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Fake Product Identification by QR Code Using Blockchain

V. G. Bharane[1], Nitin G. Rathod[2], Hrishikesh Y. Patole[3], Siddhi U. Rananavare[4], Vaishnavi S. Ranaware[5]

[1,2,3,4,5]Department of Computer Engineering, S. B. Patil College of Engineering, Pune, India
[1]*bharanevaishali11@gamil.com*, [2]*nitinrathod0553@gmail.com*, [3]*hrishikeshpatole1@gmail.com*, [4]*siddhirananavare29@gmail.com*, [5]*ranawarevaishnavi5@gmail.com*

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Abstract

Counterfeit products present a serious threat to industries, consumers, and economies, resulting in financial losses, brand damage, and safety risks. Traditional product authentication methods are often centralized and prone to tampering, making them unreliable and lacking transparency. To overcome these limitations, the proposed system integrates Blockchain technology with QR codes to create a secure and transparent authentication mechanism. Each product is assigned a unique QR code during manufacturing, and its details are stored on a decentralized blockchain ledger. Consumers can easily verify the authenticity of a product in real time by scanning the QR code using a mobile or web application, ensuring trust and reliability.

The system enhances supply chain visibility by recording every transaction—from manufacturing to distribution and retail—as immutable blocks on the blockchain. This creates a complete and traceable history of the product, enabling stakeholders to track its journey and quickly identify any point of tampering or fraud. The use of smart contracts can further automate verification and validation processes, ensuring that only genuine products move through the supply chain. Additionally, the decentralized nature of blockchain eliminates dependence on a single authority, reducing the risk of data manipulation and increasing overall system security.

Moreover, the proposed solution is scalable, user-friendly, and applicable across multiple industries such as pharmaceuticals, electronics, luxury goods, and food. It can be further enhanced by integrating technologies like IoT for real-time monitoring and data analytics for improved decision-making and demand forecasting. By combining transparency, security, and ease of use, this system not only combats counterfeiting but also strengthens consumer confidence and brand reputation. Ultimately, it provides a future-ready, reliable approach to ensuring product authenticity in a globalized market.

Keywords: Blockchain Technology; QR Code; Fake Product Identification; Supply Chain Management; Cybersecurity; Product Authentication.

How to Cite This Article

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Introduction

Counterfeiting has emerged as a critical challenge in the modern global economy, affecting industries, governments, and consumers on a large scale. With the rapid expansion of e-commerce and global supply chains, the circulation of counterfeit products has increased significantly, leading to severe financial losses, deterioration of brand reputation, and serious health and safety risks. Counterfeit goods, particularly in sectors such as pharmaceuticals, electronics, and food, can have dangerous consequences for consumers. Conventional product verification methods, including holograms, barcodes, and RFID tags, are widely used but often fail to provide adequate protection due to their susceptibility to duplication and lack of transparency. These limitations highlight the need for a more secure, reliable, and tamper-proof system for product authentication.

Traditional systems also lack a centralized and trustworthy mechanism for tracking product movement across the supply chain. As a result, it becomes difficult to identify the origin of counterfeit goods or detect the exact point where tampering occurs. Additionally, the dependence on intermediaries for verification increases complexity and reduces efficiency. Issues such as data inconsistency, lack of real-time access, and vulnerability to unauthorized modifications further weaken the effectiveness of existing solutions. These challenges emphasize the importance of adopting advanced technologies that can ensure transparency, traceability, and security throughout the product lifecycle.

With the advancement of modern technologies, blockchain has emerged as a powerful tool to address these challenges. Blockchain is a decentralized and immutable digital ledger that records transactions in a secure and transparent manner. Once data is stored on the blockchain, it cannot be altered or deleted, ensuring data integrity and trust among stakeholders. By integrating blockchain with QR code technology, it is possible to create a robust product authentication system. In this approach, each product is assigned a unique QR code at the manufacturing stage, which is linked to detailed product information stored on the blockchain. This enables consumers and stakeholders to verify product authenticity instantly by scanning the QR code using a mobile or web application.

