EtherDrug - Enhancing Drug Supply Chain Transparency And Security Through Ethereum Blockchain

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***Abstract*—**Research introduces "EtherDrug," a decentralized Pharmaceutical Supply Chain Management System leveraging Ethereum blockchain technology to combat counterfeit drugs and pharmaceutical trafficking. By utilizing a technology stack comprising Ethereum, MetaMask, Ganache, Truffle, Solidity, HTML, and CSS, the project orchestrates a systematic approach, beginning with node registration and order placement with Medicine ID and quantity specifications. The system meticulously controls each transaction, allowing individual nodes to accept or reject orders, while real-time tracking provides precise updates on the location and timestamp of medicines within the supply chain. This innovative solution not only addresses the immediate need for transparency and security in drug supply chains but also contributes to the broader discourse on blockchain's application in ensuring pharmaceutical quality, safety, and efficacy, offering a practical solution to industry-wide challenges.

***Keywords*—**EtherDrug, Ethereum Blockchain Technology, Counterfeit Drugs, Pharmaceutical Trafficking.

I. INTRODUCTION

The research project on a blockchain-powered Pharmaceutical Supply Chain Management System focuses on crucial issues within the pharmaceutical industry, with a primary emphasis on combating the widespread circulation of counterfeit drugs. The prevalence of falsified medications poses significant risks to public health, leading to adverse effects and complications for unsuspecting patients. The research recognizes the urgent need to enhance transparency within the pharmaceutical supply chain, addressing the current lack of a unified and traceable system that allows for the infiltration of substandard or unregistered drugs. The economic impact of counterfeit drugs, including the costs associated with treating affected patients and the erosion of trust in pharmaceutical products, underscores the multifaceted challenges faced by the industry. Furthermore, the research aims to tackle regulatory gaps, proposing a decentralized and tamper-proof system that can adapt to evolving tactics employed by those engaging in the production and distribution of falsified drugs. These critical issues collectively underscore the necessity for a comprehensive and technologically innovative solution to ensure the integrity, safety, and authenticity of pharmaceuticals throughout the supply chain.

The pharmaceutical supply chain is a complex network involving multiple stakeholders, including manufacturers, distributors, wholesalers, and retailers. The lack of a unified and transparent system makes it challenging to trace the journey of drugs from production to consumption accurately. This opacity in the supply chain opens avenues for the circulation of counterfeit drugs, posing severe risks to patients and undermining the credibility of the pharmaceutical industry.

Blockchain technology, with its inherent characteristics of transparency, immutability, and decentralization, holds immense promise in revolutionizing the pharmaceutical supply chain. By implementing a blockchain-based system, we aim to create an environment where every transaction related to drug production, distribution, and authentication is recorded securely and can be traced back to its origin, mitigating the risks associated with falsified drugs.

In summary, the prevalence of falsified drugs in the pharmaceutical supply chain demands a comprehensive solution that prioritizes public health, economic stability, and regulatory compliance. The integration of blockchain technology offers a compelling avenue to address these challenges, paving the way for a secure, transparent, and decentralized pharmaceutical supply chain management system.

II. LITERATURE SURVEY

Paper [1] introduces the Drug Supply Chain Management and Recommendation (DSCMR) system, comprising two main modules. The first employs Hyperledger Fabric for real-time supply chain monitoring. The second employs N-gram and LightGBM models to provide effective consumer drug recommendations, facilitated by blockchain integration. This integrated approach presents a promising strategy against counterfeit drugs.

The literature of [2] demonstrates the expanding application of blockchain beyond Fintech,

leveraging its trust-building features in fields reliant on transparency and value. This paper introduces Gcoin blockchain for transparent drug transaction data, proposing a shift in the drug supply chain regulation model from inspection-centric to a participatory surveillance net model. This approach encourages all supply chain stakeholders to engage simultaneously, mitigating counterfeit drugs and enhancing public safety.

