International Journal of Computer Trends and Technology
ISSN: 2231-2803 / https://doi.org/10.14445/22312803/IJCTT-V68I3P111

Volume 68 Issue 3, 56-60, March 2020

Review Article

Application of Blockchain Technology to HealthCare Sector: A Review

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Received Date: 11 February 2020
Revised Date: 23 March 2020
Accepted Date: 26 March 2020

***Abstract* —** *Blockchain can be described as a distributed ledger technology capable of recording safe and continuous transactions between parties. It is an emerging technology that has drawn considerable interest from financial institutions, energy supply firms, the academic community and also the healthcare industry. Blockchain promises transparent, tamper-proof and secure systems that can enable novel solutions, especially when combined with smart contracts. Decentralization is a significant characteristic of Blockchain that can benefit healthcare applications, making it possible to implement distributed healthcare apps that do not depend on a centralized authority. In addition, the fact that the information in the Blockchain is duplicated among all the nodes in the network creates an environment of transparency and openness that allows healthcare stakeholders and patients, in particular, to understand how their data is used, by whom, when and how. This paper presents a review of the application of Blockchain to the health care sector.*

Keywords *– Blockchain Technology, Immutability, Healthcare, Privacy.*

I. INTRODUCTION

Blockchain can be described as a distributed ledger technology capable of recording safe and continuous transactions between parties. Blockchain fundamentally eliminates the need for intermediaries who were earlier needed to behave as trusted third parties to check, record and coordinate transactions by' sharing' databases between various parties [1]. It is an emerging technology that has drawn considerable interest from financial institutions, energy supply firms, the academic community and also the healthcare industry. Blockchain promises transparent, tamper-proof and secure systems that can enable novel solutions in the healthcare sector, especially when combined with smart contracts [2]. This paper presents a review of the application of Blockchain to the healthcare sector. It is arranged as follows: Section one presents an introduction to the Study,

Blockchain Technology in healthcare and its benefits are presented in sections two and three, respectively. Section four presents different areas in the healthcare sector where blockchain technology can be applied. A review of related works is presented in section five, while the conclusion is presented in section six.

II. BLOCKCHAIN TECHNOLOGY IN HEALTHCARE

Healthcare is one sector in which Blockchain is expected to have significant impacts. Decentralization is a significant characteristic of Blockchain that obviously benefits healthcare apps, making it possible to implement distributed healthcare apps that do not depend on a centralized authority. In addition, the fact that the information in the Blockchain is duplicated among all the nodes in the network creates an environment of transparency and openness that allows healthcare stakeholders and patients, in particular, to understand how their data is used, by whom, when and how. Hence, by its design, Blockchain can safeguard health information from future information loss, bribery or safety assaults, such as the attack against ransomware [2].

Furthermore, Blockchain's immutability property, which makes it impossible to change or alter any record attached to the Blockchain, is very well aligned with the requirements for storing health care records— it is very important to ensure the integrity and validity of health records for patients. Moreover, the use of cryptographic algorithms to encrypt the data stored on the blockchain guarantees that they can only be decrypted by users who have legitimate data access permissions, thereby enhancing data security and privacy. In addition, since the identities of clients in a blockchain are pseudonymized by using cryptographic keys, patient health information can be shared among health care stakeholders without exposing patient identities. Blockchain also promotes smart contracts that can be used to program guidelines that enable patients to regulate how they share or use their health records.

III. BENEFITS OF BLOCKCHAIN TO HEALTHCARE

The benefits of Blockchain to healthcare applications are listed below [2]:

A. Decentralization

A decentralized leadership scheme is required for the very nature of healthcare, in which there are distributed, stakeholders. Blockchain can become the decentralized core of health data management from which all stakeholders can have restricted access to the same medical records without someone holding a central authority's position over global health information.

B. Improved Data Security and Privacy

Blockchain's immutability property significantly enhances safety if the health information stored on it is unable to corrupt, alter or retrieve information once returned to the Blockchain. All blockchain health information is encrypted, time-stamped and chronologically appended. In addition, health information is stored on Blockchain using cryptographic keys that assist safeguard patients ' identity or privacy.

