

A Secure Healthcare System Design Framework using Blockchain Technology

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Abstract— Blockchain, the technology of the future neutrally facilitated the financial transactions in cryptocurrencies by strictly eliminating the need for a governing authority or a management that was required to authorize the transactions based on trust and transparency. The Blockchain Network also follows the principle of absolute privacy and anonymity on the identification of the users associated in a transaction. Since the time of its inception, the Blockchain Technology has undergone research that has demonstrated some various kinds of methods to sort out the access control system of the conventional system. In recent years Blockchain has also shown optimum reliability in multiple sectors such as Smart Home, Healthcare, Banking, Information Storage Management, Security and etc. This work in terms is further concerned to the sector of Smart Healthcare, which has grown to a much affluence regarding the efficient technique of serving and dictating medical health care to the patients with the point of maintaining privacy of the patients' data and also the process of laying out real time accurate and trusted data to the medical practitioners. But in the scenario of Smart Healthcare, the primary concern arises in the fact of Privacy and Security of the data of the patients due to the interoperability of multiple stakeholders in the process. Also, there has been a fact of determining accurate and proper data to the doctors if the concerned subject is out of reach from the in hand medical service. Therefore, this Concern of privacy and also mitigation of the accurate data has been very much managed in the work by regulating, a monitoring and sensing paradigm with accordance to the IOT and the Blockchain as a transaction and access management system and also an appropriate medium for laying out accurate and trusted data for serving with deliberate medical care and benefits to the patients across.

Keywords— Blockchain, Healthcare, IOT, Smart Healthcare, Wearables, Security, Privacy

I. INTRODUCTION

Smart Healthcare and Biomedical advancement have always been a major concern to be uplifted in every possible way with the technological advancement that is seaming out throughout the globe. Enhancing the structure, trust, procedure, and efficiency of health care services and supporting the patients with qualified nourishment and care is of the sole importance. The world in the present day has been observing people being more reluctant towards personal healthcare until a major hardship shows up. Such a thing can be often regarded as a

segment of over engagement to the customized busy life and tuned lifestyle structure. Therefore, if a system is developed in such a way that measures or detects typical anomalies in the health suite of a human and can report to the designated personal health care supervisor of the person, then the whole scenario would be much more convenient and also an effortless consultation can be done on the patient in the right moment and within a sheltered duration.

The ongoing advancements in the field of Internet of Things (IoT) have exponentially increased the scope of connectivity between remote devices connected to the internet for data and access transfer. Therefore, IoT revolutionized and disrupted almost every industry that exists in the globe starting from education sector to supply chain management. In the Healthcare sector, IoT has also shown an excellent performance by easing the diagnostic procedures and efficiently monitoring the activities of the patients. Moreover, the major factor that we are focussed on for IoT is that it supports the monitoring of patients even during the nonactive hours of the patient which sometimes is very tough to be achieved in the conventional system. Also remote access to the data and continuous analysis of it also shows up some extensive possibilities towards faster diagnosis and efficient treatment.

Recently, with the advent of Blockchain, the complete access, transaction, and storage management was taken over by the technology. Blockchain has also shown immense hold and potential across multiple sectors such as Retail, Supply Chain Management, Finance, Healthcare and etc. In healthcare, the primary issue that always comes up is the privacy and security of the data as it is often utilized by a lot of stakeholders for pursuing respective actions. For example, insurance companies are one of the stakeholders in the providing a particular service to the patient for which it is often needed that the insurance provider must get the hold of the data of the patient for analyzing it properly and lay out the services, but it can be often seen that the data is manipulated by the companies and also leaked. Therefore, to protect the data from the misuse and also to maintain a definite trust between the different stakeholders, this system is a bonafide solution.

II. RELATED WORK

Dey et al. [1] proposed an Internet of Things Model based on Blockchain for a more systematic management of transactions that are carried out by Medical Sensors and Devices. The

architecture proposed the utilization of MQTT protocol, which can be used as the primary agent for connecting the bio-sensors to the IoT platform. Moreover, the architecture also consisted of the IPFS (InterPlanetary File System) which can ease out the state entries or the changes in the blocks when some particular transactions are appended to the blocks to reduce the deduplication of the transactions that are stored.

Budida et al. [2], proposed an interactive environment regarding a healthcare system governed by IOT. The proposed architecture basically lies on the foundation of generative data ingestion from the smart wearable devices and bio sensors and following up with some definitive feedback and easy solutions to the patients. Sivagami et al. [3], proposed a Smart Hospital system that unites the efficiency of the Sensors and also suggests human reaction for a faster and timely advice to the patients. The proposal advances the usage of RFID, WSN and Smart Wearables which operates with each other over a single platform to perform certain tasks such as smart sensing of the environment of the patient, allocation of the patient to a particular ward based upon the doctor placement requirements, monitoring the movement of the patients and report analysis based upon the data that has been calculated by the system, post the data has been uploaded by the sensors.

