Fuzzy Systems and Soft Computing
ISSN : 1819-4362

BLOCKCHAIN FOR DRUG TRACEABILITY IN HEALTHCARE SUPPLY CHAINS

[#1]NEREDUKOMMA ANIRUDH,
[#2]SABAHATH,
[#3]MIRZA AMAAN AHMED BAIG,
[#4]PEDDI KISHOR, *Associate Professor*,
Department of Computer Science and Engineering,
SREE CHAITANYA INSTITUTE OF TECHNOLOGICAL SCIENCES, KARIMNAGAR, TS.

ABSTRACT: The healthcare supply chain is a complicated network of links that crosses numerous industries and countries. It provides the underlying support for a wide range of critical services required for humanity's survival. Because of their intrinsic complexity, these systems are prone to damage from variables such as a lack, ambiguity, or inaccuracy of data sources. One unfortunate effect of these limits on current supply chains is the widespread circulation of counterfeit drugs, which represent a significant risk to public health and place significant economic strains on the healthcare industry. Prior research has demonstrated the need of establishing a robust and comprehensive monitoring and tracing mechanism within pharmaceutical supply chains. To eradicate counterfeit items from the pharmaceutical supply chain and ensure product safety, a thorough product tracing system is required. Currently, a substantial part of track and trace systems function in a centralized manner, which presents challenges in terms of data privacy protection, data authenticity assurance, and supply chain transparency promotion. This research paper provides a decentralized off-chain storage solution and an Ethereum blockchain-based smart contract-based technique for improving product tracking efficiency in the healthcare supply chain. All transactions are recorded in an immutable ledger that is open to all participants. The smart contract eliminates the need for intermediaries and guarantees the data's authenticity. An explanation of the system architecture and the specific algorithms that enable the effective implementation of our proposed resolution is provided. To assess the potential efficacy of pharmaceutical supply chain innovations, a thorough cost and security study is performed, as well as a number of testing and validation methods.

Keywords:Drug Traceability,Supply Chain Management (SCM),Immutable Records

I. INTRODUCTION

The healthcare supply chain is a complex web of interconnected organizations. It includes manufacturers, pharmacists, hospitals, patients, and basic material suppliers. A variety of variables hamper product tracking in this network, including centralized control, inconsistent shareholder behavior, and a lack of data. Furthermore, the complexity of the healthcare system's architecture, as demonstrated by the challenges encountered during the COVID-19 pandemic , not only reduces its efficacy but also complicates efforts to combat the spread of counterfeit medications due to their rapid entry into the healthcare supply chain. Counterfeit pharmaceuticals are chemical substances that are synthetic in nature and intended to simulate genuine medications, including their identification and origin. This person's sentence is." These drugs may contain contaminants, reconstituted substances, improper active pharmaceutical ingredients (API), insufficient API amounts, or poor API quality. It is possible to manufacture counterfeit drugs using inferior conditions and unlawful substances.

According to the Health Research Funding Organization, over 30% of medications supplied in underdeveloped countries are counterfeit. Furthermore, a recent World Health Organization (WHO) study found that counterfeit pharmaceuticals are a major contributor to death in developing countries, with children being disproportionately affected. In addition to inflicting harm to people's health, counterfeit

pharmaceuticals place a major financial burden on the pharmaceutical business. The counterfeit pharmaceutical sector in the United States loses approximately $200 billion each year.

Figure 1 depicts a typical way for moving medications through the supply chain. An API supplier is in charge of supplying the raw materials required for the manufacture of medications that have been approved by regulatory organizations such as the US Food and Drug Administration. The medications are either repackaged by the producer or assembled in bulk. The major distributor obtains large amounts of the product and then distributes them to pharmacies based on market demand. If there are too many lots, new distributors may be able to hasten their delivery to pharmacies. Finally, pharmacies give medication to consumers based on a physician's prescription. Drugs are regularly transported via the supply chain by autonomous logistics service providers like UPS and FedEx. Additionally, carriers may use their own vehicle fleet to convey the cargo. Sophisticated healthcare supply chains are the principal source of counterfeit drugs entering the market. Despite its complexity, this method efficiently and quickly distributes medication while minimizing paperwork and leaving little trace. To avoid the spread of counterfeit items in the healthcare supply chain, it is vital to be vigilant, streamline management processes, and thoroughly monitor all products.

An increasing number of nations around the world are legislating and prioritizing drug surveillance, often known as "track and trace." The pharmaceutical industry is required by the U.S. Drug Supply Chain Security Act (DSCSA) to build a computerized, interoperable system to monitor and segregate prescription medications during their countrywide journey. Since 2008, China has introduced a legislation requiring all people involved in pharmaceutical distribution to record exact data about the drugs in a specific computer system whenever the drugs are transferred to or from storage facilities. Drug traceability is now an important part of the pharmaceutical supply chain since it allows people to monitor and trace the product's chain of command throughout its full life cycle.

