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RFID Application in the Food Industry: A Case Study of Korean Food Safety Information Systems Project

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RFID APPLICATION IN THE FOOD INDUSTRY: A CASE STUDY OF KOREAN FOOD SAFETY INFORMATION SYSTEMS PROJECT

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Abstract

The main goal of this study is to investigate the opportunities, challenges, and prospects of applying Radio Frequency Identification (RFID) technology to the food supply management context where food safety issue is highly valued. Several key factors and implications have been identified based on longitudinal data gathered from a real life RFID project that was initiated and implemented by the Korean Food Industry Association (KFIA), Ministry of Information and Communication (MIC), National Information Society Agency (NISA) and other major industrial companies. The authors utilize the case study approach that serves well with this research by focusing on the organizational role of RFID. Being in line with the objective of evaluating RFID's potentials as technology enabler, this paper renders the following important findings: item level tagging requires detailed and customized guidelines; standardized system development procedures among stakeholders is critical to the success of RFID implementation; not only does RFID facilitate management operations, when properly communicated, it can also effectively formulate or impact the customer's purchase intention.

Keyword: Radio Frequency Identification (RFID), RFID Application, RFID Privacy, Food Safety.

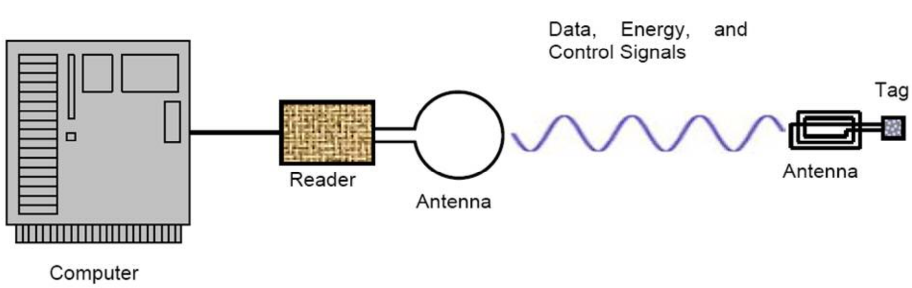
Introduction

To date, food safety regulations and quality assurance issues have been on the forefront as governments and public agencies (e.g., the Food and Drug Administration in the U.S.) globally assume critical responsibilities. Regulations are becoming increasingly stringent, as consumers' awareness on quality and safety issues has heightened due to an unfortunate chain of food safety outbreaks across the U.S. and worldwide. In 2006, the outbreak of E. coli bacteria tied to fresh-bagged spinach not only affected over 200 U.S. citizens, caused 3 fatalities, but also produced a disastrous economic loss to the agricultural industry in California, where the outbreak originated (Nall and Hoffman 2006). Back in 2005, the Bird Flu pandemic affected more than eight Asian countries, from China to Japan, Vietnam and other countries, which served as evidence of the difficulty in tracking or controlling the disease-affected food circulation across international borders. Moreover, disputes among international trading partners can stem from food safety issues. Attempting to prevent the spread of the mad cow disease, the Korean government's ban on imported American beef has been considered a breach of the Free Trade Agreement (FTA) by the U.S. counterpart. These cases lend themselves to call for a need of effective solutions to assist in food safety administration, one of which is the RFID. It has been argued by practitioners that RFID has the capability in tracing products throughout the entire lifecycle (Hecker 2005). In the U.S., the FDA calls for RFID usage in drug industry to enhance and maintain drug safety level and fight against potential threats such as bioterrorism and counterfeit medications (Chater 2006). It has been argued that RFID has the potential to fundamentally change and improve the supply chain management of the drug industry by tracking and handling the products delivered to consumers (Shim et al. 2006).

The management of short shelf-life and perishable goods poses specific challenges to product traceability and storage (Karkkainen 2002). In response to the need for more powerful food safety assurance and control medium, Korean public agencies and private sectors launched the project of Food Safety Information Management Systems (FSIMS). To reach meaningful insights implied in this project, both program implementation and effects from case studies are utilized in this paper. The former helps researchers to estimate the compliance between actual implementation and program intent, hence, pinpoint problems coming into existence, whereas the latter attempts to measure effects of the program and infer reasons for its success or failure. Although a case study, when serving as a research strategy, can be based on any mix of quantitative and qualitative evidence (Yin 2002), it is our intention to emphasize the qualitative side of the approach since the organizational role of RFID is of interest. In addition to looking at traceability, this study also explores the potential of RFID in a ubiquitous environment that contains other technologies (e.g. hand-held PC). In general, the authors aim to provide a systematic view of such events, through which a sharpened understanding is obtained in respect of why RFID is an important avenue to protect food safety and facilitate corresponding management activities. This paper provides researchers and practitioners with a referential guide in terms of drawing upon successful practices and experiences.

Overview & Prior Research in RFID

RFID provides real-time data with remote tracking capabilities for an item or produce, via an attached tag containing a small microchip and an antenna. Inside the tag is stored detailed identification and descriptive information about that item (Shim et al. 2006). With RFID, the authorities can now track the origin of certain produce, which will help them eliminate goods in an event of a health crisis. As shown in Figure 1, a description of RFID system structure contains a transmitter (tag) and a receiver (a reader that transfers data over the network). Depending on the energy source, tags can be categorized in: active, passive, and semi-passive. Active tags rely on the battery energy that it carries. Passive tags receive energy transmitted through radio waves between tags and receivers while semi-passive tags adopt a hybrid of passive and active modes. Active tags have stronger signal strength; thus, longer ranges than passive tags, in which the manufacturing expense is not as high as that of active tags (Asif and Munir 2005).



