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Blockchain Technology and its Implementations in Medical and Healthcare Field

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***Abstract*:- Blockchain is probably one among the most important buzzwords in both finance and technology today, and has gained considerable attention, with an escalating interest during a large of various applications, like financial services, cyber security, IoT, and food science to healthcare industry. There has been an interesting interest witnessed in utilizing applications of blockchain for the delivery of safe and secure healthcare and data management. Also, blockchain is reforming the normal healthcare practices to a more reliable means, in terms of effective diagnosis and treatment through safe and secure data sharing. Within the long run, blockchain might be technology which will potentially help in personalized, authentic, and secure healthcare by merging the whole real-time clinical data of patient's health and presenting it in an up-to-date secure healthcare setup.**

In this paper, we review the foremost important developments within the field of healthcare by implementing blockchain; we also mention the applications of blockchain, and discuss the challenges faced and future perspectives.

Keywords:- Blockchain, hash, healthcare, privacy, transparency, distributed ledger technology, cryptography.

INTRODUCTION

The healthcare industry is one among the world's largest industries, consuming over 10% of gross domestic product of the foremost developed nations [1].

Tele-medicine and e-health are the two highly used domains, where clinical data is transferred remotely to specialist (at a distant location) for an expert opinion. In these two online clinical setups, the patient's data is transferred either via a "store-and-forward technology", or by the means of online real-time clinical monitoring (e.g., tele-monitoring, telemetry, and like) [5, 6].

Using these online clinical settings, the patients are remotely diagnosed and treated by clinical experts by means of exchange clinical data. In all such clinical arrangements, the security, sensitivity, and privacy of clinical data are variety of major challenges to occur, because of the case-sensitive nature of patient data. Thus, the facility to exchange data safely, securely, and scalably is extremely important for supporting healthy and meaningful clinical communications, regarding remote patient cases. Because the safe and successful exchange of data helps in clinical communication by gathering recommendations or confirmations from a gaggle of clinical specialists, which end in improved diagnostic accuracy and effective treatment [7,8].

Healthcare data is fragmented across several parts, which negatively affecting research and services, about half the clinical trials are never reported, the worth of drug discovery is ever increasing, and fake medicine is still a huge problem.

Blockchain has the potential to unravel these problems because it provides trust with none intermediaries, has traceability as a default feature, and promises new business models by enabling novel incentive structures.

Being a complex system of interconnected entities under heavy regulatory boundaries, patient data is highly fragmented and the cost of healthcare delivery is continuously rising due to inefficiencies in the system and dependence on several intermediaries.

This has raise a need for an information technology system and that can remove the middlemen and cut costs while maintaining trust and transparency.

The blockchain is a revolutionary technology which can assist in solving the challenges of healthcare by providing decentralized trust. Blockchain enabled decentralization promises to minimize the problem of vendor lock-in that has plagued the healthcare industry.

The records written on the blockchain are immutable and cannot be altered or deleted. This characteristic of blockchain provides primitives like data integrity and origin, which can be used to build solutions to prevent drug counterfeiting and medical frauds. For instance, fraudulent results and removal of data, can be prevented by enforcing the integrity of data in blockchain. In addition, it allows keeping an immutable log of subject's consent in a clinical trial.

On the financial side, using blockchain could save hundreds of billions for pharmaceutical industry by defining a chain-of-custody in the supply chain [4].

BLOCKCHAIN

Blockchain is an open distributed ledger, meaning that anyone given the requisite credentials can access and increase the ledger. Each block contains the relevant encrypted data, which is mentioned as a hash, and therefore the hash of a previous block. The kind of knowledge contained within a block depends on the sort of blockchain being utilized.

Each block also features a unique hash that identifies the block and its contents. Any changes made inside a block will cause the hash to vary. Each block also has a hash of the previous block such that each successive block points to the immediately preceding block, and the first block, known as the "genesis block" cannot have a hash from a previous, by definition.

