



AN OVERVIEW OF BLOCKCHAIN TECHNOLOGY IN THE HEALTHCARE SECTOR

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Abstract

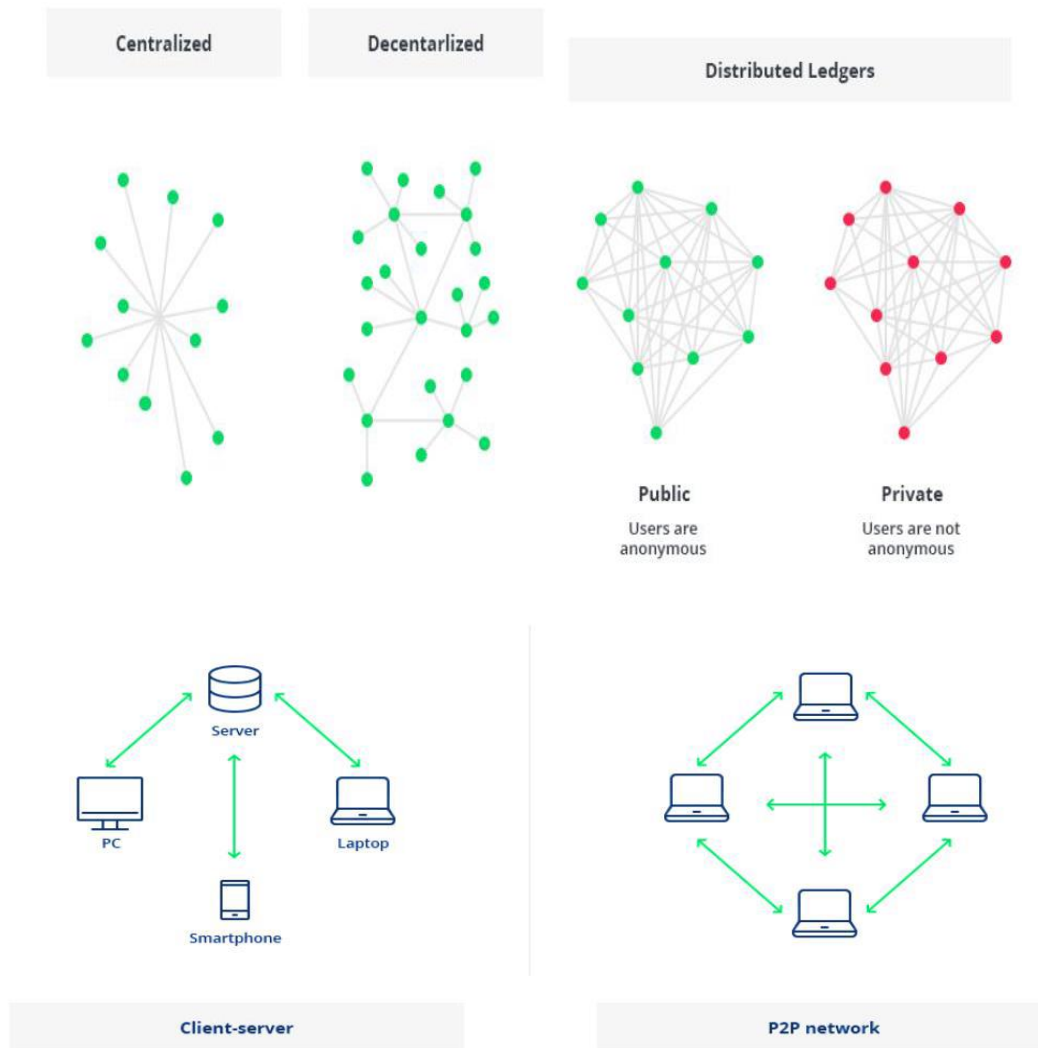
The healthcare industry is going through a significant digitization change, with an increasing focus on data security, interoperability, and patient-centered strategies. Blockchain technology, which is well-known for being decentralized and tamper-proof, is proving to be a game-changing answer to these problems. Here we examine the review of blockchain, importance of blockchain in the society, components of blockchains, the possible effects and applications of blockchain technology in healthcare and the research issues and future trends of blockchain in healthcare. The fundamental characteristics of blockchain, such as data immutability, transparency, and cryptographic security, give managing sensitive medical data a secure base. Blockchain makes ensuring that patient records, medical histories, and other important information remain tamper-proof and available only to authorized parties by creating a distributed ledger. As a result, data breaches and unauthorized access are protected and patient privacy is strengthened.

