

## **A Blockchain Enabled Personal Donation System Development Scheme**

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**Abstract.** Driven by the development of information and communication technology (ICT) along with the social consciousness of civil societies, a cultural practice of donation using ICT resources is emerging. However, owing to problems with the trust and transparency of donation systems and public revelations of corruption on the part of some groups accepting donations, the donation participation rate is gradually decreasing. Because social welfare is considered a problem that cannot be solved only by the state, the operation of sound social welfare organizations that individuals can consistently trust and donate to is necessary. In this study, we propose a personal donation system designed to help ensure transparency in the operation of groups accepting donations and to encourage personal donations. To this end, we review the main factors in participant decisions to donate and make continuous donations. The proposed system and detailed module were designed based on a consortium blockchain and implemented by configuring the blockchain channel. We aim to provide a meaningful solution to important social problems using ICT and blockchain technology.

**Keywords:** Personal donation system, transparency guarantee, consortium blockchain, recommendation system, donation activation

## 1. Introduction

In modern society, as the social consciousness of citizens develops, consideration for general welfare is increasing, and a culture of donation has thus emerged (Suh 2016). However, from surveys up to 2019, excluding the impact of the COVID-19 pandemic, it can be observed that the number of people participating in donations continues to decrease. Today, almost all countries in the world are actively involved in the development and formation of a national cryptocurrency.

Korea ranked 38th out of 126 countries on the World Giving Index (WGI), surveyed by the Charities Aid Foundation in the UK, with roughly 34% reporting having made a donation over 10 years prior to 2018. However, based on the Organization for Economic Cooperation and Development (OECD), it ranked only 20th out of 36 countries (Waniak-Michalak et al., 2020). According to the results of the 2019 social survey conducted by the National Statistical Office, the proportion of people who have made donations has continuously decreased from 34.6% in 2013 to 25.6% in 2019. The proportion of potential donors willing to donate was 48.4% in 2013, but decreased to 39.9% in 2019 (Statistics Korea, 2019). In a survey conducted by Giving Korea, a donation organization, the donation participation rate was 68.6% in 2003, but it gradually declined to 46.5% in 2019.

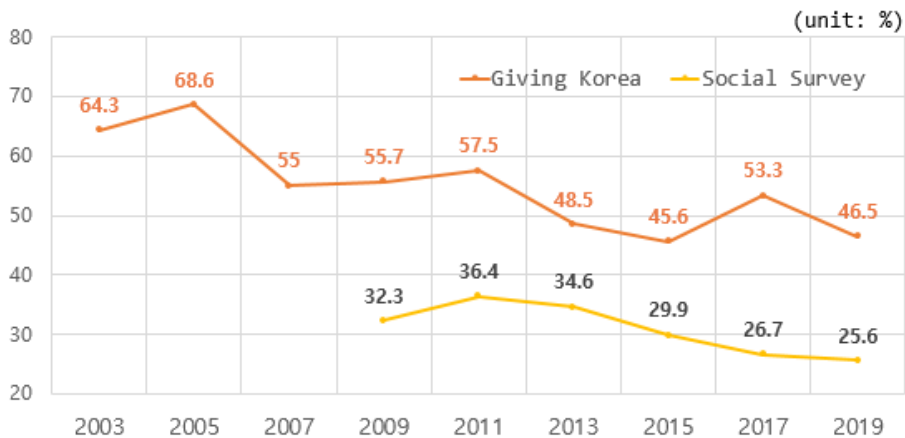


Fig. 1: Donation participation rate

Various factors influence the donation culture. The increase in accessibility and convenience for donations by integrating information and communication technology (ICT) such as the Internet and smartphones is a factor that increases the donation participation rate. In a study on the Beautiful Foundation (2020), it has been noted that the method of donation participation has been rapidly changing, such as using the Internet and mobile phones, since 2013 (Jeon, Jang, 2020). Conversely, one of the main reasons for the declining donation participation rate is

the reliability issue in the operation of donations. It was revealed recently that the donations raised by well-known domestic donation organizations are being used as advertising fees for large-scale donor recruitment and by executives for luxurious stays when traveling abroad. In addition, various allegations of misconduct, such as conflicts within fundraising organizations and corruption of the management, have been raised, with a damaging effect on the entire donation culture.

