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Enhanced Pharmaceutical Supply Chain Management Using Ethereum Blockchain

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Abstract:- The presence of counterfeit drugs in the healthcare industry is evident with one in ten medical products in developing countries being substandard or falsified. This means that there are a lot of patients unaware that they're taking medicines that fail to figure as prescribed. This problem of counterfeits arises due to a complex supply chain compounded by the lack of transparency in the products' end-to-end journey. Supply chain management on its own is a complicated process and the amount of time it takes to settle transactions and regulations causes a lot of overhead. Blockchain technology is perfect for supply chain management as it features a decentralized and immutable digital ledger. Blockchain provides security and its user-friendly features help supply chain management overcome many issues. The inherent features of the blockchain are further enhanced by smart contracts which are computer programs that will automatically execute, control, and record events consistent with the terms written in them. Our solution uses smart contractswritten for the ethereum blockchain to record the drugs through-out their life cycle the supply chain. This will provide how to prove the authenticity of medicines and stop counterfeits from entering the market. Being transparent in nature the regulators (legal dept.) can easily verify the openly available records at any time. The bills are often settled between the participants via the trustless smart contract. All this smoothens the whole process and saves valuable time which may again cut costs. By ensuring minimal delay in transactions and assuring the authenticity of medicine the present pharmaceutical supply chain is often furtherenhanced.

I. INTRODUCTION

The prevalence of counterfeit drugs in the health care sector is clear, with one in ten medicinal items in devel- oped countries being under-standard or falsified [1]. Falsified medicines can contain incorrect ingredients and doses or display no presence of the active ingredient. This means that millions of patients are unaware that they are taking drugs that do not perform as prescribed. Not only do they fail to treat patients, but some of the counterfeits can cause major illness or even death. Counterfeits are a major commercial drain on individuals and health care facilities and can in some cases, contribute to additional financial pressures on the health care system if the patient is consequently in need of treatment.

All these problems arise due to the existence of several loopholes in the supply chain of pharmaceutical industries. Supply chain management is a complex business-to-business and business-to-customer network. Such a system exists for the seamless sharing of product-related information between stakeholders. Some supply chains are quite complex and the lifetime of a product on these chains can span months. This long lifetime and complexity make it vulnerable to unethical practices.

Blockchain technology[2] is perfect for supply chain man- agement solutions. This is because blockchain is a trustless environment. Normal supply chains are held together by trust. By bringing the trustless nature of blockchain into the supply chains we can bring about a layer of security where stakeholders cannot deceive each other. The inherent features of blockchain such as transparency, immutability, and dis-tributed setup are all powerful features that were unthinkable before. Here we are looking at five different studies on using blockchain and coming up with a

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solution on our own that focuses on bringing a balance between traditional systems andblockchain-driven systems.

II. RELATED WORK

Here we look at some of the related works in the fieldof supply chain management using blockchain:

1) In the paper "Blockchains Everywhere – A Use-caseof Blockchain in the Pharma Supply Chain" [4], a startup called Modum.io is discussed. It uses IoT sensor devices to monitor temperature variances and leverages blockchain technology to assert data immutability on these records. The medical industry has strict environ- mental control protocols to ensure quality and regulatory compliance. The IoT devices automatically transfer sensor data to the smart contracts where they are processed to check whether the quality is satisfactory. This level of automation can save money and bring trust to the industry. This stored data is tamper-proof and can be used in the future for verification in case of disputes. But a good internet connection is necessary for the devices totransmit effortlessly, but common warehouses are known for bad internet connectivity.
2) The study "Smart Contract-Based Product Traceability System in the Supply Chain Scenario" [5] traces individual products along the supply chain. By validating the authenticity of each specific product, is an effective strategy to avoid counterfeits. The study goes on to say that present traceability methods are inherently opaque, and that data is mostly maintained within businesses. The cost of tampering with data is therefore relatively minimal. The study offers a blockchain-based decentralized product traceability system. Unnecessary activities will be avoided, and an immutable ledger will be used to record all events. Scalability concerns, privacy, rules and regulations, and identity registration are just a few of the major obstacles that any blockchain system must overcome. The paper demonstrates how they implemented their solution using three smart contracts. However, one of their contracts must be deployed repeatedly, causing the system's cost to skyrocket.
3) The paper "DL-Tags: DLT and Smart Tags for Decentralized, Privacy-Preserving, and Verifiable Supply Chain Management" [6], shows the use of special third-party QR codes and IoT devices to implement their verifiable supply chain system. The special QR codes used here are made of special ink that changes color to different environmental conditions. This coupled with IoT devices and android devices that scan these codes bring about a good verifiable blockchain system. Stake- holders involved in the supply chain are required to reach a consensus about the data that is to be stored on the blockchain via smart contracts. This prevents anyonefrom blaming others for unacceptable facts being stored on the chain. The cost of registering a product on the chain is high and might not be suitable for products with small value. Another main feature of this solution is that sellers are forced to disown a product when selling it. This prevents frauds like not delivering the product after selling.
4) This provides a supply chain management solution that incorporates inputs from IoT sensors, feedback provided by supply chain entities, and physical audits. Physical quality checks performed by officials and quality control experts need to be logged. This means that it has asystem where multiple entities need to verify data. This also showcases a reputation system where stakeholders are ranked according to their previous performances.
5) The paper "Blockchain-Based Safety Management System for the Grain Supply Chain" [8], uses blockchain technology to determine the safety of the grain sup- ply chain. The solution also has a powerful privacy-preserving methodology where only necessary data is shown to participants. To improve system storage capacity, they have proposed a multi-mode storage mechanism that combines chain storage and a distributed database with the multilevel backup. A customized smart contract for reading and writing is shown to manage business data and hazard information.

