Research on the Anti-counterfeiting and Traceability System of Tea Based on Blockchain

Yazhen He[a], Yuzhuo Pan[b*], Yuchao Liao[c], Zengbeining Zhou[d], Sihan Zheng[e], Liping Guo[f], Tianying Wu[g]

Quanzhou Normal University, Fengze, Quanzhou, Fujian, China

[a]2898726985@qq.com, [b*]yzpan@qztc.edu.cn, [c]1739990534@qq.com, [d]591334953@qq.com, [e]1051167919@qq.com, [f]lpguo@qzt.edu.cn, [g]26583073@qq.com

Abstract. Utilizing the Ethereum Geth client, we constructed a consortium blockchain and developed a smart contract in the Solidity programming language. The smart contract encompasses three primary modules: system initialization,anti-counterfeiting information upload, and anti-counterfeiting information retrieval. Through the Remix Integrated Development Environment (IDE), the smart contract was successfully deployed onto the Ethereum blockchain network. To ascertain the robustness and security of the smart contract, we conducted exhaustive deployment and invocation tests using the Ganache testing software in conjunction with the MetaMask lightweight Ethereum wallet, thereby validating the reliability and efficacy of the functions for uploading and querying anti-counterfeiting information.

Keywords: blockchain, Smart contract, Ethereum

1 Introduction

The proliferation of counterfeit tea products in the market has posed significant challenges to consumers and legitimate tea producers. These fake products undermine consumer trust and damage the reputation of branded tea. To address this issue, this paper introduces a blockchain-based tea anti-counterfeiting and traceability system. By leveraging the immutability and transparency of blockchain technology, this system aims to ensure the authenticity and integrity of tea products from production to consumption. The research delves into the design and implementation of the system, highlighting the key modules of the smart contract, including system initialization, anti-counterfeiting information upload, and retrieval. This study contributes to the development of more secure and transparent traceability systems in the commodity industry.

H. Sun et al. (eds.), *Proceedings of the 2025 10th International Conference on Social Sciences and Economic Development (ICSSED 2025)*, Advances in Economics, Business and Management Research 332,
https://doi.org/10.2991/978-94-6463-734-2_94

2 Design of Smart Contracts

Tea has increasingly gained popularity among the masses in recent times. However, driven by high profits, branded tea has repeatedly been targeted by counterfeit tea, which not only impairs the interests of consumers but also undermines the reputation of branded tea[1]. A blockchain-based tea traceability system not only ensures the authenticity and integrity of product data but also achieves full transparency and traceability from production to consumption, significantly enhancing traceability efficiency and impartiality.

This system adopts Ethereum for the purpose of developing and deploying decentralized applications (DApps), primarily because Ethereum stands as the pioneering blockchain platform that introduced the notion of smart contracts, thereby positioning it as a formidable instrument for constructing decentralized applications (DApps)[2]. Smart contracts empower developers with the capability to deploy and execute sophisticated logical operations on the blockchain, thus facilitating the creation of a wide array of blockchain applications that are both open and adaptable. In comparison, other blockchain platforms may exhibit certain constraints in the realm of smart contract functionality, falling short of the flexibility and comprehensiveness exhibited by Ethereum.

There are numerous algorithms in blockchain technology, among which the Elliptic Curve Digital Signature Algorithm (ECDSA) plays a vital role. It provides a reliable digital signature mechanism for transactions on the blockchain, ensuring transaction security, integrity, and immutability.An elliptic curve is defined over a finite field

$$\mathrm{E}\left(\mathrm{F}_{\mathrm{P}}\right) \tag{1}$$

with the equation being

$$y^2 = x^2 + ax + b(\bmod p)(4a^2 + 27b^2 \neq 0(\bmod p)) \tag{2}$$

and its points form an abelian group, providing the mathematical foundation for ECDSA.