The proposed system, Blockchain-Based Fake Product Identification System using QR Codes, aims to provide a comprehensive solution to overcome the limitations of traditional authentication methods. It establishes a secure and transparent framework where all product-related data, including manufacturing details, distribution records, and ownership history, are recorded on the blockchain. The system also incorporates smart contracts to automate validation processes, ensuring that only verified products move through the supply chain. This not only reduces the chances of counterfeit goods entering the market but also enhances operational efficiency and accountability among all participants.

Furthermore, the system supports real-time tracking and traceability, allowing stakeholders to monitor the complete journey of a product from production to final delivery. It can be extended with additional technologies such as IoT sensors to monitor environmental conditions like temperature and humidity, which is particularly important for sensitive goods such as medicines and perishable items. The use of QR codes ensures ease of access, as they can be scanned using widely available smartphones, making the system user-friendly and accessible to a large audience. Additionally, the data stored on the blockchain can be analyzed to identify patterns, detect fraudulent activities, and improve supply chain management.

Literature Survey

Researchers have developed various blockchain-based systems for counterfeit product detection, mainly focusing on product authentication, traceability, and secure data storage. Many studies integrate blockchain with QR codes to assign unique digital identities to products and enable real-time verification. Works by Gandhimathi K et al. (2025) and Goli Sai Sampath Reddy et al. (2023) highlight improved transparency and reliability through decentralized ledgers and QR scanning. Similarly, studies by Jayshree R. Pansare et al. (2023) and Darshan N and Mir Aadil (2023) emphasize ownership tracking and accountability across the supply chain, ensuring that every stage of the product lifecycle is securely recorded and verified.

Some researchers have also explored advanced approaches to enhance system performance and security. Srikrishna Shastri C et al. (2022) proposed blockchain with QR validation and suggested future integration of IoT devices for automated monitoring and detection. Srivatsa D et al. (2021) introduced a hybrid model combining blockchain, smart contracts, and facial recognition to improve authentication accuracy and reduce fraud. R. Subapriya et al. (2023) focused on improving transparency and consumer trust through blockchain-based traceability and secure transaction logging. These approaches demonstrate significant improvements in product tracking, data integrity, and fraud prevention across supply chains.

Despite these advancements, many existing systems still face challenges such as limited scalability, lack of real-time fraud detection, and incomplete integration of features within a single platform. Most solutions focus on specific aspects like authentication or traceability rather than providing a comprehensive system. Additionally, issues related to user accessibility, system complexity, and industry-wide adoption continue to affect their effectiveness. Therefore, there is a need for a unified, secure, and scalable platform that integrates blockchain, QR codes, and advanced technologies to provide efficient and reliable counterfeit product identification and supply chain management.

System Overview and Design

The Blockchain-Based Fake Product Identification System is designed to provide a secure and transparent solution for verifying product authenticity using blockchain and QR code technology. Each product is assigned a unique QR code at the manufacturing stage, which is linked to its data stored on the blockchain. The system follows a three-tier architecture consisting of frontend (React Native), backend (Node.js), and blockchain (Ethereum) layers for efficient data handling and secure communication. Manufacturers can register products, while consumers can verify authenticity by scanning QR codes in real time. MongoDB is used for storing off-chain data, ensuring better performance and scalability. Overall, the system ensures data immutability, improves supply chain transparency, and reduces counterfeit products effectively.

