Journal of Information Technology Management
ISSN-OnLine: 2980-7972
University of Tehran

A Blockchain Network for Public Health Interoperability and Real-Time Data Sharing

Ghadi Alwehaibi*

*Corresponding author, Department of Information Technology, College of Computer, Qassim University, Buraydah, Saudi Arabia. E-mail: g.alwehaibi@outlook.com

Rwaida Salem

Department of Information Technology, College of Computer, Qassim University, Buraydah, Saudi Arabia. E-mail: rwaida.1265@gmail.com

Nahed Alrshidi

Department of Information Technology, College of Computer, Qassim University, Buraydah, Saudi Arabia. E-mail: nahed.alrshidii@gmail.com

Abeer Alghulayqah

Department of Information Technology, College of Computer, Qassim University, Buraydah, Saudi Arabia. E-mail: amgliekh@qu.edu.sa

Abstract

In terms of storage and consumption, blockchain technology is poised to transform the way we manage healthcare data. The primary goal is to empower individuals to take charge of their health records, allowing them to become independent of the institutions or organizations they use. Elec-tronic Health Records (EHRs) can be tracked in a novel and unique way through blockchain tech-nology and smart contracts. This technology can give patients more control over their data. Health practitioners and institutions, such as hospitals, may be granted access to patient data controlled by other organizations. This research highlights how blockchain technology can be used to manage EHRs while improving operational efficiency through process simplification and transparency. Additionally, the study proposes an architecture for managing and sharing healthcare data across enterprises. The suggested approach could significantly reduce the time required to transfer patient data among various health organizations while lowering overall costs.

Keywords: Blockchain, EHR, Smart Contract, Styling, Ethereum.

Journal of Information Technology Management, 2024, Vol. 16, Issue 4, pp. 18-37
Published by the University of Tehran, College of Management
doi: https://doi.org/ 10.22059/jitm.2024.99049
Article Type: Research Paper

Received: June 12, 2024
Received in revised form: July 25, 2024
Accepted: September 13, 2024
Published online: October 16, 2024

Introduction

The movement of health data and information from one institution to another is one of the most frequent issues faced by patients and clinicians. As a result, improving patient care has become a top priority to achieve high levels of patient satisfaction. Systemic changes are required to improve healthcare. Among the most advanced technologies available today is blockchain technology. Numerous applications, such as those in financial services, cybersecurity, the Internet of Things (IoT), and network data management, have generated significant interest (Alajlan & Ibrahim, 2022). Blockchain technology is employed in various areas, including clinical research, neuroscience technologies, genetics, medical supply chain management systems, electronic health records (EHRs), and pharmaceuticals. Blockchain provides a secure and practical option for storing and retrieving patient medical information, ensuring data is transmitted safely.

Storing patient files in a system that unites all hospitals would save time when opening or creating files for patients visiting for the first time, enabling faster treatment. Additionally, this system would offer a detailed report on the patient's condition and medical history, facilitating more informed decisions about their care. Moreover, paper records are becoming obsolete, as they are difficult to manage, easy to lose, and can be altered by unauthorized individuals. This research aims to design and implement a computerized system to address these issues. People will use this system as a medical record to track information about their medical appointments, tests, x-rays, diseases, and medications, or they may authorize their doctors to do so if they trust them. Over time, everyone will build their medical history.

As a result, we'll make things simple for:

- Patients will be able to obtain and share their info with doctors or others while retaining privacy and security.
- Doctors and hospitals can access patient data if they are authorized to do so or if there is an emergency.
- Doctors, patients, and hospitals can register in the system while adhering to minimum verification rules.
- People in medical care centers by providing them with a central location to store their medical information. They won't have to deal with messy papers or folders, and their

information won't get lost or misplaced. Make sure they have the correct information at the right moment, no matter where they are.

Following our discussion of these issues, this research attempted to address them by developing a mobile and web application to assist patients and clinicians. Firstly, addressing the major issues that currently exist in the way hospitals manage their data, such as the absence of data sharing with other institutes, by allowing them to readily access information from many institutes in one location. Secondly, patients can have access to all their medical information because it is difficult for them to maintain track of their medical history, whether it is complex or lengthy. Thirdly, patient medical history, which we can assist you with gathering, can be extremely valuable in an emergency where time is of the essence. Patients' medical information might spell the difference between life and death.

The rest of this paper is organized as follows; Section 2 provides the background of Blockchain implementation in the electronic health record, and current applications and discusses the most recent techniques. Section 3 explains the evolution of Blockchain in the health industry. Section 4 provides an outline of the system we'll develop. Section 5 explains all the different features and specifics of implementing the proposed system. Section 6 presents major findings discussion, and conclusions.

Literature Review

Blockchain technology has demonstrated significant adaptability in strategies for incorporating it into their operations, indicating its versatility. Many projects in other service-related industries, including health care, appear to be shifting. This article focuses on the introduction of Blockchain technology to the healthcare business. Examples of public healthcare administration and user-centered medical research are shown (Mettler, 2016).

Blockchain

Blockchain could be defined as digital ledgers that are decentralized, distributed, and public. It's used to record transactions across many computers without altering all subsequent blocks, any relevant record cannot be changed in the past (Mettler, 2016). Blockchain works in an expanding list of encrypted, linked documents called blocks, to do away with the need for a central server. Peer-to-peer computer networks independently verify each transaction, stamp it with a time stamp, and add it to a growing sequence of data. The data can't be modified once it's been registered. Data accessibility is based on the type of data. The following are some of the several types of Blockchains:

- Public Blockchain: This kind of blockchain makes transactions open to all users to read and publish.
- Private Blockchain: In this kind of Blockchain, transactions can only be read and submitted by one company or by all its subsidiaries.

