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NitiLedger: A Blockchain based Public Fund Allocation, Tracking and Fraud Detection System Using Hyperledger Fabric

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Abstract: Public fund allocation and tracking is a important role of public administration, but existing systems face problems such as corruption, lack of transparency, delays in auditing, tampering of documents, and poor tracking of records within system. Many-a-times ,centralized systems also face unauthorized changes in data, leading to fraudlent projects and improper management of funds. To solve this, paper proposes a blockchain-based public fund allocation system which helps in tracking funds and helps in fraud detection which is implemented using Hyperledger Fabric.

This system aims to provide transparent and integrated system for all financial transactions and project documents. Documents will be stored offline using object storage, and their corresponding hashes will be stored online using blockchain algorithm to ensure integrity. This system also provides biometric-based authentication for identity verification and helps in fraud detection which is based on some rules. The system provides role-based dashboards for administrators, government officers, contractors, auditors, and citizens.

This system aims to improve governance by ensuring transparency, integrity, and accountability for public funds
mangement.

Index Terms **-** Blockchain, Hyperledger Fabric, Public Fund Tracking, Fraud Detection, E- Governance, Document Verification, Audit Logs

I. INTRODUCTION

Many government infrastructure development schemes, welfare measures, and service delivery projects involve allocation and distribution of funds to various departments. The efficient management and tracking of funds is a major issue in public administration. Traditional methods of fund management is centralized and highly relies on documentation and manual data entry into database. This might lead to corruption, tampering of documents, unauthorized disbursal of funds, and lack of accountability.

One of the main issues in the management of funds is the lack of real- time tracking and auditing of funds.It is difficult to track the utilization of funds in the proper execution of the projects due to the lack of transparency between departments.

Blockchain is a decentralized technology that provides a ledger in which data cannot be altered or changed once it has been recorded. This technology provides transparent, accountable, and traceable methods for all financial transactions. Hyperledger Fabric is a blockchain platform which provides a permissioned blockchain network which helps to perform various operations in enterprise and government applications. This network helps in providing identity management, access control, and smart contract execution with high transaction capacity.

This paper proposes a blockchain-based solution for public fund allocation, milestone tracking, document verification, biometric authentication, fraud detection, and audit logging, which can be referred to as NitiLedger. This solution ensures secure fund tracking, prevents document tampering, detects fraud, and provides transparency through a public interface.

II. OBJECTIVES

- To design a transparent public fund allocation system.
- To monitor the utilization of funds at various level of the project completion
- To prevent tampering of documents by using hash verification.
- To implement biometric identity verification.
- To detect fraud using rule-based methods.
- To maintain immutable audit logs using blockchain technology.
- To provide transparency using a citizen dashboard.
- To enhance accountability in government fund management.
- To prevent corruption and financial fraud.
- To implement role-based access control to enhance security.

III. LITERATURE REVIEW

Blockchain technology plays a vital role and as a promising solution for improving transparency, accountability, traceability, and security. Many researchers have explored the application of blockchain frameworks such as Hyperledger Fabric and Ethereum in domains like fund tracking, e-governance, decentralized auditing, and secure transaction management. Here, are some of the existing research works relevant to the proposed NitiLedger system and their limitations which helps in identifying research gap.

3.1 Existing Research.

[1] Blockchain for Government Fund Tracking Using Hyperledger

The paper *"Blockchain for Government Fund Tracking Using Hyperledger"* proposed a blockchain-based framework for monitoring public fund allocation and utilization using Hyperledger technology. The primary objective of the system was to improve transparency. This demonstrates how blockchain technology can provide immutable transaction records.

However, the system lacks in functionalities like fraud detection, biometric verification, decentralized document validation, audit analytics, citizen participation mechanisms, and role-based access control..

NitiLedger extends this work by integrating AI-based fraud detection, biometric authentication, milestone-based fund verification, immutable audit logging, decentralized document verification using SHA-256 hashing, citizen-driven milestone validation, and role-based dashboards for multiple stakeholders.

[2] Hyperledger, Ethereum and Blockchain Technology: A Short Overview

The paper *"Hyperledger, Ethereum and Blockchain Technology: A Short Overview"* represents a comparative study of technologies including Hyperledger Fabric and Ethereum. This paper explained blockchain fundamentals, consensus mechanisms, peer-to-peer architecture, smart contracts, distributed ledgers, and permissioned blockchain infrastructure.
The paper highlighted that Hyperledger Fabric is more suitable for enterprise and government applications due to its permissioned architecture, scalability, and strong access control features. Important components such as peer nodes, ordering services, chaincode execution, certificate authorities, and membership service providers (MSP).

Paper provided strong conceptual base regarding blockchain architecture, it did not focus on practical
implementation.NitiLedger applies the architectural concepts of Hyperledger Fabric in a real-world governance environment involving secure public fund allocation, fraud prevention, citizen transparency monitoring, geotagged milestone verification, and transparent audit management.

[3] Design of Trading Energy System Management Using Blockchain Hyperledger Fabric

"Design of Trading Energy System Management Using Blockchain Hyperledger Fabric" proposed a blockchain-based peer-to-peer energy trading management framework using Hyperledger Fabric. This system aims to provide secure and transparent electricity trading while maintaining transaction privacy and integrity.
The main key contributions of the paper was the implementation of Hyperledger Caliper benchmarking for evaluating blockchain network performance. It analyzed metrics like transaction throughput, latency, scalability, and transaction validation time under different networking conditions. The outcome was that Hyperledger Fabric helps in efficient handling of transactions with high volumes with better performance.
However, the proposed framework was specific to energy trading applications and did not include governance functionalities such as public fund monitoring, fraud detection, milestone validation, citizen auditing, or secure document verification.
NitiLedger adopts similar scalable blockchain deployment strategies and extends them for e-governance applications by integrating fraud analytics, citizen-based milestone verification, audit logging, secure document management, and role-based monitoring capabilities.

[4] E-Governance: A Tendering Framework Using Blockchain With Active Participation of Citizens

"E-Governance: A Tendering Framework Using Blockchain With Active Participation of Citizens" introduced a blockchain-based e-tendering platform designed to improve transparency and accountability in government systems. It used Ethereum blockchain technology to create decentralized and immutable tender management records.
The study emphasized citizen participation in governance by allowing citizens to monitor tender activities and track the utilization of public resources. The proposed model addressed problems such as corruption, centralized control, and lack of transparency in conventional tendering systems but lacks in verifying and reviewing the reports.The Ethereum based implementation provides decentralization and transparency ,however public blockchain deployment introduces challenges such as gas transaction costs, scalability limitations, higher operational expenses, and lower transaction throughput under heavy network usage.

