

A Survey on Applications of Blockchain In Healthcare Sector

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Abstract

Blockchain technology is among the most perturbing technologies. Blockchain is a time-stamped sequence of immutable data records that is maintained by a network of computers not operated by any single party. Various sectors are embracing the blockchain technology to reinvent how they work. One of the sectors is the healthcare industry, which continuously aims to improve the services provided to the people by incorporating latest technologies. While there are many areas of improvement in the healthcare ecosystem, blockchain has the potential to enhance and transform healthcare, by taking care of challenges of healthcare by improving health data protection, privacy, and interoperability. By making many applications such as electronic medical records, Smart Contracts, Telesurgery in healthcare field more effective, disintermediated, and safer, this technology could provide a new paradigm for health information exchanges (HIE). This modern, rapidly developing sector provides fertile ground for innovation, research, and concrete evidence-of-concept testing, but it might not be the ideal solution.

Keywords - Application Programming Interfaces (APIs), Electronic Health Records (EHR), Health Information Exchanges (HIE), Parallel Healthcare Systems (PHS), Smart Contracts (SC).

I. INTRODUCTION

Blockchain has grown in a tremendous way. Blockchain gives a powerful, profitable, reliable and protected system for managing and recording any action, transaction without the support of any third parties. It is also called as Distributed Ledger Technology. The database of Blockchain is distributed that manages and stores data in the form of blocks. It is secured by cryptography. These blocks are associated to each other, so that one cannot alter or tamper the stored data. When we are using blockchains, blocks can be added only in the end. They use hash function for each block. There are public Blockchains and private blockchains. Blockchain technology is decentralized, ownable, consistent and transparent system. Transactions can be verified by the participants

independently. Every transaction on a blockchain is protected with a digital signature. It permits to reach an agreement for all the network peers. Blockchain provides an astounding opportunity to overcome issues, challenges, difficulties that are present in healthcare system. This technology addresses current difficulty for syncing patient records between multiple hospital information system. Blockchain addresses protection issues linked with a database of patient's data which could be managed by many people such as caretakers, hospitals, insurance companies etc. The advantages of using blockchain in healthcare industry are integrity, security, low cost maintenance, interoperability and universal access. Blockchains can be used in pharma industry where they need to have a secured drug supply chain.

Tracing and keeping track of drugs in pharmaceuticals is one of the challenges. Blockchain gives increased trust via agreements and immutability. It blocks the interruption of third parties. It reduces the complexity of drug chain. Blockchains eliminates the existing issues and challenges in telesurgery. It provides immutability. It provides better precision in diagnosis procedures. In this paper we have explored various applications of blockchain in healthcare. Blockchain provides security for patient's data, ensures the safety of drug and medicines supply management, helps for genomics, used in telesurgery, research purposes etc. We have also discussed many challenges for implementing Blockchain in healthcare.

II. APPLICATIONS OF BLOCKCHAIN

A. Blockchain For Storing And Securing Patient Records

The main application of Blockchain in healthcare is maintaining the health records or documents of patients. Due to this Blockchain application it is easier to access patient's data. Using Blockchain based Mobile applications, anyone can maintain their personal health data.

Zainab Alhadhrami et al.[1] explained how blockchains can be used in maintaining the e-health documents of patients, healthcare centres and stakeholders to utilise data among themselves. It enhances the interoperability. Based on the number of participants in the chain network, blockchain design could be selected.

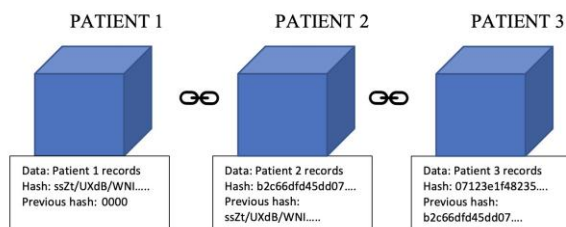


Fig. 1. Blockchain For Health Records

Mainly two kinds of blockchains are there, Permissionless blockchains and Permissioned blockchains. They are used to setup smart contract between healthcare supplier to allow each other access to specific data or patients records.

