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Blockchain Empowered Interoperable Framework for Smart Healthcare

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ABSTRACT

In the past, healthcare industry used paper-based systems to manage and store medical records. However, these systems are vulnerable to data breaches, loss, and errors. To overcome these issues, a research study has been conducted to create a safe and efficient Electronic Data Interchange (EDI) system for healthcare using blockchain technology. The study utilized various tools and methods including Python as the programming language to implement the blockchain environment, the pyQT5 library for graphical user interface (GUI), and the MySQL database management system as a repository for Electronic Health Records (EHR) with DBeaver, a cross-platform tool for data management. The research work involves the development of a blockchain-based smart contract for the storage, exchange, and retrieval of EHR. Additionally, a Python application based on pyQT5 is created to provide users with a friendly GUI. The proposed blockchain-based healthcare system provides a secure and efficient platform for storing and managing EHR as well as enabling secure EDI among healthcare stakeholders like practices, doctors, labs, and pharmacies. Furthermore, the system is scalable and user-friendly, and includes various features like patient visits, history, practices, doctors, and appointment scheduling. Blockchain technology ensures EHR integrity, secure EDI, and confidentiality, while the user-friendly interface enhances the user experience compared to the existing EDI standards like health level 7 (HL7).

1. INTRODUCTION

Electronic Data Interchange (EDI) in healthcare is among the hottest areas of research where the data is exchanged among several stakeholders without human intervention [1]. It enables seamless, efficient, hassle-free, and error-free data exchange. In this regard, several grammars, languages, and standards, such as Health Level 7 (HL7), have been introduced to provide interoperability among healthcare service providers such as practices, doctors, laboratories, pharmacies, and insurance companies [2]. The EDI is not just limited to the healthcare sector but also in finance, education, and other areas that benefit from it [3, 4]. In these systems, data integrity and privacy are the key features where the grammar takes care of potential errors occurring during file transfer and provides the related data to the intended stakeholder. HL7 complies with the Health Insurance Portability and Accountability Act (HIPAA) 1996, ensuring privacy of the patient data [3, 4]. However, data security was not a prime consideration at that time. So, the data encoded by HL7 or similar grammar is potentially vulnerable to breaching. The problem to be tackled involves the security, integrity, and validity of the patient's profile as different hospitals and organizations handle it. These profiles' synchronization and up-to-date information can slowly drift apart with time and as different instances are made consequently [5].

For instance, a generic web interface designed by Alhiyafi [6] featuring various standards and versions of HL7 to assist healthcare stakeholders in interoperability across various channels. The interface is helpful and enhances interchangeability with privacy; however, it needs more security because the native data interchange is vulnerable to breach. The motivation behind the study is to create a secure and efficient environment regarding exchanging electronic medical/health records of patients in the hospital. Every piece of patient-related data is considered sensitive, so the recent advancements in blockchain technology will improve the process quality, security, and exchange of this medical multi-transaction data while maintaining reasonable costs for the stakeholders.

The proposed system secures the remote data exchange of a patient's health records and tracking it across hospitals and related organizations. The healthcare system project using blockchain technology aims to revolutionize the healthcare industry by providing a secure and efficient way of storing and retrieving medical records and using specialized encryption formats like hashing and storing keys in a blockchain. The data will be blocked for other irrelevant departments. For example, when a patient visits a doctor, the doctor will collect the patient's data related to various clinics or practices. Like suggested medications and operation costs meant for health insurance companies, these operations need to be secure and safe to protect patients' sensitive data and be readily available and up-to-date so as not to hinder transactions.

After reviewing blockchain capabilities and observing its performance in modern applications like cryptocurrency exchange, it is evident that the blockchain offers valid solutions to some long-lasting problems faced in current conventional data exchange methods. It helps verify and trace multi-transaction data, provide security, minimize costs, and increase information availability. The aims and objectives of this study are to improve and modernize the medical staff operation through:

- Taking advantage of blockchain advancements to enhance the security of medical sector operations.
- Improving the availability of healthcare resources.
- The benefit of blockchain's chain method is the ability to track transactions more accurately.
- Streamline services for casual users and patients, including working storage capacity, medical reports data, data security and privacy, and Access and edit privileges for different roles.

The rest of the paper is organized as follows: Section 2 is dedicated to the review of related literature. Section 3 focuses on the implementation of the proposed blockchain in healthcare environments. Section 4 contains the results of implementation, Section 5 provides the discussion on the results, and Section 6 concludes the paper.

2. LITERATURE REVIEW

The process of converting data from one schema (the source) to another (the target) using a set of rules that represent source-to-target dependencies is known as data exchange [1]. However, in some cases, a single mapping can satisfy more than one legitimate target instance, which contradicts the main objective of data exchange. The goal is to create a unique materialized target instance that can answer queries about the target schema without relying on the source instance. To address this problem, a new concept called definability abduction is introduced in this study. It tries to identify additions to the initial schema mappings to ensure the uniqueness of the materialized target instance. The study uses various semantic criteria to choose appropriate additions and offers sound and thorough methods. The study also examines several data interchange contexts, including those with source and target dependencies.

