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A DECENTRALIZED LEDGER TECHNOLOGY APPLICATION IN HEALTHCARE SECTOR – BLOCKCHAIN

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ABSTRACT

Blockchain is a secured form of a public or private ledger through which transactions occur. It is the latest trending technology that is being used in Bitcoin. Such cryptocurrencies are employed by blockchain. Leading pharmaceutical companies like International Business Machines (IBM) show significant interest in peer-to-peer network technology. Such a digitalized peer-to-peer network is attained by blockchain. This system provides secured and enormous storage for the data. The distributed ledger mechanism provides an effortless transaction and is executed in a consensus manner. It also provides an encrypted form of sharing of records to multiple nodes. This review concentrates on the possible aspects of the healthcare sector where blockchain is pervasively implemented. It is a patient-centric, traceable, scalable and trustworthy application. Thereby significance in the healthcare field is explained that helps as a paradigm for future researchers to understand blockchain technology.

KEYWORDS: Blockchain, decentralized, consensus, supply, clinical trial, neuroscience.

1. INTRODUCTION

The concept of distributed ledger technology application called blockchain is now finding wide applications in both financial and non-financial streams.[1] Distributed ledger technology is an infrastructure with protocols that allows simultaneous access and validation. Records are immutably updated across multiple entities. Blockchain technology enables collaboration between different users. The digital ledger database called blockchain is a computerized technology used to record information in blocks. The stored blocks were finally chained together with the help of cryptography. This is a data structure that comprises a list of records called blocks.[2, 3] Any modification in the chains is resistant to individual, it is

needed to be approved by officials for editing. In 1982, a blockchain protocol was first coined by Cryptographer David Chaum.[4] In 2008, a person named Satoshi Nakamoto was the first who conceptualized the blockchain model in a white paper mainly for the currency. It acts as a communication tool for transactions of digital currency.[5] Blockchain is visualized as a block connected, formulated with algorithms for recording transactions. Blocks of data are linked together by hash, which is a digital signature of random letters and numbers, to form a chain of data that contains a complete history of transactions and renders it tamper-resistant. Hash number contains numerals that encrypt the data in the block. A cryptographic hash function generates a fixed-length string character for data records of any length. These data records with the hash number are distributed to every entity or node. Every node has similar data or transaction that is encrypted in the block. All the blocks are chained together one after the other, forming a chain called the blockchain.[2]

The two important characters of a blockchain are the distributed consensus and anonymity. A distributed consensus means an agreement or the proposal of data among the users or the nodes. A consensus algorithm may be defined as the mechanism through which a blockchain network operates. Pseudomisation or anonymization is provided by cryptographic functions through which the true identity of the participants is not known. This is done by using the public or private key. This kind of data can be accessed only by service providers who are authorized.[6] Authentication is done by cryptography, a string of data that is used to access. This removes human involvement in the verification process, reducing human error. The other characteristics, which potentiate the application of blockchain in healthcare, are immutability, decentralization, transparency, the accuracy of transactions. Blockchain allows everyone in the network to view all the information stored, thus this transparency provides a significant application in the healthcare sector. The traceability of data makes blockchain more efficient in the healthcare sector. The verifiable timestamps act as the tool to trace the data. The word decentralization refers to that there is no single authority or entity for any transaction or blockchain does not store any of its information at the central location.[6] It is a peer-to-peer network. Every new block framed is chained to the already existing blockchain. This gets updated automatically at each node.[7] Proof of Work (PoW), is a form of cryptographic zero-knowledge proof in which the user proves to the verifier, that a certain specific computational effort has been spent. It is the decentralized mechanism used for cryptocurrency transactions making it authorized and accurate for transactions. Proof of Work employed through blockchain technology is called blockchain mining.[8, 9]

2. THE BLOCK – STRUCTURE AND PROCESS

The basic structure of a block contains the data, hash number, and timestamp. The timestamp is a unique serial number that determines when the block is mined or validated in a blockchain. Hash is used to identifying a block and its contents. It is always unique and once the hash is changed, it detects the data changes in the block. Once the hash is changed, it is no more the same block so that it forms a new block with a hash of the previous block. Hence, it forms a blockchain.[2, 10] There are different types of blockchain namely, public and private or business blockchain. Public network-based blockchain is the popular cryptocurrency bitcoin and private blockchain is not open to the public but authorized by a group of trusted participants. Within the network, it is distinguished between permissioned and permissionless blockchain systems. In a permissionless system, members remain anonymous or pseudo-anonymous and everyone can append a new block to the chain. The permission system can identify each member who controlled the right to validate a new block. Hybrid blockchain or consortium blockchain combines the elements of both private and public systems. Organizations set up a private permission-based system alongside a public permission system, allowing them to differentiate the controls who can access specific data stored in blockchain between public and private.[7] The blocks with unique IDs are arranged in chronological order. It operates with a consensus mechanism. For any changes in the blockchain, it has to undergo verification by all the users to protect the data stored. A flowchart diagram portrays the transaction process.[2, 11. 12] **Fig. 1**

