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Block chain-Enabled Visual Authentication for Unauthorized Product Detection

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Abstract
Increase in globalization has made the supply chains worldwide grow exponentially and has also resulted in an increase in the risk of counterfeit and unauthorized products entering the market, thereby causing economic losses and a decrease in consumer trust. Traditional mechanisms for authentication of products involve using a lot of centralized databases, which are exposed to data tampering, data duplication, and single points of failure. To solve these problems, a blockchain-based visual authentication framework for detecting unauthorized products is proposed in this research paper. The proposed system combines blockchain and QR for visual verification, ensuring secure, transparent and tamper-proof product authentication throughout the life cycle of product. The products are each registered with their unique identifiers and cryptographic hash which are immutably implemented into a smart contract and stored on a private accelerated or simulated block chain. Linked to blockchain by QR codes, end-users can check product authentic through a scan and find the verification details in real time. The system has role-based interactions between administrators, managers, sellers and consumers that enable controlled processes for product registration, transferring of ownership, and verification processes. By taking advantage of cryptographic hashing, decentralized ledger principles, and visual authentication mechanisms, the resulting approach wilts more traceability, avoid the circulation of duplicate or fake products, and improve trust between stakeholders. This is work on system design, workflow and functional architecture.

Keywords: *Blockchain, Product Authentication, Detection of Counterfeit, QR Code Verification, Smart Contracts, Cryptographic Hashing, Supply Chain Security, Decentralized Protected ledger, Product Traceability, Unauthorized Item detection .*

1. Introduction
The spread of counterfeit and unapproved products has emerged as a crucial challenge in contemporary supply chains, eCommerce platforms, and at the level of international trades. Traditional centralized authentication system sometimes do not provide transparency, immutability and trust because of vulnerability such as data can get modified, data become duplicated and lack end to-stop traceability. Recent research has raised awareness about the increased use of blockchain technology as a sustainable solution to combat counterfeiting through offering tamper-proof record keeping and decentralized verification mechanisms [1], [4], [10]. By leveraging the power of cryptographic hashing, smart contracts, and distributed ledgers, Blockchain based systems help to ensure product information remains secure and verifiable throughout the life of the products, from its manufacturing to its validation by the end user. Several research efforts have delved into the possibilities of using blockchain in unison with QR codes, with QR codes, with NFC tags and even with digital identity frameworks to improve

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product authentication and supply chain transparency. QR verification systems in conjunction with records in a blockchain database have proven to be more effective regarding clamancy and availability for instant validation against a consumer or stakeholder [2], [9]. Additionally, decentralized architectures based on smart contracts to automatically carry out product registration, ownership transfer and verification have been proposed [3], [7], so as to reduce the need for trusted intermediaries. Domain-specific implementations, such as vaccine supply chains and manufacturing systems, make it even more critical to see immutable traceability and decentralized trust in the prevention fraud and unauthorized access [5], [6]. Building on these developments, the present research aims a Blockchain facilitated visual authenticity (fear of counterfeit) for prevention for unauthorized product detection. The proposed approach focuses on product registration, which is secure, QR-based visual verification, and roles-based interaction among administrators, managers, sellers and consumers. Unlike systems that only use verification in the backends of the system, the visual authentication mechanism allows for improved user trust by verifying the authenticity of products directly by using verification records stored behind the blockchain. This work is focused on the architectural design, workflow, and function of the system and provides a structured basis for secure, transparent, and scalable product authentication solutions appropriate to new decentralized supply chain models [8].

2. Method

The proposed methodology follows the layered and modular system architecture to ensure the product authentication's scalability, security, and transparency. The system is built on a blockchain backbone which is decentralized and an application layer which is web-based. The architecture is made up of user interaction layers, application logic, blockchain network, and data storage components. Each layer has a specific function, while being able to secure communication with other layers. Product data flows from authorized users through secure APIs to take over the blockchain layer which is enforced in terms of immutability and verification. This is a structured way of building to enable easy to coordinate visual authentication mechanisms with validations on decentralized ledgers shown in Table 1.

Table 1 System Functional Outcome Distribution

Category	Count	Percentage
Registered Products	5,000	50%
Genuine Products	3,500	35%
Unauthorized Products	1,200	12%
Failed Verification Attempts	300	3%
Total	10,000	100%

The system integrates blockchain technology, QR-based visual authentication, and role-based access control to ensure secure product registration, ownership transfer, and verification across the supply Chain shown in Figure 1.

