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A NOVEL STRATEGY FOR PRODUCT VERIFICATION USING BLOCK CHAIN TECHNOLOGY

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ABSTRACT

Companies and customers alike face a formidable obstacle in today's globalised economy: guaranteeing the genuineness and quality of goods at every stage of the supply chain. There have been major monetary losses and dangers to consumer safety due to the proliferation of fake products. In light of these difficulties, we suggest a new approach to product verification based on Blockchain Technology, which provides a distributed and unchangeable way to certify goods along the supply chain. The optimal solution for guaranteeing product authenticity is blockchain due to its intrinsic qualities of transparency, security, and traceability.This method uses distributed ledger technologies and smart contracts to record every step of a product's lifecycle, from production to final sale. Everyone involved in the supply chain, from producers to buyers, can check the product's legitimacy in real-time thanks to the blockchain's record of every transaction and movement of the commodity. An unparalleled degree of confidence and dependability is provided by the system, which guarantees that data cannot be edited or tampered with once captured.To monitor the product's physical condition and whereabouts while in transit and handling, our suggested solution combines blockchain technology with Internet of Things (IoT) sensors. After that, the data is recorded on the blockchain, which makes the verification process safe and transparent. This technology makes the supply chain more efficient and trustworthy, boosts customer confidence, and drastically decreases the possibility of counterfeit items entering the market. Industries as diverse as pharmaceuticals and high-end goods stand to benefit from this strategy's potential to radically alter product authentication processes while also offering a scalable and cost-effective solution.

I. INTRODUCTION

Counterfeit goods, fraud, and tampered products are on the increase in today's global economy, making product

verification a major concern. Not only do these problems endanger the health and safety of consumers, but they also cause huge financial losses for businesses. The increasing sophistication of counterfeit goods makes it increasingly difficult to differentiate between real and imitation items, particularly in industries like medicines, electronics, and luxury goods. There is a growing need for stronger solutions to address the growing challenges that consumers, producers, and regulatory agencies have when trying to verify the authenticity of items.

A potential answer to these problems is blockchain technology, which is decentralised, transparent, and immutable by definition. From production to retail, blockchain technology provides an immutable record of every step of a product's journey. An immutable audit trail is generated when every product transaction is recorded in a distributed ledger, which is accessible to all authorised participants. At each stage in the supply chain, the product's authenticity may be confirmed thanks to this degree of traceability and security.

Our plan to use blockchain technology for product authentication will change the game when it comes to making sure products are real. Together, blockchain technology and IoT devices can monitor a product's whereabouts, state, and condition as it makes its way through the supply chain, allowing for an open and trustworthy verification procedure. Improving market confidence and decreasing dangers of counterfeit products, this system enables all market participants—manufacturers, suppliers, distributors, and consumers—to instantly confirm a product's authenticity.

Industries such as electronics, medicines, and high-end items stand to benefit greatly from the implementation of blockchain-based product verification. This strategy increases supply chain efficiency, promotes brand integrity, and decreases financial losses caused by fraud and counterfeit goods by guaranteeing that items are authentic, secure, and tamper-proof. It also enhances customer safety.

II. LITERATURE REVIEW

Because of the proliferation of fake products, which cause enormous monetary losses and endanger consumers, product authentication has emerged as a major problem for businesses throughout the world. Counterfeiters are becoming more and better at using traditional product verification methods like holograms, barcodes, and serial numbers. Because of this, there is a rising tide of interest in using new technology like

Blockchain to make product authenticity verification processes more foolproof, open, and safe.

Blockchain for Supply Chain Management

Although blockchain was first presented as the foundational technology for digital currencies like Bitcoin, it has since attracted a lot of interest for uses outside of digital money, especially in supply chain management. Blockchain is impenetrable to fraud and manipulation since data is stored across several nodes, according to its decentralised structure. For this reason, blockchain technology has recently gained popularity as a means to improve supply chain visibility and auditability. Every participant in the supply chain, from producers to buyers, can confirm the genuineness of a product at any stage thanks to an immutable distributed ledger that records every transaction. Tian (2016) and Saberi et al. (2019) are just two of many studies that have shown how blockchain technology may improve supply chain traceability by making it more transparent, allowing for real-time monitoring, and decreasing the likelihood of fraud.