Theodouli et al. [4], facilitated a Healthcare Data Sharing system that overtakes the contemporary system by unleashing the pseudonymity of privatizing the identification of the users whose data is being shared and being utilized by the Medical Research Centers. The work also established the concept of a Consensus Algorithm, "Proof of Interoperability", that would allow institutions organized on the system regarding smoother and efficient transactions based completely on the Interoperability of the various nodes on the Network. Moreover, the author also suggested a three-level architecture on various stages namely, Web Platform- which will be utilized by the patient for uploading the Health Records and maintaining an Access Management Suite, Cloud Middleware- will be used to maintain the data fetch from the Web Platform using REST API services and to call on the Smart Contracts for performing the specified registration of newer blocks and to support consensus of the Nodes across the Blockchain network that is held in the third level.

Wang et al. [5], advances a Parallel Healthcare System developed around the ACP Approach developed on a Blockchain network. The system defines the usage of a Parallel Healthcare System based on the real word therapeutic knowledge and experience of the doctors and patients, and the usage of an Artificial Intelligence system that determines the implementation of Virtual Doctors and Virtual Patients to undergo and define a Parallel approach in dictating the treatment that are needed to be carried out by doctors on the patients. The second Segment of the ACP approach points to the very segment of Computational Experiments, where it combines the Clinical Significance and the Experience of the 4 to determine the generic Clinical and Experimental Procedure that is to be carried out on the patients. The third segment allows the Parallel Execution between the Artificial Health Care System and the Actual Healthcare System, which governs

the approach between the real world doctors and Artificial or Software-defined doctors. The basic fundamental proposition of the parallel system relies on the fact that the artificial or software-defined doctors will perform the computational experiments on the patients based on the features that have been fed to the system, the results that will be generated out by the Artificial Doctors will be further verified and updated by the doctors. The Complete Healthcare System was further incorporated with a Blockchain Network having the consortium of the Doctors, Hospitals, Patients, Healthcare Bureaus and Medical Researchers, which can be utilized for review and sharing of the data.

Zainab Alhadhrami et al. [6], discussed the various kind of blockchains architectures available in the present scenario and discussed the basis of all the types of blockchains and how it can be used in the healthcare sector for maintaining, validating and storing the data. Also, the system that mostly came out of the box for storing of the healthcare data was marked to be the consortium blockchain. Consortium blockchains are basically those which are permissible blockchains where the node owner, as well as the miners, get the access control. Moreover, the consortium blockchain works on the theory of consensus from a majority number of stakeholders or the nodes associated with the blockchain network.

Liu et al. [7], proposed an advanced blockchain architecture for the system governing e-health care systems. The primary concern of the work focused much on the development of interoperable and an adaptable networking solution for the effective and proper sharing of the health care data within multiple stakeholders. Moreover, the advanced blockchain architecture follows the methodology of primary audits by the stakeholders such as the insurance companies, hospitals, and doctors with regard to the authenticity and credibility of a record that is been shared over the platform.

Ahram et al. [8], developed a health care blockchain where the privacy rule facilitated by HIPAA was addressed using the data that possessed the demographic and racial information of the patients were kept under control. Moreover, the work also showed a generative architecture of a blockchain network which consisted of three types of network namely, urgent care network, referral network, and primary care physician network. Raj et al. [9] defined and developed a novel approach for monitoring health and also support the basic implementation of telemedicine technology for the remote areas where the connectivity is a vital concern. The work developed a portable system for sensing the patients who are situated in remote locations. The system consisted of pulse oximeter, ECG, EMG and etc, moreover, the system also has the capability of working in both online and offline mode where the small data packets from the sensors can be stored in a local database in the system and further can be carried out to the medical practitioners either on the go or using internet which should be convenient at the time. The system also addressed the method of using a multi-channel framework for the doctor, where they can take over the cases of the patients from the Remote Sensing Centres.

