Design and Implementation of IoT-Based Intelligent Condition Management System for the Industrial Facilities

Jaekeun Lee, Soono Seo, Myeong-in Choi, Yongkwen Hwang, Tacklim Lee, and Sehyun Park(✉)

School of Electrical and Electronics Engineering, Chung-Ang University, 84 Heuseok-Ro, Dongjak-Gu, Seoul, Korea
{li0825, ssoabc, auddlscjswo, dydrms06, tacklim34, shpark}@cau.ac.kr

Abstract. A condensation phenomenon occurs when the water vapor in the air turn into water droplets. Many industrial facilities are damaged by the condensation phenomenon. An ammunition storage is one of the facilities that are damaged by this phenomenon. Therefore, this paper proposes an IoT-based intelligent condition management system (ICMS) in for the industrial facilities. The proposed system prevents a condensation phenomenon by measuring the temperature and humidity and provides alerting service about intrusion and gas exposure through a smartphone application. Therefore, it has become possible to manage the ammunition efficiently.

Keywords: Environmental monitoring system · Condensation phenomenon · Ammunition storage · Zigbee communication · Internet of things

1 Introduction

A condensation phenomenon is easily shown in our daily lives. This phenomenon is caused by difference between internal temperature and external temperature. Generally, when the air temperature gets high, the amount of saturated water vapor is increased. However, if warm air suddenly becomes cold, the amount of saturated water vapor is also reduced [1]. For this reason, water vapor changes to water droplets. The condensation phenomenon easily occurs during the summer when temperature and humidity are especially high. This phenomenon causes a lot of problems. For example, water droplets corrode metals and woods and promote the growth of mold. The army ammunition storage facility is also one of the facilities damaged by condensation. Because most ammunition is expensive, scale of damage is greater than the other problems. Therefore, many studies have been conducted in order to prevent this problem. However, most studies have presented a solution of the problem with architectural approaches. And, this solution can only be applicable to the initial construction of ammunition storage and requires high cost. Currently, most of ammunition storages were built in the form of igloo for the purpose of protection and camouflage. The igloo type ammunition storage has bad air circulation between inside and outside.

R. Giaffreda et al. (Eds.): IoT360 2014, Part I, LNICST 150, pp. 48–53, 2015.
DOI: 10.1007/978-3-319-19656-5_7

Thus, it is particularly vulnerable to condensation. Nowadays, in order to prevent the condensation phenomenon, an administrator opens the door of ammunition storage and directly checks the value of temperature hygrometer which is installed internally. If it is the condensation conditions, the administrator should turn on the fan using the internal switch of ammunition storage. This management system is an inconvenient for managing temperature and humidity.

Recently, with the changes in the IoT paradigm, many studies on IoT based temperature and humidity monitoring system have been conducted [2, 3]. Devices shown in these studies consist of a sensor module, a communication module, and a micro controller unit (MCU). The sensor module measures ambient temperature and humidity. The communication module sends the information, which is collected through the sensor module, to users via WiFi, Bluetooth, ZigBee communication. The MCU analyzes the information of temperature and humidity and creates services for the users. By controlling the appliances in the room through this monitoring system, user can be provided optimal air control service in the space [4]. However, these studies have mostly focused on home and building as application target areas.

Therefore, this paper proposes an IoT-based intelligent condition management system (ICMS) for the industrial facilities. The ICMS measures the temperature and humidity and determines whether the condition phenomenon occurred based on these collected information. If it is condensation condition, ICMS turns on the fan installed inside the ammunition storage. The operating fan reduces the difference between internal temperature and external temperature by letting outside air in. This method is capable of automatically preventing condensation according to the condition of the ammunition storage and improves the conventional method which has been managed manually. The ICMS also includes a motion sensor and a gas sensor. Therefore, if an intruder enters the ammunition storage or gas is detected in the space, an administrator can be provided alerting service through a smartphone application.

