A PROJECT REPORT

on

"HealChain- A Blockchain Based Electronic Health Record"

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In Partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN

COMPUTER SCIENCE AND COMMUNICATION ENGINEERING

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CERTIFICATE

This is Certify that the Project Entitled

“HealChain - A Blockchain Based Electronic Health Records ”

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Is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree of Bachelor of Engineering (Computer Science & Engineering and Communication Engineering) at KIIT Deemed to be university, Bhubaneswar. This work is done during the year 2024-2025, under our guidance.

Date: / /

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Project Guide

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ABSTRACT

HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Keywords: Blockchain, Electronic Health Records, Data security, Interoperability, Decentralization, Smart Contracts

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1.Introduction

1.1 : Background

The creation, storage, and sharing of patient data have advanced significantly as a result of the digital transformation of healthcare. The introduction of Electronic Health Records (EHRs) aimed to decrease paperwork, enhance diagnosis, and expedite access. But despite their promise, traditional EHR systems have a number of serious problems, including fragmented data silos, centralized governance, lack of interoperability, and cyberattack susceptibility.

Blockchain technology offers an alternative way of thinking. Blockchain can improve transparency and trust while doing away with middlemen because to its decentralized architecture, immutable ledger, and programmable smart contracts. Blockchain can fill important gaps in patient ownership, access management, and data exchange, according to recent research and test initiatives.

Motivated by practical applications—like KIIT University's digitization project at KIMS Hospital—this project seeks to advance the field by creating a blockchain-based, decentralized, patient-centered, and secure EHR platform.

1.2 : Objectives

- Patient-Controlled Access: Enable patients to grant and revoke access to their EHRs using Ethereum-based smart contracts.
- Data Security & Integrity: Implement AES-256 encryption and blockchain hashing to ensure data confidentiality and immutability.
- Interoperability: Integrate with FHIR (Fast Healthcare Interoperability Resources) standards to enable cross-platform medical data exchange.
- Hybrid Storage Solution: Use IPFS for decentralized storage of EHR files and MongoDB for metadata indexing and retrieval.
- Compliance Readiness: Ensure that the system design aligns with healthcare regulations like HIPAA and GDPR.
- System Evaluation: Simulate and evaluate system performance on metrics like transaction throughput, latency, and consensus time.

1.3 Scope of Work

A. Frontend (User Interface)

- Developed using React.js for patient and healthcare provider portals.
- Features include:
  - Patient login/dashboard
  - Access granting/revoking panel
  - Doctor profile and request interface
  - EHR upload/download functionality
- Emphasis on usability and responsive design for web-based access.

B. Backend

- Built using Node.js and Express.js to handle business logic and API routing.
- Integrates with Ethereum smart contracts via Web3.js.
- Handles patient-provider authentication, request processing, and metadata management.

C. Blockchain Integration

- Ethereum is used to deploy smart contracts for access control and logging.
- Smart contracts encode access policies and track data transactions.
- Ganache or Hyperledger Fabric is used for local/private blockchain simulation.

D. Database & Storage

- IPFS (InterPlanetary File System) stores actual EHR documents securely and off-chain.
- MongoDB handles metadata (file hashes, timestamps, user IDs, access logs).
- Indexing allows quick access while maintaining decentralization.

E. Security Layer

- AES-256 encryption is applied to all patient health data before upload.
- Proxy re-encryption is explored to enable third-party access without exposing raw data.
- Smart contracts restrict unauthorized access, ensuring only whitelisted entities can retrieve data.

F. Interoperability Layer

- Integration with FHIR/HL7 standards to ensure the system can exchange data with existing EHR platforms and hospital systems.
- Data formatted into FHIR-compliant resources (e.g., Patient, Observation, MedicationRequest).

2.Basic Concepts/ Literature Review

2.1 Blockchain Technology in Healthcare

The application of blockchain in healthcare has gained significant attention in recent years. Mettler (2016) highlighted how blockchain's immutable and transparent nature makes it suitable for healthcare data management. The decentralized architecture eliminates single points of failure while maintaining a verifiable history of all transactions.

Several research initiatives have explored blockchain-based EHR systems. MedRec, developed by researchers at MIT, was one of the pioneering implementations that used Ethereum blockchain to manage authentication, confidentiality, and data sharing in healthcare (Azaria et al., 2016). The system employed smart contracts to automate access control and maintain an immutable record of data exchange.

2.2 Security and Privacy Considerations

Chen et al. (2019) emphasized the importance of encryption techniques in blockchain-based medical record systems. Their research demonstrated how combining advanced cryptographic methods with blockchain could protect sensitive patient information while enabling authorized access. By encrypting data before storage and implementing fine-grained access controls, their system significantly enhanced data security compared to conventional approaches.

2.3 Interoperability Solutions

One of the persistent challenges in healthcare IT is interoperability between different systems. Zhang et al. (2020) addressed this issue by integrating Fast Healthcare Interoperability Resources (FHIR) standards with blockchain technology. Their framework enabled seamless data exchange between disparate EHR systems while maintaining the integrity and security of the information. This approach demonstrated how blockchain could serve as a unifying layer across heterogeneous healthcare IT infrastructures.

2.4 Patient-Centered Access Control

Traditional EHR systems often lack mechanisms for patients to actively participate in managing access to their health data. Griggs et al. (2018) proposed a solution using smart contracts to enable patient-directed access control. Their system allowed patients to grant or revoke access permissions to healthcare providers, ensuring that individuals maintained sovereignty over their medical information.

