TrustLend: Using Borrower Trustworthiness for Lending on Ethereum

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Abstract: The practice of personal lending, also known as Peer-to-Peer (P2P) lending, has been increasing globally. However, providing unsecured loans to peers without requiring collateral remains a challenge. We present a platform called TrustLend, which enables using borrower trustworthiness as an alternative to collateral in personal lending transactions. TrustLend is a blockchain-based platform implemented on Ethereum. We introduce a borrower trustworthiness score with variable selection rules to help lenders decide on reliable candidates as borrowers. We describe the prototype implementation, which is a Decentralized Application (DApp) that uses smart contracts. The prototype demonstrates fundamental features and supports borrowers, recommenders, and lenders/investors in establishing loans and approvals. Finally, the prototype shows how end-users can easily access loans with minimum collateral without hidden costs and swift transactions.

1 INTRODUCTION

In general, micro-businesses and individual debtors find it difficult to get loans from banks without access to loan guarantors, and collateral (Pokorná and Sponer, 2016). In P2P lending, borrowers directly interact with peer lenders, making financing more accessible and efficient (Mammadli, 2016; Orús et al., 2019; Zhang et al., 2019) which means a higher credit risk for lenders. Credit risk is the possible loss a bank or other lender suffers after offering a loan to a borrower. This includes the risk of the borrower defaulting on the loan on time and the potential risk of default due to a decrease in credit score (Li et al., 2016) or a reduction in the borrowers' ability to repay.

P2P lending continues to increase worldwide every year. For example, in 2013, it reached 3.5 billion U.S. dollars. P2P lending is a new trend of the "sharing economy" an exponential increase is estimated to reach one trillion U.S. dollars in 2050. However, a P2P lending platform can also create risks for lenders when the borrower cannot make payments according to the agreement. Trustworthiness (Bartoletti et al., 2018; Kanagachidambaresan et al., 2012) is a critical

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component in deciding for lenders whether borrowers are accepted or rejected to get some loans. The bank or financial institutions have taken many borrower assets due to not fulfilling payments or experiencing delays in payments. Blockchain technology is emerging and successfully applied in many business applications, such as banking and other financial institutions (Larios-Hernández, 2017; Lee and Shin, 2018; Rana et al., 2019).

Blockchain technology encourages our motivation to study the potential of the Ethereum blockchain (Norta and Leiding, 2019). Recently, it has been applied in P2P and crowdfunding lending systems (Yum et al., 2012). The benefit of this new technology has led to explosive growth in the blockchain-based application, which exists within a highly secure system. Distributed ledger technology allows transaction and problem settlement without third-party risk (Zhao et al., 2017). The access to credit provided by the personal lending platform is intended to let the world of blockchains grow beyond the economic limitations of simply traditional money transactions. Loans (Capital, 2021; Zhao et al., 2017) is not only an important economic factor, but they are also a vital component of personal financial freedom and give individuals greater purchasing power.

This paper introduces TrustLend as a personal lending platform Ethereum blockchain-based and

presents its fully functional prototype design and implementation details. The paper builds upon our prior research work (Uriawan. et al., 2021). We describe the prototype architecture and conduct experiments and various personal loans simulations. This paper's remainder is structured as follows: Section 1 introduces the potential of a personal lending platform. Section 2 related work. Section 3 is our proposal for the trustworthiness prototype for a personal lending platform. Section 4 implements the prototype and input/output design. Section 5 discusses. Section 6 concludes and future work of this paper.

2 RELATED WORK

Everex is a financial technology that creates decentralized, global credit histories and scorings for individuals and Small Medium Enterprises. Everex supported enables transfers, borrowing, and trading in any fiat currency from anywhere in the world. Its Crypto cash Ethereum ERC20 token-based, regulated by fiat currencies, is tradable on the Everex Wallet and third-party applications and exchanges. Ethereum provides distributed ledger system and incorporates Turing-complete programming languages on the protocol layer to realize smart contract capabilities. It is implemented on the Ethereum blockchain and uses Solidity as a smart contracts language (Modi, 2018; Norta and Leiding, 2019).