Source: Shim et al. 2006

Figure 1. RFID System Structure

The origin of RFID technology can be traced back to 1940s during World War II; however, it was not until 1973 when the first patent was filed by Charles Walton, who was considered the father of RFID (Takahashi 2004). Due to the high cost of adoption, the usage of RFID is limited to a few ways, including the automated toll-paying systems along the U.S. east and west coasts (Asif and Munir 2005). Over the last two decades, the benefits of RFID have received increasing attention and valuation as the business process diversifies and globalization overruns. At the same time, technology evolution has driven the manufacturing cost of RFID to an operationalizable range. The global sales of RFID systems and software were estimated to reach $2.1 billion in 2005 with a compound annual growth rate of 37% since 2003 (Davis and Luehlfing, 2004). Industry players such as Wal-Mart, Target, Lowe's required their respective suppliers, partners, and intermediates to enforce RFID implementation through the business process re-engineering. RFID applications suffice when rich information exchange occurs and the feasibility of implementing alliances is entailed in a supply network (Lee and Padmanabhan 1997; Straub and Rai 2004). Cost reduction can be realized when minimizing the loss the information during the process of product/service transmission. For instance, the General Accounting Office reported in 2003 a $ 1.2 billion discrepancy between the material supply and the actual material supply received by Army in Iraq (Tegtmeier 2004). Wal-Mart projected to save millions through efficient distribution in logistics by implementing RFID systems so as to maintain its edge in low-cost practices innovation. Although problems and doubts hinder such a technology leap, competitors follow Wal-Mart's futuristic vision in that RFID has emerged as an option to rationalize how firms conduct business and provides solution to current woes generated by poorly designed/communicated logistic procedures.

There is a plenty of literature on RFID research, whose major themes allocate in: artifact (Dipert 2004; Harrop and Das 2004), privacy (Lee and Hunt 2005; Neumann and Weinstein 2006), and synergy (Asif and Munir 2006; Janz et. al 2005). These studies are rooted in either the technical or organizational role of RFID. We attribute such "plethora" phenomenon to the rich potential as well as the profound impact of RFID application in changing a wide range of business operations and concepts. These applications can be found in: electronic payment (Krauss 2002); retail and logistics (Bednarz 2002), automotive manufacturing (Lawrence 2000); homeland security (Werb and Sereiko 2002); fashion industry (Loebbecke et al. 2006); and health care industry (Janz et al., 2005) etc.

The Food Safety Information Management Systems (FSIMS) Project

Preventing and controlling the damages and social consequences of food safety outbreaks are treated as critical responsibilities of governments across many countries. Several widely known serious incidents occurred in recent years: the Bird Flu affected 10 Asian countries and caused 20 fatalities; Mad Cow disease spread across the member countries of EU; Genetically Modified Organism (GMO) corn called StarLink which is permitted only for animal feed is used for human consumption. Therefore, food safety threats facing international trade partners increase as the global economy becomes more interconnected. The number of countries which engaged to FTA has increased; the openness of agriculture food market has enlarged leading to increased possibilities to import the harmful agriculture or daily products, such as GMO food or heavy-metal residues in food.

Korean Food Indistry Association (KFIA) launched the project to help customers by providing useful information on food products. The project was coordinated by KFIA and cooperated by 6 food manufactures. We contacted the technicians in each company, who took charge of managing the system or server as well as the official staffs in KFIA who planned and controlled the project. We had phone interview with them to identify the key stones such as purpose, schedule, system design, and test result of new system. Since our purpose was to see the blue print of the project, we assigned more time to have interview with KFIA staffs. Technicians in each food manufacturer only involved in technical parts and were not aware of the flow of the project. The main duty of the technicians were designing and constructing servers in their own manufacturing company. Another reason to focusing KFIA staffs was that all materials and data of each manufacture were reported to KFIA and staffs in KFIA synthesized them. We were so restricted in accessing data since the KFIA is governmental organization and the staffs were required to get permission from their supervisor to answer questions in interviewing, So we constructed the questions based on the final report of the project. We used funnel structured interview method which is to start with generalized questions and to end with specific questions.

Background

This project aims to construct the information infrastructure in analyzing the cause of food safety outbreak and taking the proper action through food tracking systems which the food manufacturers, logistics, and retailers can access and share food product information. It also assesses the effectiveness of RFID implementation, thereby directing efforts to consider rising demand for food safety from the society. The project coordinator is the Korean Food Industry Association while public agencies and organizations include Ministry of Information and Communication and National Information Society Agency. The project is supported by primary industrial participants who constitute leading market share of the Korean food supply market. These companies include Nong-shim, Mega Mart, Dongwon Industries, Dongwon F&B, C&J Group, and Paris Baguette (see Table 1). The schedule for project implementation is listed in Table 2.

Table 1. Test participating companies and products

Industry	Company Name	Product / location
Food Manufacturer	Paris Croissant	Andersen Cake Moca Java Cake
	CJ	Instant steamed rice(210g)
	Nong-shim	Shin raymen (noodle)
	Dongwon F&B	Green tea PET 350ml
Logistics	LOEX	Yang-san logistics center
Retailers	Paris Baguette	Seoul Su-seo branch
	MEGA Mart	Busan Dong-nae branch

Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

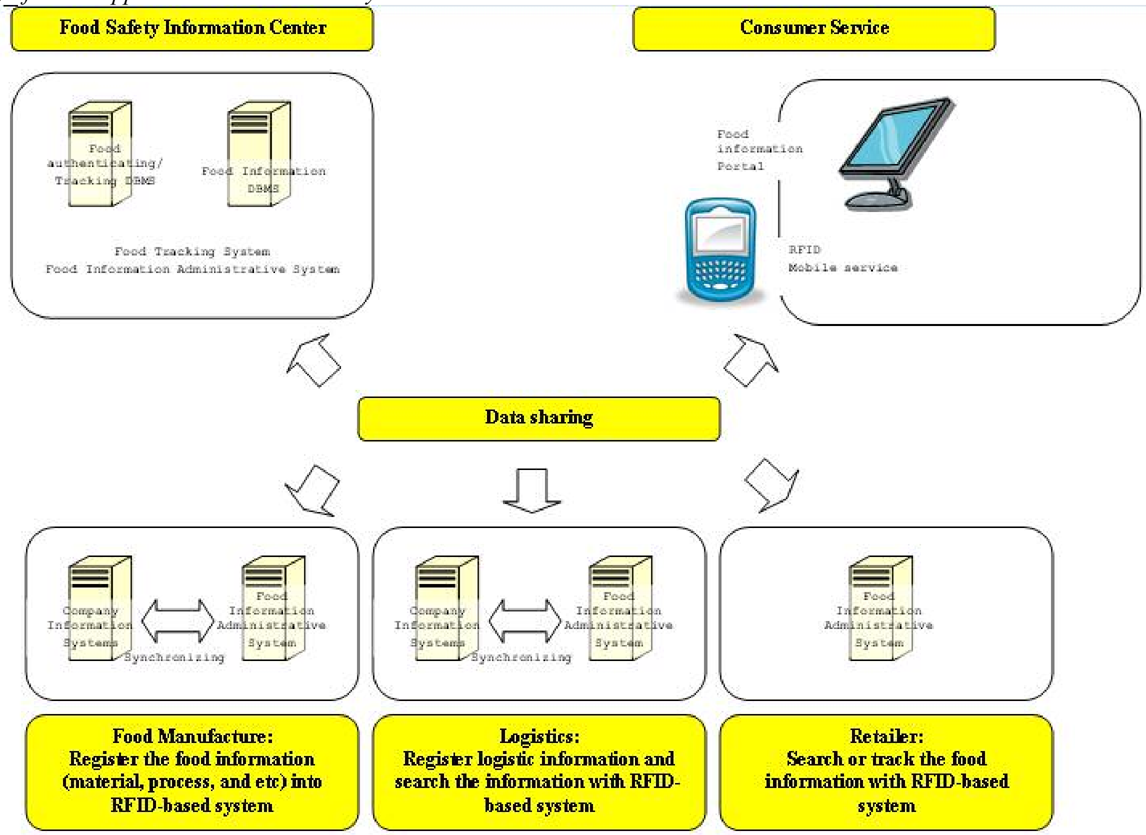
Table 2. Schedule Chart for FSIMS Project

	June				July				August				September				October				November				December			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
System Developing	**Planning and Analyzing** - Project workshop - Interview with participating firms - Requirement analysis - Analysis report							**Designing** - System design - Interface design - Database design - Design report			**Developing and Testing** - Program development and test - System synchronizing test (between center and participating firms) - System performance test - System manual documentation												**Model operation** - User/Operator training - System stabilization - Maintenance					
Systems/Equipments installing			Environment analysis					Equipments/Internal Test						External Test		Installation			Testing and Customizing				Model operation					
									▼Equipment ordering						▼Tag improvement													
						Preparing development (e.g. equipment entering)					System Developing									System test/operation environment setup			Model operation					
							▼Equipment ordering													▼Sever transfer								
Code standardizing			Strategy establishment				Environment analysis					Development Model establishment						Execute planning				Project advertisement						
Quality supervising				▲Meeting for checking											▲Middle supervision									▲Final supervision				

Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Systems Design & Key Components

The RFID-based information system for food safety supported by KFIA serves as a valuable practice in demonstrating how RFID can be incorporated with wireless and mobile device, such as cellular phones. The customer and supplier can track forward and back to the origin. Additionally, RFID tags can allow for food manufacturers and retailers to quickly be notified and retrieve spoiled produce, hence preventing food outbreaks. The design is presented in Figure 2.



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 2. Components and Design of FSIMS Project

There are twenty four administration processes designed in this project:

- Food authentication/tracking administrative system: 5 processes
- Standard food information administrative system: 9 processes
- Mobile service system: 3 processes
- Food safety information portal system: 7 processes

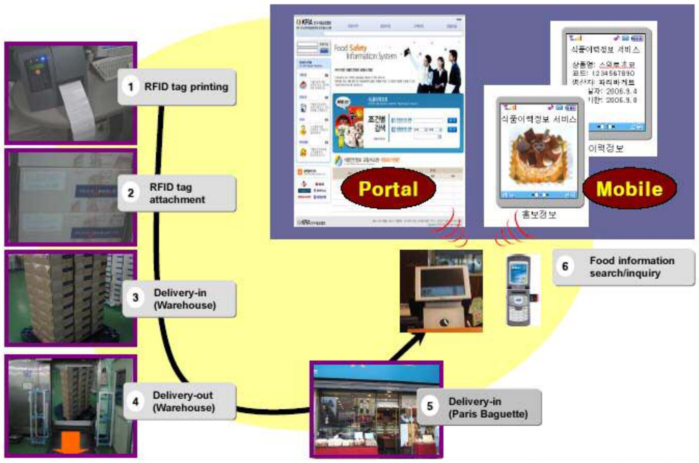
The project is composed of the following key components:

1) Food registration and tracking system, which is designed and implemented to realize food authentication and registration. It also conducts food information search and tracking service which enhances the process of retrieving spoiled products and product claim administration.
2) Standardized food information administrative system involves food production information and tag administration, management of product warehousing and sales administrating, synchronizing the systems to the intermediate systems of participating companies, and RFID equipments installation.
3) Food safety portal and food information mobile service, which provides food information searching and tracking service, builds Food Safety Information Center and mobile-related service that stores/disseminates food information, commercials, relevant information etc.
4) Standard food information systems installation, ISP, and project advertisement adjust registration guideline, law, and institution, develop the standard RFID definition, code system, and design, and publicize the project with Video on Demand (VOD) introducing the RFID-attached products.

The responsibilities of afore mentioned centers are further articulated as:

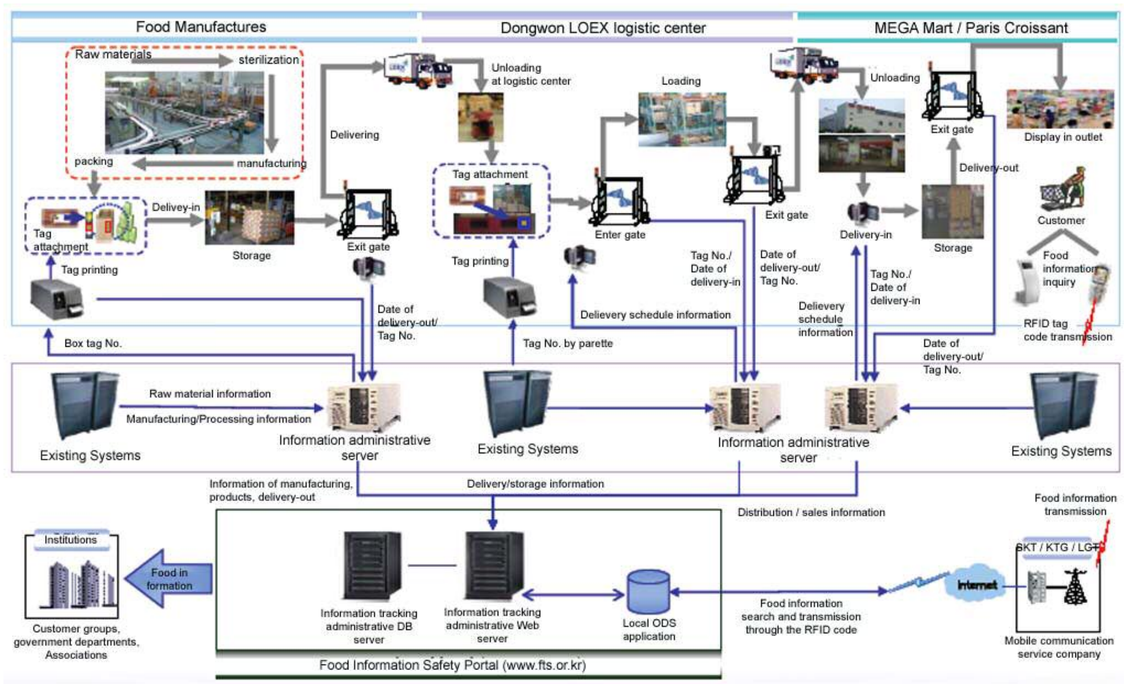
- Food Safety Information Center
  - Developing the RFID code contained tag
  - Developing the mobile link module
  - Developing mobile query interfaces
- Mobile Service Center
  - Developing exterior RFID reader for mobile
  - Developing the wireless platform
  - Developing the interface for mobile phone

To illustrate how projected systems should work, we describe the operational model in Figure 3 using company Paris Baguette as an example. Work flows are delineated in Figure 4. In addition, Figure 5 describes how actual systems are installed and interconnected.



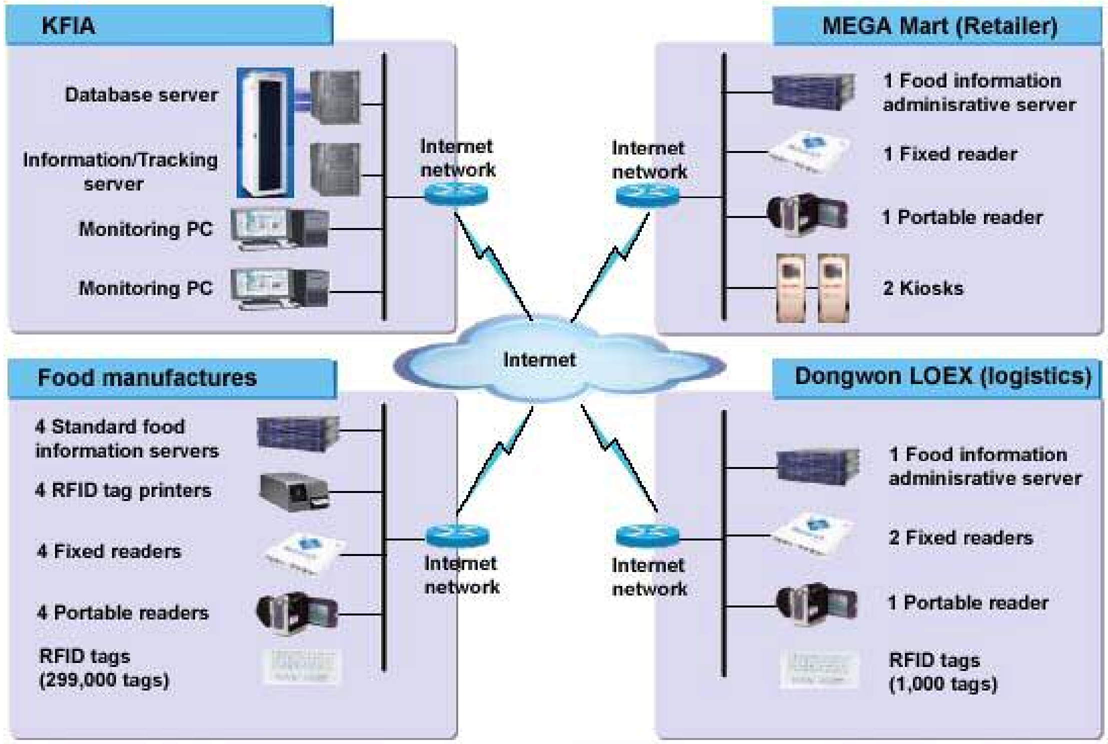
Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 3. Operational Model of FSIMS Project



