IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MEDICHAIN-SECURING PHARMA SUPPLY CHAIN WITH BLOCKCHAIN

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Abstract: The pharmaceutical industry plays a vital role in safeguarding global health. However, its supply chain is complex, susceptible to fraud, and often inefficient. Pharmaceutical supply chains are characterized by multiple stakeholders, including manufacturers, distributors, suppliers, and healthcare providers. The intricate nature of this supply chain makes it vulnerable to issues like counterfeit drugs and data inaccuracies. Blockchain, with its inherent features of transparency, immutability, and decentralization, offers a compelling framework to mitigate these challenges. Blockchain enhances transparency by creating an immutable ledger of all transactions. Each drug batch is assigned a unique identifier, recorded on the blockchain and associated with relevant data such as manufacturing details, shipping records and quality test results. Stakeholders across the supply chain can access this information in real-time, ensuring complete visibility and traceability. Counterfeit drugs cause serious problem to public health. Blockchain's secure, tamper-proof records enable consumers and healthcare professionals to verify the authenticity of pharmaceutical products. Smart contracts, self-executing agreements triggered by predefined conditions can automate verification processes, reducing the risk of counterfeit drugs entering the supply chain. Blockchain's cryptographic techniques ensure data security, privacy and protecting sensitive information. Pharmaceutical recalls can be costly and time-consuming. Blockchain's traceability allows for targeted recalls, pinpointing affected batches quickly. Smart contracts can automate the recall process, notifying relevant parties and facilitating the return of products. This efficiency not only saves resources but also enhances patient safety.

Index Terms **- Blockchain, counterfeit drugs, pharmaceutical supply chain, smart contract.**

I. INTRODUCTION

The pharmaceutical industry is crucial for making and delivering important medicines worldwide. But behind the scenes, there's a complicated system called the pharmaceutical supply chain. It's like a network connecting drug makers, distributors, rules makers, healthcare providers, and the people who need the medicines. This system covers everything from making the medicine in a factory to sending it to pharmacies and finally to the people who use it. Each step in this journey has strict rules and checks, but sometimes, the different players struggle to work together smoothly.

Now, imagine blockchain as a super clear window into this whole process. Every medicine gets a special code on the blockchain like its own ID card. This code follows the medicine from where it's made to how it gets to the pharmacy. This transparency is a big help in fighting against fake medicines. Anyone can check if a medicine is real just by scanning its code. There are also smart contracts that make sure checks happen automatically. This not only makes sure fake medicines don't sneak in but also builds trust that the medicines we rely on are genuine. As the medicine world gets more tech-savvy, blockchain is becoming a big part of keeping medicines safe and trustworthy. But for it to work well, everyone from big companies to rule makers needs to team up and make it happen. This teamwork promises a future where medicines are not just life-saving but also safe and trusted.

II. REVIEW OF LITERATURE STUDY

The integration of blockchain technology into the pharmaceutical supply chain represents a transformative frontier in the healthcare industry, holding the promise of revolutionizing the way pharmaceutical products are manufactured, distributed, and monitored. The inherent challenges within the pharmaceutical supply chain, including issues of counterfeiting, traceability gaps, and data integrity, have spurred growing interest in leveraging blockchain's decentralized and transparent nature to address these critical issues. This literature survey aims to comprehensively explore the current state of research, developments, and challenges surrounding the adoption of blockchain technology in the pharmaceutical supply chain.

A. D. Shetty, S. Shenoy, D. Sreedhar, A. Shetty, R. Rao, K. D'souza [1]. The pharmaceutical industry's research and development process is complex and lengthy beginning with drug discovery and culminating in regulatory approval. This proposes a solution using blockchain technology to design a secure and transparent pharmaceutical supply chain. Blockchain's potential in the pharmaceutical industry lies in its ability to create a shared ledger of information, including the drug's source, product license and transactional data.

S. Sarkar [2]. Digital transformation is reshaping industries, including pharmaceuticals by introducing new ways of doing business and enhancing existing processes. Companies in the pharmaceutical sector are re-evaluating their operations from internal systems to customer interactions with a focus on digitization. Implementing digital traceability, including barcodes has proven effective in minimizing such risks.

S. Gomasta, A. Dhali, T. Tahlil, M. Anwar, A.B. Ali [3]. Pharmaceutical companies prioritize maintaining distribution quality and patient safety throughout the complex pharmaceutical supply chain. Counterfeit medications, often substandard and improperly formulated, pose a significant risk, including the absence of active pharmaceutical ingredients, contaminants or repackaged expired drugs. The solution involves a network architecture with pharmaceutical companies, regulatory authorities and local vendors like hospitals and pharmacies.

