

Using LabVIEW to Integrate RFID System and Database for Supply Chain Efficiency Improvement

Wern-Kueir JEHNG, ShihSen PENG and Wei-Hsun HUANG

Abstract—An RFID-based traceability system and its wireless communication technology are emerging to the supply chain management around the world. RFID (Radio Frequency Identification) is one of the greatest innovations in the field of real-time information acquisition technique without the line-of-sight. Current large data storing capability and fast identifying speed are key features of an RFID technology, and these two advantages enable RFID to replace the traditional barcode in an increasing pace. The technology is not only to substitute the barcode with RFID tags, but also improves the effectiveness of mass information transmission on the supply chain control system. This study constructs a dynamic automatic conveyor system to demonstrate real time monitoring of material flow with RFID tags. A database is constructed by Access System (AS) and integrated by the powerful LabVIEW System with high-speed signal acquisition hardware, server computer and software. The developed interface is able to identify whether the products are entering correct places of the assigned warehouse. Therefore, the material flow from supplier, manufacturer, distributor and customer can be controlled, monitored and coordinated. This mechanism of supply chain operations can improve the efficiency and performance of all the supply chain members in current industrial systems.

Index Terms— Radio Frequency Identification (RFID), Supply Chain, LabVIEW, Database

1. INTRODUCTION

Today, most of the retailers still use a barcode system in their supply chain management even though it has several disadvantages. First of all, the barcode scanning product process is too slow since its reader can only read one barcode at a time and there are often thousands or millions of products in a supply chain system. Reading all of them needs much time. Second, if a product in a wrong place, an operator cannot identify it easily. They may only realize the mistake during the inventory process. Third, since a barcode reader cannot pass the paper or metal of a sized packaged box or carton product, the barcode scanning may not be able to identify the product directly or immediately. These disadvantages show that today's barcode technology must be improved.

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A new technology, RFID, has better functions than the traditional barcode. Its major advantages are that many tags can be identified at the same time, each tag can contain more data inside and the radio signal transferring distance is longer. Since the function of RFID is superior to barcode, it is replacing the current barcode technology for improving the efficiency of the supply chain management. RFID can solve the problem of slow reading, because an RFID reader can read many tags at the same time. In a complicate supply chain, the RFID system is developed to distinguish whether the product is delivered into a correct warehouse. A system that integrates the new technology and control system can really improve the efficiency of a supply chain. Developing such a system is hence very important.

As the biggest retailer in the world Wal-Mart used to spend \$70million every year because products were misplaced or miss-checked by their employees [1]. The cost from theft was about 1.5% of the total turnover each year. The characteristics of RFID can help the company to solve these kinds of problems. In 2003, Wal-Mart required its top 100 suppliers to use RFID before 2005. Wal-Mart requested its top 200 suppliers to put the RFID on the entire trailer in 2006. But in recent years, Wal-Mart has found that the cost of RFID is too high and it is difficult to have a system that can connect the total process of the supply chain with an RFID technology.

An RFID technology is able to change the applications of supply chain management and inventory control [2] and we need to prepare for the change. Automatic identification and process control are keys to improve business efficiency [3]. Using the RFID technology can accomplish the part of automatic identification, but how to integrate RFID with the process control system in the supply chain is the baffling part. To prepare for the change of RFID, we must develop a new process control system that integrates with an RFID technology.

Many researchers are devoting resources and knowledge to reconfiguring and creating innovative new structures and systems in order for companies to overcome the crises [4], pursue more efficient operations [5], and gain an economic advantage [6]. Therefore, using a new technology such as RFID is not enough; the new technology has to be integrated with the control system to benefit the industry. This study intends to integrate the RFID technology with the supply chain product database for the process control to gain efficiency improvement with the help of LabVIEW.

