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BLOCKCHAIN-BASED PRODUCT VERIFICATION AND COUNTERFEIT PREVENTION

P. Kamakshi Thai [1], **Dentusliya Sonam** [2], **G Bhanu Prakash** [3], **C Prakash Naik** [4]
[1]Assistant Professor of Department of CSE(AI & ML), ACE Engineering College, An Autonomous Institution, Ghatkesar, Hyderabad, Telangana, India.
[2,3,4] Students of Department of CSE(AI & ML), ACE Engineering College, An Autonomous Institution, Ghatkesar, Hyderabad, Telangana, India.

ABSTRACT

Counterfeit products are a growing concern across various industries such as pharmaceuticals, electronics, and luxury goods, leading to significant economic losses and risks to consumer safety. Traditional product authentication methods lack transparency, are centralized, and are prone to manipulation. This project introduces a blockchain-based solution for product verification and counterfeit prevention by leveraging the immutable, decentralized nature of blockchain technology. Each product is assigned a unique digital identity via a QR code, which is registered on the blockchain through smart contracts at the point of manufacturing. As the product moves through the supply chain, its history is securely updated and tracked on the blockchain ledger. End users can scan the QR code using a mobile or web application to verify the product's authenticity in real-time. The system also implements protection against QR code duplication by logging scan metadata, including timestamp and location, and identifying suspicious activities such as repeated scans or geographic anomalies. This approach not only enhances product traceability but also builds consumer trust by ensuring the genuineness of the products.

Keywords : Blockchain, Product Authentication, Counterfeit Detection, QR Code Verification, Supply Chain Transparency, Immutable Ledger

1. INTRODUCTION

The Blockchain-Based Product Verification and Counterfeit Prevention System is developed to address the rapidly increasing problem of counterfeit goods that affect numerous industries such as pharmaceuticals, electronics, luxury items, and consumer products. Counterfeiting leads to serious economic losses for manufacturers and distributors, poses significant health and safety risks to consumers, and damages brand reputation and customer trust. Existing product authentication methods, including traditional barcodes, holograms, and centralized databases, often lack sufficient security and transparency. These systems are vulnerable to data tampering, duplication, and unauthorized access, making it easier for counterfeit products to infiltrate the supply chain. As modern supply chains become more global and complex, ensuring reliable product authentication and traceability has become a critical requirement.

To overcome these limitations, the proposed system leverages blockchain technology to provide a decentralized, secure, and transparent mechanism for product verification across the entire supply chain. Each product is assigned a unique digital identity, typically represented through a QR code or RFID tag, which is linked to a blockchain-based record. Product information is continuously updated at various stages, including manufacturing, distribution, and retail, with all transactions being validated and recorded using smart contracts. These smart contracts ensure that data is automatically verified and permanently stored in an immutable ledger. Consumers can easily authenticate a product by scanning the QR code through a mobile or web application, which retrieves verified information directly from the blockchain. This approach ensures tamper-resistant tracking, reliable data integrity, and complete traceability, ultimately reducing counterfeit

activities, enhancing supply chain transparency, and building greater trust among manufacturers, retailers, and consumers.

2. LITERATURE SURVEY

[1] Title: Supply Chain Management System Application Using Blockchain (2025).

Authors: Saravana Gokul G, Rupesh L, and Rithika M

This paper "Supply Chain Management System Application Using Blockchain" by Saravana Gokul G, Rupesh L, and Rithika M (2025) introduces a blockchain-based framework aimed at enhancing transparency, traceability, and efficiency in supply chain operations. The proposed system integrates blockchain technology with QR code-based authentication to securely record and verify every transaction across the supply chain and is organized into functional modules such as authentication, QR code generation and verification, inventory monitoring, reverse logistics, supplier recommendation, and data analytics. These modules work together to ensure seamless coordination between stakeholders manufacturers, suppliers, distributors, and customers while maintaining the integrity and immutability of shared data. The system enhances efficiency through automated inventory management and data-driven supplier recommendations, while also supporting reverse logistics for product returns and recycling, thereby promoting sustainability. However, the paper highlights that the system is still in its development and testing phase, lacking large-scale performance validation. It also points out challenges such as scalability, integration with legacy systems, and the need for widespread industry adoption. Despite these limitations, the study provides a strong conceptual foundation for building a secure, transparent, and intelligent blockchain-based supply chain ecosystem capable of transforming traditional management processes.