In the context of blockchain technology, three distinct types of chains can be identified based on their permission structures: public chains, private chains, and consortium chains. The supply chain participants in the tea traceability system designed for this research endeavor encompass a diverse array of stakeholders, including growers, processors, storage and transportation providers, distributors, administrators, and others[3]. These participants must engage in collaborative efforts to upload their respective information onto the blockchain. Given this unique characteristic, the implementation of a consortium chain is deemed necessary for the tea traceability system. This is due to the fact that a consortium chain necessitates the presence of central nodes, which contributes to its greater stability in comparison to a public chain. Additionally, the admission and expulsion of consortium members necessitate authorization, thereby fostering a higher degree of authenticity, openness, and transparency in the information shared within the system[4].

To achieve the functionality of uploading tea anti-counterfeiting information onto the Ethereum blockchain, we need to interact with the blockchain through smart contract programs, uploading and storing the anti-counterfeiting information as additional data within transactions. Solidity, an advanced programming language specifically designed for smart contracts on the Ethereum blockchain, is capable of incorporating a clear and well-defined user login and registration process within the smart contracts[5]. When a user attempts to log in to the system, the system will first verify whether the user has completed the registration process. If the user has not registered, the system will automatically initiate the registration process, prompting the user to select their role type (such as producer, retailer, consumer, or regulator). Upon completion of role selection, the user's account address will be bound to their selected role type, and the system will set a clear identifier to record the user's successful registration status.details are shown in Fig. 1

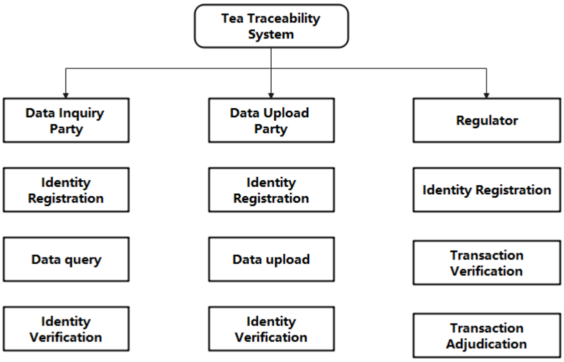


Fig. 1. Function module design

2.1 Functional Code Design

Role contract: Create the add() function and the remove() function to add and remove roles, respectively. In the add() function, it accepts a Role struct and an address as parameters. Within the function, it first invokes the has function to check whether the address already possesses the role. If not, it adds the address to the mapping and sets its value to true, indicating that the address holds the role. Conversely, in the remove() function, if the address possesses the role, it removes the address from the mapping and sets its value to false, indicating that the address no longer holds the role.

- Implement adding role addresses
- Check whether the role address is authorized

Manufacturer contract: Import the Roles library to manage the membership of the producer role. Create an addProducer(address account) function to allow members of the producer role to add new producers, enabling the dynamic adjustment of the producer list without the need for redeploying the contract. Develop a removeProducer() function that allows any caller (including non-producers) to remove themselves from the producer role. Establish an isProducer(address account) function to check whether an address holds the producer role and verify whether the caller possesses the corresponding role permissions. Create a modifier onlyProducer() to ensure that only members of the producer role can execute certain sensitive operations, thereby maintaining the security of the contract and the consistency of its data.

- Producer role management: Create and validate producers

Distributor contract: The relevant algorithms are analogous to those employed in the Manufacturer contract.

- Reseller Role Management: Create and verify resellers

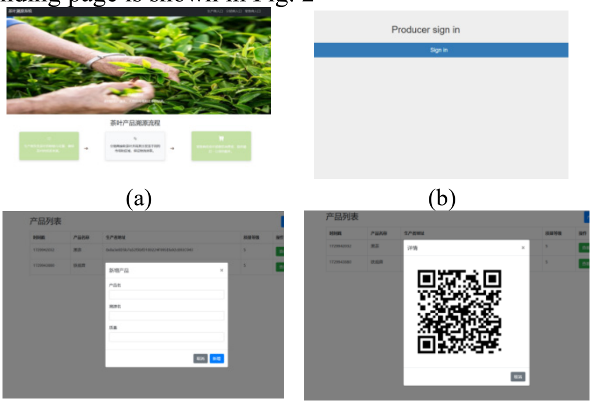
Retailer contract: The relevant algorithms are analogous to those employed in the Manufacturer contract.