C. Health Data Ownership

Patients must be in possession of their information and have control over how their information is used. Patients need to be assured that other stakeholders do not misuse their health information and should have a means of detecting such misuse. By using powerful cryptographic protocols and well-defined smart contracts, Blockchain helps satisfy these demands.

D. Availability/Robustness

Since the blockchain records are duplicated in various nodes, the availability of health data stored on Blockchain is guaranteed as the system is durable and resistant to data losses, data manipulation and some security threats on data availability.

E. Transparency and Trust

Blockchain generates an environment of confidence around distributed healthcare applications through its open and transparent nature. This makes it easier for health stakeholders to accept such requests.

F. Data verifiability

The integrity and validity of these records can be verified even without accessing the plaintext of the records stored on Blockchain. This characteristic is very helpful in healthcare fields where a necessity is to verify documents, such as managing the pharmaceutical supply chain and handling claims for insurance.

IV. BLOCKCHAIN APPLICATION IN HEALTHCARE

The applications of Blockchain to healthcare include managing electronic medical records (EMRs), pharmaceutical supply chain, biomedical research and education, remote patient tracking (RPM), health claims, health data analytics, and other prospective healthcare applications fields.

A. Electronic Medical Record (EMR)

One of the popular healthcare blockchain applications is electronic medical records (EMRs) management. EMRs, sometimes interchangeably used with electronic health records (EHRs) or personal health records (PHRs), are related to the electronic creation, storage and management of personal, medical or health-related data of patients. Blockchain's features of decentralization, immutability, data provenance, reliability, robustness, intelligent contracts, safety and privacy are the characteristics that make it very appropriate for storing and managing electronic medical records (EMR) of patients [2].

B. Biomedical Research and Education

In biomedical research and education, Blockchain has been effectively applied. Blockchain may help eradicate falsification of information in clinical trials and under-reporting or removal of unpleasant clinical research outcomes. Blockchain makes it easier for patients to give the approval to use their information for clinical trials due to the inherently encoded anonymization in the information [5]. All of these are some of the considerations why biomedical research is supposed to revolutionize Blockchain. It was also observed that Blockchain has the ability to revolutionize the peer review process of clinical research papers based on its decentralized, immutable and transparent characteristics [4]. Another prospective implementation of Blockchain to education in healthcare professions (HPE) is suggested by [6], who presented a case for using Blockchain to construct an HPE scheme that will be value-based, competence-based, and deliver credential services without depending on a third party.

C. Remote Patient Monitoring (RPM)

Remote patient monitoring includes collecting biomedical information via body area sensors (or IoT devices) and mobile phones so that patient status can be monitored remotely outside traditional healthcare settings such as the hospital. Blockchain has been suggested as a way to store, share and retrieve the biomedical information collected remotely. [7] show how smart contracts on the Ethereum blockchain platform can support the implementation of real-time patient monitoring capable of delivering automated procedures in a safe setting. A blockchain-based patient-centric agent (PCA) was also developed by [8], an ongoing remote patient monitoring application to achieve end-to-end data security and privacy.

D. Health Data Analytics (HDA)

Blockchain also offers a distinctive chance to leverage the authority of other developing technologies such as in-depth teaching and transfer of learning methods to carry out predictive analyzes of health care information and advance research in the field of precision medicine [9]. [5] and [4] also mentioned in their papers the use of Blockchain for health data analytics., while [8] provided a comprehensive roadmap on how this can be realized. [10] performed an experimental study in which Blockchain is used for the classification of arrhythmia in a deep-learning design.

E. Health Information Exchange

The true value of interoperability could be unlocked by a Blockchain driven exchange of health information. A significant aspect of solving the difficulties of system interoperability and accessibility of medical records is the exchange of Personal Health Records and Health Information Exchange (HIE) information through the Integrating Health Care Enterprise (IHE) protocol. While blockchain technology is not a magic solution for data standardization or system integration difficulties, it offers a promising fresh distributed structure to amplify and promote health care information integration across a spectrum of uses and stakeholders. It addresses several current points of pain and allows a more effective, disintermediate and safe system [11].

