COUNTERFEIT MEDICINE AUTHENTICATION SYSTEM USING BLOCKCHAIN AND IOT

A Blockchain-Based IoT Solution for Combating Counterfeit Medicine

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Abstract: The pharmaceutical industry is currently dealing with many problems. Nowadays, there are many fake drugs in the pharmaceutical industry. Health research groups estimate that 10% to 30% of drugs on the market are counterfeit. All over the world, this deadly problem brings with it many health risks. The World Health Organization estimates that this problem is getting worse in almost every region of the world. Because the drugs are used in many different networks, it is difficult to detect fake ones. By integrating blockchain technology into the network, pharmaceutical products will become safer. Medicines are tracked with information from every area of the network, allowing the identification of counterfeit medicines. Blockchain security increases system transparency and reliability. The program focuses on quality medicine, occupational safety and data protection using blockchain technology. This project identifies counterfeit medicines, increasing the trust of the system and helping blockchain become a stable and widely used technology. IoT technology is also used to detect whether counterfeit drugs are being distributed.

Index Terms: Blockchain, Smart Contracts, IoT, Drug supply chain, Fake drugs.

I. INTRODUCTION

At a time when technological advancement is reshaping industries, the medical industry is not immune to the wave of change. The fact that counterfeit medicines pose a serious threat to public health underscores the need for strong certifications to ensure the safety and effectiveness of medicines. The project aims to solve this important problem by offering new solutions that use the power of the Internet of Things (IoT) and blockchain technology. We are revolutionizing the way we ensure the integrity of medicines in the supply chain. With counterfeit drugs entering the market, there is an urgent need for reliable and tamper-proof authentication systems. The data is not modified to be shared. At the heart of CMAS is a network of IoT devices embedded in devices. These devices are equipped with sensors and communication modules that enable continuous monitoring of various parameters such as temperature, humidity and location. Information is now securely recorded on the blockchain, making it transparent and traceable at all stages of drug use. Using the Internet of Things, the system can detect the difference in storage quality, thus reducing the risk of drug abuse. The use of smart contracts in blockchain makes it easier to verify identities. Smart contracts are self-signed contracts with predefined rules and conditions. In the context of CMAS, smart contracts identify chemicals at each control point in the supply chain. If the process is successful, transactions are verified and added to the blockchain, making it secure and efficient. Information about the drugs they

purchased. Through a user-friendly interface, customers can access detailed information about product activity, delivery dates and facts by scanning the Generated ID available on the website.

The ability to make informed decisions that create a safe healthcare environment. CMAS also contributes to the larger goal of combating the global problem of counterfeit medicines. The system's decentralized nature and transparency facilitate collaboration between stakeholders, including companies, distributors, regulators and physicians. This collaboration supports the entire pharmaceutical ecosystem, making it more resilient to the threat posed by counterfeit drugs. A huge leap forward. The urgent problem of counterfeit drugs. As we enter this transformation process CMAS has the potential to reform the field of pharmacy certification.

II.   LITERATURE SURVEY

A literature review is an overview of the works that recognized academics and researchers have published on a certain subject. It comprises the state of the art, encompassing significant discoveries as well as theoretical and methodological advancements on a given subject. Reviews of the literature do not present newly conducted experiments; instead, they rely on secondary sources. A literature review enables us to improve and showcase our abilities in two primary domains: locating knowledge and evaluating it critically.

2.1 BLOCKCHAIN BASED COUNTERFEIT MEDICINE AUTHENTICATION SYSTEM.

[1] Without a trusted system and a strong monitoring authority, syndicates can easily produce counterfeit drugs. With the shift of life-critical health care, it becomes a necessity to provide low-quality medicines. Because counterfeit medicine has a deadly effect on the human body and has disastrous consequences. To detect counterfeit medicine, They designed a medicine tracking system using blockchain technology. The system is able to detect non-standard and anomalous drugs from the manufacturer to the patient's hand. It can also verify defective and expired drugs in the market using smartphones by scanning a QR (Quick Response) code. Blockchain security could make the system more transparent and reliable. The aim of this paper is to ensure drug quality, transaction security and data security using blockchain technology.

This system involve the use of smart contracts, decentralized databases, and cryptographic techniques to ensure the authenticity and traceability of pharmaceutical products throughout the supply chain.