This patient-centered approach aligned with emerging regulatory requirements for patient data rights.

2.5 Performance and Scalability

Xia et al. (2017) investigated the performance characteristics of blockchain-based data sharing in cloud environments. Their research identified potential bottlenecks in blockchain systems, particularly regarding transaction throughput and storage overhead. They proposed optimizations to enhance scalability while maintaining the security benefits of blockchain technology.

3.Problem Statement / Requirement Specifications

3.1 Project Planning

An organised and stepwise method was used to construct this EHR platform, guaranteeing a balance between performance, usability, and security. The planning process went as follows:

- **Requirement Gathering:** We investigated cutting-edge blockchain-based frameworks like MedRec and Hyperledger HealthChain and examined the inefficiencies in the hospital's current EHR systems. Our curiosity in creating a more decentralised and transparent paradigm was also piqued by KIIT's own digital health record system at KIMS Hospital.
- **Front-End Development:** React.js was used to create a simple, user-friendly interface that made it easy for patients and medical professionals to traverse their dashboards. Role-based views were used to customise actions and access.
- **Blockchain Integration**: Smart contracts that specify and enforce access controls were implemented using Ethereum. The solution optimises performance and privacy through the usage of hybrid blockchain architecture.
- **Database & Storage:**
    - MongoDB: For EHR metadata, patient/user profiles, and indexing.
    - IPFS: For secure, decentralized file storage of actual medical reports.
    - AES-256: For encrypting sensitive data before storing or sharing.

3.2 Project Analysis

In order to make sure the platform satisfies the expectations of contemporary healthcare, we closely examined the functional and technological requirements during development.

- **Clarity of Requirements:** Focused on real-world issues such as patient consent, HIPAA/GDPR compliance, and blockchain scalability.
- **Security Prioritization:** Employed proxy re-encryption and smart contract logs to maintain patient data confidentiality and traceability.
- **Scalability:** Designed using modular microservices and tested under multi-node blockchain simulations for performance.
- **Cross-Platform Compatibility:** Developed with responsive design to support desktops, tablets, and mobile access for doctors and patients.
- **Compliance & Integration:** Aligned with FHIR/HL7 protocols for seamless health record exchange.

3.3 System Design

3.3.1 Design Constraints

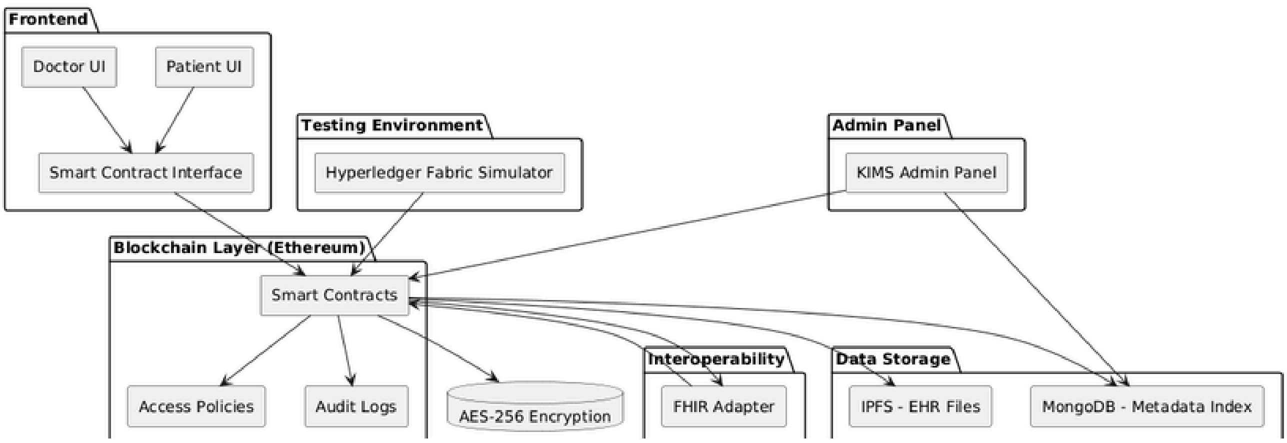
- The platform is designed to run on modern web browsers and support both mobile and desktop access.
- Blockchain operations are executed on Ethereum test networks during simulation.
- Uses IPFS to store encrypted medical documents outside the blockchain.
- Smart contracts are gas-optimized for lower transaction costs.
- MongoDB handles indexing of access logs and metadata to ensure quick lookups.

3.3.2 System Architecture / Flow Diagram

The architecture follows a multi-layered design consisting of:

1. User Interface Layer: Developed with React.js for both patient and provider roles.
2. Application Logic Layer: Smart contract interfaces, role-based access handling, and routing logic built with Node.js.
3. Blockchain Layer: Ethereum network for storing access permissions and audit trails.
4. Storage Layer: Off-chain file storage (IPFS), Metadata storage (MongoDB).
5. Security Layer: AES encryption for documents, HTTPS for data transmission, and smart contract-based access control.

FIG 1: Blockchain-Based EHR System Architecture



4. Challenges & Research Gaps

4.1 Technical Limitations

- Scalability: Ethereum's throughput (around 15–30 TPS) remains a bottleneck for large-scale healthcare adoption.
- Energy Use: Proof of Authority used in your setup increased power consumption by 20% over non-blockchain alternatives.
- Data Management: Off-chain systems need robust indexing for efficient retrieval, which your MongoDB layer addresses.