Tran Le Nguyen et al.[4] aim to create a model which is diagrammatic concept of medical apps using blockchain to maintain the data of all patients, bills, doctors when they undergo a surgery. Learning the drawbacks and loopholes of the previous models, this model is built. This application could be used on smartphone which uses bitcoin for payment. It maintains a well relationship between patients and doctors. This application helps patients have a nice analysis of cost, procedure before and after the surgery.

In [7], author Dasaklis, T. K et al. has portrayed the mutual association between smart health and blockchain. The author has emphasized on the various opportunities handed out by blockchain for the healthcare sector such as cost-effective transactions, increase in transparency of reports on regulatory provisions, efficient and systematic healthcare data management and enable ubiquitous feature of healthcare records. Without a doubt, healthcare industry is a sector that needs to continually catch up with modern tools and technologies and also apply it for further improvement of the services provided to patients, and increase the overall efficiency of the system.

The author [7] infers that blockchains are being used in various applications, such as security, privacy, efficient healthcare data management and interoperability. Further increasing the bandwidth of

employability, several applications has been described by the author. One of the applications is the EHR(Electronic Health Records). An EHR is a document containing a brief medical history of an individual or a citizen including the medical record, as well as observations, predictions and information of all kinds relating to the person's health status. It also includes data related to a patient's clinical progress throughout the treatment. EHR can be stored in blockchain as seen in Fig. 1. Such EHR needs a high-level security as the privacy factor of medical records must be ensured. Hence the author has proposed that the blockchain serves the aforementioned purpose. The author has also discussed about various other ways where blockchain synergizes with healthcare such as consent management, data sharing and health research commons.

In a similar fashion, the author Le NguYen et al. [11] has proposed a healthcare model that integrates blockchain. A conceptual node-oriented surgery model using Blockchain hybrid technology is proposed. The blockchain allows the process of surgery to be faster and more cost efficient. The Blockchain technology, specifically in node encryption keys will address the interoperability challenges. Under the proposed model, all stakeholders would be able to share enormous amounts of genetic, nutritional, economic, lifestyle-concerned and health data while the protection and privacy aspects are also ensured. By using the standardized application programming interfaces (APIs) and modularized technology on mobile devices, the proposed blockchain compliant surgical model of this paper will be able to include millions of individuals, healthcare practitioners, medical research organizations, market research firms, doctors, patients, insurance providers in the system which exchange health data libraries.

The author Wutthikarn et al. [12] has proposed a model designing a prototype application of healthcare services in dental clinic service. In order to keep records of the activities that are accessible and tracked by the participants' authority, a transaction ID number is assigned which is created by a hash number mechanism run by the composer Hyperledger (Table 1.). This application aims at establishing a relationship of trust in which the objective is to create a list of stakeholders in an ecosystem that the healthcare service needs in the area of medical equipment distribution and transaction. This would save a spectrum of costs and make the clinical processes interoperable.

TABLE I
Transaction Ids of Stakeholders

Block No.	Transaction ID (SHA 256 Hash)	Data Transaction	Previous transaction/ block hash
1.	c64cba6fba914044c29fa9221fa12ec993220b2	Health Record Transaction1	0000
2.	9d1d32d816853622c18b4bcb84cb2690a294c01	Health Record Transaction 2	c64cba6fba914044c29fa9221fa12ec993220b2
3.	35273244c142afc4a9d816979b2e2f636a758ac	Health Record Transaction 3	9d1d32d816853622c18b4bcb84cb2690a294c01

B. Smart Contracts In Healthcare

Author Gupta R. et al.[8] has proposed a telesurgery framework that incorporates the technology of blockchains. Telesurgery appears to have tremendous potential to deliver surgical medical services in real time to even the most remote and distant areas with precision and high quality over the wireless communication network. It also provides security, privacy, and interoperability for the proposed framework. The proposed system is a framework called HaBiTs (Blockchain based Telesurgery Framework for Healthcare), which is a secure and flawless interoperable telesurgery platform based on blockchain, where Smart Contracts (SCs) are used to achieve immutability and interoperability. SC is a computer protocol which intends on digitally facilitating, verifying or enforcing the negotiation of a contract. These transactions are deemed to be credible due to its trackable and irreversible features without the involvement of third parties. The code of SC is written in solidity which is a language specific to blockchain that helps in establishing transparency and trust among all the parties connected by blockchain. It also eliminates the need for a third party to share the data. The author also addresses several problems of the current telesurgery procedures and how the new HaBiTs model eliminates them.