2. RFID TECHNOLOGY

2.1 Components of RFID

An RFID system basically consists of three components, tags (transponders), reader (scanners or antenna) and an application system for further processing of the acquired data. A tag contains a microchip, capacitors and an antenna coil that is embedded into an encapsulation material, e.g., a coin, glass body, plastic substrate, smart label or standard ID-1 card. The coil-on-chip technology allows very small tags with only 6 mm diameter and 1.5 mm thickness [7]. The tags communicate via radio signals with an RFID-Reader, which is a central component of an RFID System. A reader can either be a peripheral or handheld device. Another possibility is that it is integrated into a fixed, installed system. RFID systems usually operate on the ISM (Industry, Scientific, and Medical) frequency bands. There are two types of tag-reader couplings: Inductive coupling uses frequencies below 30 MHz and Backscatter coupling uses frequencies above 100 MHz.

2.2 Applications of RFID

Today, we know that the RFID technology is used in the supply chain of retailers, such as Wal-Mart and Metro System in a big city. During the tsunami in Indonesia in 2005, RFID was applied to the management of dead bodies for easier identification and transportation [9]. It has been used in a library management system [10]. Currently, most of the application focus on supply chain management, such as an RFID based Resource Management System [8, 11].

RFID used in the supply chain is growing every year. For instance, the transponder shipment of RFID has increased about seven times from \$232million in 2002 to \$1,621million in 2007. Also, in 2002, the percentage of using RFID in the supply chain was only about 1%, but in 2007 it increased up to 46% [12].

2.3 Challenges of RFID

The preceding subsections mentioned the advantages and characteristics of RFID, but RFID cannot be well used in all applicable areas. Studies of barcode history showed that it took approximately 25 years from the development of the first barcode by the Drexel Institute of Technology in Philadelphia in 1949 to the first commercial barcode scanner installation at a Marsh's Supermarket in Ohio in 1974. The developmental timeframe of RFID is similar. Approximately 25 years have passed between the first RFID technology developed by Los Alamos Scientific Laboratories in 1977 and EPC Global's announcement of the EPC Generation 1 RFID standard in 2003 [13]. The interval between development and application of RFID is longer than the barcode, because there are several reasons that RFID cannot be used extensively. First, the price of the tag and reader are still too high. RFID holds much promise for increasing goods screening and monitoring efficiency, but costs still stand in the way. The major reason is that the price of RFID is too high. One reader costs almost \$700, while a barcode reader costs only \$79. An RFID reader costs nearly nine times more than a barcode reader. A tag has three types, active, semi-active and passive. An active tag

costs about \$100 and passive tag about 30cents to \$50, while barcode tag only 3 cents. For the industry, the price of a tag must be less than 5 cents or the cost is too high to be widely used. Lower price of RFID components is the most important factor to push RFID to be used more extensively. Second, to integrate the application system costs much. Not only a reader and tag, the application system also cost much. Because all of the old systems need to be replaced, the new systems need to be developed and employees have to be trained to use the new systems. The biggest enterprise in the world Wal-Mart has spent almost \$100billion to develop the total process to utilize RFID and it is not complete yet. The risk is too high to develop such a system by enterprises. Not all of them have that many resources and time to develop it. The third reason is that the standard of RFID has not been unified. There are two major international standards for RFID, i.e., EPC global and International Standards Organization (ISO). Standards are still evolving and are not completely compatible with each other. Using any one of the standard will influence other companies that support another standard. A unified, globally interoperable RFID standard is ideal to realize the full benefits of RFID applications. The lack of a complete and unified RFID standard has caused many companies to hesitate in adopting the RFID systems; these companies were afraid of making a commitment that might render their entire RFID system investment worthless in the future. How to unify the standard is also an important issue to make RFID more convenient to be used in the world. Fourth, people think that RFID will invade their personal privacy. RFID tags have the capability of monitoring what we buy and where we go [14]. This makes customers reluctant to accept RFID. The privacy and security is also a very important topic for the growth of RFID in the future. To increase privacy and security, authentication systems are being developed, and individual information protection employing an RFID technology has begun. Finally RFID is not totally safe yet. RFID transfers data and information by using radio frequency. If people can intercept the signal, the data might be changed or stolen. The forward channel from the reader to the tag has a longer range and is at more risk than the backward channel [15]. Ayoade innovated on the APF (Authentication Processing Framework) [16] to stop thieves from changing the data or information in the tag, but it cannot totally defend all kinds of attack. In the market there is a tag that can provide a code to protect the data in the tag which costs more, but the data cannot be completely secured. Protecting the data in the tag without being changed remains a challenging issue.