[5] Leveraging Zero-Knowledge Proofs for Blockchain Interoperability

*"Leveraging Zero-Knowledge Proofs for Blockchain Interoperability"*is a advanced cryptographic approaches for secure communication and interoperability between distributed blockchain networks. This paper focuses on privacy-preserving authentication, replay attack prevention, secure identity verification, and cryptographic validation using zero-knowledge proof techniques.
It discusses about advanced blockchain security models and emphasized the importance of trust validation mechanisms and secure communication protocols in decentralized systems.

However, the primary focus was on cryptographic interoperability and did not address practical governance workflows such as public fund tracking, fraud monitoring, citizen transparency systems, geotagged evidence validation, or decentralized audit management.
NitiLedger system incorporates several security oriented principles from by this research, including secure authentication, immutable transaction verification, secure communication, citizen-driven project validation, and future blockchain interoperability possibilities.

A. Citizen Based Milestone Verification

NitiLedger system helps in a citizen driven milestone verification mechanism which aims to improve transparency and accountability in public projects and in tendering system. Citizens residing near the project area can upload geotagged photographs of ongoing or completed work through the public transparency dashboard.

The uploaded images contain:

- GPS coordinates.
- Timestamp metadata.
- Project ID or Project name.
- Milestone reference information.
- Device-related information.

The system compares the uploaded citizen photos which acts as the evidence with contractor-submitted milestone reports which helps in validating the actual project progress. If inconsistencies or any suspicious activities are detected between contractor claims and citizen submissions, the fraud detection engine flags the milestone for auditor review.
To ensure the integrity, the uploaded image hash is stored on the blockchain using SHA-256 hashing algorithm, while the actual images are securely stored in decentralized object storage (MinIO/IPFS). This helps in enabling community driven auditing and enhances trust, transparency, accountability in real time field verification.

B. Limitations of Existing Systems

Limitations can be observed in existing blockchain-based governance systems are:-

- Most systems focus only on transaction recording and transparency without integrating fraud detection mechanisms.
- Existing system does not provide milestone-based fund verification and approval workflows.
- Biometric identity verification for secure authorization is absent in most existing solutions.
- Many systems lack decentralized document verification mechanisms to prevent document tampering or missue.
- Existing governance models provide limited citizen transparency and real-time monitoring features.
- Citizen-driven geotagged milestone validation and real time project verification are absent in most of the cases
- Existing systems lacks to combine blockchain security, audit logging, document integrity, fraud detection, and citizen monitoring which NitiLedger overcomes it.

C. Research Gap

The reviewed literature demonstrates, blockchain has more potential to improve transparency and accountability in governance systems. However, existing systems mainly address isolated functionalities.

To overcome these limitations, NitiLedger system introduces a blockchain-based public fund allocation, tracking, fraud detection, and citizen-based milestone verification framework using Hyperledger Fabric integrated with biometric authentication, fraud analytics, secure document verification, audit logging, role-based access control, and transparent citizen monitoring mechanisms.

D. Summary of Literature Review

Through blockchain technology one can significantly improve transparency, accountability, and security in governance and enterprise applications. Existing research has applied blockchain frameworks in domains such as e-governance, energy trading, and decentralized auditing. However, most existing systems lacks in integrated fraud detection, biometric verification, fund tracking, geotagged citizen validation, secure document integrity mechanisms, and intelligent governance analytics.

The proposed NitiLedger system helps in bridging up these research gaps by combining Hyperledger Fabric-based blockchain infrastructure with fraud detection, biometric authentication, decentralized document verification, citizen-based milestone validation, immutable audit logging, milestone-based project monitoring, and public transparency dashboards.