Therefore, in this study, we propose a blockchain-based personal donation system to protect the socially disadvantaged and to overcome the opacity of use that may occur in the operation of donations. To this end, the scope of this work included the design of a blockchain channel through a factor analysis applied to the personal donation system and testing on sample data by implementing the system.

Because the personal donation system presented in this paper can increase the system transparency by using a distributed ledger based on blockchain, it can ultimately contribute to the revitalization of the donation culture by increasing the donation participation rate.

## **2. Related works**

### **2.1. Donation factor and importance analysis**

In this study, we reviewed the main factors that affect donation behavior in order to construct a personal donation system that enables continuous donation and to design detailed modules. In a study by Lee et al. (2015), the reliability of the donation group was found to be the highest determining factor, and the use of donations and transparency of activities were analyzed as the second factor (Lee et al., 2015). Moreover, in a study by (Yang, 2015), distrust in donor organizations was derived as a motivating factor not to donate. Therefore, in this study, the reliability and transparency of the donation system were considered as the most important factors.

In addition, we reviewed factors that enable donations to continue in order for the donation system to be continuously operated. In a study by (Jung et al., 2013) and (Lee et al., 2018), each factor of donation persistence was analyzed using the analytic hierarchy process (AHP). AHP is a methodology that can be used to evaluate the relative importance of each factor through pairwise comparisons. In the first-level analysis, the “donation target” was derived as the first priority with a weight value of 0.325, and “donation group” was confirmed as the third priority with a value of 0.238. The results of the second-level analysis are shown in Table 1. Based on the weight values, the donation purpose and target characteristics of the “donation target” ranked first and third, respectively, and the reliability of the “donation group” ranked second.

Table 1. Analysis of relative importance of donation persistence factors

Classification		Weight	Ranking
Donation Agency	Reliability	0.156	2
	Experience	0.042	10
	Characteristic	0.040	11
Donation Target	Characteristic	0.108	3
	Purpose	0.159	1
	Method	0.059	6
Donation Amount	Amount	0.056	7
	Frequency	0.032	14
	Term	0.040	12
Promotion	Openness	0.064	5
	Professionalism	0.084	4
	External Exposure	0.034	13
Accessibility	Payment Method	0.054	8
	Accessibility	0.026	15
	Convenience	0.048	9

Therefore, in this study, the proposed system was configured such that the donor can check the characteristics and details of the “recipient” who is the donation target. By applying the blockchain to the proposed system, we designed and implemented a highly reliable personal donation system by increasing the transparency of the donation group and guaranteeing the anonymity of the donor.

## 2.2. Blockchain

A blockchain is a data structure that stores records of transactions, which generally comprise user-to-user transaction history data, in the form of a single block and connects blocks to form a list. Until the advent of blockchain technology, centralized institutions traditionally solved the problem of double payment of digital data in such a manner that the service provider was the subject of each transaction and managed the users’ records (Nakamoto, 2008). However, in such a structure, the central authority can manipulate records with malicious intent. The consensus algorithm implemented in blockchain can synchronize transaction information and data information in P2P (Peer to Peer); thus, it can increase the transparency of the system and guarantee the reliability of all entities (Damianou et al., 2019, Andoni et al., 2019, Hughes et al., 2019, and Nyamtiga et al., 2019).

The blockchain technology can be divided into public and private types, as shown in Figure 2. Nodes can join a public blockchain network without any restrictions (Lee, 2018). In contrast, a private blockchain is specially created by a single institution; only those who have been verified through the authentication

method created on the network can participate in the private blockchain by connecting to the network.

