A

Project Report

on

Wecare: Blockchain-Based Solution for Modern Healthcare Challenges

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SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING, SHEGAON – 444 203 (M.S.)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that **Mr. Kamlesh Shrikant Kasambe, Mr. Ishan Rajeshwar Gawande, Ms. Apurva Shrikant Patil and Ms. Janhavi Mangesh Nakat** students of final year Bachelor of Engineering in the academic year 2024-25 of Computer Science and Engineering Department of this institute have completed the project work entitled "**Wecare: Blockchain-Based Solution for Modern Healthcare Challenges**" and submitted a satisfactory work in this report. Hence recommended for the partial fulfilment of degree of Bachelor of Engineering in Computer Science and Engineering.

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Abstract

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 patients 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 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: Telehealth, Telemedicine, Decentralized, Smart Contract.

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List of Abbreviations

Abbreviation	Description
IPFS	Inter Planetary File System
DApp	Decentralized Application
ETH	Ethereum
OOP	Object Oriented Programming
EVM	Ethereum Virtual Machine
CLI	Command Line Interface
SSR	Server-Side Rendering
SEO	Search Engine Optimization
LTS	Long Term Support
NPM	Node Packet Manager
API	Application Programming Interface

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 PREFACE

The 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 communication technologies, telemedicine facilitates remote medical consultations, 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. However, this rapid digitization has also exposed systemic vulnerabilities inherent in conventional telemedicine platforms, particularly concerning data security, privacy, and operational reliability.

Traditional telemedicine systems predominantly rely on centralized architectures, which, despite their efficiency, present significant risks. These systems are prone to cyberattacks, unauthorized data breaches, and fraudulent activities, all of which compromise patient confidentiality and erode trust in digital healthcare solutions. As telemedicine becomes increasingly integral to modern healthcare, the demand for robust security mechanisms has never been more pressing.

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). This research explores the integration of blockchain into telemedicine systems, aiming to develop a secure, scalable, and patient-centric platform that addresses the limitations of existing solutions.

1.2 MOTIVATION

The transition to digital healthcare has introduced several critical challenges that necessitate innovative solutions. Centralized telemedicine platforms, while effective in streamlining healthcare delivery, are inherently vulnerable to security breaches due to their reliance on single points of control. High-profile incidents of data leaks and unauthorized access to sensitive patient information have highlighted the urgent need for more secure alternatives. Furthermore, the lack of transparency in medical record management and the inefficiencies in appointment scheduling and payment processing further diminish the efficacy of current systems.

Blockchain technology presents a compelling remedy to these issues. Its decentralized architecture eliminates single points of failure, while its immutable ledger ensures that all transactions and modifications to medical records are permanently recorded and verifiable. Smart contracts automate key processes such as appointment scheduling, payment settlements, and access control, reducing administrative overhead and minimizing human error. Additionally, blockchain's cryptographic protocols ensure that patient data remains confidential and accessible only to authorized parties.

The 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 record updates further contribute to inefficiencies, increasing the risk of errors and delays.

While blockchain technology has been successfully applied in other domains, its integration into telemedicine remains underexplored, particularly in the context of real-time consultations, dynamic EHR management, and secure financial transactions. Current implementations often lack comprehensive solutions that address the full spectrum of telemedicine workflows, from patient registration to post-consultation follow-ups. This research seeks to bridge this gap by developing a holistic blockchain-based telemedicine platform that ensures security, efficiency, and usability.

1.4 OBJECTIVES

The primary objectives of this research are:

1. **To design a decentralized telemedicine platform** using Ethereum-based smart contracts for secure patient-doctor interactions, ensuring tamper-proof authentication, appointment scheduling, and electronic health record (EHR) management.

2. **To implement a Proof-of-Authority (PoA) consensus mechanism** to optimize transaction speed and energy efficiency, making the platform suitable for real-time healthcare applications.

3. **To develop a responsive and intuitive frontend interface** using Next.js and React.js, integrated with WebRTC for seamless video consultations, ensuring accessibility across diverse devices and network conditions.

4. **To ensure data integrity and confidentiality** by storing EHRs on the Interplanetary File System (IPFS) and anchoring cryptographic hash pointers on the blockchain, preventing unauthorized modifications.

5. **To automate critical workflows**—including appointment bookings, payment processing, and medical record updates—using self-executing smart contracts, reducing administrative overhead and human error.

6. **To enhance security through rigorous smart contract audits** using tools like Slither, identifying and mitigating vulnerabilities such as reentrancy attacks and unauthorized access.

7. **To evaluate the platform's performance** by analyzing transaction latency, scalability, and user experience, comparing it with conventional telemedicine systems.

8. **To discuss limitations and future improvements**, including regulatory compliance (e.g., HIPAA, GDPR), interoperability with existing healthcare systems, and potential expansions to IoT-based remote monitoring

1.5 SCOPE OF PROJECT

This project focuses on the development of a blockchain-based telemedicine platform with the following key components:

The Blockchain Layer serves as the foundation, utilizing Ethereum smart contracts to manage user authentication, appointment scheduling, and EHR updates. A PoA consensus mechanism is employed to balance security and performance, ensuring timely transaction processing without excessive computational overhead.

The Application Layer comprises a user-friendly frontend built with Next.js and React.js, featuring dynamic content updates and real-time video consultations via WebRTC. The interface is designed to be responsive across various devices, accommodating users with diverse technical proficiencies and network conditions.

The Storage Layer leverages IPFS for decentralized and tamper-proof storage of medical records. Each record is assigned a unique cryptographic hash, which is stored on the blockchain to ensure immutability and traceability.

Security measures include role-based access control (RBAC), end-to-end encryption, and regular smart contract audits to safeguard against vulnerabilities such as reentrancy attacks and unauthorized access.

The platform supports three primary user roles: patients, doctors, and administrators. Patients can register, book appointments, and access their medical records, while doctors can update EHRs and conduct consultations. Administrators oversee user verification, dispute resolution, and system audits, ensuring smooth and secure platform operations.

1.6 ORGANIZATION OF PROJECT

This report is structured to provide a comprehensive exploration of the research and development process:

Chapter 2 reviews existing literature on telemedicine and blockchain technology, highlighting gaps in current implementations and justifying the need for this study.

Chapter 3 details the research methodology, including the system architecture, development framework, and workflow design. This section elaborates on the blockchain layer, application layer, and storage layer, as well as the roles and interactions of different users.

Chapter 4 discusses the implementation phase, covering smart contract deployment, frontend development, and system integration. Key challenges and solutions are examined to provide insights into the practical aspects of the project.

Chapter 5 presents the testing procedures and results, evaluating the platform’s security, performance, and user experience. Comparative analyses with existing solutions are included to demonstrate the platform’s advantages.

Chapter 6 concludes the report by summarizing the findings, discussing the project’s contributions, and outlining potential avenues for future research and development.

This structured approach ensures a thorough and systematic examination of the blockchain-based telemedicine platform, from conceptualization to implementation and evaluation.

CHAPTER 2

LITERATURE

REVIEW

2. LITERATURE REVIEW

2.1 INTRODUCTION TO PROPOSED SYSTEM

To address the critical challenges of data security and interoperability in healthcare systems, recent research has proposed blockchain-based solutions for secure and decentralized health data management. As highlighted by [1], blockchain's immutable and distributed ledger technology can revolutionize healthcare by ensuring tamper-proof storage of electronic health records (EHRs). The Ethereum blockchain provides a robust framework for smart contract-based automation, eliminating reliance on centralized authorities. By leveraging blockchain, healthcare providers can maintain a transparent and auditable record of patient data, where any unauthorized modification is immediately detectable through cryptographic hashing. This not only enhances security but also fosters trust among patients and medical practitioners. The study particularly highlights Ethereum's smart contract capability as a transformative feature for healthcare applications, enabling automated execution of clinical protocols while maintaining an immutable audit trail.