IV. PROPOSED SYSTEM

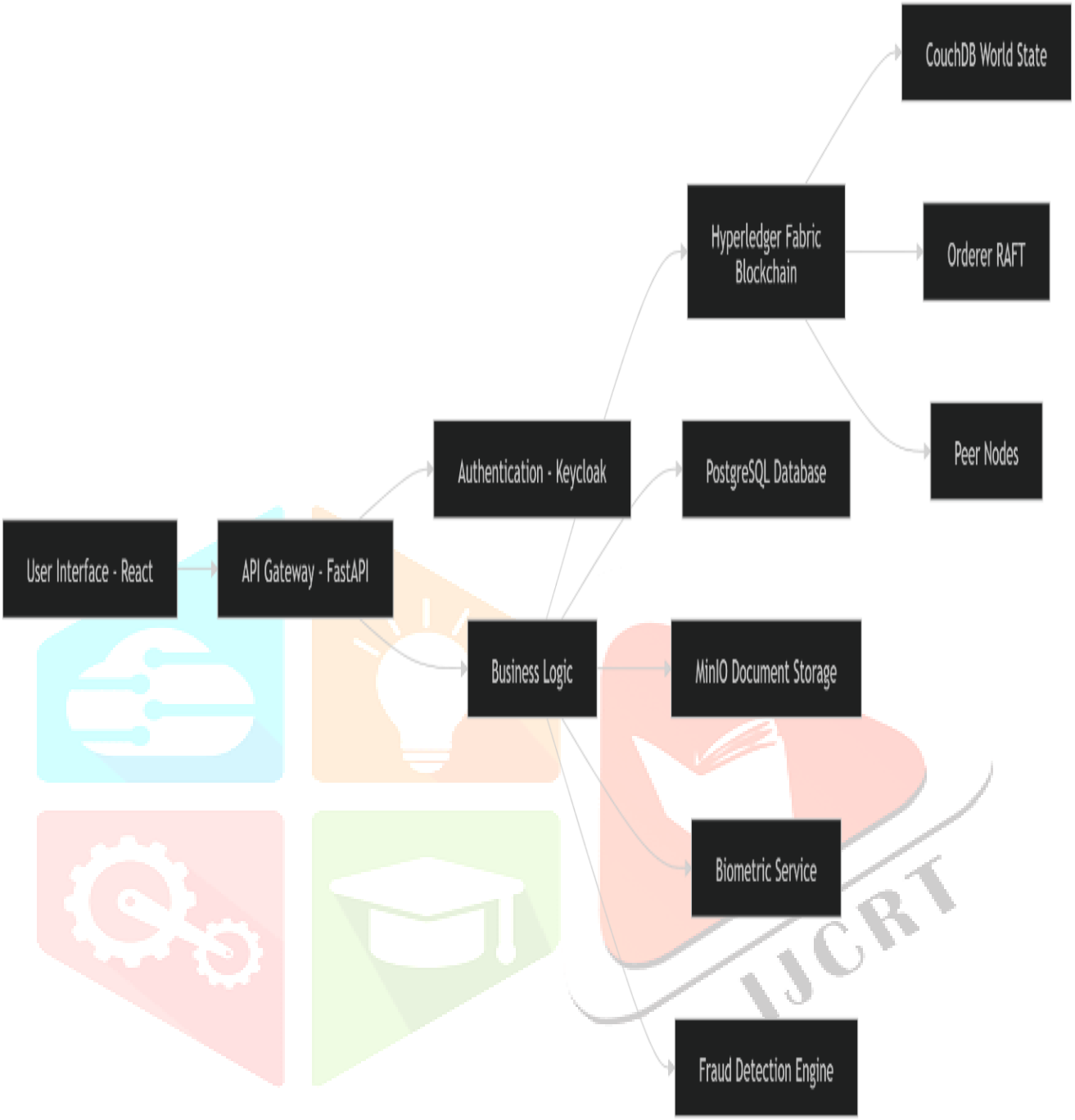

Figure 4.1: Proposed system overview

NitiLedger, is a blockchain-based system that is useful to manage the allocation of funds in the public sector, monitor the progress of projects, verify documents, detect fraud, and keep transparent records of audits.

The system is intended to be a multi-role system where administrators are responsible for creating projects and allocating funds, government officers are responsible for managing project milestones, contractors are responsible for uploading project documents, auditors are responsible for checking transactions, and citizens are responsible for viewing public project information.

The primary aim of the proposed system is to ensure that funds are allocated and utilized in the right manner, documents are not altered in any way, fraud is easily identified, and all activities are recorded in a transparent manner using the blockchain technology.

Main Modules of the System

- Authentication and Role Management
- Project and Fund Management
- Milestone Tracking
- Document Upload and Verification
- Blockchain Ledger Storage
- Fraud detection system
- Biometric Verification
- Audit Logs
- Public Transparency Dashboard

V. SYSTEM ARCHITECTURE

The system architecture of NitiLedger is based on a layered architecture, where each layer is designed for a specific purpose.

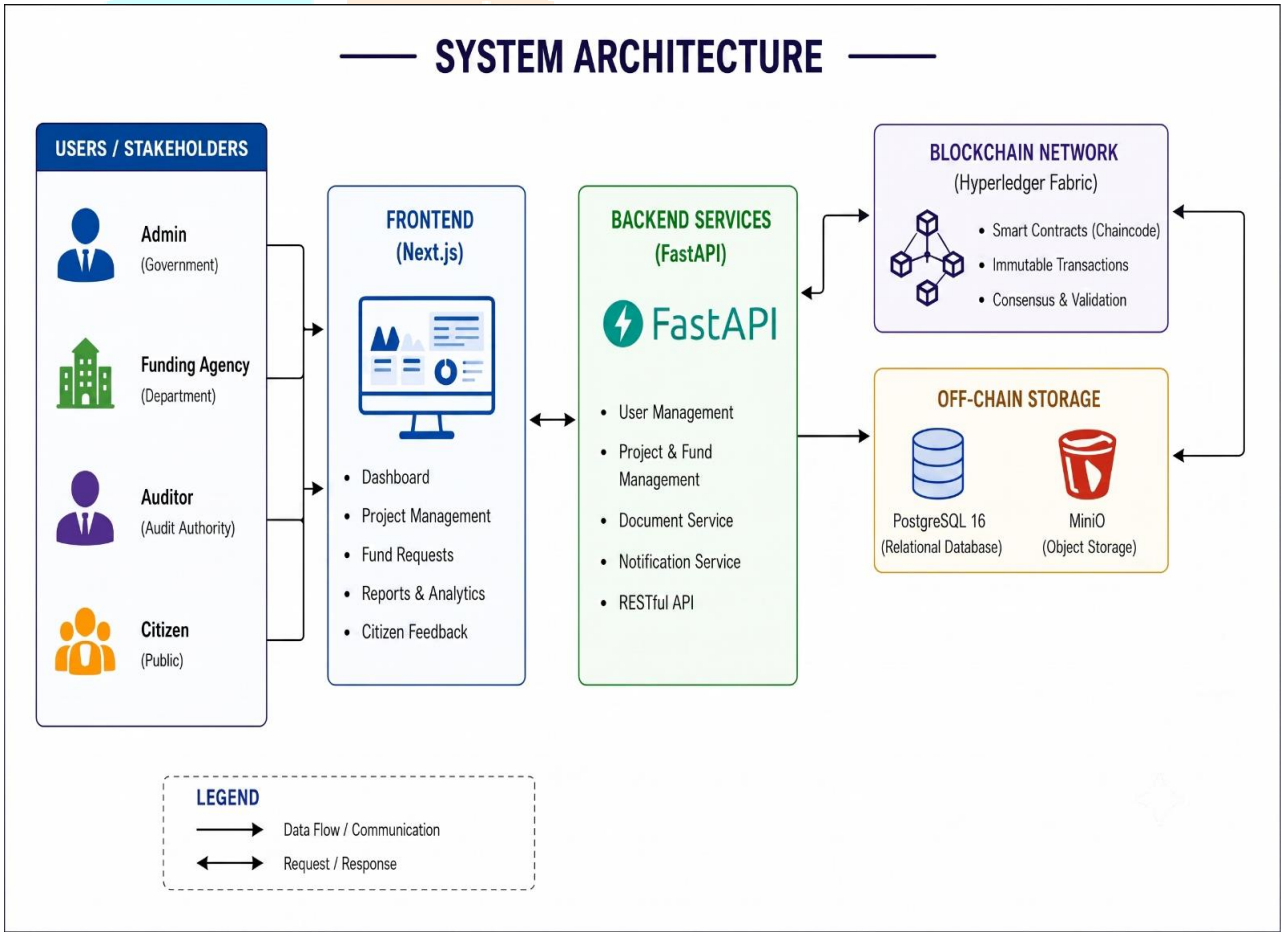

Figure 5.1: Proposed system overview

5.1 Layers of the System Architecture

1. Presentation Layer

   This layer includes web-based dashboards built using NextJs. Various dashboards are provided for admin, government officals, contractor, auditor, and citizen.

2. Application Layer

   This layer is built using FastAPI. This layer includes business logic, API requests, fraud detection logic, and communication with blockchain and database systems.

3. Identity Layer

   Keycloak is used for authentication, authorization, and role-based access control. This ensures that only authorized users can access the system.

4. Blockchain Layer

   Hyperledger Fabric is used for storing immutable transaction records, document hashes, and audit logs.

5. Storage Layer

   The PostgreSQL database is used for storing structured data like project information and fund transactions. MinIO is used for storing documents.

6. Analytics Layer

   This layer includes the fraud detection engine, which analyzes financial transactions and performs fraud detection.