[2] **Title**: SPOQchain: Platform for Secure, Scalable, and Privacy Preserving Supply Chain Tracing and Counterfeit Protection (2024).

Authors: Moritz Finke, Alexandra Dmitrienko, and Jasper Stang.

This paper proposes an advanced blockchain-based platform called SPOQchain, designed to enhance security, scalability, and privacy in supply chain management. The system integrates batch-based and on-demand tracing with Physical Unclonable Functions (PUFs) for unique product identification and employs a permissioned blockchain with off-chain IPFS storage to ensure data privacy and efficiency. Implemented on Hyperledger Sawtooth using GoLang, it supports interoperability and provides end-to-end product traceability through Android applications. Evaluation results show that SPOQchain achieves high efficiency, strong privacy, and scalability while reducing blockchain transactions via batch processing. However, the platform remains at a prototype stage, relying on a trusted consortium and facing implementation complexity due to its multi-technology architecture. Despite these challenges, SPOQchain demonstrates strong potential for secure and transparent anti-counterfeiting in global supply chains.

[3] **Title**: An Ethereum-based Product Identification System for Anticounterfeits (2023).

Authors: Shashank Gupta.

This paper presents a blockchain-based solution for verifying product authenticity and ownership using the Ethereum network. The system employs smart contracts, QR codes, and the MetaMask wallet to create a decentralized platform that records product identities and transaction histories, allowing transparent tracking without third-party intermediaries. Each product is assigned a unique QR code linked to a smart contract that stores its ownership status, ensuring traceability and immutability. Implemented on the Goerli testnet, the model was evaluated for transaction efficiency, gas usage, and smart contract performance. The results show that the system provides secure and transparent product authentication, allowing consumers to verify product legitimacy easily while maintaining cost efficiency for small-scale applications. However, the study notes limitations such as Ethereum's scalability issues, high gas fees, and lack of privacy and offline verification, along with the assumption of trust among supply chain participants. Despite these constraints, the research serves as a strong proof-of-concept, demonstrating blockchain's potential to combat counterfeiting and improve trust and transparency in digital supply chains.

[4] **Title**: Decentralizing Supply Chain AntiCounterfeiting Systems Using Blockchain Technology (dNAS) (2021).

Authors: Neo C. K. Yiu .

This paper presents a decentralized blockchain-based system to combat counterfeiting in the wine industry. The proposed dNAS (Decentralized NFC-enabled Anti-Counterfeiting System) integrates blockchain technology, distributed storage (IPFS), and NFC-based product tagging to securely track product origin, ownership, and movement across the supply chain. Built on an enterprise consortium blockchain using Quorum/Ethereum PoA and Solidity smart contracts, the system ensures product provenance and real-time verification through web and mobile apps (TagWINE and ScanWINE). The study demonstrates end-to-end traceability, tamper-proof provenance, and enhanced transparency among stakeholders, offering a practical model adaptable to other industries. However, it faces challenges such as high infrastructure costs, governance complexity, and limited scalability, as it remains a prototype with restricted real world testing. Despite these limitations, dNAS marks a major step toward secure, transparent, and decentralized anti-counterfeiting solutions for modern supply chains.

[5] **Title**: A Blockchain-Bas ed Application System Product AntiCounterfei ting(2020).

Authors: Jinhua Ma, Shih-Ya Lin, Xin Chen, Hung-Min Sun, Yeh-Cheng Chen, and Huaxiong Wang.

This paper proposes a decentralized system using Ethereum-based smart contracts to verify product authenticity and track ownership across the supply chain. The system involves manufacturers, sellers, and consumers, with each transaction immutably recorded on a private Ethereum blockchain (Geth), supported by Web3.js and Node.js for implementation. It provides a low-cost, transparent, and tamper-proof solution ideal for SMEs, improving trust, traceability, and real-time verification without third-party intermediaries. However, it remains limited to small-scale testing, with challenges in scalability, energy efficiency, and Ethereum gas fees, and lacks integration with physical IoT or NFC tags. Despite these constraints, the study establishes a strong foundation for using blockchain to enhance product authentication and supply chain transparency.

