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SahayChain: Intelligent Welfare Aid Traceability System

Anshu Jaiswal[1], Sujal Vishwakarma[2], Prajwal Kotian[3], Sunita Naik[4]
Department of Computer Engineering, VIVA Institute of Technology

Abstract: ***Most of the charitable organizations face inefficiencies, mistrust among donors, and misutilization of funds due to a lack of transparency in their usually cash-based donation mechanisms. This work proposes SahayChain-an intelligent welfare aid traceability system that will integrate blockchain and artificial intelligence to develop a transparent, accountable, and efficient donation ecosystem. Item-based donation is offered on the platform, wherein the donors fund the verified NGO requests fulfilled by registered suppliers. Blockchain maintains immutable logs of transactions with automated fund release via smart contracts. AI modules enhance the reliability through anomaly detection, demand forecasting, supplier recommendation, and sentiment analysis. The hybrid architecture ensures traceability of every contribution from donor to delivery, hence reducing fraud and maximizing the impact. Experimental validation confirms that the model has improved transparency, fairness, and trust for all stakeholders and is further positioned as a scalable model for digital humanitarian aid management.***
Keywords: Artificial Intelligence, Blockchain Technology, Donation Management, Resource Allocation, Smart Contracts, Transparency, Welfare Traceability

I. INTRODUCTION

Charitable organizations are very important in poverty-stricken areas and include orphanages, old-age homes, and welfare centres. However, most of the conventional donation systems used have problems of inefficiency and lack of transparency; sometimes, they even misuse funds. Since most donations are provided in the form of cash, it is quite difficult for the donors to trace back where exactly their money is being spent. This brings down the level of trust and engagement a donor wants to achieve. With emerging technologies like blockchain and AI, there are several potential solutions to these challenges. Blockchain is tamper-proof, transparent, and traceable, while AI enhances decision-making, prediction, and fraud detection. However, most of the existing systems adopt these technologies piecemeal and not as an integrated approach which can actually couple transparency with intelligence. This paper introduces SahayChain-a blockchain-and-AI-powered welfare aid traceability platform, which guarantees secure item-based donation among donors, NGOs, and verified suppliers. Blockchain encases donation records immutably and enables automated fund release through smart contracts. The AI modules of anomaly detection, demand forecasting, supplier recommendation, and sentiment analysis assure better traceability. SahayChain aims at coupling the transparency and intelligent automation in order to build up the trust, efficiency, and accountability across all the humanitarian ecosystem actors. This provides a scaling-up framework in terms of ethical and data-driven donation management.

II. RELATED WORK

The rapid advancement of digital technologies such as Artificial Intelligence (AI) and Blockchain has significantly transformed various sectors, including finance, supply chain management, and non-profit organizations. In the context of donation systems, these technologies offer promising solutions to challenges such as lack of transparency, fraud, and inefficient resource allocation.

Recent research has extensively explored the use of Artificial Intelligence for fraud detection. Rahman et al. [1] proposed a machine learning-based fraud detection system using algorithms such as Isolation Forest and Random Forest. Their study demonstrates that machine learning models can effectively identify anomalous patterns in transaction data, thereby reducing fraudulent activities and improving system reliability. Similarly, Moradi et al [2] introduced a hybrid model combining Isolation Forest and Support Vector Machine for anomaly detection in supply chains. This approach enhances detection accuracy and robustness, making it suitable for complex real-world scenarios involving multiple stakeholders. Further advancements in AI-based fraud detection are highlighted by Yaseen et al. [3] and Zhao et al. [4], who utilized deep learning techniques for behavioural transaction analysis. These studies show that deep learning models can capture complex transaction patterns and provide real-time fraud detection, significantly improving trust in digital systems. However, these approaches are primarily focused on financial systems and do not directly address donation-specific challenges such as resource tracking and beneficiary verification.

