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# A Secure Blockchain Based Remote Health Monitoring System for Chronic Disease Using IOT

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**ABSTRACT:** With the increasing pervasiveness of chronic diseases, there is a great demand for effective and secure health monitoring systems. This paper proposes a solution leveraging the decentralized and tamper proof nature of blockchain technology to enhance the security, transparency and accessibility of remote health monitoring for chronic diseases and Iot devices to collect the patient real time health metrics. IoT devices are employed to collect real time patient health parameters, which are encrypted and securely transmitted to blockchain networks, ensuring a reliable and up-to-date record of patient health status. The data is transmitted securely to the blockchain network, ensuring immutability, transparency and decentralized control. The use of blockchain provides tamper-resistance and auditable record for health information, addressing concerns related to data integrity and unauthorized access. To enhance security the system employs advanced encryption techniques. Smart contracts enforce access control rules, ensuring only authorized parties can access and utilize the patient data. So whenever the doctor wants to access the patient data, the doctor must request for access. Accordingly, patients can grant or revoke access. This decentralized approach mitigates the vulnerability of singular points of failure and minimizes the potential for data breaches. The anticipated system shows the potential to revolutionize remote patient monitoring for chronic disease by providing a secure, privacy-preserving and decentralized platform for managing patient health data. By leveraging the power of blockchain technology and IoT, the system can improve patient care and reduce healthcare costs. The system delivers a steadfast foundation for building a secure, scalable and interoperable remote health monitoring infrastructure, ultimately improving the quality of life for patients with chronic diseases.

**KEYWORDS:** IoT-Internet of things, Blockchain, Smart contract.

## I. INTRODUCTION

Chronic diseases are major global health concern, accounting for over 70% of deaths worldwide. The quick progression of technology has facilitated the emergence of creative solutions in healthcare, particularly in the domain of remote health monitoring for chronic diseases. Chronic disease such as diabetes, cardiovascular conditions, and respiratory disorders requires continuous monitoring and management to ensure timely interventions. The existing remote health monitoring system face challenges related to data security, privacy and integrity. Our main purpose is to develop a secure blockchain based remote health monitoring system for chronic disease using Iot. The incorporation of Iot and blockchain technology enables the continuous monitoring of patients with chronic disease. The primary objective of this paper is to provide security for the patients data by encryption and decentralized identity management to protect sensitive health information. The project has significant social impact by enhancing the patients care, promoting data privacy and improving the patients accessibility, potentially contributes to environmental sustainability by reducing the need for in person medical visit for a particular location. Here in this project we are integrating Iot and blockchain technology to establish a robust framework for continuous monitoring and also emphasizes the importance of data protection and privacy. The blockchain technology ensures decentralized and tamper resistance nature which is the ideal solution for the security and privacy of patients data. By establishing a secure and transparent distributed ledger, blockchain ensures immutability of health data, preventing unauthorized access and guarantees the data integrity. IoT devices are used which collects the patients real time health metrics from various sensors like temperature, oximeter, enhancing the overall efficiency and accuracy of the monitoring system. These devices allow for continuous monitoring of vital signs and improves the lifestyle of the patients by offering a comprehensive and personalized view of patients health status. There are both social as well as environmental impact in this proposed system. Social impact is, it improves the lifestyle of the patient, patients can track health records continuously and can take medications or treatment accordingly, they will have the accessibility to view there data and improve health metric accordingly. Environmental impact includes, patient need not go to a particular location for treatment they can take treatment remotely. This section delves into the intricacies of the systems architecture, highlighting the synergies between blockchain and Iot components. In this project our main focus is to provide security measures and ethical considerations to safeguard patients data. The encryption techniques are implemented which ensures confidentiality and integrity of health records. Decentralized management on the blockchain enhances user privacy. This system operates

as ,firstly the continuous real time health data of patient is collected through IoT devices, these data are transmitted to blockchain and stored in encrypted format to provide the security for the patients data.If the doctor wants to access the patient record ,doctor has to request for access from patient.Patient will have the access to grant or revoke the request.Whenever there is a fluctuation in any of the health metrics, an alert is sent to doctor so that an immediate treatment or medication is given to prevent from an attack.Here we are using elliptical curve cryptography method to provide security for the patient data .As the data which we collect is massive, we are storing those data in IPFS(Interplanetary File System). This section provides an in-depth exploration of the security measures embedded in the system, including encryption methodologies and identity management strategies. Ethical considerations are also discussed, addressing the importance of responsible data handling and ensuring that the remote health monitoring system aligns with regulatory frameworks and ethical standards.This system provides a resilient infrastructure for storing and sharing health data while managing privacy and security. By integrating all these technologies our main aim is to empower healthcare providers and patients with timely and accurate information, facilitating active management of chronic disease. The proposed system holds the potential to redefine how chronic diseases are monitored and managed remotely.By ensuring security, privacy and integrity of patient health data.This approach not only enhances the quality of care but also promotes patients empowerment and engagement in their health journey.

