HEALTHCARE INSURANCE FRAUD DETECTION USING BLOCKCHAIN AND AI

A PROJECT REPORT

Submitted by

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(An Autonomous Institution, Affiliated to Anna University, Chennai)

BONAFIDE CERTIFICATE

Certified that this project report "**Healthcare Insurance Fraud Detection Using Blockchain and AI**" is the bonafide work of AFRA FATHIMA M A [211421104011], HARSHA K [211421104094] and KAVYAA A K [211421104123]" who carried out the project work under my supervision.

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We **AFRA FATHIMA M A (211421104011), HARSHA K (211421104094)** and **KAVYAA A K (211421104123)** hereby declare that this project report titled **"Healthcare Insurance Fraud Detection Using Blockchain and AI"**, under the guidance of Dr. VINMATHI M S is the original work done by us and we have not plagiarized or submitted to any other degree in any university by us.

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that the following final year B.E (Computer Science and Engineering) students of Panimalar Engineering College, Chennai has successfully completed their project work titled "**Blockchain and AI Empowered Healthcare Insurance Fraud Detection**" during December 2024 to March 2025 in our organization.

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We wish them all success for their future endeavors.

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ABSTRACT

Health insurance has become an essential part of people's lives as health issues continue to rise. Healthcare emergencies can be troublesome for people who can't afford huge expenses. Health insurance helps people cover healthcare services expenses in case of a medical emergency and provides financial backup against indebtedness risk. Health insurance and its several benefits can face many security, privacy, and fraud issues. For the past few years, fraud has been a sensitive issue in the health insurance domain as it incurs high losses for individuals, private firms, and governments. So, it is essential for national authorities and private firms to develop systems to detect fraudulent cases and payments. A high volume of health insurance data in electronic form is generated, which is highly sensitive and attracts malicious users. Motivated by these facts, we present a systematic survey for Artificial Intelligence (AI) and blockchain-enabled secure health insurance fraud detection in this paper. This paper presents a taxonomy of various security issues in health insurance. We proposed a blockchain and AI-based secure and intelligent system to detect health insurance fraud. Then, a case study related to health insurance fraud is presented. Finally, the open issues and research challenges in implementing the blockchain and an AI-empowered health insurance fraud detection system is presented.

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LIST OF ABBREVIATIONS

AI	-	Artificial Intelligence
HI	-	Health Insurance
HIC	-	Health Insurance Claim
IPFS	-	Inter Planetary File System
RF	-	Random Forest
KNN	-	K-Nearest Neighbor
SVM	-	Support Vector Machine
ANN	-	Artificial Neural Network
CNN	-	Convolutional Neural Network

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INTRODUCTION

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INTRODUCTION

1.1 AIM

The main aim of this project is to detect healthcare insurance fraud and eliminate it using a combination of blockchain technology and machine learning. By leveraging blockchain's transparency and security features, along with machine learning's ability to identify fraudulent patterns, this system ensures a more efficient, accurate, and tamper-proof fraud detection process.

1.2 SYNOPSIS

Health insurance helps individuals cover healthcare expenses during medical emergencies and provides financial protection against the risk of indebtedness. While health insurance offers several benefits, it is also vulnerable to security, privacy, and fraud-related challenges. Various security concerns in health insurance include data breaches, fraudulent claims, and identity theft.

Insurance plays a crucial role in financial protection, risk-sharing, assessing the value of risk, capital generation, economic growth, and promoting saving habits.

This paper presents a taxonomy of health insurance fraud and proposes a blockchain and AI-based secure and intelligent system to detect and prevent fraudulent activities. By leveraging blockchain's transparency and AI's predictive capabilities, the system aims to enhance security, improve fraud detection efficiency, and ensure a more reliable insurance framework.

1.3 PROBLEM DEFINITION

Health insurance fraud is a growing concern worldwide, involving multiple parties such as healthcare providers, policyholders, and insurance firms, leading to financial losses and compromised trust in the system. Fraudulent activities, including duplicate doctor prescriptions, fake hospital bills, exaggerated claims, and unauthorized access to health records, are facilitated by the ease of data manipulation and lack of transparency. Existing fraud detection methods often fail due to their reliance on outdated, centralized systems that are vulnerable to tampering. Therefore, there is a need for a secure, intelligent, and tamper-proof fraud detection system that leverages blockchain technology for transparency and machine learning for real-time fraud identification, ensuring a more reliable and efficient health insurance ecosystem.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2
LITERATURE REVIEW

Blockchain and artificial intelligence combined for healthcare insurance fraud detection has been widely studied to enhance security, data integrity, and fraud prevention. Various methodologies have been explored, leveraging machine learning, blockchain based smart contracts, and big data analytics. A blockchain-powered fraud detection system employing Random Forest, SVM, and Decision Tree demonstrated improved fraud identification accuracy and resistance to data manipulation [1].

A hybrid approach combining supervised and unsupervised learning showcased superior fraud detection overrule-based methods, though dataset preprocessing remained a challenge due to class imbalance [2]. Blockchain's application in securing insurance transactions through smart contract-based fraud prevention frameworks has ensured transparency, traceability, and security, although legacy system integration remains a significant challenge [3].

Benchmarking of Naïve Bayes, XGBoost, and Deep Learning models revealed that ensemble methods achieve superior fraud detection accuracy, albeit with increased computational overhead [4]. Unsupervised learning techniques, including Autoencoders and Isolation Forests, have been effective for anomaly detection, but high false positive rates pose an ongoing challenge [5].

The adoption of Hyperledger Fabric and Ethereum based smart contracts has enhanced fraud detection auditability but concerns regarding scalability and transaction costs persist [6]. AI-driven frameworks leveraging feature engineering and predictive analytics on historical claims data have improved fraud detection rates but require extensive labeled datasets for optimal model performance [7].

Deep learning models such as CNN and LSTM have achieved high fraud detection accuracy, yet their real-world applicability is constrained by

computational complexity and data requirements [8]. Hybrid AI-blockchain approaches integrating smart contracts and anomaly detection models have enhanced fraud detection efficiency, though blockchain transaction latency remains a limitation [9].

To address class imbalance, resampling techniques such as SMOTE and ADASYN have been employed, improving classification accuracy but sometimes introducing synthetic noise [10]. Blockchain-based frameworks integrating smart contracts for fraud prevention have improved data transparency and security, although computational costs and scalability issues persist [11].

AI-based fraud detection employing K-means clustering has enhanced anomaly detection in medical claims, outperforming rule-based approaches while facing challenges with high false-positive rates due to dataset variability [12]. Implementations utilizing BigchainDB have improved insurance transaction security and claims processing efficiency, though interoperability limitations hinder broader adoption [13].

Studies benchmarking ensemble and deep learning models for fraud detection in medical claims indicate that ensemble methods improve accuracy but require substantial computational resources, highlighting a trade-off between precision and efficiency [14]. Porter's value chain and Berliner's insurability criteria have been used to assess how digitization affects insurance fraud, revealing increased operational efficiency but heightened cybersecurity risks, necessitating regulatory adaptations [15].

AI based fraud detection techniques leveraging supervised learning methodologies have shown promise in recognizing fraudulent claims but require further advancements in false-positive reduction [16]. Privacy and security concerns in healthcare big data applications have been addressed using real-time

monitoring and encryption techniques, with ongoing concerns about vulnerabilities in patient data protection [17].

A big data analytics framework for fraud detection utilizing Hadoop has been developed, improving Electronic Health Record (EHR) management, although scalability remains a concern [18]. Digitalization's effect on insurance risk assessment has been studied using Porter's value chain, highlighting efficiency gains while emphasizing regulatory challenges and data security risks [19].

A big data-driven e-health insurance model using Infinispan and MapReduce has improved data segregation and extraction, though challenges in data consistency and privacy persist [20]. Protection of Electronic Health Records (EHRs) during storage and transmission has been studied, proposing secure encrypted storage with controlled access, enhancing HIPAA compliance but requiring better interoperability mechanisms [21].

Blockchain technology's benefits and threats in healthcare fraud detection have been categorized, highlighting enhanced security and data tracking, though energy consumption and interoperability remain adoption barriers [22]. The ML models like SVM and clustering have been used in healthcare to detect fraud using big data analytics, outperforming traditional rule-based methods but requiring better data integration strategies for handling heterogeneous datasets[23].

Medicare fraud detection studies emphasize the need for standardized preprocessing techniques to enhance machine learning effectiveness, addressing gaps in data fusion methodologies [24]. AI-driven security frameworks integrating blockchain have been proposed for healthcare data protection, with models such as SVM, KNN, and VFDT proving effective in anomaly detection, though high computational costs remain a constraint [25].

This literature review highlights the growing importance of blockchain- based and AI-powered healthcare to detect fraud, showcasing advancements in machine learning models, big data analytics, and blockchain-based security mechanisms. While significant progress has been made, challenges such as scalability, interoperability, computational costs, and false positive rates need to be addressed to enhance the efficiency and reliability of these fraud detection frameworks.

CHAPTER 3
THEORETICAL BACKGROUND

CHAPTER 3

THEORETICAL BACKGROUND

3.1 IMPLEMENTATION ENVIRONMENT

Health insurance (HI) is a contract between the insurance provider and insurance subscriber in which the provider compensates the insurance subscriber's healthcare expenses. The Health Insurance Association of America stated that healthcare insurance covers losses resulting from accidents, healthcare expenses, incapacity, accidental injury, and damage. Insurance subscribers have to pay the premium regularly for this compensation. The insurance provider can be from the commercial world or a government body.

Nowadays, HI has become a necessity for each individual due to the rising hospitalization and treatment costs and getting income tax rebates. Earlier, the health insurance claim (HIC) process was manual and offline, with many shortcomings, such as insurance subscribers needing to visit the insurance office during office hours only to fill out the premium and inquire about the HIC status, which wastes time and money in terms of transportation costs.

This procedure is wholly based on pen and paper, so human resource necessity and the possibility of error are more for auditing HIC. Maintaining and integrating the paper-based health claim data is very tedious and challenging work. Health claim records are easily alterable and accessible. So, the chances of fraud occur from the insurance provider, insurance subscriber, and healthcare service provider due to lesser transparency and privacy. It is less cost-effective due to the involvement of the intermediary broker or agent costs. In the digital era, every piece of information is gathered in a digital form, which revolutionizes the HIC worldwide.

The following are various benefits of digitization: (i) it provides convenience to the parties involved with HIC (ii) communication between subscribers and providers becomes efficient, (iii) it makes auditor's complex and tedious work easy, (iv) any kind of fraudulent behavior can be easily identified using Artificial Intelligence (AI), (v) it also reduces the human resource cost, and (vi) verification of claims becomes fast using web-generated reports, so insurance subscribers get insurance coverage fast and automatically during any medical emergency.

3.1.1 HARDWARE AND SOFTWARE SPECIFICATION

HARDWARE REQUIREMENTS

1. Hard Disk : 80GB and Above
2. RAM : 4GB and Above
3. Processor : P IV and Above

SOFTWARE REQUIREMENTS

1. Windows 10 and Above (64-bit)

Use: The operating system provides a stable and compatible environment for running the required software.

Role in Project: Ensures smooth execution of blockchain-based applications, machine learning models, and database management.

2. JDK 11 (Java Development Kit 11)

Use: Required for running Java-based applications and frameworks like Spring Boot.

Role in Project: Essential for developing the backend logic, integrating APIs, and managing blockchain smart contracts.

3. Python 3.9

Use: A programming language widely used for artificial intelligence and machine learning applications.

Role in Project: Implements fraud detection algorithms using machine learning models to analyze insurance claims.

4. MySQL

Use: A relational database management system (RDBMS) for structured data storage and retrieval.

Role in Project: Stores patient records, insurance claims, fraud detection results, and user authentication data.

5. Node.js

Use: A JavaScript runtime that enables running server-side applications.

Role in Project: Manages API interactions, handles blockchain communication, and processes user requests efficiently.

6. Ganache

Use: A local Ethereum blockchain simulator for testing and deploying smart contracts.

Role in Project: Simulates blockchain transactions for insurance claims and fraud detection without using a real blockchain network.

3.1.2 TECHNOLOGIES USED

1. Blockchain

Use: A decentralized ledger system that ensures secure and transparent data storage.

Role in Project: Prevents data manipulation and ensures tamper-proof insurance claim processing.

2. IPFS (Inter Planetary File System)

Use: A distributed file storage system that securely stores and shares patient records and insurance documents.

Role in Project: Ensures secure and efficient storage of medical records and claim documents.

3. Machine Learning

Use: A technique that enables systems to learn and make predictions based on data.

Role in Project: Detects fraudulent insurance claims using classification algorithms such as Random Forest and Gradient Boosting.

4. Spring Boot Framework

Use: A Java-based framework for developing backend applications with microservices.

Role in Project: Manages APIs, authentication, and server-side logic for fraud detection and claim processing.

PROGRAMMING LANGUAGES

1. Java

Use: A programming language used for backend development.
Role in Project: Implements business logic and API handling using the Spring Boot framework.

2. Node.js

Use: A JavaScript runtime environment for server-side development.

Role in Project: Manages smart contract transactions and API interactions with the frontend.

3. Python

Use: A high-level programming language for data processing and artificial intelligence.
Role in Project: Implements fraud detection models and analyzes claim data.

4. Solidity

Use: A programming language for writing smart contracts on the Ethereum blockchain.
Role in Project: Defines the logic for insurance claim verification and fraud prevention on the blockchain.

5. SQL

Use: A query language for database operations.

Role in Project: Manages structured data storage for patient records, claims, and fraud analysis reports.

6. HTML, CSS, JavaScript

Use: Web development languages used for designing the user interface.

Role in Project: Provides a web-based platform for users to interact with the insurance claim system.

Fig. 3.1 SHA-256 Hash Generation Interface for Data Encryption

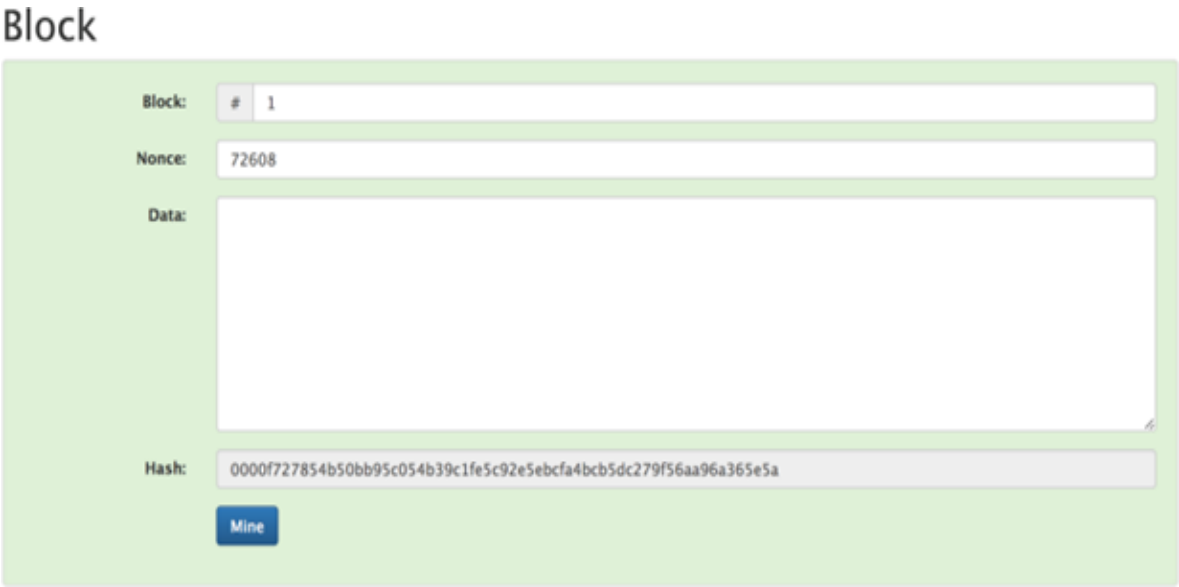


Fig. 3.2 Block Structure with Nonce, Data Input, and Mining Functionality

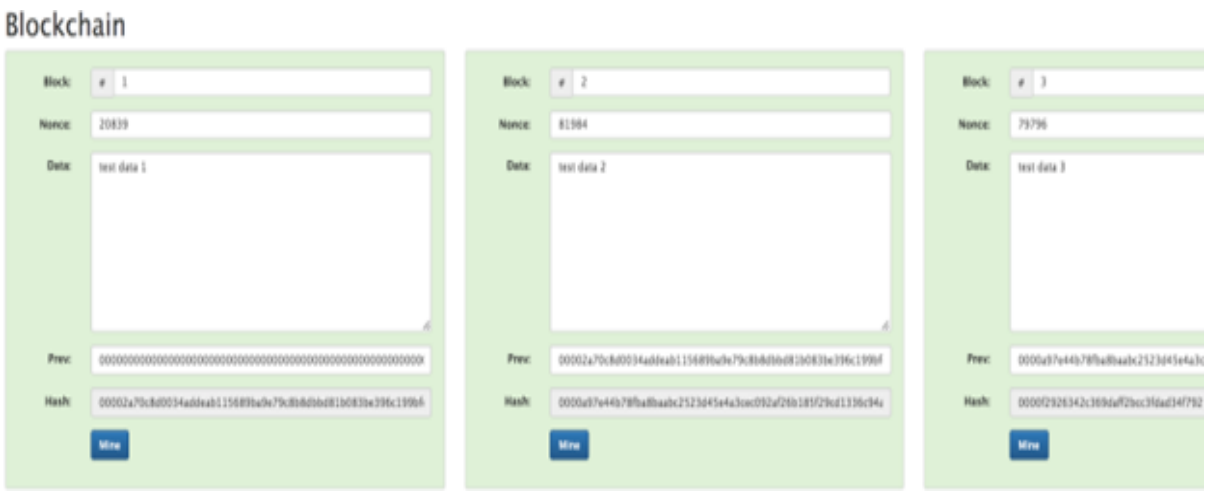


Fig. 3.3 Blockchain Visualization Displaying Multiple Mined Blocks

3.1.3 SYSTEM FEATURES

Table 3.1 System Features of Blockchain and AI-Based Healthcare Insurance Fraud Detection

Feature	Description	Technology Used	Benefit
Immutable Data Storage	Stores insurance claims and patient records securely, preventing tampering	Blockchain (Hyperledger, Ethereum)	Ensures data integrity and trust.
AI-Based Fraud Detection	Detects fraudulent patterns in claims using machine learning.	Decision Trees, SVM, KNN, Random Forest	Identifies and prevents fraudulent claims efficiently.

Decentralized Data Storage	Stores medical records securely to prevent unauthorized modifications.	IPFS (InterPlanetary File System)	Reduces the risk of data breaches and ensures data availability.
Smart Contracts for Claims Processing	Automates claim verification and settlements based on predefined rules.	Solidity, Ethereum Smart Contracts	Eliminates manual processing, reducing delays and fraud.
Real-Time Fraud Alerts	Detects suspicious transactions instantly and alerts insurers.	AI-driven anomaly detection	Helps in proactive fraud prevention.
User Identity Verification	Ensures that policyholders and claimants are legitimate.	Biometric Authentication, KYC Verification	Prevents identity theft and fake claims.
Transparent Audit Trail	Keeps track of all transactions for accountability.	Blockchain-based logging	Enhances trust and regulatory compliance.

3.2 SYSTEM ARCHITECTURE

The system architecture illustrates the end-to-end process of healthcare insurance verification, integrating Artificial Intelligence (AI) and Blockchain (IPFS) to enhance security, transparency, and fraud detection.