2.2 BLOCKCHAIN BASED APPLICATION TO TRACE HEALTHCARE SUPPLY CHAIN ACROSS SRI LANKA.

[2]Healthcare Supply Chain (HSC) traceability involves a wide range of stakeholders, including raw material suppliers, manufacturers, distributors, regulatory authorities, pharmacies, hospitals, and patients. For a HSC system that is unalterable, trustworthy, accountable, and transparent, blockchain-based drug tracking offers a promising solution. In this piece, they examine the challenges associated in tracking products within the HSC and then go on to discuss how blockchain technology may be used to effectively combat counterfeit pharmaceuticals by providing a provenance, track, and trace solution. To fulfill the fundamental requirements for drug tracing, such as confidentiality, honesty, openness, safety, authentication, and scalability, they had introduced two different blockchain-based decentralized architectures: Hyperledger Fabric and Besu. They highlight many open research issues about blockchain technology's potential for use in medication tracking and provide answers to those questions. Research and Development motivation toward the Health Informatics Sector now has a useful guide for creating and implementing a comprehensive blockchain-based solution for the healthcare industry in Sri Lanka.

This paper discusses how blockchain can improve the traceability in the healthcare supply chain sector.

2.3 DRUG GOVERNANCE: IOT-BASED BLOCKCHAIN IMPLEMENTATION IN THE PHARMACEUTICAL SUPPLY CHAIN.

[3] Pharmaceutical drugs are essential in diagnosing and treating patients. However, over the past decade, the issue of fraud and abuse drugs in the pharmaceutical supply chain has become increasingly apparent. To solve these problems, a transformation of the current pharmaceutical supply chain to include tracking technologies, from the source of the ingredients to the consumer, is recommended. In this paper, they investigated the novel pharmaceutical governance based on IoT and Blockchain technology. Internet of Things (IoT) based blockchain is a type of distributed ledger (DLT) that maintains an immutable record of all transaction information that is incapable of being falsified and is visible to all participants. Implementing an IoT-based blockchain system would provide the tools for the pharmaceutical industry to improve drug governance along the supply chain, thus making healthcare more efficient and reliable.

2.4 BLOCKCHAIN TECHNOLOGY IN THE FUTURE OF HEALTHCARE.

[4] Healthcare supply chains are complex structures spanning across multiple organizational and geographical boundaries, providing critical backbone to services vital for everyday life. The inherent complexity of such systems can introduce impurities including inaccurate information, lack of transparency, and limited data provenance. Counterfeit drugs is one consequence of such limitations within existing supply chains which not only has serious adverse impact on human health but also causes severe economic loss to the healthcare industry. Consequently, existing studies have emphasized the need for a robust, end to-end track and trace system for pharmaceutical supply chains. Therein, an end-to-end product tracking system across the pharmaceutical supply chain is paramount to ensuring product safety and eliminating counterfeits. Most existing track and trace systems are centralized leading to data privacy, transparency, and authenticity issues in healthcare supply chains. In this paper, an Ethereum blockchain-based approach leveraging smart contracts and decentralized off-chain storage for efficient product traceability in the healthcare supply chain is presented. The smart contract guarantees data provenance eliminates the need for intermediaries and provides a secure, immutable history of transactions to all stakeholders.

In this paper, the challenge of drug traceability within pharmaceutical supply chains are investigated and highlighting its significance especially to protect against counterfeit drugs. It is developed and evaluated a blockchain-based solution for the pharmaceutical supply chain to track and trace drugs in a decentralized manner.

2.5 BLOCKCHAIN-BASED SECURE FRAMEWORK FOR E-LEARNING DURING COVID-19.

[5] Tremendous growth of information and communication technologies (ICTs) have positively affected the field of E-Learning (EL). However, recently the education mode is shifted from the traditional classroom towards EL due to widespread COVID-19. The selection of suitable EL tool and security of EL data and environment are still the key challenges that need to be addressed. The objective of this paper is to guide the EL Practitioners in the selection of suitable EL tool and to provide a detailed framework for maintaining privacy and security of EL data and environment. Purpose: This study aims to help EL practitioners in the selection of suitable EL tool and to provide a secure framework for the security of EL data and environment. Method: Realtime statistics are gathered and analyzed to visualize the impact of COVID-19 on education around the world. The increasing demand for EL during COVID-19 is analyzed, and a detailed taxonomy is provided to make the EL practitioners aware of existing distance learning solutions. A comparison of commonly used EL tools is provided that will help in the selection of EL tools according to institutional requirements. A Blockchain-based EL framework is proposed that will help EL designer in managing the security of EL data and environment. Conclusion: The proposed framework is expected to provide a promising solution for developing a fair and open learning online education environment and will overcome

the deficiencies caused by school closures during COVID-19.