Keywords: Blockchain, Healthcare, Decentralized

Blockchain applications are used by many industries, including finance, healthcare, manufacturing, and education, to benefit from the special features that this technology offers. (Odeh, 2022). Everybody needs access to healthcare data. It maintains a physical record of our bodies. Electronic medical records (EMR), which are more practical for data access and storage, have replaced the initial paper records used to capture medical information. As a result, more consideration must be given to safeguarding the privacy of data used for disease diagnosis and treatment (Adamu et al. 2020). Blockchain technology has a lot of potential for both scholarly investigation and practical industry use. It enables decentralized public ledgers to safely store and ensure the immutability of immutable data. Social networking, supply chain management, luxury goods, and financial assets are few sectors that have substantially benefited from this technology.

Blockchain has some distinctive qualities that make it useful for applications in the healthcare industry. Unquestionably beneficial to healthcare applications is decentralization, a key feature of blockchain that permits the construction of distributed healthcare apps without relying on a centralized authority. All parties involved in healthcare, especially patients, can know how, by whom, when, and how their data is utilized thanks to the blockchain's data being copied throughout all of the network's nodes. Furthermore, the ledger's present state is unaffected by the compromise of any one node in the blockchain network because the data in the ledger is replicated across a number of network nodes. As a result, blockchain is built to protect against security risks like ransomware as well as possible data loss, corruption, and other risks (McCharty et al 2016). Additionally, the immutability attribute of blockchain, which makes it impossible to change or delete any record that has been appended to the blockchain, extremely well matches the needs for keeping healthcare records. It is essential to ensure the accuracy and reliability of patient medical records. Furthermore, by utilizing cryptographic methods to encrypt the data stored on the blockchain, it is ensured that only users who are permitted to view the data can decode it, improving the security and privacy of the data. Furthermore, healthcare stakeholders are able to share patient health data without having to know the patients' real names because patients' identities in a blockchain are pseudonymized using cryptographic keys. The blockchain's smart contracts technology, which is another characteristic, can be used to design the regulations that offer patients control over how their medical records are shared or used.

Blockchain Architecture



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The blockchain is a decentralized, distributed ledger of many transaction types compiled into a peer-to-peer (P2P) network. It may be open to the public or not. This network of many computers cannot update the data without the network as a whole agreeing to do so.

Blockchain Technology Characteristics

- **Highly Secure:** It uses a digital signature function to carry out fraud-free transactions, making it difficult for other users to damage or edit a person's data without that user's personal digital signature.
- **Decentralization:** The decentralized nature of blockchain technology is one of its most important characteristics. Blockchain relies on a network of computers (nodes) that each retain a copy of the complete



blockchain, as opposed to a central authority like a bank or government. As a result, security and transparency are improved, and intermediaries are no longer required.

- **Immutability:** It is quite challenging to change a block's contents after it is added to the blockchain. Consensus techniques and cryptographic hashing are used to achieve this. Immutability increases security and trust in the system and makes it impervious to fraud and tampering.
- **Consensus:** A transaction's legitimacy must be accepted by all of the network's active nodes.
- **Provenance:** Every member of the network can see the history of an asset that has been registered on a blockchain.

Types of Blockchain

Public blockchain: There are no limits on access to a public blockchain. It is available to the public and is kept up by a public neighborhood. Anyone with an Internet connection can transmit transactions and verify them, taking part in the execution of a consensus protocol. These networks provide financial rewards for those who secure transactions and make use of a Proof of Stake or Proof of Work method. Ethereum and Bitcoin are two examples of public blockchain networks.

