Blockchain based Pharmaceutical Supply Chain Management System

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***Abstract*- The improving technologies have increased the quality of the health care system drastically. Introduced smart services, and smart transportation and brought the government to authorize the systematic workflow of pharmaceutical supply chains. However, technological growth for efficient infrastructure implementation is on its way. It is a great advantage to use blockchain technology in the Supply Chain Management system for systematic and strategic management to create value for increased customer satisfaction. Introduced Ethereum blockchain for better pharmaceutical supply chain management. Using blockchain in supply chain management increases efficiency, transparency, security and provides immutable data with complex encryption algorithms. Using blockchain instead of database brings enhancement in product traceability without tampering data. Earlier, Supply chain management system uses cloud and database for storage to monitor delivery networks, bottlenecks, and prioritize slower moving shipments. Admins can update real-time data for tracking and managing the service or product to avoid conflict and most importantly it stores mutable data which can be modified at any time. Traceability and effective control of products in healthcare supply chain is a necessity. Hence uses supply chain management and it attempts to centrally control or link the production, shipment and distribution of a product.**

Keywords: Supply Chain in pharmacy, Blockchain, Ethereum, Solidity, Decentralized access

1. INTRODUCTION

Supply Chain management (SCM) is the act of preserving data efficiently on a centralized or decentralized platform for traceability and effective control of products [1]. Its goal is to improve the proper coordination among various entities in the supply chain. It's difficult to imagine the world without supply chains. Because, it follows set of guidelines for increasing standardization. Thus, we can ensure optimization of processes. Instead of implementing Supply Chain Management in Pharmaceuticals using Database and Cloud, blockchain technology can be used efficiently. In this a decentralized network have the whole access instead of centralized authority. Thus, ensures security and robustness. Decentralization is an important factor which provides security in a double layer manner [2],[17],[18]. Blockchain also provides transparency to the customers and the information obtained will be accurate in case of product tracking. It creates immutable record of all transactions, so it is possible to track assets from manufacturing to delivery. Therefore, blockchain is essential in pharmaceutical industry, where speed, coordination, transparency is critical to the delivery of products. In addition to the above features, Blockchain in pharma Supply Chain can reduce theft issues and can manage inventory too.

Nowadays, real-time tracking of products like medicines using conventional methods such as database management system and cloud-based storage lacks trust and security [3]. It relies on centralization and hence arises risk in data confidentiality. Anyone on the supply chain can tamper the data and false information about product will reach at the customer. That is, such a centralized system cannot prevent mutability of data. Also, It's less transparent at all.

For example, if all the entities in the public network have an access on an attribute at the same time, then it will be beneficial to the organization as well. So, blockchain technology raises a lot of possibilities for the synchronization of decentralized access. Supply chain management involves integration of manufacturer, Suppliers, distributors, transporters etc. It provides an

appropriate strategy to deliver products and services to customers at the right time, in the right quantities, and under the right conditions. It' s main feature is admins and customers will get an end-to-end visibility of data. Customers will get accurate details such as materials used, other manufacturing details, suppliers as well as distributors, transporting conditions etc. about the medicine when they enter the unique id of that product. Accordingly, the process will become transparent to all and the property that is the immutability of data ensures advanced security too. Throughthe blockchain based supply chain management system, the organization can reduce complaint rates tremendously. The Following figure 1 is represented Stakeholders and their relationship in SCM.

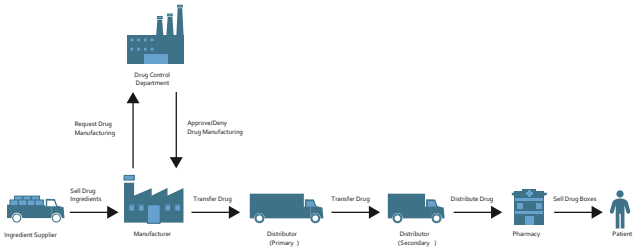

Figure 1: Stakeholders and their relaonship in SCM

2. RELATED WORK

2.1 Cloud based supply chain management

Cloud based supply chain management is a widely used application for its simplicity, flexibility etc.