Research in [3] represents the prevalent issue of counterfeit drugs in pharmacology, particularly prominent in developing nations with rates of 10-30% fake drugs, has spurred a pressing need for intervention. The World Health Organization (WHO) highlights that around 30% of medicine in Africa, Asia, and Latin America is counterfeit, exacerbating risks to human health. The rise of online pharmacies has compounded the challenge, as complex networks facilitate counterfeit drugs infiltrating genuine supply chains. This paper introduces a novel solution using Hyperledger Fabric-based blockchain for secure drug supply chain management. By recording transactions on the blockchain, a smart healthcare ecosystem is established, granting time-limited access to electronic drug and patient health records through smart contracts. Experimental validation and benchmarking using Hyperledger Caliper underline the system's effectiveness in terms of transaction performance and resource utilization.

The research mentioned in [4] focuses on the integration of Artificial Intelligence (AI) and Blockchain to enhance transparency in governance, addressing challenges in data availability and information imbalances. Three qualitative evaluation methods conceptual modelling, analysis-based, and implementation based are employed to assess research in this domain. The study presents an in-depth analysis of two papers for each method, highlighting the use of AI and Blockchain for governance transparency. Conceptual modeling emerges as the preferred approach, supporting the overarching research objective.

The authors of paper [5] focus on the innovative integration of blockchain and artificial intelligence (AI) in the healthcare sector. Data from various sources including Web of Science and Google surveys are analysed to explore the potential of these technologies. The study discusses the possibilities of combining blockchain and AI to enhance healthcare through improved risk management, reliable AI models, and patient record accessibility for healthcare professionals. The integration is expected to lead to greater service efficiency, cost reduction, and democratization of healthcare. The review emphasizes that blockchain's cryptographic record storage complements AI's data-driven capabilities, thereby advancing the healthcare system.

In the comprehensive review [6] the paper talks about the major issues with present SCM systems such as security, transactional transparency, traceability, stakeholder involvement, product counterfeiting, additional delays, fraud, and instabilities. A Pharma supply chain traceability system that combines IoT and Blockchain technology. The system includes IoT sensor devices, a back-end, and a user interface. It uses an Ethereum Blockchain and a server node for monitoring and implementing smart contracts. Gcoin is a Blockchain - enabled pharmaceutical supply chain framework for tracking medicine shipping and distribution.

The paper [7] is about rapid COVID-19 vaccine rollout which is crucial for global success, but its effectiveness depends on a transparent distribution chain audited by all stakeholders. This paper presents the need for Blockchain and Machine Learning in supply chain management and demand forecasting for the vaccine. The convergence of Blockchain technology and Machine Learning ensures seamless distribution with transparency, data integrity, and end-to-end traceability. Demand forecasting is performed for appropriate COVID-19 vaccines based on geographical area and storage facilities. The paper discusses research challenges, limitations, and future directions.

The 2020 surge in demand for COVID-19 medical equipment has led to an inefficient forward supply chain. Authors in [8] explain that Current systems lack traceability, reliability, operational transparency, security, and trust features. This paper proposes a decentralized blockchain-based solution to automate these processes and enable secure, transparent, traceable, and trustworthy information exchange among stakeholders. The system integrates Ethereum blockchain with decentralized storage of interplanetary file systems, and algorithms define interaction rules and penalties for violations. The solution's performance is evaluated through cost analysis and security analysis.

The research paper [9] focuses on the serious issue of counterfeit drugs, which becomes worse during pandemics. It looks at the problems caused by the complicated pharmaceutical supply chain. The paper suggests using blockchain technology, specifically Ethereum and Hyperledger Fabric, to make things better. These technologies can help make the process more open, trackable, and safe. The paper explains a way to do this using special QR codes on products. These QR codes would be protected by blockchain's unchangeable record-keeping and agreement methods like Proof of Work and Raft consensus. The paper talks about the good and not-so-good things about public and private blockchains and prefers Hyperledger Fabric because it's better at growing bigger and has an extra level of security. The paper ends by saying that there's a big need for a strong system to keep track of things, and it suggests using blockchain, especially Hyperledger Fabric, to stop fake drugs and make the pharmaceutical supply chain more dependable and safer.

