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Quasi Real-Time Field Network System for Monitoring Remote Agricultural Fields

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Abstract: The introduction of ubiquitous computing technology in agriculture will allow the creation of a new agricultural system. To this end, a Japanese group has developed a number of new technologies over the past decade. One new technology is the "Field Server". However, as a result of our long-term monitoring trials, some unexpected problems with the Field Server are now emerging. Here we improved the Field Server based on our experiences in several agricultural fields, and developed a quasi real-time field network system incorporating a Field Router and legacy data logger.

Keywords: Field network system, Field router, Quasi real-time monitoring, Ubiquitous computing, Sensor network.

1. INTRODUCTION

Agriculture field is vital sector to ensure sufficient food for the people. Challenges in maintaining the sustainability of agriculture practices have been increasing due to the increased population and reduced arable area. Moreover, climate change issues have been affecting agriculture activities particularly in paddy fields[1]. Therefore, increasing land productivity, water productivity, labor productivity and weather resiliencies should be the main means to develop sustainable agriculture by minimizing environmental impacts such as greenhouse gas emission.

To achieve those objectives, it is important to improve the technology and management practices by considering all environmental parameters. Hence, precious environmental data sets such as meteorological, soil and crop data are needed to support agriculture management in term of precision farming.

Since 2007 the technology to collect real time precious environmental data have been developed through field monitoring by Field Server, under the "Database-Model cooperation system" project of the Ministry of Agriculture, Forestry and Fisheries of Japan [2, 3]. The Field Server is an automatic monitoring system consisting of a CPU (a Web server), an analog-to-digital converter, an Ethernet controller; sensors to measure air temperature, relative humidity, solar radiation, soil moisture, soil temperature and electrical conductivity; and a CCD camera. It can transfer high-resolution pictures of fields and sensing data through Wi-Fi broadband networks[4].

However, there was a problem limiting its stability. From our field experiences, the Field Server broke down after only half a year when the heat and ultraviolet light weakened their acrylic poles in Thailand [5]. The stability depends on the field solar power supply, the antenna, the local electrical power supply, and the Internet connection. If any of them has a problem, the data will be lost because the Field Server does not have any data logging function.

Therefore, a "new" generation of Field Network System (FNS) is being developed by using Field Router. Table 1 shows comparison of Field Server and the Field Router. The FR has capability of sending the data daily through internet connection. A newly developed FNS is a hybrid remote monitoring system which comprises of Field Router and connected some data loggers.

Table 1 Component of Field Server and the Field Router

No	Item	Field Server	Field Router
1	Monitoring	Real time and continuous	Daily monitoring/ quasi real time
2	Operation	All day	A half hour/day
3	Power	High power consumption by using big solar panel (100 W size: 1m x 2m	Lower power consumption by using 6 W solar panel
4	Internet line	Internet with static IP address	Mobile phone internet (3G/GSM)
5	Internet cost	More expensive	Cheaper
6	Data logger	No data logger function, data are directly and continuously sent to the server	Any data loggers can be connected
7	Set up process	Difficult system set up: Phone setting, internet modem setting, IP cam, WiFi AP and sensors	Easy set up: -Device name, mobile name company -Automatic data logger detection
8	Collecting data	Data lost when power or internet fail	Data secured in each data logger. However, the data will be lost immediately if the sensor cable unplug and the battery depleted

This paper describes the basic concept of the newly developed FNS including its components, how the connection system works in the field and the application in the agriculture fields based on our field experiments.

2. FIELD ROUTER (FR)

Fig.1 shows Field Router (FR) that we developed. The FR consists of 3G/GSM modem, mini PC, camera, battery and timer then all of those components are kept in a water proof and dust tight box. The advantages of the FR are small power source (6W solar panel), easy set up, cost-effectiveness (using mobile line), can check battery level from the remote lab, no data loss because the data secured by data logger and stored in data center. Even if there are some problems related to internet connection and electrical power, the data will be saved and stored in data loggers.

