

NGO-Chain: A Decentralized Platform for Transparent Donations and Milestone-Based Fund Release)

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Abstract: Traditional philanthropic organizations often suffer from limited transparency, where donors have minimal visibility into how their contributions are utilized after donation [1,14]. To address this issue, this paper presents NGO-Chain, a hybrid Web3 platform designed to improve accountability and transparency in charitable fund management. The proposed system utilizes a milestone-based conditional escrow mechanism in which donated funds are locked within blockchain smart contracts and released incrementally only after administrative verification of uploaded proof documents stored on the InterPlanetary File System (IPFS) [4,5]. The architecture combines React-based frontend interfaces, Spring Boot middleware, decentralized IPFS storage, and Ethereum/Polygon smart contracts to create a scalable hybrid infrastructure capable of supporting real-time public transaction monitoring [14,12]. In addition, the platform integrates donor reputation tracking and blockchain-backed transaction auditing to strengthen trust between donors and NGOs [6,7]. By combining decentralized financial management with milestone verification workflows, NGO-Chain provides a secure and transparent framework for milestone-driven charitable donations while reducing dependency on centralized trust mechanisms.

Keywords: Decentralized Philanthropy · Conditional Escrow · Public Ledger · Smart Contracts · IPFS.

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I. INTRODUCTION

Traditional philanthropic organizations frequently suffer from a critical “black box” transparency deficit [1]. Once a donation is made, contributors typically lose visibility into how their funds are utilized and whether the intended project is successfully executed [1,3]. This information asymmetry often creates mistrust, as donors must rely entirely on centralized authorities to manage funds and report outcomes [14,11]. In many conventional donation systems, funds are disbursed as lump sums, increasing the risk of mismanagement, administrative inefficiencies, and reduced accountability [6,13].

To address these transparency and accountability challenges, this paper presents NGO-Chain, a decentralized donation platform designed to improve trust in philanthropic ecosystems. The proposed system combines blockchain smart contracts, decentralized file storage, and middleware synchronization to create a transparent donation lifecycle

where every major financial action remains traceable through a public ledger. The architecture integrates Web2 application layers with Web3 blockchain infrastructure to support scalable and auditable fund management.

II. SYSTEM ARCHITECTURE AND DESIGN

The NGO-Chain platform implements a milestone-based conditional escrow mechanism for controlled donation management [1,8]. Instead of releasing campaign funds immediately, donations are stored within blockchain smart contracts and distributed gradually in predefined milestones of 30%, 40%, and 30%. Each release requires administrative verification of uploaded proof documents before the next installment is approved. The uploaded reports, invoices, and utilization documents are securely stored on the InterPlanetary File System (IPFS), ensuring immutability and preventing unauthorized modification of records [5, 4].

Furthermore, the platform follows a hybrid architecture integrating blockchain infrastructure with off-chain relational storage, as illustrated in Fig. 1. The Spring Boot middleware synchronizes blockchain events with MySQL databases to

improve frontend responsiveness and reduce unnecessary blockchain queries [14, 12]. This hybrid approach allows donors to track fund utilization through a public ledger while maintaining scalable storage management.