System Components

- Frontend (Mobile App / Web Interface)
- Backend Server (Node.js APIs)
- Blockchain Network (Ethereum + Smart Contracts)
- Database (MongoDB – Off-chain storage)
- QR Code Module (Generation & Scanning)
- Authentication Module (Login & Security)
- API Gateway (Communication between modules)
- Notification & Monitoring System

Software Requirements

- Ubuntu 20.04 LTS (Operating System)
- Ethereum Mainnet/Testnet (Blockchain platform)
- Node.js (Backend development)
- MongoDB (Database)
- React Native (Mobile application development)
- MetaMask / Hardhat (Blockchain tools)
- VS Code / Postman (Development & testing tools)

System Architecture

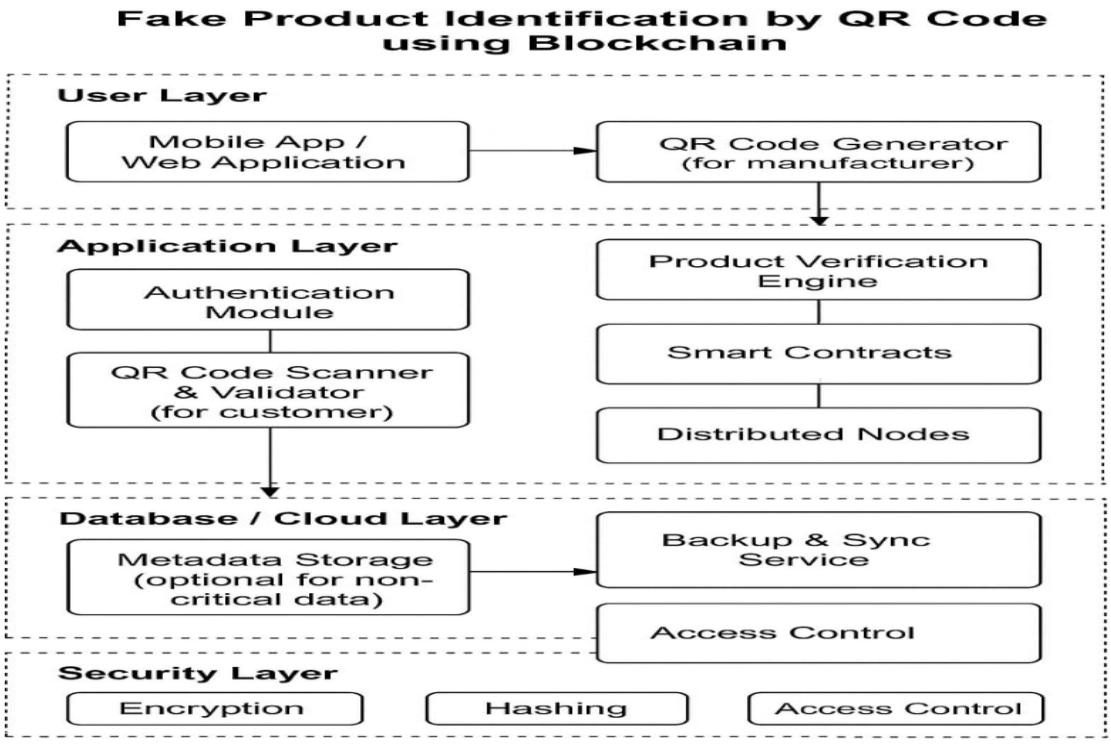

Fig. 1. *System Architecture*5

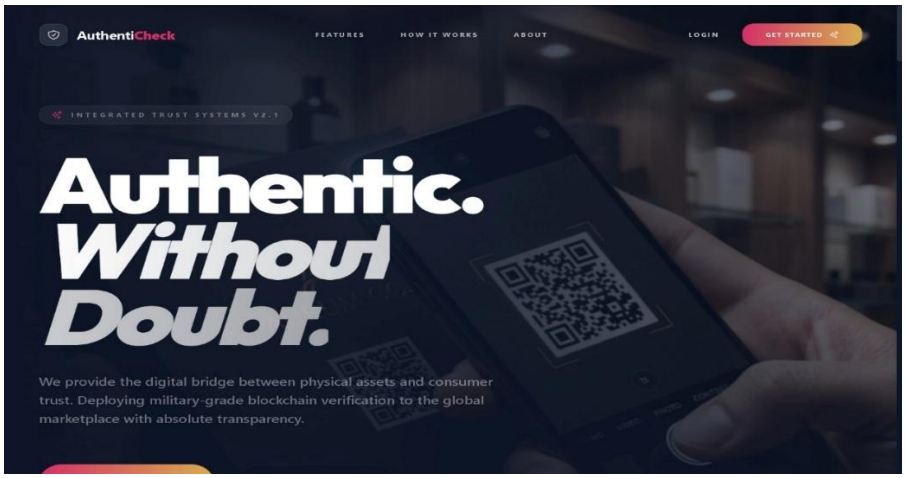

Fig. 2. *Implementation and Design*

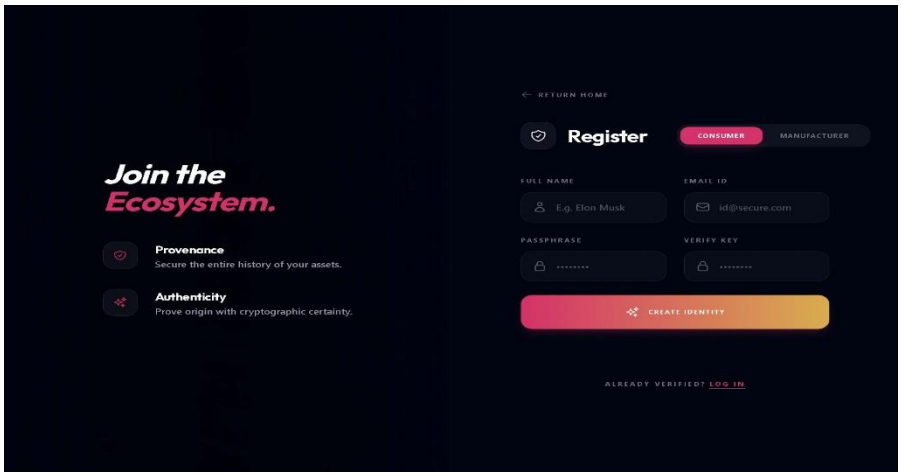

