Implementation of an Agricultural u-SCM (Ubiquitous Supply Chain Management) Solution

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Abstract: - Radio Frequency Identification (RFID) is a method of identifying the unique items using radio waves. The RFID based supply chain management yields convenience, efficiency and productivity gains. Based on the pervasive deployment of RFID tags, we develop a new RFID application, which is developed to serve farmers' products in aggregation center through the supply chain. The objective of this research is to describe how the RFID application software can be applied and how we can de-sign the RFID SCM application software. This RFID application provides an effective way to manage all the relevant information through the whole supply chain by writing/reading data to/from tag and updating the database automatically or manually.

Key-Words: - RFID, SCM, Database, Agriculture, Implementation[1]

1 Introduction

Radio Frequency Identification (RFID) is a method of identifying the unique items using radio waves. The technology of RFID deals with the remote collection of information stored on a tag using radio frequency communications [4]. Standard RFID technology consists of four main parts: host computer, tag, coupler and antenna [3], [14]. The tags and readers enable the automated identification of tagged objects, and the application system performs the important tasks using this captured information [5]. An RFID tag is a small and low-cost device that can hold a limited amount of data and report that data when queried over radio by a reader [6].

A typical scenario of exploiting RFID is supply chain management. It aims at reducing supply chain inefficiencies and improving inventory flow, whilst considering the returns process [2]. Aside from supply chain applications, RFID technology is also found in proximity cards, car security devices, pet tracking, and other specialized applications. Most supply chain applications focus on tagging cases or pallets holding merchandise [7]. RFID based supply chain management has several beneficial features over traditionally used bar code. First it doesn't require line-of-sight access to read, second the reading range of RFID is larger than bar code, though it's still short range, third the tags can be read simultaneously and inventory can be obtained in a very short time without line of sight at the entrance, because multiple tags can be read at the same time, and fourth the tags can store more data, such as the unique ID for a certain product and data from the readers and the environment. We have seen strong evidence that RFID tag technology will soon provide the long-awaited, cost-effective mechanism that will fully automate supply chain logistics [1].

In this research we developed a new RFID application for the supply chain management system of agricultural products. Each item is registered by a RFID reader as they arrive at the Aggregation center. We wanted the tags to reveal their identity to authorized RFID readers (e.g., those owned by the aggregation center), so that the aggregation center can track products as they are checked in and out. The information management units in our u-SCM are items, boxes and pallets. This application is based on passive RFID technology [3] since it is cost-effective. It consists of passive tag, antenna, coupler and host computer. Application software is installed on the host computer and communicates to database server through the internet and also communicates to RFID readers. Readers interrogate tags for their contents through RF antenna and interface to back-end

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databases for more functionality through the Application software.
The objective of this research was to describe how the RFID application software can be applied and how we can design the RFID SCM application software. Our RFID application provides an effective way to manage all the relevant information through the whole supply chain by writing/reading data to/from tag and updating the database automatically. Here we described an implementation of the ubiquitous supply chain management application for the agricultural area.
The rest of the paper is organized as follows. Section 2 and 3 illustrates the system architecture and the use case of the aggregation center module, respectively. Section 4 deals with the implementation details while section 5 concludes the paper.

2 System Architecture

Our u-SCM(Ubiquitous Supply Chain Management System) has 3 application mod-ules, namely, Aggregation center module, Distribution center module and Retail Store module. But in this paper, we pocus on the Aggregation center module since much part of each module is similar. Actually these application modules are connected with each other through the internet and are shared through one global database. An RFID application reads all the product information and stores the information back into the database. Each item (actually tag information attached to the item) will be read by RFID readers as the pallets or boxes leave/reach every subsystem, and the proper modules update the stock automatically or manually.
Aggregation centers register all the items by RFID writers and store the information of items on the database through the internet. In this system, we use PicoTag™ and M300-2G reader [9]. PicoTag™ is a family of contactless memory chips compliant with ISO 15693 standard. It can communicate at up to 1.5 m distance with a gate antenna and up to 70 cm distance with a single antenna. And tags the unique serial number of this system is 64 bit [8] [9]. The M300–2G is a high performance 13.56 MHz contactless coupler compliant with ISO 15693 standard [12],[13], specifically designed to provide long distance communication with contactless chips. Single 12v to 15v power supply makes easier the connection to a wide range of power supplies [10]. Operating distance is up to 1.5 m, depending on the type of transponder and antenna. Host interface is serial port RS232 [3]. This coupler connects to antenna and host computer. Of course, a coupler can read information from a tag and send it to a PC (read mode), or it can read information from the PC and send it to an RFID tag (write mode). The coupler and host computer exchange data by 80h port.
First coupler selects a chip and then reads the chip memory, and then takes a serial number from the memory and finally halts the chip. For those processes we developed ActiveX methods and C Library functions. We used these ActiveX components, which are put into Microsoft Windows library, to connect application software and coupler to select/read/write/halt serial number of tags. Application software is installed on a host computer. It receives data of items from a coupler through wires and it sends data to global database server through the internet. In this system, we used Ms-SQL server and ODBC (Open Database Connectively). The ODBC is a programming interface that enables applications to access data in database management system that uses Structured Query Language (SQL) as a data access standard. Basically application software is connected to global database in the internet through the ODBC (Figure 1).
We used passive tags since the cost is not expensive and we do not need a long reading distance. Each item with a tag constantly moves through the supply chain. To detect this flow of in and out the readers should be installed in some strategic places which maximizes the detection rate. Furthermore since we do not need to read/write much data from/to a tag - unique ID number and other basic information, a high data rate [3] [11] readers/writers are not required. Radio signal interference does not make a serious problem as we read the tag data within a short range with little risk of distur-bance from other systems..

