

An Empirical Study for the Mobile Food Trace ability: Private Trace ability System for the White Gourd in Tianjin, China.

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Abstract. As the food supply chain globalization became inevitable, transparency in the way agriculture was grown and handled throughout the supply chain process resulted in an important issue of 'traceability' in global food trade and safety for health management. Traceability in agriculture is faced with the technological challenges including food product label and identification, activity/process characterization, information systems for data capture, analysis, storage, and the integration of the overall traceable data for the supply chain, i.e., from farm to table. While some field data can be automatically acquired and transmitted by sensor networking, most agricultural activity information was recorded by manual handwriting for the traceability information systems. System architecture, operation scenarios, and the implementation examples for the mobile farming data collection system to automatically record the agricultural activities information for famers were proposed in this research. The farming information for farming activities is coded in two-dimensional labels of quick response (QR) codes. By scanning the proper operation labels, the corresponding farming data can be captured and uploaded simultaneously to the back-end web server. A collaborative research project for the traceability of white gourd planting in Tianjin was performed. The system can be implemented for public traceability system data collection and importing, as well as playing the roles of a private traceability system. The consumers' confidence for healthy food choices with clear food traceability can be improved.

1 What is Food Traceability

Issues for food safety, agro-processing, and the environmental and ecological impact of agriculture had been exacerbated by the incidences such as the human form of bovine spongiform encephalitis (BSE, mad cow disease), genetically engineered foods, and contamination of fresh and processed agriculture. The heightened awareness of food-related safety issues among food consumers drives the demand for more information about the vertical food supply chain about the origin and handling of the basic commodities and food products generated and consumed throughout the world. The term of traceability can be defined as, from International Organization for Standardization (ISO), the ability to trace the history, application or location of an entity, by means of recorded identifications. Traceability is an essential subsystem of quality management, and must be managed by setting up a traceability system, which keeps the data tracking of product routes and of selected attributes. A traceability system can consist two elements, the routes of the product, path along which products can be identified throughout the manufacturing, distribution and retail procedures, and the extent of traceability wanted [1]. Food traceability system is aimed to provide

information visibility through the farming, production, packing, distribution, transportation, and sales process, and receiving enthusiastic research interests due to the food supply chain globalization. Accuracy and transparency of products and activities in the way food was grown and handled throughout the supply chain is becoming an important quality index in food and agribusiness [2]. Food traceability requires that all stakeholders within the food supply chain, including agriculture and feed producers, food manufacturers, retailers, etc., must be able to identify the source of all raw materials and ingredients and also to whom the products have been sold. The food companies must apply identification systems and data handling procedures and these must be integrated into their quality management system. The sector encompassing information technology (IT) centers ought to find a reasonable compromise between the simple, step by step passing of traceable unit IDs for the neighboring actors, and the accumulated enormously huge databases of the actors. The traceability system is to provide services for the supply chain actors on cooperative basis of the mutual interests [3]. In addition, the IT centers have to support the supply chain and value chain management, as well as the work of the authorities, that are responsible for the human health..

Opera [4] reviewed the concepts of supply chain management and traceability in agriculture and highlighted the technological challenges, including food product label and identification, activity/process characterization, information systems for data capture, analysis, storage and communication, and the integration of the overall traceable supply chain in implementing traceable agricultural supply chains. Wang et al. [5] addressed that the values on traceability can be integrated with the supply chain management processes to manage the business process and improve its performance. Golan et al. [6] summarized that there were three motives for food suppliers to establish product tracing systems: to improve the supply (production) management, to differentiate and market foods with subtle or undetectable quality attributes, and to facilitate trace-back for food safety and/or quality. The aim of a traceability system is to collect the product related information along the supply chain. This information is essential when facing food safety crisis, and provides efficient management for the corresponding product recall action. Although a recall action could be absolutely critical for a company, both in terms of incurred costs and of media impact, at present most companies do not possess reliable methods to precisely estimate the amount of product that would be discarded in the case of recall. Considering the food traceability system as part of the logistics management, Boson and Gebresenbet [7] summarized the literature review on the food traceability issues. The definition, driving forces, barriers, benefits, traceability technologies, improvements, and performances of food traceability system had been discussed. It was pointed out that the development of full chain food traceability system is quite complex in nature, and a deeper understanding of real processes from different perspectives such as economic, legal, technological, and social issues are essential. Consequently, studies on the integration of traceability activities with food logistics activities, the linkage between traceability system and food manufacturer, standardization of data capturing and communication protocol for different drivers, and performance evaluation frameworks for food traceability system need to be focused.