In a blockchain system, there's no central authority; instead, transaction records are stored and distributed across all network participants. Interactions with the blockchain become known to all or any participants and need verification by the network before information is added, enabling trustless collaboration between network

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participants while recording an immutable audit trail of all interactions.

Importantly, blockchain can be programmed to record and track almost anything, and the technology offers a potential solution to a number of the challenges facing the healthcare industry.

BLOCKCHAIN DRAWS THE ATTENTION OF THE HEALTHCARE INDUSTRY

Many aspects of blockchain technology, such as the immutability of the data stored in a blockchain, are drawing the attention of the healthcare sector, and bright prospects for many available cases are being discussed. Blockchain technology is expected to improve medical record management and the insurance claim process, accelerate clinical and biomedical research, and advanced biomedical and healthcare data ledger [2].

These expectations are based on the key aspects of blockchain technology, such as decentralized management, immutable audit trail, data provenance, robustness, and improved security and privacy.

Although several possibilities have been discussed, the most notable innovation that can be achieved with blockchain technology is recovery of data subjects' right.

Medical data should be possessed, operated and allowed to be utilized by data subjects other than hospitals. This is a key concept of patient-centered interoperability that differs from conventional institution-driven interoperability. There are many challenges arising from patient-centered interoperability, such as data standards, security and privacy, in addition to technology-related issues, such as data standards, security and privacy, in addition to technology technology-related issues, such as scalability and speed, incentives, and governance.

Blockchain technology can facilitate the transition from institution-driven interoperability to patient-centered interoperability [3]. Blockchain technology allows patients to assign access rules for their medical data, for example, permitting specific researchers to access parts of their data for a fixed period of time. With blockchain technology, patients can connect to other hospitals and collect their medical data automatically.

In addition, these functions, which can be implemented with blockchain technology, maybe useful for ensuring the rights of data subjects as defined by the EU General Data Protection Regulation. Because of the typical size and sensitivity of medical data, it is generally believed that the tag information of medical data not medical data itself, will be stored in data blocks. However, some important information, such as information on drug allergies, can be published in a public blockchain.

THE ADVANTAGES OF USING BLOCKCHAIN TECHNOLOGY IN HEALTHCARE

Some of the feature that allow blockchain to act as secure record of financial transactions are also applicable to storing medical data.

Since most blockchains are designed as distributed systems that record and protect files through the utilization of cryptography, it's extremely difficult for somebody to disrupt or change the info without having the approval of all other participants of the networks.

Therefore, immutability is one of the features that enable the creation of incorruptible databases for medical records.

Moreover, the peer-to-peer architecture used in blockchain allows all copies of patient's record to be synchronized with one another as updates are made, even though they are stored in different computers. In fact, each network node holds a replica of the whole blockchain, and that they communicate regularly to make sure data is up so far and authentic. Thus, decentralization and data distribution are also important aspects.

BLOCKCHAIN APPLICATIONS

Basically, blockchain was designed for its implementation in the field of economics and cryptocurrencies, but today this technology is at the center of many current developments in the healthcare and medicine industry, we will discuss some areas of these domain that uses blockchain.

I. Drug discovery and Pharmaceutical research:

Drug discovery and research take a significant cost on the operations of any pharmaceutical company. With increasing costs of healthcare, together with the need to innovate faster on new medicinal treatments, it is imperative that multiple pharmaceutical companies find an approach to collaborate competitively. Blockchain can enable the technological platform to facilitate the transfer of trusted information and knowledge among multiple parties. The usage of blockchain for robust digital proof of Intellectual Property (IP) through immutable records and time-stamping is one fitting proposition for the collaboration. Blockchain-based solutions also can provide mechanisms to share clinical and trial data competitively. Even under a non-collaborative research and drug development scenario, blockchain provides benefits for effectively tracking and managing various aspects of clinical trials like data management, consent management, tracking side-effects of drugs usage, etc. Also, it's not uncommon for a pharmaceutical research company to outsource their clinical research projects. In this case, blockchain could provide a feasible mechanism to assure data integrity and proper outcome validation. In the current system, the pharmaceutical companies might have incentives to misrepresent results, e.g. in disclosing the side-effect of new drugs. With an open research ecosystem supported blockchain technology, research outputs are transparent, and research outputs are validated making the false representation of the results difficult.