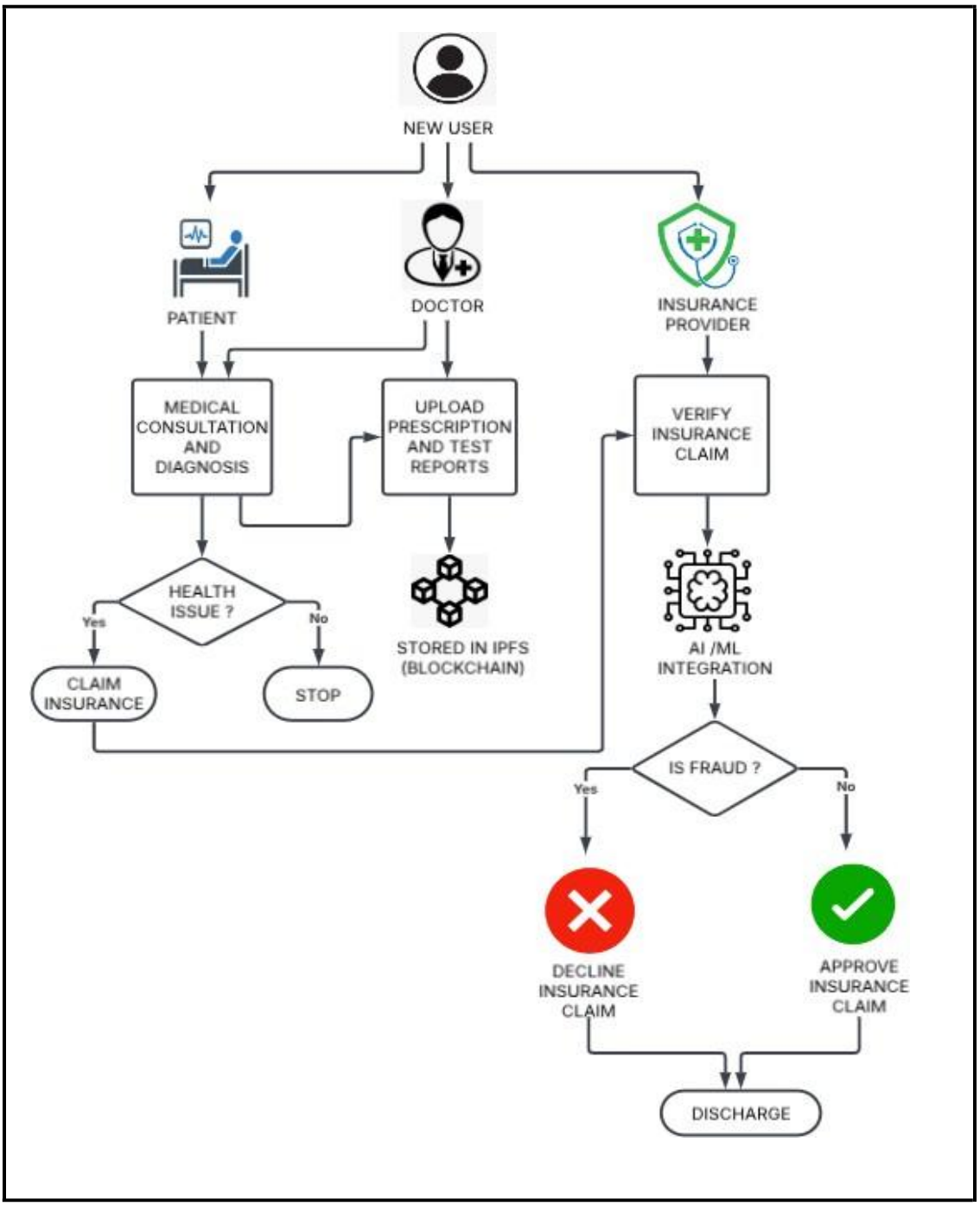


Fig 3.4 Architecture Diagram for Healthcare Insurance Fraud Detection

1. Initiation of the Process

- The system starts when a new user (patient) enters the healthcare system.
- The user could be either a patient seeking medical assistance or an insurance provider handling the verification process.

2. Patient Consultation and Diagnosis

- If the user is a patient, they proceed to a medical consultation where a doctor diagnoses the patient's condition.
- The doctor uploads the patient's medical prescription and test reports into a secure IPFS-based blockchain storage system, ensuring data integrity and preventing unauthorized tampering.

3. Health Condition Evaluation

- If the patient is diagnosed with a health issue that requires financial coverage, they can proceed to claim insurance for medical expenses.
- If there is no significant health issue, the process terminates at this stage.

4. Insurance Claim Submission and Verification

- Once the insurance claim is filed, it is sent to the insurance provider for verification.
- The insurance provider verifies the claim and assesses whether the submitted documents (stored in blockchain) meet the policy criteria.

5. AI-Based Fraud Detection and Decision-Making

- The system integrates Machine Learning (ML) algorithms to analyze transaction patterns and detect potential fraudulent claims.

- The AI model evaluates whether the claim is fraudulent or legitimate based on historical data and predefined risk factors.

6. Fraud Detection Outcome

- If the claim is fraudulent, the system declines the insurance claim, preventing financial losses for the provider.
- If the claim is legitimate, it is approved, and the patient can proceed with medical treatment.

7. Final Stages

- Once the insurance claim is approved, the patient undergoes the necessary treatment and discharge process.
- The system ensures secure record-keeping and transparent transactions, maintaining trust between all stakeholders (patients, doctors, and insurance providers).

3.3 PROPOSED METHODOLOGY

The proposed system enhances healthcare insurance fraud detection using Artificial Intelligence (AI) and blockchain technology. It consists of three primary layers that ensure secure, transparent, and efficient processing of insurance claims.

1. Data Storage and Management Layer

This layer is responsible for securely storing patient records, prescriptions, test reports, and insurance claims. It uses InterPlanetary File System (IPFS) for

decentralized data storage and blockchain to ensure data integrity and prevent unauthorized modifications.

How It Works:

- Patient records are converted into unique digital hashes before storage, ensuring they remain tamper-proof.
- IPFS generates a unique identifier (CID) for each record, making it easy to retrieve data securely.
- Blockchain stores only the hashes of claims, ensuring that original medical data remains confidential while still being verifiable.
- Since blockchain records are immutable, fraudulent alterations to medical records and insurance claims are prevented.

2. Fraud Detection Layer

This layer uses AI and machine learning models to analyze past claims and detect potential fraud. The system applies a Random Forest Classifier, which examines multiple decision trees to predict whether a claim is legitimate or fraudulent.

Key Features of AI-Based Fraud Detection:

- Detects patterns of fraudulent claims based on historical data.
- Provides real-time fraud analysis, speeding up claim verification.
- Reduces false positives and negatives, ensuring genuine claims are approved while fraudulent ones are identified.
- Continuously improves over time as it learns from new data.

3. Claim Verification Layer

This layer automates the insurance claim validation process using smart contracts on a blockchain network. Smart contracts are self-executing agreements that automatically determine whether a claim is valid or fraudulent.

How It Works:

- When a claim is submitted, the AI model assigns a fraud probability score based on past data and claim characteristics.
- The system compares this score with a predefined fraud threshold:
- If the claim is valid, it is approved for processing.
- If the claim is fraudulent, it is rejected.
- Each claim is assigned a unique identifier (CID) in IPFS, ensuring that data remains secure and traceable.

3.3.1 DATA SET DESCRIPTION

The dataset consists of 303 entries and 14 columns, primarily used for heart disease prediction. Below is a description of each column:

- age (int) - Age of the patient.
- sex (int) - Gender of the patient (1 = Male, 0 = Female).
- cp (Chest Pain Type) (float) - Indicates the type of chest pain experienced (0-3 categories).
- trestbps (Resting Blood Pressure) (float) - Blood pressure measured in mm Hg at rest.
- chol (Serum Cholesterol) (float) - Cholesterol level in mg/dl.
- fbs (Fasting Blood Sugar) (float) - Whether fasting blood sugar is > 120 mg/dl (1 = True, 0 = False).

- restecg (Resting ECG Results) (float) - Electrocardiographic results (0-2 categories).
- thalach (Maximum Heart Rate Achieved) (float) - Maximum recorded heart rate.
- exang (Exercise-Induced Angina) (float) - Chest pain triggered by exercise (1 = Yes, 0 = No).
- oldpeak (ST Depression Induced by Exercise) (float) - Deviation from baseline ST segment.
- slope (Slope of Peak Exercise ST Segment) (float) - Categorizes the slope of ST segment (0-2).
- ca (Number of Major Vessels Colored by Fluoroscopy) (float) - Indicates the number of blocked vessels.
- thal (Thalassemia Type) (int) - Categorized as 1 (Normal), 2 (Fixed Defect), 3 (Reversible Defect).
- target (Heart Disease Diagnosis) (int) - 1 indicates the presence of heart disease, 0 indicates absence.

Key Observations:

The dataset contains both categorical and continuous variables.

The target column is the classification label indicating heart disease presence.

3.3.2 INPUT DESIGN (UI)

The user interface (UI) plays a crucial role in ensuring a seamless and efficient interaction between users and the system. The design follows a modern and user-friendly approach to facilitate ease of use for different stakeholders, including hospitals, patients, and insurance providers. The UI components are designed with a responsive layout, ensuring compatibility across various devices.

1. Insurance Portal Interface

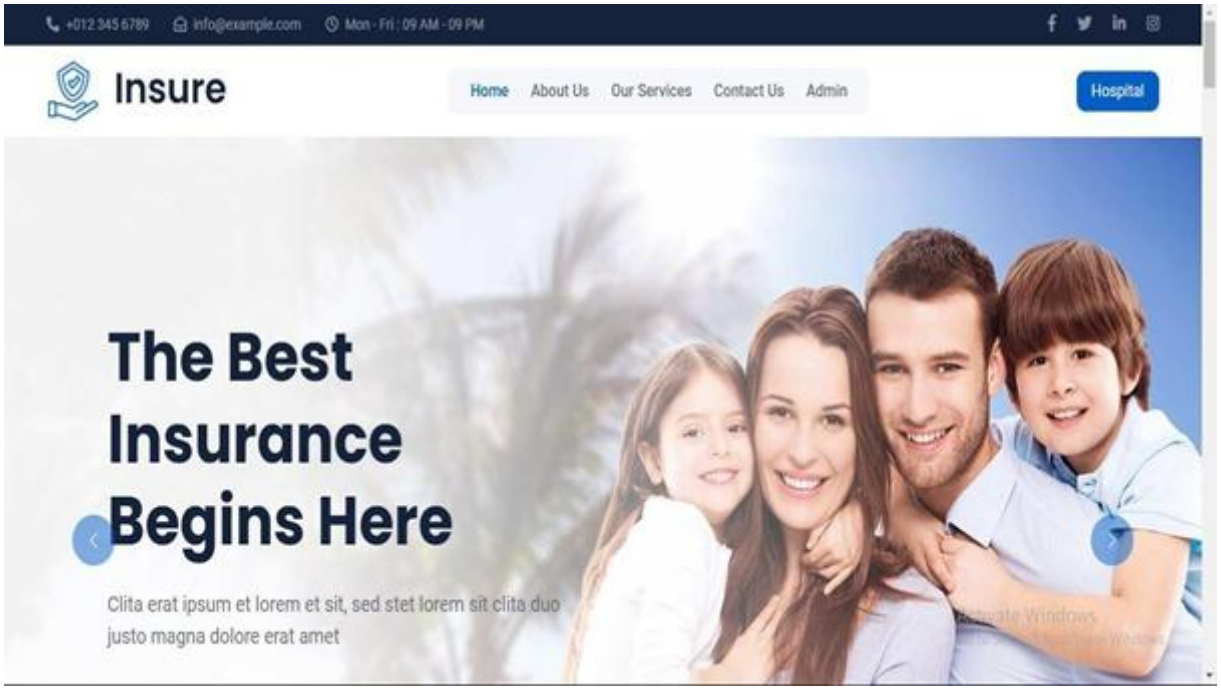


Fig 3.5 Insurance Portal Interface

This interface serves as the primary access point for insurance-related services. Users can navigate through various sections such as Home, About Us, Services, Contact, and Admin. The UI is designed with a clean and professional look to enhance user engagement. Key features include:

- A navigation bar for easy access to different modules.
- A well-structured homepage with an intuitive design.
- A clear call-to-action (CTA) for insurance claims and processing.

2. Hospital Management Interface

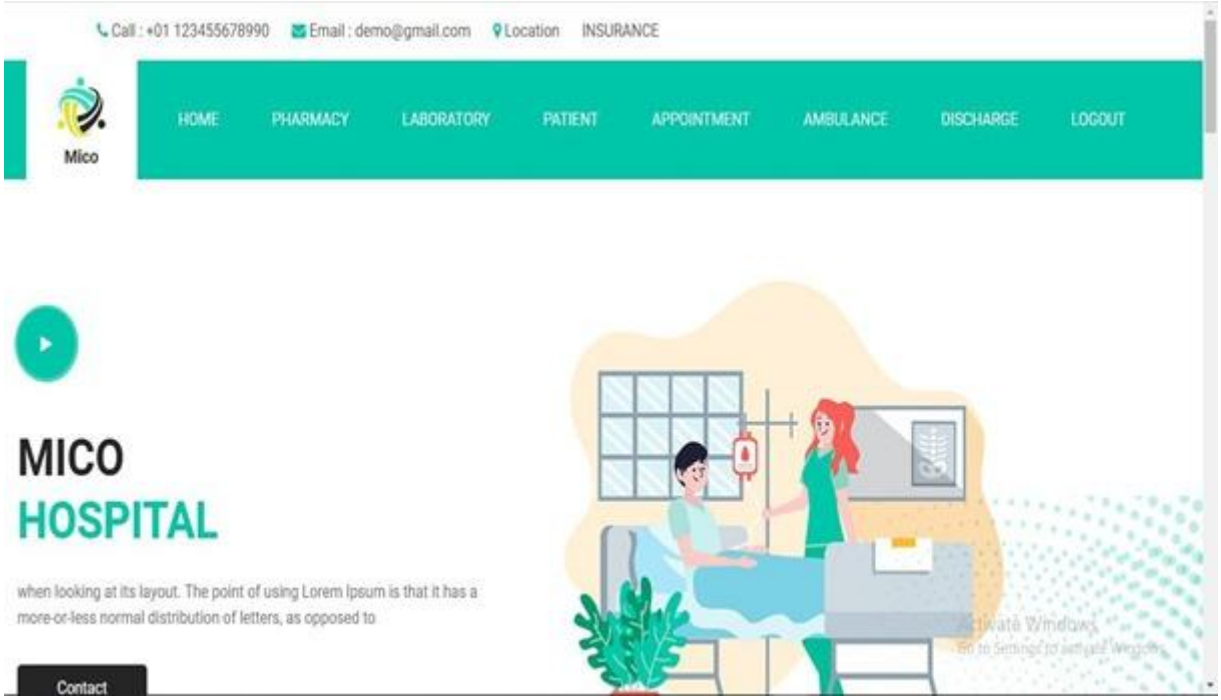


Fig 3.6 Hospital Management Interface

This UI is tailored for hospital-related services, including pharmacy, laboratory, patient appointments, and ambulance management. The design ensures smooth workflow and enhances coordination between hospitals, insurers, and patients. Key features include:

- A structured menu for accessing various healthcare services.
- A dynamic and visually appealing dashboard for hospital administrators.
- Secure login and authentication mechanisms.

These UI designs focus on usability, accessibility, and security, providing a robust foundation for efficient healthcare insurance fraud detection using Blockchain and AI.

3.3.3 MODULE DESIGN

The given diagram outlines the major modules involved in Health Insurance Fraud Detection, which integrates multiple technologies and services. Below is a detailed description of each module:

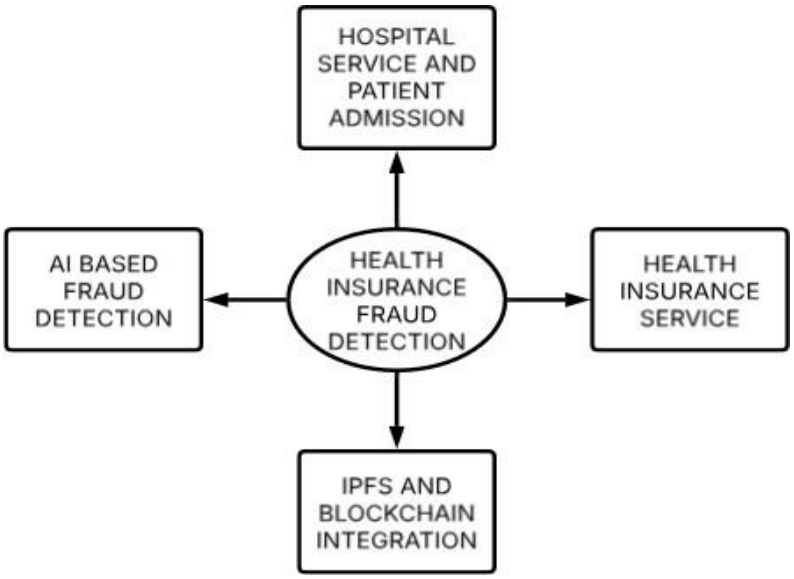


Fig. 3.7 Module Diagram
for Healthcare Insurance Fraud Detection

1. **Hospital Service & Patient Admission**: Collects patient records, validates hospital services, and checks for fraudulent admissions.
2. **Health Insurance Service**: Manages policies, verifies claims, and detects inconsistencies.
3. **AI-Based Fraud Detection**: Uses ML to analyze fraud patterns, flagging suspicious claims.
4. **IPFS & Blockchain Integration**: Secures data, ensures transparency, and prevents fraud with tamper-proof records.

3.3.2.1 USECASE DIAGRAM

A Use case Diagram is used to present a graphical overview of the functionality provided by a system in terms of actors, their goals and any dependencies between those use cases.

Use case diagram consists of two parts:

Use case: A use case describes a sequence of actions that provided something of measurable value to an actor and is drawn as a horizontal ellipse.

Actor: An actor is a person, organization or external system that plays a role in one or more interaction with the system.

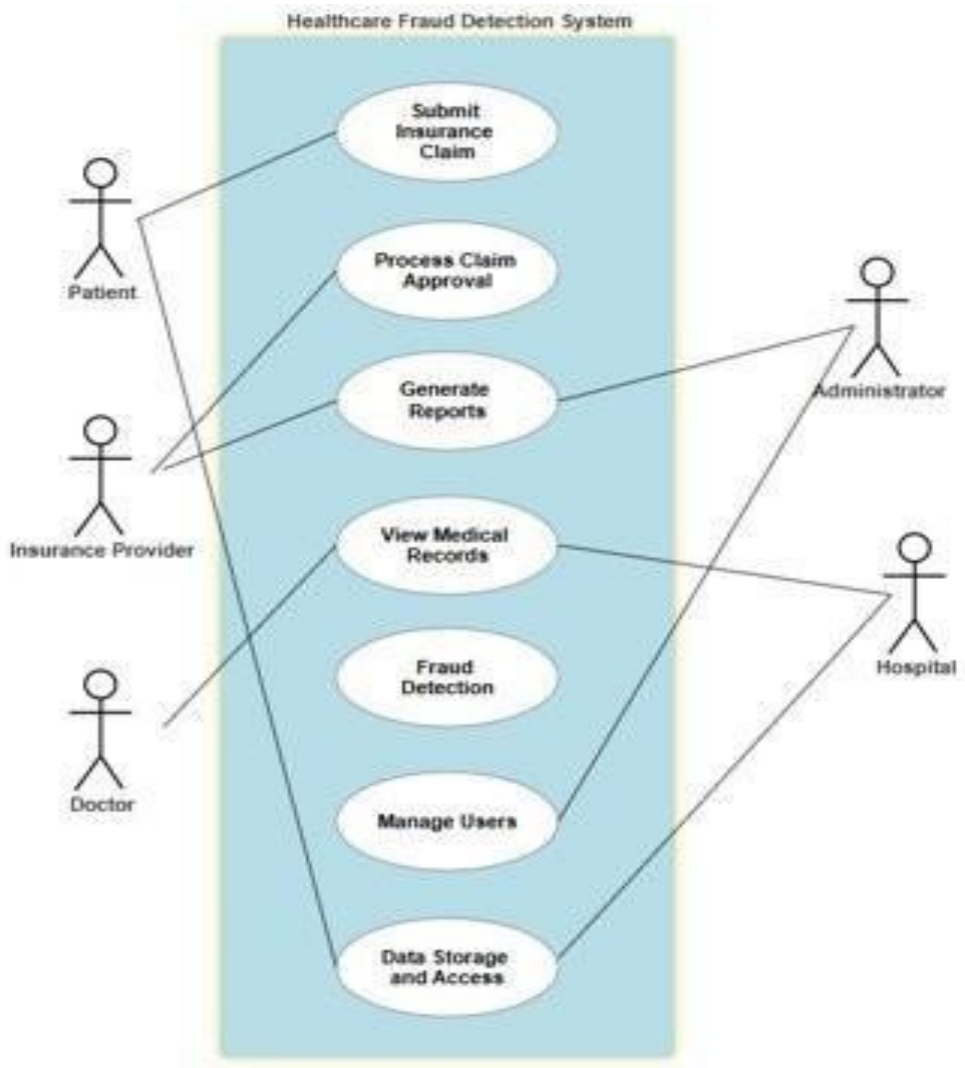


Fig 3.8 Use case Diagram for Healthcare Insurance Fraud Detection

Actors in the System:

1. **Patient** – A user who submits an insurance claim for medical expenses.
2. **Insurance Provider** – Responsible for processing the claim and verifying its legitimacy.
3. **Doctor** – Provides medical records and necessary approvals related to the claim.
4. **Administrator** – Manages users, data access, and system functionalities.
5. **Hospital** – Provides medical records and assists in claim verification.

Use Cases in the System:

1. **Submit Insurance Claim** – Patients submit claims for medical expenses.
2. **Process Claim Approval** – The insurance provider reviews and approves/rejects claims.
3. **Generate Reports** – The system generates reports for fraud detection and audits.
4. **View Medical Records** – Doctors, hospitals, and administrators access patient records.
5. **Fraud Detection** – The system analyzes claims and identifies potential fraudulent activities.
6. **Manage Users** – Administrators handle user access and system permissions.
7. **Data Storage and Access** – The system securely stores and retrieves patient data.

3.3.3.2 SEQUENCE DIAGRAM

A Sequence diagram is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of Message Sequence diagrams are sometimes called event diagrams, event sceneries and timing diagram.