This research proposed a secure EL framework using the Blockchain. The proposed Blockchain-based layered architecture for implementing security in existing EL solutions. In the future, they are planning to test the proposed framework by implementing it in a real-life EL system.

2.6 BLOCKCHAIN-BASED SMART TRACKING AND TRACING PLATFORM FOR DRUG SUPPLY CHAIN.

[6] The arising awareness of drug safety has brought tremendous demands on improving traceability and transparency in the supply chain. Conventionally, centralized/distributed database-based traceability platforms are adopted by many drug companies to control drug quality and improve transparency levels. However, it is still challenging to link drug stakeholders into an information-sharing chain due to the potential data manipulations and interest conflicts. In this context, this paper proposes a unified five-layer Blockchain and Internet of Things-based smart tracking and tracing (BIoT3, in short) platform to provide a decentralized traceability solution in the drug supply chain. Following the five-layer blockchain platform architecture, a practical roadmap is provided for the drug industry to achieve blockchain design, development, application, and evaluation. Moreover, three core enabling components are presented: IoT-based drug identity management, on-chain off-chain mechanism, smart contract enabled drug services. According to the real data from collaborating companies, the feasibility and efficiency of the BIoT3 platform have been verified using Hyperledger Fabric blockchain. The case study demonstrates that it not only gains useful insights into transaction sizes configuration for optimal blockchain performance, but also provides a feasible blockchain-based solution for drug traceability and visibility.

It consists of various smart IoT assets, e.g., QR code, RFID tags, and readers, sensors, etc. Notably, the typical scenario of the drug supply chain is shown at the bottom . The collected data will be transferred to the IoT gateway. Notably, IoT gateway defines, configures, and analyzes the data, such as the origin of raw material, drug manufacturing data, drug logistics data, etc. Those data have three typical features: constant accumulation, the large data scale, and continuous refinement of data granularity. The core of the off-chain layer is the blockchain gateway, which serves as a middleware. It has three critical components, including device management, data validation, and data cache. Device management refers to each IoT device having a unique identity, such as public and private keys. The data validation is conducted to verify the transaction data structure and device identity. Data storage is used to store transaction data until the data uploaded to the blockchain network. The input data of the blockchain gateway comes from two parts: IoT assets and enterprise information systems. The format of the input data is predefined using a JavaScript Object Notation (JSON) file. The outputs of the blockchain gateway are the transactions to the blockchain network from drug stakeholders. The blockchain layer contains consensus, smart contract, cryptography and peer-to-peer (P2P) network, etc.

This paper introduces a blockchain-based smart tracking and tracing platform to achieve a transparent, secured, and integrated drug supply chain. Firstly, a unified five layer blockchain architecture is systematically designed to track and trace drug production, logistics, sales, and usage. Secondly, an on-chain and off-chain standard is built to determine whether the drug data is put on-chain or off-chain storage

2.7 BLOCKCHAIN AND AI IN PHARMACEUTICAL SUPPLY CHAIN.

[7] At present, counterfeit drugs pose a serious threat as it is difficult for people to know the true value of purchased medicines due to a significant lack of transparency in the current system. Also, tampering within the supply chain is difficult to investigate when suspicion of illegal or unethical practices. The solution is an amalgamation of two powerful technologies - Blockchain and AI. Blockchain is an open, distributed ledger that can efficiently record transactions between two parties in a verifiable and permanent way. Since blockchains are decentralized, distributed, transparent, and immutable, they can easily solve counterfeit medicines. AI in pharmacology helps improve customer service, loyalty and enables easy access to blockchain based medical intelligence. This paper proposes a system that uses blockchain and AI for the safe supply of medical drugs throughout the supply chain. Each product within the chain can be transferred between authenticated entities of the chain using an event request-response mechanism. All transactions between entities are recorded into the blockchain using smart contracts with the help of which a product can be traced to its source. The Rasa chatbot integrated into a Flutter app enabling ordering, tracing back medicines, and enhancing blockchain-based credit evaluation.