II. Clinical Trials:

Blockchain also has use cases within the management of the clinical test process for pharmaceutical research. Recently, IEEE Standard Association [12] organized a forum on Blockchain for Clinical Trial with the aim to use blockchain to make innovations in patient recruitment, ensure data integrity, and make rapid advances in drug development. Scrybe [13], a blockchain project

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Vol. 9 Issue 09, September-2020

presented in the forum, enables an efficient and trusted mechanism to expedite the clinical trials and research process. Of others, it allows an easy and transparent framework for legal and ethical validations of the trial process by the auditors. The work in [14] shows how blockchain can be used to manage the consent, data, and outcome from a clinical trial in a trustful and open manner. Such innovations in clinical trial rollout and management are crucial for advancements in pharmaceutical research. A lot of clinical trials run over the budget and timelines. Competitive sharing of clinical and trial data can accelerate research and discovery. Further, the research aspect of pharmaceuticals is quite broad that pervades the drug discovery process to device manufacturers and clinical trial outcomes. A solution across this spectrum is provided by BlockRX [15] using so-called Advanced Digital Ledger Technology (ADLT). The overarching goal is to inter-connect the currently disconnected parties in silos.

III. Medical Fraud Detection:

One huge application of blockchains in medical industry includes medicine supply chain management. Supply management may be a crucial issue to safeguard altogether sectors, but it's a greater importance in healthcare, thanks to its increasing complexity. This is because any compromise to the healthcare supply chain effects the wellbeing of a patient [24]. Supply chains are vulnerable, and consists of holes for fraudulent attacks as they involve a number of moving parts and people. Blockchains provide a secure and secure platform to eliminate this problem and, in some cases, prevent fraud occurrence also, by introducing higher data transparency and improved product traceability. Since a record in blockchain can only be validated and updated through a smart contract, manipulating the blockchain isn't easy [16].

IV. Billing Claims Management:

Financial aspects of medical care are inherently important in the healthcare landscape. This area of financing aspect in healthcare is rife with inefficiencies, mostly related to the trust and transparency, which can potentially be optimized by the use of blockchain. Blockchain provides a mechanism for direct links between patients (one who makes claims) with the bearers (one who clears the claim), as there is trust inbuilt. Smart contracts can be used in the premium negotiating phases. Data regarding the current health status, medication usage, lifestyle, etc. tied through blockchain to evolving premiums, through smart contracts. When many parties or intermediaries are involved in the claim handling, there might be a lot of repetitive tasks and checks involved which might be burdensome for the end customer.

Some propositions are brought forth using blockchain for billing claims management and broader financial aspect of healthcare delivery. Gem [17] is using Ethereum to streamline the claim management in healthcare services, among others. It brings the patients, providers, and the insurers together into one ecosystem to provide real-time insights into patient's health journey and ease health claims management. Change healthcare [18] is using the HyperLedger Fabric framework [19] for blockchain based claims and revenue management.

V. Healthcare Data Management

The management of healthcare data which includes storage, access control, and sharing of the data is an important aspect of the healthcare industry. Proper management of healthcare data improves healthcare outcomes by allowing holistic views of patients, personalized treatments, and efficient communication. It is also critical for operating healthcare industry cost-effectively and efficiently. However, managing healthcare data is a challenging task due to its sensitive nature and subsequent trust issues. And it is one of the main reasons why the healthcare system is disconnected—healthcare data and services exist in disparate forms in several silos. This disconnected system is a culprit for several inefficiencies in healthcare and is a major hurdle for healthcare research. Healthcare professionals generally do not have access to the complete data of patients, thereby, hampering the subsequent diagnosis and treatment steps; and researchers struggle to find the desired data for their studies, thereby, slowing down healthcare research.