The possibility of blockchain technology to combat pharmaceutical sector counterfeiting was investigated in a research by Kamath and Madhusoodhanan (2018). They came to the conclusion that blockchain technology, by recording the safe and transparent flow of goods from producer to consumer, might aid in the authentication of pharmaceuticals. Similarly, Mougayar (2016) highlights the capacity of blockchain to do away with supply chain middlemen, which in turn reduces costs and increases transparency and traceability.

Blockchain Integration with IoT for Product Verification

Blockchain technology alone isn't enough to guarantee a product's legitimacy; when coupled with the IoT, it becomes a formidable weapon. During transit and handling, Internet of Things (IoT) devices like RFID tags, sensors, and GPS trackers may record and monitor the physical state, position, and condition of a product. By recording this data in real-time on the blockchain, we can add verification levels beyond what is possible with paper records.

There have been a number of investigations into potential supply chain uses for blockchain and IoT integration. By integrating blockchain technology with the internet of things (IoT), Zhang et al. (2019) suggested a way to monitor the

whereabouts, humidity level, and temperature of perishable items in real-time. Their findings demonstrated that by combining blockchain technology with Internet of Things (IoT) sensors, product traceability was enhanced and the likelihood of fraud, tampering, and spoiling was reduced. The integration of blockchain technology with the internet of things (IoT) was also investigated by Kouhizadeh et al. (2020) in the food sector, and they found that it might enhance food safety and guarantee the authenticity of products by collecting and constantly monitoring important data as it moves through the supply chain.

Smart Contracts for Automating Product Verification

The use of smart contracts is another important part of blockchain technology that improves product verification. Smart contracts are agreements whose terms are encoded into code and can execute themselves. They have the ability to automatically check the delivery of a product or ensure compliance with regulatory requirements, among other things, and then carry out specified steps to enforce product authenticity.

Smart contracts have the ability to automate product verification procedures, which may help guarantee that items are up to par before they are sent to customers (Christidis and Devetsikiotis, 2016). Reduce the possibility of human mistake and fraud by automating the confirmation of product authenticity via the integration of smart contracts with blockchain. This will benefit all parties involved in the supply chain.

Challenges and Future Directions

There are a number of obstacles that must be overcome before the potential advantages of integrating blockchain and IoT for product verification can be fully realised. Scalability is a major concern with blockchain networks. The size of the blockchain ledger grows in relation to the number of transactions, which may cause transaction fees and speeds to rise. As a result, researchers are working on a number of scaling solutions to make blockchain networks more efficient, including sharding and layer-2 solutions. Getting other businesses to use blockchain technology is another obstacle. Blockchain technologies may be easily implemented by major corporations, but smaller organisations may find the adoption process too complicated and expensive. Furthermore, for blockchain-based product verification systems to be compatible across multiple industries, industry-wide standardisation

is necessary.

Lastly, making sure the IoT devices are secure is essential for blockchain integration with IoT devices. Any security hole in Internet of Things (IoT) devices might jeopardise the blockchain network's reliability because of how susceptible they are to hackers and manipulation.

III. PROPOSED MODEL

Using blockchain technology and Internet of Things (IoT) devices, we provide a new approach to product verification that improves supply chain security, visibility, and traceability. To increase supply chain efficiency, decrease counterfeit concerns, and guarantee product authenticity, our suggested solution uses a mix of blockchain, IoT, and smart contracts.

1. System Architecture

There are primarily three parts to the design of the suggested model:

Distributed ledger technology that records all product transactions in an immutable and transparent manner is known as a blockchain network. From production to distribution or even to the consumer's hands, every transaction on the blockchain signifies a different step in the product's lifecycle.

Various Internet of Things (IoT) devices, such as radio frequency identification (RFID) tags, global positioning system (GPS) trackers, environmental sensors, and so on, are affixed to items at each step of the supply chain. These gadgets monitor the whereabouts and condition of products in real time, collecting data on factors like temperature and humidity. Secure and transparent logging is achieved by sending the data to the blockchain.

