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Fake Product Detection with Blockchain Technology

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Abstract

Consumers and brands are at serious risk due to the growth of counterfeit goods, especially in regions like Nigeria. Conventional techniques, such border inspections and market raids by the Standards Organization of Nigeria (SON), are inadequate for detecting counterfeit goods. To ensure traceability, transparency, and immutability in the supply chain, this article suggests utilizing blockchain technology. The decentralized and encrypted characteristics of blockchain, when bolstered by smart contracts, enable efficient product tracking from producers to end users, hence impeding the infiltration of fake goods. Using a permissioned blockchain network, this system attempts to confirm the legitimacy of products at every point along the supply chain—manufacturers, distributors, retailers, and end users. The Remix IDE is used to deploy and test Ethereum-based smart contracts that were created in Solidity for the proposed system. This blockchain-based strategy aims to decrease the spread of counterfeit goods, protect consumer confidence, and preserve brand reputation. To offer a user-friendly interface for wider accessibility, future advancements will link this system with decentralized apps (DApps).

Keywords: Blockchain, Fake Product, Decentralized Apps (DApp), Smart Contract.

1. Introduction

Fake products are counterfeit products, goods copying the style, appearance and likeness of another good or product usually of inferior (lower) quality, usually sold under the brand name of a popular product. As the development of a product improves so does its popularity and most importantly its market, but these also come risks such as counterfeiting,

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duplications and a host of other acts that can tarnish the image of the brand in the form of fake product. Identifying these fake products in the market or in circulation is of the utmost importance, and is also a great task for the consumers who suffer first-hand the bad experience of using a fake product. It is necessary for the users(consumers) to be able to check the counterfeit product and verify the authenticity of a product before purchase [1].

There is rarely any form of consequence for selling fake products as the sellers most times cannot be held responsible for their actions as they easily change locations or simply cannot be tracked. With the increased usage of online local stores; small vendors who peddle fake products, especially third-party sellers on e-commerce platforms, the increased usage of e-commerce platforms has increased the risks of fake products [2].

In Nigeria, the Standards Organization of Nigeria (SON) is the body charged with enforcing compliance with standards for the purpose of protecting the Nigerian citizenry from fake and substandard products. And it achieves its main aim by compiling Nigerian industrial standards, compiling product inventory for standardization, and ensuring standard measures among a host of other activities [3]. Nigeria being the most populous country in Africa and a large market for various products is facing an epidemic of fake products with places like Yaba and the Lagos Island markets in Lagos and the Aba market in Abia state, including e-commerce platforms being the major hubs where buyers face the problems of having to deal with a large number of fake products which are often sold as original products, with packaged foods, pharmaceuticals, footwear, clothing, leather products, automotive spare parts, cosmetics and cables being the products most counterfeited and flooding the Nigerian markets [4].

SON was established by an enabling act number 56 of December 1971. However, in monitoring the circulation of fake products, SON uses traditional methods of border checks, open market raids, product registration, and on-site factory testing all of which are not enough. SON is partnering with the National Agency for Food and Drug Administration and Control (NAFDAC) to bring up product scratches and text code for confirmation of a product, which is good but still not enough [5]. However, with advances in technology, specifically the Blockchain technology which is a cutting-edge technology and has limitless application, the problem faced by SON can be tackled by its adoption.

Blockchain is a powerful and emerging technology whose effectiveness presently cannot be compared to any other technology, and can be used in the identification of these fake

products that are in circulation [6]. Blockchain is a type of distributed ledger that stores data in a sequential form immutably in a manner that is decentralized with encryption and consensus algorithm [7]. Blockchain is designed to prevent tampering using smart contracts, encrypted and distributed algorithms, the study intends to use this to detect fake products [6]. The present distribution chain lacks clear visibility in the transfer of goods(products) from the manufacturer to the final users, this provides a gap that has been exploited with the circulation of fake products [8]. The adoption of blockchain technology comes with a variety of advantages which include transparency. Blockchain has an architecture that supports traceability, transparency, and immutability which ensures that data records created on the network cannot be changed thereby eliminating the creation of fake product records in the network [9]. Smart contracts will be utilized in product identification to provide non-tamperable information to supply chain participants, including the ultimate consumer. All product-related data and agreements between participants will be stored on the blockchain network, beginning with manufacturer and product data [6]. Once a product detail is stored on the Blockchain network, a hash code is generated for that product enabling the maintenance of all transaction records of the product to the final consumer, the transaction records can be the movement of the product through the product supply chain, with all transactions stored in a chain of blocks on the network [1].

