International Journal of Advancements in Electronics & Electrical Engineering– IJAEEE 2018
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Volume 6 : Issue 2 [ISSN : 2319-7498] - Publication Date: 25 June , 2018

Design and Implementation of Private LoRa(Long Range) Remote Control System for Smart Farm

Hak-Hui Choi, Hong-Keu Jo, Jae-Min Lee, Dong-Seong Kim*

***Abstract*— This paper proposes a remote control system for managing Smart Farm using LoRa(Long range) which is one of the wireless communication technology with low energy and long range. While an existing LoRa communication service can occur the security problem caused by saving user's information on a server belong to tele-communication company. And this service generates a lot of fee consistently, if a lot of communication devices are in system. To solve these problems, in this paper a private remote control system based on LoRa and 3G communication technology is proposed to manage greenhouse in real-time for privatizing information from the system and reducing maintenance expense. Also with LoRa network's performance test on LOS(Line of Sight) and NLOS(Non Line of Sight) conditions, the optimal solution is provided depending on greenhouse's environment.**

***Keywords*—Smart Farm, LOS(Line of Sight), NLOS(None Line of Sight), LoRa(Long Range), IoT(Internet of Things).**

I. Introduction

Smart Farm is an intelligent farm based on info-communication technology and automation equipment for increasing amount of harvest and improving work environment's condition. Data gathered in greenhouse such like temperature, humidity, amount of sunshine and carbon dioxide is processed on greenhouse administration system. And then with this data, greenhouse administration system operates ventilating opening and sprinkler to make suitable environment for plants[1].

In this paper, to constitute smart farm we design a remote control system for managing smart farm using LoRa(Long Range) and 3G networks. And with LoRa network's performance test on LOS(Line of Sight) and NLOS(Non Line of Sight) conditions, the optimal solution is provided.

After session 1, this paper is written in the following order. In session 2, we analyze what is the problem to constitute smart farm with commercial LoRa. After that proposed system model is explained in session 3. Made testbed is showed in session 4, and finally we talk about conclusions and future works.

II. Problems Analysis

With evolving information and communication technology such like the smart farm, IoT(Internet of Things) market's scale is increasing nowadays. Figure 1 is a commercial IoT platform of a tele-communication company.

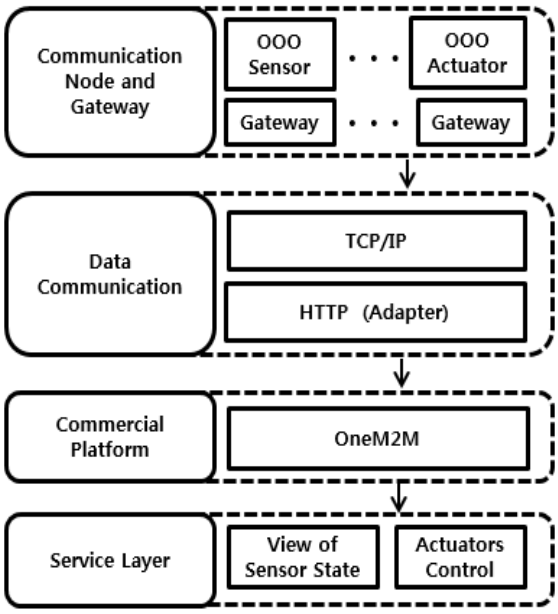

Figure 1. Diagram of Commercial IoT Platform.

On first layer, sensors make data to detect some events in greenhouse and actuators are driven with user's control. On second and third layers transfer and process the data which come from first layer. Lastly, information made with the data are served to user on forth layer. To preoccupy the IoT market, a tele-communication company constructs IoT network using LoRa, one of wireless communication technologies and provides services through this networks.

However, there are serious problems, to compose smart farm with commercialized LoRa networks. First, Every data from users' communication devices belongs to tele-communication company which provide the service to users. It means that the data produced by users' devices is progressed on the company and information from the data is

Hak-Hui Choi
Dept of Electronic Engineering, Kumoh National Institute of Technology
Gumi-City, South Korea

Hong-Keu Jo
Dept of Electronic Engineering, Kumoh National Institute of Technology
Gumi-City, South Korea

Jae-Min Lee
Dept of Electronic Engineering, Kumoh National Institute of Technology
Gumi-City, South Korea

Dong-Seong Kim*
Dept of Electronic Engineering, Kumoh National Institute of Technology
Gumi-City, South Korea

shared with them. In terms of commerce competition with other farms, it is fatal to smart farm's users. The other problem of using commercialized LoRa networks is too expensive to maintain a lot of communication node. Each price of the service is different, but more sensitive and powerful smart farm for providing suitable environment to plants means that it has a lot of sensor, actuator and communication nodes. To realize the smart farm with reasonable price, a new structure or platform considered the problems is needed.

