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EDULOAN: SECURE LOAN PROCESSING AND MANAGEMENT SYSTEM WITH PERMISSIONED BLOCKCHAIN AND SMART CONTRACTS

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Abstract- *Traditional education loan systems suffer from centralized control, lack of transparency, and vulnerability to fraud. This paper proposes EduLoan, a blockchain-based framework for end-to-end education loan lifecycle management built on Hyperledger Fabric. The system employs a permissioned distributed ledger and smart contracts to automate loan application submission, multi-level stakeholder verification, weighted eligibility assessment, conditional approval, and sequential year-wise fee disbursement. An intelligent multi-factor evaluation model incorporating CIBIL score analysis, debt-to-income ratio, employment classification, and institution tier ensures unbiased credit decision-making. An automated repayment scheduling engine and auto-debit EMI simulation engine process repayments with real-time blockchain recording across multiple organizations, culminating in automatic loan closure upon full repayment. All transactions are immutably recorded, ensuring data integrity, non-repudiation, and complete auditability. By integrating SHA-256 cryptographic security, MSP-based role access control, and multi-party endorsement consensus, EduLoan establishes a secure, transparent, and automated ecosystem for education finance in India.*

***Key Words*: Blockchain, Hyperledger Fabric, Education Loan, Smart Contracts, Chaincode, Role-based Access Control, EMI Automation, Loan Lifecycle Management**

1. INTRODUCTION

The accelerating evolution of digital financial ecosystems has underscored the critical need for secure, transparent, and resilient infrastructures to support education financing [1]. Existing loan processing frameworks are deeply entrenched in centralized, legacy-driven architectures that are inherently inefficient, opaque, and vulnerable to systemic risks [2]. These systems rely on manual workflows, fragmented data repositories, and intermediary-dependent validation mechanisms, resulting in prolonged processing cycles and limited auditability [3].

The multi-stakeholder nature of education loan systems introduces data asymmetry, lack of interoperability, and inconsistencies in decision-making [4], while the absence of a tamper-resistant infrastructure exposes the system to identity fraud, document falsification, and unauthorized fund diversion [5]. These limitations highlight a pressing need for decentralized, trust-enforcing architectures [6].

Blockchain technology has emerged as a disruptive innovation offering decentralization, immutability, cryptographic security, and consensus-driven validation [7]. Permissioned frameworks such as Hyperledger Fabric provide fine-grained access control and identity management via Membership Service Providers, making them highly suitable for regulated multi-party financial governance [8][9].

This paper introduces EduLoan, a blockchain-enabled framework built on Hyperledger Fabric that automates the complete education loan lifecycle — from application and credit evaluation to disbursement, EMI repayment, and loan closure — ensuring security, transparency, and auditability through MSP-based role access control and multi-party endorsement consensus [7][8][9].

The key contributions of this paper are: (1) a fully permissioned three-organization Hyperledger Fabric network with MSP-based role enforcement across all loan lifecycle phases; (2) a deterministic weighted scoring model for bias-free credit evaluation; (3) sequential year-wise disbursement governance with automated email notifications; and (4) an integrated auto-debit EMI simulation engine with real-time blockchain recording and automated loan closure.

2. RELATED WORK

Researchers have extensively investigated blockchain-based frameworks and smart contract architectures to address inefficiencies, fraud vulnerabilities, and transparency limitations in digital financial systems. Sonawane and Motwani [10] proposed a blockchain-powered financial services platform facilitating peer-to-peer payments, crowdfunding, and loan services within a unified decentralized ecosystem. However, the system is built on a public blockchain, introducing limitations in access control granularity, participant identity management, and data confidentiality — factors critical in regulated education loan environments. Gazali et al. [11] proposed a prototype system for managing education loan repayment using blockchain and smart contracts, motivated by persistent default payment issues faced by Malaysia's National Higher Education Fund Corporation. However, the prototype addresses only the repayment phase and lacks multi-organizational architecture, role-based access control, and

end-to-end lifecycle coverage. Abbas et al. [12] proposed a blockchain-based framework to secure financial technology loan processing through smart contract integration. While the system reduces fraudulent transactions and processing delays, it does not encompass multi-party enrollment verification, institution-specific sequential disbursement, or automated EMI processing. Legowo et al. [13] proposed a smart contract-based blockchain framework to govern peer-to-peer lending operations, eliminating dependency on traditional financial intermediaries. However, the platform lacks structured credit evaluation, institution-tier-based eligibility scoring, sequential disbursement enforcement, and role-based access control through distinct organizational identities. Saleem et al. [14] proposed a blockchain-powered loan management system integrating smart contracts to automate end-to-end loan processing. While the system reduces manual processing overhead, it does not address education-domain-specific requirements such as CIBIL-based weighted credit scoring, sequential year-wise disbursement, or automated EMI repayment scheduling.

