

Implementation of Property Rental Website Using Blockchain with Soulbound Tokens for Reputation and Review System

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Abstract

The rising number of rental scams is a concern for the community as certain illegal practices tarnish the sector's image. Landlords rent the property without a written rental agreement to charge excessive maintenance charges, tenants provide wrong background information or refuse to pay rent or maintenance, and so on. This paper proposes introducing a decentralized profile reputation system using soulbound tokens and digital currency for transactions in rental listing websites to minimize the number of rental frauds. A non-transferable non-fungible token is provided to the new user that records their reputation across their time on the website. The lease agreement is secured via a smart contract and only initiates once the security deposit has been paid by the selected tenant and signed by the landlord. All rental transactions take place on-chain, and only registered users with a tenant-landlord relationship can give reviews. This ensures the credibility of the review system. The decentralized ledger can also be used to supervise property rental affairs. This method facilitates convenient and authentic background checks, easy transactions, and market supervision.

Keywords

Blockchain, Soulbound Tokens, Real-estate, Reputation building, Rental Website, Web3, NFTs, IPFS

1. Introduction

The real estate sector is an important area in stimulating economic growth. Real estate is a type of property to possess and use. The developments of the real estate sector boosted the growth of retail, hospitality, entertainment, housing, and services business. An electronic version of the real estate industry, Internet real estate is the concept of disseminating housing estates for sale or rent online, and for consumers seeking to buy or rent properties through such platforms. The Internet real estate industry has faced several criticisms due to the lack of rules and regulations to protect developers and buyers. People who are looking to rent a property are often caught in housing and lease scams. In such cases, deceivers show themselves as either brokers or owners of the desired unit and tell the interested tenants to make transactions to their accounts for renting the house. Once the amount is transacted, they escape and disconnect with the renters. Tenant scams on the other hand take advantage of unassuming landlords who fail to implement the right procedures for screening renters, writing contracts, and collecting payments. Scams can take many forms and can be costly for landlords, both in terms of time and money. Some common examples include submitting false employment records, faking credit reports, forging checks and pay stubs, attempting to reset the eviction process, stealing a landlord's listing, and hiding property damages. These types of scams can put a landlord's income and business at risk. Today,

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numerous landlords and property management companies in urban corridors have transitioned from in-person dealings with rental applicants to digital interactions to cater to customer preferences. However, this has made it more difficult to verify application validity. In fact, between 2016 and 2018, 97% of property management companies have experienced fraud in some capacity, with 80% experiencing it up to 20 times, according to the Forrester study. Overall, about 59% of rental applications are submitted online, and this digitization of the rental application process has opened new avenues for fraud. The shift from in-person to digital applications, coupled with the COVID-19 pandemic, has also played a role in the increase of fraud in the rental housing industry.[1]

1.1. Proposed Solution

To solve such problems, the paper proposes the use of a property rental website which uses blockchain as its main technology. This will be achieved by minimizing online rental fraud and introducing profile reputation using Soulbound Token (SBT) for customers. It will allow tenants to look for available rental options, and landlords to list their properties. A Soulbound Token will be issued to the user that will monitor their profile reputation and authenticity. A soulbound token is a publicly verifiable and non-transferable non-fungible token (NFT) that can be used to represent an individual's credentials, affiliations, and commitments. Landlords can list their properties in the form of smart contracts on the network. A smart contract is a paperless digital code that defines a set of promises on prewritten conditions that the parties of a transaction have agreed upon [2]. Listing involves paying a minimal crypto fee to the admin as a security deposit which can be liquidated if the user violates the terms and conditions. A rental agreement only initiates once the tenant has successfully deposited the security fees which can further be retrieved when the agreement period ends. The terms and conditions of rent between the parties will be secured via a smart contract and all transactions henceforth will take place via smart contract methods. These programs are executed on a decentralized network of blockchain that provides the benefit of being immutable. Only users that have been in the tenant-landlord relationship can give reviews to each other, thus ensuring that the review system is credible. This could help revolutionize the online rental industry by minimizing the number of frauds and scams and increasing the trust between landlords and tenants.