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In parallel, blockchain technology has emerged as a powerful tool for ensuring transparency and trust in donation systems. Mariyam et al [5] proposed a blockchain-based framework for charity donation tracking using Ethereum smart contracts.

The system ensures immutability of records and prevents tampering, thereby reducing the risk of fund misuse. Similarly, Almaghrabi et al.[6] developed a blockchain-based donation traceability framework that provides end-to-end visibility of donation flows. By integrating IPFS for off-chain storage, the system balances transparency with privacy, addressing a major limitation of traditional blockchain systems. Early contributions such as Shelar et al.[7] introduced a smart platform for donation handling, focusing on digitization and process efficiency. While the system reduces manual errors, it lacks advanced features such as fraud detection and intelligent decision-making. Balamurugan et al.[8] extended this concept by integrating blockchain into donation supply chains and introducing an incentive mechanism to encourage donor participation. This approach enhances user engagement but does not fully address real-time tracking and AI-based verification. Pawar et al.[9] proposed a hybrid system combining blockchain with centralized databases to balance transparency and privacy. The use of one-time account addresses ensures anonymity, which is crucial in donation systems. Nguyen et al.[10] further explored blockchain-based crowdfunding platforms, highlighting their ability to reduce costs and increase trust through decentralization.

However, issues such as regulatory challenges and cryptocurrency volatility remain significant barriers. Naiknavare et al.[11] addressed the issue of fraudulent beneficiary claims by proposing a blockchain-based charity application with unique identifiers for beneficiaries. This ensures authenticity and prevents duplication, thereby improving system reliability. These studies collectively demonstrate the effectiveness of blockchain in ensuring transparency and security but lack integration with intelligent systems.

Beyond blockchain and AI, several studies have focused on supply chain and NGO operations. McGrath et al.[12] analysed transparency in global supply chains using technologies such as blockchain, AI, IoT, and ERP systems. The study emphasizes that a relational approach, which focuses on collaboration rather than control, is more effective in achieving sustainable transparency. Yashas et al.[13] proposed a supplier engagement model that highlights the importance of governance and trust in NGO–supplier relationships. Their findings indicate that strong collaboration improves flexibility and response time in supply chains. Gunasekaran et al. [14] investigated the role of blockchain in humanitarian supply chains and found that it significantly improves information alignment and coordination among organizations. This is particularly important in disaster management scenarios where timely delivery of resources is critical. Cordery et al. [15] discussed the impact of digital transformation on NGOs, emphasizing the need for accountability, inclusivity, and effective governance.

Rathi et al.[16] studied the use of technology in non-profit organizations and found that NGOs rely on cost-effective tools such as cloud platforms and donor management systems due to budget constraints. Ji et al.[17] conducted a large-scale statistical analysis to understand the role of NGOs in disaster mitigation, revealing that different types of NGOs have varying levels of impact. Nikita et al.[18] highlighted the challenges of digital transformation in NGOs, including lack of funding, resistance to change, and limited technical expertise. Dube et al.[19] examined the adoption of AI chatbots in NGOs and identified trust and performance expectancy as key factors influencing adoption. While Rathi et.al.[20] introduced AI chatbots to improve service delivery, their implementation is hindered by infrastructure and financial limitations. From the comprehensive review of literature, it is evident that significant progress has been made in applying AI for fraud detection and blockchain for transparency. However, most existing systems focus on these technologies in isolation. There is a clear lack of integrated solutions that combine AI-driven intelligence, blockchain-based traceability, and supply chain optimization within a single platform. Furthermore, existing donation systems predominantly rely on monetary transactions, which are prone to misuse and lack accountability. Very few studies address item-based donation systems, which can directly ensure that resources reach beneficiaries.

To overcome these limitations, the proposed SahayChain system integrates Artificial Intelligence and Blockchain technologies with a supply chain-driven approach. It introduces an item-based donation mechanism, ensuring transparency, reducing fraud, and improving efficiency. By combining these technologies into a unified platform, SahayChain addresses the critical gaps identified in existing research and provides a comprehensive solution for modern donation systems.

