SDG BLOCKCHAIN ACCELERATOR

Technical Architecture Document

1. Project Information

- **Project Name:** Blockchain-Enabled CRF Fund Disbursement System
- **Challenge & UNDP Office:** UNDP Bangladesh
- **Document Version:** V1

2. Project Overview

This prototype demonstrates a **hybrid cooperative loan management platform** that integrates **Cardano blockchain smart contracts** with **traditional finance systems** (mobile money/ fiat).

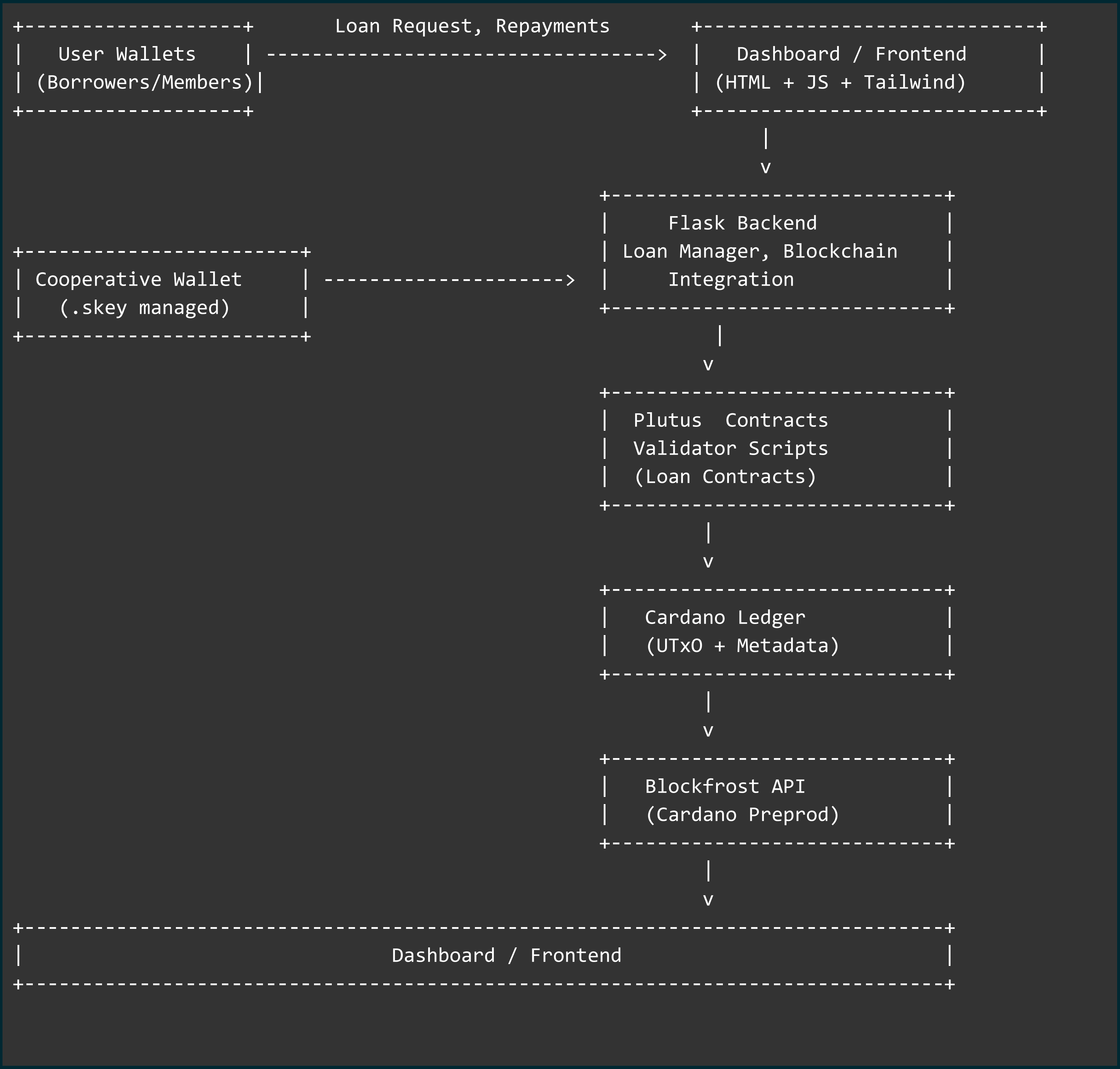
3. System Architecture Diagram

The system integrates **off-chain services** (Flask backend + dashboard) with **Cardano blockchain components** (UTxO ledger, Plutus contract stubs, user wallets).