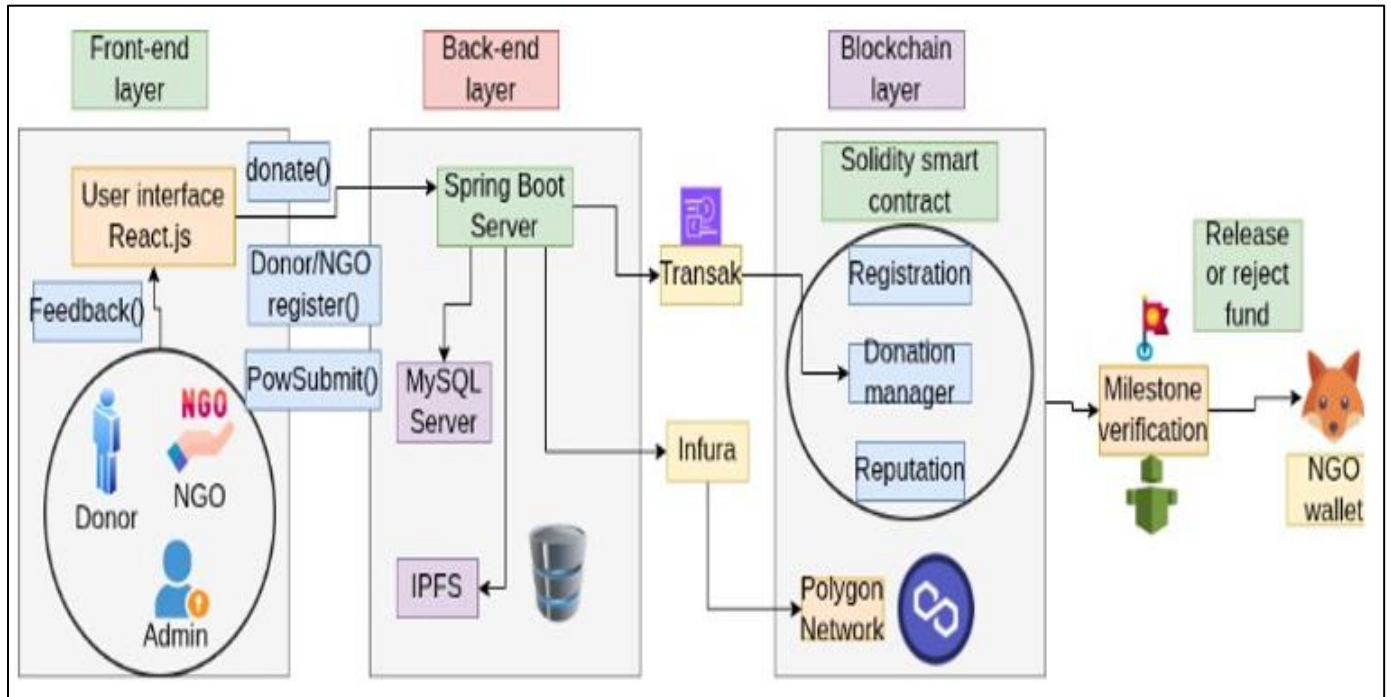


Fig 1 The Three-Tier Hybrid Web3 Architecture of NGO-Chain, Illustrating the Inte Gration of off-Chain Middleware (Spring Boot) with Decentralized Storage (IPFS) and on-Chain Smart Contracts

➤ Hybrid Data Harmonization

To reduce blockchain storage costs and improve scalability, NGO-Chain adopts a hybrid storage architecture [14,1]. User profiles, campaign metadata, and application-related information are maintained within a MySQL database, while large files such as NGO certificates and milestone proof documents are stored on IPFS using Kubo and Pinata services. Only critical financial states and IPFS content identifiers are recorded on-chain through Ethereum and Polygon smart contracts [5]. This separation enables efficient storage management while pre serving blockchain auditability for financial operations.

➤ Middleware Synchronization

The system utilizes a Spring Boot middleware integrated with the Web3j li bary to synchronize blockchain activity with the application database [14,1]. The middleware continuously listens to blockchain events and stores transac tion information within the blockchain_ledger table for efficient retrieval. This synchronization process allows the React frontend to display transaction history, campaign updates, and milestone activities with low latency while avoiding ex cessive direct blockchain queries. Table 1 summarizes the storage layers and their associated technologies.

Table 1 Middleware Synchronization

Storage Level	Technology Used	Primary Function / Data Type
Consensus State (On-Chain)	Ethereum / Polygon	Escrow balances, milestone logic, reputation scores
Decentralized File (IPFS)	Kubo / Pinata	Immutable proof-of-work docu ments and NGO certificates
Relational Meta data	MySQL	User profiles, UI state hydration, and ledger caching
Middleware Inte gration	Spring Boot / Web3j	Transaction indexing and asyn chronous event listening

➤ Conditional Escrow Execution Model

To manage secure and controlled fund release, the smart contract logic follows a predefined milestone allocation strategy [1]. Let T represent the total campaign goal and M represent the milestone allocations

S. A. Gavali et al. The release of each milestone depends on successful verification of uploaded proof documents and sufficient campaign balance availability. The smart contract validates these conditions before approving fund transfer requests [4].

$$T = \sum_{i=1}^3 m_i \quad \text{wherem}_1 = 0.30T, m_2 = 0.40T, m_3 = 0.30T \tag{1}$$

$$R(m_i) \Leftrightarrow (V_proof = True) \wedge (A_admin = True) \wedge (B_camp \geq m_i)$$

Here, Vproof denotes the uploaded IPFS proof document, while Bcamp represents the available campaign balance. Finally, Aadmin represents the administrative approval performed by the platform authority.

