

Digital Tokenization For Loans In Banking Integrating NPL

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Abstract: *This project introduces a decentralized application to tackle the main problems of opacity and inefficiency in managing Non-Performing Loans (NPLs). It uses a smart contract on the Ethereum blockchain to create a secure, unchangeable, and clear ledger that covers the entire loan lifecycle. The system has a role-based structure that separates public loan applicants from authorized bank employees. The proof-of-concept shows how blockchain technology improves data integrity, simplifies auditing, and builds more trust and efficiency in the financial ecosystem. The system ensures secure loan status updates and clear access control. It aims to improve regulatory oversight and operational efficiency in banking loan management.*

Keywords: Ethereum Blockchain, Smart Contracts, Meta- Mask Wallet

I. INTRODUCTION

In traditional management of Non-Performing Loans (NPLs), reliance on centralized private bank ledgers makes it hard for regulators and stakeholders to obtain a clear and timely view of loan statuses [1]. This lack of transparency creates challenges in auditing and tracking loan lifecycles, which ultimately erodes trust in the financial system. To tackle these problems, this project offers a decentralized application that uses a smart contract on the Ethereum blockchain. By using blockchain's unchangeable and shared ledger, the system provides accurate and real-time visibility of loan data. This improved transparency not only boosts accountability but also builds confidence among all financial participants[2].

The smart contract-enabled system provides a clear and unchangeable ledger that tracks the entire loan process, from the initial application to approval and updates on loan status, including identifying non-performing loans (NPLs)[3]. Its role-based access control system ensures that only authorized bank employees can approve loans or change the status to NPL. At the same time, applicants can submit loan requests and securely monitor their progress. This setup improves security by stopping unauthorized changes and creates a lasting, auditable record of all transactions[4].

The system combines blockchain technology with a React-based frontend and a MetaMask wallet for user interaction. The smart contract is deployed on the Sepolia public testnet to validate real-time interactions[5]. The backend safely manages user data and directs the application's logic. The smart contract maintains data integrity and transparency on-chain[6].

The system is built around a main smart contract, CreditHistory.sol. This contract manages the entire loan process, including application submissions, status updates, and final resolutions with Non-Performing Loan (NPL) identifications[7]. The smart contract uses a strong role-based access control model, giving different permissions to public loan applicants, bank employees, and system administrators[8]. This separation of duties improves security and maintains data integrity, stopping unauthorized changes to loan statuses[9].

The program shows a major improvement in banking technology. It demonstrates how digital tokenization and decentralized applications can change loan and non-performing loan management. This change makes these processes more secure, clear, and efficient[10].



II. LITERATURE REVIEW

A. Loan Origination and Management

The main focus is loan management. Chen et al. (2024) show that a blockchain-based system can automate loan origination and processing workflows. However, this research has a key gap. It focuses on origination and does not address the entire loan lifecycle, including the management of Non-Performing Loan (NPL) statuses. Similarly, Rodriguez (2023) confirms that Solidity is a strong language for defining financial terms and repayment schedules, but the proposed model is general and not specifically designed for the NPL lifecycle.

B. Tokenization of Assets

Tokenization is a significant trend. Sharma and Diwakar (2023) present a theoretical framework that shows tokenizing illiquid assets can greatly improve liquidity. This work is still conceptual and lacks a functioning prototype or specifics on user versus system access control. Gangabathina (2023) builds on this by suggesting a framework for "tokenization-based loan offer enablement." However, this proposal remains high-level and is intended for private groups.

C. Decentralized Finance (DeFi) and Credit Risk

Moving beyond traditional banking, Lee and Kim (2022) look at credit risk in DeFi lending protocols. They find that on-chain over-collateralization can effectively defend against sybil attacks. A major limitation of this study is that it does not include traditional banking contexts and overlooks important regulatory and compliance aspects.