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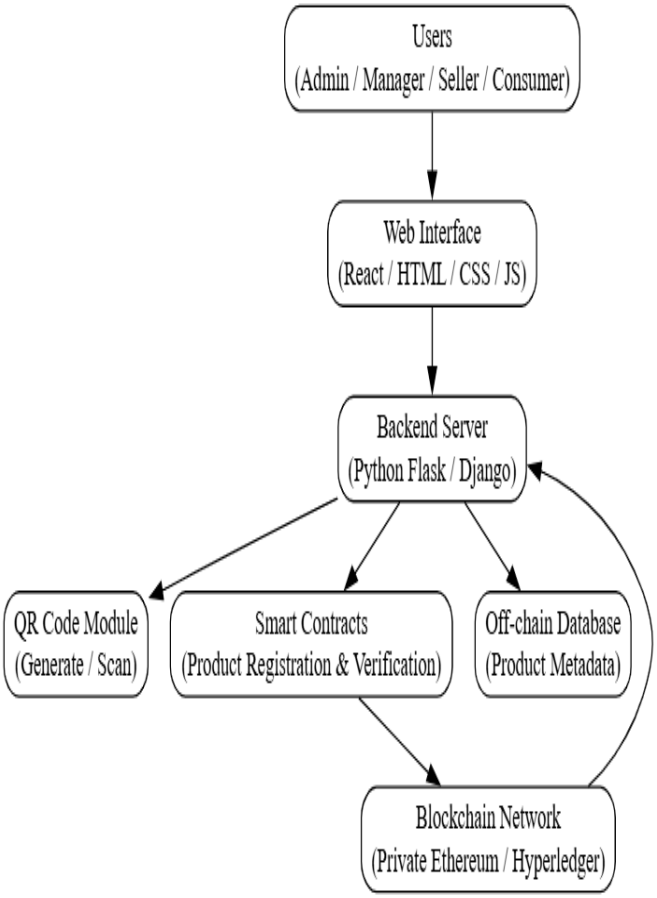

Figure 1. Architecture of the proposed blockchain-enabled visual authentication system for unauthorized product detection

3. Results And Discussion

3.1. Results

- Product Authentication Outcome Analysis
The proposed system ensures reliable product authentication by verifying each request against immutable blockchain records. When a QR code is scanned, the system checks whether the product is registered, legitimately transferred, or duplicated. Genuine products are confirmed with full lifecycle details, while duplicates are flagged as unauthorized. This approach enhances consumer trust by combining visual authentication with decentralized blockchain validation.

Table 2 Functional Outcome Summary

System Function	Observed Outcome	Discussion Insight
Product Registration	Successfully stored on blockchain	Ensures immutable identity
QR Code Verification	Accurate authenticity response	Enables user-level validation
Ownership Transfer	Properly recorded	Maintains lifecycle traceability
Unauthorized Detection	Effectively flagged	Prevents counterfeit circulation

- Counterfeit and Duplicate Product Detection ResultsThe system detects counterfeit and duplicate products by comparing scanned data with blockchain hashes and transaction history. Products with mismatched hashes, invalid ownership transitions, or missing records are flagged as suspicious. The one-to-one mapping between product identity and blockchain entry enables accurate duplicate detection. This ensures transparent tracking and helps identify counterfeit products across the supply chain.

Table 3 Comparison with Traditional Authentication Systems

Aspect	Traditional System	Proposed Blockchain System
Data Integrity	Centralized, mutable	Decentralized, immutable
Transparency	Limited	Full traceability
Counterfeit Detection	Reactive	Proactive
Trust Model	Single authority	Distributed trust

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3.2.Discussion

The results demonstrate that the proposed blockchain-based authentication system effectively verifies product authenticity and detects unauthorized items. The integration of QR-based visual verification with immutable blockchain records ensures secure and transparent validation of products. The system successfully tracks ownership transfers and maintains complete product lifecycle traceability. Overall, the approach enhances supply chain transparency and reduces the risk of counterfeit product circulation shown in Figure2 .

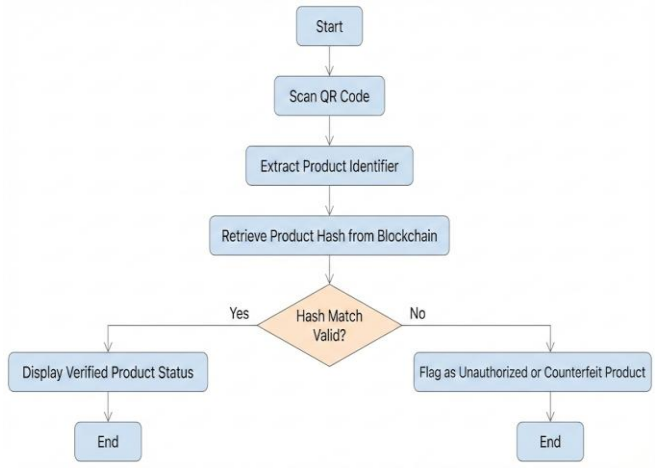

Figure 2. Product Verification Flowchart.

Conclusion

This research proposes a blockchain-based visual authentication framework to detect unauthorized products and improve supply chain trust. Using cryptographic hashing, smart contracts, and QR verification, the system ensures secure product registration and ownership tracking. The blockchain ledger prevents tampering and detects counterfeit or duplicate products. The decentralized design removes reliance on centralized authorities while enabling real-time verification. Overall, the framework supports practical real-world implementation.

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