

Estimation of Greenhouse Gas Emissions in Cement Manufacturing Process Through Blockchain and SSL Based IoT Data Analysis

Byeongseop Kim, Myungsoo Kim, and Jongpil Jeong(✉)

Department of Smart Factory Convergence, SungKyunKwan University, Suwon, Gyeonggi-do 16419, Republic of Korea
{for98ever, sioals, jpjeong}@skku.edu

Abstract. Recently, the Internet of Things (IoT) system, which supports human activities based on various types of real data, has attracted attention in various fields. However, the behavior of the system is determined based on the actual data, so if an attacker changes the data, a critical problem can occur on the system. Therefore, to ensure the reliability of real data, many researchers have studied data management platforms that use security management technology. In the proposed platform, the pre-manufacturing phase of the cement manufacturing process attempted to ensure the reliability of the generated data by having data produced using blockchain techniques through the distributed ledger of blockchain. In the manufacturing phase, Secure Socket Layer (SSL), also known as digital certificates, is also used to establish encrypted connections between the browser or user's computer and the server or website. SSL connections protect sensitive data exchanged in each session from interference from unauthorized users. Design a management platform that can verify the integrity of stored data over proposed SSL and block chain. Testers collected in real time from the system provide integrity for the calculation of carbon emissions. You will have the opportunity to drastically reduce the manpower and time funds required for the current first and second stages of verification.

Keywords: Internet of Things (IoT) system · Blockchain · SSL · Greenhouse gas emissions

1 Introduction

Recently, various types of IoT systems have been developed to support human activities in various fields. For example, to support physical distribution systems, existing IoT systems attempt to deploy GPS devices to continuously track the location information of the transport vehicle to avoid production location camouflage [1].

These IoT systems can generate real data and analyze and achieve data in an appropriate manner. However, the behavior of the system is determined based on the actual data, so if the data cannot be reliably stable, the system can have a critical problem. In particular, many devices such as GPS and smartphones that generate real data may not have sufficient functionality for security measures, so the generated data is prone to tamper. In a physical distribution system, location information through

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manipulation of GPS data in transport vehicles provides inaccurate data to intermediate traders or end consumers, such as distance to the country of origin and to the country destination through modulation or modification of the country of origin invoice.

To ensure the reliability of real data, many researchers have studied data management platforms that utilize block chain technology [2–4]. A block chain is a highly available distributed system consisting only of user terminals and can monitor data update procedures between terminals to ensure the integrity of records. For IoT systems, the block chain is used as a distributed database to ensure the integrity of stored data. Therefore, this study suggests a platform for calculating carbon emissions in cement manufacturing process through real-time data management by establishing encrypted connections using block chains and Secure Socket Layer (SSL) authentication, also known as digital certificates at the manufacturing stage, to provide stable IoT services by ensuring actual data integrity and reliability during the pre-manufacturing stage [5].

The proposed platform verifies the integrity of the titer modulation by applying the distributed ledger function of the block chain at the pre-manufacture stage, standard security technology for building encrypted links at the manufacturing stage, and establishing a secure connection between the web server and the browser. Design a platform for a s. real-time data collection system called 'SSL Handshake' that end users cannot see to assess the validity of the proposed platform. The design platform measures the data collected at each data generation point and calculates carbon emissions based on it. Data with such real-time and integrity can be effectively verified for calculating greenhouse gas emissions.

