Decentralized AI and Blockchain for Secured Health Record Information System

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ABSTRACT

In recent years, blockchain has been a trending technology which paved ways for individuals to deal directly with each other in a decentralized and secure platform without any third party involvement. Besides, the large volume of data and IoT devices may result in critical data privacy, security and business management challenges. In order to achieve a secure, decentralized, smart and efficient business operation and management, the joint combination of blockchain and machine learning will positively impact and attract great interests from both academia and healthcare industry. The integration of Blockchain and artificial intelligence technologies can help to mitigate issues such as limited access to health record, lack of interoperability, the quality and quantity of data for healthcare research. A distributed healthcare system avails various solutions for collecting patient data and offers access and effective reports to patients and healthcare practitioners. However, it's a risk factor for single-point failure, security, privacy, and vulnerble to insider's attack. In resolving such issues, this paper proposed artificial intelligence (AI)-enabled decentralized healthcare platform to access and authenticates trust and transparency in patient health records. The platform is AI-enabled smart contract and the conceptualization of the ethereum blockchain network for the protected e-health record.

Keywords: Distributed ledgers, Blockchain, Artificial Intelligence (AI), Decentralized Technologies.

1. INTRODUCTION

Distributed ledgers are emerging and recent technologies that have made huge a impact in handling real life problems, especially in finance (FinTech), aviation, telecommunication, agriculture, healthcare sectors, etc. The distributed ledger comprises distinct features such as integrity, immutability, the P2P network, tracking, transparency and security to ensure data security and reliability. Recently, the electronic health information (EHI) becomes vital and sensitive for the prediction and treatment of ailments in the healthcare sector. Therefore, regular distribution and sharing of data among health providers, pharmacies, patients' families and so on, is required [1]. In the healthcare sector, transactions are defined as the medium in which medical records are uploaded, created and transferred among peers. Online transfer of patients data by major hospitals via email may encounter risk during transmission [1]. Similarly in 2019, the critical information incident was due to the unauthorized or external access to potential violation of patient record [14]. This posed adverse security risks as patients have no autonomy over their health records.

A report by [15] also exposed an incident in the United States, in 2018, where an insider constantly snooped patient's data for several years without being caught. Hackers maximized over 2million patients data from a healthcare company in one incident [15]. Health records contains critical data that may affect the security of a nation. For instance, the democratic intelligence of a society is obtainable with this information, which can be exploited in social engineering attacks, to govern behaviour and launch attacks on political targets [2]. Health Data privacy is another concern in securing the identity and records of the patient. Access should be granted only to those who need them. In the same vein, [16], stated the need to provide privacy preserving technologies to protect privacy in the distributed network. Furthermore, the healthcare systems are faced with frauds in health service devices and fake drugs. In a report by the World Health Organization [18], about 10 percent of health products, mostly in developing countries are either counterfeit or sub-standard. Another work by [17] discussed the frauds and risks in developing countries.

Consequently, fake healthcare devices and drugs can result in adverse serious health problems [2]. However, the security services that can forestall trust between different parties such as institutions and individuals should be provided without an intermediary. Autonomous systems which are capable of providing the privacy and security demands of the healthcare record can be developed by decentralized solutions. Blockchain can address the present challenges in healthcare infrastructure and represent the standard for healthcare distributors, the agents and clinical researchers to securely distribute e-health information. Despite the benefits of implementing heath information on the decentralized platform, challenges such as high energy consumption by miners in validating blocks, scalability, privacy of health data and security still persists. Integrating AI with Blockchain will help to improve the computations so that miners don't spend time and resources in validating transactions and also enhance the security of health records. In this paper, we implemented a decentralized AI for preserving and enhancing the security of health records.

2. LITERATURE REVIEW

2.1 Decentralized Technologies.
Decentralized technologies are P2P network which provides the solution for direct communication between nodes [12] and where each node act as a server and a client. In this section, we discussed the blockchain technology, challenges of blockchain, decentralized AI, Blockchain for AI and the machine learning algorithm.

