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Secure and Versatile Decentralized Ledger System Based on Blockchain for P2P Communication

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***Abstract*– Data sharing between peers is also required, just like a secure data sharing infrastructure. Since, present systems have a centralized architecture that requires authentication from only a single authority, there have been a lot of privacy, security, and interoperability issues and security concerns have grown. Blockchain is considered to build the transparent, decentralized, and trustworthy systems. In this research, a framework has been proposed based on Blockchain technology offers a novel tool for solving information security, product traceability and efficiency, privacy, and cost reduction in peer-to-peer information exchange high security and cost-effectiveness for peer-to-peer data exchanging without the intervention of third-party. This framework has eliminated the need for third-party authentication systems, that ultimately save time and money. As a proof of concept, a use case of healthcare has been taken. There is an increasing necessity of immediate access to relevant healthcare information as in most of the cases there is need of data and information exchanging between different hospitals for better treatment of patients. Additionally, the proposed framework ensures the security of patients' health information using data encryption, enabling the establishment of a conditional access control system where only authorized parties are permitted to view patients' medical records. The cost and time analysis of proposed framework is also provided in this research.**

***Index Terms*– Smart Contract, Peer-To-Peer Communication, Blockchain, Ethereum and Electronic Health Record System**

I. INTRODUCTION

MANY new innovative platforms are being developed to improve the information sharing system. Technology is considered to be a vital tool in providing reliable information to help the processing of services. Data sharing between peers is also required, just like a secure data sharing infrastructure. Since, present systems have a centralized architecture that requires authentication from only a single authority, there have been a lot of privacy, security, and interoperability issues and security concerns have grown. Ensuring interoperability, privacy, and security, it is necessary to add revolutionary technology to improve interoperability, transparency, and security of centralized databases.

Blockchain is considered to build the transparent, decentralized, and trustworthy systems. Bitcoin was the first implementation of blockchain technology [1]. Bitcoin makes use of Public Key Infrastructure to ensure that users' trust and privacy are secured. Blockchain technology is used not only for development of cryptocurrency platforms, but also for creating a distributed ledger for enterprise platforms. The main purpose of this research is to define a methodology for exchanging data using a blockchain network. The method allows data to be consistent and accessible across all peers that have joined the blockchain network, also have complete control over data access privileges.

II. LITERATURE REVIEW

To strengthen the supervision of the peer-to-peer (P2P) loan market by utilizing consortium blockchain. The partial decentralized consortium blockchain, which has a restricted number of pre-determined nodes, can significantly improve secure data transmission, making it ideal for financial regulation. The Hyper-ledger-based Peer-to-Peer Loan System (HyperP2PLS) is designed to address the anomalies in the P2P lending sector. The system's application paradigm and business rules, in which a nationwide P2p Trading Centre will be constructed to combine all Payday loan market transactions and data. Then, using the blockchain network, applications, and HTTP server, build the system design. The implementation methodology as well as the web app for users have been thoroughly demonstrated. HyperP2PLS can provide reliability, safety, integrity, and efficiency, according to the results of the performance assessment [2].

One of the greatest impediments to rapid and transparent trade between small Irrigators and small or medium customers is financial resolution requiring several institutions or fiat currencies. In this paper authors investigate the feasibility of a light-weight peer-to-peer water trade system based on smart contracts on private blockchains in this research. The smart contract and water flow sensor readings are stored on a blockchain, which assures immutability and transparency, as well as hashing and consensus among participating nodes. A Geth client is implemented on each node in the system, which operates on a private Ethereum blockchain. Geth is a Go-based command line interface for launching a complete Ethereum node. An Ethereum Virtual Machine runs on all nodes in the private blockchain (an overlay P2P network made utilizing Raspberry Pi boards as nodes) (EVM). Each node's local copy of the smart contract is managed by the Geth client. Geth is controlled by a Node.js web server in the proposed architecture [3].