III. OPERATIONAL WORKFLOW

The operational workflow of NGO-Chain is illustrated in Fig. 2. The donation lifecycle begins when a donor converts fiat currency into USDC stablecoins using the Transak gateway. The donated funds are then transferred into the DonationManager smart contract deployed on the Polygon blockchain network. Every transaction is recorded on-chain, allowing donors to monitor campaign funding activity through the public ledger system [1,10].

After completing a campaign milestone, the NGO uploads supporting documents such as invoices, reports, and utilization records to IPFS. The generated Content Identifier (CID) is submitted to the smart contract, initiating the administrative verification process. Once the administrator validates the submitted evidence, the corresponding milestone payment is released to the NGO wallet through the conditional escrow mechanism [5,4].

The middleware layer continuously monitors blockchain transactions using Web3j event listeners and synchronizes transaction data with the relational database. This process enables the frontend application to display campaign progress, milestone approvals, and transaction history with near real-time responsiveness. After milestone completion, donors can additionally provide feedback and reputation scores through the ReputationManager contract [6,7].

If the submitted proof documents fail verification, the pending fund release request is rejected and the remaining campaign balance remains locked within the escrow contract. Additionally, the administrator may restrict further campaign activity for NGOs associated with fraudulent submissions. This workflow strengthens accountability and ensures that donated funds remain associated with verified project execution.

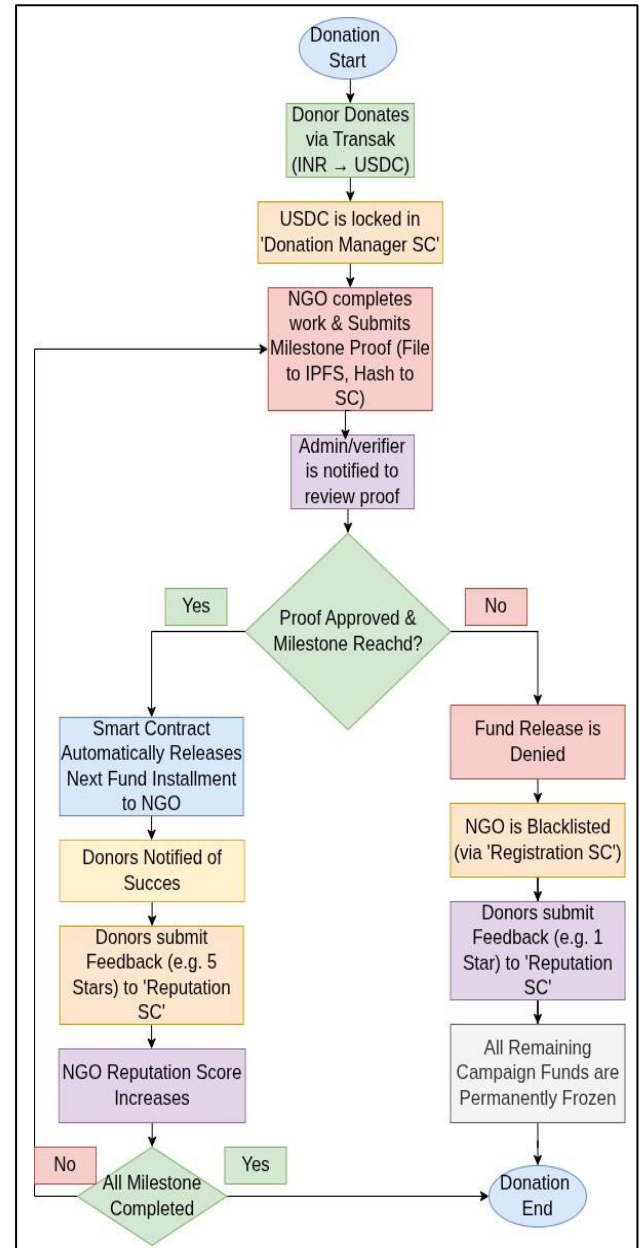


Fig 2 Operational Workflow of Milestone Verification and Conditional Fund Release.

IV. IMPLEMENTATION AND EXPERIMENTAL RESULTS

The NGO-Chain platform was implemented using a hybrid Web3 architecture integrating React for the frontend interface, Spring Boot for middleware orchestration, Solidity smart contracts, and Polygon blockchain infrastructure. The implementation successfully integrated MetaMask wallet authentication, milestone driven conditional escrow execution, decentralized IPFS document storage, and real-time public ledger synchronization.