Usually cloud lifecycle is used by most companies while shifting from traditional supply chain methodologies to cloud SCM [16]. It can be effectively implemented in logistics, forecasting, planning, service and spare parts management, sourcing etc.

2.1.2 Forecasting and planning: Cloud based technology has a huge application that it assists companies to improve quality of services by integrating the various stakeholders in the supply chain management. It can continuously evaluate data gathered from internet and can execute to get more and more accurate and relevant statistical demand forecasts for all SCM partners.

2.1.3 Sourcing: It is a technique for the appropriate selection of suppliers as Cloud computing acts as a database which contains multiple data about various suppliers. Then the companies can execute comparison between those suppliers based on their previous work records such as ability to provide quality raw materials and semi products based on specifications. Another advantage of cloud-based technology is that it is able to create contracts among companies and suppliers.

3. PURPOSE

While looking at the issues of cloud-based approach we realized that the pharmaceutical industry requires an updated supply chain system. The objective of the new system is to assimilate the features of blockchain technology and add traceability, security, and to provide visibility to manufactures of the SCM system. In such outlines where we need data intimacy and data accessibility both at the same time, Blockchain technology is the adequate option [4]. Every time a product changes a hand, the transaction can be documented to create a permanent history of a product, from manufacture to sale. This will dramatically decrease time holdups, expenditures, and human errors that arise in transactions. The purpose and aspects of the blockchain based SCM system for the pharmaceutical industry are abridged as follows.

3.1 To Increase Trust and Transparency - With producer and customers being able capable of track pharmaceutical merchandise at some point of the supply chain, they will agree with each other. Manufactures may be capable of see that the products they need to deliver is effectively obtained by the intended client. On the other hand, the consumer could be capable of see that the product he wants to buy is evolved by using a valid manufacture, and here were given it in its original form [5].

3.2 Traceability - Once the manufacturer produces a product, he will check in it at the blockchain, and hereafter the drug will be tracked, traced, and authenticated at every degree of its path. Because the drug's ownership changes physically, it's possession may be transferred simultaneously on the blockchain community [6]. Drug producers could be capable of see the voyage of their products at any time, from production to packagers, and from packagers to distributers.

3.3 Extended Security - Blockchain is considered as one of the maximum secured ledger systems on this planet [7]. Blockchain is an immutable database and the records once stored on it, it cannot be deleted or modified. In the proposed system, a permissioned blockchain could be used that is more secure then the public blockchain, wherein most effective valid contributors could be granted privileges to push data to the blockchain.

3.4 Immutability of data - Immutable ledger in blockchain refers to any records that have the capability to remain unchanged. It can't be altered and subsequently the records can't be changed quite simply, thereby ensuring that the security is pretty tight. Immutability method that it is very hard to make modifications without collusion [14].

4. BLOCK CHAIN BASED SUPPLY CHAIN MANAGEMENT SYSTEM

4.1 SYSTEM ARCHITECTURE

Traditional systems to achieve trust and industrial growth within pharma companies are inefficient because of the lack of capability to prevent fraud and cyber offence. Transparency and traceability are the major factors which helps in the growth of trusted partnerships and this will reduce the issues of mistrust among the users. The users

should know the exact life cycle that the drugs go through from manufacturer to their hands via various intermediaries. In our proposed system, we use Blockchain to trace and track drugs to verify its root source. Blockchain is a decentralized technology and anyone on the network can see the content for verification and it will save every transaction made on the network. Blockchain cannot be operated by a company in its own and no one has been granted an opportunity to tamper the entries once made. Every stakeholder on the blockchain network are the nodes and each node in the network can preview the entire status of drugs. Blockchain, as the name suggests blocks are interconnected like chains. Each block contains Data, Hash and Hash of previous block [8]. The working principle of hash is similar to finger prints as it is unique for each block. After entering data, if anyone tries to modify it, the hash value changes and successive blocks can't verify validity of entered data. It purposefully delays the time for saving data entered. Hence provides security and consistency. This is the working principle of Blockchain. The admins keep a record of whole data from pharmaceutical manufacturing to customers. Each admins have copy of these entire blocks, so if anyone modifies it, they can access the modified details and the person who modifies it. Blockchain provides complex inbuilt encryption algorithm for ensuring security. The structure of blocks in blockchain is shown in figure 2. The Blockchain architecture consists of various components and each have different features which are really important for Supply Chain Management [15].

