ISSN 2409-2665
Journal of Logistics, Informatics and Service Science
Vol. 1 (2014) No. 2, pp. 55-67

System Design Based on MAS & RFID Supplied for Traceability of Swine Supply Chain

Huidan Zhao*, Yong Zhang
School of Transportation, Southeast University, Zhejiang, China
536517175@qq.com; 631407802@qq.com

(*Received Jul 2014, accepted Nov 2014*)

Abstract. To design a traceability system and achieve food safety monitoring is of great importance. Through in-depth analysis of pork supply chain, by using Multi-Agent System (MAS) and Radio Frequency Identification (RFID), the paper proposed the structure of a pork traceability system and investigated its constructive measures. A traceability system that overcomes information asymmetry and node heterogeneity can add value to supply chain. Proceeding from the value, the paper provided new thoughts for a win-win situation among consumer, regulator and enterprise on the premise of food safety.

Keywords: Supply Chain, Traceable, Pork, MAS, RFID

1 Introduction

It is undoubtedly a great shock to Chinese who take pork as the main varieties of meat that "Lean Meat Power" event of Shuanghui group co. is exposed on 3.15 special programs in 2011. The fact that meat couldn't get effective supervision in production, processing and circulation, and consumers couldn't purchase quality-assured meat, can be put down to that the problem location on food supply chain is not well-organized. In order to ensure food safety, it's one of the effective solutions to build a traceability system. That is to track and trace food information in each node on the entire supply chain, to form a complete information chain with the flow of entity and to seamlessly connect each node through the use of computer network technology.

The paper would base traceability system on MAS structure, and make full use of RFID technology to identify meat and its product, to reach the goal that the system is reasonably designed and can function smoothly.

2 Literature Review

This chapter would summarize the domestic and foreign research on traceability and consumer behavior, in order to provide theoretical reference and practical basis for the building of system.

2.1 The Domestic and Foreign Research

(1)Domestic research

In recent years, some scholars began to study how to safeguard food quality from the entire supply chain, to promote each participant on the chain to form a risk pooling, benefit sharing, and information changeable operation mode. Xia, et al. discussed security issues in terms of food quality from the aspect of food quality identification system and food supply chain management. Hu, et al. agreed that the new mode of "supermarket + leading enterprises + farmers" can help to guarantee agricultural products' quality and improve the management level. Sun, et al., combined with process management idea, built a agricultural product supply chain quality management system, ensured safety starting from the stages.

(2)Foreign research

Denmark scholar T Moe held that food traceability system could be divided into standard, data, product, information technology and planning, 4 levels in all, and he defined the scope as enterprise and inter-enterprise traceability. Castrol's study suggests that, despite the establishment of traceability system will certainly increase the cost of supply chain, partly increase food prices, but the consumers with relatively high income are willing to bear these costs. Christain analyzed the role of mutual cooperation among enterprises in European pork, beef and grain supply, and discussed traceability system construction under the guidance of food safety. E. W. Schuster played the part of RFID in the supply chain, to trace the food from the origin to the consumer.

2.2 Consumer Behavior in Traceability

Major food safety incidents increased customers' awareness and concerns of food safety risks. Consumers were changing the habits of manual recognition. They demanded the food to be produced in a system that possible sources of risks could be promptly and accurately identified. While food traceability system is considered to be an organism or platform that can deliver food quality and safety information to customer and identify the source of risk.

Gauthier's survey found that consumers' awareness of traceability vary. Most of them prefer to get data in all production stages and are prepared to pay more. They obtained confidence by identify valid information. Gracia and Zeballos investigated Spanish consumers and retailers' attitude towards the EU beef traceability and labeling system. The results showed that they highly agreed the positive effect and the disadvantage is rarely mentioned.

As for consumer expectations, Verbeke and Ward found that consumers expected traceability to be simple information such as quality and source, rather than the detail. Rozes was acknowledged that customers disliked trace back the product through telephone or Internet, instead, they hoped the label offered the exact and minimum information.

