Massively Distributed Monitoring System Application of Field Monitoring Servers using XML and Java Technology

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Abstract: Recently, in the field of agriculture, it is important to monitor field information (temperature, humidity, photosynthesis photon flux density, etc.), to get field/crops view for growing conditions, and to record field operations. We have developed a "Field Server" which automatically monitors field information and controls some equipment via a Web browser. Field Servers can be used easily to build massively distributed monitoring system (MDMS). In the MDMS, it is one of the most important problems that specifications of Field Servers are different to treat data complicatedly. In this paper, we developed an "Agent System" which accesses Webs of Field Servers periodically to gather monitoring data using XML and Java. The data based on XML can be commonly used for Web programming and distributed databases. Describing all specification data by XML, we can construct and update the MDMS of Field Servers at any time. Using this application, we can easily access all data of Field Servers in a Web system. By connecting the MetBroker (Middleware for weather data), we can use a lot of applications designed for the MetBroker.

Keywords: Field Server, XML, Java, MDMS, Internet, MetBroker

Introduction

In the field of agriculture, it is important to monitor on-site field information about environment conditions (such as temperature, humidity, photosynthesis photon flux density, etc.), growth states of the crops (obtained by the field/crops view), and field operations (about sprinkling of water, agricultural-chemicals spraying and so on). This information is very useful for investigation of a production plan, prediction of growth and the amount of harvest, and prevention of an agricultural calamity. Recently, we consider using such information for the traceability of crops. Moreover, some researchers have developed many various applications for growth simulation of crops and predicting the occurrence of diseases and noxious insects to support the agriculture (Takahashi et al. 1998; Ohtani et al. 2001). So a lot of people want to use these applications with their own on-site field information. On this background, we have developed a "Field Server (Fukatsu et al. 2002)" which automatically, reasonably, and easily monitors on-site field information and controls some equipment via a Web browser. Field Servers are compact monitoring robots which are equipped with sensor, computer, and network functions, and we have studied the massively distributed monitoring system (MDMS) based on them.

One of the most important problems in the MDMS is to treat various data which are related to different measurement items and obtained from different installation places. Especially in the agricultural field, there are many situations in which we need to treat various data. For example, we want to measure various data for every crop and to change measurement items and installation places according to the season or the growth. Increasing measurement points for monitoring crops will lead to intermingling of many kinds of measuring equipment. In the MDMS, how we treat various different data is important. On the other hand, Field Servers are equipped with the features that allow them to form a network with built-in wireless LAN and exchange monitoring data on a Web. Then, in this study, we develop an “Agent System” which accesses the Webs of Field Servers to gather monitoring data uniformly using XML and Java technology, and construct the MDMS based on Field Servers.

The Field Server

In the MDMS, it is necessary to install many kinds of measuring equipment in order to monitor on-site field information, and how reasonably and easily we can install, secure a network, and treat monitoring data is an important subject. Then, we have developed Field Servers which have a network function with wireless LAN and a Web Server built in main computer card, and we have tried to construct the MDMS.

By using wireless LAN for Field Servers, we can use a high-speed transmission network without spending communication expense, and without needing installation construction. Therefore, we can install Field Servers in favorite places according to the situations, keeping a good network. By building a Web Server in Field Servers, we can easily monitor and control Field Servers using a Web browser (e.g. Internet Explorer, Netscape) like accessing a Web page. Therefore, we can access various kinds of Field Servers easily and uniformly, and use various applications for Field Servers on the Web.