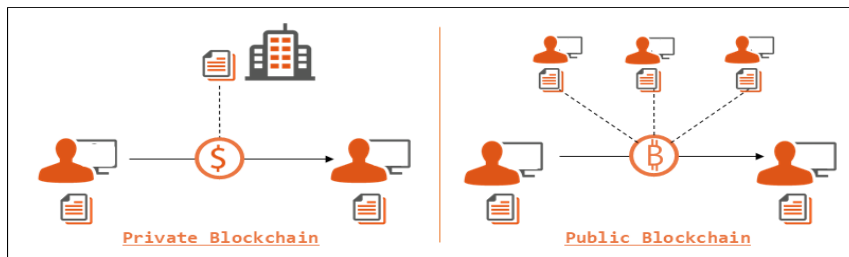


Fig. 2: Blockchain types

Recently, a consortium blockchain technology that can be said to be a hybrid form of public and private methods has been developed. Unlike private blockchains, consortium blockchains complemented fairness and scalability by forming a consortium by several institutions with the same purpose (Li et al., 2018, Zhang et al., 2018, and Li et al., 2017). The personal donation system presented in this study is designed based on a consortium blockchain structure using Hyperledger Fabric (Androulaki et. al, 2018). The donor organization that provides the service can identify and authorize people who wish to participate in the system and can designate the permissions available to members based on their membership. Through such a system configuration, the transparency of donation operations can be increased, while donors and recipients can be easily and continuously managed.

### 3. Personal donation system design

#### 3.1. System scenario design

Figure 3 shows the overall scenario of the individual donation system presented in this study. The proposed system consists of a donation group, which includes service principal roles, donors, and recipients. In addition, a governance agency was formed to reduce the blind spot for donations caused by the polarization of information and to provide more accurate identification of donation targets and support for donation groups.

The governance agency can find and identify donation targets, register recipients, and register donors who wish to donate. The governance agency may provide relevant information collected to the donation group and monitor and support the donation group. In addition, statistical information received from the donation group can be used to create social research data, and social welfare policies can be established using this information.

The recipient can request donations by registering their circumstances or characteristics in the donation group's personal donation system, and the donor can

register themselves in the system and find the recipient through the donation group. The personal donation system can match and recommend recipients that meet the donor's purpose and needs.

When a donor decides to donate, the donation transaction is recorded, and the recorded content is distributed and stored in the blockchain network by creating a golden copy. The personal donation system utilizes the blockchain to ensure the anonymity of donors as well as to increase the transparency of the ledger as donation details are distributed and stored as golden copies.