The purpose of this work is to use LabVIEW to innovate a system that can integrate RFID and database of the products in a supply chain to improve the efficiency of the supply chain. This system can identify what products enter the warehouse and where they are.

3. ACCESS

Access is one of the members of the Microsoft Office system. It is a relational database management system from Microsoft which combines the relational Microsoft Jet Database Engine with a graphical user interface. Access can

use data stored in Access/Jet, Microsoft SQL Server, Oracle, or any ODBC-compliant data container.

This work establishes a database made by Microsoft Access to select the data of the entire product inventory to recognize where a product belongs to. It uses Access to set up the database because Access is a popular system and is easy to use. Inside the database it has information as follows: the database of destination one and two, and database of all products.

4. LABVIEW

Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) is a high-level programming language with Graphical Language developed by National Instruments. It can support interfaces such as GPIB, USB IEEE1394, MODBUS, SERIAL, PARALLEL, IRDA, TCP, UDP, Bluetooth, NET ActiveX, SMTP, etc. LabVIEW is usually used for data acquisition, instrument control, and industrial automation on all kinds of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS. The latest version of LabVIEW is version 8.5, released in August of 2007. The version used in this work is version 8.2.

LabVIEW is built for the design, simulation, modification, and compilation of digital instrumentation systems. The basic entity of the resulting program is the virtual instrument (VI) that consists of executable code controlled via a graphical front panel on the screen similar to a real instrument.

In contrast to conventional programming languages, LabVIEW is programmed on the basis of block diagrams and front panel elements. These elements are connected by means of a wiring tool. The main application areas are data acquisition, system management and the simulation of a digital signal processing system. In cases where real input/output connections are required, IEC, VXI and MXI compatible equipment with serial links or plug-in boards for the PC can be accessed via available drivers. After having tested a virtual instrument, the graphical language built from an application, compiles standalone executable code. The compiled code is executed with a speed comparable to normal compiled C-programs. The execution code may also contain communication calls for different types of supported platforms. A test executive, available in diagram source code, can be added in order to support tests and modifications at runtime. Also, the LABVIEW provides an easy-to-use graphical environment that permits the system operators to process easily the collected data, using complex data-processing algorithms, without detailed knowledge of the data-acquisition system design.

LabVIEW can integrate the RFID system and the database. The interface of LabVIEW can help us to find out which product is not in the correct place.

5. SYSTEM IMPLEMENTATION

ClarIDy EPC is one of the middleware can be used for the RFID systems processing. As shown in Figure 1, the ClarIDy EPC interface has six steps to operate the RFID system:

Step 1: Initially, the circle 1 button indicates “connect” and there is no any connection shown in circle 2, By pressing the circle 1 button, the button will change into “disconnect” indication. The computer then starts to connect with the RFID reader of the system.

Step 2: The communication interface shows “success” as in the circle 2. This means the ClarIDy EPC has connected to the reader.

Step 3: Pick the readers to be used as shown in circle 3.

Step 4: Press the button of “start polling for tags”. The reader starts searching the tags as shown in circle 4.

Step 5: We can see the communication interface pop-up that antenna 2 searches for one tag as shown in circle 5.

Step 6: At tag’s interface as shown in circle 6, it shows “Ant2 300833B2DDD901 40280A0000”. This means that a tag named as 300833B 2DDD90140280A0000 is found by antenna 2.