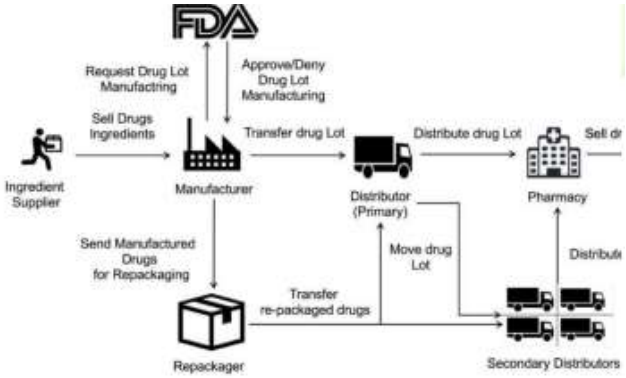

Fig: Drug Supply Chain Stakeholders and Their Relationships

Because of the Bitcoin application's efficient use of the data format, a new approach to designing blockchain-based applications has evolved. The linked list notion is strikingly similar to the fundamental principle that governs the blockchain data structure. The longest chain is dispersed across all network nodes, with each server keeping a unique copy of each block beginning with the genesis block. New applications, such as those for the Internet of Things, e-Government, and online document administration, have been created. This software takes advantage of blockchain technology by incorporating it. Hashes are used to self-cryptographically validate transactions, and a peer-to-peer network offers access to a public distributed ledger of transaction data. When blocks are linked with cryptographic structures (hashes), changing the records becomes an extremely difficult operation because it necessitates reexamining every transaction from the beginning to the most current.

This represents a step forward in the field of using blockchain technology to monitor and trace pharmaceutical supply chains. A comprehensive monitoring system for the full lifetime of drugs, including purchase and disposal, has been established. Nonetheless, it is critical to realize that our research only addresses a subset of these difficulties. Although our reaction is similar in some ways, we take a broader approach to the pharmaceutical supply chain and use blockchain technology. Our strategy varies from others in that it recognizes and embraces all key parties in the pharmaceutical supply chain, including patients,

suppliers, manufacturers, distributors, and the FDA. We evaluate all parties, rather than just the supplier, manufacturer, and wholesaler. By portraying pharmacists in this way, they are unjustly accused of being essential components of the medicine supply chain, which is not the case in reality. Furthermore, we intend to address the current lack of understanding about the interconnections between decentralized storage systems, smart contracts, on-chain resources, and users. Furthermore, detailed explanations have been provided to address any ambiguities and provide clarity. In contrast, these classifications exclude stakeholder engagements. By utilizing smart contract technology, we can achieve continuous and real-time monitoring with minimum human intervention or delays, hence improving our operational effectiveness. Each pharmaceutical container is tied to a unique smart contract. The DApp user sees a catalog of events generated by the smart contract in response to an ownership change. Smart contracts, as opposed to, are designed to carry out specific operations, such as those of a supplier, distributor, or creator. Each party is required to manually verify and affirm the pharmaceuticals received in line with the provisions of this agreement. Mistakes or disturbances during this process have the ability to harm the unalterable data stored in the ledger. To assess the efficiency of the proposed solution, we conducted a thorough analysis of its financial consequences and safety aspects, as well as considering its potential functioning across various supply chains.

The pharmaceutical sector has made numerous efforts to address the well-known difficulty of traceability through anti-counterfeiting techniques. Nonetheless, a thorough review of the data reveals certain challenges and potential answers for efficiently integrating blockchain technology for pharmaceutical monitoring. The reminder in this document is arranged as follows: Section II provides a comprehensive examination of prior initiatives to monitor hospital resources. In the final section, the possible use of a blockchain-based system for pharmaceutical item monitoring and traceability is explored. Section IV demonstrates the recommended approach's implementation, while Section V explains the testing and assessment procedures. Section VI provides a detailed explanation of the technique for evaluating the proposed system, as well as a comprehensive analysis of the evaluation results. Section VII provides a complete assessment of the key findings as well as potential routes for further research, acting as the paper's conclusion.

II. LITERATURE REVIEW

Blockchain technology in healthcare: The revolution starts here

The author of this article asserts that. In recent years, a wide range of enterprises have looked at the possible applications of blockchain technology. This demonstrates its adaptability. So far, research has focused mostly on the financial services sector. Several publications published in service-based industries, like healthcare, show that this is starting to change. This article examines the possible healthcare applications of blockchain technology in depth. This essay will examine the implications, objectives, and prospects of this developing technology using case examples from counterfeit pharmaceutical drugs, public health, and user-centered medical research.