III. PROPOSED SYSTEM

As we've seen there are quite lot of various ap-proaches to solving supply chain management issues. What wehope to realize may be a supply chain management solution that has all the newest features of any modern software and mixing it with blockchain to further enhance its capabilities. a number of the papers discussed above specialise in IoT devices to watch environmental conditions. This approach focuses mainly on the transport of a product then traceability. differently is to specialise in tracking individual products throughout their lifecycle. This involves giving unique identities to every product and updating their ownership throughout the chain. Although this is often an honest method the quantity of knowledge which will be stored on a blockchain is extremely limited. Individual keys stored on the chain can take up tons of space and therefore the money required in sort of transaction cost for product registration, changing ownership and every one other logic implementation are often quite high. this will make the system quite expensive and unattractive to customers. So thought has got to put into determining the quantity of knowledge that must be stored on the chain without compromising security and authenticity. we've also seen the utilization case of QR codes to implement product traceability.a number of these QR codes also use special inks to trace temperature data. But this also falls within the same category as above. Systems, where multiple entities are required to verify data et al. where multimode data storage mechanisms are used, also are quite good.

But some systems mentioned here use private chains and their own tokens to implement supply chain solutions. within the context of bringing true decentralization, we should always be that specialize in public chains. Private chains although they need blockchain characteristics they are doing not have the raw computing power of the larger public chains. Here we are using Ethereum public chain to implement our solution. A supply chain management

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application with its dataintegrity backed by blockchain is our true goal. So during a sense, we'll be implementing something almost like the grain supply chain [8] in terms of knowledge storage. Softwarebuilt using MongoDB database, React frontend, and Solidity smart contracts seem appropriate. As in terms of knowledge storage, we don't get to store everything of knowledge on the Ethereum chain but only the hashes seem necessary. This hashstorage should only happen after the stakeholders have reached a consensus a bit like in DL-Tags [6]. Signing via Ethereum addresses is often proven useful to implement consensus. Upon reaching consensus a function should calculate the hash of the presented data and push it onto the chain. This data hash is often formed again and cross-referenced with the info that was previously stored on the blockchain thus proving data authenticity. By controlling the info whose hashes are calculated we could also implement product traceability by keeping data like the entire number, place, and current owner of the drugs in order that counterfeits cannot impersonate them. albeit a counterfeit appears it either will have a replica number or its identity wouldn't exist on the chain in the least. Going further individual hashes of consensus data needn't be stored one by one. We could calculate the hash of the hashes of two separate deals and mix them together. this might mean the info inside a specific timeframe say one hour or maybe at some point is often stored as one hash. But this might also mean one manipulation of knowledge can render a whole days' worth of deals corrupt. So keeping it simple seems necessary. Such a system would also require only select participants as anyone with an Ethereum address shouldn't be allowed to participate during this system. APIs are often provided in order that outside applications can integrate with our system. thisis often necessary because not all companies use that very same software. All the papers mentioned above assumes that each one participant would use their solution. But that's just impossible, intervention from the govt level would be needed for such a feat. So at now in time, we will only prove the authenticity of medicine from one company and a couple of others surrounding them.