Blockchain technology is a new tool to address product traceability, information security and privacy, payment efficiency, and cost reduction in cross-border e-business because of its properties of anonymity, persistency, decentralization, and auditability. The paper summarizes the issues with existing cross-border e-business payment methods and assesses the likelihood of blockchain technology being used in the sector of cross-border e-business payment [4]. The study introduces a blockchain-based payment application architecture and focuses on blockchain-based letter of credit payment under cross-border B2B e-business conditions. The hierarchy and functional modules of a blockchain-based cross-border e-business payment network is discussed in this paper. In cross-border e-business, this paper proposes a three-level chain structure and data categorization management to build an alliance chain involving banks, customers, traders, and regulators.

Using blockchain to execute a payment is a simple and error-free process. In this type of setup, hackers will never be able to complete their jobs. In general, blockchain is chosen because it is the safest method of doing transactions in any online system. A database management system serves as the foundation for the primary business model [5]. The transaction can no longer be guaranteed to be secure once it has been completed. On the other side, resolving any fraudulent transactions through a middleman is quite costly. A suggestion for a model that is entirely made up of blockchain system has been proposed in order to address concerns of security and worthlessness. There are several blocks of data for each and every trace in the proposed system. Consumers will be able to transact on blockchain networks through cryptocurrency by the use of proposed algorithm. It differs from the current system in that customers will be able to transact without the assistance of third parties, and sellers will be able to complete their transactions with ease.

While Bitcoin (Peer-to-Peer Electronic Cash) addressed the double-spend problem and offered work with timestamps on a public ledger, it has not yet expanded the blockchain's capabilities beyond a transparent and public payment system [6]. Continuing Nakamoto's vision by developing a set of commercial-grade services that support a wide range of business use cases, such as a fully developed blockchain-based decentralized marketplace, secure data storage and transfer, and unique user aliases that connect the owner to all services controlled by that alias.

This paper proposes two new methodologies for assessing the bilateral trading preferences of households in a fully peer-to-peer (P2P) local energy market have been proposed. To generate the results in a day-ahead context, a decentralized fully P2P energy trading market is being implemented. The decentralized P2P trade market is implemented on a digital platform using a permissioned blockchain-smart contract technology. Real data from a residential neighborhood in Amsterdam, The Netherlands, including various types of distributed energy resources, was used for the simulations. The results reveal that the two solutions minimize the cost of energy procurement and the grid interaction of all P2P trading participants when compared to a baseline scenario. When trading preferences are based on distance, the overall amount of P2P energy traded is shown to be higher, which might be used as a proxy to improve network energy efficiency by boosting P2P trading among adjacent households [7].

Peer-to-peer eLearning is becoming increasingly vital in today's world, especially when in-person learning is limited, such as in the case of a pandemic (e.g., COVID-19) or for students from low socioeconomic backgrounds, for whom tutoring costs can be a significant factor. Peer-to-peer eLearning has been shown to be quite beneficial. There has been a lot of research into the use of Blockchain technology in eLearning in general, but not nearly enough research into peer-to-peer eLearning specifically. This research examines and analyses previous and current research on using Blockchain technology in peer-to-peer eLearning, investigates and explores the opportunities and challenges that Blockchain technology may face in this area, and proposes recommendations for using Blockchain technology in peer-to-peer eLearning to create value that will benefit the community and increase the usability and popularity of this technology [8].

Blockchain is quickly gaining traction as a critical technology for securing future commercial and economic competition around the globe. In the developing sharing economy, it is considered as a facilitator of trust and security. In this paper, we show how Blockchain can be used in smart grid energy peer-to-peer (P2P) trading. On the IBM platform, utilizing hyperledger composer, a smart contract for managing trust and transactions is built and implemented for a use case in energy P2P trade. Furthermore, existing issues that may be encountered while using Blockchain to secure energy P2P exchange are studied and highlighted [9].

A smart contract on the Ethereum blockchain has been used to construct a peer-to-peer (P2P) energy trading system between prosumers and consumers. The smart contract is stored on a blockchain that is shared by all participants, ensuring precise trade execution and maintaining immutable transaction records. It eliminates the enormous costs and overheads required to protect traditional server-based P2P energy trading systems against hacking or intervention. Making use of a microgrid Dynamic pricing has been adopted to prevent double sales by automatically balancing total supply and total demand. The trading mechanism is developed as a smart contract on Ethereum, and trades are carried out automatically and autonomously at the end of each period [10].