2 Related Work

2.1 Energy Management System

Energy Management System (EMS) is defined as an integrated energy solution for visualizing and optimizing energy flow and use of energy for commercial buildings, workplaces (factories), housing, social infrastructure (power networks, transportation networks, etc.) using ICT technology and control technology [6, 7]. EMS is classified as HEMS (Home EMS) for residential use, Building EMS for building use, Factory EMS for factory use, and CEMS (City/Community) for regional use, and has monitoring of energy flows such as gas, power, and control of facilities and equipment. In Korea, the FEMS Installation Verification Criteria Guide is provided by the Korea Energy Management Corporation by applying it to factories through the IT-based Energy Service Company (ESCO) pilot project promoted by the Ministry of Industry in 2011 [8]. In particular, FEMS is a factory energy management system that monitors and controls the energy supply and use of energy and operation of power distribution, air conditioning, lighting, etc. as well as production line facilities in the plant [9]. These systems include monitoring functions that collect and show values from facilities, as well as process management, performance management, control, analysis functions and related databases that manage the facilities, existing Enterprise Resource Program (ERP) and linkage with the Manufacturing Execution System (MES). The energy management

system should be able to propose production process methods and energy policies that reduce energy by analyzing energy usage using the data collected. In particular, it is starting to introduce an active ICT-based energy management system that provides the ultimate goal of optimal energy patterns by combining IoT technology, big data, and smart factory [10, 11].

2.2 Greenhouse Gas Generation in Cement Manufacturing Process

Direct emission factors related to greenhouse gas generation in the cement manufacturing process include emissions from fixed combustion facilities such as boilers, emissions from the manufacturing process, combustion of transportation means for transportation, use of refrigerant for each facility, and emission of omission due to substation of fire extinguishing facilities. etc. [12]. The indirect emission factors can also be defined as the purchase of electricity, and the distinction between the manufacturing process operating boundaries for direct and indirect emissions of the business site in relation to the calculation can be defined as shown in Fig. 1.

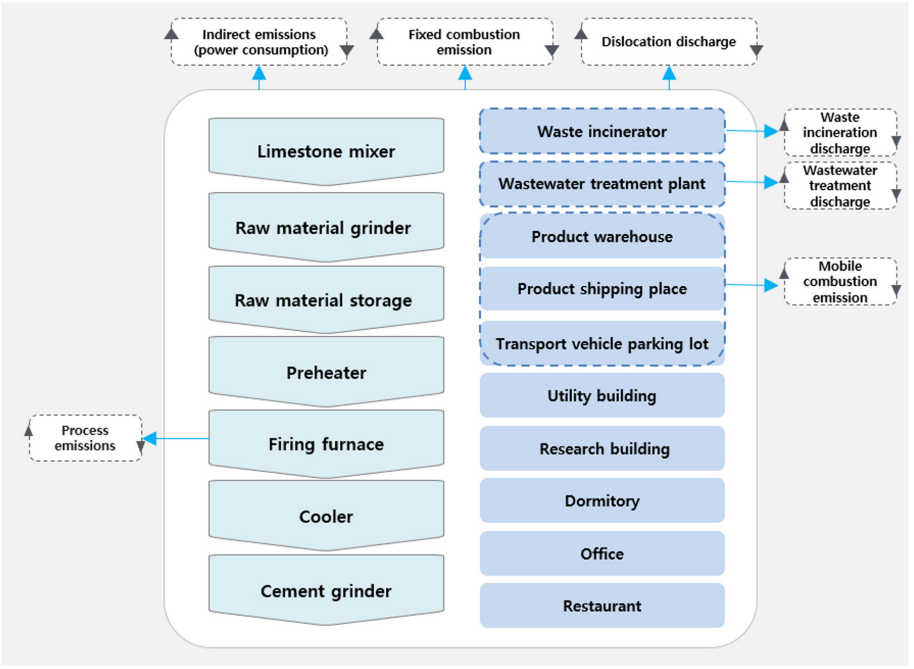

Fig. 1. Boundaries for the calculation of greenhouse gas emissions at cement sites

2.3 Block Chain Technology

A block chain is a distributed data management platform originally proposed for cryptocurrency. When a call is exchanged between users, the history is registered in a "block," a unit of data structure. Blocks are continuously generated to form a one-way list of links that can detect unauthorized data changes. Each block has a hash value calculated by entering the contents of the previous block into a prescribed one-way hash function. When data in a particular block is modulated, the hash value of the block differs from the hash value of the next block, making it easy to detect data modulation and ensure the integrity of the recorded data.