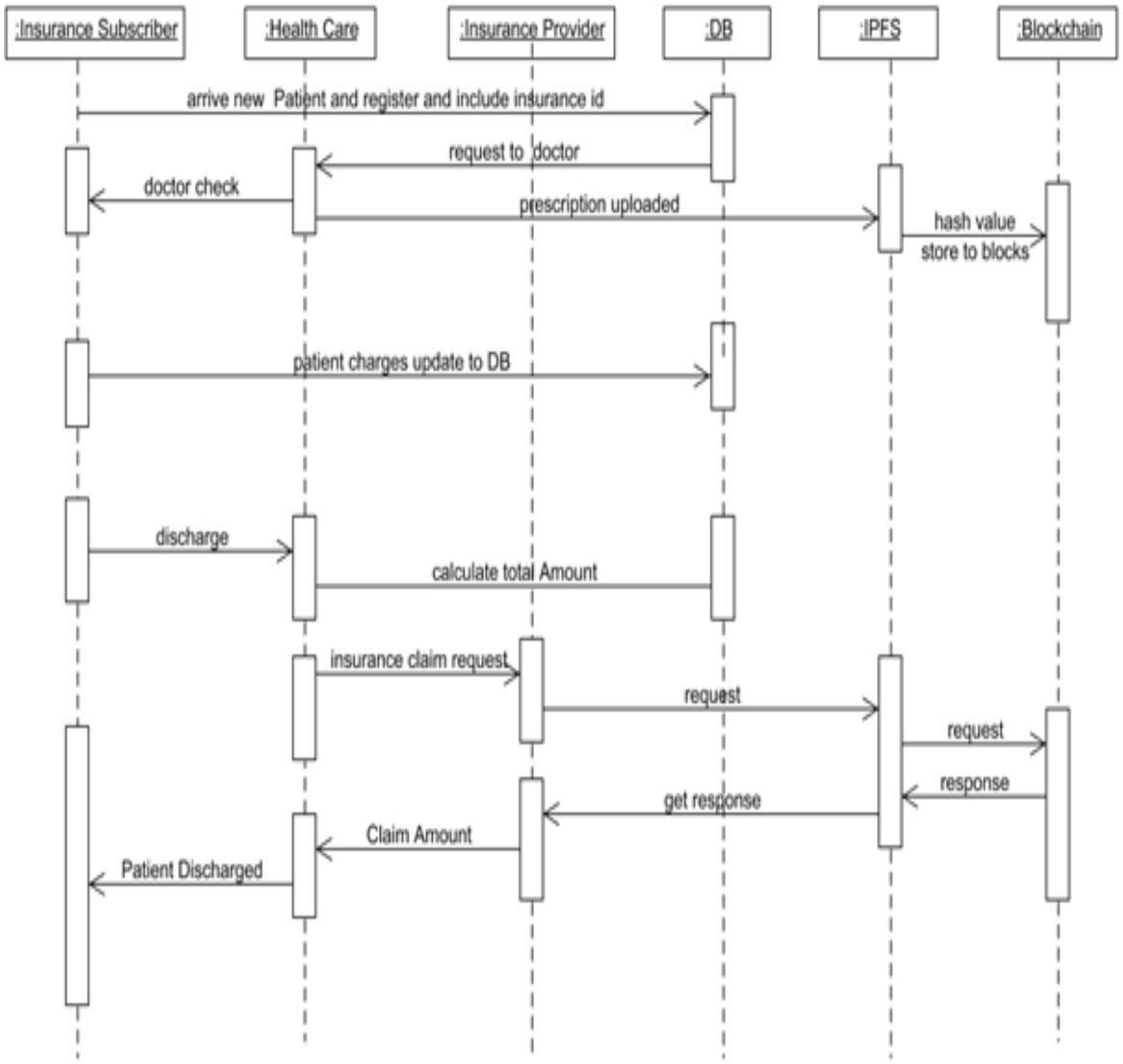


Fig. 3.9 Sequence Diagram for Healthcare Insurance Fraud Detection

3.3.3.3 ACTIVITY DIAGRAM

Activity diagram is a graphical representation of workflows of stepwise activities and actions with support for choice, iteration and concurrency. An activity diagram shows the overall flow of control.

The most important shape types:

- Rounded rectangles represent activities.
- Diamonds represent decisions.
- Bars represent the start or end of concurrent activities.
- A black circle represents the start of the workflow

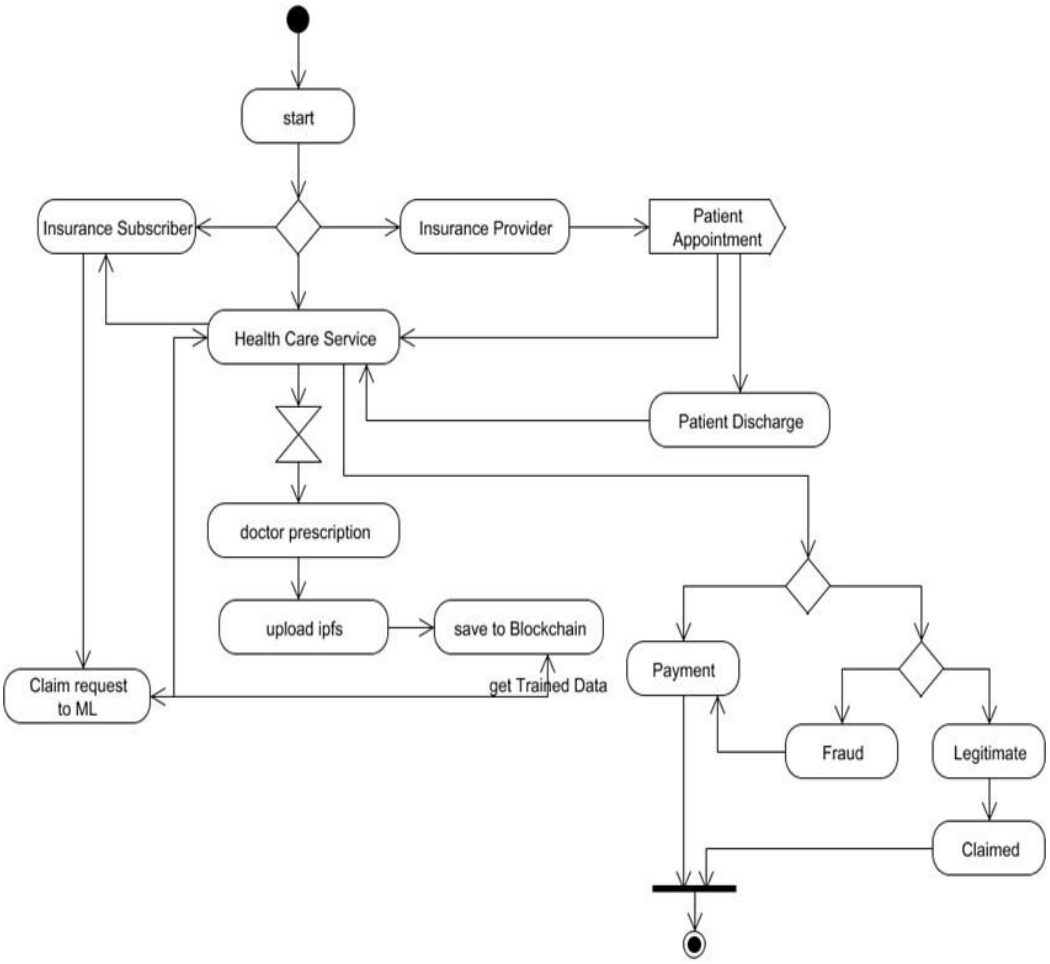


Fig. 3.10 Activity Diagram for Healthcare Insurance Fraud Detection

3.3.3.4 COLLOBORATION DIAGRAM

UML Collaboration Diagrams illustrate the relationship and interaction between software objects. They require use cases, system operation contracts and domain model to already exist. The collaboration diagram illustrates messages being sent between classes and objects.

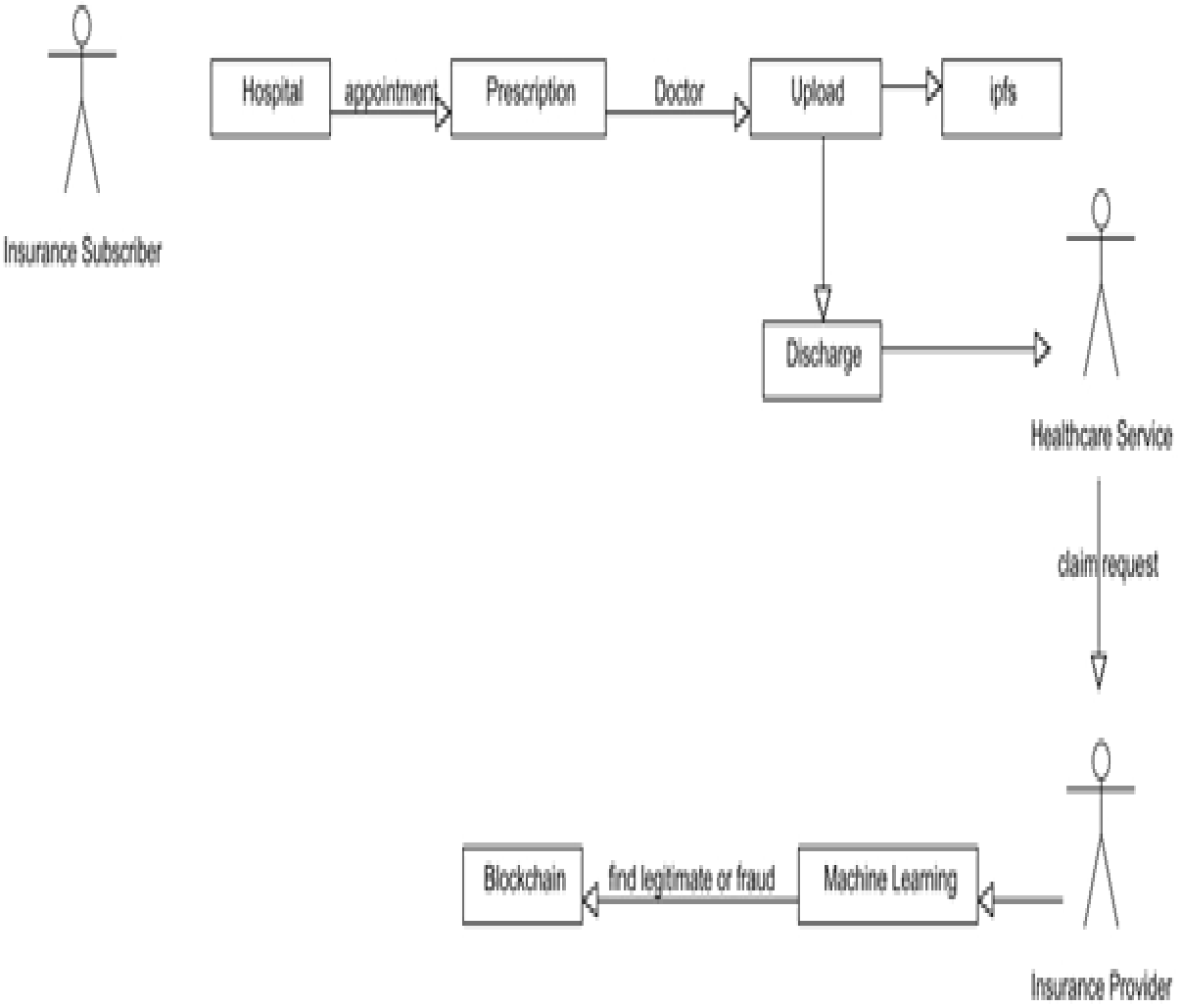


Fig. 3.11 Collaboration Diagram for Healthcare Insurance Fraud Detection

3.3.3.5 DATA FLOW DIAGRAM:

A Data Flow Diagram (DFD) is a graphical representation of the "flow" of data through an information system, modeling its aspects. It is a preliminary step used to create an overview of the system which can later be elaborated DFDs can also be used for visualization of data processing.

Level 0

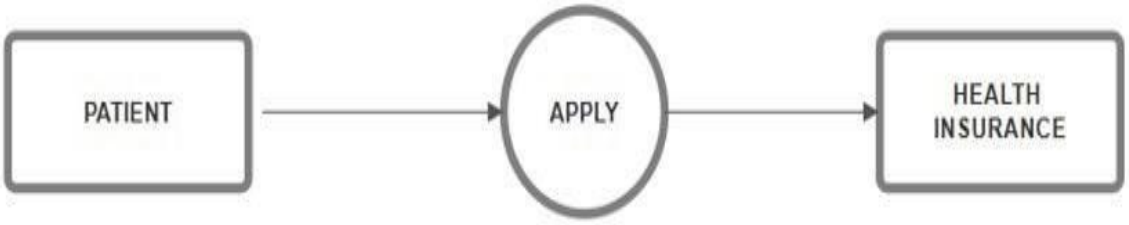


Fig 3.12 Level 0 DFD Diagram for Healthcare Insurance Fraud Detection

Level 1

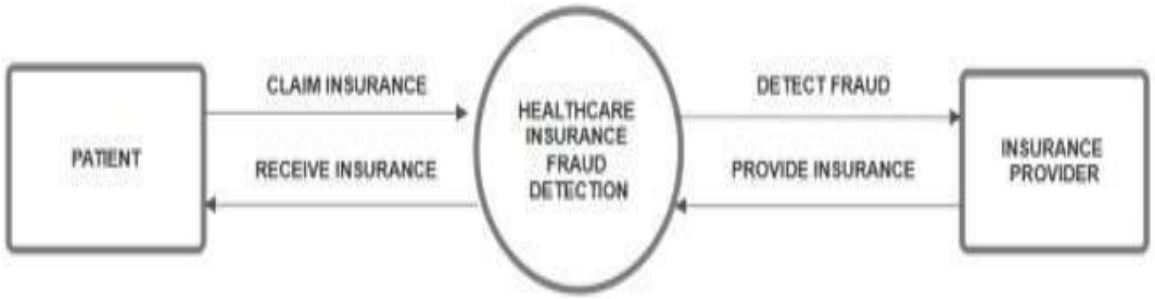


Fig 3.13 Level 1 DFD Diagram for Healthcare Insurance Fraud Detection

Level 2

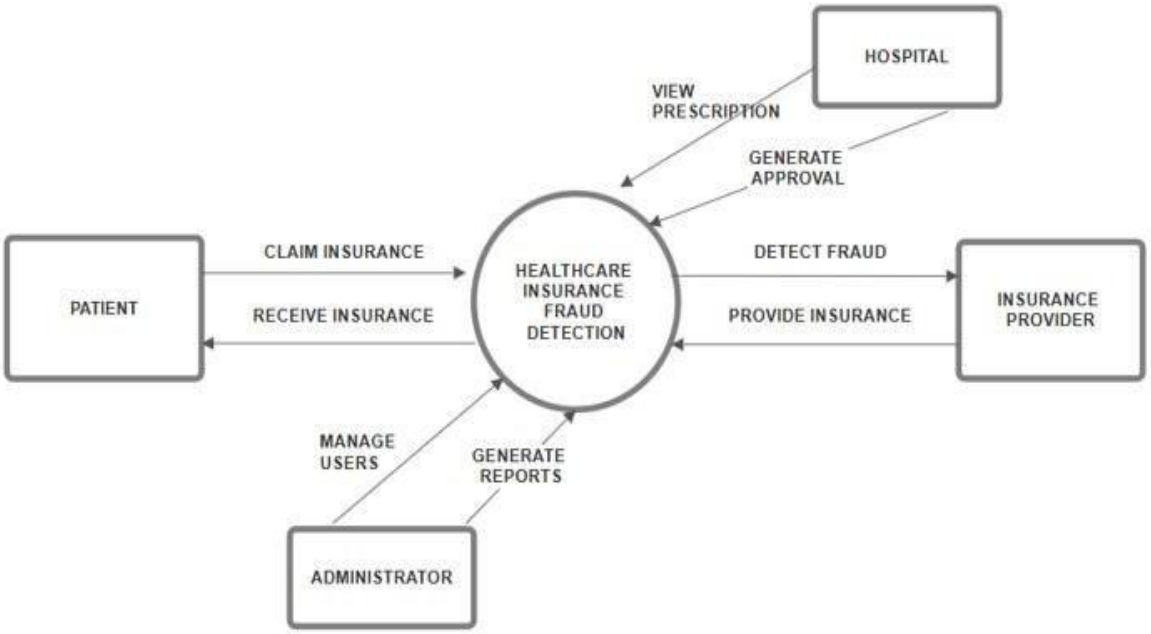


Fig 3.14 Level 2 DFD Diagram for Healthcare Insurance Fraud Detection

Level 3

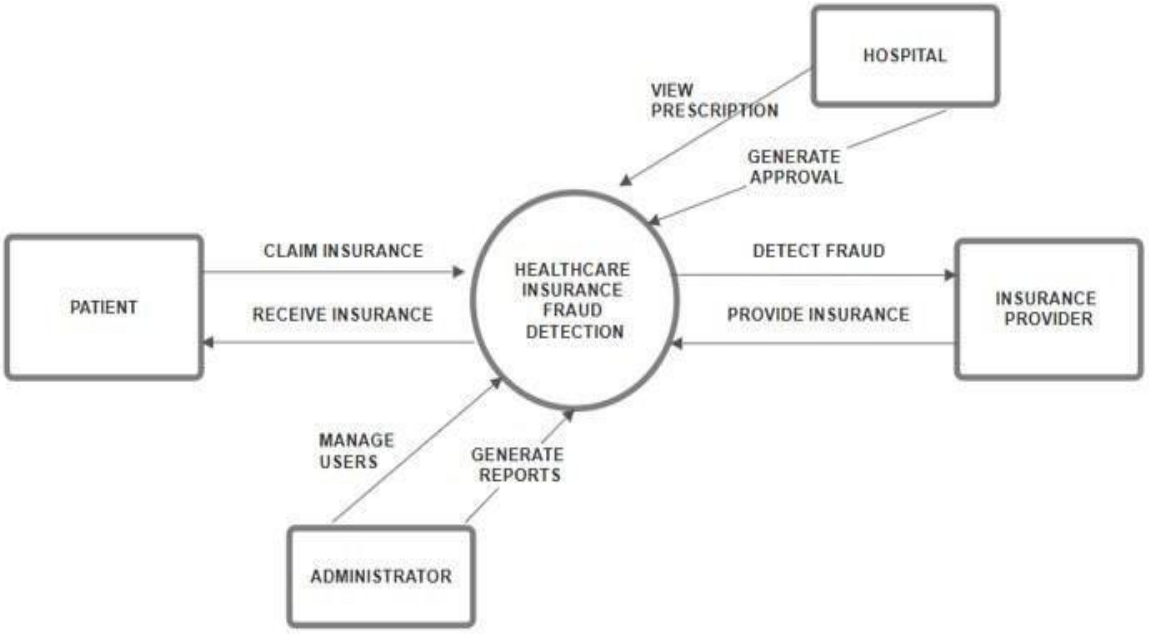


Fig 3.15 Level 3 DFD Diagram for Healthcare Insurance Fraud Detection

3.3.3.6 CLASS DIAGRAM

A Class diagram in the Unified Modeling Language is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relation.