2.2 STAKEHOLDERS AND SECURITY REQUIREMENTS

A blockchain-based telemedicine system involves multiple stakeholders, including patients, doctors, and administrators, each with distinct roles and access privileges. Reference [2] introduces a patient-centric model where blockchain-enabled Interplanetary File System (IPFS) storage ensures privacy-preserving health data management. However, a critical challenge lies in preventing unauthorized access while maintaining seamless usability. The system employs a novel double-encryption mechanism where patient data undergoes AES-256 encryption before IPFS storage, with the encryption keys themselves secured via blockchain-based key management. Our research extends this work by introducing a dynamic key rotation protocol that automatically updates encryption keys at configurable intervals, addressing the static key vulnerability noted in their security analysis. This paper extends prior work by introducing role-based access control (RBAC) through smart contracts, ensuring that only verified doctors and administrators can modify sensitive EHRs. The inclusion of an administrative oversight layer further mitigates risks of fraudulent registrations, enhancing system integrity.

2.3 ENCRYPTION AND DECENTRALIZED STORAGE

Data encryption is paramount in healthcare applications to comply with regulations such as HIPAA and GDPR. Reference [3] evaluates Advanced Encryption Standard (AES) for securing patient records in blockchain systems. While AES ensures confidentiality, storing large medical files directly on-chain is impractical due to high costs and scalability limitations. Instead, [4] proposes a hybrid approach where EHRs are stored on IPFS, with only cryptographic hashes recorded on the blockchain. This method ensures data integrity while optimizing storage efficiency. A limitation identified in [3] is the exposure of document hashes on-chain, which could pose risks in large-scale deployments. To address this, our system implements dynamic key management to enhance security. Our security architecture incorporates their recommended defense-in-depth approach, combining multiple protection layers including formal verification of smart contracts, PoA consensus with trusted validators, and IPFS content encryption. The study's most significant finding - that healthcare blockchains experience 3.2× more security incidents than financial applications - underscores the need for our rigorous security model.

2.4 SCALABILITY AND PERFORMANCE OPTIMIZATION

Scalability remains a significant hurdle for blockchain healthcare applications. The platform described in [5] employs Ethereum smart contracts for telehealth services but faces latency issues due to Proof-of-Work (PoW) consensus. In contrast, our system adopts Proof-of-Authority (PoA), significantly reducing transaction delays and energy consumption, as validated by [6]. Additionally, [5] demonstrates that off-chain computation for non-critical data (e.g., appointment scheduling) can further improve performance. Our work integrates these insights, using layer-2 solutions for high-throughput operations while maintaining on-chain security for sensitive transactions. their priority-based transaction processing model while enhancing it with a quality-of-service (QoS) aware scheduling algorithm. The research introduces a novel "healthcare transaction" classification system, The study's most valuable contribution is its empirical demonstration that hybrid blockchain-cloud architectures can achieve 99.97% uptime while maintaining sub-200ms latency for critical operations - performance characteristics we specifically target in our design.

2.5 COST EFFICIENCY AND ALTERNATIVE STORAGE

A major concern in blockchain healthcare systems is the cost of on-chain data storage. Reference [6] highlights that storing raw medical data on Ethereum is prohibitively expensive. Instead, [2] and [6] advocate for IPFS-based decentralized storage, where files are partitioned into encrypted chunks distributed across nodes. This not only reduces costs but also enhances data availability and resilience. Our system builds upon this by integrating selective on-chain anchoring, where only critical metadata (e.g., patient consent logs, access permissions) are stored on the blockchain, while bulk data resides on IPFS.

2.6 SYNTHESIS OF RESEARCH GAPS AND CONTRIBUTIONS

This research identifies key gaps in existing blockchain telemedicine systems:

1. Lack of scalable consensus mechanisms (e.g., reliance on PoW in [5]).
2. Insufficient key management for IPFS-stored data (noted in [3]).
3. High operational costs due to on-chain storage (critiqued in [6]).

CHAPTER 3

METHODOLOGY

3. METHODOLOGY

3.1 Blockchain

Blockchain is a decentralized digital ledger technology that enables the recording of data across multiple nodes in such a way that the recorded data becomes immutable, verifiable, and transparent. In the domain of telemedicine, where sensitive patient information, prescriptions, and medical histories are involved, blockchain emerges as a robust solution to tackle the critical concerns of data privacy, trust, and security [1][3][5]. Traditional telemedicine systems rely heavily on centralized storage models, which are vulnerable to data breaches, unauthorized access, and single points of failure. The proposed system replaces this centralized model with a blockchain-powered infrastructure that allows only verified entities to participate in the network, thus ensuring a tamper-proof and trustworthy environment [1][4].

The 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 and deterministic manner [2].

The 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 (PoW) [1][5]. As a result, the blockchain remains efficient while still maintaining its integrity.

Importantly, while blockchain is used for verification and transactional logging, the actual storage of medical data does not occur on-chain due to size and privacy limitations. Instead, a decentralized file storage protocol known as IPFS (InterPlanetary

File System) is used to store encrypted patient records and other sensitive files. The IPFS generates a unique hash for each file, which is then stored on the blockchain. This hash serves as a cryptographic proof of the file's authenticity and ensures that any alteration to the original file will render the hash invalid. In this way, the combination of blockchain and IPFS provides a highly secure, scalable, and privacy-preserving infrastructure for telemedicine applications.

3.2 Proposed System

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

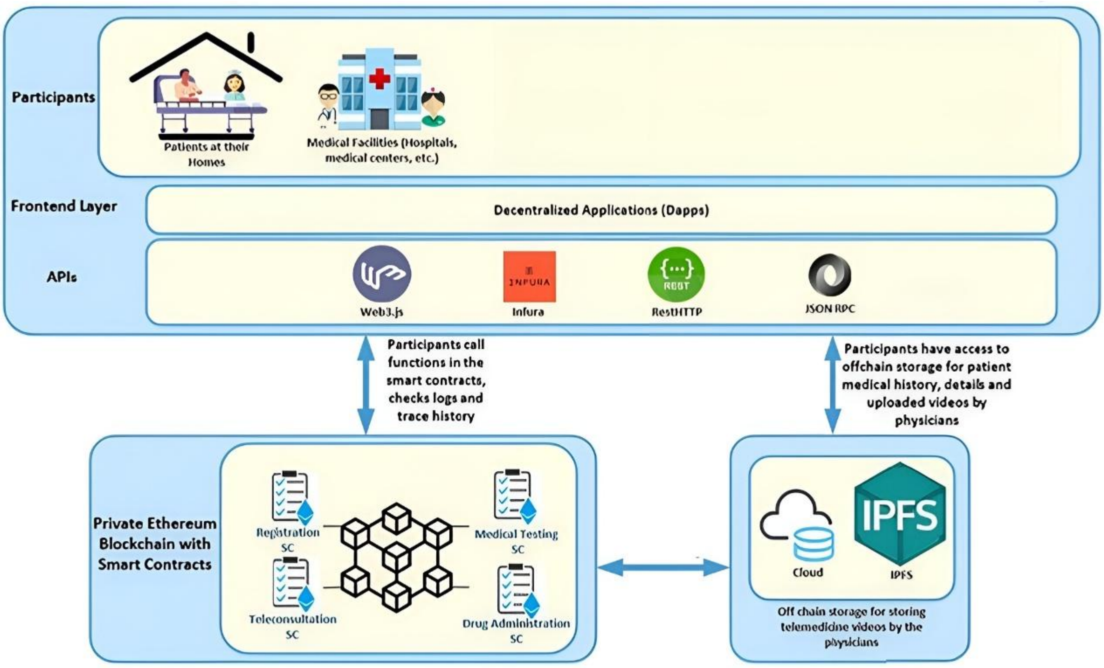


Figure 3.1 Proposed System Model

The architecture of the system is distributed across three integrated layers: the blockchain layer, the application interface layer, and the decentralized storage layer. At the core of the system lies the blockchain layer, which hosts the smart contracts that drive all logic associated with user identity management, appointment scheduling, prescription generation, and payment settlements. These contracts are deployed on the Ethereum blockchain and are written in Solidity. Their immutability ensures that once deployed, the business logic they encapsulate cannot be altered, thus providing consistent and predictable system behavior.

