

Managing health supply chain using blockchain technology: state of art challenges and solution

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ABSTRACT

The COVID-19 flare-up in late 2019 caused a worldwide medical crisis. In a little more than a quarter of a year, the quantity of COVID new cases has risen to in excess of 1,000,000 around the world. The fast transmission of the infection prompts new cases to be accounted for all around the world constantly. At the same time, mortality rate and contaminations keep on rising rapidly. Therefore, the COVID-19 pandemic has led to the implementation of lockdowns and social distancing rules that negatively impact global economies. It has upturned many challenges which are mentioned in this paper, we proposed a solution to these major problems, blockchain technology can play a vital role in closing maximum escape clauses in the present system to improve visibility and traceability and to provide a clear far vision for the stakeholders present in pharmaceutical industry.

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1. INTRODUCTION

Flow of different goods, flow of information, and flow of services between different entities of that particular business cycle demand a secure network. In every industry, poor supply chain is an open invitation for many major issues but there is an additional risk of patient's health in healthcare sector. Healthcare industry requires optimized solutions that can smooth different operations and processes of supply chain [1]. As in healthcare sector compromise with a fragile supply chain is nothing but compromise with the patient's health, the extent to which a pharmaceutical organization disregards the security in the business supply chain is directly proportional to the intensity of health risk. Among various other challenges in pharmaceutical business, delivering an original product (medicine) to the consumer after a long process of drug formulation, clinical trials, and final development is a big one. If we look in the light of recent COVID-19 pandemic, the presence of more manpower holds a risk of fast spread of virus [2].

In present system of supply chain in pharma industry every component whether they are manufacturer, distributor, or any other component, everyone is working on their own methods and systems for management of flow and manufacturing of medicines [3]. Lack of visibility in a supply chain raises many questions like how a manufacturing firm will know about the raw materials requirement, and tracing of goods stored in warehouse in semi-finished and finished form as in a multi-layered supply chain management of inventory is an important factor to be taken in account. If a manufacturer and a distributor don't have a clear vision about

raw materials present, raw materials required, and quantity of semi-finished and finished goods, all these factors lead to inefficient inventory management which results in many problems such as the problem of understocking, overstocking, wastage of resources, less profit, cost increment, and imbalance of overall business flow. If we talk about pharma industry, India has emerged as a leading, dominant, and wide pharmaceutical industry in terms of volume in the world [4]. India's exportation of drugs has increased from 6.23 US billion dollars in 2006–2007 to 8.7 US billion dollars in 2008–2009 [5].

However, all these loop holes discussed are major causes of drug shortages [6]. So in order to avoid the issue of drug shortage, drug managers should have a clear vision about the availability of inventory for the production of medicines at their end. How a distributor will know about the source of asked drugs whether they are coming from authorized source or from some other malicious intermediate entity. Among 10 drugs, 1 drug is fake or substandard [7]. According to a WHO report 20 million pills, bottles of falsified medicines were seized in Egypt during a raid in 2009 in Egypt by ICPO [8]. These counterfeited drugs contain toxic ingredients and many times active ingredients either in incorrect measure or in impure manner, which deals with the health of patients abruptly. After intake, even original medicine fails to work properly in some cases [9]. Counterfeiting also violates intellectual property rights.

How two entities will get to know about the location of a patched medicine during transportation? How a consumer will know the details about medicine, like its actual price, date of manufacturing, date of expiry, and so on to be ensured about the authenticity of medicine. All these security features are missing from the existing system of supply chain in the healthcare sector. Cold chain shipping of drugs, which are temperature sensitive, can lose their potential when exposed to hot temperature is an additional issue. Cold chain refers to the normal distribution of goods in a standard supply chain but with controlled humidity and temperature [10]. Out of 50 drugs, 26 need to be shipped through cold chain [11]. All these problems like proper inventory management in order to scale up with market's demand–shifting data gathered by internet of things (IoT) sensors during cold chain shipping, and last but not least, that is counterfeiting—can be solved by the transparent nature of blockchain technology. Blockchain among existing ledger systems on the planet is considered as one of the most secured ones [9].