IV. METHODOLOGY

The entire Open Capsule system has been designed with reliability and ease of use in mind. The solution to the authenticity problem in pharmaceutical supply chains was to develop a system where we could prove the authenticity of data stored in normal databases. Storing the hashes of data in a tamper-proof environment seemed to be a viable solution.

The process can be further made tamper-proof by makinga decentralized application that can take care of major tasks in the supply chain scenario. And thus a decentralized application was to be designed using Ethereum blockchain. Ethereum waschosen because it was the most developed smart contract-based blockchain available at the time. In theory, our solution can be implemented in any blockchain capable of smart contracts with minimal changes.

React was chosen to implement the front end of this application as it is a versatile and capable framework. React along with web3.js will be used to speak to the smart con-tract deployed on the Ethereum network. Besides, react other technologies like Node.js server and Mongo DB will also be used to implement key features inside the application. The scalability of such a system is always an issue. To solve that problem we are planning an application that aims to use the decentralized nature of the smart contracts and the high speed and storage capabilities of traditional systems hand in hand which should give us a hybrid system that serves common industry needs.

A. Architecture

The user interface of the application is to be made in React.js and hosted on a firebase server. The node.js server will be hosted separately on the Heroku server and MongoDB atlas will be used to host the MongoDB database. The smart contract will be hosted on the ethereum test networks. The application will use the different technologies in an interwovenform to serve its' functionality.

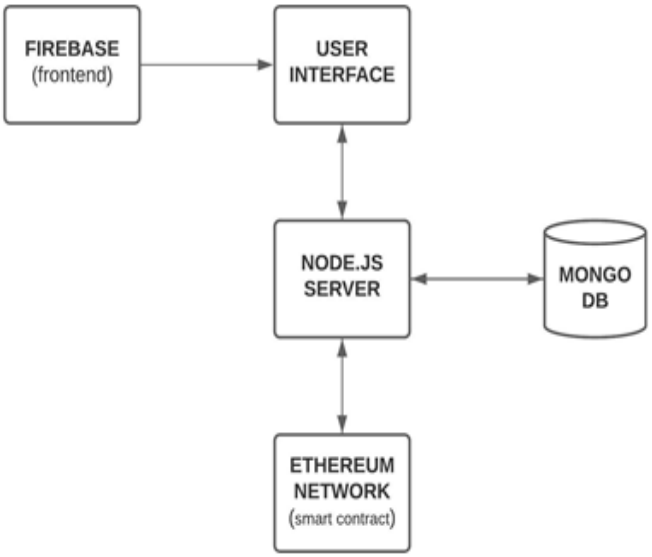

Fig. 1: Architecture diagram

B. Block Diagram

The participant creation module gives us companies thatare open to using the system. They can create their unique products and units of those products open for buying by other participants. The product creation module is responsible for accepting required data and creating products in the smartcontract. These products can produce units which are doneby the factory module which accepts serial numbers and assigns the ownership. The created units are available inside the buy/sell module. On using the buy/sell module to create a transaction an agreement is cooked up by the contract module and their hashes are stored inside.

