

Pharmaledger - An Improved Solution to identify counterfeit drugs in Supply Chain

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Abstract-- According to an analysis of drug samples done by WHO it was found that around 10.5 percent of pharmaceutical drugs in low and middle-income countries were fake or substandard[1].Counterfeit drugs can potentially cause problems for populous regions like India and China as they are two of the biggest drug manufacturers[2].Attributed to issues like these, pharmaceutical supply chain which is one of the biggest business verticals is at a threat. Solutions to battle these issues and to make drug supply chains secure are constantly under development. Our aim is to propose a possible solution for achieving the goals of making the pharmaceutical supply chain more secure and free it from counterfeit drugs or frauds which introduce subpar quality of drugs in the chain. Blockchain and IoT can be used to develop a solution which fulfills this aim as blockchain is an immutable distributed ledger which will guarantee transparency thus preventing frauds and IoT can help monitor status and environment of the drugs so that subpar quality drugs can be eliminated.

Keywords-- BlockChain, IoT, Supply Chain, Pharmaceutical Supply chain, Information Security, Counterfeiting.

I. INTRODUCTION

The presence and use of understandard and falsified medical products in countries by patients is threatening to undermine progress towards achieving the Sustainable Development Goals. Such goods can be of low quality, unhealthy or ineffective, posing a threat to the safety of those who take them.As globalized manufacturing and distribution systems grow ever more complex, the problem of understandard and falsified medical products continues to rise. That complexity increases the risk of factory-consumer production errors, or medicines degrading demand for pharmaceutical products, vaccines and other medicines in nearly every country, In addition to weak supply chain management and the rise of e-commerce, it also creates incentives for the introduction of counterfeit drugs into the supply chain.

Our aim is to solve the problem of Drug Manufacturers as they are struggling to find an effective way to securely, transparently, and rapidly track the origin of these drugs, or access data required to combat counterfeit drug sales. Any fraud in the Drug Industry may lead to catastrophic effects damaging several lives. Centralized database to store the information of the drug supply chain is highly susceptible to unauthorized modifications which might lead to loss of all the stakeholders. Thus there is a need for high transparency and distribution in the system.

Our Application that is Pharmaledger is a supply chain monitoring software for drugs.Our objective is to reduce counterfeit drugs from the supply chain which costs the life of people and ensure goals such as End to End Visibility of drug , Inferred trust between stakeholders, fraud detection and cost effectiveness.Problems with existing supply chains are that they use Centralized database to store the information of the drug supply chain which is highly susceptible to unauthorized modifications and might lead to loss of all the stakeholders and cannot ensure the transparency between stakeholders , traceability of drugs, maintain privacy and most importantly they are not able to detect counterfeit drugs in the supply chain.

Through blockchain technology, the distributed ledger technology would allow information about each transaction across the process to be viewed and not changed. This could highlight where any issues are and help businesses involved in making changes to improve efficiencies.

As some medicines are restricted to particular temperature so temperature sensors fixed in transportation vehicle will help us to monitor the temperature of medicine continuously and ultimately receiving stakeholders will be notified about the same

Features provided by our Application are as follows :-

- End to End Visibility of drugs using smart contracts and consensus Algorithms provided by blockchain enables transparency in the system
- Traceability of drugs using automatically generated QR codes and monitored temperature data from IOT sensors and expiry drugs are also tracked.
- Privacy is ensured cryptographic hash functions are used to encrypt data
- Fraud Detection will be enabled by the transparent and auditable features of Blockchain and Iot
- Temperature restricted drugs are monitored and tracked with the help of IOT sensors

II. LITERATURE SURVEY

A. Blockchain Ready Manufacturing Supply Chain Using Distributed Ledger :

The blockchain technology will theoretically boost the problems of accountability and traceability within the supply chain by utilising immutable data recording, distributed storage, and user access control. The system proposed by author facilitates a vast amount of data to be collected about the products and users in the manufacturing industry, which can be beneficial to a variety of individuals, organizations, governments and researchers. For example, this allows consumers to readily access accurate data specific to any product manufactured through supply chains enabled by a blockchain[3].

B. Blockchain technology and its relationships to sustainable supply chain management :

The evolution of supply chain management based on blockchain is introduced enabling the development of shared, stable, transparent ledgers, autonomous smart contracts, and trustworthy and safe networks. It also supports transactions between partners (peer-to-peer) by reducing the role of intermediaries within the network. Reliability and transparency of blockchain technology are intended to facilitate more effectively the flow of material and information through the supply chain; with automated governance requirements. This transition will lead to a wider change from an industrial sustainable, commodity, products economy to an information economy[4].

