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Architecture Design of Food Supply Chain Traceability System based on Internet of Things

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Abstract: This article analyzes the sources of food traceability and a few basic elements of the food traceability, designs and architects the food supply chain traceability system based on Internet of things. The system structure is composed of perception layer, transport layer and application layer. System is architected from the user interface presentation layer (USL), Business Logic Layer (BLL), Data Access Layer (DAL). The transport layer adopts savant middleware to improve the data processing and storage.

Key words: Food traceability, internet of things, savant middlewar

FOOD TRACEABILITY

"Food traceability" (Begona and Alberto, 2008) is the "food quality and safety traceability system" for short. It is the food safety management system that was gradually established by European Union to cope with the problem of "mad cow disease" since 1997.

Food traceability (Begona, 2008) means food and other related information in every link of the food chain (including production, processing, distribution and sale, etc.) will be traced and recalled. Thus, it makes the food's production and business operation activities under effective monitoring. Nevertheless, there are many expressions for Food Traceability's definition (1) The International Standard Organization (ISO9000/2000) defines food traceability as: ability of tracing product location, usage and sources, (2) Codex Alimentarius Commission (CAC) defines food traceability as: Ability of identifying and recognizing how the food changes, where do they come from, where will they go and the relationship between food products and (3) The European Union defines food traceability as: The possibility of detecting and tracing food production, processing, distribution and the feed of animals used in food production or other raw materials in the whole process of food chain. All of the definitions indicate that at present, there is no unified definition of food traceability internationally. However, this does not affect people's understanding, mastering and using of the basic key elements of food traceability. In Agricultural and Food Chain Traceability System, the Food Traceability has the following basic elements:

- **Product traceability:** Position or location of food in the food supply chain through the traceability which facilitate the registration management, the implement of food recall and notifications to consumers and interested party
- **Process traceability:** Behaviors and activities that affect food safety in the process of food growth and process through the traceability which includes the interaction between product and the food pollution caused by environment factors and food migration
- **Genetic traceability:** Genetic constitution of the products through the traceability, including the gene's source and type of genetically modified food and crop varieties and so on
- **Input traceability:** Types and sources of the material input in the process of planting and breeding through the traceability which includes ingredients, chemical spray water, irrigation headwaters, livestock feed, additives used to preserve food and so on
- **Disease and pest traceability:** Through the traceability, traces back to disease's epidemiological data, biological hazards (including bacteria, germs and other contaminated food pathogenic bacteria) and other biological products absorb materials from other agricultural productions
- **Measurement traceability:** Through traceability, detects food, environmental factors and the health of food producers and traders to obtain relevant information

Food traceability is Proactive Strategy based on the information which could collect traceability information

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correctly and completely in the process of food quality and safety management. Although food traceability can not improve the food safety, it helps to discover problems, find out reasons, adopts administrative measures and investigates and affixes the responsibility (Zheng, 2012).

INTERNET OF THINGS TECHNOLOGY

The Internet of things (Hossain, 2010) is a network that according to the contract agreement connects any item with the Internet, exchanges and communicates information to realize intelligent identification, location, tracking, monitoring and management through radio frequency identification (RFID), infrared sensors, global positioning system, laser scanners and such information sensing devices. The Internet of things is "Internet connecting objects to objects". There are five characteristics about The Internet of things. One is to achieve a unique identifier; the second is to classify objects quickly; the third is to monitor objects on real time; the fourth is to realize the automatic non-contact processing on objects; the fifth is to realize the information sharing of each link in the supply chain. The Internet of things technology provides the foundation platform for food supply chain traceability (Sun and Zhou, 2011).

FOOD SUPPLY CHAIN TRACEABILITY SYSTEM

Introduction of the Internet of things technology in the field of food quality and safety supervision, could set up food supply traceability system based on Internet of things, realize more comprehensive perceptions of foods from the cultivation (breeding), primary processing, manufacturing, warehousing, transportation, packaging, circulation to consumption, more interactive sharing and further more intelligent food regulation (Huang, 2012; Meng, 2011).

System architecture: Following the mainstream of the Internet of things' architectural design, considering the food safety business applications, the system consists of three levels (1) Perception layer: given priority to the technology of RFID, sensor, EPC coding, starting from the production, it will implant the unified EPC coding logo into food, install readers in the key link of food production and circulation, record automatically dynamic data of food from production to the final consumer, realize the recognition of "things", (2) Transport layer, it will keep the data to the Internet information platform of the food supply chain through the network, realize the sharing of massive amounts of data transmission and (3) The application layer: it is a concrete application of all kinds of business model on the Internet of things, including food safety information platforms, food product supply chain information platforms and other system software operating platform. Specific details are as follows in Fig. 1.