III. PROPOSED SYSTEM

A. System Overview

The SahayChain is an intelligent donation management and welfare aid traceability platform wherein the transparency, accountability, and efficiency of charitable resource distribution are ensured. In contrast to the conventional cash-based model of donations, SahayChain allows for item-based donations wherein a donor can directly fund verified needs of registered NGOs, which are then fulfilled by verified suppliers. Every transaction is recorded on a blockchain ledger, while AI and ML modules automate the process of verification, selection of suppliers, fraud detection, and feedback analysis.

The approach will establish a closed-loop ecosystem by connecting donors, NGOs, and suppliers in a digital network that is transparent, verifiable, and tamper-proof.

B. System Architecture

1) User Interface (UI):

The front end provides dedicated portals to each stakeholder.

- Donors can view verified NGO requests and then fund all types of needs.
- NGOs can post item-based requirements and confirm deliveries.
- Suppliers can observe only the funded demands, accept the orders, and update the delivery status.

The interface is built using ReactJS, guaranteeing a responsive and user-friendly interaction.

2) Backend Services:

The back-end acts as the control hub, implemented on FasAPI-Python for seamless integration. It manages data exchange, request validation, processes donations, and communicates with the blockchain and AI layers. It grants the security of interactions via REST APIs and provides real-time updates.

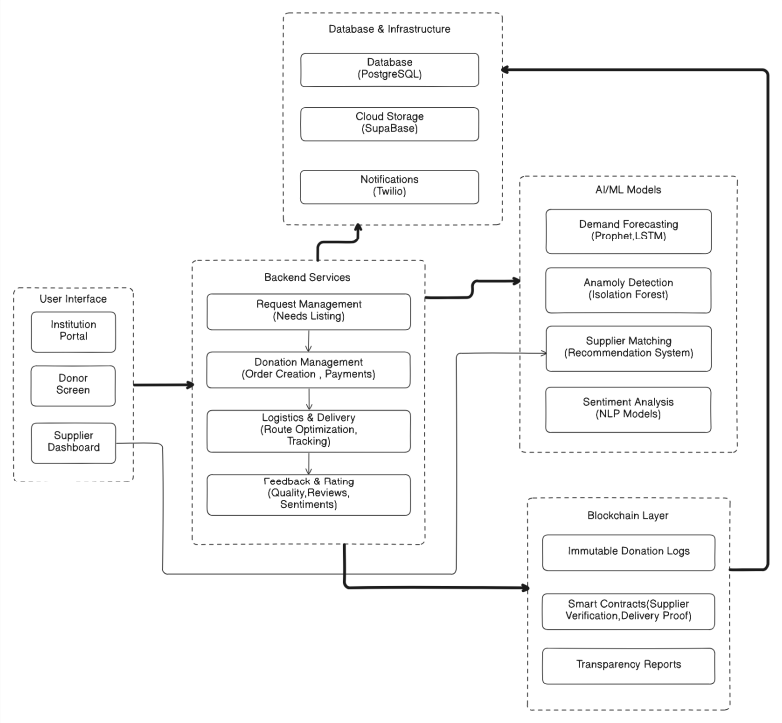


Fig.1 Block Diagram of SahayChain

3) AI/ML Layer:

The intelligence layer is central to both automation and decision support in SahayChain. It includes:

- Anomaly detection using the Isolation Forest to flag fraudulent or exaggerated requests from NGOs.
- Demand Forecasting: Using models like Prophet or LSTM to predict the resource requirements for some time in the future based on seasonality and contextual trends.
- Most Suitable Supplier Recommendation System which picks up suppliers in front based on past performance, cost, and proximity.
- Sentiment analysis using NLP models will be used in reviewing feedback from NGOs in order to have constant reevaluation of the reliability of suppliers.