C. Blockchain Technology Innovations :

The authors of this paper described blockchain technology as a catalyst for emerging use cases in the financial and non-financial sectors such as industrial manufacturing, supply chain and healthcare. The paper indicates that blockchain can play a key role in transforming the digitisation of industries and applications by enabling secure confidence frameworks and creating an agile value chain. Author explains how blockchain technology can be used to help optimize system effectiveness whilst improving safety and scalability[5].

D. Using IoT in Supply Chain Management :

Author has explored various subsections of Supply chain like manufacturing, distributing, etc. where IoT can enhance the working and make the chain secure. Simple RFID tags can also make the products uniquely identifiable and thus provide tracking and security. The introduction of IoT and its applications in supply chain management has grown to a degree that it not only helped track and in-transit goods, but has also influenced

efficient inventory management and minimized supply chain losses. This has contributed to significant economic benefits for the enterprises and helped to extend the supply chain operations over vast geographies[6].

III. IMPLEMENTATION DETAILS

Blockchain is a distributed ledger technology, commonly used in the crypto currency Bitcoin. The Financial Times (2016) defines Blockchain as a “network of computers, all of which must approve a transaction that has taken place before it is recorded, in a ‘chain’ of computer code. The details of the transfer are recorded on a public ledger that anyone on the network can see.”

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

If IoT and Blockchain can be implemented together, they can support each other and create a system which gets the best out of both technologies. Security by both, authentication by both, Quality management by IoT and trust establishment by transparency enabled by blockchain can make the drug supply chain seamlessly fraud proof and help establish a healthy relationship amongst the stakeholders/actors in the chain.

A. *Actors or participants :*

1) *Manufacturer :*

He is the origin point in this chain, manufacturer is a company which basically manufactures a drug and supplies it to the wholesalers. Manufacturer has the role of producing the drugs in bulk and receiving orders from wholesalers and supplying drugs accordingly.

2) *Wholesaler :*

Wholesaler is the one who places bulk orders to a manufacturer and handles the orders from retailers. Wholesaler buys the drugs in bulk at lower prices from the manufacturer and redistributes them to retailers at a marginal profit rate. He is the second actor in the drug supply chain.

3) *Retailer/Pharmacist :*

He is the third actor after wholesaler. He can be a drug store owner or a pharmaceutical shop owner commonly known as a pharmacist. He places orders to wholesalers and sells them at market price to customers or consumers who are the last actors in the chain.

4) *Customer/Consumer :*

He is the last actor in the chain and is the one who will be directly affected by a fraud or fake or subpar quality drug if he buys one from the pharmacist.

B. *Methodology :*

As seen in the diagram below, a drug's journey before reaching the consumer can be seen and is also explained below:

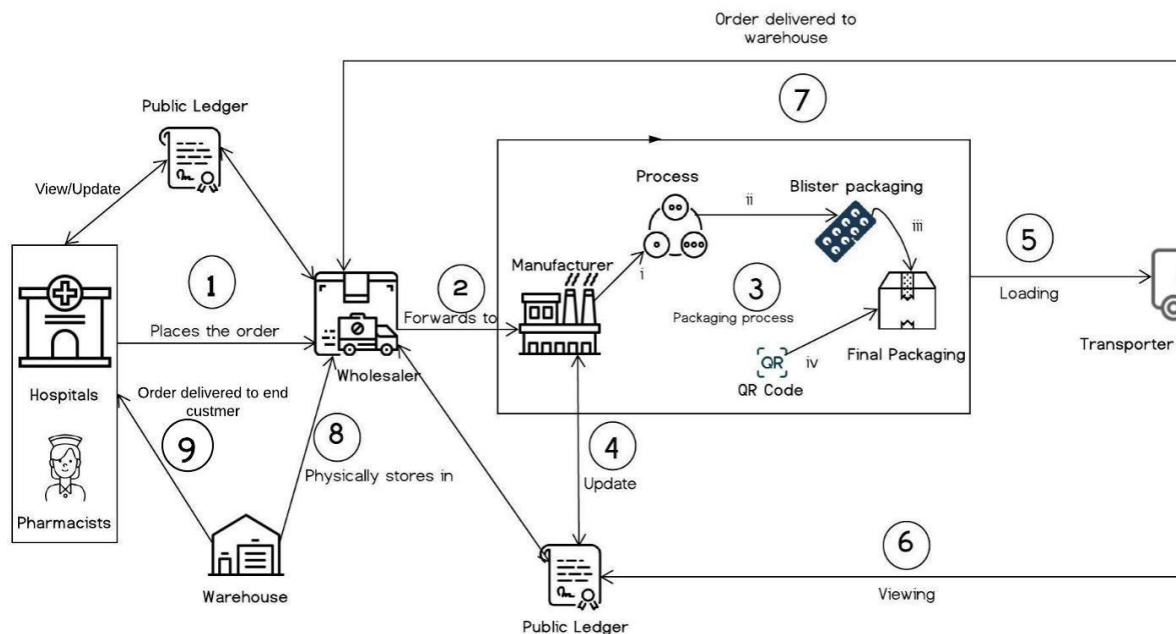


Fig. 1 Modular Diagram of the proposed system.