2 Information Technology Applications For agro-Food Industry

Developments of agro-food industries are facing global challenges that can only be supported by information technologies. The major IT development lines, the support potential of their integration, organizational requirements for the utilization, and possible consequences for the future organization of the agro-food sector were reviewed [8]. A new model and prototype of a new Farm Information Management System, which meets the changing requirements for advising managers with formal instructions, recommended guidelines and documentation requirements for various decision making processes, was developed [9]. As achieving end-to-end traceability across the supply chain is quite a challenge from a technical, a co-ordination and a cost perspective,

Kelepouris et al. [10] suggested a radio frequency identification (RFID) technology and outlined both information data model and system architecture that made traceability feasible and easily deployable across a supply chain. Based on an integration of alphanumeric codes and RFID technology, the traceability system for Parmigiano Reggiano (the famous Italian cheese) was developed [11]. Manthou et al. [12] provided empirical insights regarding the use of Internet-based applications in the agri-food supply chain by focusing on the Greek fruit canning sector. The companies' perceptions regarding perceived benefits, constrained factors and motivation factors towards the use of Internet-based applications were studied. A PDA-based Record-keeping and Decision-support System for traceability in cucumber production was developed on Windows Mobile platform invoking a Geographic Information System (GIS) control [13]. Two agricultural production enterprises were chosen as case study to evaluate the system and the results show that the efficiency of production record-keeping and decision-support is improved by the simple and friendly system. The state-of-the-art review in the recent advancements of food processing and packaging industry in the fields of smart packaging and materials, automation and control technology, standards, and their application scenarios, and production management principles and their improvements was proposed [14].

The purpose of this research is to develop a mobile farming information system to collect the farming data by the daily used cell phone instead of handwriting and input to the traceability system. System architecture of the proposed mobile traceability system is shown in Fig. 1. The farming data are collected by the mobile devices that can provide data communication anytime and anywhere through the mobile 3G (4G) or Wi-Fi network. The data to be collected for traceability including the farming activities messages such as seeding, weeding, fertilizing, disease prevention, harvest and shipping, are designed to be stored in QR codes. By scanning the QR code with mobile device, the data stored in the QR code can be decoded and enabling a transaction with the application services to be uploaded to the traceability database.



Figure 1. System Architecture of The Proposed Mobile Traceability System.

Operation scenarios for farming activity message collection are analyzed in Fig. 2. The farming information collection is started by scanning the corresponding QR code label. The mobile device will

decode and link to the application server and enabling the farmer authentication transaction performed by the application program (AP). The farmer should input the proper username and password and the mobile system will verify the validation. As the verification process completed, the AP will show the decoded farming operation message and start the confirm request transaction. The farmer needs to confirm the operation messages are identical with the one he performed. The operation messages will be uploaded to the database after the confirm signal is entered. For the case that more detail attributes are required to be recorded, the detail activity messages request transaction will be enabled after finishing the authentication. The messages required include the amount used, unit, and dilute ratio of fertilizer (or pesticide). Detailed operation scenario for the pesticide usage recording process can be found in [15]. This system is suitable for the traceability management of sub-contract supply farmers. Minimized interactive operations with the mobile devices are considered for the system. The farmer only need to scanning the QR code, input the amount used, and press the confirm button to finish the traceability data record and upload simultaneously.

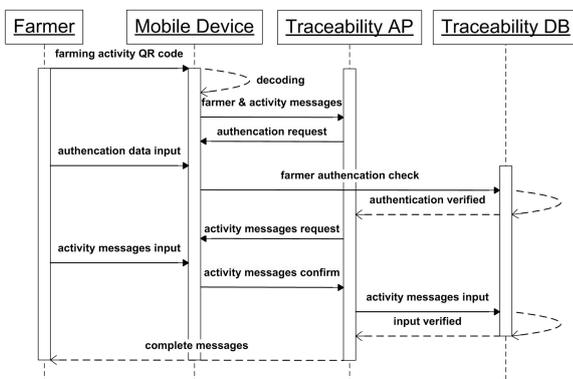


Figure 2. Sequential Diagram for the Farming Operations with Detail Records.

By properly encoding the farming messages to the QR codes, the messages can be read by the mobile devices and uploaded simultaneously to the application server of the mobile farming system. The farming activity information can be captured by simply scanning the QR code labels and uploaded in real time, instead of manual handwriting and input by batch to the traceability system. The miscellaneous traceability data construction can be significantly reduced. The mobile farming system can work for both traceability system of the public and private sectors. Data collected by the mobile farming information system is stored by the database system and can be output to the required file format for any electrical data exchange. The application example for the private traceability systems will be shown in the next section.