In the healthcare industry, patients often receive treatment at multiple hospitals or clinics, making it essential to share their health records securely and efficiently. For cancer patients, proper communication and interaction are crucial, given their critical health conditions during treatments. An up-to-date and temporal history of the patient is vital for assessing and enhancing the care provided. As a result, there is a growing need for immediate provisioning of the patient health records (PHR) [3]. Existing solutions for exchanging data include blockchain technology, which has been applied in oncology data sharing.

Access to Personal Health Records (PHR) can enable precision treatment and improve the quality of healthcare. However, healthcare data is vulnerable to misuse. Therefore, it is essential to ensure that patients have control over who can access their data and when. This is particularly important as a patient's medical history can play a significant role in determining their treatment [4]. One issue that needs to be addressed is how to maintain the completeness and security of patient data while ensuring quick and easy retrieval following the patient's consent, even in the presence of PHR and electronic health data exchange (EHDI) environments. Recent advancements in blockchain technology have generated a lot of interest from both corporate and academic communities.

Blockchain is a peer-to-peer distributed ledger technology that provides a transparent and tamper-proof record of each transaction for each registered network user. It is secured using cryptographic techniques such as digital signatures, hash functions, and encryption [5-7].

In a blockchain network, participants broadcast and digitally sign transactions, which are then timestamped and organized into blocks according to their chronological order. The content of each block is hashed, creating a unique identification for that block. This identification is then kept in the block. Blockchains can be programmed to perform various tasks, which are executed through smart contracts or chain codes written in a domain-specific or general-purpose programming language. A consensus process is used to add a new block to the ledger. Depending on how a member's identity and right to participate in the consensus is defined, blockchain systems can be either public or private, permission or permissionless. In a permissionless system, every participant can submit a transaction or participate in the consensus mechanism, and their identities are either pseudonymous or anonymous. A permissioned blockchain offers a mechanism to identify the nodes that can modify the shared state and regulates who can initiate transactions. Such a blockchain can be either private, where access to the ledger is controlled at the level of users' membership or identity, or public, where anyone can view the ledger, but only a specific group of users can participate in the consensus process [8].

A list of consensus protocols commonly used in permissioned blockchains, such as Hyperledger Fabric, Tendermint, R3 Corda, and MultiChain, have been described by Cachin and Vukolić [5]. Blockchain technology allows users to have complete control over their data and privacy without the need for a centralized point of control, making it an efficient, secure, and cost-effective solution for developing applications for sharing EHR. The blockchain has been proposed and implemented as a secure hospital system based on several motivations observed during literature review [9]. Although several EDI-based systems have been presented in the literature for the automated exchange of information in areas other than healthcare, they are vulnerable to security breaches due to the possibility of eavesdropping, even though the data is interchanged in a machine-readable form [10]. A blockchain-based EDI system for the healthcare sector is the need of the hour to address this issue [11]. Table 1 summarizes the reviewed literature.

Table 1. Summary of literature review

Application	Description	Limitation	Future Work
Drug Traceability	Drug traceability is typically managed through a centralized system, but certain challenges such as privacy, data authentication, and system flexibility remain [2]. To address these issues, several decentralized models have been developed. One such model is the blockchain-based system called Drugledger, which has been proposed to ensure the authenticity and privacy of traceability data [3]. Drugledger integrates blockchain technology with the drug supply chain to facilitate drug traceability.	While the drug traceability scenario presented in this paper is straightforward, real-life situations can be far more complicated. It's worth noting that the current system falls short when it comes to identifying and preventing the use of illegitimate medications [4]. As such, we must continue to strive toward creating more advanced and comprehensive solutions to ensure the safety and well-being of everyone involved.	To determine which drug traceability framework is more secure against DoS attacks, we will compare the proposed framework with existing frameworks.
Patient Supervising/Electronic Health Record (EHR)	The International Organization for Standardization (ISO) defines the Electronic Health Record (EHR) as a digital storage system for patient data that is securely exchanged and only accessible to authorized personnel [8, 9]. EHR contains confidential information about an individual's health problems and aims to provide competent assistance to the patient.	The verification of each block in the blockchain causes delays, and preserving each node is challenging.	This system utilizes the Ethereum blockchain, and future platforms will be built on this framework.
Handling EHR and Related Records	The use of healthcare applications in conjunction with IoT has the potential to address various drawbacks such as security and privacy concerns, as well as the issue of doctors recommending unnecessary medications and tests for profit. One solution to these problems is a proposed framework for IoT in healthcare that utilizes blockchain technology [8]. Additionally, blockchain technology can be used to secure data transferred from IoT devices within the healthcare system [9].	Transaction time is the central aspect, but this framework has yet to prioritize it.	No illegal operations are performed within this framework, but the cost requirement is not included. Therefore, in the future, communication will be expensive.

3. IMPLEMENTATION

Implementing the proposed study involves developing a healthcare system using blockchain technology. That is implemented by using Python programming language tools such as pyQT5 by using Anaconda to have pre-build libraries for building the graphical user interface.

3.1 System architecture

The system is designed to improve the efficiency and security of Electronic Health Record management by leveraging blockchain technology's decentralized and immutable nature [12]. Figure 1 shows the proposed blockchain-based EDI architecture for healthcare (coined as X-Chain-ge).