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 4. Work Flow Diagram



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

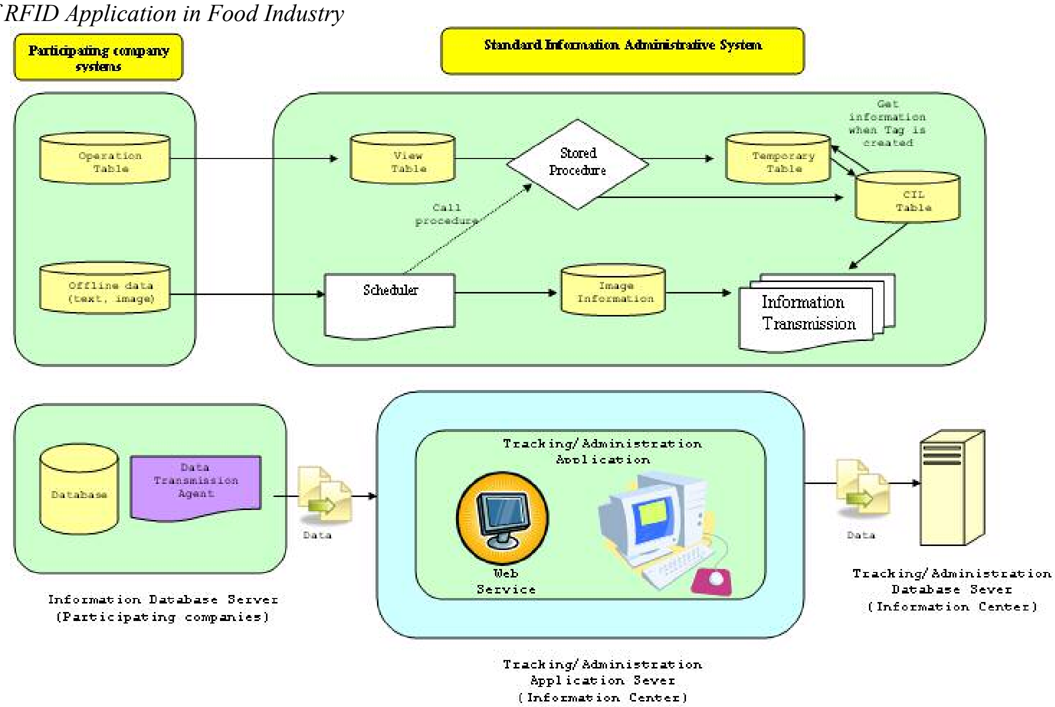
Figure 5. Systems Installation

Systems Construction & Interfaces

All together there were four systems constructed and tested in this project. They fulfill their respective functions as food authentication /tracking administrative system; standard food information administrative system; mobile service system; food safety information portal system.

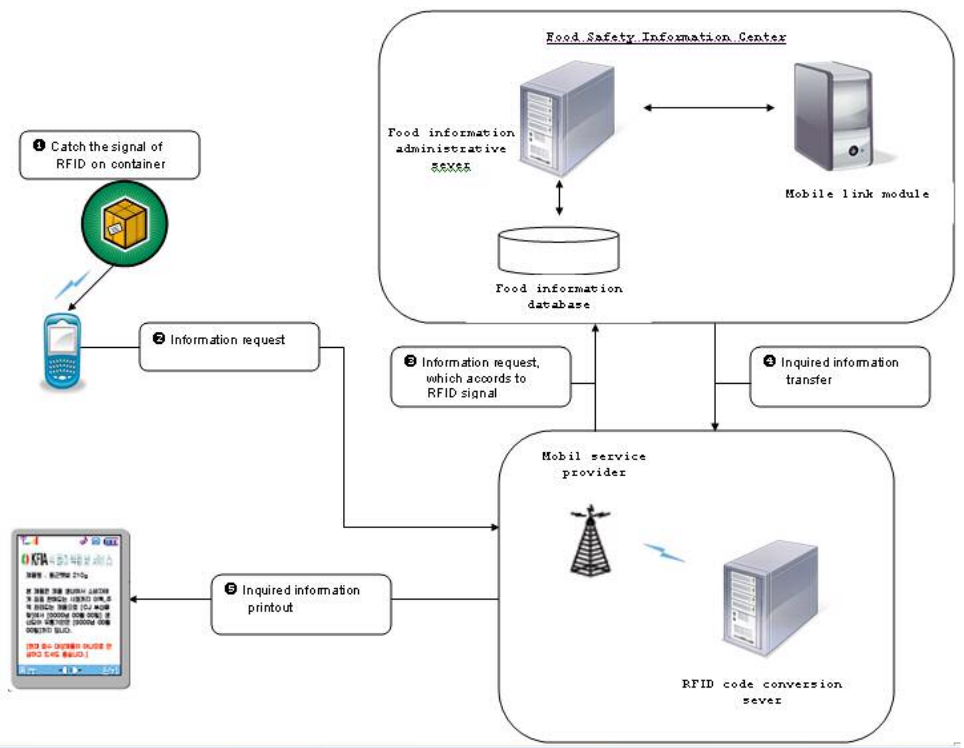
- Number of tasks: 115 unit task
  - Food authentication /tracking administrative system: 45 tasks
  - Standard food information administrative system: 44 tasks
  - Mobile service system: 8 tasks
  - Food safety information portal system: 18 tasks
- Number of interfaces: 167 interfaces

Among the 167 interfaces, interface design output and mobile link output deserve the most attention. These two interfaces are described in Figure 6 and Figure 7.



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 6. Interface Design Output



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 7. Mobile Link Output

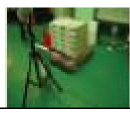
Results & Implications

The primary implications generated by the project are extended in the following areas: RFID tagging, system development protocol, and customer perception.

Item Level Tagging

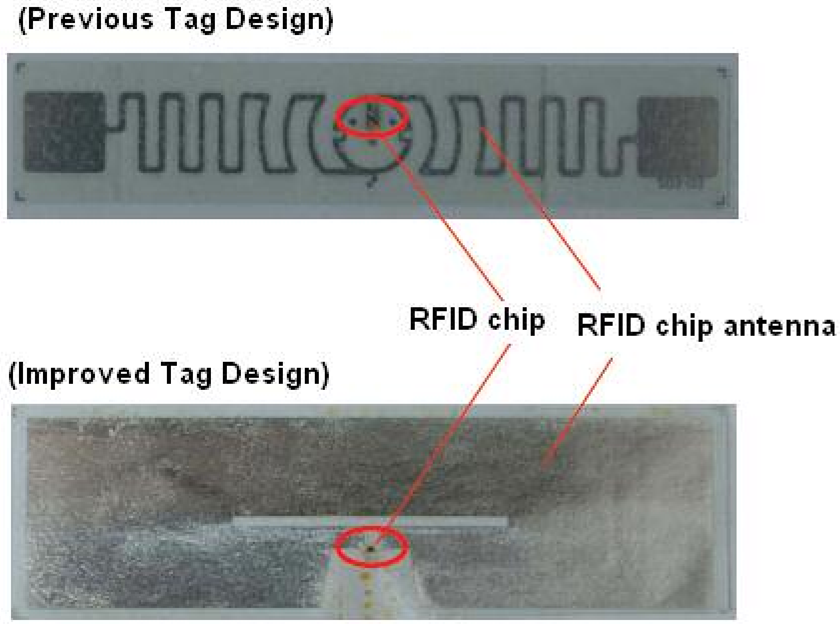
It has been shown that the package design, wrapping technique, and package materials independently affect the signal strength of RFID. The summarization of RFID tests is included in the table blow.