"Smart Contracts" are blockchain-encoded, self-executing agreements that may check the state of a product automatically according to certain criteria. As an example, a smart contract may check whether the goods has reached its destination or if the transportation circumstances were appropriate.

2. Blockchain Integration

At its heart, the suggested approach is based on blockchain technology, which generates an immutable record of each product's movement through the supply chain. At the time of production, every item is given a unique identification (such as a QR code or an RFID tag). The product's location, condition, and handling may be tracked in real-time by Internet of Things sensors as it goes

through the supply chain. Every attempt to change the product's status or history is instantly identifiable since this data is maintained on the blockchain in an immutable ledger.

Everyone from producers to buyers to wholesalers to retailers to consumers is a part of the blockchain network. Everyone involved can see the product's purchase history, which lets them check its legitimacy in real time. Customers may be certain the goods is authentic because of this degree of openness on the product's origin.

3. IoT Device Integration

Integrating IoT devices is essential to the suggested approach since it enables constant tracking of the product's physical condition as it moves through the supply chain. The product's circumstances are tracked in real time by Internet of Things (IoT) sensors like GPS modules and environmental sensors (e.g., temperature, humidity, shock sensors, etc.). The pharmaceutical, food, and electronics sectors, among others, rely heavily on this data since their products' integrity is quite vulnerable to environmental variables.

For instance, when it comes to pharmaceuticals, there are often precise temperature ranges that drugs must adhere to while being transported. This condition is checked by the IoT sensors, which promptly report any deviations from the permitted range into the blockchain. Because of this, stakeholders may check the product's status at any stage of its journey.

4. Smart Contracts for Automation

To automate the verification process, smart contracts are an integral part of the suggested approach. When a product reaches a distribution centre or passes a quality check, for example, smart contracts are set to activate after it has entered the supply chain. These smart contracts will notify the appropriate parties and update the product's status on the blockchain automatically.

As an example, a smart contract may verify automatically that a product is ready to be sent to the next step of the supply chain after passing quality inspection. Similarly, the smart contract may confirm the product's delivery and release it for retail or consumer purchase once it reaches its ultimate destination. Smart contracts automate these steps to make the product verification process more efficient, less prone to human mistake, and more secure.

5. Security and Privacy

To prevent data breaches and manipulation, the suggested approach uses strong security measures to encrypt product information. The cryptographic techniques used by the blockchain encrypt all data, and the public-private key pairs allow authorised users to safely access the data. Furthermore, authorised users can only see the product's status updates and examine restricted data thanks to permissioned blockchain networks.

An additional crucial factor in this strategy is privacy. Blockchain technology allows for openness, but it may also be set up to protect private information, such company operations or confidential facts. It is possible to selectively disclose data pertaining to a product's journey while protecting the privacy of transactional data that can belong to certain stakeholders.

6. End-User Interface

The concept incorporates a user-friendly end-user interface (such as a web portal or mobile app) to make product verification easier for customers. The product's QR code or RFID tag may be scanned by consumers to access the product's record on the blockchain. All of the product's purchase details, including where it came from, who handled it, and how it was transported, will be shown on the app. The ability to access information in real-time allows customers to confirm the legitimacy of items and make well-informed purchases.

7. Scalability and Interoperability

Because of its modular architecture, the suggested system may easily be implemented in a wide range of sectors. Internet of Things (IoT) devices may be customised to meet the unique requirements of various items, such as medicines for temperature monitoring or electronics for shock sensors, and the blockchain network can be scaled up or down according to demand. Furthermore, the model is designed to be compatible with various supply chain systems, making it easy to include old technology and making it suitable for a variety of sectors to use.

IV. DATASET AND DATA ANALYSIS

1. Dataset Overview

The suggested blockchain-based product verification methodology can only work if the dataset used to monitor and authenticate items throughout the supply chain is both high-quality and exhaustive.

Data pertaining to products and data pertaining to transactions make up the bulk of the collection.

Attributes of products include their kind, date of manufacture, expiration date, condition at different points in the supply chain, and unique identifiers (such RFID tags or QR codes) for products. The product's physical characteristics, such as its temperature and humidity levels, are examples of such situations.

throughout contrast, transactional data includes logs of the product's actions and whereabouts as they occur throughout the supply chain. Interactions between stakeholders, such as product inspections, shipments, and quality control checks, as well as timestamped records of each step of the supply chain (from producer to distributor and distributor to retailer) are all part of this data set. By recording this data on the blockchain, we guarantee its transparency and immutability, giving us an unchangeable record of the product's history.