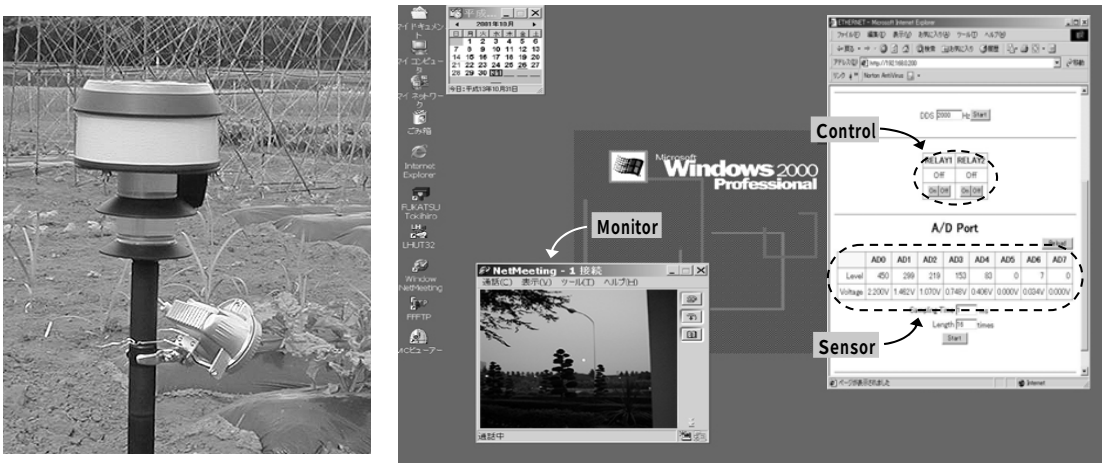

Figure-1. A standard Field Server and its operational situations on Windows2000

Figure-1 shows one of the standard Field Servers and its operational situations on Windows2000. A Field Server has a wireless LAN of 11Mbps (IEEE1394.11b) and a Field Server Engine which is a main computer card for controlling measurements. And the manufacturing cost of a standard Field Server is about 60,000 yen. The Field Server Engine has a 10 bit A/D converter which takes in the values of temperature, humidity, photosynthesis photon flux density, and distance from sensors. After monitoring data, we can exchange data by accessing the Web Server built in the Field Server Engine. These hardware connections between inside/outside devices are standardized by Ethernet (10/100base-T) to eliminate legacy hardware problems and to easily extend various peripheral equipment, such as a Web Camera and DOS/V PC. A standard Field Server can be driven by the external power supply of AC100V or DC12V, and also be driven by private power generation like a solar panel (Hirafuji et al. 2002). We can access Field Servers from a Web browser connected with the network via wireless LAN or the Ethernet port such as PDA and DOS/V PC, and get monitoring data in html format. Moreover, we can operate some equipment connected to Field Servers by remote control on Web, and get camera view (if a Web camera is connected). Thus, we develop an Agent System which performs monitoring and controlling of these data, and finally we construct the MDMS based on Field Servers.

The Massively Distributed Monitoring System

In the field of agriculture, it is important to monitor various data here and there at a field. Especially, grasping growth states of crops and considering preventing the occurrence of diseases and noxious insects, require us to monitor many data which change with place and time. Thus, in constructing the MDMS, an important problem is how we treat various kinds of data which differ according to installation places, measurement items, monitoring intervals and so on.

On the other hand, Field Servers are equipped with a wireless LAN for networking and a Field Server Engine with a Web Server, and so we can construct the MDMS utilizing these features of Field Servers. When many Field Servers are installed in a field, they can construct a network with built-in wireless LAN, and it can exchange data among all Field Servers only by connecting to one somewhere. Furthermore, if we connect just one Field Server to the Internet, we can access all Field Servers at any place Internet is available, and we can construct the MDMS easily. Via a built-in Web Server, we can access any Field Server of any type or any measurement item. Thereby, we can eliminate legacy problems and monitor various data.

Then, in this paper, we develop a Field Server Agent System using XML and Java technology as an application for constructing the MDMS based on Field Servers. An Agent System has some applications which monitor and control Field Servers via a network and

make a database. As the applications based on Java and the data based on XML can be commonly used for web programming and distributed databases, we can construct the MDMS with the Agent System. Figure-2 shows the outline of a Field Server Agent System using XML and Java technology.

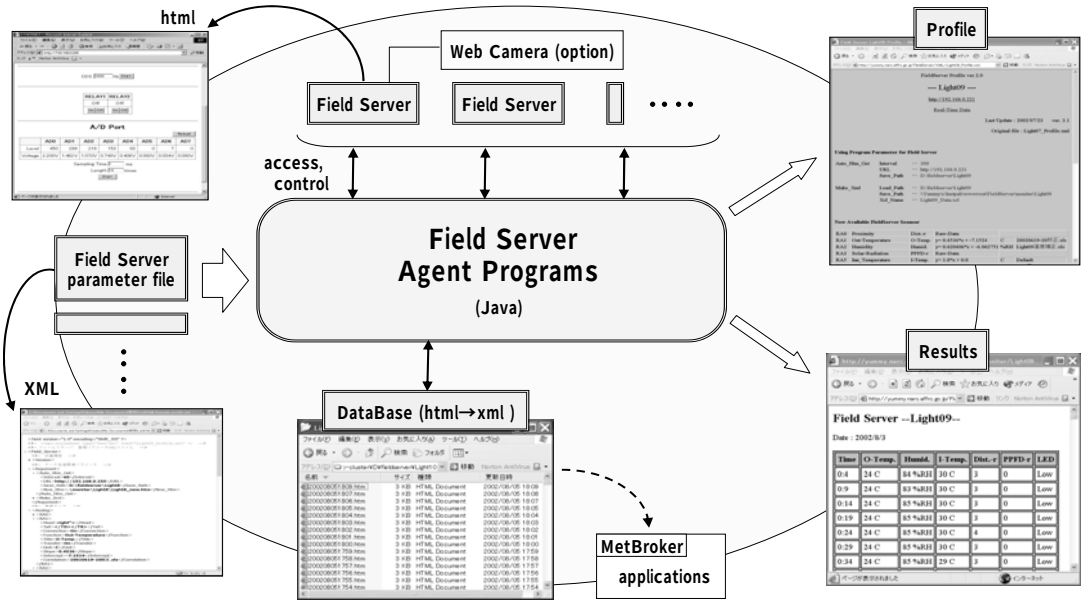

Figure-2. Field Server Agent System using XML and Java technology

Each Field Server has its own parameter file in XML format which stores the installation place, measurement items, calibration parameters, etc., and the Agent System executes some programs based on these XML files. Therefore, we can access with the same application by updating the parameter file, even when sensors, installation place or other factors of Field Servers are changed. By describing in XML format, we can treat a parameter easily with XML Node name, and we can see the profile of Field Servers easily using an XSL file. Therefore, the Agent System using XML format is very useful for treating various kinds of equipment.