- Retailer Role Management: Create and validate retailers

Product information contract: In the process of constructing the tea traceability smart contract, we have defined a series of state variables to ensure that comprehensive and accurate information is recorded and tracked throughout the entire chain of tea, from production to sales. The following is an elaboration of these state variables: timestamps to record transaction names and descriptions, transaction addresses, quality ratings, food names and current statuses, transaction statuses, and contract owners.

- Store product information: The contract may

The corresponding page is shown in Fig. 2



(a) (b) (c) (d)

Fig. 2. System Page Layout Design.

- store traceability information about the tea, such as tea name, traceability information about the tea, and the status of the tea.
- Enable product traceability: Distributors and retailers add traceability information.
- View product information.

Traceability contract: By importing the aforementioned modules and integrating multiple roles (producers, distributors, and retailers) along with a contract designed for storing tea information, we aim to ensure that every step in the tea's journey from production to sales can be accurately recorded and traced.

- Manage product traceability contracts: Manufacturers produce product contracts through which various roles can track and manage product traceability

3 Implementation of Web-based Software for Traceability System

The front-end interface of the system is mainly responsible for visual display, which is convenient for users to operate, including the following interfaces: the main page of the system, the manufacturer interface, the distributor interface, and the retailer interface. The front-end is mainly implemented through Html, Css, Javascript, Jquery, Bootstrap and other technologies.

The main function of the server side of this system is to operate the database function, realize the double database system, and ensure the data backup of this system.[6] Before the goods are connected to the chain, the system will first store the link data in the Mysql database of Alibaba Cloud, and return the product id in the database, and then store the product id in the blockchain as the traceability id on the blockchain, read the data information of the product id and generate a two-dimensional code, which is stored in the static resource file.

3.1 System Interface

The system interfaces primarily encompass the main system dashboard, manufacturer login interface, manufacturer main interface, distributor login interface, distributor traceability interface, distributor detailed view interface, retailer login interface, among others.

4 System Testing

Initially, the smart contract is deployed onto a testnet provided by Ganache[7], simulating the subsequent process of deploying the smart contract onto a public blockchain. Within the deployment environment of the Remix IDE, Ganache is selected, with the correct chain ID and RPC port being added. Upon confirmation, the deployment proceeds, and verification is conducted to ascertain whether the smart contract has been successfully deployed onto the testnet. The specific results are shown in Table 1.

Table 1. Tea traceability data upload test cases.

Test number	Test items	Expected result
1	Connect Ganache	connection-successful signal
2	Publish to Ganache	Transaction information appears
3	Ganache Compare with terminal transaction information	Release success

Prior to uploading tea traceability data, identity registration is required. To ensure system credibility, it is necessary to conduct tests on the tea traceability data upload function to verify its authenticity. To safeguard system reliability, two aspects of testing need to be implemented: firstly, testing the registration status of the uploading transaction participants; secondly, verifying the authenticity of the tea traceability data. The transaction tests encompass identity verification of the uploader and confirmation of their registration status. The specific results are shown in Table 2.

Table 2. Tea traceability data upload test cases.

