Framework and Case Studies of Intelligence Monitoring Platform in Facility Agriculture Ecosystem

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Abstract*—Facility agriculture area in China is expanding, and is leading the world. However its ecosystem control technology and system is still immature, with low level of intelligence. This puts significant constrain on the efficient, high-quality, safe and sustainable production of facility agriculture. Promoting application of modern information technology in agriculture will solve a series of technical questions in information collection in wide area, efficient and reliable information transmission, intelligent system integration for different needs and environment. This will be a catalyst for the transition from traditional farming to modern farming. This also provides opportunity for creating new technology and service development in IOT (internet of things) farming application. This paper presents an intelligent monitoring platform framework and system structure for facility agriculture ecosystem based on IOT. The solution is divided into four function layers based on the difference in information exchange process and task logical handling, i.e. sensor layer, transmission layer, monitoring layer, application layer. Among them, sensor layer is responsible for numerical sensor of physical values in farming. The sensor module formats and processes collected data based on public standard, and transforms to information and stores. The transmission layer summarizes collected data from sensor layer, using internet technology e.g. wireless sensor network. It provides data for upper layer to invoke, analyze and process. The monitoring layer uses the summarized data as input parameters, and intellectually control task in farming, by regulating automatic control algorithm. It results in better ecosystem that better suits crops' growth, reduces human interference, and eventually achieves more accurate farming process. The application layer summarizes and analyzes huge volume of information across locations and industries, through advanced open-ness and intelligence. It helps build up the industry's information service on environment, and better supports decision-making and action. The same rules are used in communication between different layers. Adjacent layers in the same system use standard interface to transmit data. This paper applies the above-mentioned framework in intelligent monitoring platform of facility agriculture ecosystem in Shanghai, and analyzes and verifies the whole implementation process and selection of decision-making model. This framework is proven to be reliable and adaptable.

Keywords—IOT(internet of things); wireless sensor network; Smart agriculture; facility agriculture ecosystem; intelligence; framework

I. INTRODUCTION

Protected Agriculture is a modern agricultural production method aiming for high yield and quality. It provides suitable growth environment through engineering techniques under artificial facilities protection conditions. The ultimate goal of Protected Agriculture is making agricultural production, like industrial production, free from natural environmental factors and achieving automatic efficient production. It is a combined product of biology, environment, engineering and IT. The key to Protected Agriculture is the construction of the facility habitat's control and monitoring system.

Both at home and abroad, practice shows that information technology is the key to develop urban modern agriculture. Booming Internet of Things (IOT) brings this fusion into a new stage of intelligent agricultural, which focuses on perception, interconnection and intelligence [1]. Through the introduction of of information and knowledge element in key areas of agricultural industry chain, the return is maximized given the limited investment and labor factors. In addition, the entire process of agricultural production and business activities is controlled through information technology, making agricultural growth depend largely on information and knowledge resources rather than on natural resources [2].

This paper presents an intelligent supervisory control platform framework and system structure based on the Internet of Things (IOT). According to the information flow process and business logic processing, it divides the whole solution into 4 functional layers, that is, sensor layer, transmission layer, control layer and application layer. The framework above is used in intelligent control cases of facilities habitats in Shanghai, China. The whole implementation process and the selection of decision models is analyzed and validated. The

Supported by Special Fund for Agro-scientific Research in the Public Interest of China (200903056), special funds for Shanghai Zhangjiang national independent innovation demonstration area(201209-SJ-A0-001) and the National High Technology Research and Development Program ("863" Program) of China (2012AA101405).

results show that the framework can have good reliability and adaptability.

II. OVERALL DESIGN OF PLATFROM

IOT (The Internet of things) interconnects the information sensing devices such as RFID, sensors, GPS system, two-dimensional codes according to pre-determined protocol. It exchanges information and communicates through wired or wireless network. The IOT can achieve functions such as intelligent recognition, data acquisition, intelligent control, location tracing, tracking, monitoring and management.

Base on IOT technology, solutions are described by functional layers. According to the information flow process and different business logic processing, overall solutions are divided into four different functional layers (sensor layer, transmission layer, control layer, application layer), as shown in Figure 1. Same layers in different systems use the same protocol for communication. Adjacent functional layers in the same system transmit information through standard interface.

