International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 /doi:10.14445/22315381/IJETT-V68I10P220

Volume 68 Issue 10, 117-120, October 2020

Blockchain Adoption Opportunities in Healthcare Sector

Maha M. Althobaiti

College of Computers and Information Technology, Taif University, Saudi Arabia
maha_m@tu.edu.sa

Abstract - *In the last decade, blockchain technology has gained significant attention as an innovative tool that allows cloud storage decentralization. It comprises lists of records and possesses the following key properties: integrity, confidentiality, security, and openness. Blockchain technology has been notably applied in many fields, such as the financial industry, insurance, supply chain management, transportation, and healthcare. It brings numerous benefits to these applications, such as reducing transactional costs, preserving privacy, improving application security, and enhancing application resilience. Despite these myriad applications, blockchain technology implementation has not been comprehensively reviewed. Thus, this paper focuses on the healthcare sector, discussing the potential contexts in which blockchain technology has been applied and how it enhances such applications' operation process.*

Keywords — *Blockchain; healthcare; application.*

I. INTRODUCTION

The blockchain concept was developed in 2008 to support the cryptocurrency Bitcoin [1]. A blockchain is an innovative technology and architecture platform that offers decentralization, distribution, and immutability of the recording ledgers' information stored in all computing devices [2]. The most prominent blockchain example is Bitcoin, which has no central server – all of its records are visible to everyone, and individuals have the opportunity to participate in the consensus process. In blockchains, each stack of records is called a 'block,' and these blocks are connected using cryptographic techniques. A hash code for the previous block, a timestamp, and other transaction data is used to identify each block [2]. The first block in the chain is called a 'genesis block,' as it does not have a parent block. Figure 1 illustrates the main components of a blockchain.

Blockchain technology has become a vital aspect of financial technologies; however, it has also begun to gain academia's attention. Its usage has been investigated in other sectors, such as supply chain management, transportation, and healthcare. According to Grand Review Research [3], the blockchain market is expected to reach USD 57,641.3 million by 2025. This significant growth in blockchain investment is the expanded adoption of this innovative technology among different sectors. However, little empirical or academic research has investigated the technology's benefits, potential adoption domains, and implications [4]. Moreover, most of the published research focuses on the financial applications of blockchains and their related aspects and challenges [5,6], and little research has addressed the use of blockchains in healthcare [7].

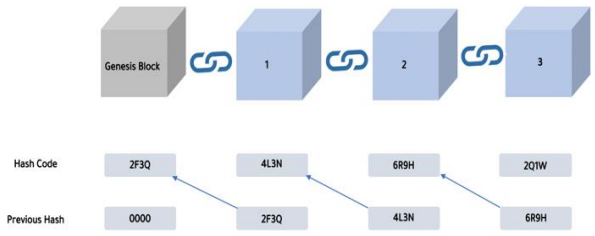

Fig 2: main components of the blockchain

Particularly in the healthcare field, blockchain technology is used to improve the security of its applications and can significantly change the operation processes of these applications [8]. According to the reviewed literature, blockchains offer valuable benefits – including enhanced security, trust, privacy, and confidence – because they provide full transactional disclosure to all participating users in the network [9,10]. These blockchain protocols work on a peer-to-peer network, an architecture that provides numerous benefits to the blockchain platform:

- It allows participants to review all blockchain statuses without depending on a third party.
- It validates blockchain transactions based on consensus, which is considered a strong governance rule.
- It is impossible to remove the network blockchain because of the high number of participating nodes in the network.
- It is difficult to attack all the participating nodes at the same time.

Within the healthcare sector, blockchain technology can be used, for example, to manage a patient's information securely and to enhance the drug supply chain, improving the quality of all workflows in the healthcare sector. This paper investigates the opportunities for blockchains to be applied in the healthcare sector, and ultimately, used to

contribute to the field's digital transformation. There is little published research focusing on blockchains in healthcare; thus, the current paper enriches the body of literature and provides a comprehensive survey of blockchain-based applications in the healthcare industry.

