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Blockchain revolution in healthcare: A comprehensive survey

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ABSTRACT: The healthcare industry is about to undergo a profound transformation due to the potential for blockchain technology to drastically change its fundamental policies and practices. This comprehensive survey paper, titled "Blockchain Revolution in Healthcare," examines the numerous ways that blockchain technology is impacting healthcare systems and services. In this paper, the key components of blockchain—smart contracts, decentralized ledgers, and cryptographic security—as well as their applications to healthcare are discussed. First section of the research paper gives an overview of the challenges and inefficiencies that the healthcare sector is currently dealing with, with a focus on issues related to interoperability, patient privacy, and data security. The way in which blockchain technology can help with safe, open, and immutable data management and sharing is explained in the following section.

Keywords: Blockchain technology, Healthcare industry, Transformation, Interoperability & Data security

1 INTRODUCTION

The healthcare industry, one of the significant pillars of modern society, is undergoing a radical makeover that will probably change its fundamental practices and organizational structures. At the core of this revolution is blockchain technology, an invention that has the ability to solve prevailing problems and usher in a new era of healthcare(Hölbl).

In a world where data security, interoperability, and patient privacy are now top concerns, blockchain technology exhibits promise. With its promise of safe, open, and unbreakable data sharing and management, it holds the key to solving issues that have long plagued healthcare systems.With the fitting title "Blockchain Revolution in Healthcare," this extensive survey paper sets out to investigate the various ways that blockchain technology may affect healthcare services and systems. We will explore the fundamental elements of blockchain technology smart contracts, decentralized ledgers, and cryptographic security together, revealing their uses in the medical field. We will discuss the current issues facing healthcare, such as interoperability and data security, and show how blockchain technology can help by empowering patients, fostering transparency, and safeguarding medical data. We'll talk about the problems that the healthcare industry is currently facing like interoperability and data security and demonstrate how blockchain technology can support the industry by empowering patients, promoting transparency, and protecting patient data.

This study, "Blockchain Revolution in Healthcare," aims to provide a insightful and contemporary examination of the implications of blockchain technology for the healthcare sector. We will investigate the current state of adoption of blockchain technology, assess its impact on data security and privacy, discuss the advantages and disadvantages of implementing it, and exchange insights gained by doing this, we hope to shed light on how the pharmaceutical industry, healthcare professionals, and patients view blockchain's potential (Ghin) to revolutionize the healthcare system. Table 1 shows the comparative analysis between public and private Blockchain networks.

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Table 1. Comparative analysis between public and private Blockchain networks.

Features	Public	Private
Authorization to join a network	Open	Restricted
Transaction Transparency	All members	Selected Authorized members
Consensus decision-makers	All block generators	Selected nodes
Confidence in the network	Not Required	Required
Information privacy	Low	High
Output	Low	High

2 CHALLENGES IN MODERN HEALTHCARE

The modern healthcare industry is grappling with several critical challenges that have significant implications for patient care and the overall efficiency of healthcare services. One of these key issues is the secure and compliant interchange of healthcare data.Additionally, achieving nationwide interoperability remains a major hurdle, as legacy systems often lack a unified standard for sharing patient data, hindering the seamless flow of critical information. To add to the complexity, the tracking of medical devices and drugs is of paramount importance to ensure patient safety, reduce healthcare costs, and prevent fraud. As the healthcare sector continues to grapple with these issues, blockchain has the potential to transform the industry, offering innovative solutions to enhance data integrity, security, and the efficient management of healthcare resources (Sharma). In addition to the fundamental issues mentioned, the modern healthcare industry faces other critical challenges, including the need for streamlined administrative processes, enhanced patient privacy, and efficient management of medical records. Table 2 shows the issues faced by modern healthcare industry.

Table 2. Issues faced by modern healthcare industry.

ISSUE	ACTIVITY
Information Sharing in Healthcare	Patients, insurers, and healthcare providers must exchange data in a manner compliant with industry data protection regulations.
Across the Country Interoperability	When patient data exchange is standardized, which legacy systems often do not, data transfers between healthcare providers are made easier.
Monitoring of Medical Devices	Medical device tracking provides fraud analytics, expedites device retrieval, prevents needless repurchasing
Tracking of Drugs	The patient's chain of custody may be tracked from the supply chain thanks to blockchain technology.