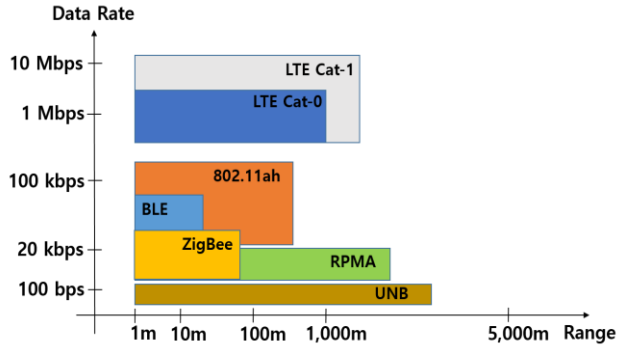

Figure 2. Range and Data Rate of Each Wireless Communication Technology.

The Figure 2 shows that each wireless communication technology's range and data rate[2]. On LOS condition, it has 21km communication range in maximum without any repeater, system algorithm or access points. As a result, the network topology is simple and the cost of constituting smart farm system is cheap[1][3]. There are powerful competitors, for example LTE Cat, NB-IoT. But LoRa wireless communication technology using 920MHz non-licensed band has advantages that everyone can construct networks liberally. Even it has possibility to be infringed by Ubiquitous Sensor Network or Radio Frequency Identification.

III. Smart Farm System using Private LoRa Networks

To overcome such these problems, we propose the smart farm system using private LoRa networks. The Figure 3 is a structure of smart farm applied LoRa wireless communication networks.

Greenhouse integration management system collects environment information what conditions are suitable to raise up plants. And then greenhouse administration system uses database composed of the information to set the greenhouse's environment. Depending on the kind of crop, the setting of greenhouse condition is adjusted by user's opinions which come from their experience. The greenhouse administration system transmits the setting to a greenhouse integration controller to handle actuator. On the other hand, sensors in greenhouse gather data such like temperature, humidity and inform it to the greenhouse integration controller and the greenhouse administration system step by step to analyze the data.

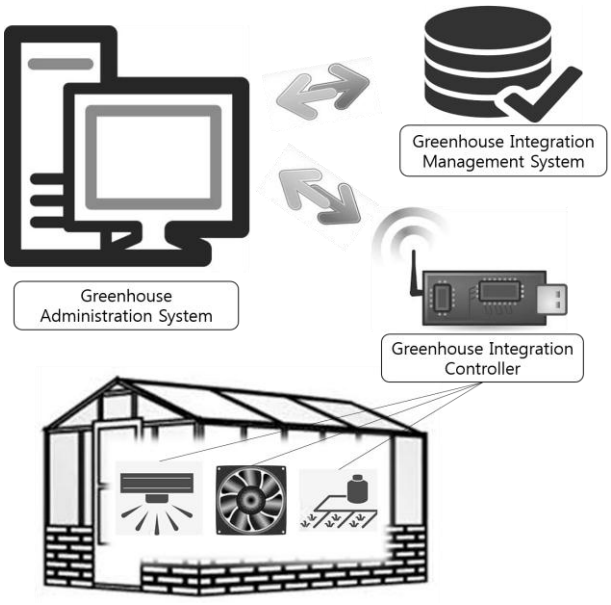

Figure 3. Structure of Smart Farm System.

In this paper, LoRa wireless communication technology is applied between the greenhouse administration system and the greenhouse integration controller to overcome a distance between them. One of the LoRa wireless communication's profit, simple topology is suitable to comprise the wireless communication part[4]. Figure 4 is a diagram of designed LoRa networks in this paper.

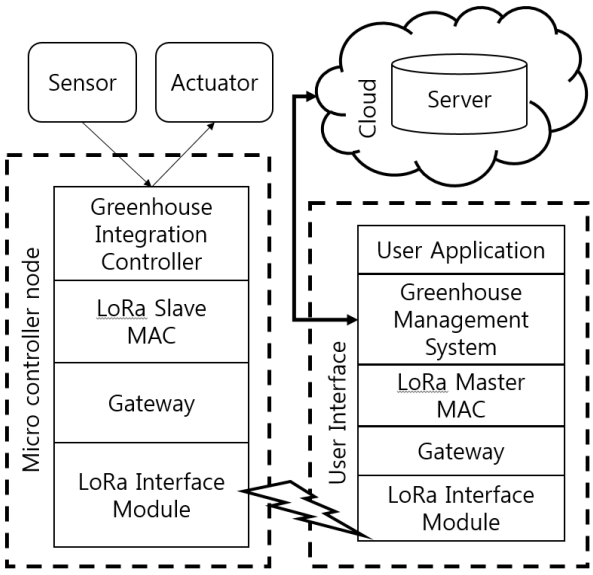

Figure 4. Block Diagram of Proposed Smart Farm System.