The paper [10] focuses on the utilization of blockchain technology to address challenges in logistics and supply chain management. Introducing blockchain as a novel solution, the study aims to shed light on its potential benefits and integration into the complex supply chain landscape. The investigation highlights issues such as the intricate global business network, lack of traceability, and visibility problems. By

emphasizing transparency and trust, blockchain is positioned as a promising solution to these challenges. The paper discusses the amalgamation of blockchain with other technologies like the Internet of Things (IoT) and its role in enhancing traceability and real-time monitoring. The study concludes by underscoring the need for collaboration and explores avenues for future research, including regulatory concerns and integration complexities associated with blockchain adoption in supply chains.

The healthcare supply chain's complexity leaves it vulnerable to fraud and data inaccuracies, necessitating a decentralized track-and-trace system. This study of [11] proposes a solution using Ethereum blockchain and smart contracts to enhance transparency and traceability. By storing data in a distributed ledger and automating agreement execution, the system ensures data protection, real-time information access, and reduced reliance on intermediaries. The proposed architecture is tested with Solidity smart contracts, demonstrating its efficiency through gas cost analysis. This approach offers a promising strategy for addressing transparency and security challenges in healthcare supply chains, improving patient safety and overall efficiency.

In the paper [12] "Blockchain-Enabled Drug Supply Chain" discusses the application of blockchain technology in the pharmaceutical industry to combat counterfeit drugs and enhance supply chain management. Counterfeit medicines pose serious health risks and undermine the industry's credibility. The paper suggests that blockchain's decentralized and tamper-proof nature can provide security, traceability, and transparency to the supply chain. The proposed architecture involves stakeholders interacting through a central web server and blockchain network, ensuring accurate and immutable data storage. Existing research on blockchain adoption in supply chains is also reviewed. The paper concludes that this framework can improve pharmaceutical supply chain security and traceability, and suggests potential enhancements and broader applications in the future.

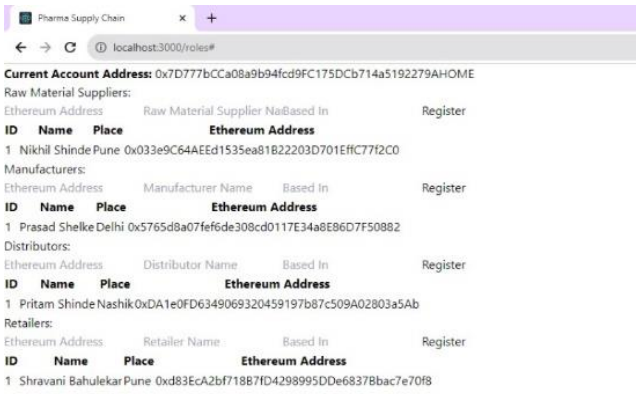
The paper titled "Blockchain-Enabled Drug Supply Chain" [13] is authored by Sheetal Nayak, Prachitee Shirvale, Nihar Naik, Snehpriya Khul, and Amol Sawant. This collaborative effort introduces a solution to the critical issue of counterfeit drugs in the pharmaceutical industry using blockchain technology. By leveraging the unique properties of blockchain, the authors aim to enhance supply chain management by ensuring transparency, traceability, and security. Through a proposed architecture involving a central web server and a distributed blockchain network, the paper presents a distinctive approach to combating counterfeit drugs compared to existing research. The authors conclude with optimism about the potential of their framework and highlight the need for further exploration and development.

