Transparent Donation Management with Smart Contract-Based Blockchain

Sefa Tunçer[1], Ali Özdede[2], and Cihan Karakuzu[3]

Abstract—Smart contract-based blockchain applications are preferred because they provide traceability, immutability and security in verification processes. All transactions, money transfers and queries are recorded with the distributed ledger it contains. The consensus algorithm, which enables transactions in the blockchain to be confirmed among the nodes in the network and recorded in the distributed ledger, provides security against brute force attacks. In this study, a transparent donation system that provides crypto money transfer with a smart contract published on the blockchain between the donor organization and the donor/institution without the need for a central data processing unit has been developed. In the system, the transactions made on the blockchain with the smart contract are recorded. The proposed study is a decentralized application that enables transparent tracking of the donor, the amount donated and the donated institutions. It is aimed to ensure that donations are transferred to more than one institution at the same time with a smart contract. This study is carried out in order to encourage donations received from the public by ensuring that institutions are honest, reliable and transparent.

Index Terms—Solidity, smart contract, transparent donation, Ethereum.

I Introduction

Blockchain is a distributed database that allows for the creation of a digital record of transactions. It is a decentralized system that allows for the secure recording of transactions without the need for a central authority. It provides an effective communication environment based on cryptographic foundations. In this way, it is used effectively in many areas. Blockchain is used in many areas, including healthcare [1], insurance [2], supply chain [3], decentralized finance [4], identity tracking [5], voting [6], online games [7], entertainment [8], investment [9], military [10]. Efforts are being made to improve existing methods in various industries using Ethereum smart contracts. Ethereum smart contracts are used in the fields, especially for games, exchanges, gambling, finance, property, wallet, etc [4]. This study presents a transparent charity donation application based on the smart contract-based Ethereum blockchain. Transparency and honesty have become the most sought-after concepts, as the trust environment in charities has started to decline in recent years. In the current system, donations made through banks and mobile applications decrease due to undesirable situations. It is aimed to conduct a study where donations can be publicly tracked and immutability is ensured thanks to the distributed ledger in the blockchain. In this way, an environment of trust is created and charities are gathered under a single roof with a decentralized application, enabling them to be monitored and examined. The most important feature that distinguishes this study from other studies in the literature is that it is designed to allow for simultaneous donations to well-known donation institutions under a single roof. This study is recommended to ensure that donations can be made to all institutions involved in the smart contract through a blockchain-based application and that donations are audited. In this way, it is aimed to monitor all donations transparently.

Alassaf and Yusoff [11] used blockchain to develop a donation application based on trust and transparency. They state that the use of blockchain technology will increase honesty as trust in charities is questioned and transparency becomes a necessity. It supports that the most suitable system for transparent donation applications is the Ethereum platform. They state that the choice of network type, cryptocurrency, smart contract and consensus algorithm play an important role in determining the appropriate blockchain platform for transparent donation. In order to choose the proper platform, according to the decision support mechanism, the network type of the blockchain system is public, the consensus algorithm in terms of security is Proof of Work or Proof of Stake, it is based on smart contracts and cryptocurrencies, and Ethereum is determined depending on parameters such as high transaction speed. In addition, with the decentralized application (DApp) they developed, philanthropic evaluators and donors are included in the system, thus preventing fraudulent situations. Two separate smart contracts have been determined for campaign organization and donor funds. In a similar study [12], a transparent donation platform model was proposed. It is aimed to track and monitor where, when and to whom the donations made to the aid funds go. Donors do not know whether donations from bank accounts or mobile applications reach the desired institution. Therefore, they have proposed a smart contract-based system such as Ethereum and Hyperledger Fabric. They have created a criteria table for those who want to create the donation

[1]*Corresponding author mail: sefa.tuncer@bilecik.edu.tr (https://orcid.org/0000-0001-6672-3605)
Department of Computer Engineering, Bilecik Seyh Edebali University, Bilecik
[3] Second author mail: cihan.karakuzu@bilecik.edu.tr (https://orcid.org/0000-0003-0569-098X)
Department of Computer Engineering, Bilecik Seyh Edebali University, Bilecik

platform. The table contains information about whether the blockchain platform is public or private, the number of transactions it can perform per second, the block size, and the consensus protocol. Apart from this information, the reliability, scalability, dynamic structure of the platform, transaction fees, the size of the audience and the programming language in which it was developed are important.

