Implement Smart Farm with IoT Technology

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***Abstract*— With the advent of Internet of Things (IoT) and industrialization, the development of Information Technology (IT) has led to various studies not only in industry but also in agriculture. Especially, IoT technology can overcome distance and place constraints of wired communication systems used in existing farms, and can expect agricultural IT development from automation of agricultural data collection. In this paper, smart farm system using low power Bluetooth and Low Power Wide Area Networks (LPWAN) communication modules including the wired communication network used in the existing farm was constructed. In addition, the system implements the monitoring and control functions using the MQ Telemetry Transport (MQTT) communication method, which is an IoT dedicated protocol, thereby enhancing the possibility of development of agricultural IoT.**

***Keywords*— Internet of things, Smart farm, Smart agriculture, Sensor network, Wireless communication.**

I. INTRODUCTION

In accordance with industrialization, the application of automation technology to agriculture is attempting from the necessity of mass production of food. Agricultural automation began with information technology and the collection of crop growth. The data collection requires a sensor to collect environmental and growth data and a server to store the data, and the farmer adjusts the environment and cultivates plants based on the collected data [1]. Since the current smart farm has evolved based on the greenhouse environment, the farmer's environment can be controlled from the control of devices such as fans, heaters and air conditioners installed in the greenhouse. However, most of the smart farm systems so far have difficulties in installing additional devices as wired communication systems, and environmental sensing and control are confined to the greenhouse range. Wired communication systems have limitations in distance and location [2, 3], so sensors cannot be installed in large areas of arcs, mountains, sea, or animals in the housing. [4]

We want to improve the scalability and usability of the new smart farm system by overcoming the problem of application limitations of wired devices in agriculture by using wireless communication module. However, since the current technology level of the wireless communication system suffers from a power shortage problem, the development of the low power wireless communication module is being activated, and with the development of the battery technology, the change speed from the wired system to the wireless system is accelerating [6]. In the transition period of wired and wireless communication in agriculture, this paper implements sensor monitoring and control functions as using low power Bluetooth and LPWAN communication modules as well as existing wired communication method based on Arduino, and uses MQTT communication protocol which is a dedicated IoT [5]. Since this system is a merged structure of existing method and new technology, it is anticipated that it will be possible to save maintenance cost of existing devices and to provide compatibility with new devices.

The rest of this paper is organized as follows. Section II introduces system construction. Section III shows the results and future work. This paper is concluded in section IV.

II. SYSTEM CONSTRUCTION

The overall structure of the system consists of nodes, gateways, servers, databases, and smartphones as system accessors. Figure 1 shows the physical structure of smart farm system.

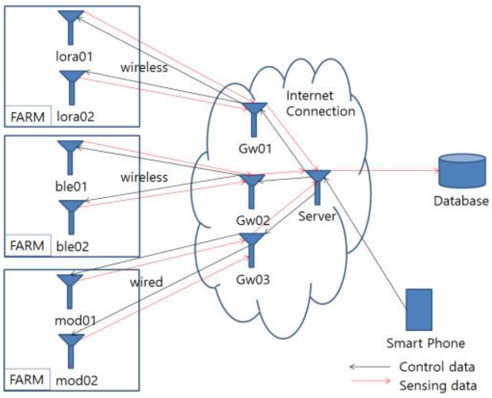

Figure 1. The physical structure of smart farm system.

The nodes are classified into LPWAN, Bluetooth, and RS485 communication, and the environmental data collected through the sensors on the node in the farm are transmitted to the gateway through each communication network. The sensors used are temperature, humidity and carbon dioxide measurement sensors, and the sensing data is transmitted in real time. The gateways responsible for each communication network are connected to the Internet and relay the communication between the server and the nodes. And, since the message protocol between the server and the gateway uses

MQTT, it is easy to construct additional gateways or servers, and connection with service accessors is possible only by IP address. Therefore, the server collects sensing data in real time through each communication network and records it in the database or transmits the command of the service accessor to the gateway.

A. Hardware Design

Figure 2 shows the hardware configuration for each network. All systems are equipped with sensors and communication modules based on Arduino, and consist of two sensor nodes and one gateway. All gateways have a wireless Internet module, which enables MQTT communication based on IP with the Server.

The communication module used in the LPWAN communication network is a low-power and high-efficiency radio frequency communication module compliant with the IEEE802.15.4e standard. It supports the IPv6 address system in the UDP-based communication environment and has a communication distance of up to 10km at 900MHz [7].

The communication module used in the Bluetooth communication network conforms to the V4.0 standard and has a maximum communication distance of 100m in the 2.4GHz frequency band. Nowadays, Bluetooth has interoperability with all smart phones, enabling direct communication with each node as well as through the server, enabling sensor communication and device control at close range [8].