The use of Blockchain technology in the identification of fake products allows for the on-the-spot verification of a product and if a product on the network is below standard, the manufacturer can be held accountable and compensate for damages, however, the purchase of produced not registered on the network will be the sole responsibility of the consumer. The key contributions of the research include the following:

i. Identifying the problem faced by the organization charged with maintaining and regulating the quality of products within the country

ii. Proposing a solution that makes use of the Blockchain technology because of its transparency, traceability and immutability which would prevents the abuse or manipulation of the system.

iii. Finally, the paper identifies all the actors involved in the flow of products from the manufacturers down to the final consumers, detailing their roles, and how they interact with the system, all of which is defined in the Smart Contract.

1.1 Problem Statement

The problems associated with fake products cannot be overemphasized, and it also causes long-term damage. From reducing the sales of an authentic product to damaging the reputation of a company making similar products, destroying the trust and loyalty to a product that has taken years to build to sometime forcing companies to pay for damages. All these, form a huge economic burden to a manufacturer [7]. Additionally, the use of fake products, which are often of low quality, can harm the users, leading to unnecessary expense both in terms of health and finances. Customers may need to replace the fake product before its intended time or avoid using them to prevent potential accidents [8].

2. Related Work

Mirabelli et al. [9] discussed the use of Blockchain technology in the traceability of products, defining traceability "as the ability to access any or all information relating to a product under consideration throughout its entire cycle (from creation by the manufacturer to final purchase by the consumer) using recorded identification". Traceability can be done in two ways: Tracking which is following the product from the beginning of the cycle to the end and Tracing which is reconstructing the history of the product with information recorded of the product at each chain stored in blocks. Blockchain enables the monitoring of a product this way, it can also be used to preserve transaction history, including parcel numbers (unique identifiers) and data like a person's legal and natural identification number. Additionally, transaction rules and transaction validity checks can be implemented, because many countries have successfully implemented blockchain technology and achieved positive results, the Nigerian government (all three tiers; Federal, State, and Local Government) should train all land administration stakeholders on how to use and implement blockchain at all levels to modernize the system for proper record keeping [10].

A blockchain-based management system was proposed that works on smart contracts and is used to provide comprehensive provenance information to both consumers and producers. The system makes use of two main methods; representing physical goods in the form of digital tokens and processes that enables a transformation functionality that will validate cross-business traceability including: certifying goods, transferring, splitting and, combining tokens. A smart contract is created for each type of product, with tokens representing physical products, each token corresponds to a product that can be measured in

items and weight. Product information is stored through IPFS or Swarm by adding their corresponding hashes [10]. According to [11] as there are no proper solutions in tackling the problem, barcodes are easily copied and give no guarantee of differentiating fake products from originals. The proposed system makes use of distributed applications (DApps) which will be used in accessing a network developed on the Hyperledger fabric (HLF) using the Delegated Proof of Stack (DPoS) or Practical Byzantine Fault Tolerance (PBFT) consensus algorithm. The system allows the enrolment of a product to the network, monitoring the movement of the product through the chain of supply and accessing by the customers. The customers will be equipped with android applications to scan the QR codes on the product and request a code to confirm the authenticity of the product thereby concluding the purchase. Also, [12] proposes a fully functional anti-product forgery system; by paying a very low transaction fee, users of the system need not be concerned about the possibility of purchasing a counterfeited product. Manufacturers can use the system to store relevant information on product sales in Blockchain which is accessible to everyone. The total amount of sales that can be sold by the seller and the number of products currently left by the seller are transparent. The user can use the functions provided by the system to immediately perform vendor-side verification. The system provides identity verification by using digital signatures. There are no other means to decrypt the private key of the key owner unless the key owner accidentally leaks the key.

