

# Improving Nuclear Material Accounting and Control System using Blockchain Technology

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## 1. Introduction

The Republic of Korea (ROK) has signed a comprehensive safeguards agreement with the International Atomic Energy Agency (IAEA) and established a national safeguards system to respond to the IAEA's requirements. In order to carry out the state accounting report, the Nuclear Safety and Security Committee (NSSC) and Korea Institute of Nuclear Nonproliferation and Control (KINAC) collect and verify the individual accounting reports reported by nuclear operators using the state declaration portal (SDP) system and report them to the IAEA. Recently, with the development of blockchain technology, the number of application cases for financial and logistics systems, which are similar to the accounting and control systems, is increasing. In this light, we studied ways to improve the nuclear material accounting and control system by applying blockchain technology.

## 2. Blockchain Implementation in Logistics

### 2.1 Basic Properties of Blockchain

Blockchain technology has three characteristics. First, blockchains are decentralized. All members keep a copy of the ledger in their repository. Second, blockchains have strong security by using encryption techniques with public and private keys. Third, blockchains cannot be tampered with because the ledger is updated through a consensus algorithm.

Exploiting these characteristics of blockchains, they are being used in the fields of logistics, finance, public service, health and medical care, etc. In particular, blockchain's characteristics are suitable for use in the fields of finance and logistics.

Public blockchains such as Bitcoin are open to everyone, and therefore they issue cryptocurrencies to operate the network, and the transaction speed is also very slow. By using a private blockchain such as 'Hyperledger' developed by IBM as an open source to apply blockchain technology to various industries, a small network can be configured. This significantly reduces the resources required to create ledgers, allowing operators to manage the network without a cryptocurrency.

### 2.2 Blockchain Implementations in Logistics

There are advantages of using a blockchain in the logistics sector, including improved transparency, consensus-based information verification, and automation through smart contracts. As an actual application case, Walmart collaborated with IBM to build 'Food Trust Solution', a blockchain-based food supply chain process, reducing the time to find an infected source from 7 days to 2.2 seconds. In addition, the global shipping company Maersk collaborated with IBM to build and operate a global cargo movement tracking management system 'TradeLens', in 2018. However, operation was terminated in 2023 due to global standardization and profitability issues.

As such, blockchain technology has the advantage of being able to safely and transparently manage all transaction records. On this basis, it is being developed in connection with financial systems, and efforts are being made to apply it to logistics as well. In order to overcome the disadvantages of increasing system operating costs and difficulty in changing the system to improve operation, groups are developing a private blockchain platform system that limits the number of participants required for a transaction.

## 3. Blockchain Application for NMAC System

### 3.1 Present NMAC System

The current ROK nuclear material accounting and control (NMAC) system is operating using the SDP system operated by NSSC and KINAC. This system receives reports on inventory and transaction details of nuclear materials owned by nuclear operators and collects and reports this information to the IAEA.

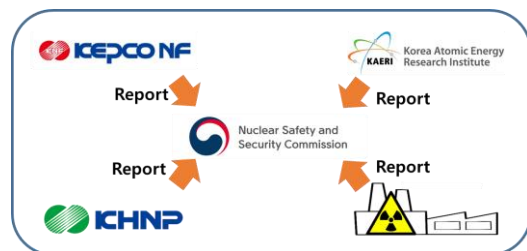


Fig. 1. Reporting scheme of current ROK NMAC system

In the current system, only KINAC allocates resources to operate the SDP server, and this is efficient because the SDP manages the inventory and transaction history of all facilities. However, if a server is attacked or an administrator makes a mistake, an error may occur in the accounting report.

### 3.2 Proposed NMAC System Using Blockchain

If a blockchain-based system is built to compensate for the shortcomings of the existing system, domestic nuclear material inventory and transaction details can be shared with each nuclear operator. Through this system, the details of the transaction parties can be shared in a consistent manner and the domestic nuclear material inventory can be easily managed. In addition, records can be maintained through a distributed ledger even if a problem arises at the central server. In particular, it will be possible to prevent the frequent occurrence of cases where it is difficult to prove the history of past transactions in institutions that possess small quantities of nuclear materials.

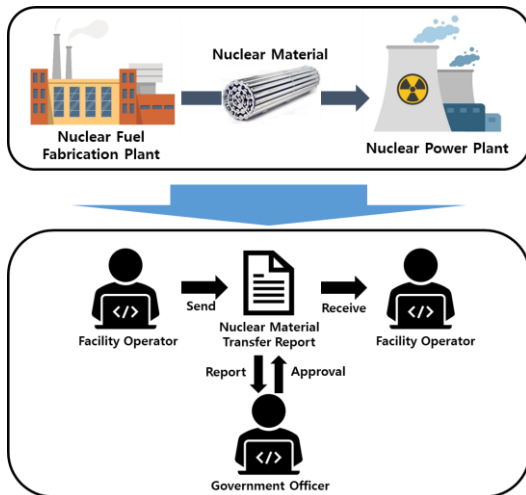


Fig. 2. Diagram of nuclear material transfer reporting process

In order to execute reliable transactions without a regulatory body, transactions between business operators can be performed through “smart contracts” that define contract rules in advance, and each transaction can be operated in a form approved by the regulatory body.

In addition, applying multiple ledgers to ROK nuclear material transaction network sub-ledgers such as the nuclear power operator, nuclear research institute, and small-scale nuclear material users can be organized under the top ledger of domestic nuclear materials, and a manager can be designated for each ledger to manage nuclear material transactions under its jurisdiction.

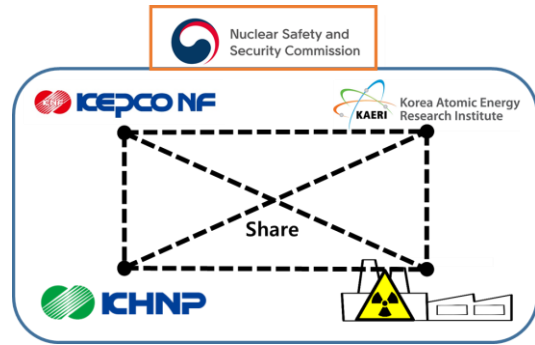


Fig. 3. Proposed ROK NMAC system basis of blockchain

### 3. Conclusions

Securing the reliability of nuclear material transaction details is a very important point in maintaining the national measurement and control system. Improving the system by utilizing the characteristics of a blockchain would help the operation of the nuclear material accounting and management system.

Using the case of a private blockchain applied to the logistics industry, we reviewed whether it can be applied to domestic nuclear material transaction management. As for the existing web service, it is difficult to secure transaction reliability and prevent forgery and alteration because it is a centralized system managed by NSSC and KINAC. By developing a small-scale private blockchain system for domestic nuclear material users, reliability can be guaranteed without significantly increasing operating costs.

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