By addressing the issue of transparent donation, Lee et al draw attention to the privacy concern in [13]. Donors or beneficiaries do not want this to happen in some cases. It refers to the necessity of a system based on both transparency and confidentiality. In their proposed study, they designed a system that uses a one-time account address to protect personal information. The address of the donor who wishes to remain anonymous is changed to a different address by the voting group specified as the authority, and the donation is transferred to the person receiving the aid. In this way, the person does not know the donor who donated to him. The confidentiality of the donor's identity is ensured by a structure similar to the Diffie-Hellman key exchange algorithm. Verification is made using private and public keys, which are also found in digital signature algorithms [13]. Wu and Zhu [14] propose a blockchain-based architecture to measure feasibility and reliability for charities' service requests. Although there are suggestions similar to those made in [12] and [13], there are information about the read-write access, centrality level, usage areas of the blockchain that can be used. It is accepted that Ethereum is more preferred because it has a well-known, stable and well-functioning mechanism.

The Ethereum-based CharityCoin digital currency for charity donation management is comprehensively presented in [15]. Initial Coin Offering (ICO) for CharityCoin, purchasing CharityCoin with official currency, layers of the framework, transferring fundraising and distribution stages to the smart contract are explained in detail. Their study differs from the others because the supply of a digital currency is realized and a real-time system has been developed. There are two basic smart contracts required for donation in the system. In this way, after checking the validity of donations and whether they are personal or corporate donations, transactions are carried out by verifying and security analysis [15].

In a detailed review of smart contracts [16], their analysis of the Ethereum platform is given. The activity level, age and current idle time of a contract used in Ethereum were analyzed. It is stated that currently confirmed contracts are at the level of 2.2% and these contracts are used around 72%. There appear to be many unconfirmed contracts used for testing purposes. According to the study, the areas of use of the verified contracts, respectively, are games, exchanges, gambling, finance, property, and wallet.

Similarly, [17], [18], [19] studies were carried out to monitor activities such as aid, donation, charity and fund. In addition, a solution designed for blood donation [20] and to use Ethereum-based smart contracts privately is presented in [1]. Although there are differences in blood donation, privacy and security are at the forefront. In addition, the use of private blockchains in storage and authentication systems included in this study, but not the focus, is another element that increases security. Tanriverdi [21] developed a special blockchain-based authentication system in his research. It has become the reason for preference with its features such as recording all transactions on the data in the blockchain, being included in the system with permissions thanks to the private blockchain, and providing confidentiality with a public-private key. In another study [15], the information of the credit card used in the e-commerce application is stored using a private blockchain. To ensure confidentiality, each credit card information is stored in a separate block and encrypted.

II Proposed Transparent Donation

In this study, it is aimed to establish the foundations of a blockchain-based system that can be donated with cryptocurrency, which can be used by non-governmental organizations and organizations that receive donations. Thanks to this approach, third parties can be eliminated and money transfers can be tracked by everyone in a completely transparent way. The use of donations in places suitable for the donation, with the help of blockchain technology, can be more easily monitored, verified and creates an environment of trust between the end user and the institutions. Thanks to this system, instead of banks, intermediary services and software where the end user cannot see the transactions in the background, an environment where cryptocurrency donations can be made easily all over the world is created. Since it is a decentralized application, it also plays a vital role in creating an environment of trust in the donation ecosystem.

There are many options other than the preferred programming language in this project to donate crypto money over the blockchain. The most important criterion in choosing the Solidity programming language is the complexity of the decentralized application development process. The Truffle framework was chosen because of the many conveniences it offers in smart contract writing, publishing and testing on Ganache, which is used as a local blockchain. A decentralized application development has many differences in terms of coding, compiling, testing, basic working principles and working logic compared to developing a central application with known programming languages. Since the application is not dependent on any authority, many issues such as an illegal situation, service disruption, unforeseen coding errors that may occur outside of the purpose of achieving a targeted service or solution need to be addressed in depth. The fact that Ethereum's security, scalability and speed criteria are sufficient makes the application reliable in terms of performance criteria. The technologies used in the application and the architectural structure of the application are explained in the following subsections. In addition, the reasons for choosing Ethereum for smart contract development are stated.

