International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Blockchain-Powered Product Authentication and Anti-Counterfeiting System

Nitish Srinivasa[1], Muskan Kwatra[2], Prof. K Deepa Shree[3], Rahul Pokala[4], Pallavi Harish[5]

[1,2,4,5]Student, 4th Year, B.E, Computer Science and Engineering, Dayananda Sagar Academy of Technology & Management Bengaluru, India
[3]Assistant Professor, Computer Science and Engineering, Dayananda Sagar Academy of Technology & Management Bengaluru, India

Abstract
In recent years, blockchain has received increasing attention and numerous applications have emerged from this technology. A renowned Blockchain application is the cryptocurrency Bitcoin, that has not only been effectively solving the double-spending problem but also it can confirm the legitimacy of transactional records without relying on a centralized system to do so. Therefore, any application using Blockchain technology as the base architecture ensures that the contents of its data are tamper-proof.
This study proposes a blockchain-powered system to enhance counterfeit detection by securely tracking products' supply chain history. Blockchain's decentralized and immutable nature ensures transparency, traceability, and protection against data tampering, offering a robust solution to mitigate counterfeiting effectively. Its immutable nature prevents data alteration without consensus, thereby safeguarding information and minimizing vulnerabilities. This paper proposes a blockchain-powered system designed to detect and mitigate product counterfeiting effectively.

Keywords: Blockchain Technology, Product Authentication, Anti-Counterfeiting System, Supply Chain Traceability, Decentralized Systems, QR (Quick Response), Counterfeit Detection, Secure Data Sharing

I. INTRODUCTION

The current global market poses a challenge in the sale of counterfeit products, especially affecting luxury goods, electronics, pharmaceuticals, and food industries. Besides causing business loss, it also poses threats to health and safety on the part of the consumers. For example, fake pharmaceutical products may lead to serious health problems, while defective electronics can cause malfunctions and accidents.
Counterfeiting is a growing problem that affects almost every industry, with the UN estimating that the counterfeit market is worth US$250 billion annually. Companies face significant risks from counterfeiting, including lost revenue and damage to brand reputation [1]. Counterfeiting also affects the brand reputation, as consumers unknowingly associate poor-quality counterfeit items with genuine brands, resulting in distrust and negative publicity.
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The need for an effective solution is urgent to protect consumers, restore brand trust, and secure supply chains.

Blockchain technology, known for its transparency and immutability, offers a promising approach to addressing this issue. The system employs smart contracts and decentralized ledgers to securely register and authenticate products. Key areas of implementation include frontend and backend integration, blockchain architecture, and performance assessment. The results show that the method successfully supports product verification based on a secure and transparent mechanism. Blockchain enables secure storage of product details, including manufacturing and ownership history, ensuring that product authenticity can be verified easily by scanning a QR code. Unlike traditional solutions, a blockchain-based system not only secures product data but also ensures real-time traceability, reducing the risk of tampering at any stage of the supply chain. This approach bridges the gap between manufacturers, suppliers, and consumers, fostering trust and accountability while enhancing operational efficiency.

This study details the technical deployment of a blockchain based anti-counterfeiting platform with emphasis on the technological components, architectural design, and verification mechanisms employed.

II. RESEARCH METHODOLOGY

2.1 System Architecture

Nowadays, with the rise of technology and markets the problem to differentiate with original and duplicate has also incurred a lot of damage to consumers, distributors, retailers and also manufacturers. Therefore, in order to combat this a blockchain based application fake product detector is proposed. This chapter briefs the design of the system including a full description of the function and user interface of the system. The goal is used to use the blockchain features to provide a convenient, accurate and low-cost product anti-counterfeiting solution. The system is a blockchain based web application used to detect counterfeit products on daily basis.

Although the implementation of blockchain technology in a platform can overcome challenges posed by illegal manufacturers, a blockchain-supported platform charges an operating fee to legitimate manufacturers and retailers for product traceability and authentication [5].

