

UAV-assisted Automated Oxygen Level Monitoring and Alerting Scheme in Smart Factory with the assistance of MEC and Blockchain

Md Masuduzzaman, Anik Islam and *Soo Young Shin

Department of IT Convergence Engineering,
Kumoh National Institute of Technology (KIT), Gumi, South Korea
Email: {masud.prince, anik.islam, *wdragon}@kumoh.ac.kr

Abstract

Continuous oxygen O_2 gas level monitoring in the smart factory is crucial to alert an emergency in critical condition to all the employees in time for saving thousands of lives. This research focuses on an automated oxygen level monitoring and emergency alerting scheme for the smart factory. A UAV-based continuous O_2 gas data collection technique is proposed with the assistance of electrochemical sensors in the smart factory. A multi-access edge computing (MEC) server is introduced to process all the collected data from the UAV at the edge of the network to determine the O_2 gas level in different regions of a smart factory. Moreover, a blockchain-based emergency alerting method is designed to avoid any third-party interaction in this proposed scheme. Finally, result analysis has been demonstrated the feasibility of the proposed scheme.

I. Introduction

One of the important issues in the smart factory is to monitor the oxygen (O_2) level for all the employees as different types of chemicals and equipment are used frequently that might reduce the O_2 level. Therefore, electrochemical sensors can be placed in different sections and floors of the smart factory to monitor the O_2 level continuously. An unmanned aerial vehicle (UAV) can be employed in the smart factory to collect data very rapidly [1]. Therefore, UAVs can be used to collect data about the O_2 level from the sensor nodes in a smart factory. However, due to the limited battery capacity, the data can be offloaded to a multi-access edge computing (MEC) server for processing purposes [2]. The security issues must be considered during data transfer and processing by a MEC server. Therefore, a blockchain-based employee alerting technique is introduced by using the MEC server to avoid third-party interaction in this proposed scheme.

II. Proposed Methodology

The system model of the proposed scheme is drawn in Figure 1. First, electrochemical sensors are placed in different areas in a smart factory to monitor the O_2 level. Multiple UAVs are dispatched in different regions of the smart factory to collect the data continuously from the electrochemical sensors. Due to the limited battery capacity, the UAV offloads the collected data securely to the MEC server to process and determine the O_2 level. The MEC server verifies the collected data first and then processes it.

A threshold value of O_2 is set in the smart contract of the MEC server. After processing the data, if the O_2 level is decreased below the threshold value, the smart contract is executed automatically to alert the employee about an emergency in the smart factory.

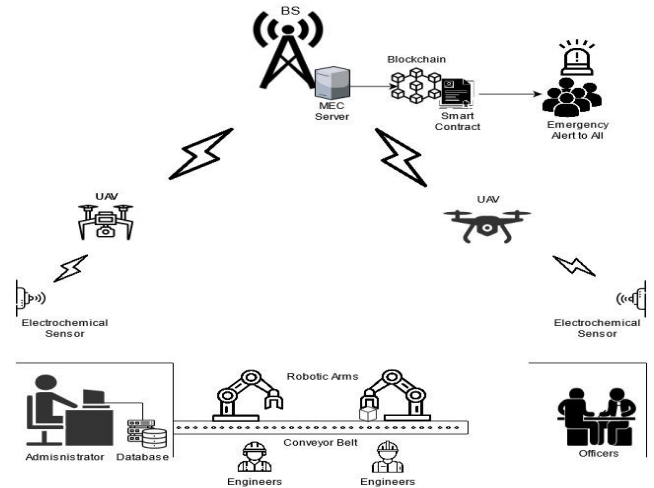


Fig. 1. Overall System Model

The electrochemical sensors collect the O_2 level data from a smart factory in analogue format and convert the data into a digital one by using analogue to digital converter (ADC). After converting the data into a digital one, the data is transferred to the MEC server using the UAV. The O_2 level data collection and transferring process are shown in Figure 2. To secure the data transmission among the entities, public key infrastructure (PKI) is used in this scheme. The architecture of PKI is drawn in Figure 3 for the reliable data transmission inside of the proposed network. After receiving

the O₂ level data from the sensor nodes, the MEC server

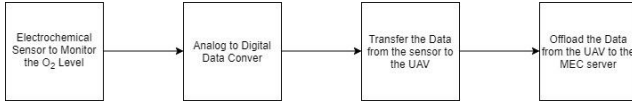


Fig. 2 O₂ Level Detection and Data Transfer Process

processes the data. For securing the processed data in the MEC server and avoiding any third-party involvement, blockchain can be beneficial because of its distributed ledger that is immutable [3]. Additionally, to make the proposed scheme automated, the smart contract of the blockchain can be beneficial to avoid third-party interaction to call an emergency in the smart factory.