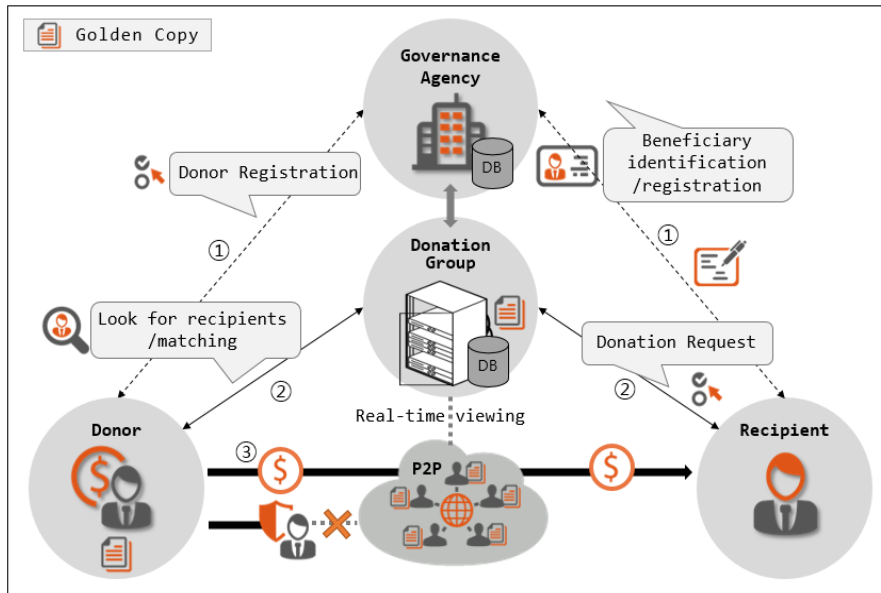


Fig. 3: System scenario

### 3.2. Blockchain channel design

The blockchain network constructed to develop this system is illustrated in Figure 4. The donation channel, a channel in which all four entities participate, stores the history of recommending recipients of donation groups, the use of donations, and the purchase of vouchers. De-identified recipient personal information is stored in the channel in which the recipients and the governance agency participate, and de-identified donor personal information is stored in the channel in which the donors and the governance agency participate. Finally, de-identified recipients' and donors' personal information is stored in channels in which donation groups and the governance agency participate.

In the 'channel1\_chaincode.go' file, the chaincode of channel 1 is defined. Channel 1 is a channel in which four entities participate, including the donors, recipients, donation group, and governance agency. A 'voucher struct' is defined in this file, with 'amount' and 'giveget' variables, where 'amount' represents an amount,

and 'giveget' represents a purchase or donation for a donor and a donation or use for a recipient.

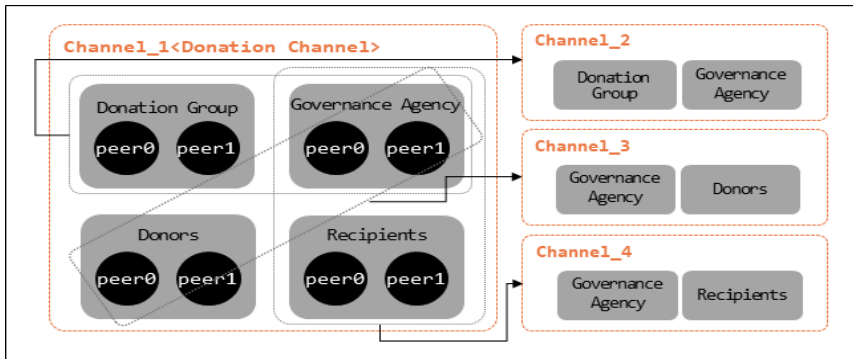


Fig. 4: Blockchain channel configuration

Figure 5 shows the chaincode of channel 1 defined in the 'invoke' function. Because channel 1 stores donation-related details, the 'initLedger' function does not process anything. The 'purchaseVoucher' function is called when a donor purchases a voucher, and it stores information about the purchased voucher using the donor's social security number as a key. The 'queryVoucher' function is called to query a donor or recipient's voucher purchase history. The 'allVoucher' function is called when the governance agency retrieves all vouchers purchased by a given donor. The 'donateV' function is called when a donor donates a voucher. The number of blocks of the donor is subtracted, and the number of blocks of the recipient is increased. Lastly, the 'voucherUsage' function is used to inquire as to a donor's voucher usage history.

```
func (s *SmartContract) Invoke(APIstub shim.ChaincodeStubInterface)
sc.Response{
// Retrieve the requested Smart Contract function and arguments
    function, args := APIstub.GetFunctionAndParameters()
    // Route to the appropriate handler function to interact with the
    ledger
    if function == "initLedger" {
        return s.initLedger(APIstub)
    } else if function == "purchaseVoucher" { //Donor: Buy a
Voucher
        return s.purchaseVoucher(APIstub, args)
    } else if function == "queryVoucher" { //Donor: vouchers Search of
the recipient
        return s.queryVoucher(APIstub, args)
    } else if function == "allVoucher" { //Government: Search all
```

```

vouchers purchased
    return s.allVoucher(APIstub)
} else if function == "donateV" { //Donor: Sponsor a Voucher
return s.donateV(APIstub, args)
} else if function == "voucherUsage"{ //Donor: Search voucher
usage history
    return s.voucherUsage(APIstub, args);
}
return shim.Error("Invalid Smart Contract function name.")
}
}

```

Fig. 5: Channel 1 chaincode

In the 'channel2\_chaincode.go' file, the chaincode of channel 2 is defined. Two entities participate in channel 2, including a donor and a governance agency. A 'supporter struct' is defined in this file, including variables 'name, id, account, email, password, address, phonenum'.