The integration of Blockchain and AI in the pharmaceutical supply chain heralds a new era of efficiency, security, and transparency. By leveraging the strengths of both technologies, this initiative addresses critical challenges, such as counterfeit drugs and supply chain inefficiencies. As the healthcare industry embraces this technological convergence, the potential for safer and more reliable pharmaceutical supply chains becomes not just a possibility but a reality, promising significant benefits for patients, manufacturers, and all stakeholders involved.

2.8 PHARMACHAIN: BLOCKCHAIN BASED DRUG SUPPLY CHAIN PROVENANCE VERIFICATION SYSTEM.

[8] Over the last decade, pharmaceutical businesses have battled to standardize product traceability across the supply chain process, enabling counterfeiters to enter the market with counterfeit pharmaceuticals. As a result, an end-to-end product tracking system is crucial for ensuring product safety and eliminating counterfeit products across the pharmaceutical supply chain. In this paper, we introduce PharmaChain, a decentralized hyperledger fabric framework that leverages confidentiality, accountability, and interoperability. This system enables on-chain and offchain storage for secured, rapid transactions, along with smart contracts establishing data provenance. To demonstrate security, they have provided double signing through the elliptic curve digital signature algorithm, hash data encryption, and 33% node attack. The purpose of this suggested framework is to engage particular governance disciplines to assess its effectiveness in improving drug traceability across the pharmaceutical supply chain to preserve public health by preventing counterfeit pharmaceuticals. In this paper, the proposed system is a Hyperledger fabric based system named PharmaChain that ensures data provenance in the pharmaceutical supply chain. To be more specific, PharmaChain leverages the cryptographic fundamentals of distributed ledger technology to create tamper-proof logs of supply chain events and deploys smart contracts embedded in the hyperledger fabric for the automation of events to be accessible to all stakeholders. Transactional logs enable patients, nurses, physicians, researchers, and pharmacists to securely store, retrieve, and communicate personal medical information. Additionally, PharmaChain protects against malicious efforts to compromise the security, accessibility, transparency, and nonrepudiation of transaction data, which is crucial in a comprehensive and multi-environment like the pharmaceutical supply chain.

2.9 A NOVEL BLOCKCHAIN-BASED PRODUCT OWNERSHIP MANAGEMENT SYSTEM (POMS) FOR ANTI-COUNTERFEITS IN THE POST SUPPLY CHAIN

[9] For more than a decade now, radio frequency identification (RFID) technology has been quite effective in providing anti-counterfeits measures in the supply chain. However, the genuineness of RFID tags cannot be guaranteed in the post supply chain, since these tags can be rather easily cloned in the public space. In this paper, they propose a novel product ownership management system (POMS) of RFID-attached products for anti-counterfeits that can be used in the post supply chain. For this purpose, they leverage the idea of Bitcoin's blockchain that anyone can check the proof of possession of balance. With the proposed POMS, a customer can reject the purchase of counterfeits even with genuine RFID tag information, if the seller does not possess their ownership. They have implemented a proof-of-concept experimental system employing a blockchain-based decentralized application platform, Ethereum, and evaluated its cost performance. Results have shown that, typically, the cost of managing the ownership of a product with up to six transfers is less than U.S. $1.

2.10 AN AGRI-FOOD SUPPLY CHAIN TRACEABILITY SYSTEM FOR CHINA BASED ON RFID BLOCKCHAIN TECHNOLOGY

[10] For the past few years, food safety has become an outstanding problem in China. Since traditional agri-food logistics pattern can not match the demands of the market anymore, building an agri-food supply chain traceability system is becoming more and more urgent. In this paper, they study the utilization and development situation of RFID (Radio-Frequency Identification) and blockchain technology first, and they analyze the advantages and disadvantages of using RFID and blockchain technology in building the agri-food supply chain traceability system; finally, they demonstrate the building process of this system. It can realize the traceability with trusted information in the entire agri-food supply chain, which would effectively guarantee the food safety, by gathering, transferring and sharing the authentic data of agri-food in production, processing, warehousing, distribution and selling links.

