Featured Articles

Cloud Services Supporting Plant Factory Production for the Next Generation of Agricultural Businesses

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OVERVIEW: Issues such as the decreasing agricultural workforce and the diminishing proportion of food produced domestically have risen to prominence in recent years. There are also global concerns about the rising imbalance between food supply and demand due to factors such as population increase and abnormal weather causing poor harvests. The use of "plant factories" has attracted attention as one way of solving these problems. In response to these new trends in agriculture, Hitachi intends to supply its Intelligent Operations for Agriculture solutions for more efficient and sophisticated farming that cover everything from the cultivation and production of agricultural products to their sale and distribution.

INTRODUCTION

INTERNATIONALLY, there have been major changes in global food and agriculture sectors in recent years, with rising concerns about the risk of disruption to the balance between the supply and demand for food due to the reduction in cultivated land area caused by rapid population growth together with changes in the global environment; the decrease in the agricultural workforce and its uneven distribution; and also growing demand for safe and high-quality agricultural products particularly among the wealthy in the emerging economies of Asia. In Japan, meanwhile, the structure of the agricultural sector has changed significantly. The total value of agricultural production peaked in Japan in 1984 and has been gradually falling ever since; down to about 8,530 billion yen in 2012. The agricultural workforce is also aging, with an average age of 65.8 years. This has created a need both to reduce the workload for agricultural workers and to increase productivity. Agriculture is also shifting toward the use of information technology (IT) for efficient and highly productive production, with changes to agricultural law now permitting companies to enter the industry, and with an increase in new entrants to the agricultural business in the form of large companies from other industries such as distribution or manufacturing. This article describes an example of "plant factories" (closed growing systems) in Japan, an initiative that is in step with these new developments in the agriculture sector.

HITACHI'S CONCEPT OF AGRICULTURAL IT SERVICES

Background

Being heavily influenced by weather conditions, conventional agriculture (particularly outdoor cultivation) is clearly an uncertain business when considered from a management perspective. Underpinned to a large extent by the experience and intuition of producers, conventional agriculture is also a difficult field for younger generations to participate in. The increasing number of fields and rice paddies that have been abandoned and are no longer cultivated, and the falling and aging farming population are becoming problems for society, reducing the proportion of food produced domestically. One solution is to look for ways of transforming the "knowledge from experience" possessed by farmers into data that makes agricultural management more predictable and to assist new entrants into the industry.

Looking instead at consumers, the market is becoming increasingly fragmented due to the diversity of life styles and preferences together with rising concerns that encompass health, safety, trustworthiness, and self-sufficiency. Together with these consumer needs, a recognition has emerged of the need for farmers to build cooperative and collaborative relationships. In response, Hitachi is seeking to identify ways of conveying data on agricultural product traceability to the people who need it, as well as the information on produce quality

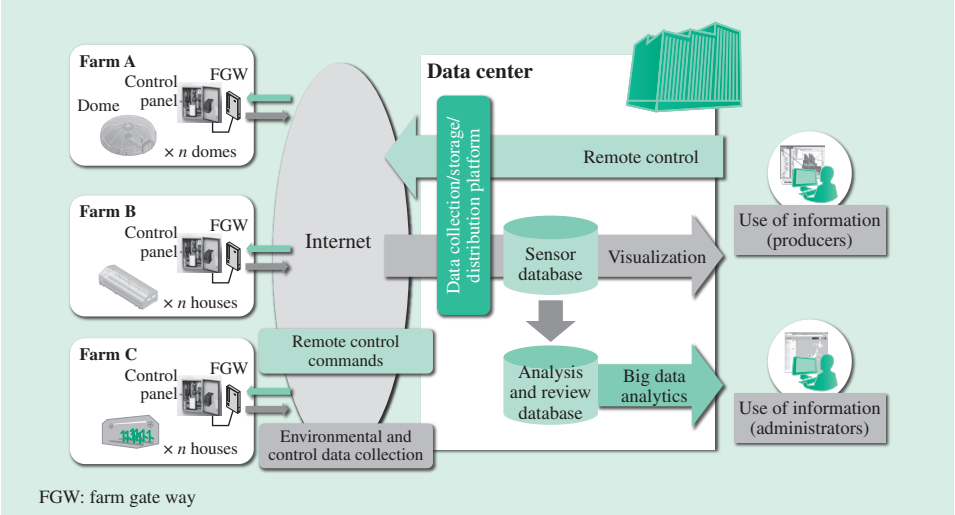

Fig. 1—Overview of Cloud Services Supporting Plant Factory Production.
The service collects data from sensors on plant factory growing conditions and production equipment operation and stores it in an FGW. Along with supplying this information to producers, equipment administrators, and others in realtime, the service can also control growing conditions and production equipment.

and quantity demanded by consumers and retailers. One such initiative aims to support plant factories that can grow produce anywhere by controlling all aspects, including growing conditions, utilizing IT such as sensor networks and the cloud, and modeling that is adapted to the "collect, store, analyze, and utilize" cycle for cultivation and other environmental data.