A Ethereum-Based Smart Contract

Ethereum-based Solidity language was used during the implementation of the application. A web-based application was developed that hosts the Truffle framework during the implementation and testing of smart contract software, Ganache for the publication of the smart contract written on Truffle and the use of the contract in the web interface, and the web3.js library for the use of end users and organization owners. Truffle is a soft-

ware framework for building, publishing and testing smart contract applications on blockchains using the Ethereum Virtual Machine (EVM).

Ganache is a personal blockchain development environment used for Ethereum-based smart contract application development, release, and testing. The testing phase especially checks whether the application has a secure and deterministic structure.

Solidity is a contract-based programming language. It has been developed with influence from C++ and Python languages and is designed to run on the EVM. In this study, the smart contract used for donation was written and tested using Solidity language and Truffle framework.

Smart contracts are the code of the agreement between the sender and the receiver. Agreements with the smart contract converted to code are stored on a blockchain. The code cannot be changed by a third party after it is published, and it creates a mechanism that controls, monitors and makes irreversible the actions done on it. A blockchain can contain one or more smart contracts. Users within the network can use smart contracts or just use whatever they want. The working principles of smart contracts can be defined simply as "if/when-then" situations and recording them in the blockchain by arranging them as code. Computers connected to the blockchain network perform transactions upon fulfillment of the conditions in the contract and verification. These transactions can include transferring money to certain parties, registering a vehicle, sending a notification or issuing a ticket. When a transaction is executed, the distributed ledger is updated by adding it to the blockchain with that transaction. This means that the transaction cannot be changed or reversed. Only authorized users/organizations can see the results.

EVM is the program that connects all the nodes in the blockchain. It has a decentralized structure thanks to the EVM it contains in the Ethereum structure. The execution and maintenance of smart contracts are done by EVM. Because it runs the algorithm and contracts, it avoids double-spending, which is one of the problems found in the blockchain. It is ensured that there is no double spending as the transaction is propagated and recorded to the nodes in the network after it has taken place. Metamask is a crypto wallet application where users can hold ether and other cryptocurrencies. Its primary purpose is to communicate with the Ethereum blockchain. It also allows users to interact with decentralized websites. It provides access to the Ethereum wallet using a browser extension or mobile app.

Bitcoin [22], Ethereum [4], Hyperledger Fabric [23], Corda [24], EOS [25], Nxt [26], Tron [27] etc. are popular blockchain applications. They have different features in their structures according to their intended use. Table 1 presents the important criteria that influence the selection of blockchain platforms to be used in transparent charitable giving. In addition, Table 1 also shows the blockchain (Ethereum) selected in this study and its features. Transparent charity donation applications should include smart contracts and the blockchain network should be public. Consensus protocol should meet expectations in terms of security and speed. The Proof of Work (PoW) consensus protocol, which is at the highest level in terms of security, causes transactions to occur very slowly. In addition, if the block size is not determined according to the consensus protocol, transaction delays increase considerably. Therefore, Proof of Stake (PoS), which is an alternative to Ethereum, should be chosen. The fact that the Solidity programming language is deterministic is one of the most important reasons for using it. Apart from all these criteria, the acceptance of the platform by a large audience, the fact that it has proven itself against attacks and the advantages it provides during the smart contract development phase are effective in its preference.

B Smart Contract Architecture

In the proposed system, the user interface and the smart contract are designed independently of each other and then integrated. First, a smart contract was developed in the Solidity programming language using the Truffle framework. Then, the web interface was designed depending on the parameters included in the smart contract. All functions of the smart contract published on the blockchain can be used in the web interface with the help of the web3.js library.

TABLE 1
Evaluation criteria of blockchain platforms.