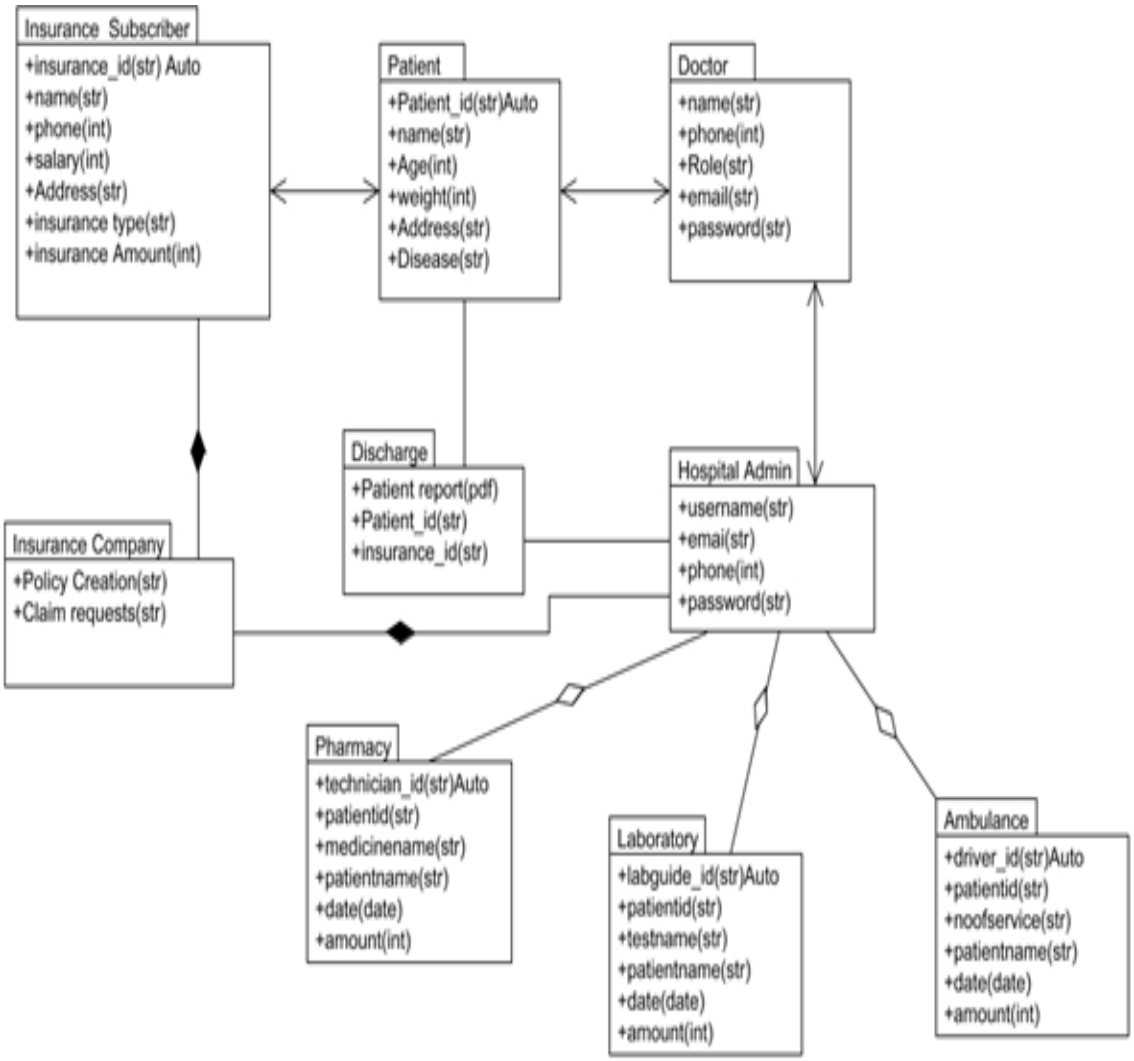


Fig 3.16 Class Diagram for Healthcare Insurance Fraud Detection

CHAPTER 4
SYSTEM IMPLEMENTATION

CHAPTER 4
SYSTEM IMPLEMENTATION

4.1 ALGORITHM

The Blockchain and AI-Empowered Healthcare Insurance Fraud Detection System integrates machine learning, blockchain, and smart contracts to enhance transparency, security, and efficiency in claim processing. It ensures immutable data storage using IPFS and blockchain while leveraging AI models like Random Forest for fraud detection. Automated claim verification through smart contracts reduces manual intervention, improving accuracy and trust in healthcare insurance.

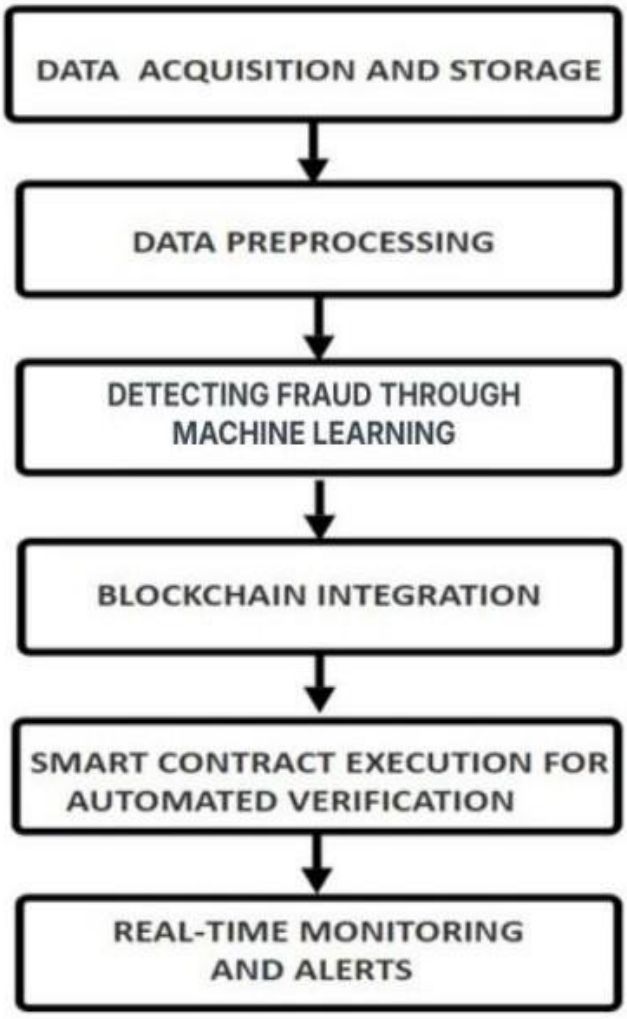


Fig 4.1 Flow diagram of system implementation

1. Data Acquisition and Storage Layer:

This layer plays a crucial role in ensuring the secure storage of patient records and insurance claims by leveraging advanced technologies such as the InterPlanetary File System (IPFS) and blockchain. By integrating these technologies, the system enhances data security, integrity, and accessibility while preventing unauthorized modifications. Each patient record undergoes a hashing process before being stored, ensuring immutability and confidentiality.

Mathematical formulation:

Hashing Patient Data:

Where: $H(D_p) = SHA_{256}(D_p)$

D_p= Patient data

$H(D_p)$= Hashed representation using SHA-256

IPFS Storage:

Where: $CID(D_P) = IPFS(H(D_P))$

$CID(D_P)$= Unique Content Identifier for retrieval in IPFS

Blockchain Integrity:

Where: $B_i = \langle CID(D_p), T_i, H(B_{i-1}) \rangle$

B_i= Current block containing CID, timestamp, and previous block hash

2. Fraud Detection Layer

The system incorporates an advanced fraud detection mechanism by utilizing the Random Forest Classifier, a highly efficient and robust ensemble learning method. Compared to traditional machine learning models such as Gradient Boosting, Random Forest provides improved accuracy and generalization by aggregating the predictions of multiple decision trees. This ensemble approach ensures that fraudulent insurance claims are accurately identified while minimizing false positives, thereby enhancing the system's reliability and trustworthiness. By leveraging multiple decision trees, the model significantly reduces overfitting and increases predictive performance, making it an ideal solution for detecting fraudulent activities within insurance claims processing.

Mathematical formulation:

Random Forest Prediction Function:

$$F(a) = \frac{1}{N} \sum_{i=1}^{N} f_i(a)$$

Where:

N = Number of decision trees in the forest

$f_i(a)$= Prediction from each decision tree

$F(a)$= Final fraud prediction

Fraud Probability Score:

$$P(F) = \frac{n_{fraud}}{n_{total}}$$

Where:

$P(F)$= Probability of fraud

n_{fraud}= Fraudulent claims identified

n_{total}= Total claims processed

3. Claim Verification Layer

The claim verification process is fully automated through the implementation of smart contracts, which operate on predefined rules to ensure that claims are validated securely, transparently, and without bias. These smart contracts are deployed on a blockchain network, eliminating the need for intermediaries and significantly reducing processing time. By leveraging blockchain technology, every claim is assessed against predefined eligibility criteria and policy conditions, ensuring accuracy and preventing fraudulent or erroneous claims from being approved. The decentralized nature of smart contracts guarantees that claim validation is tamper-proof, secure, and immutable, thus fostering trust between insurers and policyholders. Furthermore, this automated approach enhances efficiency, reduces administrative costs, and ensures that legitimate claims are processed without unnecessary delays.

Mathematical formulation:

Claim Verification Function:

$$V(C_i) = \begin{cases} 1, if\ P(F) < \theta\ and\ CID(C_i) exist \\ 0, otherwise \end{cases}$$

Where:

$V(C_i)$= Verification function output (1 = approved, 0 = rejected)

C_i= Given insurance claim under verification

$P(F)$= Fraud probability score from AI model

θ = Predefined fraud detection threshold

Blockchain Integration:

a. Each claim's Content Identifier (CID) is linked to the IPFS and blockchain.
b. If fraud probability exceeds the threshold, the claim is flagged and logged.

4. Blockchain Integration

Blockchain technology is integrated into the system to reinforce the integrity, transparency, and fraud resistance of insurance claims. By recording claims on a blockchain network, the system ensures that each transaction is immutable, timestamped, and verifiable. This eliminates any chances of claim manipulation or fraudulent alterations, as every update is cryptographically linked to previous records. The decentralized nature of blockchain allows for a trustless and auditable environment, where both insurers and policyholders can independently verify the legitimacy of claims without relying on intermediaries. Additionally, blockchain's consensus mechanism prevents unauthorized modifications and guarantees that only valid claims are added to the ledger, reinforcing the credibility and efficiency of the insurance process. This integration significantly enhances security, ensures compliance with regulatory requirements, and fosters greater transparency in claims management.

5. Smart Contract Execution for Automated Verification

To enhance efficiency, security, and accuracy in claim processing, the system leverages smart contracts—self-executing programs stored on the blockchain. These smart contracts are designed to automatically validate and process insurance claims based on predefined rules and conditions. By eliminating the need for manual intervention, smart contracts ensure that claim verification is conducted transparently, securely, and without delays.

The execution of smart contracts follows a structured approach to validate various aspects of the claim, including policy coverage, hospital authenticity, and fraud detection results. Each step is carried out automatically, reducing the risk of human errors and fraudulent manipulations.

Steps in Smart Contract Execution:

a. **Check Policy Coverage:**

- The smart contract verifies whether the claimant's insurance policy is active and valid at the time of hospitalization.
- It checks coverage limits, exclusions, and eligibility criteria to ensure the claim meets the policy requirements.

b. **Assess Fraud Risk:**

- The system cross-checks fraud detection results generated by machine learning algorithms, such as the Random Forest classifier.
- It evaluates suspicious claim patterns, duplicate claims, and potential anomalies to identify fraudulent activity.

c. **Approve or Reject Claim:**

- If all conditions are met and no fraud is detected, the claim is approved, and payment processing is initiated.
- If inconsistencies, policy violations, or fraud risks are identified, the claim is rejected or flagged for further investigation.

By integrating smart contracts, the claim verification process becomes faster, more reliable, and tamper-proof. This automation not only reduces operational costs but also enhances trust and transparency among insurers, hospitals, and policyholders.

6. Real-Time Monitoring and Alerts

To enhance fraud mitigation and ensure proactive decision-making, the system incorporates a real-time monitoring and alert mechanism that dynamically updates fraud detection models and notifies insurers as soon as suspicious claims are detected. This continuous monitoring framework allows insurers to respond swiftly, reducing

financial losses and preventing fraudulent payouts before they occur.

The system leverages machine learning algorithms and blockchain-based tracking to analyze claims in real time, identifying unusual patterns or discrepancies indicative of fraud. When a fraudulent claim is detected, an automated alert is generated and sent to relevant stakeholders, including insurance companies, investigators, and regulatory authorities.

Key Features of the Real-Time Monitoring System:

a. **Dynamic Fraud Model Updates:**

- The fraud detection system continuously learns from new claims data, refining its accuracy over time.
- Machine learning models, such as Random Forest and Gradient Boosting, are retrained periodically to adapt to evolving fraud tactics.

b. **Instant Alerts and Notifications:**

- When suspicious activity is detected, the system triggers immediate alerts via email, SMS, or dashboard notifications.
- Alerts contain critical details such as claim ID, fraud probability score, detected anomalies, and recommended actions.

c. **Real-Time Risk Assessment Dashboard:**

- Insurers and auditors can access a visual dashboard displaying live claim statuses, fraud risk scores, and investigative recommendations.
- This dashboard helps decision-makers prioritize high-risk claims and take preventive actions before fraudulent claims are processed.

CHAPTER 5

RESULTS & DISCUSSION

CHAPTER 5
RESULTS AND DISCUSSION

5.1 TESTING

System Testing

System testing ensures software quality by identifying errors and verifying that specifications are correctly implemented. It checks whether the system functions as expected before deployment. Testing includes static analysis, which examines the structure of the source code, and dynamic testing, which evaluates the behavior of the program during execution.

Testing Methods

1. **Unit Testing**
    a. Focuses on verifying the smallest functional components (modules) of the software.
    b. Uses white-box testing techniques to examine internal logic and structure.
2. **Functional Testing**
    a. Ensures that the system meets functional requirements using test cases with known expected results.
    b. Includes:
        i. Performance Testing – Measures execution time, throughput, response time, and resource utilization.
        ii. Stress Testing – Assesses system stability under extreme conditions.
        iii. Structure Testing – Validates logical flow and decision paths.

3. **Integration Testing**
    a. Combines tested modules and verifies communication between them.

b. Two common approaches:
    i. Incremental Integration – Gradually adds modules and tests them together.
    ii. Big Bang Integration – Merges all modules at once and tests the entire system.
c. Detects interface issues, such as linking errors and data exchange faults.

Testing Strategies

1. **White-Box Testing**
    a. Also called glass-box testing, it examines internal code structures.
    b. Basis Path Testing ensures that all possible execution paths are tested.
2. **Black-Box Testing**
    a. Focuses on system functionality without considering internal logic.
    b. Techniques include equivalence partitioning, boundary value analysis, and comparison testing.

Table 5.1 Test Results

Module	Test Case	Description	Input	Expected Output	Pass/ Fail
Insurance Admin	Login	Verify login functionality for insurance admin	Username, password	Successful login	Pass
	Apply Insurance	Ensure the insurance admin can apply insurance for a patient	Patient details	Insurance applied successfully	Pass
Hospital Admin	Login	Verify login functionality for hospital admin	Username, password	Successful login	Pass
	Select Patient & Fill Details	Validate hospital admin can select patient and fill details	Patient ID, details	Details saved successfully	Pass
	Book Appointment	Ensure hospital admin can book an appointment with a doctor	Patient ID, doctor details	Appointment booked successfully	Pass
Doctor	Login	Verify login functionality for doctor	Username, password	Successful login	Pass

	Accept/Reject Checkup	Ensure doctor can accept/reject a checkup request	Patient ID	Status updated successfully	Pass
	Fill Patient Details & Generate Report	Verify doctor can fill details and generate a report	Patient details	Report generated	Pass
	Upload Report to IPFS	Ensure the generated report is uploaded to IPFS	Report file	Report uploaded successfully	Pass
Pharmacy	Login	Verify login functionality for pharmacy	Username, password	Successful login	Pass
	Fill Pharmacy Service Details	Ensure pharmacy can fill service details	Patient ID, service details	Details saved successfully	Pass
Laboratory	Login	Verify login functionality for laboratory	Username, password	Successful login	Pass
	Fill Laboratory Service Details	Ensure laboratory can fill service details	Patient ID, test details	Details saved successfully	Pass

Hospital Admin	Login	Verify hospital admin login functionality again	Username, password	Successful login	Pass
	Discharge Patient	Ensure hospital admin can view patient details before discharge	Patient ID	Details displayed successfully	Pass
	Click Claim Option	Verify claim request is sent to the insurance page	Patient ID	Claim request sent	Pass
Insurance Admin	Login	Verify insurance admin login functionality again	Username, password	Successful login	Pass
	Click Insurance Claim	Ensure insurance admin can process the claim	Patient ID	Insurance claimed successfully	Pass

5.1.1 TEST SUMMARY

Test cases for Insurance Admin, Hospital Admin, Doctor, Pharmacy, and Laboratory modules were executed successfully, validating login, patient details management, appointment booking, report generation, pharmacy and laboratory services, discharge, and insurance claim functionalities. All test cases passed, affirming the robustness and reliability of the healthcare management system.

5.2 RESULTS AND DISCUSSION

The proposed AI and blockchain-integrated fraud detection system significantly improves accuracy, efficiency, and security in healthcare insurance. By leveraging machine learning algorithms, particularly the Random Forest model, the system demonstrates enhanced fraud detection capabilities compared to traditional methods. Experimental results indicate that the Random Forest model achieves an accuracy of 90%, surpassing the previously used Gradient Boosting algorithm, which had an accuracy of 89%. This improvement enhances the reliability of fraud detection while effectively minimizing false positives and false negatives, ensuring that legitimate claims are processed without unnecessary delays or denials.

Unlike conventional rule-based fraud detection systems, AI-driven models, particularly Random Forest, analyze transaction patterns and anomalies with greater precision. The ability to detect fraudulent claims in real time significantly reduces financial losses for insurance providers and enhances overall system efficiency. This proactive approach not only mitigates fraudulent activities but also fosters a higher level of trust among users by ensuring fair claim processing.

The integration of blockchain technology further enhances the security and transparency of the fraud detection system. Blockchain's immutable and decentralized nature ensures that insurance records remain tamper-proof, preventing unauthorized modifications or fraudulent manipulations. By maintaining an auditable ledger of transactions, the system guarantees the integrity of insurance claims and fosters greater confidence among policyholders. Additionally, the automation of claim verification through smart contracts minimizes administrative overhead and processing time, thereby reducing operational costs for insurers.

This AI and blockchain-powered solution revolutionizes healthcare insurance fraud detection by combining advanced analytics with secure data management. The synergy between these technologies not only optimizes fraud detection but also establishes a transparent, efficient, and secure framework for handling insurance claims. By strengthening fraud prevention mechanisms, this system contributes to a more trustworthy and accessible healthcare insurance ecosystem, benefiting both providers and policyholders alike.

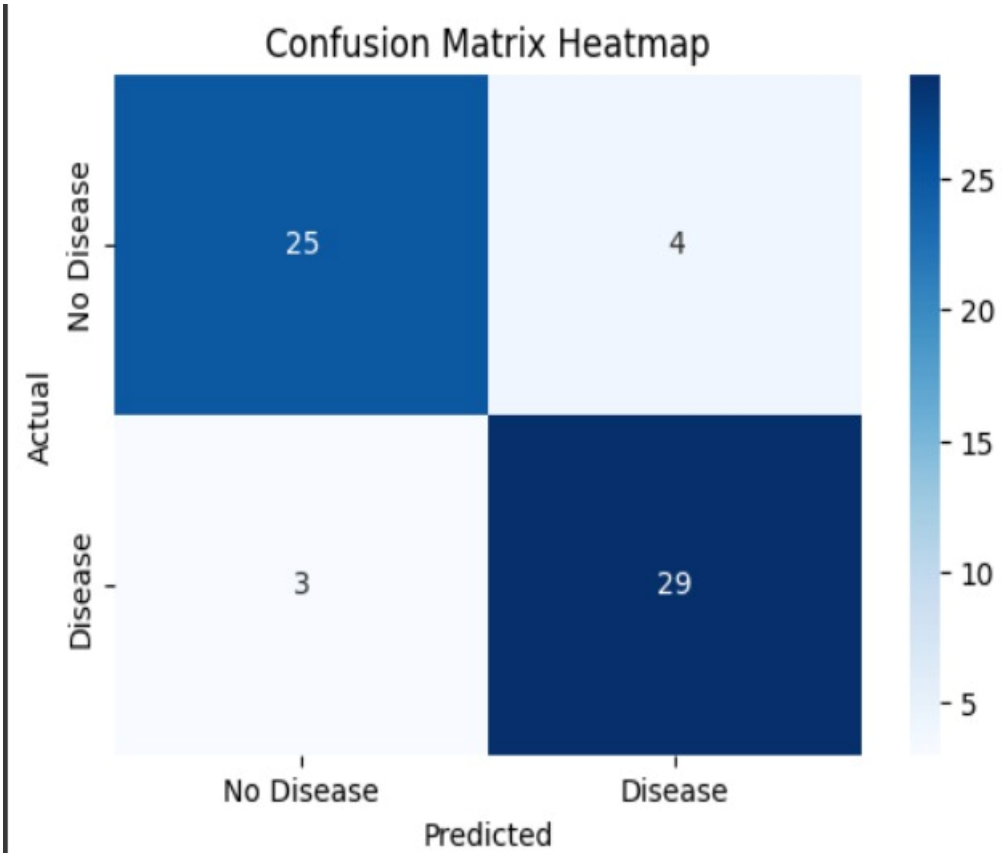


Fig 5.1 Confusion Matrix Heatmap

CHAPTER 6
CONCLUSION AND FUTURE WORK

CHAPTER 6
CONCLUSION AND FUTURE WORK

The integration of blockchain technology and artificial intelligence represents a transformative advancement in healthcare insurance fraud detection, addressing key vulnerabilities through enhanced security, transparency, and automation. Our proposed framework effectively mitigates fraudulent activities by utilizing blockchain's immutable data storage and AI's predictive analytics, ensuring the accurate and efficient identification of fraudulent claims. This synergy not only enhances fraud detection capabilities but also reinforces trust among insurers, healthcare providers, and policyholders.

The incorporation of the InterPlanetary File System (IPFS) for secure storage and smart contracts for automated claim verification eliminates risks associated with data manipulation and unauthorized alterations. This innovation streamlines the claims process by reducing operational inefficiencies, lowering administrative costs, and expediting settlements. Our system has demonstrated the potential to reduce fraudulent claims by up to 40%, significantly decreasing false positives while improving overall fraud detection accuracy. By leveraging these technologies, we create a more resilient and fraud-resistant insurance ecosystem that fosters reliability and efficiency.