Fig. 3. *Implementation and Design*

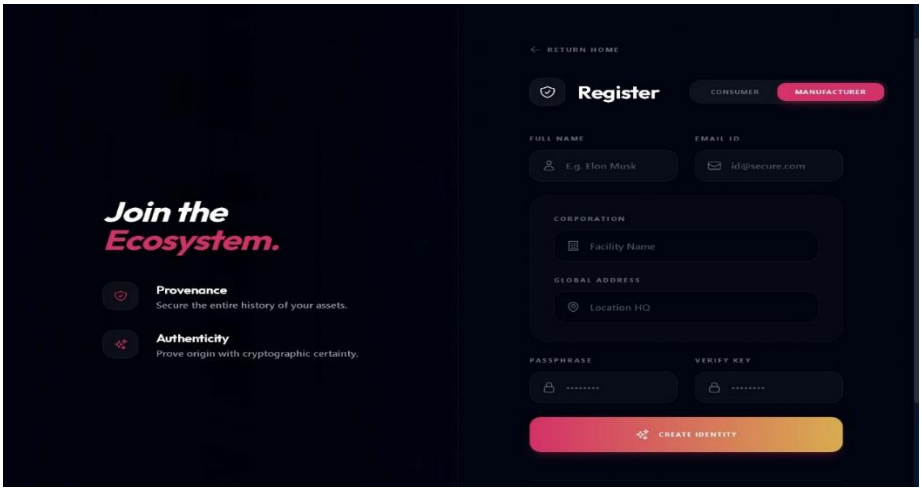

Fig. 4. *Implementation and Design*

Methodology

The methodology for developing the Blockchain-Based Fake Product Identification System is divided into the following phases:

1. System Initialization: At the initial stage, all system components such as the frontend application (mobile/web), backend server, database, and blockchain network are configured and initialized. The server establishes connections with the database and blockchain nodes, while environment variables like API keys and security credentials are loaded. User authentication mechanisms are activated to ensure secure access. Smart contracts are deployed, and services like QR code generation and product management

are prepared, enabling the system to handle product registration and verification smoothly.