Table 3. The outputs of RFID tests

	Method	Result	Problem	Solution
Paris Croissant (Butter cake) 	- 30 box - Use loading palette - Attach tag onto box surface	- Reach: 3m - Signal receive rate: 100%	No problem	- Improve the tag quality - Find the optimal design place for antenna - Change the loading method
Nong-shim (Shin-raymen) 	- 70 box - Use loading palette - Attach tag onto box surface	- Reach: 4m - Signal receive rate: 29%	- Aluminum in packing deters the signal - No signal from the tag between the boxes	
Dongwon F&B LOEX 	- 90 box - Use loading palette - Attach tag onto box surface	- Best reach: 4m - Maximum reach: 7m - Signal receive rate: 83%	- Certain angles are found, which deter the signal	
CJ(Instant steamed rice) 	- 72 box - Use loading palette - Attach tag onto box surface	- Best reach: 4m - Maximum reach: 6m - Signal receive rate: 75%	- No signal from the tag between the boxes	
MEGA Mart 	- Test products: Shin-ramen, Instant steamed rice, green tea -Warehousing test - Delivery test	- Shin-raymen: 49% Others: 100%	- Aluminum in packing deters the signal	

Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

A few differences are noted in the before-and after RFID tag designs in Figure 8.

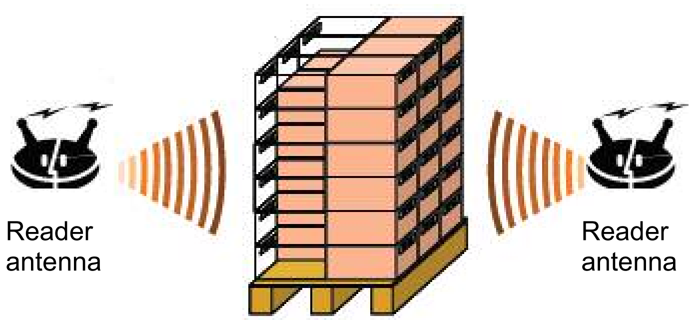


Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 8. Before and After Tag Design Comparison

The improved design allows RFID tag to enlarge the length and width of antenna to 90mm by 40mm and increases the receiving rate of the reader significantly. Such improvement in signal strength is illustrated in Figure 9, which is in compliance with the quality criteria of receiving rate of:

- Precondition for defining the quality
  - Loading 45 boxes for each palette
  - Tag should be attached on the side of the box to exposure the antenna
- Quality criteria of receiving rate
  - Reach: over 3 meters for fixed reader or 1 meter for portable reader
  - Spontaneous receiving rate: over 95% for fixed reader or 100% for portable reader.



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 9. Illustration of Improved RFID Tag Design

Standardized Systems Design Protocol

In addition to tag antenna design, developing a standardized food information trace system (procedure, database, and application) is critical to share the information among stakeholders (manufacturers, distributors, and retailers). In the Systems Installation and Work Flow Diagram, the importance of using standardized protocol/procedure is fairly obvious.

Customer Satisfaction

A big question facing RFID penetration is what it does for the consumer and their perception in adopting the technology, especially when privacy concern is involved. Some research studies pointed out that companies who fail to consider customer's interests cannot generate accurate estimates on RFID's ROI (Eckfeldt 2005). Another challenge is to verify that the information system works as it is designed. There be the chance that customer could have different perspective on the information system since the project had been focused on the technology, RFID, and its application. So the responses of the customers are an important test to identify the application potential of new technology. Simply customers can be satisfied with the traditional way, which is to see the printed information. If customers show the positive response to the new technology, it suggests that RFID applied information system is superior and preferred to traditional way. Therefore, the FSIMS project valuates end user's perception by broadly surveying actual customers in malls about their thoughts on the purchase experience of RFID-enabled products. According to the survey, consumers expressed a fairly high degree of satisfaction (93%) regarding the systems of mobile devices and portals in which food information is accessible. Such satisfaction, reflected in the surveys, plays an important role in formulating purchase intention. The survey is distributed to over 1,000 consumers and the results are given in the following tables:

Table 4. The customer satisfaction survey

Demographic data

Total survey	1,359 participants
Gender	Female (1,046; 77%), Male (313; 23%)
Type	Housekeeper (52%), worker (23%), student (15%), etc (9%)
Age	Over 40 (55%), 30s (23%), 20s (13%), 10s (10%)

Degree of satisfaction of food safety information/tracking systems

Very satisfied	Satisfied	Not satisfied and not dissatisfied	Dissatisfied	Very dissatisfied
46%	47%	5%	0.5%	1.5%

Intention for using the system

Use frequently	Use occasionally	Not use	Miscellaneous
58%	28%	13%	1%

Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Lessons Learned

The task-technology fit (TTF) model has been used to explain how technology supports the task and increases the performance (Goodhue and Thompson, 1995). The model proposes that users adopt technology or tools which are recognized to increase the task performance and the cognitive is affected be the match between the technology capabilities and task requirements (Dishaw and Strong, 1999).

Several types of task-technology fit (TTF) model have been proposed due to the different 'focus' which researchers emphasized (Dishaw and Strong, 1999). Goodhue and Thompson (1995) categorized the different research into 3 major streams: utilization focus, fit focus, and combining utilization and fit. Utilization focus studies argue that the utilization of information systems is predicted by the users' attitudes and beliefs. On the other hand, task-technology fit focus literatures propose that the performance is the product of fit between the technology support and task requirement. The last model is combining utilization and fit synthesizes the two models to overcome the limitations of the focuses. More detailed and accurate depiction of these models is provided by technology-to-performance chain (TPC) model. TPC model is influenced by two major theories: theories of fit and theories of attitudes and behavior (Goodhue, 1992). TPC model argues that technologies should support and fit the task requirement. Users' technology acceptance and performance are led by task-technology fit and utilization. Task-technology fit are determined by the degree at which the technology support the task. Utilization is influenced by the users' attitudes or behaviors such as social norms.

