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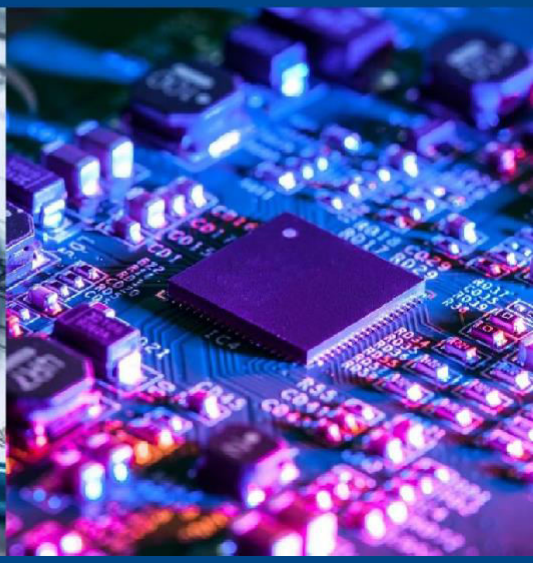

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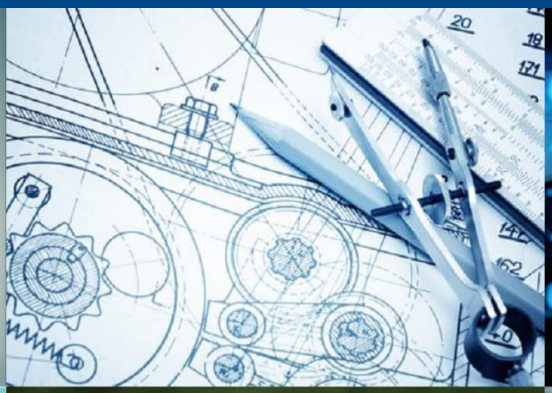

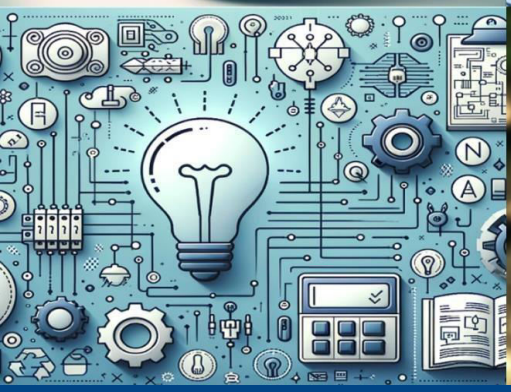

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LEDGERLIGHT: Illuminating NGO Spending with Blockchain

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ABSTRACT: Non-Governmental Organizations (NGOs) are crucial catalysts for social welfare and relief efforts, yet they consistently grapple with fundamental issues of financial transparency and accountability. The current opaque nature of fund utilization creates significant mistrust among donors, often leading to reduced contributions and reputational damage.

This project introduces LEDGERLIGHT, a robust, blockchain-based fund tracking and management system designed to restore and solidify trust between donors and NGOs. LEDGERLIGHT leverages the inherent security, immutability, and transparency of blockchain technology to create a complete auditable ledger of all financial transactions. Every donation received and every expenditure made by the NGO is recorded on this decentralized ledger.

Key functionalities include the integration of a digital wallet for real-time fund tracking by all stakeholders, and the use of smart contracts to automate and govern fund disbursement. These smart contracts ensure that money is released only upon the fulfillment of predefined conditions, such as the submission of project completion proof or procurement evidence, effectively minimizing the risk of mismanagement or fraud

KEYWORDS: Blockchain, Smart Contracts, Transparency, Accountability, Non-Governmental Organizations (NGOs).

I. INTRODUCTION

The global non-profit sector faces a profound crisis of trust and accountability because opaque, traditional financial systems enable corruption and fund leakage. This deficit creates a significant "trust deficit," which ultimately restricts sustainable funding and undermines the effectiveness of global aid efforts.

The LEDGERLIGHT project resolves this by proposing a paradigm shift through a Decentralized Application built on Distributed Ledger Technology. Its core mechanism uses Smart Contracts to act as autonomous financial governors. Donor funds are locked and are only released upon the submission of a cryptographically verifiable proof-of-expenditure from the NGO. This architecture moves accountability from a manual process to an automated, code-enforced protocol.