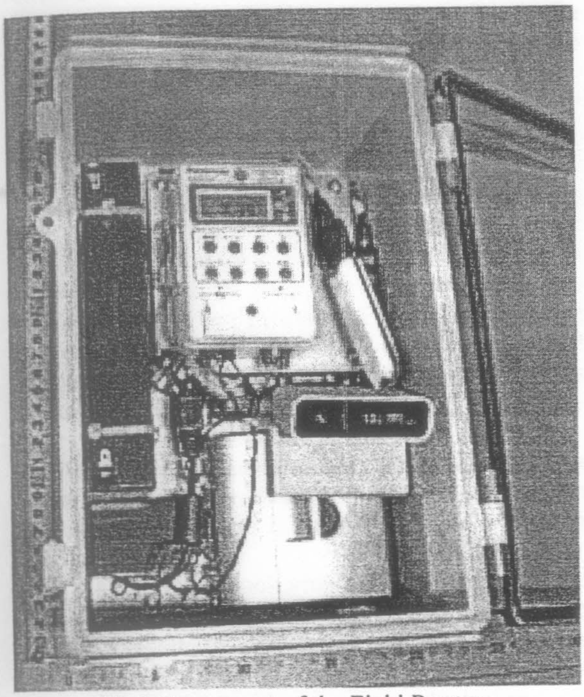

Fig.1 Component of the Field Router

3. FIELD NETWORK SYSTEM (FNS)

3.1 Component of FNS

Principally, a new developed Field Network System (FNS) consist of three main components, i.e. Field Router (FR), data logger and sensors. The function of FR is collecting data from the data logger and then sending to the server through the Internet connection. The data logger stores the measurement data that are measured by the sensors. The schematic diagram of Field Network System (FNS) is shown in Fig.2.

First, three main components of FNS should be installed and set up in the real field as shown in Fig.3. In the soil domain, Decagon soil sensors (for an example 5-TE) will measure soil moisture content, soil temperature and soil electrical conductivity (EC). Then, all those data will be collected and stored by Decagon soil data logger (Em50 data logger) at every desired time. In the atmosphere, Davis meteorological sensors (Davis Device Inc.) measure meteorological parameters such as air temperature, humidity, wind speed, solar radiation, rain precipitation and the data will be collected and stored in the Davis console (Davis Vantage Pro2).

3.2 FR operation

Fig.4 shows flowchart that FR sends data from field.

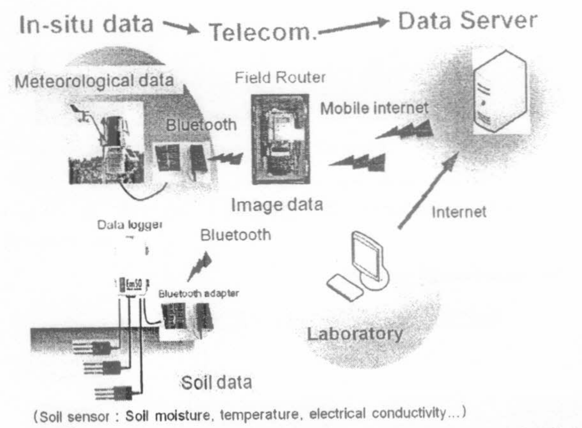

Fig.2 Schematic diagram of the newly developed Field Network System

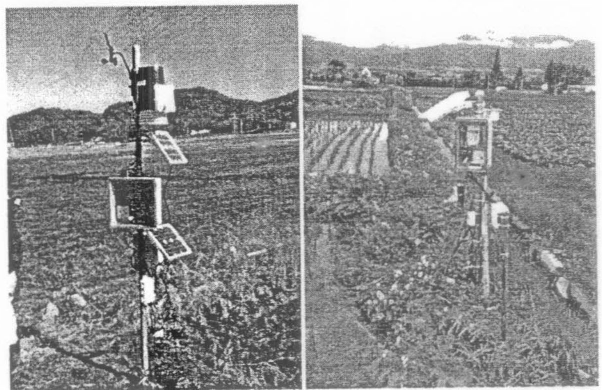

Fig.3 Setup images of Field Network System (FNS) in real fields.

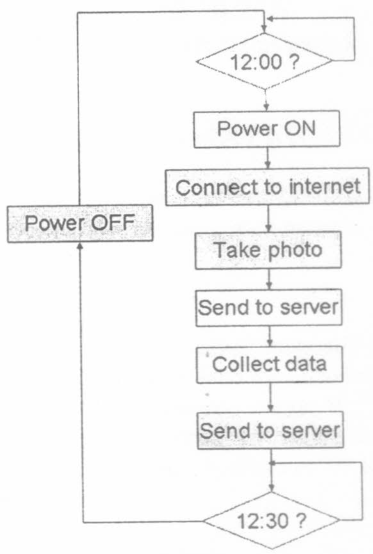

Fig.4 FR flowchart

A FR equipped with an in-situ camera works within a specific interval time, for example, within the 12:00-12:30 local time. During that time, The FR boots automatically and becomes ready to connect to the internet through 3G/GSM, then the FR acquires plant image by the in-situ camera and then sends to the server (Fig. 4). Then, it collects soil data from the Decagon soil data logger thorough cable or Bluetooth connection. Recently, it collects meteorological data from Davis console by Bluetooth connection. The FR sends the collected data to the data server through 3G/GSM connection which is plugged-in the USB modem in the mini PC. The user can easily access and download the data from the official website.

