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On a Hierarchical Blockchain-based Data Management for Supply Chain Management

Mostofa MD Naheed† Akimitsu KANZAKI‡

Graduate School of Science and Engineering, Shimane University†

Institute of Science and Engineering, Academic Assembly, Shimane University‡

1 Introduction

Recently, *blockchain* system attracts much attention not only for cryptocurrency but for a wide variety of IoT applications, like smart homes and supply chain management (SCM). To apply blockchain to such applications where multiple systems connect with each other, it is necessary to construct multi-blockchain system where each blockchain may share its own managed data with others. In this case, it becomes important to define an efficient procedure to exchange data while protecting privacy in each blockchain.

In this paper, we propose a multi-blockchain-based data management framework, focusing on SCM system. Our framework introduces a *hierarchical blockchain* that contains three layers, the public layer, the smart contract layer and the private layer. In this architecture, each data source in a supply chain (e.g. warehouse and distribution companies) individually constructs a blockchain in the private layer. While private data is managed only in these private blockchain (private-BC), data will be shared to the public blockchain (public-BC) based on the smart contracts defined in the smart contract layer. Using this architecture, users can utilize the integrated data from multiple blockchains by accessing the public-BC, while protecting privacy in each private-BC.

2 Related Work

In [1], a multi-blockchain framework for SCM is proposed. This framework introduces a multi-blockchain model where each data item is stored in one of the data chains based on its characteristics. However, this platform stores data generated in a blockchain (e.g., company) only in its own blockchain. In [2], a multichain-based data sharing framework is proposed. Similar to our framework, this framework constructs a three-tiered architecture and introduces a hierarchical access control through a smart contract. However, it is difficult to define shareable/non-shareable data for each private-BCs, especially when a large number of private-BCs join the system.

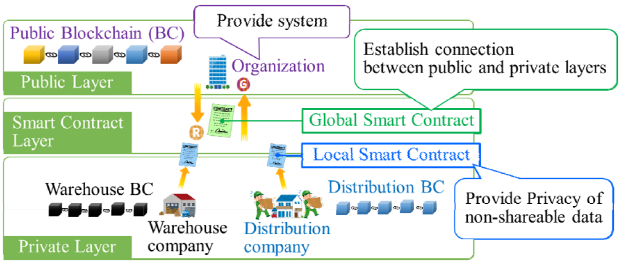

Fig. 1: Overview of our proposed framework.

3 Design of Our Proposed Framework

Fig. 1 shows an overview of our proposed framework. For simplicity, let us explain using a system consisting of only two data sources, warehouse and distribution companies, as shown in this figure.

3.1 Layers

The private layer is constructed for sharing data including private non-shareable data. In Fig. 1, each of warehouse and distribution companies constructs individual private-BC.

In **the smart contract layer**, two kinds of smart contract are defined. The global smart contract establishes the connection between the public and private layers. On the other hand, the local smart contract is an interface between global smart contract and its corresponding private-BC. This controls data access from public layer by defining shareable/non-shareable data in private-BC.

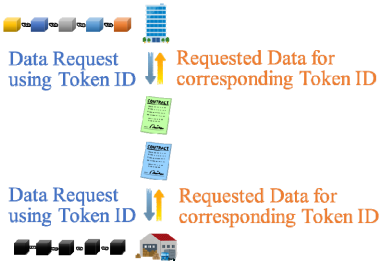

Fig. 2: Data Sharing.

The public layer constructs a public-BC which manages integrated shareable data from private-BCs and provides accessibility to the data for users. By accessing the public-BC, users can obtain data managed in this layer. Note that users cannot access private data managed in private-BC.

3.2 Data Sharing and Access Control

Fig. 2 shows an example of data sharing between public-BC and private-BC. As shown in this figure, the data sharing is performed based on the request-based procedure using token ID. Specifically, the request is issued in the public layer, and transferred to the global smart contract. After that, only the shareable data, which is defined in the local smart contract, is replied from private-BC.

4 Implementation and Result

To verify the functionalities of our framework, we have implemented a prototype using Kaleido [1] and Ethereum. In this prototype, we created two environments of blockchain systems (one public-BC and one private-BC) and added some functions for data sharing between these systems. Currently, we have implemented only the data sharing mechanism using the global smart contract. For achieving data sharing, we utilized *transfer* method defined in token swaps.

On this prototype, we generated a data transaction in the private-BC whose address is 0xfee8E6d89993426857a6255851B6354fAF0E9-8FD and issued a request for the data on public layer. Fig. 3 shows the result of transfer method. From this result, we can see that the transfer method performed

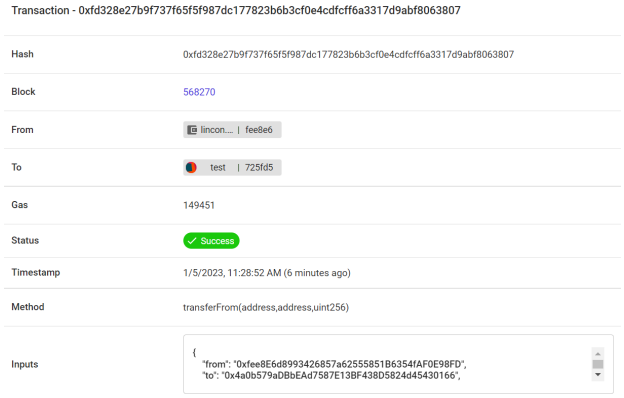

Fig. 3: Result of Data Sharing

successfully and the data from the address in the private-BC can be appropriately obtained.

5 Conclusion

In this paper, we proposed a hierarchical blockchain-based data management framework for SCM. We also implemented a prototype of our proposed framework and verified that our framework appropriately achieves data sharing between public and private layers.

As described in Section 4, we have implemented only the data sharing mechanism without considering the protection of privacy of private data. Thus, as our future work, we plan to add functionality of local smart contract that define shareable/non-shareable data in private-BCs. In addition, we plan to add functionality that enables to safely share between multiple private-BCs.

References

[1] Z. Liu and Z. Li, “A blockchain-based framework of cross-border e-commerce supply chain,” Int. Journal of Information Management, vol. 52 (2020).

[2] J. Chang, J. Ni, J. Xiao, X. Dai and H. Jin, “SynergyChain: A multichain-based data sharing framework with hierarchical access control,” IEEE Internet of Things Journal, vol. 9, pp. 14767-14778 (2022).

[1] https://kaleido.io