ISSN: 2249-7196

IJMRR/April. 2025/ Volume 15/Issue 2s/419-424

Guntuboina Guru Sankara Venkatesh/ International Journal of Management Research & Review

Blockchain-Quality of Assurance and Food authenticity using blockchain

Guntuboina Guru Sankara Venkatesh
PG scholar, Department of MCA, CDNR collage, Bhimavaram, Andhra Pradesh.
B.S.MURTHY
(Assistant Professor), Master of Computer Applications, DNR collage, Bhimavaram, Andhra Pradesh.

Abstract

In recent years, ensuring transparency, security, and traceability in supply chain management has become a critical need, especially in sectors like agriculture and food distribution. This project introduces a decentralized, blockchain-enabled *Food Supply Chain Management System* ***that leverages*** *Ethereum smart contracts* ***and*** *Python (via Django)* ***to monitor, record, and verify transactions involving farmers, producers, distributors, and consumers in a tamper-proof manner. The core of this system is a*** *smart contract deployed on a local Ethereum blockchain (Ganache)****, which securely stores user credentials, product information, and purchase transactions. Using*** *Web3.py****, the application interacts with the smart contract to perform functions such as product addition, purchase tracking, status updates, and QR code generation for verification. The blockchain ensures that once data is recorded, it cannot be altered, thus enhancing data integrity and trust between stakeholders. Each product added by a farmer or producer is assigned a unique QR code containing details such as owner, product ID, description, and transaction history. These details are displayed along with product images and are accessible to consumers and distributors through dedicated user interfaces. The Django web framework provides intuitive screens for different user roles, ensuring seamless interaction and real-time updates. By automating traceability and reducing reliance on centralized systems, this project demonstrates the potential of blockchain in transforming traditional food supply chains into*** *transparent, efficient, and secure ecosystems****. It ensures that all participants in the supply chain—from the origin of the product to its end consumer—are accountable and verifiable at every step.***

INTRODUCTION

In the age of digital transformation, supply chain transparency and traceability have emerged as critical components for industries—especially the food sector—where safety, authenticity, and trust are paramount. Traditional food supply chains are riddled with inefficiencies, data manipulation risks, and a lack of visibility across stakeholders, making them vulnerable to fraud, contamination, and unethical practices. As the demand for food traceability and consumer confidence grows, there arises an urgent need for a more robust, tamper-proof solution to track and authenticate food products from their origin to the end consumer.

Blockchain technology, a decentralized and immutable ledger, offers a revolutionary approach to these challenges by ensuring that all transactions in the supply chain are securely recorded and verifiable. This project introduces a **Blockchain-based Food Supply Chain Management System**, implemented using **Ethereum smart contracts**, **Python**, and the **Django web framework**, to address these challenges. The system leverages the transparency and security features of blockchain to create a traceable food supply network where farmers, producers, distributors, and consumers interact within a trustless environment.

In this system, each participant in the supply chain has a defined role. Farmers and producers upload product data such as name, quantity, price, description, and date of harvest using the web interface. Each product is assigned a unique **QR code**, which acts as a digital identity for the product, storing all relevant transactional and ownership details on the blockchain. Distributors and consumers can scan this QR code to verify the product's authenticity and its movement through the supply chain.

Using **Web3.py**, the application connects to a locally hosted Ethereum blockchain (via Ganache) and executes smart contract functions such as creating user accounts, adding new products, initiating purchases, and updating order statuses. All critical operations are securely logged on the blockchain, ensuring transparency and immutability. The system's front end, powered by **Django**, provides a clean and intuitive interface for different users to interact with the blockchain without requiring any technical expertise.

Furthermore, the use of QR code technology bridges the physical and digital aspects of the supply chain, allowing users to visually verify the provenance and legitimacy of food items. Consumers are empowered to make informed decisions, and producers can build greater trust with end-users through verifiable data.

In conclusion, this system is a robust example of how emerging technologies like blockchain can be integrated into real-world applications to solve pressing problems in food safety, security, and supply chain management. It not only enhances operational transparency and efficiency but also introduces a new standard for accountability across the entire food production and distribution ecosystem.