Using Smart Contracts on the Ethereum Blockchain Platform, a novel peer-to-peer (P2P) energy trading strategy for a Virtual Power Plant (VPP) is suggested. P2P energy trading is a new trend that the power society is eager to adopt, with multiple pilot projects underway, because it makes it easier to develop and exchange renewable energy sources in a dispersed manner within the local community. Blockchain and smart contracts are newcomers to the information technology sector, and they used to be regarded cutting-edge research issues in power systems. The suggested approach uses a public blockchain network and a smart contract to run the auction, which addresses both cost and security concerns. Bidding, withdrawal, and control are all examples of smart contract implementation and execution in a VPP architecture. The suggested architecture is tested using real-world data in the Ropsten Test Network's Ethereum Virtual Machine (EVM) environment [11].

III. EXISTISTING SYSTEMS

Because blockchain storage can give the Electronic Health Record a long-lasting medium, blockchain usage in the healthcare sector is becoming more and more popular. So, any data update can be quickly identified by the new block created when a modification occurs and hence the storage of data on the blockchain is immutable. As a result, information saved on the blockchain will eventually become unchangeable and allow non-repudiation. In general, this section outlines two distinct blockchain implementation strategies for exporting data.

1. Putting the complete EHR on a blockchain network for storage.
2. Putting the EHR in third-party cloud storage and storing the EHR's information on the blockchain network.

In 2019 a system named SHAREChain was proposed [12]. The idea is to build a network based on private blockchain that ensure during medical data exchanging. In this system the patient's metadata is stored on the Blockchain serve as a registry to provide index to the desired record stored on the database repository. Although this provides some efficacy in accessing the data but did not ensure data privacy and security as there is no encryption applied on the data while storing on the database as well as attacker can attack the database and all data get lost due to centralized database.

Guo et al. [13] based on blockchain a health management system which is more comprehensive is proposed using key-policy attribute-based encryption. This technique offered a multiauthority predetermined attribute set key distribution policy, where each attribute must be met for the user to be able to decrypt the protected file. With the help of this protocol, forward security may be guaranteed while allowing users to freely upgrade their access without affecting other authorized users. The user access update is dynamic but still health record system is dynamic in this system. As a result, the data owner is unable to dynamically update or remove the encrypted patient records. Furthermore, the searchability of the encrypted patient data was not the main focus of proposed technique.

Andola et al. [14] proposed a framework known as a secure approach for healthcare management system using blockchain (SHEMB). SHEMB used blockchain to store and retrieve data without intervention of third-party. The proposed system includes three phases to store and retrieve data on the blockchain by ensuring data interoperability. However, the attackers may be hostile or compromise the nodes in the blockchain network like doctors, patients, or departments. Currently, the proposed framework does not handle server-side or user-side validation, which is essential to ensuring that no such malicious behaviors can occur across the network.

A plan based on the five polynomial-time algorithms was developed by Chen et al. [15]. The suggested method makes use of Boolean expressions to extract the keywords from the medical records and creates an index that enables database searches on the encrypted data. In addition, the blockchain's usage of the idea of smart contracts can ensure that payments made between user nodes and miner nodes in the network remain fair. This plan focuses more on the search algorithm, which looks into things like search effectiveness and payment equity. Storage enforcement and accessibility are not being thoroughly addressed in this work. Additionally, there is no actual implementation for studying the practicality of the proposed scheme.

A blockchain-based permission-based system for sharing healthcare data was proposed by Asad et al in 2020 [16]. The authors established a permission-based access control where the data owner can choose who and which permission levels are authorized, by leveraging the Proof of Authority (PoA) algorithm's implementation. However, as the block size is constrained and the storage must be divided into numerous transactions to fit the patient's data, storing the entire set of medical records on the blockchain is not the best option. The authors also didn't pay attention to the security and privacy of the data that was outsourced.

Parameswari and Mandadi [17] proposed a healthcare data protection scheme leveraging blockchain technology. This scheme lacks confidentiality and the integrity of the patient’s health records. Neither encryption scheme nor verification algorithm is used during the outsourcing of the patient’s health data. The health records storage approach is the same as the scheme proposed in [16], which is inefficient due to the high transaction fees incurred.

