A flexible architecture for RFID based laundry management systems

Yingliang Lu, Hao Yu
Fujitsu R&D Center CO., LTD.
luyl@cn.fujitsu.com, yu@cn.fujitsu.com

Abstract- **This paper novel proposes a flexible RFID based production process management system architecture with the service oriented architecture technology. The system managers can add a new function or a new production process by the visual interface of our architecture. This architecture is used to construct a visualization system prototype which can be used to manage laundry process effectively by using the washable RFID tags. A set of system requirements are developed that cover the design of the nodes of the shops, the storehouses and the laundry factories, the design of the network, the design of the interface, the capabilities for remote data access and management, and the easily expansible services. For easily accessed by internet, this system is developed as a web application. Our system enables reliable laundry management running cheaply and effectively.**

I. INTRODUCTION

Radio Frequency Identification (RFID) is a method of identifying unique instances of items using electromagnetic energy. The usage of RFID-based solutions already plays an important role in different application areas like production, supply chain management, healthcare, and finance. It allows to uniquely identified objects that are tagged with RFID transponders, enabling typical Auto-ID infrastructure services. An automatic laundry shop and laundry factories have to tell customers where their clothes locate, and when their clothes could be washed in schedule, and which processes are done on their clothes, and what time is appropriate to go to shop to take back their washed clothes. On the other hand, for the laundry shop managers, they want to know which process is a bottleneck in their automatic laundry process, they also want find out the operators who are work hard or lazy, and they also want to monitor the processing with remote access by internet. Furthermore, in the laundry quality control field, we want to trace back the links of laundry process and transport process where the problems happened. A visual system and a flexible architecture for RFID based laundry management systems are needed.

Therefore, we originally descript a flexible architecture of RFID management system that a programmer can easily add new devices and services from a web based interface. In order to cut down the cost of development, this architecture is always constructed to address special requirements of the work process in a special business. In our implementation which is proposed in this paper, the flexible architecture is addressed to laundry business for laundry factory and shop monitoring in general. Moreover, we develop a visualized RFID based laundry process management system. At this system, to set an ID on each clothes, a shop assistant attach a washable RFID tag on every clothes at the beginning when he received the clothes from customs, and he will take off those tags from clothes when these clothes is returned to customs. Therefore, an operator can monitor all washing processes and transportation route of the tagged clothes by monitoring the positions and the logged time of the attached tags.

The remainder of the present paper is organized as follows. Section 2 provides an overview of research related to applications with RFIDs. In Section 3, we describe the novel RFID based manufacture process management system architecture. We describe the implementation of our algorithms and architecture in section 4. Finally, in Section 5, we conclude the paper and present ideas for future study.

II. RELATED WORK

RFID is a means of storing and retrieving data through electromagnetic transmission using a radio frequency (RF)-compatible integrated circuit. Today, RFID is applied widely in supply-chain tracking, retail stock management, parking access control, library book tracking, marathon races, airline luggage tracking, electronic security keys, toll collection, theft prevention, and healthcare. A number of different approaches have been proposed for the RFID applications. An RFID system usually consists of three main components: tags, readers and the supporting software. A tag has a unique identification number (ID) and memory that stores additional data such as manufacturer name, product type, and environmental factors including temperature, humidity, and so on. The reader can read and/or write data to tags through wireless transmissions. The supporting software can map the virtual IDs (the ID of RIFD tags) to the real world objects. In a typical RFID application, tags are attached or embedded in objects that must be identified or tracked. By reading nearby tag IDs and then consulting a background database that provides mapping between IDs and objects, the reader can monitor the existence of the corresponding objects.

A representative application of the RFID can be found in [5]. It introduces a framework for group tour-guiding services in which each group has a group leader and several members. Each member may follow the moving path of its leader or occasionally roam around randomly, based on his or her interest. The system performs positioning of the group leaders

978-1-4244-3709-2/10/$25.00 ©2010 IEEE

using WSN technology. If a group member must find the leader, it is done by reading the member's tag, associating the member with the leader, and then showing the location of the leader based on the information obtained from the WSN. Integration in which a WSN is used for providing location and RFID is used for identifying objects or people.

In recently, several research institutes and firms are researching the use of RFID in supply chain management. Wal-Mart's RFID mandate requires their top 100 suppliers to tag shipments, down to the casing and pallet level, prior to delivery. Hence, supply chain management is present focus on RFID.

