Blockchain: A Solution for Improved Traceability with Reduced Counterfeits in Supply Chain of Drugs

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Abstract

The Pharmaceutical supply chain needs huge attention while developing technology-based solutions as there is a great need of surveillance in the production and distribution of fake, substandard, counterfeit and grey market medicines, which account for hundreds of billions per year across the globe. Counterfeit drugs have captured the global markets over the period and affecting and risking many lives in a large [1]; solutions to address these have become inevitable. Studies revealed a lot of pharmaceutical products, medicinal devices and doctors have been subjected to counterfeiting the drug supply chain which is prone to lots of pharmaceutical crime. The pharmaceutical market's growth and a rise in world-wide sale of drugs leading to invention of many forms of technology and digital-based platforms trying to come up with solutions for the supply chain. Besides pharmaceutical frauds, increasing security and addressing vulnerabilities of the medical supplies is an area of concern. This leads to the formation of many technology solutions to make supply chains secure, trustable and remove counterfeit drugs from it by applying various methods and approaches. Our System proposes to leverage blockchain technology to make the supply chain of drugs transparent to increase trust among actors and provide security, authenticity and traceability with the help of IoT.

1. INTRODUCTION

As proposed by a study conducted by the World Health Organization (WHO), more than 100,000 deaths a year in Africa are due to counterfeit/fake drugs ordered from unknown or untrusted vendors[2,3]. The actors involved in the pharmaceutical supply chain cannot completely guarantee the authenticity of drugs because ownership of drugs changes continuously in the supply chain, secondly as supply chain does not connect the physical and information flows of drugs i.e. where the product/drug is exactly at any particular moment which is untraceable most of the time and hence for drugs regulatory authorities traceability of drugs is quite costly practice. Hence patients at the end are the victims of any counterfeit drugs supplied. Thus one of the major reasons for the drug's counterfeiting is the current pharmaceutical supply chain in which the lack of end to end visibility, security, trust and traceability are major issues to be addressed.

Information and Communication Technology (ICT) is being empowered by Blockchain technology in all the ways. This research aims to evaluate the implication of blockchain technology on the supply chain and procurement in the pharmaceutical industry. Blockchain can positively influence tracking, tracing, visibility, trust through smart contracts in the supply chain, and thus will positively impact the operation of the pharmaceutical industry. Our idea is to bring all these features to the supply chain by leveraging the advantages provided by blockchain and IoT.[10,11,12]

2. LITERATURE SURVEY

Blockchain solutions to non-financial applications and its integration in business strategy is facing resistance as it requires a great amount of sharing of information. As per *Perboli, G. et al.*[4] the utmost need is to involve all users/actors in blockchain while implementing it. *Author* described the application of the blockchain in the supply chain as an enhancement that has the ability to assist all the stakeholders/actors in the flow of the chain. An accurate implementation of the blockchain in the supply chain must begin with an study of the objectives of all the actors involved, to build a business design suited to stating the returns of a solution.

Mettler M. [5] discussed *Hyperledger*, a research network across industries involving Cisco, IBM , Bloomberg , Accenture, Intel and Block Stream recently launched the Counterfeit Medicines Project which has an eye on the issue of pharmaceutical drug counterfeiting. Each drug is marked with a timestamp under this project.

Time and place of drug production can be known due to this approach. Using Blockchain technology the origin of a product is identified, and any transfer of ownership of product in each case is made visible and available to everyone. Fraud, manipulated or subpar quality goods can be traced and detected.

In paper [6], the author describes the challenges and future requirements within the pharmaceutical industry for tracing products. The author also describes blockchain offers the best and most effective solution for securely sharing the data and efficiently in the entire supply chain and product life cycle.

A. Jabbari *et al*. [7] describes that for blockchain to have a considerable hit on supply chain, it must remove the need for dependable third parties and to be remodeled to the explicit demands to supply chains undermost various requirements and in terms of the evidently complicated structure of supply chain.

As per the report by Deloitte[8], the evolving technology behind sensors and electronic chips makes them increasingly portable and can be used as an opportunity for an organization to attach sensors to physical products for better tracking and thereby detecting frauds. If the sensors collecting large chunks of data are connected to a blockchain administering authorization,traceability and transparency, value can be created on accumulated data.