The paper [14] titled "Blockchain Technology – A Algorithm for Drug Serialization" by Madalsa Kumar, published in the Universal Journal of Pharmacy and Pharmacology in 2022, explores the application of blockchain technology in the pharmaceutical industry. The paper discusses how blockchain's unique features, such as transparency, security, and decentralized data storage, can address challenges related to drug traceability and authenticity in the supply chain. The author highlights initiatives like the Drug Supply Chain Security Act (DSCSA) in the USA, which utilized blockchain for pilot programs to ensure the authenticity of drugs. The paper outlines the benefits of implementing blockchain in healthcare, including improved data transparency, drug traceability, and patient safety. The author also compares two potential blockchain architectures—Hyperledger Fabric and Hyperledger Besu—for drug authentication and traceability. Overall, the paper emphasizes the potential of blockchain technology to enhance the pharmaceutical supply chain and ensure the authenticity of drugs.

III. METHODOLOGY

Step 1: Registering Individual Nodes with Place Names

Each physical location within the supply chain, such as manufacturing facilities, warehouses,



distribution centers, and pharmacies, is registered as a node on the blockchain network. These nodes are identified by their respective names or locations, ensuring transparency and accountability at each stage of the supply chain.

Fig.1. Registration Page

Step 2: Placing Orders with Medicine ID and Quantity

When an order for medicines is initiated, it is logged onto the blockchain network with specific details such as the Medicine ID (identifying the type of medicine) and the required quantity. This information is securely recorded and accessible to all registered nodes within the network.

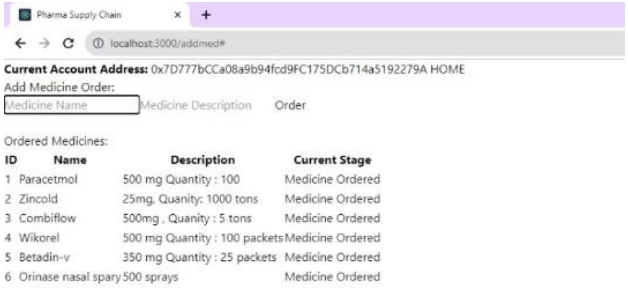


Fig.2. Order Page

Step 3: Controlling Transactions at Individual Nodes

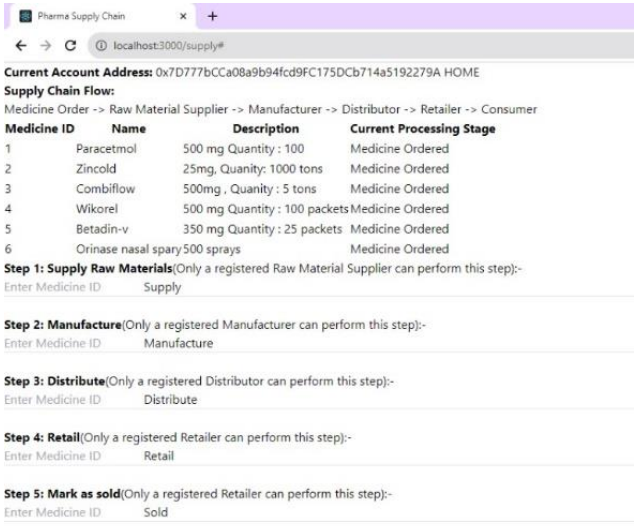


Fig.3. Control Page

Each node involved in the supply chain process has the capability to interact with the blockchain network. When an order is placed, individual nodes can access this information and have the authority to either accept or reject the order based on various factors like availability, quality checks, or compliance with regulations. These transactions are securely recorded on the blockchain, ensuring transparency and auditability of decision-making at each node.

Step 1: Tracking Medicine Delivery:

To track the delivery of medicines, the blockchain network maintains an immutable record of each transaction as the medicines move from one node to another. Through the use of timestamps and unique identifiers, the system precisely logs the exact time and location where the medicines arrive at each node. This tracking mechanism allows stakeholders to monitor the progress of the delivery in real time, providing transparency regarding the location and status of the medicines at any given point in the supply chain.