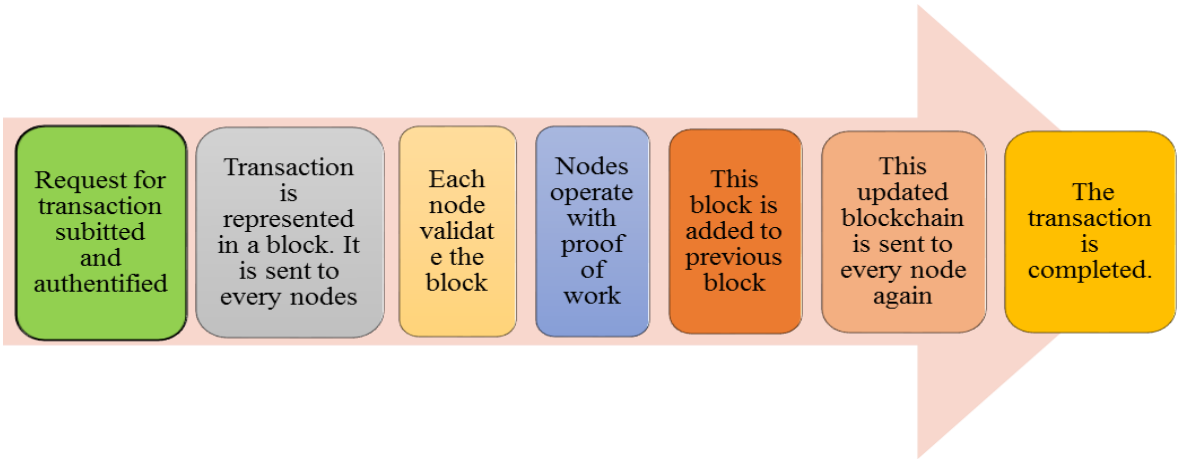

Fig. 1: Schematic diagram representing the blockchain transaction process.

3. BLOCKCHAIN IN HEALTHCARE

The Health care system is a vast problem-driven sector. It needs a trustworthy interoperable system of records management. This sector operated intending to improve the individual

health of the patients. The integrity of the data has to meet the expected quality by the organizations. This blockchain system in healthcare maintains the data provenance and optimizes the quality of the organization. It reduces third-party intervention, access control sharing, drug counterfeiting, etc. Several departments under healthcare operating with a blockchain data sharing system are discussed.[1, 2]

3.1. PHARMACEUTICAL SUPPLY CHAIN

Pharmaceutical supply chain (PSC) based on blockchain management required an encrypted network with multi-nodes actor points (manufacturer, retailers, and customers). It should provide authenticity, manageability, privacy for the supply information along with a virtual contractual relationship called the smart contract which is also recorded, in the PSC-based blockchain.[2, 13] Access was provided to all the actors to know the entire product profile for the relevant supply. This type of PSC-based Blockchain gives a clear solution between the stakeholders and the manufacturer about the drugs or medicines for supply. Emergency removal or withdrawal of a product from the market can be made very easily using the PSC-based blockchain.

Based on the PSC blockchain, they are group into Back-end and Front-end[14] **Fig. 2**

- Registrars – they are the concerned team or person to give unique identification information for the supply according to the protocols.
- Standard organizations – play a vital role in the eligibility scheme for particular goods or products based on the industry protocols.
- Certifiers – provides certification for the supply of the products to the actors according to the government protocols.
- Actors – includes manufacturer, retailers, and the customers
- Blockchain platforms like Ethereum, Block verify, International Business Management (IBM) Blockchain, T-mining, etc.,[15] work efficiently and transparently globally with help of this blockchain supply management system.