[6] **Title**: A Blockchain-Bas ed Medicine Production and Distribution Framework to Prevent Medicine Counterfeit (2023).

Authors: Iyolita Islam, Muhammad Nazrul Islam.

This paper presents a blockchain-based framework designed to address the growing problem of medicine counterfeiting, particularly in developing and underdeveloped countries where falsified drugs pose serious public health risks. The research first examines the factors contributing to medicine counterfeiting through content analysis and semi-structured interviews with key stakeholders in the medicine manufacturing and distribution system in Bangladesh. Based on these insights, the authors propose a blockchain-enabled digital solution that incorporates identified features necessary to securely record and monitor the production and distribution of medicines, thereby reducing fraud and improving accountability. A prototype of the framework was developed and evaluated, with results showing acceptable block execution and block times, indicating the system is secure, scalable, customer-oriented, and practical compared to existing approaches. The study demonstrates the potential of blockchain technology to improve the integrity of medicine supply chains and contribute to public health protection.

[7] **Title**: A Blockchain-Bas ed Solution for Medication Anti-Counterfeiting and Traceability (2020).

Authors: Peng Zhu, Jian Hu, Yue Zhang, Xiaotong Li.

This paper presents a blockchain-based system designed to address the critical challenges of medication counterfeiting and poor traceability in pharmaceutical supply chains. The authors propose a decentralized framework that leverages blockchain's immutable ledger to securely record detailed drug information and track products from manufacturing to final delivery. The system ensures that stakeholders including manufacturers, distributors, pharmacies, and patients have access to verifiable and tamper-proof data, enabling them to confirm the authenticity and history of medications at each stage. By integrating smart contracts and distributed ledger technology, the proposed solution enhances transparency, accountability, and trust across the entire pharmaceutical value chain. The implementation details include the design of data structures and interactions that support efficient blockchain operations while minimizing storage overhead. Evaluation results indicate that blockchain can significantly improve traceability and reduce opportunities for counterfeit drugs to enter the market, thereby protecting patient safety and reinforcing regulatory compliance.

[8] **Title**: Towards a Blockchain-based Approach to Fight Drugs Counterfeit (2021).

Authors: Rawya Mars, Jiddou Youssouf, Saoussen Cheikhrouhou, Mariem Turki.

This paper proposes a blockchain-based framework aimed at combating the widespread issue of drug counterfeiting, which poses serious risks to public health and safety. The authors highlight how traditional centralized supply chain systems are vulnerable to data tampering, lack of transparency, and fraudulent practices that allow counterfeit drugs to infiltrate legitimate distribution channels. To address these challenges, the paper introduces a decentralized solution that leverages blockchain technology to ensure secure, immutable, and transparent recording of drug production, distribution, and verification events. By recording critical drug information on a distributed ledger, each stakeholder from manufacturers to pharmacies and end consumers can authenticate product legitimacy at each stage of the supply chain. The framework also discusses the use of smart contracts and decentralized identifiers to automate verification processes and ensure traceability. Through this approach, the system aims to strengthen accountability, reduce the incidence of counterfeit medicines, and build trust among supply chain participants.

[9] **Title**: Planning the Application of Blockchain Technology in Identification of Counterfeit Products: Sectorial Prioritization (2019).

Authors: Sachin Modgil, Vandana Sonwaney.

This paper explores how blockchain technology can be strategically applied to identify and prevent counterfeit products across various industry sectors. It examines the limitations of conventional counterfeit detection methods and highlights why blockchain's inherent features such as decentralization, immutability, and transparency offer significant advantages for securing supply chains. The study proposes a sectorial prioritization framework to determine which industries would benefit most from blockchain implementation based on their vulnerability to counterfeiting, economic impact, and traceability requirements. Through qualitative and quantitative analysis, the authors evaluate sectors such as pharmaceuticals, electronics, luxury goods, and automotive parts, identifying key criteria that influence blockchain adoption potential. The paper emphasizes how blockchain can improve product authentication, data sharing efficiency, and stakeholder trust, while also discussing practical considerations such as integration challenges, cost factors, and readiness of industry infrastructure. By outlining a prioritized roadmap for blockchain application, the research provides actionable insights for policymakers and industry leaders looking to leverage distributed ledger technology to combat counterfeiting more effectively.