The proposed EduLoan framework addresses all identified limitations through a fully permissioned three-organization Hyperledger Fabric network with deterministic chaincode-driven lifecycle automation, intelligent weighted credit scoring, and an integrated auto-debit EMI simulation engine.

3. PROPOSED SYSTEM

3.1 System Architecture

The EduLoan framework is architected on a three-organization Hyperledger Fabric permissioned blockchain network, comprising Org1MSP (Platform — applicant-facing operations), Org2MSP (Bank — disbursement and repayment governance), and Org3MSP (Institution — enrollment verification and confirmation). Each organization operates an independent peer node backed by a dedicated CouchDB instance, enabling rich JSON-based state queries and indexed ledger access across all loan lifecycle records.

All participating peers communicate through a single Raft-based ordering service deployed on a shared orderer node, ensuring deterministic transaction sequencing and fault-tolerant consensus across organizations [8]. A unified channel named "loan" serves as the shared communication fabric, through which all endorsed transactions are committed to the distributed ledger [7].Smart contracts (chaincode) written in JavaScript and deployed on the loan channel encapsulate the complete business logic of the loan lifecycle, organized into five functional modules: application and eligibility, collateral and enrollment, year-wise disbursement, repayment and EMI management, and audit and transparency. Access to each chaincode function is strictly governed by MSP-based role authorization, ensuring that only authorized organizations can invoke sensitive operations [8][9].

The backend layer comprises a Node.js Express API server that interfaces with the Fabric network through the Fabric Gateway SDK, while the frontend is a React-based student and admin portal. An integrated email notification service triggers automated communications at every critical lifecycle event, ensuring complete stakeholder awareness throughout the loan process.

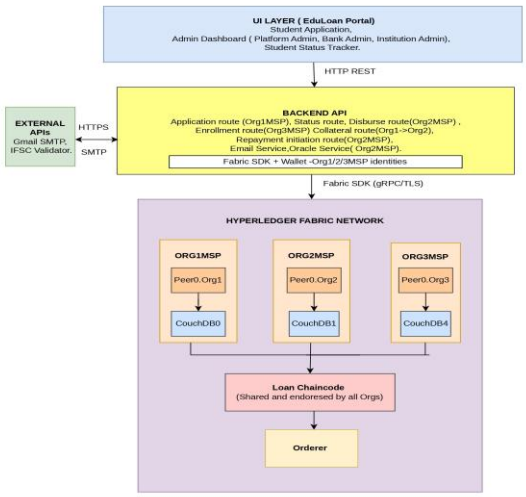

Fig -1: System Model

3.2 Methodology

The EduLoan framework adopts a structured, phase-driven methodology that maps each stage of the education loan lifecycle to a corresponding smart contract

module deployed on the Hyperledger Fabric permissioned blockchain. The methodology ensures end-to-end automation, auditability, and multi-party governance across all participating organizations [8].

3.2.1 Loan Application and KYC Submission

The loan lifecycle initiates when a student submits an application through the React-based EduLoan portal. The application captures personal identity information including PAN, Aadhaar, date of birth, mobile number, and email address, alongside academic details such as institution, course, duration, and total course fees, and financial details including the requested loan amount, repayment period, bank account number, IFSC code, and co-applicant information. Upon submission, the backend API invokes the submitApplication chaincode function authorized exclusively to Org1MSP. All sensitive identifiers are cryptographically hashed before being recorded on the distribut-

ed ledger, ensuring data integrity and privacy [7]. The transaction is endorsed by peers across all three organizations before being committed to the loan channel, establishing an immutable application record [8].

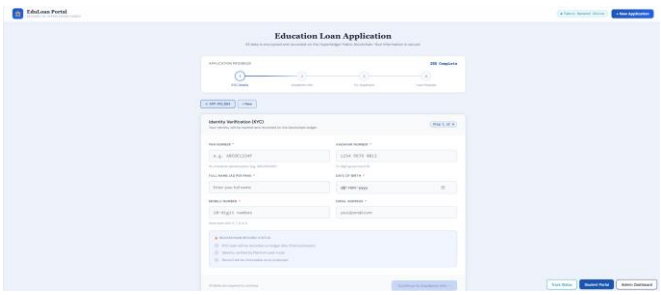

Fig -2: Student Application

3.2.2 CIBIL-Based Credit Evaluation

Following successful application submission, an automated CIBIL evaluation is triggered through the recordCIBILResult chaincode function, also authorized to Org1MSP. The system queries an external credit scoring oracle via the Razorpay IFSC validation API to retrieve the co-applicant's credit profile based on their PAN number. The retrieved CIBIL score is classified into predefined bands — Excellent (750 and above), Good (700–749), Fair (650–699), and Poor (below 650) — and recorded immutably on the ledger. This score subsequently feeds into the weighted eligibility assessment model, ensuring that credit history is a deterministic factor in loan decision-making.