VI. SYSTEM WORKFLOW

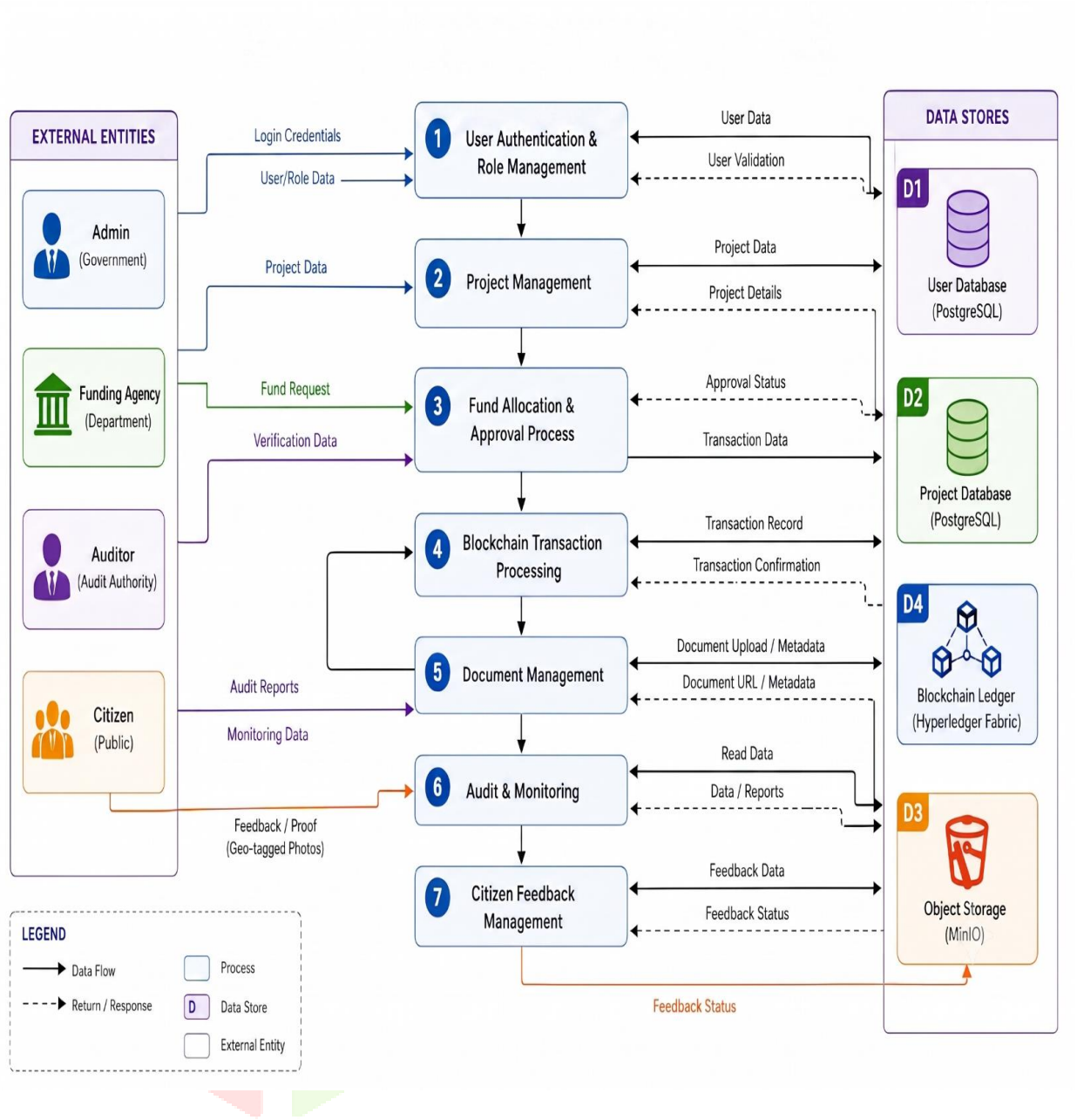

Figure 6.1 System Workflow

The system workflow describes how funds are allocated, documents are uploaded, verification of transactions, and fraud detection.

System Workflow Steps

1. The administrator creates a new government project in the system.
2. Funds are allocated to the project.
3. The contractor uploads documents such as invoices and progress reports.
4. The system generates a SHA-256 hash of the uploaded document.
5. The document is stored in secure storage, and the hash is stored on the blockchain.
6. The contractor performs biometric verification.
7. The fraud detection system analyses the transaction.
8. The auditor reviews suspicious or fraudulent transactions if any
9. Citizens can view project details on the public dashboard

