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Blok Zinciri Kullanarak Tedarik Zinciri Yönetimi

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Abstract. In this study a supply chain management system was developed using blockchain technology. The system, which may be suitable to environment sensitive products involves a simple market place, where a smart contract is introduced between the seller and the buyer using ethereum when an order is placed. Upon completion of this contract a different smart contract is established between the seller and the shipping company. This latter contract involves the shipping conditions such as temperature and humidity of the transport medium. These data are recorded using a sensor system in the container and kept in a private blockchain but are available to all the parties involved. Upon delivery of the goods, the buyers approves payment to the supplier if the conditions set for delivery were complied with. Then the seller approves the payment to the shipper and the file is closed. All the transactions are performed using Ether and the private blockchain assures that the shipper has honoured the conditions set forth in the contract.

Keywords: Blockcahin · ethereum · supply cahin management.

Öz: Bu çalışmada blok zinciri tabanlı bir tedarik zinciri yönetim sistemi geliştirilmiştir. Sistem özellikle çevre duyarlı ürünler için uygun olup, bir alışveriş sitesi içermektedir. Buraya verilen siparişler ile ilgili olarak satıcı ve alıcı arasında ethereum tabanlı bir akıllı kontrat oluşturulmaktadır. Bu kontratın ardından satıcı herhangi bir kargo şirketiyle ayrı bir akıllı kontrat oluşturmaktadır. Bu ikinci kontrat sıcaklık, nem gibi taşıma koşullarını da içermektedir. Taşıma işlemi boyunca bu değerler sensörler aracılığıyla okunarak kaydedilmekte ve özel bir blok zincirine kaydedilerek tarafların erişimine sunulmaktadr. Ürünlerin teslim edilmesi halinde alıcı bu değerleri kontrol etmekte, başta belirlenen şartlar sağlanmışsa ödemeyi yapmaktadır. Aksi halde alıcının kontratı iptal etme ya da bir indirim alma hakkı doğmaktadr. Alıcının teslimatı onaylamasının ardından satıcı nakliye şirketine ödemeyi yapabilmektedir.

Keywords: Blok zinciri · ethereum · tedarik zinciri yönetimi.

1 Introduction

In supply chain management, how products, especially agricultural products, are transported has great importance. The buyer wants to know under what circumstances the products he/she buys are transported and which stages they have gone through. The conditions under which the products are transported such as temperature or humidity as well as the location could be recorded periodically to assure the buyer that he will receive the goods as expected. If there is something wrong in the data like exceeded temperature value, this data should be available to third parties. In this respect, block chain may play a big role to control the circumstances.

Although blockchain technology was developed for Bitcoin, a crypto currency, it has become one of the major future technologies that would reshape many areas and industries. Reliable collection and protection of the data is very important for many industries. Altering/changing data (deleting security camera records, modifying important data in companys favor) is one of today's main problems. In such cases, it is safer to keep records in the blockchain, instead of keeping the records in a single database, i.e. on hard discs or cloud systems. Through the transparency provided by the blockchain, fraudulent actions may be reduced and the trust between parties will be increased. Also, if we think of a supply chain scenario which involves the transportation of fresh vegetables, fruits or dairy products, it enhances the food safety. There is also less food wastage because every single piece of food is accounted for and it also provides the customers trustful information about their food and empowers them to make better buying choices.

Blockchain can also be used to introduce smart contracts for trade operations between buyers and sellers. An order where a smart contract sets the conditions introduces more reliability into the process. When an order is placed, the seller needs to be sure that he/she will receive the payment, and the buyers would like to be sure that they will receive what they have asked for. There is also a shipping company involved in such transactions and their payments could also be governed by smart contracts. This approach also allows one to make the transfer of payments faster. It will increase the processing speed, and in most cases, eliminate the involvement of third parties such as banks, thereby reducing costs. The main contribution of blockchain to data integrity is that generated transaction can only be read and only new transactions can be added to the block chain. Altering them would be extremely difficult.

In this study, a system which offers a block chain solution to supply chain management, which also answers the above requirements is proposed. On the one hand, a smart contract is established between the seller and the buyer using ethereum block chain network, and all the financial transactions are carried out using this system. On the other hand the shipment conditions are monitored continuously and recorded to a private block chain to make sure that all the parties involved in the sales process, that is the seller and the shipper, comply with the requirements stated in the contract.

In the proceeding section similar studies and commercial applications in this area will be introduced. In section 3 the proposed system will be described. Discussions are included in section 4.