Private Blockchain: Access is restricted in this kind of Blockchain. The network is run by a person or a business. Without express permission from the owner or the central administrator, no one is allowed to add new blocks or transactions to the network, check the history of the ledger, or take part in the consensus.

Consortium Blockchain: Several organizations get together to establish a consortium. Only members of the organization are permitted to enter transactions and read information from the shared ledger. This architecture, which is frequently considered to be somewhat decentralized, uses both public and private blockchains for trust and efficiency. Hyperledger is a consortium blockchain example.

Hybrid blockchain: These networks integrate public, private, or consortium blockchains to speed up transactions. This is a new type of blockchain. By maintaining information's confidentiality and making access possible via a smart contract, it is another attempt to achieve the best of both worlds.

Social effects of blockchain technology

- Blockchain technology has benefited many people through the use of financial services like digital wallets, including Bitcoin, which is the main use of the technology. It has given microloans and permitted micropayments to people in less-than-ideal financial situations, so bringing new life to the global economy.
- Since consumers can track a product's origin and path, supply chain management is one area where blockchain's transparency and tamper-proof properties can promote confidence.
- Blockchain technology can be used to handle intellectual property rights and establish ownership of digital assets. The way that musicians, artists, and other creators are paid for their work may undergo a radical change as a result.
- The Internet of Things (IoT) is a brand-new world that is already brimming with smart gadgets that can do everything from start your washing machines to drive your cars, maneuver your ships, plan trash pick-up, and control traffic safety in your neighborhood. Blockchain can help with this. Utilizing blockchain technology to build Smart Contracts can help any firm both streamline processes and maintain more accurate records in all of these situations (and more).
- Organizations or apps like Airbnb and Uber can benefit from a decentralized peer-to-peer network made possible by blockchain technology. It enables consumers to pay for expenses like parking and tolls.
- For the goal of securely keeping sensitive patient data, the healthcare sector can leverage blockchain technology. The technology allows health-related institutions to establish a central database and communicate information with only those who have the necessary authorizations.

Components of Blockchain

Node: In the blockchain architecture, a node is a user or computer that possesses a separate copy of the whole blockchain ledger.

Transaction: The smallest unit of a blockchain system (records, information, etc.) is a transaction, which serves as the technology's main use case.



Block: A block is a type of data structure that is used to store a group of transactions and distributes them throughout all network nodes.

Chain: Blocks in a specified order are arranged in a chain.

Miners: a subset of nodes that verify blocks before adding them to the blockchain structure.

A consensus is a set of guidelines and agreements used to conduct blockchain operations.

Literature Review

Odeh et al. (2022), in their research article, examine the problems and potential applications of blockchain technology in the healthcare and medical industries, focusing on the unique difficulties and features. In order to address the research topic, the study used a systematic review of secondary literature. The purpose of their article was to explore the many difficulties and worries associated with applying blockchain technology to the healthcare system in order to enhance its overall performance. This covers particular applications including electronic health records (ERH), patient observation, and drug traceability. This adoption supports the use of asymmetric cryptography, including as hashing, digitally signed transactions, and public key infrastructure, in a secure decentralized system for storing and sharing symmetric patient records with the right alliance of hospitals and healthcare providers.

The article by Xi et al. (2022) assesses the various viewpoints. To research how blockchain technology in healthcare is developing Due to its inherent advantages of being tamper-proof and traceable, blockchain technology and smart contracts are demonstrated to have a clear benefit in the field of medical data. The authors of this study examine various blockchain-based application scenarios in their research paper. Which are blockchain-based electronic medical record sharing, blockchain and the Internet of Medical Things, and blockchain-based federal learning. The three application scenarios for sharing healthcare data are also summarized in the study, along with a comparison to more conventional methods. The three application scenarios were compared to the conventional cryptography-based model, and it was found that the blockchain-based model is more intelligent and safe since smart contracts play a significant role.

A thorough evaluation of the ongoing research into the use of blockchain technology in healthcare is reported in Cornelius et al.'s (2019) study. Using the systematic mapping study process, a systematic review was undertaken, and a map of all pertinent research was produced. The study's goals were to identify the blockchain technology's potential applications in the field of healthcare, as well as those that have already been created as examples, as well as their difficulties and drawbacks, as well as the methods currently being used to create them and potential future research areas. They found 65 papers using their search and paper selection procedure, which were then examined to answer the research questions.