LoRa devices have 64bits MAC address and device address which consist of 8 bits network ID and 24 bits network address to distinguish each LoRa networks and devices on the service. And it has mobility for user with server.

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IV. Testbed of Smart Farm System

To analyze performance of private LoRa remote system on diverse environments, making testbed is progressed on. Figure 5 is testbed components of smart farm system.

Figure 5. Testbed Components of Smart Farm System.

There are boards and modules including LoRa or 3G wireless communication module implemented on raspberry pi's shield and extra antenna modules to serve stable data transmission and diverse functions to users. Also we add bluetooth module on sensor boards to check data in short time. By including communicating function in sensor nodes without greenhouse integration controller, this smart farm network has hierarchical diversity architecturally to get data directly from sensor nodes[5].

To manage sensor module with two AA size batteries, ultra-low energy consumption micro controller one kind of STM32L family is used in sensor modules. A server and sensor modules are prepared to test on and software developing for sensor module's are progressed on to add more diverse functions.

In application layer, SQLite3 open library is used to collect sensor values to save on database. Figure 5 shows Client UI(User Interface) transmitting data and server UI receiving and showing the data to users. The client application includes listviews and slider controls to show sensor's data and control actuators on optimized environment. And server application shows receiving data on console. In the data packet from sensors, there are node ID, device ID and value. Otherwise, data packets transferred to actuators include some value edited by slider control to drive actuators.

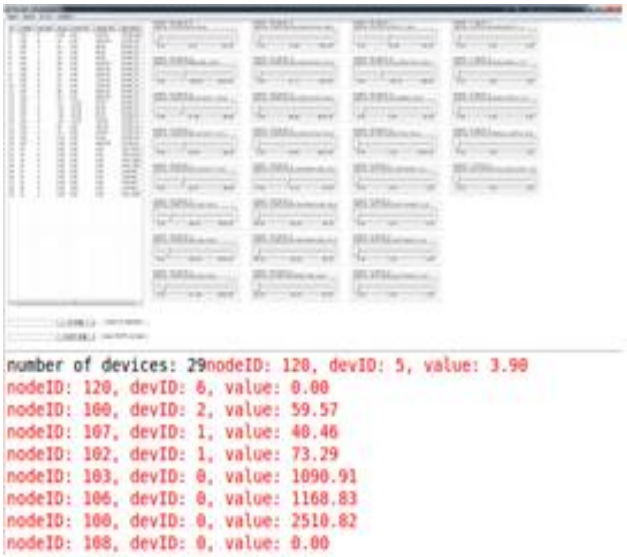

Figure 5. Server and Client Application for Smart Farm.

V. Conclusions and Future Works

This paper proposes a remote control system for managing Smart Farm using LoRa which is one of the wireless communication technology with low energy and long range. With the testbed using LoRa combined with 3G network modules, making the performance analyze environment is progressed on in LOS and NLOS. In the future, we will provide suitable solution for each environment for smart farm with the performance analyze with LoRa and 3G wireless communication networks. Furthermore, we will try to apply the system on other applications.

Acknowledgment

This research was financially supported by National Research Foundation of Korea (NRF) through the Human Resource Training Project for Regional Innovation 2015 (NO. NRF-2015H1C1A1035971), the MSIP(Ministry of Science, ICT and Future Planning), Korea, under the "Creative ICT Convergence Human Resource Development Program" (NO. IITP-2017-H8601-15-1011) support program supervised by the IITP(Institute for Information and communications Technology Promotion) and BK21+ Project in Kumoh National Institute of Technology.

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He is a Master student at IT Convergence Department, Kumoh National Institute of Technology, South Korea. His research interests are wireless sensor networks and embedded systems.

He is a Master student at IT Convergence Department, Kumoh National Institute of Technology, South Korea. His research interests are wireless sensor networks, virtualization and embedded systems.

Dong-Seong Kim received his Ph.D. degree in Electrical and Computer Engineering from the Seoul National University, Seoul, Korea, in 2003. From 1994 to 2003, he worked as a full-time researcher in ERC-ACI at Seoul National University, Seoul, Korea. From March 2003 to February 2005, he worked as a postdoctoral researcher at the Wireless Network Laboratory in the School of Electrical and Computer Engineering at Cornell University, NY. He is currently a director of kit Convergence Research Institute and ICT Convergence Research Center supported by Korean government at Kumoh National Institute of Technology. He is IEEE and ACM senior member. His current main research interests are industrial wireless control network, networked embedded system and Fieldbus.

Jae-Min Lee received his Ph.D degree in in Electrical and Computer Engineering from the Seoul National University, Seoul, Korea, in 2005. From 2004 to 2016, he worked at Samsung Electronics Co., Ltd. as a researcher. He is currently a Prof. of ICT Convergence Research Center, Kumoh National Institute of Technology, South Korea. His research interests are real-time network, analysis of wireless network