A blockchain supply chain system is proposed by [13] that authenticates each product and detects counterfeits, in two phases; the initialization phase and the verification phase. Initialization is done by the manufacturer with each manufactured product equipped with an NFC tag containing the product details. Each NFC tag is registered as a genesis block of the supply for that product, and signs the product using the digital signature of the manufacturer, upon shipping of the goods the genesis block is broadcasted to the network. The verification is done by the supply chain nodes as the product goes through the supply chain, and is verified locally and globally. The application of blockchain to the supply chain brings about transparency in the procurement of products, removes hidden payments made to middlemen, develops smart contracts for payments eliminates the delays in payment for products, and improves tracking of goods purchased. The research also identified the most important questions in the usage of blockchain technology in identifying the issues of the traditional supply chain and solving them. [14].

A literary survey was performed on the various applications of blockchain technology to the supply chain and concluded that many of the suggested applications of blockchain in the supply chain for tracking and tracing products have been practically tested in the industrial environment, and suggested the integration of more ICT with blockchain, conducting studies on the security and privacy in assessing cloud databases for consumers [15].

3. Proposed Work

The proposed system aims to make use of permissioned blockchain [17] network based on Ethereum network to retain the advantages of the network, identifying fake products with blockchain technology. A permissioned blockchain network works in a constrained environment, such as a closed network, or is owned by a single entity. The permissioned blockchain is the selected network type because it provides controlled access and restricts participation to the network to only manufacturers, distributors, and retailers who have registered to regulatory authority, in this case the Standard Organization of Nigeria (SON). The most common networks are public, allowing the details of transactions to be easily accessible down to the wallet addresses involved in the transactions due to the public nature of the networks, to address this, the permissioned Blockchain will only allow registered actors of the supply chain to provide privacy for the actors and their products from piracy and abuse of proprietary information.

Finally, the permissioned blockchain will have a lesser number of users when compared to the public blockchain, which would make the network faster in verifying the authenticity of products and making tracking easy in case of products with defaults. The criteria for selecting the permissioned blockchain can be summarized into: Controlled access, Privacy, and Efficiency. Blockchain has an architecture that supports traceability, transparency, and immutability which ensures that data records created on the network cannot be changed thereby eliminating the creation of fake product records in the network [16]. In product identification, smart contracts will be used to present non-tamperable information to members of the supply chain including the final consumer, with all information regarding the products and agreements between the members stored on the blockchain network starting with the manufacturer information and product information [6]. A product's hash code is generated once it is stored on the Blockchain network, allowing for the maintenance of all transaction records for the product up until the point of sale. Transaction records can include the product's movement

through the supply chain, with all transactions being stored in a series of blocks on the network [1].

The actors in the supply chain are identified and given clearly defined functions and roles, the actors include manufacturers, distributors, retailers, and customers. The chain of distribution will be set up as a permissioned blockchain with all the actors in the supply chain having controlled access to the blockchain network. The manufacturer alone can create a chain, by creating a genesis block of product information by registering a product to the network.

The next actor in the supply chain will be the distributor or wholesaler who has the permission to only verify the arrival of products, verifies the authenticity of the product, and prepares the product for forward movement along the supply chain. The retailer is the last actor in the supply chain before the customer, the retailer is responsible for distributing products in consumable quantities to the consumers, and the consumer verifies the authenticity of the product before its delivery to the final consumer.

The final consumer on the supply chain is the last actor in the private blockchain. Figure 1 shows a diagrammatic representation of this chain.