➤ NGO-Chain: Blockchain Based Transparent Donation Platform.

➤ Frontend and Wallet Integration

The frontend layer was developed as a responsive React single-page application (SPA) designed to provide intuitive interaction between donors, NGOs, and administrative authorities. Wallet authentication and blockchain transaction signing were securely handled through MetaMask integration, while the Transak gateway enabled fiat-to-USDC conversion for simplified onboarding of non-technical users.

➤ Public Ledger Synchronization

The middleware continuously monitored blockchain transactions through asynchronous Web3j event listeners and synchronized immutable ledger events into the relational database layer. This synchronization mechanism enabled donors to visualize campaign funding activity, milestone approvals, and transaction history with near real-time responsiveness.

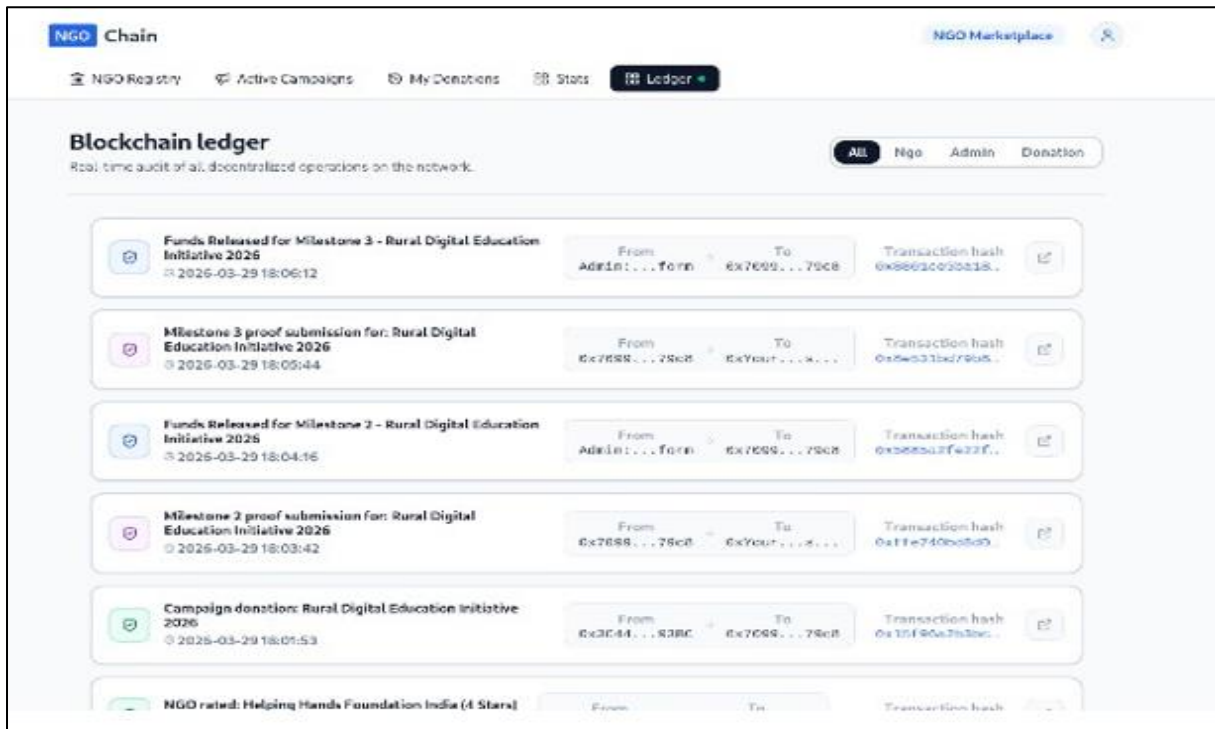


Fig 3 Public Ledger Interface Showing Synchronized Blockchain Transaction History and Donation Audit Trail.

➤ *Administrative Verification Module*

The platform additionally implemented a milestone verification interface allowing administrators to validate uploaded IPFS proof documents prior to conditional fund release execution. This governance layer ensured that milestone disbursements remained strictly bound to verified

project progress and immutable proof-of-work evidence.