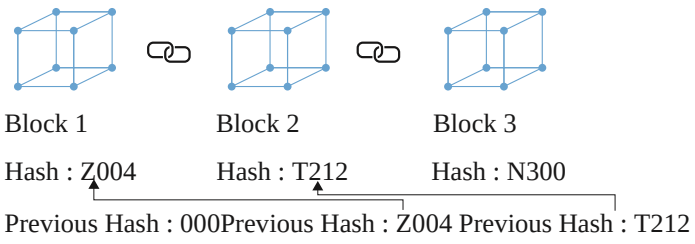

Figure 2 : Structure of Blockchain

4.1.1 The Block: Blockchain, as the name suggests blocks are interconnected like chains. A block is composed of a Data, Hash and Hash of previous block. Blocks have specific storage capacities which when filled may become close and will link to previous block. Blockchain provides trust without the use of a trusted third party.

4.1.2 Hash: It is used to identify a block because each block has a unique hash. Hash is similar to finger prints. After entering data, if anyone tries to modify it, the hash value changes and successive blocks can't verify validity of entered data. It purposefully delays the time for saving data entered. Hence provides security and consistency [8].

4.1.3Decentralized ledger: Decentralization property of Blockchain ensures the authenticity of data introduced by pharmaceutical companies [9]. Blockchain technology performs data isolation by solving problem. Each participant on the network has the copy of all the blocks and no one owns it. That is; when a participant creates a new block then all nodes in the blockchain network will get this new block. Each node must validate the blocks and then only a new block will add to the chain.

4.1.4 Proof of Work (PoW): All miners on the network are competing among themselves for making transaction in the blocks. In order to do so they should solve a problem. The one who solves the problem very fast will be allowed and others should verify it. Then the winner gets reward. Proof of work concept makes blockchain more secure and prevents tampering of data. It is a type of consensus method and it determines the validity of each block and rejects tampered blocks [10].

4.2 SYSTEM DESIGN

Proposed system uses Blockchain technology instead of database and cloud for diminishing existing drawbacks. It is impossible to store complete data on the Blockchain as the resource requirement for each node will be very high. Due to the limited capacity of Blockchain, we introduce IPFS (Inter Planetary File System) [11]. There is no central server in IPFS rather it is a distributed file system to store data with integrity and flexibility. IPFS can distribute large amount of data without cloning. Each file uploaded in the IPFS file system has a unique hash string. This hash string is used to retrieve files. The following Figure 3 represents high level architecture of blockchain based SCM.