Components:

- **User Wallets**: Borrowers' Cardano testnet addresses.
- **Cooperative Wallet**: Managed via `cooperative.skey` for disbursement and repayment signing.
- **Plutus loan contracts**,
- **Simulated generated unique identifiers.**
- **Backend Services (Flask)**: Core logic, DID registration, loan management, transaction building.
- **Cardano Ledger (UTxO model)**: Records actual ADA transfers with metadata.
- **Blockfrost API**: Interface for submitting and tracking transactions.
- **Dashboard (Frontend)**: Displays members, loans, transactions, and statuses.

Illustration:



```
+-------------------+       Loan Request, Repayments       +-----------------------------+
|   User Wallets    | ---------------------------------->  |   Dashboard / Frontend      |
| (Borrowers/Members)|                                     | (HTML + JS + Tailwind)      |
+-------------------+                                      +-----------------------------+
                                                                 |
                                                                 v
                                                   +-----------------------------+
                                                   |     Flask Backend           |
+------------------------+                         | Loan Manager, Blockchain    |
| Cooperative Wallet     | --------------------->  |     Integration             |
|   (.skey managed)      |                         +-----------------------------+
+------------------------+                                   |
                                                            v
                                                   +-----------------------------+
                                                   |  Plutus  Contracts          |
                                                   |  Validator Scripts          |
                                                   |  (Loan Contracts)           |
                                                   +-----------------------------+
                                                            |
                                                            v
                                                   +-----------------------------+
                                                   |   Cardano Ledger            |
                                                   |   (UTxO + Metadata)         |
                                                   +-----------------------------+
                                                            |
                                                            v
                                                   +-----------------------------+
                                                   |   Blockfrost API            |
                                                   |   (Cardano Preprod)         |
                                                   +-----------------------------+
                                                            |
                                                            v
+--------------------------------------------------------------------------------+
|                                Dashboard / Frontend                            |
+--------------------------------------------------------------------------------+
```

4. Blockchain Design

Smart Contracts:

- Plutus contracts generated per loan.
- Example snippet (from logs):

```
-- Plutus Loan Contract for Loan ID: fe22080f-5dfc-47ef-9e04-fb0140b3d8f4
-- Borrower DID: did:cardano:cooperative:77b12b9bab56b253
-- Principal: 100000000 Lovelace
-- Interest Rate: 1000 basis points
```

Datum Structure:

- **Borrower DID**
- **Loan ID**
- **Principal & Interest rate metadata**

Redeemer Structure:

- **Actions:** `Disburse`, `Repay`

UTxO Model Usage:

- **Inputs: Cooperative wallet UTxOs**
- **Outputs: Borrower address with ADA + metadata (loan ID, DID)**
- **Repayment outputs return ADA to the cooperative wallet**

Token Management:

- **No native tokens in this demo. (Future extension: issue cooperative loan tokens.)**

Security Considerations:

- **Cooperative signing key required for disbursements and repayments**
- **Metadata ties transactions to loan records**
- **Replay protection enforced by unique transaction hashes**

5. Data Flow & Transaction Lifecycle

Lifecycle Example:

1. **Register Member**
    - DID created: `did:cardano:cooperative:77b12b9bab56b253`
    - API: `POST /api/members`
2. **Create Loan**
    - Loan ID: `fe22080f-5dfc-47ef-9e04-fb0140b3d8f4`
    - Smart contract address generated: `script_c8736511...`
    - API: `POST /api/loans`
3. **Disbursement**
    - Fiat equivalent: 100 ADA
    - Tx ID: `1239a7673a799df2e...`
    - API: `POST /api/loans/{loan_id}/disburse`
4. **Ledger Update**
    - 37 UTxOs found
    - Total available: `9994720073 Lovelace`
    - Tx submitted and confirmed on Cardano Preprod
5. **Dashboard Update**
    - Transactions table updated via Blockfrost polling

6. Off-chain Components

Flask Backend

- Loan Manager
- Blockchain integration (pycardano + blockfrost-python)

Frontend Dashboard

- Tailwind + JavaScript
- Tabs: Members, Loans, Transactions, Contracts

Key Management

- Cooperative `.skey` loaded from root.