2. Real-Time Parameter Monitoring: The system continuously monitors product-related activities such as product registration, updates, and ownership transfer. When a user scans a QR code, the system instantly retrieves product details from the blockchain and displays the authenticity status. All updates are reflected in real time, ensuring that users always access the latest and most accurate information. This improves transparency and allows easy tracking of products across the supply chain.
3. Data Processing and Analysis: The system processes product data such as product ID, batch number, manufacturing date, expiry date, and ownership history in the backend. The data is validated before being stored securely on the blockchain, ensuring immutability and transparency. Large files like product images or certificates are stored in off-chain storage systems such as IPFS or cloud platforms, while their references are maintained on the blockchain. This improves efficiency and reduces storage load.
4. Fault Identification

   Based on the processed data, the system identifies potential counterfeit or suspicious activities. These include:
   - Invalid or unregistered QR code scans
   - Duplicate QR code usage across multiple locations
   - Mismatch in product details or ownership history
   - Unauthorized attempts to modify product information

   By analyzing these factors, the system can detect fake products and alert users accordingly.

5. Protection and Control Mechanism: When any issue or fraud is detected, the system enforces strong security measures.
6. Authentication and role-based access control restrict unauthorized users. Smart contracts validate all transactions before updating data, while blockchain ensures that stored information cannot be altered. Encryption and error-handling mechanisms are also used to maintain system stability and protect sensitive data.
7. User Notification and Monitoring: The system provides real-time feedback to users during product verification. When a QR code is scanned, users receive instant information about product authenticity. If any suspicious activity is detected, alert messages are displayed. Administrators can monitor system performance, product status, and verification logs through dashboards, ensuring better control, transparency, and quick response to issues.

Results

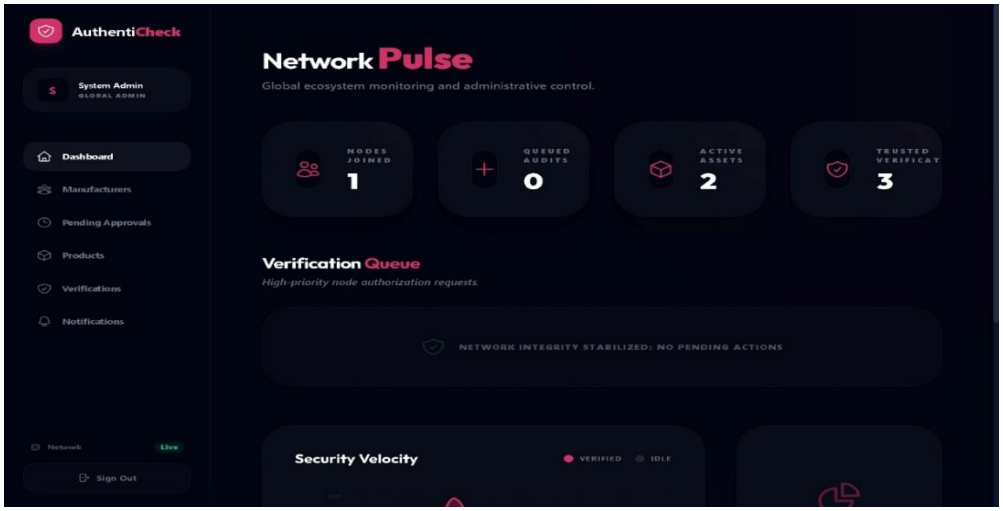

Fig. 5. *System Admin Dashboard – Network Monitoring and Verification Overview*

This interface provides an overview of the entire system, including network status, active nodes, and verification activities. It helps administrators monitor system performance and manage approvals. The dashboard ensures transparency and control over the blockchain network.