The FSIMS project is the good case to show how technology supports the task requirements and provides the task/technology fit. To purchase safe food, consumers want to see the food information such as valid date. Tracking the food information is very important when purchased foods have problem. Tracking the food information in the whole distribution process is complicate and complex task because many people are involved and meta-data are required. However, traditional way does not satisfy the requirements of the task since it requires much time, data, and human effort. The people involving in the distribution process are independent each other although they are strongly connected. They have no obligation to use same type of data, to produce data, or to keep the data. If some steps in the chain are found to have no data or lose data, tracking the food information will be really tough task. Therefore, tracking the food information with traditional way requires much time and labor effort. RFID applied food information tracking system provides the functions which the task requires. RFID chip and constructed information tracking system enable the customers to identify the food information at the time of purchase and to track the food and verify the problem in a few minutes. Consequently, RFID applied food information system offers the task/technology fit and increases the performance of the task.
The UTAUT model which was proposed by Venkatesh et al (2003) presents practical insights in the perspective of customers (positive performance expectancy). The task/technology fit creates the positive perception that the technology will help and increase the performance. Another important precondition to success is how much effort has to be given to use the technology. Cellular phone is disseminated to almost all Koreans and they are expert in using the device. It means that technical infrastructure is already constructed well and will affect on the perception of customer positively (positive facilitating condition). Also they are so skillful to use the machine. People enjoy seeing drama or movie and listening music with their cellular phone. So they have no extra effort to use the mobile phone to check the food information. Customers perceive that less effort is required to use the technology (positive effort effectancy). However, since this technology is staying at the experiment, social influence factor has no influence.

To sum up, in order to be practically viable, it is suggested by the findings that the implementation of RFID should be deployed and monitored throughout the entire supply chain, from the origin where goods are manufactured, to storage, packaging, to logistics, transportation and shipment, and finally to inventory control and destination. Never under-estimate the need and benefits of building an effective and efficient supply network (Food Logistics, 2006). Before the actual systems roll out, however, ground work such as protocols and standards establishment regarding data connection interface and meta-data management among business partners should be laid out in order to ensure clear communications and minimize information lost. Item level packaging techniques and material significantly affect the signal transmission between RFID tags and receivers. Guidelines and “rule of thumb” should take shape through thorough inspection of products that RFID is applied to. Moreover, the applications for RFID are foreseen in playing an increasingly important role in boundless business settings, as there is great potential in ubiquitous environment through its integration with wireless and mobile devices including customer’s cellular phone, personal digital assistance, and hand-held electronic devices.

Some other meaningful implications have been generated from the FSIMS project: Begin with simple small implementation and expand from the proved successful practices. Whenever an issue occurs, it would be less complicated to pinpoint the problem. In FSIMS project, Paris Baguette serves as the lab example while the process and data of experiment are shared by other participants who at the same time overhaul their operational infrastructure and generate report of compliance. Secondly, companies should revisit and examine the supply systems frequently enough to ensure the persistence of advantages brought by RFID as the technology evolution is dynamic and keeps changing.

Issues & Challenges

Privacy

Privacy worries rise as the RFID technology penetrates further in its application areas. Some potential risks pertain to consumer location privacy and corporate/military security, which would in a way serve as an inhibitor to RFID adoption. Some believe that: “…regardless of privacy enhancing technology employed, consumers feel helpless toward the RFID environment, viewing the network as ultimately more powerful than they can ever be” (Gunther and Spiekermann 2005). Some consider RFID as unique challenges of privacy as well as monetary and security benefits (Peslak 2005) while others then point out RFID has been hyped far beyond what is realistic (Neumann and Weinstein 2006). To answer privacy concerns, educational efforts and regulation adjustment are necessary to ease consumer’s mind (Ohkubo et al. 2005), as the FSIMS project participants stress on the importance of communications with RFID end user. In Figure 10, we delineate such concerns and suggest opportunities by doing a simplified SWOT analysis.

Strength	Opportunity
• Real-time Traceability; • Rich Information Exchange; • High Efficiency;	• Technical potentials; • More complicated business processes;
• Privacy threat; • 2-D/3-D Barcode are competitive in many situations;	• Costs of deployment and maintenance; • Technical Weakness;
Threat	**Weakness**

Figure 10. RFID SWOT Framework

Cost

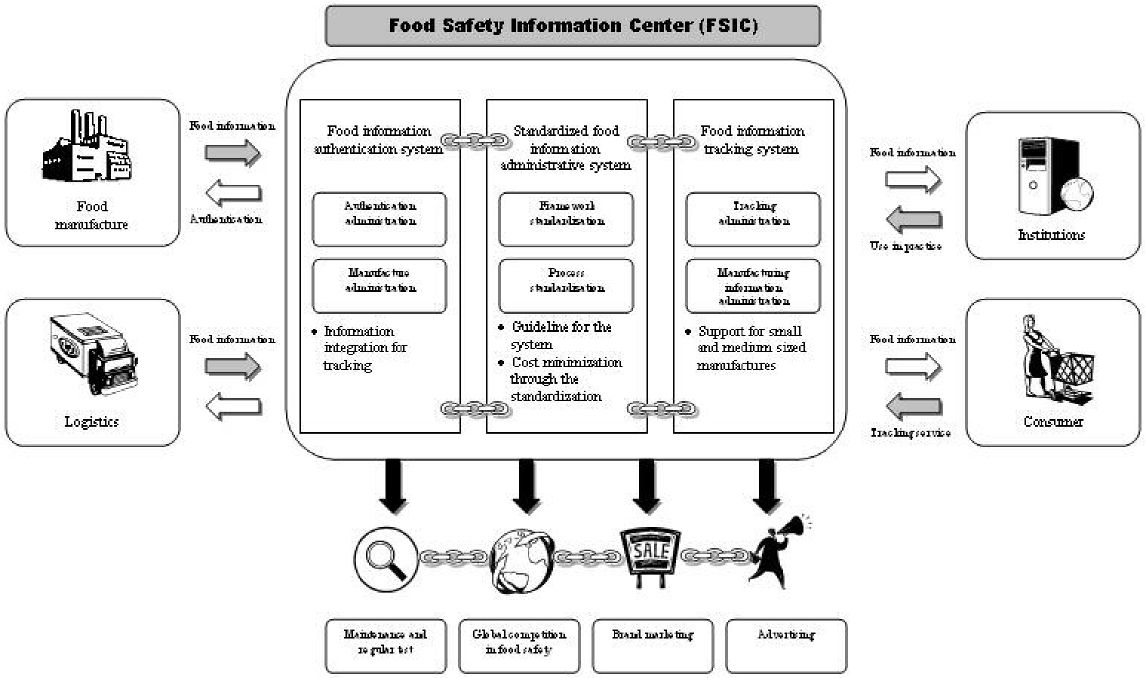
Another prominent challenge of RFID proliferation lies in the foreseeable ROI. The favorable cost effective solution does not seem to produce instant financial rewards. On the other hand, cost-saving hurdles still exist. Wal-Mart, the pioneer in chopping expenses through technology innovation, did not reach the goal of promoting RFID among its more than 100 distribution centers across the country in 2006. Nevertheless, none of the giant retailer companies, including Best Buy and Target, have shown hesitation in leaping toward RFID adoption. Millions dollar projects are underway and competition is becoming fierce among technology providers, including Motorola and Texas Instruments.