Objectives

Growing conditions control information is collected by providing the means for the integrated management of plant factories in the form of a cloud service. The time-series analysis of this information can be used to identify the causes of poor harvests and provide farmers with services that support plant factory management. Collecting timely information about the diverse needs of the consumers, processors, distributors, and retailers on the demand-side and then conveying this to farmers (producers) makes it possible to do such things as adjusting the volume of agricultural production or producing agricultural products that people want to buy by providing suggestions for product improvements to things like taste and flavor. In other words, building IT platforms that allow sharing of information between producers and consumers can advance the transformation of agriculture into part of the social infrastructure in Japan and elsewhere in the form of a smart industry that is responsible for the future of food.

CLOUD SERVICES SUPPORTING PLANT FACTORY PRODUCTION

Overview

The establishment of plant factories to provide a reliable supply of agricultural products is currently on the increase. These "factories" ensure reliable production by controlling growing conditions to suit the requirements of the crop. This in turn has created a demand for services that monitor production conditions and equipment operation remotely to improve productivity through the use of various data analyses and by optimizing control of energy and other aspects of the environment.

The "Cloud Services Supporting Plant Factory Production" service uses the cloud to collect and manage data on plant factory growing conditions, control data from production equipment, and other information. It can supply management information to producers and equipment administrators in realtime as well as control growing conditions, production equipment, and other aspects of plant factories (see Fig. 1).

Features

Cloud Services Supporting Plant Factory Production is a full-featured service for plant factories that can help improve crop quality and productivity by controlling growing conditions in plant factories, while also providing information from the analysis of these activities. It collects solar radiation, temperature, humidity, nutrient content, pH, electrical conductivity (EC)[*1], and other data on growing conditions in plant factories, and also data on the operation of heating and cooling equipment, nutrient solution pumps, shading curtains, and other production equipment. This data is collected from sensors and stored in a farm gate

*1 A quantity that is indicative of the concentration of various different ions in soil or in an aqueous solution. EC measurements are used in agricultural science as indicators of nutrient concentration in soil or in aqueous solutions.

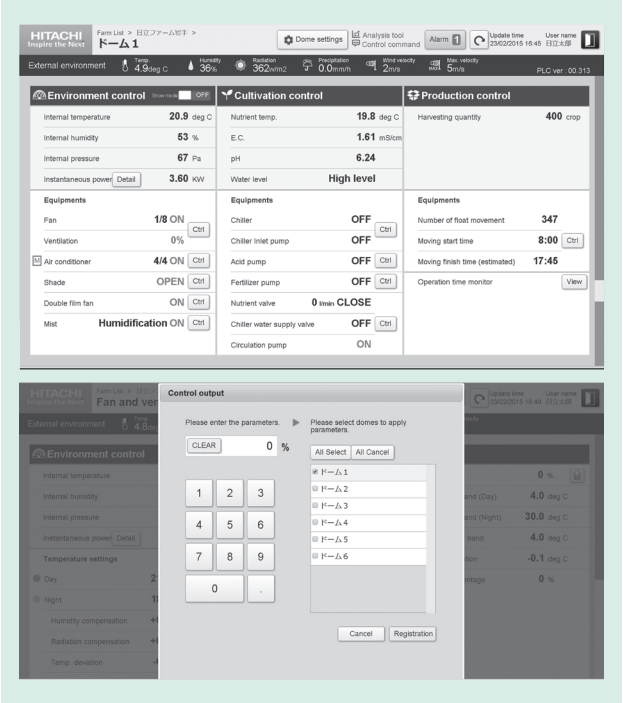

Fig. 2—Example Monitor and Setting Screens.
Collected data is displayed on the administrators' monitor screens via the data collection/storage/distribution platform at the data center. The system can also remotely control settings for sensors and production equipment at the plant factories.

way (FGW)[*2], which is a data collection and control device. This data is then sent to the monitor screens of administrators in realtime via the data collection/storage/distribution platform at a data center. The service can also remotely specify control settings for the sensors that collect data on growing conditions and the production equipment. All of the collected data is stored in a database where it can be analyzed and reviewed using business intelligence (BI)[*3] tools to optimize growing conditions and provide support for decision-making from a management perspective.

Fig. 2 shows examples of the monitors and setting screens.

Use at Granpa Dome

The service has been adopted for the Granpa Domes[*4] developed by Granpa Co., Ltd. (see Fig. 3) and is being progressively deployed to each of the domes.

