Enhancing Consumers' Financial Accessibility with Blockchain-Powered Credit Scoring: A Decentralized Method for Approval of Personal Loans

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***Abstract*—Credit allowances for individuals who are seeking financial opportunities are vital for their growth and sustainability. Traditional credit scoring systems don't allow them to get personal loans, as individuals lack collateral or have a limited financial history. This paper approaches a novel solution that makes use of blockchain technology to overcome these issues and improve individuals' access to financing. The main benefits of blockchain technology are transparency, security, and decentralization, which have the potential to completely transform the credit rating system. We aim to develop a decentralized credit scoring system that incorporates a wide range of parameters by combining international standard scoring systems like FICO and EQUIFAX to make it more efficient. Moreover, the decentralized credit scoring system ensures data integrity and security, reducing the risk of fraud and manipulation in the credit scoring process.**

***Index Terms*—Personal Loans, Collateral, Blockchain Technology, Transparency, Security, Decentralization, Social Reputation, Manipulation, Credit Score.**

I. Introduction

According to the World Bank, small enterprises are the backbone of world economies, making up about 90% of businesses and providing more than 50% of jobs globally [1]. In Bangladesh, these small enterprises, along with many individuals, are a big part of our economy [2]. But both groups face major challenges when trying to get loans [3]. One key reason is that they often don't have a formal credit history or valuable assets to use as collateral. On top of that, corruption, lack of transparency, and biased decisions by some bank officials make the situation even worse [4]. Additionally, loan approval still depends heavily on manual checks and personal judgment, which often leads to unfair treatment and becomes very lengthy process.This heavy reliance on human participation raises the possibility of human error.

To address these issues, we explored how blockchain technology can help to make the credit scoring and loan approval process more fair, secure, and efficient. Blockchain's immutable nature ensures that records remain unalterable and transparent to all stakeholders [5]. In our research, we designed a system where borrowers' financial data, like account balance, payment history, and job stability—is recorded and checked using smart contracts. These contracts run automatically on the Ethereum blockchain, without the need for bank staff to make manual decisions. We also proposed a hybrid form of blockchain in our system that achieves an optimal level of privacy and openness, where protected information is kept private using the Quorum permissioned blockchain feature and non-sensitive public data remains accessible using Ethereum public features.

The key contributions of this paper are:

- we propose a new credit scoring model using blockchain;
- we build a system that uses both public and private blockchains for the transparency and to protect sensitive data;
- we use multiple factors from different scoring system like FICO , CIBIL and EQUIFAX Risk score to evaluate credit score ;
- we create smart contracts that automate credit checks and loan approvals; and
- we develop a user-friendly mobile app using Flutter, so users can apply for loans and see their credit scores in real time.

Our proposed system uses the decentralized, transparent, and tamper-proof nature of blockchain to improve the credit evaluation and loan approval process. By removing the need for manual checks, it helps reduce delays and minimizes the risk of human bias. Smart contracts handle credit assessments automatically, ensuring fair and consistent decisions. Through a user-friendly mobile app, individuals and small businesses can apply for loans and view their credit scores in real time. We believe this approach can strengthen trust in the financial system and create better access to funding for those who need it most.

II. Literature Review

Blockchain technology has emerged as a transformative solution in addressing the challenges associated with traditional credit scoring systems, particularly with issues related to transparency, security, and accessibility. Numerous studies have explored the potential of blockchain to revolutionize credit evaluation processes, providing a more secure, transparent, and decentralized system. A Blockchain-Based Autonomous Credit System, as proposed by Yinsheng Li et al [6], seeks to rectify the shortcomings of current credit systems such as brokerage dependency, integrity issues, and unscientific evaluation models.Similarly, the development of a blockchain-based personal credit evaluation model discussed by Wei Wang et al [7] focuses on ensuring data integrity and decentralized verification. The destruction of coins for credit evaluation, as part of the model, further ensures transparency and security, making it a promising alternative to traditional methods. For Small and Medium Enterprises, blockchain provides a more reliable and transparent credit evaluation system Wei Wang et al [8]. The traditional credit assessment methods often fail due to a lack of transparency and accessibility. The introduction of blockchain-based systems could improve it's access to funding and help strengthen their financial credibility. This argument is echoed by the Bit-Score model [9], which addresses the inefficiencies of conventional credit scoring methods for underprivileged individuals, utilizing decentralized digital identities and transaction records to promote financial inclusion and trust. This model ensures fairer credit evaluation by speeding up verification and removing the need for central authorities.

