Design of Intelligent Agriculture Management Information System Based on IoT

Duan Yan-e

Beijing University of Agriculture, Beijing, 102206, China
duanyane@126.com

***Abstract*—Agricultural information technology (AIT) has been broadly applied to every aspect of agriculture and has become the most effective means & tools for enhancing agricultural productivity and for making use of full agricultural resources. As an important sub-technology of AIT, the using of technology of Agriculture Information Management directly affects the degree of agricultural informatization and efficiency of agricultural production's decision. In this paper, on the basis of introducing the concept of agricultural information management and analyzing the features of Agricultural data, the designing method and architecture of Intelligent Agriculture MIS was discussed in detail, finally, this paper gives an implementation example of system in agricultural production.**

Keywords- Agriculture MIS, Internet of Things, Wireless Sensor Network, RFID

I. PREFACE

The former American vice-president AI Gore put forward the concept of "Digital Earth" in a speech addressed at the California Science Center on January 31, 1998. From that time, the concept of "Digital Earth" has aroused great concern and become one of the newest researching hotspots in the field of global science and technology. It has remarkably accelerated the development of digitalization in different industries. Digital Agriculture is one of the most important parts of Digital Earth and is the extending of "Information Superhighway", "Digital Earth" and "Knowledge Economy" within the field of agriculture. It has been bringing the changes of agricultural management, production and distribution and the changes of agricultural science, technology and education. Digital Agriculture is also called informational agriculture or intelligent agriculture, which involves many high-new-techs of agriculture, such as farmland information fast acquisition, farmland cultivation, land management, agricultural chemicals utilization, contamination control, agricultural engineering equipments and their industrialization technology. As an important embranchment of computer application field, information management is an important part of Digital Agriculture and is the basis of intelligent decision of agriculture production.

II. INTRODUCTION OF AGRICULTURAL INFORMATION MANAGEMENT

In the 21's century, agriculture will turn into water-saving agriculture, mechanical and intelligent agriculture, and high-quality, high-yield, pollution-free agriculture. Agriculture informatization is a necessary and effective approach to realize all of these purposes, and is the core technology of modern agriculture. The essence of agriculture informationization is to utilize the digitization of each process in every aspect of agriculture (including crop production, animal husbandry, aquatic products industry, forestry) through Information Technology. During this process of informationization, Agriculture Management Information System (AMIS) is required to unite all the parts of Digital Agriculture and manages various data formats; both standardized as well as proprietary and are able to exchange data with services that provide computation for digital agriculture. At present, AMIS has steadily increased in their level of sophistication as they have generally included new technologies with internet connectivity and application of Internet of Things (ToT).

Agricultural informationization has been developing fast in all countries of the world, especially in developed countries. For example, in Japan, computers have been widely used in farming, crop breeding, conservation of crops and forest and insect utilization, agricultural weather report, agricultural operations, agricultural product processing and so on. In the United States, farmers are linked with mass information flow, a farm at home has the access to the database of governmental information centers, universities, research institutes and libraries, can get the latest data of price fluctuations, seed melioration, new type of agricultural machines and prevention and treatment of plant diseases and pests and so on. Computers can aid farms to analyze when and what kind crop should be planted and which farming mode is the best, then farms can get the maximum outputs and benefits. In Finland, there are a few major commercial providers of FMIS; namely Wisu and Agrineuvos, both of which have plug-in or related software available for the various specialties of farm management [1].

China is a great agricultural country with a large population, limited soil resources and traditional manual farming methods, with these challenges, the central government has been attaching great importance to the development of agriculture and put forward a new agricultural technology revolution -- the transformation from traditional agriculture to modern agriculture and from extensive farming to intensive farming. From 1998, China officially initiated the concept of "Digital China", and this brings about the encouraging development of Digital Agriculture which can promote agriculture technology revolution [2]. To-date many provinces have built different kinds of system about Digital Agriculture including an expert system of wheat, crop simulation, pesticide ranking, web-based seedling production management and so on.

978-0-7695-4353-6/11 $26.00 © 2011 IEEE
DOI 10.1109/ICICTA.2011.262

III. CHARACTERISTIC OF AGRICULTURAL DATA

It is extremely important to instruct the agricultural production by knowing the related and available information. The agricultural data are the basis of AMIS, the accuracy of collecting and processing of agriculture data would directly affect the result of agriculture information management. Because the environment of farmland is a very complicated ecology system and involves many different kinds of factors, from environment to humane, from ecology to economic, from geography to society etc, the collecting of data usually incurs the substantial costs and technologies [3].