- Community/Consortium Blockchain: With this form of Blockchain, a group of organizations can submit transactions and read transaction data.
- Hybrid Blockchain: Any of the three Blockchains—public, private, or community/consortium—may be utilized to support transactions in this new category. Blockchain platforms can be configured in multiple ways and submit transactions thanks to the hybrid blockchain (Shrivas, 2018).

Each block in this technique represents a structural and functional unit. A block holds the data, its own hashed value, and the hashed value of the block before it. These blocks are connected, much like a chain. In the Blockchain, digital information, or data, is contained in each block. Every block contains transactional data. Every block also has the identification of the preceding block and its unique identification. We call these identifiers "hashes". As a result, every block contains both its hash and the hash of the block before it. The blocks are very safe and widely available. As a result, changing a block on the Blockchain will be exceedingly challenging. The block-chaining process is considered a set of 5 steps:

- Initiation: somebody starts an invitation or dealings.
- Distribution: The request is transmitted to the computer node network.
- Validation: at least 50 percent of the nodes validate the request.
- Blocking: for the request, a new block is created. This block includes wrappers for the transaction with additional details. The information hash is determined to avoid data alteration.
- Chaining: The newly generated block is chained in read-only mode with the current blocks. This means that from now on it cannot be modified or eliminated (Ullah et.al.,2020).

Some of the remarkable and inherent characteristics of blockchain technology that enable its widespread application in the management of healthcare data are decentralized storage, transparency, stability, authentication, connection, and security, as illustrated in Figure 1.

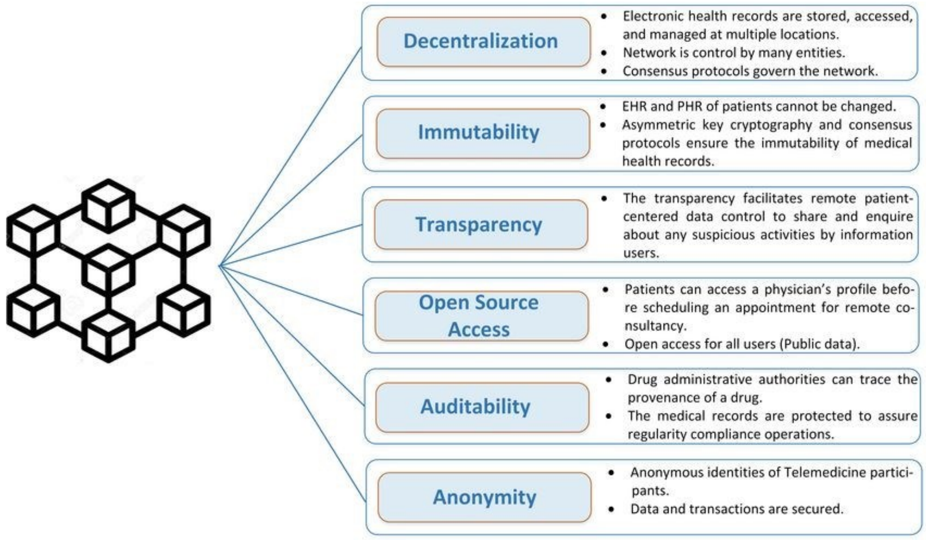

Figure 1. Features of the Blockchain

Smart contract Blockchain healthcare

The benefits of adopting smart contracts in healthcare are becoming more widely recognized as blockchain technology gains traction. However, many people are still unaware of the positive impact they may have on the sector. One of the most powerful uses of blockchain is smart contracts. Smart contracts and their digital agreements are applicable in many areas, including healthcare, due to the security and safety provided by blockchain technology. As the number of people needing medical treatment has grown, healthcare professionals have faced a significant burden. Many practitioners struggle to manage their patients' health information, records, and data. Additionally, multiple cases of fraud have occurred due to the vulnerability of outdated systems, such as those used by the Project Documentation Template IT Department. These challenges cannot be addressed by practitioners alone, which is where smart contracts come into play.

Smart contracts enable the storage of medical records and data on a digital ledger. This means that if a patient wanted to transfer from one hospital to another, they could do so promptly without the need to fill out numerous forms. The patient's preferred physician could then access the information via the blockchain network. Hospitals and healthcare organizations use various databases to store patient data, but these can be too restrictive to allow for the global exchange of potentially life-saving information. Without blockchain and smart contracts, it may take a long time for this information to reach its intended recipient, and it could be compromised. If health records were stored in a smart contract and maintained on the blockchain, hospitals, and research institutions worldwide would be able to access the data. With widespread adoption, a person could visit any hospital in the world for treatment, and the institution would be able to access their information with the patient's private key.

Currents related techniques

The current medical record systems of healthcare institutions are at high risk of modification, falsification, and potential data loss. Additionally, patients with lengthy medical histories often face the inconvenience of bringing numerous reports to doctor's appointments. While healthcare institutions may choose to digitize patient information, human intervention is typically required to verify and input the data into their databases, making this an unreliable approach for handling sensitive information. Under the existing record-keeping system, patients are frequently required to move from one assistance desk to another to obtain the information they need. Many of these issues are either overlooked or accepted as standard practice in healthcare.

Moreover, there have been cases where doctors prescribed the wrong medication based on unverified reports or patients were asked to return without consultation because they failed to bring the necessary paperwork. Blockchain technology can mitigate these issues by using blockchain data structures to validate and store data. The information provided by the end user is encrypted to ensure that only authorized individuals can access it. A decentralized system further enhances security and accessibility by verifying the data and adding it to a block. The data is stored as key-value pairs within each block, which are correctly linked to both the previous and subsequent blocks.