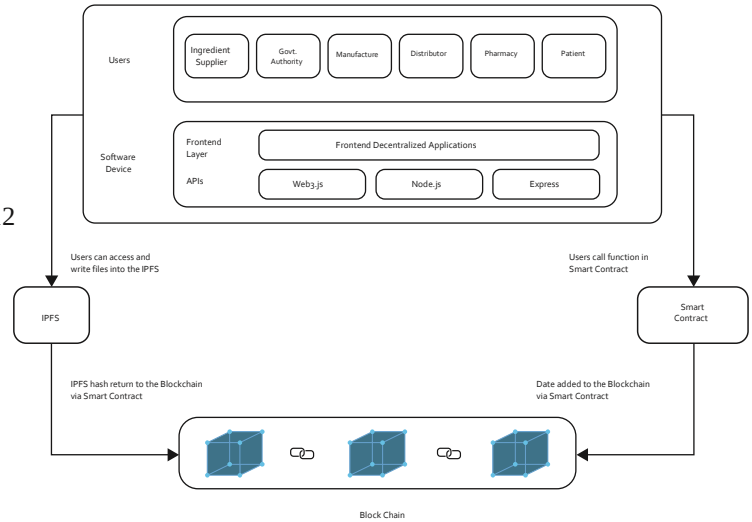

Figure 3: High Level Architecture of Blockchain based SCM

Only the hash string is stored in Blockchain which map to the complete data in IPFS system. The express application is connected to IPFS and Blockchain via smart contract. Users register and login into the application and through smart contract communicates with Blockchain and the files of certificates stored into IPFS and its hash is stored

into Blockchain. A smart contract is a computer protocol and its intention is to digitally facilitate, verify or enforce the performance of a contract [12]. It allows the performance of credible, trackable and irreversible transaction without third parties. An Ethereum account has an Ethereum address and each admin has a wallet associated with them which manages the Ethereum account. Wallet is only a tool for managing an Ethereum account[13]. This wallet address will be unique and it will provide decent number of Ethereum coins to them. If they wish to do some transactions or want to add data to the blockchain they should pay for that from this Ethereum coins. An Ethereum address is a 42-character hexadecimal address derived from the last 20 bytes of the public key controlling the account with 0x appended in front. Sequence diagram of relationship between various entities in blockchain based SCM shown in figure 4.

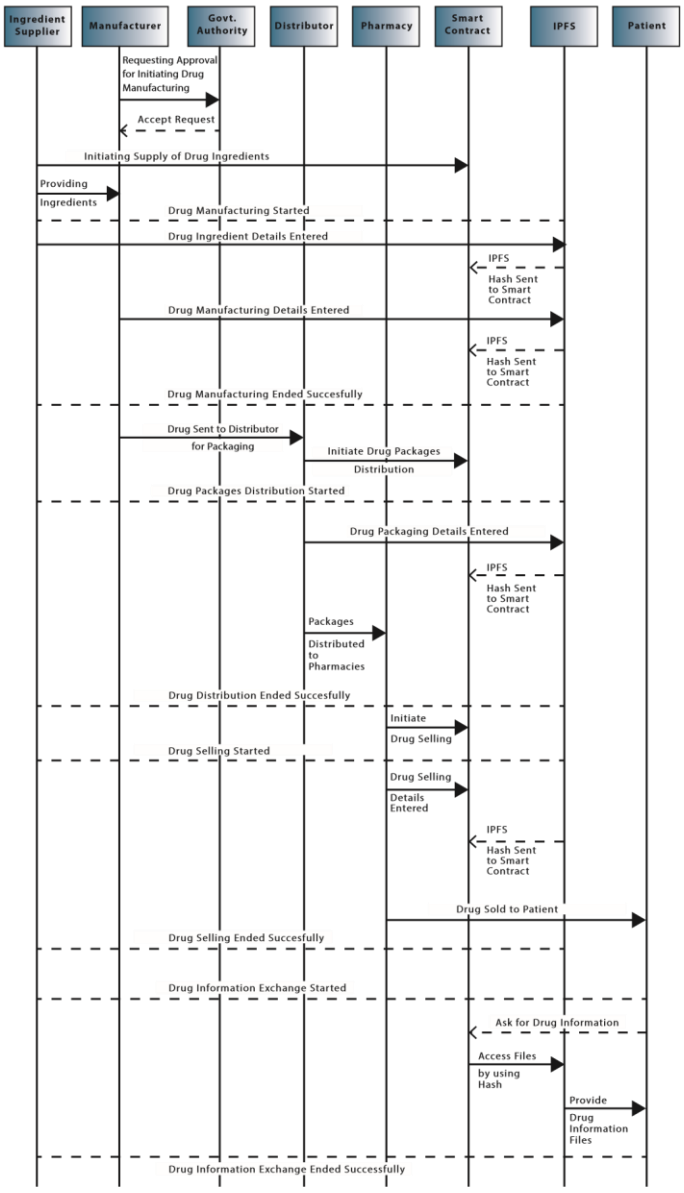

Figure 4: Sequence Diagram of Relationship Between Various Entities in Blockchain based SCM