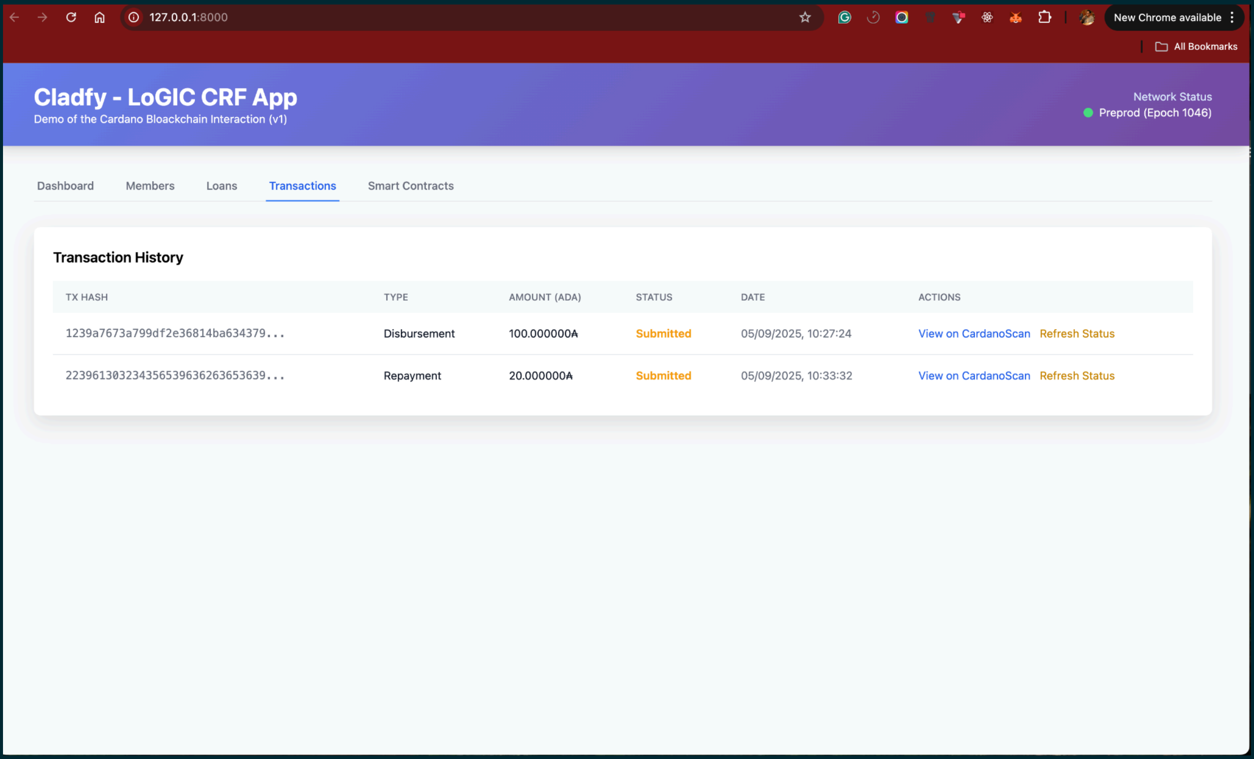
Blockfrost API

- Preprod network, Project ID `preview2ooNJb2xOmENf3TmqsEIBthNIrIgRkTS`

7. Sandbox/Testnet Results

Test Run (Logs Extract):

- Member Registered: ✅ `did:cardano:cooperative:77b12b9bab56b253`
- Loan Created: ✅ ID `fe22080f-5dfc-47ef-9e04-fb0140b3d8f4`
- Disbursement: ✅ Transaction `1239a7673a799df2e36814ba634379688917768f26f5ce7c2dfaf39facec6735`