Benefits and guidelines for utilizing blockchain technology in pharmaceutical supply chains: Case Bayer Pharmaceuticals

Denotes user-supplied data. The report's author makes proposals for improving the pharmacy supply chain through the use of blockchain technology and investigates the potential benefits of such a strategy. As an employee at Bayer, a pharmaceutical and life science company, I undertake research on potential blockchain applications within the enterprise to aid with supply chain management.Before we proceed, I'll present an overview of the drug supply chain, blockchain technology, and smart contracts. In the following parts, I will outline the benefits and how to implement them. The following parts will cover blockchain infrastructure and governance, logistics, contracts and payments, information flow and participating organizations, transparency, and product security.According to some

calculations, blockchain technology has the potential to greatly benefit Bayer and the business as a whole. Blockchain technology allows for the sharing of information while protecting trade secrets. Precious, private, and speedy transactions are facilitated, while commodities are made transparent and secure. It is possible to build a system that allows concurrent transactions, thereby benefiting all participants.

Drugledger: A practical blockchain system for drug traceability and regulation:

The user-entered text is contained with tags. Drug monitoring devices can track the placement of drugs, as suggested by the author. They are essential for the proper operation of pharmaceutical companies and the protection of public drug distribution. The outdated centralized server-client paradigm's technology solutions have fallen short of meeting needs such as data integrity, privacy, system resilience, and adaptability. This page provides an article about Drugledger, a blockchain-based system specifically designed for drug monitoring and control. Drugledger's service architecture is organized into three distinct components, which ensure the secrecy and validity of traceability data. Drugledger is significantly more dependable than rival options due to its peer-to-peer architecture. Furthermore, Drugledger increased its storage capacities, resulting in a stable and satisfactory blockchain storage solution. Drugledger's upgraded UTXO method serves as the foundation for the creation of algorithms that simulate the logical activities of the medicine supply chain. Such algorithms can extract, repack, and pack items. This pioneering study investigates the practical and theoretical aspects of developing a blockchain-based system for pharmaceutical surveillance and control.

Design of cold chain application framework (CCAF) based on IOT and cloud

Expression of the individual. Our research establishes a framework for intelligent cold chain applications (SCCAF). The technology includes cloud computing and the Internet of Things (IoT). Our goal at SCCAF is to provide PaaS (Platform as a Service) and IaaS (Infrastructure as a Service) solutions that let individuals develop and run cold chain management systems in an efficient and cost-effective manner. SCCAF also makes it easier to operate a wide variety of Internet of Things (IoT) devices, such as RFID tags, Bluetooth Low Energy (BLE) sensor nodes, and WSN sensor nodes. The use of Hadoop and Spark during the SCCAF system's development was critical since they allowed for the scalable storage and processing of huge data streams in a timely way. The strategy aims to identify potential dangers and detect occurrences in the cold chain. By combining the operational capabilities of existing cold chain management systems, it is possible to gain common components.

III. RELATED WORK

EXISTING SYSTEM

Exhausting Setup Modern healthcare operations rely primarily on extensive supply networks that extend across national and regional borders. These systems are inherently opaque and may introduce impurities in the form of inaccurate information or data while troubleshooting. The current adoption of supply chain constraints has resulted in the creation of counterfeit drugs. This situation not only has a negative impact on public health but also puts significant financial strain on the healthcare industry. As a result, past research has highlighted the significance of a dependable end-to-end tracing and monitoring system in pharmaceutical supply chains. To combat counterfeiting and ensure product safety, the pharmaceutical supply chain must establish a thorough monitoring system. The bulk of healthcare supply chains currently use centralized tracking and tracing technologies. This raises further concerns about authenticity, privacy, and transparency.

PROPOSED SYSTEM

The Drug Traceability System uses blockchain technology to track the movement of pharmaceuticals across the hospital supply chain. The healthcare supply chain includes many

different entities and organizations, including wholesalers, suppliers, pharmacies, hospitals, and other major stakeholders. The medication may be counterfeited or mislabeled during its path from the manufacturer to the patient or client. The recommended solution is as follows. When spotting difficulties in the healthcare supply chain, examine the possibility that a patient has been storing pharmaceuticals for an extended period of time. Delaying the release of pharmaceuticals until there is a significant increase in demand. The act of accumulating medicine has a significant negative impact on the ability to give urgent medical care to patients. To address this issue, information is being gathered about the amount of pharmaceuticals possessed by one side and the timeline for transporting them to the other. To achieve all of our goals, we will use blockchain technology, which is a decentralized ledger that records transactions among participants as blocks.

IV. IMPLEMENTATION

A detailed description of the proposed drug traceability system's main framework, including how stakeholders will interact with the smart contract. A Decentralized Application (DApp) is a piece of software that communicates with a smart contract, on-chain resources, and a decentralized storage system using an application program interface (API) such as Infura, Web3, or JSON RPC. It has a front-end layer that communicates with these items. Stakeholders can leverage the smart contract, autonomous storage system, and on-chain resources. When stakeholders interact with the smart contract, they initiate the supply chain's pre-approved track transactions. They can see and read files saved on the IPFS, such as pamphlets with information and images of pharmaceutical batches.