A. *Spatiality*

Agricultural production is closely related with multi-source spatial factors, such as resource, ecology and environment. Spatial data also known as geospatial data or geographic information which is the data or information that identifies the geographic location of features and boundaries on Earth, such as natural or constructed features, oceans, and more. Spatial data is usually stored as coordinates and topology, and can be mapped.

B. *Complexity*

The collection and expression of agricultural data includes not only directly related factors, but also indirectly related factors. Collected data also come from multiple sources (on-board sensors, soil sampling, remote sensing etc.), there are many kinds of data are involved, such as spatial data, non-spatial data, image and video, the work comparing and analyzing miscellaneous data must be done before the management level. Therefore, firstly, it is required to transfer this information from the collecting equipment to the analyzing computer, in order to analyze it and to establish classify, statistics, mapping etc. After that, it is necessary to transfer data again in the reverse direction, to carry out variable rate applications according to the requirement of farmers.

C. *Enormousness*

As a whole, any agricultural system has four kinds of factors: geographical biological, environmental, technical, social and economic. Each factor contains many sub-factors. For example, in the crops of biological factor, there are wheat, paddy rice, corn, cotton and other factors. And the same crop's growth also includes environmental factor which sub-factors include soil, fertilizer, moisture, sunshine, temperature, atmosphere and other factors. So, for the whole AMIS, it would involve the collecting and analysis of different mass data and this would directly decide the performance of system.

D. *Dynamics*

From seeding to harvesting, the crop typically undergoes various crop handling stages. The factors of effecting crop is always changing, For example, a crop handling process may begin at a farm, where the important characteristics of the crop production environment, such as water and nutrient supply, often vary considerably over space and time within a single agricultural field. Spatial variation in crop performance can be caused by soil as well as by diseases, weeds, pests, and previous land management. So, for the agriculture production, in-time acquisition of agricultural data is vital for improving the accuracy of agricultural production management and decision.

IV. CONCEPT OF IOT

In 1995, in the book of "the road ahead", BILL GATES firstly brought up the concept about connection of "thing to thing". In 1999, EPCglobal united more than 100 enterprises and created the international Telecommunication Union and formally brought up the concept of IoT (Internet of Things). According to the definition of ITU, the technology of IoT mainly solves the interconnection between thing to thing, human to thing, and human to human. The purpose of IoT is to create a huge network through the combination of different sensor devices (such as RFID, GPS, RS, laser scanner) and networks to realize the information sharing of global things [4]. IoT can comprise millions of networked embedded devices also called smart items [5]; these devices are capable of collecting information about themselves, their environment, and associated devices and communicate this information to other devices and systems via the all-connecting internet (Fig1).

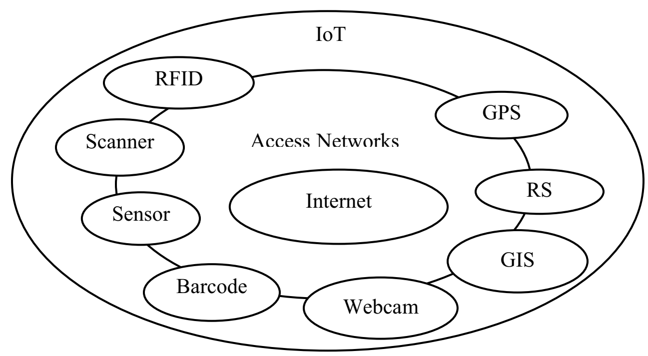

Figure 1. Concept Model of IoT

V. ANALYSIS OF SYSTEM'S ARCHITECTURE AND TECHNOLOGY

The purpose of Agriculture MIS is to improve the level of agricultural information process and enhance the intelligent management and decision of agricultural production. According to the requirement and characteristic of agriculture production, we can design the AMIS according to hierarchical structure. This system mainly includes three layers: data collection, data transmission, data analysis and process (Fig2).