So far, a data management system utilizing block chain technology has been proposed to support various IoT systems [1, 2, 13–15]. Such research has used block chain technology to establish a stable data management system to ensure the integrity of stored data.

However, if the data were modulated before it was stored in a block chain, the accuracy of the data cannot be guaranteed. Data modulation can cause some problems in the IoT service. For example, in a raw material delivery system, the location information of the country of origin and the transport zone can be modulated by malicious users to disguise the production zone, which can cause serious problems in calculating carbon emissions.

3 Data Management Platform for Estimation of Greenhouse Gas Emissions

In this study, we want to establish a data management platform that can store various types of data generated through IoT service delivery procedures. Update records, as well as the latest data, are recorded by SSL and blockchain on the assumed data management platform.

3.1 Pre-manufacturing Process

Figure 2 shows an overview of external data management systems using blockchain. As illustrated in this drawing, various types of IoT data, such as location information, are transmitted from IoT devices such as GPS sensors, and the management function of each data is implemented as an external smart contract on the block chain. Similar to the functional entity supported by the new block chain appearing in external smart contracts and automatically performs the programmed procedure when a request is received from a user or other smart contract [16, 17]. Smart contract execution records are recorded in the block chain, allowing users to access update records as well as the latest values of each data. In smart contracts, templates for data structures are defined and users invoke the ability to update data structures when registering data. As a result, the data is recorded as transactions in the block chain as illustrated in Fig. 2.

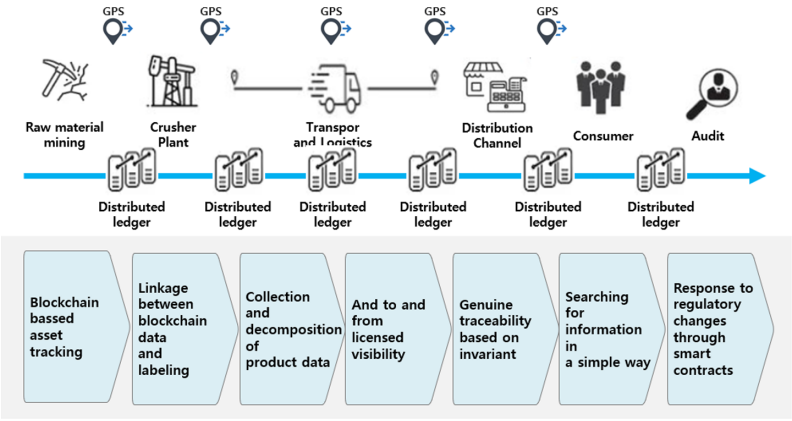

Fig. 2. Tracking raw material information using blockchain

It can minimize problems such as data modulation that can occur during the distribution process of raw materials, save time and cost of identifying causes when problems arise, and raw material mining and processing companies enter key information into the blockchain network along with transaction details. Distributors can check the source and information of raw materials in real time and identify customer evaluations and preferences. In addition, the consumer's headquarters (supervisor) can check compliance with regulations across the supply chain, generate certification and audit records for supply chain management, and in the process, all raw material mining companies, processing companies, logistics warehouses, distributors and regulators will be participants in the distribution process, and consumers can access the blockchain network of mobile application servers to check necessary information.

3.2 Manufacturing Process

The facility energy monitoring system proposed in Fig. 3 is a schematic diagram of the hierarchy with the systems associated with other production facilities. IoT devices will be installed in each of the plant's corresponding facilities and the accumulated instructions that are inspected through the gateway will be transmitted wirelessly to the server. At this time, PLC, monitoring control, and data collection system (SCADA) are operating systems that control sensors. The Energy Management System (EMS) is a system that monitors and controls energy use and operation status, and has a system with monitoring and analysis functions proposed in this paper, such as control functions, process management, and performance management. The energy management system plays an interim role in organically connecting and expanding with the Enterprise Resource Planning (ERP) that manages the production process through the Manufacturing Execution System (MES) and Product Lifecycle Management (PLM) to manage the products such as the top raw materials. For data generated within the manufacturing process, each management system is encrypted with Secure Socket Layer (SSL) in real time to ensure that data received through the integrity network has not been changed as a burden [18].