RFID technology offers real-time tracking and monitoring capabilities, enabling stakeholders to trace the movement of products throughout the supply chain accurately. By attaching RFID tags to individual items or containers, data can be collected and transmitted seamlessly, providing valuable insights into each stage of production, processing, storage, distribution, and sale. However, while RFID technology offers significant advantages in terms of data accuracy and efficiency, it also presents challenges such as cost and scalability limitations. In contrast, blockchain technology offers a decentralized and immutable ledger system, ideally suited for establishing trust and transparency in the agri-food supply chain. By recording transactions in a tamper-proof manner, blockchain ensures that information remains secure and verifiable, reducing the risk of fraud or manipulation. Moreover, blockchain facilitates seamless data sharing among stakeholders while preserving data privacy and confidentiality. Nevertheless, implementing blockchain solutions requires overcoming technical hurdles and ensuring interoperability with existing systems.

In conclusion, the development of an agri-food supply chain traceability system leveraging RFID and blockchain technologies represents a critical step towards ensuring food safety and integrity in China's rapidly evolving market. By harnessing the power of these innovative technologies, stakeholders can establish a transparent and trustworthy supply chain ecosystem, ultimately benefiting both producers and consumers alike.

III. EXISTING SYSTEM

The proliferation of counterfeit medicines poses a significant threat to public health worldwide, necessitating the development and implementation of robust authentication systems. The existing system for counterfeit medicine authentication involves a combination of technological solutions, regulatory frameworks, and collaborative efforts among stakeholders to address this pervasive issue. The widespread availability of counterfeit medicines presents a multifaceted challenge to global public health, endangering patients, undermining trust in healthcare systems, and fueling the rise of antimicrobial resistance. To combat this pressing issue, the existing system for counterfeit medicine authentication adopts a comprehensive approach, leveraging a combination of technological innovations, regulatory frameworks, and collaborative initiatives among stakeholders. There are various technological components:

- **Barcode and QR Code Technology:** The use of unique barcodes and QR codes on medicine packaging is a common feature of the existing authentication system. These codes serve as digital fingerprints, allowing consumers and authorities to verify the authenticity of the product. Advanced encoding techniques and secure databases are employed to generate and store these unique identifiers.

- **Track-and-Trace Systems:** Modern pharmaceutical supply chains incorporate track-and-trace systems to monitor the movement of medicines from manufacturers to distributors to pharmacies. This traceability ensures that each unit of medicine can be accounted for, reducing the likelihood of counterfeit products entering the market unnoticed.

- **Mobile Authentication Apps:** Mobile applications designed for counterfeit medicine authentication have become increasingly popular. Consumers can scan barcodes or QR codes using their smartphones to access real-time information about the product, including its manufacturing details and batch number. Authentication apps often leverage cloud-based databases to ensure the information.

- **Data Analytics and Insights:** The system can leverage data analytics tools to gain insights into supply chain operations, identify trends, optimize processes, and detect potential counterfeit activities or anomalies in real-time.

- **Data Capture and Transmission:** The IoT devices collect data from sensors and scanners and transmit it securely to a centralized database or a blockchain network. This data includes not only environmental conditions but also timestamps, geolocation, and any relevant events or transactions in the supply chain.

- **Ethical Sourcing and Sustainability**: The system promotes ethical sourcing practices and sustainability initiatives within the pharmaceutical supply chain. Blockchain technology can be used to track the provenance of raw materials and ensure compliance with ethical standards, such as fair trade practices and environmental regulations.

IV. LIMITATIONS IN EXISTING SYSTEM

The existing system for counterfeit medicine authentication, employing IoT (Internet of Things) and blockchain technologies, faces several limitations that hinder its effectiveness and reliability:

- **Scalability Issues:** As the volume of transactions and data increases, the scalability of the blockchain network becomes a concern. Current blockchain platforms may struggle to handle the vast amount of data generated by IoT devices, potentially leading to network congestion and delays in transaction processing.

- **Cost:** Implementing and maintaining an IoT and blockchain-based authentication system can be expensive. The cost of IoT devices, blockchain infrastructure, and ongoing maintenance can pose significant financial barriers, particularly for smaller pharmaceutical companies or healthcare providers. Developing custom software applications and smart contracts to integrate IoT data with the blockchain platform adds to the overall cost.

- **Data Privacy Concerns:** While blockchain technology offers immutability and transparency, it also raises concerns about data privacy. The sensitive information collected by IoT devices, such as patient health data or medication usage patterns, must be adequately protected to comply with privacy regulations and prevent unauthorized access.

