Applying IT to Farm Fields—A Wireless LAN

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Abstract

As the farm population of Japan continues to shrink and grow more elderly, it is important to find ways to increase agricultural productivity and save labor. This article describes the deployment of a wireless LAN in farm fields and a pilot program using the LAN to map plant growth and implement greenhouse remote control to raise productivity and save labor.

1. Increasing need to extend IT to farm fields

Farming has always depended to a great extent on the weather and other natural forces, so the application of information technology (IT) to farmland—fields planted with food crops, pasturage, and so on—has been difficult and farming has clearly lagged behind other industries and sectors in seeing the benefits of IT. Especially in Japan, where the agricultural labor force is shrinking and aging rapidly, finding ways to improve the productivity of the nation's farmland and saving labor are more imperative than ever before. These were the main concerns inspiring researchers to investigate how farmers might benefit from the application of IT and computers.

Meanwhile, ordinary consumers are showing greater concern and awareness about food-related issues such as BSE (Bovine Spongiform Encephalopathy, more familiarly known as mad cow disease), the false or misleading labeling of food products, and food-safety-related issues such as residual pesticides in food products. People are demanding traceability for food products, involving an information trail all the way back to the farm producing it. The application of IT should prove effective here.

Motivated by these concerns, NTT Energy and Environment Systems Laboratories joined forces with the Hokkaido University Agricultural Research Department in pursuing this collaborative research project.

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2. Wireless technology that can be used in farm fields

We recognized from the outset that it would be difficult to apply wired networks in the agricultural sector—particularly to farm fields and livestock pastures—considering the high construction cost and the disruption to farm work caused by such construction. Instead, we opted for a wireless system, which has much lower initial startup costs. Figure 1 shows the range of wireless systems that are currently available.

Considering their great popularity in recent years and the fact that they could be applied to farm fields, our first inclination was to use mobile phones. Although there are several viable systems currently available, we concluded that the calling charges would probably make the cost too high.

Instead, using a wireless LAN or Personal Handyphone Service (PHS) for the farms and fields offered the major advantages of permitting the construction of a self-managed base station and supporting a stable local service. A wireless LAN solution seemed especially appealing considering its transmission range of several kilometers and the fact that it is well supported by international standards. Wireless LANs have also come into use over the last few years to support hotspot services in urban areas, and this has helped reduce the cost of wireless LAN equipment. Applying a wireless LAN to farm fields raises the issue of how it could

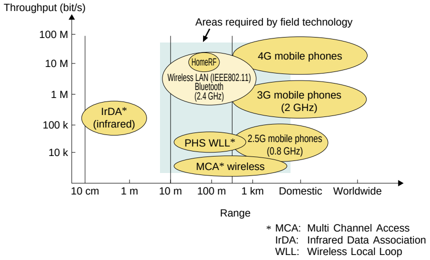


Fig. 1. Large choice of wireless systems.

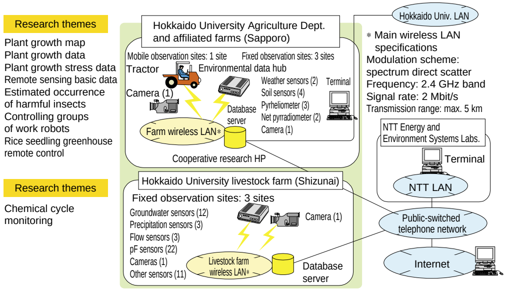


Fig. 2. Overview of experimental network system for farming.

be modified to consume less power, but we nevertheless concluded that a wireless LAN-based network is a key technology for applying IT to farm fields.

3. Overview of Hokkaido University's farm and pasture wireless LAN system

3.1 Overview

Figure 2 shows a schematic overview of the entire network that was constructed to support these collaborative trials. Wireless LANs were deployed at two farm sites affiliated with Hokkaido University's Field Science Center for Northern Biosphere: i) the Sustainable Bioproduction Experimental Farm in Sapporo and ii) the Shizunai Livestock Farm in Shizunai. These LANs were then connected over the public-switched telephone network (PSTN) to LANs on the Hokkaido University Sapporo campus and at NTT Energy and Environment Systems Laboratories in Musashino and Atsugi. Various sensors and cameras were connected to the wireless LANs deployed on the farms to monitor the farm and pasture environments (weather, soil, water quality, images, and so on), and the data from these various sensors and input devices were collected in real time. The research themes that were investigated using this network configuration

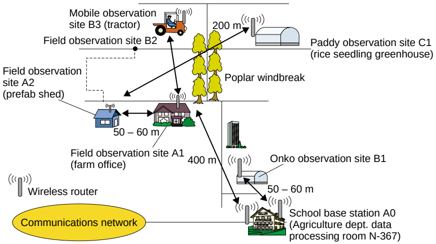


Fig. 3. Hokkaido University wireless network (Sapporo farm).

are listed on the left side of Fig. 2.

3.2 Field wireless LAN configuration

Figure 3 shows the wireless network configuration used to conduct trials at the farm in Sapporo. Base station A0 was set up in the Agriculture Department building and connected to two fixed observation sites B1 and B2 and one mobile observation site B3 by way of two relay stations A1 and A2. The base station in the school building contains the field environment information database, including all the data collected by the various sensors at the different observation sites, and a public Web server used to support the collaborative trials. This base station is connected over the PSTN to the Hokkaido University LAN, the Shizunai LAN, and the two NTT LANs.