A RFID network system referencing to the RFID project in Taiwan hospital named Location-Based Medicare Service (LBMS) is proposed in [6]. Its system architecture is shown in Figure 4. Alike to common RFID system, the LBMS system employs RFID readers in tracking tagged persons or objects. Information stored in RFID tags acquired by readers would be transformed into the records to join in the relational database.

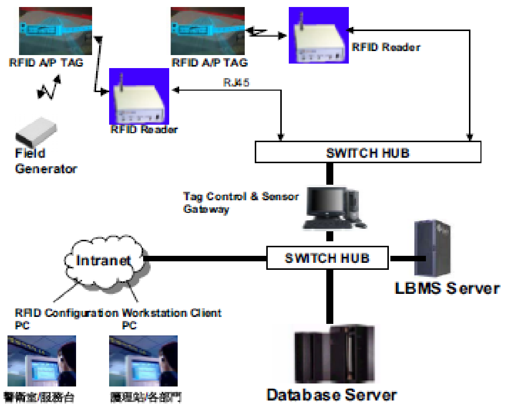

Figure 1. The RFID infrastructure of Taipei Medical University Hospital

RFID data cleaning is very important in RFID applications. Some conditions can greatly effective the read result of a RFID reader [3][4], for example, the number and type of reader antennas, reader power level, the orientation of the tag with respect to the antenna, the distance from the reader antennas to the objects, and the location of the tag on the object. In real world applications, to add some real world constraints into the reasonable and feasible constraints in the virtual world can improve the reliability of RFID readers. Hagiwara [1] propose a accompany constraint and route constraint as two conditions to clean and correct raw RFID data of the supply chain applications. The accompany constraint means that multiple objects in the real world are sometimes treated as a group, that is, moves together, such as multiple products in a market basket. If the system knows the composition of such groups, the system can infer the existence of the all elements of a group, only by identifying one or more element of the group, such as all the products in the basket can be assumed to be identified when only one product is identified by a reader, even if several products could not be identified directly. The route constraint means that an object in the real world is sometimes designated a specific or several possible routes to move. For example, products are routed on belt conveyers in a distribution center. These routes of the objects can be made use of by the system to detect read errors of RFID readers, since an invalid route log obtained by the RFID readers can be considered as an read error.

We also can improve the reliability of RFID read process by add a redundancy RFID reader. In [2], the authors use two RFID readers to do a read process, their result show that their method can effectively improve read precision. However, it would improve the equipment investment in the initial stage of RFID system architecture. In our implement, we add some restrictions including accompany constraint and route constraint as read conditions to improve the precision of RFID read processes.

III. SOFTWARE ARCHITECTURE AND DATA CLEANING

In order to make a system developer can rapidly and easily develops a new function for a new business service. We propose new software architecture with 4 levels. The layer 0 is the hardware including RFID tags, R/Ws and some actuators. The layer 1 is the drivers and control components software which is the interface between our business processes and hardware. The layer 1 and layer 2 are implemented in data collection servers (Fig.3). The layer 3 including user interfaces can be rapidly developed and modified by the end user developers. Only layer 3 is implemented in the application server.

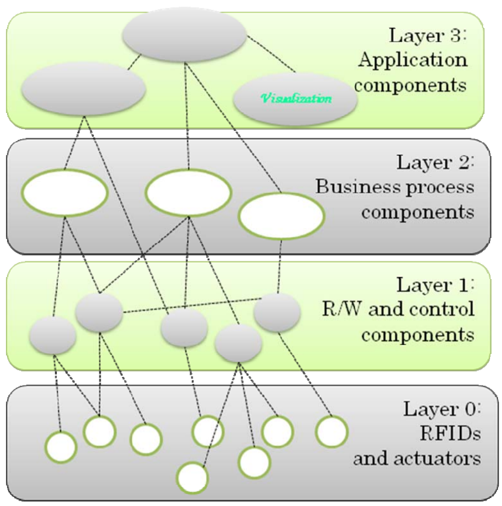

Figure 2. application system architecture

We implement our business process in the layer 2 shown in Fig.2. In this layer we integrate business services and data cleaning algorithms and provide open interface to the application layer. We have to modify old models that are defined by the different services in layer 2 or add a new module as a new service provider into layer 2. Therefore, this software architecture can help a system developer rapidly and easily to implement a new function for a new business service.