By using CVM method, Angulo, et al. investigated the consumers' willingness to pay for traceable beef. The results showed that 75% of the respondents believed that producers are responsible for food safety and the additional costs should not be borne by consumers. While the North American consumers are more willing to pay an extra price. The perception of food safety, consumption, price and income are the main factors to affect consumers' willingness.

2.3 Traceability Development of China

In the aspect of meat traceability, the EU and Japan have the deepest mandatory system. They link the information from the source to the retail stores through the label on final packaging. Australia, Brazil, Canada and other countries have also built their mandatory traceability system. China, in contrast, the relative concerns started late, the food security situation is still grim. However, most of the research stays in the quality management stage, lacking of a systematic and operable embodiment. The paper aims at providing some suggestions from the status quo.

3 Feature and Traceability Demand of Pork Supply Chain

In every link (production, processing, storage, distribution, consumption) of pork supply chain, many risks such as pathogenic micro-organisms or factors, pesticide and veterinary drug residue, environmental pollutants and fungal toxins exist. So food safety of pork is a system control engineering from farm to table. It must be started from the source to prevent and eliminate issues regarding pork safety.

The target of pork traceability system can be summarized as follows, source traceable, production & processing recorded, flow direction trackable, information available, product could be recalled, responsibility could be investigated. Of the 6 goals above, the former 3 ones are inductions of the pork supply chain traceability system's function, while the latter refer to the effect of system.

4 MAS & RFID Demand of Monitoring on Pork Supply Chain

The pork supply chain can be regarded as a network consisting of a set of nodes and relative activities. The nodes can be breeding, slaughtering and processing, transportation, sales enterprises or departments participating in these activities. From the view of interconnection of information systems, each node of supply chain traceability system has its own information system and the systems are self-contained. The information sharing and business interaction problems are the current barriers to implement traceability. Whereas Agent technology is an effective method for heterogeneous systems to achieve interoperability. From the view of modular theory of management, the supply chain traceability system can be taken as a unified system, each node being a module of the entirety. Each module is independent of the other. However, they need to work with the other. The every module does not have to make it clear how the other ones work, just to know its own mission and how to be called. It's known that Agent technology is the best tool for modular design.

RFID-based electronic identification is not only easy to use, but has long reading distance and high data accuracy compared with barcode. What's more, it is available in the whole process, which defeats the latter two identification methods. So RFID has the best prospective. Yet it remains initially applied for cost constraint.

5 Traceability System Framework Based on MAS & RFID

When it comes to building the traceability system, the applications of MAS and RFID have different priorities. MAS is mainly used to support the overall structure, while RFID plays the role of channels of information transmission among the subsystems. Both are the theoretical and practical basis of the traceability function.

5.1 Overall Framework

After analyzing pork supply chain, the author divides the whole process (from animal feeding to the final consumer) into the following stages, breeding stage, slaughtering and processing (including preliminary processing and further processing) stage, transportation stage, sales stage. Figure 1 illustrates the function framework of the system.

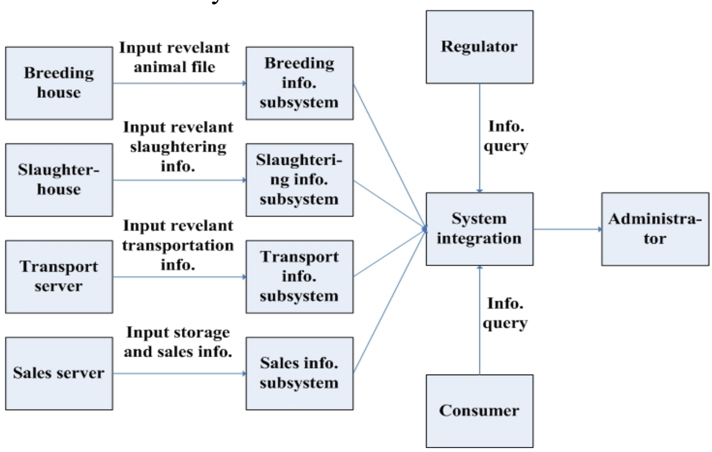

Fig. 1. The concept of system function

At each node in the supply chain, setting up their own sub-MASs (including breeding MAS, slaughtering and processing MAS, transportation MAS, sales MAS) to maintain the links among the nodes. The sub-MASs, coordination Agent as their center, constitute a federal structure. The coordination Agent is the interface between traceability MAS and each sub-MAS's Agents. Figure 2 illustrates the MAS-based traceability system framework.