Blockchain may enable the efficient sharing of healthcare data while ensuring data integrity and protecting patient privacy. Secure, efficient, cost-effective, and interoperable HIE are often built with its right use alongside with other technologies. Moreover, the adoption of blockchain can barge the movement of patient-centric healthcare model where patients control their healthcare data. The major hurdles behind data-sharing in both patient-centric and traditional models are lack of trust and lack of incentives to share. The blockchain technology can solve both problems by acting as a trust layer and introducing the incentive mechanisms such as rewarding crypto tokens for sharing data. Moreover, blockchain are often the bridge for the mixing of medical device data and healthcare internet of things; the healthcare and lifestyle data collected by wearable devices are often critical for correct diagnosis but are underutilized since there is a lack of a proper way for a physician to access the patient-generated data. With blockchain-enabled trust and incentive structure, there's a promise for a worldwide HIE and a marketplace on top of it. But the lack of common healthcare data standards can be one of the major obstacles to overcome before the development of an interoperable HIE connecting

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multiple disparate data silos. However, there is a possibility that the incentives introduced by blockchain-based data exchange may fuel the creation and the development of the open data standards. Blockchain-based HIE will be an interesting use case that requires the balance among privacy, transparency, and efficiency. Moreover, country-specific regulations will be another obstacle for a HIE connecting multiple regulatory regions. Since patients have full ownership of their healthcare data in many countries, blockchain enabled patient-centric healthcare data model can be one fitting way to bypass these regulatory challenges. [22][23]

CHALLENGES FACED BY BLOCKCHAIN

Every new technology will have its own limitations and problems. Challenges are involve transparency and confidentiality. Everyone can see everything on a blockchain network. Many believe that medical data itself is stored off-chain and only the hash of the tag information is stored in the blockchain. Considering that the number of transactions in the healthcare is enormous, a blockchain technology revolution is needed. In addition, the threat of a 51% attack, it is a theoretical but possible risk and a clear solution for this should be suggested [2]. We will demonstrate some of these issues.

i. Scalability

There is an increase in blockchain usage volume and rise in the number of transactions occurring daily basis, therefor blockchain has become huge in size. Transactions are stored in nodes for getting validation. First, the present transaction source must be validated before transaction itself. The block size restriction and time break required to provide new block plays a significant role in not satisfying requirement for the simultaneous processing of the many transactions in real time environment. In few cases, size of block may also create issue in delay of transactions [9].

ii. Privacy Leakage

Main vulnerability of blockchain is leakage of transaction privacy because the balances and details of public keys are going to be visible to every and each one available on network. One suggested solution is to urge anonymity in blockchain. This can be classified in anonymous solution and mixing solution [10].

iii. Selfish Mining

It is a major challenge in blockchains. A block is vulnerable of cheating albeit alittle a part of hashing power is employed. Here, the miner keeps with him the mined block with no broadcasting on network and can create a personal branch which can be broadcasted after meeting certain requirements.

Due to this, legitimate miners will waste time and resources and private chain will be mined by selfish miners [10].

iv. Fork Problems

It is related with decentralized node version, also as agreements when the software update. This is very crucial because it involves a good home in blockchain.

There are basically two sorts of forks – hard fork and soft fork.

When systems comes with new agreement or version, and if it's not compatible with older version, then the older nodes can't be accept as true with mining of latest nodes. And this makes one chain in to two. This is called hard fork.

When systems comes with new agreement or version, and if it's not compatible with older version, then the new nodes can't be accept as true with mining of older nodes. Older nodes and new nodes still still work on an equivalent chain. This is called soft fork.

