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PHARMA SUPPLY CHAIN MANAGEMENT SYSTEM USING SMART CONTRACT

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ABSTRACT

This study describes a blockchain-based strategy to improving traceability in the pharmaceutical supply chain, with the goal of combating counterfeit pharmaceuticals and increasing product legitimacy. The suggested approach removes middlemen, guarantees data provenance, and gives users a safe, unchangeable transaction history by utilizing smart contracts and decentralized storage. Centralized control, a lack of information, and complicated stakeholder behavior make it difficult to track products effectively in a healthcare supply chain that includes raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients. This intricacy makes it easier for counterfeit medications to infiltrate, which the World Health Organization reports are a major cause of death, especially for children, and make up as much as 30% of medications sold in developing nations. Additionally, counterfeit medications cause the pharmaceutical industry to suffer significant financial losses. The proposed method offers a distributed and easily accessible way to keep an eye on every phase of the medication supply chain by introducing a smart contract architecture that verifies data provenance, traceability, and immutability. We describe the entity-relation diagram, operational algorithms, and architecture of the smart contract system in detail and verify that it is effective in enhancing supply chain transparency. As evidenced by our findings, this blockchain framework provides a general, scalable approach for secure traceability that can be applied to a variety of pharmaceuticals supply chains, helping to create a reliable, impenetrable drug tracking and verification system.

Keywords: Blockchain, Pharma Supply Chain, Counterfeit, Medicines, Drugs.

I. INTRODUCTION

DETAILS OF PROJECT WORK

In order to ensure product authenticity, reduce the risk of counterfeit medications, and eliminate reliance on central authorities or intermediaries, this project proposes a blockchain-based framework that uses smart contracts and decentralized storage to improve traceability and data provenance within the pharmaceutical supply chain. A key component of the project is the smart contract system architecture, which provides an immutable transaction history accessible to all supply chain stakeholders, including raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients. This transparency across each stage of drug distribution improves efficiency and accountability, addressing the essential requirement for traceable information within a complex network of multiple stakeholders.

The pharmaceutical supply chain faces significant challenges related to transparency and control, which are exacerbated by its multi-tiered structure and a lack of information-sharing among participants. Issues such as centralized control, fragmented information flow, and stakeholder competition lead to inefficiencies and enable counterfeit pharmaceuticals to enter the market. Counterfeit drugs pose severe risks to public health, particularly in underdeveloped nations where up to 30% of drugs may be counterfeit. This blockchain-based solution tackles these issues by introducing smart contracts that facilitate reliable traceability and validation processes, making it more difficult for counterfeit drugs to bypass checkpoints undetected.

The project describes the smart contract code and algorithms controlling pharmaceutical product traceability and verification in order to verify the efficacy of the system. These algorithms are intended to track and record every transaction in the supply chain, providing a continuous and unalterable record of the drug's journey from manufacturer to end user. In order to evaluate the system's performance, we also offer a variety of implementation techniques and testing scenarios. According to our research, the suggested approach greatly improves traceability, lowers inefficiencies, and offers a general framework that can be used to other

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pharmaceutical goods. The system's decentralized and transparent architecture fosters stakeholder confidence while also setting a new standard for combating counterfeits in the global pharmaceutical supply chain.

OBJECTIVE

This blockchain-based system for pharmaceutical supply chain traceability aims to improve transparency, security, and operational efficiency within the complex network of the healthcare supply chain. In order to guarantee the integrity and provenance of data for all supply chain participants—including raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients—the system first seeks to create an unchangeable, decentralized storage framework. By leveraging smart contracts, the proposed solution seeks to remove intermediaries, streamlining data transactions and providing a secure, automated mechanism to verify each stage in the drug supply journey.

Additionally, this solution targets a significant reduction in counterfeit pharmaceuticals by enabling constant, real-time tracking of drug movement across the supply chain. This will help reduce risks associated with fake medications reaching the end-user market, a problem that has led to severe health consequences, especially in underdeveloped countries. Another objective is to enhance traceability in response to supply chain inefficiencies that became evident during crises like the COVID-19 pandemic. By improving visibility, the system enables rapid response to potential disruptions, protecting the supply of authentic medications.

