A Blockchain Based Data Sharing System for Health Care Applications

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Abstract: - Researchers recently were battling to produce an ever-more effective prediction model. Studies have found that when the artificial intelligence (AI) model is trained with a wealth of information, it performs better and generalizes better. Research institutions, testing labs, hospitals, and other organizations can share their information and work together to improve the training algorithm. All companies wanted to respect the confidentiality of their data, but they still want effective and precise teaching methods for a spectrum of uses. Regarding the ethical and regulatory concerns about medical data privacy, data sharing among numerous organizations is limited. In health care systems,we describe a unique solution that integrates locally taught AI from over blockchain for enhancing disease prediction by addressing the identified gap, while maintaining anonymity and allowing data exchange. Using the information to ensure privacy poses a number of issues. This study provides a Modified Needleman-Wunsch algorithm (MNWA) for data sharing. The Artificial Neural Network (ANN) model is used for trust-enabled smart contracts. Python software performs the implementation work. A detailed experimental survey was performed to test the importance of our proposed strategy for effective early prediction and diagnosis. The proposed model's extensive experiments demonstrate a proposed method may detect ailments and boost efficiency.

Keywords: Blockchain, Healthcare, Data sharing, Artificial neural network and Modified Needleman algorithm

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I. INTRODUCTION

Individuals have used multiple kinds of mobile and wearable devices, such as smart glasses, smart bands, smart watches, smart phones, and so on, to recognize various health-related application forms, such as elderly care, disease monitoring, and remote diagnosis, due to the fast development of mobile computing, wireless sensing, and wearable technology [1]. Such devices provide a lot of private health information, whichisa valuable resource for healthcare and business uses [2]. Many associated parties including companies, researchers, patients, device users, and even the entire public health service, would gain from correctly exchanging personal health information [3]. Health records must be owned and controlled first by a user individually as private property; however, they are usually controlled by several providers, device manufacturers, or spread across many health care.

A blockchain-centric software architectural layout is used to ensure workflow automation [4], accountability auditing, patient pseudonymity, and shared data integrity besides utilizing inherent characteristics of blockchains like accountability, auditability, and immutability combined with the use of smart contracts [5], a transaction-aware state machine process thatin which entails patient pseudonymity and shared data integrity.Clients could be afraid to disclose one‘s data, despite the many benefits underlined above, because an improper disclosure of one‘s data identities had a straightforward effect on health, as well as oblique socioeconomic consequences to its employers, insurers engaged, and etc [6].

Generally, this creates hurdles for information sharing and compromises privacy and security, as these centralized data storage and authorization sources are an appealing target for the internet [7]. Given the popularity of cryptocurrencies, blockchain had acquired a lot of traction in recent times, especially in the banking industry [8]. Through combining thresholds data encryption with public key [9], where the collaboration of multiple parties is needed to decrypt data and block cipher is used to verify communications with members of the social system, problems can be treated potentially lessen data leak concerns [10]. This article proposed a blockchain-based data sharing system for health care applications.

Rest of the article is summarized as: Section 2 explains the related works and the work background is explained in section 3. The proposed methodology is illustrated in section 3 and deals with the experimental results are discussed in section 4. Finally, section 5 ends up the article.

II. RELATED WORKS

Based on cloud storage, Blockchain-based personal health data sharing (B-PHDS) system was suggested by Zheng et al. [11].This research offers an analytical model enabling securely and transparently sincere continual clinical information utilizing cloud storage and blockchain technology. In addition, to have control over data integrity, it provides data quality check modules depending upon the machine learning approaches. The main allow customers to securely share, control and own its personal health information in a way that complies with the General Data Protection Regulation (GDPR) so that they can profit from their own data. It also enables cooperate data and researchers and users to acquire elevated personal health records for commercial and research and reasons in an effective manner.

The blockchain based an efficient healthcare data sharing (B-EHDS) method was investigated by Shen et al. [12].It uses organized peer-to-peer networking, digest chains, and blockchain technologies to address the aforesaid inefficiency problems in present methods to exchanging all kinds of health records. Session-based health information strategy is created oriented on MedChain, which provides data sharing flexibility. The findings of the study suggest that MedChain could improve productivity while also meeting security criteria in data exchange.

For healthcare management, Khatoon et al. [13] introduced a blockchain-based smart contract system (BBSCS). Numerous health processes including sophisticated medical operations such as clinical studies and surgery have been designed and developed to use the blockchain platform. Collecting and maintaining a vast level of healthcare information is a part of the job. The frequency for this technology has been calculated for the deployment of the processes of the healthcare intelligent contract for health managers in order of a feasibility report that is completely described. Two or more parties participating in the health industry could benefit from this study, which could also help them provide good healthcare services at lower prices.