Bangladesh's microcredit industry has also been identified as a sector that could benefit from blockchain technology. The Micro chain framework proposed by Md Asaduzzaman et al [10] aims to tackle trust and security challenges in microcredit, emphasizing the importance of transparency and privacy in enhancing financial inclusion. Finally, the integration of blockchain into loan sanctioning systems in traditional banking, as outlined by Md Rabbi et al [11], demonstrates how blockchain can streamline loan processing by enhancing transparency, security, and efficiency through smart contracts and decentralized data storage.

III. Illustration of our proposed model

In the existing model, there are lots of problems, which are mentioned in the introduction part, like heavy dependency on manual checks, corruption, unfairness, lengthy process and many more. To solve all these problems, we have proposed a blockchain-based hybrid model for credit scoring as well as for loan approval.

Here is Fig : 1, which presents our proposed solution, where the loan approval system is automated through smart contracts. Borrowers can be easily registered using an application by inputting some necessary data. Users' data is securely collected and stored on a decentralized network. However, sensitive data like users' financial details and personal identification will be stored on a private blockchain. Based on the borrower's information, the system will calculate the borrower's credit score, which would help the lenders decide whether or not to sanction the loan. This model would make the decision faster, prevent data tampering, and promote fairness by removing most manual intervention.

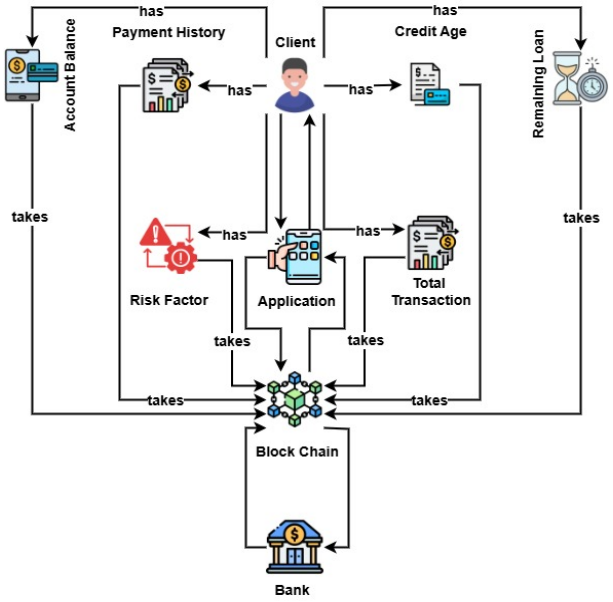

Fig. 1: Architecture of the Proposed Hybrid Blockchain-Based Credit Scoring and Loan Approval System.

IV. Methodology

A. Technology

Blockchain's decentralized structure supports secure, transparent, and efficient financial transactions across platforms, aligning well with embedded finance principles [12]. Its immutability and consensus mechanisms prevent fraud and ensure data integrity. To balance privacy and openness, we adopt a hybrid blockchain model—public chains store general credit data like payment history and credit age, while Quorum, a permissioned Ethereum variant, protects sensitive information such as identity and financial records. Quorum enables both public and private transactions, ensuring only authorized entities such as banks or regulators, can access confidential data. With strict security protocols and multi-signature controls, our system ensures both transparency and trust, which offering a robust, decentralized solution for credit scoring and loan management.