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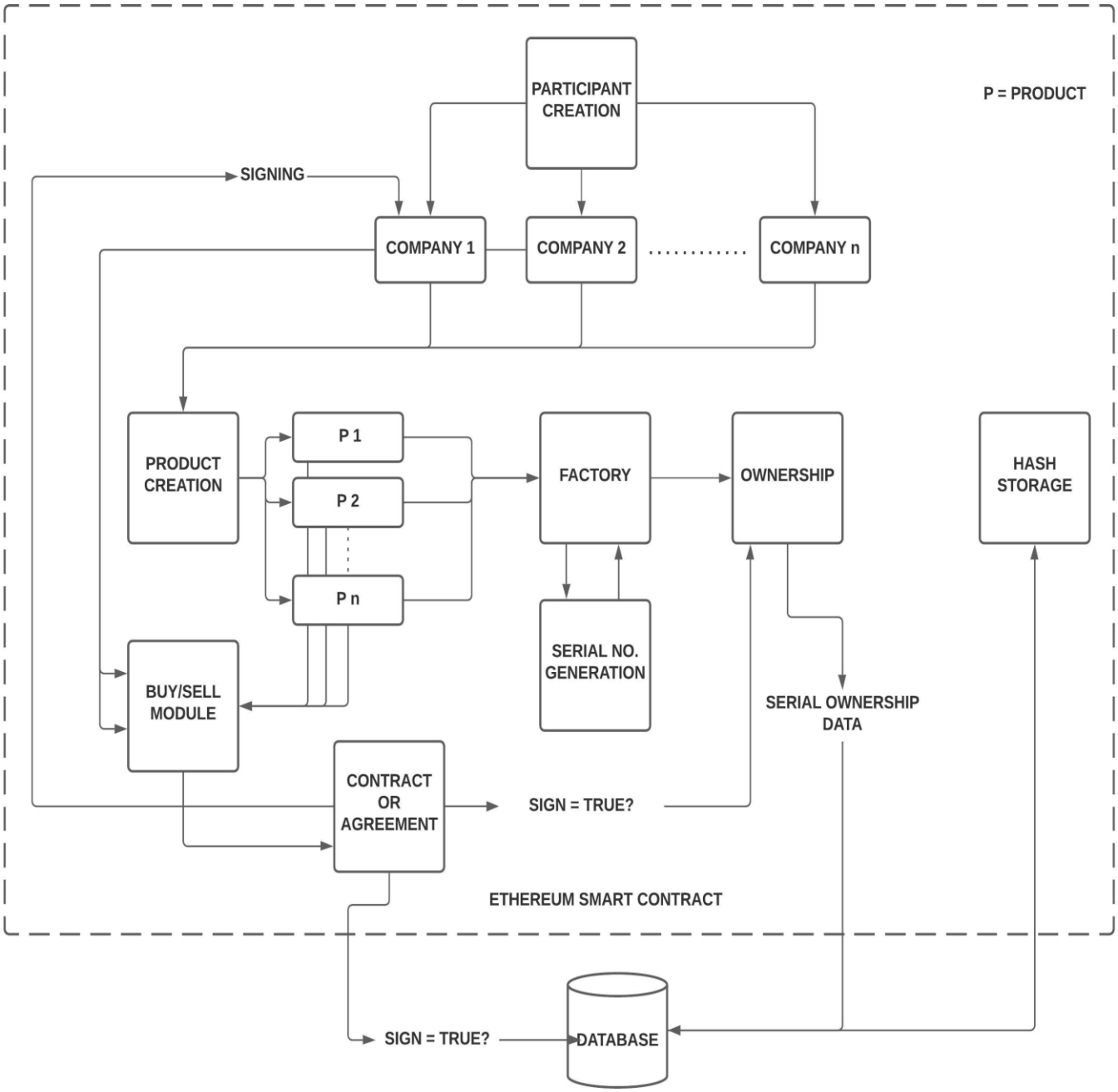

Fig. 2: Block diagram

C. Flowchart

The system first checks whether the wallet address logged in is that of the smart contract owner or not. If so then administrator privileges like participant creation and deletion are available. Participant creation requires manual input of participant data from the administrator. If the logged-in address doesn't match that of the administrator then the system checks whether the address is that of a participant company. If yes then participants can go on to create new products in their inventory or to buy other products. If chosen to create a new product then their details have to be manually inserted. Once done they are stored in the smart contract storage open for all to view. The participant can go on to create new stock units of the created products. Product data has to be retrieved from the smart contract and serial numbers and ownership for these units are automatically assigned. These details are uploadedto the MongoDB storage.

If the participant has previously chosen to buy products then the entire list of products from different companies is available to them. If chosen to buy an agreement is sent to the seller andif signed and accepted by the seller the buyer can proceed to payment. After this, the ownership of the units is transferred to the buyer. The data is updated in Mongodb and hashes are stored to the blockchain.