[Ref.]	Blockchain	Smart Contract	Blockchain Network	Consensus Protocol	Token	Block Size	Transaction Per Second	Programming Language
[22]	Bitcoin	No	Public	PoW	Yes	1 MB	7	C++
[4]	Ethereum	Yes	Public	PoW, PoS	Yes	80 KB	20000-100000	Solidity
[23]	Hyperledger Fabric	Yes	Private	BFT, Raft, Kafka, Solo	No	Variable	3500	Go
[24]	Corda	Yes	Private	BFT	Yes	Variable	20000	Kotlin
[25]	EOS	Yes	Public	DPoS	Yes	1 MB	1000000	C++
[26]	Nxt	No	Public	PoS	Yes	42 KB	255	Java
[27]	Tron	Yes	Public	DpoS	Yes	1.9 MB	2000	Solidity

PoW (Proof of Work), PoS (Proof of Stake), BFT (Byzantine Fault Tolerance), DPoS (Delegated PoS)

Within a smart contract, enough conditions can be specified to complete a task. Conditions that increase the complexity of the code should be avoided during the writing of the contract. Every transaction made within the smart contract is evaluated with fee

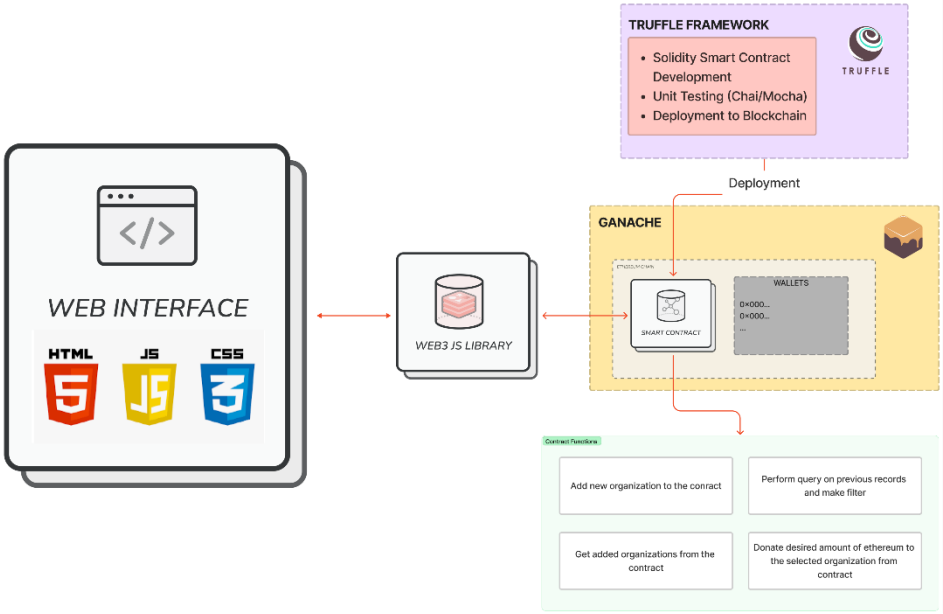

Figure 1 Smart contract-based application development scheme

called Gas. The complexity of the smart contract codes and the transaction sizes that will grow on the blockchain can increase By using the Ganache component, all relevant layers are enabled to operate on the blockchain. The working principles of the basic functions in the smart contract in the proposed system in Figure 1 are as follows;

- Making a crypto wallet connection to the web interface via Metamask
- New organization registration to the contract with name, type and wallet values
- Checking previous records with the wallet where the transaction was made
- Querying the wallets registered to the smart contract
- Checking whether the individual wallet is registered as an organization in the smart contract
- Direct donations from anonymous wallets to one or more organizations that have only signed up for the smart contract
  - ¬ Checking whether the donor and recipient addresses are different
  - ¬ Checking the current balance in the wallet for the donated amount
  - ¬ Percentage distribution of donations made to more than one address at the same time
- Querying and filtering the amount of all donations made
- Recording of smart contract donations and registered organizations as an event in transaction blocks on the blockchain

The main functions such as the purpose of the methods and architecture used in the application, the validating and intermediary role of the smart contract, the verification of addresses within the contract, the prevention of transactions outside of registered organizations and the control of the proportional distribution of donations based on the smart contract are explained above. All vulnerabilities that may occur in terms of security in the application have been tried to be prevented by the smart contract. Therefore, security checks on the user interface are minimized. All transactions, valid or invalid, are recorded in the blockchain through the smart contract. Since these transactions in the distributed ledger are irreversible and cannot be deleted, the security is at a high level.