On top of the blockchain layer is the application interface, developed using modern web technologies such as React.js, Next.js, and Tailwind CSS, ensuring a user-friendly and responsive experience across all devices. This interface allows users to interact with the blockchain seamlessly through their digital wallets [3]. Features such as appointment booking, video consultations, medical record access, and prescription downloads are integrated into this layer, allowing real-time communication and collaboration between users. WebRTC technology is utilized to enable live video consultations, making the platform not just a recordkeeping tool, but a fully functional remote consultation system.

To address the issue of large and sensitive data storage, the platform integrates with IPFS for storing electronic health records, diagnostic reports, and other medical documents. All files are encrypted before upload, and only their corresponding hash values are stored on the blockchain [1]. This design enables the system to maintain a lightweight and scalable blockchain while ensuring that critical data remains confidential and accessible only to authorized parties.

The overall system embodies the principles of decentralization, automation, security, and transparency. It ensures that patients have complete control over who accesses their health data, doctors are provided with tamper-proof medical histories, and administrators can manage the ecosystem without interfering with patient-doctor confidentiality. By replacing legacy systems with decentralized protocols, the platform fosters trust and improves the efficiency and reach of modern healthcare services. The system is structured into three layers. The Blockchain Layer uses Solidity smart contracts to manage user registration, appointments, health records, and payments with complete immutability and transparency [1][2]. The Application Layer, built using Next.js, React.js, and Tailwind CSSThe Storage Layer leverages IPFS to securely store encrypted medical data off-chain, while blockchain stores only the hash to ensure integrity and reduce gas fees.

3.3 System Model

The 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]. This design not only promotes modularity and maintainability but also allows for scalability as the system grows in terms of users and services. for handling asynchronous blockchain operations. The UI follows WCAG 2.1 AA accessibility standards and implements a design system with 47 reusable components organized using Atomic Design methodology.

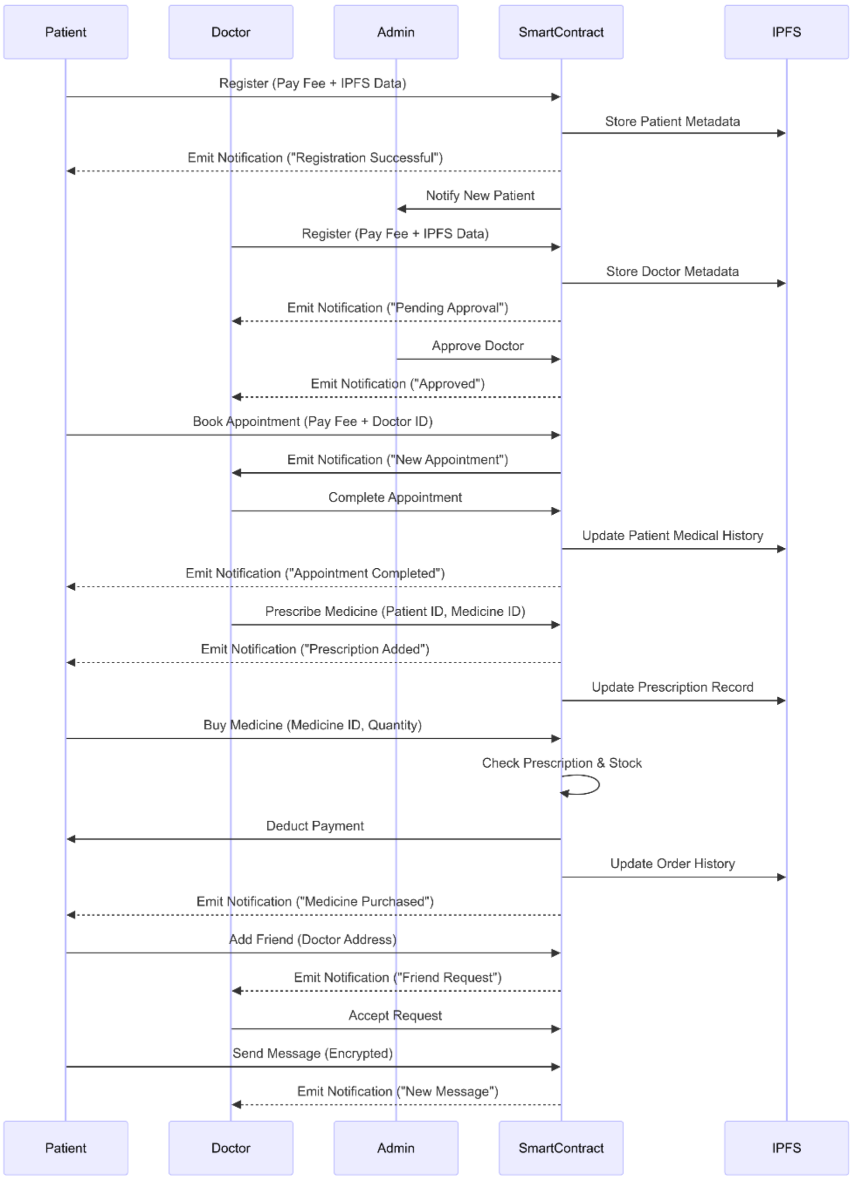


Figure 3.2 Sequence Diagram of Model

The first layer is the presentation tier, which is the 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. The interface is designed to be intuitive and adaptive, offering personalized dashboards, appointment management views, consultation chat rooms, and access to encrypted prescriptions. Integration with Web3 wallets such as MetaMask ensures that users can seamlessly authenticate themselves and sign transactions directly on the blockchain.

The second layer is the application tier, which comprises the smart contracts deployed on the Ethereum blockchain. These contracts encapsulate the business logic of the telemedicine system and are responsible for handling various operations such as patient registration, doctor verification, appointment management, prescription issuance, and financial transactions [2][4]. Each action performed by the user triggers specific functions within the contracts, and every transaction is logged on-chain, ensuring accountability and traceability. The smart contracts also emit events to which the frontend can subscribe, allowing real-time updates to be reflected in the user interface without the need for manual page refreshes [1].

The final layer is the data tier, where off-chain storage is managed through IPFS. All sensitive information, such as medical reports, diagnostic images, and prescriptions, is encrypted and stored in IPFS. The corresponding IPFS hash is then embedded in the blockchain through a smart contract transaction, serving as a verifiable reference point for future access. This ensures that the integrity and authenticity of the stored files can be verified while maintaining patient privacy [2][3]. 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].

This three-layer model ensures a seamless integration of user experience, business logic, and secure data handling, all of which are vital for the successful deployment and operation of a decentralized telemedicine solution. Interfaces for patients, doctors, and administrators. Ethereum-based contracts for user authentication, role management, appointment scheduling, medical record updates, and payment processing.

3.4 Modules

The telemedicine platform is composed of several interconnected modules that collectively deliver a secure, automated, and patient-centric healthcare experience [1][3][5]. Each module is designed to fulfill a specific functional requirement and operates in coordination with the others to maintain a cohesive and efficient workflow throughout the system.

The user management module is responsible for handling the registration, authentication, and role-based access of all platform participants. Patients, doctors, and administrators are required to create accounts using their Web3 wallet addresses, which are then mapped to their identity profiles stored on the blockchain. Doctors must undergo a verification process by the admin before they are allowed to offer consultation services. This ensures that only licensed professionals participate in patient care [4].