2.2 Blockchain Technology
Initially, Blockchain technology existed as an alternative to fiat currency, which was referred to as Blockchain 1.0 or bitcoin. As there continued to be an advancement in innovative technology, the second generation blockchain, known as Blockchain 2.0 or the Ethereum was introduced. Then, the decentralized applications blockchain or blockchain 3.0 was developed and lastly blockchain 4.0 or business-based platform. The technology creates trust among parties through hashing and cryptographic techniques. Healthcare poses a major sector with many implications for Blockchain. The health sector is advancing into a decentralized ledger for health data operations and storage [2]. The extent of health information disclosure is overwhelming, unsatisfactory and counterfeit drugs remain a paramount issue which require urgent attention. Blockchain display great potentials in addressing such substantial problems in health sector. Blockchain technology is a decentralized, distributed, append-only, peer-to-peer and secure ledger operated by organized groups to permanently record and store online transactional records. Blockchain in health service applications can improve mobile health, medical information, and data storage. Each block has an independent unit and a dependent link that holds its report and makes regulated participants to store and share the data without any third-party intervention [10].

Members can also transfer information successfully without presenting the nodes to attacks and forgery using the distributed ledger. In [11], blockchain was classified into three layers namely the infrastructure, platform and the distributed computing layers. Firstly, the infrastructure layer is made up the storage component and the network facilities for effective communication among different distributed platforms. The hardware components carry out transaction execution, validation and block generation while retaining the ledger copy. Secondly, the platform layer comprises the Remote Procedure Calls, Web App Program Interface and Representational State Transfer (REST) APIs for the Communication purpose. Lastly,the distributed computing layer confirms the local access to data, immutability, fault tolerance, security, and authenticity. In addition, the platform layer is takes care the user authentication and data privacy using the encryption and a hashing techniques respectively. In the decentralized P2P network, nodes store the same ledger transactions to provide the network immutability and uses an algorithm to reach a consensus [11].
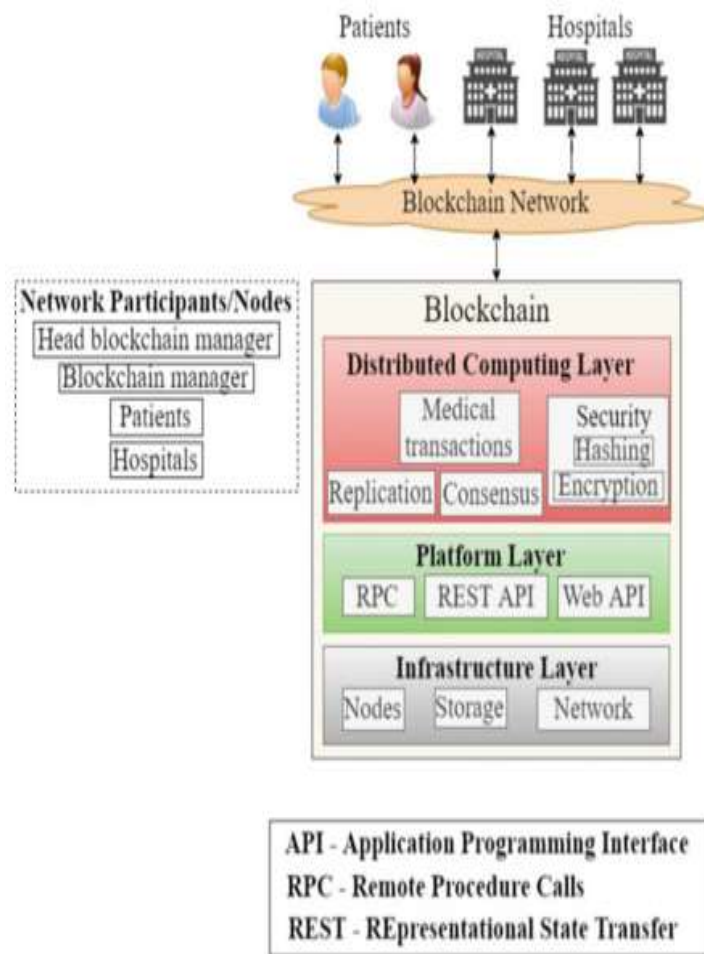

Figure 1: Layers of Blockchain Technology in HealthCare [11]

2.3 Challenges Of Blockchain

This section describes the implementation issues in the distributed ledger which must be addressed to attain maximum benefits. Blockchain platforms are faced with challeges that could limit their usage. In [2], the core challenges are summarized as follows:

i. Scalability
ii. High energy consumption
iii. Slow transaction and confirmation times
iv. Interoperability
v. User privacy.
vi. cryptology and ledger security in the upsurge of quantum computing

Artificial Intelligence (AI) is capable of changing the administration of blockchain networks for more efficiency. By integrating AI with blockchain, the present blockchain model will be able to handle block confirmation, authorization and distributed transaction processes faster. Decentralized AI increases the security of the blockchain and provides better protection against malicious miners or any attacks eminent in the network platform.