B. Parameter

- Account Balance: The Account Balance category, with a 25% weight, is a crucial indicator of a borrower's financial health in the credit scoring system.
- Total Transactions: Total transactions category carries a 15% weight in the credit scoring system.
- Payment History: In the credit scoring system, payment history is the most important category which carries the

TABLE I: Credit Scoring Parameters and Their Impact on Loan Decisions

Category	**Sub-Category**	**Weight (%)**	**Impact on Loan Decision**
Account Balance	Current Balance	25	Best Terms (Low Interest)
	Recent Deposits	-	
	Savings Account	-	
	Liquidity Status	-	
Transactions	Frequency	15	Standard Terms
	Transactions Size	-	
Payment History	On-time Payments	30	Higher Interest Rates
	Missed or delayed payments	-	
Total Remaining Loan	Current Outstanding Loan	10	Caution, may require
	Loan Types	-	
Credit Age	Length of Credit History	10	Contributes to overall trustworthiness
	Oldest Active Account	-	
	Average Credit Age	-	
Professional Risk Factor	Job Stability	10	Strict conditions or rejection
	Income Level	-	
	Employment Type	-	

highest weight of 30%. It includes sub-categories like on-time payments, missed or delayed payments, outstanding debts, and debt recovery efforts.

- Total Remaining Loan: The Total Remaining Loan category, with a 10% weight, evaluates a borrower's financial obligations by examining Current Outstanding Loan, Loan Types, and Loan Terms.
- Credit Age: The credit age category carries a 10% weight which plays an important role to understand and evaluate borrower's experience with managing credit over time.
- Professional Risk Factor: The Professional Risk Factor category, weighted at 10%, assesses a borrower's employment and income stability.

C. Algorithm

The blockchain-based credit scoring and loan management system collects borrower information, including financial and credit history, which is validated and securely stored on the blockchain. As shown in Algorithms 1 and 2, the system includes several functions to handle borrower information, calculate credit scores, and offer some extra features.

D. Equation for Credit Score Estimation

1) Total Credit Score Formula: The overall credit score is calculated as a weighted sum of all main categories and their respective sub-categories. The formula for the overall credit score is represented as follows:

Algorithm 1 Borrower Management and Credit Evaluation Functions

```
function ADDBORROWER(nid, name, profession, accountBalance, totalTransactions, paymentHistory, totalRemainingLoan, creditAge, professionRiskFactor)
    Store Borrower in mapping borrowers using nid as key
end function

function CALCULATECREDITSCORE(nid)
    Retrieve borrower from borrowers
    Calculate score based on borrower data (accountBalance, transactions, paymentHistory, etc.)
    return total credit score
end function

function GETMAXLOANAMOUNT(nid)
    Calculate creditScore
    return max loan amount based on creditScore
end function

function GETCREDITRATING(nid)
    Calculate creditScore
    return credit rating based on creditScore
end function
```

$$\text{Credit Score} = \sum_{i=1}^{n} \left(\text{Category Weight}_i \times \sum_{j=1}^{m_i} \left(\text{Sub-category}_{ij} \times \text{Sub-category Score}_{ij} \right) \right) \tag{1}$$

i represents each main category such as, Account Balance, Payment History. M_i is the number of sub-categories within each category. Category Weight$_i$ is the weight of the main category. Sub-Category Weight$_{ij}$ is the weight of each sub-category within the main category. Sub-Category Score$_{ij}$ is the score calculated for each sub-category.

2) Account Balance Formula: Sub-Category Balance (SCB) represents the score for each sub-component within the Account Balance category, such as current balance, savings, and liquidity assets. It reflects the borrower's financial strength by comparing available funds against the requested loan amount, as calculated in Equation (2):

$$\text{SCB} = \min\left(\frac{L}{B}, 100\right) \tag{2}$$

L represents the borrower's desired loan amount. B represents the borrower's current balance, savings account balance, or liquidity assets price.

3) Total Transactions Formula: The total transactions category is evaluated by considering two sub-categories. The Transaction Capacity Score (TCS) is calculated as:

Algorithm 2 Additional User Functions

function GETCREDITSCOREBREAKDOWN(borrowerID)
    Retrieve *borrower* from *borrowers* using *borrowerID*
    breakdown ← { "Account Balance", "Payment History", "Credit Age", "Professional Risk Factor" }
    return *breakdown*
end function

function CHECKREPAYMENTSTATUS(borrowerID)
    Retrieve borrower loan data using *borrowerID*
    status ← { "Total Loan Amount", "Paid Amount", "Remaining Balance", "Current Status" }
    return *status*
end function

function VIEWCREDITSCORETREND(borrowerID)
    Retrieve borrower credit score history using *borrowerID*
    return borrower.creditScoreHistory
end function

$$\text{TCS} = \min\left(\frac{T_f \times T_s}{L} \times 100, 100\right) \tag{3}$$

T_f is the average number of transactions per month. T_s is the average transaction size. L is the loan amount requested.