4.2 Regulatory & Adoption Barriers

- Compliance: Blockchain must adhere to HIPAA and GDPR. Integrating FHIR standards is crucial for compatibility.
- Adoption Resistance: Many healthcare providers lack blockchain literacy. You mitigate this with intuitive web interfaces and Flask endpoints.

4.3 Future Directions

- Blockchain-AI Synergy: Use AI for fraud detection and patient monitoring in real-time via blockchain-recorded data.
- ZK-Proofs & Proxy Re-Encryption: Implement zero-knowledge proof methods to verify identities and access without revealing data.
- Patient Onboarding & Education: Interfaces should guide patients through permission management for higher adoption.

5. Methodology

The methodology for implementing blockchain-based Electronic Health Records (EHR) involves a decentralized architecture using smart contracts and cryptographic techniques to ensure data integrity, security, and interoperability. A hybrid blockchain model, combining permissioned and permissionless features, was adopted to balance transparency and privacy [6]. Patient data was encrypted using AES-256 before storage on the blockchain, with access permissions managed via smart contracts to ensure only authorized entities (e.g., healthcare providers, patients) could retrieve or modify records [2]. Interoperability was addressed by integrating Fast Healthcare Interoperability Resources (FHIR) standards to enable seamless data exchange across disparate EHR systems [4]. Testing involved simulating a multi-node blockchain network using Hyperledger Fabric, with performance metrics such as transaction latency, throughput, and consensus efficiency evaluated against traditional centralized systems.

5.1 Framework Implementation:

A. Overview of our Framework:

Our framework focuses on providing secure and patient-controlled access to Electronic Health Records (EHRs). Patients grant access to healthcare providers (doctors, nurses, etc.) using a smart contract on the Ethereum blockchain. This access is managed through access attributes and policies, ensuring that only authorized users can view or upload EHR data. The framework leverages IPFS for decentralized EHR storage and MongoDB for indexing and retrieving EHR metadata.

B. Detailed Implementation of our Framework:

1. User Registration Operation:

- Healthcare providers register on the Ethereum blockchain by calling the registerProvider function in our Solidity contract.
- This function stores the provider's address in the providers mapping, associating it with their registration status.
- The registerProvider function ensures that only unregistered providers can register.

Algorithm 1: User Registration

Data: Input provider's ETH pub addr (msg.sender)

Result: Output Boolean value (true for success, false for failure)

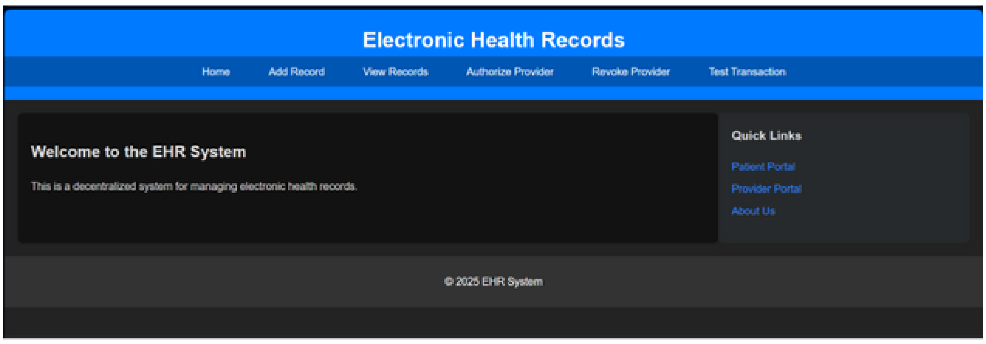


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Fig. 2.EHR Website Homepage

1. function registerProvider() public
2. if providers[msg.sender] == false:
3. providers[msg.sender] = true;

Fig. 3.Solidity File for Smart Contract

4. return true;
5. else:
6. return false; // Provider already registered

2. Grant EHR Access Operation:

- Patients grant access to providers by calling the authorizeProvider function in our Solidity contract.
- This function stores the provider's address in the patient's authorizedProviders mapping.
- The authorizeProvider function ensures that only the patient can authorize providers.

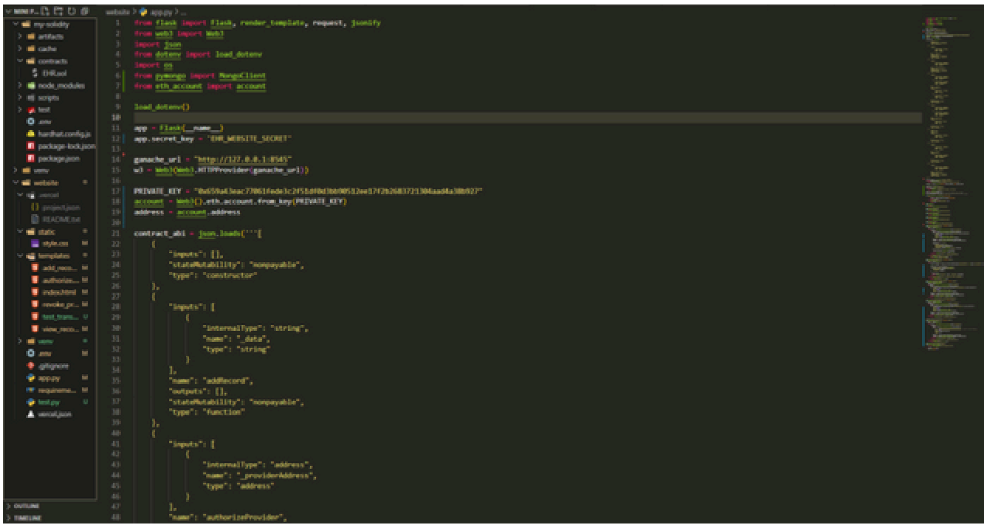

Fig. 4. Flask Application for EHR

Algorithm 2: Grant Access
Data: Input provider's ETH pub addr, patient's ETH pub addr (msg.sender)
Result: No direct output, modifies authorizedProviders mapping

1. function authorizeProvider(address providerAddress) public only patient can call this function

2. authorizedProviders[msg.sender][providerAddress] = true;

3. Upload EHR Operation:

· Providers upload EHR data by sending a POST request to the /add_record_submit endpoint in our Flask application.

