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Original Article

Blockchain-Based System for Authenticating Counterfeit Medicines

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ABSTRACT
The proliferation of counterfeit medicines creates threats to trust in public health, safety, and the pharmaceutical sector all over the world. This research intends to authenticate medicines and mitigate the risk associated with counterfeit medicine by using blockchain technology. In this paper, a novel authentication system is proposed to track the provenance of pharmaceutical products from production to consumption following with the Leveraging the immutable and decentralized nature of blockchain. Blockchain is securely stored transactional data in interconnected databases by a decentralized digital ledger. Here we suggest using Quick Response (QR) codes which is an effective method for verifying product authenticity, which is linked to the blockchain. Scanners will compare scanned codes with entries in the blockchain, that will confirm genuineness or flagging counterfeits. This swift process will ensure that the customers receive accurate product information or not and it will also help manufacturers to address any further issues promptly.
Keywords: blockchain technology, counterfeit medicine, decentralized, pharmaceutical products, quick response (QR).
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INTRODUCTION
There is a huge menace in the public health sector due to the global spread of fake drugs which is dangerous to the consumer and the pharmaceutical industry. They undermine client well-being as well as the integrity of drug distribution lines globally. Consequently, this study intends to use blockchain to verify medicine and reduce dangers related to rogue pharmaceuticals. The main aim of this research work is to design a new authentication system that should be able to trace the authenticity of pharmaceutical products from the manufacturer through to the end user using blockchain. By exploiting the indelible distributed ledger technology behind blockchain, the intended solution will enable the creation of a visible non-alterable trust-based path for every drug along its supply chain. The new idea focuses on enhancing confidence levels and creating more possibilities within the pharmaceutical industry to ensure health standards are maintained at all costs.

The proposed authentication system will utilize QR codes that will be used to verify if a product is authentic. This particular QR code will be linked with Blockchain so that whenever you scan one, other ones are also scanned in this decentralized ledger. Such a process ensures that one can always authenticate a product at any given time making it easier for both customers who want to buy things well and producers who wish to do better than counterfeiters in their line of production [1]. Presented in this paper was an in-depth exploration of possible methods for deploying blockchain technology to fight against fake pharmaceutical products, showing how it could be very disruptive to verifying the authenticity of drugs in the pharmaceutical industry. Therefore, this study gives an overview of the current issues facing pharmaceutical supply chains and authentication techniques; providing a basis for our own proposal that relies on the use of blockchain technology. In addition to that, the study delves into the technical architecture behind an authentication system whereby smart contracts play a critical role by ensuring transparency within checksums as well as utilizing consensus algorithms that will secure databases from tampering [2]. The main thrust of the research is to support the continued fight against counterfeit drugs by suggesting an authentication system based on blockchain technology that is strong and effective. In order to make sure that we keep public health and safety policies intact while at the same time building trust among the service providers, we have to work on

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

the root causes of fake drugs and add more traceability and transparency in our supply chain.

LITERATURE REVIEW

In the pharmaceutical industry, a good number of studies have been carried out to comprehend the causes of counterfeit medicine and also develop efficient forecasting models for it. After a large-scale analysis of existing research, the aim is to prepare valuable insights into the evolution and effectiveness of the Counterfeit Medicine Authentication System.

M. A. A. Noman, M. J. Hossain, M. M. Kalimulla, S. Azad, and M. A. H. Wadud [1] discussed a significant issue with drug purity and safety, especially in the pharmaceutical sector, where fake drugs kill many people annually as disclosed by literature. The existing methods that have been employed to control counterfeit drugs at an international level have not been successful, leading to the consideration of blockchain technology. Because blockchain is decentralized, it maintains data accuracy among all the people involved, thus becoming an appropriate technology for use when researching how medicines move from production sites up to patients and at the same time keeping track of their performance over time. It argues that blockchain could be used to improve the traceability of drugs within the pharmaceutical supply chain, enforcing authenticity in medicines production and allowing for secure inter-peer exchanges of patient information without disclosing personal identification information.