LEDGERLIGHT ensures end-to-end transparency and integrates proactive governance. It uses Layer 2 scaling for efficiency and low costs and incorporates an AI Fraud Detection Module and DAO principles for community-based governance. The primary objective is to develop this comprehensive, self-governing financial platform, providing the secure, transparent solution needed to fully restore public trust and maximize global aid impact.

II. OVERVIEW

The LEDGERLIGHT project addresses the fundamental crisis of trust and accountability in the Non-Governmental Organization (NGO) sector caused by opaque financial systems and endemic corruption. Traditional accounting methods lack the verifiable, immutable traceability necessary for modern philanthropic finance, leading to significant fund leakage and donor skepticism.

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LEDGERLIGHT solves this by implementing a Decentralized Application built on Distributed Ledger Technology. The core mechanism involves Smart Contracts that lock donor funds and enforce a conditional release protocol, ensuring that money is only disbursed upon the submission of a cryptographically secure proof-of-expenditure from the NGO.

The system is architected for real-world use via Layer 2 scaling for high-throughput and low transaction costs. Its comprehensive suite of modules includes the Core Ledger Module for immutable recording, an AI Fraud Detection Module for proactive anomaly analysis, and a Donor/Stakeholder Governance Module based on DAO principles. LEDGERLIGHT's objective is to provide an end-to-end transparent, self-governing financial platform, ultimately maximizing the efficiency of global aid and fully restoring public confidence in charitable giving.

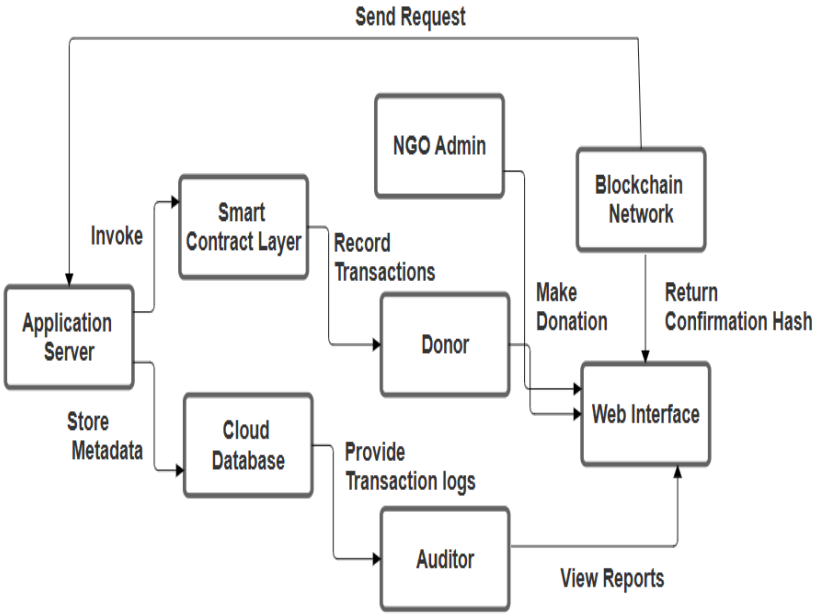

Fig.2.1. Architecture diagram for proposed system

III. COMPONENTS

1. Core Ledger Module (DLT) Function: Immutable public record (L2) logging all transactions and fund state changes, ensuring end-to-end financial traceability.
2. Smart Contract Protocol Function: Autonomous governor containing conditional fund release logic, executing payment only upon cryptographic proof validation.
3. Donor/Wallet Interface Function: Front-end allowing donors to connect wallets, make donations, track status, and access governance voting.
4. NGO Expenditure Tracking Module Function: Secure interface for managers to submit requests, upload evidence, and generate the cryptographic proof needed to unlock funds.
5. AI Fraud Detection & Analytics Module Function: Uses Machine Learning (ML) models to analyze ledger data in real-time, proactively flagging anomalous or suspicious spending behavior.
6. Donor/Stakeholder Governance Module (DAO) Function: Integrates DAO principles, enabling stakeholders to vote on key financial decisions for decentralized control and fairness.

IV. EXISTING SYSTEMS

Existing systems for NGOs rely on traditional centralized accounting and rudimentary crypto methods, both lacking robust accountability. Traditional management uses opaque, retrospective audits, leading to high administrative overhead, manual errors, and high vulnerability to corruption once funds enter a private bank account. Even simple

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crypto donations fail, as transparency ends at the wallet receipt; subsequent spending decisions occur off-chain without any automated control over fund use, thus failing to resolve the fundamental "trust deficit" with donors.