4. FNS OFFICIAL WEBSITE

The admin server maintains the data and uploads them in the official website at http://www.iai.ga.a.u-tokyo.ac.jp/fns/. The interface can be seen in the Fig. 5. Here, the users could see the overview of the currently installed FRs. Users can select "my favorite sites" by making check boxes on left windows or clicking a "Project" from Project list as shown in Fig. 6. As shown in Fig. 7, the user can see the history of FR status by clicking "Site overview" button. The figures denote the percentage of successful data transmission for image, meteorological and soil dada in each site. This function is helpful to make a plan to maintenance of the FR.

We called this monitoring as "Quasi real-time monitoring of Farmland using Field Router" because the environmental and image data are sent daily during the specific time. In addition, there are "I", "M","S" letters representing the status of image, meteorological and soil data, respectively. The status of today and previous day are shown in right and left side of the picture. If all letters appear in a specific day, it means that FR can send all data during that day.

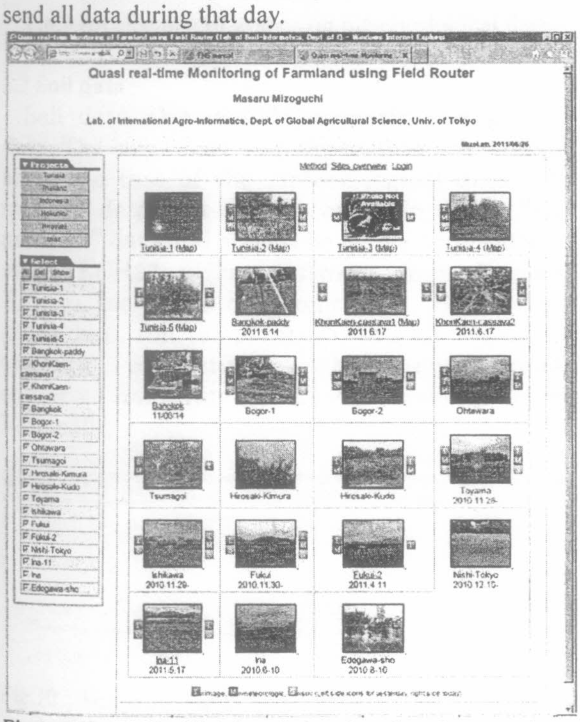

Fig.5 The FNS official website showing the overview of farmland monitoring all over the world (http://www.iai.ga.a.u-tokyo.ac.jp/fns/)

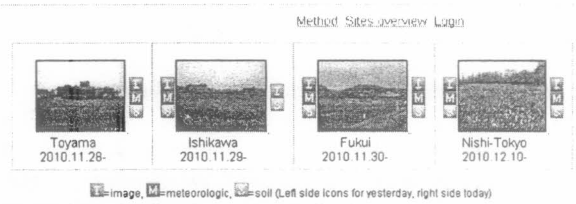

Fig.6 A "Project" category display selected from Project list

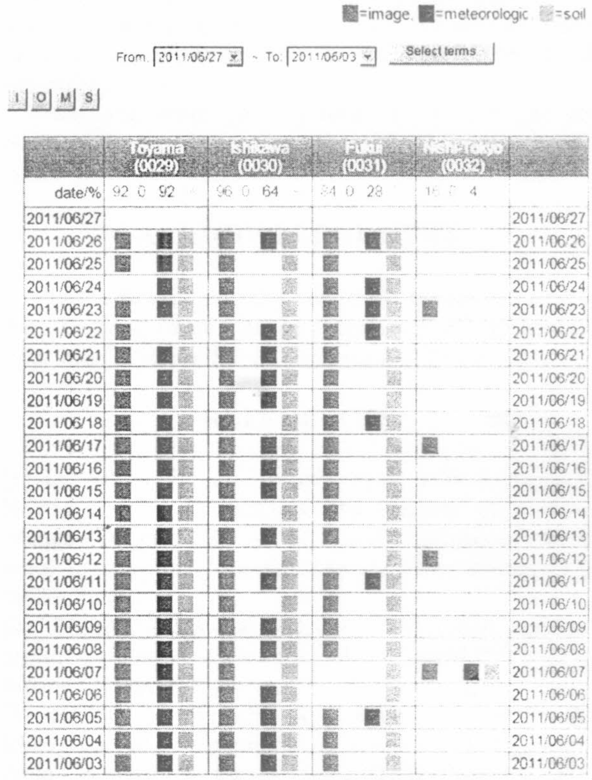

Fig.7 History of FR status page for maintenance

5. ACCESSING DATA FROM THE WEBSITE

All measurement data can be downloaded from the website as the numeric and graphic data as well as image data (Fig.8).

5.1 Image data

Image data can be saved manually by right clicking of the computer mouse and then choose sub menu "Save Image As...". Moreover, there is "image calendar" menu to see the overview of images during monitoring. The "image calendar" button can be found in above of daily image data.