Currents Applications. HEALTH APPLE APP. Achievements: To view your progress in one place, the health app gathers health data from your iPhone, Apple Watch, and other apps. Health automatically tracks your walking and running distances as well as your steps. Your Apple Watch will track your activity data if you have one. You can also insert data into a Health category or get data from any Health-compatible app or device. Shortcomings: The patient's phone may be switched off. They were unable to access the mobile due to the obstacles of the accident. The difference: With blockchain technology, our project will offer features that make it easier for patients to access information by storing, gathering, and displaying patient data.

ESTONIA PERSONAL HEALTH RECORDS. Achievements: Estonia, a pioneer in the digitalization of public services, is successfully deploying an electronic health record based on blockchain technology. In 2008, the government created a nationwide electronic health record, and in 2016, introduced a new electronic health record based on KSI Blockchain technology. Shortcomings: It is set up in such a way that any doctor can access all public health records. All accesses are permanently recorded on Blockchain. The patient is allowed to access and modify the medical record. The difference: In our project, the patient is not allowed to modify his medical file, only the doctor (Meier et.al., 2021).

SEHHATY APP. Achievements: The Sehhaty app was created after the COVID-19 pandemic to allow all citizens and residents to receive the COVID-19 vaccine by scheduling an appointment with the date and nearest center, and then receiving a message with the exact date of vaccination. Additionally, it enables users to access medical e-services and health information offered by different health institutions in the Kingdom, as well as retrieving and sharing sick leaves. Shortcomings: View limited information from the patient's history. Patient records cannot be exchanged between hospitals. The difference: It is used to schedule a COVID-19 vaccine, but our Blockchain project is focused on storing all patient records in one place and our recorded information is not modified.

ANALYSIS OF PATIENT DATA IN GERMANY. Achievements: It is a project in Germany that helps collect the patients' data whose medical information is stored with their insurance company which is where they enrolled coverage. By using the insurance number, the needed information is shared with other hospitals. Shortcomings: If the patient does not have insurance, he will not be able to benefit from this project. The patient can have a subscription from more than one insurance company, and there may not be information sharing between insurance companies. The difference: There is a slight difference between our project and this project, which is that they use the insurance number and the unique number to review the medical record.

Discuss the most recent techniques. Blockchain is now generally used because it's simpler and safer. Other similar systems have guaranteed, Security, confidence, and ease were ensured. There's always a modify the recorded information. Our framework using Ethereum, in our view, would prevent modifying the recorded information by making electronic health records.

ETHEREUM. Blockchain is considered a decentralized distributed ledger execution that records the collection of documents and transactions that multiple users create. In addition to being a modern variant of a distributed one, the nature of smart contracts, a pseudo-anonymized and un-tamperable database, such as a modern system distributed, replicates the computing model along with certain complexities (Ferrettiet.al., 2020). Ethereum is one of the common Blockchain, and it is based on the Turing- complete scripting language that promotes the development of decentralized applications (Buterin, 2020). Ethereum is a shared virtual machine that belongs to everyone, but it is not managed by anyone. Ethereum is permanently accessible; no one can interrupt or censor the execution (D'Angelo et.al., 2020). Public code executions are carried out with multiple nodes which are considered part of a network. Ethereum has a cryptocurrency called Ether. This Ether could be passed through transfers between accounts which is used to pay the miner node that maintains the evolution of the Blockchain. however, it is not just the cryptocurrency; Ethereum implements four key features in the system: Token: various currencies live in a Blockchain. Smart Contract: a digital contract with code-stated guidelines. Smart Property: is the way to claim a physical (means non-digital) asset's ownership. DAO: the Decentralized Autonomous Entity, organized as a series of smart contracts specifying the organization's tokens, resources, and government regulations.

SMART CONTRACTS. A smart contract is an integral part of the architecture of Ethereum. They consider computer programs, which are caused by unique transactions, residing on the Blockchain. They don't have a central authority. In addition, they can be tracked and not updated until the Blockchain is deployed. Smart contracts are semi-autonomous business logic to transfer money and force payment as the result of a transaction. Contracts can store money, executable code, and data. In addition, the smart contract can connect with the other contracts and build new ones. The contract is a reactive entity, for example, an external event from an external account causes them.

Literature Review

In this section, we present an overview of blockchain development in the healthcare industry. Blockchain-enabled healthcare end-users data, including patient-generated health data, is considered the new gold. A significant stream of data that could be utilized for medical research is produced by the abundance of wearable and downloadable health applications available worldwide. There are numerous applications of blockchain technology in patient-generated health data. For instance, when it comes to data transfers and the sharing of private health information, Healthbank, a global startup in the Swiss digital health space, adopts a different strategy. This company offers its clients a secure platform where they can manage and monitor their medical records while maintaining authority over their information. Blockchain is applied and implemented by Healthbank as part of its core business concept. In the future, personal health data generated by patients (such as blood pressure, heart rate, and medications) could be securely stored in Healthbank and retrieved from wearables, health apps, or doctor visits using blockchain technology (Mettle, 2016; D'Angelo et al., 2020).

Mettler (2016) emphasizes that handling and processing the enormous volume of data generated by patients securely is essential. Additionally, the blockchain network manages the implementation of a crucial module known as the access management system, which is necessary when multiple stakeholders are involved in the data generation process. This study outlines two essential blockchain networks in the proposed architecture: the External Record Management (ERM) Blockchain and the Personal Health Care (PHC) Blockchain. The PHC Blockchain is typically maintained by the patient and uses personal wearables to collect and identify data. The information is available to doctors, who can use it to assess the patient's condition and prescribe the appropriate treatment. The data gathered from wearable devices is stored in a third-party cloud database managed by the blockchain network.

