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MATERIAL TRACKER FOR CONSTRUCTION LOGISTICS

Jae-Hong Song, Nam-Su Lee
Dept. of Civil, Architectural,
and Environmental System Engineering
Sungkyunkwan Univ.
Suwon 400-746, S. Korea
{jaysong0828, hisoo17}@naver.com

Su-Won Yoon, Soon-Wook Kwon
Sangyoon Chin, Yea-Sang Kim
Dept. of Civil, Architectural,
and Environmental System Engineering
Sungkyunkwan Univ.
Suwon 400-746, S. Korea
{yoonsuwon, swkwon ,schin,Yskim2}
@skku.edu

ABSTRACT

It is necessary to manage materials (including prefabricated components) and identify their data communication process by collecting relevant information in real time for effective and efficient material management in construction projects. Recently, there have been many studies and developments using various wireless technologies including Radio Frequency Identification (RFID) for acquiring material information in real time in the construction industry.

However, since existing research project and developments on the application of RFID technology have focused on identification of material and monitoring its logistics by only using RFID technology, they have limitations on identifying material moving flow in logistics and tracking location in an accurate manner.

Therefore, the objective of this research is to develop a system that can identify logistics flow and location of construction materials with better performance by using RFID and wireless sensor networks such as Zigbee technologies. The system developed in this research is named as material tracker (MT), and its technical feasibility was verified through a lab test comparing with the existing tracking method using RFID technology only.

KEYWORDS

Material management, Logistics, RFID(Radio Frequency Identification),WSN (Wireless Sensor Network)

1. INTRODUCTION

The construction logistics is one of the significant management factors in order to proceed construction project. If materials which are needed in construction project do not supply in right place on time, it can make problems such as delaying schedule, increasing the cost of construction and reducing productivity. The identification of material, identifying materials moving flow in logistics and tracking materials location are needed for successful project management in construction.

Recently, many studies using Radio Frequency Identification (RFID) with specific materials such as concrete, structural steel works, finishing material, curtain walls, etc have tried for the collecting data of materials in real time and effective management. [2], [3], [5]

Furthermore, the study, the track of construction vehicle and location of workers, has been processed with GPS for location tracking and monitoring. In addition, the study, the location tracking of equipment, machinery, materials and other resources with RFID technology, has been tried. [1], [4], [5]

However, since existing research and developments on the application of RFID technology have focused on identification of

material. [2],[5]. In addition, identification of material with RFID technology is performed by human power. For that reason, not only are human power and time spent, but many errors are also occurred. And, there are some limitations such as installation of equipments, recognition in the shade, economical efficiency (high priced equipments) and management of supplying power (amounts of power consumption) due to the conditions of construction site such as vibrations and dust when using GPS for tracking location of materials.

This study considers WSN (Wireless Sensor Network) technology to overcome some limitations which are mentioned above.

WSN is a technique which can transfer automatically collected data by wireless in real time.There are the varieties of WSN technology such as Bluetooth, UWB and Zigbee. In particular, Zigbee, which is small, low price and low power consumption, does not need light-of-sight between nodes. And, it is possible to monitor tracking location of data through the specific ID of Zigbee.

Therefore, the first purpose of this study is to develop Material Tracker (MT) based on RFID and Zigbee technology for identification of materials, identifying its moving flow in logistics and tracking its location. And, its technical feasibility was verified through pilot test.

2. MATERIAL TRACKER

2.1 The Function of MT

The study is to develop Material Tracker (MT) in order to automate collecting data in materials, identify materials moving flow in logistics and manage tracking location based on RFID and Zigbee technology.

Developed MT recognizes the data of materials such as bulk and bundle type which is loading through RFID reader installed on MT and can check the flow and location of materials within the management of logistics through Zigbee in real time

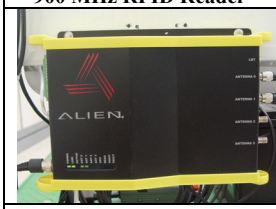
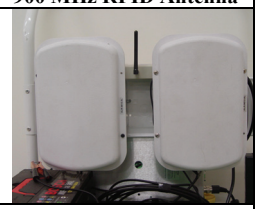
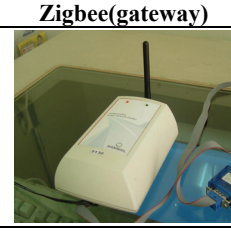
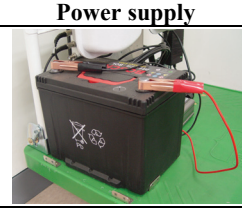
2.2 Components of MT

Material Tracker (MT) is consist of RFID reader which is in order to recognize RFID tag of loading materials, RFID antenna, Zigbee (sink node) which is for transmitting recognized data of materials to server, and power supply.

