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# Blockchain based Secured Telecare Medical Record Management: A System Design

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***Abstract*—Remote healthcare is very necessary in current pandemic times. Telecare empowered remote healthcare but mostly healthcare organizations manage telehealth information in centralized systems which are prone to various cybercrimes like ransomware, DDOS etc. Privacy and security of sensitive telehealth data is essential to ensure improvement in patient health. Blockchain technology in integration with wearable fitness technology has potential of securing telehealth records due to its unique characteristics like tracking, collusion resistance, transaction visibility, tamperproof and provenance. The aim of this work is to develop Telecare medical record(TMR) management system for uploading and retrieval of real time fitness monitoring and medication data using blockchain technology and smart healthcare 'devices. Developed system permits healthcare providers to achieve fast access to fitness tracking data of patient in order to prescribe suitable medication over blockchain network. The system also keep track of all past TMR records that patients can access anytime in future. This system can prove to be a very beneficial mechanism to secure telehealth in current pandemic time. In designed system, unique IDs are computed for each TMR by universally unique identifier(UUID) and the hash generation of each TMR block is performed using secure hash algorithm(SHA)-256. The designed model comprises four building modules which are TMR uploading, TMR mining, TMR addition and TMR retrieval. All four modules of the developed prototype are tested and few execution outcomes are illustrated in the result section. Execution results shows that developed system is appropriate in TMR management for better health outcomes.**

***Index Terms*— Security, telecare, medical record, health, blockchain, management.**

## I. INTRODUCTION

Healthcare is the one of the most precious elements for strengthening the economy and development of any nation [1]. Wearable fitness technology and blockchain technology has been growing rapidly due to increasing demand of public to track their health parameters and medication quickly in order to improve health outcomes. Remote healthcare is very necessary in current pandemic times. Telecare empowered remote healthcare but mostly healthcare organizations manage telehealth information in centralized systems which are prone to various cybercrimes like ransomware, DDOS etc. Privacy and security of sensitive telehealth data is essential to ensure improvement in patient health. Blockchain technology in integration with wearable fitness technology has potential of securing telehealth records. Confinement of diverse natures of various health records is a significant issue [2]. Distributed ledger technology has attracted the business owners in different fields including medical [3]. Blockchain contributes digital data security, transparency, trustworthiness and also provides secured health

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data sharing [4, 5]. An optimized cybercrime free design can be achieved for safe transfer of health data by using distributed ledger technology [6]. Even the complex nature of healthcare record management system can be improved using blockchain [7]. Blockchain can play an important role in handling variety of health data like genomic information [8]. Blockchain eliminates the requirement of third party in scenarios that are suspected to be impacted by cybercrimes [9]. When health records are recorded in a distributed manner then it is almost impossible to access the data illegally [10]. In the process of exchanging or sharing data, blockchain confirms that data cannot be tampered [11].

## II. Related Works

This section covers the prior work related to medical record management systems. In [12], the author presented a blockchain based medical information monitoring system in cloud conditions. The author enlightened the secured sharing of genomic data of cancer patients in [13]. The challenge of latency in transferring the treatment case to other healthcare institute was showcased in [14]. Validation strategy for electronic health record using distributed technology was designed in [15]. The safe exchange of TMRs using blockchain was developed in [16]. The system for certificateless cloud based healthcare data was explored in [17]. Participant oriented structure for EHR was designed in [18]. Usage of blockchain in healthcare including electronic health record were investigated in [19, 20]. The blockchain based sharing system for fitness monitoring data among professionals was developed in [21]. Cloud supported and protected electronic health record system was developed in [22]. In [23], Scalable electronic healthcare system for medical records using blockchain was designed. Options for exchanging healthcare data were evaluated in [24].
In [25], the effective and customized telemedicine system using blockchain was suggested. In [26], cloud assisted medical information sharing model using distributed ledger technology is designed. In [27], protection defensive health data sharing mechanism using blockchain potential was explored. In [28], a prototype for access control based health record management was recommended. A design for integral solution for medical record handling was introduced in [29]. In [30], It was evaluated that blockchain based systems are complicated than traditional sharing systems. Literature survey shows that blockchain is appropriate for TMR management due to their enormous advantages like security, immutability, transparency, and provenance of the stored data.

