Blockchain Implementation in Indian Pharmaceutical Supply Chain Diminish Counterfeit Product

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Abstract. The pharmaceutical counterfeit product problem has become a harmful problem for people in India and has drawn significant attention from everyone. It is very crucial for healthcare and daily life. The pharmaceutical industry and its supply chain are humongous and complex in management. The pharmaceutical industry and its supply chain are massive and complex in direction. It is very crucial for healthcare and daily life. Indian Pharmaceutical is the world's 3rd largest by volume and 14th largest in value. Not only is it complex, but it is inherent with the challenges like lack of transparency, traceability, security trust, and risk of counterfeit drugs. Forgery of pharmaceutical goods could be highly profitable. During globalization, the growth of online pharmacies and fraud cases are significantly increasing, leading to high death rates. Although there have been many studies on blockchain adoption in pharma supply chain management globally, it has been seen studies do not entirely investigate highlights. The advantages of blockchain enablers in pharmaceutical industries within India benefit the supply chain management performance. Therefore, this study bridges the research gap and analysis the enabler of the Blockchain technology and its adoption to have a sustainable supply chain. The study sheds light on how blockchain technology reduces the risks at each segment of the supply chain nodes. In addition, it also makes recommendations for deploying smart contracts in the pharmaceutical sector, which helps detect counterfeit goods to improve supply chain performance.

Keywords: Block chain · Security · Supply chain

1 Introduction

Supply chain management is employed to obtain the pharmaceutical products which the healthcare industry is depended upon to treat patients. The present healthcare industry faces a serious challenge with acts such as corruption and abuse, which cost the

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industry enormous amount of money every year [1].The healthcare supply chain is a complicated web of numerous independent businesses, including retailer pharmacies, hospitals, manufacturers, stockiest, sub-stockiest, distributors, and raw material suppliers. Due to several issues, including a lack of information, centralized control, and rivalry among stakeholders, tracking goods across this network is challenging Drug traceability (track and trace) is becoming more and more important, and many nations throughout the world are implementing new technologies [1]. Countries throughout the world are adopting new technologies, technologies such as Blockchain helps managers in developing a number of supply chain models utilizing a data-driven methodology [2]. Blockchain technology gives supply chain participants more privacy protection, data transparency, and tamper-proof systems [3]. A "shared, cryptographically unmodified distributed ledger," or blockchain technology, is used to store and preserve the history of digital transactions.

Every linked node on the blockchain system keeps a copy of all previously recorded records and transactions on the relevant system. It is significant to notice that no one stakeholder owns the system in this case, making it decentralized, visible to all stakeholders, and auditable for all activities carried out on it. Therefore, such systems would establish a promise of trust for modern business [4]. Additionally, the blockchain-based system does not need middlemen between public and private institutions, significantly lowering transaction costs. The participants in a blockchain-based system must place their trust in computer code rather than themselves because the code is fully verifiable [5]. For maintaining supply chain management, blockchain technology is a suitable approach. Therefore [6], transparency and visibility are significantly increased when the supply chain system is mitigated by combining SC and blockchain technologies. We proposed Hyperledger fabric framework transaction flow where all participants make available proof of provenance without disclosing privacy-sensitive information.

2 Literature Review

2.1 Transparency

Supply chains are evolving into very complicated process, handling new partners and the progression of old ones, regionally dispersed, and with a rigorous focus on satisfying progressively increasingly discerning clients, claim [7]. Simultaneously, traceability and transparency are now essential criteria in a multinational supply chain.

- **Distribution Transparency**: A new block is distributed around the whole network when it is created by someone.
- **Transaction Transparency**: A cognitive processing unit that matches to a list of simple procedures that must be checked, confirmed, and then stored.
- **Performance Transparency**: When the Blockchain is implemented in Supply chain, during the flow, there is an improvement in data transparency. Transferring goods from the producer to the consumer from the retailer and distributor. Additionally, Blockchain's performance in Supply chain results in an increase in trust between SC stakeholders' strategy.

- **Logistics Transparency**: Applications of blockchain in logistics are anticipated to offer a real benefit based on transparency. For example, highlight the availability of essential data since the information.

2.2 Traceability

The existing supply chain is obscure, meaning that not all supply chain members can see the processes taking place there. Due to this, dishonest supply chain actors can alter, corrupt, or substitute medications as they go through the chain without the awareness of other members [8]. As a result, the supply chain needs a method to trace pharmaceutical medications from manufacture to supplying. Therefore, the authors researched what to do to trace pharmaceutical products in a supply chain system adopting blockchain technology in order to achieve traceability in the supply chain process.