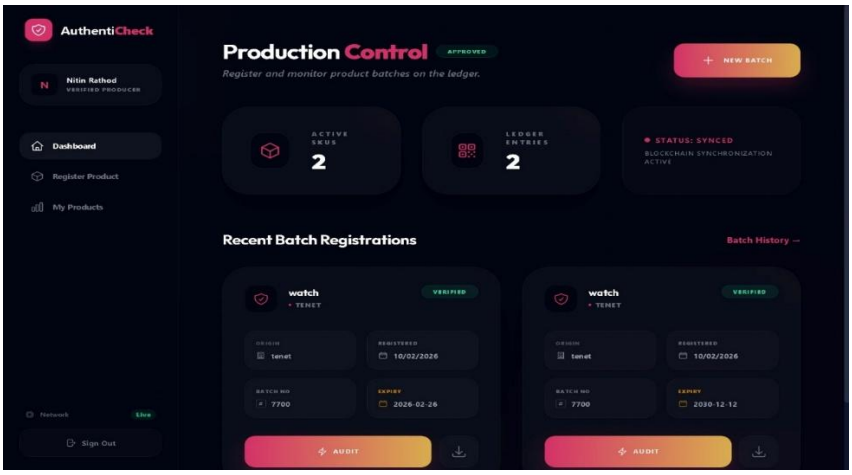

Fig. 6. *Manufacturer Dashboard – Product Registration and Batch Management Interface*

This screen allows manufacturers to register products, create batches, and store product details on the blockchain. It displays batch information, ledger entries, and product status. The interface helps in managing and tracking products efficiently.

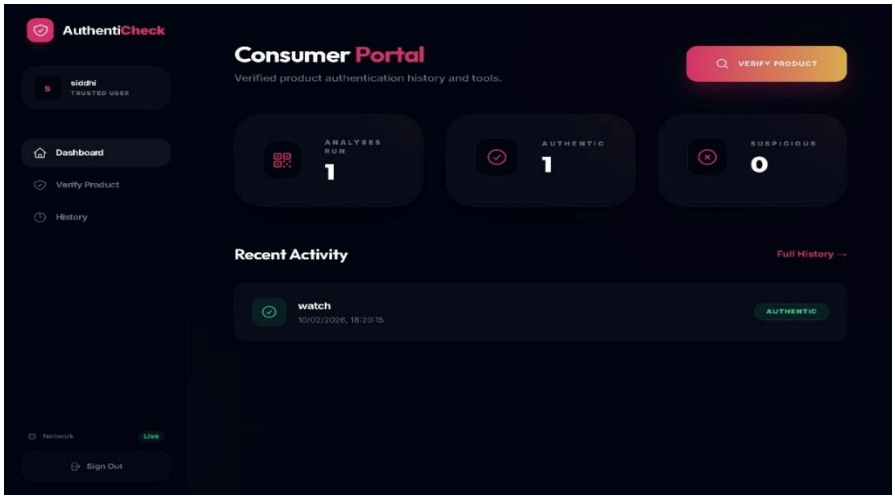

Fig. 7. *Consumer Portal – Product Verification and Authentication Interface*

This interface allows consumers to verify product authenticity by scanning QR codes using a mobile or web application. It provides real-time verification results along with product details and history. The portal enhances user trust by clearly indicating whether a product is genuine or suspicious. It also maintains a record of past verifications for better tracking and awareness.

The proposed Blockchain-Based Fake Product Identification System was successfully implemented to provide secure and reliable product authentication. The system enables real-time verification using QR codes and ensures data integrity through blockchain technology. It effectively detects counterfeit products by identifying invalid or duplicate entries. The user interfaces for admin, manufacturer, and consumer provide smooth and efficient interaction. Overall, the system improves transparency, enhances trust, and proves to be a scalable solution for supply chain security.