- **Interoperability Challenges:** Integrating IoT devices with blockchain platforms may encounter interoperability challenges, especially when dealing with diverse hardware and software systems. Ensuring seamless communication and data exchange between IoT devices and the blockchain network requires standardized protocols and robust integration solutions.

- **Reliability of IoT Data:** The accuracy and reliability of data collected by IoT devices are crucial for the effectiveness of the authentication system. Factors such as device malfunctions, data tampering, or network connectivity issues can compromise the integrity of the data, leading to inaccuracies in the blockchain ledger.

- **User Adoption:** User acceptance and adoption of the authentication system are essential for its success. Healthcare professionals, patients, and other stakeholders may require education and training to understand the benefits and functionalities of the system fully. Resistance to change and skepticism about new technologies could impede widespread adoption.

V. PROBLEM STATEMENT

Counterfeit medicines pose a significant threat to public health worldwide, leading to numerous adverse effects such as treatment failure, drug resistance, and, in extreme cases, fatalities. As pharmaceutical markets expand globally, the risk of counterfeit drugs infiltrating the supply chain has escalated, necessitating robust and technologically advanced authentication systems. The problem statement revolves around the urgent need for a comprehensive and efficient counterfeit medicine authentication system to safeguard public health and restore trust in the pharmaceutical industry.

One of the primary challenges in addressing this issue is the sophistication of counterfeiters who continually adapt and employ advanced methods to produce convincing replicas of genuine medications. These illicit operations exploit gaps in the existing supply chain, compromising the integrity of pharmaceutical products. Current authentication mechanisms, relying predominantly on traditional methods like holograms and packaging labels, have proven insufficient in combating these increasingly sophisticated counterfeit practices. As a result, there is an imperative to develop a more sophisticated and foolproof authentication system that can outsmart counterfeiters and ensure the authenticity of medications. The geographical extent of the counterfeit medicine problem further complicates the situation.

VI. PROPOSED SYSTEM

The proposed system uses a decentralized storage solution and is built on the Ethereum blockchain network. We have designed a medicine smart contract to connect with the Ethereum network, and a ID based identification system is used to allow end-users and salespersons to scan and authenticate products using their smartphones.
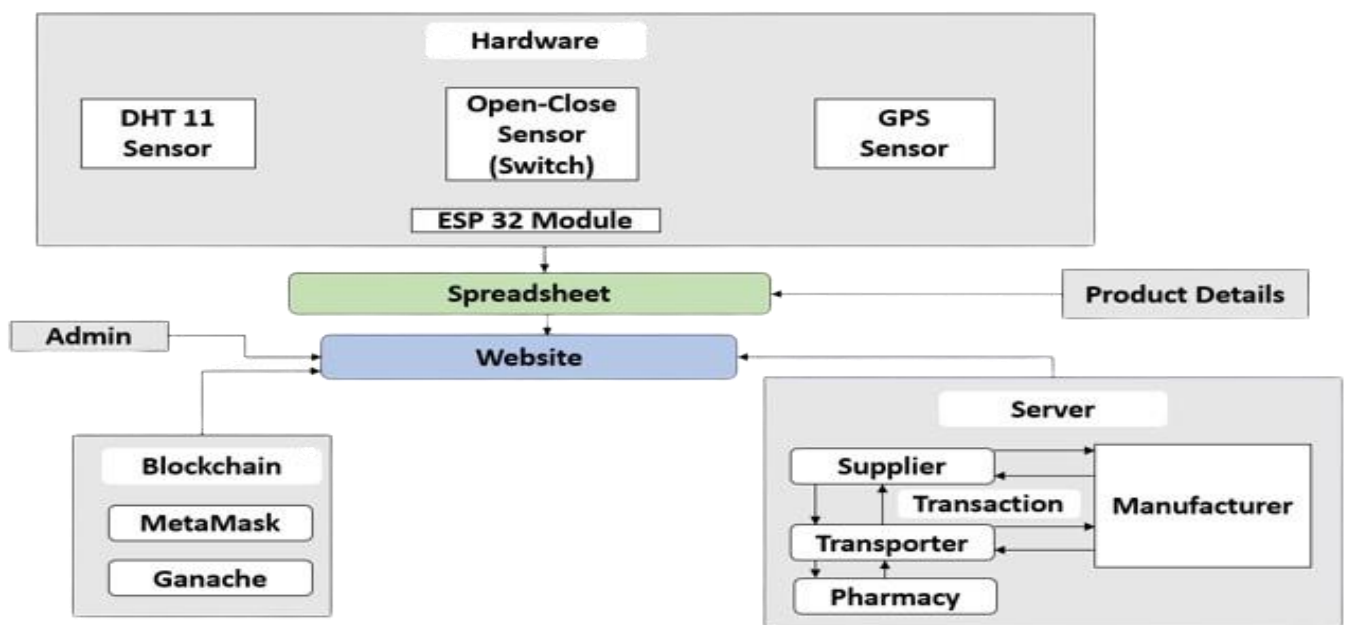
Figure 1. System Block Diagram

