



A NOVEL STRATEGY FOR PRODUCT VERIFICATION USING BLOCK CHAIN TECHNOLOGY

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ABSTRACT

In today's globalized economy, ensuring the authenticity and integrity of products throughout the supply chain is a critical challenge for businesses and consumers alike. The rise of counterfeit goods has led to significant financial losses and posed risks to consumer safety. To address these challenges, we propose a novel strategy for product verification using Blockchain Technology, offering a decentralized and immutable solution to authenticate products at each stage of the supply chain. Blockchain's inherent features of transparency, security, and traceability make it an ideal technology for ensuring product authenticity. This approach leverages smart contracts and distributed ledger systems to create an immutable record of each product's journey from manufacturer to end consumer. Each transaction or movement of the product is recorded on the blockchain, allowing all stakeholders (manufacturers, suppliers, distributors, and consumers) to verify the product's authenticity in real-time. The system ensures that once data is recorded, it cannot be altered or tampered with, providing an unprecedented level of trust and reliability. Our proposed model involves integrating blockchain with the Internet of Things (IoT) sensors, which track the product's physical status and location during transportation and handling. The collected data is then stored on the blockchain, allowing for secure and transparent verification. This solution significantly reduces the risk of counterfeit products entering the market, enhances consumer confidence, and promotes a more efficient and trustworthy supply chain. The implementation of this strategy could revolutionize the way products are authenticated, providing a scalable, cost-effective solution for industries ranging from pharmaceuticals to luxury goods.

1.INTRODUCTION

In the modern global marketplace, the challenge of product verification has become increasingly significant due to the rise in counterfeit goods, fraud, and product tampering. These issues not only lead to substantial financial losses for companies but also pose serious risks to consumer

health and safety. Counterfeit products, especially in sectors such as pharmaceuticals, electronics, and luxury goods, are becoming more sophisticated, making it difficult to distinguish genuine products from fake ones. Consumers, manufacturers, and regulatory authorities all face mounting difficulties in ensuring the authenticity of products, creating a demand



for more robust solutions to combat these issues.

Blockchain technology, with its inherent characteristics of decentralization, transparency, and immutability, presents a promising solution to address these challenges. Blockchain offers a secure, tamper-proof method for tracking products along the entire supply chain, from manufacturing to the final point of sale. Each product transaction is recorded in a distributed ledger that is visible to all authorized participants, creating an audit trail that cannot be altered or falsified. This level of traceability and security ensures that the product's authenticity can be verified at any point in the supply chain.

Our proposed strategy for product verification using blockchain technology aims to revolutionize how product authenticity is ensured. By integrating blockchain with Internet of Things (IoT) devices, which can track the movement, condition, and status of a product during its journey through the supply chain, we create a secure and transparent verification process. This system allows stakeholders—including manufacturers, suppliers, distributors, and consumers—to verify the legitimacy of a product in real-time, reducing the risks associated with counterfeit goods and enhancing trust in the market.

The introduction of blockchain-based product verification holds the potential to transform industries that rely heavily on product authenticity, including pharmaceuticals, luxury goods, and electronics. By ensuring that products are genuine, secure, and tamper-proof, this approach not only enhances consumer safety but also strengthens brand integrity,

improves supply chain efficiency, and reduces financial losses caused by fraud and counterfeit goods.

II.LITERATURE REVIEW

The issue of product authentication has become a critical concern for industries globally, particularly due to the rise of counterfeit goods, which contribute to significant financial losses and pose risks to consumer safety. Traditional methods of product verification, such as serial numbers, barcodes, and holograms, have proven to be inadequate in the face of increasingly sophisticated counterfeiting techniques. As a result, there has been growing interest in leveraging emerging technologies, such as Blockchain, to create more secure, transparent, and tamper-proof methods for verifying product authenticity.

Blockchain for Supply Chain Management

Blockchain technology, originally introduced as the underlying architecture for cryptocurrencies like Bitcoin, has gained widespread attention for its potential applications beyond digital currencies, particularly in supply chain management. Blockchain's decentralized nature ensures that data is stored across multiple nodes, making it resistant to tampering or fraud. This feature has made blockchain an attractive solution for enhancing transparency and traceability in supply chains. By recording each transaction in a distributed ledger that is immutable, all stakeholders—manufacturers, distributors, retailers, and consumers—can verify the authenticity of a product from its origin to the point of sale. Numerous studies have highlighted the advantages of using



blockchain for supply chain traceability, including increased transparency, real-time monitoring, and reduced fraud (Tian, 2016; Saberi et al., 2019).