An example of donation records in the distributed ledger in the blockchain is shown in Figure 2. The event that takes place is a donation, money transfer or inquiry etc. can be a transaction. When a donation event occurs, the block number, transaction hash value, index value, address of the donor, digital signature record, address of the donor institution, block hash value, the hash value of the previous block and the confirmation of the transaction on the network (type) are recorded in the distributed ledger. In addition, the Gas fee information calculated based on the smart contract is also stored in the Ethereum network. The most important part that ensures the immutability of the distributed ledger in the blockchain is the block hash value and the hash value of the previous block.

The general structure of the algorithm performed for event creation and donation distribution related to charitable donations is shown in Table 2. The general working scheme of the functions in the smart contract is given and does not include all the codes.

the gas fee to very high levels. In addition, the excess of rules in the written contract can increase the possibility of errors. In this study, the institutions to be donated and their addresses were determined in the web interface. To avoid high gas fees within the contract, only the validity of the selected address is checked.

Figure 2 Example of donation record in distributed ledger

TABLE 2
Creating events and charity distribution for smart contract.

Initialize Owner	**Func(**deposit**)**
Initialize Enum Organization Type	**Type:** Payable
Education, //0	**Input:** address payable destinationAddress, address payable[] memory otherAddresses, uint256 mainPercentage
Health, //1	**Require:** [msg.sender] != destinationAddress
Environment, //2	**Require:** transferAmount > 0
Religion, //3	**Require:** charityAddresses[] contains destinationAddress
CivilSociety, //4	**Require:** charityAddresses[] contains otherAddresses
International, //5	**Require:** check mainPercentage is between 0 to 100
BigInternational, //6	uint256 donationAmount = ([msg.value] * mainPercentage) / 100 ;
GovernmentOrganized //7	uint256 actualDeposit = [msg.value] - donationAmount;
Initialize Struct Organization	uint256 otherAddressAmount = actualDeposit / otherAddresses.length;
address payable organizationAddress;	destinationAddress.transfer(donationAmount)
string organizationName;	***Charity Distribution*** for(otherAddresses[i].transfer(otherAddressAmount))
OrganizationType[] organizationTypes;	totalDonationsAmount += donationAmount
Initialize address payable[] charityAddresses;	**if** donationAmount > highestDonation
Initialize uint256 totalDonationsAmount;	**then**
Initialize uint256 highestDonation;	highestDonation = donationAmount;
Initialize address highestDonor;	highestDonor = [msg.sender];
Creating Events	**End Func**
event Donation(address indexed _donor, uint256 _value, address indexed _destinationAddress)	**Func(**depositDirect**)**
event OrganizationAdded(Organization indexed _organization)	**Type:** Payable
Setting Up Mapping	**Input:** address payable destinationAddress
mapping (address => bool) isManagerAddress	**Require:** [msg.sender] != destinationAddress
mapping (address => Organization) charityAddressInfos	**Require:** transferAmount > 0

```
Setting up functions
Func(addNewOrganization)
Input: string memory organizationName, OrganizationType[] memory organizationTypes
Require: charityAddresses[] not contains [msg.sender](address)
charityAddressInfos[[msg.sender]] = Organization({
organizationAddress: payable([msg.sender]),
organizationName: organizationName,
organizationTypes: organizationTypes,
isValidated: false
});
charityAddresses.push(payable([msg.sender]));
End Func
Func(getAddresses)
Return charityAddresses
End Func
Func(getAddressInfos)
Input: address payable charityAddress
Return ('Organization' struct values of input address)
End Func
Require: charityAddresses[] contains destinationAddress
uint256 donationAmount = [msg.value];
destinationAddress.transfer(donationAmount);
totalDonationsAmount += donationAmount;
if donationAmount > highestDonation
then
        highestDonation = donationAmount;
        highestDonor = [msg.sender];
End Func
Func(getTotalDonationsAmount)
Return totalDonationsAmount
End Func
Func(getHighestDonation)
Return highestDonation, highestDonor
End Func
Func(Destroy)
Require: Restrict To Owner Of Contract
Self destruct of contract
End Func
End Smart Contract
```