A. Chandras, S. Agrawal, M. Chaudhary, A. Deshmukh, and S. Shinde [2] addressed the global problem of medicine falsification not only has broad economic, health, and safety consequences but influences economies of both more and less developed countries. Traditional means of drug verification appear to be powerless against counterfeit medicines, which suggests a requirement for creative measures. The decentralized nature of its ledger makes blockchain technology highly transparent and accountable, which is why it seems reasonable to use it for counterfeit protection. To guarantee information safety and combat Sybil attacks, this concept merges blockchain and access control models. This proposed system makes it easier to trust the health system while providing cost advantages with medicine authentication, which is essential to combat fake drugs.

M. Medhat, P. Wagih, M. Mamdouh, K. Ashraf, M. Farid, and A. Abo-Alian [3] discussed how the unprecedented increase in fake products has happened due to globalization and technological improvement in recent times. Producers' response to the fight against this is increasingly becoming a call for the use of blockchain technology to enhance transparency in the supply chain. The concept suggests an autonomous, decentralized application involving the use of Blockchain technology which identifies fake products (DApp) and duplicates them. It is safe as a customer uses QR codes that link to the blockchain in order to verify necessary information. Among these are the challenges of educating users on platforms that live on cryptocurrency prices such as Ethereum and also the fluctuations in these transitions itself. Further studies are needed in automating various processes while taking into consideration newer technologies in data integration specific forms of cryptocurrencies building strong technologies whose base is automated internet systems among others.

X. Xu, N. Tian, H. Gao, H. Lei, Z. Liu, and Z. Liu [4] discussed that the lack of transparency in conventional supply chain management for drugs has made the problem of fake and smuggled drugs worse globally. Of course, since data control is centralized and subsequently vulnerable to manipulation, the situation has turned from bad to worse. Blockchain comes in handy with its ability to offer transparency, data sharing, and self-governing procedures aided by cryptographic algorithms, smart contracts, and consensus mechanisms. Be that as it may, issues such as scalability, interconnectivity, and regulation make its adoption challenging (Makhdoom et al., 2018). This work draws attention to six key areas where blockchain can enhance the operation of pharmaceutical supply chains within academia and industrial setups alike. These include interoperability; scale; privacy versus openness; authenticity of data; blockchain security; and gaps in regulation.

P. Malshan and T. D. B. Weerasinghe [5] discussed the complexity of Healthcare Supply Chain (HSC) traceability as well as the diverse stakeholders involved that have been highlighted in the literature. It is noted that blockchain technology has the capability to ensure that no changes can be made to data, other than being a transparent and trusted method that can be used in tracking pharmaceuticals. Two architectures of blockchain, Hyperledger Fabric,

and Besu, are provided in this paper to support drug traceability requirements. This document deals with open topics for future research suggesting appropriate includes blockchain implementation direction.

E. O. Igbekele, J. Aideloje, A. A. Adebiyi, and A. Adebiyi [6] address an urgency for strong verification measures under the supervision of rule-making institutions in different markets due to the rapid growth of unauthorized goods. Its unchangeable and non-centralized form makes it clear that technologies like blockchain are helpful in dealing with counterfeit products associated with supply chains. The purpose of this systematic review is to investigate studies that have addressed the utilization of blockchain in preventing the replication of goods, determining its efficiency as well as challenges in its implementation. There are those who argue that the application of the technology could aid in securing supply chains while others believe that it is not as effective as other ways [9]. For further studies, there should be efforts to authenticate the superiority of blockchain in comparison to traditional methods and develop ways of overcoming barriers experienced during the process of implementing it in order to reinforce the supply chain mechanisms against counterfeit goods.

DESIGNED FRAMEWORK

A. Storage of Supply Chain Data for Medicines in Blockchains:

One way in which the proposed model seeks to realize a secure and transparent supply chain is by linking drug administration, manufacturers, wholesalers, and drugstores' information systems. A verification authority appointed by the administration of drugs keeps track of whether participants are genuine or not in a blockchain network. As for Bitcoin transactions, it will be useful to have transaction data mirrored on each of its users. Each medicine has its unique QR code. This code contains detailed medicine information under encryptable so as to stop copying. The access to information on designated medicines is controlled by cryptographic authorization through Cryptographic Signatures. Sender authentication is validated by these signatures on messages while encrypted QR codes make medicine non-duplicable [Fig. 1].