3.2.3 Weighted Eligibility Assessment and Loan Decision

The evaluateLoanApplication chaincode function implements an intelligent multi-factor weighted scoring model that evaluates each application across four dimensions: CIBIL score band (40% weight), debt-to-income ratio (30% weight), employment classification of the co-applicant (20% weight), and institution tier (10% weight). Each parameter is assigned a normalized score, and the composite weighted score is computed deterministically on-chain, eliminating subjectivity and human bias from the credit decision process [12]. Applications scoring above the approval threshold are marked APPROVED, those meeting conditional criteria are marked APPROVED WITH CONDITIONS requiring collateral submission, and those falling below the minimum threshold are marked REJECTED with enumerated rejection reasons recorded on the ledger [9].

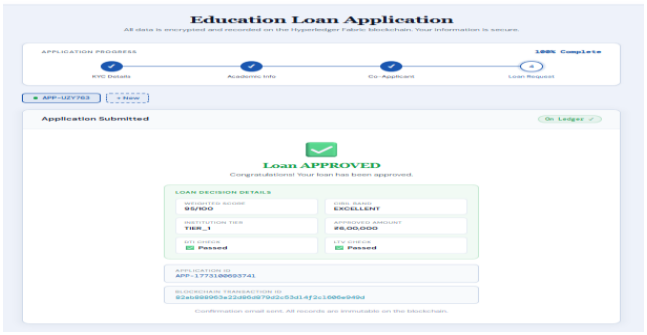

Fig -3: Loan decision

3.2.4 Collateral Submission and Enrollment Verification

For conditionally approved applications, the student is required to submit collateral details including type, estimated value, and document reference through the portal. The submitCollateral chaincode function records these details on the ledger, after which Org2MSP performs physical verification and invokes approveCollateral to confirm acceptance. Subsequently, Org3MSP confirms student enrollment by invoking the confirmEnrollment function, which transitions the application to an active disbursement-ready state.This three-phase verification ensures that loan funds are released only upon complete institutional and financial validation [13].

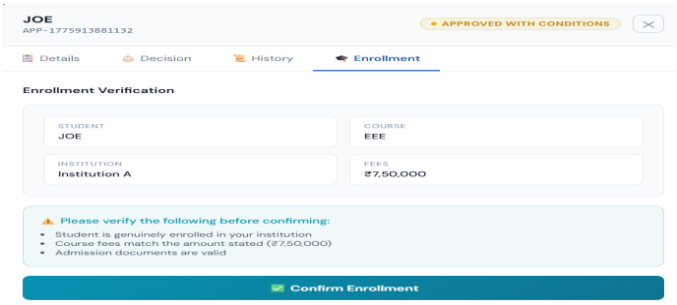

Fig -4: Enrollment confirmation

3.2.5 Sequential Year-Wise Fee Disbursement

The disbursement methodology enforces strict sequential governance — Year N fees cannot be disbursed until Year N-1 disbursement is confirmed on-chain. The recordDisbursement chaincode function, authorized to Org2MSP, accepts the application identifier, a unique UTR number, and the academic year as parameters. Upon successful on-chain commitment, the backend triggers automated email notifications to the student, institution, and bank, maintaining complete transactional transparency. This sequential enforcement prevents premature fund release and ensures alignment with actual academic progression [10][13]