Application layer: System application layer includes raw materials tracing management module, food production management module, food warehouse management module, food transportation management module, sales management module and the query module food traceability.

Raw material tracing management module includes management of raw material production and foster growth, warehouse management of raw materials, raw materials transportation management, raw material purchasing management.

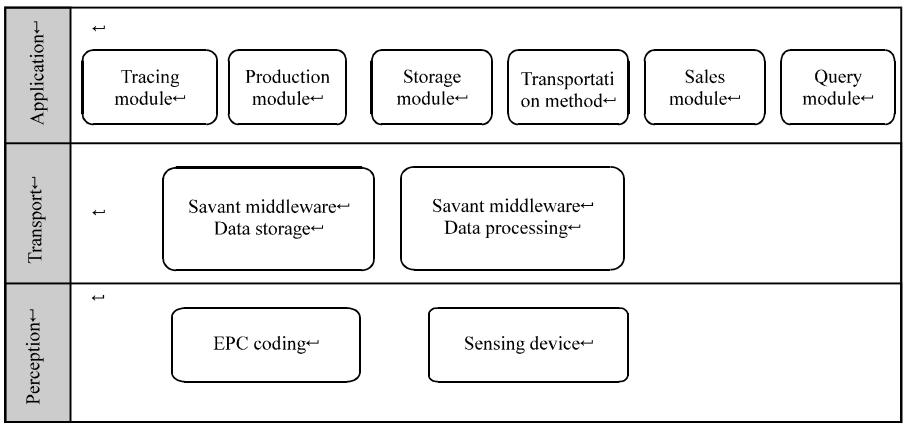

Fig. 1: System architure

Food production management module includes food production process management and food packaging management.

Food warehouse management module includes food in-out put warehouse management and food storage process management.

Food transportation management module includes food transportation process management.

Food sales management module includes wholesale market sales management, farmer's market sales management and supermarket sales management.

The query module food traceability includes website query, terminal query and mobile query.

Specific system application layer architecture is as follows in Fig. 2.

Transport layer: The core of transport layer is the middleware of Internet of things, including the two modules of data processor and data collector. Data collector module realizes the control of data collection equipment through the integration of the interfaces from data acquisition device manufacturers, publishes the equipment's invoke event at the same time, makes the business system complete the data collection for the equipments in the mode of event subscription and then realizes application independence. Data transmitter provides definitions for data filtering rules and functions of distribution and management, achieves internal and external filter for redundant data and provides routing strategy definition on network channels and the upper application. According to routine strategy, data will be sent to different top business systems by using different network channel.

Perception layer: Perception layer mainly collects data, codes data electronically, produces unique EPC coding.

Based on the RFID, Qr code technology, it also monitors the related site activities of food production on time, collects, transmit and manage image data and EPC coding data. Thus, the perception layer puts data acquisition and tracking through the whole flow of food production, processing, transportation, wholesale and retail. All the data of the food safety traceability system comes from the first line.

System establishment

System architecture: It adopts three-layer architecture: user interface presentation layer (USL), Business Logic Layer (BLL) and data access layer (DAL):

- **User interface presentation layer (USL):** Mainly for accepting the user's request, returning data and providing the client with access application

