ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0024

Blockchain based Emergency Supplychain System

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Abstract

With occurrence of natural disaster, emergency supply chain is used more widely. Meanwhile, the information and management issues along the chain are exposed gradually. Nowadays, the idea that resolving this sort of issues through blockchain becomes a hot spot. This article illustrates the method that using solidity and smart contact based on blockchain to solve out several problems, including goods loss due to human management, invisible donation and receiving information and privacy invasion. The BBESS(blockchain based emergency supply system) system mentioned in this article achieves the solutions and is expected to contribute a lot on the improvement of emergency supply efficiency and security.

Keywords

Blockchain; Emergency supply chain system; Ethereum; Internet of things.

1. Introduction

Blockchain is the current mainstream distributed accounting technology. Providing a foundation of trust for each other in multiple fields is considered to be the cornerstone of the trust network and the Internet of value. Applications have gradually expanded from the financial field to government, supply chain management, industrial manufacturing and other fields. The blockchain has four core technologies: distributed accounting system, consensus algorithm, smart contract and cryptography. Among them, the smart contract can run automatically, remove any third-party interference, and enhance the decentralization of the network, thereby saving costs and saving time. In addition, its "unchangeable" feature can also ensure safety. By several research, we found that it might have possibility to figure out some existing problems in the following. A large proportion of goods and donation on the supply nodes are still controlled or recorded by human, with loss of IT management. This leads to difficulties to track the position or state of them, which causes a lower management efficiency [1]. Also, loss of IT management results in unconnected nodes. This makes each node be difficult to know the amount gained by other nodes. Supersaturation of goods stored in disaster nodes then occurs as a result of that. But both two problems can be resolved by transparency of blockchain, with the help with another system. Considering of the donation node itself, security issue of donator privacy needs to be taken into account as well [2]. Because of collection of their privacy during registration, invasion of privacy cannot be avoided whether through the website itself or steeling by other hackers. However, we propose that anonymity of blockchain is tend to deal with this issue.

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2. Literature Review

In the papers by searching for similar projects in the past, we found a lot of related ideas. However, many of them are just superficial, without specific implementation and implementation. What's more, they are all stuck in the policy [3]. Yet in this article, there was only some theories and ideas pointed out, without process of manifestation. To make the idea be more realistic, it becomes one of our reference to innovate the program to achieve further development. In the paper "Improving the Material Agreement Reserve System in Hunan Province" (March 2021) written by Liang E, the author proposed a perfect plan to strengthen the information sharing and business response between the government and the private sector [4]. However, the author did not propose how to strengthen it. At this time, another article attracted our attention. Its name is "Energy Blockchain Platform Design for Optimal Scheduling of User-side Source Storage Resources", which was uploaded in April 2021. The part of node identity authentication attracted our attention. It proposes that when a node is encrypted with a unique private key, only the corresponding public key can be used for decryption [5]. After a node announces the public key and address, the rest of the nodes can verify whether the node corresponds to the wallet address; at the same time, the node sends the information can be verified by other nodes with the public key that has been published. Because only the node holds the private key, if the public key can be used to verify the information, the source of the information is authenticated, thereby realizing the identity of the node. This is very important for trading, and it does have a great effect on us, but the trading system is only one part of our design. Therefore, another article "A decentralized vehicle anti-theft system using Blockchain and smart contracts" has become a valuable reference for us [6]. Among them, as to how the entire complete system works, it has a complete and clear flow chart, which helps us a lot. The only shortcoming is the different application areas. Therefore, the mind map we designed is largely derived from its design map.