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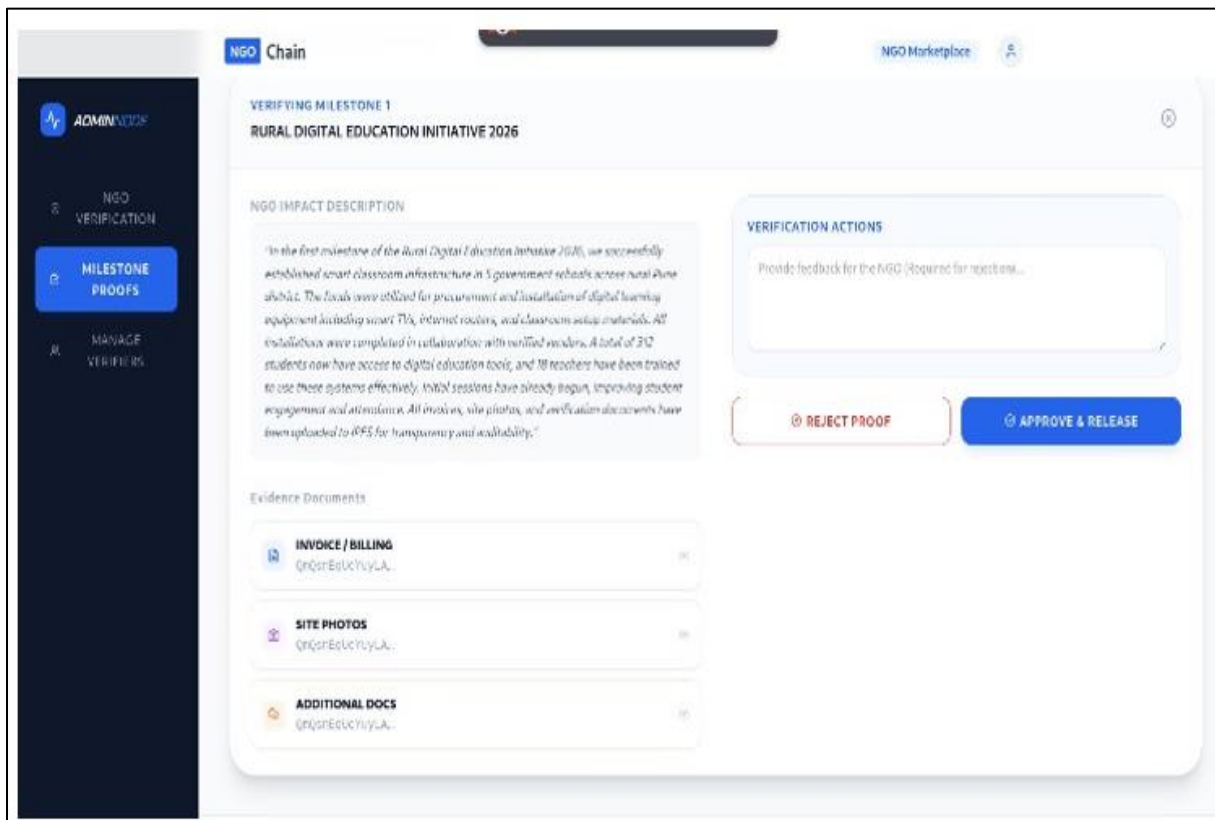


Fig 4 Administrative Verification Interface for Milestone Proof Validation and Conditional Fund Release Approval.

V. CONCLUSION

This paper presented NGO-Chain, a blockchain-enabled donation platform designed to improve transparency and accountability in charitable fund management. The proposed system combines milestone-based escrow smart contracts, IPFS document storage, and real-time public ledger synchronization to create a transparent and auditable donation workflow. The hybrid integration of React, Spring Boot, Polygon blockchain infrastructure, and Web3 middleware demonstrated the practical feasibility of combining scalable application interfaces with decentralized financial management. Furthermore, the implementation of milestone verification and reputation tracking mechanisms improved donor visibility and strengthened trust between contributors and NGOs. The proposed framework therefore provides a scalable approach for secure and transparent milestone-driven donation management.

VI. FUTURE WORK

Future improvements to NGO-Chain may include decentralized milestone verification, where campaign donors can review uploaded proof documents and provide validation feedback instead of relying entirely on administrative authorities. Additionally, AI-based sentiment analysis can be integrated to evaluate donor reviews and ratings, helping verifiers make more informed approval decisions based on collective donor trust and feedback patterns.

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Disclosure of Interests. The authors declare that they have no competing interests related to this work.

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