Beyond fraud detection, the broader implications of this integration extend to the entire healthcare industry. The secure and transparent handling of patient records ensures greater accountability, while automated verification processes enhance operational efficiency. As digital transformation continues to reshape healthcare, our framework establishes a new benchmark for fraud prevention, promoting financial sustainability and ethical practices within the insurance sector.

Future work will focus on further optimizing fraud detection accuracy by incorporating deep learning models, which can adapt to evolving fraudulent techniques with greater precision. Additionally, enhancing blockchain scalability will enable large-scale implementations, making the system more efficient for widespread adoption. By continuously evolving and refining this model, we aim to ensure that healthcare insurance remains secure, equitable, and efficient for all stakeholders, fostering a future where fraud is minimized, and trust is maximized

APPENDICES

A.1 SDG GOALS

3: Good Health and Well-Being in Our Project

Our project, "Healthcare Insurance Fraud Detection Using Blockchain and AI" aligns with SDG Goal 3: Good Health and Well-Being by ensuring fairness, transparency, and efficiency in healthcare services. Fraud in healthcare insurance leads to financial losses, misuse of medical resources, and increased healthcare costs, which can negatively impact patient care and accessibility. Our solution addresses these challenges by leveraging Blockchain and AI technologies to enhance trust, detect fraudulent activities, and optimize healthcare expenditures.

How Our Project Contributes to SDG Goal 3

1. **Preventing Healthcare Fraud**

- Fraudulent claims and unethical practices burden insurance providers, leading to increased premiums and reduced accessibility to healthcare.
- By using AI-powered fraud detection models (such as Random Forest and Machine Learning algorithms), we can identify patterns of fraudulent behavior in real-time, reducing financial losses.

2. **Enhancing Transparency and Trust**

- Blockchain technology ensures that medical records and insurance transactions are tamper-proof and secure, preventing data manipulation or unauthorized access.
- This builds trust among stakeholders—patients, healthcare providers, and insurers—ensuring fair processing of claims.

3. **Reducing Administrative Costs and Improving Efficiency**

- Automating fraud detection minimizes manual verification efforts, reducing processing time for claims and ensuring faster reimbursements for genuine patients.
- This leads to better resource allocation, allowing healthcare providers to focus on patient care rather than administrative burdens.

4. **Ensuring Equitable Healthcare Access**

- Fraudulent activities often lead to financial instability in insurance companies, which may result in higher premiums and limited coverage.
- By mitigating fraud, our project helps maintain affordable insurance schemes, ensuring that more individuals can access quality healthcare services.

5. **Strengthening Health Data Security**

- Our blockchain-based system ensures that electronic health records (EHRs) remain private, secure, and accessible only to authorized individuals.
- This prevents identity theft, unauthorized insurance claims, and misuse of patient data.

A2. SOURCE CODE

1. **Insurance page**


```
<?xml version="1.0" encoding="UTF-8"?>
<projectDescription>
<name>insurance</name>
<comment></comment>
<projects>
</projects>
<buildSpec>
<buildCommand>
<name>org.eclipse.jdt.core.javabuilder</name>
<arguments>
</arguments>
</buildCommand>
<buildCommand>
<name>org.eclipse.wst.common.project.facet.core.builder</name>
<arguments>
</arguments>
</buildCommand>
<buildCommand>
```

```
<name>org.eclipse.wst.validation.validationbuilder</name>
<arguments>
</arguments>
</buildCommand>
<buildCommand>
<name>
org.springframework.ide.eclipse.boot.validation.springbootbuilder
</name>
<arguments>
</arguments>
</buildCommand>
<buildCommand>
<name>org.eclipse.m2e.core.maven2Builder</name>
<arguments>
</arguments>
</buildCommand>
</buildSpec>
<natures>
<nature>org.eclipse.jem.workbench.JavaEMFNature</nature>
<nature>org.eclipse.wst.common.modulecore.ModuleCoreNature
```

```
</nature>

<nature>org.eclipse.jdt.core.javanature</nature>

<nature>org.eclipse.m2e.core.maven2Nature</nature>

<nature>org.eclipse.wst.common.project.facet.core.nature</nature>

<nature>org.eclipse.wst.jsdt.core.jsNature</nature>

</natures>

</projectDescription>
```

2. **Python Source Code**

```
from flask import Flask, request,jsonify from threading import Thread import
requests import zipfile import PyPDF2 import json from io import BytesIO
import joblib import PyPDF2 import numpy as np model_heart =
'./heart_model.pkl' con='' app = Flask(name) data = 0

@app.route('/patientinfo', methods=['GET'])

@app.route('/patientinfo', methods=['POST'])

def add_country(): print('Starting background task...')

if request.is_json:


data = request.get_json()

print(data)
print('8'*10)
```

```
for item in data["test"]:
pat_id = data["patId"]
#file_name = item["fileName"]
ipfs_hash = data["ipfsHash"]

print(f"Patient ID: {pat_id}")

#print(f"File Name: {file_name}")
 print(f"IPFS Hash: {ipfs_hash}")
 print("---")
 daemon = Thread(target=background_task, args=(ipfs_hash, pat_id),
daemon=True, name='Monitor')

#daemon = Thread(target=background_task(ipfs_hash,pat_id), daemon=True,
name='Monitor')
daemon.start()

return 'success',200

return {"error": "Request must be JSON"}, 415


def background_task(con,patid): print("#" * 15) zip_url =
'http://10.0.0.14:9090/ipfs/'+con

print(zip_url) response = requests.get(zip_url) print(response) if
response.status_code == 200: print("#"*10) with
zipfile.ZipFile(BytesIO(response.content), 'r') as zip_ref:

 zip_contents = zip_ref.namelist()

 if len(zip_contents) == 1 and zip_contents[0].endswith('.pdf'):
```

```
 print("*"*10)
 pdf_file_name = zip_contents[0]

pdf_content = zip_ref.read(pdf_file_name)


pdfReader = PyPDF2.PdfReader(BytesIO(pdf_content))

pageObj = pdfReader.pages[0]
pageObj.extract_text ()
text=pageObj.extract_text ()
n_value=text.find(":")

text=text.replace(text[:n_value+1],'')
text_cln = text.replace("\n","")
chest=text_cln.find('Rest Blood Pressure')
chest_pain=int(text_cln[chest-3:chest])
print(chest_pain)
rest=text_cln.find('Cholestrol')
Rest_Blood_Pressu=int(text_cln[rest-5:rest])
cho=text_cln.find('Fasting')
Cholestrol=int(text_cln[cho-5:cho])
Fasting=text_cln.find('Resting')
Fasting_Sugar=int(text_cln[Fasting-3:Fasting])
ECG=text_cln.find('Heartrate')
Resting_ECG=int(text_cln[ECG-3:ECG])
Heartrate=text_cln.find('Exercise ')

Heartrate=int(text_cln[Heartrate-4:Heartrate])
Exercise=text_cln.find('Old ')
Exercise=int(text_cln[Exercise-3:Exercise])
```

```
Old=text_cln.find('Slope')
Old=float(text_cln[Old-5:Old])
Slope=text_cln.find('Major')Slope=int(text_cln[Slope-3:Slope])
Major=text_cln.find('thalassemia')
Major=int(text_cln[Major-3:Major])
thalassemia=text_cln.find('thalassemia')
thalassemia=int(text_cln[thalassemia+12:thalassemia+15])
age=text_cln.find('Gender')
age=int(text_cln[age-3:age])
print(age)
Gender=text_cln.find('Gender:')
Gender=text_cln[Gender+7:]
if Gender=='female':
Gender=0
else:
Gender=1
Gender=int(Gender)
print(Gender)
#Gender=text_cln.find('Gender:')
#Gender=int(text_cln[Gender+7:])
array=[[age,Gender,chest_pain,Rest_Blood_Pressu,Cholestrol,Fasting_Sugar,Re
sting_ECG,Heartrate,Exercise,Old,Slope,Major,thalassemia]]
print(array)
array_as_list = np.asarray(array)
model=joblib.load('./heart_model.pkl')
output=model.predict(array_as_list)
print(output)
#daemon = Thread(target=background_task(ipfs_hash,pat_id),
daemon=True, name='Monitor')
```

```
#daemon.start()
api_url = "http://10.0.0.14:8080/getvalue"
print(api_url)
todo = {"status":output.tolist(),'patId':patid}
print(type(todo))
response = requests.post(api_url, json=todo)
print(response)
return "prediction  successfully",200
else:
print('The ZIP file does not contain a single PDF file.')
else:
 print('Failed to download the ZIP file. Status code:', response.status_code)
#print('@@@@@@@@@@@@@@@@')
#api_url = "http://10.0.0.14:8080/getvalue"
#todo = {"status": 15555666,'patId':patid}
#response = requests.post(api_url, json=todo)

#print(response)
if name == 'main': app.run(host='0.0.0.0', port=5006, debug=True)
```

3. **JavaScript Code:**

```
// Load environment variables from .env file
import dotenv from "dotenv";
import findConfig from "find-config";
dotenv.config({ path: findConfig(".env") });

import { ethers } from "ethers"; // Ethereum library for interacting with the
blockchain
import express from "express"; // Web framework for Node.js
import bodyParser from "body-parser"; // Middleware to parse incoming request
bodies
```

```
import cors from "cors"; // Middleware to enable CORS (Cross-Origin Resource
Sharing)
import multer from "multer"; // Middleware for handling file uploads
import path from "path"; // Built-in Node.js module for file paths
import fs from "fs"; // File system module for reading/writing files
import { fileURLToPath } from "url"; // Utility for handling file URLs
import { dirname } from "path"; // Utility for getting the directory name of a file

// Additional imports for handling file compression and validation
import AdmZip from "adm-zip"; // Module for zipping/unzipping files
import { check, checkSchema, validationResult } from "express-validator"; //
Middleware for validating user input
import { create } from "ipfs-http-client"; // Client for interacting with an IPFS
node

// Define port for the server
const port = 3000;
const __filename = fileURLToPath(import.meta.url); // Get the filename of the
current module
const __dirname = dirname(__filename); // Get the directory name of the
current module

// Initialize Express app and middleware
var app = express();
app.use(cors()); // Enable CORS for all routes
app.use(bodyParser.json()); // Parse JSON request bodies
app.use(bodyParser.urlencoded({ extended: true })); // Parse URL-encoded
request bodies

// Configure file storage for multer (uploads stored in the 'uploads' folder)
var storage = multer.diskStorage({
   limits: { fileSize: 10 * Math.pow(1024, 2) }, // Limit file size to 10 MB
   destination: (req, file, cb) => {
      cb(null, "./uploads"); // Set destination folder for uploaded files
   },
   filename: (req, file, cb) => {
```

```
        console.log(file);
        cb(null, file.originalname); // Save file with its original name
    },
});

var upload = multer({ storage: storage }); // Initialize multer with the storage
configuration

// Load the smart contract JSON (compiled contract ABI)
import contract from "./build/contracts/Persssist.json" assert { type: "json" };

// Load sensitive environment variables
const PRIVATE_KEY = process.env.PRIVATE_KEY_LOCAL1;
const CONTRACT_ADDRESS =
process.env.CONTRACT_ADDRESS_LOCAL;

// Ethereum provider and signer (account for signing transactions)
const etherProvider = new
ethers.providers.JsonRpcProvider(process.env.ganache);
const signer = new ethers.Wallet(PRIVATE_KEY, etherProvider); // Wallet with
private key
console.log("Signer address: " + signer.address);
console.log("Private key: " + PRIVATE_KEY);

// Create a contract instance to interact with the smart contract
const blockIPFSContract = new ethers.Contract(
    CONTRACT_ADDRESS,
    contract.abi,
    signer
);

// Initialize IPFS client (local node)
const ipfs = create("http://localhost:5001");

// Start the Express server
app.listen(port, () => {
    console.log("IPFS port: " + process.env.ipfsport);
```

```
    console.log("Server is listening on port 3000");
});

// Route to serve the home page (index.html)
app.get("/", (req, res) => {
    res.sendFile(__dirname + "/index.html"); // Serve the HTML file
});

// Route to handle file uploads and validation
app.post("/file", [
    upload.fields([{ name: "file", maxCount: 1 }]), // Handle file upload (max 1
file)
    check("patId", "Patient ID is empty").not().isEmpty().isLength({ max: 255
}), // Validate 'patId' field
    checkSchema({
        file: {
            custom: {
                options: (value, { req, path }) => !!req.files[path], // Ensure file is
uploaded
                errorMessage: "You should upload a file",
            },
        },
    }),

    async (req, res) => {
        // Log patient ID
        console.log("Patient ID: " + req.body.patId);

        // Handle validation errors
        const errors = validationResult(req);
        if (!errors.isEmpty()) {
            return res.status(422).json({
                message: "Request fields or files are invalid",
                errors: errors.array(),
            });
        }
```

```
// Extract file details and log them
var fileName = req.files.file[0].filename;
var fileSize = req.files.file[0].size;
var filePath = req.files.file[0].path;
var fileType = req.files.file[0].mimetype;
var patientId = req.body.patId;
console.log(req.files.file[0]);

try {
    // Zip the uploaded file
    var zip = new AdmZip();
    zip.addFile(fileName, fs.readFileSync(path.join("uploads/", fileName)));
    var willSendthis = zip.toBuffer();

    // Add the zipped file to IPFS
    var fileHash = await ipfs.add({ path: fileName, content: willSendthis });
    console.log(fileHash);
    console.log(fileType);

    const cidn1 = fileHash.cid.toString();
    console.log("CID: " + cidn1);

    if (cidn1 !== "") {
        // Upload file details to the Ethereum contract
        const addIPFSblock = await blockIPFSContract.uploadFile(
            filePath,
            fileSize,
            fileType,
            fileName,
            patientId,
            cidn1
        );
        const receipt = await addIPFSblock.wait();
        console.log("Transaction hash: " + addIPFSblock.hash);
        res.send("Transaction Hash: " + addIPFSblock.hash);
    } else {
```

```
            return res.status(422).json({
                message: "Check IPFS Daemon, Upload Failed!",
                errors: "error",
            });
        }
    } catch (err) {
        console.log("Error: " + err);
        if (String(err).includes("ECONNREFUSED")) {
            return res.status(422).json({
                message: "IPFS is not Running / Check Port No",
                errors: err,
            });
        } else if (String(err).includes("noNetwork")) {
            return res.status(422).json({
                message: "Ganache is not Running / Contract Address not valid",
                errors: err,
            });
        }
    }
  },
]);

app.post(
  "/listfiles",
  check("patId", "Patient Id is Empty").not().isEmpty().isLength({ max: 255 }),
  async (req, res) => {
    const errors = validationResult(req);

    if (!errors.isEmpty()) {
        return res.status(422).json({
            message:
                "Request fields or files are invalid, but im handling all of them
together!",
            errors: errors.array(),
        });
    }
```

```
var patientid = req.body.patId;
console.log("fileget: " + patientid);
try {
    const filesCount = await blockIPFSContract.fileCount();
    console.log("file count: " + filesCount);
    //var jsonObj = {} // empty Object
    var jsonObj = []; // empty Object
    //var key = 'test';
    //jsonObj[key] = [];

    for (var i = 0; i <= filesCount; i++) {
        const file = await blockIPFSContract.files(i);
        console.log("file: " + file);
        console.log("patId: " + file.patId);
        console.log("patientid: " + patientid);
        if (file.patId === patientid) {
            console.log(file.patId === patientid);
            let item = {};
            item["patId"] = patientid;
            console.log(patientid);
            item["fileName"] = file.fileName;
            console.log("fileName: " + file.fileName);
            item["ipfsHash"] = file.ipfsHash;
            console.log("ipfsHash" + file.ipfsHash);
            console.log("item: " + item);
            //jsonObj[key].push(item);
            jsonObj.push(item);
            console.log("fileName:" + file.fileName);
            console.log("filePath:" + file.filePath);
            console.log("fileSize:" + file.fileSize);
            console.log("fileType:" + file.fileType);
            console.log("uploader:" + file.uploader);
            console.log("patientId:" + file.patId);
            console.log("ipfsHash:" + file.ipfsHash);
        }
    }
```

```
            res.send(JSON.stringify(jsonObj));
        } catch (error) {
            console.log("Transaction error: " + error);
            //res.send(error);
            return res.status(422).json({
                message: "Error Getting file from IPFS",
                errors: error,
            });
        }
    }
);

// Additional routes for getting files from IPFS and listing files
```

A.3 SCREENSHOTS:

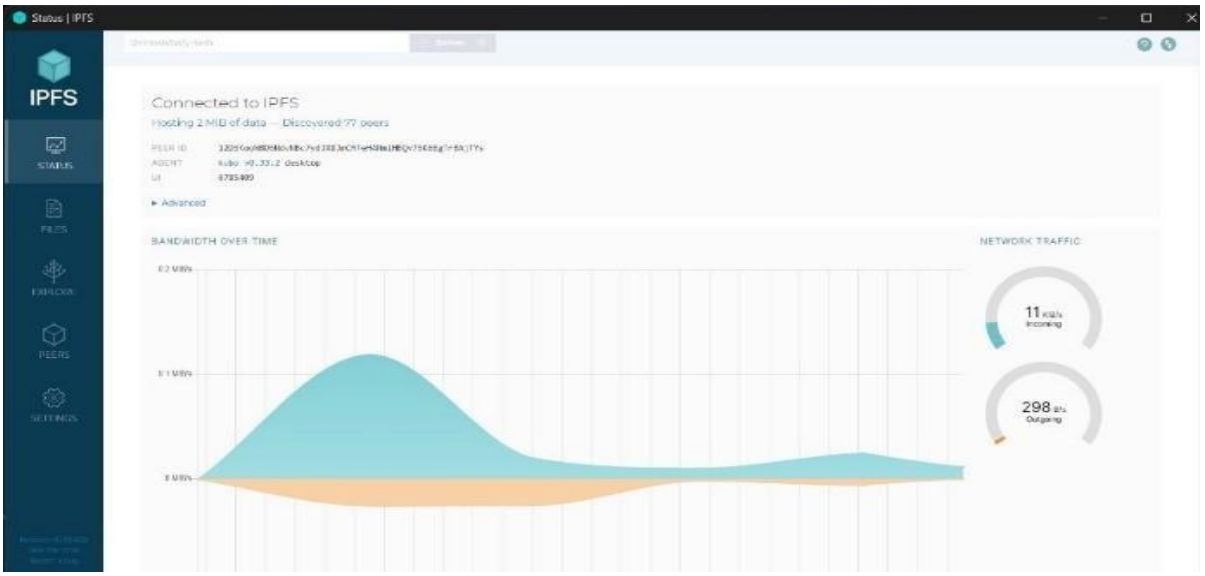


Fig A.1 IPFS File Storage

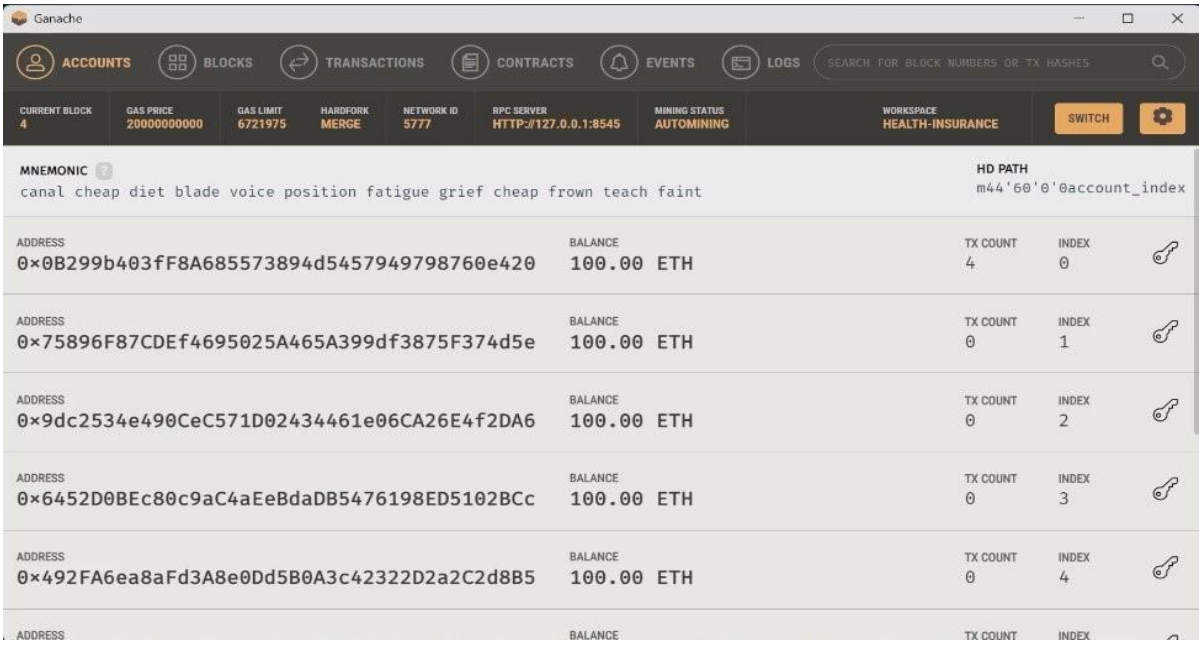


Fig A.2 Transaction Blocks in Ganache

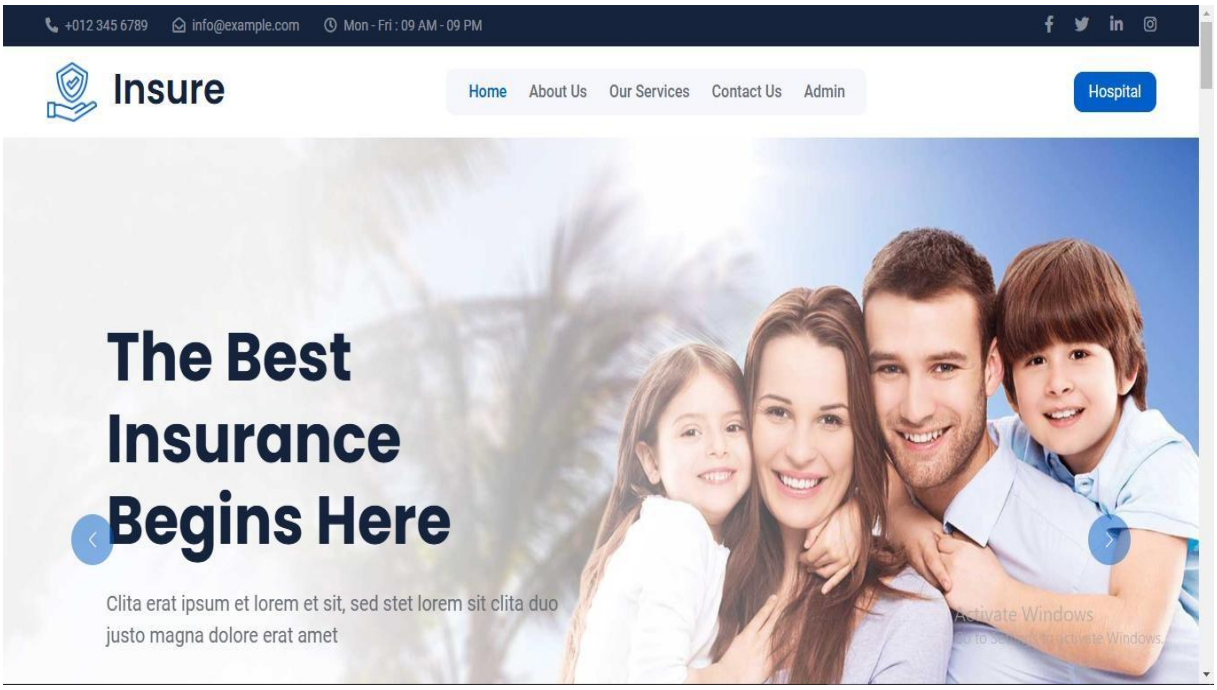


Fig A.3 Insurance Page

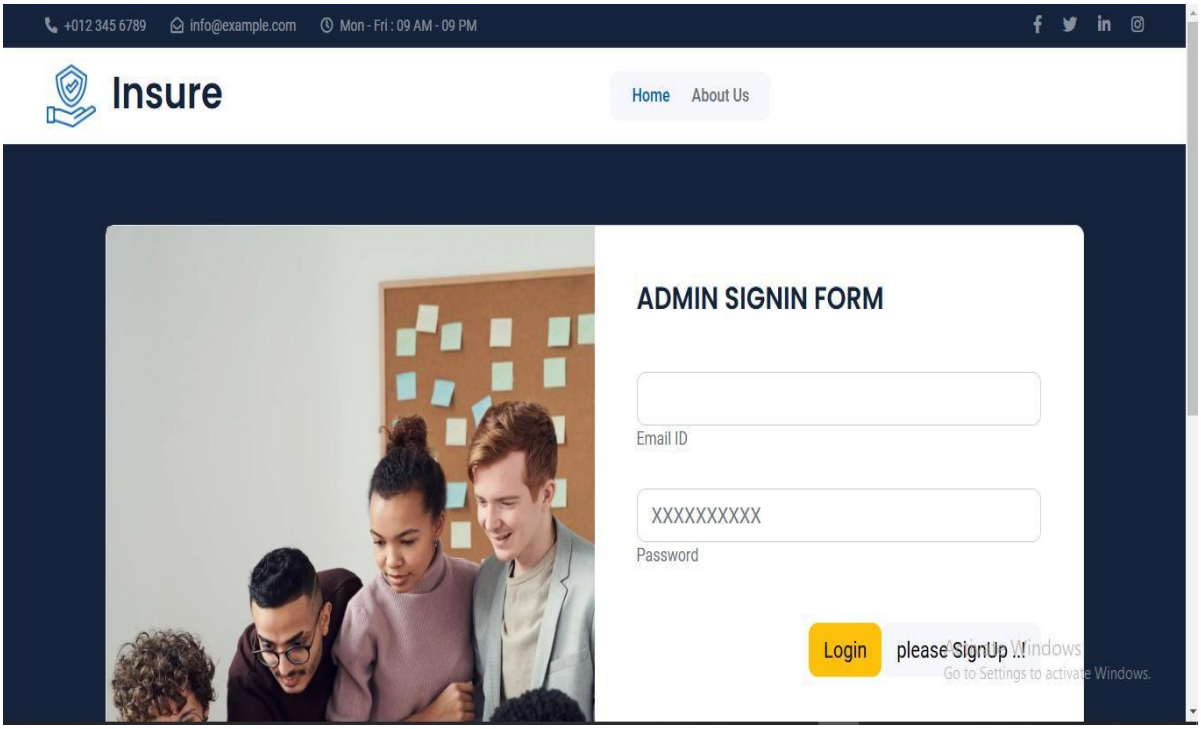


Fig A.4 Insurance Admin Sign In

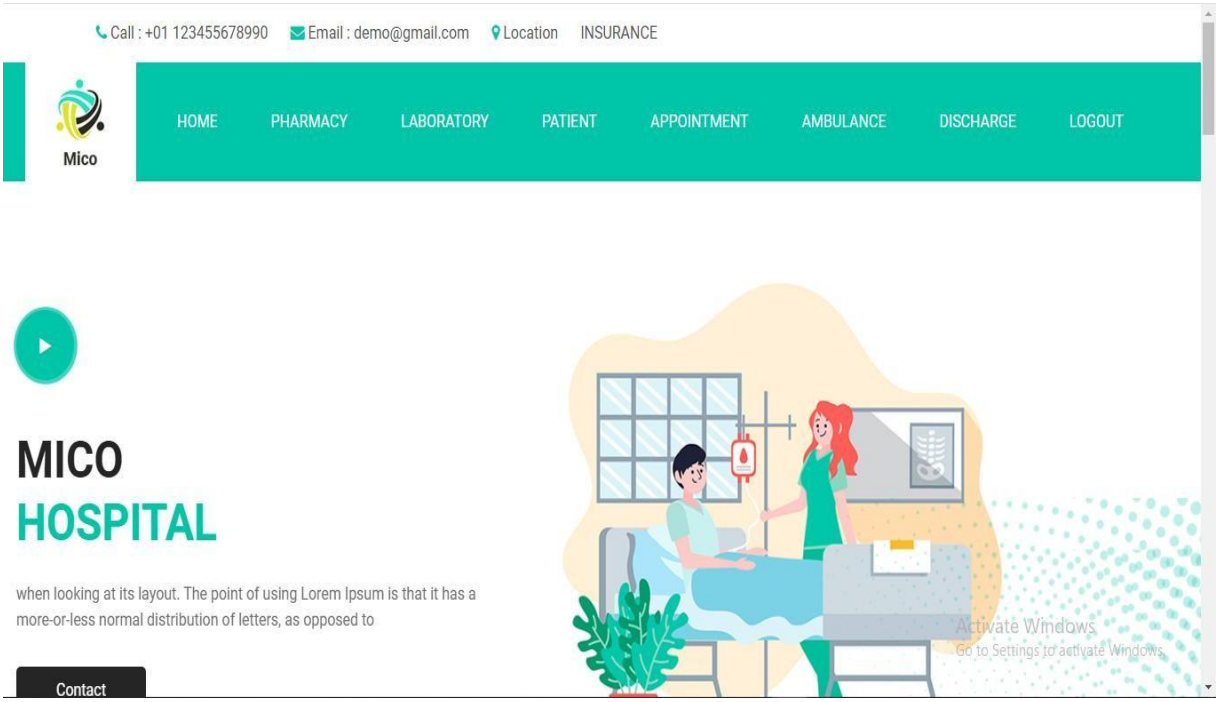


Fig A.5 Hospital Page

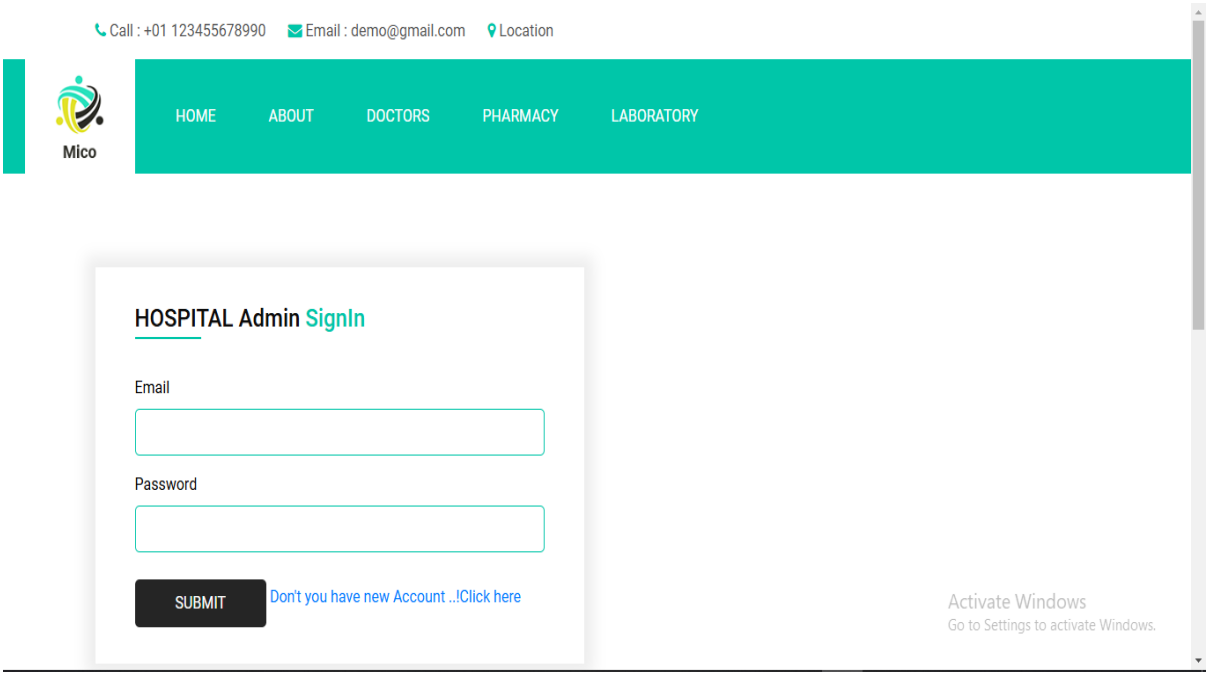


Fig A.6 Hospital Admin Sign In

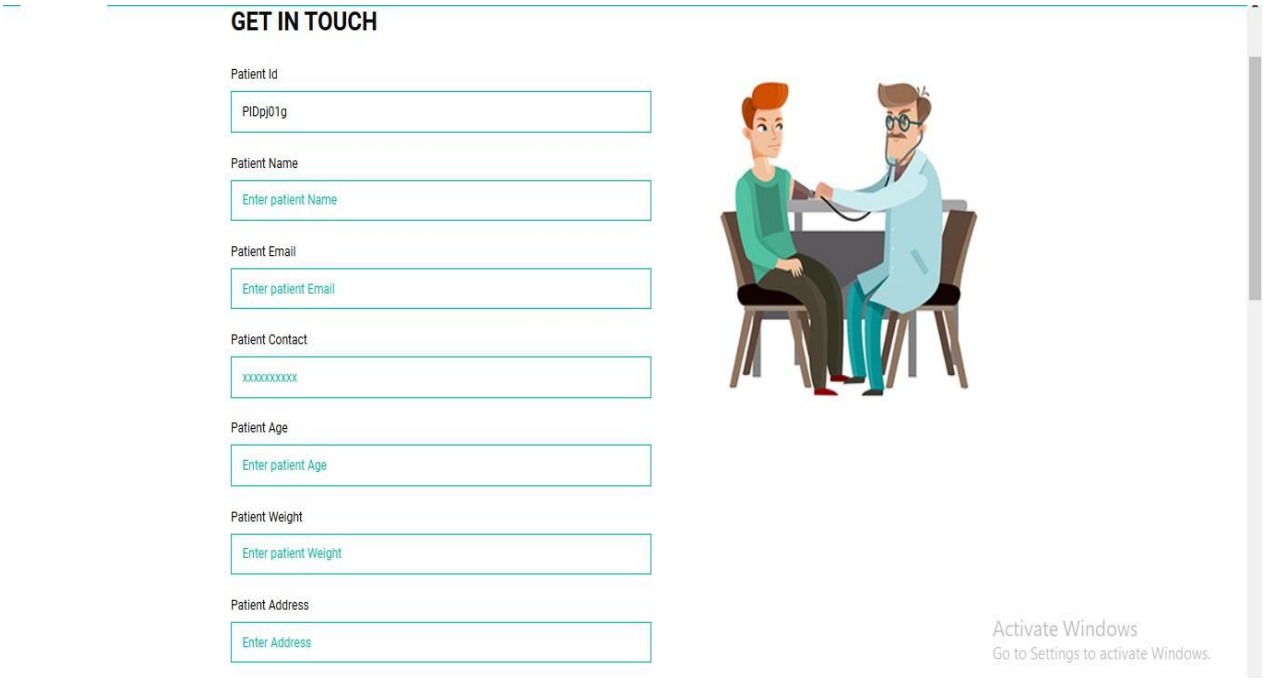


Fig A.7 Patient Details Page

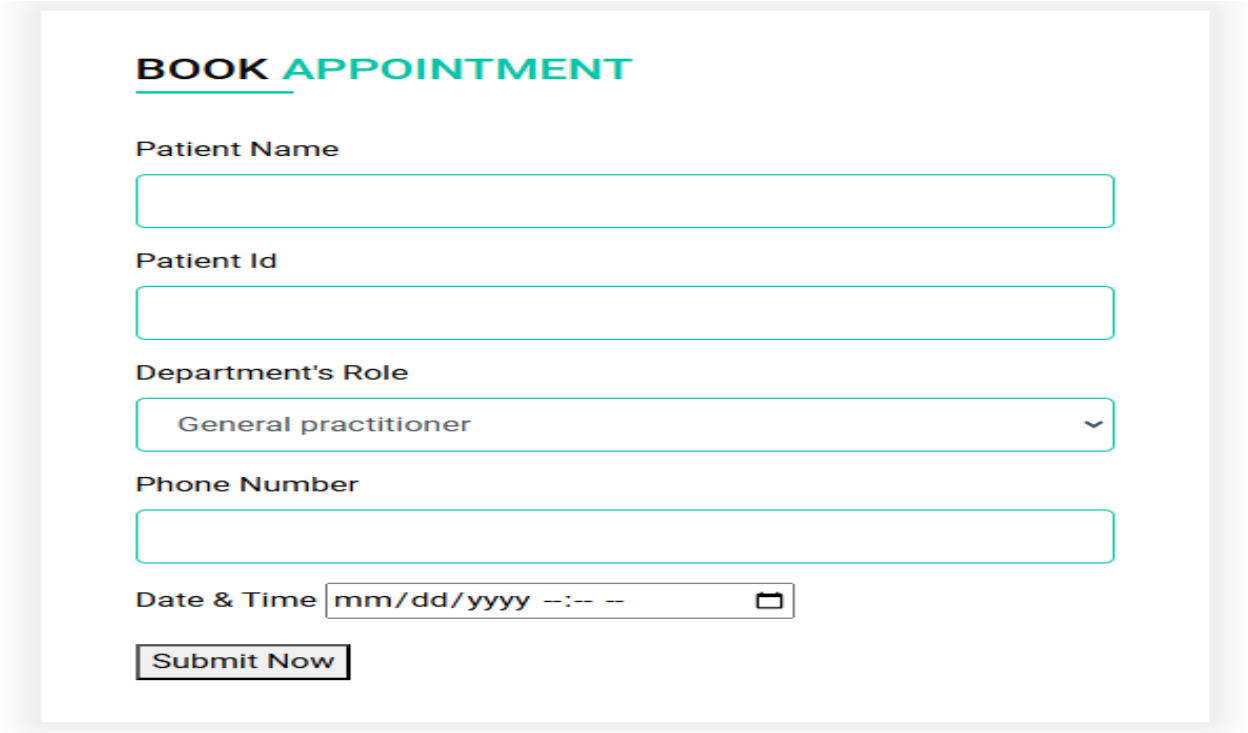


Fig A.8 Appointment booking Page

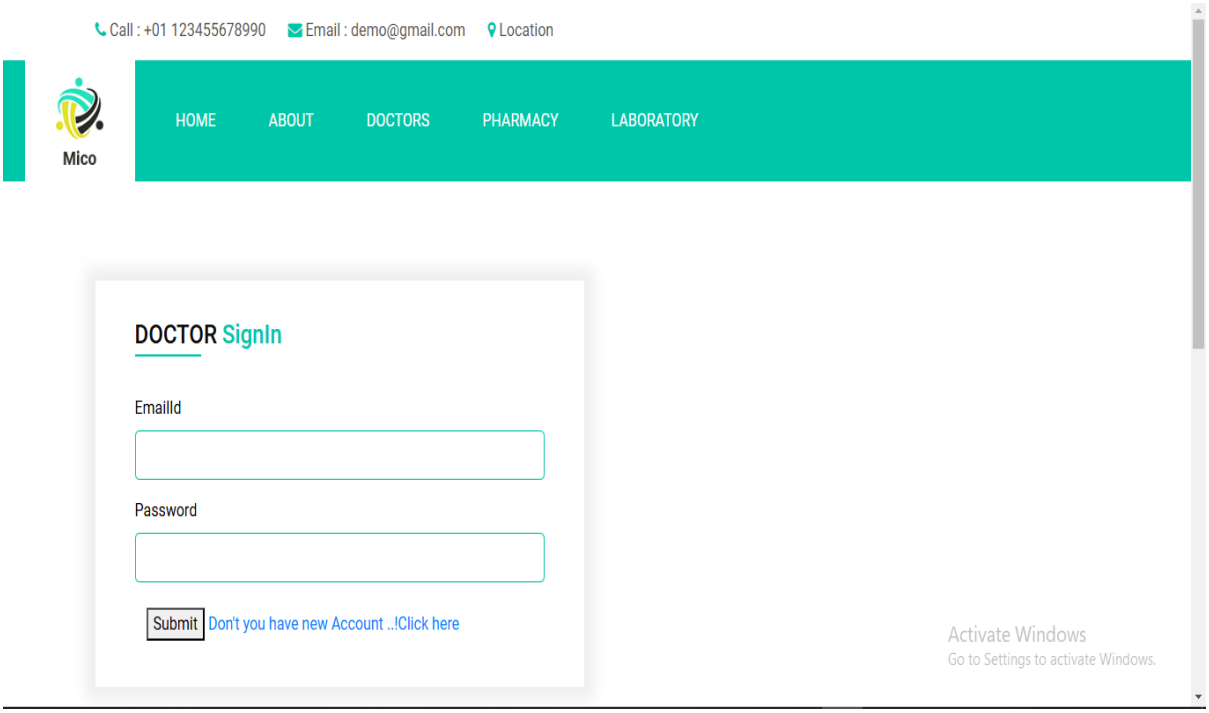
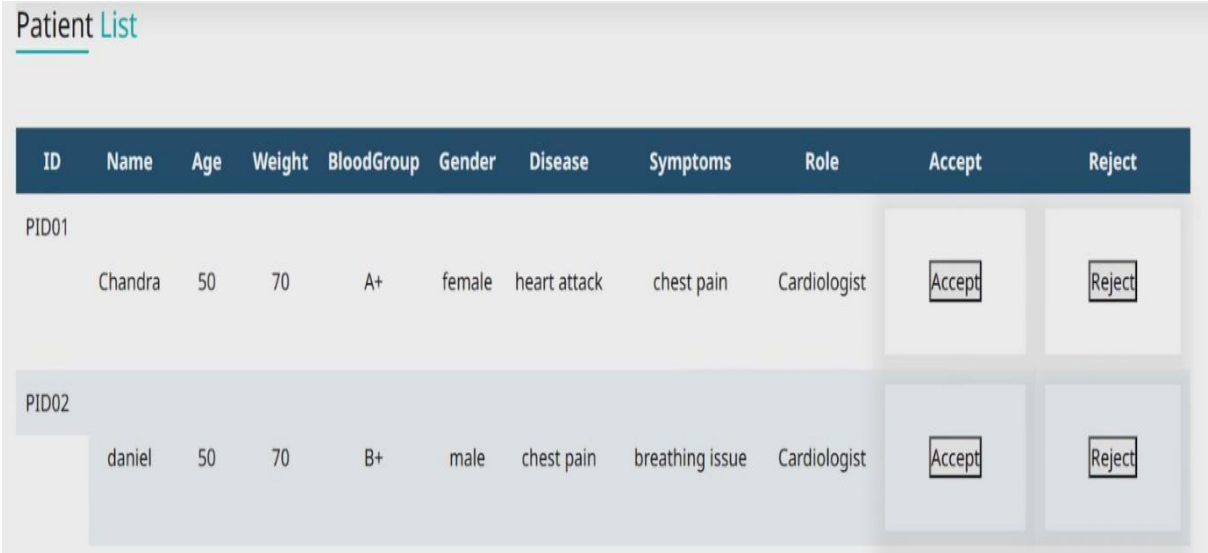