Due to the absence of common architectures and norms that would allow the secure transfer of delicate data among stakeholders in the scheme, the present state of health care records is disjointed and stove-piped. Every time a medical service is provided, health care providers track and update the common clinical data set of a patient. This information involves normal data, such as the gender and date of birth of the patient, as well as distinctive information in accordance with the particular service given, such as the procedure done, treatment plan, and other notes. This data is typically monitored in a database within a unique organization or within a specified health care stakeholder network. This flow of information from the patient through the health care organization does not have to stop at the individual, organizational level every time a service is performed. Rather, health care organizations could take a further move and direct a standardized collection of data to a nationwide blockchain transaction layer in each patient interaction. Surface data on this transaction layer would contain data that is not Protected Health Information (PHI) or Personally Identifiable Information (PII); instead, select and non-personally recognizable demographics and services rendered data could provide access to an expansive and data-rich collection of data for health care organizations. Information deposited on the Blockchain could be widely accessible through the blockchain private key systems to a particular person, allowing patients to exchange their data much more effortlessly with health care organizations [11].

V. REVIEW OF RELATED WORKS ON THE APPLICATION OF BLOCKCHAIN TO HEALTH CARE

[12] Suggested a reliable and effective data sharing method for exchanging knowledge about healthcare. The authors used structure based on Merkle Tree to connect each block to the preceding block. Transactions do not provide direct details about the patient. Alternatively, they used Fast Healthcare Interoperability Resources (FHIR), an evolving standard designed to exchange Electronic Health Records (EHR) by offering public access via APIs. Proof of Interoperability was used as the consensus algorithm for the mining block method. Medical data must be verified by the miners in order to ensure their interoperability in terms of semantic and structural standards. Transactions are sent to the miner coordinating the distribution of transactions. Network nodes will then check the block after the coordinating node has assembled all transactions. After being returned during the signed block return process, the coordinating miner signs the block, and then the block is inserted and distributed. The value sets are stored in a repository with a single point of failure, removing the idea of decentralization as a result. Patient identification is achieved by assigning addresses to records, which in effect enables multiple addresses to be kept on the Blockchain by one single patient.

[13] Introduced a blockchain-based knowledge management system called MedBlock, which was implemented for the management of medical information. An enhanced hybrid-consensus system was put in place to fix the problems of network congestion and high energy consumption. The system allows efficient data upload to avoid network congestion caused by patients conducting several procedures in a centralized period. To demonstrate high information security, MedBlock incorporates symmetric cryptography and custom access control. MedBlock uses bread crumb mechanisms that allow users to effectively find encrypted information they are interested in. MedBlock provides an efficient method of accessing and retrieving from EMRs.

[14] Proposed to SMEAD a health care model tailored for patients with diabetes via a regulated end-to-end framework. The proposed model involves three wearable devices (smart neckband, smart boots, and smart wristband) to monitor the statuses of patients and forecasts the conditions of patients. They also introduced MEDIBOX (a self-served collaboration network for the e-distribution of pharmaceutical and healthcare products) to act as a tool for patients to alert and remind. MEDIBOX offers daily control of the insulin dosage in patients. Using smart contracts, Blockchain offers encryption and access control of data to trusted parties. Public key cryptography is used to encrypt data, and users are authenticated. Smart contracts are used for the securing of transactions to resolve privacy concerns.

[15] Introduced another powerful blockchain-based management system to handle medical records, called MeDShare. This system is proposed for cloud repositories that manage shared medical records and data between big data medical entities. The proposed system uses cryptographic keys to ensure data provenance, confidentiality, auditing, and user verification. The framework for exchanging data with MedShare is divided into four layers, namely: user, data query, data structuring and provenance, and an existing infrastructure layer for the database. Where a user wishes to access a database, the user must produce a private key and sign it digitally. The query method then forwards the request to the data structuring and the provenance layer. A smart contract to share data between cloud service providers will then be implemented.

Blockchain has been developed by [16] to monitor and exchange EMR data for cancer patient treatment. The authors used permitted Blockchain to tackle three key goals: primary patient care, data collection for research purposes, and improved patient care by linking different healthcare agencies. The architecture consists of several nodes for achieving network consensus, repositories for managing off-chain storage, membership service and various users ' APIs. Data of patients are held in two separate repositories, a local database and a cloud-based server. Each database stores the data in various data structures. Consensus nodes operate through a custom chain code implemented within them, acting as a peer validating Hyperledger via the PBFT consensus algorithm. The proposed structure aims to minimize the processing time and minimize operating costs while enhancing processes for decision-making.

