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Product Validation in the Digital Age: A Blockchain Perspective

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ABSTRACT

The smuggling of counterfeit goods into the global supply chain remains a formidable challenge, not only undermining economic stability but also threatening the welfare of end users. From RFID tags to QR code systems, traditional systems have stumbled in providing robust protection against this growing threat. This study advocates the integration of blockchain technology as a revolutionary shield against fraudulent attacks on counterfeit products and begins a pioneering journey. The study highlights various applications of blockchain, extending traceability, decentralized anti-counterfeiting systems, and avant-garde cloud-based architecture of the supply chain of the products in circulation in the market. The proposed system fusing encrypted QR codes, state-of-the-art camera scanners, and relentless Ethereum blockchain Provides richness and superior efficiency. The counterfeiting of the products is not only the loss of capital of the manufacturer as well as the consumer but it is also the concern of their safety. In today's scenario, we encounter hundreds of counterfeit products in circulation that are widely used by people all over the globe just because of their low cost and tempting offers. The proposed solution overcomes the limitations of its predecessors and complements the disruptive potential of blockchain technology. By carefully tracing the historical flow of goods in the supply chain, blockchain is incomparably stronger against counterfeit attacks Its decentralized architecture appears as a formidable watchdog, generating data prescribed is indestructible without stakeholder disagreement—an intrinsic property that strengthens the system against weaknesses.

1. Introduction

Counterfeiting of products is a major problem for businesses and customers around the world. They not only cause huge financial losses, but also undermine trust, quality, and safety. To fight against this menace, we need to adopt smart and effective measures that can deter, detect, and prevent counterfeiting. The global sales loss from counterfeit and pirated goods was estimated to be 3.3% of world trade in 2020, amounting to $509 billion. The clothing sector suffered the most from counterfeiting, with a loss of 26.3 billion euros1. In India, counterfeiting incidents increased by 24% in 2019, created an over Rs 1-lakh-crore loop hole in the economy. Counterfeiting and piracy pose a serious threat to the innovation, growth, and welfare of various industries worldwide. In this paper, we will look at some of the best practices and methods that have been used to protect genuine products from being copied or faked. We will also learn from the examples of how different industries have tackled this challenge successfully. The prevalence of counterfeit products is rampant in industries from fashion to pharmaceuticals, causing huge financial losses and putting unsuspecting customers at risk According to the Authentication Solutions Providers Association, the annual cost in India for finance alone is a staggering Rs 1 billion On the multifaceted challenges faced by consumers ranging from sub-par cosmetics, machine malfunctions due to counterfeit electronics, substandard clothing and footwear, the paper seeks to put an end to a complete solution based on blockchain technology will provide, empowering end users and suppliers to securely track product authentication throughout the supply chain does so [1].

The seizure of counterfeit handbags, clothing, and shoes by the United States Customs and Border Protection, which it was estimated that it will reach a retail value of about $1.5 billion by 2020, highlights the magnitude of the counterfeiting challenge plant Liars take advantage of loopholes in weak governance and policy, in forced internet use. As companies grapple with increased operating costs to combat counterfeits, the introduction suggests blockchain as a potent solution. The immutable and transparent nature of blockchain, with its attributes of immutability, complex structure, transparency, and audibility, makes it an ideal candidate for creating an anti-counterfeit system, rendering it formidable against malicious actors seeking accreditation for their illicit products. The potential applications of blockchain technology extend beyond the anti-counterfeiting realm, offering a decentralized and transparent system applicable to various industries consisting manufacturing, clothing, education, food, and healthcare. This adaptability positions blockchain as a versatile tool in the fight against counterfeiting [2,3]. In essence, this paper emerges as a magnum opus, synthesizing insights from a mosaic of previous works. It aspires to be a seminal contribution, untethered by plagiarism or content theft, presenting a holistic understanding of the anti-counterfeiting landscape, rooted in the transformative brilliance of blockchain technology. The journey begins — the quest for authenticity, guided by the unwavering light of blockchain brilliance [4].

Blockchain technologies have emerged as a great solution for the validation of several luxury merchandises and other legitimate products and for making sure that their integrity remains rigid and unaffected. The complexity of blockchain and decentralized databases involves multiple stakeholders and

various processes which makes it easy to ensure the authenticity and quality of the products and various drugs. From previous studies on the counterfeiting of products it is concluded that blockchain technologies have emerged as one of the best solutions to tackle the various challenges by providing a secure and safe system for tracking and verifying the movement of various products varying from several luxurious items, electronic to several drugs through the supply chain from the previous research works it is seen that the counterfeiting of the products is generally categorized in two major parts i.e., Deceptive counterfeits and Non-deceptive counterfeits.