VII. BLOCKCHAIN IMPLEMENTATION

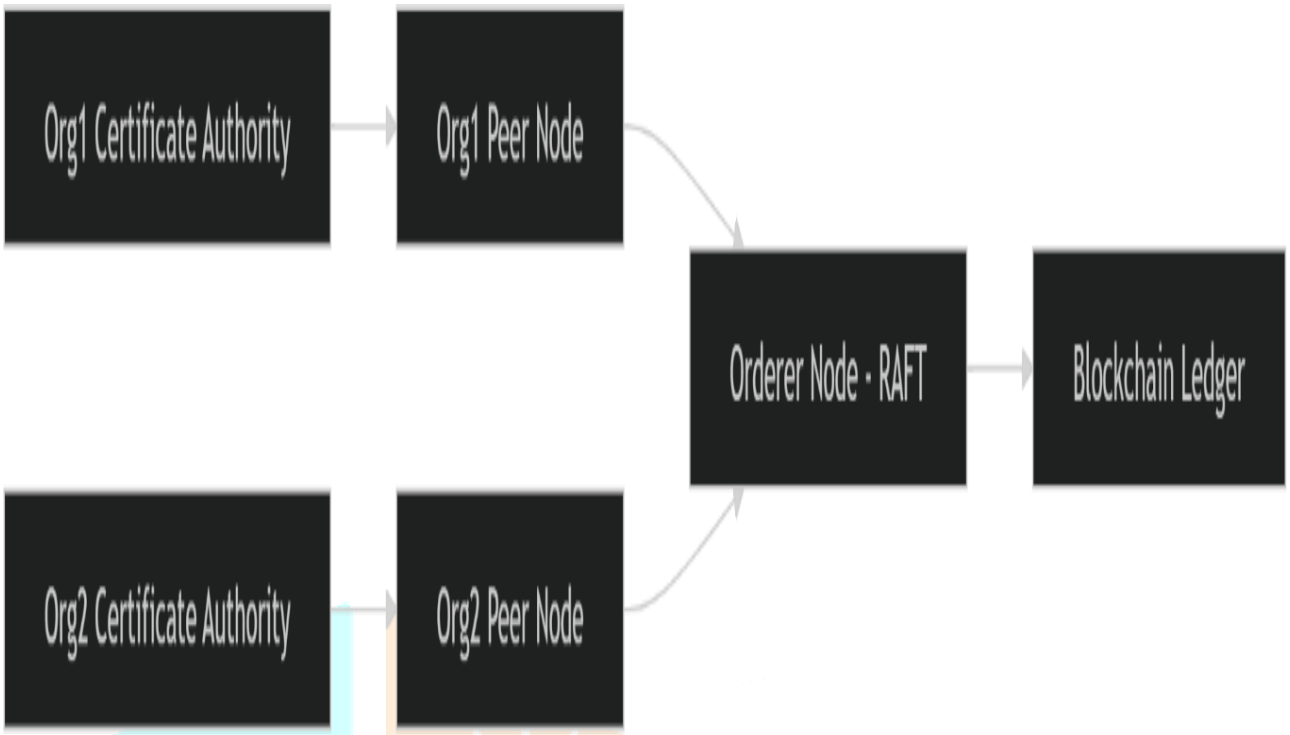

Figure 7.1 Blockchain Implementation overview

Here ,Hyperledger Fabric plays a vital role because it is a permissioned blockchain suitable for government and enterprise applications.

It stores:

- Fund allocation transactions
- Milestone approvals
- Document hashes
- Fraud alerts
- Audit logs

7.1 Blockchain Components

Component	Function
Peer Nodes	Store ledger copies
Orderer	Orders transactions into blocks
CouchDB	Stores world state data
Certificate Authority	Manages identities
Chaincode	Smart contract logic

7.2 Smart Contract Functions

- **CreateProject()** : This function is used to create a new project on the blockchain, and details like project ID, name, and budget are included. Once the project is created, it is immutable and cannot be changed. This ensures that all projects are uniquely identified and securely located in the system.
- **AllocateFunds()** : This function is used to allocate funds to a specific project, and the details of the fund allocation are recorded in the blockchain. It includes details like the amount, project ID, and timestamp. This ensures all fund allocations are transparent and traceable.
- **AddMilestone()** : This function is used to define the different stages of a project, and each stage has its own allocated budget and deadline. It helps in dividing the project into smaller stages for better tracking. Funds are released only after verifying the completion of the milestone stages.
- **StoreDocumentHash()** : This function is used to store the hash of the document, and it is done using SHA-256. The document is not stored in the blockchain, and only the hash is stored. If any change is made to the document, the hash will not match, indicating a change in the document.
- **VerifyMilestone()** : This function checks whether a milestone has been successfully completed based on submitted documents and conditions. If verification is successful, the system allows further actions like fund release. It prevents premature or fraudulent payments.
- **LogFraudAlert()** : This function is responsible for recording any suspicious or fraudulent activity detected in the blockchain. It stores the details of the fraudulent activity, such as the ID of the transaction, type of fraud, and the risk level. This helps in maintaining a permanent record of fraudulent activities.
- **RecordAuditLog()** : This function is responsible for recording all activities performed in the system. It includes all the activities performed by users.

VIII. FRAUD DETECTION SYSTEM

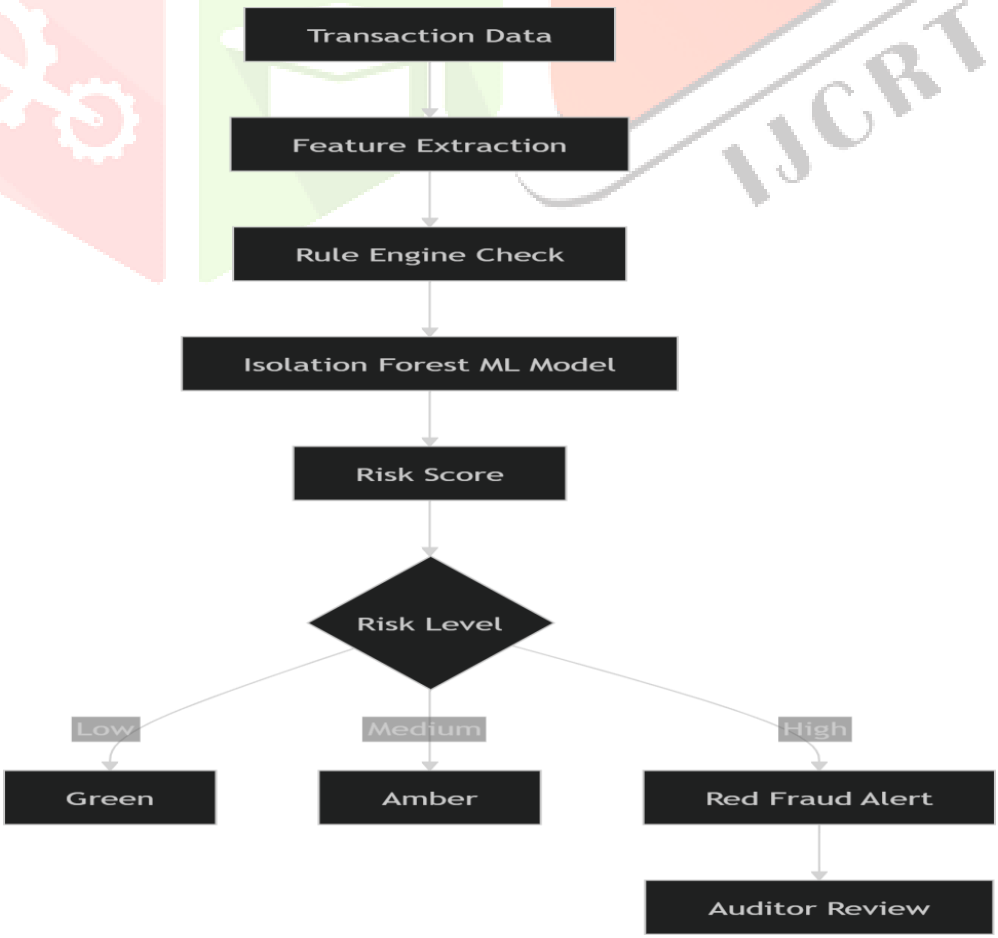

Figure 8.1 Fraud detection system

The fraud detection system is used to identify any suspicious financial transactions in the network and prevent misuse of public funds. The system will employ a hybrid approach to use both rule-based systems and machine learning-based anomaly detection.

8.1 Rule-Based Fraud Detection

Fraud will be detected if:

- Funds are released before completing milestones
- Invoice amount exceeds milestone budget
- Multiple fund releases within a short time
- Document hash mismatch detected
- Biometric verification fails
- Same contractor found repeatedly in multiple projects

IX. BIOMETRIC VERIFICATION

The verification of contractors and officers' identity through biometric verification is performed before approving their fund transactions or document submission.