[17] Proposed to BlocHIE, a knowledge network for healthcare that uses Blockchain as its base technology. Electronic Medical Records (EMRs) and Personal Healthcare Data (PHD) are stored in the proposed infrastructure using EMR-Chain and PHD-Chain, which are loosely-coupled blockchains. The EMR-Chain reduces reliance on cloud providers by integrating on-chain authentication and off-chain storage to improve privacy. BlocHIE uses the distributed hospital databases to ensure off-chain storage, while a transaction uses the hash value of medical records for on-chain authentication. Two fairness-based packing algorithms for transactions, namely FAIR-FIRST and TP&FAIR, are proposed to boost fairness and throughput. BlocHIE uses PoW as their algorithm for consensus. The established practicability and efficacy of the proposed framework are based on assessments by writers.

[19] Introduced a privacy-conserving system for Ancile to give third parties, providers and patients optimal access, interoperability and protection for medical records. The proposed system focuses on protecting the privacy and protection of patients using cryptographic techniques and enables access control and data obfuscation by the use of Blockchain-based on Ethereum and smart contracts. They use six smart contract forms to maximize patient experience, minimize any conflict between contracts and patients and reduce threats to privacy. Such smart contracts implemented allow patients to maintain control of their own medical records.

[20] Implemented a privacy protection strategy focused on Personal Health Information (PHI) sharing scheme (BSPP) and blockchain technology to boost e-Health Systems diagnostics. The architecture suggested allows the use of two types of blockchains: private and consortium. Stable PHI indexes are tracked using the blockchain consortium, while the PHI is stored by private Blockchain. To achieve safe search, privacy protection, access control and data security, the public key is used to encrypt all data, including PHI, with keyword search. The functionality of the device is assured by allowing block generators to provide proof of conformity when adding new blocks. The system provides access control, data auditing, privacy preservation, secure search, and time-controlled revocation.

MedRec was proposed by [21] as a simple and adaptable record management method. This network of electronic records of management (EMRs) was developed in a decentralized manner by leveraging the properties of blockchain technology. MedRec seeks to tackle many major healthcare problems, including data quantity and quality, interoperability of the system, fragmented medical data, patient organization and poor access to medical information. A collection of APIs was designed to provide interoperability for the integration of provider databases. Using a database of the medical relationships between patients and providers, smart contracts in the Ethereum blockchain are used for data recovery instructions and display permissions. A cryptographic hash is used to guarantee data confidentiality and ensure that the data is not tampered with. By accepting or refusing new information, the Parties control their data. An authentication server for the database is used to validate the blockchain permissions. MedRec allows for the exchange of personal information, confidentiality, authentication and transparency. To prevent a single point of failure, MedRec depends on multiple participants.

V. CONCLUSION

Blockchain technology has evolved from the time it was introduced through Bitcoin into a general-purpose technology with its application in many sectors, including the healthcare sector. This paper presented a review of the application of blockchain technology to the health care sector. Blockchain Technology in healthcare and its benefits were discussed; different areas in the healthcare sector were blockchain technology has been/can be applied was also presented. Finally, a review of related works on Blockchain's technology application to healthcare was presented.

REFERENCES

[1] Accenture ., Accenture, Microsoft Create Blockchain Solution to Support ID2020 Accenture Newsroom, (2017).

[2] Agbo, C., Mahmoud, Q., & Eklund, J., Blockchain Technology in Healthcare: A Systematic Review, Healthcare, 7(2) (2019) 56

[3] Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., Peacock, A., Blockchain technology in the energy sector: A systematic review of challenges and opportunities, Renewable and Sustainable Energy Reviews, 100 (2019) 143–174.

[4] Roman-Belmonte, J. M., De la Corte-Rodriguez, H., & Rodriguez-Merchan, E. C., How blockchain technology can change medicine, Postgraduate Medicine, 130(4) (2018) 420–427.

[5] Kamel Boulos, M. N., Wilson, J. T., & Clauson, K. A. ., Geospatial blockchain: promises, challenges, and scenarios in health and healthcare, International Journal of Health Geographics, 17(1) (2018).