[10] **Title**: A Blockchain-Bas ed Framework for Supply Chain Provenance (2019).

Authors: Pinchen Cui, Julie Dixon, Ujjwal Guin, Daniel Dimase.

This paper presents a blockchain-based framework designed to enhance supply chain provenance and traceability, addressing challenges such as product fraud, data tampering, and lack of transparency across distributed networks. The authors propose a decentralized system that uses blockchain's immutable ledger to record key events in a product's lifecycle, enabling stakeholders including manufacturers, distributors, and consumers to reliably verify a product's history and authenticity. The framework incorporates smart contracts to automate key functions like data validation and access control, and it links physical goods to digital records through identifiers such as QR codes or RFID tags. Implementation details include the structure of transaction records on the blockchain, consensus mechanisms for securing updates, and methods to optimize data storage and retrieval to support scalability. Experimental evaluation demonstrates that the framework can provide secure, tamper-resistant tracking of goods, improving trust among participants and enabling real-time provenance queries without relying on centralized authorities. The study also discusses practical considerations, such as handling large data volumes and ensuring efficient transaction throughput in real-world supply chain environments.

2.1 Comparison Table

S. No	Authors(s)	Title	Proposed Methodology	Findings from the Reference Paper
1	Saravana Gokul G, Rupesh L, and Rithika M	Supply Chain Management System Application Using Blockchain (2025)	Proposed a block supply chain system integrating blockchain with QR/NFC authenticating products.	Enhanced traceability, transparency,and counterfeit prevention. Automated inventory and supplier analytics.
2	Moritz Finke, Alexandra Dmitrienko, and Jasper Stang	SPOQchain: Platform for Secure, Scalable, and Privacy Preserving Supply Chain Tracing and Counterfeit Protection (2024).	Proposed SPOQchain, a privacy preserving blockchain platform combining batch-based tracing PUF-based identification for counterfeit prevention.	Offers scalable and privacy-focused supply chain tracing. Enhances security and interoperability across products.
3	Shashank Gupta	An Ethereum-based Product Identification System for Anti Counterfeits(2023)	Developed a blockchain product tracking system Ethereum (Goerli testnet). Uses smart contracts, QR codes, MetaMask wallet on and for authentication and ownership tracking of products.	Enables secure and transparent product verification via blockchain and QR codes. Strengthens trust and ownership tracking across the supply chain with gas-efficient transactions.
4	Neo C. K. Yiu	Decentralizing Supply Chain AntiCounterfei ting Systems Using Blockchain Technology (dNAS) (2021)	Developed Decentralized NFC enabled Anti Counterfeiting System (dNAS) wine for supply chain. Converts legacy NAS into decentralized enterprise consortium model.	Achieved end-to-end traceability and tamper-proof provenance using blockchain NFC. Enhanced supply chain security trust.
5	Jinhua Shih-Ya Xin Ma, Lin, Chen, Hung-Min Sun, YehCheng Chen, and Huaxiong Wang	A Blockchain-Bas ed Application System Product Anti Counterfeiting(2020)	Implemented a smart-contract based decentralized anti-counterfeiting system on Ethereum. Defined manufacturer, seller, and consumer roles with transparent record-keeping	Created a low-cost decentralized verification model SMEs. Improved trust and product provenance without third-party intermediaries.
6	Iyolita Islam, Muhammad Nazrul Islam	A Blockchain-Based Medicine Production and Distribution Framework to Prevent Medicine Counterfeit (2023)	Blockchain-based framework using Hyperledger Fabric, smart contracts, and QR-code–base d medicine tracking, evaluated in a simulated private blockchain environment.	Enables end-to-end traceability of medicines and effective detection of counterfeit drugs. Improves transparency and trust across medicine supply the