The smart contract architecture aims to provide a robust framework that enforces secure, transparent, and tamper-resistant transactions, enabling seamless tracking and accountability from the source to the end consumer. To support system scalability and flexibility, the design is made adaptable, ensuring that it can accommodate the tracing and verification needs of any pharmaceutical product, regardless of its specifics. This adaptability will allow healthcare organizations to incorporate the system broadly and manage complex, cross-border drug supply chains effectively.

Furthermore, the solution seeks to optimize data accessibility across stakeholders while safeguarding privacy through distributed ledger technology, offering all participants a trusted and transparent view of the drug's journey without compromising confidentiality. By focusing on secure, real-time data sharing, this blockchain framework intends to foster collaboration among various stakeholders, promoting unified efforts to safeguard patients and uphold regulatory compliance across jurisdictions. Lastly, the validation and testing of the proposed solution aim to confirm its operational efficiency, resilience, and overall effectiveness in improving traceability and reducing counterfeit risks within pharmaceutical supply chains.

SCOPE OF THE PROJECT

This project's scope includes developing and deploying a blockchain-based solution to improve pharmaceutical supply chain traceability, with an emphasis on getting rid of fake medications and guaranteeing product authenticity. . By utilizing blockchain technology, the system enables decentralized data storage and employs smart contracts to establish an immutable and secure transaction history. This approach removes the need for intermediaries, allowing all stakeholders, including raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients, to access a transparent and verified chain of custody for each product. The smart contract system architecture and algorithms provide a secure foundation for data provenance, establishing a trustworthy network that is crucial in tracking the movement of pharmaceuticals from production to end-users.

Moreover, this solution addresses specific challenges in the pharmaceutical supply chain, such as the complexity of distribution, lack of transparency, and limited control over data accuracy, which often contribute to the infiltration of counterfeit drugs. By continuously monitoring each transaction within the blockchain framework, the project aims to improve overall supply chain efficiency, prevent counterfeit drugs from entering the market, and significantly reduce the risks to public health. The generic framework provided by this project can be adapted to various drug types within the pharmaceutical supply chain, thus establishing a universal standard for secure and distributed traceability.

MOTIVATION OF THE PROJECT

The pharmaceutical supply chain is a complex, multi-layered network involving numerous stakeholders, including raw material suppliers, manufacturers, distributors, pharmacies, hospitals, and patients. This intricate network faces significant challenges in ensuring efficient tracking and tracing of products, exacerbated by

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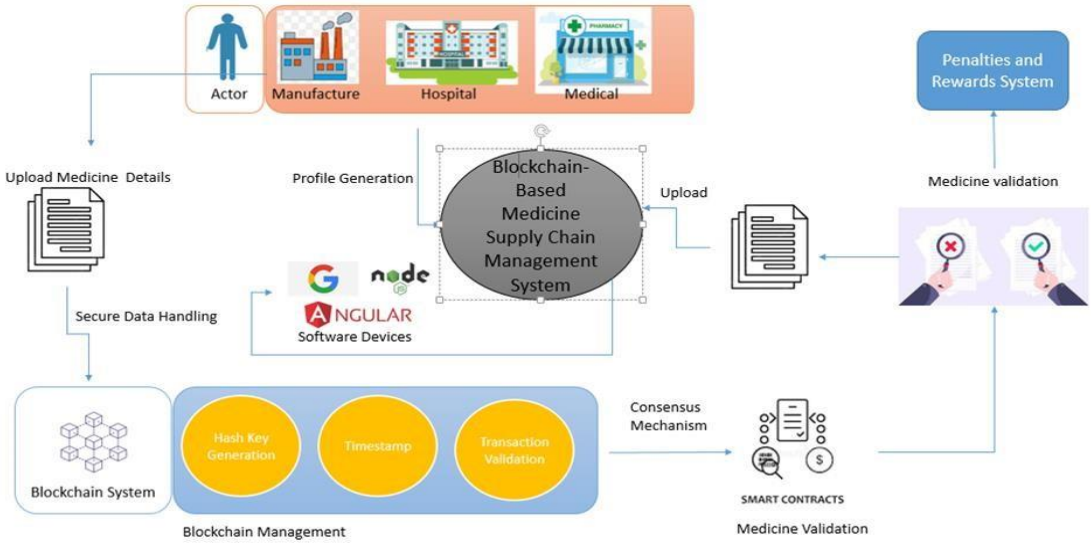
centralized control, lack of transparent data sharing, and competing stakeholder interests. These issues have led to serious inefficiencies, as seen during the COVID-19 pandemic, and have facilitated the infiltration of counterfeit drugs into the market, especially in developing countries. Counterfeit pharmaceuticals not only threaten public health and safety but also result in substantial financial losses for the pharmaceutical industry. Addressing these problems demands a solution that provides continuous monitoring, clear data provenance, and tamper-proof documentation of drug movements across the entire supply chain.