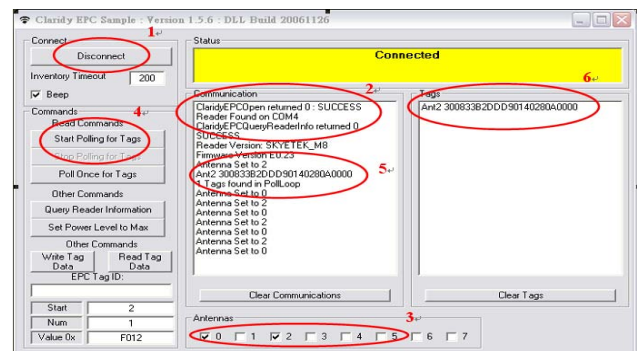


Figure 1. ClarIDy EPC interface for RFID system

Nevertheless, the system described above can only connect the existing antenna to read its related tags, it can not help operator to monitor whether the tagged product is delivered to the right place of the warehouse. To improve this problem, this study integrates the ClarIDy EPC interface with the Microsoft Access and LabVIEW software to develop a technique that is able to identify whether the tagged product is delivered to the right place of warehouse automatically.

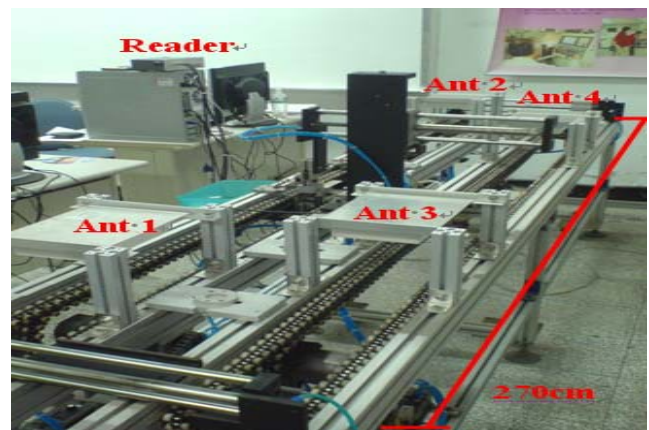


Figure 2. Experiment set up circumstance

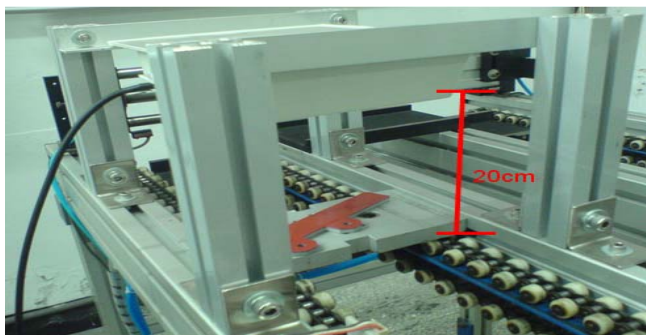


Figure 3. The tag passing the antenna and be read



Figure 4. The ClarIDy plastic tags



Figure 5. The control desk of the delivery belt

As shown in Figure 2 to Figure 5, an automatic delivered system at the Department of Industrial Engineering and Management at Kaohsiung University of Applied Science, Taiwan is implemented using the developed technique. The system can be used at the warehouse of any retailers. According to the designed system, retailers can find out which product is not in the warehouse. The warehouse is able to control the transformation of the products from the beginning. A retailer requires all the information and data of the products; the system is set up to help the retailer to handle any mistakes that could happen. In this research, only two retailer stores are depicted for study; each of them has two RFID readers. To simplify the discussion, there are nine tags and nine products, with four products belong to warehouse 1 and five products belong to warehouse 2.