The appointment scheduling module enables patients to browse available time slots, book appointments with their preferred doctors, and receive confirmation based on the doctor's availability. Smart contracts automate the lifecycle of appointments, updating the status in real-time and emitting notifications to both parties [2][4]. This removes the need for manual coordination and reduces administrative overhead.

The electronic health records (EHR) module allows doctors to access patient medical histories, add new diagnoses, and upload diagnostic files securely. Every interaction with a medical record is logged on the blockchain, ensuring traceability and accountability. The medical data itself is stored off-chain in IPFS to maintain scalability, while blockchain entries serve as immutable pointers to those files.

The payment and escrow module facilitates secure and transparent financial transactions between patients and doctors. Payments are made through cryptocurrency and are held in a smart contract until the consultation is successfully completed. Once the appointment concludes and both parties confirm satisfaction, the smart contract automatically releases the payment to the doctor's wallet, ensuring fairness and eliminating disputes [3].

Following a consultation, doctors can issue digital prescriptions through the prescription module. These prescriptions are encrypted and uploaded to IPFS, with the hash reference stored on-chain. Patients can access their prescriptions securely and share them with pharmacies if needed.

In addition to these functional modules, the notification and event-handling system ensures that all participants remain informed of changes in real time. Whether it's a new appointment, a payment confirmation, or the availability of a prescription, the platform promptly communicates updates to relevant users, thereby enhancing engagement and responsiveness.

Each module, while distinct in function, works in harmony with others, resulting in an integrated and comprehensive telemedicine ecosystem powered by blockchain and decentralized storage technologies.

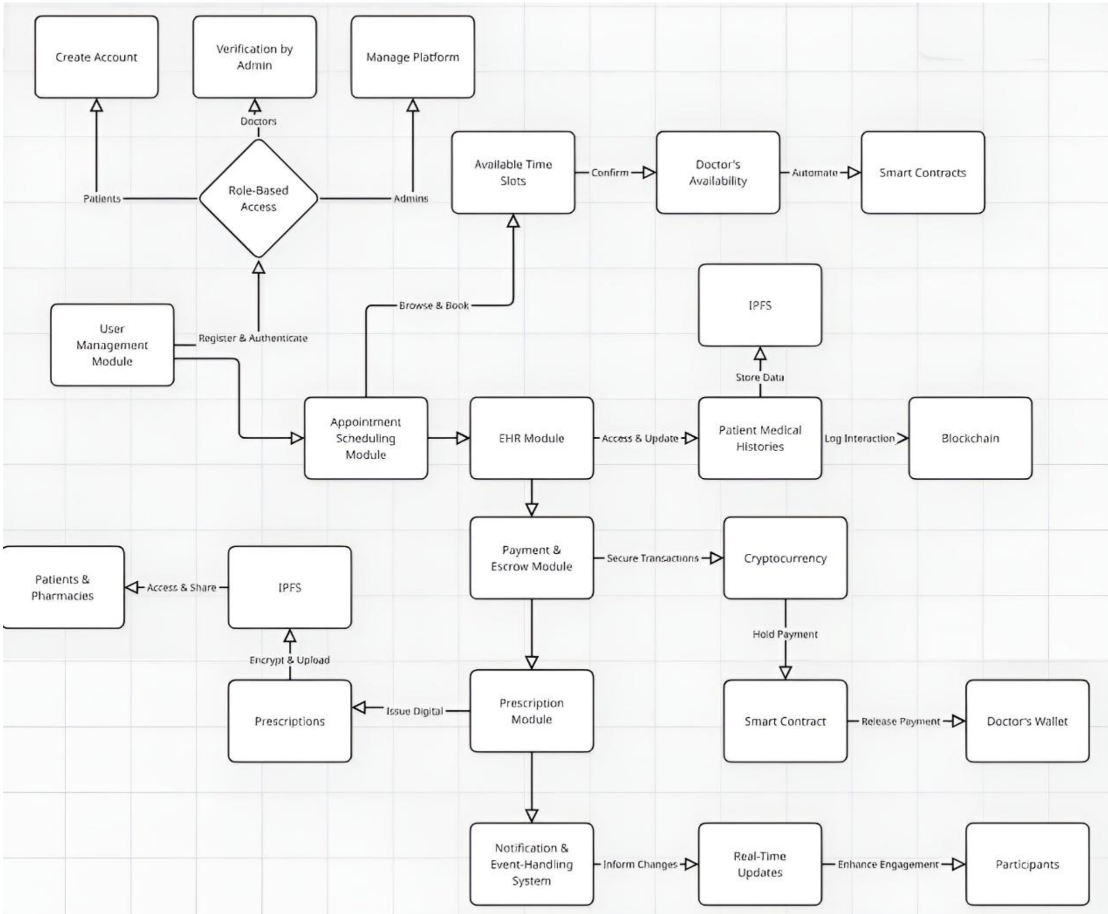


Figure 3.3 Flow Diagram of Model

3.5 Entities in the System

The decentralized telemedicine system comprises various entities that interact with each other to deliver healthcare services in a secure, efficient, and transparent manner. These entities include human participants, digital objects, and smart contract constructs that collectively define the behavioral and structural blueprint of the platform.

At the center of the system are the users, who are categorized into patients, doctors, and administrators. Each user is identified by a unique blockchain wallet address and possesses a digital identity stored on the blockchain. Patients use the system to book appointments, access their health records, and receive consultations. Doctors interact with patient records, diagnose illnesses, issue prescriptions, and manage their appointment schedules [4][5]. Administrators act as super-users who verify doctors' credentials, resolve disputes, and oversee the platform's operations [1][5].

Appointments form a key entity in the system. Each appointment is linked to a patient and a doctor, and includes metadata such as date, time, consultation mode, and current status. Appointments are stored as smart contract instances, enabling them to be tracked and updated through blockchain events [1][2].

Medical records are another crucial entity. These records store health data such as symptoms, diagnostic results, treatment notes, and medication histories. Rather than storing the full data on-chain, the system encrypts these records and uploads them to IPFS, storing only the hash on the blockchain for verification purposes [2][3].

Prescriptions are digital entities generated by doctors following a consultation. They contain a list of prescribed medicines, dosage instructions, and any follow-up advice. Like medical records, prescriptions are stored off-chain, and the blockchain holds the reference to their storage location.

Supporting these entities are a range of smart contracts, each responsible for specific functionalities. The AppointmentManager handles creation and updates of appointments, the EHRManager oversees health record access and updates, the PaymentManager manages the escrow system, and the MedicineManager facilitates prescription handling.

<u>CHAPTER 4</u>

IMPLEMENTATION

4. IMPLEMENTATION

The WeCare decentralized telemedicine platform is implemented as a comprehensive Ethereum smart contract that handles all core functionalities including medicine management, doctor-patient interactions, appointment scheduling, and secure messaging. The system leverages blockchain technology for transparency and security while utilizing IPFS for decentralized document storage.

4.1 SMART CONTRACT ARCHITECTURE

The Healthcare smart contract serves as the backbone of the system, implemented in Solidity version 0.8.0. The contract maintains several critical data structures including Medicine to track pharmaceutical inventory with details like price, quantity, and IPFS storage links; Doctor to manage physician profiles with approval status and performance metrics; and Patient to store medical histories and treatment records. The contract implements role-based access control through modifiers like onlyAdmin and onlyDoctor to ensure proper authorization for sensitive operations.

```
ADD_NOTIFICATION(msg.sender, "You have successfully update, patient medical history", "Doctor");

ADD_NOTIFICATION(patients[_patientId].accountAddress, "Your medical history updated by doctor", "Doctor");

ADD_NOTIFICATION(msg.sender, "Patient medicial history is updated", "Doctor");
```

The notification system is integrated directly into the contract through the ADD_NOTIFICATION internal function, which creates timestamped records of all significant events

```
emit MEDICINE_ADDED(medicineCount, _IPFS_URL, _currentLocation);
```

These notifications are stored in a mapping indexed by user addresses, allowing efficient retrieval of user-specific alerts. The contract emits events for all major operations including MEDICINE_ADDED, APPOINTMENT_BOOKED, and MEDICINE_PRESCRIBED to provide transparent logging on the blockchain.