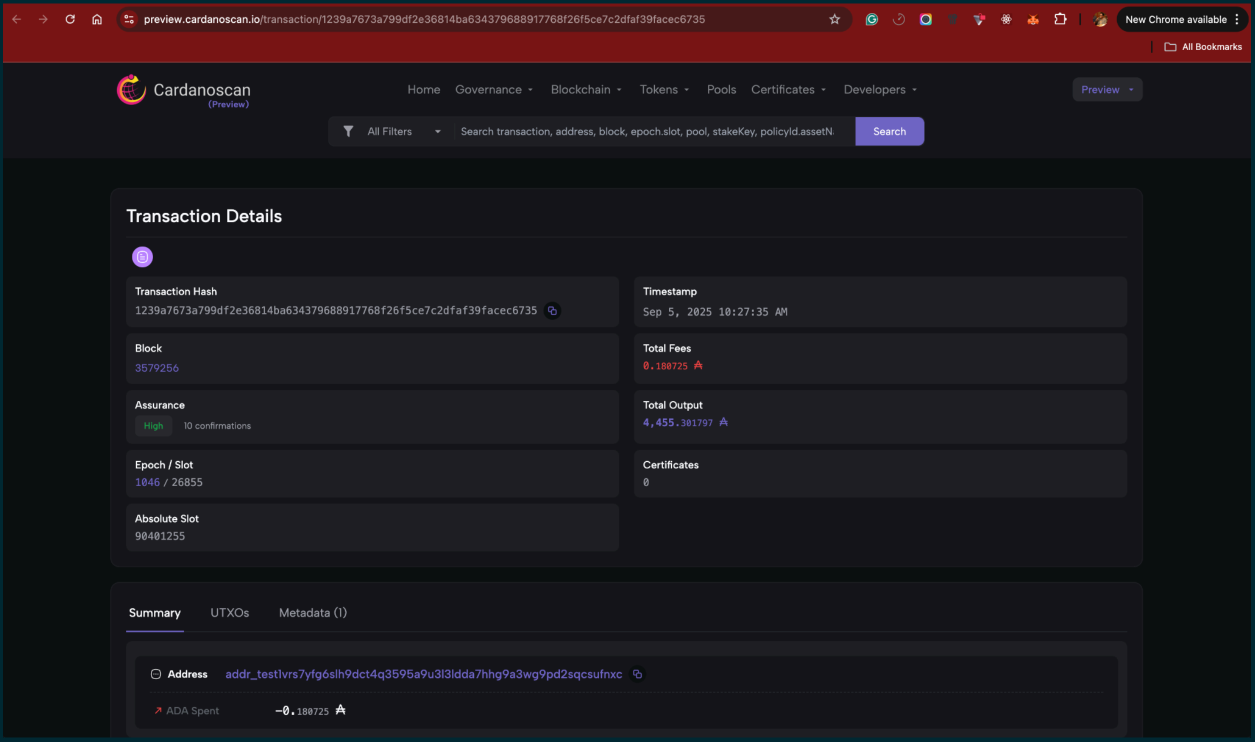
Cladfy - LoGIC CRF App

Demo of the Cardano Bloackchain Interaction (v1)

Network Status
● Preprod (Epoch 1046)

Transaction History

TX HASH	TYPE	AMOUNT (ADA)	STATUS	DATE	ACTIONS
1239a7673a799df2e36814ba634379...	Disbursement	100.000000₳	Submitted	05/09/2025, 10:27:24	View on CardanoScan Refresh Status
223961303234356539636263653639...	Repayment	20.000000₳	Submitted	05/09/2025, 10:33:32	View on CardanoScan Refresh Status


preview.cardanoscan.io/transaction/1239a7673a799df2e36814ba634379688917768f26f5ce7c2dfaf39facec6735
New Chrome available
All Bookmarks
Cardanoscan
(Preview)
Home
Governance
Blockchain
Tokens
Pools
Certificates
Developers
Preview
All Filters
Search transaction, address, block, epoch.slot, pool, stakeKey, policyId.assetN
Search

Transaction Details

Transaction Hash
1239a7673a799df2e36814ba634379688917768f26f5ce7c2dfaf39facec6735