3. PROBLEM DEFINITION

The problem is lack of end to end visibility, security, trust and traceability in the current pharmaceutical supply chain. The actors involved in the supply chain cannot completely guarantee the authenticity of drugs and thus the patient at the end is the victim of any faulty/fake drugs supplied. Our idea is to bring all these features to the supply chain by leveraging the advantages provided by blockchain and IoT. Blockchain will provide secure transactions among the stakeholders of the System and thus ensure security and prevention of fake or faulty transactions among them ,while IoT can help verify the authenticity of drug which will increase the trust among the stakeholders. It can also keep track of the temperature in the drug's surroundings and keep the track of the location of the drug which can connect the physical and information flows of the supply chain making every order trackable and secure. . As all transactions are logged on the distributed ledger. As every node in the blockchain keeps a report of the transaction, it is possible to identify the source of the drug, the supplier/ owner/manufacturer and the wholesaler right away.

4. IMPLEMENTATION

4.1. Proposed System

In this work, we explore a blockchain structure applied to the Pharmaceutical Supply Chain [10-12].

A blockchain technology is a distributed ledger technology for network online data transactions that may be public or private depending on all users, it facilitates data storage in a trusted and dependable way [15,16]. Public key cryptography is used in blockchain to generate an timestamped , immutable, append-only chain of data

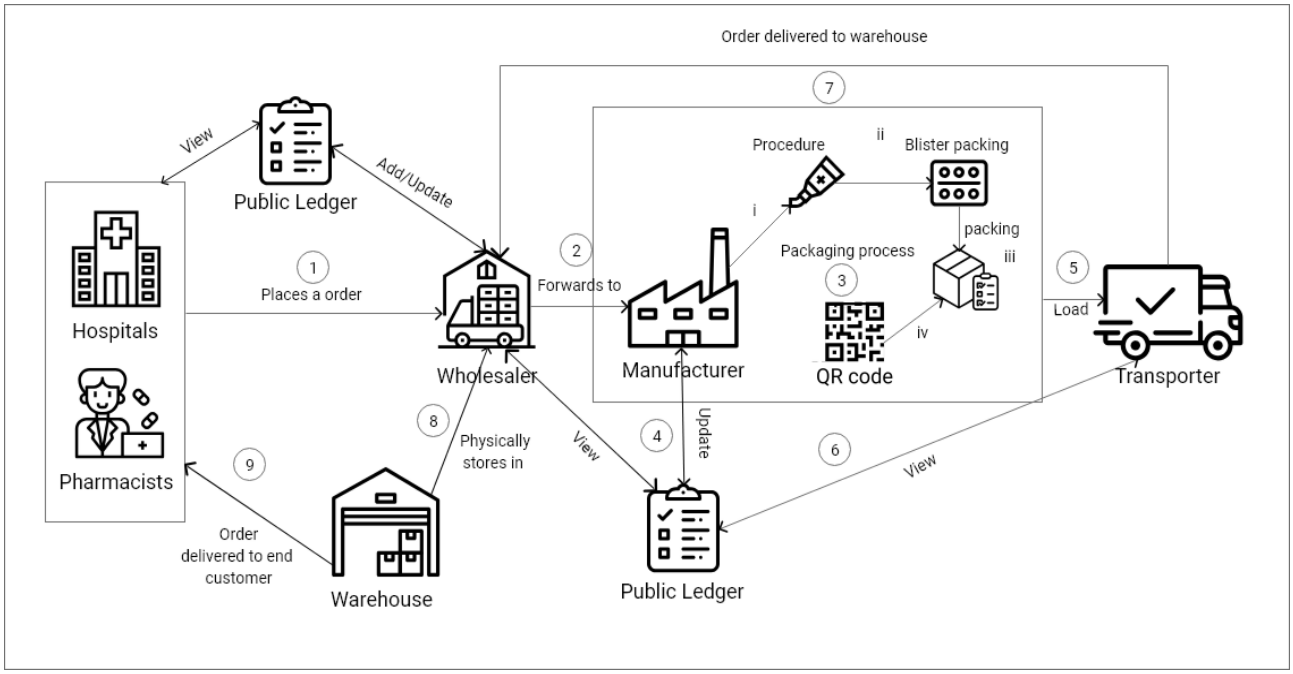

Fig. 1: Modular Diagram of the proposed System

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nodes.There is a separate copy of blockchain on each and every node participating in the network.