4) Payment History: To evaluate payment history, the percentage method is used. For instance, if a borrower misses 3 installments and pays 7 on time, their score will be 70. The Loan History Score is calculated as:

$$\text{Loan History Score} = \left(\frac{\text{Lotp}}{\text{Lotp} + \text{Lmp}}\right) \times 100 \tag{4}$$

Lotp is the number of on-time payments. Lmp is the number of missed or delayed payments.

5) Total Remaining Loan: The total remaining loan is evaluated based on total outstanding loans and loan types, with weights of 60% and 40%, respectively:

$$\text{Total Remaining Loan} = (0.6 \times \text{Cols} + 0.4 \times \text{Lts}) \tag{5}$$

Here, Cols is the current outstanding loan score and Lts is the loan types score.

6) Professional Risk Factor: The Professional Risk Factor evaluates a borrower's job stability (40%), income level (30%), and employment type (30%) to assess employment-related risk. Higher income relative to loan obligations and stable, full-time jobs lead to better scores, while less stable employment types receive lower ratings.

Let S_{js} represent the Score for Job Stability, S_{il} the Score for Income Level, and S_{et} the Score for Employment Type. The Professional Risk Factor Score is then computed as follows:

$$\text{Professional Risk Factor Score} = (0.4 \times S_{\text{js}} + 0.3 \times S_{\text{il}} + 0.3 \times S_{\text{et}}) \tag{6}$$

7) Credit Age: The Credit Age Score evaluates the borrower's experience in managing credit over time by considering three sub-categories: Length of Credit History, Oldest Active Account, and Average Credit Age. Each of these sub-categories contributes differently to the final score, with Length of Credit History having the highest influence at 50%, followed by Oldest Active Account at 30% and Average Credit Age at 20%. These components collectively reflect how long and how consistently a borrower has maintained credit relationships.

Let S_{lch} represent the Score for Length of Credit History, S_{oaa} the Score for Oldest Active Account, and S_{aca} the Score for Average Credit Age. The Credit Age Score is then calculated using the weighted formula:

$$\text{Credit Age Score} = 0.5 \times S_{\text{lch}} + 0.3 \times S_{\text{oaa}} + 0.2 \times S_{\text{aca}} \tag{7}$$

8) Credit Score Evaluation: In our credit scoring model, each main category—Account Balance, Transactions, Payment History, Total Remaining Loan, Credit Age, and Professional Risk Factor—is scored on a 100-point scale based on its subcategories. After calculating each category's score, it is adjusted according to its weight in the overall model, such as Account Balance at 25% and Payment History at 30%. These weighted scores are then summed to form a total credit score on a 100-point scale, offering a comprehensive evaluation of the borrower's creditworthiness.

9) Maximum Loan Amount Calculation Model: The maximum loan amount a borrower is eligible for is determined by their credit score and debt-to-income (DTI) ratio. A higher credit score increases the borrowing capacity, while a higher DTI ratio reduces it. To compute the maximum loan amount, the model applies a multiplier based on the borrower's credit score, annual income, and debt level. Let CS represent the Credit Score (on a 100-point scale), I the Annual Income of the borrower, MT the Base Multiplier Threshold representing a typical loan-to-income ratio cap, and DF the Debt Factor Adjustment derived from the borrower's DTI ratio. The formula used to calculate the maximum loan amount is:

$$\text{Maximum Loan Amount} = \left(\frac{\text{CS}}{100} \times \text{MT} \times I\right) \times (1 - \text{DF}) \tag{8}$$

10) Multiplier Threshold (MT): The Multiplier Threshold (MT) presents in Table II, is essential in this credit scoring model, as it sets the base loan-to-income ratio that a borrower may qualify for. The MT is determined based on industry lending practices, the type of loan product, and the lender's risk tolerance, which is closely tied to the borrower's credit score.