				chain with acceptable system performance.
7	Peng Zhu, Jian Hu, Yue Zhang, Xiaotong Li	A Blockchain-Based Solution for Medication Anti-Counterfeiting and Traceability (2020)	Blockchain-bas ed medication traceability system using smart contracts, PBFT consensus, and access control, implemented through simulation in Python.	Provides tamper-proof and transparent tracking medications across the supply chain. Enhances data security and privacy while reducing dependence on centralized authorities.
8	Rawya Mars, Jiddou Youssouf, Saoussen Cheikhrouhou, Mariem Turki	Towards a Blockchain-based Approach to Fight Drugs Counterfeit (2021)	Ethereum-based blockchain system using smart contracts, IPFS for off-chain storage, and IoT sensors for drug transport monitoring.	Enables secure end-to-end traceability and immutable drug provenance. Improves transparency and helps detect counterfeit or damaged drugs.
9	Sachin Modgil, Vandana Sonwaney	Planning the Application of Blockchain Technology in Identification of Counterfeit Products: Sectorial Prioritization (2019)	Conceptual analysis using AHP and ISM for sector-wise prioritization of blockchain adoption.	Prioritizes pharmaceuticals, luxury goods, and electronics for blockchain-bas ed counterfeit prevention. Proposes a decision-makin g framework to support blockchain adoption.
10	Pinchen Cui, Julie Dixon, Ujjwal Guin, Daniel Dimase	A Blockchain-Based Framework for Supply Chain Provenance (2019)	Permissioned blockchain framework using smart contracts for secure supply chain provenance and data sharing.	Improves product provenance and end-to-end traceability. Reduces counterfeit risks and increases trust among supply chain participants.

3. RESEARCH GAPS IN EXISTING SYSTEMS:

Based on the literature review, several critical research gaps have been identified in existing blockchain-based product verification and counterfeit prevention systems. Although blockchain technology offers strong features such as decentralization, immutability, and transparency, current solutions still face limitations that hinder large-scale adoption and interoperability across industries. These gaps highlight the need for further research to improve standardization, security, and real-world applicability of blockchain-enabled authentication systems.

3.1 Standardization of Product Identity

One of the major research gaps identified is the lack of standardized formats for representing product identities on blockchain platforms. Existing systems employ diverse identification mechanisms such as QR codes, RFID tags, serial numbers, and proprietary identifiers, leading to inconsistencies across

implementations. This absence of a universal product identity standard causes interoperability issues between different supply chains, industries, and blockchain networks, making global product verification difficult. Inconsistent data formats slow down system integration and increase deployment complexity, thereby limiting widespread adoption. There is a clear need for globally accepted standards, such as Decentralized Identifiers (DIDs), Verifiable Credentials, or GS1-based formats, to enable seamless cross-platform and cross-industry product authentication.

3.2 Physical–Digital Link Authentication

Another significant research gap lies in securely linking physical products to their corresponding digital identities on the blockchain. While blockchain can protect digital records from tampering, it cannot inherently prevent counterfeiters from copying or reusing legitimate QR codes, barcodes, or tags and attaching them to fake products. This creates a vulnerability where consumers may unknowingly trust counterfeit items if the scanned code appears valid on the blockchain. The gap between physical objects and their digital representations undermines the overall reliability of authentication systems. Addressing this challenge requires further research into tamper-resistant and unclonable technologies, such as NFC tags, RFID systems, Physical Unclonable Functions (PUFs), and smart tagging mechanisms, to strengthen the physical–digital trust link and ensure end-to-end authenticity.

4. BACKGROUND AND FUNDAMENTALS

Figure 1: System Overview of the Proposed Blockchain-Based Product Verification System

4.1 Counterfeiting and Product Authentication in Web-Based Systems

Counterfeiting has emerged as a major challenge in modern supply chain systems, affecting industries such as pharmaceuticals, electronics, and consumer goods, and leading to economic losses, safety risks, and erosion of consumer trust. With the increasing digitization of commerce, traditional offline verification methods are no longer sufficient to address the scale and sophistication of counterfeit activities. Web-based product authentication systems provide an effective solution by enabling real-time verification of product authenticity through online platforms. By leveraging browser-based applications, consumers can instantly verify products using digital identifiers, while manufacturers can securely manage product records. Such systems enhance transparency, accessibility, and trust by allowing all stakeholders to interact with a centralized verification interface without requiring specialized hardware.