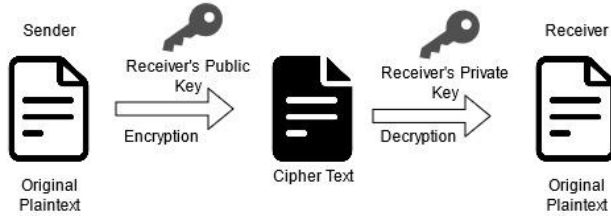


Fig. 3 PKI-based Reliable Data Transfer Mechanism.

Different logic can be set inside of a smart contract to be executed automatically when it meets the policy. First, a threshold value of the O₂ level needs to be set as a policy in the smart contract. If the O₂ level decreases below the threshold value, the smart contract is automatically activated to place an emergency alert to all the employees. Therefore, third-party cannot modify the sensor data as well as declare a false emergency alert to the employee in a smart factory because of the blockchain network.

III. Result Analysis

The experiment for the proposed scheme is conducted using parrot bebop 2 as a UAV and Raspberry pi 4 model B is attached with the UAV. An Intel (R) Core (TM) i5-4590 CPU @3.30GHz with 16 GB memory is used as the MEC server. First, an electrochemical sensor is used to monitor the O₂ level in a smart factory and then transfer the information to the MEC server using the UAV. Public key cryptography is used for transferring the data from one end to another. Therefore, calculating throughput inside of the network is important to observe the performance of the network. A python code is formulated to observe the throughput before and after applying the cryptographic technique as shown in Figure 4. It represents the throughput in the reliable and unreliable channel. Here, the throughput of the unreliable channel is higher than the reliable channel because the public key cryptographic technique is applied in the reliable channel. Therefore the throughput is lower in the

unreliable channel as no cryptographic technique is applied during data transmission. Alongside, both the throughput is decreased with times due to the packet loss and network jitter in the channel. However, reliable data transmission is always preferred as the transmitted data is secured.

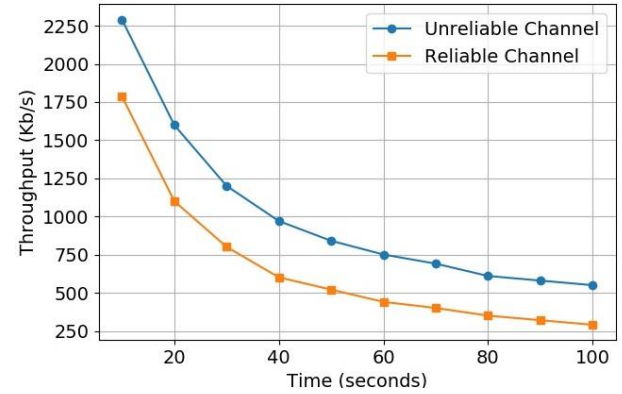


Fig. 4 Throughput analysis of the proposed scheme

IV. Conclusion and Future Work

Our proposed scheme can monitor the oxygen level continuously and alert the employee in a critical situation. In this scheme, an electrochemical sensor collects the oxygen level in a smart factory and transfers the data to the MEC server using a UAV. The MEC server contains a blockchain to store the data and avoid any third-party involvement in an automated alerting scheme. However, other types of toxic gas detection in a smart factory can be considered as a future work of this research.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government. (MSIT) (No. 2019R1A2C1089542).

Reference

- [1] M. Masduzzaman, A. Islam, and S. Y. Shin, "A blockchain-enabled CO₂ controlling scheme with the assistance of the internet of things," *Journal of the Korean Institute of Communication Sciences*, pp. 114–115, 2020.
- [2] A. Islam, T. Rahim, M. Masduzzaman and S. Young Shin, "A Blockchain-Based Artificial Intelligence-Empowered Contagious Pandemic Situation Supervision Scheme Using Internet of Drone Things," in *IEEE Wireless Communications*, doi: 10.1109/MWC.001.2000429.
- [3] K. Sadia, M. Masduzzaman, R. K. Paul, and A. Islam, "Blockchainbased secure e-voting with the assistance of smart contract," in *IC-BCT 2019*, D. Patel, S. Nandi, B. Mishra, D. Shah, C. N. Modi, K. Shah, and R. S. Bansode, Eds. Singapore: Springer Singapore, 2020, pp. 161–176.