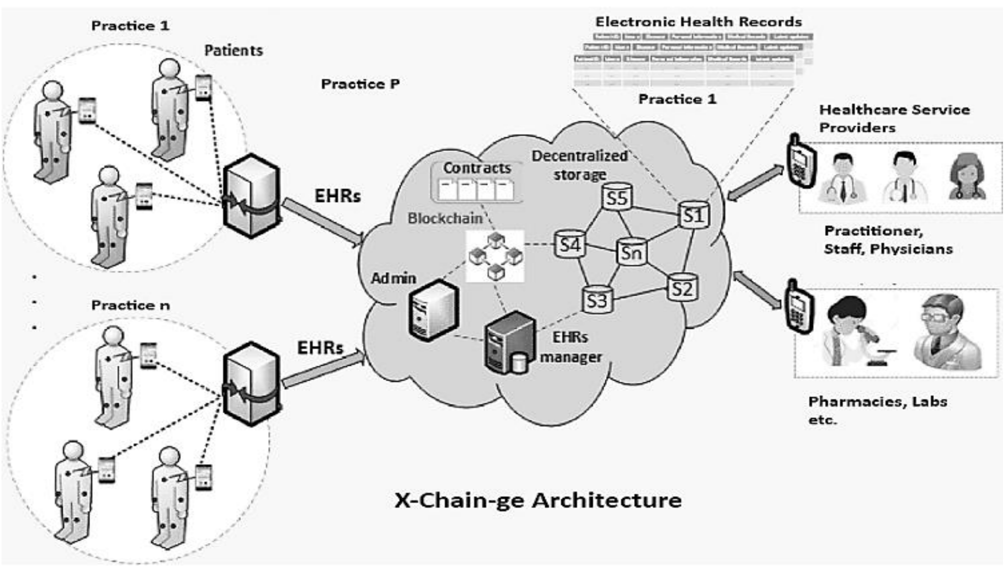

Figure 1. Proposed system architecture

Assuming there are 'n' number of practices (hospitals, clinics), several patients appear to be in these practices, and their HER has been maintained via the proposed blockchain-based system. Several stakeholders interact with the system through a secure EDI system, such as practitioners (doctors, nurses, midwives, therapists) and medical technicians such as laboratories and pharmacies. Decentralized storage is provided, and the proposed blockchain implementation provides the contracts and ledgers.

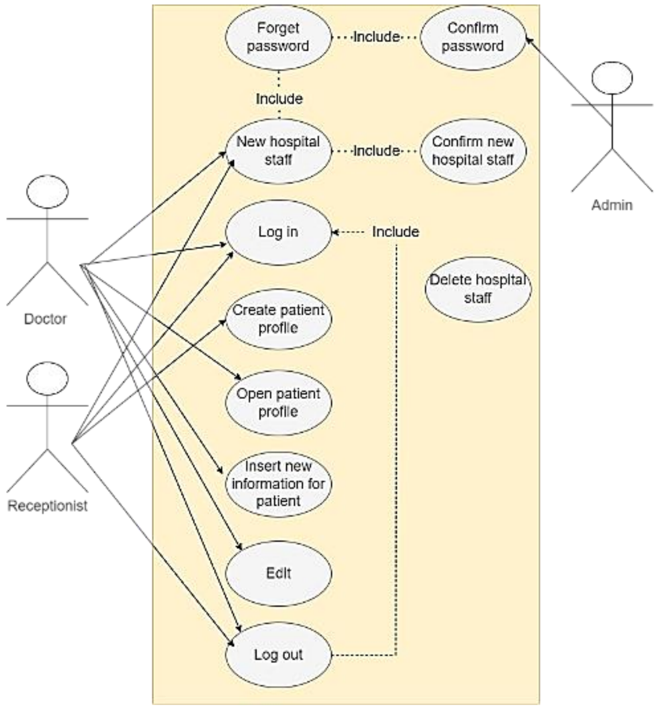

Figure 2. Case diagram for the roles

3.2 User roles and functions

The project has been built to have three roles: Administrator, Doctor, and receptionist. The scenario we have built begins with login as an administrator with four functions. First, sign up for practitioners (doctors) and staff (nurses, receptionist) with all the information needed, like first name, last name, major, and department. It is the first step for the admin to do; second, we have the delete staff function that will delete any Doctors or receptionist in the system by entering the user name for the staff that wanted to be deleted, third, view staff function and this function will display all the staff in the system with all the information needed, fourth, we have confirming changing password for doctors and receptionist that they forgot their password. Now, the user can enter as a doctor by entering the user name and password for the doctor registered in the system. The doctors have their functions like visiting the pharmacy to check that the hospital has medicine, showing all the appointments assigned to them with all the information needed, such as the patient's name and age, or seeing his profile or patient profile. He can write any description needed for each patient for his condition. After signing up for the receptionist/medical worker or nurse, the receptionist can now enter his/her page to work with the function that the receptionist has. The first function is to sign up for a patient and insert all the information needed for the doctor, and second, make an appointment for any registered patient for any doctor we have in the system for each department; third, change appointment information like the date, doctor, or even the patient. Fourth, the receptionist can change patient information if needed; fifth, the receptionist can add insurance for the patient if they have (optional); in this function, the receptionist can take the insurance card and enter a patient ID, insurance number, and the discount or the limit for his insurance type. Finally, a brief description in the form of a figure (Figure 2) is provided to show a use case diagram to simplify the role of each user in the system:

3.3 System design

The study has been divided into multiple stages. Initially, a smart contract on a blockchain platform has been developed to store and manage medical records. Solidity, a programming language created explicitly for the Ethereum blockchain, has been utilized to develop this smart contract. Subsequently, a Python application has been developed in the second stage, which interacts with the smart contract and allows users to create, read, update, and delete electronic medical records. The application will incorporate the pyQT5 (designer) library [13] to provide an easy-to-use graphical interface.