2 Related Work

Use of blockchain in food logistics is an important issue studied by many academic and commercial gorups. In [1] the author proposed an RFID based system where blockchain technology is utilized. In [2], the authors reviewed the current status of blockchain technology. They also investigated potential use of this technology in manufacturing and they proposed a future blockchain ready manufacturing supply chain. Article referenced in [3] studied both the transaction side and the logistic side, similar to our study, of adoption of blockchain in logistics industry. Another study on this subject is "Smart Contracts and their Application in Supply Chain Management" which is a thesis carried out at MIT where supply chain is attempted to be improved using smart contract [4].

Supply chain management using block chain has also found many commercial applications which involve Internet of Things (IoT). IOTA is the the first open-source distributed ledger that is being built to power the future of the Internet of Things with feeless micro transactions and data integrity for machines [5]. IoT Chain(ITC) is developed as a lite operating system using the block chain concept allowing data to be layered and stored in a decentralized manner and providing protection with the combined strength of the millions of IoT nodes within the network[6]. Atonomi provides IoT developers and manufacturers with an embedded solution to secure devices with blockchain-based immutable identity and reputation tracking [7].

In supply chain management side a similar work is the implementation of Coffee Supply Chain using Smart Contract developed by ImperialSoftech [8]. Walmart has chosen IBM Food Trust, which has been developed for consumer companies, like Dole, Wegmans and Unilever, to track products moving through the supply chain using block chain technology. During the transportation process, manual entry is made on the blockchain for receiveing and handing over the goods. Maersk Line, which is a maritime transport company, has been using blockchain technology since 2017 for tracking and managing its cargo. In this system, the company, Dutch customs and US Homeland Security could access data on the cargo. The shipping company UPS(United Parcel Service), together with the Blockchain in Trucking Alliance (BiTA) is working to develop blockchain standards for the freight industry [9].

The main difference between the work described above and our proposed system is that our project operates as an e-commerce site. The other thing is, ether cryptocurrency is used for transactions.

3 The proposed system

In our proposed system the smart contract involves the buyer, the seller and the shipper. Upon receiving an order, the seller creates a smart contract, and this transaction is transmitted in the ethereum network and added to a block. The seller then generates another transaction with the shipper, indication the shipping conditions, such as the container temperature and humidity. This transaction is also recorded into a block, again in the ethereum network.

During the transportation process the conditions in the container are recorded by the sensors periodically and these values are kept in a private block chain. Once the buyer receives the goods, he/she can check the private block chain through the user interface provided and if convinced that the goods have been transported as promised, approves the transaction to the seller. The seller, having received the payment as Ethers, approves the payment to the shipper, again as Ethers. If, however, the temperature or humidity exceeded the required values during transportation, then the buyer may cancel the order or he/she may be offered a discount on the contract.

The proposed system has two main components: the smart contracts implemented on ethereum, and the container monitoring system which has been implemented using a private block chain. The block diagrams of both systems are shown in Fig. 1, Fig. 2 and Fig. 3 .

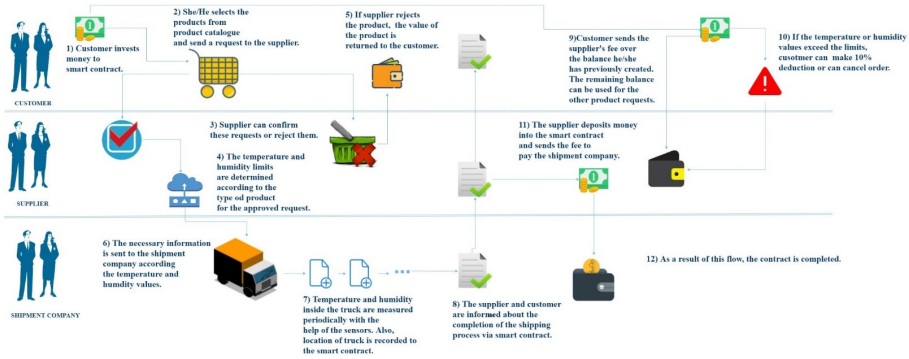

Fig. 1. The smart contract

Ethereum block chain which is used to keep records and the smart contract is written using *solidity* language and implemented on website. In this project, *Metamask* is used for deploying smart contract, exchanging payment between supplier (seller and supplier have been used interchangeably, as well as the customer and buyer throughout the text) and customer; and, supplier can also send shipper fee with this tool. In other words, it acts as a bank account. Also, Ether crypto currency is used to exchange funds.