## II. RELATED WORKS

[2]. This Chapter details the work in reference to develop a secured remote healthcare system using IoT and blockchain. Distributed Off-chain storage of patient diagnostic reports in the medical field using IPFS and Blockchain published by Randhir Kumar, NingriniaMarchang and Rakesh Tripathi on COMSNETS. Technologies like blockchain, IPFS and python flask were used to develop consortium blockchain by the knowledge of IPFS based off chain models for storing and maintaining patient reports. The major challenge they have faced is that they fail to provide fair service to authorized peers. [4]. A design of intelligent wearable Health Monitoring system Based on Iot published by Yunfao Zeng and Lianda Zhu on IEEE. Technologies like IoT,ZigBee network were used to implement wearable health monitoring devices which continuously monitor long-term asthma patients. The issue faced during implementation was not being able to obtain accurate algorithms to develop the system and the data which was collected from various devices were prone to security attacks. [8]. Blockchain for IoT-Based healthcare background, consensus, platforms and use cases published by ParthaPratim Ray and Neeraj Kumar on IEEE and technologies like IoT and blockchain were used to develop IoT-Based blockchain framework for accessing and managing EHR data. The author was conveying the message to readers to use EHR data for security and it is cost-effective. [5]. Healthcare System using Blockchain published by GauriLodha and AshwiniJaralli on ICICCS, technologies like Ethereumblockchain, IPFS, React JS used for digitalization of medical records which also helps in faster admission of patients and patient need not carry the hard copy of their previous reports. They failed to secure the data while implementing this model. [7]. A Taxonomic Review Of the use of IoT and Blockchain in Healthcare applications published by S.J.Andaloussi and L.Fetjah on Journal(Science Direct), technologies like Blockchain, IoT were used to integrate these two technologies in order to build the health monitoring system for tracking and monitoring disease considering the existing applications. The author also suggest to use advanced technologies like AI and cloud computing for improving the system.[6].A review of IoT and blockchain in healthcare: chronic disease detection and data security published by SitiRubaeah and Purwono on JAHIR, technologies like Blockchain,IPFS and IoT were used to develop Health Monitoring system to help health sector where the doctors can predict as soon as possible. The authors also suggested while implementing the system, we need to ensure security measures and secure the data which was collected through IoT sensors to avoid security threats and follow the CIA principle. [1]. A GDPR-Compliant framework is designed to maintain PHR records by using Blockchain which was published by Bandar Almri and Ibrahim Tariq Javed on IEEE, technologies like blockchain and IPFS were used to develop a GDPR-Compliant framework which collects the data from patient's health record which is stored in EHR. The objective of this project is to provide data privacy where they encourage patient to share the record in controlled way to provide data privacy and by utilizing the IoT data in privacy fashion. [3]. A Secure Healthcare System Design Framework using Blockchain Technology which was published by Sabyasachi Chakraborty and SatyabrataAich on ICACT , technologies like Blockchain and IoT were used which works on blockchain principal which was used in various sectors such as Smart Phone, Banking, etc., to provide data privacy. They have divided the project in 3 subdivisions likeIoTModule, Blockchain Module and Machine learning Module. In the IoTmodule,they have collected the data, Transaction happens in the Blockchain Module and analyzes the data in the Machine Learning Module.

### III. PROPOSED WORK

In this we have both hardware and software approach , in hardware approach we are using sensors and modules to collect real time patient data and in software approach we are implementing blockchain technologies and algorithm such as elliptical curve cryptography.