The study demonstrates that blockchain has numerous applications in the field of healthcare, including the management of electronic medical records, the management of the pharmaceutical and medication supply chain, biomedical research and teaching, remote patient monitoring, and health data analytics, among others. On the basis of developing blockchain concepts such smart contracts, permissioned blockchain, off-chain storage, etc., a number of healthcare-related blockchain applications have been developed as prototypes.

Elangovan et al. (2022) systematically reviewed studies on the use of blockchain technology in the healthcare industry and also examined the traits of the studies that had adopted blockchain technology. They used PubMed, SpringerLink, IEEE Xplore, Embase, Scopus, and EBSCOhost to look for pertinent papers. Researchers discovered that blockchain technology will be helpful in actual health care settings, as well as for the administration of electronic medical records, biomedical research and education, remote patient monitoring, pharmaceutical supply chains, health insurance claims, health data analytics, and other potential areas. Data integrity, access control, data logging, data versioning, and nonrepudiation were found to be the primary drivers for the adoption of blockchain technology in the healthcare industry. Their research may aid in the scientific community's comprehension of the practical application of blockchain technology.

Wei et al. (2021) carried out a systematic review that summarizes the state of research with blockchain technology for both COVID-19-related and unrelated applications in healthcare. Ethereum and Hyperledger were the platforms they employed. They carried out a thorough analysis of blockchain applications in healthcare

that were both COVID-19-related and weren't. Up until July 29, 2021, we found pertinent articles in MEDLINE, SpringerLink, Institute of Electrical and Electronics Engineers Xplore, ScienceDirect, arXiv, and Google Scholar. Both clinical and technological concepts, with or without prototype development, were covered in the articles. A total of 85 375 articles were assessed, and 415 full-length reports—37 of which were connected to COVID-19 and 378 of which were unrelated—were ultimately incorporated into the analysis. The three main COVID-19-related applications that were reported were contact tracing, monitoring of immunity or vaccine passports, and pandemic control and surveillance. Management of electronic medical records, internet of things (such as remote monitoring or mobile health), and supply chain monitoring were the top three non-COVID-19-related applications.

The idea of a decentralized marketplace for patient-generated health data is put up by Subramanian (2023) in their research study. This marketplace might enhance provenance, data accuracy, security, and privacy. Using a proof-of-concept model using Ethereum smart contracts and the Interplanetary File System (IPFS).

Blockchain in Healthcare: 2023 Predictions from around the Globe is a topic that Talisha Shine et al. explored in their study from 2022. They examine forecasts made by BHTY editorial board members about how the use of blockchain in healthcare may develop further in 2023. We projected, spoke about, and examined the responsibilities listed below. Blockchain-enabled patient-mediated healthcare exchange, wearable technology and digital twins, consumerization of health data, and the metaverse all make use of the concept of monetization.

Application Area of Blockchain



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Several use cases for blockchain are shown in the graphic above; a thorough description of how blockchain is used in healthcare is provided below.

Blockchain applications in the healthcare industry

Blockchain technology have the potential to improve a number of healthcare and wellbeing-related topics. These consist of insurance, clinical studies, drug tracing, and device tracking. (Liam Bell et al.)

Device tracking enables hospitals to keep tabs on their assets across a blockchain network, including for the course of a device's lifecycle. The objective is to label medical equipment with a functional ID while also incorporating trust in device identification and tracking. When a gadget, such an infusion pump, is discovered to be broken, tracking the item might help determine the problem and save needless repurchasing in the instance of lost technology. By avoiding needless repurchases, adopting fraud analytics, and establishing a strong trust infrastructure based on the identification of medical equipment, these risks could be reduced.