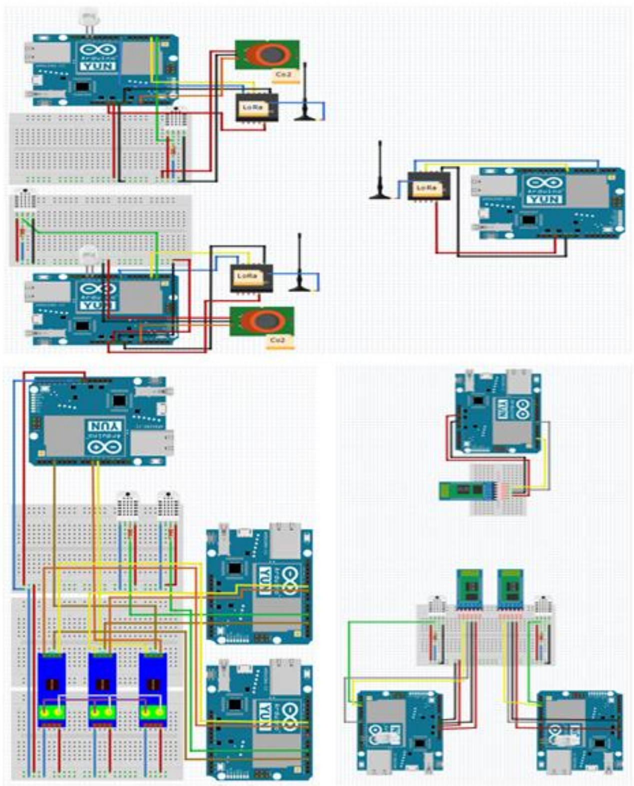

Figure 2. The sensor communication system implementation.

RS485, which is used as a wired communication network, is used as a serial communication module used in most wired equipment installed in a greenhouse to implement a hybrid wired / wireless system. There is no limit to the additional installation of the device, communication is possible up to 1.2km distance, and it is used in many industries because of its low price [9].

B. Message Design

Figure 3 shows the overall structure of the message delivery path through MQTT. Every node has its own physical network, but each network converges to its own gateway, which is connected to broker as a server. The reason for this centralized structure is that an external user can access the broker through the Internet, such as a smartphone, a tablet, and a PC, and control all the nodes through the broker. Therefore, each gateway and broker acts as an IoT hub that connects the database, external access, and end node as a platform of communication network. We implemented this platform using MQTT. MQTT is a lightweight messaging protocol that enables asynchronous communication of devices with limited resources [10]. The MQTT consists of a broker acting as a server and one or more clients. The message delivery model is a publish / subscribe structure. The publisher and subscriber are distinguished by topic and determined by the send / receive role.

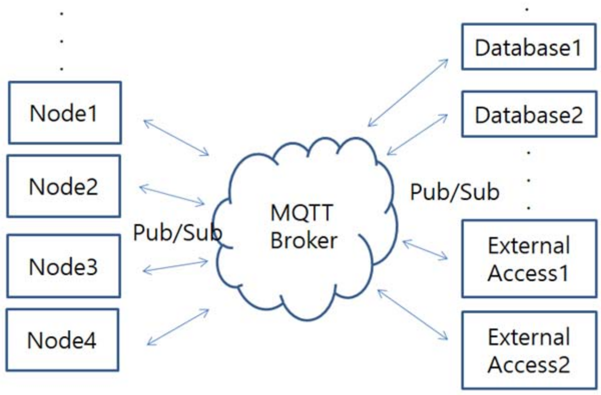

Figure 3. The communication connection of system.

The publisher / subscriber structure of this system depends on the topic which depends on the sensing message and the control message. Figure 4 shows the topic structure of the tree structure. When specifying publisher / subscriber between each node and external device or database, it indicates the order of target specification to be specified in the message. The main topics used in this system are sensing data and control messages. Sensing data is a message periodically transmitted from node to gateway and from gateway to server. The gateway publishes the message to the server, and the server composes a relationship of subscribing the gateway. On the other hand, since the control data transmits the message received by the server from the external terminal end to the gateway, the gateway subscribes the server and the server subscribes the terminal end. As shown in Figure 4, it has the form of gate address / node address / sensor or actuator according to the order of the tree in order to specify concrete target according to the topic, and then the actual intention such as ‘temp’, ‘state: on’ data was designed to follow. Figure 4 shows the message structure as an acknowledgment message for the control and sensing messages received by a node from the server.

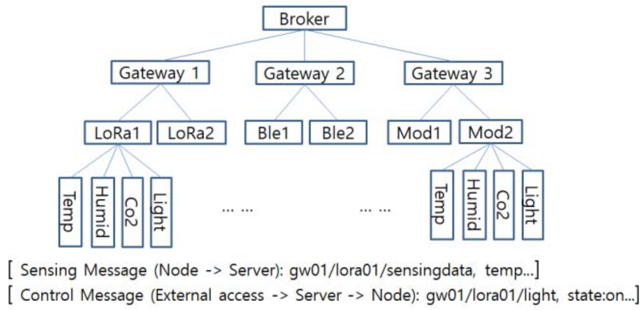

Figure 4. The communication connection tree and message structure.