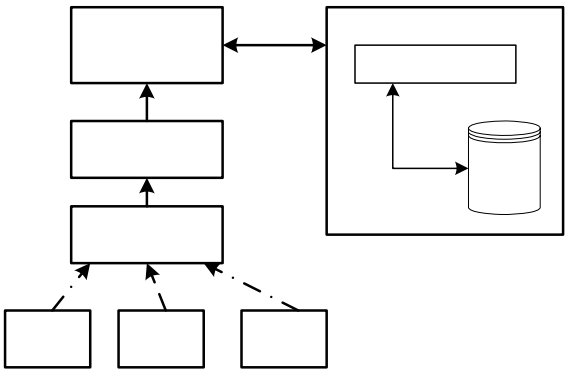

Fig. 1. RFID application architecture

3 Application Software

We assume that there are 5 kinds of users - producer, aggregation clerk, mover, and distributor and distribution shipper in the Aggregation center (Figure 2).

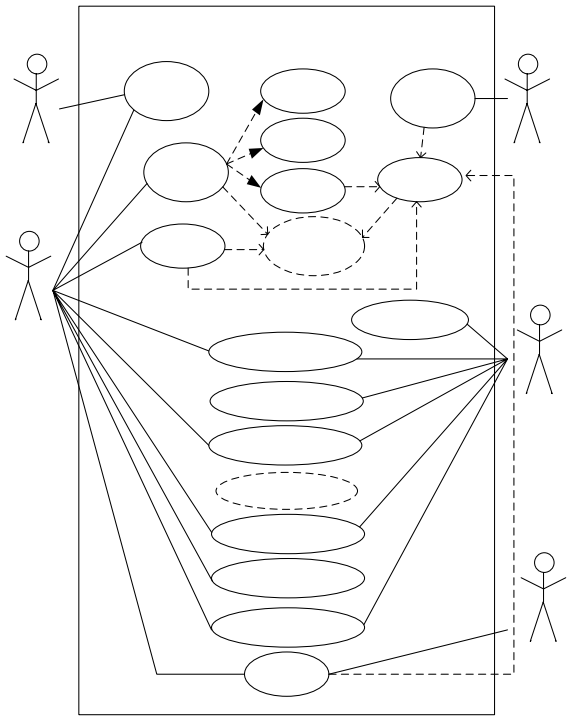

Fig. 2. Use Case of Aggregation center

The producer is a farmer who receives fee for products from aggregation center and deliver the products to the aggregation center. The mover is employee of Porter Company who is registered on the database by a system manager. The mover only shelves product. The distribution shipper is a porter company that ships product from the aggregation center to the distribution center. The distributor is employee of distribution center who can see list of product and makes orders to aggregation center and also manages the shipment. Information on the members has to be stored on the data-base. The Aggregation clerk has a secret key to enter the system and can see all information on items from database. Also the Aggregation clerk manages inventories, writes/reads tags, receives products from farmer and performs some special tasks such as making orders to some products, creating the porter company record.

At first, farmers' products arrive at the Aggregation center and the products are registered by a RFID reader/writer. Our registration software sends a signal to coupler, then coupler receives signal and write the basic information such as an identification code into the tag.

