

Blockchain Based Solution for Modern Healthcare Challenges

Samiksha R Hajare¹, Prof. S. V. Raut²

Department of Computer Science and Engineering, DRGIT&R College of Engineering Amravati

Abstract

Blockchain-enabled paradigms in healthcare are increasingly positioned as transformative frameworks to address entrenched challenges of secure medical data exchange, interoperability, and patient-centric control. Theoretical discourse surrounding blockchain healthcare thus emphasizes not only its potential to complexities that continue to shape its research trajectory and practical deployment. The rapid evolution of telehealth and telemedicine has redefined the landscape of healthcare delivery, enabling remote consultations and improved resource management. However, many existing telemedicine systems depend on centralized architectures, which are increasingly vulnerable to data breaches, fraud and other security threats. This paper proposes the integration of blockchain technology into telemedicine platforms to enhance security, transparency, and data integrity. By leveraging a decentralized and tamper-resistant ledger, the proposed framework seeks to safeguard patient records and bolster trust among healthcare providers and patient alike. Key features of the system include secure appointment scheduling, reliable and efficient management of electronic health records- all implemented within a user-friendly interface. Initial analyses indicate that the blockchain based approach can effectively mitigate the risks inherent in centralized systems, thereby paving the way for more robust and resilient in centralized systems, thereby paving the way for more robust and resilient remote healthcare solutions. Ultimately, this research contributes to the advancement of telemedicine by addressing critical security challenges and proposing a scalable, secure platform that is particularly beneficial in areas with limited access to traditional healthcare services.

Keywords

Blockchain; Telehealth; Electronic health records; Telemedicine; Security; Decentralized; Transparency; Smart Contract;

1. Introduction

1.1 Preface

Healthcare sector has experienced a paradigm shift with the emergence of telehealth and telemedicine, fundamentally altering the dynamics of patient-provider interactions. Enabled by advancements in digital communications, diagnostics, and treatment, effectively mitigating geographical and logistical

barriers to healthcare access. The global COVID 19 pandemic served as a catalyst for the widespread adoption of telemedicine, underscoring its critical role in maintaining healthcare delivery during crises. Blockchain technology, characterized by its decentralized and immutable nature, offers a transformative

solution to these challenges. By leveraging distributed ledger technology (DLT), cryptographic security, and smart contracts, blockchain can enhance the integrity, transparency, and security of electronic health records (EHRs).

1.2 Motivation

Motivation behind this research stems from the growing recognition of blockchain's potential to revolutionize telemedicine. By addressing the security and operational inefficiencies of conventional platforms, a blockchain-based telemedicine system can foster greater trust among patients and healthcare providers, ultimately enhancing the quality and accessibility of remote healthcare services.

1.3 Problem Statement

Despite the widespread adoption of telemedicine, existing platforms suffer from several critical shortcomings. The centralized nature of these systems makes them susceptible to cyberattacks, data breaches, and unauthorized access, jeopardizing patient confidentiality. Moreover, the lack of transparency in medical record management raises concerns about data integrity and accountability. Manual processes for appointment scheduling, payment verification, and updates further contribute to inefficiencies, increasing the risk of errors and delays.

1.4 Objectives

The primary object of this research are:

- To study a decentralized telemedicine platforms using Ethereum -based smart contracts for secure patient-doctor interactions, ensuring tamper-proof authentication, appointment scheduling, and electronic health record (HER) management.
- To study a Proof-of-Authority (POA) consensus mechanism to optimize transaction speed and energy efficiency, making the platform suitable for real-time healthcare applications.
- To study a responsive and intuitive frontend interface using Next.js and React.js, integrated with web RTC for seamless video consultations, ensuring accessibility across diverse devices and network conditions.
- To study data integrity and confidentiality by storing EHRs on the Interplanetary File System (IPFS) and anchoring cryptographic hash pointers on the blockchain, preventing unauthorized modifications.
- To automate critical workflows-including appointment bookings, payment processing, and medical record updates-using self -executing smart contracts, reducing administrative overhead and human error.