## III. Proposed Work

### *A. Overview*

The proposed telecare medical record(TMR) management system is developed for uploading and retrieval of real time fitness monitoring and medication data using blockchain technology and smart devices. Developed system permits healthcare providers to achieve fast access to fitness tracking data of patient in order to prescribe suitable medication over blockchain network and also allows patients to access this data. Fig. 1 represents the use case scenario of blockchain based TMR management system.

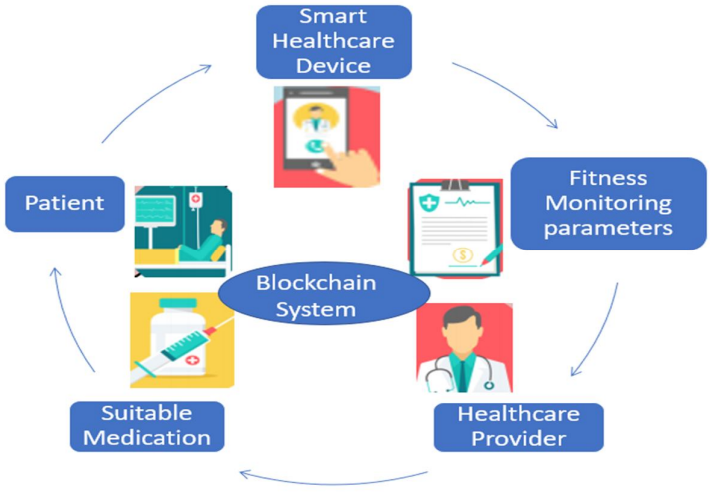


Figure 1. Use case scenario of proposed TMR management system

This use case scenario shows the transaction of patient's fitness monitoring parameters generated by smart healthcare devices to the healthcare provider and also the transaction of suitable medication prescribed by healthcare provider to the patient in real time. This system can prove to be a very beneficial mechanism especially in current situation of covid-19 pandemic. The benefits of proposed system are listed as follows.

- Tracking: Allows care providers to track patients in real time and eventually leads to better health outcomes.
- Cybersecurity: Privacy and security of confidential patient data due to blockchain mechanism and hence Prevent attackers from blocking TMRs for forgery purpose.
- Cost reduction: Cost effective for patient due to elimination of conveyance cost involved in visiting clinic and for healthcare provider due to less need of infrastructure and staff.
- Freedom from single point failure: Free from the harm of losing past records due to single point failure which is suffered by most of the current telecare systems.
- Interoperability: Quick sharing of TMR with multiple experts for better treatment delivery to the patient in
- secured manner.

*B. Proposed System Architecture of TMR Management*

The proposed TMR management system is essential to improve public health in current pandemic period. The Proposed model overcomes the challenges of traditional telecare system by covering all the aspects of healthcare domain like privacy, security, transparency, proper record management etc. that makes smooth communication between patients and healthcare providers. Endorsement policy like patient consent is necessary to keep the confidentiality of sensitive data so that only genuine healthcare providers can have TMR access rights. Fig. 2 illustrates the architecture of proposed TMR management system.