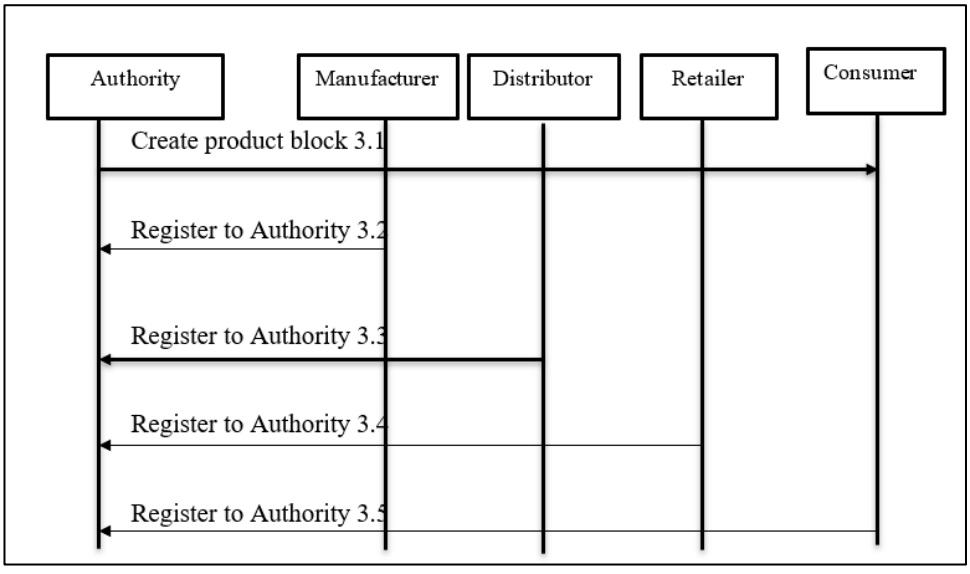

Figure 1. Supply Chain Network

The Supply Chain Network diagram shows the major actors of the supply chain with an arrow starting from the Authority and ending on the customer, this indicates the creation of a product block with 3.1 labelling indicating it is the starting point. This means a product has been registered on the network, and as it flows it will be tracked.

A high-level view of the proposed solution of the fake products in the supply chain is shown is Figure 2