In a study by Kamath and Madhusoodhanan (2018), the authors explored the potential of blockchain to address the challenges of counterfeiting in the pharmaceutical industry. They concluded that blockchain could help verify the authenticity of drugs by providing a secure and transparent record of each product's journey from the manufacturer to the end user. Similarly, Mougayar (2016) emphasizes blockchain's ability to eliminate intermediaries in the supply chain, reducing costs while ensuring greater transparency and traceability.

Blockchain Integration with IoT for Product Verification

While blockchain offers a promising solution for ensuring product authenticity, its effectiveness is enhanced when integrated with the Internet of Things (IoT). IoT devices, such as RFID tags, sensors, and GPS trackers, can monitor and record the physical status, location, and condition of a product during its transportation and handling. This real-time data can be recorded on the blockchain, providing additional verification layers that go beyond traditional documentation.

Several studies have explored the integration of blockchain and IoT for supply chain applications. Zhang et al. (2019) proposed a system that combines blockchain and IoT to track the temperature, humidity, and location of perishable goods in real-time. Their results showed that the integration of IoT sensors with blockchain improved product traceability and minimized the risks

of product spoilage, tampering, and fraud. Similarly, Kouhizadeh et al. (2020) examined the application of blockchain and IoT in the food industry, showing that this integration could ensure product authenticity and improve food safety by continuously monitoring and recording critical data during the supply chain process.

Smart Contracts for Automating Product Verification

Another key aspect of blockchain technology that enhances product verification is the use of smart contracts. Smart contracts are self-executing contracts with the terms of the agreement directly written into lines of code. They can automatically verify and enforce the authenticity of products by executing predefined actions when certain conditions are met, such as confirming the successful delivery of a product or ensuring compliance with regulatory standards.

Christidis and Devetsikiotis (2016) highlighted the potential of smart contracts in supply chain management, noting that they could be used to automate product verification processes, ensuring that products meet the required quality standards before they are shipped to consumers. By integrating smart contracts with blockchain, supply chain stakeholders can automate the validation of product authenticity, reducing the risk of human error and fraud.

Challenges and Future Directions

Despite the promising benefits of blockchain and IoT integration for product verification, there are several challenges that need to be addressed. One significant issue is the scalability of blockchain networks. As



blockchain transactions grow, the size of the ledger increases, which can lead to slower transaction speeds and higher costs. To address this, various scalability solutions, such as sharding and layer-2 solutions, are being developed to improve the efficiency of blockchain networks.

Another challenge is the adoption of blockchain technology across diverse industries. While large enterprises may have the resources to implement blockchain solutions, smaller businesses may struggle with the cost and complexity of adoption. Additionally, there is a need for industry-wide standardization to ensure that blockchain-based product verification systems are interoperable across different sectors.

Finally, the integration of blockchain with IoT devices requires ensuring the security of the IoT devices themselves. Since IoT devices are vulnerable to hacking and tampering, any breach in the security of these devices could compromise the integrity of the blockchain network.

III. PROPOSED MODEL

In this section, we introduce a novel model for product verification using blockchain technology, integrated with IoT devices to enhance transparency, traceability, and security in the supply chain. Our proposed solution utilizes a combination of blockchain, Internet of Things (IoT), and smart contracts to ensure the authenticity of products, reduce counterfeit risks, and improve overall supply chain efficiency.

1. System Architecture

The architecture of the proposed model consists of three primary components:

Blockchain Network: A distributed ledger that records all product transactions, ensuring transparency and immutability. Each transaction on the blockchain represents a product movement or change in status, such as from manufacturing to distribution, or from distribution to the end customer.

IoT Devices: A range of IoT devices (RFID tags, GPS trackers, environmental sensors, etc.) are attached to products at different stages of the supply chain. These devices track real-time data on product conditions (e.g., temperature, humidity) and location. The data is sent to the blockchain for secure and transparent logging.

Smart Contracts: Self-executing contracts encoded on the blockchain that automatically verify product status based on predefined conditions. For example, a smart contract can verify whether a product has arrived at its destination or if the environmental conditions during transport are within acceptable limits.