#### A. HARDWARE APPROACH

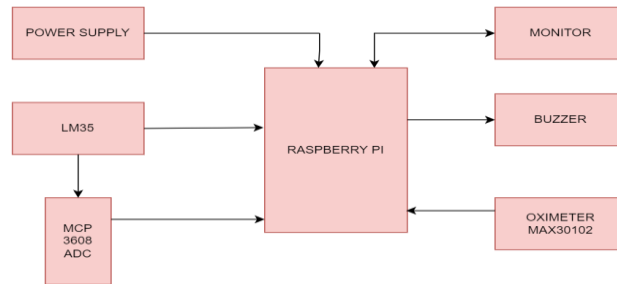


Fig . 1. Block Diagram

As represented in the above block diagram Fig. 1 our hardware approach consists of hardware components such as raspberry pi ,MCP, LM35,oximeter and buzzer. Initially the power is supplied to the microcontroller that is raspberry pi then the LM35 (which is a temperature measuring device and gives analog output) is connected to the raspberry pi via MCP which acts as analog to digital converter and then the oximeter that is MAX30102 is connected to the micro controller.we are also connecting 5v buzzer to the raspberry pi which beeps when finger is not placed properly or when the patient have abnormal temperature, spO2,BPM levels .With the LAN cable, the components are connected to the laptop.

#### B. SOFTWARE APPROACH

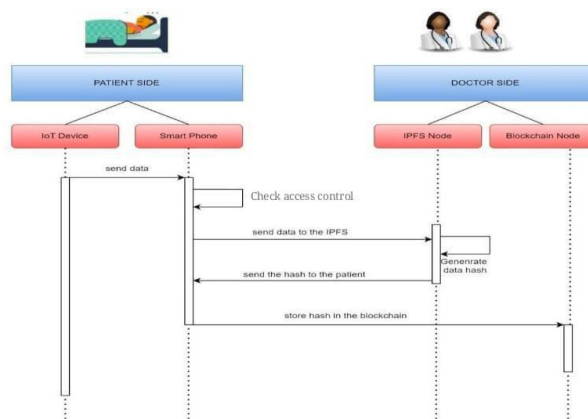


Fig. 2. Flowchart

On the patient's side, we will be monitoring patients' health with the help of IoT devices. When the data is collected from the IoT device the data is sent to the app interface.We need to check the access control of the patient if the patient has the access then the data is sent to the IPFS.The IPFS acts as a storage component.From the IPFS the hash of the data is generated and the hash is sent back to the app interface so that it becomes easy for the patient to view their records using the generated hash. The generated hash is stored in the blockchain.

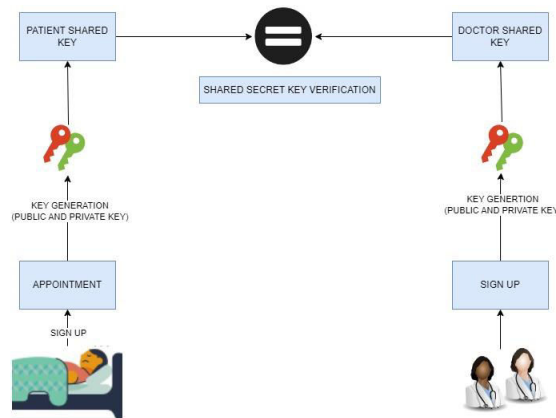


Fig.3. Elliptic curve cryptography

Specifically, we make use of elliptic curve cryptography (ECC) for key generation and encryption, combined with AES-GCM encryption for secure data transmission. The proposed design also manages tasks such as key generation for doctors and patients, verification of shared secret keys, file upload, download operations using IPFS for decentralized storage, and Ethereum-based transactions for handling financial operations or smart contract interactions. Additionally, it handles tasks related to Ethereum transactions, potentially involving the transfer of digital assets or execution of smart contracts. Overall, the design provides a comprehensive framework for secure communication, data storage, and financial transactions within the healthcare context.

#### IV. RESULTS AND DISCUSSIONS

The remote health monitoring system incorporates blockchain technology, Raspberry Pi, various sensors, and IPFS storage, and has yielded promising results in advancing patient care and bolstering data security. Through our extensive testing and analysis, several notable outcomes have emerged.

The utilization of blockchain technology has ensured the integrity and security of patient health records. Each transaction is securely logged on the blockchain, creating an unmodifiable and tamper-proof ledger of data. This has instilled confidence in both patients and healthcare providers regarding the authenticity and reliability of the stored health data.

The health monitoring system, employing Raspberry Pi alongside oximeter modules and temperature sensors, showcased promising outcomes in tracking patient health parameters. Through rigorous testing, the system provided real-time monitoring of vital signs, including oxygen saturation levels and body temperature. The integration ensured accurate and reliable data collection, empowering healthcare professionals with valuable insights for patient assessment and diagnosis. Additionally, the system facilitated seamless data transmission and visualization, allowing remote access to health information through user-friendly interfaces. Alert mechanisms triggered timely interventions upon detecting deviations from predefined thresholds, enhancing patient safety and care delivery. Furthermore, the system allowed for scalability and adaptability to diverse healthcare settings, promoting patient empowerment and engagement in their healthcare management.