The proposed System allows the addition of arbitrary logic to process, validate, and access the data.Smart Contracts which reside on all the nodes in a blockchain help us implement this. Smart Contracts are like a code or a program that can guarantee authorized access as they execute only if certain conditions are met .The ability to create smart contracts makes blockchain appropriate for health care, where strict regulations decide how sensitive data can be used. Information exchange using smart contracts is transparent, hassle-free, and discards a middleman's need, as blockchain allows the data sharing based on the predetermined conditions in the contract [17,18].

4.2. Methodology

There are four stakeholders in the proposed System.

- Manufacturer/Pharmaceutical Companies
- Wholesaler
- Retailer/Pharmacist/Hospitals
- Consumers

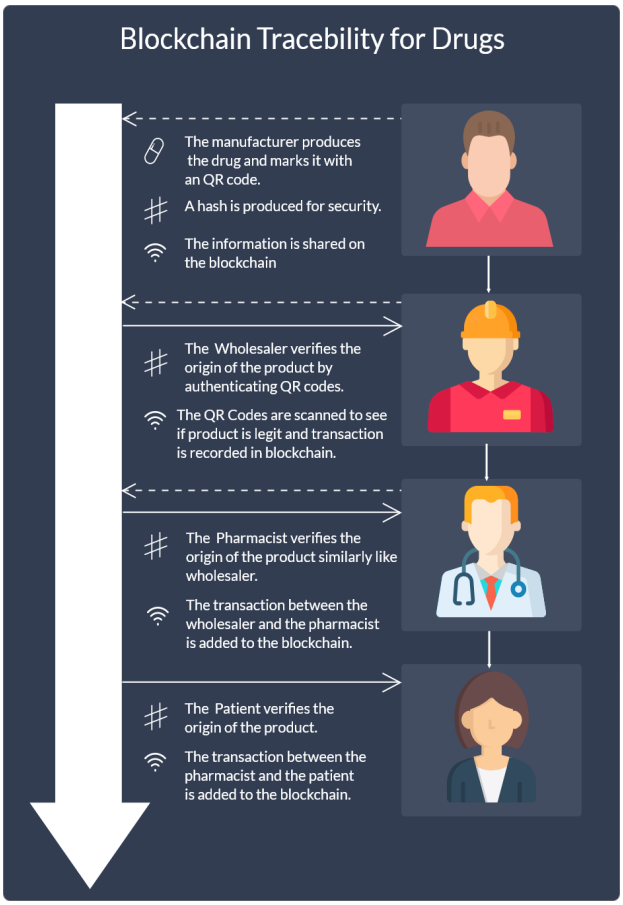

Fig. 2: Flow diagram of the pharmaceutical supply chain using Blockchain and IoT.

1. **Manufacturer/Pharmaceutical Companies:**A company owner or a CEO or director of a branch for a pharmaceutical company or an entire company or manufacturing factory responsible for manufacturing a drug/medicine that is then supplied to wholesalers.
2. **Wholesaler:**Person or a distributor or a firm that buys goods (here drugs)and stores them to later distribute and sell to the retailers/pharmacists/hospitals.They usually buy in large amounts and stack their warehouses and sell in bulk at comparatively less profit.
3. **Retailer/Pharmacists/Hospitals:** These people are at the end of the chain just before consumers.They operate at stores who do retail in general i.e. they sell medicines/drugs bought from the wholesalers to consumers.They usually own shops or work at shops selling drugs.
4. **Consumers:** A consumer is the one who pays something to consume goods and services produced. In our case, a person at a retail shop to buy drugs/ medicines of any kind.

4.3. Functioning

Following is a detailed explanation of what our proposed solution does to maintain security and authenticity using blockchain.

- **Generation of QR code and uploading block on blockchain:** The manufacturer produces the drug and marks it with a unique code, QR Code in this case. QRcode has the benefits of one-dimensional barcodes as well as the benefits of the other 2D barcodes, like high reliability, large capacity, effective encoding of words and images, strong confidentiality, etc.[19]. Some of the most brilliant features are super-fast decoding of data and omnidirectional reading. QRcode has the maximum storage of 7089 digital data, or 4296 characters, or 2953 bytes data. A hash is produced using the SHA1 algorithm which is the information in QR Code, and block is stored on the blockchain for authentication purposes. SHA-1 (Secure Hash Algorithm) is a hash function that takes an input and produces a 160-bit (20-byte) hash value known as a