And, there are not only Zigbee, sensor node, has the data of location, but also Zigbee, gateway, receives the data of MT and then transfer it to server. Each function of equipments is as shown table 1

Figure 1 Material Tracker (MT)

Table 1 Details of the Function of Equipment

900 MHz RFID Reader	**900 MHz RFID Antenna**
	
function : Interrogating an RFID tag	function : Emitting radio waves
Zigbee(sink node)	**Zigbee(gateway)**
	
function : Passing data (Zigbee ID and Tag ID) to a gateway from sensor nodes	function : Receiving data (Zigbee ID and Tag ID) from a sink node
Zigbee(sensor node)	**Power supply**
	
function : Transmitting Zigbee ID to a sink node	function : Supplying power to each part of MT

2.3 Data Communication Architecture of MT

The structure of data for recognizing materials of MT and tracking location is as shown in figure 2. And following is explanation of data communication architecture of MT.

1) The data of materials attached RFID tag recognizes automatically through RFID reader which is installed on MT.
2) Zigbee(sink node) of MT receives the data of location from external Zigbee(sensor node) having the data of location and communication facilities.
3) Collected data of materials through RFID and location data by Zigbee is not only transferred to server throughout sink node of MT, but also monitored.

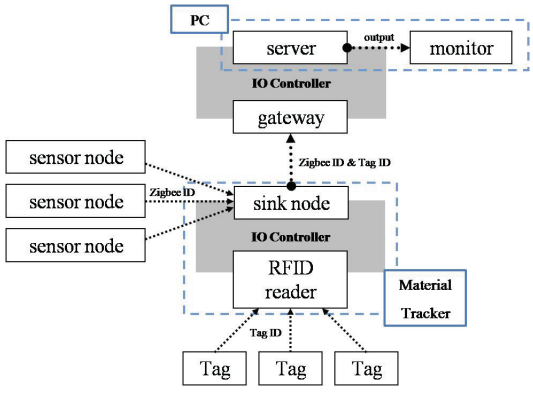


Figure 2 Data Communication Architecture

3. PILOT TEST

In this study, MT prototype based on the RFID technology and Zigbee has been developed. Moreover, technical feasibility of MT has been examined with pilot test.

The experimental set up and the results are as follows.

3.1 Overview of the Scenario for the Pilot Test

The variations of tracking location depended on the movement of MT and the function of recognizing location of MT located in a planned storage area have tested.

3.1.1 Test 1 (location tracking)

Test 1 is performed to examine the possibility of tracking location in moving MT. it is tested in office building due to the limitation of arrangement in construction site.

1) Sensor nodes, which have the data of location, are set up on the first floor to fourth floor and main gate of office building as shown in figure 3.
2) After carrying MT with material boxes attached RFID tags in building, MT has to be moved in each area.
3) Loaded material data of MT and location data of moving MT are monitoring throughout server.

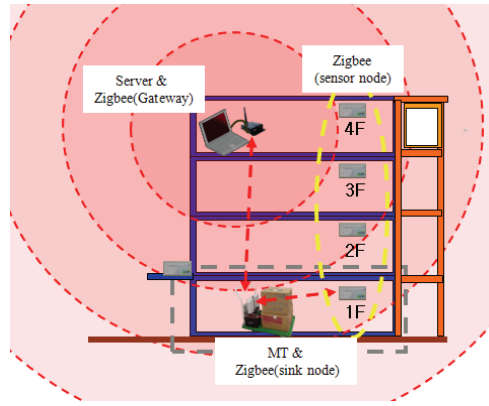


Figure 3 Test 1 Scenario

The status of installing sensor is as shown in figure 4.

Figure 4 Installation of Equipment

3.1.2 Test 2 (location recognizing)

Field test is performed in order to examine the localization of boxed materials in planned zones of the field by communication range of Zigbee nodes.

1) The communication range of the distance between each sensor node is set up as 30m. Thus, the distance between sensor nodes are increased to 80m in order to avoid the duplication of range, which is as shown in figure 5.
2) The sensing data of boxed material of MT and the sensing data of MT location in each zone are monitored throughout server.
3) The optimum distance for data communication is measured by moving MT within the communication range of Zigbee node which is set up in each area.

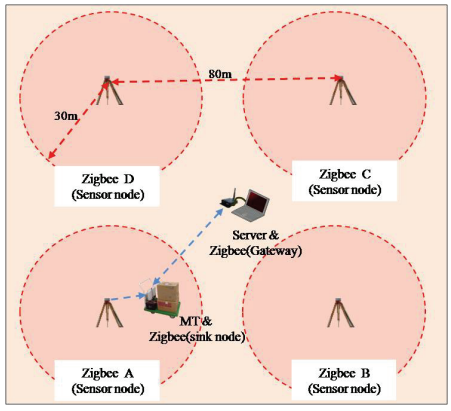


Figure 5 Test 2 Scenario

The status of installing main equipment is as shown in figure 6.