3. Blockchain based Emergency Supplychain System(BBESS)

The technical resource layer transmits the data stored in the material transaction data center to the material whole-process control module through the data interface to realize the monitoring of the material's whole-process information. The process of data transmission relies on the unique smart contract and consensus mechanism of blockchain storage technology. Smart contracts can shorten mutual real-time recording and updating. Under the action of smart contracts, the transaction process can be basically automated, decentralized, and more secure and transparent, thus saving time and costs. Purchasing personnel, financial personnel, warehouse management personnel and other authorized approval personnel can log in to the blockchain information system through a network interface for real-time monitoring, retrieval and query operations, and can enter the material supply data center interface to engage in data entry and data collection. After each node submits and summarizes the purchase application, the management and other authorized reviewers directly monitor and adjust through the blockchain network. When there is an abnormal situation in the supply of medical supplies, both the donor and the recipient will know this fact by querying the logistics status. Visitors to the interface (including donors and donors) can use its search function to query all businesses and details related to material procurement, warehousing, logistics, etc., which is conducive to more accurate material management. All employees participate in the whole process of materials, which can better monitor the cost of materials and maintain the safety of material transportation.

3.1 Overall description

This section mainly demonstrate the proposed BBESS which is depicted as figure1. Five actors are included in the BBESS system, which are respectively Goods Node (GN), Money Donator Node(MDN), Disaster Node (DIN). MDN and GDN are inherited from Donator Node (DN), more generally, DIN and DN are children of Logistic Node (LN). The function of each node can be attributed in to four aspects: Publish Goods Donation information, Make transaction, Donate, Filter Supply.

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LN: A unique ID number can be used to identify a specific logistic Node, and the authority of the logistic node can login to the system through a password and a unique username registered on the blockchain. LN is the parents of all the other dispersed nodes which can perform function: Add logistic information, implementing the function of recording logistics information for all the passing-by goods.

DN: A node which can provide other nodes with supply can be referred to as a DN. All the DNs can perform the function of Donate where node can choose to either publish goods Donation information or publish money donation information on block chain, thus implementing the function of directly monitoring and adjust.

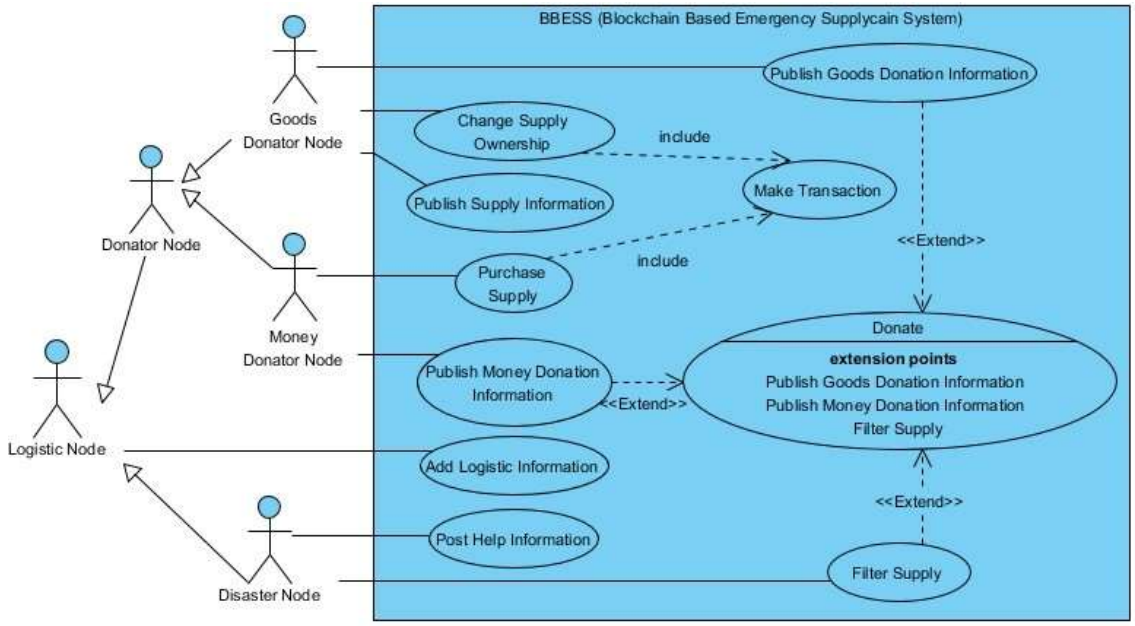

Figure 1: System overview of BBESS

MDN: The DN that is able to donate money can be noted as MDN with the function of purchasing supply from a GDN and publish money donation information on the system. As soon as the transaction is done, the blockchain can record the transation information, thereby keeping the invariance of property of the data. In addition, it can also publish money donation information which can be directly transferred to the DIN in need.