2 System Architecture

The architecture of the proposed system is shown in Fig. 1. The ICMS is installed in each of the ammunition storages. It collects the information of temperature, humidity, movement, and gas in the internal ammunition storage. A server is located in the center of ammunition storages. It plays a role in storing the information which has been measured by the ICMS and transmitting these information to administrator. The ICMSs adjacent to the server are named header node, the others are named general node. The general nodes transmit the measured information to header nodes. And, the header nodes transmit these information to the server. This method helps to prevent server overload. The ICMS and server are connected via ZigBee communication, and the server is connected to administrator's smartphone via military's intranet. The two key functions that the proposed system has are as follows.

2.1 Preventing the Condensation Using an ICMS

Figure 2 describes the process of preventing the condensation phenomenon in the proposed system. The possibility that the condensation will occur is deeply related to

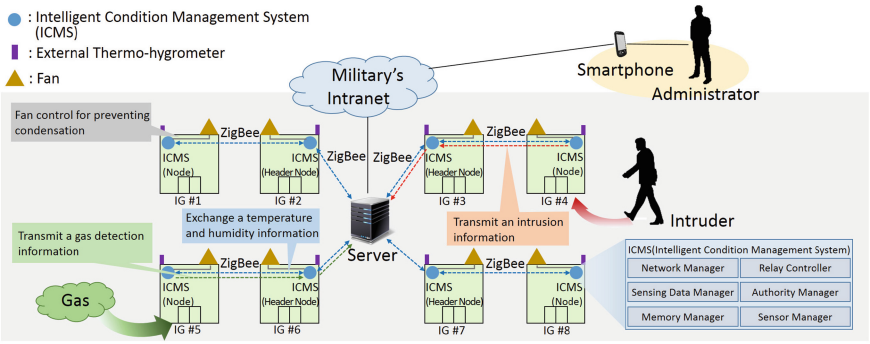

Fig. 1. Overview of the proposed system architecture.

the difference between indoor and outdoor temperature. Thus, in this Fig. 2, the high possibility that the condensation will occur means the temperature difference between indoor and outdoor ammunition storage is over one degree or the humidity is over 80 %. Moreover, ICMS has an ability to control the fan by comparing the internal and external temperature information collected from the sensor manager. The process of the comparison process is performed by the sensing data manager in ICMS. In the scenario 1, when ICMS detects a high possibility that the condensation will occur, the network manager of ICMS forwards a control packet to the fan and an information packet to the server. Then, the fan is activated by the relay controller and the server

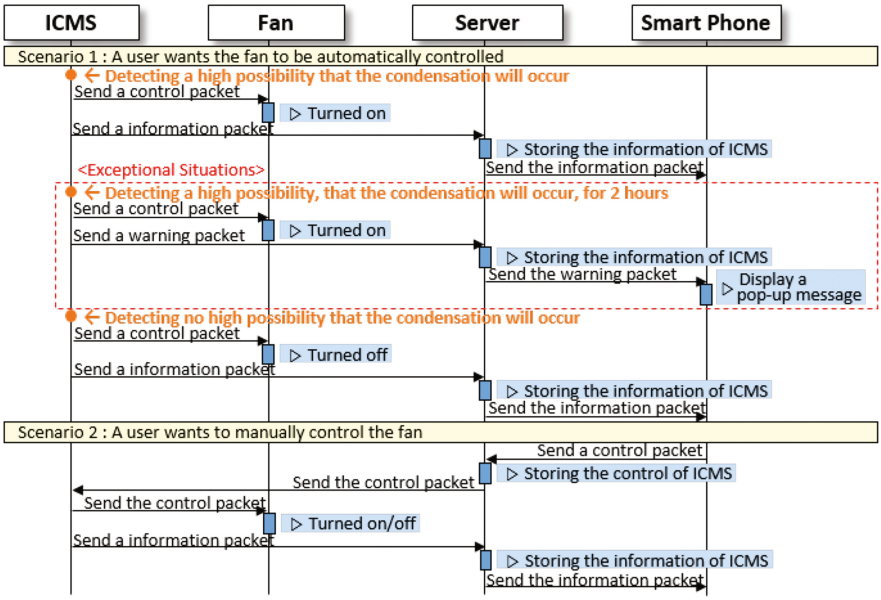

Fig. 2. Sequence diagram for preventing the condensation using an ICMS.

stores the information packet. After storing the information of ICMS, the server sends the information packet to the smart phone. Similarly, when ICMS does not detect the high possibility that the condensation will occur, ICMS forwards a control packet to the fan and an information packet to the server. After receiving the control packet, the fan is deactivated and the server stores the information of ICMS. Then, the server transfers the information packet to the smart phone.