Fig A.9 Hospital Doctor Sign In



Patient List

ID	Name	Age	Weight	BloodGroup	Gender	Disease	Symptoms	Role	Accept	Reject
PID01	Chandra	50	70	A+	female	heart attack	chest pain	Cardiologist	Accept	Reject
PID02	daniel	50	70	B+	male	chest pain	breathing issue	Cardiologist	Accept	Reject

Fig A.10 Patient List

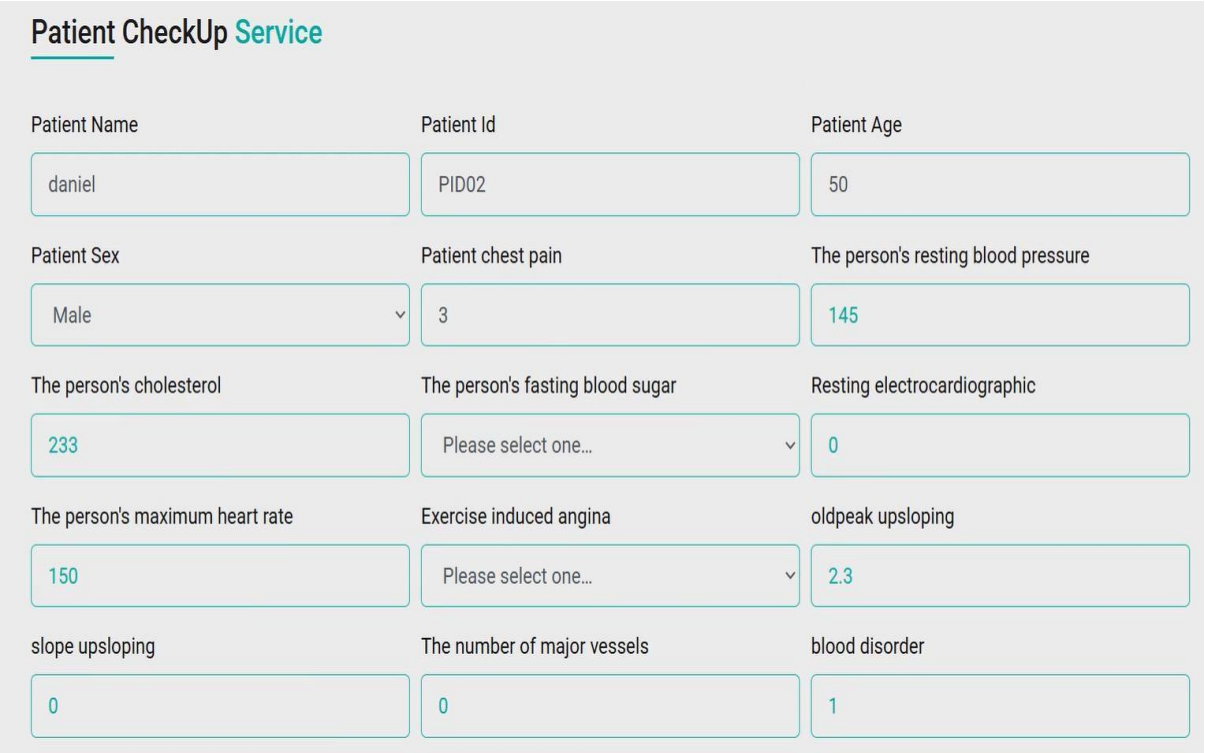


Fig A.11 Details of Patient filled by Doctor after Check-up

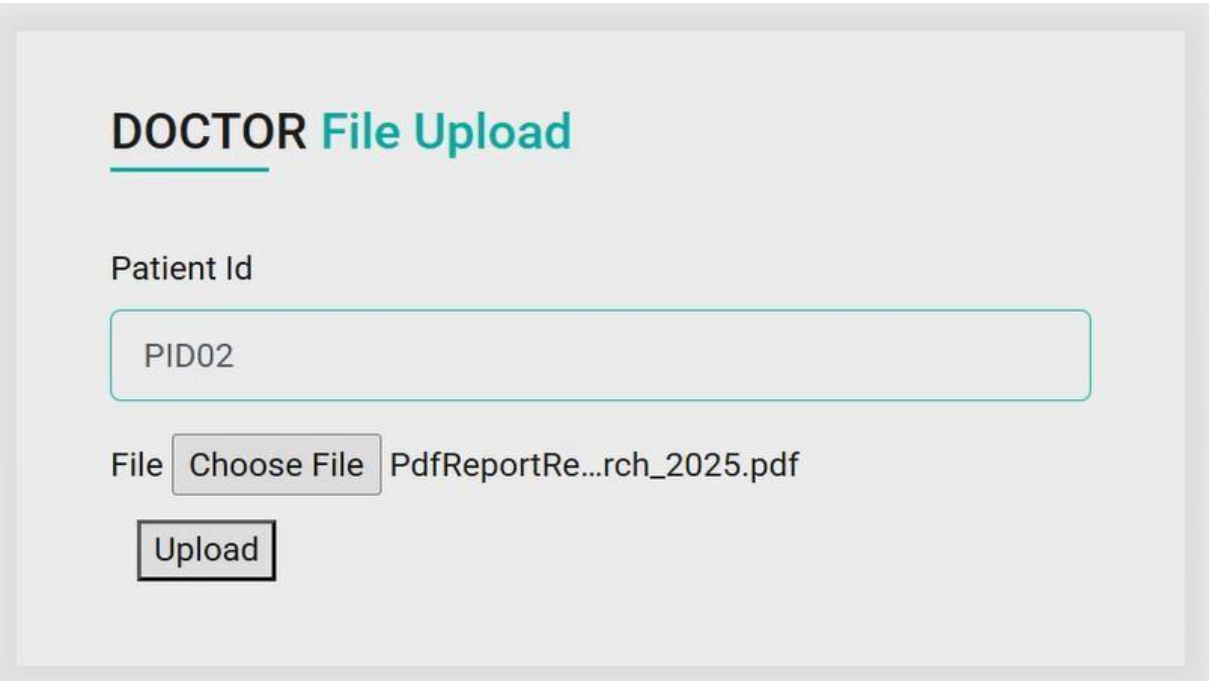


Fig A.12 Doctor Uploads the Report Generated to Store in IPFS

Dr. Demo Doctor
M.B.B.S,M.D,M.S | Reg. No. 123456
Mob. No : 1234567890

Care Clinic
No. 7 Demo street,
chennai-122
Ph:2222333444
Timing: 09.00 AM – 02.00 PM

Patient Name:daniel
Patient Age:50

Patient id:PID02
Gender:1

Diagnosis and History of Patient:

Chest Pain: 3

Rest Blood Pressure: 145

Cholestrol: 233

Fasting Sugar: 1

Resting ECG: 0

Heartrate: 150

Exercise Induced Angina: 1

Old Peak: 2.3

Slope: 0

Major Vessel Nos: 0

thalassemia: 1

GET WELL SOON

Report generated on "15 March 2025 13:37:31"

Fig A.13 Generated Report

Fig A.14 Confirmation Screen of Report Uploaded to IPFS

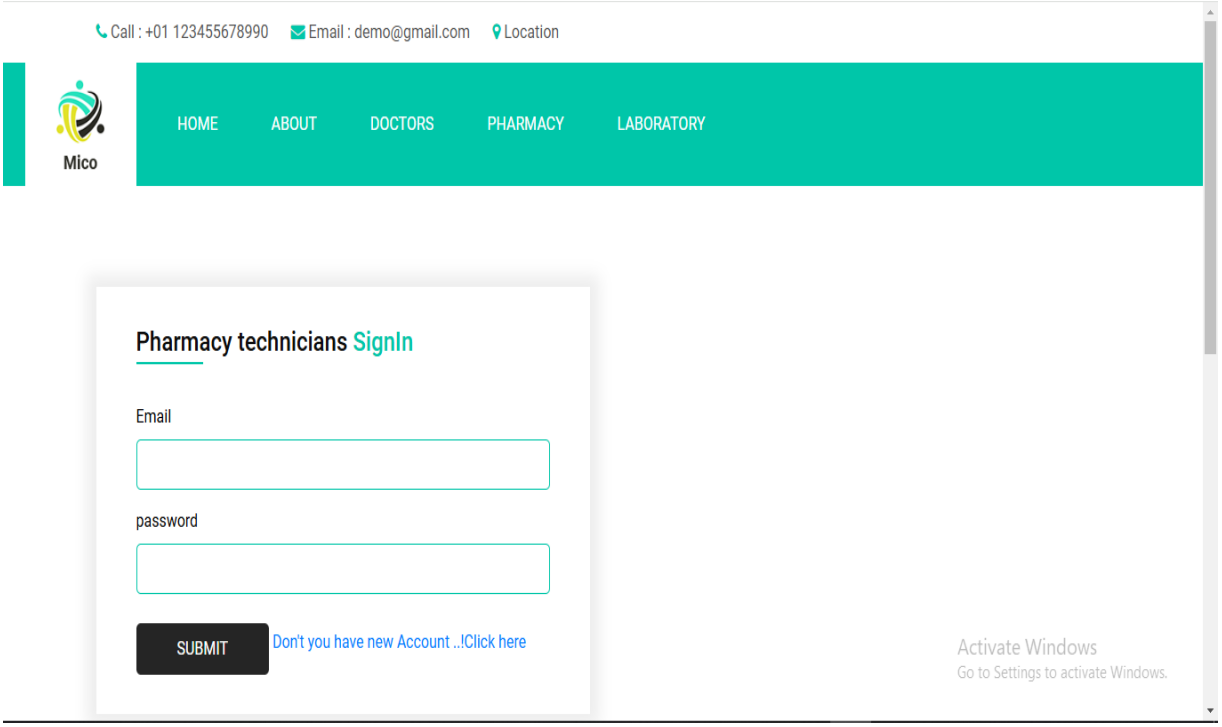


Fig A.15 Pharmacy Sign In

Fig A.16 Pharmacy Service Details

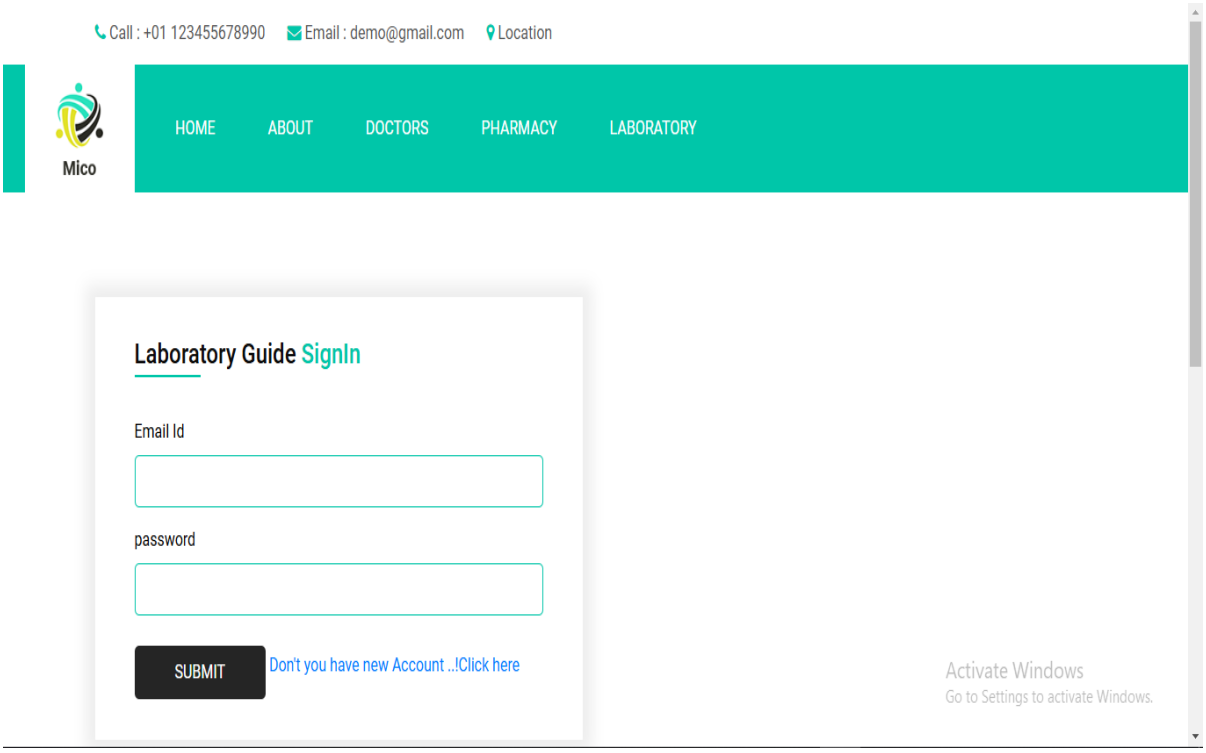


Fig A.17 Laboratory Sign In

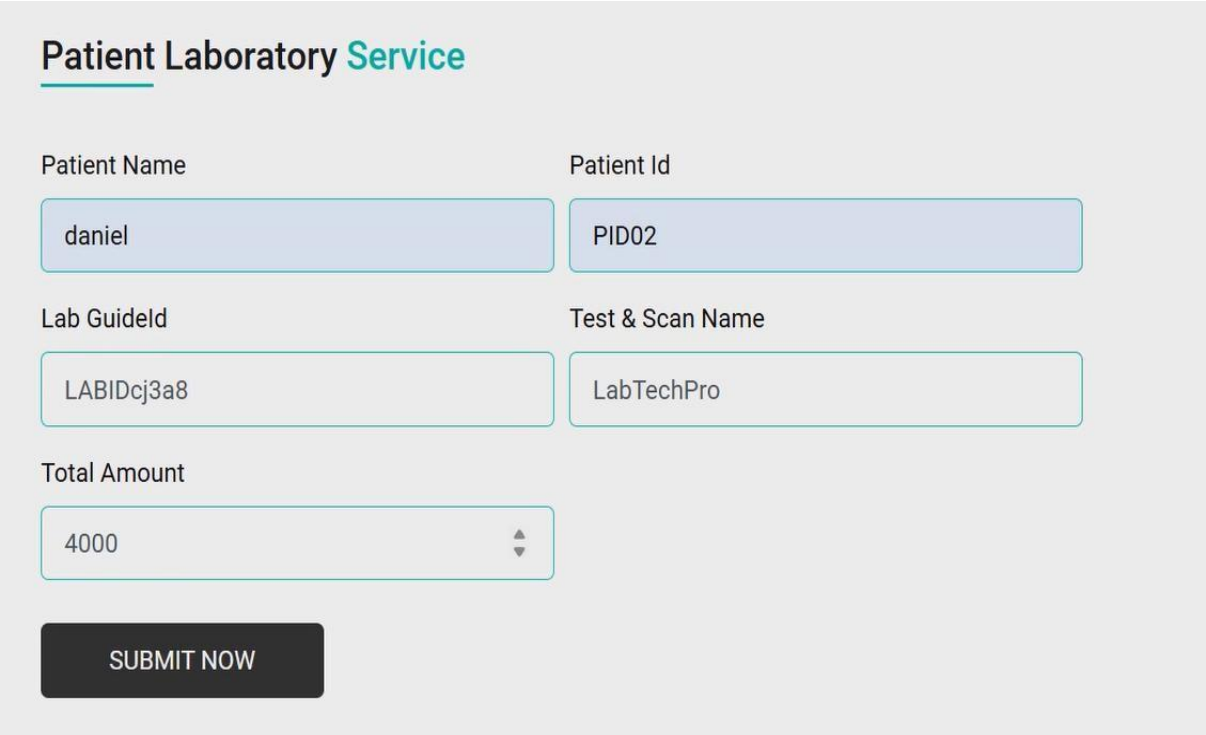


Fig A.18 Laboratory Service Details

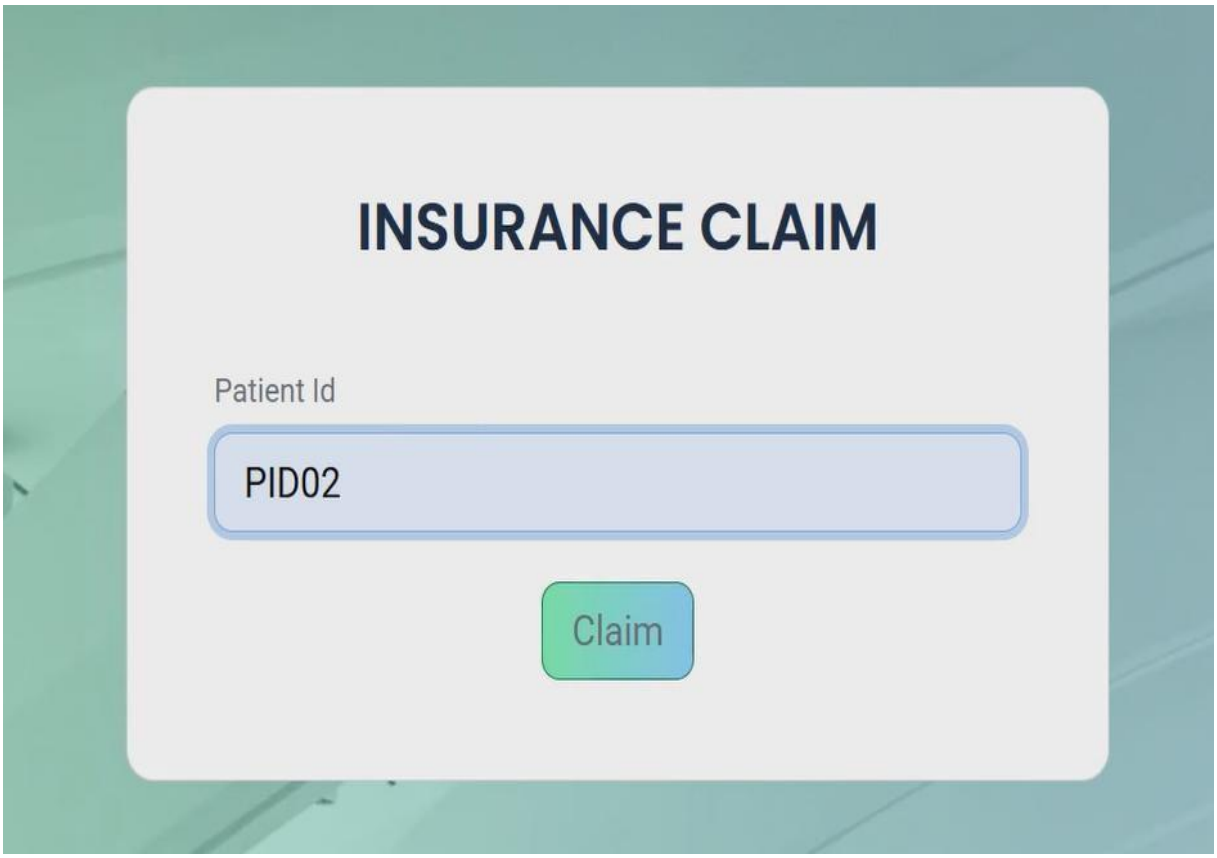


Fig A.19 Insurance Claim Page

Fig A.20 Insurance Claim Output Screen

A.4 PLAGARISM REPORT

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Healthcare Insurance Fraud Detection Using Blockchain and AI

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Abstract— Any major problem in healthcare insurance fraud can result in significant challenge, leading to financial losses and can also erode systemic confidence. With the increasing reliance on health insurance for covering medical expenses such as hospitalization, treatment, and preventive care, ensuring security and fraud prevention has become crucial. Conventional rule-based fraud detection techniques find it difficult to keep up with changing fraudulent patterns. To address this, a blockchain and AI-powered system is introduced, leveraging blockchain for secure and tamper-proof data management and AI-driven analytics for intelligent fraud detection, enhancing transparency, accuracy, and security.

Keywords— Health insurance, fraud detection, blockchain, artificial intelligence, privacy, economic growth.

I. INTRODUCTION

Health insurance fraud is a growing global concern, causing significant financial losses and undermining trust in healthcare systems. Recent data reveals the staggering scale of this issue. Globally, healthcare fraud accounts for 6-10% of total healthcare expenditures, resulting in losses worth hundreds of billions annually. In the U.S., fraud costs approximately $68 billion each year, while in India, 15-20% of health insurance claims are flagged as potentially fraudulent, leading to annual losses exceeding ₹10,000 crore.