2. Methodologies

2.1 Blockchain

System leverages the Ethereum blockchain, a leading platform known for its support of smart contracts. Smart contracts are self-executing pieces of code that operate autonomously once predefined conditions are met. In the context of our telemedicine solution, these contracts govern operations such as user authentication, appointment scheduling, health record access, payment disbursement, and prescription

issuance [4]. By removing the need for a central authority, smart contracts significantly reduce administrative overhead, increase transparency, and automate workflows in a secure deterministic manner[2]. Consensus algorithm adopted in the system is Proof of Authority (POA), which is particularly well-suited for permissioned environments such as healthcare. In POA, selected validator nodes are granted the authority to verify and add new blocks to the chain. These validators are pre-approved and known to the network, ensuring fast transaction finality with reduced computational resource consumption compared to Proof of Work [1] [5].

2.2 Proposed System

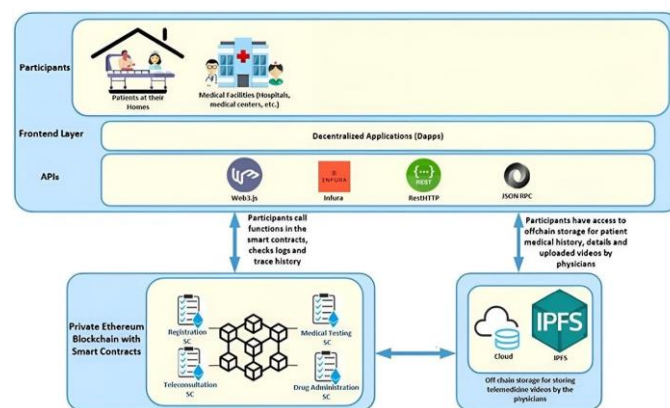


Figure 2.2 Proposed System Model

The proposed system is a decentralized platform that harness the combined strengths of blockchain and IPFS to securely manage the interactions between patients, doctors, and administrators [1][3]. Designed with the aim of eliminating traditional inefficiencies associated with healthcare systems, such as delay in data retrieval, risk of unauthorized data manipulation and lack of transparency in financial and procedural operations.

2.3 System model

System model follows a comprehensive three-tier architecture that divides the platform into distinct functional layers, each responsible for specific operations and governed by secure interactions [4]. Design not only promotes modularity and maintainability but also allows for scalability as the system grows in terms of users services. For handling asynchronous blockchain operations. UI follows WCAG 2.1AA accessibility standards and implements a design system with 47 reusable components organized using Atomic Design methodology.

- First Layer **presentation tier**, which graphical user interface that allows patients, doctors, and administrators to interact with the system. It acts as the communication bridge between the user and the backend logic hosted on the blockchain.
- Second layer **application tier**, which comprises smart contracts deployed on the Ethereum blockchain. These contracts encapsulate business logic of the telemedicine system and are responsible for handling various operations such as patient registration, doctor verification, appointment management [2][4].

- Final layer is **Data tier**, where off-chain storage is managed through IPFS. Furthermore, because the data resides in a decentralized file system, it remains available even if certain nodes go offline, ensuring high availability and fault tolerance [2][5].

3. Implementation For Healthcare

3.1 Smart Contract Architecture

Healthcare smart contracts serves as the backbone on system, implemented in Solidity 0.8.0. Contract maintains several critical data structures including medicine to track pharmaceutical inventory with details like price, quantity, and IPFS storage links; Notification system integrated directly into contract through `ADD_NOTIFICATION` internal function, which creates timestamped records. Notification system is stored in a mapping indexed by user addresses, allowing efficient retrieval of user-specific alerts. Contract emits events for all major operations including `MEDICINE_ADDED`, `APPOINTMENT_BOOKED`, and `MEDICINE_PRESCRIBED` to provide transparent logging on the blockchain.

3.2 User Registration and Management

System implements distinct registration processes for doctors and patients. Doctors register by paying a 0.0025 ETH fee and submitting their credentials, which are stored in the doctors mapping pending admin approval. Patients register with a 0.00025 ETH fee, with their data recorded in the patients mapping. The `CREATE_ACCOUNT` function establishes user profiles with names and types, while the registered Doctors and registered patients mappings track approved participants.

