

## Research Article

### Logistics Tracings in Food Safety Emergencies Based on the RFID Technology

<sup>1</sup>Xie Dong, <sup>2</sup>Xiao Jie and <sup>3</sup>Wang Pin

<sup>1</sup>Department of Information Science and Engineering, Hunan University of Humanities, Science and Technology, Loudi 417000, China

<sup>2</sup>Department of Information Science and Engineering, Hunan First Normal University, Changsha 410205, China

<sup>3</sup>School of Mathematics and Information Science, Guangxi College of Education, Nanning, Guangxi 530023, China

**Abstract:** It is difficult to locate questionable foods in food safety emergencies, this study builds a food logistics framework from producers to retailers based on the RFID technology and designs a food logistics tracking systems, which transfers and tackles underlying data from logistics nodes. Tracking queries get IP addresses of logistics nodes from the address resolution service system by Internet. The queries are decomposed and composed to obtain and synthesize data from all the underlying data sources to trace food information for effectively tracing locations of questionable foods. The work is very important to prevent more spreads of food safety emergencies.

**Keywords:** Food safety, logistics, RFID, tracing

#### INTRODUCTION

According to the World Health Organization estimations, foodborne illnesses caused by food safety issues consumers are on the rise in the world (WHO, 2014). In China, food safety accidents are serious threats to public health. However, in the event of food safety emergencies (such as "Melamine Milk" event), current food circulation systems lack effective tracing mechanisms. As a result, it is difficult to quickly and accurately locate questionable foods which are distributed to other communities, so we are unable to recall questionable foods, which can lead to the further spread of food safety emergencies.

Food supply chains are still on the traditional transportation modes (Wu, 2011; Su and Wu, 2010) and foods are highly perishable and contaminated in the logistics process. Food manufacturers and logistics companies tend to care only about operating costs and they are weak to monitor food safeties in logistics processes because they are lack of restraint mechanisms. "Melamine Milk" incident has exposed the manufacture and circulation of food logistics and other aspects of the vulnerability, which causes the problem food to easily enter circulation. The food logistics tracking has become an urgent which need to be addressed the food safety issues. Establishment of the food logistics tracking system is an important means of monitoring food safeties and it is an urgent need to develop related technologies to quickly and accurately

locate location-specific and timely recall of questionable foods for preventing the further spread of food safety accident.

RFID (Radio-Frequency Identification) (Meng *et al.*, 2014) is a non-contact automatic identification technology with a lot of advantages such as waterproof, anti-magnetic, resistant to high temperature, long life, long reading distance, data encryption, storage of large volumes of data and changeable information. The simultaneous recognition of multiple targets can be achieved. The RFID system consists of readers, electronic tags and processing systems. A reader launches a particular frequency RF signal to the electronic tags to get the tag data and the reader receives reading data and transmits them to the processing system to make the appropriate treatment (Zhao and Yang, 2013).

In recent years, RFID applications are increasing in the supply chain (Ilic *et al.*, 2009). RFID applications can track objects to find the current and historic locations of objects, interval between different locations via the Internet according to object location information of different logistics nodes in the supply chain (Roussos *et al.*, 2009). This technique can make the necessary intervention in a timely manner under the circumstances (such as recall questionable foods) and can radically change the ability to monitor the world around us. In the food logistics tracking, RFID is able to monitor the food production and food safety factors

**Corresponding Author:** Wang Pin, School of Mathematics and Information Science, Guangxi College of Education, Nanning, Guangxi 530023, China

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and provides a transparent management of the food safety in the food logistics.

At present, the logistics tracking technology based on RFID is still at the initial research stage. Previous studies (Zhao and Xie, 2007; Sun *et al.*, 2014) use the GIS technology to design emergency systems for the food logistics safety management, but the GIS technology is difficult to locate and navigate to the end of the supply chain. More recently, Wang *et al.* (2013) uses the RFID technology in the food safety tracing, but they are difficult to provide a unified interface in supply chain logistics node for effectively processing heterogeneous information.

This study will focus on the urgently development of the logistics tracking technology in food safety emergencies and design a food logistics tracking systems. The system can quickly and accurately locate questionable foods for tracking and recalling questionable foods in the supply chain. The system also improves the traceability of questionable foods in food safety emergencies and protects the public health.

**Logistics tracking problems in food safety emergencies:** Food logistics consists of manufacturers, distributors, wholesalers, retailers and consumers. Food logistics is the process from the manufacturer to the consumer through transport, storage, packaging, handling and distribution. Chinese logistics industry speeds up food storage, manufacturing and transport

infrastructures and builds the basic framework of food logistics services.