Figure 6 shows the chaincode of channel 2 defined in the 'invoke' function. The donors' personal information is stored in channel 2. In the 'initLedger' function, the existing 'support' information is stored in the blockchain with the resident registration number as a key value. The 'registerSupporter' function is called when registering a donor, and it is executed when a new user registers as a donor. The 'queryAllSupporter' function enables a governance agency to search all donors. The 'querySupporter' function is used when a donor inquires as to their stored personal information. When this information is modified, the 'changeSupporterInfo' function is called to save the changed information in the blockchain. The 'queryWithOtherInfo' function allows users to search by e-mail instead of the resident registration number, which is the key value.

```

func (s *SmartContract) Invoke(APIstub shim.ChaincodeStubInterface)
sc.Response{
    // Retrieve the requested Smart Contract function and arguments
    function, args := APIstub.GetFunctionAndParameters()
    // Route to the appropriate handler function to interact with the
    ledger
    if function == "initLedger" {
        return s.initLedger(APIstub)
    } else if function == "registerSupporter" { //Donor
Registration
        return s.registerSupporter(APIstub, args)
    } else if function == "queryAllSupporter" { //Donor Search

```



```

    return s.queryAllSupporter(APIStub)
  } else if function == "querySupporter" { //Donor: search for
personal information
    return s.querySupporter(APIStub, args)
  } else if function == "changeSupporterInfo" { //Donor: Update my
information
    return s.changeSupporterInfo(APIStub, args)
  } else if function == "queryWithOtherInfo" { //Search by email
instead of resident registration number
    return s.queryWithOtherInfo(APIStub, args)
  }
  return shim.Error("Invalid Smart Contract function name.")
}

```

Fig. 6: Channel 2 chaincode

In the 'channel3\_chaincode.go' file, the chaincode of channel 3 is defined. Channel 3 is a channel in which two entities, namely, a recipient and a governance agency, participate. A 'recipient struct' is defined in this file, containing variables 'name, id, age, sex, account, email, password, address, phonenum, job, story, status, reason'.

Figure 7 shows the chaincode of channel 3 defined in the 'invoke' function. Channel 3 stores the recipients' personal information. In the 'initLedger' function, the existing recipient's information is stored in the blockchain with the resident registration number as a key value. The 'registerRecipient' function is called when registering a recipient, and it is executed when a new user registers as a recipient. 'queryAllRecipient' queries all recipients of the governance agency.

The 'queryRecipient' function searches the recipient by the key value of the resident registration number, and the 'approveRecipient' function approves the recipient's application and updates the recipient's 'status' to 'Y'.

The 'pendingRecipient' puts the recipient application on hold, and updates the recipient's 'status' and 'reason'.

The 'changeRecipientInfo' is used to modify the recipient's personal information, and 'changeAllRecipientInfo' is used to modify the entire set of information. The 'queryWithOtherInfo' function allows users to search for a recipient by e-mail rather than the resident registration number.

```

func (s *SmartContract) Invoke(APIStub shim.ChaincodeStubInterface)
sc.Response{
    // Retrieve the requested Smart Contract function and arguments
    function, args := APIStub.GetFunctionAndParameters()
    // Route to the appropriate handler function to interact with the
ledger
    if function == "initLedger" {
        return s.initLedger(APIStub)
    }
}

```

```

    } else if function == "registerRecipient" { //Recipient
registration
    return s.registerRecipient(APIstub, args)
    } else if function == "queryAllRecipient" { //Recipient Search
    return s.queryAllRecipient(APIstub)
    } else if function == "queryRecipient" { //Recipient: search
for personal information
    return s.queryRecipient(APIstub, args)
    } else if function == "approveRecipient" { //Recipient Approval
    return s.approveRecipient(APIstub, args)
    } else if function == "pendingRecipient" { //Recipient Pending
Approval
    return s.pendingRecipient(APIstub, args)
    } else if function == "changeRecipientInfo" { //Recipient:
update my information
    return s.changeRecipientInfo(APIstub, args)
    } else if function == "queryWithOtherInfo" { //Search by email
instead of resident registration number
    return s.queryWithOtherInfo(APIstub, args)
    } else if function == "changeAllRecipientInfo" { //Full
information update
    return s.changeAllRecipientInfo(APIstub, args)
    }
    return shim.Error("Invalid Smart Contract function name.")
}