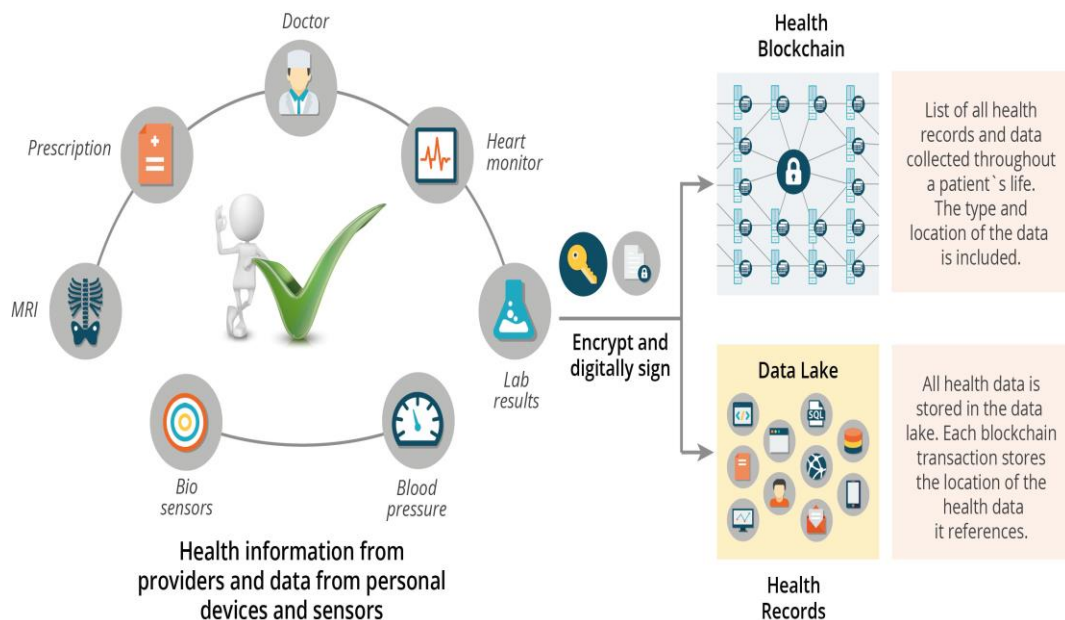
Pharmaceutical tracing: The pharmaceutical industry can use blockchain technology to help reduce the hazards connected with unlicensed and fake drugs, which are on the rise. Creating smart contracts for drugs and then identifying pill containers with embedded GPS and chain-of-custody reporting are both possible options, similar to device monitoring.

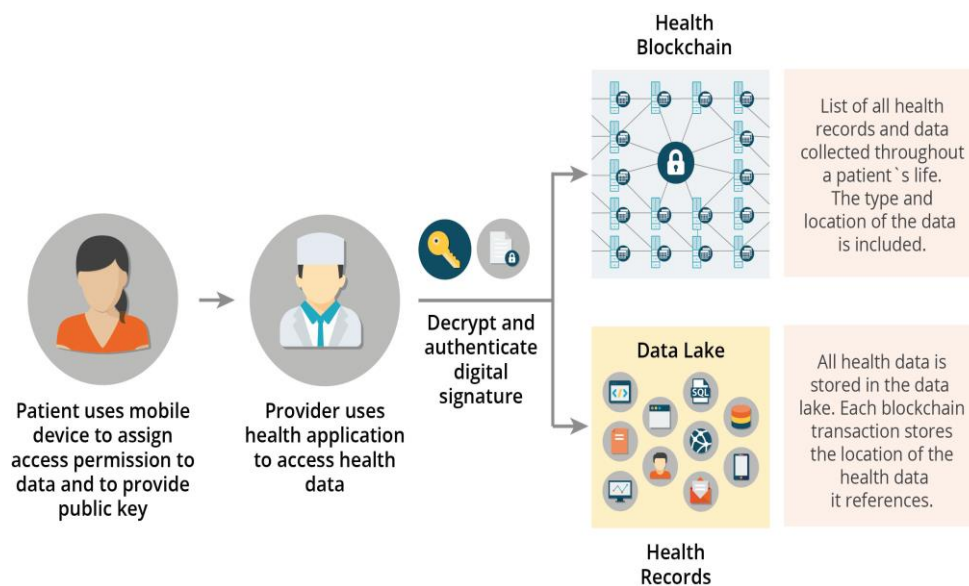
Clinical trials: Blockchain can be used in clinical trials to solve issues like removing data that doesn't reflect the bias of the researcher or the funding source and fake results. This will ensure that clinical trials are ethical. Additionally, it enables the keeping of an unchangeable log of trial subject consent.