In the Field Server Agent System, some Agent Programs written in Java are executed to control and monitor each Field Server based on parameter files, and they make a database and results. Monitoring results are extracted from the Web Servers inside Field Servers in html format, and Agent Programs change them into XML format for a database. Using XML format, we can uniformly treat monitoring data of various Field Servers, and we can get any result of arbitrary items easily by using XML Node. Moreover, a database in XML format can be treated easily to connect the MetBroker (Laurenson et al. 2000) which is a middleware for weather data, and we can use a lot of applications for agriculture designed for the MetBroker with own on-site field information.

Results and Discussions

We consider the implementation of the MDMS by building an Agent System using XML format and Java programs installed in many Field Servers at a field. Then, by actually installing Field Servers in various parts of a field and executing Agent programs, we try to monitor field information and make a database. Some Field Servers (maximum: 10) are installed at the field of our research institute (Tsukuba, Ibaraki) and others are also installed at the field of farm (Memuro, Hokkaido). Agent programs are built on DOS/V PC (OS: Windows2000), and designed to collect monitoring data to make a database in XML format. These results are opened to the public at this URL (http://yummy.narc.affrc.go.jp/FieldServer).

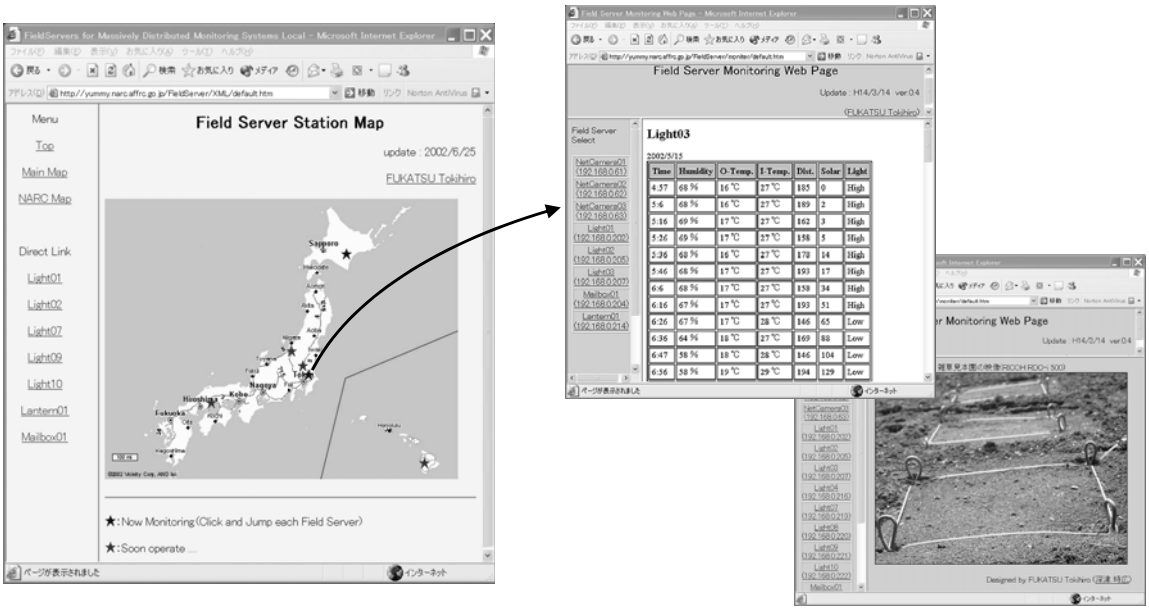

Figure-3. An example of monitoring results of the database

Figure-3 shows an example of monitoring results of the database created by an Agent System. Based on the parameter file of each Field Server, installation places are displayed on a Web map. If we click the mark of installation places, we can see the detailed profile of each Field Server, monitoring data and field live view (if a Web Camera is connected). Installation of Field Servers and operation of an Agent System were performed more than half a year from February, 2002, and an operation stabilized under various environments is able to be checked. In this system, we can uniformly monitor and control Field Servers installed not only at the field of our research institute but also in Hokkaido which is over 500km away. These results show us the implementability of MDMS.

In this paper, it was shown that the MDMS of a field could be constructed easily and reasonably with Field Servers and an Agent System. At present, we are conducting

employment experiments in much more places, and examining various subjects. Especially about networking, it becomes increasingly important to ensure security because Field Servers are not only monitoring robots for MDMS but also infrastructures of a field that are expected for development in the further agricultural form (Hirafuji 2000). In addition, it also becomes important to standardize XML parameter files for adapting various kinds of equipment in the MDMS. The XML file of the database should be standardized too. And how the database will be utilized has become an important subject. Now, we are trying to operate this system together with the MetBroker. By connecting to the MetBroker, we will be able to use a lot of applications designed for the MetBroker, and further utilization of MDMS are expected.

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