The ERM Blockchain, on the other hand, is used to store data generated during patient consultations, such as pharmaceutical bills, medical test reports, prescriptions, and imaging data. Based on the "Proof of Stake" mechanism, which requires consensus from all blockchain participants, the data is securely attached to the chain (Chakraborty, Aich, & Kim, 2019; Mettler, 2016).

This study also discusses BlockHR, a system for managing medical records that helps doctors and patients diagnose, treat, and monitor health conditions more effectively. In terms of security and privacy, BlockHR outperforms the traditional client-server model. Testing results show that BlockHR's data retrieval is 20 times faster than the client-server approach (Ismail, Materwala, & Sharaf, 2020; Chakraborty et al., 2019).

The Health Information System (HIS) involves gathering, organizing, and distributing Electronic Medical Records (EMR) to manage healthcare data and support hospital operational management. Furthermore, HIS adheres to industry standards such as the ICD-10, which includes codes for diseases, symptoms, signs, external sources of illness or injury, social context, complaints, and anomalies. HIS also uses DICOM (Digital Imaging and Communications in Medicine), a protocol for the exchange, storage, and management of medical imaging data. Additionally, BiiMED, a blockchain platform for enhancing data integrity and interoperability in the Electronic Health Record (EHR) exchange, was highlighted. BiiMED manages and validates data sharing between medical facilities. This blockchain framework was developed using the Ethereum platform, and smart contracts were created using the Solidity programming language (Kamel et al., 2020; Chakraborty et al., 2019).

Pftom is a blockchain technology that employs fingerprint authentication. It generates a private key whenever a sensitive activity is carried out by selecting a user's fingerprint image at random and creating a local fingerprint feature database for identity verification. Pftom combines blockchain technology and fingerprint identification. Using Delegated Proof of Stake (DPOS) as the blockchain consensus technique, Pftom generates private keys by hashing a random fingerprint image to a fixed-length string (Lv et al., 2020; Ismail et al., 2020).

By 2025, healthcare systems that implement blockchain technology are projected to save between $100 billion and $150 billion annually by reducing data breaches, fraud, and counterfeit items. Blockchain adoption will also reduce operational costs by boosting data efficiency and fostering trust. The inherent characteristics that make blockchain suitable for healthcare data management include decentralized storage, transparency, immutability, authentication, flexible data access, interconnection, and security. Blockchain's use of smart contracts can eliminate intermediaries by defining terms and conditions that all healthcare partners in the network accept, reducing administrative costs. Blockchain consists of three main components: peer-to-peer networks, public key cryptography, and consensus protocols.

Access to comprehensive medical information is crucial for providing personalized treatment, especially since most medical systems today do not offer adequate trust, privacy, or security. Patients cannot claim complete ownership of their medical records as they may alter or erase information. When patients move to another hospital, they often must repeat tests, which increases costs. Blockchain addresses these challenges by storing data on a decentralized peer-to-peer network that is only accessible through smart contracts (Yousof et al., 2021; Jabbar et al., 2020).

Blockchain technology can also enhance the reliability of clinical trials (CTs) and precision medicine by ensuring data integrity and transparency, addressing issues of inaccurate CT data reporting. Blockchain improves the precision of data analysis and supports patient recruitment, clinical supply chain tracking, auditing, and preserving trial data integrity, ultimately shortening trial durations. In precision medicine, blockchain can manage genetic sequencing, which aids in the proactive treatment of various conditions. About 10% of chronic diseases are hereditary, and understanding individuals' DNA profiles through genetic sequencing can help prevent certain illnesses. Patients can share their genetic information to support drug development, public health studies, and medical research (Samer et al., 2021; Qi et al., 2020).

The management of patient records is one of the most prominent blockchain applications in the medical field. Patient data is often split into sections by insurance categories, which simplifies the process of organizing a patient's medical history without requiring inquiries from previous medical practitioners. However, this process can be time-consuming and prone to human error. Blockchain technology enables the storage of health information securely and efficiently. Patients should have direct and transparent access to their medical history, which becomes easier when all patient information is maintained in one location. This allows both patients and clinicians to access data more conveniently.

Medical records have become increasingly important. Patients, however, do not have full ownership of their health records, as they may alter or remove information from them. Repeating medical tests is often necessary for patients who switch to a different medical facility, which leads to increased healthcare costs. A decentralized, peer-to-peer network for storing data can address these issues, allowing smart contracts to grant access to the information. This data can then be safely shared between hospitals, helping new physicians understand patient histories and improving treatment outcomes (Bazel et al., 2021; Yaqoob et al., 2021).

Blockchain technology has the potential to provide an immutable record of a product's journey through the supply chain, offering a framework that allows transparent and auditable access to off-chain health information for various stakeholders. In the healthcare industry, blockchain has been applied to systems that track and trace food products and medications. In health insurance, blockchain technology could streamline claim resolutions and manage payments in real-time by using smart contracts. This could enhance process efficiency and transparency for payers, providers, and patients (Xavier et al., 2021; Omar et al., 2021).

Blockchain bridges the gap in understanding mobile health applications by offering robust security and functionality (Reinert & Corser, 2021; Bazel et al., 2021). The difference between personal health record (PHR) systems and electronic health record (EHR) systems extends to how they incorporate Health Internet of Things (h-IoT) technology. This study examines modern PHR systems, focusing on maintaining patient privacy in a data-interoperable manner while integrating IoT data. It also considers the European General Data Protection Regulation (GDPR) rights for all citizens, including patients (Alamri et al., 2021; Velmovitsky et al., 2021).