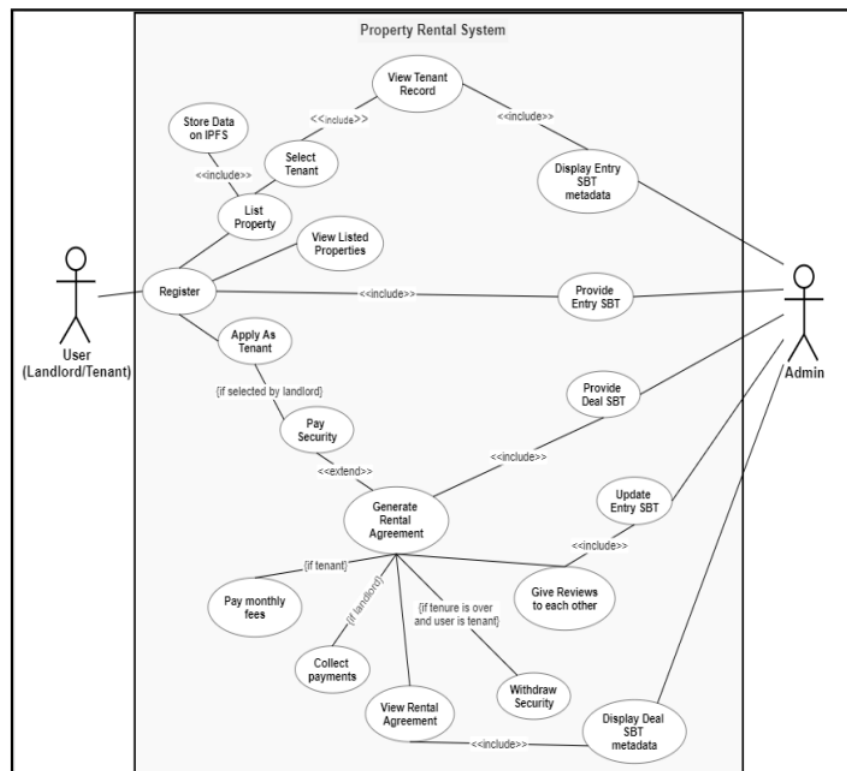


Figure 1: Use Case Diagram

2. Technical Background

2.1. Blockchain

Blockchain is an open, distributed ledger that records transactions between parties efficiently and in a verifiable and permanent manner. The present state of blockchain is often compared to that of the Internet in the mid-1990s, still in its infancy, when its value and potential were not understood. A blockchain is a decentralized and digital system that records transactions or events across multiple devices and locations. It functions as a public ledger of all the activities that the participating parties have conducted. The system uses the consensus of its participants to validate each transaction and once entered, it cannot be altered. One of the primary advantages of blockchain technology is its increased security and transparency, which fosters trust among participants. But its benefits go beyond that, as it also improves speed, efficiency and automation, resulting in significant cost savings. The use of blockchain technology reduces paperwork and minimizes errors, leading to less overhead and transaction costs, and in many cases eliminates the need for intermediaries to verify transactions. Every user has a wallet address associated with them which is used to carry out transactions on the chain. One of the crucial features of blockchain is its transparent nature. The transaction is visible to all the users on the chain and thus any type of fraud or deceit can be caught by the nodes of the chain and such a user is removed from taking part in any other activities of the chain.