The verification data comes from a variety of places, such supply chain management systems, GPS devices, RFID systems, and Internet of Things sensors. The pharmaceutical, food, and electronics sectors, among others, rely on real-time data captured by these Internet of Things sensors on product parameters including location, temperature, humidity, and physical disturbances (e.g., shock detection) to ensure product quality.

2. Data Preprocessing

It is necessary to preprocess the raw data in order to guarantee its consistency and quality before doing any analysis or building any models. Cleaning and normalising data acquired from various sources is a common practice to guarantee consistency and trustworthiness in the final dataset.

Dealing with Missing Data: When data collection is faulty or there is a communication breakdown between IoT devices, missing values are common. As a result, imputation approaches are used to deal with these missing values. In these techniques, missing data points are either approximated using the existing data or, in extreme cases, eliminated altogether.

Detecting Outliers: Incorrect data inputs or malfunctioning sensors may cause outliers. This is why it's important to use outlier detection methods like statistical analysis or machine learning models to find and eliminate these outliers. This way, you can be sure that your dataset is correct and trustworthy.

The Internet of Things (IoT), radio frequency identification (RFID) technologies, and blockchain transaction

logs are just a few of the data sources used in the integration process. To improve verification, all of this data is combined into one big database so that every step of the supply chain can see the same information about the products, their conditions, and any changes to their status.

Extracting and engineering important characteristics from raw data improves the model's accuracy and predictive ability. It is possible to establish new characteristics, such as the amount of quality checks done or the duration between product moves, or to aggregate sensor data, such as to calculate the average temperature or total distance travelled.

3. Exploratory Data Analysis (EDA)

In order to find trends, patterns, and correlations in the dataset, exploratory data analysis (EDA) is used. Understanding the distribution of the data, finding connections between variables, and recognising problems with the data all depend on this critical stage.

How Products Are Distributed: The time and frequency of product transitions across supply chain stages may be determined by analysing movement patterns. Any delays or snags that can compromise the authenticity of the product or make counterfeiting more likely can be detected with the use of this research.

Analysis of Conditions: EDA may also be used to analyse the transportation environment by applying it to sensor data (such as humidity, temperature, and shock levels). To keep the product's integrity intact all the way through its journey, any trends or deviations from permitted parameters are recognised and recorded on the blockchain.

Ensuring the efficient and safe operation of the blockchain-based system, these preprocessing and exploratory analysis approaches prepare the dataset to facilitate accurate product verification.

V. CONCLUSION

We presented a new method for product verification in this article that makes use of blockchain technology, which is combined with smart contracts and Internet of Things devices. The model's stated goal is to provide a solid answer to the problem of counterfeit goods by increasing supply chain process transparency, traceability, and security. The model provides a thorough mechanism for authenticating items at every step of their path by using the immutability of blockchain, real-time data from IoT devices, and the

automation of smart contracts.

Key advantages of the suggested paradigm include the capacity to track items throughout their entire lifespan, from production to delivery to the customer, and the provision of transparent, immutable data to all parties involved. This boosts customer trust in the things they buy while also reducing the likelihood of counterfeit goods. Better operational efficiency and less error-prone human intervention are two further benefits of the model's use of smart contracts to automate the verification process.

We showed that IoT devices can provide real-time insights into product conditions via data analysis and collecting, and that blockchain can store this data safely and openly. Companies in the pharmaceutical, electronics, and luxury goods sectors, among others, place a premium on ensuring the authenticity and quality of their products. By combining these technologies, they provide a safe, scalable, and versatile solution.

Finally, the suggested blockchain-based product verification model offers a strong answer to problems with counterfeit goods, inefficient supply chains, and ensuring product quality. With its emphasis on security and openness, this system has the potential to revolutionise supply chain tracking and verification, leading to more confidence and less fraud in businesses throughout the globe. Improving the model's scalability and expanding its use to more sectors might be the focus of future research to increase its potential influence.

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