E. Application

The proposed application uses Ethereum, Remix IDE, and Flutter to develop a blockchain-based credit scoring and personal loan management system. The platform will provide a transparent, secure, and decentralized way to evaluate borrower creditworthiness and manage personal loans. The combination

TABLE II: Multiplier Threshold Based on Loan Type and Credit Score Range

Loan Type	Good (80-100)	Moderate (60-79)	Poor (40-59)	Very Poor (<¡40)
Unsecured Loans	5x	4x	1x	0x
Secured Loans	10x	6x	3x	0x
Mortgages	10x	6x	4x	0x
Small Profitable Business Loans	8x	5x	3x	0x

of these technologies will allow seamless interaction between smart contracts and the user interface, ensuring reliability.

1) Ethereum for Blockchain Integration: Ethereum, a leading blockchain platform, will form the backbone of the decentralized system. Its capability to execute smart contracts securely makes it ideal for managing the credit scoring and loan processes.

- Smart Contracts: These are used to automate key processes including credit scoring, loan approval, and maintaining data integrity. They utilize borrower data recorded on the blockchain, such as account balances and transaction history, to calculate credit scores. When the credit score meets the required threshold, the system automatically generates suitable loan terms. All loan disbursements and repayments are managed transparently on the Ethereum blockchain, ensuring trust and preventing fraud. To maintain both privacy and openness, the system uses a hybrid blockchain model where non-sensitive information is stored on the public Ethereum network, and sensitive data is securely handled through a private blockchain.
- Public vs. Private Blockchain: A hybrid blockchain approach can be implemented where public blockchain (Ethereum) records non-sensitive data such as payment history, transaction records, while sensitive personal information such as identity verification and private financial records, is handled off-chain or via a private blockchain.

2) Remix IDE for Smart Contract Development: Remix IDE, a browser-based Ethereum development tool, is used to build, test, and deploy the smart contracts that power the core features of the application. These contracts, written in Solidity, manage everything from borrower profiles to credit scoring and loan approval. With built-in support for real-time debugging and testing, Remix makes it easy to catch issues early and ensure the contracts work as intended before deploying them to either the Ethereum testnet or mainnet, depending on the development stage.

3) Application Workflow Design: This process involves several stages from loan application to repayment, all automated using Ethereum smart contracts for security and transparency as shown in the Fig : 2.

Here is a detailed breakdown of the workflow steps: The workflow begins when the borrower submits personal and financial information through the app. The system validates this data, prompting corrections if needed. Once verified, a smart

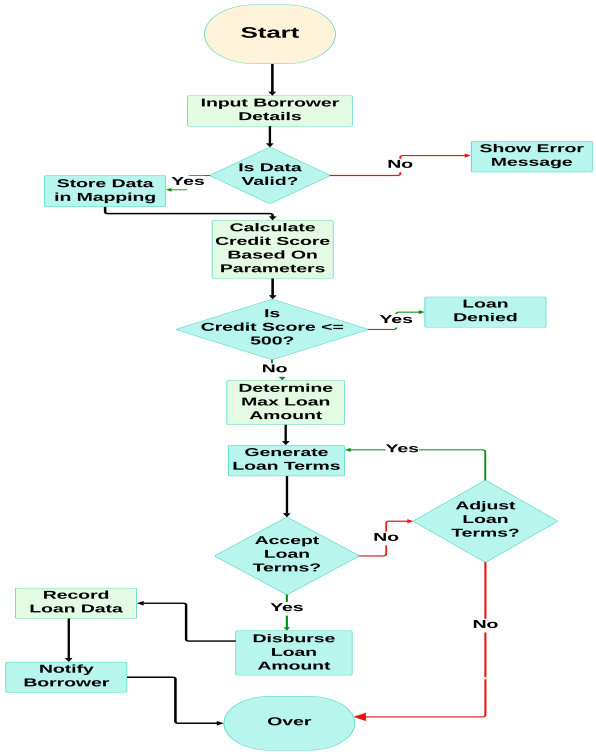

Fig. 2: Workflow Diagram of the Decentralized Credit Scoring and Loan Processing System.