In the practical applications, data transmission between a shop and a laundry factory usually use GPRS or other usage-based billing wireless transmission protocols. In order to reduce the cost, the transferred data have to be cleaned and compressed before the transmission. We develop a edge cleaning model to construct our laundry process management system (Fig.3)

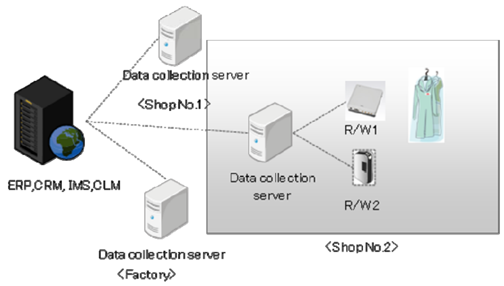

Figure 3. The network topology in our implementation

There is a data collection server at each shops or a laundry factory. The data collection server is connected to RFID readers. It receives raw RFID data from RFID readers and cleans raw data using rules. Then the data collection server will generate events by the cleaned data and send the events to the application server. Users can implement their ERP, CRM and CLM on the application server. Furthermore, users and custom can monitor laundry process different detail by the web browser from internet, because we build a web server on the application server.

IV. SYSTEM IMPLEMENTATION

The RFID system is designed to replace handwritten paper records or barcodes, which can be misread, lost or easily damaged. Unlike barcodes that require line of site and item-by-item manual scanning, RFID-tagged garments can be read while stored in bags or racked on hanger bundles. Up to now, most of the laundry factory and shop use barcode label like Fig.4 to identify garments, therefore, they have to be read closely, and only one code could be read in a read process. So, it is very difficult to find the localization of an object by a given code of a barcode label. These weak points of the barcode label make it almost impossible to improve productivity and reduce defective rate scientifically on the process of laundry manufacture by tracing the identification of the clothes monitoring the laundry manufacture process.

Therefore, to resolve the problems mentioned above, we construct a demo RFID based laundry management system with a flexible architecture. We implement our data cleaning and filtering algorithms and architecture on this system. In our demo system, we use 200 washable tags and 3 Fujitsu RFID readers in our demo system. Software, we use Microsoft IIS as our web server to provide web services for remote monitoring and process management of the laundry process, we use Microsoft access as our real-time database to save clean RFID data, events and the data of customers.

982613461460000005

Figure 4. A sample of laundry barcode

We adapt the UHF RFID laundry tag WT-A501 which can be used more than 200 washing cycles as the identification of a cloth in our implemented laundry manager system. The heat resistance of this washable tag is more than 200°C. This feature is designed for ironing process. A tag example is shown in Fig.5. Because of its anti-collision feature, it is possible for one reader to simultaneously read many tags, very quickly and without line of sight. This is one among many of the major advantages compared to barcode-based solutions. Because of its good remote read feature, it is also possible for the reader to read these tags which have less than 2m distance away from the antenna of the reader. This feature can help laundry manager system to find the location of an identified cloth by RFID reader efficiently and rapidly. This is also a very important advantage compared to barcode-based solutions.

Figure 5. Fujitsu washable tag tag WT-A501

A state-of-the-art laundry process which happened at the laundry shop everyday includes receiving clothes, returning clothes processes, and cleaning processes such as washing, drying, ironing, etc. which are done at the laundry factory, and the transport and delivery process between shops and factory. The figures (see Fig. 2 and Fig. 6) show the interface and the architecture of our system.

A RFID based laundry management system always include following main steps.

Step1: Attach a RFID tag on each clothes in each store.

In period, laundry factory and shop use barcode label like Fig.4 to identify clothes, therefore, they have to be read closely, only one code could be read in a read process. By this step the id of the tag is attached to the clothes. Users can monitor the clothes status by tracing the id of the attached tags. In order to facilitate management the ids of clothes, we use the attached tags id as the id of the cloth in our demo system.