Figure 1 shows a food supply chain from the manufacturer (Shenzhen) to the consumers (Wuhan) and the consumers (Changsha). The manufacturer (Shenzhen) uses the container to load C1, C2, C3 and C4 and they are uninstalled and redistributed in the dealer (Guangzhou). C1 and C2 are sent to the wholesaler (Wuhan) and C3 and C4 are sent to the wholesaler (Changsha). The wholesaler (Wuhan) sends C2 to the supermarket (Wuhan) and the wholesaler (Changsha) sends C3 to the supermarket (Changsha). Eventually, the foods of the boxes are sold to consumers.

If foods purchased by consumers in C2 cause food safety emergencies (foods are contaminated), we require not only track locations of other questionable foods in C2 and recall them in time, but also track other questionable foods in C1 (C1 and C2 are in the same big box in the logistics process). If the food in C1 is not contaminated, it is not necessary to track other questionable foods; if the food in C1 is not contaminated, it is not necessary to further track other questionable foods in C3 and C4 in the upstream supply chain. However, it is difficult to quickly track questionable foods of the logistics nodes because of the lack of unique identification for food logistics system.

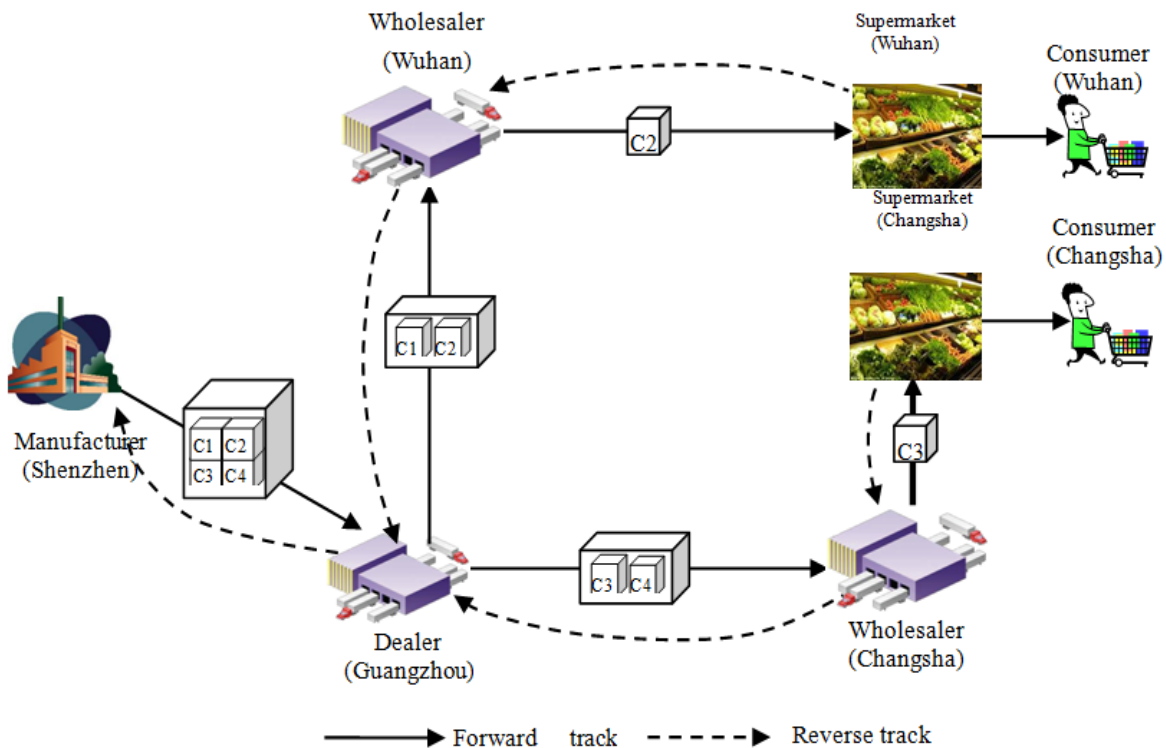


Fig. 1: A food supply chain

## **METHODS FOR TRACING QUESTIONABLE FOODS**

It is difficult to foresee food safety emergencies, which has a huge social impact of unforeseen events affecting the public safety. We need to immediately start incident emergency plans and take appropriate contingency measures, which calculate mass RFID data to track questionable foods via different nodes in the information systems of the supply chain. In addition, the measures track questionable foods from the same batch with the same packages and quickly determine the specific locations and other questionable foods and recall in a timely manner. As a result, this may prevent further spreads of the influences and minimize the impacts of food safety emergencies (Liu, 2013).