4.2 USER REGISTRATION AND MANAGEMENT

The 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 registeredDoctors and registeredPatients mappings track approved participants.

```
//CREATE ACCOUNT
function CREATE_ACCOUNT(string calldata name, address _address, string memory _type) internal {
    require(CHECK_USER_EXISTS(_address) == false, "User already exists");
    require(bytes(name).length>0, "Username cannot be empty");

    userList[_address].name = name;
    userList[_address].userType = _type;

    getAllUsers.push(AllUserStruck(name, _address));
}
```

4.3 APPOINTMENT MANAGEMENT SYSTEM

The appointment system allows patients to book consultations by calling the BOOK_APPOINTMENT function with specified time slots and conditions. The 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.

```
/// BOOK_APPOINTMENT
function BOOK_APPOINTMENT(uint _patientId, uint _doctorId, string memory _from,string memory _to,string memory _appointmentDate,string memory _condition, string memory _message, address _doctorAddress, string calldata _name) public payable {
        require(_patientId <= patientCount, "Patient does not exist");
        require(_doctorId <= doctorCount, "Doctor does not exist");
        require(doctors[_doctorId].isApproved, "Doctor is not approved");
        require(patients[_patientId].accountAddress == msg.sender, "Only the patient can book their appointment");
        require(msg.value == appointmentFee, "Incorrect appointment fee");

        uint adminShare = msg.value / 10;
        uint doctorShare = msg.value - adminShare;

        appointmentCount++;
        appointments[appointmentCount] = Appointment(appointmentCount, _patientId, _doctorId, block.timestamp, _from,_to, _appointmentDate, _condition, _message, true);

        doctors[_doctorId].appointmentCount++;

        payable(admin).transfer(adminShare);
        payable(doctors[_doctorId].accountAddress).transfer(doctorShare);

        //CHAT FRIEND
        ADD_FRIEND(_doctorAddress, _name, msg.sender);

        ADD_NOTIFICATION(_doctorAddress, "You have a new appointment", "Patient");

        ADD_NOTIFICATION(msg.sender, "You have successfully booked an appointment", "Patient");

        ADD_NOTIFICATION(admin, "New appointment booked", "Patient");

        emit APPOINTMENT_BOOKED(appointmentCount, _patientId, _doctorId, block.timestamp);
}
```

```
function COMPLETE_APPOINTMENT(uint _appointmentId) public onlyDoctor {
    require(_appointmentId <= appointmentCount, "Appointment does not exist");
    require(appointments[_appointmentId].doctorId == GET_DOCTOR_ID(msg.sender), "Only the assigned doctor can complete the appointment");

    appointments[_appointmentId].isOpen = false;
    doctors[GET_DOCTOR_ID(msg.sender)].successfulTreatmentCount++;

    ADD_NOTIFICATION(msg.sender, "You have successfully completed the appointment", "Doctor");

    ADD_NOTIFICATION(patients[appointments[_appointmentId].patientId].accountAddress, "Your Appointment is successfully completed", "Doctor");

    ADD_NOTIFICATION(admin, "Doctor completed appointment successfully", "Doctor");
}
```

4.4 MEDICINE MANAGEMENT AND PRESCRIPTIONS

The admin maintains the medicine inventory through functions like ADD_MEDICINE and UPDATE_MEDICINE_QUANTITY.

```
///ADD MEDICATION
function ADD_MEDICINE( string memory _IPFS_URL,  uint _price, uint _quantity,uint _discount, string memory _currentLocation) public onlyAdmin {
    medicineCount++;
    medicines[medicineCount] = Medicine(medicineCount, _IPFS_URL, _price, _quantity, _discount, _currentLocation, true);

    ADD_NOTIFICATION(msg.sender, "New Medicine added to marketplace successfully!", "Medicine");

    emit MEDICINE_ADDED(medicineCount, _IPFS_URL, _currentLocation);
}
```

```
//UPDATE MEDICATION QUENTITY
function UPDATE_MEDICINE_QUANTITY(uint _medicineId, uint _quantity) public onlyAdmin {
    require(_medicineId <= medicineCount, "Medicine does not exist");
    medicines[_medicineId].quantity = _quantity;

     ADD_NOTIFICATION(msg.sender, "Medicine quantity updated successfully", "Medicine");

    emit MEDICINE_QUANTITY(_medicineId, _quantity);
}
```

Doctors can prescribe medications via the 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.

```
function PRESCRIBE_MEDICINE(uint _medicineId, uint _patientId) public onlyDoctor {
    require(doctors[GET_DOCTOR_ID(msg.sender)].isApproved, "Doctor is not approved");

    prescriptionCount++;
    prescriptions[prescriptionCount] = Prescription(prescriptionCount, _medicineId, _patientId, GET_DOCTOR_ID(msg.sender), block.timestamp);
    emit MEDICINE_PRESCRIBED(prescriptionCount, _medicineId, _patientId, GET_DOCTOR_ID(msg.sender), block.timestamp);

    ADD_NOTIFICATION(msg.sender, "You have successfully prescribed medicine", "Doctor");

    ADD_NOTIFICATION(patients[_patientId].accountAddress, "Doctor prescribed you medicine", "Doctor");

    ADD_NOTIFICATION(admin, "Doctor prescribed medicine successfully", "Doctor");
}
```

```
function BUY_MEDICINE(uint _patientId, uint _medicineId, uint _quantity) public payable {
    require(_patientId <= patientCount, "Patient does not exist");
    require(_medicineId <= medicineCount, "Medicine does not exist");
    require(patients[_patientId].accountAddress == msg.sender, "Only the patient can buy their medicine");
    require(medicines[_medicineId].active, "Medicine is not active");
    require(medicines[_medicineId].quantity >= _quantity, "Not enough medicine in stock");

    uint totalPrice = medicines[_medicineId].price * _quantity;

    medicines[_medicineId].quantity -= _quantity;

    patients[_patientId].boughtMedicines.push(_medicineId);

    patientOrders[_patientId].push(Order({
        medicineId: _medicineId,
        price: medicines[_medicineId].price,
        payAmount: totalPrice,
        quantity: _quantity,
        patientId: _patientId,
        date: block.timestamp
    }));
```

4.5 SECURE MESSAGING SYSTEM

The contract implements an encrypted messaging system where users must first establish connections through the ADD_FRIEND function.

```
function ADD_FRIEND(address friend_key, string calldata name, address _myAddress) internal {

    require(CHECK_USER_EXISTS(_myAddress), "Create an account first");
    require(CHECK_USER_EXISTS(friend_key), "User is not registered!");
    require(_myAddress != friend_key, "Users cannot add themselves as friends");


    if (!CHECK_ALREADY_FRIENDS(_myAddress, friend_key)) {
        _ADD_FRIEND(_myAddress, friend_key, name);
        _ADD_FRIEND(friend_key, _myAddress, userList[_myAddress].name);
    }
}
```

Messages are stored in the allMessages mapping indexed by a unique chatCode derived from participant addresses. The _SEND_MESSAGE function validates sender-receiver relationships before storing messages with timestamps,

```
//SEND MESSAGE
function _SEND_MESSAGE(address friend_key, address _myAddress, string calldata _msg) external{
    require(CHECK_USER_EXISTS(_myAddress), "Create an account first");
    require(CHECK_USER_EXISTS(friend_key), "User is not registered");
    require(CHECK_ALREADY_FRIENDS(_myAddress, friend_key), "You are not friend with the given user");

    bytes32 chatCode = _GET_CHAT_CODE(_myAddress, friend_key);
    message memory newMsg = message(_myAddress, block.timestamp, _msg);
    allMessages[chatCode].push(newMsg);

    ADD_NOTIFICATION(_myAddress, "You have successfully send message", "Message");

    ADD_NOTIFICATION(friend_key, "You have new message", "Message");

    ADD_NOTIFICATION(admin, "message send successfully", "Message");
}
```

while GET_READ_MESSAGE allows retrieving conversation histories.