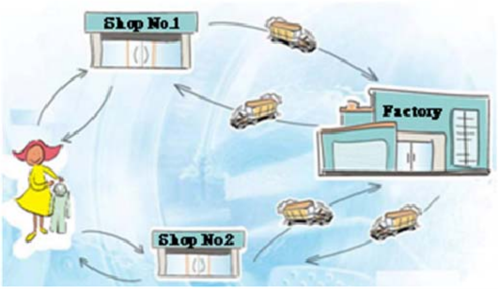

Figure.6 the skeleton diagram of the transport steps of our RFID based laundry management system.

Step2: Keep in storehouse – before clean.

At this step we need to manage the clothes to prevent to lose clothes. At the end of this step we package up clothes and send to laundry factory.

Step3: Send the collected dirty clothes to laundry factory, and monitor the process of cloth cleaning.

Like the graph shown in Fig.7, at this step system will log process detail into database such as the tag ID, the operator ID, operated time, some memos of the operator, etc. When washing accident happened, these data can make system is traceability. Furthermore, this laundry process management system can help the laundry shop manager to find out machine stoppage or mistake of the operators rapidly and effectively.

Step4: Send back to storehouse of each store – after clean.

At this step we need pick the clothes by the RFID identification and package them then send them to the original storehouse where the clothes are received.

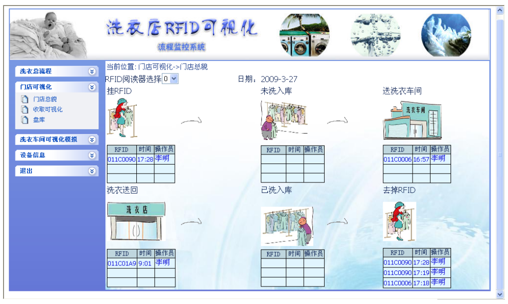

Figure 7. The interface of our RFID based visualized laundry management system.

Step5: Keep in storehouse – after clean.

Write the statues of clothes as (ID, position, and transport time) into database for logging clothes status. Then contact the customers who owner the clothes to come to storehouse to take back their clothes by calling or sending a short message. In this step, to prevent clothes from losing, it is very important that make an inventory of cloths in a storehouse. Because many RFID tags can be remote read and can be simultaneously read, our system can make an inventory of cloths in a storehouse rapidly and effectively.

Step6: Remove the RFID tag from each clothes.

When a customer comes to storehouse and want to take back their cleaned clothes, storehouse assistants have to find out their clothes rapidly. In addition we develop an algorithm to find out the identified cloth quickly. At the end of this step, in order to take back RFID tags for reuse, the assistant of storehouse have to take off the attached RFID tags from the clothes of the customer.

V. CONCLUSION

In this paper, we novel proposed a RFID based visualized laundry management system. In fact, a laundry chain have to monitor all steps of the clothes cleaning process of customs, the system architecture is proposed to address these requirements for laundry factory and shop monitoring using RFID in general. In addition, the distributed data collection servers are be used in order to reduce transferred data on the network. The proposed software architecture show good performance in our implementation. In addition, our approach also can be implemented on supply-chain.

REFERENCES

[1] Sozo Inoue, Hiroto Yasuura, Daisuke Hagiwara: Systematic Error Detection for RFID Reliability. ARES 2006: 280-286

[2] Yu-Ju Tu and Selwyn Piramuthu. Reducing False reads in RFID-Embedded Supply Chains. Journal of Theoretical and Applied Electronic Commerce Research, 3(2) August 2008.

[3] Ahmad Rahmati, Lin Zhong, Matti Hiltunen, Rittwik Jana, "Reliability Techniques for RFID-Based Object Tracking Applications," dsn, pp.113-118, 37th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN'07), 2007

[4] Sidney K. D'Mello, Eric Mathews, Lee McCauley, James Markham: Impact of Position and Orientation of RFID Tags on Real Time Asset Tracking in a Supply Chain. JTAER 3(1): 1-12 (2008)

[5] P.Y. Chen et al., "A Group Tour Guide System with RFIDs and Wireless Sensor Networks," IPSN'07, 2007, pp. 561–62.

[6] S.W. Wang, W.H. Chen, C.S. Ong, L. Liu and Y.W. Chuang, "RFID Application in Hospitals: A Case Study on a Demonstration RFID Project in a Taiwan Hospital," Proceedings of the Annual Hawaii International Conference on System Sciences, Vol.8, pp.184a, Jan. 2006.