In Fig. 2, the exceptional situation means that the environmental condition has not be improved for 1 h after the fan is turned on. For example, the exceptional situation is can occur due to the fan's breakdown. If ICMS detects the exceptional situation, ICMS will transfer the control packet to the fan again and the warning packet to the server. Then, the server stores the information of ICMS and sends the warning packet to the smart phone. After the smart phone receives the warning packet, the smart phone shows a pop-up message that alarms the administrator through the mobile phone application. Due to this pop-up message, the administrator can immediately recognize the problem of the ammunition and quickly handle the problem.

Furthermore, the administrator is able to remotely control the power supply of fan by using the smart phone. The scenario 2 in Fig. 1 shows the process of the remote control. When an administrator sends a control packet to the ICMS through the server, the authority manager of ICMS first identifies the administrator for the security, and then the control packet is sent to the fan. For this purpose, the authority manager has an ability to entitle specific administrators to access the ICMS. If an administrator has access authority, ICMS will forward the control packet to the fan to activate or deactivate the fan. After the fan is turned on or off, the ICMS sends an information packet to the server. Then, the server stores the information of ICMS and transfers the information packet to the administrator's smart phone.

2.2 Providing an Alerting Service Through Smartphone Application

Figure 3 describes the process of warning the administrator of an intruder's movement or a gas leak in the ammunition storage. When ICMS detects the motion of human or gas exposure, ICMS forwards a warning packet to the server. The server, then, stores the information of ICMS and transfers the warning packet to the smart phone. After receiving the warning packet, the smart phone immediately warns the administrator of detecting the motion of a human or a gas leak with a pop-up message of the mobile phone application.

3 Implementation and Test

Figure 4(a) shows the prototype of ICMS. It consists of a micro controller unit (MCU), a power module, an environmental monitoring sensor module, a ZigBee (IEEE 802.15.4) module, and a buzzer. The environmental monitoring sensor module is divided into 3 parts: a temperature and humidity sensor, a gas sensor, and a motion sensor. A smartphone application is shown in Fig. 4(b). Using the mobile application, an administrator is able to both observe the condition of the ammunition storage and

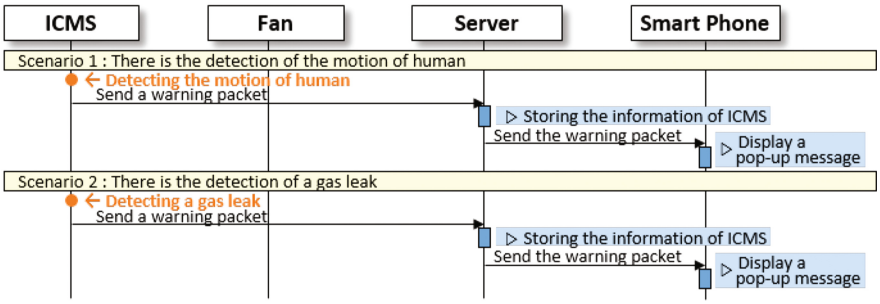

Fig. 3. Sequence diagram for alerting service.

remotely control the fan to decrease a gap between indoor temperature and outdoor temperature. Moreover, the mobile application displays pop-up messages and warns an administrator of urgent problems such as detecting an intruder and the air condition that has not been improved for 1 h. We implemented the proposed system in the test bed shown in Fig. 4(c). It was made as a model analogous to the environment of an ammunition storage. The test bed consists of ICMS, an external thermometer, and a fan. Figure 4(d) shows temperature changes in the test bed. When the temperature difference became over one degree between inside and outside, the fan was activated.