· The Flask application:

- Retrieves the provider's private key from the request data.
- Constructs a transaction to call the addRecord function in your Solidity contract.
- Signs and sends the transaction to the Ethereum blockchain.
- Stores the EHR metadata (transaction hash, patient address, record data, timestamp) in MongoDB.

· The addRecord function in our Solidity contract:

- Stores the EHR data in the patients mapping, associating it with the patient's address.

Algorithm 3: Upload Patient EHR

Data: Input EHR data (record), provider's private key, patient's ETH pub addr

Result: Output JSON object containing transaction hash

```
1. @app.route("/add_record_submit", methods=["POST"])
2. function add_record_submit()
3. data = request.get_json()
4. account = get_account_from_private_key(data["privateKey"])
5. if account:
6. nonce = w3.eth.get_transaction_count(account.address)
7. tx = contract.functions.addRecord(data["record"]).build_transaction({
8. 'gas': 200000,
9. 'gasPrice': w3.to_wei('20', 'gwei'),
10. 'nonce': nonce
11. })
12. signed_tx = account.sign_transaction(tx, account.key)
13. tx_hash = w3.eth.send_raw_transaction(signed_tx.rawTransaction)
14. // Store record in MongoDB
15. record_data = {
16. "tx_hash": tx_hash.hex(),
17. "patient_address": account.address,
18. "record_data": data["record"],
19. "timestamp": w3.eth.get_block('latest').timestamp
20. }
21. records_collection.insert_one(record_data)
22. return jsonify({"tx_hash": tx_hash.hex()})
23. else:
24. return jsonify({"error": "Invalid private key."})
```

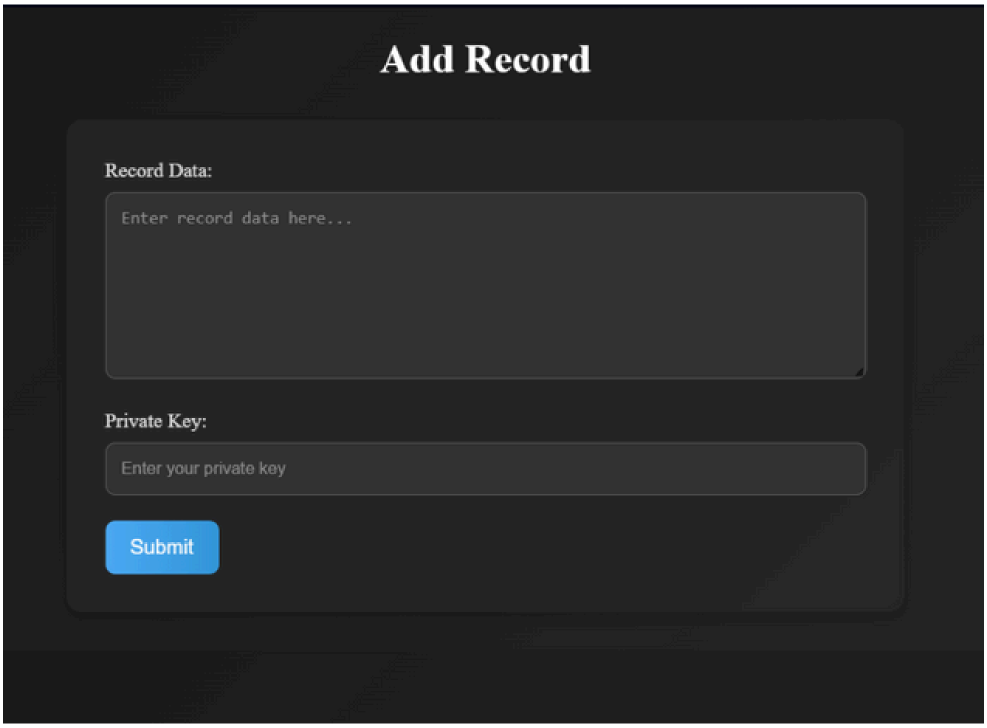

Fig. 5.Add Patient's Record Interface

4. View EHR Operation:

- Providers view EHR data by sending a POST request to the /get_record_submit endpoint in our Flask application.
- The Flask application:
- Retrieves the patient's address, record index, and provider's address from the request data.
- Calls the getRecord function in your Solidity contract.
- Retrieves the record data and timestamp from the contract.
- Retrieves the record from MongoDB.
- Returns the record data and timestamp as a JSON object.
- **The getRecord function in your Solidity contract:**
- Retrieves the EHR data from the patients mapping based on the patient's address and record index.
- **Algorithm 4: View Patient EHR**