The health monitoring system's successful implementation signifies its potential to revolutionize healthcare delivery. By enabling real-time monitoring, accurate data collection, and timely interventions, the system enhances patient outcomes and elevates the quality of healthcare services.

##### A. EXPERIMENTAL SETUP:

**Raspberry Pi (Model X):** The Raspberry Pi served as the core computing platform for the remote health monitoring system. Its compact size, low power consumption, and GPIO capabilities made it an ideal choice for interfacing with various sensors and managing data transmission.

**Sensors:**

**LM35:** The LM35 is a precision temperature sensor that outputs a voltage proportional to the temperature in Celsius. The LM35 has a typical accuracy of  $\pm 0.5^{\circ}\text{C}$  and a supply voltage range of 4 to 30 volts. It is available in a TO-92 package and is easy to use.

**MAX30102:** The MAX30102 is a pulse oximeter sensor that tracks blood oxygen saturation (SpO<sub>2</sub>) and heart rate. It is a small, low-power sensor that is ideal for wearable devices. The MAX30102 uses infrared (IR) and red (RED) LEDs to measure the amount of light absorbed by blood. It then calculates the SpO<sub>2</sub> and heart rate from this data. The MAX30102 is available in a 20-pin QFN package and is easy to use.

**Breadboard:** A breadboard is a prototyping tool that is used to test and debug circuits. It consists of a perforated board with holes that are connected electrically by metal strips. Breadboards are commonly used to experiment with electronic circuits without the need to solder components together.

**Raspberry Pi:** The Raspberry Pi is a series of small, single-board computers, it is a complete computer built into a single board, with a microprocessor, memory, graphics processing unit (GPU), and other peripherals

**Buzzer:** A buzzer is an electronic device that produces a sound when an electric current is passed through it. They can be powered by either direct current (DC) or alternating current (AC). The Buzzer is used to alert the doctor when the threshold of a certain patient's medical parameters fluctuates.

**Blockchain Technology:** A blockchain network, based on [platform/protocol], was deployed to ensure the credibility and assurance of patient health records. Smart contracts were employed to govern data transactions and access control within the network.

**InterPlanetary File System (IPFS):** IPFS was chosen for decentralized and distributed storage of patient health data. Its robust architecture and content-addressed storage model provided an ideal solution for ensuring data availability and resilience.

*B. OUTPUT:*

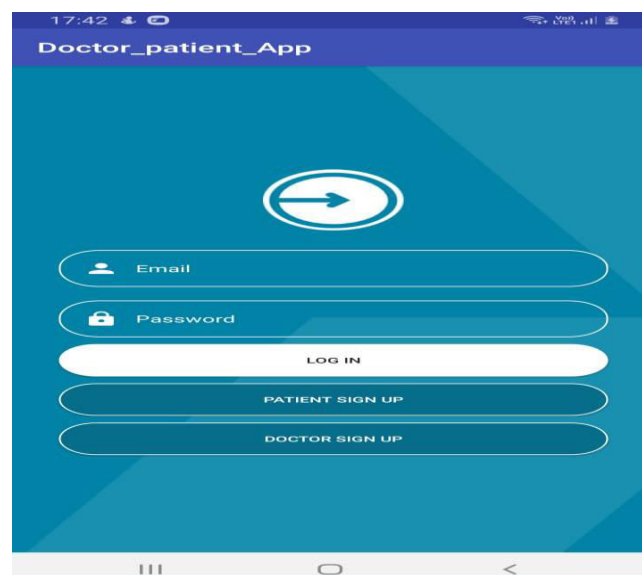


Fig. 4. Login screen

The login page for patients serves as the gateway to accessing their health data stored securely on the Ethereum blockchain. Through a user-friendly interface, patients input their unique credentials to authenticate and gain access to their health records. The login process ensures data privacy and integrity, utilizing blockchain technology to encrypt and store patient information in a decentralized manner. By leveraging the Ethereum blockchain, the login page

provides patients with seamless and secure access to their health data anytime, anywhere, fostering trust and transparency in healthcare management.