The main objective in designing this system is to utilize blockchain technology and develop an anti-counterfeit system that can enhance and secure the security and integrity of the products by using the mechanism of generating QR codes and enabling the clients to access all the required details of the product. It will not only enable the integrity but also increase the product's transparency. This provides a system for identifying and preventing the availability of fake and counterfeit products in the marketplace.

The availability of counterfeit products in the present scenario supply chain has created an urgent requirement for a system that can be used to overcome counterfeit products and can help to keep a reliable and safe record of the products. The system proposed can be used with the implementation of blockchain and QR-based validation to tackle this counterfeit in the supply chain.

2. Literature Survey

In recent years, the counterfeiting of products played a vital role in the economy. This affects the sales and profit of the company. In today's scenario, counterfeited products have arisen as a huge problem in various industries ranging from medically prescribed drugs and high consumer luxury goods including watches, perfumes, beauty products, and leather goods to products such as several machines, expensive chemicals, rare drugs composition, spare parts, to commonly used consumer products such as toys, foodstuffs, clothes, and several electronic items. Counterfeited products are not only less effective and can the numerous health, safety, and economic risks and losses to the consumers but they also effectively affect the legitimate and genuine producers and manufacturers of several products.

G. Vidhya et al. [5] introduced a novel blockchain-based inventory management system integrating QR codes and OpenCV. By leveraging blockchain technology, the study aimed to establish a transparent and immutable ledger for monitoring stock items. The results demonstrated the system's efficacy in reducing stock errors and enhancing overall supply chain efficiency.

Jinhua Ma. et al. [6] presented a blockchain-based application system specifically addressing product anti-counterfeiting concerns. This innovative system utilized blockchain technology to establish a distinctive digital identity for each product, accessible and verifiable through smartphones. The examination concluded that the implemented system successfully curtailed the spread of counterfeit products, consequently bolstering consumer trust.

Detection of Counterfeit Products using Blockchain Wasnik et. Al. [7] in their paper proposed solutions varying from RFID-based systems, AI applications, and the use of public and private keys as QR codes and further the Scanning of QR code to decrypt the information of product. The RFID-based system was proposed to allow consumers to validate the legitimacy of the product in the store with the help of tags attached to them. This RFID-based system was suitable for large-scale implementation in the retail environment to tackle anti-counterfeiting.

The limitations in the previous system used the technology of QR codes, and RFID tags on the products for its validation. In this the QR code can be easily copiable and manipulated which can be further used to level the counterfeit product while in the RFID-based system, the RFID tags were easily cloned which makes it unsuitable. The AIML based application, and Convolutional Neural Network requires extra time, memory, training, and various testing phases before its actual deployment, and where this model fails to detect the validity of the product. To overcome this widespread problem of counterfeit products we proposed the blockchain-based system which involves the QR code-based system to identify counterfeit products and validate legitimate products.

3. Technologies

Blockchain: A distributed database which shares several nodes among the computer network. They are well known for their use in cryptocurrency (Bitcoin, Ethereum) for maintaining a secure and decentralized record of transactions. The use of bitcoin is not only limited to cryptocurrency but it is used to make the data immutable in any industry because it is very hard to change and alter the information stored in a block. Blockchains contain scripts that do the usual things you do in a database: enter and access information and save and store it somewhere. As it is distributed, by creating multiple copies and storing it on multiple machines, they all must match to work. The blockchain in the project is used to store the data of the products registered in the form of blocks in the database so that it adds an extra layer of security in the project because the data stored in the blocks is not easily accessible and editable [8].

Ethereum: Ethereum, a global blockchain-powered platform, utilizes Ether (ETH) as its native cryptocurrency. It enables the creation of secure digital solutions and offers tokens for compensating tasks and conducting transactions. Known for scalability, systematic design, security, and decentralization, Ethereum is the go-to choose for developers and enterprises transforming business operations and daily life. We used Ethereum in our project to pay the gas fees required during the commitment of any transaction related to the product like adding product details, seller's details, and so on.

Solidity: Solidity, created by the Ethereum Network team, is a specialized programming language for developing and executing smart contracts on blockchains. It generates machine-level code compiled on the Ethereum Virtual Machine (EVM). Dominant in Ethereum and used in private blockchains like Hyperledger Burrow, Solidity is essential for crafting business logic in smart contracts [9,10].

NodeJS: Node.js, a powerful open-source server environment, simplifies the creation of scalable and high-quality business plans for developers. Its cross-platform design ensures compatibility with various operating systems such as Windows, Linux, UNIX, and macOS. With Node.js, developers can seamlessly handle both front-end and back-end aspects of their applications. In our project, Node.js played a crucial role in server-side programming, emphasizing non-blocking and event-driven server deployment [11,12].

MySQL: SQL (Structured Query Language) queries form the cornerstone of prevalent open-source relational databases, serving as a key language for data manipulation and transformation within databases. Widely employed for managing data in applications, MySQL proves especially valuable in addressing scenarios related to counterfeit detection of goods.