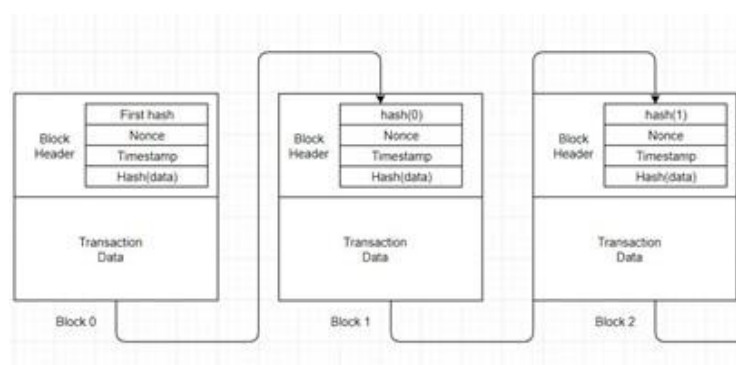


Figure 2: Blockchain Structure

The immutable attribute of blockchain is credited to its structure. The chain is built up by segments called blocks. Every time a transaction takes place, the nodes mine a block, generating a unique hash with its header. This hash is then used as an input in the next block to be minted and thus forms a chain. If any user tries to tamper with the data, they end up with a hash different from the other nodes of the chain. And as soon as such action is detected, the node is removed from the chain. Advantages of using blockchain to pay rent [4]:

1. Increased flexibility: Blockchain-based payments enable digital and mobile transactions, allowing landlords and tenants to make and receive payments 24/7, with no restrictions of traditional banking hours.
2. Easier cross-border payments: - Renting internationally can be challenging, especially when dealing with different currencies. Cryptocurrency allows for immediate, low-cost international transactions, saving time and money for both parties
3. Lower transaction fees: Online rental platforms often impose fees for credit card payments, typically 2.5%-2.9% of the rent amount, paid by the tenant. However, by using cryptocurrency, both parties can avoid these fees and potentially save hundreds or even thousands of dollars over time.

4. Greater privacy for renters: - Blockchain-based payments also provide increased privacy for tenants, as it uses anonymous addresses that change for every transaction. This means that payments do not require personal information, credit card numbers or account numbers, making the transaction untraceable.

2.2. Smart Contracts

A smart contract is a paperless digital code that describes a set of contracts on prewritten conditions that the parties of a transaction have decided upon. The parties interacting can set conditions that can launch a series of actions when required or when the conditions are met [2]. The use of smart contracts can automate the process of managing rental properties, enabling efficient and streamlined operations. For example, a smart contract can be used to automatically gather rent payments and distribute them to the landlord, or to automatically initiate the eviction process if a tenant fails to pay rent. Overall, the usage of smart contracts in the real estate industry can enhance the efficiency, safety, and transparency of property transactions and surveillance.

2.3. Reputation

Reputation systems operate by establishing trust relations based on evidence of a party's past behaviour. These systems rely heavily on trust data as the primary form of exchanged information. Such systems maintain mechanisms to monitor and record the reputations and credibility of participants [5].

2.4. Non-Fungible Token (NFT)

A non-fungible token is a unique, digital asset stored on a blockchain, that cannot be replaced by another identical asset. The term "fungible" originates from economics and accounting, referring to items that can be exchanged for equivalent items. Common forms of currency, like cash, are fungible as they are considered of comparable value and can be used as a medium of exchange. NFTs are unique, one-of-a-kind tokens, which makes them non-fungible [6].

2.5. Soulbound Token (SBT)

A soulbound token is a type of non-transferable, non-fungible token that can be publicly verified and represents an individual's credentials, affiliations, and commitments. These tokens are used to track reputation and are added to addresses but cannot be bought or sold [7].

2.6. InterPlanetary File System (IPFS)

The InterPlanetary File System (IPFS) is a decentralized method for sharing and accessing files through a peer-to-peer network. Unlike traditional systems which rely on a centralized server, IPFS utilizes a distributed network of nodes to store and distribute data. This allows for the sharing and access of a variety of content including documents, images, audio and video files, and more, all without the need for a centralized server infrastructure.

2.7. Uniform Resource Identifier (URI)

A Universal Resource Identifier (URI) is a string of characters that identifies a name or a resource on the Internet. URIs can be broken down into two types: URLs (Uniform Resource Locators) and URNs (Uniform Resource Names). A URL, or Uniform Resource Locator, is a subset of URIs (Uniform Resource Identifiers) that identify the location of a resource on the Internet. For example,

<https://www.example.com/index.html>” is a URL that identifies the resource located at the root of the “example.com” domain, which is an HTML file named “index.html”.