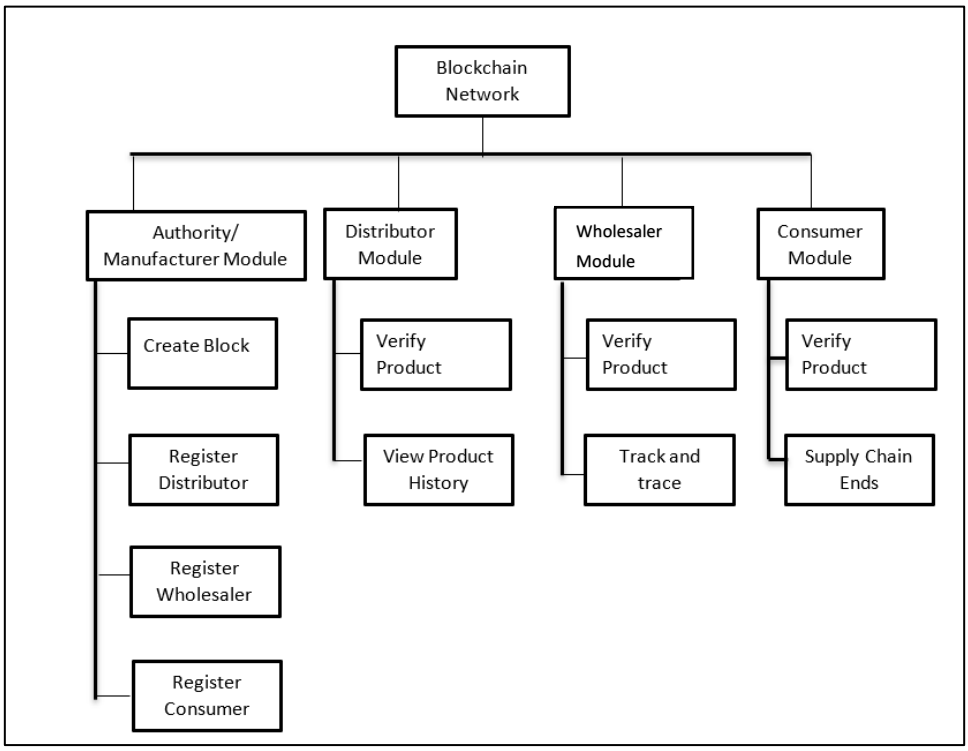

Figure 2. High Level Overview of the Network

The authority/manufacturer module is the first module and creates a block containing the information about the product. For the manufacturer to efficiently make use of the blockchain network, the database contains the details of the of the products, distributors, and consumers. It makes tracking and tracing of a product seamless and prevents the switching or replacement of products with a fake.

The distributor and wholesaler modules enable the verification and tracing of products as they move along the supply chain, this ensures the authenticity of the products. The consumer module is the last module and the last actor in the blockchain, upon purchase of a product the consumer also verifies the authenticity of the product before use.

Authority/ Manufacturer Module: This module allows the Standards Organization to register manufacturers and products on the network and allows the Organization to monitor the distribution of products in the chain while also allowing the manufacturer to regulate the network, responsible for creating a genesis block, and registering the different actors of the supply chain.

Distributor Module: The module that allows the distributor to verify, track and trace products within the network.

Wholesaler Module: The module responsible for the low-quantity acquisition, verification, and validity of products

3.1 Architecture of the Proposed Work

The architecture of the system showing the key actors of the fake product detection system is shown in Figure 3.

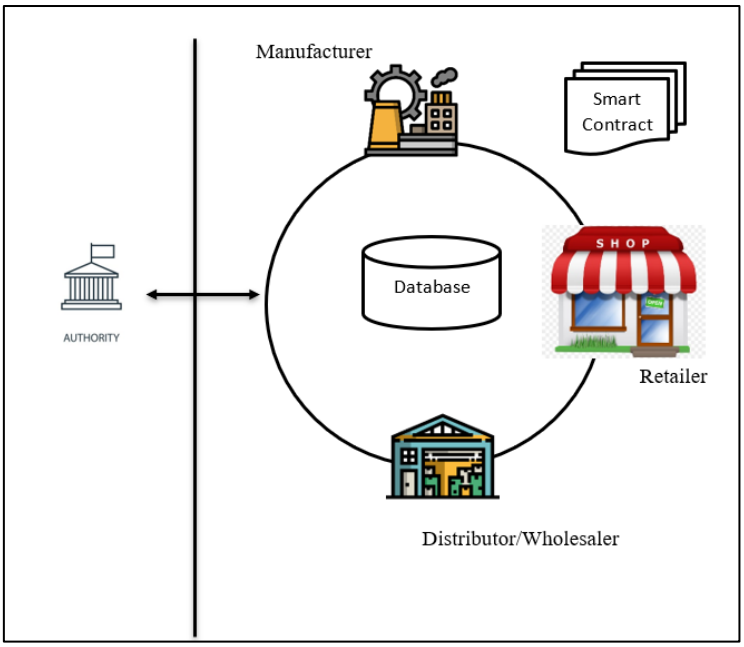

Figure 3. Architecture of Fake Product Detection

The Authority: The Authority is responsible for setting up the network and registering the Manufacturers, Distributors and Retailers. These is to enable the registration of products to the network by the Manufacturers and tracking their movement down the supply chain.

The Manufacturer: Product makers that are registered to the network are considered licenses by the authorities to manufacture goods. The manufacturer creates a genesis block by registering a product to the network, containing the information and details of the products, and generates a hash code for each.

The Distributor: They will verify the authenticity of products purchased from the manufacturer, and update the Blockchain network on the movement of the products, thereby enabling tracking.

The Wholesaler: Purchase from the Distributor and market to the consumer, they also verify the authenticity of products purchased from the Distributors and update the Blockchain network.

The Smart Contract: The smart contract is set of programmable instructions that control and regulate how the network functions, the verifying of products, updating of the network and tracking are all enabled by the Smart contract.