A. Bapatla, S. Mohanty, E. Kougianos and D. Puthal [4]. The intricate nature of the pharmaceutical supply chain has introduced challenges in tracking and tracing drug products making them vulnerable to counterfeit drugs, which can be dangerous to consumers. It leverages Ethereum and Hyperledger Fabric platforms to enhance the security and transparency of pharmaceutical supply chains. The system aims to revolutionize pharmaceutical supply chains by providing end-to-end transparency, combating counterfeit drugs and enhancing consumer confidence in drug authenticity.

M. Rahaman, B. Chappu1, A. Widodo, A. Wisnujati, A. Haque, R. Sarkar, H. Chen [5]. Blockchain offers supply chain managers the ability to develop data-driven models, enhancing privacy protection, transparency and tamper-proof systems. This technology utilizes a shared, cryptographically unaltered distributed ledger to record and secure digital transaction histories. By leveraging blockchain technology the pharmaceutical industry aims to safe and efficient delivery of critical healthcare products.

S. D'souzaa, D. Nazareth, C. Vaz, M. Shetty [6]. The pharmaceutical supply chain can be susceptible to improper or unethical activities, making investigations challenging. Blockchain is a distributed ledger database that records transactions transparently and immutably. It enhances trust among supply chain entities by providing complete transparency and uses smart contracts to record transactions.

M. Uddin, K. Salah, R. Jayaraman, S. Pesic, S. Ellahham [7]. Counterfeit medications pose a significant threat to public health, leading to detrimental consequences for patients and treatment outcomes. These blockchain architectures can establish private permissioned ecosystems within the pharmaceutical industry, with regulatory authorities or stakeholders overseeing registration and control.

A. Abuhashim, C. Tan [8]. Traditional blockchain platforms like Bitcoin and Ethereum use proof-of- work consensus, which is computationally intensive and inefficient for querying data. Querying data from a blockchain ledger is cumbersome, as there are no primary keys or indexes, making it inefficient compared to centralized databases. To address this, the article explores smart contracts as a way to optimize data indexing and retrieval in the blockchain.

G. Kumar [9]. Modern information technology solutions have facilitated the development of inter-organizational networks, enabling real-time information processing and exchange. Blockchain also finds use in tracking shipments and improving supply chain visibility. Technological factors, including information quality and system benefits, influence the adoption of drug traceability systems within organizations.

A. Ghadge, M. Bourlakis, S.Kamble, S. Seuring [10]. Despite regulatory efforts and industry initiatives, drug breaches continue to rise, potentially costing billions in healthcare fraud. The findings reinforce the alarming statistics regarding substandard and counterfeit drugs highlighted by the World Health Organization.

M. Dave, K. Patil, R. Jaiswal, R. Pawar [11]. The global pharmaceutical commodity trade has surged from $113 billion in 2000 to $629 billion in 2019, a six -fold increase, resulting in increasingly complex and opaque pharmaceutical supply chains. A key element is a drug traceability system that can effectively monitor the movement of pharmaceuticals across various supply chain stakeholders. The proposed solution employs a permissioned blockchain, specifically Hyperledger Fabric, which provides access control, permitting only registered users to execute actions within the system. Endorsing peers simulate transactions to ensure their stability, while ordering peers package and distribute transactions to committing peers.

L. Gupta, M. Bansal, M. Gupta, N. Khaitan [12]. Blockchain based supply chain systems offer users the ability to access and manage critical information such as product location, pricing, dates and quality. By tracing and tracking pharmaceuticals through the supply chain, the system can pinpoint the source of issues caused by faulty manufacturing processes, enabling targeted recalls and protecting consumer safety. It employs QR codes for product tracking, ensuring data integrity and traceability.

A. Pathak, S. Shrivastava, P. Vardhini, A. Meka, D. Swami, Z. Hussain, M. Borah [13]. The introduction of blockchain technology has revolutionized this landscape. It operates on a request-response mechanism, ensuring that all parties involved in a transaction agree on the transfer of medical drugs. The data stored on the blockchain ledger is tamper-proof, enhancing security and trust.

J. Ma, S. Lin, X. Chen, H. Sun, Y. Chen, H. Huaxiong Wang [14]. The system's primary objectives are to enhance brand anti-counterfeiting certification, expand sales channels and empower small vendors to validate the authenticity of their products. It achieves this by storing relevant product sales information on a transparent and immutable blockchain accessible to anyone.

III. METHODOLOGY

The pharmaceutical supply chain employs blockchain technology to establish a transparent and secure ecosystem. Manufacturers, distributors, retailers and consumers interact within this blockchain-powered framework. Manufacturers register and upload product details, including QR codes, onto the immutable ledger. Distributors access and update product information as it moves through the supply chain, while retailers retrieve data for sales and consumers verify product authenticity. Security measures, including user authentication and data encryption, protect sensitive information, and regular audits maintain data accuracy. The blockchain ledger ensures data immutability and transparency, facilitating efficient traceability and real-time alerts on product status. While recognizing limitations like scalability challenges, the proposed system represents a significant step toward enhancing pharmaceutical supply chain management, bolstering patient safety, and combating counterfeit drugs. Future work could explore IoT and AI integrations and collaboration with regulatory bodies to further improve the system.