4.6 IPFS INTEGRATION

```
//READ MESSAGE
function GET_READ_MESSAGE(address friend_key, address _myAddress) external view returns(message[] memory){
    bytes32 chatCode = _GET_CHAT_CODE(_myAddress, friend_key);
    return allMessages[chatCode];
}
```

All medical documents including patient records and prescription details are stored on IPFS, with the resulting content identifiers (CIDs) stored in the 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.

4.7 ADMINISTRATIVE CONTROLS

The admin address manages system parameters through functions like

```
function UPDATE_REGISTRATION_FEE(uint _newFee) public onlyAdmin {
    registrationDoctorFee = _newFee;

    ADD_NOTIFICATION(admin, "You have successfully updated Registration fee", "Admin");
}
```

```
function UPDATE_ADMIN_ADDRESS(address payable _newAddress) public onlyAdmin {
    admin = _newAddress;

    ADD_NOTIFICATION(admin, "You have successfully updated admin address", "Admin");
}
```

UPDATE_REGISTRATION_FEE and UPDATE_ADMIN_ADDRESS. Administrative actions generate notifications and emit events to maintain transparency.

```
//GET FUNCTION FOR MEDICATION
function GET_ALL_REGISTERED_MEDICINES() public view returns (Medicine[] memory) {
    Medicine[] memory allMedicine = new Medicine[](medicineCount);
    uint counter = 0;
    for (uint i = 1; i <= medicineCount; i++) {
        allMedicine[counter] = medicines[i];
        counter++;
    }
    return allMedicine;
}
```

The contract includes comprehensive view functions like GET_ALL_REGISTERED_MEDICINES and GET_DOCTOR_APPOINTMENTS_HISTORYS to facilitate data retrieval.

```
function GET_DOCTOR_APPOINTMENTS_HISTORYS(uint _doctorId) public view returns (Appointment[] memory) {
    require(_doctorId <= doctorCount, "Doctor does not exist");

    uint count = 0;
    for (uint i = 1; i <= appointmentCount; i++) {
        if (appointments[i].doctorId == _doctorId) {
            count++;
        }
    }

    Appointment[] memory doctorAppointments = new Appointment[](count);
    uint counter = 0;
    for (uint i = 1; i <= appointmentCount; i++) {
        if (appointments[i].doctorId == _doctorId) {
            doctorAppointments[counter] = appointments[i];
            counter++;
        }
    }
    return doctorAppointments;
}
```

The implementation demonstrates a complete healthcare management solution that leverages blockchain technology for security, transparency, and automation while maintaining practical usability through thoughtful system architecture and smart contract design patterns.

CHAPTER 5

RESULT

AND

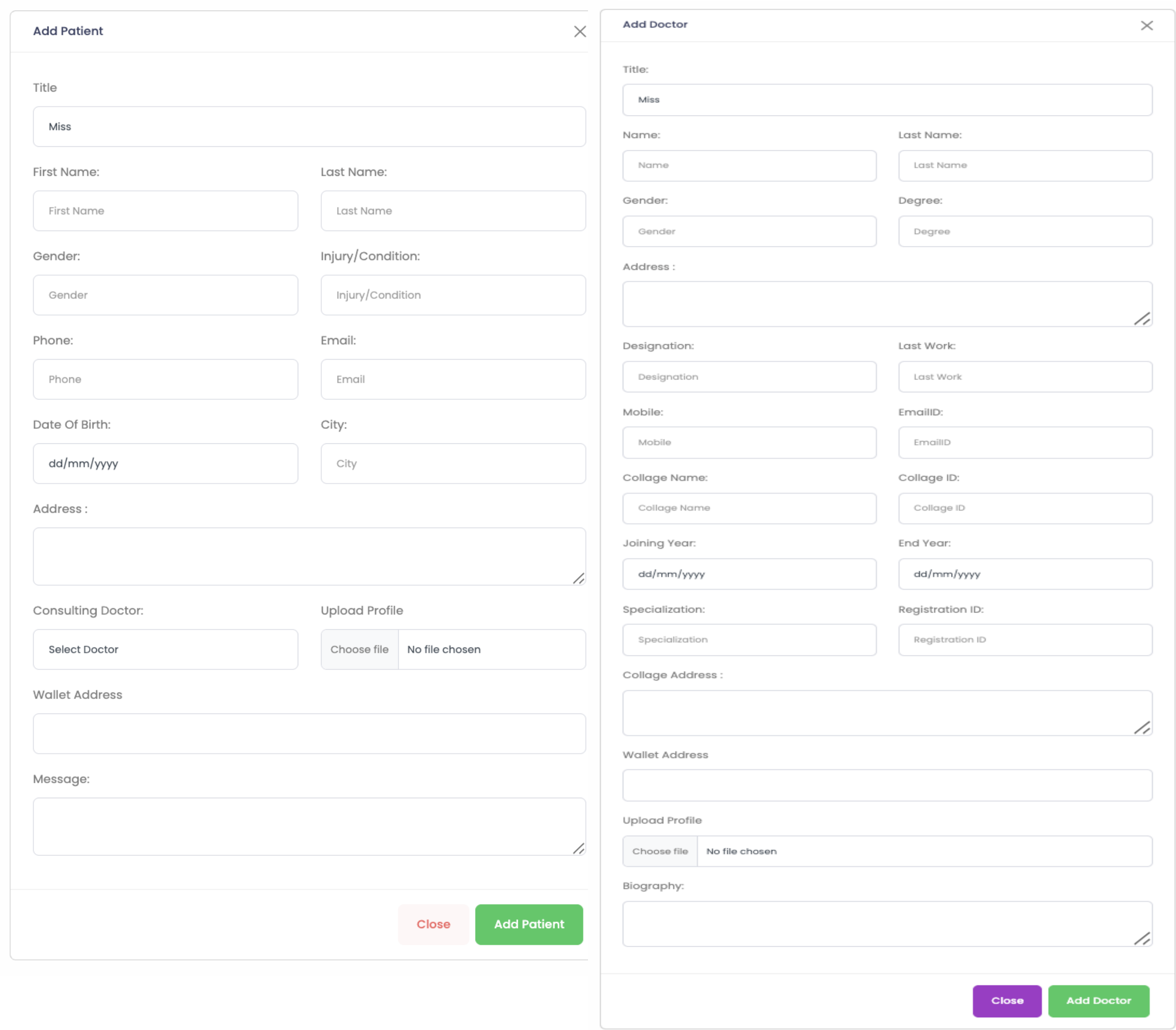
DISCUSSION

5. RESULT AND DISCUSSION

5.1 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). The MetaMask account address is automatically recorded during registration, and users must provide their personal information stored on IPFS.