Blockchain is defined as the network of connected systems called blocks. Each block of blockchain technology represents a set of information. Every entity in a blockchain network will have a copy of each block. And all of them will be aware of all transactions going on. So whenever a new block is added or updated, it will require verification from other entities in the network, and only after verification process, person can access the information. So use of this technology for managing supply chain will provide a network where every component will be aware of all transactions, like information about the manufacturer, drugs sources and its movement in between, and blockchain for traceability along with IoT for cold chain shipping. This way blockchain puts efforts in maintaining visibility and traceability.

2. PROBLEM STATEMENT

Blockchain technologies can contribute to the operations and supply chain domain as well. Currently, supply chains are becoming more and more complex in structure, difficult in terms of task, and diverse in terms of stakeholders, and many organizations do not have an integrated view of the entire supply chain. Many large organizations have built their own identities and systems to maintain a global coverage of operations and have power to instruct their suppliers. Otherwise, they have to rely on centralized regulatory bodies or intermediaries. This low transparency causes many problems and difficulties in the supply chain mechanism in terms of security, traceability, authentication, and verification system. There are numerous problems in the existing system of supply chain in the healthcare sector; some of them are listed below [11].

2.1. Counterfeiting of drugs

Counterfeiting of drugs is emerging as the biggest challenge for the pharma industry to tackle around the globe. Counterfeiting refers to the illegal process of formation of duplicate goods in the name of legitimate good. They enter in the pre-established business supply chain through the loopholes present in it. A counterfeit drug is a medicine which either doesn't contain proper dosage or contain in an improper manner. Counterfeiting of medicines is a criminal offence as it atrociously deals with patient's health. According to WHO among 1 million deaths from malaria per year, 0.2% of them was the result of falsified drugs [9]. In developing countries, 30% of the total drugs sold are fake [9]. The sale of fake drugs has been increased from 75 billion US dollars

in 2009 to 600 billion US dollars in 2018 [8]. These falsified drugs enter the supply chain mostly during transportation between different entities due to the lack of traceability in the present system.

2.2. Counterfeiting (threat to intellectual property rights)

Counterfeit drugs manufacturers sometimes use the brand logo of legitimate manufacturers and make fake products used in daily life, that's less harmful. But in many cases they affect the drugs for the treatment of cancer, painkillers, cardiovascular disorders, antibiotics, contraceptives and other prescription drugs, that can lead to very serious results. Estimates of the numbers of counterfeit pharmaceuticals range from 10 to 15 percent of the world drug supply. 30% of the drugs sold in developing countries are counterfeit [2]. WHO estimates that of the 1 million deaths that occur each year due to malaria, 0.2 million of them are the result of counterfeit anti-malarial drugs. Counterfeiters use logos of legitimate manufacturers in many cases, which violate intellectual property rights and IP laws. Also making a fake drug means using someone's innovation without their consent which is illegal.

2.3. Loss of legitimate manufacturers

Counterfeiting of drugs is not harmful only for consumers but also for legitimate manufacturers. Production of original medicine requires more resources and manpower and involves cost as compared to the production of falsified drugs. In addition, it is easier to sell fake drugs. In US pharmaceutical industry, fake drugs caused a total loss of 200 billion US dollars [7].

2.4. Drug shortage

Drug shortage problem arises due to the lack of visibility in the pharma supply chain in the present system. Many times, it is quite difficult for inventory managers to keep track of market demand, cost of manufacturing, time required to produce a final medicine, quantity of raw material, and different types of goods developed. When these factors result in under stocking, this leads to drug shortage in the market.

2.5. Sensitive drug shipping

Sensitive shipping is also known as cold chain shipping. Cold chain shipping is defined as the shipping of goods in a controlled temperature environment. This is because most of the drugs are temperature sensitive and require a desired temperature during storage in warehouses and during transportation.

2.6. Data security

Security of data collected is also a major concern after analyzing the unfavorable features of centralized database as a threat to data security. Data gathered is also risky to put on a centralized database because of its less secured nature as compared to blockchain [12]. Following is the question asked here in this paper: question: how to increase visibility and traceability in a medicine supply chain to solve the problems of drug shortages, counterfeiting, inventory management, and data security of cold chain shipping by using blockchain technology?