The FogChain architectural paradigm combines the Internet of Things (IoT), fog computing, and blockchain technology for healthcare applications. Fog computing can be considered a layered service framework extending cloud computing, using low-power processing nodes with limited hardware capabilities to deliver cloud services more quickly (Mayer et al., 2021; Reinert et al., 2021).

ElectionBlock is a voting system operating on a centralized network of nodes with a biometric scanner to maintain vote integrity. This system design ensures data integrity and distinguishes between registered and unregistered voters. A fingerprint reader retrieves biometric data from a voter database, ensuring both security and control for users (Ibrahim et al., 2021; Alamri et al., 2021).

Types of health records: EMRs, or electronic medical records, are defined by the ability to store an infinite amount of patient data, protect patient privacy, detect a wide range of cases, including contagious and non-communicable illnesses, and analyze the data fast to identify patients who may be at risk, ultimately leading to better patient treatment. The electronic health record, or EHR, is a technology that supports the coherence, efficiency, and effectiveness of medical treatment. It also makes it easier for users to access information quickly and efficiently and enhances user performance. Health technologies are essential for tracking and recording data such as blood markers, stress, sleep patterns, medication intake, and other information. Electronic Personal Health Records (ePHRs) are an electronic program in a private, secure, and confidential environment where patients see, exchange, and maintain their health information. They also allow patients to make appointments and communicate with medical professionals (Cerchionea et al., 2023; Mayer et al., 2021).

The NewbornTime project aims to develop an AI-based system using video recordings from births and newborn resuscitations. The project includes the development of a semi-supervised deep neural network (DNN) model to recognize activity from thermal video and an automated system to securely collect data. This system assesses compliance with resuscitation guidelines and identifies successful resuscitation patterns. By enhancing treatment protocols and increasing patient safety, the project is expected to reduce the number of newborns suffering from birth asphyxia (Bach et al., 2023; Ibrahim et al., 2021).

The Internet of Things (IoT) plays an essential role in monitoring public health by continuously recording physical activity, glucose levels, blood pressure, and heart rate. Remote Health Monitoring (RHM) technologies are increasingly available and trustworthy, allowing for early detection and treatment of illnesses. These wearable healthcare monitoring technologies enable physicians to remotely monitor their patients' conditions. By incorporating blockchain technology, privacy and reliability in these systems can be further enhanced (Upadrista et al., 2023; Cerchione et al., 2023). Although several additional studies have been reviewed, the most notable ones with unique ideas and content are highlighted here.

Proposed Work

In this section, we'll outline the system we'll develop to keep track of a patient's medical history in one place and make it accessible from anywhere at any time using Blockchain technology. During our research into previous studies and research on Blockchain applications in the health field, we discovered several flaws, the most notable of which is giving the patient full control over his health record, where he can agree or refuse to look at his health record, potentially withholding important information about his health from his doctor, causing a slew of issues. In this respect, we seek to develop the system through our project proposal, which seeks to construct a unified health record system in which all patient data and information, such as patient history, analyses, x-rays, prescriptions, clinical trials, and so on, it is stored in a single location, making data sharing across hospitals simple and convenient thanks to Blockchain technology. Our objective is to develop a system that is simple and secure. As a result, we can realize our goal of saving the lives of many people.

The architecture will be put into practice as a decentralized Blockchain network application. The major goal is to use Blockchain smart contracts to facilitate information sharing by enabling medical professionals, labs, and emergency rooms to exchange patient data with as many parties as possible (Figure 2). The major aim is to reduce the mistake rate caused by physician misinterpretations by eliminating the long waiting time process, removing the fraud aspect from the system, and simplifying the prescription processing process. The doctor prepares a prescription for the patient and uses smart contracts to enter it into the patient's medical records. The pharmacist then uses the Blockchain to access the prescription. When a patient attends a laboratory for a blood test, this is the case. The patient receives these notifications via the Blockchain, which is a notification that the processed results of the test can be accessed. If the patient has an emergency and is not responding, the emergency department will be able to quickly access the patient's information via the Blockchain and he will be able to provide treatment to the patient. Allowing a patient's medical data to be published on the healthcare Blockchain eliminates the hassle of carrying lab results or arranging for data to be sent to other doctors. It also guarantees that all healthcare practitioners have access to the data they need to give the best treatment possible.

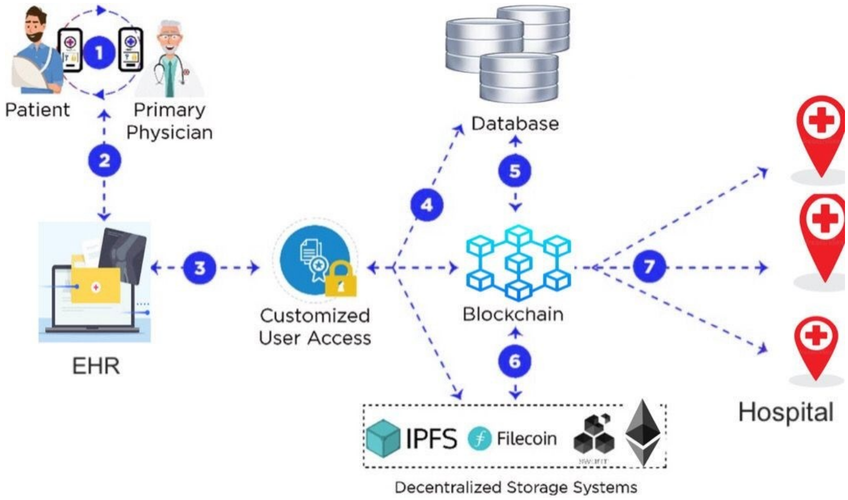

Figure 2. Blockchain-based patient record management

Proposed Work Requirements

The requirements for the project are divided into two main categories: hardware and software. Software Requirements: Latex, Word, PowerPoint. DFD design software online (for Architectures, DFDs). Plagiarism Checker X (to detect plagiarism in research papers). Blackboard and Zoom for meeting and discussing. Remix IDE for writing Solidity smart contracts. Truffle Framework for testing and development of Smart Contract. React Framework for front-end development. Drizzle Framework to enable frontend to interact with deployed Smart Contracts. Ganache to create a local Ethereum Blockchain for developing and testing. MetaMask to manage Ethereum accounts.