3.3 Appointment Management System

Appointment system allows patients to book consultations by calling `BOOK_APPOINTMENT` function with specified time slots and conditions. Function verifies doctor availability, collects a 0.0025 ETH fee (with 90% going to the doctor and 10% to admin), and creates a new entry in the appointments mapping. Doctors can mark appointments as completed through the `COMPLETE_APPOINTMENT` function, which updates their successful treatment count.

3.4 Medicine Management and Prescriptions

Admin maintains medicine inventory through functions like `ADD_MEDICINE` and `UPDATE_MEDICINE_QUANTITY`. Doctors can prescribe medications via `PRESCRIBE_MEDICINE` function, which creates records in the prescriptions mapping, patients purchase medicines through `BUY_MEDICINE`, which verifies stock levels, processes payments, and updates both medicine quantities and patient purchase histories.

3.5 Secure Messaging System

Contract implements encrypted messaging system where users must first establish connections through `ADD_FRIEND`. Messages are stored in all messages mapping indexed by a unique chat code derived from

participant addresses. The `_SEND_MESSAGE` function validates sender-receiver relationships before storing messages with timestamps.

3.6 IPFS Integration

Medical documents including patient records and prescription details are stored on IPFS, with resulting content identifiers (CIDs) stored in respective structs (e.g. Patient `IPFS_URL`). This hybrid approach combines blockchain security for access control and verification with IPFS efficiency for large document storage.

Implementation demonstrates a complete healthcare management solution that leverages blockchain technology for security, transparency, and automation.

4. Result of Blockchain

4.1 Authentication

Users begin by selecting their role (doctor or patient) and registering by paying the required fee (0.0025 ETH for doctors, 0.00025 ETH for patients). MetaMask account address is automatically recorded during registration, and users must provide their personal information stored on IPFS.

4.2 Admin Dashboard

Admin oversees entire system, managing medicine inventory, approving doctor registrations, and setting fees. Admin can add/update medicines, their prices, quantities, locations, and has access to all system activities and notifications.

4.3 Doctor Portal

Doctor's complete registration by paying fee and waiting for admin approval. Approved doctors can view appointments (which increases their successful treatment count).

4.4 Medicine Management

System maintains a comprehensive medicine inventory tracking ID, IPFS, URL, price, quantity, discount, current location, and active status. Patients can view and purchase available medicines with proper validation of stock levels.

4.5 Messaging System

Platform includes encrypted messaging system where patients and doctors can communicate after becoming friends. All messages are timestamped and stored securely on-chain.

4.6 Notification system

All user actions generate real-time notifications stored on-chain, categorized by type (Medicine, Doctor, Patient, Message). Users can view their complete notification history.

5. Future Scope

Future development of this decentralized telemedicine platform empowered by blockchain technology holds significant promise for broader adoption and enhanced functionality. Furthermore, tokenization could introduce incentive mechanisms, rewarding patients for maintaining healthy habits or participating in medical research. As regulatory frameworks for blockchain in healthcare continue to evolve, this system can adapt to comply with global standards such as HIPAA and GDPR. Future iterations may also explore quantum-resistant cryptography to safeguard against emerging security threats. With these advancements, the platform has the potential to become a universal healthcare management solution, bridging gaps in medical accessibility and setting new benchmarks for efficiency and transparency in the industry. The successful implementation of this project illustrates how blockchain technology can revolutionize healthcare administration while laying foundation for innovative applications that prioritize patient welfare and operational excellence. By continuing to refine and expand this system, we can move closer to a future where healthcare services are more accessible, secure, and patient-centred than ever before.

6. Conclusion

In this paper, WeCare: a secured and decentralized telemedicine platform empowered by blockchain technology developed through this project demonstrates transformative potential technology in modernizing medical services. By implementing a decentralized framework, the system establishes a secure and transparent ecosystem for patient-doctor interactions, medicine tracking, and medical record management. Immutable nature of blockchain ensures that all transactions, from appointment bookings to prescription verifications, are permanently recorded and protected against unauthorized alterations. Traditional healthcare systems often face challenges such as delayed verifications, paperwork inefficiencies, and vulnerability to data breaches. This blockchain-based approach addresses these issues by creating a trust less environment where all stakeholders can interact securely. The built-in notification system further enhances communication, ensuring timely updates for patients, doctors and administrators.

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