This paper's remainder is organized as follows: Section II gives an overview of the blockchain principle. Section III addresses the benefits of using blockchain technology. Section IV discusses the potential healthcare applications where blockchain can be applied to enhance such applications' operation process. Finally, the conclusion is presented in Section V.

II. BLOCKCHAIN PRINCIPLE

The blockchain is a mechanism used to cryptographically archive a log of transactions and provide each node in the network with a consistent view of these transactions. Blockchains can be classified into three categories:

A. *Public (permissionless) blockchains*. This type of blockchain architecture is the most well known, as it is deployed in the Bitcoin system. Its authorization process allows each peer to enter the network to view and store the transaction events [11].

B. *Private (permissioned) blockchains.* Here, only identified participants are granted permission to access the network; thus, the blockchain governs the event log transactions and restricts access permissions [2].

C. *Consortium blockchains.* In this type of blockchain, only selected sets of nodes will be allowed full control to view, read and store transaction events; thus, it is a combination of public and private blockchains and is considered more efficient than public blockchains [2]. All paragraphs must be indented. All paragraphs must be justified, i.e., both left-justified and right-justified.

III. BENEFITS OF BLOCKCHAIN

There are numerous benefits of blockchains:

- *Decentralized management.* Blockchains enable each user to have a copy of the transaction ledger. This feature improves transparency, eliminating interference by a central authority or third party [12].
- *Immutability.* Data in the blockchain cannot be changed because they have been stored in each block; this feature makes the data very secure. Viewing the data or information can be assured that the data are original and authentic [13].
- *Availability.* Based on blockchain architecture, each node has a copy of the full transactional disclosure [14]. This is considered a benefit of blockchain technology because it guarantees the continued availability of the transaction history.
- *Anonymity*. Blockchain technology uses cryptographic algorithms such as the Secure Hash Algorithm (SHA-256), which resolves trust issues and improves anonymity by generating a user address represented by a hash value instead of its actual identity.
- *Transparency*. Blockchain technology provides a full and auditable ledger of transactions for anyone who joins the blockchain network – the network is checked every ten minutes to reconcile transactions. Besides, all alterations to the stored information are recorded, improving transparency.

IV. BLOCKCHAINS IN THE HEALTHCARE SECTOR

A. Medical Data Management

Handling patient information through electronic data management systems is a significant challenge in healthcare; this is due to the many different databases used in different hospitals and privacy and security concerns. This paper reviewed several studies that focused on introducing blockchains to overcome the challenges mentioned above. For example, the authors in [18] propose a system for managing patient information based on a blockchain technology called 'Medlock,' which has two main features: 1) it allows patients to view the medical records of different hospitals, and 2) it allows hospitals to view patients' medical records before consultations. In general, using blockchain to design MedBlock ensured efficient privacy for the data shared among authorized users. Other authors, such as in [19], propose a secure medical record solution based on a blockchain called 'SEHRTB,' which controls medically sensitive information based on a proposed framework that allows authorized users smart contract to compare the requirements of requested access. The authors evaluated the SEHRTB method found that it reduced execution time by 1.08 seconds. The author in [20] proposes a hybrid blockchain-based secure privacy-preserving (BSPP) protocol to improve the sharing of personal health information. The designed scheme uses two kinds of blockchains – 1) a private blockchain for storing personal health information, and 2) a consortium blockchain for saving the records of the personal health information indexes. The authors emphasize securing patients' identities by encrypting their personal health information and allowing only authorized doctors to access patient profiles. The results of their proposed schema and related strategy for the authorization process meet privacy and security objectives. In [21], the authors introduce a privacy-preserving scheme for electronic health records systems that uses a multiple authority attribute-based system based on blockchain technology. In the scheme scenario, all the information related to patients is encapsulated and stored in one chain block, improving the health records' immutability and anonymity. In [22], the authors introduce a solution to overcome managing access control in e-health records using blockchain technology. The designed approach

stores the transactional information and access control policies in a blockchain, which achieves superior scalability, integrity, and authenticity compared to other systems and approaches.