```

Fig. 7: Channel 3 chaincode

In the 'channel4\_chaincode.go' file, the chaincode of channel 4 is defined. A governance agency and donation groups participate in Channel 4. In this file, a 'recipient struct' is defined for recipient de-identification, which includes 'name, age, sex, address, job, story, status'.

```

func (s *SmartContract) Invoke(APIstub shim.ChaincodeStubInterface)
sc.Response{
    // Retrieve the requested Smart Contract function and arguments
    function, args := APIstub.GetFunctionAndParameters()
    // Route to the appropriate handler function to interact with the
ledger
    if function == "initLedger" {
        return s.initLedger(APIstub)
    } else if function == "recipientNonIdent" {
        return s.recipientNonIdent(APIstub, args)
    } else if function == "queryAllRecipient" {
        return s.queryAllRecipient(APIstub)
    } else if function == "queryRecipient" {
        return s.queryRecipient(APIstub, args)
    }
    return shim.Error("Invalid Smart Contract function name.")
}

```

Fig. 8: Channel 4 chaincode

Figure 8 shows the chaincode of channel 4 defined in the 'invoke' function. Channel 4 stores the recipients' de-identified personal information. In the 'initLedger' function, the existing recipient information is de-identified and the resident registration number is stored in the blockchain as a key value. The 'registerNonIdent' function is called when the governance agency approves the recipient. This function de-identifies and stores the recipient's information. The 'queryAllRecipient' function retrieves all recipients from the donation group, whereas the 'queryRecipient' function retrieves a specific recipient by resident registration number.

## 4. System implementation

### 4.1. Donor functions

In this study, we implemented the designed system and input sample data to test the operation of the system and the blockchain. Donors and recipients can use the services provided through membership registration on the web. All contents required for membership registration are stored in the blockchain 'couchdb', and a column called 'status' is added so that the recipient can check whether the subscription is approved. The 'status' of a recipient who signs up for the first time is set as 'N', and the recipient must be approved by the public institution and the 'status' must be changed to 'Y' to receive a voucher. The names, emails, and passwords among the contents written in the form are stored in MySQL, an external database, for convenience of login. The password is hashed to enable it to be stored. When a user enters their ID and password on the login page, different top bars and My Page screens are displayed according to the user's group, as shown in Figure 9.

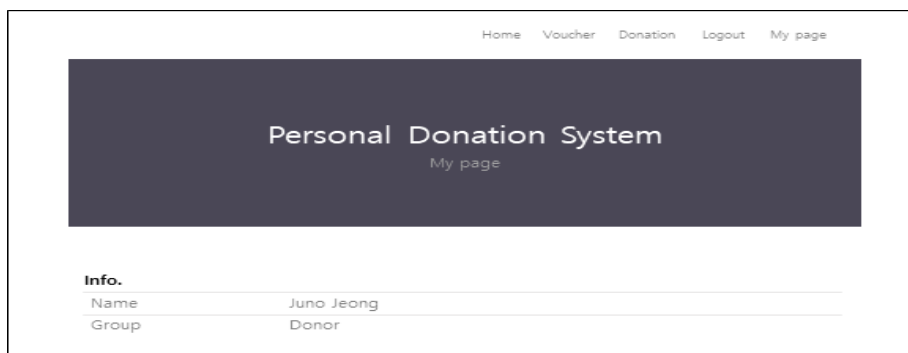


Fig. 9: Donor's my page

Donors can purchase the necessary vouchers to make a donation on the voucher purchase page. A user can purchase a voucher after verifying their identity by entering their resident registration number and password, and they can purchase vouchers in blocks. The block is a unit of currency used in this system; for the test,

it was arbitrarily set at 100 won per block. If a user presses the purchase button to purchase a voucher, a window for purchase is displayed, as shown in Figure 10. Donors with vouchers (blocks) can donate by selecting one of the recipients or by being recommended by the system.