Figure 6 Installation of Equipment

3.2 Results and Analysis

The test results according to the experimental plans are as follows.

3.2.1 Test 1

Test 1 was performed five times over in total. As a result of test, when MT passed through the communication range of sensor nodes which are set up on on each floor, it was possible to recognize an accurate data of materials and location of MT through output data from server.

Output data of material and location of MT through the monitor of server is as shown in figure 7.

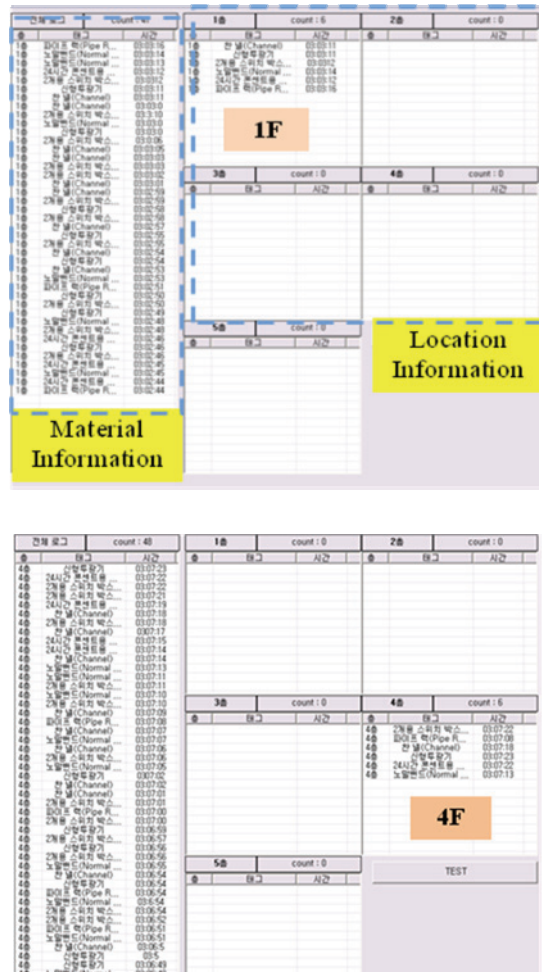


Figure 7 Data Collection

3.2.2 Test 2

Test 2 was performed five times over outside in total. As a result of test, the available commutation range between each sensor node and sink node of MT is as shown in table 2. In addition, the error in the communication range of the fixed sensor node is within less than 5m, which might be due to the environmental factors such as temperature and humidity.

Table 2 Result of Reading Range

	Case 1	Case 2	Case 3	Case 4	Case 5	Ave.
sensor node A	23m	28m	22m	26m	27m	25.2m
sensor node B	26m	26m	23m	27m	27m	25.8m
sensor node C	21m	24m	23m	24m	26m	23.6m
sensor node D	28m	29m	27m	29m	25m	27.6m

4. CONCLUSION

This study about development of MT integrated with RFID and Zigbee technologies to collect the data of materials and to manage the material moving flows in logistics of a construction site. We then conducted pilot tests in order to analyze any technological feasibility of the MT. According to the tests conducted, it was possible to recognize the location tracking within planned range through the movement of MT as well as in the stock yard.

However, it was not possible to collect data of any location exactly through sink node due to a interference when conducting the test in the stock yard with set of communication range of sensor node. Furthermore, it is limited that RFID reader clearly scans RFID tag data of the loaded material on MT but that fact was not considered to this test.

In the future in order to apply this automated tracking system to an actual construction project, it is necessary to find out ways to scan the data of materials completely using RFID reader.

Moreover, there is a need for finding out problems due to communication interference between Zigbee nodes. It is important to perform the test to check exact recognition range for tracking materials, which is able to improve to the efficiency of logistics management.

5. REFERENCES

[1] Navon, R. (2005), “Automated project performance control of construction projects”, Automation in Construction

[2] S. Chin (2005), "An RFID-Based Supply Chain Management System for Curtain Walls", CITC-III "Advancing Engineering, Management and Technology" 15-17, September 2005, Athens

[3] E. J. Jaselskis, T. EI-Misalami (2003), "Implementing Radio Frequency Identification in the Construction Process" Journal of Construction Engineering and Management, ASCE, 129(6)

[4] Ming Lu, Wu Chen, Xuesong Shen, Hoi-Ching Lam, Jianye Liu (2007), “Positioning and tracking construction vehicles in highly dense urban areas and building construction sites”, Automation in Construction

[5] J. Song, C. T. Hass, C. Caldas, E. Ergen, B. Akinci (2006), "Automating the task of tracking the delivery and receipt of fabricated pipe spools in industrial projects", Automation in Construction

[6] P. M. Goodrum, M. A. McLaren, A. Durfee (2005), "The application of active radio frequency identification technology for tool tracking on construction job sites", Automation in Construction.