Liang et al. [10], integrated a Blockchain Network for the Sharing the Data and Collaboration with the Blockchain

Architecture. The system described in the work generally pursued the interoperability of a group of entities such as the patient, doctor, healthcare providers, and health insurance companies on the sharing and collaboration in the health data. The wearable device which is fastened on the patient is linked to the cloud database or the network which stores the complete data of the patient. As every day a huge amount of data comes into the storage so for efficient data processing and integrity management of the data, the work proposes to form batches of data to be stored in a Merkle tree-based architecture for efficient and smooth data processing. The patient can share data with the healthcare providers and insurance companies for either getting the services or insurance quotes respectively. The system defined in the work was defined to be a user-centric system where the patient had got complete rights regarding the data to be shared or not. This kind of systems can be very helpful in terms of medical research and also the preservation of personal medical records, where the privacy and security of data is of major concern.

III. PROPOSED FRAMEWORK

The amalgamation of the Internet of Things (IoT), Blockchain and Machine Learning for the anomaly detection in the behaviour of the health data of the patient is the crust of the complete framework. The methodology demonstrated is basically a system that demands the use of the Internet of Things module to intercept and fetch the data that is been generated by the wearable devices worn by the patient. The Blockchain system depicted is preferably utilized for storing

and maintaining the data of the patients in the form of multiple transactions and also support access control to the different stakeholders respectively. Moreover, the Blockchain architecture is also used for supporting the medical research by maintaining the pseudo-anonymity of the patient's identification and to provide authenticated and trusted data for a more accurate research. The Machine Learning model is used basically for the detection of anomalies and to forecast certain scenarios that may arise in the due course of time by analysing the data based on the parameters that are passed on by the Doctors for basic identification of the conditions that are faced by the patients.

A. The IoT Module

The module deals with the process of fetching and sensing the data from the wearable devices and the biosensors that are either worn by the patients or that are present in the environment in which patients are monitored. In a more perspicuous way, if a patient is undergoing some mild treatment and is following up with some medical tests, then a wearable sensor is a prime course of monitoring the data of each and every second the patient is generating. The Data that can be considered based upon the wearable worn by the patient is Heart Rate, Calorie Release, Breath Strengthening, and Sleep Stage Monitoring. Also, if blood pressure measuring sensors are used and also if pacemakers are implanted on the patient, then such data can also be remotely sensed using the IoT application module. Now, if the patient is bedridden or is admitted to the hospital, then there is a massive requirement

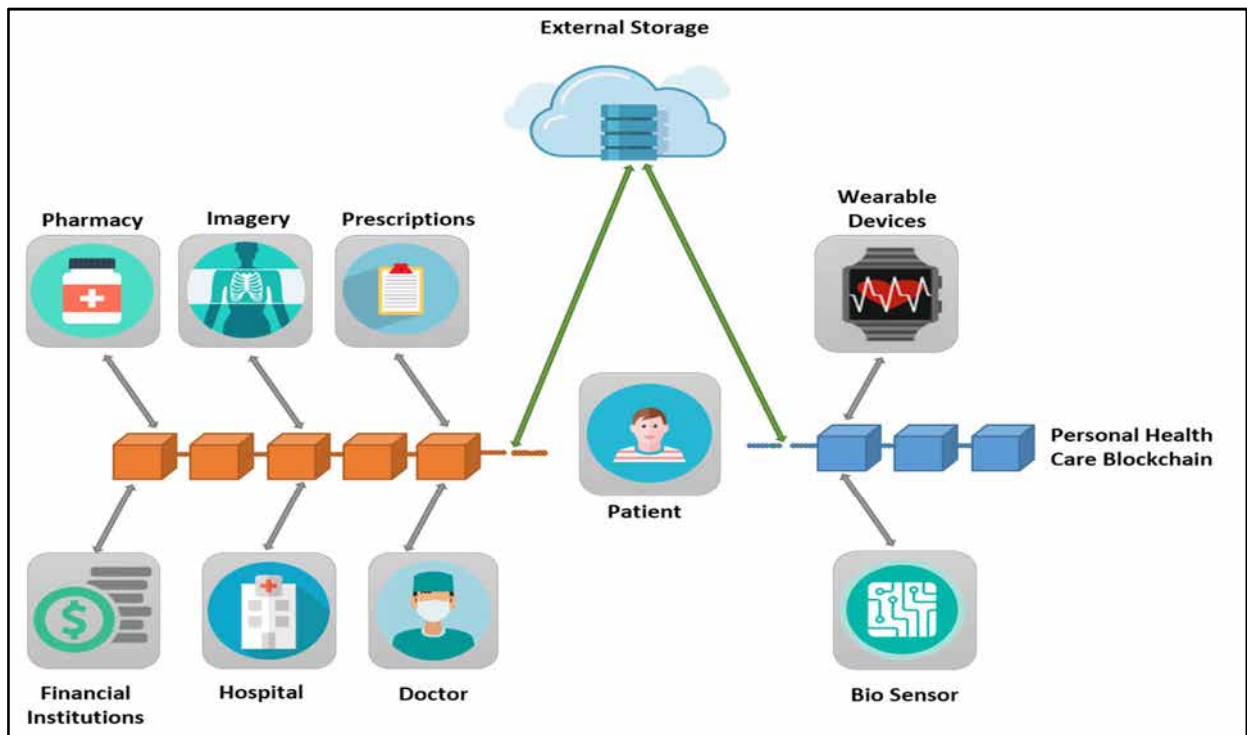


Figure 1: Framework for the complete Healthcare System

that the IoT sensors or the Bio Sensors are to be placed upon which can realize the environmental conditions and take actions based upon the situation.