III Conclusions and Discussion

Table 3 shows the estimated minimum Gas fees for a donation made by a donor to a certain number of addresses, depending on the smart contract. In the designed system, the amount donated does not affect the Gas fee. There are factors other than those that affect the Gas fee on the Ethereum network. An estimated calculation has been made by ignoring the tip, base wage and wage increase. In this way, when multiple donations are made, the Gas fee, which is formed according to the conditions in the smart contract, is compared with each other.

TABLE 3
Ethereum fees based on donations.

Donor Address	Amount Donated (ether)	Number of Addresses Donated	Gas Fee (gwei)	Gas Fee (ether)
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	1	2172880	0,00217288
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	2	2736380	0,00273638
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	3	3299880	0,00329988
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	4	3863380	0,00386338
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	5	4426880	0,00442688
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	6	4990380	0,00499038
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	7	5553880	0,00555388
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	8	6117380	0,00611738
0x770709b48c26933c4964ae5884bbfb6ef9052e20	0,05	9	6680880	0,00668088

The Gas fee is stated in gwei, a unit of Ethereum and can be converted to ether. Both are available in Table 3. Figure 3 shows the graph of the Gas fee, which changes depending on the number of addresses to which donations are made at the same time. As the number of donated addresses increased, there is a linear increase in the amount of approximately 0.0005635 ether. Since the design of the system is designed for multiple donations with a smart contract, the donor can donate to more than one institution at once. In cases where donations are made individually, the transaction fee will increase as the minimum Gas fee will be supplied each time. In addition, the consensus algorithm used in the application affects the Gas price.

Since Ethereum has a well-known, stable and well-functioning mechanism, it is preferred in more than 90% of similar studies.

This work can also be done with Hyperledger or a similar smart contract-based blockchain mechanism. However, reasons such as the absence of a token in the structure of Hyperledger, the fact that it is private, and the difference in the consensus algorithm make it difficult to develop the infrastructure of such a system. The biggest factor in the use of Ethereum is that it has proven itself by using smart contracts, security, easy integration and many applications. The number of transactions per second and transaction fees can be said to be the disadvantage of Ethereum.

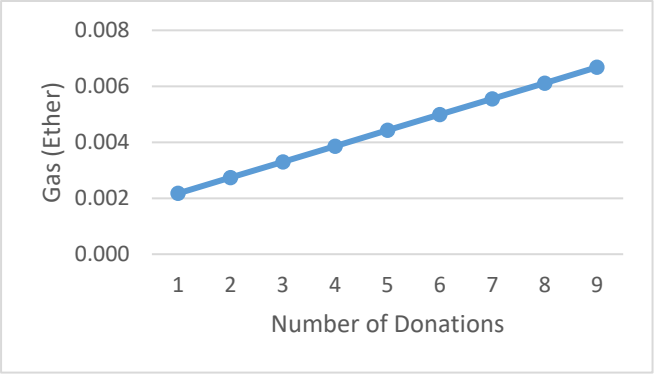

Figure 3. Gas fee depending on the number of donations

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Sefa Tunçer is a researcher assistant at the Department of Computer Engineering, Bilecik Şeyh Edebali University. He is continuing his PhD using the Hyperledger Fabric based blockchain framework. His research is about image encryption and smart contract-based blockchain. In addition, he aims to improve herself in this field by concentrating on software and blockchain.

Ali Özdede is a computer engineering student at Bilecik Şeyh Edebali University and is also a full-time software expert in the field of learning technologies. He is a full-stack software developer in the institution he works for and takes part in R&D studies. He focused on .Net technologies in his career and gained experience by developing blockchain applications.

Cihan Karakuzu is full professor at the Department of Computer Engineering, Faculty of Engineering, Bilecik Şeyh Edebali University, Bilecik, Turkey. His research interests include intelligent and artificial learning systems, fuzzy and neuro-fuzzy systems, data-driven models, system identification and modeling and meta-heuristic algorithms.