The critical gap across all these systems is the absence of conditional, code-enforced financial governance. Earlier DLT applications merely log data but lack the necessary Smart Contract logic to control or prevent fund misuse proactively. LEDGERLIGHT closes this gap by introducing a self-governing DLT layer that mandates a verifiable proof-of-expenditure for every transaction before fund release. This approach transforms fund management from a reactive, manually-audited process into an automated, trustless, and proactive system of financial accountability.

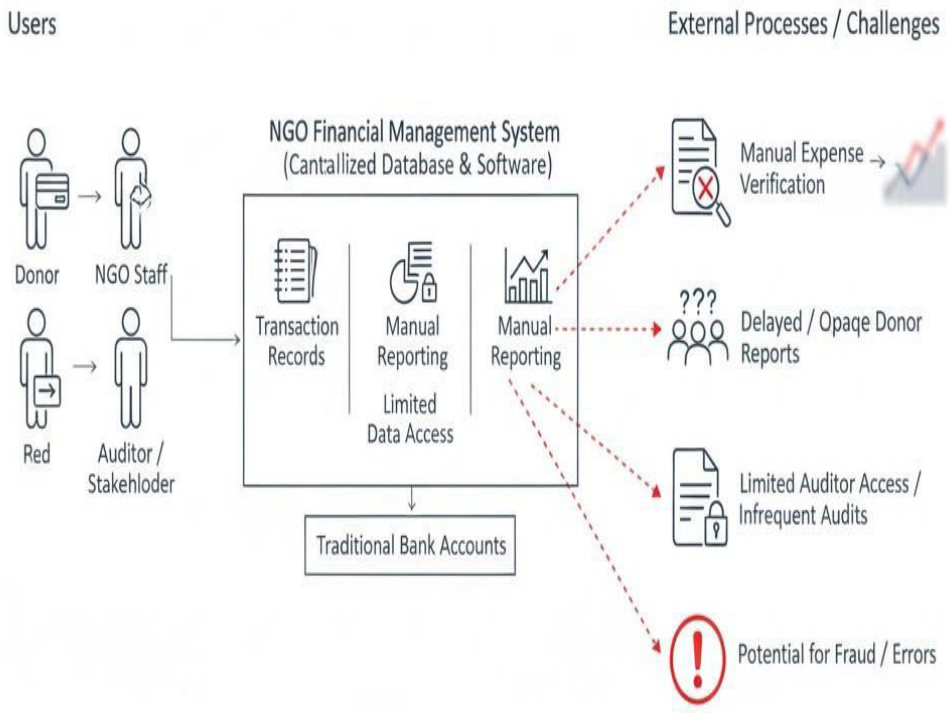

Fig.4.1. Traditional NGO Spending Tracking

V. PROPOSED SYSTEM

A. Objective

The core objective is to automate conditional fund disbursement via Smart Contracts, contingent upon verifying a proof-of-expenditure. The system aims to establish immutable DLT records to eliminate manual auditing, dynamically manage fund flow to reduce corruption, and integrate AI detection to proactively monitor spending anomalies. The ultimate goal is to restore public trust and maximize aid efficiency.

B. Methodology

The LEDGERLIGHT system provides real-time fund control and adaptive financial governance using Smart Contract automation. It integrates the Core Ledger Module, Smart Contract Protocols, and AI-driven Analytics for efficient and transparent fund allocation.

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1. Proof-of-Expenditure Submission via NGO Tracking Module

The authorized NGO manager initiates an expenditure request via a secure interface. They upload evidence (e.g., receipts) which generates a unique cryptographic hash (proof). This hash, not the sensitive document, is sent to the Smart Contract. This automated proof submission eliminates manual verification, increasing efficiency and auditability.

2. Smart Contract Processing and Conditional Fund Release

The Smart Contract Protocol processes the received cryptographic hash against its predefined rules. If the proof is valid and conditions are met, the contract automatically executes the command. This action releases the locked funds from escrow to the final vendor or beneficiary. Automated execution prevents unauthorized or corrupt fund diversion.

3. Real-Time Tracking & Reporting Illumination for Enhanced Transparency

Immediately after execution, the Core Ledger Module records the immutable transaction details and proof hash. The Real-Time Tracking & Reporting Interface pulls this public data. This illuminates the complete fund journey from donor wallet to vendor for all stakeholders. This process ensures high visibility and prevents the "transparency black hole" of traditional finance.