3.3.1 Graphical user interface

To use a graphical user interface (GUI), one must learn how to implement GUI in Python language, so we had to search for resources on YouTube and Pythonguis (website) [14]. However, after all, we had to use "Designer," which will be installed with the PyQt5 by entering this command [15]: that is, “pip install pyqt5”. Figure 3 shows the system's output implemented for blockchain in Healthcare 5.0.

Then, one can use the application that has drag and drop. The administrator can download the file as ".ui" and use a Python file to connect it by using libraries, or you can use a command that converts “.ui” to “.py" (from User Interface to Python file) by entering this command in cmd [16]:

“pyuic4.bat -x filename.ui -o filename.py”

This command will rewrite all the user interface code to Python code to make all the UI can be manipulated by Python by the programmers to use the code with no limits, so we have used this command to convert the UI code to Python code to edit all the UI function and connect them to our program function like adding staff, adding patient information and connecting program with MySQL and Mumbai testnet [17]. It is to transfer all the data in the blockchain and the database; we performed this step to make sure that the information that has been imported into the system is not manipulated by outsiders by comparing the hashed information in the blockchain with the information that has been entered in the database (Figure 4).

3.3.2 Relational database management system

In addition to the smart contract and Python application, the healthcare system will also require a database system to store and retrieve medical records. The database will be designed to ensure data consistency, availability, and durability. A relational database management system (RDBMS) such as MySQL to store medical records [18] can be utilized in this regard.

DBeaver [19] creates and manages database schema, tables, and views. The tool will also perform ad-hoc queries, export data, and monitor database performance. The database will be optimized to ensure fast read and write access to medical records. For the database we have made it by DBeaver that is connected by MySQL to simplify making the database with the needed information for all the table. The entity relationship diagram (ERD) for the proposed system is given in Figure 5.

There are various ways to implement the blockchain for EDI-based systems. However, the chosen components in the study are purely based on the related work in the review of literature. Further, some components are utilized based on their availability in the public domain because the current study is purely for educational purposes.

The Python application will interact with the database and the blockchain smart contract. When a new medical record is created, the application will create a new entry for the patient in the database and store their details, such as name, date of birth, and address. The medical record will then be stored in the blockchain smart contract, and the hash of the record will be stored in the database to ensure data integrity. The Python application will use pyQT5 to provide users a graphical user interface (GUI). The GUI will allow users to log in, view, and edit their medical records. The application will also provide features such as appointments and scheduling for the patients and doctors and alerts and notifications.