Test number	Test items	Test input and procedure	Expected result
1	Connect Ganache	Open the front interface and check whether available accounts are displayed	successfu lconnection
2	login account	Log in to an account that is not registered	login successfully
3	login account	Log in to the first account that has been registered as a manufacturer	login successfully
4	Food traceability dataupload	Upload food traceability data and verify this transaction information	verify successfully
5	login account	Log in to a second account that is not registered	login successfully
6	login account	Log in to the second account that is registered as a retailer	login successfully
7	Submit trading information	Verify that the transaction was uploaded	verify successfully

5 Conclusion

This paper delves into a tea anti-counterfeiting and traceability system grounded in blockchain technology. By leveraging the Ethereum Geth client to establish a consortium blockchain and utilizing Solidity to code smart contracts[8], the system achieves the functionality of uploading and querying anti-counterfeiting information onto the blockchain. Leveraging the immutability and traceability of blockchain, the system effectively addresses the issues of counterfeiting and opaque traceability information prevalent in the tea market. The anti-counterfeiting information uploading module ensures that every stage of the tea's journey, from production to consumption, is securely recorded, providing consumers with authentic and reliable traceability data[9]. Meanwhile, the anti-counterfeiting information querying module offers a convenient interface for inquiries, thereby enhancing market transparency and consumer trust. Looking ahead, with the continued advancement of blockchain technology, this system holds promise for application in numerous additional fields, ushering in further innovations and transformations within the commodity traceability and anti-counterfeiting sectors[10].

Acknowledgments

This work was financially supported by the Quanzhou Normal University National-level Innovation and Entrepreneurship Training Program(No. 202310399001), which has played a pivotal role in enabling the successful execution of this research. The grant received has not only provided the necessary resources but also fostered an environment

conducive to innovation and exploration. We are deeply grateful for their commitment to advancing knowledge and scientific inquiry.

References

1. Federico Girolametti,Anna Annibaldi,Silvia Illuminati,Elisabetta Damiani,Patricia Carloni,Behixhe Ajdini,Matteo Fanelli,Cristina Truzzi.Unlocking the elemental signature of European tea gardens: Implications for tea traceability.[Z].Food chemistry.2024.
2. Tan Evrim,Dan Sorin,Shahzad Khuram.Guest editorial: Bridging the chasm between “what could be” and “what is”: the impact of blockchain technologies on public service management[Z].International Journal of Public Sector Management.2024.
3. Qi Yu,Min Zhang,Arun S. Mujumdar.Blockchain-based fresh food quality traceability and dynamic monitoring: Research progress and application perspectives[Z].Computers and Electronics in Agriculture.2024.
4. S. Suganthi,T. Sree Kala.A novel secure aware privacy preserved data sharing framework in an E-government system based on a consortium blockchain[Z].Journal of Control and Decision.2024.
5. Modi Ritesh.Solidity Programming Essentials:A guide to building smart contracts and tokens using the widely used Solidity language[Z].Packt Publishing Limited.2022.
6. Kamil M. Amer,,Dominick V. Congiusta,,Jennifer E. Thomson,,Samer Elsamna,,Iftikhar Chaudhry,,Anthony Bozzo,,Rami Amer,,Brianna Siracuse,,Michelle Ghert,,Kathleen S. Beebe.Epidemiology and survival of liposarcoma and its subtypes: A dual database analysis[Z].Journal of Clinical Orthopaedics and Trauma.2020.
7. Kose John,Barnabé Monnot,Peter Mueller,Fahad Saleh,Caspar Schwarz Schilling.Economics of Ethereum[Z].Journal of Corporate Finance.2024.
8. Mezquita Yeray,Casado-Vara Roberto,González Briones Alfonso,Prieto Javier,Corchado Juan M.Blockchain-based architecture for the control of logistics activities: Pharmaceutical utilities case study[Z].Logic Journal of the IGPL.2021.
9. Xiangyin Meng,Bingbing Liu,Miao Zhang.Design and Implementation of Blockchain-based Commodity Anti-counterfeit Traceability System[Z].Proceedings of the 2nd International Conference on Bigdata Blockchain and Economy Management, ICBBEM 2023, May 19–21, 2023, Hangzhou, China.
10. Shaoning Pang,Shyh Wei Teng,Manzur Murshed,Cuong Van Bui,Priyabrata Karmakar,Yanyu Li,Hao Lin.A survey on evaluation of blockchain-based agricultural traceability[Z].Computers and Electronics in Agriculture.2024.