Different parameters such as sealers, block-time, and block-gas-limit were analyzed to achieve the best possible results for our consortium blockchain. We choose to implement our solution using the Ethereum platform as it facilitates developers to deploy their smart contracts in a secure and simple manner. However, PETchain can be implemented over any consortium blockchain platform that supports the deployment of smart contacts.

Emerging Intelligent Infrastructures (II) that interconnect various IoT applications and services are meant to provide convenience to people, open new benefits to society, and benefit our environment. There are many IoT applications and use cases that are either already implemented or are in varying research stages heading towards potential implementation. The general overview of IoT environments and applicable scenarios are depicted.

Nevertheless, connected objects, sensors and digital systems around peoples lives form a large intelligent network that can serve as a medium for the leakage of personal data [61, 27, 63]. It is essential during the design and application stages of intelligent networks to include privacy protection into incoming infrastructures and IoT applications.

LITERATURE SURVEY

The traditional food supply chain is plagued by numerous challenges, including lack of transparency, traceability issues, and inefficiencies in tracking product movement from farm to consumer. The literature shows a growing trend in integrating blockchain technology into supply chain systems to address these issues. This survey explores significant research contributions and implementations that have informed and inspired the development of a blockchain-powered food traceability system.

1. IBM Food Trust (2020)

IBM's Food Trust platform, built on Hyperledger Fabric, provides a permissioned blockchain network for retailers and suppliers. It allows participants to record and access data on food items as they move through the supply chain. Walmart has been one of the notable adopters, using the platform to track products such as mangoes and pork. IBM’s solution demonstrates the potential of blockchain in improving food safety by enabling fast and accurate product recalls.

Reference: IBM Food Trust – https://www.ibm.com/blockchain/solutions/food-trust

2. Tian, F. (2016).

Tian proposed an agri-food traceability system that integrates blockchain and RFID technologies. In this model, RFID tags collect information from the supply chain stages, which is then stored on a blockchain for immutable access. This model reduces data tampering risks and increases the reliability of food origin information, especially within the context of China’s food safety concerns.

Reference: Tian, F. (2016). "An agri-food supply chain traceability system for China based on RFID & blockchain technology". *13th International Conference on Service Systems and Service Management (ICSSSM).*

3. Caro et al. (2018)

Caro and colleagues developed a blockchain-based framework for food traceability using Ethereum smart contracts. Their system allowed different supply chain actors to interact with the blockchain to add or view product data. The study emphasized the importance of transparency and verified records in detecting fraud and ensuring consumer trust.

Reference: Caro, M. P., Ali, M. S., Vecchio, M., & Giaffreda, R. (2018). "Blockchain-based traceability in Agri-Food supply chain management: A practical implementation". *IoT Vertical and Topical Summit on Agriculture-Tuscany (IOT Tuscany)*.

4. Kamath, R. (2018)

Kamath's study focused on blockchain's real-world implications in improving the agri-food system. The research explored the use of blockchain for establishing trust and automating transactions using smart contracts. It also highlighted case studies from India and suggested scalable architectures for decentralized systems.

Reference: Kamath, R. (2018). "Food traceability on blockchain: Walmart's pork and mango pilots with IBM". *The Journal of the British Blockchain Association*, 1(1), 1–12.

5. Galvez et al. (2018)

This paper provided a critical evaluation of blockchain's role in food traceability. The authors discussed the technology's strengths in ensuring food safety and reducing fraud, while also pointing out its limitations, including high implementation costs, regulatory challenges, and lack of standardization.

Reference: Galvez, J. F., Mejuto, J. C., & Simal-Gandara, J. (2018). "Future challenges on the use of blockchain for food traceability analysis". *TrAC Trends in Analytical Chemistry*, 107, 222–232.

6. Leng et al. (2020)

Leng and his team introduced a double-chain architecture for food traceability that integrates IoT and blockchain. They addressed performance and scalability by separating sensitive and public data using sidechains. Their work showed how performance bottlenecks in blockchain can be resolved using hybrid approaches.

Reference: Leng, K., Bi, Y., Jing, L., Fu, H.-C., & Van Nieuwenhuyse, I. (2020). "Sustainable operations of smart supply chain management based on blockchain and RFID technology". *Sustainability*, 12(9), 3966.