3. Related Works

The applications and need for soulbound tokens were introduced by Weyl in 2022 [8]. This paper presents the importance and necessity of a decentralized identity in web3. It depicts how non-transferable tokens can be used to build trust across economic activities and personal brand building. Hildebrandt further worked on establishing soulbound tokens as a method for an authentic decentralized profile in the anonymous network of blockchain accounts [9]. The relationship between user experience and customer reviews has also been studied and evidence of the role of reviews in trust building has been established. Askalidis & Malthouse demonstrated this through an analysis of the number of reviews to the conversions rate in 2016 [10]. The findings indicate about a 270% increase in conversion rate. The equation used includes an exponential deterioration of the weightage of reviews with time. Varma also conducted a study in 2020 to indicate the impact of social media identity in e-commerce and how this is subjected to reviews. A few studies focus on blockchain immutability for credible review systems. In 2018, Wang introduced the utilization of the blockchain ledger to avoid fraudulent and manipulative reviews [11]. It discusses the importance of reviews in the e-commerce segment. The system validates a new review by verifying the identity of purchasers. There are significant studies on the subject of peer-to-peer reputation systems and their importance. Works by Battah in 2021, Mekouar in 2009 and Dennis & Owen in 2015 [5,12,13] describe the disadvantages of the centralized reputation system. These studies show how the current system is prone to attacks, as well as how merchants and other entities can profit from these attacks on centralized servers which manage the stature of all users. The characteristic of transparency and immutability of blockchain makes tampering with such data extremely difficult. An attacker must have access to the majority of the chain, to manipulate data (51% attack), which gets exponentially harder as the number of active nodes on the chain increases. In 2018, Karamitsos implemented blockchain in the field of real estate utilizing its immutability, transparency and security [14]. The paper extends the advantages of decentralization to the real estate sector and proposes the use of smart contracts for securing sensitive data such as rental agreements, ownership papers etc. It further depicts the uses of smart contracts in tackling problems of real estate such as modification of data, lack of trust among parties and need for intermediation. Wang demonstrated a housing rental system using a redactable blockchain. A landlord would submit the documents verified by a trusted third-party organization to the accounting node, which after verifying will list the property to insure credibility. Xue worked on introducing an alliance chain to this system [15]. An alliance chain is a decentralized organizational structure in which multiple organizations can participate. It allows landlords to list their properties on the application, and tenants to submit their applications, which are then verified by the alliance chain. Once the tenants' intentions are cleared, the data is added to the chain.

4. Proposed Method

The present methods of online rental systems in real estate have posed certain problems. For example, there is no way to track the authenticity of the customer or the landlord and hence committing a scam on either end is highly likely. The terms and conditions of the contract may not be clear and can be altered to suit either party. To tackle this, the system will be introduced on blockchain and SBTs will be used for profile reputation with the help of an online rental website. Steps involved:

- Upon successful registration, an Entry Token SBT will be issued to the user who may enter as a tenant or a landlord. This token will be used to track the reputation, number of properties etc. of the user. After this, every time the user tries to log in, it checks for the Entry Token Id associated with the user's wallet address and if the user is blacklisted due to their reputation having a value less than the minimum set in terms and conditions.

```

{
  "name": "Entry Token",
  "image": "Sample String",
  "attributes": {
    "userName": "Sample Name",
    "fatherName": "Sample Name",
    "reputation": 100,
    "reviews": [
      "Sample String"
    ],
    "numberOfReviews": 100,
    "isTenant": false,
    "dealTokens": [
      "Sample String"
    ],
    "permanentAddress": "Sample Addr",
    "profession": "Sample Profession",
    "phoneNumber": "9999999999",
    "emergencyContact": "9999999999",
    "propertiesOwned": {
      "Sample String"
    },
    "nearestPoliceStation": "Sample Addr",
    "aadharNumber": "Sample String",
    "proofOfAddress": "Sample String",
    "passportPhoto": "Sample String"
  }
}