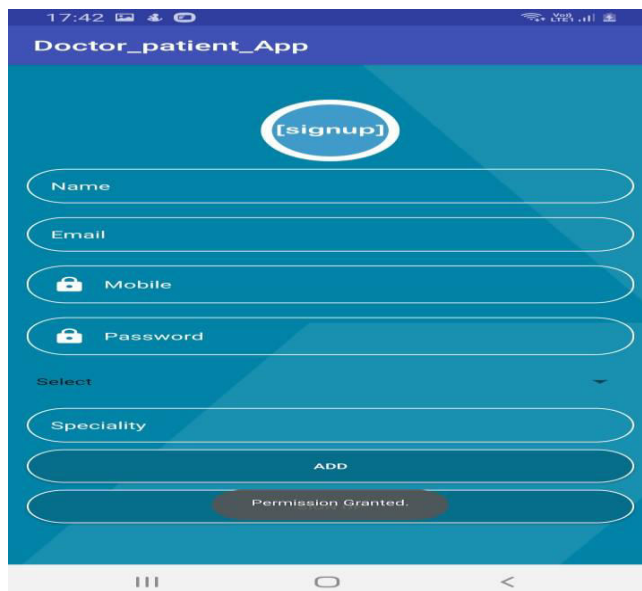


Fig. 5. Signup screen for doctor

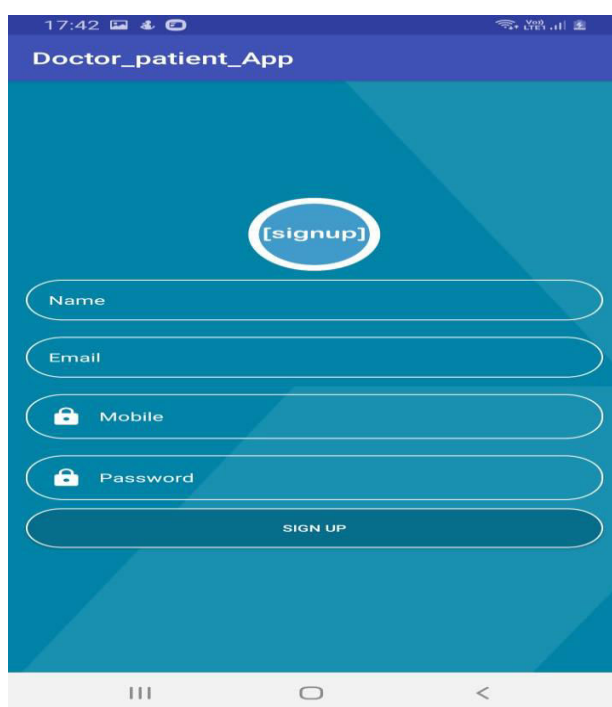


Fig. 6. Signup for patients

The sign-up screen for both doctors and patients offers a seamless entry point into a decentralized healthcare ecosystem stored on the Ethereum blockchain. For doctors, the sign-up process includes the addition of their specialty, enhancing the platform's ability to match patients with relevant medical expertise. Patients and doctors input their unique credentials, which are securely encrypted and stored on the blockchain, ensuring data integrity and privacy. Through this sign-up interface, doctors can specify their areas of expertise, enabling efficient patient-doctor matchmaking. Patient registration enables secure storage of personal health information, fostering a transparent and patient-centric healthcare environment.

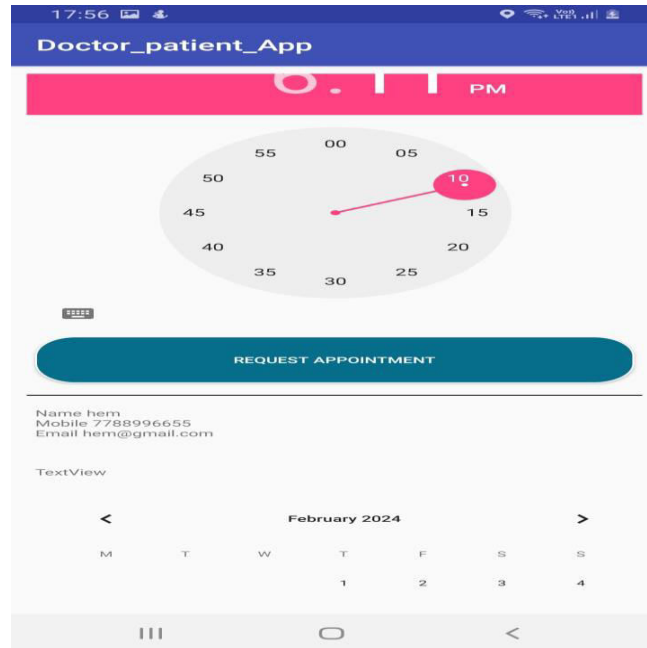


Fig. 7. Book Appointment

In the appointment request feature, patients are empowered to schedule appointments at their convenience by specifying preferred dates and times for consultations with doctors. Patients can input their desired appointment date and time through a user-friendly interface, facilitating efficient communication with healthcare providers. The system securely records patient appointment requests on the Ethereum blockchain, ensuring data integrity and confidentiality.