The plan of Chelladurai and Pandian [18] takes a unique approach to the topic's implementation. There are four different models in the plan. The electronic health record creation model is required for new EHR data entry, and the electronic medical record update model is in charge of any modifications or new changes to the EHR. The user's access to the EHR is governed by the information sharing and monitoring models. The authors give a thorough analysis of the use and implementation of blockchain technology in the day-to-day operations of the healthcare industry. The suggested system allows for dynamic EHR updates. The encrypted data and keyword search on the protected EHR are not addressed by this plan, though. Additionally, this scheme's authorization model does not include entity verification.

Table I and Table II compare and summarize the various characteristics of the studied systems. Due to the distributed ledger on blockchain's natural support for various security features, all systems offered achieved a certain level of data security. Even so, before storing data over the Blockchain, an encryption method should be incorporated to properly protect the data confidentiality from any active or passive attacks. Instead of using as a storage purpose, blockchain technology should also be used as the method for securing data.

IV. PROPOSED METHODOLOGY

Blockchain technology has the potential to dramatically revolutionize how important data is handled and protected in the healthcare industry. There is an increasing need for immediate access to crucial healthcare information in today's culture. The variable storage of patient data among many medical institutions makes it challenging to access a patient's standardized data [19]. As mentioned in Fig. 1 by using Blockchain technology data in secured and stored on-chain and any trusted authority can access the data based on some smart contract.

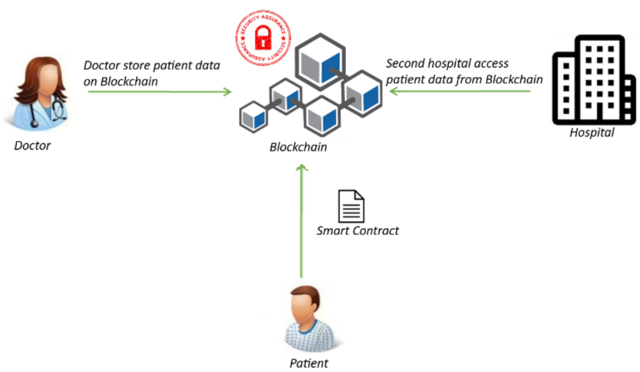

Fig. 1. Peer to peer communication between different hospitals based on Blockchain.

In proposed methodology there are 4 main steps. First data is gathered then AES encryption algorithm is applied. After encryption data is compressed through GZIP compression the n compressed and encrypted string is moved to Blockchain for storage that is definitely efficient in terms of time, cost and no third-party is required. Fig. 2 depicts the proposed methodology in which tow type of techniques are used for better comparison. In first approach data stored as it is but in second approach above mentioned steps applied.

V. IMPLEMENTATION

Personal health information is regarded as extremely sensitive information, and the public's access to such datasets is constrained by the need for approval from the appropriate authorities. Due to such constraints, in this research data is generated from self-written java code. The approaches mentioned in the methodology are implemented simultaneously. In first approach data has been stored as it is onto the Ethereum Blockchain without any encryption and compression on data. For that purpose, a smart contract is implemented which store complete patients' data on the Blockchain. 2500 patients' records stored over the Blockchain against the contract address 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4.

After storing all the records indexes on the Blockchain, each transaction information has been extracted for analysis of gas consumption, time and total transaction fee.

In second approach, AES 256 encryption technique written in java named AESEncryption has been implemented which encrypt data as sown in Fig. 3.