The blockchain-based system (BCS) design was introduced by Theodouli et al. [14] for healthcare data sharing.Patients who submit their healthcare data face a number of privacy and security concerns. They suggested a blockchain-based system architecture to demonstrate the feasibility of Blockchain technologies in terms of healthcare data access permission processing, auditable and private healthcare data handling.

For healthcare 4.0 applications, Tanwar et al. [15] introduced a blockchain-based electronic healthcare record system (B-EHRS). Various alternatives, including frameworks to analyze the effectiveness of such systems, are investigated utilizing blockchain technologies to optimize present constraints in medical systems. Additionally, the data accessibility between healthcare providers are improved by introducing an access Control Policy Algorithm. Unlike standard EHR systems, which are built on a client-server architecture, the suggested solution is built on blockchain that improves and security efficiency.

III. BACKGROUND:

The proposed framework related to the background review of smart contract and blockchain model is described as follows:

3.1 Intelligent contract:

An Intelligent Card is a contract of digital arrangement between two companies in the code of executable model that is based on particular rules. To take action depending on a contract, the Blockchain network employs decentralized applications [16]. The blockchain network permits an organization to maintain a record of all transactions that are transparent and irrevocable out without the involvement of a third party.

An intelligent contract's major purpose is to demonstrate a secure manner while lowering costs. Furthermore, the consensus mechanism is completely public across the system, allowing for user involvement. Different organizations that operate over autonomous public blockchain recognize the rules of a smart contract, that could normally run based on user circumstances. There are three qualities of a shared ledger such as the data is always available, transparent and immutable.

3.2 Interplanetary File System (IPFS):

The distributed file system is IPFS that provides websites, images, files and sort data. The protocol's structure allows for Internet modifying in the same way that GitHub's repo versioning does [17]. A cryptographic hash is used to assign a unique identification to every block and file inside it. Multiples are deleted from across the system, and then every file's revision histories are monitored. Figure 1 depicts the IPFS process was successful.

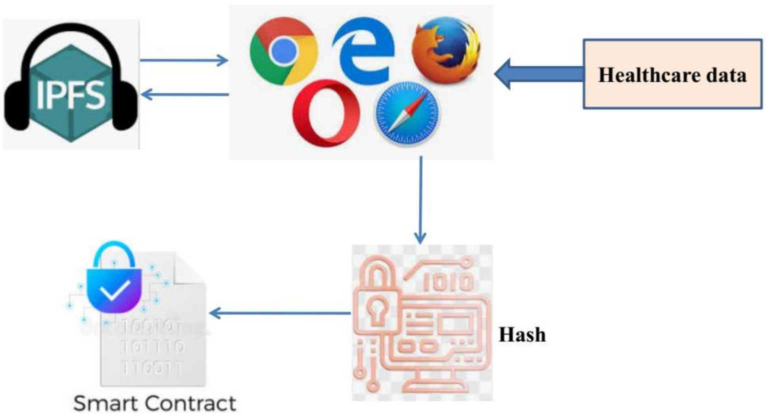

Fig 1. Architecture of IPFS

IV. PROPOSED METHODOLOGY

The three-stage framework describes the proposed model, which are data sharing based on blockchain, trust enabling via smart contract and ANN model. The proposed framework is illustrated in Figure 2. Initially, the hospital authentications are stored via local model weights in inter-planetary file system (IPFS). The blockchain ledger stores the IPFS hashes. The blockchain nodes and the local model weights are combined and calculated via ANN model. The better performance is obtained and stores the updated weight of hashes.