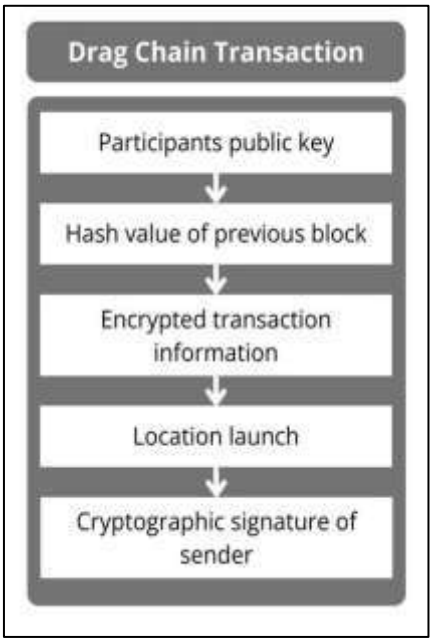

Fig. 1. Drag chain storage for medicine safety

B. Detecting counterfeit medicine

Fake drug detection is possible through Artificial Intelligence or AI. We use deep learning models, feature extraction engines, and anomaly detection officers all working together to identify the pharmaceuticals that are fake. Products suspected of being counterfeit are immediately segregated from the rest so that even if they are discovered later on then within a given time frame they can still be disassociated with reputable brands' images [7]. To boost the security of our system, we integrated into our blockchain prototype a location tracker that logs where any transaction takes place; during every transaction event, the Google Geolocation API is used by the system to determine the exact place of this transaction. This extra aspect related to location confirmation brings added importance to our system. In case where transaction locus varies with the authorized participant designated point, then that particular block will be considered null and void, it ceases to exist as a part of the blockchain hence protecting supply chain integrity; thereby hindering the entrance of fake medication [10]. The use of this technique will increase reliance on the pharmacy chain while also preventing individuals who are affiliated with dangerous medications from being supplied with them. The pseudocode is::

• Pseudocode 1:

Pseudocode 1 Matching with the location.

```
1. getLocation( ){
2. navigator.geolocation.getCurrentPosition(x,y);
3.  x ← position.coords.latitude;
```

4. y ← position.coords.longitude;
5. }
6.
7. isBlock Valid(location){
8. if Other_conditions && (location === this.fromAddress.location)
9. then return true;
10. }

If an unfamiliar address is identified, the system finds the block as insufficient and hence is omitted from the string – an unregistered provider cannot include in the supply chain any counterfeit drugs.

• Pseudocode 2 illustrates bellow:

Pseudocode 2 validation at the customer end.

1. qrScanning(scannedValue, buyQuantity){
2. for (value ← this.chain.block){
3. if value === scannedValue
4. then chain.block( );
5. }
6. x ← this.fromAddress.quantit ('Medicine name')
7. if buyQuantity <= x
8. then valid;
9. x - = buyQuantity;
10. else invalid;
11. }

To make sure drugs are not counterfeit, QR codes are placed on the packaging. When individuals scan them, they find out about blockchain information associated with them. Whenever a person scans a unique QR code, they receive a form of identification which is then verified using information found in blockchain records. Security can be improved further by linking the quantity of drugs at a retailer's place on an event-by-event basis such that only specific kinds are cross-checked [8]. This implies that verification measures have been met before releasing any unauthorized drugs onto the market. Equally important is that Prompts for the purchase' are unauthentic.

C. Prototype Methodology

The prototype methodology has been put in place, which is validated by the drug administrator who mandates validation by the drug administrator for inclusion of participants, using a private blockchain system. To administer these digital signatures participants get public addresses from the admin to ensure trust. In this case, transacted information like medicine details will include the sender's public key and the receiver's public key among other public keys [11][12]. This shared data is encrypted in blocks with 1 block being visible to only a single person for read access; however, it is open for viewing for anyone else in terms of how much (quantity) is in that particular block plus when it was created on the blockchain network (timestamp). Each transaction block has got information about exactly where it came from which will boost the entire level of protection. Whenever there is a successful transaction in place then another block gets added and then sent across to everyone else on the network. On the other hand, an implemented data compression algorithm gets rid of expired medication details from the blockchain itself so that current and useful data can be maintained [Fig. 2]..