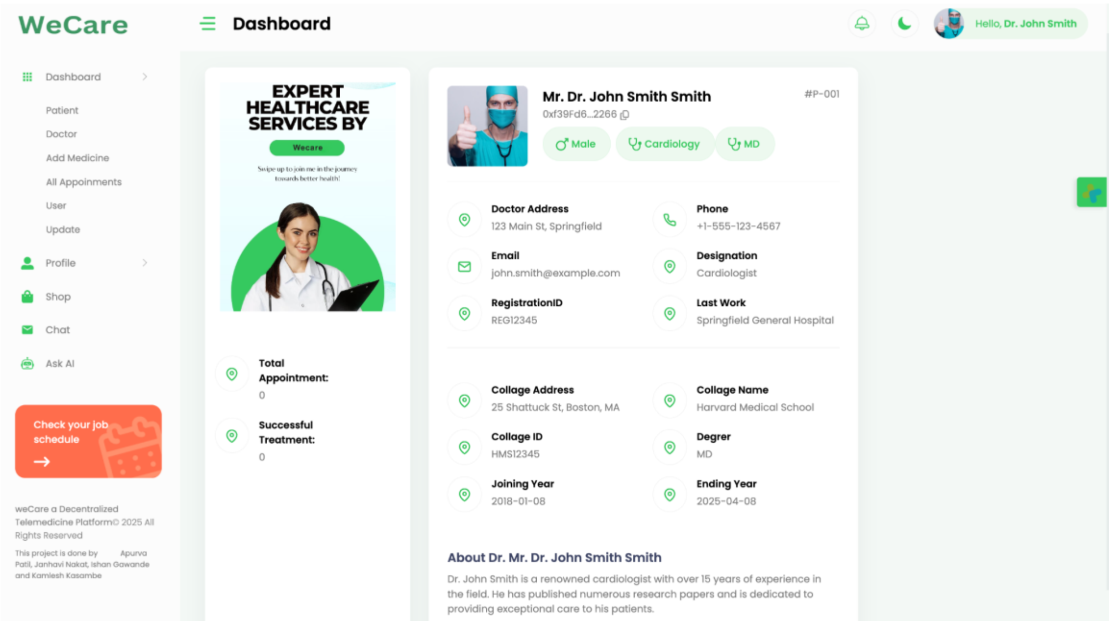
Screenshot 4.1 Authentication Page



Screenshot 4.2 Registration Page

5.2 ADMIN DASHBOARD

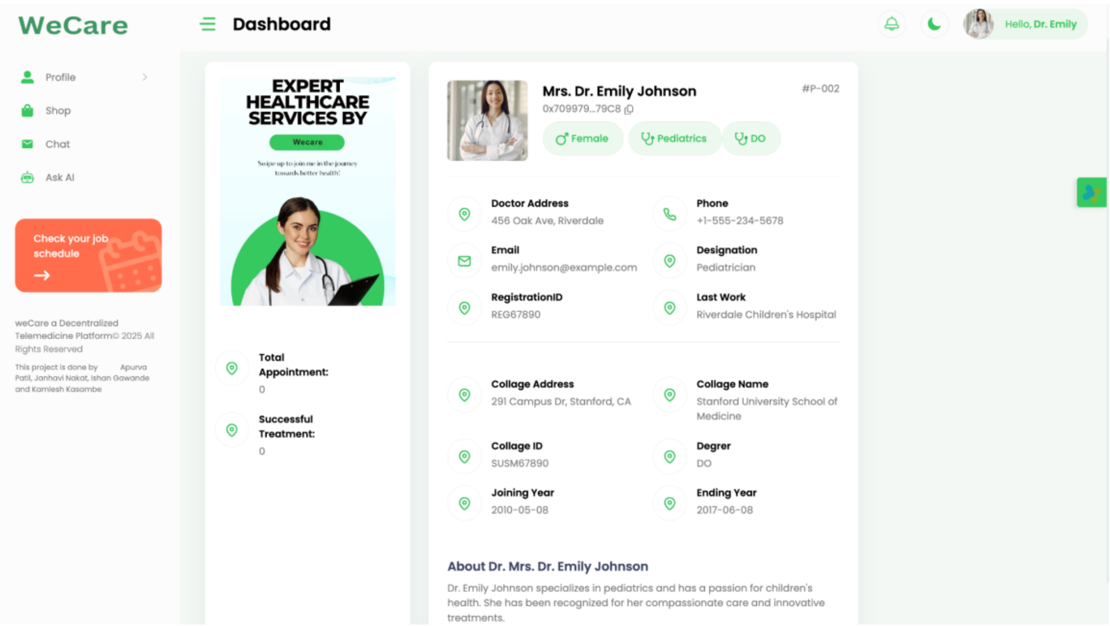
The admin oversees the entire system, managing medicine inventory, approving doctor registrations, and setting fees. The admin can add/update medicines, their prices, quantities, and locations, and has access to all system activities and notifications.



Screenshot 4.3 Patient Portal

5.4 DOCTOR PORTAL

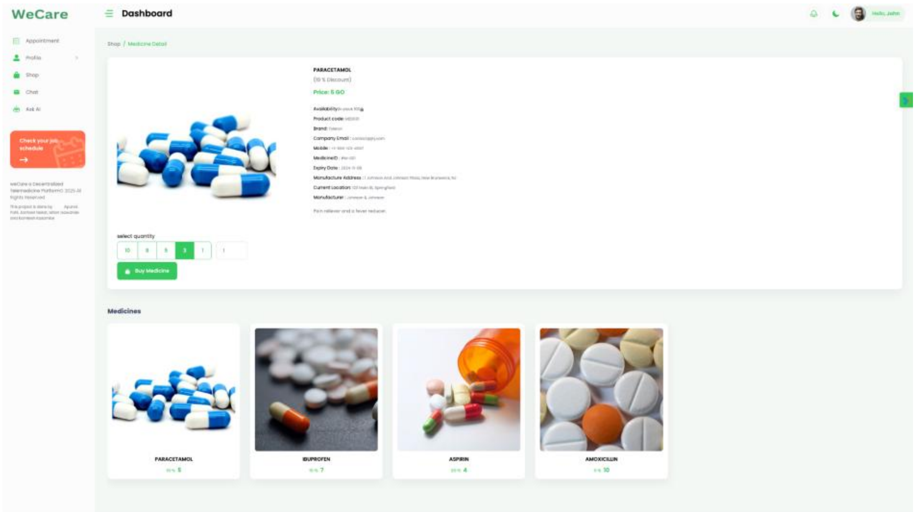
Doctors' complete registration by paying fee and waiting for admin approval. Approved doctors can view appointments, update patient medical records, prescribe medicines, and complete appointments (which increases their successful treatment count).



Screenshot 4.4 Doctor Portal

5.5 MEDICINE MANAGEMENT

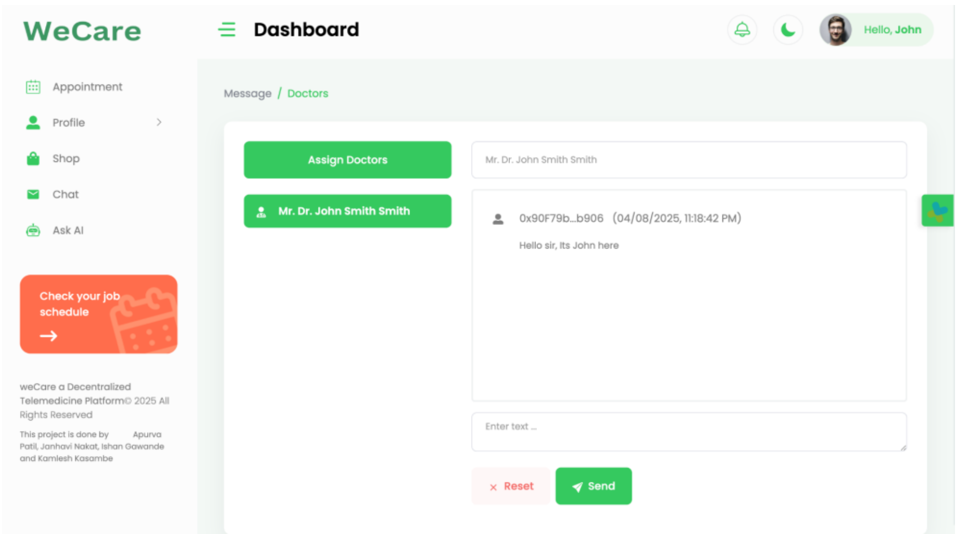
The system maintains a comprehensive medicine inventory tracking ID, IPFS URL, price, quantity, discount, current location, and active status. Patients can view and purchase available medicines with proper validation of stock levels.