- **Reverse** Traceability: The purpose of blockchain-based reverse traceability logistics is to obtain something back in order to support a green, sustainable supply chain.
- **Product Traceability**: Utilizing digitalization, it provides access to product-related information for the duration of the product.
- **Process Traceability**: It is possible to keep an eye on each and every process of the chain, including where the raw materials come from, how they are produced, shipped, and when they are delivered [9].
- **Consumer Involvement:** Blockchain technology can improve consumer involvement as it allows them to independently evaluate sustainability-related data.

2.3 Enhance Supply Chain

The use of blockchain outside of banking has primarily been tentative. Supply chain, energy, and food/agriculture applications of blockchain are anticipated to be among its most potential non-financial uses. These industries could be considered good candidates for blockchain. At an initial stage of blockchain development, these industrial use cases are thought to produce real ROI [10].

- **Profitability**: Forward logistics supports the forward supply chain of commodity sales, which is centered on profit and cost efficiency, using blockchain technology.
- **Cost reduction**: Eradicating paper records, If IoT-based technologies have already been utilized to identify, measure, and monitor crucial SCM processes, there will be no or very low marginal costs to develop blockchain code [8].
- **Product safety**: Blockchain also offers a precise method of determining product quality as it is being transported.
- **Market environment**: Blockchain is a developing technological innovation that lays the groundwork for the market environment of the future; thus it is critical that businesses remain cognizant of these disruptive innovations [11].

2.4 Attain Sustainability

There have been difficulties to solve sustainability challenges in the developing countries because of lack of trust and high intermediation costs [12]. Blockchain can be an effective solution for solving these difficulties. Previous studies have shown that this technology is essential for building trust, supporting the decentralization of markets, and enabling the disintermediation of conventional business and governance models [13].

- **Return**: The role of blockchain as a technology tool for enhancing trash transportation and product return strategy implementation.
- **Recycle**: By turning plastic waste into money, the blockchain-based initiative Social Plastic has demonstrated how plastic waste may be minimized.

2.5 Security

The vulnerability of IoT devices regarding hacking and manipulation is a problem when using them. Therefore, it is argued that employing a decentralized, autonomous, and trusted network like blockchain is vital [14]. Blockchain can be used to increase the security of devices by lowering their susceptibility [15].

- **Counterfeit** product **detection**: BCT could be applied to stop Counterfiet and guarantee beneficial transactions [16].
- **Smart contract**: The smart contract ensures data authenticity, cuts away with the necessity for middlemen, and gives all stakeholders access to a safe, immutable history of transactions.
- **Peer** validation: Verification of each transaction via consensus among the peers. All the detailed information recorded by sensors is stored in a blockchain that lets both farmers and consumers know the status of the products at various stages of the supply chain. The system also helps to track the changing market price and incorporate the current market price in the blockchain [17]
- **Consensus mechanism**: The requirements that must be fulfilled are determined by the set of accepted instructions.

2.6 Decentralization

The use of centralized systems entails dangers such as errors, hacking, and corruption [18]. With the help of blockchain technology, these issues can be resolved (BCT). A blockchain is a decentralized database of unchangeable digital records that is maintained by a network of nodes and is not owned by any one person [19].

- **Managerial commitment**: Instead of depending on a centralized organization to run the chain, blockchain technology uses a peer-to-peer network that anybody can join.
- **Information sharing**: the supply chain and BCT optimizes supply chain activities when combined together it allows information sharing among the stakeholders. Supply chain operations are strengthened by the exchange of transactional and strategic information.

- **Reduce Lead-Time**: By requiring only a few numbers of permissions from a central server and offering numerous access points, it is capable of reducing the processing time for blockchain transactions to a few minutes, so minimizing the strain on the central system.
- **Proper inventory management**: Proper inventory management based on blockchain enhances inventory systems between vendors and retailers.

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- **Proper inventory management**: Proper inventory management based on blockchain enhances inventory systems between vendors and retailers. (*The Threat of Political Bargaining to Climate Mitigation in Brazil\Nature Climate Change*, n.d.) presented a blockchain-based Internet of Things architecture to guarantee grain quality by using a tracking system, dissemination of standardized business rules, and immutable transaction data among supply chain participants.
- **Temper proof**: Blockchain's verification method maintains security by preventing fraud and making it hard to tamper with blocks.
- **Autonomous decision making**: Every data transaction in a blockchain is based on a decentralized autonomous mutual consensus that has been reached.
- **Cryptography**: Each of these blocks of data is secured and connected using cryptographic principles.
- **Risk reduction**: The problems with auto information that are given by supply chain participants can be solved by blockchain's "ultra-auditable." tackling, the full spectrum of risk sources.

