The Development of Wireless Radiation Dose Monitoring Using Smart Phone

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Abstract - Radiation workers at a nuclear facility or radiation working area should hold personal dosimeters. Some types of dosimeters have functions to generate audible or visible alarms to radiation workers. However, such devices used in radiation fields these days have no functions to communicate with other equipment or the responsible personnel. Our project aims at the development of a remote wireless radiation dose monitoring system that can be utilized to monitor the radiation dose for radiation workers and to notify the radiation protection manager of the dose information in real time. We use a commercial survey meter for personal radiation measurement and a smart phone for a mobile wireless communication tool and a Beacon for position detection of radiation workers using Bluetooth communication. In this report, the developed wireless dose monitoring of cellular phone is introduced.

Key words : Wireless dose monitor, Bluetooth, Smart phone, Beacon, APP, IoT (internet of things)

INTRODUCTION

Internet of things (IoT) technology has recently shown a large flow of IT trends in human life. In particular, our lives are now becoming integrated with a lot of items around the 'smart phone' with IoT, including Bluetooth, Near Field Communication (NFC), Beacons, WiFi, and the Global Positioning System (GPS). Our project focuses on the interconnection of radiation dosimetry and IoT technology.

The radiation workers at a nuclear facility or radiation working area should hold personal dosimeters such as a Thermo-Luminescence Dosimeter (TLD), an Optically Stimulated Luminescence Dosimeter (OSL), pocket ionization chamber dosimeters, an Electronic Personal Dosimeter (EPD), or an alarm dosimeter on their body. Some of them have functions that generate audible or visible alarms to radiation workers in a real nuclear facility or a radiation field. However, such devices used in radiation fields these days have no functions for communicating with other equipment or the responsible personnel in real time. In particular, when conducting a particular task in a high dose area, or a number of radiation works within a radiation field, radiation dose monitoring is important for the health of the workers and the work efficiency. Our project aims at the development of a remote wireless radiation dose monitoring system that can be used to monitor the radiation dose in a nuclear facility for radiation workers and a radiation protection program. In this report, we report the design of a radiation dose monitoring system using smart phone and a demonstration case in a real radiation field.

MATERIALS AND METHODS

The main components of the remote wireless radiation

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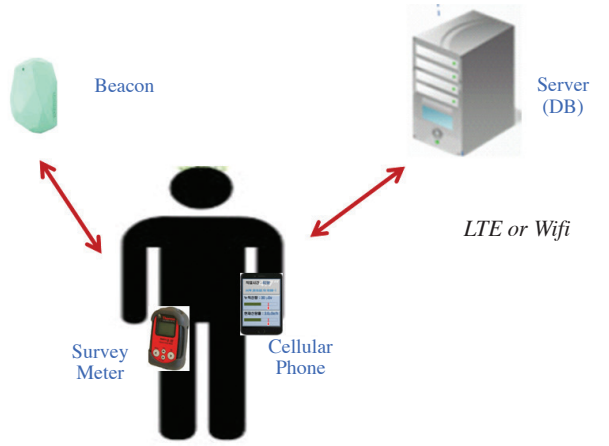

Fig. 1. The basic idea of remote wireless radiation dose monitoring system.

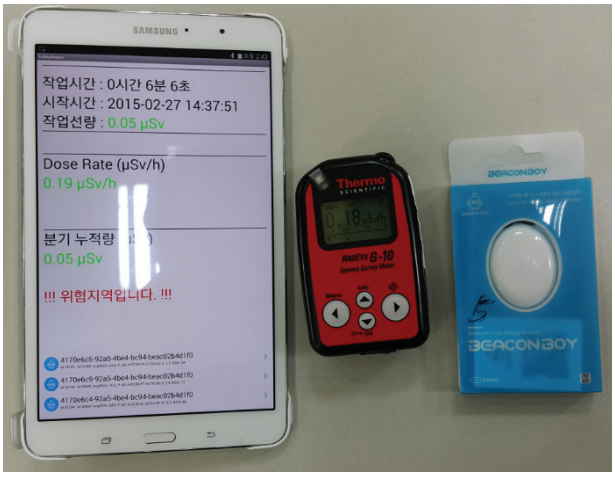

Fig. 2. Smart Phone, survey meter and beacon.

dose monitoring system are a smart phone, Beacon and a radiation survey meter. In addition, the data communication between the components uses Wifi or commercial mobile communications, for example, LTE or LTE-Advanced, Bluetooth, etc.

The information is generated during the radiation work on the survey meter module, and the beacon module automatically transfers this information to the private APP, i.e., mobile personal application program on a cellular phone in real-time at the radiation zone. In addition, it is sent back to the server administrator to accumulate the personal dose to provide a radiation protection administration. Finally, the data will be used to set the precise dose of radiation workers for proactive and reliable data management.