3.3 Calculation Process

As shown in Fig. 4, when calculating greenhouse gas emissions in the cement manufacturing process, a template of IoT data structure is defined during the pre-manufacturing and manufacturing phase, and the user invokes the function of updating the data structure when registering the data. As a result, data generated during the manufacturing process is encrypted and real-time interface with Secure Sockets Layer (SSL) as shown in Figs. 2 and 3, and data generated from outside is recorded as a greenhouse gas emission calculation platform after being collected in the data control system by verifying integrity as a transaction in a block chain.

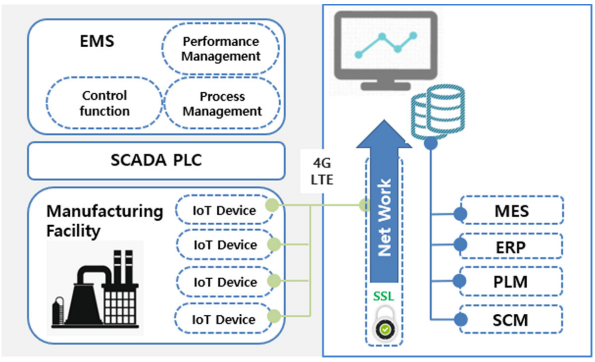

Fig. 3. Manufacturing process IoT data management system using SSL

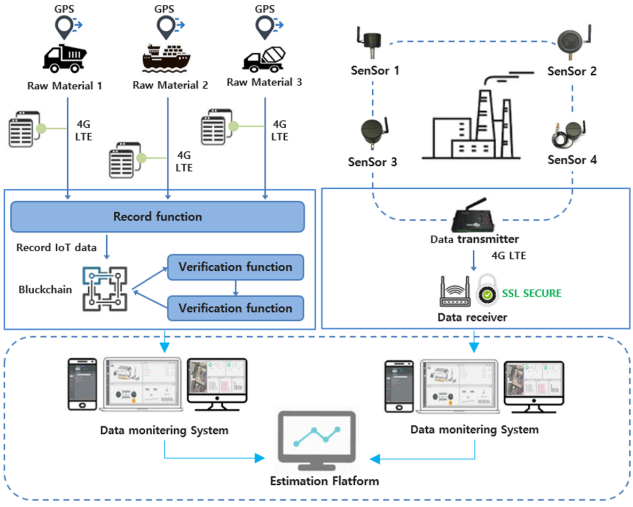

Fig. 4. Manufacturing process IoT data management system using blockchain & SSL

4 Implementation and Use Cases

Reducing greenhouse gas emissions to prevent climate change has now become an irresistible trend. Since the Paris climate agreement was reached in 2015, countries around the world have laid legal grounds to implement the agreement, and South Korea has begun to control local companies' greenhouse gas emissions by introducing a "carbon emission trading system" that prices greenhouse gas emissions.

In line with government policies, local companies are at a considerable cost to reduce greenhouse gas emissions. However, although most of the policies being implemented to achieve the national greenhouse gas reduction target are focused on the industrial sector, they go through the process of identifying sources of greenhouse gas emissions, calculating emissions, and verifying the systematic structure of the results, but lack real-time feasibility. In addition, cement manufacturing sites that are being discussed in the study face the real problem of purchasing carbon credits, which are increasing day by day over time [19].