Fig. 3: Unique QR Code generation based on order-id

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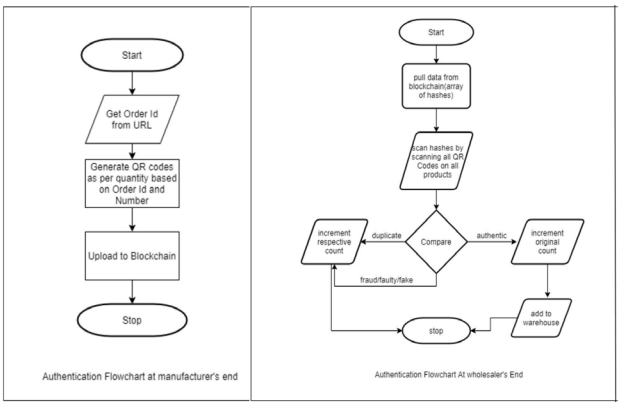

Fig. 4: Authentication process flowcharts for manufacturer-wholesaler cycle

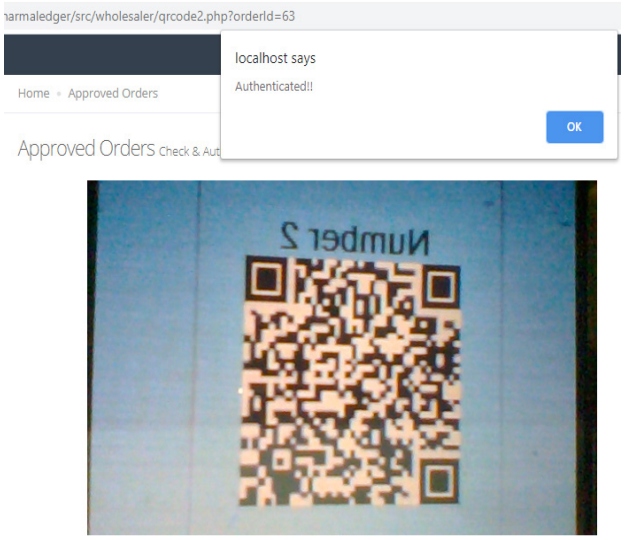

Fig. 5: Authentic QR Code scanning.

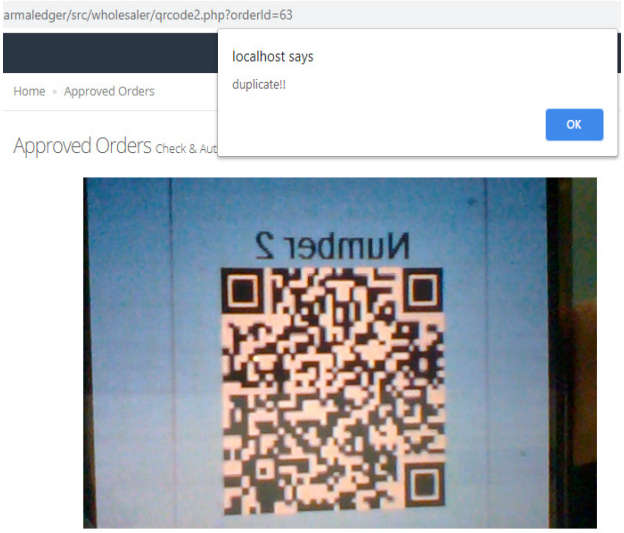

Fig. 6: Duplicate QR Code scanning.

message digest.Some widely used security applications and protocols, SSH, IPSec,TLS and SSL, PGP, and S/MIME use SHA-1 [9,13]. Once these are generated, they are uploaded to blockchain as seen in Fig. 9 along with some other data(order_id,manufacturer_id,wholesaler_id and hash data) as seen in the figure. These are used to authenticate the products.