Screenshot 4.5 Medicine Marketplace

5.6 MESSAGING SYSTEM

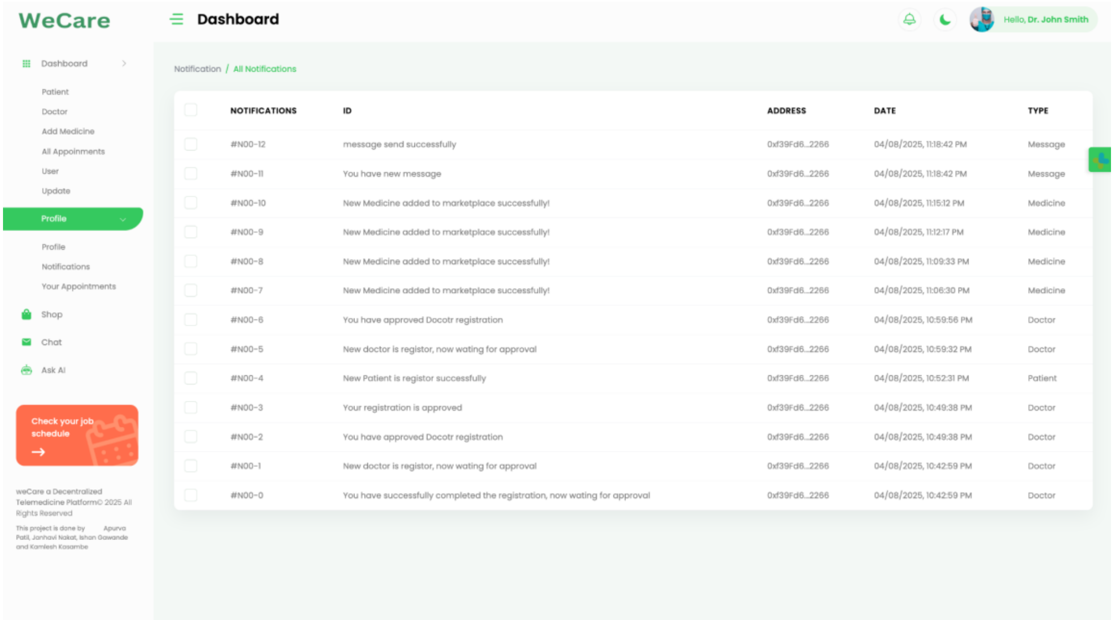
The platform includes an encrypted messaging system where patients and doctors can communicate after becoming friends. All messages are timestamped and stored securely on-chain.



Screenshot 4.6 Messaging Interface

5.7 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.



Screenshot 4.7 Notification Center

5.8 GAS USAGE METRICS

The Ethereum gas usage varies by operation in this healthcare management system:

Function	Gas Used	Gas Price	Gas Fee (ETH)
Register Doctor	210,450	20 Gwei	0.004209

Table I: Doctor Registration Gas Cost

Function	Gas Used	Gas Price	Gas Fee (ETH)
Book Appointment	185,320	20 Gwei	0.003706

Table II: Book Appointment Gas Cost

Function	Gas Used	Gas Price	Gas Fee (ETH)
Prescribe Medicine	92,750	20 Gwei	0.001855

Table III: Prescribe Medicine Gas Cost

The gas metrics demonstrate that more complex operations like registration and appointment booking require higher computational resources, while simpler functions like prescribing medicine use less gas. The system optimizes gas usage by storing large files (medical records, documents) on IPFS while keeping critical transaction data on-chain.

CHAPTER 6

CONCLUSION

6. CONCLUSION

6.1 CONCLUSION

The WeCare:a secured and decentralized telemedicine platform empowered by blockchain technology developed through this project demonstrates the transformative potential of blockchain 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. The immutable nature of blockchain ensures that all transactions, from appointment bookings to prescription verifications, are permanently recorded and protected against unauthorized alterations.

A key achievement of this system is the automation of critical healthcare processes through smart contracts, which eliminates intermediaries and reduces administrative burdens. Patients benefit from direct access to their medical histories and prescribed treatments, while doctors gain a streamlined workflow for managing appointments and patient data. The integration of IPFS for storing medical documents complements the blockchain infrastructure, providing a scalable solution for handling large files while maintaining data integrity.

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 trustless environment where all stakeholders can interact securely. The built-in notification system further enhances communication, ensuring timely updates for patients, doctors, and administrators.

6.2 FUTURE SCOPE

The future development of this decentralized telemedicine platform empowered by blockchain technology holds significant promise for broader adoption and enhanced functionality. One potential advancement involves incorporating cross-chain compatibility to enable seamless data exchange between different healthcare providers and institutions. This would facilitate comprehensive patient care across multiple facilities while maintaining privacy and security standards.

Another area for expansion is the integration of artificial intelligence to analyze patient data and provide predictive insights for preventive healthcare. AI algorithms could assist doctors in diagnosing conditions earlier and recommending personalized treatment plans. Additionally, the system could be extended to support telemedicine services, allowing remote consultations with blockchain-secured identity verification and automated payment settlements.

The adoption of decentralized identity solutions would empower patients with greater control over their medical records, enabling them to share specific health data with providers on a need-to-know basis. 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 the 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-centered than ever before.

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WECARE: BLOCKCHAIN-BASED SOLUTION FOR MODERN HEALTHCARE CHALLENGES

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ABSTRACT

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 patients 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 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: Telehealth, Telemedicine, Decentralized, Smart Contract.

I. INTRODUCTION

The rapid evolution of telehealth and telemedicine has fundamentally transformed the way healthcare services are delivered worldwide. Advances in digital communication and mobile technologies have enabled patients to receive medical consultations and treatment remotely, reducing geographical and logistical barriers to accessing quality healthcare. This transformation has been accelerated by global events such as the COVID-19 pandemic, which underscored the necessity for robust and accessible telemedicine solutions in times of crisis.

Despite its many advantages, the widespread adoption of telemedicine has also revealed significant challenges, particularly in the realms of data security, privacy, and system reliability. Most existing telemedicine platforms rely on centralized architectures that, while efficient, are inherently vulnerable to cyber-attacks, unauthorized data breaches, and fraudulent activities. Such vulnerabilities not only jeopardize patient confidentiality but also undermine the trust that is essential for effective healthcare delivery [3][5]. As healthcare providers and patients increasingly depend on digital platforms, the need for enhanced security mechanisms becomes ever more pressing.

Blockchain technology emerges as a promising solution to these security challenges. Characterized by its decentralized and immutable nature, blockchain offers a robust framework for safeguarding sensitive health information. By distributing data across a network of nodes and employing advanced cryptographic protocols, blockchain can eliminate single points of failure and ensure the integrity of medical records. This technological shift has the potential to revolutionize telemedicine by providing a secure, transparent, and tamper-proof system for managing patient data [1][2].

In this paper, we explore the integration of blockchain technology into telemedicine systems with the objective of addressing the limitations of conventional centralized platforms. The study aims to develop a theoretical and practical framework for a blockchain-based telehealth platform that enhances data security and operational transparency. Through this research, we seek to contribute to the ongoing evolution of telemedicine by offering innovative solutions that ensure patient data is handled with the highest standards of security and reliability.

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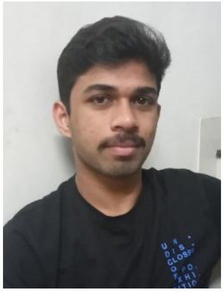

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