Finally, we applied an alternative method to prevent bit loss caused by message transmission using wireless communication module from node to gateway. In the experiment, the original message was recovered from repeated transmission message because some bits are lost at random position in single message transmission. A total of 10 identical messages are sent, and the recipient selects the most received words for each word by cutting the message to word size. The gateway finally lists the selected words in order and delivers them to the server. Figure 5 shows how to recover from an error in the sensing data message ‘stpoint: gw01 / lora02 / sensingdata, temperature: 22, humidity: 57.3, co2: 330’.

Word separate & Counting

Send	stpoint:	10	gw01/	10	lora02/	10	sensingdata,	10	temperature:	10	22,	10	humidity:	10	57.3,	10	co2:	10	330	10
Recv	stpoint:	6	gw01/	7	lora02/	6	sensingdata,	9	temperature:	8	22,	10	humidity:	9	57.3,	8	co2:	9	330	7
	stpoint?	2	?w01/	2	lora0?/	2	sensingdata?	1	??mperature:	2			humidity?	1	?7.3,	1	co2?	1	??0	2
	??point:	1	gw01?	1	lora???	1									57.3?	1			33?	1
	???oint:	1			?ora02?	1														

Figure 5. The message recovery method with repeated transmission and work ranking.

III. Results & Future Work

Although the wireless communication network had worries about data loss compared to the wired network used in the existing farms, the implementation of this paper confirmed that the result of similar pattern was received, so that the proposed system could be used in ICT agriculture. In case of LPWAN network, it was confirmed that data can be transmitted and received at a distance of 500m outside the building when a gateway is installed in the building. LPWAN is a low power wireless transmission module that can be used not only for the smart farm implemented in this paper but also for the management system for attaching and grazing to livestock body. If data transmission / reception in km units is guaranteed in accordance with the distance in the specification, an additional relay gateway may be installed to enable long distance radio frequency control. It could also serve as a low-power module for use in pest-resistant emergency networks within the province or integrated management of local greenhouse data. And the bluetooth modules could also be used to build remote controller for farm use by using low-power long-distance modules.

In the future, the proposed system is expected to be a base system for studying the development of environmental algorithms for optimal growth of plants using cultivated environment data and plant growth data.

IV. Conclusions

The proposed system in this paper is a smart farm wired / wireless system with node - server - database and external control structure. A conclusion may review the main points of the paper. In order to solve the power problem and space limitation of the wired system, which is a limitation of the existing smart farm, we implemented a communication method using Bluetooth and LPWAN module as low power module. In addition, by applying a simple solution to the bit loss that can occur in wireless communication, the inter-module message exchange has been successfully performed and by applying a standardized message exchange method that can be applied as an existing related technical field, the possibility of expanding the technology application in the IoT field can be confirmed.

As communication between objects is expected to be the starting point for industrial automation, environmental and growth data collected from the proposed system can be expected a cornerstone for future big data agriculture and artificial intelligence agriculture.

Acknowledgment

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References

[1] I. A. Aziz, M. H. Hasan, M. J. Ismail, M. Mehat, and N. S. Haron,“Remote monitoring in agricultural greenhouse using wireless sensor and short message service (SMS),” International Journal of Engineering & Technology IJET Vol: 9 No: 9

[2] G. V. Satyanarayana, SD. Mazaruddin, "Wireless Sensor Based Remote Monitoring System for Agriculture Using ZigBee and GPS", Conference on Advances in Communications and Control System 2013

[3] A. Dhivya, J. Infanta and K. Chakrapani,“Automated Agricultural Process Using PLC and ZigBee” Journal of Artificial Intelligence, 2012.

[4] T. Chi, M. Chen, and Q. Gao, "Implementation and study of a greenhouse environment surveillance system based on wireless sensor network", The 2008 International Conference on Embedded Software and Systems Symposia (ICESS2008)

[5] Benjamin Aziz, "A Formal Model and Analysis of the MQ Telemetry Transport Protocol", International Conference on Availability and Security, 2014

[6] Uk-hyeon Yeo, In-bok Lee*, Kyeong-seok Kwon, Taehwan Ha, Se-jun Park,Rack-woo Kim, and Sang-yeon Lee, "Analysis of Research Trend and Core TechnologiesBased on ICT to Materialize Smart-farm", 2016

[7] PLNetworks, "PLM100 LoRa Module Hardware Datasheet", 2016

[8] Texas Instruments, "2.4-GHz Bluetooth low energy and Proprietary System-on-Chip", 2013

[9] Texas Instruments, "RS-422 and RS-485 Standards Overview and System Configurations", 2002

[10] http://www.embedded101.com/DevelopM2MIoTDevicesEbook/DevelopM2MIoTDevicesContent/tabid/155/ArticleId/217/3-1-MQTT-Introduction.aspx

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