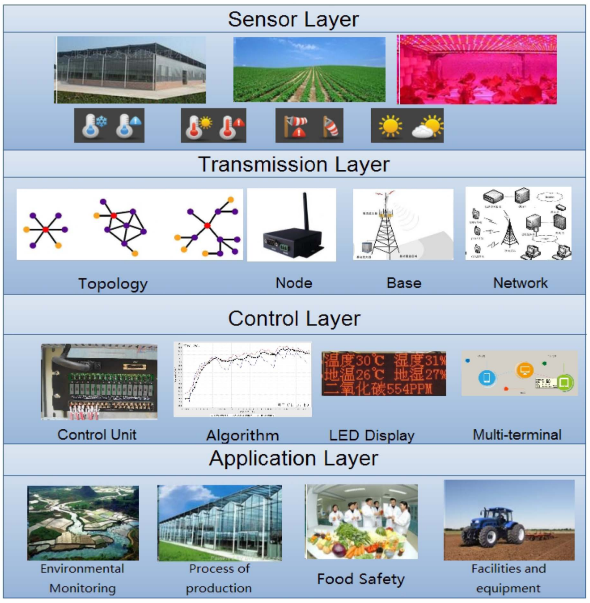

Fig.1 Platform Framework

The sensor layer is responsible for numerical sensor of physical values in agricultural production, relying on the ubiquitous sensor deployment. The sensor module formats and processes collected data based on public standard, and transforms to information and stores.

The transmission layer summarizes collected data from sensor layer, using internet technology and integrates geographic information collection point. It provides data for upper layer to invoke, analyze and process. According to different transmission media, it could be in wired network mode, wireless network mode and mixed mode. For example, in long distance telecommunication we can choose 3G or GSM wireless network depending on local condition; and ZigBee mode can be chosen for short distance communication. These could ensure the stable operation of the network system.

The control layer uses the summarized data as input parameters, and intellectually control task in agricultural production, by regulating automatic control algorithm. It results in better habitat that better suits crops' growth, reduces human interference, and eventually achieves more accurate farming process.

The application layer displays and expresses the specific business logic of agriculture through interactive interface. Based on the needs of multi-terminal adaptation and relying on a service-oriented structure, it builds a more humane, automatic and intelligent information system and application platform fit for agriculture industry chain [3].

III. CASE STUDY

A. *Ubiquitous Sensor and Network*

Achieving a thorough sensor, i.e. using any equipment, system or process to sense, measure, capture and transmit information at any time and any place, so as to assist with taking actions and long-term planning.

The sensor layer of the platform needs ubiquitous sensors and network employment. "Ubiquitous" here mainly means the ubiquity of wireless network coverage, and the sensor nodes of wireless sensor network, RFID, magnetic cards, bar codes, etc. The gathering of comprehensive information is an important foundation to intelligent agriculture, while achieving the goal of low-power, small size and low cost during the process is the key to promoting IOT in the agriculture [4].

In the process of agricultural production, people can use intelligent sensors to achieve real-time collection of production environment information and use self-organizing intelligent IOT to submit remote real-time data. Using the IOT technology to monitor the environment parameters of agricultural production such as soil moisture, soil nutrients, PH value, precipitation, temperature, air humidity and air pressure, light intensity, CO_2 concentration, etc. can provide scientific evidence for precise regulation of greenhouse facilities and optimize the growing environment of crops. This can not only achieve the best growing environment of crops, but also improve the quantity and quality of crops as well as improve the utilization and output rate of agricultural inputs such as water and fertilizer. Besides, the combination of long-distance transmission of information via the Internet and wireless sensor nodes closing the terminal short-range can achieve the deployment of rural information, thus solving the transport problem of "the last kilometer" in the real sense.

Meanwhile, in the circulation of agricultural and food products, with the integration application of agricultural and food products' tracking system, such as electronic tag, bar code, sensor network, mobile communication network, computer network and so on, the quality tracking, the traceability and the visual digital management of agricultural and food products can be achieved. It helps monitoring intelligently the overall process of the agricultural products from production to sale. The seamless connection of agricultural and food products' quality and safety information between different stages will become a reality. It will not only establish the digital logistics of agricultural and food products but also increase the agricultural and food products' quality enormously [5]. Figure 2 indicates the habitat intelligence model and its solution in Shanghai Pujiang Base.

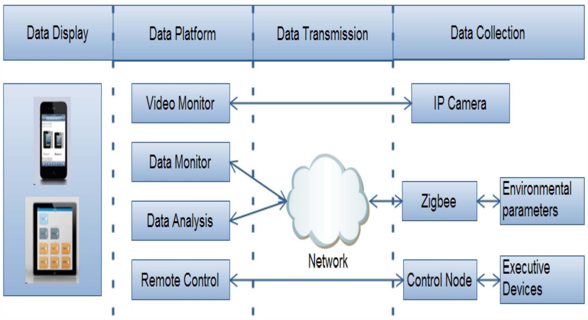

Fig.2 The Habitat Intelligence Model and Its Solution in Shanghai Pujiang Base

B. *Collaborative intercommunication and integration*

Achieving a more comprehensive collaborative connection i.e. share and exchange between information restored by different systems in industrial chain, eventually to realize the seamless connection in the operation flow and the real time monitoring of operation state [6].