Ganache: Ganache serves as a private blockchain tailored for Ethereum development, enabling developers to preview and deploy their decentralized applications (dApps) on the main Ethereum network. This platform offers a local blockchain environment with valuable features like an integrated Ethereum wallet, a block explorer, and a contract debugger. Notably configurable, Ganache allows developers to simulate diverse conditions, including network latency and mining challenges [13,14]. For Ganache to simulate real-world Ethereum communities, architects can choose to address any capacity issues before implementing their dApp principal network, to ensure smooth and robust delivery.

PROPOSED WORK

The main goal of the proposed system is to develop a system that can overcome the counterfeiting of products and improve the economy.

- To develop a fake product validation system using blockchain to protect brand value and its integrity.
- To validate the details of the products which helps in its easy identification and traceability throughout the supply chain.
- All the necessary details of the product are secured and stored in a unique QR code which is further used in identification and stored in the block of blockchain for enhanced security.
- Manufacturers can easily add and generate a unique QR code which can be further used by retailers, distributors, and even customers to ensure that the product bought is original.

Nowadays, with the boom in technologies, there is a problem with easily differentiating original and counterfeit products. This has also caused a lot of damage not only to the manufacturer but also to the retailer as well as the consumer. Therefore, to tackle this problem a blockchain-based application for product validation is proposed. Our suggested approach involves blockchain technology in the complex supply chain network of the product with an effort to strengthen the integrity of the product and stop the spread of counterfeit goods [15].

Manufacturer End

The voyage of the product begins at the manufacturer's doorstep itself where the necessary details like the product's name, serial number, manufacturer ID, model ID, and product ID are carefully documented to create a unique QR code for every product which functions as a digital encryption representing the individuality of the product.

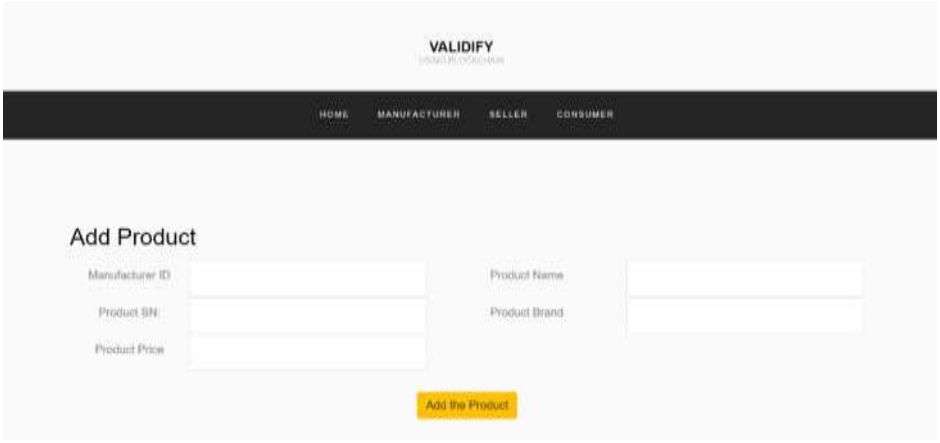

Fig. 1. Interface to add the product

Fig. 1 shows the manufacturer's interface where the products can be added to generate the unique QR code. As an expansion of the data repository, we also need to capture the more required details of the product as it moves from manufacturer to distributor which includes the supply chain information of the vendor ranging from name, brand, code, contact number, address, and manufacturer ID are carefully recorded. Further, the combination of the

manufacturer and distributor data details results in the data creation which is safely kept in blockchain. The decentralized structure of blockchain ensures the data integrity against unwanted changes and more importantly, it also maintains transparency of the data.

Distributor End

At the end of the distributor, the details of the products are matched by scanning the QR code of the product and matched with the database. Once they are matched it is sold to the consumer by entering the required necessary details and where the location, and date of selling the product are stored.

Fig 2. Interface to verify the product

Consumer End

The above Fig. 2. describes that an end user can verify the authenticity of the product bought. When the product reaches the end of the supply chain then the customer can easily validate the authenticity of the product by scanning the QR code and can easily check whether the product is authentic or it is counterfeit. Once it is done then the customer can be assured that the product is legitimate and this can also happen when the product data is matched with the data stored in the blockchain.

CONCLUSION

In conclusion, the proposed blockchain-based product validation system presents a robust solution to the pervasive issue of counterfeiting in the market. By leveraging blockchain's decentralized and transparent nature, the system ensures the integrity of product information throughout the supply chain. The unique QR code assigned to each product serves as a digital fingerprint, enabling manufacturers, distributors, and consumers to easily verify authenticity. This innovative approach not only protects brand value but also instils confidence in consumers, fostering a more secure and trustworthy marketplace. The integration and addition of blockchain technology mark a significant stride towards eliminating counterfeit products and bolstering economic growth.

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