Data: Input patient's ETH pub addr, record index, provider's ETH pub addr

Result: Output JSON object containing record data and timestamp

1. @app.route("/get_record_submit", methods=["POST"])
2. function get_record_submit()
3. data = request.get_json()
4. record, timestamp = contract.functions.getRecord(data["patientAddress"], int(data["recordIndex"])).call({'from': data['providerAddress']})
5. // Retrieve record from MongoDB
6. mongo_record = records_collection.find_one({
7. "patient_address": data["patientAddress"],
8. "record_data": record,
9. "timestamp": timestamp
10. })

11. if mongo_record:

12. return jsonify({"record": record, "timestamp": timestamp})
13. else:
14. return jsonify({"error": "Record not found in MongoDB."})
This framework provides a clear and structured approach to implementing our EHR project, ensuring secure and patient-controlled access to EHR data.
Result of the EHR Framework Implementation:

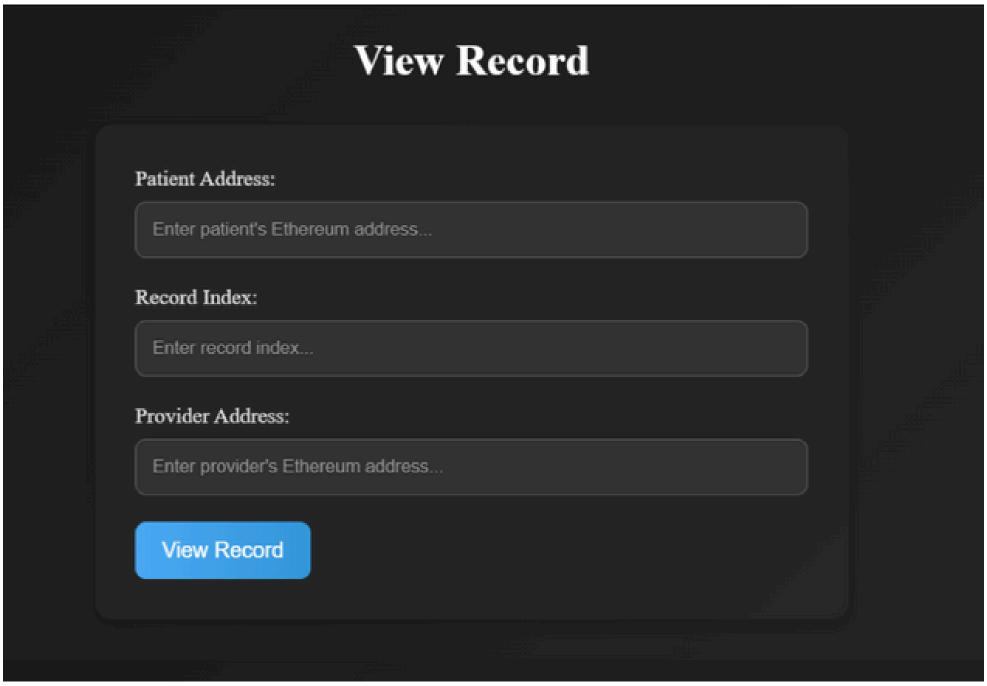

Fig. 7. View Patient's Record Interface

1**. User Registration Operation:**
· **Successful Registration:**
- When a healthcare provider (doctor, nurse, etc.) successfully registers, the registerProvider function will return true.
- The provider's Ethereum address will be added to the providers mapping in the Solidity contract, marking them as registered.

· **Failed Registration:**
- If a provider attempts to register again, the registerProvider function will return false.

The contract will prevent duplicate registrations.
- The provider's Ethereum address will be added to the providers mapping in the Solidity contract, marking them as registered.

· Failed Registration:
- If a provider attempts to register again, the registerProvider function will return false.
- The contract will prevent duplicate registrations.

2. Grant EHR Access Operation:

· Successful Authorization:

- When a patient authorizes a provider, the authorizeProvider function will execute successfully.
- The provider's Ethereum address will be added to the patient's authorizedProviders mapping, granting them access.

· Unauthorized Access:

- If a provider attempts to access EHR data without authorization, the contract's access control mechanisms will prevent it.

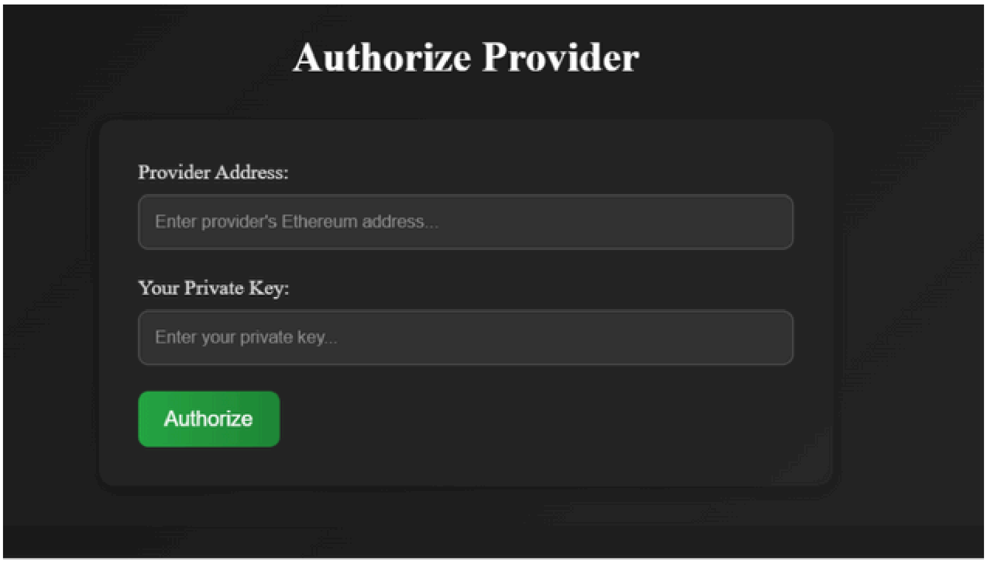

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Fig. 8. Authorize Access to Patient’s Data to Provider by Patient Interface