Blockchain technology is defined as the network of connected systems called blocks. Every block represents a piece of information. All systems connected to a blockchain are known as entities. All entities have a copy of every block with them, and whenever any person or system tries to edit data available in any block, it will reflect all entities in the network and access operation can't be performed without the verification process. Systems already present will check if the system that wants to make a transaction is an authorized person or not. After verification, approval for further processing will be given in this fashion and blockchain makes a network more secure by keeping eye on each transaction by every side. This is also known as distributed ledger technology (DLT) [13]-[20]. This concept will be used for improving traceability in medicine supply chain and to close doors for counterfeiting of medicines.

3. THE PROPOSED METHOD

The proposed solution after accounting for major problems, challenges, and loopholes in the present system, along with blockchain as a major solution, makes use of IoT-enabled vehicles for cold shipping. IoT is the network of interrelated smart objects or devices that are able to collect data and exchange data over internet. In an IoT network, every object connected with every other object is called a "thing". These smart devices are embedded with sensors that are responsible for capturing data. Here in the proposed model/solution, IoT-enabled vehicles will be used for cold chain shipping purposes. They will ensure that the drug that needs to be

transported between two entities in the supply chain will be getting desired controlled temperature to reach the destination in their original form. Whenever the temperature desired for the drug changes, sensor in the vehicle will automatically shift the temperature according to the need of a drug.

3.1. Research method: blockchain in supply chain

This solution talks about solving the issues of counterfeiting, inventory management, and data security of medicines by making use of blockchain technology for traceability and cold chain shipping with the help of transportation of medicines between different entities through IoT-enabled vehicles. Entities in the blockchain which will have access to the information contained in blocks for keeping track of flow of medicines to avoid counterfeiting at any stage are classified as follows [5]: manufacturers, distributors, pharmacies (retailers and wholesalers), hospitals, consumers and travel agencies first of all, a highly authorized body needs to be established which will work under the surveillance of government. The main function of this body is to assign a unique ID to the genuine and legitimate manufacturers and distributors present in the pharma industry and to regulate the movement of batches [21]-[26]. It will keep an eye on the functioning of manufacturers and distributors and will explain the uniform standards for their functioning. The steps are as follows:

Step 1: manufacturers will be assigned a unique ID by the authorized body which will work as a private key for transaction between manufacturer and distributors. Manufacturing firm will send finished medicines to distributors according to the demand or order placed by them. This information will be added as a block in the blockchain network, and as a working mechanism of blockchain, all entities will be notified about this transaction. This block will contain the following information: date of manufacturing, date of expiry, ingredients used and their composition, manufacturer's unique Id, manufacturing firm's name, and date of dispatching.

Step 2: demanded batch of medicines will be transported to the distributor. For transportation, IoT-enabled vehicles will be used by transportation agencies for maintaining cold chain shipping. This will ensure that medicines will reach consumers in their original form as they will get desired controlled temperature with the help of IoT sensors embedded in the vehicle. This set of information will be added as a new block which will contain information, such as: vehicle no. and travel agency's name (Figure 1).

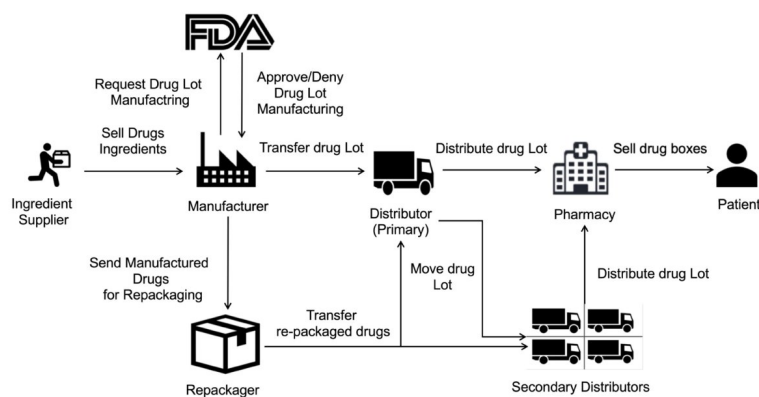


Figure 1. Drug flow from manufacturer to end users

Step 3: now distributor will receive the medicines with unique ID of manufacturer and other useful information. Here distributor's ID and manufacturer's ID will work as a private key between them. On receiving, arrival time will be noticed, and new information will be added by the distributor again through this transaction and all entities in the network will know that distributor has received the medicines. New added information are as follows: distributor's Id, arrival time, name of distributing firm, and quantity of medicines.