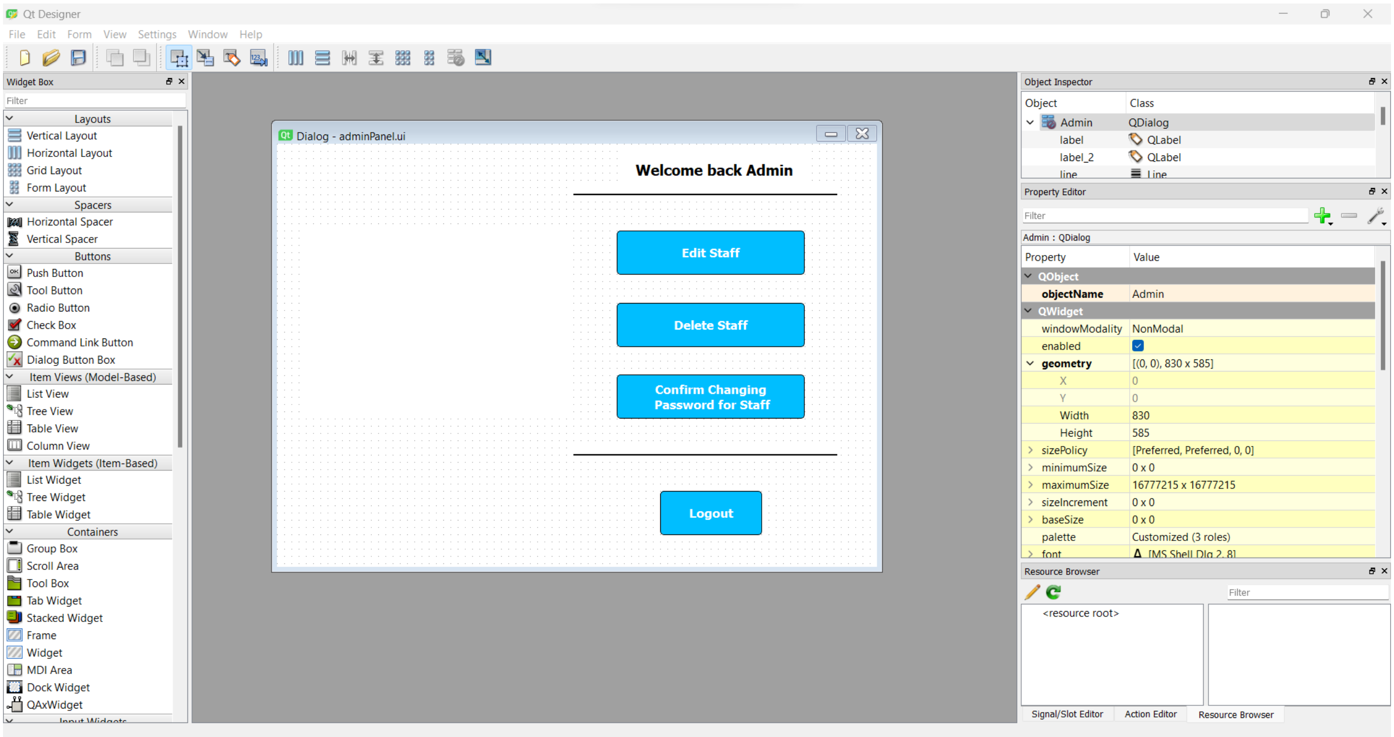

Figure 3. PyQt5 designers

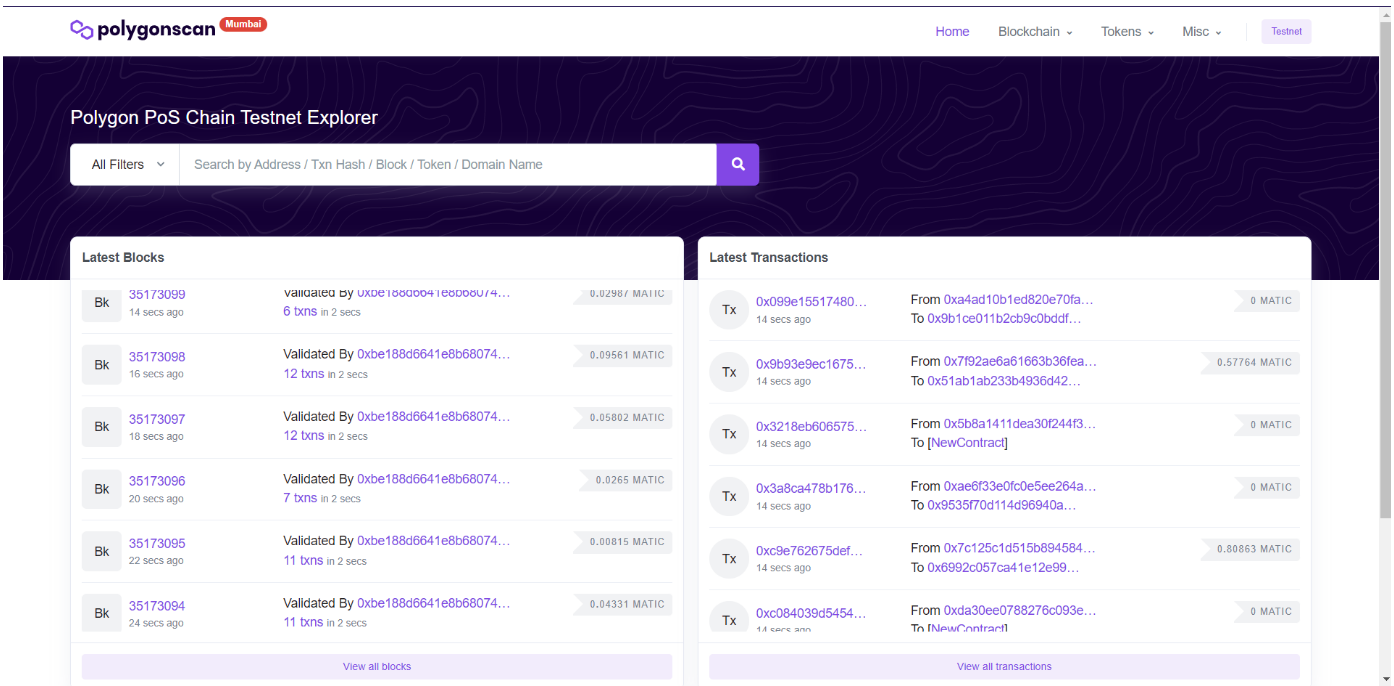

Figure 4. Polygon Mumbai testnet

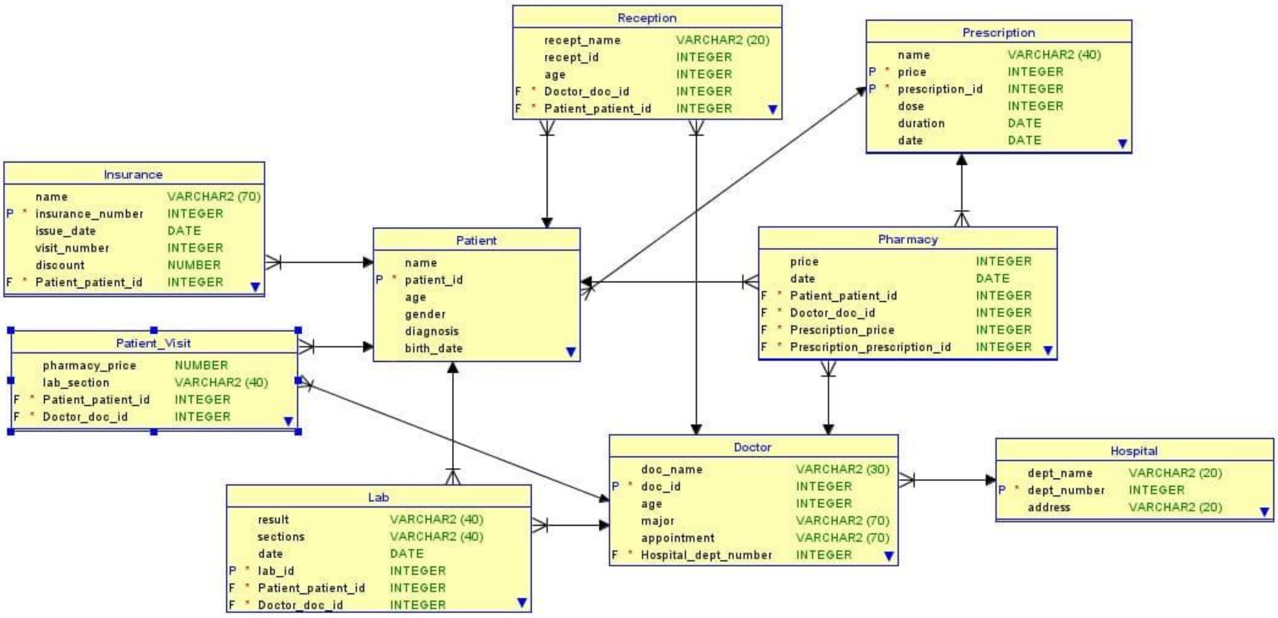

Figure 5. Relationship diagram

3.3.3 Blockchain integration

The application will implement a role-based access control (RBAC) mechanism to ensure that only authorized users can access the system. Different roles, such as doctors, nurses, and patients, will have different system access levels. In addition to the smart contract, Python application, MySQL database, and DBeaver app, the healthcare system has also used Mumbai testnet blockchain explorer to transfer medical information. Mumbai is a tenet of the Polygon network that supports Ethereum-compatible smart contracts. The database will be encrypted using an encryption algorithm such as SH256 to ensure the confidentiality of medical records. For using blockchain, we had to make a wallet in MetaMask [20] to add a token (without inserting real money) for our wallet to make a transaction in the polygon, so there is a need to follow the given steps: First, we had to go to ChainList [21] website and connect your wallet to the website then you must search “Polygon” and press “testnet" button, and then you can see Mumbai, and you can connect it to the MetaMask. It is depicted in Figure 6 visually.

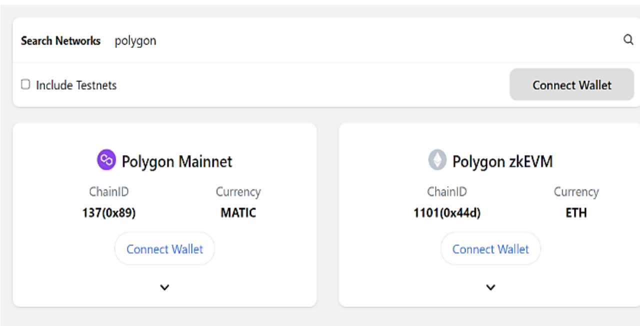

Figure 6. ChainList to add to the wallet