System Design Procedure

From systems theory to product development, the process of specifying the architecture, parts, modules, interface, and data is known as system design. In this section, we'll use the DFD and UML diagrams to construct our system.

Diagram of Data Flow a crucial tool for requirement analysis, DFD is a graphical tool that makes it simple for users to comprehend and analyze system data flow. It eliminates the system's specific content and accurately describes the system's functions, inputs, outputs, data storage, and other components logically. It also allows you to model the relationships between the various data flows and how the data ends up in different locations.

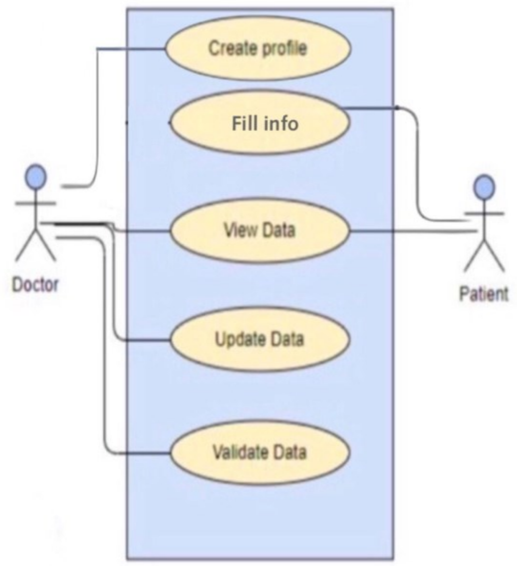

Figure 3. Use Case Diagram of our proposed work

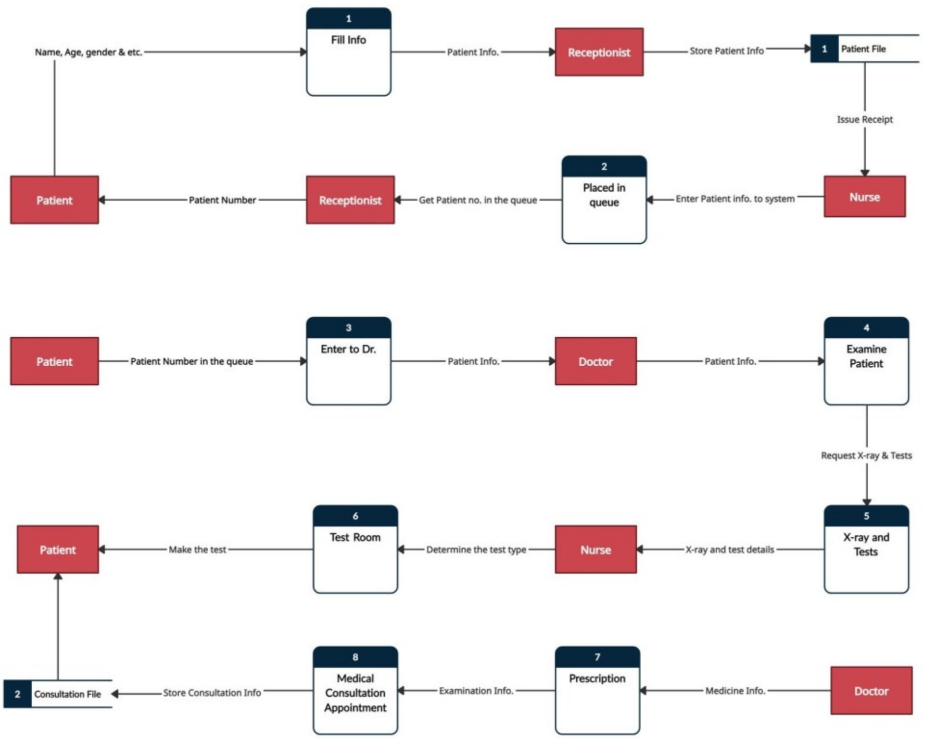

Figure 4. DFD Diagram of our proposed work

Implementation and Testing

This section discusses all the many parts and features involved in the proposed system's implementation. The chapter focuses on providing a broad overview of the system's architecture and design, as well as going into further detail on the various technologies and designs included.

Implementation Steps

While there are numerous steps involved in system installation, the main ones we are focused on for this website are development, testing, training, and documentation. The objective of these processes is to translate the physical system specifications into hardware and software that functions and is dependable, to document the work completed, and to offer support to both present and future system builders and users. We will explain the system services and how to build them in this part.

Implementation Procedure

The suggested framework is a dApp, or decentralized application. The dApp is built from the backend and the front end, which are linked together using Node.js, a JavaScript runtime environment. The framework's backend incorporates smart contracts. The smart contracts were created with the solidity programming language and the combination of truffle and ganache. Truffle is an Ethereum development framework that makes it easier to create and deploy smart contracts. Ganache is a personal Ethereum blockchain that simplifies the process of testing and executing smart contracts. The system's front-end is constructed with React.js, a JavaScript framework designed for simple integration with HTML and JavaScript to create user interfaces. Furthermore, the front-end requires a cryptocurrency wallet; Meta-Mask was utilized in this system, and it allows users to connect with an account to the Blockchain network, which is required to participate in the system and complete transactions.