ETHLend is an Ethereum-based decentralized lending platform worldwide connecting borrowers and lenders. It allows anyone to lend or borrow with an Ethereum address. ETHLend is decentralized lending on the Ethereum network by using ERC-20 compatible tokens or Ethereum Name Service (ENS) domains as collateral. ETHLend solves the problem of reducing the loss of loan capital on default (Tran, 2019). WeTrust is an Ethereum blockchain to give mutual aid equal footing with existing social capital and trust networks. Trusted Lending Circles to create a Rotating Savings and Credit Association (ROSCA) powered by smart contracts. It eliminates the need for a trusted third party, which cuts fees, improves incentive structures, and decentralizes risks. It will eventually incorporate mutual insurance, voting within reciprocal aid organizations, and P2P lending (Token, 2018).

3 OUR PROPOSAL

This section presents the Trustlend architecture describing all functions, the lending platform proto-

type, trustworthiness score, and development principles. The architecture shows a DApp platform (Uriawan. et al., 2021) for Ethereum blockchain-based personal lending to assist borrowers, recommenders, and lenders/investors in the lending process.

This architecture minimizes or eliminates the collateral need by assessing the borrower's trustworthiness score for the loan's repayment users who interact with the system as borrowers, recommenders, and lenders/investors are shown in Figure 1.
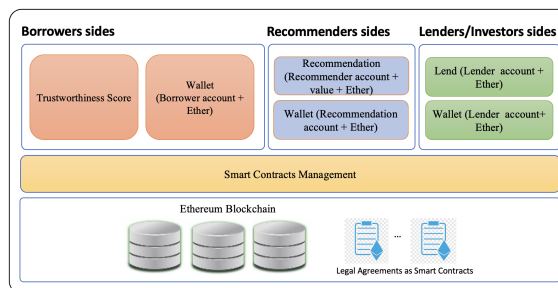

Figure 1: Trustlend Architecture Design.

Smart contracts will handle trustworthiness scores, recommendations, lenders/investors, and the wallet. Borrowers', recommenders', and lenders'/investors' transactions will be stored on the Ethereum blockchain.

3.1 Trustworthiness Score

The trustworthiness score formula (Uriawan. et al., 2021) is based on the user behavior attributes of risky attitude, trustworthiness, time preference, and impulsiveness (Arya et al., 2013). We adapt the trustworthiness score formula in terms of the reliable borrowers in Equation (1) and Equation (2). The trustworthiness score that we propose is a value of borrowers set by the smart contracts so that all parties (borrowers, recommenders, and lenders/investors) understand each other's obligations and risks that will be accepted. The variables include loan risk, activity, profile, and social recommendation.

$$\begin{aligned} Trustworthiness\ Score = &\ Loan\ Risk\ score \\ &+ Activity\ score + Profile\ score \\ &+ Social\ Recommendation\ score \end{aligned} \quad (1)$$

with:
Trustworthiness Score: Borrower Trustworthiness Score.
Loan Risk score: Information of the record from another loan of Borrower.
Activity score: Business activity or job information of Borrower.
Profile score: Personal information of Borrower.

Social Recommendation score: The recommendation value of Borrowers from Recommender.

and we added positive weight for each variable, in equation 2:

$$Trustworthiness\ Score = w_l * Loan\ Risk\ score$$
$$+ w_a * Activity\ score + w_p * Profile\ score \qquad (2)$$
$$+ w_s * Social\ Recommendation\ score$$

where $\{w\ in\ \mathbb{R}\ |\ w \leq 1\}$, and $w_l, w_a, w_p,\ and\ w_s$ are positive weights of the trustworthiness parameters such that $w_l + w_a + w_p + w_s = 1$. The weights of the trustworthiness attributes are predetermined based on their priority value that can modify by consensus. For example, $w_l = 0.25$, $w_a = 0.2$, $w_p = 0.25$, $w_s = 0.3$. In this example, social recommendation is given the highest value whereas activity is given the lowest value it's show that the social recommendation is the priority to measure the good borrower candidate.

3.2 TrustLend Prototype Development Principles

The prototype principles we adopt are standards codes and conventions, automated units testing, and static analysis tools. Some regulations relate to our prototype, as follows (Brown, 2013):

1. **Layering strategy**, the prototype applies a layers strategy to make every design flexible for the borrowers, recommenders, and lenders/investors.

2. **Placement of business logic**, our prototype ensures that business logic permanently resides in a single place for reasons related to performance or maintainability among the borrowers, recommenders, and lenders/investors.