2.4 Decentralized AI

Decentralized AI is the integration of artificial intelligence and Blockchain technology. This implies combining a human-centric artificial network with the capacity of doing wonders with blockchain features such as transparency, immutability and trustworthiness. AI provides security and assist in decision making without the need for a third party. With machine learning algorithm, malicious miners find it very difficult to enter the network and verify the transaction records [2]. AI solutions are enabled with machine learning and deep learning techniques. Deep learning is described as machine learning algorithm applied to huge datasets for an enhanced decision making process [3]. In another work, [9] proposed a faster and convenient means of detecting diseases using classification and prediction techniques. The process requires real medical information of the patient on a disease to discern generalizations and patterns for prediction. Confidentiality and privacy are the basic requirements of health record and permission must be requested and granted for the collection and usage of this record ina limited time frame [4] [5]. AI algorithms must be trained properly so that the prediction mechanisms can work successfully to give the desired solutions [7]. Blockchain-based health information can overcome scalability and lack of data management issue.

Decentralized AI has the ability to offer solutions and benefits in diverse areas. [6] and [8] highlighted the benefits of integrating both technologies. Thus:
a. Enhanced information security
b. Increase trust level
c. Improve privacy-preserving
d. Scalability issue handled
e. Better efficiency

AI-based decentralized systems consequently create the world's best reliable, resilient and decision technology for greater insights and prediction in the healthcare industry [13].

2.5 Blockchain For Artificial Intelligence (AI)

Today data science faces a major challenge, which is the collection of proper dataset to train artificial intelligent algorithms. Blockchain evolve to boost the potentials of AI in diverse ways [2]. The distributed technology is available for sensitive data protection and sharing.

Besides the features of the blockchain, integrating the technology with AI will elevate the ability to add value to medical diagnosis and health sectors, improving predictive analysis techniques and keeping electronic health record secured and private. The advantages of utilizing blockchain architecture for AI technology in healthcare sector include:

i.   Data Monetization
ii.   Improved collective decision making, utilizing diverse data and improved trust
iii   Enhanced data security, storage and protection.

In figure 1, AI and Blockchain would allow patients, drug producers, lab scientists, health researchers, drug physicians and radiologists to share data in a trusted-based and secured environment. Interplanetary file system (IPFS) is employed to securely store health information (HI) in the cloud while hash values are kept as records in the blockchain.
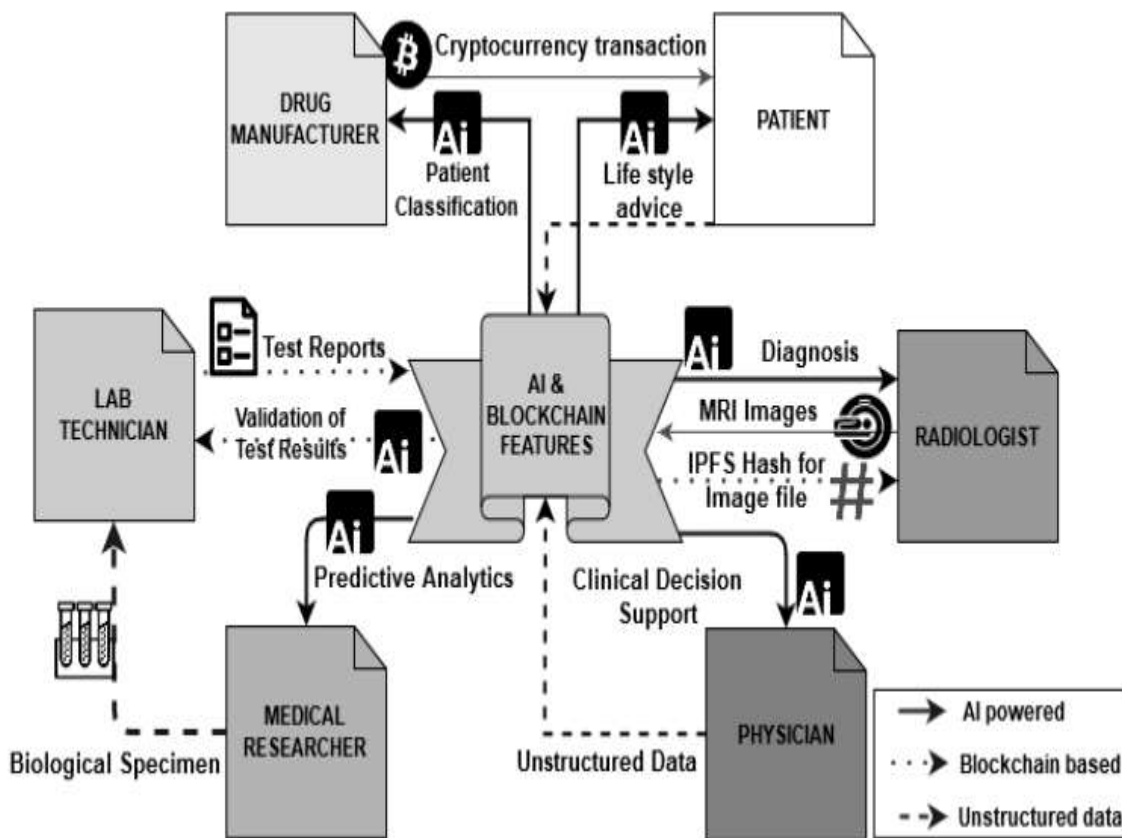