5.2 Meteorological data

Meteorological data can be downloaded as numeric and graphic data. Numeric data can be accessed by clicking the "RAW" button located following "DavisVantagePro2" script in Fig.8. The data will be saved as a csv file and can be further analyzed by using Microsoft Excel. Meanwhile, graphic data can be accessed by clicking graph icon left to "RAW" button in

Fig.8. There are ten graphic data sets including battery level of the Davis console. The first to the tenth graphic data sets are of temperature, relative humidity, rain precipitation, wind speed, wind direction, solar radiation, evapotranspiration, UV index and battery level, respectively.

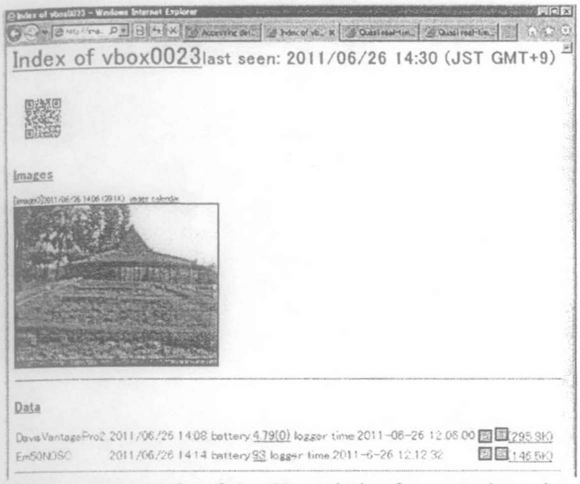

Fig.8 An example of the FR website for an Indonesian paddy field

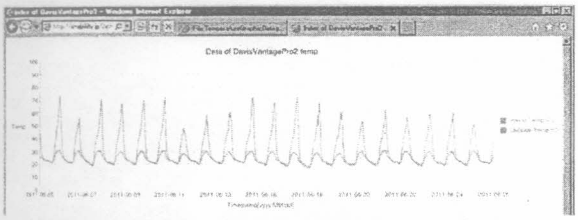

Fig.9 An example of graphs on meteorological data

5.3 Soil data

Soil data also include numeric and graphic data. The steps accessing those data are as same as in the case of the meteorological data. The numeric data that are presented in the website are "raw" data and should be converted firstly by using ECH20 utility software from Decagon Device, Inc. (www.decagon.com). By clicking graph icon, soil temperature, soil moisture and electrical conductivity, which are already converted from "raw" data, can be seen as shown in Fig.10.

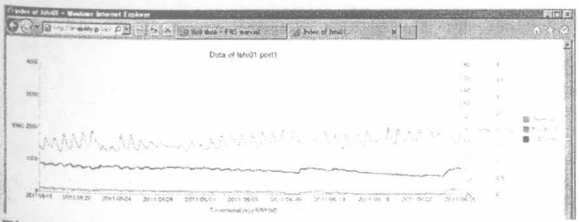

Fig.10 Soil temperature, soil moisture and electrical conductivity graphs

6. CONCLUSION

A quasi real-time field network system incorporating a Field Router and legacy data logger is a powerful tool for monitoring remote agricultural fields all over the world. Although we have just started to test the system, stable and easy access to the data logger is reducing the worries that we felt before. However, there remain fundamental risks such as electric power outage and network disconnection. Consequently, we urgently need to train field network engineers to maintain the field network system.

When you input the keyword of "fns info.ga" on Google, you can find the manual of FNS (Field network system) http://info.ga.a.u-tokyo.ac.jp/fns/Main_Page.

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REFERENCES

[1] De Silva CS, E K Weatherhead, J W Knox, J A Rodriguez-Diaz, "Predicting the impacts of climate change—A case study of paddy irrigation water requirements in Sri Lanka", *Agric. Water. Manag.* 93: 19-29, 2007.

[2] NARO, "Database-Model cooperation system project", "http://www.agmodel.net/DataModel/" (in Japanese), 2007.

[3] Honda K, Shrestha A, Chinnachodteeranun R, Mizoguchi M, Shimamura H, Kameoka T, "Spinach Field Monitoring for Bridging Thai Producer and Japanese Consumer under Sensor Asia", Proceeding of SICE Annual Conference, The University Electro-Communications, Japan, pp.2582-2585, 2008.

[4]NARO, "IT-AG national project", "http://model.job.affrc.go.jp/FieldServer/default.htm", 2009.

[5]Mizoguchi M, Tetsu Ito, Shoichi Mitsuishi, "Ubiquitous Monitoring of Agricultural Fields in Asia for Safe Agricultural Production Management", *Proceeding of International Conference on Promising Practices for the Development of Sustainable Paddy Fields*, Bogor: October 7-9, 2009. GI.15 : 1-8, .2009.