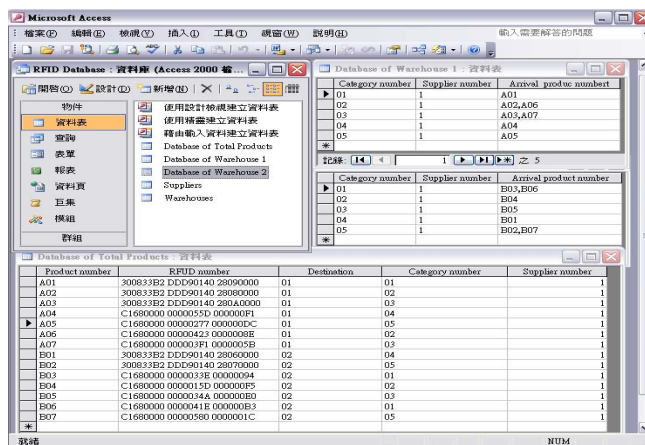


Figure 6. Database of warehouse and total products

To start the process, product database is created first. Five databases are required i.e., total product database with all information of the nine products, warehouse 1 database with the information of the four products belongs to it and warehouse 2 database contains the information of five products. The last two databases contain the information of the supplier and warehouse 1 and 2. Figure 6 shows all the database information of both products and warehouse.



Figure 7. Steps to set up the Access Database

There are several steps needed to connect the database and LabVIEW as shown in Figure 7 and depicted as follows:

At first, enter the System Manage Toll and choose the ODBC Data Resource Manager. Increase a new data resource that is Microsoft Access Driver. The new resource name should be of the same format of "RFID Database". Then find the required database and choose it, such that LabVIEW will find the database needed. It is important for this initial process since without this process LabVIEW could not identify which database is required and the LabVIEW system will not be able to connect the product database even after the process is set up. Figure 8 shows the front panel of RFID and database process control. Figure 9 shows the high level block diagram of RFID and database process control system. The front panel can control and monitor the products that are delivering into

the warehouse. The high level block diagram shows how this program works.

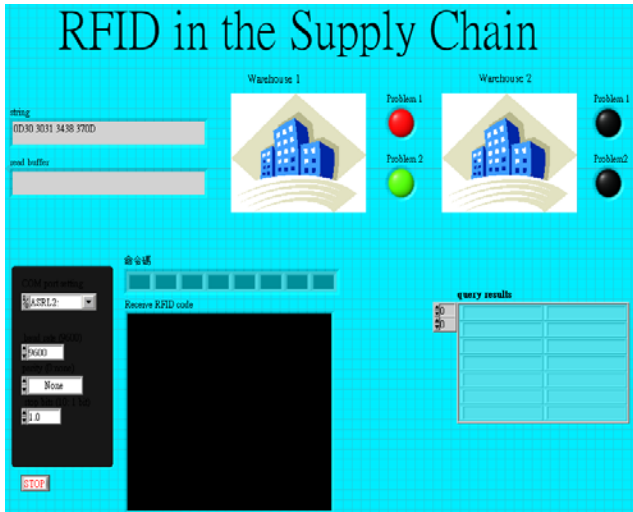


Figure 8. Front panel of RFID and database process control system

In Figure 8, the blank space shows that the RFID tag numbers are entering or have entered the stockroom of the retailer. Figure 8 can also check all information of warehouse 1 and warehouse 2. Each warehouse has two warning lights, i.e., red light and green light each. Red light means that products have been in this warehouse already but have not been in the retailer yet. Green light means that the products are not required but have been delivered to the retailer. If both don't happen in each warehouse, the light will be black. These two lights can help the panel operator to figure out whether there are any products dispatched to a wrong warehouse. Because the front panel can also show the situation of another warehouse, the operator can locate from the front panel where the product is. If it is in warehouse 1, the red light shines, the operator can then find the misplaced product in warehouse 2. If green light shines, warehouse 1 can inquire warehouse 2 for any missing products they may have.