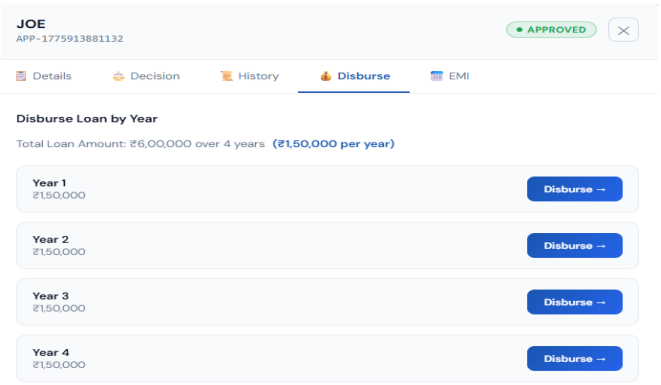

Fig -5: Year-wise fee disbursement

3.2.6 Repayment Initialization and EMI Scheduling

Upon completion of all four disbursement years, Org2MSP invokes the initializeRepayment chaincode function, which computes the complete EMI schedule based on the sanctioned loan amount, applicable interest rate, interest type (simple for public sector banks, compound for private sector banks), and repayment tenure. The moratorium period of one year post-course-completion is factored into the repayment start date in compliance with RBI guidelines. The generated schedule, comprising monthly EMI amounts, due dates, and statuses, is recorded immutably on the ledger [11][14] and an automated email notification is dispatched to the student containing the complete loan summary, EMI schedule with due dates and amounts, and designated bank account details for auto-debit processing.

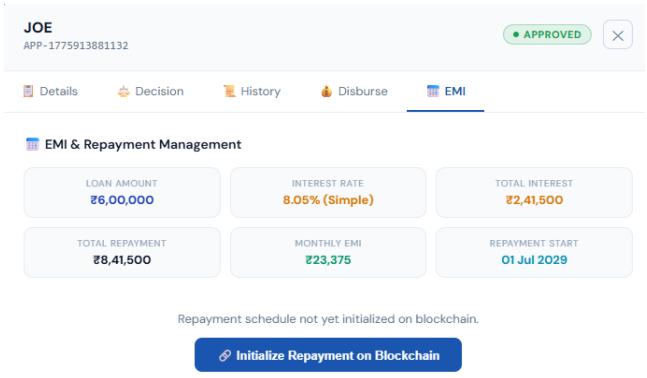

Fig -6: Repayment initialization

3.2.7 Automated EMI Processing and Loan Closure

The auto-debit EMI simulation engine, integrated into the backend, periodically processes EMI payments by invoking recordEMIPayment on Org2MSP. In the event of insufficient balance, recordEMIBounce is invoked, applying a 2% penalty on the outstanding EMI amount and recording the bounce event on the ledger [14]. Email notifications are dispatched to the student upon every payment and bounce event. Upon successful completion of all EMIs, the system automatically transitions the loan status to LOAN CLOSED, recording the closure transaction immutably on the distributed ledger and dispatching an automated email notification to the student confirming full repayment and blockchain-recorded closure.

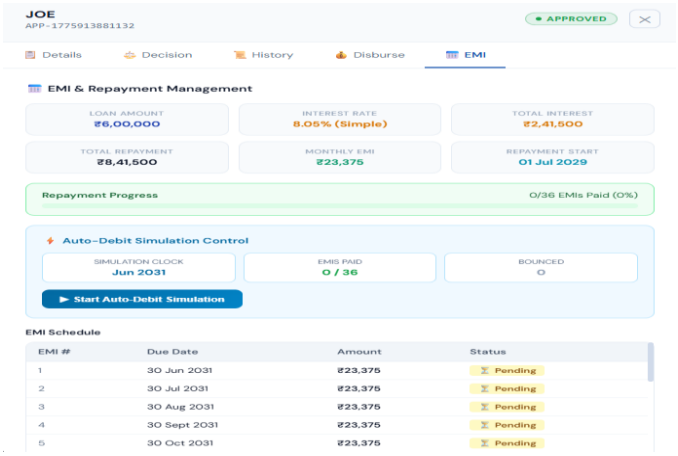

Fig -7: Auto-debit EMI simulation

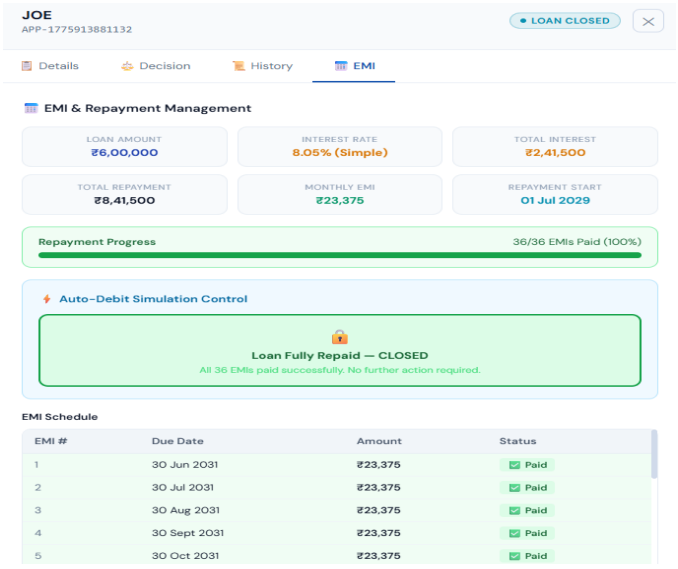

Fig -8: Loan closed

4. EXPERIMENTAL EVALUATION

4.1 Experimental Setup

The EduLoan blockchain system was deployed and evaluated on a local development environment running Ubuntu 22.04.5 LTS on Windows Subsystem for Linux 2 (WSL2). The host machine is equipped with a 13th Gen Intel Core i3-1315U processor and 8 GB of RAM. The con-