Donors can inquire about the number and details of blocks used to purchase or donate. To search, users are required to verify their identities by entering their resident registration number and password. As shown in Figure 11, the search results show the total number of blocks currently owned by the donor and the history of block purchase and use. The block purchase and usage history includes the number of blocks since the current event, the number of blocks increased or decreased in the current event, transaction time, and transaction ID.

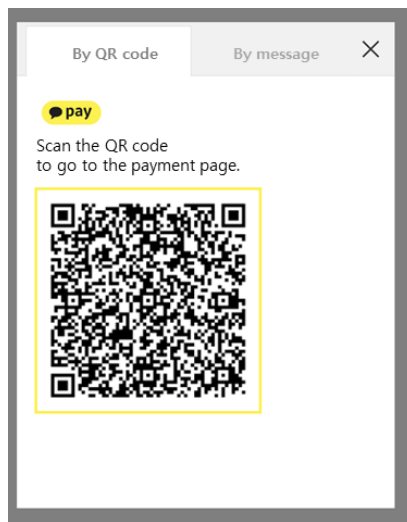


Fig. 10: Voucher payment

Total Number of Blocks		90	
Number of Blocks	+/-	Trading Hours	Transaction ID
90	-10	2021-06-07 17:32:22.247 +0000 UTC	e643798e24d1095f36fd229204ab7b035124b3cf8e0051ca328eec1882db1
100	+100	2021-06-07 17:31:50.621 +0000 UTC	9260a8d63510ccd61019f514c420ba21a9acd35a4462afe5b9a3b7b51ddca

Figure 11: View voucher history

Age	<input type="radio"/> 0-20	<input type="radio"/> 20-45	<input type="radio"/> 45-65	<input type="radio"/> 65-
Job	<input type="radio"/> student	<input type="radio"/> jobless		
<input type="button" value="Search"/>				
Name	Contents	View Details		
Ho Lee	hello, I recently lost my job in a car accident. Please help me recover so I can live ...	<input type="button" value="View Details"/>		

Figure 12: Search and recommend recipients

A donor can be recommended a recipient with the desired conditions they prefer. Age and occupation were arbitrarily set as the conditions for classifying the recipients for the test. On selecting a desired condition, users are shown a list of recipients that match it, as shown in Figure 12. Detailed information of the recipient can be checked by clicking the View Details button of one of the recipients in the list. At this time, to protect the recipient's personal information, the name is de-identified and can be identified in the form of 'O-block'. In addition, users can check the details of the recipient's request for donations.

#### 4.2. Recipient functions

Figure 13 shows a recipient's application processing status. If approved, they become a recipient, and they can receive donations from donors. However, if approval is withheld, users are not able to receive donations from donors. By checking the reason for the suspension, it is possible to correct the information according to the recipient's condition and attempt to register the recipient again.

Recipient Approval Results	
Name	Jae Seo
Approval status	Hold
Reason for hold	wrong address

The 'recipient' application has been put on hold. Please check the reason for the hold and correct the information.

Fig. 13: View a recipient's approval status

Recipients can check the number of vouchers they have and how much they have used, as shown in Figure 14. After entering a resident registration number and password to verify their identity, if the entered information is the same as the recipient's registered information, they can check the number of vouchers they have and usage history. The transaction time and transaction ID can also be checked.