D. Applications in Adjacent Domains

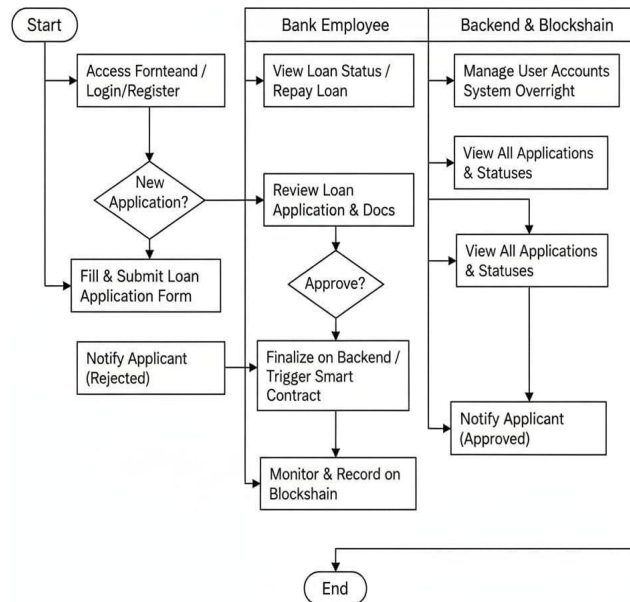
The literature draws insights from related fields. Al-Jabri (2022) examines blockchain in supply chain finance and concludes that it offers complete transparency in cash and goods flow. This approach focuses on cross-border trade instead of corporate loans, but his model raises concerns about performance and transaction speed. Similarly, Gupta (2021) outlines a framework for e-tendering. Although this area is different, he shows that the workflow for submitting and approving is similar. Gupta also notes that a public blockchain can support secure and transparent processes. These studies together highlight how blockchain builds trust in multi-party environments.

E. High-Level Conceptual Impact

The literature, including Müller (2020), offers a broad analysis suggesting that blockchain will transform banking operations. This change will mainly affect clearing, settlement, and trade finance by eliminating intermediaries. However, this study does not provide detailed technical information and does not tackle the scalability issues related to using public blockchains in high-volume banking.

III. ACTIVITY DIAGRAM

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IV. DISCUSSION

Digital tokenization for loans in banking, which includes Non- Performing Loans (NPLs), introduces a decentralized application to address the key issues of transparency and inefficiency in managing these loans. By using a smart contract on the Ethereum blockchain, the system creates a secure, unchangeable, and clear record for the entire loan lifecycle. It has a role-based setup for public loan applicants and authorized bank employees. The result is a successful proof-of-concept that shows how blockchain technology can greatly improve data integrity, simplify auditing, and build more trust and efficiency within the financial system.

A. The Core Problem: The NPL "Anchor"

Non-Performing Loans (NPLs), also called "distressed assets," are a major challenge for banks. Capital Lock-Up: These are illiquid assets that remain on a bank's balance sheet. They tie up capital that could be used for new lending. This directly affects the bank's profitability and capital adequacy ratios, such as CET1).

High Management Costs: Managing and trying to recover these loans is costly, takes a lot of time, and needs many resources. It requires specialized legal and asset management teams.

Illiquid Market: The traditional market for non-performing loans (NPLs) is unclear and inefficient. Banks find it hard to sell large NPL portfolios quickly without giving a huge discount. The buyers are typically a small group of large institutional investors or specialized hedge funds.

The main idea of your project is that the current NPL market is flawed. It lacks liquidity, is centralized, and moves slowly. Digital tokenization provides a solution by turning these "dead" assets into liquid, tradable financial instruments.

B. The Solution: Digital Tokenization as Modern Securitization

Tokenization is not magic. It is a technological development of securitization.

Traditional Securitization: A bank groups thousands of loans, such as mortgages, into a package. It sells this package to a legal entity known as a Special Purpose Vehicle (SPV). The SPV then issues bonds, like Mortgage-Backed Securities, to investors. Investors receive payments as homeowners make their mortgage payments. Digital Tokenization: This process is similar, but it includes a significant technology upgrade.



Bank sells NPLs. The bank sells its portfolio of NPLs to an SPV. This true sale removes the troubled assets from the bank's balance sheet.

SPV issues tokens. Instead of issuing traditional bonds or security receipts, the SPV issues digital tokens on a blockchain, such as Ethereum, Polygon, or a private chain like Hyperledger.

Tokens represent a claim. Each token is a fractional legal claim on the future cash flows from the NPL recovery. For example, if the SPV recovers \$1 million by selling a foreclosed property, that money is shared among all the token holders.