The platform's infrastructure construction needs the collaborative intercommunication of mass information. Collaboration means the process or the ability to accomplish one common task by planning and coordinating between two or more bodies. Intelligent agriculture is the new manifestation of the collaboration in the information society. It brings great challenge caused by the scale of collaboration, amount of information and the complexity of behavior.

Nowadays, there exists the phenomenon of heterogeneousness and its resulting isolation of information, which explains the barriers to information sharing in urban agricultural industry, wasting of resources and repeated construction [7]. The heterogeneousness comes from following:

- Difference in system: the difference between application system, database management system, operating system and hardware platform which data sources depends on
- Difference in model: there are differences in storage modes in data source. Relational mode is the mainstream storage mode of urban agriculture industry information system nowadays. But even the same kind of storage mode can have differences in model structure.
- Differences semantics: the differences between the semantics of information resources may cause all kinds of conflicts.

The key to solve this problem depends on how to face the challenges of the complicated system caused by the language differences, platform differences, protocol differences and data structure differences. Therefore, it is necessary to introduce a standardized knowledge representation in the process of collaborative interconnection and solve the interoperability features of multi-source heterogeneous information in the semantic level.

In the implementation process, we build a series of generic models (such as ontology library, domain model, UI, input and output, etc.), based on the extraction of common features between different information systems, to express the system. It generates parts of codes through code generator or run the model directly on the framework. The researchers can pay more attention to writing business codes, so as to achieve reusability on the framework level. It can improve the reuse granularity of software's production process, reduce the cost of building new software system and increase the software's reliability. Figure 3 shows the production model and solutions of multi-terminal adapter remote control software. The production can be used on various terminals such as: PC tablet PC or smart phones.

Fig.3 multi-terminal adaptive control software model

C. *Open and intelligent applications and services*

Achieving more in-depth openness and intelligence, i.e. integrating and analyzing vast amounts cross-regional cross-industry information, improving ecological environment construction of information service, so as to support better decision-making and action planning

The interface platform for end-user is an application and service built on the top of sensor layer and interconnection layer. How to send the massive data and complex business to end-user, generated by the application system of all steps, is the key to success of agriculture information. The supply of more open and intelligent application and service is consistent with efficient transmission of information under current internet environment [8].

The demand of the complete application and the supporting system of the products usually consists of several simple service units (i.e. content services, data services, inspection services, training services and business services, etc). It needs to solve a series of optimization problems such as service support network, service resource and client relationship and so on. To continuously improve the complex service process. The feedback from the service evaluation system should also be considered. As a result, an open, intelligent service model and operating strategy is an integrated application of information, systems and control theories, a truly multidisciplinary integration.

In the process of the construction of applications and services, we also need to explore the establishment of a mechanism that made up of government-led public services and market-operation of non-public services, leading to the formation of multi-win pattern in the agricultural information services. It calls for exploring an information service model of sustainable development in the light of local conditions. We are focused on establishing a sound legal system of agricultural information services, regulating the behavior of the information services subjects, building agricultural information markets and optimizing information service environment, which creates conditions for the long-term operation. Figure 4 shows a content management service system of application platform, including information publishing, visual presentation, monitoring and early warning and assessment functions, etc.

Fig.4 Content Management Service System of Application Platform

IV. CONCLUSION

Promoting the development of facility habitat intelligence monitoring platform will solve a series of technical questions in information collection, efficient and reliable information transmission, intelligent system integration for different needs and environment. This will be a catalyst for the transition from traditional farming to modern farming. This also provides opportunity for creating new technology and service development in IOT agricultural application.

The framework mentioned in this paper applies to intelligent monitoring platform of facility habits in Shanghai. It will lead to the integration of resources to form a system for application and promotion in the base of IOT、ICT and sensing technology. It will have significant implication in the areas of changing the traditional mode of agricultural management, improving prevention and control capabilities of flora and fauna epidemic disease, ensuring the quality and safety of agricultural products, healthy development of modern agriculture, improving production efficiency, shortening production cycle, improving the level of intelligent agricultural production, achieving the maintenance and appreciation of values in the product circulation.

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