GDN: Simiarly, GDN can make transaction with MDN after which it can change the goods ownership. Also, it can publish supply information classified by categories for DIS to browse which supply is its real needs.

DIN: DIN can publish help information on the blockchain where other DNs can prepare goods to donate. More importantly, it can filter particular donation information via BBESS, thus eliminating the incorrect information match.

3.2 Implementation

To implement BBESS, three smart contracts were utilized, which are respectively donation, supply-Chain and transaction. Each authority of an area is represented as a Logistic Node (LN). Through these smart contracts, authorities can carry out operations such as Register node information, publish donation information, transfer goods, filter donation and goods information and transact goods with other LN, which are automatically maintained by the smart contract. The smart contract is embedded in the backend of the Ropsten testing network, an Ethereum trading blockchain-based network. LNs can interact with the BBESS through a front-end interface running on a server powered by web3.js and react. LNs can call any of the functions simply through a click of mouse with a human-centered interface.

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Node Registration: The authority of an area can register on BBESS through calling register Node function, where a username, a password and other information are required to identify an unique LN. Then, an informing message can be sent back to tell the user whether the registration is success or not. More specifically, the username need to be unique comparing to others, therefore, each LN can have a unique account on the system. Likewise, each time when a LN wants to login from another location, it needs to provide correct identification to access its own account.

Node Transfer Good: All the LNs have the responsibility to transfer supplies to its destination sent by other nodes, in which the nodes play a role as supply chain router. Although it is widely accepted that people may make mistakes in recording the information of the transferred goods, it can be done via RIFD, an automatic tracking and recognition system, in which maloperation.

originated from people can be reduced[7]. Thus, through combining RIFD and BBESS, goods transfer processes can be recorded on the blockchain via smart contract with minimal unexpected abnormality. Furthermore, to check the transfer process of the goods, receiver nodes can inspect into the transfer process of their designated donations and logistic information, where the detailed routing path and address of router nodes can be found, thus ensuing the transparency of the donation process.

Node publish Donation: The GDN has the ability to publish goods donation information classified by goods types on the platform, providing donation information for DSN to check and filter what it indeed needs. Then, DSN can apply for receiving the donation by the coordination of smart contract. In addition, MDN can directly publish money donation information on BBESS, then, DSN could filter the suitable money donation information via smart contract, and finish the money transfer process without the meddling of a third-party, thereby implementing the decentralized management of the donation.

Make Transaction: To provide the convenience for MDN and GDN to match their donation needs, they can make transactions on the platform. MDN can find the goods it wants to purchase on the platform published by GDN, then transactions can be handled automatically by smart contract. Furthermore, the transactions can be recorded on the blockchain, which cannot be falsified by any means.

3.3 Testing and Deployment

This proposed system was written in solidity, a language based on smart contract. And it was tested via an online IDE called Remix combined with meta-mask, an open-source Ethereum wallet that helps users manage their Ethereum digital assets empowered by blockchain backend. We only tested several main functions of our designed system which represented the real situation happening during disaster. All the functions are included in one single file called BBESS.sol, and they are shown in table1.

Table 1: Functions and corresponding usages

	Functions	Usages
Mutators	nodeRegister nodeDonateGood nodePublishGood nodeTransferGood nodePublishMoney transferMoneyDonation	Verify the authority of a LN Donate goods GD publishes goods for sale Record the transfer process of a good MD publishes money donation information Transfer the ownership of an amount of money
Observers	getClassGoods getAvailableClassGoodDonation getMoneyDonation getReleasedGoods getGoodTransferProcess getUserName	Get goods filtered by species Get available classified good donations Get money donation publish by MDN Get the goods released by one particular LN Get the logistic trajectory of a good Get the user name of an LN

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To simulate the real situation of an emergency disaster, roles of actors, and operations an actor can carry out, we developed a white-box testing strategy by following the process shown below.

3.4 Test Node Registration, Donation and Good Transferring

The solidity code runs under the compiler version of 0.4.24, and the chosen means of deployment is JavaScript VM which was empowered by sandbox blockchain in the local browser. And the EVM version is set to compiler default.