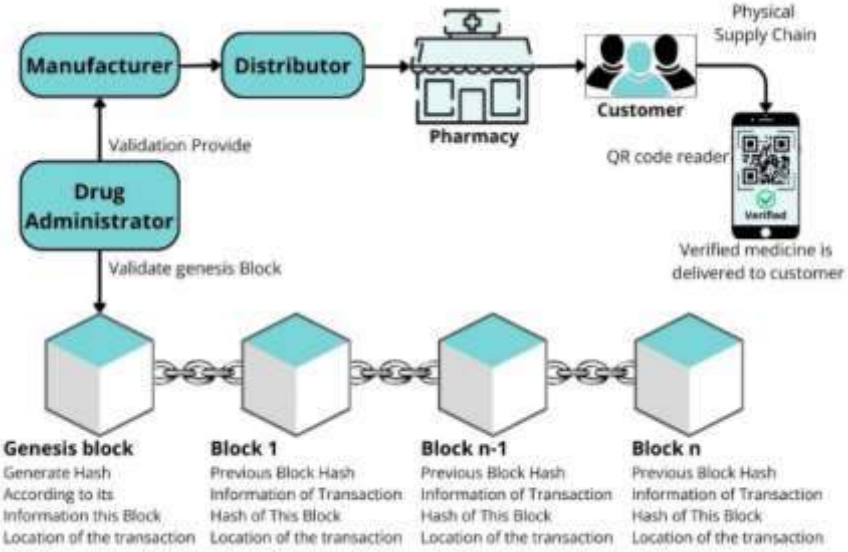

Fig. 2. Prototype Workflow

QR code scanning is an option for people to check if a drug is real or fake using a blockchain system, which guarantees drug safety from production to consumption with encrypted data transmission,

transaction transparency, location confirmation, data relevance maintenance mechanisms in place for conforming to user-friendly authenticity validation protocols [Fig. 2].

IMPLEMENTATION AND EVALUATION

A. Implementation

The current prototype consists of validation, blockchain, key generation, and transaction logic modules developed using JavaScript and the Angular web framework. It relies on well-known open-source libraries such as SHA256, elliptic, and qrious. In particular, elliptic is used for the public-private key generation functions within the key generator module. Keys are allotted by the validation module to participants according to the prescript of the drug administrator. Currently, AngularJS is used in the development of the front end and it helps to address the challenges encountered while developing single-page applications, with the prototype being operated on localhost using Node.js, which is a cross-platform back-end JavaScript runtime, such that transactions are managed through the transaction module with valid transactions added to the blockchain using the blockchain module. This configuration guarantees a resilient and effective drug monitoring system in the supply chain, and can be used easily by anyone involved, reliability of such secure key management, and at the same time transactions which are open to public view

B. Evaluation

1) Practically: Our prototype focuses on being practical by ensuring we have data privacy, cutting-edge security technologies like authentication, and location-based transaction tracking that will go a long way towards counterfeiting. It also provides user-friendly interface as well as single-unit verification, leading to more stable storage of data with expiration date controls needs addressed at the expense of some other priorities which might not be quite as important today but would have been in future works.

2) Security: Our prototype is secure from cyber attacks as it runs on a permissioned blockchain system with drug administrators overseeing the access of participants. To prevent unauthorized access, it maintains a peer-to-peer design thus reducing chances for DoS attacks while at the same time providing strong protection against fraud.

3) Efficiency: Our prototype, which is designed to meet the practical needs of medicine supply chains, is centered on boosting the communication efficiency, the effectiveness of consensus algorithms, and the practical throughput. Upon a further quantitative analysis, its appropriateness in real production systems will be assessed.

CONCLUSION

In this paper, we introduce a functional blockchain-driven structure specifically designed for the safe handling of the healthcare delivery network between selected stakeholders. By utilizing blockchain technology, our system is capable of providing a unique identity to the medications, thus making it easy to distinguish between counterfeit drugs as well as fake suppliers. The traditional medicine supply chain service architecture has been revolutionized by the prototype. I guarantee you that both medicine security and manufacturer authenticity are assured by this system. When transaction location tracking is incorporated it will in turn enhance system reliability. Therefore, optimization of blockchain data storage by removing expired medicine data enhances chain stability and overall acceptability.

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