System Design

The system is divided into four major tiers. The four key levels are the UI layer, the blockchain layer, the contact layer, and the data layer. This part will explain the role of each layer in the system, beginning at the bottom.

Contract layer

Each smart contract deployed on the Blockchain is part of the contract layer. The primary goal of smart contracts is to carry out transactions between two peers on the Blockchain, with specified requirements that must be met for the smart contract's functions to work successfully. The concept of smart contracts is intended to give fine-grained access control to the system's multiple transactions, guaranteeing that no unauthorized access occurs.

Blockchain layer

The system makes use of Ethereum blockchain technology/network. Ethereum was created during the creation of the cryptocurrency Ethereum, with the overall goal of developing an open-source smart contract platform. Ethereum has its currency, Ether, which is the global currency used for transactions on the Ethereum Blockchain. Ethereum also includes its programming language, Solidity, which allows developers to create smart contracts for the Blockchain.

Data layer

- The Interplanetary File System (IPFS) is used to store decryption keys, which is a public key for a doctor.
- MongoDB is used to store patient data.

UI layer

The UI layer refers to the system's front end, which was built using React.js. The UI layer's goal is to make the process easier for users and to collect the arguments needed for the system's actions. The UI layer also features MetaMask integration, which allows each system node to execute different functions dependent on the user's role.

Sampling Procedure

The main parts of our website are explained with some samples. Through the registration page, (doctors, patients, and hospitals) can register in the system, and its data is linked to a metamask and their data is stored in the database.

Major Findings and Discussion Work

The expected result of this work:

- Improving the quality of health care and patient safety through standardizing medical records.
- Updating patient records with new information such as the patient's medical history, and drugs.
- In addition, the patient's previous medical records are kept.
- Allow the patient to view all his/her medical information and test results.
- Maintain medical records consistently and professionally to protect patient confidentiality and privacy while giving sufficient access to service providers to improve patient care quality.
- Reducing misdiagnosis due to a doctor's lack of knowledge of the patient's health state and making the procedure of sharing medical records between hospitals easier.

The primary goal is to empower individuals to take charge of their health records so they are not dependent on other organizations or hospitals that they may visit. Electronic health records (EHRs) may be tracked in an inventive and enjoyable way with the use of blockchain technology and smart contracts. With the use of this technology, patients may be able to better manage their data. Hospitals and other healthcare providers have access to patient data that is held by other entities.

EHR is constructing the future of healthcare on Blockchain. Similar initiatives exist, but EHR's distinct goal shines out. It comes with the specialty of using Blockchain. Because it includes an updated medical record of the patient, Blockchain technology makes it simple to monitor population health, and identify dangers and patterns in the spread of any disorders. This contributes to the promotion of effective therapy for people all around the world. Because it is decentralized, it is not held by a single party, and the data is cryptographically stored and extremely safeguarded. The system's outcomes were as predicted.

Conclusion

The medical industry and healthcare systems face challenges, as many deaths are attributed to misdiagnoses by doctors, which are mostly brought on by incomplete patient histories. At present, the patient has the responsibility of providing the physicians with his or her medical history and ensuring that he or she always has medical bills, radiological scans, and lab results on hand. A study by the American Academy of Allergy, Asthma, and Immunology found that multiple drug intolerance syndrome affects 2–5% of patients who seek medical attention. All these issues will be resolved when we create a system that stores the medical record histories of all patients. Of course, there are many of these systems, and they all have serious issues because they use traditional databases. Here, Blockchain technology emerges as a solution to these problems, and Medicare is created. Medicare strives to provide patients with a safe and secure way to save and exchange their medical records with their doctors. To achieve this, we plan to use a Permissioned Blockchain Network as the backend. This network guarantees an immutable history and prevents data manipulation. Our goal is to develop a secure system that uses blockchain technology to store patient histories and link patients and healthcare facilities worldwide. Connecting all hospitals and patients digitally is our vision and the passion that keeps us going. In the future work, we will seek to achieve the following goals to improve our work for the better:

- Develop a desktop application for use in hospitals.
- Integration with IoT devices such as smartwatches and healthcare devices to offer all necessary additional data to the medical record profile.
- Provide an emergency method for chronic disease sufferers to remember to take their medicine.
- Integration with smart assistants to recall appointments with doctors and remind people to take their medications, as well as to aid doctors.
- Enrich the website with vast data and utilize it in conjunction with algorithms to forecast and plan doctors' schedules, prioritizing critical cases first.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Alamri, B., Javed, I. T., & Margaria, T. (2021, April). A GDPR-compliant framework for IoT-based personal health records using blockchain. In *2021 11th IFIP International Conference on New Technologies, Mobility and Security (NTMS)* (pp. 1-5). IEEE.

Bazel, M. A., Mohammed, F., & Ahmed, M. (2021, August). Blockchain technology in healthcare big data management: Benefits, applications, and challenges. In *2021 1st International Conference on Emerging Smart Technologies and Applications (eSmarTA)* (pp. 1-8). IEEE.

Buterin, V. (2013). Ethereum: A next-generation generalized smart contract and decentralized application platform. *Blockchain Papers: Curated Cryptoasset Publications*, 475-483.