The system incorporates facial recognition technology for verification purposes.

Biometric Verification Process

- User's live face image is captured.
- Image features are extracted.
- Image features are matched against stored image features.
- Similarity score is computed.
- If similarity score is above threshold → Verification is a success.
  If similarity score is below threshold → Verification is a failure

X. DOCUMENT VERIFICATION

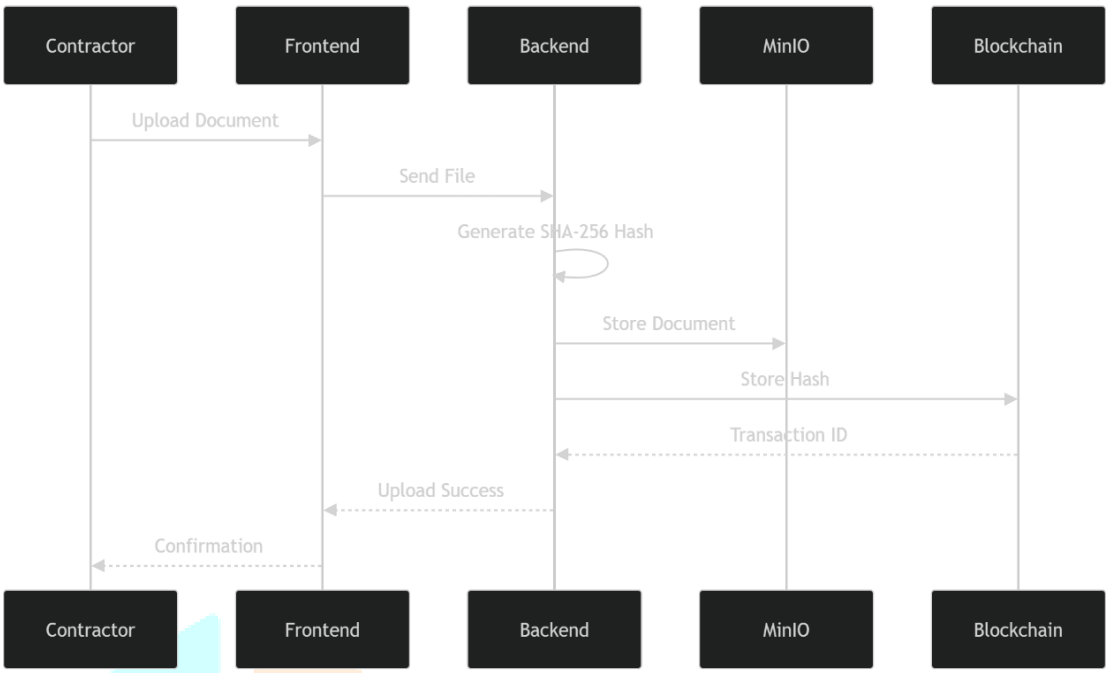

Figure 10.1 Document Verification

Document verification ensures that uploaded documents are not tampered after submission.

Document Verification Process

- Contractor uploads the document.
- System computes the SHA-256 hash of the document.
- Document is stored in MinIO storage.
- Hash is stored in the blockchain.
- Hash is recomputed during the verification process.
- Hash is compared with the hash stored in the blockchain.
- Hash matches? Then the document is valid.
- Hash does not match? Then the document is tampered.

XI. SECURITY ANALYSIS

The NitiLedger system includes multiple security mechanisms to protect data and transactions.

Security Feature	Purpose
Blockchain	Immutable transaction records
SHA-256 Hashing	Document integrity
TLS Encryption	Secure communication
RBAC	Role-based access control
Biometric Authentication	Identity verification
Audit Logs	Activity tracking
Smart Contracts	Automated validation

Security Benefits

The system prevents:

- Data tampering
- Unauthorized fund release
- Fake document submission
- Identity fraud
- Unauthorized system access

XII. COMPARSION WITH EXISTING SYSTEMS

Sr. No.	Research Paper	Main Contribution	Limitations of Existing System	How NitiLedger Overcomes the Limitation
1	*Blockchain for Government Fund Tracking Using Hyperledger*	Proposed a blockchain-based framework for transparent government fund tracking and immutable transaction recording using Hyperledger.	Lacks in fraud detection, biometric verification, decentralized document storage, citizen participation, and role-based access control. Scalability and performance evaluation were limited.	NitiLedger integrates fraud detection, biometric authentication, immutable audit logs, milestone-based fund release, decentralized document verification, citizen-driven milestone validation, and role-based dashboards.
2	*Hyperledger, Ethereum and Blockchain Technology: A Short Overview*	Provided comparative analysis of blockchain platforms such as Hyperledger Fabric and Ethereum, including consensus mechanisms and permissioned architecture.	Primarily conceptual and did not implement any real-world governance workflow or public monitoring system.	NitiLedger implements a governance architecture using Hyperledger Fabric with public fund allocation, fraud analytics, citizen monitoring, and secure audit management .
3	*Design of Trading Energy System Management Using Blockchain Hyperledger Fabric*	Developed a scalable blockchain-based energy trading system using Hyperledger Fabric and Hyperledger Caliper for benchmarking.	Domain-specific to energy trading and lacked governance functionalities such as public auditing, fraud detection, citizen validation, and document verification.	NitiLedger adopts scalable Hyperledger deployment strategies and extends them for e-governance.
4	*E-Governance: A Tendering Framework Using Blockchain With Active Participation of Citizens*	Introduced an Ethereum-based decentralized e-tendering framework with citizen participation and transparent procurement management.	Ethereum-based implementation involves gas transaction costs, scalability limitations, higher operational expenses, and lacked AI-driven fraud detection, biometric verification, geotagged milestone validation, and decentralized document integrity mechanisms.	NitiLedger overcomes these limitations by utilizing Hyperledger Fabric, which eliminates gas fees, provides higher scalability, faster transaction processing, controlled access, and enterprise-grade security. Additionally, NitiLedger integrates AI-driven fraud detection, biometric authentication, blockchain-based document hashing, geotagged citizen milestone verification, immutable audit logging, and secure multi-role governance monitoring.

5	*Leveraging Zero-Knowledge Proofs for Blockchain Interoperability*	Proposed advanced blockchain interoperability and privacy-preserving authentication using cryptographic zero-knowledge proof mechanisms.	Focused mainly on interoperability and cryptographic security without addressing governance workflows, public fund monitoring, or citizen transparency systems.	NitiLedger incorporates secure authentication, immutable blockchain verification, citizen-driven project validation, secure communication mechanisms, and future interoperability support for government deployment.