The mobile APP serves the radiation worker the working

Table 1. Surveymeter specifications

Items	Information
Model name	Radeye G10
Detector	Energy compensated Geiger-Muller tube
Measuring range	0.05 μSv h^{-1} ~ 100 mSv h^{-1}
Energy range	50 keV ~ 3 MeV
Sensitivity	1.7 cps per μSv h^{-1} at Cs-137 (662 keV)
Linearity error	Max. 10%

Table 2. Surveymeter communacation specification

Items	Information
RF transmission	Bluetooth V2.0 + EDR SPP profile (serial port protocol) + 4 dBm output power max. (Class 2) ~ 82 dBm receive sensitivity
Range	10 m at line of sight condition 115.2 kBd (8 data bits, no parity, 1 stop bit)
Baud rate	115.2 kBd (8 data bits, no parity, 1 stop bit)

time of a nuclear facility or a radiation zone, the start time of radiation zone, the working dose during the radiation work, the dose rate in real-time, and the quarter cumulative dose. When the worker enters the radiation area, the Beacon detects the smart phone carried by the individual and generates a radiation caution signal, which will be sent to the smart APP for the radiation worker to recognize as soon as entering the radiation fields. The history of entering and exiting the radiation zone can be found through the beacon module data at the server administrator (Park 2014).

The information sent to the server gives to the personal APP the real-time data when connected to a wireless communication system (3G, LTE, Wifi). The information transmitted by the administrator to monitor the real-time radiation exposure of workers can be noticed. From the operation information, the dose collected quarterly can be calculated.

The radiation workers at a nuclear facility or a radiation field should hold personal dosimeters such as a film badge, a TLD, and an OSL on their body which has no alarm function but is to be traceable as mandated by law.

In addition, they use survey meters or pocket ionization chamber dosimeters, and an EPD as an alarm dosimeter. Some of them have functions to generate audible or visible alarms to radiation workers in a real working area. However, ordinary commercial survey meters have no functions to communicate with other systems in real time.

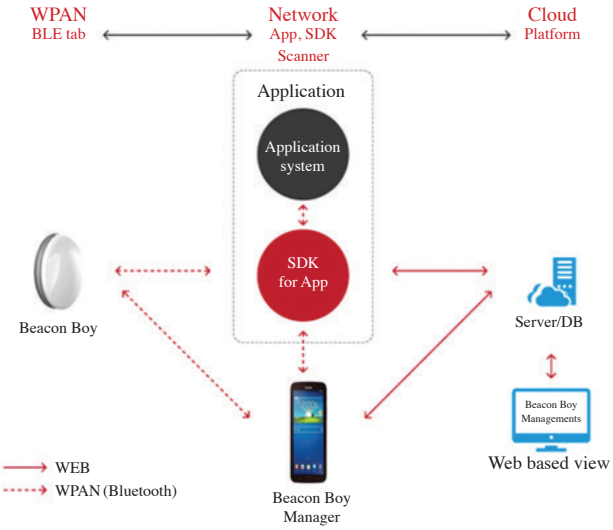

Fig. 3. The example of beacon communication.

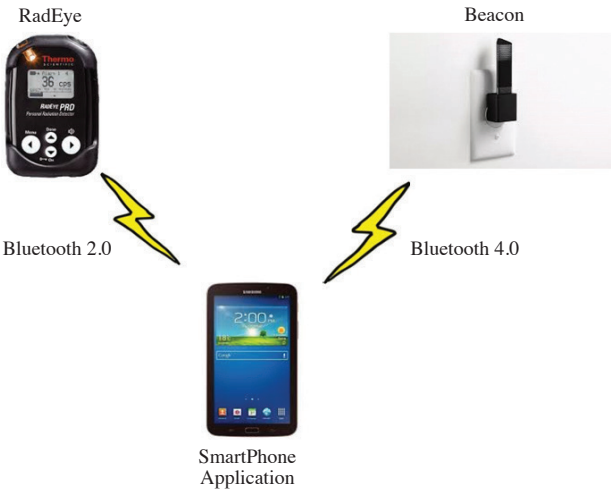

Fig. 4. The communication between smart phone and survey meter, beacon.

In this project, we chose the Geiger-Muller survey meter which has the function of RF transmission to communicate with a smart phone and Beacon. The detailed information of the survey meter is described in Tables 1 and 2.

A Beacon is an intentionally conspicuous information technology device designed to attract attention to a specific location (Adamu and Muazu 2014). Beacons can also be combined with other indicators to provide important information, such as the status of a specific facility, by the color and rotational pattern of its airport beacon. When used in such a fashion, beacons can be considered a form of optical telegraphy. In wireless networks, a beacon is a type of frame that is sent by the access point (or wifi router), to