The RFID technology in food safety emergencies plays a vital role. Food safety monitoring to track locations of questionable foods need to establish effective mechanisms and a food logistics structure for tracking and processing methods based on the RFID technology. We need to make manufacturers, distributors, wholesalers and retailers as nodes of information corresponding to the information processing systems to achieve the full tracking of questionable foods throughout the supply chain.

We need to use RFID to track other specific locations and timely recall of questionable foods when a food safety emergency occurs. Generally, there are three tracking methods.

**Forward track:** The forward track is in the same direction with the food distribution. Manufacturers track questionable foods from upstream to downstream in the supply chain when food safety emergencies issue, that is, manufacturers track the locations of other questionable foods and recall them in a timely manner from manufacturers, distributors, wholesalers to retailers.

**Reverse track:** We track questionable foods from downstream to upstream in the supply chain when consumers buy foods and discover security issues, that is, we track the locations of other questionable foods and recall them in a timely manner from retailers, wholesalers, distributors to manufacturers.

**Bi-directional track:** Bi-directional track is a hybrid form with the forward and reverse track. When food safety problems are found in the middle of the supply chain (such as distributors, wholesalers and other logistics nodes), it is necessary to track the locations of other questionable foods and recall them in a timely manner from the downstream of the logistics nodes (e.g., retailers) and the upstream of the logistics nodes (e.g., manufacturers) in the supply chain.

To achieve the transparent track in all logistics nodes such as manufacturers, distributors, wholesalers and retailers, we must insert RFID and write

information about each layer from the origins of food productions from manufacturers to retailers. Manufacturers join the RFID tags and write production place of food raw materials, producer, production date and packaging information; dealers write dealers, the date of purchase, distribution, packaging and other information; wholesalers write wholesalers, the date of purchase, packaging and other information; retailers write dates of write retailers, the date of purchase, packaging and other information.

## **TRACKING SYSTEM**

If the tracking system is maintained by the one of logistics nodes in the supply chain, the relatively closed system is unable to adapt to the Internet-based flexible application environment. If a food safety emergency occurs, it is difficult to quickly and accurately track the foods for closed systems. Since all logistics enterprises correspond to information systems in the current supply chain and the logistics environment is relative complex, so we must combine information systems of all logistics enterprises to establish the logistics track system based on RFID. We also consider the data standard interface and the compatibility of information systems in the logistics node enterprise, so food track queries can find specific location of questionable foods by Internet in the supply chain.

We design a food tracking system based on the RFID technology. The system framework includes the query processing, the data processing and the address resolution service. The local application systems of manufacturers, distributors, wholesalers and retailers accordingly process RFID electronic label information (e.g., production date, shelf life, etc.), which are attached to foods by logistics nodes such as food manufacturers. RFID readers fetch relative food information which are stored in databases of logistics nodes and RFID tag information are registered to the Internet address resolution service system for processing redundant data by the RFID middleware. In order to provide services for RFID application systems, tracking queries use the address resolution service to get IP addresses of information systems in logistics nodes by Internet for determining the exact location of questionable foods (Fig. 2).

**Query processing:** Since foods need a lot of electronic tags, RFID generally use relatively inexpensive electronic tags. RFID readers receive and read the data radio waves by electronic tags. Foods with RFID tags give off electromagnetic waves when they enter the reading ranges of RFID readers and electronic tags generate electromagnetic fields and activate the tags to read and decode RFID tag data by RF module. Moreover, RFID electronic tags receive matching messages with timestamps into the database server for managing and controlling the RFID data.