3 HOW BLOCKCHAIN ADDRESSES HEALTHCARE NEEDS

Blockchain technology gives a comprehensive set of features and applications that makes it an ideal solution which meets the specific requirements of the healthcare industry. Its fundamental strengths lie in security, assurance, immutability, and authentication. Blockchain ensures the permanence and integrity of healthcare data, protecting it from tampering and unauthorized access (William). Additionally, it facilitates controlled data access and secure sharing among authorized parties, enhancing collaboration and interoperability in the healthcare ecosystem. The decentralized storage and mobility capabilities of blockchain technology improve the availability and accessibility of data, hence reinforcing its revolutionary potential within the healthcare sector. In conclusion, as Figure 1 illustrates, the security, interoperability, data sharing, and data access requirements of the healthcare industry are strongly aligned with the capabilities of blockchain.

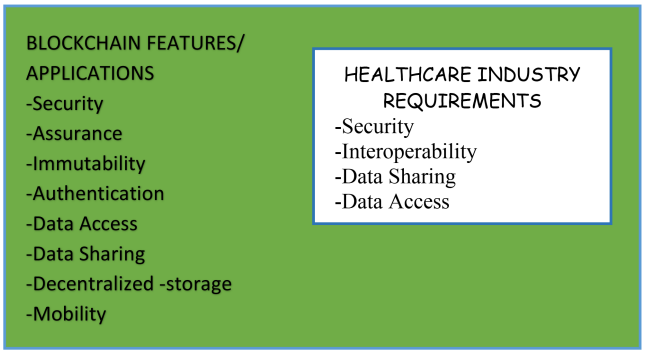

Figure 1. How blockchain fulfils needs in healthcare.

4 HISTORICAL IMPLEMENTATIONS

Since its initial experimental projects in the mid-2010s, which mostly concentrated on safeguarding electronic health records (EHRs), the historical application of blockchain in the clinical sector has taken many different forms.

4.1 *COVID-19 pandemic response (2020-Present)*

The global health care sector has been significantly impacted by COVID-19 (Yan). It greatly accelerated the medical industry's use of digital technologies. Because of its unique characteristics (including immutability, decentralization, and transparency), blockchain is one of these new digital technologies that can be implemented in many various situations (including mobile health, electronic medical record management, and access rights). An informatic system should put user-friendliness and quick turnaround times first in order to efficiently track and report on epidemic patterns in real-time. But data flow without a defined process, like blockchain-based protocols, might be subject to misinterpretations or changes when shared between several users. However, blockchain-based protocols have the potential to improve privacy and restrict the exchange of medical data. Blockchains are by their very nature intended to function in settings where data trust is more valuable than physical trust. Data stored on a blockchain are by nature immune to tampering or alteration.

4.2 *MedRec (Massachusetts Institute of Technology)*

MedRec, an innovative blockchain-based project developed by researchers at the Massachusetts Institute of Technology (MIT), stands as a prominent example of how blockchain technology is transforming electronic health records (EHRs) and patient data management within the healthcare sector. The project's fundamental objective is to address the longstanding challenges associated with healthcare data, primarily focusing on putting patients in control of their own health information (Danu). The challenge of healthcare interoperability is another topic covered by the project. Using blockchain technology, MedRec provides a standardized and secure platform for medical data exchange between various healthcare providers.

5 AN OVERVIEW OF THE ALGORITHMS USED

In the current medical blockchain systems, the POX series of consensus algorithms is widely used.

5.1 *Proof of work (POW)*

Proof of Work (POW) is a basic consensus method used in blockchain networks, and its most well-known application is in Bitcoin. The POW algorithm was developed to solve the problem of getting participants in a decentralized network that are distrustful of one another to agree. POW (Chen) aims to offer a distributed, secure way to add new transactions to the blockchain ledger and validate existing ones.

5.1.1 *Key components of POW*

The POW algorithm's implementation entails the following crucial steps and procedures:

5.1.1.1 *Validation of transaction* Validating new transactions is the first step in the POW process. A cryptocurrency transaction is announced to the network when a user starts one.

5.1.1.2 *Candidate block creation* Miners, the participants in the network responsible for creating new blocks, aggregate a set of valid transactions into a candidate block.

5.1.1.3 *Proof-of-work puzzle* The POW method's keystone is the proof-of-work puzzle. Finding a nonce, or random number, that, when combined with the transactions in the candidate block and the hash of the previous block, would result in a hash that meets predefined requirements known as the "target" or "difficulty" is the aim of mining (Chen).