This project is motivated by the need to establish a secure, reliable, and decentralized system for tracking pharmaceutical products, thereby enhancing traceability and ensuring authenticity. By leveraging blockchain technology and smart contracts, this proposed solution aims to provide an immutable, transparent transaction history that is accessible to all stakeholders, eliminating intermediaries and reducing vulnerabilities to counterfeit drugs. Such a system would allow stakeholders to trace a drug's journey from production to the end user, ensuring a chain of custody that is both verifiable and accessible. This not only fosters accountability within the supply chain but also strengthens efforts to protect public health by preventing counterfeit medications from reaching patients.

II. LITERATURE SURVEY

Sr.no	Title	Author	Description
1	Smart Contract for Pharma Supply Chain.	Rahul R.Konapure, Shankar D.Nawale.	This paper presents a blockchain-based solution for decentralized storage
2	Blockchain-Based Systems in Transportation	Astarita.V, Giofrè V.P	This paper presents a literature review about the application of blockchainbased systems in transportation
3	Drugledger- A Practical Blockchain System	Yan Huang, Jing Wu	In this paper, we propose a scenario-oriented blockchain system for drug traceability and regulation called Drugledger

III. SYSTEM ARCHITECTURE



Smart contracts and decentralized storage are used in the paper's blockchain-based pharmaceutical supply chain traceability system to guarantee the safe, transparent, and unchangeable tracking of pharmaceutical products from suppliers of raw materials to end consumers. Suppliers of raw materials, manufacturers, distributors, pharmacies, hospitals, and patients are all part of the intricate network that is the supply chain. . It

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is challenging to properly track items because of its complexity, centralization, and lack of transparency, which can lead to the supply chain becoming infiltrated by fake drugs. To overcome these issues, the proposed solution use blockchain to offer data provenance, eliminating the need for middlemen and allowing secure, traceable transactions among all participants. Smart contracts, which are self-executing agreements with predetermined rules, uphold the system's operating principles by guaranteeing that transactions are carried out in accordance with established conditions and that every supply chain stage is accurately documented. These contracts are immutable, which means that once data is recorded on the blockchain, it cannot be changed, ensuring the highest level of security and trust among all parties. All players may access the same version of the truth about the product's route through the supply chain since the blockchain is decentralized, meaning that no single entity controls the data.

The system works by integrating smart contracts into the various stages of the pharmaceutical supply chain. When a pharmaceutical product is produced, its details—such as the manufacturer, raw material source, production batch number, and other relevant information—are recorded on the blockchain. As the product moves through the distribution process, each transfer or transaction is recorded on the blockchain, ensuring that the product's journey is fully traceable. This allows stakeholders, such as manufacturers, distributors, and pharmacies, to verify the product's authenticity and ensure it has not been tampered with. Additionally, the system allows real-time monitoring and tracking of pharmaceuticals, preventing counterfeit products from entering the market and improving overall supply chain efficiency. Smart contracts automatically verify that all required conditions are met before a transaction is approved, ensuring compliance with regulatory standards and preventing fraud. The decentralized ledger ensures that all parties have access to the same information, and any attempts to alter or falsify the data are easily detectable. This traceability framework is not limited to specific drugs; it is designed to be adaptable to any pharmaceutical product, ensuring trusted and distributed traceability across the entire pharma supply chain. The system's design offers scalability, enabling it to be implemented for a wide range of pharmaceutical products while maintaining high levels of security and transparency.

IV. SYSTEM REQUIREMENTS

1. Hardware Resource Required

- Processor : i3 Or Higher
- Processor speed: 2.0GHz Or Higher
- RAM : 8 GB
- Disk Space : 120 GB SSD.

2. Software Resource Required

- Operating System : Windows 10
- Platform : VS Code, Node JS. Angular JS
- Database : Firebase

REQUIRED ANALYSIS

In this step of water-fall we identify what are various requirements are need for our project such are software and hardware required, database, and interfaces.