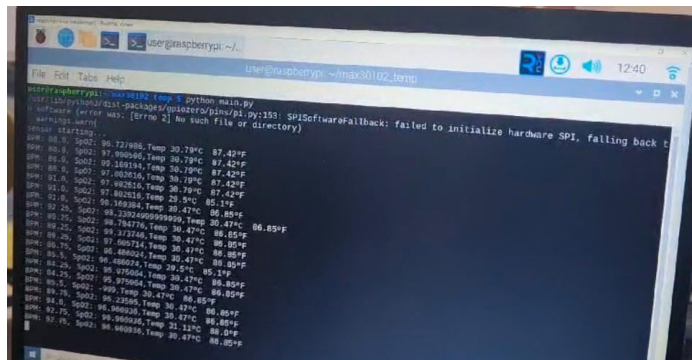
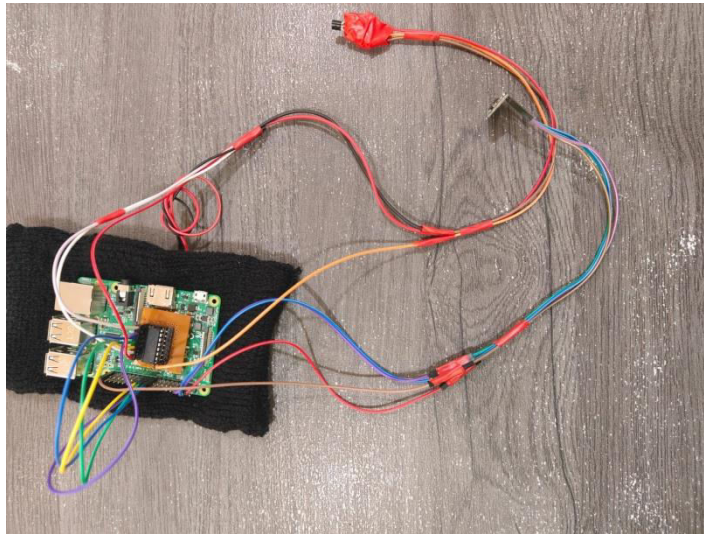


Fig. 8. Sensors data collected from Raspberry Pi

Patient's temperature, oxygen saturation (SpO2), and blood pressure levels are recorded using a Raspberry Pi interface with sensors such as the LM35 temperature sensor and an oximeter module. The LM35 temperature sensor measures ambient temperature, providing real-time data on patient body temperature variations. Simultaneously, the oximeter module captures oxygen saturation levels and blood pressure readings.





*Fig. 9. Hardware band*

The hardware implementation combining Raspberry Pi with the LM35 temperature sensor, MAX30102 oximeter module, and buzzer demonstrated effective monitoring of a patient's vital signs. The system accurately measured temperature and oxygen saturation levels, providing real-time data crucial for healthcare assessment. Alerts triggered by predefined thresholds enabled timely interventions, ensuring patient safety.

## V. CONCLUSION AND FUTURE WORK

In this work, we have implemented a healthcare system for monitoring myocardial infarction patients by using IoT devices. We have designed a Health Monitoring system by using Blockchain and IoT devices to provide data security and data privacy. This system also follows the CIA principles. The proposed design is divided into two modules which include a patient module and a doctor module. In the patient module, where the data will be collected from IoT devices such as Temperature sensor(LM35) which will monitor the temperature, Oximeter Module(MAX30102) which will monitor the BPM and SPO2 levels continuously and the data will be sent to the doctor module in the form of file which will be stored in IPFS. If any of the parameters goes above the threshold value then an alert will be sent to their respective doctors. In the doctor module, Doctors can open the patient's details with the help of an elliptical curve cryptography. The doctor can diagnose the patient's condition and send the required treatment to the patients.

In the future, we aim to extend the work by integrating Artificial intelligence into our system to act smarter and include more features. It will also help the doctors to make better clinical decisions.

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