3 Proposed Method

For the process of pharmaceutical goods production, when a company decides to start producing pharmaceutical goods and when the finished pharmaceutical goods appear. Our proposed pharmaceutical goods supply chain (SC) framework followed the following stages. Pharmaceutical Research and Development Company (PRD), Manufacturer (MF), Stockroom In (SI), Distributor(D), Stock room Out (SO), and Retailer

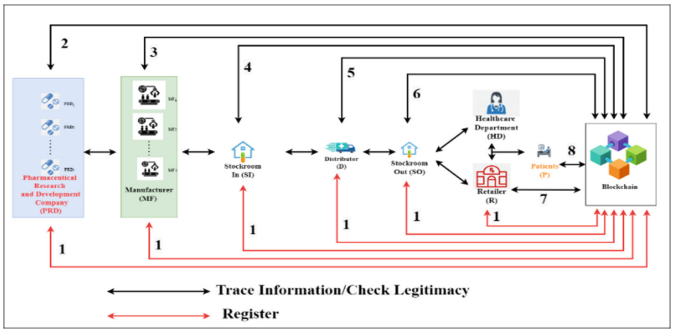

Fig. 1. Pharma Supply chain Process in Block chain.

(R) each node is associated in SC in a Hyperledger Fabric-based pharmaceutical goods anti-counterfeiting management system. The supply chain flow management of pharmaceutical goods register and checking the legitimacy of products are shown in Fig. 1.

3.1 Associate Transaction Process of Proposed Framework

In our proposed diagram scenario, total actors from the PRD to the Patients (P); we used the logistics and distribution framework for the anticounterfeit systems to trace the original pharmaceutical products or counterfeit pharmaceutical products. In the Fig. 1 sequence of steps is shown below.

- Step 1. In the supply chain model, all contributors for the pharmaceutical products PRD, Manufacturer (MF), Stockroom In (SI), Distributor (D), Stockroom Out (SO) Retailer (R), P should be registered and authenticated by Certificate Authority (CA) node in the Hyperledger Fabric Blockchain network. In this step, registration is the central part of the system. When the authentication process is done from the CA node, the other function can exchange information have to supply specific product with the private key or address to the MF.
- Step 2. PRD produces pharmaceutical goods according to the MF requirement for different D. PRD sends the pharmaceutical goods information certificate to the MF by deriving batch numbers. Once the MF verified the pharmaceutical goods, which belongs to PRD, the MF confirmed action by sending a legitimacy message to the PRD. When ordering information is correct and verified, the pharmaceutical goods PRD stores information to Blockchain via sorting node and update. PRD produces pharmaceutical goods with unique id from Blockchain address, and PRD creates smart contract for transaction. The MF creates many goods by getting different types of pharmaceutical goods from PRD. This step is more vital and valuable to reduce counterfeit products. Pharmaceutical goods have several batch numbers from the PRD, and our proposed model reconfigures the SC operation by making a contract between every batch number presented in the pharmaceutical goods.
- Step 3. In this step, MF sends the final product to Stockroom In (SI) according to their demand and stores order information and sender information into the Blockchain.

Once distributor confirms the received product and verifies the order placed to SI, confirms information then SI sends confirmed transaction information to the MF. When pharmaceutical goods need to be sent for SI, it has a smart contract for stock record in SI.

- Step 4. SI sends pharmaceutical goods to distributor (D) according to their orders. Once D get the product, they verify whether the number of products and types of products they placed an order to the SI is correct. If Information is Correct from SI, distributor sends a verified message to SI, and all transaction information is stored or uploaded into the Blockchain.
- Step 5. D sends pharmaceutical goods to Stockroom Out (SO) according to their orders. Once SO get the product, they verify whether the number of products and types of products they placed an order to the D is correct. If Information is correct from D, SO sends a verified message to D, and all transaction information is stored or uploaded into the Blockchain.
- Step 6. Stockroom Out (SO) sends pharmaceutical goods to retailer (R) according to their orders. Once R get the product, they verify whether the number of products and types of products they placed an order to the SO is correct. If Information is Correct from SO, R sends a verified message to SO, and all transaction information is stored or uploaded into the Blockchain.
- Step 7. Patients (P) purchase from the retailer, and the retailer decides information about transactions registered by the P. Retailer, after verifying all the information with the distributor(D) and Order Placed by the P to the R, the retailer now checks the transaction information from the P and stores the transaction information to the Blockchain.
- Step 8. This step is vital for P and the whole supply chain process. P can verify by the pharmaceutical product by the batch number in the Blockchain network with the help of an App or web client to check the legitimacy of the pharmaceutical product.