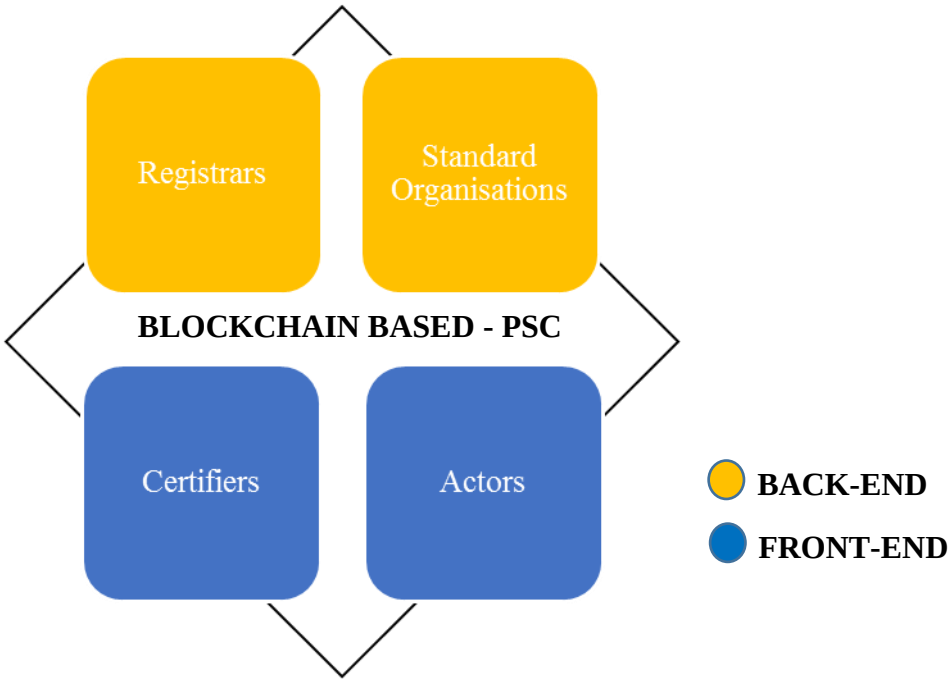

Fig. 2: Schematic diagram representing the Pharmaceutical supply chain groups.

3.2. PURPOSE FOR BLOCKCHAIN IN PSC

After manufacturing the drug, it should be traceable for each step in the market to ensure the efficacy and safety of the drug. This helps to enhance the trust between the customers and the manufacturer and be transparent. Thereby avoids the counterfeit of the drugs in the market.[16]

3.3. BLOCKCHAIN IN COUNTERFEIT DRUGS

Ongoing counterfeiting of drugs in the market, over $200 billion loss in revenue in the pharmaceutical industry.[17] Nearly 280000 deaths, which includes children (180000) due to counterfeit drugs used for malaria and pneumonia. According to World Health Organization statistics, around 30% of counterfeit drugs had been sold in Latin America, Asia, and Africa.[18,19] Hyperledger is a private blockchain type that was launched to eradicate the spread of counterfeit drugs. Recently, Accenture and many other companies collaborated with Hyperledger to stop the counterfeit drug from spreading over the market using Blockchain-PSC.[20]

3.4. BLOCKCHAIN IN CLINICAL RESEARCH

Blockchain is a decentralized and immutable form of a system that is secure and implemented in healthcare. A comprehensive patient's data are enrolled and accessed only by patients through smart contracts. This makes the patient records confidential and accessed by restricted professionals. As many as patients get enrolled, patient health records are stored in

the blocks and given encryption details. This improves quality, accountability, and data integrity. It also reduces the costs and the fraudulence of data. Thereby it provides the solution to a wide network of nodes, increasing the efficacy of the operations.[2] This kind of Electronic Healthcare Records (EHR) needs to be transparent and easily communicable for the healthcare team. EHR is a key to clinical research management. EHR is managed by different frameworks namely, Ethereum (Medrec[21,22], FHIRChain[23], MIStore[24]), Hyperledger Fabric[25], Bitcoin[26], and proprietary[27, 28] (MedBlock, BlockHIE).[11] Ethereum based application is the Medrec, currently used in MIT (Massachusetts Institute of Technology) Media Lab and Beth Israel Deaconess Medical Center make the decentralized system of authentication and data management.[21, 22] Another one is the FHIR chain, which shares scalable and secured clinical information. This aids in the clinical decision-making by healthcare professionals. FHIR provides interoperable data that meets the requirements by the *Office of the National Coordinator* (ONC) *for Health Information Technology*.[23] The Blockchain system of MIStore helps in the data management of patient history needed for the insurance claim. This provides immutable and transparent data stored in an Ethereum based system.[24, 29] Electronic Health Records is a consolidated form of patient's history that is significant for the follow up with physicians for the treatments. It is regarded as the legal requirements for the hospitals that cannot be accessed by everyone. These documents can be encrypted by blockchain technology.[25] This blockchain records complete data about the patients. It helps in tracking the patients to improve compliance and recording of clinical data. Even the physicians who gave inappropriate treatments can be traced.[30] This entire patient record management by blockchain improves the speed and efficacy of clinical trials. This makes trials by smart contracting with integrity and time stamping. Blockchain overcomes significant medical challenges in clinical trials, personal data privacy concerns, and difficulties associated with patient enrollment in the clinical trial.[31, 32]