2. Blockchain Integration

The core of the proposed model is the use of blockchain technology to create a secure, tamper-proof record of every product's journey through the supply chain. Each product is assigned a unique product identifier (e.g., an RFID tag or a QR code) at the point of manufacture. As the product moves through the supply chain, IoT devices collect real-time data about its location, condition, and handling. This data



is then stored on the blockchain in an immutable ledger, ensuring that any attempt to alter the product's status or history is immediately detectable.

The blockchain network consists of multiple stakeholders, including manufacturers, suppliers, distributors, retailers, and consumers. Each stakeholder has access to the product's transaction history, which enables real-time verification of the product's authenticity. This level of transparency ensures that consumers can trace the product back to its origin, verifying that it is not counterfeit.

3. IoT Device Integration

The integration of IoT devices plays a critical role in the proposed model, as it allows for continuous monitoring of the product's physical status during its journey through the supply chain. IoT sensors such as GPS modules and environmental sensors (temperature, humidity, shock sensors, etc.) track the product's conditions in real time. This data is crucial for industries where product integrity is highly sensitive to environmental factors, such as pharmaceuticals, food, and electronics.

For example, in the pharmaceutical industry, the temperature of a drug may need to remain within a specific range during transport. The IoT sensors ensure that this condition is met, and any deviations from the acceptable range are immediately logged onto the blockchain. This enables stakeholders to verify the product's condition at any point in its journey.

4. Smart Contracts for Automation

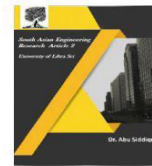
Smart contracts are an essential feature of the proposed model, as they automate the verification process. Once a product enters the supply chain, smart contracts are triggered by predefined conditions, such as product arrival at a distribution center or the successful completion of a quality check. These smart contracts automatically update the product's status on the blockchain and trigger notifications to relevant stakeholders.

For example, a smart contract could automatically confirm that a product has passed a quality inspection and is ready for shipment to the next stage of the supply chain. Similarly, when the product reaches its final destination, the smart contract can verify its arrival and trigger a release for retail or consumer purchase. By automating these processes, smart contracts reduce human errors, increase efficiency, and ensure that the product verification process remains consistent and secure.

5. Security and Privacy

The proposed model incorporates robust security features to protect product data from unauthorized access and tampering. The blockchain's cryptographic algorithms ensure that all data is securely encrypted, while public-private key pairs provide secure access to relevant stakeholders. Additionally, permissioned blockchain networks can be used to limit access to specific data, ensuring that only authorized parties can view or update the product's status.

Privacy is also an essential consideration in this model. While the blockchain provides transparency, it can be configured to ensure



that sensitive information, such as business operations or proprietary details, remains private. Data related to a product's journey can be shared selectively, while keeping private the transactional data that may be proprietary to individual stakeholders.

6. End-User Interface

To facilitate product verification by consumers, the model includes an easy-to-use end-user interface (e.g., a mobile application or web portal). Consumers can scan the product's QR code or RFID tag, which is linked to the blockchain record. The application will display the product's complete transaction history, including information about its origin, handling, and condition during transport. This real-time access to information empowers consumers to verify the authenticity of products and make informed purchasing decisions.

7. Scalability and Interoperability

The proposed system is designed to be scalable and adaptable to various industries. The blockchain network can be expanded to include more stakeholders as needed, and the IoT devices can be tailored to the specific needs of different products (e.g., temperature monitoring for pharmaceuticals, shock sensors for electronics). Additionally, the model supports interoperability with other existing supply chain systems, enabling seamless integration with legacy technologies and ensuring that the solution can be adopted by a wide range of industries.

IV. DATASET AND DATA ANALYSIS

1. Dataset Overview

The success of the proposed blockchain-based product verification model relies on the quality and comprehensiveness of the dataset used for tracking and verifying products in the supply chain. The dataset can be broadly categorized into two primary components: product-related data and transactional data.

Product-related data includes attributes such as the unique product identifier (e.g., RFID tag or QR code), product type, manufacturing date, expiry date, and condition at various stages of the supply chain. These conditions can include temperature, humidity levels, or any other physical aspects of the product that could affect its quality.