4.2 Barcode-Based Product Identification and Verification

Barcodes and QR codes are widely adopted as cost-effective and scalable methods for product identification in supply chain systems. Each product is assigned a unique barcode that serves as a digital reference to its associated information stored in the backend system. However, barcodes are inherently vulnerable to

duplication and unauthorized reproduction, making them insufficient as standalone security mechanisms. To overcome this limitation, barcode-based systems require backend verification mechanisms that validate scanned codes against secure and tamper-resistant records. By integrating barcode scanning with backend validation, it becomes possible to detect duplicate scans, verify product authenticity, and ensure that each product's lifecycle information remains consistent and trustworthy throughout the supply chain.

4.3 Manufacturer and Consumer Authentication Workflow

A structured authentication workflow involving both manufacturers and consumers is essential for ensuring the reliability of product verification systems. Manufacturers are responsible for registering products by securely entering product details into the system, which are then linked to unique barcodes and stored in a protected backend or blockchain-based ledger. This process establishes an authentic digital identity for each product at the point of origin. Consumers, on the other hand, interact with the system through a web-based interface that allows them to scan or enter barcode information to verify product authenticity. The system validates the request by cross-checking the barcode against stored records and returns verification results in real time. This dual-role authentication workflow strengthens trust, ensures accountability, and minimizes the risk of counterfeit products entering the market.

5. METHODOLOGY:

5.1 System Architecture and Web Application Design

The proposed system follows a web-based architecture that integrates a user-facing application with a backend blockchain layer to enable secure product verification. The architecture is composed of three main components: the web application interface, the backend processing layer, and the blockchain-based data storage module. The web application is developed using HTML, CSS, and JavaScript to provide intuitive and responsive interfaces for both manufacturers and consumers. HTML is used to structure the login and verification pages, CSS enhances usability through responsive design, and JavaScript enables dynamic interactions such as form validation and barcode scanning. The frontend communicates with the backend to submit product information, retrieve verification results, and display authenticity status in real time, ensuring seamless interaction between users and the underlying blockchain system.

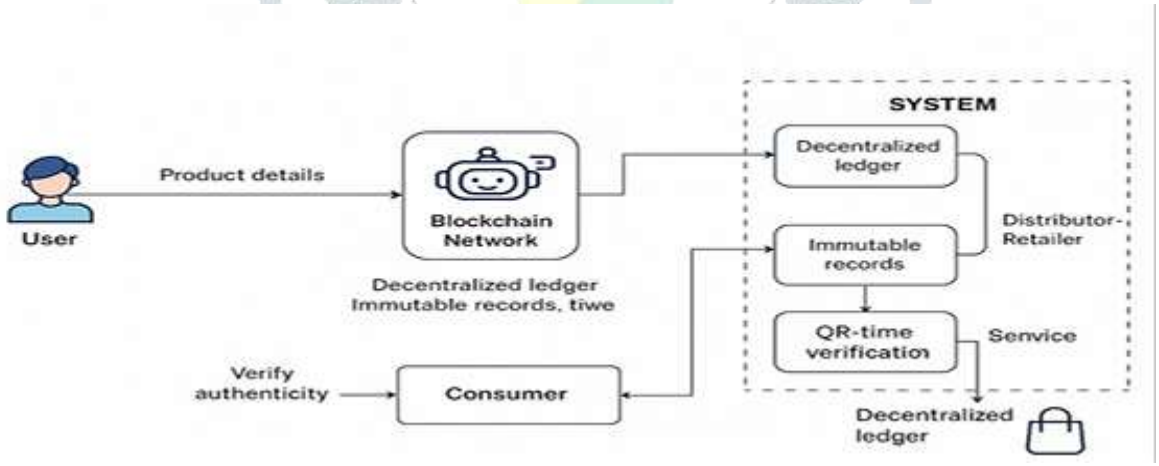

Figure 2: Proposed Architecture

5.2 Product Registration and Barcode Generation Process

Product registration is initiated by authenticated manufacturers through the web application interface. During this process, manufacturers enter essential product details such as product name, batch number, and manufacturing information. Each registered product is assigned a unique barcode that acts as a digital identifier linking the physical product to its corresponding digital record. The barcode generation process ensures uniqueness and consistency, allowing products to be tracked and verified throughout their lifecycle. Before storage, the entered data is validated to prevent incomplete or incorrect records. By associating each physical product with a unique barcode and a corresponding digital entry, the system establishes a reliable foundation for subsequent verification and traceability.