3.4.1 Deploy smart contract

This system has been deployed from an account 0x5B38Da6a701c568545dCfcB03FcB875f56 beddC4 to an address 0xd9145CCE52D386f254917e481eB44e9943F39138 on the blockchain. The result is shown below:

Figure 2: Contract deployment

3.4.2 Register LNs

In this testing process, two LNs are generated for simulation of the real-world situation, which are respectively Node A and Node B.

(a)Node A register (b) Node B register

Figure 3: Node Register

3.4.3 LNs publish goods

Node A publish first item and second item which are class 0, Node B publish third item which is class 1, where the class of an item is represented by a number. This operation is accomplished via calling Node PublishGood.

(a)Node A publish first item (b) Node A publish second item

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```
decoded input      { "address _nodeAddress": "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "string _goodName": "thirdItem", "uint256 _goodPrice": "3000", "uint256 _class": "1" }

decoded output     {}

logs               [ { "from": "0xd9145CCE52D386f254917e481eB44e9943F39138", "topic": "0xabeade7e8348f275c2c98e808ad0a036573195ce6092d7d899a4ac363d5e4a7e", "event": "NodePublishGood", "args": { "0": "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "1": true, "2": "Publish Success!", "_nodeAddress": "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "isSuccess": true, "message": "Publish Success!" } } ]
```


(c) Node B publish third item

Figure 4: Node B publish third item

3.4.4.Get Available good donations

This action can be accomplished through calling get Available Good Class Donation, and it will return first item and second item when finding goods belonging to class 0. Likewise, it will return third item when calling goods belonging to class 1. Through this operation can the LNs filter the goods that meet their real needs. The results is shown in Figure 5.


```
decoded input      { "uint256 _class": "0" }

decoded output     { "0": "uint256: 2", "1": "string[]: firstItem,secondItem,", "2": "uint256[]: 1000,2000,0", "3": "address[]: 0x5B38Da6a701c568545dCfcB03FcB875f56beddC4,0x5B38Da6a701c568545dCfcB03FcB875f56beddC4,0x0000000000000000000000000000000000000000" }
```


(a) Get class 0 goods


```
decoded input      { "uint256 _class": "1" }

decoded output     { "0": "uint256: 1", "1": "string[]: ,,thirdItem", "2": "uint256[]: 0,0,3000", "3": "address[]: 0x0000000000000000000000000000000000000000,0x0000000000000000000000000000000000000000,0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2" }
```


(b) Get class 1 goods

Figure 5: Get classified goods

3.4.5 Node A donate first item to Node B

We can call node Donate Good function to transfer the ownership of a good to be donated from a donator to a receiver, which represents the donation process of a real-world item. In our testing example, Node A donates its first item to Node B, and the result is shown below:


```
decoded input      { "address _seller": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4", "address _buyer": "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "uint256 _goodID": "0" }

decoded output     {}

logs               [ { "from": "0xd9145CCE52D386f254917e481eB44e9943F39138", "topic": "0x9fc41360ac28b250ab5c1af47486ade9000f25fb0b02664f8d65c8c291e4c21d", "event": "NodeDonateGood", "args": { "0": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4", "1": true, "2": "Donate Success!", "seller": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4", "isSuccess": true, "msg": "Donate Success!" } } ]
```


Figure 6: Node A donate first item to Node B

3.4.6 Get possessed goods of Node B

After executing the above 6 steps, Node B should possess first item and third item. We can get a LN's possessed goods by calling get Possessed Goods.

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```
decoded input      { "address _nodeAddress":
                   "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2" }

decoded output     { "0": "uint256: 2", "1": "uint256[]: 2,0", "2": "string[]:
                   thirdItem,firstItem", "3": "uint256[]: 3000,1000", "4": "address[]:
                   0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2,0xAb8483F64d9C6d1EcF9b849A
                   e677dD3315835cb2" }
```