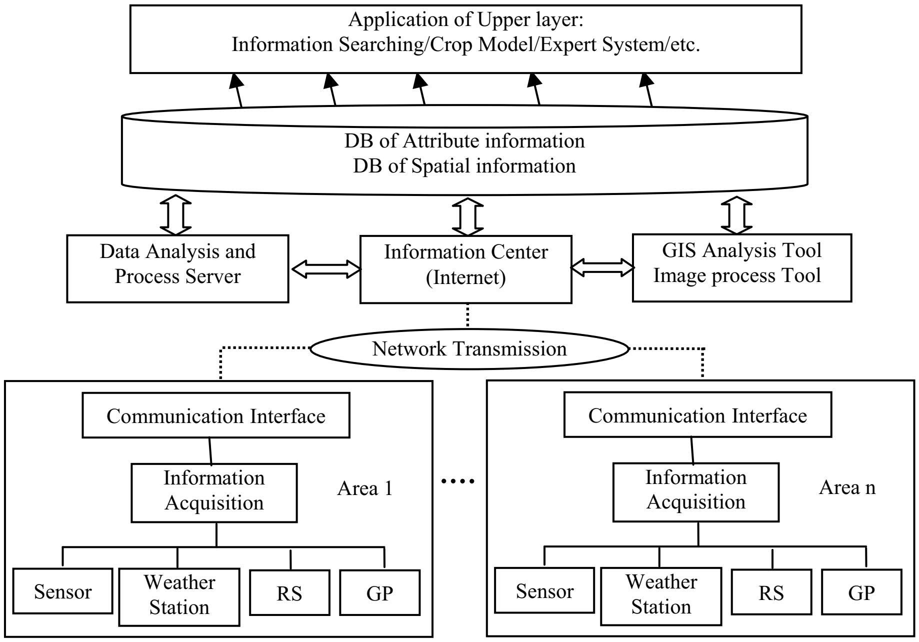

Figure 2. Architecture of System

A. Data Collection

The collection of data still proves a demanding task and directly affects the efficiency and quality of AMIS. The potential of using these data will reach its full extent when suitable collecting technology and method are developed to achieve beneficial management practices. Nowadays, with the increasingly deep research of the IoT and its application, IoT's attributes of information's overall sensing, reliable transferring, and intelligent operation makes it begin to become the main method of data acquisition and transmission. Since the agricultural production involves different stages and process, such as crop growth, crop storage and sell, we should select different collecting technology and method for getting more precise information.

1) Stages of crop' growth

For collecting the data of environmental factor, such as soil, fertilizer, moisture, sunshine, temperature, we can deploy different kinds of sensors according to the farmland' attribute of geography and crop's attribute of growth. Sensor has the capability of large scale deployment, low maintenance, scalability, adaptability for different scenarios etc. It allows the deployment of sensing systems and actuation mechanisms at a much finer level of granularity, and a more automated implementation than has been possible before. For example, sensors and actuators can be used to precisely control for example the concentration of fertilizer in soil based on information gathered from the soil itself, the ambient temperature, and other environmental factors. Incorporating feedback into the system through the use of sensors, actuators, and adaptation algorithms will allow a more fine-grained analysis that could adjust flow rate and duration in a way that is informed by local conditions [6].

For acquiring the geographic information of farmland, we can use global positioning system (GPS) to measure geographic location such as, provide data on location in terms of latitude, longitude and altitude of farmland. In addition, airborne data collection systems through remote sensing (RS) technologies, such as aerial photographs and satellite remote sensing provide periodic land use, land cover and other thematic information [7].

2) Stage of crop's storage and sell

For tracking crop status, we should think of the ability of trace back and can query the database for information on identification/location of crop with specific attributes or characteristics, link to other spatial and non-spatial databases for identifying other attribute information associated with the crop, and identifying alternative sources of food and export safe crop when potential contamination or agro-bio-terrorism events occur (Fig3).