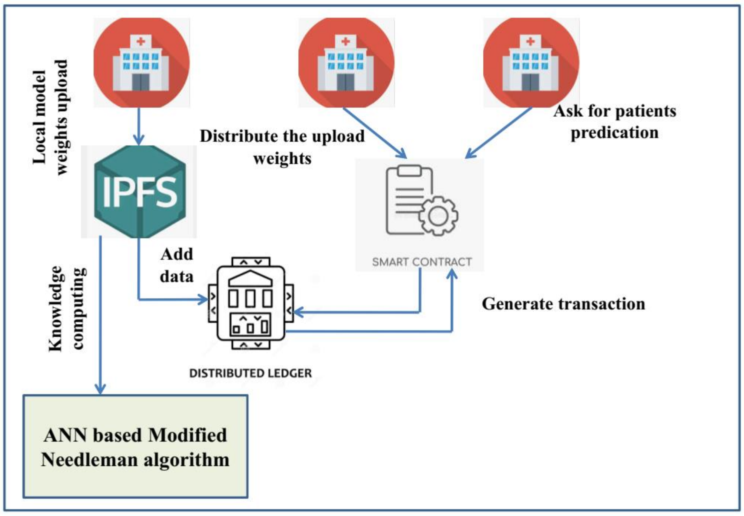

Fig 2. Proposed framework

4.2 Modified Needleman-Wunsch algorithm (MNWA) for data sharing:

The consensus mechanism ensures that data communication between hospitals is secure and private. The contract is utilized for something like data storage trade in order to automatically allow medical image sharing. It creates settings depending upon the data-sharing agreements and conditions.

Needle-Wunsch algorithm [18] is a type of prime dynamic programming algorithm and can be used to evaluate global solutions. This algorithm mainly focuses on the determination of minimal distance among the two strings of DNA nucleotides sequences and can be formulated as below,

Series 1	Series 2
G	A
C	C
A	A
G	T
C	T
T	A
G	G

Henceforth the letters with identical values are matched and then these two nucleotides are organized as shown below,

Series 1	Series 2
G	-
C	-
A	A
G	-
C	C
-	A
-	T
T	T

-	A
G	G

The clustering of data can be made with the modification metric with basic characteristics such as (a) close matching indicative can be obtained with the smaller value, (b) possess symmetric value, and (c) with the aid of self pointing the zero score value can be obtained [19].

- **Variables:**

The transfer of various healthcare datasets from different healthcare centers is considered here. The pathways of various sources are also considered and swapping is also made. To begin the process we have considered a no-swap variable value. When swapping is allowed for the same class of activities then it might have led to the group of introduction.

- **Grouping and Weightings:**

When the pathways are at the same points then the activities happen between the same classes. Meanwhile, different activities are conducted at different points. This might have led to the rise in complexity of the proposed algorithm. The weight of the activities is designed and domain experts rank the activities based on their priority. The activity that occurs frequently is ranked as 0 and the least significant activity is assigned as 1.

- **Equations:**

The next step is to define and merge both the groupings and weightings. The methods involved in the algorithm are explained below:

$$PE = Z[j-1][k-1] * \left(D + \frac{1}{Z[j-1][k-1] + V_j} \right) \tag{1}$$

The initial value of zero is propagated to match the equating by using the multiplication factor D. The main element that allows the above process is by the point itself. This can be ensured and matched by the positive events as,

$$PE = Z[j-1][k-1] + R + ABS(V_j - V_k) \tag{2}$$

Here, V_j and V_k are the weightings at the jth and kth points. The swapping is permitted to achieve activities that are closer to the maximum values. The determination of the no-swap equation is given as,

$$PE = Z[j-1][k-1] + NR + (V_j - V_k) \tag{3}$$

The modified weighting direction is given as,

$$h = Z[j-1][k] + M + V_j \tag{4}$$

$$g = ZY[j][k-1] + M + V_k \tag{5}$$

The minimum values from the h, g, d are chosen based on the altered value.

- **Penalty values:**

Based on the equation guidelines the values from the variables are selected as the match<swap<no-swap.

$$J < M \tag{6}$$

$$J < R \leq M \quad (7)$$

$$NR = 2M + 1 \quad (8)$$

$$D = 1 \quad (9)$$

The multiplication value D is set as 1. The value of NR is higher than $2M + 1$ when there is no need for swapping. The minimal penalty values are $D = 1$, $R = 2$, $M = 1$ and $NR = 5$. Based on the standard NWA values the penalty values are estimated with the outcome. The user will choose the values of M and R values. When there is a higher difference between the values M and R the distinction is higher.

To share image data between hospitals, a smart contract is used. In the blockchain database, the IPFS records every local model hashes and weight. Through the smart contract, certified institutions exchange the weights of qualified MNWA. Only a recognized organization may obtain the shared weights because the blockchain is a completely distributed and multi-party data collection environment. The blockchain's openness and dependability are ensured by the contract among multiple geographical nodes.

4.2 Smart contract-based trust enabled via ANN:

The partnership is an arrangement for medical enrollment and sharing of patient data using permissions. With the Register Data function, the organization files its data. The data is retrieved using the price attributes, description, address, and hash. All institutions can download the information once it has been uploaded to the blockchain network with the approval of many other institutions. The authenticator allows data to be accessed. A set of medical data can be shared between organizations, and authorized clients can view it. The ANN model is used to allow the trust-based smart contract in this case.