3. **High cohesion and low coupling**, our prototype focuses on building small, highly cohesive blocks. There is no need to require many dependencies to do their job. Part by part development related to our prototype architecture design.

4. **Use of the HTTP session**, the prototype can often depend on many things, including scaling strategy, where session-backed objects are stored, what happens in the event of a server failure, whether using sticky sessions, the overhead of session replication,

5. **Always consistent versus eventually consistent**, prototypes have discovered that it often needs to make trade-offs to meet complex non-functional requirements.

4 IMPLEMENTATION

Trustlend is the personal lending platform prototype is a client-blockchain serverless application, where the entire flow of the app happens between the client and the blockchain. The client code can be hosted anywhere, and Amazon Web Services with Simple Storage Service features, Google Cloud, Github Pages, Netlify, other cloud providers, or own server. Our prototype is able to query the blockchain, and we use a web3 provider Metamask. A browser extension handles the actual web3 connection to a node shown in Figure 2.
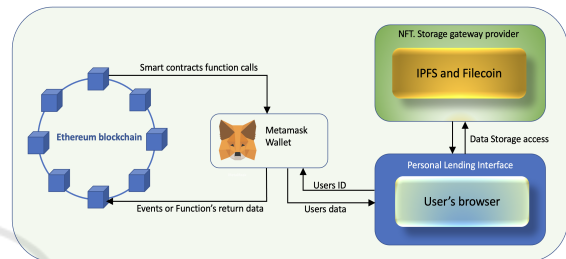

Figure 2: Prototype of a Trustworthy Personal Lending Platform.

For example, all the business logic, loans, and user history are handled and stored in the blockchain, which is decentralized. However, the Ethereum blockchain platform or any other Ethereum Virtual Machines blockchain-based like Polygon charges fees for each written transaction (Modi, 2018). We are able to store the data not used in smart contracts calculations to pay fewer fees, and choose the Interplanetary File System (IPFS) to store the loan description, images, and necessary data supported (Sicilia et al., 2019). Once the data is stored in the IPFS, the content identifier (CID) is returned and stored in the loan smart contracts to find this data later. We use NFT (Non-Fungible Token) (Buterin, 2014) storage (Free, decentralized storage and bandwidth for NFTs) to store the project's info into IPFS.

4.1 Trustlend Smart Contracts

The main smart contract that the client interacts with is the loan controller. It creates loans, handles investments, recommendations, repayments, etc. From the moment the user applies for a loan, the apply for loan function in the loan controller is called and creates a unique loan contract related to the loan in question. The smart contracts necessary of information about the loan, including 1) Borrower (represented by User contract instance), 2) Requested amount, 3) Repayment's count, 4) Interest, 5) Loan creation

date, 6) Last repayment date, 7) Return amount, 8) Lenders/Investors (array), 9) Recommenders (array), 10) Tscorecontroller contract (to handle user's trustworthiness score).

The recommenders and lenders/investors can call functions in the loan controller to lend/invest and recommend by providing the address of the loan contract. These smart contracts require a communication process and are defined as a legal agreement between borrowers, recommenders, and lenders/investors shown in Figure 3.

```
Tscore Smart Contracts (SocialRecommendations)
pragma solidity ^0.8.0;

import "./TScoreControllerInterface.sol";
import "./User.sol";
import "./Loan.sol";

contract    TScoreController    is    TScoreControllerInterface,
ExponentialNoError {

constructor() {
        admin = msg.sender;
    }

function updateSocialRecommendationScore(address _loanAddr,
address _userAddr, uint _recommenderWeight, uint _givenScore)
external override returns (uint) {
        User user = User(_userAddr);
        Loan loan = Loan(_loanAddr);
        Exp memory weightedScore = Exp({mantissa: 0});
        Exp[] memory weights;
        uint8[] memory scores;

(weights, scores) = loan.getRecommendersWeightsAndValues();
        for (uint i = 0; i < weights.length; i++) {
            weightedScore = add_(mul_(weights[i],
scores[i]), weightedScore);
            }

user.setSocialRecommendationScore(weightedScore);
        return user.getTScore();
    }

function updateActivityScore(address _loanAddr, address
_userAddr, uint _recommenderWeight, uint _givenScore) external
override returns (uint) {
        User user = User(_userAddr);
        return user.getTScore();
    }

function updateProfileScore(address _loanAddr, address
_userAddr, uint _recommenderWeight, uint _givenScore)  external
override returns (uint) {
        User user = User(_userAddr);
        return user.getTScore();
    }

function updateLoanRiskScore(address _loanAddr, address
_userAddr, uint _recommenderWeight, uint _givenScore) external
override returns (uint) {
        User user = User(_userAddr);
        return user.getTScore();
    }

function updateTScore(address _loanAddr, address _userAddr, uint
_recommenderWeight, uint _givenScore) external override returns
(uint) {
        User user = User(_userAddr);
        return user.getTScore();
    }

function getTScore(address _userAddr) external view override
returns (uint) {
        User user = User(_userAddr);
        return user.getTScore();
    }
}
```