B. Medicine Supply Chain

The pharmaceutical supply chain that provides medicine is an important process in the healthcare industry, as the distribution of drugs from one point to another requires proper tracking and monitoring. Several entities are involved in drug distribution, including manufacturers, hospitals, wholesalers, and retailers; they require advanced technology to avoid drug counterfeiting, ensure optimal drug usage, and provide an immutable chain of transaction ledgers. Blockchain has been introduced as an emerging technology in the p*harmaceutical* supply chain domain. It has shown promising results in detecting prescription drug fraud, enabling record ownership, and improving the traceability process. The authors in [23] propose using the G-Coin blockchain system designed for governance purposes to overcome the drug counterfeiting problem. The authors use the consortium proof-of-work mechanism to establish trust between two nodes of participants in the drug supply chain, improving the medicine supply chain's security and efficiency. In [24], the authors adopt blockchain-based Hyperledger Fabric to propose a drug supply chain system for managing supply chain records and transactions. The proposed system serves doctors, pharmacists, nurses, and patients and provides a secure approach for managing the drug lifecycle. In their study, the authors highlight the significant role of blockchains in standardizing drugs and detecting counterfeits. In another use case, the authors [25] develop a distributed system based on using the Ethereum and Hyperledger Fabric blockchain platforms to validate each pharmacy surveillance transaction. The author uses a smart contract to identify the contract-based relationships between involved participants, including the manufacturer, the Food and Drug Administration (FDA), the retailer, and the wholesaler. The proposed system's main benefit is that it enables customers to scan a QR code to review the drug's manufacturing and distribution history. The researchers in [32] have developed a blockchain-based traceability system using smart contracts. In their proposed approach, each manufacturer produces a recipe for the product's defined components – each part of the recipe is identified in the form of a cryptographic token, and the final product is a combination of tokens. During the implementation process, a new token is initialized, enabling the traceability of the product's transformation.

C. Telemedicine

Telemedicine is the process of remotely monitoring, diagnosing, and treating patients. This process can benefit from blockchain technology by providing a secure and trusted approach between patients and medical professionals. The applications of blockchain technology in telehealth and telemedicine have recently become of great interest because of the potential opportunities for increased security digitization processes, managing patient identities, and establishing clinical data provenance in telemedicine systems. The authors in [27] have introduced the Fast Health Interoperability Records and Blockchain (FHIRChain) scheme to share medical data in telemedicine clinics. Another use case of adopting blockchain in telemedicine appears in a study in [28] – here, the authors developed a blockchain-based system for real-time patient monitoring. The proposed protocol is based on a smart contract and analyzes the sensors' data to send notifications and alerts to the proper participant. The system primarily solves the security vulnerabilities at each node. This section's last use case is in [29], where the authors have designed a blockchain-based patient-centric agent (PCA) for patient monitoring while ensuring patient confidentiality.

D. Medical Analytics and Research

Blockchain technology enables emerging technologies to enhance medical research and facilitates predictive analytics. One of the most important studies in this field is that of [30], in which the authors propose a framework called 'ModelChain' that integrates a private blockchain network with privacy-preserving online machine learning to secure and enhance an inter-institutional medical prediction model between healthcare institutions (without disclosing the sensitive data of patients' medical records). Generally, medical predictive modeling using blockchain and other technologies contributes to accelerating and enriching health research. In the medical education domain, the authors in [31] discuss and analyze several use cases of blockchain adoption in the medical health education ecosystem. They highlight the significant role that blockchains play in improving educational system management, such as establishing smart networks.

As reviewed above, blockchain technology has immense potential to improve the healthcare sector through different applications and provide numerous advantages such as security, privacy, anonymity, and decentralization.