4.1 Configuring Devices and Features

In the study, the company designs an encrypted IoT data management platform and calculates greenhouse gas emissions. In this system, location information measured by a transport vehicle's GPS device is subject to verification of authenticity, and the measured data is submitted to the Internet's block chain via a 4G/LTE cellular network. In addition, data generated during the manufacturing process is used to create symmetrical session keys, which are encrypted over SSL by encrypting data in transit.

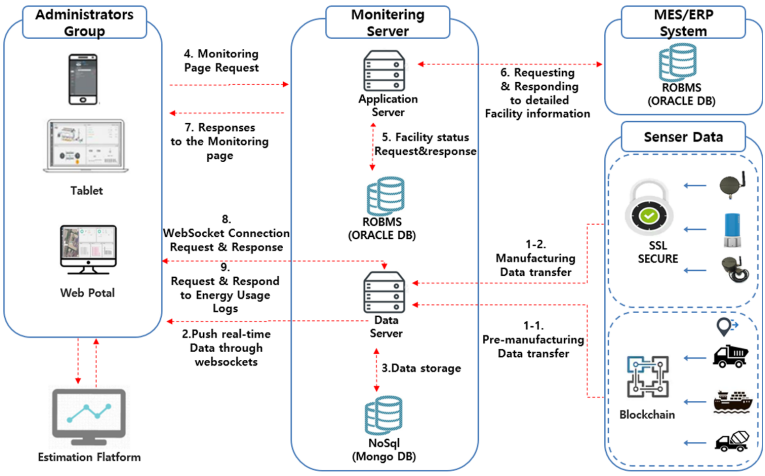

Fig. 5. Greenhouse gas emissions estimation system

Figure 5 shows an implementation environment for calculating carbon emissions by monitoring and retrieving data collected in real time before and during the manufacturing phase. Servers use Tomcat WAS servers and use Mongo databases and Oracle databases for search and analysis to collect data entering IoT devices. It is implemented on a Web-based basis and run in the Web, App environment of computers and mobile tablets so that field workers can conveniently input and search in real time at work sites.

Sensor data transmitted from IoT devices is sent to data service via web network and stored in database in real time. In addition, when an administrator requests monitoring data after setting up a configuration for the set-up period, he or she accesses the MES/ERP system through the application server and receives the information to respond.

4.2 System Implementation and Practices

Mobile devices such as smartphones are equipped with management programs so that process-related teams can monitor greenhouse gas emissions in real time anytime, anywhere. Service support of server data allows smartphones to view real-time update emissions results and visually display construction activities synchronized with virtual models. The system was first implemented to test the viability and applicability of the actual manufacturing process. It is supported by block chain data through various SSL-encrypted IoT devices in the manufacturing stage and GPS systems in the manufacturing shear system. Implementation and direct emissions can be monitored by the computing platform in real time and displayed visually as shown in Fig. 6.

Figure 7 shows the current status of installation and operation of IoT sensors installed at the site.

This is the result of the search screen for the calculation of carbon emissions by quarter or year for the entire facility. The results of pattern analysis from real-time to maximum years can be derived according to the calculation time setting for data retrieval, including direct and indirect carbon emission analysis corresponding to each calculation history. Thus far, it has served as an opportunity to develop the passive calculation process for carbon emission calculations into an active process.



