New Field Server Addition Method for Low-Price Rice Cultivation Management System

Shogo Ishii
Kanazawa Institute of Technology
Engineering Department
Nonoichi-city, Japan
e-mail: b1700581@planet.kanazawa-it.ac.jp

Sota Tatsumi
Kanazawa Institute of Technology
Engineering Department
Nonoichi-city, Japan
e-mail: b1700639@planet.kanazawa-it.ac.jp

Mikiko Sode Tanaka
International College of Technology
Global Information and Management
Kanazawa, Japan
e-mail: sode@neptune.kanazawa-it.ac.jp

Yuki Okumura
Kanazawa Institute of Technology
Engineering Department
Nonoichi-city, Japan
e-mail: b1700547@planet.kanazawa-it.ac.jp

Tatsuya Kochi
Kanazawa Institute of Technology
Engineering Department
Nonoichi-city, Japan
e-mail: b1702871@planet.kanazawa-it.ac.jp

***Abstract*—We are developing a rice cultivation management systems using a field server to reduce the workload of farmers. The feature of our field server is a reasonable price. In order to achieve the reasonable price, the accuracy of time synchronization is sacrificed. At present, it is possible to manage environmental data for crops and fields using sensors. However, there are some points to be improved in the current field server. The first is transmission scheduling in advance is had to set up. The second is that field servers cannot be added during the operation. This paper describes a method to notify all nodes of additional field server information and scheduling to solve the above problem. Simultaneous transmission type flooding method is described in detail. We will also report the experimental results. This protocol is robust for the rice cultivation management systems because the field server is stable. Therefore, it meets farmers' expectation to utilize a reasonable field server.**

Keywords-LoRa; IoT; multihop; rice; time synchronization

I. INTRODUCTION

According to data from the Ministry of Agriculture, Forestry and Fisheries, the agricultural working population has decreased by about 925,000 compared 2010 with 2019 [1]. In recent years, the population of farmers has decreased in Japan, and the situation surrounding agriculture has been severe. We have developed a field server and its associated applications that can support people engaged in agriculture [2]. However, there are some points to be improved in the current field server. The first is transmission scheduling in advance is had to set up. The second is that field servers cannot be added during the operation.

Recently, simultaneous transmission type flooding technology has been proposed as a data collection technology [3]. This method can build a stable and efficient sensor network by repeating flooding without using any routing. However, this method has a problem that high-precision time synchronization is required and the apparatus becomes expensive. In Japan, a low cost field server is desired. In order to realize a low price, special elements such as crystals cannot be used, a time error occurs, and communication becomes difficult.

We are developing a rice cultivation management systems using a field server to reduce the workload of farmers. The feature of our field server is a reasonable price. In order to achieve the reasonable price, the accuracy of time synchronization is sacrificed. At present, it is possible to manage environmental data for crops and fields using sensors. However, there are some points to be improved in the current field server. The first is transmission scheduling in advance is had to set up. The second is that field servers cannot be added during the operation. This paper describes a method to notify all nodes of additional field server information and scheduling to solve the above problem using simultaneous transmission type flooding technology. The proposed method is a simultaneous transmission type flooding technology that reduces the time synchronization accuracy. We will also report the experimental results.

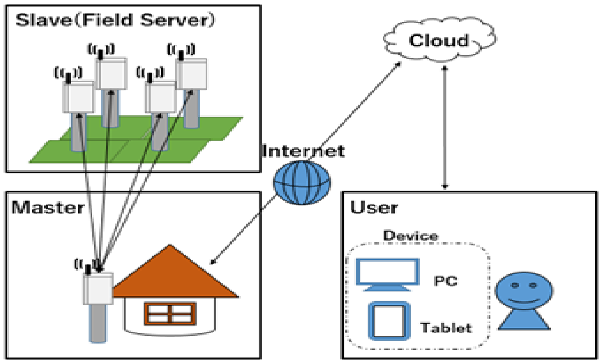

Figure 1. Rice cultivation management system.

II. Overview of Rice Cultivation Management System

The rice cultivation management system monitors the water level in rice fields. The system is composed of the field server system, master unit system, and cloud service. Figure 1 shows the overall structure of the rice cultivation management system. The field server system is installed in the rice fields and get the sensor data of water level. Further, the data is sent to the master unit system through the LoRa wireless network. The master unit system integrates the sensor data from the field server system and sends them to the cloud service through the 4G line or Wi-Fi. The water level can be checked on a mobile terminal or the like via the cloud. These services provide data to farmers to alert them about water levels, propose a suitable work plan, preserve work records etc.