When the tagged products are contacted to an antenna, a coupler reads a unique identification code of the tag. Then the coupler sends the unique identification number to the application software. In this case, all the procedures are processed in the InputRead section(or module). In this section, the unique identification number of a product is saved in the database with some other information. Of course, all the information is configured by reading the unique identification number of tag. That means the unique identification number is primary key of tables on the database. An aggregation clerk inputs some additional information into database using the application soft-ware. This additional information is listed below: (Fig. 3).

- Product type
- Product name
- Counted Number (which kind of counting unit)
- Quantity
- Unit price
- The place of origin

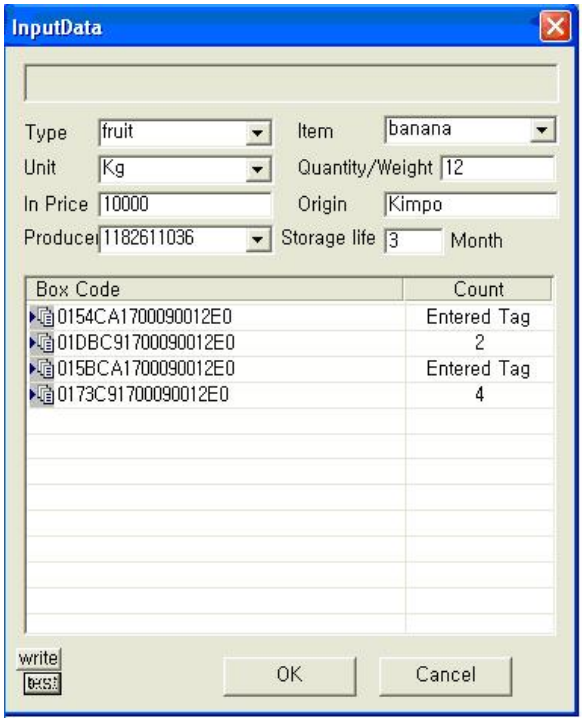

Fig. 3. InputRead Section

After all that information is saved on the global database, the aggregation clerk can see all the information. From time to time some clerks may change the product data. If products go out from the aggregation center, they are not deleted from database

but the status data of those products is changed. Clerks can see the status of the products in the supply chain.
If an aggregation clerk wants to send some products to the distribution center, she/he uses OutputData section(or module) which handles the output or sending process. This section includes information of products which leave the aggregation center (Figure 4).

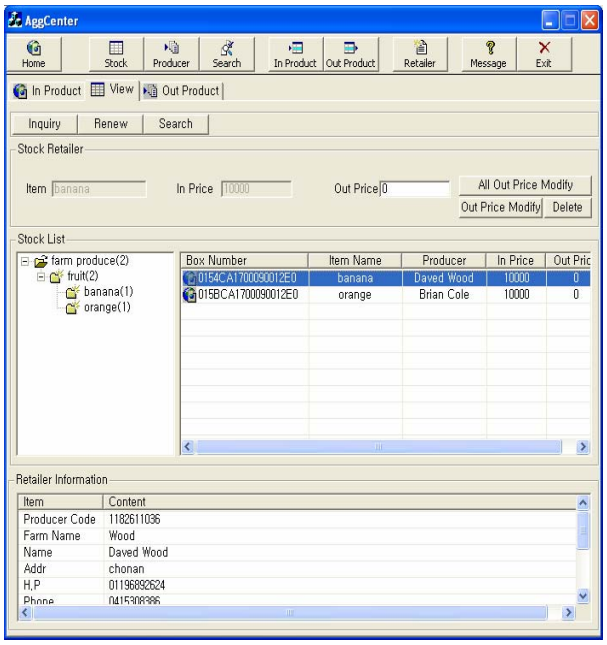

Fig. 4. Main GUI of application

These InputData, View and OutputData sections have some information that is de-scribed below:
- In/Out Date
- Primary Key (Tag Code)
- Product name
- Producer
- Buying cost
- Selling cost

This information is already on the Database. When a RFID reader scans a tag, the reader sends an unique identification number to the application software which downloads some information from database and shows to a user such information - the code, cost, storage life time(expiration date), the place of origin and input date of products. A system manager can configure, modify, delete or search all the information of products or information of producers on the database.
If products go out from the aggregation center, products information can be automatically read by a reader which is installed on the exit gate. Then aggregation clerk manages the product output process using the application software. This information is described below: (Figure 5).
- Name of Porter Company
- ID of Porter
- Distribution center code
- Cost of shipping