- **Verification of QR through Blockchain:** The wholesaler verifies the origin of the product by

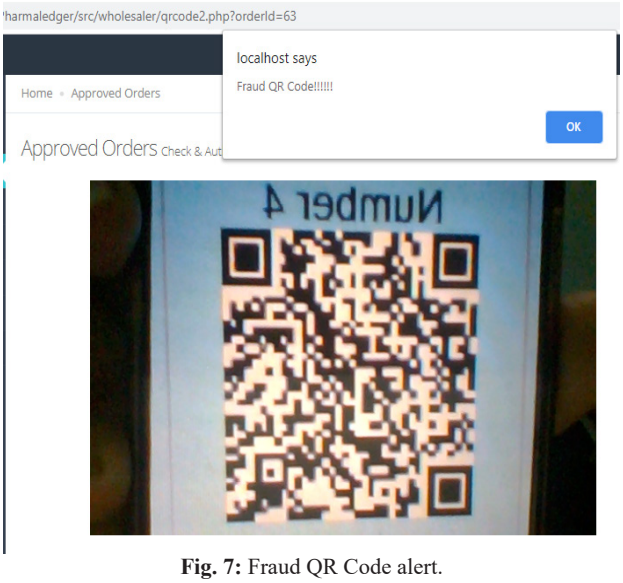

Fig. 7: Fraud QR Code alert.

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2_deploy_contract.js
====================

   Replacing 'ApproveOrder'
   ------------------------
   > transaction hash:    0xa283c425860cde0a66779dbafd9ffcd8463a28a7df8a23c8d62fc1b3b8e44091
   > Blocks: 0            Seconds: 0
   > contract address:    0x6D007eA3a5FD6038b284b7CD675e68A0FEdf1CDa
   > block number:        3
   > block timestamp:     1586284047
   > account:             0x47cCB5b54f81a8E0A2D1eB73b33fbf07210C140b
   > balance:             99.9870065
   > gas used:            346387
   > gas price:           20 gwei
   > value sent:          0 ETH
   > total cost:          0.00692774 ETH


   Replacing 'ApproveRetailerOrder'
   --------------------------------
   > transaction hash:    0xebfbb6c54e43128898b9a95496a634cda4251ae3030dcb260c2cb5e26a602a93
   > Blocks: 0            Seconds: 0
   > contract address:    0x0D4AfF5F1409D53295725e62906F1764bD09594F
   > block number:        4
   > block timestamp:     1586284047
   > account:             0x47cCB5b54f81a8E0A2D1eB73b33fbf07210C140b
   > balance:             99.98007876
   > gas used:            346387
   > gas price:           20 gwei
   > value sent:          0 ETH
   > total cost:          0.00692774 ETH


   > Saving migration to chain.
   > Saving artifacts
   -------------------------------------
   > Total cost:          0.01385548 ETH


Summary
=======
> Total deployments:   3
> Final cost:          0.01908078 ETH


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Fig. 8: Blockchain showing deployment of contracts

Fig. 9: Blockchain showing uploaded data

scanning the QR Code and matching the hash of the product received with the one on the blockchain to authenticate it. The wholesaler pulls the hashes from the blockchain and matches them one by one to the hashes scanned from QR Codes on the received products. Only the authentic products have added to the warehouse after a thorough scan of the QR Codes on the shipment received. Fig. 5, 6 and 7 demonstrate the process of authentication at the wholesaler's end. This process is depicted in flowcharts below in Fig. 4. The transaction between the manufacturer and the wholesaler is added to the blockchain after verifying its authenticity.

- The pharmacist verifies the origin of the product in a similar way as the wholesaler did. The transaction between the wholesaler and the pharmacist is added to the blockchain.The process of authentication in this cycle of retailer/pharmacist-wholesaler is the same as wholesaler-manufacturer cycle.
- The patient/consumer verifies the origin of the product. The transaction between the pharmacist and the patient is added to the blockchain.

5. CONCLUSION

The research shows that pharmaceutical companies can pursue blockchain as an effective solution to adhering to future track-and-trace regulations in the pharmaceutical industry. It also has the potential to reduce counterfeiting and corruption across the supply chain. Furthermore, companies can achieve significantly overhead cost reductions related to administering procure-to-pay activities by adopting blockchain for developing smart contracts. It can also potentially improve the security of IoT devices across the company's supply chain. With this understanding, the System aims to prioritize and pilot blockchain applications for serialization and track and trace applications in the near term. In the medium term, the System will explore blockchain for IoT devices' security and eliminate counterfeiting. In the long run, it wants to try blockchain for smart contracts. With the proposed System, traceability security and transparency can be handled well by combining blockchain and IoT results.From the current status of the project, it can be very well seen that the authentication part has been taken care of with the help of blockchain and QR Codes.This concludes the parts of security and authentication to a greater extent. Temperature Sensing and monitoring part can be seen as an enhancement to the System as it is a quality control measure and is considered as a future scope for the system.

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