Figure 7: Get node B possessed goods

3.4.7 Node A Transfer first item to Node B

After donating a supply, the supply chain has the responsibility to transport the goods to its destination. Every node can record the transfer process of a passing item. If we call get Good- Transfer Process, we can inspect into the passing node of the examined good. Here we firstly transfer good Num.0 from Node B to Node A, after calling the function, we can get:


```
decoded input      { "uint256 _goodID": "0" }

decoded output     { "0": "uint256: 2", "1": "address[]:
                   0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2,0x5B38Da6a701c568545dCfcB0
                   3FcB875f56beddC4" }
```


Figure 8: Get transfer process of good 0

3.4.8 Get available money donations

If a MDN publishes money donation information on the system, DIN can query available money donation information directly through get Money Donation which will return the message it needs. In our testing process, we assume that Node B has published Money Donation 0 and 1. It should return all the two donations which is shown as figure 9:


```
decoded output     { "0": "uint256: 2", "1": "uint256[]: 1000,2000", "2": "uint256[]:
                   1628303610,1628303625", "3": "address[]:
                   0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2,0xAb8483F64d9C6d1EcF9b849Ae
                   677dD3315835cb2" }
```


Figure 9: Get available money donations

3.4.9 Transfer money donation

Through calling transfer Monet Donation function, we can transfer the proprietorship of a money donation from the donator to receiver. Depending on the immutability of the blockchain network, the transaction will not change since its creation on the system. Here we successfully transfers the ownersphip of money donation 0 from Node B to Node A shown as Figure 10.


```
decoded input      { "address _from": "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2",
                   "address _to": "0x5B38Da6a701c568545dCfcB03FcB875f56beddC4", "uint256
                   _moneyDonationNumber": "0" }

decoded output     {}

logs               [ { "from": "0xd9145CCE52D386f254917e481eB44e9943F39138", "topic":
                   "0x03cd78e62c9f769e37a71ff64aca31ce2f352109a66e6d01da316f1838962a3e",
                   "event": "NodeTransferGood", "args": { "0":
                   "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "1": true, "2":
                   "Transfer Success!", "seller":
                   "0xAb8483F64d9C6d1EcF9b849Ae677dD3315835cb2", "isSuccess": true,
                   "msg": "Transfer Success!" } } ]
```


Figure 10: Transfer money donation

4. Evaluation

Our system has some advantages, for example, we can make the transmission of information more authentic. Through real-time query, donors and recipients can be more assured of the circulation of materials. Not only that, the decentralized design also allows donors to be more assured in payment, thereby better stimulating people to contribute more to the disaster-stricken areas . However, we still have some unresolved problems. For example, sometimes someone may artificially publish false

ISSN: 2414-1895 DOI: 10.6919/ICJE.202112_7(12).0024

information on the chain, which requires more technical personnel to supervise, and we cannot control it alone. Furthermore, it takes a long time for donation information to be chained, and real-time performance is difficult to guarantee [8]. In our preliminary tests, our winding time is as long as 20 minutes, and as short as about 5 minutes, and disaster relief requires a race against time. This problem is difficult to solve with gas. Finally, the bottom layer of the blockchain may be damaged by network attacks, and it is difficult for us to deal with the consequences of the damage [9].

5. Conclusion

Blockchain technology is developing rapidly in various fields with its characteristics such as unfakable, whole-process tracking, traceability, openness and transparency, and collective maintenance. It is a decentralized computing and information-sharing platform that enables us to connect multiple untrusted nodes to collaborate and coordinate in an intelligent decision making process. It can be seen from this outbreak that although China performed the best in the world in this outbreak, it can still be seen that the emergency management system in China is not sound enough to deal with the epidemic. Therefore, it is necessary to establish a perfect emergency materials management system, which can directly show the materials owned by each node, the traded materials and the flow direction of monitoring materials. In terms of technology, the blockchain technology can not be forged, can be traced and open and transparent characteristics, to achieve the complete transparency of material management, intuitive support more direct and fast. In addition, the smart contract can automate the large amount of data that is generated during the process of distributing materials and records all kinds of information. It also takes on the responsibility of making the data public, so it can effectively reduce the cost of managing and processing the data during the pandemic. The structure of smart contracts is described and can be modified as needed.

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