ALGORITHM Smart Contract Algorithm

Smart contracts are self-executing agreements that have their terms encoded directly into the code. The smart contract mechanism in this pharmaceutical supply chain system makes sure that all product movements, transfers, and transactions between various stakeholders—including manufacturers, distributors, pharmacies, hospitals, and patients—are safely documented on the blockchain. The algorithm validates each action, checks for required conditions, and ensures immutability of transaction history. It helps to automate processes, eliminate intermediaries, and ensure transparent, trusted execution.

Hashing Algorithm

Blockchain systems typically use hashing algorithms to ensure data integrity and immutability. In this solution, a cryptographic hashing algorithm, like SHA-256 (Secure Hash Algorithm), is used to securely hash each

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transaction, product data, and the entire supply chain history. Once hashed, the data becomes tamper-proof, meaning that if someone tries to alter the data, the hash value will change, making it detectable. This ensures that product information, such as the authenticity of drugs and raw materials, is traceable and immutable across all points in the supply chain.

Consensus Algorithm (e.g., Proof of Stake)

A consensus algorithm is necessary to guarantee the blockchain's legitimacy and integrity. Since the study proposes a decentralized method, Proof of Stake (PoS) or comparable consensus techniques may be used. In proof-of-stake (PoS), miners, also known as validators, are chosen to validate transactions and produce new blocks according to their stake, or the quantity of cryptocurrencies or tokens they own. By avoiding double-spending and guaranteeing that data contributed to the blockchain is genuine and validated, the consensus algorithm makes sure that all network users concur on the blockchain's current state.

Entity-Relation Algorithm

This algorithm helps to model the relationships between various entities in the pharmaceutical supply chain. The Entity-Relationship Diagram (ERD) is used to represent the data model, showing how entities such as suppliers, manufacturers, distributors, and pharmacies are interconnected. This algorithm helps in organizing and structuring the supply chain data, ensuring that each transaction or record can be traced accurately through its relationships across the supply chain.

Public Key Infrastructure (PKI) Algorithm

Public Key Infrastructure (PKI) algorithms are used to encrypt and secure the communication and transactions within the blockchain system. Each participant (e.g., suppliers, manufacturers, etc.) would be assigned a public and private key pair, enabling secure signing of transactions and authentication. RSA (Rivest-Shamir-Adleman) or ECDSA (Elliptic Curve Digital Signature Algorithm) are common cryptographic algorithms used for securing transactions, ensuring that each party's identity is verified and their transactions are securely recorded on the blockchain.

Decentralized Storage Algorithm

To store data off-chain and ensure that the data remains accessible, Interplanetary File System (IPFS) or Storj could be used as the decentralized storage solution. The algorithm ensures that data (such as product details, shipping information, and batch records) is stored in a decentralized, distributed way, allowing participants to retrieve it when needed while maintaining data integrity and security.

Transaction Validation Algorithm

This algorithm ensures that all transactions (e.g., product shipments, ownership transfers, and product movements) across the supply chain are valid and meet predefined conditions before they are recorded on the blockchain. The validation process includes checking that the product is in the correct state, the correct participants are involved, and that any associated metadata (e.g., batch numbers, expiration dates) is valid. This algorithm helps to prevent fraudulent or invalid transactions from being added to the blockchain.

Audit Trail Algorithm

The audit trail algorithm ensures that every action performed on a product, from raw material sourcing to its final delivery to the patient, is logged and tracked. Each transaction is appended to the blockchain, creating an immutable record of the product's journey. This algorithm facilitates transparency and accountability, making it possible to trace a product's entire lifecycle and detect any discrepancies or instances of counterfeiting.

These algorithms collectively contribute to enhancing traceability, ensuring data integrity, and supporting the decentralized, transparent, and immutable nature of the blockchain solution for pharmaceutical supply chain management.

V. CONCLUSION

In conclusion, this paper presents a blockchain-based solution that addresses the complexities and inefficiencies of the pharmaceutical supply chain, particularly in combating counterfeit drugs. By utilizing smart contracts and decentralized storage, the proposed system ensures data provenance, traceability, and immutability without the need for intermediaries, providing a transparent and secure transaction history for all participants. The solution's design and algorithms have been validated and tested to demonstrate their

effectiveness in improving traceability, ultimately enhancing product authenticity and safeguarding public health. This approach offers a scalable and trusted framework that can be applied to ensure the integrity of pharmaceutical supply chains globally.

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