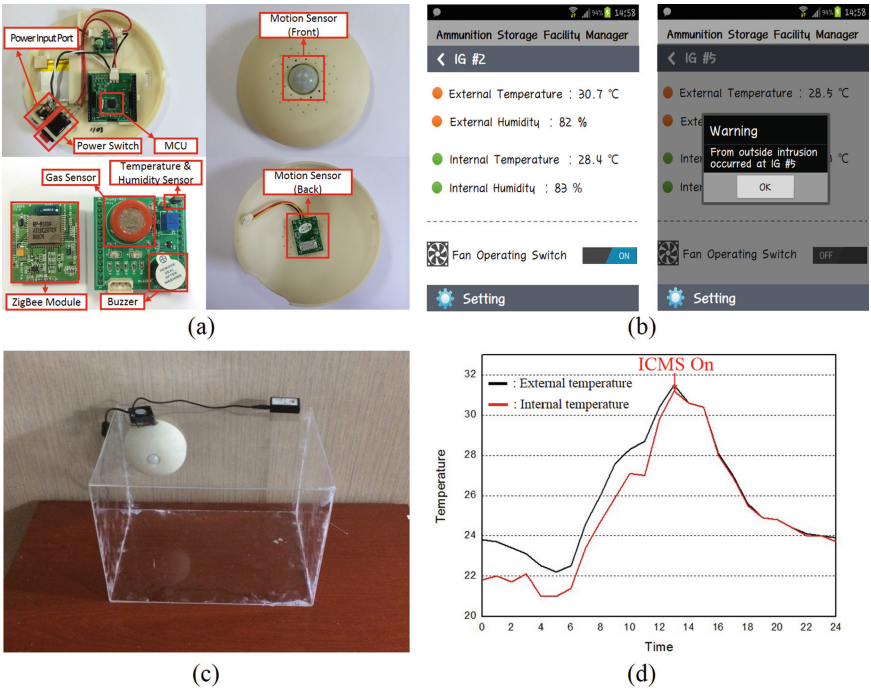

Fig. 4. (a) Prototype of the ICMS, (b) smartphone application, (c) test bed of the proposed system, (d) experimental result.

And then, the temperature difference was decreased. Owing to this process of the proposed system, the condensation phenomenon could be prevented.

4 Conclusion

For the efficient ammunition storage management, an intelligent condition management system (ICMS) is proposed. The ICMS measures temperature and humidity in real time and turns on an installed fan by analyzing these measured values. Therefore, it prevents condensation phenomenon automatically. The ICMS also provides alerting service for security and safety. An administrator can receive the message about intrusion or gas exposure via smartphone application. We implemented the proposed system in a test bed to verify efficiency. The proposed system prevented the condensation phenomenon by controlling a fan.

Acknowledgments. This work was supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the ITRC (Information Technology Research Center) support program (NIPA-2014-H0301-14-1044) supervised by the NIPA(National IT Industry Promotion Agency), and by the Human Resources Development (No. 20124030200060) and the Energy Efficiency & Resources (No. 20132010101850) of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy.

References

1. Jia, L., Peng, X.: Heat transfer in flue gas with vapor condensation. Tsinghua Sci. Technol. **7**, 177–181 (2002)
2. Lazarescu, M.T.: Design of a WSN platform for long-term environmental monitoring for IoT applications. IEEE Trans. Sel. Top. Circuits Syst. **3**, 45–54 (2013)
3. Chi, Q., Yan, H., Zhang, C., Pang, Z., Xu, L.D.: A reconfigurable smart sensor interface for industrial WSN in IoT environment. IEEE Trans. Ind. Informat. **10**, 1417–1425 (2014)
4. Perera, C., Zaslavsky, A., Christen, P., Georgakopoulos, D.: Context aware computing for the Internet of things: a survey. Commun. Surv. Tuts. **16**, 414–454 (2014)