Timestamp
Sep 5, 2025 10:27:35 AM

Block
3579256

Total Fees
0.180725 ₳

Assurance
High 10 confirmations

Total Output
4,455.301797 ₳

Epoch / Slot
1046 / 26855

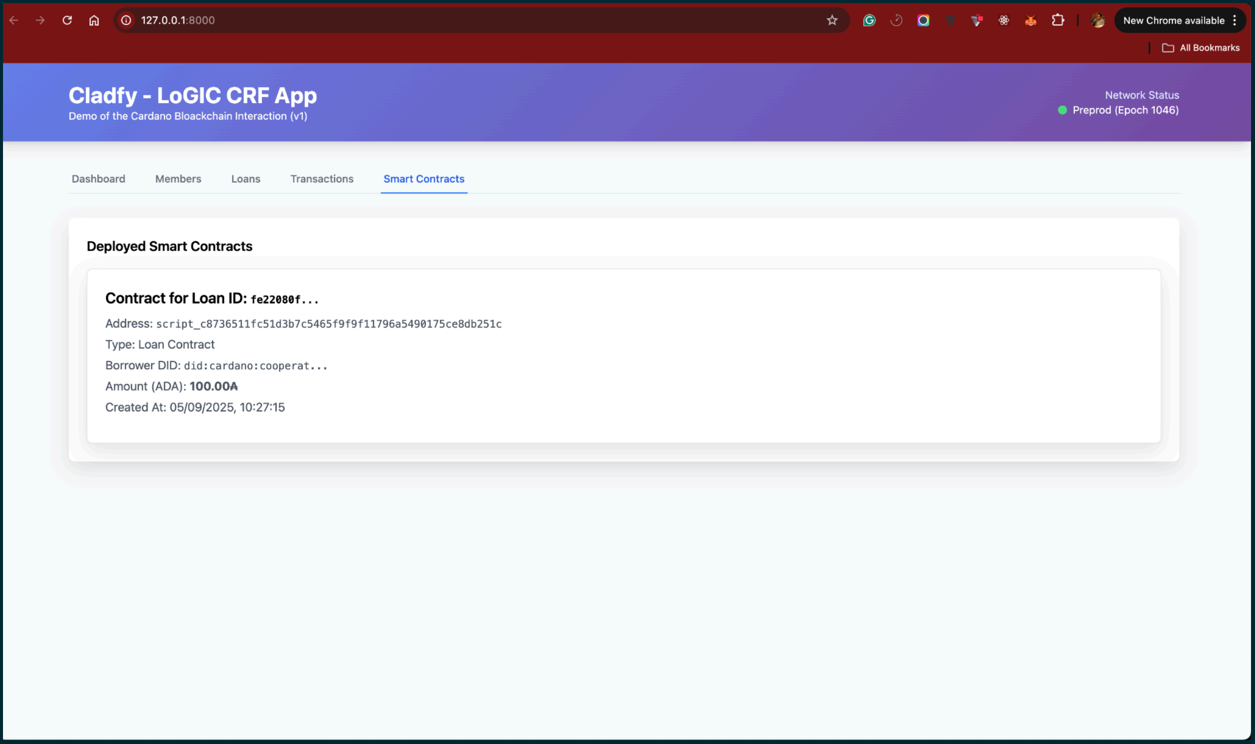
Certificates
0

Absolute Slot
90401255

Summary
UTXOs
Metadata (1)

Address addr_test1vrs7yfg6slh9dct4q3595a9u3l3ldda7hhg9a3wg9pd2sqcsufnxc

ADA Spent −0.180725 ₳



Cladfy - LoGIC CRF App

Demo of the Cardano Bloackchain Interaction (v1)

Deployed Smart Contracts

Contract for Loan ID: `fe22080f...`

Address: `script_c8736511fc51d3b7c5465f9f9f11796a5490175ce8db251c`
Type: Loan Contract
Borrower DID: `did:cardano:cooperat...`
Amount (ADA): **100.00₳**
Created At: 05/09/2025, 10:27:15

Example:

Tx Hash	Type	Status	UTxOs	Notes
`1239a7673a799df2e...`	**Disburse**	**Success**	**37**	**Loan 100 ADA sent to borrower**

Transaction ID	Contract Action	Status	Notes	Transaction ID	Contract Action
`1239a7673a799df2e...`	Loan Disbursement	Success	Submitted via Flask → Blockfrost integration	`1239a7673a799df2e...`	Loan Disbursement
`c8736511fc51d3...`	Loan Contract Created	Success	Generated conceptual Plutus script	`c8736511fc51d3...`	Loan Contract Created

8. Tools and Environments Used

- **Python 3.10** with `Flask`, `pycardano`, `blockfrost-python`
- **Cardano Preprod Network**
- **Blockfrost Project ID**: `preview2ooNJb2xOm`

Local Development Server

- Flask running at `http://127.0.0.1:8000`

Cooperative Keys

- Loaded from `cooperative.skey`

Frontend

- Tailwind CSS + vanilla JS

9. Remaining Considerations / Next Steps

- **Persistence**: Move from in-memory storage → PostgreSQL
- **Multi-Cooperative Support**: Add registry for multiple co-ops and committees
- **Smart Contracts**: Improve contract validators
- **Integrations**: Link with the current Multi-Cooperative management system
- **Governance**: Add DAO-style voting in Phase 2
- **Security Audit**: Implement HSM/multi-sig for cooperative key management.
- **Scaling**: Benchmark disbursement throughput and transaction confirmation delays.