Cerchione, R., Centobelli, P., Riccio, E., Abbate, S., & Oropallo, E. (2023). Blockchain's coming to hospitals to digitalize healthcare services: Designing a distributed electronic health record ecosystem. *Technovation*, 120, Article 102480. https://doi.org/10.1016/j.technovation.2023.102480

Chakraborty, S., Aich, S., & Kim, H. C. (2019, February). A secure healthcare system design framework using blockchain technology. In *2019 21st International Conference on Advanced Communication Technology (ICACT)* (pp. 260-264). IEEE.

D'Angelo, G., Ferretti, S., & Marzolla, M. (2018, June). A blockchain-based flight data recorder for cloud accountability. In *Proceedings of the 1st Workshop on Cryptocurrencies and Blockchains for Distributed Systems* (pp. 93-98).

Engan, K., Meinich-Bache, Ø., Brunner, S., Myklebust, H., Rong, C., García-Torres, J., Ersdal, H. L., Johannessen, A., Pike, H. M., & Rettedal, S. (2023). Newborn Time-improved newborn care based on video and artificial intelligence-study protocol. *BMC Digital Health*, 1(1), Article 10. https://doi.org/10.1186/s42492-023-00006-3

Ferretti, S., & D'Angelo, G. (2020). On the Ethereum blockchain structure: A complex networks theory perspective. *Concurrency and Computation: Practice and Experience*, 32(12), Article e5493. https://doi.org/10.1002/cpe.5493

Ibrahim, M., Ravindran, K., Lee, H., Farooqui, O., & Mahmoud, Q. H. (2021, March). ElectionBlock: An electronic voting system using blockchain and fingerprint authentication. In *2021 IEEE 18th International Conference on Software Architecture Companion (ICSA-C)* (pp. 123-129). IEEE.

Ismail, L., Materwala, H., & Sharaf, Y. (2020, October). BlockHR–A blockchain-based healthcare records management framework: Performance evaluation and comparison with client/server architecture. In *2020 International Symposium on Networks, Computers and Communications (ISNCC)* (pp. 1-8). IEEE.

Jabbar, R., Fetais, N., Krichen, M., & Barkaoui, K. (2020, February). Blockchain technology for healthcare: Enhancing shared electronic health record interoperability and integrity. In *2020 IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT)* (pp. 310-317). IEEE.

Mayer, A. H., Rodrigues, V. F., da Costa, C. A., da Rosa Righi, R., Roehrs, A., & Antunes, R. S. (2021). FogChain: A fog computing architecture integrating blockchain and Internet of Things for personal health records. *IEEE Access*, 9, 122723-122737. https://doi.org/10.1109/ACCESS.2021.3108251

Meier, P., Beinke, J. H., Fitte, C., Schulte to Brinke, J., & Teuteberg, F. (2021). Generating design knowledge for blockchain-based access control to personal health records. *Information Systems and e-Business Management*, 19, 13-41. https://doi.org/10.1007/s10257-020-00504-2

Mettler, M. (2016, September). Blockchain technology in healthcare: The revolution starts here. In *2016 IEEE 18th International Conference on e-Health Networking, Applications and Services (HealthCom)* (pp. 1-3). IEEE. https://doi.org/10.1109/HealthCom.2016.7749528

Omar, I. A., Jayaraman, R., Salah, K., Yaqoob, I., & Ellahham, S. (2021). Applications of blockchain technology in clinical trials: Review and open challenges. *Arabian Journal for Science and Engineering*, 46(4), 3001-3015. https://doi.org/10.1007/s13369-021-05249-3

Qi, Y., Fu, Y., Wang, T., & Lv, H. (2020, November). Pftom: A blockchain based on fingerprint. In *2020 Chinese Automation Congress (CAC)* (pp. 5338-5344). IEEE. https://doi.org/10.1109/CAC51453.2020.9355723

Reinert, J., & Corser, G. (2021, March). Classification of blockchain implementation in mobile electronic health records and Internet of Medical Things devices research. In *SoutheastCon 2021* (pp. 01-05). IEEE. https://doi.org/10.1109/SoutheastCon49436.2021.9432938

Shrivas, M. K., & Yeboah, T. (2019). The disruptive blockchain: Types, platforms, and applications. In *Fifth Texila World Conference for Scholars (TWCS) on Transformation: The Creative Potential of Interdisciplinary* (pp. 17-39).

Ullah, H. S., Aslam, S., & Arjomand, N. (2020). Blockchain in healthcare and medicine: A contemporary research of applications, challenges, and future perspectives. *arXiv preprint arXiv:2004.06795*. https://arxiv.org/abs/2004.06795

Upadrista, V., Nazir, S., & Tianfield, H. (2023). Secure data sharing with blockchain for remote health monitoring applications: A review. *Journal of Reliable Intelligent Environments*, 9(3), 349-368. https://doi.org/10.1007/s40860-023-00183-5

Velmovitsky, P. E., Bublitz, F. M., Fadrique, L. X., & Morita, P. P. (2021). Blockchain applications in health care and public health: Increased transparency. *JMIR Medical Informatics*, 9(6), e20713. https://doi.org/10.2196/20713

Yaqoob, I., Salah, K., Jayaraman, R., & Al-Hammadi, Y. (2022). Blockchain for healthcare data management: Opportunities, challenges, and future recommendations. *Neural Computing and Applications*, 1-16. https://doi.org/10.1007/s00500-022-06003-8

Bibliographic information of this paper for citing:

Alwehaibi, Ghadi; Salem, Rwaida; Alrshidi, Nahed & Alghulayqah, Abeer (2024). A Blockchain Network for Public Health Interoperability and Real-Time Data Sharing. *Journal of Information Technology Management,* 16 (4), 18-37. https://doi.org/ 10.22059/jitm.2024.99049