By implementing this methodology, stakeholders can access a transparent and secure system that facilitates real-time tracking and verification of medicine delivery, ensuring accountability and reliability throughout the pharmaceutical supply chain. The use of blockchain technology enables immutable records, enhancing trust among stakeholders and reducing the risk of counterfeit medicines entering the market.

IV. Result and Discussion

Increased transparency in the pharmaceutical supply chain is crucial in fighting counterfeit medicines. By making information about medicine production and distribution more accessible, stakeholders can verify the legitimacy of products. This transparency discourages counterfeiters, making it harder for fake medicines to enter the market undetected. It also builds trust among everyone involved, from manufacturers to consumers, ensuring the safety and reliability of pharmaceuticals.

Technological advancements, particularly blockchain technology like Ethereum, enable better tracking of medicines. This creates an unchangeable record of a medicine's journey, from its creation to its use, ensuring the accuracy of its details. This transparency helps quickly identify and address any issues while holding the supply chain accountable. Smart contracts further improve this system by automating compliance with regulations, reducing mistakes, and ensuring that industry standards are consistently met. Overall, these technological integrations create a more secure, transparent, and dependable pharmaceutical supply chain.

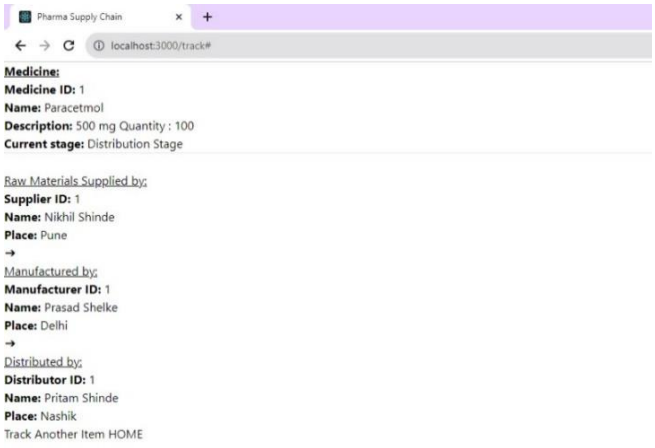


Fig.4. Final Result after Delivery of Drug

V. Conclusion and Future Scope

"EtherDrug" represents a pioneering initiative in combating the pervasive issues of counterfeit drugs and pharmaceutical trafficking through the implementation of a decentralized Pharmaceutical Supply Chain Management System. Leveraging the robust Ethereum blockchain technology along with a comprehensive technology stack, the project systematically addresses the challenges faced by the pharmaceutical industry. The process begins with the registration of individual nodes, assigning unique identifiers based on location, followed by a secure and transparent order placement mechanism. Crucially, the system grants autonomy to individual nodes, allowing them to meticulously control transactions, ensuring a transparent and secure supply chain. Real-time tracking enhances accountability by providing precise updates on the delivery progress, including location and timestamp information for each medicine. Beyond immediate problem-solving, this research contributes to the broader discourse on the application of blockchain in pharmaceuticals, emphasizing the potential of technology to ensure the quality, safety, and efficacy of drugs.

As we envision the continued evolution of "EtherDrug," several avenues for potential future work emerge. Firstly, enhancements in user interface design and experience can be explored to streamline interactions within the system. Additionally, further research can be conducted to integrate advanced data analytics and artificial intelligence tools to derive valuable insights from the vast dataset generated by the blockchain. Collaborations with regulatory bodies and industry stakeholders can also be pursued to establish

standards and frameworks for broader adoption. Furthermore, exploring the integration of emerging technologies like smart contracts and Internet of Things (IoT) devices could further fortify the security and efficiency of the supply chain. Continuous monitoring of regulatory changes and advancements in blockchain technology will be essential to ensure the sustained relevance and effectiveness of "EtherDrug" in meeting the evolving demands of the pharmaceutical landscape.

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