Challenges in FSIMS Project

One of the challenges is to build the standardized model (e.g., integrated and standardized process and framework) to minimize the cost and time in tracking and accessing the food information. Cost is vital in succeeding the system since food manufacturers have to take a big burden to take part in the system including RFID tag cost and system installation expense. Standardizing the process and framework is expected to drop the required costs to participate into the system (e.g., database construction), in which the participating food manufacturers would increase the demand of RFID tags.

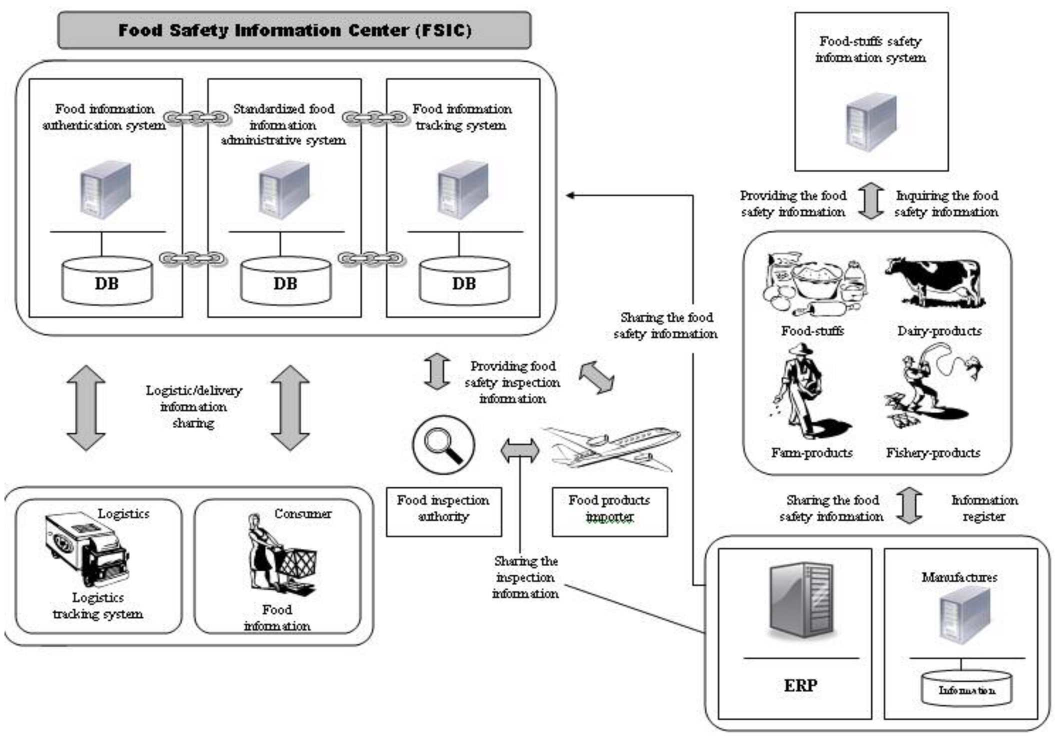
Another challenge is to empower the function of food safety information center (FSIC), as seen in Figure 11. In the system, FSIC is supposed to take four key functions which determine the success of the system. First is to integrate and administrate the food information through the servers which is synchronized into the server in manufactures and to provide food information and tracking service to customer, manufactures, and government departments. Second is to standardize and maintain the system. Core equipments and process should be maintained and developed regularly to have the system work properly. Supports for the small and medium sized manufactures which have a poor or unequipped information infrastructure are the vital task of the center. Brand marketing and advertising the system to customer and manufactures are necessary for the progress of the system.

One of the characteristics of the foods is that the quality is mostly determined by the food stuffs such as raw materials or ingredients used in the foods. To make the most use of the system, the integration with the food information system of food products in agriculture, fishery, and dairy industry is essential and required as seen in Figure 12. Due to globalization, food products are the subject of the international trade. This requires the system to be connected into systems of many government departments, including department of customs and commerce.



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 11. Food Information Center Integration I.



Source: Adopted from *Food safety information system based on RFID,* final report, KFIA, 2007

Figure 12. Food Information Center Integration II.

Discussions & Conclusions

Challenges and issues notwithstanding, RFID's influence is extending to broader areas. The FSIMS project provides implications that RFID might not generate short-term economic value but may prove to be practically effective in a sense of private and public cooperation - food safety assurance and control. It can be inferred from previous research that RFID has the potential to deliver long term benefits provided that proper guidelines are framed and adhered to, careful thoughts are given to implementation plan, and vigorous teamwork among partners is realized. Some previous studies found similarities between Electronic Data Interface (EDI) and RFID in terms of industry wide acceptance (e.g. Loebbecke et al. 2006). It is discovered in EDI development that getting started early on the learning curve provides lessons of practices and first move advantages (Nygaard and Bjoern 1994; Brousseau 1994).

One of the goals of conducting this research has been to push one step further to formulate future academic endeavors where hypotheses developed from case study will be tested (Flyvbjerg 2006). Further evidences are to be obtained from follow-up projects in order to expand the knowledge base that eventually formulates meaningful intellectual inputs, such as validated hypotheses, to construct a generalizable model (e.g., technology diffusion and user adoption) which technically can be reproduced as closely as possible in different contexts that are similar in nature.

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