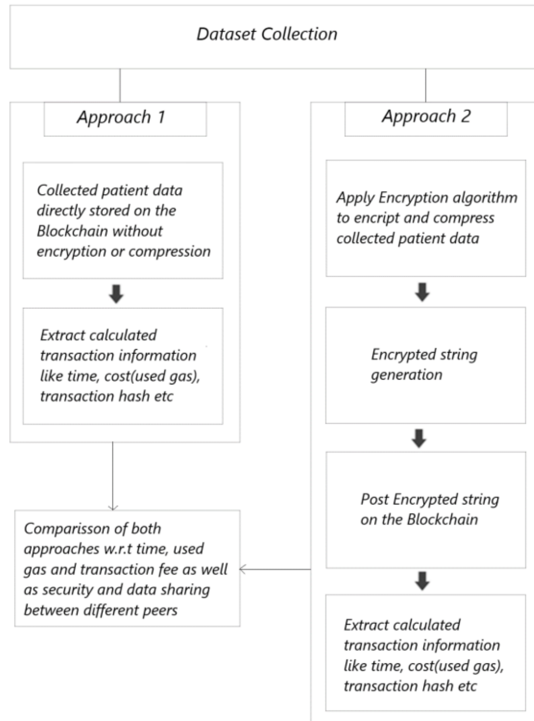

Fig. 2. Methodology of proposed framework

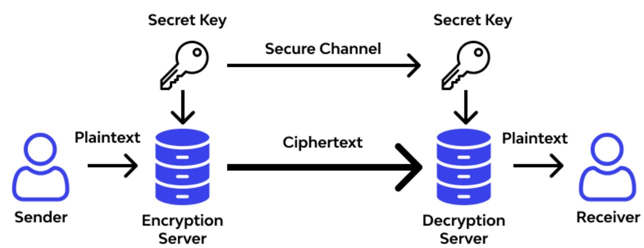

Fig. 3. AES algorithm working

After encryption compression algorithm is applied to compress the data using GZIP.

Encryption is applied on the patient record and an encrypted string has been generated. Next step is to store output of encrypted patient data string onto the Blockchain using Smart Contract which is written in Solidity language. All the encrypted patients' records stored on the Blockchain.

VI. RESULTS

Gas is a unit of cost for a specific operation a computer needs to perform. On Ethereum Blockchain it is required to pay for every operation which need to be performed. Comparison of GAS consumption of both approaches has been done to identify the best approach. Graphical representation of comparison is given in Fig. 4 and Fig. 5.

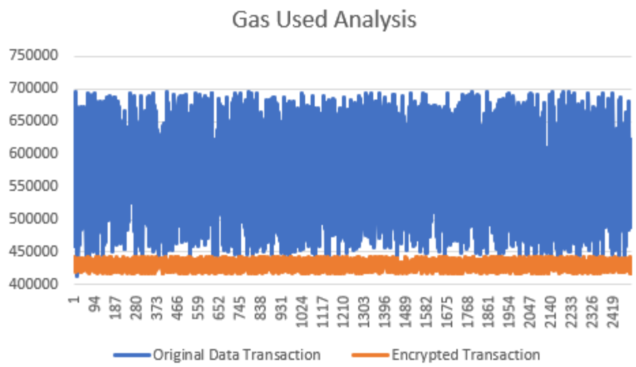

Fig. 4. Graphical Representation of Gas Used Analysis

Blue line depicts GAS used by approach 1 and orange line is for approach 2. The graph in Fig. 4 shows that to store original data attributes on Blockchain higher percentage of GAS is used. Whereas second approach consumes lower GAS, in which all attributes are combined and then apply encryption to post it on Blockchain. Gas used analysis summary is also provided in below Table III.

Table III. Used gas analysis summary.

Attribute Title	Original Data	Encrypted Data	Difference %
Average Used Gas	599729.8	422723.7	34.6238%
Max Used Gas	695518	443122	44.3329%
Min Used Gas	443691	417195	6.15552%

In Ethereum, the transaction fee is calculated in Ether, which is given as:

$$Ether = Tx\ Fee = Gas\ Limit * Gas\ Price$$

Where,

Gas Limit = On Ethereum network, gas limit refers to the amount of gas that is used for the computation

Gas Price = The amount of Ether a user is required to pay

Graphical representation of transactional cost analysis is given in following Fig. 5. Blue line and orange line depict the transaction of approach 1 and approach 2 respectively. The graph in Fig. 5 shows that transactional cost of approach 1 higher than approach 2. Transaction cost summary also provided in Table IV.