Second, to add some tokens to our wallet, we must go to the "faucet polygon" [22] website you must, select Mumbai, and select the token that we want to use. You must enter your wallet address, and after submitting, you must wait a few moments to fill your wallet with the tokens. The token addition process is shown in Figure 7. Third, must deploy your transaction to the wallet to have an address. After deploying the tokens, you have to go to "Mumbai PolygonScan" and copy the address in the search. After entering the address, you can see the main page of the contract that you have to validate it by scroll down to the contract-> "verify your contract secure code," then you have to enter your address again and select "Solidity (single file)" then you have to select the type license that you have, then you have to copy the code for your contract. The configuration code is depicted in Figure 8 to accomplish this.

Finally, you can publish or verify your contract. Then you can connect your application with the contract that you have now by writing the following script in a file in your application to call it whenever you want to access the blockchain and make transactions [23].

A. Provider
B. Contract filename
C. Address
D. Contract address
E. Private key

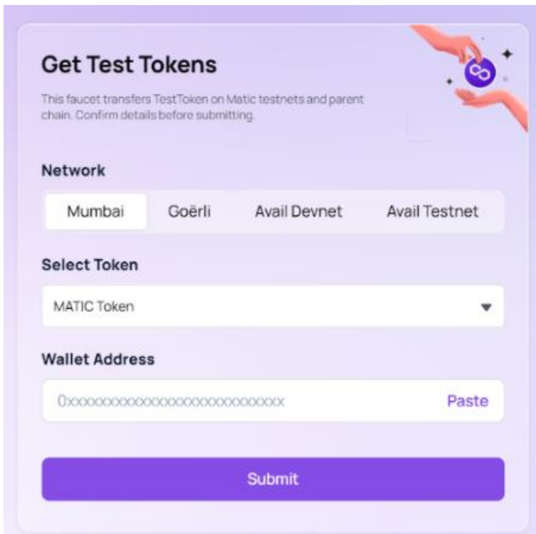

Figure 7. Faucet polygon to add tokens to the wallet

```
{
    "provider": "https://rpc-mumbai.maticvigil.com/",
    "contract_filename": "verification_contract.abi",
    "address": "address",
    "contract_addr": "contract_addr",
    "pvt_key": "private key"
}
```

Figure 8. Code configuration

After making the UI for all the pages and the function that we have, and after building the DB with all the tables that we need, we can connect the blockchain to the function that we have to write. The example UI diagrams are shown in Figures 9 and 10 for staff signup and insurance information, respectively.