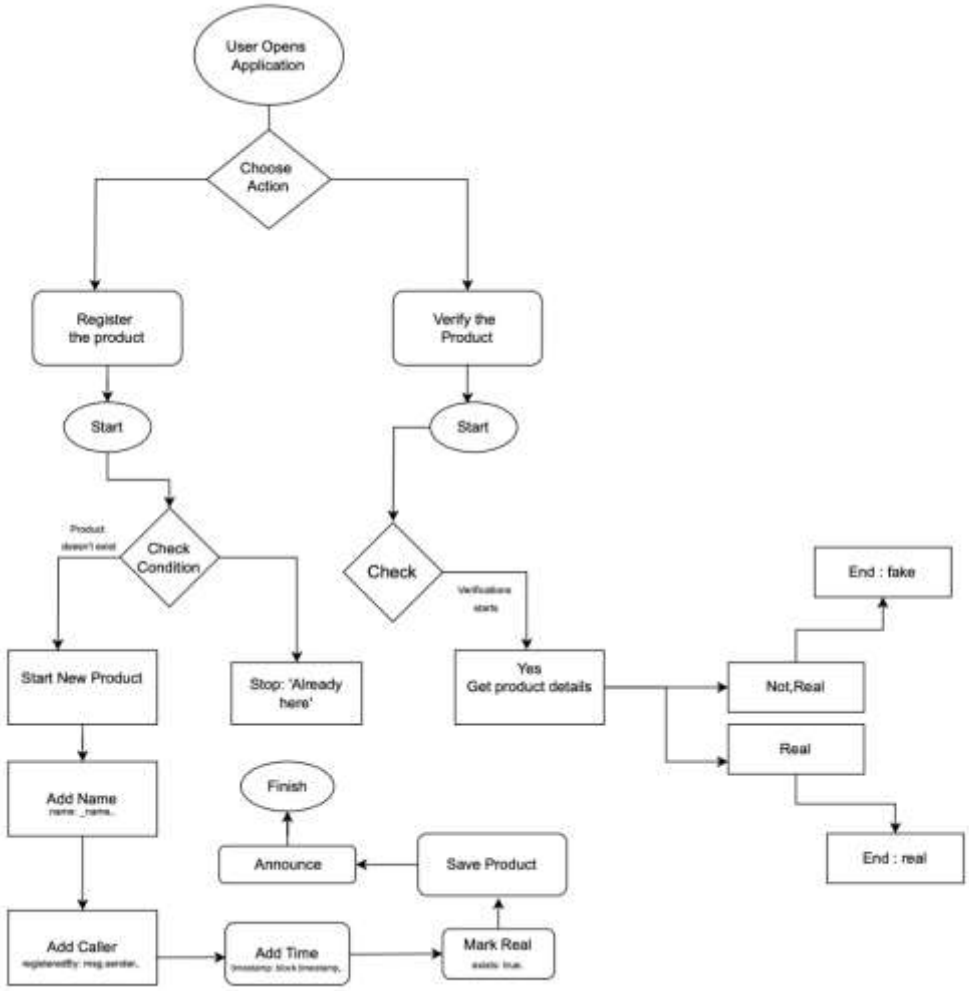

Fig. 1 : Flow Diagram

III. PROPOSED SYSTEM

3.1. System Operation

1. Login Process: Before establishing a connection to the system, the user has to choose which account to log in. Logging in involves choosing an account, entering the Keystore file (with the encrypted private key), and entering the contract address. [2]
2. **Public Information of Contract:** With the goal of information disclosure, the information about sellers is completely public. Our system provides smart contract data search functions, which can return the seller list, consumer list, all seller information, and the remaining number of products of each seller. [2]
3. **Adding New Sellers and Products Number:** In our system, manufacturers can control the seller's information, including adding new seller addresses and as well adding the number of products that can be sold from a specific seller. Manufacturer determines seller data and product quantities. Authorized manufacturers can only add new sellers and assign product quantities.[2]
4. **Providing Exchange for Consumers:** Buyers who order for product replacements should present identity and shipping information. The maker confirms authenticity first before changing the product status within the agreement.[2]

5. **Recording the consumer on Smart Contracts:** Sellers enroll consumers when they buy by adding their addresses to the smart contract's product ownership field. This field may only be edited by sellers.[2]
6. **Identity Verification:** Users define their identity using Ethereum's digital signatures. Buyers determine the identity of sellers by requesting an encrypted message, which is verified using cryptographic techniques. After successful verification, buyers make secure transactions.[2]
7. **Secure Information Exchange:** Consumers encrypt shipment information using their own private key before sending it to producers. The producer authenticates the information using smart contract functionality prior to processing the request.[2]

IV. RESULTS

Fig. 2 : Registration

This is the default state of the system when no product has been registered or verified yet. The user needs to input details and perform an action to interact with the blockchain.

Fig. 3: Logging in as Customer for verification.

Upon logging in as a customer, the user is redirected to a dedicated dashboard designed specifically for product verification. This interface allows the customer to input or scan the product's unique identifier (ID) to initiate the verification process. Since the product details are immutably stored on the blockchain. The system guarantees a tamper-proof and transparent verification mechanism. This ensures that only products that have been legitimately registered by authorized sellers can be validated, thereby reinforcing trust and authenticity in the ecosystem.

Fig 4: Customer Dashboard.

The verification system checks if a product exists on the blockchain. If a product is not found, it may be unregistered or counterfeit. This ensures authenticity and prevents fraud.

This system enables customers to verify product authenticity through QR code scanning. Each registered product is associated with a unique QR code that contains its identifier. When a customer scans the QR code using the interface. system retrieves the product details stored immutably on the blockchain.

Fig. 7: QR Code for Product getting verified.

This screen displays the user's Ethereum wallet address, allowing secure blockchain interactions. The QR code enables quick access, ensuring seamless transactions within the system.

Fig. 8 : MetaMask Wallet

This MetaMask wallet is integrated with the Pandora Box system for handling blockchain transactions. It operates on Hardhat for testing, ensuring secure and efficient product authentication.
MetaMask acts as the bridge between the web interface and the blockchain. It allows users to connect their Ethereum wallet and interact with the smart contract. Through MetaMask, transactions like product registration and verification are securely signed and sent to the blockchain.