7. Tripoli & Schmidhuber (2018)

Published by the FAO, this report highlighted blockchain as a transformative technology in agriculture and food sectors. It emphasized that blockchain could reduce corruption, fraud, and inefficiencies in food trade by enabling end-to-end traceability and digital certification.

Reference: Tripoli, M., & Schmidhuber, J. (2018). "Emerging opportunities for the application of blockchain in the agri-food industry". *FAO & ICTSD Joint Report*.

PROPSOED METHOD

The proposed system aims to implement a decentralized, transparent, and secure food supply chain solution using **Blockchain technology** integrated with a **web-based platform built in Django**. This method ensures traceability, authenticity, and data integrity from the origin (farmer) to the final consumer.

4.1 Overview

The system leverages **Ethereum Smart Contracts** to record transactions and actions performed by stakeholders such as farmers, producers, distributors, and consumers. Each operation—from product addition to purchase—is stored immutably on the blockchain, providing an auditable history of the food item. **QR codes** are generated for each product to allow users and customers to verify origin and track movement.

4.2 Key Modules and Stakeholders

User Roles

- **Farmer**: Adds raw agricultural products to the blockchain.
- **Producer**: Purchases from farmers and creates processed food products.
- **Distributor**: Procures from producers and sells to retailers or consumers.
- **Consumer**: Views product history, authenticity, and purchases products.
- **Admin** (optional): Monitors and manages user registration.

Modules

- **User Management**: User registration, login, and role selection.

Product Registration: Product details, images, and metadata are uploaded and hashed.

Blockchain Smart Contract Integration: All operations are written to and read from the blockchain via Web3.py.

Purchase and Sale Management: Enables transaction recording across user roles.

Tracking and Traceability Module: Users can trace a product's full history using its ID or QR code.

RESULT

CONCLUSION

The implementation of a Blockchain-Based Food Supply Chain Management System has proven to be a significant technological advancement that addresses key challenges in food product tracking, transparency, and trust among stakeholders. By leveraging the immutable nature of blockchain, this system ensures that all transactions—from production and processing to distribution and consumer delivery—are securely recorded and easily verifiable.

Throughout the project, smart contracts were successfully integrated to automate and validate operations such as product uploads, purchase tracking, and ownership transfers. This automation minimizes the potential for human error and fraud while significantly improving efficiency across the supply chain.

Moreover, the use of QR codes to trace product information provides end-users with confidence about the origin, authenticity, and handling of their food. This empowers consumers to make informed choices and holds producers and distributors accountable for the quality of their goods.

The system also promotes decentralization by eliminating the need for a centralized authority to manage product records. It fosters trustless interactions among farmers, producers, distributors, and consumers, encouraging transparency and integrity in all transactions.

In conclusion, this project not only enhances the operational efficiency of the food supply chain but also introduces a paradigm shift in how data transparency, traceability, and accountability are maintained in food logistics. The solution sets the foundation for a more secure, intelligent, and ethical food distribution ecosystem, particularly beneficial in combating counterfeit products and enhancing food safety.

REFRENCES

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   a) Explores the integration of smart contracts and IoT, relevant for automating transactions and monitoring in supply chains
6. **Hyperledger Fabric Documentation**, https://www.hyperledger.org/use/fabric

a) Official documentation on Hyperledger, useful for understanding permissioned blockchain frameworks.

7. **Web3.py Documentation**, https://web3py.readthedocs.io/
   a) Explains how to interact with Ethereum blockchain using Python, which was applied in your Django backend.
8. **Solidity Documentation**, https://docs.soliditylang.org/en/v0.8.21/
   a) Official documentation for Solidity, used to write smart contracts for managing supply chain operations.
9. **Ganesh, D., & Jadhav, R. (2021)**, *Smart Agriculture and Supply Chain Monitoring using Blockchain*, *International Journal of Engineering Research & Technology (IJERT)*.
   a) Describes the relevance of blockchain in improving agricultural product transparency.
10. **Ethereum Foundation**, https://ethereum.org/
    a) Provides foundational knowledge on Ethereum blockchain, used for implementing smart contracts in this project.