Explanation for the diagram above :

- 1) Order placed by any retailer to wholesaler
- 2) Order passed on to the manufacturer by wholesaler.
- 3) Unique QR Code generated for each medicine
- 4) These QR Codes are uploaded to Blockchain for authentication purposes.
- 5) , 6) and 7) Shipment on the way to wholesaler
- 8) Wholesaler receives the shipment and authenticates using blockchain.
- 9) Retailer receives the shipment by wholesaler and authenticates it.

1) QR Generation Module :

This module is responsible for producing unique QR code for each medicine to be shipped. A drug/medicine after production can be labelled with a QR Code instead of barcodes, as QR Codes are 2-dimensional as compared to 1-dimensional barcodes. Superfast decoding, high reliability, large capacity and anti-counterfeiting are some other advantages of a QR Code [7]. Before encoding string into QR Code, it is passed through SHA-1 algorithm which is a hashing algorithm. SHA-1 (Secure Hash Algorithm) is a cryptographic hash function which takes an input and produces a 160-bit (20-byte) hash value known as a message digest. Several widely used security applications and protocols, TLS and SSL, PGP, SSH, S/MIME, and IPSec may use SHA-1 [8]. Hence, the data encoded in the QR code is double secure now.

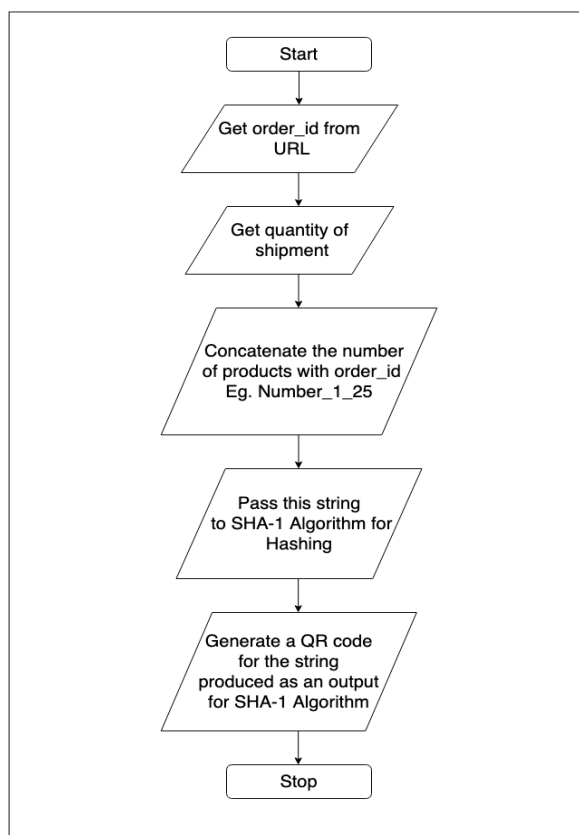


Fig. 2 QR Code generation flowchart.



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

2) Authentication Module :

This module is responsible for secure transfer of drugs from one stakeholder to another. The QR Codes generated by QR Code generation module are uploaded to blockchain after generation. The shipment when received by receiver is scanned one by one and while doing so, the QR Code on each drug is matched with the QR Codes pulled down by blockchain (which were uploaded by sender). Upon matching each drug will be categorised into 3 categories : authentic, fraud or duplicate. Separate count for each of these categories will be maintained and only the authentic drugs will be added to warehouse of the receiver. Consider manufacturer-wholesaler cycle, flowcharts for which are as follows:

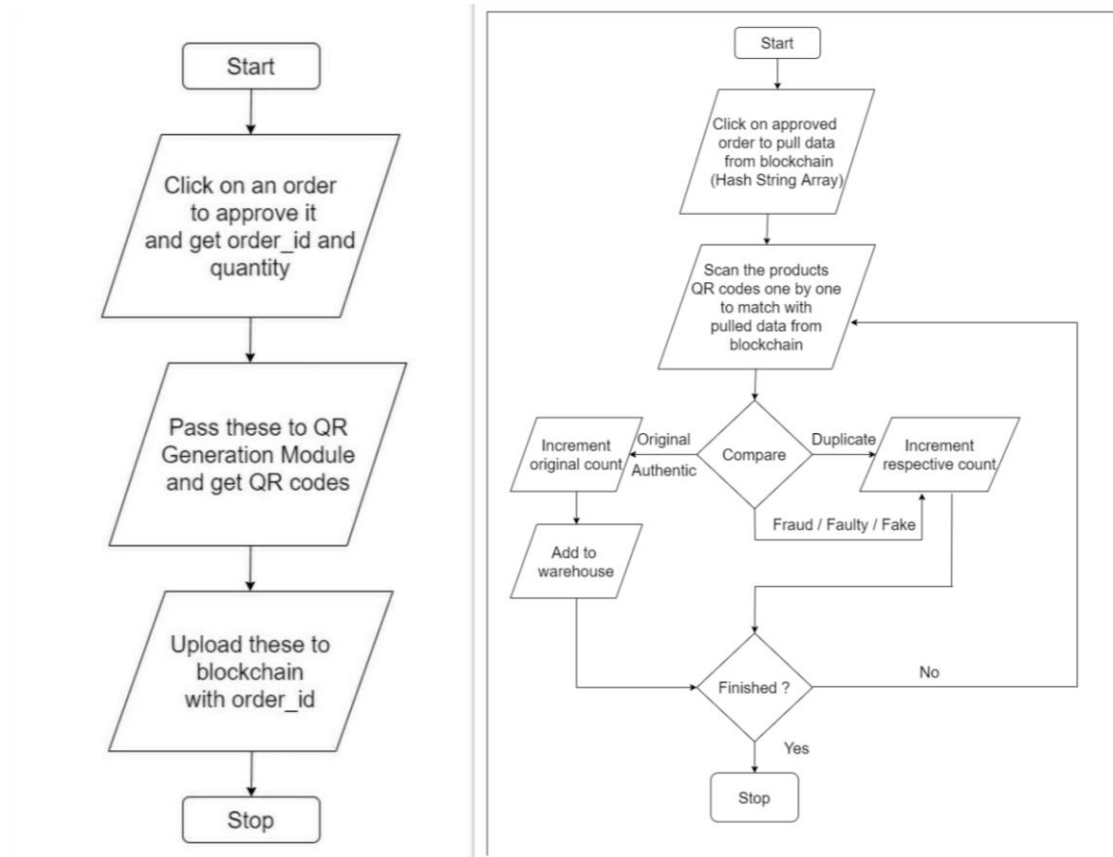


Fig. 4 Flowcharts showing authentication at manufacturer and wholesaler ends respectively.

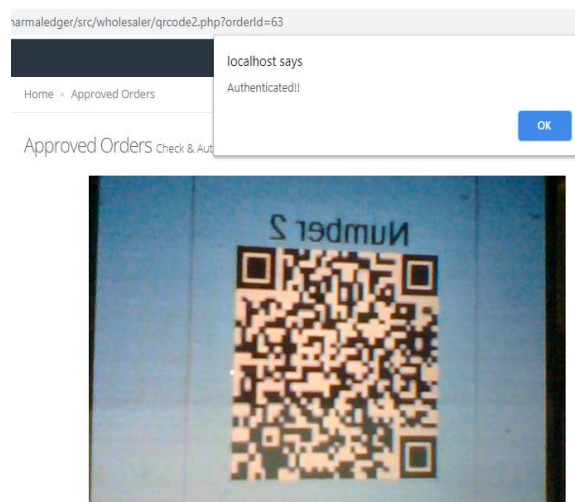


Fig. 5 Authentic QR Code scanning.

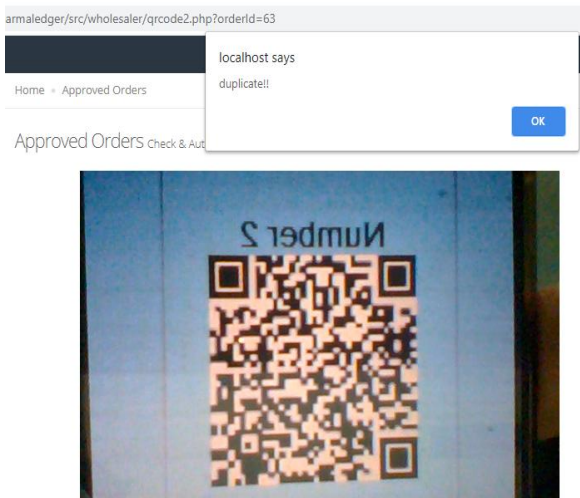


Fig. 6 Duplicate QR Code scanning.