Fraudulent activities are becoming increasingly sophisticated. Studies show that 40% of fraud cases involve collusion between providers, patients, and intermediaries, while 30% are linked to fabricated medical records or inflated billing. These practices drive up insurance premiums by 10-15%, burdening genuine policyholders. Traditional detection systems, reliant on centralized databases and rule-based methods, are inadequate. Surveys indicate that 65% of insurers still use outdated systems, with 70% failing to detect emerging fraud patterns like AI-generated fake documents or blockchain-manipulated claims.

We provide a creative way to deal with these issues by combining blockchain and AI technologies. Blockchain ensures data security, immutability, and transparency, while AI enhances fraud detection accuracy. Our framework aims to reduce fraudulent claims by up to 40%, lower operational costs by 25%, and improve detection efficiency by 30%. This research seeks to transform health insurance fraud detection, safeguarding insurers and policyholders while fostering a more transparent and efficient healthcare ecosystem.

II. RELATED WORKS

Blockchain and artificial intelligence combined for healthcare insurance fraud detection has been widely studied to enhance security, data integrity, and fraud prevention. Various methodologies have been explored, leveraging machine learning, blockchain-based smart contracts, and big data analytics.

A blockchain-powered fraud detection system employing Random Forest, SVM, and Decision Tree demonstrated improved fraud identification accuracy and resistance to data manipulation [1]. A hybrid approach combining supervised and unsupervised learning showcased superior fraud detection over rule-based methods, though dataset preprocessing remained a challenge due to class imbalance [2].

Blockchain's application in securing insurance transactions through smart contract-based fraud prevention frameworks has ensured transparency, traceability, and security, although legacy system integration remains a significant challenge [3]. Benchmarking of Naïve Bayes, XGBoost, and Deep Learning models revealed that ensemble methods achieve superior fraud detection accuracy, albeit with increased computational overhead [4]. Unsupervised learning techniques, including Autoencoders and Isolation Forests, have been effective for anomaly detection, but high false-positive rates pose an ongoing challenge [5].

The adoption of Hyperledger Fabric and Ethereum-based smart contracts has enhanced fraud detection auditability, but concerns regarding scalability and transaction costs persist [6]. AI-driven frameworks leveraging feature engineering and predictive analytics on historical claims data have improved fraud detection rates but require extensive labeled datasets for optimal model performance [7]. Deep learning models such as CNN and LSTM have achieved high fraud detection accuracy, yet their real-world applicability is constrained by computational complexity and data requirements [8].

Hybrid AI-blockchain approaches integrating smart contracts and anomaly detection models have enhanced fraud detection efficiency, though blockchain transaction latency remains a limitation [9]. To address class imbalance, resampling techniques such as SMOTE and ADASYN have been employed, improving classification accuracy but sometimes introducing synthetic noise [10]. Blockchain-based frameworks integrating smart contracts for fraud prevention have improved data transparency and security, although computational costs and scalability issues persist [11]. AI-based fraud detection employing K-means clustering has enhanced anomaly detection in medical claims, outperforming rule-based approaches while facing challenges with high false-positive rates due to dataset variability [12].

Implementations utilizing BigchainDB have improved insurance transaction security and claims processing efficiency, though interoperability limitations hinder broader adoption [13]. Studies benchmarking ensemble and deep learning models for fraud detection in medical claims indicate that ensemble methods improve accuracy but require substantial computational resources, highlighting a trade-off between precision and efficiency [14]. Porter's value chain and Berliner's insurability criteria have been used to assess how digitization affects insurance fraud, revealing increased operational efficiency but heightened cybersecurity risks, necessitating regulatory adaptations [15]. AI-based fraud detection techniques leveraging supervised learning methodologies have shown promise in recognizing fraudulent claims but require further advancements in false-positive reduction [16].

Privacy and security concerns in healthcare big data applications have been addressed using real-time monitoring and encryption techniques, with ongoing concerns about vulnerabilities in patient data protection [17]. A big data analytics framework for fraud detection utilizing Hadoop has been developed, improving Electronic Health Record (EHR) management, although scalability remains a concern [18]. Digitalization's effect on insurance risk assessment has been studied using Porter's value chain, highlighting efficiency gains while emphasizing regulatory challenges and data security risks [19]. A big data-driven e-health insurance model using Infinispan and MapReduce has improved data segregation and extraction, though challenges in data consistency and privacy persist [20].

Protection of Electronic Health Records (EHRs) during storage and transmission has been studied, proposing secure encrypted storage with controlled access, enhancing HIPAA compliance but requiring better interoperability mechanisms [21]. Blockchain technology's benefits and threats in healthcare fraud detection have been categorized, highlighting enhanced security and data tracking, though energy consumption and interoperability remain adoption barriers [22].

The ML models like SVM and clustering have been used in healthcare to detect fraud using big data analytics, outperforming traditional rule-based methods but requiring better data integration strategies for handling heterogeneous datasets [23]. Medicare fraud detection studies emphasize the need for standardized preprocessing techniques to

enhance machine learning effectiveness, addressing gaps in data fusion methodologies [24]. AI-driven security frameworks integrating blockchain have been proposed for healthcare data protection, with models such as SVM, KNN, and VFDT proving effective in anomaly detection, though high computational costs remain a constraint [25].

This literature review highlights the growing importance of blockchain-based and AI-powered healthcare to detect fraud, showcasing advancements in machine learning models, big data analytics, and blockchain-based security mechanisms. While significant progress has been made, challenges such as scalability, interoperability, computational costs, and false-positive rates need to be addressed to enhance the efficiency and reliability of these fraud detection frameworks.

III. PROPOSED MODEL

The proposed system consists of three main layers:

1. Data Storage and Management Layer

This layer secures patient records and insurance claims using InterPlanetary File System (IPFS) and blockchain. Each record is hashed before storage, ensuring immutability:

$$H(D_p) = SHA_{256}(D_p)$$

$$CID(D_p) = IPFS\left(H(D_p)\right)$$

Where, D_p is patient data, and CID is a unique identifier for retrieval. Blockchain blocks store claim hashes, preventing unauthorized modifications.

2. Fraud Detection Layer

AI models analyze historical claims to identify fraudulent activities. The system uses Random Forest Classifier.

$$F(x) = \frac{1}{N}\sum_{i=1}^{N} f_i(x)$$

where fi (x)→ prediction from each tree.

3. Claim Verification Layer

Smart contracts automate claim validation:

$$V(C_i) = \begin{cases} 1, if\ P(F) < \theta\ and\ CID(C_i) exist \\ 0, otherwise \end{cases}$$

V(Ci)→ The claim verification function, which outputs 1 (valid) or 0 (fraudulent).
Ci → The given insurance claim under verification.
P(F) → The fraud probability score assigned to the claim by AI-based fraud detection models.
θ → The fraud detection threshold, a predefined limit beyond which a claim is flagged as fraudulent.
CID(Ci)→ The Content Identifier (CID) linked to the claim in the InterPlanetary File System (IPFS) and blockchain.
1 (Approved Claim) → The claim is valid and gets approved for processing.
0 (Rejected Claim) → The claim is flagged as fraudulent and denied.

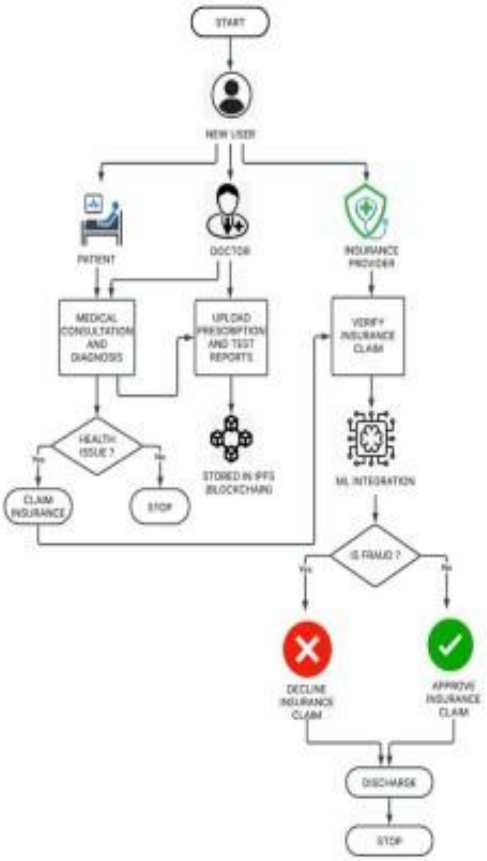

Fig.1. Blockchain and AI-Empowered Healthcare Fraud Detection System Architecture

Patients undergo diagnosis, and doctors upload reports to IPFS. The insurance provider verifies claims using machine learning for fraud detection. Approved claims proceed, while fraudulent ones are declined, ensuring a secure, transparent, and efficient healthcare insurance system.

IV. METHODOLOGY

Data collection, preprocessing, fraud detection, blockchain integration, and smart contract execution are all steps in a structured methodology that makes fraud detection in the healthcare insurance industry safe, scalable, and effective.

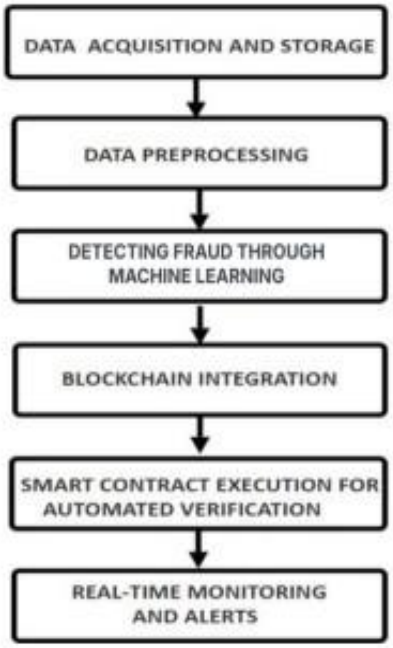

Fig. 2. Flow Diagram

1. Data Acquisition and Storage

Healthcare claim records, including patient details, diagnosis reports, treatments, and billing history, are collected from hospitals and insurance firms. Key attributes like age, blood pressure, cholesterol, heart rate etc. help assess heart disease risk. Data is securely stored in IPFS, assigned a unique CID, and linked to blockchain for integrity verification, ensuring fraud prevention and secure medical record management.

2. Data Preprocessing

Raw claim data undergoes preprocessing to enhance accuracy and consistency. Normalization standardizes numerical values, feature selection extracts key attributes like claim amount and patient history, and anomaly detection identifies suspicious patterns, improving the efficiency and reliability of AI-driven fraud detection models.

3. Detecting Fraud Through Machine Learning

Algorithms for machine-learning are trained on labeled historical claims to classify future claims as legitimate or fraudulent. The fraud detection model utilizes Random Forest, to analyze transaction patterns.

4. Blockchain Integration

Once classified, claim records are stored on a private blockchain network to ensure immutability and transparency. Each claim's transaction hash is linked to the previous block, forming a tamper-proof ledger. The system employs the SHA-256 hashing algorithm to generate cryptographic proof of data integrity. If any data alteration occurs, the blockchain invalidates the modified record due to hash mismatches.

5. Smart Contract Execution for Automated Verification

Smart contracts are self-executing scripts that automate claim validation by verifying predefined conditions. Upon claim submission, they check policy coverage eligibility using blockchain records, assess fraud risk based on AI model predictions, and ensure hospital authenticity and treatment consistency before approving or rejecting payments, reducing manual intervention and fraud.

Fig. 3. IPFS file storage

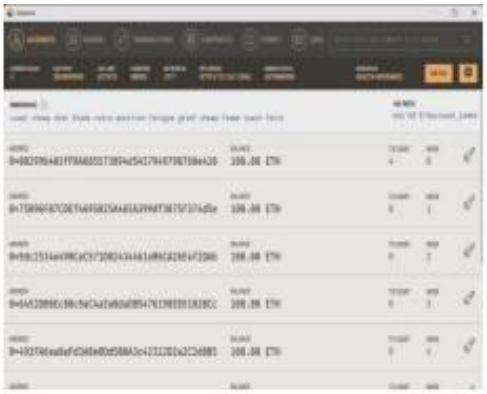

Fig. 4. Transaction blocks in Ganache

6. Real-Time Monitoring and Alerts

The system dynamically updates fraud detection models and alerts insurers for review if fraud is detected. Integrating machine learning, blockchain, and smart contracts ensures secure, transparent, and efficient claim processing.

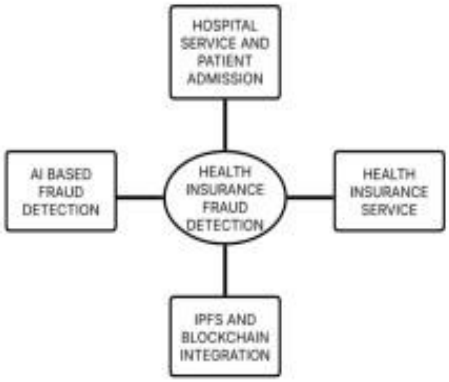

Fig. 5. Module Diagram

The system integrates hospital management, insurance services, and AI-driven fraud detection using blockchain and IPFS for secure, transparent data handling.

V. RESULTS AND DISCUSSION

The proposed AI and blockchain-integrated fraud detection system demonstrates significant improvements in accuracy, efficiency, and security. Experimental results show that the Random-Forest model surpasses the previously used Gradient-Boosting algorithm, achieving 90% accuracy opposed to 89%. This improvement enhances fraud detection reliability while reducing false positives and false negatives.

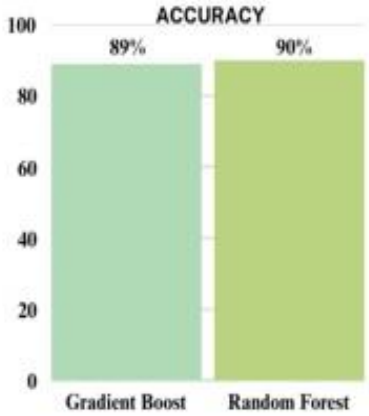

Fig. 6. Performance Comparison

Compared to traditional rule-based systems, AI-driven models especially Random Forest demonstrate superior fraud detection by analyzing transaction patterns and anomalies more effectively. The system's ability to detect fraudulent claims in real time not only reduces financial losses but also strengthens user trust in healthcare insurance.

Fig. 7. Output screen

The combination of blockchain and AI significantly enhances fraud detection efficiency, reducing processing time and administrative costs. User trust is improved due to blockchain's transparent and immutable nature. Future improvements will focus on enhancing fraud detection accuracy using deep learning models and optimizing blockchain scalability for large-scale implementations.

VI. CONCLUSION

A paradigm shift in healthcare insurance fraud detection is brought about by the combination of blockchain technology and artificial intelligence, which addresses vulnerabilities with a combination of security, transparency, and automation. Our proposed framework revolutionizes fraud prevention by leveraging blockchain to ensure tamper-proof data storage and AI's predictive analytics to detect fraudulent claims with enhanced precision.

By incorporating InterPlanetary File System (IPFS) for secure storage and smart contracts for automated claim verification, the system eliminates the risk of data manipulation and unauthorized alterations. This not only enhances trust among insurers, healthcare providers, and policyholders but also significantly reduces operational inefficiencies, lowering administrative costs and expediting the claim settlement process. Our framework has the potential to reduce fraudulent claims by up to 40%, decrease false positives, and enhance overall detection accuracy, ultimately creating a more resilient and fraud-resistant insurance ecosystem.

Beyond fraud detection, this integration fosters broader implications for the healthcare industry. Secure and transparent patient records and automated verification processes contribute to a more accountable and efficient insurance landscape. As digital transformation continues to redefine the healthcare sector, our model sets a new standard for fraud prevention, ensuring financial sustainability, ethical practices, and consumer trust. By embracing blockchain and AI, we not only mitigate the risks associated with fraud but also open the door to a future in which health insurance is more effective, safe, and equitable for all stakeholders.

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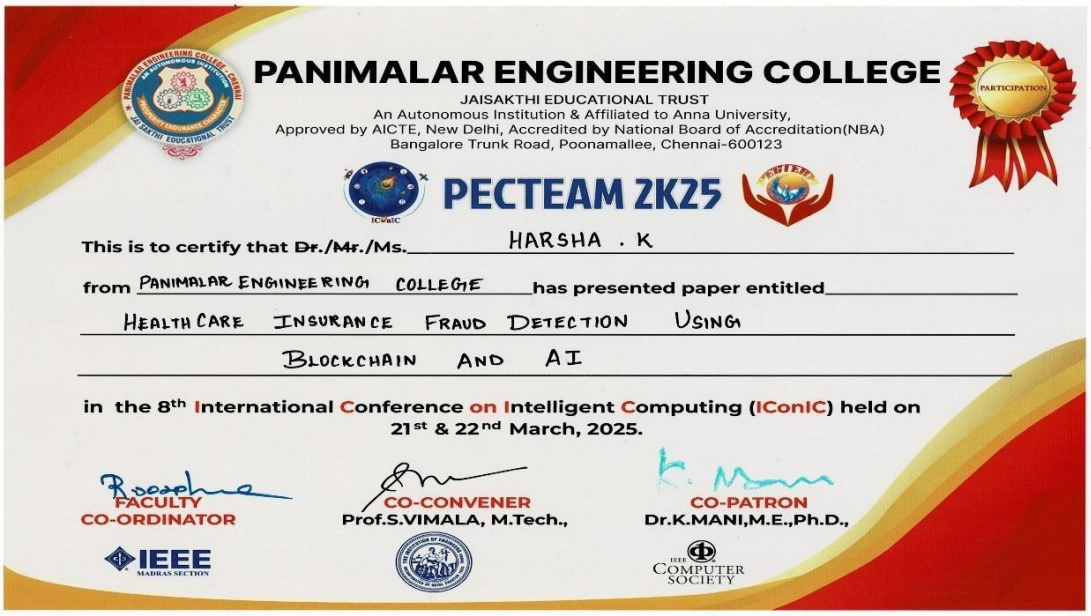
A.5 PAPER PUBLICATION

Participated and presented our paper titled "HealthCare Insurance Fraud Detection Using Blockchain and AI" in the 8th International Conference – **ICONIC 2K25** held at Panimalar Engineering College on 22.03.2025.



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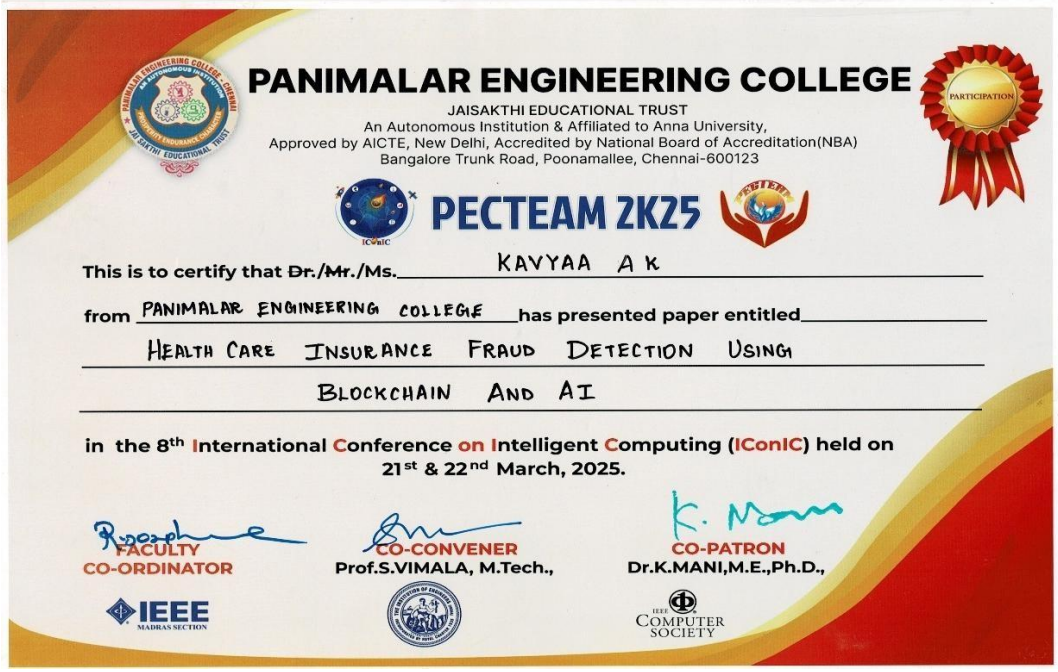
This is to certify that ~~Dr./Mr.~~/Ms. HARSHA . K
from PANIMALAR ENGINEERING COLLEGE has presented paper entitled
HEALTH CARE INSURANCE FRAUD DETECTION USING
BLOCKCHAIN AND AI
in the 8th International Conference on Intelligent Computing (IConIC) held on 21st & 22nd March, 2025.

FACULTY CO-ORDINATOR
CO-CONVENER Prof.S.VIMALA, M.Tech.,
CO-PATRON Dr.K.MANI,M.E.,Ph.D.,



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