Step 4: here on completion of previous transaction by distributor on receiving the medicines from manufacturer, travel agency will also be notified as it is a part of blockchain network. So, they will take the drug from distributors to transfer them to hospitals, retailer pharmacies, and wholesaler pharmacies. This is the point where chances of counterfeiting are more. This transaction will also notify others so it fills the loophole in the supply chain. This block will contain: travel agency's details, vehicle no., and dispatched time from distributor's warehouse.

Step 5: drugs from distributors can be directly sent to hospitals and also to retailers and wholesale pharmacies. When drugs are directly sent to hospitals in this case, whole similar activity of addition of new block will take place with notification to all. This block will contain following info: verification status and arrival time.

Step 6: if the distributor sends medicines to pharmacies, same procedure will repeat. Consumer can get the medicine from retailer, now as being a part of blockchain network consumer will be aware of the source of medicine whether it is coming from an authorized source or not. Proper tracking of information at every transaction in supply chain will help manufacturers to be aware of market demand, and they can manage inventory accordingly to answer the question of drug shortage. This traceability feature achieved by blockchain will also overcome the issue of counterfeiting.

Blockchain at the place of a centralized database will be used for storing data collected by IoT-enabled vehicles during transportation. Data collected by sensors embedded in vehicles used in transportation is a useful data for further processing, and sharing this data over a centralized database could be a data threat. As in a centralized database, all data and records are stored at a single location. Consequently, it is easier for a malicious entity to make changes in the data as it is the only copy, but sometimes difficult to account for malicious entity and time consuming. Whereas in blockchain system each entity will have (Figures 2 and 3). A copy of all the information and no new transaction can take place without verification from any of the entity present in the network.

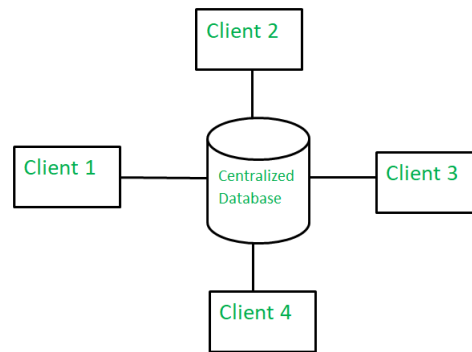


Figure 2. Centralized database

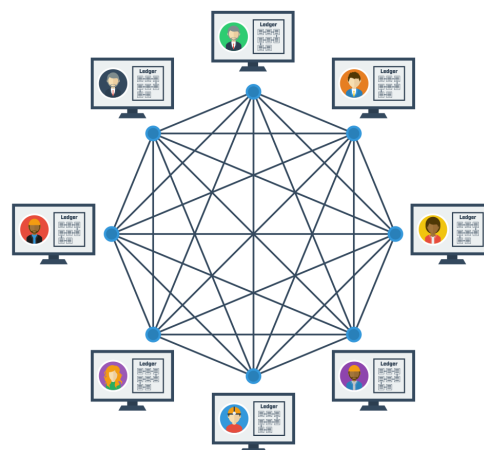


Figure 3. Blockchain distributed system

4. CONCLUSION

After a thorough study of the supply chain in pharmaceutical industry and knowing the different issues in the present system used by supply chains, this conclusion can be made that there are so many escape clauses in it which can lead to many major problems like drug shortage, counterfeiting of medicines, sensitive drug's transportation, and compromise that can directly affect a patient's health. As a solution to these major problems, blockchain technology can play a vital role in closing maximum escape clauses in the present system to improve visibility and traceability and to provide a clear far vision for the stakeholders present in pharmaceutical industry. This solution will not only improve the working efficiency of a medicine business cycle but also open gates for amazing opportunities for business in this sector. This blockchain solution could be used in the upcoming scenario of vaccine distribution of COVID-19 in India. It will also result in fewer cases of deaths from falsified drugs and reduce suffering of patients due to drug shortage in the market.




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