This creates a liquid secondary market where investors can buy, sell, and trade these "NPL-backed tokens" any time, just like a stock.

C. The Technical & Legal Architecture (The "How") The Legal-Technical "Bridge"

An NPL is a real-world legal contract. A token is just code. You must legally and technically link them.

The Legal Wrapper (Off-Chain): The SPV is the legal owner of the NPLs. The legal documents for the token offering, such as the prospectus or offering memorandum, state that owning a token gives the holder a direct contractual right to the SPV's recovery proceeds.

The Digital Representation (On-Chain): The token, such as an ERC-20 token for fractional shares or an ERC-721 for a unique, single NPL, is the digital proof of ownership.

Blockchain Layer: This is the decentralized ledger that keeps track of who owns which tokens.

Public, Permissionless: Using a chain like Ethereum or a Layer-2 solution like Polygon makes it globally accessible, but it requires careful security and compliance measures. Private/Permissioned: Using a chain like Hyperledger Fabric gives the bank and regulators more control. It limits participation to "whitelisted" investors only.

Smart Contract Layer: This is the "engine" of your project. The smart contract is a piece of code that automatically runs the rules of the investment. Its key functions are:

Compliance Enforcement: It can be set up so that tokens can only move between wallets that have completed KYC/AML (Know Your Customer/Anti-Money Laundering) checks.

Automated Distribution (The "Payment Waterfall"): This is a key feature. In NPL recovery, money is distributed in a complex, tiered order. Servicers get paid first, followed by senior investors, then junior investors. A smart contract automates this "payment waterfall." When the SPV receives recovery funds, the smart contract automatically and instantly distributes the funds to all token holders in the correct, pre-defined order.

Oracle Layer: Blockchains are isolated systems. They cannot see the real world. An oracle, like Chain link, is a secure data feed that bridges this gap.

Function: The oracle provides important off-chain data to the smart contract. For example, "The servicer confirms \$500,000 has been recovered from the sale of asset XYZ".

Trigger: This data serves as a trigger. The oracle data informs the smart contract, "The money is in the SPV's bank account. You can now execute the payment waterfall".

D. Key Benefits (The "Why") For the Bank:

Immediate Liquidity: Sells the NPLs for cash today.

Better Balance Sheet: Cleans the balance sheet, which improves capital ratios and how investors see the company.

Lower Costs: Automation through smart contracts lowers the high administrative and service costs of traditional securitization. For the Investors:

Access opens a historically closed-off asset class to a larger group of investors, such as smaller funds, family offices, or qualified retail investors).

Fractionalization means an investor doesn't need \$10 million to invest in a portfolio. They can purchase a \$1,000 token, which enables precise portfolio diversification.

Transparency: Every transaction and distribution is recorded on an unchangeable blockchain. This creates a clear, verifiable trail.



Price Discovery: A liquid, 24/7 secondary market allows the NPLs to be priced more fairly and efficiently based on real-time supply and demand.

E. Major Challenges & Risks (The Discussion)

The number one challenge is regulatory uncertainty. This is the biggest hurdle.

What is it? Regulators are having a hard time figuring out how to classify these tokens. Are they securities? Are they a new kind of asset?

United States: In the US, a tokenized NPL would almost certainly pass the Howey Test and be classified as a security. This means it must be registered with the SEC or, more likely, sold only to accredited investors under an exemption like Regulation D.