Communication between the field server system and the master unit system using LoRa is capable of long-distance communication. LoRa has been found to have a practical communication distance of 3,000 to 4,000 m as shown by the basic communication characteristics survey conducted by us[2]. The rice field of Ishikawa prefecture was assumed, and the linear distance between the master unit system and the field server system was within 3,000 m. For this reason, we adopted LoRa, which enables direct communication between the field server system and master unit system.

III. Simultaneous Transmission Type Flooding Algorithm

The proposed algorithm is explained. The first one broadcasts data to its range and powers down. Each node that receives the data immediately broadcasts it and turns off the power. This is repeated until all the field servers are turned off.

Figure 2(a) and (b) shows an example of the 7 filed servers. In step 1, the master unit broadcasts data. The field server 2, 3, and 4 receive the data. In Step 2, the field server 2 broadcasts the data. Also, the field server 3 and 4 broadcast the data. The field server 5, 6, and 7 receive the data.

Simultaneous transmission type flooding method increases the number of packet transmissions compared to the routing method, but this method was adopted because all nodes need to obtain information on routing information transmission and addition of new field server.

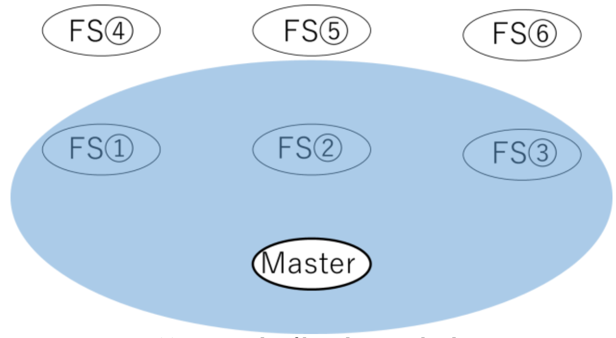

Figure 2. (a) A example of broadcasting the data in step1.

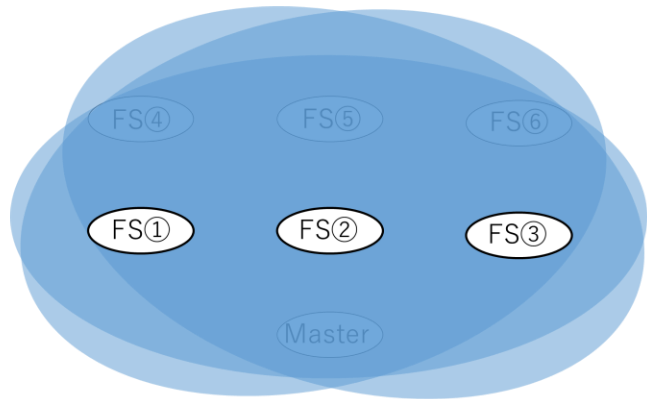

Figure 2. (b) A example of broadcasting the data in step2.

IV. New Field Server Addition Method

When adding a new field server, after turning on the power at the office and initializing, the field server is installed in the rice field. The added field server notifies the master unit of the addition in the communication slot provided at the end of the sensor data transmission time. At this time, use the simultaneous transmission type flooding method. The master unit understands the location of the added field server based on the multi-hop information of the data, performs rescheduling [4], and transmits the schedule result to all field servers using the simultaneous transmission type flooding method. Each field server receiving the new schedule result transmits the data at the time of transmitting the next sensor data according to the schedule result.

V. Experimental Results

We aim to create a low-cost field server. For this reason, the time error of the microcomputer is accepted and an expensive element such as a special crystal is not used. In the proposed method, the time is corrected once every hour when data is transmitted. The figure 3 shows the results of measuring the time error of the microcomputer we selected. The average time error is 3 seconds, the variance is 9, and the maximum error width is 7 seconds.

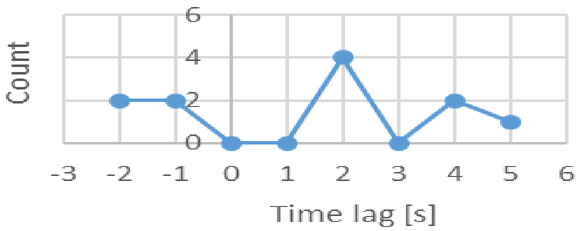

Figure 3 Microcomputer time error.