Figure 3: Smart Contracts Trustworthiness score.

4.2 Lending Transaction Process

The Trustlend is built on React framework, an open-source javascript library. The application the criti-

cal main pages, The prototyping functionality is offered to three users: Borrowers, Recommenders, and Lenders/Investors. The borrower can access their menu on the borrower page. Before accessing the prototype, they (Borrowers, recommenders, and Lenders/Investors) should have the Metamask wallet and login. After the loan application has been received, the borrower user can make installment payments according to the agreement.

The lenders/investors user can access their menu and lend/invest with a selection of borrowers who propose the loan. In these cases, the lender/investor user determines the allocation of funds for the desired. The recommenders user can access the recommendation score menu to give each borrower a recommendation score and amount of funds (in ETH format). The lenders/investors use the trustworthiness score to decide and grant the loan. The main page
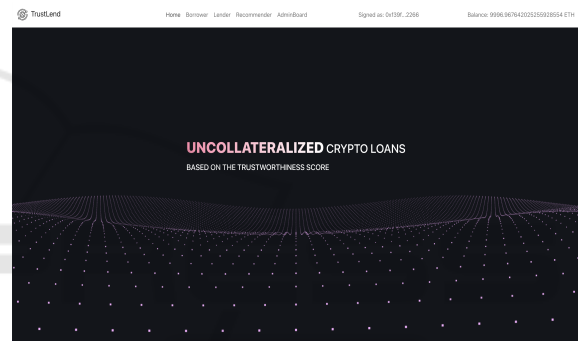

Figure 4: Trustlend main page.

provides a menu for borrowers, recommenders, and lenders/investors, is shown in Figure 4. Users can access it after being connected to their Metamask wallet. The Trustlend combines trustworthiness score and consensus in a legal agreement among the borrowers, recommenders, and lenders/investors. Users obtain permission only, such as security, immutability, and ledgers that can be changed through the consensus.

Metamask wallet is required by prototype, and users can install individual with terms and conditions shown in Figure 5 (a). Users manage the private key to receive the payments per transaction by their wallets. Unsigned transactions are sent from the wallet to the Trustlend for other payments transactions and verified by the borrowers, recommenders, or lenders/investors. The personal wallet screen is confirmed via Metamask as third-party, then approved by the user ID.

4.2.1 Borrower Page

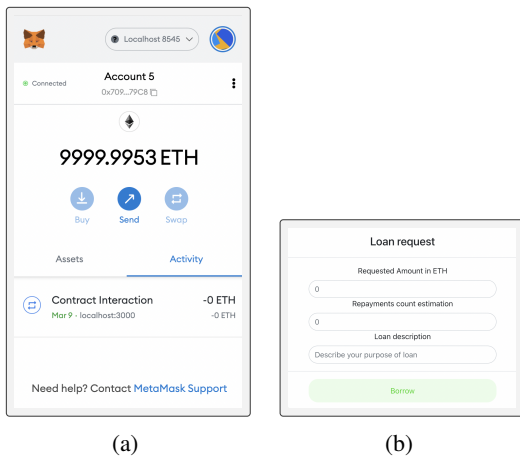The borrowers can access the prototype in Figure 5 (b). The system provides how the borrowers propose

Figure 5: Trustlend Metamask Wallet (a) and Trustlend Borrower Request a Loan (b).

some loans with terms and conditions. Some users give some loans information, and signals are sent to all recommenders and lenders/investors. The borrower page is provided to borrowers when trying to apply for some loans, with the proposed loan amount, installment period, and loan description being the purpose of the loan.