V. CONCLUSION

This paper presents several ways to leverage blockchain technology in the healthcare industry by discussing various use cases. Specifically, the paper highlights blockchain's potential opportunities in different healthcare applications, including medical data management, medicine supply chains, telemedicine and medical analytics, and research.

REFERENCES

[1] S. Nakamoto, "*Bitcoin: A Peer-to-Peer Electronic Cash System*" (2008), https://bitcoin.org/bitcoin.pdf.

[2] Z. Zheng, S. Xie, H. Dai, X. Chen and H. Wang, "*An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends,"* Proceedings of the 2017 IEEE International Congress on Big Data, Honolulu, HI, USA, (2017) June 25-30, pp. 557-564.

[3] Grand Review Research. *"Blockchain Technology Market Worth $57,641.3 Million By 2025*" Online report (2019) https://www.grandviewresearch.com/press-release/global-blockchain-technology-market

[4] O. Ali, M. Ally, Clutterbuck, and Y. Dwivedi, "*The State of Play of Blockchain Technology in the Financial Services Sector: A Systematic Literature Review*," International Journal of Information Management., vol. 54, no.1, (2020).

[5] M. C. K. Khalilov and A. Levi, "*A Survey on Anonymity and Privacy in Bitcoin-Like Digital Cash Systems*," IEEE Commun. Surv. Tutor., vol.20, no.3, (2018), pp. 2543—2585

[6] M. E. Conti, C. Lal, and S. Ruj, "*A Survey on Security and Privacy Issues of Bitcoin*," IEEE Commun. Surv. Tutor., vol.20, no.4, (2018), pp. 3416—3452

[7] S. Khezr, M. Moniruzzaman, A. Yassine and R. Benlamri, *"Blockchain Technology in Healthcare: A Comprehensive Review and Directions for Future Research*," Appl. Sci., vol. 9, no.9, (2019), pp. 17--36.

[8] N. Kshetri, "*Blockchain's Roles in Meeting Key Supply Chain Management Objectives*," Int. J. Inf. Manag., vol. 39, (2018), pp. 80-89.

[9] R. Beck, J. S. Czepluch, N. Lollike, and S. Malone, "*Blockchain: The Gateway to Trust-Free Cryptographic Transactions*" (2016). Research Paper.153. http://aisel.aisnet.org/ecis2016_rp/153

[10] R. Beck, C. Müller-Bloch, and J. L. King, "*Governance in the Blockchain Economy: A Framework and Research Agenda*," J. Assoc. Inf. Syst., vol. 19, no. 10, (2018), pp. 1020-1034.

[11] M. Pilkington, Blockchain Technology: *"Principles and Applications*". Research Handbook on Digital Transformations. Edward Elgar Publishing. (, 2016).

[12] J. L. B. Cisneros, "*Public Health Surveillance Using Decentralized Technologies*," Blockchain in Healthcare Today, (2018), pp. 1—14

[13] A. P. Joshi, M. Han, and Y. Wang, "*A Survey on Security and Privacy Issues of Blockchain Technology*," Mathematical Foundation Computing, vol. 1, no.2, (2018), pp. 121-147.

[14] L. Martin, "Blockchain vs. Relational Database: Which is Right for Your Application?", TechBeacon, (2017) https://techbeacon.com/Blockchain-relational-database-which-right-for-your-application.

[15] P. Dutta, T. Choi, S. Somani, and R. Butala, "*Blockchain Technology in Supply Chain Operations: Applications, Challenges, and Research Opportunities*," Transportation Research Part E: Logistics and Transportation Review. vol. 142, (2020), pp. 1—33

[16] R. B. Fekih and M. Lahami, "*Application of Blockchain Technology in Healthcare: A Comprehensive Study*," International Conference on Smart Homes and Health Telematics, (2020), pp. 268–276.

[17] T.-T. Kuo, H. Zavaleta Rojas, and L. Ohno-Machado, "*Comparison of Blockchain Platforms: A Systematic Review and Healthcare Examples*," Journal of the American Medical Informatics Association, vol.26, no.5, (2019), pp.462—478.