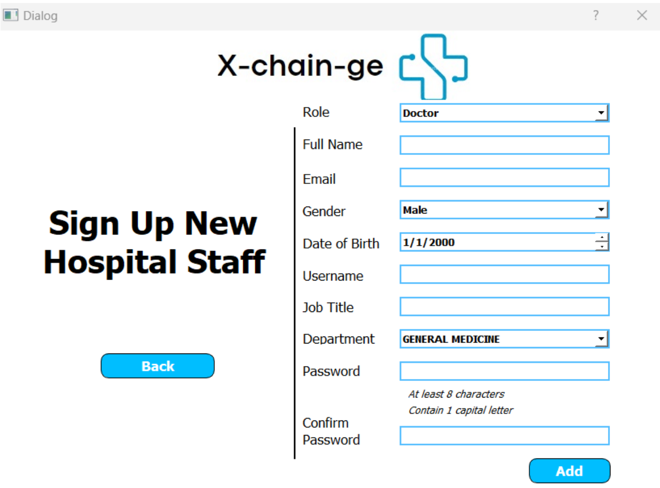

Figure 9. System UI for new staff signup

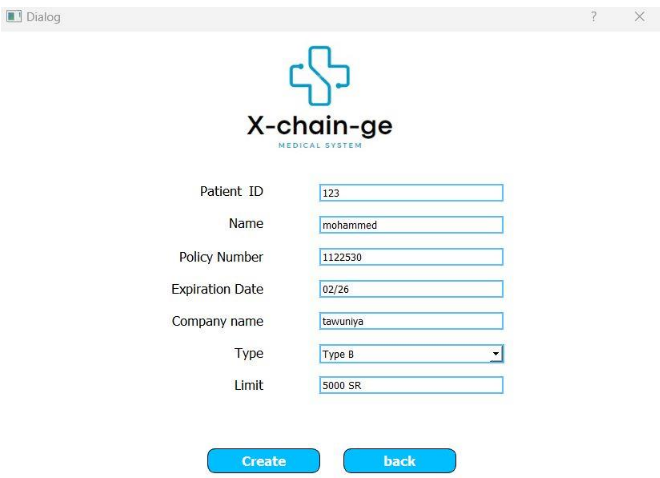

Figure 10. System UI for insurance information

You can encrypt the data before inserting it to the DB and the blockchain to save it, this step will make your security stronger by making a function that will compare the hashed data that we have in the DB and the hashed data in the blockchain to check that all the information that was imported from them that is verified and not manipulated by any outsiders. Implementing the healthcare system using blockchain technology, Python tools such as pyQT5, MySQL database, and DBeaver app will provide a secure and efficient way to manage medical records [24-26]. The system will revolutionize the healthcare industry by enabling patients to take control of their medical records and ensuring that medical information is accurate, secure, and accessible to authorized individuals [27, 28]. The concept of bitcoin can easily be incorporated into the designed framework where the predicted values of the bitcoin can be utilized as a potential source of the transaction in the framework. It is mainly the scenario where the insurance companies, their claims as well as the billing and transcription companies are involved [29, 30]. The insurance companies that are also potential stakeholders in the current picture pay the doctors, labs, and pharmacies. The payments can be made through cryptocurrency as a futuristic expansion of the study. In this regard, several studies have been conducted [31-33].

It is worth mentioning that the proposed framework will be a part of the existing hospital management system. Thus, certain operations such data backup and recovery measures, audit logs, and the way system ensures EHR confidentiality and complies with regulations such as General Data Protection Regulation (GDPR) or HIPAA.

4. RESULTS

Implementing a hospital management system based on blockchain technology has proven to be a significant leap toward improving the healthcare industry's efficiency, transparency, and security. Blockchain has enabled the creation of a secure, transparent, and tamper-proof platform for managing medical records and facilitating communication between healthcare providers and patients. Which has resulted in significant improvements in the accuracy and efficiency of diagnosis and treatment, leading to better patient outcomes.

One of the main advantages of a blockchain-based hospital management system is its ability to provide a tamper-proof and transparent platform for managing medical records. Using cryptographic algorithms, blockchain ensures that medical records are securely stored and accessed by authorized parties. it reduces the chances of errors and fraud while promoting transparency and trust between healthcare providers and patients. Another significant advantage of a blockchain-based hospital management system is its increased efficiency in administrative processes such as billing, insurance claims, and drug supply chain management [34-38].

With blockchain, transactions are faster, cheaper, and more secure, reducing the risk of fraud and errors while promoting transparency. Which not only benefits patients by reducing costs but also healthcare providers by streamlining administrative processes and reducing paperwork. Moreover, using blockchain in a hospital management system has also facilitated better communication between healthcare providers and patients. By giving patients more control over their data, they can decide who can access their information and when. It enhances patient privacy and confidentiality while promoting better communication and trust between healthcare providers and patients. Adopting a blockchain-based hospital management system has also significantly impacted coordination between different departments and institutions in the governance sector [39, 40].