contract on Ethereum calculates the credit score using factors like account balance and transaction history, storing the result on the blockchain. If the score meets the required threshold, loan eligibility is confirmed. The system then generates loan terms—including amount, interest rate, and schedule—based on the credit score. Borrowers can accept or request changes to these terms. Upon agreement, the loan is disbursed via smart contract. Repayments are tracked and recorded on-chain, with real-time notifications keeping borrowers updated on disbursements and due dates.

4) Flutter for Cross-Platform Application Development: Flutter will be utilized to create a seamless, user-friendly interface that can run on multiple platforms (iOS, Android, and web).

- Flutter's flexibility in UI design : The app will allow borrowers to apply for loans by submitting personal and financial data, which smart contracts will process automatically. Users can monitor loan status, including disbursements, repayments, and balances, with real-time updates recorded on the blockchain. Additionally, the app will display the borrower's credit score along with a breakdown of how it was calculated. As shown in Fig : 3, the app interface is designed to be intuitive and user-friendly.
- Real-time Notifications: Borrowers will receive real-time notifications on loan status, credit score updates, payment due dates, etc., ensuring that they stay informed.

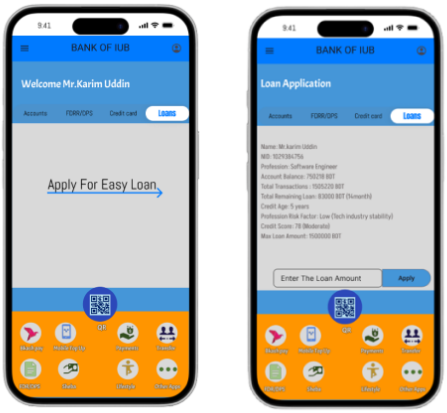

Fig. 3: User Interface of the Mobile Application Showing Real-Time Credit Score and Loan Status.

5) Backend and Integration: The application will communicate with Ethereum using `web3dart` (Flutter), enabling interaction with the smart contracts. A centralized backend service can be added for non-blockchain data storage and user management.

- Secure Data Handling: All sensitive borrower information will be encrypted and stored securely, with only the necessary data being recorded on the blockchain to ensure privacy and security.
- API Integration: For features like user identity verification or additional financial information (such as fetching credit data from external financial institutions), the app can also integrate APIs.

6) Technological Stack Summary & Security Considerations: The technological stack integrates several components to support a decentralized loan application. Flutter is used for building a cross-platform user interface, while Ethereum handles decentralized credit scoring and loan management. Smart contracts are developed using Solidity and tested in the Remix IDE. The backend is powered by Node.js and Express, acting as the API gateway and managing backend logic. An encrypted database stores non-essential off-chain data. Finally, the web3dart library connects the Flutter frontend with Ethereum smart contracts, enabling seamless blockchain interactions.

To ensure data security and privacy, a hybrid approach is used only essential information is stored on the public blockchain, while sensitive borrower data remains off-chain. This sensitive data is encrypted both during transmission and when stored. Smart contracts are thoroughly tested in the Remix IDE to detect and fix any vulnerabilities before deployment. Additionally, all API and blockchain interactions require user authentication to prevent unauthorized access and ensure secure usage.

V. Conclusion and Future Works

This study highlights how blockchain can revolutionize credit scoring and personal loan management by improving transparency, security, and accessibility. Using Ethereum smart contracts, the system tackles trust and bias issues in traditional methods, especially in underserved regions. Its decentralized design enhances data integrity, while a Flutter-based interface ensures user-friendliness. The solution offers a scalable, secure, and inclusive financial model.

In future, we plan to boost the system's speed, scalability, and usability by using Layer 2 solutions like rollups and Ethereum sharding to cut costs and speed up transactions. We'll also explore machine learning to make credit scoring smarter and more accurate. Integration with DeFi platforms is in focus to enable direct peer-to-peer lending, removing the need for traditional banks.

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