The metrics employed in this neural network model are investigated by the polygon characteristics. The length, direction, area, and distance differences in the inputs correspond to the analyzed pair [19]. The distance metric $A_1(e, f)$ is computed using the equation below.

$$A_1(e, f) = \frac{\sqrt{\left(X_e - X_f\right)^2 + \left(X_e - X_f\right)^2}}{0.5 * L_{ef}} \quad (10)$$

Where, $\left(X_e - X_f\right)$ and $\left(X_e - X_f\right)$ are the centroid of e and f, respectively. The shortest bounding rectangle is L_{ef}. The area of measure $A_2(e, f)$ is calculated using the equation below.

$$A_2(e, f) = \frac{\left|s_e - s_f\right|}{\max\left\{s_e, s_f\right\}} \quad (11)$$

The area of e and f can be calculated using this equation. The direction measure $A_3(e, f)$ is calculated using the equation below.

$$A_3(e, f) = \frac{\left|\theta_e - \theta_f\right|}{\pi/2} \quad (12)$$

Where, e and f point in the same direction. Equation (5) is used to get the direction measures $A_4(e, f)$ in which L_e are L_f the diagonal lengths.

$$A_4(e, f) = \frac{|L_e - L_f|}{\max\{L_e, L_f\}} \tag{13}$$

Under this case, the consensus mechanism sets out the rules for data sharing between enterprises. The hospital's owner certifies the information's ownership and affixes a unique identifier to it. In the blockchain ledger, the token is created. The ANN model ensures a photograph transmitted is from an authorized origin. With the signature of the registered hospitals, the contract transfers the information to the public blockchain. It also aids in providing more decision support and accurate prediction while preserving concerns in mind.

V. Experimental Setup

The proposed model is developed in the LUCE platform which is a blockchain-based data-sharing platform along with the python and the Ganache Ethereum network [20]. LuceVM virtual machine [21] is used in the system of 64 bits Ubuntu 16.04 LTS. The memory of the virtual machine is 1024 MB.

5.1 Dataset description:

The performance of our proposed approaches is analyzed by using the publicly available dataset known as DINAMO [22]. These are gathered from the 512 patients who used wearable smartphone technology. The dataset includes 364 normal and healthy patients (N#001-364) and 148 diabetic patients (S#001-148). The data's collected over 4 weeks and included the activity, heart rate, BP gathered by the wearable sensor.

5.2 Profiles of data providers:

There are three types of data providers include: (i) open data providers, (ii) restrictive data providers, and (iii) very restrictive. All the statements are available open for the first data provider type. They make a profit from this. Second type providers only share data for health research purposes and make a profit from this. These providers avoid sharing data for the general researchers. The third type of providers share their data only for the purpose of disease-related research such as cancer, diabetics, etc., Table 1 illustrates the different data providers.

Table 1. Different types of data providers

Types of Data Providers	DS Research	General Research	HMB research	Profit-use
Open	NO	YES	NO	YES
Restrictive	NO	NO	YES	YES
Very Restrictive	YES	NO	NO	NO

DS research: Disease-Specific research

5.3 Profiles of Data Requesters

The profiles of data requesters are divided into three classes. The first category data requester 1 is the request to access the data for the general research purpose and for profit-making. The second type of requester (Data requester 2) requests the provider for the data to profit-making and HMB research. Meanwhile, the third requester (data requester 3) accesses the data for the non-profit purpose i.e., disease-specific purpose only. The different types of data requesters and their characters are explained in Table 2.

Table 2. Different types of data requesters

Types of Data Requesters	DS Research	General Research	HMB research	Profit-use
Data requester 1	NO	YES	NO	YES
Data requester 2	NO	NO	YES	YES
Data requester 3	YES	NO	NO	NO

DS research: Disease-Specific research

According to the profiles of data providers we have to consider the following conditions.

(i) Condition 1: open 100%
(ii) Condition 2: open (40%), Restrictive (40%), Very-restrictive (20%)
(iii) Condition 3: Open (30%), restrictive (30%), very-restictive (40%)

Consent matching of Condition 1 is illustrated in table 3.

Table 3. Condition 1 consent matching

Patients type	N#003	S#003
Total no. of data providers	364	148
Data requester 1	YES	YES
Data requester 2	NO	YES
Data requester 3	YES	NO

The data sharing scenario of condition 2 is explained in table 4.