By creating a decentralized and secure platform, healthcare providers can easily access patient records, reducing duplication of effort and ensuring better coordination between different departments and institutions. This results in a more efficient and streamlined healthcare system, which benefits healthcare providers and patients in a multimodal way [41-44]. In Saudi Arabia, many hospitals are yearning to achieve the milestone of employing a blockchain-based EDI system in their healthcare setup, which is also aligned to the Kingdom's Vision 2030 [45].

In this regard, King Fahd University Hospital (KFUH) has been working in specific directions and this undergoing study is a potential proposed framework this regard. Typical national hospitals across the kingdom follow the layout and organizational structure.

In conclusion, implementing a hospital management system with its Electronic Data Interchange based on blockchain technology has significantly improved the healthcare industry's efficiency, transparency, cryptocurrency and security. By providing a secure and decentralized platform for managing medical records and facilitating communication between healthcare providers and patients, blockchain has enabled better diagnosis and treatment, reduced costs, streamlined administrative processes, and enhanced patient privacy and confidentiality. With the adoption of a blockchain-based hospital management system, the healthcare industry has taken a significant step toward providing high-quality care while ensuring patients' privacy and confidentiality. It is even essential while using internet of medical things (IoMT) devices [46-50].

5. DISCUSSION

In several industries, including healthcare, blockchain technology has emerged as a promising alternative for secure and transparent data administration. Electronic Health Records (EHRs) can be shared and stored decentralized and widely across various stakeholders, including patients, physicians, hospitals, insurance providers, and researchers. Additionally, blockchain can preserve patient data privacy and confidentiality while ensuring the authenticity, integrity, and immutability of EHRs. Additionally, blockchain can help EHR systems become more scalable and interoperable and lower the costs and dangers related to centralized data administration [51-55].

In that research, we suggested an electronic data exchange (EDI) framework for smart healthcare in the context of smart cities supported by blockchain technology. To enable secure and effective EHR maintenance and exchange among multiple entities in the smart healthcare ecosystem, the proposed platform makes use of the benefits of blockchain technology [56-60]. Four essential parts made up the proposed framework:

(1) Personal servers are local storage devices that store and encrypt EHR and communicate with cloud servers.
(2) EHR sensors are smart devices that collect and transmit health data from patients to personal servers.
(3) Cloud servers, which are distributed nodes that store and validate EHRs using blockchain consensus mechanisms and smart contracts, and
(4) EHR consumers are end users of Electronic Health Records.

The proposed system framework adheres to the general requirements of a hospital management system to be integrated. Further, it addresses some of the key challenges and requirements of EHR management and exchange in smart healthcare, such as:

- Security: the proposed framework uses cryptographic methods like hashing, digital signatures, encryption, and decryption to guarantee the security of EHRs. The proposed system uses the immutability and consensus features of the blockchain to prohibit illegal access to and change of EHRs. Additionally, our architecture uses pseudonyms and anonymization methods to safeguard patients' identities and privacy.
- Transparency: By utilizing the distributed ledger function of the blockchain, our system makes EHRs transparent. All network members can observe and confirm the transactions and data kept on the blockchain by virtue of the proposed system. By utilizing the provenance and timestamping capabilities of the blockchain, the proposed framework also offers auditability and traceability of EHRs.
- Interoperability: By utilizing the standardization and compatibility aspects of the blockchain, our framework makes it easier for EHRs to interact together. The proposed framework enables data transmission between various EHR systems using a standard homogenious data format and protocol. Using the data transformation and normalization capabilities of blockchain, the proposed framework also offers data integration and aggregation from diverse sources and formats, such as HL7.
- Scalability: By utilizing the parallelism and partitioning capabilities of the blockchain, the proposed system promotes the scalability of EHRs. Using blockchain's parallel computing and sharing techniques, the proposed system enables the quick processing of numerous transactions and information. The proposed system also supports data compression and deduplication by utilizing blockchain's data optimization and pruning algorithms.

6. CONCLUSIONS

The healthcare industry is rapidly evolving, and the adoption of advanced technology is playing an essential role in improving patient outcomes and experiences. Blockchain is one such technology that can potentially transform the healthcare industry. Blockchain technology ensures the confidentiality and integrity of patient data by providing a secure and tamper-proof method of storing and retrieving medical records. As a result, developing a healthcare system based on blockchain technology is a critical step toward transforming the healthcare industry. The traditional healthcare system has several flaws, including inefficient data management, transparency, and security flaws. These constraints frequently result in serious issues such as miscommunication, data breaches, and medical errors, all resulting in poor patient outcomes, by utilizing blockchain technology to create a healthcare system. The blockchain-based healthcare system project aims to provide a user-friendly interface for efficient medical record management. The motivation behind the project is to address the challenges that the traditional healthcare system faces while also providing a secure and efficient method of storing and retrieving medical records. The project will be built with Python, PyQt5, MySql, and the Mumbai testnet for MATIC transactions. The system will provide admin, doctor, and receptionist access levels to manage and access patient records. To summarize, developing a healthcare system based on blockchain technology is an essential step toward revolutionizing the healthcare industry by addressing the challenges the traditional healthcare system faces while providing a secure and efficient method of managing medical records. We can improve patient outcomes and experiences. The EDI in healthcare system using blockchain technology is a promising solution that can potentially transform the healthcare industry. In this regard, deep learning paradigms, especially federated and transfer learning, can be investigated to improve further the security of the blockchain.

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