3.5. NEUROSCIENCE

Technologies have been developed that record and interrupt the electrical signals and activities of the brain. These signals are converted into commands and received as outputs. Complex algorithms are involved in it. This kind of digitalization requires a place to store the data. For that, blockchain is being blended with the already existing artificial intelligence. This blockchain helps in the simulation of signals, brain augmentation, thinking, etc. It is an input processing-output computational programming system. Artificial intelligence, human enhancement, and potential with blockchain integrate to improve the research on the brain.

This helps to store and recollect information like neurons. It can be carried out without third-party intervention and executed with a monetary benefit. The memories, sensory signaling by the brain, thinking, learning, decision making, rehabilitation, and imaginations can be researched on every individual in the trials. Neurogress is a system employed to control robotics, smart appliances, drones, etc. It is certified in Geneva in 2017. It helps to build neuronal science communication. Neurogress with blockchain makes it private and decentralized. Thus it becomes a secured and transparent platform that is easily traceable.[33 – 35]

3.6. ORGAN AND BLOOD DONATION

Science has been developed in organ transplantation despite many hindrances such as graft rejections, verifications, organ supply, storage, and indulging hospitals, institutions, organizations, families, etc. When blockchain is implemented with organ or blood donation, it ensures a transparent, traceable, immutable, and trustworthy mode of supply to the donors. It makes an easier record of donors and acceptors along with the history of that particular organ or blood. This helps in saving a life without any corruption, lack of time, and critical cases also. UAE is the first to donate organs through blockchain in partnership with Dhonor Health Tech Company in 2019.[34, 36]

3.7. BLOCKCHAIN INNOVATIONS IN COVID-19

In the current pandemic, people are searching for the best solutions in testing for COVID – 19 infections, information about the spread of the disease, development of vaccines, etc. Blockchain technology emerged as a useful resource for tracking platforms in various categories – clinical trials, supply chain, data aggregation, and privacy protection. This gives detailed chronological order information about the disease in a single place that makes an easier and encrypted form of the permanent record for people over the world.[37]

3.7.1. CLINICAL TRIALS

In search of a vaccine for Coronavirus, blockchain technology helped phase–III clinical trial, which upholds a huge number of patients participation, which makes challenging to maintain the records manually. By using this blockchain safety and privacy of the patients, record maintenance, etc. can ensure.[38, 39]

3.7.2. DATA AGGREGATIONS

For maintaining a real-time data aggregation from all over the world, a blockchain-based MIPASA project joined hands with the team of IBM blockchain. This provides helpful support to give data on the platform for COVID – 19 streaming services.[40]

3.7.3. MEDICAL SUPPLY CHAIN

During the enhanced demand of supply, blockchain helps in bringing the entire stakeholders into a single platform network with included 100% of transparency. This gives proper details along with processing operations and validation of the drug supply.[41] The new KN95 masks from China were ensured using the Vechain platform. In addition, the production, distribution, and allocations of the vaccine can be maintained with a neat record in a single platform.[42]

3.7.4. PRIVACY AND SAFETY PROTOCOL

By designing a blockchain for privacy protocol in this COVID -19 for patients, which gives digital connection to the healthcare professionals for their treatments. A German Tech MYNXG – a blockchain technology, uses smartphones for maintaining reports in the privacy of patients.[41]

4. CONCLUSION

This decentralized ledger blockchain technology is currently blooming the world in various fields such as banking and financial services, media entertainment, telecommunications, automobile industries, shipping, agriculture, E-commerce, construction, and education. Implementing such technology in the pharmaceutical healthcare sector helps in the progression of the field with security and privacy. Management of both patient and organizational records is a leading issue in many health centers. This technology can be the solution for many concerns in future aspects.

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