Health insurance: Many aspects of the industry, including enhanced incident reporting and the automation of underwriting procedures, could profit from a reliable record of the events that occurred along the patient pathway. Additionally, agreements could be spelled out in detail before being put into effect, such as automated payments for a portion of the patient pathway.

A Blockchain-Based Healthcare Model

Any blockchain used in the healthcare industry must be open to the public and incorporate technology answers for three crucial issues: scalability, access security, and data privacy.





Research Concerns and Unsolved Issues

What Existing Research Problems and Research Topics Need More Study?

Due to the fact that the application of blockchain technology in the healthcare industry is still in its infancy, researchers must develop additional proof-of-concepts and prototypes. This will aid academics in understanding the technology and its development for this application. Many of the suggested frameworks, ideas, models, and architectures—like Mamoshina et al. (2017)—need to be evaluated in the real world to see what benefits and drawbacks they have.

Interoperability, security, a lack of standards, storage needs, hospitals' reluctance to share patient data, patients' lack of trust in healthcare providers, a shortage of medical professionals' skills, and finally accountability and data ownership are the main obstacles to the application of blockchain technology in the healthcare industry. Within the blockchain network as a whole, interoperability in the healthcare industry refers to the exchange of pertinent information. A big, diverse collection of suppliers as well as its extensive open existence make it the main cause for concern. Odeh et al., 2022.

To provide interoperability between multiple blockchain implementations, open standards are necessary. Right now, the focus is on demonstrating principles through the use of blockchain prototypes. However, before blockchain can be fully embraced and utilized in real healthcare systems, open interoperability standards must be created. In light of this, it is imperative that researchers start looking into the issues with standards and interoperability. There is already a standards group (ISO/TC 307) for academics to contribute their works. M.A. Engelhardt (2017).

The open research issues of data security and privacy, interoperability, scalability, and speed that characterize blockchain-based healthcare applications must be addressed in concerted additional research engagements in order to increase stakeholders' trust in the technology's use and encourage its adoption in healthcare.

Future Trend

Blockchain technology is transforming society by giving us the Internet of value, a brand-new platform that will change how commerce is conducted. It employs mathematics and cryptography to enable transactions worldwide, transcending all geographical and physical boundaries. The ability of blockchain to preserve and retain the history of person-to-person transactions means that there are no opportunities for fraud, hacking, or outside influence.

Healthcare providers, researchers, and patients themselves will be able to safely and interoperably share patient health data thanks to blockchain. Patients will have more control over their data and will be able to choose which parties they want to grant access to, which will improve care coordination and enable better medical decisions.



Decentralized clinical trials will change as a result of blockchain technology's transparency and tamper-resistance. By improving the management of permission, data collection, and trial outcome verification, smart contracts will hasten the discovery of novel medications.

Blockchain will allow for secure patient identity management and consent tracking. Clinicians will be allowed access to patient data when required in order to guarantee the accuracy of medical records, ensure patient ownership of their health data, and enable informed decision-making.

Integration of artificial intelligence (AI) will enable advanced analyses on data stored on blockchains. AI algorithms will be powered by blockchain-based medical records, treatment outcomes, and research data, resulting in tailored treatment plans, predictive analytics, and improved patient outcomes.

Conclusion

Healthcare data is very interested in blockchain since it is decentralized, traceable, and tamper-proof. With new mechanisms and computational methods, the blockchain mechanism's use is improving every day. Nowadays, a lot of internet-based methodologies make use of both the blockchain mechanism and the benefits of distributed systems. Any data entered into the system will always be secure after submission, allowing for a wide range of applications in the banking industry and other relevant fields. Blockchain technology unquestionably has a role in the health IT ecosystem, and the healthcare industry should seriously consider adopting blockchain to develop precision medicine and as the foundation for their interoperability plan.

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