Figure 2: AI-Blockchain Structure [2].

2.6 AI and Blockchain Integration In Healthcare

The two new technological innovations in the healthcare sector are Blockchain and artificial intelligence (AI). With the combination of the distributed ledger technology and machine learning algorithms, healthcare professionals will be able to access the medical records of the patient on the blockchain and take appropriate decision. In addition, the potential capabilities of integrating these technologies will improve service efficiency, cost reduction and democratized healthcare systems. However, some doctors apply caution when using artificial intelligence in controlling health challenges especially when it has to do with the patient's wellbeing. In blockchain, cryptographic records needed by AI are stored securely. Furthermore, AI helps to evaluate the vast amount of patient details and execute complex computational functions.

Besides the healthcare sector, the automobile industry has utilized AI in delivering driverless vehicles. Consequently, some companies have demonstrated several ways to detect fraud and any financial threat by maximizing machine learning [20]. AI and blockchain flaws can be addressed efficiently by merging these two technological ecosystems [19]. However, AI algorithms rely on data or information to learn, interpret, and make conclusions. When data is acquired from a data repository or a dependable, safe, trusted, and credible platform, machine learning algorithms performs better. Blockchain acts as a cryptographically secured, validated, and agreed-upon distributed ledger for data storage, exchange and verification.

Data on the blockchain cannot be tampered with due to the robust and high level of integrity in storage. Smart contract can be trusted and unquestionable when used to make judgment and do analytics using machine-learning algorithm. Combining AI and blockchain can lead to a safe, immutable, decentralized system for the sensitive data collection, storage and usage [23]. The resultant effect is the utilization of primary data and information security in diverse industries such as medical services, banking services and finance, trading, and lawful data [22]. AI and Blockchain integration will facilitate the intelligent decentralized autonomous agents (DAOs) in validating digital value and enhancing automatic assets transfer among various authorities [21].

3. SYSTEM DESIGN

In the proposed system, blockchain and artificial intelligence (AI) technologies were used to store and secure patent medical information in a decentralized database. Blockchain is used on the network to devise the security and privacy of the patient information. The Records are validated to form a block for each patient in the blockchain as a ledger registry. The ledger is kept distributed in the AI nodes connected to the Decentralized database. Trust between peers is established by decentralized solution and totally eliminating central intermediaries. The patient can be given data ownership, with the right to share the information only to authorized users. The AI system monitors where and how information are kept and shared in the blockcahian.