Decentralized Storage System

Provides a low-cost off-chain storage alternative for securely storing supply chain transaction data while ensuring its reliability, availability, and authenticity. To ensure data security, the computer generates a unique hash for each file received. After uploading the files, their unique hashes are stored on the blockchain and can be retrieved via contracts. Any changes to any of the submitted files affect the relevant hash.

Ethereum SmartContractis used to monitor the supply chain's structure. Participants can use a smart contract to obtain supply chain information. This contract is essential for keeping track of transactions and saving hashes from the decentralized storage server. In addition, the smart contract specifies the responsibilities of each participant in the supply chain. Modifiers ensure that only approved persons are permitted to perform certain activities. A modifier is a component of a function that improves it by introducing additional features or limitations. A smart contract can also be used to facilitate transactions such as the sale of pharmaceutical cartons or lots.

On-chain Resources Storage methods are necessary to keep the events and records generated by the smart contract, allowing for easier monitoring and control. A registration and identification system connects the Ethereum addresses of function calls to decentralized storage systems, providing an extra on-chain resource for data retrieval. Finally, they will connect to on-chain resources to retrieve data such as logs, IPFS hashes, and transactions. The following sections contain detailed descriptions of the system's components.

Stakeholders This group includes patients, manufacturers, distributors, pharmacies, and regulatory organizations such as the Food and Drug Administration. These people are involved in the SAR transaction and have specific responsibilities because of their position in the supply chain. Users can also view the decentralized, easily understandable text recorded on the blockchain, as well as its history and logging data.

V. RESULTS

Fig Homepage: our project has been start its operations in the home page

Fig: view all drug chart results: In this page we have to view drug chart

VI. CONCLUSION

This study investigates the issue of drug traceability in pharmaceutical supply lines and demonstrates how vital it is, particularly in preventing individuals from using counterfeit medicines. We used blockchain technology to develop and test a decentralized system for tracking and locating drugs in the pharmaceutical supply chain. Our proposed solution employs the Ethereum blockchain's smart contracts to automatically record occurrences, ensuring that everyone can view them. It also employs blockchain cryptography to create unchangeable logs of supply chain occurrences. We demonstrated that our proposed technique is cost-effective by displaying how much gas is consumed to carry out the various actions initiated within the smart contract. Our security analysis also found that our proposed solution effectively prevents hostile efforts to compromise the availability, integrity, and nonrepudiation of transaction data. This is especially crucial when there are many persons involved, such as in the pharmaceutical supply chain. Our key goal for the future is to implement the proposed system, which will make drug usage entirely transparent and easy to monitor. We are now focusing on improving the efficiency of pharmaceutical supply lines.

REFERENCES

1. "Shortage of personal protective equipment endangering health worker worldwide" https://tinyurl.com/v5qauvp. [Accessed on: 3-June-2020]
2. Chambliss W, Carroll W, Yelvigi M, el al. "Role of the pharmacist in preventing distribution of counterfeit medications". J Am pharm Assoc. 2012;52(2): 195-199.
3. Ziance RJ. "Roles for pharmacy in combating counterfeit drugs". J Am pharm Assoc. 2008;48: e71- e88.
4. World Health Organization, "Growing threat from counterfeit medicines", 2010.
5. Daniela Bagozzi, C.L. "1 in 10 Medical Products in Developing Countries Is Substandard or Falsified". 2017. Available: https://www. who.int/news- room/detail/28-11 2017-1-in-10-medical-products- indeveloping-countries-is-substandard-or-falsified.[Accessed: 3-June- 2020].
6. Marucheck, Ann; Greis, Noel; Mena, Carlos; Cai, Linning (November 2011). "Product safety and security in the global supply chain: Issues, challenges and research opportunities". Journal of Operations Management. 29 (7 8): 707–720
7. U.S. Food and Drug Administration, "Drug Supply Chain Security Act". Available: https://fda.gov. [Accessed: 3-June-2020].
8. A. Suliman, Z. Husain, M. Abououf,M.Alblooshi, and Khaled Salah, "Monetization of IoT data using smart

contracts", IET Networks, issue 1, volume 8, pages 32-37, 2019.

9. K. M. Khan, J. Arshad and M. M. Khan,"Simulation of transaction malleability attack for blockchain-based e Voting", Computers & Electrical Engineering, volume 83, pages 106583, 2020,
10. N. Nizamuddin, K. Salah, M. A. Azad, J. Arshad and M.H. Rehman, "Decentralized document version control using ethereum blockchain and IPFS", Computers & Electrical Engineering, volume 76, pages 183 - 197,2019.