Table 4. Condition 2 consent matching

Patients type	N#003	S#003	N#006	S#006	N#009	S#009
Total no. of data providers	127	56	218	98	301	121
Data requester 1	YES	YES	NO	NO	NO	NO
Data requester 2	NO	YES	YES	YES	NO	NO
Data requester 3	YES	NO	YES	NO	YES	NO

Meanwhile, the data sharing in condition 3 is different from the other conditions. From the table, we can study the data-sharing scheme of condition 3.

5.4 Execution cost evaluation

The performance of the proposed approach can be analyzed with the help of execution cost analysis. Following parameters are considered for the evaluations

- The amount of gas spent during the process
- The consumption of gas while performing the execution of data providers
- Consumption of gas while performing the execution of data requesters queries
- Gas is required while performing the matching process.

The execution cost can be estimated with the calculation of the cost spent during the interactions between the data providers and requesters and the total cost of contract deployment. The cost required for the sharing of the data can be evaluated by the cost of submitting the data, the cost of querying, and more. The gas consumption at various conditions is illustrated in figure 3. From the graph, it is observed that the consumption of gas by several data providers is higher than the other approaches.

Table 5. Condition 2 consent matching

Patients type	N#003	S#003	N#006	S#006	N#009	S#009
Total no. of data providers	112	52	156	92	289	104
Data requester 1	YES	YES	NO	NO	NO	NO
Data requester 2	NO	YES	YES	YES	NO	NO
Data requester 3	YES	NO	YES	NO	YES	NO

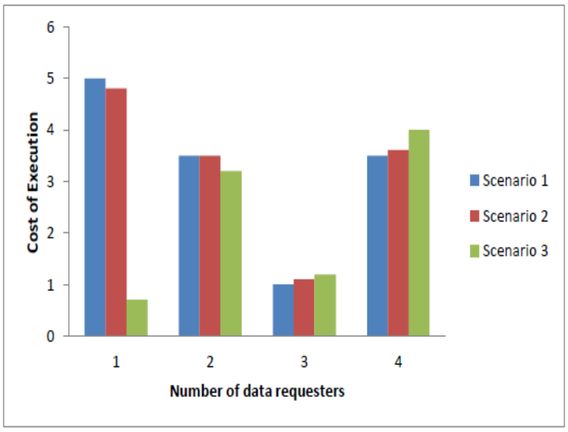

Fig 3. Consumption of gas for the dataset at different conditions

Figure 4 explains the performance analysis of detection results. Here, we have described various performance measures such as B-PHDS [11], B-EHDS [12], BBSCS [13], BCS [14] and the proposed method. The detection accuracy of the proposed method is superior to other existing methods.

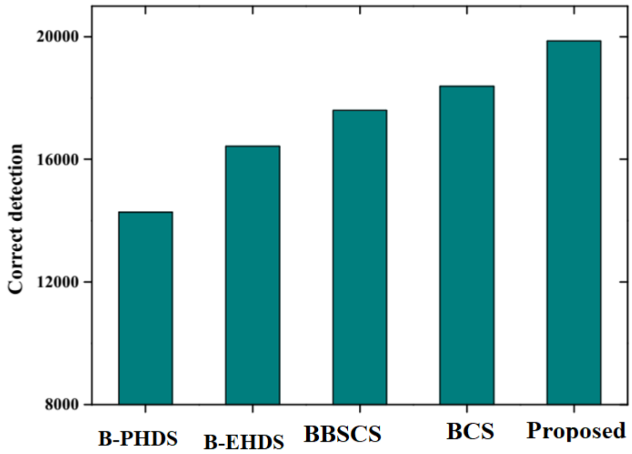

Fig 4. Detection result analysis

VI. CONCLUSION:

This study introduced a blockchain-based data sharing system for health care applications. The blockchain has been employed to train the model and to generate the blockchain. The problem of computing resources will be addressed by the public blockchain that will broadcast the prediction results on the blockchain.The proposed model is built on the LUCE platform, which is a blockchain-based data-sharing platform that uses Python and the Ethereum network Ganache.The performance of our proposed approaches is evaluated using the DINAMO dataset, which is freely available. These are the results of a survey of 512 patients who utilized a wearable Smartphone.The disease detection accuracy of the proposed method is superior to other existing methods.

Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

Human and Animal Rights

This article does not contain any studies with human or animal subjects performed by any of the authors.

Informed Consent

Informed consent does not apply as this was a retrospective review with no identifying patient information.

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Availability of data and material:

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Code availability: Not applicable

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