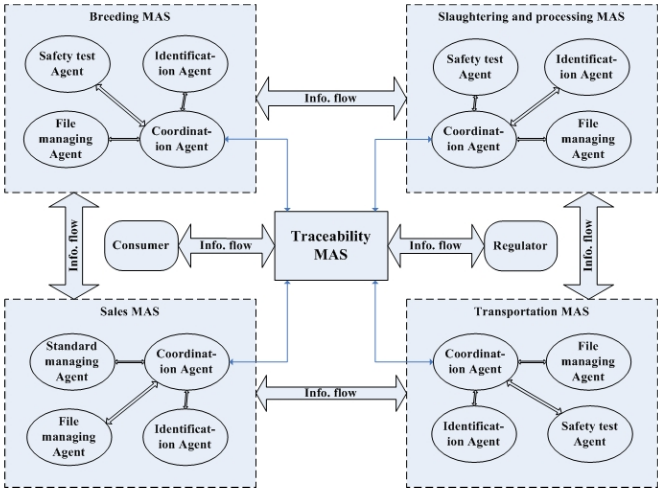

Fig. 2. The traceable MAS framework.

5.2 Subsystem Structure

RFID technology plays an important role in the operation of each sub-MAS. Among the four subsystems (breeding, slaughtering and processing, transportation, sales) , in addition to the first one, for the remaining subsystems, only when the information on RFID is completely consistent with the information of the former subsystem, can the relative information of their own be input into RFID tag and data center. In this way, food safety supervision department as well as the parties involved can carry out regulatory and query on the data. Then the traceability of pork can work.

(1)Breeding subsystem

Breeding MAS contains 3 sub-Agents (not including interface). Figure 3 describes its corresponding function.

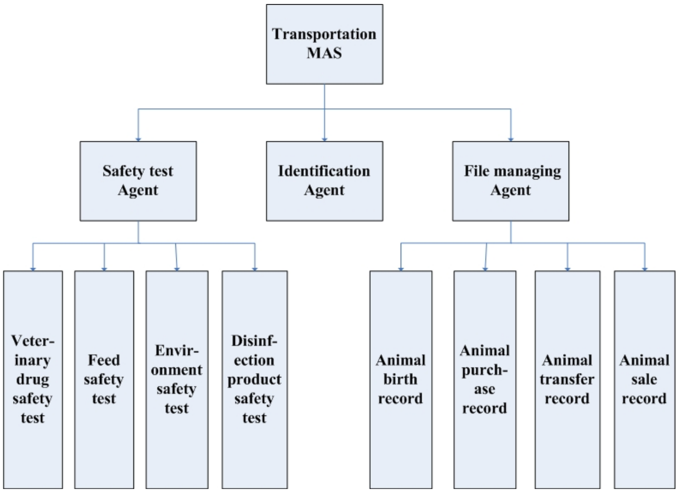

Fig. 3. The structure of breeding subsystem.

The use of RFID in this subsystem mainly helps for information entry work. By handheld devices, the breeder timely transmit information such as feed, immunization, quarantine to RFID tag placed on swine, and to data center. The following tips need to be paid attention to in this subsystem.

The information entried in RFID tag and data center should include the detection information of harmful and limited substances in the feed to protect the quality of pork from the source.

The information entried in RFID tag and data center should include the swine's disease treatment and medication. When the breeder accidentally select the banned drug stipulated by the state, sound the alarm.

RFID tag must be a throwaway safe tag which couldn't be used again upon removal. Strictly avoid some breeding house reusing the tags on the sick or dead swine.