In the system doctor and patient will create an account. When the patient is assign to a doctor an id is generated to map the patient id and the doctor id together including medical information are all store in the blockchain. AI will make intelligent decisions to check where records are kept on the chain. The proposed system is categorized into two major users; the doctor and the patient. Patients are connected with Login and View Past Records. Patient will grant access to the doctor to diagnose patients, view medical information while Doctors are interconnected with laboratories. Doctor can view all patient key id and name in the hospital and part of the medical history including the medical prescription.
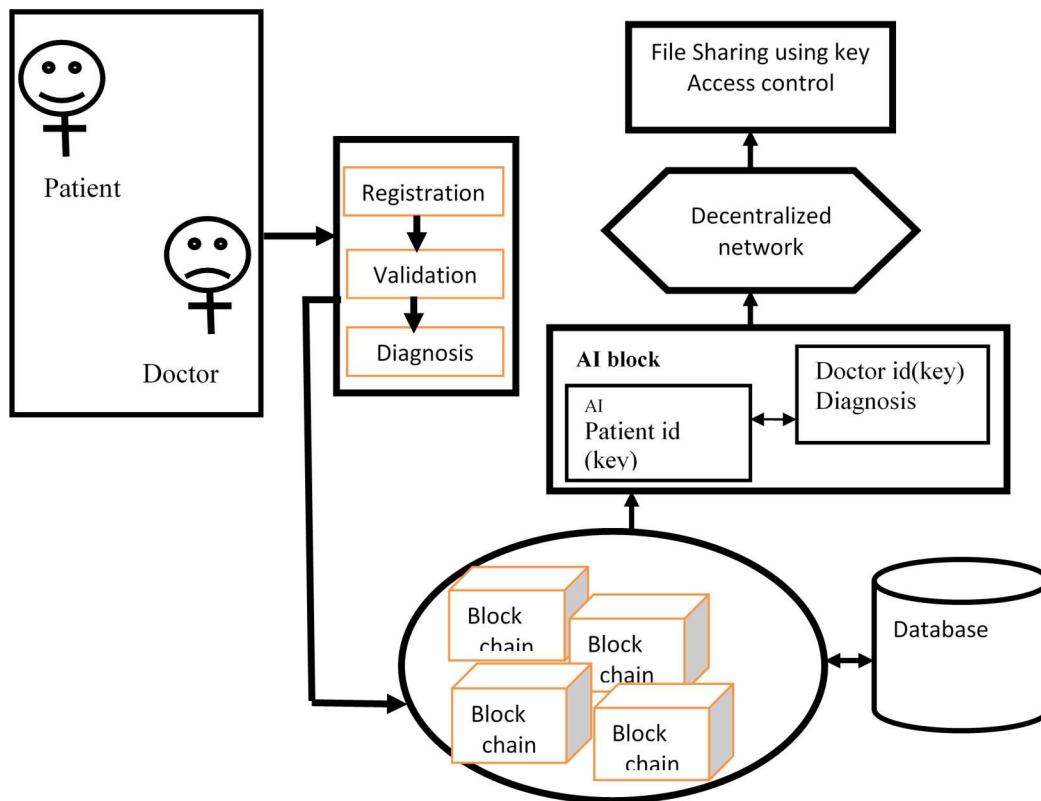
Figure 3: Architecture of the Proposed System

4. RESULT AND DISCUSSION

We have been able to achieve a decentralized and artificial intelligence-based platform for the management of patient medical records. A solution where each on-chain node can act as a server and a client where information in the ledger is distributed across the numerous nodes for validation and verification without any third party or central authority. This system utilizes key mapping for direct communication between nodes, doctor and patient. In the system, both the patient and the doctor must have a network account where their profiles are stored in the blockchain. The doctor will search the network for patient information and then send a request to the patient.

When the patient receives the queued request in his dashboard, he/she can authorize access by inputting their private key. After the operation is completed, AI will update the blockchain network. JavaScript, CSS, HTML, and Solidity tools were used to create this integrated system. The whole system is viewed as a private and artificial intelligence network where all medical records are stored for data security, privacy and integrity. As a result of these features, artificial intelligence and blockchain technology will provide enhancement for several services that include security, traceability, trust, and transparency of information in the decentralized public network.

5. CONCLUSION AND FUTURE SCOPE

Blockchain technology enables secure storage of information in a way that affords only doctor's access to a patient's existing health records while researchers are only allowed to view the statistical data instead of patients' health record. However, artificial intelligence and blockchain technology has helped to simplify the processing of health records, payments, hospital staff identification, drugs prescription, diagnosis, doctor screening and information management for more accurate, transparent, and secure health services. In this paper, we were able to present the integration of blockchain and artificial intelligence a secured and decentralized sharing of health record model as well as the efficient operation of business processes. Initially, the blockchain technology, challenges of blockchain, decentralized AI and then the integration of AI and blockchain in healthcare domain were analyzed.

However, we highlighted the benefits of AI and blockchain which include enhanced information security, increase trust level, Improve privacy-preserving, scalability issue handled and better efficiency for trustful decision-making. In conclusion, research on the integrated blockchain and artificial intelligence (machine learning) in the healthcare industry is quite broad with a large number of unmentionable challenges. For widespread implementation, AI systems must gain approval from healthcare regulators, integrated with health information management (HIM) systems, standardized to a maximum degree with similar products in a similar manner, exposed physicians, accepted and paid for by public or private organizations and constant update in the field. Hence, these challenges might be time-consuming for real life implementation but can be overcome in due time.

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