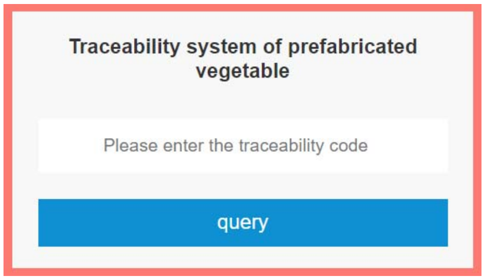

Figure 6 System login screen

VI. END

The blockchain system was implemented using the HyperledgerFabric platform, which, in contrast to the traditional traceability system, offers decentralization and distributed data storage. It also creates a new trust mechanism to ensure the security and reliability of information, overcoming technical limitations in the former and offering a reliable platform for the traceability of pre-made food products that is independent of third parties. Since blockchain technology is still in its early stages of development, future research should concentrate on finding ways to enhance the system's performance and consensus efficiency.

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