4. Proactive Security and Stakeholder Governance

The AI Fraud Detection Module continuously monitors the Core Ledger's data feed, dynamically analyzing spending patterns. This module proactively flags any anomalous behavior for immediate review. Concurrently, the Donor/Stakeholder Governance Module (DAO) allows the community to vote on decisions. This ensures efficient fund utilization and maximizes decentralized control.

VI. IMPLEMENTATION OF PROJECT

The LEDGERLIGHT system is implemented through a structured process involving on-chain development, off-chain service integration, system testing, and final Layer 2 deployment to enable automated fund disbursement and DLT-based financial control. The process begins with the deployment of Smart Contract Protocols onto the chosen Layer 2 network (e.g., Polygon/Arbitrum) to establish the Core Ledger and the conditional escrow logic. These contracts receive transaction requests and cryptographic proofs from the off-chain NGO Expenditure Tracking Module, which is built using modern web frameworks The contracts process the input according to the State-Transition Logic Algorithm and automatically execute the fund release.

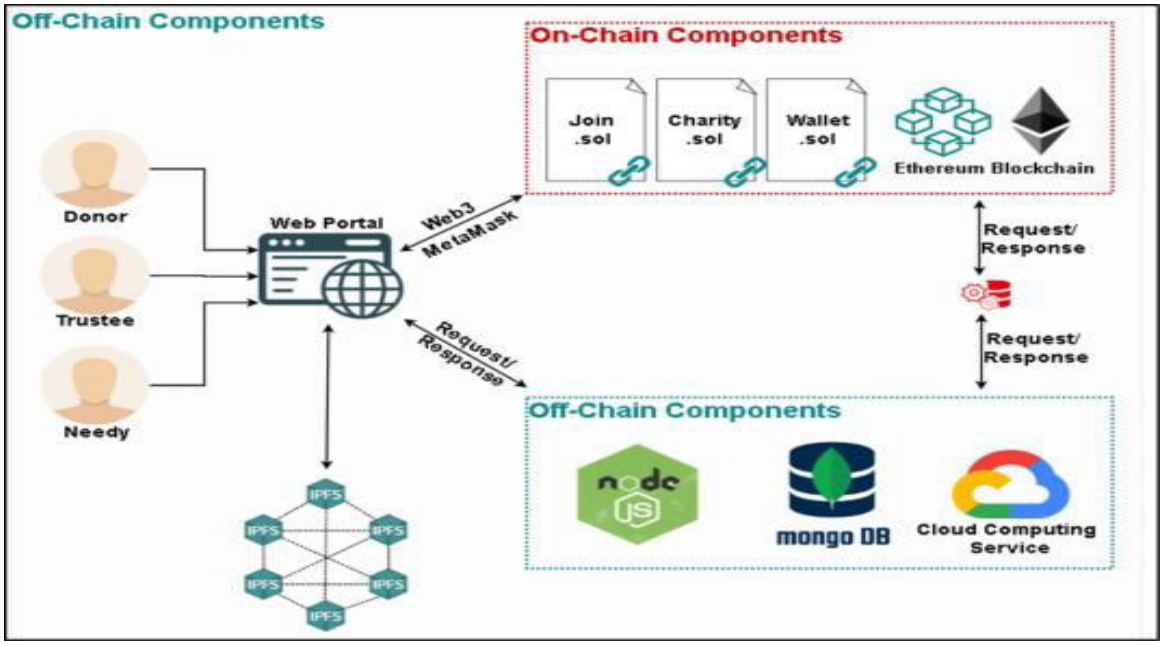

Fig.5.1. Implementation of Blockchain based tracking

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The successful execution is immediately recorded immutably on the Core Ledger, ensuring real-time coordination between donors, NGOs, and auditors. This ledger data instantly populates the Real-Time Tracking & Reporting Interface, effectively illuminating the fund's complete journey for all stakeholders, especially in times of crisis or high-volume aid distribution. The off-chain services, including the AI Fraud Detection Module, are continuously powered by cloud infrastructure, ensuring continuous monitoring and analysis of spending patterns to flag anomalies immediately.

The software for LEDGERLIGHT is primarily coded using Solidity for the Smart Contracts and React/Node.js for the interfaces and off-chain services. The entire system undergoes rigorous unit testing and security auditing (using tools like Hardhat and Slither) to ensure accurate conditional execution and reliable immutability. Once validated through a Testnet environment, the system is deployed on the Layer 2 Mainnet, where it dynamically manages financial governance based on real-time proof-of-expenditure submissions and predefined accountability rules.