Soft fork makes the older nodes unaware about consensus rule changes. Also it will not affect stability and effectiveness as both types of nodes are on single chain [11].

v. Standards Challenges

Blockchain technology is still in its start growth, and thus towards its practical implementation in medicine and healthcare it will certainly face standardization challenges. A number of well-authenticated and certified standards would be required from international standardization authorities. These predefined standards would be helpful to evaluate the size, data nature, and format of the information exchanged in blockchain applications. These standards will not only scrutinize the shared data, but also must serve as precautionary safety measures.

vi. Acceptance and Adoption

Accepting and adopting a technology that is completely different from the traditional work methods won't be easy. Although the medical industry is slowly moving towards digitization, there's still a long way to go for it to completely move on to this technology, especially to ones like blockchain which has yet not been validated in clinical aspects. Convincing doctors to switch from paperwork to making use of technology will take time and effort.

Due to its low adoption rate in the health sector, the technology and policies offered are relatively untrusted [26]. Because all of these challenges and threats, we cannot, to date, term it as an applicable and universal solution for all issues in healthcare [25].

FUTURE PERSPECTIVES AND EXPECTATIONS

Blockchain technology is constantly improving rather than completed, and it has several potential challenges that must be dressed for it to be adopted for biomedical and healthcare applications.

The features of blockchain technology are numerous especially in medical industry. This technology is likely to take medical science to the next level in the future, by reducing the costs of monitoring, configuration, and having a central server of data. Doctors won't need to worry about the patient giving them an honest medical record, thanks to their ability to look at the first, authentic, and quality source-documented data in real time. Likewise, the patients won't have to worry about having a second opinion from another doctor, due to the transparency of the data. In addition,

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Vol. 9 Issue 09, September-2020

patient will have a complete autonomy on their data, and they will decide who to share the data with.

The successful implementation of blockchain technology in healthcare clinical settings would surely open new research avenues for the advancement of biomedical research. While, on the opposite hand, in precision medicine applications, the safe, secure, and scalable acquisition, storage, and sharing of this clinical data would assist in developing potential strategies for the diagnosis and treatment of diseases. A blockchain might be used for neural-control systems, and a digitized brain might be stored on a blockchain. Neurotechnology remains at a really experimental stage, and only a get few companies have gone thus far as confirming a task for blockchain technology.

Consequently, this blockchain-based healthcare framework will engage individuals more in their healthcare, which can ultimately improve the standard of life during a more befitting manner.

Of course nobody can accurately predict the future. Yet the trajectory for blockchain in 2019 and going forward appears to point during a clearly upward direction. And that journey is the story of growth and potential that disruptive technologies characteristically take, offering adopters tangible strategic advantage in ways that few thought imaginable before.

DISCUSSION AND CONCLUSION

Like any new technology there will be development and adoption fits and starts over time. But in the case of blockchain, there appears to be a concerted effort to move the technology forward. Other potential applications include: informed consent management, clinical trial data management, insurance coverage, and claims adjudication. Over the next two five years we will likely see success stories that will prove that these early stage investments were worth the effort.

Overall, blockchain applications in health records are at a rather initial stage of maturity. Less than half (42%) show some degree of implementation, which is limited to laboratory or simulation testing. No study presents a real-world demonstration or evaluation of the proposed solution. We anticipate that as technology matures and more industrial applications emerge, real world pilot demonstrations will help shape the field and will reveal the most suitable applications of blockchain in medical records. Indeed, in 2016, the Estonian Health and Welfare Information Systems Centre launched a project to create and secure a log file of all medical data processing activities in the national health record system using blockchain technology; the project, probably the first nationwide deployment, and is currently in pilot stages [20]. The same underlying blockchain technology is now being used in other industrial products to power personal care records in the UK [21].

Finally, and despite the immense potential of blockchain technology and the large interest around it, I found that its impact on healthcare is still in the early days, because most of the blockchain healthcare solutions are still in the form of new concepts represented by whitepapers. However, the field is evolving rapidly, so I anticipate a significant positive impact of blockchain in medicine and healthcare in the future.

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