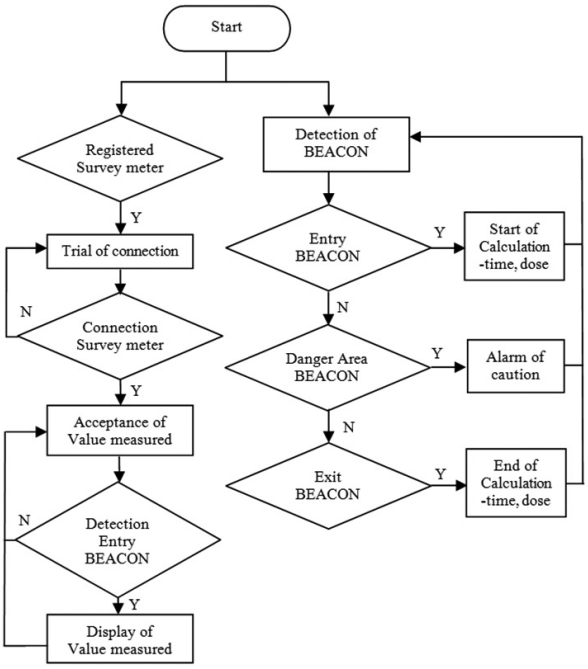

Fig. 5. The flow chart of remote wireless radiation dose monitoring system.

indicate that it is on. In this project, a Beacon is used for the wireless starter for the detection, communication, and position of the worker using BLE (Bluetooth Low Energy). Fig. 3 shows an example of an ordinary beacon communication using Bluetooth (Foss 1991; Im *et al*. 2008).

Bluetooth is a wireless technology used to transfer data between different electronic devices. The distance of the data transmission is small in comparison to other modes of wireless communication (Adatkar *et al*. 2015). This technology eradicates the use of cords, cables, and adapters, and permits the electronic devices to communicate wirelessly with each other. The aim of Bluetooth technology was to enable users to replace cables between devices such as printers, fax machines, desktop computers and peripherals, and a host of other digital devices. The technology was intended to be placed in a low cost module that can be easily incorporated into electronic devices of all sorts. Bluetooth uses the license free Industrial, Scientific and Medical (ISM) frequency band for its radio signals and enables communication to be established between devices up to a maximum distance of around 100 meters, although much shorter distances were more normal. In this project, the major use was for wirelessly connecting a survey meter and Beacon for smart phones, allowing radiation work to use the APP (application program) of smart cellular phone.

The interface between the smart phone and beacon is Bluetooth 4.0. However, The interface between the smart phone and survey meter is Bluetooth 2.0 because the specifications of the survey meter (Radeye) are old compared to those of the beacon. Sooner or later, we can anticipate that the Bluetooth version of the survey meter or personal dosimeter will be up-graded.

RESULTS

The smart phone receives information of the measurement of the survey meter (RadEye) and location information received from the beacon device from the result of the communication. In addition, the screen of the smart phone displays the received information for the user to recognize easily and quickly, for example, the dose, dose rate during the operation, and the total working time (Chen *et al*. 2013).

Each beacon has a unique ID (Address), and the installation place of the beacon in a given management area such as the entrance, middle area, and exit of the radiation zone can generate different management information such as an event signal and precautions to radiation workers through a smart phone. In addition, it is possible for the radiation protection manager to identify the radiation worker and the position information sent to the server through a smart phone by using the beacon reception intensity. When the radiation workers enter the radiation entry zone, the signal of "Entry into the workplace" and the radiation measurement information can be noticed from their smart phone. In addition, when they enter the radiation zone, the signal of "danger zone approach" is displayed for the attention to the radiation exposure to them. In addition, when they come out from the radiation zone after radiation work, the signal of "gone out from radiation zone" is indicated and the measurement information in the radiation area is updated and sent to the server computer.

From the APP (application program) of a smart phone or tablet PC, radiation workers and the radiation manager can confirm the radiation measurement information such as the dose and dose rate, and status information of the survey meter (RadEye) by real-time transmission. Simultaneously, the information obtained from the beacon and the survey meter (RadEye) in real-time can be sent to the radiation worker and the server of the radiation safety team, which can be used for a radiation safety program.

DISCUSSION

These days, smart phones and tablet PCs are so common to people that the Internet of things (IoT) technology has recently shown a large flow of IT trends. In addition, the usage of a smart phone will be greater than we expect in the future. Thus, in this project, we integrate a smart phone with a radiation survey meter and beacon using Bluetooth to combine radiation dosimetry with IoT technology. Although we use a beacon for position detection and an announcement as IT equipment, there are many types of IT equipment that have been recently developed, and other equipment can be utilized depending on the circumstance (Park 2014).

CONCLUSION

In this project, a radiation surveymeter is a detection device for a personal radiation dose, a smart phone is the mobile wireless communication tool, and Beacon is the wireless starter for the detection, communication, and position of the worker using BLE (Bluetooth Low Energy) to make the personal wireless radiation monitoring system. And, the interconnection of radiation dosimetry and IoT technology is possible in the real time and place from our project.

This technology based on IoT (Internet of things) can be applied to the real radiation fields and a nuclear facility for a radiation protection program. In addition, we can confirm that the new wireless radiation monitoring method and technique will follow up with the development of mobile smart IT technology.

ACKNOWLEDGMENT

This work was performed by the supporting program of small and medium-sized enterprises (program No.: 79636-14) and financially supported by a grant from Korea Atomic Energy Research Institute (grant No.: 523260-16).

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Received: 10 June 2016
Revised: 13 July 2016
Revision accepted: 1 August 2016