The proposed Simultaneous transmission type flooding method was tested on a low-cost field server with time error. The experiment environment was assumed to be indoors. We used without an antenna. One master unit system and six field servers were placed and the method shown in chapter 2 was operated. A self-made measuring instrument using a current sensor module called INA219 was used for current and time measurement [5]. Figure4(a) shows the self-made measurement instrument. Figure4(b) shows a field server installed in a paddy field. The transmission channel is set as shown in table 1 so that no collision occurs.

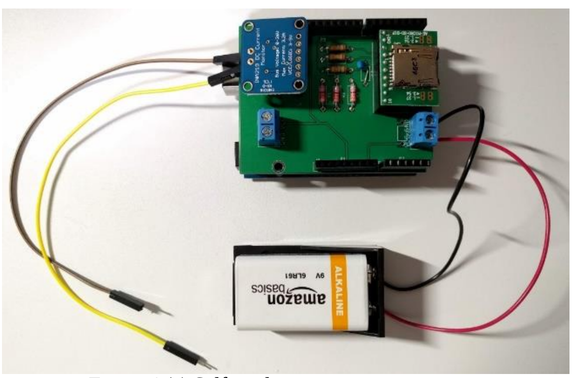

Figure 4 (a) Self-made measuring instrument.

Figure 4 (b) Field server in the rice field.

We aim to develop a low-cost field server, and sacrificed time accuracy to achieve it. An experiment was conducted in which the scheduling result was transmitted from the master unit to the filed servers. Therefore, a different delay error occurs every time, resulting in a different transmission order. Here, two representative examples are shown as experimental results, indicating that they are operating correctly.

TABLE I. FIELD SERVER CHANNEL SETTINGS

	Node number	Channel
Master Unit	1	1
FS①	2	1
FS②	3	1
FS③	4	1
FS④	5	1
FS⑤	6	1
FS⑥	7	1

First one measurement results for one round are shown in the figure 5. In step 1, the master unit transmits the scheduling information by broadcast. The field server 1, 2, and 3 receive the data and change the mode from reception mode to transmission mode. Mode change requires 10 seconds. In step 2, since there are individual differences between the field servers, in this example, the filed server 1 transmits data first. Since the transmission cannot be performed at the same time, the other filed servers wait for the transmission to end. The data sent by the field server 1 was received by the field servers 6. The field servers 6 change the mode to the reception mode. Field server 2 sends the data and field server 5 receives it. Field server 3 sends the data and field server 4 receives it. Field servers 4, 5, and 6 also transmit data. This is useless processing, but there is no way to confirm that there is no field server that has not received data. Whenever the field server receives the data, it sends the data and completes the processing.

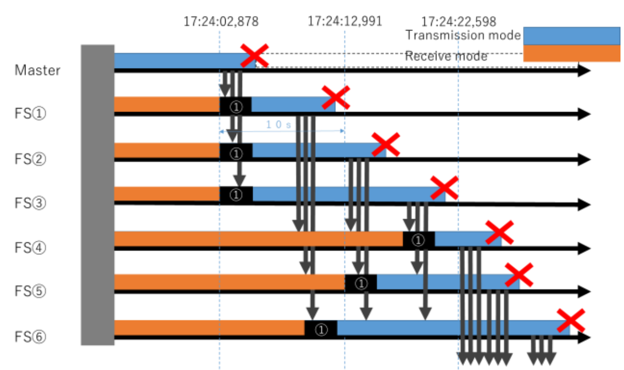

Figure 5. Measurement results for one round of example 1.

Figure 6 shows the measurement results of the current waveform during operation in Figure 5. The waveforms of the master unit and the field servers 2 and 6 are shown.