*2 A data collection and control unit that periodically collects growing conditions, production equipment control, and other plant factory data and sends it to a data center; and also receives commands from the data center and controls production equipment.
*3 Tools and techniques for collecting, analyzing, and processing large quantities of corporate or other organizational data, and for utilizing it in management and other decision-making.
*4 Plant factories made from air domes that utilize natural sunlight and an automatic spacing system with circular water tanks.

Fig. 3—Exterior and Interior Views of Granpa Dome.
Cloud Services Supporting Plant Factory Production has been adopted for the Granpa Domes developed by Granpa Co., Ltd.

Before adopting the service, the Granpa Domes collected growing conditions, production equipment status, and other data on control panels located inside the domes. This meant that operations such as viewing the data or changing environmental settings needed to be done on the control panel monitor screens at the dome, making it very difficult to maintain realtime monitoring and control of the multiple geographically separated domes. The service collects approximately 1,000 items per minute of growing conditions, production equipment, and other data from each dome at a data center, and provides consolidated realtime monitoring and control of information from the multiple geographically separated domes on monitor screens at headquarters. Using the service has enabled the company to implement efficient operational management.

TECHNOLOGIES UNDERPINNING AGRICULTURAL CLOUD

Data Collection/Storage/Distribution Platform

The data collection/storage/distribution platform is used to provide unimpeded communications between the plant factories and the data center for the growing conditions, production equipment control, and other data generated by the factories (see Fig. 4).

To perform remote monitoring in realtime, Cloud Services Supporting Plant Factory Production sends operation logs from the plant factories to the data center at one-minute intervals. Because the data collection/storage/distribution platform needs to receive data from a large number of plant factories at frequent intervals, it stores data in memory to eliminate disk access overhead by using a distributed in-memory key value store (KVS) with high-speed data processing capabilities to receive the data. Data reception is handled independently (asynchronously)

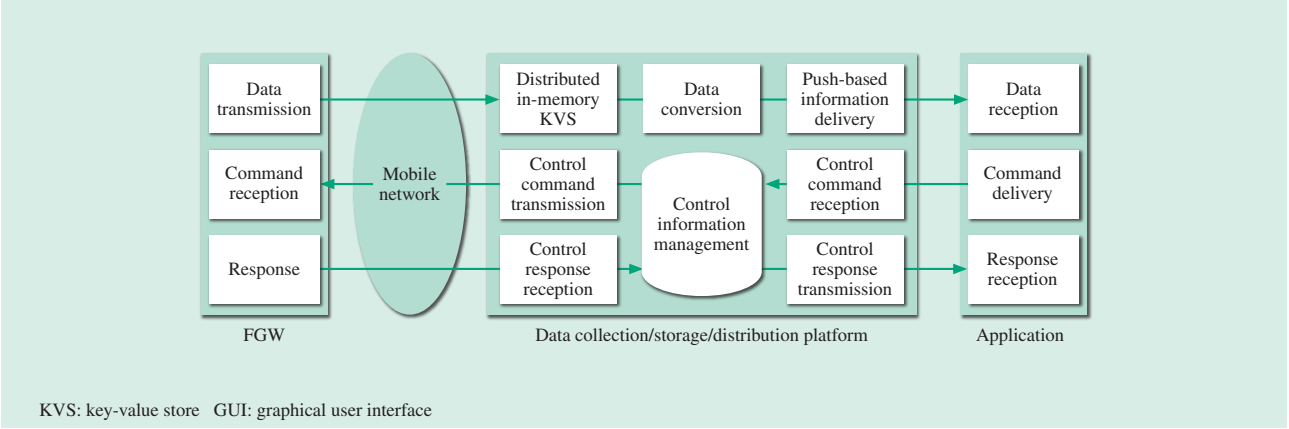

Fig. 4—Overview of Data Collection/Storage/Distribution Platform Functions.
Because of the need to receive data from a large number of plant factories at frequent intervals, the data collection/storage/distribution platform includes a distributed in-memory KVS with high-speed data processing capabilities. The platform also includes functions for ensuring unimpeded exchange of data between the plant factories and data center, including an ability to define data conversions using only a GUI.

of the transfer of data to applications to ensure that data reception throughput is maintained, and realtime operational monitoring is implemented by passing the received data to applications using push-based information delivery.

To keep the volume of operation logs from plant factories to a minimum, it is transmitted in binary rather than in more bulky text format. Accordingly, a binary-to-text conversion function is required to make the collected data easier to handle by applications and people. The data collection/storage/distribution platform is designed to allow operation logs with different structures to be added without the need for new program development, allowing data conversions to be defined using only a graphical user interface (GUI).