The various sensors—weather sensors, net radiometers, soil sensors, sunlight sensors—and cameras at the Onko observation site B1 and field observation site B2 are connected to the wireless LAN by an environmental data hub, and all the data from the different sensors and cameras are collected and stored in real time. The environmental data hub is a field-ready box computer running the Linux operating system. It has two RS-232C ports, two PC card slots (one contains an AD converter), and an Ethernet interface. The miscellaneous sensors are connected to the wireless LAN (on the Ethernet side) through these interfaces. In addition, a wireless router mounted on a tractor serves as a mobile observation platform. Seven wireless routers were used as nodes (connection points) interconnecting the wireless LAN.

The wireless LAN deployed at Shizunai is configured in much the same way, except that a number of different sensors are connected to the LAN to monitor chemical cycles. These additional sensors include groundwater sensors, pF (soil moisture suction force) sensors, TDR (soil moisture content) sensors, precipitation sensors, water gauge sensors, and EC (electric conductivity) sensors. The Shizunai site is also unique in that the LAN has a self-sustaining power-supply. This approach was taken because the pastureland is very extensive and it would be costly to hook up to a commercial power source. We also wanted to avoid any disruption to the work being done on the farm.

3.3 Overview of the self-sustaining power-supply system

The self-sustaining power-supply systems, which are powered mainly by solar battery panels (approximately 200 W), were deployed at two locations at the Shizunai site and are used to supply power to all the sensors and other observation equipment, the environmental data hub, and the wireless routers. Where more power was required, we added a wind-powered generator (certified for about 72 W). To avoid power shortages as much as possible during the winter months when days are short and skies are often overcast, we installed a switchbox so we could reduce power to the more power-hungry sensors to the absolute minimum required to do their jobs. In addition, we chose to use lead-acid batteries for cycle use (permitting long-term continuous use) and designed them to be switched over to a deep-cycle mode. These innovations enable the system to operate non-stop for several months if conditions are favorable. The next challenge we need to address is how to make the

(1) Base station antenna (Agriculture dept. data processing room
(2) Wireless router antenna (paddy observation site)
(3) Self-sustaining power-supply system (pasture)

Fig. 4. Wireless LAN deployment.

maintenance-related aspects of the system more economical.

You can see the various kinds of environmental data being measured in fields and pastures by the sensors connected to this wireless LAN by visiting the website for this collaborative trial. The three photographs in Fig. 4 show the primary components of the wireless LAN, including a shot of the self-sustaining power-supply system.

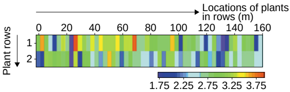
4. Efforts to increase productivity and reduce labor using the wireless LAN

The wireless LAN is being used to investigate a number of different themes, as listed in Fig. 2. Here we take a closer look at two themes that are closely related to increasing productivity and reducing labor.

4.1 Plant growth map

The concept of precision farming has been generating enormous interest in recent years among agricultural circles. Essentially, it relates to the fact that there is considerable variation within a farmer's fields: some sites will produce excellent plant growth while other will not; some areas will be more afflicted by disease and harmful insects while other areas will be relative immune. Not knowing the variation that exists in their fields, farmers have up to now simply blanketed them with a uniform heavy dose of fertilizers and pesticides, which of course has an enormous impact on the environment. Precision farming enables producers to identify the variance of factors within their fields—soil types, yields, and so on—so they can develop site-specific management plans. By tailoring the amount of fertilizer and pesticide to the various conditions across the field, farmers can be far more environmentally friendly and cost-effective.

(1) Image capturing equipment



(2) Typical plant map (soybeans, amount of dry product)

Fig. 5. Plant growth map.

Contributing to a precision farming approach, NTT has made good progress in developing a non-destructive method of assessing the amount of plant growth and a mapping technique, as shown in Fig. 5. A video camera and computer mounted on a tractor automatically generate a crop growth map, which is sent to a server over the wireless LAN. For example, in the crop growth map shown in Fig. 5(2)., red/orange indicates good growth sites, while blue/green indicates relatively poor growth. The application of supplementary fertilizer can then be precisely tailored to the requirements of plants in a specific site. This approach improves productivity while at the same time minimizing the adverse impact on the environment.

4.2 Rice seedling greenhouse remote control

It is obvious from the common farm wisdom in Japan that the control and management of seedlings

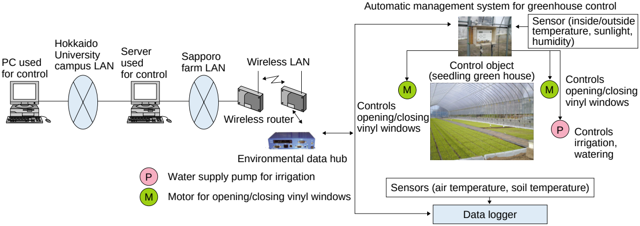


Fig. 6. Rice seedling greenhouse control.

in the cultivation of rice, despite accounting for a small percentage of the entire process, is critically important to the later growth and yield of rice plants after the seedlings have been transplanted to paddies. The problem is exacerbated as business operations grow larger, fewer people are content to remain on farms, and the agricultural population ages rapidly. To solve this problem, efforts are being focused on developing ways to automate and reduce the labor needed to maintain rice seedling greenhouses while improving yields and productivity.

We have constructed a wireless LAN-based seedling greenhouse remote control system (Fig. 6). It remotely checks the temperature, soil temperature, soil moisture, and sunlight in the greenhouse every ten minutes, and collects and analyzes basic data for environmental changes inside the greenhouse. We are also developing a program that runs on a PC and uses this data to remotely regulate the greenhouse environment itself. From the PC, for example, one can open and close vinyl windows on the side of the greenhouse to increase or decrease ventilation and automatically control the irrigation and watering of the seedlings.

Reference

[1] http://ecodb.agr.hokudai.ac.jp/www/(in Japanese)

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