2.1 Pharmaceutical supply chain entities:

The pharmaceutical supply chain consists of various entities like Admin, Transporter, Raw Material Supplier, Wholesaler, Distributor & Customer. They perform the handover of the drug package so whenever there is any handover of the package between two entities a transaction gets recorded on the Blockchain network.

2.1.1 Admin/ Owner:

He will CREATE a new user to be added to the chain the users could be anyone like Transporter, Supplier, etc. He will READ the information of any user; the owner can use it for identification of entities into the supply chain. He can UPDATE the roles of a user and can DELETE a user from the chain.

2.1.2 Transporter:

They verify the package (Raw Material or Medicine) which they have to transport. They can Pick the package from an entity (based on transporter type) and deliver it to another entity.

2.1.3 Raw Material Supplier:

They can CREATE a Raw Material. Raw material Supplier can fetch the addresses of the Raw Materials that have been created.

2.1.4 Manufacturer:

They can Receive the Raw Material from the Supplier through the Transporter. They verify the source of the product received and CREATE a new Medicine using received raw materials.

2.1.5 Wholesaler:

The wholesaler receives the medicine from the manufacturer through the Transporter. They can verify the source of the medicine received.

2.1.6 Distributor:

They receive the medicine from the Wholesaler through the Transporter. Verify the source of the medicine. Transfer the ownership of the medicine.

2.1.7 Customer:

Get medical drug information. They will get the medicine from the Distributor through the Transporter and they can verify the source of the medicine. They can place orders in a mobile application.

2.2 Smart Contracts Implementation:

2.2.1 Supply chain contract:

It defines roles and permissions for entities. It has the functions for adding, updating, and deleting entities. It handles event emissions for these actions.

2.2.2 Raw material contract:

It has the functions for managing raw materials. It handles the events for raw material transactions.

2.2.3 Medicine contract:

It has the functions for processing raw materials and manufacturing medicines. It has events for manufacturing transactions.

2.3 Events and Authorization:

Define a standardized event structure for various transactions. Emit events in smart contract functions. Implement a system for the transporter to verify and authorize transactions based on emitted events.

2.4 User Interface:

2.4.1 Admin Dashboard:

Created web-based dashboards for admin, supplier, manufacturer, and transporter using ReactJs and Tailwind css. Using web3.js to interact with the smart contracts from the UI. Block chain technologies like Solidity, Ganache, Truffle, metamask and Web3 are used for contract execution and deployment.

2.4.2 Customer React Native App:

Develop a React Native app for customers to browse and purchase medicines. Utilize a library like web3.js to interact with the smart contract.

2.5 Database:

Used MongoDB for storing all the transaction details and medicines. These medicines and transactions are fetched by react native application to show it to the customer.

2.6 Integration:

Connected the UI components with the smart contracts, allowing entities to perform actions through the UI. We used the Ethereum provider like metamask to handle user wallet interactions.

IV. DESIGN DETAILS:

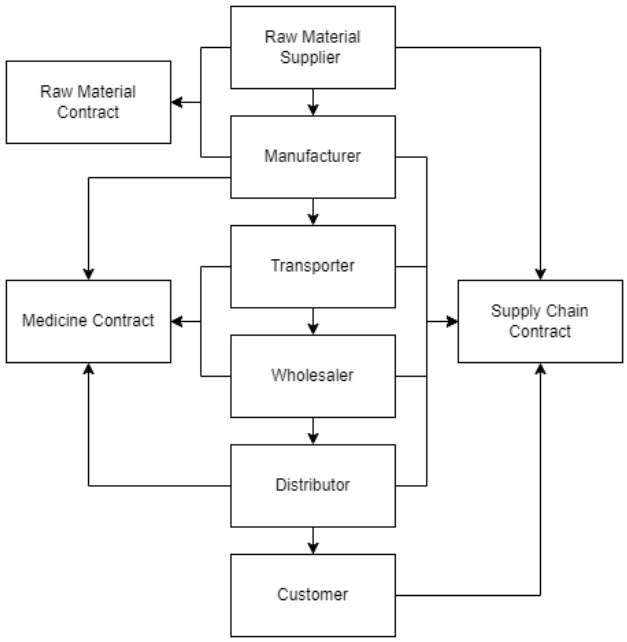

Fig. 1: Block Diagram

The above figure shows the different modules of the project. The blocks are the different entities involved in project. This figure shows how those blocks are connected to each other and work. The project contains different entities like Raw Material Supplier, Manufacturer, Wholesaler, Distributor, Customer (End User). There are 3 different contracts that help those entities to connect and coordinate with each other. The contracts are Raw material contract which connects the Raw material supplier and manufacturer, Medicine contract which connects Manufacturer, wholesaler and distributor, Supply chain contract connects all the entities in supply chain. Supply chain contract is very important contract that can handle all the details of the supply chain.