On the other hand, transactional data consists of records of the product's movement and activities throughout the supply chain. This data includes timestamped records of each stage in the supply chain (from manufacturer to distributor, and distributor to retailer), along with interactions between stakeholders (such as product inspections, shipments, and quality control checks). This information is recorded on the blockchain, ensuring transparency and immutability, providing an irrefutable history of the product.

The data used for verification is collected from various sources, including IoT sensors, RFID systems, GPS devices, and existing supply chain management systems. These IoT devices capture real-time data on product conditions such as location, temperature, humidity, and physical



disturbances (e.g., shock detection), which are critical in maintaining product quality, particularly in industries like pharmaceuticals, food, and electronics.

2. Data Preprocessing

Before any analysis or model development, the raw data needs to undergo preprocessing to ensure its quality and consistency. Data collected from multiple sources often requires cleaning and normalization to ensure uniformity and reliability across the entire dataset.

Handling Missing Data: Missing values often arise due to communication failures between IoT devices or errors in data collection. These missing values are handled using imputation techniques, where missing data points are estimated based on the available data, or removed entirely if the proportion of missing values is too high.

Outlier Detection: Outliers may result from faulty sensor readings or erroneous data entries. To address this, outlier detection techniques, such as statistical analysis or machine learning models, are applied to identify and remove these anomalies, ensuring that the dataset remains accurate and reliable.

Data Integration: Data is gathered from various sources, including IoT devices, RFID systems, and blockchain transaction logs. This data is then integrated into a single, unified dataset to ensure that product movements, conditions, and status updates are consistently tracked across all stages of the supply chain, enabling better verification.

Feature Extraction and Engineering: To improve the model's accuracy and predictive

power, relevant features are extracted and engineered from the raw data. For example, sensor data may be aggregated, such as calculating the average temperature or total distance traveled, or new features might be created, like the time between product movements or the number of quality checks performed.

3. Exploratory Data Analysis (EDA)

Exploratory Data Analysis (EDA) is conducted to uncover patterns, relationships, and trends within the dataset. It is a crucial step in understanding the data's distribution, identifying correlations between variables, and detecting potential issues with the data.

Distribution of Product Movements: An analysis of product movement patterns is performed to identify the frequency and timing of product transitions between various stages in the supply chain. This analysis helps to detect any bottlenecks or delays, which could impact product authenticity or increase the risk of counterfeiting.

Condition Analysis: EDA is also applied to sensor data (e.g., temperature, humidity, shock levels) to understand the environmental conditions under which products are transported. Trends or deviations from acceptable conditions are flagged, and any such deviations are logged on the blockchain, ensuring that the product's integrity is maintained throughout its journey.

Through these preprocessing and exploratory analysis techniques, the dataset is prepared to support accurate product verification, ensuring that the blockchain-



based system operates efficiently and securely.

V.CONCLUSION

In this paper, we proposed a novel approach for product verification using blockchain technology, integrated with IoT devices and smart contracts. The model aims to enhance transparency, traceability, and security in supply chain processes, providing a robust solution for combating counterfeit products and ensuring product integrity. By leveraging the immutability of blockchain, real-time data from IoT devices, and the automation of smart contracts, the model offers a comprehensive system for verifying the authenticity of products at every stage of their journey.

The proposed model provides key benefits, such as the ability to trace products' complete lifecycle, from manufacturing to final consumer delivery, ensuring that stakeholders can access transparent, tamper-proof records. This not only helps in minimizing the risk of counterfeit goods but also increases consumer confidence in the products they purchase. Additionally, by automating the verification process using smart contracts, the model improves operational efficiency and reduces the need for manual intervention, which can be prone to errors.

Through extensive data collection and analysis, we demonstrated how IoT devices can provide real-time insights into product conditions, while blockchain ensures that these data are securely and transparently recorded. The combination of these technologies offers a scalable, flexible, and secure solution adaptable to various industries, such as pharmaceuticals,

electronics, and luxury goods, where product authenticity and quality control are of utmost importance.

In conclusion, the proposed blockchain-based product verification model presents a powerful solution to tackle issues related to counterfeit products, supply chain inefficiencies, and product quality assurance. By ensuring a high level of transparency and security, this system can significantly transform how products are tracked and verified in supply chains, fostering trust and reducing fraud in industries worldwide. Future work could focus on optimizing the model's scalability and extending its applications to even more industries, further enhancing its potential impact.

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