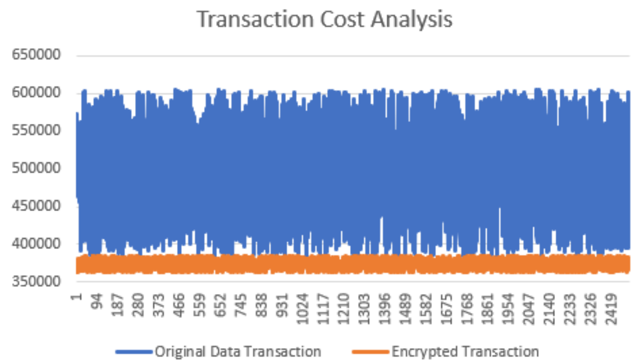

Fig. 5. Graphical Representation of Transaction Cost Analysis

Table IV. Transactional Cost analysis summary

Attribute Title	Original Data	Encrypted Data	Difference %
Average Transactional Cost	449058	376281	17.6357%
Max Transactional Cost	384110	362778	5.71224%
Min Transactional Cost	604797	385323	44.3328%

VII. CONCLUSION

Blockchain technology is predicted to be a disruptive technology in different fields hence getting the attention of stakeholders of different fields. Because of its rich features, a larger number of organizations have shown interest in Blockchain technology. In order to implement Blockchain technology, they need to completely restructure their existing legacy systems. Therefore, a framework by combining Blockchain for data storage and sharing and to detect data tempering in minimum cost is proposed in this research. For proof of concept a patient record keeping system is developed which can be replaced with existing traditional systems. By using the proposed framework different hospitals can share data and there is no need to additional third-party which defiantly reduce time, security risk and additional cost. Implemented system provides a fully secured platform for hospital-to-hospital patient data exchanging and storing. In future the proposed framework may be used with different type of patient records which may be in the form of images and videos and different laboratories may also be connected with same blockchain network. In future same framework can also be developed with other type of Blockchain technology like Hyperledger. Moreover, other features like patient's data validation can also be incorporate.

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Table I. Literature Survey Table comparison

Ref	Year	Target	Limitation
[3]	2018	Peer-to-peer water trade system based on smart contracts on private blockchains	Need more information to store on blockchain
[4]	2021	Blockchain-based letter of credit payment under cross-border B2B e-business conditions	Not included automatic payment based on letter of credit and not storing invoices, insurance policies, bills of lading and other complete data
[5]	2021	To authenticate user without third party and sets transaction on hold in case of uninformed	Particularly for authentication. Time consumption in public and private keys
[6]	2017	Decentralized marketplace, secure data storage and transfer, and unique user aliases	Electronic cash system for business purposes
[7]	2021	Two novel strategies proposed for determining the bilateral trading preferences of households participating in a fully Peer-to-Peer (P2P) local energy market	Two strategies proposed and compared for energy trading
[8]	2020	Research on Blockchain in eLearning and proposed methodology of using Blockchain technology in peer-to-peer eLearning	eLearning platform based on Blockchain.
[9]	2019	Demonstrated. the feasibility of implementing. BC technology in P2P. energy trading. and sharing. over. the hyperledger. composer. on IBM platform	Focused on energy trading on IBM platform
[10]	2021	A smart contract-based. P2P. energy trading system with a dynamic. pricing. Mode is proposed	An energy trading system
[11]	2020	A Virtual Power Plant (VPP). is proposed by using Smart Contracts. on Ethereum. Blockchain. Platform.	
Proposed System	2022	Secure and Versatile Decentralized Ledger System based on Blockchain for P2P Communication	Not store data in the form of images or vides and does not validate the patient's records

Table II. Key features comparison of existing systems

Ref	Storage Utilization	Cost Effective	Time Reduction	Encryption	Searchability	Update
[24]	Metadata on Blockchain and EHR on repository	✗	✓	✗	✓	✗
[25]	Encrypted index on Blockchain and EHR on cloud storage	✓	✓	✓	✓	✗
[26]	Entire EHR on Blockchain	✗	✗	✗	✓	✗
[27]	Encrypted index on Blockchain EHR on cloud storage	✓	✗	✓	✓	✗
[28]	Entire EHR on Blockchain	✗	✗	✗	✓	✗
[29]	Entire EHR on Blockchain	✓	✓	✗	✓	✗
[30]	EHR's hashes on Blockchain EHR on databases	✗	✗	✗	✗	✓
Proposed framework	Complete Data stored on the Blockchain after data encryption	✓	✓	✓	✓	✓