Fig. 6. Greenhouse gas emissions estimation system

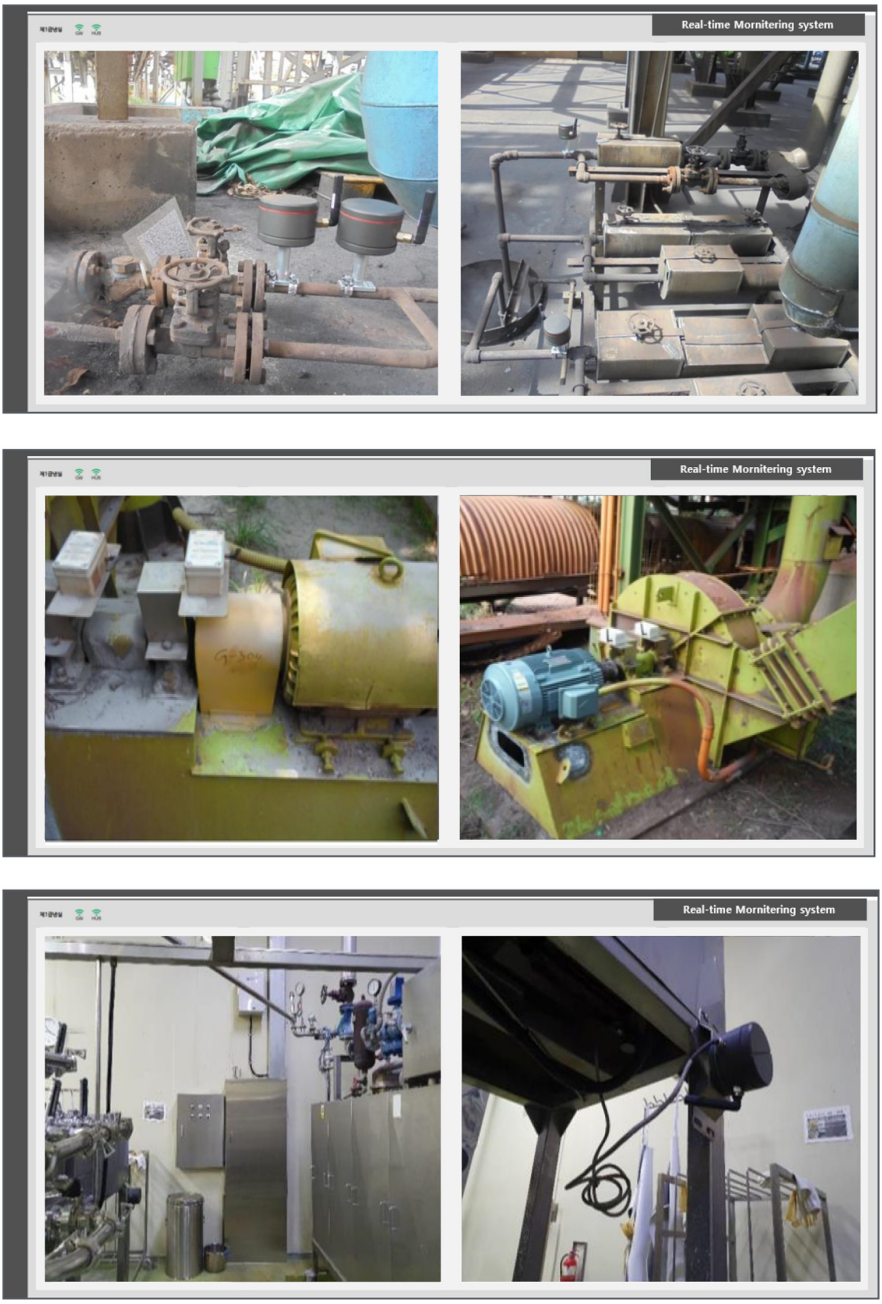

Fig. 7. IoT sensor monitoring system

5 Conclusion

In this study, we proposed a platform for calculating carbon emissions through reliable IoT data management that prevents data modulation by using SSH internal network security, block chain and transaction data analysis that can guarantee both the integrity and reliability of IoT data. The proposed platform made clear that the reliability of the measured data for the system can be correctly verified, indicating the efficiency in calculating the corresponding carbon emissions from the proposed platform. In the future, we will study technologies that speed up data extraction through the introduction of distributed access through edge computing to the block chain or the introduction of industrial 5G. In order to enhance the reliability of the verification results, the government will also study ways to incorporate some of the verification functions implemented by the relevant ministries and agencies of the country into the block chain to expand the scope of application of the program to local governments or national levels.

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