The structure of supply chain smart contract in our project is as follows:

- The customer sends the request to the seller to buy the product(s) and starts the smart contract.
- Customer should also contribute to the contract to prove that she/he has funds for payment to the supplier.
- Supplier can see this request. If supplier approves the requests, he/she creates another smart contract with shipper to initiate shipment.
- If supplier denies the requests, customer is informed immediately, and product fee is refunded to the customer via Metamask.
- With shipment contract, supplier should define lower and upper limits of temperature and humidity
- These values are read from the sensors in the container periodically and automatically saved to the private block chain.
- When everything is completed, customer finalizes the smart contract and transfers the money to supplier. This transfer is provided by Metamask using ether virtual money.
- After customer makes the payment, supplier should send the fee to shipper.
- If the sensor limits are exceeded during the transportation process, customer can deduct a pre-set amount from supplier or cancel the order. Supplier my then apply the same process to the shipment company.

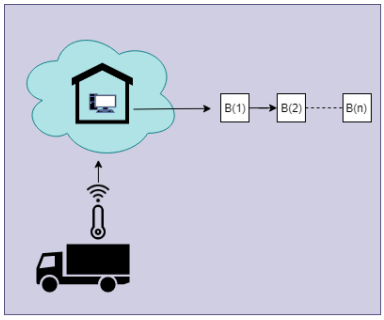

Fig. 2. The private block chain located at the container

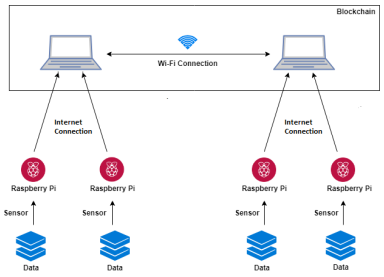

Fig. 3. The sensors and the private blockchain

In our proposed solution we employed data collector sensors and a controller (Raspberry Pi) at the cargo section of the truck in order to collect temperature and humidity data. This data is then recorded in a blockchain. The sensor board DHT11 is used for measuring the temperature and humidity. The user interface designed allows the supplier to keep track of the orders from different customers, and the customers are also provided with a user interface where they can access the instantaneous values read from the transportation medium. This way, all of the data will be transparently available to anyone. So, any party involved in this transportation process will take advantage of using block chain as opposed to using traditional database systems.

Each transaction is mined in nearly 0.25 seconds in the prototype. Also, the amount of gas used for each transaction is almost 0.000021 Ether. The performance of the prototype is limited by the Ethereum network capacity. If the number of Ethereum blocks increase, the mining time is also increased.

4 Discussions and Conclusions

In this study, an Ethereum based smart contract system and a private block chain based IoT solution is described. The smart contract protects the payments to be received and paid by the seller and buyer respectively. The IoT system makes sure that the goods are transported as agreed. The smart contracts is integrated with the user interface and presented to the user as e-commerce site. The transfer step of the product from the vendor to the buyer is recorded in a private block chain. The changes that the products have undergone during the transfer phase have been presented to all parties simultaneously. In the payments, banks were removed and shopping with crypto currency was provided.

Through using block chain:

- The need for a central server is eliminated: the data stored in the blockchain is shared by everyone who is part of blockchain network.
- The data stored in blockchain is immutable since it is protected by cryptographic hash functions. Merkle Tree implementation is how we check the integrity of the data.
- Every single operation (in our case, the temperature and humidity data collection) in the supply chain will be recorded in the blockchain transparently. So anyone who is part of the blockchain network will be able to see these data. Everyone will, therefore, be forced to be accountable for their actions.
- If there is significant change in the temperature and/or humidity data, the manager of operations will be able to see the change through the web immediately and take an action accordingly to avoid any problem before it grows bigger.

It is generally desired to have low latency in the IoT devices, however, block mining is time consuming operation that is caused by the encryption algorithms that run to keep the data safe. This is one of the issues related to our proposed system which needs further study to be solved. In the future, instead of ether cryptocurrency, a new cryptocurrency can be devised. The speed of mining is expected to decrease as the number of blocks is reduced.

There is a risk of loosing WiFi connection which can be an important problem. In this case, local storage devices must be used in each container in order to store the generated data to prevent loss.

There is also the possibility of the devices in the transportation vehicle being hacked hence sending faulty, fraudulent data. Possible solutions to this problem could be only making necessary ports available and not allowing the services to accept transactions coming form other ports. Also, there are still some open

questions about how we can establish distributed trust among parties in the presence of vulnerabilities to Denial of Service(DoS) attacks, 51

In conclusion, in our proposed solution, we tried to introduce a supply chain management system using blockchain technology with its basic features. With certain changes and modifications, our proposed solution can accomodate to new technologies such as artificial intelligence and machine learning.

As future work, solutions to the current shortcomings will be searched and a mobile application for accessing the data and performing similar operations like the web page will be developed.

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