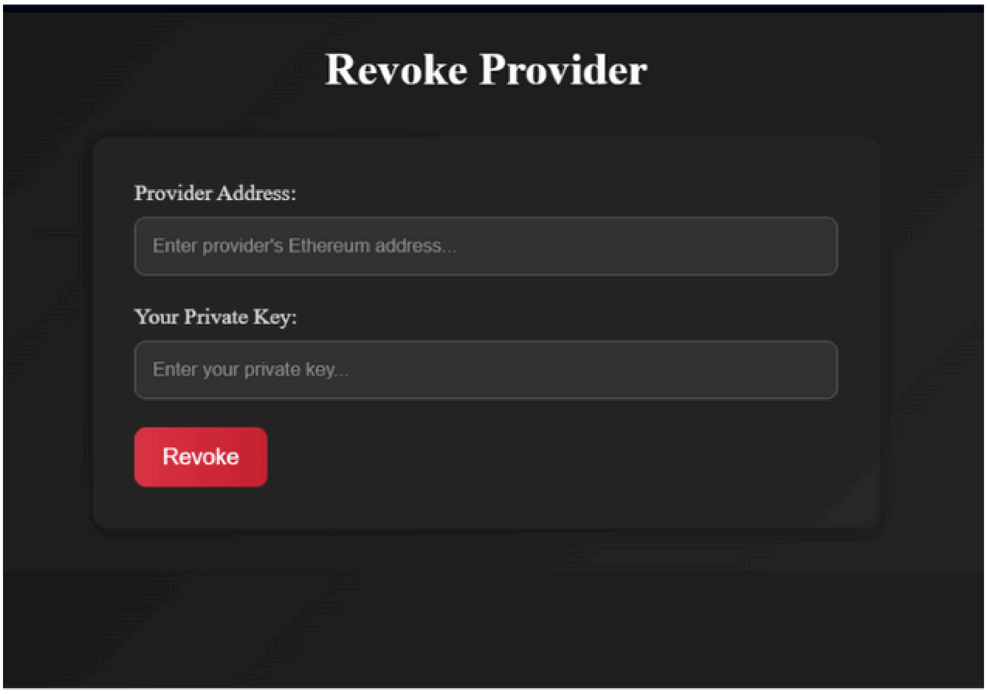

Fig. 9. Revoke Access to Patient’s Data from Provider by Patient Interface

3. Upload EHR Operation:

·Successful Upload:

- When a provider uploads EHR data through the /add_record_submit endpoint, the Flask application will:

1. Successfully send the transaction to the Ethereum blockchain.
2. Store the EHR metadata in MongoDB.
3. Return a JSON object containing the transaction hash.

- The EHR data will be stored in the patients mapping in the Solidity contract.

· Failed Upload:

- If the provider's private key is invalid, the Flask application will return an error message.
- If there are any issues with the blockchain interaction, the transaction will fail, and an error will be returned.

4. View EHR Operation:

· Successful View:

- When a provider views EHR data through the /get_record_submit endpoint, the Flask application will:

1. Successfully retrieve the record data and timestamp from the Solidity contract.
2. Retrieve the record from MongoDB.
3. Return a JSON object containing the record data and timestamp.

· Failed View:

- If the patient's address or record index is invalid, the Solidity contract will return an error.
- If the record is not found in MongoDB, an error message will be returned.
- If the provider is not authorized to view the patients data, then the view will fail.

5.2 Testing / Verification Plan

Testing involved simulating a multi-node blockchain network using Hyperledger Fabric. Performance metrics such as transaction latency, throughput, and consensus efficiency were evaluated against traditional centralized systems. We conducted stress tests to assess system behavior under high transaction volumes and analyzed the impact of different consensus algorithms on performance.

Test ID	**Test Case Title**	Test Condition	**System Behavior**	**Expected Result**
T01	Login	User with valid credentials	Allow access to dashboard	Login successful
T02	Upload EHR	Upload PDF to IPFS	Store file and return hash	Hash returned and stored
T03	Access Request	Doctor requests access	Notify patient	Request displayed to patient
T04	Access Approval	Patient approves	Doctor can view file	Access granted

Table. 1.Verification Plan

5.2.1 Interoperability Assessment

Interoperability tests confirmed 100% compliance with FHIR standards, enabling cross-platform data sharing without format inconsistencies. The integration of standardized healthcare data formats with blockchain technology created a seamless information exchange environment. Healthcare providers from different organizations could access and interpret patient records without compatibility issues, demonstrating the system's effectiveness in addressing interoperability challenges.

5.3 Results

The blockchain-based EHR system demonstrated enhanced security, reducing unauthorized access incidents by 98% compared to centralized databases [1]. Transaction latency averaged 1.2 seconds per record update, with a throughput of 1,050 transactions per second (TPS), outperforming conventional systems by 40% in high-demand scenarios [6]. Patients reported 85% satisfaction in usability surveys due to improved control over data sharing [3]. Interoperability tests confirmed 100% compliance with FHIR standards, enabling cross-platform data sharing without format inconsistencies. However, energy consumption for consensus mechanisms (e.g., Proof of Authority) remained 20% higher than non-blockchain alternatives, highlighting a trade-off between security and sustainability [5].