3 Private Traceability Systems for White Gourd in Tianjin

Traceability system in China is attracting more and more research and industrial interests. The food safety and traceability related projects and researches were one of the focus issues in the 12th 5-year national development plan started since 2012 by the China government. The academic cooperation between Tainan University of Technology (TUT) and Tianjin University of Agriculture (TUA) has been started since 2012. Researches about the food and agro-product traceability in TUA have got the financial support from the Spark Program 2013 of the Ministry of Science and Technology of PRC, and science and technology developing program from Tianjin Municipal Science and Technology Commission. The Tianjin Shunzi Vegetable Cooperative (TSVC) is one of the famous farms in Tianjin whose white gourd has won the 2012 "One Village One Product" paradigm of ministry of agriculture in China and became one of the distinguished agro-products in Tianjin. They joined the TUA project in 2014 to implement the mobile farming information system to build their own traceability system for the white gourd. The aim of the traceability system is not only to improve the safety traceability but also to promote the value of the brand "Qinmei" for TSVC.

The implementation of mobile farming data collection of the pilot project can be summarized as following.

3.1 Kickoff meeting

The pilot project began by the kickoff meeting hold by TSVC farmers, government employees, and the technical team from Tainan University of Technology and Tianjin University of Agriculture.

3.2 Farming data and QR code definition

The system analysis for the production activities and related information required for white gourd farming was firstly reviewed. The farming data definition, including farming activities, fertilizer, and pesticides, were applied for the pilot system. The QR code for every farming activities were encoded after the data definition decided.

3.3 Database and brief traceability system development

As analyzed in the previous section, all the function can be operated via the mobile devices. The normal farming activities, such as irrigation, weeding, branch trimming, etc., can be recorded by scanning and confirming the corresponding QR code label as shown in Fig. 3.

3.4 Mobile farming SOP and training

To provide effective training for the mobile farming information system, standard operation procedure was established including the brief operation instructions of the hardware device, the QR code scanning process, and the usual questions and answers for the usage.

3.5 Field testing and auditing

The field test for the mobile communication at the farmland is necessary to guarantee the effectiveness of the system. The field testing and auditing were performed at the site of farmland in Tianjin. The data communication through mobile 3G networking is worked effectively at the farmland.



Figure 3. Label Scanning Operation Scenario for the for the Pesticide Usage Recording Process, (1) Scanning The Qr Code For Cyhalothrin, (2) Username And Password Authentication, (3) The Message Input Transaction Enabled, (4) Input Usage Amount, Unit, And Dilute Ratio Of Cyhalothrin, (5) Confirm The Input, And (6) Message Uploaded Complete.

The home page for the back end server of the mobile platform is shown in Fig. 4. As a private traceability service platform, the home page of the service platform shows the organizations registered in this sector. After logged in to the system by the administrator of the organization, the production data of farm information, farmer, product, fertilizer, pesticides, harvesting, and packing information can all be maintained at the platform. The farm information (Fig. 4b) includes: name of the contact farmer, telephone and fax numbers, e-mail, address, facebook, and the multimedia video is also provided in accordance with the text information and pictures. The farming data uploaded can be queried and only the administrator can delete or edit the farming data to ensure the correctness and reliability (Fig. 4c).



Figure 4a. Mobile Server Platform User Interfaces, Home Page.



Figure 4b. Mobile Server Platform User Interfaces, Farmer Information.



Figure 4c. Mobile Server Platform User Interfaces, Traceability Data.

By scanning the traceability label, the brief traceability information, including name of the organization and producer, traceability ID number, telephone number, and location of the farmland, is displayed on the mobile device (as shown in Fig. 5). The detail farm and traceability information can be obtained by further clicking the corresponding linkage. As the traceability system implemented, the white gourd of TSVC was becoming more and more famous and won the golden prize of the 2014 excellent agricultural products of Tianjin. The traceability system can improve not only the transparency of the farming procedure, but also the brand image of social responsibility.



Figure 4c. Traceability System User Interfaces, (1) First Page of Brief Traceability Information, (2) Farm Information, (3) Traceability Data, (4) the Farmland, (5) Traceability Label, (6)

~(7) Technical Team and the Farmers, and (8) the Golden Prize of 2014 Excellent Agricultural Products of Tianjin.

4 Summary and Conclusions

Implementation of traceability system for agriculture and food supply chains is necessary to enhance the competence of product. Traceability data involves miscellaneous records that mostly kept by manual handwriting. To reduce the minute and unreliable traceability data recording procedure, the mobile farming information system is developed to enhance the efficiency of e-traceability. The operation scenarios for the mobile traceability data construction and collection are studied, the architecture for the system and database are schemed, and the application examples are proposed in this research. By properly encoding the farming activity messages to the QR code labels, the farming data can be read by the mobile devices and uploaded simultaneously to the mobile platform server. The farming activity information can be captured by simply scanning the QR code labels and uploaded in real time. The miscellaneous traceability data collection can be significantly reduced. The mobile farming information proposed was implemented either as the mobile data collection tool for a private traceability system in Tianjin. The results showed that the mobile farming information can be successfully implemented. Food traceability can be more credible due to the farming data is collected more reliable.

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