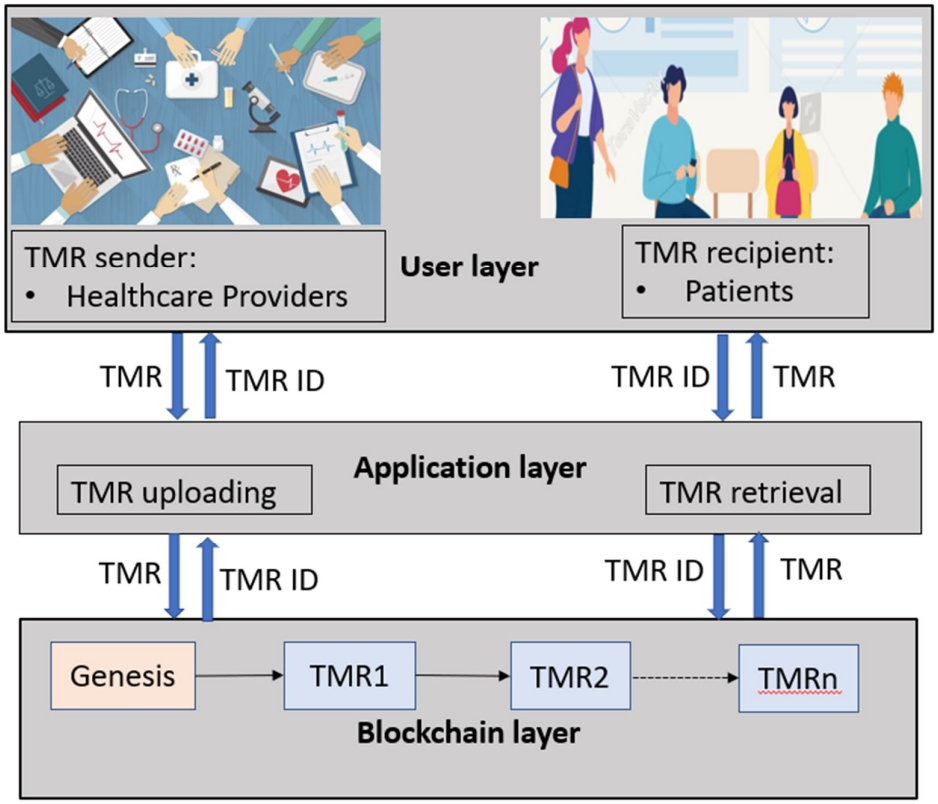


Figure 2. Architecture of proposed TMR management system

The developed system is a three layer structure that includes user layer, application layer and blockchain layer. The user layer enables the transaction of health parameters of patients generated by smart healthcare devices to

the healthcare providers over blockchain network. This layer also facilitate healthcare providers to send the medications based on patients health parameters to the patients over blockchain network. Smart healthcare devices like fitness tracker, blood pressure monitor, ECG monitor, sugar level monitor etc can be used to monitor physical condition of patient in real time. Health parameters representing fitness data and medication data will be stored in the form of TMR in the blockchain ledger of developed system. Healthcare providers and patients can view transferred TMR on blockchain ledger through the user layer.
but healthcare providers can view TMRs with the consent of patient only. The application layer is used for handling the TMR uploading and retrieval process and acts as interface between user layer and blockchain layer. The various purposes of blockchain layer are as follows.

1. Broadcasting the uploaded TMR to all blockchain network nodes.
2. Creating the new TMR block.
3. Mining the new TMR block.
4. Validation of new TMR block by all network nodes to append it into the blockchain ledger.

In blockchain layer, first block is representing the genesis block and rest blocks representing the transferred TMRs(TMR1, TMR2...TMRn). Fig. 3 shows the workflow of developed TMR management system.