tainerized Hyperledger Fabric network was managed using Docker Desktop v4.68.0 on Windows, managing Docker Engine v29.2.1 inside WSL2. The backend API was implemented using Node.js v22.22.0 and the React-based frontend was served on port 3000, with the backend REST API running on port 3001.

The Hyperledger Fabric network consisted of three organizations — Org1MSP (representing the loan application authority), Org2MSP (representing the bank), and Org3MSP (representing the educational institution) — each running a peer node backed by a CouchDB instance for rich query support. The ordering service used a single orderer node. The smart contract (chaincode) was written in JavaScript and deployed on a channel named loan. All three organizations endorsed and committed the chaincode with an endorsement policy requiring approval from all three peers.

The system was tested end-to-end covering the complete loan lifecycle: application submission, CIBIL evaluation, collateral management, year-wise disbursement, and EMI-based repayment tracking. For performance benchmarking, a dedicated benchmark script was developed using the Fabric Node.js SDK to invoke chaincode functions directly and measure transaction latency and throughput under controlled conditions.

4.2 Performance Evaluation

Two categories of transactions were benchmarked using the Fabric Node.js SDK. Query transactions invoke evaluateTransaction, reading state directly from the peer's CouchDB ledger without passing through the ordering service. Submit transactions invoke submitTransaction, triggering the full Hyperledger Fabric lifecycle — proposal endorsement across all peer organizations, ordering, and block commitment to the ledger.

Table 1: Query Transaction Latency (getAllApplications – 10 runs)

Average Latency	Minimum Latency	Maximum Latency	Throughput
123 ms	96 ms	218 ms	~8 TPS

Table 2: Submit Transaction Latency (SubmitApplication – 10 runs)

Average Latency	Minimum Latency	Maximum Latency	Throughput
2242 ms	2183 ms	2371 ms	~0.45 TPS

Query transactions averaged 123 ms at approximately 8 TPS, reflecting the efficiency of direct CouchDB peer reads that bypass the consensus pipeline. The elevated first-run latency of 218 ms is attributable to gateway initialization overhead, with subsequent runs stabilizing between 96 ms and 130 ms. Submit transactions averaged 2242 ms at approximately 0.45 TPS, a result of the multi-phase Fabric transaction lifecycle involving cross-peer endorsement,orderer batching, and ledger commit across three organizations on a resource-constrained WSL2 environment. Across 10 runs, the spread between minimum and maximum latency was 188 ms, confirming the stability and determinism of the consensus pipeline under test conditions.

4.3 Security and Access Control

The system enforces organization-level access control via Hyperledger Fabric's MSP framework. Each chaincode function validates the invoking MSPID — submitApplication and recordCIBILResult are restricted to Org1MSP, recordDisbursement and initializeRepayment to Org2MSP, and confirmEnrollment to Org3MSP. Unauthorized invocations are rejected at chaincode level. Sensitive fields — student PAN, Aadhaar, and co-applicant PAN — are hashed using SHA-256 before ledger storage, ensuring no personally identifiable information is persisted in plaintext. The immutability of the Fabric ledger guarantees all records are permanently tamper-evident and auditable.

5. CONCLUSION

This paper presented EduLoan, a decentralized education loan management system built on Hyperledger Fabric, designed to address the transparency, security, and accountability deficiencies prevalent in traditional loan processing frameworks. By mapping each phase of the loan lifecycle — application, credit evaluation, collateral verification, disbursement, and repayment — to dedicated smart contract modules enforced across three distinct organizations, the system achieves tamper-evident record-keeping, role-based access control, and automated multi-stakeholder coordination without reliance on a central authority. Sensitive student data is protected through SHA-256 hashing prior to ledger storage, ensuring compliance with data privacy principles. Experimental evaluation on a three-organization Hyperledger Fabric network demonstrated query latencies averaging 123 ms at 8 TPS and submit latencies averaging 2242 ms at 0.45 TPS, consistent with permissioned blockchain consensus overhead. The results validate that blockchain technology can serve as a robust, auditable, and secure foundation for education loan governance in India.

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