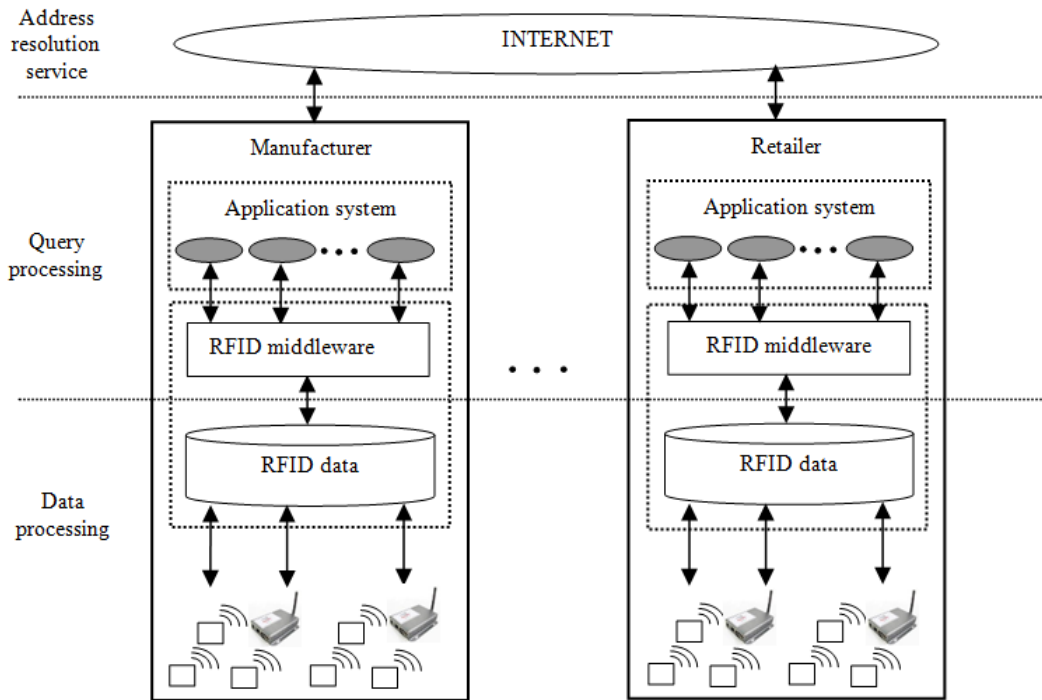


Fig. 2: The framework for the tracking system

**Data processing:** Data processing includes function management, data integration, query decomposition and synthesis and data aggregation and interaction.

**Functional management:** The RFID middleware includes the RFID reader management, the RFID data preprocessing and the RFID database management functions between the RFID data and the RFID system. The functional management enables and disables reading device equipment, filters and eliminates large redundant data and wrong reading data collected by RFID readers to transfer them to the RFID application system; configures addresses, users, passwords and database names of each bottom data sources (due to each logistics node of bottom data sources is completely independent, thus new and original data sources are easy to be processed).

**Data integration:** The query processing needs shield bottom hardware differences and the data integration will coordinate data of each bottom data sources to provide the unified data interface for the RFID application system. The data integration can combine data with different sources and different structure as an integral whole by hiding bottom data details in logic. The data integration also can make user regard integrated data source as an integral whole for data processing, thus this provides a unified data service for enterprises of the supply chain.

**Query decomposition and synthesis:** The query decomposition decomposes tracking queries into performable sub-queries in the underlying databases

and queries execute according to different kinds of data sources corresponding to the drivers for realizing query operations on different underlying databases. According to requests of the user tracking, synthesis and conversions of data are as a final result from the underlying data sources, which are returned to the users through Internet interface for implementing tracking and the data access and exchange of information systems of logistics nodes.

**Data aggregation and interaction:** The raw data are simple information from the RFID readers, RFID data are gathered and processed to provide meaningful information for RFID application systems, produce meaningful event information; then event information are passed into the RFID system and are generated to specification XML data.

**Address resolution service:** The address resolution service includes the RFID information registration and Address parsing and access.

**RFID information registration:** Due to tracking requires access to decentralized information systems of different nodes in the supply chain, tracking requires must be indexed by the address resolution service. RFID tag information attached to foods on logistics nodes such as food manufacturers and the food information are recorded in the local information service system. The RFID information registration establishes relevance between the RFID tag encoding and foods and register RFID tag information to the Internet address the resolution service system.

**Address parsing and access:** Tracking queries issue query signals to the address parsing service system via Internet. The address parsing service system generates recognizable standard strings after it gets RFID information and obtains IP addresses of information system servers corresponding logistics nodes by address parsing and dynamic search. The track queries of the clients access the information systems with IP corresponding addresses logistics nodes to obtain specific location information of questionable foods.

### CONCLUSION

It is difficult to locate questionable foods in view of food safety emergencies. This study focuses on the problems and designs a food logistics tracking system based on the RFID technology from manufacturers to retailers. The system can effectively track specific locations of questionable foods in the circulation. This is great significant for preventing the further spread of food safety incidents. Next we will combine wireless sensor networks, GPS and GIS technology to further extend the functionality of the system.

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