Total Number of Blocks		100	
Number Of Blocks	+/-	Trading Hours	Transaction ID
100	+100	2021-04-22 06:43:25.455 +0000 UTC	fd2b3761f8de7fd70bc8217c30846438edcbf887f8ddea299e5712b17246d

Figure 14: View voucher holding/usage history

### 4.3. Governance agency functions

The governance agency can check the list of recipients for whom the application for silver recipient status has been approved, as shown in Figure 15. In contrast to donors and donation groups, they can check information that is not de-identified and can revoke approval. In addition, the governance agency can check the list of unauthorized recipients and their detailed information. Alternatively, a reason can be recorded for withholding or granting the approval. If approved, the recipient's 'status' is changed to 'Y', and the recipient's information is de-identified and stored on the blockchain.

Name	Phone	Mail	Address	Approval	Contents	Approval Cancel
Kyu Kim	01012345678	abc@dongguk.edu	Seoul	Y	hi My daughter is 8 years old. She was born prematurely and was always weak.	<input type="button" value="Cancel"/>
Ria Son	01023456789	aria@gmail.com	Gyeongju	Y	You need a lawyer. I was unfairly accused.	<input type="button" value="Cancel"/>

Figure 15: Check recipients list

To monitor the transparent donation flow, the governance agency can inquire as to the number and details of blocks used by each user to purchase or donate, as shown in Figure 16. By entering the user's resident registration number, authorized users can inquire about the history of the desired user's voucher use.

Number Of Blocks	+/-	Trading Hours	Transaction ID
80	-10	2021-06-08 12:02:26.374 +0000 UTC	3936ca613b244ab45c5b833d453512b833d486ef36fd2d229207fea6cf4297
90	-10	2021-06-07 17:32:22.247 +0000 UTC	e643798e24d1b098f36fd2d229204abccd610197b0351243cf8eec1882db1
100	+100	2021-06-07 17:31:50.621 +0000 UTC	9260a8d63510cdd61019f51423b2447ab1ba21a9ac462afa5b9z3b7b51dda

Figure 16: View user voucher usage history

#### 4.4. Donation group functions

The recipient's information approved by the government agency is de-identified as a 'block' and delivered to the donation group. In addition, to monitor the transparent donation flow, the donation group can inquire as to the user's voucher usage history. First, the social security number of the user to be searched is entered. If the entered resident number matches the stored resident registration number, the voucher usage history of this user is displayed, as shown in Figure 17.

#### 5. Conclusion

With the development of ICT in parallel with the development of the social consciousness of civil society, a culture of donation using ICT resources is emerging. However, owing to corruption on the part of some donation groups and problems with the trust and transparency of the donation system itself, the donation participation rate is gradually decreasing. As the trust and transparency of donor organizations are confirmed as important factors for many citizens to participate in donations and make donations continuously, donor organizations need to introduce a donation system with guaranteed transparency.

Number Of Blocks	+/-	Trading Hours	Transaction ID
900	-100	2021-06-09 05:35:57.491 +0000 UTC	f808fed645392bf9ed4a48e27f10a1d88469bcbc241b8d11281ea3a059c24
1000	+1000	2021-06-09 05:34:32.785 +0000 UTC	26673f8fcb2136f4a221a8f259abe8813f1600c88d2f0db467ebd

Figure 17: Search voucher usage history by user

In this study, we implemented a personal donation system that can help ensure transparency in the operation of donation groups and encourage individual donations. To this end, we designed a system architecture based on a consortium and constructed a blockchain channel. In this system, when a donor makes a donation to a recipient, personal information other than the amount is not retained; thus, the donor's privacy can also be protected. The donation system can be kept transparent because the voucher purchase history and usage history are all copied and recorded in a distributed common ledger. In addition, because donors can receive recommendations and matches considering their donation purpose and the characteristics of recipients, the proposed approach can contribute to increasing donation satisfaction and the establishment of a sustainable donation culture.

However, the effectiveness of the recommendation method of the proposed system was not sufficiently evaluated, and the method of exploiting the anonymity of the system was not analyzed. Nevertheless, the proposed method is expected to contribute to the solution of important social problems through ICT as it can

effectively support the welfare of socially underprivileged people of various classes otherwise poorly served by existing systems. Therefore, in future studies, we will evaluate the effectiveness of the system's recommendation method and analyze the system's abuse potential.

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