IPFS is a file sharing system that can be used to store and share large files more efficiently. It is based on cryptographic hashes that can be easily stored on the blockchain. IPFS will link all these different block chains in a similar way to how the internet connects all websites. A secure repository that allows a user to store the private and public key pair. It interacts with the Ethereum network so that a user can receive and send digital currency (Ethereum) and monitor their balance. Figure 5 shows the workflow of the application including digital authentication and validation.

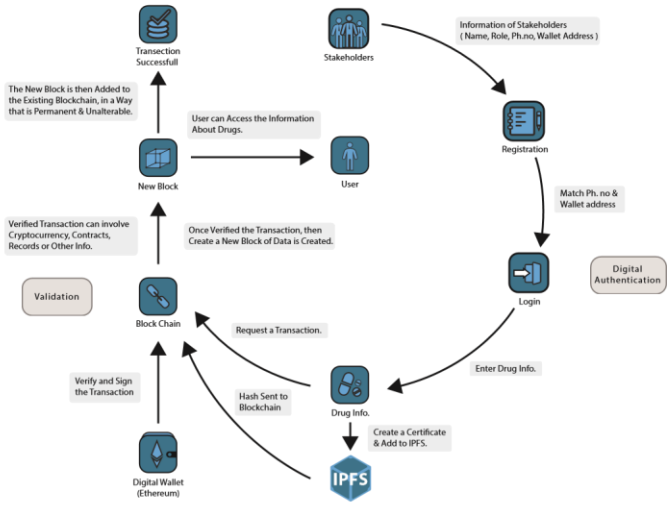

Figure 5: Workflow of the Application Including Digital Authentication and Validation

RESULT

In this paper, we have developed a web-based Supply chain management system that relies on Blockchain technology. The user or the one who wishes to seek information about the pharma product can enter the product ID in our web interface and he will get entire details regarding the product from the ingredients used to the end of the pharma life cycle. The information entered by the user will not be exposed to the 3rd party as our project is specifically meant for data security and integrity. Figure 6 shows the result obtained after which the user enters the Product ID.

Figure 6: Product Certificate Stored in IPFS

The stakeholders can register on this website by providing basic details like names, number, password and at last, he should enter a unique wallet address allotted to him. This wallet address is the stakeholder's Ethereum account in which he owns some amount of Ethereum coins. To make some transactions in it he should pay some Ethereum amount for that. Figure 7 shows some of the wallet addresses we have generated

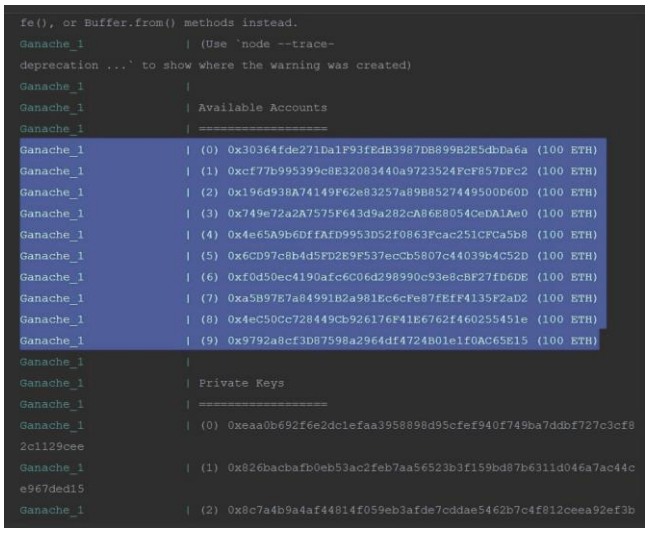

Figure 7: Wallet Address

The section analyses our project model from various perspectives like security, storage space, transparency, etc.