[6] Funk, E., Riddell, J., Ankel, F., & Cabrera, D., , Technology: A Data Framework to Improve Validity, Trust, and Accountability of Information Exchange in Health Professions Education, Academic Medicine, 93(12) (2018)

[7] Griggs, K. N., Ossipova, O., Kohlios, C. P., Baccarini, A. N., Howson, E. A., & Hayajneh, T., Healthcare Blockchain System Using Smart Contracts for Secure Automated Remote Patient Monitoring, Journal of Medical Systems, 42(7) (2018)

[8] Uddin, M. A., Stranieri, A., Gondal, I., & Balasubramanian, V. Continuous Patient Monitoring With a Patient-Centric Agent: A Block Architecture. IEEE Access, 6 (2018) 32700–32726.

[9] Shae, Z., & Tsai, J., Transform Blockchain into Distributed Parallel Computing Architecture for Precision Medicine, IEEE 38th International Conference on Distributed Computing Systems (ICDCS). (2018).

[10] Mamoshina, P., Ojomoko, L., Yanovich, Y., Ostrovski, A., Botezatu, A., Prikhodko, P., Zhavoronkov, A, Converging blockchain and next-generation artificial intelligence technologies to decentralize and accelerate biomedical research and healthcare, Oncotarget, 9(5) (2017).

[11] Krawiec, R., Housman, D., White, M., Filipova, M., Quarre, F., Barr, D., Tsai, L., Blockchain: Opportunities for Health Care, (2016).

[12] Peterson, K.; Deeduvanu, R.; Kanjamala, P.; Boles, K. ., A Blockchain-Based Approach to Health Information Exchange Networks, Proc. NIST Workshop Blockchain Healthc. 1 (2016) 1–10.

[13] Fan, K.; Wang, S.; Ren, Y.; Li, H.; Yang, Y, MedBlock: Efficient and Secure Medical Data Sharing Via Blockchain. J. Med. Syst., 42 (2018) 1–11.

[14] Saravanan, M.; Shubha, R.; Marks, A.M.; Iyer, V. ,SMEAD: A secured mobile-enabled assisting device for diabetics monitoring, In Proceedings of the 11th IEEE International Conference on Advanced Networks and Telecommunications Systems Odisha, India(2017) 1–6.

[15] Xia, Q.; Sifah, E.B.; Asamoah, K.O.; Gao, J.; Du, X.; Guizani, M. ,MeDShare: Trust-Less Medical Data Sharing among Cloud Service Providers via Blockchain. IEEE Access, 5 (2017) 14757–14767.

[16] Dubovitskaya, A.; Xu, Z.; Ryu, S.; Schumacher, M.; Wang, F. ,Secure and Trustable Electronic Medical Records Sharing using Blockchain., Am. Med. Inf. Assoc., (2017) 650–659.

[17] Jiang, S.; Cao, J.; Wu, H.; Yang, Y.; Ma, M.; He, J. Blochie: ,A blockchain-based platform for healthcare information exchange, In Proceedings of the SMARTCOMP. The 4th IEEE International Conference on Smart Computing, Sicily, Italy, 18-20 (2018) 49–56.

[18] Zhang, P.; White, J.; Schmidt, D.C.; Lenz, G.; Rosenbloom, ,S.T. FHIRChain: Applying Blockchain to Securely and Scalably Share Clinical Data,. Comput. Struct. Biotechnol. J. 16 (2018) 267–278.

[19] Dagher, G.G.; Mohler, J.; Milojkovic, M.; Marella, P.B. Ancile: Privacy-preserving framework for access control and interoperability of electronic health records using blockchain technology,Sustain. Cities Soc. 39 (2018) 283–297.

[20] Zhang, A.; Lin, X. , Towards secure and privacy-preserving data sharing in e-health systems via consortium blockchain , J. Med. Syst. 42 (2018) 140.

[21] Azaria, A.; Ekblaw, A.; Vieira, T.; Lippman, A. MedRec: Using blockchain for medical data access and permission management, In Proceedings of the 2016 2nd International Conference on Open Big Data, OBD Vienna, Austria, 22–24 (2016) 25–30.