B. Transaction and Access Management using Blockchain

The storage of the huge amount of data that is being generated by the patient is required to be managed and processed by maintaining some secured protocol. Moreover, when there are multiple stakeholders associated with the data being generated then a key module that is an access management system is to be implemented which is further addressed by the Blockchain Network. In the proposed architecture we have defined the usage of two vital blockchain networks namely the Personal Health Care (PHC) BlockChain and the External Record Management (ERM) Blockchain. The Personal Healthcare Blockchain is typically maintained by the Patient as it senses and captures the data from the personal wearable devices. The access to the data can be further communicated to the doctor which will be utilized for proper medication and understanding of the ailment that the patient is going through. The data generated by the wearable devices are further stored in an external cloud database which is regulated by the blockchain network.

The External Record Management Blockchain is utilized for the purpose of managing the data that is being generated when a patient goes to the doctor. The ERM Blockchain usually stores the data generated by the healthcare centers, pharmacy bills, medical test reports, prescriptions and image data. The data is being appended to the chain based upon the consensus of all the stakeholders of the blockchain on the "Proof of Stake" algorithm. In the case of ERM Blockchain, the majority stake lies with the Healthcare Center and the Doctor as all other stakeholders are a cumulative holding of them. The Blockchain network also welcomes the access of insurance companies for validating the data of the patient in case of a claim is being raised by the patient.

C. Machine Learning Module

The Machine Learning Module works on the basis of the data that is been generated by the patient for detection of any types of anomaly in the data. The anomaly detection can be very much addressed by running the model to fetch out abnormalities in the data that is being generated. Whenever an anomaly is detected a notification is sent to the doctor and based upon the instance a suitable action can be taken up.

IV. DISCUSSION

The proposed methodology described in the work completely overcomes the issue in terms of efficiency and also the security and privacy of the data that is being generated in the conventional Healthcare system. The proposed framework very well establishes the complete supervision of a cure or an ongoing treatment or generic healthcare from the beginning to the very end. The primary notion that is always observed in the case of healthcare data research is the trust or authenticity of the data. When the data is generated and stored with regard to Blockchain framework then we could always ensure that the

data is authentic as it has been merged to the chain based upon the consensus of multiple stakeholders and not one single governing authority.

The transition in remote monitoring and environment control form the manual accompaniment is always regarded as to be more guided and effective solution. In the conventional system, a tip to tip monitoring was not possible or rather can lead to multiple inconsistencies, therefore a remote network of sensing all the related data and notifying the healthcare providers or the doctors in case of an abnormality can be very much considered to be one of the optimum solutions.

In terms of the usage of data generated in the conventional system, there was always a question that arises, that is trust or whether the data is authentic. But in the case of the implementation of Blockchain in storage and access management, we can always trust the data. Moreover, the proposed framework also provided much aid to the Insurance companies as when a patient holds up a claim for the reimbursement, the insurance company need not look for all the paper works and vet the scenario rather can ask the Healthcare Centre to directly provide an access to the ERM Blockchain and can validate the data.

V. CONCLUSION

The World present day has moved on to the verge where global connectivity and synchronization is the primary thing that everyone is looking. Also, the present scenario of people around the world has shown a change in terms of the lifestyle and a busy schedule so, it has always been observed that people tend to neglect minor abnormalities with regard to the health. Therefore, the proposed system implements the notion of fetching data remotely from the patient's wearable devices and Bio Sensors if any to provide them with timely and adequate support.

With much consideration to the Accuracy, Security, and authenticity of the data generated from the patients, there has always been a requirement that the data must be always governed in a proper way. Therefore, for access management and storage of the data to manage the transactions, we tend to propose the concept of blockchain which is a consortium of multiple stakeholders such as Hospital, Doctors, Pharmacy, Pathology, Imaging Centres, Medical Research Centres, and Insurance Companies. Therefore, such systems can be considered as a significant whole in uplifting the society with accurate and efficient healthcare.

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