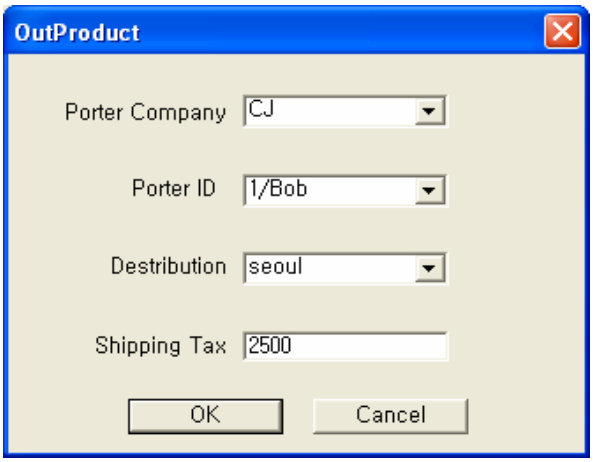

Fig. 5. OutRead Section

4 Implementation Details

4.1 Module Specification of Application software

We used Visual C++ programming language for building the application software. In figure 6 we describe the software module specification diagram. This application software integrates the database server and RFID readers (Figure 6).

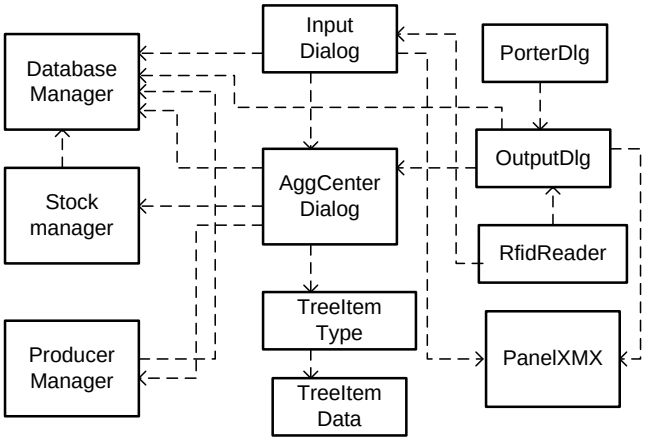

Fig. 6. Module specification of RFID application software

This specification includes InputData, OutputData, View and Producer sections etc. It can be connected to

database through the DatabaseManager and sends data or retrieves data to/from database. It collaborates with ProducerManager and StockManager to manage the information of products and producers. Here is the brief explanation of each module.

StockManager: This module handles data related with product stock and it interacts with AggCenterDialog.

ProducerManager: It works on the producer section in the AggCenterDialog. Also it shows all the information of producers and sends/retrieves producer's information to/from database.

InputDialog: It inputs the product information into the Database. It receives signals from RFIDReader module, then it is connected to PanelXMX module. It receives an ID of a tag and the system manager inputs some other information to system with this module. Also it is connected to AggCenterDialog module to show the product relevant information in the InputData section.

OutputDialog: It is output module of the application. It sends all the information of output (or delivery) products into the database through the DatabaseManager module. This module receives signal from RFIDReader module, then it is connected to PanelXMX module. It receives an ID of tag and the system manager inputs some other additional information to the system with this module. Also it is connected to AggCenterDialog module to show product-relevant information in the OutputData section.

RFIDReader: It detects the movement action of products (input or output). It is used by InputDialog module and OutputDialog module.

PanelXMX. This module is a component module and integrates other modules with RFID readers. There are two kinds of reading process in our application. One is input and the other is output process. So it is connected to InputDialog or OutputDialog modules. All the tag procedures are handled by this module, such as read/write tag and select card/pages. This module is used for connecting application software to RFID readers.

DatabaseManager. This module is database module used for connecting database to other modules. It can be connected to database through the internet.

TreeItemType. This module shows the hierarchical tree structure of item type on the main window and it is used by AggCenterDlg module.

TreeItemData. This module show the hierarchical tree structure of item on the main window of application and it is used by TreeItemType module.

4.2 Database Configuration

We used Ms-SQL server and ODBC (Open Database Connectively). The ODBC is a programming interface that enables applications to access data in database management system. We designed 14 tables to store all the information required by the supply chain management system.