[18] K. Fan, S. Wang, Y. Ren, H. Li, and Y. Yang, "*Medlock: Efficient and Secure Medical Data Sharing Via Blockchain,"* Journal of Medical Systems, vol. 42, no. 8, (2018).

[19] A. Mubarakali, S. C. Bose, K. Srinivasan, A. Elsir and O. Easier, "*Design a Secure and Efficient Health Record Transaction Utilizing BlockChain (SEHRTB) Algorithm for Health Record Transaction in BlockChain*," Journal of Ambient Intelligence Humanized Computing, (2019), https://doi.org/ 10.1007/s12652-019-01420-0

[20] A. Zhang and X. Lin, "*Towards Secure and Privacy-Preserving Data Sharing in e-Health Systems via Consortium Blockchain*," Journal of Medical Systems, vol. 42, no.8, (2018), pp. 1--18

[21] R. Guo, H. Shi, Q. Zhao, and D. Zheng, "*Secure Attribute-Based Signature Scheme with Multiple Authorities for Blockchain in Electronic Health Records Systems*," IEEE Access, vol. 6, (2018), pp. 11676-11686.

[22] J. P. Dias, L. Reis, H. S. Ferreira and Â. Martins, "*Blockchain for Access Control in e-Health Scenarios"*, doi: 10.1007/978-3-030-17065-3_24, (2018),

[23] J.-H. Tseng, Y.-C. Liao, B. Chong, and S.-W. Liao, "*Governance on the Drug Supply Chain via Gcoin Blockchain*," International Journal of Environmental Research and Public Health, vol. 15, no.6, (2018), pp. 10--55

[24] F. Jamil, L. Hang, K. Kim, and D. Kim, "*A Novel Medical Blockchain Model for Drug Supply Chain Integrity Management in a Smart Hospital,"* Electronics, vol. 8, (2019).

[25] P. Sylim, F. Liu, A. Marcelo, and P. Fontelo, "*Blockchain Technology for Detecting Falsified and Substandard Drugs in Distribution: Pharmaceutical Supply Chain Intervention*," JMIR Research Protocol., vol. 7, no. 9, (2018).

[26] Russell N. Alfonso, Marlon C. Leyesa, Donald M. Lapiguera, Noel Florencondia, Gener S.Subia "*Proposed Design for Framework Management of Cryptocurrency: Study of the World"s First Digital Currency*" International Journal of Engineering Trends and Technology 68.1 (2020):57-63.

[27] P. Zhang, J. White, D. C. Schmidt, G. Lenz and S. T. Rosenbloom, "*FHIRChain: Applying Blockchain to Securely and Scalably Share Clinical Data,"* Computational Structural Biotechnology Journal, vol. 16, (2018), pp. 267-278.

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

[29] M. A. Uddin, A. Stranieri, I. Gondal and V. Balasubramanian, "*Continuous Patient Monitoring with a Patient-Centric Agent: A Block Architecture*," IEEE Access, vol. 6, (2018), pp. 32700-32726.

[30] T. T. Kuo, C. N. Hsu and L. Ohno-Machado, *"ModelChain: Decentralized Privacy-Preserving Healthcare Predictive Modeling Framework on Private Blockchain Networks*" (2016), https://www.healthit.gov/sites/default/files/10-30-ucsd-dbmi-onc-blockchain-challenge.pdf.

[31] N. Naqvi and M. Hussain, "*Medical Education on the Blockchain*," J. Br. Blockchain Assoc., vol. 1, no. 2, (2018), pp. 85-89.

[32] M. Westerkamp, F. Victor and A. Küpper, "*Blockchain-Based Supply Chain Traceability: Token Recipes Model Manufacturing Processes*," IEEE international conference on internet of thing and IEEE green computing and communications and IEEE cyber, physical and social computing and IEEE smart data, 30 July-3 Aug. (2018) Halifax, NS, Canada.