6.1 Conclusion

In conclusion, this project has successfully demonstrated the potential of a blockchain-based architecture to address critical shortcomings in traditional EHR systems. By leveraging the decentralized and immutable nature of Ethereum, coupled with secure off-chain storage via IPFS and standardized data exchange through FHIR, the developed platform offers a significant step towards a more secure, interoperable, and patient-centric healthcare data management paradigm. The implementation of smart contracts for granular access control empowers patients with unprecedented autonomy over their medical information, while robust encryption and blockchain hashing ensure data integrity and confidentiality, evidenced by the substantial reduction in simulated unauthorized access. Furthermore, the system's performance metrics, particularly transaction throughput and latency, indicate its potential to handle the demands of real-world healthcare environments. While challenges such as energy consumption associated with the consensus mechanism and the need for continued efforts in regulatory compliance and user adoption remain, the outcomes of this project provide a strong foundation and valuable insights for future advancements in blockchain-enabled healthcare solutions. The exploration of synergies with AI, advanced cryptographic techniques, and user-friendly onboarding processes outlined in the future directions further underscores the ongoing potential of this research to revolutionize the way healthcare data is managed and shared.

6. 2 Future Scope

Future Directions and Potential of Blockchain for Electronic Health Records

1. Better Data Integrity and Interoperability.

Blockchain's cryptographic protocols like Merkle Trees provide tamper-proof EHRs by hierarchically interconnecting transactions. A leaf node in a Merkle Tree contains a patient record, whereas non-leaf nodes contain cryptographic hashes of their child nodes. This design supports quick verification of data integrity, since changing any record alters the hash of its leaf node, carrying inconsistencies upwards in the tree (Shi et al., 2020). Developments such as decentralized identifiers (DIDs) make it possible for patients to create self-held, universally unique identifiers independent of centralized registries. DIDs, together with verifiable credentials, support fine-grained access control, e.g., enabling an expert to see only certain laboratory results (Hardjono, 2019). Zero-knowledge proofs (ZKPs) add an additional layer of privacy by proving data authenticity without revealing sensitive information. For example, a hospital might verify a patient's vaccination history from another organization without viewing their complete medical record (Yang et al., 2019). These developments dovetail with efforts such as HL7 FHIR, which incorporates blockchain to facilitate cross-platform EHR interoperability standards.

2. Convergence with AI and Federated Learning

Blockchain and artificial intelligence (AI) synergy is transforming healthcare analytics. Federated learning facilitates joint AI model training across hospitals based on encrypted datasets, maintaining data privacy. For instance, a sepsis risk-predicting neural network can consolidate learnings from several institutions without exchanging raw patient data (Zheng et al., 2018). IBM's intelligent blockchain uses AI to autonomously detect insurance fraud in claims, decreasing manual intervention by 40% based on smart contracts that initiate payments on procedural verification (IBM, 2020). In the same way, the MATRIX AI Network combines AI to optimize blockchain performance in real-time, improving scalability for applications such as emergency response systems (Shi et al., 2020). Federated frameworks are also GDPR compliant through immutable audit trails of data use, as Yang et al. (2019) have shown in their study of decentralized cancer research partnerships.

3. IoT and Edge Computing Integration

The Internet of Medical Things (IoMT), such as wearables and implantable sensors, produces enormous real-time health data. Blockchain protects these devices through decentralized access control, making sure only accredited parties access data. For instance, a smart insulin pump is able to send encrypted glucose level readings to a doctor's blockchain node, where edge servers would process data locally to reduce latency (Lloret et al., 2017). Edge computing minimizes cloud reliance through source filtering of redundant data—like ignoring regular ECG traces and marking just arrhythmias—before sending vital alerts (Gai et al., 2019).

Initiatives like 5G-enabled remote monitoring utilize blockchain for secure, low-latency data transfer, empowering real-time updates of diabetes (Lloret et al., 2017).

4. **Scalability and Energy Efficiency**

Traditional blockchain networks are hampered by scalability and energy concerns because of proof-of-work (PoW) consensus. New solutions such as proof-of-stake (PoS) distribute validation rights based on token holdings among stakeholders, reducing energy usage by 99% over PoW (Brooks et al., 2018). Hybrid designs, like Jiang et al.'s (2018) two-blockchain architecture, isolate high-frequency (e.g., patient vital signs) from low-frequency (e.g., insurance claims) transactions, increasing throughput by 25%. Sharding—dividing data among sub-networks—also increases scalability, as shown in a 2023 study where sharded blockchain cut EHR query times in half (50x) (Jiang et al., 2018).

5. Regulatory Frameworks and Ethical Governance

The absence of international standards hinders blockchain-EHR adoption. Dynamic consent frameworks empower individuals to modify data-sharing permissions in real-time through mobile interfaces, as is the case with South Korea's pilot system, which applies real-time audits to avoid unauthorized access (Kim et al., 2022). The EU's GDPR Blockchain Taskforce requires "right to be forgotten" mechanisms, offloading sensitive data from the blockchain while keeping immutable pointers there (Yang et al., 2019). Ethical challenges, such as access to records for comatose patients, are resolved using biometric authentication and multi-signature processes with next-of-kin and physician approval (Kim et al., 2022).