Advantages

Security: POW is renowned for its robust security, making it exceedingly costly for malicious actors to tamper with the blockchain's history since altering it would demand more computational power than the entire network combined.

Decentralization: POW actively promotes decentralization by allowing miners from around the world to participate. The competitive nature of POW ensures that no single entity can assert control over the network.

Incentives: POW provides powerful incentives for miners to behave honestly. Through the rewarding of miners with cryptocurrency coins and transaction fees, it motivates them to validate and include legitimate transactions.

Disadvantages

Energy Consumption, Resource-Intensive, Limited Scalability.

5.2 *Proof of Stake (POS)*

A straightforward consensus mechanism called Proof of Stake (POS) provides a more ecologically and energy-efficient means of validating and securing transactions on blockchain networks.POS selects validators based on the amount of cryptocurrency coins they are willing to "stake" as collateral. These validators enable the blockchain to remain secure by proposing and approving new blocks.

5.2.1 *Key components of POS*

5.2.1.1 *Transaction validation* The first step in the POW process is the validation of new transactions. When a user initiates a cryptocurrency transaction, it is broadcast to the network. Network nodes independently verify the validity of each transaction to ensure that the sender possesses the required funds and that the transaction adheres to network rules.

5.2.1.2 *Security* POS depends on validators' financial incentives to maintain a high degree of security. Validators have a stake in keeping the network secure because they risk losing the coins they have staked if they don't.

5.2.1.3 *Environmental friendliness* The reduced energy consumption of POS contributes to its environmental friendliness. It has a significantly lower carbon footprint compared to

POW, making it more sustainable and aligned with global efforts to reduce energy consumption and environmental impact.

Advantages
Energy Efficiency: One of the primary benefits of POS is its reduced energy consumption. Unlike POW, which requires miners to perform computationally intensive tasks, POS operates on the basis of ownership stake.
Transition Capabilities: POS allows for smoother transitions between network upgrades or shifts in consensus algorithms, making it adaptable to changing network needs and challenges.
Security Mechanisms: POS systems employ various security mechanisms to address concerns like the "nothing at stake" problem and other potential vulnerabilities.
Disadvantages
Security Concerns, Initial Distribution Concerns, Reduced Decentralization.

5.3 *Delegated Proof of Stake (DPOS)*

The Delegated Proof of Stake (DPOS) (Surya) algorithm gives an innovative approach to blockchain governance and block validation. In a DPOS network, token holders select a small group of delegates—also known as block producers—to validate and produce new blocks. The block creation process is more efficient and streamlined because there is less rivalry and less likelihood of a fork because these delegates operate in a deterministic order. This consensus algorithm is the best choice for blockchain projects that prioritize community responsiveness.

5.3.1 *Key components of DPOS*

5.3.1.1 *Delegate selection* Token holders use a voting mechanism in DPOS networks to choose community delegates. The task of verifying transactions and creating new blocks falls to these delegates.

5.3.1.2 *Deterministic block production* A deterministic order is applied to block production by DPOS. The delegation creates blocks in shifts, ensuring a seamless and uniform process. The likelihood of network forks and conflicts is reduced by the frequency of block production.

5.3.1.3 *Faster transaction confirmation* DPOS systems are known for having exceptionally fast transaction confirmation times.

Advantages
Efficiency and Speed: DPOS is well known for how quickly it can process transactions and create new blocks. Transaction confirmation times are accelerated by the deterministic selection of block producers and the predictable block production order when compared mechanisms such as POW.

Community Governance: Through the governance mechanisms built into many DPOS systems, token holders can actively engage in network decisions. This feature increases inclusivity and transparency by letting the community vote on changes, additions, and other network-related matters.

Reduced Barriers to Entry: DPOS makes network participation more accessible to a large range of consumers by doing away with the need for specialized mining hardware. Wider community involvement is encouraged by this inclusivity.

Disadvantages
Limited Delegates, Challenges with Network Governance, Negative impact on the environment.

6 CONCLUSIONS

In conclusion, our research has shown how much potential blockchain technology has to revolutionize the healthcare industry. By addressing significant problems like data security, interoperability, and administrative inefficiencies, blockchain offers a workable solution for a safer, more collaborative, and patient-centered healthcare environment. It is important to be aware of the disadvantages of blockchain technology, including issues with scalability and data storage costs. Innovation and cooperation are crucial if blockchain technology is to reach its full potential in the healthcare industry.

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