We didn't use the cloud in this because the main agenda behind this project is to store data in a highly secured area as leakage of data from cloud storage is common and we prefer a decentralized data storage facility. Instead, we used IPFS based storage model. Only the hash of the file is stored in the blockchain and the files of the certificate are stored in IPFS. Calculation of block header hash is mainly based on IPFS hash. Once a fraudulent node wants to tamper with the data which has already been entered its IPFS hash also changes. Thus, an invalid block won't be validated by Blockchain. In this storage space is also optimized because of the use of hash itself. Next we checked for transparency and downloaded the Ether scan website for analysing the transparency provided by the Blockchain' which helped us to view all transactions in the Ethereum public chain. In this system, transparency between peer can be achieved only by using public chain. i.e.; public network is open network which doesn't require permission for participation. Anyone in the network will get entire access within blockchain. It doesn't control the network as it's a decentralized one. It ensures high security due to the mining and follows 51% rule, it's open for all and allow everyone to be anonymous in it. But in private blockchain, transactions are private and it's is a permissioned blockchain. Participant need consent from administrator to join the network. i.e.; it relies on third parties to transact. It's more prone to data breaches and less secure due to the centralization property. But in public network, it's impossible for the one (bad actor) to attack the system because there is active participation among large number of nodes in the network. The following figure 8 shows the transaction execution receipt from Blockchain.

Figure 8: Transaction Receipt

This is the data returned after the execution of a transaction. It contains the transaction hash, the block number of that particular block, the sender's and receiver's wallet address, information regarding how much Gas is used, etc.

CONCLUSION

In our system, we use a decentralized network for making data more secure, traceable and structured. A blockchain not only enables one to add new data to the database but it also guarantees that all the users in the network have exactly the similar data. Thus, a blockchain is a distributed and decentralised linked data structure for data warehouse and retrieval which also guarantees that the data is unwilling to any transformation. Used for tracing and tracking illegal drug products. With blockchain, drug companies can closely track medications throughout the universal supply chain by product id.

The network ledger records production updates by serial number, and serves as a tamper-proof source of truth that eliminates the opening popular actors. Applicable to all real-world scenarios which requires transparency like online shopping, defence contract etc. The primary challenge of our proposed system is, it's a task to ensure the trustworthiness of input data given by users even it works in a decentralized peer to peer network. Since we use public blockchain, it consumes more energy. It requires significant number of electrical resources to function. In the future, we can implement hardware unit (IIoT devices) to detect and analyse physical quantities in the medical field.

REFERENCES

[1] I. I. el Farouk and F. Jawab, "Improving sustainability in public hospital through Medicines Supply chain management," 2020 IEEE 13th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA), pp. 1-5, 2020, doi: 10.1109/LOGISTIQUA49782.2020.9353937.

[2] Q. Ding, S. Gao, J. Zhu and C. Yuan, "Permissioned Blockchain-Based Double-Layer Framework for Product Traceability System," in IEEE Access, vol. 8, pp. 6209-6225, 2020, doi: 10.1109/ACCESS.2019.2962274.

[3] P. A. Abdalla and A. Varol, "Advantages to Disadvantages of Cloud Computing for Small-Sized Business," 2019 7th International Symposium on Digital Forensics and Security (ISDFS), pp. 1-6, 2019, doi: 10.1109/ISDFS.2019.8757549.

[4] S. Johny and C. Priyadharsini, "Investigations on the Implementation of Blockchain Technology in Supplychain Network," 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS), pp. 1-6, 2021, doi: 10.1109/ICACCS51430.2021.9441820.

[5] B. Craggs and A. Rashid, "Trust Beyond Computation Alone: Human Aspects of Trust in Blockchain Technologies," 2019 IEEE/ACM 41st International Conference on Software Engineering: Software Engineering in Society (ICSE-SEIS), pp. 21-30, 2019, doi: 10.1109/ICSE-SEIS.2019.00011.