```

Figure 3: Sample Entry Token URI

- If the user is a landlord, they will have the option to list a property. A separate contract will be created for all individual properties. The property data including information such as property images, rent, location, current reviews etc. are hosted on IPFS and stored in their respective smart contracts. This data is also kept in a centralized server to facilitate the searching of properties using required filters. Changes will be triggered to modify the landlord's Entry Token upon listing a property.
- If the user is a tenant, they can approach the listed property. After successful negotiations and commitments, the tenant pays the security deposit. After this, an SBT called Deal Token will be issued to the tenant via the property contract. The tenant period will also commence henceforth, storing the due dates of rent and the termination period of the contract. The agreement cannot be terminated before the set tenure end date unless both parties agree or if anyone violates the terms and conditions stated. In case the tenant violates the rental agreement, the landlord has the right to revoke the security deposit.
- The tenant can pay the rent and have access to other features of the property as long as the Deal Token associated with the particular property is valid. During this time, the landlord can review the tenant and vice-versa. The reviews will remain on the Entry Token of both users and the contract forever. Since only the members with a tenant-landlord relationship can review each other, the possibility of review bombs is minimized and the credibility is increased.
- After the contract period is over, the Deal Token will be maintained in the Entry Token of the tenant and they can withdraw their security deposit. The tenant record is updated in the property contract.

4.1. Smart Contracts and their Functionalities

1. Admin.sol - Admin.sol is the administrative smart contract. It is used to monitor the market status and provide Entry Token SBT to all new users. The mapping of Token Id to Token URI is used to retrieve user data stored on IPFS. Gas: 2590763 gas; Transaction cost: 2252837 gas.
2. PropertyFactory.sol - PropertyFactory.sol is a smart contract that is used to deploy Property contracts in real time. This contract is accessible only to verified members or users with an Entry Token Id provided by the admin. A user willing to list their property can access the functionality of this contract to upload property data and pay minimal collateral to the admin. This deposit can be liquidated on the violation of the terms and conditions. Gas: 4294054 gas; Transaction cost: 3733960 gas.
3. Property.sol (Template) - Property.sol is a template smart contract. Each property listed on the website has its Property contract deployed with its data in the state variables. This contract is used to mint Deal Token SBTs and provide these to the selected tenant

after they have paid the property security money. This amount is stored in the contract and can be retrieved back by the tenant once the rental agreement has successfully ended. The contract contains an array of reviews given to the property and all methods necessary for all other rental transactions. Gas: 3828185 gas; Transaction cost: 3328856 gas.

4.2. Equations

The reputation system is a vital component of the website as it implements accountability. The most recent behaviour has slightly more relevance over past experiences, therefore the equation must give priority to the current review. In the case of rental review history, all conduct is crucial. Thus, the weight of reviews must not degrade [5]. The review system is based on a star rating system with a range of [1,5], where 1 indicates multiple violations and 5 indicates excellent behaviour. The use of $1 - \log_5 x$ ensures that each rating holds different graveness and each rating directs to an appropriate degradation of reputation. The equation for determining a user's reputation score is

$$R = \frac{[1.01 \times (R_{max} - \{R_{min} \times [1 - \log_5 x\})] + [R \times (n - 1)]}{n} \quad (1)$$

where R is the current reputation score stored on the Entry Token URI. R_{max} is the maximum reputation score allowed. It is set to a constant value of 100. R_{min} is the minimum reputation score possible. It has a constant value of 50. n is the total number of reviews. x is the current rating score given which falls in the range [1,5]. The current rating score is multiplied with a factor of 1.01 to give higher weightage to the latest reviews over older ones [5].

The sum of current The current reputation must not exceed the maximum reputation score allowed. Equation (2) is used to prevent overflow.

$$R \geq R_{max} \Rightarrow R = 100 \quad (2)$$

If a user's reputation score falls below this threshold, their collateral will be liquidated and their low score on the Entry Token will prohibit them from accessing the website in the future. Equation (3) is the liquidation equation.

$$R < R_{min} \Rightarrow R = R_{min} \quad (3)$$

4.3. Performance Analysis

4.3.1. Cost

Securing the data stored is an essential part of the system. This data includes sensitive information such as rental agreements, verification documents, ownership papers, images and property data and the reviews of users and properties. Data storage can have one of three approaches - a centralized cloud system, a decentralized storage IPFS, and storing all data on-chain. While the first approach is the quickest and most cost-efficient, it does carry the disadvantage of being centralized. Between the latter

two, the unit of measurement is the gas used. The cost of storing a 256-bit word on the smart contract is 20k gas [16].