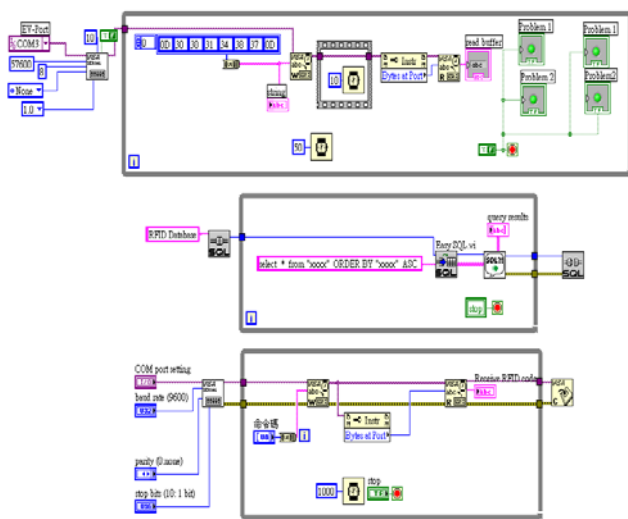


Figure 9. High level block diagram of RFID and database process control system

In the high level block diagram as shown in Figure 9 there are three case structures with different functions. The first case structure connects the RFID hardware, PC and the LabVIEW system; this case structure allows the LabVIEW system to control and obtain the data from the RFID. This

function () helps LabVIEW to control the USB equipments, such that the RFID hardware can be controlled by LabVIEW. The numbers before this function () are the code and data of the RFID hardware. Without these numbers the RFID hardware cannot be identified, and this can not be used by LabVIEW. The coded number () shown in this screen is the RS232 code of RFID tag coded by ClarIDy. The number can transform the RFID tag code into any type needed. The reading speed of the antenna is 10 milliseconds (), and every 50 milliseconds the system

shows a code number at the front interface (). The four problems are shown by different light colors to be easier to identify (), but the colors will be changed at the front panel. The purpose of the first structure is to connect the RFID system and hardware of ClarIDy to be used by LabVIEW, to set up the transform code of the tags, to establish the reading speed of the reader (antennas), and set to connect the problem lights. The second case structure is to receive the data from the Access database. The database has been established at the beginning which includes the information of the warehouse, product and the tags, etc. The

function () means that this case structure uses the SQL function, and the database is used for the RFID database (). This case structure searches the data collected by the RFID reader and compare with the set up database, and then find out the product that does not belong to

this warehouse (). The third case structure is similar to the first one, but the system needs to receive the RFID code () to compare with that in the database.

To establish this LabVIEW system there are three steps. First is to build up the database. This database should have entire information of the products and warehouses, such as Figure 6. Second is to set up the relationship between the database and LabVIEW system as shown in Figure 7. Without this, LabVIEW cannot find the needed database. The last step is to design the high level block of LabVIEW. This high level block establishes the system to identify the RFID USB hardware, identify the tags that are entering the warehouse and control the warning lights, as shown in Figure 9. The operator's interface is like that shown in Figure 7.

This system uses the characteristic of RFID that can read many tags in one scan and automatically deliver the information in a short time. Traditional barcode can only read one at a time, and thus cannot have this function. This feature can help a retailer to find out whether the product is at the right place or not. If the product does not belong to this

warehouse the system can show where the product is at that moment, and the operator can deal with the problem immediately. Thus, the retailer or warehouses do not have to wait until the operators check the entire stocking inventory.

The biggest advantage to use this system is the mistakes can be detected right away. An RFID reader can read many tags concurrently and the information about the tag is sent to the system immediately. The system can easily identify whether right products are in the right warehouse, and also the operator can deal with the problem once it appears. Because the interface can also show the information of other warehouses, the operator would be easy to figure out where the missing products are located.

6. CONCLUSION AND FUTURE RESEARCH

The applications of RFID for the supply chain management are important in the industry. Proper technology to integrate the database efficiently is the key to success. Much has been written in industry press regarding recent RFID mandates from Wal-Mart and the U.S. Department of Defense (DOD). Many inventory management applications demonstrates the versatility and impact of RFID solutions across a variety of industries and all areas of the supply chain. Thus, many retailers are searching for new technology and new process control systems to increase their efficiency of the supply chain management. This work uses LabVIEW to integrate the supply chain product database and RFID technology to increase the operational efficiency, prevent one from dispatching goods to wrong place, and help an operator to relocate the misplaced products immediately. The developed integrated technique using LabVIEW can help a retailer to reduce the supply chain management problem as well. Our further work in this field is to apply the developed technique and system in the cases of complicate supply chain systems for large-scale industrial retailers.

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