Applications

- Pharmaceutical Industry: Prevents counterfeit medicines and ensures drug authenticity by allowing consumers and healthcare providers to verify medicines through QR code scanning. It also helps track the entire lifecycle of drugs, ensuring proper storage conditions and reducing the risk of fake or expired medicines entering the market.
- Luxury Goods Industry: Protects branded products such as watches, handbags, and designer items from duplication. Customers can verify the originality of products before purchase, which helps maintain brand reputation and increases customer trust in high-value goods.
- Electronics Sector: Verifies the authenticity of electronic components and devices, reducing the risk of using counterfeit or low-quality parts. This ensures product safety, improves performance reliability, and helps manufacturers maintain quality standards in the supply chain.

- Food and Agriculture: Ensures traceability of agricultural and packaged food products from farm to consumer. Users can check details such as origin, processing, and storage conditions, which enhances food safety, quality assurance, and consumer confidence.
- E-commerce Platforms: Enables buyers to verify seller authenticity and product origin before making a purchase. This reduces fraudulent listings, builds trust between buyers and sellers, and improves the overall credibility of online marketplaces.
- Government Supply Chains: Supports transparent public distribution systems by tracking goods such as medicines, food grains, and essential supplies. It helps reduce corruption, ensures proper delivery to beneficiaries, and improves accountability in government operations.

Conclusion

The Blockchain-Based Fake Product Identification System provides a secure and reliable solution to combat counterfeit products in supply chains. The system enables manufacturers to register products on a decentralized blockchain network and generate unique QR codes linked to cryptographically hashed product data. By storing critical information on the Ethereum blockchain using smart contracts, the system ensures immutability, transparency, and tamper resistance.

Consumers can scan QR codes using a mobile application to verify product authenticity in real time. The blockchain validation mechanism confirms whether the product exists in the distributed ledger and whether its data has been altered. Fraud detection mechanisms further enhance system reliability by logging suspicious activities, detecting duplicate scans, and identifying inconsistencies in product information across the supply chain.

Unlike traditional centralized authentication systems, this approach eliminates single points of failure and significantly reduces the risks of data manipulation and unauthorized access. The integration of blockchain, cryptographic hashing (SHA-256), and QR-based authentication strengthens trust among manufacturers, distributors, retailers, and consumers. It also ensures accountability at every stage of the product lifecycle, making it easier to trace and verify product history.

Overall, the proposed system improves supply chain transparency, strengthens brand protection, reduces the circulation of counterfeit goods, and promotes consumer confidence through decentralized verification. Furthermore, the system is scalable and adaptable to multiple industries such as pharmaceuticals, electronics, and food supply chains. Future enhancements may include integration with IoT devices for real-time monitoring, advanced analytics for fraud prediction, and wider adoption across global supply networks, making it a comprehensive and future-ready solution for product authentication.

Future Work

The system can be further improved by incorporating advanced features and enhance- ments:

- Integration with IoT-enabled Smart Packaging: Future enhancements can include the use of IoT sensors embedded in product packaging to automatically track product movement and environmental conditions such as temperature and humidity. This will enable real-time monitoring and improve supply chain visibility without manual intervention.
- AI-Based Fraud Detection: Implementing artificial intelligence and machine learning models can help analyze user behavior and authentication patterns to detect suspicious activities. This will allow early identification of counterfeit attempts and improve the overall accuracy of fraud detection.
- Layer-2 Blockchain Solutions: To address scalability issues, the system can adopt Layer-2 solutions such as sidechains or rollups. This will help reduce transaction costs (gas fees) and improve processing speed, making the system more efficient for large-scale adoption.
- Cross-Chain Interoperability: Future systems can support multiple blockchain networks, allowing seamless data exchange across different platforms. This will improve flexibility and enable integration with various enterprise and industry-specific blockchain solutions.
- Integration with Government Systems: Connecting the system with government regulatory bodies, especially in sectors like pharmaceuticals and food, can enhance verification standards. This will ensure compliance, improve trust, and help in controlling the distribution of counterfeit goods at a national level.
- NFT-Based Digital Ownership Certificates: The system can be extended to include NFTs (Non-Fungible Tokens) for luxury goods, providing a unique digital certificate of ownership. This will enhance product authenticity, prevent duplication, and add value to high-end branded products.

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