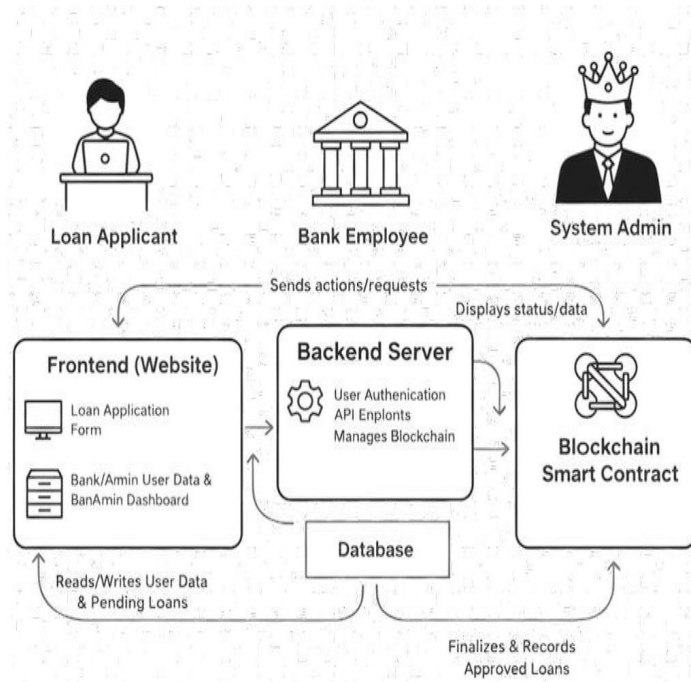
India: This is a very active area. The challenge is that the key securitization law, SARFAESI Act, recognizes "Security Receipts (SRs)" issued by Asset Reconstruction Companies (ARCs), but it does not formally recognize "tokens." The current workaround is to run projects in a SEBI regulatory sandbox or to tokenize the SRs themselves.

Europe: The MICA (Markets in Crypto-Assets) regulation gives a clear framework. However, many asset-backed tokens like these may still be treated as traditional securities under MiFID II.

Smart Contract Risk: A bug in the payment waterfall code could be exploited or lead to incorrect fund distribution. The code needs to be flawless and undergo thorough audits.

Valuation Risk: How do you determine the value of a token supported by a troubled asset? The underlying non-performing loans (NPLs) have a high chance of recovering nothing. This is a speculative investment, making valuation challenging.

V. SYSTEM ARCHITECTURE



VI. FUTURE DIRECTIONS

1. AI-Driven Predictive Valuation & Recovery

The next step is to integrate Artificial Intelligence (AI) directly into the NPL servicing process. Instead of using static valuations, AI models will analyze millions of data points, such as borrower behavior, market trends, and legal case



progress. These models will create a predictive recovery score for each NPL. This score will give investors a more precise, real-time estimate of the asset's true value and expected recovery timeline.

2. Integration with DeFi Liquidity Pools

To solve the liquidity "cold start" problem, NPL tokens will be added to high-quality Decentralized Finance (DeFi) protocols. This change will let token holders deposit their NPL tokens into a liquidity pool, like Aave or Compound. They will be able to borrow against these tokens or earn yield. This setup creates a market that is always open, offering instant liquidity without needing to wait for a direct buyer.

3. Atomic Settlement using Wholesale CBDCs

The future of settlement involves using Central Bank Digital Currencies (CBDCs). In India, this would mean using the RBI's upcoming Unified Markets Interface (UMI) to settle trades in wholesale CBDC (e₹-W). This allows for "atomic settlement." The NPL token and the digital rupee are exchanged at the same time in one risk-free transaction. This process removes all counterparty and settlement risks.

4. Creation of "Dynamic" NPL Tokens (DNFTs)

The token will change. Instead of a fixed token, the project can use a "Dynamic NFT" (DNFT). The metadata for this token, which is its on-chain data, will be updated in real time by oracles. For instance, the DNFT could automatically show the latest AI-driven recovery score, the current legal status of the loan, or the most recent servicer update. This will make the asset completely transparent at a glance.

5. Cross-Chain Interoperability for a Global Market

NPL tokens will not be confined to one blockchain. By using interoperability protocols like Chain link's CCIP, these assets can move smoothly between different blockchains, such as from a private bank chain to Ethereum to Polygon. This is essential for creating a single global marketplace. It would enable a bank in India to sell its NPL-backed tokens to an investment fund in Singapore or London.

VII. CONCLUSION

This project provides a clear and practical solution to the long-standing challenges surrounding Non-Performing Loans (NPLs) by transforming opaque, illiquid assets into transparent, tradable digital tokens. Through the use of a Special Purpose Vehicle (SPV) and smart contracts, it enables instant liquidity for banks and fully automates the payment waterfall, eliminating manual processes and reducing operational costs. The approach enhances transparency, supports broader investor participation through fractionalization, and ensures trust through immutable, auditable records. By enabling real-time price discovery via a liquid secondary market, the model creates fairer valuations and a more efficient marketplace. Ultimately, this project not only addresses NPL inefficiencies but also establishes a scalable blueprint for digitizing a wide range of real-world illiquid assets.

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