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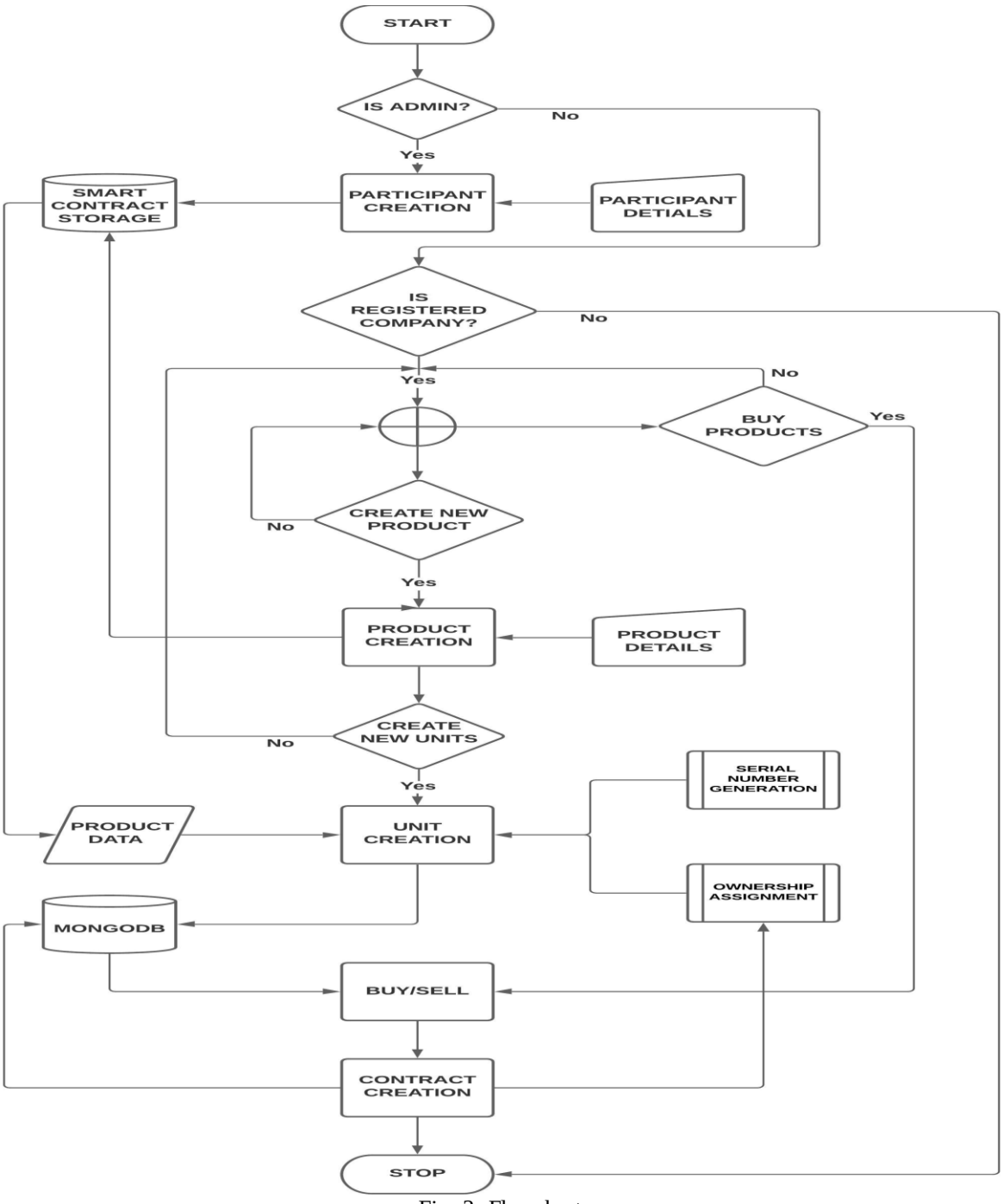

Fig. 3: Flowchart

V. RESULT

Blockchain may be a shared database that promotes honest transparency. Through this technique, all companies have the responsibility to upload their information and data about their product. A digital collection of accurate data will improve accountability and trust between partners. Our system will build communication between different companies, as a re- sult, a streamlined process with shorter lead times, reduced redundancy, fewer delays, and ultimately a leaner supply chain. Our system also will make sure that quality standards are met, giving the vendor more control of the assembly of the merchandise from A to Z. The proposed system will improve the business operations and customer relationships of a corporation. If a corporation wants to maneuver a product from one entity to a different, our proposed system can ensure a secure, streamlined transfer.

Through Blockchain technology, digitization of logging will occur which will lead to less administrative work and more consistent data tracking. Companies will not have to try to connect with Their partners to get the information they need, they just have to sign on to the blockchain to instantly download that information.