3.2 Hyperledger Fabric Transaction Process in Blockchain

Through this scenario shown in Fig. 2, how manufacturer and Pharmaceutical Research and Development Company have a transaction in the supply chain. If the manufacturer and Pharmaceutical Research and Development Company want to communicate to get information about any products, they need to register through node manager in CA node. It will issue private and public keys as identity credentials. Each node de-ploys its certificates and copies the ledger to store in the channel. Now in Hyperledger Fabric order node sorted out the transactions created in the channel stored that information in the Blockchain network.

Assume that the manufacturer and Pharmaceutical Research and Development Company want to communicate. PRD and MF, first register with the CA via a client, then the CA node issues a certificate to verify the identity of each other. PRD stored transaction information by encrypting the data into the Blockchain network following the transaction order through node manager. Hyperledger Fabric framework transaction contains "commit" to stored data through the channel. The channel instructs the smart contract to update the Blockchain ledger, where the information is received by the assembler.

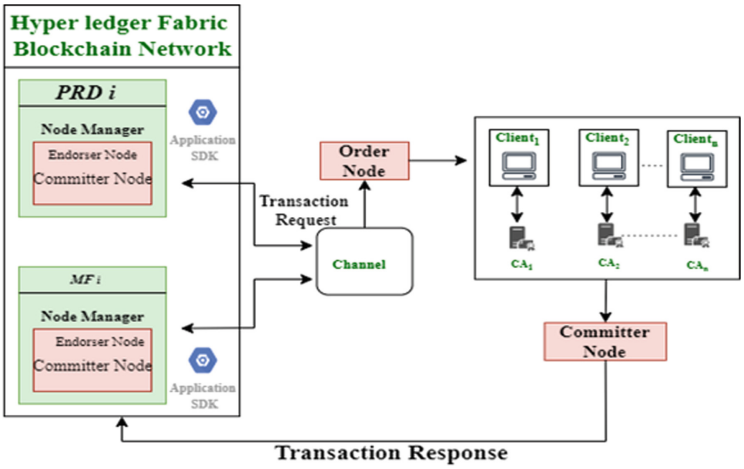

Fig. 2. Hyperledger Fabric Framework

3.3 Key Generation in Hyperledger Fabric Network

The private key generates a public key, and Blockchain uses the Elliptic Curve Digital Signature Algorithm also in this curve, one curve used is called secp256k1. Each private key creates a unique signature that authorizes the transaction of Blockchain for the owner, and it should be kept confidential and not shown to other people except the owner. In Blockchain, the public key is another significant number that allows it to be locked, received, and shared publicly. A hashed smaller version of the private key is the address of Blockchain [20]. There are many signatures scheme but the schnorr digital scheme uses elliptic curve cryptography (ECC). Key Accumulation is the most important advantages of schnorr signature. Schnorr Signatures is significant for implication of key accumulation.

1. Generation Signature

- M_{PRDi} produce a nonce r
- M_{PRDi} getting the public key K_{pub} by multiplying r and G
- Where $K_{pub} = \mathrm{r} * \mathrm{G}$
- M_{PRDi} send message Msg, where K_{pub} is public key $P = k * G$ to the Pt_j, where k is private key selected by M_{PRDi}. ($Pt_j = Numberofpatients$)

2. Signature Verification

- M_{PRDi} and Pt_j generate the combination by hashed function to the transmitted data. Where, $e = H\left(K_{pub} \| P \| Msg\right) e$ is common challenge.
- M_{PRDi} figure out signature, $s = r + k.e$
- Pt_j do not know the number of r and k, M_{PRDi} can determine $(r + k.e).G = r.G + (k.G).e = K_{pub} + P.e$

- At last, Pt_j sends outcome $K_{pub} + p.e$ to the M_{PRD_i} for verification $S.G = K_{pub} + P.e$

4 Conclusion

The very purpose of this study is to investigate and highlight the main characteristics of the Blockchain. What are the enablers of the blockchain and their feature to enhance the supply chain of Indian Pharmaceutical industry. In addition, to that this study demonstrate the impact on trust, transparency, traceability, security, decentralization, and immutability. This study shows the effect of blockchain through the framework. The framework highlights the impacts of enablers pre implication and post implication. Since the pharmaceutical product is very messy and fragmented, the presence of a significant numbers in the supply chain and quality issue of the product, implementation of blockchain technology could help achieve privacy improvement and the pharmaceutical supply chain process will be transparent to each customer.

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