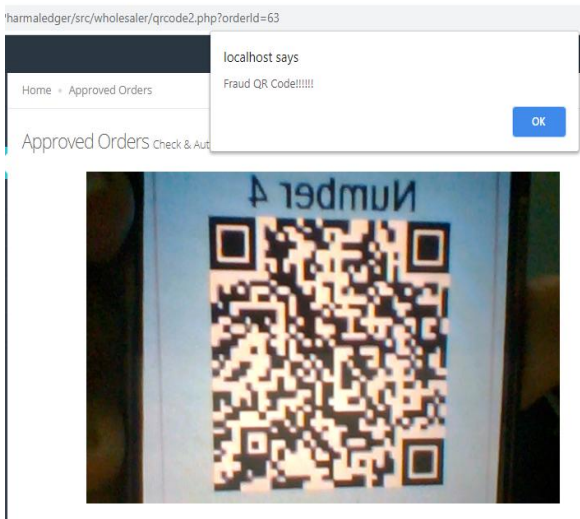


Fig. 7 Fraud QR Code alert.

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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

C:\wamp64\www\BE-main>

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Fig. 8 Blockchain showing deployment of contracts

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truffle(development)> ApproveOrder.deployed().then(function(instance){i=instance})
undefined
truffle(development)> i.orders()
<BN: 1>
truffle(development)> i.wholesalerorder(1)
Result {
  '0': <BN: 32>,
  '1': <BN: 1>,
  '2': <BN: 4>,
  '3': <BN: 3>,
  '4':
    '2b173659603a97cfff198e13c2b3fb0c911cecaf,67d0f7d0c6b5569b263b449172d83ee67e0655643,64cdeb3a27fc0c619000c3aa56d87909b5bd716b,ddf27b47a5c400632e57910b75942ab6fb07ba92',
  order_id: <BN: 32>,
  manufacturer_id: <BN: 1>,
  wholesaler_id: <BN: 4>,
  count: <BN: 3>,
  hash:
    '2b173659603a97cfff198e13c2b3fb0c911cecaf,67d0f7d0c6b5569b263b449172d83ee67e0655643,64cdeb3a27fc0c619000c3aa56d87909b5bd716b,ddf27b47a5c400632e57910b75942ab6fb07ba92' }
truffle(development)>

```

Fig. 9 Blockchain showing uploaded data

3) *Iot Module :*

Certain drugs need a certain type of environment, like temperatures not exceeding a certain limit, or moisture not surpassing a certain level, etc. IoT can help in monitoring the temperature of the surroundings of a drug being shipped and inform the receiver about violations of certain temperatures or thresholds of parameters which will be predefined.

Temperature Violated Shipments

Sr No.	Product Name	Product Temp Range	Quantity	Date-Time	Manufacturer/Company Name	Accept	Reject
1	Crocin	45	4	2020-03-07 09:45:09	Sahil	Accept?	Reject?
2	Combiflam	30	10	2020-03-07 09:45:22	Sahil	Accept?	Reject?
3	Combiflam	30	6	2020-03-07 09:45:32	Sahil	Accept?	Reject?
4	Crocin	45	15	2020-03-07 09:45:39	Sahil	Accept?	Reject?
5	HH LEVO M	45	5	2020-03-07 09:45:16	Dhiraj	Accept?	Reject?
6	HH LEVO M	45	5	2020-03-07 09:30:46	Dhiraj	Accept?	Reject?
7	HH LEVO M	45	5	2020-03-07 09:38:48	Dhiraj	Accept?	Reject?
8	HH LEVO M	45	5	2020-03-07 09:38:51	Dhiraj	Accept?	Reject?
9	HH LEVO M	45	5	2020-03-07 09:38:54	Dhiraj	Accept?	Reject?

Fig. 10 Temperature violation notifications

VI. CONCLUSION

By proposed solution ,if completely implemented,the aim to make the supply chain free of frauds,counterfeit and subpar drugs will be achieved through introduction of blockchain and IoT.Blockchain as seen can make the system secure by using distributed ledger and involving all stakeholders at every step and providing authentication at each step of transfer.This ensures that transfer of drugs in a secure and authenticated way between two stakeholders thus increasing the trust amongst the stakeholders or participants.IoT on the other hand is meant for quality management of the drugs by monitoring the surroundings and keeping a track of the shipment.In this way the physical and information flows of the chain are connected this will provide end to end visibility and quality management.Proposed system can be seen as a viable solution to address all the major issues in drug supply chain as the potential benefits of applying blockchain and IoT to the supply chain of drugs have been demonstrated.

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