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VI. CONCLUSION

This work analyzed the counterfeit drug problem and existing solutions and evaluating their effectiveness. The inputs from relevant industry professionals working in boththe pharmaceuticals industry and blockchain technology are considered. Further research is required to see how we will achieve the shortest amount of your time for a transaction to realize consensus and this is often necessary for a tamper- proof system. Another key area is to seem at the way to reduce the cost of the whole operation. Patient record systems on the blockchain also are on the increase, a hybrid system incorporating supply chain and patient records is additionally possible. The existence of regulators is additionally a key pointto think about while developing a system. the quantity of participation from a consumer standpoint is additionally tobe considered. Blockchain also has its limitations, including a scalability issue. At this stage, it might be difficult to deploya blockchain solution to all or any parties involved within the supply chain. Large-scale deployments across multiple customers would require far more rigorous testing to make sure success. We believe that our proposed solution has found a balance between traditional supply chain management applications and blockchain-driven decentralized applications.

REFERENCES

[1]. "1 in 10 medical products in developing countries is substandard or falsified,"World Health Organization, Geneva, 2017. [Online]. Avail- able: https://www.who.int/news-room/detail/28-11-2017-1-in-10-medical- products-in-developing-countries-is-substandard-or-falsified

[2]. **Satoshi Nakamoto**, "Bitcoin: A Peer-to-Peer Electronic Cash System"

[3]. Bitcoin.org, 2008, [Online]. Available: https://bitcoin.org/bitcoin.pdf

[4]. **Thomas Bocek, Bruno B. Rodrigues, Tim Strasser, Burkhard Stiller**, "Blockchains Everywhere - A Use-case of Blockchains in the Pharma Supply-Chain", 2017. Communication Systems Group (CSG), Department of Informatics (IFL), University of Zurich (UZH), Zurich Switzerland.

[5]. **Shangping Wang, Dongyi Li, Yaling Zhang and Juanjuan Chen**, "Smart Contract-Based Product Traceability System in the Supply Chain Scenario", 2019, *IEEE Open Acess Journal, vol. 7, 2019.*.

[6]. **Federico Matteo Benčić, Pavle Skočir and Ivana Podnar Ž arko**, "DL- Tags: DLT and Smart Tags for Decentralized, Privacy-Preserving, and Verifiable Supply Chain Management", 2019.*IEEE Open Access Journal,vol. 7, 2019.*

[7]. **Sidra Malik, Volkan Dedeoglu, Salil S. Kanhere, and Raja Jurdak**, "TrustChain: Trust Management in Blockchain and IoT supported supply chains", 2019,*IEEE International Conference on Blockchain.*.

[8]. **Xin Zhang, Pengcheng Sun, Jiping Xu, Xiaoyi Wang, Jiabin Yu, Zhiyao Zhao, and Yunfeng Dong,**"Blockchain-Based Safety Manage- ment System for the Grain Supply Chain", 2020. *IEEE Open Access Journal, Special Section on Blockchain-Enabled Trustworthy Systems.*

[9]. **Xin Zhang, Pengcheng Sun, Jiping Xu, Xiaoyi Wang, Jiabin Yu, Zhiyao Zhao, and Yunfeng Dong,**"Blockchain-Based Safety Manage- ment System for the Grain Supply Chain", 2020. *IEEE Open Access Journal, Special Section on Blockchain-Enabled Trustworthy Systems.*

[10]. **Q. Lu and X. Xu**,"Adaptable blockchain-based systems: A case study for product traceability ", *IEEE Softw.*, vol. 34, no. 6, pp. 21-27, Nov./Dec. 2017.

[11]. **S. Malik, S. S. Kanhere, and R. Jurdak**,"ProductChain: Scalable blockchain framework to support provenance in supply chains ", in *Proc. IEEE 17th Int. Symp. Netw. Comput. Appl. (NCA)*, Cambridge, MA, USA,Nov. 2018, pp. 1-10.

[12]. **K. Salah, N. Nizamuddin, R. Jayaraman, and M. Omar**,"Blockchain- based soybean traceability in agricultural supply chain",*IEEE Access*, vol. 7, pp. 73295-73305, 2019.

[13]. **G. Wood.** *Ethereum: A Secure Decentralised Generalised Transaction Ledger.* Yellow Paper. Accessed: Jun. 28, 2019. [Online]. Available: https://ethereum.github.io/yellowpaper/paper.pdf