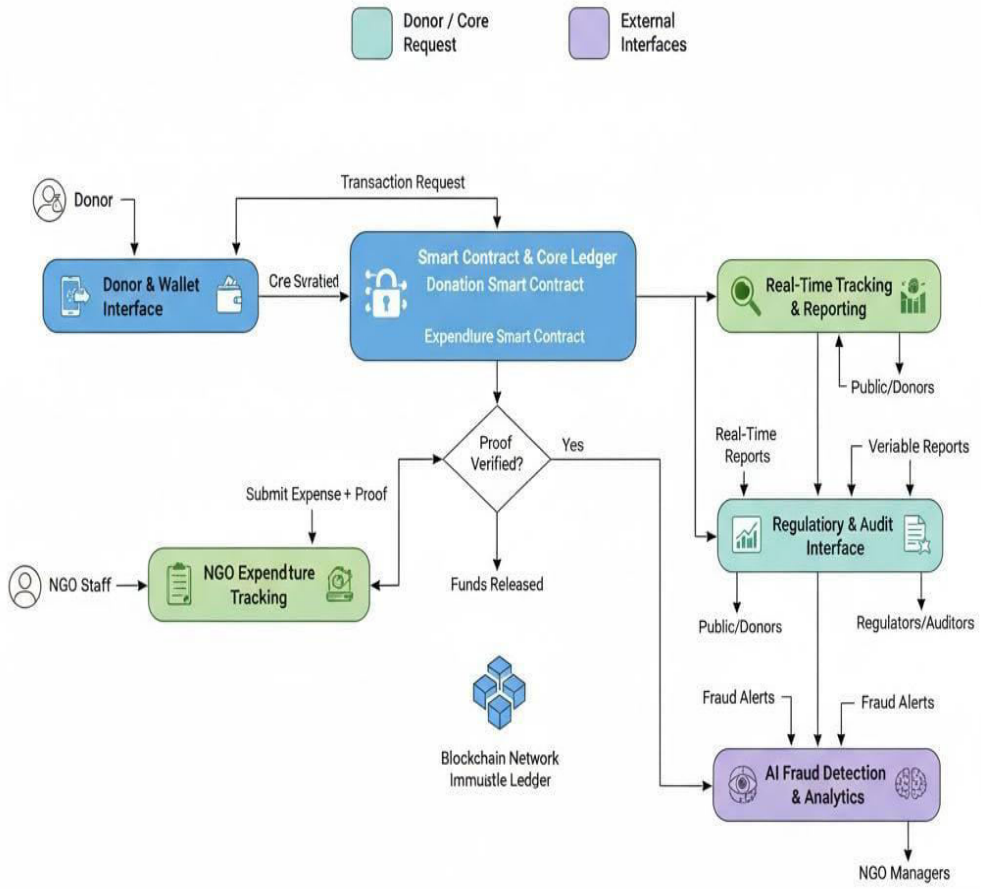

Fig.5.2. Working flow Blockchain based Tracking system

VII. ADVANTAGES

1. Stops Corruption: Smart Contracts prevent fund misuse by enforcing conditional release only after verifiable proof-of-expenditure is submitted.
2. Builds Trust: The use of an immutable, public ledger provides donors with end-to-end, real-time transparency, eliminating skepticism.
3. Saves Money: Automation eliminates the need for expensive, manual auditing and reduces overall administrative and banking overhead.

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4. Proactive Security: The AI Fraud Module actively monitors transactions, allowing the system to flag and prevent financial anomalies in real-time.

VII. FUTURE ENHANCEMENTS

1. Privacy and Auditability: Integrate Zero-Knowledge Proofs (ZKPs) to allow auditors to verify compliance and expenditure proofs without exposing the sensitive, underlying data of donors or beneficiaries.
2. Outcome-Based Funding: Implement Decentralized Oracle Networks to pull verified, real-world data directly into Smart Contracts, enabling automated fund release based on verifiable project milestones or outcomes.
3. Global Scalability: Expand the architecture to support Cross-Chain Interoperability, allowing the system to seamlessly handle asset transfers and governance across multiple diverse blockchain networks.

VIII. CONCLUSION

The LEDGERLIGHT project successfully presents a trustless, automated solution to the pervasive accountability crisis in the NGO sector. By deploying Smart Contracts on a DLT platform, the system enforces conditional fund release and end-to-end transparency, actively eliminating corruption. This platform maximizes the efficiency of aid and restores donor confidence, establishing a new, robust standard for ethical financial governance.

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