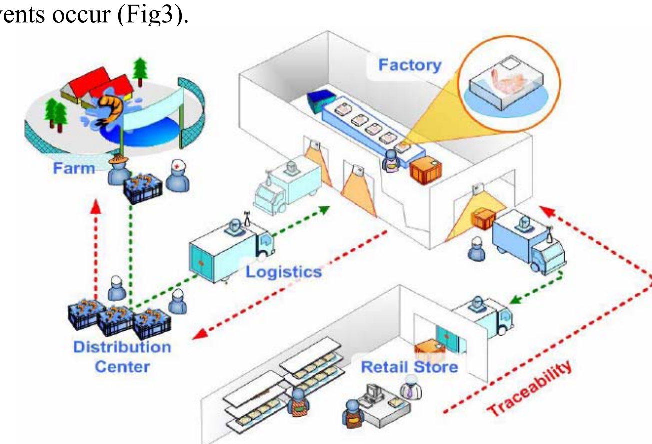

Figure 3. Track Back Flow of Crop

In this process, the radio-frequency identification (RFID) tag is the main component of the proposed crop tracking system. RFID will start linking up the supply chain from the farm gate to the restaurant plate – and every point in between. The tag is dimensioned to approximate a size of an individual crop and multiple such tags are deposited in a container of the crop at the harvesting stage. At each crop handling stage the tags are programmed with the time and location of the event as well as any other attributes relevant to the crop handling process, e.g., serial number of equipment etc. Therefore, the entire history of crop handling is stored in the tags and can be detected and identified automatically at any time. New tags can be inserted in the grain or removed from the crop at any crop processing stage, as needed.

B. Data Transmission

The main function of this layer is to ensure that the information from collecting layer can be reliably transmitted to Internet through network infrastructure, such as mobile communications network (GSM, TD-SCDMA), wireless sensor network, satellite communication network etc. WSN is one of the most suitable technologies for capturing real world data. Therefore, connecting WSN to the Internet in order to publish contextual data in standard ways so that they can be shared with other entities, analyzing these data, taking decisions in remote premises, and finally implementing these decisions back in the real world through sensors(Fig4)[9], is a challenging activity where complementary technologies may be applied[2]. Advances in electronics have made it relatively easy to set up wireless sensor networks for monitoring all sorts of environmental phenomena, for example, weather, temperature, and noise. Many commercially available wireless communications nodes are available including Lynx Technologies, and various Bluetooth kits, including the Casira devices from Cambridge Silicon Radio, CSR[8].

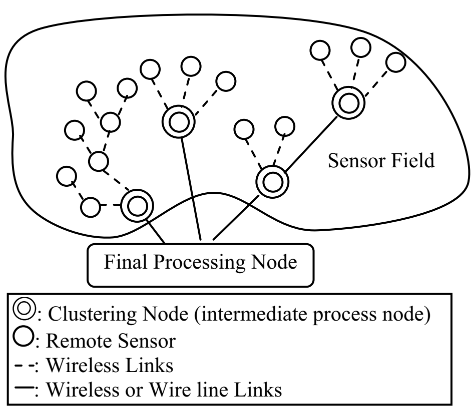

Figure 4. Typical sensor network arrangement

C. Information Analysis and Process

For the spatial data, GIS has proved to be an efficient and effective tool for spatial analysis and management of natural resources. GIS is a specialized branch of geo-spatial information technology that helps store, manage and analyze geographical reference data. GIS is also a tool that integrates statistics with geographic location to derive meaningful and informative maps, graphs and tables that can be used for better decisions to meet at different scales [7].

For the non-spatial data, database and data mining are the main processing and analyzing technologies. Data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information- information that can be used to increase revenue, cuts costs, or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. For example, one Midwest grocery chain used the data mining capacity of Oracle software to analyze local buying patterns.

Finally, for further improving the efficiency of analysis and process, the technology of cloud computing has been used, cloud computing is web-based processing, whereby shared resources, software, and information are provided to computers and other devices (such as smart phones) on demand over the Internet. Using the intelligent cloud computer platform can ensure that enormous information of internet are real-time analyzed, processed, managed and controlled and create an efficient and reliable decision service system for the high level management and large-scale industry application.

VI. Example of Application

In the case of fertilization, the use of an identifier on the crops and sensors in the farmland which could automatically be read would enable the tractor/implement combination to make records about what is being put into the implement's hopper or tank, this information could be used to make sure that application rates are within recommended limits and combinations of fertilizer are also approved. Knowledge of the fertilizer, combined with field, weather and operator data, would allow automatic monitoring of buffer zone width, thus ensuring compliance and generate automatic and detailed records of the day's fertilizing activities. The information held in the computer with a standard format, would then be accessible to those further down the food supply chain and can be searched by the terminal customers through Internet or cell phone (Fig5) [10].