The Database: The Blockchain network itself is a database storing the details of products and information, however, once the system is integrated with a Frontend for user interaction, images for the products would be stored on Interplanetary File System (IPFS), which is also a distributed storage system that works together with the Blockchain network.

The Consumer: The last link of the supply chain, the consumer would interact with the Blockchain network through a Decentralized Application (DApp). The consumer can verify the authenticity of the product purchased from the retailer. Further work would include the development of a Decentralized Application to enable this.

3.2 Technology Stack

The paper focuses on the development of the backend component for the Fake Product Detection system, the technology stack includes the following:

i. Blockchain Network: The Ethereum blockchain network, a decentralized platform known for its powerful smart contract capabilities, is utilized for the fake product detecting system, because it allows the creation and implementation of smart contracts, which are self-executing and have the terms of the agreement explicitly written into code. After it is created, the contract is put into use on the Ethereum network. To develop and test the smart contract, the Sepolia test network is utilized. Sepolia is a Proof-Of-Stake (PoS) testnet of the Ethereum network, designed to simulate the main Ethereum network's environment without the need for real Ether (ETH) for transactions. By using Sepolia, developers can write, test, and deploy smart contracts in a controlled and cost-effective manner, ensuring that the contract functions correctly before deploying it to the main Ethereum network.

ii. The smart contract for the fake product detection system is written using Solidity, a high-level programming language specifically designed for implementing smart contracts on the Ethereum blockchain. Solidity version 0.8.0 is used in this project,

which offers various features and improvements over previous versions, such as enhanced security mechanisms to prevent common vulnerabilities and support for new language features.

iii. The Remix IDE (Remix Integrated Development Environment), serves as the development environment for the fake product detecting system. Specifically developed for creating, evaluating, and implementing smart contracts on the Ethereum blockchain, Remix IDE is an effective and intuitive tool. Benefits of the Remix IDE include syntax highlighting, autocompletion, and error checking to guarantee accurate and effective code. The smart contract is deployed straight from the Remix IDE to the Ethereum blockchain following extensive testing and validation.

iv. For the blockchain interaction, Ethers.js which is a JavaScript library is used for the interaction with the network. Ethers.js is used to communicate with the Ethereum blockchain smart contract within the framework of the fake product detection system. It makes it possible for the system to send transactions for product registration, authenticity verification, and supply chain tracking. Ethers.js ensures the integrity and openness of the product information by effectively reading and writing data to the blockchain.

3.2.1 Smart Contract Development

Several clearly defined phases will be involved in the creation of the smart contract for the fake product detecting system. To identify the roles (producer, wholesaler, distributor, and consumer) as well as their unique rights and responsibilities within the supply chain, the requirements will first be collected and examined. The structure of smart contract is developed based on this, defining features for tracking, endorsement, registration, and verification of products. The programming language used to create Ethereum smart contracts is Solidity. Coding the contract to incorporate features like register will be part of the development for manufacturers to record new items and to obtain the product's history, product for actors to verify the legitimacy and status of products. Figure 4 shows the code snippet of the Smart Contract.

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract ProductSupplyChain {
    enum ActorRole { Manufacturer, Distributor, Retailer, Customer }

    struct Actor {
        address actorAddress;
        ActorRole role;
        bool isRegistered;
    }

    struct Product {
        string productId;
        address manufacturer;
        address distributor;
        address retailer;
        address customer;
        bool isAuthentic;
    }

    address public regulatoryAuthority;
    mapping(address => Actor) public actors;
    mapping(string => Product) public products;