4) Blockchain Layer:

The blockchain serves as the trust layer, providing immutability and transparency. Implemented using Ethereum smart contracts (Solidity), this layer performs three key functions:

- Creation of tamper-proof donation records.
- Automated fund escrow and release only upon verified delivery confirmation.
- Creation of donor impact reports and tokenized rewards.

Each critical event, creation of donation, submission of delivery proof, and release of payment, is recorded as an immutable transaction.

5) Database and Cloud Infrastructure:

The off-chain data management uses PostgreSQL for structured information such as user profiles and order tracking, and Supabase Cloud Storage for storing delivery proofs (images, invoices). File hashes are stored on the blockchain for authenticity verification. Finally, real-time notification sending for a user will be performed using Twilio.

C. System Methodology

SahayChain's methodology operates within the flow that has full traceability from the very creation of a request to confirmation of delivery:

1) An NGO sends in an item-based request.
2) Authenticity validation through an anomaly detection model in AI.
3) Once approved, the request is published for donors.
4) A donor funds the request, and the system creates a smart contract on blockchain to hold the funds in escrow.
5) The module of AI supplier recommendation selects the best supplier.
6) The supplier completes the order by updating the delivery status.
7) The NGO confirms the delivery and uploads the proof of delivery.
8) The smart contract releases the payment to the supplier and generates a verified impact report for the donor.
9) Feedback provided by NGOs is gauged through the sentiment model to once more update the ratings of the suppliers.

This automated pipeline is fully transparent; it eliminates manual errors and delivers donations to the right recipients.

IV. RESULTS AND DISCUSSION

A. Implementation

The SahayChain demonstrates the functionality involved in integrating the major components of the system: user interface, backend services, blockchain layer, and AI-driven modules. The frontend has been created using ReactJS, providing separate role-based dashboards for donors, NGOs, and suppliers. The backend is powered by FastAPI (Python) and NodeJS; it manages request validation, API management, and interaction with both the blockchain and AI layers. Training datasets prepared synthetically have been used in training anomaly detection and supplier recommendation AI modules; these show effective filtering of unrealistic NGO requests and accurate supplier ranking according to cost, rating, and proximity

B. Comparative Evaluation

A comparison was done between SahayChain and traditional donation systems based on various parameters like transparency, automation, and donor trust.

Table 1. Feature Comparison Table

Parameter	Existing System	SahayChain
Donation Type	Cash-Based	Item-based with on-chain validation
Transparency	Limited, manual record	Full traceability via blockchain
Fraud Detection	Absent	AI-based Anamoly detection
Supplier Integration	Manual or missing	Automated supplier recommendation
Donor Feedback	Non-Quantifiable	NLP-driven sentiment analysis