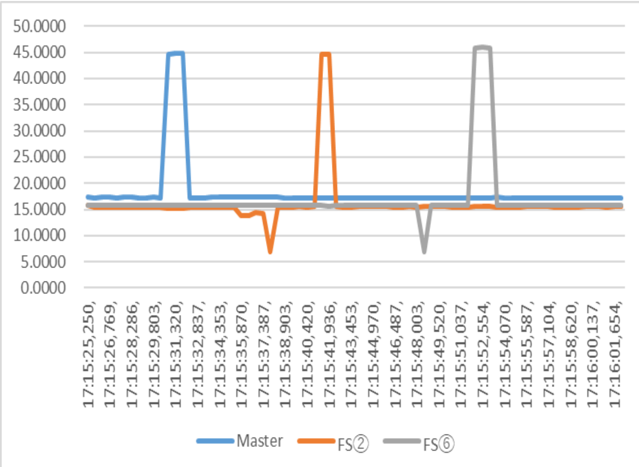

Figure 6. Current measurement results for one round.

Second measurement results for one round are shown in the figure 7. In step 1, the master unit transmits the scheduling information by broadcast. The field server 1, 2, and 3 receive the data and change the mode from reception mode to transmission mode. Mode change requires 10 seconds. In the setp2, since there are individual differences between the field servers, in this example, the filed server 1 transmits data first. Since the transmission cannot be performed at the same time, the other filed servers wait for the transmission to end. Field server 1 data could not be received by any field server. However, the field server 1 ends the processing without resending. Field server 2 sends the data and field servers 5, 6 receives it. Field servers 5 and 6 change the mode from reception mode to transmission mode. Field server 3 sends the data, field server 4 receives the data, and changes the mode from reception mode to transmission mode. Field servers 4, 5, and 6 also transmit data. This is useless processing, but there is no way to confirm that there is no field server that has not received data. Whenever the field server receives the data, it sends the data and completes the processing.

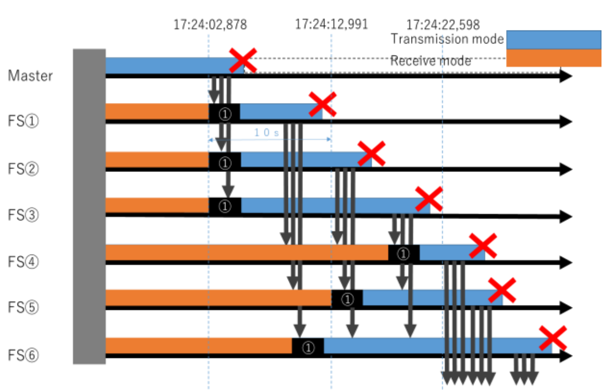

Figure 7. Measurement results for one round of example 2.

In this way, even if the field server cannot receive the data due to some influence, it can receive data from other nodes because of the redundant transmission. Therefore, it is a robust algorithm.

The disadvantage is that it takes time because all data must be sent once. However, it is an effective method because there is no need for scheduling and all field servers can receive the scheduling result.

VI. Conclusion

We proposed a new communication protocol for new field server addition, constructed a local wireless network, and conducted the experiment. In the field servers for the rice field using the LPWA technology, which require only batteries for operation, the proposed method is an important technology for the purpose of reducing the cost of field server. As a result of the experiment, We have confirmed that scheduling results can be sent to all field servers. This protocol is robust for the rice cultivation management systems because the field server is stable. Therefore, it meets farmers' expectation to utilize a reasonable field server.

Acknowledgment

This research is supported by 2018, 2019 Ishikawa commercialization promotion support project.

References

[1] Ministry of Agriculture, Forestry and Fisheries, https://www.maff.go.jp/j/tokei/sihyo/data/08.html

[2] Koichi Tanaka, Mikiko Sode, Masakatsu Nishigaki, Tadanoro Mizuno, “Time synchronization method for rice cultivation management system with IoT specialized outdoor communication procedure,” International Workshop on Informatics 2018, 2018/9/9-12.

[3] F. Ferrari, M. Zimmerling, L. Thiele, and O. Saukh, “Efficient network flooding and time synchronization with glossy,” Proc. IPSN, pp.73–84, 2011.

[4] Tatsuya Kochi, Sota Tatsumi, Yuki Okumura, Shogo Ishii, Mikiko Sode Tanaka “Experimental Results of Aggregated data communication algorithm for rice cultivation” IEEE 2nd Global Conference on Life Sciences and Technologies (LifeTech 2020) , 2020/3/10-12.

[5] Yumeto Kojima, Mikiko Sode Tanaka, “Current measuring instrument for field management field server using LoRa ,” 2018 IEICE Society Conference, 2018/9/11-14.