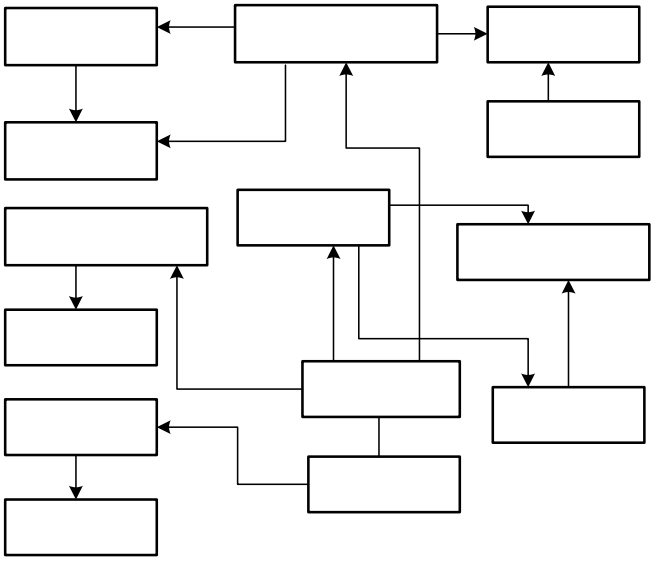

Fig. 7. The correlations of the tables

1. agg_center (id, name, address, telephone number)
2. agg_emp (employee's id, name, picture, job of each employee, id of agg_center)
3. aggregation_prod (contain all information of products of aggregation center)
4. producer (contains farmer information such as name, id, address, mobile_num…)
5. product (contains farmer's product information such as id, type, name, date, ship_start_date…)
6. retail_product (contains the information of product exist in the retail store)
7. sale_product (contains the information of the sold product from retail store)
8. ship_product (has all the shipping information from aggregation to distribution)
9. porter_company (has all the information of the Porter Companies)
10. Porter (has the information of porters who belong to the Porter Companies)
11. ship_product_final (has all the shipping information of products from distribution to retail store)

12. retail_store (includes the information of retail store)
13. des_emp (includes the information of employee of the distribution center)
14. des_center (includes the information of the distribution center)

The correlations of all tables are shown in figure 7.

5 Conclusion

In this paper we described an implementation of ubiquitous supply chain management application for the agricultural area. The RFID concepts and its implications for supply chain management, inventory and distribution are only the beginning of the potential applications.
We developed an RFID application, which is designed to manage the supply chain system to serve farmers' products. It aims at reducing supply chain inefficiencies and improved inventory flow whilst considering the returns process. An additional important direction of research is the extension of our u-SCM system so as to enable efficient security and privacy protection.

References:

[1] An Approach to Security and Privacy of RFID System for supply chain IBM china research lab, IEEE International Conference on E-Commerce Technology for Dynamic E-Business (2004) 2206-2208

[2] A Ubiquitous Architectural Framework and Protocol for Object Tracking using RFID Tags using RFID Tags, Pradip De, Kalyan Basu and Sajal K. Das, Proceedings of the First Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services (2004) 132-138

[3] RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification, Second Edition, Klaus Finkenzeller, John Wiley & Sons, Ltd. ISBN: 0-470-84402-7, (2003) 6-28

[4] Developing Auto-ID Solutions using Sun Java System RFID Software , http://java.sun.com/developer/technicalArticles/Ecommerce/rfid/sjsrfid/RFID.html

[5] EPC Network Architecture, Kin Seong Leong, Mun Leng Ng, Daniel W. Engels, Auto-ID Labs, School of Electrical & Electronic Engineering, University of Adelaide SA (2005) 1-25

[6] Privacy and Security in Library RFID Issues, Practices, and Architectures CCS'04 (2004) 152-155

[7] Radio Frequency Identification: Applications and Implications for Consumers RFID Workshop Comment, US Federal Trade Commission, (2004) http://www.epic.org/privacy/rfid/ftc-comts-070904.html

[8] Secured 2K bits chip for contactless ISO protocol 15693 - datasheet, (2003) http://www.insidefr.com

[9] EPC Tag Data Standards Specification Version 1.1 (2004) http://www.epcglobalinc.com/standards_technology/EPCTagDataSpecification11rev124.pdf

[10] M300-2G proximity Reader MHz for ISO chips - 15693 – datasheet, (2003) http://www.insidefr.com

[11] A Feasibility study of new RFID Applications, Trond Henning Johansen's master thesis Agder University College, Grimstad, (2004) 7-16

[12] 13.56 MHz ISM Band Class 1Radio Frequency Identification Tag Interface Specification: Candidate Recommendation, Version 1.0.0 http://www.epcglobalinc.com/standards_technology/Secure/v1.0/HF-Class1.pdf

[13] Another Link in the Chain, Card Technology Today, Volume 16, Issue 4, April (2004) 11-12, http://www.sciencedirect.com/science/journal/09652590

[14] Understanding RFID, A Practical Guide for Supply Chain Professionals by Tom Singer, Principal, Tompkins Associates, (2003) http://www.tompkinsinc.com/