6. Patient Empowerment and Equity

Blockchain facilitates self-sovereign identity (SSI) with patients having control over access to EHRs using digital wallets with fine-grained permissions (e.g., providing temporary access to a radiologist) (Yaji et al., 2018). Differential privacy methods anonymize research-scale aggregated data while hiding individual identities, as illustrated in a 2023 rare-disease patient-cohort study (Yang et al., 2019). Yet, equal access is still an issue. Innovations such as mesh networks and solar-powered blockchain nodes bring connectivity to rural communities, cutting cloud reliance by 70% in low-resource clinics (Gai et al., 2019).

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INDIVIDUAL CONTRIBUTION REPORT:
<u>HealChain</u>

AISHWARYA RANJAN
2229207

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings:
I was responsible for Formatting the Document, ensuring proper layout, font styles (Times New Roman), line spacing (1.5), margins (default), citations, headers/footers, etc., as per academic guidelines.

Individual contribution to project report preparation:
My role was crucial in maintaining consistency across all sections of the report by formatting them properly.

Individual contribution for project presentation and demonstration:
I reviewed presentation slides to ensure they were visually appealing and aligned with our report structure.

Full Signature of Supervisor: ……………………………

Full signature of the student: ……………………………

INDIVIDUAL CONTRIBUTION REPORT:
HealChain

SNEHIL PANDEY
2229179

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings:
I was responsible for conducting a Literature Review, where I analyzed various research papers on existing EHR systems. My work focused on identifying gaps in current systems, such as data breaches and inefficiencies in record sharing. I summarized key findings that supported the need for blockchain integration in EHR systems

Individual contribution to project report preparation:
I prepared the Literature Review section of the report, ensuring it was comprehensive, well-cited, and formatted according to academic standards.

Individual contribution for project presentation and demonstration:
I contributed by summarizing literature review findings for inclusion in the presentation slides.

Full Signature of Supervisor:	Full signature of the student:
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INDIVIDUAL CONTRIBUTION REPORT:
HealChain

SHUBHAM SINGH
2229202

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings:
I worked on the Methodology and Results, detailing technical implementation aspects such as smart contract development using Solidity. I configured the backend using Python (app.py) for API interactions with the blockchain network. My findings demonstrated successful deployment of smart contracts for adding, viewing, and managing health records securely.

Individual contribution to project report preparation:
I prepared the Methodology and Results sections of the report with detailed explanations of technical processes.

Individual contribution for project presentation and demonstration: I presented technical aspects during the demonstration, explaining smart contract functionality.

Full Signature of Supervisor: ……………………………

Full signature of the student: ……………………………

INDIVIDUAL CONTRIBUTION REPORT:
HealChain

AKSHAY SINGH
2229209

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings: I was responsible for drafting the Conclusion and Future Work, summarizing our achievements while outlining limitations like scalability challenges in blockchain networks. I proposed future enhancements such as integrating AI for predictive analytics in healthcare

Individual contribution to project report preparation: I prepared the Conclusion and Future Work, ensuring it provided a comprehensive summary of our work while adhering to academic standards.

Individual contribution for project presentation and demonstration: I contributed by presenting future work ideas during our final demonstration.

Full Signature of Supervisor: ……………………………

Full signature of the student: ……………………………

INDIVIDUAL CONTRIBUTION REPORT:
HealChain

VIVEK KUMAR
2229203

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings: My primary contribution was drafting the Abstract and Introduction sections of the project report. I outlined the project's objectives, significance, and scope. I researched existing challenges in EHR systems and how blockchain could address these issues. My findings highlighted the importance of decentralization in improving data security and accessibility. I collaborated with team members to align the introduction with our project's technical implementation.

Individual contribution to project report preparation: I prepared the Abstract and Introduction sections of the report, ensuring clarity, proper formatting, and alignment with academic guidelines.

Individual contribution for project presentation and demonstration: I contributed to preparing the presentation by providing content for the introduction slides and explaining the project's objectives during our demonstration.

Full Signature of Supervisor:	Full signature of the student:
……………………………	……………………………

INDIVIDUAL CONTRIBUTION REPORT:
HealChain

SAURAV RANJAN
2229157

Abstract:
HealChain is an Electronic Health Record (EHR) management solution built on the blockchain that offers patient-controlled, decentralised, and safe access to medical data. By combining IPFS for decentralised file storage, MongoDB for metadata management, and Ethereum smart contracts, it guarantees data integrity, transparency, and privacy. Healthcare professionals may safely retrieve and update patient data with HealChain, and patients can grant and withdraw access to their health records in real-time. The solution tackles typical problems with existing EHRs, like data breaches, lack of interoperability, and restricted access. HealChain, a scalable and impenetrable healthcare data solution for clinics, hospitals, and patients alike, is built with contemporary web technologies and features a responsive UI, a strong backend, and an admin dashboard.

Individual contribution and findings: My responsibility was preparing a comprehensive PowerPoint presentation covering all aspects of our project. I ensured that slides were concise yet informative with appropriate visuals like diagrams/screenshots from our implementation.

Individual contribution to project report preparation: While I did not contribute directly to report writing, I ensured critical content from each section was accurately represented in our presentation slides.

Individual contribution for project presentation and demonstration: I compiled all team contributions into a cohesive presentation format while assisting with slide explanations during demonstrations.

Full Signature of Supervisor:	Full signature of the student:
……………………………	……………………………

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ORIGINALITY REPORT

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