    event ActorRegistered(address actor, ActorRole role);
    event ProductRegistered(string productId, address manufacturer);
    event ProductVerified(string productId, address verifier, ActorRole role);
    event ProductSold(string productId, address customer);
```

Figure 4. Snippet of Smart Contract Code Written in Solidity

After the writing of the Smart contract, it is then compiled and checked for errors, which are corrected and then compiled.

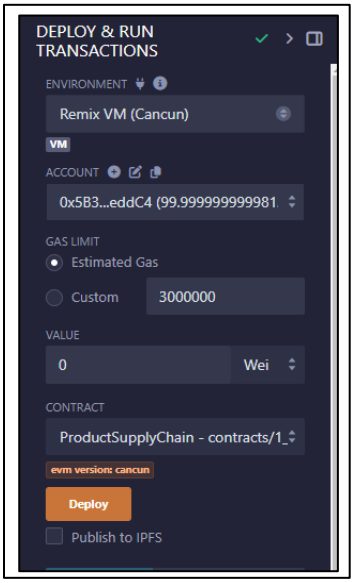

Figure 5: Screenshot Showing the Deploy Button

After the smart contract has been compiled, it can then be deployed onto the network, the deployment is simply adding the code to the Ethereum network as shown in Figure 5.

4. Results and Discussion

The Solidity programming language, which was created especially for creating smart contracts, is used to create the smart contract. Remix IDE, a specifically designed tool for creating, testing, and implementing smart contracts straight in the browser, is used to build and

implement the contract. The smart contract is assembled and put through a rigorous security and functionality test in Remix IDE before being deployed. Using the integrated deployment tools in Remix, the contract is released onto the Ethereum test network when it has been verified to be functioning properly. Remix IDE offers an intuitive interface for deploying contracts to several Ethereum networks; test networks were the ones utilized in this instance.

The smart contract has been deployed and is now active on the Ethereum network. To maintain security and transparency throughout the product lifecycle, this contract keeps track of and records product information. Products may be verified and tracked by a variety of parties, including customers, distributors, and wholesalers, once manufacturers register them on the blockchain. All products not registered on the network are considered fake products, as manufacturers are expected to register all products on the networks.

There is no frontend interface or connection with a decentralized application (DApp). The implementation and operation of the smart contract on the blockchain are the only things under consideration. The smart contract itself is the primary element assuring the authenticity and traceability of items for the time being, but future steps will require developing a DApp and combining it with the contract to create a user interface for interacting with the blockchain. Figure 6 shows an overview of Remix IDE with the Smart Contract “ProductSupplyChain” being written and deployed.

Figure 6. Deployed Smart Contract

Figure 6 shows the transaction hash, block hash, contract address and the wallets which initiated the deployment. All these information can be used to identify the Smart Contract on the network.

5. Conclusion

In conclusion, a major step forward in guaranteeing product authenticity and safeguarding customers is the creation of a smart contract that uses Blockchain technology to identify counterfeit goods. Through the utilization of Blockchain's distinct characteristics, including transparency, traceability, and immutability, the smart contract facilitates the safe and independently verified documentation of product details.

By ensuring that only genuine products are sold, this smart contract lowers the amount of counterfeit goods on the market and safeguards brand reputation. The smart contract achieves this by implementing a secure, transparent, and immutable ledger where each product's journey from manufacturer to consumer is recorded. Each product is assigned a unique digital identity that can be tracked and verified at every stage of the supply chain. Consumers can easily access the product's history and verify its authenticity through a simple scan, increasing confidence in the brand.

Also, because every transaction in the smart contract is encrypted and connected to the one before it, establishing a safe chain of custody, the adoption of blockchain technology lowers the possibility of fraud and manipulation. This makes it easier to identify and remove fake goods from the market in addition to discouraging counterfeiters. As a result, companies can lessen the possibility of losses and legal problems related to counterfeit items, preserve consumer trust, and protect their intellectual property. Businesses may improve overall market integrity and guarantee that consumers receive only genuine, high-quality products by utilizing blockchain-enabled smart contracts.

Solidity is used to create the smart contract, and the Remix IDE is used to deploy it on the Ethereum test network. This provides a stable environment for creating, testing, and executing the contract. While the deployment and functionality of the smart contract are the only things being worked on right now, future enhancements will involve combining it with a Decentralized Application (DApp) to offer a user-friendly interface for more engagement and accessibility. This Blockchain based solution benefits producers, distributors, retailers, and consumers alike by providing a promising method to fighting the problem of counterfeit items.

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