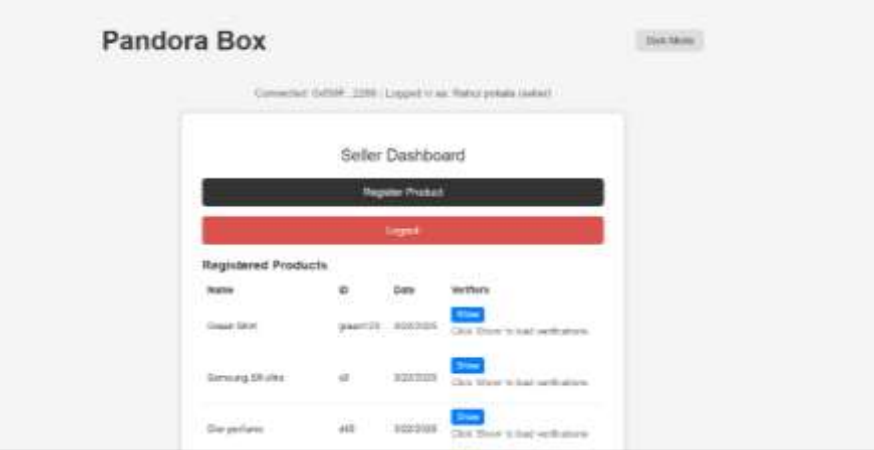

Fig. 9: Seller Dashboard

The seller dashboard displays a list of all products registered by the seller, including their names, IDs, and registration dates.
Each product entry includes a “Show” button that reveals the verification history—listing all users (verifiers).
Who scanned or verified the product, along with timestamps.
This helps sellers track product activity and builds transparency by showing when and by whom a product was verified.

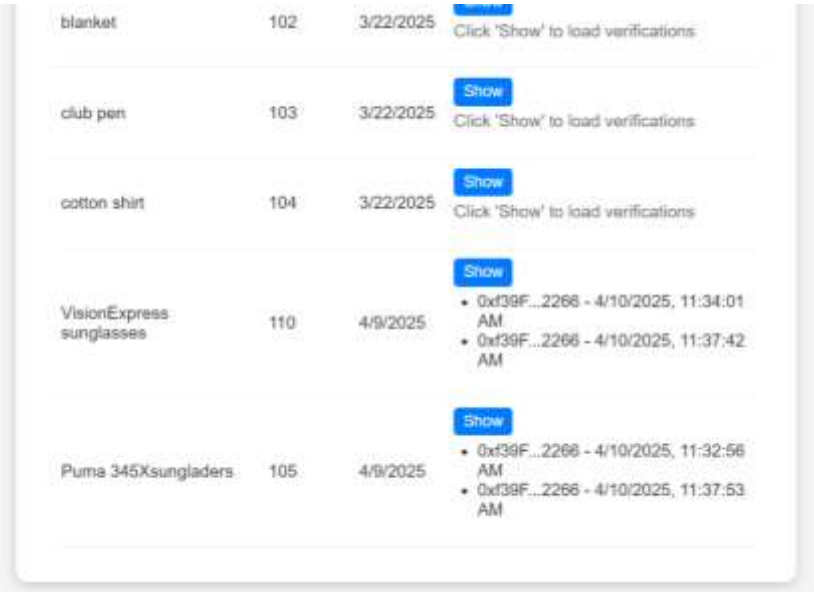

Fig. 10: Sellers who verified a Product can be seen.

The seller dashboard enhances **transparency and accountability**. By showing a real-time list of registered products and their verification history, it allows sellers to track which products are being verified and when. This can help detect any suspicious activity, provide evidence of product circulation, and build trust with customers by proving that their products are being actively authenticated by users. It also helps sellers gain insights into **customer engagement**, as each verification reflects real-world interactions, indicating demand, distribution reach, and the effectiveness of product authenticity measures.

V. CONCLUSION

This study shows that blockchain technology can effectively address product counterfeiting and supply chain inefficiencies by enhancing transparency, traceability, and decentralization. Blockchain may not always be beneficial to all stakeholders; however, it can result in increased profits for legitimate manufacturers when their production costs are high and can encourage retailers to trade on blockchain-based platforms, particularly in price-sensitive markets. The study highlights that the blockchain technology overcomes problems of information asymmetry and uncertainty in e-commerce and helps increase trust among stakeholders with a reduced possibility of counterfeit. However, the still persisting challenges are scalability, latency, and speed of transaction processing. First of all, preliminary investigations into the blockchain technology reveal the ability to securely distribute information along the supply chain, from which consumers can trace and identify counterfeit products, yet issues related to scalability remain unsolved for its feasibility in practical environments. Additional research and subsequent pilot runs are necessary to assess the scalability of blockchain technology, especially with regard to international supply chains, and to determine its compatibility with existing legacy systems.

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