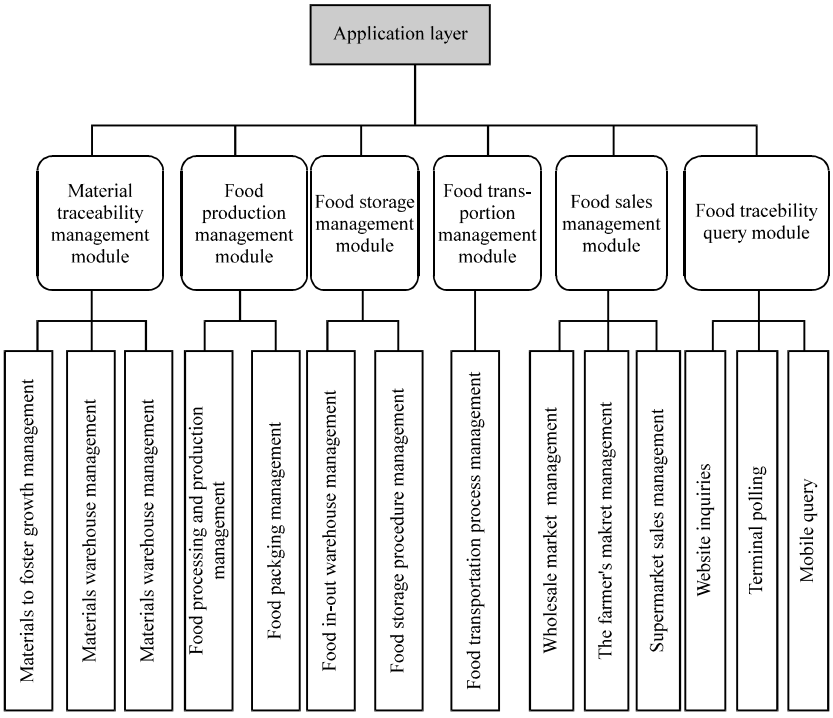

Fig. 2: Application layer

- **Business logic layer (BLL):** Mainly responsible for the operation of the data layer. That is the combination of some data layer's operations
- **The data access layer (DAL):** Mainly refers to operational layer for the original data (such as the forms of data storage like database or text files), instead of raw data. It provides data services to the business logic layer and presentation layer

System standards: It mainly includes RFID, Qr code standard and can be divided into four categories: technical standard, data content standards, consistency standards, application standard. The standard contents related to Food safety traceability information have: commodity bar code (GB 12904), the time representation (GB/T 7408), date element, information exchange format and data exchange date and specification and standardization of the information technology data elements (GB/T 18391 2002), etc.

Data processing and storage: In a typical food supply chain, the first thing needs to buy are raw materials, then manufactures products in one or more factories, after that products will be transported to the temporary storage warehouse and then shipped to retailers or customers. Supply chain involves a number of different types of enterprises or many enterprises of the same kind of type. From the network environment, the food supply chain is cooperation between different merchants or different departments of one merchant in the network computing environment. It is not only the combination of hardware and software but rather is a complete system of network application. Through the mobile Internet, it connects all parties of business activities, including suppliers, manufacturers, distribution centers and customers and makes the information of different databases from all parties of business activities realize the data sharing. Because the Internet of things system in EPC data is very large, data transmission and management is a big problem. So we use the Savant middleware for data processing and data storage

- **Savant middleware Dou *et al.* (2012):** Savant system adopts distributed structure, organizes and manages data flow with the hierarchical organization, has functions of data collecting, data filtering, data integration and transmission and so on. So that useful information can be transferred to the enterprise backend applications or other Savant systems. Each Savant system distributed at all levels of the supply chain node, such as production workshop, warehouse, distribution center and retail stores, even on the transport. Each level of Savant system will collect, store and process information and communicate with other Savant systems. A Savant system running in the store, for example, may have to notify the distribution center that it also need other products, then the Savant systems in the center of the distribution informs that a batch of goods has been shipped on a specific time

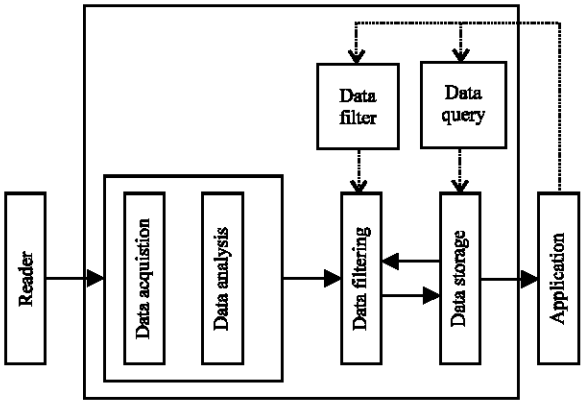

Fig. 3: Data processing and storage of savant middleware

- **Data processing and storage of savant middleware Bai and Hui (2012):** Savant middleware completes the data collection and data analysis by read and write interface and then filter data and store data. Refer to Fig. 3. In Fig. 3 the filter not only can filter the redundant data, can also filter high levels of food information combined with user requirements

CONCLUSION

The application of The Internet of things in the food security is still in the stage of exploring. At home and abroad, mature business model only involves parts of agricultural and animal products. According to the present situation and various basic conditions of China's Internet, applications of Internet of things in the field of food safety is still has a hard way to go. However, the Internet of things will play a positive role on our country's economy through the joint efforts of all aspects.

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