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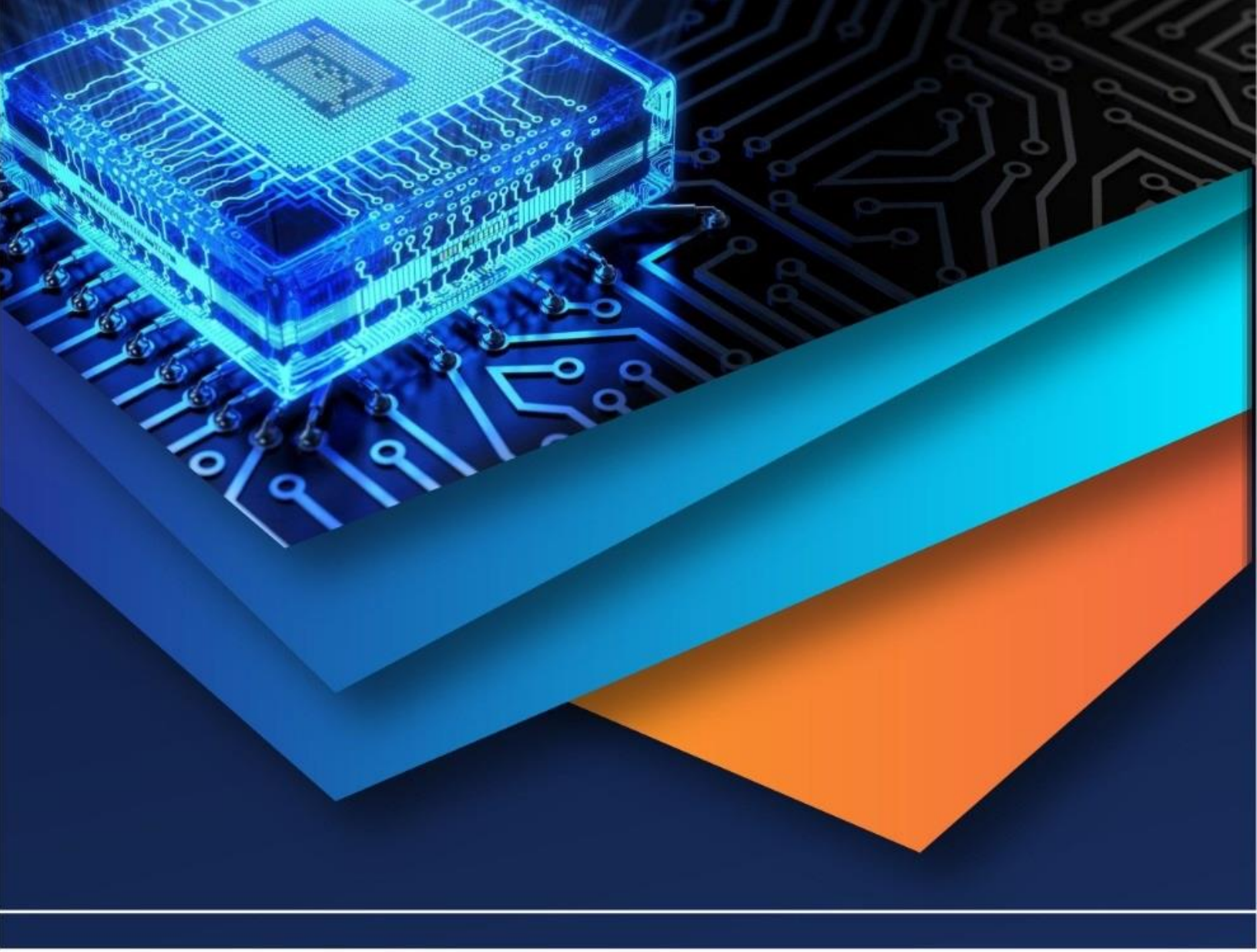
The evaluation highlights that SahayChain ensures superior traceability and reliability by replacing cash transactions with verifiable item-based donations and integrating automation at every stage of the process.

V. CONCLUSION

This paper presented SahayChain, an intelligent welfare aid traceability system that leverages blockchain along with artificial intelligence to establish transparency, accountability, and efficiency in charitable donations. The proposed framework replaces traditional cash-based donations with item-based and verifiable transactions, linking donors, NGOs, and suppliers into a unified ecosystem. Smart contracts based on blockchains will provide immutable records, automated fund release, and confirmation of tamper-proof delivery of aid. AI and ML modules comprising the process for fairness, optimization of resources, and prevention of fraudulent activities include anomaly detection, demand prediction, supplier recommendation, and sentiment analysis. Partial implementation is done to validate the feasibility of integrating blockchain and AI technologies to provide solutions for real-time humanitarian sector challenges related to transparency. Initial results demonstrate increased donor trust with more operational reliability that allows traceability. Scaling SahayChain up to support large NGO networks, deployment of the system on a public blockchain network, and enhancing the AI models using real-world data to make them more accurate and adaptable are the future scope of work for SahayChain. This integration of emerging technologies positions SahayChain to serve as a sustainable and scalable solution for transforming the management of digital humanitarian aid.

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