[6] Y. Zhang, M. Jin, G. Zheng and H. Li, "Design and Application of Product Traceability Blockchain-based Platform," 2020 3rd International Conference on Smart BlockChain (SmartBlock), pp. 125-131, 2020, doi: 10.1109/SmartBlock52591.2020.00030.

[7] A. K. Singh, "A Multi-Layered Network Model for Blockchain Based Security Surveillance system," 2020 IEEE International Conference for Innovation in Technology (INOCON), pp. 1-5, 2020, doi: 10.1109/INOCON50539.2020.9298422.

[8] F. Wang et al., "An Experimental Investigation Into the Hash Functions Used in Blockchains," in IEEE Transactions on Engineering Management, vol. 67, no. 4, pp. 1404-1424, Nov. 2020, doi: 10.1109/TEM.2019.2932202.

[9] M. C. Xenya and K. Quist-Aphetsi, "Decentralized Distributed Blockchain Ledger for Financial Transaction Backup Data," 2019 International Conference on Cyber Security and Internet of Things (ICSIoT), pp. 34-36, 2019, doi: 10.1109/ICSIoT47925.2019.00013.

[10] P. R. Nair and D. R. Dorai, "Evaluation of Performance and Security of Proof of Work and Proof of Stake using Blockchain," 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), pp. 279-283, 2021, doi: 10.1109/ICICV50876.2021.9388487.

[11] Q. Zheng, Y. Li, P. Chen and X. Dong, "An Innovative IPFS-Based Storage Model for Blockchain," 2018 IEEE/WIC/ACM International Conference on Web Intelligence (WI), pp. 704-708, 2018, doi: 10.1109/WI.2018.000-8.

[12] A. Abuhashim and C. C. Tan, "Smart Contract Designs on Blockchain Applications," 2020 IEEE Symposium on Computers and Communications (ISCC), pp. 1-4, 2020, doi: 10.1109/ISCC50000.2020.9219622.

[13] S. Jianjun, L. Ming and M. Jingang, "Research and application of data sharing platform integrating Ethereum and IPFs Technology," 2020 19th International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES), pp. 279-282, 2020, doi: 10.1109/DCABES50732.2020.00079.

[14] F. Hofmann, S. Wurster, E. Ron and M. Böhmecke-Schwafert, "The immutability concept of blockchains and benefits of early standardization," 2017 ITU Kaleidoscope: Challenges for a Data-Driven Society (ITU K),pp. 1-8, 2017, doi: 10.23919/ITU-WT.2017.8247004.

[15] T. Ali Syed, A. Alzahrani, S. Jan, M. S. Siddiqui, A. Nadeem and T. Alghamdi, "A Comparative Analysis of Blockchain Architecture and its Applications: Problems and Recommendations," in IEEE Access, vol. 7, pp. 176838-176869, 2019, doi: 10.1109/ACCESS.2019.2957660.

[16] Toka, Agorasti, Aivazidou, Eirini, Arvanitopoulos-Darginis, Konstantinos, Antoniou, Antonios, "Cloud Computing in Supply Chain Management: An Overview", E-Logistics and E-Supply Chain Management: Applications for Evolving Business (pp.218-231), Edition: 1st, Chapter: 12, Publisher: IGI Global, January 2013, DOI:10.13140/2.1.2717.2800.

[17] Om Pal, Bashir Alam, Vinay Thakur, Surendra Singh, "Key management for blockchain technology", ICT Express, Volume 7, Issue 1,Pages 76-80,ISSN 2405-9595,2021, https://doi.org/10.1016/j.icte.2019.08.002.

[18] H. Bai, G. Xia and S. Fu, "A Two-Layer-Consensus Based Blockchain Architecture for IoT," 2019 IEEE 9th International Conference on Electronics Information and Emergency Communication (ICEIEC), pp. 1-6, 2019, doi: 10.1109/ICEIEC.2019.8784458.