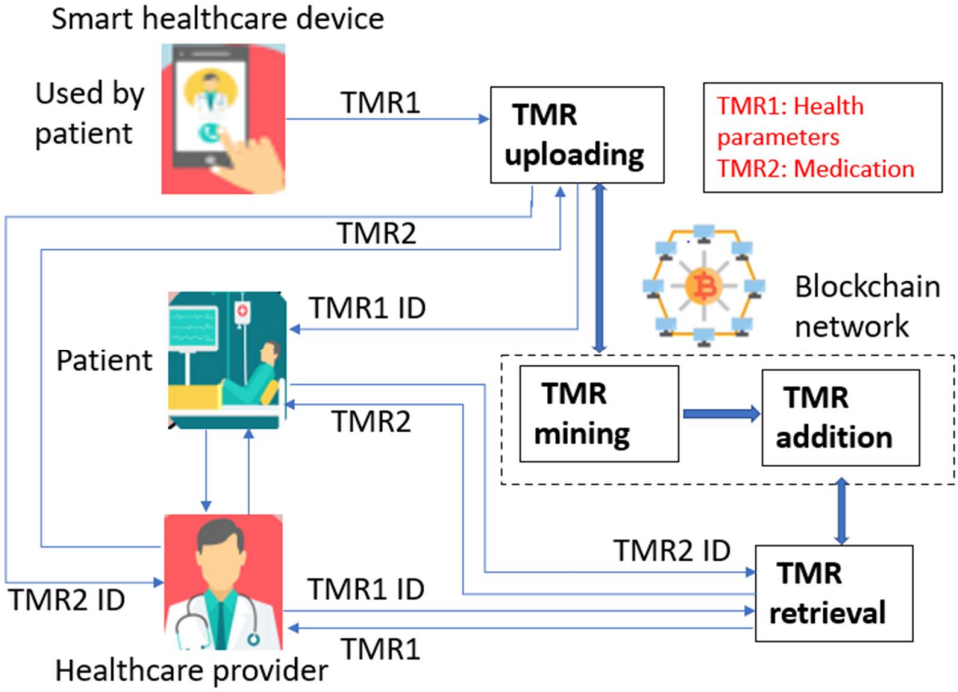


Figure 3. Illustrates the workflow of developed TMR management system

Initially smart healthcare device used by patient generates and transfer TMR(say TMR1) containing patient's health parameters to the healthcare provider over blockchain ledger. Upon transferring TMR1, unique TMR ID(say TMR1 ID) is created and sent to the patient by blockchain layer. Patient can share TMR ID with the healthcare provider for medication. Transferred TMR is broadcasted to all the nodes of blockchain layer. A new block indicating uploaded TMR1 is created and mined to calculate its hash value using SHA-256 algorithm. The block hash depends on the previous block hash, current block information and nonce. The procedure of mining gives proof of work for new block verification. Blocks are encrypted by hashes to secure information inside blocks. After mining process, this new block is approved by all nodes and block containing TMR is finally added into the blockchain network. After transferring TMR1, it is retrieved by healthcare provider with the consent of patient using TMR ID of TMR1. Then healthcare provider uploads the next TMR(say TMR2) containing medication to send it to the patient over blockchain layer. Upon transferring TMR2, unique TMR ID(say TMR2 ID) is created and sent to the healthcare provider by blockchain layer. Healthcare provider can share TMR ID with the patient for prescribing medication. Again a new block indicating TMR2 is created, mined and added into the blockchain network. Finally, patient can retrieve the medication prescribed by healthcare provider using TMR ID of TMR2. In a similar fashion, uploading and retrieval of various TMRs can be done.

## IV. Implementation and Result

This design study suggests a blockchain-based approach for secured TMR management. In developed system, TMRs are sent to the healthcare providers and patients by smart healthcare devices and by healthcare providers itself and can be retrieved by healthcare providers and patients. In proposed model, TMRs have been created in json format using postman software (for simulation purpose). Visual studio code software has been used to develop the own blockchain and node js programming language for source coding. The implemented design has four building modules which are TMR uploading, TMR mining, TMR addition and TMR retrieval.

In proposed design, Both TMR uploading and retrieval modules have two phases to complete one cycle of fitness tracking and medication. In first phase of TMR uploading, smart healthcare devices transfers TMR1 containing health parameters of patient over blockchain network. Health parameters included walking distance, body temperature, blood pressure and blood sugar level. Then unique TMR ID is sent to the patient and uploaded TMR is broadcasted as pending transaction to all network nodes of the blockchain ledger. A unique TMR ID is generated for uploaded TMR using uuid(universally unique identifier) function.

In TMR mining module, Further proof of work for uploaded TMR is obtained by miner node. Miner node called validator node creates new block for each TMR using SHA(secure hash algorithm)-256 algorithm. Obtained new TMR block contains current TMR, block index, timestamp, nonce, current block hash and hash of previous block. Upon current block mining, TMR addition module confirm approval through all blockchain nodes. If TMR block is approved by all nodes, then it is appended into blockchain ledger. Fig. 4 shows the execution result of TMR1 addition module.


Figure 4. Execution result of TMR1 addition module

In first phase of TMR retrieval module, healthcare provider can retrieve the TMR1 of patient with their consent using TMR ID safely. Fig.5 shows the execution result of TMR1 retrieval module.

In second phase of TMR uploading module, healthcare provider uploads TMR2 containing medication information and send it to the patient over blockchain. Patient can retrieve using TMR ID shared by healthcare provide. Fig. 6 shows the execution result of TMR2 addition module and Fig.7 shows the execution result of TMR2 retrieval module.