6.1 IoT Data Collection Layer:

Deploying IoT devices such as sensors, and GPS trackers at key points along the pharmaceutical supply chain, including manufacturing facilities, warehouses, distribution centers, and pharmacies. These IoT devices collect real-time data on factors like product origin, temperature, agent name, humidity, and location and display it using Google sheets at an interval of 10 seconds.

6.2 Blockchain Authentication Layer:

Implement a blockchain network to serve as the backbone of the authentication system. Record each step of the pharmaceutical supply chain, from manufacturing to distribution to dispensing, as immutable transactions on the blockchain ledger. Use smart contracts to automate authentication processes, such as verifying product authenticity based on predefined criteria and rules

6.3 Authentication Verification Interface:

Develop user-friendly interfaces, such as web-based portals or mobile applications, for stakeholders to access and verify authentication information. Enable healthcare professionals, pharmacists, and consumers to scan product identifiers (e.g., QR codes) using their smartphones or dedicated scanning devices to verify product authenticity. Provide real-time feedback on authentication status, alerting users to any discrepancies or suspicious activities detected by the system.

6.4 Data Analytics and Monitoring:

Employ data analytics techniques to analyze the vast amounts of data collected by the system. Detect patterns, anomalies, and trends indicative of counterfeit activity, such as deviations in product distribution patterns or instances of tampering. Generate insights and actionable intelligence to support decision-making and proactive risk mitigation strategies.

6.5 Supply Chain Module:

This includes the transactions between the supplier, manufacturer, pharmacy, and the transporter entities in the supply chain. The respective address keys of different entities provided can be used to make a secure and sound transaction between them. The product details can be monitored through the website.

6.6 Cross-Border Tracking:

With the global nature of pharmaceutical supply chains, the system can facilitate cross-border tracking and authentication of medicines, helping to combat counterfeit medicines in international markets.

6.7 Cost-Efficiency:

While implementing such a system may require initial investment, the potential cost savings from preventing counterfeit incidents, reducing product recalls, and optimizing supply chain processes can outweigh the expenses in the long run.

6.6 ALGORITHM :

1. Import necessary modules/packages.

2. Set up and specify views directory.

3. Set up static file from the "public" directory.

4. Initialize location to store user data, raw materials, and product requests.

5. Define routes for Home page, Admin login, Admin dashboard, Supplier dashboard, Transporter dashboard, Manufacturer dashboard, Pharmacy dashboard, Order to render the order form and process order submissions and Product details.

6. Process form submissions for various dashboards to add/update data as per user actions.

7. Generate a unique key for raw materials and product requests.

8. Store raw materials and product requests.

9. Start the Express server on port 5000.

VII. RESULTS AND DISCUSSION

The integration of IoT (Internet of Things) and blockchain technologies in a counterfeit medicine authentication system represents a groundbreaking advancement in the battle against the global menace of counterfeit drugs. Blockchain, as a decentralized and tamper-resistant ledger, serves as the backbone of the authentication system. Each transaction or event related to the pharmaceutical supply chain is recorded in a block, and these blocks are linked in a chain. This not only ensures the integrity of the data but also establishes a traceable and auditable record.

The Implementation of counterfeit medicine authentication system utilizing Ganache, Metamask for transactions, temperature sensors, GPS and ESP32 Wi-Fi module for monitoring robust results in enhancing supply chain security and ensuring the authenticity of pharmaceutical products. The data obtained using the modules will be stored in Google Sheets, which can be later used to ensure the integrity of the medicine when traversing the supply chain and to detect any anomalies found in it.

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