The remote control of plant factories requires both the transmission of control information from applications to the factories and the reception by applications of the results of control operations at the factories. If this were implemented synchronously, it would require the applications to wait when a communication fault or other problem interrupted the return of results from the plant factories. Accordingly, asynchronous communications is also used for control commands issued by applications, which are routed via the data collection/storage/distribution platform. To achieve asynchronous communications, the data collection/storage/distribution platform includes a mechanism for managing whether control information has been sent and whether the result of that has been received. When control results are returned from a plant factory, the data can be forwarded to applications in hypertext transfer protocol (HTTP) format using push-based information delivery.

FGW

The plant factories are controlled by programmable logic controllers (PLCs) that collect sensor data and control equipment at the factory. To provide factory operation logs to local administrators, this information is collected periodically by a data logger device connected to the PLC.

For remote monitoring of plant factories, an FGW is used to send operation logs to the cloud-based data collection platform and to forward factory commands from the data collection platform. To prevent the FGW from being an additional cost, it is designed to combine the functions of the existing data logger device and the connection to the cloud. The functions of the FGW are the collection and storage of factory operation logs, data logging, transmission of collected data to the data collection platform, reception of factory commands from the data collection platform, and the forwarding of these commands to the factory (see Fig. 5).

The interfaces with the PLCs that control the plant factories are implemented using an application bundle based on the OSGi[*5] framework that simplifies changes to equipment configuration associated with factory expansions. To allow the long-term storage of large amounts of data, collected data is stored on the FGW in a database for embedded systems.

A mobile network can be used for connecting to the data collection platform to provide greater flexibility in

*5 OSGi is a trademark or a registered trademark of the OSGi Alliance in the United States, other countries, or both.

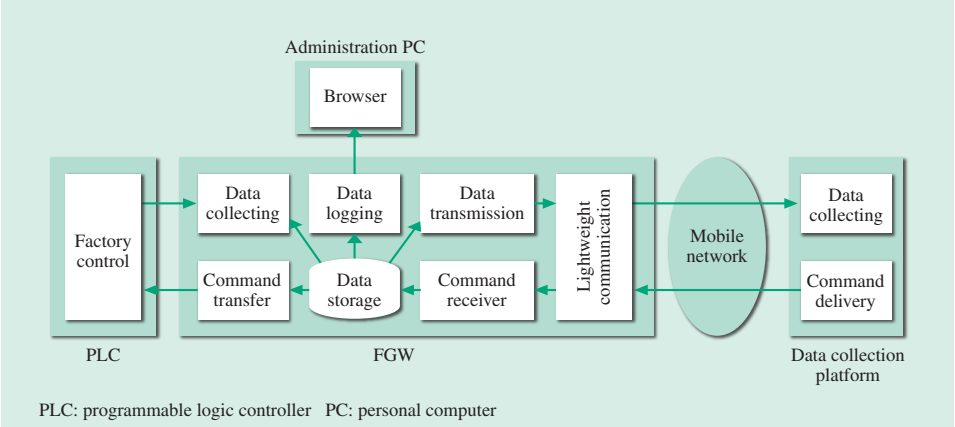

Fig. 5—Overview of FGW Functions.
The FGW functions are a collection of packages supplied by Hitachi Solutions, Ltd.

choice of location, using lightweight communications based on a protocol with small packet size to minimize the data transmission volumes. Although use of a mobile network requires measures to deal with unreliable communications, this is achieved by the queuing of transmission data and retry control.

FURTHER EXPANSION OF AVAILABLE SERVICES

Hitachi supplies products and services for the smart information sector under the banner "Intelligent Operations." Through the development and supply of its Intelligent Operations for Agriculture solutions for agriculture based around Cloud Services Supporting Plant Factory Production, Hitachi is making agricultural production more reliable and transforming agriculture into a "senary industry[(3)]" (a term used in Japan to refer to the added-value production and distribution of agricultural goods). In the future, Hitachi intends to add new services and to integrate them with other cloud services, including simulating supply and demand for the output of agricultural production, assisting with the acquisition of Global Good Agricultural Practice (GLOBALG.A.P.)[(4)] certification, and providing cultivation simulations. Hitachi also intends to expand beyond plant factories to offer horticultural services for small and medium-sized operations, as well as services for assisting companies that are deploying these outside Japan.

CONCLUSIONS

This article has described a solution for the next generation of agriculture in the form of a service that supports farm administrators and farmers by collecting environmental and control data from plant factories and making it available via the cloud.

IT is beginning to be adopted for operational and efficiency improvements in agriculture, a field that in the past has made little progress on utilizing IT. In the future, Hitachi intends to improve convenience across society through initiatives such as those that use IT to link producers, processors and distributors, retailers and the hospitality industry, and consumers.

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