(2) Slaughtering and processing subsystem

Slaughtering and processing MAS contains 3 sub-Agents (not including interface) . Figure 4 describes its corresponding function.

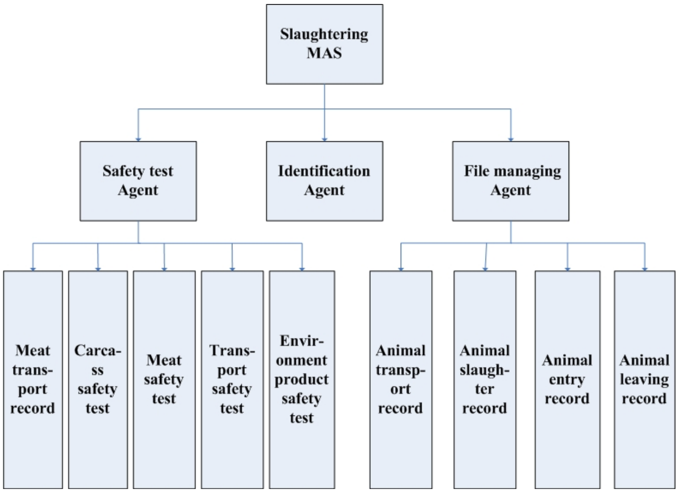

Fig. 4. The structure of slaughtering and processing subsystem.

The use of RFID in this subsystem mainly helps for information fetch and entry work. The control key of this subsystem lies in adding new number into the RFID tag after slaughtering. Identification information such as slaughtering number should be corresponded to column lot. Only in this way can pork be closely associated with swine, and then complete the information traceability in slaughtering and processing successfully.

(3) Transportation subsystem

Transportation MAS contains 3 sub-Agents (not including interface). Figure 5 describes its corresponding function.

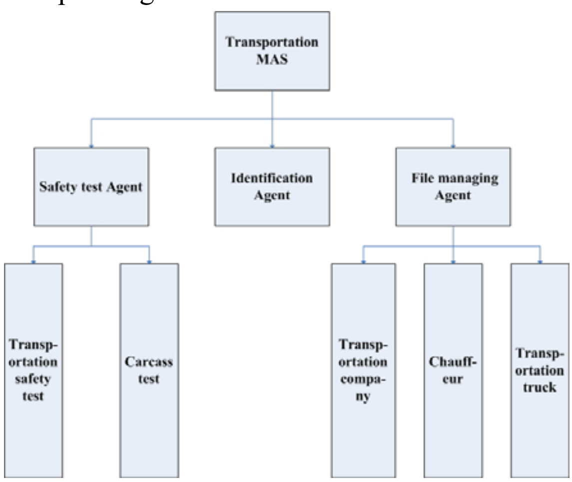

Fig. 5. The structure of transportation subsystem.

The use of RFID in this subsystem mainly helps for information fetch and entry work. After the truck with swine is disinfected, the quarantine inspector guides the car to the monitor and do the inspection. The inspector checks one by one the information of the swine on the car with the health sector's regulatory system with RFID reader. Only when the information from two parts is exactly the same, could the inspector transmit the license plate of the vehicle, truck owner and destination, entry and leaving time of this quarantine station to RFID tags and information center.

(4)Sales subsystem

Sales MAS contains 3 sub-Agents (not including interface) . Figure 6 describes its corresponding function.

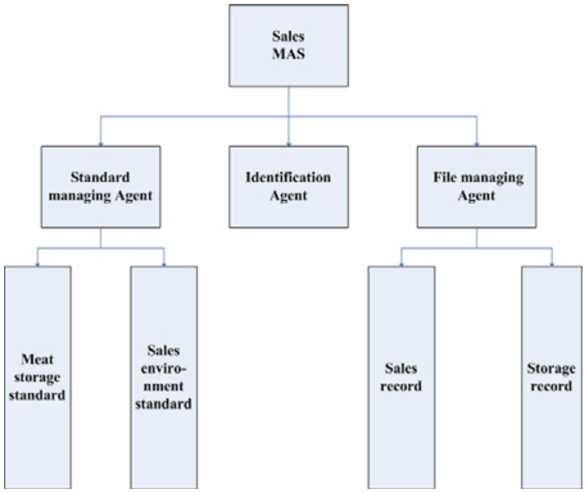

Fig. 6. The structure of sales subsystem.