4.2.2 Recommender Page

The recommender can access the Trustlend with their wallet. Trustlend will provide the borrowers who need recommendations. Then the recommenders give some ETH and score/value see in Figure 6 (a). The Trustlend provides the recommendation page to ensure the lenders/investors can grant the loan.
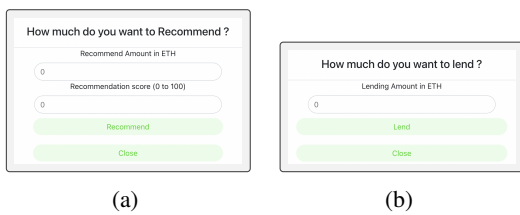

Figure 6: Social Recommendation score input (a) and Lender/Investor page input (b).

4.2.3 Lender/Investor Page

The lender/investor page is for lenders/investors looking for eligible borrowers. This page includes information on borrowers, loan amount, and interest in APY (Annual Percentage Yield) see in Figure 7. It is possible to be customizable between borrowers and lenders. The system will present borrowers who proposed a loan. The lenders/investors will get an opportunity with several borrowers' prospects, is shown in Figure 6 (b).

The smart contracts as a legal agreement (Borrowers, Recommenders, and Lenders/Investors sides) are the core of the lending prototype we are proposing. The excellent trustworthiness score of borrowers is a significant factor in this lending prototype. Reducing collateral dependence is replaced by social recommendation. Many lending platforms and banks still require a guarantee, which is burdensome for the borrower to provide.

4.2.4 Summarize the Loan Request

The borrower loan information describes the loans proposed for each borrower, including the amount requested, lenders/investors information, recommenders, trustworthiness score, collateral in crypto/token, and interest. It is reasonable to expect a high credit score associated with the payments process, is shown in Figure 7.
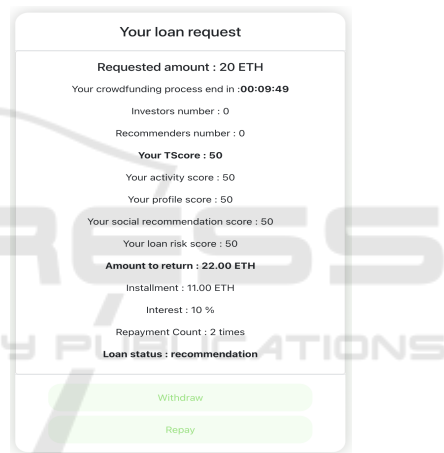

Figure 7: Trustlend Borrower Request a Loan.

5 DISCUSSION

The objectives of this prototype are to avoid impulsive borrowers who have difficulty resisting the temptation to borrow and increase debt for consumptive needs. Lenders/Investors are able to monitor the borrower and manage their lend/investment by choosing eligible borrowers to minimize their losses. Each lender/investor can choose by determining borrowers who can pay off and get the highest trustworthiness score. The trustworthiness score formula is well defined (such as weight percentage, variables, etc.), and is not possible to change after deployment.

Blockchain technology has advantages with immutability, integrity, and equal rights for all network members to get some information, and protect users' data from unauthorized access and encryption.

There is no personal information of borrowers, recommenders, and lenders/investors shown. We provide a prototype with an autonomous transactions process supported by smart contract functions after deployment. Smart contracts pay attention to borrower trustworthiness scores on a personal lending platform so that lenders can consider the potential risks that will be incurred. The value of trust among borrowers, recommenders, and lenders has a strong influence on a personal lending platform.

The disadvantages are that performing off prototype transactions will increase transaction time because the need for recommendation score and granted from lender/investor must be approved. In particular, all users are aware of the risk and the borrower's trustworthiness.

6 CONCLUSIONS

The Trustlend is a prototype of trustworthy Ethereum blockchain-based for personal lending that can provide a loan for borrowers who need without collateral. The social recommendation as a guarantor to convince lenders/investors to grant the loans to borrowers. This prototype is one of the lending platforms suitable for personal lending applications that apply blockchain advantages dimensions: anonymous, decentralized, immutability, and secure. This prototype proposes to minimize the difficulty by introducing the trustworthiness score to support borrowers, recommenders, and lenders/investors. The Trustlend is expected to be implemented in private environments that can be scalable to many members possible.

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