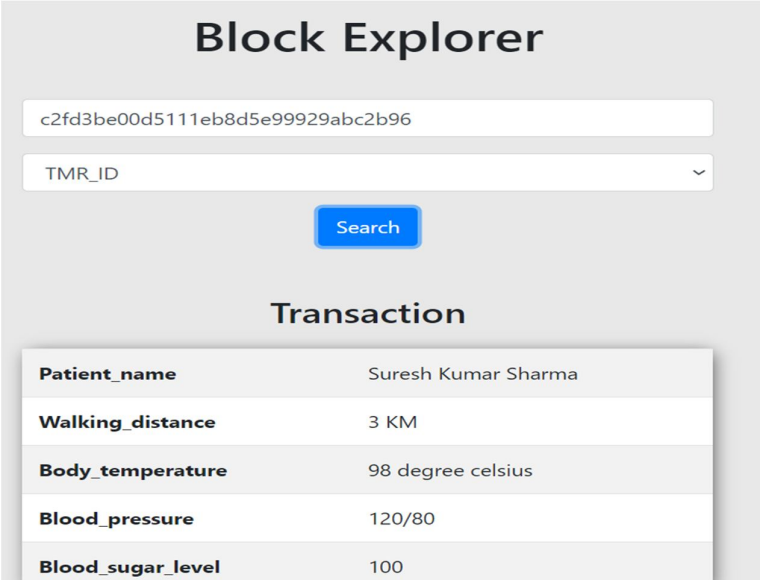


Figure 5. Execution result of TMR1 retrieval module


```
"index": 3,
"timestamp": 1602596761112,
"transactions": [
    {
        "Patient_name": "Suresh Kumar Sharma",
        "Medication": "Ecosprin 75mg-2 tablets/day, Cardace 2mg-
        1tablet/day",
        "Sender": "Dr. Jagat",
        "TMR_ID": "39bbd1800d5a11eb814307e60b24ea55"
    }
],
"nonce": 323648,
"hash": "000009cd552cbf3e216ea5fb78b7592fa820799ad639c4028f19daf6cdcc4b79"
```


Figure 6. Execution result of TMR2 addition module

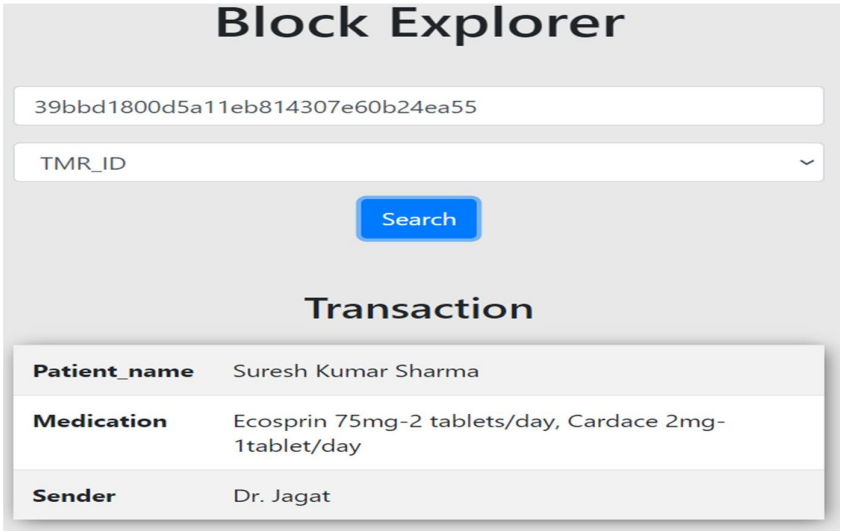


Figure.7. Execution result of TMR2 retrieval module

## V. CONCLUSIONS

Blockchain technology plays an important role in cybersecurity and can be used for secured TMR management system. This technology has capability of preventing attackers from blocking TMR data so that patient health cannot be affected at any cost. This work proposes a blockchain based approach for secured TMR management for fitness monitoring and medication. The proposed system permits smart healthcare devices to send TMRs of patients over blockchain network. The system also empowers healthcare providers to retrieve the confidential TMR with the consent of patient and prescribe suitable medication to the patient. The developed system can also be used to ensure availability of genuine health data during future treatment, insurance claim, drug discovery etc. The designed model of proposed system consists of four modules which are TMR uploading, TMR mining, TMR addition and TMR retrieval. The execution results indicates that created blockchain based model manages TMRs of patients for fitness monitoring and medication effectively.

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