XIII. EXPERIMENTAL RESULTS

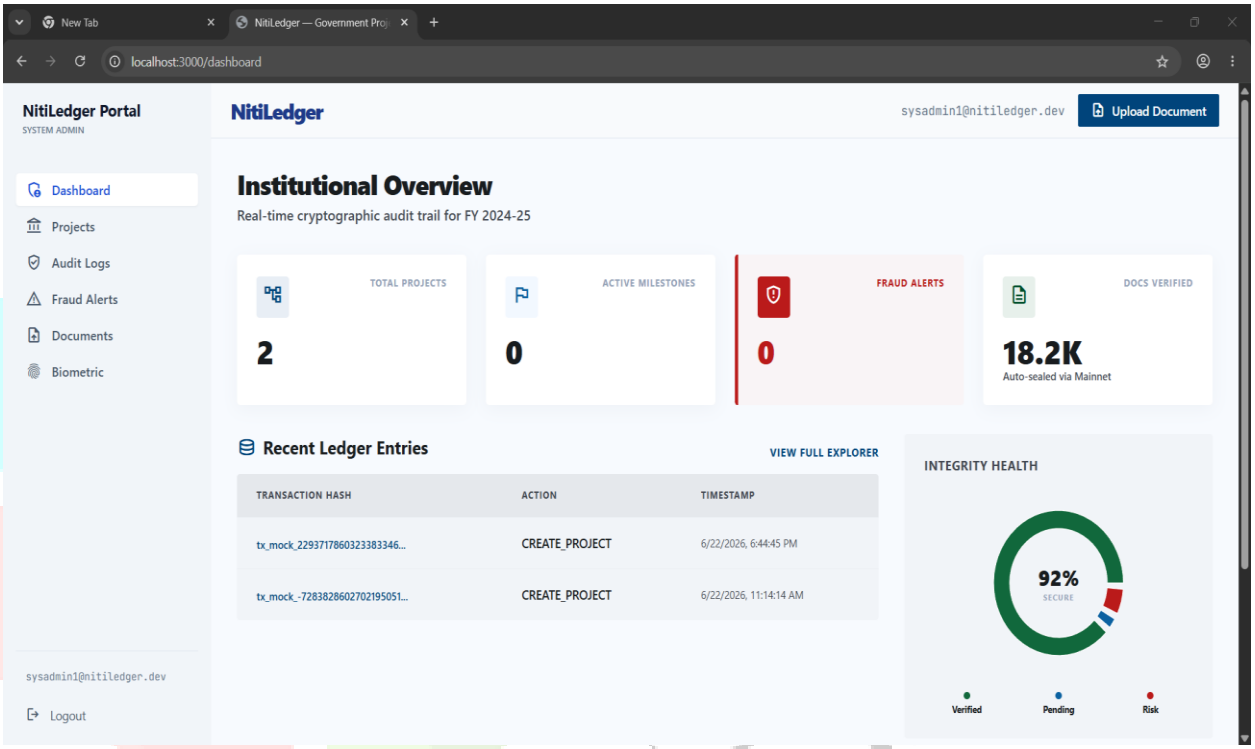

Figure 13.1 Admin Dashboard

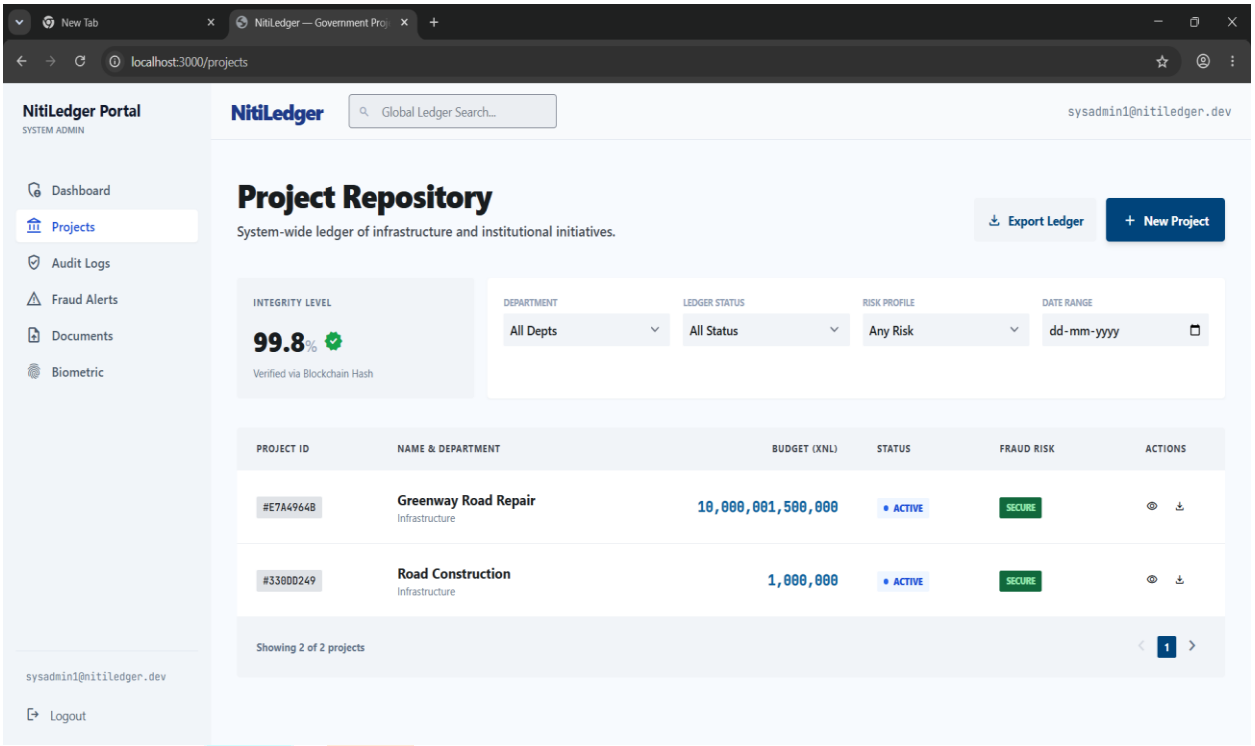

Figure 13.2 Project Creation Module

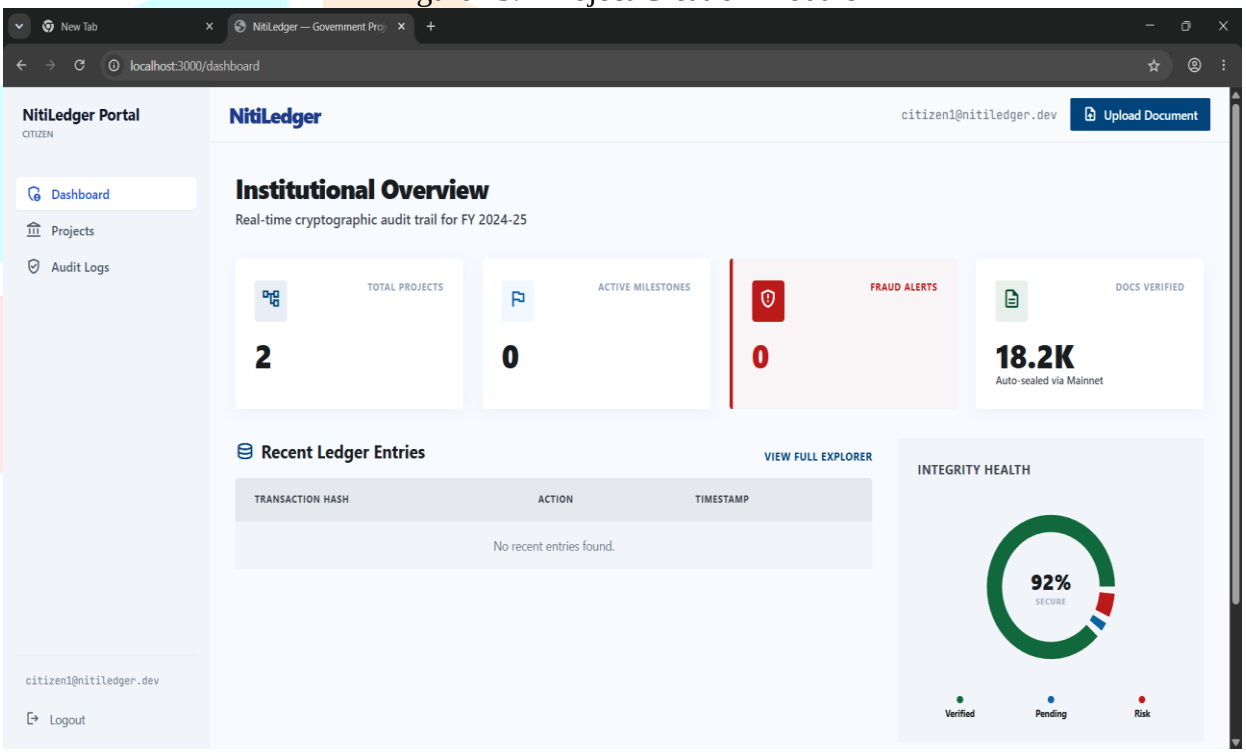

Figure 13.3 Citizen Login

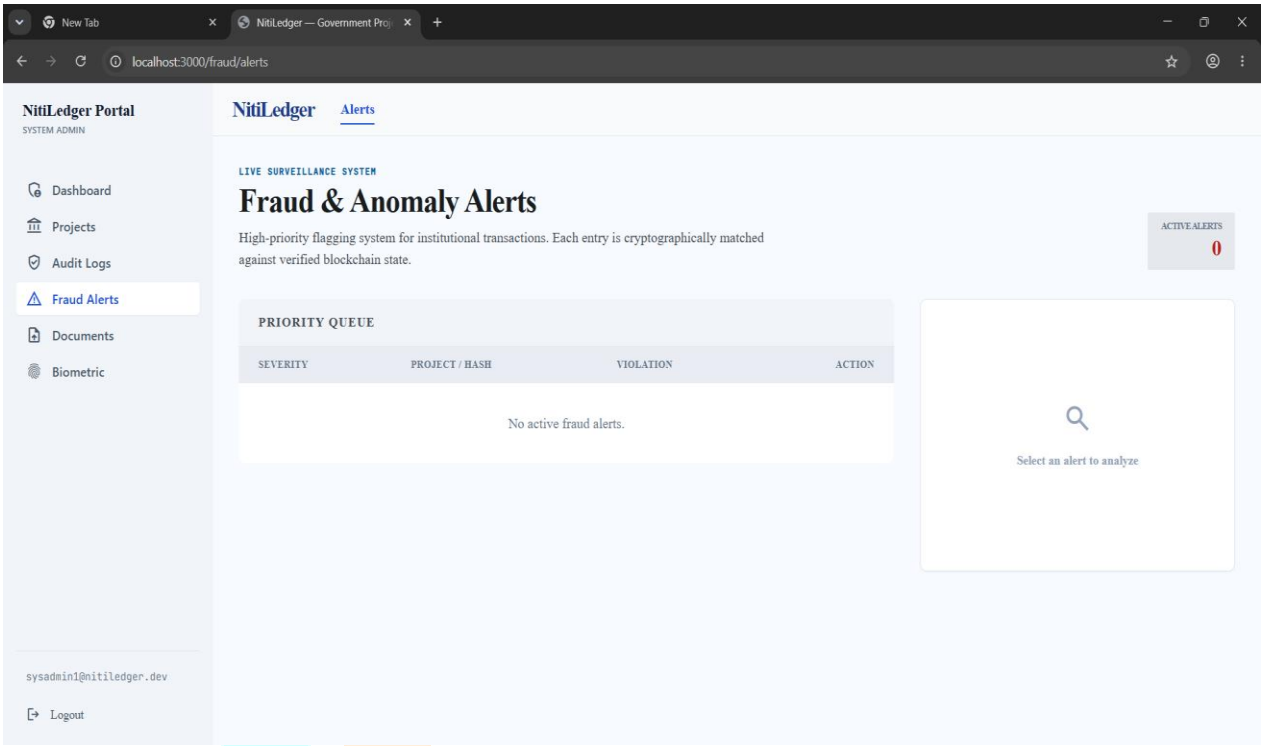

Figure 13.4 Fraud Detection Alert

XIV. FUTURE SCOPE

The system can be further improved by adding:

- AI-based fraud prediction
- Mobile application
- Aadhaar integration
- Smart contract automation
- National-level deployment
- GIS-based project tracking
- Real-time analytics dashboards
- Blockchain interoperability

XV. CONCLUSION

This paper is a blockchain based public fund allocation, tracking, and fraud detection system which is developed using Hyperledger Fabric. This system integrates fund tracking, document verification, biometric authentication, fraud detection, and audit logging to improvise transparency and accountability within public and public fund management.

Blockchain technology ensures that the records are immutable, the fraud detection algorithms helps in identifying any suspicious financial activities and prevent them if they do so. Document hashing prevents document tampering, and biometric verification ensures identity authentication. The system also enables public to provide a transparent dashboard for citizens to monitor government projects.

The proposed system aims to reduce corruption, improvise transparency , prevent financial fraud which in result will help to increase trust in government financial systems and also improving governance. The

system can be implemented at different levels such as municipal, state, and national levels for transparent governance and efficient public fund management.

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