V. IMPLEMENTATION RESULTS:

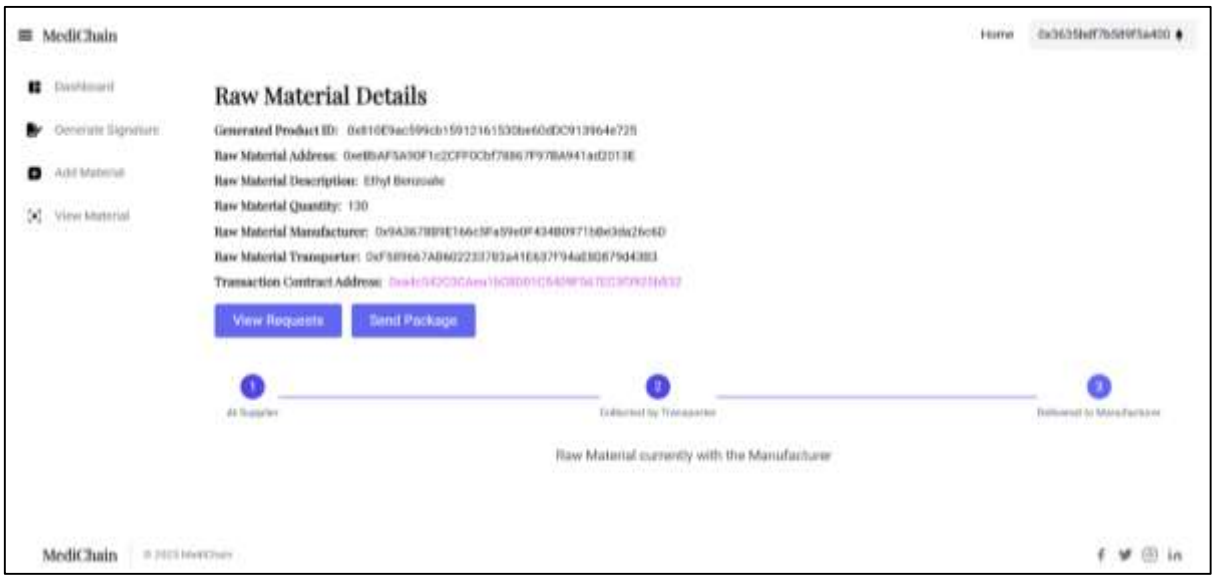

Fig 5.1: Raw Material Details

The Figure 5.1 shows the raw material details. This window is handled by the raw material supplier. They can add the raw material details. Along with the raw material details some blockchain details are also included since it is uploaded on the blockchain. The raw material supplier can view the requests comes for that specific raw material and can send the raw material according to the requests.

Fig 5.2: Medicine Details

The Figure 5.2 represents the medicine details that are manufactured. Similar to the raw material there are medicine details like source address, description, transaction details are also embedded along with actual medicine details. The manufacturer had an access to view the requests coming for the medicine and send the medicine as per the requests.

Fig 5.3: Transaction Details

The Figure 5.3 shows the Transaction history of the medicine. This transaction history is very important to trace the counterfeit product in the supply chain. There is a hash code of each transaction along with the hashes of the sender and receiver. No one can change these hashes since it is generated by the blockchain. On the basis of the current transaction hash and previous transaction hash one can detect that the product received is real or fake.

VI. CONCLUSION:

The implementation of blockchain technology in the pharmaceutical supply chain represents a significant stride toward addressing critical challenges in the industry. By enhancing transparency, traceability and security, blockchain not only helps combat the global issue of counterfeit drugs but also safeguards patient health and builds trust among stakeholders. The proposed system demonstrates the potential to revolutionize pharmaceutical supply chain management, offering real-time visibility and immutable data records that can be audited for accuracy. While acknowledging scalability and adoption challenges, the future outlook for blockchain in this domain is promising. Collaboration with regulatory bodies, integration with emerging technology, efficient improvements underscore the continued growth and impact of blockchain in ensuring the safe and reliable delivery of medications to patients worldwide. This project sets the stage for further innovation and collaboration within the pharmaceutical industry, emphasizing the transformative role of blockchain technology in safeguarding public health and maintaining the integrity of pharmaceutical supply chains.

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