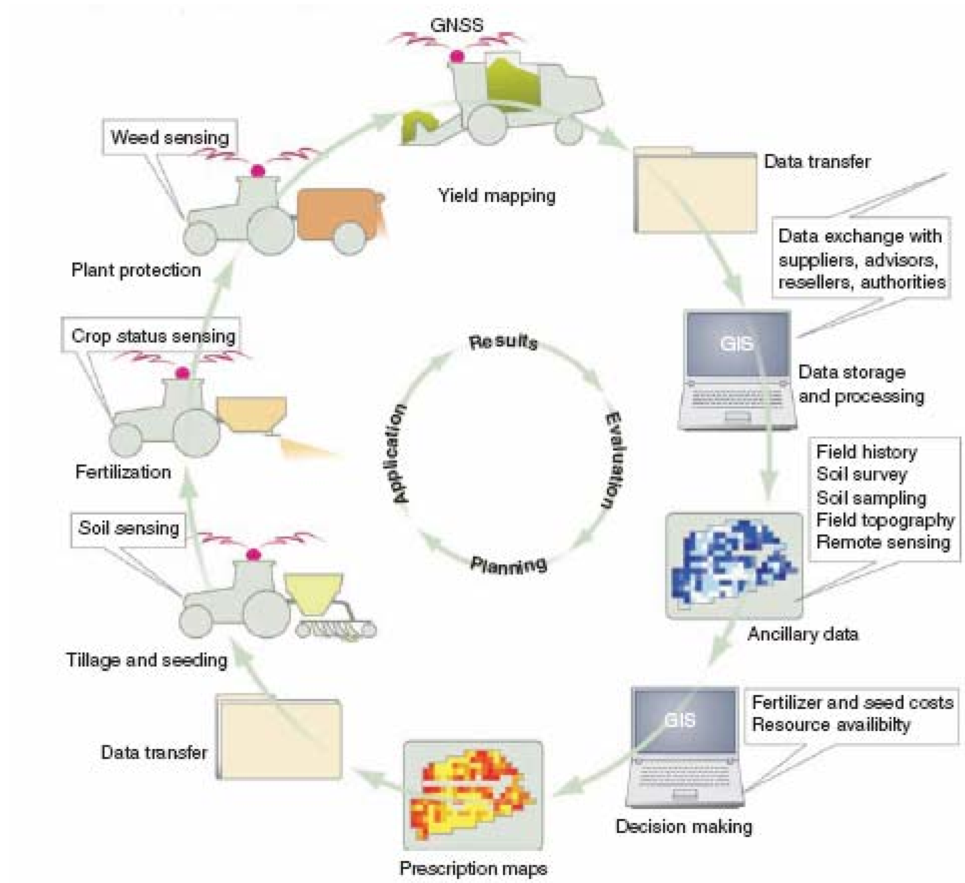

Figure 5. Exam of Agriculture Information Management Flow in Crop Production

ACKNOWLEDGMENT

This work is elaborated within the project of "Research on Growth Evaluation and Physiological-Ecological Simulation of Peach", No. KM201010020011 funded by the Beijing Municipal Commission of Education.

REFERENCES

[1] Jicheng Cheng, Shanzhen Yi. Digital Agriculture--One of Application Domain of Digital Earth [J]. Proceedings of the International Symposium on Digital Earth. Science Press, 1999

[2] Yong Liang, Xiu-shan Lu, De-gui Zhang, Fu Liang. Study on the Framework System of Digital Agriculture [J]. Chinese Geographical Science. 2003, 1(13): 15-19

[3] Xuanli Liu, Macon Nelson, Mohammed Ibrahim. The Value of Information in Precision Farming. Paper of the Southern Agricultural Economics Association Annual Meeting, 2008

[4] Su-bin Shen, Qu-li Fan, Ping Zong. Study on the Architecture and Associated Technologies for Internet of Things. Journal of Nanjing University of Posts and Telecommunications (Natural Science).2009, 29(6):1-11

[5] ITU. ITU Internet Reports 2005: The Internet of Things.

[6] Christos Goumopoulos, Achilles D. Kameas, Alan Cassells. Ontology-driven system architecture for precision agriculture applications. Int. J. Metadata, Semantics and Ontologies. 2009, 1(4): 72-84

[7] M. Narayana Reddy, N. H. Rao. Integrating Geo-spatial Information Technologies and Participatory Methods in Agricultural Development. CURRENT SCIENCE. 2009, 1(96):23-25

[8] F. L. LEWIS. Wireless Sensor Networks. Smart Environments: Technologies, Protocols, and Applications. New York, 2004: 1-14

[9] KAZEM SOHRABY, DANIEL MINOLI, TAIEB ZNATI. WIRELESS SENSOR NETWORKS--Technology, Protocols and Applications. A JOIN WILEY &SONS, INC.2007

[10] Robin Gebbers, Viacheslav I. Adamchuk. Precision Agriculture and Food Security. Science, 2010(2):829-831