Table 1
Difference in cost of storage methods

| Storage Method | Gas Used approx.(1kb data) | Cost[17](in ETH) |
|--|----------------------------|------------------|
| Storing data directly in smart contract | 640,000 | 0.029356 |
| Storing the IPFS hash of data in the smart contract (string) | 85,000 | 0.003898 |

While both approaches provide the same immutability and security to the data, the gas used in storing data on-chain is huge, making it an extremely expensive process. Therefore, it is not a viable method to store data such as property images or contract documents, that can be multiple and can have a size of more than 1kb directly on the chain.

4.3.2. Time

Renting or finding a lease property can be a tedious and labour-intensive process. Clients may have to wait several days for a formal agreement, and additional paperwork can prolong the process. The presence of both parties is also required to prevent deceit. This can be reduced by introducing the blockchain. Automating each process reduces the overall time. Using SBT also reduces the time to check backdoor references. decentralized applications further make the concept of long-distance rentals easy and secure. The time taken for the agreement is subject to negotiation between the two parties. The collection of rent, maintenance or other fees can be done by one withdrawal transaction. Reading data that the SBT holds from a blockchain is relatively quick. Other operations such as writing data or making transactions can take longer, depending on the specific blockchain, the speed of the network, and the complexity of the operation. The average time taken to add a block to Ethereum is approximately 14.4 seconds [18].

4.3.3. Security

The decentralized ledger of blockchain offers the advantage of being immutable and transparent. All transactions across the system are visible to members. Most blockchains use consensus algorithms to ensure that the data recorded on the blockchain is accurate and valid. These algorithms require multiple nodes on the network to reach a consensus about the validity of a transaction before it is added to the blockchain. The security of the data helps to transform the network from a trust-based system to a cryptographic-guarantee-based network. Blockchains use cryptographic hashing to secure the data stored on them. Cryptographic hashing involves taking a piece of data and running it through a mathematical algorithm, which produces a unique "hash" that represents the data. This hash can be used to verify the authenticity of the data without revealing its actual content.

5. Conclusion and Future Scope

In conclusion, the security and time-saving advantages provided by the model can act as a method to improve the current state of online property rental systems. The applications of SBTs in this field use the significance of decentralized identities to tackle real-world problems. The reputation of these decentralized 'souls' is utilized and stored on the blockchain. The network provides security to the data due to its immutable attribute. Uploading data to a peer-to-peer distributed server IPFS instead of any other cloud services ensures that the data used on the website as property information, rent agreement

information and profile information is secure from being tampered with. The confidentiality and credibility provided by the review system help prevent attacks such as review bombs, that could have a massive impact on businesses. The model ensures that individuals are saved from the hassle of effort and time the current system takes. Verification of documents and records can be done within minutes using the system. The user SBT system also ensures that the members are safeguarded from attackers that disguise themselves as lawful associates. Such members are detected by the community and discarded from having access to the app again. The attacker will carry the blacklisted non-transferable NFT with his wallet thereafter.

Decentralized identities and their application can help improve the blockchain network. Studies for the use of SBTs in education and healthcare for documents and user data have already shown the advantages of using SBTs. The model presented uses these applications to counter the less-regulated systems of online property renting. Introducing blockchain to the sector can help tackle its problems of speed, safety and fraud. There are several potential areas for future research in this field. One potential direction is the integration of real estate transactions. Another can be the introduction of an automated system to report false reviews to improve their credibility. Another area can be around an automated entity that can verify the documents before they are uploaded on-chain. This can further increase the authenticity of the listed properties and user profiles.

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