C. Lightweight Blockchain For Healthcare

Leila Ismail et al.[3] proposed a lightweight blockchain design for healthcare data maintenance that helps decreasing the overhead compared to the Bitcoin chain by separating the network participants into clusters and having one copy of record per cluster. Their architecture presents the use of a channel, that gives procure and confidential transactions among the

participants of network. They give a solution to dodge forking which is dominant in Bitcoin chain. They present the potency of their proposed architecture in providing safety and seclusion

D. Blockchain For Health Information Exchange

The author Chakraborty S et al.f has made a proposal of designing a blockchain backed healthcare system. The proposed approach includes a method involving the use of the Internet of Things module to intercept and collect the data that is produced by the patient's wearable devices. The proposed Blockchain healthcare framework is preferably used to store and preserve patient data and records in the form of multiple transactions. It also supports access control of the records to the different collaborators. By maintaining the pseudo-anonymous nature of the of the patient's identity the blockchain architecture assists the medical research . It also sets out an authorized and reliable form of data for more efficient research. Such systems are a boon that would significantly uplift the healthcare services by ensuring accurate and efficient healthcare.

In a similar trend, the author Wang S. et al [10] has proposed an ACP based approach to Integrate the blockchain into healthcare. A design of parallel healthcare systems (PHSs) based on the Artificial Systems, Computational Experiments and Parallel Execution (ACP) approach is proposed to increase the accuracy and precision of diagnosis and treatment efficacy. PHS uses artificial healthcare systems to design and depict the medical progress, diagnostic procedures and treatment processes of patients. This concept is then subjected to analytical experiments for the study and evaluation of various therapeutic regimens. It also involves simultaneous implementation of decision-making services and real-time computation of both artificial and actual healthcare procedures.

In addition to these, the integration of evolving blockchain technology with PHS, the creation of a network using blockchain to connect patients, hospitals, healthcare groups and health offices for broader data sharing in healthcare, the medical records analysis and clinical auditing, are all deemed to be major gamechanger applications in the healthcare sector. In this paper, for the verification and demonstration of the efficacy and efficiency of the blockchain powered PHS platform, a case example called parallel gout diagnosis and a treatment system is constructed and deployed.

III. CHALLENGES AND DIFFICULTIES

Thomas K.Dasaklis et al.[2] explained the mutually beneficial relationship between blockchains and smart healthcare. They discussed many difficulties for implementing the blockchain in health industry. The implementation of blockchain needs a very good groundwork, support. It is difficult to implement it entirely. They have recognized and studied three different branches of possible synergies. They proposed the a model via supplying a global set of tools for cryptographic assurance data completeness. An application of blockchain gives an unbreakable chain that permits for individualized care. They also explain that it could be an interruptive technology related to security of data.

Holbl et al.[5] goal is to bring out the possible applications of the technology. They discuss the issues and difficulties of blockchain research. A network of associated devices can be disruptive due to inadequacy in control of blockchain. They have analyzed the gathered data and its properties. The result includes bibliometric overview. The outcome of this paper is that research of blockchain in healthcare is raising and it is mainly used for distributing and maintaining health documents. This is very efficient.

Tanesh Kumar et al.[6] explore the applications of blockchain in healthcare which explain the importance of trust less and transparent systems. They also discuss about the obstacles of implementing this technology in healthcare. Many people, hospitals are not yet ready to accept blockchain implementation. In this paper they propose a smart contract for some healthcare systems which use blockchain. It is a key for some pre-defined agreements among stakeholders.

IV. CONCLUSION

Blockchain technology provides new opportunities for complexity reduction, seamless collaboration and the development of reliable and unalterable information. Healthcare sector is right to incorporate this rapidly growing field in order to realize the full potential of the technology in health care. As discussed, various blockchain based applications ensures to overcome several challenges faced in the healthcare industry. Hence Healthcare industry should map and convey the blockchain ecosystem to affirm a promising future of efficient healthcare sector, by creating a blockchain platform for the involvement of early adopters, and thus promoting a network for research and exploration in this field. Blockchain's biggest advantages have yet to be realized. The

outcomes of successful and unsuccessful blockchain implementations in healthcare, will however ultimately lead to the promise of consumer driven health care systems in the form of open market for health data and precise and efficient medicine.

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