5.3 Blockchain-Based Data Storage Using Python

The backend of the system employs a Python-based blockchain implementation to securely store and manage product information. Each product registration event is recorded as a transaction, which is grouped into a block and added to the blockchain ledger. The blockchain structure consists of a sequence of interconnected blocks, where each block contains product data, a timestamp, and a cryptographic reference to the previous block. This chaining mechanism ensures that once data is recorded, it cannot be altered without affecting the integrity of the entire ledger. Python is used to provide a lightweight and flexible environment for implementing blockchain functionality. This decentralized storage approach enhances data integrity, transparency, and resistance to tampering.

5.4 Cryptographic Hashing and Product Verification Workflow

To ensure data security and integrity, the system incorporates a cryptographic hashing mechanism based on the Secure Hash Algorithm (SHA). For each block added to the blockchain, a hash value is generated using the block's contents, creating a unique digital fingerprint. Any modification to the stored data would result in a mismatch of hash values, enabling immediate detection of tampering. During the product verification process, consumers access the web application to scan or enter the product barcode. The system retrieves the corresponding blockchain record and verifies its authenticity by validating the stored hash values and block sequence. The verification result is then presented to the consumer in real time, indicating whether the product is genuine or potentially counterfeit. This integrated workflow combines cryptographic security with user-friendly verification, ensuring transparency, trust, and reliability in product authentication.

6. CHALLENGES AND LIMITATIONS

6.1 Scalability and Performance Constraints

The proposed system is designed as a web-based application integrated with a Python-based blockchain, which is effective for small to medium-scale deployments. However, as the number of registered products and verification requests increases, system performance may be affected. In high-volume supply chain environments, handling concurrent manufacturer entries and consumer verification requests may pose scalability challenges. Optimizing block size, transaction handling, and backend processing is therefore necessary for large-scale real-world adoption.

6.2 Barcode Duplication and Physical–Digital Trust Gap

Although barcode-based identification offers a cost-effective solution for product verification, it remains vulnerable to duplication and reuse. A counterfeit product may replicate a legitimate barcode and associate it with a fake item, creating a gap between the physical product and its digital blockchain record. While backend verification can detect repeated or suspicious scans, it cannot fully prevent physical cloning of barcodes. This limitation highlights the need for stronger physical–digital binding mechanisms, such as tamper-resistant labels or advanced tagging technologies, to improve the robustness of authentication systems.

6.3 Data Privacy and Information Exposure

The transparency offered by blockchain-based storage enhances trust but also introduces privacy concerns. Storing product-related data in an immutable ledger may expose sensitive manufacturer information if access control mechanisms are not carefully implemented. Additionally, logging consumer verification activities, such as scan time or frequency, may raise privacy issues related to user behavior tracking. Ensuring a balance between transparency and confidentiality remains a challenge, particularly in web-based systems where multiple stakeholders access shared information.

6.4 Adoption and Integration Challenges

The practical adoption of the proposed system depends on the willingness of manufacturers and supply chain participants to integrate blockchain-based solutions into existing workflows. Small-scale manufacturers may lack technical expertise, while larger organizations may face difficulties integrating the system with legacy databases and enterprise resource planning systems. Additionally, the absence of clear regulatory guidelines for blockchain-based product authentication can slow down adoption and raise compliance concerns. These factors collectively pose challenges for widespread real-world implementation.

7. CONCLUSION AND FUTURE SCOPE

The Blockchain-Based Product Verification and Counterfeit Prevention System provides a reliable, secure, and transparent solution to address the growing problem of counterfeit products by utilizing the decentralized and immutable characteristics of blockchain technology. By ensuring tamper-proof storage of product information, real-time traceability across the supply chain, and automated validation through smart contracts, the system significantly improves product authenticity, trust among stakeholders, and consumer confidence. It minimizes dependency on centralized authorities while enhancing accountability and data integrity at every stage of the product lifecycle. In the future, the system can be further enhanced by integrating IoT sensors for real-time condition monitoring, AI-based anomaly detection for identifying suspicious activities, and interoperability across multiple blockchain platforms to improve scalability and adoption. These advancements can make the system more intelligent, adaptable, and globally applicable, ultimately contributing to a transparent, secure, and counterfeit-free digital marketplace.

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