The use of RFID in this subsystem mainly helps for information fetch and entry work. The transaction data on RFID tag of each piece of goods records the origin, purchase time, safety inspection and quarantine results and other information. This subsystem mainly confirms the exactitude of the information on the electronic tag and the data from information center, at the same time input transaction information on the markets, so as to trace the whereabouts of the pork.

6 Building Measures of Traceability System

To build a traceability system, it is a must to take constructive and operational measures into consideration. The paper would make the analysis from the following perspectives.

(1)To protect the interests of consumers

The existing domestic traceability system only completely open to enterprises on supply chain and partly open to food safety supervision. It can be said that, the crisis of consumers' confidence in food safety is the result of information asymmetry between consumers and links on the supply chain. The system designed in the paper takes the degree of transparency and fluency of information transmission as performance evaluation index. The high level of consumers' participation is the characteristics of it. The advantage of RFID-based system also lies in the feasibility to set reader in supermarkets and stores. By scanning electronic tags on meat products, provide consumer with a information request path (a string of number encoded similar to bar code) . Then building a Internet-based public inquiry platform. Consumers can obtain the information of the entire supply chain according to the need. On the public platform, error function can also be added to perform timely feedback of food safety issues to enterprises, which is of help for enterprises to recall products of the same batch or take other actions promptly after a review. It's a way to protect the interests of consumers.

The feature of this pattern is that it's practicable whether the behavior is of several or of the whole industry. System building and maintenance costs are relatively low. It also has a quite positive effect on branding.

(2)To give full play of retailers' role

Located in the bottom of the supply, retailers associate production and processing with consumers. Only in the sales terminal, with the appropriate equipment and facilities, can consumers inquire the traceability information. Product quality standards set by the retailers play an important part of the quality system in the traceability system. And with a increasingly significant position, retailers can further promote the construction of the system. If the retailers claim a standard for products to be sold, or take traceability as a premise, the suppliers wouldn't be able to ignore their requirements.

(3)To seek rent for enterprises

Enterprise, dominant in the supply chain, is the main part that directly faces the quality test. So, it should be an active promoter of the traceability system. The traceability systems in most enterprises have poor logistics management capacity. Taking pork and its products as an example, the scale development of production is uneven, products' price is relatively low, the level of standardization is not high, which all result in high cost. Therefore, it's of great importance to open up a space of interest for enterprises to perform traceability. So that enterprises could possess the power and strength to maintain the system, (4)To make good use of macro-control

Food security sector can make use of its credibility to encourage traceability system through publicity. Give full play to the efficiency of markets to open up new revenue for this service. And provide the first batch of enterprises to implement the system with quality assurance and certification for the supply chain. Finally establish benchmark enterprises to promote the gradual transformation of the enterprises at all levels of the industry .

Through the improvement of relevant laws and regulations, government can provide an institutional environment for enterprises to develop the systems. Government can take punitive measures (fine or closing factory) to increase the cost of selling unsafe food. The policy to be drew up ought to raise detection degree. Once the external environment produces pressure of quality and safety, enterprises would gain the willingness to strengthen food safety and construct the traceability system.

7 Conclusion

The paper presents a MAS & RFID-based pork supply chain traceability system, suggesting opened to enterprises, consumers and regulators. Nowadays, as the expansion of food safety demand, tracking and tracing throughout the whole journey could improve the value of food supply chain. The enhanced consumers' power of purchasing such security and guaranteed food could bring economic benefit, at the same time contributes to the transformation from the traditional breeding to a modern one, further reducing production cost, thereby forming a virtuous circle. Being able to trace back where problems emerge and take corrective measures as soon as the food quality problems arise, or even before the products entering market when it is found that information cannot match, can make it more promising to pursue food safety control.

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